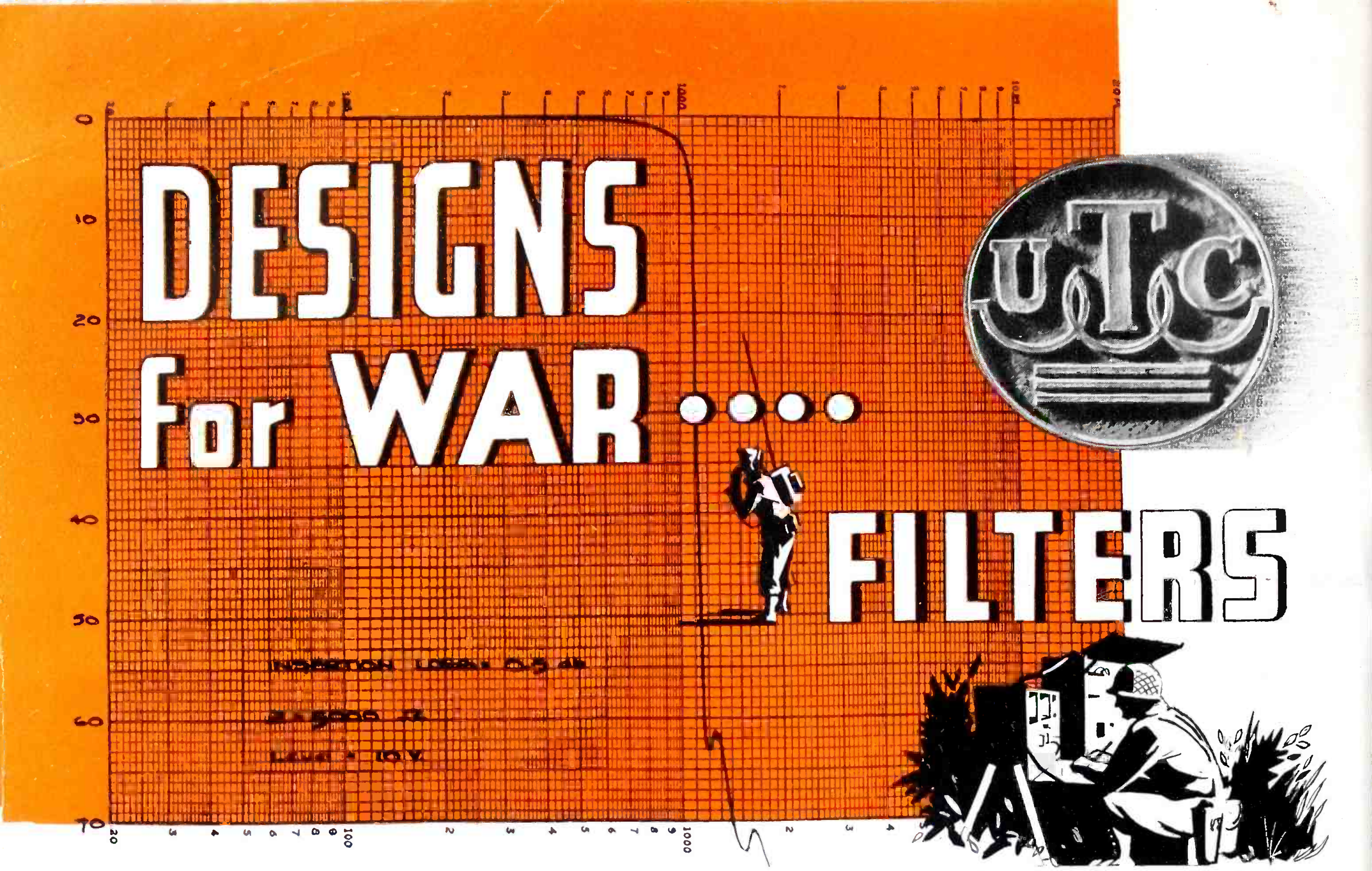
NOVEMBER · 1943

electronics

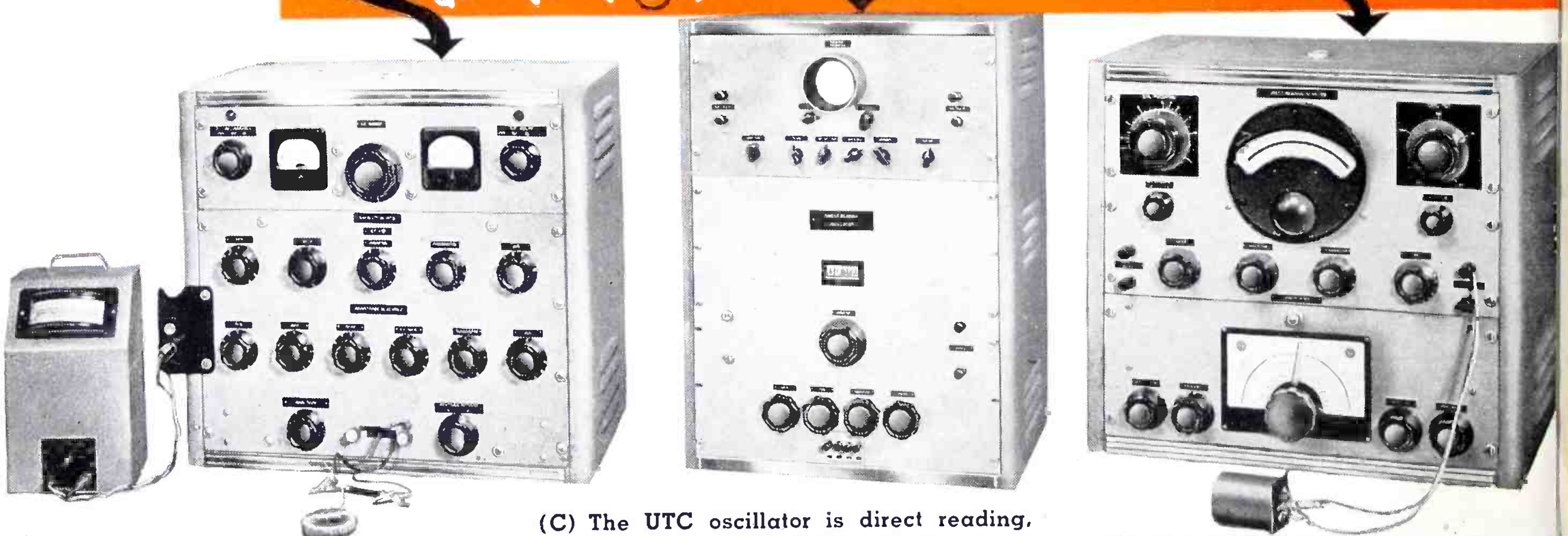
A McGRAW-HILL PUBLICATION

DESIGNS For WAR .... FILTERS



(A) Filter performance is dependent upon three major factors, basic design ... Q of coil and capacitor elements ... and precision of adjustment. The superiority of UTC products in this field has been effected through many years of research and development on core materials and measuring apparatus. We illustrate below a typical filter formula and some of the UTC apparatus used to determine quantitative and qualitative values:

$$\frac{(LC\pi^2 f_\infty - 1)\left(\frac{1}{f} + 1 - \left(\frac{f_\infty}{f}\right)^2\right)}{\frac{1}{Q^2} + \left(1 - \left(\frac{f_\infty}{f}\right)^2\right)^2} = U_m \text{ (ATTENUATION CONSTANT)}$$



(B) The UTC inductance bridge is capable of four digit accuracy and covers a range from extremely low values to over 100 Hys. The effective resistance and inductance values are direct reading, eliminating the possibility of error in conversion.

(C) The UTC oscillator is direct reading, where the frequency desired is set as in a four digit decade box, and is accurate within 1 cycle at 1,000 cycles. The range is 10 cycles to 100 kc. Accuracy of this type is essential with filters having sharp attenuation characteristics. This instrument is augmented by a UTC harmonic analyzer for the output measuring device.

(D) The UTC Q meter is a unique de[...] which has helped considerably in the de[...]velopment of the special core materials u[...] in our filters. It is also of importance in m[...]taining uniform quality in our produc[...] coils. The Q is read directly and covers [...] entire range of possible Q factors over [...] entire audio frequency band.

UNITED TRANSFORMER CO.

150 VARICK STREET • NEW YORK 13, N. Y.

EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y., CABLES: "ARLAB"

electronics

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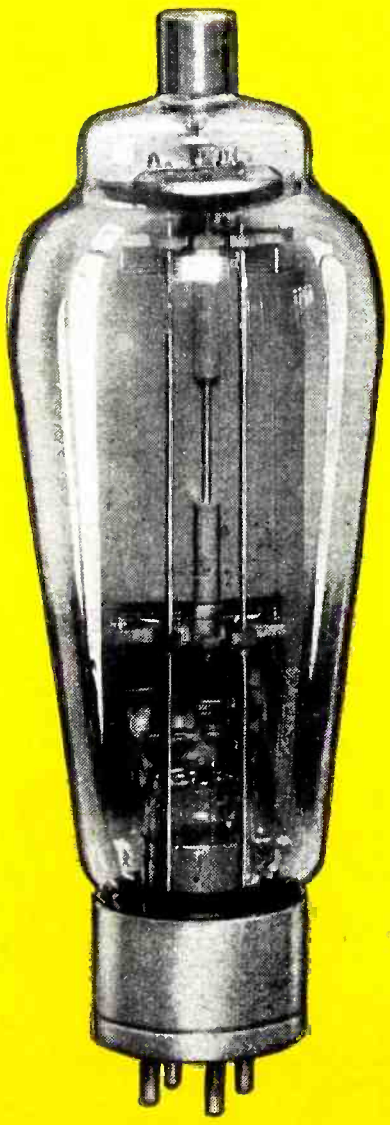
ADVANCED DESIGN—IMPROVED MANUFACTURING METHODS—MODERN PRODUCTION FACILITIES—PLUS LONG AND CONSTANTLY GROWING EXPERIENCE . . . ENABLE GENERAL ELECTRIC TO ANNOUNCE

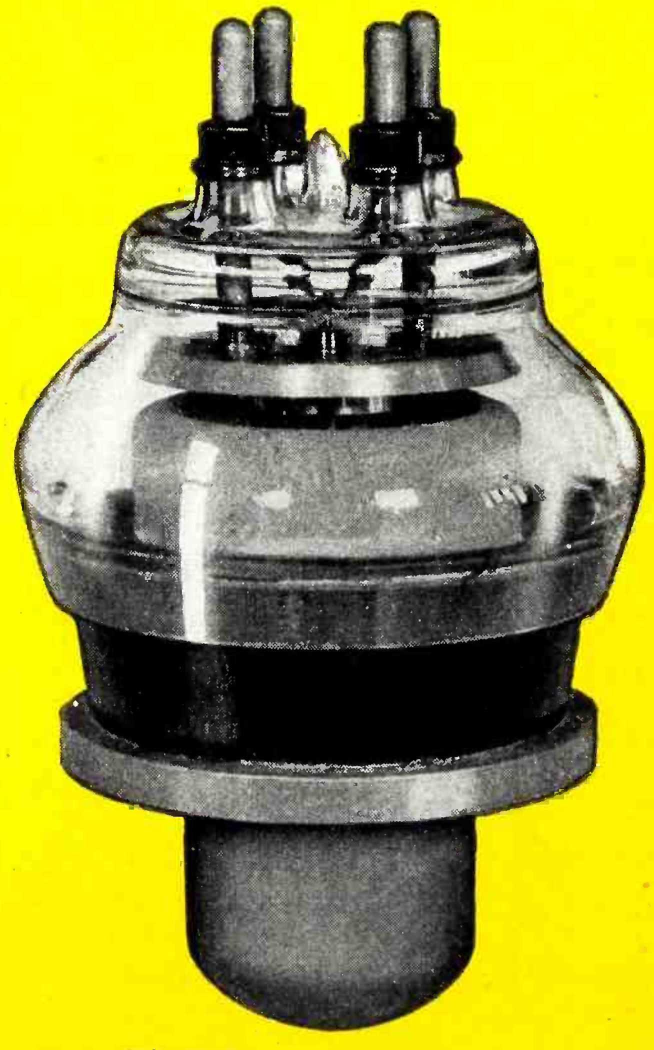
SUBSTANTIAL PRICE REDUCTIONS IN G-E TRANSMITTER TUBES



GL-169 (and GL-159)

Transmitting triodes—for police radio

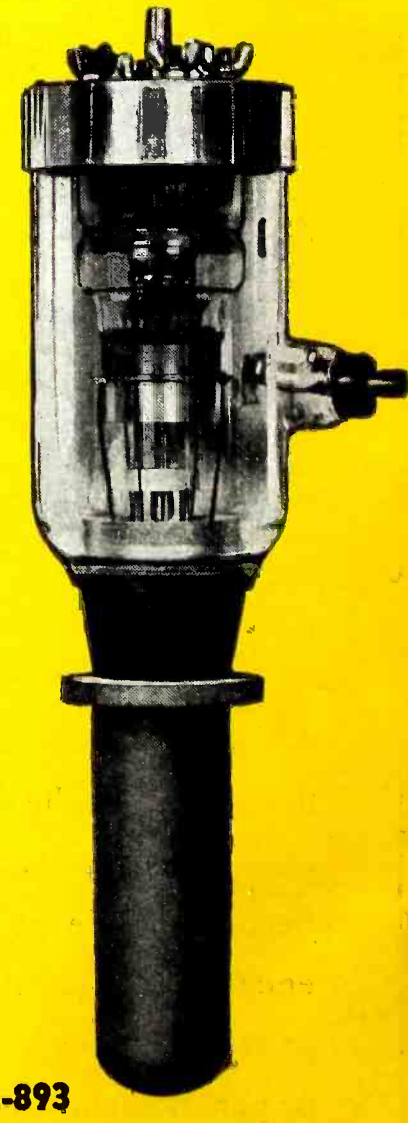
Old price $80
NEW PRICE $60



GL-880

High-frequency triode—for international short-wave, frequency modulation

Old price $850
NEW PRICE $600



GL-893

Transmitting triode—for broadcast, international short-wave, and also for high-frequency heating

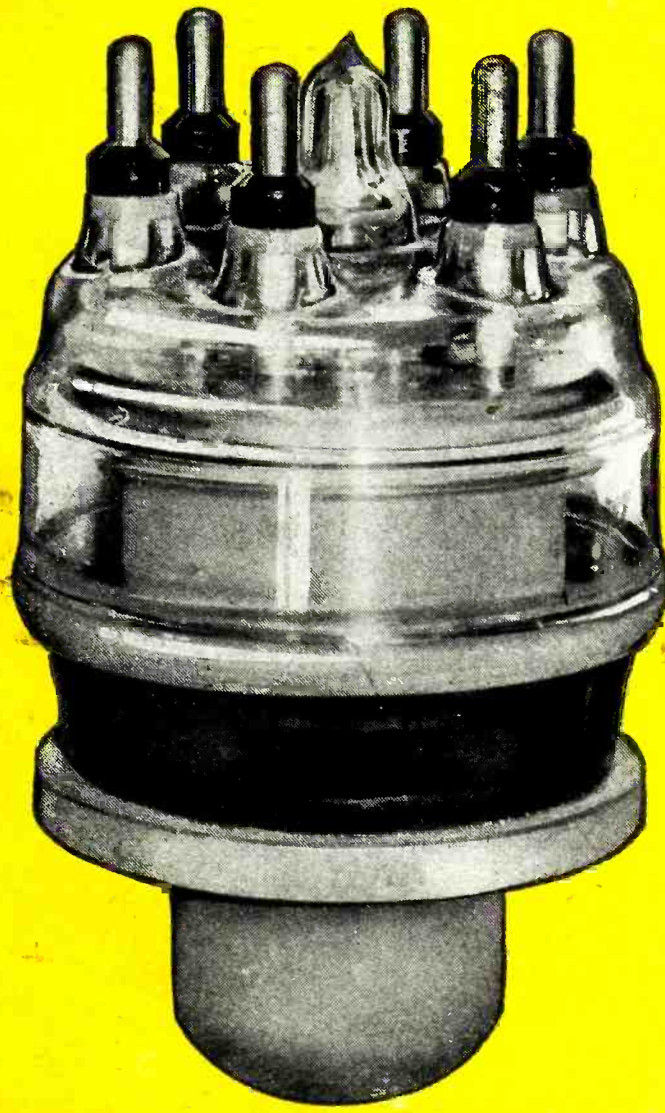
Old price $750
NEW PRICE $650

THERE'S A G-E ELECTRONIC TUBE FOR EVERY PURPOSE

GL-862 (and GL-898)

100-kw triodes — for 50-kw broadcast, and also for high-frequency heating

Old price $1650
NEW PRICE $1250



GL-8009

High-frequency triode—for frequency modulation and television

Old price $1100
NEW PRICE $850

GL-857B (and GL-266B)

Mercury vapor rectifiers — for 50-kw broadcast and international short-wave

Old price $240
NEW PRICE $200

Write for COMPLETE new price list showing reductions on additional tubes (Publication ET-5). Address Dept. 6-215, *General Electric, Schenectady, N. Y.*

LEADERSHIP. General Electric has probably made more important contributions to the development of transmitting tubes than any other manufacturer. For example: G.E. did much of the early development work on tubes and circuits to produce the high-frequency oscillations that make radio broadcasting possible. G.E. developed the first water-cooled transmitting tube which made high-power broadcasting possible. G.E. developed the hot-cathode mercury-vapor tubes which cut broadcasting power costs greatly.

G-E research, tube developments and manufacturing improvements go on—endlessly. Savings gained in this progress will always be reflected in favorable price advantages, in still higher tube efficiency, and in longer service.

• *Tune in* "The World Today" *every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E* "All Girl Orchestra" *at 10 P.M. E.W.T. over NBC.*

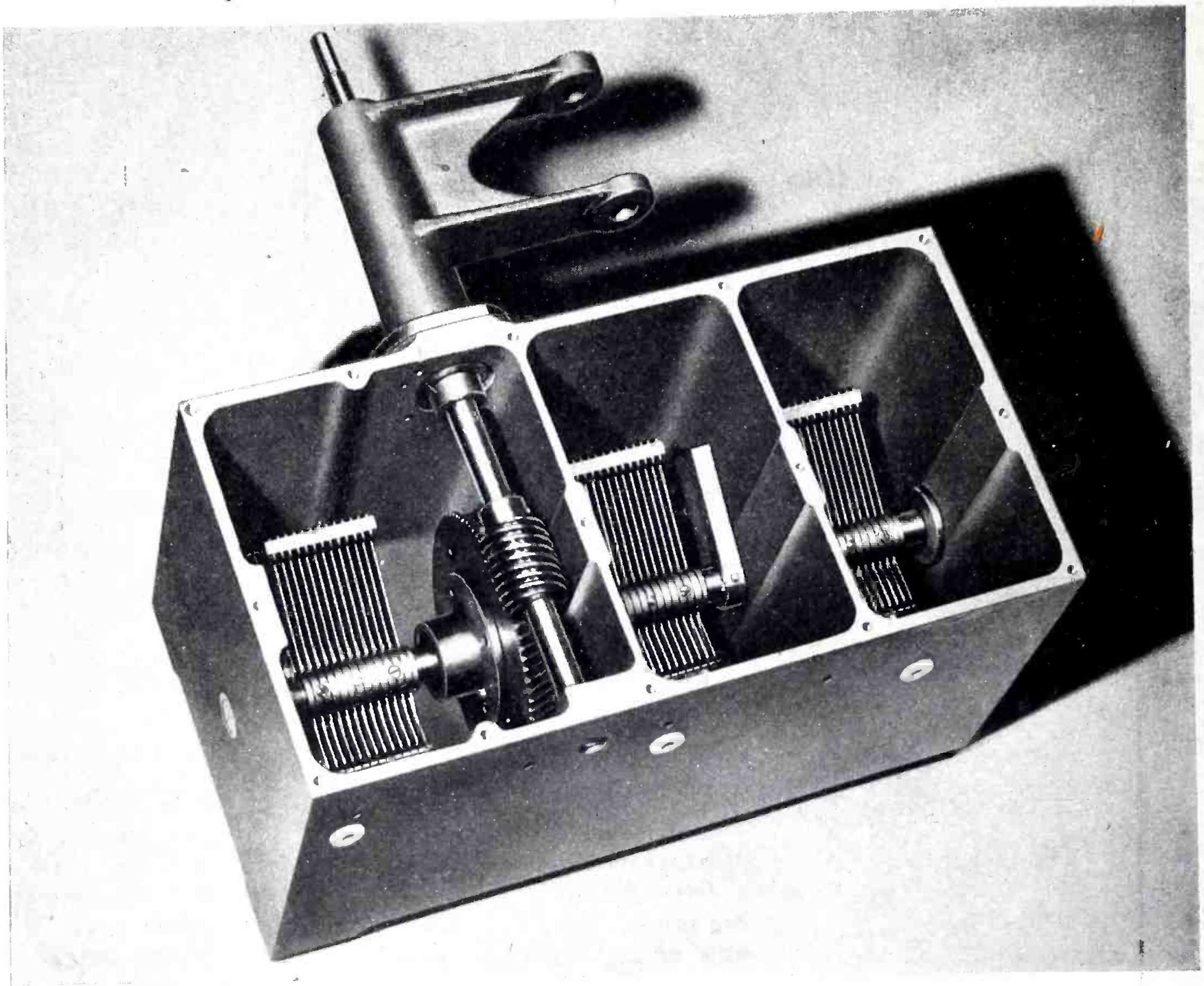
★ ***BACK THE ATTACK—BUY WAR BONDS!*** ★

STATION AND STUDIO EQUIPMENT • TRANSMITTERS • ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

GENERAL ELECTRIC

160-B10

GEARED TO THE JOB



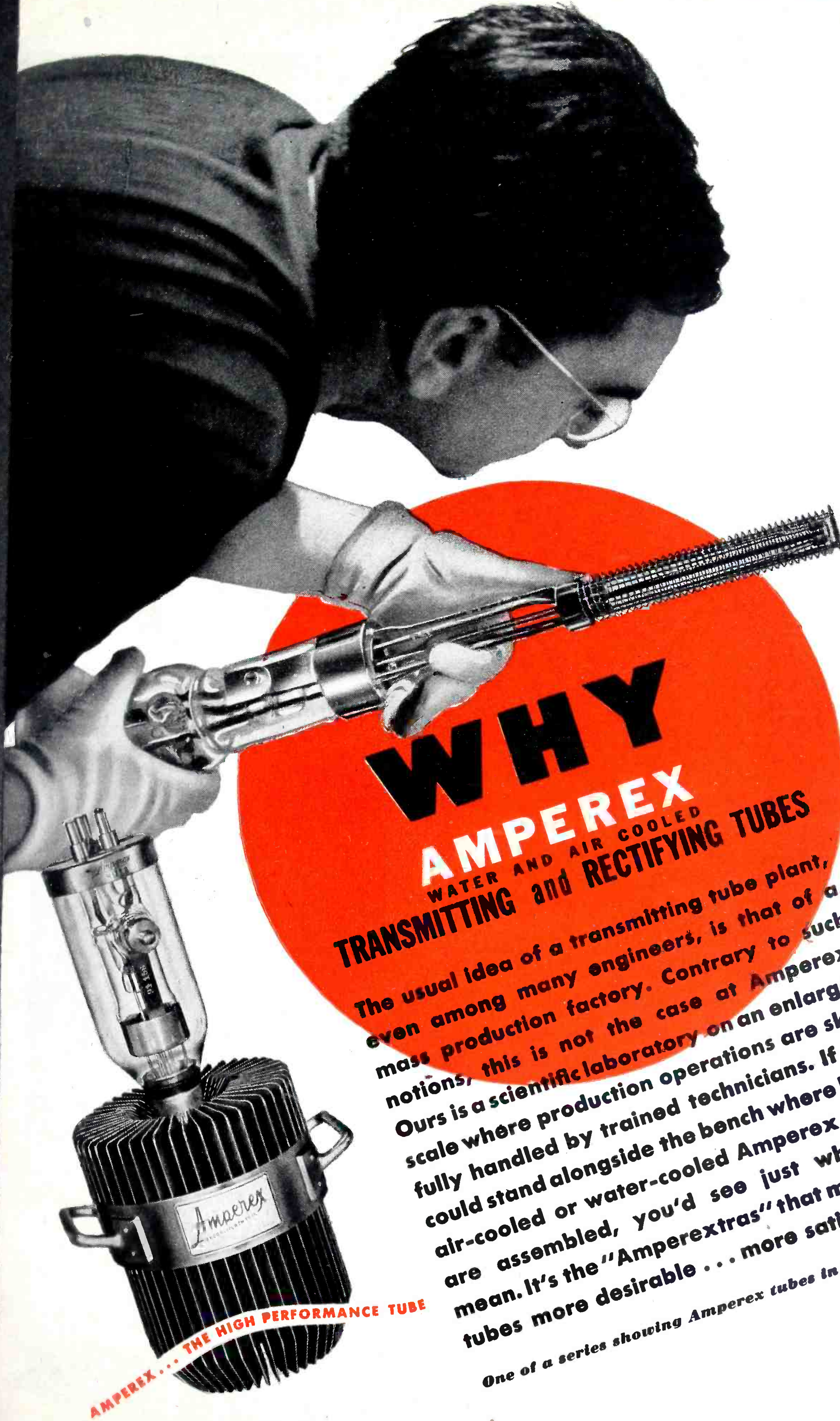
Designed to meet a wide variety of essential requirements.

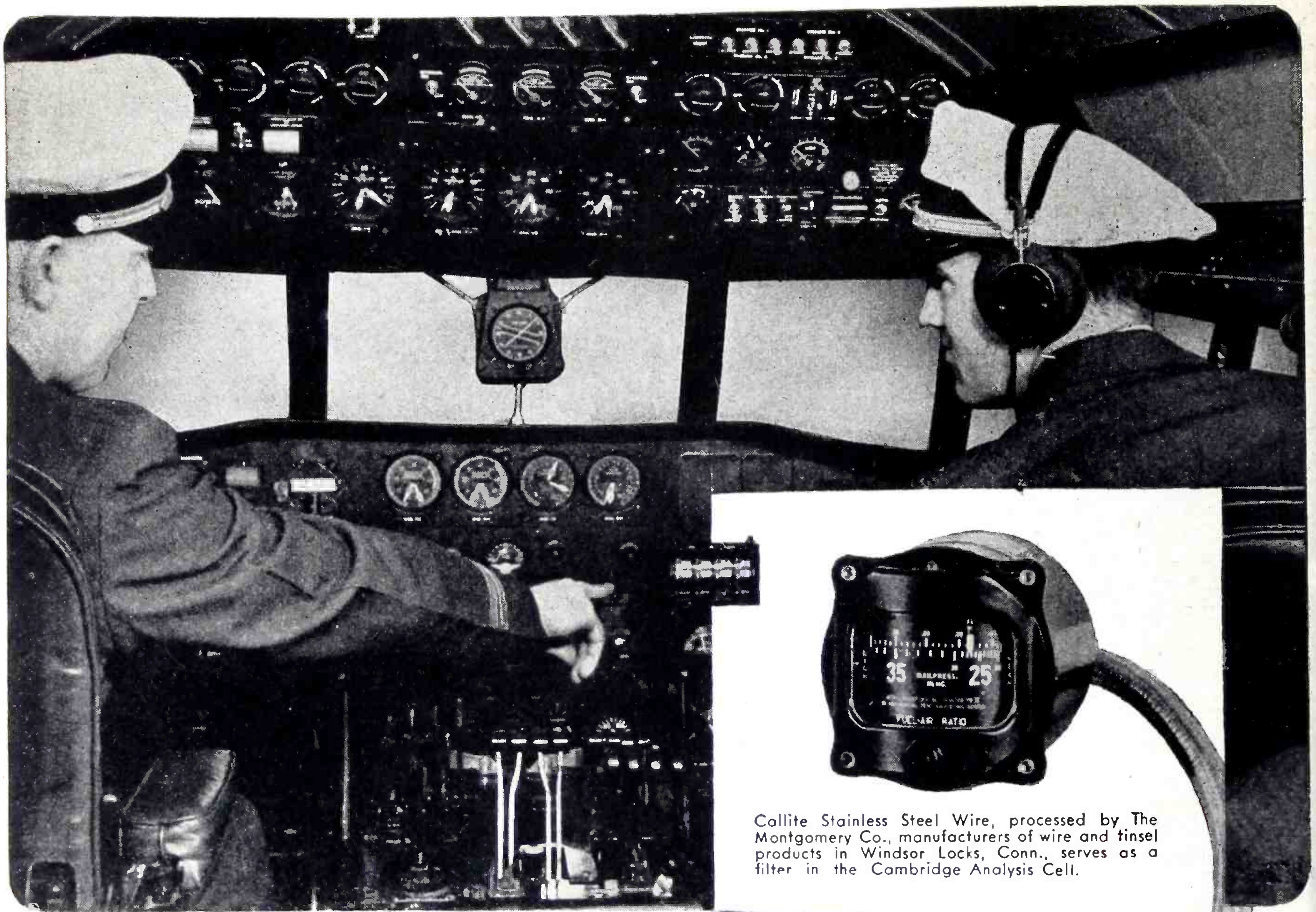
EVERY HAMMARLUND variable condenser is "geared to the job." Combining mechanical and physical features with electrical characteristics to meet specific requirements is an art for which Hammarlund engineers have built an enviable reputation.

THE SIGN OF QUALITY IN RADIO

THE HAMMARLUND MANUFACTURING CO., INC.
460 West 34th Street, New York, N. Y.

HAMMARLUND

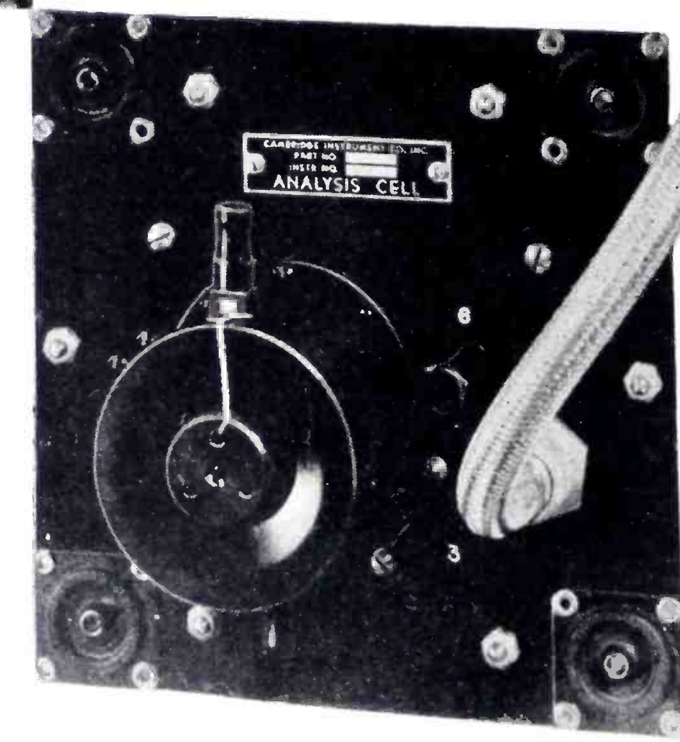




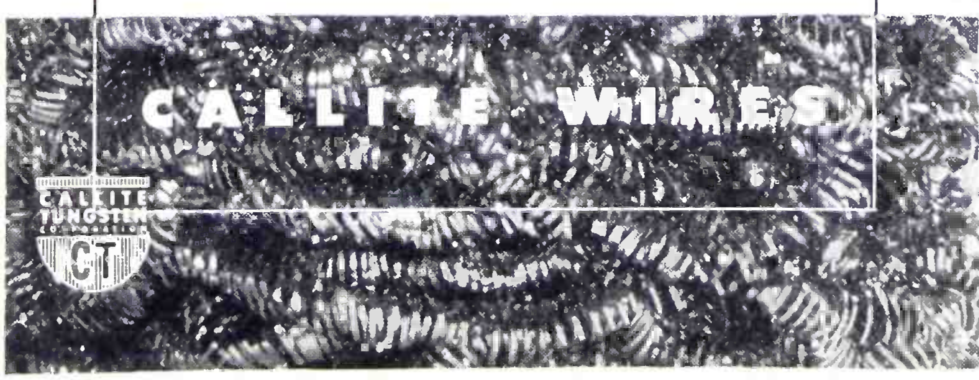
Callite Stainless Steel Wire, processed by The Montgomery Co., manufacturers of wire and tinsel products in Windsor Locks, Conn., serves as a filter in the Cambridge Analysis Cell.

CHECK ALL FOUR

Precision flight depends on the teamwork of many men. In a T.W.A. Stratoliner, a vitally important precision device, the Cambridge Aero-Mixture Indicator constantly informs the pilot of the fuel mixture in all four powerful motors. This constant check enables optimum engine performance . . . greater safety. Unseen delicate spiral wire in the Analysis Cell functions faithfully, resisting torrid heat and corrosion.



Callite offers fine alloy wires for springs, instrument parts, scratch brushes, control cables, bonding jumpers, and sieves; in 9 major metals and their alloys; in precision diameters down to .002 or smaller, drawn to your specifications. Callite Tungsten Corporation, 544 — 39th St., Union City, N.J.



Seek teamwork in your sources of supply . . . check these four factors — √ Precision Production, controlled by long-experienced, technically trained men; √ Expert metallurgical and engineering cooperation; √ Consistent deliveries — the ability to meet emergencies; √ A fair price.

ARMY E NAVY

REMEMBER YOUR FIRST DESIGN JOB?

Chances are you do and will never forget that first contribution you made to a new and growing industry. That's the way we feel about our "first job", too — Varnished Cambric and Tape.

Shortly after the turn of the century, Varnished Fabrics became a vital factor in controlling the current that was harnessing electric power to the wheels of industry. For it was then that the Irvington Varnish & Insulator Company, a pioneer in the field of electrical insulation, began its career by developing an improved yellow varnished cambric and perfecting the manufacture of black varnished cambric. Later, as the need became evident, Irvington also developed and first introduced seamless bias cut tape.

Today, with a line embracing a wide range of electrical insulation requirements, we still regard Varnished Cambric and Tape as our "first job" and steadfastly maintain the standards which earned their early success. From its founding 38 years ago, on an unswerving policy of high quality and rigidly controlled production methods, the name "Irvington" still signifies outstanding electrical insulation.

If you do not already use the dependable products manufactured by Irvington, send for latest literature on any of those listed at the right. Or, if specific information is needed on any unusual problems, our engineers are always ready to assist you. Write Dept. 106.

- Varnished Paper
- Varnished Tubing
- Varnished Nylon
- Varnished Rayon
- Varnished Canvas & Duck
- Varnished Fiberglas
- Insulating Varnishes
- Extruded Plastic Tubing
- Varnished Slot Insulation

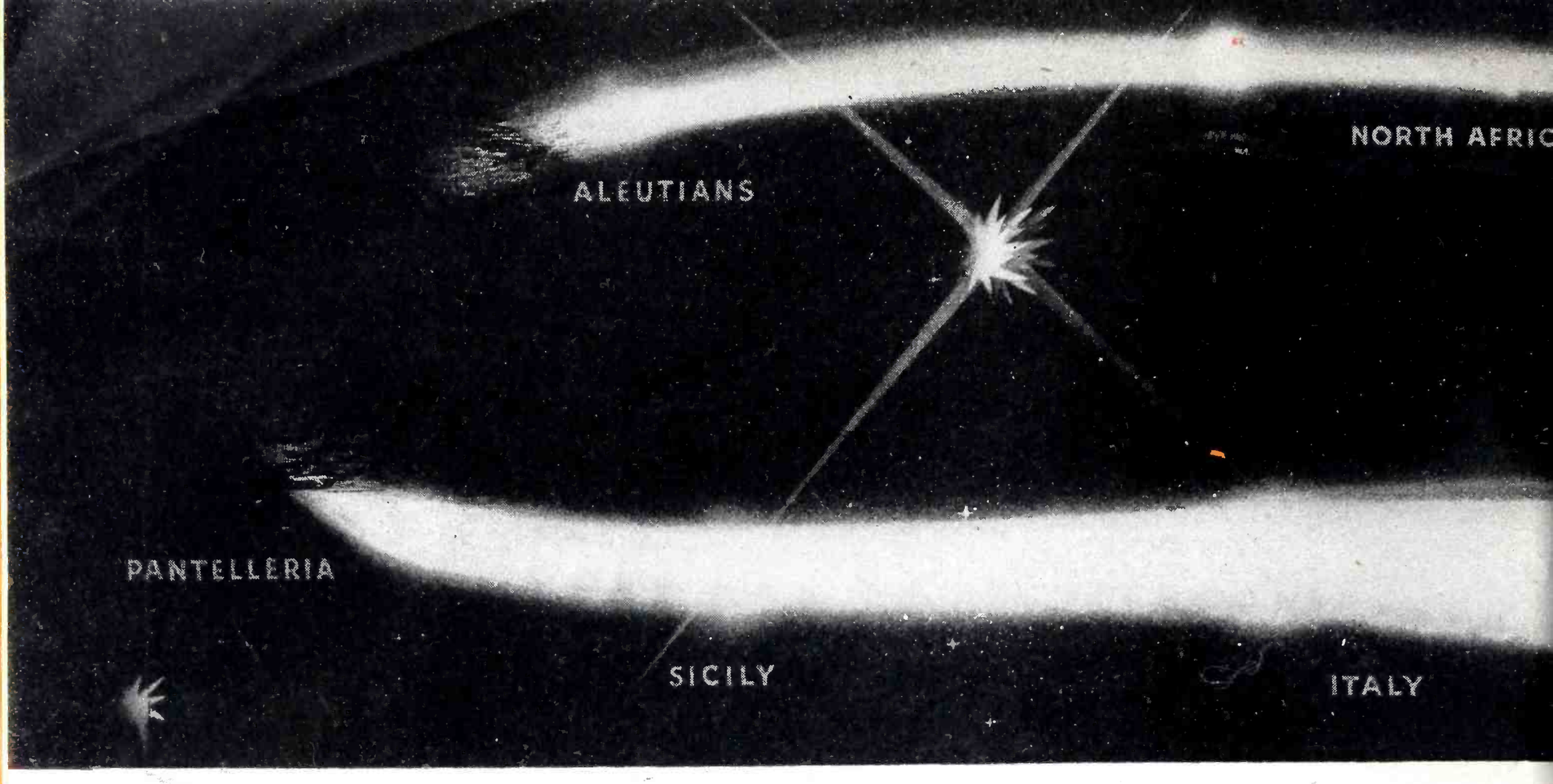
IRVINGTON VARNISH & INSULATOR CO.

Irvington, New Jersey, U. S. A.

Plants at Irvington, New Jersey, and Hamilton, Ontario, Canada

Representatives in 20 Principal Cities

IRVINGTON *Electrical* INSULATION



In our nine years, Superior has become a strong company, through careful management with inherent economy as our watchword.

As we start our tenth year, we are interested more in winning the War than in plans for Post War.

Let us, as we work to win, keep our Domestic House in order. When we come out of this conflict as winners, we can then, with high purpose, work together to go forth in the Peace.

S. L. Gabel

SUPERIOR PRODUCTS IN SMALL TUBING

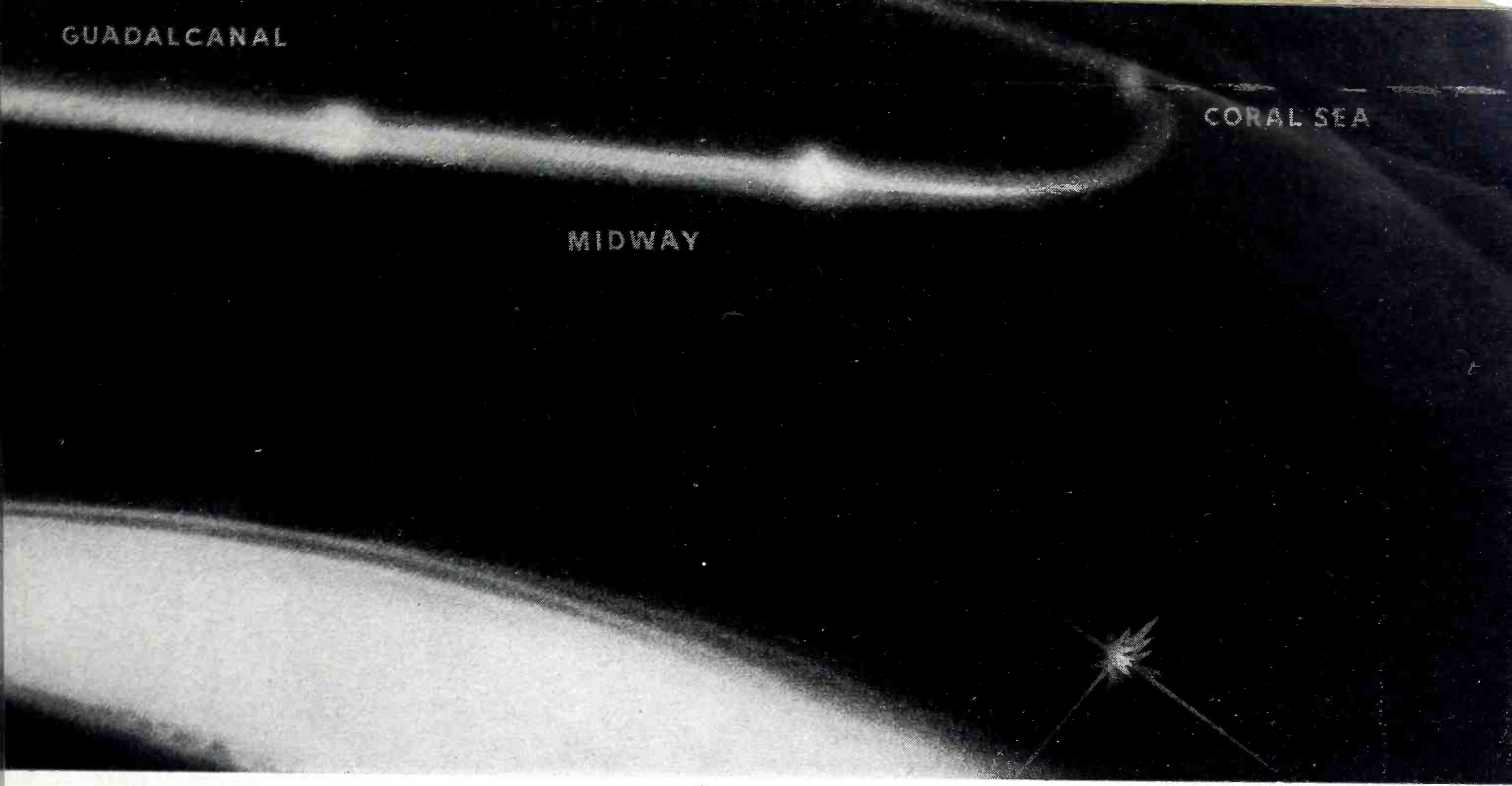
(⅝" OD and Smaller)

CARBON STEELS
ALLOY STEELS
STAINLESS STEELS
(Seamless and Weldrawn*)
NICKEL AND "INCONEL"
"MONEL"
(Seamless and Brawn*)
ALUMINUM
COPPER AND BERYLLIUM COPPER

SUPERIOR is the only American producer of pure nickel cathode sleeves in both Seamless and Lockseam.**

* Registered U. S. Trademark ** U. S. Patented

SUPERIOR



WAR TELESCOPES TIME

ONE YEAR AGO, we at Superior thought our sights were set and that we were ready for war-time production. But in this year since our eighth birthday, we have successfully re-cast our ideas to a program which far exceeds our earlier expectations.

Superior fine small metal tubing, sometimes erroneously called "specialty" tubing, is being produced today in a mill which has upheld quality standards in the face of labor shortages and greatly increased demands for a wide variety of tubing.

In electronics, aviation, instruments, and hundreds of mechanical applications, the fruits of our labor are going out to do battle as radio equipment, aircraft engine and structural parts, surgical and other instruments, fire alarm systems, and a myriad of tubular parts for tanks, ships, and industry.

What is just as important is the healthy impact that the past year has had on our organization and our plant equipment. Today we are ready for any task for tomorrow—capable and tried in the heat of battle production. *Superior is doing a big job in small tubing.*

THE BIG NAME IN SMALL TUBING *for Uncle Sam!*

TUBE CO.

NORRISTOWN, PENNSYLVANIA

WITH SWEAT AND TEARS!

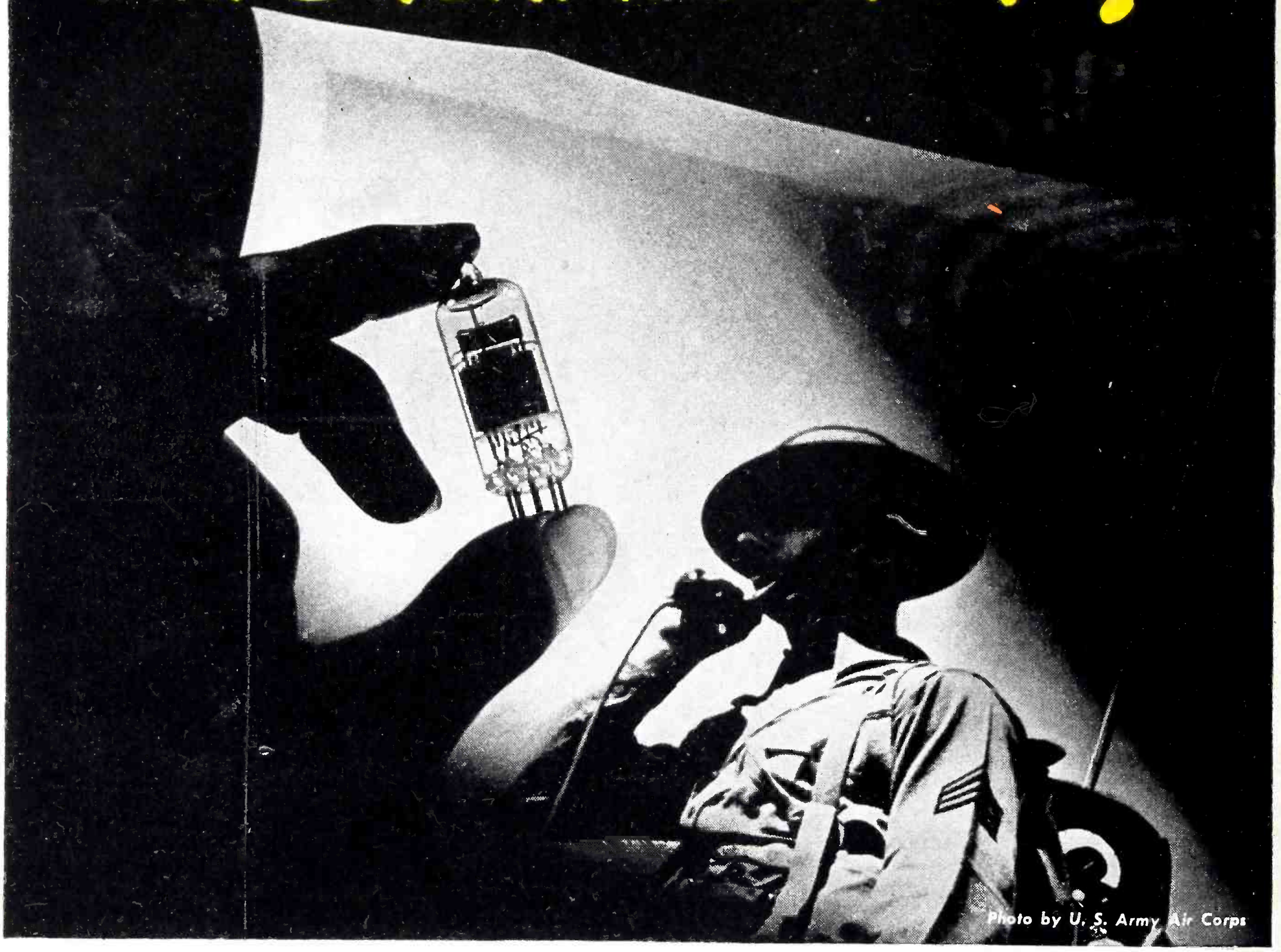


Photo by U. S. Army Air Corps

THE war record of America's radio tube engineers is an impressive one. Yet these able and ingenious men, too, have their "problem children".

In this category are the miniature tubes used by our combat troops in communication radio sets. Admittedly these tubes are tough little "hombres" — especially "tough" for that selected group of engineers whose responsibility is to produce them by the tens of thousands. Only because of the sweat and tears of these men has the flow of miniatures to our armed forces been maintained and steadily expanded month after month.

That National Union is one of the nation's important manufacturers of miniatures is evidence of the success of N.U. engineers in helping to solve one of this Industry's most difficult war production problems. Thus do research and development experiences in wartime build a reservoir for post-war accomplishment. Whenever problems involving vacuum tube design and application press for solution, look to National Union engineers for the answers. Learn to *count on* National Union.

NATIONAL UNION RADIO CORPORATION, NEWARK, N. J.
Factories: Newark and Maplewood, N.J., Lansdale and Robesonia, Pa.

NATIONAL UNION
RADIO AND ELECTRONIC TUBES

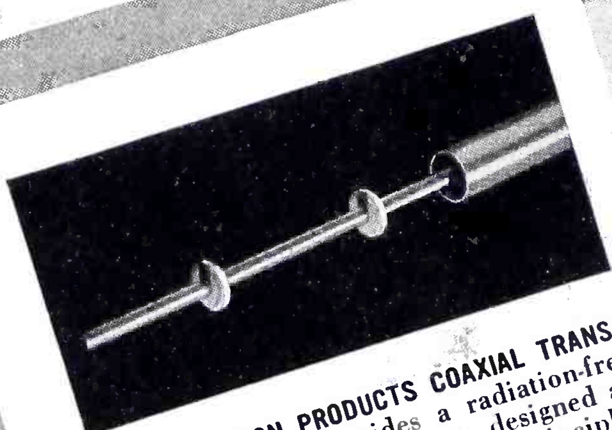
Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs

Ever "Call up" a Locomotive?

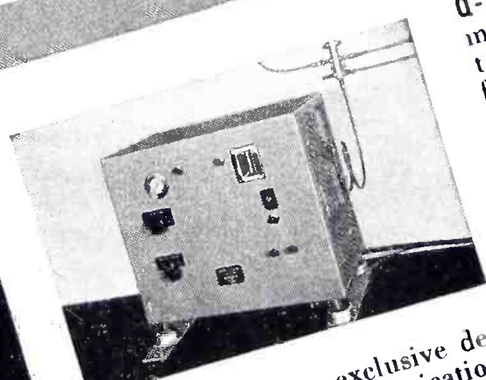
In the railroad systems of Tomorrow, it is possible that locomotives will be reached by telephone—as easily as you would "call up" the drug store today. By means of radiotelephony a yardmaster, for example, may contact locomotive engineers in their cabs, or conductors, yard foremen and other supervisory personnel in direct two-way communication.

Indeed, the postwar potentialities for expansion of communications through new applications of radio and television have only begun to be explored. In precisely what new directions this expansion may go, and how soon, is of course still anybody's guess.

Right now, the entire output of Communication Products is needed for war purposes. But with Victory, the items shown here will again be available for peacetime purposes. And if their contribution to the war program is any indication, these products will have a vital part to play in Tomorrow's applications.

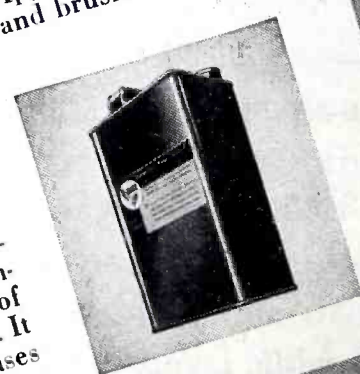


COMMUNICATION PRODUCTS COAXIAL TRANSMISSION LINE provides a radiation-free line of copper or aluminum, designed according to sound engineering principles. Four sizes are available: A flexible ¼-inch line with spun-glass insulation for receiving or low power purposes; a new and improved ⅜-inch semi-flexible ceramic insulated line for low power applications; a ⅞-inch rigid type; and a 1⅝-inch ultra high frequency line for high power use.



AUTO-DRYAIRE, an exclusive development of Communication Products, is a completely automatic device for maintaining coaxial transmission lines at pre-set pressures of moisture-free air. It will function for indefinite periods at the rate of 1000 cubic inches per minute. It is independent of critical gases and heavy cylinders.

Q-MAX A-27 is a remarkable new, extremely low-loss, fast air-drying lacquer for use in treatment or impregnation of radio frequency components. Applied by dipping and brushing.

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COMPANY
Through the use of the
NEW HM-119
Heat resistant
"LUCITE" by DuPont
presents startling new develop-
ments in the injection molding of
component metal-plastic parts.
These new methods coupled with
the superior specifications of
H M-119 "LUCITE" will prove
invaluable to the Electronic
and Plastics Industry.
Additional information on this new
technique and its application to your
problems will be sent on request...
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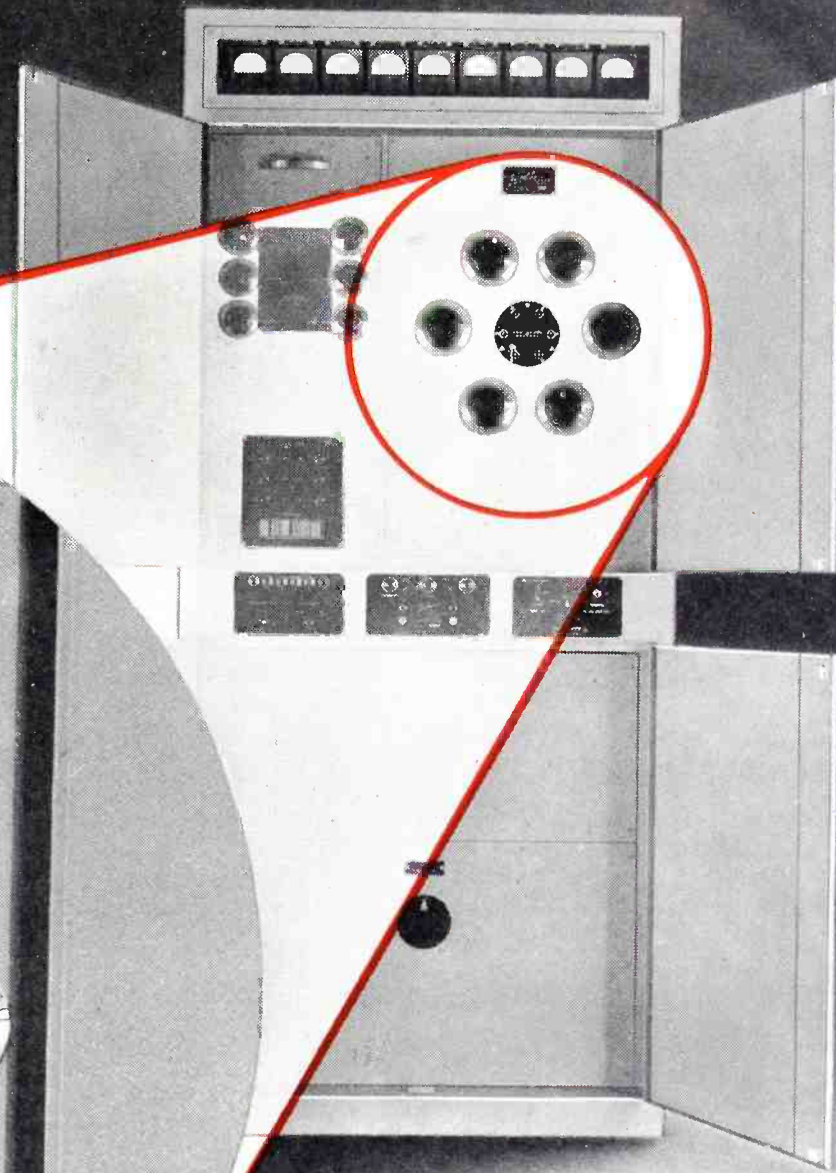
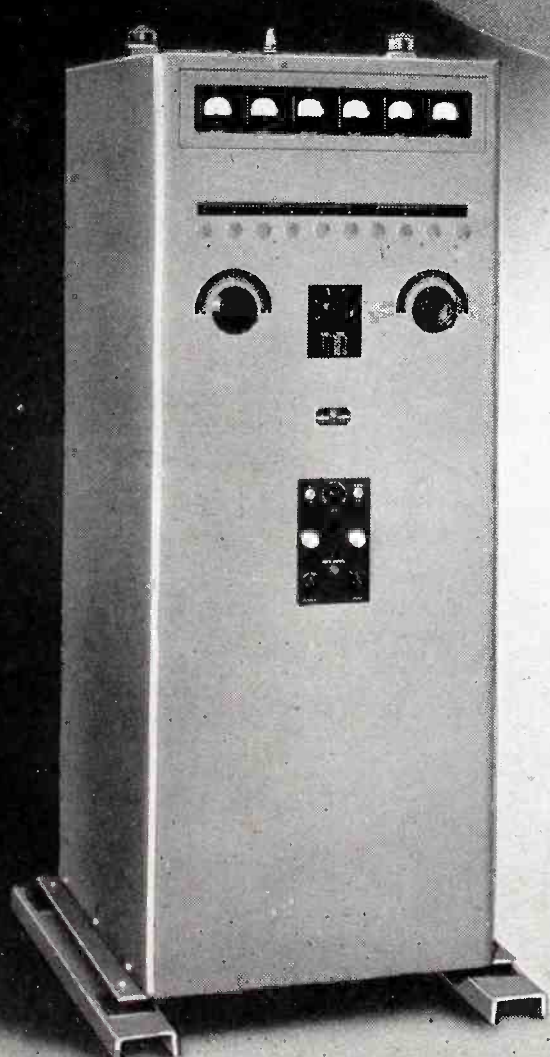
The Final Touch
THAT ASSURES PERFECT CRAFTSMANSHIP



Above: TEMCO Model 1000 AG-CW 1000 watt radio telegraph transmitter with pretuned tank circuits for 6-frequency operation with motor driven frequency selection.

•

Below: TEMCO Model 350 AG 350 watts output 6-frequency band switching mobile transmitter, designed for military service aboard trucks.



Hundreds of hand operations enter into the custom-style construction of every TEMCO unit.

Of all these, the last and simplest is the most important: the affixing of the TEMCO name plate, which sets our "hand and seal" to certify that the last detail of perfect workmanship has been patiently and skillfully built in . . . assuring years of dependable service.

Application of the name plate signifies that the job has passed the most exacting inspections and tests imposed by our own engineers . . . and now invites inspection by U. S. Government services, or any other users employing the most critical standards.

TEMCO

RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.

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

Winning THE WAR . . . on the BATTLE FRONT and HOME FRONT alike

OUR WAR EFFORT . . .

From January 1941 to December 1942, Aerovox

- Stepped up production output 500% for our armed forces.
- Increased production floor space 300%.
- Sought, hired, trained and put to work additional workers—a 300% increase in productive personnel.
- Opened second plant in Taunton, bringing work to available workers there.
- And—doing more and more, growing week by week.

• Our Army, Navy, Air Forces, function with clockwork precision, thanks to perfected radio coordination. Meanwhile, by spotting and ranging approaching aircraft even a hundred miles distant, regardless of weather, by night or by day, radio eliminates another Pearl Harbor sneak attack. Lurking U-boats are losing their concealment. To cap it all, up-to-the-minute world news is available at the twist of a dial in millions of American homes whose radio sets keep functioning through proper servicing and replacement parts. We remain the best informed people. Our morale is unbeatable. Victory is in sight.

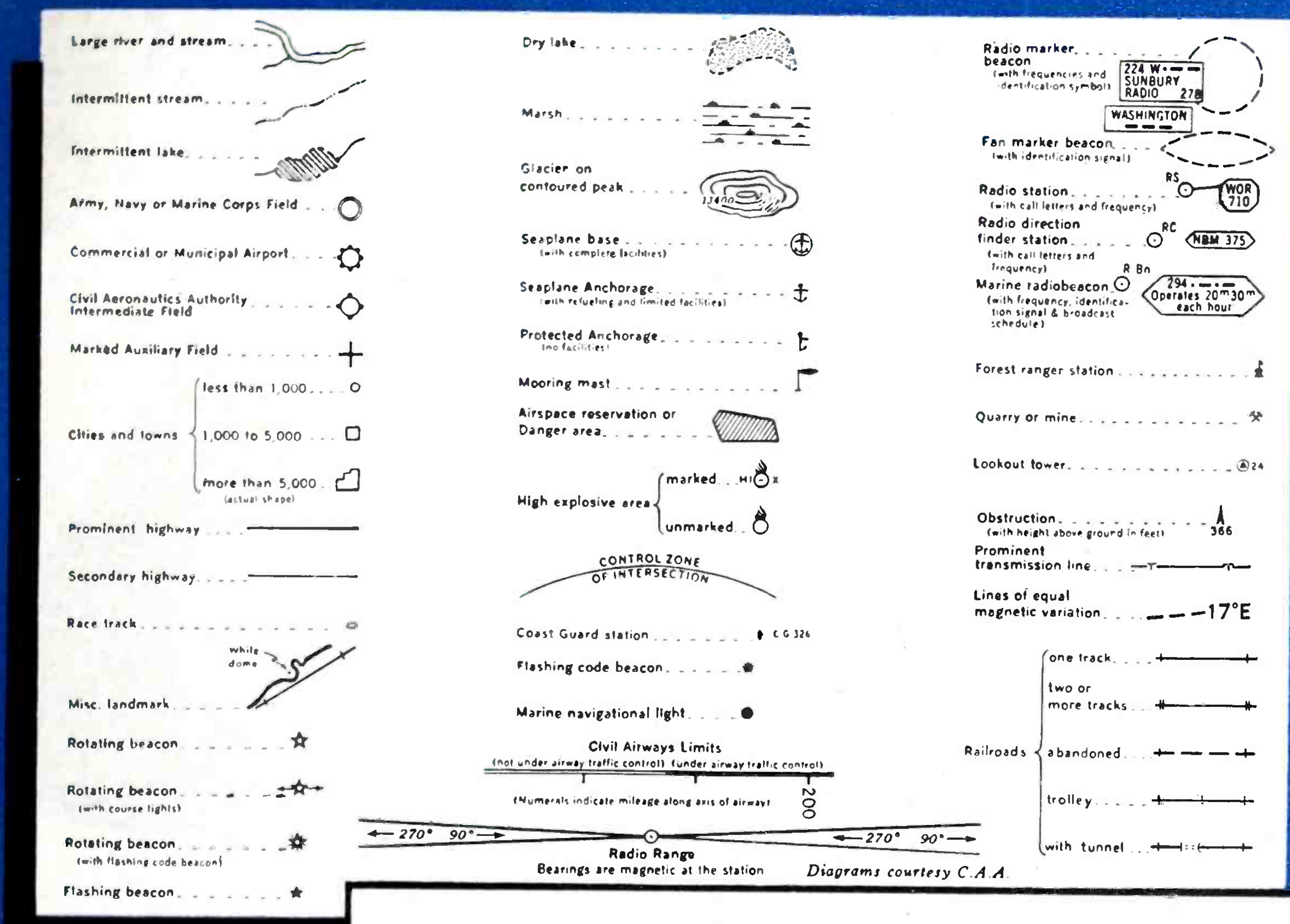
Thus a truly radio war. Radio means capacitors. Capacitors spell Aerovox. Today, working at an all-time production peak in meeting military needs and civilian replacements, Aerovox contributes its full share towards winning the war on battle and home fronts alike.

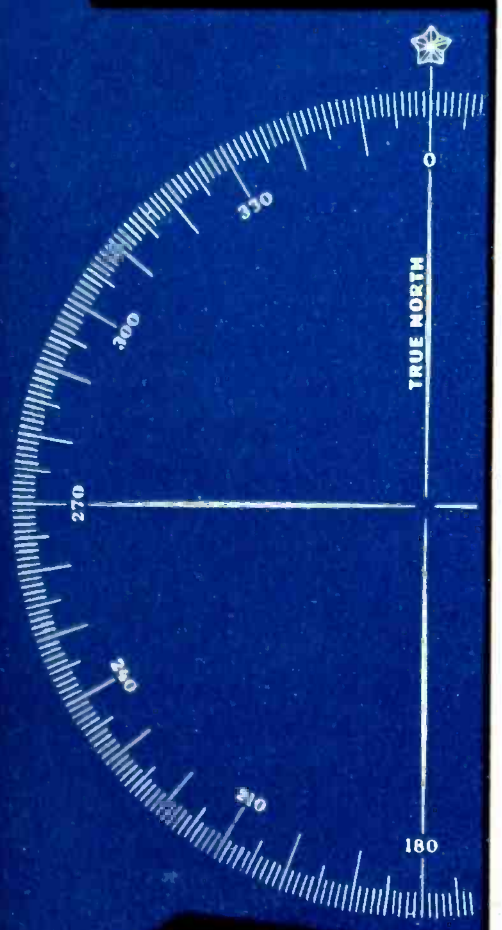
• Consult our local jobber regarding your wartime capacitor needs. Ask for latest catalog; also free subscription to the Aerovox Research Worker. Or write us direct.

AEROVOX *Capacitors*

INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. • SALES OFFICES IN ALL PRINCIPAL CITIES
Export: 100 VARICK ST., N. Y. C. • Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.





SYMBOLS...

some of safety and some of danger...all are aids to navigation of the airways—the "Highways Of The Air".

Another symbol—RR—the trademark of RADIO RECEPTOR CO., INC.—stands for advanced design, honesty in manufacture and reliability of operation on all types of airline and airport radio equipment.

AIRPORT TRAFFIC CONTROLS
RADIO RANGES • MARKERS • LOCALIZERS
COMMUNICATION TRANSMITTERS AND RECEIVERS

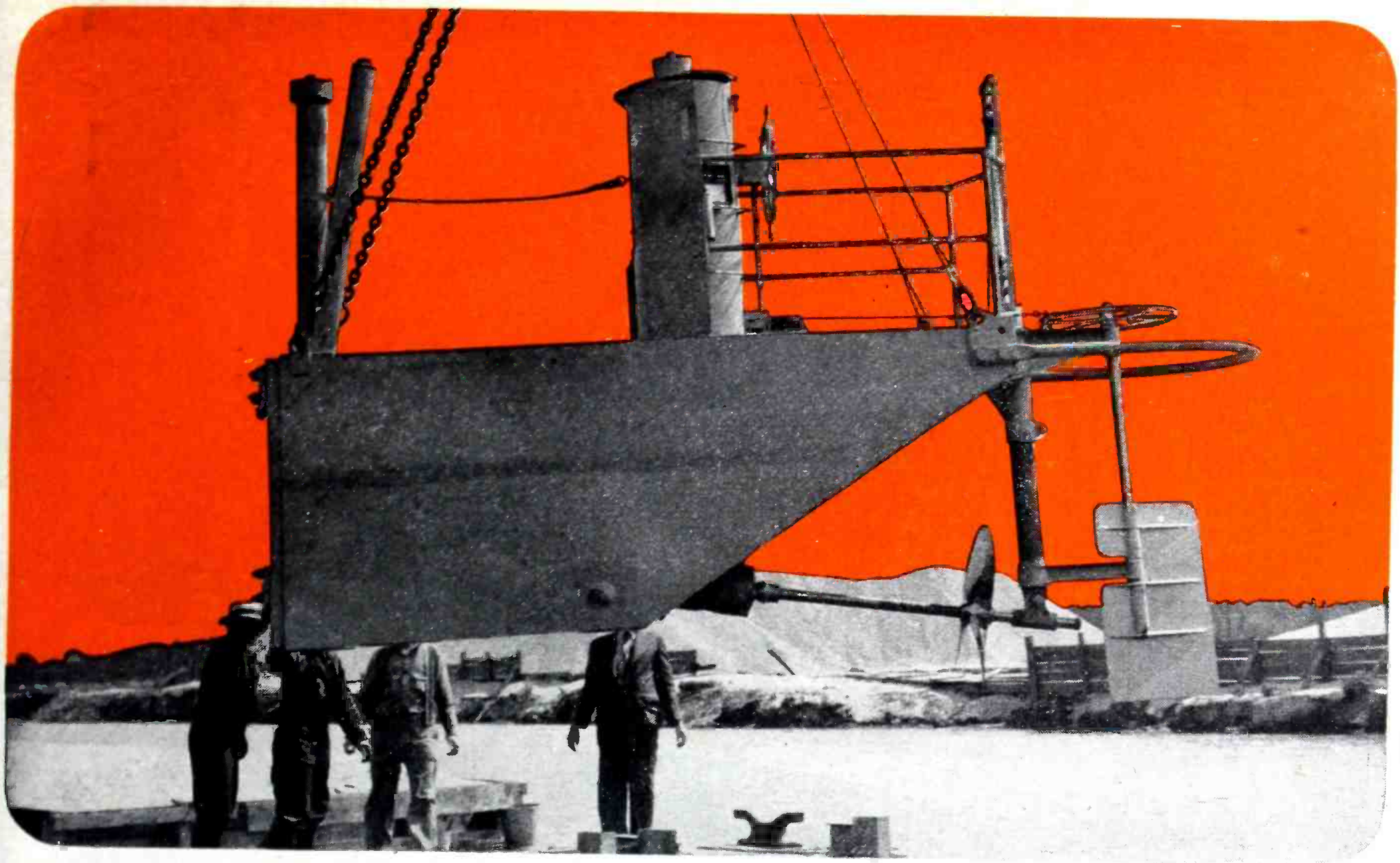
Please do not ask us *now* for catalogs or technical literature because all of our efforts are concentrated on war work. We shall, however, have off the press shortly an interesting non-technical booklet, "HIGHWAYS OF THE AIR", which we will send on request.

EXECUTIVE OFFICES, 251 WEST 19th STREET, NEW YORK 11, N.Y.

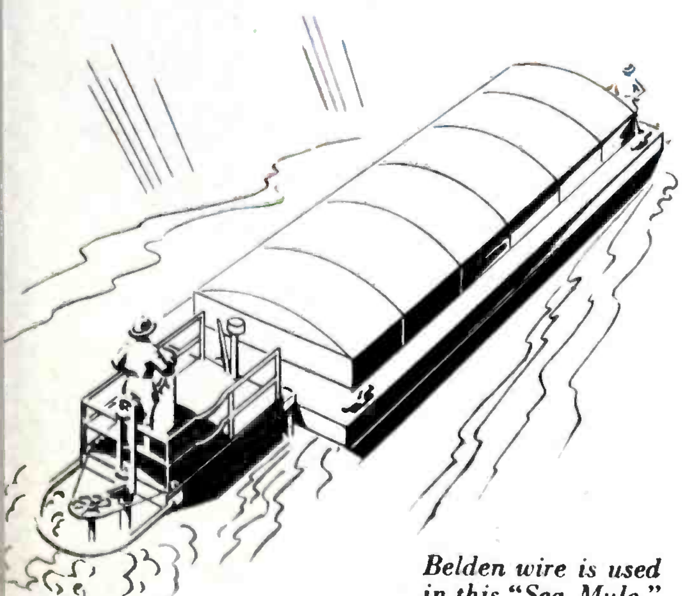
Keep It Up—Buy More War Bonds

RADIO RECEPTOR CO., INC.

SINCE 1922 IN RADIO AND ELECTRONICS



at last—A MULE FOR WAR SERVICE THAT DOESN'T BALK



Belden wire is used in this "Sea Mule."

Science has finally proved that it can outstrip nature—by devising a mule that doesn't balk. This offspring of a tugboat has outgrown the stubbornness characteristic of the old Missouri Army Mule. A small, floating power unit for propelling barges, scows, and many other types of motorless vessels, it has to be thoroughly dependable.

If you are producing electrical war equipment or machines, keep them from "balking" caused by wiring failures or Corditis. Belden engineers have had over forty years of experience in building plus values into wire. Investigate Belden wire and Belden wiring assemblies.

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

Awarded the U. S. Treasury Special Citation of Merit for initiating the War Bond-or-Cash Dividend Plan

Belden WIRE

CORDITIS-FREE ELECTRICAL CORDS

This Oster 1/100 H.P. motor is designed for continuous duty in high ambient temperatures; it operates satisfactorily in a 90° ambient — standing up under the most adverse conditions in blower applications...Behind it stands the 15-year performance record of Oster motors, used exclusively before the present war as original equipment on Oster motor-driven appliances. These Oster appliances, Oster-powered, have long been a recognized leader in their field, widely used by the armed services and other departments of U. S. and foreign governments...Type C-2B-1A is one of many Oster motors now being built to power vital instruments and mechanisms in airplanes and submarines. It is ball-bearing equipped, built in an aluminum die-cast housing. 6, 12, 24, or 115 volts DC; 115 volts AC . . . For satisfactory results that are a credit to your judgment, select Oster motors. Let us help you fit this or other Oster motors to your requirements.

M-12

John Oster Mfg. Co. of Illinois

Department L-12 **Genoa, Illinois**

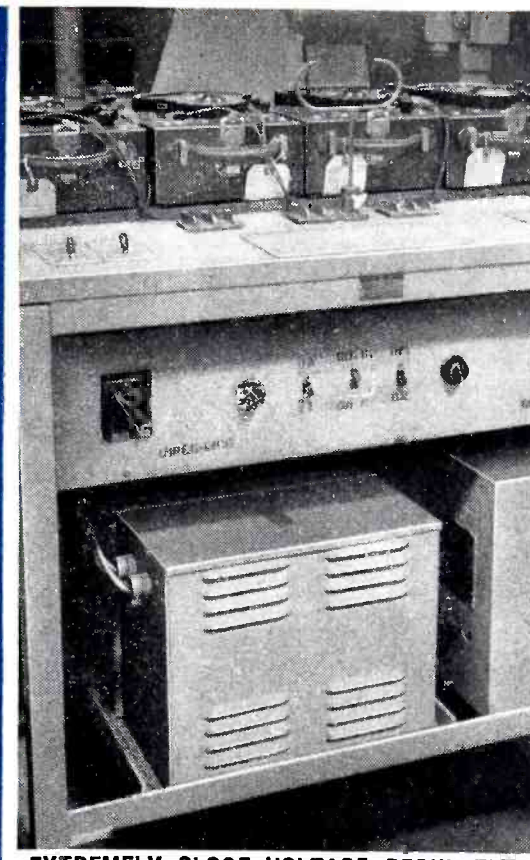
These are the BENEFITS of a CLOSELY HELD VOLTAGE SUPPLY

Better performance, greater reliability, and longer life of electronic devices

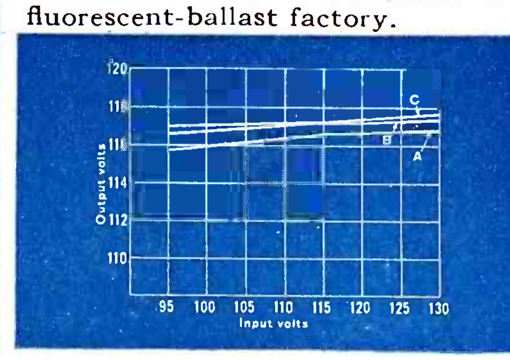
Protection of delicate instruments and machines, precision tools, and electronic tubes against sudden overvoltages

More accurate test results, fewer rejects

And manufacturers—don't forget:
A product's salability can be increased when voltage stabilization is a built-in feature.

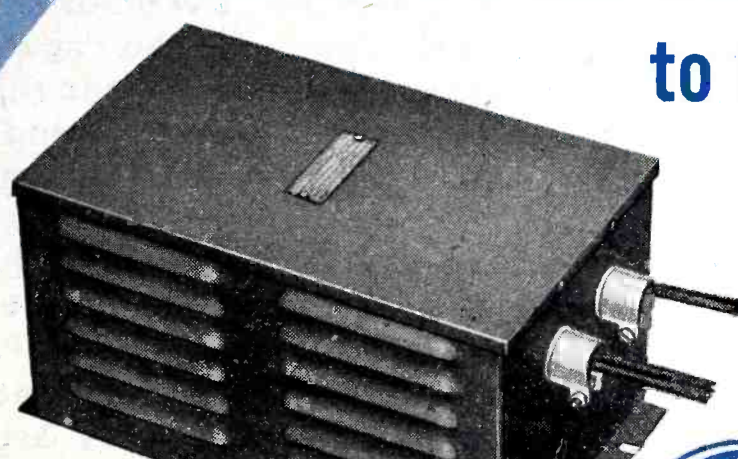


EXTREMELY CLOSE VOLTAGE REGULATION, so essential to speedy, accurate production-line testing, is automatically maintained by a 500-volt-ampere G-E stabilizer on a test bench in a fluorescent-ballast factory.



▲
LOOK AT THIS PERFORMANCE—Practically constant voltage for several typical conditions (A—Open circuit; B—Full load, unity power factor; C—Full load, 0.8 power factor lagging). Stabilizing action practically instantaneous, taking place in less than three cycles.

...and Here's the Way to Get It



VOLTAGE STABILIZERS

IMPROVES THE PERFORMANCE OF EQUIPMENT LIKE THIS:

- Radio transmitters and testing equipment
- Photoelectric equipment and other electronic-tube apparatus
- Motion-picture projectors and sound equipment
- Telephone apparatus
- X-ray machines
- Precision photographic equipment and photometers
- Color comparators
- Calibration of meters, instruments, relays
- Laboratory precision processes and testing equipment

FOR DETAILS on this stabilizer's unique circuit, write for Bulletin GEA-3634. *General Electric Company, Schenectady, N. Y.*

The best investment in the world is in this country's future—BUY WAR BONDS

GENERAL ELECTRIC

403-53-5205

This Oster 1/100 H.P. motor is designed for continuous duty in high ambient temperatures; it operates satisfactorily in a 90° ambient — standing up under the most adverse conditions in blower applications... Behind it stands the 15-year performance record of Oster motors, used exclusively before the present war as original equipment on Oster motor-driven appliances. These Oster appliances, Oster-powered, have long been a recognized leader in their field, widely used by the armed services and other departments of U. S. and foreign governments... Type C-2B-1A is one of many Oster motors now being built to power vital instruments and mechanisms in airplanes and submarines. It is ball-bearing equipped, built in an aluminum die-cast housing. 6, 12, 24, or 115 volts DC; 115 volts AC . . . For satisfactory results that are a credit to your judgment, select Oster motors. Let us help you fit this or other Oster motors to your requirements.

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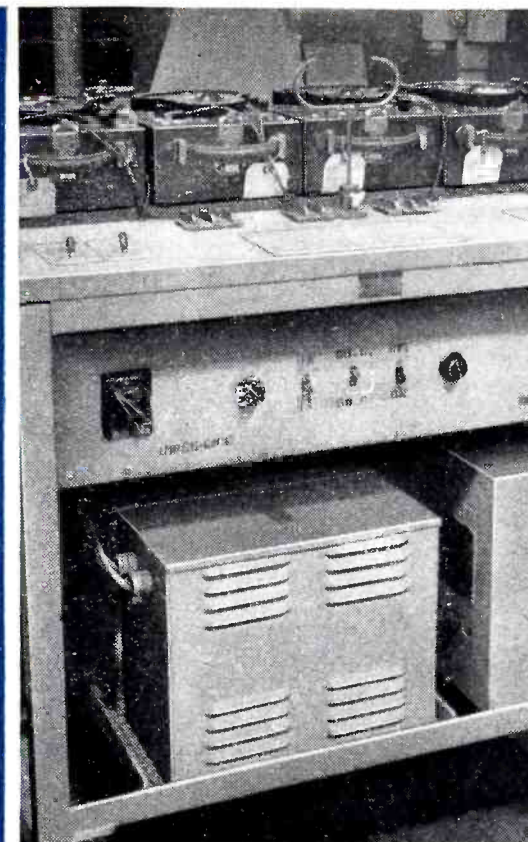

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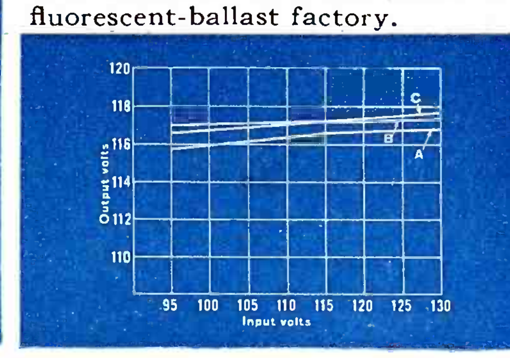

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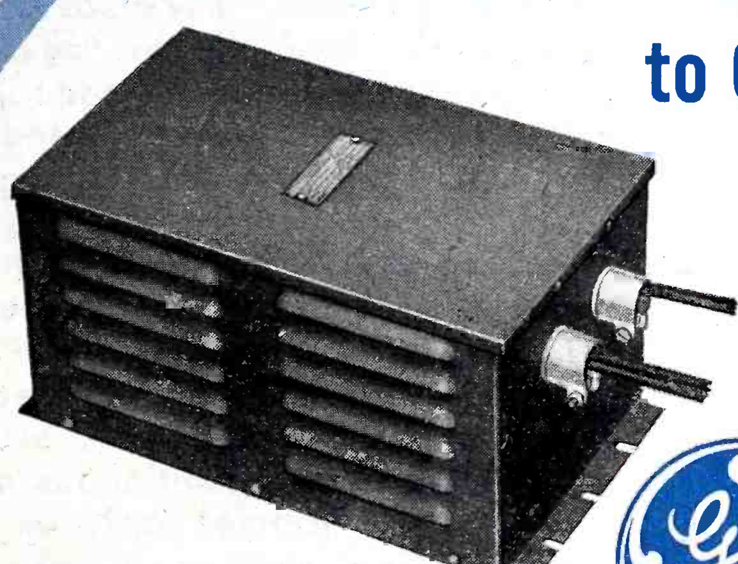
...and Here's the Way to Get It



IMPROVES THE PERFORMANCE OF EQUIPMENT LIKE THIS:

Radio transmitters and testing equipment
Photoelectric equipment and other electronic-tube apparatus
Motion-picture projectors and sound equipment
Telephone apparatus
X-ray machines
Precision photographic equipment and photometers
Color comparators
Calibration of meters, instruments, relays
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VOLTAGE STABILIZERS

GENERAL ELECTRIC

403-53-5205

The best investment in the world is in this country's future—BUY WAR BONDS

USED in aircraft applications, the AmerTran Airborne RH Transtat Voltage Regulator for 400 Cycle A. C. is a new addition to the already famous Transtat family. It meets the rigid tests of combat aircraft equipment in action.

Like other Transtats, the Airborne RH is a highly efficient transformer type regulator. The velvety smooth Transtat system that controls without circuit interruption is further refined in this newer unit. And, similar to its predecessor, it does not distort wave form or interfere with radio reception. Small, compact, its weight is the minimum achieved for its power rating.

Well suited to incorporation in other electrical equipment where precise line voltage correction or special voltage maintenance is required, its dramatic wartime performance presages a useful peacetime future.

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

AMER TRAN

AMERICAN TRANSFORMER COMPANY
178 EMMET STREET, NEWARK 5, NEW JERSEY

AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

DELCO RADIO PRODUCTION METHODS

represent the practical application of research and invention

The products of research and invention become factors of Victory only after methods are developed for mass-producing them.

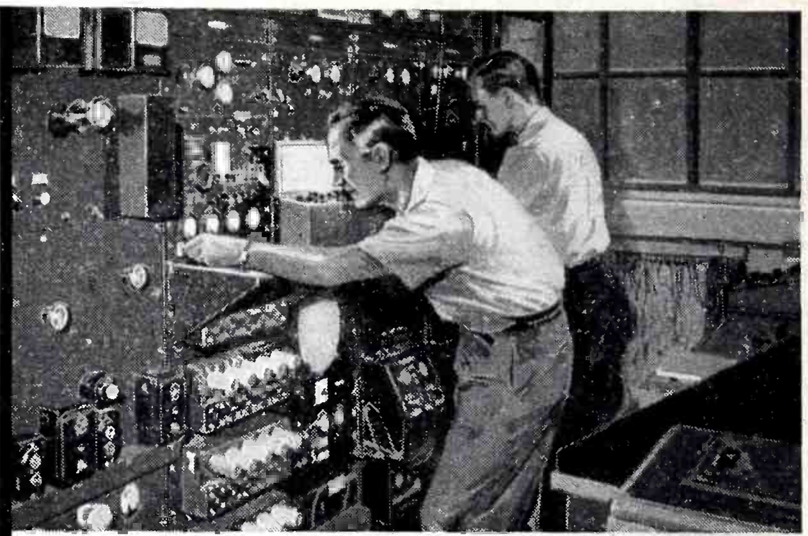
This is a skill which Delco Radio has acquired through years of automotive radio manufacturing for millions of cars. It is serving wartime needs through the volume production of highly intricate radio communication parts and equipment . . . push-button tuning for tank radio receivers . . . parts for air-borne communication equipment . . . complete transmitters and receivers for artillery equipment . . . and many other products.

Yesterday, Delco Radio's ability to combine research with production worked for higher entertainment value. Today it works in Victory's cause. Delco Radio Division, General Motors Corporation, Kokomo, Indiana.

. . . *Back the Attack*

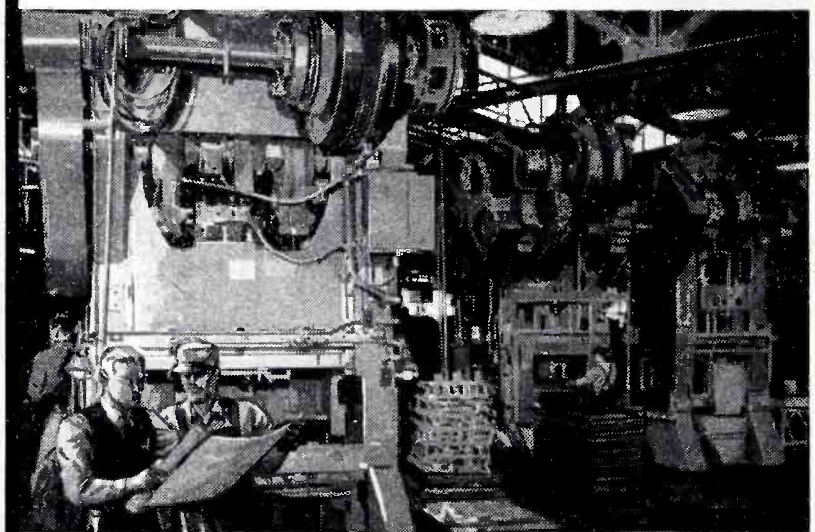
WITH WAR BONDS

★ ★ ★ ★ ★ ★ ★ ★ ★



ELECTRONICS RESEARCH

Technicians of Delco Radio are carrying forward pioneer research in the field of radio and electronics.



PROCESS ENGINEERING

Delco engineers are equipped through years of experience to translate swiftly the product of research and design into practical, useful products.

PRECISION ON A PRODUCTION BASIS

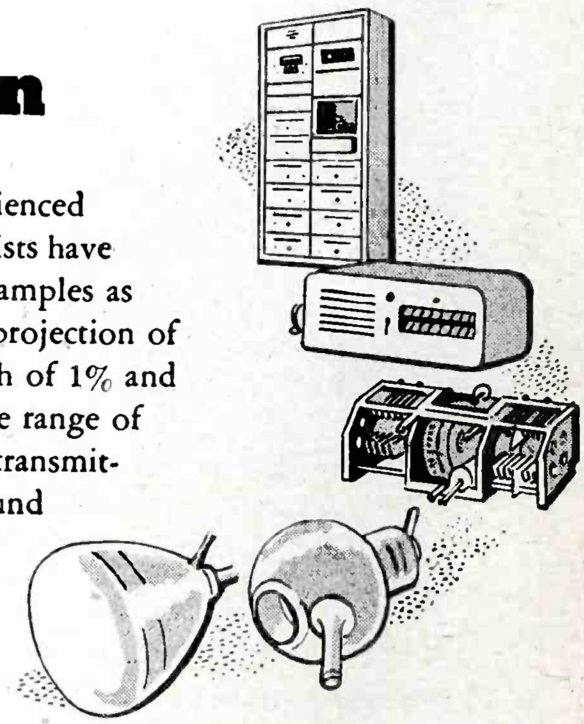
Delco specializes in the ability to mass-produce highly intricate products. Years of experience in the automotive radio field qualify Delco for vehicular radio production for war.

Delco Radio

DIVISION OF

GENERAL MOTORS

Doorway to Electronic Vision



Control of the forces of electronics begins with vision . . . especially by experienced engineering minds accustomed to achievement. RAULAND engineers and scientists have earned recognition in the field of electronic achievement with such notable examples as (1) *High Powered Cathode Ray Tubes* for large screen (15 *foot* x 20 *foot*) television projection of fine line definition. (2) *Frequency Standards* having a control accuracy of 1/100th of 1% and maintaining this almost unbelievable control throughout the entire temperature range of minus 30°C to plus 50°C. (3) *Communications,* as exemplified by precision-built transmitting type tuning condensers, two-way radio and intercommunicating and sound control units for industry. All of the fruits of RAULAND *Electroneering** are at work for our war effort today as they will serve industry in the new days to come.

** The Rauland word for all of the carefully thought out steps in electronics from vision to completion.*

RADIO . . . SOUND . . . **Rauland** . . . COMMUNICATIONS

Electroneering is our business

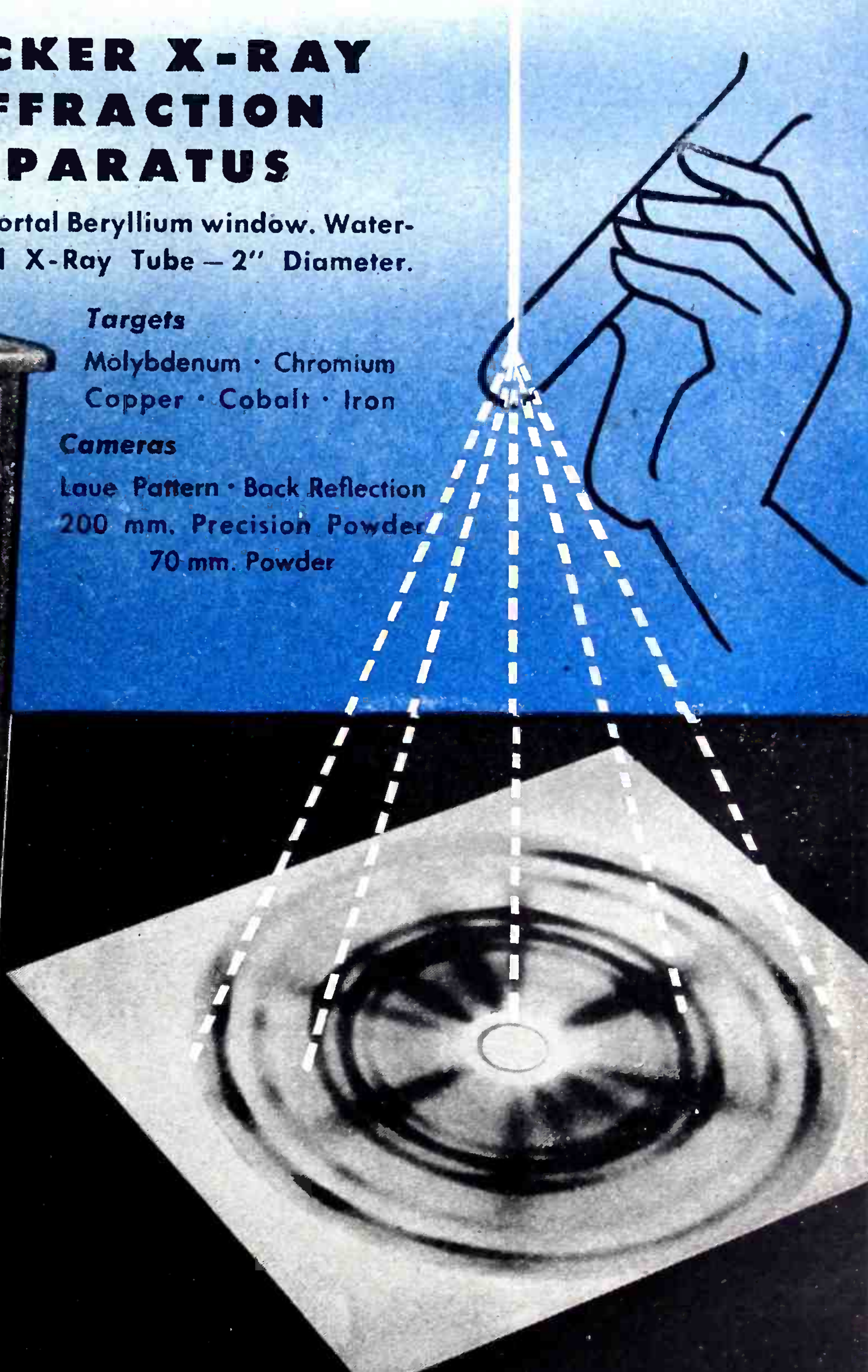
THE RAULAND CORPORATION . . . CHICAGO, ILLINOIS

Buy War Bonds and Stamps! Rauland employees are still investing 10% of their salaries in War Bonds

quick, accurate

Picker X-Ray Diffraction Equipment is serving industry in many diverse roles . . . in the identification of unknowns . . . in quality control . . . in analysis of sub-microscopic crystal structures. It provides quick, accurate determinations in a fraction of the time required by other methods, and has wide applications, particularly in cold work, alloy structures and silicates in clays.

chemical and physical determinations



PICKER X-RAY DIFFRACTION APPARATUS

Two Portal Beryllium window. Water-cooled X-Ray Tube — 2" Diameter.

Targets

Molybdenum · Chromium
Copper · Cobalt · Iron

Cameras

Laue Pattern · Back Reflection
200 mm. Precision Powder
70 mm. Powder

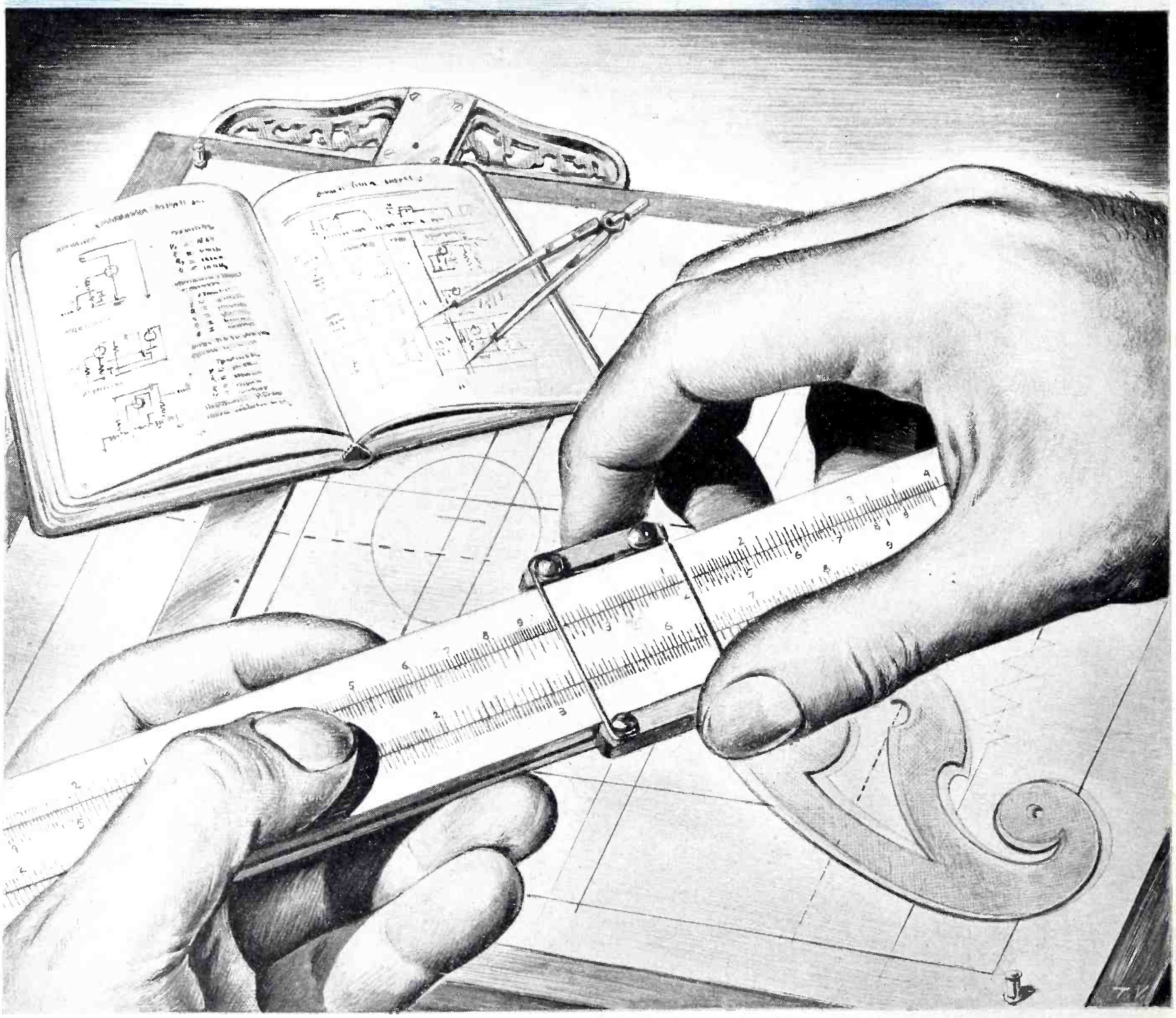
PX

PICKER X-RAY CORPORATION

300 Fourth Avenue, New York, New York
WAITE MANUFACTURING DIVISION CLEVELAND, OHIO
MANUFACTURERS OF HIGH VOLTAGE ELECTRICAL APPARATUS SINCE 1879

PROVING GROUNDS

for post-war plans



Westinghouse

Electronic Tubes *AT WORK*

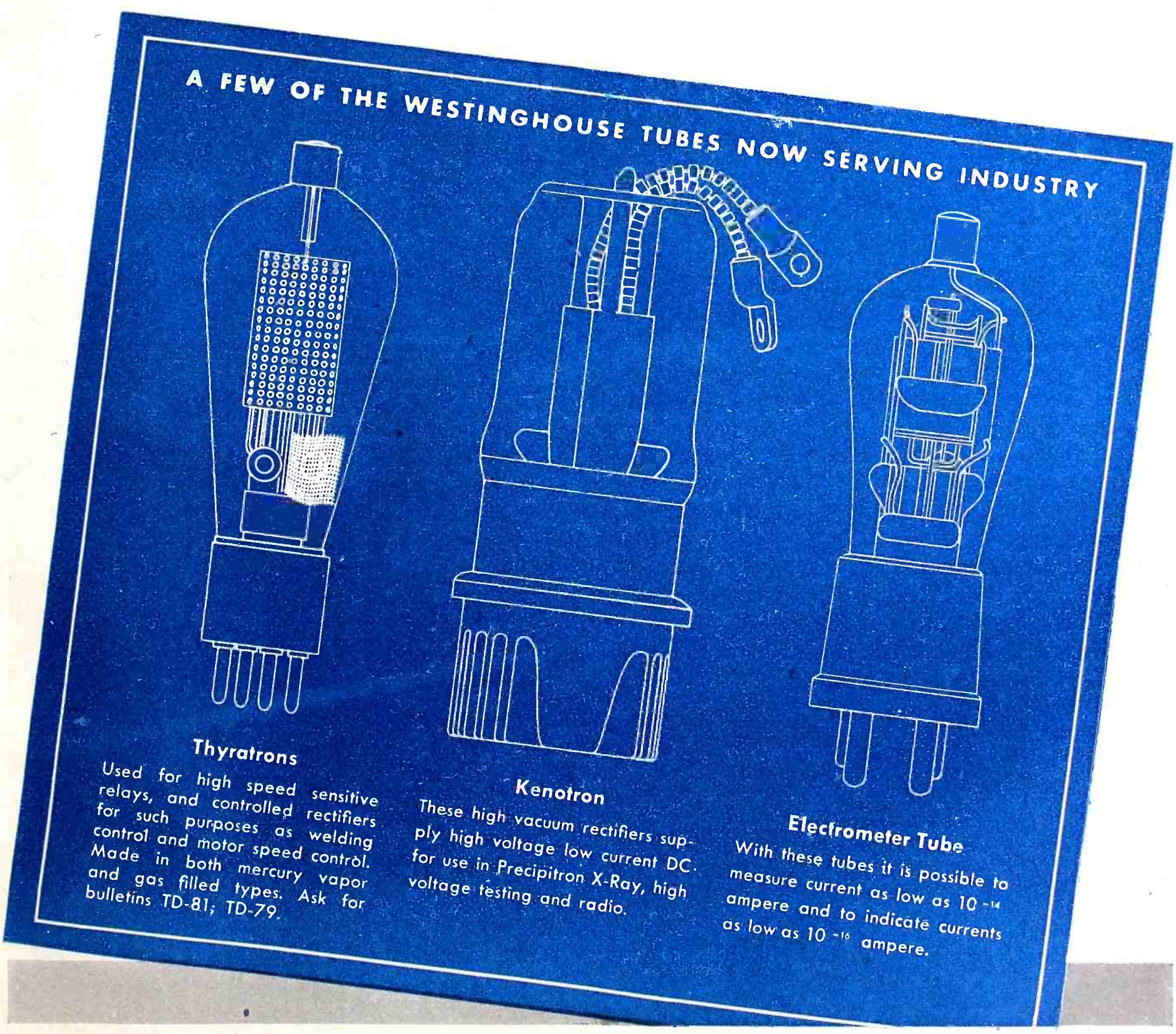
TOMORROW is on the drawing boards of today!

Yes, it's here in sketches, charts, plans—proved and being proved by today's engineers and designers. It's here in tried and tested formulae. Here in the performance records of electronic tubes and countless other devices which bring Victory nearer!

Consider now the help that Westinghouse and Westinghouse Electronic Tubes can give you! Tubes, which "stop" and record the flight of a bullet! Tubes which make wood strong as steel, weld metals, clean the air of every particle of dust in vast rooms! Tubes which see, hear, feel, perform endless jobs with speed, accuracy and dependability!

All this is yours to command in planning products . . . electronic tubes built with all the care and skill for which Westinghouse is famous . . . *plus* the "know-how," the advanced technical assistance, Westinghouse can offer to help pre-prove your ideas for the post-war world of tomorrow.

For further information, address Westinghouse Electric and Manufacturing Company, Bloomfield, New Jersey.

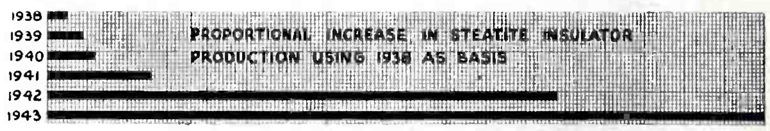


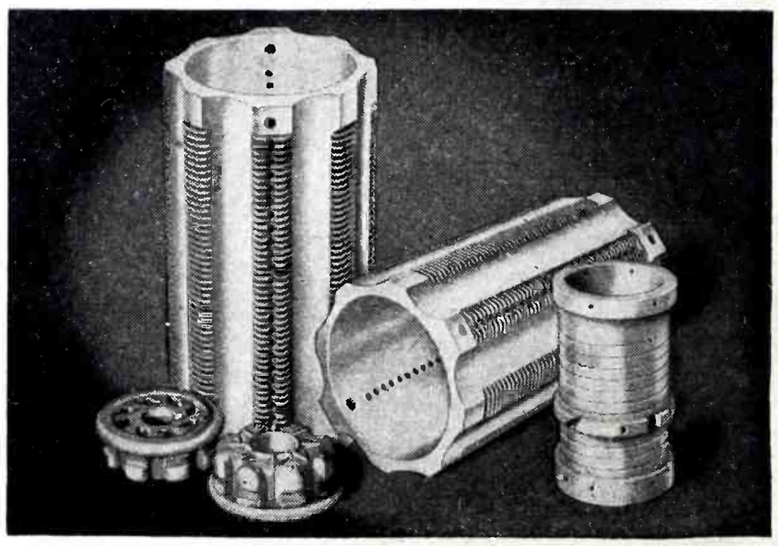
WHEN THE ELECTRONIC ENGINEER NEEDS HELP...

General Ceramics is at his beck and call to help with his insulator problems. In nine cases out of ten the solution will be STEATITE.

Electronic Engineers know that there is a very sound reason for the extensive demands made on the Steatite Industry, demands that are clearly portrayed by the almost astronomical increase in the production of Steatite insulators since 1938 (see graph).

During the course of this unprecedented progress, General Ceramics has been in the foreground both in regard to increased productive capacity and engineering skill in the development of new methods and products — meeting the strict specifications of the United States Army and Navy for the best and only the best in Steatite insulators.





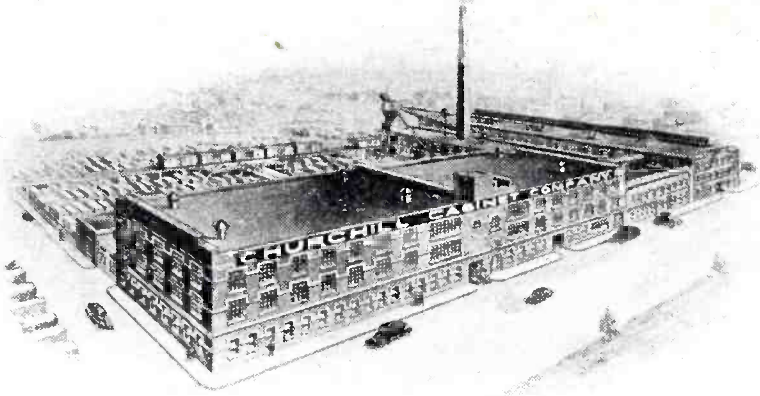
For all your insulator problems whether specialized or standard, our Engineering Department is always at your service.

General Ceramics

GENERAL CERAMICS AND STEATITE CORPORATION — STEATITE INSULATORS

AND STEATITE CORPORATION
KEASBEY • NEW JERSEY

4842



"CHURCHILL-MADE" cabinets go to war . . .

with the Hallicrafters Built SCR-299

The SCR-299 Mobile Radio Communications unit is equipped with tables and cabinets built by Churchill Cabinet Company.

This valuable new weapon is designed for the "Blitz" type of warfare and has proven its ability to fight successfully the "Battle of Communications."

Dependable equipment built by Churchill Cabinet Company is serving with this excellent transmitting unit that is giving such superb service on all fighting fronts.

Two of Our Peace-time Communication Products.

By Invitation Member

CHURCHILL CABINET COMPANY

2119 CHURCHILL ST., CHICAGO, ILLINOIS

FOR RADIO MEN IN THE SERVICE!

"WRITE A LETTER"

As you know, the Hallicrafters make a wide range of Radio Communications equipment, including the SCR-299 Mobile Communications unit. We are proud of our handiwork, proud of the job you men have been doing with them on every battlefront.

RULES FOR THE CONTEST

We want letters telling of actual experiences with this equipment. We will give $100.00 for the best such letter received during each of the five months of November, December, January, February and March! (Deadline: Midnight, the last day of each month.)

We will send $1.00 for every serious letter received so even if you should not win a big prize your time will not be in vain.

Your letter will be our property, of course, and we have the right to reproduce it in a Hallicrafters advertisement.

Good luck and write as many letters as you wish. V-Mail letters will do.

W. J. Halligan

BUY MORE BONDS!

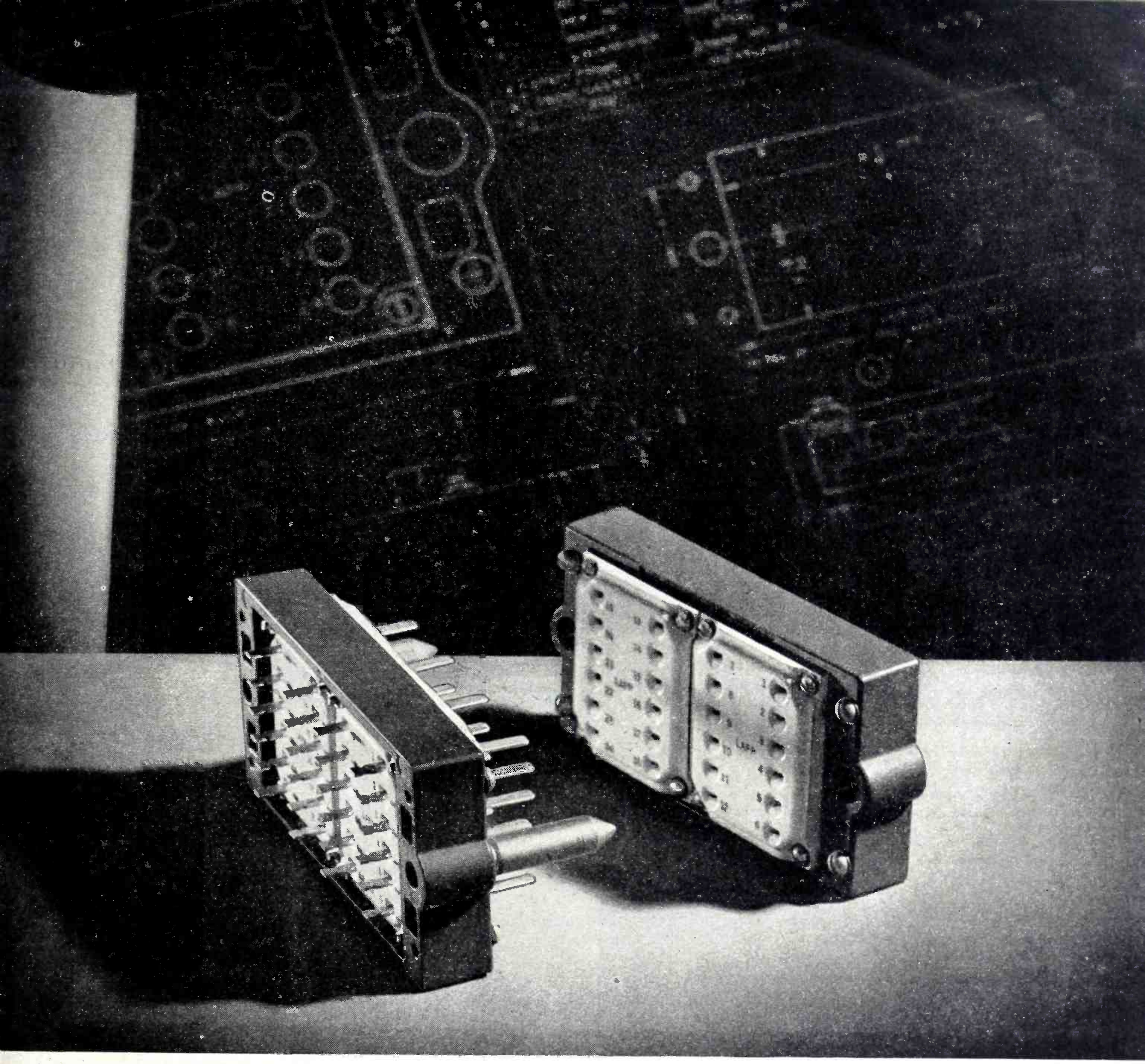
the hallicrafters co.

CHICAGO, U.S.A.

2611 INDIANA AVENUE · CHICAGO, U.S.A.

MAKERS OF THE FAMOUS SCR-299 COMMUNICATIONS TRUCK

STEWART
SOLDERLESS
TERMINALS
Production Boosters
"GRIP-IT"
The Solderless Terminal that
STAYS PUT
PERMITS uniform installation with unskilled labor. Provides a strong mechanical joint that withstands severe vibration.
Used by leading electrical contractors. Approved by prominent electrical engineers.
Cut down installation time and save valuable man-hours by using "Grip-it" Solderless Terminals.
IN THREE FINISHES
Silver Nickel Hot Tin
Send for Samples and Quotations.
Let us have your prints and specifications.
Quick response to inquiries!
STEWART STAMPING COMPANY
621 East 216th St., New York 67, N. Y.
BUY MORE
WAR BONDS



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

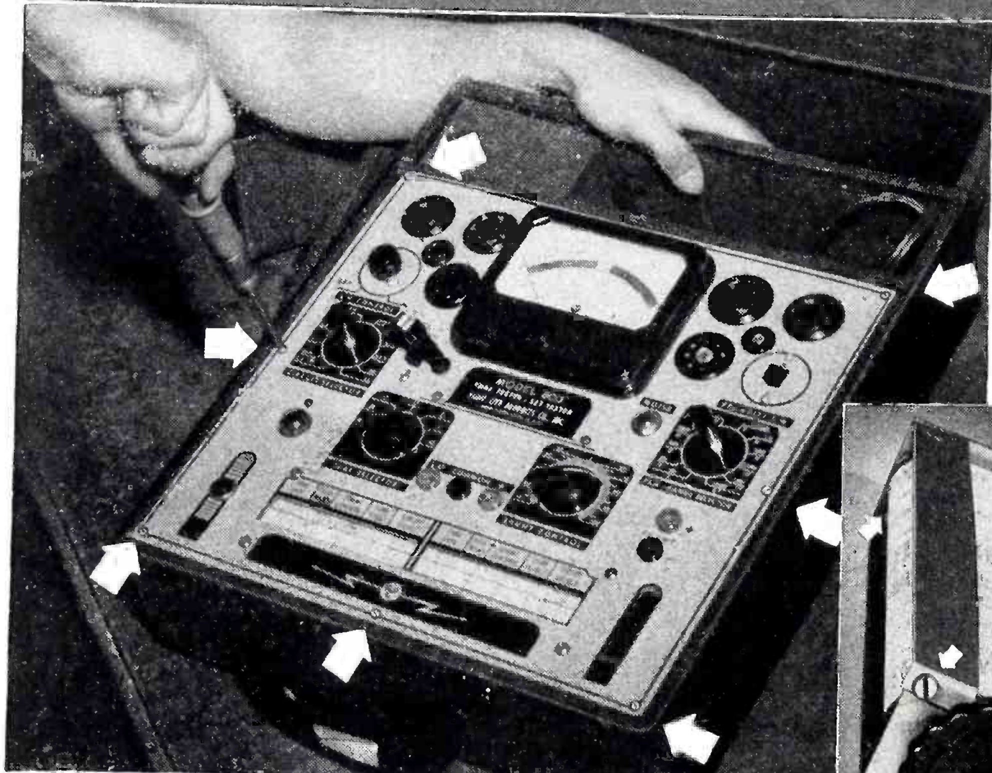
There may be a way you can improve performance, cut costs and cut production time through use of Lapp-designed and Lapp-built sub-assemblies. We'd like to discuss your specific requirements with you.

Lapp Insulator Co., Inc., LeRoy, N. Y.

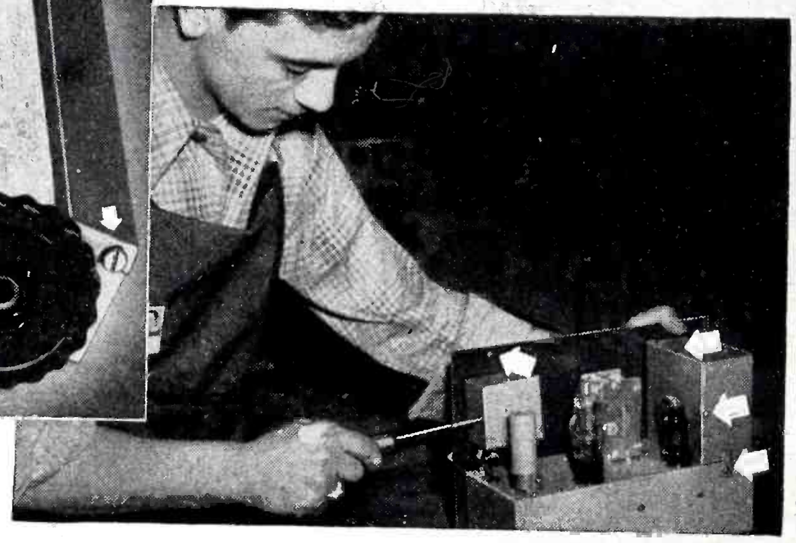
Lapp

ARMY E NAVY

OUT GOES TAPPING..IN COME Savings



Instrument Manufacturer Questions Every Fastening and changes to the simple P-K Self-tapping Screw method!

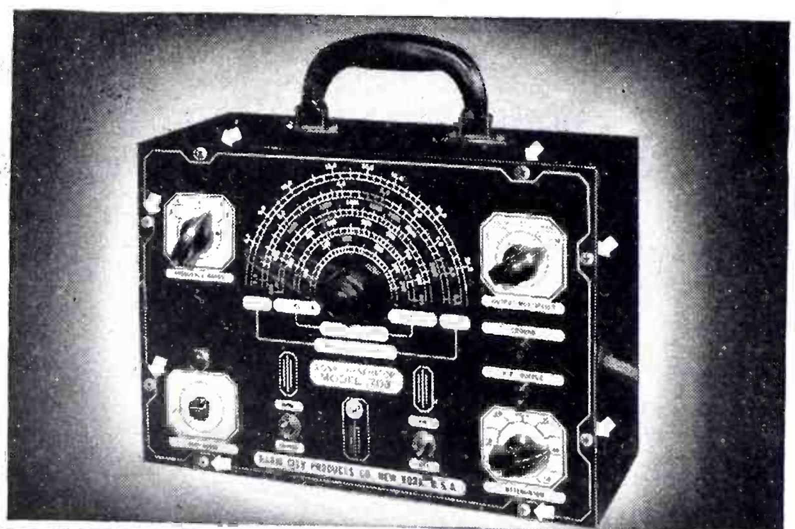


TOP — P-K Type "A" Screws fasten instrument to wood housing . . . provide better holding power than wood screws because they are more mechanically correct and are threaded to the head.

CENTER – P-K Type "Z" Screws fasten index roller to 1/32" steel panel.

RIGHT — P-K Type "Z" Screws fasten steel cover to 1/16" steel shield container, and coil shield to 1/16" steel chassis.

BELOW – P-K Type "A" Screws fasten instrument to 1/32" metal housing.



Multiply the fastenings illustrated here by many hundreds of similar war-needed assemblies made daily in the plant of the Radio City Products Co., New York. You will then have an idea of the many vital work-hours this company saves by adopting P-K Self-tapping Screws wherever possible, and avoiding tapping holes for machine screws.

The simple P-K Self-tapping Screw method of making fastenings not only does away with tapping and tap maintenance. It also ends the slow washer-placing and nut-running that goes with bolts; the difficulties of riveting in hard-to-reach places; the need for inserts in molded plastics. With Self-tapping Screws, only one easy operation is necessary . . . turning the Screws into plain holes. No special tools or skilled help are required.

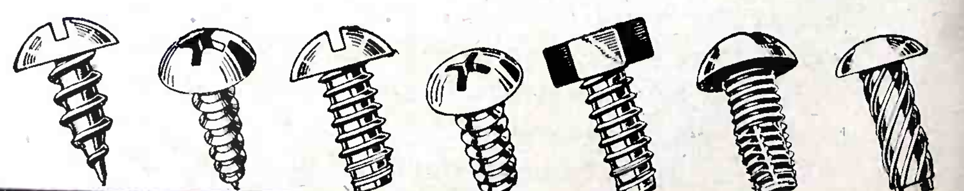
Whether your assemblies are of thin or heavy sheet metal, of castings or plastics, you'll find, in 7 out of 10 cases, that you can simplify work, and improve products with P-K Self-tapping Screws. *Question every fastening job* on your drafting boards, and on your production lines, now! Ask for a P-K Assembly Engineer to call and help you check your fastening jobs for opportunities to save time, labor, and money. If you prefer, mail assembly details for recommendations. Parker-Kalon Corp., 192-194 Varick St., New York 14, N. Y.

PARKER-KALON

Quality-Controlled

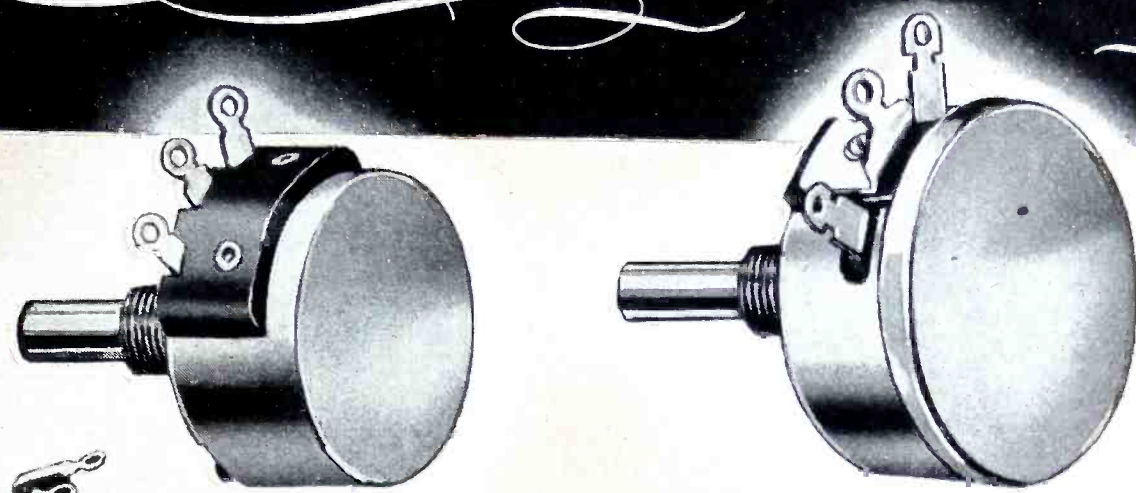
SELF-TAPPING SCREWS

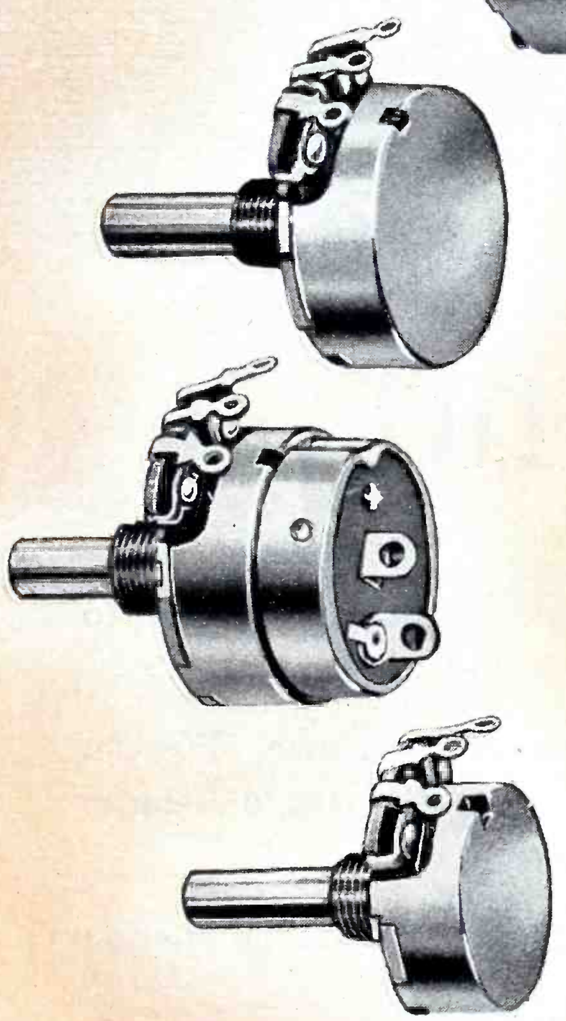
Give the Green Light to War Assemblies



A TYPE FOR EVERY METAL OR PLASTIC ASSEMBLY

a Message to: MANUFACTURERS OF ELECTRONIC EQUIPMENT





. . . who use Variable Resistors

The products of the Chicago Telephone Supply Company have been standard for high quality and fine workmanship throughout the world for 46 years. Chicago Telephone Supply has specialized in variable resistors (carbon and wire wound) for 15 years and production of them in the last peacetime year exceeded 14 million. Wartime production must remain a military secret but Chicago Telephone Supply will continue to serve the electronic industries with the quality workmanship and the service that customers have grown accustomed to during the years.

Chicago Telephone Supply facilities are also being used to produce plugs, jacks, switches (separate and in combination with variable resistors).

ARMY E NAVY

Plugs Jacks Switches
Variable Resistors

CTS

Telephone Generators and Ringers

CHICAGO TELEPHONE SUPPLY *Company*

ELKHART ★ INDIANA

Representatives

R. W. Farris
2600 Grand Ave
Kansas City, Mo
Phone: Victory 3070

Frank A. Emmet Co
2837 W. Pico Blvd.
Los Angeles, Calif.

Branch Offices

S. J. Hutchinson, Jr
401 N. Broad Street
Philadelphia, Pa.
Phone: Walnut 5369

In Canada

C. C. Meredith & Co
Streetsville, Ontario

Manufacturers of Quality Electro-Mechanical Components Since 1896

MEASURE YOUR FREQUENCY • DRIVE YOUR RECORDER • SEE THE ANSWER AT A GLANCE

WITH THE NEW

Norelco DIRECT READING FREQUENCY METER

HERE is a brand new Norelco tool for industry—an electronic direct reading frequency meter remarkable for its compactness, simplicity and wide range of applications.

Six scale ranges make possible the accurate coverage of all frequencies from 0 to 50,000 cycles. The six scale ranges are:

0 — 100 cycles per second
0 — 500 cycles per second
0 — 1,000 cycles per second
0 — 5,000 cycles per second
0 — 10,000 cycles per second
0 — 50,000 cycles per second

Any standard 5 milliampere recorder may be connected to the frequency meter and be driven without the aid of an auxiliary amplifier. It operates on 110 volts AC and requires only 100 watts of power. It measures frequencies to an accuracy within 2% regardless of the input voltage, which may vary from ½ volt to 200 volts.

Adaptable for either relay rack or cabinet mounting, the new Norelco Electronic Direct Reading Frequency Meter is as useful in the laboratory as it is in the industrial plant. This instrument can be used in testing quartz crystals, or experimentally as the base of an FM modulation indicator. Combined with a photo-electric cell and amplifier, it can be made into a speed indicator. It permits the reading of high speeds, such as are encountered in *ultra*speed centrifuges. It is equipped with safety cutout to prevent meter and recorder burnout from accidental overload.

The new Norelco Electronic Direct Reading Frequency Meter is only one of several Norelco devices designed to help industry achieve better quality, flexibility and product control. Write to North American Philips engineers today and get the benefit of our wide experience in solving problems for industry.

For our Armed Forces we make Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes for land, sea and airborne communications equipment. *For our war industries* we make Searchray (X-ray) apparatus for industrial and research applications; X-ray Diffraction Apparatus; Electronic Temperature Indicators; Direct Reading Frequency Meters; Tungsten and Molybdenum in powder, rod, wire and sheet form; Tungsten Alloys; Fine wire of practically all drawable metals and alloys: bare, plated and enameled; Diamond Dies; High Frequency Heating Equipment. *And for Victory we say: Buy More War Bonds.*

Norelco ELECTRONIC PRODUCTS by NORTH AMERICAN PHILIPS COMPANY, INC.

Industrial Electronics Division, 419 Fourth Ave., New York 16, N. Y.

Main factory and offices in Dobbs Ferry, N. Y.; other factories at Lewiston, Maine (Elmet Division); Mount Vernon, New York (Philips Metalix Corporation). Represented in Canada by Electrical Trading Company, Ltd., Sun Life Building, Montreal, Canada

"It pays to have rigid specifications — eh boys?"...

HYTRON TOLERANCES ARE TIGHTER THAN CUSTOMER TOLERANCES . . . . . .

When measuring aesthetic curves, or when conducting electrical and mechanical tests on vacuum tubes, the more stringent the adherence to accepted standards, the more desirable the resulting selection.

Impracticable as it is to manufacture all tubes of a given type exactly alike, it is possible to insure against slight meter inaccuracies and the human element by observing specification tolerances tighter than customers' requirements. Each Hytron tube is thus made to fit precisely the circuit constants with which it must operate. For example, strict observance of specifications for grid-to-plate capacitance makes easier the adjustment of tuned circuits to any Hytron tube of the chosen type.

Simplify your design problems for initial and replacement tubes by taking advantage of Hytron's insistence upon close tolerances. Specify Hytron.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

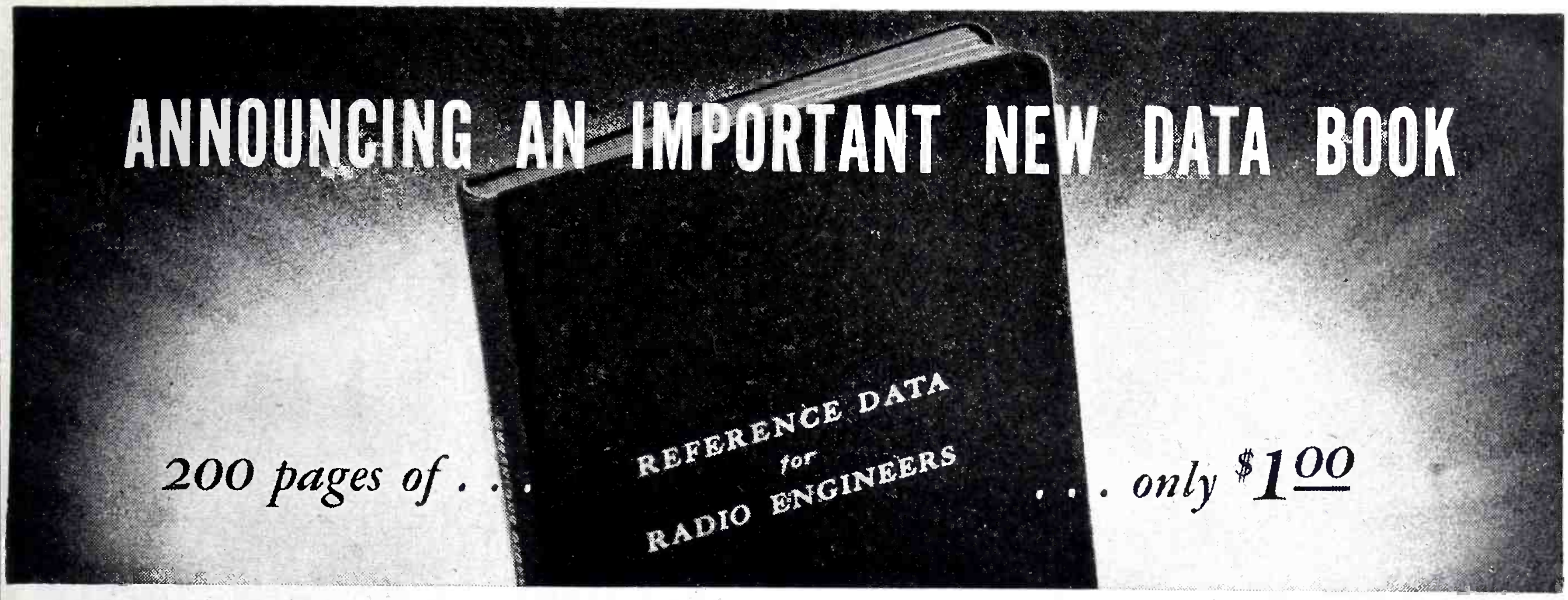
HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

The men and women of National Company take great pride in the reception of the Army-Navy "E" Award for excellence in production. To us it brings a special satisfaction, for twenty-five years ago we received a similar award for service to the Nation in World War I. Old timers have set the pace in winning both awards, but new hands have joined with old skills in putting our difficult job across. It is our pride and our pledge that we of National Company shall keep our record of service bright.

NATIONAL COMPANY, INC.

MALDEN, MASS., U. S. A.



Appreciating the present special need for radio reference data in compact, convenient form, the Federal Telephone and Radio Corporation presents *"Reference Data for Radio Engineers"* as an aid to radio research, development, production and operation.

In selecting material for this book, the aim was to provide for the requirements of the engineer as well as the practical technician. Hence, more fundamental data are included than usually found in a concise radio handbook, in order to fill a gap that has existed in the past between handbooks and standard radio engineering text books. Special effort also was directed to making the material useful both in the laboratory and in the field.

A glance at the table of contents, listed at the right will show the wealth of subject matter included. All material is presented in a concise, practical form generously illustrated, with more than 175 charts, graphs and tables — all conveniently arranged for ready use.

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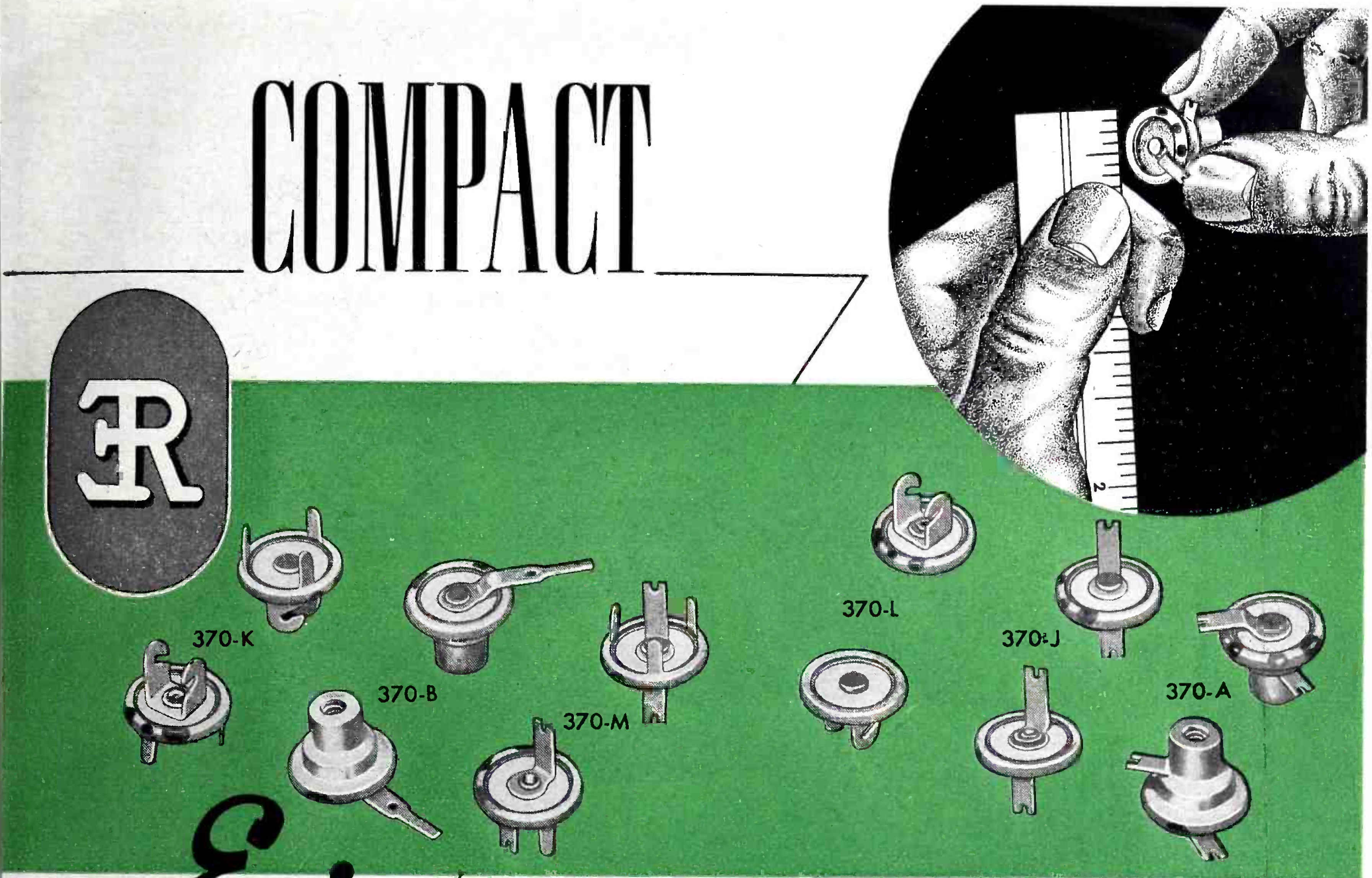

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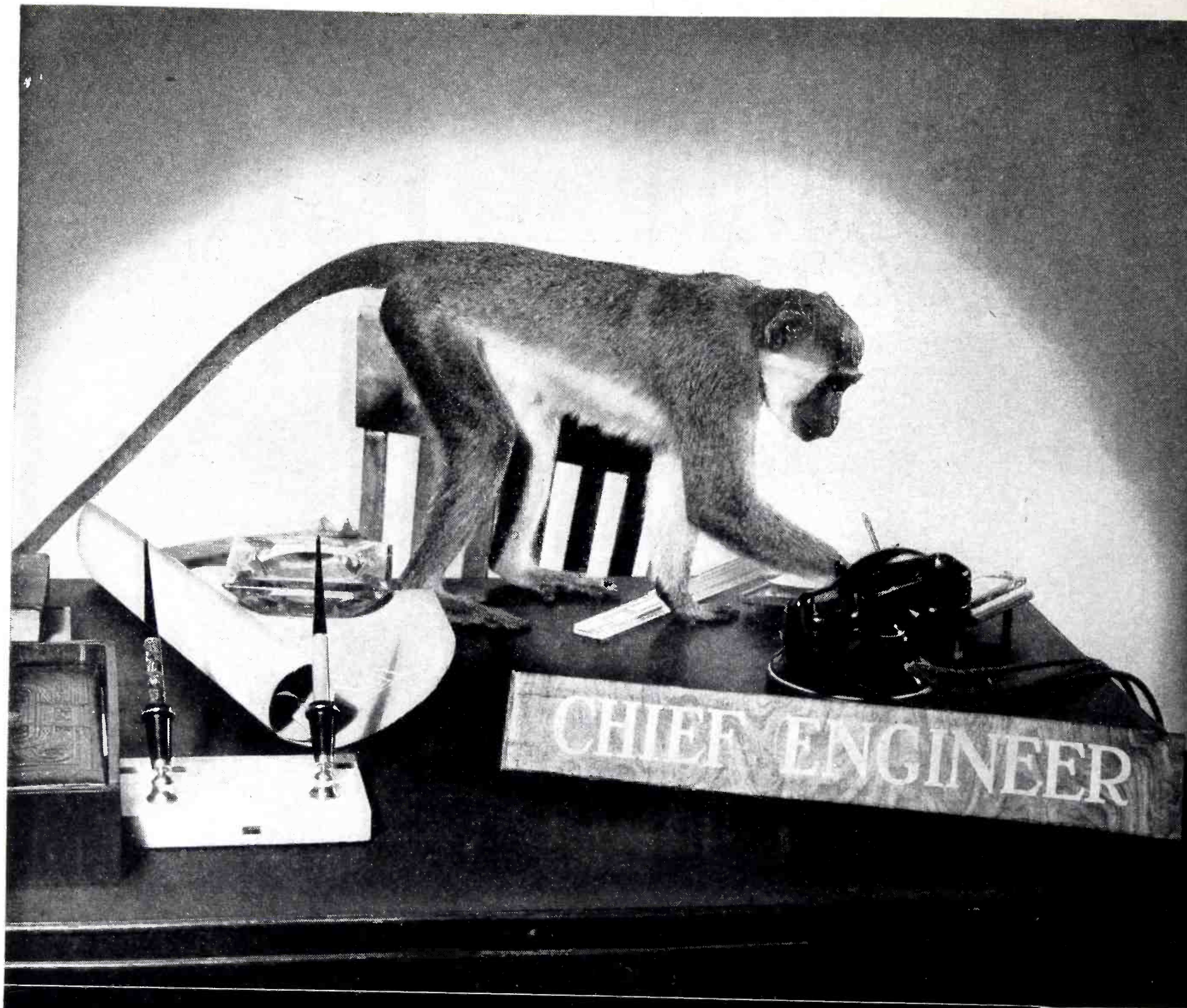

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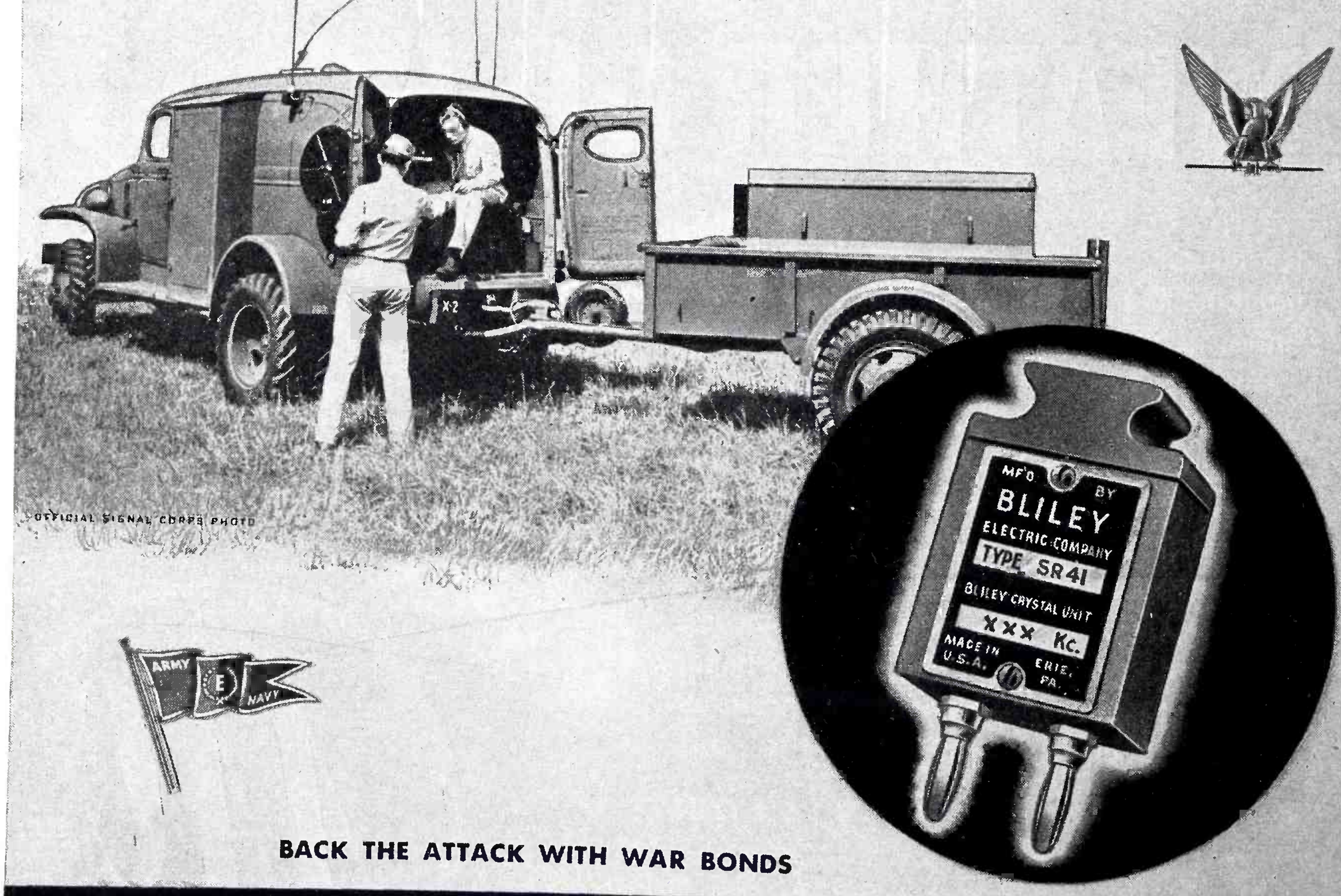

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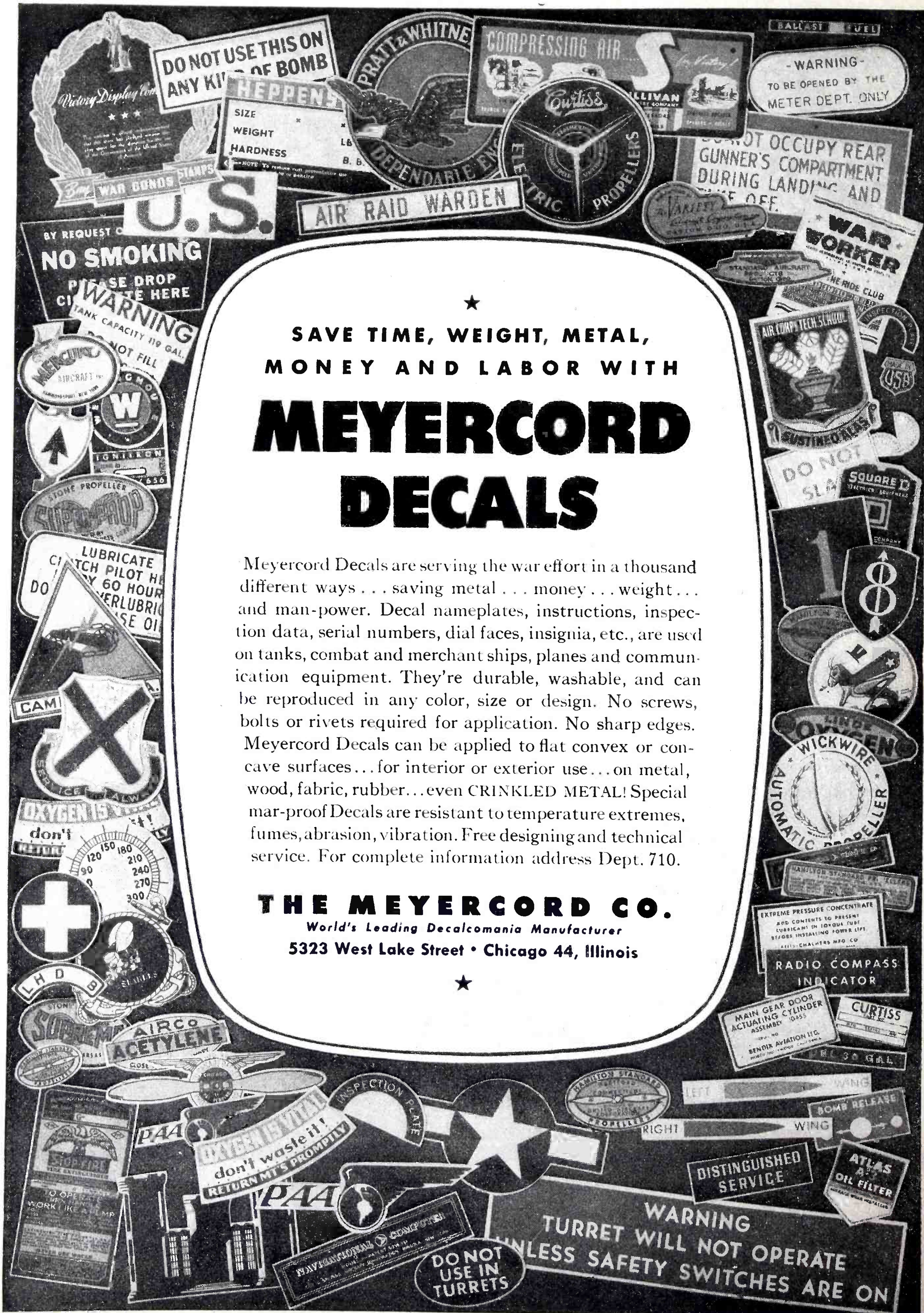
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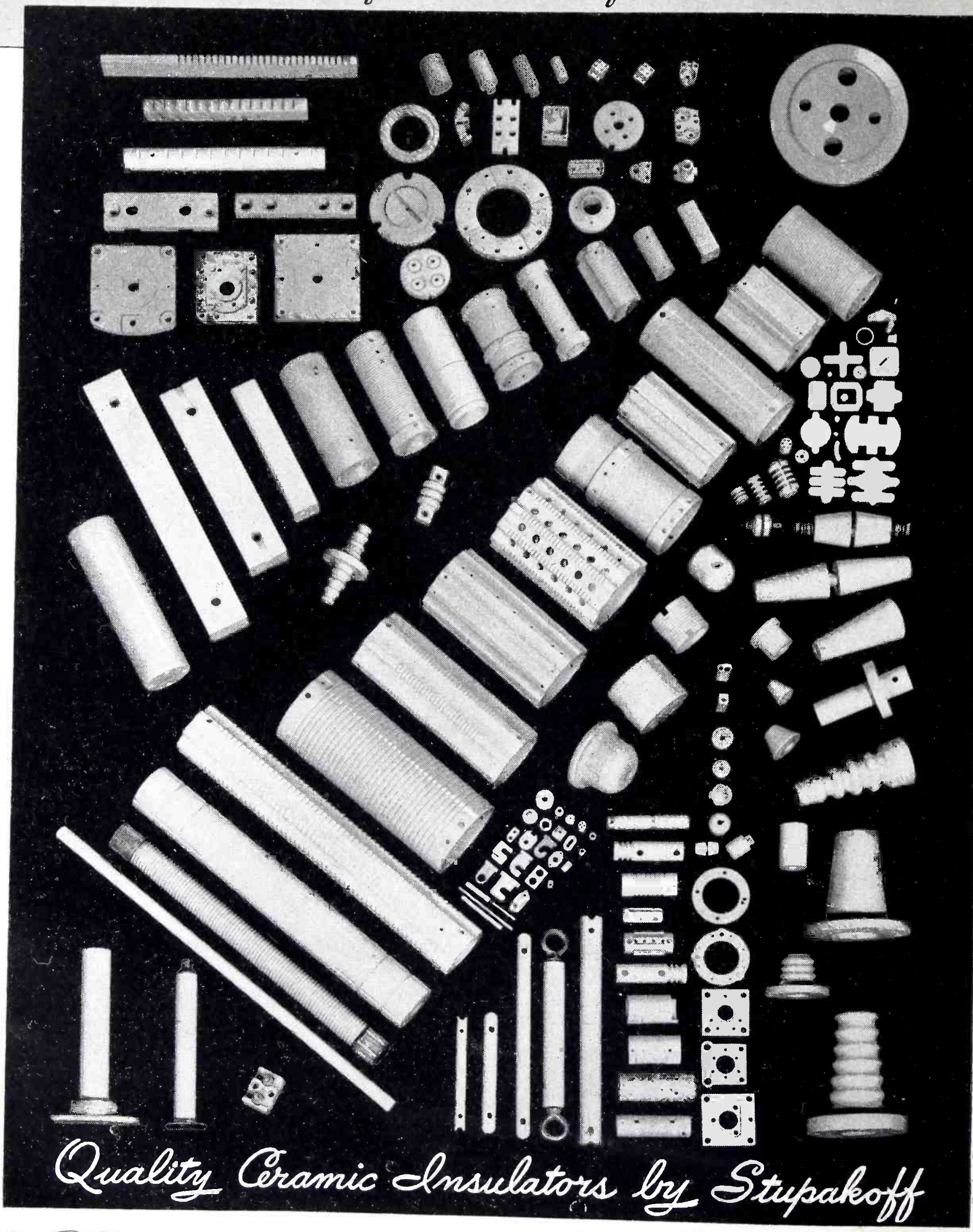

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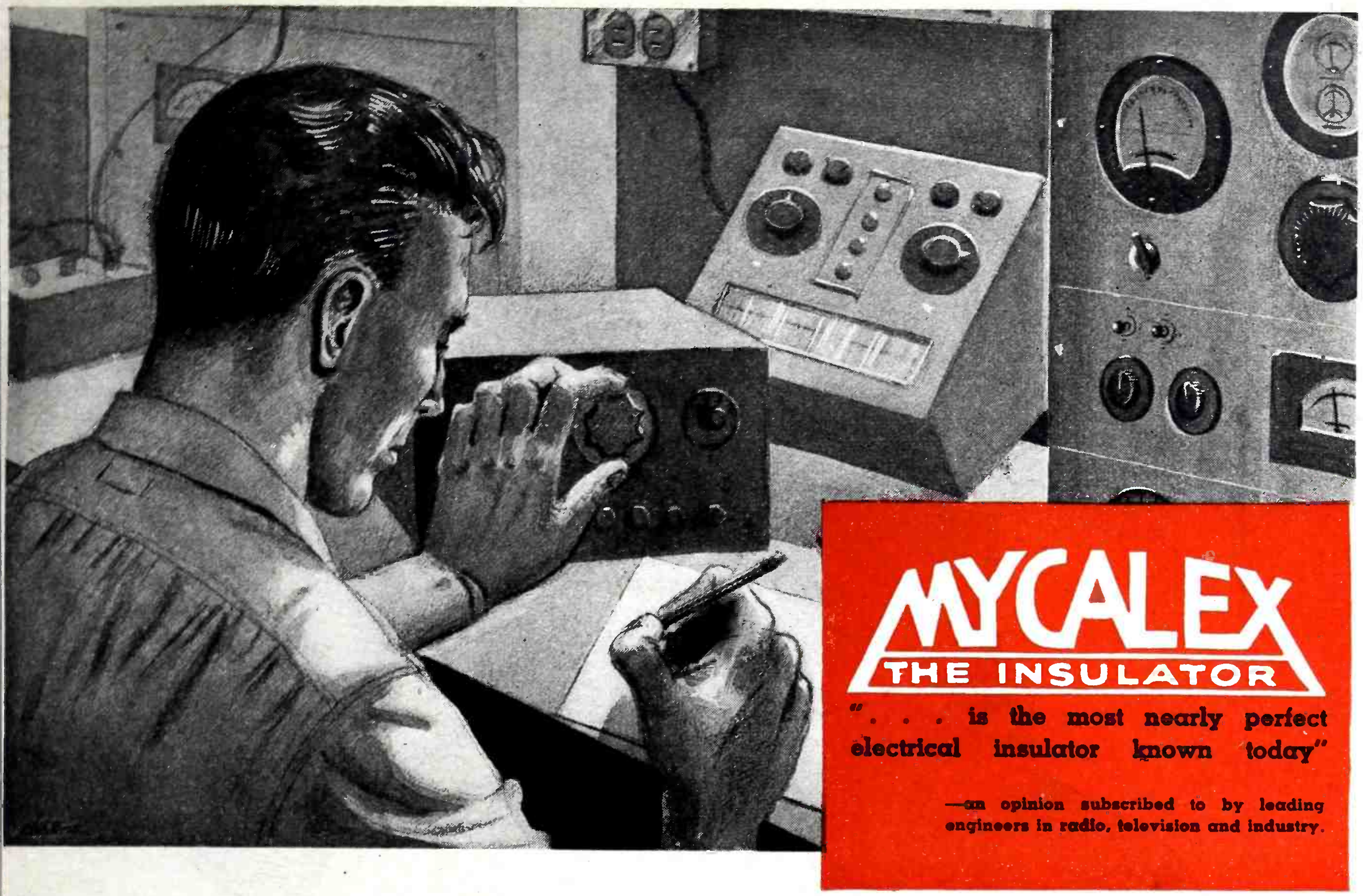

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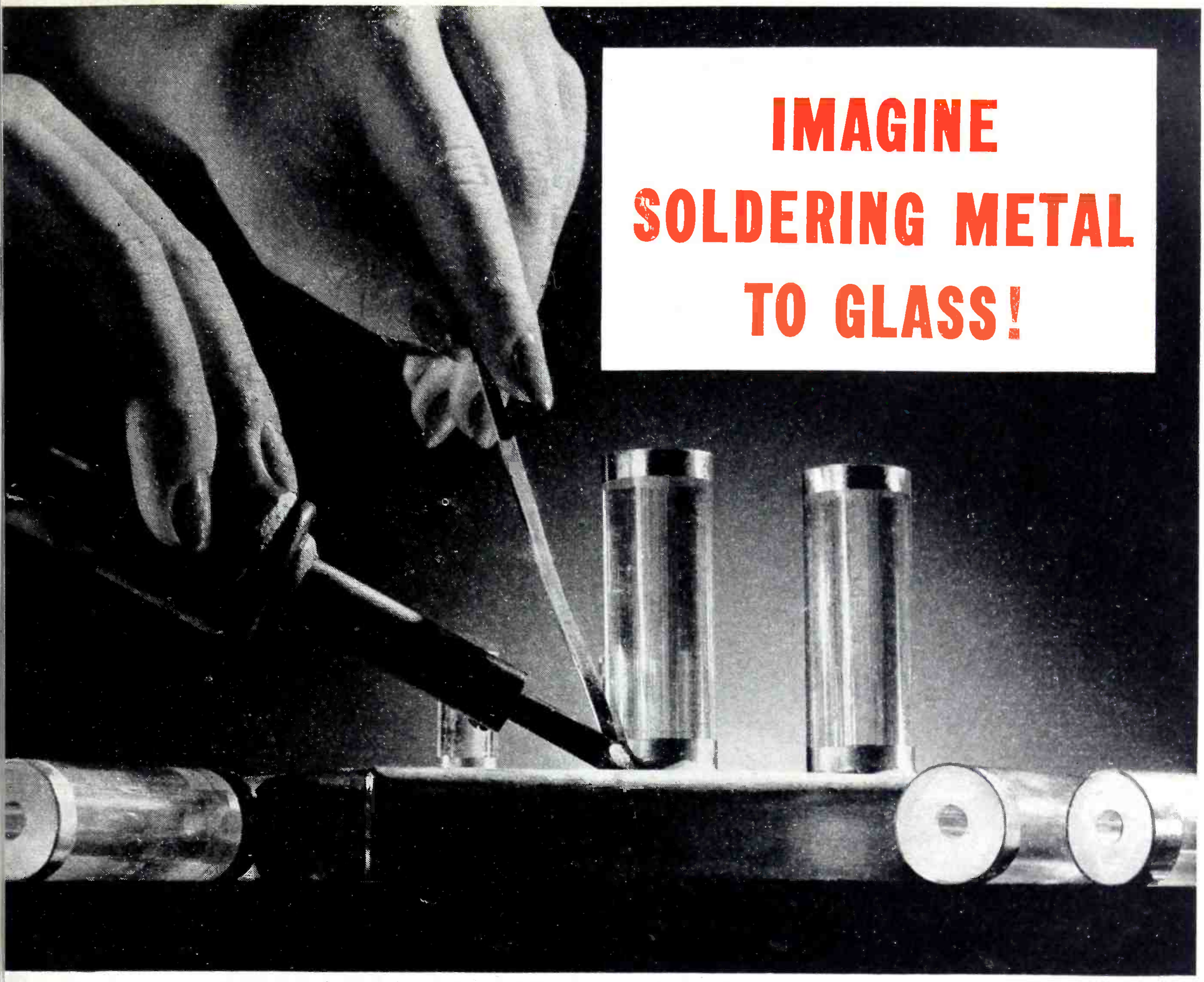

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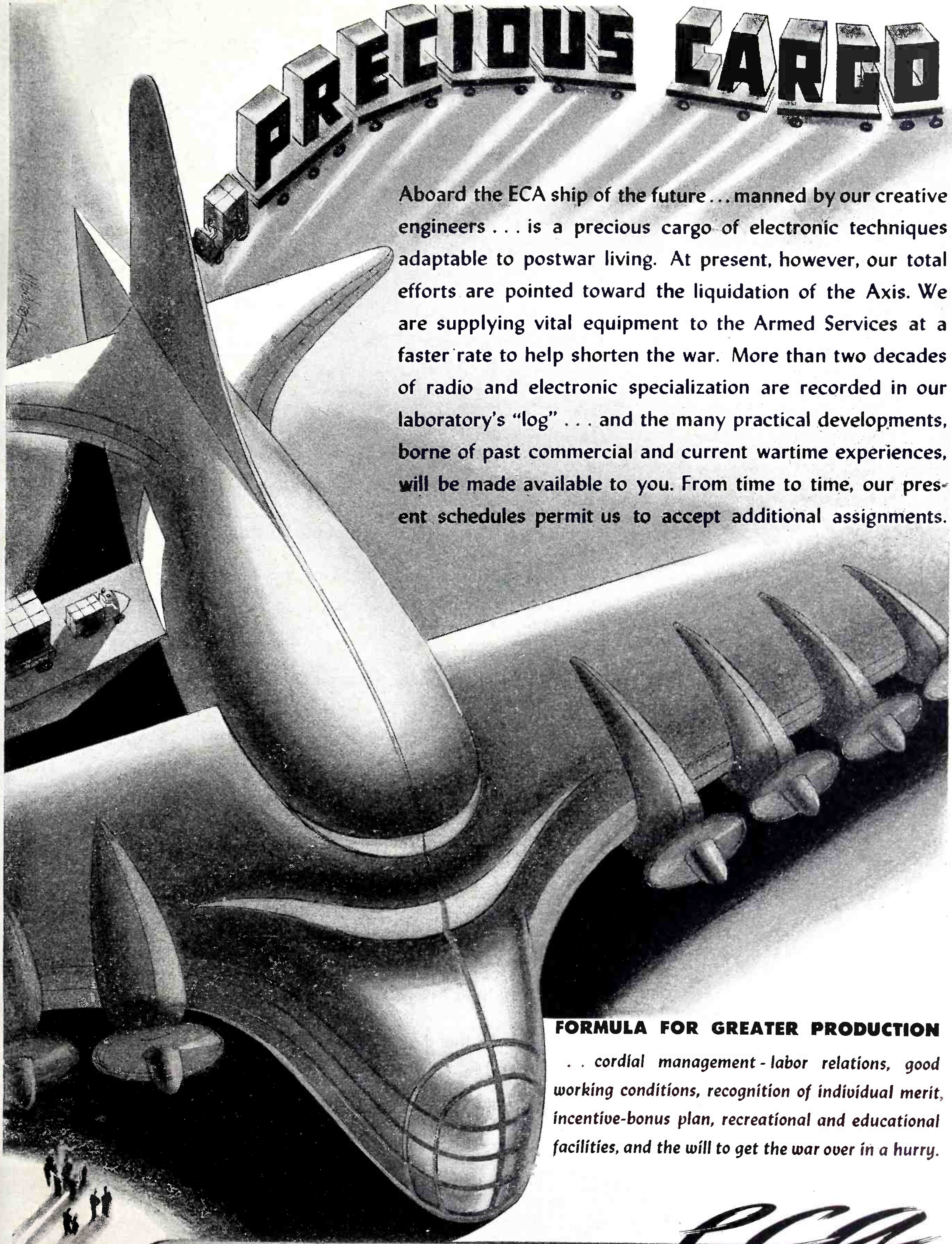

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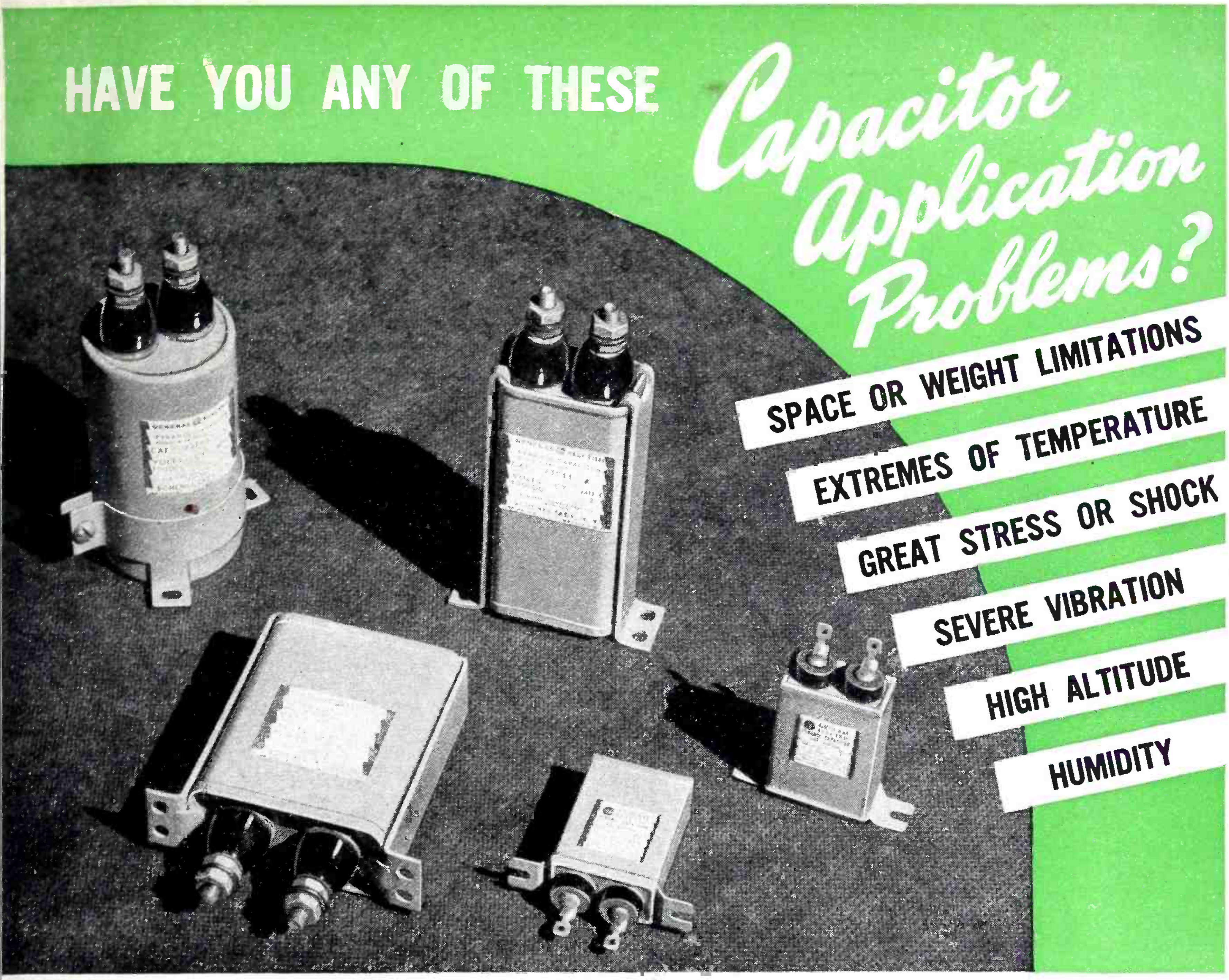

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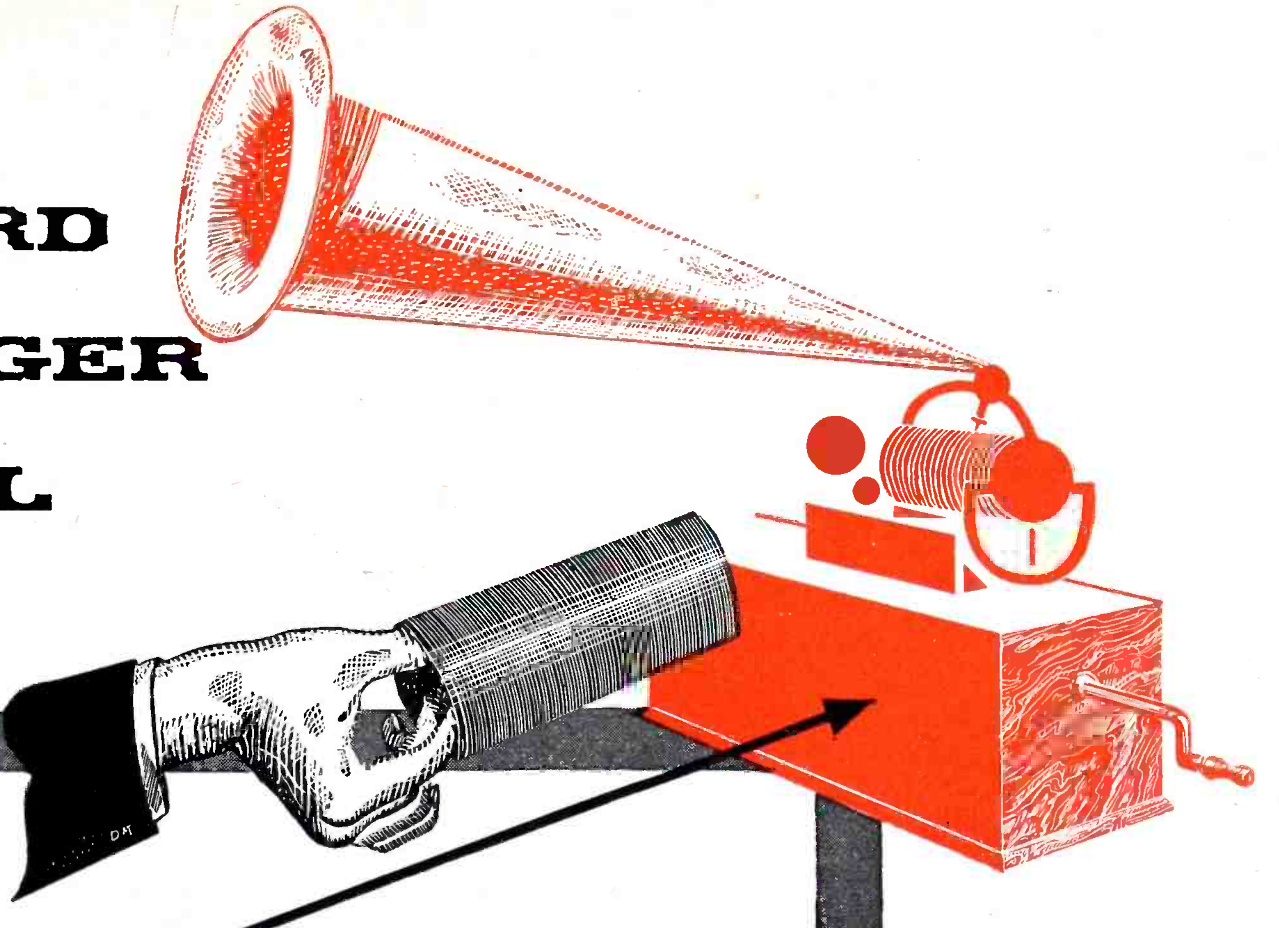

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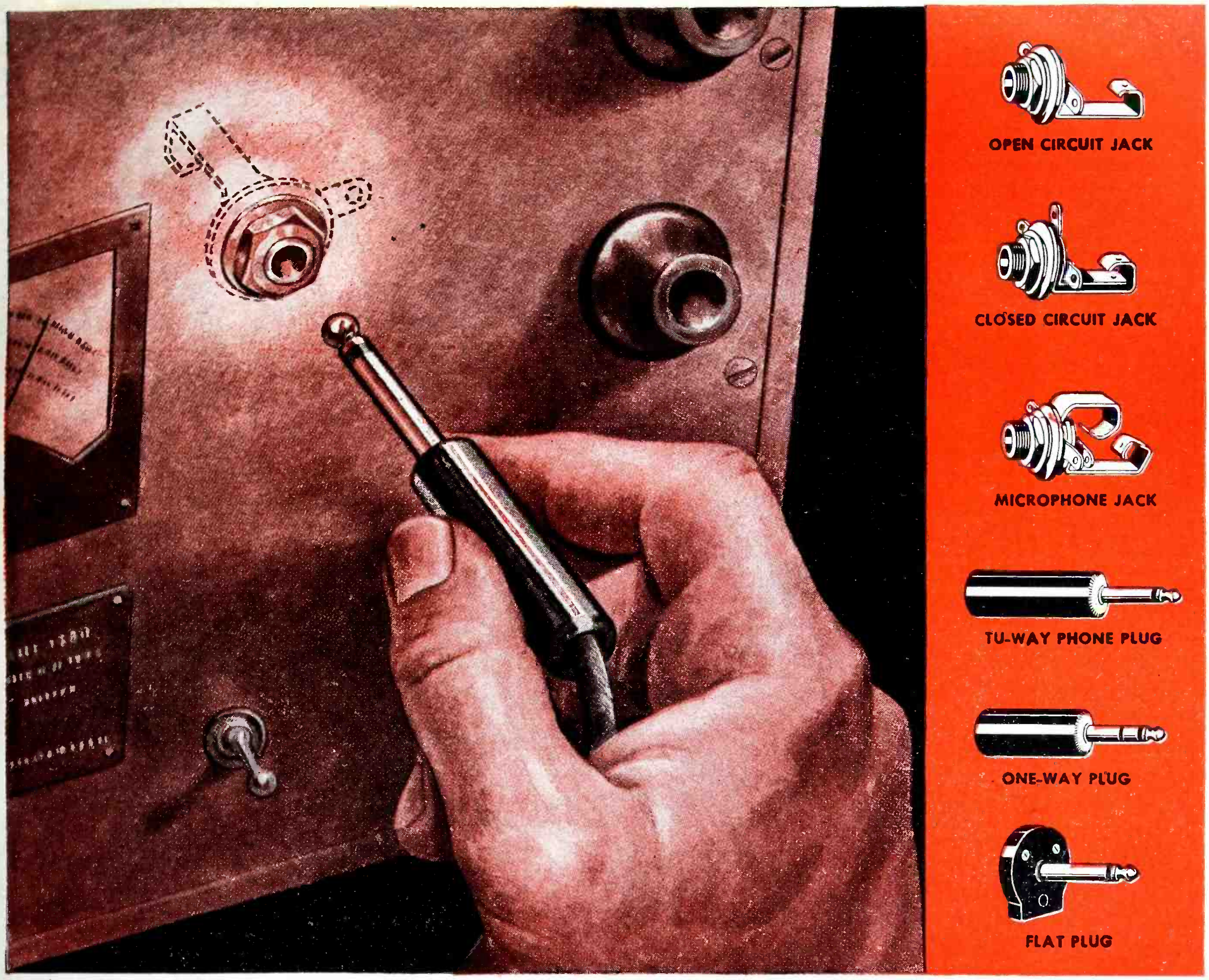

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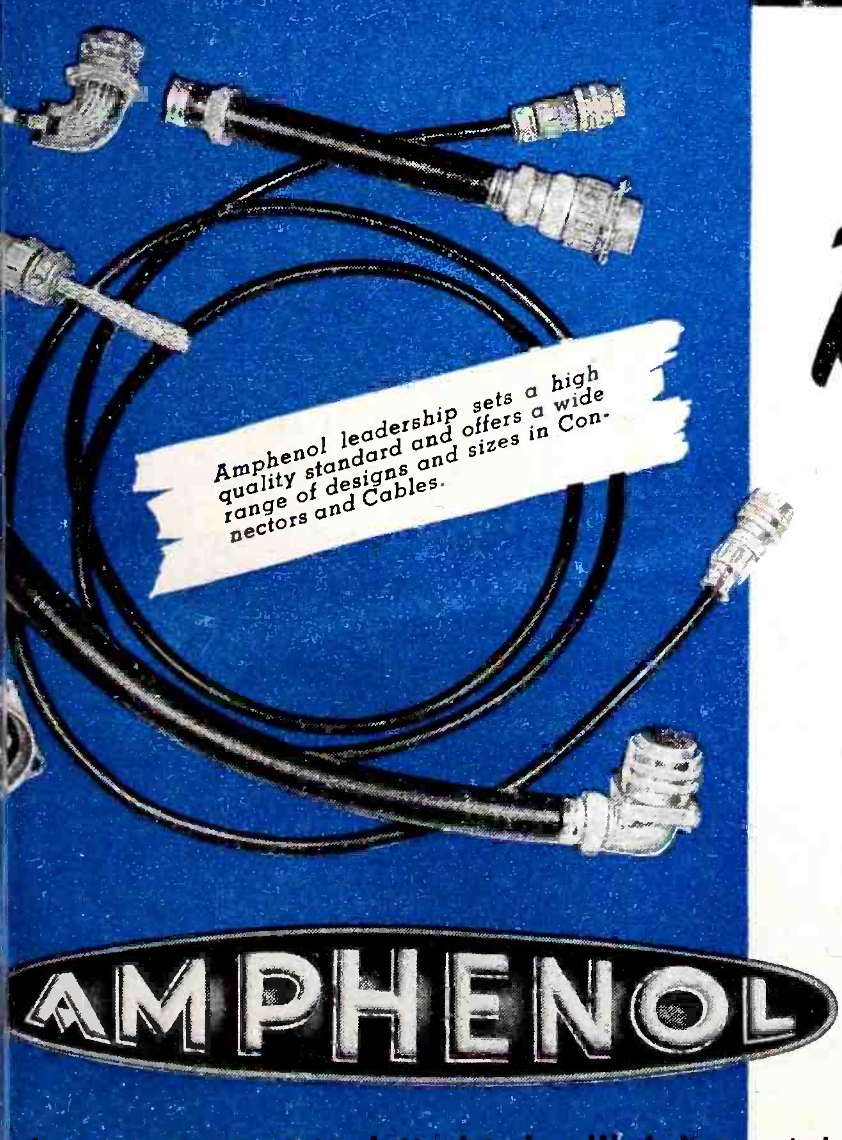

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PANELYTE policy for the past 13 years has been to work in closest cooperation with the engineering staffs of leading firms in the Automotive, Aviation, Central Station, Chemical, Communications, Electrical Equipment, Marine, Transportation, Petroleum, Radio, Refrigeration, Textile and Paper Industries. PANELYTE engineers designed or assisted in the design of many structural parts which are recognized as important advances in the Aviation and Electrical Industries. Our thorough knowledge of the design, manufacture, and use of structural laminated resinous plastics may help you with some immediate problem — or in planning for future production. Samples and factual Data Sheets are available.

* PANELYTE DIVISION, ST. REGIS PAPER COMPANY . . . AMERICA'S LARGEST PRE-WAR MANUFACTURER OF THERMO-SETTING MOLDED LAMINATED PLASTICS

PANELYTE *the structural plastic*

PANELYTE DIVISION
ST. REGIS PAPER COMPANY
230 PARK AVENUE, NEW YORK

MASS PRODUCTION OF SHEETS, RODS, TUBES, MOLDED FORMS, FABRICATED PARTS

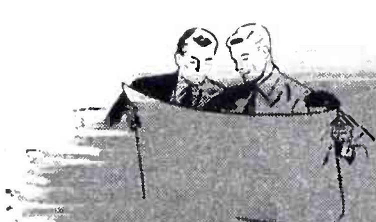
Sales Offices: Atlanta, Chicago, Dallas, Denver, Detroit, Houston, Kansas City, Los Angeles, Montreal, New Orleans, St. Louis, St. Paul, San Francisco, Seattle, Toronto, Vancouver

Experienced and reliable Fabricators in Industrial Centers from coast-to-coast

At first glance, the intricate designs of many wire forms look like the "doodlings" on an engineer's scratch pad; yet each twist and turn serves a necessary function—either that of cushioning, retaining, or joining. One Muehlhausen wire form may be used to cushion the huge reflector of a defensive searchlight; another may firmly grip the ceramic insulator in a power line circuit breaker.

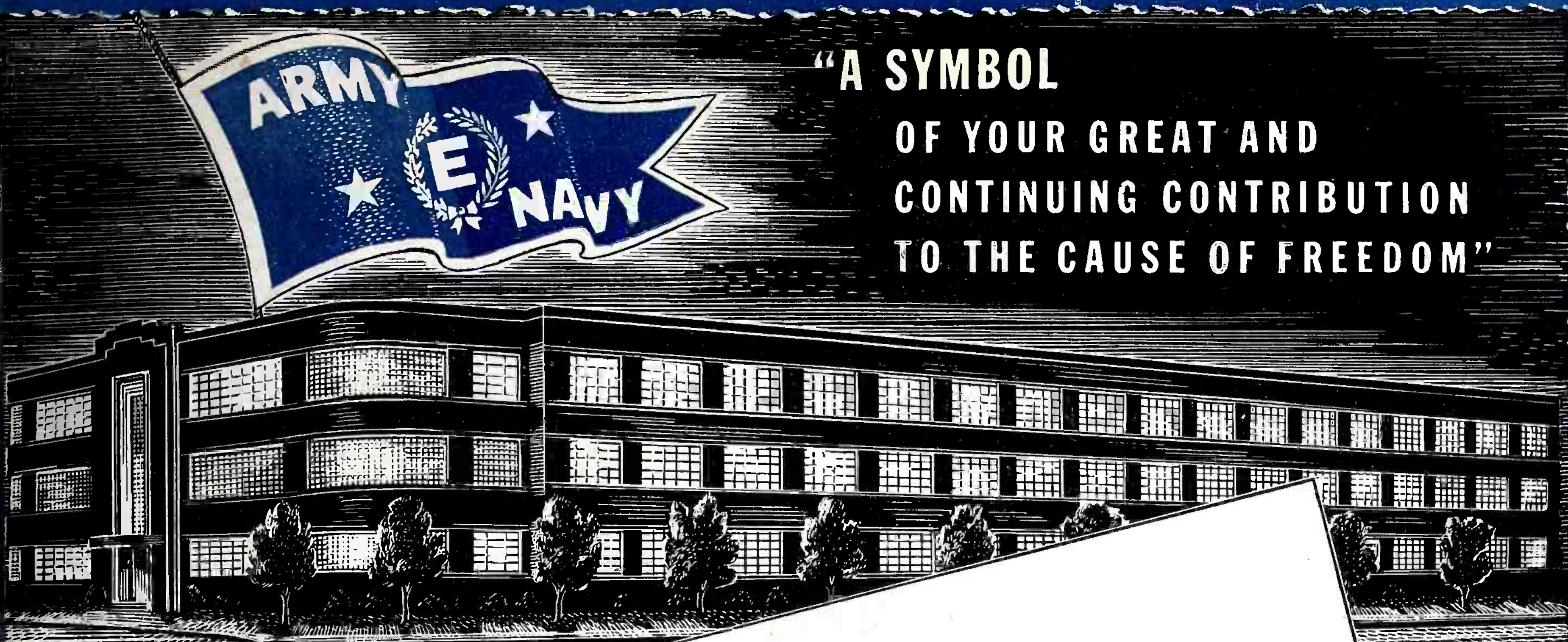
Muehlhausen is currently producing a variety of wire forms for use in war products, the unusual requirements of which are being met by this company's experienced designers, skillful tool makers, and extensive fabrication equipment.

MUEHLHAUSEN SPRING CORPORATION
Division of Standard Steel Spring Company
760 Michigan Avenue, Logansport, Indiana



...Leading product designers in every industry are consulting Muehlhausen Engineers to secure springs of lasting efficiency.

MUEHLHAUSEN
SPRINGS
EVERY TYPE AND SIZE



"A SYMBOL OF YOUR GREAT AND CONTINUING CONTRIBUTION TO THE CAUSE OF FREEDOM"

WAR DEPARTMENT
OFFICE OF THE UNDER SECRETARY
WASHINGTON, D.C.

25 September 1943

To the Men and Women
of the American Lava Company
Chattanooga, Tennessee

I am pleased to inform you that you have won for the third time the Army-Navy Production Award for high achievement in the production of war materiel.

In maintaining the fine record which first brought you distinction, you have set an inspiring example for your fellow Americans on the production front.

This second renewal adds a second White Star to your Army-Navy Production Award flag, and stands as a symbol of your great and continuing contribution to the cause of freedom.

Sincerely yours,

Robert P. Patterson
Under Secretary of War

ALSIMAG

TRADE MARK REGISTERED U. S. PATENT OFFICE

STEATITE CERAMIC ELECTRICAL INSULATION FOR ELECTRONIC USES

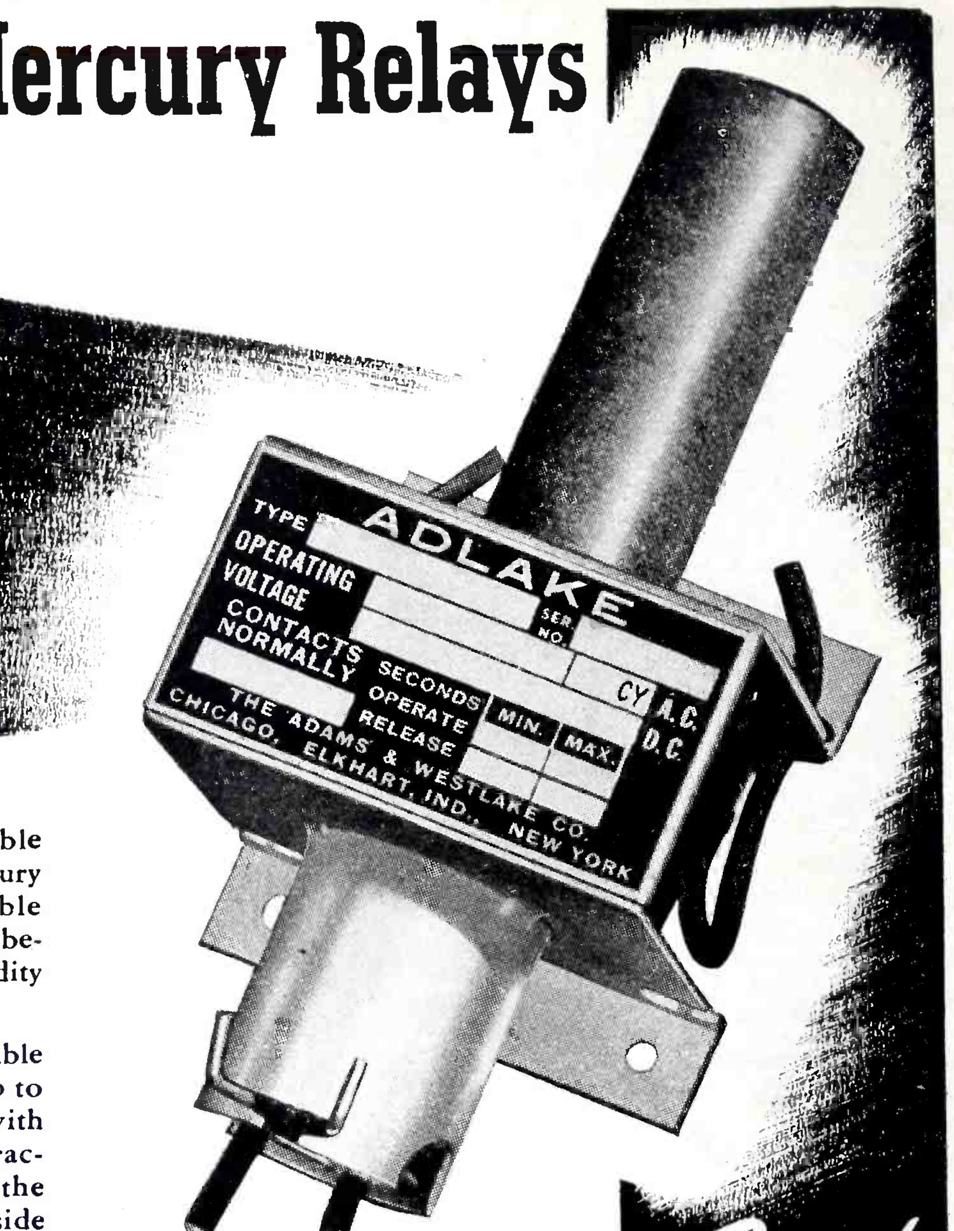
AMERICAN LAVA CORPORATION

CHATTANOOGA 5 TENNESSEE


AVAILABLE IN ALL STANDARD SIZES, ANY QUANTITY ★ FLEXIBLE, NON-FRAYING AND NON-BURNING ★ ACID, MOISTURE AND OIL RESISTANT ★ HIGH DIELECTRIC VALUES
..all these general features
TURBO
SATURATED SLEEVING • VARNISHED TUBING
will do your job tomorrow!
Here's the insulation for your present essential needs, and post-war plannings! Smooth bore, non-deteriorating and non-absorbent characteristics, and resistance to wear, abrasion and impact assure higher operating efficiencies under most severe conditions. Moreover, because many applications today require insulation embodying specific properties in varying degrees to meet great divergence in electrical and mechanical requisites, a range of TURBO products are available for particular needs — Flexible Varnished Oil Tubing, Varnished Glass Tubing, and Extruded Tubing. Also, to safeguard circuits, TURBO Wire Identification Markers are offered.
☆ ☆ ☆
Check the advantages of each TURBO product below. Sample board, with specimen of each and list of standard sizes will be sent on request.
WILLIAM BRAND & COMPANY
276 FOURTH AVE. NEW YORK, N. Y.
325 W. HURON STREET CHICAGO, ILL.
..and these individual features!
FLEXIBLE VARNISHED OIL TUBING:
resistant to deteriorating influences
This TURBO insulation meets the diversity of requirements necessary to stand up against general break-downs, impairment through moisture absorption, and the general deteriorating influences caused by acids, alkalis, etc.
EXTRUDED TUBING:
resistant to sub-zero temperatures
Where the effects of extreme low temperatures are apt to induce insulation embrittlement, TURBO Extruded Tubing is especially suited. Sudden climatic changes, wide fluctuations in temperature, or refrigerant operating conditions will not effect the dependability
VARNISHED GLASS TUBING:
resistant to extremely high heat
The extensive use of this TURBO product is directly attributable to its excellent characteristics under high heat conditions. Heavy duty operating conditions, confined areas where ventilation is minimized and other similar problems are solved
WIRE IDENTIFICATION MARKERS:
to meet rigid ordnance specifications
The facilitating of production and assembling operations, with corresponding increases in functional efficiency, are effected with this TURBO insulation product. Available in any size, length or color, these TURBO markers are strictly in accord with Army, Navy and Air Corps

Adlake *Plunger-type* Mercury Relays

STAMINA
SIMPLICITY
DEPENDABILITY

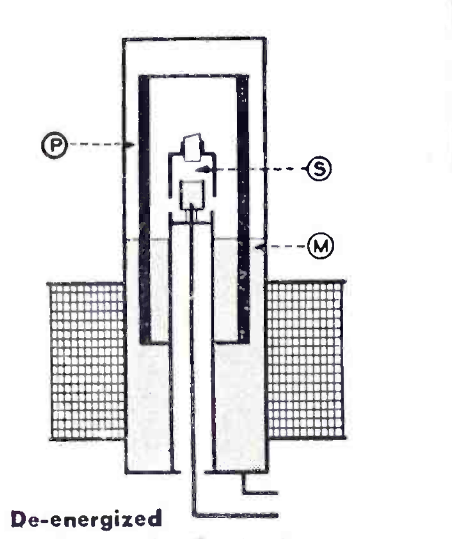


Automatic power control can be no more dependable than its relays. That is why the plunger-type mercury relay is replacing other types. It is the most dependable relay thus far developed for many types of service, because dirt, dust, moisture, temperature changes, humidity etc. can not affect its hermetically sealed contacts.

ADLAKE Plunger-type Mercury Relays are available for either quick or time delay action . . . for A. C. up to 440 volts . . . for D. C. up to 115 volts (and higher, with outside resistors) . . . and contact capacity from a fraction of an ampere to 100 amperes. All operate on the same basic principle. All are armored against outside impact. All have *hermetically sealed mercury to mercury contacts* which are *positive, chatterless, noiseless* and *arcless*. For complete data, request bulletin.

Adlake Relay No. 1040—(for A.C.)
5½" high, 2½" wide, 2$\frac{9}{16}$" projection. For panel mounting. Contact normally open or closed. Quick or time delay action. Contact protected by metal armor.

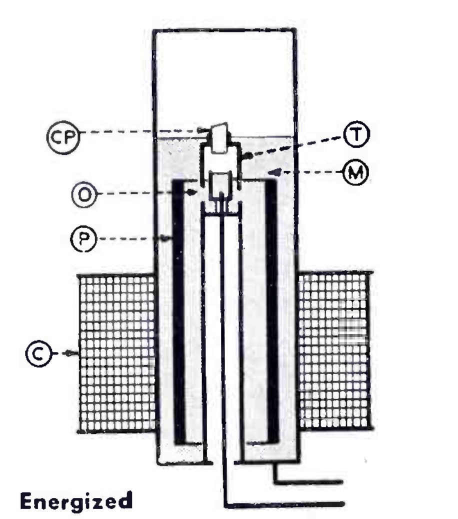
S I M P L E, U N F A I L I N G, P O S I T I V E A C T I O N



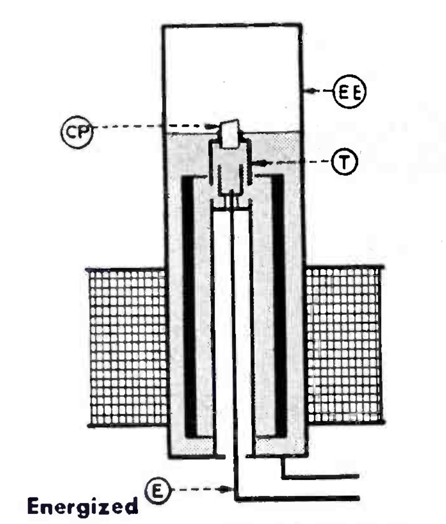
De-energized
Plunger P is floating in mercury M. Space indicated by S is filled with inert gas.

•

The above and accompanying sketches are not mechanical drawings. They show how Adlake Relays work, not construction detail.



Energized
Coil C pulls plunger P down into mercury M. Mercury thus displaced enters thimble T through orifice O. Inert gas in thimble has not yet escaped through ceramic plug CP, thus effecting time delay.



Energized
Mercury now fills thimble T, is completely leveled off and mercury to mercury *contact established between electrodes E and EE. Degree of porosity of plug CP determines length of time delay—and* accurately.

Proved
IN THESE AND OTHER APPLICATIONS

- Radio transmission
- Electric time controls
- Photo-electric apparatus
- Heating and ventilating controls
- Production line time controls
- Remote and automatic controls
- Air conditioning controls
- Signals and indicators
- Refrigeration controls
- Voltage regulators
- Burglar alarms
- Electric call systems
- Across the line motor start switches
- Motor reversing switches
- Sign flashers
- Animated displays
- Telephone circuits
- Mill and factory service
- Navigation buoy flasher light controls
- Dry cleaning equipment
- Surgical lighting controls
- Electrolysis prevention
- X-ray control

Adlake TRADE MARK

THE ADAMS & WESTLAKE COMPANY

ESTABLISHED IN 1857 — **ELKHART, INDIANA** — *NEW YORK · CHICAGO*

MANUFACTURERS OF ADLAKE HERMETICALLY SEALED MERCURY RELAYS FOR TIMING, LOAD, AND CONTROL CIRCUITS

Free Enterprise

WHAT IS IT? HOW DOES IT WORK?

OURS is a free-enterprise economy the chief motivating forces of which are the prospective rewards for effort and risk-taking. Its smooth operation depends: first, on adequate incentives for risk-taking, innovation, and individual effort; and second, on sufficient competition to minimize the need for government regulation and to prevent artificially high prices or wages from being maintained in large segments of the economy. Trouble comes when these incentives and this competition are tampered with or removed.

America was founded by men who had the urge to better themselves and the courage to take a chance. These men uprooted themselves in Europe and braved the unknown. They risked all for freedom. They knew that, to be free, they had to attain economic freedom. Their goal was an economic freedom which permits the private ownership of property, the free choice of jobs, and free entry into entrepreneurial pursuits. Their efforts, therefore, were directed toward individual opportunity with no limit on individual achievement. Their foresight and the endeavors of those who followed them created the world's greatest industrial nation enjoying the highest standards of living.

We can take pride in the knowledge that our country has been the greatest single contributor to the world's physical assets even though we remember that an abundance of natural resources contributed materially to America's economic development. But the fact that our progress has been interrupted, again and again, by depressions which resulted in enormous wastes of our human and material resources is sobering proof that our economic mechanism still is far from perfect.

Our production per man-hour has been increasing at the rate of 2½% per year. Improved machines and greater efficiency have more than tripled the output per hour of work since 1900. Looking to the future, this annual rise indicates that our production per hour of work will double in the course of the next 25 to 30 years. This means that we can have twice our present volume of goods and services per capita or an equivalent combination of more production and more leisure. In other words, we can further increase the living standards and further decrease the working hours of the American people by further intensifying our industrial efficiency.

This is no idle dream. It can be achieved, and it will be achieved, if only we maintain the essential features of our system of individual enterprise which alone makes possible this near-utopian goal. Intensification of our efficiency, however, means that we can have full employment only if we expand enormously our production, and particularly our production of new goods. We can expand total production only if we have the markets and the demands for the vast output of goods and services made possible by our technological development. To attain these, we will need to venture into new markets, new inventions, and new methods. Such ventures involve risks, and risks will be taken only if there is sufficient prospect of reward.

Let us never lose sight of the fact that the essential features of free enterprise are the prospective rewards for risk-taking as well as for effort.

The evidence is clear that incentive methods of wage payments will boost production. Carefully devised systems of salary payment with large differential inducements for superior performance have been powerful means of raising the standards of managerial accomplishment.

Free enterprise cannot operate effectively unless the wage and salary system offers greater rewards for greater effort. Neither can it operate effectively unless the prospects for profit are sufficient to encourage the employment of resources which otherwise would be kept idle.

Unless the prospects of profit are superior to the prospects of loss, new ventures will not be undertaken and going concerns will not expand or continue long in business. When the hope for profits wanes, employment and production slump; when that hope revives, employment and production recover.

Business initiative must be given every possible inducement in order that maximum employment may be achieved through private enterprise. This involves the removal and avoidance of restrictions on business by government, by labor, and by business itself.

Competition is the life-blood of the free enterprise system. Business and industry must rely upon efficiency rather than upon protection from competition for their survival.

Those government controls which were made necessary during the war by the magnitude of government demands for goods should be lifted at the earliest possible moment. As soon as the danger of inflation has receded, price controls must be removed and profit margins again left free to be determined by market forces. The excess profits tax must be repealed and the burden of other taxes on business profits greatly reduced. Tax laws should be revised so as to permit adequate rewards for assuming risks. The modernizing of anti-trust laws and their vigorous enforcement, not indiscriminate persecution, will be supported by all who really want free enterprise. Such measures will strengthen the incentives to expand old businesses and to start new ventures.

Grants of unlimited monopoly powers to labor unions which enable them, consciously or not, to sabotage the profit incentive in business must be withdrawn. Labor has certain legitimate rights; and in order to preserve them and its freedom, labor must come to realize that its best interests lie in a well functioning, self-disciplined competitive free-enterprise economy.

There must be evolved in the minds of business, labor, and the public a recognition of the need for private business enterprise and a realization that policies which throttle it are harmful not only to businessmen but to workers and consumers as well. Unless we achieve this understanding and avoid needless deterrents to business expansion, we are likely to pay for our folly in the destruction of our free enterprise system.

We cannot tolerate conditions in which special interest groups in business, labor, agriculture, or politics prevent free access to the market by would-be competitors. Such monopolizing of opportunities stifles progress and creates profits or wage rates based on artificial scarcity. In such cases government interference to open the market to all comers is clearly indicated. We must recognize the need for constructive policies by business, labor, and government which will insure the competition necessary for the successful operation of our economy.

Increased government regulation and control of business activities is not conducive to strengthening the virility of private enterprise. Government ownership and operation of productive resources certainly is not to be condoned. The more government rules and regulates business, the less will be the incentive to assume risks and to exercise individual initiative. Government regulation of the detailed operation of industry inhibits progress, is prey to political pressures, and is subject to the human failings of its administrators. *Better far the rough guidance and justice of vigorous, though somewhat imperfect, competition than the uncertainty of arbitrary regulation.*

The gravest threats to our competitive system exist in legalized monopolies, such as the N.R.A. once comprised, such as the labor unions and farm groups have recently achieved, such as businessmen themselves have sometimes sought. The power of labor monopolies to encroach on business profits will tend to interfere seriously with the needed flow of new investment. And when any group is strong enough to move the average level of costs as much as the labor groups and the farm groups are able to do, there is good reason to fear that, when we begin to approach high levels of employment and production in time of peace, these groups will induce a price-wage spiral which will waste money incomes on price increases instead of permitting them to draw unemployed resources into production. While the demands of labor for collective bargaining rights and the demands of farmers for protection against the rigors of depression have validity, there can be no reason for excessive grants of power and privilege which threaten to make our system of free enterprise unworkable.

Ours is a complex economic structure. The functions which prices, income, savings, investments, and taxes play in this system are difficult to comprehend.

As I have said before: Thinking is hard work, and we will have to work hard if we are to develop business policies, labor policies, and government policies which will insure full employment and the opportunity for consistent profit. Yet only through such policies can we guarantee that private enterprise will be the predominant source of jobs, income, and production.

Even more difficult than thinking, and more important, is the implementation of many policies that are in the interest of the free enterprise system. Not all measures will satisfy all people. Special interests will have to be subordinated to the total interests of the nation. Sacrifice and vision have been essential to the winning of the war. They will be no less essential to the winning of the peace.

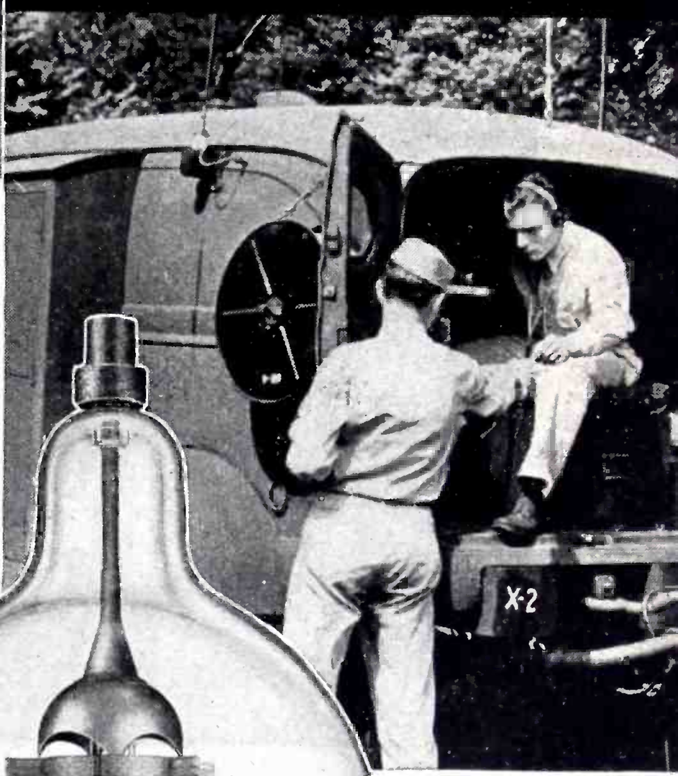
If we can gain recognition of the crucial role of incentives for enterprise, if we stand squarely for competition and against protection or privilege for special interests, and if we bend our efforts to find satisfactory ways and means to prevent large-scale unemployment, we can have the full benefits which only a free enterprise system can produce—in industrial progress, in improved standards of living, and in the preservation of our democratic ways of life.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

SCR-299

Complete High Power Radio Transmitter and receivers mounted in light army truck. These transmitters are in service in all theatres of war and in most all branches of the army.



The radio amateur is fighting this war, too

The radio amateur is off the air as an amateur but he's still in radio. He's there in person and he's everywhere in the products created to satisfy his progressive demands. Many of the world's leading electronic engineers are radio amateurs and much of the equipment in use today by the armed services is a product of the great amateur testing grounds. Two outstanding examples are: the SCR-299 Transmitter and Eimac tubes.

The SCR-299 transmitter, designed by Hallicrafters, is an adaptation of the model HT-4 which is a 450 watt rig designed primarily for amateur use. Its characteristics and performance capabilities were such that it was easily adapted to military use and it is today seeing service throughout the world in all branches of the army. It is significant to note that Eimac tubes... created to satisfy the demands of the amateur...occupy the key sockets of the SCR-299. Yes, and Eimac Vacuum Tank Condensers, too, are in this now famous transmitter.

The SCR-299 offers a striking confirmation of the fact that Eimac tubes are first in the important new developments in radio...first choice of the leading engineers throughout the world.

Follow the leaders to

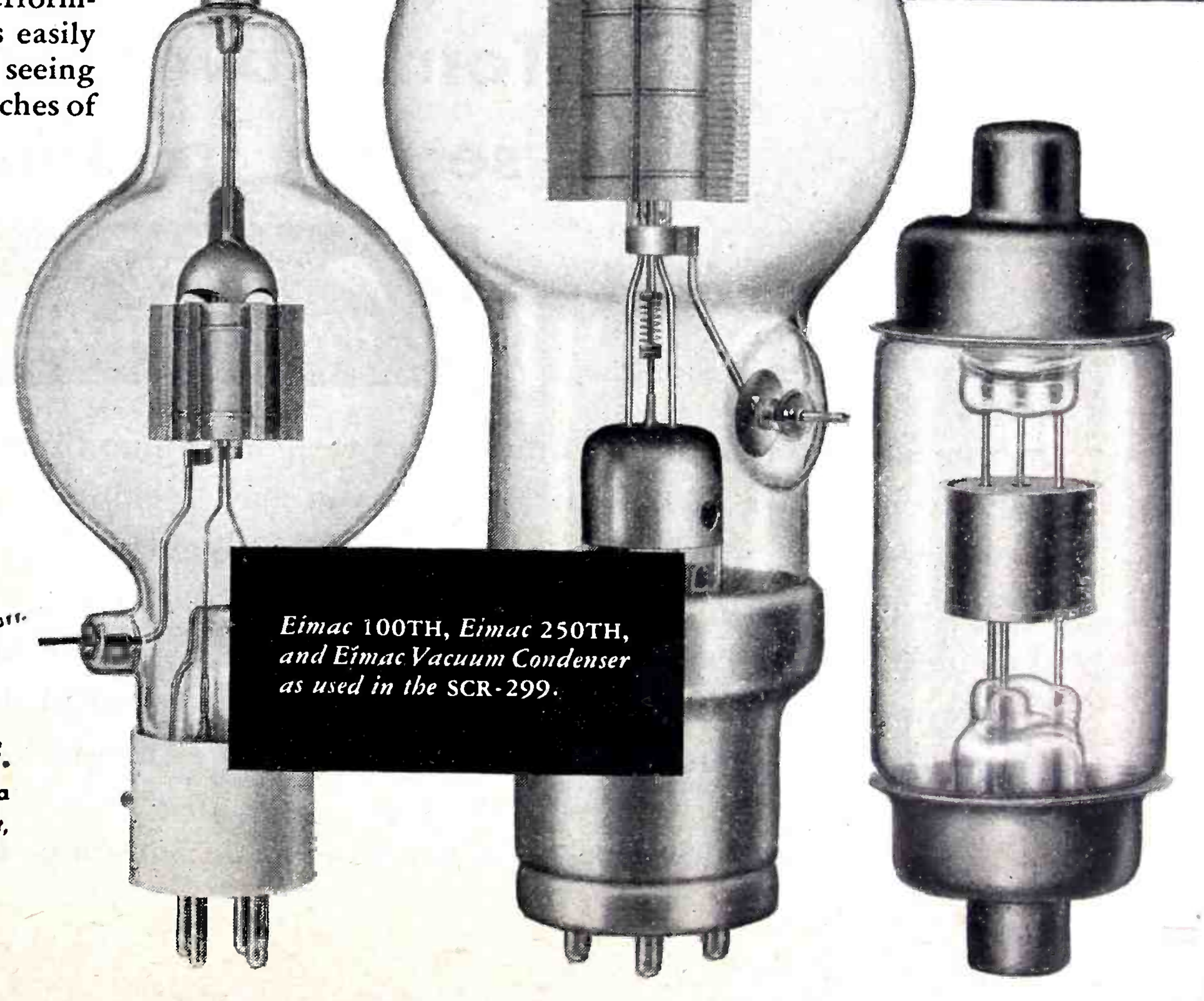
Eimac REG. U. S. PAT. OFF. **TUBES**

ARMY E NAVY

EITEL-McCULLOUGH, Inc., SAN BRUNO, CALIF.

Plants at: Salt Lake City, Utah and San Bruno, California

Export Agents: FRAZAR & HANSEN, 301 Clay Street, San Francisco, California, U. S. A.



Eimac 100TH, Eimac 250TH, and Eimac Vacuum Condenser as used in the SCR-299.

WASHINGTON FEEDBACK

☛ Because it has undergone such tremendous expansion, the electronics industry is particularly concerned with two phases of government-industry relations that are now receiving intense consideration in Washington, namely, the procedures that are to be established for cancellation of contracts and those which are to be set up for renegotiation of present contracts.

As regards cancellations, the principal procurement officials agree that whatever program is set up must meet two primary requisites. First, manufacturers must be assured that government will put contract termination on a basis to cover costs and profits not only on that part of the contract that has been completed but also to permit a profit on the uncompleted portion in order to cover time, planning, materials, capital tied up, etc. Second, the procedures must provide for speedy adjustment in order that both prime and subcontractors will have capital to effect a change-over from war production to peace production, with the least disturbance to employment and plant organization.

Contract Adjustment Speed—Manufacturers are told that delays currently encountered in the settlement of cancelled contracts are largely due to the time lapse between notice of cancellation and the submission of claim statements. This is tantamount to a warning that a large part of the job is up to the manufacturers themselves.

Attention is directed to Procurement Regulation 15, a handbook on cancellation management, described as a "tentative guide". Also, a manual which has been published recently by the Fiscal Division of the War Department is available for use where auditing is necessary.

Congressional Action—Concern of Congress over conversion financing is evident in the bill introduced by Senator Murray (D) of Montana, Chairman of the Small Business Committee of the Senate. It provides, among other things, that within 30 days of the filing of a contract claim, the government would be obligated to pay 75 percent of it, with the stipulation that any overpayment would be returned to the government with 6 percent interest.

Such payments, it is said, would give contractors cash needed for immediate postwar planning. Unquestionably, this bill will undergo many refinements and changes before it reaches the stage of final enactment.

Renegotiation Palaver—As for renegotiation, the powerful Ways and Means Committee of the House has completed extensive hearings on the issue as to whether the present law should be changed. It is not possible to determine yet whether it will reach any different conclusions from that arrived at by the Naval Affairs Committee after similar hearings, that is, in favor of retaining the present law in its essentials. Government procurement agencies, including the Army and Navy, are dead set against repeal.

Manpower Pressure—Recognizing the No. 1 problem of industry now as manpower, Donald Nelson, Chairman of WPB, has issued a directive in which procurement agencies are told not to place contracts in areas of acute labor shortage whenever it is practical to place the contract elsewhere. As soon as the demand for an item diminishes, contracts will be terminated in labor shortage areas. On the Pacific Coast the order prohibited any further contracts involving employment increases without approval of WPB.

Flowers for Industry—The contribution of the Electronics Industry to the war in terms of dollar volume was impressively set forth in a recent statement by Brig. Gen. John R. Gardner, Assistant Chief, Procurement and Distribution Service, Signal Corps.

Since September 1941, the Signal Corps has ordered $7,000,000,000 worth of radio, telephone, wire and other communications equipment. Deliveries of equipment for 1943 must total $3,250,000,000, about two and one-half times the 1942 production. In 1944, the production must represent $4,500,000,000 worth of material, one third more than in 1943. From now on, monthly production must exceed 12 times that of the entire prewar radio industry. In 1944, the volume of all Air Forces signal equipment will be approximately two-thirds greater than in 1943.

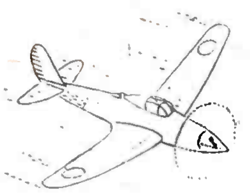
Tubes for Civilians—Current report to the effect that a large number of U. S. radio homes are without radio service because of lack of critical tubes and batteries as well as repair service is discounted by Radio and Radar officials of WPB. As a matter of fact, it is pointed out, a recent survey shows only a possible 5 percent without one or more radios in working order.

Tubes for civilians totalled between one and one and a half million in July, over a million in August and probably about that number for September.

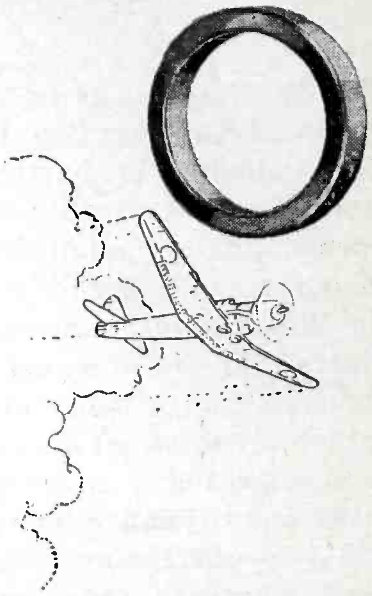
Mica Relaxation — Several changes have been effected in the definition of and availability of substitute grades of mica in WPB's Conservation Order M-101, in view of the present shortages.

Definitions of "strategic mica" and "scrap mica" have been rewritten to eliminate questions of interpretation. The prohibition on the use of larger grades and higher qualities than usually required, for particular purposes, and the prohibition against fabrication of larger sizes than required to produce a certain pattern, have been changed so that relief may be obtained by authorization rather than by a formal appeal.

Fly, on Frequency—Speaking before the Federal Radio Education Committee recently in Washington, FCC Chairman James L. Fly pointed out that "Whole new portions of the spectrum, formerly deemed useless, have been opened up through wartime research, while the expanding need for world-wide communications and especially the vast new aviation uses of radio, will probably crowd the postwar ether even more tightly than the comparatively small spectrum was jammed before the war."—G.T.M.



Metallurgical Help for "The Little Man Who Isn't There"



The gyro-pilot is aptly nicknamed the "Little Man Who Isn't There." The device provides marvelous relief for pilots on distance flights, keeping the plane on its course with uncanny accuracy, despite wind and weather.

Developing the newest and most efficient gyro-pilot posed some pretty problems for the maker, including a design that called for unusual rotor rings. They required a metal with the greatest weight that could be contained in the smallest possible area.

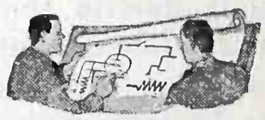
Having worked with Mallory on other applications, the manufacturer asked Mallory to find the metal—and without delay.

A Mallory material — Mallory 1000 — was suggested. It is a material of high specific density and provides maximum mass weight in minimum space. It filled the bill exactly.

Here again was proof that metallurgical progress grows from meeting the service needs of many industries. Mallory 1000 was developed originally to shield the gamma radiation in radium beam therapy. Now its applications extend not only to gyro-pilots but to fly wheels and counterweights in aircraft where space is at a premium.

Where product plans call for experience and "know-how" with contact designs and materials, Mallory engineers and metallurgists may give real help. Bring your problems to them.

While the design is still in blueprint form



CONSULT MALLORY
for Contacts and Contact Assemblies

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA
Cable Address—PELMALLO

CROSS TALK

▶ **JOY-KILLER** . . . We do not enjoy "viewing with alarm" the present whoopla about electronics, about all the wonderful gadgets everybody will want to own after the war, gadgets using tubes. But electronics is the present gift of the gods to copywriters and maybe you think they are not going to town with it. A popular indoor sport today is to watch the promises being made the public about the future of electronics, promises engineers will have to make good on.

Not long ago this office was visited almost daily by representatives of brokerage houses wanting advice as to the stocks their clients should buy to get in on the ground floor of the big electronic boom. This phase has passed; now visitors are the post-war research men from companies whose job is to dig up hot electronic items which should be made after the war.

An executive of a large eastern company writes this office stating that several of his friends are going to make some electronic devices—but what device, he asks, should they make? And where can they get a staff of good engineers!

All these straws in the wind indicate that people do not know the facts of life about electronics.

The bald truth is that electronics, as an industry, has existed for years. Just as in the past, radio receivers and tubes will be the big immediate post-war electronic business. Bigger than ever, no doubt.

So far as the use of vacuum tubes in controlling industrial processes is concerned, this is old stuff. Industry will buy more electronics than it ever has, thanks to the speed-up during the war, and thanks to some new devices developed by the war. Companies which pooh-poohed the whole idea before Pearl Harbor have now been exposed to the electronic idea, and will be more receptive after the war.

But there is still no single bit of package merchandise using tubes (except radio sets) which can be sold by the millions—and that seems to be what many post-war thinkers want.

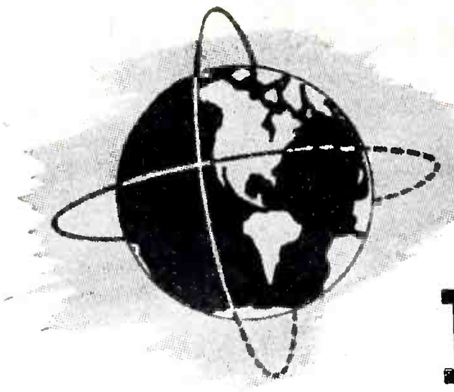
▶ **SONICS** . . . In response to an inquiry, a large dairy-product laboratory admitted that some work on supersonics had been carried out unsuccessfully, but finally said, "The main newsworthy item was the complaints made by those living in the immediate neighborhood of the noise of the method."

▶ **1922** . . . "I should like to refer to another possible application of these (short) waves which, if successful, would be of great value to navigators.

"As was first shown by Hertz, electric waves can be completely reflected by conducting bodies. In some of my tests I have noticed the effects of reflection and deflection of these waves by metallic objects miles away.

"It seems to me that it should be possible to design apparatus by means of which a ship could radiate or project a divergent beam of these rays in any desired direction, which rays, if coming across a metallic object, such as another steamer or ship, would be reflected back to a receiver screened from the local transmitter on the sending ship, and thereby immediately reveal the presence and bearing of the other ship in fog or thick weather.

"One further great advantage of such an arrangement would be that it would be able to give warning of the presence and bearing of ships, even should these ships be unprovided with any kind of radio."—Guglielmo Marconi on the occasion of the presentation of the IRE Medal of Honor, January 20, 1922.



Post-War FM and

Frequency allocation is the key to expanded broadcast service. Current research in connection with military projects will lead to important developments in the civilian equipment field. Planning for new services is definitely a war-time project calling for clear thinking

By BEVERLY DUDLEY

Western Editor

IN LABORATORIES and electronic equipment factories throughout the country, hope runs high that there will be vast distension of the radio communication system through the extension of the useful portion of the electromagnetic spectrum. This is expected to be one result of research so greatly stimulated by the present war.

Vast demands on frequency allocation are bound to be made upon the conclusion of hostilities, and undoubtedly most of the new services requesting space in "the ether" will be able to show that their proposals are in the public interest.

High up on the list of services to which serious attention is bound to be given in any program of frequency allocation are two which will profoundly affect the citizenry of this country in the post-war era: (1) frequency modulation and (2) television.

War Stimulates Research

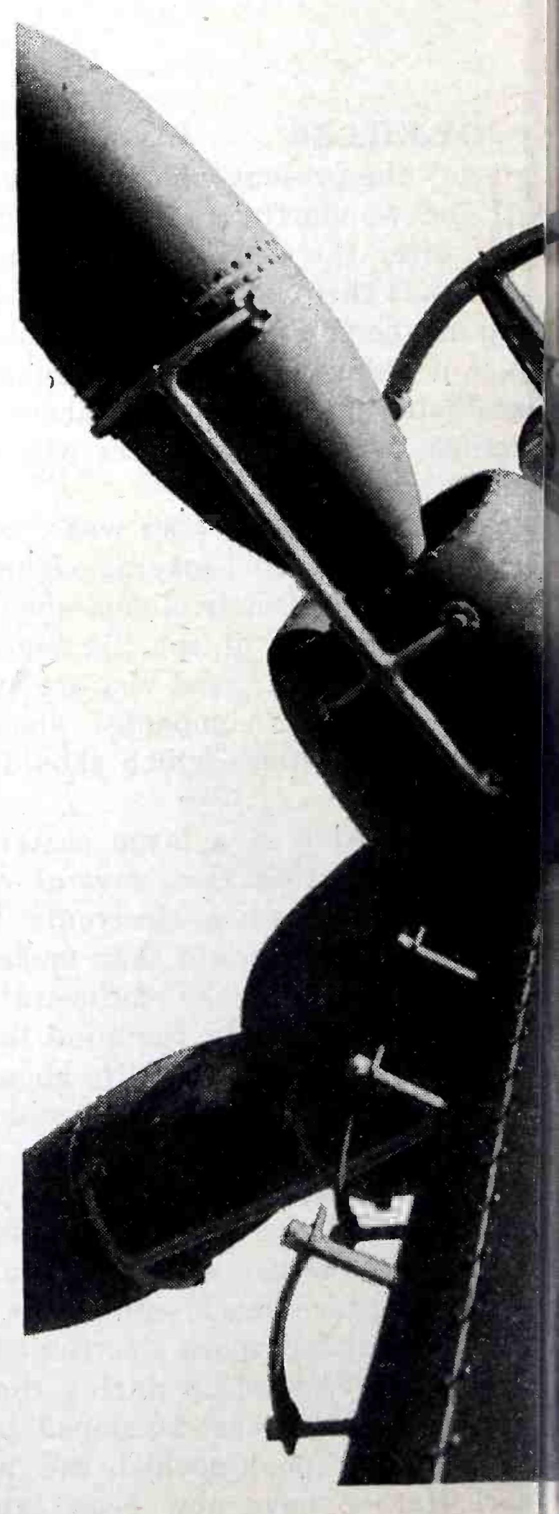
In many respects, conditions in World War II are very similar to those of World War I. The engineer and scientist will be quick to recognize that, in the field of technology, both wars goaded us into accelerated research activity which has had (or will have) a tremendous impact on the post-war era.

After World War I radio broadcasting became possible and popular and was responsible for building up one of the major manufacturing industries of the United States. It is expected that World War II will likewise make tremendous contributions to the civilian communication system by way of frequency modulation and television, both of which were, technically, developed prior to December 7, 1941 to a point far beyond the radiotelephone equipment of 1918 which ultimately led to radio broadcasting.

Both frequency modulation and television have market potentialities which, properly exploited, can make broadcasting services which have gone before pale into comparative insignificance. When the technical developments which have led to these two new services are combined with the extended frequency spectrum which war research has made practical, there is good reason for optimism. A very much expanded radio industry (some will wish to call it a completely new industry) may well be expected to arise as a result of technological advantages and sociological advantages which f.m. and television make possible.

Technical developments of themselves are of little or no practical importance without a definite—and appropriate— application to the needs of society at large. The time is ripe for the radio industry to take those steps which will lead to the definite and appropriate application of frequency modulation and television to the post-war needs of society.

The benefits to accrue from the establishment of a definite program of frequency allocation, technical standards of operation, and the mechanism by which post-war production of civilian radio equipment is to be inaugurated are, of course, post-war. The program itself, however, is definitely a part of our war



TELEVISION

activity; if the planning itself is relegated to the post-war period many needless obstructions will doubtless occur during the reconstruction period. Not only will frequency modulation and television have the capability of aiding post-war employment, but these services will also lead to important dissemination of education and entertainment, and can make possible a more rapid and more intelligent reconstruction.

Advance Planning Essential

The problems calling for attention are many times more difficult than those requiring the allocation of frequencies after broadcasting practically suffocated itself out of existence by "360-meter" operation. A highly complicated radio communication system is already in satisfactory operation, and the interests vested in this field cannot be lightly nor quickly brushed aside even if this were technically desirable. At the same time many new types of services may be expected to make a bid for their share of channel space.

Extensions of world-wide point-to-point communication, of aviation radio, of personal transmitters and receivers, of new range and direction-finding methods in the communication field will require channel assignments, as will probably also industrial developments in the electronics field such as diathermy, electronic heating, intrusion detectors and locators.

Neither f.m. nor television services can develop to their full potentialities if allowed to grow at random and without the cooperation of the entire industry. Engineers well know the many technical problems which must be overcome in order that a complete, nation-wide system may be installed and operated satisfactorily. The American system also requires a minimum of jurisdiction from governmental agencies and the freest expression of individual initiative for the full flowering of the maximum benefits to all. Thus, the radio industry has a double challenge.

What are some of the problems facing the full and complete utilization of the technical achievements of frequency modulation and television? To answer these questions, it may be well to review the status of these two types of communication systems as of the time when events at Pearl Harbor brought the United States into the present war.

Summary of Progress to M-Day

Broadcasting by the then relatively new method of frequency modulation was in a promising position when this country went on a war basis. The f-m system was furnishing good service, was receiving favorable public acceptance, and was growing rapidly and soundly.

The Federal Communications Commission had set up complete standards for f-m broadcasting and had placed this service in the category of commercial broadcasting. It has been estimated that as many as 500,000 f-m receivers (or combination a-m and f-m sets) had been sold. The majority of manufacturers were either selling f-m receivers or were planning to do so. Many f-m stations were in operation or under construction and the FCC had nearly two hundred requests for permits for f-m facilities on hand.

Several years of experience in f-m broadcasting as well as in the manufacture of f-m receivers indicates that the present system is completely commercial from a technical point of view, although it could probably be improved by reconsidering the channel assignments for this class of service and by granting permission to increase the power of f-m transmitters so that improved signal strength would expand the proposed service areas.

By December 1941 television engineering had progressed to a point where pictures of satisfactory definition, detail, and freedom from flicker, having high entertainment and educational value, could be produced and made to serve large audiences in metropolitan areas.

Most promising development was in the realm of black and white pictures, but a mechanical system of color television had been in satisfactory operation and had received considerable attention. Satisfactory agreement on television standards had been reached, after considerable time and effort, and the stage was set for commercial broadcasting; in fact, the Federal Communications Commission had adopted regulations making commercial television possible.

A division of television services into two frequency allocations had been made. One band extended from approximately 50 to 100 mc.; the other band, starting in the vicinity of 150 mc., extended somewhat beyond 200 mc. The intermediate region was not opened for television service. This assignment of two separate channels is bound to come in for consideration at some later date. Full utilization of the capabilities of television rests on an economic and manufacturing structure which will make receivers available at a reasonable price to the average American family. A split frequency allocation for television service complicates engineering design and increases manufacturing costs. Engineers already familiar with this condition question the advisability of initiating post-war television services with split-channel frequency allocation.

The problem of propagation of television signals has not been adequately surveyed, although progress is being made in this direction. Some evidence appears to be forthcoming that the lower-frequency channels are freer from ghosts or undesirable reflections, but the wide band required for modulation of television signals clearly indicates some advantage in going to higher carrier frequencies. The number of channels currently available in the low-frequency band is probably wholly inadequate if television is to become an important factor in the life of the average American citizen. Good economics and good engineering seem to call for more channels in a single television band.

F.M. is extensively used by the armed forces and a great deal of communication equipment made for use in this war employs principles and techniques similar to those required for television.

Contributions from War-time Developments

Frequency modulation has been extensively adopted by the armed forces and, as a result, engineers have gained much valuable experience in the design and construction of equipment. Many engineers have been trained anew in this comparatively recent technical development and will be able to bring their abilities to bear on civilian communication activities or in industrial electronics. It would seem that the most important thing which has been learned about frequency modulation as a result of war activity is greater respect for it.

Pre-war television work has been of considerable value to this country in its war effort by providing trained personnel and devices which permitted rapid progress to be made in our program of war production of special military equipment. Many thousands of skilled engineers, scientists and mathematicians have been organized into a vast network of laboratories throughout the country for scientific research activities. The work which these groups are doing parallels television research and many of the benefits of war-time research will be carried over into peace-time endeavors.

Civilian radio equipment also stands to gain in the quality of components going into all types of transmitting and receiving gear, since manufacturers are now well acquainted with the necessity of building well (rather than to a price). They have been forced to install temperature, humidity, and other test equipment to assure, so far as is humanly possible, that equipment will meet military specifications and will not fail in practice. The industry has every opportunity to carry over into its peace-time program this concept of quality. If the industry as a whole capitalizes on this experience and forgets at least the most drastic of its previous "cut-throat" price slashes and the dumping of excess production, manufacturers stand a chance of doing a more profitable, businesslike business.

Finally, the techniques—begun before the war, but accelerated by it—developed for extending the practical utilization of microwaves will open up a vast new region in which certai types of communication can be carried on. Vacuum tube developments, for both transmitters and receivers, make the move to higher frequencies practical. It is still too early to predict what services will be assigned to this new region of the spectrum, but the closing of the gap between radio waves of ordinary length and heat and light waves will undoubtedly be one of the scientific highlights of the present period.

Immediate Post-War Outlook

Probably the peace-time developments in radio communication, and in frequency modulation and television in particular, must be divided into two divisions: (1) the immediate post-war outlook, in which we shall begin production and operation approximately where we left off in the spring of 1942 and which will not take full advantage of the technological developments of the war, and (2) the long-term post-war developments, in which full advantage of war developments can be taken, and in which many new services and communication systems can be planned, engineered, designed, constructed, and operated. The two are quite different and distinct.

Problems of the immediate post-war period must, necessarily, be concerned with the reconstruction and improvement of existing facilities, with the replacement of old and obsolete transmitters and receivers, with the building up of a full complement of personnel, and with the reconversion of factories to civilian production. In brief, such a program is largely concerned with maintaining the status quo.

By its very nature such a program cannot take full cognizance of the range of technical developments which the war has made possible. Even if this were possible, it would still take time, money, equipment and personnel to establish new stations, new services. As a result, civilian radio communication services immediately following the war are bound to be pretty much along the same pattern as those currently in use. But the immediate post-war period may well be a transition period, linking our present systems with those which will ultimately evolve. If so, it will have a useful and highly important role in the expanding field of electronics and electrical communication.

Frequency modulation is in an excellent position to move forward immediately after the war. Its progress may be expected to be rapid, and there is prospect of providing real improvements in service. The industry has a particularly brilliant opportunity to place broadcasting on a quality, high-fidelity basis, and many will make the sincere effort toward this goal. But since there is nothing inherent in the method of frequency modulation which guarantees that all f-m equipment will necessarily be of high fidelity, care must be exercised to prevent the virtual wrecking of the system through mishandling.

The problems related to f-m broadcasting are not a major obstacle. Several years of field experience and manufacturing have not brought forth serious difficulties in present f-m standards. It is desirable, however, that higher power be permitted so that stronger signals can be laid down in the service area. There is also need for additional f-m channels, and this need will, no doubt, continue to expand in the future, particularly as high-quality live music is made available. It is also desirable that the channels assigned for f-m service be continuous, to avoid band-switching complications in receivers.

There seems to be much current interest in f-m broadcasting on the part of a large number of operators of amplitude-modulation broadcast stations. In addition, it can be expected that there will be newcomers aiming to provide f-m service who have had no previous experience in the operation of radio stations. This all points to a sizeable market for replacement receivers as well as for new receiving equipment after the war. Undoubtedly the demand for f-m equipment will keep pace with the amount of f-m service rendered.

While frequency modulation will be widely utilized for broadcast service because of the improved signal-to-noise ratio, the necessity of employing high-frequency carriers and wide-band transmission will probably limit the service range to such an extent that it is doubtful that f.m. will become the sole broadcast service available in this country. To people living in isolated areas, radio has become a sustaining factor and these people will require signals capable of travelling beyond the horizon. For this reason, as well as because there already exists a vast network of stations feeding some 60 million receivers in the 550 to 1600 kc band, all indications are that a-m broadcasting in this band will be retained.

Television is not in as favorable a position as f.m. for immediate post-war development. This service has not yet received widespread acceptance as a commercial service in spite of many attempts to bring television out into the open. Many economic

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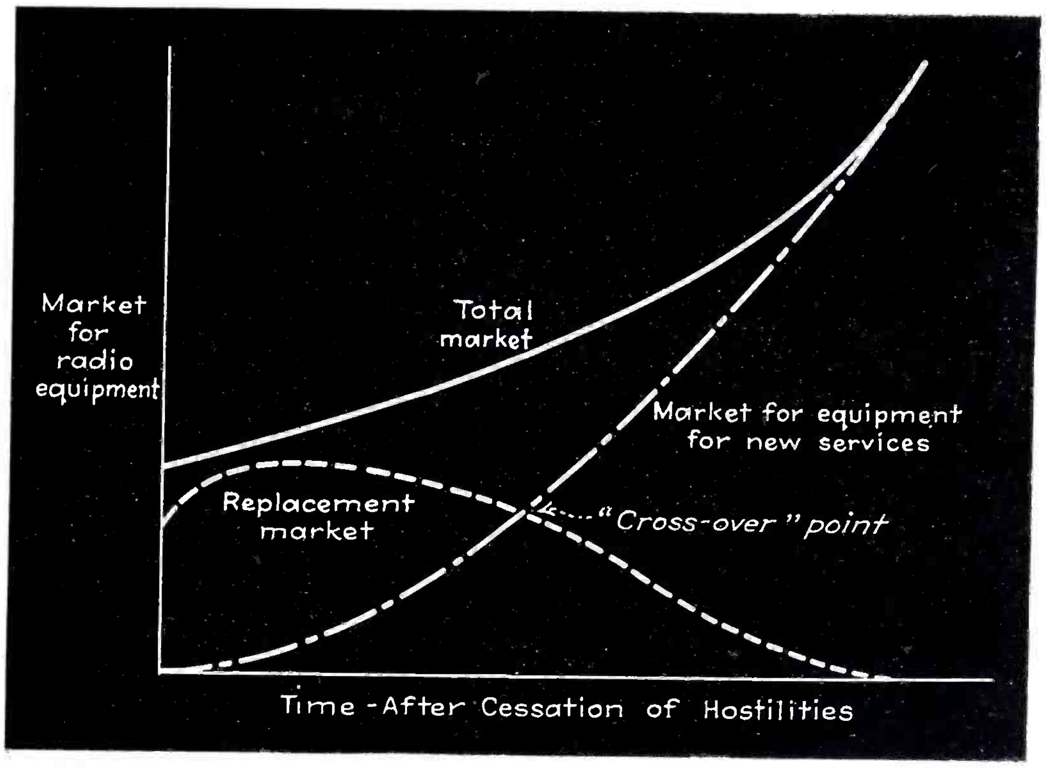


GRAPH ILLUSTRATING the possibilities of the replacement market as a means of providing stop-gap production until exploitation of newly created services can assume full post-war importance

AIRCRAFT RADIO DESIGN

By A. F. TRUMBULL

Former Superintendent of Aircraft Radio Service
United Air Lines—Chicago

THE FIRST CONSIDERATION in the design of aircraft radio equipment is reliability. A unit which is to be used in an airplane must function correctly under any and all of the conditions through which an airplane may fly. Radio is the only direct link through which information can be exchanged between the ground and an airplane in flight; when information vital to the safety of the plane must be transmitted to it, the equipment in the plane must be functioning correctly if the craft is to receive it.

In normal operation, an airplane can encounter widely varied climatic conditions. In the space of a few hours, it can travel between regions of high humidity (over 90 percent) and low humidity (less than 10 percent), encounter temperatures ranging from 130 deg. F. down to 50 or 60 deg. below zero, and fly at elevations from sea level up to 25,000 feet.

Insulation Requirements

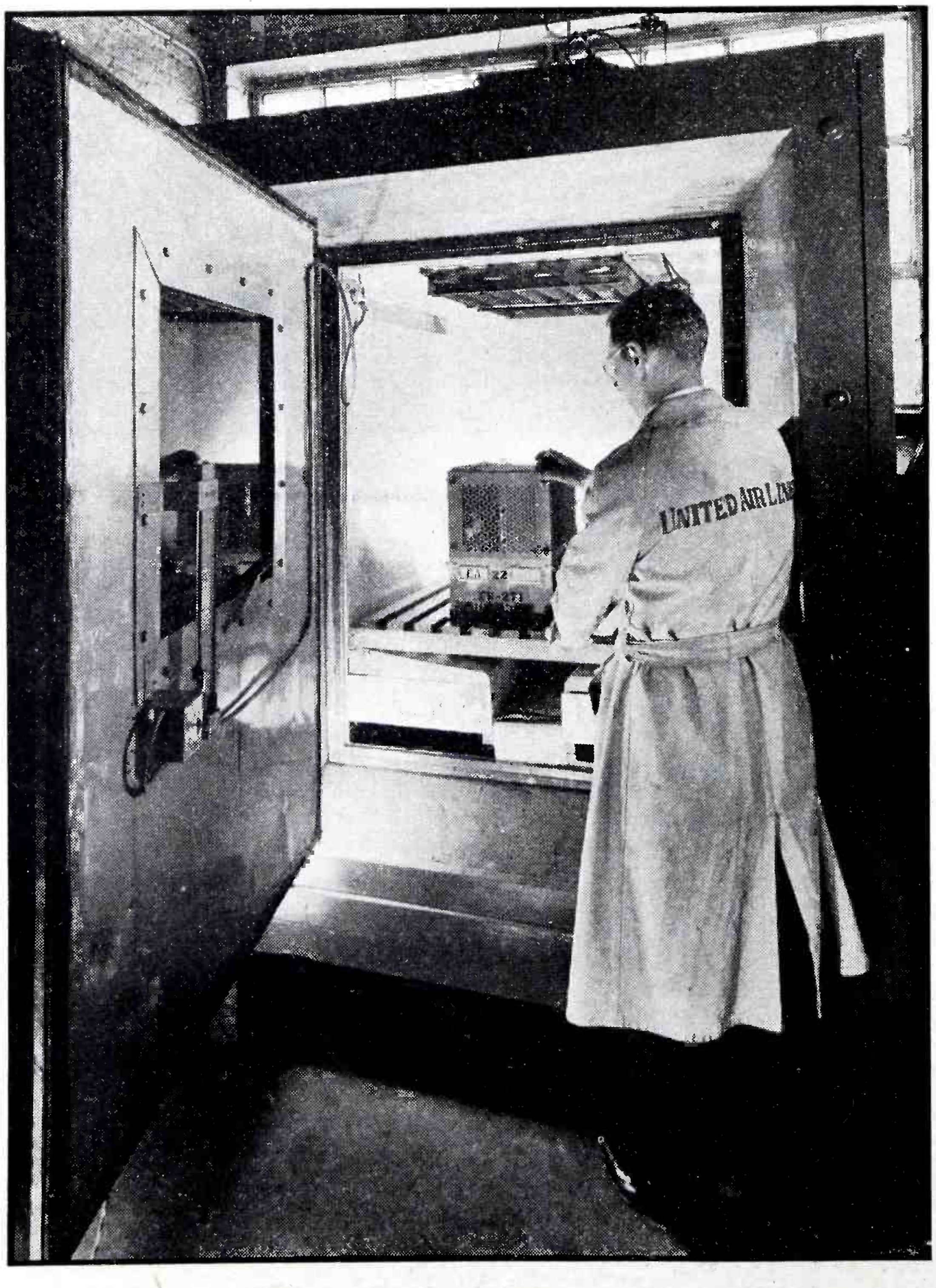
Waxes used to impregnate r-f coils, audio transformers, capacitors and other parts must not soften sufficiently to flow at 140 deg. F., nor crack and chip at −40 deg. F. Oil-filled capacitors must not leak when the air pressure outside them is reduced to a pressure corresponding to 40,000 feet altitude. Continued exposure to 95 percent humidity and a temperature of 100 deg. F. must not reduce the equipment performance beyond certain limits that are set forth in Civil Aeronautics Authority specifications.

All wiring in the equipment must be insulated with nonhygroscopic insulation (such as glass) or impregnated with wax to eliminate leakage. Metal parts must be protected against corrosion by using noncorrosive metals, by plating, by painting, by hermetically sealing, or by other means. This is particularly true when the equipment is to be used in the tropics or on routes over oceans or along coasts where salt air is encountered. All insulating materials must be either nonhygroscopic, or, if laminated, must be vacuum-impregnated with wax.

Conductors which carry sufficient current to heat to incandescence in the event of short-circuits, irrespective of whether such circuits are protected by fuses or not, should have flame-proof insulation. Where wiring must be metallically shielded, it is generally preferable to run the wires in solid, rigid metallic tubing.

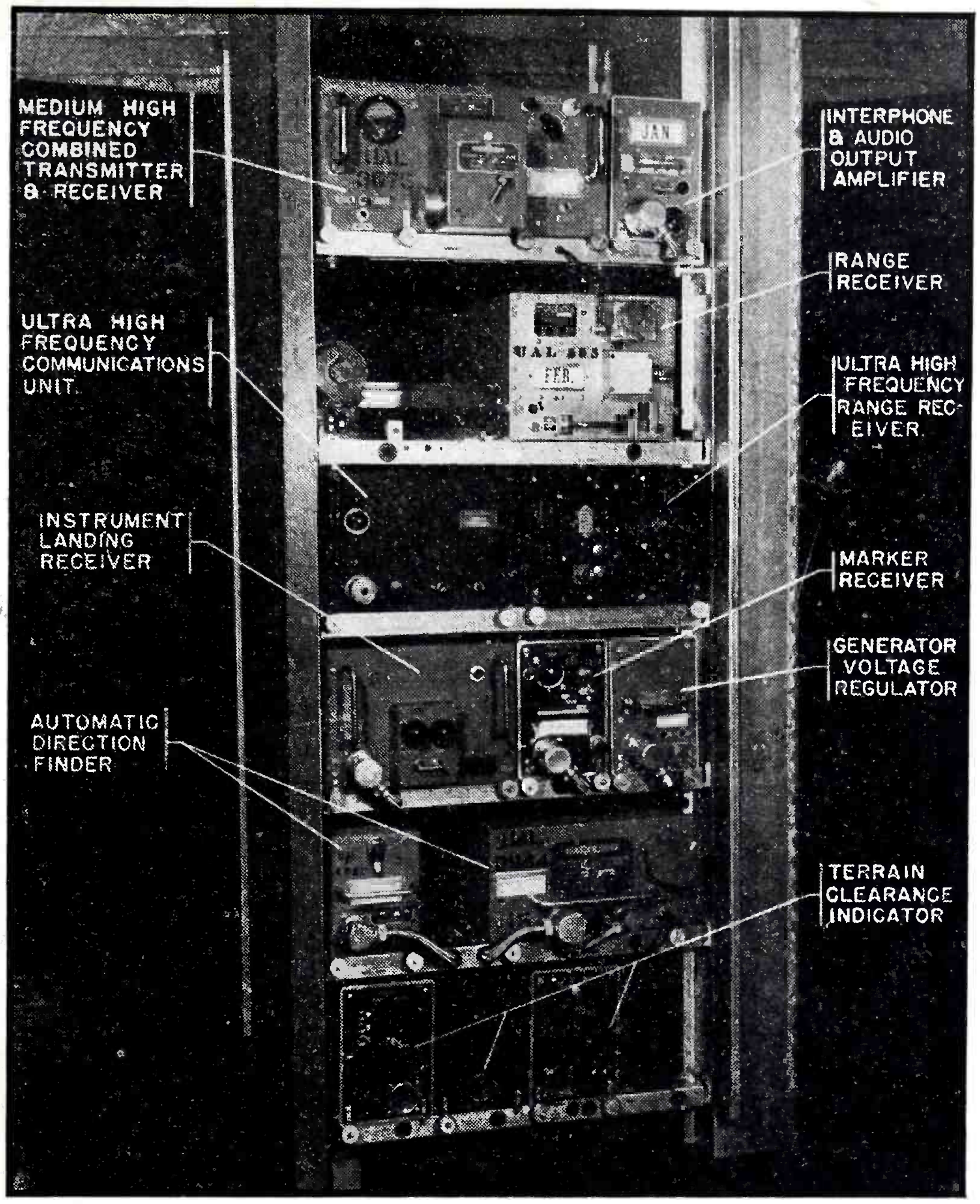
Mechanical Requirements

Vibration is a serious factor in aircraft radio equipment design. All components must be securely anchored to withstand vibration involving acceleration up to 10 G in any direction. This means that all screws must have lockwashers or other



Temperature and humidity chamber in which aircraft radio equipment is operated through the entire range of arctic, tropic and ocean weather conditions that might be encountered in flight. Performance must not be affected beyond certain limits prescribed in CAA specifications

Practical tips on the mechanical and functional design of radio equipment for post-war commercial aircraft. Explanations, examples and photographs are presented to show why design must differ in many respects from that of mass-production equipment



An example of what the fully equipped commercial aircraft of the future may carry in the way of radio equipment

Controls that can be operated by sense of touch, illustrated here, are essential for aircraft radio equipment. Control panels with identical symmetrically positioned knobs might confuse the pilot and cause operational errors

means of preventing their loosening. Small parts such as capacitors and resistors must be fastened to terminal boards, and no parts may be suspended by their leads unless these leads are less than ½ inch long. It also means that aircraft radio equipment is invariably shock-mounted.

Weight and space are always at a premium on an airplane, so it follows that aircraft radio equipment must be as small and as light as possible. There has been a definite attempt toward the standarization of sizes of radio equipment among the commercial airlines of this country, working through Aeronautical Radio, Inc., and these panel sizes should be adhered to whenever possible. Keeping weight at a minimum means using aluminum and its alloys for the majority of the structural parts. Soldering requirements, bearing requirements and other usage will demand other metals in some parts.

It is highly important that dimensions of all units be held to a tolerance that will assure accurate and true alignment insofar as interchangeability of units is concerned.

Production Economics

Cost is always an important item in the design of a piece of equipment. As aircraft radio production is in relatively small quantities and as quality must be kept high, the engineer has to choose methods of construction which are adaptable to small quantity production even though they might be uneconomical for mass production. Standard component parts are frequently purchased outside, both because this is generally more economical and because it is then easier for the customer to get replacement parts. Parts which require the construction of expensive dies are seldom used as the cost of the die is not often warranted. Simple dies, sand castings, bent and welded pieces and extruded sections are most frequently used in special construction.

Sense-of-Touch Controls Are Essential

The operation of aircraft radio equipment must be as simple as it is possible to make it. In the majority of cases the pilot or co-pilot is also

Machine used by United Air Lines for applying vibration tests to aircraft radio equipment

the radio operator and has no time to devote to difficult or complicated tuning procedure, or for making any other critical adjustments.

Most controls in an airplane are operated by the pilot using his sense of feeling rather than that of sight. For this reason, it is undesirable to employ a great number of controls of identical physical size on control units.

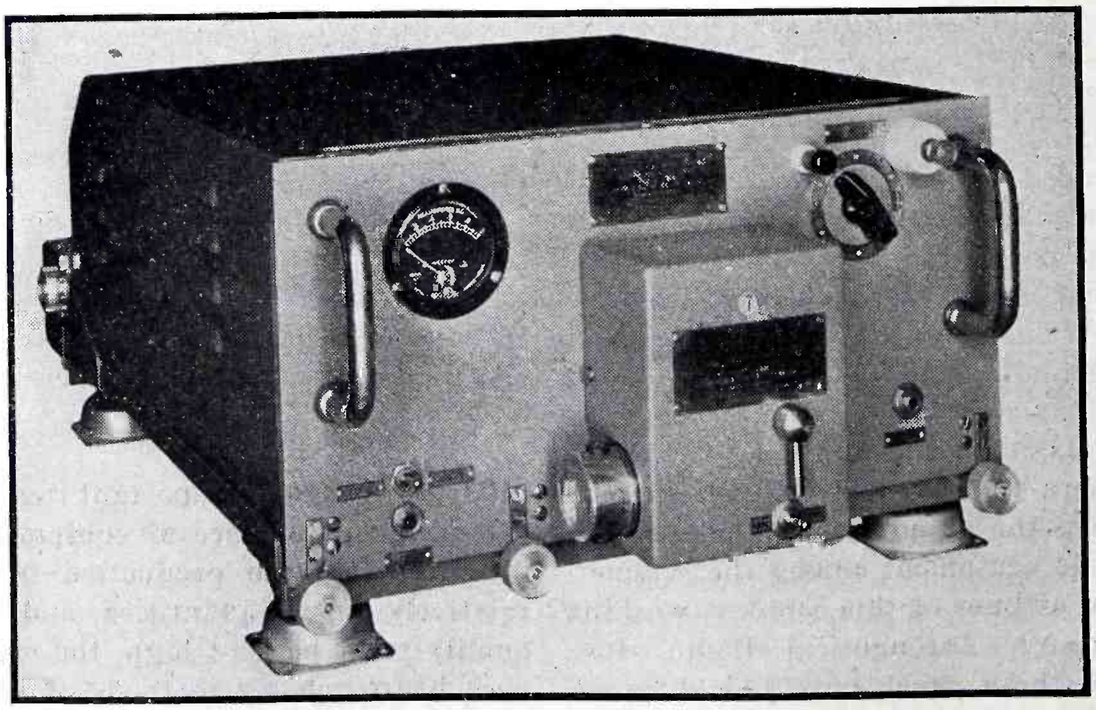
An example of a practice to avoid is illustrated in the case of a control panel recently submitted for certification. This particular unit was a master control for operation of all radio equipment in an air carrier aircraft, and contained twelve identical knobs. The design engineer's attempt to achieve symmetry of appearance prompted him to use rotary-type switches for simple on-off functions where a single-pole, single-throw toggle switch could have been employed. The panel contained an eight-point frequency selector switch using a knob identical to all other knobs on the panel, with an arrow engraved on the face of the knob approximately five-eighths inch away from the engraved numbers on the panel. This would have made it necessary for the pilot or co-pilot to move his head directly in front of the control to avoid parallax in choosing a desired setting.

A pilot is not a radio technician. His duties primarily involve the navigation of his aircraft, and the operation of the radio equipment is only one of many duties involved. Radio controls must, therefore, be kept to an irreducible minimum to avoid functional operational hazards. The design of the equipment must be such that failure to operate a certain control is immediately apparent. Thus, if the pilot desires to use a multichannel receiver on the "range" band and forgets to move the frequency selector switch from the "broadcast" band, the reception of broadcast programs should immediately remind him to reset the selector switch.

Controls Must Be Fool-Proof

Even though a transmitter is designed in accordance with the best engineering practices and made of the best materials obtainable, so that it is capable of passing all of the physical tests prescribed for type certification, it cannot be approved by CAA for aircraft use unless it also meets certain functional requirements as to the operating controls. This in essence involves designing all controls in such a way that any possible improper sequence of operation cannot cause failure of or damage to either the transmitter or receiver.

An example of hazardous functional operation is an actual case in which the pilot held down the press-to-talk switch on the microphone while he operated the frequency change mechanism of a multi-frequency transmitter. The design of the transmitter circuits in this in-



Combination 10-channel receiver and transmitter for aircraft, showing shock-proof mounting that has proved satisfactory stance was such that high voltage was not removed from the circuits during the frequency change cycle. This resulted in an arc flashover to an r-f choke, which was open-circuited by the flashover and the transmitter was thereby rendered inoperative.

Such hazards may be eliminated by the use of properly sequenced relay systems or equivalent methods which automatically remove high voltages from the transmitter circuits during the frequency change cycle. Automatic voltage-removing means should be provided unless operating tests under the most adverse simulated service conditions indicate that they are unnecessary.

Other Practical Suggestions

In a multi-channel receiver, it is often desirable to provide avc on certain frequency bands and eliminate it on others. The provision of a separate avc switch to accomplish this constitutes a functional hazard, in that the pilot may not set such a switch to the proper position for the frequency band on which he desires to operate the receiver. This hazard may be eliminated by incorporating the avc switch in the frequency band selector switch, so that avc is automatically provided only on the desired bands.

In the design of remote control equipment, special attention should be given to the elimination of separate switches to perform various functions which might be more satisfactorily accomplished by a multipoint multi-section rotary switch. For example, an automatic direction finder system may be designed to provide the pilot with the following separate functions: (a) automatic direction finder; (b) regular receiver—ICW or MCW reception; (c) regular receiver—CW reception; (d) aural-null direction finder—ICW or MCW reception; (e) aural-null direction finder — CW reception. Good engineering practice, with due consideration for the elimination of superfluous controls, should immediately suggest the possibility of using a single multi-section six-point rotary switch to accomplish selection of these operational functions. An on-off switch may be eliminated by utilizing the first or dead position of the switch, with connections to make the complete receiver and its power supply inoperative.

In a multi-frequency band receiver designed to operate on the "range" and other frequency bands, it is necessary to provide a simultaneous range filter in the output circuit of the receiver. This introduces the possibility that the pilot might inadvertently leave the filter selector switch in the "range" position when attempting to use the receiver on frequency bands in which voice reception is desired, resulting in an apparent failure of the receiver on these frequency bands. This functional hazard may be eliminated by providing means in the frequency selector switch design for disabling the simultaneous range filters on all but the "range" band.

Similarly, when pretuned circuits are provided in the range band for voice reception of airport traffic control towers on 278 kc, the "range-airport" switch should automatically disable the range filter when the switch is thrown to the "airport" position.

Another example of a functional hazard was found in a range receiver equipped with a visual tuning meter. The purpose of the meter was to enable the pilot to adjust the receiver circuits to resonance with the frequency of the desired station by so tuning the receiver that maximum

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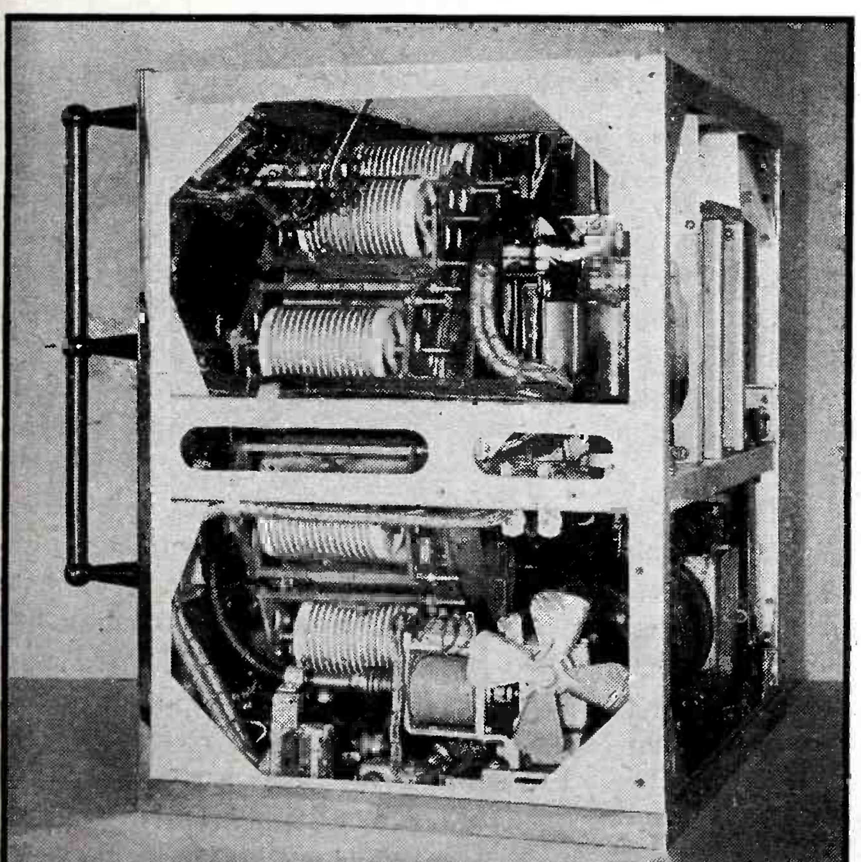
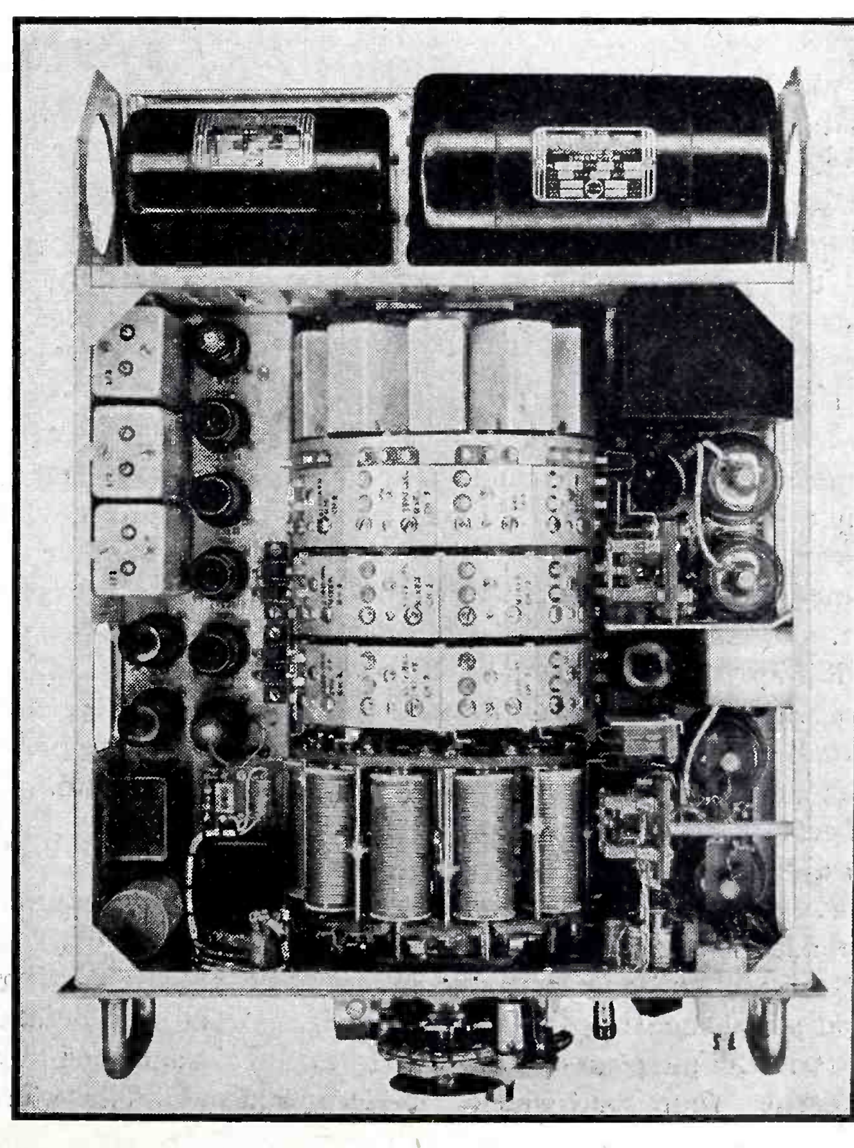


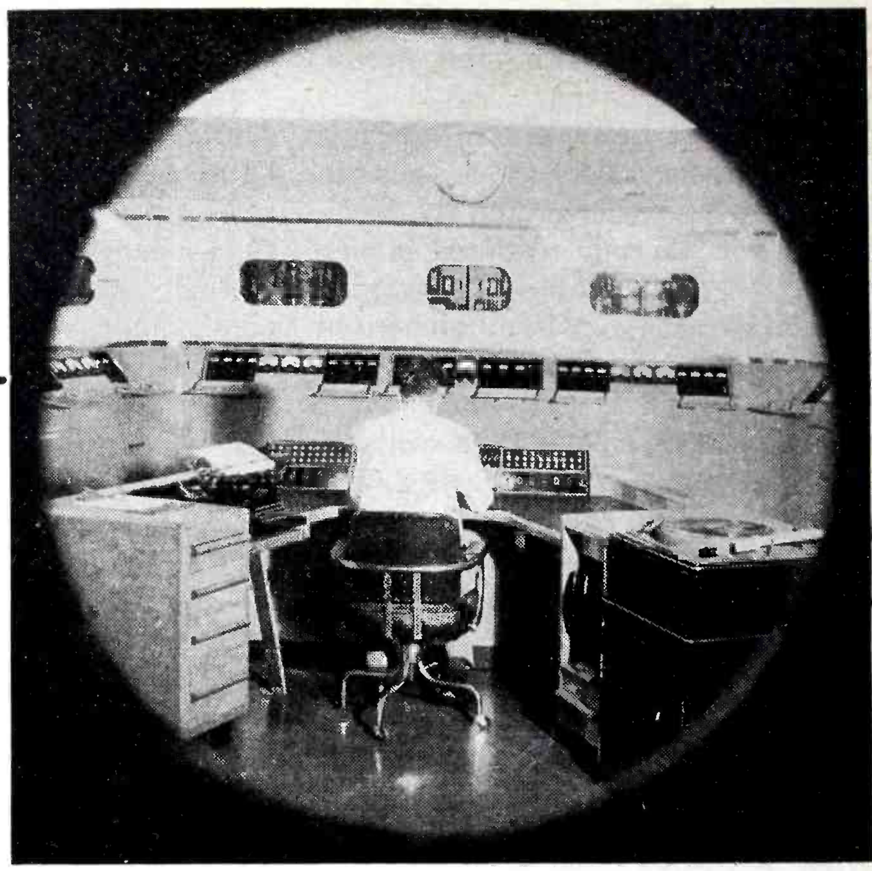
Example of elaborate 10-channel radiotelephone transmitter for aircraft use with fan for forced-draft ventilation



Example of an aircraft radio receiver employing a revolving-turret frequency selector that reduces the tuning operation to changing the setting of a switch. Note accessibility of dynamotors

With automatic timing of carrier interruptions, the operator on duty does not have to write down the exact time of failure for FCC reports before looking for the trouble

Opposite page—Aerial view of KMOX



Automatic Control Circuits for BROADCAST TRANSMITTERS

Four manpower-saving electronic circuits for transmitters, providing protection against arcs during storms, automatic restoration of the carrier after an overload, automatic starting after breakdown, and automatic timing of each carrier interruption

By W. R. SLOAT

Transmitter Engineer
Columbia Broadcasting System
Station KMOX, St. Louis

PROBABLY THE most important criterion by which a broadcast station is judged is dependability. Of course, audio quality and program content are important, but it is the primary obligation of the entire staff to keep the station on the air.

Dependability may be considered a measure of how much program time is lost. Accident and error are the contributing factors to lost time; error is failure of the personnel to function properly, and accident is an equivalent failure of equipment. Both may be, and usually are, unpreventable. Time lost through both causes may nevertheless be minimized to a large extent through use of certain automatic devices designed to aid the operator in clearing temporary faults, locating trouble, quickly restarting the transmitter after over or underload, and in general supplementing the human hand.

It is the purpose of this article to present four automatic devices, three of which were designed by the author and the fourth, the carrier restoring device, by the transmitter staff of WABC under the supervision of Mr. R. W. Newby. All have been in use at KMOX for some time, giving excellent service.

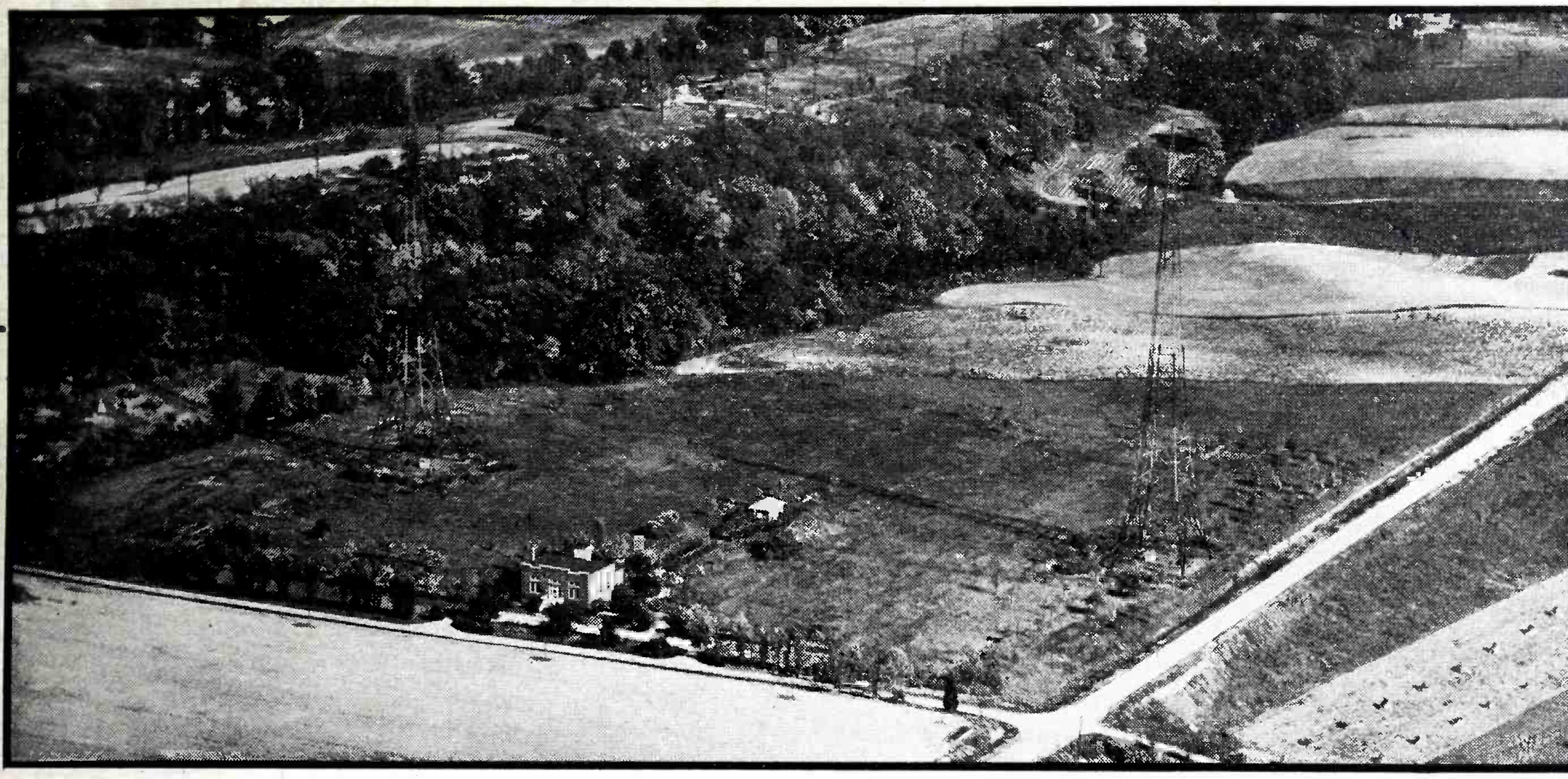
The four devices are independent of one another, and each self-sufficient for its purpose. Collectively they provide comprehensive and measureable improvement in station dependability. All contain only small standard components that are ordinarily at hand.

Carrier Protective Device

Under certain conditions, radio-frequency arcs become established at a transmitting antenna by electric storms or static discharges and are sustained by the transmitter output. These arcs may be of insufficient magnitude to operate the transmitter overload relays, although capable of damaging parts of the equipment. Two methods of stopping these arcs are momentarily cutting the carrier or reducing the output of the transmitter to a point where it will not maintain the arc.

Initiating devices to achieve one of these methods fall into several classes. One comparatively complicated type, usually difficult to handle, balances out-of-phase components of the r-f energy in one stage or the transmission line against that in the preceeding stage. Another method, applicable only to a case where the arcs occur repeatedly at the same point, uses a phototube to actuate the system. A third method uses the arc itself as a conducting path for relay current.

A fourth method, in use at KMOX, is one operating directly from a portion of the radiated carrier power. It can be used with low-level modulated transmitters without any



restarting equipment. An independent restarting device, having no tubes and only one relay, can be used in conjunction with the device for protecting high-level systems.

The circuit of the KMOX carrier-protective device for low-level systems is shown in Fig. 1. The instrument is controlled by carrier energy picked up by a short antenna and fed to the diode section of the 117L7. The diode develops positive bias for the tetrode section of the tube, which is also cathode-biased.

When normal energy is radiated, two relays, RY_1 and RY_2, are energized by the tetrode plate current by virtue of positive grid bias from the diode and RY_3 is also energized. Under this condition, the coil of RY_1 is paralleled by R_3, and only a slight drop in plate current will cause RY_1 to open. An abnormal condition anywhere in the transmitter resulting in a moderate drop in radiated energy will cause such a drop in plate current, and RY_1 will release RY_3, applying high negative bias to the buffer and modulated amplifier stages.

RY_3, may, of course, have any contact arrangement desired for the application of this bias, which must

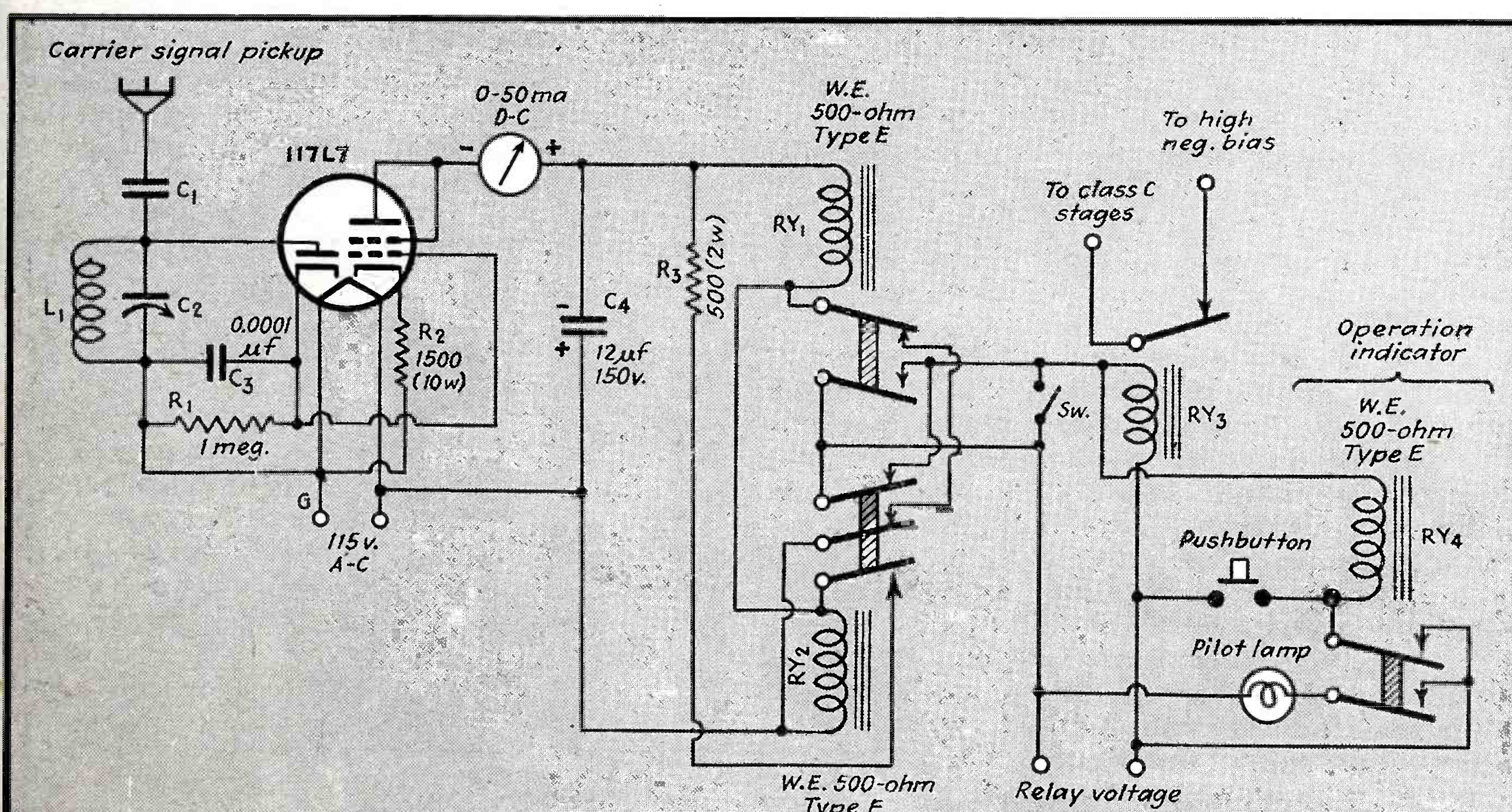


FIG. 1—If an r-f arc becomes established and is sustained by the transmitter output without drawing enough current to trip overload relays, this carrier-actuated protective circuit automatically reduces the transmitter output momentarily to about 15 percent of normal to kill the arc. If RY_2 is inherently slow enough, the interlock with RY_1 may be omitted

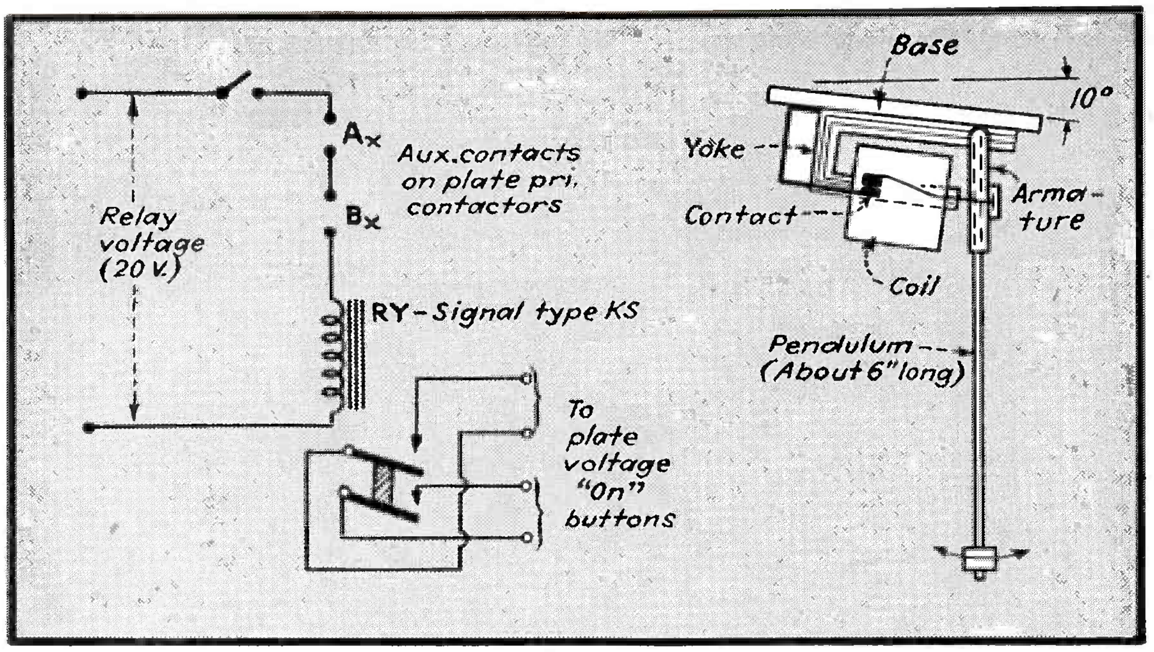


FIG. 2—In the event of carrier failure due to overload, this simple relay arrangement performs the standard three-shot and lockout cycle of reclosing devices. It makes three attempts to restore power, working so fast that listeners are not aware of trouble

be determined to suit the individual transmitter. This bias should be sufficient to reduce the carrier power to about 15 percent of normal, which will not sustain arcs unless there has been some damage to equipment. When the power drops to this low value, RY_2 will not have sufficient current to hold and will drop out, picking up RY_3 through a set of de-energized contacts, removing the high bias and returning the carrier to normal. These de-energized conacts on RY_2 also perform the useful function of protecting the device against tube failure, since the relay cannot pick up without plate current, and these contacts hold in RY_3.

When RY_2 opens two other functions occur: R_3 is removed from its position in parallel with the coil of RY_1, and RY_2 is locked out through its remaining de-energized contact and a similar one on RY_1. Thus, RY_1 is subjected to the full plate current, and will now pick up on a smaller current than is present when it opens, and RY_2 is prevented from picking up until after RY_1 has closed. RY_1 closes at about 25 percent normal power, and RY_2 at about 80 percent when the tetrode plate current is large enough to keep RY_1 energized as the paralleling resistor R_3 is reconnected. The instrument is now recycled. If damage has occurred to the transmitter or other trouble is present to prevent the carrier from returning to full power, the device will remain static, with RY_2 open, RY_1 open or closed, and transmitter bias normal (RY_3 closed).

The contacts of RY_1 should make before break and the springs should have about half the tension of those on RY_2. C_4 is provided to avoid relay chatter on the rectified alternating current in the plate circuit of the 117L7. A switch SW is provided in parallel with the energized contacts of RY_1 in order to hold in RY_3 when adjusting the device or taking it out of service for some other reason. C_1 must be used to isolate the antenna from the power system, so that in the event the power source becomes reversed, the antenna will not be at line potential. C_1 also provides a convenient means of limiting the r-f input to the instrument. Enough r-f energy, however, should be fed to L_1C_2 so that this tank may be operated somewhat detuned from the station frequency, and C_3 used as a control of the tetrode bias and the dropout point of RY_1. When properly adjusted for dropout at 75 percent of full carrier, the plate current should be about 22 ma, and about 7 ma when the high bias is applied to the transmitter during an overload.

For use with high-level systems, where power reduction by means of high bias is more difficult to achieve, the contacts of RY_3 would be placed in series with the plate OFF button or in series with the series-overload circuit of the transmitter, both generally arranged as normally closed circuits. Operation of the device would then result in an interruption of the plate-contactor holding circuit, shutting off the high voltage. As previously pointed out, a carrier-restoring device will be necessary for this method of operation, unless manual restoring of the carrier is to be depended upon.

An operation indicator is a desirable accessory to the carrier protective device. The one in use at KMOX is shown at the right in Fig. 1, and is so simple that very little explanation will be needed. Under normal conditions (RY_1, RY_2 and RY_3 closed), RY_4 is energized by the push button, seals itself in through RY_1, and lights the pilot lamp. When RY_1 is opened, RY_4 will drop out and put out the pilot light, which will remain out until the operator resets it with the pushbutton. The protective device

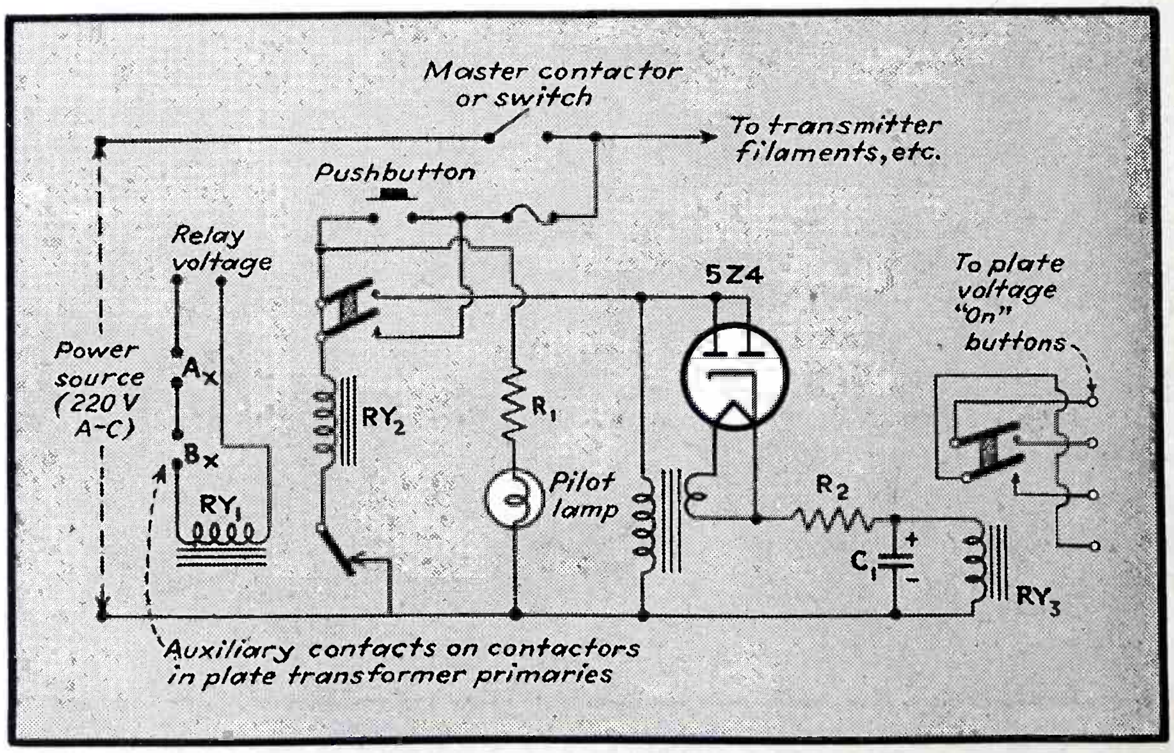


FIG. 3—Automatic starting circuit for getting back on the air after a breakdown with a minimum of lost time

will continue to operate when called upon to do so, regardless of conditions in the indicator.

WABC Carrier-Restoring Device

Overloads are probably the most common cause of carrier interruptions in broadcast stations. These result in operation of the protective relays and removal of the plate voltages. Where a manual operation is necessary to restore plate voltages, there is usually a delay of at least several seconds before the operator can reach the switch to restore the carrier to the air.

The carrier reset to be described cannot be praised too highly. It has been in service at WABC and then at KMOX since 1933, and has proven itself thoroughly dependable. The author does not know of a single case of trouble due to failure of this device. It is probably the simplest gadget yet designed that is capable of performing the standard three-shot and lockout cycle of reclosing devices. This unit, shown in Fig. 2, needs only as many relay contacts as there are protected plate circuits in the transmitter. It will operate within 0.3 second on the first attempt to restore the carrier, and within 0.6 second on the two subsequent attempts. Under these conditions, instead of a definite program interruption, a simple overload results in a momentary break of such short duration that only the most attentive listeners will be aware of it. In addition to its electrical and mechanical simplicity, it has no buttons to push to recycle it after a lockout. It is completely automatic in every respect. Its contacts never break a circuit and consequently never need attention.

This reclosing device consists essentially of a relay with one set of de-energized contacts for each protected plate circuit, and a pendulum associated with the relay armature. Most transmitters have only two protected plate circuits, a medium voltage for the exciter and driver stages, and a high voltage for the buffer and final amplifiers. This is the case at KMOX, as represented in Fig. 2. The relay contacts are paralleled with the plate ON control buttons, so that the high-voltage circuit breakers are closed by operation of the relay. The relay is energized by current flowing through auxiliary contacts *Ax* and *Bx* on the plate voltage primary contactors. Thus, when either contactor is opened as a result of an overload, the reset relay becomes de-energized and the pendulum-yoke arrangement is released. The contacts will close at the end of the first half swing of the pendulum and the plate voltage will be reapplied.

If the overload has cleared, the contactor will remain closed, energizing the reset relay and restoring conditions to normal. If the overload still exists, the plate contactor will reopen by action of the protective relays, and the reset relay pendulum will continue to swing. If the overload has not cleared by the time the third application of plate voltage has been made, lockout will occur as the reset pendulum has lost its kinetic energy and will come to rest in a neutral position. The carrier must now be restored manually. As soon as the plate contactors remain closed simultaneously long enough to energize the reset relay, the device is ready for another operation cycle.

Nearly any type of clapper relay is suitable for conversion into a pendulum reset device. The relay voltage source may be chosen to fit the relay, or vice versa. The relay used at KMOX is a Signal Electric and Manufacturing Co. type KS, operating from the 20-volt filament supply. Connections are made to the moving contact arms by means of flexible leads. The pendulum is of such a length that three full swings take place, resulting in three contact closures before the arc of the swing has become too short to close the contacts. A complete swing of the pendulum requires about 0.6 second, but the first closure occurs in half that time since only a half swing is required.

A quarter-inch rod of any material will suffice for the pendulum, and several nuts may be threaded on the end to provide weighting for en-

(*Continued on page* 274)

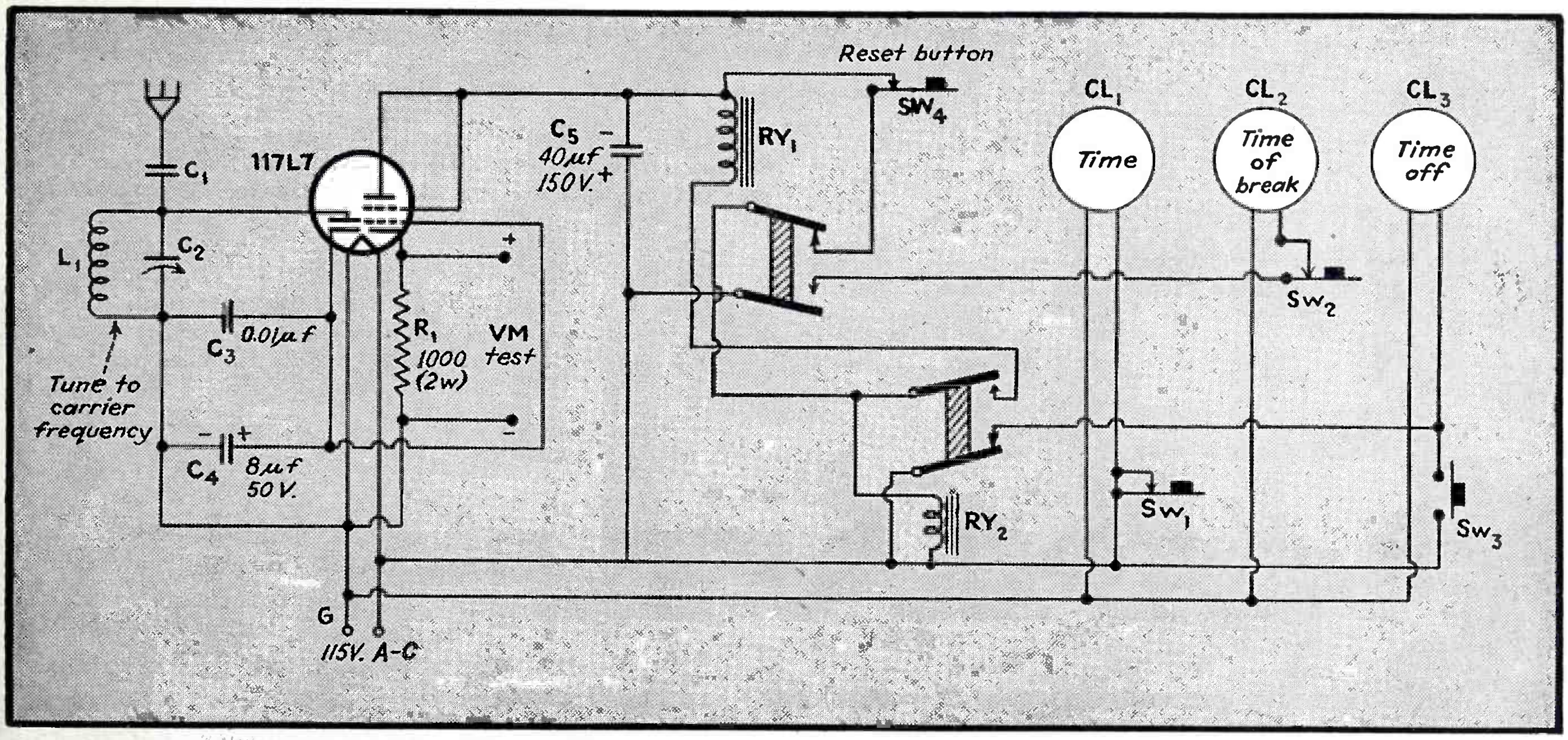


FIG. 4—Arrangement for securing automatically a record of the time that carrier failure occurred and the duration of the failure

A RADIO-FREQUENCY GUN

By JOHN P. TAYLOR
RCA Victor Division
Radio Corporation of America
Camden, N. J.

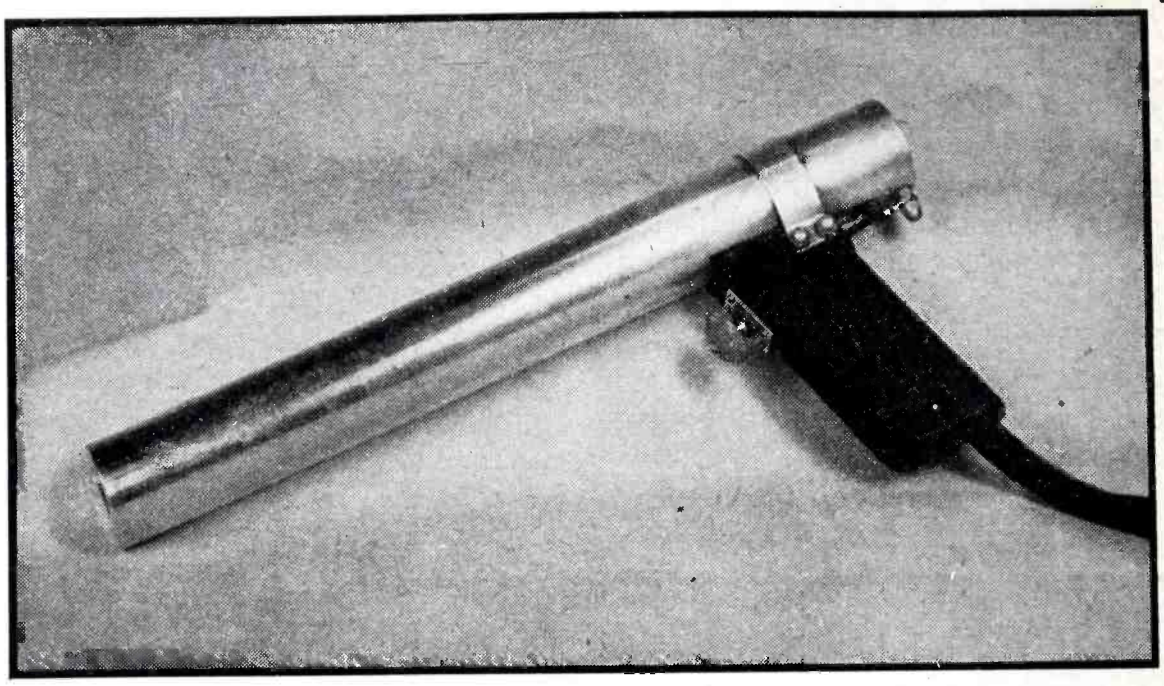


FIG. 1—The first model of the radio-frequency gun. The inner and outer conductors of a short length of concentric transmission line form the electrodes by means of which r-f power is used to spot-glue thin sheets of wood veneer together at selected points

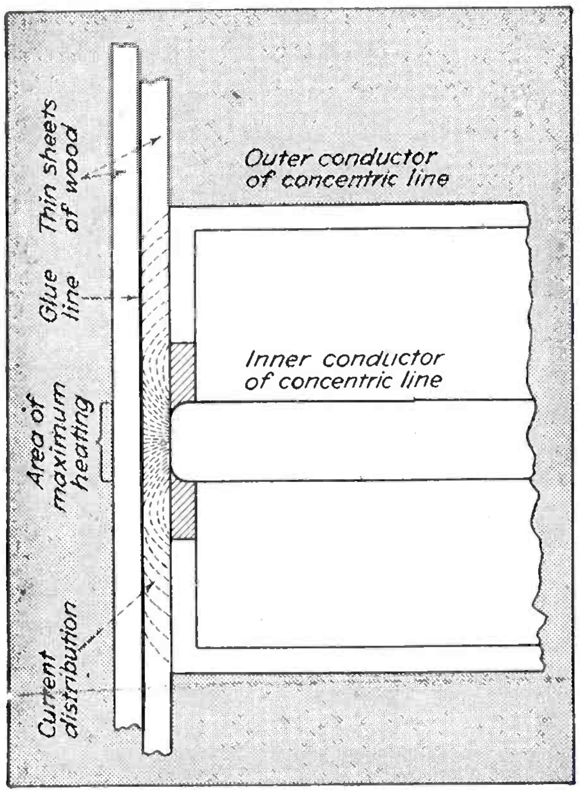


FIG. 2—Flow of current between electrodes when the gun is held against the surface of two thin sheets of wood which have a glue line between them. Current tends to follow the glue line and concentrate in a small area opposite the inner conductor

A RADIO-FREQUENCY "GUN" for spot-gluing thin sheets of wood together—much as sheets of metal are spot-welded—is one of the many interesting applications of r-f heating which have recently emerged from the laboratories.

During the past few months an r-f spot-gluer has been tested in the field under conditions simulating those of production operations. The tests have shown that this device can successfully be used for tacking together layers of wood veneer during the process of forming over a shaped mandrel. This is a necessary preliminary to the final curing or bonding of veneers in an autoclave. The operation is of particular interest in the manufacture of molded plywood shapes such as aircraft fuselages, wing elements, stabilizers, and the like by the so-called rubber-bag method.[1]

The device also has possible applications in other operations involving preliminary assembly of structures composed of wood veneers, paper-base laminates, and sheet plastics. In modified form it may ultimately be used in the final assembly and sealing of materials of this type, performing in this case a function similar to that of a stitch-welder for metals.

To electronic engineers the r-f gun will be of interest as another example of the numerous specialized applications to which r-f heating is particularly adaptable.

Principle of Operation

The r-f spot-gluer consists of a low-power ultrahigh-frequency oscillator, a flexible concentric cable, and an applicator of special design. An early form of this applicator, shown in Fig. 1, consisted of a short length of concentric transmission line mounted on a Bakelite block which formed the handle. From the pistol-like appearance it was inevitable that this would be called a gun. The name is, perhaps, not too unfortunate in that it at least serves to emphasize the fact that the radio-frequency currents travel somewhat (even if only a sixteenth of an inch or so) beyond the end of the applicator.

The r-f spot-gluer was originally devised by a group of engineers under the direction of Dr. G. H. Brown—the same group, incidentally, that developed the electronic "sewing machine" for sheet plastic materials.[2] In principle the two devices are much alike. In each case heat is produced in a dielectric material by causing intense radio-frequency currents to flow in the part of the material which it is desired to heat.

In the sewing machine the means of directing this current is a pair of rollers between which the material progresses. Current flowing between these rollers must pass through the material. In other applications of r-f heating which have been described previously—as, for instance, gluing of aircraft spars[3] and preheating of molding materials[4]—the material is similarly placed between the electrodes.

Electrode Arrangement

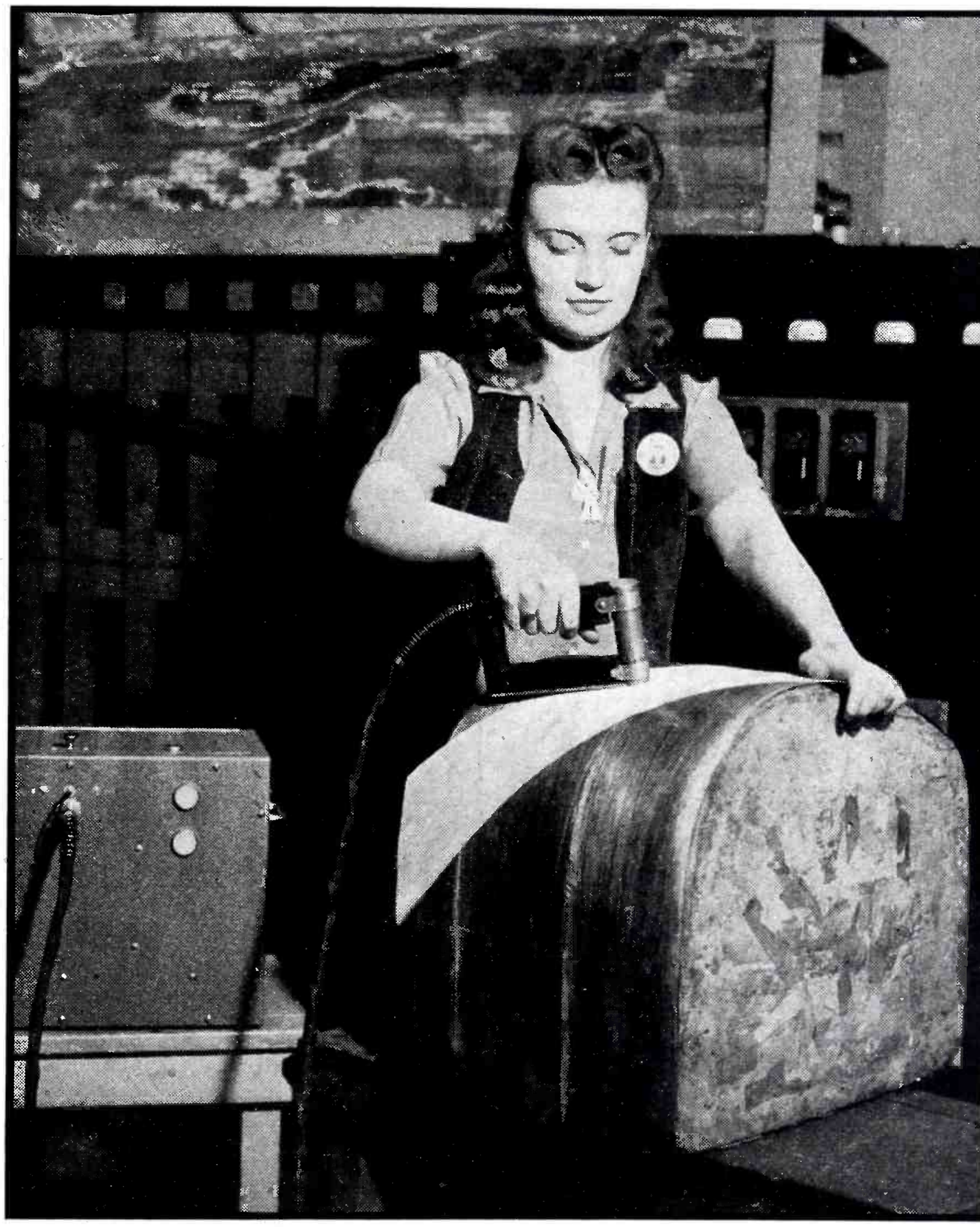
In the spot-gluer placement of electrodes on either side of the material is not possible since in many, if not most, instances only one side of the assembly can be reached. Even where both sides could be reached it would usually be inconvenient to do so.

FOR SPOT-GLUING WOOD

Temporary setting of glue by high-frequency heating with the gun-like end of a 200-Mc coaxial cable speeds construction of shaped plywood objects. Spotting holds veneer layers in position during preliminary laying up and handling. Tedious stapling is eliminated

The two electrodes used in the spot-gluer are the inner and outer conductors of a section of concentric transmission line. Figure 2 illustrates the flow of current between these electrodes, when the gun is placed against the surface of two sheets of wood veneer which have an adhesive between them. Since the dielectric constant of the wood is greater than that of air, most of the current flows through the wood. Moreover, since the glue line (at least in its original rather moist condition) presents a lower-resistance path than the wood, there is a tendency for the current lines to concentrate in the glue. These effects produce a concentration of current in the glue line opposite the inner conductor.

Some current, of course, is present in an area of the wood equal to the cross-section of the outer conductor. However, only in the vicinity of the inner conductor is the current concentration sufficient to produce appreciable heating; in general, the size of the heated spot is about the size of the inner conductor.



Using the special ironing-type r-f gun to smooth out and tack down layers of veneer on a mandrel, in much the same way that the wire stapler is ordinarily used

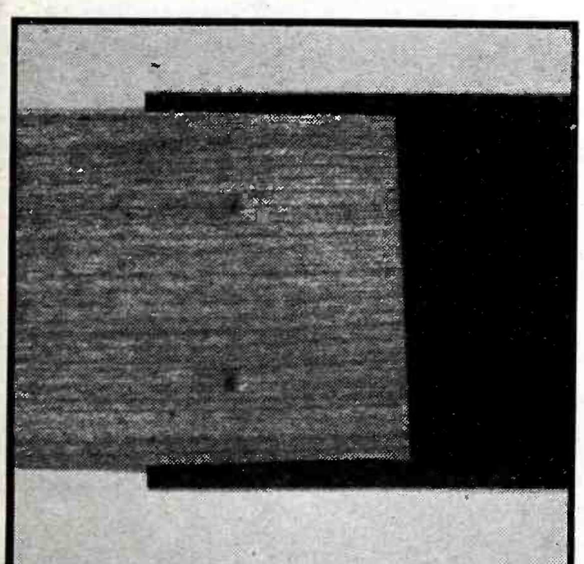


FIG. 3—Two pieces of aircraft veneer which have been spot-glued at two points. Small indentations are caused by the pressure of the inner electrode on the wood which has been softened by heating

The amount of heat produced in the spot is determined (for a given power) by the length of time that power is applied. The temperature required for barely tacking the glue (which, as will be explai ed later, is often desirable) is attained for thin veneers in about one second. Applying power for one and a half to two seconds results in a completely set or cured glue spot. In this case the spot glued has, with adhesives of the types used in aircraft manufacture, greater strength than the wood itself. This is demonstrated by the fact that when subjected to shear tests (tension parallel to the face of the wood) the ultimate failure will be largely in the wood.

In Fig. 3 are shown two pieces of aircraft veneer which have been spot-glued at two points.

Present Methods Of Molding

The advantages of the r-f spot-gluer in laying up molded plywood

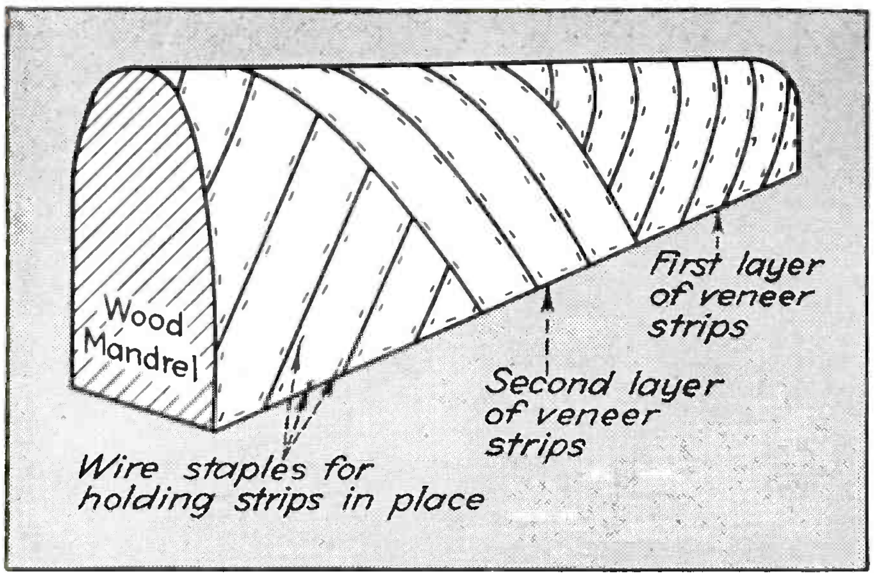
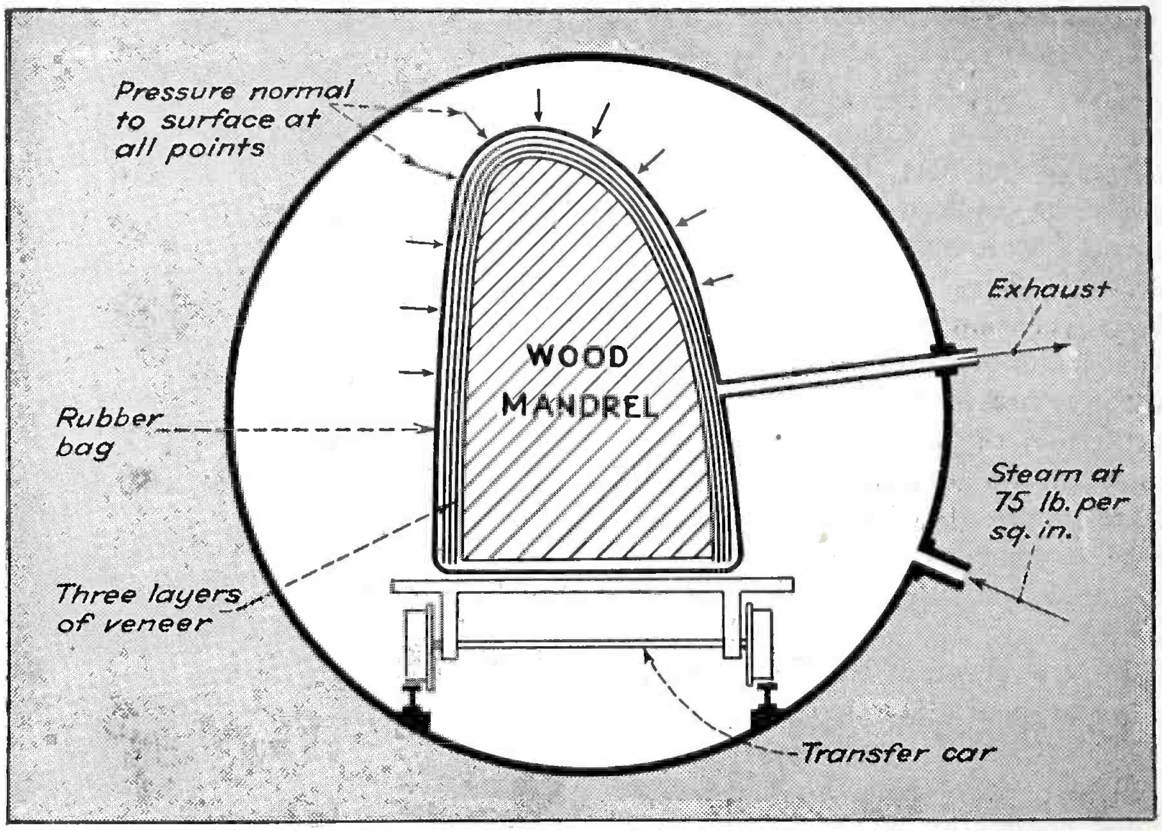


FIG. 4—First step in the present process of making formed plywood structures. Thin strips of veneer are tailored to fit and fastened to a wooden mandrel by means of wire staples. As layers are added, the staples in the previous layer must be removed

FIG. 5—Second step in making formed plywood. The mandrel on which veneers have been wrapped is enclosed in a rubber bag from which the air is exhausted. The whole assembly is then placed in an autoclave, as shown, and heat and pressure are used to bond the veneers into a single homogeneous piece



assemblies are best illustrated by first considering briefly the present methods. While there are several such methods, the best known of which are the Vidal[5] and the Duramold[6] they are all more or less similar in the pattern of operations. These operations consist of two principal steps. In the first or wrapping step, narrow strips of thin veneer (from $\frac{1}{64}$-inch to $\frac{1}{16}$-inch thick) to which a resin adhesive has been previously applied are laid-up or wrapped on a wooden mandrel, as shown in Fig. 4. Where necessary, individual strips are tailored to fit by goring or trimming. As each strip is fashioned to the mandrel it is held in place by means of wire staples driven through the strip and into the mandrel. These are inserted with a hand stapler.

As each additional layer of veneer is added—and there may be as many as nine layers—the staples in the previous layer must be pulled out and new staples put in through the added layer. When the final layer has been placed, as many of the staples as can be safely extracted without damage to the assembly are removed.

The whole assembly is then placed in a rubber bag and the air exhausted from the bag so that it fits tightly and smoothly over the assembly. The bag has several purposes. Primarily it provides a means of insuring fluid pressure over the entire surface. In addition it protects the lay-up and mandrel from moisture. It also helps to hold the veneers in place during handling.

In the second or "cooking" step in the process the assembly, still in the rubber bag, is placed in an autoclave, as shown in Fig. 5, and heat and pressure are applied. Compressed air, steam, hot water, or combinations of these are used to obtain ultimate pressures of the order of 75 lb. per sq. in. and temperatures of 250 deg. F. to 300 deg. F.

For the first few minutes of the heating cycle, however, only relatively low pressures are used. During this period the resin adhesive (with which all the plies were coated before wrapping) gradually softens and eventually goes through a flow stage before reaching the curing temperature. This flow characteristic allows the plies to shift slightly with relation to each other so as to conform exactly to the contours of the mandrel. This ability to give somewhat is essential in obtaining maximum strength-weight characteristics.

After the preliminary period, during which the veneers have been gently pressed into position, the pressure is brought up to the specified maximum and the assembly allowed to cook (or cure) from 15 minutes to an hour or more, depending on the thickness of the material. This bonds the resin and veneers so completely that when the form is removed it has an evenness and homogeneity which give it a uniformity approaching and a stiffness-to-weight ratio exceeding that of sheet metals.

Drawbacks of Present Methods

The use of a wire stapler in the "wrapping" part of the process is one of the chief drawbacks to the rubber-bag method of making shaped plywood. While the staples can be inserted quickly, the necessity of removing them from each previous layer as new layers are added makes the wrapping of multiple layers a lengthy and costly job.

There are other disadvantages. For one thing, the assembly is left with many tiny holes in it, and the holes in the outer layer at least must somehow be filled up during the finishing process.

Again, the necessity of leaving a

considerable number of staples in during cooking limits the movement of the plies with respect to each other, and unless these staples are left at specific points which have been carefully predetermined, warping or wrinkling of plies may occur.

Finally, as a result of the inadvertent breaking of staples during the removal process often-times staple ends remain and, under pressure, protrude and puncture the bag. When this happens not only the bag, but the assembly, and sometimes even the mandrel (due to moisture getting into it) are ruined. Obviously the elimination of stapling would be a big step forward.

Advantages of the R-F Spot-Gluer

The r-f spot-gluer was originally designed with the specific idea that it would supplement, if not actually replace, the stapler in operations of the above type. It was hoped that it could be used instead of the stapler to tack the separate plies of a shaped layout together in such manner that they would hold together during preliminary handling—and yet would be free to move slightly with respect to each other when heat and pressure were applied to the assembly in the autoclave. Fortunately the glues used in molding practice (or at least such of these as have been tested to date) pass through a more or less thermoplastic stage before reaching the final temperature (at which they are, of course, thermosetting). When heat is applied just long enough to raise the temperature (in the spot) to this thermoplastic stage, it is found that the veneers adhere sufficiently to hold them securely in place during reasonable manipulation of the assembly-while at the same time the cure is insufficient to obtain final setting. Some degree of "flow" therefore occurs when additional heat is applied (as during the normal cooking cycle).

If the spotting cycle is too long the spots, of course, receive a final cure. In this case the strength of the joints is such as to pull wood, as previously mentioned. If, however, these spots of complete cure are of small size and not too many are used, they will ordinarily be broken off by the shearing forces which occur when pressure is applied in the autoclave. This will, of course, leave small unglued spots in the final piece, but these have an insignificant effect on overall strength values.

Thus, either method, that of partially gluing (tacking) a considerable number of spots or that of completely setting a smaller number, may be used. Where the characteristics of the glue used are not too critical (which would make the in-between point too hard to hit) the first is to be preferred.

In one series of tests the experimental spot-gluer was used by a girl operator whose only previous experience was with the regular wire stapler. Under these conditions the time for making the individual spots was considerably longer than with the stapler. However, because of the time saved by not having to pull out staples, the overall time was of the order of 25 percent less than with

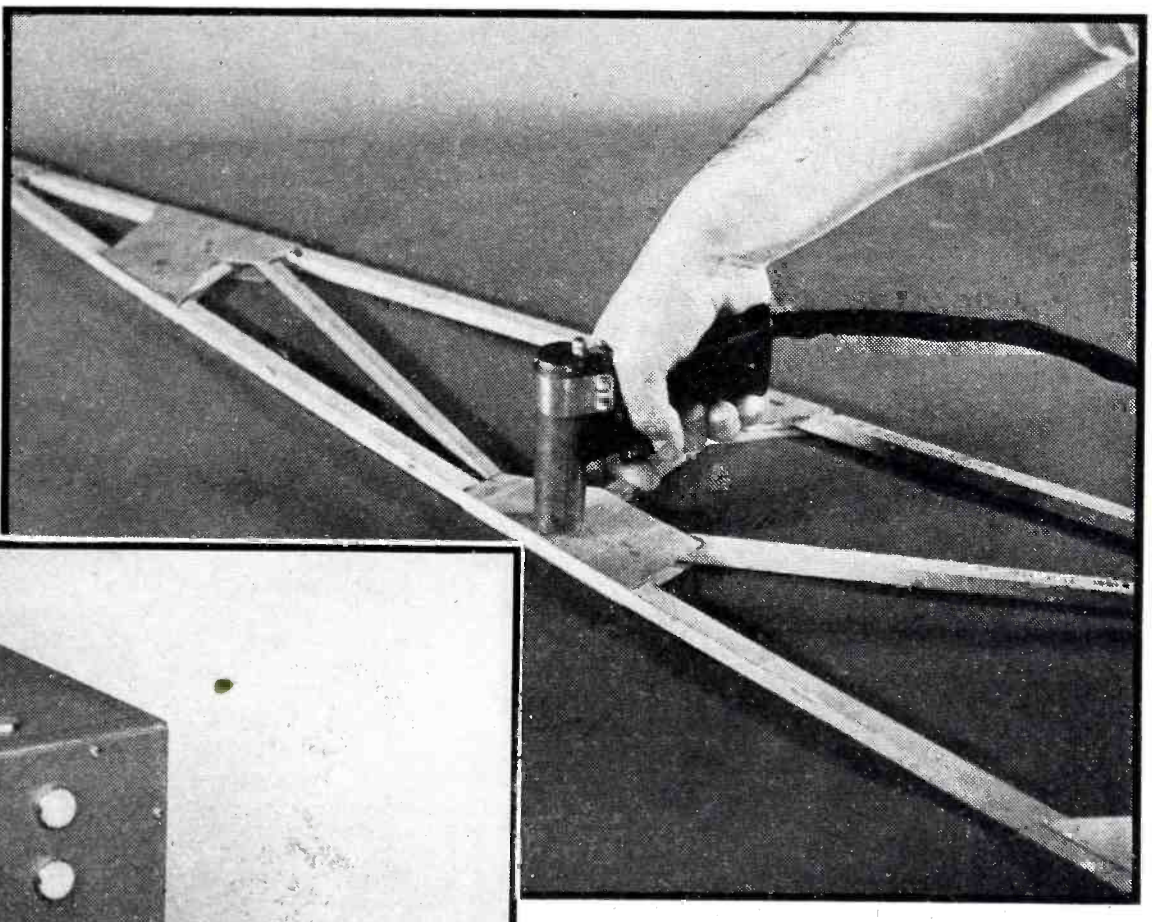


FIG. 6—Using the r-f gun to tack a gusset plate of thin veneer on small capstrips making up an aircraft ribweb. The temporarily glued assembly can be placed in a hot-plate or r-f equipped press and cured in a few minutes

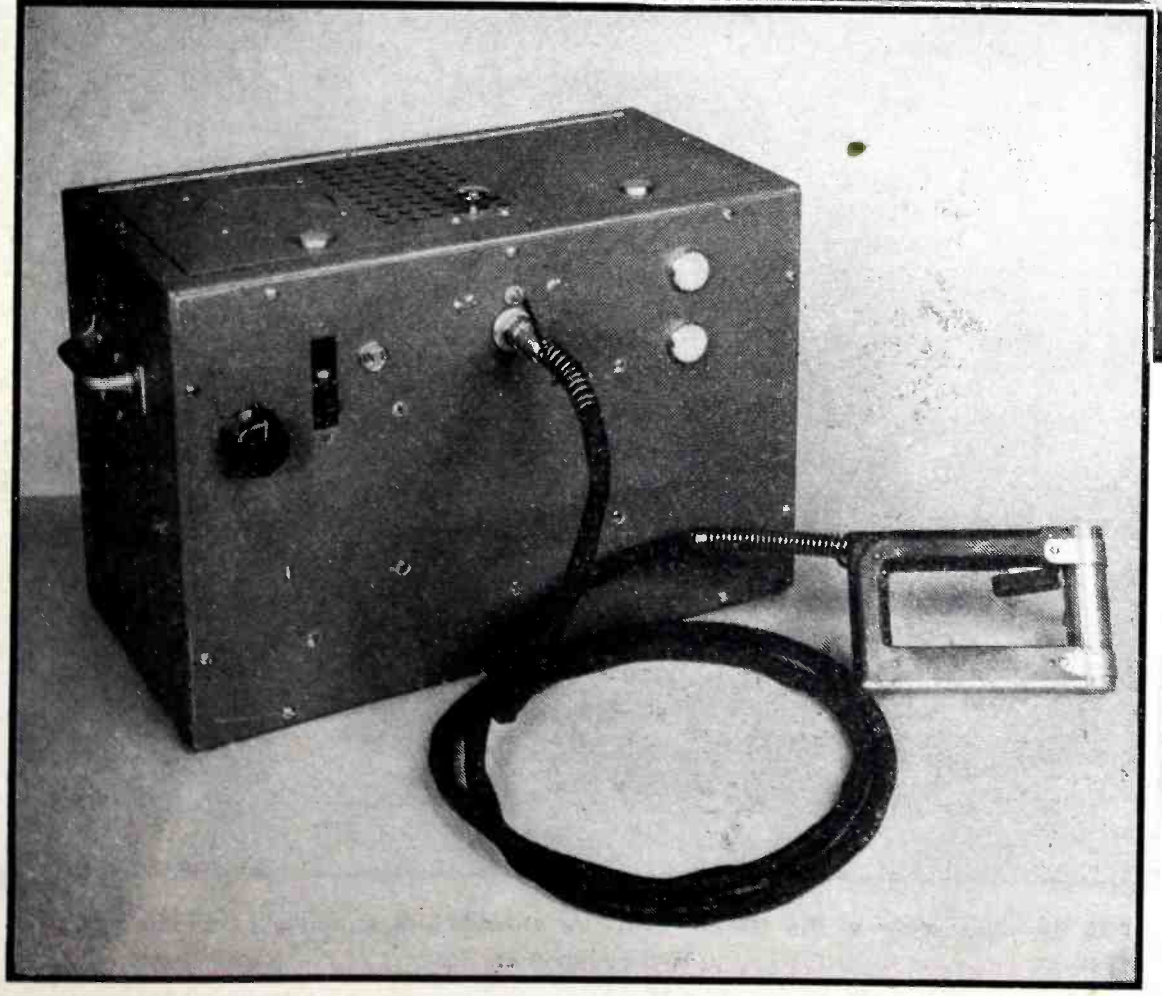


FIG. 7—Model of the spot-gluer used in field tests. The oscillator cabinet has a plug-in cable connector so that several different models of the gun may be used interchangeably. The gun shown is the one developed especially for veneer wrapping, and permits an ironing motion for smoothing wrinkles in the veneer

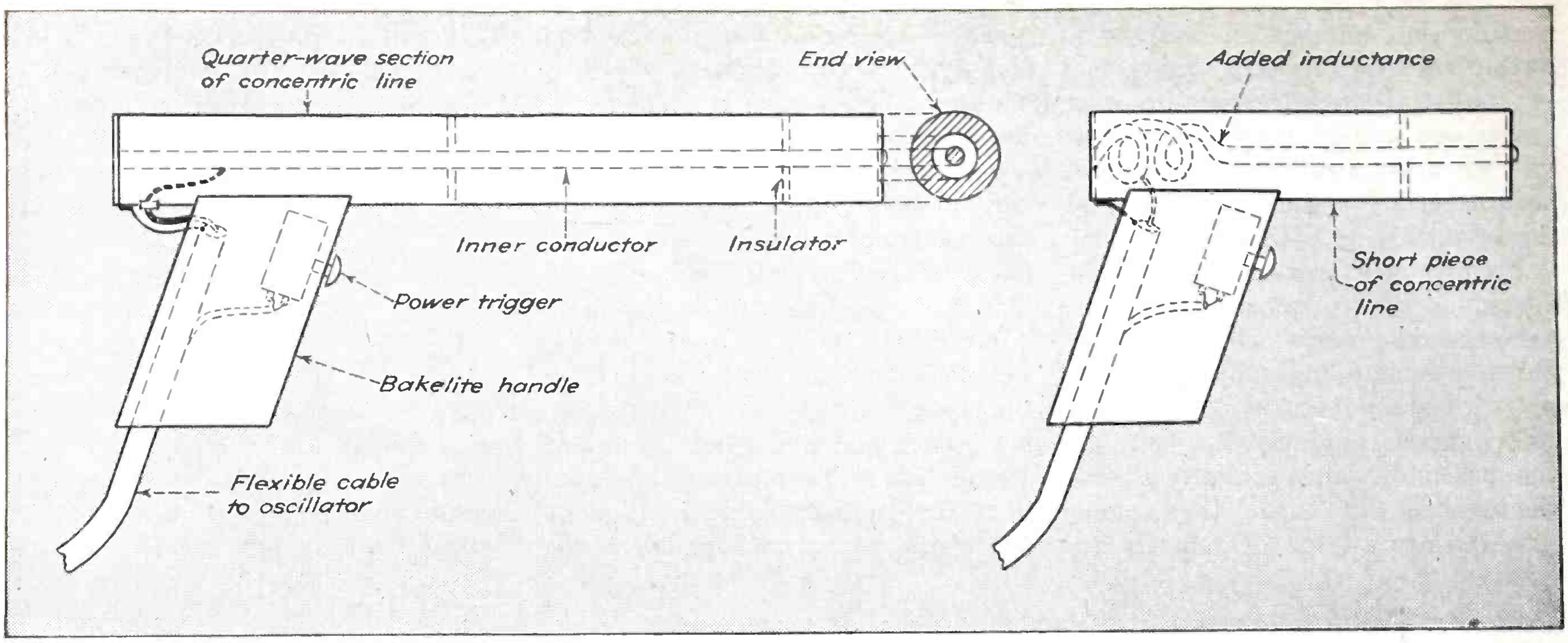


FIG. 8—Cross-section sketch of the original gun, consisting of a quarter-wave section of concentric transmission line with the hot lead of the cable from the oscillator tapped on the inner conductor at a point chosen to give an approximate impedance match

FIG. 9—Cross-section of the second model of the gun. A lumped inductance has been placed in series with the inner conductor in order to retain the effect of a quarter-wave line. The overall length of this unit is conveniently short

the stapler. With experience a 50 percent saving in time may be possible.

In the present method the wrapping time is definitely the bottleneck. A reduction of 50 percent—if borne out in actual production—would be extremely important. It might go far toward justifying the making of many articles (predictions run all the way up to automobile bodies) by methods now limited largely to aircraft parts.

In addition to the time saving there are also the advantages that the wire holes are not present, the likelihood of wrinkling is decreased, and the danger of puncturing the bag (which in itself is an expensive item) is eliminated. There is one further advantage which in the future may be of importance. If radio-frequency heating is eventually to be used in the final cooking process (thereby eliminating the inconvenience of the autoclave and greatly reducing the cooking time), the use of wire staples, which would short across the electrodes, is obviously not feasible. Some experimental work along these lines has been done, and although present molded plywood production schedules probably do not warrant the use of large-scale r-f heating (because of the relatively small quantities of each piece required), it seems quite possible that peacetime production will justify the high setup costs involved. If so, the r-f spot-gluer will certainly be a necessary adjunct.

With most applications of r-f heating one idea leads to another—and the spot-gluer is no exception. Originally intended for use in making molded plywood, it has already been suggested and in some cases, tried for other uses. Most of these had to do with assembly operations on various objects made of plywood, paper-base laminates, sheet plastics, and the like. In such cases, of course, a permanent seal or weld between overlapping pieces is usually desired.

Other Applications

Boxes and other small containers are typical examples. For some of these the spot-gluer in its present form will be fairly suitable. For most, however, more power, differently shaped electrodes, higher fre-

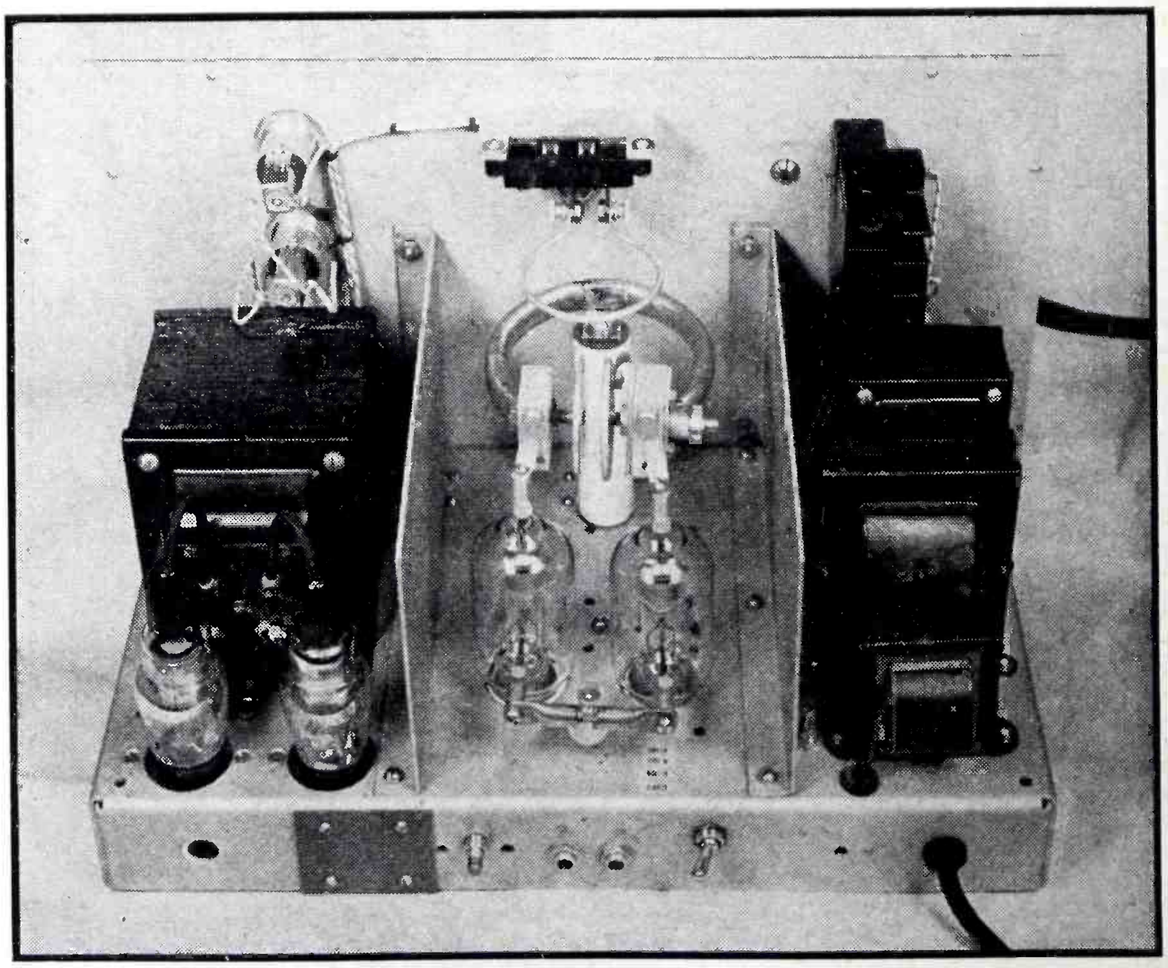


FIG. 10—Rear view of the 200-Mc oscillator chassis that supplies r-f power to the spot-gluing gun

quency, or other changes will be desirable. An r-f device somewhat comparable to a welding machine, and of fairly flexible characteristics, would have wide application and will undoubtedly be the next development in this field.

In addition, there are numerous operations in the woodworking industry which are more or less similar to that for which the spot-gluer was actually designed. Most of these are in jobs where the advantages of a preliminary assembly suggest themselves.

The aircraft rib-web shown in Fig. 6 is an example. Such webs are usually assembled in a jig, the gusset plates being held in place by toggle clamps or some other clamping device. At room temperature a period of four to eight hours is required to set the glue used. By placing the assembly in a hot-plate press (or in a press equipped with r-f heating) the glue can be set in a few minutes. In either case the clamps are a drawback and handling would be much easier if some other means of keeping the assembly together until pressure was applied were available. The spot-gluer may fill this requirement. It can be used to tack the gusset plates in place, thereby holding the assembly together so that it can if desired be removed from the jig for gluing in a press.

When r-f heating is used, a number of webs can be bonded at one time simply by stacking these up between the electrodes. An arrangement of this kind enormously steps up the output of a given set of jigs.

There are, obviously, many similar operations in peacetime wood manufacturing where this method might be of value. In fact, it is likely that only by the adoption of such new production tools will the wood industry be able to compete with plastics and light metals in those borderline fields where any of the three materials might conceivably be used.

The model of the spot-gluer which was used in the field tests mentioned is shown in Fig. 7. This unit was designed by Mr. J. E. Joy of the RCA Development Engineering Section. The oscillator box is provided with a plug-in cable connector so that it can be used interchangeably with several models of the gun.

Details of Gun Construction

The original gun consisted of a quarter-wave section of concentric transmission line with the hot lead of the connecting cable tapped on the inner conductor at the proper point to obtain an approximate impedance match, as shown in Fig. 8. This gun was about 12 inches long, and because of its unwieldiness required two hands for accurate manipulation.

A second model was made up in which the overall length was reduced to about 5 inches. The effect of an electrical quarter-wave was retained by placing a small inductance in series with the inner conductor and tapping on to this at the proper point for matching, as shown in Fig. 9.

As a result of further field tests still another model of the gun was made up. This unit, shown in Fig. 7, somewhat resembles in form the wire stapling machine now used. It was found desirable due to the fact that in using such a device for laying up veneer on a mandrel the operator performs a sort of ironing movement which smooths out the wrinkles in the veneer and holds it flat in place. Experience indicates that this and possibly other different applicators will be used, depending on the requirements of various jobs.

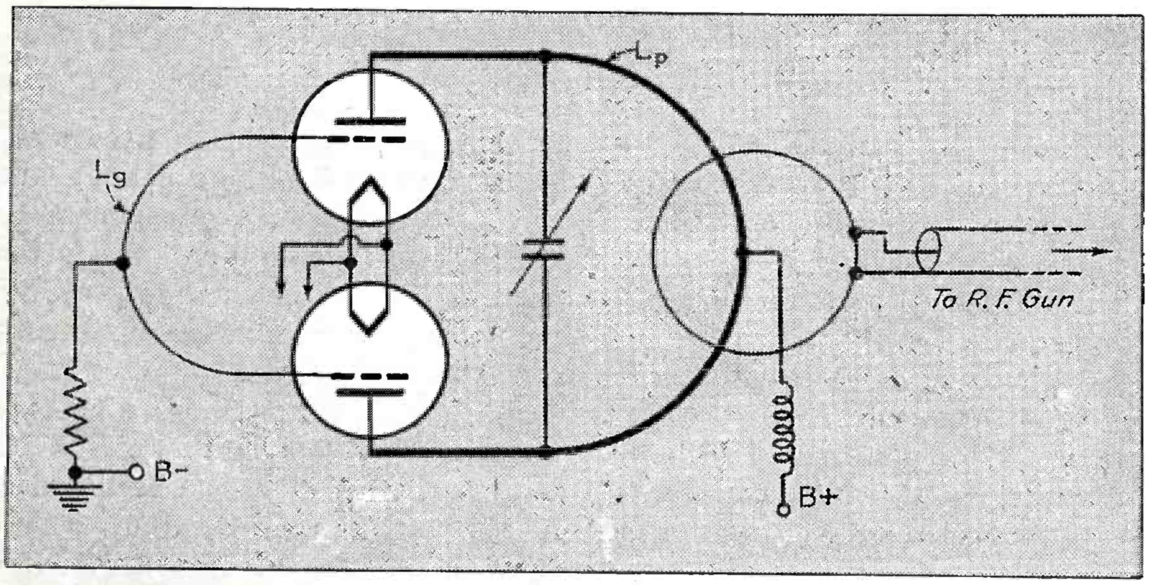


FIG. 11—Schematic diagram of the r-f circuits of the 200-Mc oscillator. Rectifier circuits, not shown, are of usual design

Details of Chassis Construction

A rear view of the oscillator chassis is shown in Fig. 10. The oscillator proper occupies the center space, with power supply components on either side. The push-pull tuned-grid tuned-plate oscillator circuit (Fig. 11) allows a very simple form of construction to be used. At the frequency of operation (approximately 200 Mc) the grid inductance is a straight piece of tubing, while the plate inductance is a single turn. Tuning is accomplished by means of a threaded screw-type condenser. A hinged loop loosely coupled to the plate inductance forms the output coil.

Direct voltage for the oscillator plates is supplied by a full-wave rectifier using two RCA-816's (at the left in Fig. 10). Plate input power is about 150 watts.

The amount of power actually converted into heat in the wood is probably rather small. It is obvious, however, that overall efficiency is not particularly important in a device of this kind, since power cost is in any event negligible. The controlling item in design is, rather, the necessity of getting the required speed of heating without having excessive voltage between electrodes. This problem is more or less general to r-f heating of dielectrics and has been discussed previously[3].

In the case of the spot-gluer the voltage problem is accentuated by the small area of the electrodes and the relatively long current path through the wood. Moreover, in spot-gluing the in-between layers on a mandrel the r-f gun comes in direct contact with the adhesive which has been previously spread on the veneer. (Practice is to spread both sides of the in-between layers.) Under this condition, and with the glue at least slightly moist, it is certain that arcs will occasionally occur. The inter-electrode voltage must be such that these arcs will not be sustained. The only way in which this voltage can be kept down and still produce sufficient

(Continued on page 310)

CATHODE

By WALTHER RICHTER

*Allis-Chalmers Mfg. Co.
Milwaukee, Wisc.*

A comprehensive analysis of recently-developed cathode follower circuits, which serve as highly efficient transformers for coupling high-impedance sources to low-impedance loads. The circuits discussed are strictly power amplifiers. Voltage amplification is always less than unity

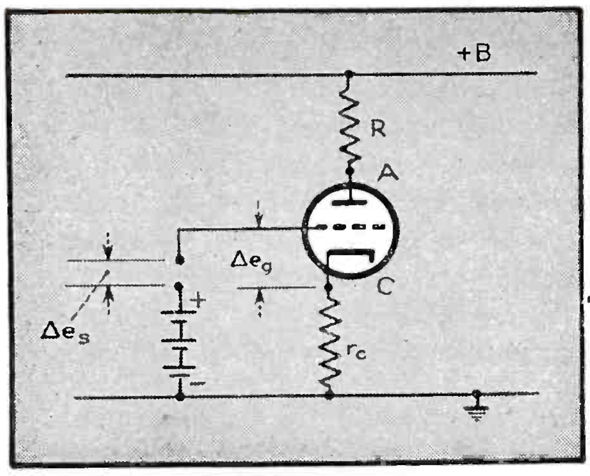


FIG. 1—Fundamental schematic wiring diagram of tube used as degenerative amplifier for phase inverter or cathode follower

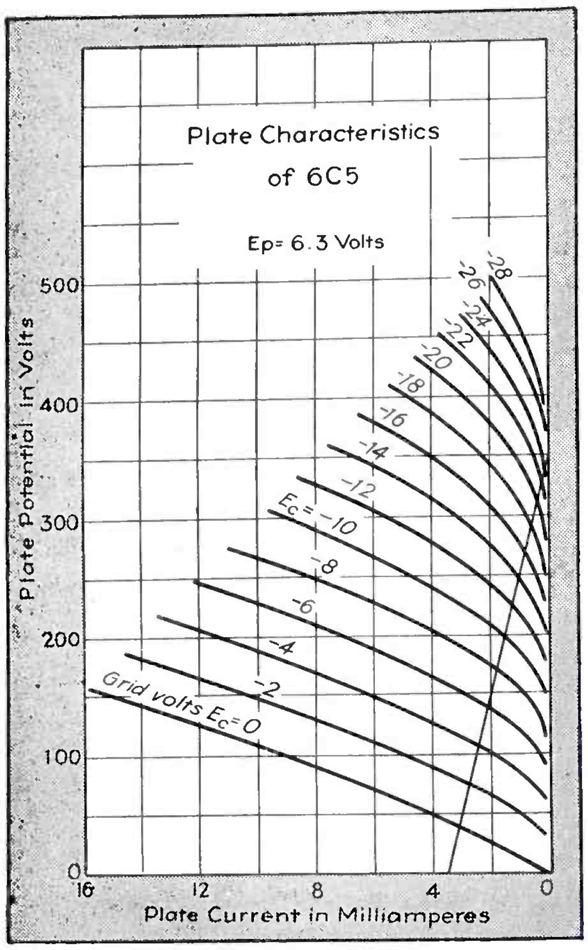


FIG. 2—Family of plate characteristics for triode, illustrating the operation of cathode follower

THE placement of a resistor in the cathode circuit of a single tube, or of a pair of tubes having their cathodes connected together, produces certain effects which have been put to good use in many applications. This discussion attempts a summary and analysis of these circuits, so that their behavior may be visualized and predicted.

Suppose a signal Δe_s is applied to a tube as shown in Fig. 1. Evidently the actual grid voltage change, that is the voltage change between grid and cathode, will not be as large as Δe_s. If the signal voltage makes the grid more positive, for instance, more plate current will flow; this will cause an increase of voltage across r_c, making the cathode also more positive. The cathode "follows" the grid, so to speak.

The mathematics of this case have been presented in this magazine once before[3], but will be repeated here for the sake of completeness.

If Δi_p is the plate current change due to the signal voltage change Δe_s, the actual grid voltage change will be given by

$$\Delta e_g = \Delta e_s - \Delta i_p r_c \qquad (1)$$

The fundamental relation between plate current change, grid voltage change and plate voltage change is given by the well known equation

$$\Delta i_p = \frac{\mu \Delta e_g + \Delta e_p}{r_p} \qquad (2)$$

An increase Δi_p in plate current causes a decrease—or negative increase—of plate voltage given by

$$\Delta e_p = - \Delta i_p (R + r_c) \qquad (3)$$

Substituting Eqs. (1) and (3) into Eq. (2) gives

$$\Delta i_p = \frac{\mu (\Delta e_s - \Delta i_p r_c) - \Delta i_p (R + r_c)}{r_p} \qquad (4)$$

When this equation is solved for Δi_p, we obtain

$$\Delta i_p = \frac{\mu \Delta e_s}{R + r_p + (\mu + 1) r_c} \qquad (5)$$

It is worthwhile to study Eq. (5) in detail. With $r_c = 0$, the equation assumes the familiar form

$$\Delta i_p = \frac{\mu \Delta e_s}{R + r_p} \qquad (5a)$$

In this case, representing fixed bias, signal and grid voltage change are of course identical. Comparing Eqs. (5) and (5a) we note that the introduction of r_c in the cathode lead has the same influence on the plate current change due to a signal voltage change, as if the tube were operating with fixed bias, but a resistor of the value $(\mu + 1)\, r_c$ had been added in the plate circuit. Another, sometimes more convenient, way to visualize the influence of the cathode resistor, can be deduced as follows: if we substitute Δi_p from Eq. (5) into Eq. (1), we obtain

$$\Delta e_g = \Delta e_s \frac{R + r_p + r_c}{R + r_p + r_c + \mu r_c} \qquad (6)$$

Now $R + r_p + r_c = R_t$ is the total resistance in the plate circuit, since obviously r_c is just as much a part of the plate circuit as R. However, r_c is also part of the grid circuit, and its presence there causes the actual grid voltage change to be less than the signal voltage change in the ratio

$$\Delta e_g = \Delta e_s \frac{R_t}{R_t + \mu r_c} \qquad (6a)$$

We can therefore also state the influence of a cathode resistor by saying that its presence reduces the value of the signal voltage in the ratio given by Eq. (6) or Eq. (6a) before it reaches the grid.

While Eqs. (1) to (6) were set up for resistive values in the plate and cathode circuit, they are just as

FOLLOWER Circuits

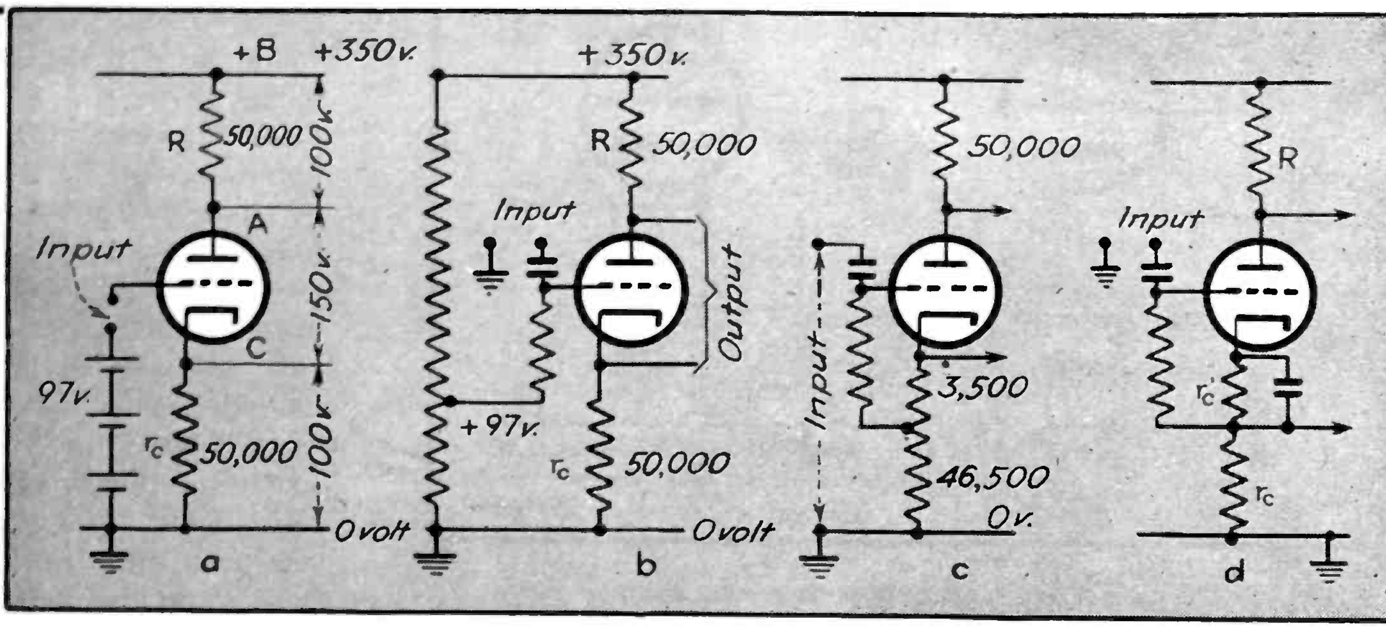


FIG. 3—Various circuit connections for phase inverter circuits

valid if the resistances are replaced by impedances (provided, of course, that there is a path for the direct-current component of the plate current). Thus the influence of a resistor by-passed with a condenser can be calculated by means of Eqs. (5) or (6) by simply replacing the value r_c with the complex value of the impedance representing the parallel combination of resistor and condenser.

Cathode Follower Arrangement

The case of a true "cathode follower," or impedance changing tube is obtained for $R = 0$. The question arises how much signal we shall obtain across r_c in this case.

The voltage change Δe_o across r_c due to the signal voltage change Δe_s is of course simply equal to the current change Δi_p, obtained from Eq. (5), multiplied by r_c; we have therefore

$$\Delta e_o = \Delta i_p r_c = \frac{\mu \, \Delta e_s \, r_c}{r_p + (\mu + 1) r_c} = \frac{\mu \Delta e_s r_c}{r_p + \mu r_c + r_c}$$
$$= \Delta e_s \frac{\mu \, r_c}{\mu \, r_c + r_p + r_c} \qquad (7)$$

Since the denominator is always larger than the numerator, the fraction will always have a value less than unity. This means that we cannot obtain voltage amplification with this circuit.

If R is made equal to r_c, the voltages across R and r_c will be equal, since the same current flows through them. But an increasing current will swing point A of Fig. 1 more negative, while point C will swing more positive. These two points may be capacity-coupled to a push-pull stage furnishing the 180 deg. phase displaced signals required for such a stage.[4]

The procedure of designing such a stage may best be shown on an example. Suppose 350 volts is available for the stage and that a 6C5 is to be used. If we were to design a conventional resistance-capacity coupled stage, we would draw a load line with the chosen value of the load resistance and decide on a proper operating point. This is exactly what we do now, except that the load resistance will be split into two equal parts, one to be placed into the plate lead, the other into the cathode lead. However, it might be desirable to hold the load to lower values than usual, to minimize the effect of cathode leakage and capacity. (For an excellent discussion of the effect of cathode capacity on the performance of cathode follower circuits, see C. E. Lockhart, "The Cathode Follower".[1]) Suppose we take a load of 100,000 ohms. Figure 2 shows the plate characteristic of the 6C5 with the load-line representing 100,000 ohms and inspection shows that a good operating point is 2 ma, with 150 volts across the tube and 200 volts across the 100,000-ohm load. The actual grid voltage for this condition would have to be about -7 volts, as seen from Fig. 2. Splitting the 100,000 ohm load into two resistors of 50,000 ohms results in the circuit shown in Fig. 3a. The operating—or quiescent—current of 2 ma causes a drop of 100 volts across r_c, and in order to have an actual grid voltage of -7 volts, a bias of $+93$ volts will be required.

The output voltage obtainable from such a stage for a given signal voltage can be determined in two ways, just as for a conventional circuit. For small signal voltages the equivalent plate circuit theorem will give us the answer, that is, Eqs. (5) or (6) can be used, which have been derived on the basis of this theorem. For larger signals the use of the load line will be indicated. Assuming at first a small signal, say 1 volt, the application of Eq. (5) or (6) requires the plate resistance to be known. At the operating point chosen in the example, this value would be about 16,000 ohms (determined from the

Advantages of Cathode Follower

1. High input impedance
2. Low output impedance
3. Good frequency response

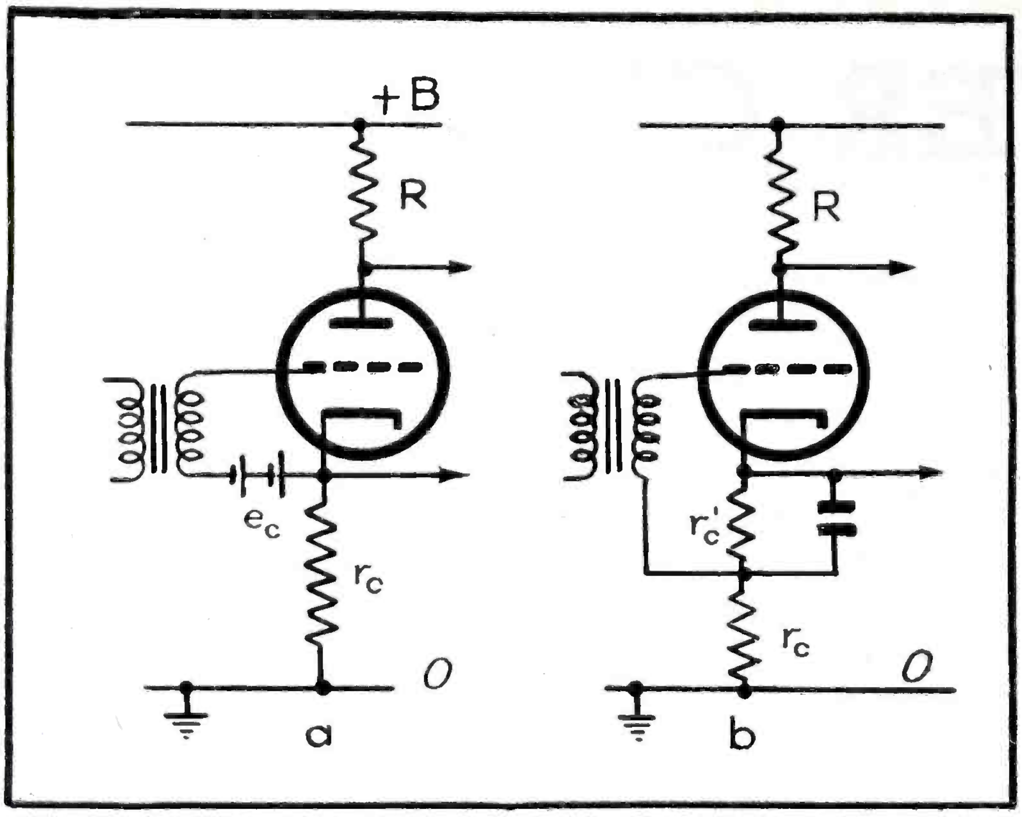


FIG. 4—Transformer input connections to phase inverter tube

cotangent at the operating point). The plate current due to a signal of 1 volt would be given by Eq. (5):

$$i_p = \frac{20 \times 1}{50{,}000 + 16{,}000 + 21 \times 50{,}000} = \frac{20}{1{,}116{,}000} = 17.92 \times 10^{-6} \quad (5)$$

The signal appearing across the cathode (or plate) resistor will be given by

$$e_o = 50{,}000 \times 17.92 \times 10^{-6} = 0.896 \text{ volt}$$

We could have used Eq. (6a), to give us first the actual grid voltage change:

$$e_g = 1 \times \frac{116{,}000}{116{,}000 + 1{,}000{,}000} = 0.1039 \text{ volt} \quad (6a)$$

If 0.1039 volt were applied to a 6C5 tube with 100,000 ohm load, the voltage across the load would be

$$e_L = \frac{\mu \, \Delta e_g \, R_L}{R_L + r_p} = \frac{20 \times 0.1039 \times 100{,}000}{116{,}000} = 1.795$$

Half of this voltage, or 0.896 volt, will appear across r_c and R. Note that there is not only no amplification, but that the phase inverted output voltages are actually smaller than the input voltage.

Use of Curves for Large Voltage Variations

For larger voltages, the use of the characteristic curves is advisable. Here the actual grid voltages are best used as a starting point. Suppose that on the basis of Fig. 2 we decided to cause an actual grid voltage swing from -2 to -12 volts. What signal voltage will be needed and what will the output voltage be? The load line tells us that the tube voltage will swing between 75 and 225 volts, while the voltage across the load will swing between $350 - 75 = 275$ and $350 - 225 = 125$ volts. Half of these values, that is 137.5 and 62.5 volts, will represent the limits of the voltage swing across the cathode (and plate) resistor. The limits of the signal voltage swing can now be found. At the instant when the drop across r_c is 137.5 volts, the grid must be 2 volts negative with respect to the cathode, or $137.5 - 2 = 135.5$ positive with respect to the negative end of the power supply; the other limit is correspondingly $62.5 - 12 = 50.5$ volts. The total swing of the grid with respect to the negative end of the power supply is therefore $135.5 - 50.5 = 85$ volts. Therefore, to obtain a swing of 75 volts of the two output voltages across r_c and R, an input voltage swing of 85 volts is needed. The ratio is $75/85 = 0.8823$ and is the same as found for small signals, within the limits of accuracy of reading the characteristics. This indicates the extremely low distortion produced by such a stage, as would be expected from the highly degenerative effect of the cathode resistor. Another indication of the low distortion is found in the comparison of the midpoint of the signal swing, which is $(135.5 + 50.5)/2 = 93$ volts with the zero signal bias, which had been determined also to be 93 volts.

To come back to this bias, Fig. 3a showed this bias as obtained from a battery. If a bleeder circuit across the power supply is available it may be conveniently tapped at the desired point, as shown in Fig. 3b, or the bias may be obtained by tapping r_c at a point furnishing the desired voltage. In the above example, with an operating current of 2 ma r_c would have to be tapped at 46,500 ohms (Fig. 3c) to furnish proper bias. The remaining 3,500 ohms are not by-passed by a condenser; such by-passing would destroy the balance of the signals while not serving any useful purpose. The inconvenience of tapping r_c, or splitting it into two odd-size resistors, however, usually makes the biasing arrangement shown in Fig. 3d preferable; R and r_c are again equal for push-pull output, but an additional resistor r_c' has been added, solely for the purpose of furnishing bias. A condenser is usually shown by-passing this resistor, but its effect is so slight on the performance of the stage (since it is usually small compared to r_c) that it may as well be omitted.

It was shown that such a stage cannot furnish amplification, i.e., that the two output voltages—or even a single one—appearing across r_c and R (with $R = r_c$) can never exceed the signal voltage. It should be pointed out that this is true only if the signal is introduced with respect to a point of fixed potential in the d-c system, such as is always the case in capacity coupled stages. If transformer coupling is used, as shown in Fig. 4a, the signal is seen to be introduced with respect to the cathode; under this condition the signal current flowing through r_c does not degenerate the signal and the stage will furnish the same amplification as a conventional stage with a load $R + r_c$ would, except of course, that the output is evenly divided between R and r_c. In this case, if self bias is used as shown in Fig. 4b, a by-pass condenser must be used, if degeneration is to be avoided.

Applications of Cathode Follower

As already mentioned, the true "cathode follower" or "infinite impedance" circuit is represented by the condition $R = 0$. Such circuits are of interest, for instance, when it is required to place a voltage divider for the purpose of voltage adjustment across a source not permitting any current drain. A well known case of this kind is the saw-tooth voltage obtained across the condenser in the usual sweep circuit for cathode-ray oscilloscopes. To adjust the sweep amplitude a voltage divider is needed across the condenser, which upsets the linearity of this voltage with time for low sweep frequencies. Such a stage can also be used as an infinite impedance detector, with a very linear characteristic. In both cases a graph showing the output voltage as a function of the input voltage is desirable. Such a graph is easy to construct if we use again the actual grid voltage as an intermediate link and as the independent variable. This procedure has at the same time the advantage of giving that value of the signal voltage at which we might expect grid current.

Example of Calculation of Cathode Follower

Suppose we use a 6C5 with a 350 volt supply, placing a 100,000 ohm resistor in the cathode lead. These values have been chosen so that we may use Fig. 2, which was representing the same case. We then prepare a table as shown below, using e_g as independent variable.

e_g	e_t	e_{rc}	e_s
0	41	309	309
—2	76	274	272
—4	108	242	238
—6	141	209	203
—8	172	178	170
—10	200	150	140
—12	225	125	113
—14	248	102	88
—16	271	79	63
—18	292	58	40
—20	312	38	18
—22	330	20	—2
—24	340	10	—14
—26	350	0	—26

In this table e_g = actual grid voltage, e_t = voltage across tube, e_{rc} = voltage across resistor in series with tube, and e_s = signal voltage. The signal voltage e_s, given in the last row, is obtained by adding the actual grid-to-cathode voltage e_g, given in the first row (negative values) to the voltage across r_c, given in the third row. The linearity, as shown in Fig. 5, from zero up to about 290 volts, where the table shows the actual grid voltage to be about −1 volt and where we might approach the point of grid current, thus losing the infinite impedance characteristic, is almost unbelievable. The use of a high quality resistor for r_c will convert a precision d-c milliammeter into a vacuum tube d-c voltmeter capable of high precision. To obtain a very linear detector or a-c vacuum-tube voltmeter capable of handling large signals, all we have to do is to apply the signal with a bias of 26 volts, as shown by the graph.

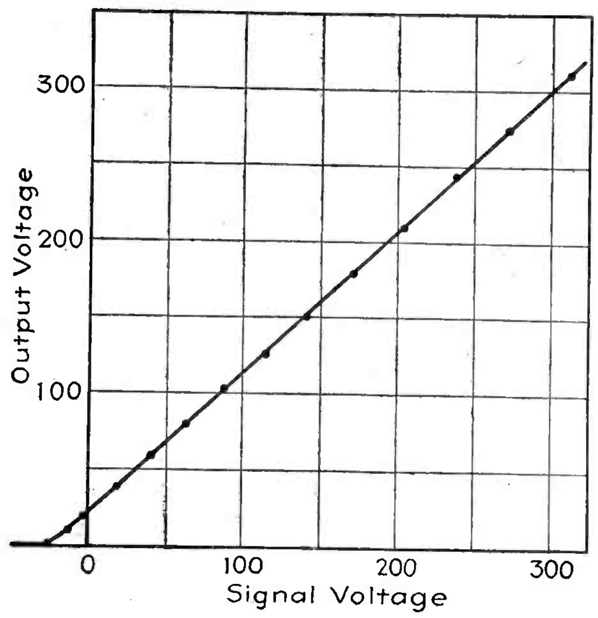


FIG. 5—Signal voltage, output voltage characteristics of cathode follower, showing wide range of linear operation

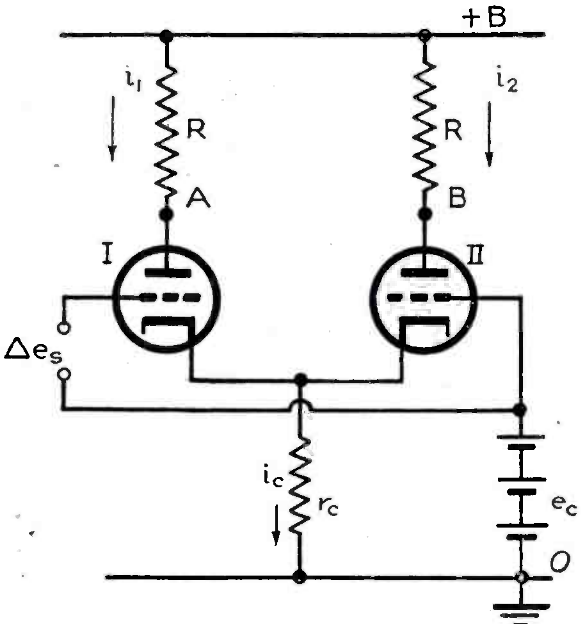


FIG. 6—Cathode resistor common to two tubes in parallel, with signal fed to grid of one tube

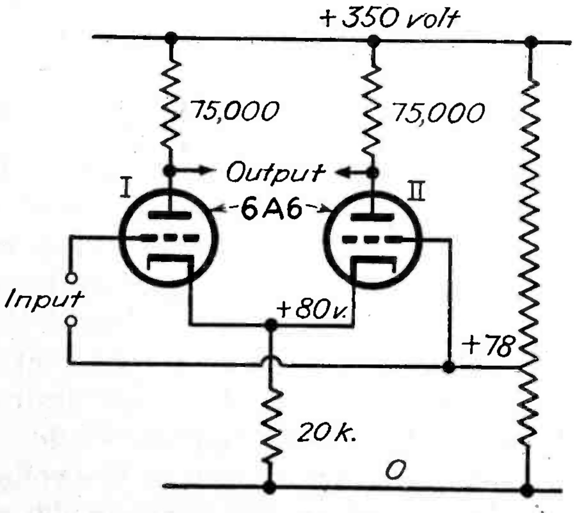


FIG. 7—Schematic circuits used to illustrate practical design of cathode follower arrangements

Of the greatest interest is the use of a cathode resistor common to two tubes, as shown in Fig. 6. The very valuable properties of this circuit were first recognized by Goldberg[3] and Schmitt,[5] apparently independently of one another.

Two Tubes as Cathode Phase Inverter

In the circuit shown in Fig. 6 the grid of tube II is held at a fixed potential with respect to ground by the bias voltage e_c (shown as obtained from a battery) while to the grid of tube I the same bias plus the signal is applied. Consider the time when the signal makes the grid of tube I more positive. The current in tube I then tends to increase; but this increase of current, passing through r_c, would like to make the cathode "follow," as explained before, and, with the two cathodes connected, the cathode of tube II will therefore become more positive with respect to its grid, or, what amounts to the same thing, the grid will become more negative with respect to its cathode. This causes a decrease of current in tube II; this decrease must be less, however, than the increase of current in tube I, otherwise the total current flowing in the cathode resistor would decrease, and the cathode could not change its potential in the direction just reasoned. The plate potentials of the two tubes, that is, the potential of the points *A* and *B* of Fig. 6 therefore change in the opposite direction: *A* becomes more negative, *B* more positive. The question arises immediately what these potential changes will be in relation to the signal applied to the first grid, and in relation to each other.

Before going into the exact treatment of this case, a quick insight may be had by a simple assumption. Let r_c be infinite, or at least very large. This would of course call for a very high voltage supply, since the drop across r_c must be covered by the supply. Under this condition the current i_c must remain substantially constant, since even a very small change would cause a large change of cathode potential. But since i_c is equal to the sum of i_1 and i_2, this means that any increase in i_1 must be accompanied by an equal decrease in i_2, and the cathodes have no other choice in responding to the application of the signal to the first grid, than to adjust their common potential to such a point that this condition will be fulfilled. For infinite r_c and linear operation of the tubes, this would obviously be the case, if the cathodes will "follow" just one half of the signal voltage change applied to the first grid. Thus, if the instantaneous value of the signal applied to the grid of tube I makes this grid let us say 4 volts positive, but if the cathodes follow 2 volts, then the actual grid voltage change on tube I will be 2 volts positive, on tube II 2 volts negative. Linear operation of the tubes assumed, the two plate currents will change equal amounts in opposite direction, thus keeping the current flowing in the common cathode resistor constant. The potential changes of point A and B are then also equal, but opposite in direction.

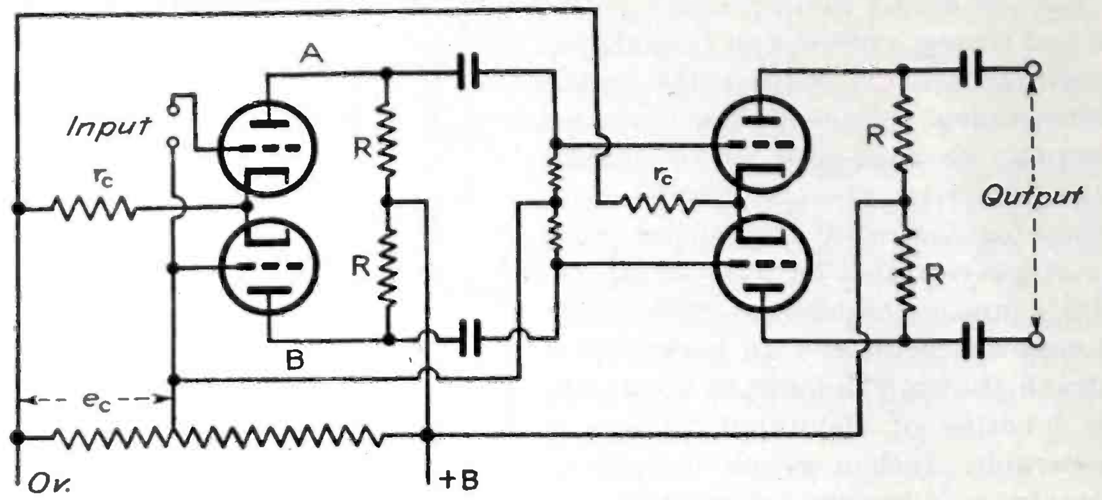


FIG. 8—Two stages of cascaded cathode followers

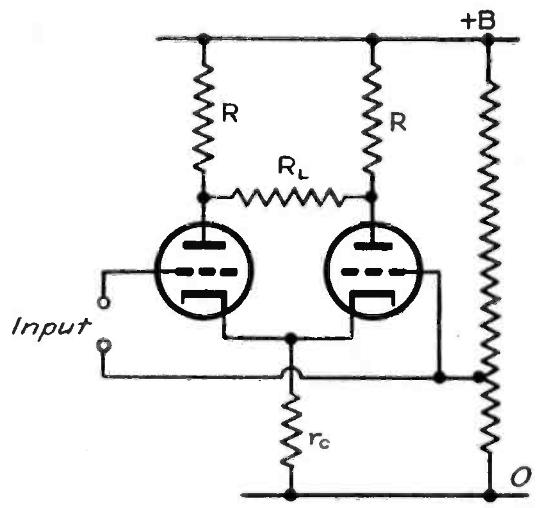


FIG. 9—Wiring diagram of two tubes in cathode follower circuit, with load taken between the two plates in a bridge arrangement

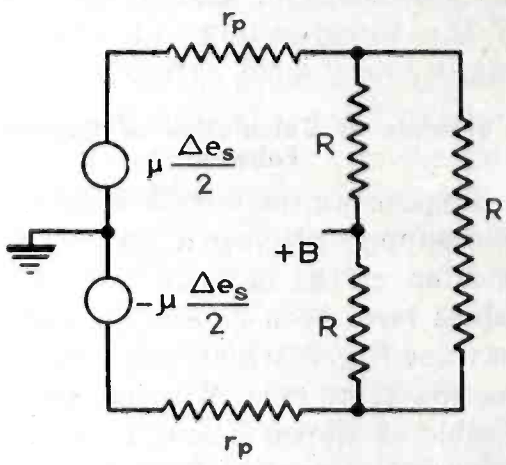


FIG. 10—Equivalent circuit for bridge type cathode follower circuit of Fig. 9

Simplified Analysis of Circuit Operation

The exact treatment of this case can be made rather involved, but it can also be made very simple by the proper method of attack.

Suppose we investigate what happens if we introduce signal voltages to both grids. Let us confine ourselves, however, to a condition where the same amount of signal voltage change is impressed on both grids, but once the two voltage changes are in phase, the other time out of phase.

If we change both grid potentials the same amount and in the same direction (by tying the two grids together, for instance) the two tubes will act just like one, with an r_p equal to one half of the r_p of each tube, and a load resistance also equal to one half of the load resistance of each tube. The total current change, due to a signal change $\Delta e_s'$ applied to both grids will be given by Eq. (5), with the proper values substituted. We obtain

$$\Delta i'_o = \Delta (i_1 + i_2) = \frac{\mu \Delta e_s'}{\frac{1}{2} R + \frac{1}{2} r_p + (\mu + 1)\, r_c} \qquad (8)$$

The plate current change of each tube will be one half of the value given by Eq. (8), that is

$$\Delta i'_1 = \Delta i_2' = \frac{\frac{1}{2}(\mu \Delta e_s')}{\frac{1}{2} R + \frac{1}{2} r_p + (\mu + 1)\, r_c} = \frac{\mu \Delta e_s'}{R + r_p + 2(\mu + 1)\, r_c} \qquad (9)$$

If we excite the grids in push-pull, that is, make grid II negative exactly the same amount that we make grid I positive, then, linear operation assumed, the current in tube I will increase as much as the current in tube II decreases. For i_o remaining constant, the cathode will not change its potential at all, and the current changes taking place can be calculated by means of the equivalent plate circuit theorem, as if the tubes were operating with fixed bias. Therefore, if we make grid I more positive by $\Delta e_s''$ while making grid II the same amount $\Delta e_s''$ more negative, the plate current changes will be

$$\Delta i_1'' = \frac{\mu \Delta e_s''}{R + r_p} ; \quad \Delta i_2'' = -\frac{\mu \Delta e_s''}{R + r_p} \qquad (10)$$

These two cases are therefore easily enough managed mathematically, but they are not what we are interested in. We want to know what happens if Δe_s is applied to one grid, while the other remains at a constant potential. But this desired change in grid potentials could be considered as the result of two steps: at first, we make both grids an amount $\Delta e_s/2$ more positive, while in the second step we make grid I an additional $\Delta e_s/2$ more positive, while making grid II more negative by the same amount. The total result of these two steps is obviously a change of Δe_s volts on the first grid, and zero change on the second grid. The current changes taking place during the first step are found by Eq. (9), substituting $\Delta e_s/2$ for $\Delta e_s'$, while the current changes due to the second step are found in a similar way by means of Eq. (10), with the substitution of $\Delta e_s/2$ for $\Delta e_s''$. Adding the results of these substitutions into Eq. (9) and Eq. (10) we obtain the total current changes Δi_1 and Δi_2:

$$\Delta i_1 = \frac{\mu \Delta e_s}{2}\left(\frac{1}{r_p + R} + \frac{1}{r_p + R + 2(\mu + 1) r_c}\right) = \frac{1}{2} \times \frac{\mu \Delta e_s}{r_p + R} \times \left(1 + \frac{r_p + R}{r_p + R + 2(\mu + 1)\, r_c}\right) \qquad (11)$$

$$\Delta i_2 = -\frac{\mu \Delta e_s}{2}\left(\frac{1}{r_p + R} - \frac{1}{r_p + R + 2(\mu + 1)\, r_c}\right) = -\frac{1}{2}\, \frac{\mu \Delta e_s}{r_p + R} \times \left(1 - \frac{r_p + R}{r_p + R + 2(\mu + 1)\, r_c}\right) \qquad (12)$$

Designating

$$F = \frac{r_p + R}{r_p + R + 2(\mu+1)r_c}$$

we could call this factor the "deviation factor from true push-pull output." For $r_c = \infty$ the value of this factor becomes zero, and the two current changes are equal in size and opposite in sign, as we had already reasoned out for this case. The amount of change is seen to be the same as if one half of the signal, i.e. $\Delta e_s/2$ had been applied to each tube under fixed bias condition.

Often the voltage between points A and B alone is of interest, without regard of the distribution. This voltage is given by:

$$\Delta e_{AB} = \Delta i_1 R - \Delta i_2 R = \frac{1}{2}\frac{\mu \Delta e_s R}{(r_p + R)}(1 + F + 1 - F) = \frac{\mu \Delta e_s R}{R + r_p}$$

This is an important result: it shows the total output voltage to be independent of the cathode resistor and just as large as if the signal had been applied to one tube only, this tube working with conventional fixed bias condition.

Example of Design Procedure

Again an example may show most quickly the relations and procedure. For each triode section of a 6A6 the following values were read from the curves:

$e_p = 120$ volts
$e_g = -2$ volts
$i_p = 2$ ma
$\mu = 35$
$r_p \cong 25{,}000$ ohms

Suppose a 350 volt d-c supply is available for the operation of the stage, and that we were willing to let the load consume 150 volts. Load and tube would therefore take 270 volts, leaving 80 volts for the cathode resistor. A current of 2 ma in each tube and 4 ma in the cathode resistor gives then the resistor values shown in Fig. 7. The grid bias will have to be −78 volts. If a one-volt signal is placed on the grid of the first tube, according to Eq. (12) the *total* output voltage (that is the voltage e_{AB}) will be,

$$e_{AB} = \frac{35 \times 1 \times 75{,}000}{75{,}000 + 25{,}000} = 26.25 \text{ volts}$$

If the output were true push-pull, the voltage change of point A and of point B would each be exactly one half of the total output, or 13.125 volts. Actually the voltage swing of points A and B (Fig. 6) will be:

$$e_A = 13.125 \times (1 + F)$$
$$e_B = 13.125 \times (1 - F)$$

The two output voltages are of opposite polarity, or, in the case of a-c, of opposite phase. In our case F is

$$F = \frac{r_p + R}{r_p + R + 2(\mu + 1) r_c} = \frac{25{,}000 + 75{,}000}{25{,}000 \times 75{,}000 + 72 \times 20{,}000} = \frac{100{,}000}{100{,}000 + 1{,}440{,}000} = \frac{100}{1{,}540} = \frac{1}{15.4} = 0.065$$

Therefore

$$e_A = 13.125 + \frac{13.125}{15.4} = 13.125 + 0.852 = 13.977$$

$$e_B = -13.125 + \frac{13.125}{15.4} = -13.125 + 0.852 = -12.273$$

Improving Balance

For many applications this unbalance of approximately 14 percent would not be of any consequence. If a closer balance is required, it is of course possible to tap the load resistor of the first tube at the appropriate place, and take the output from this tap instead of point A. Another method of improving the balance, used by Goldberg in later modifications of his high gain d-c amplifier, is based on replacing r_c by a pentode. Since in all our derivations we are interested only in variational resistances, that is in the ratio of voltage change to current change, use can be made of the very high plate resistance of a pentode, approaching values near one megohm, without the need of the high voltage supply which a regular one megohm resistor would require. If values of several hundred thousand ohms are introduced in the expression for the deviation factor, F, it is seen to approach zero for all practical purposes. Since the plate characteristics of pentodes remain flat to relatively low plate voltages, the advantage of a high r_c can be had without sacrificing a large amount of voltage over it.

Cascaded Cathode Phase Inverters

If two or more stages with cathode resistors are cascaded, as shown in Fig. 8, a considerable improvement of balance results, due to the fact that the signal applied to the grid of the second stage is already essentially a push-pull signal. The small unbalanced part of this signal—in the above discussed example about 14 percent—will again be mostly converted into a push-pull signal, so that the unbalance of output in the second stage could be called of second order. In this particular case calculations show that with an over-all amplification of $26.25^2 = 689$ for two identical stages, the two 180 deg. out-of-phase output voltages will differ less than one percent from each other. With the tolerances of commercial resistors and with the tubes hardly matching that closely, this is obviously an entirely theoretical value; the actual unbalance might be more or less than this calculated value.

Another interesting arrangement results if a load is connected between points A and B. This load may be a milliammeter such as found in vacuum-tube voltmeters of the type of the RCA Voltohmyst. The fundamental circuit is shown in Fig. 9. The current in the load, and the current changes in the resistors R due to the application of an input voltage can again easily be predicted by means of the same reasoning as in the open circuit case. The application of Δe_s on the grid of the first tube can be considered as the result of two steps, as before: (1) Voltage of both grids changed by $\Delta e_s/2$ in the same direction; (2) Voltage of first grid increased an additional $\Delta e_s/2$ in the same direction, second grid $\Delta e_s/2$ in the opposite direction. During the first step the current in both plate resistors will increase the same amount, but no load current will result; the second step represents pure push-pull operation, on which the value of r_c has no influence. The equivalent circuit for this case is shown in Fig. 10. The current in the load is given by

$$i_L = \frac{\mu \Delta e_s}{2 r_p + \dfrac{2RR_L}{2R + R_L}} \times \frac{2R}{2R + R_L} \qquad (13)$$

$$= \frac{\mu \Delta e_s R}{r_p(2R + R_L) + RR_L} = \frac{\mu \Delta e_s}{R_L\left(1 + \dfrac{r_p}{R}\right) + 2 r_p}$$

If the load is a relay, instead of a meter, it will be desirable to make its resistance of such value that the maximum power will be obtained in the coil, or stating it in a different manner, that operation will result with the smallest possible input. The value of R_L giving the best match can be found by forming the expression for the power in the coil, $P = i_L^2 \times R_L$, with the value for i_L from Eq. (13) substituted into

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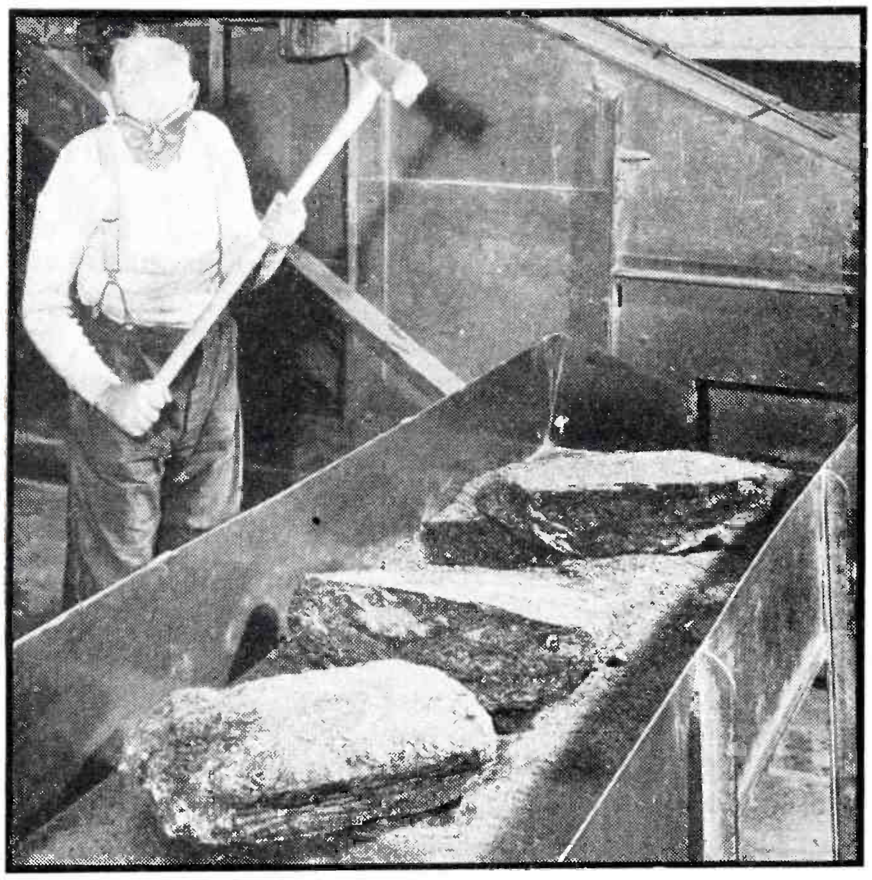
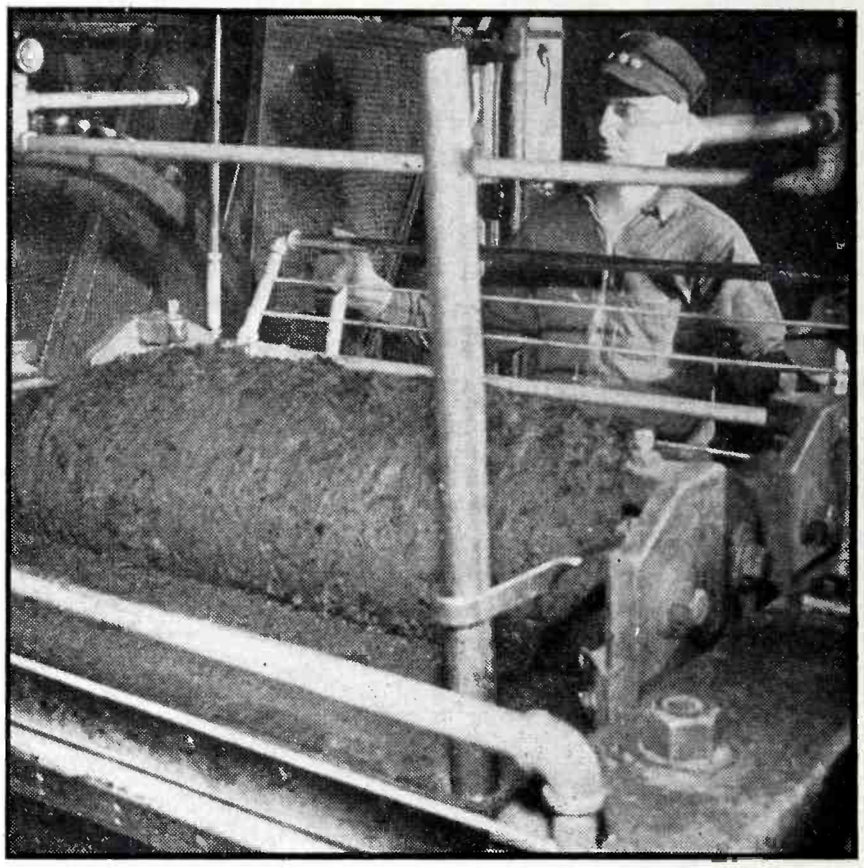
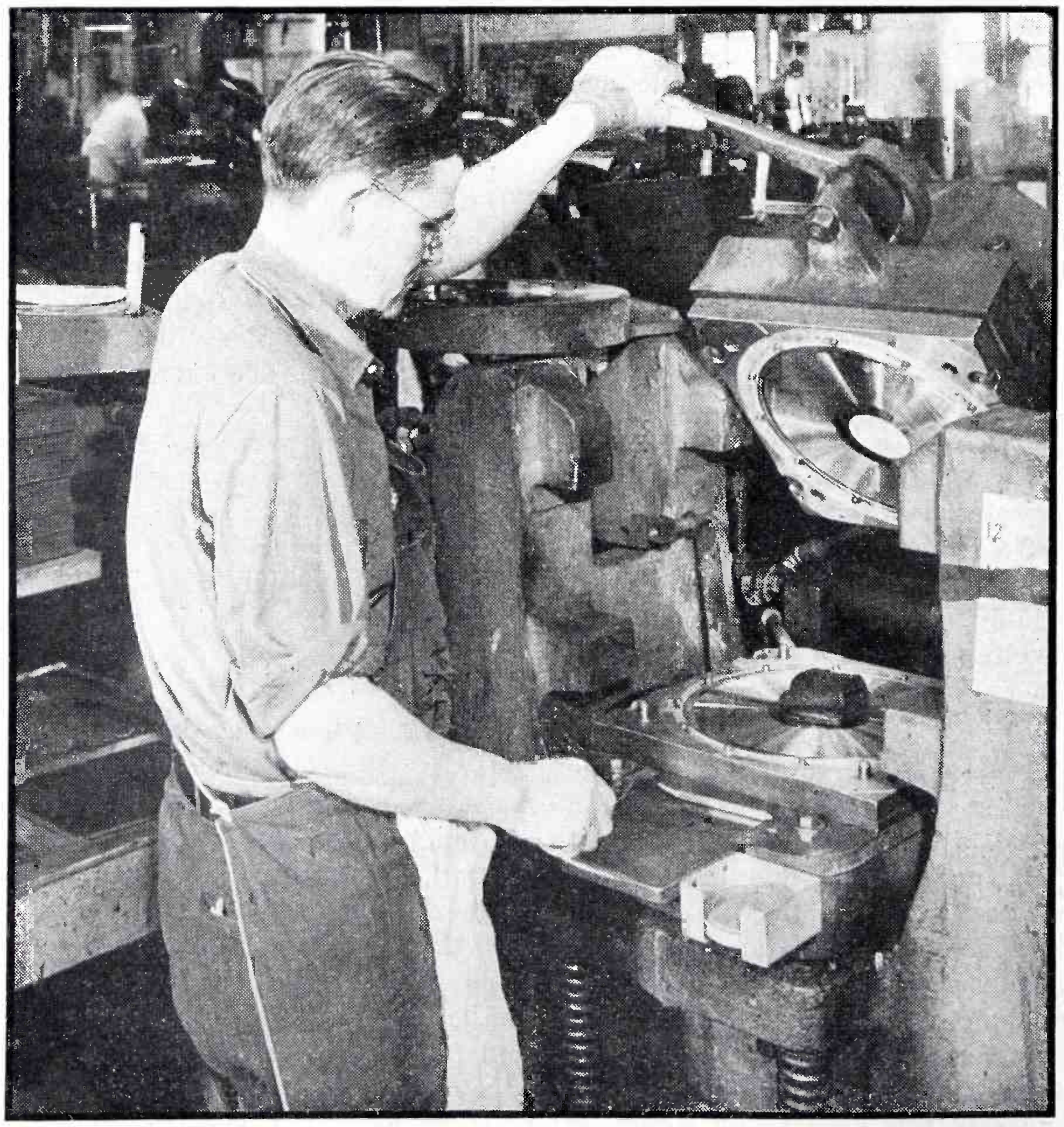
BREAKING UP SHELLAC



PREPARING A MIX



RECORDS in the

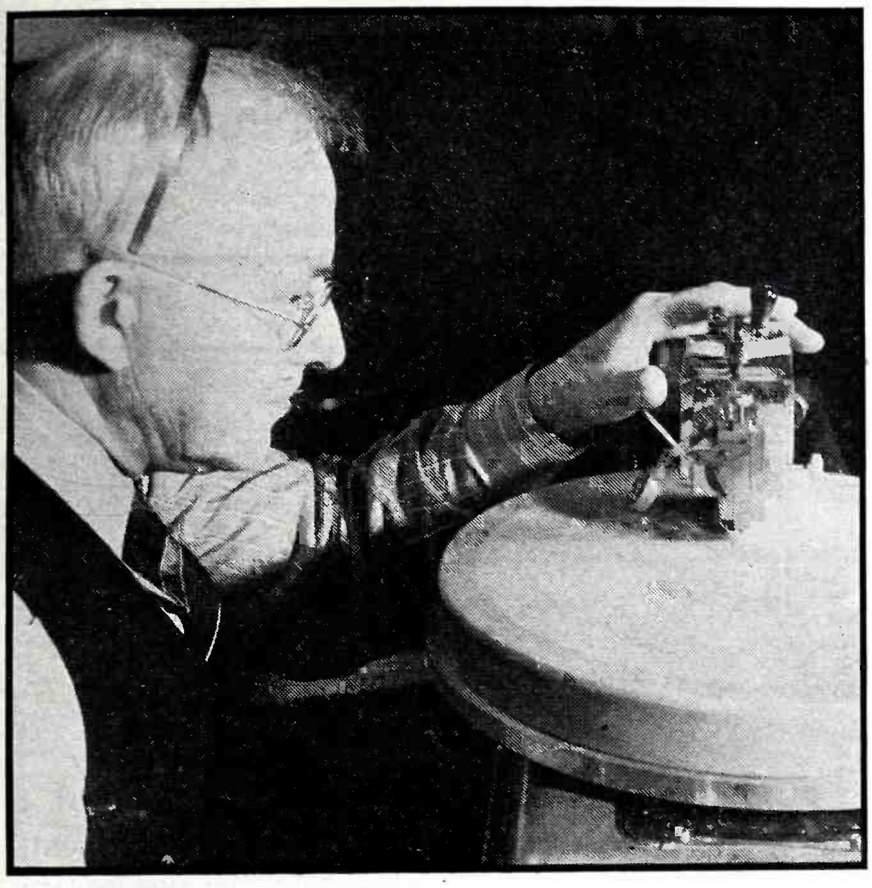


PRESSING A BISCUIT

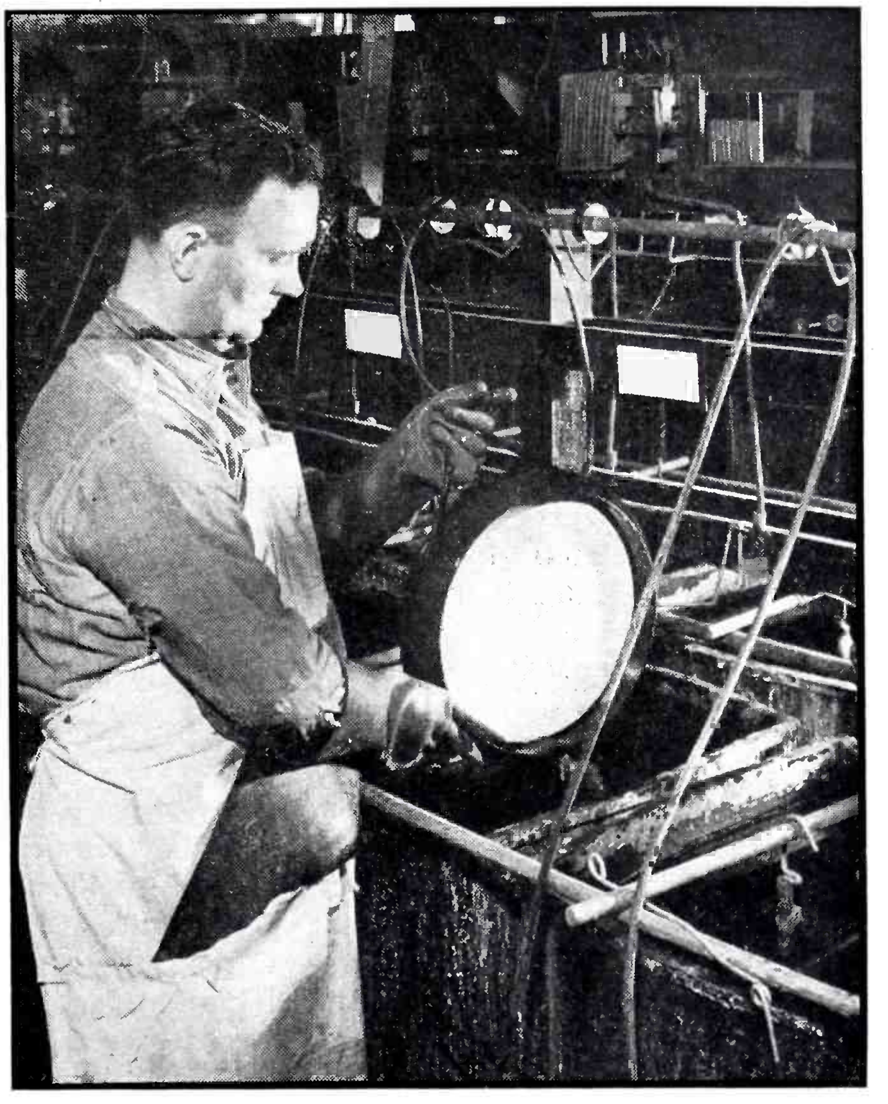
New series of photos shows some of the steps in the manufacture of discs for the public, biggest wartime business in the entertainment field of electronics. Reclaiming of old platters helps bolster the supply of critical materials

Photos by
EWING GALLOWAY

CUTTING ORIGINAL WAX



PLATING THE MASTER



MAKING

BIGGEST wartime business in the entertainment field of electronics, manufacture of phonograph records proceeds at a healthy pace despite a shortage of shellac and restrictions which prevent normal publicizing of platters over the air.

Some of the interesting processes of manufacture are shown here, in a new series of pictures taken in the Camden, New Jersey plant of the Radio Corporation of America's RCA Victor Division.

Breaking Up Shellac, an initial step shown in the photograph captioned with these three words, involves the swinging of a sledge by a millworker just before the material is carried to a grinder and pulverizer.

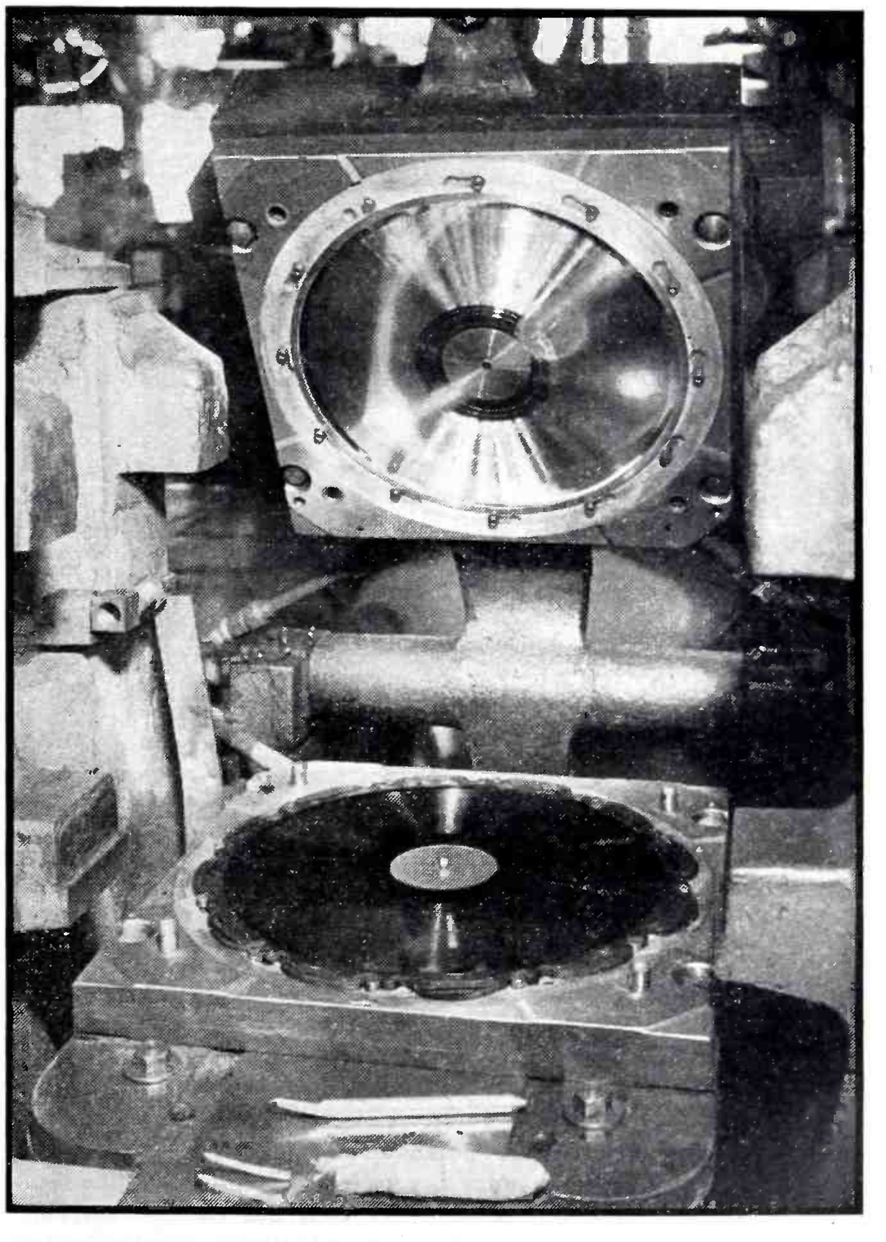
Preparing A Mix of shellac and other essential materials which are carefully weighed and batched, expert workmen deliver the complete plastic to a machine which rolls and forms it into "biscuits."

Cutting Original Wax in the recording studio is followed by the addition of the eccentric groove near the center which operates automatic stops and repeat mechanisms on the user's playback machine. This critical mechanical chore is pictured.

Plating The Master preserves it for posterity and also permits it to be used in the manufacture of "stampers" from which actual commercial pressings are made.

Pressing A Biscuit of plastic involves the use of a "stamper" and the application of 200 lb of pressure per square inch. A pre-heating grill for the cold biscuits may be seen at the left of the operator.

The Finished Record is removed from the press and is ready for labelling and packaging after the operator removes rough outside edges.



THE FINISHED RECORD

MASS SPECTROMETER Aids Research

Supplementing chemical analysis in many important industrial and manufacturing operations, the electronic mass spectrometer quickly and accurately determines the mass-to-charge ratio of ions and permits determination of constituents of mixtures

By JOHN A. HIPPLE *Research Laboratories, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.*

FIVE years ago if the practical engineer working in industry had heard of the mass spectrometer at all, he considered it a gadget that physicists in the university laboratories used for fundamental research. Furthermore he would usually associate it with Aston's work on the detection and measurement of the masses of the isotopes. However, today more and more engineers responsible for industrial research and control problems are realizing the possibilities of the mass spectrometer in their own particular fields. A contributing factor in this change has been the recent strides in developing practical electronic instruments for such work. It is the purpose of this article to acquaint executives and engineers working in the field of electronics with recent improvements and industrial potentialities of the mass spectrometer.

Since the first mass spectrograph was constructed a quarter of a century ago, there has been a gradual development of different types of instruments down through its interesting history. However, it is well to

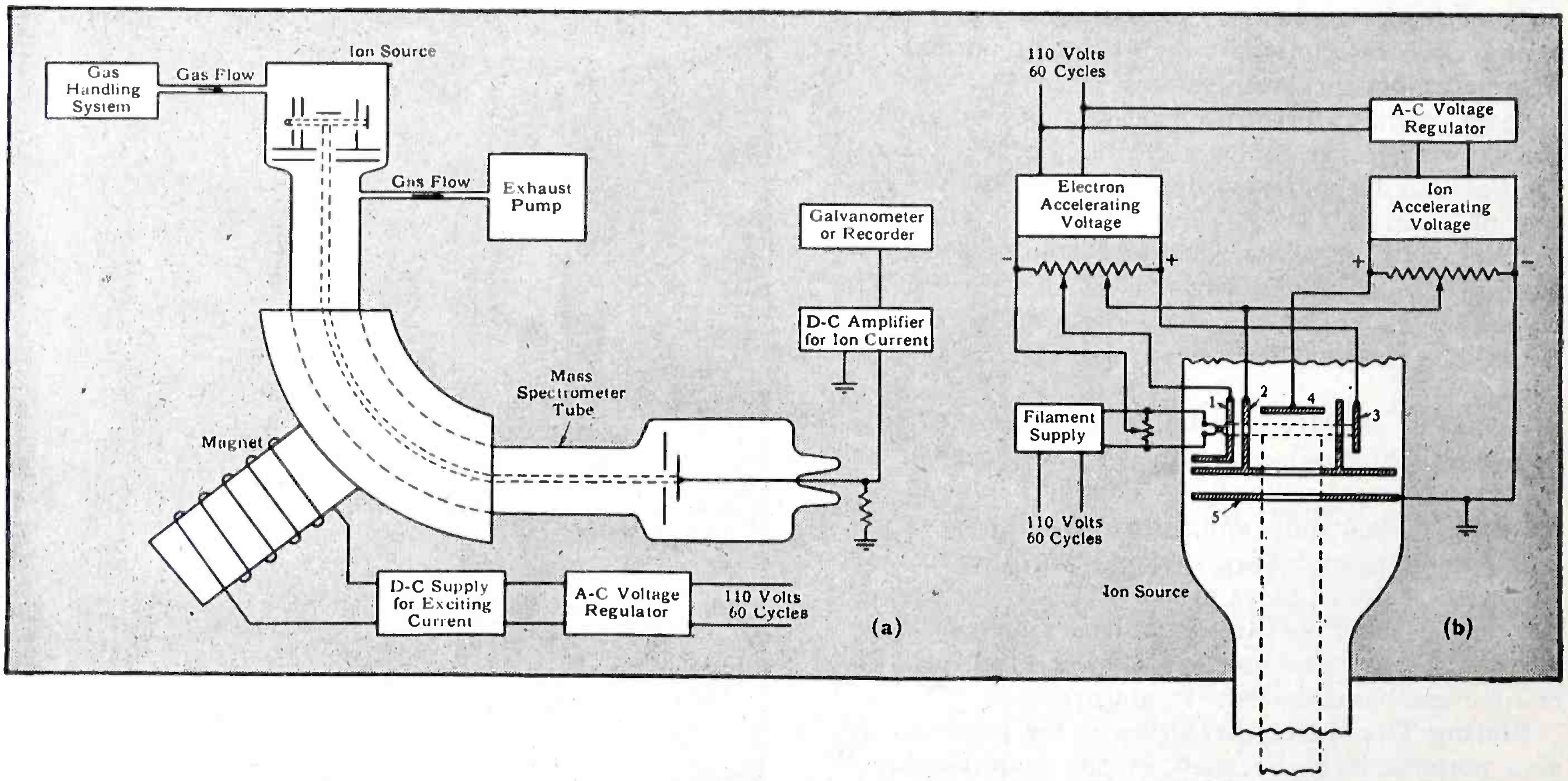
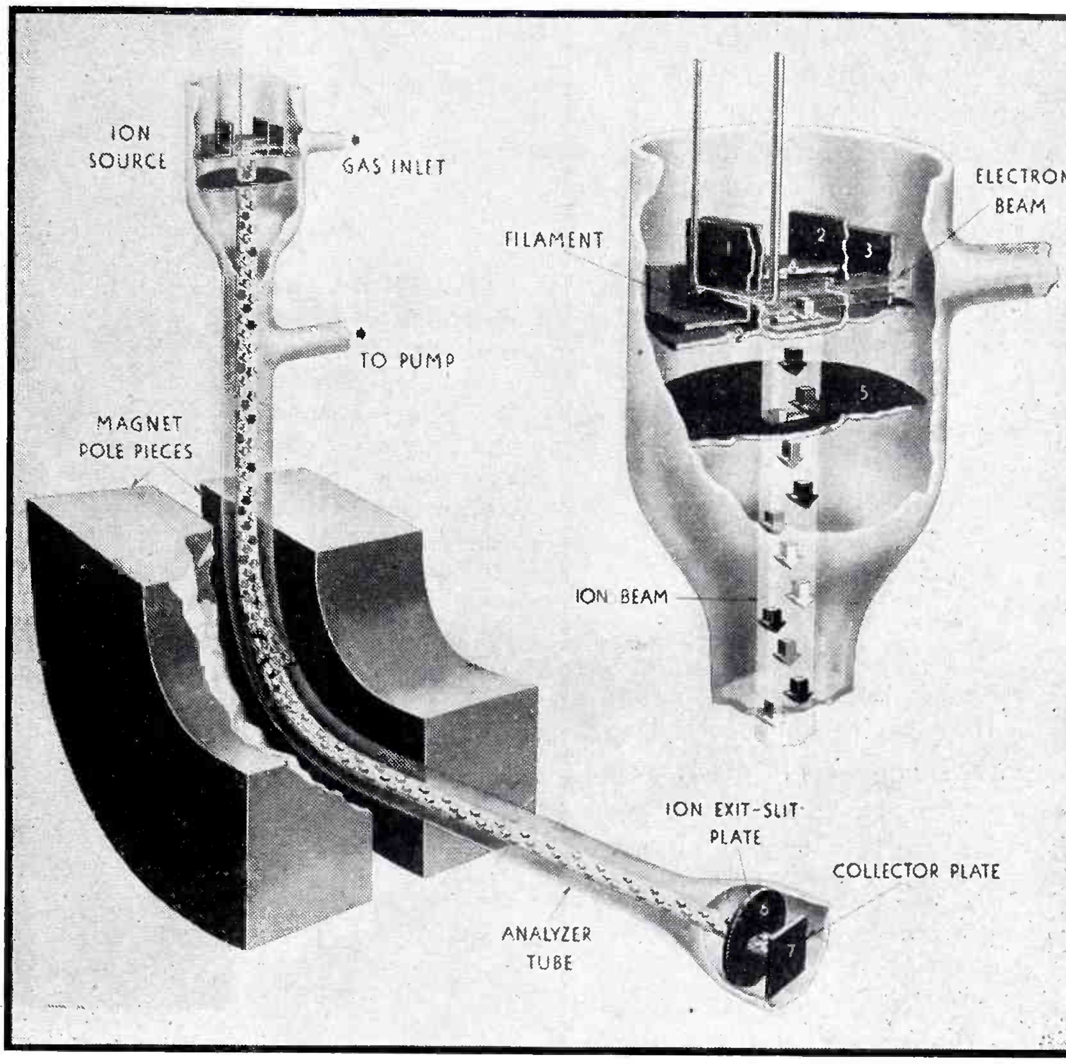


FIG. 2—Elements of mass spectrometer showing (a) a general schematic and (b) a close-up of connections at ionizing source. The magnet coil providing the proper perpendicular field to bend the ions is excited by 100 ma at 1000 volts. This power is provided with an electronic regulator. The ion accelerating voltage is then tapped off a decade potentiometer in parallel with the magnet, powered from the same source as the magnet. Since the ion accelerating voltage will increase with the magnet current (and hence the magnetic field) some additional regulation is obtained. Additional regulators supply the electron accelerating voltage, the electrometer tube amplifier for the ion current, and the current heating the filament supplying the electrons. All batteries have been eliminated with the exception of a few dry cells having a very small current drain, and principally used as reference voltage

For simplicity at (a) the electron gun has been twisted 90 deg. with respect to the ion beam in order to show all the tube elements more clearly. At (b) the electron beam is shown travelling parallel to the length of the ion slit, as is usual in mass spectrometers

FIG. 1—Phantom views of mass spectrometer, one general and the other a close-up of the ionizing structure. The sample of gas to be analyzed is admitted by a capillary leak, and the electron beam ionizes some of the molecules of the gas sample. A difference in potential draws the ions through the first slit and accelerates them to the second slit, where they emerge as a beam. This ion beam travels straight down the tube until the magnetic field bends the ions into a circular path. By proper adjustment of the ion accelerating voltage and magnetic field, ions of a particular mass (i.e. mass divided by charge) follow the curve of the tube and emerge through the exit slit. Here the ions are caught by a Faraday cage and the current corresponding to this particular mass is measured.

The resolution of a mass spectrometer is a function only of the radius of curvature of the ion beam in the magnetic field and the widths of the entrance and exit slits. The angle of deflection in the magnetic field is immaterial. Therefore, a 90 deg. deflection is used instead of 60 deg. to shorten the path and reduce probability of collision in the analyzer, simplify focusing and mounting, and to obtain sturdy mechanical assembly



keep in mind that the "mass spectrograph" and "mass spectrometer" are not the same. The mass spectrograph is an instrument used for the specialized problem of accurately measuring the masses of the elements and the exit slit is replaced by a photographic plate. The mass spectrometer uses the exit slit for escape of the ions and makes electrical measurement of the magnitude of the current, sometimes even recording it.

The big advantage of the mass spectrometer is its ability to measure quickly and accurately the magnitude of the current corresponding to the different ions in the tube. Undoubtedly the mass spectrometer will be applied to the automatic continuous control of many processes. Another very promising field of particular interest to the readers of ELECTRONICS, is its use in the study of the outgassing and leakage rate of various vacuum vessels, possible improvements in rectifiers, fluorescent lamps, and other devices that depend on a gaseous electric discharge for their operation.

To understand its possibilities for industry, let us consider a typical mass spectrometer that is in general use today for gas analysis and related problems. Figure 1 shows the heart of the mass spectrometer.

Mass Spectrometer Principles

Electrons emitted by the filament in the ion source are accelerated through the slits in the electrodes in the electron "gun" and form the electron beam as shown. The voltage and current of this beam are very carefully controlled. The ions formed by the impact of the electrons on the gas molecules just below electrode 4 are urged through the long slit in electrode 2 by a small potential difference between 4 and 2. The ion beam thus formed by this slit is then accelerated by a much larger potential difference between 2 and 5, the latter being at ground potential. Passing through the slit in 5, the narrowly collimated beam enters the analyzer region—a tube with a grounded metallic shield on the inside. Thus far the beam contains all the types of ions that were formed by the electron beam in

MASS SPECTROMETER USES

Tracing stable isotopes

Analyzing traces of gas in a mixture

Providing more rapid and complete analyses of mixtures

Making analyses when only small samples of gas are available

Continuous indication of changing composition during a process, such as the gas atmosphere in heat-treating furnaces

the ionization region. However, at this point the ion beam is caused to pass between the pole pieces of an electromagnet. As the magnetic field in this gap is perpendicular to the direction of motion of the ions, the ions are bent into circular paths; the principle involved is exactly like that causing the deflection of the electron beam in a magnetic oscillograph.

Since the ions have different masses, the radius of curvature of the different types of ions will be different. The radius of curvature in the uniform magnetic field is given by $r = \frac{c}{H}\sqrt{\frac{VM}{150e}}$ where r is expressed in centimeters, H in gausses, V is the potential difference in volts by which the ions have been accelerated, c is the velocity of light (3×10^{10} cm per second), e is the electronic charge (4.8×10^{-10} e.s.u.) and M is the mass of the ions in grams. Thus it is seen that for a given V and H the radius of curvature depends on the ratio M/e. Since the singly charged ions are most abundant, the discussion here can be limited to these and we can then consider that the radius of curvature is dependent only on the mass of the ion.

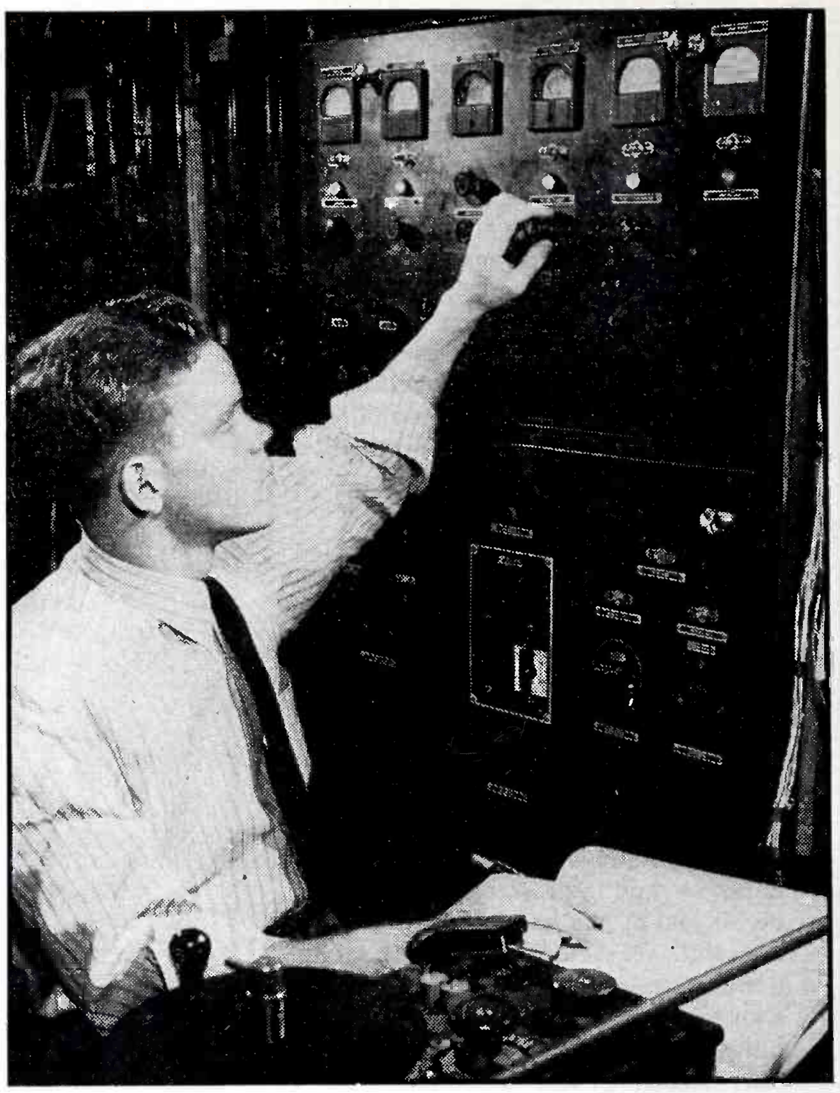


FIG. 3—Three views (front view showing operating panel, side view with cover open, and close-up of gas-flow valves) of the modern mass spectrometer discussed in the text. It operates from a 110 v, 60 cps line, drawing 15 kw

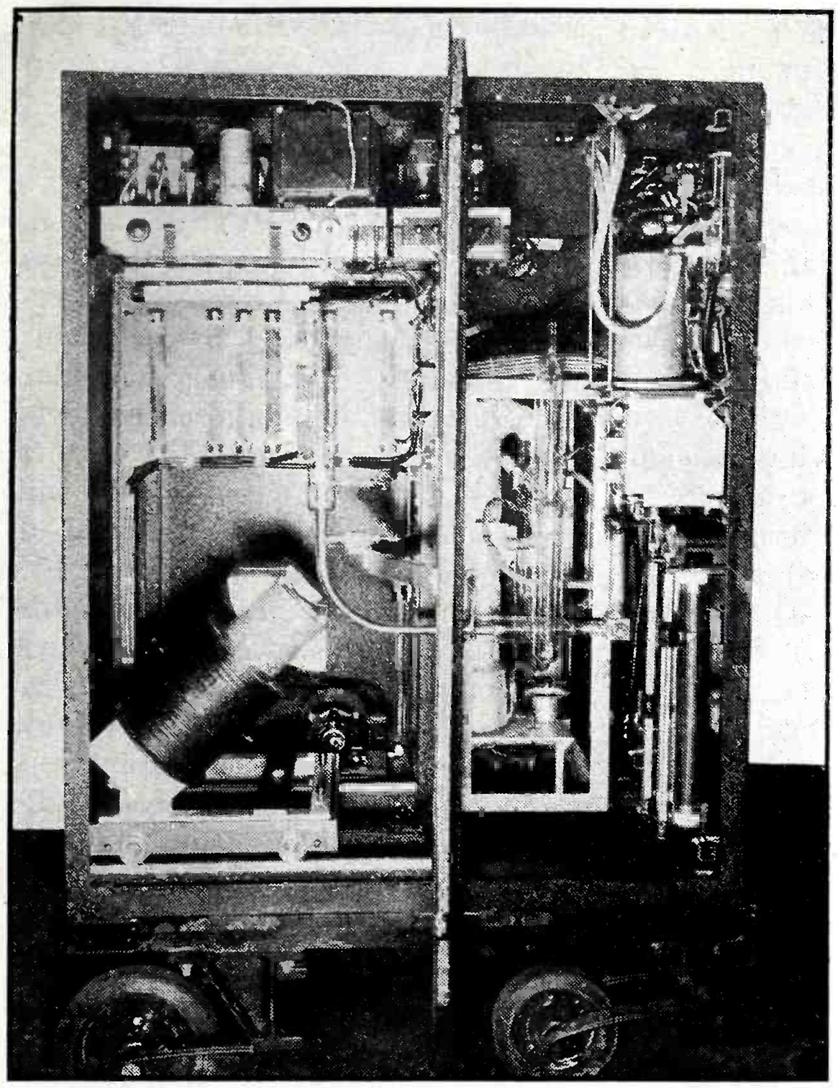
The ion accelerating voltage V and the magnetic field H can be so adjusted that ions of any desired mass will emerge from the magnetic field in Fig. 1 and pass through the exit slit of the mass spectrometer to the collecting electrode. The current reaching this electrode is amplified and measured and the amount of this current is a measure of the number of molecules of this species in the mass spectrometer. With the fields adjusted for the measurement of this particular mass, all other masses suffer greater or less deflection in the magnetic field and are lost on the grounded shield on the interior of the analyzer. After measuring the current corresponding to ions of this particular mass any other mass desired may be focused on the exit slit and measured by suitably adjusting either V or H or both.

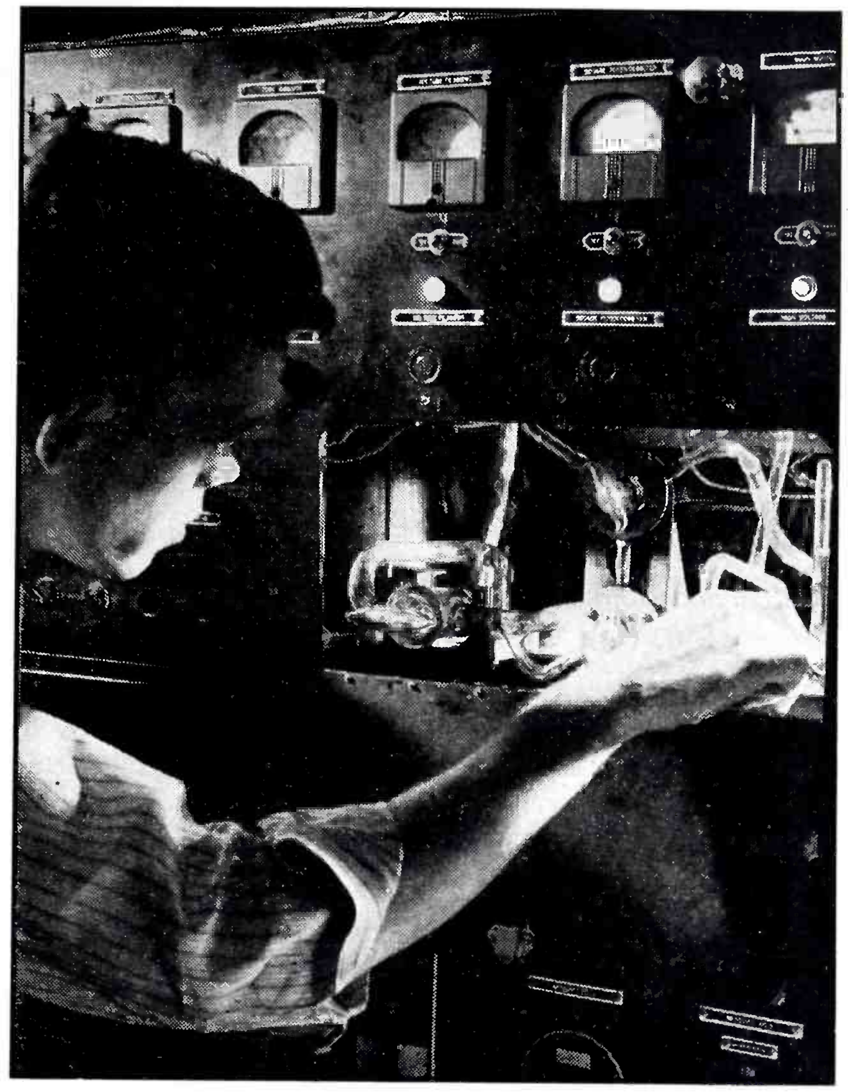
A simple example of the functioning of the apparatus is the analysis of the amount of oxygen and nitrogen in that common gas mixture, air. First a blend of oxygen and nitrogen of carefully measured proportions is prepared and allowed to flow through the mass spectrometer tube as indicated in Fig. 2. We now have ions of nitrogen and oxygen emerging from the ion source into the analyzer. The fields are adjusted so that mass 28 (nitrogen) is focused on the exit slit of the mass spectrometer and the

ANALYSIS OF SYNTHETIC BLENDS

Comparison of known values of the samples, with values determined by the mass spectrometer (M.S.)

Blend No.		1	2	3	4	5
% $i\text{-}C_4H_{10}$	Syn.	22.4	41.6	....	24.4	51.9
	M.S.	23.4	41.7	....	24.0	52.0
% $n\text{-}C_4H_{10}$	Syn.	25.4	41.2	....	14.2	48.1
	M.S.	26.1	41.4	....	13.7	48.0
% $\alpha\text{-}C_4H_8$	Syn.	26.2	....	3.7	....	....
	M.S.	25.3	....	4.1	....	....
% cis-βC_4H_8	Syn.	....	....	18.3	25.6	....
	M.S.	....	....	20.0	26.6	....
% trans-$\beta\text{-}C_4H_8$	Syn.	....	....	31.1	....	....
	M.S.	....	....	28.6	....	....
% $\gamma\text{-}C_4H_8$	Syn.	26.0	....	....	28.8	....
	M.S.	25.1	....	....	28.6	....
% 1, 3-C_4H_6	Syn.	....	17.2	46.9	7.0	....
	M.S.	....	16.9	47.3	7.1	....
% Air	Syn.	0	0	0	0	0
	M.S.	0.30	0.42	....	0.16	0.49





current measured. (The atomic weight scale will be used henceforth to differentiate between the various masses). Mass 32 (oxygen) being heavier is not deflected as much by the magnetic field and is lost on the grounded interior of the analyzer. The fields are then readjusted so that the current corresponding to mass 32 may pass through the exit slit and be measured. The instrument is now calibrated for nitrogen and oxygen in any proportions and if air is passed through the mass spectrometer, we can quantitatively determine the composition.

Magnitudes of Quantities

It will be useful to have in mind the order of magnitude of the quantities involved in the proper operation of the mass spectrometer. For instance, some question may arise about the extension of the above calibration to mixtures in which the relative proportions are far removed from that for which the calibration was made —in other words, the linearity of the ion current corresponding to a particular substance as a function of its partial pressure in the mixture. It is immediately clear that the mean free paths (average distance one molecule will travel before striking another) of both electrons and ions are long compared with the dimensions of the apparatus. The sample flows through the instrument continuously during the analysis and the pressure is lower than 10^{-4} mm of Hg. Thus the probabilities of interaction between molecules or of multiple collisions by an electron are small. The electron current in the beam responsible for the ionization is the order of 10 microamperes.

The ion current emerging from the exit slit of the mass spectrometer is 10^{-10} to 10^{-15} ampere. Usually a potential of about 1000 volts is used for the ion accelerating voltage, and for routine analyses the electron accelerating voltage is less than 100 volts. In a typical instrument the radius of curvature of the ion beam in the magnetic field would be 10 to 15 cm.

All of the power packs must be very carefully stabilized. The magnetic field and the ion accelerating voltage should be constant to one part in five or ten thousand. The essential components of a mass spectrometer are outlined in Fig. 2. Photographs of an instrument are shown in Fig. 3 and many of the vital parts shown in Fig. 2 may readily be recognized.

Practical Applications

In discussing the applications of the mass spectrometer it should first be appreciated that most of the problems of interest today are not as simple as the example using air. Even in air there are other masses present which were not mentioned. Let us consider nitrogen in more detail. There are two isotopes, (elements having the same chemical properties but different masses), N^{14} (mass 14) and N^{15} (mass 15), the latter being roughly 1 percent of the former. Thus the largest peak present will be mass 28 formed by the ion $N^{14}N^{14+}$ (the symbol + being used in the conventional manner to indicate that the nitrogen molecule composed of the two nitrogen atoms of mass 14 is positively charged or ionized.) However, there will be a weak peak at mass 29 ($N^{14}N^{15+}$) and an extremely weak one at mass 30 ($N^{15}N^{15+}$). For the use of N^{15} as a tracer in chemical or biological studies the mass 29 peak would be of importance. All of these peaks are formed by simple ionization of the nitrogen molecule by electron impact. When the electron hits the nitrogen molecule it may dissociate the molecule, producing an atomic nitrogen ion. Considering only the more abundant isotope N^{14} the simple ionization gives a peak at mass 28 whereas the combination of dissociation and ionization gives a peak at mass 14. Thus:

Simple ionization $N_2 \rightarrow N_2^+ + e^-$ (ion at mass 28)

Ionization and dissociation $N_2 \rightarrow N^+ + N + e^-$ (ion at mass 14)

where e^- represents the electron ejected in the reaction. In this case simple ionization is far more probable; i.e. the ion current corresponding to mass 28 is much larger than that at mass 14.

In some cases it is more probable to dissociate the molecule by electron impact than it is simply to ionize it. This is particularly true of hydrocarbons. For instance in normal butane (C_4H_{10}) with a parent mass at 58, the largest mass in the spectrum is at mass 43. Thus:

$C_4H_{10} \rightarrow CH_3 + C_3H_7^+ + e^-$ (ion at mass 43)

A great deal of study has been made in recent years on the energy of the electron beam at which these various fragments appear and it has been possible to correlate these results with thermochemical data.

In a molecule like normal butane with a large number of component atoms many masses are present in the mass spectrum due to the dissociation of the molecule by electron impact. A portion of the spectrum is shown in Fig. 4. This spectrum may be obtained by continuously varying either the ion accelerating voltage or the magnetic field. This so-called "cracking pattern" is helpful in an analysis of a mixture of iso-butane and its isomer, normal butane. (Isomers are substances having the same molecular weight and composed of the same component atoms, but differing in some chemical properties due to differences in the arrangement of the component atoms.) The cracking patterns differ in the two cases and an analysis can be made in spite of the fact that both parent masses are the same. In the region shown on the record the successive masses correspond to the splitting of a successively greater number of hydrogen atoms from the parent ion C_4H_{10}. The peak at mass 59 is contributed by the heavy carbon isotope C_{13}. In other cases the "cracking pattern" causes complications since the butanes contributed masses at all points in the mass spectrum at which hydrocarbons of lower mass would appear. For instance an analysis of a mixture of iso-butane and butadiene (C_4H_6 with the parent ion at mass 54) would require that we first subtract the contribution to mass 54 from the iso-butane; the remainder of the current at mass 54 is then contributed by the butadiene. As all the equations are linear, this problem can be set up mathematically and solved readily for a fairly complicated system.

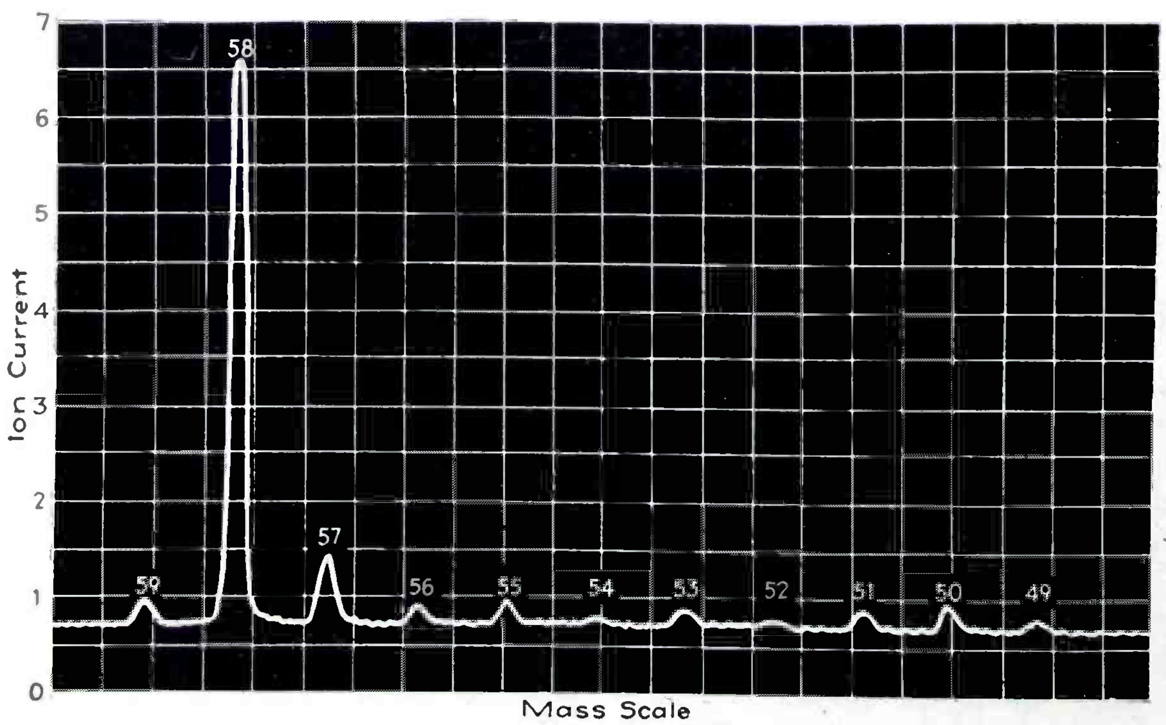


FIG. 4—Portion of the spectrum of normal butane (C_4H_{10}) showing C_4 region of the spectrum

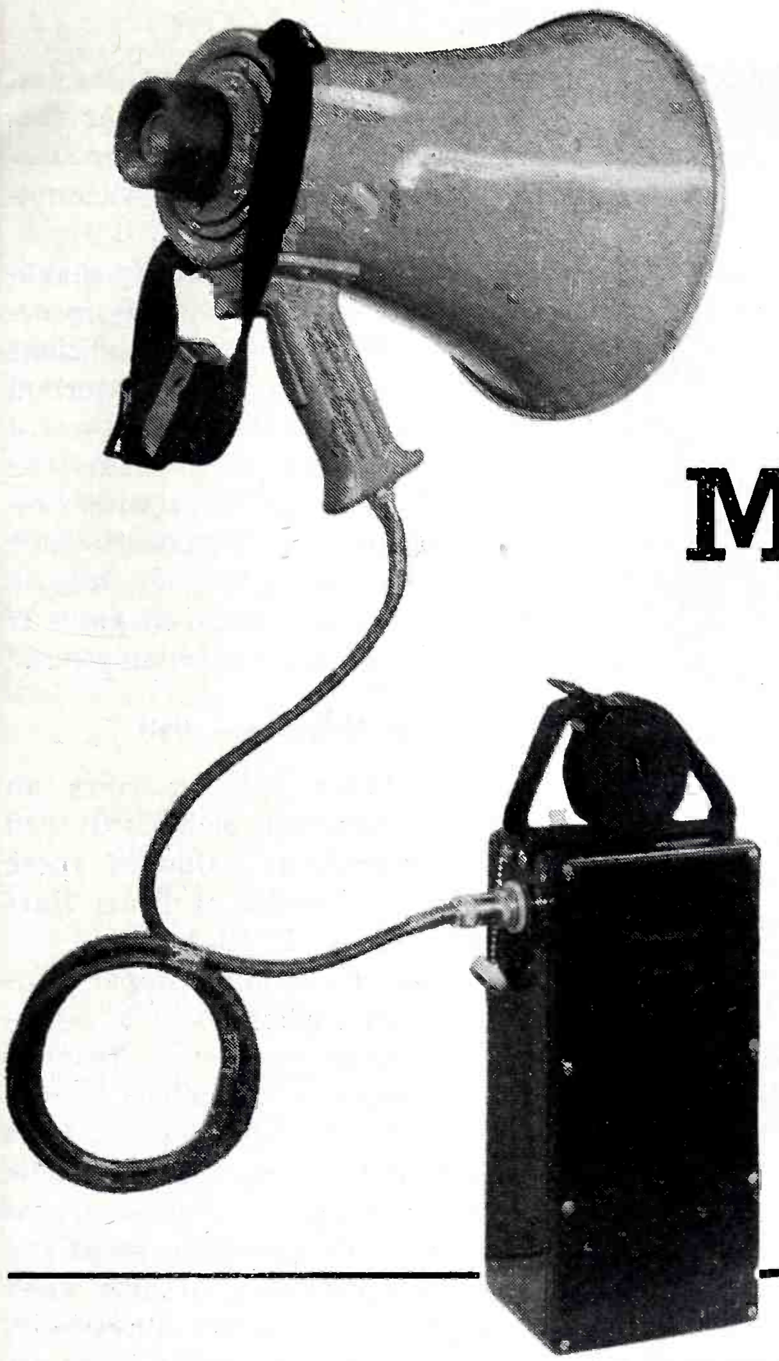
Use in Hydrocarbons Analysis

As a result of the above discussion, it should be recognized that the mass spectrometer is an extremely powerful tool in analyzing hydrocarbons for impurities of higher molecular weight than the main components since there is no longer the conflict in masses and the impurities will stand out uniquely. In general it can be said that the problem of hydrocarbon analysis becomes most difficult for the mass spectrometer when the components have the same or nearly the same molecular weight. As an example of the sort of analysis that can be made under these conditions, some results made with the Westinghouse mass spectrometer are given in the table. The synthetic blends were made with a manometer by a third party.

The problem of hydrocarbon analysis has been discussed at some length because it is a difficult one which is of importance to the synthetic rubber, aviation gasoline, and chemical industries. The infrared and ultraviolet spectrometers have had considerable success in these fields, but the entire problem is so difficult that the mass spectrometer will be a valuable supplement to existing analytical methods.

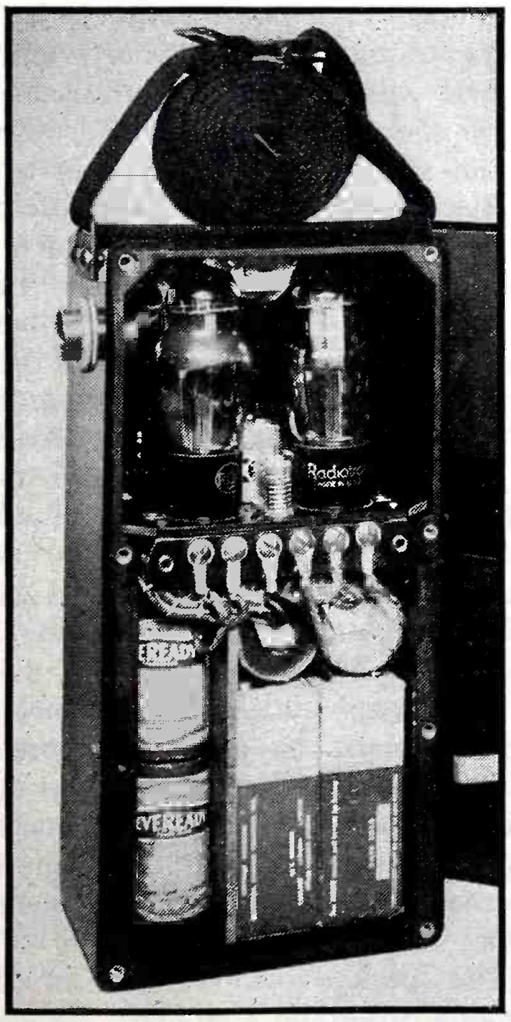
The quantity of gas necessary for an analysis is, in a sense, limited only by the design of the gas handling system since the flow through the tube is so small. This flow is about 10^{-4} cm liters per min. (approximately 10^{-8} cubic centimeters of gas per minute measured at atmospheric pressure) and can of course be made less depending on the design of the pumping system. Since the flow through the mass spectrometer tube must be maintained constant, the conventional method of attaining this is to bleed the sample through a capillary leak located in the gas flow line between the mass spectrometer and a reservoir containing a sufficient quantity of the gas that the pressure in the reservoir is not materially changed during the time required for the analysis.

Because the mass spectrometer is a practical instrument for segregating gas molecules it promises to become an increasingly valuable tool in industry.



Electronic MEGAPHONES

Resembling old-fashioned acoustic devices in appearance and nearly as easy to use, modern sound - reinforcement units using vacuum-tube amplifiers aid the Navy in its job of maintaining communications among convoyed ships that must maintain radio silence



Complete portable electronic megaphone (above) as made for U. S. Navy by Guided Radio Corp., and interior of amplifier (below)

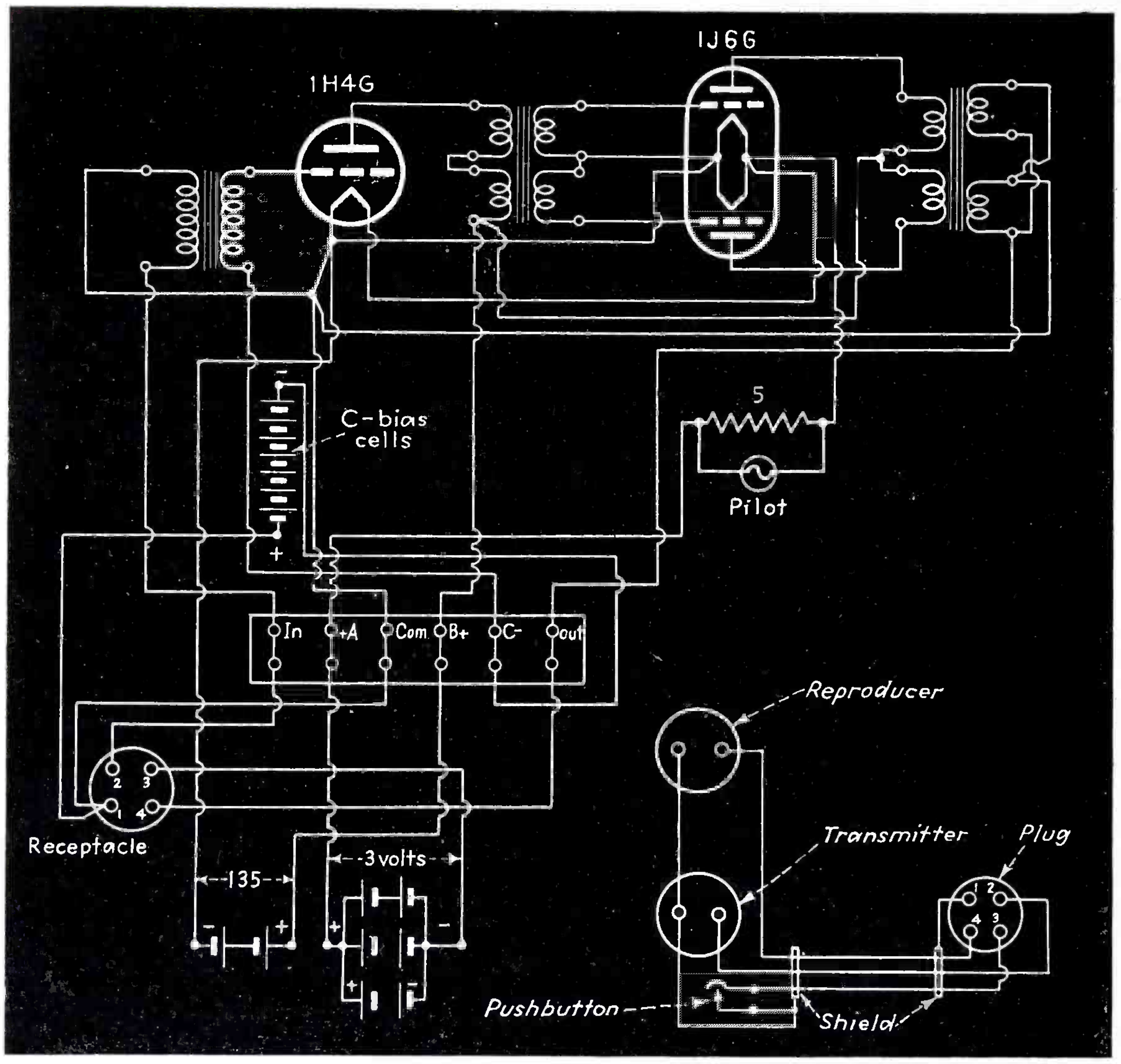
LEATHER-LUNGED SKIPPERS have bellowed messages through megaphones to seamen aboard their commands, longshoremen on docks and even the captains of passing vessels since the days of the clipper-ships.

Funnel-shaped acoustic aids give a certain amount of extra punch to lung-power, concentrating sound in the desired direction to some extent and providing a little reinforcement of volume at their resonant frequencies, but the war has created a need for gear having greater effective range. Ships travelling in convoy and maintaining radio silence must be able to communicate with each other over considerable distances. Landing operations require close liaison between covering naval forces and troops hitting the beachheads. Planes providing protective screens, or patrolling offshore, frequently find it necessary to talk to men far below on land or on the surface of the sea.

Electronic megaphones (the British call them "loud-hailers") provide a modern answer to such problems. Newest application of the public-address equipment designer's art, they comprise in simplest form small, light, sturdy two-piece units which are entirely self-contained and completely portable. Under average conditions such units transmit intelligible voice communications over distances in excess of 1,000 feet. Similar semi-portable units have conveyed intelligence to points well over a mile away.

General Specifications

Four manufacturers are at present producing electronic megaphones for the Navy Department alone: Guided Radio Corporation (New York), Operadio Manufacturing Company (St. Charles, Ill.), Powers Electronic & Communication Company (Glen Cove, N. Y.), and Radio Corporation of America (Indianapolis). Over-all design follows a general pattern in that three units capable of inter-connection are provided: (A) a combination microphone and loudspeaker unit equipped with a pistol-grip, squeeze-to-talk switch and a strap permitting the unit to be suspended from the neck or shoulder of the user; (B) a battery-powered amplifier, similarly equipped with a carrying strap; (C) a larger amplifier designed to be permanently



Circuit of the portable amplifier described in the text. Megaphone unit wiring is shown at the lower right

mounted at some convenient point on deck and operated by the ship's a-c or d-c power.

Design differs considerably in detail. Problems encountered by each manufacturer were to a major extent directly related to the need for extremely light-weight, compact, weather-proof and mechanically shock-proof equipment. Chief among the problems encountered was the minimizing of acoustic feedback between microphone and loudspeaker. Obviously, the amplifier gain that may be used and hence the distance that may be covered is largely a function of the feedback factor. Feedback is minimized in each individual design by several or all of the following palliative means:

(1) Close-talking microphones.

(2) Microphones having extremely narrow directional pickup characteristics.

(3) Highly directional loudspeaker horns.

(4) Placing of microphones in the precise center of the axis of sound emanating from the loudspeaker but acoustically 180 deg. out of phase.

(5) Careful choice of distance between microphone and outer edge of loudspeaker horn, or equivalent provision for securing desirable acoustic phasing between microphone and loudspeaker.

(6) Acoustic isolation of the microphone by the use of special suspensions or padding between the microphone and its housing, or both.

(7) Attenuation of, or shifting of, comparable microphone and loudspeaker response peaks, particularly noticeable at low audio frequencies.

Electronic megaphone unit as made for U. S. Navy by Powers Electronic & Communication Co. It differs in some details from the equipment described in the text, but serves the same military purposes

(8) Introduction of delay, or frequency-selective filters, or other electrical refinements, in the vacuum-tube amplifier circuit.

All four of the electronic megaphones under discussion, it is interesting to note, will develop sufficient acoustic feedback to howl at normal gain if they are directed toward nearby obstructions or surfaces from which sound is readily reflected. Pointing a shipboard unit toward the deck, in fact, provides a quick maintenance-check on gain. If it doesn't howl it isn't "putting out."

The Megaphone Unit

The following text describes an electronic megaphone made by Guided Radio Corporation. (One of these was placed in service at Pearl Harbor on December 2, 1941.)

The megaphone unit proper consists of a microphone and a reproducer combined in such a manner that the assembly resembles a conventional acoustic megaphone. It is provided with a pistol-grip handle incorporating a pressure-operated switch which closes the necessary battery or power-line circuits when the handle is grasped. Physically, the megaphone unit is 12 inches long, 10 inches in diameter at the bell and weighs 7½ lbs. The pistol-grip handle is located at the center of gravity so that when the megaphone is held in the hand it balances comfortably.

The microphone employed in this particular unit is of the magnetic or variable reluctance type, in which a reed coupled to a duralumin diaphragm is moved in a strong permanent magnet field. Current is thus generated in a winding by changes in magnetic flux. Output is −30 db and is nearly flat between 800 and 1,700 cps. Impedance is nominally 200 ohms. The microphone is suspended within a housing of shock-absorbing design and the housing is acoustically insulated from the rest of the megaphone assembly by means of felt pads. A protective screen keeps foreign objects out of the microphone and a soft-rubber mouthpiece is fitted over the microphone to protect the user's mouth in rough seas.

The speaker driver unit is of the moving coil-diaphragm type. Experience has shown that while such units may not be completely blast-proof, as are certain other speakers utilized aboard naval vessels and equipped with blast-valves, use of a molded-phenolic diaphragm of proper design provides considerable protection. The associated horn is of the folded, double-re-entrant type concentrating sound output in an angle of approximately 30 deg. from the axis. The horn is fabricated of spun aluminum and is protected by a metal screen installed across the opening of the bell.

The microphone and loudspeaker units comprising the megaphone proper are moisture-proof but not immersion-proof. Connection between the megaphone assembly and the associated amplifier is accomplished by means of a flexible, rubber-covered cable which emerges from the end of the handle through a cable gland. The free end of the cable is provided with a cord connector to fit a corresponding receptacle in either a portable or fixed (bulkhead) amplifier. An extension cable 40 feet long is supplied to permit the megaphone to be used at some distance from a fixed amplifier.

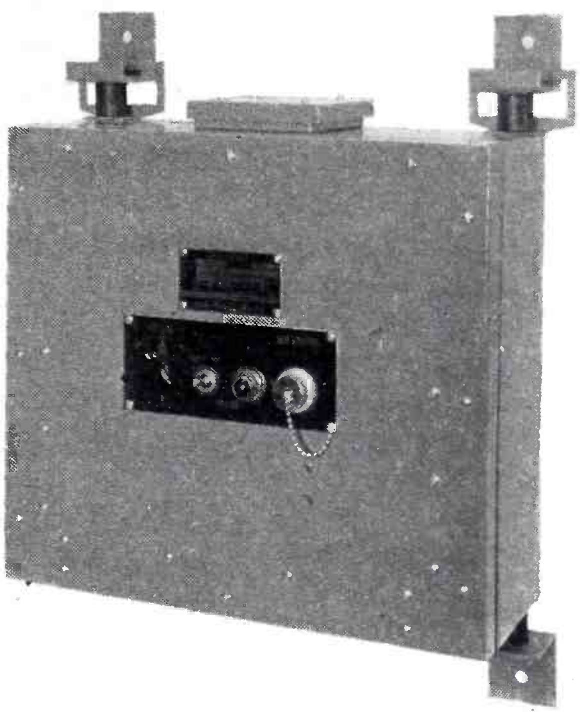
The Amplifier Units

The completely self-contained portable amplifier is a two-stage affair. A triode equipped with seven series-connected bias cells is transformer-coupled to a twin class B tube turning out 1.6 watts of audio power with not more than 10 percent harmonic distortion. Plate voltage is obtained from two series-connected 67.5-volt batteries. Filaments obtain the required 2 volts from a series-paralleled bank of six 1½-volt batteries, through a 5-ohm, 1-watt dropping resistor connected in parallel with a 2.2-volt pilot lamp. (The brilliancy of the lamp gives a quick check on the condition of the filament batteries.) In this instance, no attempt is made to "trick up" the frequency response of the amplifier, which is reasonably flat over the required speech range.

Physically, the portable amplifier measures 4 x 5 x 10 inches overall and is provided with a carrying strap. The cabinet is made of molded, high-impact phenolic material and is fitted with a molded cover, gasketted to make the interior weather-proof. The only external connections to the amplifier are through a socket which receives the plug on the end of the megaphone unit cable. No manual adjustment for controlling gain is provided. Gain is fixed, in the design of the amplifier, at the highest point consistent with the desired portability.

The bulkhead amplifier, which may be used in place of the portable amplifier for greater coverage, is also a two-stage affair. The first stage utilizes a twin-triode, which functions as a voltage amplifier and also as a phase inverter providing balanced input to the second stage. The second stage consists of four beam-power tubes connected in push-pull parallel, delivering 6 watts of audio output with total harmonic distortion of 9 percent.

A full-wave rectifier tube is included in the bulkhead unit so that it may be operated from a 115-volt, 60-cps ship's power line, the total a-c drain being 85 watts. Jumpers or straps on the terminal strip may be adjusted for operation on 115 volts d.c., the unit drawing 63 watts when so operated. The entire amplifier is mounted in a compact steel cabinet, which may be secured to a bulkhead by means of mounting angles which are insulated mechanically from the cabinet through the use of rubber anti-vibration mounts. On the front panel is a socket which receives the megaphone unit plug, a power toggle switch, a pilot lamp and a gain control. Approximately 30 seconds are required, after power is applied, for the tubes to warm up.

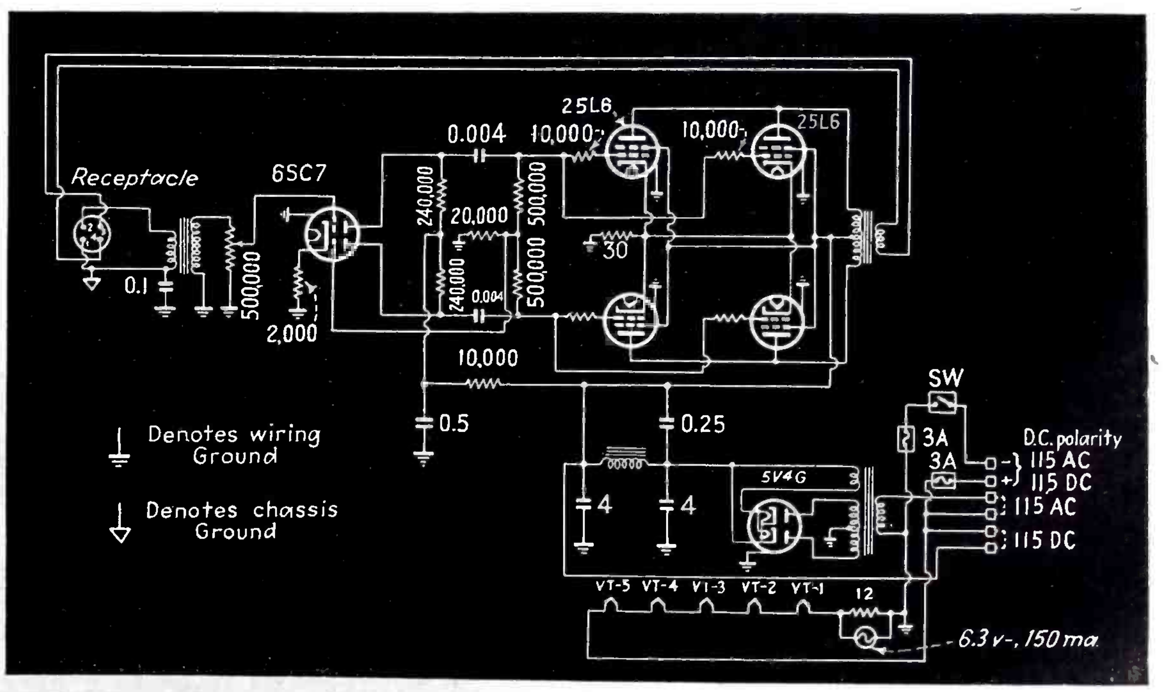


A typical bulkhead amplifier for use with an electronic megaphone

Post-War Possibilities

Vital in certain military operations, electronic megaphones obviously have peacetime market possibilities. They will, for example, be carried by most ships of any size after the war and may be considered essential emergency gear for lifeboats. Ashore, electronic megaphones appear to have distinctly useful commercial applications. Their extreme portability lends them ideally to the emergency handling of crowds and traffic. Industrial uses include communications between foremen and workmen on construction jobs.

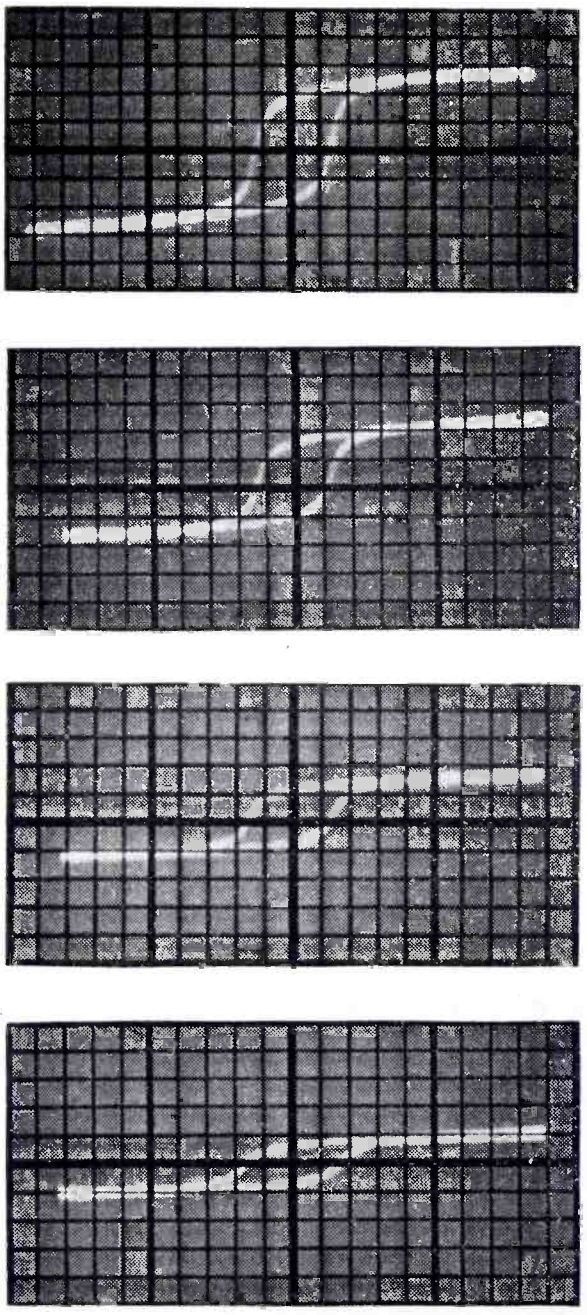
Technically, wartime experience with the design of electronic megaphones and, particularly, methods of minimizing howl caused by acoustic feedback, may result in reduction of feedback in all sorts of commercial sound equipment. Considerable data on this subject has already appeared in U. S. Patents 1,351,254, 2,063,224, 2,218,389, 2,301,459 and 2,314,108. More design data will undoubtedly be available as additional wartime patents are issued and in postwar literature.—W. MacD.



Circuit of the bulkhead amplifier discussed in the text. The input receptacle accommodates the megaphone unit plug shown schematically in the portable amplifier diagram

B-H CURVE TRACER for Lamination Samples

By **ROBERT ADLER** *Engineering Department Zenith Radio Corp. Chicago, Ill.*



Photographs of hysteresis loops obtained during a heat run, starting at 80 deg. F (top photo) and going up in three steps to 200 deg. F (bottom photo)

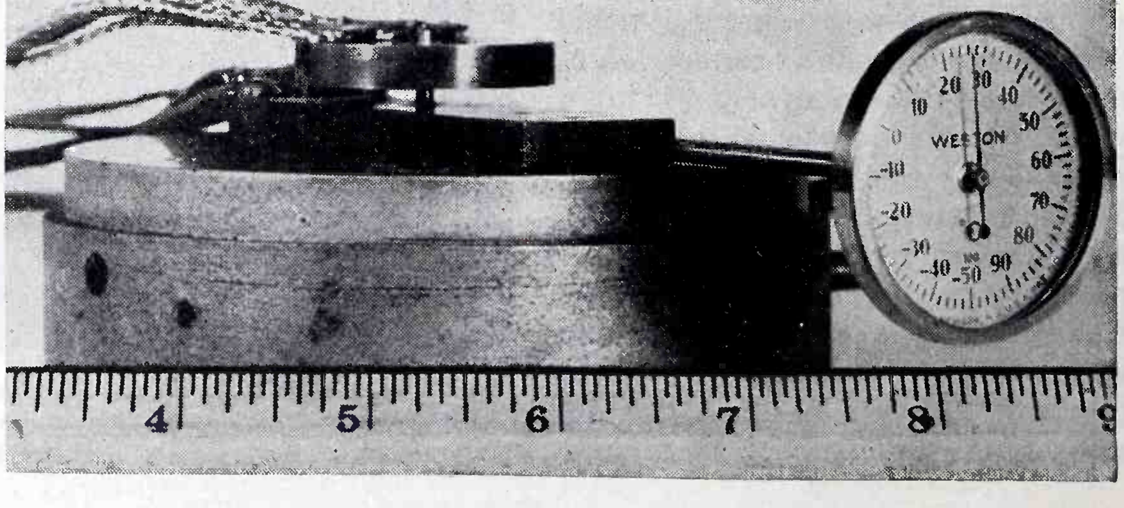
THE characteristics of the magnetic material used in transformers and chokes are not easily measurable, and introduce a factor of uncertainty in the design and production of vacuum tube equipment. All other components—resistors, capacitors, air-core and powdered iron core inductances—are rigidly tested, and equipment is generally available to measure their essential characteristics with good accuracy. But audio transformers and chokes in many cases are only tested for their d-c resistance. A specified grade of lamination material may be essential for proper operation, but the various grades look very much alike, and electrical checks are often quite difficult.

Sometimes a deterioration in the characteristics of some complex circuit defies explanation until the change is traced to a change in characteristics of magnetic materials. By then, hundreds of assemblies may have been completed with the wrong laminations, and much valuable time may be lost.

Apparatus for rapid and easy testing of magnetic materials is extremely useful in such cases. But, to obtain such data as permeability, saturation, coercive force and hysteresis loss of magnetic alloys, special equipment which is not easily available has been necessary; and even with such equipment, comparatively large amounts of sample laminations are generally needed for test, and the measurements take considerable time and effort.

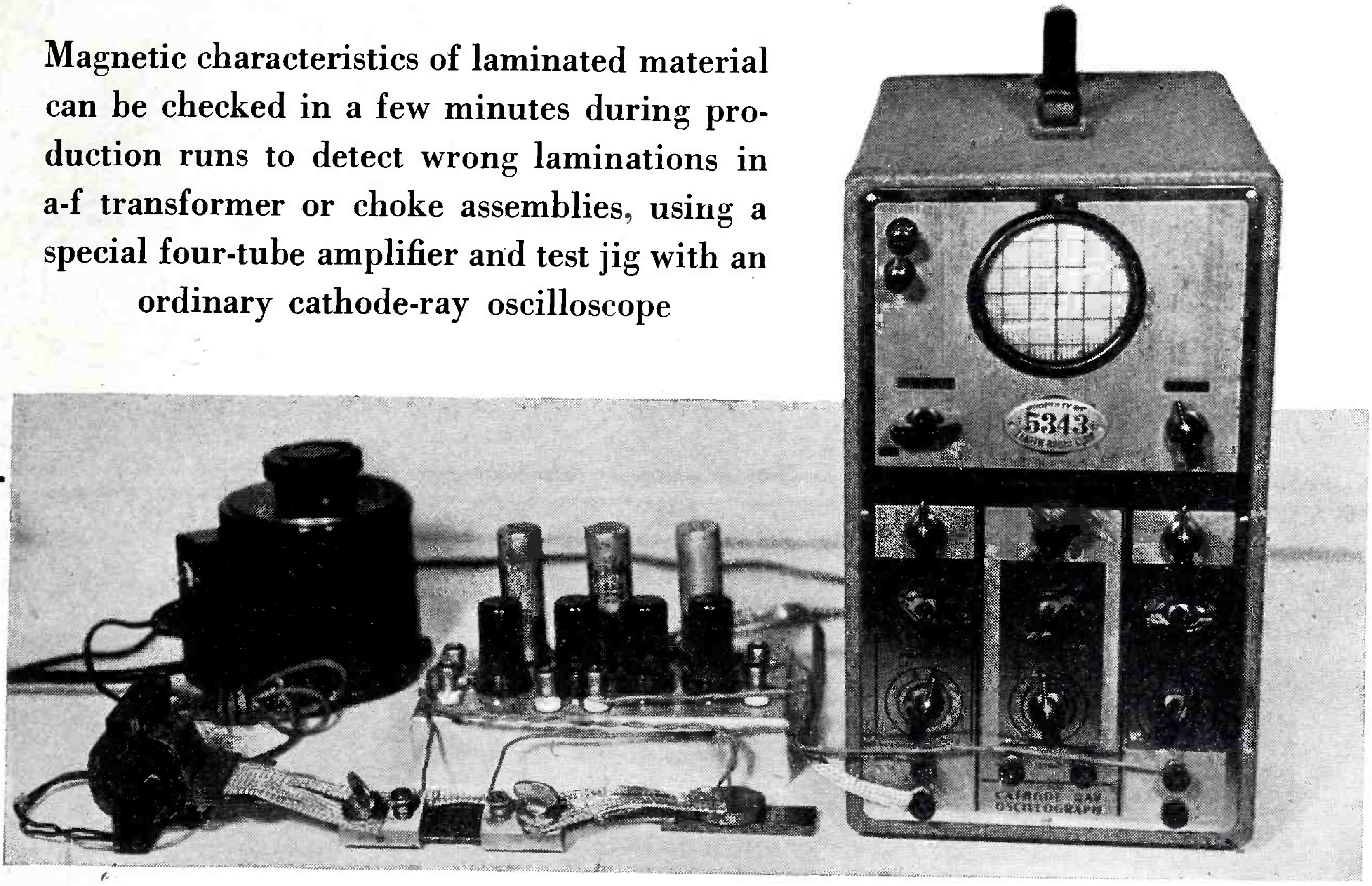
Features of Oscillographic Method

The oscillographic equipment described makes it possible to obtain this data with great rapidity. Comparison checks of a number of samples can be made within a few seconds. Initial and reversible permeability characteristics, or increase of loss with flux density can be directly observed on the screen when the current input to the sample is gradually



Sample-holder assembly mounted on a heater unit for tests at high temperatures, which are indicated by the dial thermometer

Magnetic characteristics of laminated material can be checked in a few minutes during production runs to detect wrong laminations in a-f transformer or choke assemblies, using a special four-tube amplifier and test jig with an ordinary cathode-ray oscilloscope

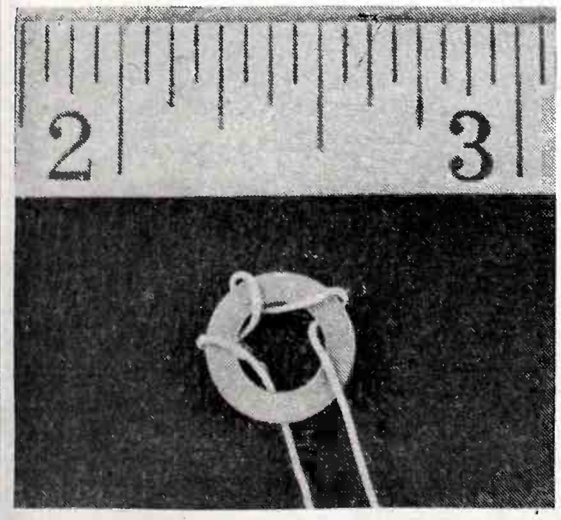


Complete equipment needed for obtaining the B-H curve of a magnetic sample almost instantaneously. The power transformer and variable transformer are at the left, with the high-current shunt and sample holder in front of the amplifier

varied—observations and measurements which take hours with older methods.

An additional advantage of the oscillographic method is that it permits the use of extremely small samples. A little washer punched from a single lamination is all that is needed. Less than one millivolt, produced in a few turns which are wound around this miniature ring, is sufficient to provide an indication of flux density in the sample. On the other hand, little power is needed to saturate so small a sample, and the whole equipment is compact and easy to handle.

The small size makes it possible to run tests at elevated temperatures by simply placing the sample with its holder on a heater a few inches in diameter. Such an arrangement is particularly valuable for tests on alloys with low permeability. Some of these alloys exhibit a large drop of permeability at high temperatures, and this characteristic is used for temperature compensation in watthour meters and other instruments. The equipment described here makes it easy to check the performance of such materials throughout the range of their operating temperatures.



Washer-shaped sample used for tests. Three loops of the fine wire are used here as coupling to the vertical amplifier

The samples have about ⅛ inch minimum inside diameter. The ratio between inside and outside diameter should be small to maintain approximately uniform field intensity throughout the piece. A ratio of about 3:2 (for instance, $\frac{3}{32}$ inch outside and $\frac{3}{16}$ inch inside) is good enough for most purposes.

Principle of Operation

Figure 1 shows a block diagram of the equipment. A 60-cycle current of low voltage and high intensity is sent through a shunt resistance and a bar and collar arrangement by the secondary winding of the power transformer. The washer-shaped sample is slipped over the bar, and one or more turns of fine wire are threaded through the gap between sample and bar. The potential appearing across the little loop is fed into the input of an amplifier which also contains an integrator. The output of this integrator is connected to the vertical plates of an oscilloscope. The potential drop across the shunt is fed through a single-stage amplifier to the horizontal plates of the oscilloscope. A variable transformer serves to adjust the primary voltage supplied to the power transformer.

At any given moment, the current flowing through the bar develops a corresponding field intensity in the sample. At the same time, a proportional potential is produced across the shunt and appears amplified across the horizontal oscilloscope plates. As the flux in the sample changes, a voltage is induced in the little loop proportional to dB/dt, the rate of change of the flux. To obtain B from this voltage, it is

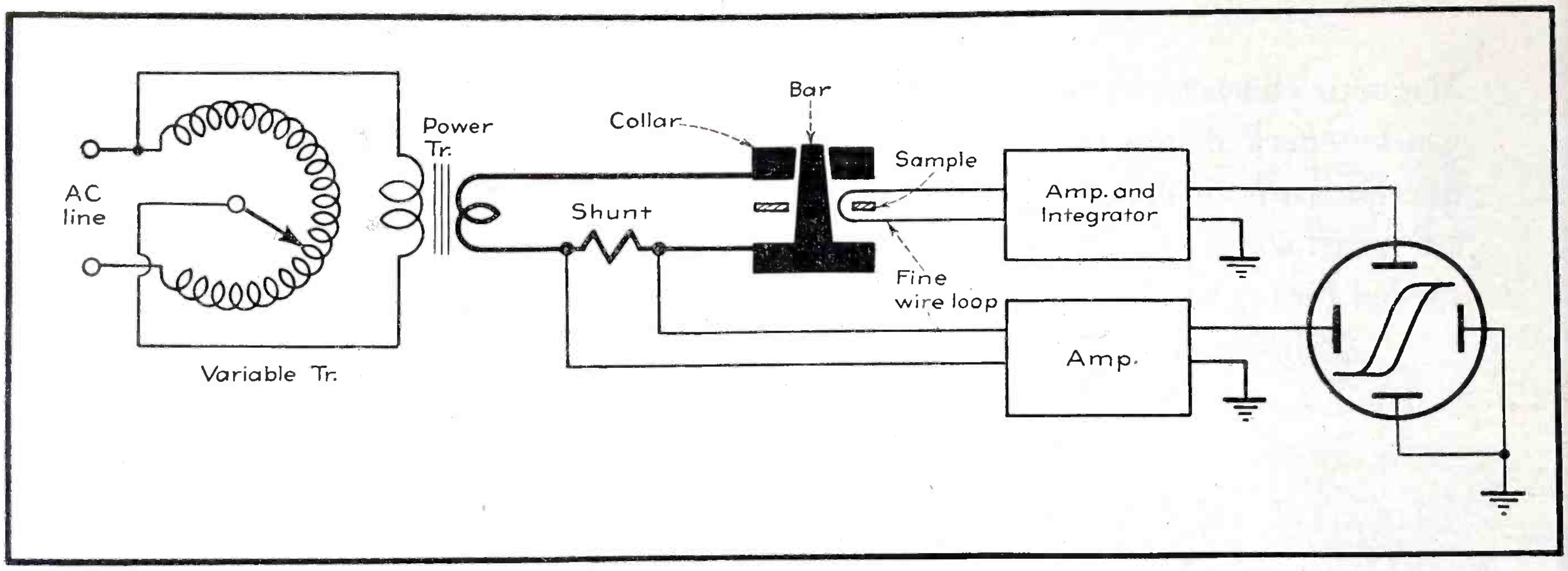


FIG. 1—Block diagram of complete B-H curve tracer. A washer-shaped sample of the lamination to be tested is slipped over the bar that forms a single-turn loop carrying a 60-cycle current of the order of 100 amperes, and the resulting magnetization is utilized by electronic circuits to produce the B-H curve of the magnetic material on the screen of the cathode ray oscilloscope

necessary to carry out a process opposite to differentiation; in other words, pass the voltage through an integrating network. A simple network of this kind is shown in Fig. 2. The output from the loop is fed into a large capacitor through a large resistance. The time constant of these two elements is large compared to one period of a 60-cycle wave. If E designates the potential produced in the loop, the voltage appearing across the capacitor is proportional to $\int Edt$. Since E is proportional to dB/dt, the voltage across the capacitor is

$$\int Edt = \int \frac{dB}{dt}\, dt = \int dB = B$$

This derivation does not take into account various constant factors. It proves, however, that the output from the integrator stage is proportional to the flux density in the material. The proper voltage for the vertical oscilloscope plates must be obtained by selecting the right gain in the amplifier.

Circuit Details

The power transformer is the type used in small radio sets, with a primary rating of approximately 40 watts. The secondary consists of a single turn formed by four strips of copper braid, $\frac{5}{16}$ inch wide, all in parallel. The open-circuit voltage across this secondary turn is about 0.1 volt, and it can handle over 100 amperes without undue drop of voltage. At this high current intensity the power developed is only in the order of 10 watts.

Figure 3 shows the high-current circuit. The same four strips of copper braid are used throughout to avoid heating. The bar is made of copper, 0.100 inch in diameter, soldered into a $\frac{1}{4}$ inch copper plate, and the braided leads are soldered to this plate. The top portion of the copper bar is slightly tapered, and another $\frac{1}{4}$ inch copper plate with a correspondingly tapered hole is used for the return connection. Contact between bar and top plate is very good if the tapers are correct, and any heat developed in the copper rod is promptly dissipated into the two end plates. The total resistance of the high-current circuit is less than 0.001

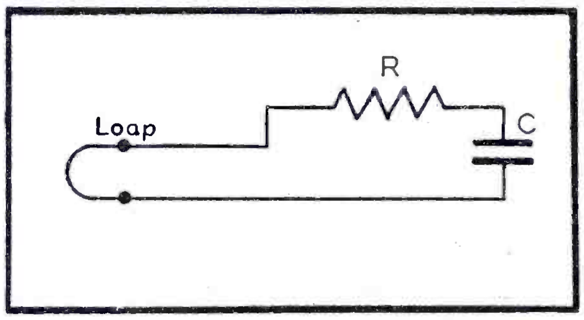


FIG. 2—Simple integrating network used to convert the induced voltage (proportional to dB/dt) to flux B

ohm. Up to 150 amperes, it can be used for short periods without undue heating.

The shunt is selected according to the range of current required for the sample. In most cases it is the largest resistance in the high-current circuit. Most shunts produce a drop of 50 mv at full rated current, and a rating close to the required current intensity should be selected. Since the full voltage available is about 100 mv, such a combination permits easy adjustment within the desired range.

With an output voltage from the shunt of 30 mv, a gain of 30 is normally needed to get full deflection on the scope. A single 6SF5 high-gain triode supplies this gain.

The output voltage from the little loop depends on the saturation flux and on the cross-section of the sample, but in most cases it is a small fraction of one millivolt. The amplifier for the loop must therefore have high gain. It uses two 6SF5 triodes with the integrator section inserted between them. A detailed diagram of this amplifier and integrator is given in Fig. 4. The peculiar characteristics required in this amplifier make it somewhat unconventional, and therefore it is described in detail.

It would be very difficult, even with the largest available by-pass capacitors, to keep the time constant of the cathode circuits large compared to one period of a 60-cycle wave; therefore, no cathode by-passes are used, even though the loss in gain is considerable. This disadvantage is somewhat compensated by greater stability of the overall gain.

The integrator stage consists of a 6SJ7 pentode with a plate load of 0.33 megohms shunted by a 1-μf capacitor. Under the operating conditions used, the internal plate resistance of the 6SJ7 is about 2 megohms, so that the effective resistance across the plate capacitor is about 0.25 megohms. The reactance of 1 μf at 60 cycles is about 2700 ohms, so that the plate load is predominantly capacitive, with a resistive component of only 1 percent. At

the higher harmonics present in this channel the ratio is even better.

The total plate and screen current for all four tubes is about 3 ma. This small amount can safely be taken from the rectifier which supplies the amplifier and sweep circuits in the scope. The filaments are also fed from the power transformer in the scope, which, in most cases, will carry this slight overload without difficulty.

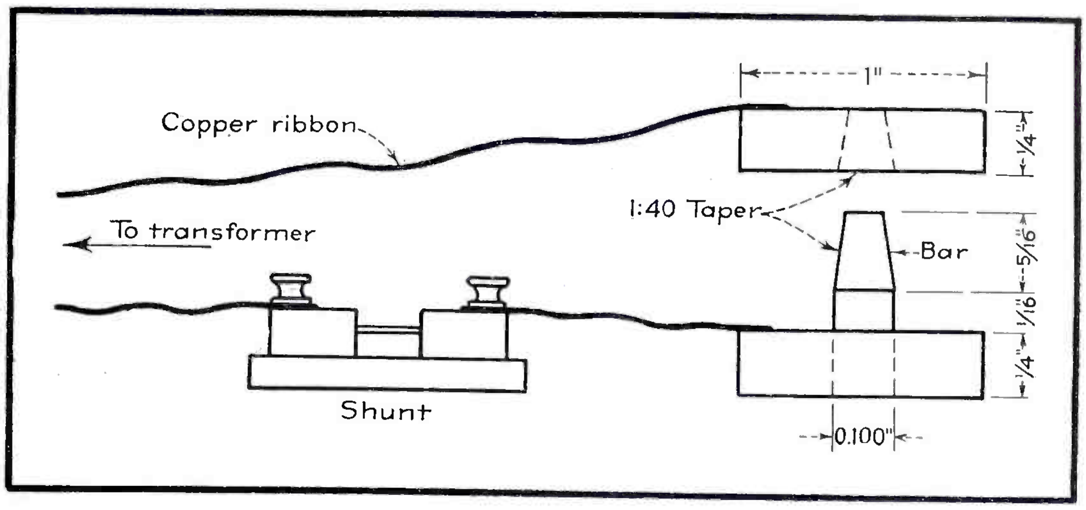


FIG. 3—Details of the bar and collar used for magnetizing the sample to be tested

Phase Angle Correction

Large coupling capacitances of 0.1 μf and grid leak resistances of 1 megohm are used throughout to keep the low-frequency response high. It would be impractical to increase the size of these parts further, because small supply voltage variations with very low frequencies would then cause large vertical excursions on the scope.

The phase error caused by all these coupling elements adds up and distorts the trace very strongly, unless means are inserted to compensate it. Here is an approximate computation of the total phase error: At 60 cycles, the reactance of 0.1 μf is 27,000 ohms; combined with a resistance of one megohm, the tangent of the leading phase angle is:

$$\tan \phi = 2700/10^6 = 0.027$$

This corresponds to about 1.5 deg. There are altogether four such networks in the vertical channel, assuming that similar coupling elements are used in the amplifier stage contained in the scope. This gives a total phase shift of 6 deg. for 60 cycles. At the third harmonic the phase shift is only 2 deg. Since the voltage in the vertical channel contains very strong harmonics, a phase shift of 4 deg. and more between fundamental and harmonics is sufficient to confuse the result completely.

An equalizer is therefore inserted in the input to the first stage of the vertical amplifier. It is drawn in detail in Fig. 5a. The function of the equalizing network is to introduce a lag inversely proportional to frequency. At high frequencies the two capacitors simply act as a capacitive voltage divider without introducing phase shift, but at low frequencies part of the input current runs through the 4000-ohm resistor. Accurate phase compensation is best obtained by adjusting this resistor, since the phase shift caused by the scope itself is different with scopes of different manufacture. Directions for the adjustment of the phase equalizer are given later. It is interesting to note that the equalizer also compensates a small residual phase error produced in the

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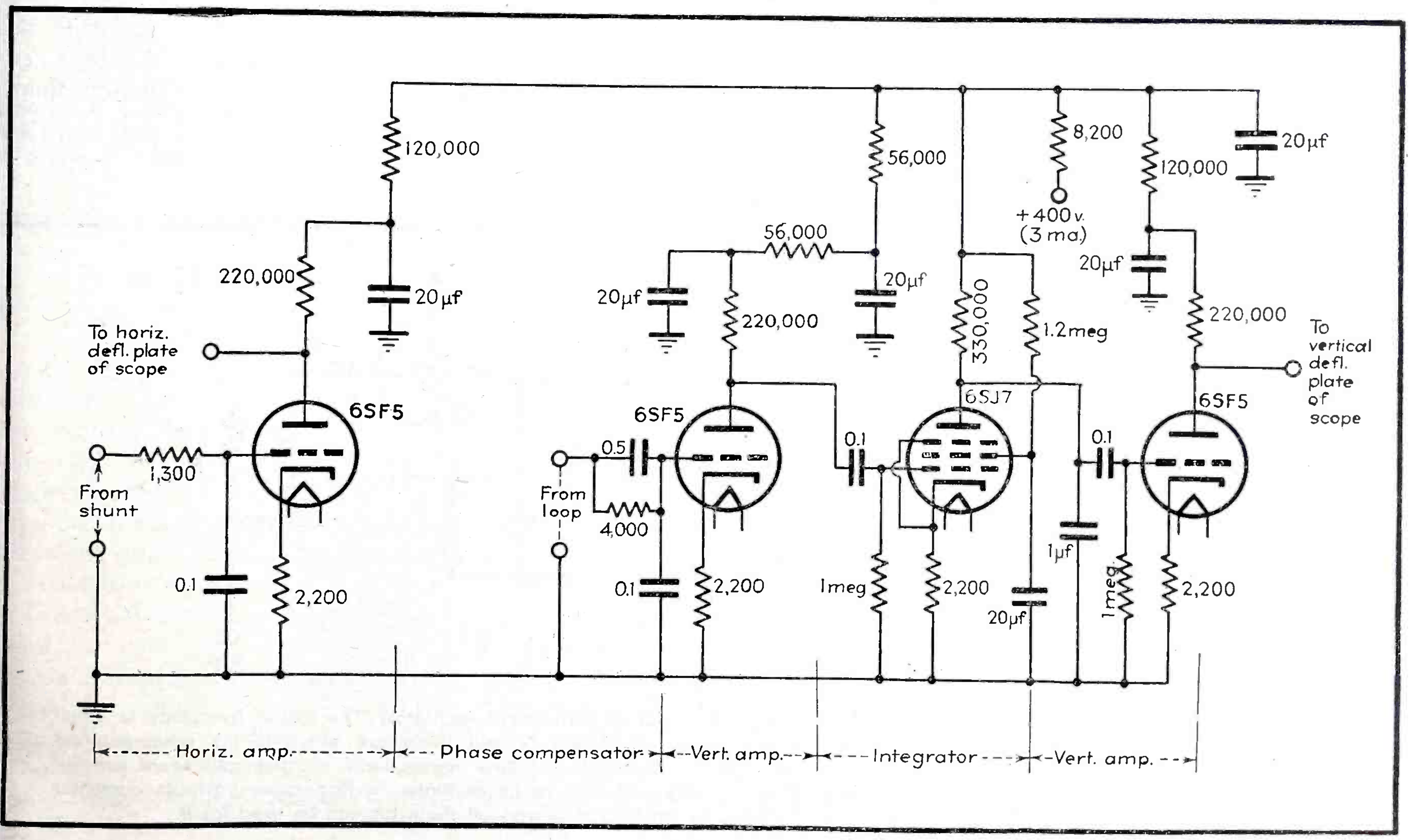
FIG. 4—Circuit used for the amplifiers and integrator



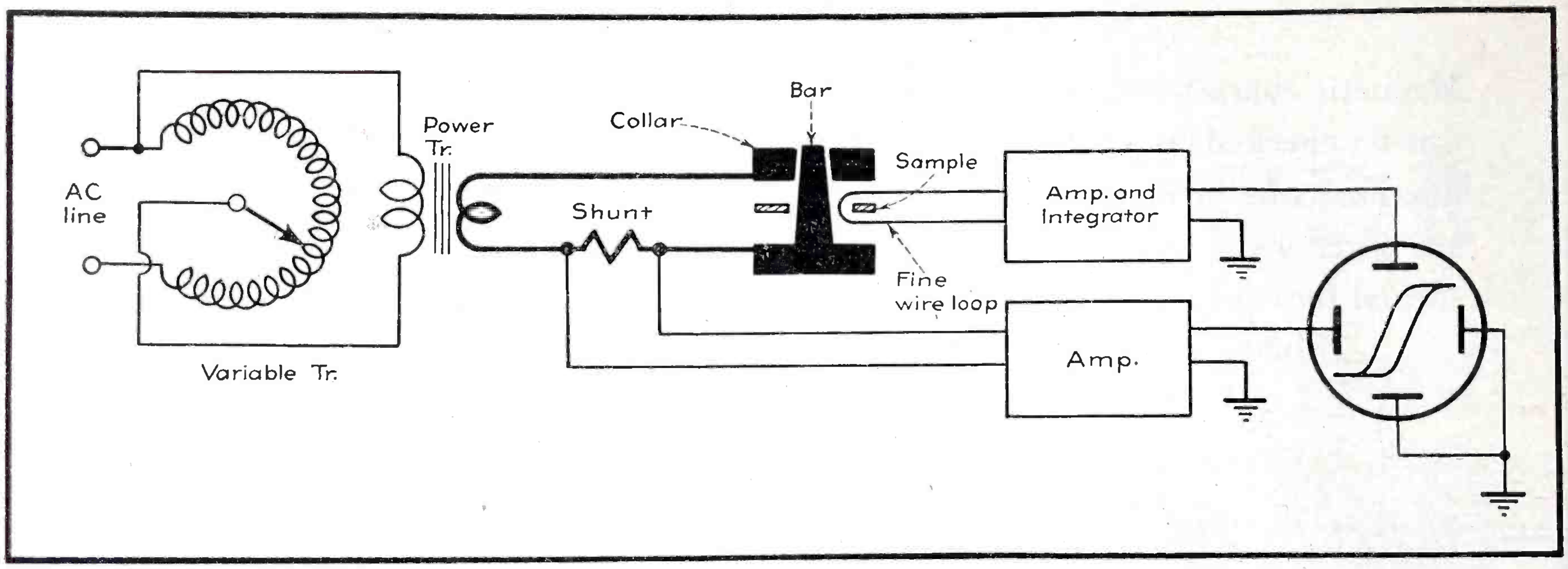


FIG. 1—Block diagram of complete B-H curve tracer. A washer-shaped sample of the lamination to be tested is slipped over the bar that forms a single-turn loop carrying a 60-cycle current of the order of 100 amperes, and the resulting magnetization is utilized by electronic circuits to produce the B-H curve of the magnetic material on the screen of the cathode ray oscilloscope

necessary to carry out a process opposite to differentiation; in other words, pass the voltage through an integrating network. A simple network of this kind is shown in Fig. 2. The output from the loop is fed into a large capacitor through a large resistance. The time constant of these two elements is large compared to one period of a 60-cycle wave. If E designates the potential produced in the loop, the voltage appearing across the capacitor is proportional to $\int Edt$. Since E is proportional to dB/dt, the voltage across the capacitor is

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Circuit Details

The power transformer is the type used in small radio sets, with a primary rating of approximately 40 watts. The secondary consists of a single turn formed by four strips of copper braid, $\frac{5}{16}$ inch wide, all in parallel. The open-circuit voltage across this secondary turn is about 0.1 volt, and it can handle over 100 amperes without undue drop of voltage. At this high current intensity the power developed is only in the order of 10 watts.

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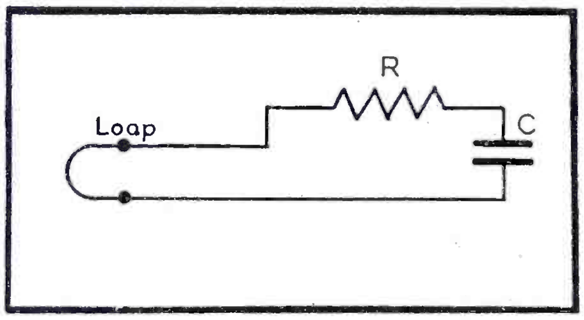

FIG. 2—Simple integrating network used to convert the induced voltage (proportional to dB/dt) to flux B

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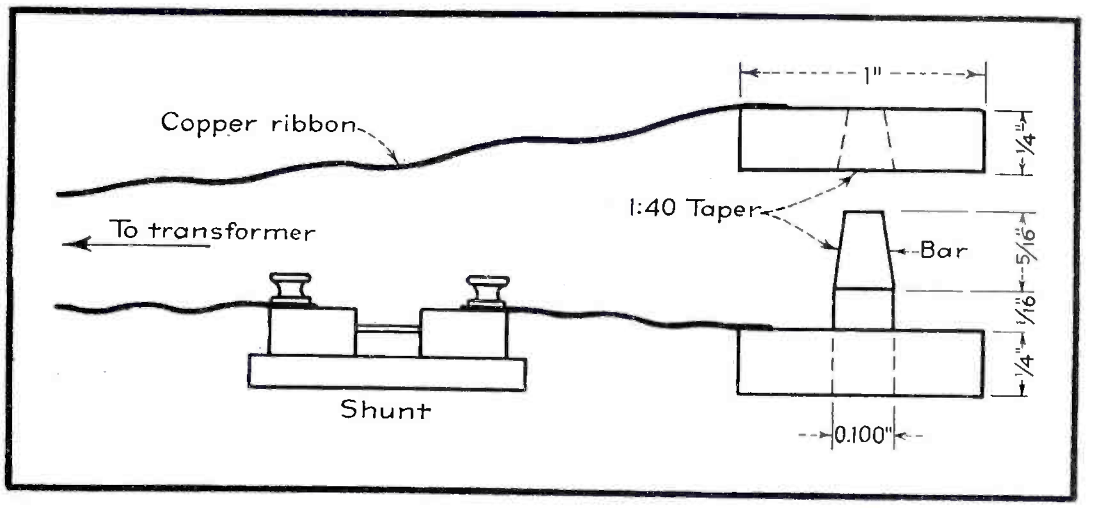

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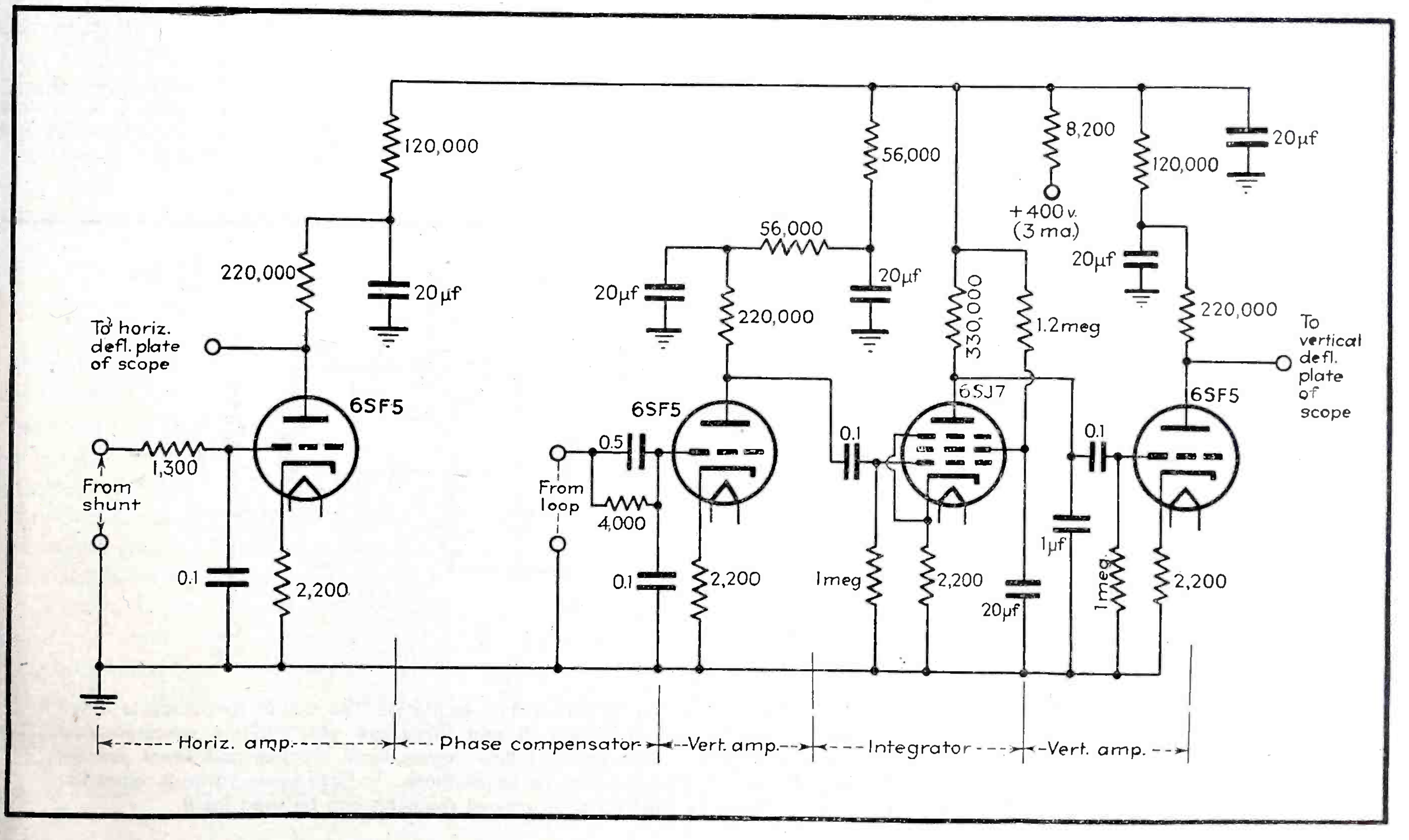
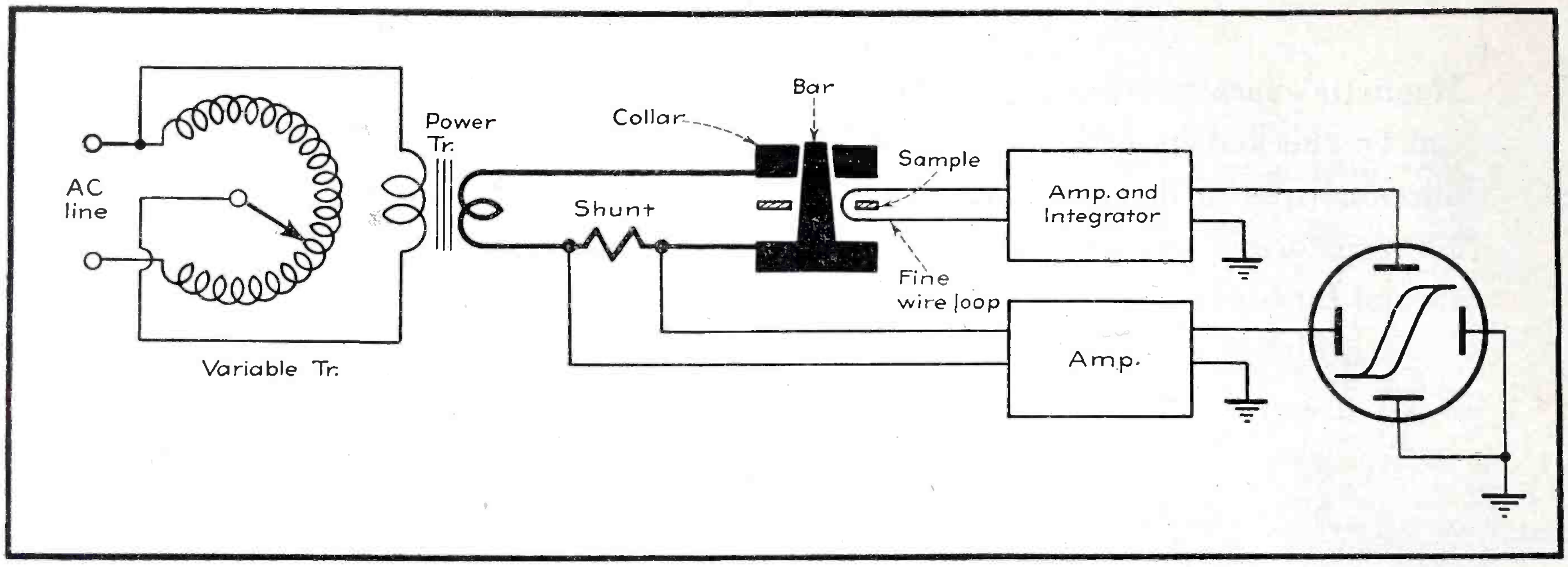
FIG. 4—Circuit used for the amplifiers and integrator





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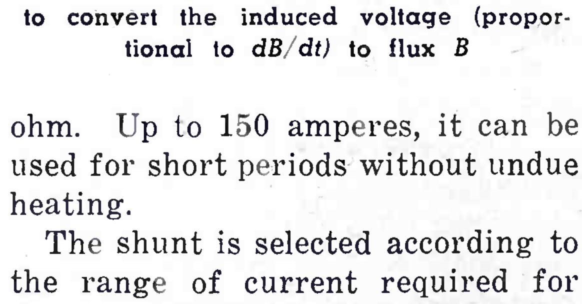

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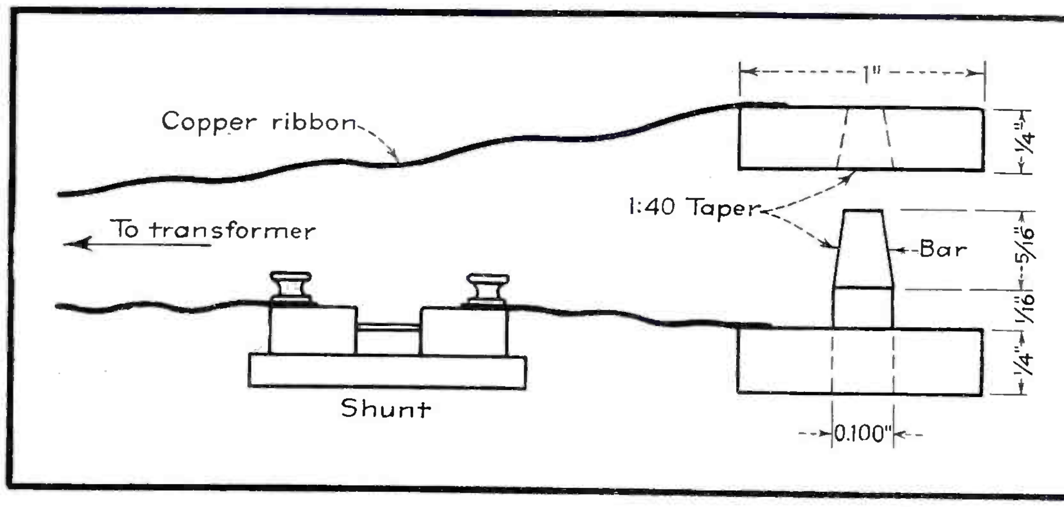

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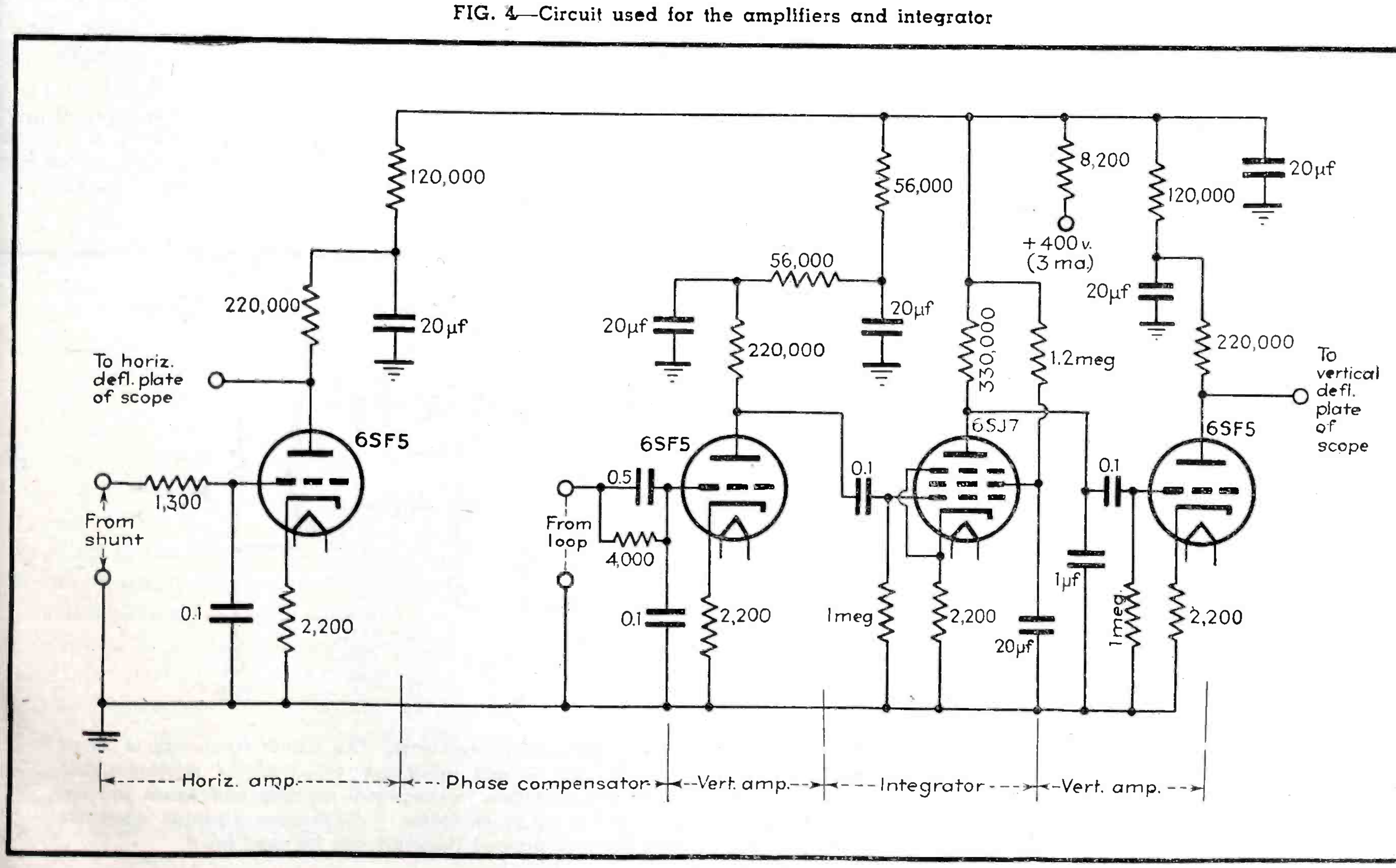


Phase-Shift Oscillator
DESIGN CHARTS

For test equipment requiring either a fixed or variable audio-frequency voltage source, the simple one-tube phase-shift oscillator offers frequency stability and good wave form at low cost. With the nomograms given here, its design reduces to simple arithmetic

By WALTER W. KUNDE

Engineering Department
Thordarson Electric Manufacturing Co.
Chicago, Illinois

In designing various types of test equipment a voltage source operating at a fixed frequency other than 60 cycles is often desired. The single-tube phase-shift oscillator has found wide application in this field due to its simplicity, excellent stability and good wave form. When followed by an amplifier designed to furnish the required output voltage, it can be used to supply power for a-c bridge measurements, insulation tests, testing aircraft transformers and their associated equipment, and many other purposes.

The basic circuit for an oscillator of this type is shown in Fig. 1. When using ordinary resistors and capacitors the actual frequency obtained may differ slightly from the computed value, due to manufacturing tolerances of the components used. Any one of the resistors or capacitors in the phase-shift network may be varied slightly to compensate this effect. This is accomplished very nicely by making one of the resistors semi-variable.

The constants used in the phase-shift network to obtain a desired frequency are determined by the formula

$$f = \frac{1}{2\pi\sqrt{6}\,RC} \qquad (1)$$

The alignment charts shown in Fig. 2 and Fig. 3 were developed to minimize errors and give a rapid, visual indication of possible RC combinations which would give the desired frequency.

It was shown by Ginzton and Hollingsworth* that the circuit gain must equal a minimum of 29 for oscillation to take place. This condition is readily met provided that $R >> R_L$, where R_L is the equivalent parallel value of the plate resistor and the grid resistor of the following amplifier tube. This is apparent when we consider the equation

$$A = 29 + 23\frac{R_L}{R} + 4\left(\frac{R_L}{R}\right)^2 \qquad (2)$$

where A is the gain required for oscillation to start. A is independent of frequency when $R >> R_L$. For example, let $R = R_L$ for some given frequency. One can readily see that the required gain for oscillation to start is aproximately double that required when R is much greater than R_L.

* Ginzton, E. L. and Hollingsworth, L. M., Phase-Shift Oscillators, *Proc. I. R. E.*, p. 43, Feb. 1941.

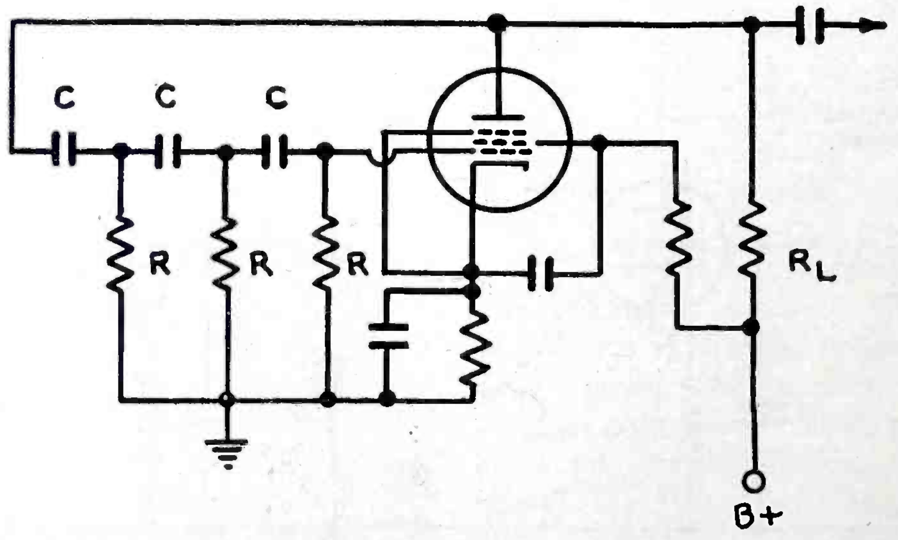


FIG. 1—Basic circuit of the phase-shift oscillator. The output frequency is determined by the values of R and C, and these are given in the accompanying nomograms. Other circuit values follow conventional practice and hence are not given. In a variable-frequency audio oscillator, a three-gang variable capacitor can be used for C or ganged rheostats can be used for R

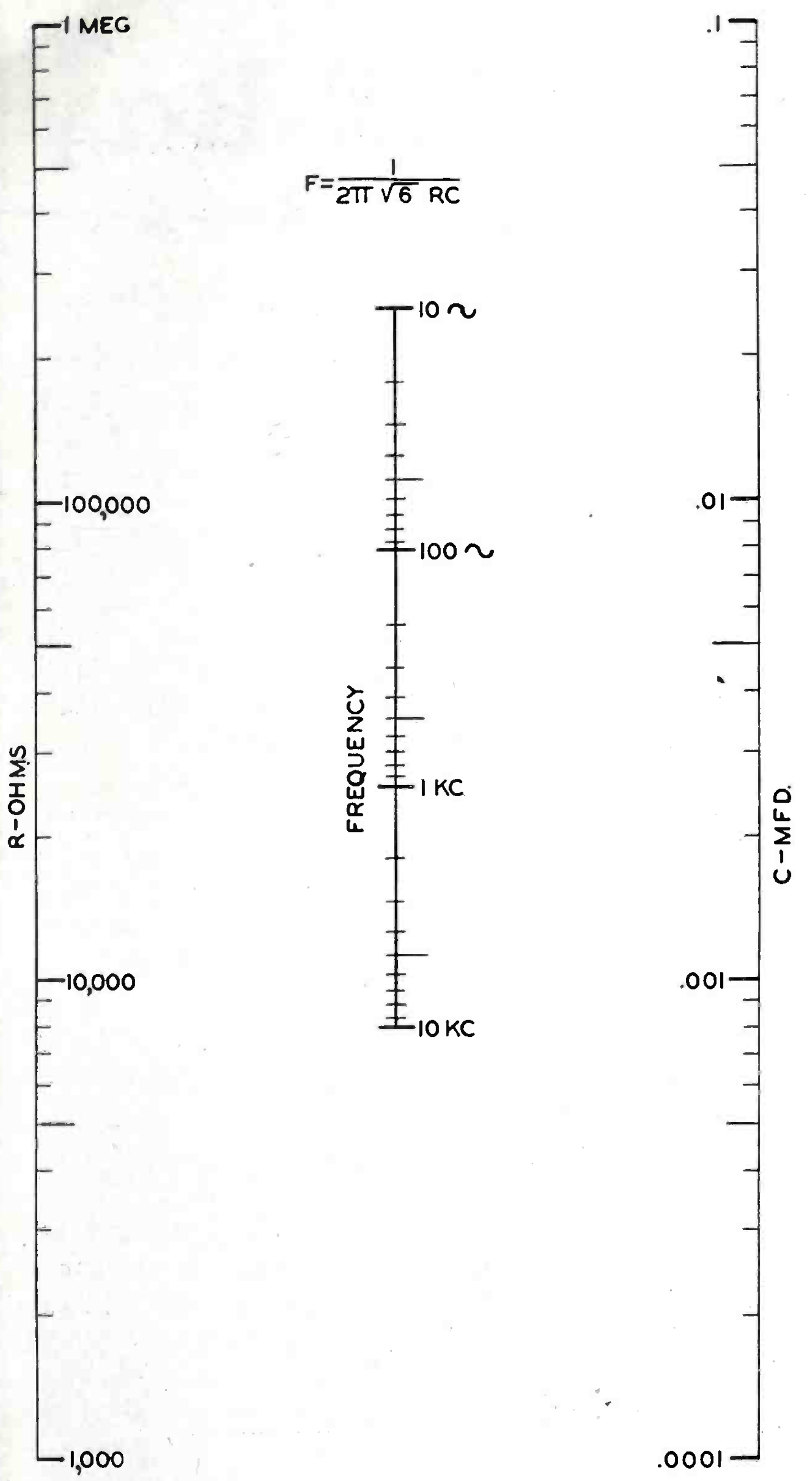


FIG. 2—Nomogram for determining values of R and C in the phase-shift oscillator circuit of Fig. 1. The ranges of values are appropriate for a fixed-frequency oscillator, permitting a choice of convenient values for the fixed resistors and capacitors

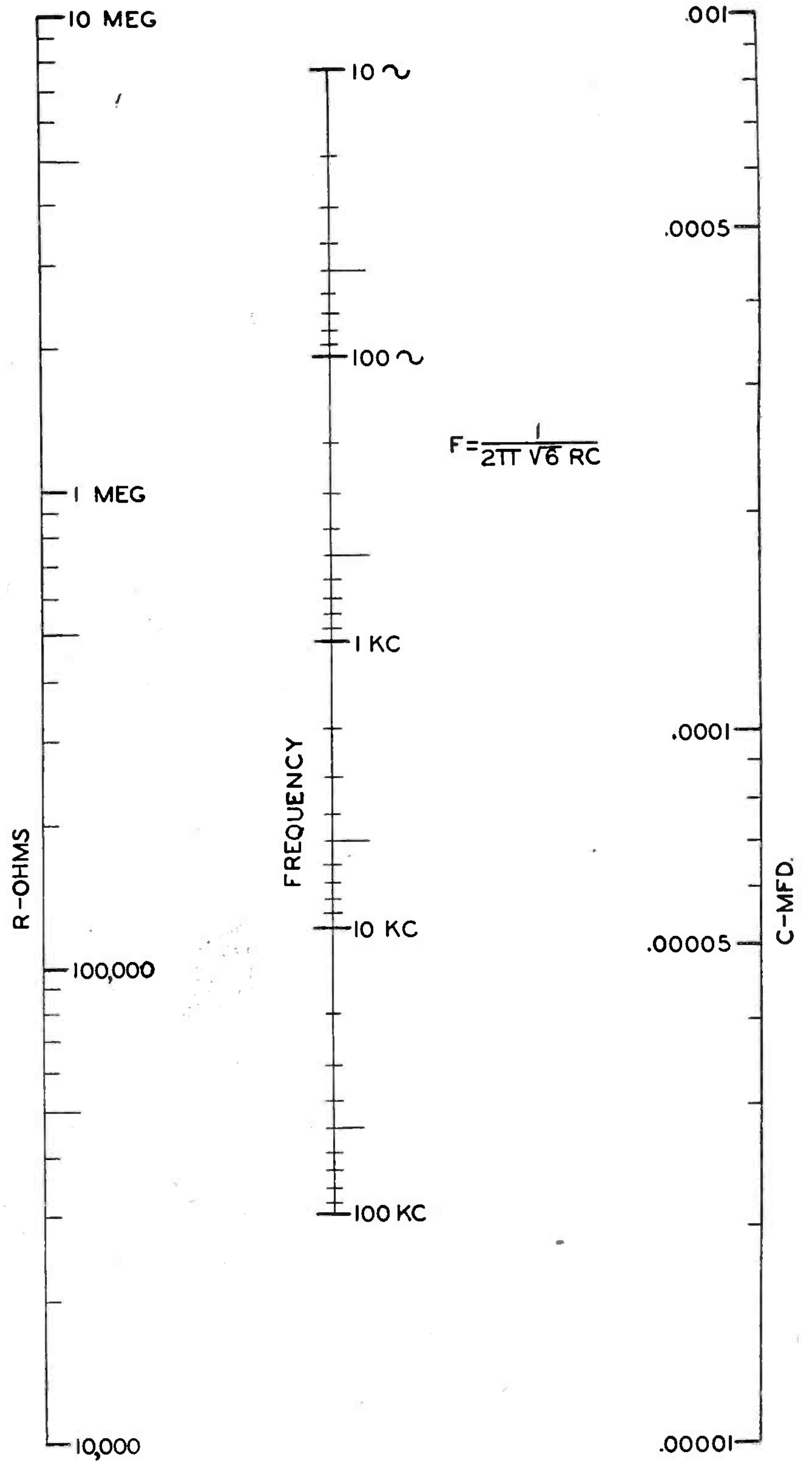


FIG. 3—Nomogram for the same conditions as Fig. 2, but with a range of capacitance values more appropriate for a variable-frequency oscillator in that it covers variable capacitor ranges that are readily obtainable. The frequency can go up to 100 kc

The chart shown in Fig. 2 is used primarily for fixed low-frequency oscillators when a high-gain tube such as the 1851 is used. Lower values of R_L are used for a tube of this type, consequently R can be made smaller for a given frequency and C is in the range of the more commonly available values.

Figure 3 is a more universal chart and is used for both fixed and variable-frequency oscillators. Note that the values of C correspond closely to the values of variable capacitors considered to be common. For variable-frequency oscillators, either the resistors R or the capacitors C may be variable and ganged together. In a laboratory oscillator requiring more than one frequency range, variable capacitors with a 10-to-1 range may be used with a switch that changes the entire set of resistors in decade steps.

Example 1: The desired frequency is 1 kc. Assume $R_L = 50{,}000$ ohms. Using either Fig. 2 or Fig. 3, determine suitable values for R and C as follows: Remembering that R must be very much greater than R_L, assume a value of 650,000 ohms for R. Place a straight edge on 1 kc and on R = 650,000 ohms, and read 0.0001 μf as the required capacitance.

Example 2: To design a variable-frequency oscillator using variable capacitors whose range is 20 to 500 $\mu\mu$f, assume $R = 1{,}000{,}000$ ohms for the middle range of frequencies, and use Fig. 3 as follows to determine suitable values of R & C: Using the assumed value of R as a pivot point, allow the straight edge to slide between the maximum and minimum values of C. The frequency range is determined immediately without any lengthy calculations, being approximately 130 to 3200 cps.

Radiography and X-Ray

Industrial radiography is an important aid in current production. Some applications of radiography, the characteristics of x-ray equipment, and the fundamentals of tube design for x-ray equipment intended for inspection purposes on factory production lines are given

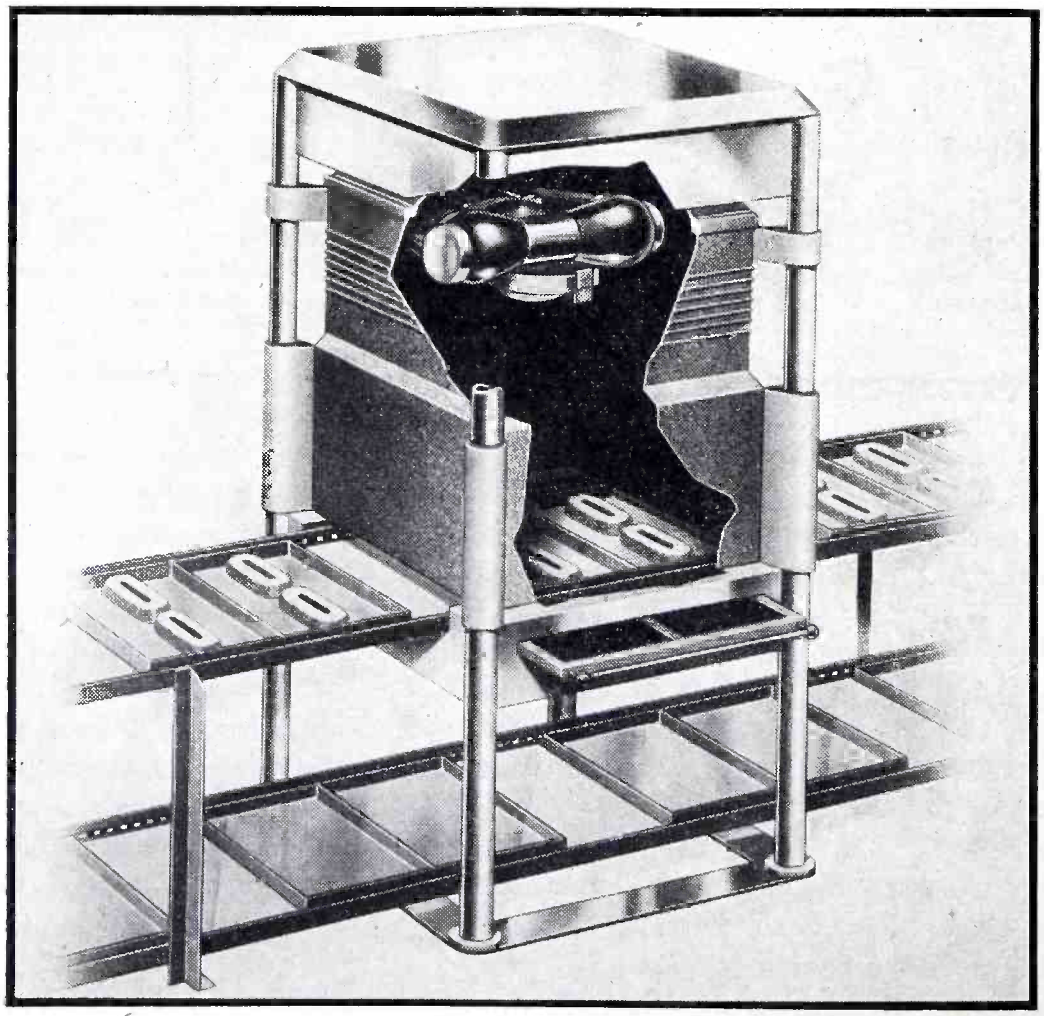
By J. LAMPERT *Westinghouse Electric and Manufacturing Co., Bloomfield, N. J. Electronics and Engineering Division*

THE ability to penetrate matter, whether it be a number of inches of hardened tool steel or a delicate and complicated network of the human organism, is not the sole requisite of a radiation which can be used in radiography. It is necessary that the material being radiographed modify the penetrating radiation in a manner indicative of its geometry and structure. It is further necessary that some method be found for decoding the message left with the quanta of radiation as they pass through the material.

In addition, it is desirable to have the source of radiation convenient and ready to operate at the lightest touch of the hand in a modern hospital, or ready for instant use on the production line of a factory. It is the purpose of this article to describe briefly the current methods of x-ray generation from the point of view of x-ray tube design.

Compared to other electronic tubes, the x-ray tube is relatively an old timer. The discovery of x-ray tubes stimulated the development of gas-discharge tubes, thus introducing the field of electronics. In addition, it provided a key to modern quantum physics, and all the rich and inexhaustible phenomena associated with the modern concept of the atom.

The art of manufacturing x-ray tubes has gone a long way since x-rays were first detected by Roentgen in 1895. The applications have progressed by leaps and bounds, to encompass the broadest variety of endeavor. Today x-ray is used as a simple and reliable tool for science, medicine, and industry.



Mass-production x-ray machine mounted over a conveyor belt and capable of inspecting 17,000 parts in a 24-hour day. Adequate lead protection is provided, permitting use of the machine at any desired location in a plant

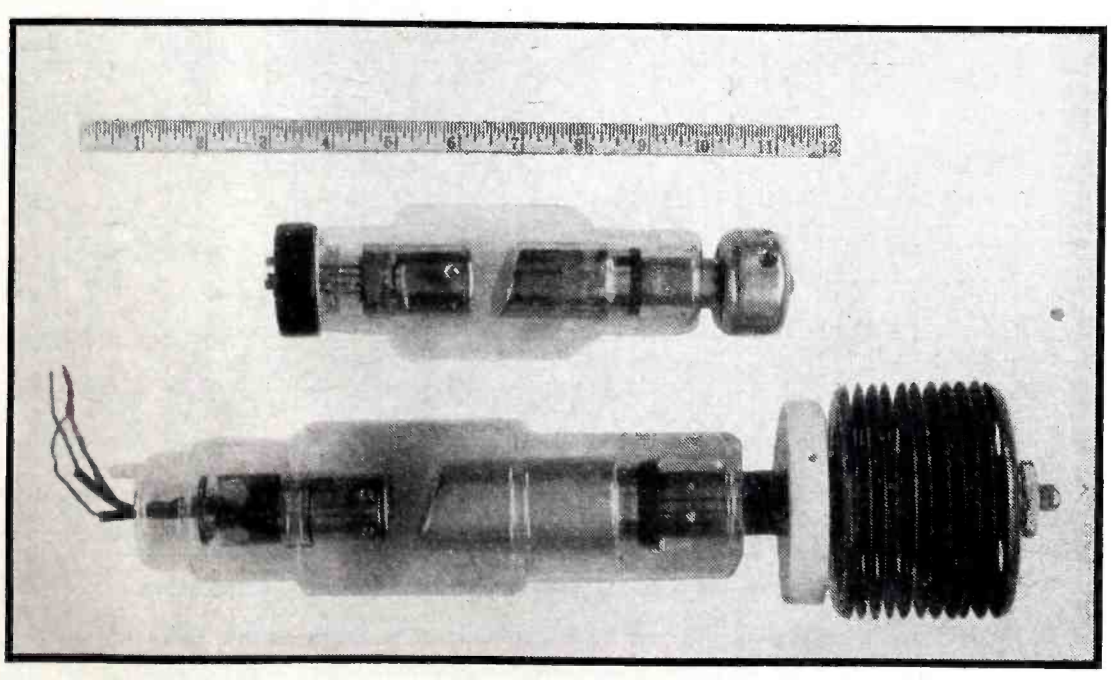
Physical Properties of X-Rays

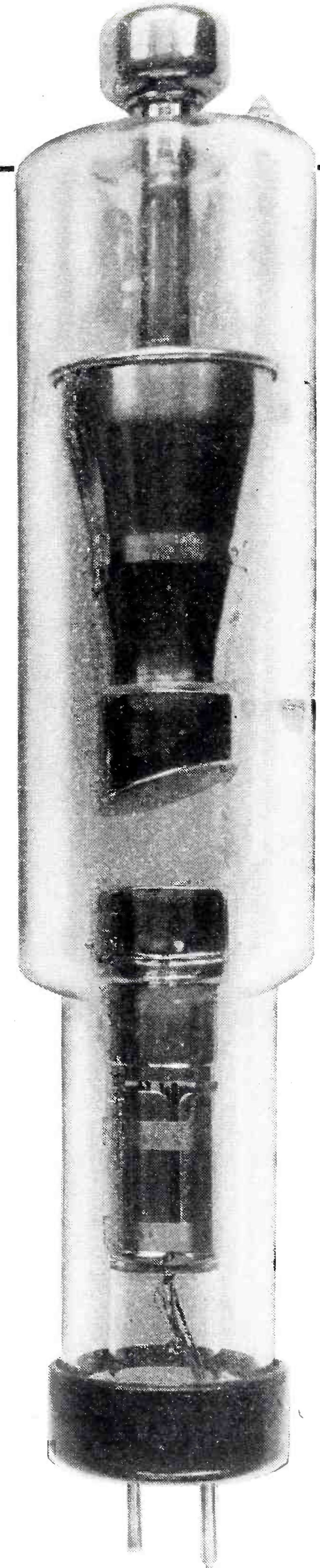
Electromagnetic radiations of extremely short wavelength are produced as the result of the collision between high velocity electrons and atoms. These radiations are propagated with the same speed as light, follow the inverse square law, are unaffected by electric or magnetic fields, and can be reflected, diffracted, refracted, and polarized. The rays can produce fluorescence and phosphorescence and, in sufficient intensities, are able to modify, damage, or destroy living cells. Their ability to blacken sensitized film in a manner proportional to their intensity, in addition to their property of penetrating solid matter in a nondestructive manner with partial absorption of the beam, has been the basis of radiography.

It would be possible to measure the quantity and intensity of x-rays in terms of the physical, chemical, or biological effects. The practical unit of x-ray quantity, the roentgen unit, is defined in terms of the ionizing properties of x-rays. One roentgen is obtained when under standard conditions of 0 deg. C and 760 mm pressure, sufficient ionization occurs in 1 cc of air to produce one electrostatic

TUBE DESIGN

Using a 220-kv portable industrial x-ray machine for radiographic inspection of a weld in a steel transformer tank





Three modern x-ray tubes. Above—100-kv shock-proof radiographic tube for oil-immersed operation. Left (top)—220-kv shock-proof tube for oil-immersed operation. Left (bottom)—100-kv air-insulated tube equipped for mounting in a ray-proof housing

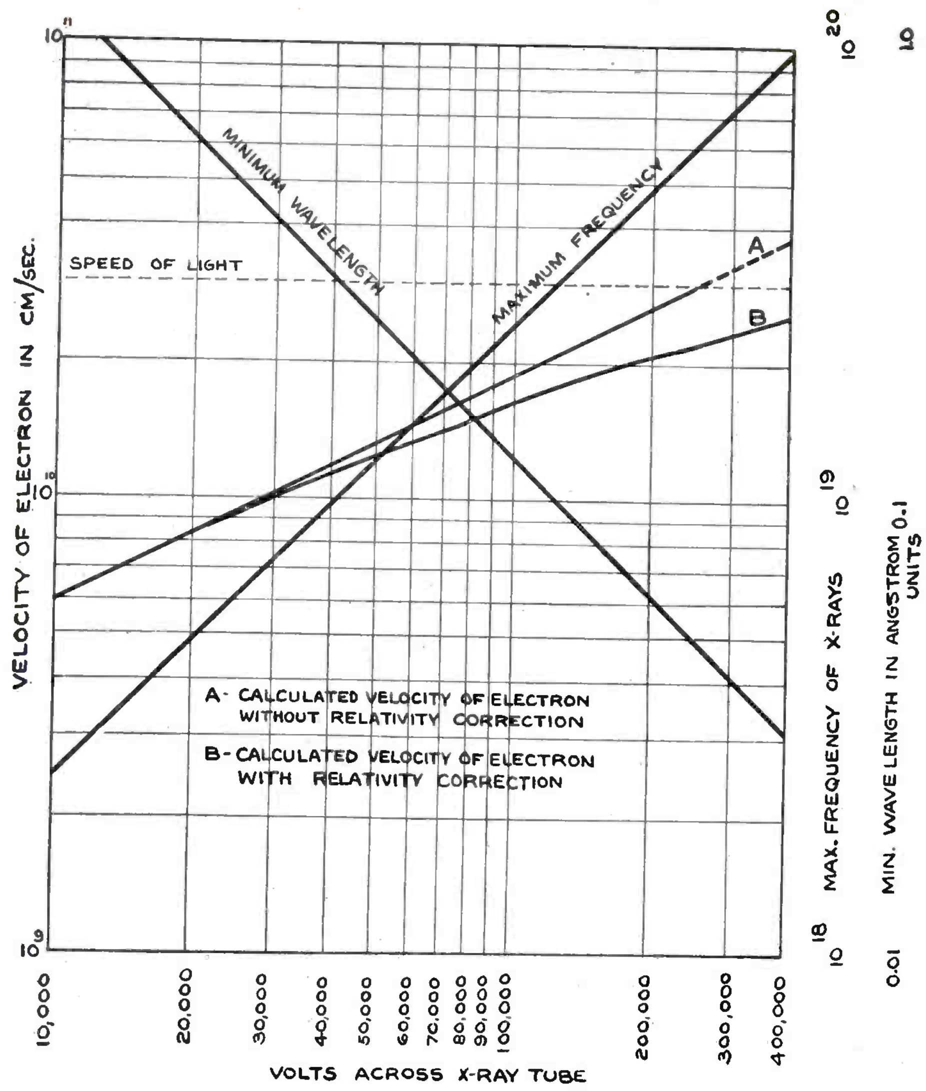


FIG. 1—Maximum frequency, minimum wavelength, and electron velocities as functions of impressed x-ray tube voltage[1]

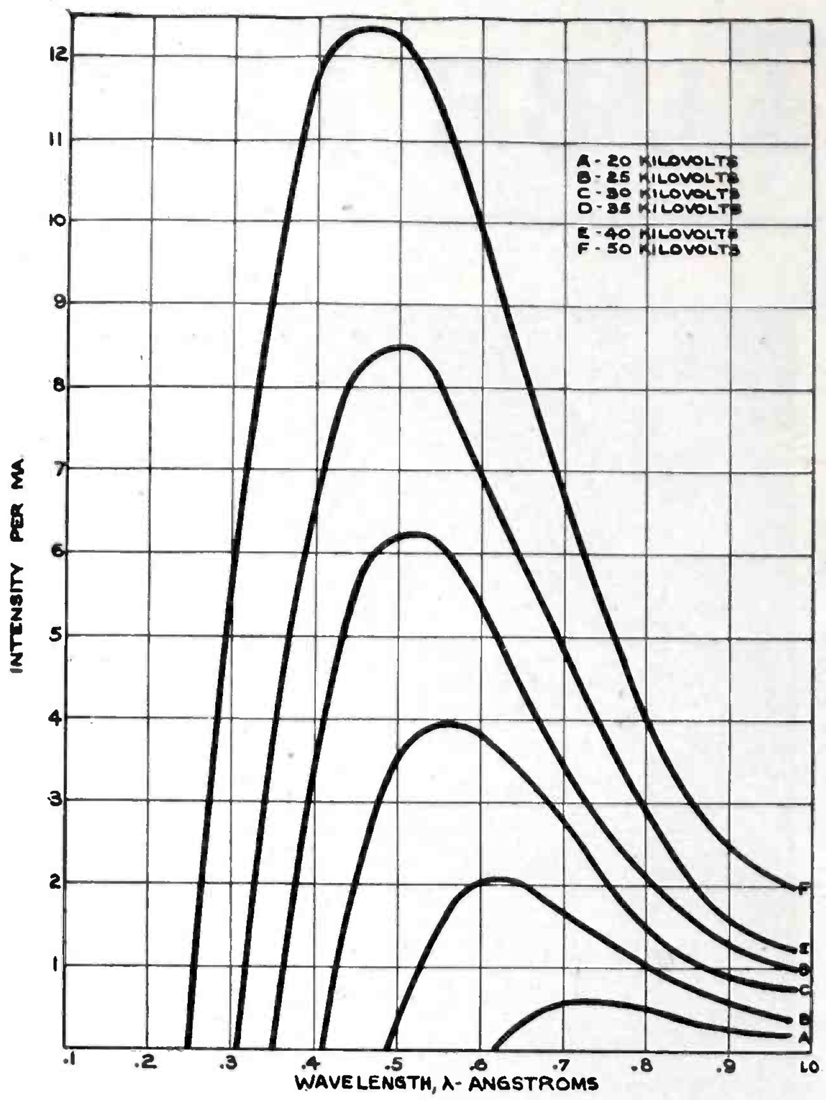


FIG. 2—Ulrey's curves for quality of x-radiation from a tungsten target. The wavelength is indicated in units of 10^{-8} cm

unit of charge at saturated current. All secondary electrons within the volume must be fully utilized and secondary radiation from the wall of the chamber avoided. The roentgen or r unit per second is the corresponding unit of intensity.

Upon collision with the material of the target, there is a probability that the kinetic energy of the electron will be released in the form of high-frequency electromagnetic radiation, the maximum frequency of which is determined by the Duane and Hunt quantum equation:

$$Ve = h\,\nu_{max} = 1/2\,mv^2 \qquad (1)$$

where V is the impressed voltage, e is the charge of the electron, h is the Planck constant, ν_{max} is the maximum frequency generated, m the mass, and v the velocity of the electron. As will be discussed in a later section, the probability that the collision will result in the generation of x-rays is very low, and is dependent upon the atomic number and the impressed voltage. Numerical values of the variables in Eq. 1 are shown in Fig. 1 for the peak voltages indicated. It is interesting to note that the electron velocity, when calculated without a relativity correction, is equal to the speed of light at 250,000 volts.

For a particular value of tube voltage it is found that a continuous spectrum of x-rays is produced, the maximum frequency of which is determined by Eq. (1).

Figure 2 indicates Ulrey's curves,[2] which demonstrate the continuous character of the rays. According to his data the total energy of the x-ray beam as represented by the area under each of the curves of Fig. 2 is proportional to the square of the exciting voltage for constant tube current. The maximum on the curve of relative intensity versus wavelength occurs at a wavelength of approximately 1.5 times the minimum wavelength defined by Eq. (1).

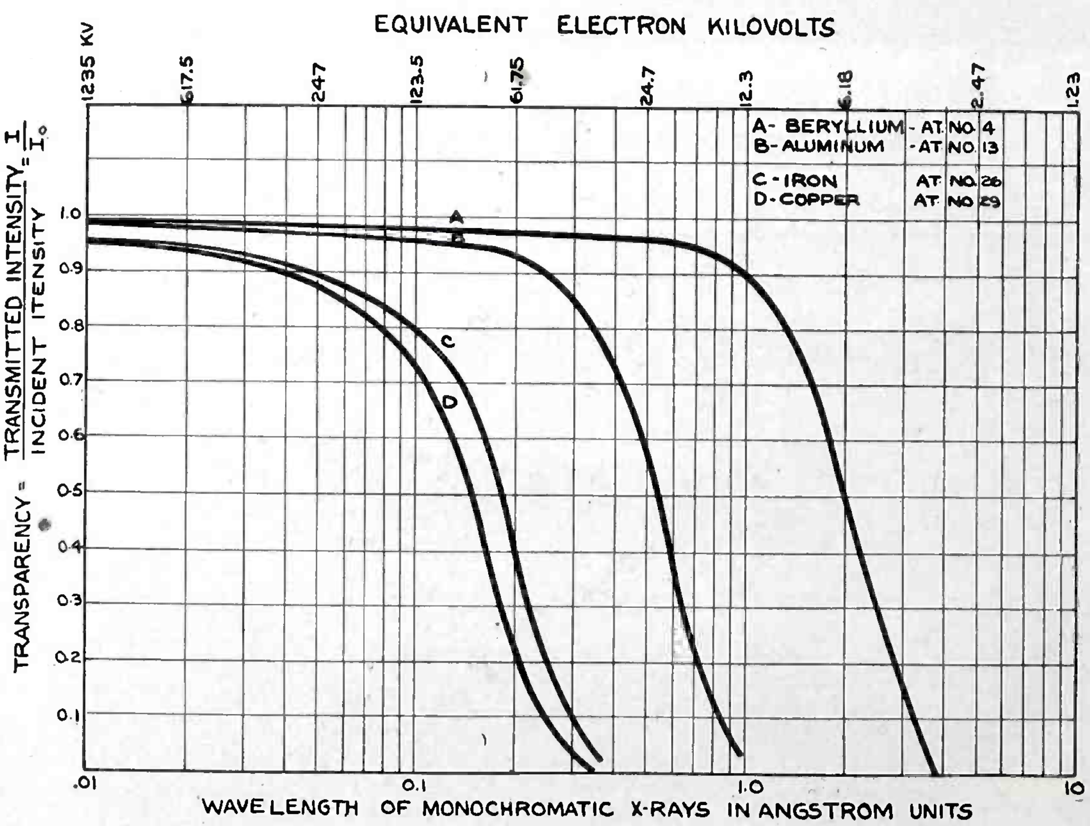
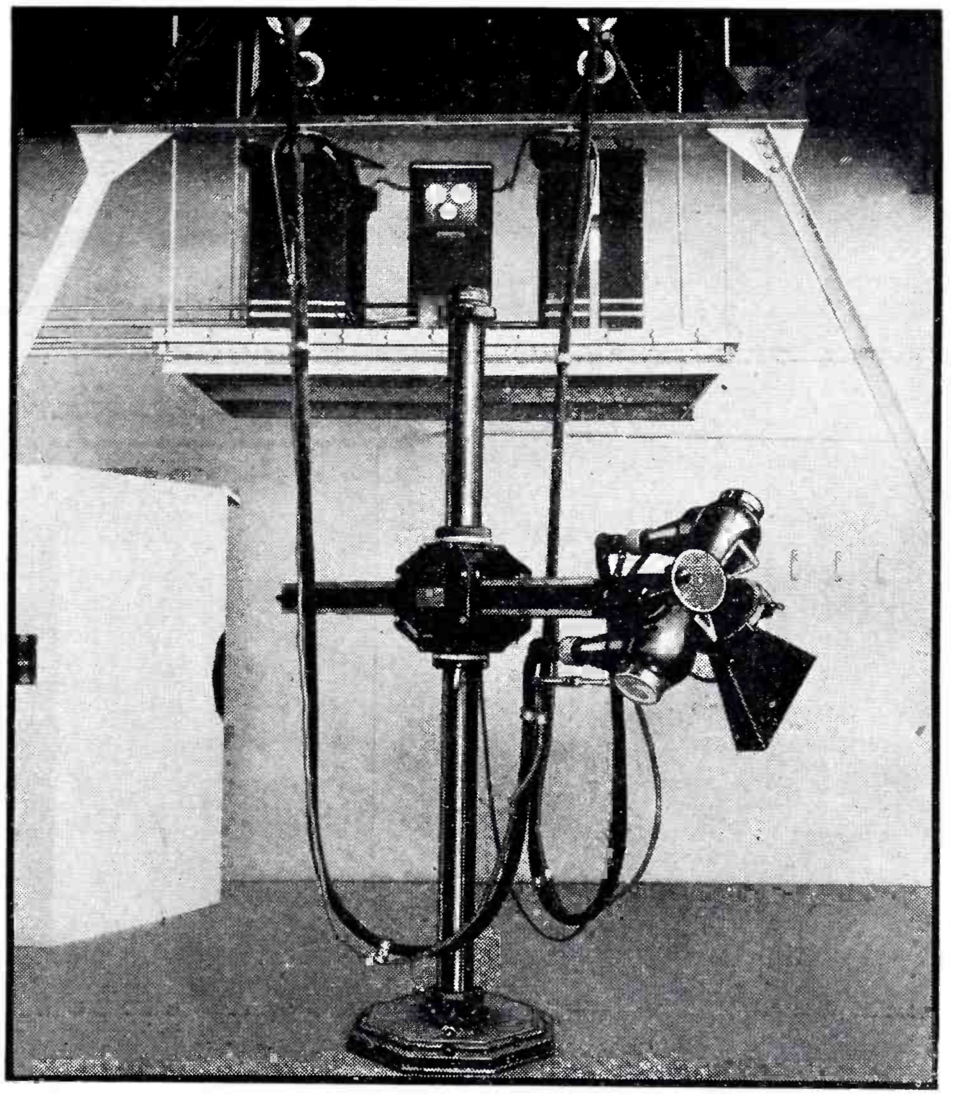


FIG. 3—X-ray transparency curve as a function of monochromatic wavelength for 0.1 cm thickness of beryllium, aluminum, iron, and copper



Shock-proof 220-kv industrial x-ray machine. The tube mounting provides maximum flexibility as to position with respect to the specimen being examined

The frequency or wavelength characteristic of the continuous spectrum is independent of the material of the target. The total energy of the continuous spectrum is found to be approximately proportional to the atomic number of the target material, to the electron current, and to the square of the impressed tube voltage for constant tube current.

In addition to the continuous x-ray spectrum, x-rays are emitted with wave-lengths which are characteristic of the target material. These characteristic radiations owe their origin to electron transitions in the various orbits of the atom. If an electron in a shell near the nucleus is removed, as by collisions with high speed electrons or photons of sufficient energy, an electron from an outer level will "fall" into the vacated position. If ΔW represents the difference in the energy between the two levels, the frequency of the excited characteristic radiation is determined by the equation

$$h\nu = \Delta W \tag{2}$$

Monochromatic lines[3] having the minimum wavelength characteristic of a given material are shown in the table. The characteristic x-ray lines corresponding to lower energy transitions have longer wavelengths than the minimum ones indicated in the table as $k\nu_1$ lines in Angstroms.

Approximately monochromatic radiation at a wavelength corresponding to the characteristic lines of a given metal can be produced by using it as the target of an x-ray tube, applying suitable voltages, and using appropriate external filters to reduce the intensities of lines in other regions of the x-ray spectrum. This approximately homogeneous radiation has proven invaluable in diffraction work in connection with the investigation of crystalline and molecular structures, in conducting research on alloys, in fabrication of metals and in many other applications.

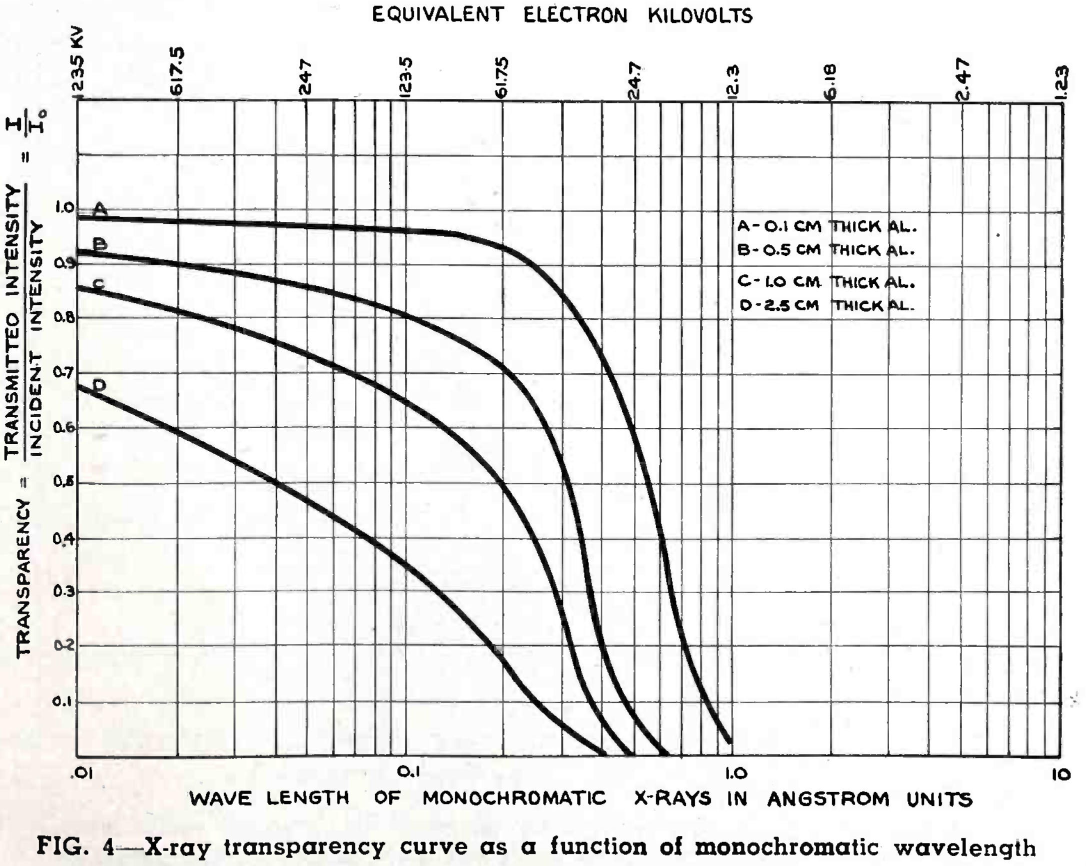


FIG. 4—X-ray transparency curve as a function of monochromatic wavelength for various thicknesses of aluminum

CHARACTERISTIC EMISSION

Element	Char. Atomic Number	Min. Wave-length (Angstroms)	Equiv. Electron Volts
Aluminum	13	7.95	1550
Chromium	24	2.06	6000
Iron	26	1.74	7100
Nickel	28	1.48	8350
Copper	29	1.38	8950
Molybdenum	42	0.619	20,000
Tungsten	74	0.179	69,000
Lead	82	0.141	87,500

Physical Basis of Radiography

The spacing between atoms of various metals is of the order of magnitude of several angstrom units. Thus as can be noted in Fig. 1, x-ray wavelengths are reasonably small compared to lattice spacings. The probability of x-ray absorption by a solid decreases as the wavelength of the x-rays decreases. The question of the absorption of x-rays is fundamental, not only because of the extreme importance of this effect in radiography, but because it is a salient factor in designing equipment with adequate x-ray protection.

In passing through material of thickness x, x-rays of intensity I_o

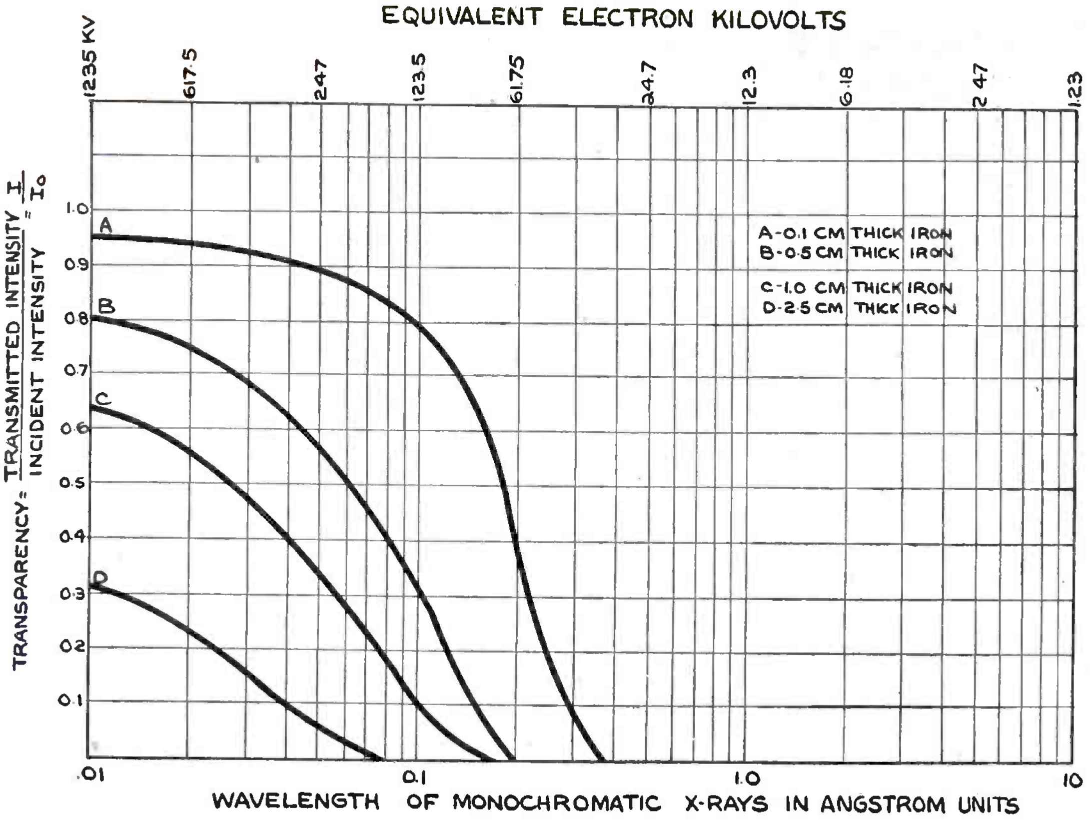


FIG. 5—X-ray transparency curve as a function of monochromatic wavelength for various thicknesses of iron

are absorbed according to the following equation:

$$I/I_o = e^{-\mu x} = e^{-\mu \rho x/\rho} \quad (3)$$

where I is equal to the intensity of the emergent beam, μ is the absorption coefficient, and μ/ρ is the mass absorption coefficient of the material. The latter coefficient is commonly used since it is independent of the physical state of the material.

The mass absorption coefficient of a metal is a function of its atomic number and the wavelength of the incident radiation. In Fig. 3 the ratio of fraction of I/I_0 as determined from various published figures[3, 4, 5] on μ/ρ is plotted for various metals as a function of the wavelength of homogeneous incident radiation.

The minimum voltage capable of producing such monochromatic radiation according to Eq. (1) is indicated for reference only at the top of each curve. Actual impressed voltages would, of course, not only produce continuous spectra similar to those described in Fig. 2, but also the monochromatic lines characteristic of the material, if the voltages are high enough to energize these levels. The increase in transparency with decrease in wavelength and atomic number is seen in Fig. 3.

That increasing the thickness decreases the amount of x-ray traversing a given material is evident in Fig. 4 where transparency curves are drawn for several thicknesses of aluminum. Similar curves for iron are shown in Fig. 5.

In actual practice the x-ray beam is heterogenous. Since the long wavelength portion of the beam does not have the penetrating ability of the short wavelength fraction, a greater proportion of the long wavelength radiation is absorbed when x-rays pass through a given material, in this way tending to shift the maximum on the continuous x-ray curve to short wavelengths. The effect of various thicknesses of aluminum in modifying the quality of the 50-kv curve of Fig. 2 is shown in Fig. 6. Since the continuous spectrum is a function of the applied voltage, it is evident that a greater predominance

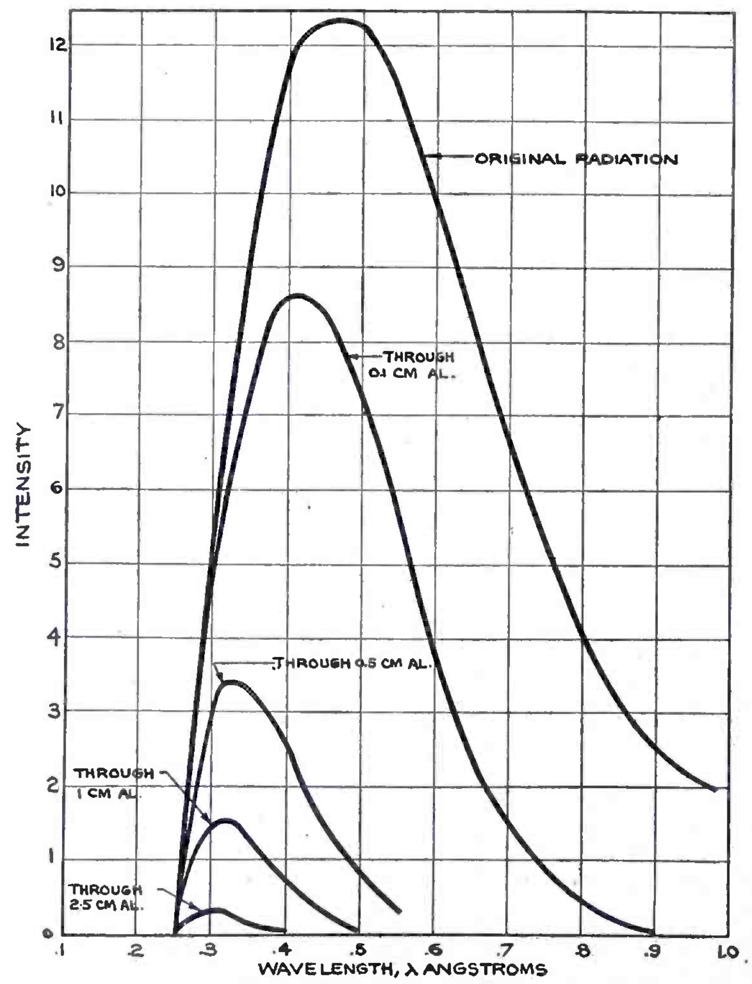


FIG. 6—Change in quality and relative intensity of 50-kilovolt radiation sent through sheets of aluminum

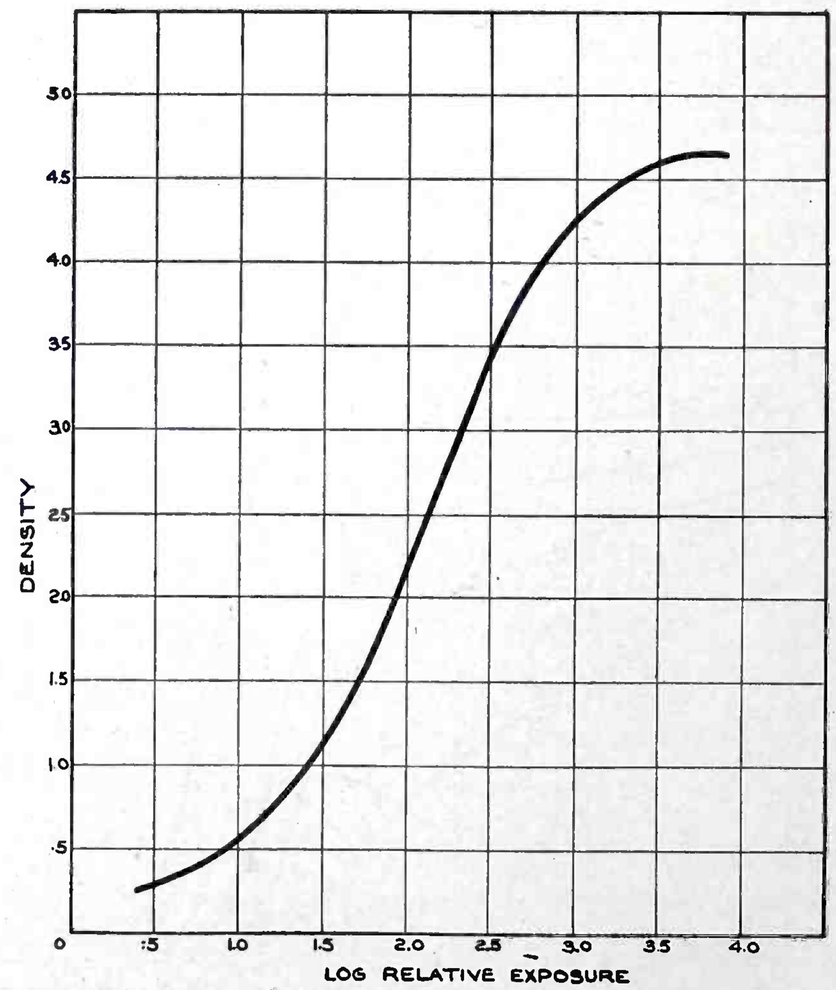


FIG. 7—Typical density-log exposure curve for commercial x-ray film. New industrial films do not have shoulder

of long-wavelength low-voltage radiation occurs when the d.c. impressed voltage is replaced by half or full-wave voltages of the same maximum values.

The ability of sensitized film to indicate by differences in degree of blackening the differences in x-ray intensities caused by nonhomogeneity of the specimen is essential in radiography. The general response characteristic of commercial x-ray film is indicated in Fig. 7. The shoulder of the curve limits the contrast at high intensities. Recently developed industrial films do not exhibit a shoulder within the range of usable densities.

In practice the quantity of x-rays reaching the film through the material being radiographed is adjusted so as to obtain film densities on the portion of the curve with steepest slope where the contrast is greatest. The amount of x-ray reaching the film through the specimen is controlled by varying the voltage across the tube, the plate current, and the time of exposure. A sample exposure chart for various sections of steel is shown in Fig. 8.

Contrast in a radiograph can also be varied by changing the plate voltage at which the exposure is to be made. It is evident in Fig. 4 that monochromatic radiation which has traversed a section of aluminum having the indicated thicknesses would have far greater relative differences at low than at high voltages. In other words, the contrast on a film exposed to the emergent beam would be greater at low voltages, as indicated by relative densities on the film.

Monochromatic radiation is an abstract concept as far as most radiography is concerned. For actual impressed d-c voltages, a continuous spectrum is obtained, rather than the monochromatic line indicated in Fig. 4. The predominance of lower voltage radiation produces in practice greater contrast than is indicated in the figure. Curves B, C and D may therefore be considered to indicate minimum contrast.

On the other hand, usual radiographic techniques cannot handle too wide a variation in the thickness of the material at low voltages, particularly when very thin sections are present. When the technique is selected for certain sections of the material, other sections may be un-

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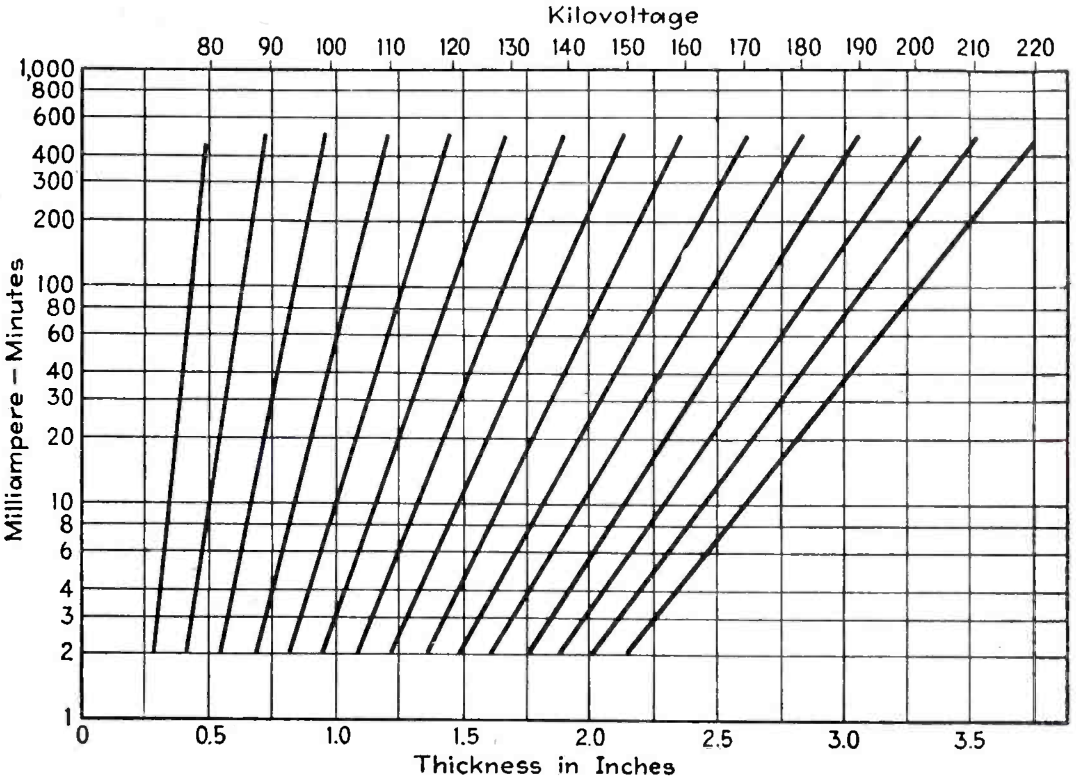


FIG. 8—Technique chart for rolled steel

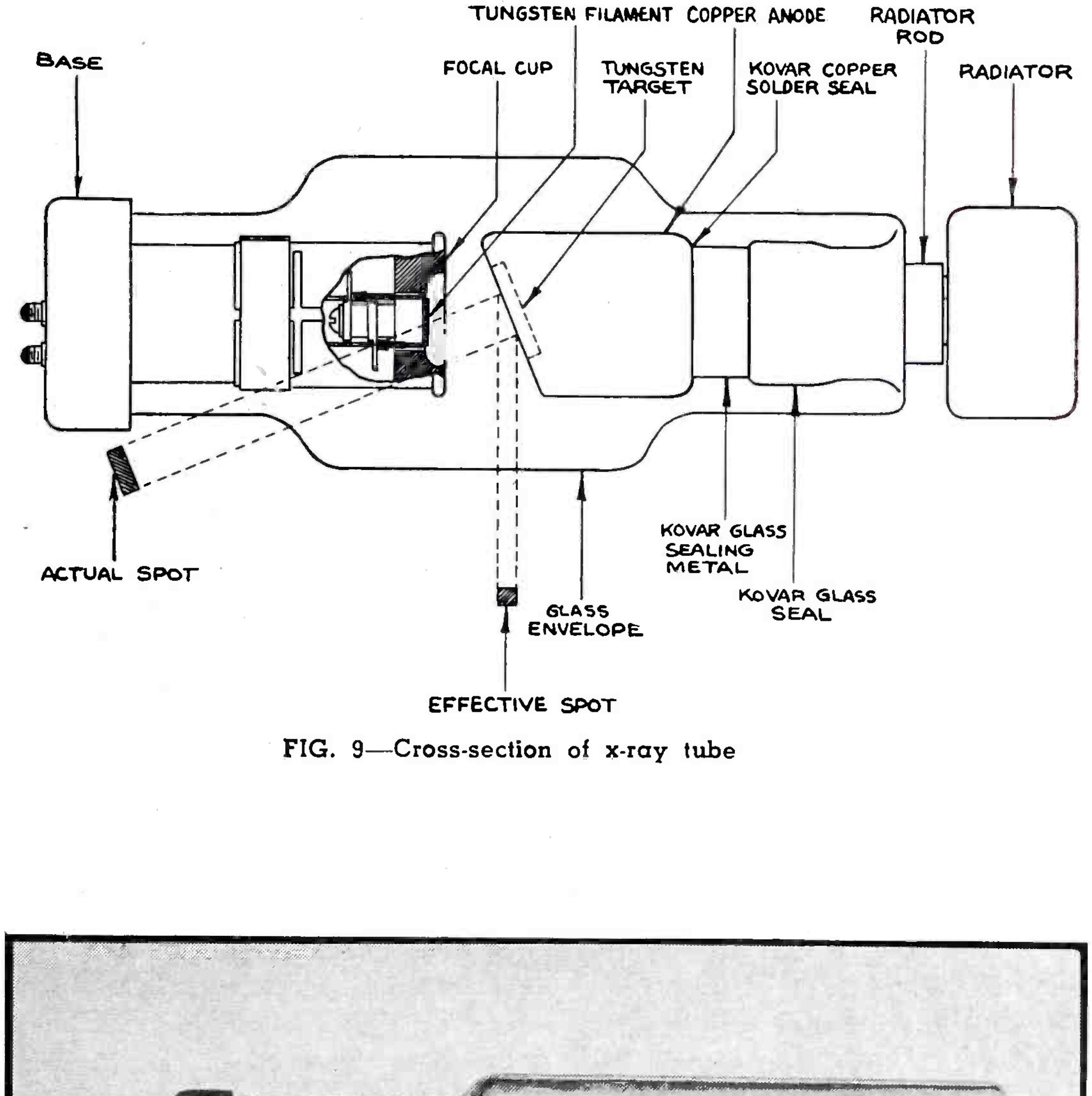
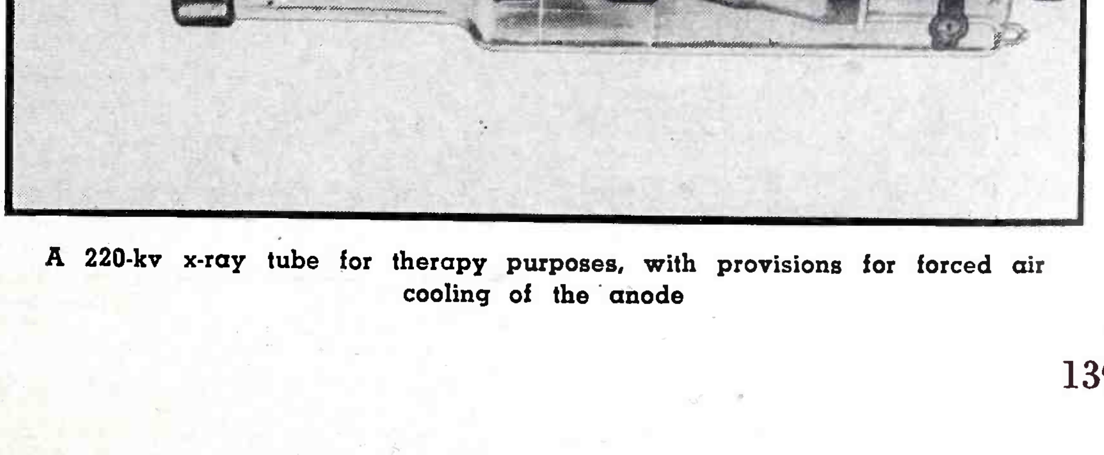


FIG. 9—Cross-section of x-ray tube



A 220-kv x-ray tube for therapy purposes, with provisions for forced air cooling of the anode

VISUAL DIRECTION

The principles of automatic and right-left types of visual direction finders are discussed in this article. Details of operation of two types of direction-finding equipment in wide use will be treated in forthcoming issues of ELECTRONICS

By DONALD S. BOND[1]

Radio Corporation of America
Camden, N. J.

In distinction to the direction finders of the aural null type which have been extensively described in the literature[2], there are numerous types in which the proper bearing is determined by means of a visual device. The operator is not required to listen for a minimum signal as in an aural null type, reception with phones being only needed for station identification or for monitoring. The purpose of a visual system of the type discussed in this paper is two-fold: (1) to provide greater convenience or accuracy in indication of bearings, and (2) to permit simple resolution of the 180 deg. ambiguity in bearings which occurs in the accurate null determination with an aural device.

Visual direction finders may be grouped in two main classes. Automatic direction finders indicate directly on a 360 deg. scale the station bearing. Right-left types utilize a zero-center meter or similar indicator and indicate deviations in bearing from the manually established loop position.

Aural null direction finders are sometimes provided with a tuning indicator or output meter. However, this will not be classed as a visual direction finder, inasmuch as the condition of giving "sense" or of elimination of 180 deg. ambiguity is not fulfilled.

A historical summary of the early types of visual direction finders has been given by Tuska[3], and refers to work by Leib, Busignies, Dieckman and Berndorfer, Hell, and Scheppmann. As a result of work by these, a visual system of the "left-right" type was developed. This system has had widespread use in aircraft in the United States. The device indicates whether the craft carrying the instrument is headed to the left or right or on a desired course.

The first successful commercial automatic direction finder in general use in the United States was developed in 1937 jointly by Radio Corporation of America and Sperry Gyroscope Company.[4] Later designs have embodied these same general principles.

Automatic Direction Finders

In order to study the detailed circuit of a self-orienting automatic direction finder, it becomes important to study two topics concerned with circuit operation: (1) balanced modulator circuits and (2) relations of carrier and sideband vectors. First, however, an examination may be made of a block diagram of the direction finder system in which balanced modulators occur. This is shown in Fig. 1.

The a-c supply serves to modulate the r-f carrier in the loop channel by means of balanced modulator *A*. In this the inputs consist of the large-amplitude local a-c signal and a much smaller r-f signal. The difference in amplitude and the fact that two different frequencies are fed in are points of importance.

Balanced modulator *B* is supplied with voltage directly from the a-c supply and also with a signal of this same frequency from the output of the a-f amplifier. Here the two am-

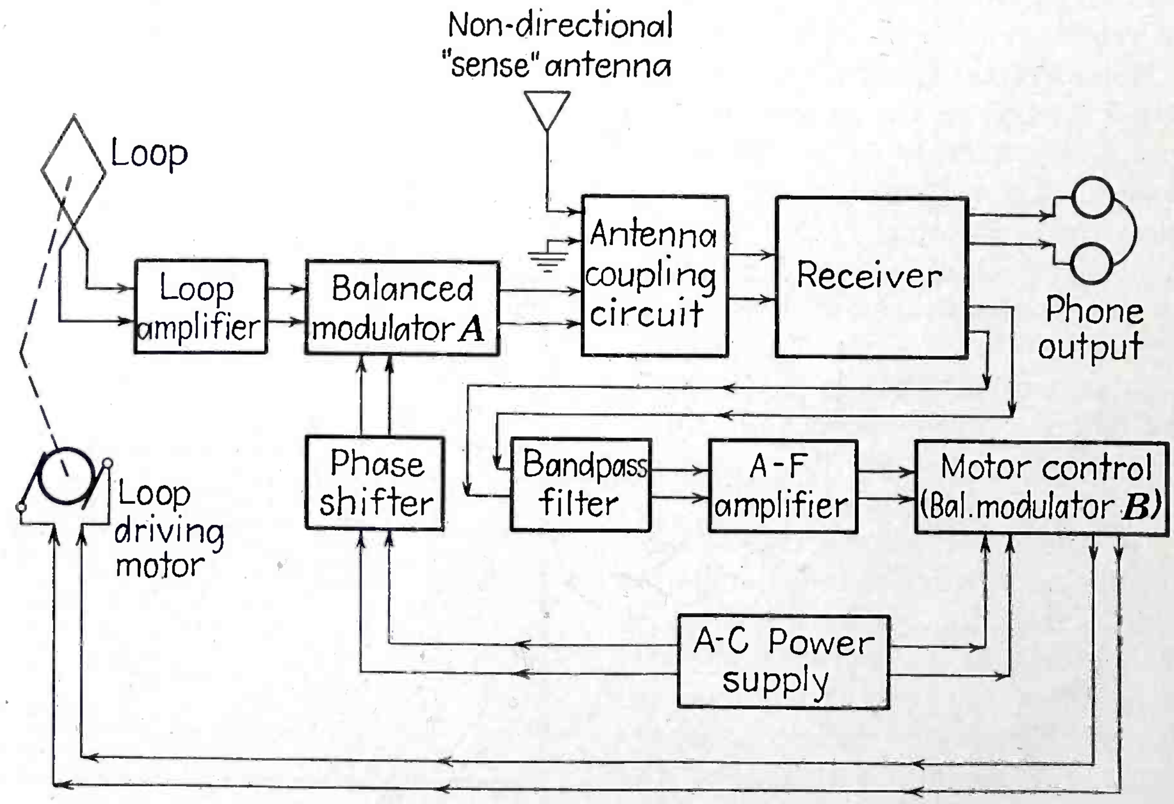


FIG. 1—Block diagram of essential electrical elements of the automatic direction finding equipment

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[1], [2] Bond, D. S., "Radio Direction Finders," to be published by McGraw-Hill Book Co., Inc. The present article is condensed from Chapter VI of this book.

[3] Tuska, C. D., Radio in Navigation, *Journal of the Franklin Institute*, 228, pg. 433, Oct. 1939; pg. 581, Nov. 1939, especially p. 582–5.

[4] An Automatic Direction Finder, *Communications*, 18, pg. 10, Oct. 1938.

FINDERS . . . Part I

plitudes may be comparable. Phase relationships become of importance for this case. Each of these two types of systems will be taken up in the following discussion.

Two-Signal Balanced Modulators

A very general type of circuit of this type employs two nonlinear elements V_1 and V_2 as in Fig. 2. It will be assumed here that $|E_A| \gg |E_B|$ to simplify the analysis. The frequencies of components present will be the same without this limitation, however.

A further assumption will be made that V_1 or V_2 behaves in nonlinear fashion so as to exhibit a forward resistance R_f during one half-cycle of E_A and a reverse resistance R_r when E_A polarizes it in the opposite sense. For these two cases the circuits are as shown in Fig. 3.

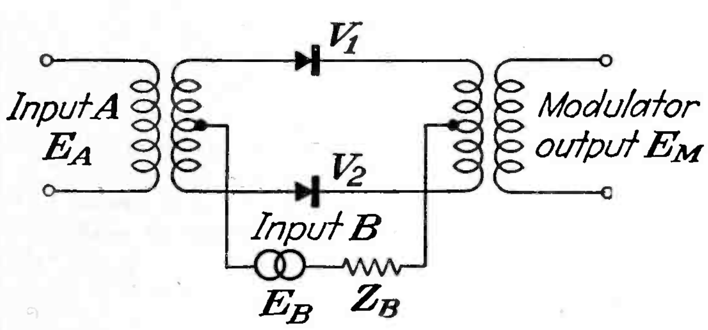


FIG. 2 (Above)—Schematic circuit of two-signal balanced modulator

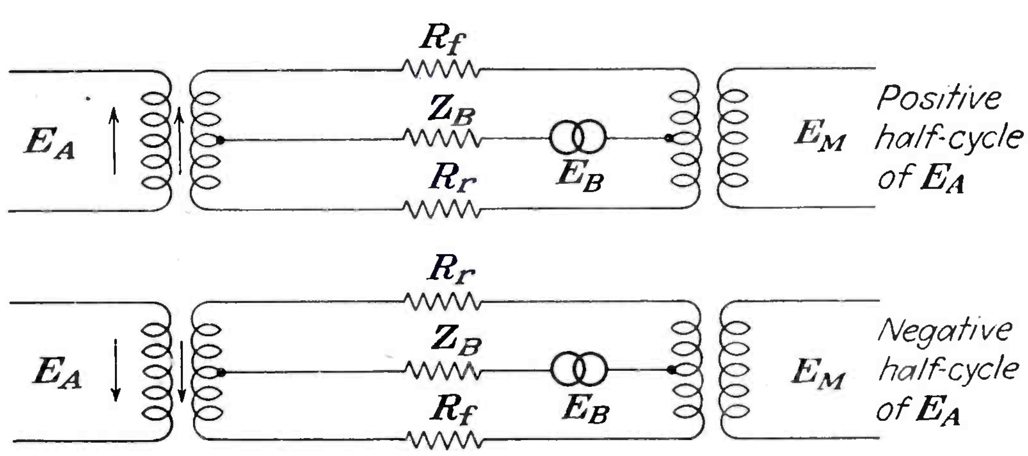


FIG. 3 (Right)—Circuits for nonlinear operation of the two-signal balanced modulator

A Fourier analysis of the wave resulting from this modulator equivalent circuit shows that there are sideband components symmetrically disposed with respect to the odd harmonics of the input E_A. Neither E_A itself nor any of its harmonics is present. This may be illustrated if one designates the E_A input and its harmonic frequencies (including d.c.) by $a\omega_A/2\pi$ where $a = 0, 1, 2, 3, \ldots$ and the E_B input and harmonics by $b\omega_B/2\pi$ where $b = 0, 1, 2, 3, \ldots$ Then such a pair of terms as $\cos(3\omega_A + \omega_B)t + \cos(3\omega_A - \omega_B)t$ would be identified by $(3\omega_A \pm \omega_B)$ in which $a = 3$ and $b = 1$. The two algebraic signs identify upper and lower sideband components, and the order of taking the difference is immaterial. The latter means that no limitation is imposed upon the relative magnitudes of ω_A and ω_B. The various magnitudes are summarized in the table.

Other combinations of two nonlinear elements may be analyzed in similar fashion either for balanced or unbalanced circuits. However for applications to direction finders the case considered is the most important two-element system.

Single-Frequency Balanced Modulators

The modulator systems considered above were supplied with two signals of different frequencies. The important case arises especially in a-f or power frequency modulator circuits when the two signals are of the same frequency, but where the phase may vary. A circuit similar to Fig. 2 may be analyzed without any limitation imposed upon the relative amplitudes of E_A and E_B. The circuit of Fig. 2 may be redrawn in accordance with Fig. 4. The voltages e_q and e_s are related to the applied voltages as follows:

$$\left.\begin{aligned} e_q &= e_B + \tfrac{1}{2}e_A \\ e_s &= e_B - \tfrac{1}{2}e_A \end{aligned}\right\} \qquad (1)$$

where conditions are such that

$$\left.\begin{aligned} e_A &= E_A \cos \omega t \\ e_B &= E_B \cos(\omega t + \phi) \end{aligned}\right\} \qquad (2)$$

since these are assumed to be of the same frequency. The phase difference between the two inputs is designated by ϕ.

A rather extended analysis would show that there is a direct current component of the output which varies as a function of the phase angle ϕ between E_A and E_B. This output current is

$$i_M = E_A E_B H_1 \cos \phi \qquad (3)$$

where H_1 is a constant of proportionality. Whether E_B reverses in phase or whether it varies continuously in phase, Eq. (3) applies to show the behavior of this type of balanced modulator. The automatic direction finder to be described utilizes the two conditions of $\phi = 0$ and $\phi = \pi$. Adjustments are provided to secure these particular phase relations to produce maximum angular sensitivity.

Carrier and Sideband Relations

The circuit in the loop channel designated as balanced modulator A in Fig. 1 is of the type discussed under the heading of Two-Signal Balanced Modulators. The large-amplitude signal E_A is of the a-c power supply frequency, while E_B is the r-f carrier. From the analysis given, it is seen that sidebands of the r-f carrier appear in the output,

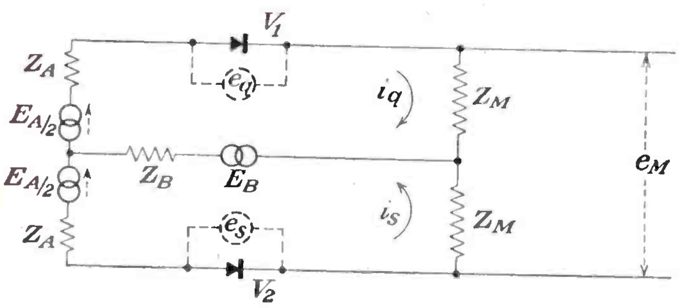


FIG. 4—Two-signal modulator circuit of Fig. 2, generalized and without limitations on operation

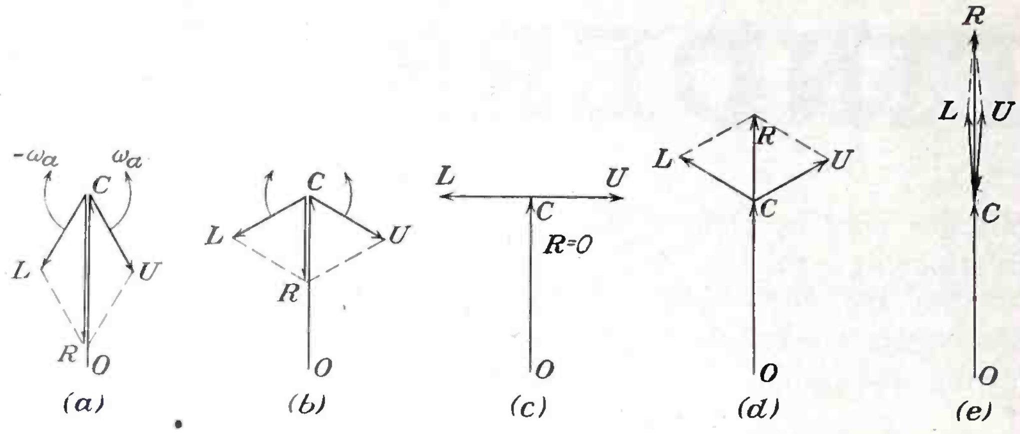


FIG. 5—Vector diagram representing the relations between the carrier and sideband frequencies, illustrating that the resultant, *OR*, varies in magnitude depending upon the phase relations of the upper, *U*, or lower, *L*, sideband

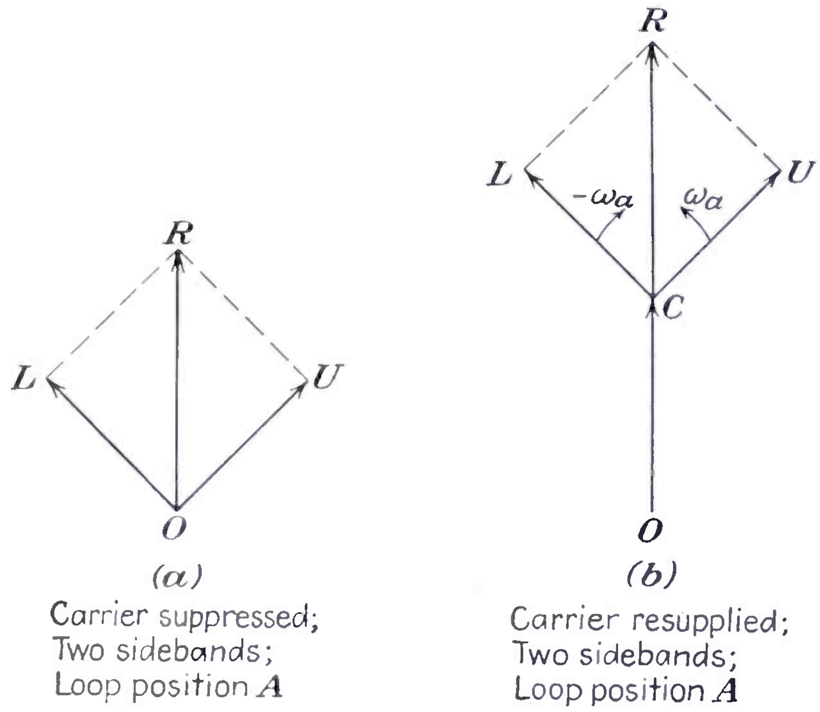


FIG. 6—Resultant vector, *R*, of upper and lower sidebands, *L* and *U*, respectively, for signals with carrier suppressed and for carrier resupplied, for position of the loop giving maximum signal

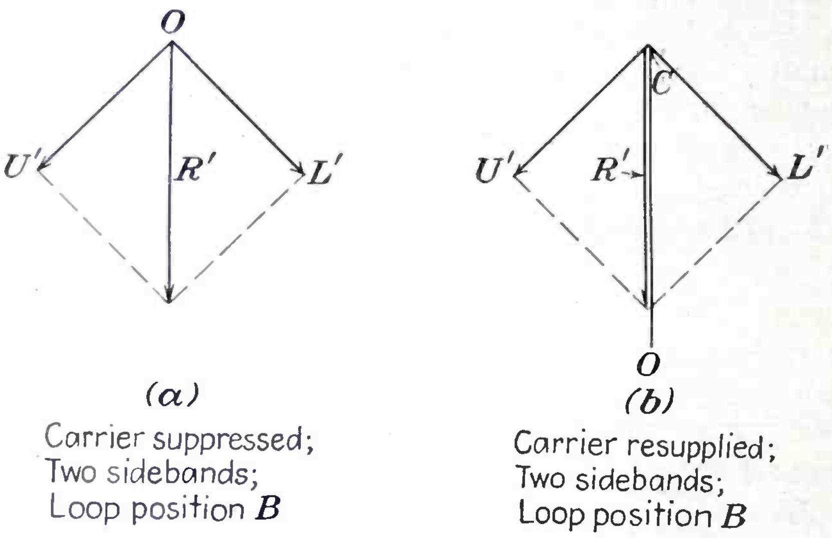


FIG. 7—Vector diagram of carrier and upper and lower sidebands, corresponding to Fig. 6, for position of loop giving minimum signal

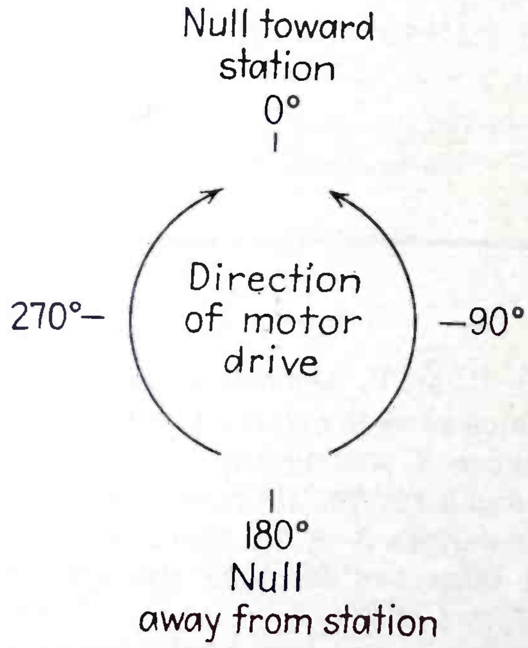


FIG. 9—Diagram illustrating the return of the motor drive to the null position

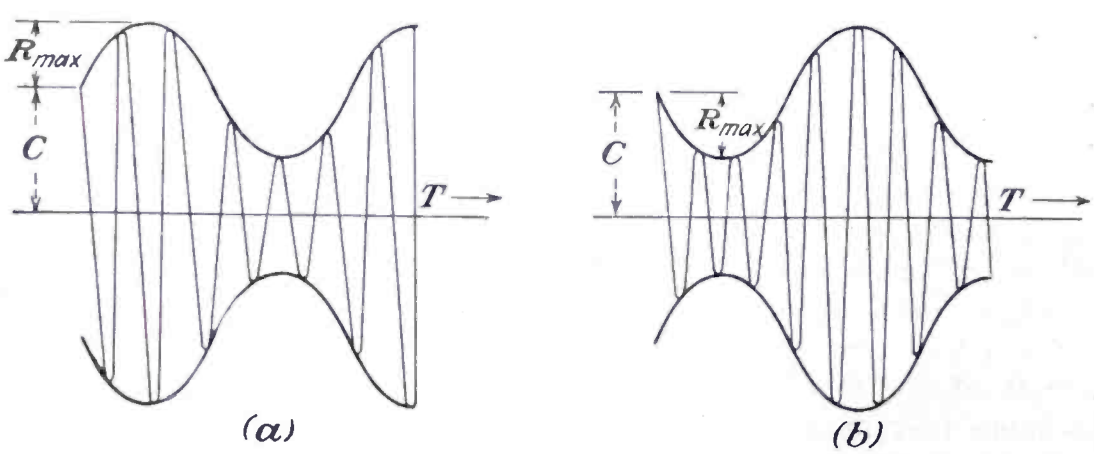
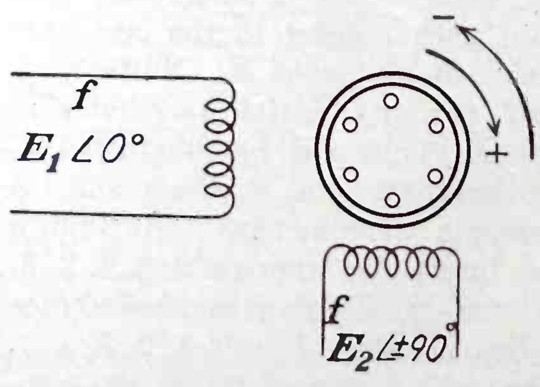


FIG. 8—The phase of the a-f envelope is reversed as at *(b)* when the carrier of the original phase is resupplied

FIG. 10—The direction of rotation of a two-phase a-c motor may be reversed by reversing the phase of one winding with respect to that of the other ➔



but the carrier itself is suppressed. Then the carrier is resupplied from the antenna by means of the antenna coupling circuit. The phase relationships among the components may best be analyzed by considering the carrier and sideband vectors.

In a normal modulated carrier system the carrier may be represented as a rotating vector C in the conventional manner for an a-c wave. If it is imagined that one examines it stroboscopically at intervals equal to its period, the lower and upper sideband components (L and U) will be vectors rotating more slowly or more rapidly than the carrier vector, so that L will appear to rotate in one direction and U in the other, with an angular velocity $-\omega_a$ or ω_a, where $\omega_a/2\pi$ is the audio modulation frequency. Furthermore it is characteristic of amplitude modulation that the vector sum of L and U always lies along C. The vectors, viewed stroboscopically for various portions of the audio cycle, are shown in Fig. 5. It will be noted that R, the resultant of L and U, is a vector of varying length but always in the same direction as C (or 180 deg. reversed).

This is the only phase relationship which can be specified, inasmuch as C, L, and U are of different frequencies. When the carrier is suppressed, the output of balanced modulator A continues to be represented by the vectors L and U of Fig. 6 for the same phase of incoming carrier as before. This may be compared with (d) of Fig. 5.

The r-f carrier in the loop channel reverses when the loop is rotated through a null point. The 180-deg. zones on the two sides of a null may be identified as Loop Position A and Loop Position B. When the carrier of fixed phase is resupplied from the antenna channel the result will be as in (b) of Fig. 6.

Since the reversal of loop position causes a 180-deg. reversal of all r-f components, the case analogous to (a) of Fig. 6 is given in Fig. 7. Then when the carrier of the original phase is resupplied from the antenna channel, one has the result of (b) in Fig. 7. The a-f envelope of the carrier is clearly reversed. This is illustrated in Fig. 8.

The phase of the a-f voltage at the

TABLE I

Relative Amplitudes of Components for Two-Signal Balanced Modulator

$\pm b$	a					
	0	1	2	3	4	5
0	0	0	0	0	0	0
1	0	$\frac{2}{\pi}$	0	$\frac{2}{3\pi}$	0	$\frac{2}{5\pi}$
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0

detector of the receiver is thus changed by 180 deg. when the loop is reversed. The general conclusion may be drawn for a system of this sort that reversal of r-f phase in the loop channel reverses the phase of the audio signal. The principal visual direction finder systems described in this paper function by virtue of this effect. When the loop is on one side of the line of nulls (bearings 0 deg. to 180 deg), audio output from the receiver is of one phase; when the loop is on the other side of the null points (bearings between 180 deg. and 360 deg.), the audio output is of the opposite phase.

Motor Control Circuits

The reversing of the a-f phase is employed to cause the loop to be driven by a reversible electric motor to a point of null loop signal pickup. Because of the fact that this motion may be in one direction when the initial position of the loop is between 0 deg. and 180 deg. and in the opposite direction for bearings 180 deg.–360 deg., it is evident that the loop will always drive to the 0 deg. null. This is indicated in Fig. 9. In the special case where the loop is exactly 180 deg. off the "correct" null, the audio output of modulation frequency is again zero, and hence there is no restoring motor torque. Any slight electrical disturbance will be sufficient to upset this balance momentarily, and the resultant motor torque in a properly designed motor control circuit will be sufficient to start the loop in motion, so that audio control voltage will be developed and drive the loop toward the correct null. Conditions at the 180 deg. (or "false") null are analogous to those of balancing a pencil on its point.

Now it is a well-known fact that a two-phase a-c motor (often used as a capacitor-type motor) requires that its two fields be excited by two voltages of the same frequency but of 90 deg. phase difference. If this difference is of one algebraic sign, the motor will rotate in one direction, while if the sign is reversed, the direction of rotation will be also reversed, as shown in Fig. 10.

Thus such a motor may be used for a reversible drive with the receiver output as voltage E_1 and a voltage E_2 serving as a reference phase and derived from the same source as used for modulator A. The requirement of adequate power of course necessitates a suitable a-f amplifier connected as shown in Fig. 1. For aircraft automatic direction finders 5 to 30 watts maximum power may be required, and this can be obtained from a class A or B output stage.

The band-pass filter serves to attenuate speech and other modulation components which may be present on the carrier, to prevent excessive motor heating or overloading of the a-f amplifier. The motor control amplifier and the motor itself constitute a phase comparing system like the type of modulators described under Single-Frequency Balanced Modulators. These therefore perform the function of modulator B of Fig. 1.

System Limitations

This system has three limitations. One results from the fact that one field of the two-phase motor is excited continuously. In small-size units operating near full power this means unnecessary heating and low efficiency of power conversion. In the second place, the efficiency of the high-level audio amplifier is somewhat low. Especially for aircraft applications, where size and a-c power supply are limited, this is a serious disadvantage. Lastly, no provision is made to keep the mechanical system from oscillating or "hunting" about its equilibrium position. The cure for this is one of the main problems of the design of servo devices or electro-mechanical follow-up systems. This will be treated more fully later.

SUPERHETERODYNE Converter Terminology

A critical analysis and summary of existing accepted terms, and suggested additions to converter terminology, plus a systematic treatment of converter theory which includes some of the latest developments

By HARRY STOCKMAN

Cruft Laboratory
Harvard University
Cambridge, Mass.

MANY difficulties in understanding frequency conversion and the relations between frequency conversion, modulation and detection are caused by improper terminology. Some terms, such as heterodyne detection, have a number of different meanings. Others are not clearly defined. In the following discussion, some standardized terms concerning superheterodyne converters are restated, and some tentatively suggested new terms are proposed. They are the result of the writer's experience in teaching classes at Cruft Laboratory, and have been extensively tried out on students with encouraging results.

Fundamental definitions already agreed upon and widely accepted are not changed and are used as a foundation for additional definitions. These accepted definitions are from the Institute of Radio Engineers' "Standards on Radio Receivers, 1938" and are cited in the appendix as a starting point for a discussion of frequency conversion, and for a comparison between frequency conversion on one side and detection and modulation on the other side. Proposed new terms are also summarized in the appendix for convenient reference.

Tentative Classification of Converters

The list of technical terms indicates many possibilities for grouping and classification of converters and mixers. The following classification has been found to have practical advantages.

A. Type of Circuit
1. *Single input mixers* (network coupling)
   a. Mixers with common input and output circuits (crystals or diodes, as in Fig. 4a.)
   b. Mixers with separate input and output circuits (triodes or pentodes, as in Fig. 2a and 4b.)
2. *Double input mixers* (electron coupling, as in Fig. 3a and 5a.)

B. Type of Tube
1. *Converter tubes* (oscillation and mixing in one tube, as in pentagrid converters)
   a. Oscillation and mixing in same electron stream (Fig. 5b).
   b. Oscillation and mixing in separate electron streams (Fig. 5c).
2. *Mixer tubes* (oscillation in a separate tube, as in a pentagrid mixer)

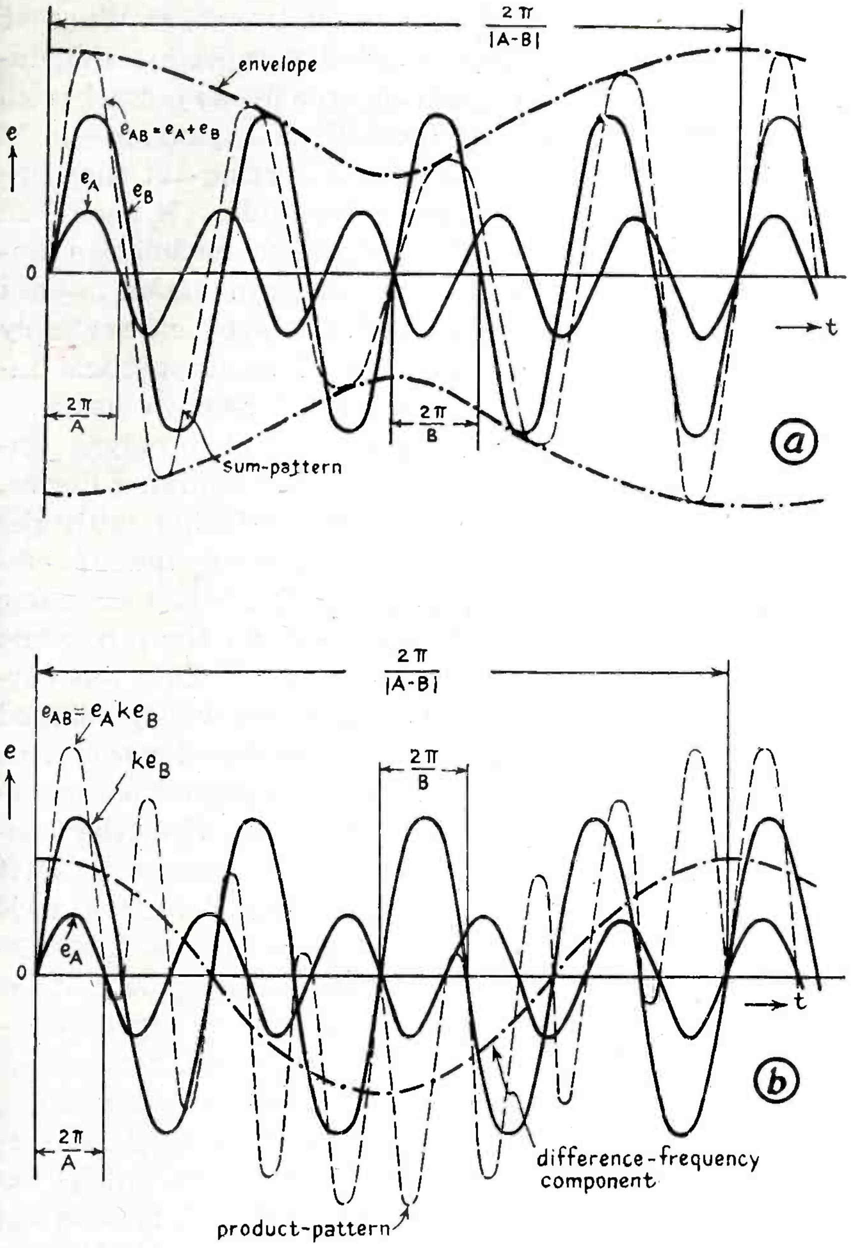
C. Electrode Arrangement
1. *Outer grid injection (OGI) converter and mixer tubes* (Fig. 5c).
2. *Inner grid injection (IGI) converter and mixer tubes* (Fig. 5b).

D. Type of Operation
1. *Sliding Q-point or FPO converters* (Fig. 2a, 4a and 4b).
2. *Shifting Q-point or CPO converters* (Fig. 3a, 5a, 5b and 5c).

This classification is not complete

CONVERTER and MIXER CLASSIFICATION

Input	Coupling	Operation	Tube	Circuit	Figure
Single	Network	Sliding Q-point	Mixer	Separate input and output	2a & 4b
Single	Network	Sliding Q-point	Diode or crystal	Common input and output	4a
Double	Electron	Shifting Q-point	Mixer		3a & 5a
Double	Electron	Shifting Q-point	Converter	Oscillator and mixer in same electron stream	5b
"	"	"	"	Osc and mixer in separate stream	5c
"	"	"	"	Inner grid injection	5b
"	"	"	"	Outer grid injection	5c



◀ FIG. 1—Sum-pattern (a) and product-pattern (b) of two waves of angular velocity A and B

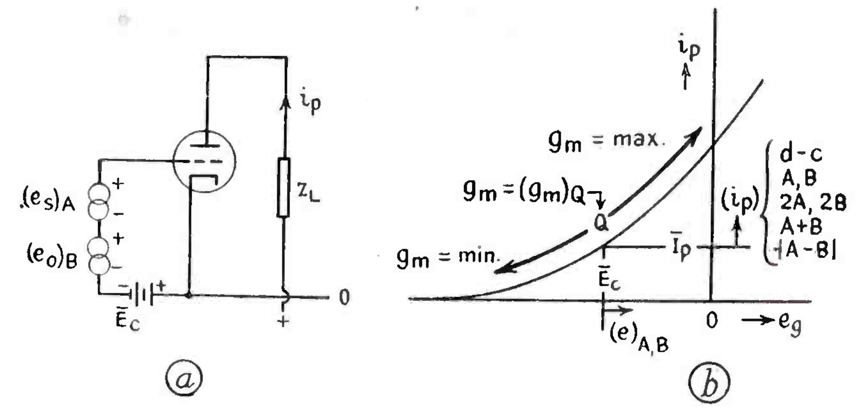


FIG. 2—Circuit diagram and i_p-e_g characteristic for sliding Q-point or FPO converter

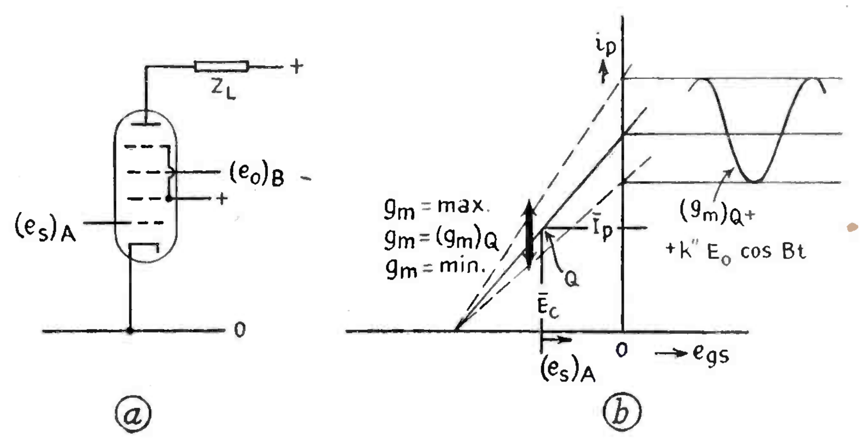


FIG. 3—Circuit diagram and i_p-e_{gs} characteristic for shifting Q-point or CPO converter

and must be extended if more extreme types of u-h-f converters are considered.

Sliding Q-point or FPO Converters

The action that takes place in a modulator or detector is frequently described in the literature as an action concerning the Q-point. To stress the similarities between frequency-converting devices and modulating or detecting devices, it is advantageous to classify and describe frequency converters from the point of view of the Q-point situation.

The first type of converter to be considered is the sliding Q-point or FPO converter (the alternative latter part of the name will be discussed later). Assume a diode* or multi-electrode tube circuit of the type indicated in Figs. 2 or 4. Assume for simplicity that the input-output characteristic of Fig. 2b is a parabola and that the load impedance Z_L is resistive and negligible compared with the inner resistance of the square-law device. If now two emf's $(e_s)_A$ and $(e_o)_B$ of frequencies $A/2\pi$ and $B/2\pi$ are applied in series, they constitute the sum pattern

$$e_{AB}=(e_s)_A+(e_o)_B=E_s\cos At + E_o\cos Bt \qquad (1)$$

This summation is shown graphically in Fig. 1a (where the generalized notations e_A and e_B have been used). It is important to note that although the sum pattern shows a periodic variation of frequency $|A—B|/2\pi$, no additional frequency has been developed. When the pattern is passed through the square-law device, however, it loses its symmetry; it becomes rectified. The rectified sum-pattern represents an output, which contains new frequency components in addition to the original ones.

When the square-law device is used as a modulator, the modulating voltage $(e_o)_B$ may be quite large compared with the r-f voltage $(e_s)_A$. The action caused by the modulating voltage may therefore be visualized as a considerable sliding movement of the original Q-point, and thus as a periodic variation of the transconductance or transadmittance (the conductance or admittance in case of a crystal or diode) of the device. Consequently the r-f wave will become periodically expanded and contracted, or amplitude modulated. If the transconductance or slope of the characteristic in the original Q-point is indicated by $(g_m)_Q = k$ and the rate of change of the slope by K, then for the e-value $e = e_{AB}$ of Eq. (1), the conventional formula for the parabola

$$i = ke + \tfrac{1}{2}Ke^2 \qquad (2)$$

yields seven different terms. These seven terms are as follows:

$i = \frac{1}{4}K(E_s^2+E_o^2)$	Rect. d-c	(3)
$+\,k\,E_o\cos Bt$	Mod. freq.	(4)
$+\,\frac{1}{4}K\,E_o^2\cos 2Bt$	2nd harmonic	(5)
$+\,k\,E_s\cos At$	Carrier freq.	(6)
$+\,\frac{1}{4}K\,E_s^2\cos 2At$	2nd harmonic	(7)
$+\frac{1}{2}K\,E_s E_o\cos(A-B)t$	Lower side freq	(8)
$+\frac{1}{2}K\,E_s E_o\cos(A+B)t$	Upper side freq.	(9)

This expansion is useful for a qualitative discussion even if the

* The treatment of the diode applies in part to crystals. One main difference between crystals and diodes is that the crystal has reversed conductivity. Crystal converters are desirable because of their high signal-to-noise ratio.

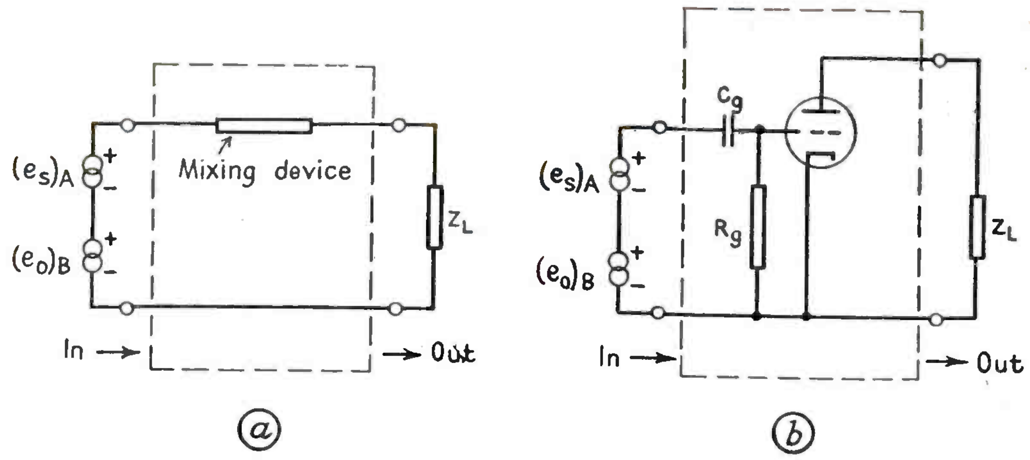


FIG. 4—Mixers with common and separate input and output circuits

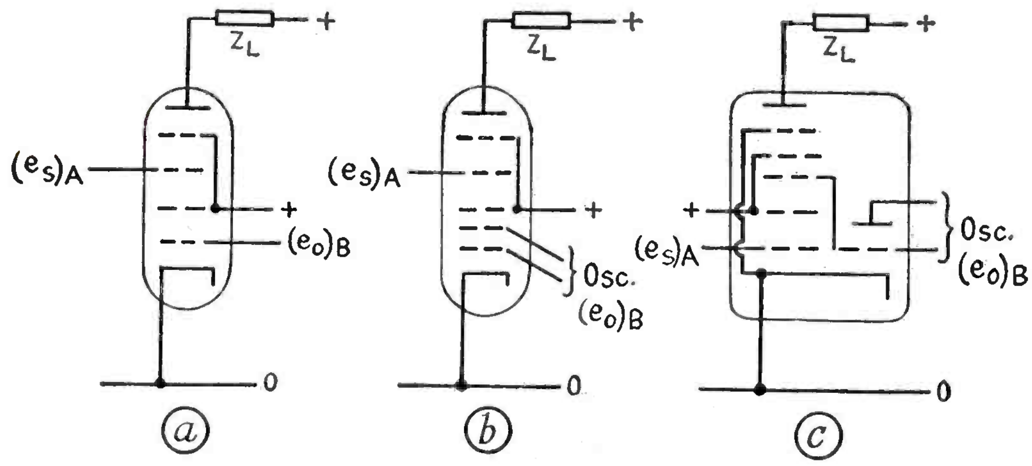


FIG. 5—Mixer and converter tubes with inner grid injection and outer grid injection

previous assumptions are not exactly fulfilled. When the square-law device is utilized as a modulator (as described above), the desirable modulation output contains the carrier (6) and the two side frequencies (8) and (9), additional components being by-passed by the load.

When the square-law device is utilized as a frequency converter, then $(e_s)_A$ represents the incoming r-f carrier voltage and $(e_o)_B$ the voltage from the local oscillator. There is not, necessarily, any difference in the mathematical treatment between this case and the previous one, so the same expansion with seven terms is still valid. The term of interest, however, is now the lower side frequency $(A—B)/2\pi$ only, all other components being by-passed by the load (in special cases the upper side frequency $(A+B)/2\pi$ only, all other components being by-passed by the load). Were the incoming wave modulated by speech or music, this modulation should pass straight through the converter, and the above treatment would apply equally well as far as the principle is concerned.

It may now be asked why one and the same device, operated in one and the same way, in the first case performs modulation but in the second case conversion. The answer is that the tuning of the plate impedance is different in the two cases. Whether the square-law device produces modulation or conversion—as judged from the mathematical expansion—is a question of the sorting-out mechanism on the output side. (It should be noted that although modulation implies $B < A$ only, conversion implies $B > A$ as well, the latter case actually being the one of most practical interest in broadcast receiver usage.

The original superheterodyne employed a detector as a mixing device, and to prevent confusion with the real detector following the i-f amplifier, the latter was given the name "second detector" and the mixer the name "first detector". This was correct but has led to the widely adopted belief that the first detector performs detection. To facilitate the understanding of the fact that the converter produces a frequency shift and does not produce detection, it is suggested that the terms first detector and second detector not be used. The conventional superheterodyne then has one detector only, like any other simple radio receiver.

Naturally the frequency conversion action may be described by detector theory instead of modulation theory. If it be assumed for the sake of simplicity that the detector characteristic is a parabola, an input voltage such as the one described by formula (1) then yields an instantaneous output current

$i = k' e^2$, so that

$$i = - - - - + k' E_s E_o \cos (A-B)\, t, \qquad (10)$$

k' being a proportionality quantity.

In practice the total or dynamic characteristic may deviate very much from the parabolic form, the result being a number of additional frequency components, representing a Fourier spectrum with a larger number of frequency component terms.

(*Continued on page* 324)

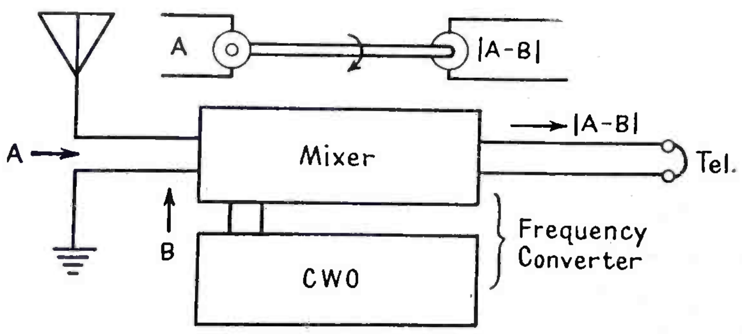


FIG. 6—Simple code receiver with mechanical analogue

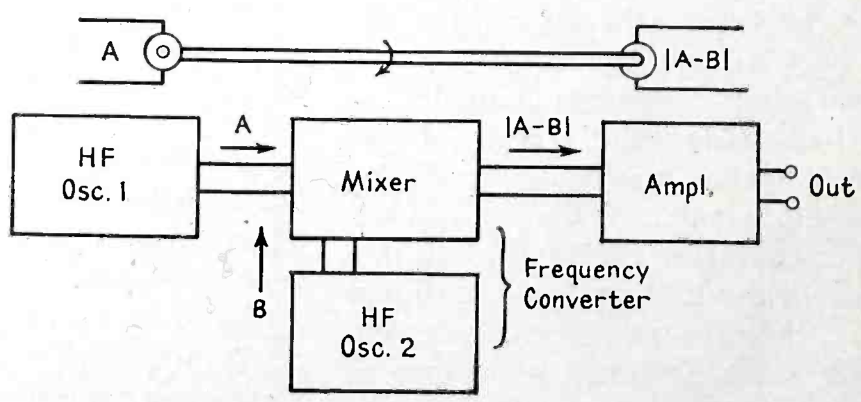


FIG. 7—Simple beat frequency oscillator with mechanical analogue

Temperature Coefficient of QUARTZ CRYSTALS

Two charts are presented for determining the temperature coefficient of frequency for quartz crystals when the nominal operating frequency and the frequency change for a given temperature are known. One chart applies to only one crystal frequency, but is readily set up for any desired frequency. The other chart is universal, for all frequencies

By NORMAN L. CHALFIN

Crystal Research Laboratories, Inc. Hartford, Conn.

THE temperature coefficient of frequency for any quartz plate of nominal frequency f_o is given by the expression

$$\text{Temp. Coeff.} = \frac{\Delta f}{(f_o\, t_{max} - t_{min})} \qquad (1)$$

Temp. Coeff. is in cps per Mc per deg. C

Δf is the change in frequency in cps between the temperatures t_{max} and t_{min}

t_{max} is the highest temperature in deg. C at which the frequency is measured

t_{min} is the minimum temperature in deg. C at which the frequency is measured

$t_{max}-t_{min}=\Delta t$ is the temperature change in deg. C for which the change in frequency Δf is observed

f_o is the nominal frequency of the quartz plate in Mc

When a large number of calculations must be made for crystals having the same rated frequency, the direct-reading chart shown on this page saves a great deal of time. The crystal frequency is the only value needed to set up a chart of this type, and individual charts can readily be prepared for any desired frequencies.

The chart is based on Eq. 1. For convenience, a temperature coefficient of 1.0 is assumed to permit converting the equation to the form $\Delta f = f_o \Delta t$, which follows the expression $y = ax$ for a straight line passing through the origin of x-y coordinates.

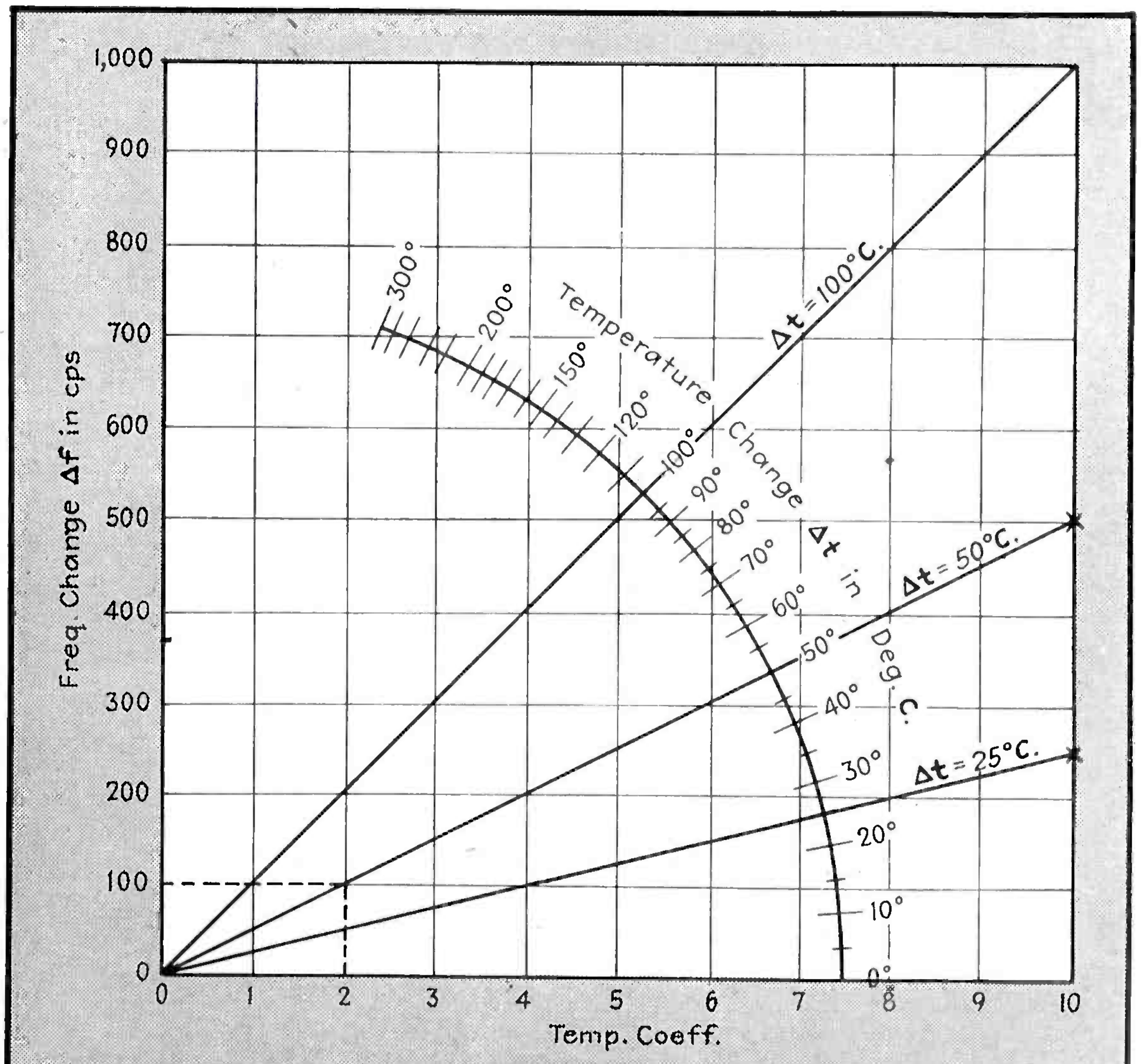
To prepare a chart for a desired temperature change value Δt, set up horizontal and vertical reference scales much as in the example on this page. Substitute the rated crystal frequency value f_o and the desired value for Δt in the equation in the preceding paragraph and solve for Δf. Now plot this value against a Temp. Coeff. value of 1.0 on the graph, and draw a straight line from zero through this point. The procedure can be repeated for as many other values of Δt as are desired. The example is drawn for $f_o = 1$ Mc.

The alignment chart on the next page is essentially a combination of an infinite number of different direct-reading charts, hence the one chart serves for all crystal frequencies.

To use the universal chart, determine the frequency change Δf in cps between the temperature limits t_{max} and t_{min}. With a straight-edge, align the value of $t_{max}-t_{min}$ on scale E with the proper value of Δf on scale D. On scale B read the value $\Delta f/(t_{max}-t_{min})$. Align f_o on A with $\Delta f/(t_{max}-t_{min})$ originally found on scale B but now transferred to scale C, and read on scale F the temperature coefficient.

If the coefficient and the nominal crystal frequency are known, the chart may be used to indicate either the temperature change in which a given frequency change will occur, or the frequency change allowable in a given temperature range for the known temperature coefficient.

An example will illustrate the use of this chart. A change in frequency of 210 cps is observed when the temperature changes from 20 deg. C to 50 deg. C and the nominal fre-



Example of a direct-reading temperature coefficient chart for a 1-Mc quartz crystal unit

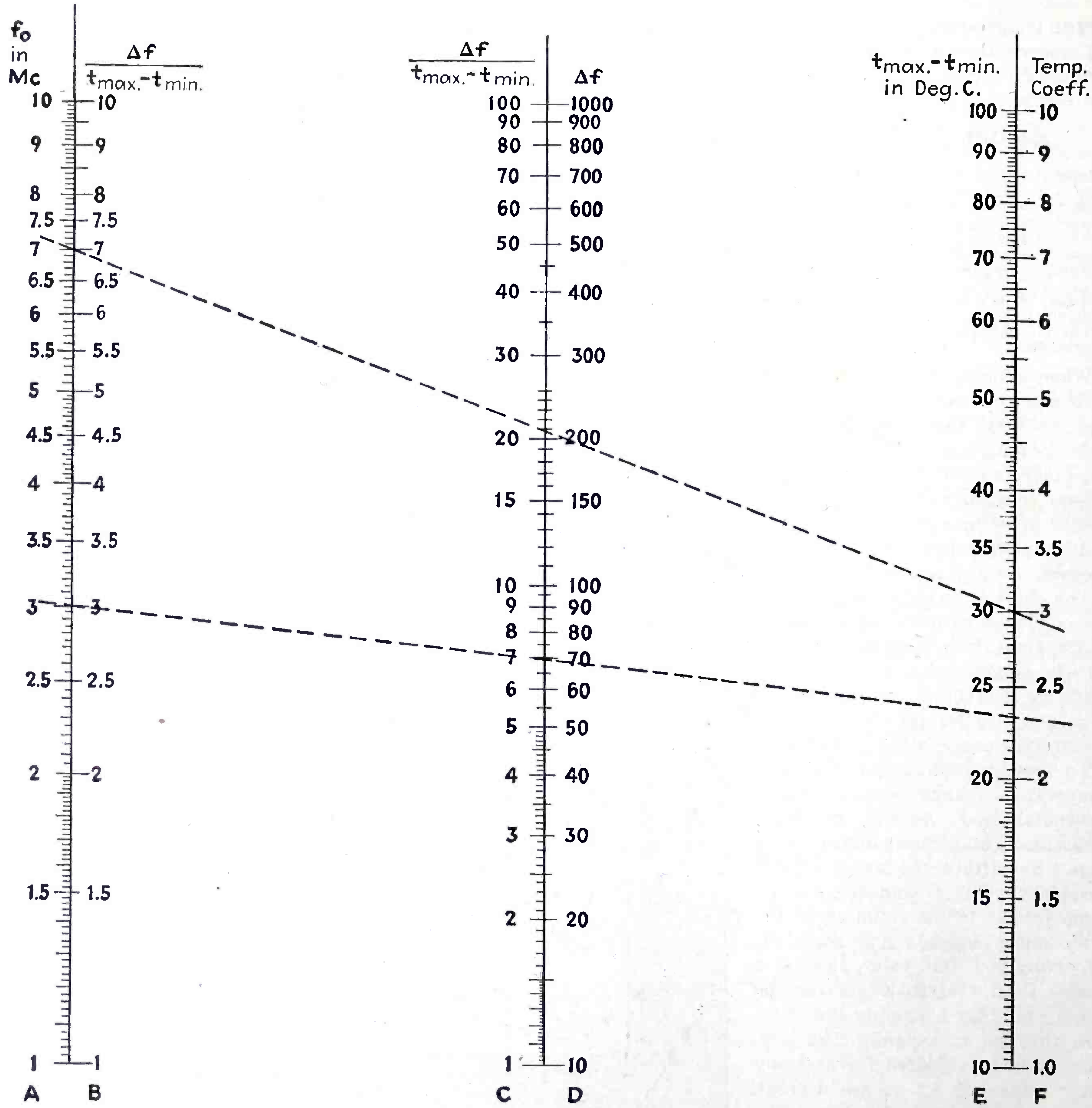
quency is 3.0 Mc. The temperature change is 50 − 20 = 30 deg. C. If this value on scale E is aligned with 210 on scale D, the frequency change per degree temperature change is found, from scale B, to be 7 cps. Transfer this value to scale C and connect 7 on scale C with the operating frequency (3.0 Mc) on scale A, and read the temperature coefficient of frequency on scale F as 2.33 cycles per Mc per degree C.

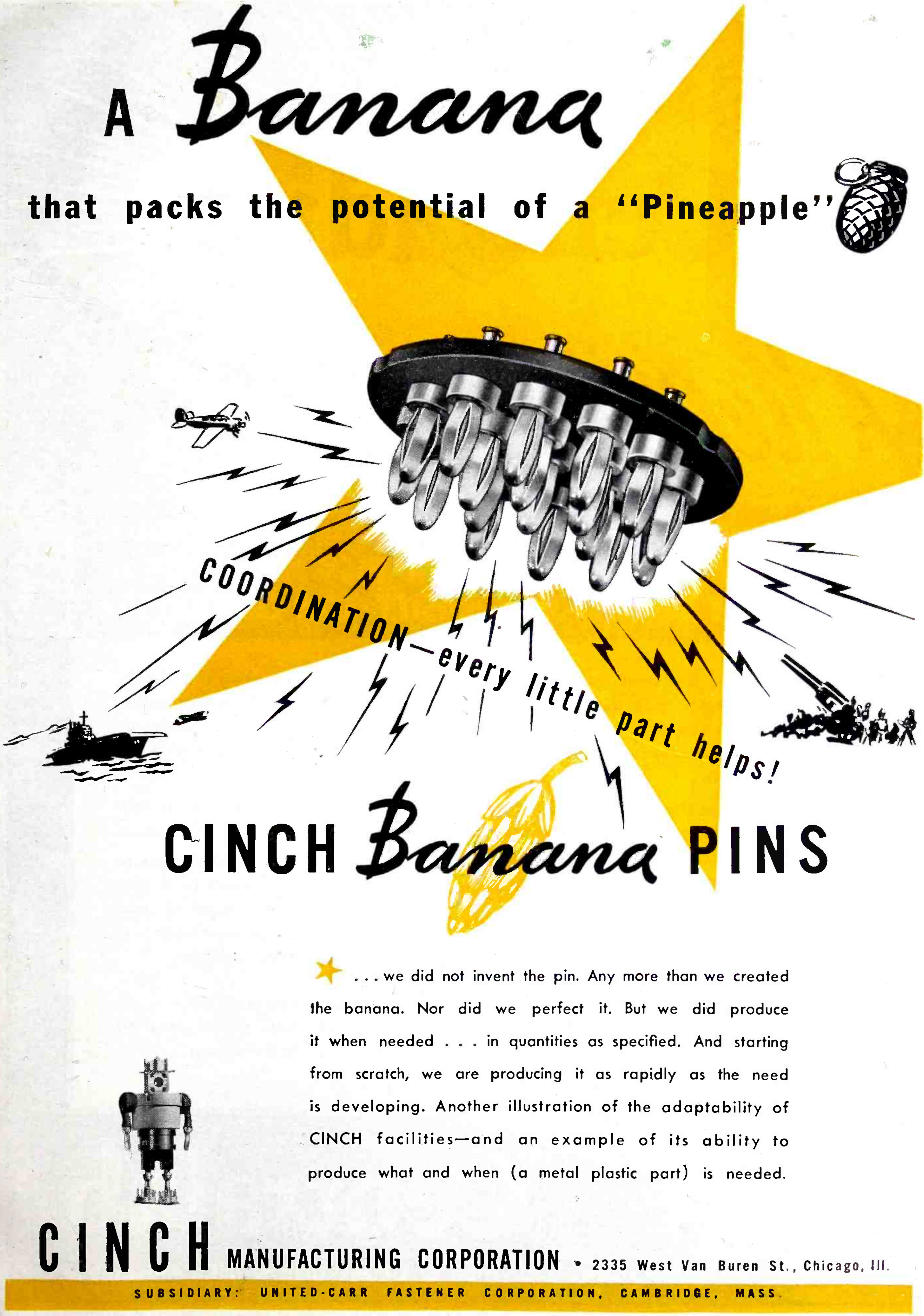
Temperature Coefficient of Quartz Crystals

In Cycles Per Megacycle Per Degree Centigrade

By NORMAN L. CHALFIN

Crystal Research Laboratories, Inc.
Hartford, Conn.

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Centradite

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Centradite has these outstanding characteristics:
LOW THERMAL EXPANSION • HIGH RESISTANCE TO HEAT SHOCK • LOW POROSITY • LOW LOSS FACTOR

These important characteristics are combined with excellent dielectric properties making it suitable for use in radio frequency circuits. (See Chart).

Centradite is particularly recommended for coil forms where thermal expansion must be low to prevent undue change in inductance.

Body No. 400	Description of Material
20-100 C° 1.9×10^{-6} 20-600 C° 3.1×10^{-6}	Thermal coefficient of expansion per degree Centigrade
13,000 lbs.	Modulus of rupture in lbs. per sq. in.
5.4	Dielectric constant
3.00 or less	Dielectric loss factor
Class "L3" or better	Grade per American Stand. C75.1-1943
Zero to .007%	Porosity or moisture absorption
White	Color of material

Centradite is ideal where the application requires that the material withstand a rapid increase or decrease in operating temperature within a short period of time.

Centradite can be supplied in various shapes by extrusion or pressing.

Centradite, due to its resistance to heat shock, lends itself to a new process of soldering metal to ceramic, whereby the ceramic surface is metalized to permit soldering.

We invite inquiries regarding the further uses which may fit your applications.

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Trimmers
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Temperature coefficients available:
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TUBES AT WORK

X-Ray Checks Hand Grenade Fuses

To prevent hand grenades from exploding improperly, an automatic x-ray unit is being used to check the powder charge and automatically reject those fuses that have too small a charge.

The fuse assembly for a hand grenade consists of a metal tube that contains two powder charges and a slow-burning fuse. In appearance it resembles a medical thermometer with an attached handle.

For the checking operation each fuse is placed in a metal cylinder that holds it upright on a moving belt. The belt carries the fuses into the x-ray machine, where a 100,000-volt x-ray passes through each fuse and causes a glow on a fluorescent screen. A phototube is mounted above the fluorescent screen to detect changes in the glow.

After passing through the x-ray beam, the hand-grenade fuses are removed from the metal containers and packed for shipment

If the powder charge is the correct amount, the screen has a constant glow and the fuse passes through undisturbed. When a fuse with insufficient powder passes through the x-ray beam the glow changes. The phototube detects the change in the fluorescent glow and four things happen automatically. A red light flashes, a bell rings, a daub of red paint is placed on top of the defective fuse, and the reject is graphically recorded on a meter chart.

The machine, the first automatic one so far devised, is the product of General Electric engineers and provides an automatic check of 4,000 fuses an hour.

War Solder Technique

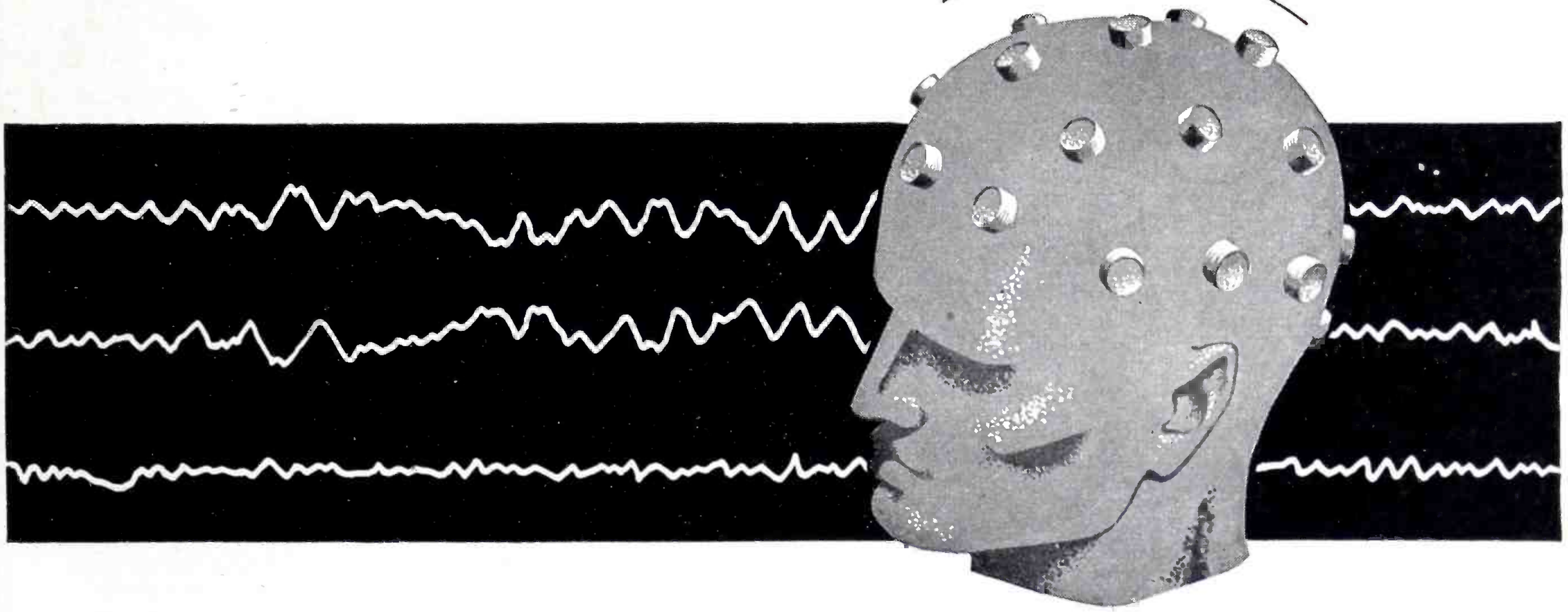
Pre-war solder was half tin and half lead, but today solder usually contains not more than 20 percent tin, with perhaps small amounts of silver, bismuth, or antimony. This requires a hotter soldering iron and attention to certain details. Instructions for the use of today's solder have been issued by the metallurgy committee of the General Electric Co. which says:

1. Keep your work clean. Guard

A defective fuse is red-painted by the x-ray machine, and is also detected by a long line on the meter graph. A bell and light warn the operator when the dud intercepts the x-ray beam

Hand-grenade fuses to be checked for powder content are placed in metal containers on a movable belt that takes them into an x-ray machine. The x-rays fluoresce a screen that is constantly watched by a phototube to detect a change of intensity caused by an insufficient charge of powder

TUNING IN ON *Brain Tissue*



WITH IRC RESISTORS

Scientists have long known that living tissue generates minute electric potentials. But only recently have researchists been able to adapt this knowledge to clinical use on the human brain through means of the Electroencephalograph.

In its functioning, tiny electrodes are fastened to the skin by collodion at the points indicated in the illustration. The average potentials of only 50 microvolts are led to a high-gain amplifier and enlarged to a size where the waves are easily visualized. Comparative studies of the graphs obtained from various brain areas indicate and localize the presence of abnormalities, if any exist.

Quite naturally for such a sensitively adjusted instrument, measuring minute voltages, details of resistor construction are of vital importance in addition to the inherent stability, precision, low noise level and other characteristics which

ANOTHER IRC DEVELOPMENT

are fundamental requirements. IRC is proud to have collaborated in the evolution of the Electroencephalograph and to have had its resistors and specialized engineering skill play a part in its development.

If you are seeking unbiased counsel on a resistance problem, consult IRC—the company that makes resistor units of more types, in more shapes, for more applications than any other manufacturer in the world.

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carefully against varnish, grease, oil, dirt, rust, or corrosion. They prevent the flux from acting and the solder from alloying with the parent metal.

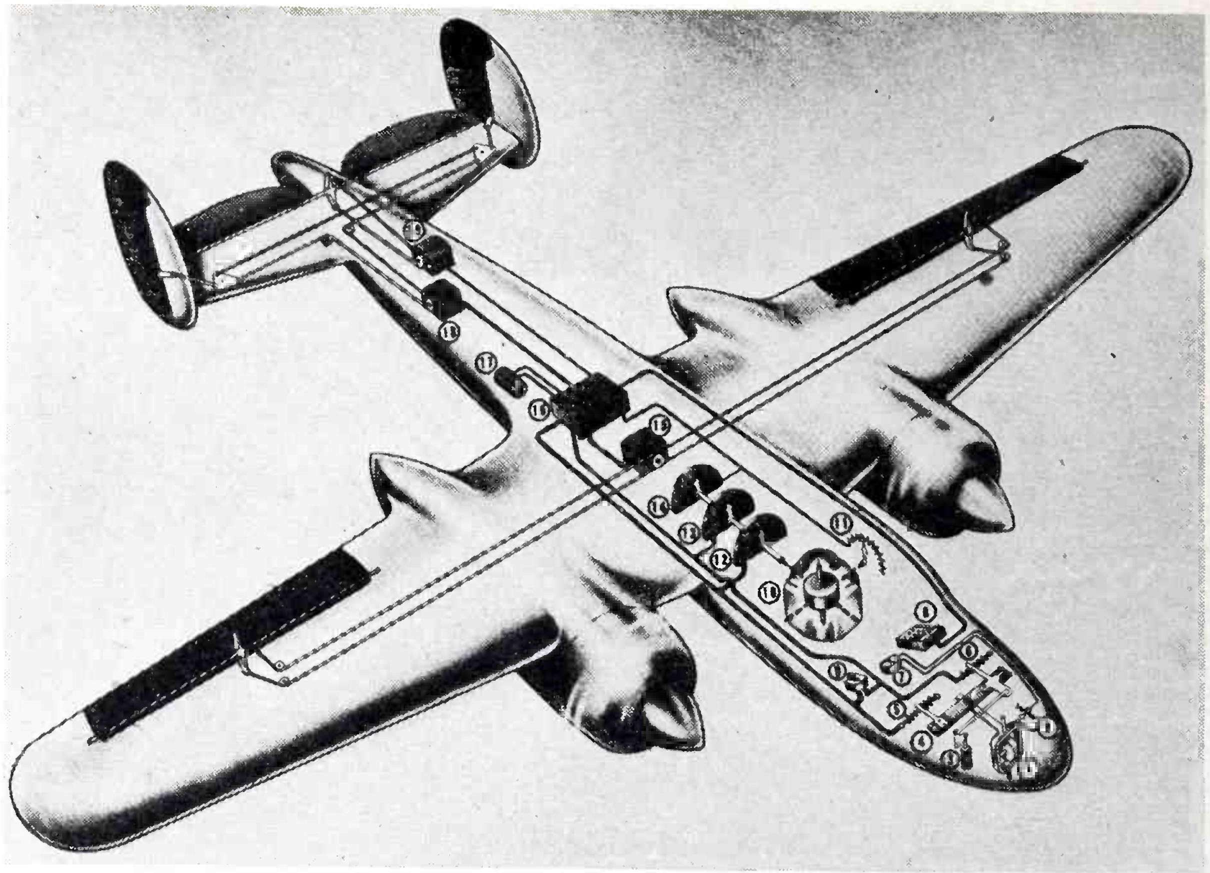
2. Keep in mind that the purpose of the soldering iron is not to melt the solder but to heat the work until the solder will flow when applied to the work.

3. Keep the soldering iron clean and, to have the quickest possible heat transfer from the iron to the work, have the tip designed to fit against the work.

4. Investigate different methods available for doing the work. A hotter electric iron, high-frequency heating or a carbon resistance soldering tool may do the job better.

5. Design your joints to have 0.003 to 0.005 in. solder thickness, and so that the two parts overlap. Lap or seam-type joints are better than butt-type joints. Have the solder fill the seam completely. Heavy fillets add little strength to the joint, and waste solder.

6. Don't hand a new solder, a flux, and a soldering job to a workman and expect a perfect job the first time. Let him get the "feel" of the new material. Don't give up a new solder after one unsuccessful trial—the chances are your technique is not what it should be for that particular solder.



Location of automatic control units in a bomber. Numbers identify the following units: 1—directional stabilizer; 2—plane direction indicator potentiometer; 3—dash potentiometer; 4—directional panel; 5—banking pot; 6—rudder pick-up pot; 7—plane direction indicator; 8—autopilot control panel; 9—turn control; 10—vertical flight gyro; 11—elevator pick-up pot; 12—aileron pick-up pot; 13—skid pot; 14—up-elevator pot; 15—aileron servo; 16—amplifier; 17—rotary inverter; 18—rudder servo; 19—elevator servo

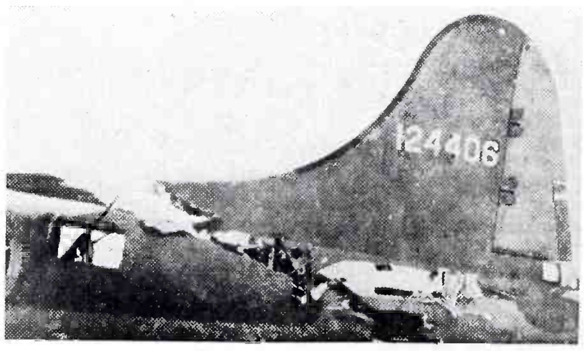
Electronic Plane Pilot

AN ELECTRONIC AUTOMATIC PILOT is credited as being one factor in the effective devastation caused by American bombers in Europe and the low ratio of bomber losses. The electronic pilot controls electric motors that position the rudder, elevator, and aileron control surfaces. Automatic movement of these correct deviations from the desired course and prevent the plane from wavering.

On bombing runs the autopilot takes over the duties of the pilot and holds the plane on its course to provide a stable platform for high-altitude bombing. The mechanism corrects for cross currents, wind variations, and air blasts from exploding antiaircraft shells. An additional advantage of the autopilot is that controls can be installed in different places in the plane so that it may be flown from several operating positions.

On a recent bombing mission one Flying Fortress was almost cut in two by colliding with a Messerschmitt 109. The German plane cut into the fuselage area just forward of the dorsal fin and severed the pilot's manual control cables connecting to the rudder and elevators. The Fortress was flown safely home on the automatic pilot because the control surface motors of the electronic system were located far in the tail of the plane and were not damaged in the mid-air crash.

In another instance a B-24 Liberator flew 2,000 miles by itself. The crew had bailed out over the east coast of the United States but the electronic autopilot flew the ship until it ran out of gas and crashed into a mountain in Mexico. Certain types of bomber-trainer planes have been equipped with the autopilot and for months it has been standard equipment on American heavy bombers. It is a development of Minneapolis-Honeywell Regulator Co., which worked on the problem at the request of Materiel Command officers at Wright Field.

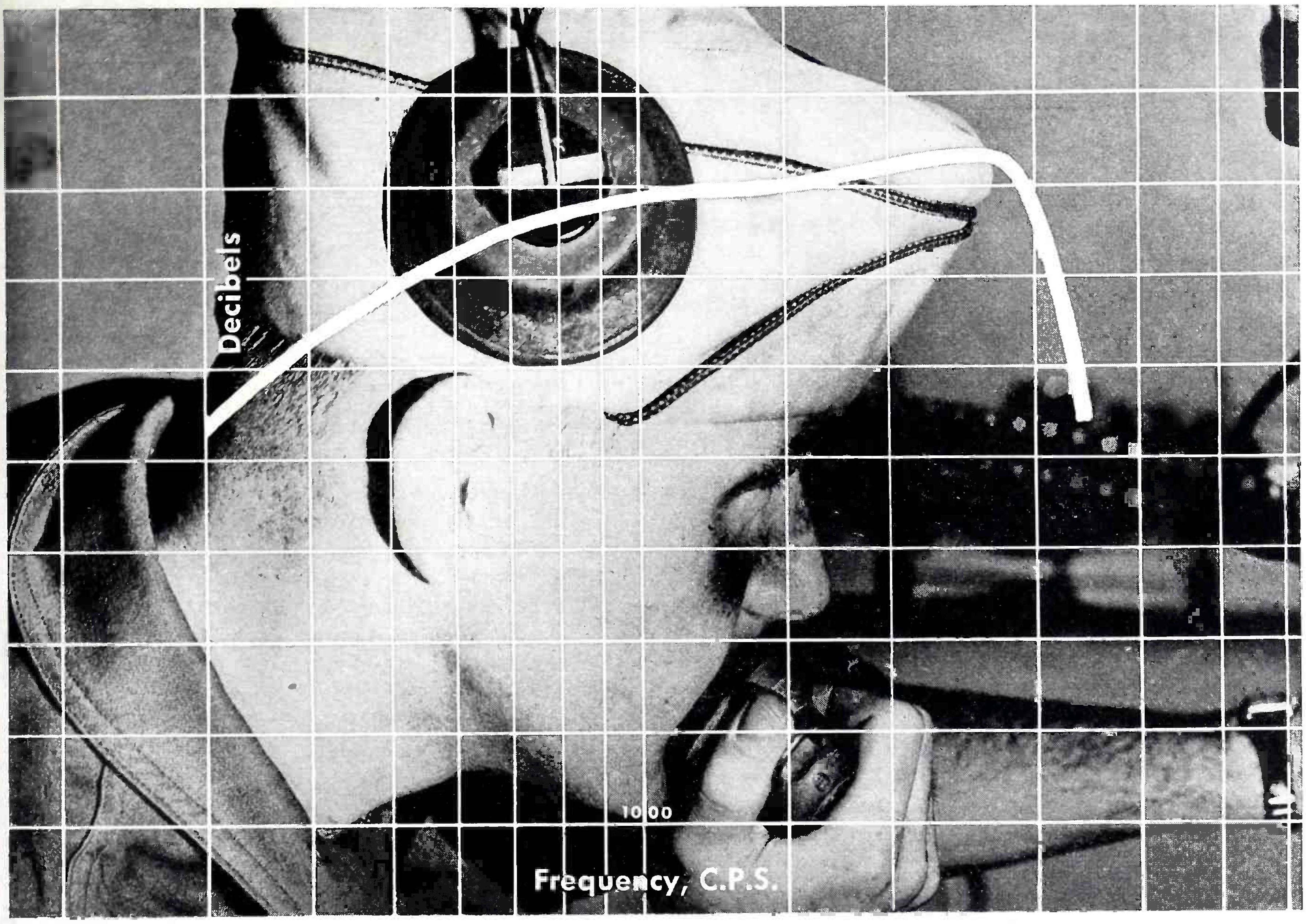


Almost cut in two after being rammed by a Messerschmitt, this Flying Fortress flew safely home guided by an electronic automatic pilot. The enemy plane hit near the tail and severed the pilot's manual control cables connecting to the rudders and elevators. Cables connecting the electronic pilot to the control surface motors located in the tail were not damaged in the crash

Automatic Transmitter Tuning with Pushbuttons

AUTOMATIC TUNING of the final stage of a high-power transmitter is fairly difficult to design at broadcast frequencies where conventional inductors and capacitors are employed, but presents an even greater problem at higher frequencies when a resonant line forms the tank circuit. In one CBS short-wave station used by the OWI for broadcasts to foreign countries, tuning of such a line is accomplished by motor-driven sliding contacts that move a shorting bar.

The station, described in a recent issue of *Electrical Communication*, was designed and manufactured by Federal Telephone & Radio Corp., an



MICROPHONES

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Microphone performance begins with design. Orders, instructions, information must come through—*audibly.* It is the designing engineer's job to bring the human voice through clearly—to eliminate as much as possible the engine noises and tumult that might garble a vital message.

The proven ability to design and manufacture microphones that serve under such conditions — as well as under other severe conditions that attend combat duty — has made Shure Brothers America's foremost manufacturer of microphones.

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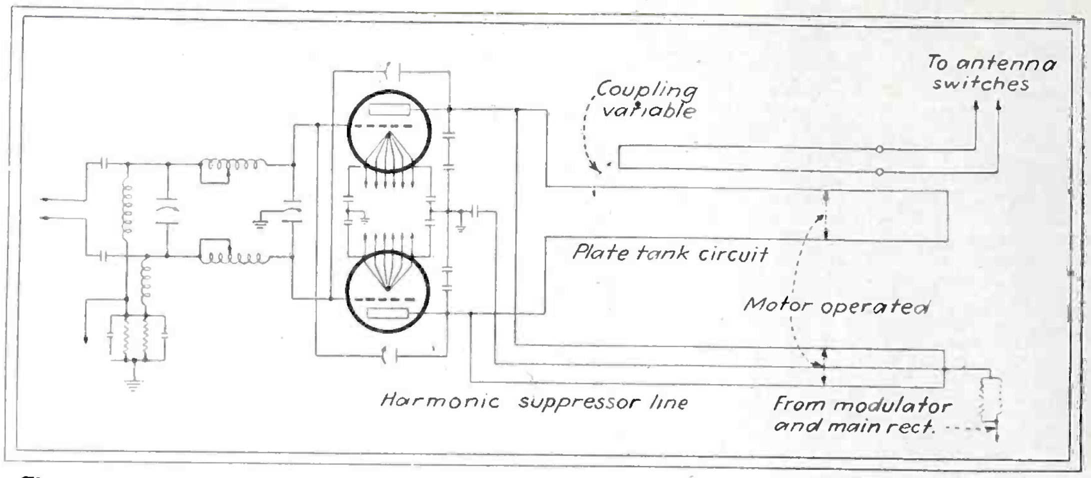
Designers and Manufacturers of Microphones and Acoustic Devices associate of IT&T. It contains two 50-kw transmitters that operate on nine frequencies, from 6 to 22 mc, and were constructed for rapid frequency shifts. In the lower power stages of each transmitter, frequency changing is accomplished by moving taps on inductors and by rotating variable capacitors. The final amplifier contains linear line elements composed of 35-foot lengths of copper pipe spaced 12 inches between centers. The resonant frequency of the circuit formed by this inductance loop shunted by the tube capacitance is determined by the position of a shorting bar along the parallel pipes.



Circuit of final amplifier of 50-kw transmitter, with motor-driven shorting bars for tuning the plate tank and a harmonic suppressor circuit

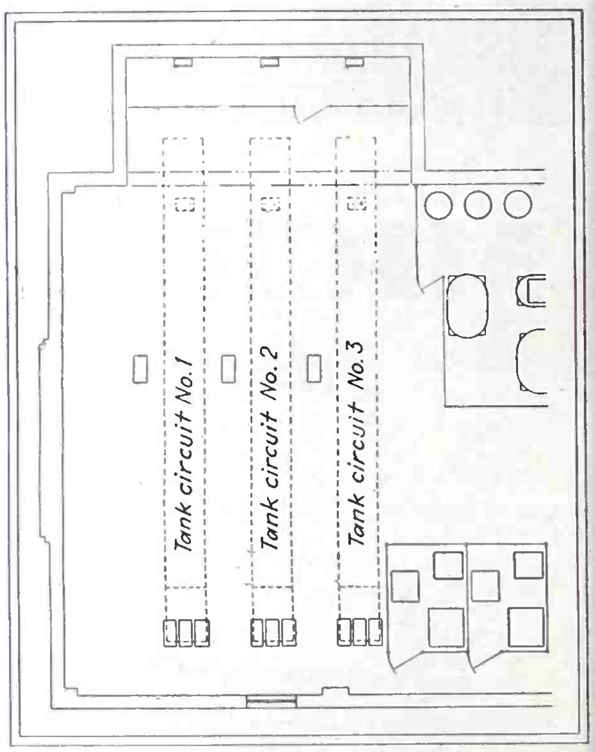
The pipes of each plate line extend from the vacuum tubes of the final amplifier through the floor of the operating room to the basement, where they are mounted horizontally on ceramic standoff insulators. Large transformers, reactors and other units of the transmitter are also located in the basement, as shown in the layout of that area in the diagram.

A second line, composed of three pipes, is mounted below the plate line to provide harmonic suppression. Tuning of this line is also accomplished by means of a motor-driven shorting bar. When this line is properly tuned it provides a low impedance path for even-order harmonics to ground.

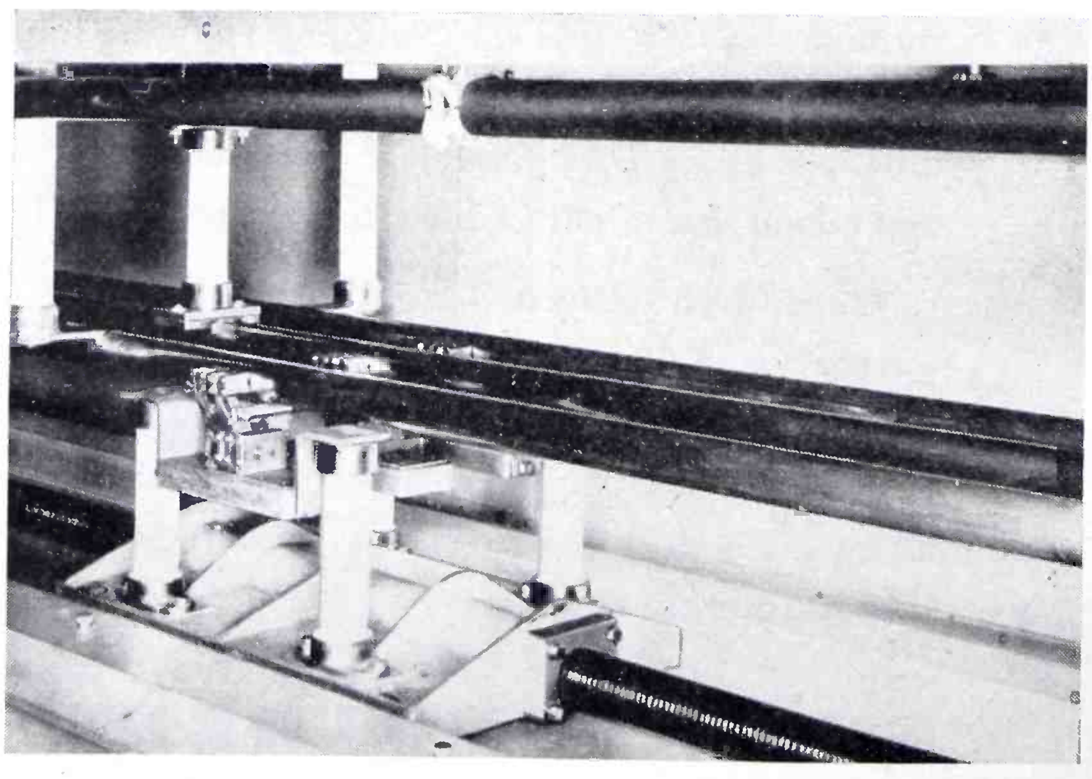
Contact to the pipes of both lines is made by V-shaped sliding shoes that are held in place by spring-action fingers mounted on a heavy copper plate. The contact assembly for the harmonic suppressor line is shown in the photograph, and is supported by ceramic standoffs fastened to a dolly or carriage. The carriage is moved along the pipes by a lead screw arrangement. The conductors forming the plate line are contacted by a similar sliding-shoe carriage.

At the end of the lines, away from the power amplifier plates, are located three-phase reversible two-speed motors that drive the lead screw through V-belt couplings. The motors of the plate line and the suppressor line are electrically interconnected to permit both carriages to travel over the lines simultaneously. Attached to the opposite ends of the worms are flexible shafts that drive counters on the operating panel on the main floor to indicate the position of each contact.

The operating panels also contain channel selector switches and push-buttons for starting and stopping the motors. A channel selector switch has six positions corresponding to six positioning switches located along the carriage tracks. Each of these positioning switches may be set to any point on the pipes. The channel selector switch also determines the direction of motor rotation necessary to drive the carriages to the desired stop.



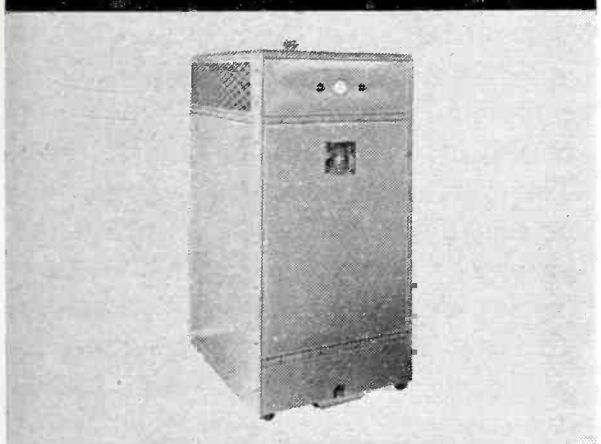
Layout of tank circuit pipe lines located in the basement of the station, with transformers and reactors of the modulators and power supplies. The antenna coupling hairpin is mounted above the plate lines and the harmonic suppressor line below. Two tank circuits connect to two transmitters, while the third is tuned to the next frequency to be used and stands by until needed



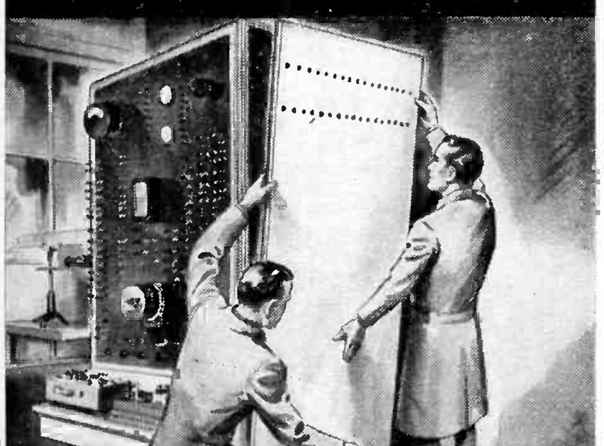
View of motor-driven carriage and sliding contacts of the harmonic suppressor line. A similar arrangement moves shorting bar contacts on the plate line

When the motor start button is depressed, power to the plates of the tubes is removed and the carriages travel in the proper direction. When the carriages reach the proper position the motors stop and plate power is applied to the tubes. Fine tuning

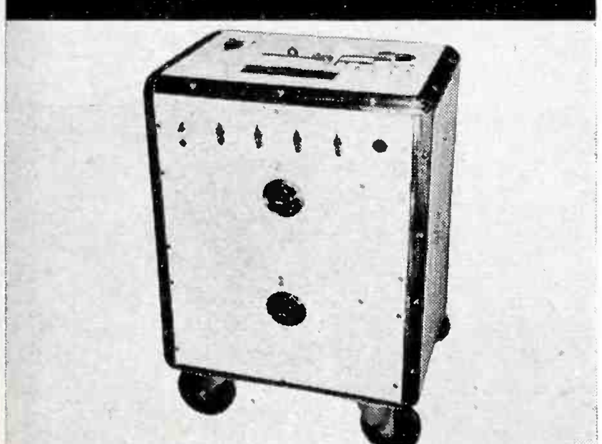
Housings



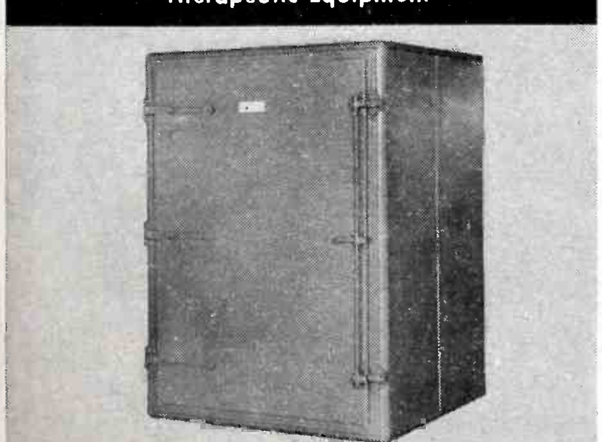
Safety Equipment



Electrical Equipment



Therapeutic Equipment



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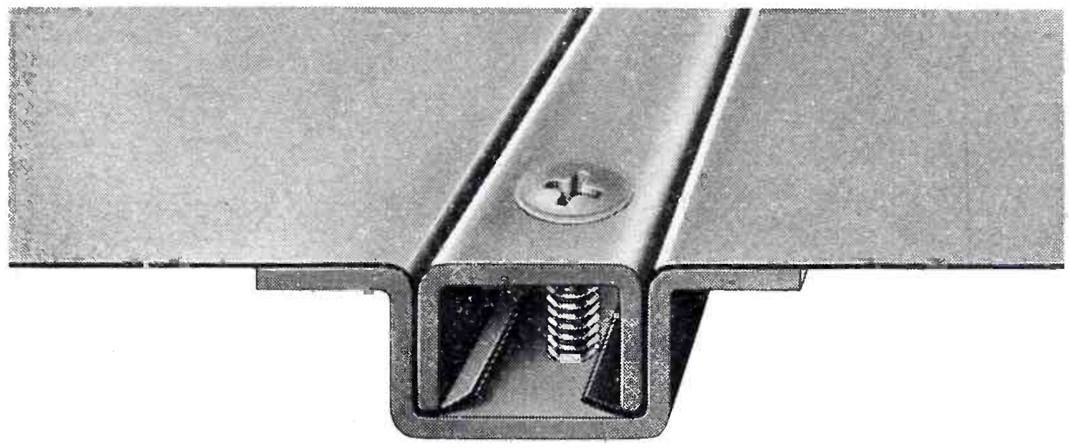
Lindsay Structure assemblies can help you speed up your production of cabinets and housings at once. With Lindsay Structure no tooling up is necessary—no special machinery is required. A sudden change of specifications causes neither production delay nor waste of materials.



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is provided by an additional switch on the panel that operates the motors at slow speed with the plate power on. Overtravel of the carriages is prevented by safety limit switches, at each end of the lines, that operate if one of the positioning switches should fail to stop the carriage. Pilot lights on the panel show when the motors are running and also indicate the tripping of safety limit switches.

In addition to acting as tank circuits, the pipes of the plate lines and harmonic lines conduct water to the plates of the tubes for cooling. Ceramic tubing is employed for some distance before the water enters and after it leaves the transmitter.

Coupling from each set of plate lines to the antenna system is provided by an inductive loop or hairpin about thirty feet long, mounted horizontally above and parallel to the plate lines. A hand wheel on the front of the power amplifier moves the coupling hairpin horizontally in relation to the plate lines and varies the area within the coupling loop.

Reactance-Type Gages

MEASUREMENTS OF THICKNESS as small as one millionth of an inch may be read with electric gages that respond to changes in reactance caused by the thickness of the material under test. Such gages are being used to measure the thickness of films or coatings on magnetic surfaces, metal platings, and the thickness of sheets of insulating material and iron and steel.

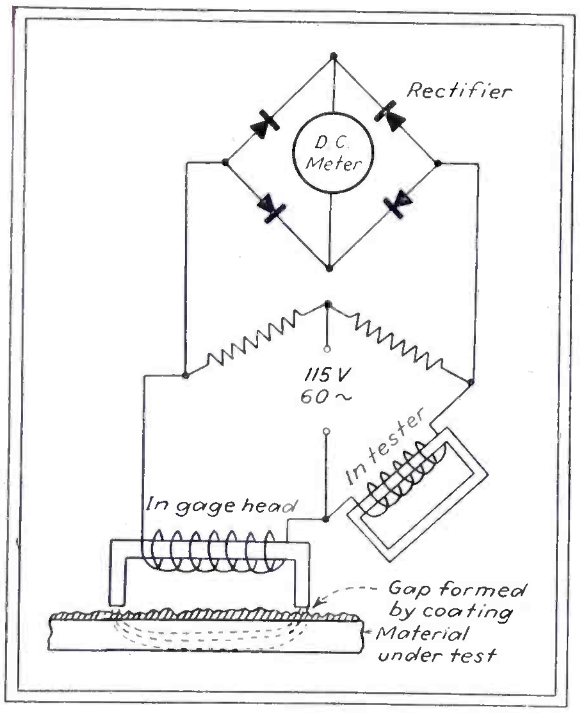

Fig. 1—Typical circuit used in the thickness gages. A Wheatstone bridge measures changes of reactance caused by the magnetic gap

Fig. 2—Thickness gage for measuring paints, lacquers, and nonmagnetic babbitt linings on steel bearing shells

Gages manufactured by the General Electric Co. that depend on a reactance change for thickness measurements contain a circuit similar to that shown in Fig. 1. Two arms of a Wheatstone bridge are formed by iron-core reactors. One of these reactors is mounted in a gage head, shown in the photograph of Fig. 2, and the other reactor is mounted in the meter unit. The latter unit also contains a rectifier and a d-c meter whose scale is calibrated in terms of the measurement to be made. Although an a-c meter may be used as the indicator, the advantages of greater sensitivity and a linear scale are obtained with the d-c meter.

The gage head consists of an iron magnetic circuit formed by two circular flanges having a connecting core between them. On this center core is mounted the gage coil that connects into the bridge circuit contained in the indicator unit. The coil is energized from the 60-cycle supply line and the magnetic flux set up by the coil traverses the iron part of the gage head, its external portion being completed through the magnetic metal of the material under test. The gaps in the field, caused by a film or coating on the material, affect the reactance of the coil, which in turn causes an unbalance of the bridge circuit. The degree of unbalance is indicated by the meter and varies directly with changes in thickness of the gap.

Film Thickness Gage

The sensitivity of the circuit depends upon the initial setting of the magnetic gap. For instance, if the initial gap setting is 0.002 in., closing the gap 0.001 in. will cause approximately a 100-percent reactance change and a large change in the bridge output. Although the sensitivity may be increased still further by reducing the initial air gap, the

Measuring babbitt thickness of a bearing with a G-E reactance-type thickness gage

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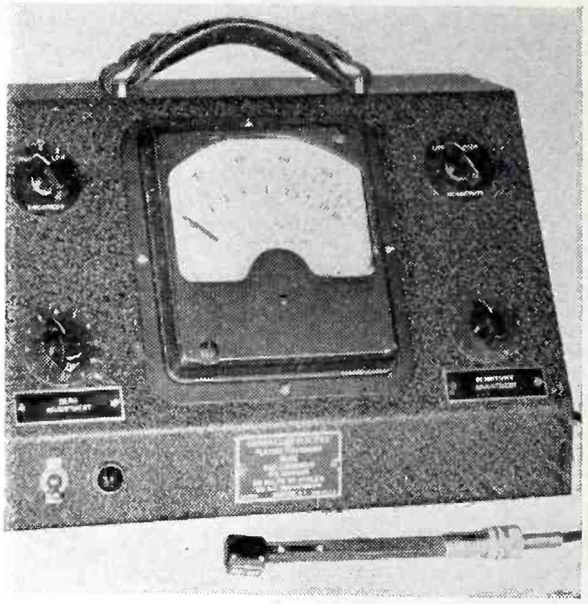


Fig. 3—Metal plating as thin as 1/10,000 of an inch is measured with this instrument without destroying the plating

practical limit is reached because of temperature expansion of the gage members and the material being gaged. Reliable readings of 0.00001 in. are obtainable with this type of equipment, while under carefully controlled conditions as small as 0.000001 in. may be read.

The gage illustrated measures thickness of films or coatings of enamel, lacquer, zinc, tin, glass, paper and other materials without injuring the continuity of the coating. The standard range indicates values from 0 to 100 mils, covered on two scales of the meter, 0 to 8 and 5 to 100 mils.

Plating Thickness Gage

Thin nonmagnetic platings of copper, tin and similar materials whose thickness ranges from 0.0001 inch to 0.01 inch require a smaller gage head and are measurable by the instrument shown in Fig. 3. The steel surface under the plating may have a thickness down to 0.015 in. In the gage head the magnetic field is concentrated between two pole pieces separated about $\frac{1}{16}$ in. to permit application to very small parts and narrow, curved or irregular surfaces. The instrument permits measurements of copper plating on gear parts prior to hardening, copper plating on vacuum tube parts as small as 0.2 sq. in. surface area, and brass and cadmium plating on machined and punched parts.

Eccentricity Gage

Another application of the principle used in the film thickness gage occurs in an eccentricity gage that determines the variation of thickness

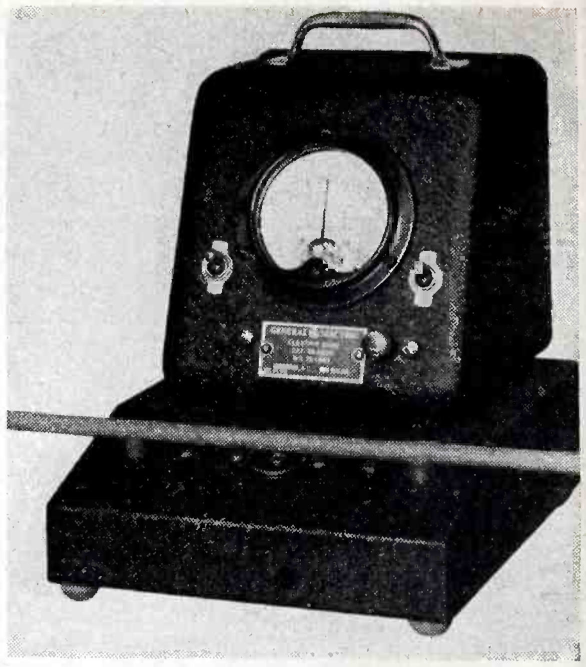


Fig. 4—The eccentricity of flux coatings on welding electrodes can be determined by the gage shown above. Four buttons of tungsten carbide hold the rod at the proper distance from the gage head mounted in the base

of coated welding rods. The G-E commercial version is shown in the photograph of Fig. 4. In this instrument the gage head is mounted in the base below the indicator unit. Two V-blocks guide the rod into position for measurement. Since the flux coating is nonmagnetic its thickness becomes the air gap between the gage head and the steel welding rod. The gage reading is proportional to the gap and the instrument is calibrated to read flux coating thickness for one rod size. For other rod sizes a correction curve is employed.

Magnetic Sheet Gage

The thickness of magnetic sheets of steel or iron that may be measured depends upon the design and size of the gage head. The head shown in Fig. 5 is intended for measurements of low-carbon, hot or cold-rolled steel sheets up to 45 mils thickness. An additional scale (10 to 25

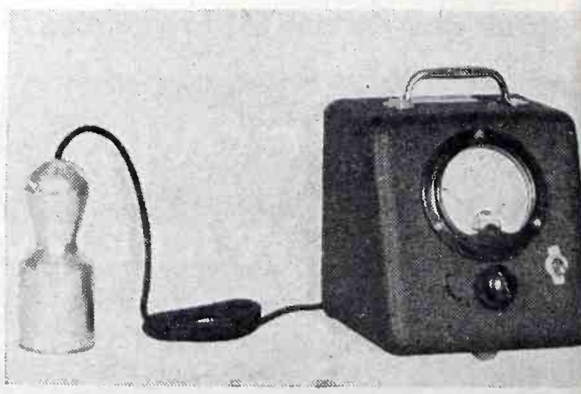
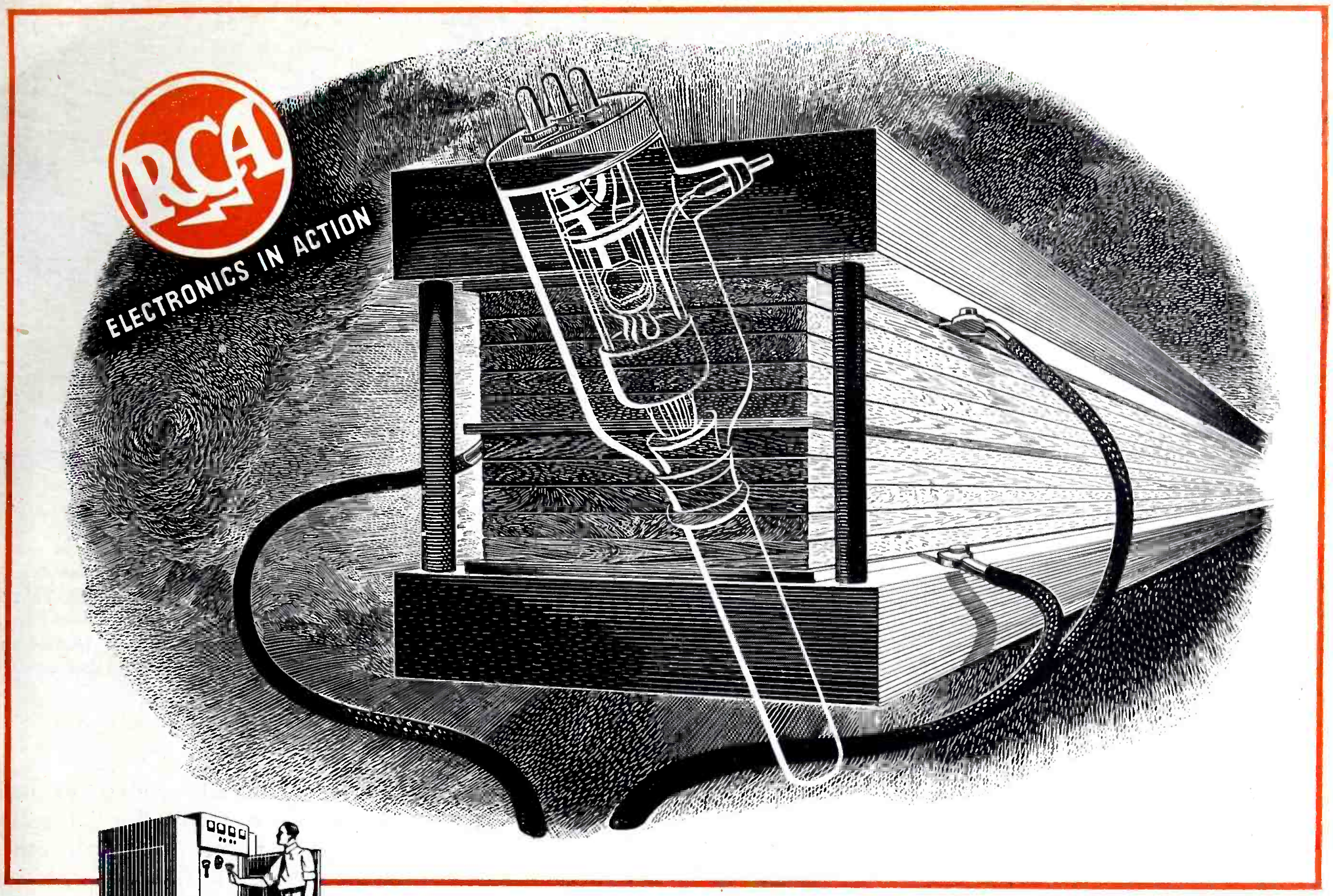
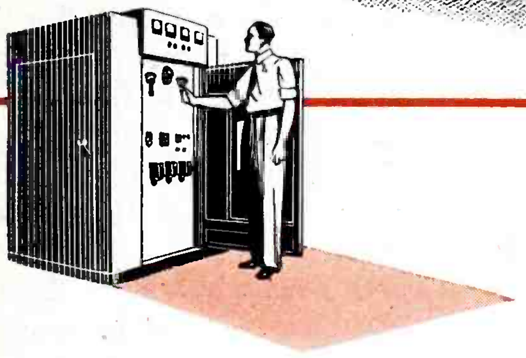


Fig. 5—Magnetic gage head (left) for measuring the thickness of steel sheet from one side





Gluing Wood with Radio Waves

GLUING wood with synthetic resin glues used to be a slow process because it took so long for the glue to "set." Aircraft and other wartime needs greatly accelerated the use of these glues—thereby sharpening demand for shortening the setting time.

Speedier gluing means faster heating of the glue lines to drive out the moisture and hasten chemical reactions. Wood, being an excellent insulator, prevents the inward flow of heat from hot platens at anything but a maddeningly slow rate. Really rapid heating therefore demands a method whereby heat is "born" right *inside* the wood.

That is exactly what electronics makes possible. Radio frequency power unleashed right inside the wood is instantaneously converted into heat and causes an almost phenomenal speeding up of the glue-setting process.

The manufacture of "compreg" — a highly compressed plastic-impregnated wood product now used extensively for airplane propellers — too, has been speeded up remarkably by such electronically generated heat. Production time has been cut as much as *60 per cent* over old methods—making it possible for expensive equipment to turn out proportionately more of badly needed products.

Radio frequency power for setting wood glues offers many attractive possibilities. Yet it is only *one* of many manufacturing processes involving a heat cycle for which RCA electronic heating offers important advantages. Moreover, all such applications collectively are but *one* phase of electronics—the art of harnessing electrons to the service of man. Bear in mind, too, that *every* electronic device of *every* kind depends basically on electron tubes. And that RCA is the fountain-head of modern electron tube development.

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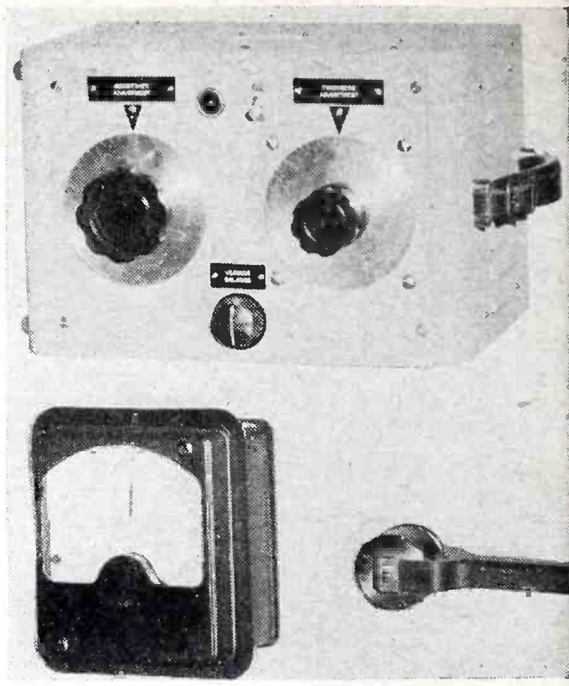


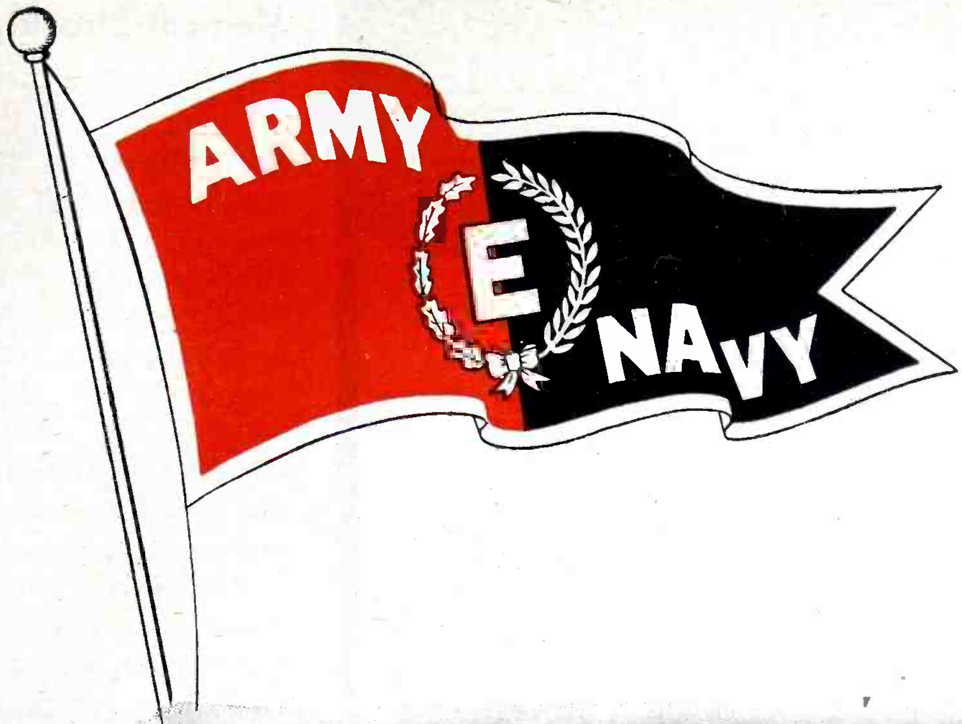
Fig. 6—Thickness gage for insulating sheets. Graduated dials on the power unit are adjusted so that the meter reads zero for the desired thickness. Deviations from this thickness are read in percentage of the standard

mils) is calibrated for steels of medium silicon content. Special scales are required for use with other metals having different saturation characteristics.

The sensitivity of the flux measuring element of this gage is high and there is a small effect from the earth's magnetic field. This requires that it be adjusted for use in the position in which it is to be used, horizontally or vertically.

Nonmetallic Materials

For measurements of insulating materials such as mica, glass, lucite and celluloid the insulating sheet is placed on a table having a steel top of uniform thickness and the gage is placed on the sheet. Dials on the instrument are then adjusted to the sheet thickness so that the indicating meter reads zero when the required standard is obtained. The gage, shown in Fig. 6, operates as a comparator gage and indicates deviations from the standard thickness in percentage. The normal position of the meter pointer is in the center of the scale and deflection indicates oversize and undersize conditions up to 15 percent. The deviation from a standard thickness of sheets from $\frac{1}{32}$ to $\frac{3}{4}$ inch thick can be measured to an accuracy of better than ten percent. With such a deviation from the standard the actual deviation may be in error one percent of the total thickness.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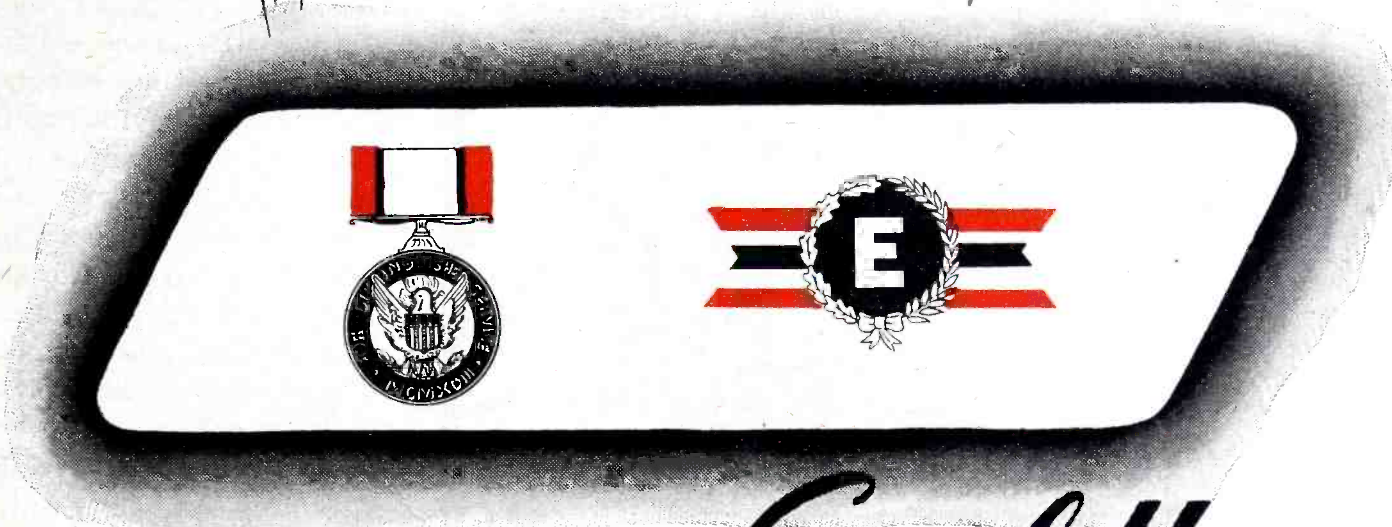
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Medical Shock Machine

By Paul Traugott, *Chief Engineer*
Electro-Physical Labs., Inc.

Electric shock therapy is used in the treatment of certain mental disorders. Electrodes are placed on opposite sides of the patient's head (usually, though not always, on the temples), and a 60-cycle alternating voltage in the range from 75 to 150 volts is applied for a duration of 0.1 to 0.5 second, the physician selecting whatever duration he thinks necessary. The patient is usually seized with a violent convulsion followed by unconsciousness; certain curative effects frequently follow the proper employment of this shock therapy.

An electric shock machine for this treatment is thus merely an instrument which provides voltages in the proper range, together with a switch and a timing device to apply the voltage for the proper duration. A current of 0.5 to 1.5 amperes rms passes in the patient circuit. With some instruments a smaller current at a lower applied voltage is used for a longer period.

A General Radio Variac provides a convenient variable voltage source, but a tapped transformer with switch serves equally as well since small voltage variations are not important. A voltmeter may be used, but the absence of critical voltage requirements makes calibration on a dial adequate for voltage indication.

Timing Arrangements

Various kinds of timing systems are in use. One simple method employs a copper slug relay in series with the patient circuit. The operation of such a relay can be delayed in varying amounts by changing the voltage which energizes its coil, although the range of timing that can be obtained in this way is quite limited. This method has another disadvantage in that a change of the line voltage on which the instrument is operated will change the timing proportionately.

Motor-driven timing cams can also be used, but a reliable motor-cam mechanism providing adequate flexibility in timing adjustment is a fairly complicated device.

There is also a variety of satisfactory electronic timers. The diagram shows an extremely simple electronic timer which gives continuously variable shock durations

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The point to the Bible story of the Tower of Babel was that progress on the greatest works of men ceased when by an unfortunate miracle each man was endowed with a different language and could not communicate or receive ideas from his fellows.

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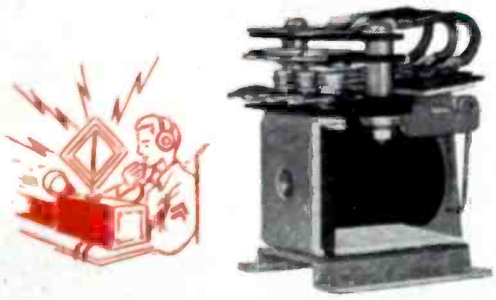
FOR EVERY CONTROL NEED

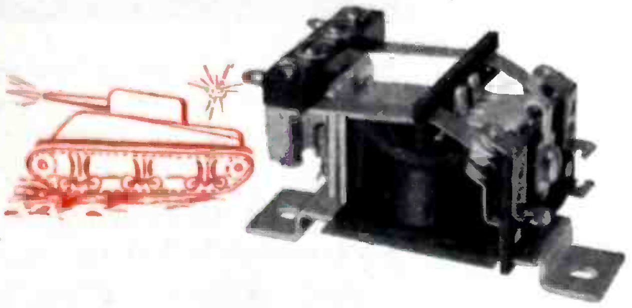


SERIES 345 RADIO RELAY

A general purpose radio relay designed for aircraft use. Contact combinations up to three pole, double throw. Coil resistances range from .01 ohm to 15,000 ohms. Standard voltage: 16-32 volts D.C. Available with delayed release or delayed attract. Weight: 6½ oz. Also built for A. C. operation (Series 340).

SERIES 195 MIDGET RELAY

One of the smallest of all relays. Built for aircraft and radio applications where space and weight are at a premium. Contact rating: 2 amps. at 24 volts D.C. Switch capacity up to double pole, double throw.



SERIES 165 VIBRATION RESISTANT

Counterbalanced armature and sturdy construction throughout give this relay an unusual resistance to vibration. Silver contacts are rated at 12½ amperes in combinations up to double pole, double throw. Rating for aircraft is 8 amperes at 24 volts D.C. Available with ceramic insulation for HF and UHF applications.

BULLETIN O-F-112

for a quick reference to standard relay types. Describes 17 relay models for war and post-war applications. Write for it today . . .

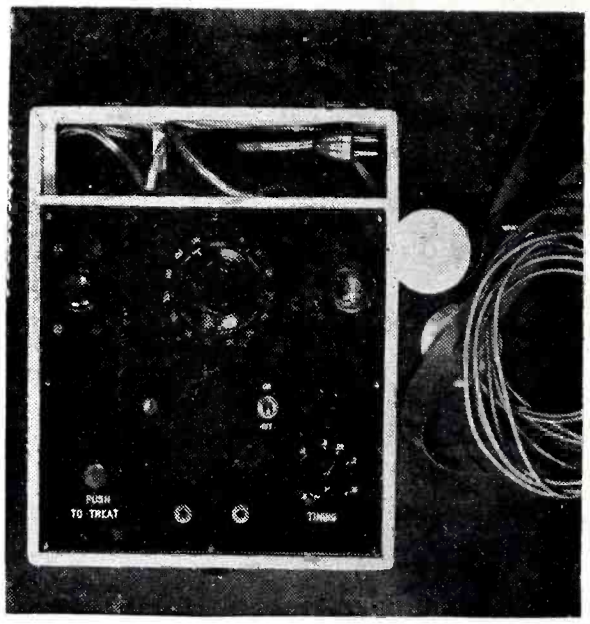
GUARDIAN ELECTRIC

1625-M WEST WALNUT STREET CHICAGO, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY between 0.15 and 0.5 second with the components indicated, and which has the considerable advantage of maintaining its timing adjustment within a few percent for line voltage changes of 20 percent.

Safety

It should be noted that a primary consideration in these devices is safety. Failure of a component should, as far as possible, result in total inoperation rather than wrong operation or excessive shock duration. This simple circuit meets this requirement also. A defective tube will prevent the passage of any shock current. Resistor or capacitor trouble will either prevent the relay from closing or make the shock of very short duration.

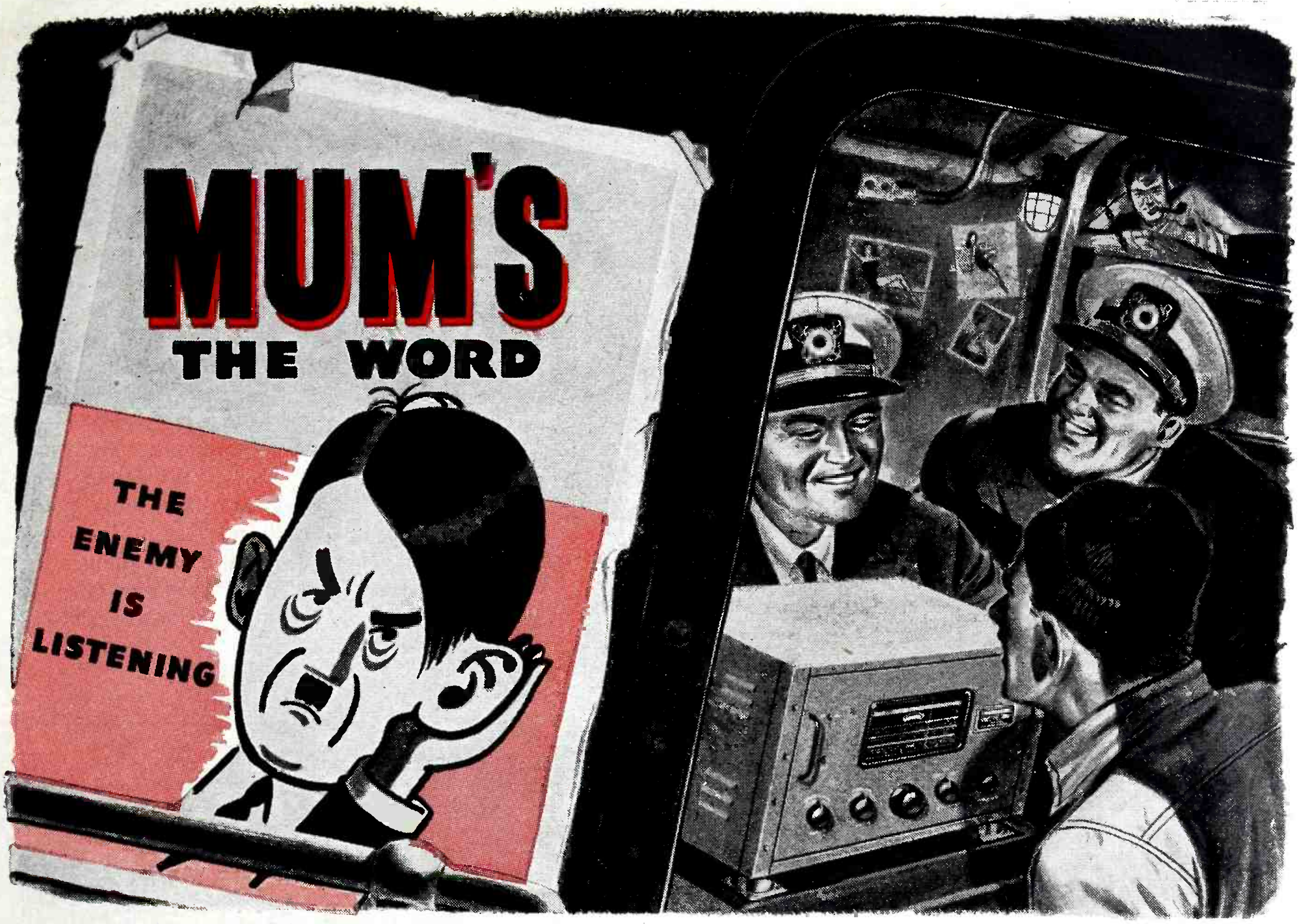


Shock therapy machine that applies about 100 volts to the patient's temples to produce certain curative effects

In order to guard against the remote possibility of the relay sticking closed through mechanical failure, the switch for administering the shock is of the pushbutton variety and the operator is instructed to hold it in the "ON" position for a period not greatly exceeding that of the selected shock duration.

Timer Circuit

In the diagram it will be seen that one side of the pushbutton switch opens the patient circuit while the opposite side closes the circuit which keeps the relay closed. When the pushbutton is depressed the patient circuit is closed through both the relay contacts and the pushbutton contacts, but the grid voltage which holds the relay closed is simultaneously removed from the tube except



SCOTT SPECIFIES AUTO-LITE WIRE

. . . New radio does not re-broadcast

Auto-Lite's research and engineering facilities on wire products are constantly helping solve baffling problems—like the production of the new Scott Marine Model Low Radiation Receiver. This amazing new product is without detectable radiation even at a distance of a few feet. (Formerly, receiver signals could often be picked up as far as 100 miles.)

Controlling factors for wire vary greatly . . . limited space, unusual shape, weight restriction or cost. Insulation is often of paramount importance. Butyrate Tape and Vinylite are two types being used for lighting and low tension circuits in radio production, aircraft construction and other vital war needs.

Our business has been built by supplying wire and wire products that solve problems for designing engineers and manufacturers. Whatever you need, unusual shapes, sizes or special insulation requirements . . . feel free to write us for authoritative recommendations.

THE ELECTRIC AUTO-LITE COMPANY

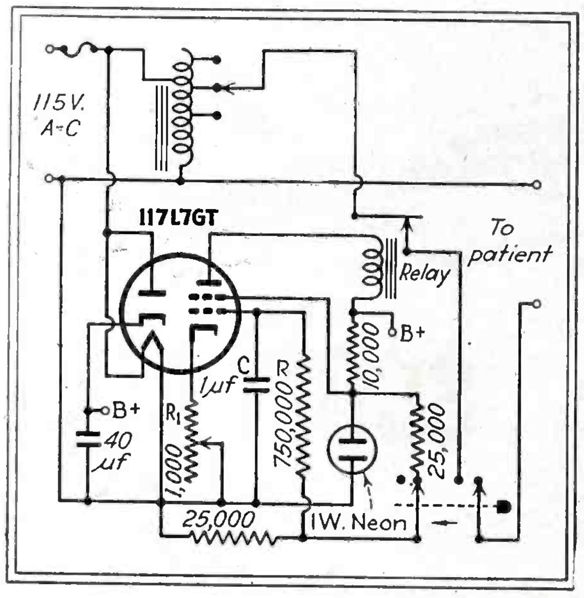
SARNIA, ONT. *Wire Division* PORT HURON, MICHIGAN

BUY WAR BONDS

AUTO-LITE *ELECTRICAL* WIRE and CABLE

IN ITS 26 GREAT MANUFACTURING DIVISIONS, AUTO-LITE IS PRODUCING A LONG LIST OF ITEMS FOR AMERICA'S ARMED FORCES ON LAND, SEA AND IN THE AIR for the charge on the capacitor. When the capacitor charge falls low enough the relay opens; the shock duration will be the time the relay stays closed after the pushbutton is depressed, and depends upon the setting of variable resistor R_1. The delay can be extended to several seconds if desired by increasing the value of R or C, provided the capacitor has low leakage and the tube is not gassy.

The spring bias on the relay affects the timing, and the final timing adjustment must be made for one specific relay adjustment. The relay should have no inherent delay. The timing adjustment is usually made by counting the cycles in the shock impulse on some kind of oscillograph; the direct writing oscillographs are of course the simplest to use for this work.

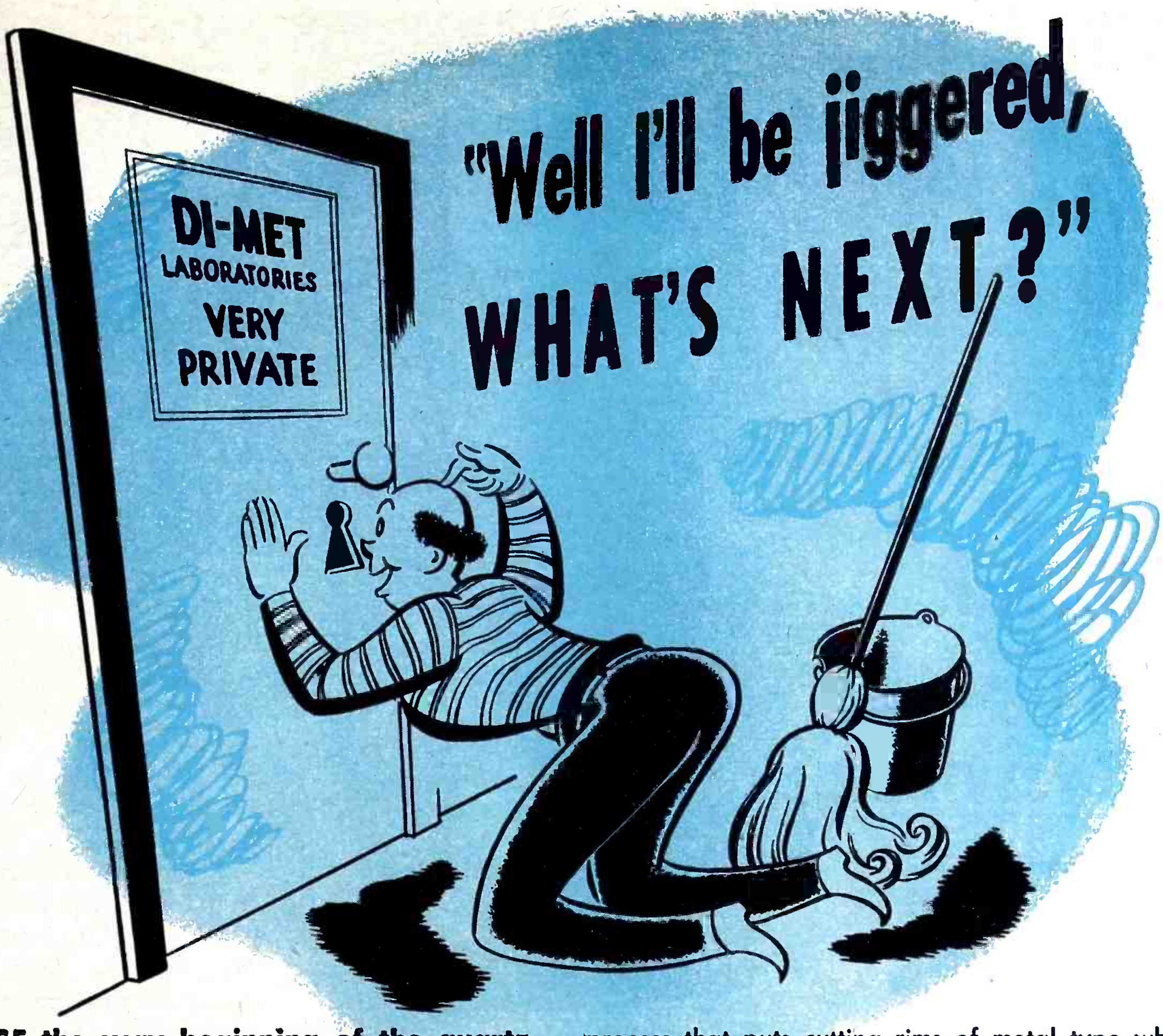


Circuit of electronic timer for controlling therapeutic shocks. A neon bulb is used as a voltage stabilizer to maintain timing adjustment within a few percent for line voltage changes of 20 percent

The electrodes need only be metal discs about 2 inches in diameter, held on the patient's temples by a rubber strap. Usually a small cloth saturated with salt solution is placed between the skin and the electrode, and the temples are rubbed with an electrode jelly to increase skin conductivity and prevent burning. Smaller electrodes may produce burning because of current concentration in too small an area.

Patient Resistance

Some electric shock machines are provided with a resistance-measuring circuit so that the resistance of the patient circuit may be determined before giving the shock. This



SINCE the very beginning of the quartz cutting program, DI-MET engineers have constantly endeavored to improve quartz cutting results through better blade and machine performance. Their success in these efforts has been substantial, starting with the first DI-MET Rimlock blade offered to the quartz industry.

The Rimlock was developed by a radical departure in bonding procedures* which greatly increased the blade life and cutting speed. For the delicate dicing operation the DI-MET Resinoid Bonded Wheel proved highly efficient producing smooth, polished surfaces.

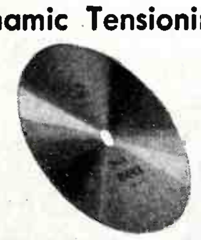
Latest developments in DI-MET laboratories include the "green-rim" resinoid bond for increased life, and Dynamic Tensioning—a process that puts cutting rims of metal type wheels under balanced tension—makes blades run flat during actual cutting operations and tends to *keep them flat* for the life of the blade!

Undoubtedly new and even better DI-MET developments are in store for quartz operators. And you can bet your share will come from DI-MET laboratories, since continuous effort and experimentation here are constantly improving existing quartz cutting techniques, producing *more* blanks per pound of quartz and eliminating unnecessary wastage. For any cutting problem—for every cutting operation—look to DI-MET!

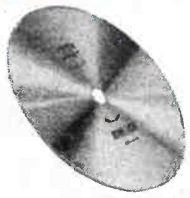
FELKER DI-MET

FELKER MANUFACTURING CO.
1116 Border Ave. • Torrance, Calif.

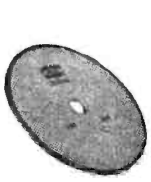
TYPE C R
Bond: Copper
SIZES
Cut Off Wheels:
3", 4" and all even diameters up to 16"
Thick body Wheels:
Diameters: Up to 6"
Thicknesses: 1/16" to ½"



RIMLOCK
Bond: Copper
SIZES
Cut Off Wheels:
3", 4" and all even diameters up to 16"
Thick body Wheels:
Diameters: 1" to 6"
Thicknesses: 1/16" to ½"



RIMLOCK
Bond: Steel
SIZES
Cut-Off Wheels:
3", 4" and all even diameters to 24"



RESINOID BONDED
Straight Wheel, Type D1T
Diameters:

Thicknesses:
1/32" to ½"

CUP WHEEL
Resinoid Bonded Plain Cupwheel, Type D6W
Diameter: 6"

MANUFACTURERS OF DIAMOND ABRASIVE WHEELS

measurement seems to have little or no significance. The measurement is made with only a few volts applied, and thus the conditions of measurement are radically different from those which obtain during the passage of the shock current. It is probably largely a measurement of the superficial skin resistance rather than any measurement of the dynamic impedance to the passage of the shock current; and no prediction as to the proper voltage necessary for treatment can be made from this superficial resistance measurement.

A few years ago this writer developed a recording surge current meter for use in electric shock measurement. Measurements made with it indicated that the impedance to the passage of the shock current in most of the observed cases averaged around 100 ohms, although the resistance of the patient circuit as determined by the low-voltage resistance measuring circuit of a conventional instrument varied from several hundred to several thousand ohms and showed no significant relationship to the instantaneous current that passed during the shock.

Without intimating the expression of a medical opinion, it may perhaps be stated that excellent results in the treatment of some mental illnesses have been reported from the use of electric shock treatment.

• • •

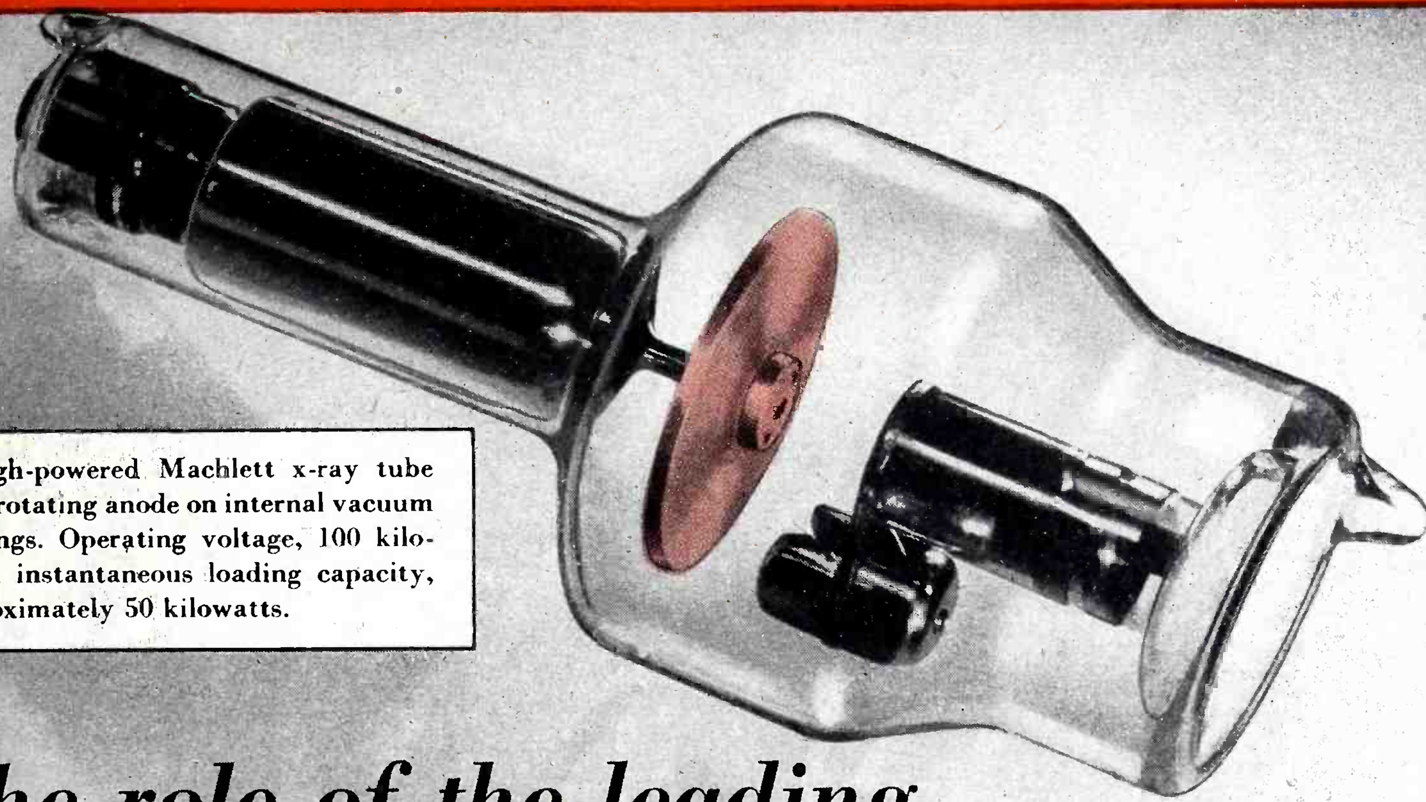
Self-Checking Carrier Tone Alarm

By Paul A. Berg
Transmitter Engineer
Station WJJD, Des Plaines, Ill.

In the design of carrier-tone alarm circuits, the prime consideration is reliability. If the key station is temporarily caused to operate at reduced power, or receiving conditions are such that a decreased signal is effected at the monitoring receiver, provision should be made to either increase the sensitivity of the alarm circuit, or to actuate the alarm and inform the operator of the existing condition, so that he may revert to audio monitoring until the normal condition has been restored.

A carrier tone alarm circuit is herewith described, with a self-checking feature that guards against varying conditions of reception of the key station. An effort has been made to

MORE POWER TO ELECTRONICS AT WAR . . .



A high-powered Machlett x-ray tube with rotating anode on internal vacuum bearings. Operating voltage, 100 kilovolts; instantaneous loading capacity, approximately 50 kilowatts.

The role of the leading X-RAY TUBE MAKER

The war program has led to the development of wonderful new electronic devices for waging war. The successful operation of these devices depends on an adequate supply of the necessary electron tubes—not just the common garden varieties of radio tubes, large numbers of which are also required, but amazingly intricate, high-powered new tubes.

Where can the enormous quantities of these tubes, such as the radio tube industry has never produced, be obtained? A large part of the answer to this question is being provided by the leading x-ray tube manufacturer. X-ray tubes are the only form of electronic tubes of comparable power characteristics and intricacy which have been commercially produced in large quantities. High operating voltages (50,000 volts upward into the millions), high power requirements (up to 50 kilowatts instantaneous demand), are commonplace to the x-ray industry. In this industry, likewise, tube production is the keystone. Only an exceedingly few organizations have developed the necessary skills and techniques.

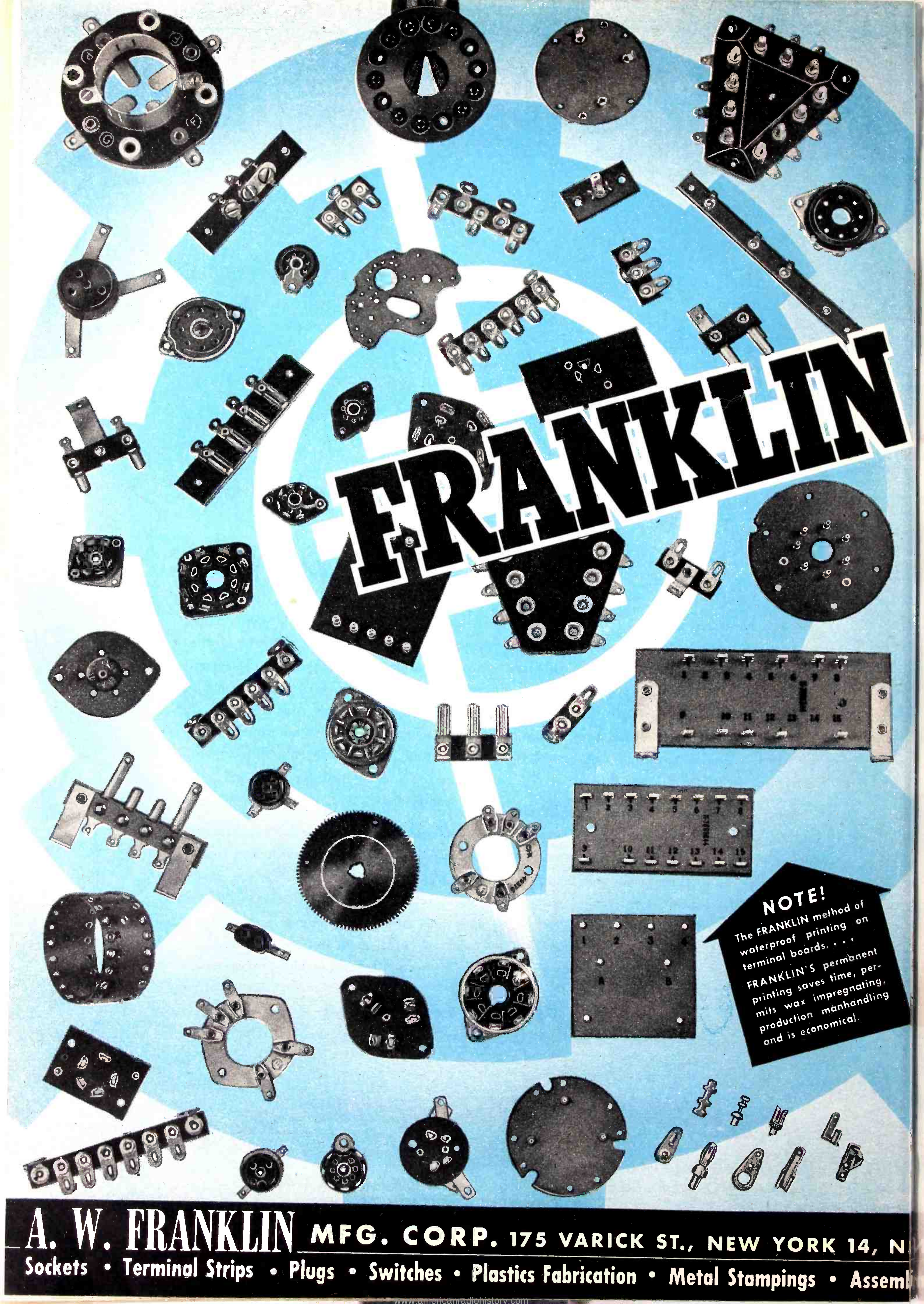
Of these few, one leader, the Machlett Laboratories, America's earliest and today's largest producer of x-ray tubes, has loaned a part of its technical skill, has developed enormous additional productive capacity, to break the bottleneck in tubes for the government's wartime electronics program.

MACHLETT
Laboratories Inc.

THE LARGEST PRODUCER OF X-RAY TUBES

SPRINGDALE CONNECTICUT

POWER TUBE DIVISION: **NORWALK, CONN.**



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The FRANKLIN method of waterproof printing on terminal boards. . . .
FRANKLIN'S permanent printing saves time, permits wax impregnating, production manhandling and is economical.
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provide a counter check on the alarm circuit itself, in a manner such that the operator may be instantaneously informed that the unit has become inoperative. Once preliminary adjustments have been made, no further compensation is required.

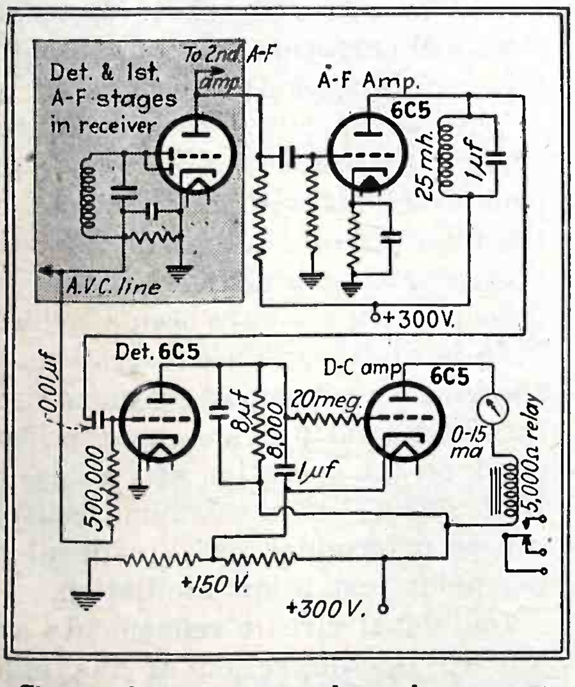
The circuit shown is applicable to any receiver of either the superheterodyne or tuned radio frequency type, capable of delivering at least ten to fifteen volts of avc voltage. The tube complement consists of three triodes of the 6C5 type, but the circuit is adaptable to any other type of receiving triode.

Tuned Circuit for Tone Signal

Amplification of the tone signal is provided by a triode tube which employs a tuned circuit as the plate load. The inductance consists of a winding of No. 21 wire, about one pound being required to obtain an inductance of 25 millihenries. This gives an approximate reactance of 160 ohms at 1,000 cycles. With a d-c resistance of 5 ohms, a Q of 30 is readily attainable.

When the inductance is resonated with a 1-μf capacitor the load impedance presented to the tube is approximately 5,000 ohms. The gain realized is approximately half of the mu for ordinary triodes. The attenuation at 20 cycles off resonance is about 20 db.

Rectification of the 1,000-cycle tone is accomplished by application of sufficient avc voltage to fix the detector operating point slightly beyond cutoff. Since the d-c pulses of



Circuit of carrier tone alarm that corrects for different receiving conditions and actuates alarm when an integral part of the receiver fails detector plate current are something less than half waves, a capacitance is provided across the detector load circuit to utilize the peak values of output to excite the d-c amplifier.

With increased values of avc voltage, resulting from a decreasing intensity of the received signal, the sensitivity of the detector is automatically increased. Likewise any decrease in operating sensivity of the receiver causes increased detector sensitivity. With proper adjustment of the detector load resistance the alarm will be actuated when the avc bias has sufficiently decreased so that detection of the alarm carrier is no longer possible. Thus automatic provision is made for checking simultaneously the operation of the receiver and the carrier of the transmitter sending out the alarm alert.

Use of D-C Amplifier

The employment of a direct current amplifier serves a dual purpose. It increases the sensitivity of the instrument and serves as a current inverter permitting use of a relay of the normally-closed type. Operation of the alarm relay in a normal holding position is a positive check against power failure or loss of the d-c potential of the power supply.

An RC constant is employed at the input of the direct current amplifier, to provide protection against the alarm circuit being actuated by sustained musical notes which are very near the alert frequency. This also rovides a delay on the carrier alarm, which will not be affected by rapid fading, carrier failures due to instantaneous transmitter overloads, or breaks of extremely short duration. Practical operation has shown that a delay of 10 seconds is adequate.

With an advanced position of the volume control the circuit may be made to oscillate at the frequency of the filter circuit, due to the distributed constants, and the fact that no decoupling filters have been provided. This is an advantageous feature in checking the resonant frequency of the filter, and provides an excellent check on the operation of the alarm. Best setting of the volume control can be determined by adjustment to the point just below oscillation.

Individual circuit refinements are left to the discretion of the individual operator. A battery and bell or automatic actuation of the monitoring channel may be incorporated.

NEW YORK • CHICAGO • LOS ANGELES • LONDON • HAVANA

"They Were the Last to Leave" . .

"Our boys in Shanghai kept their circuits going until ten minutes before the Japs walked in. Even after Jap soldiers were posted at the front entrance of our building, our boys kept working. Finally, our lookouts gave the signal, the manager herded everyone into a freight elevator and we escaped through a back door as the Japs marched in the front."

—From an eyewitness account of the capture of Shanghai.

The Press Wireless offices in Shanghai were the last communications points to close their doors when the Japs seized the city. In keeping with the traditions of the Company, Press Wireless operators, at the risk of their lives, sent news and other important dispatches up to the last moment. Some faced other perils in escaping through the Jap lines to Chungking to help staff a new station there.

In communications as in combat, today's warfare calls for loyalty, courage and enterprise of the highest order. Press Wireless, Inc., is proud to be serving front communication lines throughout the world.

PRESS WIRELESS, INC., IS DEVELOPING AND MANUFACTURING

- HIGH POWER TRANSMITTERS
- DIVERSITY RECEIVERS
- AIRCRAFT AND AIRFIELD RADIO EQUIPMENT
- RADIO PRINTER SYSTEMS
- MODUPLEX UNITS - TRADEMARK
- CHANNELING DEVICES
- RADIO PHOTO TERMINALS
- FACSIMILE MACHINES

AND OTHER TYPES OF RADIO AND COMMUNICATIONS EQUIPMENT

ARMY E NAVY

Awarded to Our Hicksville Long Island Plant for Outstanding Achievement in War Production

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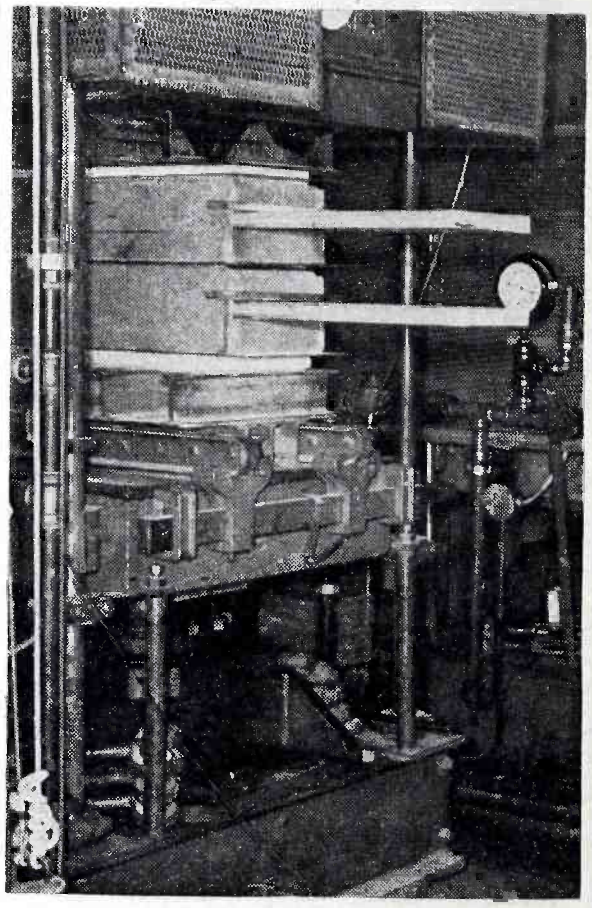
Executive Offices 435 N. MICHIGAN AVENUE, CHICAGO

Sales Office, Manufacturing Division 1475 BROADWAY, NEW YORK CITY

RIO DE JANEIRO • MONTEVIDEO • BERNE • SANTIAGO DE CHILE

Thermal Insulation for Electrostatic Heating

UNIFORM HEATING of an entire mass so that the outside surfaces are maintained at about the same temperature as the degree of internal heat is provided by the use of thermal insulation around the material. This method of application of electrostatic heating is used in the manufacture of Pregwood propeller blocks by the Formica Insulation Co. The photographs show sheets of Pregwood being glued together while inclosed in a thermal insulation box that helps prevent the loss of heat from the outer surfaces of the sheets.



One of the presses used in manufacturing airplane propellers, in which phenolic glue is cured by electrostatic heating

Gluing the sheets together to form a mass suitable for propellers presented a considerable problem since cold-setting glues are not satisfactory and steam or oven heating could not be used because prolonged heating is injurious to Pregwood. The answer has been found in the use of heat-setting phenolic glue cured by electrostatic heating. The glue is set with moderately high-temperature heat generated in the material by a self-excited oscillator that delivers 15 kilowatts to the load at a frequency of 1,740 kilocycles.

Radio-frequency power from the oscillator is connected to three presses in turn. This permits the generator to be used continuously

Today's Replacements Speeded

Two Years Before Pearl Harbor!

• It was more than 23 months before Pearl Harbor that RCA started something which today—23 months *after* Pearl Harbor—is speeding replacements of electron tubes to far-off fronts.

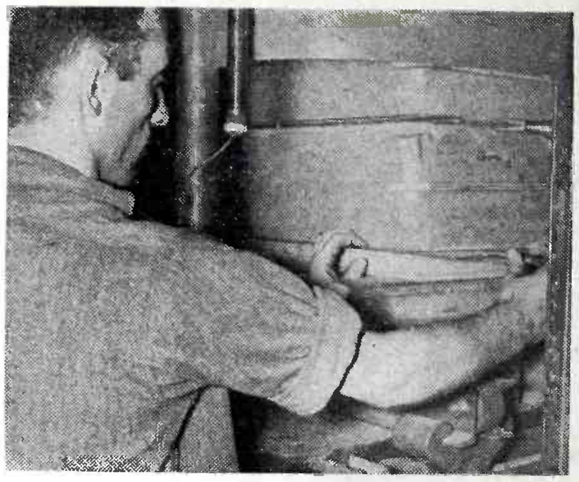
• For at that time RCA launched its *Preferred Type Tube* program. From among many hundreds of tubes of various kinds and sizes, RCA selected 36 receiving tubes—each for some basic, needed characteristic. This made possible larger manufacturing runs on fewer types, and resulted in better tubes of greater uniformity at lower cost. RCA's program was hailed immediately by equipment manufacturers. They knew that the saving in all-around efficiency would be *their* saving.

• When war came, the U. S. Government also issued a list, called the "Army-Navy Preferred List of Tube Types." (We'll be happy to send you a copy of the latest revised list on request.) And now this program is serving the country well . . . in releasing for other war purposes the stocks of vital materials formerly tied up in the several hundred tube types . . . and in making it possible to expedite delivery of standard type electron tubes wherever the fighting fronts need replacements—*fast*.

• POST-WAR POSSIBILITIES. RCA's application engineers invite inquiries from equipment manufacturers concerning tubes most likely to be on the RCA list of post-war preferred types. Remember: *The Magic Brain of All Electronic Equipment Is a Tube . . . and the Fountain-Head of Modern Tube Development Is RCA.* RCA Victor Division, RADIO CORPORATION OF AMERICA, *Camden, New Jersey.*

RCA ELECTRON TUBES

TUNE IN "WHAT'S NEW?" RCA's great new show, Saturday nights, 7 to 8, E. W. T., Blue Network.



Mounting sheets of Pregwood (encased in thermal insulation) in an electrostatically heated press. Clips connect to copper plates on each side of the material to be heated

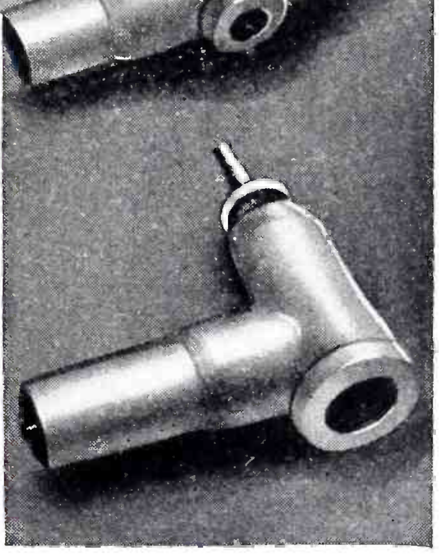
without waiting for loading and unloading of the presses. The tubes in the generator are type 892 power tubes with an input to their plates of 27 kilowatts.

• • •

C-R Tube Tests Controls

ELECTRONIC TESTING of carbon potentiometers and volume controls is accomplished by means of the fixture shown in the photograph. The resistance curve, taper, hop-off, transition points or ink blends, flaws or cracks, potential noise sources, comparative resistance values, useful rotation and grounds are checked more quickly than by conventional means. Factors such as the resistance curve, taper, hop-off, and transition points can be held within narrow tolerances by

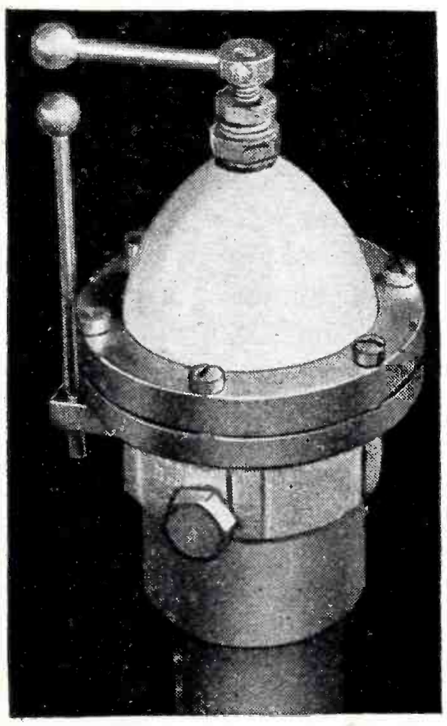
Production testing of potentiometers is accomplished by placing each control in a fixture that rotates the shaft and plots the resistance versus rotation on the screen of a cathode-ray tube

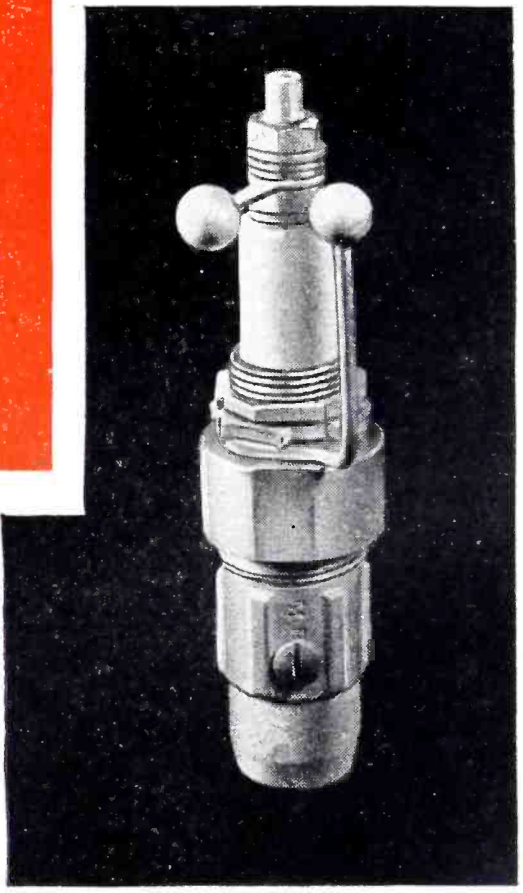


Pioneers in
COAXIAL EQUIPMENT

JOHNSON coaxial transmission line is widely used for efficiently transferring electrical energy from transmitter to antenna or for interconnecting transmitter stages. Both inner and outer conducters are of copper insulated from each other with Alsimag number 196 beads.

Five sizes of line and associated fittings are available to handle power outputs of from 250 to 100,000 watts. If as is common practice the line is to be operated filled with dry oil pumped nitrogen we will be glad to make the necessary arrangements for the gas and associated equipment. Inquire today!





General Products Catalog
967D
FREE on request

JOHNSON
a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA markings on the screen of the cathode-ray tube.

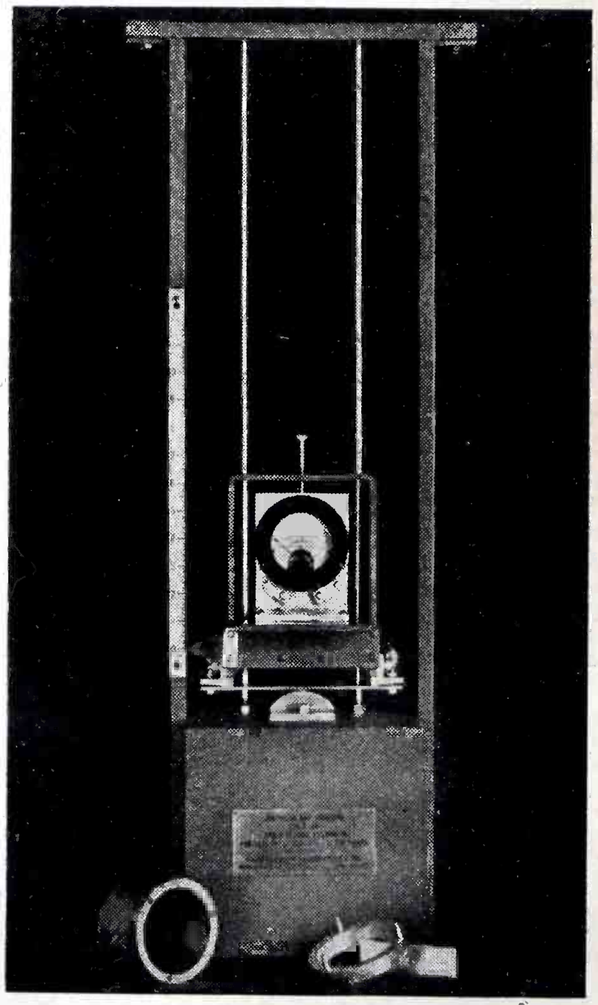
The device consists of a standard potentiometer which controls the horizontal sweep of the cathode-ray tube and which is geared to the control under test. By a movement of a lever the two controls are rotated in step with each other. The control under test actuates the vertical sweep and the dot traces the graph of the rotation against resistance on the screen of a 5-inch tube. The arrangement has been used by Clarostat for several years in production testing of their products.

• • •

Shock Tester for Meters

FOR TESTING METERS to be used in communications and electrical equipment the mechanism shown in the photograph has been designed to subject the instruments to mechanical shock to determine their ability to withstand rough handling in planes, tanks and other mobile units.

The mechanism is designed for testing 2½ and 3½-inch round, flush-mounting, panel-type meters and has been approved by the American Standards Association. It is an adaption of a design originally made



Mechanism for determining the suitability of meters for use in mobile equipment as made by Radio Frequency Labs., Inc. The meter is placed in a carriage and bounced from various heights

HERE IS WHAT YOU WANT TO KNOW ABOUT RELAYS!

Write for your copy today!

The Struthers-Dunn Catalog has been prepared with a careful eye toward enabling you to select Relays and Timers intelligently from a line that covers just about every need—and then to use them to best possible advantage.

In addition to complete descriptions of standard Struthers-Dunn types, this Catalog contains a wealth of Relay engineering and application data which should prove both interesting and helpful. Behind this, our district engineers in the cities listed below stand ready to help in solving your Relay-Timer problems.

STRUTHERS-DUNN, Inc.

1321 ARCH STREET, PHILADELPHIA, PA.

DISTRICT ENGINEERING OFFICES: ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DENVER • DETROIT • HARTFORD INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL • NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO • WASHINGTON by the National Bureau of Standards with the cooperation of the Weston Electrical Instrument Corp.

The meter to be tested is mounted in a cylinder and flange fixture, shown in the foreground of the photograph, and securely fastened to a movable carriage. The carriage is raised to the height necessary for obtaining the desired acceleration, and then dropped so that a spring mounted at the bottom of the carriage strikes a curved anvil on top of the cast-iron base. It is permitted to make a single contact and is caught by hand on the first rebound.

Theory

The kinetic energy developed is assumed to be absorbed by the spring. The kinetic energy, $\frac{1}{2}mv^2$, of the carriage, which had been transformed from the potential energy, wh, of the raised carriage, equals the potential energy of the spring, $\frac{1}{2}kd^2$. From this the maximum deflection, at which the maximum acceleration occurs, can be determined. By equating the two values and solving, the following equation for the nominal value of the acceleration results:

$$G = 2hK/w$$

where G is the nominal value of acceleration in gravity units; h is the height in inches from which the carriage dropped; K is the spring constant in pounds per inch deflection; w is the weight of the carriage and load in pounds.

The equation assumes that all of the energy is absorbed by the spring in quasi-static condition; that none is dissipated in elastic vibration of the spring or the structure, and that no yielding takes place in any other part of the mechanism or the base mounting. Although these hypotheses are not attainable, similar results will be obtained by various workers by standardization of the tester design.

Construction

To insure rigidity of the moving carriage, it is constructed of steel having a thickness of ¼ inch. The equivalent of one-piece construction is obtained by welding the carriage parts after they are securely bolted together. The curved stationary anvil is made of hardened tool steel with a radius of curvature of 1.5 inches and is bolted to a cast-iron bed made of a single piece of metal. The calibrated spring at the bot-

M-R

FIBREGLAS ELECTRICAL INSULATIONS

TUBINGS
TAPES
CLOTHS
and
FABRICATED
PRODUCTS

Protect ELECTRICAL EQUIPMENT!

MITCHELL-RAND
for
54 YEARS
THE ELECTRICAL
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EST. 1889

Overloading . . . high or low temperatures . . . moisture . . . corrosive acids, vapors or fumes . . . oils . . . greases . . . dust or dirt, the destructive elements of ordinary electrical insulations WON'T AFFECT M-R FIBREGLAS inorganic ELECTRICAL INSULATION.

The success story of FIBREGLAS ELECTRICAL INSULATION abounds with fewer breakdowns, less maintenance, elimination of waste, savings in labor and materials and proves its value as the optimum in *Electrical Insulation Protection*.

MITCHELL-RAND INSULATION COMPANY, INC.

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- Fiberglas Varnished Tape and Cloth
- Insulating Papers and Twines
- Cable Filling and Pothead Compounds
- Friction Tape and Splice
- Transformer Compounds
- Fiberglas Braided Sleeving
- Cotton Tapes, Webbings and Sleevings
- Impregnated Varnish Tubing
- Insulating Varnishes of all types
- Fiberglas Saturated Sleeving and Varnished Tubing
- Asbestos Sleeving and Tape
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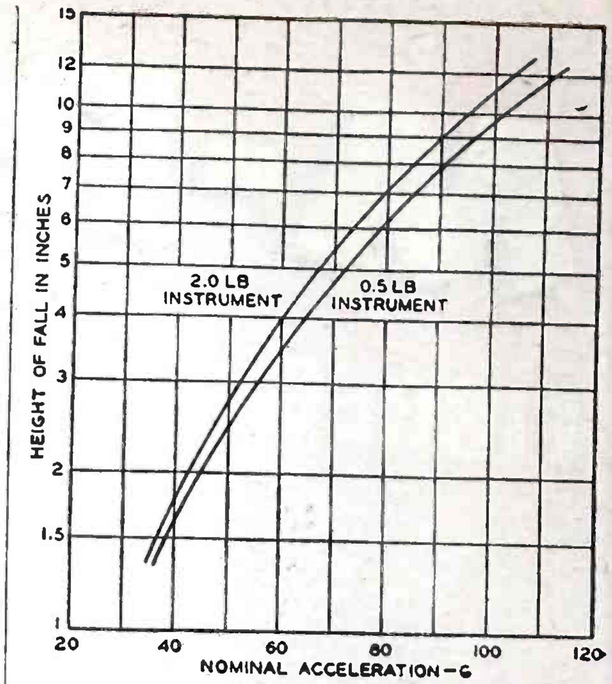
- Mica Plate, Tape, Paper, Cloth and Tubing



Curves for meter weights of 0.5 and 2.0 pounds, calculated on the basis of a mean spring constant of 5.250

tom of the carriage is made of one percent carbon tool steel, hardened and spring-tempered. The strength of this spring is dependent on the quality of the material and its heat treatment. It has a spring constant K between 5,000 and 5,500 pounds per inch deflection.

Method of Calibration

Static loads up to 500 pounds are applied to the top of the carriage frame and the deflections of the spring measured with a dial gage or height gage mounted on the top surface of the cast-iron bed. Measurements are taken at the center of the carriage face plate. The spring constant K is found from $K =$ load in lb./inches deflection. With a spring constant equal to 5,000 the deflection of a 500-pound load is 0.1 inch.

Calibration curves for various meter weights may be plotted. In most cases parallel curves for weights of 0.5 and 2.0 pounds will suffice and intermediate weights can be estimated. Curves are shown that have been arbitrarily calculated on the basis of a mean spring constant K of 5,250 and a combined carriage and fixture weight of $9\frac{3}{4}$ pounds.

If comparable results are to be obtained with copies of this testing apparatus they must be made dynamically similar. Complete specifications, including drawings of the parts and assemblies furnished by the Signal Corps, are contained in the American War Standard C39.3–1943, which may be obtained from the American Standards Association, 29 West 39th St., New York 18, for 25 cents each.

If you believe in the future of America as we do, then we're asking for an appointment immediately after the victory has been won . . . when a bright new era awaits us all.

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As a matter of fact, perhaps we can get together now, but if it happens we can't, remember we have a date in and for the future. When we both can keep it, you can again take advantage of Anaconda's service and the benefits derived from the single product control "from mine to consumer" backed by years of continuous metallurgical experience.

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Magnet wire and coils

ANACONDA WIRE & CABLE COMPANY

FM and Television

(*Continued from page 97*)

and administrative problems are still to be worked out. While most of the technical problems have been solved, so far as engineering is concerned, television cannot progress without being designed as a complete system from camera tube to kinescope. The future of television is dependent to very large extent upon the decisions which will be made by the Radio Technical Planning Board.

Television has, of course, the limitations of limited transmission distance necessitated by wide-band transmission and high-frequency carriers. As a result, chain programs or relaying, or both, will become necessary if television is to assume the important position which the future appears to have assigned to it. New developments in very short waves will probably make possible more practical relaying equipment, thus overcoming the limitation of distance and allowing national programs.

Other Post-War Considerations

In some quarters, facsimile is regarded as a natural adjunct of frequency modulation and the post-war era may possibly see the introduction of home facsimile f-m broadcasting service. The technical capacity of modern facsimile systems is far beyond anything promoted in the prewar period. It is now commonplace, technically speaking, to deliver black and white copy at the rate of twenty-four square inches per minute, from a simple and inexpensive receiver located anywhere within the normal service area of an f-m broadcasting station.

When manufacture of civilian radio equipment is resumed after the war, there will undoubtedly be a substantial replacement market, since many radio receivers now in operation will have become inoperative or obsolete. Replacement equipment must be designed and built to give service in accordance with existing services, and cannot be geared, to any appreciable extent, to new services now only anticipated. Consequently, with one market for replacement and another market for new services, two sets of conditions must be faced by he industry. Technically and economically, the replacement market should supplement that for new equipment. It would seem that the replacement market would provide a valuable stop-gap to utilize our vast radio production facilities for the manufacture of equipment which will be needed immediately after the cessation of hostilities and before equipment for new systems of f.m., television, u-h-f chain broadcasting and the like can be placed into operation. Ultimately, however, the replacement market will diminish in importance. The market for new services will exceed it and will largely constitute the radio industry of the future.

It may be expected, with a rather high degree of confidence, that radio equipment for sale to the public immediately after the war will not differ radically from that which was available during 1941, except possibly that better components may be used. One cannot expect the advantages accruing as a result of war developments to be reflected in the manufacture of civilian products until the industry has had at least one season to effect the necessary reconversion and carry out its design for peace-time applications; the war is too important to devote time now to such problems.

• • •

COMPUTING GUN SIGHT

Shown here is the Sperry computing gun sight, a model of scientific precision, used on Flying Fortresses. The gun sight makes corrections for the factors such as plane and wind velocity which might otherwise cause a gunner to miss his mark

THE ELECTRON ART

Mass Radiator for Infrared Frequencies

A MASS RADIATOR that consists of a mixture of movable metal particles suspended in a liquid dielectric medium is described by A. A. Glagoleva-Arkadieva in the Sept. 1941 issue of *Comptes Rendus* (Russian), abstracted in the August 1943 issue of *Wireless Engineer.* The mixture, called a vibrational mass, is supplied with high voltage by an inductor to produce sparking between the particles. This sparking action creates electrical vibrations in the particles, generating frequencies that extend into the region of the infrared spectrum which is scarcely accessible to other methods of generation of electrical waves.

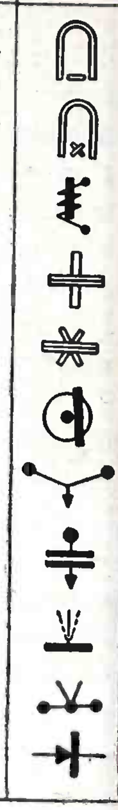
Radiation of the mass vibrator is caused by means of numerous small Hertz vibrators, each of which is formed by one pair of metal particles suspended in the dielectric medium. The radiation of centimetric waves is excited by particles arranged in a chain or otherwise, another kind of each such accumulation acting as a large Hertz vibrator. The shortest (millimetric and hectomicron) waves are radiated by the tiniest particles of the vibrational mixture. The radiation does not arise from the exterior layer of the radiating region alone, but comes from the interior layers which are under the influence of the discharge.

Resonant nichrome - constantan thermocouples were used as aerials in this investigation. The action is similar to that of a Helmholtz radiator for sound waves. Use of such resonant thermocouples allows measurements to be carried out without additional devices for the monochromatization of the radiation. Measurements have been made of the monochromatic waves in the region from 353 microns to 6.48 cm.

Symbols for Meter Dials

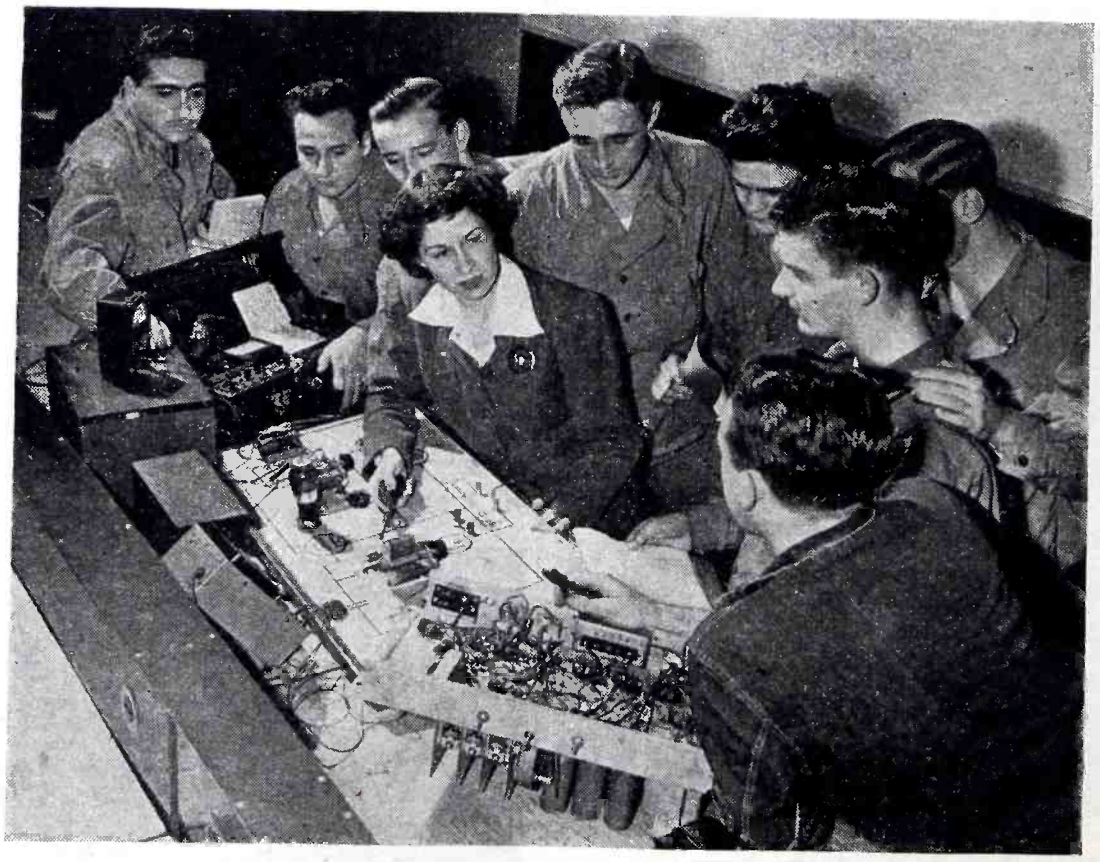
A SET OF CONVENTIONAL symbols to be marked on instrument dials is suggested for use in England in the July, 1943 issue of the *Journal of the Institution of Electrical Engineers.* The purpose of the marking is to indicate the type of movement contained in the meter. Some of the suggested symbols are shown in the diagram. The complete list contains 32 symbols in all, and has been standardized by the International Electrotechnical Commission.

TYPE OF MOVEMENT	SYMBOL
Permanent magnet, moving coil	
Ohmmeter	
Moving iron	
Electrodynamic	
Power-factor meter	
Induction	
Hot-wire	
Electrostatic	
Vibrating reed	
Thermocouple	
Dry-disc rectifier	

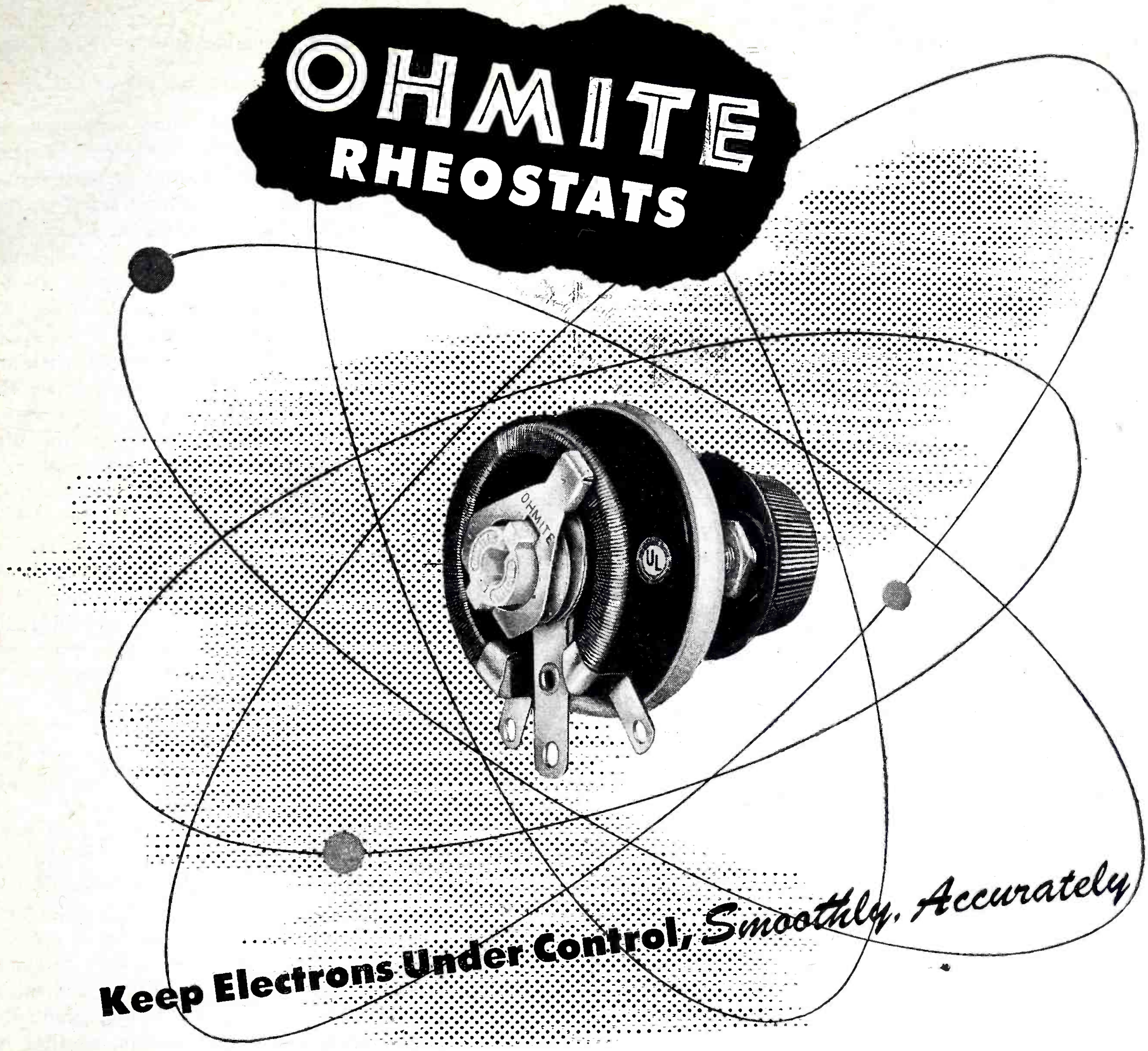


This method of marking meters has been used for some time in Europe and is said to have been extremely helpful to German and Swiss meter manufacturers in selling their products in countries of other languages. A similar system of markings might be advantageous to American meter manufacturers who anticipate post-war sales in South America and other export markets.

ARMY RECEIVES A FEW POINTERS



Mrs. Patrice Floyd, civilian instructress in radio mechanics, explains the mysteries of an oscillator board to a class of students in the Army Air Force Technical Training Command School in Chicago. The board was built from parts of an old radio receiver shown in the foreground. This set is one of 11,000 contributed to the school by the public in answer to Army requests for old radios



Busy electrons obey . . . when you turn the knob of an Ohmite Rheostat. You can always be sure of smooth-action, close-control, trouble-free service. Because of their time-proved design and construction, Ohmite Rheostats serve day-in and day-out in all types of electronic devices—under all kinds of climatic conditions. Ohmite produces ten sizes from 25 to 1000 watts, in straight or tapered windings, in stock or special designs, for every requirement. *Approved types for Army and Navy specifications.*

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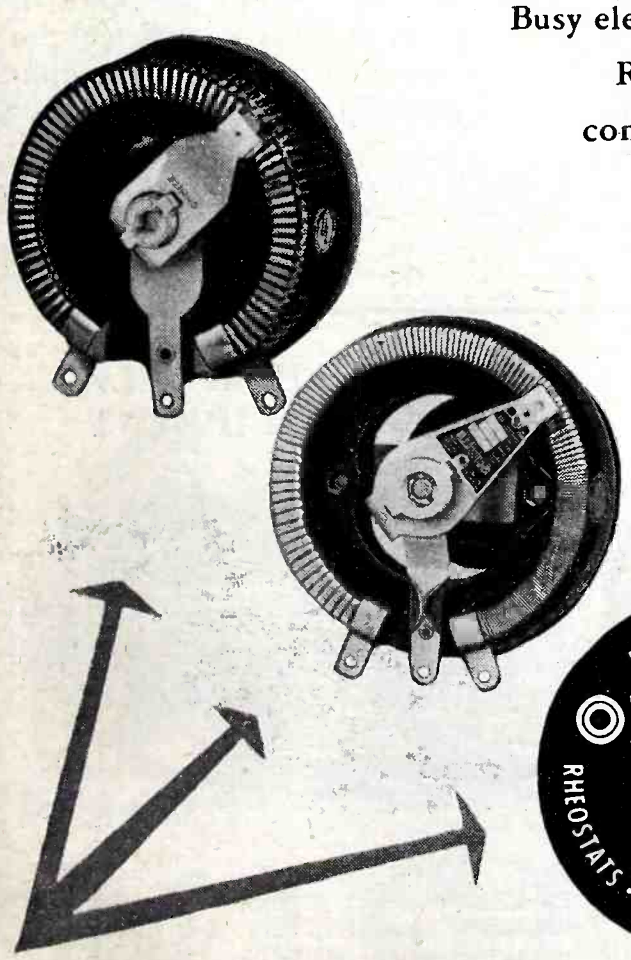


SEND FOR CATALOG and ENGINEERING MANUAL No. 40

Write on company letterhead for this helpful 96-page guide in the selection and application of rheostats, resistors, tap switches, chokes and attenuators.

Solderless Connections

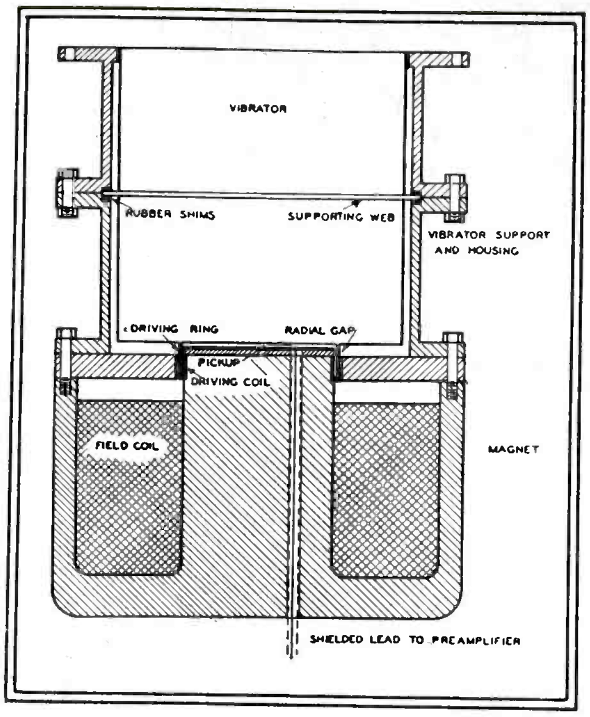
A NEW METHOD of connecting wires together avoids the use of flux and its possibility of later corrosion, and also permits joining enameled wire without removing the insulation.

Connection of the wires is accomplished by means of a device which resembles a miniature spot welder and contains two carbon electrodes having blunt, grooved tips. The wires to be joined are twisted together and laid in the groove of one carbon with a small piece of copper, silver, or phosphor-bronze. The second similarly grooved electrode is placed over the first to cover the joint. When it makes contact it closes an electrical circuit that causes the carbons to become red-hot. The grooves then form a miniature electric furnace whose temperature rises to about 3,000 deg. C. The enclosure minimizes oxidation by excluding air, while the heat burns off any varnish on the wires without damaging the metal.

The method has been patented by Technotherm Ltd. of St. Albans, Herts, England, which does not intend to manufacture the device but prefers to arrange for others to do so. It is reported in the July, 1943 issue of *Wireless Engineer*, a British publication.

Automatic Frequency Control for Mechanical Vibrators

AN ELECTRONIC APPARATUS for driving mechanically resonant vibrating sound generators, that maintains frequency very close to the resonant frequency of the vibrator, is described by E. V. Potter in the *Review of Scientific Instruments* for July, 1943. The vibrating member actuates an electrostatic pickup plate that generates an alternating voltage which is fed to a discriminator and reactor tube circuit similar to that used for automatic frequency control of pushbutton receivers. Change in phase of the vibrator motion relative to the driving force produces a direct voltage which is applied to a tube employed as a variable reactance to correct the frequency of a vacuum tube oscillator. Changes in either the oscillator frequency or the vibrator frequency, or both, of approximately 500 cps in 12 kc are followed automatically so that the oscillator frequency does not deviate from the resonant frequency of the vibrating member by more than 0.1-cps.



Cross-section of vibrating bar assembly used to generate high-frequency sounds for flocculating smoke particles. The vibrator is a duralumin bar, supported by a thin web, that vibrates at its resonant frequency

Construction of Vibrator Unit

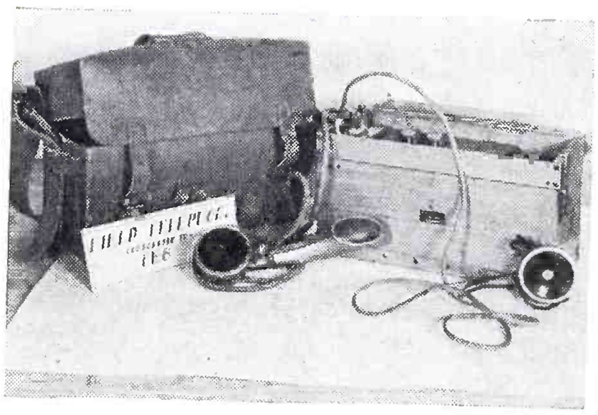
This type of sound generator, developed by H. W. St. Clair,* is used to flocculate and remove suspended particles in smoke, fumes and fog, and contains a duralumin bar that is free to vibrate at its resonant frequency. The mechanical assembly of the vibrator is shown in the drawing. An extruding ring acts as a one-turn coil which, when supplied with induced alternating current, drives the bar in much the same manner that a voice coil assembly drives the diaphragm in a dynamic loudspeaker.

A metal plate is mounted near the bar to form an electrostatic pickup whose capacitance varies with the motion of the vibrating bar. This capacitance change produces an alternating voltage which is amplified and fed back to the ring that energizes the bar. Essentially this comprises a regenerative circuit, since the motion of the bar generates an alternating voltage which is amplified and fed back to continue the bar vibrating at its resonant frequency.

Under heavy acoustical load conditions the motion of the vibrating bar may be so small in St. Clair's system that the amplifier gain may not be sufficient to maintain oscillations and the system ceases to function. Too, the vibrations are initiated at low amplitude and gradually build up to a maximum, so that in borderline cases where the gain in the system is barely sufficient to maintain oscillations it may be difficult to get it started.

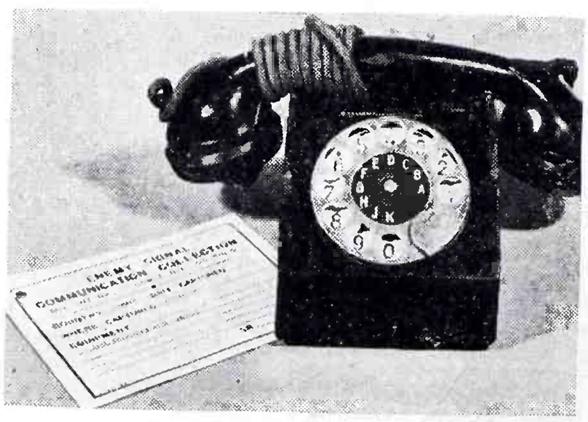
* H. W. St. Clair, *Rev. Sci. Inst.*, 12, May, 1941; ELECTRONICS, p. 79, Sept., 1941.

JAPANESE FIELD TELEPHONE



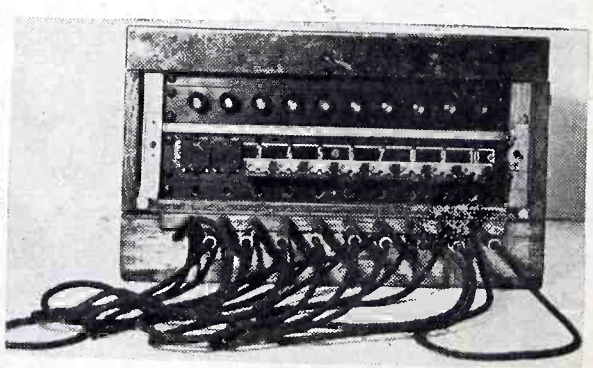
This captured Japanese field telephone equipment, when photographed in Australia, appeared to be in excellent condition

GERMAN TELEPHONE SWITCH BOX



German dial type field telephone switch box for two lines, complete with hand set

GERMAN FIELD TELEPHONE EQUIPMENT



Photograph shows a ten-line German field telephone central of the cord type, and probably used at Italian Headquarters

Micro Switch Hair Line Accuracy Guides Profilometer to Record Minute Metal Roughness

Even though metals are finished by abrasives, milling, turning and grinding, the surface remains scored with a myriad of tiny irregularities. The Profilometer, built by the Physicists Research Bureau, Ann Arbor, Michigan, measures these surface roughnesses to the ten millionth of an inch.

Micro Switch is the actuating heart of the hand operated Mototrace, here shown testing the surface of a crank shaft. The Switch was selected for its small size, precise action and its ability to function without vibration.

The Micro Switch used here is a specially built, maintained contact, reset spring plunger type that contains a specially formed, rigidly fixed spring under the Micro Switch spring to meet the critical requirements of this application.

The Profilometer application calls for a very small movement for operating release and this operation must not be affected by vibration. No other switch was able to meet these requirements. This equipment permits measurements as low as 0.1 micro inch with ease.

With Micro Switch it is just a matter of naming your requirement. There is a Micro Switch to meet it. The basic Micro Switch requires a space of only 11/16″x 27/32″x 1-15/16″, movement differential is possible down to .0002″, and will operate on a force as low as 1/4 of an ounce. It is listed by Underwriters' Laboratories with ratings of 1200 V. A. loads, from 125 to 600 volts A. C.

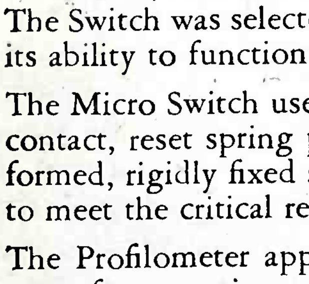
Special housings with a variety of actuators are available on the basic Micro Switch. Some of these are shown on this page. If you have a problem of precision switching, where small sized, rugged, precise switches are required, you should consider Micro Switch.

Micro Switch Corporation, Freeport, Illinois

Branches: 43 E. Ohio St., Chicago (11) • 11 Park Place, New York City (7)
Sales and Engineering Offices: Boston • Hartford • Los Angeles

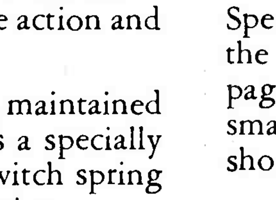
The trademark MICRO SWITCH is our property and identifies switches made by Micro Switch Corporation

How and For What Micro Switches Are Used:

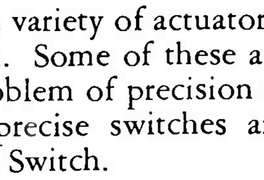


SEND FOR THESE CATALOGS:

The two catalogs illustrated here will give you the complete details—Number 60 which covers Micro Switches in general—Number 70 which deals with specified switches for aircraft.

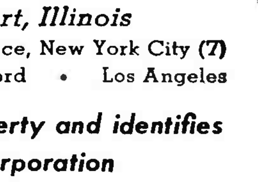


This illustration shows the Micro Switch with a spring leaf actuator serving as a break indicator as used in textile mills or paper mills.



This illustration shows the use of two Micro Switches with spring type plungers to insure safe positioning of material in a punch press or a similar tool.

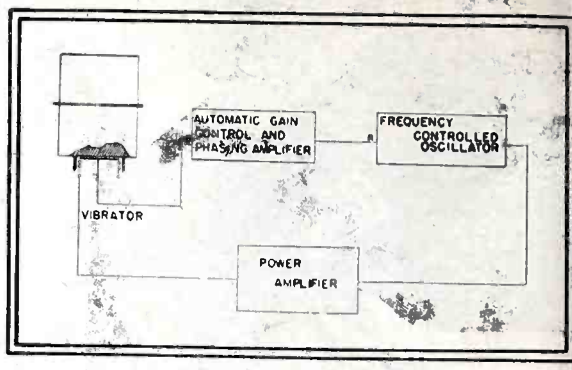
This shows an explosion proof Micro Switch used with a spray gun which automatically cuts out the entire operation of the spraying booth when the gun is shut off.



This illustration shows a Micro Switch with a pushbutton actuator used as a safety switch in a high tension cabinet door. It is a normally open switch in which the circuit is opened as the door is opened.

MICRO SWITCH

Made Only By Micro Switch Corporation . . . Freeport, Illinois



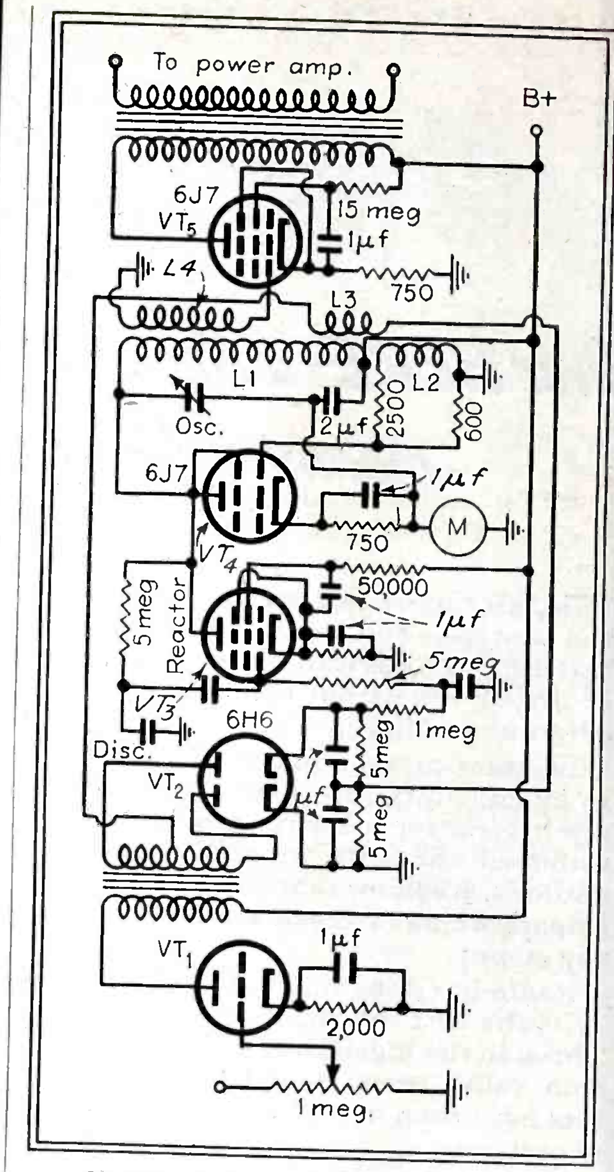
Block diagram of the complete system for generating high-frequency sound. The power amplifier supplies about 200 watts to actuate the vibrator bar

With the driving system shown in the block diagram, the power from the oscillator is always available for driving the vibrating bar and, in most cases, the pickup capacity changes are sufficient to provide automatic control over the oscillator frequency. With heavy acoustical loading the vibrating bar can still be driven and supply acoustical power. In addition, the power available for driving the vibrator has an initial value equal to the maximum output of the power amplifier, and the vibrator motion will build up to maximum in the least possible time.

Components of Frequency Control Circuit

These conditions are provided by the oscillator control circuit shown in the diagram. It consists of oscillator VT_4, voltage amplifiers VT_1, VT_5, discriminator tube VT_2, and reactor tube VT_3. The oscillator consists of tube VT_4 and coils L_1 and L_2, connected in a conventional tuned plate oscillator whose amplitude of output is controlled by the resistors connected to coil L_2. Amplifier tube VT_5 isolates the oscillator from its load and, for this purpose, coupling coil L_4 is electrostatically shielded from L_1 and L_2. Tube VT_3 is the reactor tube which, along with coil L_1 and the tuning capacitor, determines the frequency of the oscillator. The control grid of this tube receives its bias from the direct voltage produced across the diode load resistors in the discriminator circuit. Tube VT_1 amplifies the input voltage developed by a preceding amplifier.

The preamplifier converts the capacitance changes of the pickup into a voltage that, when amplified, furnishes the voltage for the discriminator. The actual motion of the vibrator bar and the resulting capacitance changes in the pickup depend



Circuit of the controlled oscillator that generates the proper frequency

upon the acoustical load on the vibrating bar and var considerably. The amplifier must supply a constant output voltage to the discriminator even though the voltage from the capacitance pickup varies from 5 to 200 millivolts. This is accomplished by incorporating an automatic gain control circuit in the preamplifier. A phase shifting network is also included so that the phase of the output voltage can be changed relative to the input voltage by substantially 360 deg. to have the proper phase relation in the discriminator circuit.

It was found that the reactor tube operated more effectively when the peak oscillator voltage was less than the direct voltage on the reactor tube plate. Using a pentode 6J7 tube, peak alternating voltage could equal the plate potential, but with tetrodes the peak voltage could not exceed half the plate voltage. In the final oscillator circuit a 6J7 was used, as shown in the diagram, because the output voltage could be readily controlled by the resistors connected to coil L_2. These were adjusted so that the peak voltage from the oscillator was about 0.9 of the direct plate potential applied to the reactor tube.

Designed and Engineered for

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PROPER DEFLECTION
PRECISE LOAD RATINGS
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Shear Type
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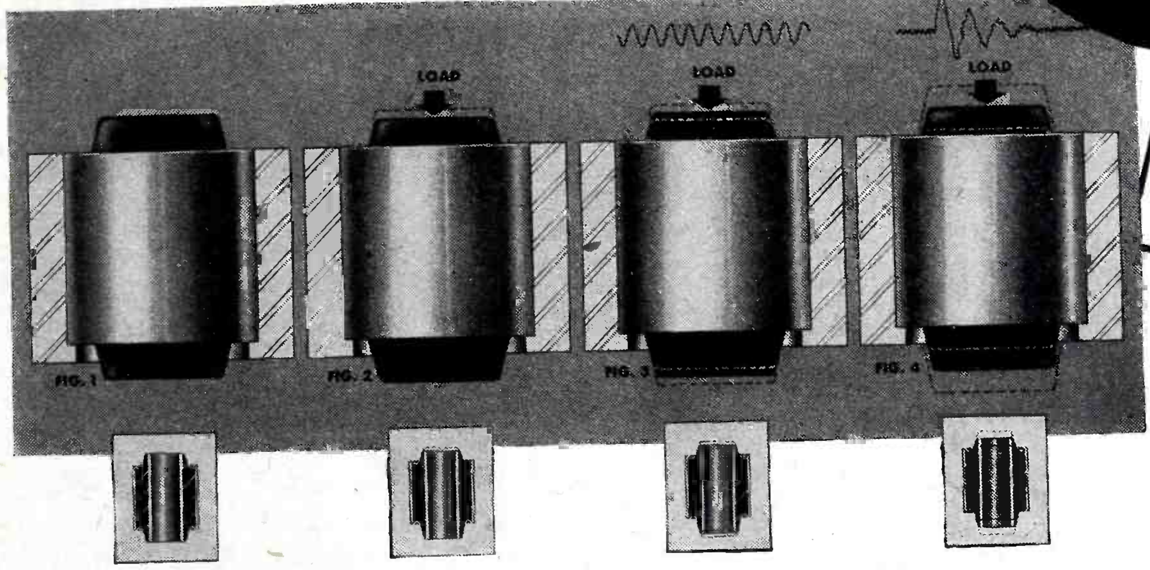

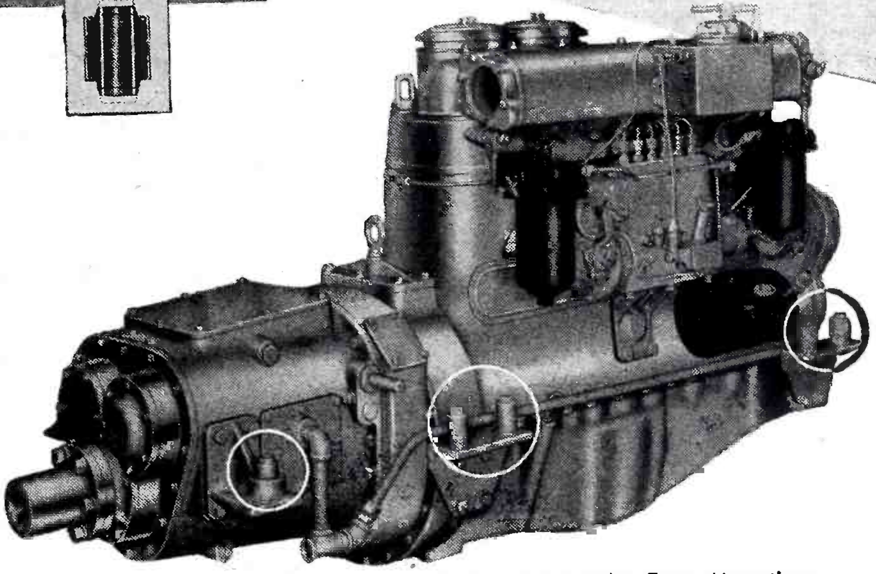

Kermath Marine Engine suspended on Lord Tube Form Mountings

OPERATION OF TUBE FORM MOUNTINGS

ALL Lord Mountings are designed to operate on the principle of having the rubber "stressed in shear" when load is applied in the direction of the main axis of the mounting. This design provides the required softness and deflection in the direction of the disturbing forces, and stability or resistance to movement in directions normal to the major thrusts.

Every Lord Mounting is designed to have a definite static deflection under its rated load. Load ratings for standard tube form mountings range from a few pounds to 1450 pounds, with rated deflections ranging from .065 inches to .123 inches when load is imposed.

Illustrations above show a Lord Tube Form Mounting in the various positions it assumes while static or in action.

Fig. 1—Under no load (as produced). Note position of center sleeve.

Fig. 2—Under rated load; note deflection of center sleeve.

Fig. 3—Operating in the zone of free shear action under normal vibration.

Fig. 4—Operating momentarily under sudden shock load or in zone of resonance.

Load ratings of Tube Form Mountings may be changed by:

1—Utilizing rubber compounds of varying degrees of stiffness.

2—Increasing length and/or cross-section of rubber element and metal parts.

3—Increasing or decreasing diameter of center metal sleeve.

These design features, plus the unified control of manufacture from raw material to finished product, account for the remarkable efficiency and dependability of Lord Mountings.

Lord Tube Form Mountings are sturdy, compact, light weight units, and are designed to cover a wide range of applications in every field of industry. They are made in various styles and many sizes with flanged or straight outer metal members, and with snubbing or non-snubbing features.

Through proper mounting selection, isolation efficiencies ranging from 75% to 85% reduction of disturbing forces may be expected, although reductions up to 97% are not unusual on equipment operating at very high frequency.

For complete information on Lord Mountings write for bulletins 103 and 104 or call in a Lord vibration engineer for consultation on your design problems. There is no obligation.

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Originators of Shear Type Bonded Rubber Mountings

Plexiglas Rule for Alignment Charts

By GIFFORD M. MAST
Special Training Devices Section
The Jam Handy Organization
Detroit, Mich.

THE ACCOMPANYING ILLUSTRATIONS show two types of special rules designed to simplify and speed calculations with alignment charts or nomograms. The two rules or readers in the photographs were designed for use in the complex calculations called for by a project under way at Jam Handy.

The reader is made from $\frac{3}{32}$ inch Plexiglas and in its simplest form has a single transparent pivot with cross hairs as shown in Fig. 1. It may also have a sliding pivot as does the reader shown in Fig. 2.

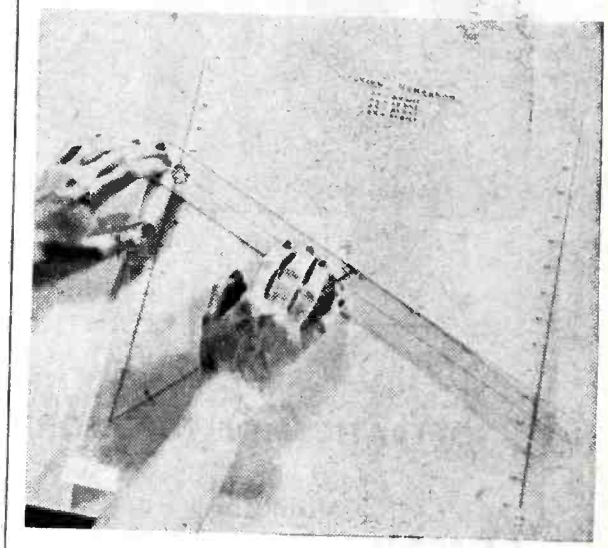
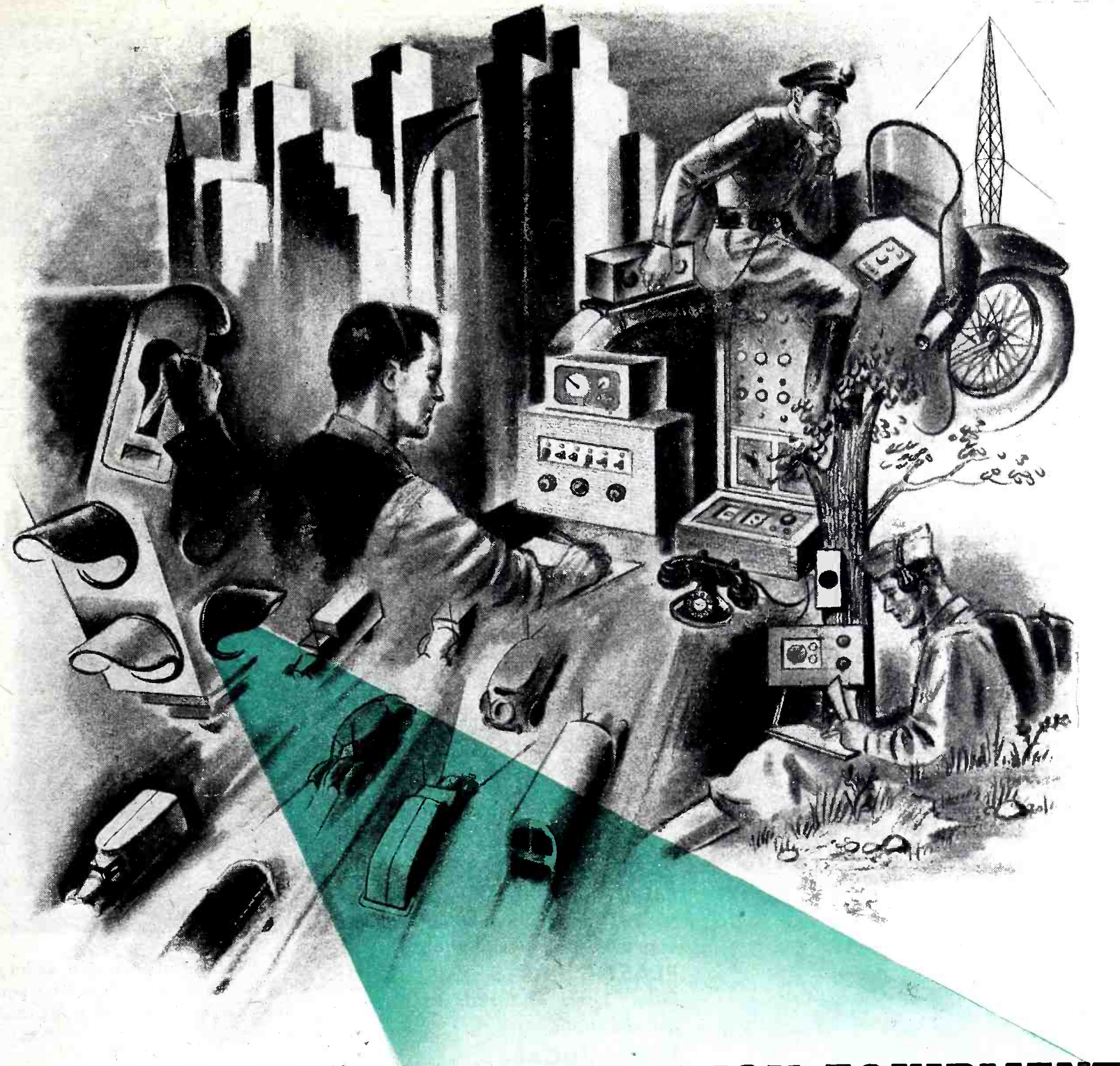


Fig. 1—A Plexiglas rule having a single transparent pivot with cross hairs speeds up reading of alignment charts

The simplest and most common nomogram is a three-scale chart, solving an equation in three variables, the values of any one of which may be read from it if the other two are known.

The usual method of reading such a monogram is to place a ruler against the known value of the first variable, rotate it until it crosses the known value of the second variable, and read the desired answer where the ruler crosses the third scale. In lining up the ruler with the second scale setting, however, it generally becomes displaced from the first one, so that several adjustments have to be made before an accurate reading can be taken.

For use with this type of chart, a reader having only one pivot is used, as shown in Fig. 1. The cross hairs of the pivot are set on the known value of the first variable



"WIN-THE-WAR" COMMUNICATION EQUIPMENT

has the green light

This company, like many others in the electronic industry, is busy twenty-four hours a day, seven days a week making war products—more and more, better and better to help win the war quickly. We are too busy to worry about post-war products just yet. We realize the great, important role radio and other electronics will play in the modernization of communication systems postwar.

Out of the laboratories of war will come electronic improvements applicable to every American home, in every city in 194V. But plans for the modernization of your city of tomorrow must wait until the war is won today.

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BACK THE ATTACK! BUY *MORE* WAR BONDS!

and a finger placed firmly on the pivot. The rule may then be rotated freely until its index line lies on the known value of the second variable without any chance of the rule becoming displaced from its first setting. The answer is then read where the index line crosses the third scale.

The transparent pivot makes it possible to accurately locate the first setting and maintain it while making the second. The index line permits more accurate reading and interpolation than does a ruler, because there is no obstacle to vision. Parallax is eliminated by having the index line etched on the lower surface of the Plexiglas rule.

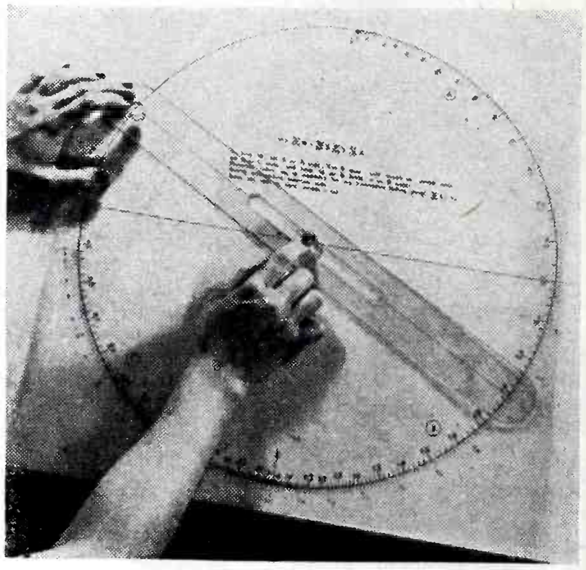

Fig. 2—A fixed pivot and a sliding pivot on the reader permit settings for equations having several known variables, and eliminate the need for pencil marks on the chart

Equations wiith more than two known variables require for their solutions the use of multiple nomograms, necessitating several settings of the rule and often the marking of a point on a blank scale. Such a nomogram is being used in Fig. 2. The old method of using such a nomogram is to set the rule on the first two known values, make a mark on the center scale, and then swing the rule to align it with this mark and the third known value. The desired answer is then read where the rule crosses the fifth scale. Usually the blank scale is soon cluttered with marks.

This nomogram reader with both fixed pivot and sliding pivot does away with most of the usual difficulties. The fixed pivot is used in the manner described before, but instead of marking the blank scale, the sliding pivot is placed on it and held there while the rule is rotated

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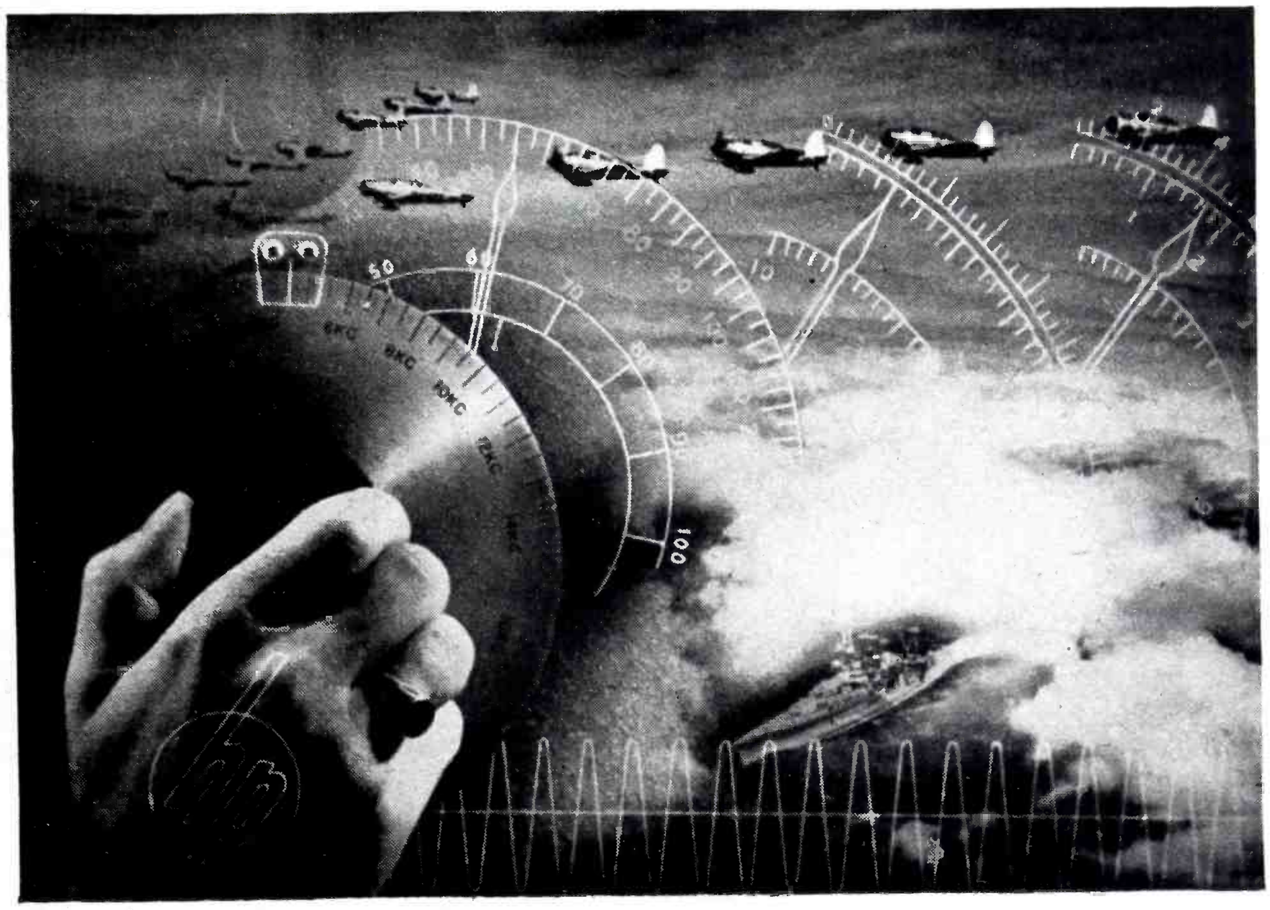

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to the third known value. The desired answer may then be read where the index line crosses the scale of the unknown.

The charts illustrated are made of Plasticele instead of graph paper and may be of interest to designers and users of nomograms. Plasticele is undistorted by humidity, withstands hard usage, and does not mark or soil easily. If soiled it can be cleaned with a moist cloth. The scales are inked on the reverse side to prevent abrasion. To facilitate plotting the scales in pencil and inking them, sheets with one frosted side are used.

• • •

Line Voltage in Middle West and South

By Charles H. Humes, *Sales Engineer*
Sola Electric Company

The extent of voltage variation to be expected on commercial and industrial supply lines is not generally appreciated by design engineers. As a consequence, the all-important factor of line voltage stability is frequently overlooked in the design and manufacture of electrically operated devices.

This oversight probably derives from the fact that much of the electronic equipment made in the past did not require close voltage control. Changes in operation which resulted from changes in supply voltage were of little significance in relation to over-all performance. A home radio receiver would still deliver music, whether the line voltage was 105 volts or 125 volts. In one case you just cranked up the gain, and in the other you simply replaced tubes and capacitors more frequently.

With the advance of the electronic art, however, has come a new concept of performance in electrical equipment. Electronic devices are now being required to perform actual miracles of precision—miracles which become possible only when the components and the individual functions of the device can be controlled to perfection. The greater the precision demanded, the closer the control required. It is at this point that attention to the regulation of supply voltages becomes mandatory, and a knowledge of what line voltage variations actually exist should be of

assistance to every engineer who is designing electronic equipment.

Field Check

A few months ago engineers of the Sola Electric Company, in conjunction with the Army Air Force, undertook a survey of line voltage variations existing at installations throughout the middle west and south. The purpose of this survey was to determine whether or not it would be necessary or advisable to incorporate an automatic voltage-regulating transformer in an electrically operated unit being used by the Army Air Forces. The nature of the equipment was such that precision operation was a prime requisite, with protection of its components as a secondary consideration. Safe operative voltage limits were established by the manufacturer at 110 to 120 volts—110 volts as the minimum value for precision performance, 120 volts as the maximum for safety to the components.

To carry out the survey, 18 installations were selected, more or less at random, from approximately 150 available in the middle west and south. At each installation a recording voltmeter was installed at the site of the equipment without disturbing or altering normal operations, and allowed to record the operating line voltage over a period of at least several hours. The meter employed was an Esterline Angus Recording Meter, and was calibrated at each test against a laboratory standard.

Results of the survey were rather startling. At 16 of the 18 locations examined, line voltage extended beyond one or both limits over appre-

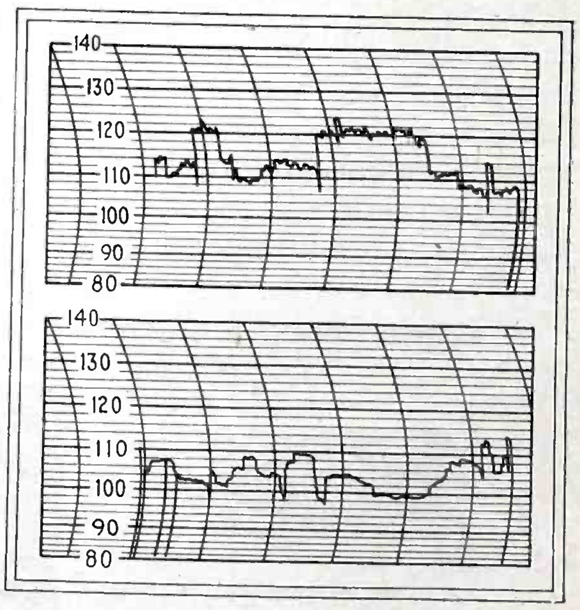

Fig. 1—Voltage variation curves considered as indicating average conditions

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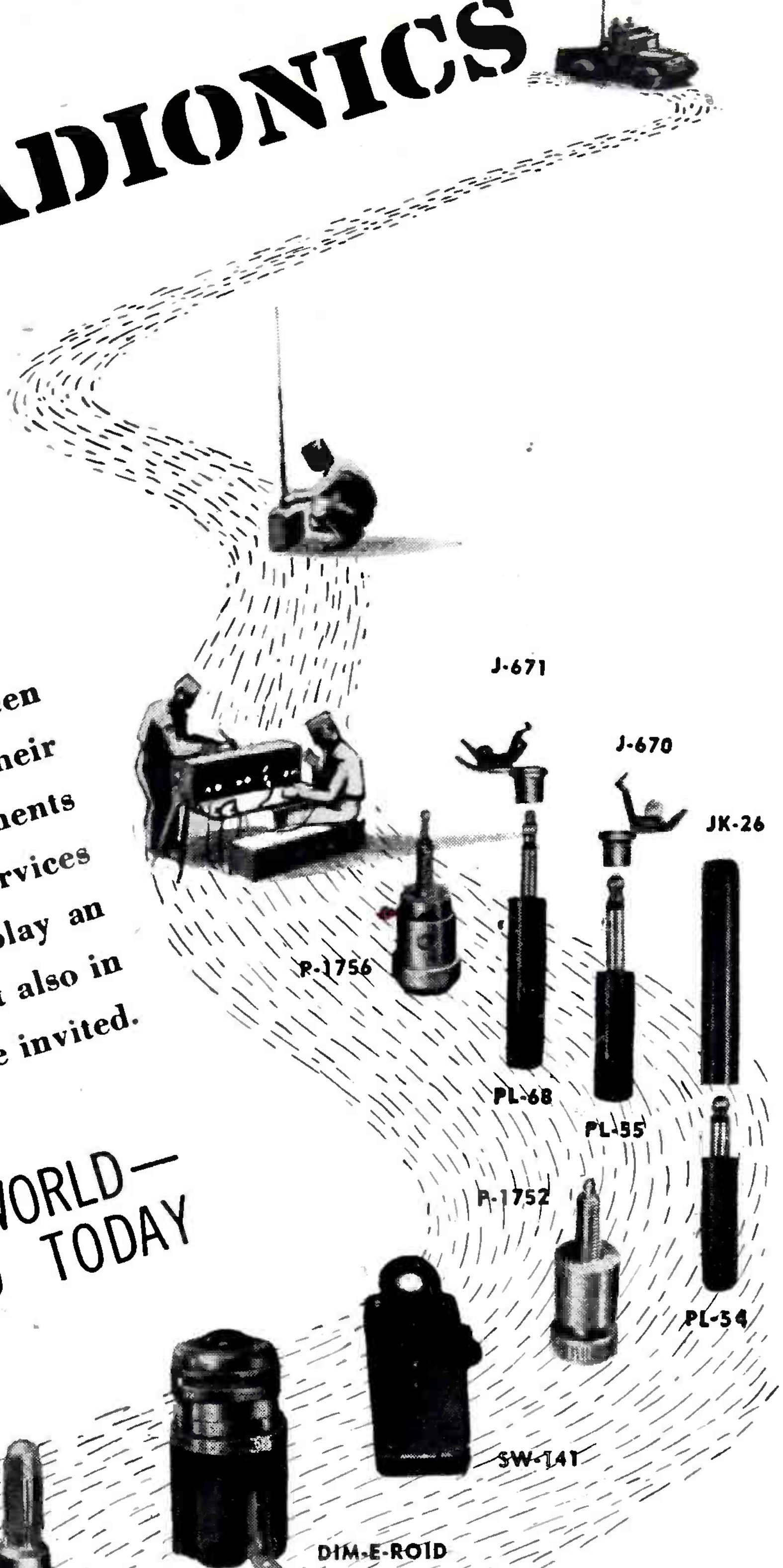

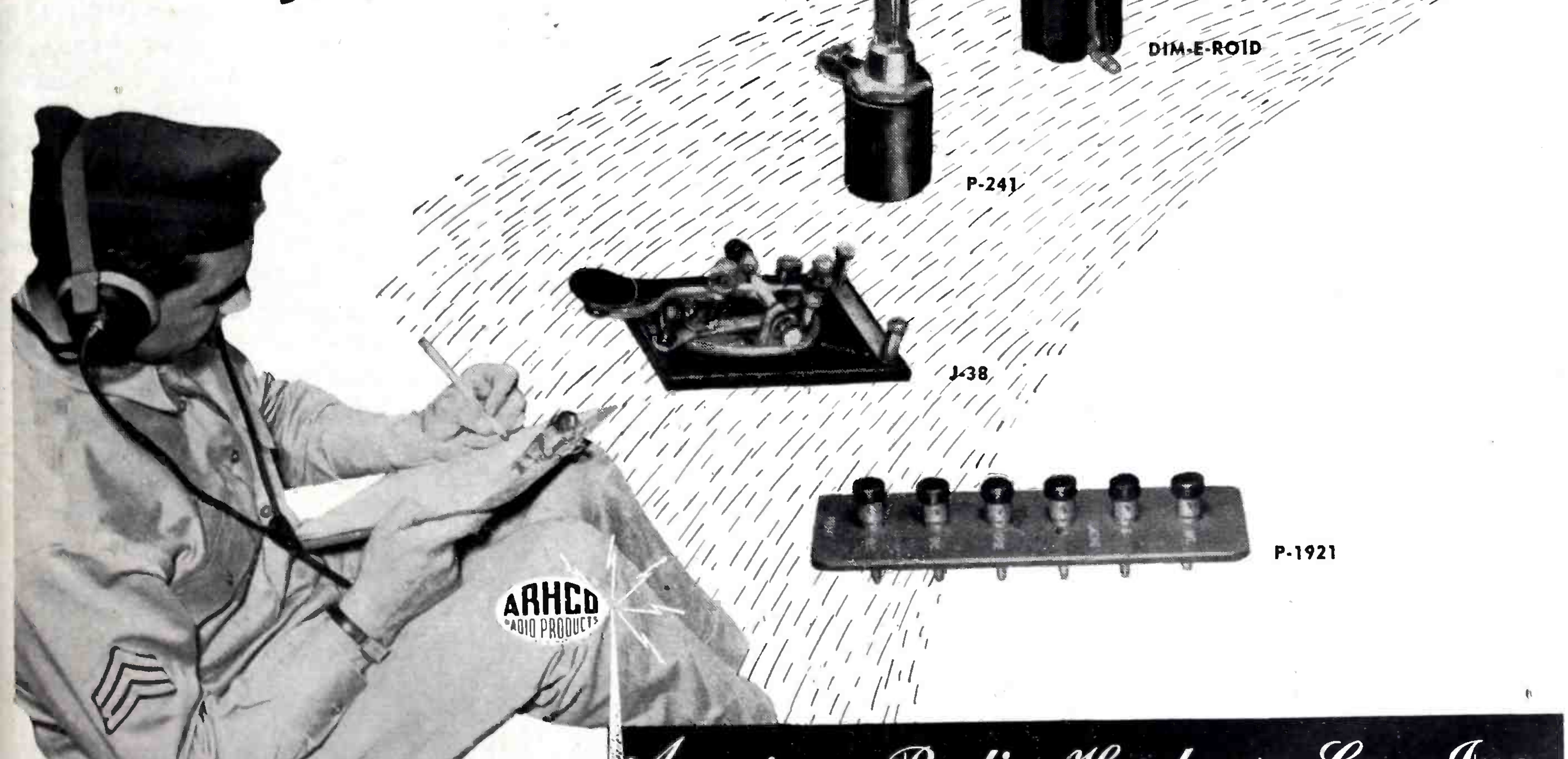

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MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT ciable periods of time. In some cases, the line voltage remained fairly stable during the test period, but was above or below the specification limits. In other cases, the voltage actually varied far beyond either one or even both limits.

Graphical Data

The tracings shown in Fig. 1 are representative of average conditions encountered. Conditions that are considered to be extreme, although by no means unusual, are shown in Fig. 2.

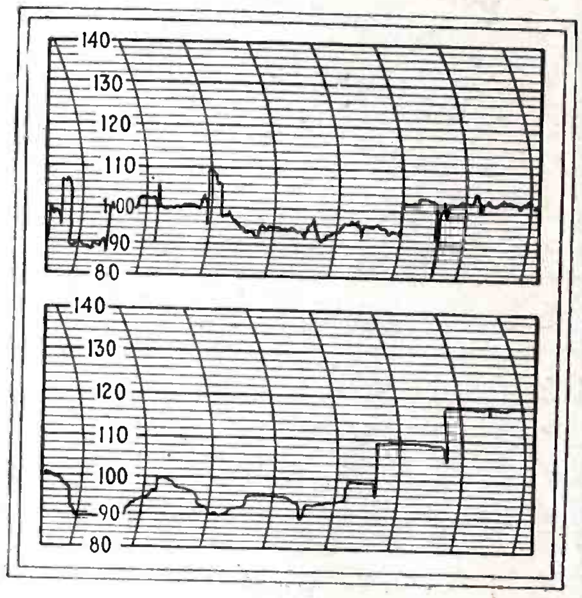

Fig. 2—Curves of extreme variations of line voltage often encountered

A particularly interesting condition is exhibited in the tracing of Fig. 3, which illustrates vividly the danger of basing estimates of voltage variation on the results of short-time or periodic voltage readings. The voltage at this location would remain relatively stable for extended periods after which violent and rapid fluctuations would occur. The extent of these fluctuations was undoubtedly greater than is indicated by the tracing, for the rapidity of their occurrence was such that the damping of the meter pen became a limiting factor. Furthermore, the effect of these fluctuations upon the

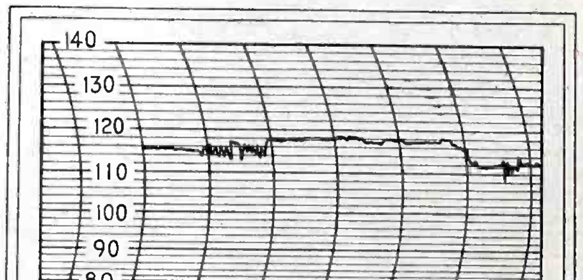

Fig. 3—In one location the voltage remained stable for long periods between intervals of rapid fluctuations

When will war production End?

Excerpt from "A Special Report on America's Industrial Future" by The Research Institute of America.

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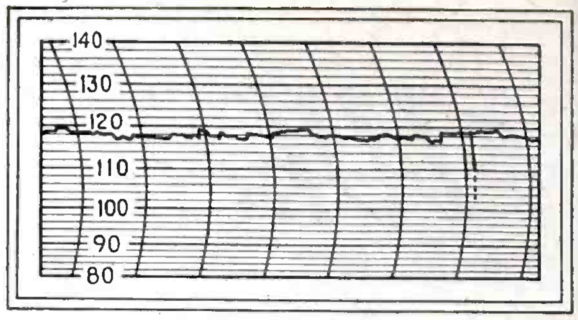


Fig. 4—Voltage on a special line from a distribution transformer with no other load varied only a few volts

equipment under observation was pronounced.

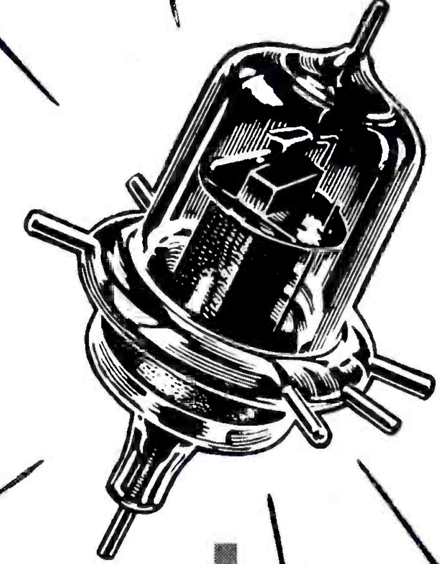
Typical of the best conditions encountered in the survey is the tracing shown in Fig. 4. Voltage at this location varied only six volts during the complete test period. However, it is interesting to note that in this particular case the equipment under test was supplied by a special line from a distribution transformer which carried no load other than that of the equipment itself.

Moral

The upshot of this particular survey was, of course, a decision to build into the equipment a voltage-regulating transformer that would eliminate all possibility of damage or faulty operation resulting from line voltage variations. In this particular case, since the equipment is used abroad as well as domestically, a constant-voltage transformer was selected which could be connected for operation on either 50 or 60 cycle supply, and on lines rated at 115, 208, 230 or 250 volts. A simple solution to an otherwise troublesome problem.

It seems to us that there is a lesson for every electronic engineer to be found in the survey reported here—the lesson that line voltage can no longer be considered as a single, stable reference point for design considerations; that "Line Voltage 115 Volts" may mean anything between 95 and 125 volts, and that the devices being designed now, as well as those being designed for the future, must take those facts into onsideration. It is no longer enough to design equipment for operation on a specific supply voltage. That voltage must be built into the equipment. Without it there is trouble ahead.

this is electronics



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Longitudinal Quartz Vibrations

THE PROPERTIES of longitudinally oscillating quartz plates and bars, with particular reference to their application as oscillators and resonators, are reported by R. Bechmann in *Hochf:tech. u. Elek:akus.* for January, 1943, abstracted in *Wireless Engineer* for August, 1943. The report contains six sections and describes measured results obtained by methods improved over those previously used by the author.

Investigations on the longitudinal vibrations of quartz plates and bars go back to the early days of the piezoelectric resonator. The properties of thin longitudinally-vibrating plates are determined by two dimensions, so that the diversity of the phenomena is considerably greater than with the transverse vibrations, whose properties depend to a great extent on one dimension only, the influence of the two other dimensions being only allowed for as a correction. The region of applicability of longitudinally-vibrating plates and bars can be put at 50 to 300 kc, though actually these vibrations can be used up to 400 kc and over. The limits are flexible and depend on the properties demanded.

Frequency Law

The report begins with the consideration of bars and plates of the $X_{90°},\psi$ cut. A simple way of orienting the bar is provided, which is of practical use particularly when the material lacks the natural faces r and r'. The numerical data given were derived from bars and plates sputtered with a thin film of silver. Thin bars are first considered: for longitudinal oscillations they have the frequency formula $N = vl = \frac{1}{2}\sqrt{1/\rho s'_{22}}$ where N is the oscillation coefficient, v the natural frequency, l the bar length, ρ the density of the material, and s'_{22} the elasticity modulus for the axis in the ψ direction.

For plates or wider bars the frequency law has to be extended; it keeps its form, but s'_{22} is replaced by an elasticity coefficient (derived from more general considerations) which for thin rectangular plates is calculated as the root of a cubic equation representing the interaction of the two longitudinal vibrations and the shear vibration. Also as Mason found, a coupling between this lat-

ter vibration and the second harmonic of the flexural vibration occurs, through which the longitudinal natural oscillation is disturbed within a small range of the ratio breadth/length. The remainder of section I deals with the temperature coefficients and equivalent inductance of these plates or wide bars.

Square and Circular Plates

Section II considers, on similar lines, plates of Yδ, ψ cut, particularly square plates where ψ is 0° and 45°, and circular plates Yδ, for all three of which the frequency law is given. The specially important cases where $\delta = 38°$ and 128° (or 127°: "DT cut" and "CT cut," in the square version) are given particular attention. As in section I, the equivalent inductance, resistance and damping are considered for the three types of plate. Particularly with square plates with $\psi = 0$ and with round plates, harmonic vibrations occur whose oscillation coefficients N plotted as a function of ψ show a course similar to that of the fundamental oscillations. For special orientations these harmonics also show small temperature coefficients of frequency.

Section III deals with the rectangular plate of $Y_{141^\circ\,30',\,45^\circ}$ cut, which for an edge ratio of 0.863 has a frequency independent of temperature over a wide range (Mason's "GT" cut). Section IV deals with the circular plate Xδ, which around $\delta =$ 40° and 50° had been found to have small temperature coefficients. The new, more accurate measurements show that for $N = 2495$ kc/mm the temperature coefficient becomes vanishing small at $\delta = 41°$, and at $\delta =$ 49° in the case where $N = 3315$ kc/mm. Square plates $X_{\delta,\,0^\circ}$ also show null-points. Both these plates have other oscillations, easily excited, close at hand, and are therefore of little practical importance.

Effect of Silver Film on Crystal

Section V discusses the holders for longitudinally vibrating plates and bars, and the effect of the silver layers, as employed by Telefunken, on the electrical properties of the crystal. The values given in the earlier sections were obtained with thin sputtered films; sintered-on films lowered the frequency by an amount roughly proportional to the ratio of the layer thickness to the plate thickness. In some cases the

change in frequency amounted to 4 percent. The temperature coefficient also was affected; with plates having a parabolic frequency/temperature curve the effect of the film was to displace the vertex towards lower temperatures by an amount depending on the crystal cut and on the ratio layer-thickness/plate-thickness. This influence on the temperature co-efficient is discussed in detail.

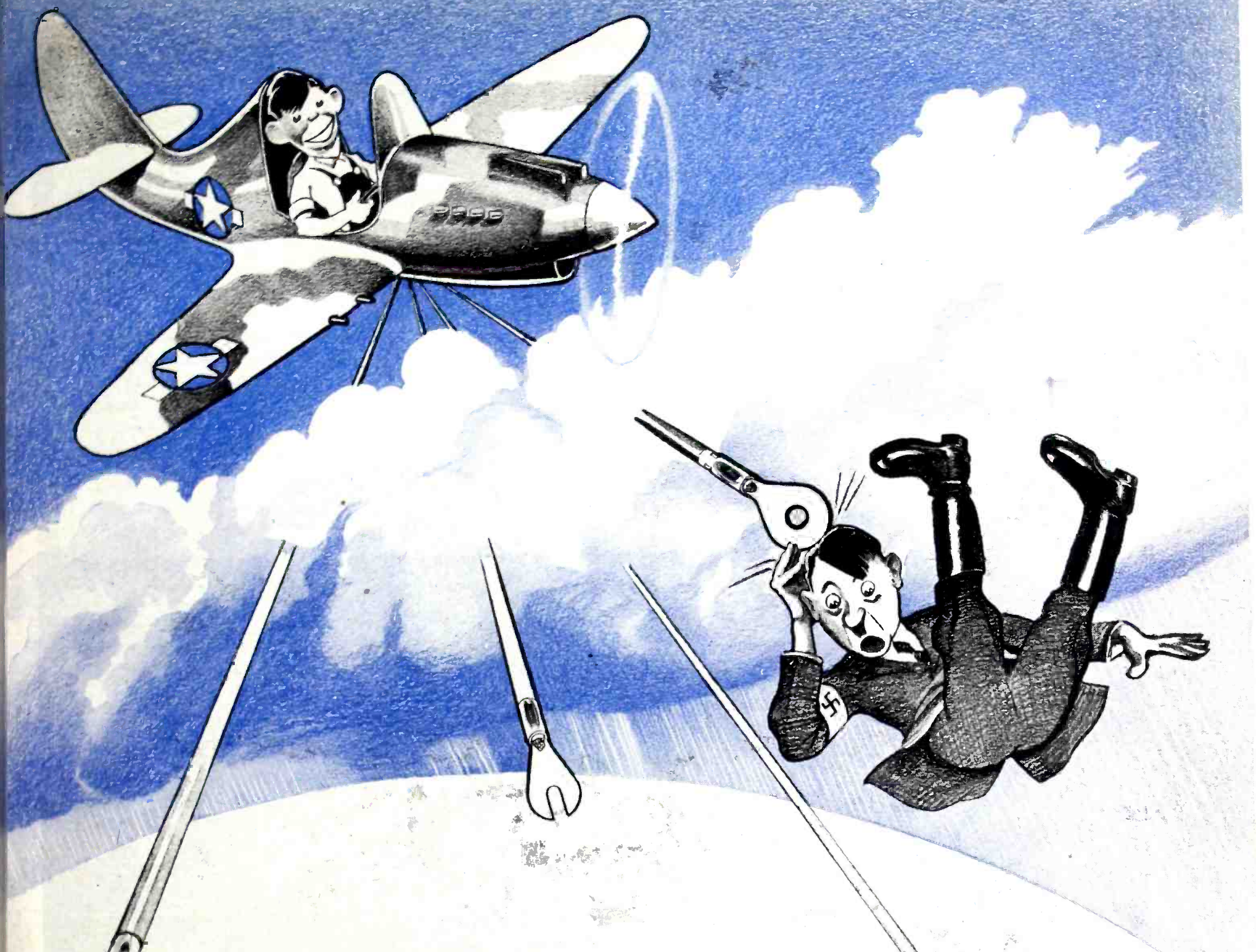
The films also have an effect in raising the inductance of the plates and bars, by an amount which may reach 10 percent. Freshly silvered and mounted plates are subject to initial changes in their properties, which decrease with time to a limiting value. By repeated tempering the changes are hastened to a stationary state. This phenomenon depends on various factors, most of all on the method of depositing the film. In some cases frequency rises occur of up to 5×10^{-5}, and resistance and damping decreases up to 40 percent.

The oscillators and resonators made on the above lines can attain a calibration accuracy of 1 to 2×10^{-6}. The damping in air amounts to 2 to 5×10^{-6}, a value about ten times greater than the best obtained with transverse oscillations. In a vacuum the damping may be reduced to 0.8 to 1×10^{-6}. These figures are found to vary little with the cut and mode of vibration. The longitudinally-oscillating crystals are free from the troubles, so common with the transversely-oscillating types, of multiplicity of oscillations near the working resonance points, and the formation of multiple resonances; this point is discussed at the end of section V. Section VI deals with the piezoelectric coefficients already used in calculating the inductances.

• • •

Fields of Air Core Coils and Applications to HF Heating

GENERAL VECTOR METHODS of determining the magnetic induction field of a helix, a simple circular coil, and two types of spiral coils are outlined in an article by C. B. Kirkpatrick in the *A.W.A. Technical Review*, Vol. 5, No. 6 (Australian). It is shown that the formula for the axial field of a solenoid is correct for any helical coil, however loosely wound. An optimum value is derived for that radius of a helical coil which



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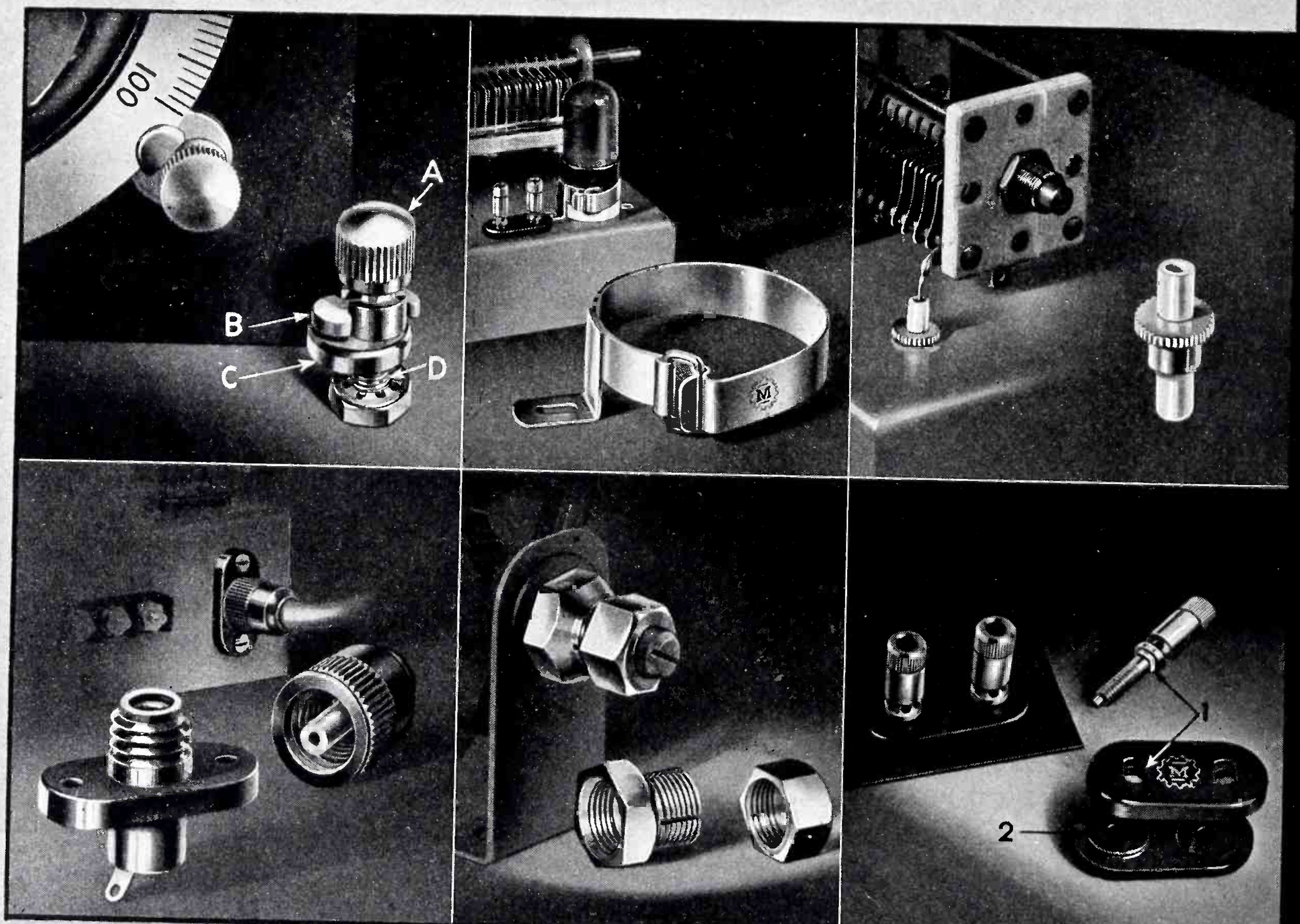

Illustrated above, left to right, top row: No. 11050 dial lock, single hole mounting, captive head; No. 33087 tube base clamp available in sizes to fit all tubes; No. 32150 Isolantite thrubushing with die cast shoulder; Bottom row: No. 37001 high voltage safety terminal and bushing. High pressure large area contact surface. L. F. and R. F. types: No. 10061 shaft lock. Converts volume controls, variable condensers, etc. from "ordinary" to "locking" types. Used in place of regular mounting nut. No. 37202 plates and No. 37222 posts, Non-turning body with captive head. Plates in steatite, and yellow and black bakelite.

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gives a maximum field at a given distance along the axis of the coil.

In the second part of the paper the design of high-frequency induction heater coils used in vacuum tube manufacture for degassing metal components and for flashing the getter during the exhaust process is discussed. The induction field is the main factor to be considered in the design of such coils.

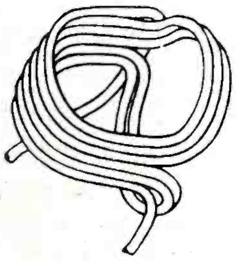

Diagram of a bonnet coil for heating vacuum tube plates

One of a number of specially shaped coils designed to meet the needs of modern tube manufacture is shown in the illustration. This coil, called a bonnet coil by the author, is used for heating flat components such as tube plates. It provides a magnetic field at right angles to the plane of the plate. Other coils use for this purpose are the helical, spiral, oval and elliptical types.

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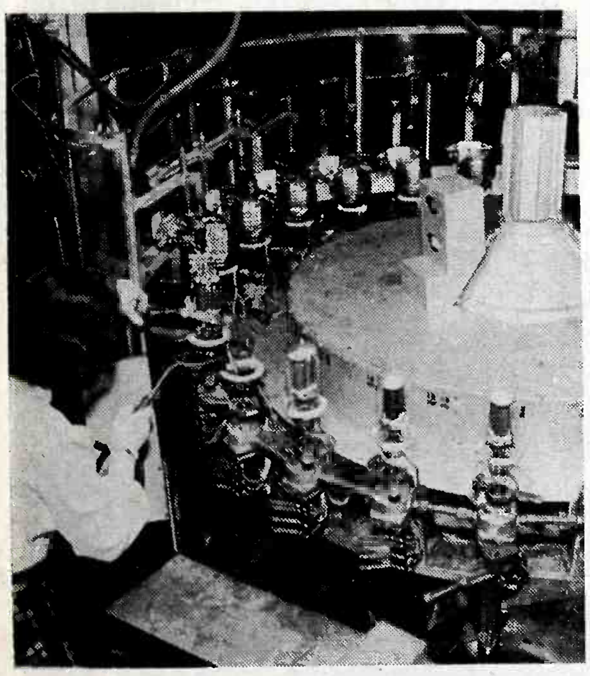
TRANSMITTING TUBE ON PRODUCTION



The exhaust machine shown here is capable of evacuating two dozen transmitting tubes as they progress around the circle. The tubes are heated to a temperature of 1,000 deg. at ten different positions on the sealex machine by means of high frequency induction coils which may be seen surrounding many of the tubes. The operator is shown placing one tube in position for its journey on this merry-go-round

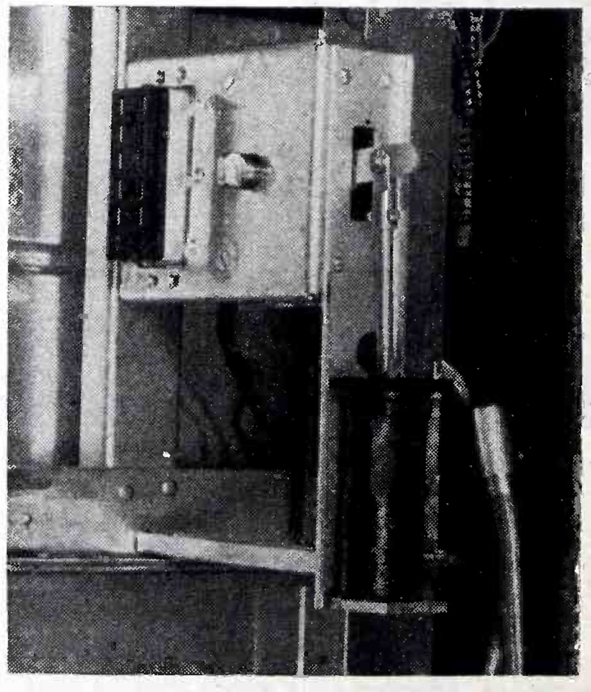
Aircraft Radio

(Continued from page 101)

meter deflection was secured. The receiver in this case was more than usually selective and was, therefore, difficult to tune properly, hence the initial need for a meter. However, this combination of high selectivity and a tuning meter resulted in the following functional irregularity when the receiver was tuned to a simultaneous range station: The tuning meter indicated resonance with the center tower of the simultaneous range station, which is desirable and satisfactory when the receiver is being used as a radio compass. However, when aural reception of range signals was desired, it was found necessary to detune the receiver approximately 1 kc from the resonant position indicated by the tuning meter to receive satisfactory aural signals.

The foregoing example illustrates how the design engineer, in attempting to correct one phase of an operational difficulty, may unknowingly introduce errors in a second functional application of a unit of aircraft radio equipment.

In the design of multi-function equipment such as automatic direction finders that use motors, relays or other controls operated from the primary power source, consideration should be given to locating the fuses, relays, etc. in the circuits in such manner that failure of a fuse or relay will still allow the unit to operate in its most simple function. For



Remote solenoid control box for actuating the frequency-shifting mechanism of an aircraft radio receiver

example, in an automatic direction finder using an alternator to supply power for operation of synchro indicating instruments, good engineering practice requires that such alternator be separately fused in order that its failure shall not disable the entire receiver.

Accessibility for Inspection

Aircraft radio equipment customarily receives routine inspection and servicing after each period of a certain number of hours of service. Therefore, all parts should be easily accessible for inspection both visually and with instruments, and all parts should be easily replaceable.

All units of equipment should be designed to afford the maximum protection to maintenance and operating personnel. The design of all equipment should be such as to preclude the possibility of operating personnel receiving an electrical shock or burn.

Civil Air Regulations

The above covers the major considerations in aircraft radio equipment design. It is well to note, however, that before a unit of aircraft radio equipment can be used in commercial airline service it must undergo a rigid routine of specific tests conducted by the Civil Aeronautics Authority, in accordance with the terms of Part 16 of the Civil Air Regulations for type certification of air carrier aircraft radio equipment. These specifications apply to all items of important radio equipment that may be required by the Civil Air Regulations to be installed aboard certificated aircraft engaged in scheduled air carrier operations. If these tests are passed, the unit is awarded a Civil Aeronautics Authority Approved Type Certificate.

OUTDOOR telephone booths are being used in war housing developments when equipment is not available for residential installations. Coin boxes are placed on front porches of homes or sometimes in booths set right on side lawns. In Detroit there are 85 such booths in service, with collections indicating about 20 outward calls per box per day.

NEWS OF THE INDUSTRY

WPB reorganization; Radio Technical Planning Board; new tubes; revised IRE Fall program; station frequency changes; London news letter; VHF bibliography; dry batteries for WERS; science talent search; OWI review

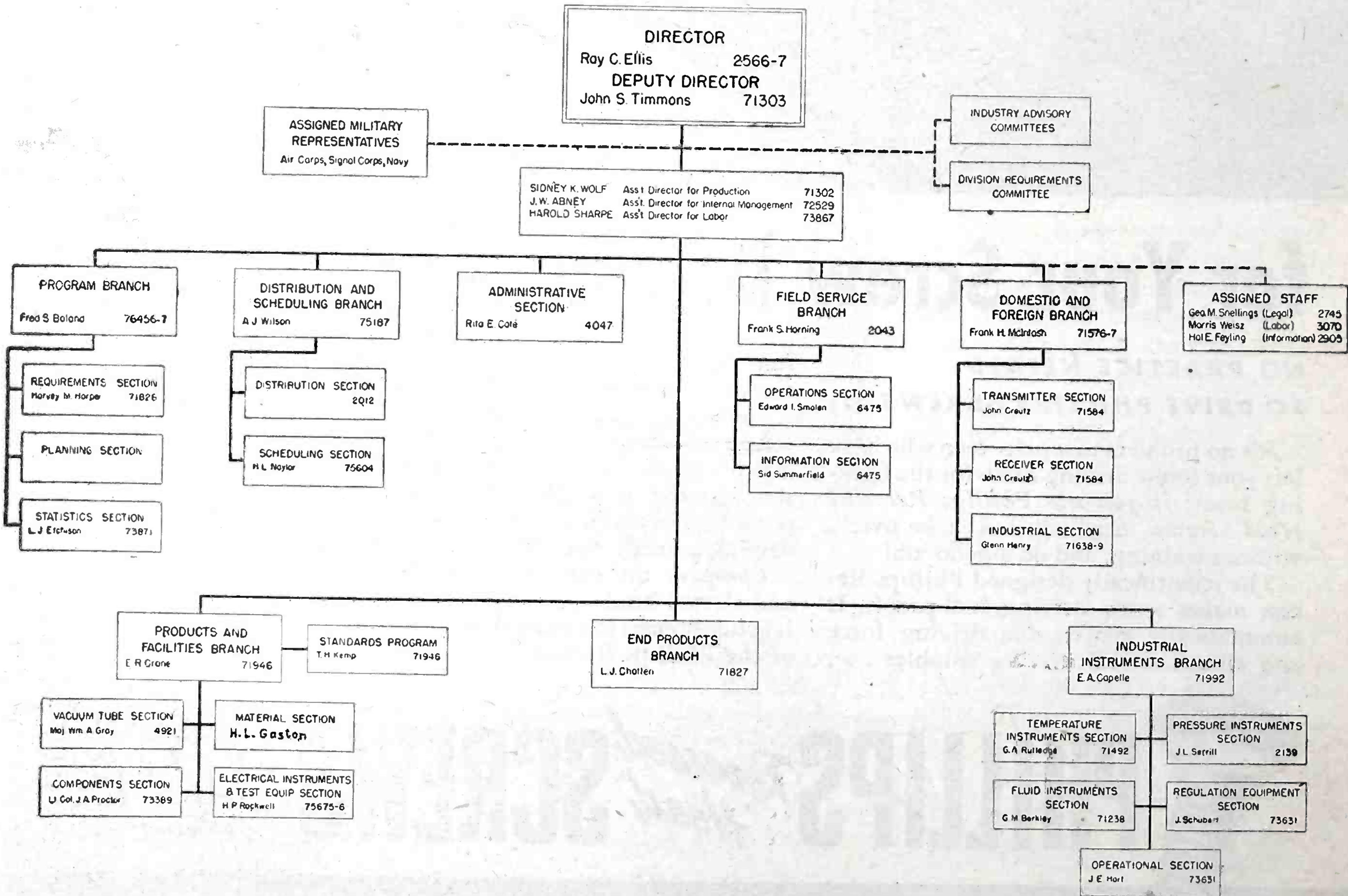
WPB Reorganization of Radio and Radar Division

REORGANIZATION of WPB's Radio and Radar Division has been completed so that the spheres of activity of the production and organizational units are more clearly defined. Ray C. Ellis, Director of the Division, with the assistance of Deputy Director John S. Timmons maintains contact with the claimant agencies, the industries and the various offices of WPB, deciding upon major policies. Cooperating with these two men are three recently appointed Assistant Directors.

Sidney K. Wolf, Assistant Director for Production, is in charge of the Products and Facilities, End Products and Industrial Instrument Branches as they relate to facilities, plant capacities, production and materials. These operational branches are responsible for the production of equipment and parts for the Armed Services and for essential civilian needs. Mr. Wolf, who has held several important positions in the Radio and Radar Division, has recently returned from the Aleutians where he was in charge of the Operations Analysis Section attached to the Eleventh Air Force.

Harold Sharpe, Assistant Director for Labor, is responsible for the manpower requirements and labor problems of the industries which report to the Division. He keeps close contact with manpower agencies of the Government and regional manpower representatives. Mr. Sharpe was formerly executive secretary of the (CIO) United Electrical Radio and Machine Workers. His appointment is in line with WPB policy of giving labor more representation and came as a result of direct joint orders of WPB Labor Production Vice Chairman Joseph Keenan and WPB Manpower Requirements Vice Chairman Clinton S. Golden.

Under Mr. Wolf's Production Units is the Products and facilities Branch, headed by Elmer R. Crane. This branch determines and administers plans for the production of components required for electronic equipment. The requirements of the Armed Services and the productive capacity of the components industry are reported in terms of a common denominator, known as prototypes. When the demand for a particular prototype exceeds the available supply, steps must be taken to expand



Organization chart for Radio and Radar Division of War Production Board as of Oct. 1, 1943. Numbers following names are extension numbers of REpublic 7500 (WPB telephone number in Washington, D. C.)

productive capacity or to find a suitable substitute. Inasmuch as this branch is staffed with men from each of the components industries, there is first-hand knowledge available when problems arise. It is further aided, as are the other branches, by Industry Advisory Committees. Interests of the branch extend to many phases of communications equipment. For instance, it is interested in increasing production through quality control simplification, concentration and standardization. The standardization program is carried on jointly by industry subcommittees, the ASA and the Signal Corps Standards Agency at Red Bank, New Jersey.

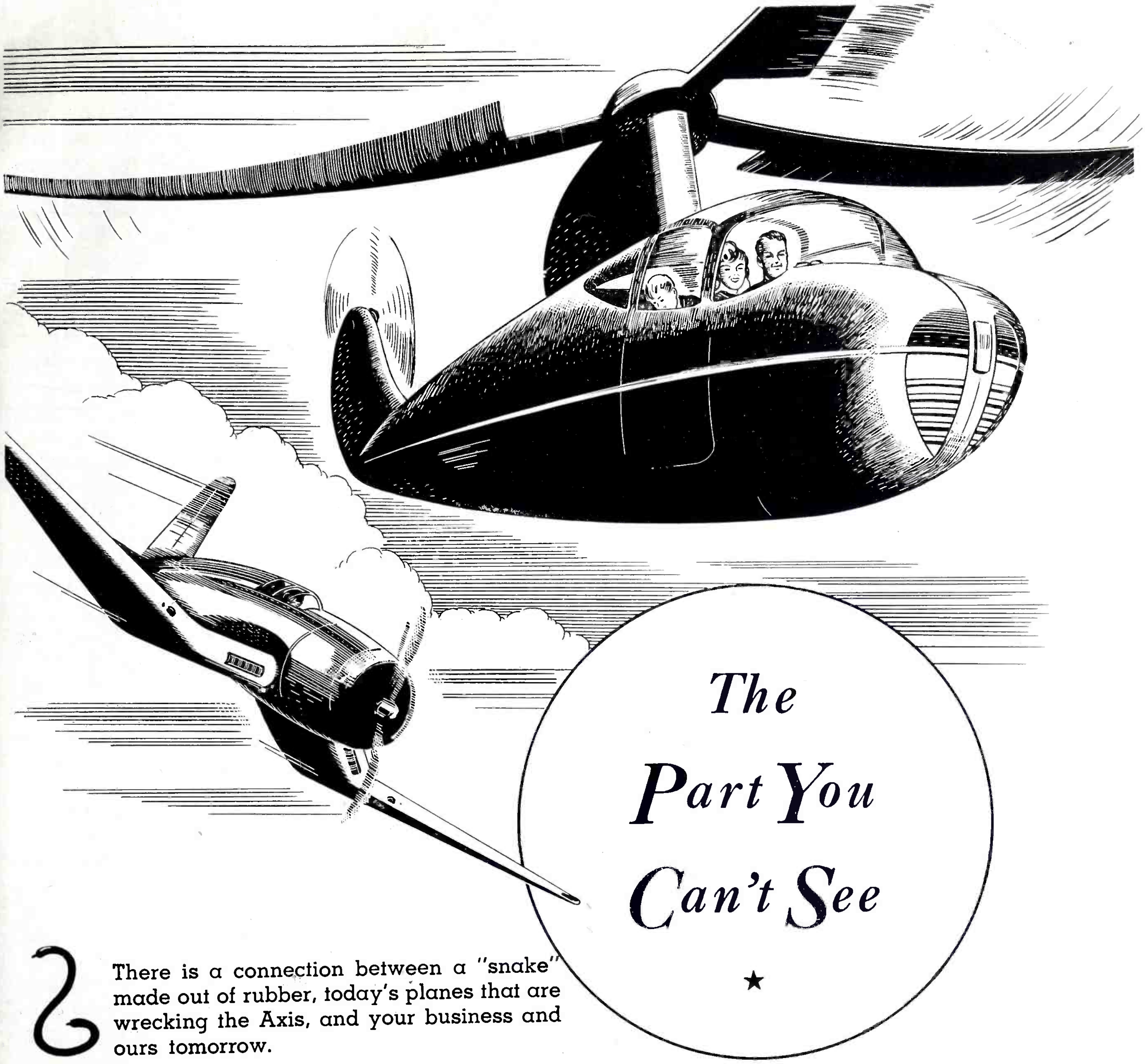
The End Products Branch under L. J. Chatten, Chief, develops and recommends to all claimant agencies plans for the procurement of electronic end products to meet military requirements, making the most efficient use of existing facilities. It cooperates with the Office of Scientific Research and Development of WPB, Government laboratories, industrial concerns and claimant agencies to assemble data on all new developments of electronic end equipment and advise the Products and Facilities Branch of technical changes or developments which may affect the requirements for components.

The Industrial Instrument Branch under E. A. Capelle acts as the focal point for all problems affecting the production and distribution of products within its jurisdiction. Manufacturers report regularly their production and backlogs for pyrometers, tube system instruments, industrial thermometers, flow instruments, combustion control equipment, dial pressure gauges, pressure controllers, etc., as well as the components used in their manufacture. Procurement difficulties of the industry are handled by the branch or channeled to the appropriate agency.

Through the Division Requirements Committee, the essential requirements of the various claimant agencies for products under jurisdiction of the branch are received. Where a critical situation exists on the distribution of certain products, scheduling of shipments is undertaken in cooperation with the claimant agencies concerned.

Under the functional or organizational units of the Radio and Radar Division are the following branches:

The Program Branch, headed by



There is a connection between a "snake" made out of rubber, today's planes that are wrecking the Axis, and your business and ours tomorrow.

A rubber "snake" made by the Johnson Rubber Company makes the variable pitch propeller possible. It's a little part you can't see . . . just one of the small parts that must operate perfectly to make Uncle Sam's war machinery unbeatable.

This particular part is molded to a tolerance of one thousandth of an inch . . . it is a precision part in rubber . . . and it must remain lively and resilient under extremes of temperature and high pressures . . . this is made possible by specifications rubber produced by Johnson formulas.

Thousands of such small parts make the efficient, unbeatable operation of America's war machines possible . . . all Johnson Rubber production today is for Uncle Sam.

There will come a day, though, when we all have to think about transferring the boys' names from the honor roll to the pay roll, and getting back to our regular job of supplying a peacetime market. To meet that great day with a minimum of time waste is important to the boys coming back . . . and important to you.

Lay your plans now. Let us help you. Johnson engineers and designers can help you solve problems in your post war products . . . and come up with the right answers in the right kind of rubber in the specific part you need . . . and this precision in rubber perfected in wartime will serve you well in peacetime.

We will be ready to supply you when the time comes . . . but the time to think about it and plan ahead is now . . . not then.

JR

The JOHNSON RUBBER CO. • Middlefield, Ohio

MOLDED & EXTRUDED RUBBER PARTS FOR INDUSTRY'S VITAL ASSEMBLIES

Indispensable in War—Essential in Peace

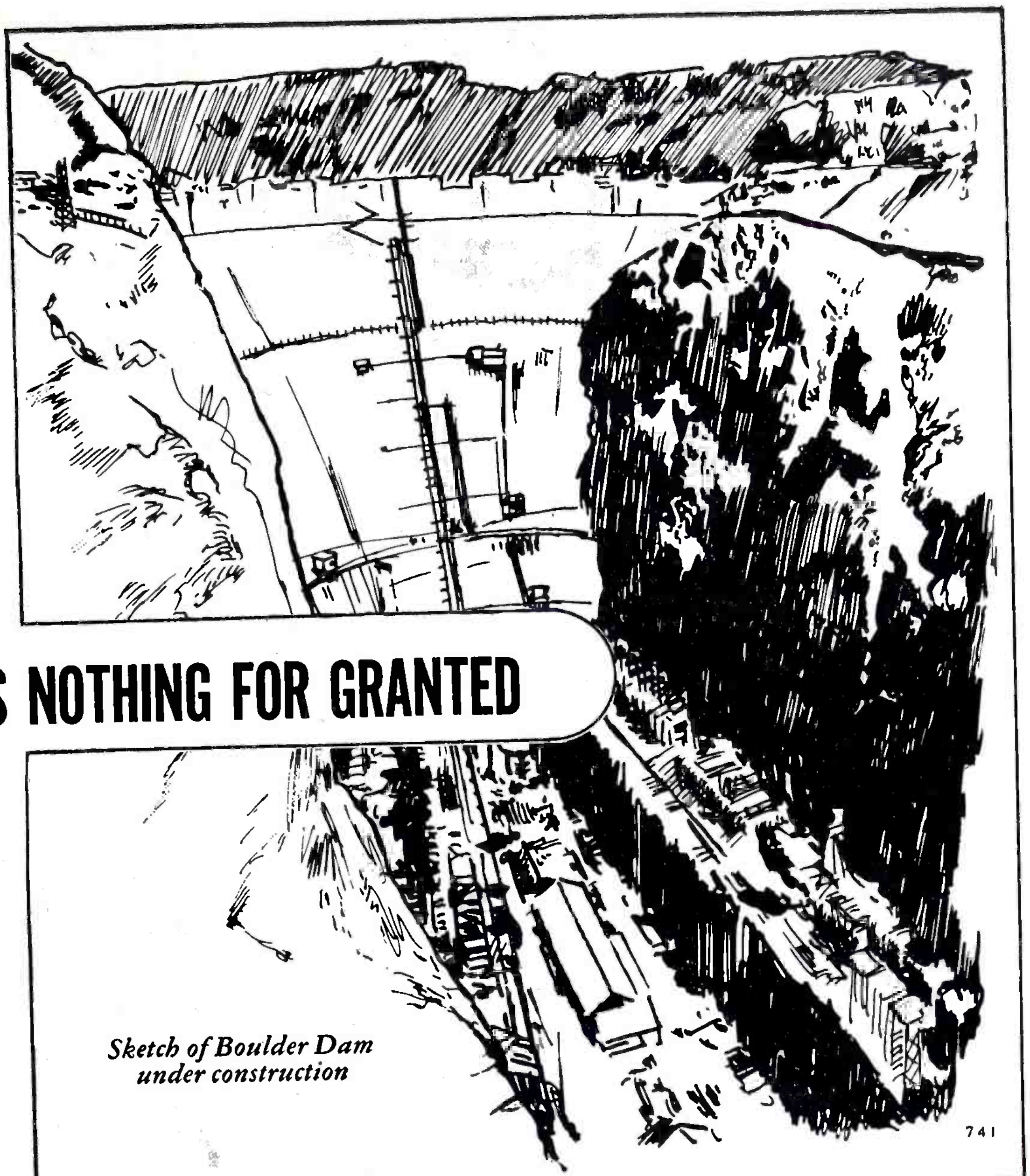
F. S. Boland, screens and correlates the requirements of all programs for the procurement, manufacture and distribution of electronic equipment for the armed forces, for export and for essential civilian requirements. The chief operating function of the branch is to plan and supervise the operations of the Controlled Materials Plan with respect to the electronics industry at the claimant agency, or consumer, level as distinguished from the distribution or manufacturers' level. It establishes statistical controls and systems necessary to know the current status of requirements, production and materials flow. It is the principal point of contact for the claimant agencies and presents statements of requirements to the Division Requirements Committee, where determination is made as to allocation of materials among claimants.

The Distribution and Scheduling Branch under A. J. Wilson, Chief, is concerned with receiving and processing applications for critical materials and scheduling production and delivery of products and critical components.

The Domestic and Foreign Branch, headed by Frank H. McIntosh, is responsible for production and distribution of components and equipment for broadcasting stations, international communications systems, public address systems and ship-to-shore communications. All matters pertaining to civilian radio requirements are handled through this branch.

The Field Service Branch, under Frank S. Horning, administers and executes all problems pertaining to field problems outside the Washington level. It is made up of 37 Radio and Radar Specialists in 13 regional offices throughout the country who coordinate the activities of producers of electronic equipment. Working with the regional offices, manufacturers are in a position to get proper interpretations of L and M orders pertaining to the industry. Manufacturers are also advised to take up their manpower and labor problems with these regional offices, which follows the general WPB decentralization program for operations as far as possible through the local field representatives.

The Administrative Section deals with office services within the Division.



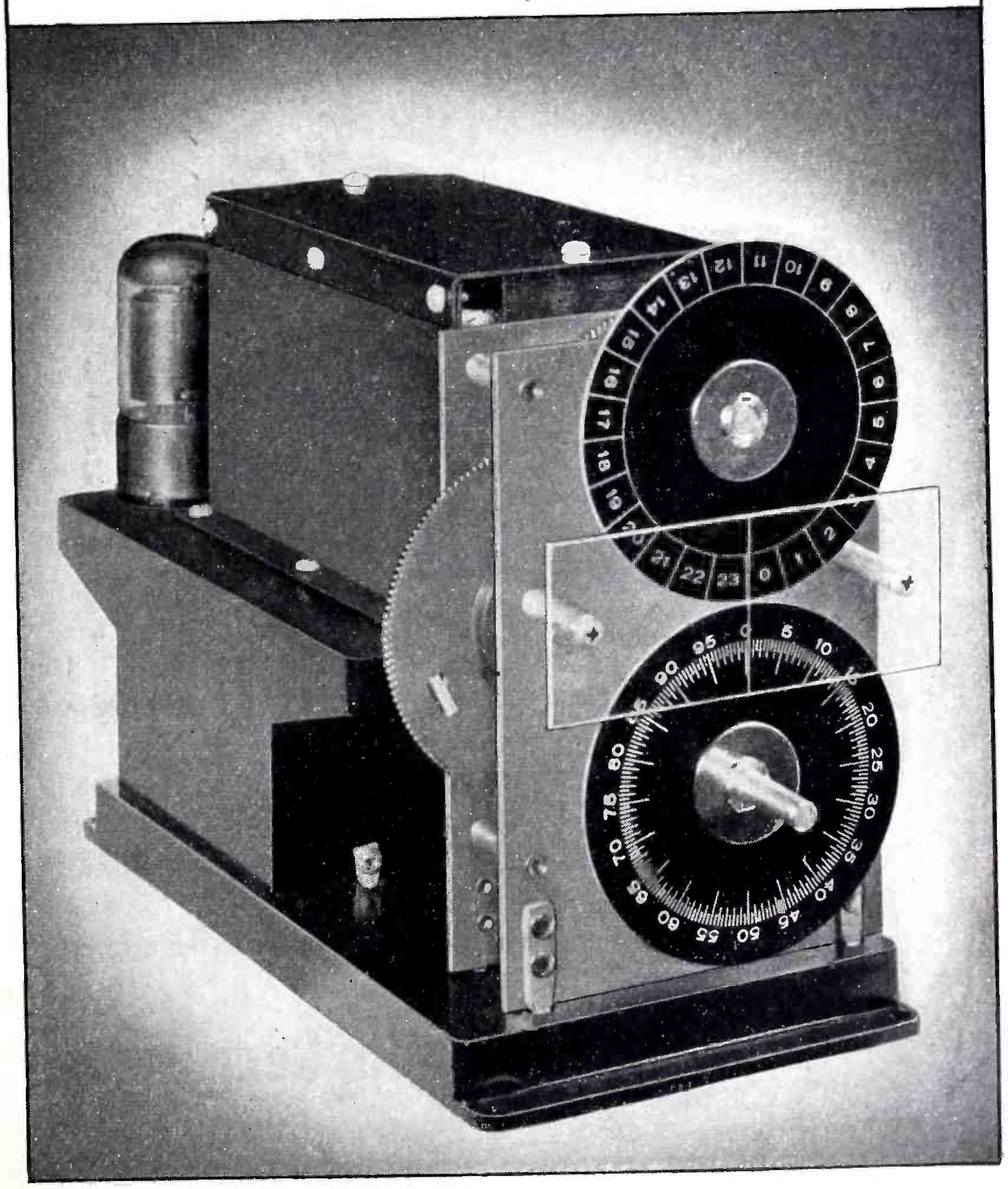
MASTER ENGINEERING TAKES NOTHING FOR GRANTED

Sketch of Boulder Dam under construction

It would be a fallacy to attempt the construction of a project as big as the Boulder Dam without careful engineering and planning. Specialized radio equipment requires this same careful consideration of the most minute details. It is, however, the combination of good engineering and productive skill that provides really dependable results.

Technical Radio Company is in the business of manufacturing radio communication equipment...everything from tiny parts to complete radio transmitters. Techrad engineers are firm believers in the principle that anything worth building at all is worth building well. The wisdom of this policy is clearly evident today, for the products of Techrad are dependably filling many important jobs in the war. The master oscillator, illustrated, represents months of development work and is simply one of many exacting components, designed for specific applications.

Today Techrad is devoting all its time and skill to the winning of the victory. Remember the name "Techrad," for when this war is over you may find here the solution to some of your problems.



TECHRAD PRODUCTS

SINCE 1925

Technical Radio Company

275 NINTH STREET

SAN FRANCISCO • CALIFORNIA

The appointment of Peter L. Jensen of Chicago as an industry specialist, in charge of matters relating to production of speakers and vibrators in the Components Section, is of interest to the industry. Mr. Jensen formerly was vice president and director of RMA and also chairman of RMA's Amplifier and Sound Equipment Division.

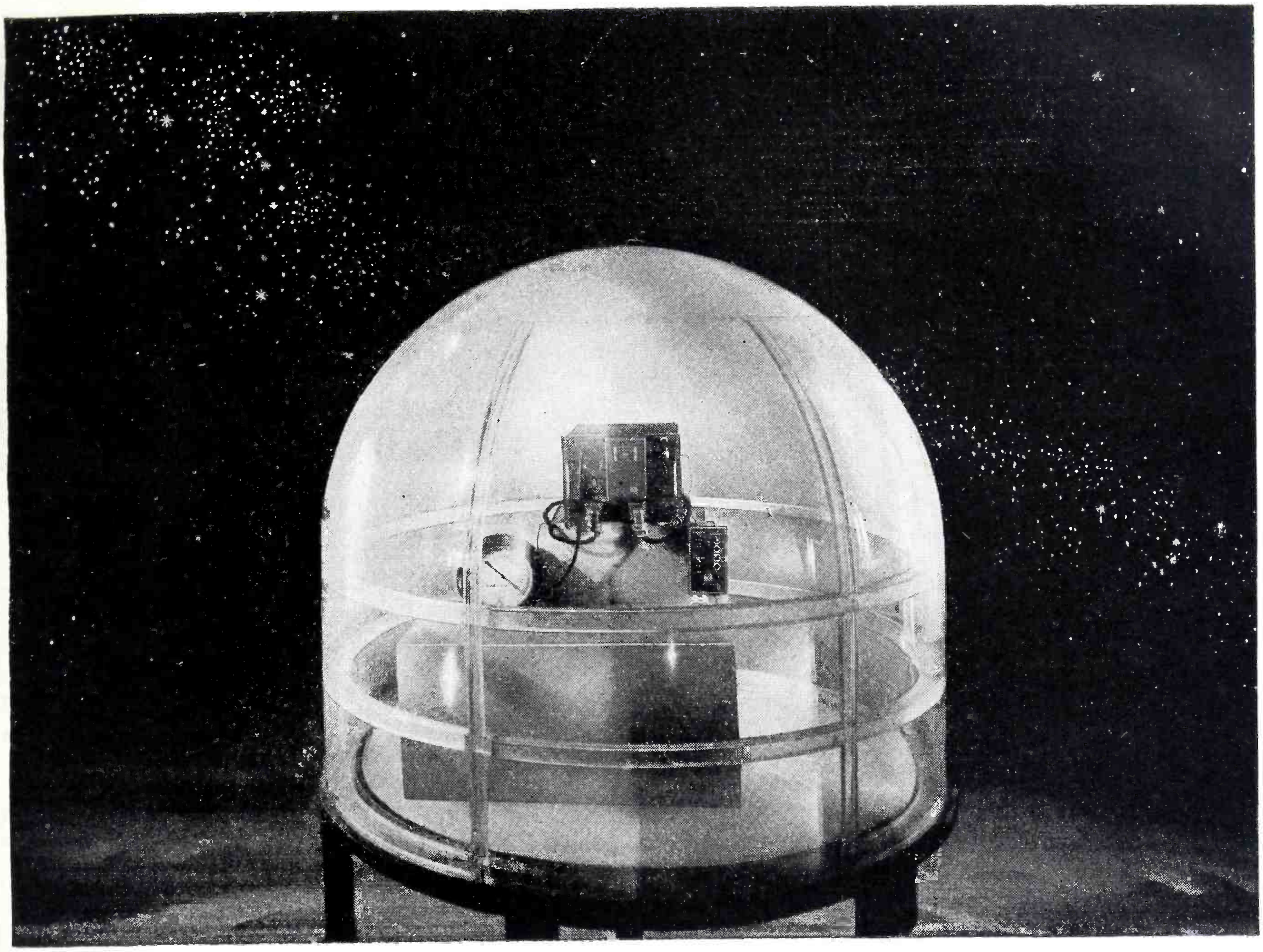
Another change in the Radio and Radar Division should be noted. J. Milton Lowenstein, chief of the Material Section, has resigned and enlisted in the Army as a private. Acting chief of the section is H. L. Gaston.

Radio Technical Planning Board

THE RADIO TECHNICAL Planning Board held its first meeting September 29, at the Roosevelt Hotel, New York. The following industry and service groups sent representatives and alternates: American Institute of Electrical Engineers, American Radio Relay League, FM Broadcasters, Inc., Institute of Radio Engineers, International Association of Broadcasters, National Independent Broadcasters, Radio Manufacturers Association, Aeronautical Radio, Inc., International Association of Chiefs of Police. Dr. W. R. G. Baker was appointed chairman of the RTPB for a term of one year. The Board will function under a plan of organization and procedure which was adopted at the meeting.

The objectives of the RTPB shall be to formulate plans for the technical future of the radio industry and services, including frequency allocations and systems standardization, in accordance with the public interest and the technical facts, and to advise government, industry and the public of its recommendations. Such planning shall be restricted to engineering considerations.

The sponsors of the RTPB shall be those nonprofit associations and societies which have an important interest in radio and which indicate a willingness to cooperate in achieving the objectives of the RTPB. The list of sponsors at the time of formation consisted of those present at the first meeting.



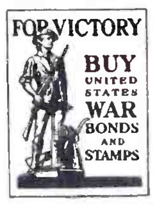
ALTITUDE: 40,000 FEET

Inside this new RCA plastic altitude chamber, aircraft radio equipment is taking a ride at 40,000 feet. As the pressure drops inside the sealed, transparent walls, expert eyes observe every part of the radio mechanism. Defects in design, details of faulty construction that would remain hidden until actual high-altitude flights, can be noticed at a glance *right on the ground*—and corrected *before* the radio is installed in a plane.

For pilots it means greater safety, better performance, *dependability*—where failure of the radio equipment might mean difficulty for a courageous crew.

RCA's new all-plastic test chamber represents another step forward in aviation radio research. Because it is entirely transparent—it enables engineers to study the *whole* set at once, to check for high altitude flash-overs and leaks at the same time, to look for tuning shifts and "breathing" parts in the set simultaneously.

This most advanced of high-altitude test chambers is typical of RCA's many facilities for aviation radio research. Today that research has but one goal—to help make America's armed might in the air the most powerful and effective flying force in the world. From that war-time research will come the knowledge, the skills, and the technique that will help *keep* America's wings the mightiest and most useful known to man.



RCA AVIATION RADIO

RCA Victor Division • RADIO CORPORATION OF AMERICA • Camden, N. J.

Dry Batteries for WERS

DRY BATTERIES that have passed their shelf-life expiration date have been acquired by the OCD and will be distributed free to WERS stations that request them. The batteries have been spot-checked, and, although a few may last only a short time, the majority are expected to give satisfactory service in emergency equipment.

There are 26 different types of batteries available and their voltages range from 1.5 to 162 volts. Applications for batteries should be made to the WERS radio aide of the local Defense Corps who will transmit the request to the State radio aide. Distribution will be made on the basis of the number of stations in operation in each state on September 1.

Licensed WERS Stations by States

Alabama	45	Nebraska	10
Arizona	7	New Hampshire	7
California	267	New Jersey	235
Colorado	2	New York	754
Connecticut	441	North Carolina	40
Dist. of Col.	27	Ohio	664
Florida	44	Oregon	12
Georgia	17	Pennsylvania	312
Illinois	223	Rhode Island	79
Indiana	210	South Dakota	12
Kentucky	50	Tennessee	9
Louisiana	26	Texas	32
Maine	6	Vermont	7
Maryland	191	Virginia	20
Massachusetts	509	Washington	78
Michigan	112	West Virginia	8
Missouri	62	Wisconsin	5
Montana	15	Wyoming	25

Electronic Lab in Hangar

THE FUTURE SIZE of bombing planes was an important factor in the design of a new hangar recently built for the aeronautical electronics laboratory of Minneapolis-Honeywell Regulator Co. After consultation with the Air Corps, the hangar was made large enough to house five large bombers. Electronic laboratories, a radio room and a machine shop are included.

At the dedication exercises of the hangar, a plaque was unveiled by the widow of Col. Douglas M. Kilpatrick, chief of the bombing branch of the Materiel Command at Wright Field, who was killed in a plane crash in 1942. He was one of the first to foresee the possibilities of an electronic autopilot for bombers, described elsewhere in this issue of ELECTRONICS.

London News Letter

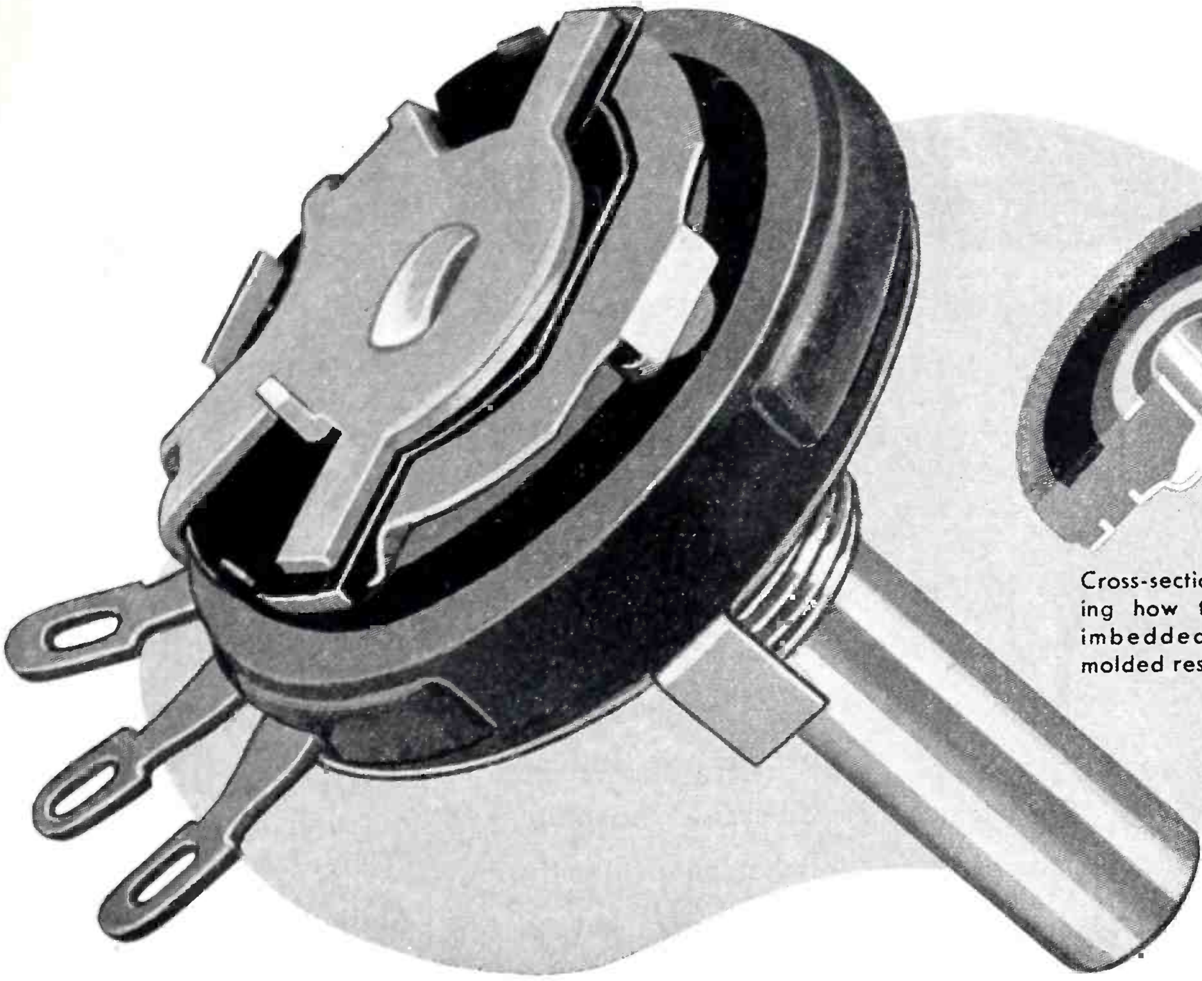
By JOHN H. JUPE
London Correspondent

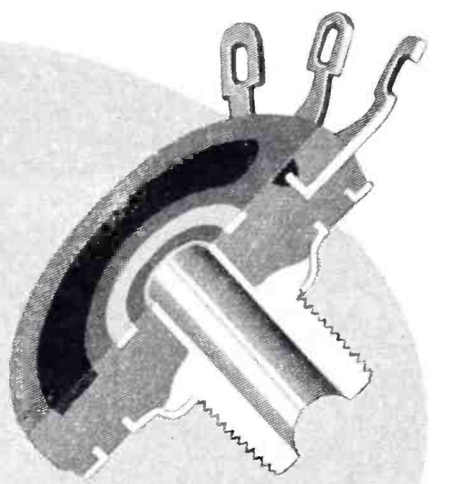
Science Training. A number of people in Britain are getting worried about the training of future scientists and the matter has crystallized recently in the action of the Institute of Physics setting up a special committee to consider the matter. This committee, under the chairmanship of Sir Lawrence Bragg, has just issued its report and the proposals make interesting reading. The present scholarship system is criticized and its replacement by a system of Government allowances to students is recommended. This overcomes a difficulty very common in Britain, namely, that those who win scholarshis often cannot proceed with the advanced studies owing to insufficient private income.

It is also pointed out that great specialization in one science, physics, for example, is undesirable. Other sciences should be included right up to the time that a man fin-

The longest single span truss ever fabricated and erected by the American Bridge Co. went into the construction of this hangar for bombers. Viewed from beneath the wing of a Flying Fortress, the doorway is 34 feet high and 180 feet wide and has no obstructions

Here's THE ONLY VARIABLE RESISTOR with a SOLID MOLDED ELEMENT





Cross-section view showing how terminals are imbedded in solid, molded resistor element.

The resistor element in the Allen-Bradley Type J Bradleyometer has substantial thickness (approx. 1/32 in. thick) and is molded as a single unit with the insulation, terminals, face plate, and threaded bushing. It is not a film, spray, or paint type resistor. Reliability and compactness are assured by this simple construction which eliminates all rivets, welded or soldered connections, and conducting paints. During manufacture, resistor material may be varied throughout its length to provide practically any resistance-rotation curve. Bradleyometers meet Army and Navy 200-hour salt spray tests.

Bradleyometers are the only continuously adjustable composition type resistors (only one inch in diameter) having a rating of two watts with a good safety factor. Available in resistance values as low as 50 ohms. They can be supplied for rheostat or potentiometer uses, with or without a switch. Write for specifications today. Allen-Bradley Company, 110 W. Greenfield Ave., Milwaukee 4, Wis.

Type J Bradleyometers may be used separately or in dual or triple construction to fit any particular control need.

FIXED RESISTORS

Type GB Insulated 1-Watt Fixed Resistor

Type EB Insulated ½-Watt Fixed Resistor

Sectional views of Bradleyunits showing the molded homogeneous resistor material, insulation, and imbedded lead wires.

A-B Quality

ALLEN-BRADLEY

FIXED & VARIABLE RADIO RESISTORS

QUALITY

ishes his University training. Furthermore, even after he has graduated there should be post graduate courses both in theoretical and experimental matters to enable him to keep abreast of the rapid developments in his chosen subject.

Contact with industry is considered to be very important to the student and although a number of suggestions have been made, the Institute of Physics Committee declines to say which it considers the best, as so much depends on circumstances.

I think that the most interesting recommendation in the report is for an increased study of the English language and literature in order that physicists may be able "to express themselves in clear, precise and attractive English". This seems to be very sound advice as I know from practical experience that many engineers are good men at their jobs and yet fail badly when it comes to incorporating an account of their work in a report for the "Chief" to read.

Radiolocation or . . .? Now that a few details of this invention have been released discussion has started as to which is the best name. I have seen the American name praised on the grounds that it is "short and sweet" but others claim that the British name gives a better idea of what the thing does.

Many of us in the radio and electronic field had a shrewd idea of

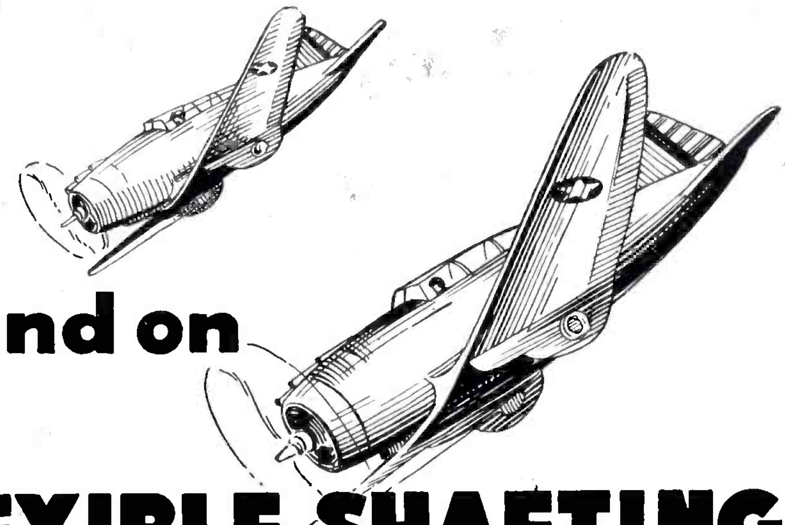
• • •

BRITISH UNIVERSITY IN WARTIME

In a British university, Craftsmen Haddon Judson (left) a prewar London insurance collector and Lance Corporal Alan Peters, a prewar surveyor have changed their occupations and are now studying radio. The photograph shows them checking the frequency of transmissions in their class

In the sky or on the ground you can depend on

WALKER-TURNER FLEXIBLE SHAFTING

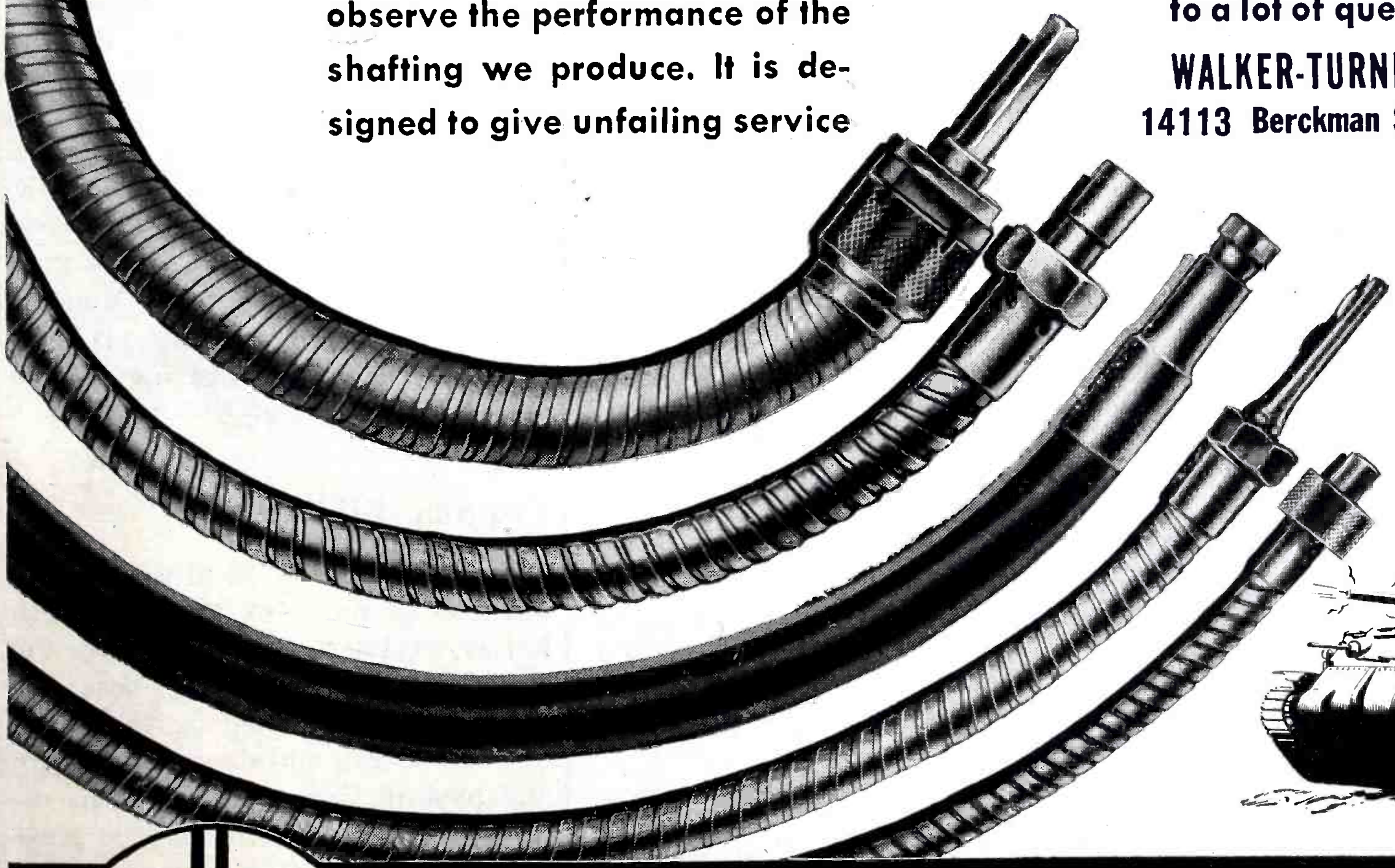


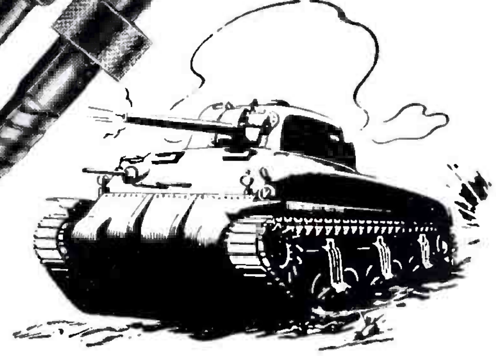
MANY of the mechanical weapons of this war are "quicker on the trigger," because of WALKER-TURNER FLEXIBLE SHAFTING. Its action is as positive in the stratosphere as on land.

As one of the largest manufacturers of flexible shaft machines for industry, we have had ample opportunity to observe the performance of the shafting we produce. It is designed to give unfailing service under the most difficult operating conditions. That is one reason why aircraft manufacturers, and others who use flexible shafting for important applications, specify "Walker-Turner".

If you have a problem in remote control or power transmission, get in touch with us. We have the answers to a lot of questions in our files.

WALKER-TURNER COMPANY, INC.
14113 Berckman Street, Plainfield, N. J.





walker-turner
COMPANY, INC.
PLAINFIELD, N.J.
U.S.A.

FLEXIBLE SHAFTING

FOR REMOTE CONTROL AND POWER TRANSMISSION what was in the wind long before any official announcement was made. To anybody who was acquainted with British patents the very name of Watson-Watt told a good story, as for several years before the war his name had been coupled with patents connected with radio direction finding, radio compasses, cathode-ray tubes, etc.

Just before war broke out I made a special trip to a certain plant to gather details of a cathode-ray compass. The tube was supported in gimbals and the beam, deflected by the Earth's field, caused electrical changes for a new type of mariners compass. All this was quite clear, as the device had been shown at a public exhibition in January, 1939. However, a few hours before I arrived there had been a frantic telephone call from a government department forbidding the manufacturer to show me anything. I have often laughed at how some obscure government official must have decided that what had been public must suddenly become secret.

Revised IRE Program

THE PROGRAM of the IRE Fall meeting at the Sagamore Hotel, Rochester, New York on Nov. 8 and 9 has been revised to include a paper entitled "Twenty-Eight Volt Operation of Electron Tubes", by Walter R. Jones of Sylvania Electric Products, Inc. This will be given at the 2:00 p.m. technical session on Monday, November 8. The complete program for the two-day meeting appeared in the October issue of ELECTRONICS.

Popular Bibliography

A REFERENCE GUIDE to ultrahigh frequencies prepared by Miss Elizabeth Kelsey, engineering correlator for the Zenith Radio Corp., has been enthusiastically received by thousands of engineers, physicists, teachers and men in the communications divisions of the armed forces. So great has been the response that a new book has been issued, containing not only additions to the reference guide but also a section that comprises brief biographical sketches of the great men of science who have contributed, directly or basically, to the development of present-day techniques. These are presented in Part

LOOKING FOR TROUBLE

You wouldn't find it much fun, sitting on a hill looking for Japs. That's what this soldier is doing, on a battlefield somewhere in the South Pacific. Every tree, every bush, every slightest movement must be scrutinized carefully. Everything may look peaceful enough, but there's plenty of trouble out there. And the big idea is to track it down, before it finds you.

This young lady, too, is on the lookout for trouble. With a microscope she is examining pivots to be used in Simpson electrical instruments and testing equipment.

From start to finish these pivots have been processed entirely right in the Simpson plant. Rounded on ends in true spherical form . . . specially heat-treated to make them hard for long wear, tough to withstand shocks and vibration . . . ground and lapped to a mirror finish to prevent rusting.

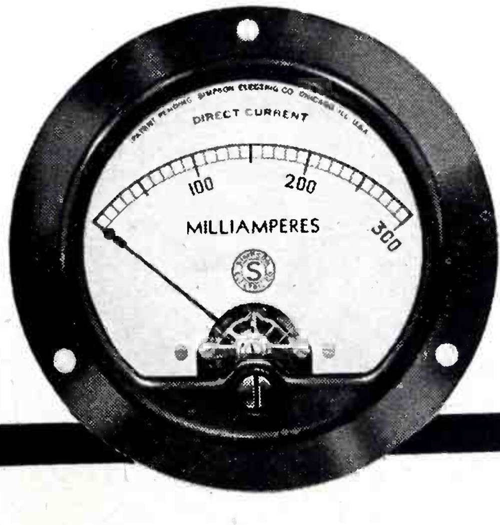
To the naked eye each one is a model of delicate precision. But Simpson doesn't stop there. It is this young lady's job to search out any microscopic flaw that might affect an instrument's accuracy.

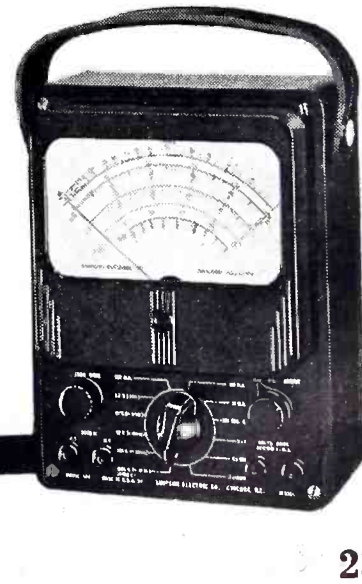
The same meticulous care attends every step of manufacture. Why? Because Simpson instruments are going forth to posts of vital importance, on the home front and the fighting fronts alike. Because it is our job not only to make *all* we can, but to make them the *best* we can.

SIMPSON ELECTRIC COMPANY
5200-5218 Kinzie St., Chicago 44, Illinois

Simpson
INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory





one of the book, which begins with Pythagoras and Thales and follows through to men of the present day, giving interesting highlights in the lives of each.

Part two contains a comprehensive bibliography of published works on ultrahigh frequencies and contains references to books, Proceedings of the IRE and miscellaneous engineering publications. These are listed under ten subheads and include VHF wave guides, tubes, measurements, wave propagation and use in aviation.

The book is entitled *Trail Blazers to Radionics and Reference Guide to Ultra High Frequencies* and is available with the compliments of the Zenith Radio Corp. Requests for copies should be sent to E. Kelsey, Zenith Radio Corp., 680 North Michigan Ave., Chicago, Ill.

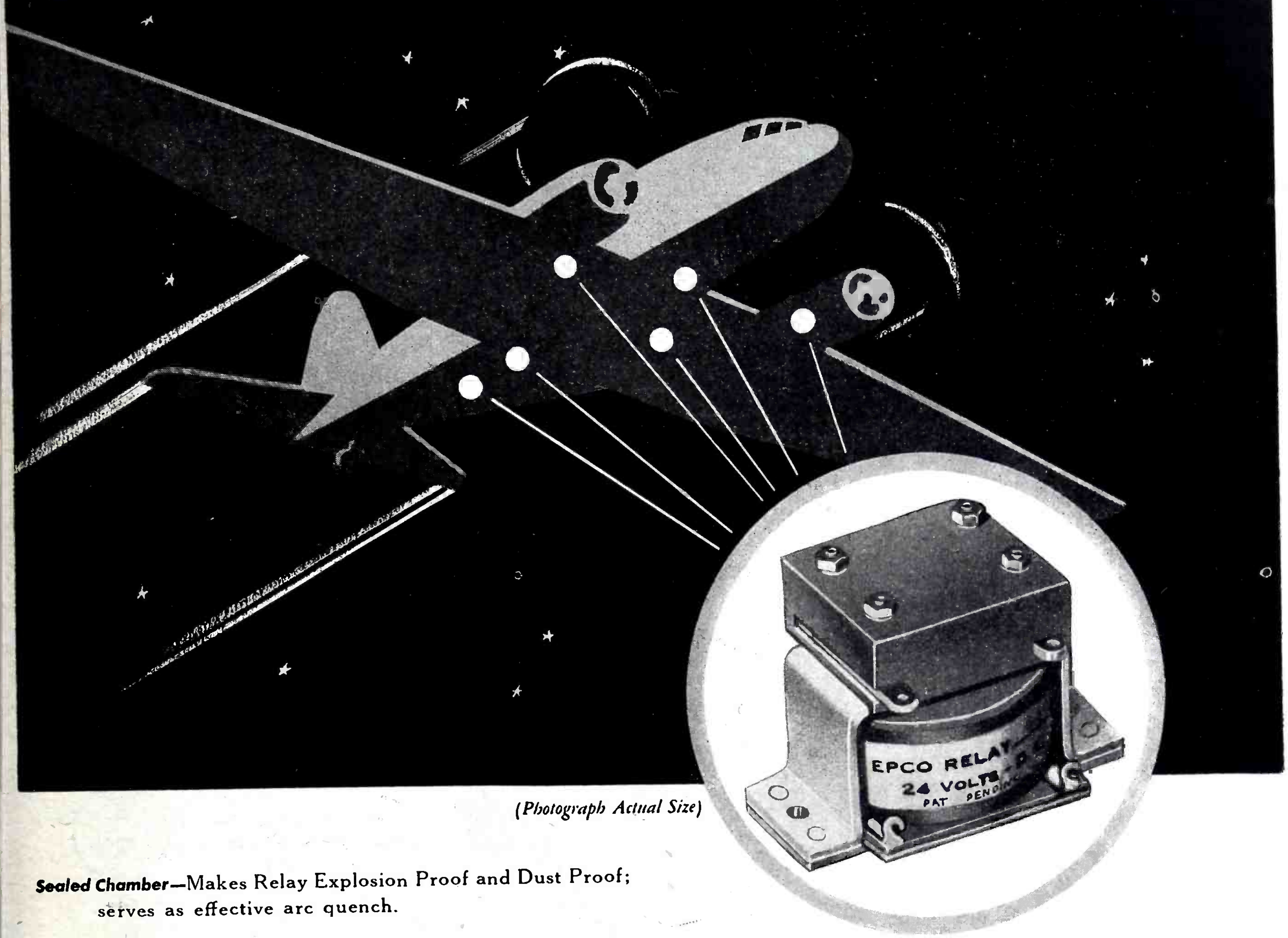
WGAR-WHBC Frequency Changes

THE FCC HAS ANNOUNCED a proposed decision to grant the application of WGAR to change its frequency from 1480 kc to 1220 kc, paving the way for 50,000-watt operation on the new frequency after the war. An increase in nighttime power from 1,000 to 5,000 watts and a change in transmitter site are included.

The change will not involve the use of critical materials since the station has crystals for 1220 kc and sufficient wire for transmission line on hand. A portion of the copper wire necessary for the ground system is also on hand and additional wire will be obtained by salvaging the former ground system of WJR, Detroit. A farmhouse will be employed to house the transmitter. The cost of moving towers and equipment has been estimated at about $5,000.

A construction permit is to be granted to WHBC, Canton, to occupy the old frequency of WGAR, 1480 kc, when that station vacates the channel. WHBC will lease the WGAR auxiliary transmitter, including crystals and coupling equipment. Seven 22-foot sections of the present 492-foot tower will be removed and used to form an additional tower for a directional antenna.

CEILING UNLIMITED



(Photograph Actual Size)

Sealed Chamber—Makes Relay Explosion Proof and Dust Proof; serves as effective arc quench.

Excess Capacity—Rated at 25 amperes; operates satisfactorily at 50 amperes; tested without failure at 120 amperes high inductive load.

Light and Compact— Standard model above (S47D) weight only 4.7 ounces; overall dimensions as follows: Height, 1 9/16"; Width, 1 21/64"; Length (less base), 1 7/16"; Overall of base, 2 1/16"; Mounting holes, center to center, 1 3/4".

Positive Action— Overtravel spring insures positive contact pressure and instant "break" release.

Tamper Proof—Factory adjusted and sealed; protection against unauthorized re-adjustments.

Reversible Contacts—If worn from excessive use contacts may be reversed in the field, thus providing new surfaces without disturbing adjustment.

Specifications—Normal Coil Rating. 24 volt - 150 m. a. - 3.6 watts. Contact Rating. 25 amps. inductive load at 30 volts.

Unit has withstood Army tests, including overload; vibration 55 cycles per second with .06" excursion; acceleration of 10 gravity units; salt spray tests of 240 hours duration.

SEALED MIDGET RELAY

Explosion proof!
Precision made!
Unaffected by highest altitude!

Electrical
PRODUCTS SUPPLY CO.
Affiliated with Electrical Products Corp.
1140 Venice Blvd. Los Angeles 15, Calif.

New Tubes

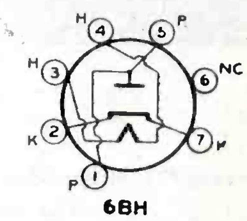
THREE NEW TUBES have been announced by RCA-Victor Division of RCA and are available to equipment manufacturers for use in connection with WPB rated orders.

One of the new tubes is the 9006, a midget diode for VHF use, having a resonant frequency of about 700 Mc. It has a peak plate current rating of 15 ma and a peak inverse plate voltage of 750 volts.

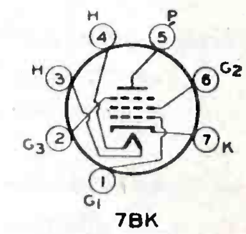
Two power amplifier pentodes are combined in a GT-type glass envelope in the 12L8-GT, another new type. They have a common cathode and each section can handle a power output of one watt with ten percent distortion in class A operation. Push-pull or parallel connection of the sections may be used. The heater requires 0.15 ampere.

The third tube announced is the 6AK6, a power amplifier pentode of the miniature type, whose electrical characteristics are essentially the same as the 6G6-G. In class A operation a single tube can handle a maximum signal output of 1.1 watts with ten percent distortion.

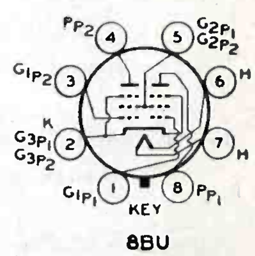
Type 9006, a midget diode, has double leads to plate and cathode for VHF



Type 6AK6, miniature power amplifier pentode, electrically similar to 6G6-G



Type 12L8-GT, double-pentode power amplifier with common cathode



Science Talent Search

HIGH SCHOOL STUDENTS will take a special aptitude examination in their home communities between December 3 and 27. The 40 that pass and otherwise qualify will attend a five-day session of the Science Talent Institute in Washington next February. Final tests during the sessions will determine scholarship awards provided by Westinghouse.

British Engineers Election

AT THE EIGHTEENTH annual general meeting of the British Institution of Radio Engineers, held in London, Sir Louis Sterling was unanimously re-elected president for the coming year. Vice-Admiral the Lord Louis Mountbatten, who was recently placed in charge of the Allied command in Central Asia, was elected a vice-president, as were Sir William Noble, Leslie McMichael, James Robinson, and Air Vice Marshal R. S. Aitken.

Electronic Megaphones

PORTABLE ELECTRONIC megaphones manufactured by Guided Radio Corporation of New York for the Navy are also, according to the company, supplied to vessels of the Maritime Commission and War Shipping Administration. In addition, the megaphones are used by the Army Transport Service and the Coast Guard and have been supplied to some lend-lease vessels.

OWI Reviews War Communications

A SUMMARY OF U. S. communications in the war has been issued by the Office of War Information on the basis of data supplied by eight government agencies and labor and industrial organizations. Portions of the report that concern radio and electronic subjects follow.

Military communications form one of the biggest parts of the picture, and the great numbers of men enrolled in the Signal Corps and in the Naval Communications Service, as well as the vast amounts of communications equipment used by these services, account in large measure for the manpower and equipment shortages in civilian communications.

The Signal Corps alone is now twice the size of the peacetime regular Army and numbers 280,000 men and 28,000 officers. In addition, large numbers of communications personnel are distributed among the other branches of the Army as airplane and tank radio operators, "walkie-talkie" and "handy-talkie" carriers and message runners. Many selectees without technical background but with high IQ's have been given Signal Corps communications train-

0.00002 to 10,000 VOLTS!

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. Over a thousand of these instruments are giving excellent service in Government, commercial and university laboratories and factories.

Send for Bulletin 8

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U.S.A.

ing in fifty military and 268 civilian schools.

Mature men with specialized background are still needed by the Signal Corps: the Corps could use all the electrical engineers and electronic physicists that it could find. As to equipment and parts, the Signal Corps had at the end of 1942 slightly exceeded its procurement objectives.

As a result of the great mobility of units and their frequently wide separation from one another, radio communications far outweigh wire communications in this war even in the Army. Of the Signal Corps' $5,000,000,000 communications equipment procurement program for this year, approximately 90 percent is destined to be spent on radio.

Total radio production in this country, which about a year ago stood at $30,000,000 a month, is now up to $250,000,000 a month, a considerably greater rate of increase than that of total war production. All such production is for the armed services.

Home Receivers

If automobile sets are included, there are 60,000,000 receiving sets in the United States. Since there are only about 31,000,000 "radio families" in the country, it is apparent that a number of American families own more than one radio.

Many domestic receiving sets are deteriorating from age and lack of adequate service, the greatest difficulty being in the securing of tubes. During the early part of this year large numbers of tubes destined for civilian use were taken over by the armed services, and, though the civilian program is being pushed, the supply is still tight.

The chief bottleneck in the manufacture of tubes is not in material but in labor. A number of manufacturers are now setting up feeder-plants for tube-making in areas where labor is available.

Broadcast Stations

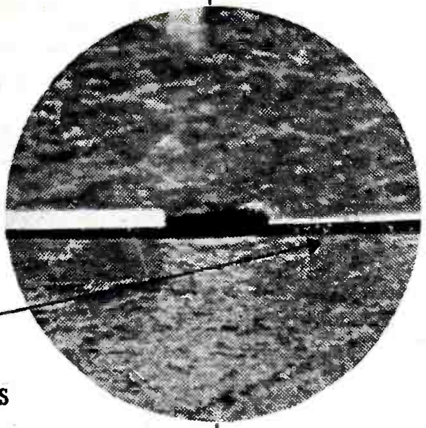
The FCC has made an inventory of excess radio equipment in the hands of radio stations throughout the country and available for purchase by other stations. Catalogues listing this equipment and its location can be consulted by stations.

At the suggestion of the War Production Board, the FCC ordered domestic broadcast stations, to make

EDGE VIEW OF A PAGE FROM THIS MAGAZINE →

EDGE VIEW OF 0.00075-INCH NICKEL STRIP

MAGNIFIED APPROX. 25 TIMES

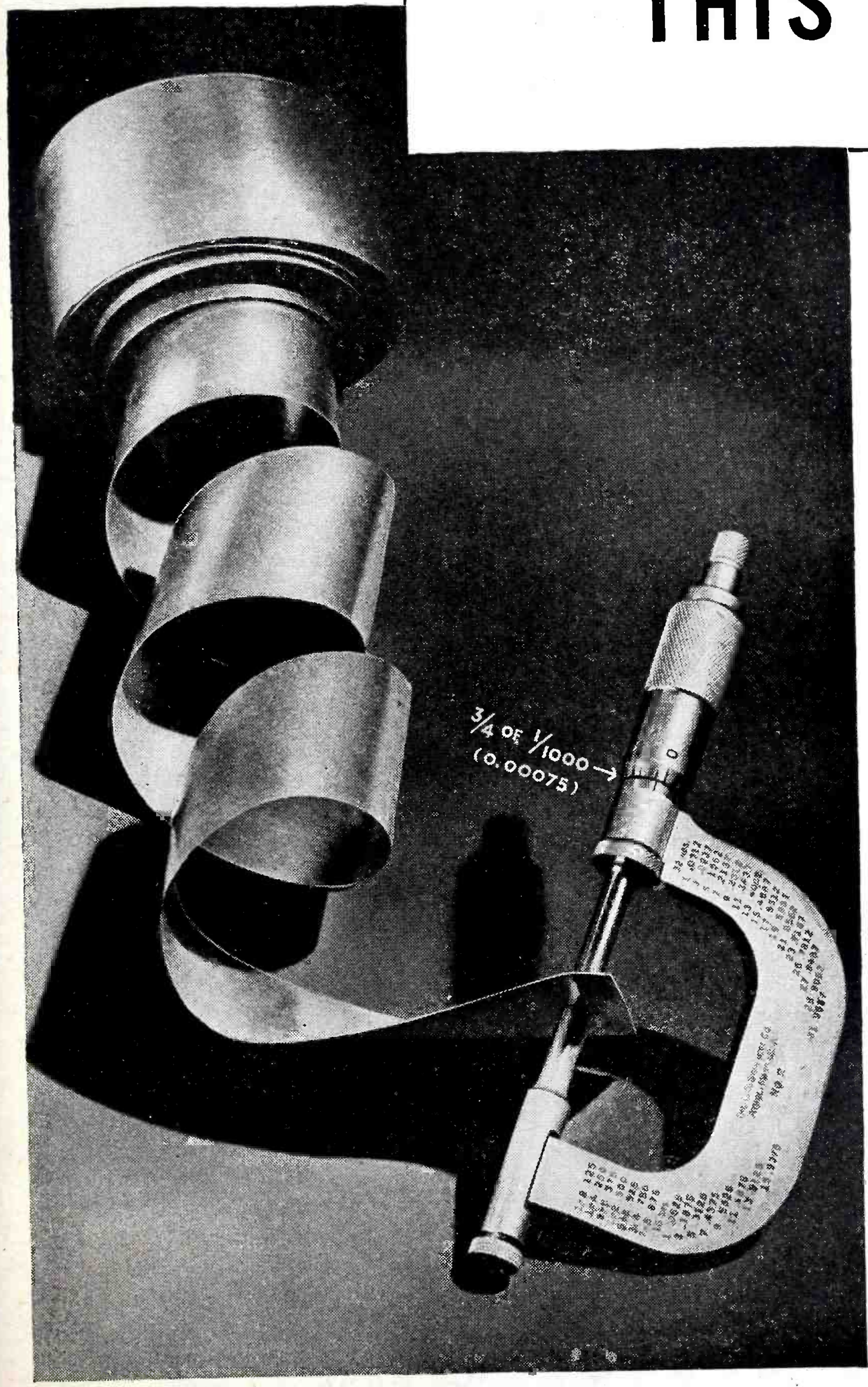


They wanted

METAL STRIP

1/3 the thickness of

THIS PAPER



. . . and they found that 0.00075-inch strip with exactly the combination of properties they wanted is a regular commercial product in INCO Nickel Alloys

Whenever you need a metal with a combination of unusual properties . . .

Look for a ready answer among the INCO Nickel Alloys. It makes little difference whether you want heavy hot-rolled plate two inches thick, or strip as thin as the foil illustrated here.

This strip is made of Pure Nickel for a delicate electrical application which requires corrosion resistance and high mechanical properties in very fine strip. Of course, every step throughout the repeated annealing and re-rolling operations is a precise, critical test of the metal rollers' skill. Even the air must be kept clean, for a particle of grit or dust on the metal could perforate it during the rolling operations. Nevertheless, this thin nickel foil is a regular commercial product of the Somers Brass Company.

• • •

All of the 8 INCO Nickel Alloys are immune to rust. All are high in strength and toughness. In addition, each alloy has individual properties that make it uniquely suited for special applications.

"Tremendous Trifles," a booklet which discusses the properties, sizes and forms of the 8 INCO Nickel Alloys, will be sent to you on request. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL
"KR" MONEL • INCONEL • "Z" NICKEL • NICKEL

Sheet . . . Strip . . . Rod . . . Tubing . . . Wire . . . Castings operating changes to extend transmitter tube life. WPB simplified and standardized parts for home radios to assure wider maintenance and repair. The FCC, in conjunction with the Board of War Communications (BWC) and the Army, has also arranged to silence any radio station in danger of being used by enemy aircraft as a radio beacon.

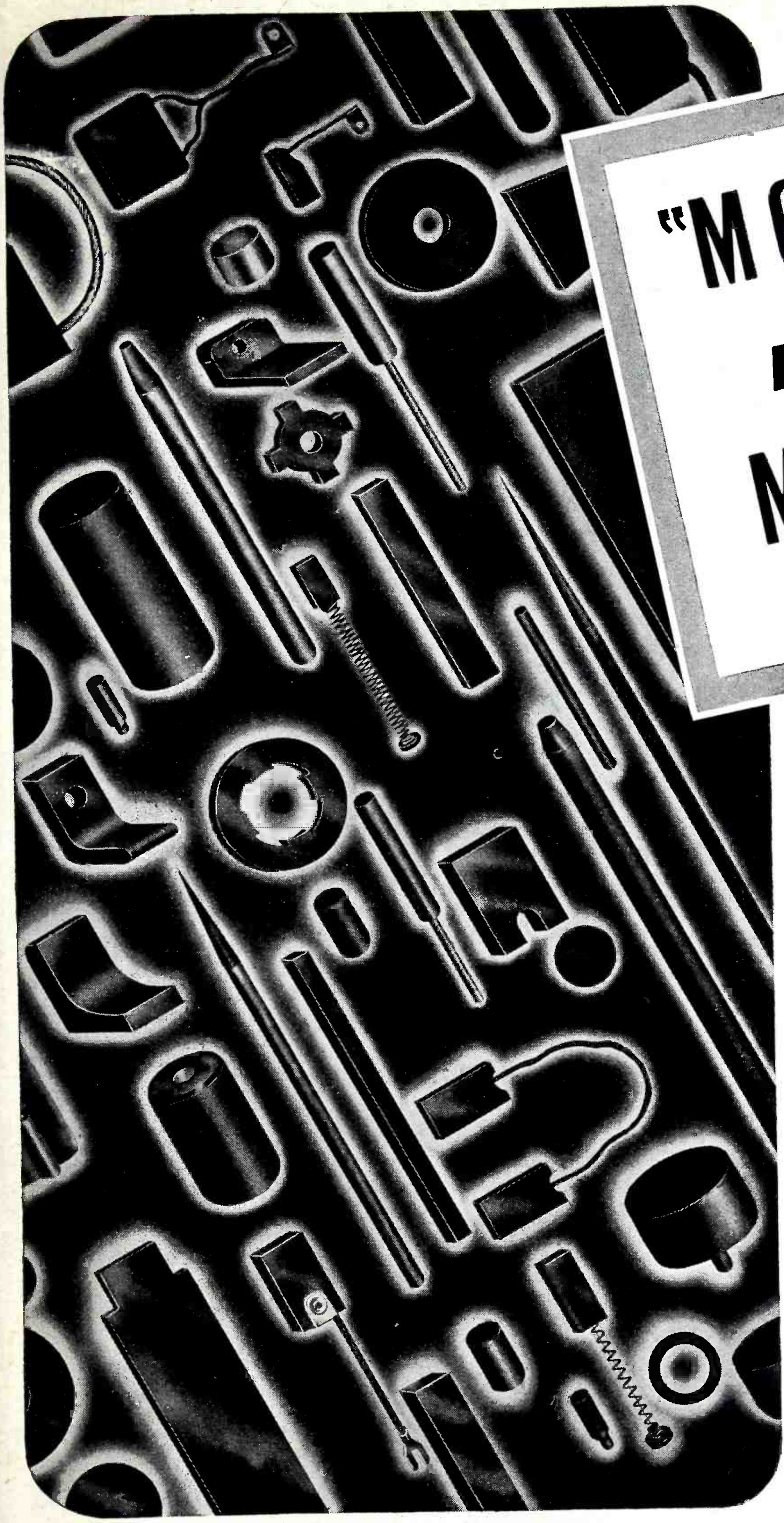
Manpower shortages are severe in manufacturing, maintenance, and broadcasting. Young men have been particularly predominant among the employees of the industry, and the need for their services in the Signal Corps and Naval Communications has led great numbers of them to enlist. Others, although eligible for draft deferment because of their employment in essential communication jobs, have not accepted deferment—and in some cases local draft boards have not granted it.

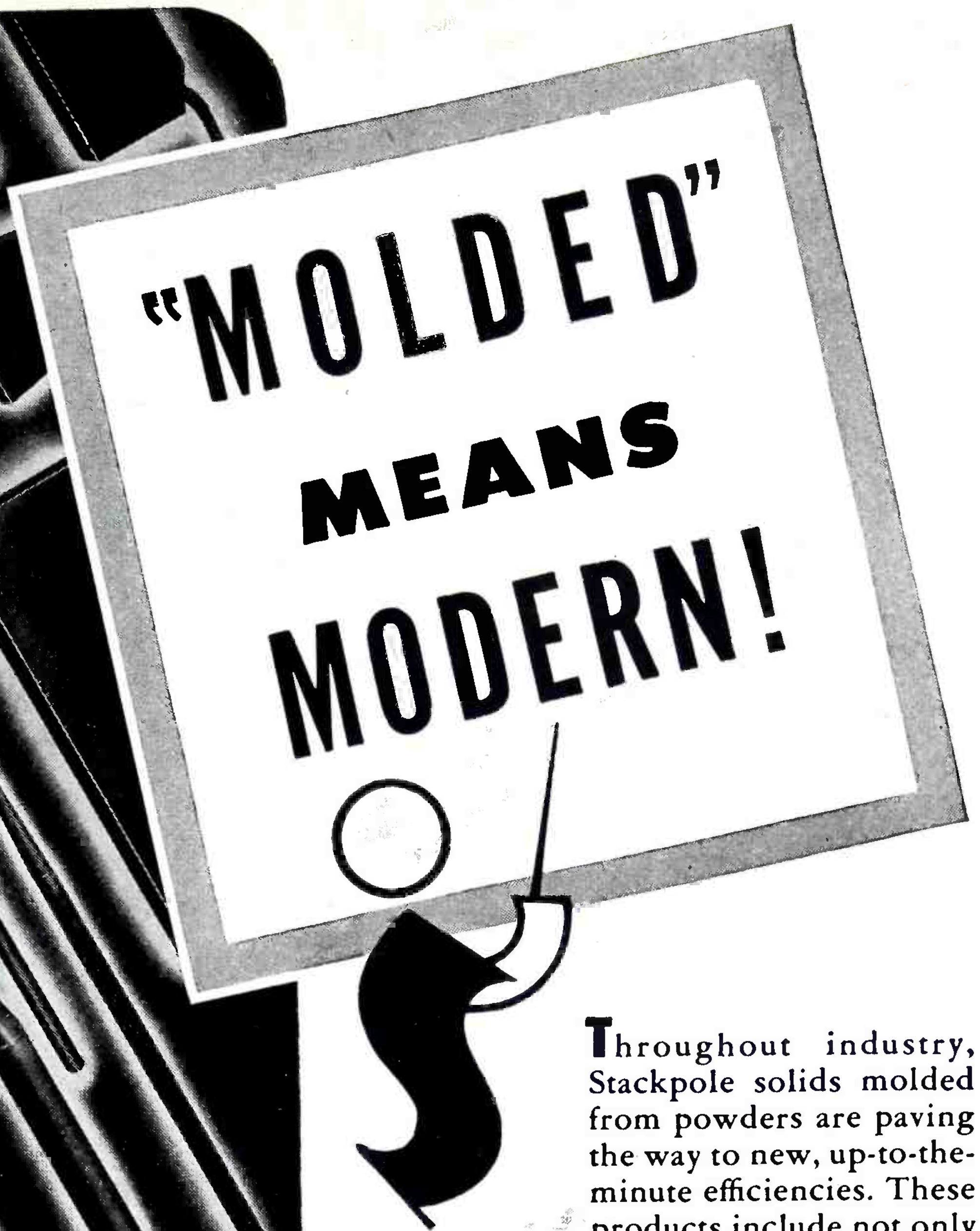
In addition to performing much wartime research in its laboratories, the radio industry has contributed much time and talent to the broadcasting of government war messages—about $140,000,000 worth during 1942. Every station in the country has been making between 9 and 12 announcements of war messages a day, from material furnished by various government agencies through the Office of War Information.

Among the stations contributing this wartime service are the 170 domestic foreign-language stations, broadcasting programs in 30 foreign languages for about 1,500 hours a week, aimed at the 25,000,000 inhabitants of this country, most of them American citizens, who speak at least one foreign language. Of these, there are 11,000,000 whose primary language is not English, and 2,000,000 who neither speak English nor understand it.

Before Pearl Harbor a considerable amount of blatantly antidemocratic and pro-Axis propaganda had gone out over some of the foreign-language stations. The three existing Japanese-language programs went off the air voluntarily when we entered the war, but in certain other programs spokesmen continued to employ intonation, inflection and selection of news items to put across their anti-American views.

Now, three groups are concerned with maintaining foreign-language broadcast security: the FBI, which checks personal history statements





Throughout industry, Stackpole solids molded from powders are paving the way to new, up-to-the-minute efficiencies. These products include not only the better-known Stackpole carbon, carbon-graphite, and composition products, including many precious metal compositions, but also new, far-reaching developments in solids formed from molded iron and iron-nickel powders. These latter utilize less critical materials, eliminate machining operations, and can be produced rapidly to exacting specifications. Our engineers will gladly cooperate in weighing the possibilities of such developments against your requirements.

TYPICAL STACKPOLE MOLDED PRODUCTS

Powder Iron and Iron-Nickel Components
Brushes and Contacts
(All carbon, graphite, metal and composition types)
Bearings • Anodes • Electrodes • Welding Rods, Electrodes, and Plates • Pipe • Brazing Blocks • Brake Lining • Packing, Piston, and Seal Rings • Rheostat Plates, and Discs, etc.

STACKPOLE ELECTRONIC COMPONENTS

Fixed and Variable Resistors
Molded Iron Cores • Line Switches

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

STACKPOLE

MOLDED METAL POWDER, GRAPHITE AND CARBON PRODUCTS

and fingerprints of all persons engaged in foreign-language broadcasts; the Office of Censorship, which administers a voluntary "Code of Wartime Practices" for the stations; and the FCC, whose interest is in the operation of licensed stations in the public interest. The stations themselves are responsible for all material which they broadcast, and censorship is thus on a voluntary basis, exercised either by the individual stations or through an industry committee, the Foreign Language Radio Wartime Control.

Television, Facsimile and FM

The development of television, facsimile and FM broadcasting has been considerably affected by the war; in each case postponement of widened service has been forced by shortages of materials and manpower.

Facsimile broadcasting is still restricted to commercial use only, in connection with private point-to-point operations, but when its development and the development of FM broadcasting are resumed, the two will doubtless be carried on in conjunction with each other on a large scale.

In the case of television, the FCC limited the licensing of transmitters to prevent the freezing of the technique at a low level of effectiveness. Many new advances resulting from laboratory experimentation in connection with military devices will improve transmission and reception when television is again allowed to develop on a commercial basis.

Non-Broadcast Radio

Since our entry into the war, certain war plants have been permitted to operate their own radio stations for communication in case of emergency. The War Emergency Radio Service, organized under the administration of the FCC and with the cooperation of the Office of Civilian Defense, includes several thousand of the country's licensed radio operators, among them many of the licensed amateurs. These operators stand ready to substitute VHF radio communication for wire service, or to supplement wire service, in case of enemy bombings, other military operations, or emergencies.

A number of the FCC's radio activities are directed toward the mainte-

nance of safety at sea. The Commission has set up special requirements for receivers to be used on board U. S. vessels, and gives its approval only to those types of receivers which do not radiate signals that could attract the attention of enemy raiders.

FCC men guard the special frequencies which ships use to send SOS (Ship Sinking) and SSS (Submarine Sighted) signals. When such a signal is heard the Anti-Submarine Command of the Army Air Forces is notified; planes are sometimes on their way to the scene within five minutes.

International Broadcasting

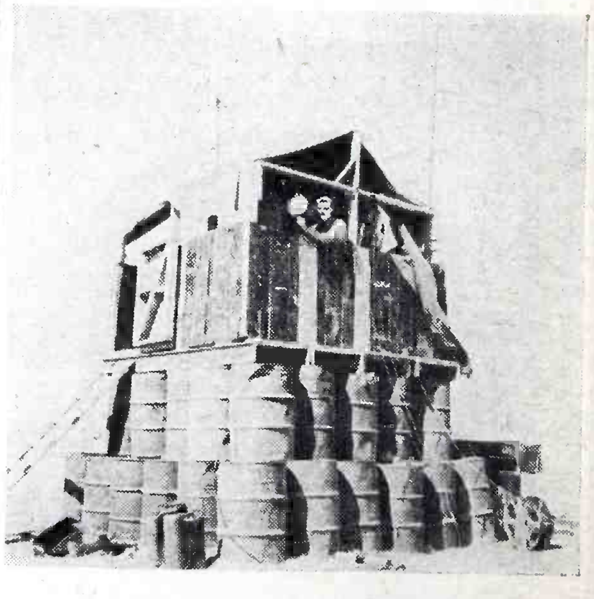
All 14 of the country's privately owned short-wave broadcasting stations and eight commercial communications transmitters formerly used for point-to-point telephone, program or radiophoto service, have been leased jointly for the duration of the war by the Office of War Information and the Coordinator of Inter-American Affairs (CIAA). Twenty-two new transmitters are now being added, and on their completion the commercial transmitters, considerably lower-powered, will be dropped.

OWI's international message, the "Voice of America," is aimed at five listening groups: enemy areas, Axis occupied areas, neutral countries, the United Nations, and Allied occupied areas. It is heard 24 hours a day in more than 40 languages and dialects.

To supplement this coverage, more

• • •

WIRELESS TOWER



An unusual control and communication tower at one of General Doolittle's medium bomber bases in North Africa, is constructed of empty oil drums. It may not be pleasing to look at but it serves its purpose and uses material readily available

Copper Sulphide or Selenium

THE KEY to many a puzzling new industrial development is frequently the right application of Power Conversion. At the heart of many of today's electrical marvels is a Metallic Rectifier Stack. Equipment designs once believed impossible or impractical are now in common daily operation—rendering efficient, dependable service.

Are **you** working on any ideas involving D. C. Power Supplies, Metallic Rectifiers, or Conversion Assemblies? Our Engineers' experience in solving many such problems is at your service. There is no obligation.

Write today on your business letterhead for Bulletin 66 giving full details on B-L Metallic Rectifiers.

BL

THE BENWOOD LINZE COMPANY • ST. LOUIS, MO.

Designers and manufacturers of Copper Sulphide and Selenium Rectifiers, Battery Chargers, and D.C. Power Supplies for practically every requirement.

than 100 programs a week are picked up by the British Broadcasting Corp. and rebroadcast on medium waves. Also, many transcribed programs are shipped abroad. Some of the "Voice of America" programs are developed by NBC and CBS from scripts prepared by various government agencies—the networks providing the talent and the direction.

There are many indications—some of which must remain secrets of war—as to the effectiveness of the "Voice of America" in combating Axis propaganda and spreading the meaning of our cause. The day after the nvasion of North Africa, when it was of paramount importance to reach French listeners in North Africa and France, the Berne correspondent of the *New York Times* cabled his paper:

"American broadcasts are listened to day and night and it is certain a great impression has been made. The French may be skeptical but they are also sentimental and President Roosevelt's reference to 'France eternal' dimmed many an eye."

A dispatch from Stockholm to the Washington Star declared:

"Paul Joseph Goebbels has been fighting a losing battle here, where American propaganda has slowly overwhelmed the Nazis' energetic and carefully planned effort to convince the Swedes that Germany has right on her side and is bound to win the war."

In French Guiana and Martinique, OWI broadcasts were an important influence in bringing about the downfall of the pro-Vichy governors and the going over of the colonies to the United Nations.

The OWI has maintained constant two-way radio contact with Algiers; and North African stations, both medium and short wave, relay many United States programs to Europe on a daily basis.

South American Broadcasts

In this hemisphere, OWI serves the three South American colonies of foreign powers and the West Indies colonies. The CIAA, on the other hand, works with all twenty of the independent American republics, sending out a total of 550 short-wave programs a week, ranging in length from five minutes to half an hour. Of these, 153, which are aimed at Brazil only, are in Portugese. One hundred eighty-six are in English and 211 in

TODAY . . .

IT'S DECIDEDLY WORTH WHILE TO RE-CHECK DIELECTRIC SPECIFICATIONS AGAINST THE UNUSUAL COMBINATION OF PROPERTIES OF

ACADIA POLYSTYRENE

TUBING · RODS
SHEETS
MOLDED AND EXTRUDED SHAPES

★ The combination of highly desirable electrical properties found in Acadia Polystyrene recommend this material for a wide variety of applications. It possesses an excellent dielectric constant value. Its dielectric strength and power factor compare favorably with the electrical quality of ceramics and mica and are superior to any other commercial plastic. Moisture absorption is zero. These and other wanted properties—plus Acadia's wide experience with plastics—suggest an immediate investigation of Acadia Polystyrene. Some values are given below. Complete data are available on request.

Dielectric Constant	2.5 to 2.6
Power Factor, 60 cycles	.0001 to .0003
10^3 cycles	.0001 to .0003
10^6 cycles	.0001 to .0008
Dielectric Strength, Volts/Mil 1/8" thickness	Short time 500 to 700 Step by Step 450 to 600
Volume Resistivity, ohms-cms	10^{17} to 10^{19}
Heat Resistance	105°F Continuous
Softening Point	190°F to 250°F
Specific Gravity	1.05

WRITE TODAY *for data sheet giving physical properties of Acadia Polystyrene, with table of specifications on electrical properties.*

Another Acadia Plastic—Styraloy*

combines the low temperature flexibility of rubber and electrical properties approaching those of Polystyrene, and is ideal for numerous electrical applications. Full information on forms available to date and physical and electrical properties may be had on request.

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Processors of Synthetic Rubber and Plastics • Sheets Extrusions • Molded Parts

Spanish. Most CIAA programs are produced by NBC and CBS, under contract.

Since its programs do not go to enemy or enemy-occupied countries, where short-wave broadcasts are the only means of communication, CIAA is able to use other forms of communication to a greater degree than OWI; some of its programs are sent out of the United States by radio telephone and rebroadcast locally, many others are produced locally in the Latin-American countries.

CIAA makes greater use of transcription than does OWI. CIAA's short-wave broadcasting is done over the same stations used by OWI but its peak of activity comes at a different time—5 p.m. to midnight, Eastern War Time, OWI's slack period, being CIAA's period of greatest activity. CIAA broadcasts about eight hours a day.

Foreign News

Although few Americans listen to them, short-wave broadcasts from Germany come to this country 11 hours every day and from Japan 4½ hours. Other short-wave programs come from our Allies, our Latin-American neighbors and neutrals.

To keep government agencies and the armed services informed of the contents of these foreign broadcasts, the Foreign Broadcast Intelligence Service (FBIS) of the FCC covers about 2,500,000 words a day, summarizes and digests the broadcasts, records the more important of them, translates them from 35 or more languages and dialects, and finally sends on the intelligence which they contain to the government departments concerned. The OWI checks the FCC intercepts of German shortwave propaganda against what the Germans are saying to their own people, or with contradictory statements which prove the falsity of the stories they broadcast to America.

The FBIS forms part of the widespread United Nations network of radio interception, cooperating especially with OWI and with British and Dominions interception services all over the world, with interchange of findings. The FBIS monitors for the Army all messages from American prisoners of war forwarded by Axis radio. These are forwarded to the War Department for notification of relatives.

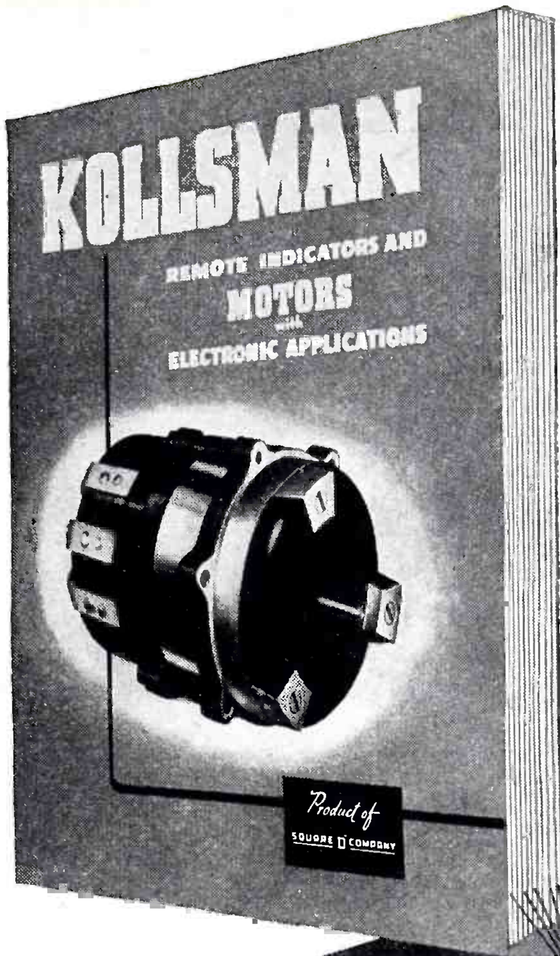
Details of the bombing of Tokio

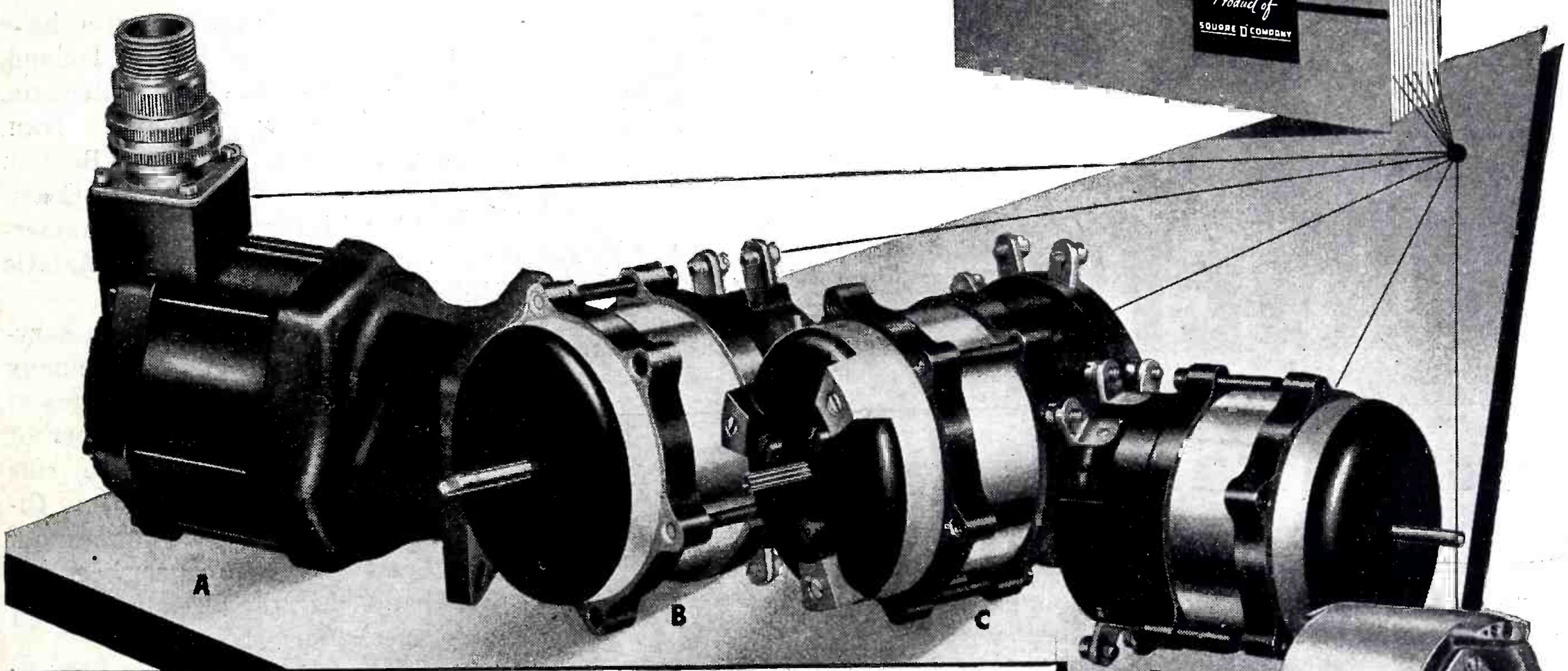
Design Engineers!

Kollsman Offers This New Line Of Miniature Motors For Special Applications

A new line of miniature motors with special remote indication and electronic control applications has been developed by Kollsman Instrument Division of Square D Company. Design engineers of electrical and electronic equipment manufacturers will find Kollsman engineers ready to assist them in applying and adapting these motors to their specialized requirements.

Complete information and performance data on the five units described here can be obtained from this catalog. Write to Kollsman Instrument Division of Square D Company, 80-10 45th Avenue, Elmhurst, New York.





A: KOLLSMAN TWO-PHASE GENERATOR—High impedance, permanent magnet, two-pole generator, capable of operating at speeds up to 2500 R.P.M., delivering up to 83 volts. Compact, light in weight, and designed to operate under widely varying temperature and humidity conditions.

B: KOLLSMAN TELETORQUE UNITS—Self-synchronizing motors operating in same manner as Telegon units. Capable of remotely indicating movement produced by relatively low torque prime movers but may be used advantageously in some remote control applications. Up to 1.56 in./oz. peak torque.

C: KOLLSMAN DRAG CUP MOTOR—Specially designed high-speed precision motors for applications requiring quick starting, stopping and reversal characteristics. This performance is obtained through the use of a light-weight, low inertia rotor of unique design. Stalled torque, .50 to .70 in./oz.

D: KOLLSMAN ROTATABLE TRANSFORMERS—Two-pole motor-like devices with high impendance phase windings and single phase rotors. Voltage output range 0 to 56 volts with 60 cycle, 32 volt input and 0 to 193 volts with 400 cycle, 110 volt input. May be rotated at any speed up to 1800 R.P.M.

E: KOLLSMAN TELEGON UNITS—Self-synchronous motors for use where only an extremely small amount of torque is available from prime mover. Also suitable for use as a rotatable transformer on such applications.

ELECTRICAL EQUIPMENT • KOLLSMAN AIRCRAFT INSTRUMENTS

SQUARE D COMPANY

ELMHURST, NEW YORK • GLENDALE, CALIFORNIA announced on Japanese broadcasts to home listeners, were first learned over the monitoring radio in Portland.

Radiotelegraph

Although entry of the United States into the war brought about the discontinuance of direct radiotelegraph circuits with Axis countries and countries occupied by the Axis, international radiotelegraph service to and from the United States has been greatly extended since the beginning of the war.

Prior to Pearl Harbor, radiotelegraphic communications between the United States and Australia were relayed via Montreal. Now the traffic is routed over direct circuits. New direct radiotelegraph circuits have been established to Egypt, Iceland, Paraguay, Bolivia, New Caledonia, Greenland, New Zealand, Iran, French Equatorial Africa, Belgian Congo, Algiers, British Gold Coast, Bermuda, Afghanistan, and numerous points in European and Asiatic USSR and unoccupied China.

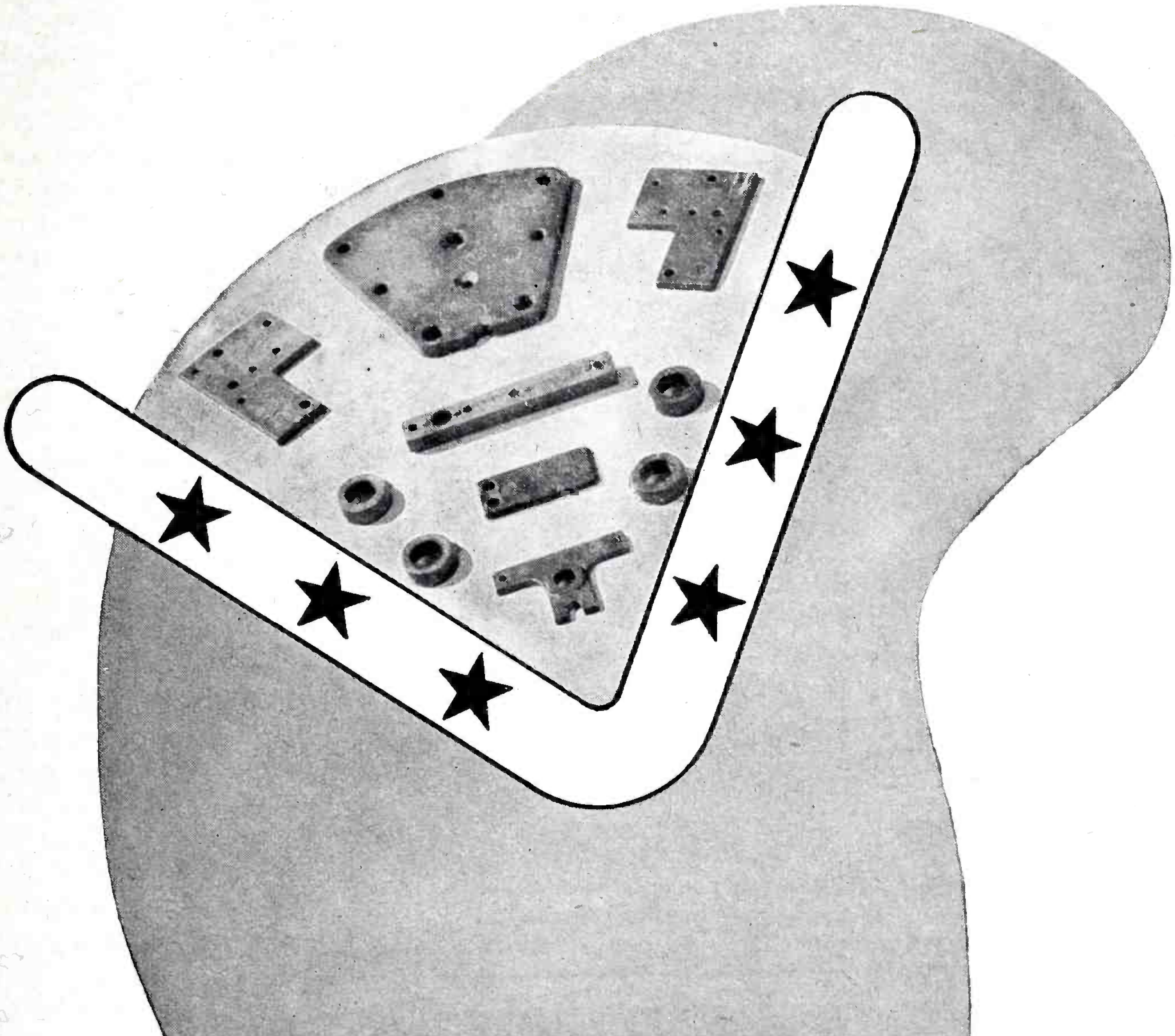
To each new point to which service is inaugurated, only one company is permitted to operate. Shortages of materials and the limited number of long-range channels available rule out parallel, competing circuits. Civilian use must be held to a minimum if any essential military services are to be handled in the already crowded radio spectrum.

Flat Rate for Soldiers

In June, 1942, special low-priced cable and wireless message rates were made available to members of the American Expeditionary Forces and persons communicating with them. A combination of any three of 104 fixed texts, designed to cover nearly all occasions, offers the sender a low message rate—60 cents or its equivalent in other currencies. This is a two-way, purely overseas service. It is available at practically every overseas base.

Policing the Ether

At present, the Radio Intelligence Division (RID) of the FCC is particularly alert for signals which might prove to be illegal. Since July, 1940, over 2,000 such cases have been investigated and many operators have been convicted. Also detected have been many radio stations oper-



ated by agents of the enemy.

For its policing work, the RID maintains twelve primary monitoring stations, ninety secondary monitoring stations (one or more of which are located in each of the 48 States, the territories and possessions) and three radio intelligence centers at Honolulu, San Francisco and Washington. Monitoring stations are usually located in isolated places far from the nearest town to procure ideal listening conditions.

Thirty mobile units of two men each maintain a continuous automobile patrol of the entire 5000-mile coast line of the continental United States. These coastal units watch for any radio transmitters on shore which might be communicating with an enemy ship at sea relative to the departure, location or cargoes of departing vessels. The whole system is so organized that a clandestine signal receivable anywhere in American territory can be traced down.

When an intruder is detected in the ether lanes, either by one of the RID's monitoring stations or by a broadcaster who reports it, direction-finding apparatus is called into play. Three or more monitoring stations collaborate in getting bearings on the signal to determine the general location of the transmitter in question.

The final task of running down the offender is performed by monitoring officers using automobiles which are fitted with the latest detection equipment, including direction-finders, all-wave receivers, and recorders. This apparatus can be operated from the auto's battery, or, upon being removed from the car, from the power supply of a dwelling, store or tourist camp.

Operation of the mobile equipment follows much the same procedure employed by the monitoring stations. Bearings finally "fix" the exact location of the transmitter in question. Even if the hunt narrows to an apartment house, hotel, or other large building, a monitoring officer can, by using a device carried in his hand or in his pocket, proceed from floor to floor and from door to door until he determines the exact room in which the equipment is being used.

Censorship

It is the opinion of the United States Office of Censorship that no nation engaged in this war preserves

Only the industry and the military know the war-story of "shorter wave-lengths or higher frequencies" and the precision thinking and disciplined imagination going into the use-development of the fundamental electric charge of the universe

For these purposes Ken-Rad makes radio and electron tubes Total production now goes to *shorten the war* The experience thus gained will be available for commercial utilization as soon as possible

KEN-RAD

TRANSMITTING TUBES
CATHODE RAY TUBES

INCANDESCENT LAMPS
FLUORESCENT LAMPS

METAL AND VHF TUBES
SPECIAL PURPOSE TUBES

OWENSBORO KENTUCKY U S A

freedom of expression more untrammeled than is the case in the United States. Except for enforcement of the provision in the Radio Act against obscene or profane language, the FCC has no censorship powers whatever, and in the field of domestic communications the Office of Censorship restricts its activities to administering its voluntary "Codes of Wartime Practices," for the press and for the broadcasting companies. The manager of each domestic broadcasting station is a voluntary censor. As mentioned above, even domestic programs in foreign languages are not interfered with except by station managers.

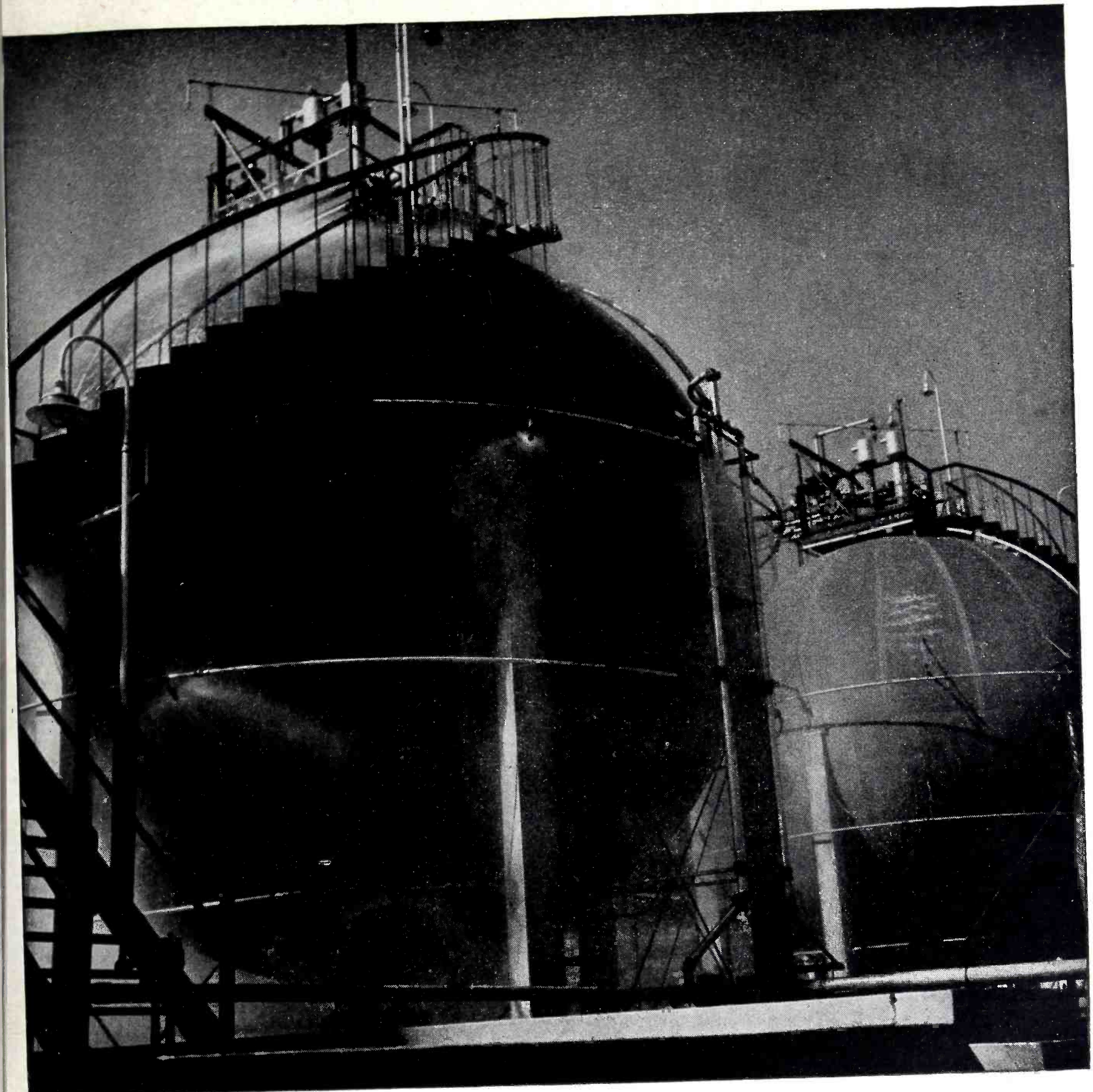
In the field of international communications, the Office of Censorship is charged by law to examine mails, cablegrams, radiograms and all other forms of messages entering or leaving the United States and its territories and possessions.

Censorship of all short-wave international broadcasting is performed by the broadcasting division. This includes censoring, for security reasons, in New York, San Francisco and other cities of all the outgoing programs sponsored by the OWI and the CIAA, among them those produced by NBC and CBS. Radiophotos are also censored.

Industrial Relations

E. FINLEY CARTER, director of industrial relations for Sylvania Electric Products, Inc., told management executives at a New York meeting of the Society for the Advancement of Management that labor and management must cooperate toward a common goal.

"There must be a sincere interest in people all the way down from the top management to the lowest level of supervision," Mr. Carter said. "A management that displays such an interest and seeks to develop a broad understanding of its responsibilities will recognize the need for incorporating in its philosophy the important principles of human relations. It will recognize that good industrial relations stem from the top and form an important part of the corporate personality. It will encourage the lower levels of supervision to develop a keen interest in and under-



standing of the personnel for whom they are responsible.

"Either management and employes will work together as a team or they will eventually separate into opposite camps. There can either be management-labor cooperation and good will in working toward a common goal with its mutual benefits, or there can and probably will be selfish battles for short-term benefits that will work to the detriment of our entire social fabric.

"There have been cases where selfish management has failed to provide adequate pay or decent working conditions for employees. Likewise, there have been cases where selfish labor groups have failed to see the necessity for competitive costs and adequate company profits and reserve. In each case, the operation of selfish gain has been a short-term success followed by serious difficulties."

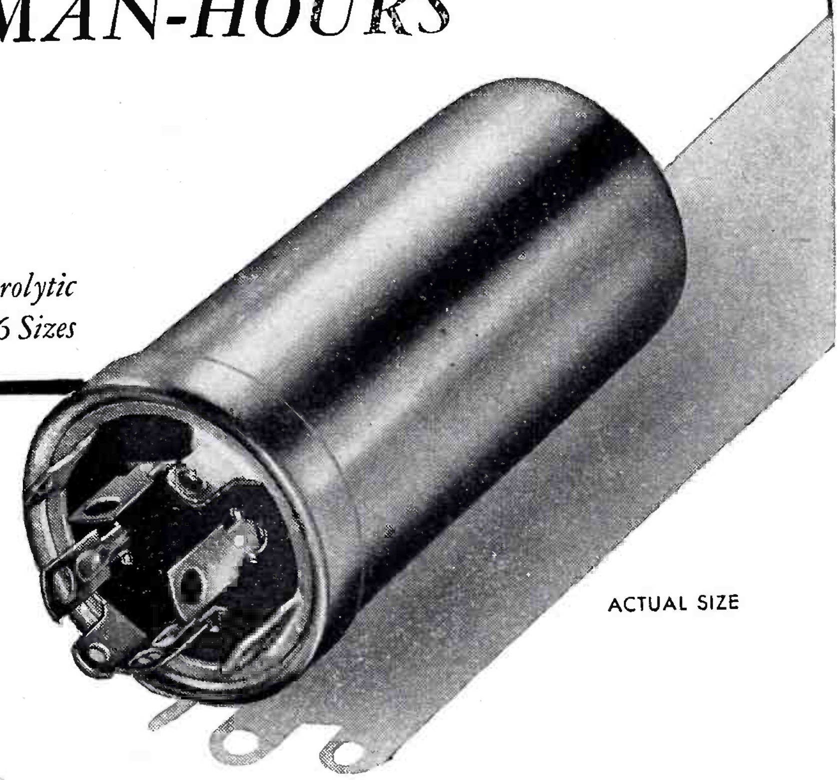
He gave his listeners a check-list of necessities for good industrial relations:

1. A sound management philosophy giving due weight to the human equation.
2. The establishment and development of this philosophy throughout the organization.
3. Realization that authority and responsibility are inseparable, but that both must be earned.
4. Unselfish cooperation for the good of the whole, with each level interested in the welfare of the group below.
5. Recognition of the fact that high wages are not a guarantee of good industrial relations, and that environment and good working conditions are also important.
6. A measure of the individual's importance by the number of people he serves, rather than the number working under him.
7. Awareness that paternalism carried too far may be resented as much as other manifestations of superiority.

BRITISH PRISONERS in Germany are taking their Associate Membership Exams for the Institution of Electrical Engineers, through arrangements made by the British Red Cross Society. Of the 19 who took last year's exams in this way, 11 passed with high marks.

☆ ☆ ☆ MAGNAVOX SAVES RADIO INDUSTRY MILLIONS IN DOLLARS AND MAN-HOURS

Magnavox Molanode Electrolytic Capacitor, Standardized in 6 Sizes



ACTUAL SIZE

REMEMBER HOW many shapes and sizes of capacitors there were before Magnavox engineers standardized them? Many were three times as large as are now used for the same capacity.

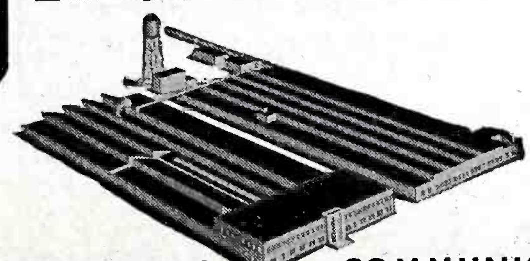
The Magnavox Molanode Electrolytic Capacitor is the end result of years of experience in this field. Through standardization of six sizes, use of a new, finely divided, fabricated aluminum anode called "Molanode" and an improved processing technique, economies were made that save incalculable money and time.

This is but one example of the problems solved day after day by Magnavox engineers, creating and manufacturing equipment for all the U. S. Armed Services and for all the United Nations. These developments range from solenoids to the most intricate types of complete radio communication systems.

Magnavox brings to the war effort the skill and "know how" developed by 32 years of designing, engineering and manufacturing for the radio industry, the splendid facilities of the completely modern new six acre plant, finest machine tool equipment and the production economies of efficient management. The Magnavox Company, Fort Wayne 4, Indiana.

Magnavox skill and craftsmanship won the Navy "E" in 1941, among the first awarded... now with 3 White Star Renewal Citations.

FOR 32 YEARS **Magnavox** HAS SERVED THE RADIO INDUSTRY



LOUD SPEAKERS • CAPACITORS • SOLENOIDS   COMMUNICATION & ELECTRONIC EQUIPMENT

21 Years of Networks

CHAIN BROADCASTING has come a long way from the first chain program, which broadcast the World Series ball games direct from the playing field in New York in 1922, to this day when world-wide hookups are not uncommon.

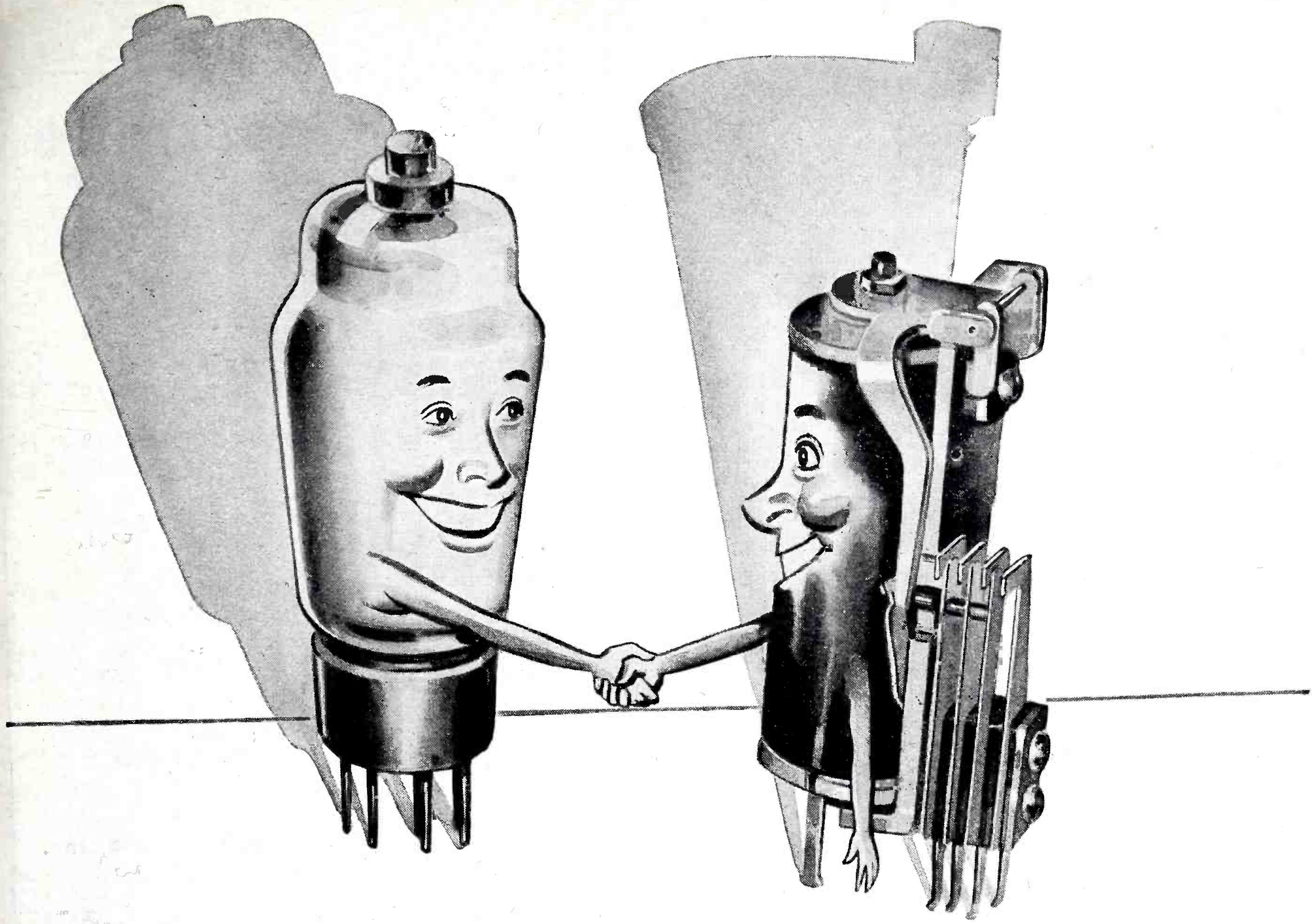
Its development in America can be attributed to that partnership of interest between listeners and stations in which the important question of supply and demand was paramount, according to Kolin Hager, manager of General Electric's station WGY which, with WJZ in New York, introduced and pioneered in chain broadcasting 21 years ago.

When WGY began broadcasting in 1922, the lack of an adequate number of program sources in the vicinity of Schenectady led to the joining of WGY and WJZ the same year. Listeners to WGY heard symphonies and Broadway shows from New York, while the WJZ audience heard talent from upstate and talks from the electrical and radio wizards such as Dr. Charles P. Steinmetz and Dr. E. F. W. Alexanderson. Then WRC, station for the nation's capital, joined the two-station "chain."

In 1924 and 1925, wire line facilities were completed to Syracuse, then to Rochester, and finally Buffalo, adding stations WFBL, Syracuse; WHAM, Rochester; WMAK, Buffalo, to WGY, WJZ, and WRC. WTAM, in Cleveland, was next added, and a station in Chicago was contemplating joining the network when NBC was formed in 1926.

The stations which had pioneered in chain broacasting then joined with NBC, realizing that through its contemplated wide-spread hookup they would be able to get the world's "best" on regular schedule.

The first television network, picking up a program from NBC sent out from the Empire State antenna and relaying it to the television audience of the Schenectady-Albany area, took place January 12, 1940. On Easter Sunday, a few months later, G-E engineers established another record, when it picked up the Easter parade as telecast by NBC and re-telecast it to a group gathered atop Whiteface mountain in the Adirondacks, 250 miles airline from New York. The war has prevented further experimentation but this promises to be resumed when peace is declared.



LET'S POOL OUR KNOWLEDGE

WORKING with electronic engineers in scores of industries has taught us a lot about electronic science—what it is doing to increase the effectiveness of our tools of war—how it is speeding up war production—about the miracles it promises for our postwar world.

We have learned, for example, how much this "new-old" science depends on the right electrical controls—the important part that relays, stepping switches, solenoids and other control devices play in putting electrons to work.

And that's *our* strong point. We know electrical control because that has been our sole business for over fifty years. So why not pool our resources? Let's apply *our* experience in electrical control to *your* problems in making electronic developments do a better job at lower cost.

First step in this direction is to make sure you have the Automatic Electric catalog of control apparatus. Then, if you need help on any specific electronic problem, call in our field engineer. Behind him are Automatic Electric's fifty years of experience in control engineering. His recommendations may save you time and money.

AUTOMATIC ELECTRIC SALES CORPORATION
1033 W. Van Buren St. Chicago
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Relays
AND OTHER CONTROL DEVICES
by **AUTOMATIC ELECTRIC**

MUSCLES FOR THE MIRACLES OF ELECTRONICS

Personnel

H. H. Friend, formerly with Scintilla Magneto Division of the Bendix Aviation Corp., is now development engineer of electronics, Airplane Division Dept. of the newly formed Development Division, Curtiss-Wright Corp. of Bloomfield, N. J.

Frank W. Walker, chief engineer of the 44 FM stations in the Michigan State Police network, was elected president of the Associated Police Communications Officers, Inc., at the close of the War Communications Conference at Madison, Wisc.

Dale Pollack, formerly with Bell Labs. and RCA, recently joined Templeton Radio Co. of Mystic, Conn. as chief engineer.

C. A. Priest, engineer of the Radio Transmitter Engineering Division of G-E at Schenectady, has been appointed manager of the Transmitter Division of the G-E Electronics Dept. and will be responsible for the operations of the Syracuse, N. Y. plant of the company.

E. F. Peterson, formerly section leader on receiving tubes in the engineering division, has been placed in charge of design engineering of receiving tubes in the Tube Division of the G-E Electronics department at Schenectady.

K. C. DeWalt, designing engineer, G-E Tube Division, will continue design engineering of all other product lines of the division.

W. L. Fattig has been appointed acting supervisor of the Technical Service section of the G-E Receiver Division at Bridgeport, to replace P. R. Butler, former manager of the section, who is now a lieutenant in the U. S. Navy.

Captain Thomas B. Inglis, Deputy Director of the Office of Naval Communications since early 1942, has been assigned to a sea command.

Captain John V. Murphy, who returned last year from 3 years sea duty in the Pacific and has since been active in the coordination of Army and Navy activities, succeeds Captain Inglis as Deputy Director of the Office of Naval Communications.

RANGES

D-C Voltage—*Measurements from 10 millivolts to 1000 volts (20,000 ohms per volt) in full scale ranges of: 1/10/50/200/500/1000 volts. (Up to 5000 volts with very compact external multiplier.)*

A-C Voltage—*Measurements from 0.1 to 750 volts (1000 ohms per volt) in full scale ranges of: 5/15/30/150/300/750 volts.*

D-C Current—*Measurements from 0.5 microampere to 10 amperes, in full scale ranges of: 50 microamperes, 1/10/100 milliamperes, 1/10 amperes. (Higher ranges with external shunts.)*

A-C Current—*Measurements from 10 milliamperes to 10 amperes, in full scale ranges of: .5/1/5/10 amperes. Higher ranges, up to 1000 amperes, with external current transformers.*

Resistance—*Measurements from 0.5 ohm to 30 megohms in full scale ranges of: 3,000/30,000/300,000/3 meg./30 meg. Center scale values are: 25/250/2,500/25,000/250,000 ohms.*

• The growing use of electronic devices and other sensitive circuits throughout industry poses no new instrument problems for contractors or maintenance departments WESTON equipped. The familiar Model 785, with its high sensitivity and broad range scope, answers these *newer* measurement requirements. But more . . . it also covers most of the *usual* maintenance needs.

Model 785 furnishes another example of WESTON'S engineering foresight . . . designing instruments always with the needs of to-morrow in mind. Other WESTONS, equally important for efficient maintenance in the days to come, are the time-saving WESTON Clamp Ammeter, and the WESTON foot candle meters which measure all types of lighting direct . . . *without correction factors.* Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

Laboratory Standards . . . Precision DC and AC Portables . . . Instrument Transfomers . . . Sensitive Relays . . . DC, AC, and Thermo Switchboard and Panel Instruments.

WESTON

Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters...Aircraft Instruments... Electric Tachometers...Dial Thermometers.

FOR OVER 55 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

Earl Minderman, director of the Division of Research and Information of the OWI Bureau of Motion Pictures for the past year, has been appointed director of information of the Federal Communications Commission.

I. J. Kaar, formerly managing engineer of the receiver division of the G-E, has been appointed manager of the receiver division of the G-E Electronics Department at Bridgeport, Conn.

Ray Zender, in addition to duties as chief engineer and sales manager of Lenz Elec. Mfg. Co., Chicago, wire manufacturers, has been appointed wire consultant to the Radio and (Censored) Section of the War Production Board on a dollar-a-year basis.

Dr. Lee DeForest celebrated his 70th birthday at his laboratory in Los Angeles, where he has been working on problems in television and diathermy.

Nelson P. Case, formerly with Hazeltine Electronics Corp., has been appointed director of the newly created Engineering, Design and Development Division of Hamilton Radio Corp., N. Y.

Jon Larson, chief radio engineer of the Coordinator of Inter-American Affairs, was drowned recently during his vacation.

Samuel R. Ryan, formerly with the WPB Communications Division, is now chief of the Communications Section, a newly created unit established by the Board of Economic Warfare. The new section is a unit of the Utilities Division that had previously handled communications matters.

LaVern E. Quinnell, coordinator of engineering at The Magnavox Co., has been appointed factory manager.

GLASS gages used for inspection of 57-mm cartridge cases at Frankford Arsenal performed 260,000 gagging operations before wear became excessive, as compared to 60,000 operations for a corresponding steel gage.

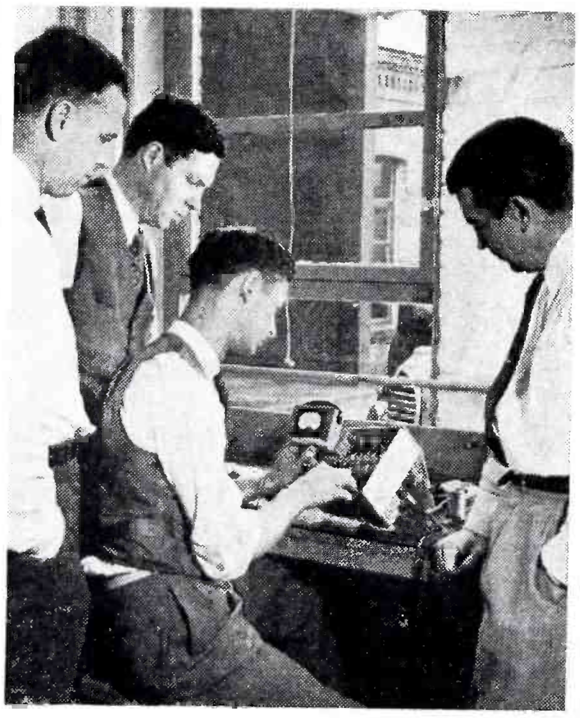
Radio Business News

VICTORY MODEL volume controls have been reduced to eleven types, following a committee meeting of the American Standards Association. The reduction was requested by representatives of the WPB and the OPA.

CHILE has bought transmitter-receiver combinations for the use of road crews in the highway department, according to the Department of Commerce.

EDUCATORS have been warned by the FCC that the five FM channels from 42 to 43 Mc set aside for educational stations would not be held open indefinitely.

THE GRENBY MFG. CO., maker of machine tools for war producers, has entered the electronic equipment field. The plant is located in Plainfield, Conn.

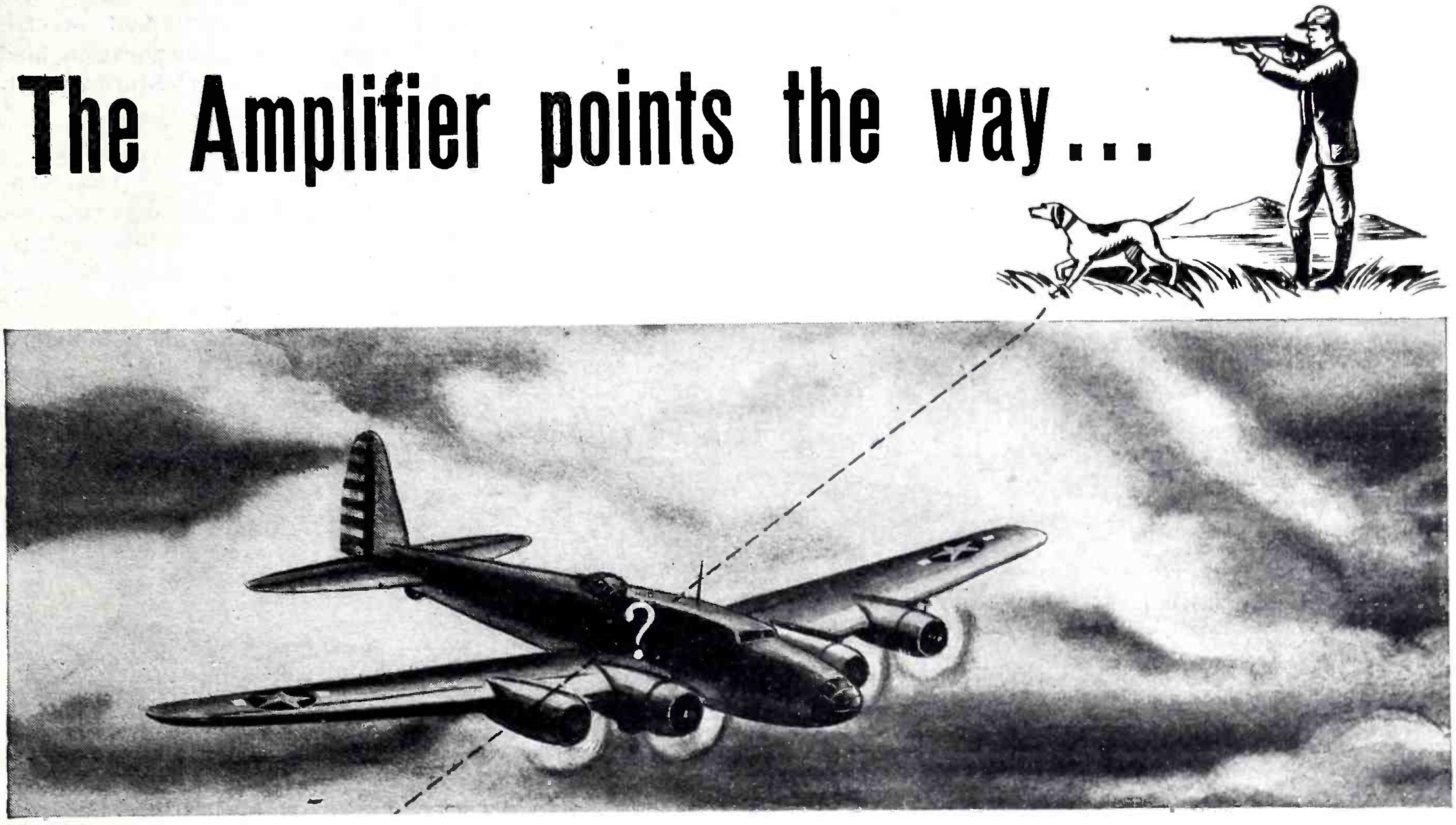


Exeuctives of newly-formed Grenby Mfg. Co., Plainfield, Conn., examine newly-designed vacuum-tube voltmeter. Left to right: Carl A. Gray, McMurdo Silver, W. A. Harrison, Ralph A. Soby

FERRANTI ELECTRIC CO. has moved its offices into the RCA Building, New York.

EMERSON RADIO & PHONOGRAPH CORP. has opened an apprentice training school under the supervision of Maxwell S. Symon, industrial engineer. The subjects to be covered include basic theory of radio, use of electrical instruments, mechanical tests, and the construction of communications equipment.

The Amplifier points the way...



Mission accomplished

More than 15 years ago, we at "Eastern" dedicated ourselves to the task of designing and manufacturing sound amplification equipment. Today, as a result of American engineering skill ingeniously applying amplification principles to highly specialized instruments, thousands of amplifiers by "Eastern" help to guide our army and navy bombers with unerring accuracy in successfully completing their vital missions.

"Eastern" is proud to have the opportunity of contributing our years of specialized training to the war effort. Of course war work gets first call at our plant and our facilities are at your service for that purpose. But busy as we are, we also have time to plan with you now for better amplifier products after victory.

Our engineering staff invites your inquiry—large and small production runs. Even single units, receive our usual prompt attention. *Write for Bulletin* 93E.

Eastern AMPLIFIER CORPORATION
794 EAST 140th STREET • NEW YORK 54, N. Y.

BACK THE ATTACK... BUY WAR BONDS AND STAMPS

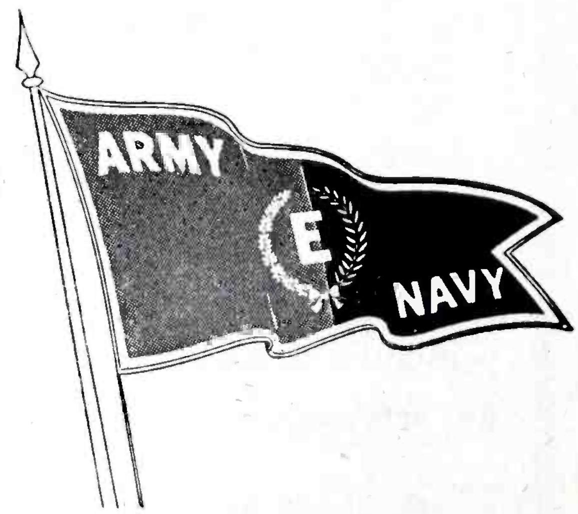
KURBAK ELECTRONIC CORP. is a new company to engage in the manufacture of electronic equipment, according to articles of incorporation filed with the Secretary of State of Illinois.

CLAROSTAT MFG. CO., INC. has consolidated all business departments, formerly spread out in three plants, at 130 Clinton St., Brooklyn, N. Y.

SAM TOUR & CO., INC. has established main offices at 65 Pine St. and laboratories at 45 Fulton St., New York. The company specializes in the metallurgical, chemical, and process engineering fields. Testing facilities include radiography, and x-ray diffraction.

KELLY-KOETT MFG. CO., maker of x-ray equipment, is adding a one-story addition to the plant at Covington, Ky.

ZENITH RADIO CORP. announces the purchase of The Microtube Labs. of Chicago, maker of midget tubes for hearing aids.



BENDIX AVIATION CORP., OWOSSO, DIVISION,
Owosso, Mich.

CALLITE TUNGSTEN CORP.,
Union City, N. J.

CANNON MFG. CORP.,
Los Angeles, Cal.

CHICAGO TRANSFORMER CORP.,
Chicago, Ill.

DOUGLAS AIRCRAFT CO., INC., LONG BEACH PLANT,
Long Beach, Cal.

HAZELTINE ELECTRONICS CORP.,
Little Neck, L. I., N. Y.

SCIENTIFIC RADIO PRODUCTS CO.,
Council Bluffs, Iowa

WHEN EACH SMALL PART, as it comes from the machine—each finished article, as it comes from the assembly line—*varies not at all* from the others, the problems of QUALITY production have been solved, and QUANTITY production presents small difficulty.

Modern electrically operated manufacturing equipment is expertly designed to produce with *absolute exactness*. That's the miracle behind today's output. *But*, the mechanical perfection of each individual unit must be matched by an unfailing, unvarying power supply. Every unit, however small, must be responsible for its own security. That is why SOLA Constant Voltage Transformers are widely used to provide protection against damaging voltage variation.

Where this control is lacking, electrically operated or controlled equipment is highly vulnerable to voltage fluctuations. Devices designed to operate at rated voltages *react differently* to drops or increases in voltage. Then uniform accuracy and synchronization of the production line no longer exists. Precision work becomes impossible. Rejects increase in number.

SOLA "CVs" protect equipment and instruments, absorbing voltage sags and surges up to 30% and deliver an unchanging, specific voltage regardless of input variations from over-loaded supply lines.

Automatic and instantaneous in action, SOLA "CVs" allow no jolts or sags to slip through. They are made with the same modern exactitude as the most intricate equipment. Immediately available in standard units, capacities from 10 VA to 15 KVA, SOLA Constant Voltage Transformers can also be built to your specification.

Note to Industrial Executives: *Where there is a problem involving voltage control, no matter what its nature, SOLA "CV" Transformers can help solve it. Ask for bulletin DCV-74.*

SOLA

Constant Voltage Transformers

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, Ill.**

Control Circuits for Transmitters

(*Continued from page* 105)

ergy storage. The relay is mounted approximately 10 deg. from the horizontal so that the contacts are open when the relay is not energized and the pendulum is at rest.

If no auxiliary contacts are available on the plate contactors, they can usually be installed without great difficulty. However, where this is utterly impossible, auxiliary relays in parallel with the plate transformer primaries could be used.

Automatic Starting Device

An automatic time-delay starting device is particularly useful in two ways, for getting back on the air after a breakdown with a minimum of lost time, and for locating trouble where the fault cannot be expeditiously located without the power on and it is impossible to keep it on without damaging equipment.

The device in use at KMOX will give a start in 10 seconds, providing the interlocking grid and filament relays are all clear, otherwise the start will wait until they do clear. This 10-seconds can be utilized by the operator in getting the studio on the order wire, or in proceeding to the point where trouble is suspected, so that he may observe the equipment at the moment the plate voltage is applied. For example, in the latter situation, the operator is enabled to locate readily a bad tube in a parallel installation when the only indication of trouble is a flash inside the tube.

Electrical details of this device are shown in Fig. 3. If either plate voltage is off, RY_1 will be de-energized and its contact closed. The method of energizing RY_1 is the same as for the reset relay. RY_2 may now be picked up by means of the pushbutton, and it will seal itself in through its lower contacts. The pilot lamp will go on and remain on until the starting action is completed. The upper contacts of RY_2 then excite the filament transformer of the rectifier tube, and apply alternating voltage to the plates of the tube. When the cathode has reached conduction temperature, RY_3 will be energized, closing its contacts across the plate ON buttons. As soon as the plate contactors close, RY_1 will operate, open-

ing its contacts and releasing RY_2. Thus the transmitter has been given one starting impulse. Subsequent starts will not require a full 10 seconds if the tube has not fully cooled. Obviously, RY_2 cannot be picked up when the plates are on or the master control off, eliminating the possibility of accident through a "stored up" start.

Resistors R_1 and R_2 are for dropping the pilot lamp and RY_3 voltages to the proper values from the 220-volt relay circuit used at KMOX. C_1 is shown across RY_3 coil for removing the chatter if RY_3 is a d-c relay. It will not be necessary if an a-c relay is used.

Carrier-Interruption Timing Device

This auxiliary device records the time at which a transmitter breakdown occurs, as well as its duration, permitting the operator to give his entire attention to the cause and repair of the failure without having to note the time both before and after the repair period. It is, like most automatic instruments, capable of greater accuracy than can be obtained by mere observation.

The KMOX timer is shown diagramatically in Fig. 0. Its operation is similar to that of the carrier-protective device described above. The control element is the carrier wave, a bit of which is rectified and used to develop positive grid voltage for the tetrode section of the 117L7 tube, also cathode biased. When the carrier is on, RY_1 and RY_2 are energized, and clocks CL_1 and CL_2 are running, while CL_3 is stopped. All three clocks are self-starting. CL_1 keeps correct time, running continuously.

When the carrier is interrupted, RY_1 and RY_2 are de-energized, CL_2 is stopped, and CL_3 is started. CL_2, therefore, determines the time that the interruption occurred. When the carrier is restored, RY_2 is picked up, stopping CL_3. This clock thus determines the duration of the interruption. RY_1 is not picked up by the carrier, for its coil is shorted through its own de-energized contact and the reset button. After the operator has noted the time of the breakdown, the reset button is pushed, allowing RY_1 to become energized and returning the instrument to its original condition.

The clocks may be set by means of switches 1, 2, and 3, at the oper-

ator's convenience. CL_2, normally running, keeps correct time until the carrier is stopped, and CL_3 is set at 12:00, ready to time any interruption in terms of hours, minutes, and seconds by direct reading.

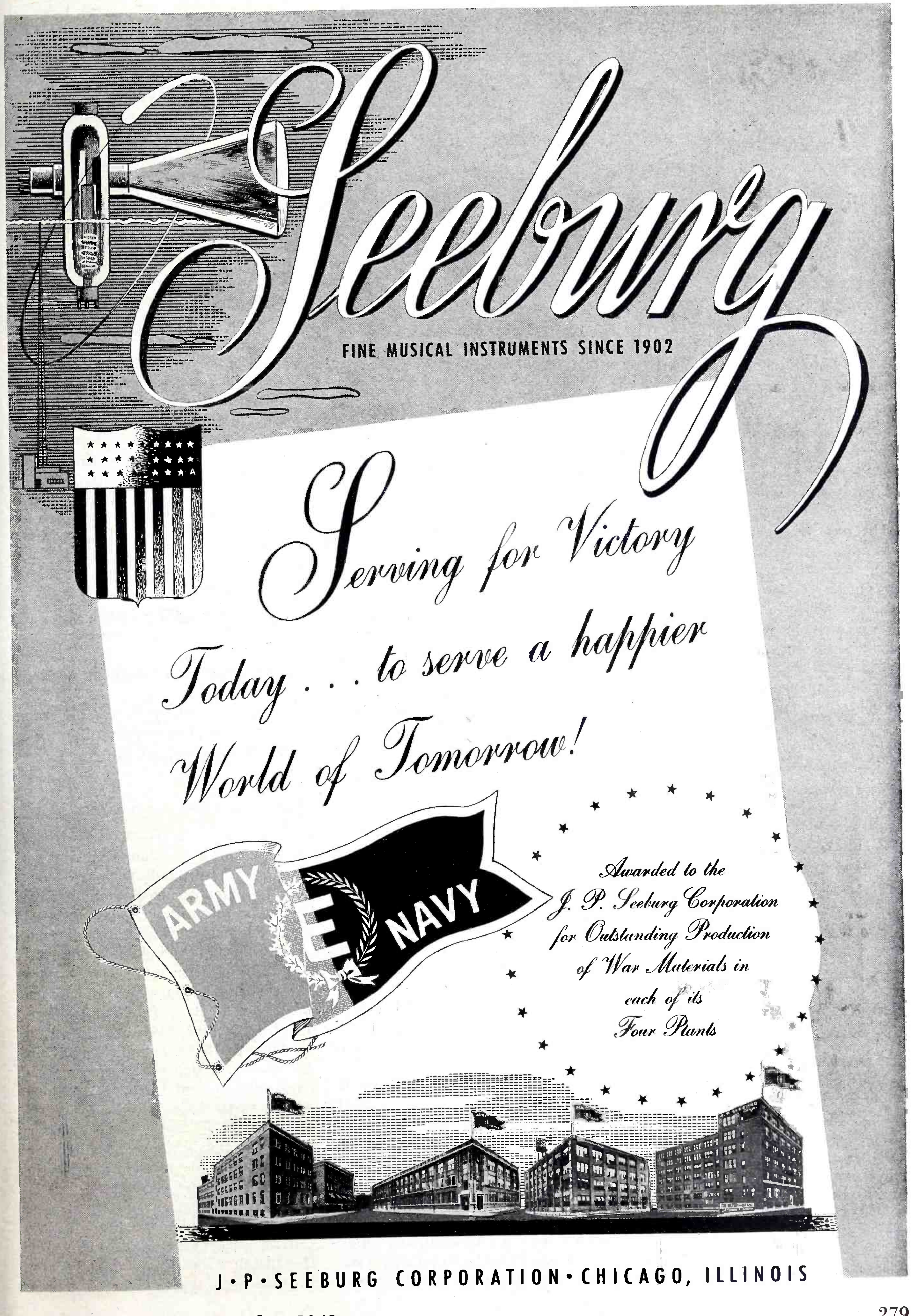
Coil is Interlocked

The coil of RY_1 is interlocked through an energized contact on RY_2 to insure simultaneous opening of both relays. This interlock may not be necessary in all cases, depending on the characteristics of the relays used.

The diode circuit is similar to that of the carrier-protective device, with two notable exceptions. C_2L_1 is tuned exactly to the carrier frequency, C_2 being fixed if desired and the tank tuned by removing turns from L_1. The other, and major exception, is the substitution of C_4, an 8-μf capacitor, for the tetrode grid leak. This provides a time delay of about one second, the time required for C_4 to discharge to the point where the bias limits the plate current to the point where it will no longer energize RY_1 and RY_2. The delay is incorporated to keep the instrument from operating on a normal reset due to overload, since this is not considered an interruption.

A grid leak is not necessary because of the conduction through the electrolyte of C_4. Cathode bias resistor R_1, being 1000 ohms, will bias the tube to a value numerically equal in volts to the plate current in ma. This provides a convenient test consideration, and leads are incorporated for measuring the bias with a voltmeter. When properly adjusted, the bias should be about 15 v with the carrier on and about 8 v with no signal. The circuit C_2L_1 may be tuned by adjusting for maximum bias voltage. Capacitor C_1 isolates the antenna and limits the r-f input. The circuit arrangement operates all the clocks on a 117L7 tube failure, and this calls the attention of the operator to the failure.

As pointed out in the introduction, these four devices are now in actual use at KMOX and are continuing to prove themselves to be well worth while in preventing damage from arcs resulting from static discharges, in saving time and trouble when breakdowns do occur, and in adding to operating convenience. Their use at stations not having similar equipment is highly recommended.


Seeburg
FINE MUSICAL INSTRUMENTS SINCE 1902
Serving for Victory
Today . . . to serve a happier
World of Tomorrow!
ARMY
E
NAVY
Awarded to the
J. P. Seeburg Corporation
for Outstanding Production
of War Materials in
each of its
Four Plants
J·P·SEEBURG CORPORATION·CHICAGO, ILLINOIS

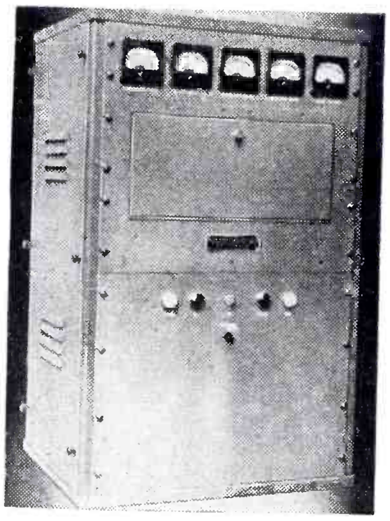
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs. Each month descriptions of these new items will be found here

Communications Transmitter and Control Console

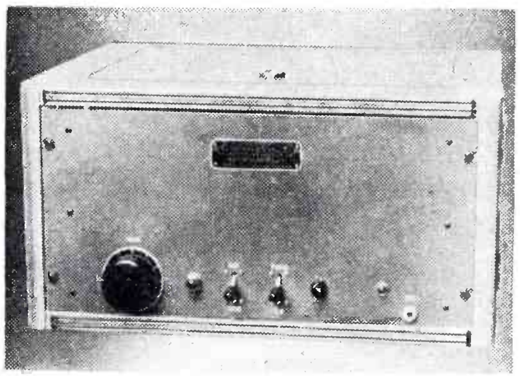
COMMUNICATIONS TRANSMITTER, Type MO-2535, is for use in applications including military, aeronautical, point-to-point, emergency, coastal harbor, relay broadcasting, forestry, and other services.

The basic operational characteristics of the instrument are: Power rating of 200 watts on CW or ordinary phone operation, and 150 watts on heavy duty phone operation; carrier frequency range includes any specified 5 frequencies in the range from 2 to 20 megacycles; audio fidelity involves low distortion between 100 and 1,000 cps; the keying speed is 60 wpm (higher on special order); modulation capability is 100 percent with a safety factor allowance for normal overload; the equipment operates on 110 volts a.c., 60 cps (special voltage and frequencies are also available); dimensions are 36x21x19 inches; weight 350 lbs. Other types of MO-2535 instruments include MO-2535-A with continuous tuning over any 7-to-1 frequency range inside 2–20 megacycles, MO-2535-B which has a tuning set-up for five spot frequency in the range of 2–20 megacycles, and Type MO-2535-C which has continuous tuning from 2–20 megacycles.



Transmitter cabinet, Type MO-2535

The equipment comprising one type MO-2535 consists of the main transmitter cabinet (described above); a set of five piezo quartz crystals, ground to customer's frequency requirements; audio frequency and control cabinet; a push-to-talk microphone with a stand; complete set of operating tubes; a set of spare tubes; a kit of miscellaneous hardware; and an interconnecting cable.



Control and Audio Console

The transmitter has a main power switch. After this one switch has been thrown at the beginning of any operation period, the transmitter is totally controlled, other than frequency changes, by switching facilities on the control and audio console. When the mode of operation is by phone the press-to-talk switch on the microphone controls the carrier off-on as desired. A cable connects the control console to the transmitter cabinet. The cable is 16 feet long but longer lengths are available.

Metering facilities on the transmitter consists of six meters which measure circuit conditions of the oscillator plate current, buffer amplifier plate current, last radio stage plate voltage, last radio stage plate current, and last radio stage grid current and modulator current.

Gates Radio & Supply Co., Quincy, Ill.

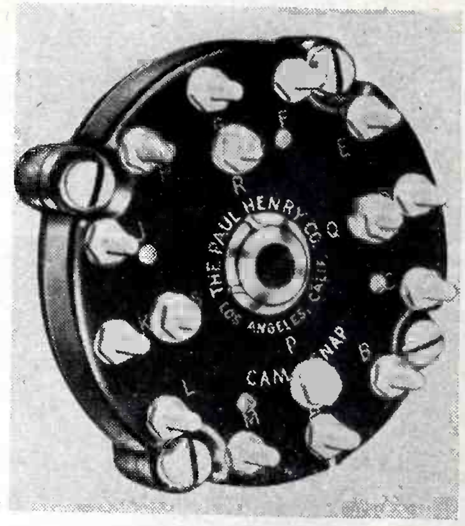
Fused Quartz

TWO TYPES OF FUSED QUARTZ are available. The type known as translucent is made from a very pure grade of sand and gets its name from its satin appearance caused by the imprisonment of millions of air bubbles during manufacture. The other type, clear fused quartz, is made from crushed natural crystals and is more transparent than glass. Both types are useful for many types of laboratory and industrial applications, particularly those having to do with electricity, heat, chemistry and optics. The manufacturer can supply fused quartz in the form of ingots, rods and tubing in a wide variety of sizes. Where standard sizes will not fulfill requirements, special sizes and shapes can be manufactured to suit individual specifications. The product is normally supplied, rough cut, for finishing to specifications by the purchaser—but the manufacturer can arrange to have finishing done upon request.

The fused quartz is available from General Electric Co., Lamp Dept., 84, Nela Park, Cleveland, Ohio.

Aircraft Selector Switch

A SNAP-ACTION, AIRCRAFT selector switch, known as "Cam-Snap Rotary Tap Switch" is made with from one to four primary circuits and twelve secondary circuits. It may be used as a pilot compartment heater control, wing flap control, cowl flap control; and in other applications where the sequence of operation affects the operation of other functional equipment. Opening and closing of a switch circuit is accomplished within three or four degrees motion of the cam. The current rating is 10 amps at 29 volts, inductive load. When the switch is used as a selector switch, it can be mounted singly or in gang and operated by a single shaft. The shaft is serrated, but is available in hex or square design. Any type of cam-operating member can be incorporated. Servicing of the switch is easily accomplished by the use of a screwdriver, which is

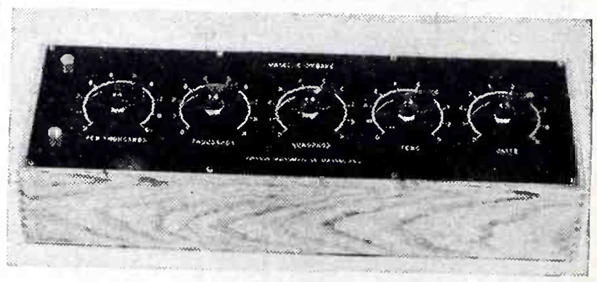


the only tool required to disassemble and assemble the unit. All circuits have screw terminals and no soldering is required. The switch weighs three to four ounces, is compact and can be furnished with detent action, if desired. It fits standard instrument mountings. The case is fully enclosed and is built of macerated phenolic to government specifications. The manufacturer states that under Bureau of Aeronautics testing the switch surpasses its normal life requirements.

The Paul Henry Co., Los Angeles, Cal.

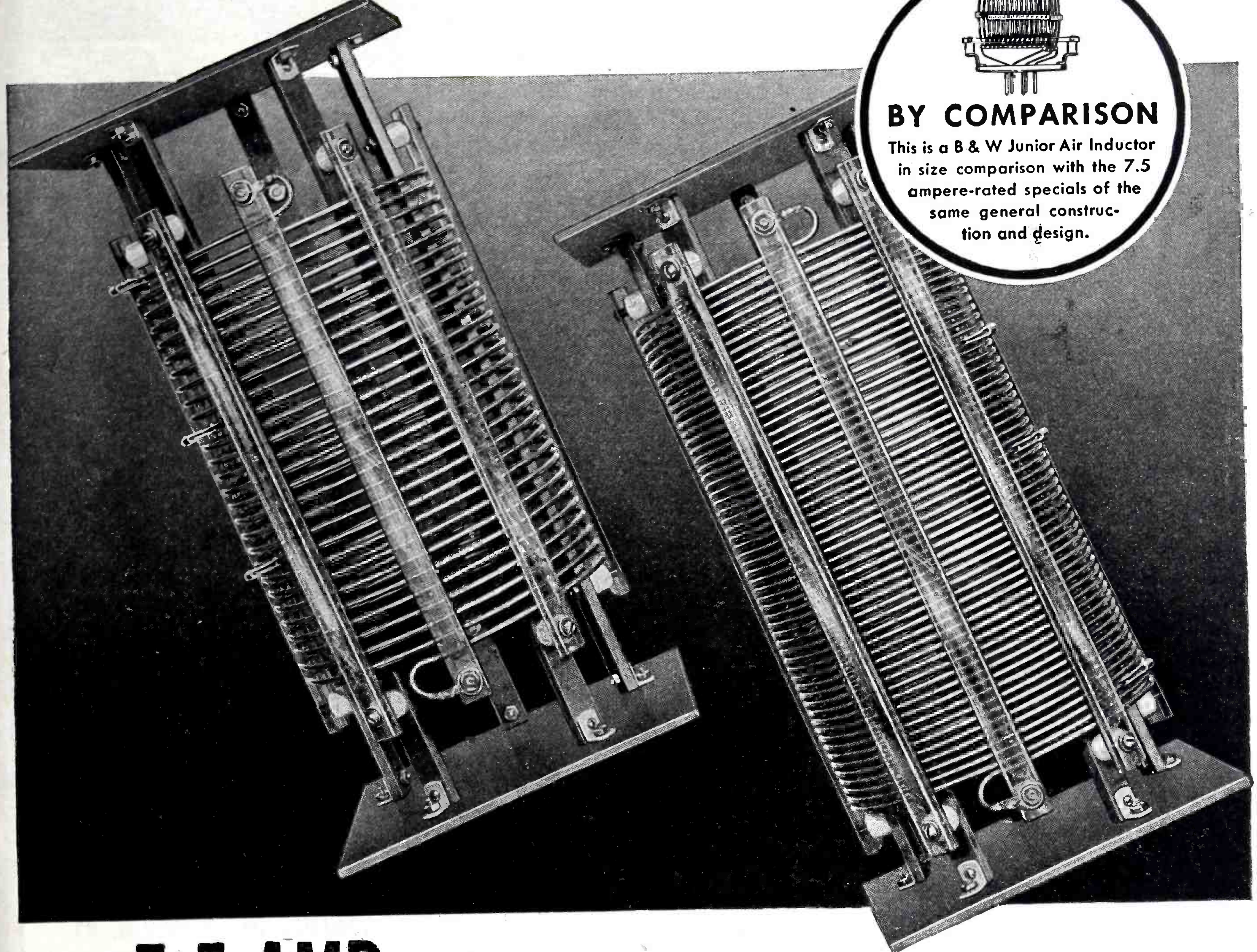
Decade Box

MODEL 5 DECADE BOX is a precise instrument which provides a choice of resistance from 1 ohm to 99,999 ohms in steps of 1 ohm. According to the manufacturer, all decades are adjusted to an accuracy of 1/10th of 1 percent. The resistors are non-inductively wound with wire which has a temperature co-efficient of ± 0.00002 between 20 deg. and 100 deg. C. Low resistance switches are used throughout the instrument. The



Bakelite panel is engraved by a "cut-in" process to eliminate the possibility of letters ever being scratched off. The instrument measures $18\frac{1}{2} \times 6\frac{1}{2} \times 3\frac{1}{2}$ inches. The price for a complete instrument is $59.50 f.o.b. New York, N. Y., and delivery is made in 15 days on a priority rating of AA-3 or better.

Superior Instruments Co., 227 Fulton St., New York 7, N. Y.



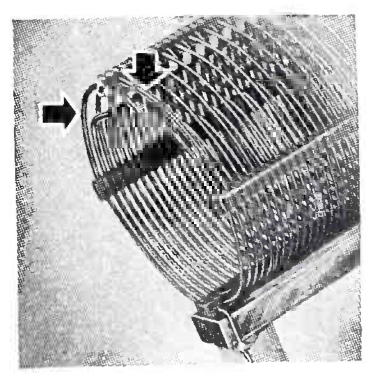
BY COMPARISON
This is a B & W Junior Air Inductor in size comparison with the 7.5 ampere-rated specials of the same general construction and design.

7.5 AMP. CONTINUOUS RATING

But the only thing "Special" is the size

Actually, these 20" giant B & W Air Inductors, wound with #8 solid wire, are simply grown-up war versions of the famous B & W Junior "Air Wound" Coils of amateur radio fame. The only special feature is the size plus, of course, the attendant bracing of triple x bakelite strips and plates for absolute mechanical rigidity. They're attractive in appearance, sturdy as you'd ever expect coils to be, and serve as interesting examples of B & W's unexcelled facilities for the production of special units—often with only a minimum of change from standard designs of unquestioned dependability.

Coils of this type are available through the entire broadcast frequency range. Adaptations are available for specific applications on any frequency. Other B & W coils in both "Air Wound" and form-construction types can be supplied for practically any inductance requirement. Details on any type, or quotations to your specifications, gladly sent.



HOW TO TAP SMALL COILS—EASILY

Ever try to tap a tiny coil where the turns were so close together you felt as though you were trying to fasten a rope to a middle tooth of a fine-tooth comb? Then you'll appreciate this special B & W small coil indent feature. The windings on either side of the turn you want to tap are indented out of the way, thus making tapping quick and easy, anywhere on the Inductor.

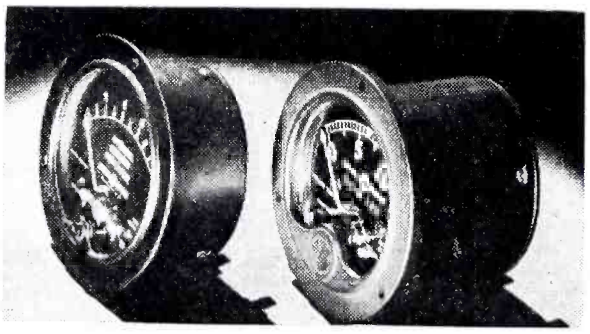
B&W

AIR INDUCTORS

BARKER & WILLIAMSON, 235 FAIRFIELD AVE., UPPER DARBY, PA.

Panel Instruments

A NEW LINE OF SMALL, thin, d-c panel instruments featuring internal-pivot construction are available for use in aircraft, radio and communications equipment, and for application on various types of machinery. Available with either brass or molded Textolite dust-proof and moisture-resisting cases in 2½ inch sizes, the line consists of d-c voltmeters, ammeters, milliammeters, micro-ammeters, r-f ammeters and milliammeters, and d-c volt-ammeters. The volt-ammeter, one of a group designed originally for naval aircraft, has a push-button-operated switch to change the reading from amps to volts. The pivots are mounted on the inside of the armature shell. One jewel bearing is mounted on top of the core-and-frame assembly, and the other is mounted in an adjustable sleeve fitted into the lower part of the soft-iron core, making the element assembly a single, self-contained unit which can be removed easily for inspection or repair in the field. The instruments will operate satisfactorily in temperatures ranging from -50 deg. C to 70 deg. C, and are accurate to within the limits of $\pm$ 2 percent of full-scale value.



The instruments are more thoroughly described in two publications. The first is GEA-4117, which covers instruments designated as Type DW-53 for naval aircraft, and the second is publication GEA-4064, covering panel-type electric indicating instruments designated as Types DW-51 and DW-52.

General Electric Co., Schenectady, N. Y.

Temporary Protective Coating

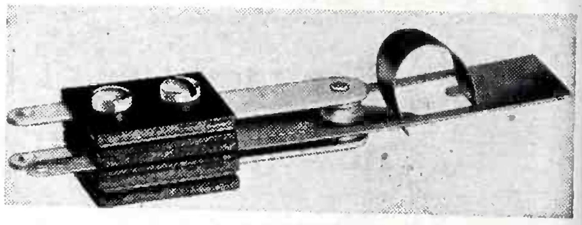
THIS COATING IS A THIN FILM which is applied by a brush or a dip on either smooth or rough surfaces. It dries in about 15 minutes. Greasing or packing in pliofilm bags is not necessary, and when it is desired to remove the coating no solvents have

to be used because the coating is easily stripped off by hand. For short-term protection coating No. 002 is used, and for long periods of storage, No. 003 is available. The manufacturer states the temporary coating has withstood without any effect, 100-hour, 3-percent salt spray tests on steel, copper, brass and aluminum.

Insl-X Co., 857 Meeker Ave., Brooklyn, N. Y.

Snap-Action Switch

DESIGNED TO insure good contact pressure and greater speed of operation, a new small open-blade snap-action switch is available for a wide variety of applications including machine tool control devices, aircraft landing gear controls and for construction of various relays and contactors. The manufacturer states that a patented rolling spring produces a positive snap action with less than 6 ounces of operating pressure,



and that smaller coils may be used in relays, and also that its extremely fast action minimizes contact burning.

The switch permits both pre-travel and over-travel. It has a rating of 15 amps on 125 volts a.c. Its overall size is $3\frac{1}{16} \times \frac{11}{16} \times 1$ inches. It is made in SP, S or DT, set and return types and may be assembled to suit the needs of relay builders.

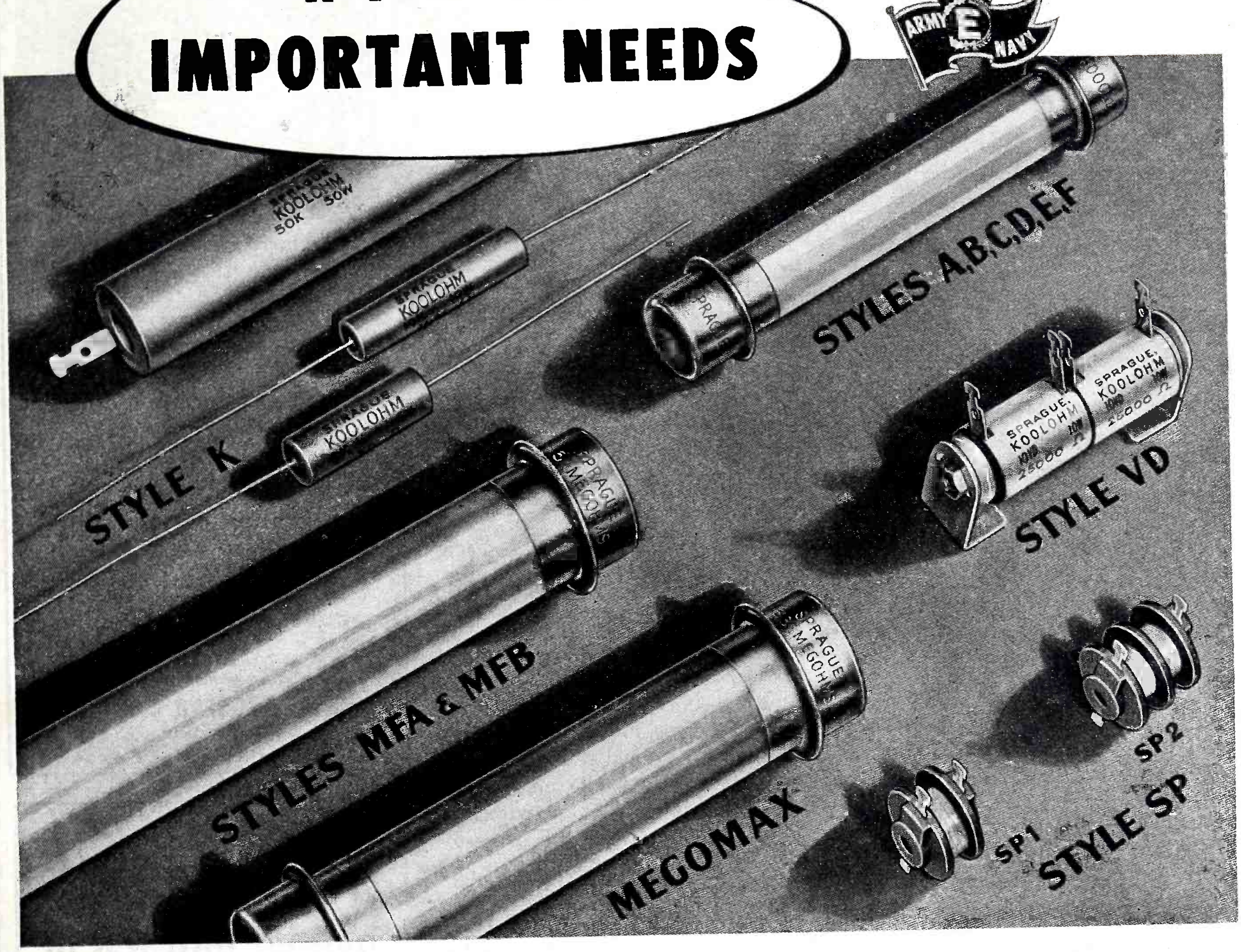
Acro Electric Co., 1316 Superior Ave., Cleveland, Ohio.

Sound System Projectors

TWO NEW INDUSTRIAL sound system projectors are available for music and voice paging, for PA systems, and for time signals or alarms. The speaker baffles are made for 12, 8 and 6-inch projector horns. Each size projector can be mounted vertically or horizontally. The speaker baffles are of rugged two-piece construction.

Available from Commercial Metal Products Co., 2251 West St. Paul Ave., Chicago, Ill.

A TYPE FOR IMPORTANT NEEDS



STYLE "K" RESISTORS: Power Wire Wound Resistors 5, 10, 25, 50, and 120 watts.

Wire lead or lug terminals on styles 5K and 10K.

Lug terminals only on styles 25K, 50K, 120K.

Non-inductive windings available.

Various types of mounting, shown in catalog.

STYLES A, B, C, D, E, F: 120, 90, 50, 35, 20, 10 watts.

Hermetically sealed power wire wound resistors. Designed to withstand salt water immersion tests.

Ferrule Terminals for fuse clip mounting.

Non-inductive windings available.

STYLE V. D.: 10 watt and 15 watt wire wound. Resistors designed to make voltage divider sections when mounted end to end on through bolt.

STYLES MFA, MFB and MFC: Precision Meter Multiplier Resistors. Hermetically sealed. Salt water immersion proof.

Type MFA—7.5 megohms max.
Type MFB—4 megohms max.
Type MFC—1 megohm max.

STYLE SP: Wire wound bobbin type resistors. Style SP-1, single section. Style SP-2, dual section.

2.5 watts, continuous rating, per section.

250,000 ohms max. per section.

MEGOMAX: High voltage, high temperature, composition resistor. Hermetically sealed.

Type 1—3400 ohms to 100 megohms
Type 2—6800 ohms to 100 megohms

Voltage and power ratings depend on resistance value.

SPRAGUE SPECIALTIES CO., Resistor Division, NORTH ADAMS, MASS.

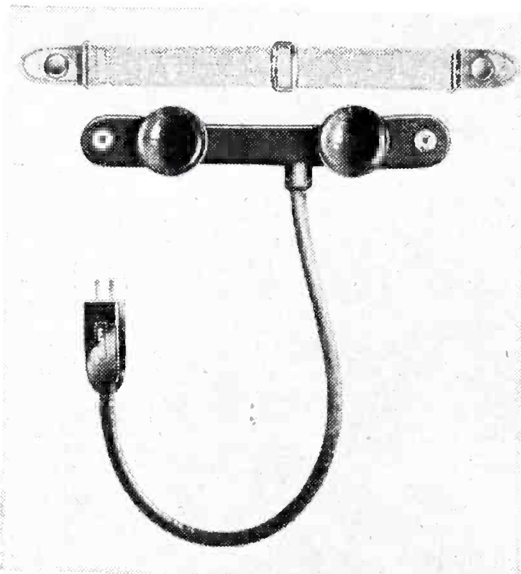
SPRAGUE KOOLOHM RESISTORS

REGISTERED TRADEMARK

Throat Microphones

BOTH THE Universal Microphone Co., (Inglewood, Cal.) and Kellogg Switchboard Supply Co. (6650 S. Cicero Ave., Chicago, Ill.) have available throat microphones.

Universal's microphone is designated as T-30 and is available in bulk orders to sub-contractors and prime government contractors for use on



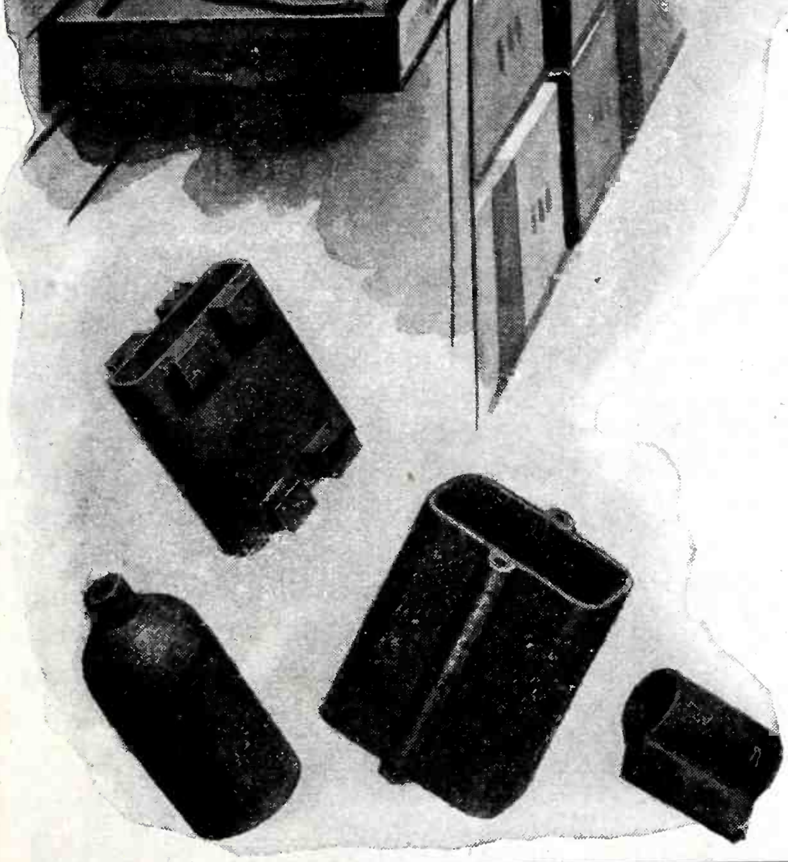
army radio equipment. It is a carbon type, mounted in a synthetic rubber neckpiece with an elastic neckband. The plug is a midget two-prong breakaway type and is non-locking and therefore easily disconnected. Also available with the microphone is an extension cord and a switch assembly which contains the press-to-talk switch for the microphone and control relay circuit.

Kellogg's equipment is a pair of tiny mikes that fit snugly against the

throat and pick up words directly from the vocal cords without noise from an engine or gunfire.

Both of these microphones, are designed to free the wearer's hands for other duties.

HOPE THIS TUBE'S LIKE THE LAST ONE



"Boy, that last transmitter tube was a honey! Dished out the old signals like a dream—for pretty nearly twenty thousand hours. You could pile on the power when you had to and the old tube never acted up afterwards. Seemed like the sky was the limit on high frequencies . . . Wish all tubes were like that..."

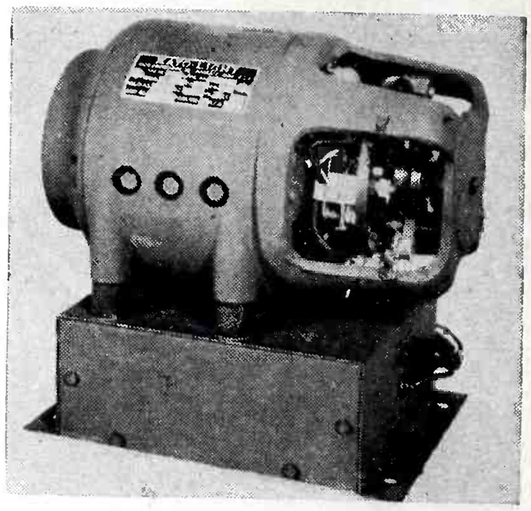
They can be, when built with SPEER graphite anodes. It's remarkable how much more life and stability you pack into rectifier and transmitter tubes with SPEER anodes. Their graphite structure dissipates heat faster, minimizes insulator leakage and gas troubles. Graphite anodes keep their original dimensions in service. Warping and fusing is impossible — even under repeated overloads. Tubes with SPEER graphite anodes materially improve the operation of any transmitter. Write for our Anode Booklet and list of manufacturers using SPEER graphite anodes.

SPEER
CARBON COMPANY
SCC
ST. MARYS, PA.
CHICAGO · CLEVELAND · DETROIT
MILWAUKEE · NEW YORK · PITTSBURGH

4690

Continuous-Duty Converters

NEWLY DESIGNED, TWO POLE, rotary "Konverters" are available in 225 and 350 volt-amps continuous load capacities at 3600 rpm with 40 deg. C temperature rise. The converter changes 32, 110 or 220 volts direct current to standard 110 volts, 60 cps, a-c current. The manufacturer has

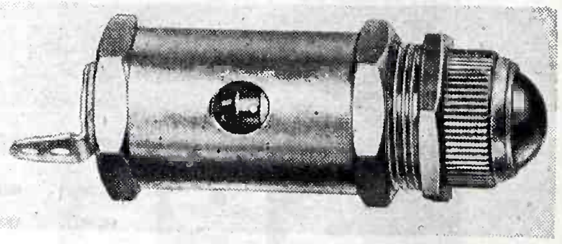


available a special filter which is contained in a sheet metal base upon which the converter is mounted which is for use when the converter is being used with especially sensitive radio or electronic devices.

Kato Engineering Co., Mankato, Minn.

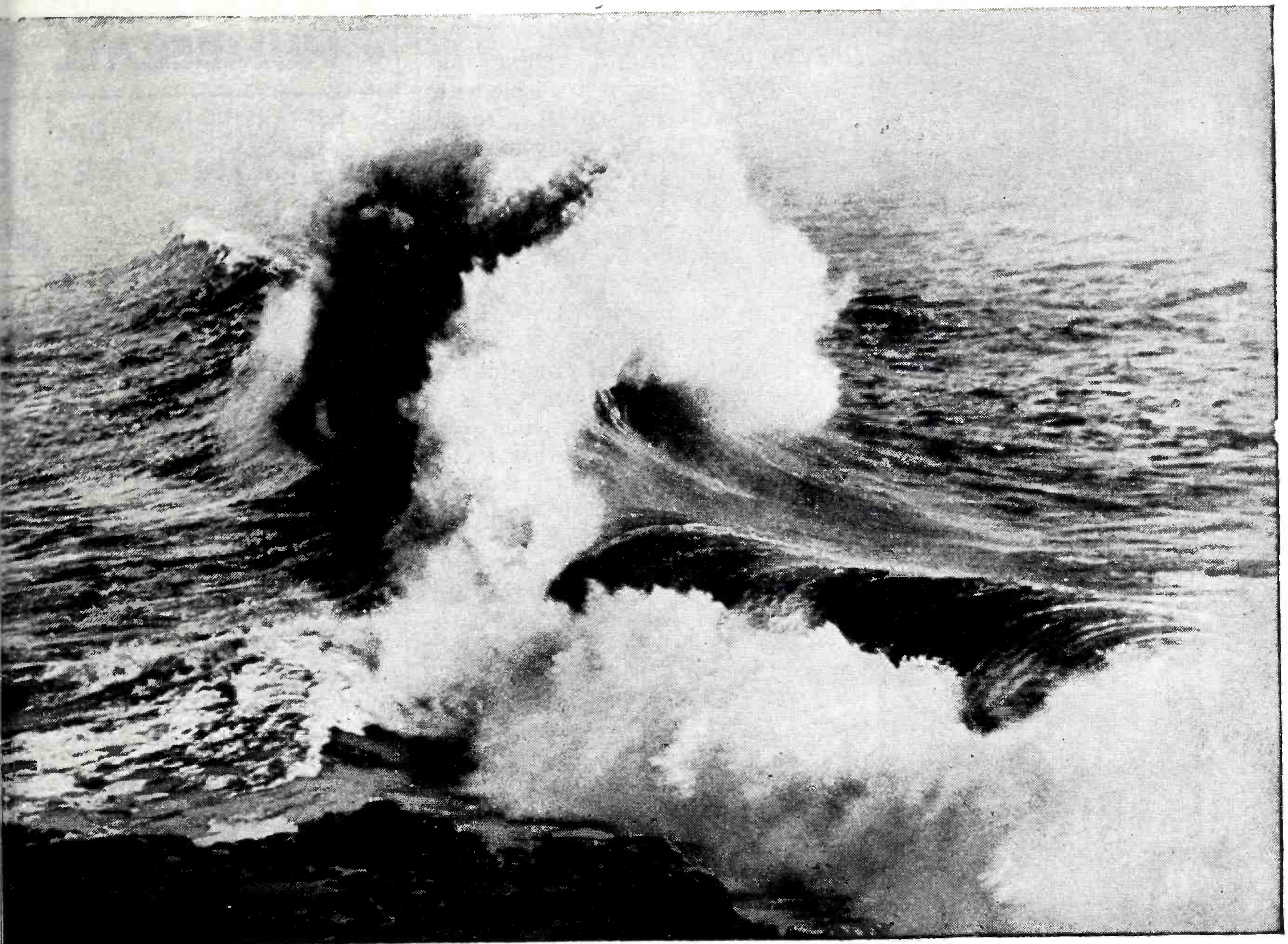
Pilot Lights

SERIES 900 PILOT LIGHTS (designed for grounded pilot light panels) measure approximately 2 inches in length, and mount on 1-inch centers to permit a number of units to be incorporated within a small space. The body of the light is of a hexagon design so that a socket wrench may be used when installing. The bulb, which automatically comes out when the jewel holder is unscrewed, may



be changed from the front of the panel without disturbing the body mounting or wiring.

Ventilated for cool operation, the pilot light is available with either faceted or plain jewels from the manufacturer, Gothard Mfg. Co., 1300 N. Ninth St., Springfield, Ill.



This is the reason they called the tube KLYSTRON*

Does it seem far-fetched to you?

Can there be any possible similarity between an ocean wave and an ultra-high frequency tube?

As a matter of fact, there's a very definite similarity.

A breaking wave is the best way we know to picture what happens to electrons in the KLYSTRON tube invented by the Varian brothers—Russell and Sigurd—and Dr. William W. Hansen.

Inside this tube, the inventors were able to direct a stream of electrons which concentrated their power and released it much as waves do when they mount into crests and crash on the shore.

That's why the tube is called KLYSTRON. The name comes from a Greek word that denotes the breaking of waves on a beach.

Initial research on the KLYSTRON was done in California at Stanford University. The Sperry Gyroscope Company was quick to see the tube's possibilities. So they helped the inventors carry on further development of the KLYSTRON as a valuable tool of war and aeronautics.

When the tube got beyond the early experimental stages, the Varian brothers and Dr. Hansen joined Sperry's staff of inventors, engineers, and research men.

With the close co-operation of the Army and Navy, the development and perfection of the KLYSTRON continued, and is still continuing.

Applications of the KLYSTRON include the generation, amplification, and reception of ultra-high frequency waves. Naturally, they are being devoted exclusively to war uses at present.

When the war is won, Sperry research will explore the fascinating field of KLYSTRONICS** in relation to the comfort and security of a world at peace.

SPERRY
GYROSCOPE COMPANY, INC.
BROOKLYN, N. Y.
Division of the Sperry Corporation

*KLYSTRON is a registered trademark of the Sperry Gyroscope Company—Registration No. 371650.
**Trademark

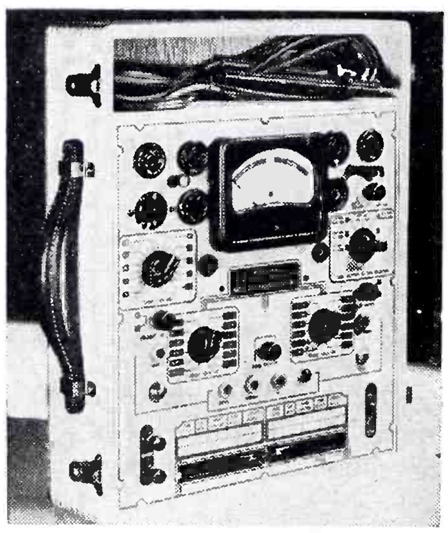
Plastic Tubing

"STRIATUBE" PLASTIC TUBING for electrical insulation is available with one or more color stripes extruded into the body of the tubing to make easy identification possible. The color stripes are an integral part of the extrusion and are as permanent as the body of the tubing itself. Either opaque or transparent tubing can be had with one or more contrasting color stripes in any combination desired. Characteristics of the tubing include high dielectric strength; non-oxydizing properties; resistance to acids, alkalies, oils and greases; and resistance to deterioration due to aging or constant exposure to light. The tubing is available in either flexible or rigid form in a wide variety of sizes, lengths and thicknesses, as well as various degrees of flexibility.

Carter Products Corp., 6921 Carnegie Ave., Cleveland 3, Ohio.

Portable Dual-Tester

MODEL NO. 804 DUAL-TESTER is a new portable tester equipped for direct testing of all acorn tubes, as well as old and new types of regular receiving tubes, rectifiers, etc. It measures 14½x13x6 inches, weighs 12¼ lbs., and comes ready for operation on 105–135 volts, 50–60 cps. Functioning as a multimeter, the ohmmeter reading ratio is 500,000,000 to 1; current reading ratio is 1,000,000 to 1; volt-



age reading ratio is 100,000 to 1. The d-c voltmeter ranges from 0-25-10-50-250-1000-5000. The a-c voltmeter as well as the output voltmeter ranges from 0-10-50-250-1000-5000; the d-c milliammeter ranges from 0-0.5-2.5-10-50-250-1000. The d-c ammeter range is 0–10 amps; ohmmeter ratings are 0-250-2500-25,000-2.5 megohms—25 megohms.

Radio City Products Co., Inc., 127 West 26th St., New York 1, N. Y.

Hydrogen Gas Purifier

REMOVING RESIDUAL OXYGEN, moisture, and other active contaminating gases from commercial hydrogen may be accomplished by a gas purifier which is available for applications such as prevention of oxidation in steel-heating furnaces, reduction of metallic parts in the production of electronic tubes, the welding or brazing of metals in an atmosphere of pure hydrogen, and also for hydrogenation in various food industries. The hydrogen gas to be purified passes through an electrically heated furnace which holds a calorized seamless steel tube containing small pieces of pure copper for removing oxygen. The gas moves progressively through three glass containers filled with purifying ingredients such as caustic potash or sodium lime. The gas finally passes to three supply lines. Each of the supply lines is controlled by one adjustable diaphragm-reducing valve which is capable of reducing the pressure down to ½ lb per square inch. The oven of the purifier operates on 110 or 220 volts. An autotransformer is provided for regulating the heat. All parts of the equipment are mounted on a frame of heavy square steel tubing. Removable caps on top and base of the glass dryers permit easy filling or occasional cleaning.

The purifier is available in different sizes from Eisler Engineering Co., Inc., 740 South St., Newark, N. J.

Alloy Plastic

THE MANUFACTURER of this plastic, known as "Emeloid", says it is a controlled plastic with characteristics similar to those brought about in steels which have been treated with different alloys. As a result, it is possible to obtain hardness, softness, elasticity, toughness, freedom from magnetic attraction, etc., or a combination of these characteristics. The plastic may be used in some applications to replace metal. The plastic can also be formed, molded, shaped, cut, sheared, sawed, punched, pierced, stamped, polished, drilled, machined, lithographed and printed. It is light in weight and available in several grades, in either clear or assorted colors.

The Emeloid Co., 287 Laurel Ave., Arlington, N. J.


MEN SHALL HEAR THE "INAUDIBLE"..
SEE THE "INVISIBLE"
Magic achievements, yesterday the dreams of man, today become working practicalities through the art of Electronics, applied to Science and Industry.
Today all the proven skill and experience of Ferranti Engineers and manufacturing facilities are properly devoted to perfecting new refinements of Transformer design and construction to speed Victory.
But TOMORROW . . . these Ferranti improvements no longer will be "military secrets." They will become working tools in a new world of American Industry. The leadership established by Ferranti Quality will help you meet the challenge of new postwar developments, with an even higher degree of efficiency than it helped in the days that have gone forever. Consult with Ferranti now — on your postwar plans for tomorrow.
Plan with Ferranti
FERRANTI
Mark of Progress and Quality
FERRANTI ELECTRIC, INC. · RCA BUILDING · NEW YORK CITY

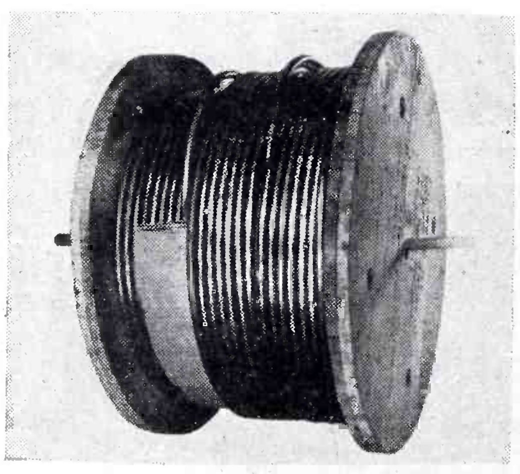
Resonance Meter

Type MW-60 Resonance indicator is a rectifier type vacuum-tube voltmeter which provides means of determining resonance in oscillators and transmitters, measuring standing wave ratios, checking transmission lines, antenna systems, tank circuits, coupling devices, and providing modulation indication. It is ruggedly constructed and may be used for resonance measurements in the field as well as in the laboratory. It is particularly useful in connection with the installation and maintenance of absolute altimeters, blind landing markers, glide path markers, airport traffic control, weather teletype, and broadcast relay circuits. Measurements are made in the ultrahigh-frequency range from 130 to 600 Mc. The meter will not be damaged by severe over-loads. The diode voltmeter head can be moved along the main axis of parallel rods so that optimum impedance matching can be obtained between the tuned circuit and the indicator. A sliding bar is provided so the operator can resonate the parallel rods to the desired frequency.

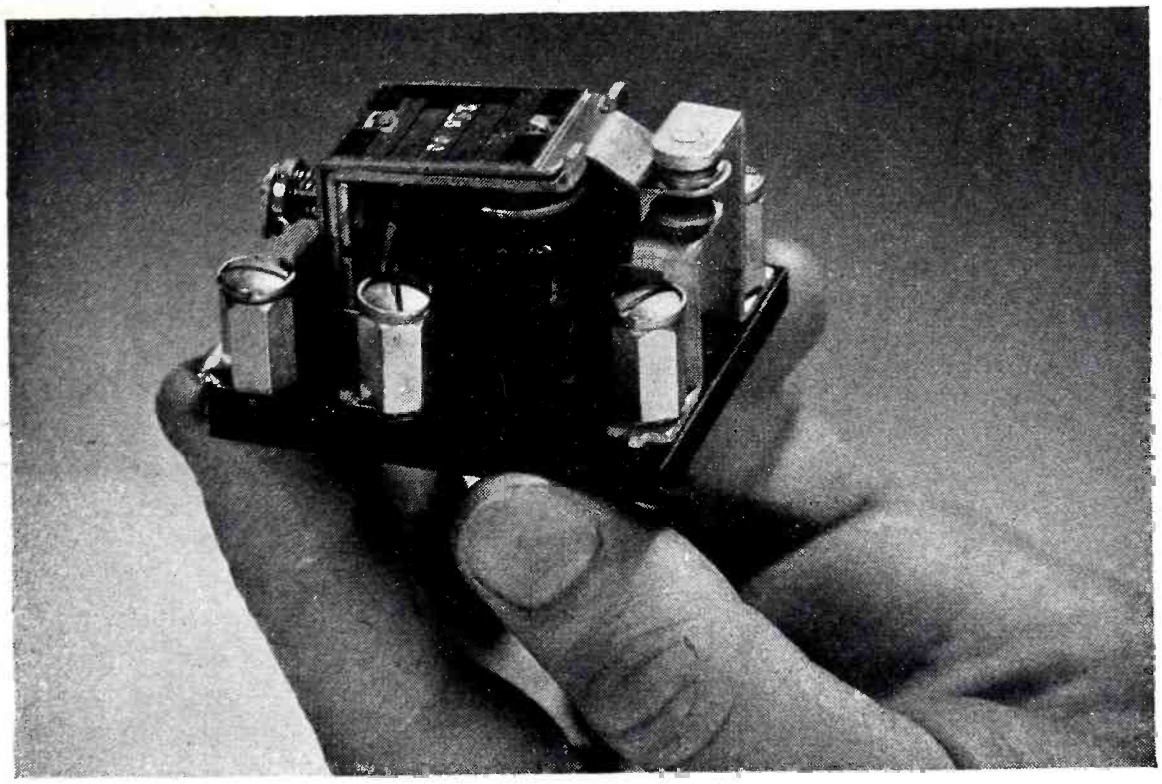
Erco Radio Laboratories, Inc., Fenimore Ave., Hempstead, N. Y.

Copper Coaxial Cable

Soft temper coaxial cable is available in continuous lengths up to several thousand feet. The cable is wound on wooden reels and has the same electrical characteristics as rigid cable of the same size (7/8 inch). The cable can be easily uncoiled and bent by hand to the desired contour. The cable may be obtained with special glass-insulated terminals, and if desired, can be shipped under pressure.

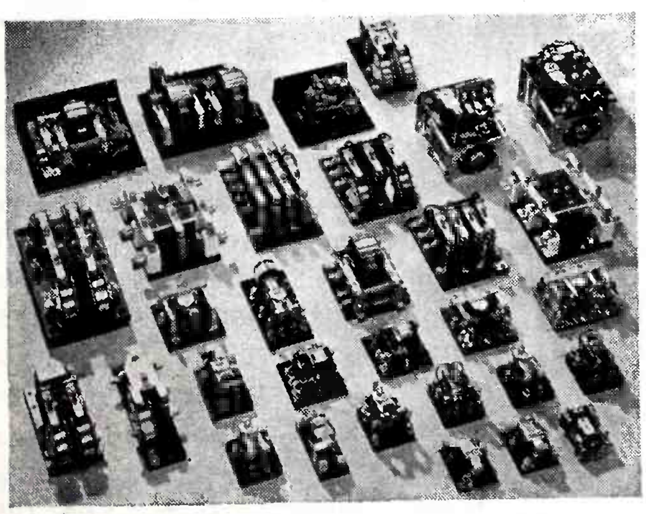


The Andrew Co., 363 East 75th St., Chicago 19, Ill.



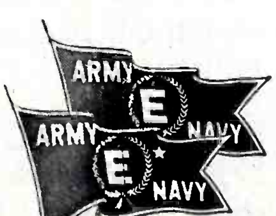
JUST THE RELAY YOU WANT

When you can select the relay that exactly meets your requirements from a regular line, you have saved man power, time and money. WARD LEONARD RELAYS include types and sizes for every application. They all have crisp action, are dependable and durable yet consume but little current. Why have a "special" designed when there is an existing WARD LEONARD Relay that will serve your purpose?



WL Relay Bulletins

Bulletins are available describing light, intermediate and heavy duty relays in various contact combinations, high voltage relays, metal and molded base midgets, aircraft power relays, transfer relays, sensitive relays, thermal and motor driven time delay relays, latch-in relays, and variouus types of radio relays. Send for the data bulletins of interest to you.



WARD LEONARD

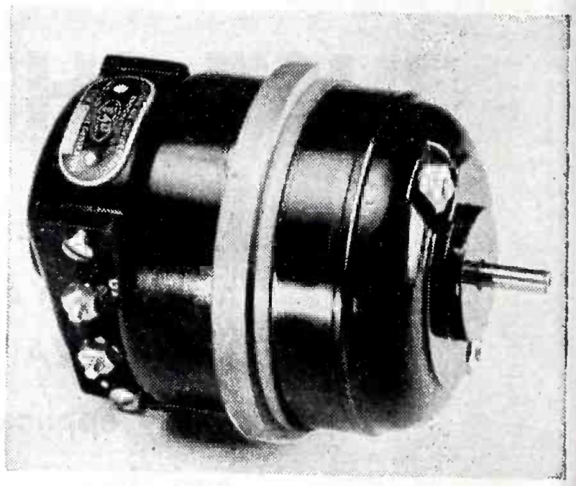
RELAYS • RESISTORS • RHEOSTATS

Electric control WL devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 32 SOUTH STREET, MOUNT VERNON, N. Y.

D-C Voltage Generator

DEVELOPED AS A CONTROL COMPONENT is a 20-ounce d-c voltage generator which uses a permanent magnet field. The unit may be used as a tachometer generator or a circuit control generator. The permanent magnets are made of Alnico. The output voltage is rated at approximately 2 volts per 100 rpm and is linear with speed within 1 percent. Voltages are equal to within 1 percent for the same speed in either direction of rotation. Internal resistance is 230 ohms. Less than $\frac{3}{4}$ ounce-inch torque is required to rotate the armature. For low-speed applications, silver commutators and brushes are available instead of copper. The mounting ring measures $2\frac{5}{16}$ inches in diameter, and



the over-all length of the aluminum housing is $3\frac{1}{8}$ inches.

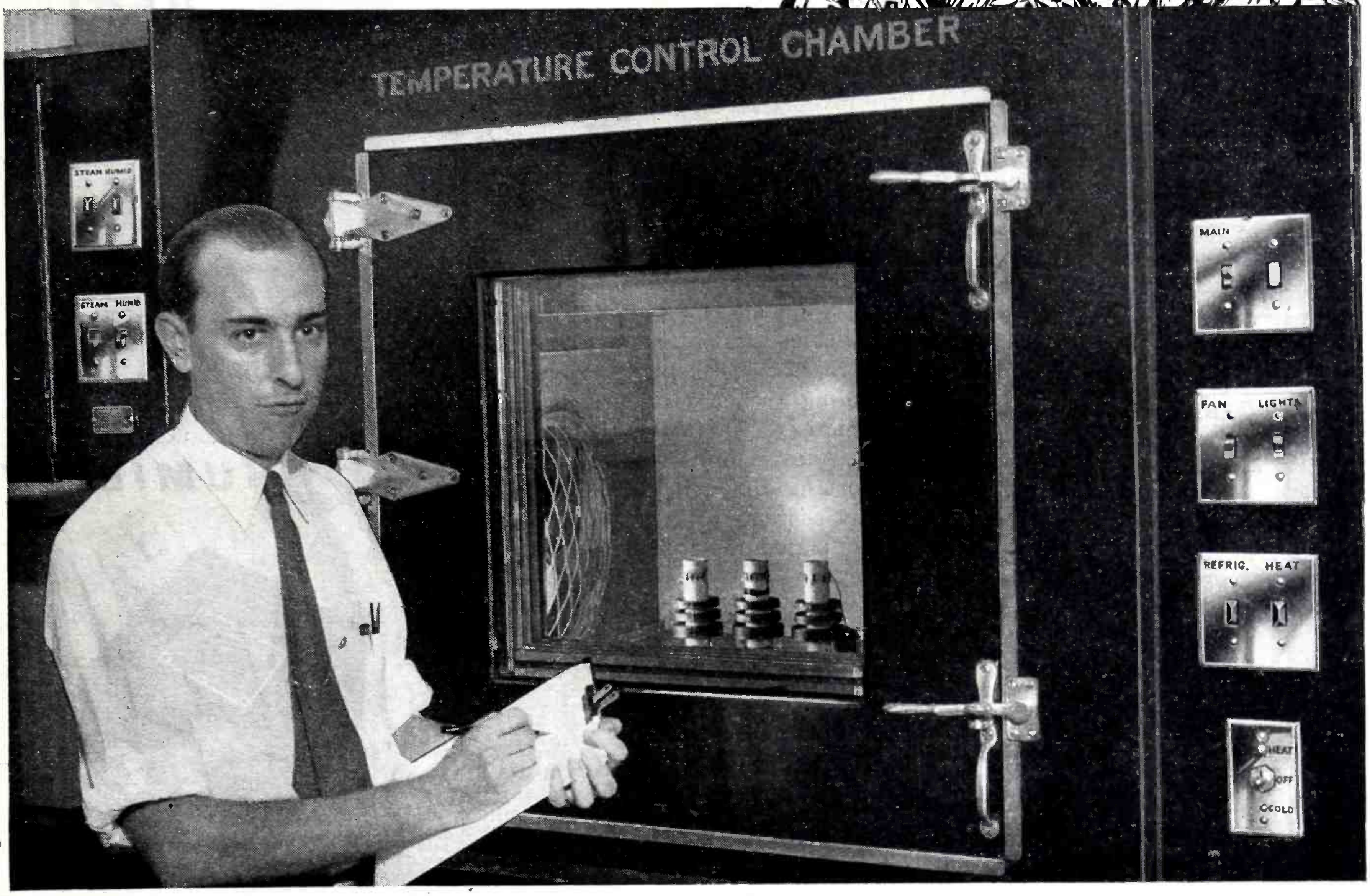
Eastern Air Devices, Inc., 314 Dean St., Brooklyn, N. Y.

Insulation Testers

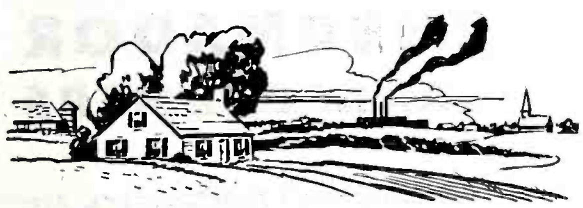
THE MANUFACTURER states these new "Megger" insulation testers are the the first instruments of their type to be made in this country. They are similar to the manufacturer's "Meg" (variable pressure) and "Super-Meg" (constant-pressure) types, rated up to 500 volts and 1000 megohms, except that they are housed in plastic molded cases. The instruments are of the "Megger" generator and direct-reading ohmmeter type which operate simply by turning a crank and reading a scale. The general assembly of the instrument includes an ohmmeter, generator, gears, crank and the main case.

Bulletin No. 1735 describes and illustrates the testers and is available from the manufacturer, James G. Biddle Co., 1211 Arch St., Philadelphia 7, Pa.

The Jungle . . .



that came to New England



In use, Sickles electronic specialties accompany the Allied armed forces into every extreme of climate—steaming tropics, burning deserts, frozen northlands . . . on land, sea, and in the air. So to help make sure that our products continue to *exceed* the rigid specifications of government procurement agencies . . . to *know* that they'll stand up in service . . . we've brought the jungle to Chicopee, and the arctic and desert as well. This hot-cold, wet-dry box duplicates conditions under which Sickles products must operate. It's part of Sickles unusually complete testing laboratory . . . one more reason why you'll benefit by specifying Sickles coils, condensers, and other units when Victory is won.

The F. W. Sickles Company, Chicopee, Massachusetts

ARMY E NAVY

SICKLES *Electronic Specialties*

Multi-Contact Plugs and Sockets

SERIES NO. 2400 of multi-contact plugs and sockets incorporate new features which include increasing the leakage path and incorporating a new type of contact designed to improve current-carrying characteristics. This series is interchangeable with the manufacturer's No. 400 series. The plug and socket bodies are made according to Navy specifications, and are interchangeable with either a cap or a bracket. Sizes range in 2, 4, 6, 8, 10 and 12 contacts and are available with either a shallow bracket for flush mounting, deep bracket for recessed mounting or with a metal cap with or without cable clamps. Contacts are mounted into recessed pockets. Barriers surrounding the contacts are designed to increase contact-to-contact and contact-to-ground distance, thereby increasing the voltage rating. The socket contacts are phosphor bronze, silver plated. The plug contacts are of brass.

Howard B. Jones, 2460 W. George St., Chicago, Ill.

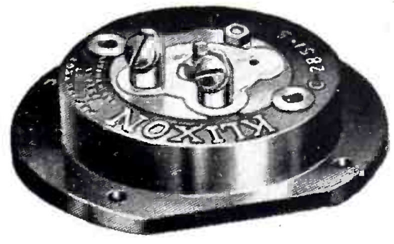
Carbon Pile Voltage Regulator

TYPE 1042 DESIGNATES CARBON pile voltage regulators which will handle many types of aircraft generating systems and will control the voltage of 24-volt aircraft systems which use engine-driven generators in either single or parallel, main engine or auxiliary engine operation and rated from 1.5 to 6 kw. The regulator can be used in conjunction with any 30-volt generator that requires a resistance range of 0.7 to 55 ohms and where the maximum regulator wattage will not exceed 75 watts continuously. For installations where the voltage regulator can be blast cooled, the unit may be operated continuously at 100 watts. The voltage regulation of the instrument will not be subject to more than 0.2 volts variation regardless of the position in which the regulator is mounted.

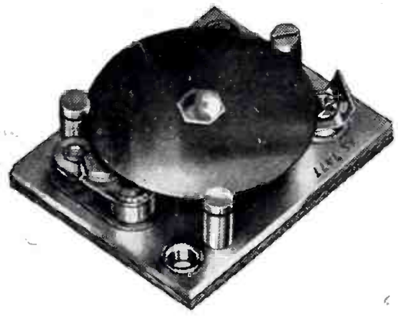
The regulator consists of a stack of carbon discs held in a supporting housing which has fins to facilitate the dissipation of heat. Carbon contact plugs at either end of the stack provide electrical contact to the carbon pile. Regulation is accomplished by increasing or decreasing

Sensitive as a dog's ear

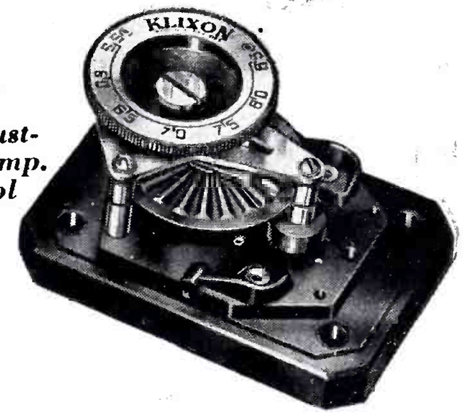
Rugged as the big rock



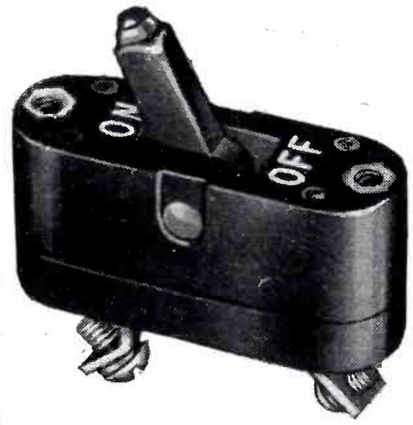
Type C-2851 Series, Used as Roughing Controls on Outer Crystal Ovens



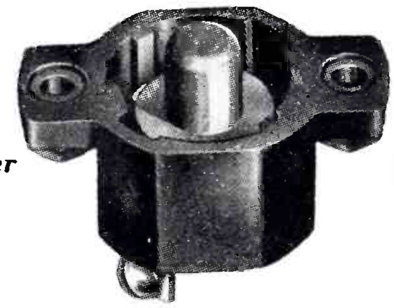
Type B-3120 Crystal Dew Point Control



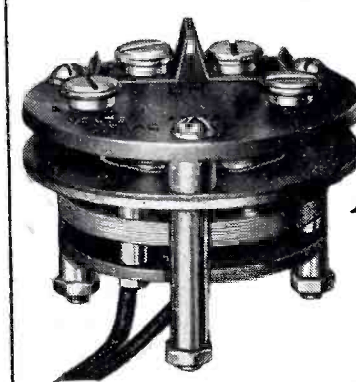
Type RT Adjustable Crystal Temp. Oven Control



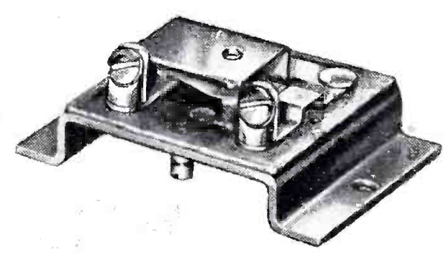
Type C-6363 Switch Circuit Breaker



Type PM (NAF-1131) Circuit Breaker



Type ER Series Ambient Compensated Time Delayed Relays



Type C-4351 Series Used for Tube Warming Tube Cooling, and High Limit Controls

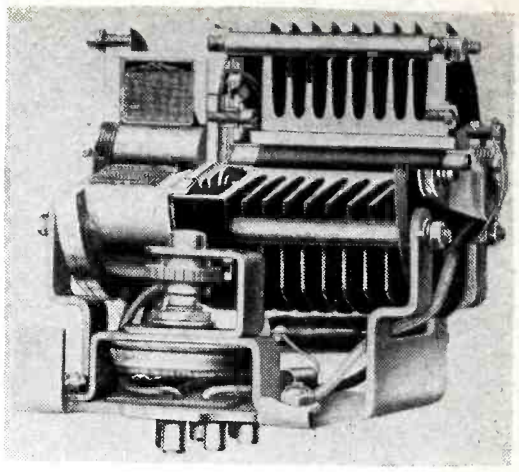
KLIXON SNAP-ACTING CONTROLS MEET ALL PERFORMANCE REQUIREMENTS

The enormous advantage of the Klixon Control is the simple, fool-proof actuating element . . . the Spencer snap-acting thermostatic disc which always makes a quick, clean break or a sure, solid make no matter how often it operates. And because the Spencer disc is snap-acting, it is not affected by shock, vibration, motion or high altitude no matter in what position it is mounted. In addition, Klixon Controls are small, compact and light in weight. Regardless of your control problems such as—motor and transformer overheat protection, or electrical circuit overload protection, or temperature controls for radio equipment, it is probable that one of the many standard types of Klixon Controls will meet your requirements.

ARMY E NAVY

KLIXON

SPENCER THERMOSTAT COMPANY, ATTLEBORO, MASS.



the pressure on the stack of carbon discs by a series of radially arranged leaf springs which are controlled by an electromagnet. This action varies the resistance of the carbon stack which is in the generator field circuit. The electro-magnet is actuated by the generated voltage. The magnet has a main shunt winding and an additional load compensating winding for use when the generator is operated in parallel with other generators.

Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

Two-Bearing Motor-Alternator Sets

A NEW LINE of two-bearing (ball), 3600-rmp motor-alternator sets in integral ratings up to 5 kva, single-phase, are available for converting direct current to alternating current for various applications. These include any applications which require a-c power, such as radio and other electronic equipment of standard a-c design. In operation, the d-c motor of the set drives the alternator, which has a field connected in series with the motor armature. An increase in the alternator load causes an increase in the motor load, so that increased d-c is drawn from the line. This greater d-c current strengthens the alternator series field, tending to maintain a constant a-c voltage.

The motor and the alternator of these sets are similar in that the armature windings are on the rotating elements and the fields are stationary, being attached to the frames. A solid shaft, supported by a ball bearing at each end, serves to mount the rotating members of both the motor and the alternator, thus eliminating a number of parts and making for saving in weight. To disas-

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In addition, applications are invited from technically experienced men with commercial qualifications:

COMMERCIAL ENGINEERS—Several are required. Should have a sound technical experience in any one, or a combination of the following fields: communications, special device circuits, quartz crystal and electronic tube applications; quartz crystal and electronic tube manufacturing processes.

Also one man who should have a background as metallurgist or physicist and preferably some practical experience with x-ray techniques.

Duties of Commercial Engineers will consist largely of personal contact and correspondence with engineering personnel among manufacturers of electrical and communications equipment, also with Government engineers.

Our war production record is good, with a substantial post-war future. We have a world-wide background of electronic research and development. If congenial association with a young and progressive organization fits in with long range plans for your own future development and prosperity, let us hear from you. Tell us your age and enough about your technical education and training, experience, draft status, availability and salary requirements to warrant an early interview in New York City, Dobbs Ferry or some mutually convenient point. A photograph will be appreciated. Address your letter in strict confidence to

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Fiberglas. The development, properties, manufacture and the uses of Fiberglas are presented in an 18-page booklet. Fiberglas can be fabricated into resilient batts or rigid, sawable boards, can be woven on a loom like cotton, and is used as insulation in boats, portable shelters, industrial pipes, war plants and planes. This booklet is available from Owens-Corning Fiberglas Corp., Toledo, Ohio.

Sound Equipment. Audio amplifiers, industrial broadcasting equipment, intercommunicators, loudspeakers, microphones, mobile systems, phono PA systems, public address systems, recording equipment, record players (portable) and other sound accessories and systems are described in Catalog 38, available from Bell Sound Systems, Inc., 1183 Essex Avenue, Columbus, Ohio.

Erie Data Sheets. Data sheets for Erie's loose-leaf resistor catalog are available. These data sheets cover Hi-K ceramicons and disc ceramicons (fixed ceramic condensers) and mica button condensers for use in v-h-f and u-h-f electronic equipment. These data sheets are available from Erie Resistor Corp., 640 E. Twelfth St., Erie, Pa.

AN Connector Charts. Two wall charts for the instruction, assembly, ordering, servicing or repair of Type AN Connectors are available from Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif. Chart No. 1 shows insert arrangements, with shell size total contacts, wire sizes and other data. Standard AN types, parts and interchangeable features are also shown, together with an explanation of the components of a complete AN identification number. Chart No. 2 contains the complete AN identification number of each of the four types of AN connectors with the inserts shown in Chart No. 1.

Flexible Rubber. Silentbloc is a union of concentric metal cylinders joined by a layer of rubber under pressure for the purpose of mounting, coupling or isolating machinery or equipment in motion. The booklet contains a chart giving the natural frequencies of vibration and one giving the deflection rates. The typical applications and characteristic advantages of Silentbloc are also given. Booklet available from The General Tire & Rubber Co., Mechanical Goods Div., Wabash, Ind.

Pressed Steatite. Crolite Pressed Steatite catalog contains a detailed listing of standard pressed steatite parts for which tools are available. The listings are in the form of detailed and dimensional drawings of bushings, trimmer-capacitor bodies, terminal strips, tube sockets, tube parts, coil bases, variable capacitor end pieces, oscillating crystal cases, etc., with corresponding numbers. A copy of this catalog may be obtained from Henry L. Crowley & Co., 1 Central Ave., W. Orange, N. J.; use business letterhead.

Insulating Materials. A 60-page catalog covering G. E. insulating materials, lists and describes varnished cloths, varnishes, Glyptals, tapes, cords, cotton sleeving, varnished tubings, mica, wedges, soldering materials, cements, compounds and many other items. Copies are available from Editorial Service, General Electric Co., Bridgeport, Conn.

Cathode-ray Bibliography. The March-April-May-June 1943 issue of the *Oscillographer* contains an up-to-date bibliography on cathode-ray subjects, including: luminescent screens, photography, oscillograph amplifiers, time-base circuits, power supply and several cathode-ray applications. Copies of the *Oscillographer* available from Allen B. DuMont Labs., Passaic, N. J.

Engineering Data. Catalog DO43 contains information on Dilecto, a laminated phenolic plastic. This catalog explains the properties, manufacture and uses of Dilecto. Catalog DO43 available from Continental-Diamond Fibre Co., Newark, Del.


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Motion Picture. A silent motion picture entitled "Lightning", explains some of the important scientific facts about natural and laboratory lightning. This 16-mm film shows animated traveling wave action and actual test performance of G-E lightning arresters and expulsion protector tubes. Some highlights of G-E research work on lightning in the field and in the laboratory are given. This motion picture, No. AX-565, is available through any General Electric office. Publication GES-402 contains ordering information.

Buying Data. The 180-page "Motor Buying Data" covers popular types and ratings of motors up to 100 hp, gearmotors and M-G sets. The 276-page "Control Buying Data" lists a wide variety of controls and accessories for d.c., single-phase, squirrel cage and wound rotor motors. The motor and control loose-leaf book contains complete product listings and information on special features for specific industries. Copies of both these booklets may be obtained from any Westinghouse district office.

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HOW FORTS KEEP ON THE BEAM

A radio compass is being tested in the Radio Division of the Bendix Aviation Corporation before delivery to the Army. The test equipment shown here simulates radio signal reception in actual flight and tests the accuracy and sensitivity of the compass and the loop antenna at the top of the picture

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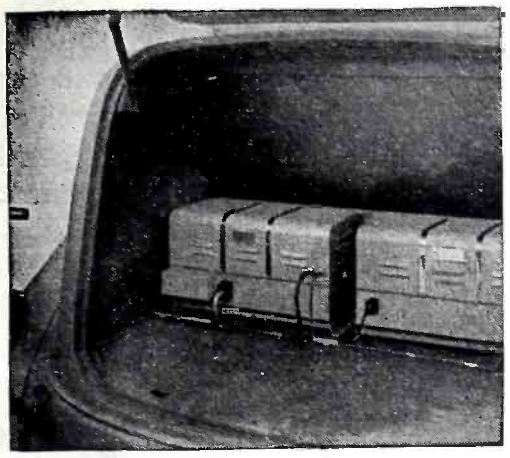

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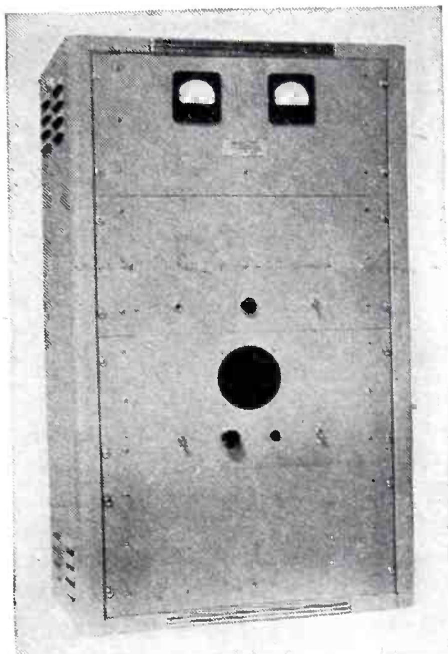

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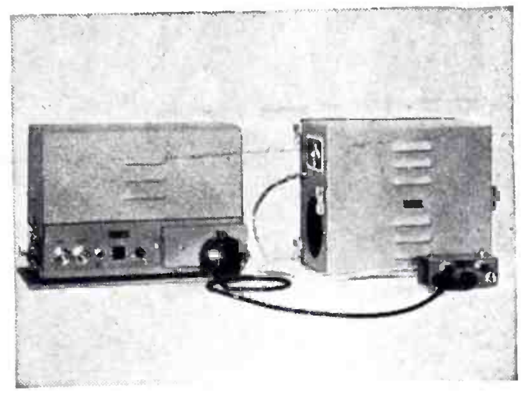

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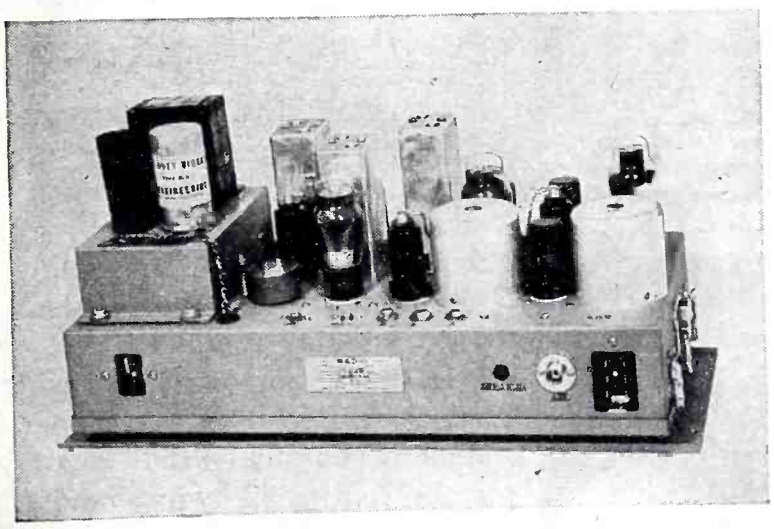
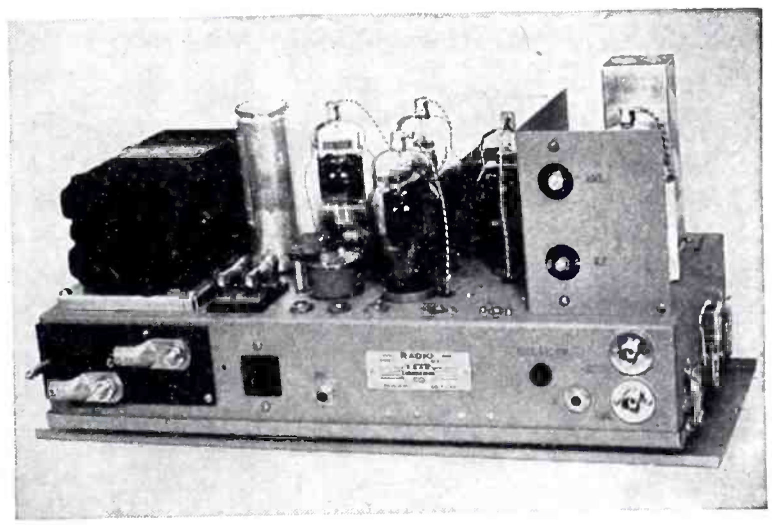


Type PRS-9X, 30-40 MC Mobile Receiver with Dust Cover Removed.



Type PTS-22X, 30-40 MC Mobile Transmitter with Dust Cover Removed.

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SERIES 6	Includes Tunable and Multi-Channel Fixed Tuned Receivers for Mobile, Marine or Central Station application.
TYPE 11A	Single Frequency Crystal Controlled Station Receiver for frequency ranges up to 8,000 KC.
TYPE 11X	Crystal Controlled Mobile Receiver, for frequency ranges up to 8,000 KC.
TYPE PTL-10X	Instant Heating 10 Watt Mobile Transmitter, for frequency ranges up to 8,000 KC.
TYPE PTL-22X	Instant Heating 22 Watt Mobile Transmitter for frequency ranges up to 8,000 KC.
TYPE PTS-22X	Instant Heating 22 Watt Mobile Transmitter, range 30-40 MC.
TYPE PR-9X	Crystal Controlled Mobile Receiver, range 30-40 MC.
TYPE PRS-9A	Crystal Controlled Station Receiver, range 30-40 MC.

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Manufacturers of High Grade Mobile and Central Station Radiotelephone Equipment

R-F Gun

(*Continued from page* 111)

heating is by the use of a relatively high frequency. Experience indicates that something of the order of 200 Mc must be used.

Control of Time Cycle

Accurate control of the heating cycle is a necessity. This is particularly true where it is desired simply to tack the veneers rather than to set the spots completely. For this reason a means of automatic timing seemed desirable. The circuit incorporated for this purpose is arranged so that the trigger on the gun serves to start the heating cycle, with the length of the cycle being determined by an adjustable timing device. The heating period is variable from a fraction of a second to ten seconds by means of a control on the back of the chassis. There is also a control cut-out switch so that the cycle can be manually controlled if desired. In this case pressing the trigger starts the cycle, and releasing the trigger stops it. A signal light indicates when power is on, but in practice it has been found that listening for the click of the relay is more convenient than watching the light.

In production operations where the device will be used by inexperienced labor it is assumed that it will be set up and adjusted beforehand for the particular operation. Thus all the operator need do is hold it firmly against the selected spot, press the trigger, listen for the click, and then go on to the next point.

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MOLYBDENUM sheet anodes have been replaced by zirconium-treated graphite anodes in tubes made for the Signal Corps by United Electronics Co., with a saving of over a ton of scarce pure molybdenum rolled sheet on one contract alone.

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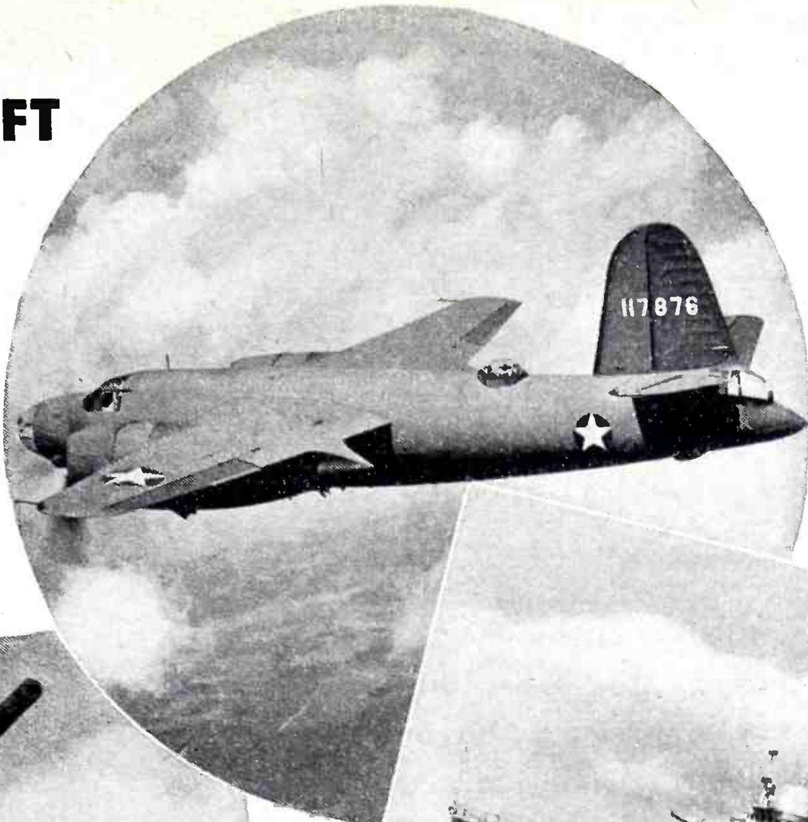
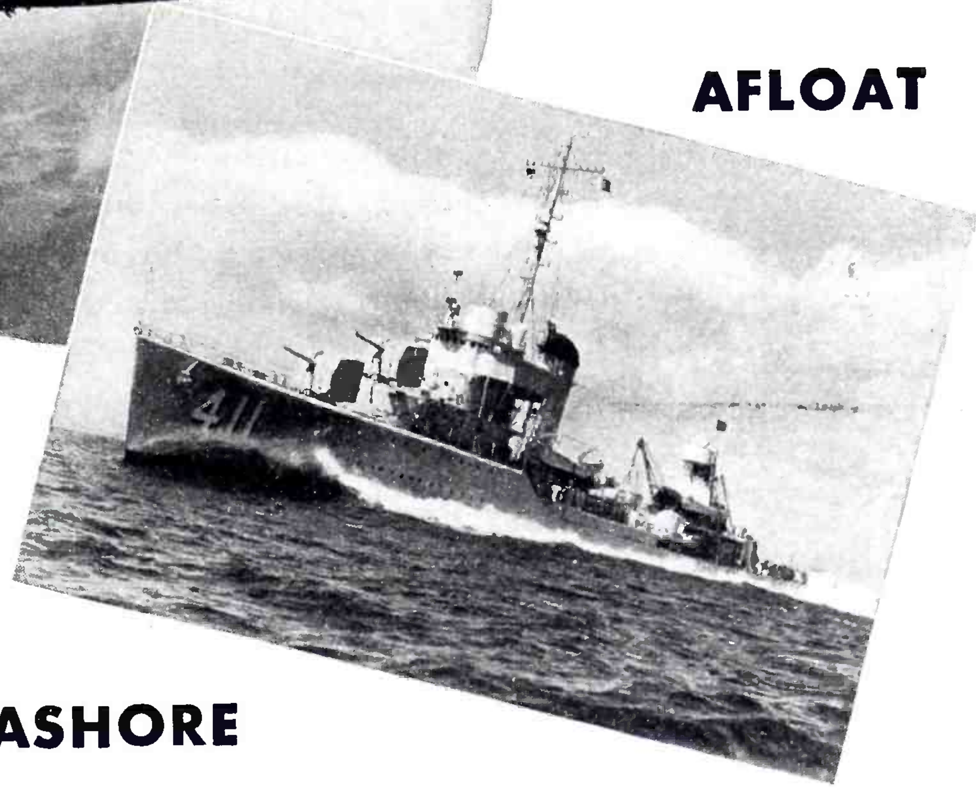


AFLOAT



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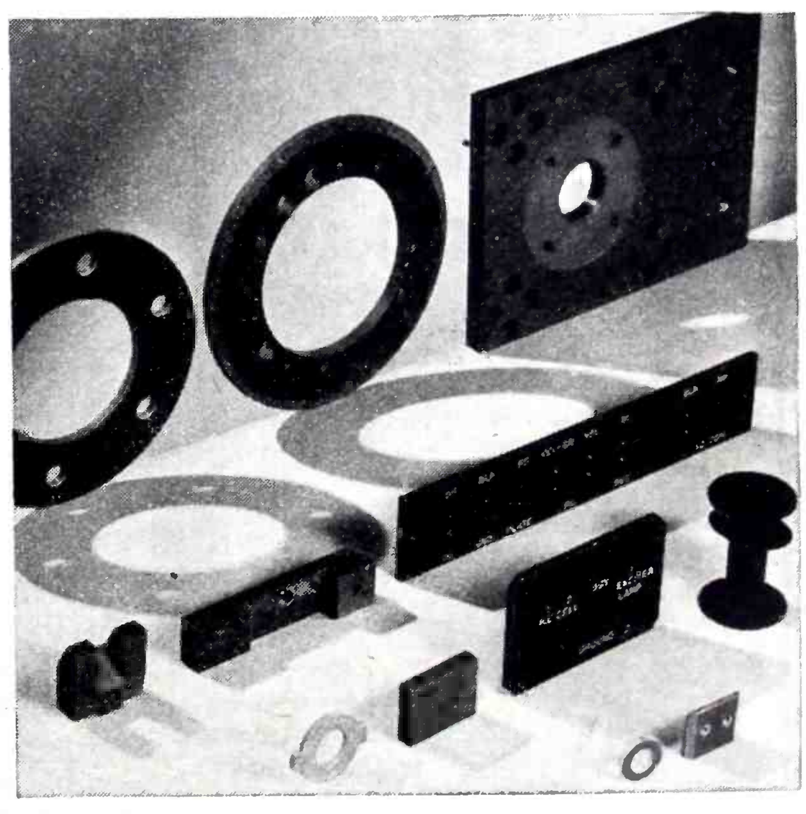

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Cathode Follower

(*Continued from page* 117)

this expression, then differentiating P with respect to R_L and equating to zero, in the well known procedure to determine maxima and minima. The value will be found to be

$$R_{L_{opt}} = \frac{2r_p R}{r_p + R} \qquad (14)$$

If R_L is given, that is, cannot be chosen, no attempt must be made to satisfy Eq. (14) by giving R a value such that Eq. (14) will be satisfied. A little thought will show that R should always be as large as possible; for R approaching infinity, $R_{L_{opt}}$ will approach the value $2r_p$. Since the plate current flows through R, however, large values would make a high voltage d-c supply necessary.

Due to the balanced condition as far as plate supply is concerned these circuits seem to show the way to the solution of the d-c amplifier problem, as shown in Goldberg's paper. It is hoped that this discussion will help workers in this field to become a little more familiar with the characteristics of them.

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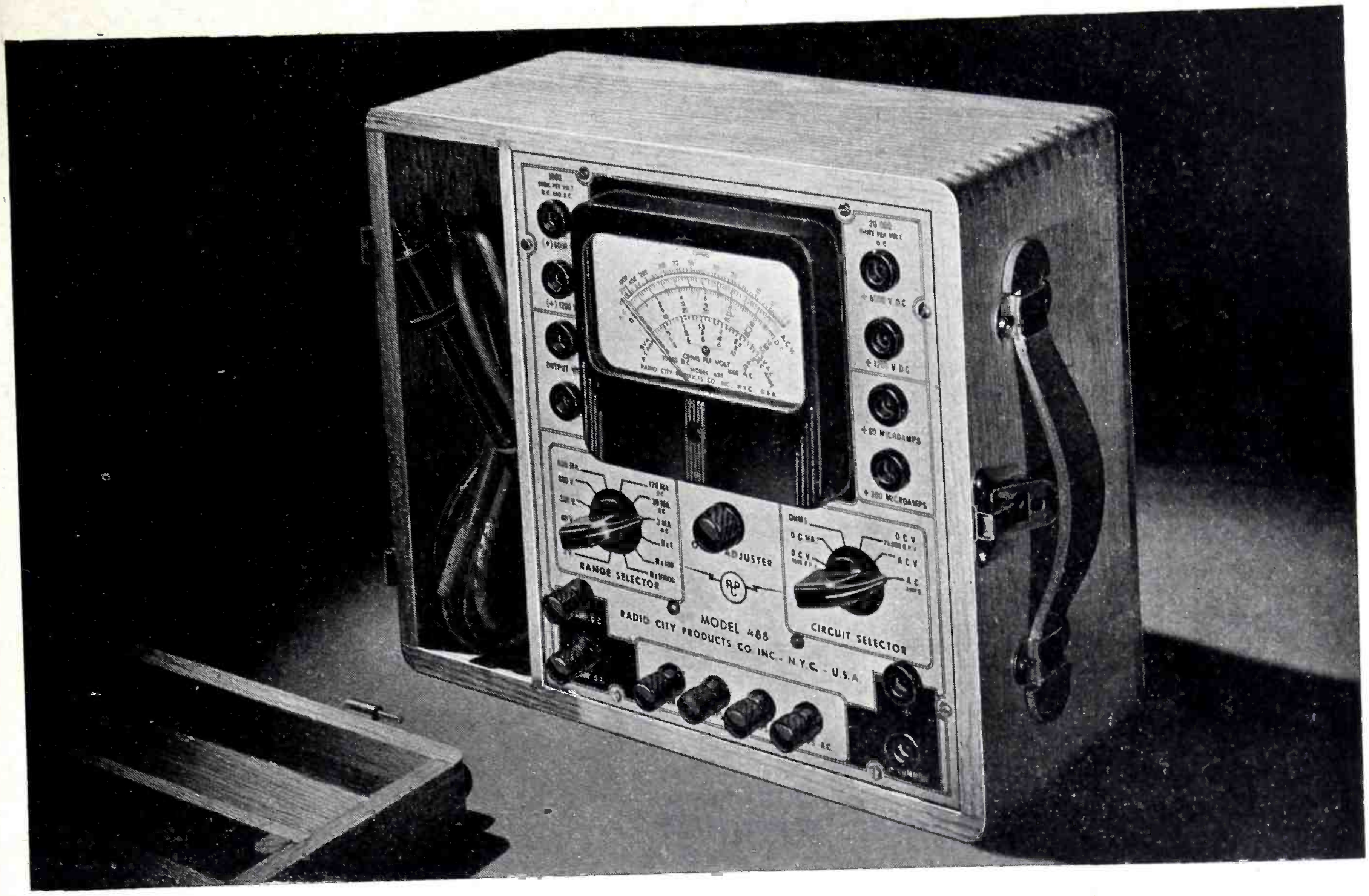

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Model 488 has Dual D.C. Sensitivity; 20,000 and 1,000 Ohms per volt . . . with measurements for A.C. Amperes. It was built to satisfy the exacting demands of the Signal Corps—sturdy, durable and complete with handsome oak carrying case—ideal for field and shop testing of military and naval electronic equipment. At this new low price Model 488 demands your attention.

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Dual D.C. sensitivity of 20,000 ohms per volt and 1,000 ohms per volt.
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Wide—scale 4½″ meter with movement of 50 microamperes.
Readings as low as 1 microampere.
All multipliers matched and 1% accurate.
Exceptionally fine ohmmeter scale spread 75 to 1 ratio from center to full scale.
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Heavy duty high voltage test leads included.
Instantly replaceable meter rectifier—no soldering or unsoldering of connections.
Batteries are readily accessible . . . can be replaced merely by releasing spring clamp. No soldered terminal connections to batteries.

RANGES

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A.C. Voltmeter . .	0-3-12-60-300-600-1,200-6.000 volts.
Output Voltmeter .	0-3-12-60-300-600-1,200-6,000 volts.
D.C. Microammeter	0-60-300 Microamperes.
D.C. Milliammeter	0-3-20-120-600 milliamperes.
D.C. Ammeter . . .	0-12 amperes.
A.C. Ammeter . . .	0-3-6-12 amperes.
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B-H Curve Tracer

(*Continued from page* 131)

integrator stage of the equipment.

A smaller amount of phase shift is produced in the horizontal channel. The output voltage from the shunt is almost exactly a sine wave, and phase shift leads to a displacement of the horizontal time base on the screen, pulling the two steep portions of the hysteresis loop apart, so that the loss area appears larger. Equalization could be obtained by the same method as in the vertical amplifier, but the low harmonic content in this channel permits the use of a simpler network, as shown in Fig. 5b. Compensation with this network is possible only for one frequency. If the 60-cycle source contains strong harmonics, the type of equalizer shown in Fig. 5a should be used in both channels.

Adjustment of the equalizers is most easily accomplished by means of samples, using some characteristics inherent in B-H curves.

In Fig. 6, a normal hysteresis loop of ordinary transformer steel is shown (*a*), together with distorted forms resulting from incorrect vertical phase adjustment (*b* and *c*). When the equipment is first put into operation, curves resembling one of these distorted patterns are usually observed. By varying the input voltage to the power transformer, no change should appear in the correct curve (*a*), except that the saturated portions (*s*) stretch out when the current is increased. Incorrect vertical phasing spreads these portions and makes them appear like (*b*) or (*c*). By adjusting the vertical equalizer, a trace similar to Fig. 6a can be obtained. With a loop containing long saturated portions (*s*), vertical adjustment can thus easily be made of extreme accuracy.

If the current is now varied, the horizontal distance between the two steep portions, corresponding to the coercive force, should not vary after saturation has been reached. Variations, if they occur, are due to incorrect horizontal compensation.

To obtain accurate horizontal adjustment, a 2-inch diameter air-wound coil of about ten turns is substituted for the little loop, connected to the vertical amplifier, and coupled inductively with the high-current circuit. Care should be taken that no iron is present anywhere near this coil. Since the permeability of air is constant, independent of field intensity, a straight line appears on the screen (Fig. 6d); its slope depends on the voltage induced in the coil. Usually, a narrow ellipse (Fig. 6e) is obtained at first, rather than a single straight line. If the horizontal phase adjustment is now varied until the ellipse is reduced to a line, phasing is accurate and complete.

Practical Data

For a great number of applications, comparison of the characteristics of different materials is of primary interest. In these cases no absolute calibration of the equipment is necessary.

As long as washers made from different materials have identical dimensions, the curves on the screen permit numerical comparison. Differences in thickness can be compensated by using a correspondingly larger number of turns for the little coupling loop on thinner pieces. For many materials only one turn is needed, and in this case, if thicknesses are different, the vertical deflection is proportional to the

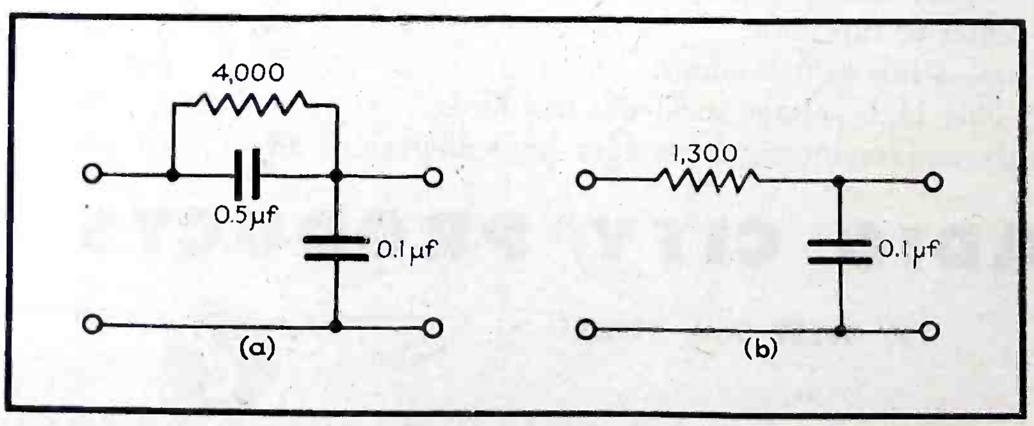

FIG. 5—Equalizing networks used to correct phase shift

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MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT thickness. The gain control on the scope can be used to equalize the calibration.

Eddy currents flowing in the sample tend to make the hysteresis loop appear wider, leaving the level of the saturated parts and the slope of the steep portions unchanged, but increasing the total area enclosed by the loop. With eddy current losses present, this area corresponds to the total core loss at 60 cycles, rather than to the hysteresis loss only. This is a valuable feature if total core loss is the object of interest, and in this case the sample should be of a thickness intended for actual use. If, however, the actual hysteresis loop and the real value of coercive force are required, samples of the smallest thickness available should be used to keep eddy current losses down to a minimum. This precaution is particularly important with high-permeability materials.

The average diameter of the sample washer determines the field intensity H produced by a given current. Washers of different average diameter, therefore, require proportionately different currents to obtain the same H. If the calibration is to be maintained for a larger washer, less horizontal gain is required. The equipment described provides enough current for saturating alloys even if the permeability is low, provided that small diameters are used.

For quick comparison, a number of samples can be slipped over the same fine wire loop and inserted one after the other around the copper bar.

Heat Runs

The holder assembly can be mounted on a heater unit for measurements at elevated temperatures. This unit consists of a heavy round iron casting with a heater winding on the inside. During the measurements the whole assembly is protected by a heat-insulating cover not visible in the picture.

The photographs of the four hysteresis loops in this article were taken during such a test, using a sample of low permeability, with the temperature rising in three steps from 80 deg. F (largest curve) to 200 deg. F (smallest curve).

To obtain permanent records, the curves can easily be photographed from the screen. With a curve of average size on a 3-in. tube with green fluorescence, an exposure of 1/50 second on high-speed panchromatic film with an f/4.5 lens gives satisfactory results. The screen should be illuminated from the outside just enough to make the mask with the calibration lines appear clearly on the print.

When the current is gradually increased from zero beyond saturation, the oscilloscope shows a hysteresis loop slowly growing out of a single point into the final curve. The changes of reversible permeability, represented by the average slope of the trace, from its low initial value to its larger "operating" value, and its final drop when saturation is approached, become clearly visible and measurable.

Calibration

While the simplest way of calibrating the equipment consists of the use of samples with known characteristics, it is also possible to apply voltages of known magnitude to the vertical and horizontal inputs and

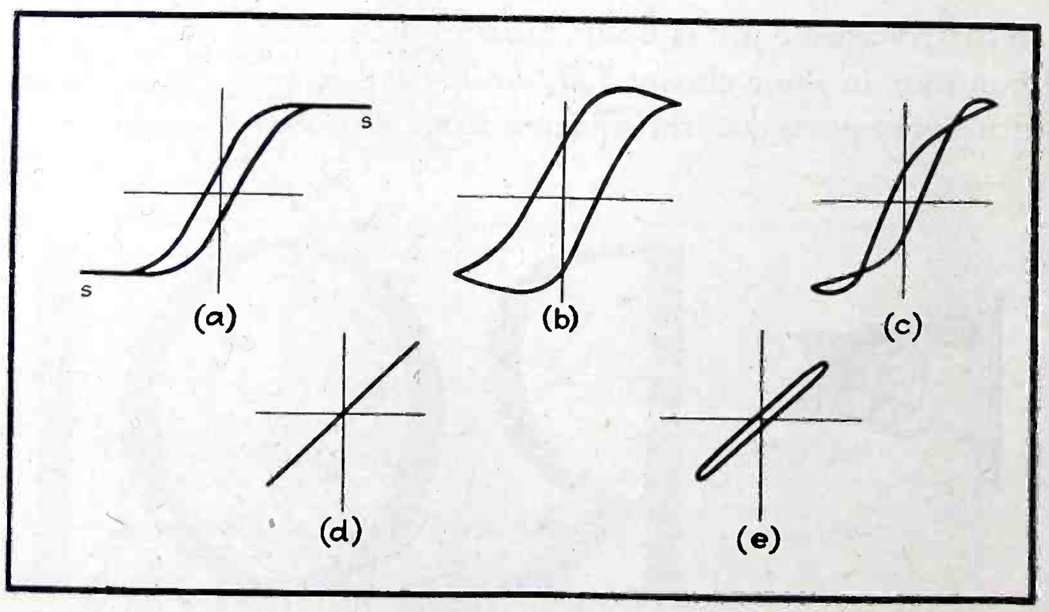

FIG. 6—Curves obtained during initial adjustments

thus obtain an absolute calibration. The following formulas are useful in this procedure; they are accurate only for narrow washers, with outside and inside diameters not too different, because of the error introduced by the assumption that the numerical average represents the true "magnetic average" diameter.

The following symbols are used in the formulas:

- I = current through bar in amperes, rms.
- E_h, E_v = voltages at horizontal and vertical amplifier inputs in millivolts, rms.
- (A), (mv) = ratings of shunt in amperes and millivolts.
- D_o, D_i = outside and inside diameter of sample in inches.
- T = thickness of sample in inches.
- n = number of turns in loop.
- H = maximum field intensity in sample in oersteds.
- B = maximum induction in sample in gausses (lines per cm^2).

The current through the bar then becomes

$$I = E_H \frac{(A)}{(mv)}$$

The field intensity is

$$H = 0.45 \frac{I}{D_o + D_i}$$

The induced flux density is

$$B = 116 \frac{E_v}{(D_o - D_i).\ Tn} \text{ (for 60 cycles)}$$

To obtain an absolute calibration, the peak-to-peak deflection of the oscilloscope per millivolt is first established for both channels. The relation between millivolts and magnetic values is then used to convert the observed deflections into peak values of H and B.

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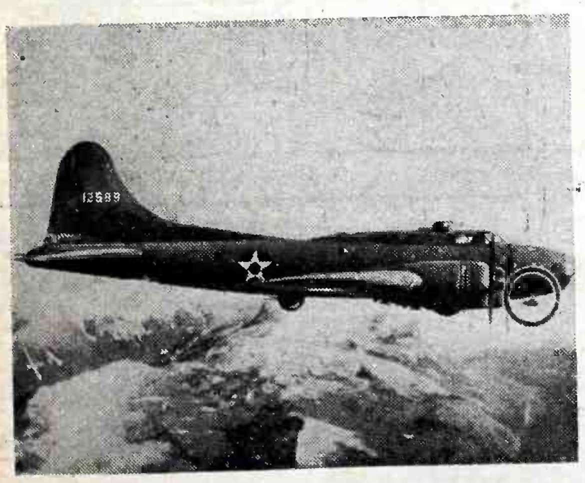
KEEPING FLYING FORTRESSES ON THE BEAM



Active bomber crews depend upon the accuracy of the automatic radio compass to help guide them safely to and from their objectives. The pear-shaped loop in the circle picks up the bearing of a radio signal which is transmitted accurately and automatically to the pilot and navigator by means of the compass

Tube Design

(Continued from page 139)

derexposed or overexposed. It is evident in Fig. 3, 4, and 5 that wider latitude in the thickness and materials of the specimen may be obtained at the expense of contrast in the film by using high voltages, since at short wavelengths the differences in the transmitted intensities of the radiation produced by differential absorption become smaller. In addition, various methods to obtain wider latitude, involving such techniques as the use of special filters, or using a number of films having different response characteristics, are part of the tricks of the accomplished radiographer's trade.

The development of film viewers with greater intensity light sources permits the ready viewing of sections of film which might previously have been considered overexposed.

In addition to the factors affecting contrast, there are other variables in respect to the quality of the radiographic results which a skilled industrial radiologist must consider. Since all materials have the property of scattering x-rays, it is necessary to take special precautions to reduce this effect to the minimum. Geometrical factors such as the size of the focal spot, the target to film, and the film to specimen distances have quite an influence on the sharpness of the radiograph, and the amount of distortion in the finished radiograph.

A rather useful way of decreasing the exposure time lies in the use of intensifying screens. Less than one percent[6] of the x-radiation which strikes a film performs useful radiographic work. The working efficiency of the x-ray beam can be substantially increased by mounting the unexposed film between layers of a material which has the property of absorbing x-rays and transforming the energy into longer wavelength radiation in the ultraviolet and visible regions of the spectrum.

The intensification factor using calcium tungstate screens is high enough to permit reductions in exposure times to between 1/10 and 1/100 of those required without screens, and even greater reductions in some cases.

Because of the finite size of the crystals in the intensifying screen, some loss of definition is entailed with their use. In general, where considerations of the speed of the exposure are unimportant intensifying screens are not used.

The radiographic efficiency of x-rays can also be increased by the use of thin lead foil intensifying screens about .005" in thickness. In this case the action is produced by the release of secondary electrons as well as by secondary x-rays produced in the lead. In addition, greater contrast and definition result because the lead tends to reduce the intensity of the longer wavelength scattered radiation to a greater extent than it does the intensity of the primary rays. The amount the exposure time can be reduced depends upon the kilovoltage, the film, and the thickness and composition of the specimens. As a matter of fact, for low voltages the exposure time may be greater with lead screens due to excessive absorption of the primary rays.

X-ray Tube Design

Most x-ray tubes are diodes, and from the standpoint of the number of elements involved, their construction and design should be very simple. As a matter of fact, it is possible to generate x-rays from rather simple tubes. Much of the simplicity of

Installing a 150-kv radiation-cooled deep therapy tube in a lead-protected testing chamber. The operator carries a piece of x-ray film (clipped to his vest pocket) that is developed and replaced at regular intervals as a check on the system of x-ray protection construction is lost, however, in making the tube suitable for routine high-quality radiographic work on an economical basis.

Tubes built for medical diagnostic uses have a voltage range in general between 40,000 volts and 100,000 volts. Medical therapy tubes in some instances are employed to 1000 kilovolts. Tubes for industrial radiography are in general used in a range between 30 and 220 kilovolts, and in some instances to 1000 kilovolts. The glass walls of the tube, which must insulate the electrodes for the total impressed voltage across the tube, are usually fabricated of a hard, highly resistant glass, such as pyrex. In order to minimize the very appreciable x-ray absorption of the glass, the x-rays are generally brought out through a specially ground window in the bulb.

The bulb tends to pick up negative charges during the operation of the tube, and for high voltages, particularly when the tube is operated on a self-rectified basis, it is frequently found desirable to use hooded anodes. This construction eliminates electron bombardment of the glass wall, in this way preventing punctures of the tube envelope which would occasionally occur otherwise due to the high electric stresses which build up.

For very high values of impressed voltage, it has been found necessary to employ the multi-section construction, which essentially permits division of the potential gradient along a series of electrodes between the cathode and the anode of the tube.

Electrostatic focusing is almost universally employed in fixing the focal spot size on the target. The tungsten filament is mounted in a specially machined focal cup similar to the one shown in **Fig. 9**. The size' of the focal spot on the target is a critical function of the widths and lengths of the mouth and throat of the focal cup, and the depth of the filament.

The efficiency of production of x-rays is approximately given by the following equation [8]

$$\frac{\text{x-ray energy}}{\text{cathode ray energy}} = KZV \qquad (4)$$

where Z is the atomic number, V is the impressed voltage, and K is a constant. At 100 kilovolts the efficiency of x-ray production is between 0.5 and 1 percent for a tungsten target, assuming a value of K = 1.11×10^{-9} as per Compton and Allison.[9] The remaining energy must be dissipated from the target as heat. For this reason the problem of heat transfer from the anode of an x-ray tube is one of the important problems of x-ray tube design.

Tungsten has been widely accepted as the material of the target for x-ray tubes because of its low vapor pressure, high melting point, high atomic number, and reasonably good thermal conductivity. Two general methods for dissipating the anode heat have found wide use among tube manufacturers. In the first and less used method, the tungsten x-ray target is supported by a molybdenum rod and the heat dissipated by radiation through the glass bulb. In the second method, the copper is cast over a tungsten button, and the resulting casting machined in the manner indicated in Fig. 9.

Under operation the energy into the anode is conducted through the envelope of the tube by a copper radiator rod. For air-insulated operation the power is dissipated into the air by convection or forced air cooling. For the case of high loading, as in 220-kilovolt tubes for industrial radiography, the heat is dissipated by a forced oil cooling system which maintains the temperature of the anode adjacent to the oil below 200 deg. C for loading as high as 25 ma at 200 kilovolts peak potential. Load limitations in this case are imposed by the temperatures at which the oil carbonizes on the cooling surface. Water, which has a higher cooling efficiency than oil, is not considered an economical cooling agent for this application because its use would require grounding the anode side of the secondary winding of the high voltage transformer rather than its midpoint, thus doubling the voltage for which the cathode side of the secondary must be insulated.

In order to permit stable operation of the tube, it is necessary to adjust the anode-cathode spacing so that no cold emission effects can occur due to high electric fields. Since adsorbed gas layers, and contamination of surfaces accentuate cold emission instability, it is necessary to use materials which can be outgassed at high temperatures on exhaust without causing deposits on the bulb.

The safety of personnel in using x-ray equipment is greatly increased

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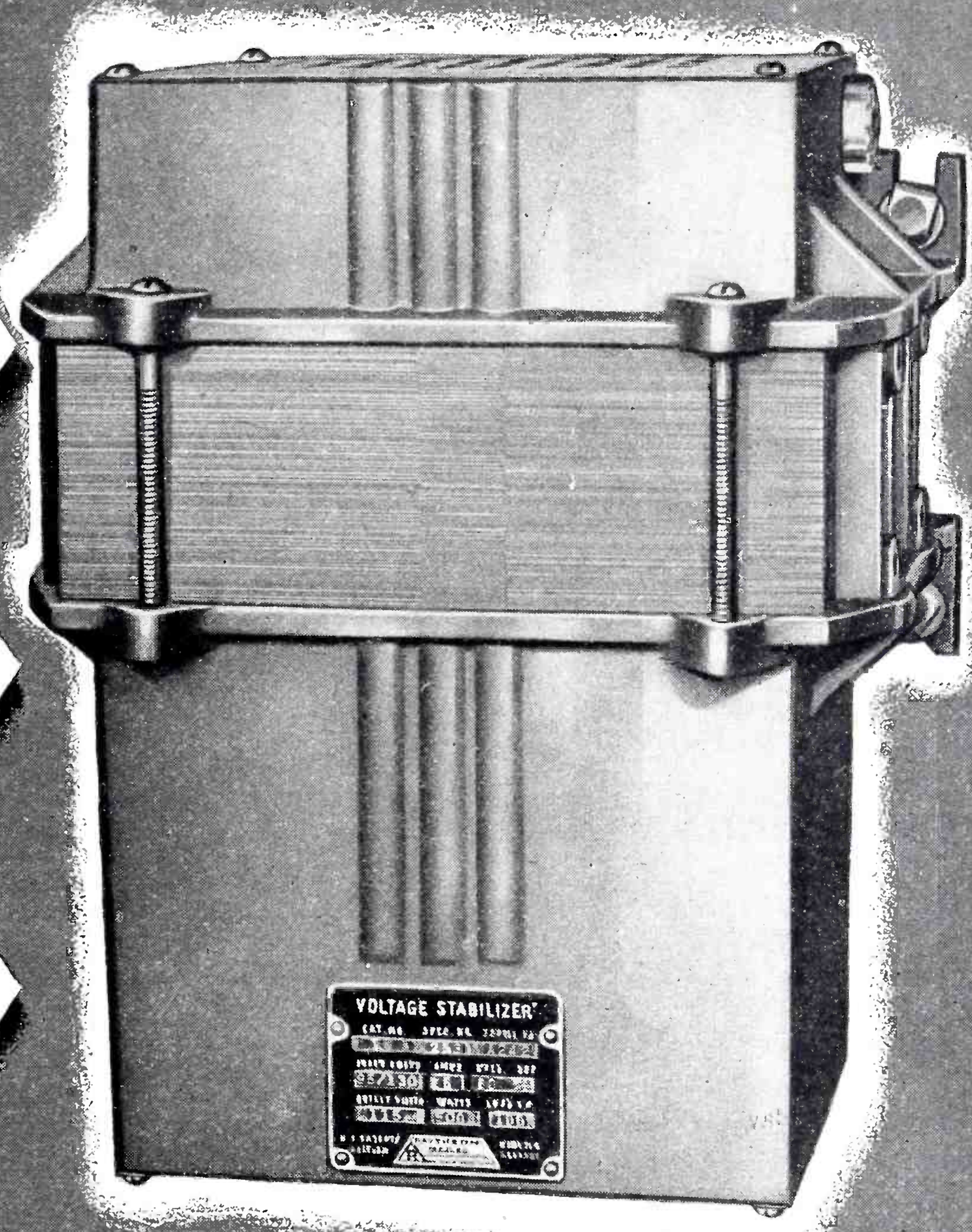

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by "shock proofing" the tube, that is, mounting it in an oil-immersed grounded head, and making high-voltage connections to it from the transformer through grounded cables. The head is generally equipped with a lead casing to provide x-ray protection. "Shock proofing" the tube permits reducing its size, since the minimum spacing required to prevent sparkover is much lower in oil than it is in air. An alternative method frequently used consists in mounting both the tube and the high voltage generating equipment in the same oil filled container.

For high-current exposures of short duration, the rating of the tube is limited by the possibility of melting the tungsten focal spot. As the current is decreased and the time of exposure becomes longer, the tube rating becomes limited by the heat capacity of the copper anode and the continuous heat-dissipating ability of the anode cooling system.

A typical rating chart for a 3.0x8.8

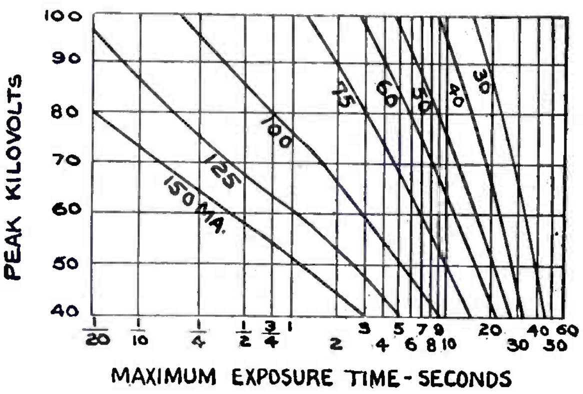

FIG. 10—Sample rating chart for 100-kilovolt x-ray tube used on full-wave rectification. Effective spot size is 3 x 3 mm

mm spot, which has an effective focal spot of 3.0x3.0 mm, is shown in Fig. 10. Greater energy of short time loading, and hence larger x-ray output, is possible with a larger focal spot. However, such increased intensities are obtained at the expense of radiographic sharpness, which varies with the size of the focal spot.

In some medical applications it is desirable to make radiographs of very short exposure times requiring high intensities of radiation, and a high degree of sharpness in the finished radiograph. In order to permit the desired loading of the tube it is necessary to rotate the anode, thus spreading the heat over a large area, and confining the source of x-rays to a very small effective area. Exposures to 200 ma are commonly used with these tubes in connection with a 1 mm effective focal spot, and in some cases as high as 500 ma with a 2 mm effective focal spot. The usual times employed in these techniques are 1/60 sec., 1/30 sec., and 1/20 sec.; and accurate timers are required to prevent overloading the tube.

The anode, which is supported on ball bearings, is rotated at high speed by an oil immersed induction motor, the coils of which are at ground potential, and are mounted around the outside diameter of the anode portion of the bulb. The rotor of the induction motor is part of the anode assembly of the tube. Since these tubes must be outgassed at temperatures considerably higher than their normal loading, it is necessary to provide a good vacuum lubricant which is reasonably temperature-resistant. These tubes have special problems in regard to dissipating continuous loadings, since the bearings provide a poor thermal conducting path to the outside of the tube envelope yet must be kept cool.

In certain industrial applications it is necessary to make radiographs in times so short as to preclude the conventional methods of timing exposures. In order to obtain useful x-ray intensities in such intervals, it is necessary that extremely large currents, of the order of 2000 amperes, pass through the tube. The hot tungsten filament tube cannot pass these currents because of the limitations imposed by space charge, and safe operating temperatures of the filament. Slack and Ehrke[10] have developed a 300-kv cold-cathode x-ray tube which permits high speed exposures (less than a micro-second).

In conclusion, I should like to acknowledge the assistance of Mr. John Walker in preparing the figures shown in the text.

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Superhet Terminology

(*Continued from page* 146)

Shifting Q-point or CPO Converters

It is assumed that the multi-electrode tube in Fig. 3a operates with electron coupling, which may be defined as a sort of coupling for which the reciprocity theorem is not valid. Thus the signal grid, carrying the signal voltage $(e_s)_A$, is coupled to the plate via the electron stream. Similarly the oscillator grid, carrying the oscillator voltage $(e_o)_B$, is coupled to the plate via the same electron stream. Due to the screen grid separating the signal grid and oscillator grid, there is no coupling between the input circuit and the oscillator circuit (space-charge coupling and other forms of coupling being neglected). It is therefore evident that although direct circuit interaction with accompanying undesirable phenomena is avoided, the plate current will contain components of frequencies $A/2\pi$ and $B/2\pi$. It will also contain components of frequencies $|A \pm B|/2\pi$.

The plate-current signal-grid-voltage characteristic of the tube discussed may be the straight line shown in Fig. 3b. When a signal voltage $(e_s)_A$ is applied, the tube behaves as a linear device—as a distortion-free amplifier. If now an oscillator voltage $(e_o)_B$ were applied to a *coplanar* grid with the same sort of characteristic as has the signal grid, the tube should work as an amplifier for both the applied voltages. No additional components of new frequencies would appear. If the oscillator grid, however, precedes or follows the signal grid in the same electron stream, then additional components of new frequencies will appear, the tube now acting as a frequency converter.

The case of inner grid injection will first be considered. When controling the intensity of the electron stream, the oscillator grid also controls the signal-grid slope g_m. This action may be illustrated as in Fig. 3b, where the $i_p - e_g$ characteristic tilts around its cut-off point (assuming for simplicity that the cut-off value remains fixed). The frequency of the tilting movement is the frequency of the oscillator voltage. In case of outer grid injection, Fig. 3a, the action is merely one of current division between the screen grid and the plate. Even in this case Fig. 3b illustrates the conditions quite thoroughly, the result as before being a tilting of the signal grid characteristic. The instantaneous slope may therefore be represented generally by the expression

$$(g_m)_{inst.} = (g_m)_Q + k'' E_o \cos Bt, \qquad (11)$$

where k'' is a proportionality quantity, and $k'' E_o = g_m$ is the amplitude of the transconductance variation. The periodic variation in transconductance between $(g_m)_Q + k'' E_o$ and $(g_m)_Q - k'' E_o$ illustrates the periodic gain variation in the tube, which causes the output wave to expand and contract—in other words, to become amplitude-modulated (compare with screen-grid and suppressor-grid modulation). The modulating device is not utilized as a modulator, as only one of the side frequencies is picked up in the output (usually $|A - B|/2\pi$). The conditions are similar to those previously described for the sliding Q-point device. Whether the modulating device acts as a modulator or frequency converter is, as before, a question of the tuning of the output impedance.

A mathematical expression for the desired output may be obtained as follows: The instantaneous plate current of interest is

$$i_p = (g_m)_{inst} (e_s)_A \qquad (12)$$

A substitution from Eq. (11), neglecting the constant term, yields

$$i_p = (k'' E_o \cos Bt)\, E_s \cos At \qquad (13)$$

$$= - - - - + \tfrac{1}{2} k'' E_s E_o \cos (A-B)\, t \qquad (14)$$

The same treatment could have been applied to the sliding Q-point converter. If the converter has a parabolic characteristic, Eq. (11) applies directly. As the plate current contains one term, such as the one shown by Eq. (12), the expansion in Eqs. (13) and (14) follows directly.

A study of the Q-point movements in Fig. 3b reveals that the Q-point keeps on shifting from one characteristic to another. The term "shifting Q-point converter" was coined and introduced to illustrate this particular condition. The "sliding-shifting" terminology has worked out quite nicely in practice, but two other terms are herewith presented as alternatives, the new terms being related to the path of operation rather than to the Q-point. As a starting point for this discussion it may be stated that over-all nonlinearity is a primary requirement on a frequency-changing device. The nonlinearity provides for periodic displacements in the output wave above and below the average value (the displacement frequency is usually $|A - B|/2\pi$). The displacements occur because the amplitude of the excursions along the path of operation follows a periodic variation, controlled by the oscillator voltage. There are two fundamental ways of controlling the excursions: to operate with a curved characteristic, which is fixed, and let the oscillator voltage directly determine the amplitude of the excursions along the fixed path of operation, or, to operate with a straight characteristic (a temporary assumption) that wiggles back and forth, and let the oscillator voltage indirectly determine the amplitude of the excursions along the now coninuously changing path of operation. When a tube with straight-line signal-grid characteristic is used, the path of operation becomes curved because of the particular geometrical configuration. To illustrate these wo different actions the terms "Fixed Path of Operation" (FPO) converter (i.e., sliding Q-point converter) and "Changing Path of Operation" (CPO) converter (i.e., shifting Q-point converter) have been introduced. The path of operation in the CPO-converter shown in Fig. 3b is of very interesting form.

In FPO as well as CPO converters he curved path of operation provides for one or more product terms, both devices acting as multipliers. The respective outputs show similarities with the so-called product-pattern, Fig. 1b, which yields variations of sum and difference frequency.

The previous discussion as applied to Fig. 3b illustrates the fact that a tube with linear input characteristic will produce conversion. The assumption of a straight characteristic was made, however, merely to bring out the principle of the action. In practice, requirements of high gain, avc-action, etc., necessitate class C operation with curved characteristics. As indicated by Eq. (14) the output amplitude is a function of the oscillator amplitude, and converters may therefore be operated with such a large oscillator swing that the mixing device is forced all the way from some sort of saturation down to far beyond cut-off. The action in a converter of conventional type is rather complicated; several phenomena show up, which in the above discussion have been left out of consideration.

Frequency Conversion Applications

A simple code receiver such as the one shown in Fig. 6 is a frequency converter. The fact that it does not produce detection is stressed by the mechanical analogue shown in the same figure. When operated by an input current of frequency A, the device is equivalent to a motor-generator, delivering an output current of frequency $|A - B|$. It is true that a code receiver usually uses a detector as mixer, but the detection components (the square wave envelope) are not utilized.

The shift in frequency from $A/2\pi$ to $|A - B|/2\pi$ is sometimes described as heterodyne detection, which term is somewhat misleading as no detection takes place. As a new and more suitable term, heterodyne code reception is suggested. (When the difference frequency is utilized, heterodyne code reception and heterodyne reception may be referred to by the common term beat reception.)

In case of a code receiver of superheterodyne type, the arrangement shown in Fig. 6 illustrates the detector stage, following the i-f amplifier. The local oscillator, which in both circuits makes code reception possible, is known as the continuous wave oscillator (CWO). Unfortunately it is still better known under the somewhat misleading name beat frequency oscillator (BFO). From the following description of a beat frequency oscillator, it is obvious that the continuous wave oscillator is not a beat frequency oscillator. It is therefore suggested that the term BFO not be used.

If the detector in the superheterodyne for code reception is a large signal diode, it may be looked upon as the mixer in a sliding Q-point converter, in which the Q-point slides on and off the tube characteristic, being forced periodically far beyond cut-off. As before, the Q-point follows the oscillator voltage, in this way producing the desired variation of the converter admittance.

A beat frequency oscillator (BFO), as the one shown in Fig. 7, is again a frequency converter. This is indicated by the mechanical analogue above the block diagram. As is well-known, a BFO may be used as laboratory equipment to produce audio or video frequencies. It has two heterodyning oscillators. The first may be considered as the source for the incoming wave to the mixer, the other one as a local oscillator. The frequency converting device may utilize either a modulator or a detector.

As a further application consider frequency conversion in FM transmitters. Here converters are used to produce in a single frequency multiplier different multiplication for the carrier and for the swing. Converters are also used in systems for indirect frequency control. These processes may be referred to by means of the terms heterodyning or frequency conversion or frequency changing, all these terms being justified and at least one of them needed. As far as FM receivers are concerned the terminology applies in general.*

One group of mixers that has not yet been discussed is the one used in broadcasting stations, public address systems, pulse generators, pulse amplifiers, etc. These mixers are in general linear *mixers* or *adders* and produce a linear or somewhat nonlinear superposition of contributions from a number of input electrodes. It is suggested that such devices are referred to as *adders* whenever risk of confusion with the superheterodyne type of mixer is present.

Conclusion

It has been shown that a frequency converter is a modulating device, in which the modulation output is not utilized—or a detecting device, in which the detection output is not utilized. Whether a modulator or a detector is used in a frequency converter is merely a question regarding practical circuits. Modulation or detection theory may be used to explain the action in a frequency converter, although a special conversion theory is sometimes desirable.

The task of explaining in a simple manner the action in various types of converters is very much a matter of using a clear terminology and a suitable classification. The system

* This discussion has not been extended to cover the details of the terminology of frequency converters in FM receivers. Such a discussion would require the introduction of several new terms, with TFM used—as a suggestion—for, true frequency modulation. The notation FM may then be used for the entire art, exactly as it is used today in newspapers and magazines. As a technically correct term for the entire art angular modulation (ANM) or time axis modulation (TAM) may be used. To follow up this idea, the field of TAM is then split up into three important groups: TFM, PM (phase modulation) and FPM (frequency-phase modulation). The last group is the one of primary interest in present broadcast technique.

adopted by the author in teaching involves an extended IRE terminology as well as a tentative classification. The discussion of movements along the path of operation or movements of the path of operation itself has resulted in such technical terms as sliding Q-point or FPO converters and shifting Q-point or CPO converters. In each case the modulating properties of the device constitutes a gain variation, controlled by the oscillator voltage. A tentative definition such as the following may therefore be formulated: *a superheterodyne converter is a device of variable admittance or transadmittance, which shifts the frequency of a passing wave by an amount determined by the periodicity of the admittance or transadmittance variation.* This periodic variation in effectiveness of the device is of fundamental importance in the understanding of the action that takes place in such modulating devices as modulators and converters.

The author wishes to thank the Director Professor E. L. Chaffee and faculty members of Cruft Laboratory for valuable suggestions concerning the material covered.

Appendix

Definitions Now in Use

Among the IRE definitions concerning superheterodyne converters the following are of primary interest:

Signal: The form of variation with time of a wave whereby the information, message, or effect is conveyed in communication.

Modulation: The process by which some characteristic of a periodic wave is varied with time in accordance with a signal.

Modulator: A device to effect the process of modulation. It may be operated by virtue of some nonlinear characteristic or by a controlled variation of some circuit quantity.

Modulated Wave: A wave of which either the amplitude, frequency, or phase is varied in accordance with a signal.

Telegraph-Modulated Waves: Continuous waves the amplitude or frequency of which is varied by means of telegraphic keying.

Demodulation: the process of modulation carried out in such a manner as to recover the original signal.

Detection: the process by which there is obtained, in response to a modulated wave, the signal imparted thereto in the modulation process.

Rectification: a process of operation on a wave to produce a unidirectional component.

Beating: a phenomenon in which two or

more periodic quantities of different frequencies react to produce a resultant having pulsations of amplitude.

Beat: a complete cycle in the phenomenon of beating.

Heterodyne Reception (Beat Reception): the process of operation on radio waves to obtain similarly modulated waves of different frequency. In general, this process includes the use of a locally generated wave which determines the change of frequency.

Superheterodyne Reception: a form of heterodyne reception in which one or more frequency changes take place before detection.

Frequency Changer: a device delivering alternating current at a frequency that differs from the frequency of the supply.

(The above formulations differ from the IRE formulations in the respect that the technical terms signal, modulation, etc., are not repeated in the beginning of the definitions.)

Proposed Definitions

Sum Pattern: a time plot of the algebraic sum of two or more waves.

Product Pattern: a time plot of the product of two or more waves.

Mixing: the process of bringing together two or more waves in a device producing a linear or nonlinear action.

Adding: the process of bringing together two or more waves in a device producing a linear action.

*Mixing Device or Mixer Stage**: a device to effect the process of mixing. Mixer stage may be abbreviated to mixer.

Nonlinear Mixer Stage or Multiplying Device: a device to effect the process of a nonlinear action. (A nonlinear mixer stage may employ a device with straight characteristics, operated in such a way that nonlinearity results.)

Linear Mixer Stage or Adder Stage or Adding Device: a device to effect the process of adding. Adder stage may be abbreviated to adder.

Heterodyning: a process of mixing for the obtaining of sum or difference frequencies.

Heterodyne Code Reception (Beat Reception): the process of operation on telegraph-modulated waves to obtain similarly telegraph-modulated waves of different frequency (usually of audible frequency).

Beat Frequency or Difference Frequency: the frequency of the amplitude pulsation of the resultant obtained in the phenomenon of beating.

Beat-Frequency Generation: a process of heterodyning for obtaining the difference or beat-frequency.

Beat-Frequency Oscillator, BFO: a de-

* Note that "converter stage" or "converter tube" and "mixer stage" or "mixer tube" are abbreviated "converter" and "mixer". To avoid confusion it is advisable always to use the complete technical term whenever there is risk of misunderstanding.

vice to effect beat-frequency generation.

Frequency Conversion or Frequency Changing: identical with heterodyne reception but may have a broader meaning, as it does not refer only to the receiving side. It is here assumed that heterodyne reception covers not only obtaining the difference frequency (Beat Reception) but also obtaining the sum frequency.

Converter Stage: a device to effect frequency conversion. A frequency converter stage may be referred to as a frequency converter (abbreviated form), being identical with a frequency changer.

Converter Tube: an electron tube which contains the electrode system of the local oscillator as well as the electrode system of the mixing device.

Mixer Tube: an electron tube which contains the electrode system of the mixing device, but not the electrode system of the local oscillator.

Detector: a device to effect the process of detection. A detector may be any device which in response to a modulated wave enables the signal (intelligence) imparted thereto to be heard, seen, felt, or recorded.

Q-point: the (moving) point of operation, the position of which is determined by locally applied voltages. (The oscillator voltage is to be considered as a locally applied voltage. The input signal voltage is the operating voltage.)

Sliding Q-point Converter: a frequency converter in which the admittance or transadmittance variation is caused by an oscillator voltage applied to the signal electrode.

Shifting Q-point Converter: a frequency converter in which the transadmittance variation is caused by an oscillator voltage applied to electrode other than the signal electrode.

Single Input Mixer: a mixer in which the signal and oscillator waves are applied to the same electrode.

Double Input Mixer: a mixer in which the signal and oscillator waves are applied to different electrodes.

Outer Grid Injection (OGI): the type of oscillator voltage injection employed when the injection electrode is further from the cathode than the signal electrode.

Inner Grid Injection (IGI): the type of oscillator voltage injection employed when the injection electrode is closer to the cathode than the signal electrode.

ON MEASURING: "I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science."—Lord Kelvin, 1883.

NEW BOOKS

Radio Networks and the Federal Government

By THOMAS P. ROBINSON, *Columbia University Press, New York, 1943, 278 pages, price $3.50.*

STARTING with the formation of the Radio Corporation of America on Nov. 17, 1919 and with the technical origin of broadcasting at KDKA on Nov. 1, 1920, this book traces the growth of the American way of broadcasting by private enterprise, as a background for analysis of the present legal battle between the Federal Communications Commission and the radio networks. Many facts and figures, a bibliography and a carefully prepared index add to the usefulness and reference value of the book to anyone interested in the political aspects of this one phase of radio broadcasting.—J.M.

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Alternating Current Circuits

By R. M. KERCHNER and G. F. CORCORAN, *Second edition, 563 pp., price $4.75, John Wiley & Sons, New York.*

ORIGINALLY PUBLISHED in the spring of 1938, the volume by Kerchner and Corcoran has been revised and is now issued as a second edition with many changes from the first. It is intended as a textbook for junior students in electrical engineering who have had adequate preparation in physics and mathematics including the differential and integral calculus.

The book represents a sincere, and undoubtedly successful, attempt to present the basic principles of alternating current circuits to students who may later elect to follow either the power or the communications field. The chapters on balanced polyphase circuits, on unbalanced polyphase circuits, and on symmetrical components definitely deal with problems of primary consideration to the power engineer. The chapters on electric wave filters, coupled circuits, and transmission line calculations are topics in which the communications engineer may be expected to be more interested. The chapter on alternating current measurement represents predominantly the point of view of the power engineer and is somewhat weak, especially for measurements beyond power line frequencies.

A distinct effort has been made to teach the fundamentals of alternating current theory rather than to dwell upon current practices which may change from time to time. There are no photographs of imposing electrical installations or power lines strung across the mountains or similar imagination stimulating photographic reproductions. Professors Kerchner and Corcoran have packed their volume with good sound engineering theory, making adequate but just use of calculus, differential equations and complex algebra. Although the book gives some treatment of transient and non-sinusoidal wave forms, the major bulk of the volume is devoted to a solution of steady state conditions with sine wave voltages and currents. The volume does contain many schematic wiring and wave form diagrams, and in many cases the latter have been supplemented by photographs of actual oscillographs.

It would seem to this reviewer that "Alternating Current Circuits" is the type of volume which the student, using it as a textbook, would find useful not only during his training as an engineering student but later as a practicing engineer when the book will undoubtedly come in handy for reference use.—B.D.

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Radio Troubleshooter's Handbook

By ALFRED A. GHIRARDI, *Radio & Technical Publishing Co., New York, 3rd Revised and Enlarged Edition, 1943, 744 pages, price $5.00.*

A COMPILATION of data useful chiefly to those servicing radio receivers, consisting essentially of the second edition (1941) with some of the text, illustrations and data brought up to date. Of particular merit is the new 28-page chart of tube characteristics and base diagrams, covering receiving, special-purpose, transmitting, cathode-ray and Army and Navy tubes. I-F peak values are given for over 20,810 models of superheterodyne receivers. Tables and charts give a wealth of other useful reference data in handy form for engineers, including addresses of many firms connected with the radio industry.—J.M.

Understanding Radio

By H. M. Watson, H. E. Welch and G. F. Eby, *603 pages, reprinted edition, price $2.80, McGraw-Hill Book Co., New York.*

THIS NEW EDITION of a popular book on elementary radio is directed primarily at the elucidation of the principles underlying radio communication. It is intended as an introduction to radio and is suitable for use in high schools, trade schools or junior colleges. It is essentially a practical book with emphasis on outlining qualitative concepts and is virtually free from mathematics even of the simplest sort.

The authors have used some novelty in certain of their diagrams and frequently have stimulated the reader by including photographs of historical interest. A list of technical terms is included at the end of each chapter, and there are many sets of questions by which the student may test his comprehension of the text which has been studied. Emphasis has been placed on the actual construction and operation of radio equipment. It would probably be unfair to classify the book as a laboratory manual but it does partake of the characteristics of a combined laboratory manual and text book.

The fundamental principles of radio are outlined in the chapters dealing with vacuum tubes, resonance phenomenon, electroacoustic devices, power supplies, transmitters and receivers, antennas and other chapters treating the usual radio topics. The volume is well illustrated with carefully drawn diagrams, and is printed on good quality paper. It is not the sort of a volume that the engineer would select for his own reading but it is the kind of book that he could well recommend to his non-technically trained friends who desire to gain some understanding of the fundamentals of electronic and radio communication.—B.D.

• • •

Dynamical Analogies

By Harry F. Olson, *Acoustical Research Director, RCA Laboratories, Princeton. 196 pages, price $2.75, 1943, D. Van Nostrand Co., New York.*

ANALOGIES ARE FREQUENTLY employed to define or describe new or previously unknown phenomena in terms of phenomena already familiar and well known. The hydraulic analog of an electric circuit is a well-known and common example of the use of such analogies. Unfortunately, however, several types of analogies are possible and often the behavior of the analog is as difficult to comprehend as the original circuit itself. Moreover, with certain types of analogies the correspondence between the two systems is not too close, so that a complete explanation in terms of the analogy is often impossible.

Fortunately, Dr. Olson has avoided all of the undesirable characteristics by treating only those analogies in which there is a complete mathematical correspondence between the

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Of Electronics, published monthly at Albany, N. Y., for October 1, 1943.

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County of New York } ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared J. A. Gerardi, who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Publishing Company, Inc., publishers of Electronics, and that the following is, to the best of his knowledge and belief a true statement of the ownership, management, (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

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McGRAW-HILL PUBLISHING COMPANY, INC.

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[SEAL] EMILY Z. SHEPARD.

Notary Public, New York County, New York Clerk's No. 768, N. Y. Co. Reg. No. 4S1275.

(My commission expires March 30, 1944)

dynamics in one system, and that in another physical system. The book deals with the analogy between electrical, mechanical, rectilinear, mechanical rotational and acoustical systems. The subject matter is developed in stages from the simple element through to complex arrangements of multi-element systems. In each case, the dynamical system is developed from its fundamental differential equation which is the same for the four physical systems selected except for the differentiation in symbols which is required to distinguish one physical system from another. Thus, the dynamical analogies treated by the author rest on a thoroughly firm foundation. They have the advantage of reproducing the equivalent performance of a mechanical, electrical and acoustical system, side by side. This feature should make the volume useful to those whose training is largely in the mechanical, electrical or acoustical field, although the tone of the book appears to be largely one emphasizing the electrical point of view, notwithstanding Dr. Olson's considerable professional work in the field of acoustics.

After an introduction in which are defined the terms employed in the volume, there is a chapter on elements of dynamical systems which should be useful to those making their debut into college physics. The next two chapters deal with dynamical systems with one, two or three degrees of freedom and this in turn is followed by chapters on corrective networks, wave filters, transients, driving systems, generating systems, circuit theorems, and a final chapter on the applications of the analogies discussed in previous sections of the book.

In the preface, the author states, "Although not generally so considered the electrical circuit is the most common and widely exploited vibration system. By means of analogies a knowledge in electrical circuits may be applied in the solution of problems in mechanical and acoustical systems. In this procedure the mechanical or acoustical vibrating system is converted into the analogous electric circuit. The problem is then reduced to the simple solution of an electrical circuit. This method has been used by acoustical engineers for the past 20 years in the development of all types of electroacoustic transducers. Mechanical engineers have begun to use the same procedure for analyzing the action of mechanism." The text assumes on the part of the reader a familiarity with the elements of alternating circuit theory and physics. Except for early sections in which circuit elements are defined, the volume is rather devoid of differential equations as such. A large part of the treatment is developed on the basis of steady state alternating current theory, making use of the customary complex vector notations with the operator. The chapter on transients is treated by the method of Heaviside's operational calculus and the required mathematical manipulations are therefore largely algebraic, in character. It appears to this reviewer that "Dynamical Analogies" may be expected to serve two useful functions. For the practising engineer it correlates four important dynamical systems, in each case showing the relationship between the elements in each system. It thus makes possible the solution of one kind of vibrating system in terms of a more familiar dynamical physical system. Secondly, for the student, the volume will serve as a means of unifying important principles of dynamics which have probably been learned several times from different points of view.—B.D.

• • •

Radio Engineers' Handbook

By F. E. TERMAN, *Professor of Electrical Engineering, Stanford University. 1,019 pages, price $6, McGraw-Hill Book Co.*

DR. TERMAN'S LATEST VOLUME is published at a particularly appropriate time and meets, extremely well, the current demand for recent technical data in the radio field. The volume chronicles much of the newer technique developed for operation of extremely high frequencies (at least, those branches of the topic which are not restricted for reasons of military secrecy) and this gives the volume an air of crisp modernity which, alone, will make this a "must" for radio engineers.

The handbook represents a tremendous undertaking for a single individual. Even though the assistance of many people and organizations entered in one way or another to bring this volume into being, nevertheless the handbook represents a distinct achievement for any one man, particularly in standards of organization, selection of material, and method of presentation.

The volume is divided into thirteen separate sections as follows: (1) Tables, Mathematical Relations and Units, (2) Circuit Elements, (3) Circuit Theory, (4) Vacuum Tubes and Electronics, (5) Vacuum Tube Amplifiers, (6) Oscillators, (7) Modulation and Demodulation, (8) Power Supply Systems, (9) Radio Transmitters and Receivers, (10) Propagation of Radio Waves, (11) Antennas, (12) Radio Aids to Navigation, and (13) Measurements. An author's index of seven pages and a subject index of fifteen pages conclude the volume. As might be expected in a handbook, these topics are treated in a rather condensed, abbreviated form, with emphasis on the significant facts. The treatment throughout is intensely practical and useful and there are many footnote references to the technical literature for those who require additional treatment of a particular subject. This volume is more than the usual handbook, for there is a distinct air or atmosphere about it which is somewhat difficult to explain or define. It seems to this reviewer, however, that this is partially attributed to the fact that the volume is a combination reference textbook and handbook, combined with a careful survey of the technical literature up to at least the end of 1941.

Topics included in this handbook and which makes the volume particularly timely include a section on wave guides and resonators of some 23 pages, the first treatment of electron optics (19 pages) to appear in a handbook, a graphical treatment of passive and amplifier circuits using generalized graphs, a 21-page section on video frequency amplifiers, a 14-page section on ultrahigh frequency oscillators, 10 pages of frequency modulation, sections on f-m transmitters and receivers, a section of almost 100 pages on the propagation of radio waves and containing a great many references, a section of some 16 pages on antennas with horns and parabolic radiators in the chapter on antennas, 9 pages on wideband and television antennas, and an unusually extensive author's index.

With the appearance of Dr. Terman's handbook, it would appear that the communication engineer, and the radio engineer in particular, is well supplied with reference handbooks. The first of these to appear was "The Radio Engineering Handbook", edited by Keith Henney, while Vol. 5, "Electrical Communication and Electronics", and edited by Pender and McIllwain represented the Wiley contribution to this important field of electrical engineering. Four or five sections in "Standard Handbook for Electrical Engineers", will likewise be of interest to the communication and radio engineer, although this volume is not directed specifically to his needs. The accompanying tabulation will show the relative space devoted to topics which may be found in the three communications handbooks currently available. It should be pointed out that the volume by Pender and McIllwain is intended to cover the general field of communication and therefore contains sections on wire communication systems which the volumes by Henney and Terman omit.

A few misspelled words occur here and there (as is bound to happen in any undertaking of this magnitude and produced under present circumstances of book publishing) and the table of physical properties of elec-

	Henney		Pender & McIlwain		Terman	
	No. Pages	%	No. Pages	%	No. Pages	%
Mathematical Tables, Formulas, etc.	26	2.75	72	7.02	25	2.45
Circuit Elements and Prop. of Mtls	76	8.06	117	11.42	98	9.6
Circuit Theory	73	7.71	49	4.89	138	13.55
Electron Tubes	51	5.40	82	3.02	78	7.65
Amplifiers	62	6.57	30	2.93	126	12.35
Oscillators	38	3.92	15	1.47	50	4.90
Demodulation & Modulation.	36	3.72	10	0.97	56	5.5
Power Supply Systems	44	4.66	7	0.68	28	2.74
Transmitters & Receivers	185*	19.6	24	2.34	52	5.10
Wave Propagation	4	0.42	18	1.76	95	9.32
Antennas	63	6.7	27	2.64	101	9.9
Measurements	51	5.4	66	6.45	93	9.13
Acoustics	52	5.5	50	4.90	....	.....
Index	17	1.8	26	2.54	23**	2.26
Total No. of Pages	945	....	1022	....	1019	....

* Including some special services.
** Including Author index.

trons and ions is taken from Birge's 1929 values rather than his latest compilation of 1940. But whatever defects Dr. Terman's book may have are so minor compared to its usefulness that they may well be overlooked. This reviewer has found "The Radio Engineers' Handbook" a stimulating source of general text reading providing an accurate, comprehensive survey of technical literature, but after all, a handbook is primarily intended for reference work and, in the few weeks in which this volume has appeared, this reviewer has yet to observe omissions of material which might be expected to be included in a handbook for radio engineers.

All told, Dr. Terman's latest volume will be an exceedingly useful and valuable contribution to the bookshelf of the professional radio engineer.—B.D.

• • •

Basic Electricity for Communications

By WILLIAM H. TIMBIE, *Massachusetts Institute of Technology. 1943. 600 pages, price, $3.50. H. John Wiley & Sons, Inc.*

IT HAS BECOME a sort of habit recently to label books as "first" in a field, meaning a book which is to be tackled before all others because of its simplicity and basic nature. Although this recent book of Professor Timbie is not so labeled, it is indeed a "first" book. The style follows that of his very successful "Elements of Electricity" of which this reviewer became an enthusiastic booster years ago.

The material consists of text in which "facts and theories are presented in simple direct statements," examples and solutions of problems involving the apaparatus, many problems for the reader to work out, summaries at the end of each chapter, and finally an appendix with wire tables, temperature coefficients, logarithms, etc.

The chapter headings give no picture of the way in which this elementary text differs from other texts, since the headings must invariably be Ohm's law, batteries, magnets, inductance, capacitance, alternating currents, vacuum tubes, etc., but once one begins to read the book he can see that the author has a highly-developed faculty for making things simple, easy to understand, difficult to forget. The problems are practical, they give a sense of values, they teach as much as the text. Some of the finest material on Thevenin's theorem this reviewer has seen will be found in this book.

A "first" book in more than one meaning of the term.—K.H.

• • •

Principles and Practice of Radio Servicing

By H. J. Hicks, *McGraw-Hill Book Co., Inc., New York, Second Edition, 1943, 391 pages, price $3.50.*

MUCH NEW MATERIAL on signal tracing, frequency modulation and antennas has been added in this second edition, and a great deal of the original material has been revised to bring it up to date as a text for radio servicemen. Fundamental principles are explained with a minimum of mathematics, practical applications to receiver circuits are taken up, and definite instructions are given for carrying out service procedures. There are many more illustrations than in the first edition, including excellent halftones showing constructional details of radio parts.—J.M.

• • •

A Course in Powder Metallurgy

By Walter J. Baeza, *President of Industrial Research Co. Reinhold Pub. Corp., New York City, 1943. 212 pages. Price $3.50.*

THE PRODUCTION of tungsten filaments, Alnico permanent magnets and both a-f and r-f transformer cores by compressing metals or alloys in powdered form to the desired shape, then processing at a temperature well below the fusion point of the product, constitutes powder metallurgy as applied to electronic devices. Although many recent developments in this field are military secrets, it can be said that the low weight of portable Signal Corps radio equipment is largely due to the use of powdered cores for transformers. Applications in other fields are almost limitless, including such diversified products as oilless bearings, cemented carbide cutting tools, molded gears, copper-graphite brushes, welding electrodes, etc.

This book is intended primarily to meet the needs of those who must acquire a detailed theoretical as well as practical knowledge of the subject in order to promote the war effort. The first 90 pages cover history and modern developments, production of metal powders, powder specifications, cohesion, manufacturing problems, and machines. The remainder of the book is in effect a laboratory manual for college students taking a course in powder metallurgy, giving instructions for setting up the course, general instructions to students, and details for performing 15 experiments.

A well-written, well-printed book, recommended to electronic engineers and any others desiring up-to-date information on a subject that may well play an important part in post-war planning.—J.M.

• • •

Electronic Control of Resistance Welding

By GEORGE M. CHUTE, *McGraw-Hill Book Co. 1943. 390 pages, price, $4.00.*

THE AUTHOR OF THIS useful book is an application engineer for General Electric, stationed in Detroit. For many months before this book was written and published he was instructing men in the use of resistance welding machines, and in how to maintain them in service. In this manner he learned what men needed to know about the subject. The book, therefore, is written in the down-to-earth easy style that distinguishes the practical man from the theorist.

After a preliminary description, in homely language, of alternating currents, fuses, volts, amperes, etc., the ignitron contactor is torn apart and described; then follows its installation and how to keep it working. The question of proper loading for ignitrons, proper measuring instruments, such as the cathode-ray oscilloscope, methods of measuring welding time, and time delay relays are taken up.

Following chapters deal with the thyratron tube and its manner of operation, automatic weld timers, pulsation welding, synchronous timing, locating trouble, energy storage systems. Descriptions of welding apparatus (made by several manufacturers) are included, and in each case the reader is well tutored in the method of operation.

This should be an excellent book for anyone having the job of maintaining in operation welders with electronic control.—K.H.

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Incentive to Invent

IN HIS LETTER in August ELECTRONICS, Mr. Eugene Mittelmann, Consulting Engineer, questions the profit incentive as being responsible for most inventions. "I do not think that in modern times any important invention was made or initiated because the man who invented it set out to make an invention in order to make money."

Admitting that an inventor can't help inventing, any more than a composer can help writing music, nevertheless the underlying incentive to patent, develop and perfect his invention, is usually one of personal financial profit. True, in today's large industrial laboratories this incentive, regrettably, is no longer an immediate cash reward or bonus from his employer (doubtless there would be far more inventions made were such talent adequately rewarded). None the less the employee does confidently expect advancement, in position and salary, if he turns in one or several worthwhile inventions. And the independent inventor almost invariably seeks to protect his idea by patent, chiefly with the hope of reaping adequate financial reward. I certainly did this when I toiled three years to arrive at the 3-Electrode Tube and Amplifier, and Mr. Mittelmann will hardly class these as not "important" inventions.

The profit motive is just as inherent and compelling with inventors as with business men, professional men, speculators, or the writers of "best sellers" or song hits. And any politics—inspired attempt or tendency to lessen this incentive, or to deny to the inventor his just and generous tribute from a benefitting society is wholly socialistic and antisocial.

I most earnestly hope that all ill-advised and hastily concocted attempts in Washington, or elsewhere, to weaken our American patent system at the cost of American inventors may be effectively throttled before more, and irretrievable, injustice and damage has been done to that class of citizens to which, more than to any single others, this Nation owes its magnificent stature, the American Inventor.

LEE DE FOREST

Patent System

YOUR CORRESPONDENT, Mr. Eugene Mittelmann, whose letter you published in August ELECTRONICS, has got hold of an important truth about the working of our patent system, but he seems to have been "too close to the trees to see the forest".

Inventors are not stimulated to invent by incentive—invention is a habit of mind plus an innate genius which leads one to see a problem as a challenge and to find its solution by unorthodox means. The *conception* of inventions is irrepressible so long as we have inventors, but the *de-*

(*Continued on page* 348)

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Dictionary of Radio Terminology in English, German, French and Russian Languages by A. S. Litvinenko. 560 Pages, Published in Moscow, U.S.S.R., Price, $5.00

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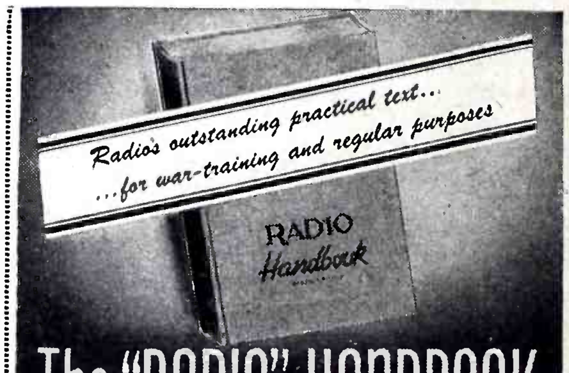

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EDITORS AND ENGINEERS

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SEARCHLIGHT SECTION

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velopment of these inventive concepts into commercial processes and commercial products does not come without an incentive and reward; and the public can benefit from inventions only as they improve, or lower the cost of, the products which the public buys.

Mr. Mittelmann cites the fact that employees of industrial laboratories solve problems without incentive. We may pass over the question whether success in their chosen field, professional invention, is not the incentive which keeps them on the important problems instead of wandering idly in the broad fields of invention, as so many amateur inventors do. The important fact is that the existence of the laboratory, with its equipment and materials, the payment of the inventors' salaries to work on the problems, and the willingness of the employer to put their inventions into commercial use, all depend upon the incentive of a reward sufficient to justify the risks and losses which always precede success in research and development. If I, as a manufacturer, undertake to develop and apply an inventive concept of my own or of an employee, I first must face large costs for experimental construction and testing of samples and equipment. When I have completed the development, I face additional costs to educate first my own engineering and production staffs, then my sales and service personnel, and ultimately the public, to the new product. In the change-over I may render obsolete, expensive equipment still on my books as a capital asset; and in the end some little thing which everyone has overlooked may lead the public to dislike it; so that I am worse off than if I had never heard of the invention. That is not imaginary—it happens every day, and most of the best research directors have such experiences.

Why should any sensible man take those risks, or change an existing successful business if he can sit back and copy any successful development of a competitor? The inventor would certainly have the urge to solve a problem if he happened to have the opportunity to learn of it; and, believing that he had a solution, he might have an urge to see it tried and used, so he might start in business if he could find anyone to put up the capital. He would pay out the expense of the research and development, he would take the risks of failure, and if he were rewarded by finding his innovation a successful solution of the problem, he could have the satisfaction of seeing it adopted by his well established competitors; then he could write off his losses to experience. Next time he would be satisfied with the mental pleasure of conceiving the invention.

Only our patent law has made it prudent to assume the risks of development and innovation. Only our patent law has made it a greater risk that a competitor might recognize a problem or solve it first.

Because the law makes it illegal to copy a patented invention, the risk of having one's product or methods or tools become obsolete is today greater than the risks of innovation. It is the recognition of this that has led American business to concentrate a large part of its effort and genius for effective organization on the competition to improve products and reduce costs by search for unrecognized problems and research for their solutions.

Take away the patent law and the risks of inaction would be at once removed while the risks of innovation would be raised so that only fools would assume them.

TRUMAN S. SAFFORD,
Counsellor at Law
New York, N. Y.

Electronic Recording

IN REGARD TO the "All-Electronic Sound Reproducer" described by Mr. Parry of KTKN of Ketchikan, Alaska in ELECTRONICS for August, I should like to say that I have been working for some time on just such a device.

The important difference in my design is that the scanning is done in a concentric continuous circle—the same type of track as found in the regular phonograph record. This type of scanning does away with the problem of the break at the end of each line as in straight line scanning.

I feel that there is a real need for this type of device doing away with the clumsy and antiquated mechanical methods of disc and moving film sound reproduction. I shall be pleased to consult with Mr. Parry or anyone interested in the further development of "All-Electronic Sound Reproduction".

BERNARD SEAMON,
Wiscasset, Maine

In important broadcasting stations, both here and abroad . . . in major motion picture and sound recording studios . . . in leading scientific and industrial laboratories the dominant note is control. Wherever dependable control is a necessity, DAVEN attenuators are the choice of discerning engineers. Precise DAVEN instruments meet every requirement of accuracy . . . dependability . . . serviceability.

DAVEN produces the most complete line of precision attenuators in the world...plus more than 80 models of laboratory test equipment for the broadcast, sound picture, television and electrical fields. A DAVEN catalog should be in your files.

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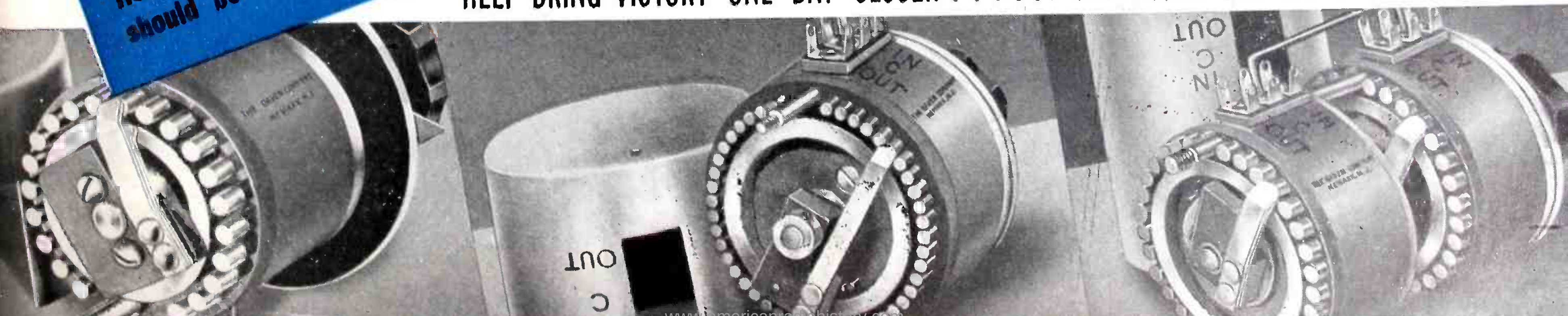

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RCA-2050...the Thyratron that started a new trend in electronic control

A THYRATRON is a "trigger" tube—a grid-controlled rectifier—which can "switch" power from full OFF to full ON with a very small change in control voltage.

The RCA-2050, announced in 1939, was a great step forward in thyratron design because it combined unusually high stability and great sensitivity.

Its characteristics were more uniform, too—from one tube to another, from one temperature to another, and throughout the life of any one tube.

Because the RCA-2050 offered such unusual performance, it quickly became a favorite tool of electronics engineers.

And it still is!

Here is a Summary of RCA-2050's Advantages

1. Stability Throughout Life. Characteristics of 2050 change relatively little throughout life of tube.

2. High Power-Sensitivity. Extremely low grid current (less than 0.1 microampere) permits use of high value grid resistor (up to 10 megohms) with consequent high sensitivity. RCA-2050 can be operated directly from a high-vacuum phototube.

3. Little Affected by Line-Voltage Surges. Stability as affected by line voltage surges is high because of the low grid-anode capacitance which results from the use of a shield grid.

4. Extreme Temperature Range. RCA-2050 is unaffected by temperature changes over the range of −50°C to +65°C!

5. All-position Mounting. You can mount the 2050 in any position since it is gas filled and contains no mercury. Its position can be changed during operation.

6. Low Voltage Drop. Xenon filling provides a tube drop of only 8 volts.

7. Quick Warm-up. Ready for operation in 10 seconds after heater is switched on.

8. Low Cost. List price of RCA-2050 is now $1.35, a 62% reduction from its original price.

9. Army-Navy Preferred Type Listing.

Application

The 2050 has found wide application in industrial control circuits. Its high power-sensitivity has made it invaluable as a link between actuating circuits and power circuits eliminating amplifier stages and sensitive relays.

The stability of the 2050 makes possible a high degree of accuracy in timing circuits.

The RCA-2050 is extensively used in control circuits for positioning, for welding, for air-doffer operation, for plastic molding, and as a relay tube in phototube control circuits.

If you have an application problem, RCA application engineers may be able to help you. Write, stating your problem, to Radio Corporation of America, Commercial Engineering Section, 521 South Fifth Street, Harrison, New Jersey.

Technical Data

Heater volts, 6.3; heater amperes, 0.6; grid-to-anode capacitance, 0.2μμf; heating time, 10 seconds; maximum overall length, 4⅛ inches; base, small shell octal 8-pin; peak forward anode volts, 650; peak inverse anode volts, 1300; average anode milliamperes, 100; tube voltage drop, 8 volts.

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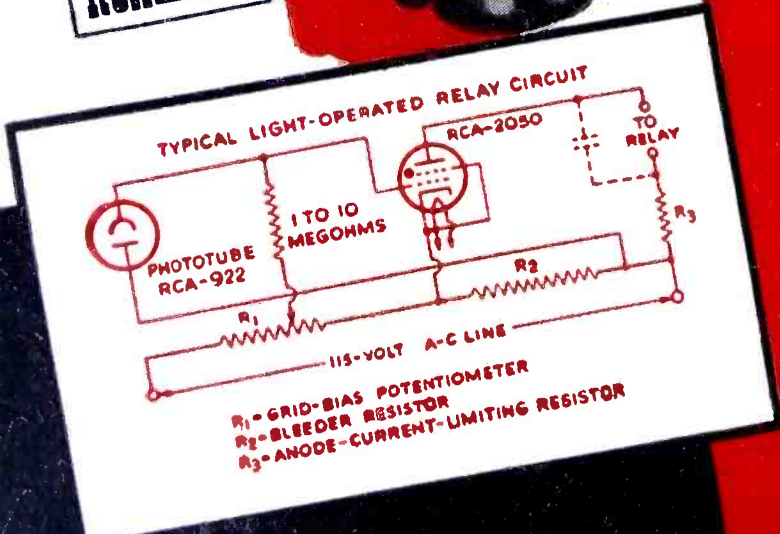

The Magic Brain of All Electronic Equipment Is a Tube and the Fountain-Head of Modern Tube Development Is RCA.

TUNE IN "WHAT'S NEW?" RCA's great new show, Saturday nights, 7 to 8, E. W. T., Blue Network.

RCA ELECTRON TUBES