J.S. Anderson

FEBRUARY · 1944

electronics

A McGRAW-HILL PUBLICATION

electronics

FEBRUARY • 1944

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ELECTRONICS, February, 1944. Vol. 17; No. 2. Published monthly, price 50c a copy. Allow at least ten days for change of address. All communications about subscriptions should be addressed to the Director of Circulation, 330 W. 42nd St., New York 18, N. Y.

Subscription rates—United States and possessions, Mexico, Central and South American countries, $5.00 a year, $8.00 for two years, $10.00 for three years. Canada (Canadian funds accepted) $5.50 a year, $9.00 for two years, $11.00 for three years. Great Britain and British possessions, 36 shillings for one year, 72 shillings for three years. All other countries, $6.00 for one year, $12.00 for three years. Entered as Second Class matter August 29, 1936, at Post Office, Albany, New York, under the Act of March 3, 1879. BRANCH OFFICES: 520 North Michigan Avenue, Chicago 11, Ill.; 68 Post Street, San Francisco, 4; Aldwych House, Aldwych, London, W.C. 2; Washington, D. C., 4; Philadelphia, 2; Cleveland, 15; Detroit, 2; St. Louis, 8; Boston, 16; Atlanta 3, Ga.; 601 West Fifth Street, Los Angeles, 13.

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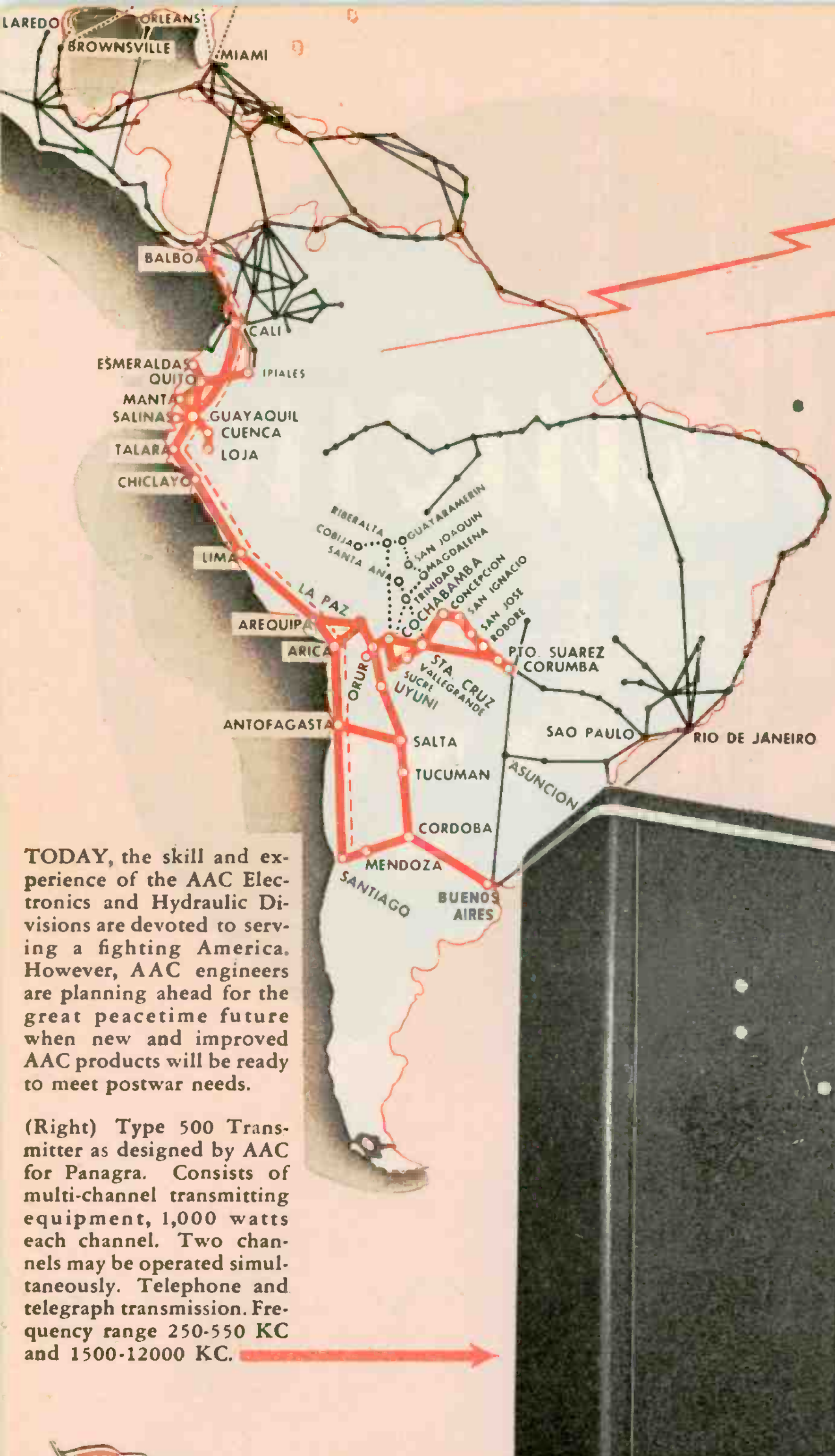
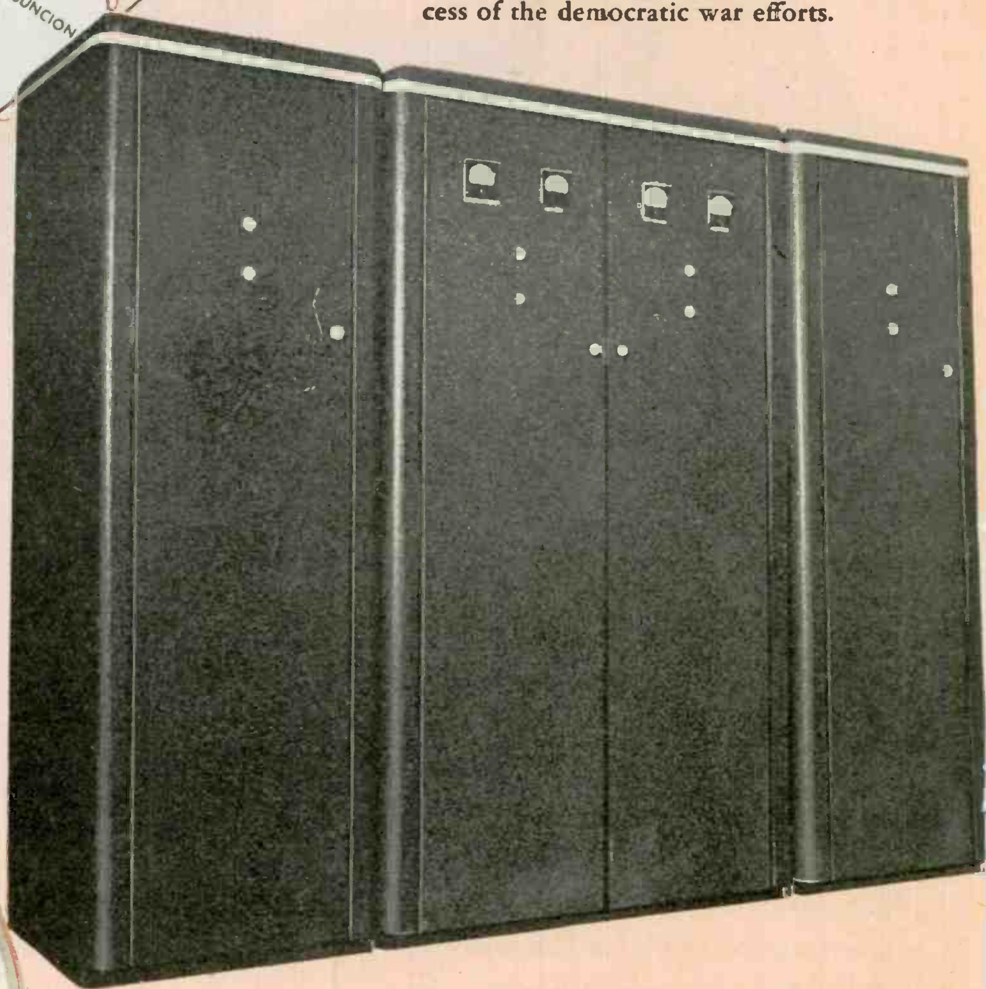


ALONG THE PANAGRA ROUTE is located AAC transmitting equipment at approximately 30 different points in Colombia, Ecuador, Peru, Chile, Bolivia and Argentina—forming the nucleus of the radio navigation and communications system.

Panagra is today primarily devoting its personnel and facilities to maintenance of aerial lifelines between the Americas, across which are speeding men, mail and materials vital to the success of the democratic war efforts.

TODAY, the skill and experience of the AAC Electronics and Hydraulic Divisions are devoted to serving a fighting America. However, AAC engineers are planning ahead for the great peacetime future when new and improved AAC products will be ready to meet postwar needs.

(Right) Type 500 Transmitter as designed by AAC for Panagra. Consists of multi-channel transmitting equipment, 1,000 watts each channel. Two channels may be operated simultaneously. Telephone and telegraph transmission. Frequency range 250-550 KC and 1500-12000 KC.



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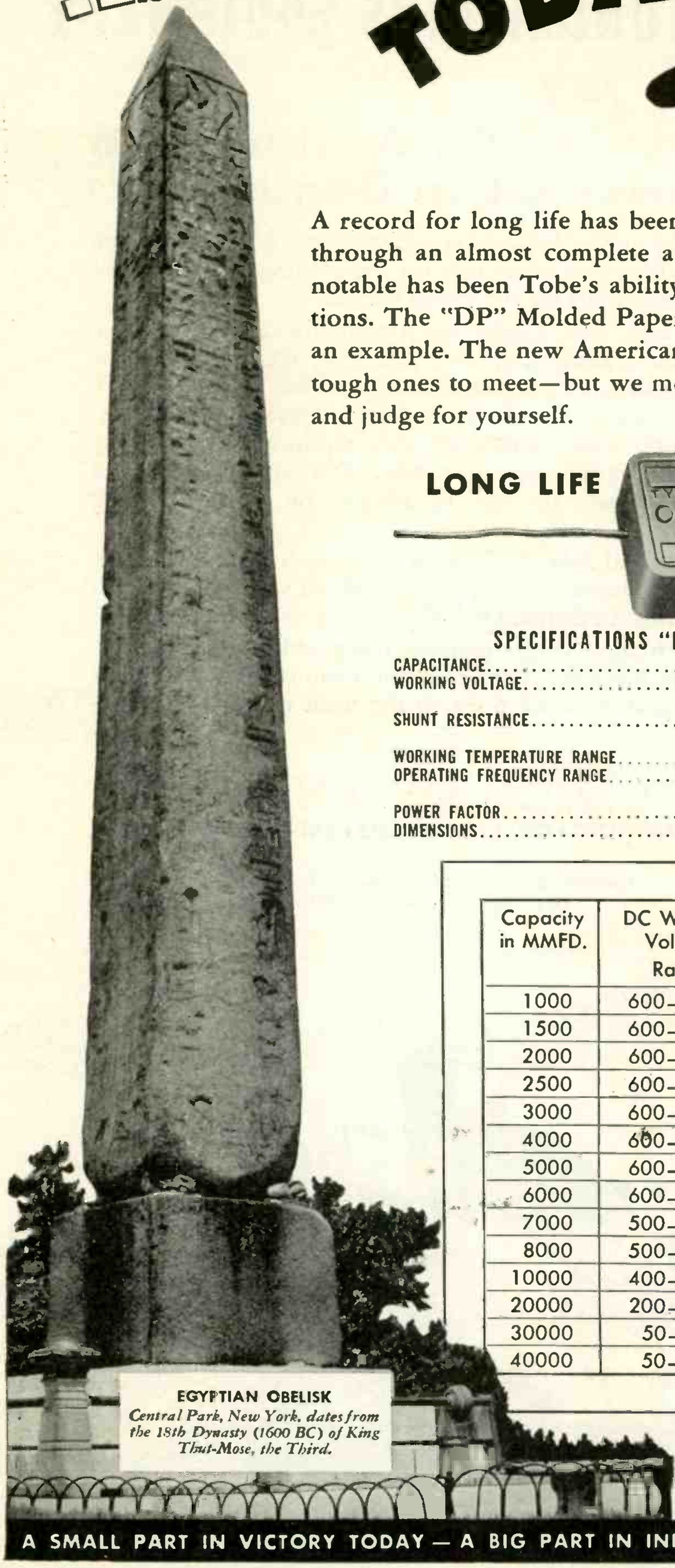

A record for long life has been earned by Tobe Capacitors through an almost complete absence of "returns". Equally notable has been Tobe's ability to master difficult specifications. The "DP" Molded Paper Condenser shown below is an example. The new American War Standards "specs" are tough ones to meet—but we meet them. Ask us for samples and judge for yourself.

LONG LIFE  **ASSURED**

SPECIFICATIONS "DP" MOLDED PAPER CONDENSERS

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

Capacity in MMFD.	DC Working Voltage Rating	TOBE & AMERICAN WAR STANDARDS DESIGNATIONS "A" Characteristic	"B"
1000	600—1500	CN35A102	CN35B102
1500	600—1500	CN35A152	CN35B152
2000	600—1500	CN35A202	CN35B202
2500	600—1250	CN35A252	CN35B252
3000	600—1000	CN35A302	CN35B302
4000	600—1000	CN35A402	CN35B402
5000	600— 800	CN35A502	CN35B502
6000	600— 800	CN35A602	CN35B602
7000	500— 700	CN35A702	CN35B702
8000	500— 700	CN35A802	CN35B802
10000	400— 600	CN35A103	CN35B103
20000	200— 300	CN35A203	CN35B203
30000	50— 150	CN35A303	CN35B303
40000	50— 100	CN35A403	CN35B403

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Central Park, New York, dates from the 18th Dynasty (1600 BC) of King Thut-Mose, the Third.

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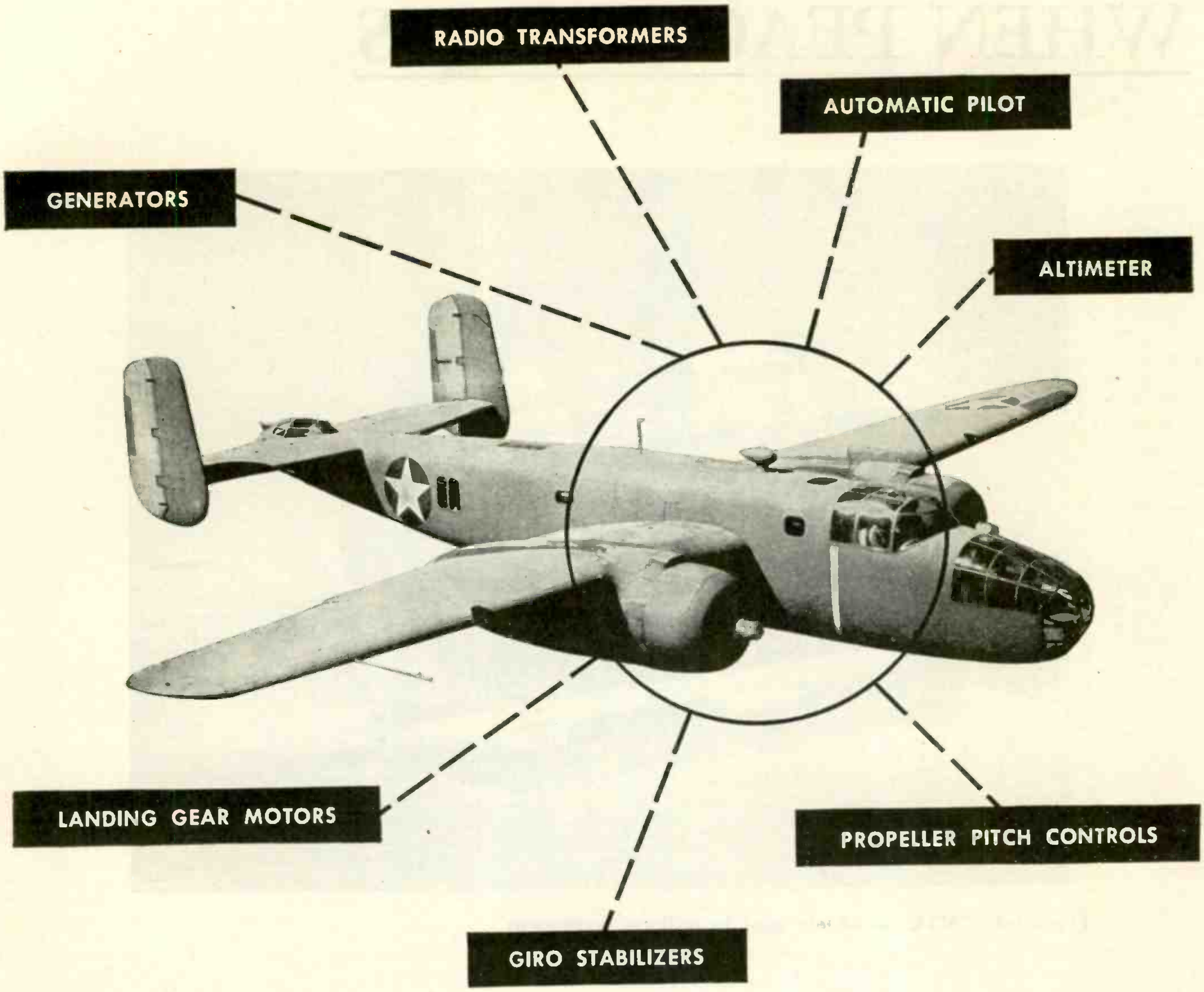
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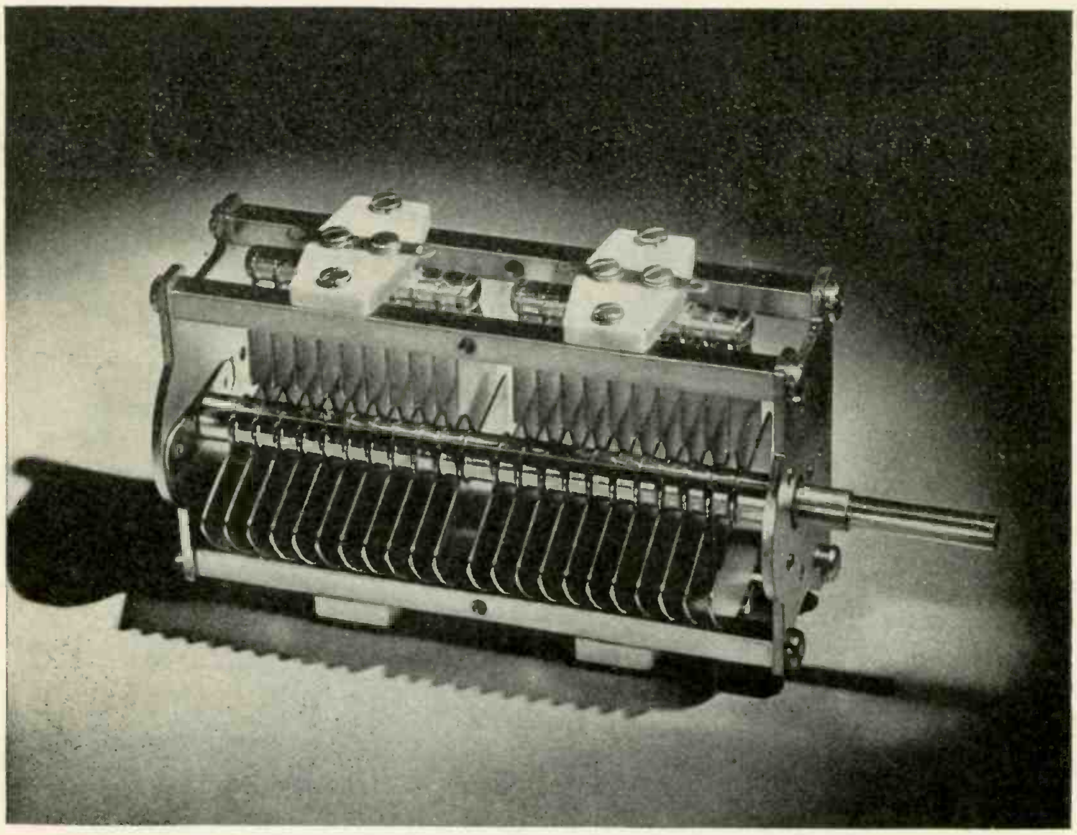
WHEN PEACE COMES



The sturdy "MTC" — widely used in military equipment

OVER three million Hammarlund variable condensers are on every front fighting for the cause of Peace. There are hundreds of new designs which, when Peace comes, will find wide application in every branch of electronics and radio communications.

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A. Good weldment.
B. Poor weldment. Note poor penetration and slag inclusions.
C. Good weldment.
D. Poor weldment. Note gas pockets.

looking inside WITH X-RAY

HELPS TRAINEES "CATCH ON" QUICKER!

They can SEE the difference between a good weld and a bad one

X-ray rules out guesswork in training, qualifying or classifying welders—or other workers—according to actual ability. It puts these all-important functions on a factual basis. For radiographs clarify . . . provide absolute proof . . . are readily understood because they *show* internal conditions that words fail to describe adequately.

They let the worker *look inside* the weldment, casting or assembly . . . show him whether it's good or bad . . . show him what to do and what to avoid. He "catches on" quicker, adheres to good, sound methods, and becomes a faster, more efficient producer from the start.

In addition to shortening training time and putting worker-classification on a factual basis, Westinghouse Industrial X-ray is doing countless other jobs faster, better and more economically. These fall into such major classifications as speeding production, saving machine and man-hours, conserving critical materials and improving quality.

For more information, write for Booklet B-3159. It suggests how and where you can benefit by using industrial x-ray. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

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SILVER MICA Capacitors
Special purpose oil impregnated silver mica capacitors particularly useful in high frequency applications.
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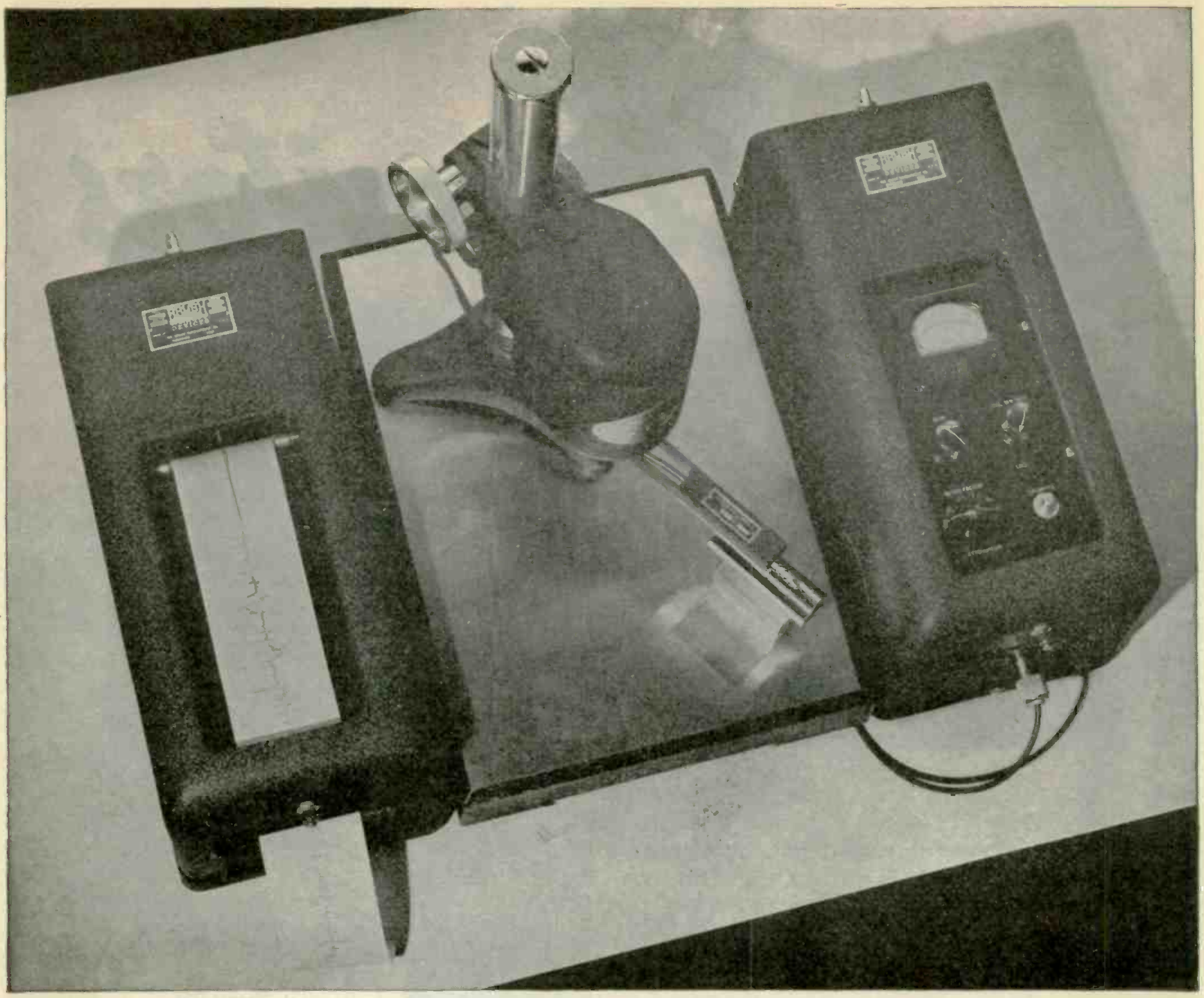

Proof of the Pudding

Among the many users of the Brush Surface Analyzer appear these prominent manufacturers who employ it to record finished surface smoothness to one-millionth of an inch:

ALUMINUM COMPANY of AMERICA	GENERAL ELECTRIC COMPANY	SPERRY GYROSCOPE COMPANY, Inc.
BENDIX AVIATION CORPORATION	GENERAL MOTORS CORPORATION	SHELL DEVELOPMENT COMPANY
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BULLETIN

NOT ONLY is G-E mycalex outstanding as a high-frequency electronic insulator but it is absolutely unique as a ceramic product . . . because metal parts can be inserted and securely anchored *right in it during the process of molding.*

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There are countless other reasons why G-E mycalex has been for more than 21 years helping to solve the toughest insulation problems. For example, it has high dielectric and mechanical strength, gives prolonged resistance to electric arcs, withstands oil, water and gas, and does not deteriorate with age.

Remember, when you choose G-E mycalex, you get the benefit of General Electric's unequaled experience in the application of mycalex. Whether or not your insulation problem is electronic, G-E engineers will help you solve it.

G-E mycalex sheets are now readily available to speed your production.

Just fill out the coupon for your copy of the data bulletin, "G-E Compression-Molded Mycalex." A free sample of G-E mycalex is available upon request. . . . *General Electric, Schenectady, N. Y.*

ELECTRONICS DEPARTMENT
GENERAL ELECTRIC CO.
Schenectady, N. Y.

Please send your descriptive booklet explaining the methods and tools to use for machining G-E mycalex.

Name ____________________

Company ____________________

Address ____________________

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

Over 21 Years of Mycalex Experience—Your Assurance of Quality

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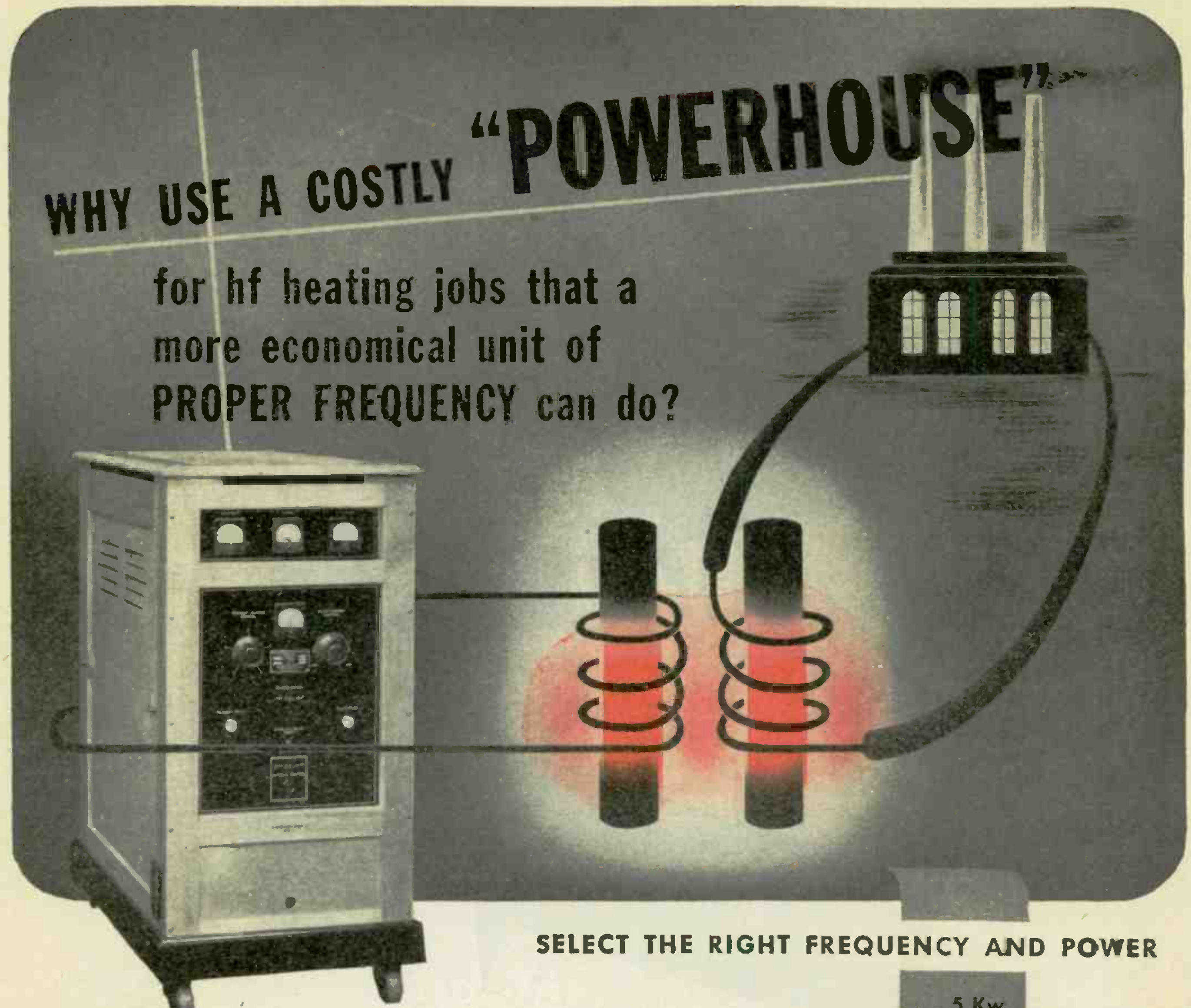

SELECT THE RIGHT FREQUENCY AND POWER

- 5 Kw
- 7½ Kw
- 10 Kw
- 12½ Kw
- 15 Kw
- 18 Kw
- 25 Kw
- 40 Kw
- 100 Kw

Frequency range up to 300 Mc

Don't tie up a big, expensive heater that delivers more than enough power at the wrong frequency . . . when a unit at a more suitable frequency would do the job just as well, with greater economy and convenience.

There is a unit of correct frequency and power for every heating operation. The cost of a h f heater and the amount of power it should consume are factors which depend on your specific applications.

Let us demonstrate how you can save by fitting the unit of proper frequency and power to the size of the parts being treated. This will release your "powerhouse" or misfit machine for work more suited to its capacity. Many users have proved that one of our installations can pay for itself many times over in the first year.

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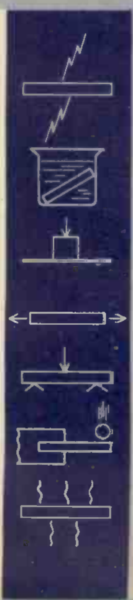
(Photo Courtesy Yerkes Observatory)

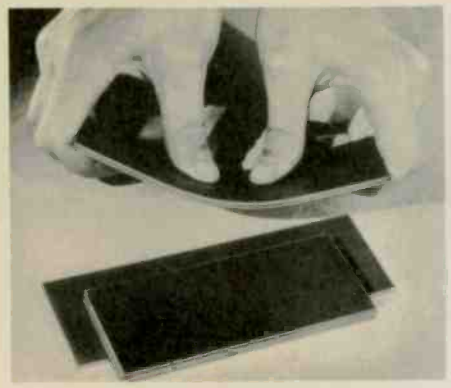


SYNTHANE "Sandwich" Materials

One of the advantages of Synthane is the ease with which it can be bonded to other materials to produce a substance with the combined advantages of the partnership. Bonding takes place under heat and high pressure, during the polymerization of the Synthane; it is not a mere joining of two surfaces with an adhesive. The resulting combination, therefore, shows little or no tendency to delaminate.

Synthane combinations are familiarly known as Synthane "sandwich" materials, an appropriate name, for many different kinds of combinations are possible.

Probably the most widely used combination brings Synthane and rubber together.

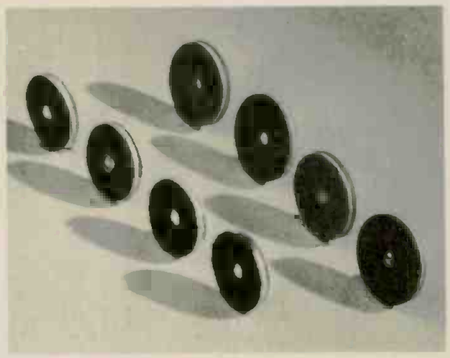


Synthane-Rubber

Synthane-rubber combinations are advantageous where the strength of Synthane is desirable to back up rubber.

An interesting application concerns a washer used in electrolytic and oil type condensers. The washer is placed on the end of tin can electrolytic condensers with the Synthane face exposed to the chemicals to prevent deterioration. The can is crimped into the rubber to make a tight seal.

A similar washer is used on "bath-tub" condensers. Tough Synthane provides a firm seat for a nut which compresses the rubber to form a tight joint.

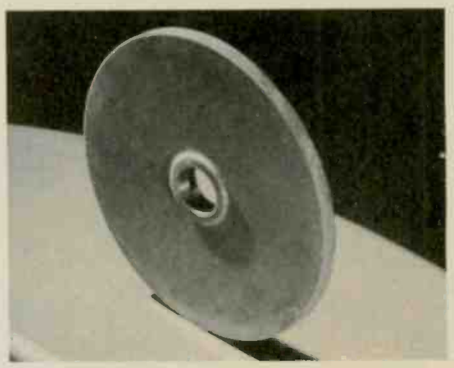


Combinations of rubber and Synthane have been furnished with rubber on one side, Synthane on the other; rubber on both sides with Synthane between; Synthane on both sides and rubber between; and alternate laminations of rubber and Synthane built up to any desired thickness.

There are many more possible uses for Synthane-rubber sandwich materials, which we cannot describe because of military censorship. There are also many important uses for a combination of Synthane and Neoprene.

Synthane-Synthane

Occasionally two grades of Synthane are combined. For instance, in certain radio tube sockets, layers of fabric



and paper base Synthane are combined. The paper base has usually better electrical properties while the fabric base furnishes added strength where the stress is greatest.

Bobbin heads in the textile industry are often made of paper and fabric bases combined. The fabric base endures rough handling, whereas the paper base on the inside of the head provides a smooth wearing surface.

Synthane-Asbestos

Synthane is wound about asbestos (or fibre) tubes and cured in the manufacture of tubing for large fuse cases. Synthane adds strength and rigidity to the fire resistance of the asbestos or fibre.

Synthane-Other Materials

Synthane can be united with a variety of materials to produce a variety of practical combinations. We have made or experimented with other combinations. If you have any combination in mind which we have not explored, we will be glad to investigate its possibilities for you.

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Under the abnormal climatic and operating conditions of war, the Signal Corps SCR-299 communications truck, built by Hallicrafters, is providing peak performance for the Allied armed forces, fighting throughout the world.

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Just as Hallicrafters Communications receivers are meeting the demands of war Today—they shall again deliver outstanding reception for the Peace—Tomorrow!

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- ★ *Oil Sealed*
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- ★ No Internal Corrosion

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The Egyptian Pyramids stand majestically, through the ages, as mute witnesses to the skill and rugged craftsmanship of the thousands of slaves who toiled to erect them ... TODAY ... not slaves ... but creative engineering skill and willing hands achieved the same result with the new DUMONT TYPE PC2 Oil Paper Capacitor ... an oil impregnated oil sealed capacitor that gives assured "LONGER LIFE" for continuous operation . . . Its special features and construction are exclusive with Dumont.

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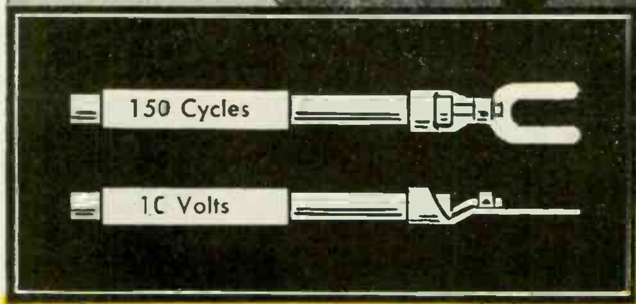
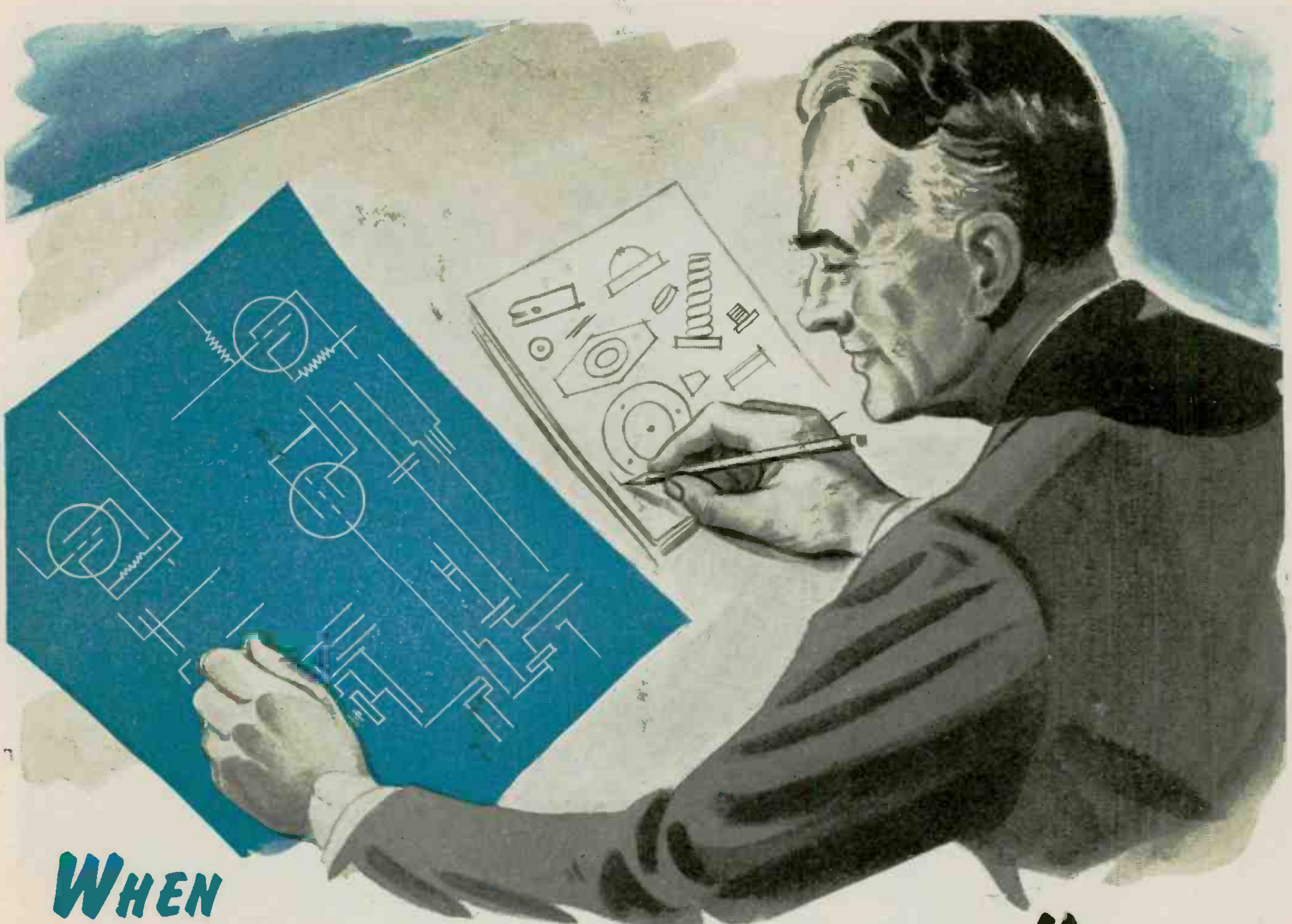

150 Cycles
1C Volts

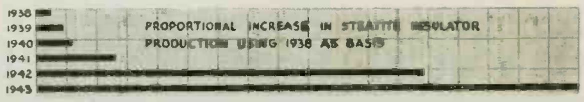


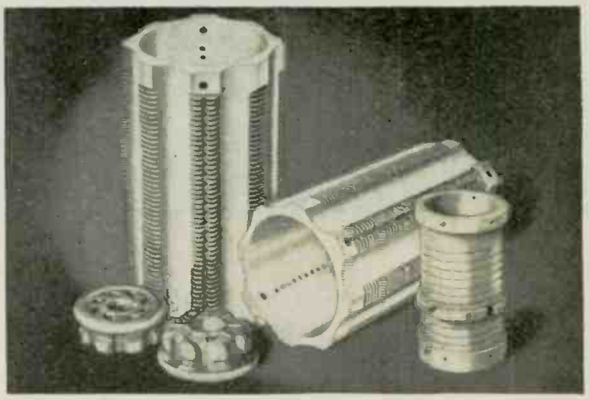
WHEN THE ELECTRONIC ENGINEER NEEDS *HELP...*

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.

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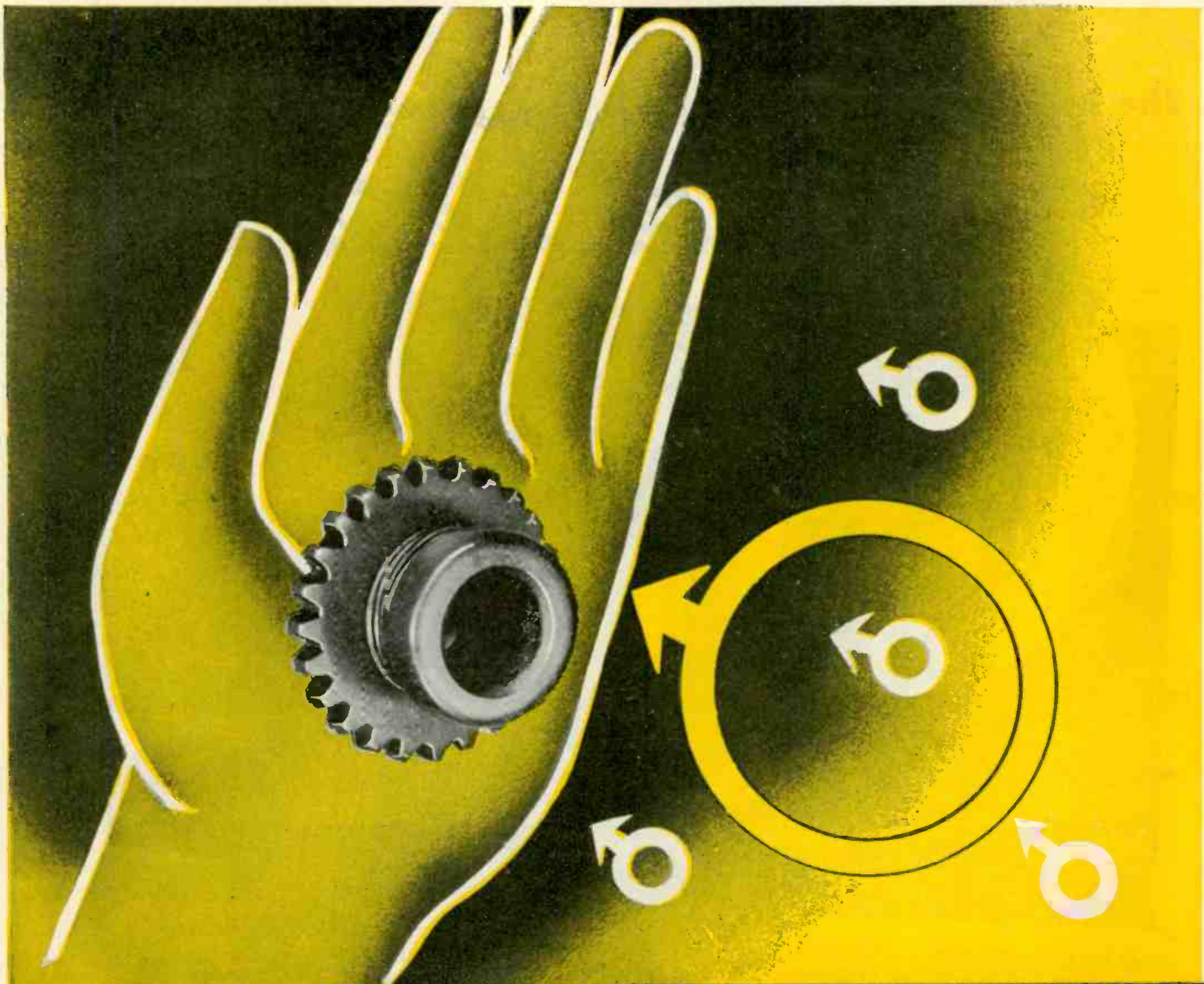
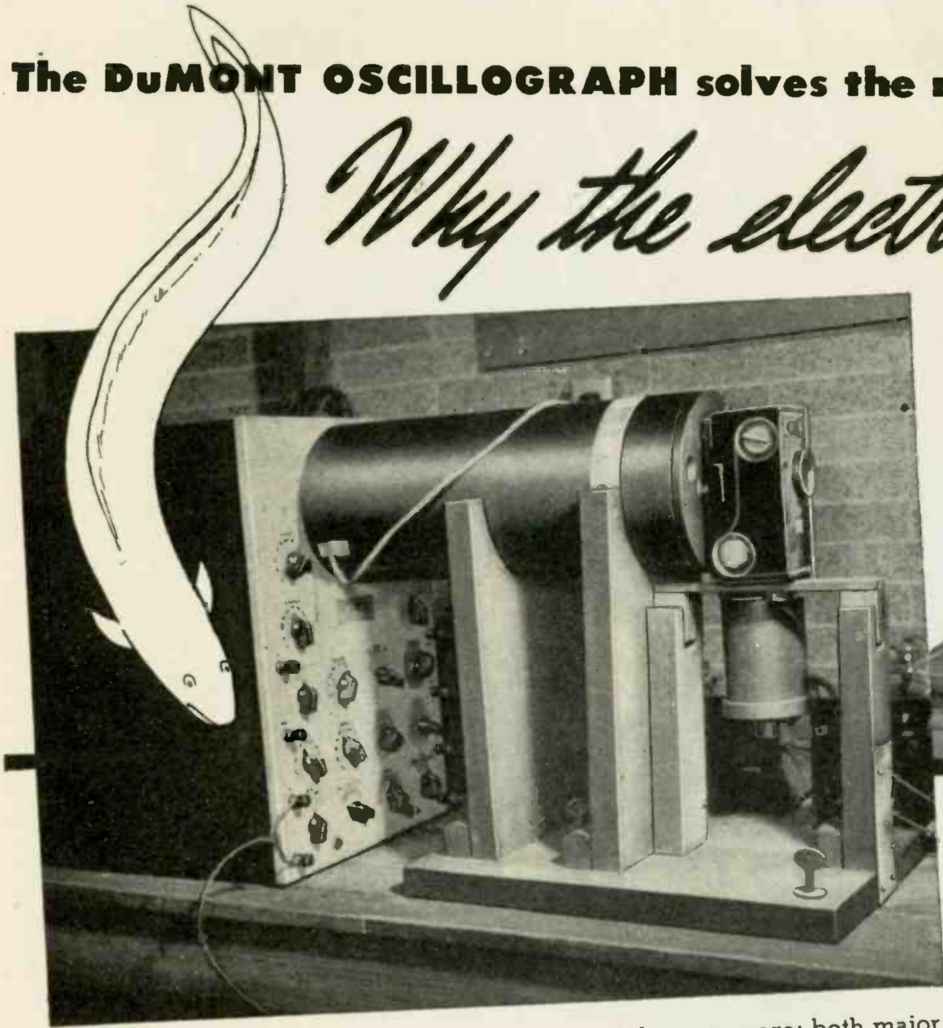


The DuMONT OSCILLOGRAPH solves the riddle...

Why the electric eel?



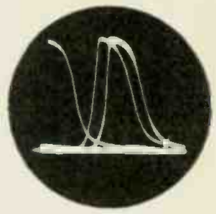
Man is stunned—sometimes killed. Fish are paralyzed at 20 feet. The electric eel even develops eye cataracts from its own shocks. But just how masses of nerve cells in that seven-foot body can generate such powerful electric discharges, has long posed a riddle for scientists. There have been many guesses as to voltage, amperage, duration, frequency. But nothing specific.

It has remained for Dr. C. W. Coates of the New York Aquarium staff, assisted by several scientists and physicists, to apply cathode-ray technique to this riddle. The electric eel now stands stripped of its operational secrets. Duly recorded are voltages as high as 600—above 500 common; discharges in trains of three or more; both major and minor discharges; average time interval between discharges as short as .002 second. These and other established details are now found in several published papers.

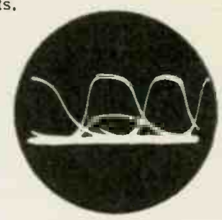
Dr. Coates places the eel in a wooden trough (note rubber gloves!). Sliding electrode strips establish contact along body. A DuMont Type 175-A oscillograph, especially suitable for transient studies, together with solenoid-operated single-frame movie camera, records recurrent discharges.

Just another case history of DuMont cathode-ray equipment engaged in solving scientific, engineering or industrial riddles.

Write for literature.



Voltage-time oscillogram of anterior segment of electric eel. Electrodes at anterior end of large organ and 10 cm. behind. Length of horizontal base corresponds to 5 milli-seconds. Peak is about 100 volts.



Voltage-time oscillogram of posterior segment. Electrodes 40 cm. and 70 cm. from anterior end of large organ. Scale same as above. Discharge of lower voltage is of the intermediate type.

DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: WESPEXLIN, NEW YORK

We dare to be different

We dare to explore...we dare to try the unfamiliar. In this manner, our creative engineers have built the world's largest organization devoted to the design and manufacture of automatic radiotelegraph apparatus.

Indicative of the *McElroy technique are these completely automatic transmitting and receiving assemblies. Designed in the McElroy plant, these installations are typical of the high-speed radiotelegraph equipment that we supply to such international companies as R.C.A. Communications Inc., Mackay Radio, Globe Wireless . . . and to the military branches of the government. Descriptive literature of all McElroy apparatus may be obtained by writing direct to us.

McElroy engineers never imitate and never copy. We create, design, build . . . and we deliver. If one of our engineers can be of service to you, let us know.

McElroy

MANUFACTURING CORPORATION
82 BROOKLINE AVENUE BOSTON, MASS.

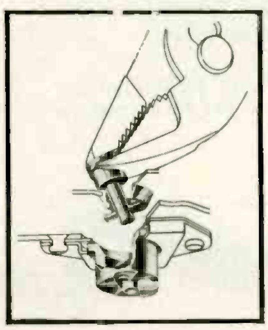
ARMY E NAVY

**Ted McElroy, World Champion Radiotelegrapher for More Than 20 Years*

ECONOMY

ALTHOUGH Camloc High Speed Fasteners are responsible for tremendous savings over worn or lost bolts and nuts, Camloc's greatest economy lies in its time savings. A quarter turn of the screw driver effects or releases a secure fastening. Installation too is a major feature of Camloc's time economy. Now exclusively for fighting aircraft, production will one day turn to the many industries which are fast coming to accept this as the modern fastening. Write for illustrated catalog.

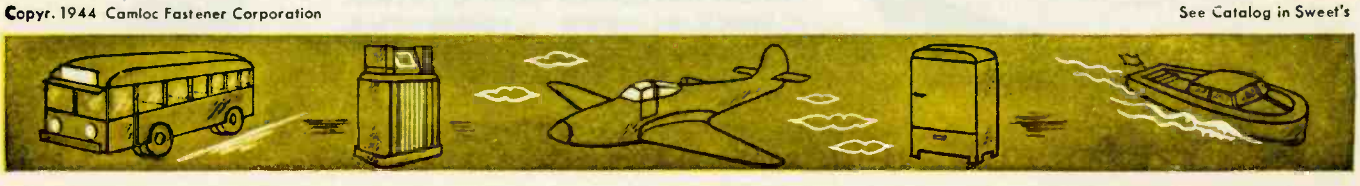
Illustration shows floating Cam Collar which is freely self-centering, thus allowing for misalignment up to 1/8" *in any direction*. Stud Assembly is easily inserted or removed as a unit. Selection of correct size at final assembly allows for cumulated tolerances. Cross pin is permanent. Stud grips Cam Collar uniformly preventing sheet warpage. A complete line of Cam Collars is available for single hole or rivet type mounting.



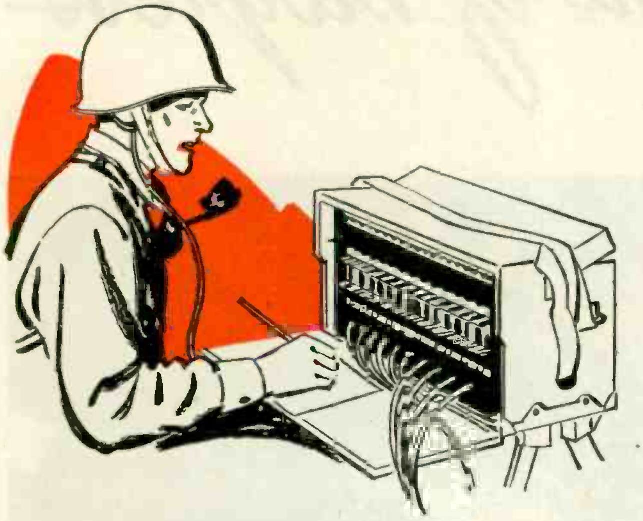
CAMLOC *high-speed* **FASTENERS**

CAMLOC FASTENER CORPORATION, 420 Lexington Ave., New York 17—5410 Wilshire Blvd., Los Angeles 36

See Catalog in Sweet's



What every officer knows . .



DEPENDS!

It depends in a large degree on what comes through his communications equipment. And HOW it comes through his communications equipment depends almost directly on the character of insulated wire and cable used in instruments and circuits.

Sure, you can load insulation on wire until you haven't room to install it, but that's costly in materials, in valuable space and in excess weight.

LEXEL Insulating Tape (cellulose acetate butyrate) is a precision product itself, and its application is a precision operation. The resulting insulated wire or cable can hit your specifications on the nose every time and all the time.

It's CENTER-SEALED and HEAT-SEALING!

Excellent properties!—**LEXEL** has high and constant dielectric strength, high insulation resistance, low moisture absorption, is flame retardant, and passes the flexibility tests specified for military aircraft insulated wire and cable in low tension service.

We'll gladly send you additional information and names of manufacturers supplying **LEXEL** Insulated Wire and Cable in all sizes.

★ ★ ★

CUSTOM-MADE INSULATION!

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

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

THE DOBECKMUN COMPANY

CLEVELAND, OHIO · OAKLAND, CAL

in Electrical Insulation

TYPICAL CHARACTERISTICS OF SHEET MICA

	Muscovite	Phlogopite
Chemical Composition (by analysis):		
Silica ($Si\,O_2$)	45.2	40.8
Alumina (Al_2O_3)	38.4	26.9
Potash (K_2O)	11.8	12.7
Magnesia ($Mg\,O$)	—	7.6
Ferric Oxide (Fe_2O_3)	—	12.0
Water (H_2O)	4.6	3.0
Specific Gravity	2.76–3.0	2.78–2.85
Hardness: Moh's Scale	2.8–3.2	2.5–2.7
Max. Temperature (deg.)	535 C	1000 C
at which employable	1027 F	1832 F
Power Factor at 1000 kilocycles	.0001–.0004	.004–.07
Dielectric Constant	6.0–7.0	5.0–6.0
Average dielectric strength (volts/mil) of fair stained quality, thickness 2½ mils, tested in oil at room temperature with 1-inch spherical electrodes	3200	2300

The selective sorting of Mica radio tube supports is shown in the accompanying photograph.

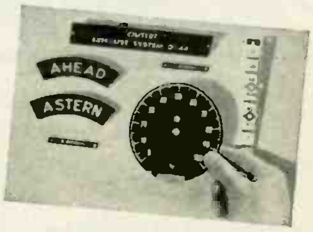
Close control of all plant operations is a Munsell "must"—from selecting Mica of the right type and grade for a particular application through splitting, gauging, sorting and punching operations. Applications of Mica insulation are so numerous and diverse that its selection for any particular purpose requires long experience and sound knowledge of its properties. These vary with the source of supply—and our long established relations have provided the ability to meet customer requirements with Mica from India, Africa, Brazil, Madagascar and Argentina, as well as from domestic sources.

Munsell Division

MICA INSULATOR COMPANY

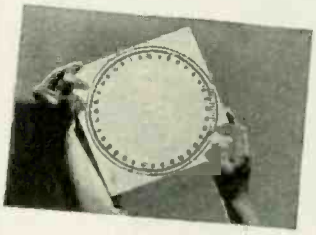
LAMICOID—FOR PANELS, DIALS AND CONTROL INDENTIFICATION

Typical parts, fabricated from Lamicoid, are illustrated. Permanent finish, color retention, dimensional stability, heat resistance, good dielectric strength, and non-inflammability of Lamicoid make it the ideal material for these and similar uses. Lamicoid can be furnished in a variety of forms, as shown below.



Graphic Lamicoid. Type matter or designs are permanently bonded *underneath* the surface of laminated plastic sheets. Available in fluorescent form for "blackout" illumination.

Engraving Lamicoid. A combination sandwich-type, opaque laminated sheet with black or colored surface and contrasting colored core which can be pantographed or sand blasted.



Translucent Lamicoid. Available in several colors, is used for rear illumination. Ideal for instrument dials and panels as it has a low coefficient of expansion and will not support combustion.

Mica Insulator Company

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

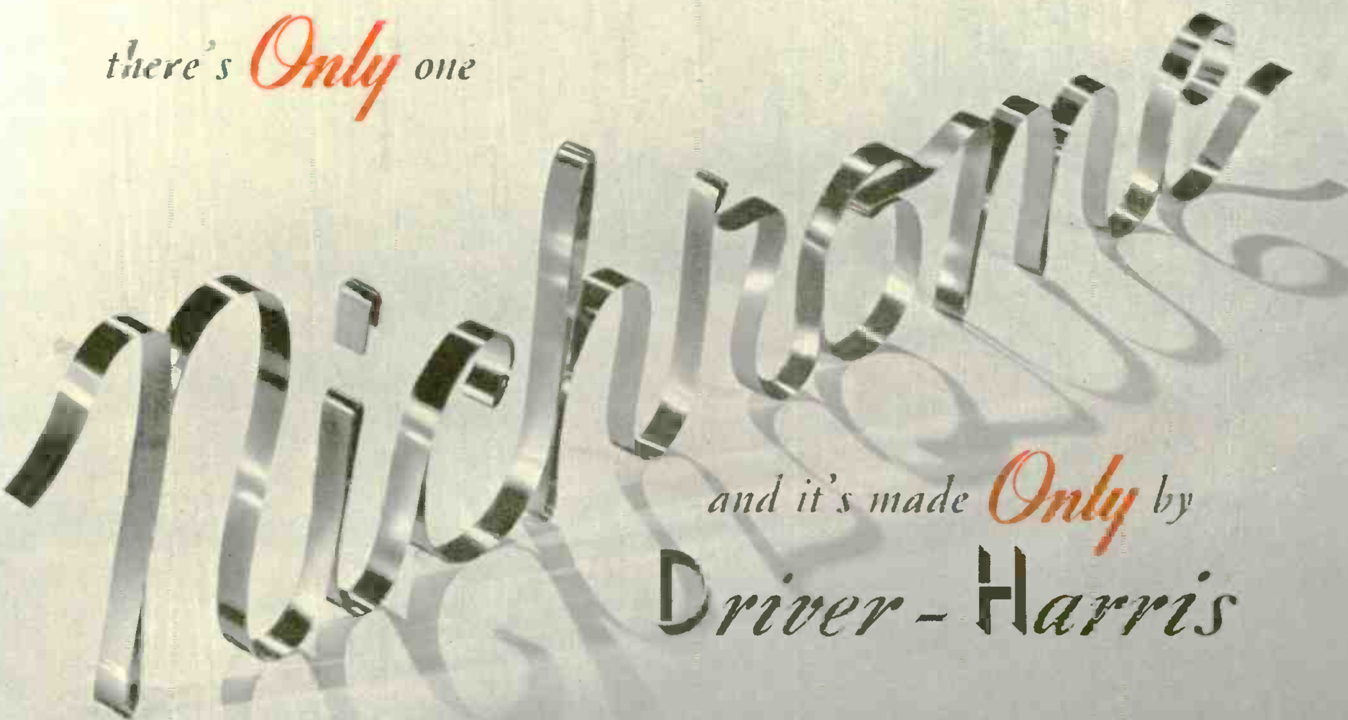
Chicago: 600 W. Van Buren St. • Cleveland: 1276 W. 3rd St. • Detroit: Book Building
Cincinnati: 3376 Meyer Place • Boston: 285 Columbus Ave.

Representatives in principal industrial centers. Micanite and Super Micanite (built up Mica), raw and fabricated Mica; Lamicoid (laminated plastic) for electrical and mechanical applications; Empire Varnished Fabrics and Papers; Mica Insulating specialists.

In all the world there's ***Only*** *one Jonker Diamond*

and in all the world of alloys

there's ***Only*** *one*



and it's made ***Only*** *by*

Driver-Harris

It takes more than a properly balanced union of nickel and chromium to produce genuine Nichrome.* There is always included at least one extra ingredient. • • Sometimes this hidden ingredient is an added trace of a third metal... an improved heating or quenching technique... or a specially developed deoxidizing anneal. But always it is the complete mastery with which D-H specialists employ their own exclusive methods and "know how." Remember this when next you buy electrical resistance or heating elements. • • For improved performance and longer life in your post-war products, specify Nichrome* and other resistance alloys by Driver-Harris—the time-tested standard of quality.

*Trade Mark Registered

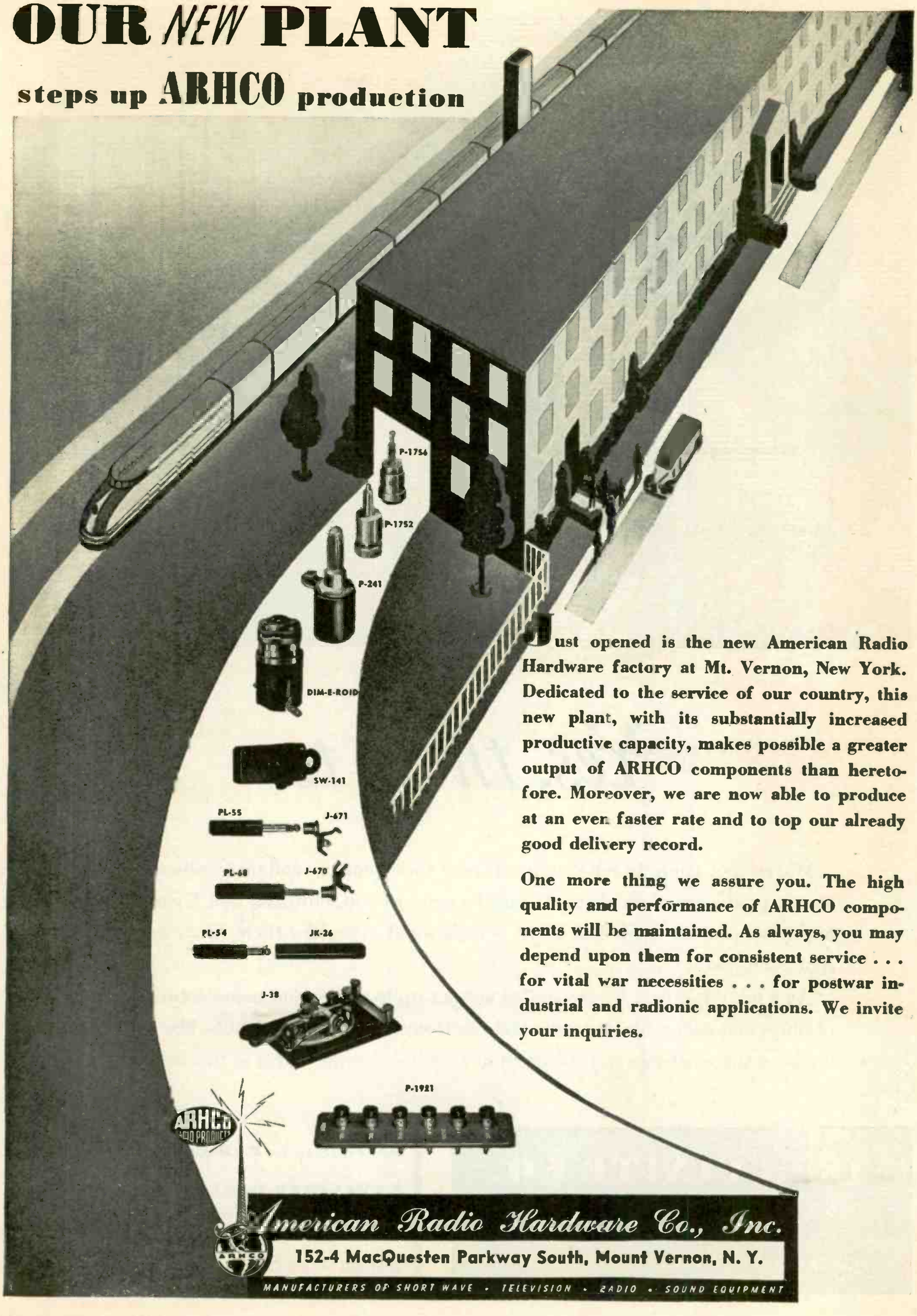
D|H

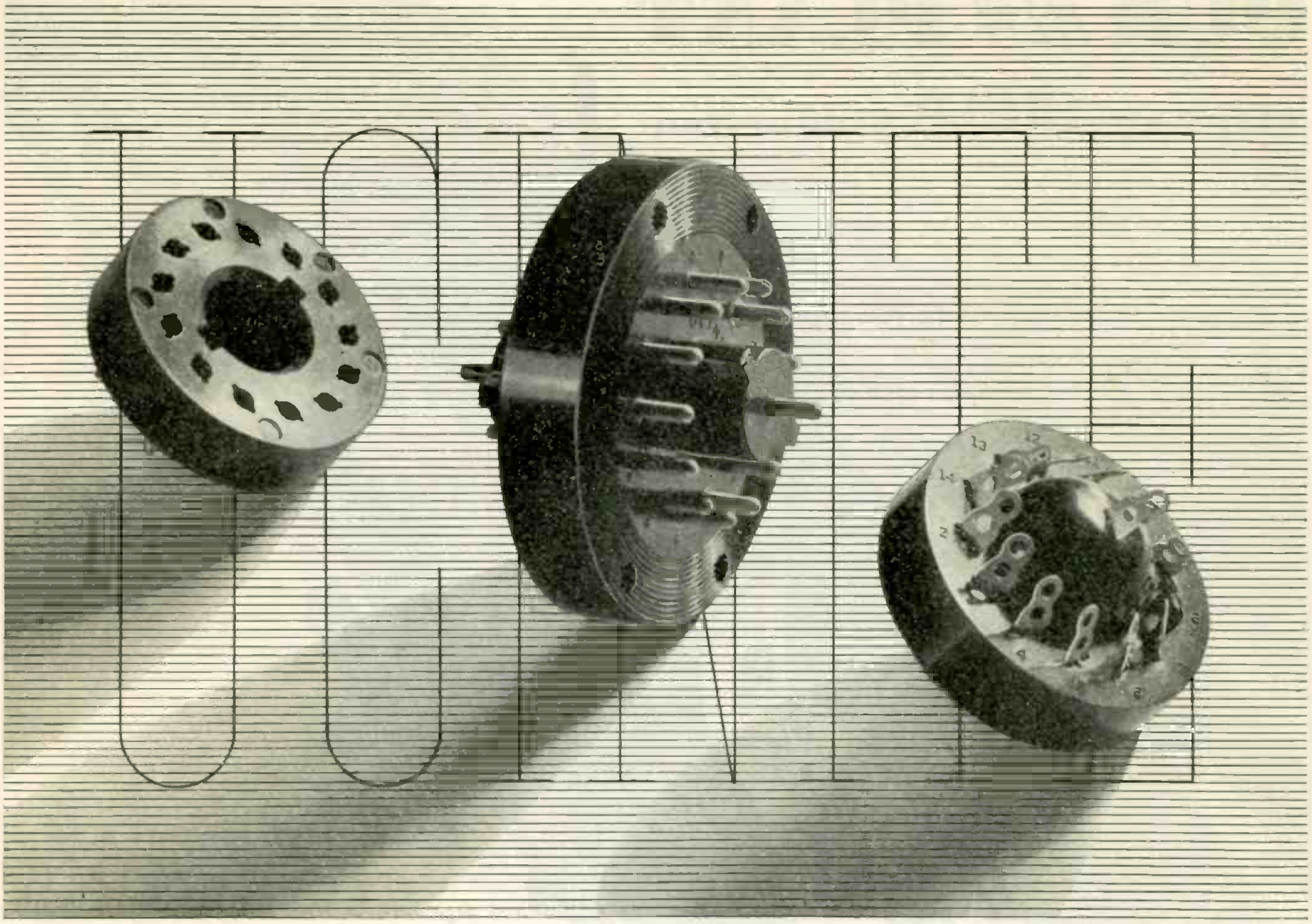
SPECIAL PURPOSE ALLOYS SINCE 1899

Driver-Harris
COMPANY

HARRISON, N. J.

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


OUR NEW PLANT
steps up ARHCO production
P-1756
P-1752
P-241
DIM-E-ROID
SW-141
PL-55
J-671
PL-68
J-670
PL-54
JK-26
J-38
P-1921
ARHCO
Just opened is the new American Radio Hardware factory at Mt. Vernon, New York. Dedicated to the service of our country, this new plant, with its substantially increased productive capacity, makes possible a greater output of ARHCO components than heretofore. Moreover, we are now able to produce at an even faster rate and to top our already good delivery record.
One more thing we assure you. The high quality and performance of ARHCO components will be maintained. As always, you may depend upon them for consistent service . . . for vital war necessities . . . for postwar industrial and radionic applications. We invite your inquiries.
American Radio Hardware Co., Inc.
152-4 MacQuesten Parkway South, Mount Vernon, N. Y.
MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT



Yes, these too

We are not going to tell you much about these plugs — and many others — which we are producing, these days. It may be news to you, however, that Ucinite makes highly specialized items like these — makes and assembles them in an under-one-roof operation.

As a matter of fact, we are staffed and set up to design and manufacture all types of plugs and connectors for radio and electronics. Special assemblies like the above are both the challenge and the proof of Ucinite's completeness in this field.

The UCINITE CO.

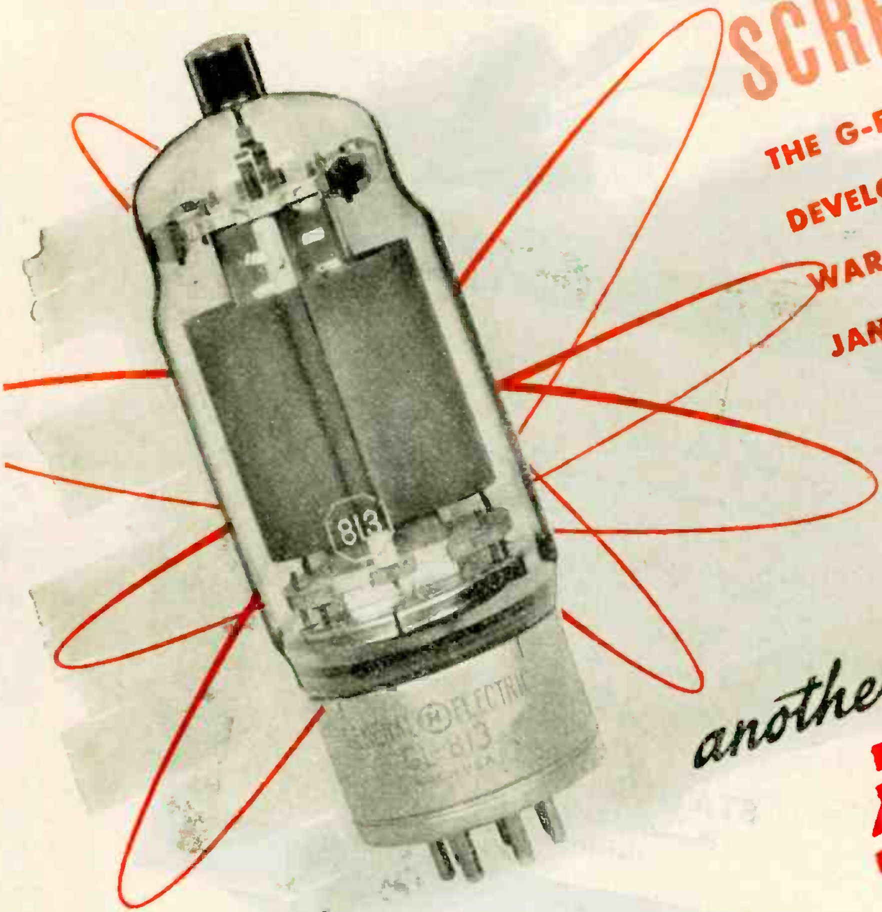
Newtonville 60, Mass.

Division of United-Carr Fastener Corp.

Specialists in **RADIO & ELECTRONICS**
LAMINATED BAKELITE ASSEMBLIES
CERAMIC SOCKETS • BANANA PINS & JACKS • PLUGS • CONNECTORS • ETC.

SCREEN-GRID

THE G-E ELECTRONIC TUBE DEVELOPMENT THAT HELPS GUARD WAR COMMUNICATIONS AGAINST JAMMING BY THE ENEMY



TYPE GL-813

another G·E electronic **FIRST!**

With a long and notable list of basic "firsts," G.E. continues to set the pace — with today's line of G-E transmitting, receiving and industrial tubes.

The screen-grid, for instance, was developed by General Electric's Dr. Hull. This element, added to a 3-element tube, has made it possible to change transmitting frequencies with the flick of a switch. This helps greatly in preventing the enemy from "jamming" our signals or locating our transmitters.

In addition, the screen-grid tube has greatly reduced transmitter and receiver costs, and has lightened and simplified radio equipment — by eliminating the expensive and cumbersome neutralizing parts formerly required. The screen-grid also made possible the design of tubes that require much less driving power. Radio receivers were made without screen-grid tubes and could be today, but they would require twice as many tubes and circuit elements and would probably cost twice as much.

You may be sure that all G-E transmitting and receiving tubes you buy today, or tomorrow, have everything that electronic research and engineering have thus far uncovered. They also have most exacting construction, highest efficiency, and longest serviceable life the world's finest tube factory can produce.

Ask your G-E electronic tube distributor or nearest G-E office for current prices and delivery dates.

G-E TUBES ARE "FIRST" IN INDUSTRY, TOO! For example, General Electric developed the thyratron tube, providing the precision control that makes possible today's high-speed welding of aluminum and stainless steel. This versatile electronic tube is also the heart of G-E Thy-mo-trol, a compact control unit that makes it possible to run G-E motors directly from A-C lines.

Ask for the free booklet — "How Electronic Tubes Work." Address Electronics Dept., General Electric, Schenectady, N. Y.

• *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.*

161-C2

GENERAL ELECTRIC

GENERAL ELECTRIC HAS MADE MORE BASIC ELECTRONIC TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

G.E. SETS THE PATTERN

The Story Behind the Plaque. Awarded to General Electric for outstanding contributions in television programming, this American Television Society recognition climaxes four years of intensive programming activity.

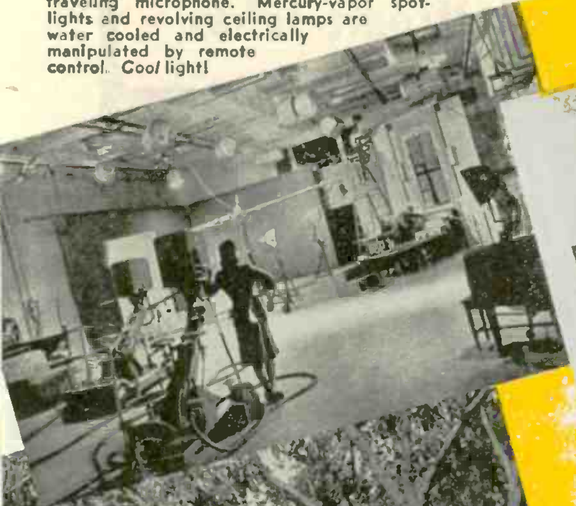
Despite the restrictions imposed by General Electric's all-out war effort, WRGB programming is being maintained on a regular 9-hour-per-week basis. This continued activity is the result of G.E.'s conviction that television will grow into a mighty post-war enterprise.

After the war, General Electric will again build complete television systems—cameras and other studio equipment, monitors, relays, antennas, and a complete line of home receivers.

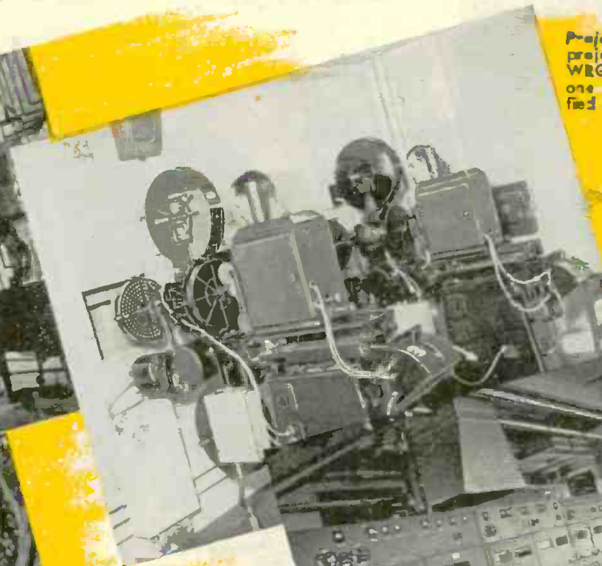
Here is WRGB, the nation's outstanding television station, in action.

"Marriage by Lantern Light" — typical WRGB television action sh from a Julius Hartt Musical Found tion playlet. Live talent programs pr dominate at WRGB.

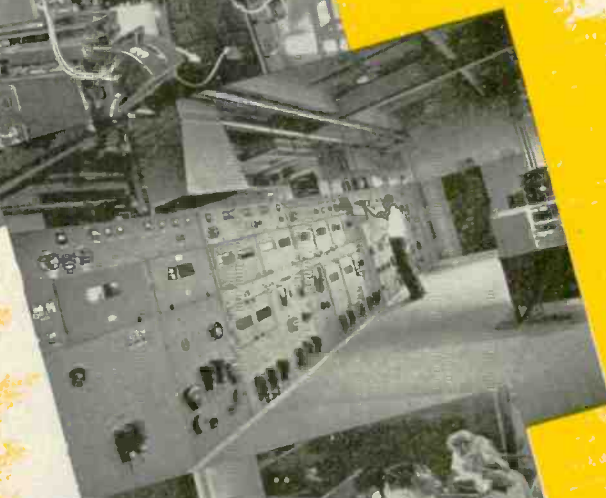
FOR TELEVISION



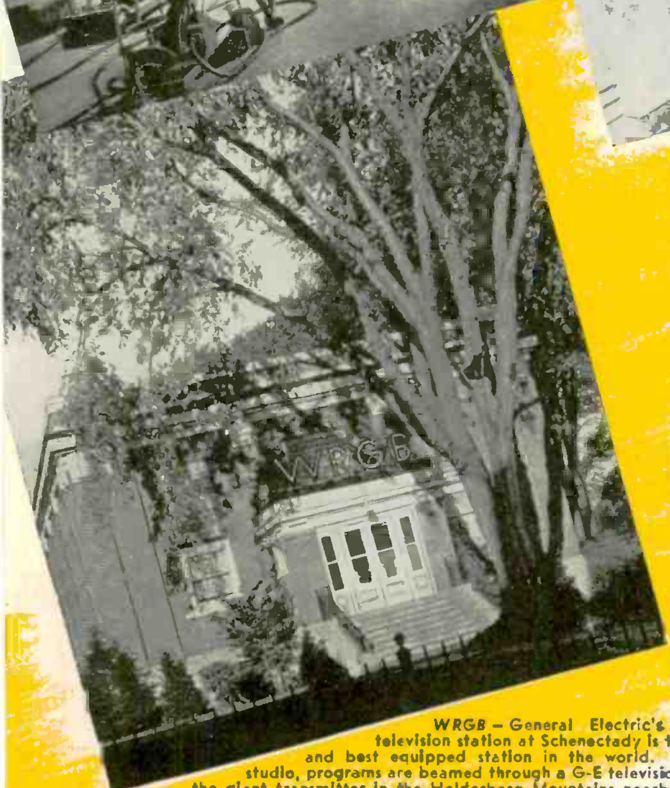
Studio **— Here you see stage props being set in the main studio of television station WRGB. Sight and sound are picked up by G-E television cameras and a motion-picture-type traveling microphone. Mercury-vapor spotlights and revolving ceiling lamps are water cooled and electrically manipulated by remote control. *Cool* light!**



Projection Room **— Motion-picture projection equipment at station WRGB includes two 35-mm and one 16-mm projectors — all modified by G.E. for television.**



Transmitter **— The main transmitter of WRGB is located in the Helderberg Mountains, 12 miles from studio. Transmitter output: 40 kw video, 4 kw audio.**



WRGB **— General Electric's workshop television station at Schenectady is the largest and best equipped station in the world. From this studio, programs are beamed through a G-E television relay to the giant transmitter in the Helderberg Mountains nearby.**

Control Room **— Control desk, and shading desk with picture monitors, manned during a television broadcast from WRGB. All action in main studio is viewed and controlled from here.**

A PLAN *that will secure your place in radio broadcasting post-war*

General Electric offers you "The G-E Equipment-Reservation Plan" . . . a plan designed to enable you to complete *your* post-war plans *now*. It will enable you to establish a post-war priority on a broadcast transmitter and associated equipment. It will enable us to plan definitely for large-scale post-war production, thereby giving you the fastest possible post-war delivery and the savings of planned production.

Investigate this plan today and assure your place in radio broadcasting post-war. *Write for your copy of "The G-E Equipment-Reservation Plan." Electronics Department, General Electric, Schenectady, New York.*

• Tune in General Electric's "The World Today" every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday evening listen to the G-E "All Girl Orchestra" at 10 E.W.T. over NBC.

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

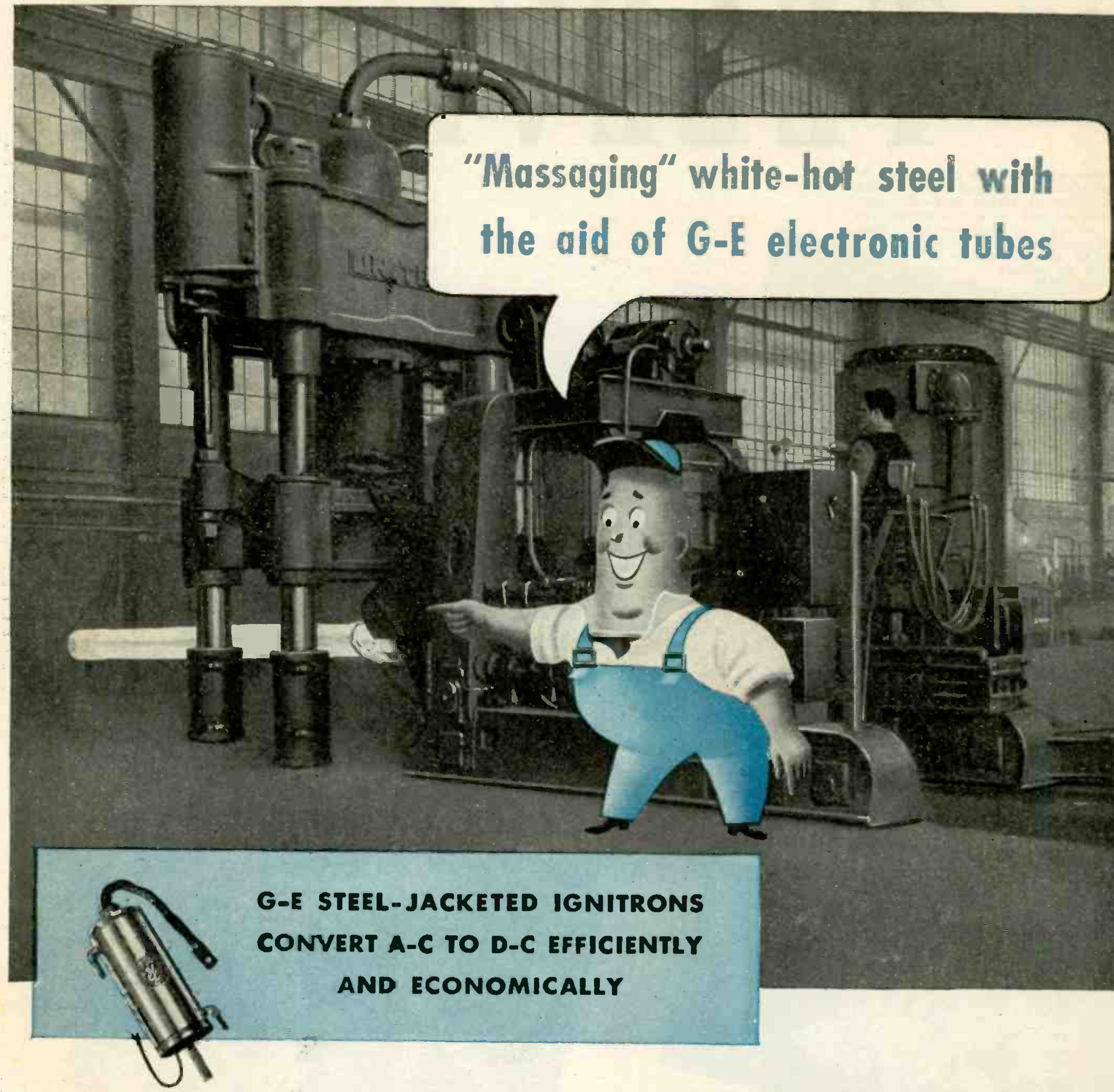
GENERAL ELECTRIC

160-C3

FM · TELEVISION · AM

See G.E. for all three!

No. 10 OF A SERIES EXPLAINING THE USES OF ELECTRONIC TUBES IN INDUSTRY



HERE'S an eight-inch billet getting a "massage" that will reduce its square waistline and shape it into a roughly streamlined gun-barrel. The manipulator which feeds the billet under the hammer — back and forth, round and round — requires D-C power for this precision operation. Sturdy G-E sealed ignitrons supply the power.

These steel-jacketed electronic tubes have no moving parts, are quiet in operation; over-all efficiency is high and practically constant over the entire load range. Available in ratings from 20 amp to 200 amp, they convert A-C into D-C economically and reliably.

Rectifiers using the G-E sealed ignitrons for D-C power at 250 volts or more generally will have about the same installed cost, but lower operating costs than a motor generator set. *Their use permits D-C power to be economically applied to "production spots" where D-C motor drives are essential even though you have an A-C power distribution system throughout the plant.*

The steel-jacketed ignitron is only one of a complete line of G-E electronic tubes now working for industry on innumerable jobs and many kinds of machinery. It is the purpose of the G-E electronic tube engineers to aid any manufacturer of electronic devices in the application of tubes. Through its nation-wide distributing system, General Electric is also prepared to supply users of electronic devices with replacement tubes.

"HOW ELECTRONIC TUBES WORK"

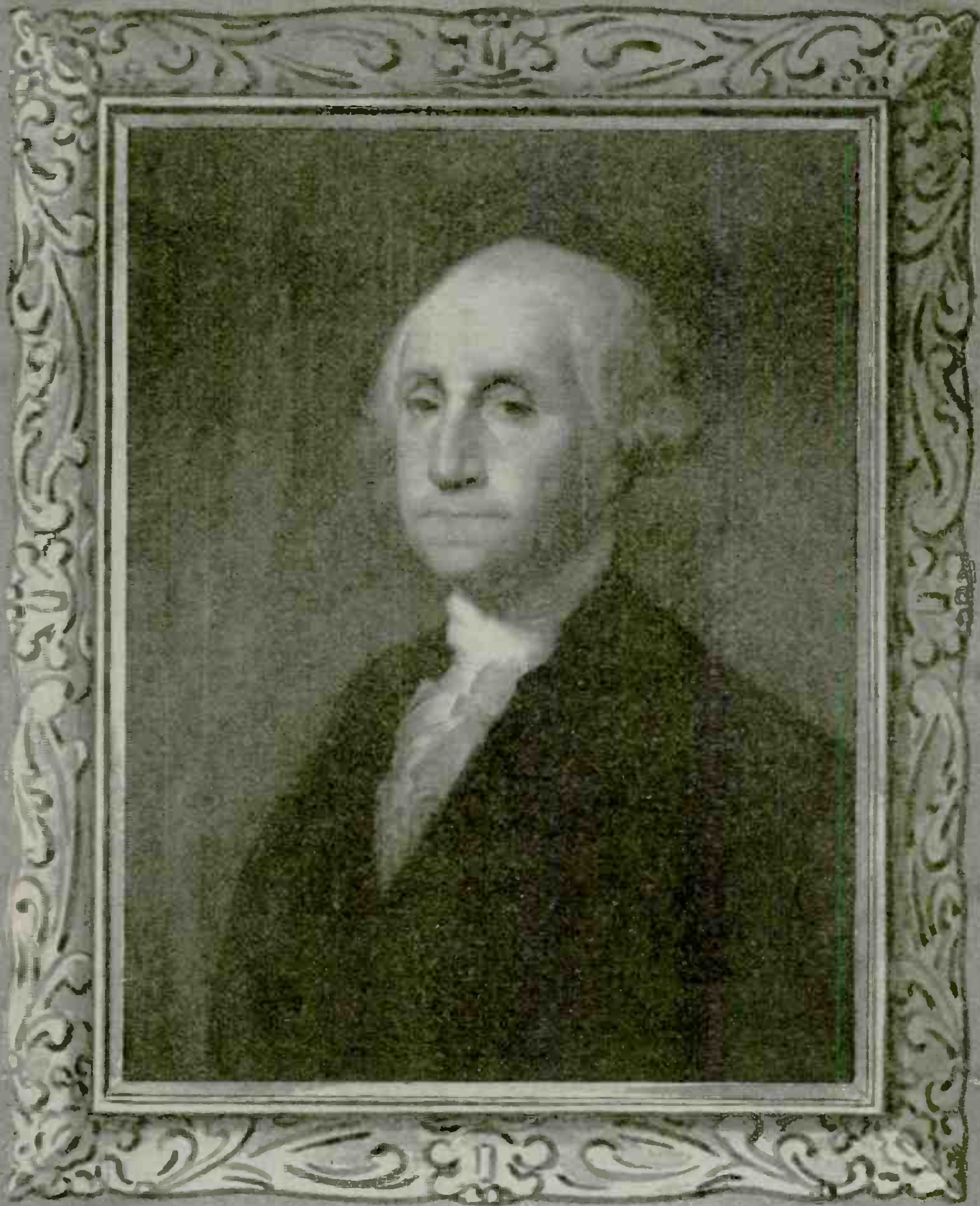
THIS BOOKLET will be mailed to you *without charge*. Its 24 pages are interestingly illustrated and written in easily understood language. Shows typical electronic tubes and their applications. Address *Electronics Department, General Electric, Schenectady, N. Y.*

• *Tune in* "The World Today" *and hear the news direct from the men who see it happen, 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.*

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

GENERAL ELECTRIC

162-C2

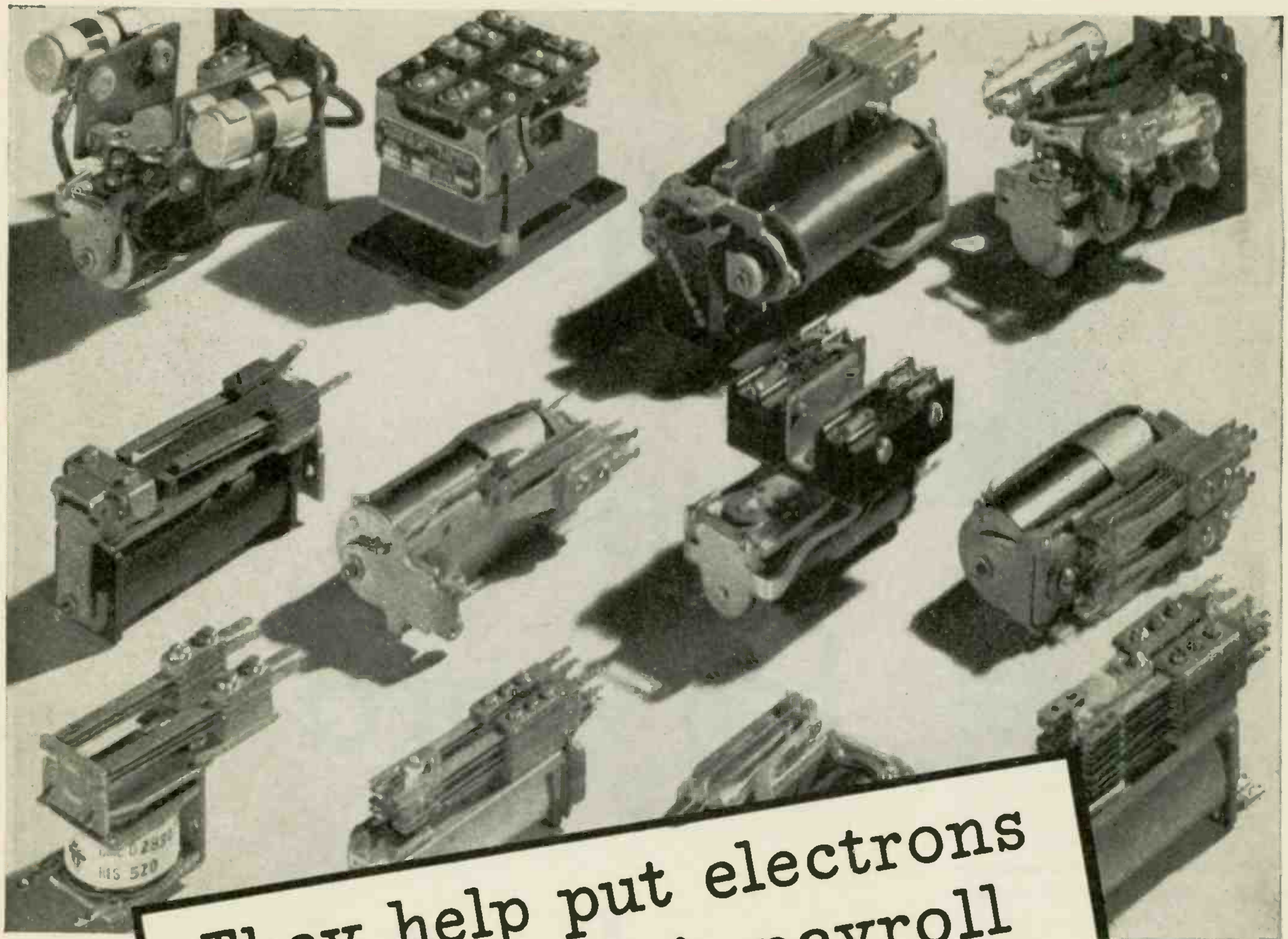


This Year Americans Are Celebrating George Washington's Birthday by Buying One of His Portraits . . . on a War Bond.

Jensen

JENSEN RADIO MANUFACTURING COMPANY
6501 S. LARAMIE AVE., CHICAGO 38, U. S. A.

Manufacturers and Designers of Fine Acoustic Equipment



They help put electrons on Industry's payroll

WITH the aid of Automatic Electric relays and other control devices, electronic science is helping industry do a thousand new jobs—speeding new electronic ideas through the laboratory and putting them to practical use on the production line.

Automatic Electric field engineers, armed with the technique which comes from long experience in electrical control applications, are working daily with the makers of electronic devices of every kind—offering time-saving suggestions for the selection of the right controls for each job.

Let us pool our knowledge with yours. First step is to get a copy of the Automatic Electric catalog of control devices. Then, if you would like competent help in selecting the right combination for your needs, call in our field engineer. His recommendations will save you time and money.

Relays AND OTHER CONTROL DEVICES by AUTOMATIC ELECTRIC

ARMY E NAVY

AUTOMATIC ELECTRIC SALES CORPORATION
1033 West Van Buren Street, Chicago 7, Illinois
In Canada: Automatic Electric (Canada) Limited, Toronto

MUSCLES FOR THE MIRACLES OF ELECTRONICS

GIANTS in miniature

In high-fidelity portable power amplifiers, sub-panel space is at a premium. Filter units must be compact. Yet they must be giant-hearted—able to withstand severe transient voltages and line surges in continuous operation. And the Type TQ Dykanol filter capacitors are just that. These little huskies with the C-D emblem will give the "longest-life" continuous service of any similar type capacitors. With two insulated terminals and universal bracket, they can be mounted wherever convenient and in any position, either above or below the subpanel assembly. Cornell-Dubilier Electric Corporation, So. Plainfield, New Jersey.

IT'S C-D FOUR TO ONE: In an independent inquiry just completed, 2,000 electrical engineers were asked to list the first, second and third manufacturers coming to mind when thinking of capacitors. When all the returns were in, Cornell-Dubilier was far in the lead—*receiving almost four times as many "firsts" as the next named capacitor.*

Type TQ Dykanol filter capacitors are designed for the limited space in high-fidelity public address systems and portable power amplifiers. Check these xtras that go with the C-D insignia:

DYKANOL "A" (CHLORINATED DIPHENYL) IMPREGNATED AND FILLED — Non-inflammable — fireproof — long life — small size — lower power-factor.

HIGH PURITY ALUMINUM FOIL — Lower R.F. resistance — light weight.

HIGH GRADE MULTI-LAMINATED KRAFT TISSUE — Higher voltage breakdown —minimum leakage — high insulation resistance.

DRIED, IMPREGNATED AND FILLED UNDER CONTINUOUS VACUUM — Lower equivalent series resistance, particularly at higher temperatures.

ADEQUATE TERMINAL INSULATORS — Glazed porcelain or Bakelite according to rating — safe for high potentials.

STRONG UNIVERSAL MOUNTING BRACKET — Provided with 3 feet — permits mounting of unit in any position with terminals above or below subpanel.

CONSERVATIVE D.C. RATING — Triple testing assures dependable service.

CONSERVATIVE VOLTAGE RATING — Can be safely operated continuously at 10% above rated voltage.

Cornell Dubilier capacitors

more in use today than any other make

1910 CORNELL-DUBILIER C-D CAPACITORS 1944

MICA • DYKANOL • PAPER
WET AND DRY
ELECTROLYTIC CAPACITORS

TRANSFORMER TERMINALS IN GLASS

ACTUAL SIZE
$1\frac{9}{16}$" diameter—$2\frac{9}{16}$" high, including terminals

. . . A

radically new design by Thordarson.

Meets

all Army and Navy requirements.

A Seal

. . . that is truly hermetic.

★

Consult us for further details

★

THORDARSON

TRANSFORMER DIVISION
THORDARSON ELECTRIC MFG. CO.
500 WEST HURON STREET, CHICAGO, ILL.

Transformer Specialists Since 1895

ORIGINATORS OF TRU-FIDELITY AMPLIFIERS

Inside
IN-FORMATION

Reveals How Finer Mechanical Construction Improves on Electrical Design

A distinguishing feature of all Temco transmitters is unusual care in wiring.

Even a casual glance reveals the masterful way in which cables are formed . . . the exceptional orderliness of routing and grouping wires . . . the extreme neatness and care used in soldering all terminals. There are no haphazard snarls; no careless tangling of wires.

As a result of this rugged construction, maximum operating efficiency is assured and maintenance problems are minimized.

Throughout the war, Temco-built equipment has won the approval of the armed services, under constant daily use. After victory, Temco will continue to build transmitting equipment embodying advanced and combat-tested features, for peacetime applications.

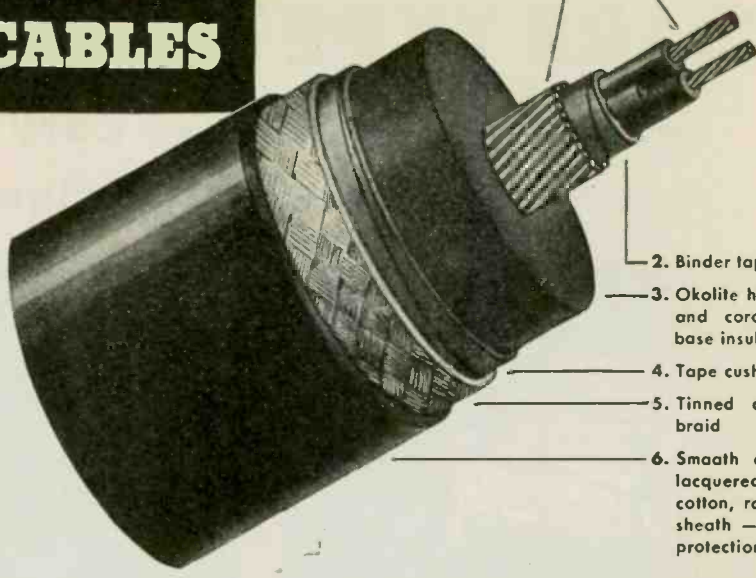
TEMCO

RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.

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

HIGH VOLTAGE FLEXIBLE CABLES



● Take x-ray cables for example!

Ever since "shock-proof" x-ray equipment was first developed over 10 years ago, Okonite has supplied shielded high-voltage cables to over 20 x-ray equipment manufacturers.

Used in industry and medicine for therapy, radiography and fluoroscopy, these cables have been made in literally scores of designs, the principal ones being the 2- and 3-conductor cables of the following types:

A. 50KV cable with 16/64" insulation for 50KV peak rectified
B. 70KV cable with 20/64" insulation for 70KV peak rectified or 45KV peak self-rectified circuits.
or 55KV peak self-rectified circuits.
C. 110KV cable with 32/64" insulation for 110KV peak rectified circuits.

(Many other types are available.)
The above are rated at voltage to ground. The set, however, operates with two cables at twice the voltage on the tube.

A typical Okolite x-ray cable is illustrated. Like other Okolite x-ray cables, it is "shock-proof" and flexible. It will stand up under the bending that occurs adjacent to the tube housing while focusing and adjusting apparatus.

The conductors are properly centered to distribute electrical stresses evenly throughout the insulation, ensuring longer life.

In addition to all standard electrical tests, Okolite x-ray cables must pass d.c. tests far in excess of their rated voltages. This is an Okonite refinement that can pick out imperfections not detected with ordinary a.c. testing.

Experience in making x-ray cables has enabled Okonite to provide many new designs of high-voltage d.c. cables in keeping with the needs of wartime electronic developments. If you have a cable problem involving either current or postwar applications, why not call in an Okonite sales engineer?

IF YOU NEED X-RAY CABLES
At the present time, Okonite has available manufacturing capacity for delivery of x-ray cable during the next quarter. To assure prompt shipment of your x-ray cable, ORDER NOW, supplying CMP allotment number and specification data on design and operating details.


Courtesy of Picker X-Ray Corporation

THE OKONITE COMPANY

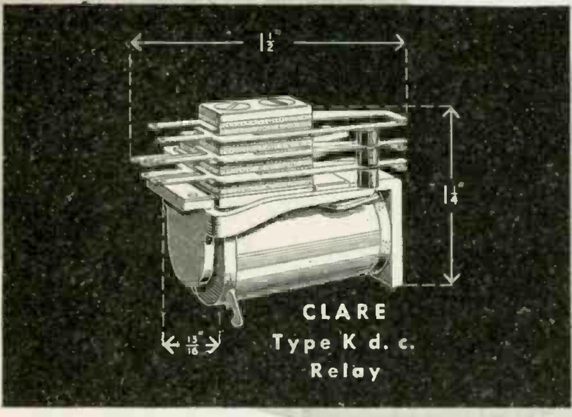
3527 PASSAIC NEW JERSEY

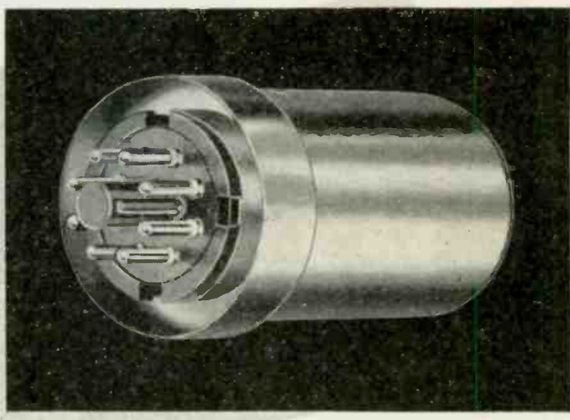
WIRES AND CABLES INSULATED WITH RUBBER, VARNISHED CAMBRIC, PAPER, GLASS AND SYNTHETICS FOR CONTROL, COMMUNICATION, POWER AND LIGHTING IN THE ELECTRICAL AND ELECTRONIC FIELDS

You can now secure the

CLARE TYPE "K" d. c. RELAY

sealed in a vacuum . . . dry air at sea level pressure . . . or inert gas





Wherever your design calls for a relay to operate at high altitudes or below sea level . . . in the midst of dust or moisture . . . where combustible gases make operation dangerous . . . this Clare Type "K" d.c. Sealed-In Relay brings its own ideal working conditions to the job.

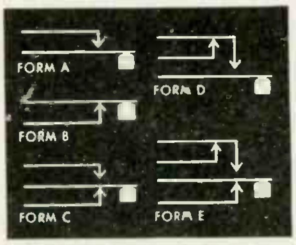
Think what it means to seal in sea level air pressure with a relay that must operate precisely at 40,000 feet . . . to seal out moist air, seal in inert gas where arcing is a problem . . . to eliminate completely the effects of abrasive dust or corrosive fumes!

This new achievement in Clare "custom-building" adds a new sphere of usefulness to the Clare Type "K" d.c. Relay, already widely used because of its small, compact size, its precise construction and its ability to withstand vibration, shock and extremes of temperature.

As illustrated, the Clare Type "K" d.c. is an extremely small relay . . . measures only 1½"x1¼" x 13/16". . . weighs approximately 1⅔ ounces. Sealed in its steel housing, it is still a relay for those spots where inches and ounces count. The overall dimensions of the housing are: 2 7/16" long, 1½" in diameter. The weight of the enclosed relay is but 2½ ounces.

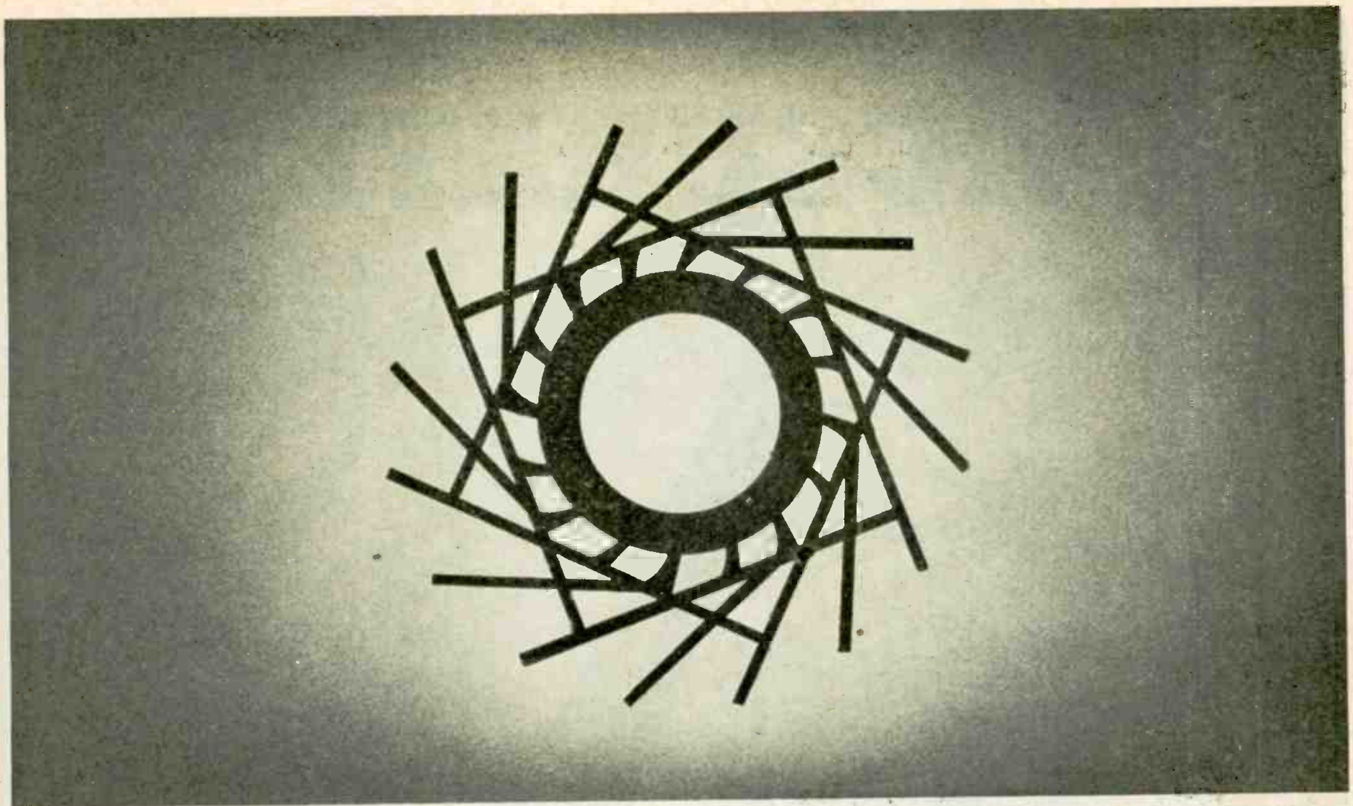
The Clare Type "K" d.c. Relay can be furnished in the contact forms shown, with any number of springs, up to and including 12 (6-in. housing shown above) . . . coil voltage range is from 1.5 volts to 60 volts d.c. . . . contacts of either 18 gauge silver, rated one ampere, 50 watts, or 18 gauge palladium, rated two amperes, 100 watts can be furnished.

Like all Clare Relays, the Clare Type "K" d.c. Relay can be "custom-built" to meet your specific design problems. Write us in regard to them and receive our suggestions. In the meantime, you should have our catalog and data book. C. P. Clare and Company, 4719 West Sunnyside Avenue, Chicago (30), Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.



CLARE RELAYS

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



American Airlines tangent airport plan for New York City from "Airports and Air Traffic Control" by Glen A. Gilbert, Chief Air Traffic Control Division, CAA.

The Shape of Things to Come . . .

In air transportation especially, the pattern of the future will not be the pattern of the past. No other field holds the prospect of greater advancement nor offers fuller opportunity for sound development.

In things which have made air travel safe and efficient — radio range beacons, markers, communication transmitters and receivers, airport traffic controls—RADIO RECEPTOR, as a pioneer, has contributed its full share of development, and will continue to lead in design and manufacture.

To "the shape of things to come" in aeronautical radio, RADIO RECEPTOR will bring more than 20 years of practical experience. These have been years of successful accomplishment in prewar aviation radio equipment plus outstanding developments born of the present conflict.

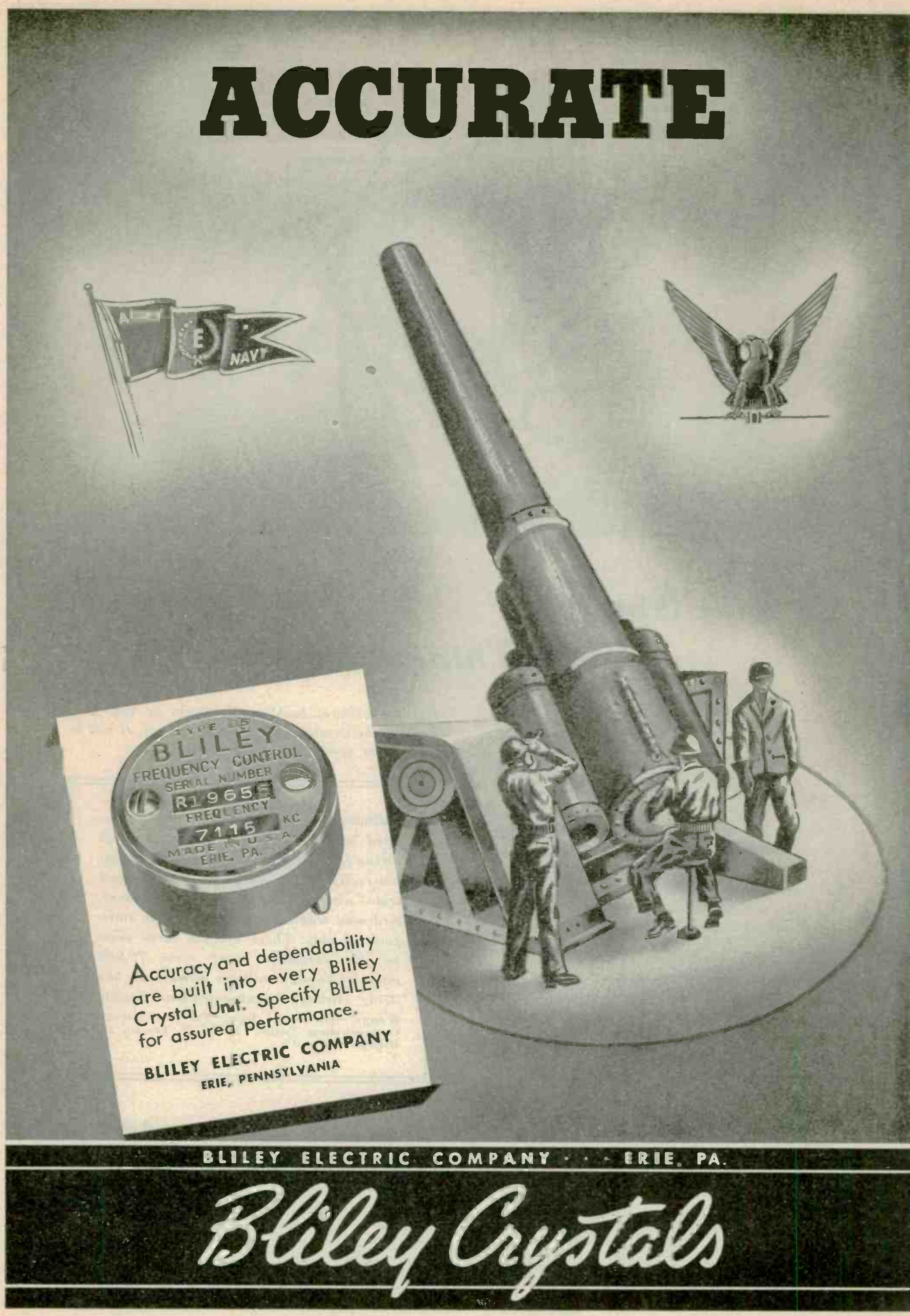
Our non-technical booklet, "HIGHWAYS OF THE AIR," explains the importance of radio to aviation. It will be sent to you upon request. Address Desk E-2

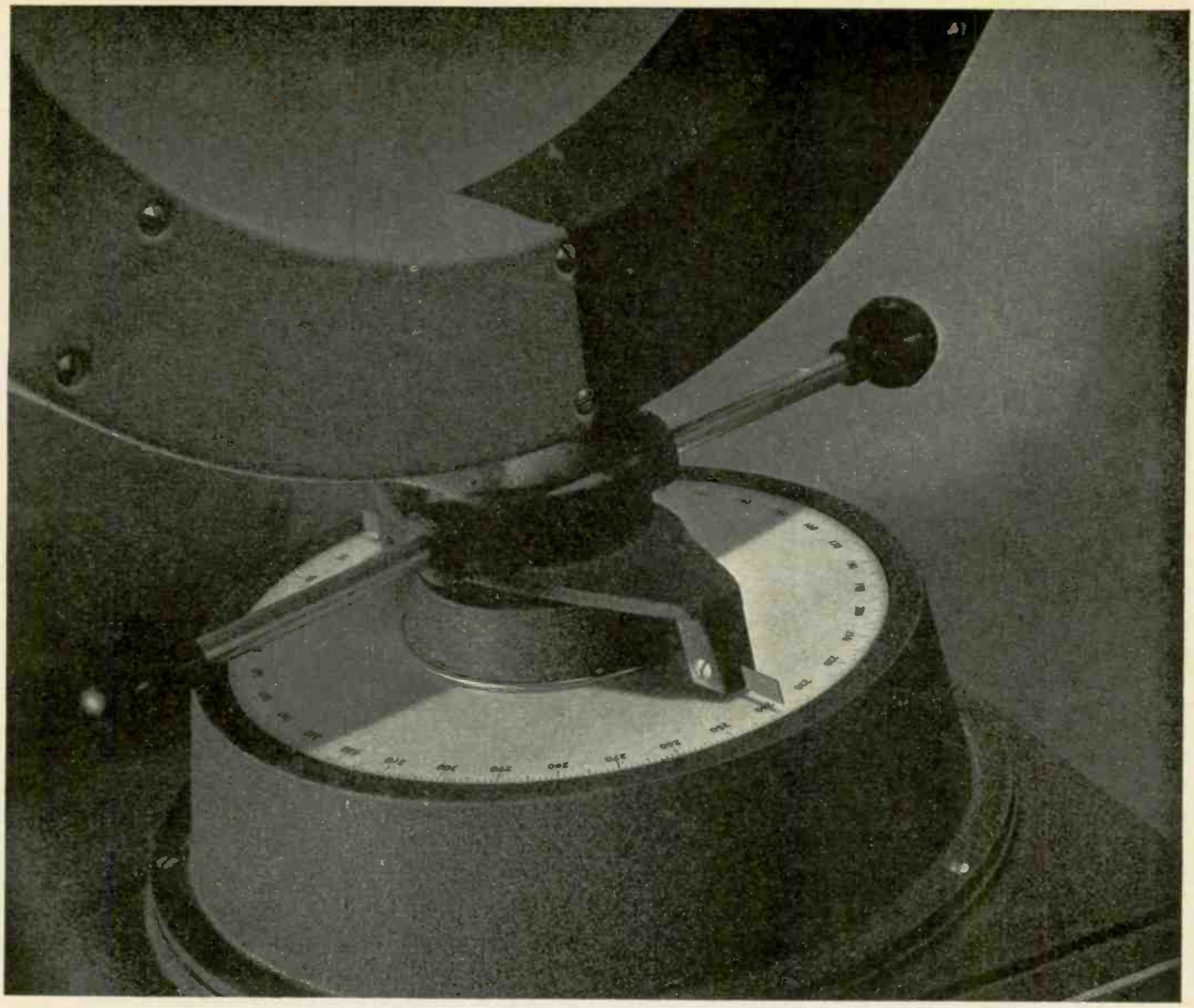
> ***"Although an airway may be loosely defined as a designated route for aircraft plying from airdrome to airdrome, it cannot really be said to exist on a practical scale without airways communications, airdrome traffic control, and radio navigational aids. These are the three components furnished, over some 70,000 miles of foreign military airways, by the Army Airways Communications System Wing."***—An excerpt from "The Army Airways Communications System," by Lt. W. Fawcett, Jr., Headquarters, AACS.

For Meritorious Service on the Production Front

Radio Receptor Co.
INCORPORATED
251 WEST 19th STREET NEW YORK 11, N. Y.

★ SINCE 1922 IN RADIO AND ELECTRONICS ★


ACCURATE
NAVY
BLILEY
FREQUENCY CONTROL
SERIAL NUMBER
FREQUENCY
KC
ERIE, PA.
Accuracy and dependability are built into every Bliley Crystal Unit. Specify BLILEY for assured performance.
BLILEY ELECTRIC COMPANY
ERIE, PENNSYLVANIA
BLILEY ELECTRIC COMPANY · · · ERIE, PA.
Bliley Crystals



The strategy of progress in radio

The development and production of fine radio equipment requires sound engineering to fix objectives and accurately design apparatus. This plan of action is as vital here as it is in warfare.

The progress of radio comes through the minds and hands of relatively few creative individuals in the industry. These are the engineers who are unwilling to accept the dictum that "it cannot be done." These are the individuals who disobey the rules and set out to accomplish the seemingly impossible tasks. Thus the strategy of progress in radio is in the hands of the *fearless* ones who keep right on experimenting and developing even though faced with great odds. Such are the men of Techrad. For this reason you can look to Techrad as a source of real progress in radio.

Years of successful research and experimentation, product development and production, have taught Techrad engineers the knack of building radio apparatus of surprisingly superior quality and of building such equipment in quantity. An example of their mechanical skill can be observed in the direction finder illustrated. In actual service the performance of this unit speaks for its technical excellence.

Because at Techrad the emphasis is on *engineering* you can have real confidence in the equipment of their manufacture. And here you will find competent help in the solution of your radio problems.

Master engineering takes nothing for granted.

TECHRAD

Technical Radio Company

Over ten years of continuous experience

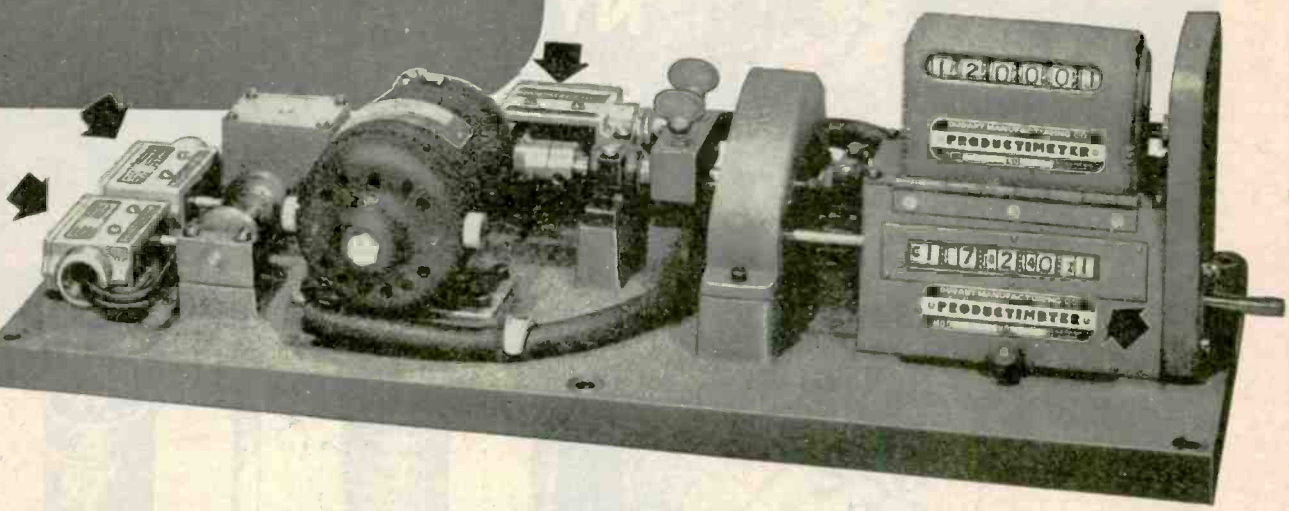
275 Ninth Street • San Francisco, California

795

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

4 Micro Switches

operate auxiliary wire cutting and reeling equipment...and reset this PRODUCTIMETER in 4 seconds



For sixty odd years the Durant Manufacturing Company of Milwaukee, Wisconsin, has been engineering and manufacturing rugged industrial type counters.

Durant has always been insistent upon quality of the parts which go into their product. Their use of Micro Switches in this Motor Reset Productimeter is a typical example of their fine engineering.

This Reset Productimeter measures predetermined lengths of insulated cable and automatically coils the cable on large reels. When the predetermined length has been wound, a Micro Switch inside the counter housing starts a small motor which resets the counter at the predetermined setting for the next operation. The reset cycle is approximately 4 seconds.

One of the Metal Clad Micro Switches shown adjacent to the motor operates a flying shears which cuts the cable. Another controls the mechanism which leads the severed ends into a waiting reel. The third starts the reel winding when it is set and ready to go.

This is but another example of the wide range of application, precision, speed, long life and absolute dependability of Micro Switch. It is typical of the vital role which Micro Switch is playing in industrial machinery of every type and kind.

New products now being designed will use hundreds of Micro Switches in hundreds of different ways. For Micro Switch can be built to meet any specifications required. The basic Micro Switch is only 11/16" x 27/32" x 1 15/16", and weighs less than an ounce. Thousands of special housings, actuators, and electrical characteristics are available now, and new features are being added every day.

Let Micro Switch engineers help you solve your design problems that call for the unusual in precision switching.

The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision snap-action switch that operates on force differentials as low as ¼ ounce and movement differentials as low as .0002". It is listed by the Underwriters' Laboratories with ratings of 1200 V.A. loads from 125 to 460 volts A.C. It can be supplied in a wide variety of housings and a broad range of actuating mechanisms.

Micro Switch Corporation, Freeport, Illinois • Branches: 43 East Ohio Street, Chicago (11)
11 Park Place, New York City (7) • Sales & Engineering Offices: Boston • Hartford • Los Angeles

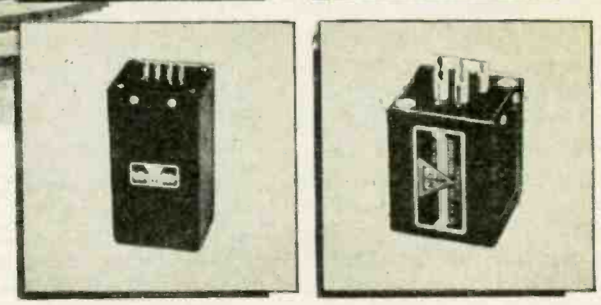
Buy all the Bonds you can!

The trademark MICRO SWITCH is our property and identifies switches made by Micro Switch Corporation

© 1943

MICRO SWITCH

Made Only By Micro Switch Corporation . . . Freeport, Illinois, U. S. A.



More than an order, the command to submerge is proof of a confidence in personnel and equipment. Where pressure, depth and enemy destructiveness are constant threats, apparatus must operate smoothly, instantly and efficiently.

The N-Y-T Sample Department provides just such equipment — audio and power transformers, chokes and filters—specially designed to function perfectly at all times. Moisture, corrosion, vibration and concussion — usual deterrents to highly-sensitive equipment operation—are of no consequence in N. Y. T. units custom built for the particular job.

Whether your post-war product involves a marine, aviation or industrial transformer for unusual application or performance, the N. Y. T. Sample Department can fulfill the requirement.

NEW YORK TRANSFORMER COMPANY

26 WAVERLY PLACE NYT **NEW YORK, 3, N. Y.**

COMBINING

The Old Crafts . . . with the new skills

Behind the scenes in Precision Aircraft Radio Manufacture . . . One of a series, Kodachrome by BR Photo

CARE and CRAFTSMANSHIP—SPEED and ACCURACY... All must be there, whether you are guiding a Bomber to its target or meeting wartime schedules on precision equipment. So today, Bendix Radio has combined Old Crafts with New Skills to maintain our precision workmanship at the speed and accuracy demanded on wartime assembly lines. Assemblies which once took hours now are completed in minutes...and all to the same high standard of perfection.

One example from many: Back of our production line, the pattern-maker pictured above is fashioning a jig for his co-worker on the assembly line. This jig will speed and simplify the positioning and assembly of those small, precision-made parts which contribute to the accurate, built-in performance so characteristic of Bendix* Aircraft Radios and Direction Finders.

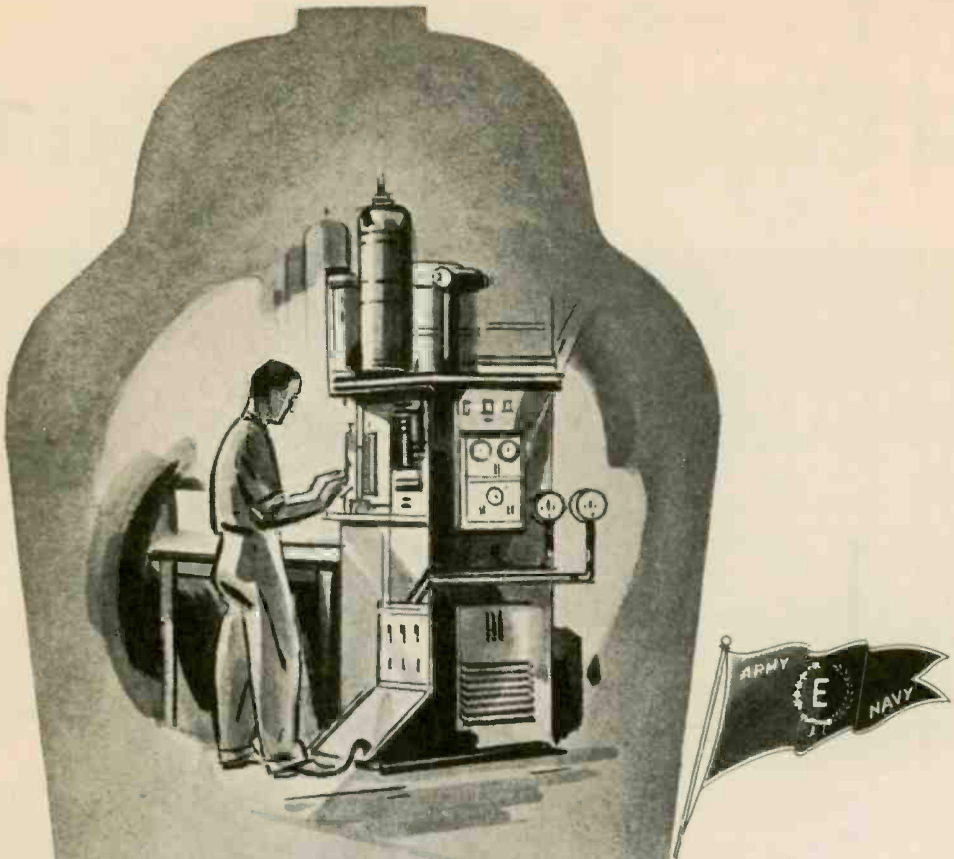
In building complex, yet compact and rugged Radio equipment for the Armed Forces, Bendix care and craftsmanship combine with speed and accuracy to hasten the day of Victory. Then, in peacetime, Bendix Radio Equipments will resume their part in the expanding network of air transport throughout the United States and the World.

THE INVISIBLE CREW
Precision Equipment by
Bendix Aviation Corporation

*TRADE MARK OF BENDIX AVIATION CORPORATION

BENDIX RADIO

BENDIX RADIO DIVISION OF THE BENDIX AVIATION CORPORATION



E-E Electronic Tubes...

...EPITAPH OF THE GREMLINS!

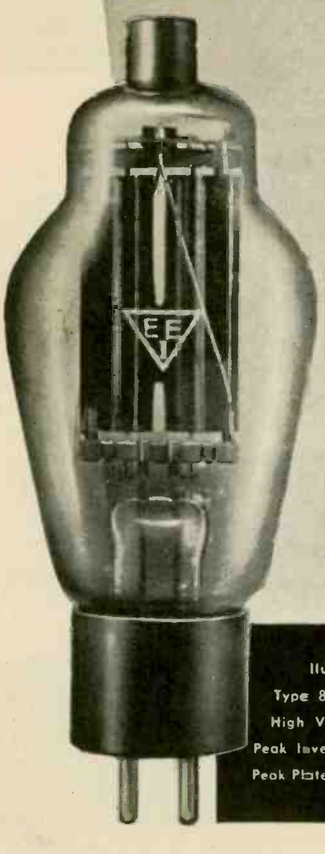


Illustration of
Type 836 Half Wave
High Vacuum Rectifier
Peak Inverse Voltage 5000
Peak Plate Current 1.0 Amp.

Through the years Dielectric, Hysteresis and Eddy current Gremlins bedeviled electrical designs. New visions, broader concepts and electronic vacuum tubes tamed this trio of power losses. Now, under the incognito of High Frequency Heating they play important roles in industry.

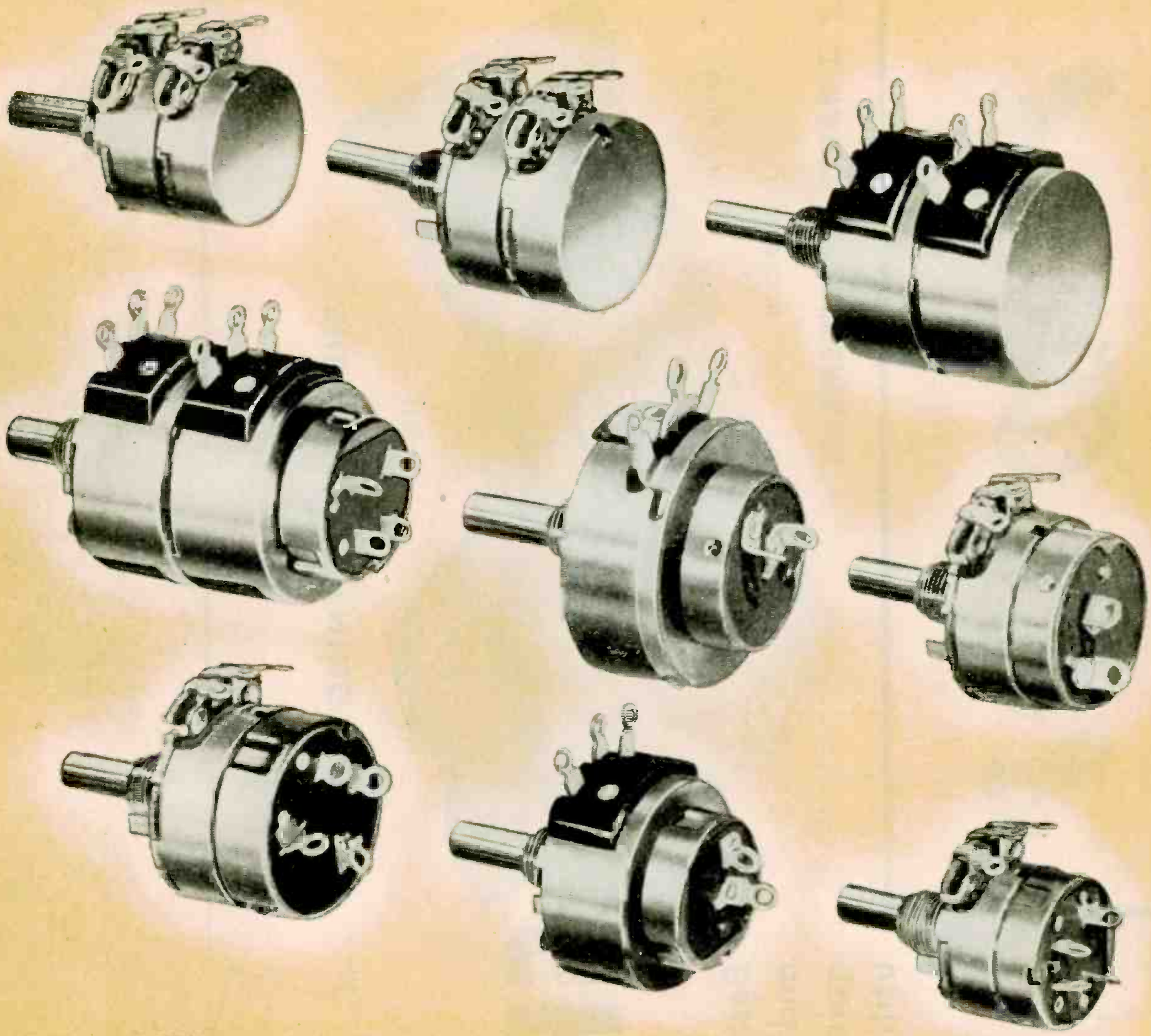
The widespread application of E-E power tubes and rectifiers in induction heating attests to their rugged, uniform characteristics—a result of precise engineering and rigid inspection. E-E specialization in power amplifiers and rectifiers has resulted in designs of unusual efficiency and merit. Why not investigate?

Complete information is contained in the informative E-E data book. Write for your copy today—there is no obligation.

ELECTRONIC ENTERPRISES, INC.

GENERAL OFFICES: 65-67 SEVENTH AVENUE, NEWARK, 4, N. J.
EXPORT DIVISION: 25 WARREN STREET, NEW YORK, 7, NEW YORK
CABLE ADDRESS: SIMONTRICE NEWYORK

ELECTRONIC e ENTERPRISES



Manufacturers of Quality
Electro-Mechanical Components
Since 1896

Plugs, Jacks, Switches, Variable Resistors — *Telephone Generators and Ringers*

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401 N. Broad St.
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In Canada:
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ELKHART ★ INDIANA

... say 23 Leading Screw Manufacturers

AMERICAN SCREW CO.
Providence, Rhode Island
THE BRISTOL CO.
Waterbury, Connecticut
CENTRAL SCREW CO.
Chicago, Illinois
CHANDLER PRODUCTS CORP.
Cleveland, Ohio
CONTINENTAL SCREW CO.
New Bedford, Massachusetts
THE CORBIN SCREW CORP.
New Britain, Connecticut
GENERAL SCREW MFG. CO.
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THE H. M. HARPER CO.
Chicago, Illinois
INTERNATIONAL SCREW CO.
Detroit, Michigan
THE LAMSON & SESSIONS CO.
Cleveland, Ohio
MILFORD RIVET AND MACHINE CO.
Milford, Connecticut
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THE SOUTHINGTON HARDWARE MFG. CO.
Southington, Connecticut
WHITNEY SCREW CORP.
Nashua, New Hampshire

FOR YEARS, leading screw makers tested ideas for recessed heads. All showed design faults. Then came the Phillips Recess. Unanimously, these makers agreed that here, at last, was the answer they'd been looking for . . . a scientifically engineered recess, *right* in every respect.

And practically the entire screw industry adopted it!

There's nothing exactly like the Phillips Recess. It's the only screw recess in which every angle, every dimension has a purpose—plays a definite part in screw driving efficiency and fastening strength.

That's why it pays to specify screws with Phillips Recessed Heads. You can get them in any head style, type, or size.

TO MAKE WARTIME QUOTAS AND PEACETIME PROFITS

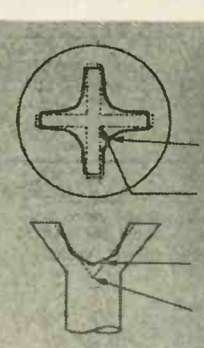
FASTER STARTING: Driver point automatically centers in the Phillips Recess . . . fits snugly. Fumbling, wobbly starts, slant driving are eliminated. Work is made trouble-proof for green hands.

FASTER DRIVING: Spiral and power driving are made practical. Driver won't slip from recess to spoil material or injure worker. (Average time saving is 50%.)

EASIER DRIVING: Turning power is fully utilized. Workers maintain speed without tiring.

BETTER FASTENING: Screws are set-up uniformly tight, without burring or breaking of screw heads. The job is stronger, and the ornamental recess adds to appearance.

IDENTIFY IT!



Center corners of Phillips Recess are rounded . . . NOT square.

Bottom of Phillips Recess is nearly flat . . . NOT tapered to a sharp point.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS
MACHINE SCREWS
SELF-TAPPING SCREWS
STOVE BOLTS

Ready for your application KAAR "INSTANT HEATING" *Mobile* TRANSMITTERS

30-40 MEGACYCLES*

RUGGED HIGH-FREQUENCY TRANSMITTERS FOR MILITARY AND CIVIL COMMUNICATION

Kaar high-frequency transmitters are skillfully engineered for efficient military, civil, and commercial communication from moving vehicles. They are designed for severe use, and for swift servicing.

The dust cover can be removed by merely releasing two snap catches . . . the entire transmitter can be removed from the vehicle by releasing only four catches.

The PTS-22X is rated at 22 watts output. It incorporates the "Instant Heating" feature with zero standby current.

Transmissions are completely controlled by the "push-to-talk" button on the microphone. This switch lights the tubes, starts the dynamotor power supply, silences the receiver, and switches the antenna to the transmitter.

**For transmission in the 1600-2900 KC range, specify the Kaar PTL-22X or PTL-10X. Other ranges available on special order.*

KAAR ENGINEERING CO.
PALO ALTO, CALIFORNIA

Manufacturers of high grade mobile and central station RADIOTELEPHONE EQUIPMENT AND ACCESSORIES

Export Agents: FRAZAR & HANSEN
301 Clay Street
San Francisco 11, California, U. S. A.

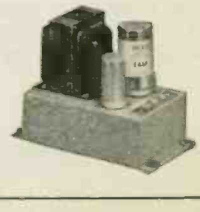
MOBILE RECEIVERS — Crystal-controlled superheterodynes for medium and high frequencies. Easy to service.

CRYSTALS — Low-drift quartz plates. Fundamental and harmonic types available in various holders.

CONDENSERS — Many types of small variable air condensers available for tank circuit and antenna tuning.

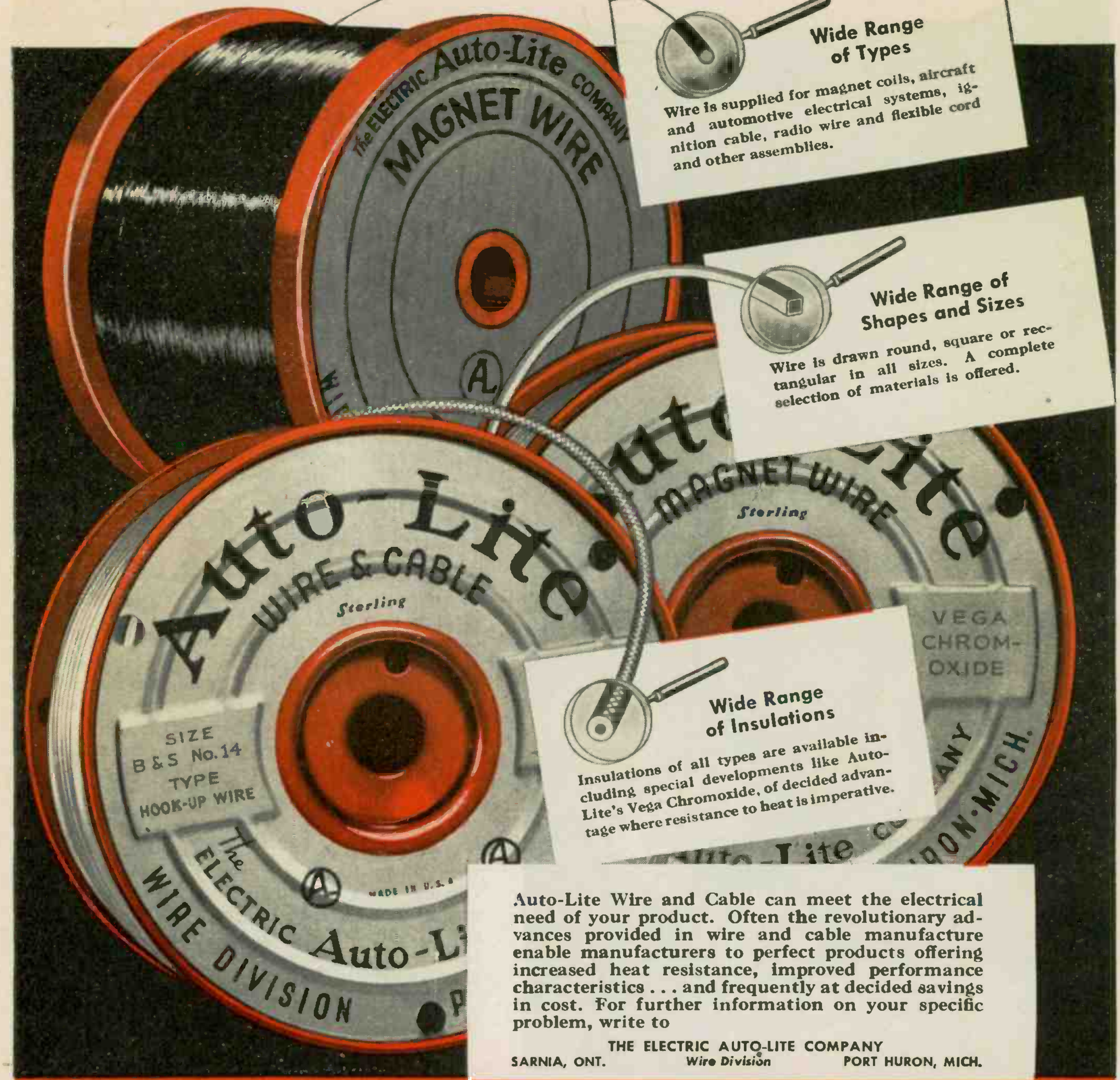
MICROPHONES — Type 4-C single button carbon. Superb voice quality, high output, moisture proof.

POWER PACKS — Heavy duty vibrators and power supplies for transmitters, receivers. 6, 12, 32 volts DC.



For Every Purpose

Back the Attack—Buy War Bonds



Wide Range of Types

Wire is supplied for magnet coils, aircraft and automotive electrical systems, ignition cable, radio wire and flexible cord and other assemblies.

Wide Range of Shapes and Sizes

Wire is drawn round, square or rectangular in all sizes. A complete selection of materials is offered.

Wide Range of Insulations

Insulations of all types are available including special developments like Auto-Lite's Vega Chromoxide, of decided advantage where resistance to heat is imperative.

Auto-Lite Wire and Cable can meet the electrical need of your product. Often the revolutionary advances provided in wire and cable manufacture enable manufacturers to perfect products offering increased heat resistance, improved performance characteristics . . . and frequently at decided savings in cost. For further information on your specific problem, write to

THE ELECTRIC AUTO-LITE COMPANY
SARNIA, ONT. — *Wire Division* — PORT HURON, MICH.

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

What's Wrong with This Picture?

The thing that is wrong about this picture is that radio engineers have been doing such a bang-up job meeting and anticipating the vast needs of our military services that not enough good things can be said about them by those engaged in the field of electronics.

Seven days a week and night after night, the radio engineers are working out the multitudinous problems of design required to give our Allies the most of the best electronic equipment in the world.

Raytheon is proud of its part in furnishing electronic tubes and equipment that meet engineering requirements of stamina, high quality and complete dependability under the most severe wartime demands.

ARMY-NAVY "E" WITH STAR
Awarded All Four Divisions of Raytheon for continued excellence in production

RAYTHEON

RAYTHEON MANUFACTURING COMPANY
Waltham and Newton, Massachusetts

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

"Anybody Got a Stick of Gum?"

THAT last bump was *it.* The waist gunner picked himself up from the floor and clung to his gun as the huge ship was brought back into control. He took a quick look out, whistled softly and spoke through the Intercom to the rest of the crew.

"Somebody better hurry up with a stick of chewing gum before our left wing leaves us!"

* * *

The ability of our flying men . . . and our flying equipment . . . to "take it" is one of the major marvels of the war, and playing its full share in the success of our aerial forces is the Communications System. No place here for equipment that's merely *good.* It must be the *best,* for failure in Communication may be more serious than the failure of an engine or a landing gear.

It is to these superlative standards that Rola builds equipment for the Army-Navy Air Forces . . . highly specialized transformers and coils, supersensitive headphones, and other electronic parts having to do with Communications. And it is to these same standards that Rola will build its after-the-war products, whatever they may be. The ROLA COMPANY, Inc., 2530 Superior Avenue, Cleveland 14, Ohio.

ROLA

Let's do more in forty-four!

MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

Two "E" pin wearers at Ray-O-Vac give Ray-O-Vac Batteries a final inspection before they are shipped to our armed forces.

8 Million Tests A Day

Most of Ray-O-Vac's large production of batteries is going into the electronic marvels of this war—portable radios and other special equipment — and specially engineered in close cooperation with the Signal Corps.

The "Know How" We Gained In Our War Work Can Be Used By You In Your Plans For The Future

Every single one of the many millions of Ray-O-Vac Batteries are tested and retested as they progress through the plant. Based on our 37 years of battery-making experience these tests insure dependability. If dry batteries are required in your products, the long-time experience of Ray-O-Vac's staff of engineers can be of real aid to you.

RAY-O-VAC
Guaranteed
BATTERIES

RAY-O-VAC COMPANY • MADISON 4, WIS.

FLASHLIGHT • TELEPHONE • LANTERN • HEARING AID • RADIO • IGNITION • MULTIPLE

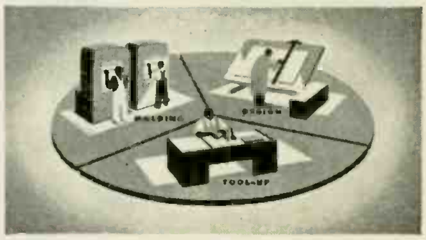
Selecting Your Plastic Molder Calls for Thought—

INVESTIGATE CAPACITY!

Plant capacity, we mean. The ability to so integrate engineering, tool-room and die-room, presses and finishing machines . . . and enough of each . . . that plastic parts keep flowing into your production lines on a smooth, uninterrupted schedule.

But plant capacity, important as it is, is only one of the reasons that so many industries come to Kurz-Kasch for so many diverse applications. There's 25 years of experience in engineering plastics . . . in knowing plastic materials as to characteristics and suitability . . . in making intricate molds to the closest tolerances . . . in learning the finest points of the different molding techniques.

Whatever your product, the chances are we can show you interesting applications engineered and molded by Kurz-Kasch that demonstrate the value of this experience to you. And in the most successful ones, you can be sure that our experience with materials and engineering was used to advantage at the *earliest* stages of development. Ask for a Kurz-Kasch development engineer!



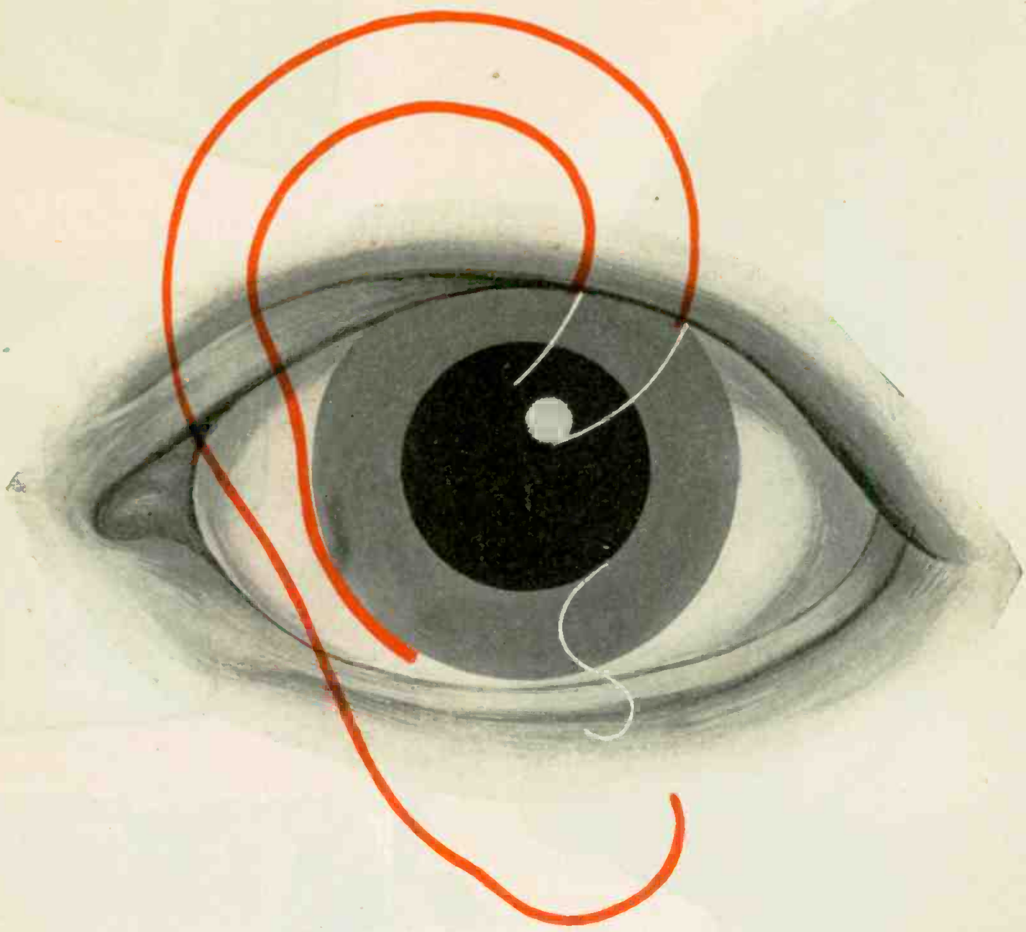
Don't contract for capacity too late! Engineering *must* take material into account, and your molder knows both best. Consult him now on your post-war needs.

KURZ-KASCH

For over 25 years Planners and Molders in Plastics

Kurz-Kasch, Inc., 1421 South Broadway, Dayton, Ohio

Branch Sales Offices: New York • Chicago • Detroit • Los Angeles • Dallas • St. Louis • Toronto Canada. *Export Offices:* 89 Broad Street, New York City



The first in our industry to be so honored
ARMY
E
NAVY

(Farnsworth television in England 10 years ago!)

LONDON's famous Crystal Palace was the scene, in 1934,* of the first foreign demonstration of the Farnsworth electronic system of television.

Since then, we've seen electronic television supplant other systems. Development has been rapid . . . and, uniquely among modern industries, without the stimulus of a public market.

Farnsworth's more than 18 years of pioneering in television has borne rich fruit. The Farnsworth Dissector Tube and Photo-cell Multiplier Tube, our synchronizing devices, circuits and other tubes have been perfected. Our consistent policy of parallel research on both circuits and tubes has proved sound and most productive.

Today, Farnsworth is in a position to supply important military devices to the Allies — all our production goes to war. But post-war television will have the benefit of our wartime experience. When peace comes, this background and our facilities will be ready to serve you.

**Another of a series of Farnsworth advertisements depicting milestones in the history of television.*

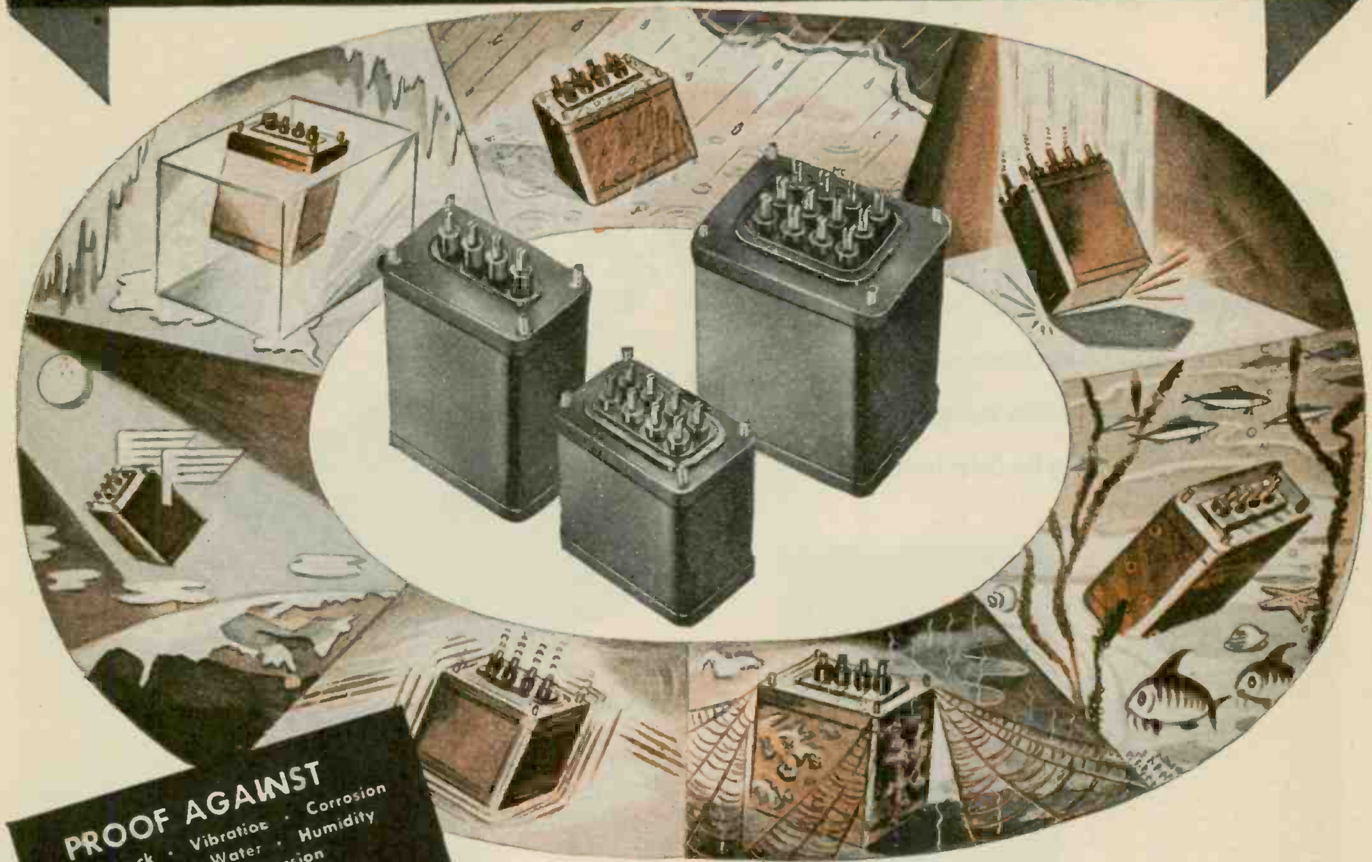
LOOK FOR the Farnsworth Television advertising in: November 27 *Collier's*, and November 15 and December 13 *Newsweek*.

FARNSWORTH TELEVISION

• Farnsworth Television & Radio Corporation, Fort Wayne 1, Indiana. Farnsworth Radio and Television Transmitters and Receivers; Aircraft Radio Equipment; the Farnsworth Dissector Tube; the Capehart, the Capehart-Panamuse; the Farnsworth Phonograph-Radio.

AMERTRAN HERMETICALLY SEALED TRANSFORMERS FOR 400 CYCLE OPERATION

THE *WORST* BRINGS OUT THEIR *BEST!*



PROOF AGAINST
Shock · Vibration · Corrosion
Fungus · Water · Humidity
Altitude · Submersion

IDEAL FOR
Airborne Installation
Fine Wire Applications

MINIMUM
Weight · Dimensions

FLEXIBLE
Size · Terminal Arrangement

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

Anyone familiar with AmerTran test methods will understand why the worst conditions of warfare only serve to bring out the best in AmerTran Hermetically Sealed Transformers. Random units from the production line are constantly subjected to immersion, impact and vibration tests often exceeding in severity those prescribed by the government. Thus, we speak conservatively when we say AmerTran Hermetically Sealed Transformers conform to today's rigid requirements.

Used as transformers, Wave Filters and Reactors in the latest 400 cycle apparatus, these magnetic components may be specified with absolute assurance of dimensional conformance and uniformity. The enclosing cases and terminal boards are die made, meeting close tolerances. In all, AmerTran Hermetically Sealed Transformers are worthy products of a company that has specialized in transformer manufacture for more than forty years.

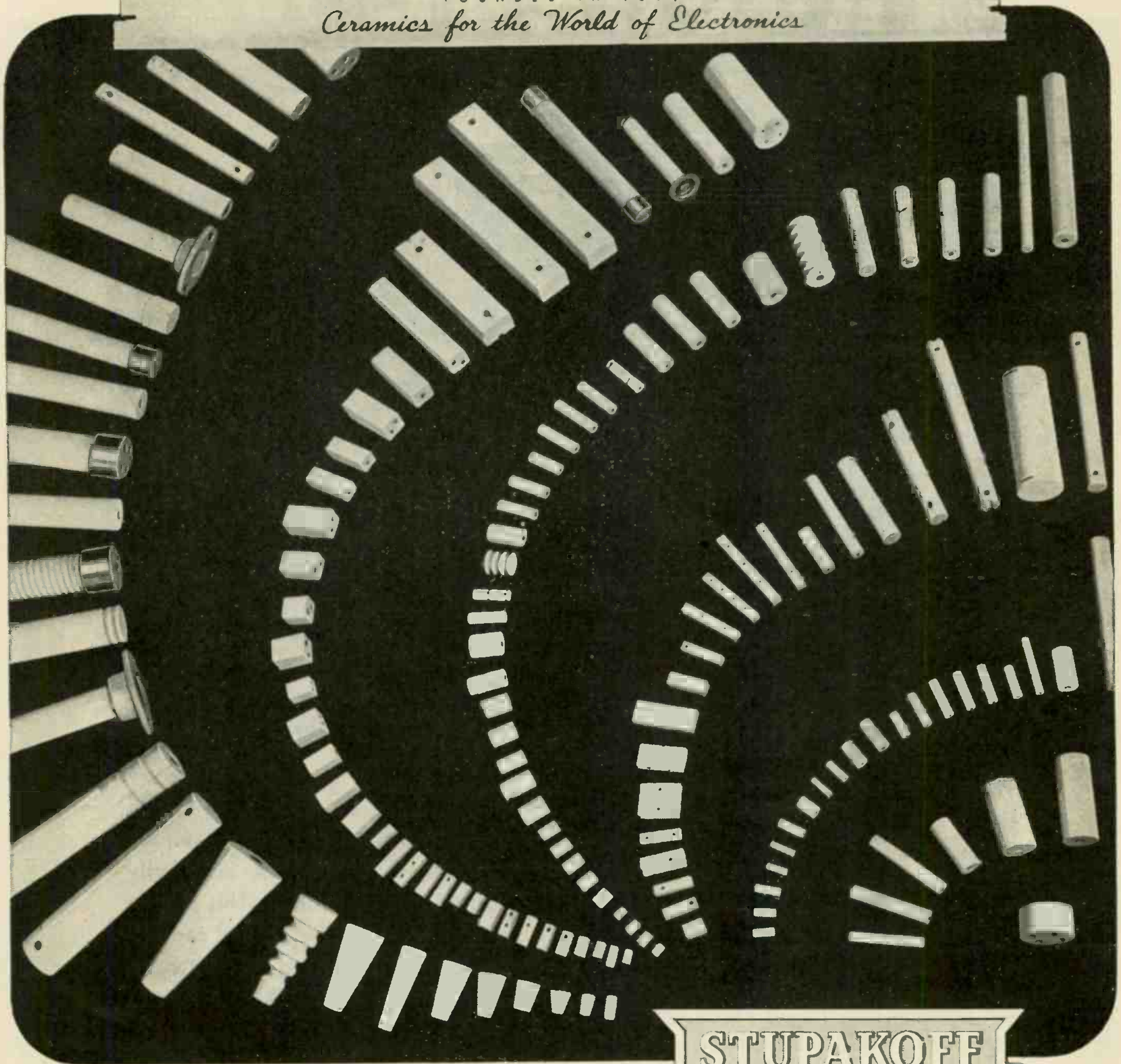
AMERICAN TRANSFORMER COMPANY
178 EMMET STREET, NEWARK 5, NEW JERSEY

AMERTRAN
MANUFACTURING SINCE 1901 AT NEWARK, N. J.

STUPAKOFF

FOUNDED IN 1897

Ceramics for the World of Electronics



STUPAKOFF *Ceramic* INSULATORS

POSTS • SPREADERS

ALL SHAPES AND SIZES

Round, conical, square, rectangular, spooled, etc. Small or large. Ends tapped as required. Glazed or unglazed. With or without metal hardware.

Many stock items. Others made promptly to specifications.

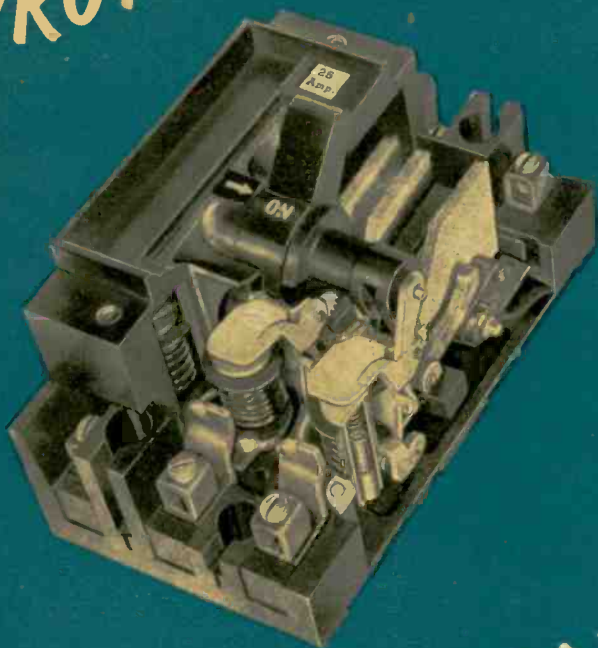
ARMY E NAVY

"for great achievement"

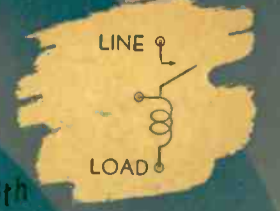
BUY WAR BONDS

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Between Line and Load there must be efficient VACUUM TUBE PROTECTION



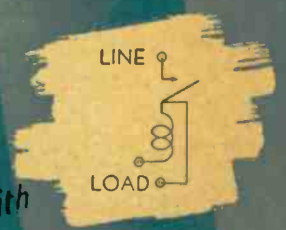
HEINEMANN MAGNETIC CIRCUIT BREAKERS



with

CALIBRATING TAP

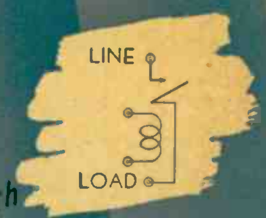
These "Re-Cirk-It" circuit breakers are assembled with an extra terminal attached to the load side of the interrupting mechanism which is the line side of the trip coil. This additional terminal can be used for an extra circuit not to have any effect on the trip coil; or it may be to provide means of connecting a rheostat or resistor in parallel with the trip coil to gain different fixed ratings; or an adjustable variation in the rating giving a much wider range in calibration of the tripping point.



with

SHUNT TRIP

These "Re-Cirk-It" circuit breakers are assembled with the trip coil connected between an extra terminal and the load side of the interrupting means. The circuit connection from the line terminal through the contacts to the load terminal is solid without an overload coil; one end of the coil being connected to the load side of the contacts (interrupting means), the other end of the coil to the extra terminal. The use of this breaker is for remote control tripping so that a circuit of very low capacity at the same voltage may control the opening of the breaker.



with

RELAY TRIP

These "Re-Cirk-It" circuit breakers are assembled with the leads of the trip coil attached to separate terminals so that the interrupting mechanism (circuit opening means or contacts) may be in one circuit which is connected to the load and line terminals while the trip coil is connected to separate terminals and may be energized by a separate control circuit or may be used with the interrupting mechanism in the primary of a transformer and the coil in the secondary circuit. The trip coil can be arranged for as low as a few volts and up to several thousand.

Single, two and three pole breakers in ratings from 10 milliamperes to [illegible]0 amperes; time delay and instantaneous trip.

HEINEMANN CIRCUIT BREAKER CO.

Subsidiary of Heinemann Electric Co., Est. 1888

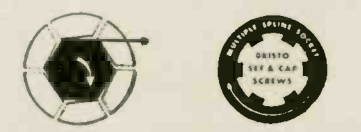
97 PLUM STREET TRENTON, N. J.

The screw that's Built like a Gear

A sound engineering principle makes Bristo Multiple-Spline Socket Set Screws your safest recommendation for protection against vibration.

This screw can be set up tighter than any other . . . for the spline design *pulls* the wrenching force *inward,* not outward. It can be turned far beyond the point where an ordinary screw would burst or at least round out to stop effective wrenching. Yet a flick of the key will loosen it for quick removal!

Any assembly man will thank you for specifying Bristo. Assembly is easier, faster, especially when the fastening point is hard to reach—the splines in the screw cling to the splines on the wrench.



Hex: key exerts outward pressure against socket wall; screw will round out or break.

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

And the man who buys and uses your product will be grateful for the stronger fastening. Because Bristos — no matter how small (even down to the No. 4 wire size) — have greater strength, will hold more tightly, than other screws of comparable size.

TYPICAL APPLICATIONS

- cameras
- radio assemblies
- computing machines
- electric shavers
- scientific instruments
- x-ray machinery
- electric refrigerators
- motor assemblies
- vacuum cleaners
- domestic appliances

See THOMAS' REGISTER for more facts, list of product applications. Remember Bristo for vibration conditions.

The BRISTOL Company MILL SUPPLY DIVISION

BRISTO MULTIPLE SPLINE SOCKET SET SCREWS

Geared to the Key—for faster, easier, tighter setting

THE BRISTOL COMPANY, 154 BRISTOL ROAD, WATERBURY 91, CONNECTICUT

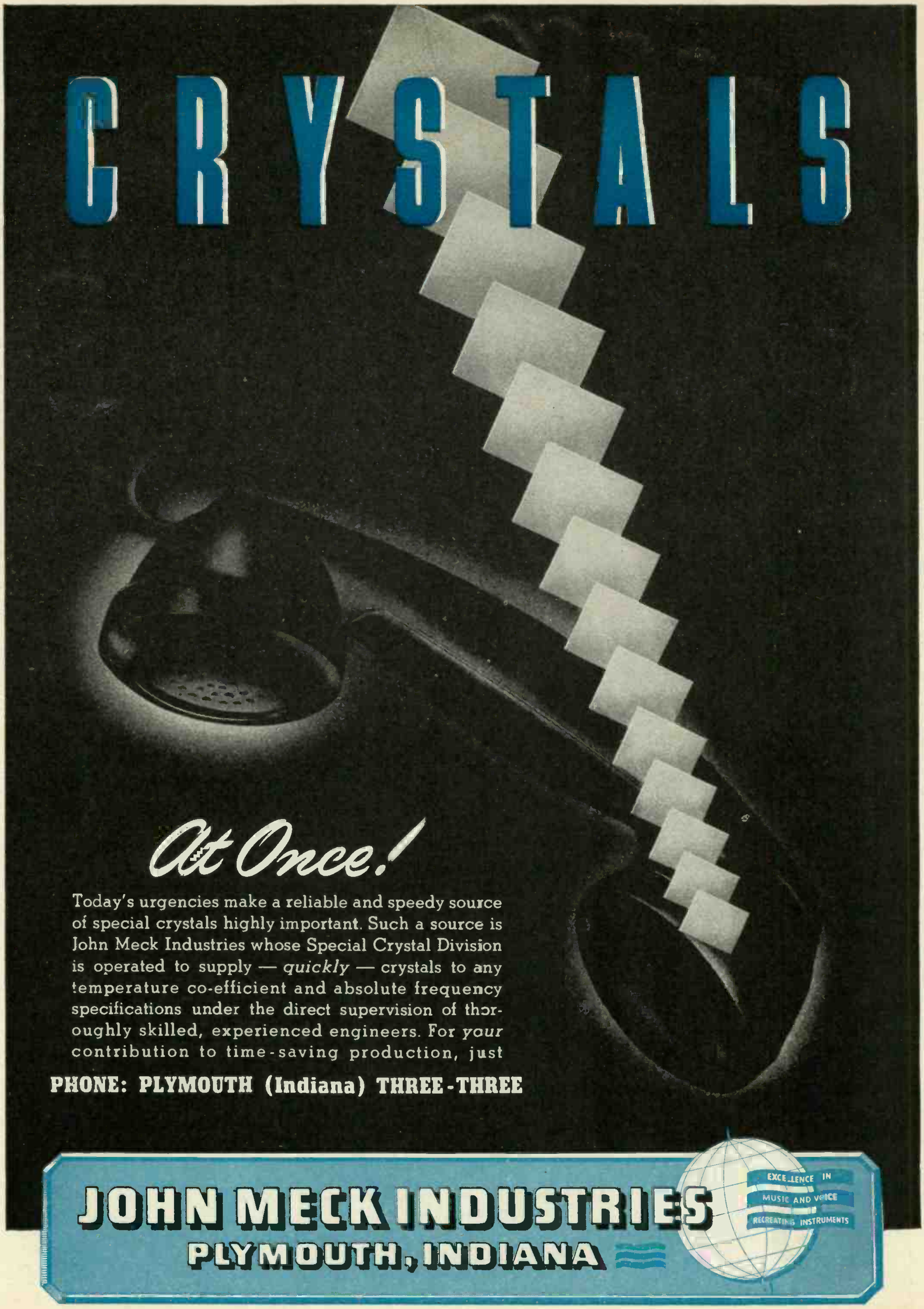
BALLANTINE
AC VOLTMETER

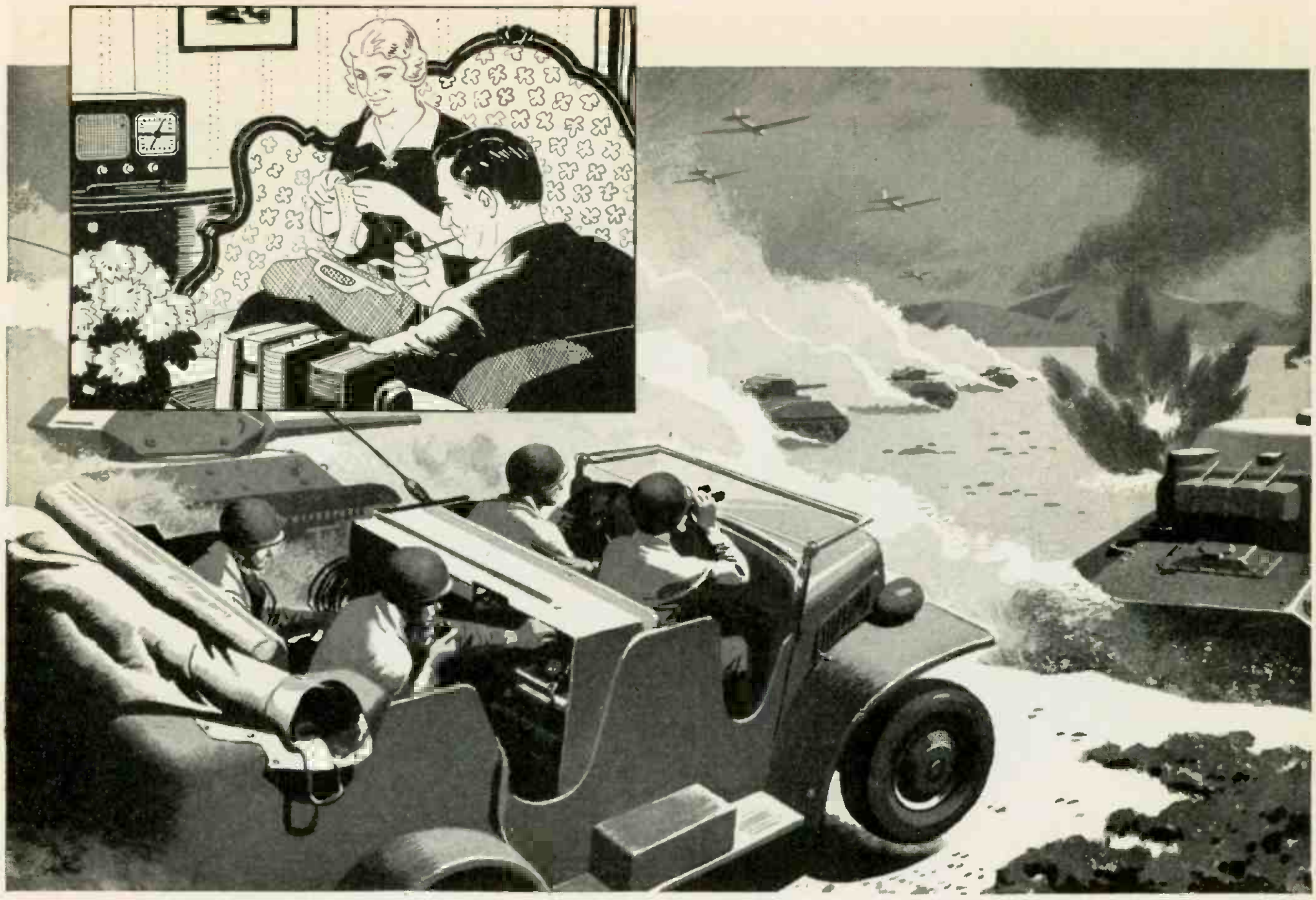
Although designed for the usages of peace thousands of these instruments are now rendering conspicuous wartime service in Government, commercial and university laboratories, factories and maintenance depots all over the world.

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. May also be used as a highly stable amplifier, 70 DB gain, flat to 150,000 cycles.

BALLANTINE
LABORATORIES, INC.
BOONTON, NEW JERSEY


CRYSTALS
At Once!
Today's urgencies make a reliable and speedy source of special crystals highly important. Such a source is John Meck Industries whose Special Crystal Division is operated to supply — quickly — crystals to any temperature co-efficient and absolute frequency specifications under the direct supervision of thoroughly skilled, experienced engineers. For your contribution to time-saving production, just
PHONE: PLYMOUTH (Indiana) THREE-THREE
JOHN MECK INDUSTRIES
PLYMOUTH, INDIANA
EXCELLENCE IN
MUSIC AND VOICE
RECREATING INSTRUMENTS



Fireside to Firing Line

It's a long way from fireside to firing line. Especially long for a radio set. For when you take this coddled precision instrument away from the peace and calm of a living room and stick it in a mobile unit at the front, you're really putting it "on the spot." Jolts, jars, concussions and extremes of temperature are the common lot of radio and electronic equipment in military service.

Fortunately, this transition was not as abrupt as it might have been, for Delco Radio technicians had tackled and solved similar problems in making automobile radios practicable. Vibration and shock . . . heat and humidity variations . . . electrical interference . . . shaking and bumping—all these obstacles were overcome one by one through the ceaseless experimentation and research of radio scientists.

With the conquest of the foes of *radio in transit* came far greater benefits than better entertainment. Years ahead of the second World War, the Delco Radio Division had solved many of the problems which inter-vehicular military radio would face. Years ahead of time, the "spirit of perfectionism" had prepared vehicular radio for its vital role at the battlefront.

Let's All Back The Attack!

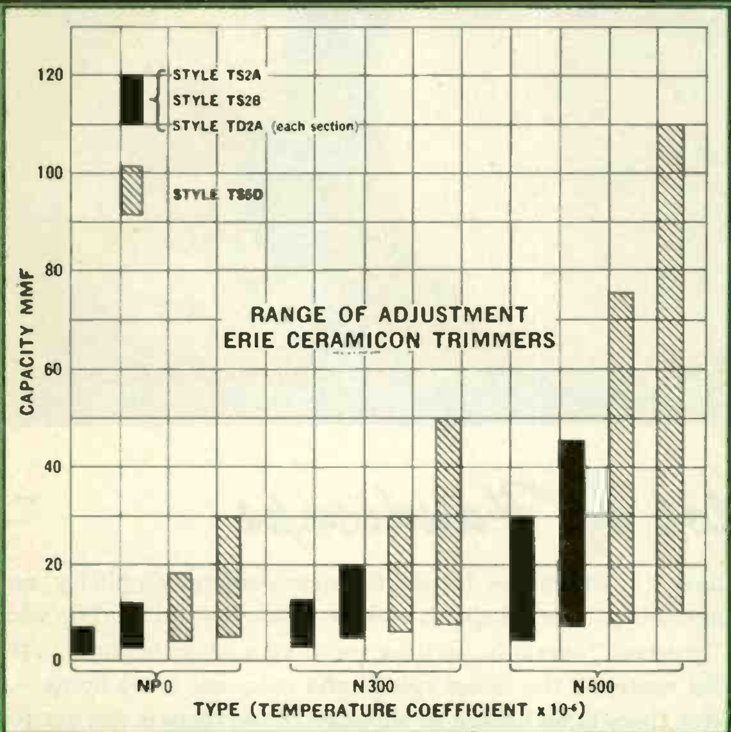
BUY WAR BONDS

Delco Radio
DIVISION OF
GENERAL MOTORS

Erie Ceramicon Trimmers

REG. U.S. PAT. OFF.

. . . DESIGNED for



- **MAXIMUM STABILITY**
- **EASE OF ADJUSTMENT**
- **WIDE RANGE OF CAPACITY**
- **CHOICE OF TEMPERATURE**

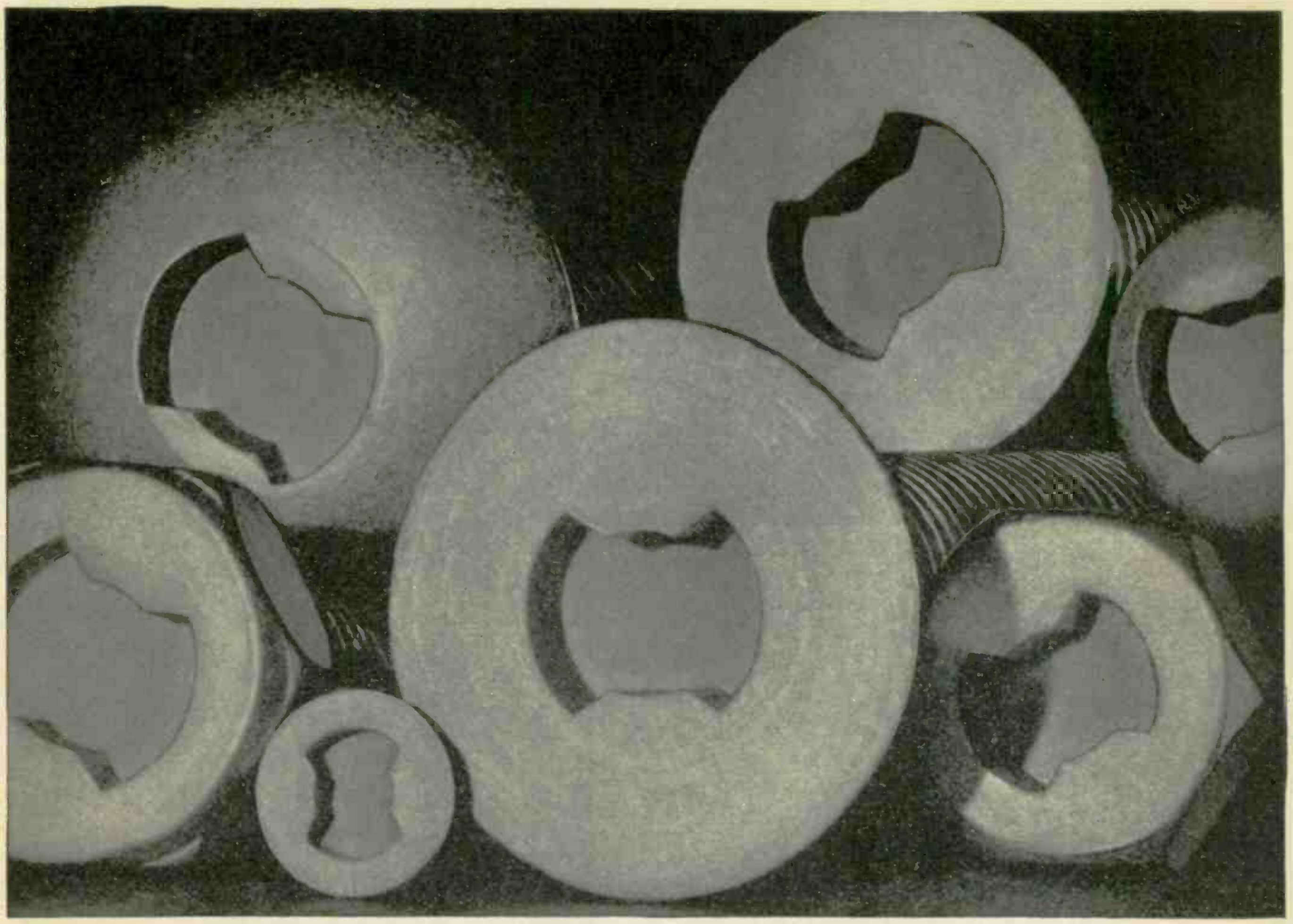
AS shown in the chart above, Erie Ceramicon Trimmers cover the wide range of temperature coefficients and capacities that are in most popular demand.

The three available temperature coefficients, zero, −300 parts per million per °C, and −500 parts per million per °C, provide a choice that covers most practical applications for temperature compensation. The high ratio of maximum to minimum capacity, combined with a low minimum capacity in each of the four standard styles of Ceramicon Trimmers, allows a wide range of applications. The sturdy base, silver-ceramic construction, and soldered connections, assure inherent stability. The rotor of Erie Ceramicon Trimmers is stamped with ℜ for identification. Temperature coefficient and capacity range are also printed on the rotor.

These and many other features are completely described in Erie Ceramicon Trimmer Data Sheets. If you are looking for a high quality trimmer that incorporates temperature compensation in its operation, write for a copy of these data sheets.

Back The Attack—With War Bonds

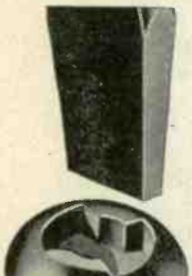
ERIE RESISTOR CORP., ERIE, PA. LONDON, ENGLAND · TORONTO, CANADA.



They "Cancel-Out" a lot of Handicaps

The phrase isn't ours. It comes from the assembly lines . . . where new factors for speed, safety, simplicity, and lower cost are rated high. CLUTCH HEAD Screws "cancel-out" the handicap of slow-down hesitation. The wide roomy clutch offers an easy bull's-eye target for the "greenest" operator, inviting speed born of confidence . . . the automatic entry of the Center Pivot Driver into dead center of the recess speeds and eases the drive home . . . and that same definite torque grip assures the operator there is no hazard of slippage. Then there is the CLUTCH HEAD Lock-On feature which nullifies the handicap of fumbling around hard-to-get-at spots by uniting screw and bit as a unit for easy one-handed reaching. In field maintenance, too, CLUTCH HEAD simplifies operations by solving hitherto accepted problems. Service men prefer this modern screw because it may be operated with the ordinary type screwdriver . . . even with a piece of flattened steel rod in an emergency. They know also that, where screws have to be removed, saved, and used again, the CLUTCH HEAD Lock-On feature obtainable with the Center Pivot Hand Driver "cancels-out" the serious handicap of dropped and lost screws.

Get personally acquainted with these many exclusive features. Send for assortment of CLUTCH HEAD Screws, sample Center Pivot Bit, and fully illustrated Brochure.



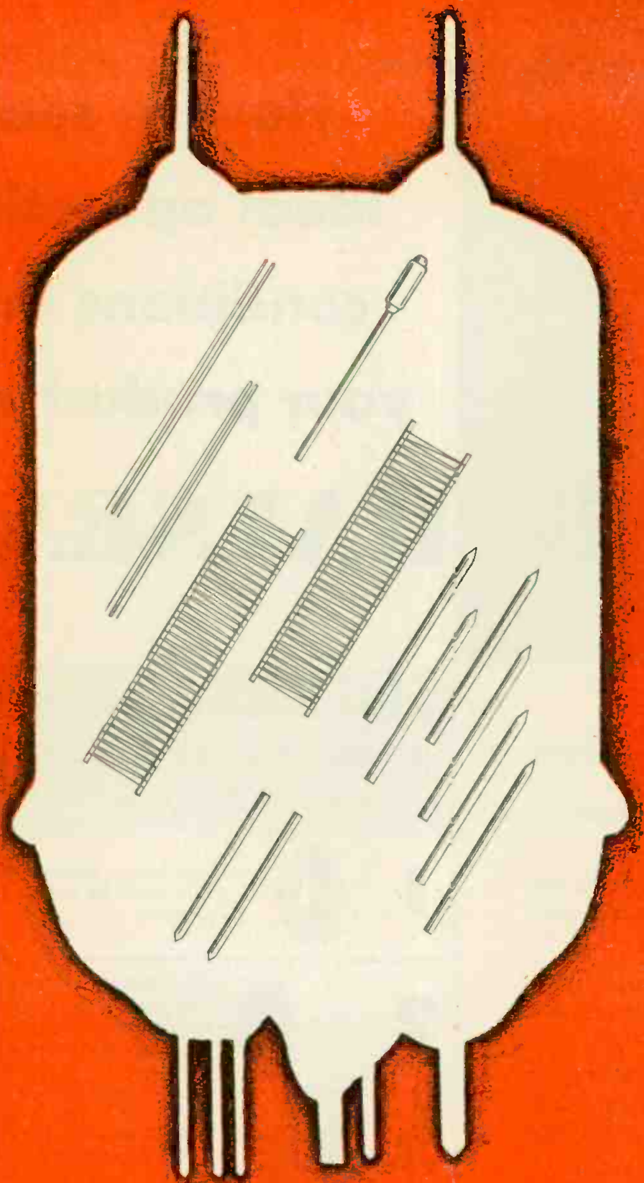
CLUTCH HEAD Screws are contributing importantly to many phases of the war effort. They are available in Standard and Thread-forming types for every purpose . . . production backed by the extensive resources of this Corporation and by responsible Licensees.

CLUTCH HEAD SCREWS

ECONOMY is an important feature of this Center Pivot Assembler's Bit. No "back-to-the-factory" shipment is necessary for reconditioning. A brief application of the end surface to a grinding wheel fully restores original efficiency.

UNITED SCREW AND BOLT CORPORATION

CHICAGO CLEVELAND NEW YORK



NATIONAL UNION chose

Callite

for dependable tube components

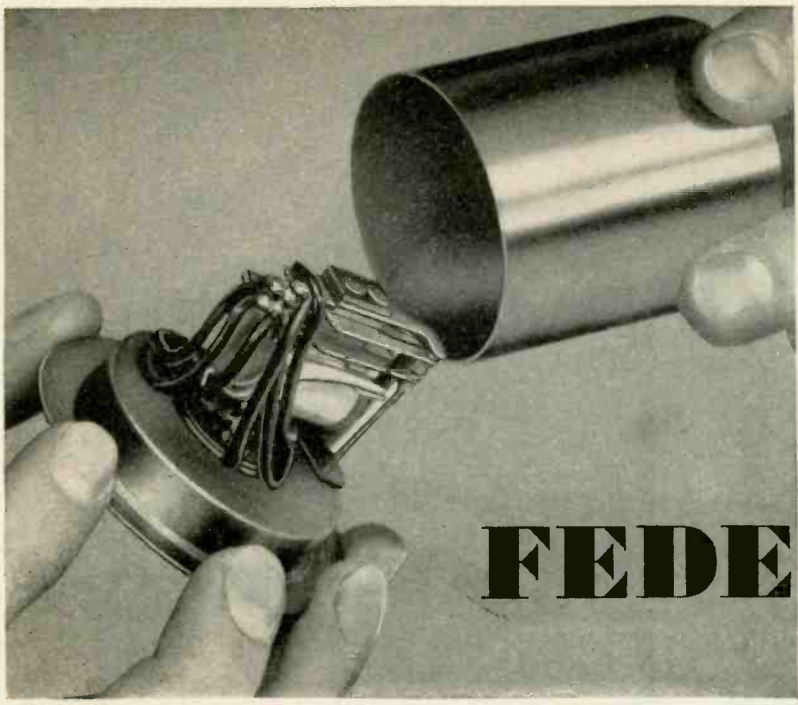
National Union Radio Corporation, large producers of tubes for military use, checked the four factors important to their vastly increased production . . . *and chose Callite* for: 1. Precision-engineered tube components, 2. Practical help on metallurgical and engineering problems, 3. Prompt aid in emergencies as well as consistent delivery, 4. Top quality at a fair price.

The urgency of war production has resulted in important forward steps in the progress of tube component manufacture. All our experience, technical skill and research facilities are available. Call on us now. Callite Tungsten Corporation, 544 Thirty-ninth Street, Union City, New Jersey. Branch Offices: Chicago and Cleveland.

Callite Tungsten
CORPORATION

CALLITE TUNGSTEN

Specialists in the manufacture of hard glass leads, tungsten and molybdenum wire, rod and sheet, formed parts, and other components for electronic tubes and incandescent lamps.



How to seal ideal operating conditions into your product with FEDERALSEAL

Does your design require your product to work at extremely high altitudes . . . under unusual moisture conditions . . . in places where destructive abrasive dust, corrosive fumes, or explosive gases prevail?

If so, then the Federalseal method of sealing ideal working conditions around the operating parts of your product will solve your problem.

By this method, sea-level air pressure can be sealed into a device that must operate precisely at 40,000 feet. Ordinary air which contains moisture can be sealed out and inert gas sealed in to prevent arcing. The wear and danger of dust and combustible gases can be sealed out and pre-determined operating conditions—a vacuum, dry air, inert gas, under any desired pressure—can be sealed in.

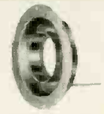
The Federalseal method of sealing pre-determined conditions in the housing of the device itself is made possible by the facilities of our organization to bring so many out-of-the-ordinary skills to bear on your problem. Long experience in working with glass . . . plastics . . . sheet metal . . . high frequency current . . . all go hand in hand to make Federalseal not just a matter of putting a housing around your product, but of sealing out unfavorable conditions and sealing in ideal operating conditions.

Federal Electric engineers will consult with you in regard to surrounding the operating parts of your products with working conditions so ideal for the job they are required to do that better performance will enhance the reputation of your product by giving the buyer this extra performance.

Federalseal may be the something new for which you have been looking. Send us details of your problem and a print of your product. Let our engineers show you what Federalseal can do for you. Call or write us today.

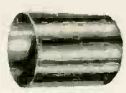
Steps showing how a relay is sealed in by FEDERALSEAL

Example: Clare Type "K" Relay

1 
Steel base is stamped. It is shown here ready for mounting of relay assembly.

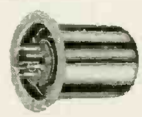
2 
Glass button with fused-in dumet lead wire which is welded to a metal ring. This ring is then brazed to a metal skirt and finally to the steel base.

3 
Relay is mounted and lead wires are soldered to the contact and coil.

4 
Steel cover is placed over the relay assembly and brazed to the base, making an air-tight assembly.

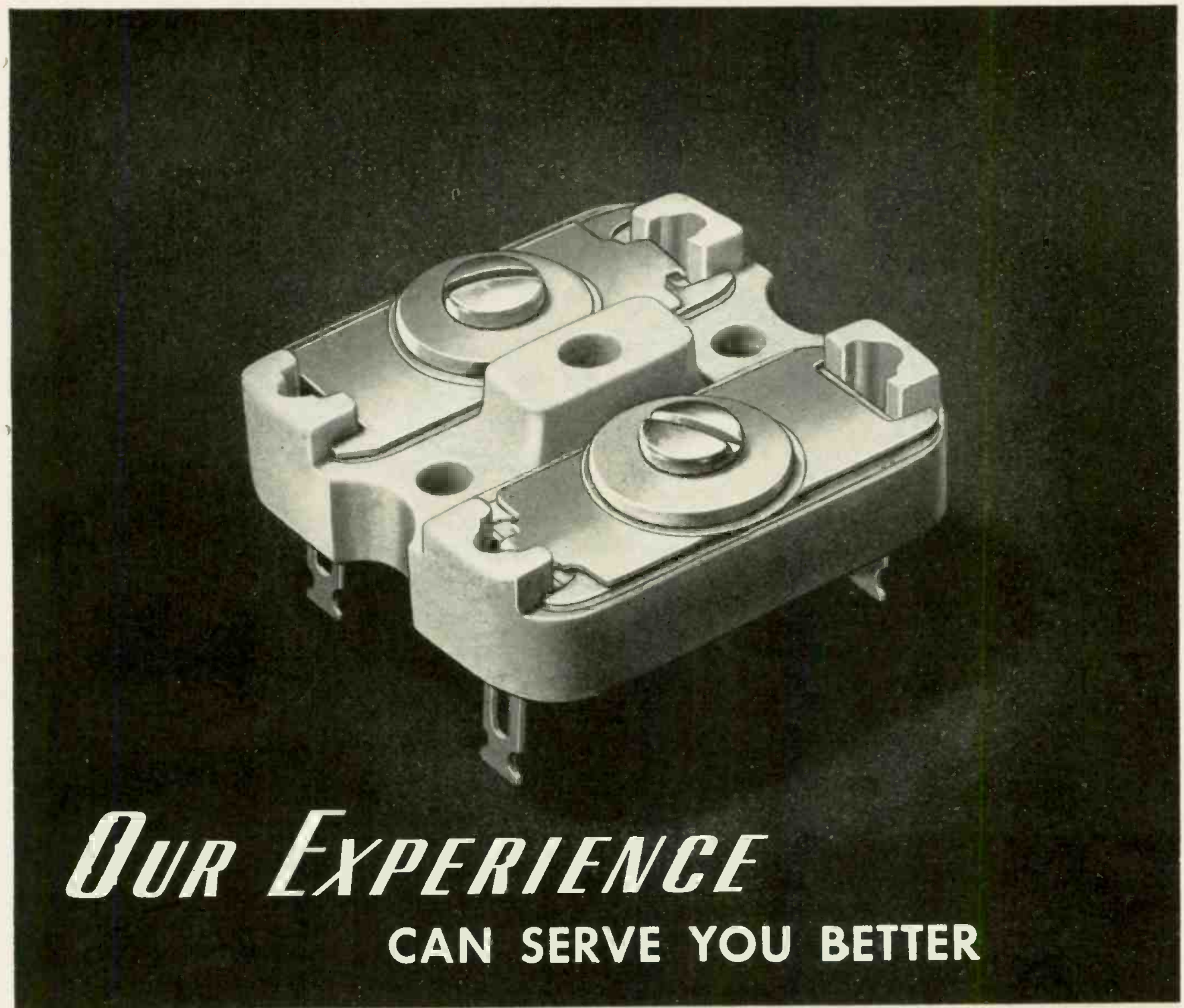
5 
Vessel is evacuated. Any pre-determined working conditions . . . vacuum, dry air, inert gas . . . at any reasonable pressure . . . is then introduced into the chamber. Glass tube is then sealed off as shown.

6 
Octal base is placed over header skirt and wires are soldered to base pins.

7 
Operating mechanism of relay is ready for use under any pre-determined conditions without regard to atmosphere, pressure, or temperature.

FEDERAL ELECTRIC COMPANY, INC.

8700 SOUTH STATE STREET, CHICAGO 19, ILLINOIS



Experience is the best teacher. In the manufacture of trimmer and padder condensers our experience is unequalled and our facilities unique.

When victory comes, the lessons we have learned in meeting urgent and extreme military needs will result in finer-than-ever service to you. All this knowledge, together with our extensive pre-war experience in completely mechanized production, will again be at your service.

★

KEEP BACKING THE ATTACK!

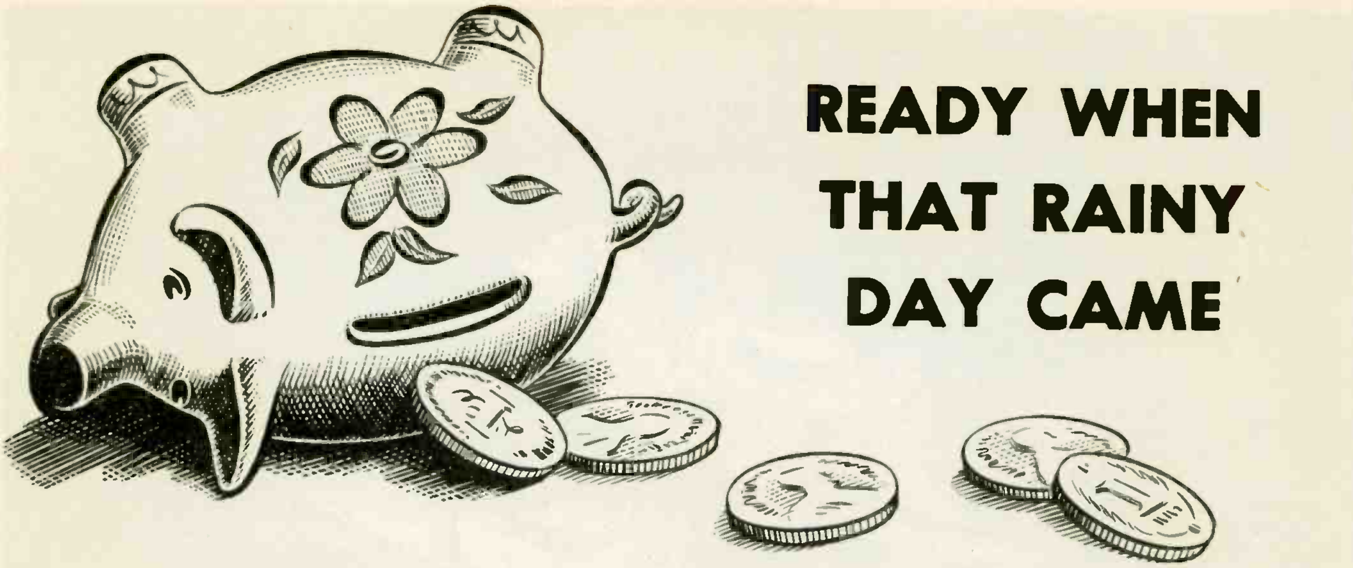
BUY MORE WAR BONDS

★

AUTOMATIC WINDING CO., INC.

COMPLETE ELECTRONIC ASSEMBLIES & COMPONENT PARTS

900 PASSAIC AVE. EAST NEWARK, N. J.

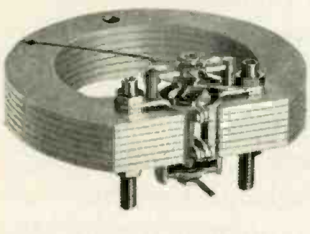


READY WHEN THAT RAINY DAY CAME

WHEN today's big emergency came along, one of America's greatest resources was the know-how and productive skill stored up by industry. Accumulated through the years, this practical experience made possible the building of the world's mightiest war machine.

Simpson Instruments offer an example. Into their making has gone all that 30 years of experience can contribute to the design and manufacture of electrical instruments and testing equipment. From this long specialization has come a noteworthy advance in instrument design — a basic movement of a type long recognized for its greater accuracy and stamina, and which now for the first time has been made a matter of rapid mass production.

Fortunately, this patented Simpson movement was ready and waiting when today's emergency brought a tremendous demand for electrical instruments. It enables Simpson to build them fast, and build them well.

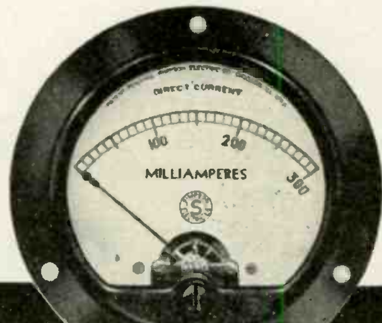


The Simpson Movement is a full bridge type with soft iron pole pieces. It refines this basically better movement to its finest expression, and eliminates the slow, costly construction which before now limited its application. Today this production speed is all-important. Tomorrow, the economies of mass production will mean far greater dollar value, in instruments that stay accurate.

SIMPSON ELECTRIC COMPANY

5200-5218 W. Kinzie St., Chicago 44, Illinois

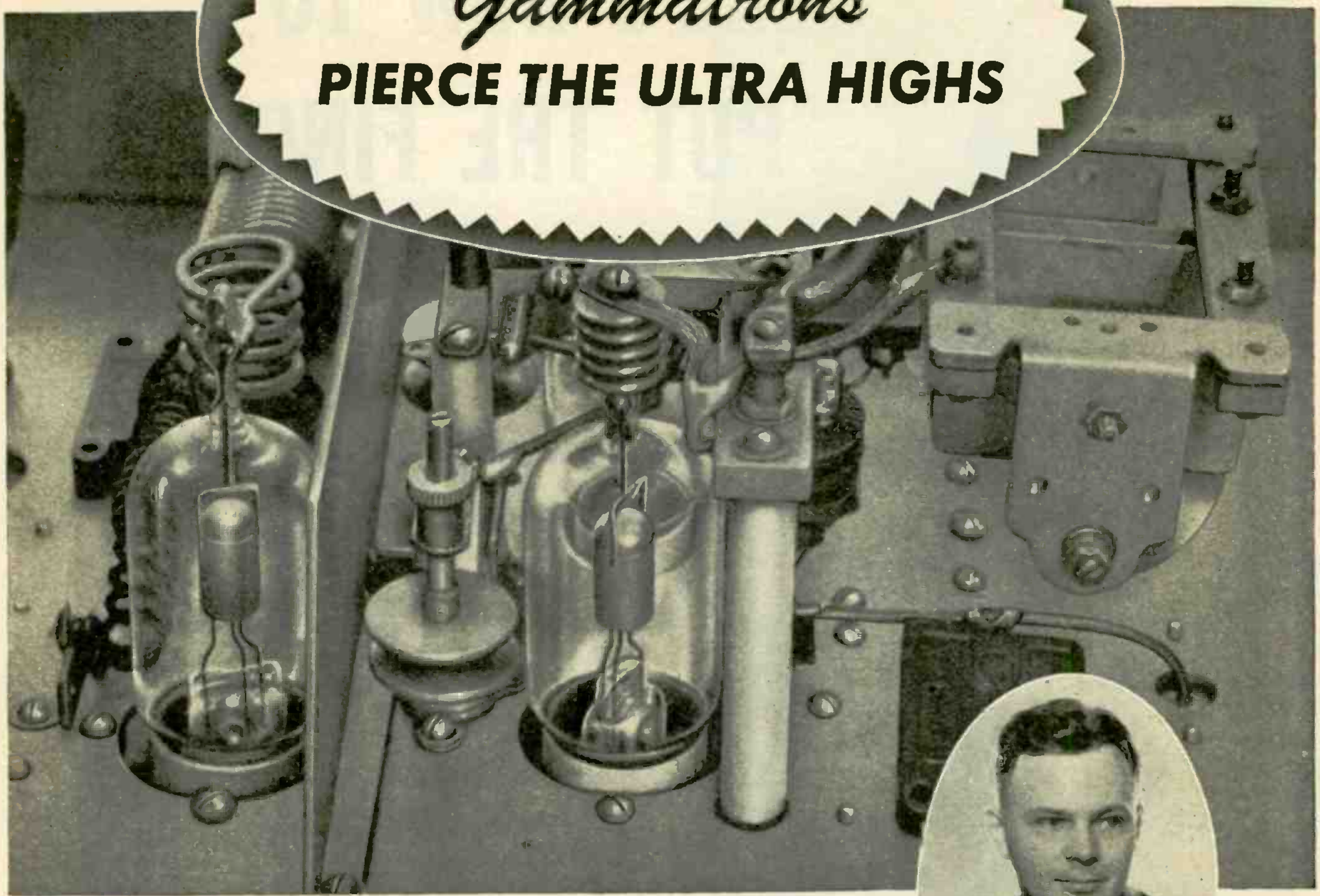
Simpson



INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory

Gammatrons PIERCE THE ULTRA HIGHS



Above: UHF section of 161.1-mc mobile transmitter operated by WGAR, and designed by W. L. WIDLAR, UHF Engineer for the Cleveland station.

"The HK-24 is the best UHF tube for operation at 161.1-megacycles"

The work of W. L. Widlar in the ultra high frequencies is attracting national attention. After several years of research and experiment between 30-mc and 250-mc at WGAR, he designed a 157.5-mc AM mobile transmitter with an operating range of 17 miles.

Two years ago the 157.5-mc special events mobile unit was modified into a 161.1-mc FM transmitter, which reduced noise and improved transmission, and has a satisfactory operating range of 20 miles from the receiving location.

Now he is engaged in testing a 10-watt 225.6-mc crystal-controlled AM transmitter, and the results will be published in the near future.

For the driver-amplifier and power-amplifier stages of these transmitters Mr. Widlar selected Gammatron tubes.

"I know from experience," he says, "that the HK-24, because of its small physical size and high efficiency, is the only available UHF tube that will operate successfully at 161.1-mc."

In addition to small size and high efficiency, there are other reasons for the ability of HK-24's to pierce the ultra highs. For example, confined electron paths, getter-free bulbs that avoid metalized resistor effects, and lack of internal insulators.

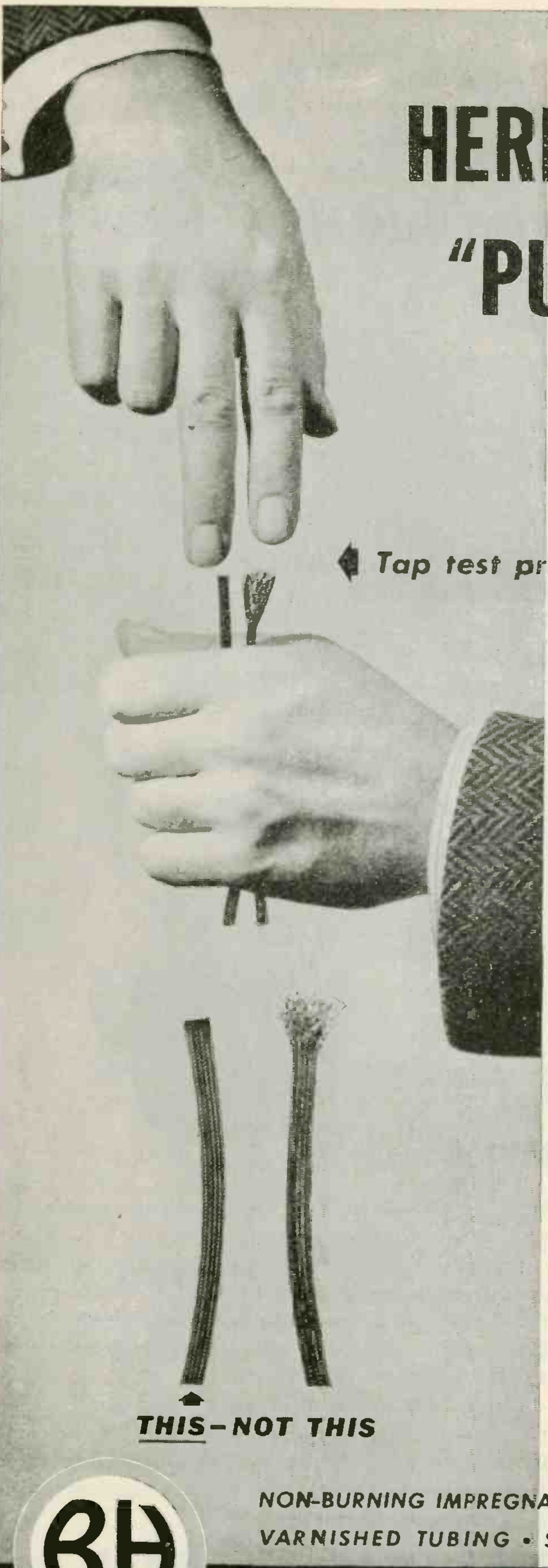
Heintz and Kaufman engineers constantly utilize the results of UHF field tests to design more efficient Gammatrons, and thus they are making an important contribution to the opening of new electronic frontiers in the centimeter region.

HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA

Gammatron Tubes

HERE'S HOW TO "PUT THE FINGER" ON SLEEVING—



Tap test proves new BH "extra flex" Fiberglas Sleeving is non-fraying

HERE'S a new sleeving that is *both* flexible and non-fraying. And you can prove it *right at your own desk* with this simple tap test:

Obtain from us a sample of BH Extra Flexible Fiberglas Sleeving equal in size to the saturated sleeving you use now. Hold both types in your left hand, as illustrated, and finger-tap each sleeving 15 to 20 times. BH Extra Flexible Fiberglas Sleeving will spread slightly, may fuzz a little, but it will not fray. The usual saturated sleeving will break down at the edges and separate. Continued manipulation will not noticeably affect the BH Extra Flexible Fiberglas Sleeving, whereas the saturated sleeving will readily unravel and become progressively worse.

NON-FRAYING • FLEXIBLE • HEAT-RESISTANT
NON-INFLAMMABLE • WATER-RESISTANT
NON-CRYSTALLIZING at LOW TEMPERATURES

The new BH Extra Flexible Fiberglas Sleeving is woven from the choicest continuous-filament Fiberglas yarns. It possesses high dielectric strength, is water-resistant and, like all BH Sleeving and Tubing—is non-inflammable.

All sizes from No. 20 to 5/8", inclusive, are available. Write for samples of this radically new and different sleeving today—in the sizes you desire. Seeing is believing! Bentley, Harris Manufacturing Co., Dept. E Conshohocken, Pa.

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

BH PRODUCTS

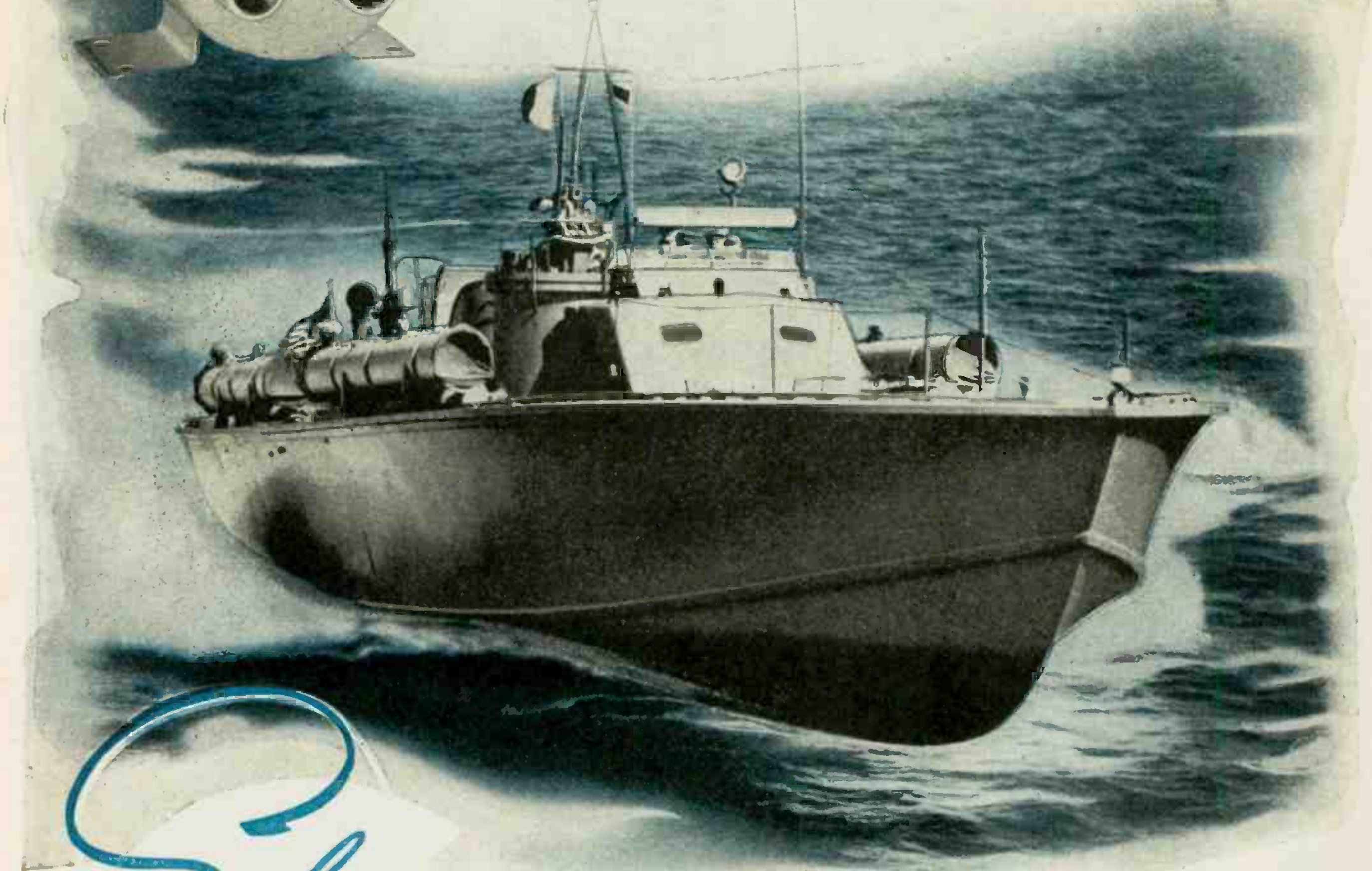
BENTLEY, HARRIS MANUFACTURING CO.
Conshohocken, Penna.


A MITE IN SIZE . . . BUT A
Giant in action!
Precision crystals are performing a mighty job under the most trying battle conditions. But only the crystals that are microscopically clean can operate indefinitely. That's what makes crystals giants.
Crystal Products Company methods of exacting cleanliness in manufacturing procedures are unsurpassed. All crystal oscillators are guaranteed free from flaws, ghosts, inclusions —and are free from optical and electric twinning.
Crystal PRODUCTS COMPANY
1519 McGEE STREET · KANSAS CITY 8, MISSOURI
Producers of Approved Precision Crystals for Radio Frequency Control

Keeping Sea Lanes FREE Lanes

More amazing than fiction are the dashing exploits of PT boats. In a war to keep free the sea lanes of the world, these combat vessels streak into action and unleash a group attack that's packed with power and punch. One reason they maneuver so successfully: the lanes of communication are kept free. Vital radio messages from boat to boat are protected against noisy local intereference.

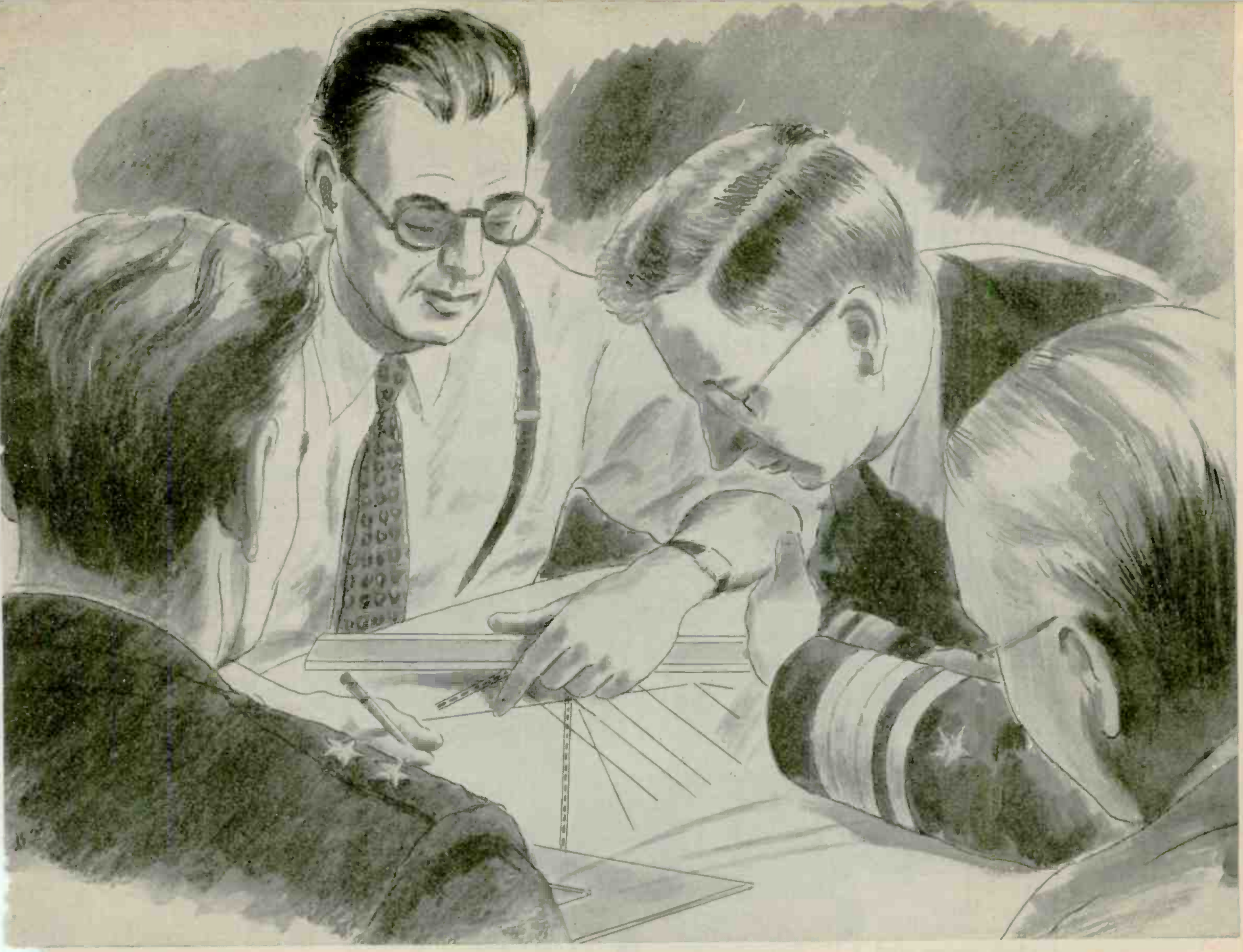
In climates tropical or polar, Solar noise-suppression systems absorb static right where it starts—at generators, motors, windshield wipers, contacts and other local sources. Solar Capacitors and Elim-O-Stats, as components of such systems, also protect others of our fighters. Men talking from plane to plane, from jeep to jeep and from tank to tank transmit and receive commands without the lost syllables that might mean lost lives. Solar engineers, pioneers in capacitor manufacture, draw on an unusually rich radio experience and uninterrupted electronic research. In days to come, their war-won knowledge will be valuable in meeting postwar communication needs, just as it is now available for military and naval demands. Solar Manufacturing Corp., 285 Madison Ave., New York 17, N. Y.



Solar SOLAR — **ELIM-O-STATS** —

CAPACITORS AND RADIO NOISE-SUPPRESSION FILTERS

5007



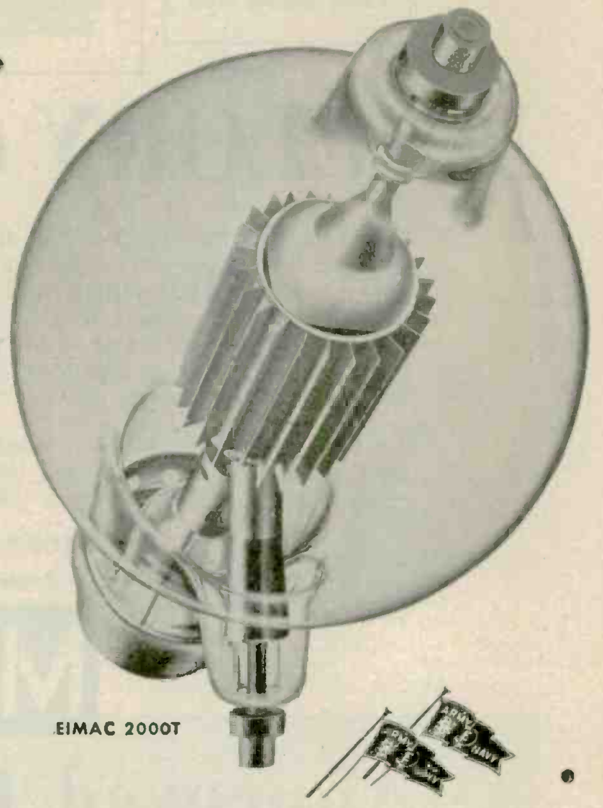
neir *hobby* is radio too . . .

These are the leaders of science and communications. They are professionals in what has become a most vital element of modern civilization . . . radio communications and the science of electronics. Some of them wear the uniforms of top ranking military officers because we are engaged in war. Others remain civilians as doctors of science . . . the leaders of radio, electronic and electrical industries which are amazing the world through their achievements. Achievements which not only aid in war but which are creating the new era of industry to follow. They are the great men of today . . . they will be still greater tomorrow . . . and they are radio amateurs.

Eimac tubes are leaders too. First choice of these leading engineers . . . first in the new developments in radio. They are first with radio amateurs too, which is no coincidence.

Follow the leaders to

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



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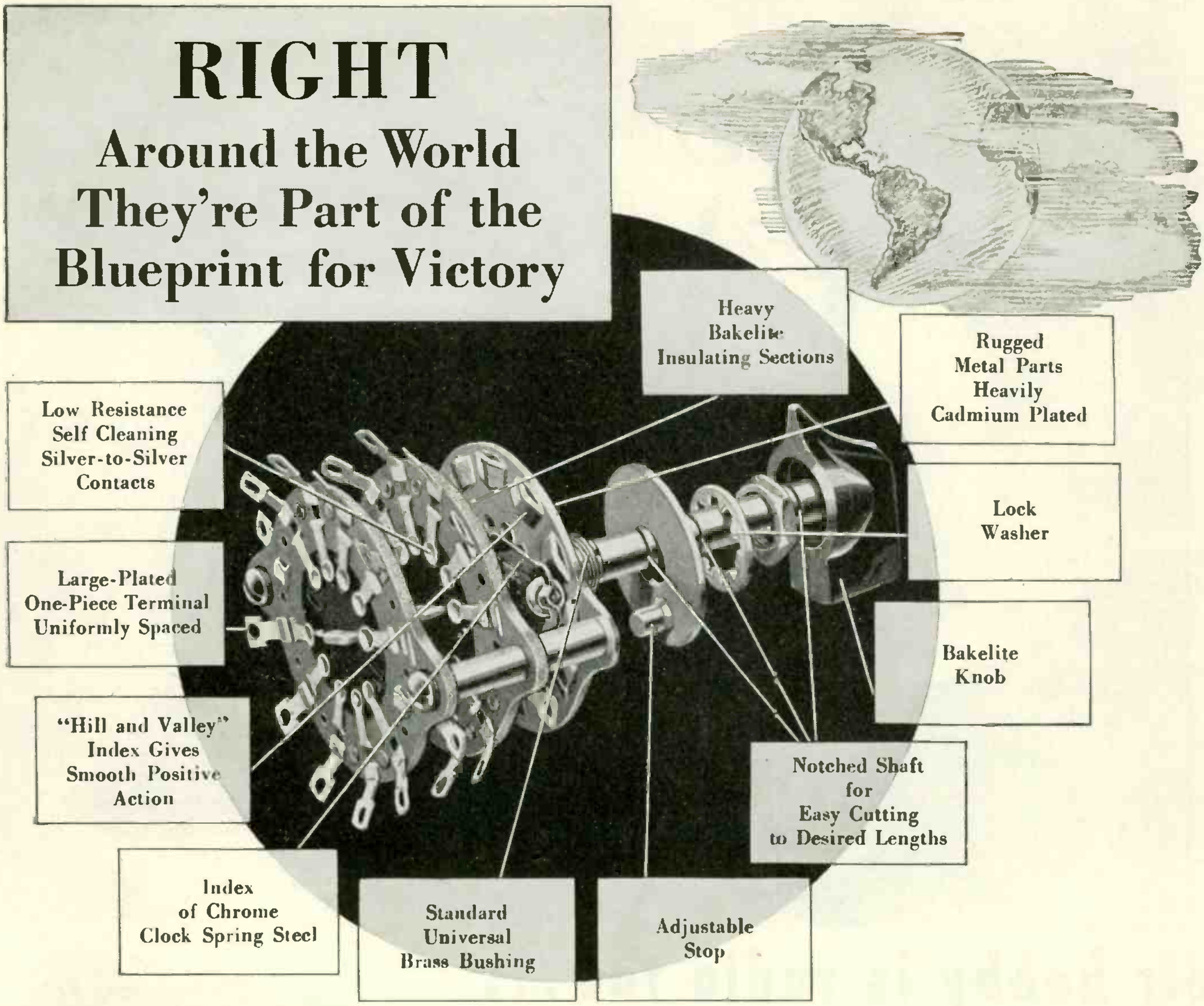

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CROSS TALK

▶ **POSTWAR** . . . There is no disguising the fact that postwar talk by manufacturers up to their necks in war contracts is highly unpleasant to military ears. The army and navy feel that our present energy should go toward increasing war materials, not toward peddling postwar goods. They feel that postwar talk is a highly contagious disease. Someone starts it; then competitive manufacturers have to take a share in it; soon production people begin to feel that a bit of relaxation is in order, now that the big shots think the war is about over.

So far as signal equipment is concerned, 1944 will require more than 1943. There will be shifts in emphasis; new models of certain equipment will be made instead of old and less useful models. But there is no sign of wholesale cancellation of contracts.

With regard to postwar talk, Lieut. General Knudson quoted a Danish adage to good effect recently. It goes:

"Don't sell the hide until you have shot the bear."

▶ **DETERRENT** . . . Recent surveys indicate that the chief deterrent to the wider adoption of electronic devices by industry is the lack of knowledge among industrial engineers of the possibilities which tubes have for them.

There is an equal lack of information among electronic engineers of the mechanical problems involved in placing a tube device in a manufacturing plant. As one reader expresses it: "At one extreme we have a trained electronic engineer who is capable of solving many electronics problems but who is not familiar with manufacturing processes. At the other end, we have a mechanical engineer who doesn't know enough about electronics to realize that many of his problems could be solved by the use of tubes."

To date, most electronic applications have been made by radio and communications men whose background is distinctly not along general industrial production lines. Failures of equipment can often be laid directly to this background.

Colleges in the postwar period must train men for these industrial-electronic jobs. The requirements differ from those needed by communication engineers. The whole approach must be different. Much of the curricula should be taught, not by electronic men, but by men with industrial engineering experience. There should be more emphasis on speed of operation, strength of materials, weight, space, reliability, factors of safety, and less on emission, cathode structure, and transconductance.

The survey already mentioned often indicates that too much "high-brow" education and writing about electronics is one of the deterrents—perhaps what is wanted is not *more* information but the *right kind* of information.

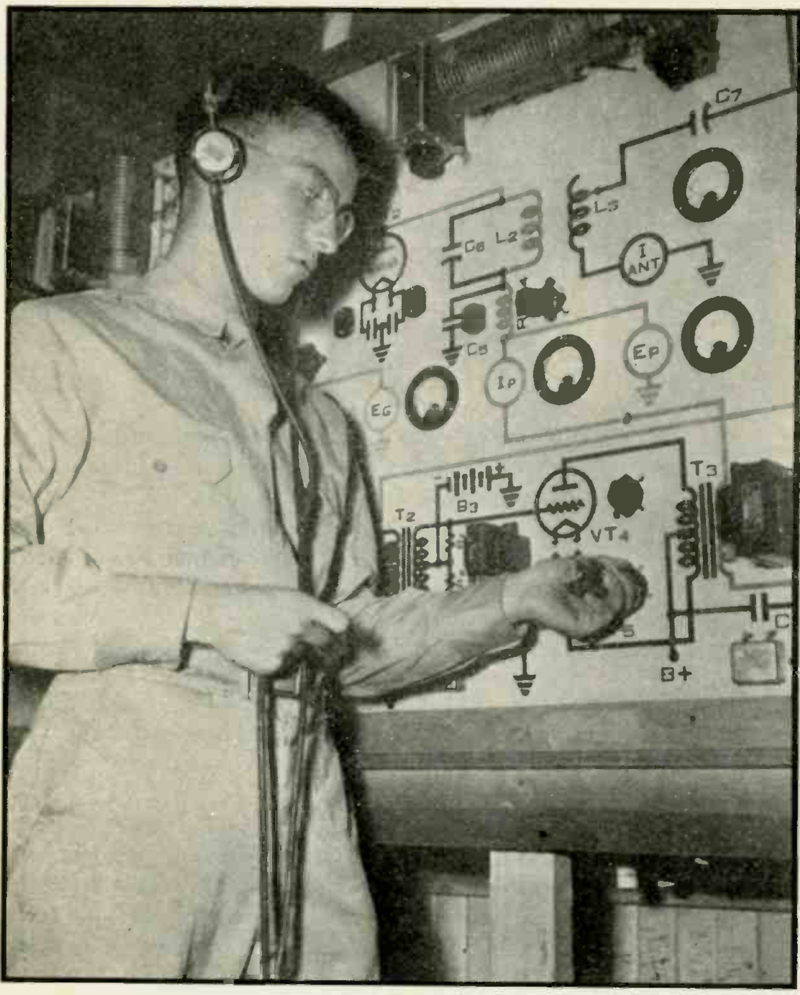
▶ **RENEGOTIATION** . . . The very subject of renegotiation is anathema to many people. There are some angles to it, however, which do not seem to have been publicized. For example, conversation with Army officials having something to do with this problem indicates that where there are two manufacturers making the same war item, the one using the fewest man-hours to do the job is likely to fare better than the less-efficient producer. In making a given item, if the two plants require 113 and 167 man-hours respectively, the 113-man-hour plant may be allowed to keep more of its profits than the 167-man-hour plant.

Man-hour utilization is an important index to Army men.

▶ **MIDGETS** . . . It has become trite to comment on the fact that the war is producing profound effects upon electronics. Some of the effects, however, are in unexpected directions. For example, the exceedingly small electron tubes have so pleased military people that they evidently want to use nothing but these small tubes. This puts a tremendous strain on tube manufacturers since the midgets are relatively more difficult to make and have greater shrinkage in manufacture.

The reasons why the military wants to use small tubes are obvious; and the same reasons will make peacetime uses for them equally extensive. More tubes in a given space and weight is the answer.

War FACTS



Manpower with which to expand the field of electronics will be plentiful in the post-war period. Many men now being trained by the Services, such as this bomber radioman, are acquiring excellent technical knowledge

NEW YEAR'S DAY, 1944, found the people of this country somewhat confused on two important matters. First, with regard to the war and its ending in the near future, and second, with regard to the great bright future after the war is over.

Optimistic statements about the war from high places led the constitutionally optimistic to bet that it would be all over in Europe by the end of 1943. Those who bet on this proposition have already lost their money and the date for the collapse of Germany is now advanced to March, or June, or any other date they can get people to put their money on. At the same time pessimistic statements from others have led us to believe that we are a long way from being out of the woods. Confusion about the date of the war's end is only natural under the circumstances.

Blue-sky statements about the wonders of post-war electronics and how it is going to revolutionize industry and the home has led many people to believe that this new something which they cannot even define is going to turn all of us into millionaires, with days of leisure occasionally punctuated by button-pushing to get our necessary menial tasks done. There is to be no more drudgery, all homes are to have air-conditioning, television, FM, a newspaper via radio, a personal radio station. There are to be telephones in every auto, helicopters and other imaginative inventions.

And yet there are doubts. Manufacturers with swollen payrolls, batting out materiel for the war effort, are concerned with the date of end of the war in a very vital way. An endless stream of visitors and letters to the editorial offices of ELECTRONICS express this concern. The gist of it is this: "Look, we used to have 35 men working for us and now we have 400. How are we going to keep them busy after the war and particularly in the days immediately after the war? What are the post-war prospects for us?" For it is certain that few manufacturers will want to go back to a 35-employees status after having sampled a 400-employee setup.

Facts Versus Fancies

Now, what are the facts? And which of the post-war fancies can we expect to come true?

First, with regard to the war. The military leaders are not the optimistic ones. They point out that we have not yet really started the Pacific offensive; that so far we have only created a diversion in Europe. It is quite likely that other diversions for Germany's army to contend with will be created before the final big Western Europe push begins. It takes time to institute diversions like that in Italy and there is not the slightest evidence that the military leaders are going to start anything until they are completely prepared to make it a success.

The truth is that the end of the war in Europe, and certainly in the Far East is still a long way off barring, of course, the unpredictable phychological or political accident which *might* occur and which *might* make unnecessary the long military

and Post-War FANCIES

War's end is not yet in sight; until then, electronics remains a 5-billion dollar business. Post-war prospects for home radio, FM and television are bright. Industrial electronics is still the enigma.

campaigns now planned and in preparation. There cannot be the slightest doubt that we are a hell of a ways from ending this war.

The safe thing to do is to assume that the war in Europe will last another year, at least, to keep one's eye on events as they occur and to be realistic about what may happen after the war's end.

Major General Code, Assistant Chief Signal Officer, speaking before a group of technical editors late in December, said that 1943's radio and electronic contribution to the war amounted to about 5 billion dollars and that 1944 would see about the same dollar volume of materiel produced. Thus the electronics industry has another year, at least, of high-speed, full-payroll production. Frank M. McIntosh, of the Domestic and Foreign Branch, Radio and Radar Division, WPB, stated about the end of December that so far as electronic devices is concerned "for every 3 in '43, we need 4 in '44." That gives an idea of the magnitude of production still to come.

All this, however, merely puts off to the future the post-war problems, and the fact that we must still work hard to provide the Services with military equipment does not answer the disquieting questions that naturally arise when we think of the days after the end of hostilities.

Postwar Electronics—What of It?

If there is confusion about the date of the end of the war, there is confusion confounded about the glamor days to come. Many companies, never before in the electronics business, have every desire to stay in it; and some, having got a taste of one kind of electronic equipment manufacturing, see no reason why they should not barge into, say, the home-set business and show the old-timers how it really should be done.

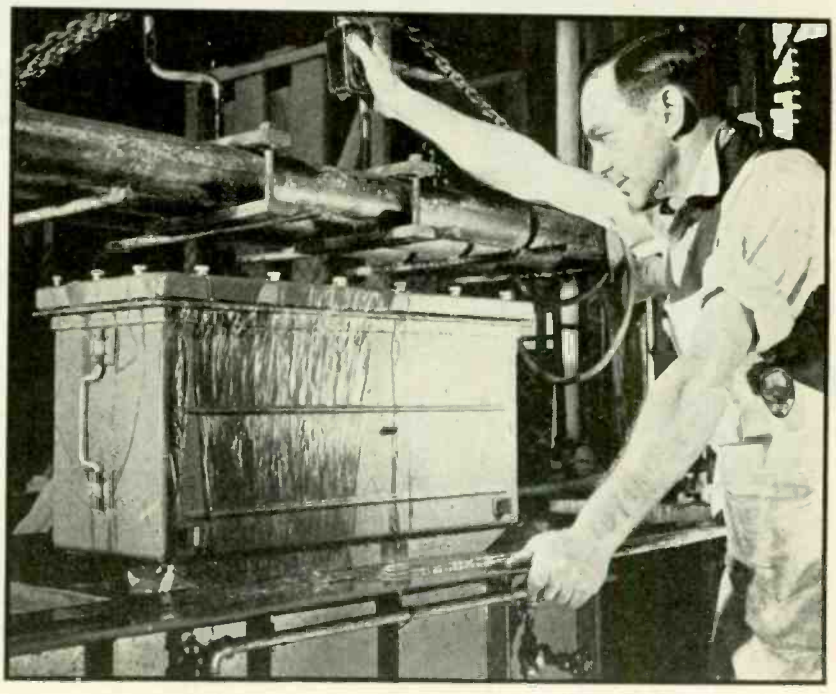
All of us are aware that the manufacture of quartz crystals has been multiplied many times during the war and that many companies now make crystals where only a few made them before. What are these people going to do after the war?

Making cathode-ray tubes is another example. Will the present high rate of construction of systems and devices using CR tubes keep up after the war? Will television and industrial CR uses go ahead rapidly enough to keep busy the many people now making this type of electron tube?

So far as the immediate post-war electronics prospects are concerned, there can be no doubt that the manufacture, sale and service of home radio receivers will be the major part of the initial peacetime business. In 1941, the last full year in which radios were made, some 13 million receivers were manufactured and 11 million of these were sold in that year, 8 million of them for replacement purposes. The net increase of 3 million receivers brought the country's set ownership to approximately 52 million, plus the 6 million sets that were in automobiles. At the same time, there were 920 broadcast stations, 1,900 police stations, 2,900 aircraft equipments, 60,000 amateur sta-

(Continued on page 212)

Design of equipment which can really "take it" is one definite wartime gain which will carry over in large measure into post-war commercial equipment. Here a Westinghouse radio designed for commando operations gets a water-test



Electronic Dehydration

Experiments with electronic methods of dehydrating foods indicate that less than 100 watts of energy per pound of compressed food is required for successful removal of practically all water. Equipment operating at 29 Mc was used

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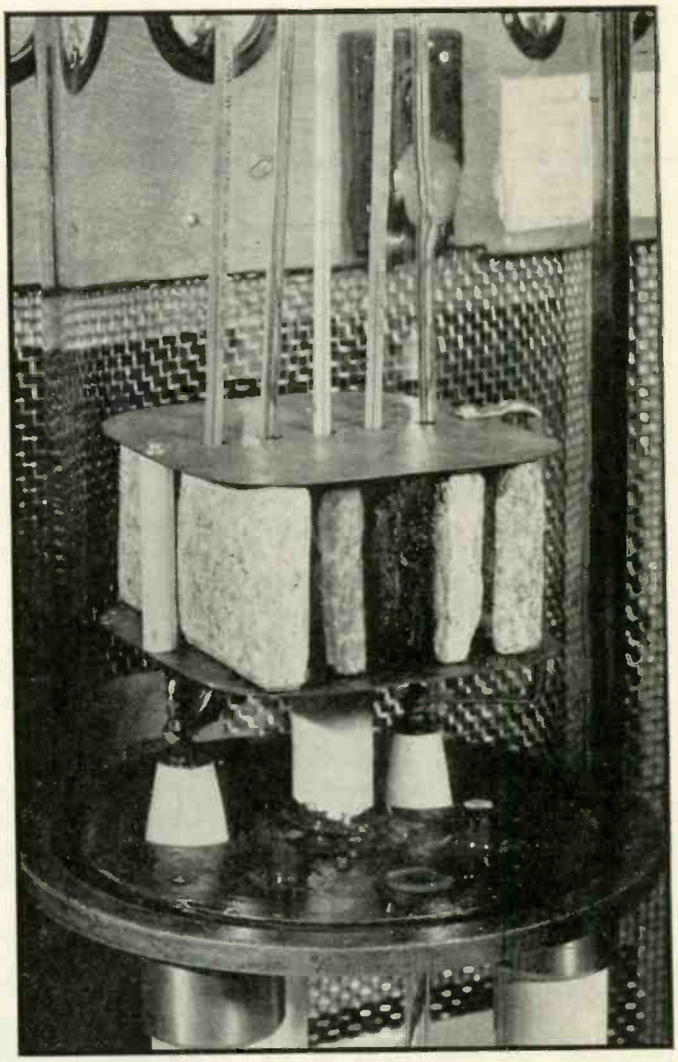
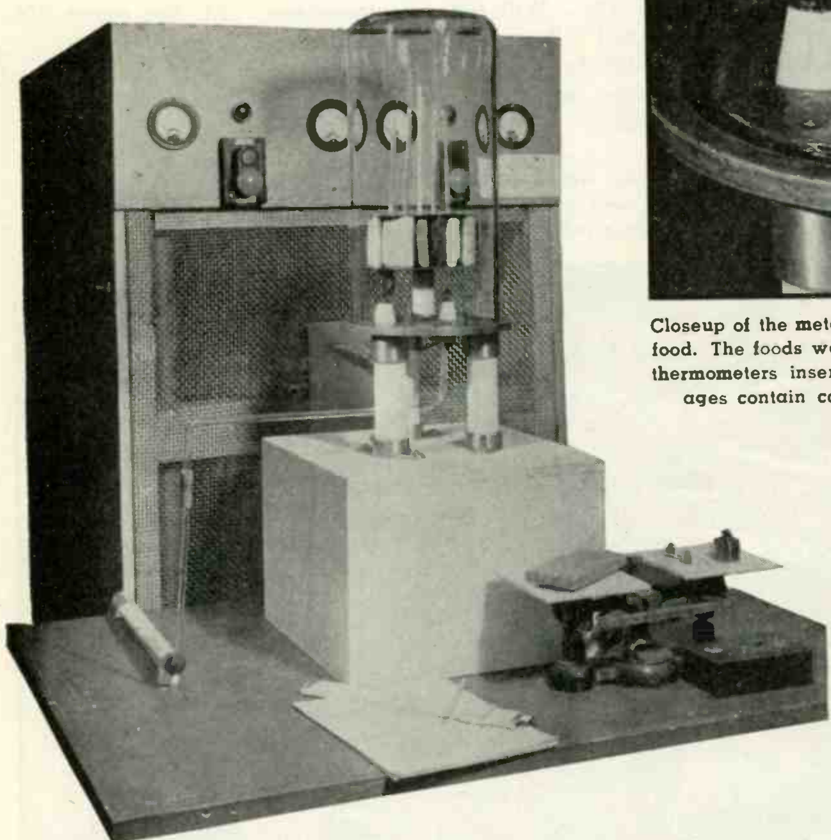


Closeup of the metal plate assembly and packages of compressed food. The foods were shredded, compressed into hard blocks, and thermometers inserted into drilled holes. Left to right, the packages contain cabbage, carrots, beets, cabbage and onions



Experimental setup of equipment used for dehydration of foods. The inverted bell-jar was evacuated and radio-frequency energy applied to metal plates above and below the packages of food. One inch of free space was left between the top plate and the food samples during the tests

Of the many proposed applications of electronic heating, one of the most interesting is its use in the dehydration of food. Experimental results establish the fact that such a process is economically and technically promising for commercial utilization on a large scale.

The food products studied included carrot shreds, beet shreds, cabbage flakes, onion flakes and riced potatoes. The tests were made on samples that had been compressed at a pressure of 500 lb per sq in. into a hard block measuring

# of Foods

6 x 3 x ¾ in. Each sample block was wrapped in heavy Kraft paper, sealed with cellophane tape, and inclosed in an additional outer cellophane-sealed envelope. Each package was marked with its actual moisture content as determined by tests previous to packaging.

Test Procedure

The food samples were subjected simultaneously to radio-frequency energy from an r-f oscillator and to a vacuum. "Megatherm" electronic heating apparatus was used to generate heat uniformly throughout the food mass. In the laboratory test, the usual procedure was to inclose five packages of food, weighing approximately 3 lb, between the heating electrodes. The fixture used for heating this food consisted of copper plates 5¾ x 6½ in., separated approximately 4 in., and supplied with r-f energy at a frequency of approximately 29 Mc. The entire heating fixture with its food samples was placed inside a bell jar which was evacuated to 29 in. of mercury.

Power was fed to the heating fixture from a push-pull Colpitts oscillator circuit using two Federal F-127-A tubes. The feedback capacitors in this circuit were approximately 25 $\mu\mu f$ and were made variable so that the amount of drive could be adjusted and balanced. The heating fixture, together with its load of compressed food, constituted a load equivalent to a capacitance and resistance in series connected across the oscillator coil.

Radio-frequency power was conducted to the heating fixture inside the bell jar through insulated seals. The vacuum system included a ½ hp Bengo-Megavac pump, a dessicator, and a mercury monometer.

As shown in the photographs, food packages were arranged side by side in a vertical position, resting on the lower horizontal plate of the fixture. To measure the temperature during processing, a hole was drilled in the center of the sides of each block of food (as well as in the upper plate of the heating electrode fixture) and after arranging the food blocks side by side on the heating fixture, a thermometer was inserted in the block. With the bell jar sealed, the vacuum was brought to 29 in. of mercury in a period of about 2 minutes. After this degree of vacuum had been obtained, radio-frequency power was applied to the heating fixture. Interruptions of the dehydrating process at intervals of 5 to 15 minutes were necessary in order to record the change of weight resulting with the progressive dehydration.

In the initial experiment, dehydration was accomplished with the

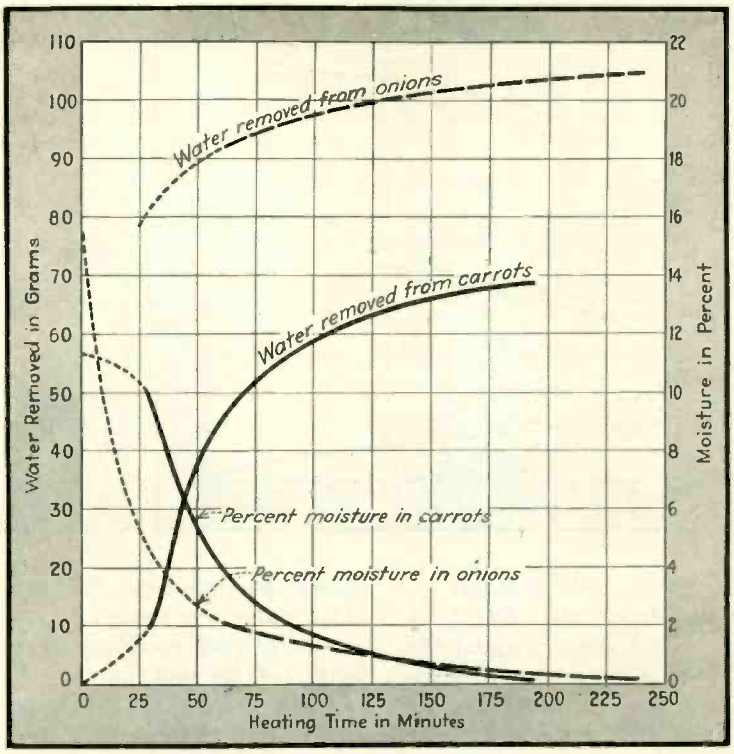
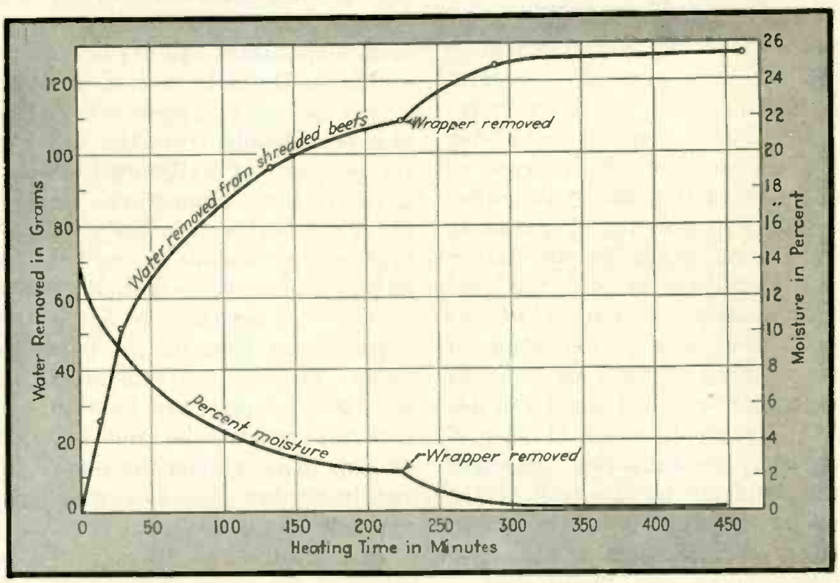


FIG. 1 (above)—Graph showing the amount of water removed from carrot shreds (solid curves) and onion flakes (dash-dash curves) wrapped in Kraft paper, during electronic dehydration. A vacuum was maintained throughout all runs, with vacuum only (no heat) for the initial dotted portion of each curve

FIG. 2 (below)—Curce of amount of water removed from shredded beets indicates that removal of the wrapping paper accelerates dehydration. Other conditions were the same as those for carrot shreds and onion flakes. The r-f power was applied intermittently in all experiments to prevent overheating



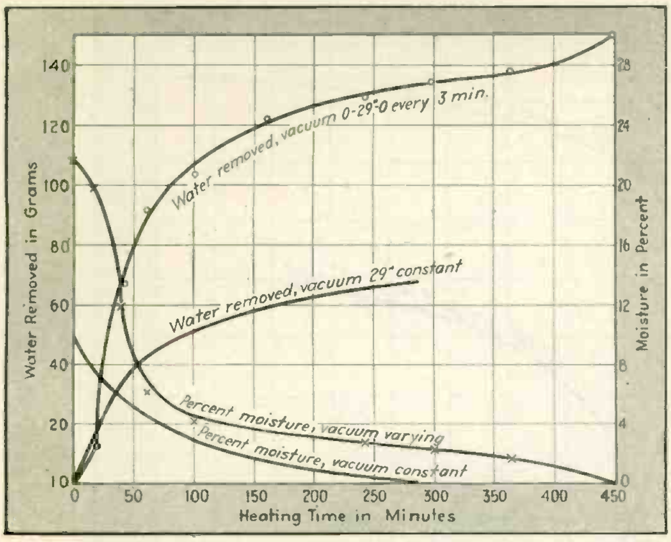
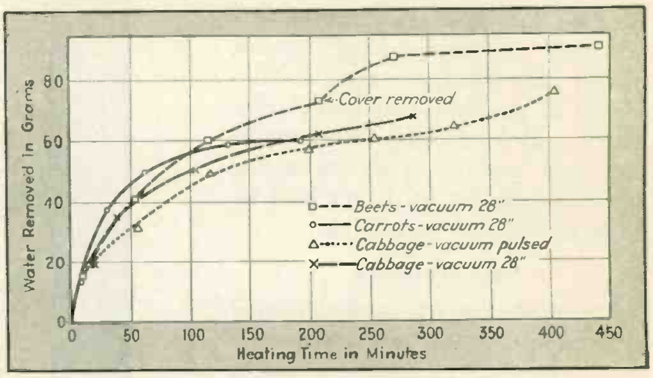


FIG. 3 (left)—Curves of the dehydration of cabbage flakes with periodic variation of the degree of vacuum, compared with those obtained with a constant vacuum

FIG. 4 (below)—Combined dehydration curves, after correction to a common reference point, indicate that commercial processing of common foods may require a little adjustment of the equipment



food samples wrapped in Kraft paper. It was found that the block would retain its shape without the paper wrapping, but as dehydration progressed, the compressed food shrunk inside its paper wrapping so as to be separated from it by approximately $\frac{1}{16}$ in. on all sides. Later experiments were carried out on compressed food blocks without wrapping. Such a procedure would have obvious advantages for dedydration on a commercial scale.

General Observations

Except for the initial warm-up period of approximately five minutes during which the temperature of the samples went up to 120 deg F in the case of the carrots or 140 deg F in the case of the other vegetables, it was found necessary to apply r-f power to the fixture only intermittently and for only approximately 10 percent of the time. There was no indication of water coming off the food until the temperature reached about 110 deg F. At temperatures of 110 deg F and over, condensation appeared quite suddenly on the wall of the bell jar and continued to collect during the time that radio-frequency power was maintained.

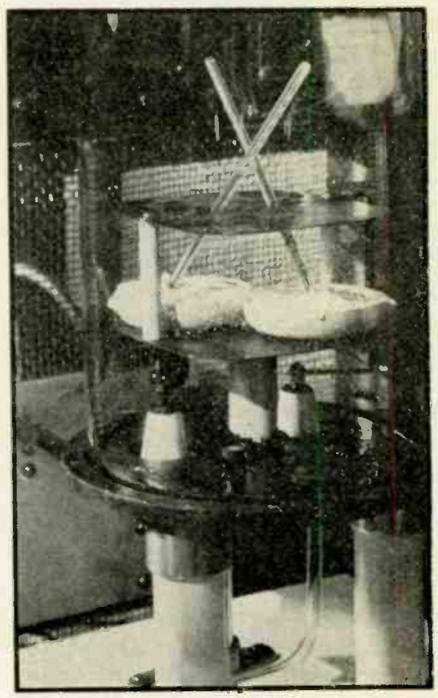
During the periods when the r-f power was turned off to prevent exceeding safe temperature in the food, condensation on the glass ceased. From this it was apparent that rapid dehydration depended directly upon the expenditure of r-f energy in the food. After dehydration had progressed for approximately 60 minutes, the rate at which water was being released was too low to give visual condensation on the bell jar wall.

It was noted that the temperature of the various packages differed considerably during the early part of a dehydration run. The packages of highest water content ran the hottest. The process turned out to be self-compensating in that the packages with the highest moisture content dehydrated most rapidly, so that before the end of the run all packages had reached a common temperature and dryness level.

During the dehydration process, it was necessary to remove the samples periodically from the bell jar for purposes of weighing to determine the loss of moisture. During the weighing periods the temperature of the samples in the heating fixture decreased, so that additional energy was required to bring the temperature back to its previous value. The loss of temperature in the food samples and heating fixture was estimated as imposing a 50 percent penalty upon the r-f power requirements; this loss would be saved in any commercial process.

It was observed that the input power to the plate of the oscillator increased slightly when moisture started coming off during the early part of the dehydration run. After having risen, it remained substantially constant until the food was quite dry and moisture on the bell jar wall had disappeared.

The curves of Fig. 1 show the amount of water removed from carrots and from onions, as well as the percentage of moisture which remained in these two types of compressed food for various periods of dehydration. The temperature of the carrots was not allowed to exceed 120 deg F and the Kraft paper was not disturbed during the first 90 minutes. In the case of onions, the temperature was not allowed to exceed 145 deg F. In both cases a vacuum of 29 in. of mercury was maintained. The water content was reduced to one percent in both cases after approximately 125 minutes of



Early experiments in food dehydration by electronic means were made on powdered whole milk in laboratory dishes operation. The amount of r-f energy required to remove one pound of water from the compressed carrots was 1.15 kwh, whereas for the compressed onions the energy was 1.62 kwh.

The curves of Fig. 2 show the same data taken for compressed shredded beets. The wrapping paper was removed after 225 minutes of treatment, after which a very rapid acceleration of dehydration was accomplished. It was evident that the paper wrapping impeded the process of dehydration and that for commercial operation paper wrapping is inadvisable. The test data obtained with the use of wrapping paper for part of the test period gives clear indication that the conclusions arrived at are definitely on the conservative side.

Effect of Vacuum Variation

The curves of Fig. 3 were taken to ascertain whether or not any beneficial dehydration effect might be obtained by periodic variation of the degree of vacuum. Although the two sets of curves appear to be of quite different shape, the original moisture content was 10 percent in one case and 21.5 percent in the other case. When the latter curve is corrected to apply for an initial condition of 10 percent moisture content, the curves practically coincide indicating no beneficial result from vacuum fluctuation.

After being readjusted to a common reference point of 10 percent moisture content, the sets of curves of Fig. 1, 2 and 3 were replotted as shown in Fig. 4. This data seems to indicate that the dehydration rate of the various compressed foods treated with r-f energy is substantially the same. From this it may be concluded that very little, if any, adjustment of the r-f equipment will be needed for foods of the common types and forms.

Conclusions

On the basis of laboratory experiments as described, the following conclusions are justified:

(1) With the electronic heating process, compressed food can be dehydrated to a water content of as little as one percent without case-hardening or burning of the food product.

(2) The food is dehydrated about ten times as rapidly as with conventional oven methods.

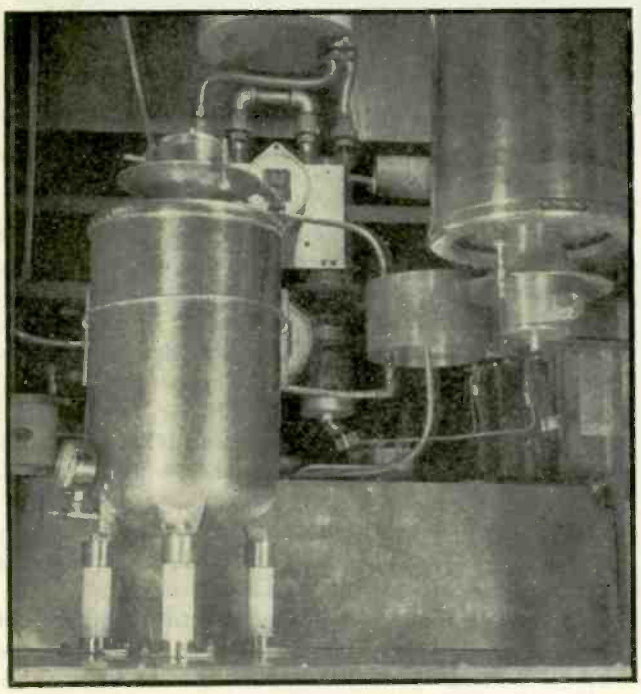
(3) Even with the small amount of r-f energy used, the rate of internal heating was so rapid that energy was required only 10 percent of the time in order to maintain a temperature of 140 deg F in the compressed food after the initial warm-up.

(4) The r-f power required was less than 100 watts per pound of compressed food treated. This figure is taken from the relatively small laboratory food load and is probably even higher than would be required for loads of commercial size.

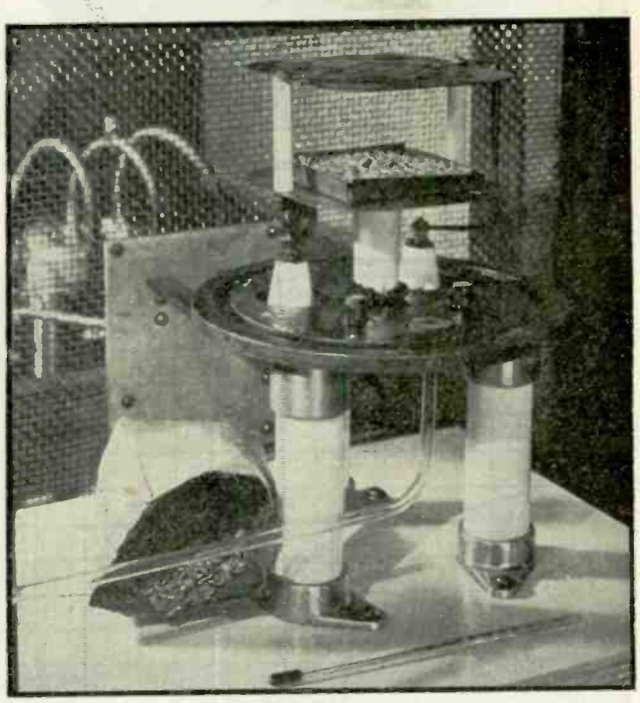
(5) The electrical energy cost of the r-f treatment is low. It appears that one kwh per pound of water removed is a reasonable and safe figure for commercial use. At commercial power rates of one cent per kwh, the cost of r-f energy for the dehydration of food becomes one cent per pound of water removed.

(6) It is preferable to treat the compressed foods in the r-f vacuum process before it is packaged. This not only removes the water, but does so in the absence of oxidizing air. It is desirable that the food be compressed edgewise into the block so that flakes lay parallel to the minimum dimension and thus facilitate uniform and relatively free escape of water vapor.

(7) The experimental results to date establish the fact that the process is decidedly promising for commercial use.



Internal view of the 60-kw experimental model of the "Megatherm" electronic heating unit used to supply r-f energy at approximately 29 Mc to the food samples



Experiments in roasting coffee were made with this simple tray arrangement. The "Megatherm" unit was originally developed by Federal Telephone and Radio Corp. for induction heating

Modifying Radio Equipment for MILITARY

In addition to obvious mechanical changes, some circuit re-design is usually necessary if gear originally developed for commercial use is to meet the special requirements of the services. Such modifications are discussed here, using a typical marine radio telephone as an example

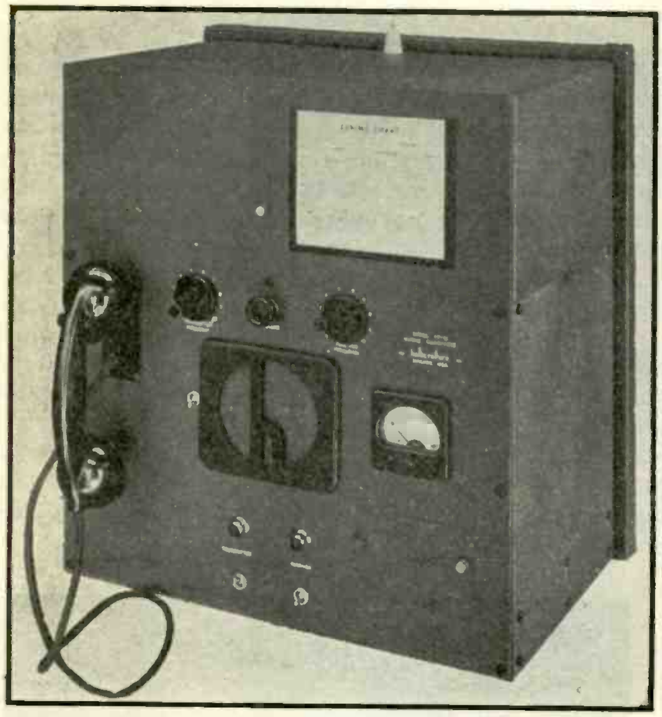


FIG. 1—Hallicrafters marine radio telephone model HT-12, designed before the war for commercial use

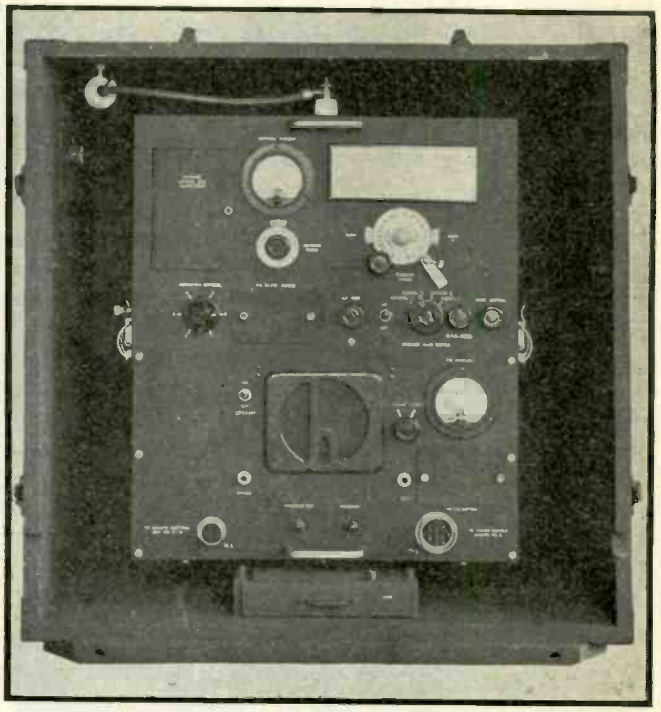


FIG. 2—Military model SCR-543, a re-design of the HT-12 for fixed and mobile net operations

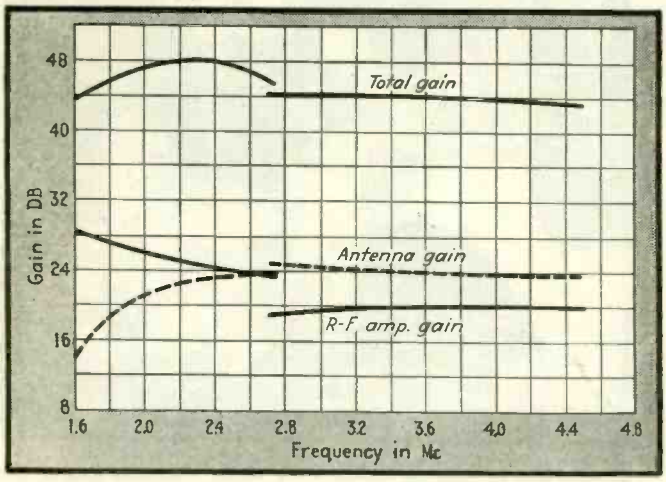


FIG. 3—Graphs showing r-f voltage gain of the receiver, obtained by using iron-core inductances throughout

IN MODIFYING commercial radio equipment for military use many problems must be solved. The obvious changes in mechanical construction, such as more rugged mountings, increase in mechanical strength to eliminate breakage and the standardization of controls are the first consideration. Of greater interest to the radio engineer, however, are the circuit changes which are essential if the equipment is to successfully fulfill the requirements of the services.

One example of successful modification is the conversion of the Hallicrafters HT-12 marine radio telephone in Fig. 1 to the SCR-543 in Fig. 2.

The SCR-543 is used for net operation where one station may be a few hundred yards away and another many miles distant, and it must work satisfactorily either as a fixed station or while moving in a truck or command car. It is desirable that the receiver be as automatic in operation as possible.

APPLICATIONS

By C. T. READ
Engineering Department
The Hallicrafters Company
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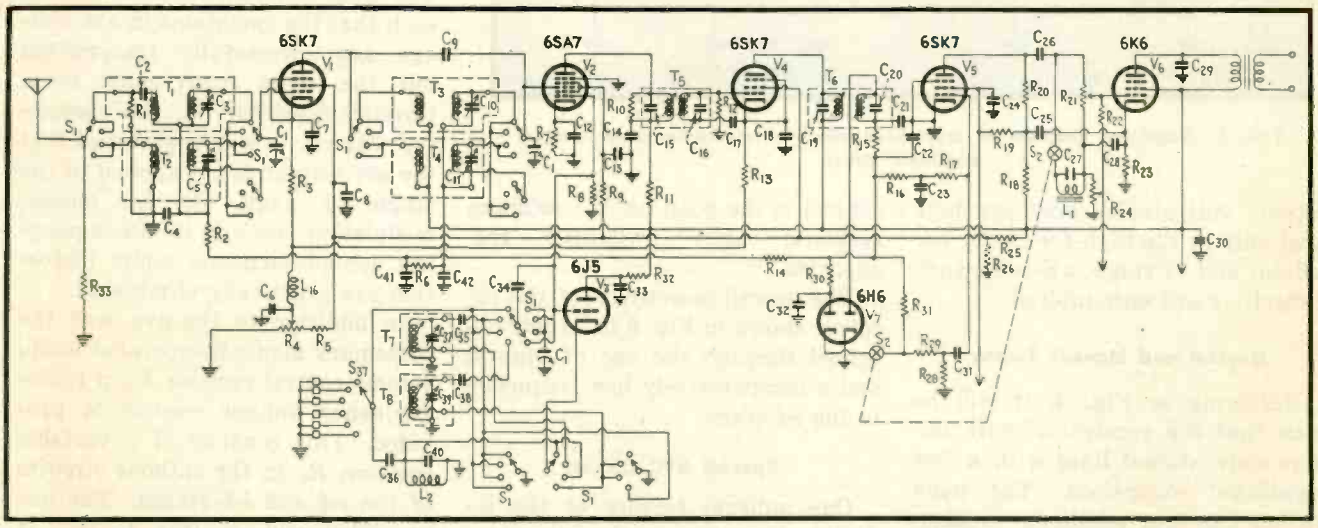

FIG. 4—Circuit diagram of receiver portion of the SCR-543, a two-band design which is crystal controlled on six pre-determined frequencies and may also be manually tuned

C_1—Variable, ganged
C_2—0.006 μf, 300 v, mica
C_3—6-25 μμf, variable
C_4—0.001 μf, 500 v, silv. mica
C_5—6-25 μμf, variable
C_6—0.05 μf, 400 v, paper
C_7—0.02 μf, 400 v, paper
C_8—0.1 μf, 400 v, paper
C_9—2.9 μμf, 300 v, mica
C_{10}—6-25 μμf, variable
C_{11}—6-25 μμf, variable
C_{12}—0.05 μf, 400 v, paper
C_{13}—0.02 μf, 400 v, paper
C_{14}—0.02 μf, 600 v, paper
C_{15}—200 μμf, 500 v, silv. mica
C_{16}—200 μμf, 500 v, silv. mica
C_{17}—0.02 μf, 400 v, paper
C_{18}—0.02 μf, 400 v, paper
C_{19}—200 μμf, 500 v, silv. mica
C_{20}—200 μμf, 500 v, silv. mica
C_{21}—50 μμf, 500 v, mica
C_{22}—50 μμf, 500 v, mica
C_{23}—0.05 μf, 400 v, paper
C_{24}—0.1 μf, 400 v, paper
C_{25}—0.05 μf, 600 v, paper
C_{26}—0.006 μf, 600 v, paper
C_{27}—0.007 μf, 400 v, paper
C_{28}—0.1 μf, 400 v, paper
C_{29}—0.002 μf, 2500 v, mica
C_{30}—0.05 μf, 600 v, paper
C_{31}—0.002 μf, 600 v, paper
C_{32}—0.05 μf, 400 v, paper
C_{33}—0.02 μf, 600 v, paper
C_{34}—25 μμf, 500 v, silv. mica
C_{35}—380 μμf, 300 v, silv. mica
C_{36}—100 μμf, 500 v, silv. mica
C_{37}—6-25 μμf, variable
C_{38}—500 μμf, 500 v, silv. mica
C_{39}—6-25 μμf, variable
C_{40}—100 μμf, 500 v, silv. mica
C_{41}—0.05 μf, 400 v, paper
C_{42}—0.0015 μf, 500 v, silv. mica
L_1—Reactor, 3.3 h
L_2—R-F choke, 1 mh
L_{16}—R-F choke, 1 mh
R_1—1 megohm, ½ w
R_2—15,000 ohms, ½ w
R_3—330 ohms, ½ w
R_4—10,000 ohm pot.
R_5—27,000 ohms, 1 w
R_6—15,000 ohms, ½ w
R_7—390 ohms, ½ w
R_8—47,000 ohms, ½ w
R_9—330 ohms, ½ w
R_{10}—1 megohm, ½ w
R_{11}—1,000 ohms, ½ w
R_{12}—1 megohm, ½ w
R_{13}—330 ohms, ½ w
R_{14}—1 megohm, ½ w
R_{15}—47,000 ohms, ½ w
R_{16}—2.2 megohms, ½ w
R_{17}—4.7 megohms, ½ w
R_{18}—33,000 ohms, ½ w
R_{19}—1 megohm, ½ w
R_{20}—220,000 ohms, ½ w
R_{21}—500,000 ohm pot.
R_{22}—2.2 megohms, ½ w
R_{23}—470 ohms, 2 w
R_{24}—470,000 ohms, ½ w
R_{25}—10,000 ohms, 10 w
R_{26}—47,000 ohms, 1 w
R_{28}—68,000 ohms, ½ w
R_{29}—100,000 ohms, ½ w
R_{30}—1 megohm, ½ w
R_{31}—100,000 ohms, ½ w
R_{32}—10,000 ohms, 2 w
R_{33}—1 megohm, 2 w
T_1—R-F trans., 1680-2750 kc
T_2—R-F trans., 2700-4450 kc
T_3—R-F trans., 1680-2750 kc
T_4—R-F trans., 2700-4450 kc
T_5—I-F trans., 385 kc
T_6—I-F trans., 385 kc
T_7—Osc. ind., 2065-3135 kc
T_8—Osc. ind., 3085-4835 kc

It must tune to pre-determined channels with no possibility of being off frequency; it must have high gain and low noise level in order to work well with a short whip antenna and it must receive all stations in the net with nearly equal volume. (Details of receiver re-design were the particular responsibility of Mr. Lee Stann.)

High-Gain Receiver R-F Coils

The transmitter and receiver are built on one chassis and have a common channel-selector switch. Both are crystal-controlled on six pre-determined frequencies and, in addition, the receiver may be tuned manually.

The frequency range of the receiver is comparatively narrow, all operating channels lying between 1500 and 5000 kc. It was possible, therefore, to secure high gain by the use of iron-core r-f coils throughout, keeping shunt tuning capacitances as small as possible. Iron-core inductances of the type used have Q values of the order of 200, whereas comparable air-core coils show somewhat more than half that value.

In order to keep the ratio of inductance-to-capacitance as high as practical the tuning range was divided into two bands. The voltage gain due to transformer action in these high-Q iron-core inductances is shown in Fig. 3. Note that over the greater part of the tuning range the gain secured through the antenna coils alone is slightly higher than the gain through the 6SK7 r-f stage and its associated coils.

In early experimental models an effort was made to use adjustable iron cores throughout, which would eliminate the need for the usual variable trimmer capacitors. The movable cores changed the self-inductance of the coils satisfactorily but they also changed the mutual inductance between primary and secondary and it was impossible to keep the coupling at a value suitable for this particular appli-

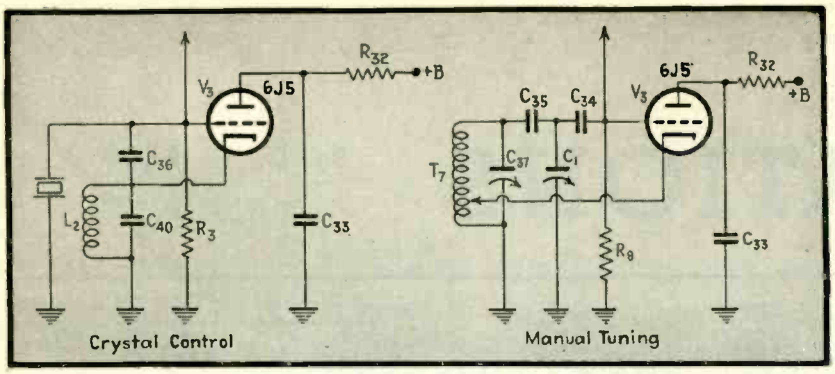

FIG. 5—Simplified diagram of crystal-controlled or manually-tuned receiver oscillator circuit

cation. Adjustable cores are now used only in the high-frequency oscillator and i-f stage, where no such difficulties are encountered.

Crystal and Manual Tuning

Referring to Fig. 4, it will be seen that the receiver circuit follows conventional lines with a few significant exceptions. The band switch has four positions—a manually-operated and a crystal-controlled position for each of the two bands. The selection of the proper crystal is accomplished by a master-operating channel-switch which also connects the crystal for the transmitter. As an intermediate frequency of 385 kc is used, the receiver-control crystal always differs from the transmitter crystal by that amount. (In the service for which this equipment was designed, transmission and reception are customarily on the same frequency.)

When the receiver is manually tuned the oscillator functions in the usual manner, the plate being at ground potential for r.f. and the output being taken from the grid. Crystal operation is similar except that feedback is obtained by means of an r-f voltage divider consisting of capacitors C_{36} and C_{40} shunted across the crystal. The r-f choke L_2 is merely a d-c return for the cathode. The voltage divider performs essentially the same function as the tap on the inductance T_7 or T_8, used with manual operation. See Fig. 5.

It will be noted that crystal control of the high-frequency oscillator does not in any way tune the r-f input of the receiver. In practice this is not serious. The tuning of the r-f and detector stages is not overly critical and operators are instructed to turn the manual-tuning control to the position of maximum response after switching frequencies.

The overall selectivity of the receiver shown in Fig. 6 is largely obtained through the use of high Q and a comparatively low frequency in the i-f stage.

Special AVC Circuit

One unusual feature of the redesigned receiver is the exceptionally flat avc curve. It was desirable that the receiver be capable of reception at full sensitivity for weak signals without blasting or excess volume from nearby transmitters operating on the same channel. In the SCR-543 this result was obtained by the introduction of avc voltage in the grid circuit of the first audio stage. With this method it is necessary to use a remote cutoff tube such as the 6SK7. Figure 7 shows the results obtained in this case. Note that an increase from 100 to 100,000 microvolts input causes an output rise of only 1.5 db.

The avc voltage is applied to the grid of the audio tube through a filter network consisting of resistors R_{16} and R_{17} and capacitor C_{28}. The time constant of this filter is such that the variations in avc voltage are successfully transmitted but the audio input must come through capacitor C_{31}, the customary channel. It will be observed that the avc voltage is not applied to the single i-f stage. By this means, modulation rise and its accompanying second-harmonic audio distortion are practically eliminated.

In addition to the avc, and the customary manually-operated audio volume control resistor R_{21}, a radio-frequency volume control is provided. This consists of a variable resistor, R_4, in the cathode circuits of the r-f and i-f stages. The ungrounded end of this control is attached to the screen-voltage supply though resistor R_5. Small variations in cathode current have very little effect when this arrangement is used, as R_4 and R_5 operate as a voltage divider across the screen supply and maintain a steady positive potential on the r-f and i-f cathodes. This arrangement also permits the use of a much lower resistance in R_4 than would be possible if it functioned as a straight

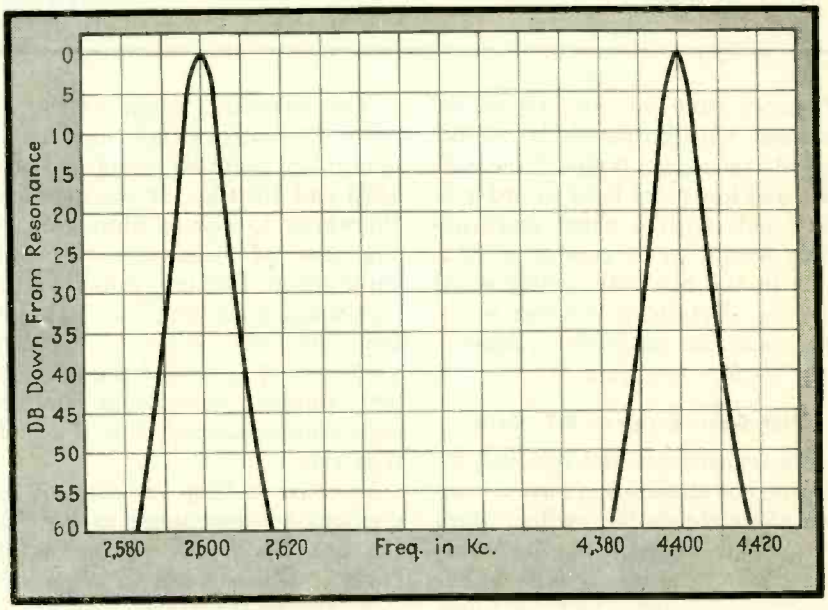

FIG. 6—Selectivity of the two-band receiver in the SCR-543 unit

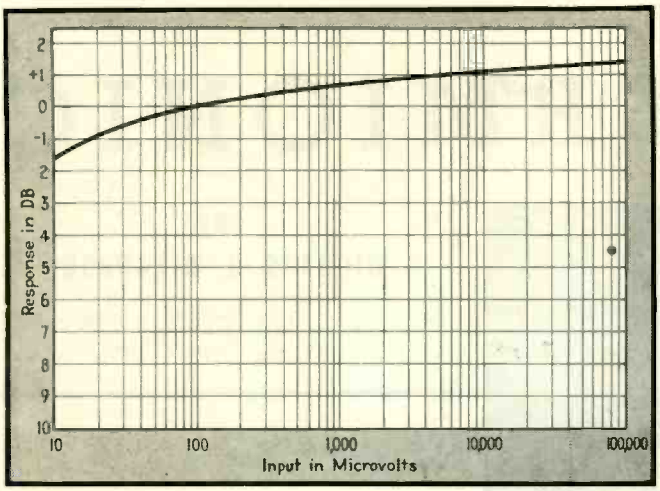

FIG. 7—Curve illustrating avc action of the military receiver

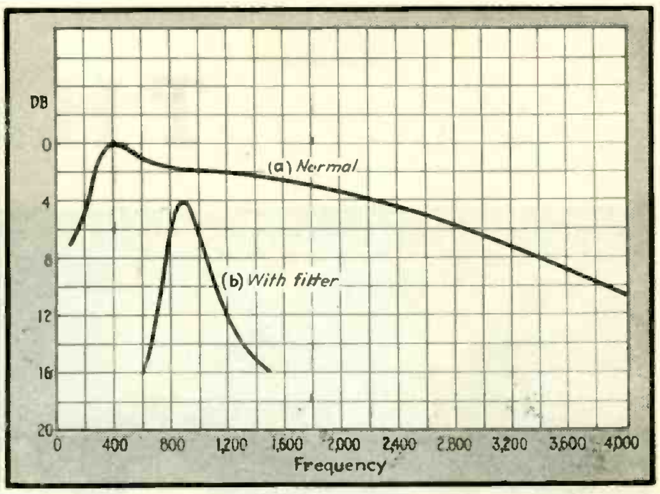

FIG. 8—Receiver audio fidelity, with and without an a-f filter

dropping resistor, thus reducing noise when the control is operated.

Noise-Limiter, A-F Filter

The audio system of the receiver was designed to give high intelligibility on the voice frequencies and at the same time eliminate all unnecessary noise. Curve (a) of Fig. 8 shows the audio response of the receiver in normal operation. When receiving conditions become exceptionally difficult an additional noise limiter and peaked audio filter may be used. Switch S_2 connects a diode clipper circuit in tube V_7 and shunts a parallel resonant circuit consisting of C_{27} and L_1 across audio volume control R_{21}. The audio filter circuit is broadly peaked at 900 cps and has approximately the same effect on phone reception as the "broad" position of a crystal filter circuit. See curve (b) of Fig. 8.

Figure 9 is a simplified schematic diagram of the detector, avc, and noise-limiter circuits. The noise limiter, of somewhat unusual arrangement, is entirely automatic in operation. It uses one of the diodes in the 6H6 and biases the plate negative with respect to the cathode by connecting it to the avc voltage through resistor R_{30}. Capacitor C_{32} and resistor R_{30} have a time constant of 0.05 second, and thus the bias can adjust itself to normal changes of avc and audio voltage but is unable to follow pulses of shorter duration.

On noise peaks the cathode of the noise-limiter diode swings negative with respect to the plate and the pulse is conducted to ground through the diode and capacitor C_{32}, while speech quality is only slightly impaired.

One of the requirements in the construction of the SCR-543 was that all electrolytic capacitors operating above a certain voltage should be of the plug-in type for easy replacement. Due to compact design there was no room available for such a capacitor in the cathode circuit of the final amplifier and some other means of by-pass had to be used. For this reason C_{28} (Fig. 4) is a paper capacitor of 0.1 μf capacitance. Connected in the manner shown it is very nearly as effective in suppressing degeneration as the customary 25 to 50 μf capacitor connected directly to ground.

Capacitor C_{25} is essential in this circuit and has approximately ten times the capacitance of C_{26}, the audio coupling capacitor. Resistor R_{24} is approximately 0.5 megohm. This circuit successfully prevents the out-of-phase audio component developed across resistor R_{23} from appearing on the grid; that part of the audio voltage is lost, however, as far as final output is concerned.

A word should be said about some of the special operating circuits. In common with most military radio equipment, the transmitter-receiver is designed for remote control and push-to-talk operation and can be modulated by means of a hand-set and remote control unit. A relay system operated from the hand-set or microphone provides antenna switching, turns the transmitter on or off and disables the receiver by grounding the screen of the first audio amplifier tube when the transmitter is in use.

When the station is being remotely controlled the operator in charge of the equipment can monitor transmission by means of a special side-tone circuit which permits a small portion of the modulator output to feed the grid of the receiver's final audio amplifier tube through resistor R_{22}.

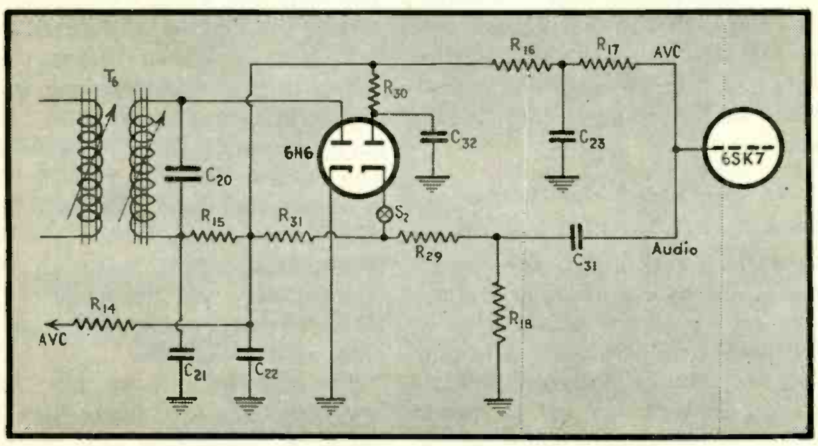

FIG. 9—Simplified diagram of detector, avc and noise-limiter circuits

THERMIONIC

By

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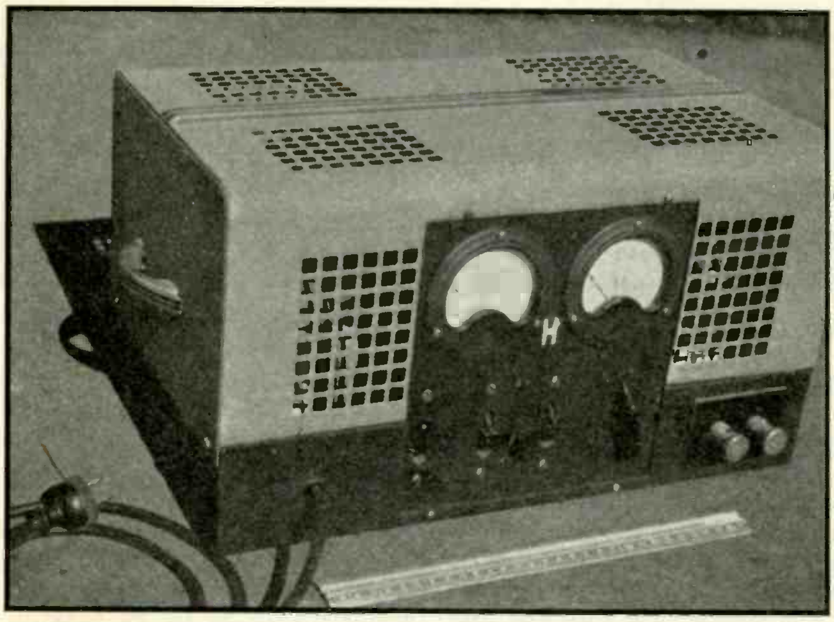


High-current gas-type full-wave rectifier assembled in well-ventilated metal cabinet, and rated to deliver up to 9 amp at 90 v. D-C output terminals are at right on panel. The meters are connected to read output voltage and current. Total weight is 39 lb—much less than an M-G set having equal capacity

THE PURPOSE of this article is to give details and performance characteristics of five rectifier tube circuits which have proven satisfactory in use over a period of several years. It is believed that this treatment is particularly appropriate at the present time because motor-generators and B batteries are expensive, scarce, and heavy compared to electronic circuits which can often be used to replace them.

The electronic circuits proposed are mainly adaptations of well-known theory[1, 2, 3] but emphasis is placed on four points; (1) the use of inexpensive tubes and components; (2) the attainment of relatively high current output; (3) light-weight construction, making for portability; (4) operation from 115-v, 60-cps source of power.

One power supply employs four argon charger-type tubes in a bridge circuit whose input connects directly to the a-c line, and will supply 9 amp at 90 v d.c. It can supply d-c equipment having 110 v nominal rating, and is particularly suited for operation of arc-lamps, electrolysis, etc. Three transformerless B supplies include a half-wave rectifier connecting directly to the a-c line and delivering 400 ma at 90 v; a half-wave doubler providing one common connection between a-c line and d-c load and delivering 130 ma at 150 v; a full-wave doubler giving 200 ma at 180 v. Finally, an eight-tube bridge circuit is represented that has proved satisfactory for obtaining 2000 v d.c. at 250 ma. It uses receiver-type tubes in an unorthodox design—a simple and economical means of supplying a cathode-ray tube.

Gas-Type High-Current Rectifier

Since a d-c arc gives about four times the light output when operated on d-c as on the same current from an a-c source it is advisable to provide d-c operation.[4] A bridge circuit originally designed to supply d.c. for a carbon arc is shown in Fig. 1. Six-ampere bulbs having high crest inverse voltage and high d-c output voltage suitable for this circuit are: Westinghouse Style No. 289416 and General Electric Cat. No. 189049. (Not all 6-ampere charger bulbs have the proper operating characteristics for this circuit).

A multiple-winding filament transformer is needed; two of the secondaries supply a single filament each (2.2 v at 18 amp), and the third feeds two filaments in parallel (2.2 v at 36 amp). The a-c line goes directly to the tubes without a transformer. Note that the d-c output cannot be grounded.

To start this circuit, the main switch is closed first. The load switch is closed after the filaments are up to operating temperature. This procedure is necessary because gas-filled tubes with oxide-coated filaments must not have plate voltage applied when cold. In the completed unit shown in the photograph, a "mark time" switch is employed; one SPST switch closes immediately, and a second SPST switch closes after a 45-sec interval.

Two fuses are shown in Fig. 1. The load fuse should be chosen to permit the desired load current to flow (not more than 12 amp) and the main fuse should be somewhat higher in rating since it must also supply current for the filaments. The purpose of using two fuses is to be sure that an overload will blow only the load fuse, while the filaments still remain heated by the transformer. An inexpensive bimetal circuit breaker was used in place of the load fuse.

The smoothing choke must have low resistance and fairly high inductance, considering that the current passing through it saturates

* *The assertions herein are the private ones of the writer, and are not to be construed as official or reflecting the views of the Navy Department or of the Naval service at large.*

RECTIFIER CIRCUITS

Circuit and performance data for five d-c power supplies operating from a 115-v 60-cps line: a gas-tube bridge circuit delivering 9 amp at 90 v; three transformerless B supplies having high current ratings; a simple high-voltage bridge rectifier for cathode-ray tubes

the core. The unit used has an inductance of 0.04 h at 60 cps with its core (0.0036 h without core) and a d-c resistance of 0.5 ohm, obtained with a coil having 490 turns of No. 12 B & S dcc wire. Coil dimensions are 1.63 in. inside diam, 3 in. outside diam and a length of 6 in. Core dimensions are 1.063 in. diam and a length of 18 in., obtained with 350 pieces of 0.05-in. diam soft iron wire.

A convenient advantage of rectification with this circuit is that an impedance may be placed in series with the load fuse to reduce the d-c output. This impedance effectively reduces the d-c output without wasting power, as would be the case with a series resistor. A range of inductance values ove ra 11:1 ratio may be obtained by inserting or removing the core from the choke.

Still greater flexibility of operation may be obtained through the use of two identical coils and cores. In the first coil the core is fixed for use as the d-c filter choke of Fig. 1. The second coil, arranged with a movable core, is connected in series with the load fuse as an a-c impedance. When the circuit is used to supply an arc lamp it has been found possible to put most of the reactance in the a-c side, and to use only a low resistance in the d-c part of the arc circuit.

Porcelain mogul sockets are needed for the 6-ampere bulbs. Due to the high operating temperatures of these bulbs, the use of flameproof or asbestos-covered wire is recommended for connections.

The characteristics of this gas-type high-current rectifier are shown in Fig. 2. The dashed load lines are for 8, 10, 20, and 40 ohms, while the three solid lines are for a-c input voltages of 100, 110, and 120 v. From these curves we see that with 110 v. a-c input and a load of 8 ohms, the d-c output is 10 amp and 80 v.

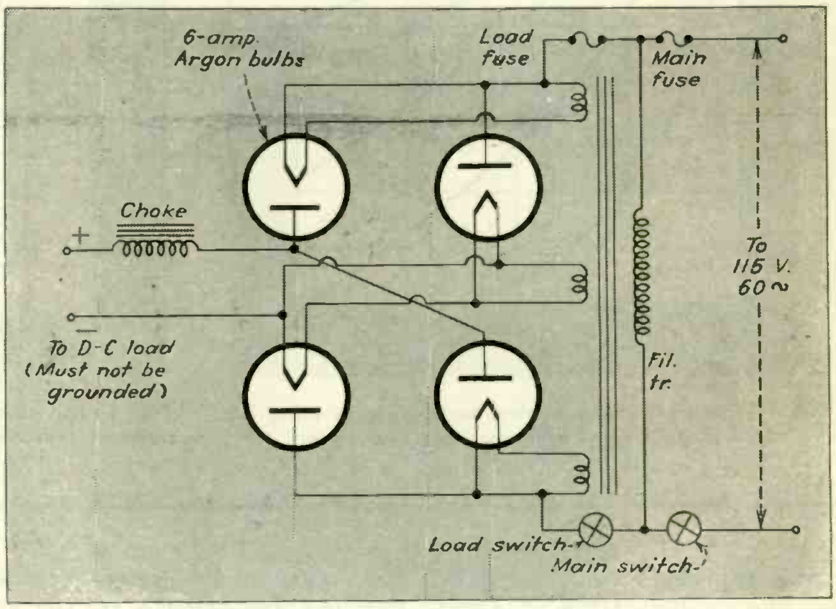
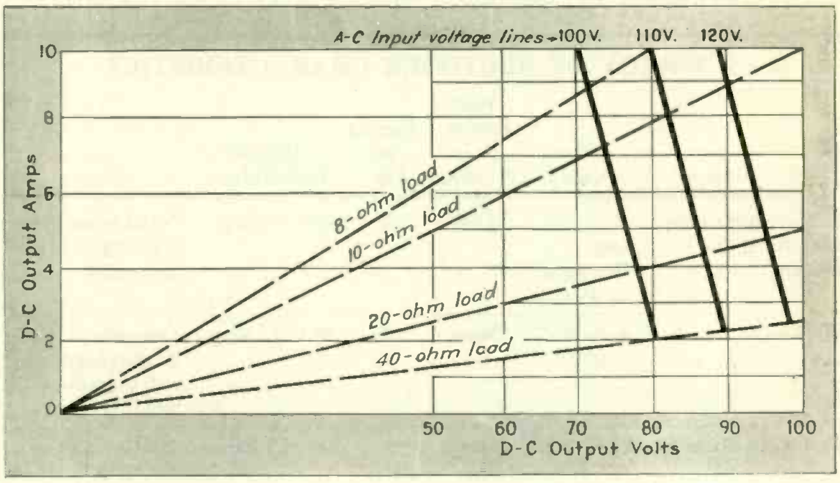


FIG. 1—Schematic diagram of high-current rectifier circuit, using four gas-type tubes to provide d-c outputs up to 9 amp at 90 v

FIG. 2—Operating characteristics of high-current rectifier circuit of Fig. 1



The total weight of the unit, including the steel cabinet, is 39 lb—about one-fifth the weight of a motor-generator of equal capacity.

Half-Wave Transformerless Circuit

Circuits using single 25Z5 and 25Z6 tubes are well known[5]. Often such circuits use a resistance in series with the heater for operation

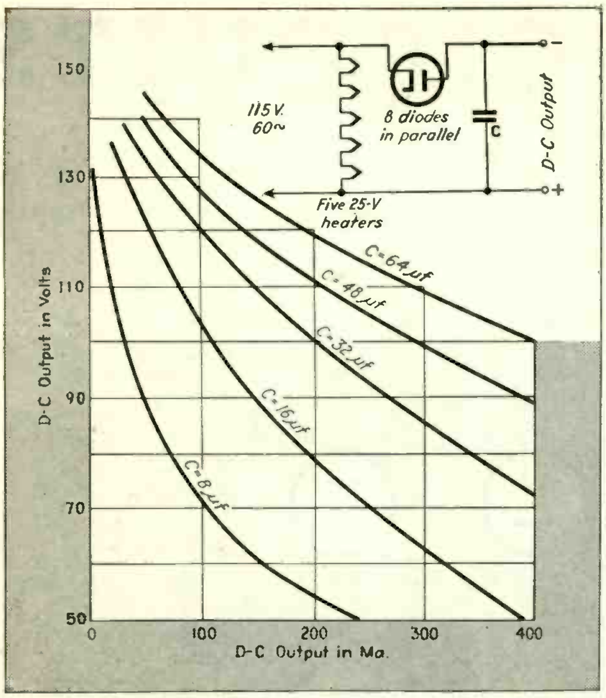


FIG. 3—Half-wave transformerless rectifier circuit using four 25Z5 or 25Z6 tubes, with operating characteristics

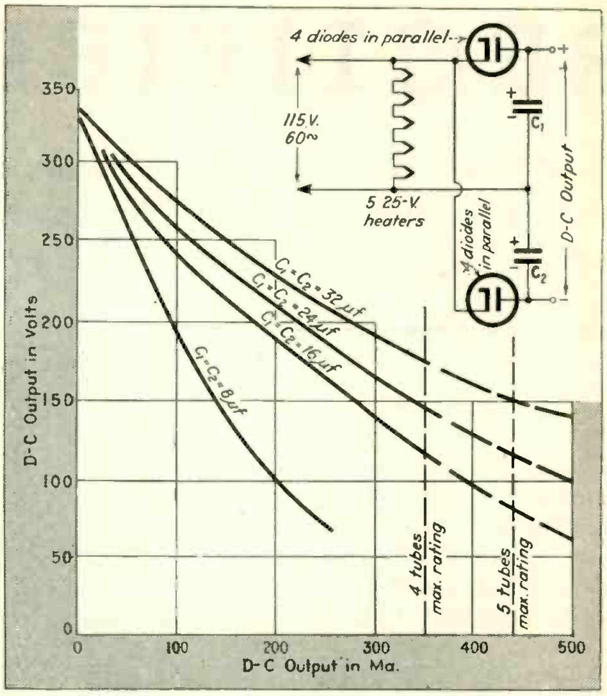


Fig. 4—Full-wave voltage-doubler rectifier circuit and performance characteristics. Output terminals cannot be grounded

directly from the 115-v line. However, the circuits of Fig. 3, 4 and 5 each use five heaters in series and therefore require no additional series resistor. Only four 25Z5 or 25Z6 tubes are used as actual rectifiers, although five heaters must be used in series across a 115-volt a-c line. Of course, one heater may be replaced by an 83-ohm resistor.

A single tube—the 117Z6GT—may also be used with these circuits. This is a two-cathode, two-plate tube with a 117-v heater element[6], requiring no series resistor on a 117-v line.

A half-wave rectifier which needs no transformers for operation from a 115-volt a-c line is shown in Fig. 3 along with its output characteristics. The d-c side of the circuit is automatically grounded with the a-c supply. For example, if the lower side of the a-c supply in Fig. 3 is grounded, the negative d-c terminal is also grounded. Note that all eight of the plates and all eight of the cathodes (2 each per tube) in Fig. 3 are connected in parallel.

Comparing the half-wave circuit of Fig. 3 with the full-wave voltage doubler circuit of Fig. 4, it will be seen that the output of the half-wave circuit is less than that of the voltage-doubler circuit, even when using the same total capacitance. The major advantage of a half-wave circuit is that its output becomes grounded whenever the a-c input is grounded. This is important for high-gain amplifiers which do not have interstage transformers, since pick-up voltages must be minimized.

SUMMARY OF RECTIFIER CHARACTERISTICS

Description	Tubes Used	Transformer Sec. Windings	Circuit in Fig.	Typical D-C Output	Notes
High-current gas-type full-wave bridge	Four 6-amp Rectigon or Tungar	3 Fil.	1	90 v, 9 amp	Neither side of d-c output can be grounded
Half-wave	Four 25Z5 or 25Z6	None	3	90 v, 0.4 amp	One side of d-c output is grounded by grounding a-c line
Full-wave doubler	Four 25Z5 or 25Z6	None	4	180 v, 0.2 amp	Neither side of d-c output can be grounded
Half-wave doubler	Four 25Z5 or 25Z6	None	5	150 v, 0.13 amp	One side of d-c output is grounded by grounding a-c line
High-voltage bridge rectifier	Eight 80	8 Fil. 1 Plate	7	2500 v, 0.25 amp	Either side of d-c output can be grounded. For 5Z3 tubes, output current is 0.45 amp

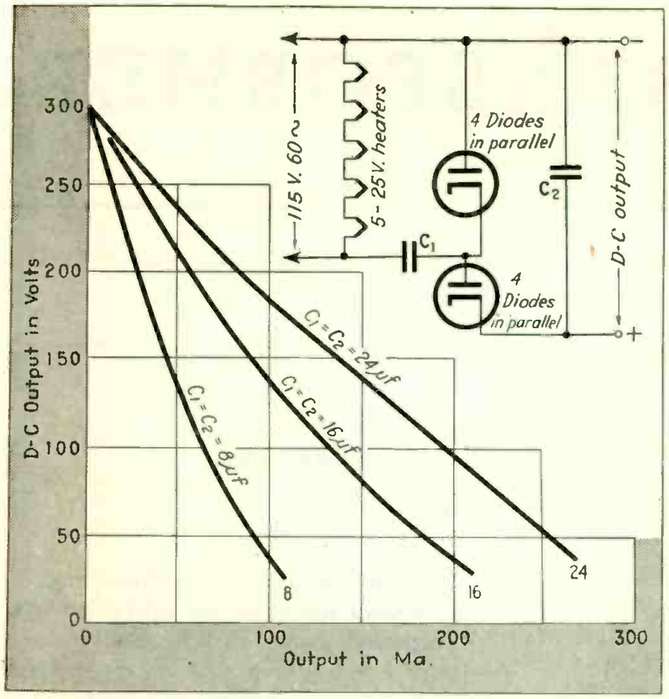


Fig. 5—Half-wave voltage-doubler rectifier circuit and performance characteristics. One side of output can be grounded

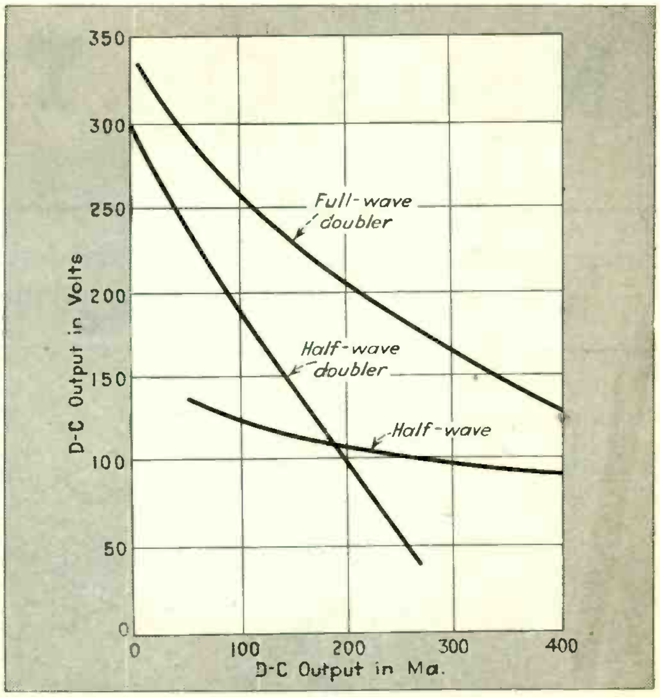


Fig. 6—Comparison of output characteristics of rectifier circuits in Fig. 3, 4, and 5

Four tubes are used in the full-wave voltage-doubler circuit[1] of Fig. 4, four cathodes and four anodes (2 tubes) being connected in parallel in each half of the circuit. As in the circuit of Fig. 3, there are five heaters rated at 25 v each in series across the 115-v a-c line, although only four tubes are connected in the rectifier-doubler.

Full-Wave Rectifier-Doubler Circuit

The capacitance marked on each curve in Fig. 4 is half the total capacitance required. For example, the 24-μf value at 100 and 500 ma means that two 24-μf capacitors are needed. Also note that the maximum output rating for 4 tubes is 350 ma.

If electrolytic capacitors are used in the circuit of Fig. 4, they must be polarized as shown. It is impossible to use a dual electrolytic of the 16-16-μf type if the negative leads are common. Such a dual capacitor can of course be used as a single 32-μf unit, in series with a similar one correctly connected.

Half-Wave Doubler Circuit

A half-wave doubler circuit[2, 7] in which one side of the a-c input is connected to one side of the d-c output is shown in Fig. 5. Capacitor C_1 is rated 150 v d.c., and preferably has a paper dielectric, but C_2 may be either a paper or electrolytic 300-v unit. For light d-c loads C_1 may be a polarized electrolytic capacitor with the negative lead connected to the a-c line. For heavy d-c loads (above about 190 ma at 110 v), the voltage on C_2 reverses, and an electrolytic is not suitable.

Comparison of Circuits

The three curves in Fig. 6 permit direct comparison of the three circuits, each of which uses a total capacitance of 48 μf, and four 25Z5 or 25Z6 tubes as rectifiers. In all cases the full-wave rectifier-doubler gives the highest output voltage and current. Of the three circuits, the half-wave doubler has the poorest regulation and the half-wave rectifier has the best regulation.

The choice between the half-wave doubler and the half-wave rectifier may be based either on the required d-c output or the regulation, considering that both have one d-c terminal at the same potential as one a-c terminal. The d-c outputs of these two circuits are equal at 190 ma, 110 v. For lower current values, the half-wave doubler permits higher voltages; for higher output currents, the better regulation of the half-wave rectifier appears advantageous in giving higher output voltage.

In general the vacuum-tube rectifiers are self-protecting to a great extent and require no preliminary heating of their cathodes, so that the circuits of Figs. 3, 4 and 5 may be connected simultaneously to the d-c loads and the a-c lines.

Eight-Tube Bridge Rectifier

An eight-tube bridge rectifier using receiving-type tubes is shown in Fig. 7. The output data for this circuit, when type 80 tubes are employed, are given in Fig. 8. A maximum output of 0.450 amp instead of 0.250 amp is possible if 5Z3 tubes are used instead of type 80 tubes. Both filament and plate transformers are needed for this circuit, and for experimental use at different voltages, a Variac supplies the plate transformer.

The filament transformer must be insulated for 5,000 volts both to ground and between the various

(Continued on page 226)

Notes On TRANSFORMER

Power transformers and filter reactors designed to minimize stray fields are described. Comparable audio types attenuate external fields about 90 db

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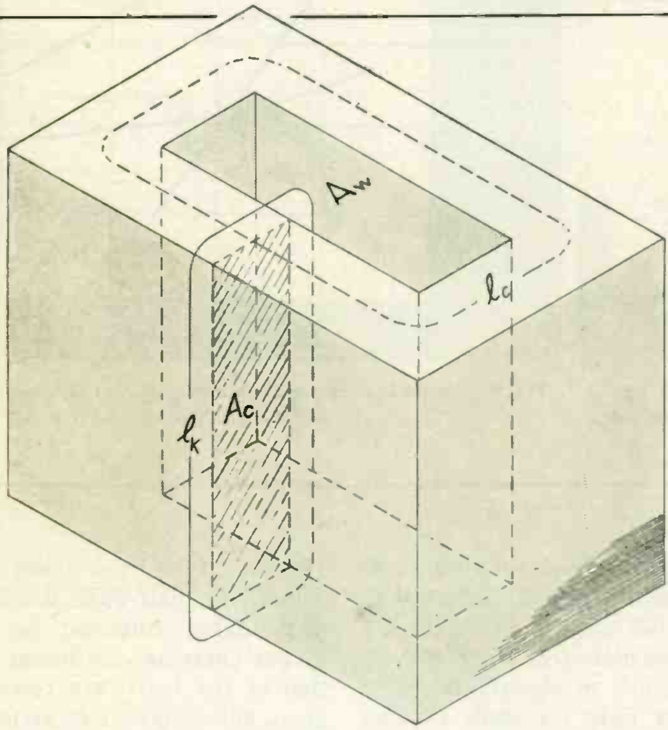


FIG. 1—Core structure of the type of power transformer discussed by the author. A_c is area of core; A_w is area of window and is equal to A_c; l_c is length of magnetic circuit; l_k is length of copper circuit and is equal to l_c

THE SOUND ENGINEER is waging a never-ending fight against extraneous noises. One of the greatest sources of noise in an amplifier is the complex field created by power transformers and filter reactors. Perhaps the most effective method of eliminating this is the reduction of fields at their source.

There are several ways of reducing, and in some instances even eliminating stray fields. For a transformer of conventional shell-type design with a given load rating, the shape and magnitude of the stray field depends on several factors, among which are the size of the transformer, the flux density at which the transformer core is operated, the geometry of the core structure, and the magnetic shielding surrounding the structure. Since the stray field increases with the size of the transformer and with increased flux density, there is an optimum size, other things being equal, which will result in the lowest stray field.

Reducing Power-Transformer Fields

In any shell-type design utilizing a single coil, the lowest stray field may still be large enough to modulate the program in adjacent audio transformers and tubes. Its influence can extend to audio transformers as much as three to four feet away, which means practically that even though the power equipment is located away from the audio components of its own channel, it may affect other channels in adjacent racks. It has been found desirable, therefore, to produce transformers designed for operation in crowded racks. These transformers are built on a core-type magnetic circuit having two coils astatically balanced, occupy less space than the conventional design, and operate at high efficiencies; that is, with low temperature rise.

Figure 1 is a sketch of the core structure around which this type of transformer is built. It can be shown that for the most efficient designs the following approximations hold:

1. The core loss in watts is equal to the copper loss in watts.
2. The mean length of the magnetic circuit is equal to the mean length of the copper circuit.
3. The cross-sectional area of the core is equal to the cross-sectional area of the window.

The geometry of the structure is such that the coils are long solenoids with their magnetic axes

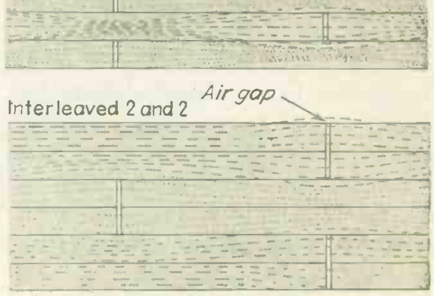


FIG. 2—Lamination joints of two types of interleaved-core assemblies

DESIGN

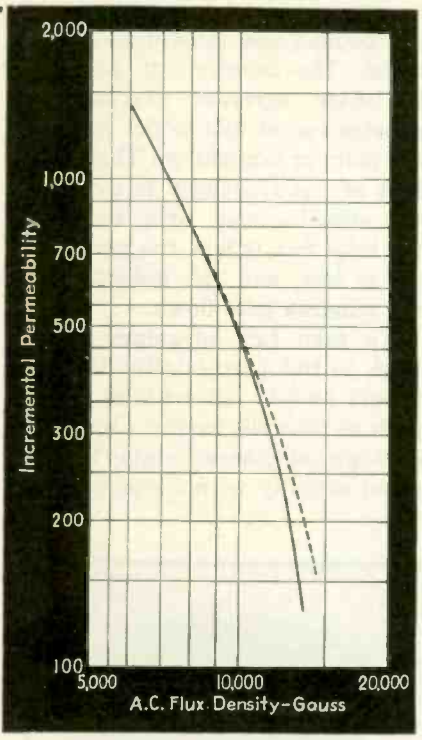


FIG. 3—Relationship between flux density and incremental permeability of total core structure of a power transformer

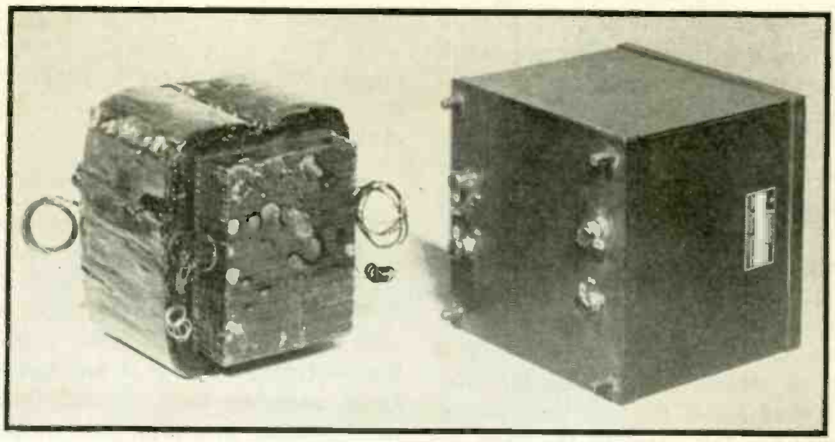


FIG. 4—Power transformer designed to provide rapid dissipation of heat, shown with and without case

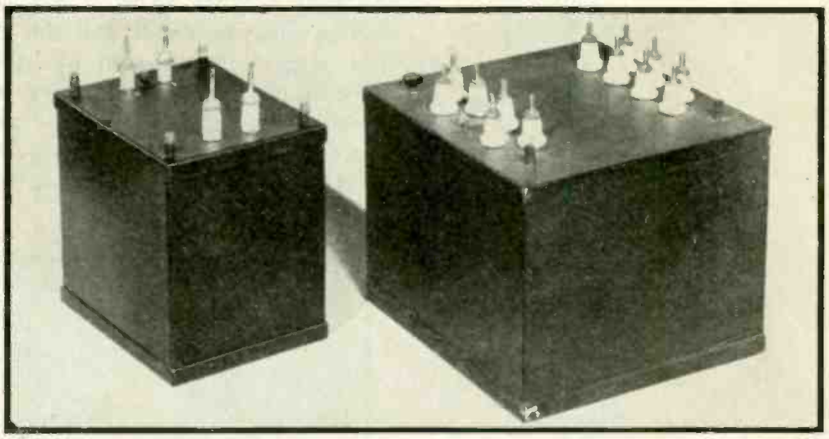


FIG. 5—Size of compact power transformer shown on left (TM-579) as compared with a conventional unit of a similar rating, on right (TW-604)

closely spaced, resulting in an almost perfect astatic balance of their fields. Measurements made on transformers built to these proportions indicate that the field is so low that moderately-shielded, low-level input transformers may be operated next to them without hum pickup.

The narrow width of the core was chosen to insure a fairly uniform flux distribution, and this flux distribution is enhanced by the method of stacking, reducing the usual areas of high flux density and resulting high loss.

In a fully interleaved core assembly (i.e. 1 and 1) as shown in Fig. 2 the reluctance of the air gap at the lamination joint causes a portion of the flux to seek a path through the adjacent laminations, raising the flux density and losses therein. Now, when the extent of the interleaving is reduced by stacking the laminations in pairs (2x2), the reluctance of the leakage path through the adjacent laminations is increased, because the length is effectively increased, forcing a greater portion of the flux to flow across the joint air-gap. The reduction of high flux density areas by this method of stacking increases the permeability of the total core structure as shown in Fig. 3, where the solid line represents the permeability of the 1 x 1 stack, and the dotted line that of the 2 x 2 stack.

Figure 4 shows a transformer built around the foregoing principles. At all points it is close to the case housing it, providing more rapid dissipation of heat to the outside air. Almost two-thirds of its coil surface is exposed. No thick-walled coil sections exist. Core heat is conducted to and radiated from the two ends of the core, which also are close to the housing.

Figure 5 illustrates the compactness of the design in comparison with a conventional unit of the same rating. Both transformers were designed to operate with the same temperature rise—less than 40 deg C. Consider particularly the comparison of the operating efficiencies, weights, and chassis space occupied:

	TM-579	*TW*-604
Volt-amperes	350	360
Efficiency	96%	92.7%
Watts dissipated	15	27.7
Weight, lbs	17½	29¼
Chassis space, sq in	23	47

Filter Reactor Design

Since their fields generally are of the most vicious type, being made up of not one but many frequencies, the companion power filter reactors were built around the same principles of design. The astatic balance is carried to the point of locating the air gap in the center of the coils where the possibility of leakage is lowest, as shown in Fig. 6. In practice, two stacks of U-shaped punchings are clamped together in the coils, with insulating spacers in the air gaps to maintain the correct gap separation.

The clamps and bolts are so located that very little magnetic flux passes through them as illustrated in Fig. 7. The removal from the magnetic circuit of this relatively high coercive force steel eliminates all the harmonics generated by the common commercial type of filter choke which is clamped together between steel frames secured by bolts passing through the core, all of which carry magnetic flux. The Q of the choke is raised appreciably so that a substantially better filtering action is obtained for a given inductance. Incidentally, audio chokes designed on these principles have shown a Q of 70 at 1,000 cycles.

Audio Transformer Improvements

The last few years have witnessed great improvements in audio transformer design. Not the least of these are due to the many kinds of core material now available. Audio transformers operate at low inductions, ranging from several thousand gausses in a high-level output transformer down to one gauss and less in low-level input and interstage transformers. The hysteresis and eddy current losses at low induction must be small, and the initial permeability should be high. Since eddy current losses vary inversely with the resistivity of the core material, and as the square of the thickness of the laminations, the core stock must also have high electrical resistivity, and must be used in thin sheets.

The presence of eddy currents in the core results in a phenomenon known as skin effect or shielding effect. This effect is merely the observed result of the loading caused by the secondary currents circulating around the individual laminations. The counter-emf generated by these currents prevents the penetration of flux to the center of the plate or lamination. This means that as the frequency is increased, the effective core area decreases, the total flux is less, the permeability is less, and the inductance of the winding goes down.

To take full advantage of the high initial permeability the core should be laid out with as short a path as possible, having a minimum of high-reluctance joints, best located actually within the windings surrounding parts of the core. It is fortunate that the requirements for small-size high-inductance transformers lay in the low-level field where the transformer has nothing to do but present to the tube grid a considerably enlarged facsimile of the input signal voltage, because it is frequently the case that high copper insertion losses are built into such a design.

The windings surrounding the core, of necessity, have distributed capacitance across themselves, between themselves and to the core and the case. These capacitances are nearly always unequal; that is, the effective capacitances across the

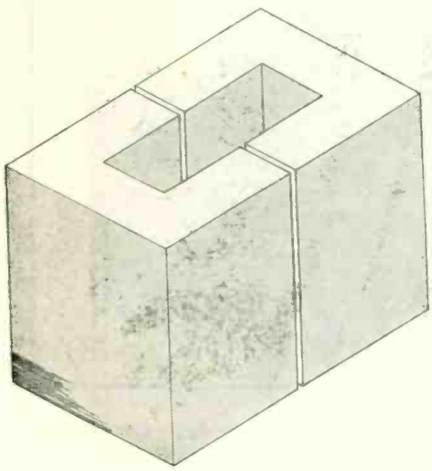


FIG. 6—To obtain minimum flux leakage, the air gap of a filter reactor is located in the center of the coils

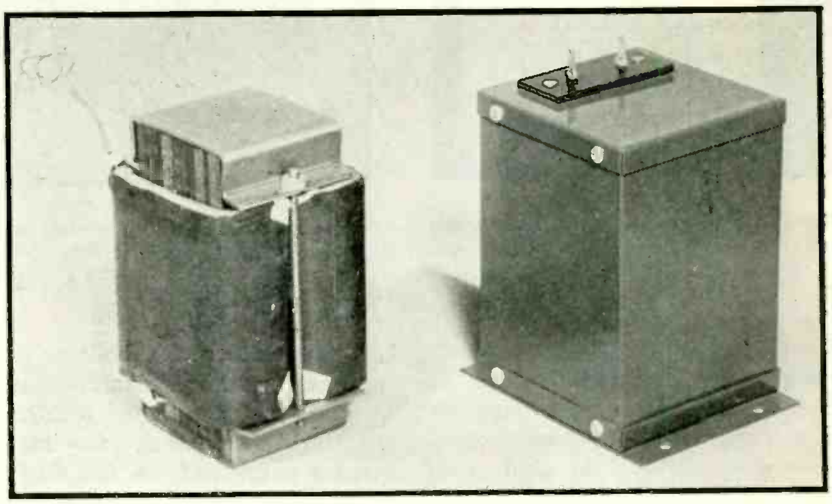


FIG. 7—A power transformer designed to eliminate harmonics generated by a filter choke clamped in the conventional manner

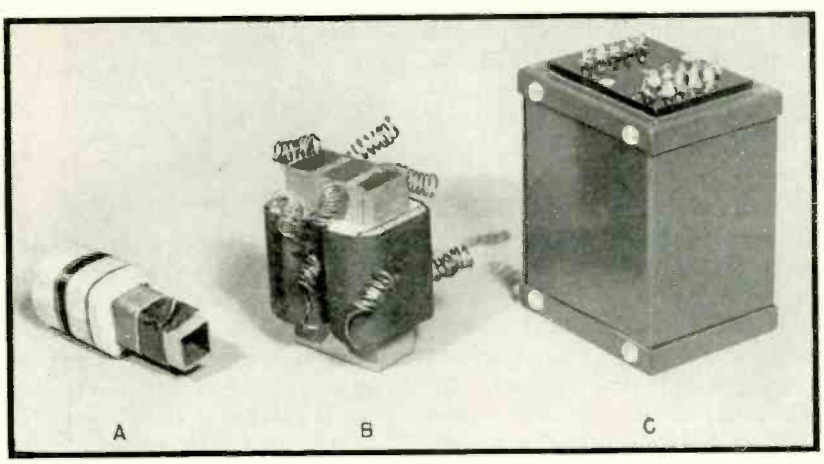


FIG. 8—A small output audio transformer designed for operation between a single-ended or push-pull tube and a line, in the range between minus 20 db and plus 20 db level

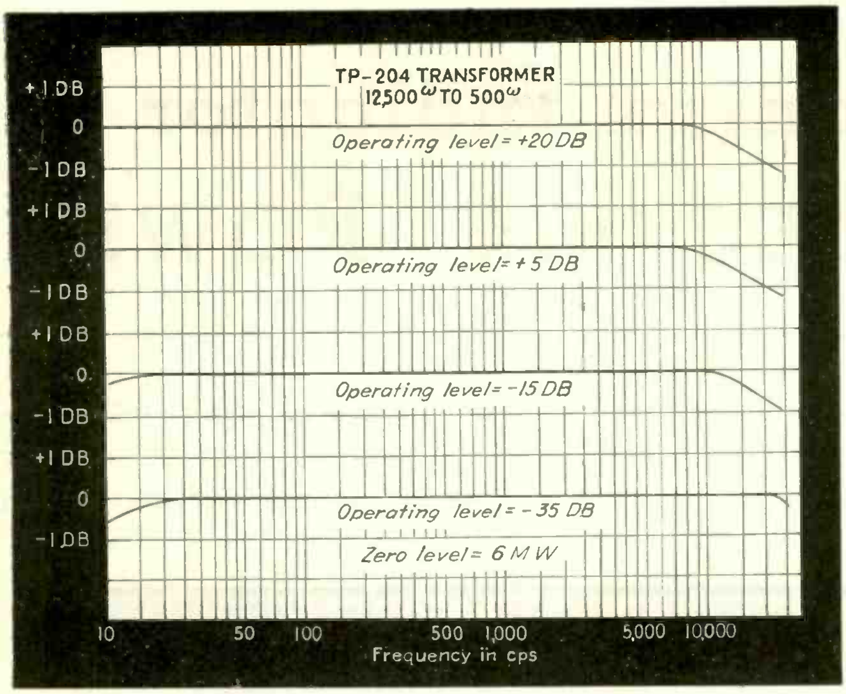


FIG. 9—Chart showing the performance of an astatically-balanced audio transformer over a wide range of operating levels

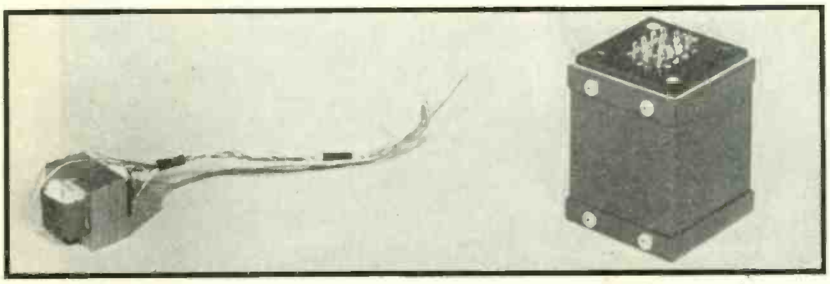


FIG. 10—A small input audio transformer designed for operation at a minus 35 db level

two ends of a coil are unlike, which in the case of a push-pull transformer will, as the frequency increases, cause increasingly unequal voltages to be impressed on the tube grids. The deviation usually is quite pronounced well below the frequency of resonance, and the point at which a measurable difference is found should be taken as the upper limit of the range which the transformer can cover.

Shielding Improves Balance

The capacitive balance between the windings can be improved or at least controlled, by the introduction of shield windings or sheets. Sometimes the shield is connected to a section of the winding; more often it is tied to ground. Frequently, windings are placed in a coil at a place where they act as shield windings because in the circuit in which they are used they are connected externally to ground.

When the shield is introduced between the primary and secondary windings and connected to ground, electrostatic shielding is also obtained, which prevents the transmission of incoming longitudinal currents past the barrier thus set up.

Since magnetic flux is not only in the core, but also linking every part of the winding, leakage links are present, causing the induction of a lesser voltage in some coils than in others with equal turns. For this reason each winding must be symmetrically located with respect to the other windings. In the case of a push-pull transformer, both secondary windings must cut the same amount of leakage flux, and the leakage flux around the start of the primary must be the same as the leakage flux around the end of the primary winding. It is this leakage flux which doesn't thread all of the windings of all of the coils that is responsible for the leakage reactance in a transformer, resulting in a drooping response at high frequency. Many transformers have had designed into them just the proper amount of leakage reactance to resonate with the high distributed capacitance across the secondary windings at a predetermined high frequency. Such a transformer will show an excellent frequency response characteristic, but will not have the same time constant for all frequencies. Neither will it reflect a constant load to the line. These faults can be only partially corrected by secondary loading, as a loss of high frequencies is sure to result.

The windings on each side of a balanced transformer must have equal resistance. In the case of a symmetrical coil arrangement this usually follows as a matter of course. However, in some designs of a special nature where one part of a coil is wound on top of another, it may be necessary to change the wire size to accomplish the desired result.

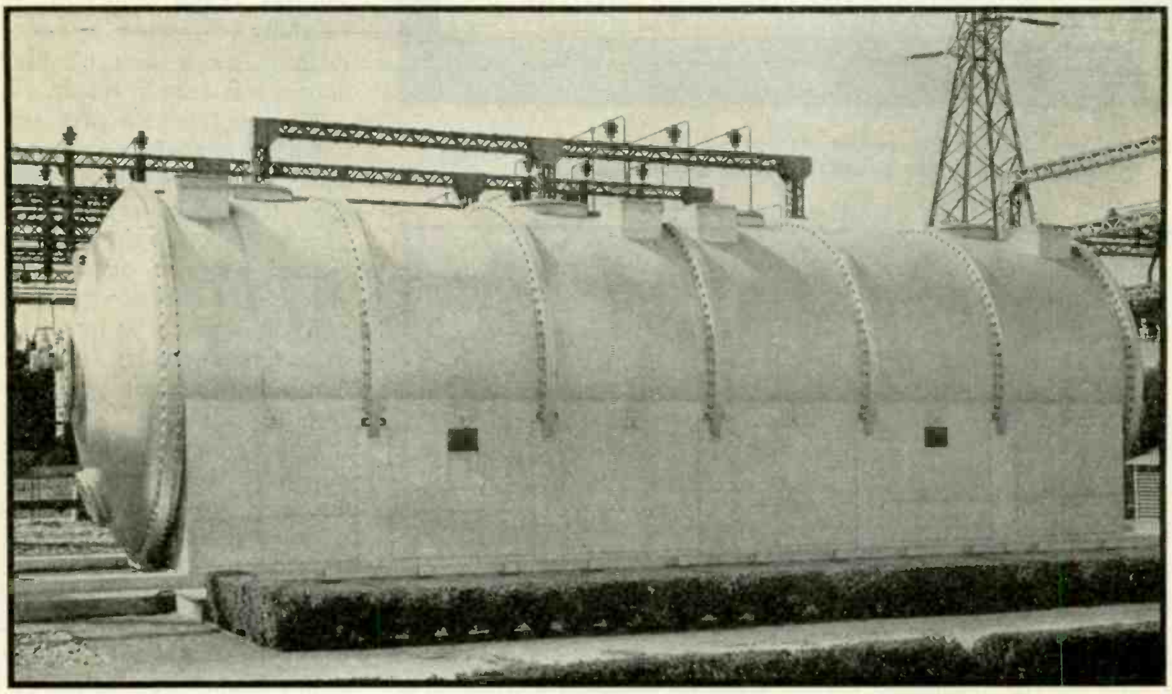
In an effort to keep the over-all size of a transformer small, very fine wires are used in the high-impedance windings. The wires are also reduced in size because the spacing between winding layers must be large to keep the distributed capacitance low. The presence of any moisture in the coil or in the paper insulation would seriously impair the balance between the coils and the high-frequency response of the transformer. This moisture would also facilitate electrolytic action between the bare coil ends where they are attached to the lead wires. It is necessary, therefore, that the coil be thoroughly desiccated and then sealed.

This may be accomplished by a vacuum impregnation system in which the coils are heated under pressure and then maintained in a heated condition at a high vacuum for 12 to 16 hours. While still heated and under vacuum the transformers are immersed in a high melting point amorphous wax which has been highly refined to remove

(Continued on page 382)

Synchronism Indicator For ELECTRIC POWER

Electronic device utilizing two cathode-ray tubes, installed in a receiving station, instantly shows out-of-step conditions in the operation of a 60,000-kva frequency changer linking 60-cps Los Angeles system with 50-cps Southern California Edison system



The 60,000-kva frequency changer for which the synchronism indicator discussed here was designed

IN THE OPERATION of an electric power system it is necessary to be able to determine the condition of any component part of the system at a moment's notice. Many electrical instruments found in power stations are used exclusively for that purpose.

Power station instruments are usually mechanical devices which respond to electrical excitation, such as voltmeters, ammeters and wattmeters. For most purposes these instruments are entirely satisfactory. However, there is one condition which is not so easily determinable with electro-mechanical instruments. This is the condition in which a synchronous machine falls "out of step".

If the station operator happens to be watching his instruments at the moment a machine falls out of synchronism, he may be able to determine that such a condition has arisen by observing the power and current swings as indicated by meters. This is not necessarily conclusive evidence of an out-of-step condition, however, because a surging or "hunting" condition in the machine may cause power and current swings as great or even greater than an out-of-step condition may cause. Also, if the machine has dropped entirely out of synchronism before the operator sees the meters, he may not be able to determine for certain that it is out of step because the meters may again be reading steady values which may be no greater than normal values of power and current for the machine.

This condition was encountered by the Los Angeles Bureau of Power and Light in its tie with the Southern California Edison Company system. This tie consists of a 60,000-kva frequency changer that ties the 60-cps Bureau of Power and Light system to the 50-cps Southern California Edison Company system.

SYSTEMS

By KENNETH C. COOK
On leave from
Department of Water and Power
City of Los Angeles
Los Angeles, Calif.

The frequency changer is located at Bureau of Power and Light Receiving Station "C" and is controlled by the station operators at this location. In order to provide the station operators with more positive indication of its running condition than the regular switchboard meters are capable of giving, an out-of-step indicator was designed and installed on the frequency-changer meter-board. It employs a pair of two-inch cathode-ray tubes, one for the 50-cps end and one for the 60-cps end of the machine. See Fig. 1 and Fig. 2.

Interpretation of Figures

Two cathode-ray tubes are connected so that machine currents produce horizontal signals and line voltages produce vertical signals. If machine currents alone are applied, the screen images are horizontal lines. If line voltages alone are applied, vertical lines appear on the screens.

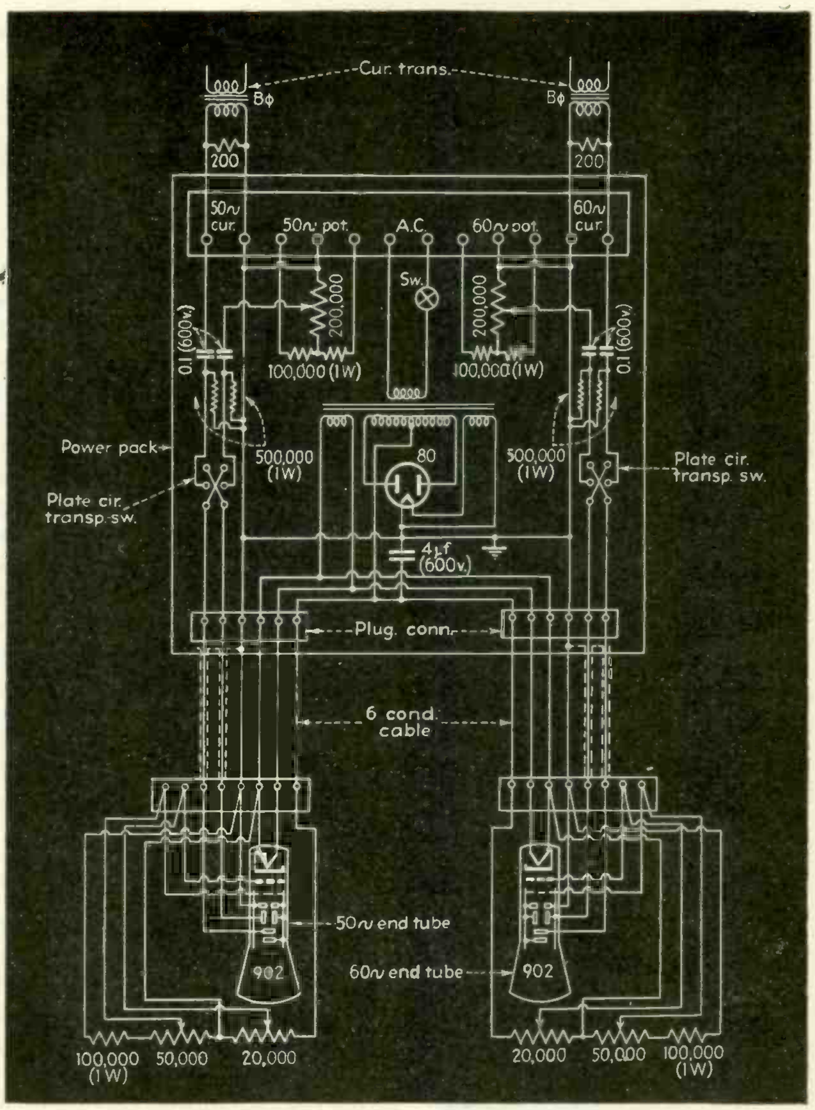
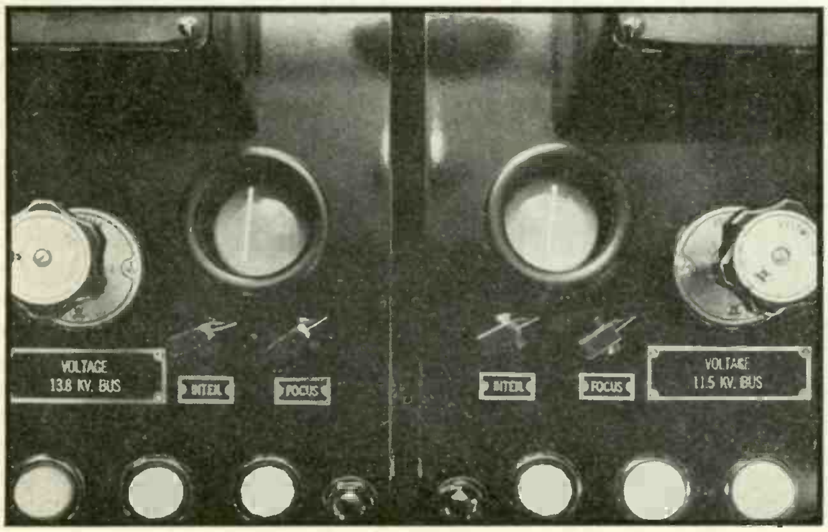


FIG. 2 (above)—Circuit diagram of the out-of-step indicator

FIG. 1 (below)—Out-of-step indicator, mounted on frequency-changer control-board



When both current and voltage signals are applied the images tilt at an angle. If current and voltage signals are in phase, the figures are tilting straight lines. If they are out of phase the figures are ellipses, tilting at an angle.

In cases of power surging the images rock back and forth as shown in Fig. 3a. If the machine slips a pole the image for the end that slips appears to rotate 180 degrees, as shown in Fig. 3b. If the

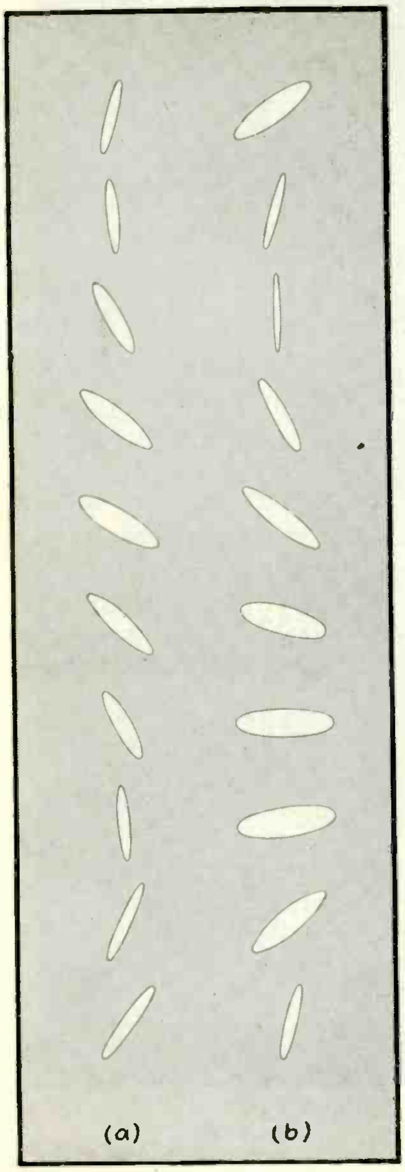
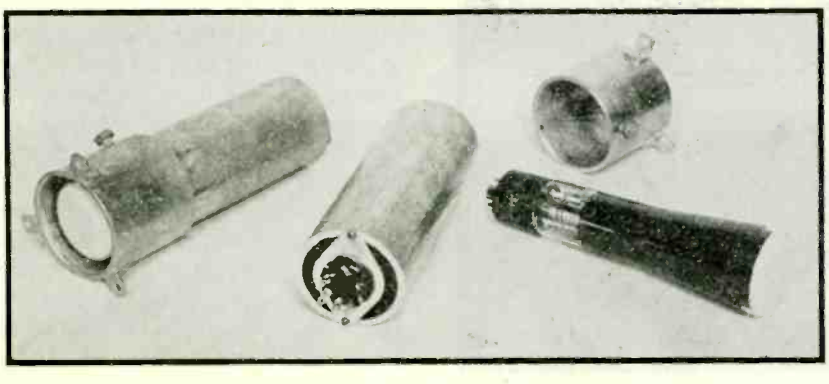


FIG. 3—(a) Progression of out-of-step indicator figure during a power surge, and (b) progression of out-of-step indicator figure during one slip cycle

FIG. 4—Construction of cathode-ray tube shield



machine continues to slip poles the image continues to rotate. If the machine drops completely out of synchronism and runs at a reduced speed, the image breaks into more complex Lissajous figures.

Circuit Design

The horizontal axis or current signal is obtained from B-phase machine current, by using the voltage drop across a 200-ohm resistor connected to the secondary winding of a 5-to-0.1-amp current transformer connected in the regular 5-amp metering circuit of the machine. The vertical axis or voltage signal is obtained from B-phase to neutral of a Y-connected resistor bank connected to open delta potential transformers. This connection gives current and voltage signals in phase when the machine operates at unity power factor. The signal voltages are connected with polarity such that the figure on the cathode-ray screen tilts in the direction of power flow.

Power Pack

The two cathode-ray tubes are connected to a common power supply, which was built up from ordinary radio parts. The power pack is operated from a small a-c generator driven by the station batteries, as the regular station service would not be satisfactory during a fault condition. On the rectified high-voltage side of the power pack a single 4-μf filter capacitor is sufficient to maintain the d-c voltage very nearly at the peak value of the a-c voltage, as the current drawn by the cathode-ray tubes is very small. With the tubes operating, the output of the power pack is about 500 volts d.c. The leads to the tubes are cabled conductors which plug into the power pack.

The intensity and focus controls are mounted below the tubes, as shown in Fig. 1. The voltage signal controls are mounted in the power pack box, and the 200-ohm load on the current transformer was chosen so that full deflection on the screen represents about three times normal full-load current.

Special Considerations

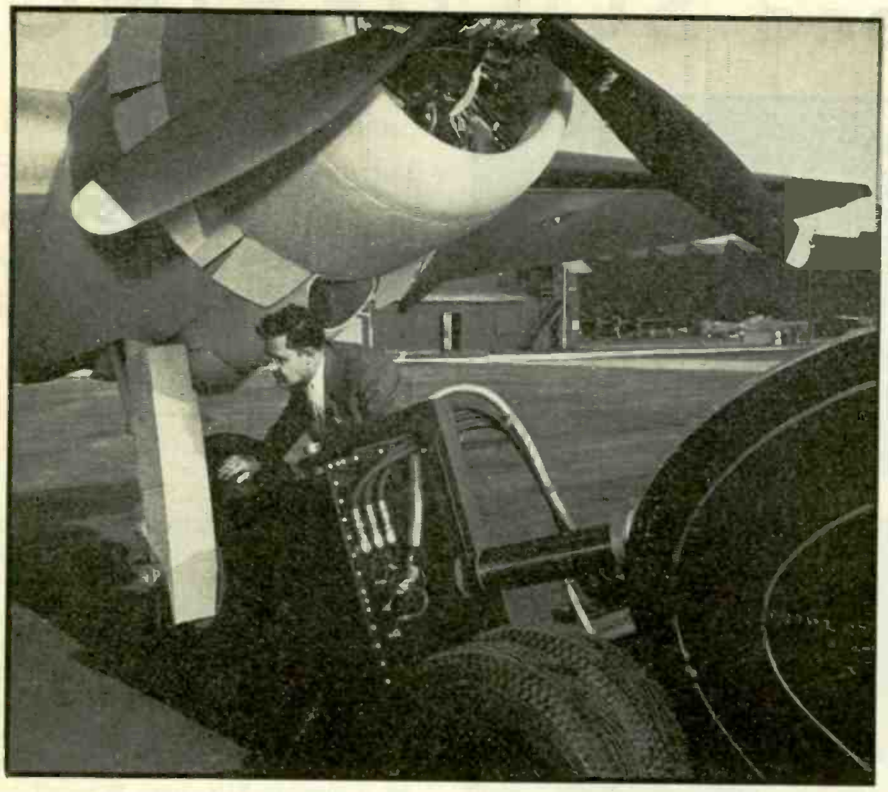
It was found necessary to enclose the cathode-ray tubes in heavy magnetic shields, due to the strong fields present from the control wiring on the back of the frequency-changer board. Pieces of ordinary iron pipe large enough to accommodate the tubes were found to be satisfactory for this purpose, and mountings were made of this material, as shown in Fig. 4.

Shading hoods are mounted over the cathode-ray tubes to make them more easily visible. These also reduce the intensity at which it is necessary to operate the tubes for satisfactory visibility, which increases the life of the tubes. At first the length of life of the tubes was approximately 1500 to 2000 hours of service. Later, however, when better shading was provided and they were operated at lower intensity, they lasted from 5000 to nearly 10,000 hours of service.

Practical Experience

With this comparatively simple and inexpensive device, when a fault condition occurs on the station system the station operators can tell at a glance whether the frequency changer is carrying the load and should be left on or if it has dropped from synchronism and should be cut free from the system.

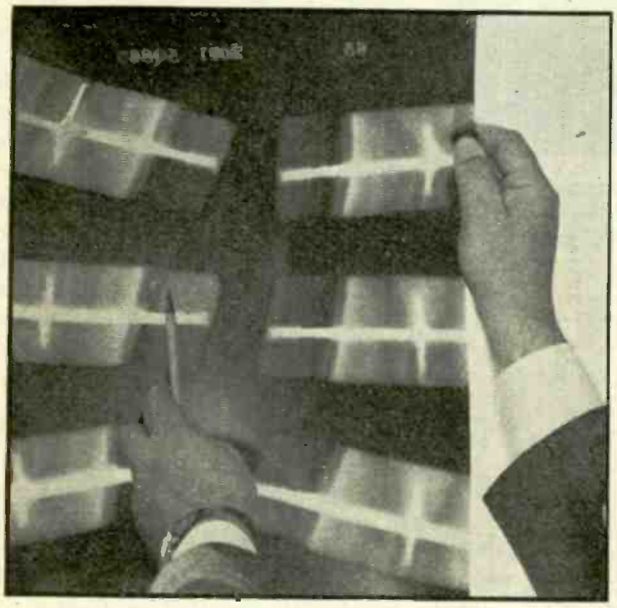
One month after the out-of-step indicators were installed on the 60,000-kva frequency changer at Receiving Station "C" system disturbance occurred which threw the machines out of synchronism. The station operators were able to recognize the condition instantly and tripped the machine free from the system in 10 seconds time. Due to this rapid action considerable time and expense were saved in restoring the station to normal operation.

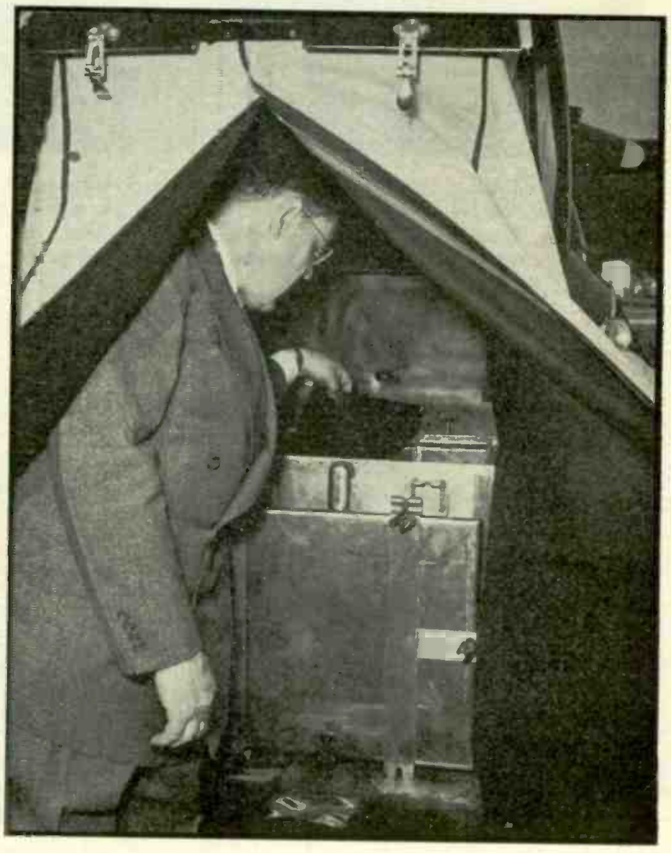


A hydraulically operated x-ray head on the trailer permits radiographing parts of a plane as low as 18 inches from the ground or as high as 8 feet. Here a landing gear on a "Hudson" bomber is being radiographed. The trailer was designed by Triplett and Barton Laboratories at Lockheed Aircraft Corp. in Burbank, Cal. Any car can tow it

With this mobile 250-kva trailer unit, propellers, landing gear and other suspected structural parts of an airplane can be x-rayed right on the airport. Plates are developed in a few minutes, telling pilot whether flight is safe

Pre-Flight Inspection





ABOVE: Typical multiple-exposure negative of an aircraft structural part. The pencil points to a flaw that makes the plane unsafe

RIGHT: X-ray negatives are developed in a tent-like darkroom at the rear of the trailer. It contains a refrigeration unit that maintains the developing solution at the correct temperature regardless of outdoor conditions

High-Speed SOLDERING

FIG. 1—Complete installation for rapid automatic soldering of capacitor cans. A continuous belt moving at a speed of 10 feet per minute carries the cans between specially designed applicator coils. As many as 2500 units per hour can be soldered with this equipment

Small metal containers, with bottoms and rings of solder in place, are carried along a moving belt and through an applicator coil at the rate of

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RADIO - FREQUENCY HEATING has been used for some time in the rapid soldering of capacitor cans, small transformer cases, and other sheet-metal containers. As a rule, soldering operations of this type have been accomplished by placing the units to be soldered, either one at a time or in small groups, in a fixed jig or coupling coil to which current was then applied for a heating period which was either manually or automatically controlled.

There have been numerous variations of method (including one in which a coupling coil, provided with an insulated handle and attached to the r-f oscillator by flexible leads, was placed successively over the units to be soldered[1]) but, so far as is known, all have involved either a put-them-in and take-them-out procedure or else some means of moving the applicator coils so as to place them successively around individual units.

In the installation described here the development of the r-f soldering process has been carried a long step forward by making the operation continuous and completely automatic. Capacitor cans, carried along by a moving belt, pass through an especially designed applicator which provides just the right amount of localized heating to flow the solder and seal the can. The equipment, shown in Fig. 1, is capable of soldering 2500 cans per hour. It can be operated by one girl, whereas by the hand-soldering method previously used, at least a dozen girls were needed to maintain the same rate of production. Moreover, the soldered seals made on this automatic equipment are more consistent than those made by hand, and rejects are therefore fewer. Since the heat is sharply localized—and applied for a relatively short time—the danger of harming the inserted capacitor pack is considerably less.

R-F Heating in Quantity Production

The details of the capacitor-soldering equipment are in themselves interesting. The installation is also of interest as an indication of the trend toward adaptation of r-f heating to quantity production.

While it is not always recognized as such, radio-frequency heating is essentially a production tool. It is of greatest advantage when applied to the production of large quantities of units of a single type. When so applied, it offers economies

with Radio-Frequency Power

2,500 per hour. Localized heating induced in the metal causes the solder to flow and seals the bottoms without endangering the capacitor

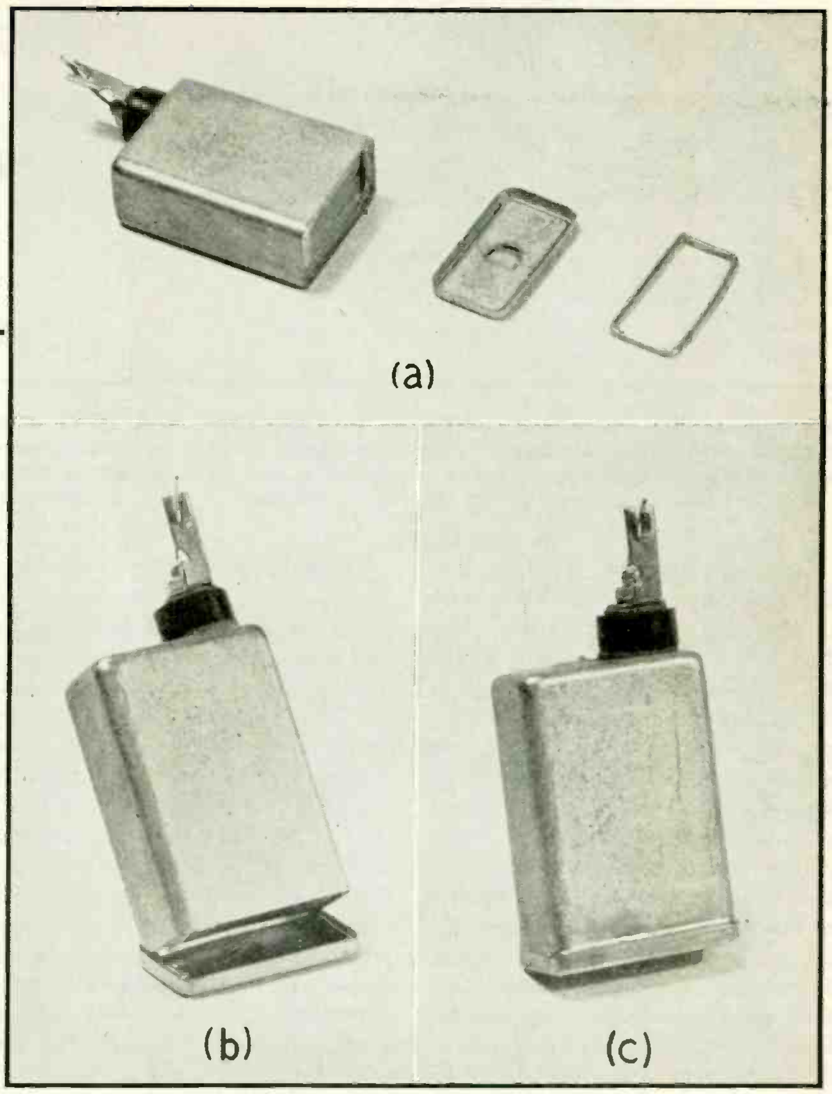


FIG. 2—Method of assembling capacitor cans: (a) left to right: the can proper, bottom piece and solder ring before assembly, (b) solder ring in bottom piece and top about to be placed, (c) completed can after soldering

which eventually will overshadow other possible advantages. This fact has often been overlooked since most wartime installations have been made either to perform an operation which could not be done by other methods (as in the production of all-molded compreg propellers[2]) or to increase the output of very important materials when the extra equipment otherwise needed was not available (as in making aircraft spars[3]). In both of these cases the value of the product was relatively high, so that the added cost of r-f heating—even when the cost of equipment was figured in—was a small and relatively unimportant item. Moreover, in most cases the urgent need of production for war purposes has been such that cost was secondary.

With a return to more normal conditions these factors will no longer be present in the same degree. Radio-frequency heating will thus have to justify its cost. Where the production quantities are small, this will be possible only when other very important advantages result. The more promising, and probably far larger, field of applications is that in which measurable economies are effected through using r-f heating to increase production greatly over older methods. One such application, which has been previously described, is the use of r-f preheating in molding operations, where the quantities run into the thousands.[4] The capacitor soldering job described here is another good illustration.

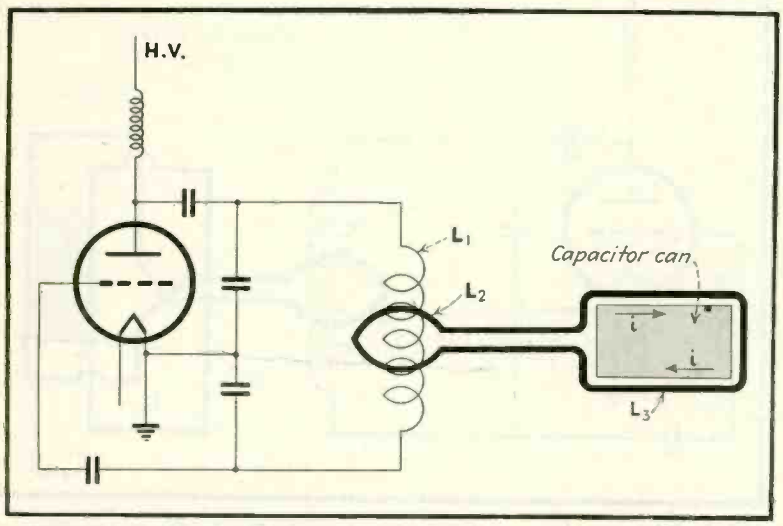
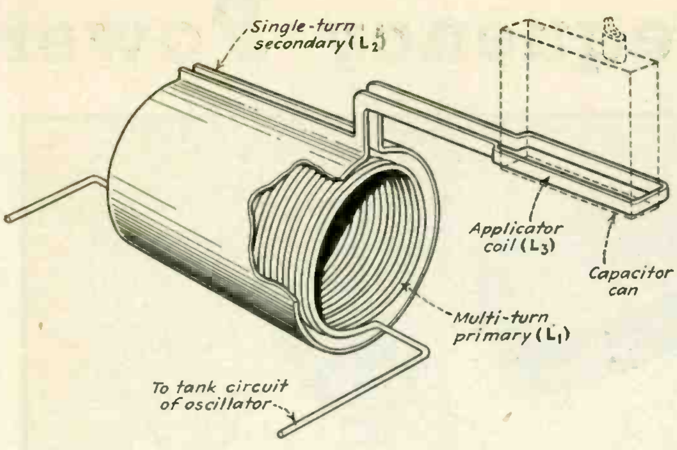


FIG. 3—Schematic diagram of older equipment for soldering cans



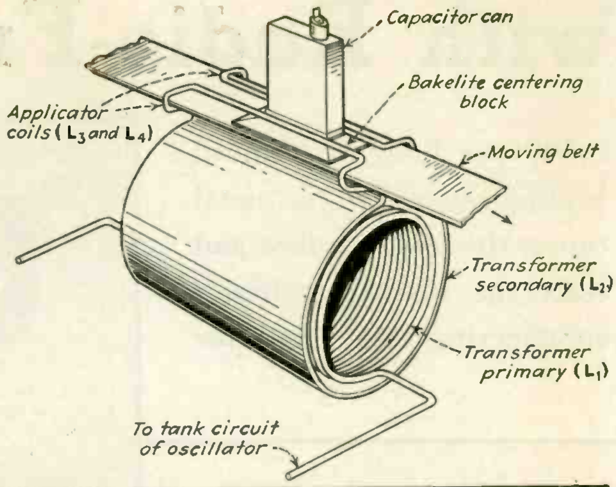


FIG. 4—Simplified drawing of a conventional coupling method employed when heating one can at a time. The current transformer consists of a multi-turn primary coil (which is also the tank coil of the oscillator) and a single-turn secondary

FIG. 5—Coupling arrangement used in continuous heating installation shown in Fig. 1. Cans are placed in centering blocks fastened to a moving belt which carries them between the two straight pieces of tubing which act as the applicators

Capacitor cans of the type soldered in this instance have been used in large quantities for some time by a number of manufacturers and will be familiar to most readers. They are ordinarily used to provide a means of mounting and protection for paper capacitors of the better type, such as those used in radio transmitters and high-quality sound equipment. The capacitor pack itself usually consists of alternate layers of oil-impregnated paper and tinfoil wound tightly and somewhat compressed to obtain a relatively larger capacitance in small volume. After assembly, the cases are filled with oil and sealed.

Method of Assembling Cans

The method of assembling one of the several types of capacitor cans which are regularly soldered is illustrated here. Figure 2a shows, from left to right, the can proper (containing the capacitor-pack), the bottom piece which is to be soldered in place and the ring of solder which is used in this soldering operation. Fig. 2b shows the method of assembling these parts. The solder ring is first laid in the bottom piece, after which the top part of the can is placed in position. A fairly snug fit, plus the fact that the units are held in an upright position, assures that the parts will remain in place while the solder is flowed. Figure 2c shows the completed can.

The only preparatory work which is done on the can parts previous to soldering is the dipping of the bottom piece, and the bottom edge of the top piece, in soldering flux. This was also required when hand soldering was employed and hence cannot be termed an additional operation. In fact, the entire procedure followed in preparing and assembling the parts, as described above, is identical to that previously employed for hand soldering. The only difference in the whole process is in the method of applying heat. Previously this was done by running a soldering iron around the rim—a time-consuming and fatiguing procedure. The same heating is now accomplished by causing r-f currents to flow by induction in the surfaces to be soldered. By concentrating the current, and hence the heating, in a narrow band running all the way around the can, the temperature of the surfaces to be soldered is brought to the point of solder flow in a fraction of a second.

Limitations of Conventional Applicators

Making an applicator coil which will produce heating in a narrow band around a single symmetrical

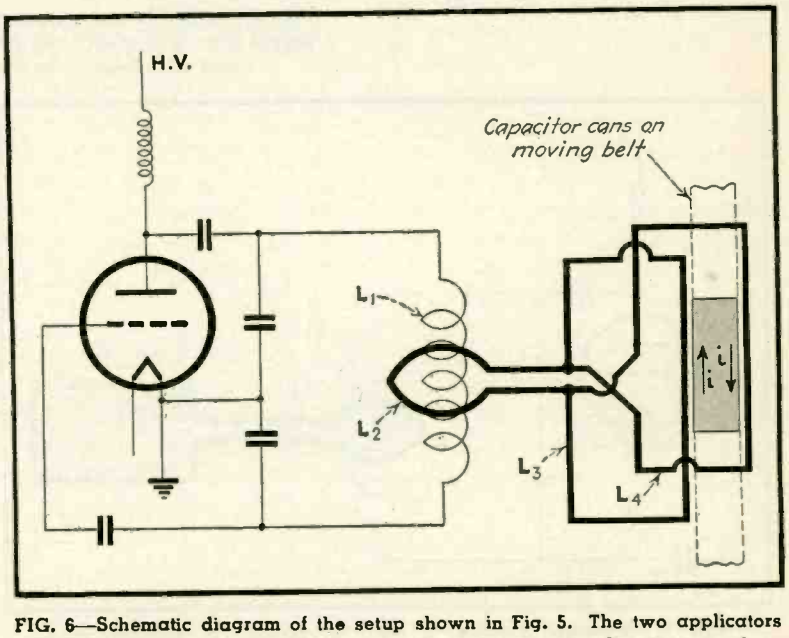


FIG. 6—Schematic diagram of the setup shown in Fig. 5. The two applicators are cross-connected so that the current flows in opposite directions in them

form such as a capacitor can is a relatively simple matter. Tests which have been made indicate that such a band can be heated very efficiently with a single turn of tubing formed to fit the piece snugly. This single-turn applicator coil is usually coupled directly to the tank circuit of the oscillator as shown in Fig. 3.

Inductance L_1, which is the tank inductance of the oscillator, and L_2, the coupling inductance, form a current transformer which serves to match the low impedence of the applicator coil, L_3, to the relatively high impedance of the tubes. Since the current flowing in L_2 and L_3 is very high—as much as several hundred amperes—it is necessary to keep the connections between these very short if high copper losses are to be avoided. This entails placing the current transformer close to the load, which usually means placing it outside the oscillator housing.

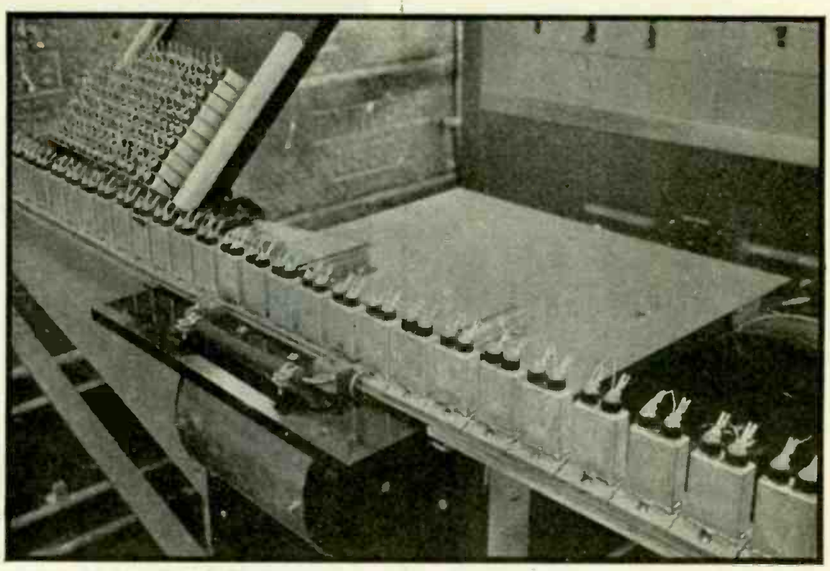


FIG. 8—Closeup of the heating position. The current transformer is mounted just under the table top. Small copper blocks mounted on the secondary form terminals for the applicator coils. The rubber hose is for cooling-water

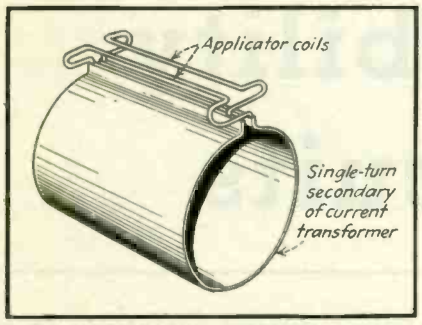


FIG. 7—Simplified sketch showing manner in which the applicator coils are mounted on the secondary of the current transformer. In the installation under discussion provision is made for cooling the applicators by passing water through

A type of current transformer, first described by Bierwirth[5] and now quite widely used, consists of a multi-turn primary coil surrounded by a single-turn secondary in the form of a sheet of copper or brass the full width of the primary. Such a transformer combines good coupling efficiency with the high step-down ratio required to match the tube impedance to the very low impedance of the coupling coil. The arrangement of the applicator coil with relation to this transformer is depicted in the simplified sketch of Fig. 4. Such an arrangement is simple, efficient, and relatively easy to replace. When the quantity of units is not large and a relatively slow rate of production can be tolerated, it is quite satisfactory. It is not, however, suitable for heating continuously-moving units, such as those on a belt or conveyor, since it requires each unit to be placed in the coil, heated, and then removed.

Design of Special Applicators

Any put-in and take-out process, such as is necessarily used with applicators of the type shown in Fig. 4, must necessarily result in inefficient use of a machine because, in effect, the machine is not operating during the appreciable handling period. In heating capacitor cans, for instance, power would be applied for only two or three seconds, at most, whereas handling might require two or three times as long. Thus the duty cycle of the machine would be something less than fifty percent. If, on the other hand, the units could be passed through continuously, the cycle could be eliminated with consequent increase of output.

In the installation under discussion, continuous operation is provided for by an ingenious arrangement originally suggested by W. M. Witty. The cans, mounted on a continually moving belt, are passed between two pieces of straight copper tubing as shown in Fig. 5. These pieces of tubing are effectively in parallel but the current flows in opposite directions in them. This arrangement will be understood after study of Figs. 6 and 7.

Figure 6 is a schematic diagram of the coupling circuit. In this diagram, L_1 is the tank inductance of the r-f oscillator, L_2 is the secondary of the current transformer and L_3 and L_4 are the two pieces of tubing which form the applicators. The two pieces of copper tubing are connected in parallel across the secondary of the transformer, as shown in Fig. 7. By reversing the connections, the current is made to flow in opposite directions in them. It will be noted, however, that the currents which the two pieces of copper tubing induce in the capacitor can are in phase. This produces a continuous flow of current around the can. Thus the current in the can is the same as if induced by placing a coil around the can as shown in Fig. 3.

The mechanical arrangement of the coupling system is very simple, an important advantage of this method of coupling. The current transformer, as before, consists of a multi-turn primary coil and a single-turn secondary in the form of a sheet of copper or brass the full width of the primary. Fig. 7 is a sketch of the secondary of this transformer, showing in simplified fashion the way in which the applicators are attached. The sheet is slit along the top of the coil, thus

(*Continued on page* 232)

By G. V. ELTGROTH

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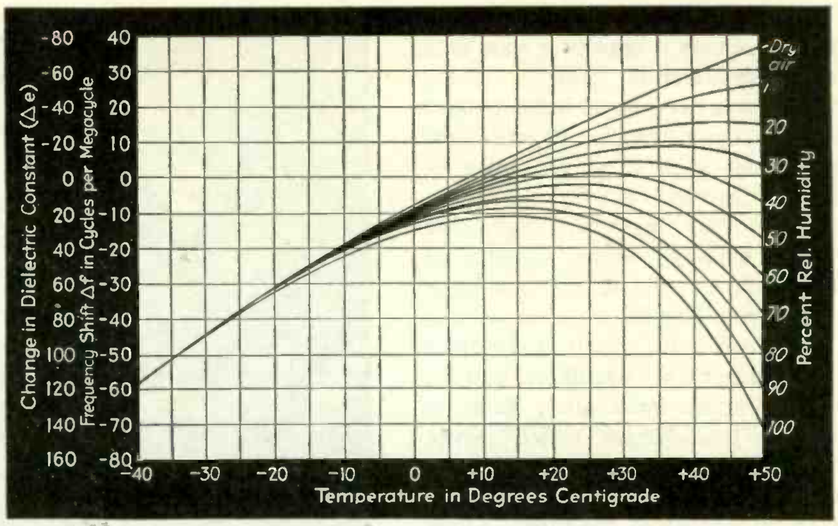

FIG. 1—Change in frequency and dielectric constant with temperature, using various values of relative humidity as a parameter. The air reference is air at 20 deg C and 50 percent relative humidity (e = 1.00056565)

Frequency Stability of Tuned Circuits

Data on the performance of coils tuned by air-dielectric capacitors, during variations in air density and humidity such as are encountered when equipment is operated over a wide range of altitudes. The effect of varying carbon-dioxide content, encountered in dry-ice test chambers, is also discussed

In order to retain standards of accuracy initially imposed upon radio and other electronic equipment employing circuits tuned by air-dielectric capacitance, the effects of natural variations in the dielectric must be understood and taken into account. This is particularly true where equipment is to be used at high altitudes and under adverse weather conditions.

There are three characteristics of air as a dielectric which may affect the resonant frequency of a tuned circuit situated in this dielectric. (In this discussion, the effects of mechanical variation of components with varying conditions will not be considered.) They are:

1. *Density.* The dielectric constant of air varies with pressure and, therefore, with altitude. The dielectric constant also varies with temperature, since this too affects the density of a gas.

2. *Composition.* The relative humidity of air is constantly changing and has a decided effect on the dielectric constant at higher temperatures (above 10 deg C). In tests where dry ice is used, the carbon-dioxide content of the surrounding medium also may rise to 60 percent or 70 percent as compared with its normal value of 0.03 percent. This will increase the dielectric constant.

3. *Saturation.* Air almost saturated with water vapor will deposit thin films on objects situated in it. This should not be confused with condensation, which occurs when the air becomes supersaturated at the temperature of the body with which it is in contact.

Each of these effects will be thoroughly discussed in the following sections.

We shall first develop a few simple required relations:

$C = He$ C = Capacitance of capacitor

$dC = Hde$ H = Constant determined by mechanical construction

$\frac{dC}{C} = \frac{de}{e}$ e = Dielectric constant of dielectric medium

Thus the percent change in C = percent change in e.

$f = \frac{A}{\sqrt{C}}$ f = resonant frequency of circuit being investigated

TABLE I—VALUES OF V FOR AIR AT VARIOUS HUMIDITY AND TEMPERATURE VALUES

(Dielectric constant $e = 1 + V \times 10^{-6}$)

Temp. °C	Relative Humidity 0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Δv
−40	682	682	682	682	682	682	682	682	682	682	682	0
−30	655	655.08	655.16	655.24	655.32	655.4	655.48	655.56	655.64	655.72	655.8	0.8
−20	629	629.232	629.464	629.696	629.928	630.16	630.392	630.624	630.856	631.088	631.32	2.32
−10	605	605.56	606.12	606.68	607.24	607.81	608.37	608.93	609.49	610.05	610.61	5.61
0	583	584.27	585.54	586.81	588.08	589.35	590.62	591.89	593.16	594.43	595.7	12.7
+10	562	564.46	566.92	569.38	571.84	574.3	576.76	579.22	581.68	584.14	586.6	24.6
+20	543	547.53	552.06	556.59	561.12	565.65	570.18	574.71	579.24	583.77	588.3	45.3
+30	525	532.95	540.9	548.85	556.8	564.75	572.7	580.65	588.6	596.55	604.5	79.5
+40	508	521.4	534.8	548.2	561.6	575	588.4	601.8	615.2	628.6	642	134
+50	493	514.7	536.4	558.1	579.8	601.5	623.2	644.9	666.6	688.3	710	217
+60	478	512	546	580	614	648	682	716	750	784	818	340
+70	464	515.5	567.0	618.5	670	721.5	773	824.5	876	927.5	979	515

$$df = -\tfrac{1}{2}\frac{A}{\sqrt{C}}\frac{dC}{C}$$

$$\frac{df}{f} = -\tfrac{1}{2}\frac{dC}{C} \qquad A = \frac{1}{2\pi\sqrt{L}}$$

Thus the percent change in $f = \frac{1}{2}$ the percent change in C, and is negative, signifying that an increase in C decreases f.

Density

The dielectric constant of dry air for pressures below 1000 lb per sq in. is given by $e = 1 + 18.25\,P \times 10^{-6} \times \frac{292}{t}$, where P is expressed in in. Hg and t in deg. K.

$$\frac{\delta e}{\delta P} = 18.25 \times 10^{-6} \times \frac{292}{t}$$

Assuming $t = 292°K$ (19°C) we have

$$\frac{\delta f}{\delta P} = -\,9.125 \times 10^{-6}$$

for constant relative humidity and temperature.

The frequency will drop 9.125 cps per Mc per in. Hg pressure increase. Reducing the pressure from 30 in. to 10 in. Hg (equivalent to an altitude of 27,500 ft) will increase the frequency 20 × 9.125 or 182.5 cps per Mc, which is 0.01825 percent.

Let P = 20 in. Hg, and let the temperature vary over a narrow range about 292 deg K.

$$e = 1 - 547.5 \times 10^{-6} \times 292/t$$

$$\frac{\delta e}{\delta t} = -\frac{547.5 \times 10^{-6} \times 292}{t^2}$$

$$\frac{\delta e}{\delta t} = -\,1.875 \times 10^{-6}$$, for constant relative humidity and pressure.

From this it is evident that the frequency will increase 0.9375 cps per Mc per deg C rise in air temperature for dry air. This is negligible in comparison with other changes normally encountered.

Composition

(a) *Humidity.* If the relative humidity is held constant at various values, and the temperature of air varied, it will be found that the curve *e* vs. *temperature* will vary in form.

$$e_{air} = 1 + 209.66\,\frac{P}{t} \times 10^{-6}$$

$$e_{vapor} = 1 + 966.83\,\frac{P}{t} \times 10^{-6}$$

P is here expressed in mm Hg, t in deg K

From these equations was derived the equation $e = 1 + [209.66 \times 760/t + 757.174\; V.P./t] \times 10^{-6}$. Setting the portion in brackets equivalent to V gives $e = 1 + V \times 10^{-6}$. This relation was used in calculating the values of V in Table I for different values of temperature and relative humidity. The right-hand column labelled ΔV contains values of the total change in V in going from 0 to 100 percent relative humidity. Values of vapor pressure $V.P.$ in mm of Hg corresponding to the indicated values of temperature and relative humidity are found in meteorological tables.

Allowance for water-film deposit on electrodes is not included. Such deposits will add to the shift in capacitance.

A curve interpreting the data in Table I in terms of change in dielectric constant in parts per million, and resonant frequency shift in cycles per megacycle, is shown in Fig. 1.

(b.) *Carbon dioxide content.* When cold tests are run with dry ice as the cooling agent, the air in the cooling chamber will have its carbon-dioxide content materially increased. The dielectric constant for carbon dioxide differs materially from that of air, the values at 19 deg C and 762 mm mercury pressure being 1.0005475 for air and 1.000921 for carbon dioxide.

Table II gives the variations in e and f with varying carbon dioxide content, for a constant temperature of 19 deg C and a pressure P of 30 in. (762 mm) of Hg.

From this table it is seen that the presence of CO_2 in the air dielectric of capacitors may produce frequency shifts up to 0.0186 percent, a very appreciable amount in a transmitter being designed for an accuracy of 0.03 to 0.05 percent. The figures apply to dry air, at 19 deg (292 deg K) C and 762 mm Hg. Values of Δe and Δf may be readily obtained for any other temperature or pressure by multiplying by the factor $292P/762t$, where P is in mm Hg and t is in deg K.

A graph of the data in Table II is shown in Fig. 2. It is important to note that with 60 percent carbon dioxide content, the frequency shift

TABLE II—VARIATIONS IN e and f WITH VARYING CARBON-DIOXIDE CONTENT

% CO_2 by Vol.	e	Δe (mult. by 10^{-6})	Δf in cps per Mc
0	1.0005475	0	0
10	1.00058485	37.35	−18.68
20	1.0006222	74.7	−37.35
30	1.00065955	112.05	−56.03
40	1.0006969	149.4	−74.7
50	1.00073425	186.75	−93.38
60	1.0007716	224.1	−112.05
70	1.00080895	261.45	−130.73
80	1.0008463	298.8	−149.4
90	1.00088365	336.15	−168.08
100	1.000921	373.5	−186.25

is over 0.01 percent. At −40 deg C, when the carbon dioxide content is only 50 percent. the frequency will be 0.0117 percent lower than with air.

Saturation

Recent experimental work has shown that moisture films form on objects situated in moist air even though conditions may be such that no condensation takes place. We shall derive the effect of water-film formation on a capacitor formed by two or more parallel plane surfaces.

The capacitance of such a capacitor may be expressed as $C = He/S$, where H is a constant depending on size of plates and system of units employed, e is the dielectric constant of the medium, and S is plate spacing.

Let the dielectric constant for the normal dielectric be e_1, and let that for the material in the film formed on the plates be e_2. Also, call C_0 the normal capacitance, C' the capacitance with film on plates, and y the film thickness. Now, with plane plates and a uniform film thickness, the film-air interface will correspond to an equipotential surface, and

$$C_1 = \frac{He_1}{S - 2y} \qquad C_2 = \frac{He_2}{2y}$$

These relations are set up by assuming a metal surface of infinitesimal thickness, at the equipotential surface of the water-air interface, and then calculating the effective capacitance on each side thereof.

The two capacitances are effectively connected in series, so we may obtain C' from the series capacitance relationship:

$$C' = \frac{C_1 C_2}{C_1 + C_2}$$

$$\text{i. e.} \quad C' = \frac{He_1 e_2}{2y(e_1 - e_2) + e_2 S}$$

The fractional change in capacitance will then be

$$\frac{C' - C_0}{C_0} = \frac{e_2 S}{2y(e_1 - e_2) + e_2 S} - 1$$

and

$$\frac{\delta}{\delta y}\frac{C' - C_0}{C_0} = -\frac{2e_2 S(e_1 - e_2)}{[2y(e_1 - e_2) + e_2 S]^2}$$

We are interested in the action of thin films of foreign dielectric and will therefore confine our calculations to the region where y is less than or equal to 0.01 S. This permits the use of the following simplified equation

$$\frac{\delta}{\delta y}\frac{C' - C_0}{C_0} = \frac{2}{S}\left[1 - \frac{E_1}{E_2}\right]$$

On the basis of this assumption, the fractional change in capacitance is

$$\frac{C' - C_0}{C_0} = \frac{2y}{S}\left[1 - \frac{e_1}{e_2}\right]$$

Now, for a practical application of this expression, assume a spacing between plates of $S = 0.05$ cm (0.020 in.) and a downward frequency shift Δf of −100 cps per Mc, which corresponds to 200×10^{-6} for $\Delta C'$. The normal dielectric is air ($e_1 = 1$) and the foreign dielectric is water ($e_2 = 81$). Let us find the required film thickness for the given frequency shift.

Solving the foregoing equation for y, substituting in it the known values, and simplifying gives a value of 5.06×10^{-6} cm for the film thickness y.

Thus, a film thickness of 5.06×10^{-6} cm or 0.00001285 in. produces a frequency shift downward of 0.01 percent. This is a film approximately 120 molecules in depth, and is quite undetectable by ordinary methods since its thickness is only about one-tenth the wavelength of green light. It is obvious at once that the formation of *actual visible condensation* on the plates of a tuning capacitor will result in shifts very many times this in magnitude, and should be strenuously avoided.

For a given film thickness, the frequency shift is inversely pro-

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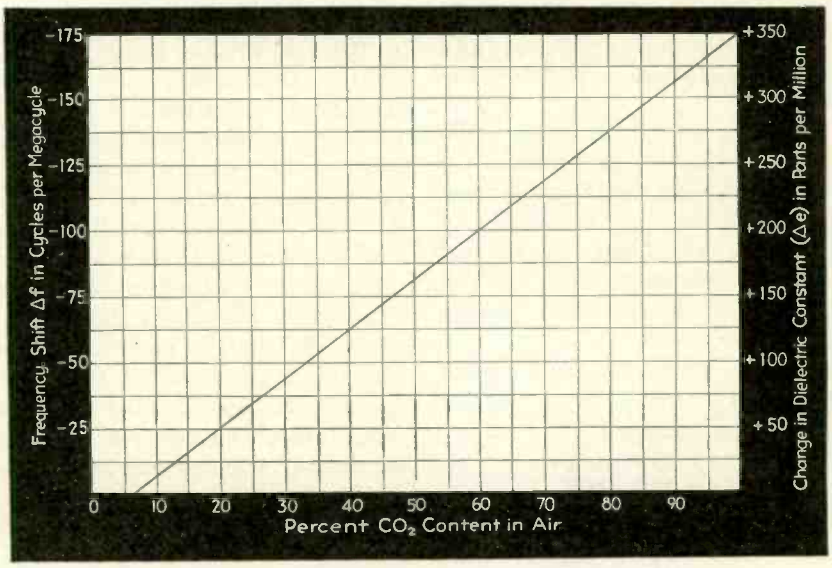


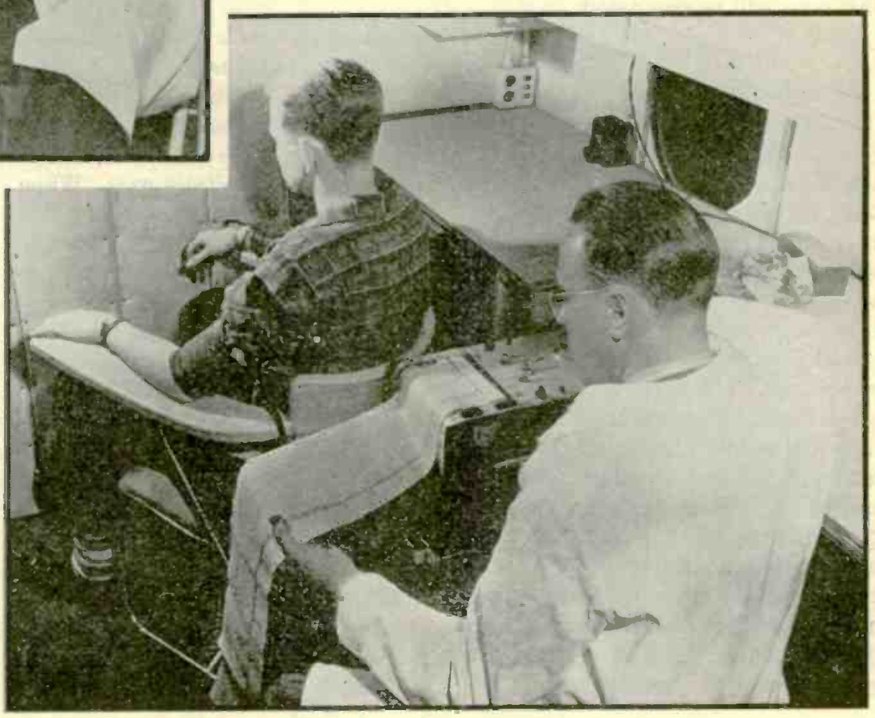
FIG. 2—Variation of dielectric constant and frequency with volume percentage of CO_2 in air. Here P is 762 mm Hg and t is 292 deg K (19 deg C)

Mobile CRIME LAB

Electronic equipment in the 29-foot bus used as a mobile crime-detection laboratory by the Illinois State Police Department includes x-ray apparatus, a lie detector, drunkometer, recorders, and radio equipment

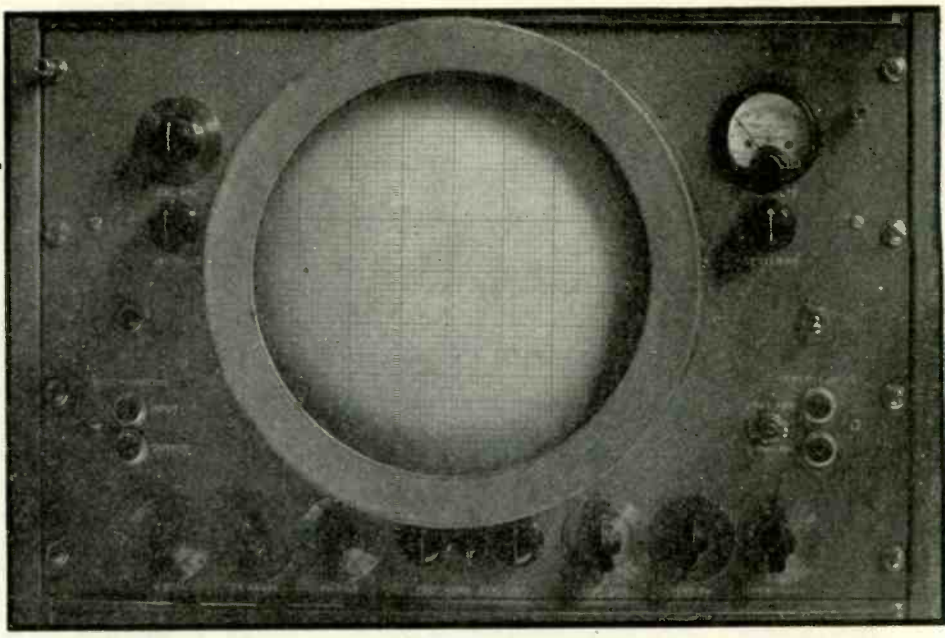
Communications gear in the bus, shown here, includes two-way radio equipment feeding into the Illinois State Police radio system. A public address system is also available for directing crowds at fires or riots

Two recording turntables permit making complete continuous records of statements and confessions of persons being grilled in an adjoining compartment, in which there is a concealed microphone



This polygraph lie-detector, being operated by psychologist Walter Beecher, records variations in blood pressure, respiration and perspiration on moving paper tape during carefully planned questioning of suspects

Front view of completed wide-band oscilloscope



Wide-Band

Description of a compact, portable, cathode-ray oscilloscope with a 9-in. screen. The unit has essentially flat vertical amplifier response up to 4 Mc, as required for investigation of wide-band phenomena

By E. H. BARTELINK

WIDE-BAND cathode-ray oscilloscopes have many applications in the field of physics, electronics and communications. However, in order to collect all the information present in a wide-band phenomenon, several conditions must be fulfilled.

The amplifier system must pass all the significant components present in the frequency spectrum. A high sweep speed must be available and the sweep repetition rate must be variable within wide limits. Interference must be reduced to a negligible amount. Finally, an exceptional degree of stability must be maintained in the deflection amplifiers and particularly in the time base. Failure to meet any of these conditions will prevent collecting all the available information.

These requirements can be met fairly easily when the weight and volume of the instrument are not put under severe restrictions. However, in many applications a compact and portable unit is needed. The special problems that arise in this case will be discussed.

Design Considerations

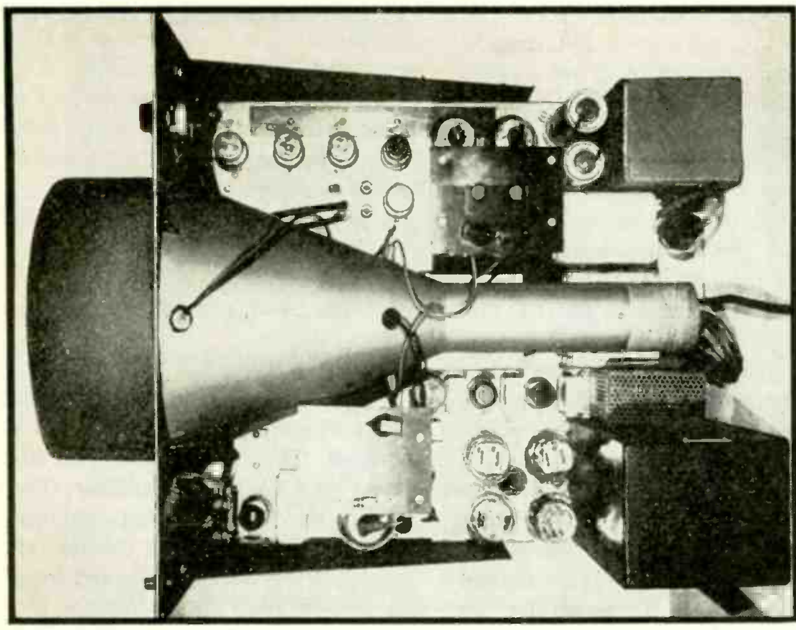
In order to get high picture quality in designing a wide-brand oscilloscope, the following steps were taken. A 9-in. tube (type 914) was used in order to get sufficient picture size. The vertical amplifiers were designed for a flat response up to at least 4 Mc. A specially stabilized multivibrator time base and a "hard" tube sawtooth generator were used. These were followed by an inverter and a push-pull amplifier which allow a full 9-in. beam deflection. Two provisions for magnification of the horizontal deflection have been incorporated; one allows magnification of the first half of each cycle, and the other magnifies the first few microseconds of every scan. In order to retain a good focus at the high writing speeds involved, a high beam voltage (3 kv) was used.

In many applications a large "spread" or expansion along the time axis is much more important than along the voltage axis. When this is realized, it becomes possible to obtain a considerable reduction in size of the apparatus by restricting the vertical deflection to approximately one-fourth of the tube diameter. A further simplification is obtained by making the vertical power amplifier single-ended. This results in a small amount of trapezoidal distortion. Its effect can be eliminated by bringing the observed portion of the wave to the center of the screen with the "centering control."

It was found that many applications do not require an extreme sensitivity of the oscilloscope, so that only two stages of vertical amplification have been incorporated. While this considerably simplifies the instrument, it still enables it to produce a 1-in. deflection for an input voltage of 1.8 v rms.

A switch enables selection of single-stage or two-stage amplification. For those cases where higher sensitivity is required, an external booster amplifier can be added. Thus the total gain used is adapted to each separate problem and attenuators have been avoided altogether. Calibrating voltage, however, is provided for each stage. This approach is thought preferable to such methods where all signals are first attenuated to a common low level and then reamplified, as it eliminates any chances of cross talk from high-level input signals.

Another considerable step to-



Chassis layout, showing protective housing for the 9-in. cathode-ray tube

Oscilloscope

wards compactness is to restrict the horizontal amplifier pass band, to where it will just pass the highest frequency sawtooth with low distortion. In most cases this makes operation possible at a fraction of the vertical band pass and at a corresponding gain in horizontal resolution.

Description

As shown in the block diagram of Fig. 1, the instrument contains the following parts: time base for the generation of sawtooth deflection voltages; horizontal amplifier, driven either by the sawtooth voltage or an external voltage; vertical amplifier and calibrating unit; cathode-ray tube and beam control; power supplies.

Time Base

A multivibrator is used to drive the time base. To obtain a high degree of instantaneous stability, i.e. to prevent erratic fluctuations in the duration of a cycle, positive grid-bias is used. To obtain stability against slow frequency drifts, negative feedback produced by unbypassed cathode resistors is used. Great care was taken in the layout and construction, and a regulated power supply was used.

As a result of these precautions, a rather remarkable degree of frequency stability was obtained. When multivibrators are used as frequency dividers, it is generally not feasible to maintain frequency ratios appreciably in excess of 50:1 because of the drift in the "free running" frequency of the multivibrator and because of instantaneous unstabilities. In this case, it was possible to observe a 1-Mc wave with a time base running at 2000 cps.

A 6-position switch changes the frequency range of the multivibrator by selecting different values of grid-plate coupling capacitors. Considerable overlap is provided between adjacent ranges. Within each range, continuous variation of the frequency is obtained by changing the amount of positive grid bias. The time base rate can be varied over a total range from approximately 10 cps to 35,000 cps.

A width control makes it possible to adjust the percentage of the cycle over which the scan is extended. For this purpose, the multivibrator output is fed to a clipper-amplifier. Its output is applied to the grid of a discharge tube which is connected in the same manner as the sawtooth generators employed in tele-

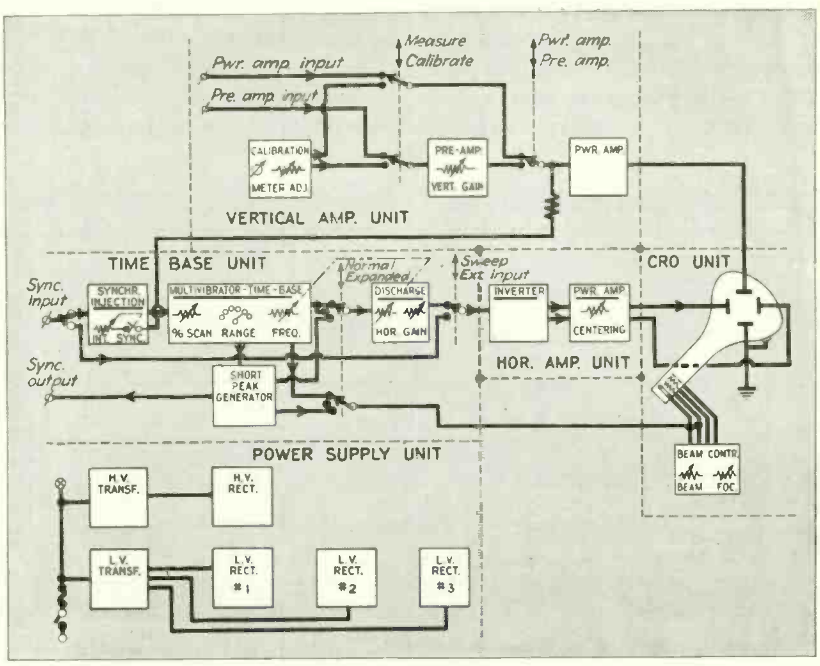


FIG. 1—Block diagram showing stages employed in the wide-band cathode-ray oscilloscope

vision. Linear deflection of the cathode-ray beam is obtained over the time that this discharge tube is cut off and this interval can be varied by changing the pulse width.

The cathode-ray beam is returned to its starting point as soon as the negative pulse is terminated, and remains stationary for the rest of the cycle. With the present circuit values, this allows variation of the sweep duration from 30 percent to 85 percent of the multivibrator cycle. Variations up to a range of 15 to 85 percent can be obtained with different circuit constants.

Another clipper-amplifier system derives a positive pulse from the multivibrator. It is used to switch the cathode-ray beam on during the scanning period and blank it out during the remainder of the cycle. This prevents the formation of a bright spot on the screen, corresponding to the "stationary" part of the cycle.

The discharge capacitors are selected by an additional arm on the frequency range switch. Part of the charging resistor is ganged with the fine frequency control in order to reduce the effect of its setting on the horizontal amplitude. The other part is used as an independent horizontal amplitude control.

In many cases it is desirable to synchronize or drive the phenomenon which is to be observed from the oscilloscope, so as to make sure that none of its initial part can escape observation. For this purpose a short-peak generator was added which delivers a sharply rising pulse of approximately 100 volts in 3500 ohms into an external circuit. The duration of this pulse is approximately 10 microseconds, and its leading edge occurs at exactly the same time that the sawtooth sweep is initiated. In order to obtain this pulse, the square wave which is used for the beam blanking is differentiated in an *R-C* circuit. The differentiated wave is clipped and amplified and applied to the cathode follower output stage, in which a final clipping takes place.

In the plate of this output stage, a negative pulse of the same duration is available. It can be switched into the grid of the discharge tube where it will produce the 10-microsecond "fast" sweep used for magnification of the initial part of each cycle. Part of the cathode voltage is simultaneously applied to unblank the cathode-ray beam over this period. As a result of the high beam voltage (3 kv), a satisfactory focus can be maintained at the high beam currents necessary to make this short-duration pattern visible.

All voltages for the preceding circuits are derived from regulated power supplies.

Horizontal Amplifiers

These are normally driven by the time base, but their input can be reached from the synchronizing plug on the front panel by throwing a toggle switch on the front panel. Thus Lissajous figures can be observed.

A cathode follower phase-inverter is used which, in turn, drives the pair of 807 tubes in push-pull. The amplifiers were designed to have a band pass of approximately 0.25 Mc. The measured response is shown in Fig. 2a. No attempts were deemed necessary to add high-frequency compensation.

A horizontal centering control is provided. With the exception of the final output plates, all circuits are operated from regulated supplies.

Vertical Amplifiers

As can be seen in Fig. 1, two stages of vertical amplification are provided. The output tube is an 807 driven by a 6AG7 preamplifier. The circuits used are conventional but great care was taken in the layout. Both amplifiers were designed for a flat response up to at least 4 Mc. The response curves for single and 2-stage operation are given in Fig. 2b and 2c. A gain control is provided in the preamplifier which allows continuous adjustment over a 8:1 ratio.

In order to reduce any possibilities of crosstalk, two separate input plugs are provided. A switch connects the power amplifier either to the output of the preamplifier or to a separate plug on the front panel. As the photograph of the chassis layout shows, the vertical deflection plate is easily accessible for direct measurements.

Voltages observed on the screen can be measured by comparing them with an adjustable 60-cps voltage, the magnitude of which can be read on a voltmeter.

A provision is made to derive "internal" synchronization from the power amplifier through a variable

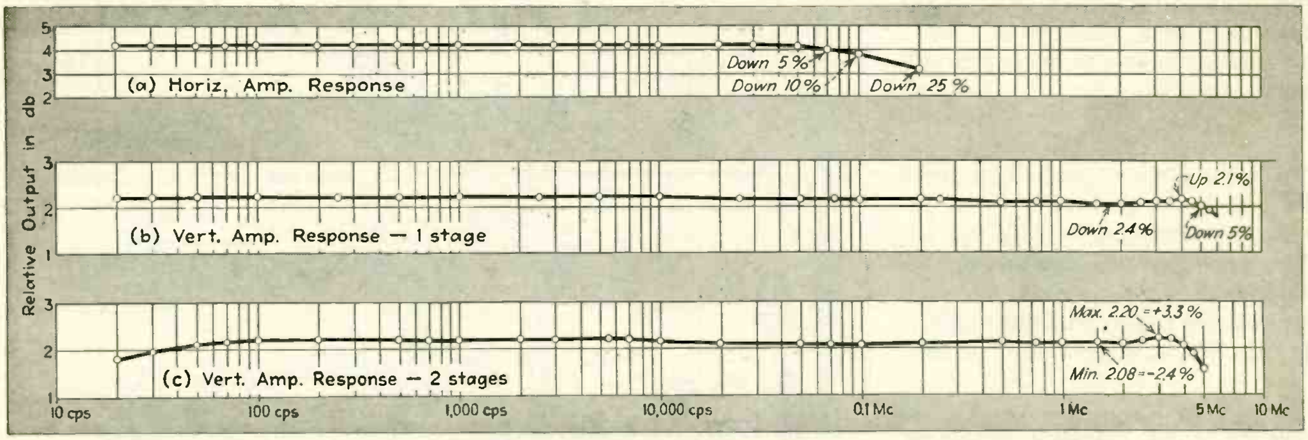
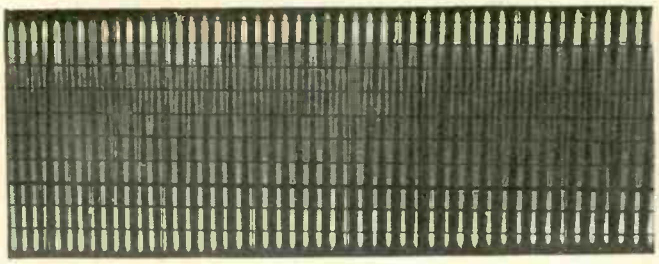
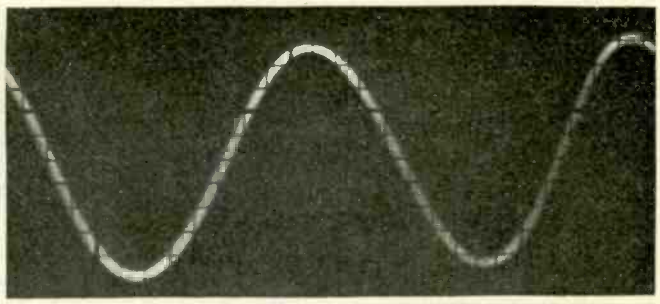


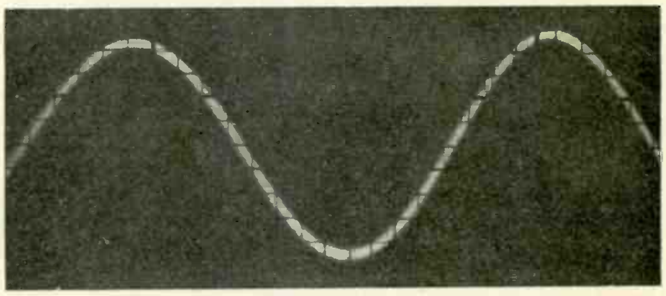
FIG. 2—Response curves for horizontal and vertical amplifiers that feed the deflection plates



(a)

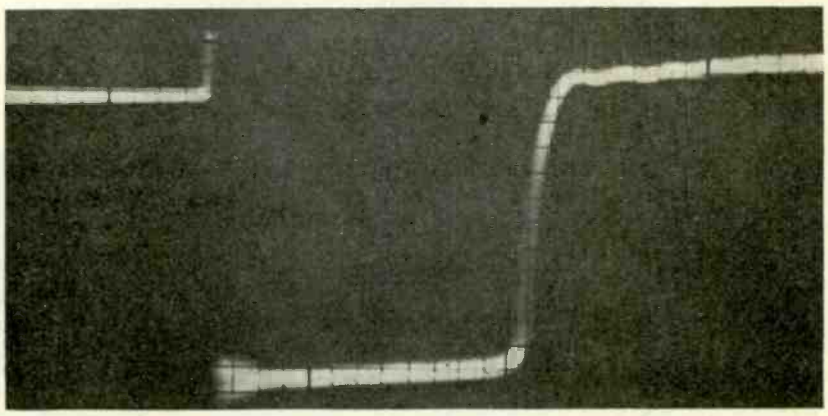


(b)



(c)

FIG. 3—Photographs (all actual size) of waveforms on screen of 9-in. cathode-ray tube in the wide-band oscilloscope, indicating performance under various conditions. (a)—Pattern with 500-kc voltage on vertical plates and 1800-cycle normal sweep synchronized directly from vertical input; (b)—Same as (a) but with fast sweep; (c)—1-Mc voltage on vertical plates, with highest possible sweep frequency; (d)—1-microsecond pulse on vertical plates, with 1800-cps magnified horizontal sweep



(d)

attenuation. A switch on this synchronizing control provides complete interruption in the minimum position. All supply voltages are regulated.

Transformers, Power-Supplies

The transformers, designed to give low external fields, are housed in a ⅛-in. welded steel case. A shield of high-permeability metal is inserted between the transformer proper and this case. These precautions, combined with a low flux density in the core, resulted in a satisfactory performance.

Separate transformers are used for the high-voltage and low-voltage supplies. The former contains a 2.5-v and a 6.3-v filament winding for both the cathode-ray tube and the rectifier heater. It is designed so that either the + or − side may be grounded. In our case the + side was grounded, which puts all amplifier outputs at low voltages.

The low-voltage supply contains one unregulated and two regulated supplies of conventional design. The whole unit is designed for mounting in a 19-in. relay rack and uses a 12¼-in. panel. Its total depth is 24 in. and its weight (without cabinet) 100 lb.

Performance

The performance can best be judged by reference to some photographs of waveforms observed on the cathode-ray screen.

The output of a 500-kc oscillator observed at a scanning rate of approximately 1800 cps using a 90-percent scan is shown in Fig. 3a. In this case the time base was directly synchronized from the same generator and was holding a frequency division rate of approximately 275:1. The synchronizing voltage applied to the time base was approximately 1.0 v rms, and the same voltage was applied to the vertical amplifier. Higher frequencies, in the order of 1.0 to 1.5 Mc, may be held and observed at the same sweep rate, but good resolution then requires lowering of the beam current which produces photographic difficulties.

The same 500-kc wave scanned at 1800 cps but observed in the "fast sweep" position where every microsecond corresponds to approximately 1 in. deflection and the total horizontal scan covers approximately 8 microseconds is shown in Fig. 3b. It is to be noted that the beam is "on" during less than 1/50 of the available time. Thus the beam current must be increased considerably in order to make observations and photography possible. The use of a high beam voltage makes this possible while maintaining sufficient focussing action.

A 1-Mc wave observed at the highest sweep frequency which the time base delivers appears in Fig. 3c. A 90-percent scan was used.

Figure 3d shows a square pulse of 1 microsecond duration, initiated by the synchronizing pulse from the shortpeak generator; a time base rate of 1800 cps was used with expanded sweep.

All photographs were taken with an aperture of $F/22$ and an exposure of 10 seconds.

Work on this wide-band oscilloscope was carried out in the Research Laboratory of General Electric Co. in Schenectady during the first three months of 1942.

Alnico machining tolerances, casting allowances, choice of alloys, cost factors, methods of mounting and other mechanical problems related to electrical design of permanent magnets are taken up, with emphasis on practical data obtained through actual experience

Mechanical Problems of PERMANENT MAGNET

By EARL M. UNDERHILL

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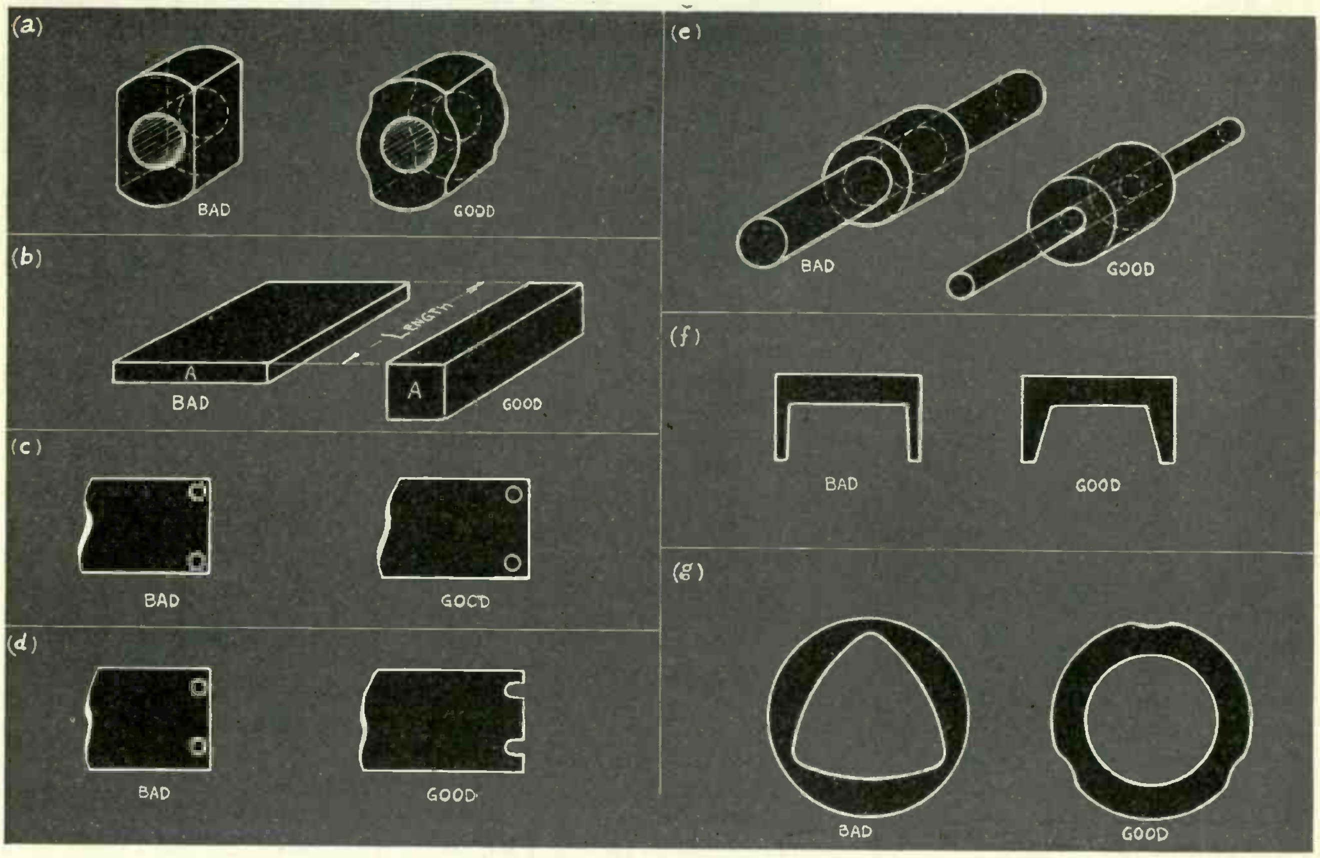
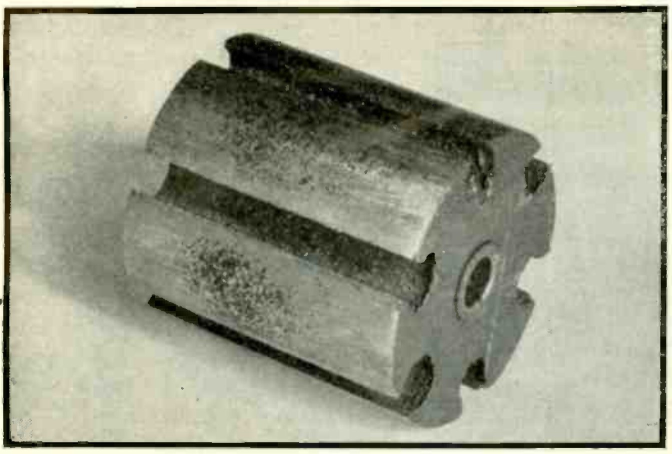
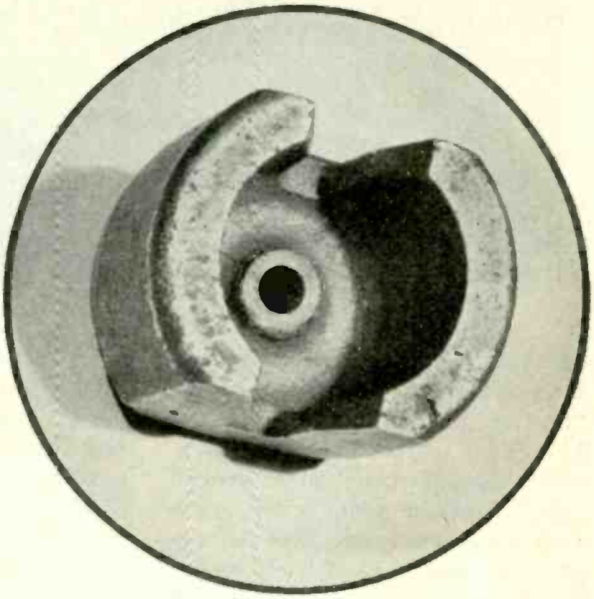


Examples of good and bad mechanical design of cast permanent magnets. (a)—widening the thinnest parts of a p-m rotor adds greatly to strength; (b)—the closer a magnet approaches a square or circle in cross-section, the fewer the cracks during production; (c)—for success in casting holes, leave ample metal between holes and outer surfaces; (d)—whenever possible, use slots in place of holes to avoid cracks; (e)—when casting a magnet around an insert like this shaft, keep the magnet area large in relation to the insert area, to prevent cracks during casting; (f)—avoid sudden changes in cross-section by tapering as shown here; (g)—strain is less when there are indentations in the outer surface than when they are on inner surfaces



Left: This rotor was cast around its bearing sleeve, then ground to final dimensions

Below: Example of a permanent magnet that has been cast around an insert of another metal



DESIGN

IN THE PREVIOUS ARTICLES of this series* we have discussed permanent magnet design from the viewpoint of obtaining optimum magnet size, i.e., the proper length and area of the smallest possible magnet, in any given alloy, capable of doing a given job.

The principles outlined in these discussions are universally applicable regardless of the designer's choice of magnet alloy. However, at some point in his work the designer is forced to make a definite choice of magnet material. Many factors usually influence this choice. Among the more important may be mentioned:

1. Space considerations.
2. Weight.
3. Economy. Here the cost of the magnet is only one factor. The designer must determine whether or not the use of a better alloy will enable compensating savings in other materials in his device.
4. Availability. This is a particularly important consideration today.
5. Machinability and workability.
6. Calibration stability and resistance to stray fields.
7. Resistance to heavy demagnetizing fields.
8. Physical strength.

Having determined the proper magnet size and alloy, the designer is obliged to make a drawing of his magnet, to specify just how it shall be mounted and to make provision for the fastening of the magnet to the rest of the magnetic circuit. This phase of the design introduces the problems of hole size and location and the methods by which the holes are formed, shaft mounting of rotors, brazing and soldering, etc. It is the purpose of this present article to consider these problems as well as those influencing the choice of an alloy. Only the aluminum-nickel-iron alloys (popularly known as Alnico and Nipermag) will be discussed here, and we shall refer to these alloys in the general sense simply as Alnico for the sake of simplicity.

Alnico Tolerances

Alnico is a very hard, brittle and (in the generally accepted sense of the word) nonmachinable alloy. It can not be turned, milled or drilled with ordinary tools but it can be ground fairly easily with any common abrasive. The alloy is cast, usually in high-frequency induction furnaces, to a size slightly greater than that to which it is to be finished, and then taken down to finished size by grinding. All holes and slots in any given piece must be cast in. If a close tolerance is required on holes in Alnico, common procedure is to cast the holes somewhat undersize and then to finish to correct size by grinding. Tables I and II list some of the known physical properties of the various grades of Alnico and Nipermag. Much of this information was obtained by the General Electric Company in its early work.

Since Alnico magnets are cast, it is, of course, impossible to form these magnets initially with a high degree of precision. Barring unusual features, a good commercial tolerance for a cast dimension of less than two inches is $\pm\frac{1}{64}$ in.; from two to four inches, $\pm\frac{1}{32}$ in. Of course, these dimensions may be ground to as small a tolerance as the user may wish and if desired Alnico may be made to take a mirror-like polish. However, the designer must bear in mind, where price is a consideration, that commercial tolerances obtain. Tight tolerances entail substantial price increases. Plus or minus 0.005 in. is a commonly specified limit between two finish ground faces of cast permanent magnets, although much closer ones can be held. The same applies to a perpendicularity

* Permanent Magnet Design, p. 126, Dec. 1943 ELECTRONICS and Designing Stabilized Permanent Magnets, p. 118, Jan. 1944 ELECTRONICS.

TABLE I—PHYSICAL PROPERTIES OF ALNICO ALLOYS AND NIPERMAG

PROPERTY	ALLOY					
	ALNICO I	ALNICO II	ALNICO III	ALNICO IV	ALNICO V	NIPERMAG
SPECIFIC GRAVITY	6.9	7.1	6.9	7.0	7.3	6.9
ELECTRICAL RESISTIVITY AT 25°C (OHM-CM/SQ.CM.)	75×10^{-6}	65×10^{-6}	65×10^{-6}	75×10^{-6}	47×10^{-6}	66×10^{-6}
TENSILE STRENGTH (POUNDS/SQ.IN.)	4000	2500	12,000	9000	5450	
TRANSVERSE MODULUS OF RUPTURE (POUNDS/SQ.IN.)	13,900	7000	22,500	24,000	10,200	
HARDNESS (ROCKWELL "C")	42-55	45-57	40-55	45-55	45-55	40-55

tolerance between a finish ground face and the center plane of the "as cast" magnet of plus or minus 1½ deg, a perpendicularity tolerance between two finish ground faces of plus or minus ½ deg, and a parallelism tolerance between opposite ground faces of 0.002 in. per linear inch across either ground face.

Casting Allowance

It was mentioned above that a casting is made slightly oversize and then ground down to finished dimensions. Well, how much oversize? This depends entirely, of course, upon the roughness of the cast surface, the thickness of its skin, and the amount of scale it bears. Generally speaking, also, the larger the surface of a casting, the more irregular it is bound to be.

These factors all add up to the following very rough but fairly accurate rule: Allow, for clean finish grinding, approximately 0.015 in. per 1.5 sq. in. of *each* surface to be ground. If, for example, we have a casting which is just 3.0 sq in. in section and which we wish to finish to a length of say 1.500 in. by grinding its two end surfaces, we should have to make this piece 1.560 in. long to allow it to clean up properly.

Actually, it would be necessary to put our casting tolerance on top of this in order to assure that even though the casting came minimum size, we should still have enough stock to clean up. Consequently, the cast length dimension for this piece should be specified as 1.576 in. ±1/64 in.

The designer must bear in mind that a magnet casting is usually made by means of a sand mold, and a mold, in turn, by means of a pattern. Provision must be made, when making the pattern, to enable its withdrawal from the mold without disturbing the sand. This is accomplished by providing the pattern with a slight taper or "draft". Naturally, this same draft is inherited by the casting itself, and the designer must be prepared for it. Fortunately, it is not large, usually amounting to about 1 deg. (This means 1 deg between a surface and the axis of the casting or 2 deg between two opposite surfaces.) For emphasis and reference convenience, the important points of the preceding few paragraphs are tabulated in Table III.

Cost Per Gauss

Economic considerations are frequently most important in the determination of the proper alloy and the proper size and shape of casting. Actual prices cannot be given as price is a function not alone of the grade of the Alnico in question but also of the weight and size of the casting, its intricacy, the amount and type of grinding, tolerances required, quantity on order, etc. Even the price relationship between the various alloys is subject to change as improvements in product and production manifest themselves.

Frequently, too, it may happen that a casting of Alnico V, for example, which has been designed to do the same job as another casting of, let us say, Alnico II, is so utterly different from the latter in size and shape that production technique of the two items is also entirely different. In such cases, any general comparison between the two alloys on a dollars per pound basis will be obviously misleading.

In general, it is necessary for the magnet designer to calculate a size and shape of casting for each alloy he has in mind to do a particular job, lay it out in detail and include all mounting holes, inserts, etc., and submit it to the magnet manufacturer for quotation. He will then be able to calculate the cost of a gauss in his working air gap for each alloy in which he is interested.

It must be borne in mind, however, that even this is not the final answer to the overall cost question. The designer must ask himself such questions as: Can I, by using a better alloy and thus increasing the flux density in my working air gap, more than effect compensating savings by using fewer turns of larger sized wire on the coil which is to operate in this gap?—or: Can I, by using a better alloy and thus reducing the weight of my magnet, more than effect compensating saving by reducing shaft, bearing and housing sizes? Also, will this reduced weight make possible entirely new applications of my device?

Factors Affecting Cost

Many factors influence the cost of a magnet. In the following tabu-

TABLE II—OPERATING TEMPERATURE RANGES AND EXPANSION DATA FOR MAGNET ALLOYS

TEMPERATURE RANGE (°C)	MEAN COEFFICIENT OF TEMPERATURE EXPANSION (INCHES/INCH/°C)×10⁶					
	ALNICO I	ALNICO II	ALNICO III	ALNICO IV	ALNICO V	NIPERMAG
20-120	11.9	11.5	13.2	12.3	11.6	11.0
20-220	12.1	12.1	13.2	12.7	11.3	
20-300	12.6	12.4	13.0	13.1	11.6	

lation is a listing of the more important factors and their qualitative effects on cost. Some of these have been mentioned previously but in the interests of completeness they are repeated.

1. *Alloy.* Alloy affects price in several ways. First, there are the raw material costs. The higher the cobalt and nickel content of an alloy, the higher its raw material cost. Secondly, there are heat-treating costs. All alloys are about on a par in this respect except Alnico V. This alloy must be heat treated in a magnetic field and hence is more costly to produce. Finally, there are spoilage costs. Certain alloys, notably those high in nickel content and low in cobalt content, require a very fast quench during heat treatment to properly establish their magnetic characteristics. Castings made of these alloys frequently develop bad cracks and rejections during production are sometimes high.

2. *Size or weight.* This is the prime basis of cost estimation. The heavier the piece (in any one alloy) the higher its cost.

3. *Quantity.* As in nearly any other field, the larger the quantity on order (up to 15,000 pieces) the lower the cost.

4. *Grinding.* The larger the surface to be ground, the higher the price.

5. *Grinding Tolerances.* The smaller the tolerances (below ±0.005 in.) the higher the price.

6. *Parallelism and Perpendicularity Tolerances.* The smaller the tolerances required (below good commercial tolerances) the higher the price.

7. *Ease of Production.* Certain magnets are of such size and shape that they may be cast as a bar of uniform cross-section and the magnets cut from the bar (by means of an abrasive cutting disc) after the pouring or heat treating operation. This procedure leads to obvious savings in production, and consequent lower prices.

8. *Shape.* Certain shapes tend to crack badly and others not at all. Production rejections due to cracks from this source seriously affect prices. More will be said of this later.

9. *Coring and Inserts.* The greater the diameter and length of the cored hole or insert, the higher the cost. In cases where the pattern is capable of forming its own core, there is no extra charge.

TABLE III—ALNICO CASTING TOLERANCES AND ALLOWANCES

ITEM		GOOD COMMERCIAL TOLERANCE
CAST DIMENSIONS	LESS THAN 2"	$\pm\frac{1}{64}$"
	2"–4"	$\pm\frac{1}{32}$"
FINISH GROUND DIMENSIONS (PLANE SURFACES)		±.005"
PARALLELISM BETWEEN GROUND PARALLEL FACES		.002"/LINEAR INCH ACROSS FACE
PERPENDICULARITY	BETWEEN GROUND FACE AND CENTER PLANE OF "AS CAST" MAGNET.	$1\frac{1}{2}°$
	BETWEEN TWO GROUND FACES.	$\frac{1}{2}°$
CASTING DRAFT		1°
GRINDING ALLOWANCE		RULE! .015"/1.5 SQUARE INCHES OF EACH SURFACE TO BE GROUND.

Mounting Magnets

One of the problems which frequently vex magnet designers severely is the answer to the question, "How shall I mount this magnet?". The material hardness of Alnico all too often presents engineers with a situation with which they are not entirely familiar. However, Alnico magnets are not difficult to mount once it is realized just what can and can not be done with them.

The most common method of mounting an Alnico magnet is by means of one or more holes or slots cast into the magnet during the pouring process. These holes usually act as clearance holes through which bolts of some sort pass and serve to clamp the magnet, usually to a plastic or nonmagnetic metallic base. Such holes are usually quite small in relation to the overall size of the casting. Much larger in this respect is the hole cast in a magneto, motor or generator rotor magnet for accommodation of the shaft on which the magnet is mounted.

Again, this mounting hole may be a clearance hole for the shaft. If it is, the magnet may be securely fastened to the shaft by means of end pieces, or the shaft may be cast into the magnet with the aid of aluminum or other suitable material such as Cerro-Matrix, a low melting alloy similar to type metal which possesses the property of expanding upon solidification and cooling. Sometimes a shaft hole is not made as a clearance hole, but instead is cast somewhat undersized and then ground to the size of the shaft. The shaft is then pressed into the magnet. This is not an advisable procedure due to the physical weakness of Alnico.

In all foundry work, the mold, of course, is the negative of the casting. Consequently, a hole in a casting is represented in the mold by some solid matter. In a sand mold, the core which forms the hole of a casting can sometimes be formed by the pattern itself when it makes its impression in the sand. This is the case where the hole has a diameter-to-length ratio great enough to allow the column of sand in the mold which forms this hole to support itself against the inrush of the molten metal during the pouring process. If the length of the hole to be formed is too great with respect to its diameter, a special core of baked sand, carbon or other materials must be placed in the

(*Continued on page* 374)

Photographing Patterns

TABLE I—Comparison of Relative Film Speeds at High and Low Densities for Various Emulsions and Fluorescent Screens

FILM	RELATIVE EXPOSURE REQUIRED					
	P1 Medium-persistence green; B = 7.5 ft-lamberts		P2 Long-persistence green: B = 1.55 ft-lamberts		P5 Short-persistence blue; B = 0.9 ft-lamberts	
	Low Density	High Density	Low Density	High Density	Low Density	High Density
Agfa Triple S Ortho	1.0	1.0	1.0	1.0	1.25	1.6
Eastman Ortho X	3.2	1.25	1.6	1.6	2.0	2.5
Eastman Superpan Press	5.0	1.25	1.6	1.6	3.2	3.2
Defender Ortho X-F	3.2	2.0	1.6	1.6	1.6	2.0
Eastman Super XX	3.2	2.0	2.0	1.6	4.0	4.0
Defender X-F Pan	4.0	2.0	2.0	2.0	4.0	4.0
Agfa Triple S Pan	4.0	2.5	2.0	2.0	4.0	4.0
Agfa Fluorapid Blue	40	....	5.0	4.0	1.0	1.0
Eastman X-ray Blue	64	....	5.0	5.0	2.0	1.6

TABLE II—Photographic Light-Producing Efficiency of Common Screens (P5 Screen-Unity)

Type of Fluorescent Screen	P1 Medium-persistence green	P2 Long-persistence green	P5 Short-persistence blue
Visual Brightness (ft lamberts)	7.5	1.55	0.9
Relative Brightness	8.3	1.7	1.0
Relative Film Speed (from Recorded Density Scales)	0.63	0.25	1.0
Test Film	Agfa Triple S Ortho	Agfa Triple S Ortho	Agfa Fluorapid Blue
Photographic Efficiency K	0.076	0.15	1.0
$1/K$ (ft lbt for equal photographic effect)	13.2	6.7	1.0

TODAY, cathode-ray equipment is in extensive use for visual observation of both transient and recurrent phenomena in nearly every field of scientific endeavor. But despite the tremendous number of applications in which such equipment is used, and the frequent necessity of obtaining photographic records of the information appearing on fluorescent screens, little information is available concerning the technique of obtaining such records and the maximum speeds of the cathode-ray beam which can be recorded photographically using standard commercial type cathode-ray tubes.

Either the published information is limited to development tubes operated under special conditions by means of which extremely high writing speeds have been recorded (up to 50,000 kilometers per second), or complicated formulas are given which the average user of cathode-ray equipment is unable to employ because of the various factors which are usually unknown and difficult to measure.

It is the purpose of this article to give data on maximum writing speeds which can be recorded photographically with commercial tubes operated at low and medium accelerating potentials. These data are based on the light output of the fluorescent screen, which, in combination with the color of the screen radiation, determines the photographic efficiency of a cathode-ray tube.

Screen brightness can be measured by simple methods which do not require connections to the high-voltage circuits of the oscilloscope. Minimum brightness values of each tube type are usually available from the tube manufacturer and thus the choice of a desirable tube is considerably facilitated.

The information given herein is divided into three parts. First, methods are outlined which lead to the determination of the most suit-

on Cathode-Ray Tubes

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Comprehensive investigation of the photography of transient traces on cathode-ray tubes indicates that writing speeds up to 1,000 km per sec can be recorded. Procedures for obtaining maximum writing speed are outlined, with alignment charts to simplify calculation

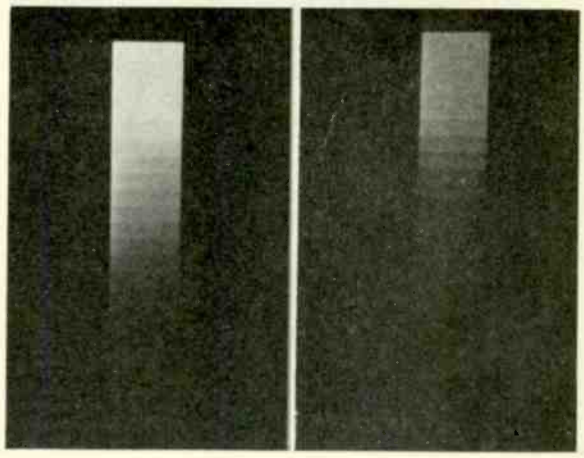

FIG. 1 (LEFT)—Step wedge gray scale as photographed from the gray scale attenuator affixed to screen of cathode-ray tube

FIG. 2 (RIGHT)—Step wedge for less sensitive film. Tables I and II were prepared by measuring such gray scales

able film emulsion and of the photographic efficiency of the more common types of standard cathode-ray tube screens. Second, the method of measuring the maximum photographic writing data is described. Finally, a tabulation of the results is given in the form of tables and graphs, with practical illustrations demonstrating the use of the tabulated data for predicting results.

Comparison Procedure

Photographic density (logarithm of opacity) and exposure (product of light intensity and time) are not related in a linear manner, but by the Hurter and Driffield or *D*-log *E* curve, in which the density, plotted against the logarithm of the exposure, results in an *S*-shaped curve. Any satisfactory method of comparing films must employ a method which permits comparison over the entire range of their sensitivity response or *D*-log *E* curve. This evaluation may be accomplished quite simply and accurately by the use of calibrated gray scales, which was the method used in this investigation. Measurements were carried out in the following manner:

(1) The visual brightness of the various cathode-ray tubes was determined in accordance with the RMA recommended procedure, i.e., with a linear raster two inches by two inches. A 60-cps saw-tooth signal was applied to one pair of deflecting plates and a 3,000-cps signal was applied to the other pair of plates producing a 50-line raster. When compressed to the extent that the line structure merges into a solid block of illumination, such a raster may be considered as a light source of equal brightness over its entire area. The brightness of the raster was measured with a Weston type 603 illumination meter provided with a Viscor filter.

(2) A calibrated photographic gray scale of the transmission type*, mounted in proximity to the fluorescent screen and illuminated by the raster, served as a calibrated attenuator with twenty approximately equal steps of brightness increase at a standard step ratio of $\sqrt[3]{2} = 1.26$. The gray scale was mounted on a protecting glass plate and was covered by a black paper through the scale. Samples of photographic records made of these gray scales under two different conditions are shown in Fig. 1 and 2.

(3) The gray scale illuminated by the raster was photographed with constant lens aperture and exposure time but with various types of fluorescent screens as light sources and different photographic emulsions. The developed negative contained a density scale graduated in successive steps exposed with exposure ratios of $\sqrt[3]{2}$. With constant development conditions, the density of the scale on the negative depends upon the brightness of the tube, the color of the fluorescent

TABLE III—Ratio of Increase of Photographic Efficiency and Visual Brightness Through Use of Intensifier

Screen	Photog. Eff. Ratio	Visual Brightness Ratio
P1 Medium-persistence green	5:1	4.7:1
P2 Long-persistence green	6.3:1	7:1
P5 Short-persistence blue	5:1	4.5:1

* Available from Eastman Kodak Co.

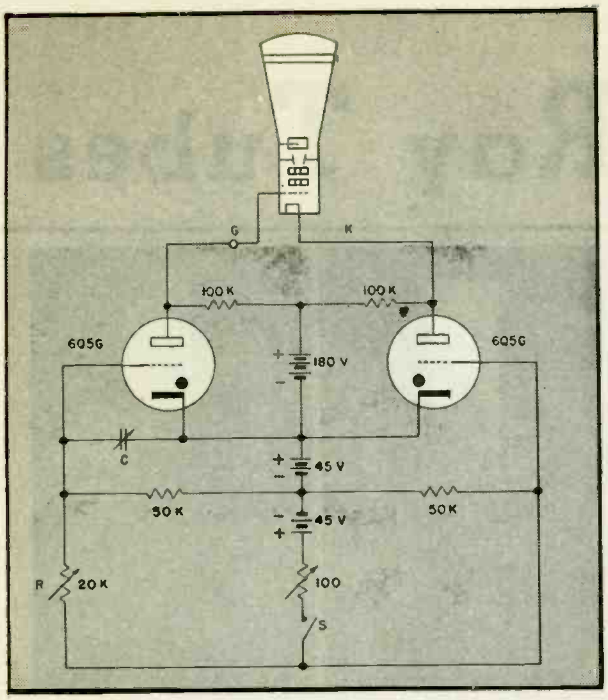

FIG. 3 (LEFT)—Schematic wiring diagram of circuit providing modulation of beam of cathode-ray tube for eliminating background light. Values used for C are 500, 5000, 50,000 and 500,000 $\mu\mu f$

FIG. 4 (RIGHT)—Calibrated density scale for determining density of photographic traces of small lines

screen, and the sensitivity of the photographic emulsion. For any given screen, the films may be compared directly by noting the density of corresponding steps on the density scale. For different screens, the comparison of different films may be made on the basis of equal visual brightness as measured by the illumination meter.

(4) Comparison of various films is easily done by superposing the films in pairs and comparing the recorded scales side by side. One of the scales is moved in a direction parallel with respect to the other until steps of equal density coincide on both scales. The number of steps by which the ends of the scales are displaced is an expression of the difference in sensitivity of the emulsion, or of the photographic efficiency of the fluorescent screen. Since adjacent steps correspond to an exposure ratio of $\sqrt{2}$, a difference of three steps means that the exposure would have to be doubled to obtain the identical negative density.

Comparison of Films

Certain emulsions behave in a very different manner at low and high densities. Therefore, the values obtained at both ends of the scales are of interest and are presented in Table I. The density of the film base and the residual fog are eliminated by this method and only densities above fog are compared.

Table I shows the relative film speeds of nine different film emulsions when exposed by the three most common types of screens employed in cathode-ray oscillography: P1 medium - persistence green, P2 long-persistence green, and P5 short - persistence blue. The films with a relative speed of 1.0 have the greatest sensitivity and serve as a reference basis. The figures shown, with relation to other film types, are the factors by which the exposure must be increased to produce the same density on the negative as was produced on the emulsion used as the basis of reference. Agfa Triple S Ortho film gives excellent results for all screen colors, while Agfa Fluorapid Blue gives slightly better results for the P5 screen.

Table II presents a summary of the photographic efficiency of the three screens, under conditions usually found in commercial equipment (Du Mont Type 175-A). The tubes were operated at medium voltages and brightness. The photographic efficiency K is obtained by dividing relative film speed by relative brightness. Note that for the P1 screen more than thirteen foot-lamberts are required to secure the same photographic effect as is produced by one foot-lambert using the P5 screen.

Effect of Intensifier Electrode

Table III indicates the extent to which the visual brightness and photographic efficiency can be increased by means of an additional electrode intensifier located between the deflecting plates and the screen. It is held at a positive potential with respect to the second anode so as to impart additional kinetic energy to the electron beam after deflection. Tube types such as the 5CP1 and 5LP1 are constructed with this additional electrode. It can be seen that the increase of efficiency corresponds to the increase of visual brightness.

To summarize the results of the initial investigation it may be concluded:

(1) Agfa Triple S Ortho Film is desirable for recording the radiation from P1, P2 and P5 screens, while Fluorapid Blue gives slightly better results with the P5 screen. For high-speed recording Triple S Ortho is somewhat superior to Fluorapid Blue.

(2) Using the film most suitable for each fluorescent screen, the P1 screen requires more than thirteen times the visual brightness (as measured with the illumination meter) of the P5 screen to produce equivalent photographic effects on the negative.

(3) Blue - sensitive emulsions such as Fluorapid Blue and X-ray Blue are not desirable for recording radiation from a P1 screen.

(4) Comparisons were made using a single standard condition for development. However, once the most suitable emulsion has been selected (from Table I) it is possible to improve results by employing film development procedures which make possible the attainment of maximum speed for the emulsion selected.

(5) Proper use of the intensifier electrode increases visual brightness and photographic efficiency

five-fold, compared to results obtained without an intensifier.

These results were obtained using the cathode-ray tube screen as a steady light source. Effects caused by screen persistence characteristics are therefore disregarded. It is in order, therefore, to investigate the behavior of the two most suitable film emulsions at high-speed dynamic conditions.

Definitions and Standards

It is essential to use certain definitions and standards as a basis for an easy comparison of photographic results. The standards employed are those used by other investigators.

The maximum photographic writing speed is the maximum speed of the luminescent spot which produces a recording of density 0.1 above fog at an object-image ratio of 1:1 with a lens aperture of $F/1$

TABLE IV—Film Sensitivity Rating Under Dynamic Conditions:

Light source: P5 tube on 175-A with intensifier. Maximum brightness B = 0.9 ft-lambert (same conditions as for Table I) Development: D76, 10 minutes. Signal amplitude: ± 1 cm constant.

Emulsion	Photographic Density		
	$f = 1$ kc, $F = 4.5$	$f = 10$ kc, $F = 1.5$	$f = 100$ kc, $F = 1.5$
Agfa Fluorapid Blue	0.36	0.34	0.02
Agfa TSO	0.36	0.37	0.04
Agfa SPP	0.30	0.30	*
Agfa TSP	0.23	0.25	*
Eastman Ortho	0.21		
Eastman Ortho X		0.23	*
Eastman SPP	0.20	0.22	*
Eastman Super XX	0.18		*
Defender KF Panchro	0.06		
Eastman SXX		0.21	
Defender XF Ortho		0.14	

* Too weak to be measured accurately.

on an unspecified high-sensitivity emulsion developed with high-contrast developer.

The relation between illumination intensity on the photographic film, I', the light radiation of the object, I, the transmission of the lens system, T, the object-image ratio, M, and the lens aperture, F, can be expressed by the formula

$$I' = \frac{I\,T}{4F^2\,(1 + M)^2} \qquad (1)$$

The artifice of recording oscillograms reduced in size permits securing higher writing speeds. If V_1 is the writing speed at the screen, recorded for an object-image ratio $M=1$ and V is the writing speed on the screen at any reduction ratio M, it follows that

$$\frac{V}{V_1} = \frac{4}{(1 + M)^2} \qquad (2)$$

This equation shows that photographic writing speed cannot be increased by more than a factor of four even with extreme reduction in size. The values appearing in this discussion for maximum writing speeds always refer to $M=1$ and $F=1$.

The manufacture of sensitive photographic emulsions is far from stabilized, and no standard emulsion has been established. The film emulsions and development procedure finally adopted were selected empirically from the most sensitive commercial emulsions and developer.

Determination of Writing Speeds

The pattern which the spot describes on the screen must be a simple geometrical form if calculation of the speed at which the spot moves is to be facilitated. Furthermore, the spot should traverse the screen but once throughout the duration of exposure for any single reading.

A geometrically simple and easily generated pattern which conforms to the above requirements is a sine-wave transient of known frequency f and amplitude A. The writing speed of the spot is then the vector sum of the horizontal and vertical velocity components. If the horizontal component is kept relatively small, as by using a low sweep frequency and a small sweep amplitude, it may be neglected; the vertical component, which follows the cosine function, then gives a close approximation to the writing speed.

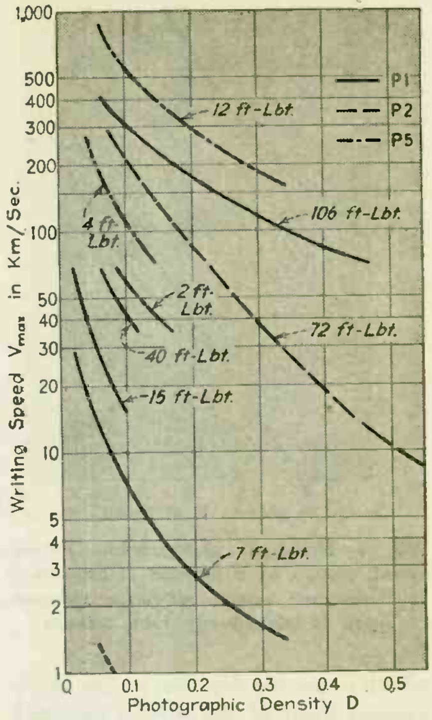

FIG. 5—Graph of writing speed plotted against photographic density for various screens and various screen brightness values in foot-lamberts

The maximum writing speed, S, of the spot describing a sine wave, occurs at the cross-over point on the axis and consequently may be expressed as $S=2\pi fA$. The sweep frequency f_s is maintained at a value of one-tenth f, the sweep amplitude at approximately five cm, and the sine wave amplitude at approximately one or two cm, peak to peak. A single-stroke sweep produced by a circuit using a high-vacuum tube is used to provide axis deflection up to a maximum speed corresponding to 5 Mc.

Elimination of Background Light

The density of the photographic images recorded on the film must remain unchanged by any external influence. Therefore, the exposures are made with the oscilloscope and camera in practical darkness. Furthermore, the light produced by the spot in its stand-by position before the operation of the single sweep must be suppressed by a black mask on the tube. The influence of the background light is kept small by using a high-speed shutter, synchronized with the single sweep.

This system operates satisfactorily up to approximately 6000 volts total accelerating potential, at

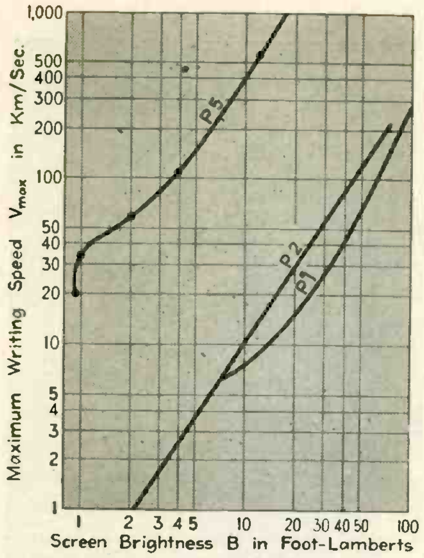

FIG. 6—Maximum photographic writing speed, plotted as a function of brightness of fluorescent screen for three common types of cathode-ray tube screens

which point the fog due to the background light of the screen becomes objectionable (even at shutter speeds of 1/100 second) and danger of permanent damage to the screen by burning becomes imminent. Finally, at high frequencies (above 1 Mc) the adjustment of the equipment becomes difficult, since the signal becomes nearly or completely invisible because of masking by the background light. (It was possible to record on blue screens with satisfactory density high-frequency transients which were completely invisible to the eye.)

Beam modulation permits overcoming background light difficulties. A recurrent sine wave is applied to the deflection plates of a tube which is biased beyond the cut-off point. Previously the tube was focused at zero grid bias, and screen brightness was measured with the two-inch standard raster. Then a single rectangular wave pulse, whose duration is equal to, or less than, one period of beam frequency, is applied to the grid of the cathode-ray tube. The amplitude of signal delivered by the beam modulation circuit shown in Fig. 3 is sufficiently high to permit full modulation of any standard cathode-ray tube up to zero bias.

This pulse amplitude is limited to the zero-bias value by means of a diode which is connected across the cathode-grid terminals of the cathode-ray tube, preventing positive grid potential. As in the case of the single transients, the sweep frequency is generally $f_s = 0.1\ f$, and the maximum writing speed of the spot on the screen is

$$V = 2\pi fA \text{ cm/sec} \qquad (3)$$

where A is measured in centimeters.

Measurement of Recorded Density

According to the definition given previously, we consider, as a maximum writing rate, the speed which produces a density of 0.1 above fog on the photographic emulsion after development in a high-contrast developer. Since the photographic record of the transient occurs as a fine line it is necessary to find a rapid method of measuring accurately the density (above fog) of a large number of thin lines whose thickness ranges from 0.1 to 1 mm.

The method employed is believed to be new and is analogous to the method of calibrated wedges previously dscribed. Briefly, a set of lines of calibrated and constant density is compared visually with the recordings to be measured. It has been found extremely difficult to compare visually the densities of areas whose dimensions are dissimilar, such as the density of a recorded thin line with respect to a calibrated standard wedge. It is even difficult to compare lines of incommensurate width. In such a case, the apparent density of the thin line will appear less than its actual density, especially at low density values. Conversely, lines which are similar may be compared with a high degree of accuracy and ease. Consequently, two sets of lines of 0.3 and 0.6 mm thickness are recorded and their densities calibrated. The density of these reference lines is determined by means of a calibrated densitometer. Since it is difficult to measure the density of the lines directly because of their small width, a larger area exposed under the same conditions and having the same density as to the corresponding line is recorded adjacent to each line.

A reduced copy of one of these reference scales is shown in Fig. 4. The comparison of the calibrated lines (with densities of longer areas recorded) is done by superposing the reference scale with the record transient, making the linear part of the sine wave pattern parallel and close to the calibrated lines, until one of these lines matches the transient. By this means, densities above fog are directly compared and the "apparent" density of the recorded lines is taken instead of the integral of density. This method permits measurement of a large number of photographic recordings in a very short time and with sufficient accuracy (density ± 0.01 at low densities.)

Measurement of Tube Parameters

The data concerning the photographic writing rates of cathode-ray tubes should be presented in such a manner that it becomes possible to determine immediately

TABLE V—Density Recorded for Different Conditions of Exposure

Screen	Freq.	Lens Aperture	Film	Recorded Density	Total Acceleration Pot.
P5	1 kc	1.5	TSO SPP	0.60 0.75	2.7 kv
P5	1 kc	16	TSO SPP	0.12 0.06	2.7 kv
P5	100 kc	1.5	TSO SPP	0.06 0.03	2.7 kv
Experimental	100 kc	1.5	TSO SPP	0.60 0.75	9.7 kv
Experimental	1 Mc	1.5	TSO SPP	0.26 0.16	9.7 kv

whether a given photographic problem in cathode-ray tube oscillography can be solved through the use of a given tube operated in accordance with given electrical conditions. The writing speed is determined by the brightness and color of the screen, which in turn are determined by the screen material, its thickness and the amount of power dissipated per unit area of the screen.

A simple and logical way to measure the photographic writing speed is to consider it a function of the brightness of the fluorescent screen rather than of the electrical parameters of the tube itself, for brightness can be measured by the user with sufficient accuracy using simple instruments.

Accordingly, the photographic writing speed is measured as a function of the screen brightness at zero grid bias and with the standard two-inch raster in focus. Consequently, the brightness of the tube is measured under the same conditions and with the same spot size which exists for the recording of the pattern. This method results in independence from individual tube characteristics, and the plots obtained result from measurements secured on several tubes of the same screen material. Finally, the results obtained give a figure of merit for the visual efficiency as well as for the photographic quality of the tubes. The electrical characteristics of the tubes are measured and recorded as parameters.

Film development time and temperature must be carefully checked and maintained constant. Fresh developer must be used for each development. By means of these precautions (and others not described) it is possible to develop each negative in a large series of films under practically identical conditions.

Electrical Conditions

Measurements are carried out using a standard commercial cathode-ray oscilloscope providing a total accelerating potential of 2700 volts as a basic power supply for the cathode-ray tube. Once the limit of recordings with the normal accelerating potential was reached, the brightness of the tube screen

TABLE VI—Brightness and Writing Speed Increase from Medium to High Accelerating Potentials (2.7-9.7 kv)

Screen	Brightness Increase	Increase in Writing Speed
P1	14.2	43
P2	46.5	300
P5	13.4	26.5

was increased by applying a variable post-accelerating potential to the intensifier electrode of the tube. The maximum post-acceleration potential was limited by the danger of screen burning, by the astigmatism of the tube, and by the intensity of background light. This limit was about 5 kv with respect to ground or about 6000 volts with respect to cathode.

Recording With Beam Modulation

As it is intended to determine the extreme limit of photographic writing speeds which can be obtained with commercial tubes, it is not undesirable to increase the brightness of the tubes further by increasing accelerating potential and beam current up to the safety limit of the tubes. An obvious method of doing this without damaging the tube is by means of beam modulation, as outlined above. The circuit used is shown in Fig. 3.

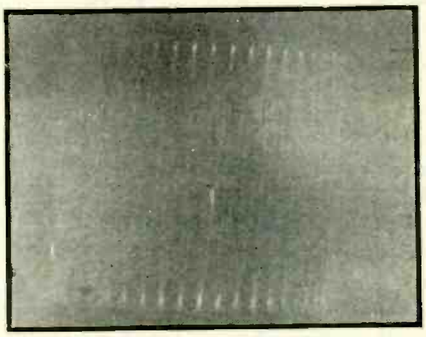

FIG. 7—Typical photograph of high-speed transient photographically recorded under the following conditions: Film: Agfa Triple S Ortho. Screen: Experimental. Lens aperture: F = 1.5. Screen brightness: 60 ft. lbt. Scanning frequency: 3.5 Mc. Trace amplitude: ± 2.1 cm. Density: 0.04 above fog. E_{A3}: 9,700 volts; E_{A2}: 3,000 volts. Writing speed: 1,040 km per sec. This represents the limit of practical operation

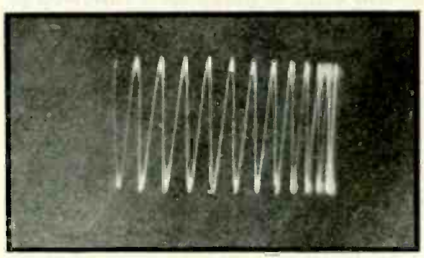

FIG. 8—A typical photographic of transient recording, made under the following conditions: Film: Agfa Triple S Ortho. Screen: P5, short persistence blue. Lens aperture: F = 1.5. Scanning frequency: 3 Mc. Trace amplitude: ± 1 cm. Density: 0.12 above fog. E_{A3}: 9,700 volts. E_{A2}: 3,000 volts. Writing speed: 440 km per sec

This circuit permits producing single rectangular pulses, the durations of which are continuously variable from about 1/30 second to a fraction of one microsecond. As the entire circuit including batteries is at cathode potential, it must be carefully insulated from ground.

Development Procedure

From the previous investigation Triple S Ortho Film was found to give the best results for P1 and P2 screens, while Fluorapid Blue was slightly better for P5 screens. Development was carried out for 10 minutes at 65 deg F using Eastman D76 developer. The behavior of these same films at high frequencies must be tested; upon the recommendation of the manufacturer, Superpan Press film was added to this list. Table IV contains a tabulation of the results.

It can be seen that a frequency of 100 kc appears to be the recording limit at low voltages. The best results are obtained with Triple S Ortho film. The density can be further increased by using a more active developer but the fog increases simultaneously with increase of density and a compromise must be made.

A satisfactory compromise can be made by developing films for 8 minutes at 65 deg F in formula D72, other conditions remaining the same. A density D=0.07 was obtained for Triple S Ortho at f=100 kc, which compares to the value of D=0.04 obtained with the former development method under the same development conditions. Fluorapid Blue produces a very high fog and must be eliminated. Consequently Triple S Ortho and development in D72 for eight minutes has been employed for all the following recordings on which the measurement of photographic writing speeds is based.

The problem was therefore con-

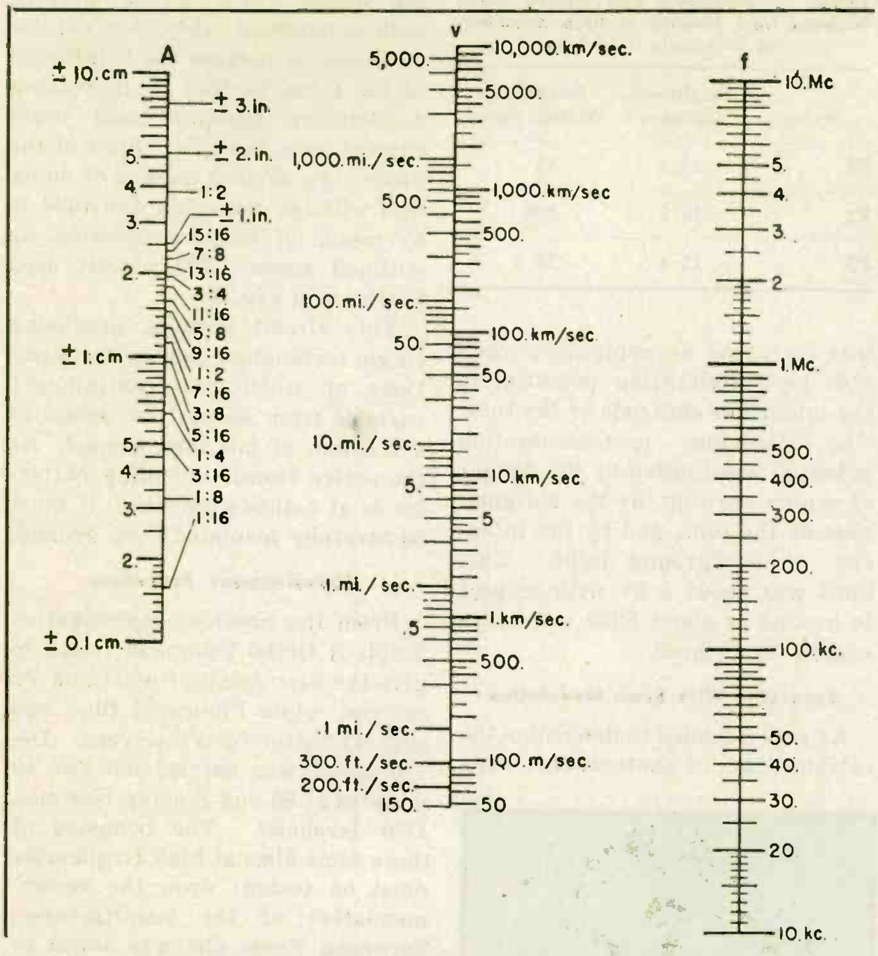

FIG. 9—Alignment chart relating amplitude, frequency, and maximum writing speed for sinusoidal traces

siderably simplified, insofar as Agfa Triple S Ortho seems to be the most sensitive emulsion for all the screen materials investigated, so long as low exposures are considered, resulting in a record density less than 0.3 regardless of the duration of the exposure. Table V shows the recorded density for different exposures.

Table V indicates that when the exposure (i.e. the product of light intensity and time) is sufficiently high, Super Pan Press gives higher recorded density and should be substituted for Triple S Ortho. It is shown that this holds true for a range from 1 kc to 1 Mc and probably beyond. It can be seen how the same pattern, recorded by lenses of different aperture, can produce results which are in favor of one or the other of both films, according to the total amount of exposure. The importance of using high-speed lenses is emphasized.

The graph of Fig. 5 has been used to determine the maximum writing speed V_{max} corresponding to density of 0.1 above fog. The values of V_{max} are referred to a lens aperture of $F = 1$ and to an object-image ratio $M = 1$ according to the definitions outlined. The values at highest brightness (9.7 kv) have been obtained with beam modulation.

Maximum Writing Speed

In Fig. 6 the maximum writing speed, V_{max}, is given as a function of brightness for different screen materials. The lowest values at which the curves start are measured with 2.7 kv accelerating potential and maximum brightness, while the highest values were obtained at nearly 10 kv total accelerating potential and with beam modulation.

It is interesting to note that at low voltages the values of the maximum writing speeds are widely different for the various screens, the minimum being 0.7 and the maximum 20 km per sec, which represents a ratio of about 1:29. At high voltages all the screen materials investigated produced high recording speeds with only slight variations. The maximum speed was 560 and the minimum 210 km per sec, giving a ratio of 1:2.7.

This result obtained for different screens is also valid for individual tubes of the same type. While at low voltages the efficiency of a tube depends to a high degree on the quality of the electron gun, at high accelerating voltages only the total accelerating potential appears important, and a number of tubes of the same type show nearly the same results.

The increase of efficiency with accelerating voltage is shown in Table VI where brightness increase (and corresponding increase of writing speed) are given for the various screens. The figures of the table are based on data plotted in Fig. 6. Table VI shows that, at low voltages, screens with a high photographic efficiency (such as the P5) show relatively little increase in photographic effectiveness as the accelerating voltage is increased. On the other hand the photographic effectiveness of the P2 screen, which has a very low overall efficiency at low voltages, increases rapidly and becomes excellent at high accelerating potentials. The fact that the photographic efficiency increases so much more than the visual brightness can be explained only by a considerable change in color at higher voltages—the light becomes richer in blue actinic radiation.

With this information available and considering the tubes selected as representing each type, the following conclusions are apparent:

(1) The P5 screen produces the highest photographic writing speed.

TABLE VII — Photographic Efficiency Rating

Medium Voltage (2.7 kv)		High Voltage (9.7 kv)	
Screen	Relative Photog. Eff.	Screen	Relative Photog. Eff.
P5	1.0	P5	1.0
P1	0.35	P1	0.53
P2	0.035	P2	0.38

(2) P2 screens should not be employed at low voltages, but give very satisfactory results at high voltages.

Ratings of photographic efficiency of various screens at medium and high voltages, referred to voltage on the tube using a P5 as reference, are given in Table VII.

Practical Applications

When the brightness of the tube which is to be used for photographic recordings is measured by means of a standard two-inch raster and an illumination meter equipped with Viscor filter, the corresponding maximum photographic writing speed V_{max} can be found on the graph of Fig. 6. Most cathode-ray tube manufacturers are in a position to provide information concerning the minimum screen brightness for any standard type of tube in cases where the user does not have access to a suitable illumination meter. Certain manufacturers have expressed willingness to provide more accurate brightness data on any single tube which is to be used for photographic recording applications. It should be considered that such brightness values will change throughout the life of the tube.

Once the maximum brightness for a tube is known, this data serves as a standard of calibration with which an ordinary exposure meter with photocell may be used to adjust the brightness level to a value desired for any particular application.

For all practical purposes it is advisable to divide the maximum writing speed, V_{max}, by two to provide a sufficient margin of safety and to obtain recordings of higher density that 0.1. Figure 7 shows a recording at $V=1040$ km per sec (density 0.04.) Figure 8 is a recording of sufficient density (density 0.12) for comparison. The values of the graph of Fig. 6 are valid for a lens with an aperture of $F=1$, an object-image ratio of 1:1 and for Agfa Triple S Ortho Film with development formula Eastman D72, 8 minutes at 65 deg F.

Figures 9 and 10 are nomographs designed to facilitate solving practical problems. Figure 9 demon-

(*Continued on page* 262)

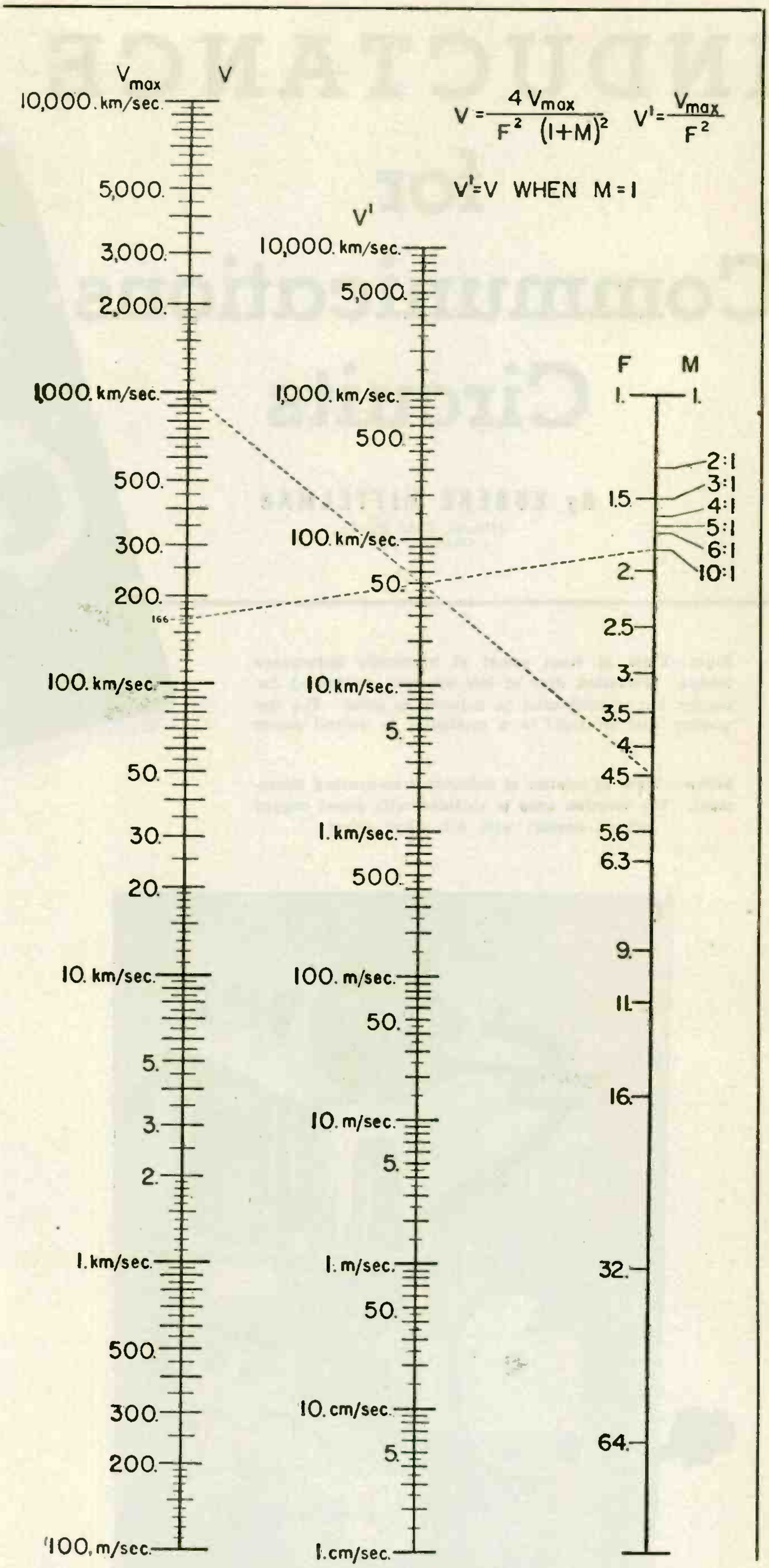

FIG. 10—Alignment chart for determining writing speed in terms of lens aperture *F*, object-image ratio *M* and maximum writing speed V_{max}

INDUCTANCE BRIDGE for Communications Circuits

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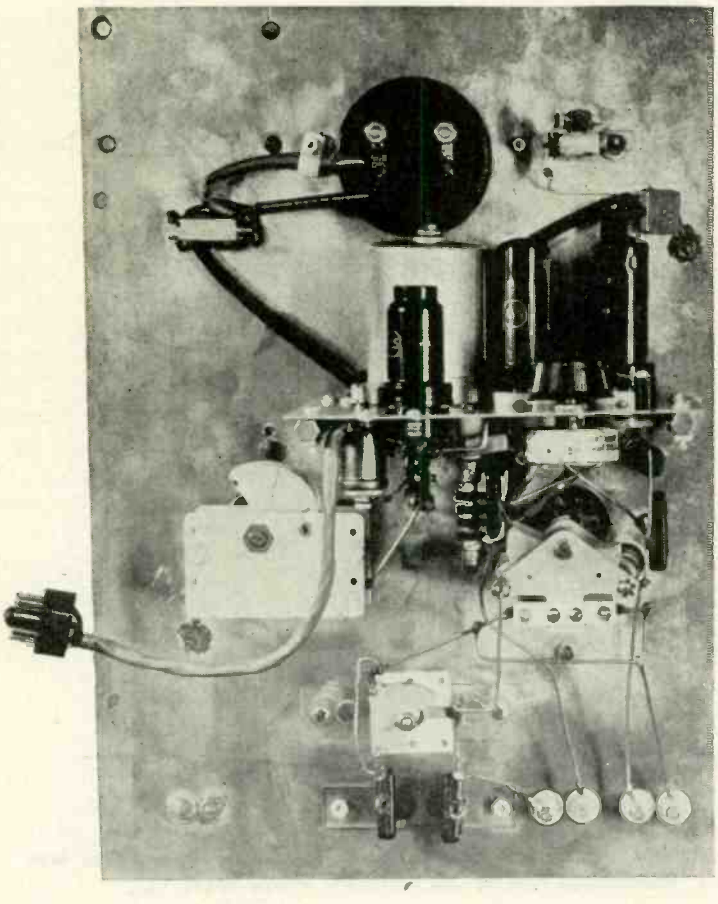
Right—View of front panel of electronic inductance bridge. Precision dial at left operates calibrated capacitor but is calibrated in inductance units. The frequency dial at right is a multiplier to extend range

Below—View of interior of inductance-measuring instrument. The wooden case is shielded with sheet copper making contact with the metal panel

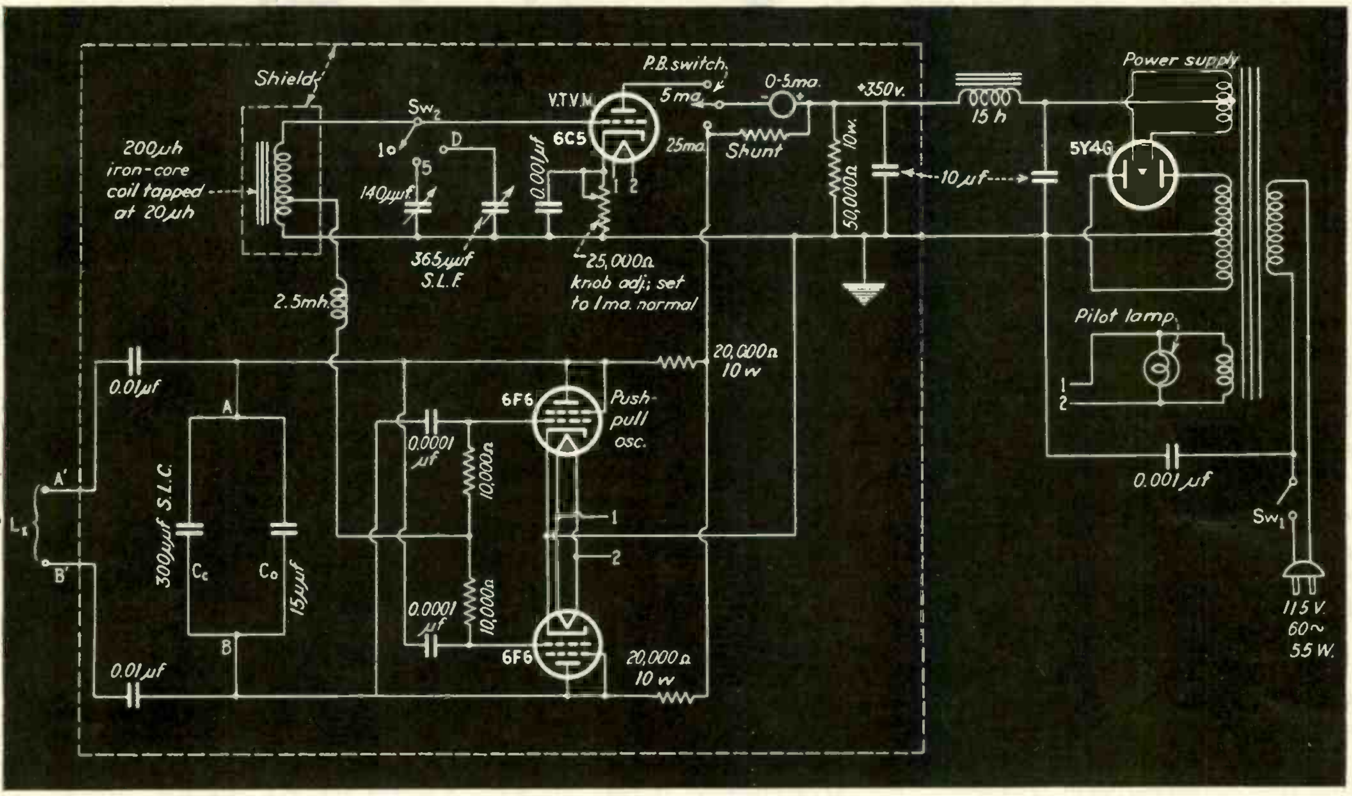


THIS article describes a combination oscillator, resonance detector and power supply suitable for the measurement of small values of inductance as used in many radio circuits. This instrument has been in operation for a number of years and its usefulness has been proven in many routine measurements in our electronics laboratory.

Essentially the instrument is composed of three separate circuits: (1) a two-terminal push-pull oscillator, whose frequency of oscillation is determined by the inductance to be measured and by the capacitance of a calibrated capacitor incorporated within the instrument; (2) a vacuum-tube voltmeter with tuned input circuit for indicating resonance; (3) a rectifier-filter power supply unit for operation from the 115-volt line.

Functionally the operation of the measuring instrument is as follows: The oscillator is made to generate alternating current at a

Values of inductance commonly employed in communications circuits may be measured accurately in terms of a calibrated capacitor and electronic resonance indicator. Low cost is a feature of this instrument



Schematic wiring diagram of oscillator, detector and power supply for measuring small inductances

frequency dependent upon the LC constants of its input circuit. A portion of the power from the output of the grid circuit of the oscillator is then fed to the tuned circuit of a vacuum-tube voltmeter whose resonant frequency is known. The calibrated capacitor of the oscillator is then varied until maximum current is found to flow in the plate circuit of the resonance indicator. From this indication and the calibration of the instrument dials, the unknown inductance can be determined.

Negative Resistance Oscillator

The two 6F6 oscillator tubes provide a negative resistance between terminals A and B in the circuit diagram. Therefore any resonant circuit connected between these terminals will be forced into oscillation at its natural frequency of resonance. The highest frequency which can be generated by this method is limited by the length of the shortest physical connections which can be made between the plates of the two tubes. Frequencies as high as 75 Mc can be obtained with such a circuit arrangement.

If a calibrated capacitor is connected between terminals A and B and a coil of unknown inductance is connected between terminals A' and B', the value of self inductance can be determined from the calibration of capacitor C_c and the frequency at which the oscillator operates. The calibrated capacitor is thus used to measure inductance and its dial is marked "Inductance".

The distributed capacitance of the coil will be in parallel with that of the calibrated capacitor and will introduce a slight error which may be eliminated by making measurements at two different frequencies. The two series capacitors of 0.01 μf each have sufficiently large capacitance that they will not introduce appreciable error. Capacitor C_o is an index adjustment which is useful in setting the zero of the instrument when a coil of known inductance is connected across terminals A' and B'. The range of measurements can be extended by changing the LC constants of the resonance indicator, as described below.

Resonance Indicator

An essential part of the measuring instrument is a vacuum-tube voltmeter resonance indicator. To obtain a known or standard frequency as the reference point, a high-Q tuned circuit is connected between the grid and cathode of the resonance detector. In the present instrument, a powdered iron-core coil of high Q is placed in a shielded metal case and, with its distributed capacitance, provides resonance at 1.7 Mc. A tap on this coil at 20 μh is connected through a 2.5-mh coil to the midpoint of the grid resistors of the oscillator tubes. This loose coupling between the oscillator and vacuum-tube voltmeter assures that the resonance of one circuit

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The MULTIVIBRATOR Applied Theory

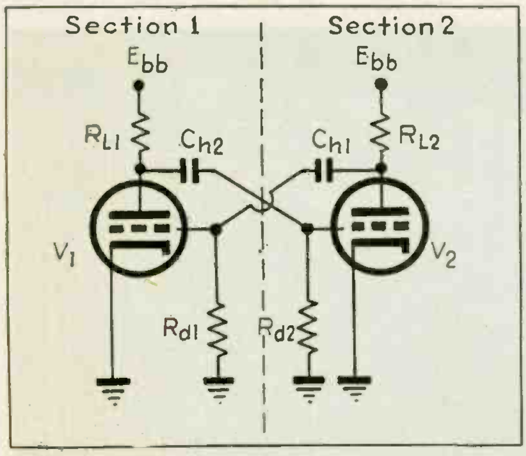

FIG. 1.1—Basic multivibrator circuit, reprinted from Part I

This, the second part of a three-part paper, considers the multivibrator in which synchronizing voltage is supplied to both tubes

IN PART one of this paper, which appeared in the January issue of ELECTRONICS, it was shown that if

$$C_{h1}\left(R_{L2} + \frac{R_{d1}\,R_{c1}}{R_{d1} + R_{c1}}\right) \lesssim \frac{T_2}{5} \quad (1.9)$$

and if

$$C_{h2}\left(R_{L1} + \frac{R_{d2}\,R_{c2}}{R_{d2} + R_{c2}}\right) \lesssim \frac{T_1}{5} \quad (1.9)$$

then the natural period of the multivibrator of Fig. 1.1 is defined by

$$T_{mv} = T_1 + T_2 = \frac{1}{\alpha_1}\log_e(k_2\,\mu_{co1}) + \frac{1}{\alpha_2}\log_e(k_1\,\mu_{co2}) \quad (1.7)$$

where $T_1 = N_1 T_s =$ the portion of the MV period contributed by section 1, i. e., the non-conducting time of V1, and T_2 is the non-conducting time of V_2. If both tubes of a MV are to be synchronized and a fraction, r, of the period of the synchronizing wave is to be included in the order of division of one section of the MV, a difference of phase

$$\phi = 360r \textit{ degrees} \quad (2.2)$$

must exist between the synchronizing pulses supplied to the two tubes. In such a case, the complementary fraction (1-r) will be included in the order of division of the other section. The overall order of division, T_{mv}/T_s, of the MV will always be an integer.

Correlation of Synchronizing Voltage Amplitude with MV Natural Frequency

Three conditions must be satisfied in the design of a synchronized MV, if the greatest possible variations in the amplitude of the synchronizing signal and from the nominal values of the capacitor-resistor time constants are to be allowed for. This is desirable to stabilize the order of division of the circuit against changes of temperature and power supply voltage, replacement of tubes, etc. If it is assumed that once the amplitude of the sychronizing voltage is adjusted it remains constant, then the nominal value of CR (the discharge time constant) and the amplitude of the synchronizing voltage must be so selected that:

Condition 1 The desired percent decrease of CR can be tolerated without the MV dividing by a smaller number.

Condition 2 The synchronizing pulse is of greater amplitude than the change of grid voltage along its exponential decay curve between the (N-1)th and the Nth pulses[5]. This is necessary to insure that the natural period of the MV cannot lie between these pulses.

Condition 3 The desired percent increase of CR can be tolerated without the MV slipping synchronism or dividing by a larger number.

It will be shown that if the MV design satisfies Conditions 1 and 3, then Condition 2 is automatically satisfied.

Condition 1 sets a maximum value on the amplitude of the syn-

[5] Although N is not limited to integral values, the pulse preceding the one that normally trips the MV will be referred to as the (N-1)th pulse.

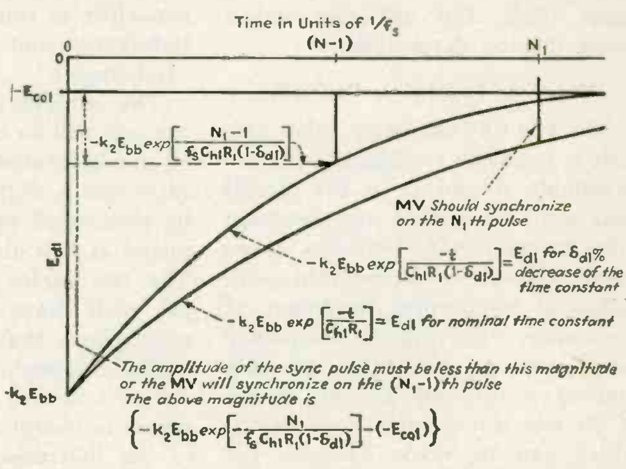

FIG. 2.3, 2.4 and 2.5—These illustrate conditions 1, 2 and 3 which must be satisfied in the optimum design of a synchronized MV

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and Design . . . Part II

chronizing pulse and Conditions 2 and 3 limit its minimum amplitude. If the maximum value permitted by 1 is at least as large as the larger of the two values required by 2 and 3, all three conditions can be satisfied simultaneously.

The equation which describes the exponential voltage across R_{d1} is [6].

$$E_{d1} = -k_2 E_{bb} \exp\left[-\frac{n}{f_s C_{h1} R_1}\right] \quad (2.3)$$

In this equation, k_2 is a function of the resistances in the circuit, $C_{h1}R_1$ is the discharge time constant and n/f_s is time.

Condition 1 is illustrated in Fig. 2.3 and is expressed mathematically as

$$E_{s1} < -\left\{-k_2 E_{bb} \exp\left[-\frac{(N_1-1)}{f_s C_{h1} R_1 (1-\delta_{d1})}\right] - \left(-E_{co1}\right)\right\}.$$

The minus sign preceding the brace indicates that the polarity of the synchronizing voltage must be opposite to that of the difference between the value of the grid voltage and $-E_{co1}$. Define $E_{s1} = A_1 E_{co1}$ and $E_{bb}/E_{co1} = \mu_{co1}$, then

$$\left(\frac{1+A_1}{k_2 \mu_{co1}}\right) < \exp\left[-\frac{(N_1-1)}{f_s C_{h1} R_1 (1-\delta_{d1})}\right]. \quad (2.4)$$

Unless (2.4) is satisfied, the MV will trip on the $(N_1\text{-}1)$th pulse if $C_{h1}R_1$ decreases by δ_{d1} percent. (Note that for values of N_1 less than one, time $(N_1 - 1)/f_s$ occurred before V_1 became non-conducting. Therefore, (2.4) is useful only for values of N_1 greater than one.)

The requirement to satisfy Condition 2 is illustrated in Fig. 2.4 and (2.5) expresses this condition mathematically.

$$E_{s1} > -\left\{-k_2 E_{bb} \exp\left[-\frac{(N_1-1)}{f_s C_{h1} R_1 (1-\delta_{d1})}\right] - \left[-k_2 E_{bb}\right] \exp\left[-\frac{N_1}{f_s C_{h1} R_1 (1-\delta_{d1})}\right]\right\}.$$

$$\frac{A_1}{k_2 \mu_{co1}} > \left\{\exp\left[-\frac{(N_1-1)}{f_s C_{h1} R_1 (1-\delta_{d1})}\right] - \exp\left[\frac{-N_1}{f_s C_{h1} R_1 (1-\delta_{d1})}\right]\right\} \quad (2.5)$$

The value $(1 - \delta_{d1}) C_{h1} R_1$ is used because it is for the maximum decrease in $C_{h1}R_1$ that there is the greatest possibility that the natural period of the MV may lie between the (N_1-) th and the N_1th synchronizing pulses.

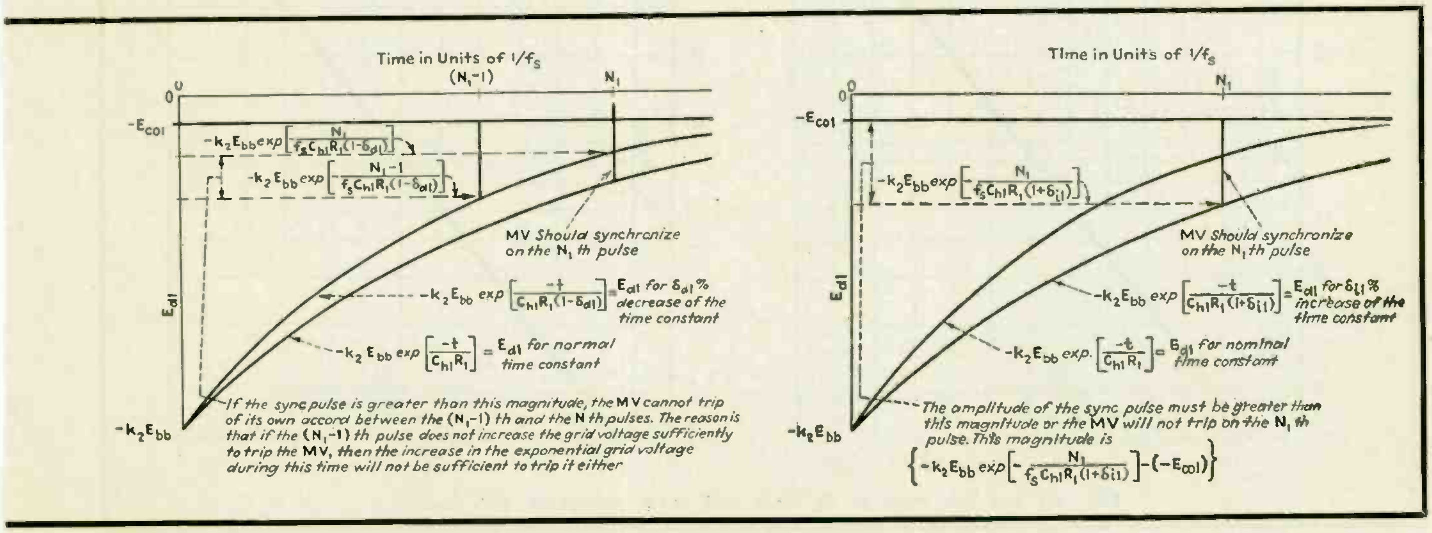
To express the third condition mathematically, it is necessary to know the critical value of grid voltage. Due to the regenerative connection of the circuit, an infinitesimal amount of current flowing in V_1, the grid voltage of which is increasing toward $-E_{co1}$, will be rapidly amplified and cause V_1 and V_2 to interchange their conduction states. Therefore, it is necessary that the synchronizing pulse increase the grid voltage to a value slightly greater (less negative) than $-E_{co1}$. Condition 3 is expressed mathematically in (2.6), and Fig. 2.5 illustrates the same condition graphically.

$$E_{s1} > -\left\{-k_2 E_{bb} \exp\left[\frac{-N_1}{f_s C_{h1} R_1 (1+\delta_{i1})}\right] - \left[-E_{co1}\right]\right\}$$

$$\left(\frac{1+A_1}{k_2 \mu_{co1}}\right) > \exp\left[-\frac{N_1}{f_s C_{h1} R_1 (1+\delta_{i1})}\right] \quad (2.6)$$

Relations (2.4) and (2.6) can be combined as (2.7).

[6] From Eq. (1.2) developed in Part I of this paper.



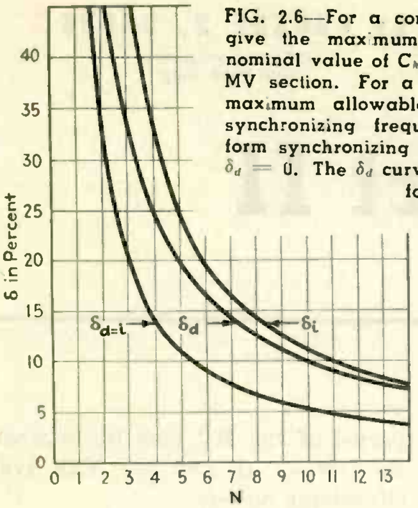


FIG. 2.6—For a constant synchronizing frequency, these curves give the maximum allowable percentage variations from the nominal value of C_hR as a function of the order of division of the MV section. For a constant value of C_hR, the curves give the maximum allowable percentage variations from the nominal synchronizing frequency. Constant amplitude, impulse waveform synchronizing voltage is assumed. The δ_i curve assumes $\delta_d = 0$. The δ_d curve assumes $\delta_i = 0$. The $\delta_{d=i}$ curve allows for equal values of δ_d and δ_b

$$\exp\left[-\frac{(N_1-1)}{f_sC_{h1}R_1(1-\delta_{d1})}\right] > \left(\frac{1+A_1}{k_2\mu_{co1}}\right)$$
$$> \exp\left[\frac{N_1}{f_sC_{h1}R_1(1+\delta_{i1})}\right]$$
$$\left[\frac{(N_1-1)}{f_sC_{h1}R_1(1-\delta_{d1})}\right] < \log_e\left(\frac{k_2\mu_{co1}}{1+A_1}\right)$$
$$< \left[\frac{N_1}{f_sC_{h1}R_1(1+\delta_{i1})}\right] \quad (2.7)$$

From (2.7) it is apparent that

$$\left[\frac{N_1-1}{f_sC_{h1}R_1(1-\delta_{d1})}\right] < \left[\frac{N_1}{f_sC_{h1}R_1(1+\delta_{i1})}\right]$$
$$\left(\frac{1+\delta_i}{1-\delta_d}\right) < \left(\frac{N}{N-1}\right) \quad (2.8)$$
$$N < \left(\frac{1+\delta_i}{\delta_i+\delta_d}\right) \quad (2.81)$$

The subscript is dropped from N, δ_d, and δ_i in (2.8), because this relation is true for both sections of the circuit. Since $C_{h1}R_1$ does not appear in (2.81), the allowable variations from the nominal value of $C_{h1}R_1$ are not functions of its original value. As long as (1.9) and Conditions 1, 2 and 3 are satisfied, the maximum variations permissible in the product $f_sC_{h1}R_1$ depend only upon the order of division of section 1. Similarly, N_2 determines the changes that can be tolerated in $f_sC_{h2}R_2$. The reason (1.9) must be satisfied is that Eq. (2.3), upon which the mathematical formulations of Conditions 1, 2 and 3 are based, was developed on that basis. For a given value of N_1, a constant value of the product $f_sC_{h1}R_1$ results in a constant ratio of the controlled T_1, which is equal to N_1/f_s, to the natural T_1, which, by Eq. (1.5a), is $(C_{h1}R_1\log_e(k_2\mu_{co1})$. When, for a given N_1, $f_sC_{h1}R_1$ varies, the ratio of controlled to uncontrolled T_1 changes. For a given value of N_1, there is a maximum range through which this ratio can be permitted to vary. The low end of this range is fixed by δ_{i1}, and the upper limit is established by δ_{d1}. For a constant $f_sC_{h1}R_1$, the ratio of controlled to natural value of T_1 is a logarithmic function of $k_2\mu_{co1}$. Consequently, if $k_2\mu_{co1} > \epsilon$, the percentage variations in T_1 will be less than those in $k_2\mu_{co1}$. See Appendix I, January ELECTRONICS. The factor $k_2\mu_{co1}$ is a function of both V_1 and V_2.

If it is desired to provide for equal increases and decreases from the nominal value of $C_{h1}R_1$, then $\delta_d = \delta_i = \delta_{d=i}$ and (2.8) becomes

$$\delta_{d=i} < \left(\frac{1}{2N-1}\right) \quad (2.8a)$$
$$N < \left(\frac{1+\delta_{d=i}}{2\delta_{d=i}}\right) \quad (2.81a)$$

In some cases it may be desired to provide for a greater increase than decrease in $C_{h1}R_1$. The limiting case would be where δ_i was allowed to be zero. Then

$$\delta_i = 0 \begin{cases} \delta_d < \dfrac{1}{N} & (2.8b) \\ N < \dfrac{1}{\delta_d} & (2.81b) \end{cases}$$

If, on the other hand, it is desired to provide for the maximum increase in $C_{h1}R_1$, let δ_d equal zero. Substituting zero for δ_d and solving (2.8) for δ_i gives

$$\delta_d = 0 \begin{cases} \delta_i < \left(\dfrac{1}{N-1}\right) & (2.8c) \\ N < \left(\dfrac{1+\delta_i}{\delta_i}\right). & (2.81c) \end{cases}$$

Relations (2.8) a, b and c are plotted in Fig. 2.6. Note that when listed according to decreasing range of permissible variation, the order is δ_i, $\delta_{d=i}$, δ_d. As an example, if a symmetrical MV is to divide by 8 then N is 4. From (2.8c), by proper design, it is possible to allow

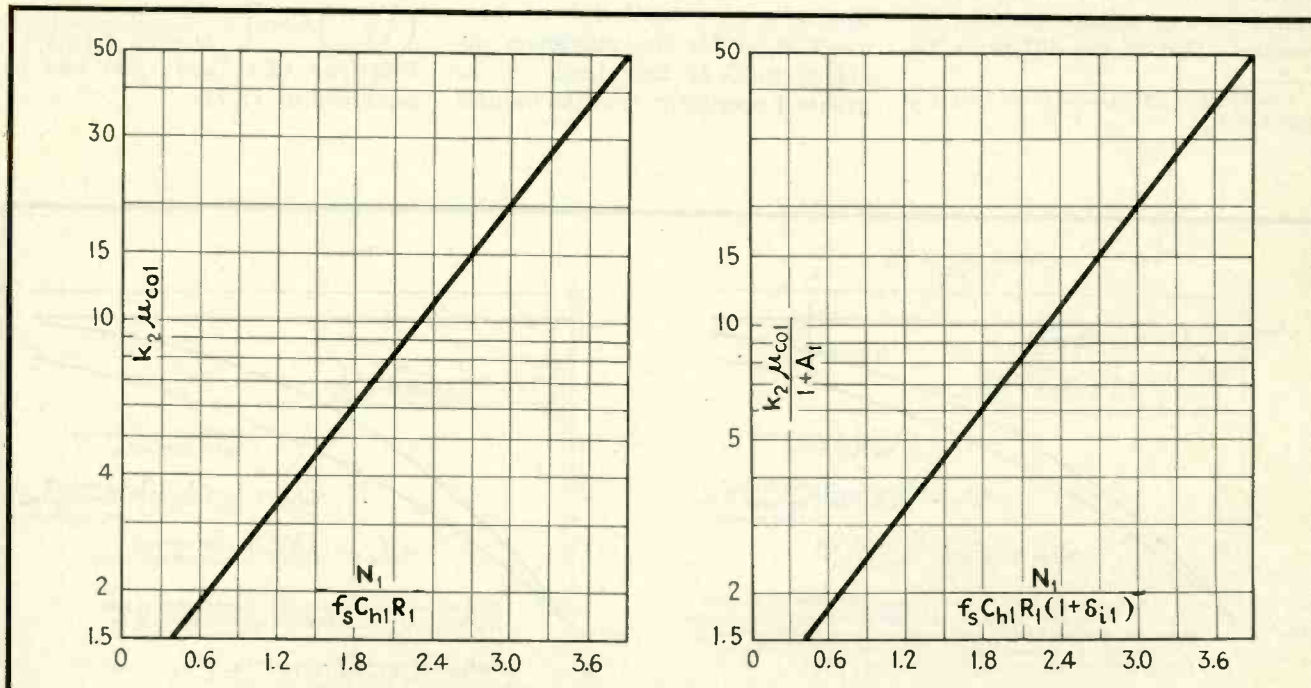


FIG. 2.7 and 2.8—Plots of Eq. (2.9) and (2.10), useful in MV design

for a $33\frac{1}{3}$ percent increase over the nominal value of $C_{h1}R_1$. From (2.8a), ± 14.3 percent or a total range of 28.6 percent could be permitted, while by (2.8b) only 25 percent decrease could be tolerated in the value of $C_{h1}R_1$. Or, solving (2.8) for $\delta_d = 5$ percent, the value of δ_i is 26.7 percent and the range is 31.7 percent. See Appendix III for experimental verification of (2.8b) and (2.8c).

For the reason cited in connection with (2.4), use of (2.8) through (2.8c) should be limited to values of N greater than one. If $N = 1$, the only limit on $C_{h1}R_1$ is its minimum value.[7] This minimum value is the one for which the natural period of the MV is equal to the desired controlled period. The product $C_{h1}R_1$ can be made as large as desired, if the synchronizing pulse is of sufficient amplitude. The maximum value of synchronizing voltage required for V_1 cannot exceed k_2E_{bb}. Therefore, if $E_{s1} \geqq k_2E_{bb}$, any variations can be tolerated in the value of $C_{h1}R_1$ as long as it does not decrease below the above-mentioned minimum value.

Designing a Synchronized Multivibrator

The problem now becomes that of designing the MV so that the maximum percentage variations of $C_{h1}R_1$ (and $C_{h2}R_2$) can be tolerated. First, δ_d and δ_i should be determined for the given order of division of each tube. These values are calculated by means of (2.8) or read from Fig. 2.6.

The characteristics of the tube and the size of the plate load resistor fix a maximum allowable value of $N_1/f_sC_{h1}R_1$. This maximum value is that for which the natural period is equal to the controlled period and is given by Eq. (1.5a).

$$\alpha_1 T_1 = \log_e (k_2\mu_{co1}) \qquad (1.5a)$$

If $N_1/f_sC_{h1}R_1$ is written for α_1T_1 Eq. (1.5a) becomes

$$\frac{N_1}{f_sC_{h1}R_1} = \log_e (k_2\mu_{co1}). \qquad (2.9)$$

Eq. (2.9) is plotted in Fig. 2.7. The value of $N_1/f_sC_{h1}R_1$ as read from this figure must be multiplied by $(1 - \delta_{d1})$. This is necessary to prevent the natural period from becoming shorter than the controlled period for δ_{d1} percent decrease of $C_{h1}R_1$.

[7] All multivibrators dividing by one as well as those dividing by two, in which each tube divides by one, fall in this category.

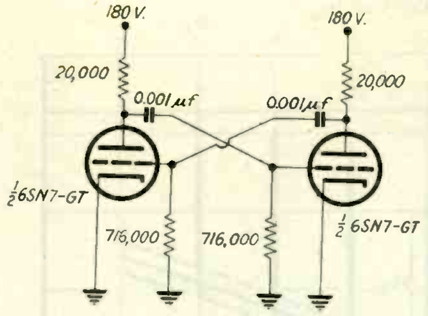


FIG. 2.9—Multivibrator designed in Example III. No specific synchronizing circuit is shown. In general, plate circuit synchronizing is desirable

It is well known that when a MV is to be synchronized, its natural period should be longer than its controlled period.[8] If such is the case, some variation is allowable in the values of the circuit components and the characteristics of the tubes for which the natural period of the MV will not become shorter than the controlled period. Therefore, the value of $N_1/f_sC_{h1}R_1$ as obtained so far should be decreased by some arbitrary amount. Twenty percent is usually sufficient, if components of commercial tolerance and non-selected tubes are to be used. Thus

[8] It is possible to employ a natural period which is shorter than the desired controlled period. In this case a synchronizing voltage of suitable polarity (negative as referred to the grid of the tube to be synchronized) and of sufficient time duration, must be supplied to the circuit to prevent the MV from tripping at the time determined by its natural frequency. This method of synchronizing is illustrated later.

a maximum has been established for $N_1/f_sC_{h1}R_1$ equal to $0.8(1 - \delta_{d1})$ times the value read from Fig. 2.7.

For this value of $N_1/f_sC_{h1}R_1$ calculate $N_1/f_sC_{h1}R_1(1 + \delta_{i1})$. This will be the same as the value of $(N_1 - 1)/f_sC_{h1}R_1(1 - \delta_{d1})$, since values of δ_i and δ_d given by (2.8) through (2.8c) make these quantities identical. To satisfy (2.7), $\log_e[k_2\mu_{co1}/(1 + A_1)]$ must lie between $(N_1 - 1)/f_sC_{h1}R_1(1 - \delta_{d1})$ and $N_1/f_sC_{h1}R_1(1 + \delta_{i1})$. Since the last two quantities are equal, set $\log_e[k_2\mu_{co}/(1 + A_1)]$ equal to them also. Then

$$\log_e \left(\frac{k_2\mu_{co1}}{1 + A_1}\right) = \frac{N_1}{f_sC_{h1}R_1(1 + \delta_{i1})}. \qquad (2.10)$$

The right-hand side of this equation is known. Refer to Fig. 2.8 and read the value of $k_2\mu_{co1}/(1 + A_1)$. From this the values of A_1 and $E_{s1} = A_1E_{co1}$ can be obtained. Any other magnitude of E_{s1} will increase the permissible range of either δ_{d1} or δ_{i1} at the expense of the other. It should be noted that any value of $N_1/f_sC_{h1}R_1$ *less* than that obtained above can be used. The natural period will increase; and A_1 and therefore E_{s1}, will increase as $N_1/f_sC_{h1}R_1$ is decreased. No change will take place in the permissible range of δ_{d1} or δ_{i1}. However, the percentage variations in the amplitude of E_{s1} that will maintain the correct order of division always decreases.

The MV as designed so far satisfies Conditions 1 and 3. It is de-

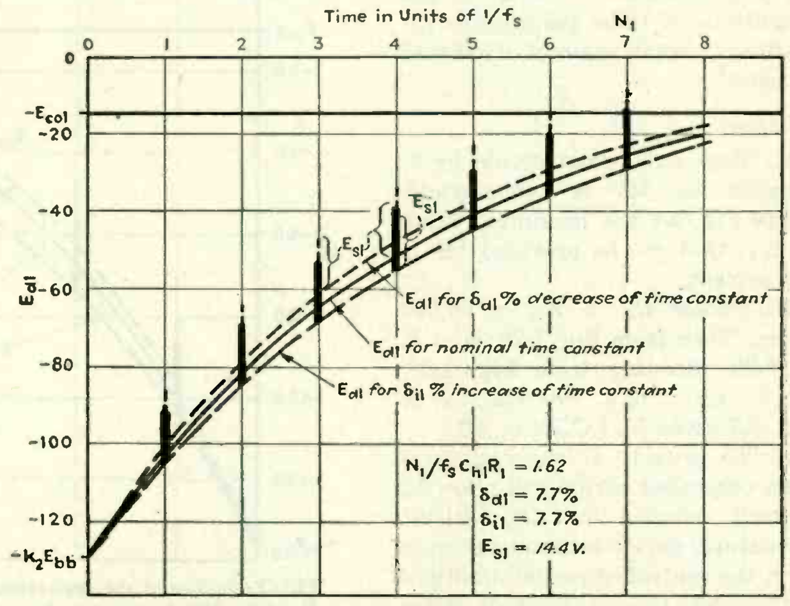


FIG. 2.10—Plot of the exponential grid voltage plus synchronizing pulses for V_1 in the multivibrator designed in Example III. Since the MV is symmetrical, this plot is the same for V_2

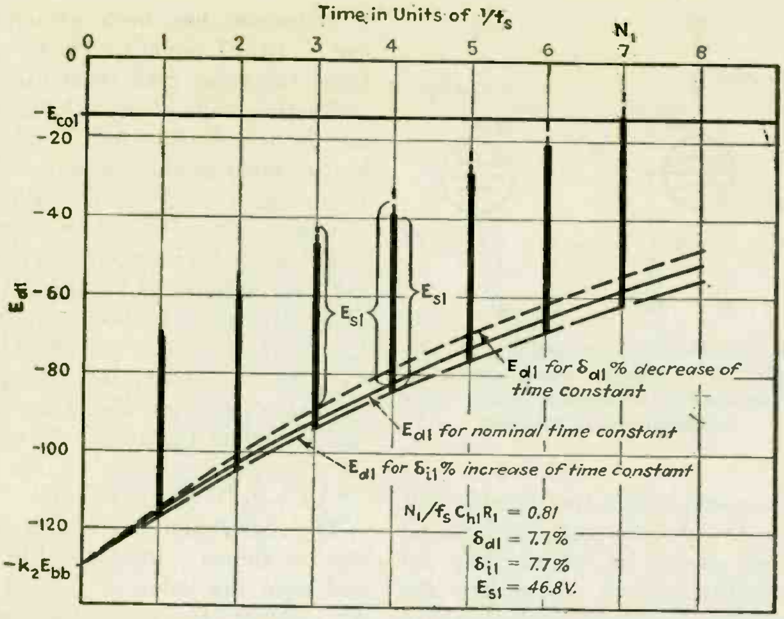


FIG. 2.11—Identical to Fig. 2.10, except for the smaller value of $N_1/f_sC_{h1}R_1$ and the larger required synchronizing voltage

sirable to show in the general case, if possible, that values of $N_1/f_sC_{h1}R_1$ which satisfy these conditions also always satisfy Condition 2. This proof is given in Appendix IV. Use of the curves of Fig. 2.6, 2.7, and 2.8 is best illustrated by means of examples.

Example III

A symmetrical MV is to divide 6000 cps by 14. The tube is a type 6SN7-GT. E_{bb} is 180 v. Design the MV to permit the maximum allowable variations equally plus and minus from the nominal values of the time constants. What is the magnitude of these permissible variations? What value of E_s should be used?

Solution:

a) Each tube must divide by 7, because the MV is symmetrical. From Fig. 2.6 the maximum value of $\delta_{d=i}$ that can be provided for is 7.7 percent.

b) Choose $R_{L1} = R_{L2} = 20{,}000$ ohms. Then from Fig. 1.7*, $k_1 = k_2 = 0.72$. Reading from Fig. 1.8*, $\mu_{co1} = \mu_{co2} = 12.4$. For $k_2\mu_{co1} = 9$, Fig. 2.7 gives $N_1/f_sC_{h1}R_1 = 2.2$.

c) To provide a longer natural than controlled period and allow δ_{d1} percent decrease in $C_{h1}R_1$ without the natural period becoming shorter than the controlled period, multiply 2.2 by $0.8(1 - \delta_{d1})$. This gives

* Figures 1.7 and 1.8 appear in Part I, January 1944 ELECTRONICS.

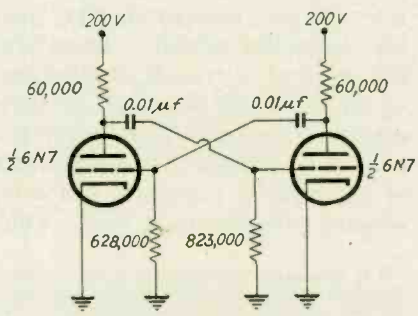


FIG. 2.12—Multivibrator designed in Example IV

$N_1/f_sC_{h1}R_1 = 2.2 \times 0.8(1 - 0.077 = 1.62.$

d) By Eq. 2.10, $\log_e[9/(1 + A_1)] = 1.62/(1 + 0.077) = 1.51.$

Reading Fig. 2.8,

$$9/(1 + A_1) = 4.53$$

$$A_1 = 0.99$$

$$E_{s1} = A_1E_{co1} = 0.99 \times 180/\mu_{co1} = 14.4 \text{ volts.}$$

Regardless of where the synchronizing voltage is injected into the circuit, its effective value as referred to the grid of V_1 must be 14.4 peak volts.

e) Before selecting values for C_{h1} and R_1, (1.9) should be checked for the maximum value of C_{h1}.

$$C_{h1\max} = \frac{T_2}{5} \times \frac{1}{\left(R_{L2} + \dfrac{R_{d1}\,R_{c1}}{R_{d1} + R_{c1}}\right)}$$

$$= \frac{7}{5 \times 6 \times 10^3} \times \frac{1}{20 \times 10^3 + 1.5 \times 10^3} = 0.0108\ \mu f.$$

If C_{h1} is chosen as 0.001 μf,

$R_1 = N_1/1.62f_sC_{h1} = 7/1.62 \times 6 \times 10^3 \times 0.001 \times 10^{-6} = 720{,}000$ ohms. This R_1 is the total effective resistance in the discharge circuit of C_{h1}. Therefore

$$R_1 = R_{d1} + R_{L2}R_{b2}/(R_{L2} + R_{b2}) = R_{d1} + 4.35 \times 10^3 \text{ ohms.}$$

Solving for R_{d1} gives 716,000 ohms.

f) Since the MV is to be symmetrical, $C_{h2} = 0.001$ μf, $R_{d2} = 716{,}000$ ohms and $E_{s2} = 14.4$ volts.

Fig. 2.9 is a schematic diagram of the multivibrator.

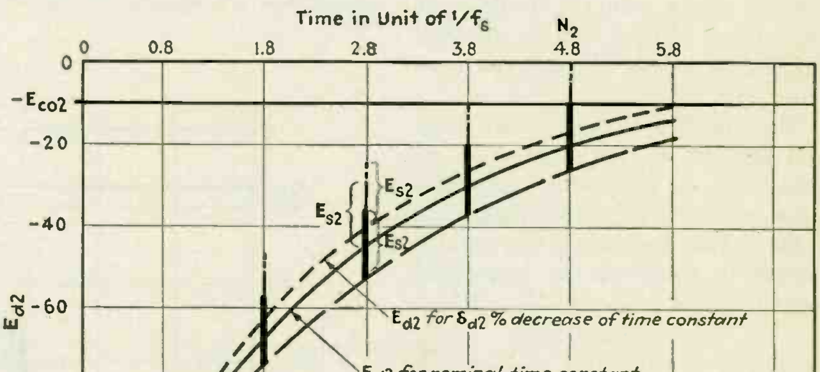


FIG. 2.13—Plot of the exponential grid voltage plus synchronizing pulses for V_1 of the MV designed in Example IV. Note that the first pulse occurs 0.2 T_1 second after V_1 becomes nonconducting. This condition is obtained by properly phasing these pulses with respect to those supplied to V_2

Figure 2.10 is a plot of the exponential grid voltage plus synchronizing voltage for V_1 of this example. Since the MV is symmetrical, the plots for V_1 and V_2 are identical. The solid curve is a plot of $-k_2E_{bb}\ \exp(-n/f_sC_{h1}R_1)$ and n takes on values from 0 to 7. Synchronizing pulses shown as light, solid lines are associated with this curve. The 7th pulse synchronizes the MV. A plot of $-k_2E_{bb}$ $\exp[-n/f_sC_{h1}R_1(1 - \delta_{d1})]$, which represents the case of δ_{d1} percent decrease of $C_{h1}R_1$ is shown as the curve made up of short dash lines. The dashed extensions of the solid synchronizing pulses indicate the heights reached by the pulses when they are added to the dashed curve. Note that any further decrease of $C_{h1}R_1$ would permit the 6th pulse to trip the circuit. There is no possibility of the natural period occurring between the 6th and 7th synchronizing pulses, because the 6th pulse is of greater amplitude than the increase of E_{d1} between the 6th and 7th pulses. Therefore, with a δ_{d1} percent decrease of $C_{h1}R_1$, the 7th pulse is still the one that synchronizes the MV.

The long dash curve is a plot of $-k_2E_{bb}$ exp $[-n/f_sC_{h1}R_1(1 + \delta_{i1})]$. This curve represents the condition for δ_{i1} percent increase of $C_{h1}R_1$. The heavy, solid pulse representing the same synchronizing voltage as before added to this curve, is still sufficient to trip the MV at $n = 7$. However, any further increase of $C_{h1}R_1$ would cause the circuit to divide by 8 instead of 7.

The value $N_1/f_sC_{h1}R_1 = 1.62$ as obtained in the design, was used in plotting Fig. 2.10. As has been explained, this represents the maximum value of this factor that should be used. Figure 2.11 is a plot of this example for $N_1/f_sC_{h1}R_1 = 0.81$, i.e., one-half the value used on Fig. 2.10. Note that while the synchronizing voltage had to be increased from 14.4 volts to 46.8 volts, its permissible variation in volts has remained approximately the same. Therefore, the percentage tolerance permissible in the magnitude of the synchronizing voltage has been decreased considerably. The larger magnitude of E_s is of value in certain cases of noise in the synchronizing circuit.

Let $C_{h1}R_1$ remain constant at its nominal value. If f_s increases to $f_s(1 + \delta_{i1})$, then the N_1th pulse will occur at the end of $N_1/(1 + \delta_{i1})$ seconds, as compared with N_1 seconds required at $f_s = f_s$. At this time, the exponential grid voltage will be more negative by exactly the amount that E_{s1} extends above $-E_{co1}$ at time equal to N_1/f_s. If f_s is increased further, the N_1th pulse will be unable to close the gap between the exponential component of grid voltage and $-E_{co1}$. For the useful, special case of $\delta_{i1} = \delta_{d1=i1}$, $N_1/(1 + \delta_{i1})$ is equal to $N_1 - 0.5$. This case can be checked in Fig. 2.10 wherein at time equal to $6.5/f_s$ the exponential grid voltage is -28.9 volts, or 14.4 volts (E_{s1}) more negative than $-E_{co1}$.

If f_s decreases to f_s $(1-\delta_{d1})$, the

(*Continued on page 363*)

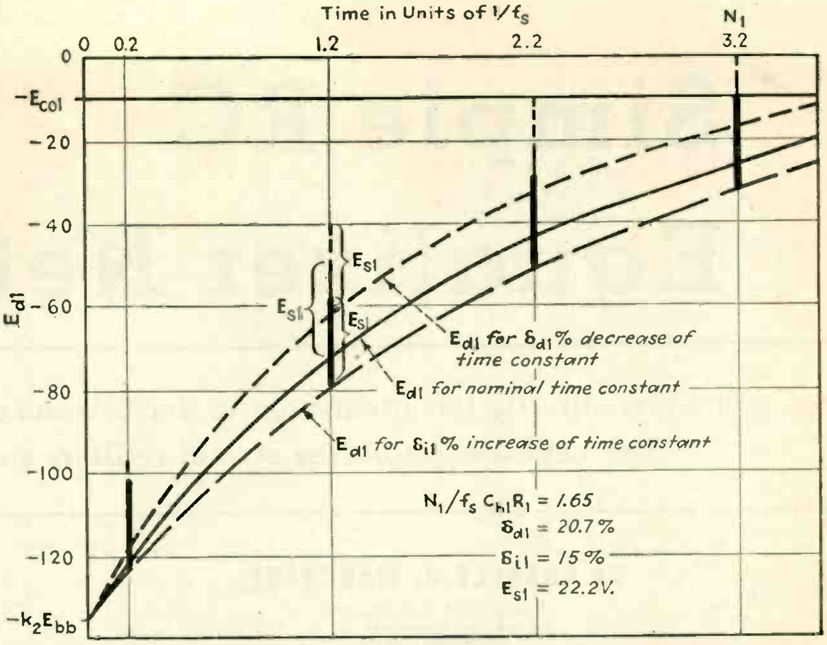


FIG. 2.31—This figure, together with the text of Appendix II and a comparison with Fig. 2.3, shows how a synchronizing pulse of finite duration decreases the maximum allowable variation from the nominal value of $C_{h1}R_1$

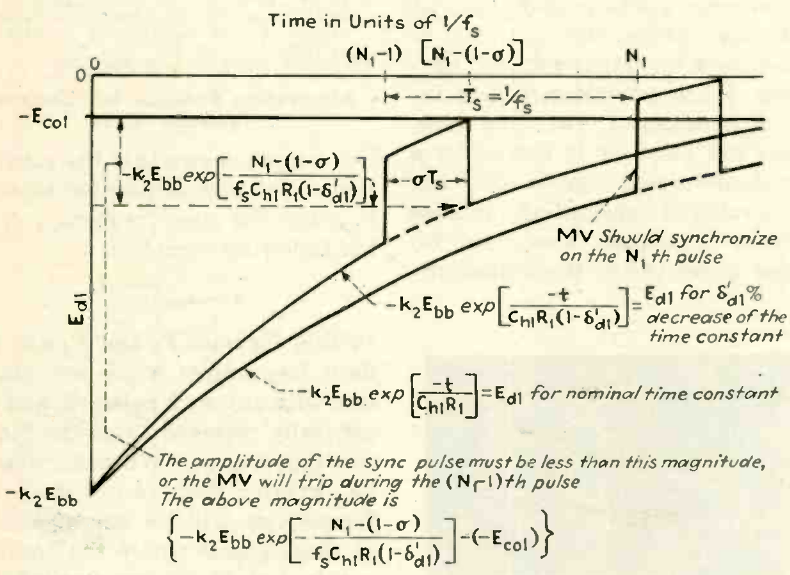


FIG. 2.14—Similar to Fig. 2.13, but applying to the grid voltage of V_1

Simple RC Equalizer Networks

Two charts give directly the attenuation in decibels and the phase shift of simple *RC* equalizer networks employing several resistors and only one capacitor

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IN DESIGNING AMPLIFIERS, it is often desirable to secure some degree of equalization without resorting to the more elaborate *LC* filters, and simple *RC* networks are commonly used to perform this function. Although these networks often contain only one capacitor, the explicit computation of their performance, nevertheless, is frequently quite tedious. By applying certain very simple theorems in computating the performance of these networks, practically all this labor may be eliminated. Formulas are derived for the attenuation and phase-shift functions and a rule is given for the computation at sight of the constants associated with these formulas.

This article is concerned exclusively with networks containing any arbitrary number of resistors and one, and only one, capacitor. Such networks will be referred to as "admissible networks." It will be assumed that we are interested only in the voltage output of such networks, or, in other words, that these networks will be terminated in an infinite load. Since such networks are generally used for coupling between stages, this is almost always the case of greatest interest.

Examples of what are meant by admissible networks are shown at (a) and (b) in Fig. 1, while an example of a network which is not admissible is given at (c). It should be noted, however, that in case capacitor C_2 and resistor R_4 in Fig. 1(c) are large enough, the network is approximately an admissible network, down to a very low frequency.

Two cases will be considered: (a) The case where the network is driven by a "constant-voltage" generator, i.e., a generator of zero internal impedance; (b) The case where the network is driven by a "constant-current" generator, i.e., a generator of substantially infinite internal impedance. Cases not included under one of these headings can be placed under one of them by including the generator impedance, if this is purely resistive, in the network itself.

The following definitions apply throughout:

E is the voltage output of the driving generator, if constant-voltage.
I is the current output of the driving generator, if constant current.
V is the voltage output of the network.
a is the attenuation, E/V, of the network, taking into account phase as well as magnitude.
$\bar{a}$ is the absolute value of a.
θ is the phase angle of a.
α is the value of a in decibels.
a_0 is the attenuation of the network at zero frequency, i. e., the attenuation with the capacitor, open-circuited.
a_∞ is the attenuation of the network at infinite frequency, i. e., the attenuation with the capacitor short-circuited. (It is obvious that both a_0 and a_∞ have zero phase-angle.)
A is the ratio of the attenuation of the network at zero frequency to the attenuation of the network at infinite frequency, i. e., a_0/a_∞.
A_{db} is the value of A in decibels.

Attenuation Formula for Constant-Voltage Case

It can be shown that the attenuation, a, of any admissible network is given for any frequency, f, by the following formula:

$$a = a_\infty \frac{f - jF_1}{f - jF_2} \qquad (1)$$

In this formula F_1 and F_2 are two fixed frequencies which are associated with any such network, and are generally referred to as the "turnover frequencies." When A_{db} is large, i.e., greater than 14 db, these two frequencies will lie almost exactly at those points where the curve is within 3 db of its zero and infinite-frequency values of attenuation. Later on a rule will be given for finding these two turnover frequencies by inspection.

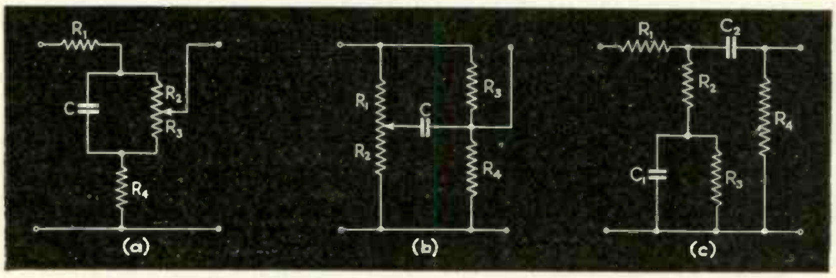


FIG. 1—Examples of tone-control circuits using several resistors and only one capacitor are shown in (a) and (b). A type of circuit not considered because it has more than one capacitor is indicated in (c)

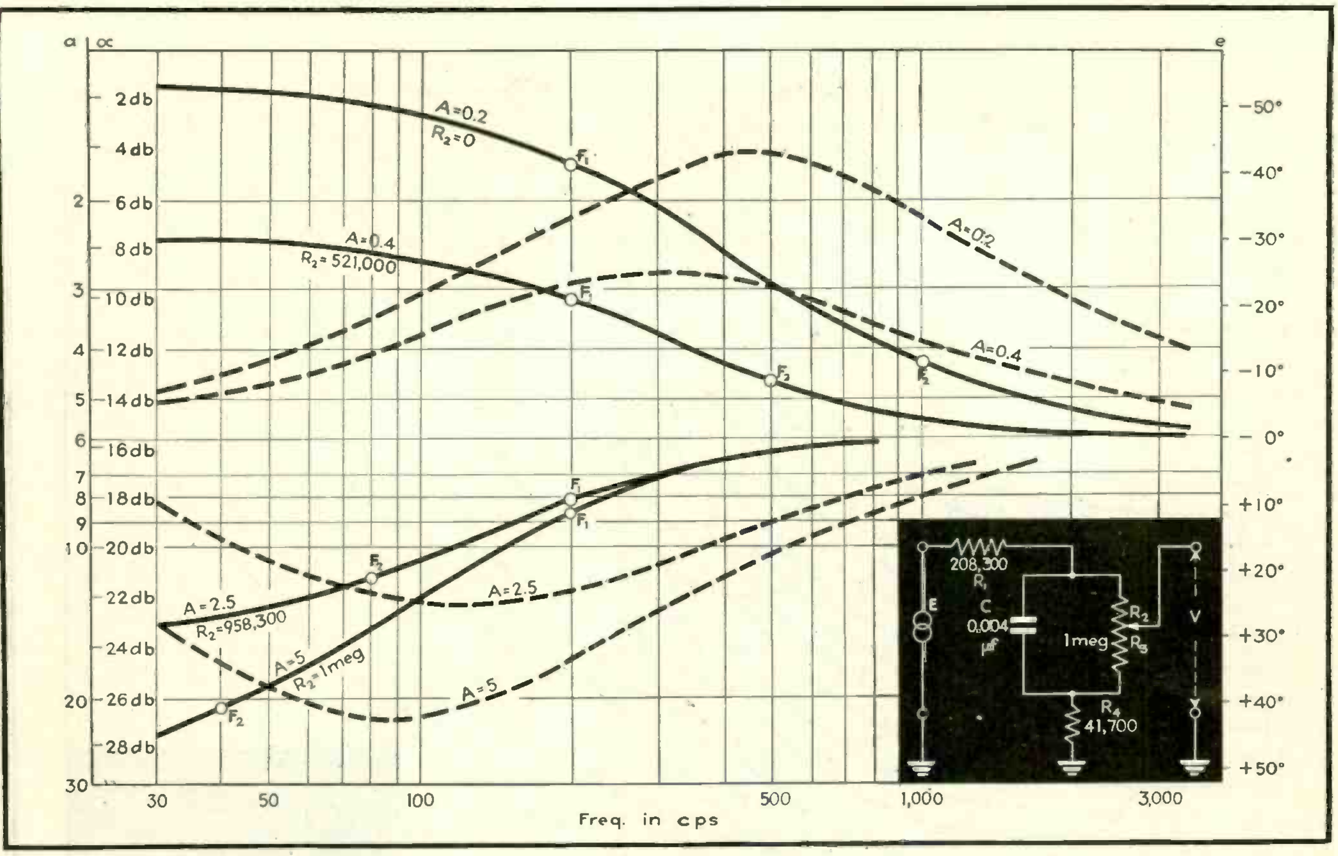


FIG. 2—Chart illustrating applications of the author's *RC* equalizer network formulas to practical variable tone-control design. Solid curves show attenuation. Dotted curves indicate the phase shift

Upon setting $f = 0$ in Eq. (1), we can immediately deduce one important relation. We then have

$$a_0 = a_\infty F_1/F_2$$

or

$$\frac{a_0}{a_\infty} = A = \frac{F_1}{F_2} \qquad (2)$$

In other words, the ratio of the turnover frequencies is the same as the ratio of the zero and infinite-frequency attenuations of the network. From this it is obvious that if we are given one of the turnover frequencies we can immediately find the other, because the computation of the zero and infinite-frequency attenuations of the network are matters of simple arithmetic.

F_1 Rule for Constant-Voltage Case

It may be shown that we can always find F_1 for any given admissible network driven by a constant-voltage generator, by the following Rule 1: *F_1 is that frequency at which the reactance of the capacitor equals the resistance it looks into from its own terminals when the driving generator is short-circuited.*

F_1 is thus seen to be nothing more nor less than the frequency associated with the generalized time constant, $R'C$, of the network, where R' is the resistance seen by C from its own terminals, and is given by the formula

$$F_1 = 1/2\pi R' C \qquad (3)$$

Driving-Point Impedance of an Admissible Network

In the event that the network is driven by a constant-current generator, the output voltage of the network will be the product of the driving generator current, the impedance of the network as seen from the driving generator, and the attenuation of the network if it were driven by a constant-voltage generator. We first, therefore, investigate the impedance function for such networks.

The impedance of any admissible network as seen from any two points in the network whatever is given by the following formula:

$$Z = Z_\infty \frac{f - jF_1}{f - jF_2} \qquad (4)$$

where F_1 is given as the frequency at which the reactance of the capacitor equals the resistance it looks into at its own terminals when the driving generator is short-circuited, and F_2 is the frequency at which the reactance of the capacitor equals the resistance it looks into at its own terminals when the driving generator is open-circuited. Z_∞ is the impedance of the network to current of infinite frequency, i.e., the impedance of the network when the capacitor is short-circuited; it is obvious that Z_∞ is purely resistive.

Attenuation Formula for Constant-Current Case

Before considering the case where the network is driven by a constant-current generator, it would be well to indicate what is meant by "attenuation" in this case. In general the term attenuation is reserved for a voltage-voltage or current-current ratio. In the present case, however, we are interested only in the voltage output of the network and hence, it would seem, the term attenuation does not apply.

However, we are often interested in the case where such a network is driven by a generator, commonly a pentode, which converts constant voltage to constant current. We may then say that the current output of such a generator is equal to a

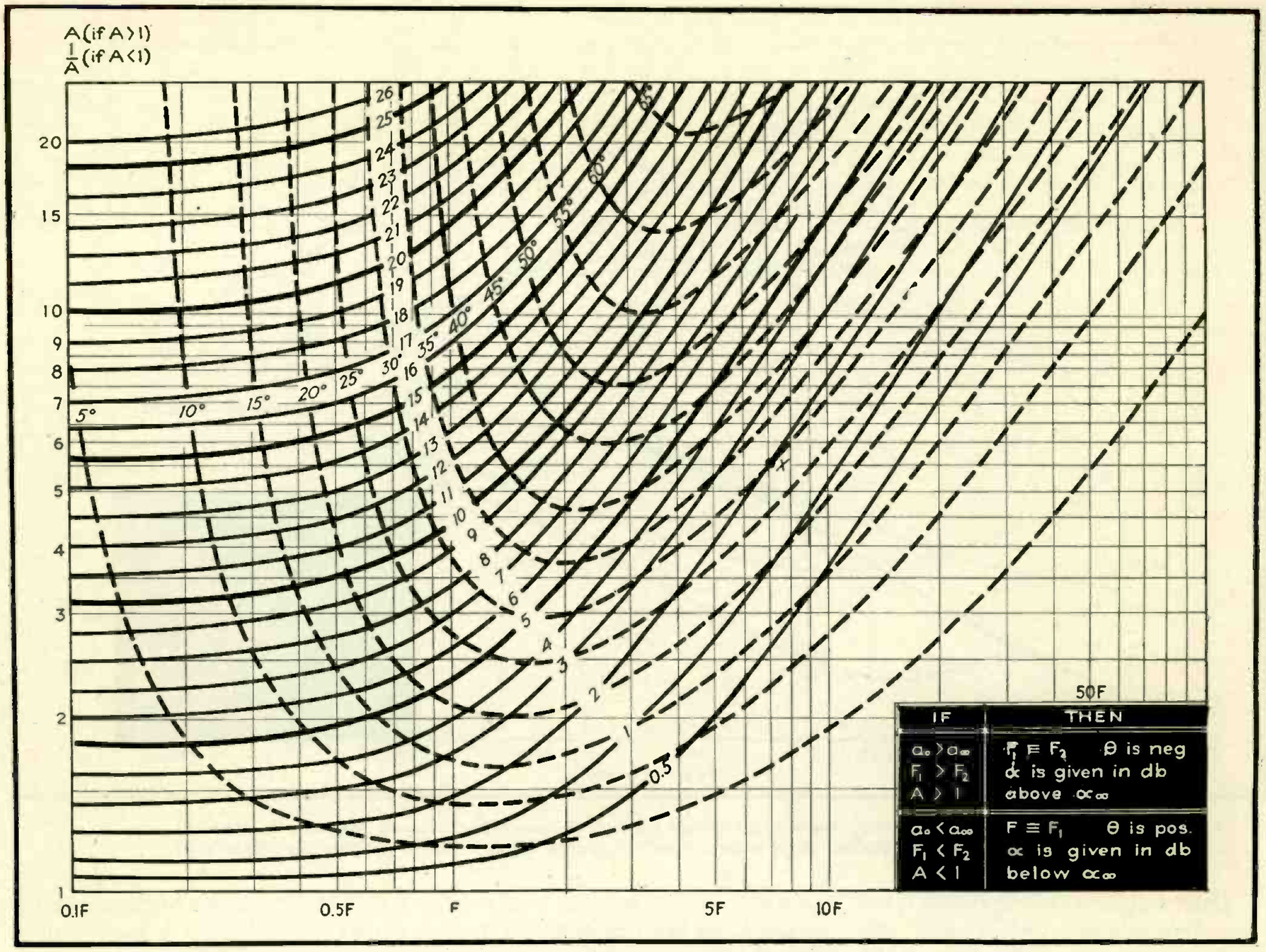


FIG. 3—Graphical determination in decibels of the attenuation and phase shift of simple *RC* equalizer circuits. Solid contour lines give the attenuation and dotted contour lines show the phase shift

constant, g, times a voltage, where g has the dimension of current divided by voltage, i.e., conductance. In view of this fact, we may legitimately speak of the attenuation of such networks when they are driven by constant-current generators, if we bear in mind that a constant of the dimensions of $1/g$ is implied in the formula.

Since the attenuation of an admissible network is always given by Eq. (1) when we know the voltage across its input terminals, it follows immediately that the voltage output of an admissible network when driven by a constant-current generator is given by the following:

$$V = I Z_\infty \left(\frac{f - jF_1}{f - jF_2}\right) \frac{1}{a_\infty} \left(\frac{f - jF_2'}{f - jF_1}\right) \quad (5)$$

where F_1 is given as under Eq. (4) and $F_2' = F_1/A$, where A is computed considering the network as being driven by a constant-voltage generator. This equation simplifies to

$$V = I \frac{Z_\infty}{A} \left(\frac{f - jF_2'}{f - jF_2}\right) \quad (6)$$

If we write gE for I, then the attenuation is given by

$$a = \frac{E}{V} = \frac{1}{g} \frac{a_\infty}{Z_\infty} \left(\frac{f - jF_2}{f - jF_2'}\right) \quad (7)$$

We see that the quantity $\frac{a_\infty}{gZ_\infty}$ must be the attenuation at infinite frequency. Therefore writing a'_∞ for this quantity, and writing F_1' for F_2, we have

$$a = a'_\infty \left(\frac{f - jF_1'}{f - jF_2'}\right) \quad (8)$$

It will be noted in this case, however, that the turnover frequency which now appears in the numerator is determined by open-circuiting the driving generator.

Polar Form of Attenuation Formula

The form of the expression for the attenuation is the same whether the network be driven by a constant-voltage or a constant-current generator. Up to this point, the formula was exclusively in the complex form. For most purposes, however, it is more convenient to make use of the polar form, $a = \bar{a}\angle\theta$. By straightforward manipulation of Eq. (1) we derive the following expressions for $\bar{a}$ and θ:

$$\bar{a} = a_\infty \sqrt{\frac{f^2 + F_1^2}{f^2 + F_2^2}} \quad (9)$$

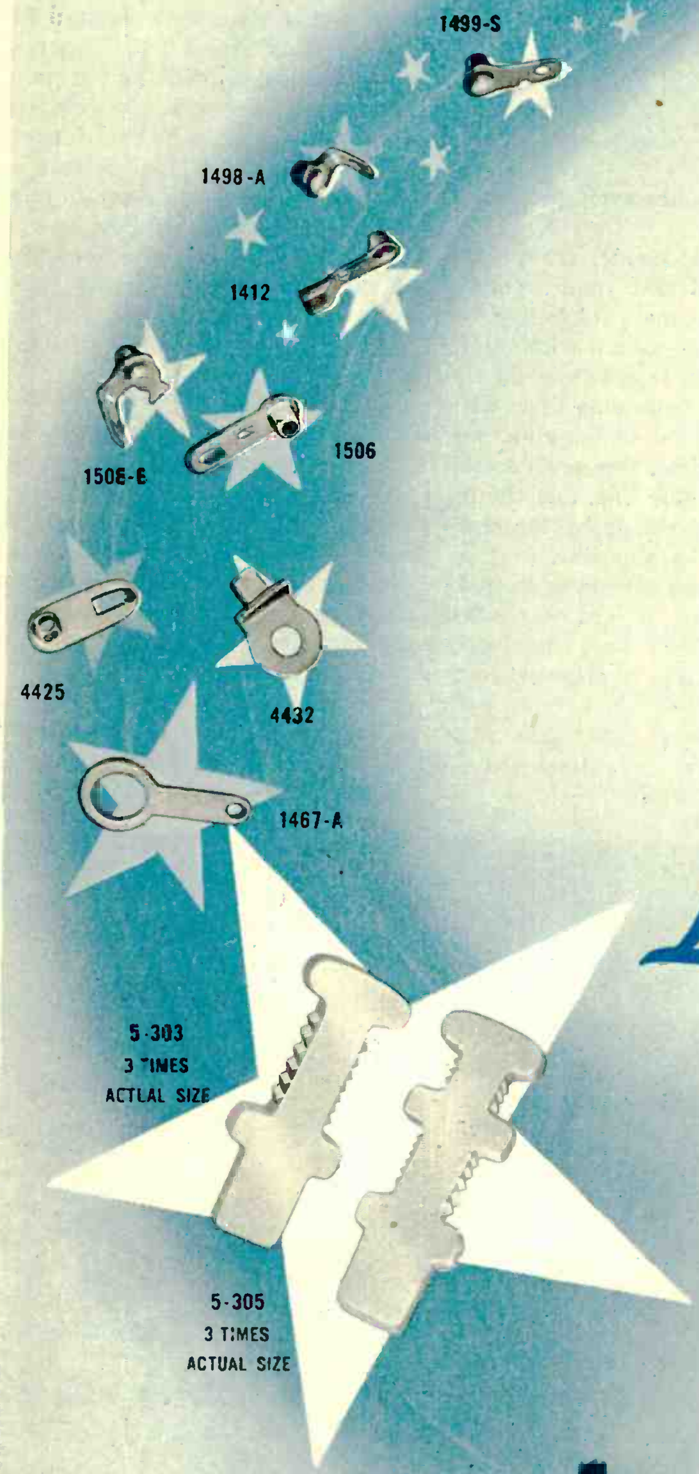
$$\theta = \tan^{-1}\left(\frac{F_2}{f}\right) - \tan^{-1}\left(\frac{F_1}{f}\right) \quad (10)$$

Here θ is either a maximum or a minimum when $f = \sqrt{F_1 F_2}$, depending on whether A is less than or greater than unity.

Application to Variable Tone-Control

As an example of the application of these formulas to a practical case, consider the tone-control circuit of Fig. 1(a), with the values shown in Fig. 2. These values were so chosen as to give either a maximum bass-boost of 14 db, or a maxi-

(*Continued on page* 377)


1499-S
1498-A
1412
1506-E
1506
4425
4432
1467-A
5-303
3 TIMES
ACTUAL SIZE
5-305
3 TIMES
ACTUAL SIZE

TUBES AT WORK

R-F Heating of Aircraft Spars and Gas Tanks

EXCEPT FOR De Havilland in England, manufacturers of the famous Mosquito wood airplane, Fairchild Engine and Airplane Corp. is one of the few companies which did not drop wood completely with the advent of stressed skin aluminum alloy airplanes. Instead, over a period of years it continued development of techniques which would make wood more usable. Out of these developments came the Duramold process of bonding plywood sheets, and a new electronic bonding technique using internally-generated high-frequency heat instead of externally applied heat.

Plywood Bonding Materials

To see why the new bonding techniques are so important, it is desirable to know something of the classes of bonding materials or glues which are available. There are three classes in general use, with many modifications of each type: casein glue, urea formaldehyde resins, and phenol formaldehyde resins. The first two classes will set at room temperature (70 to 90 deg F) in about 6 to 8 hours, although this time can be reduced by the application of heat. The last class, and the most durable, requires either room temperature (75 to 100 deg F) coupled with a long setting time (measured in hours), or high heat, 200 to 280 deg F, for the rapid setting (measured in minutes) necessary for production.

Casein glue, unless fortified with strong preservatives, loses its strength and molds when exposed to moisture. Failure of casein glue is one of the main causes for lack of confidence in wood airplanes. Modern techniques avoid the use of this glue.

Urea formaldehyde resins are moisture resistant and thereby overcome the main objection to wood structures bonded with casein glues. It is important to avoid the possibility of thick glue lines with ureas, because thick urea glue lines "craze" with time. The small cracks in the crazed glue line, and the internal stresses set up by the crazing, weaken the glue line.

To avoid thick glue lines in making assemblies, a process called Durassembly has been developed. This process uses fluid pressure to push parts, even thick ones with uneven surfaces, into such close contact that thin glue lines are assured.

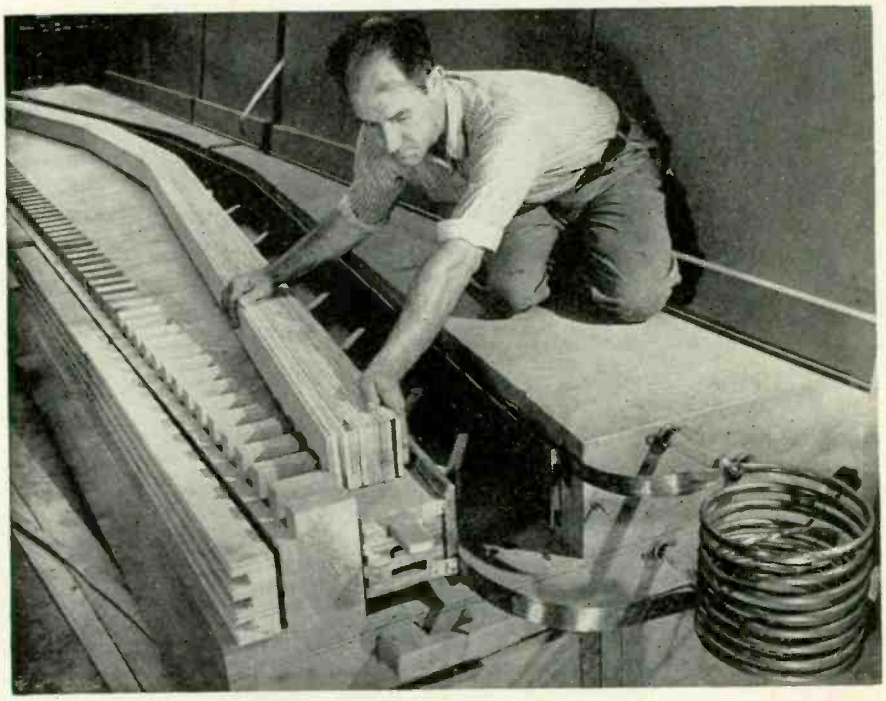
The phenol formaldehyde resins are the most durable and do not require extreme care in avoiding thick glue lines. They meet every requirement of an ideal bonding material except that they require either very long setting times at room temperatures, or the necessity—for short setting times—of heat higher than that required for quick-setting ureas. Great progress is being made in reducing the maximum setting temperatures required for quick setting of phenol formaldehyde resins and modifications of this type, such as the resorcin base resins. These new bonding agents, now under life tests, give hope that in the near future some of these types can be substituted for the ureas.

Principle of Electronic Heating

Whether ureas, present phenol formaldehyde resins or new types are used, heat is required. Earlier methods applied this heat externally, while the electronic process causes a current to flow through the wood and heat the wood uniformly throughout its thickness.

Temperature Considerations

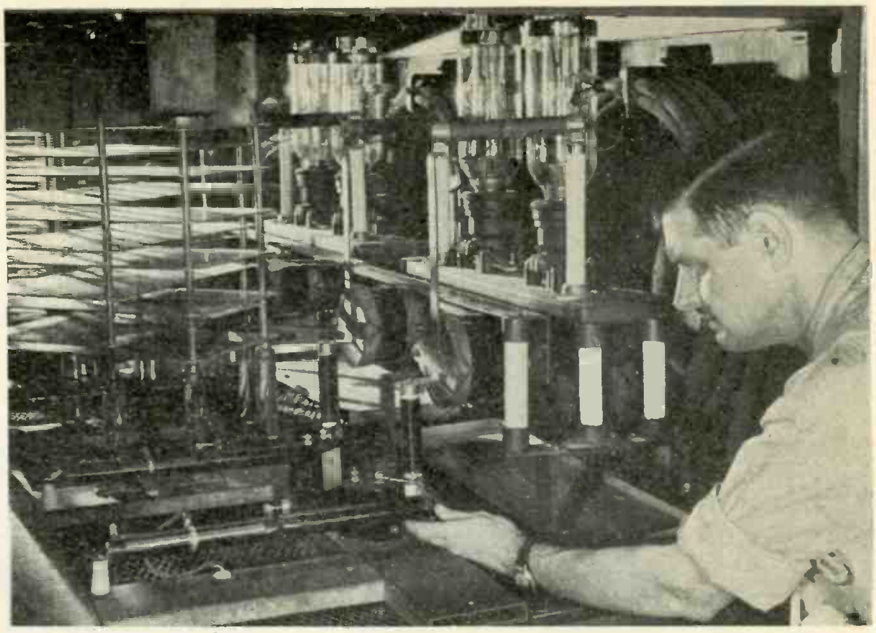
Uniform power distribution or its resultant—uniform temperature distribution—is difficult to ob-



Thirty minutes of r-f heating in this jig is sufficient to mold and cure the heavy 25-ft flange for a Fairchild AT-21 GUNNER center spar. Older external heating method took 8 hours per spar. Note the hinged blocks that support the spar in the jig, and the single-turn rotatable coil inside the tank inductance for tuning

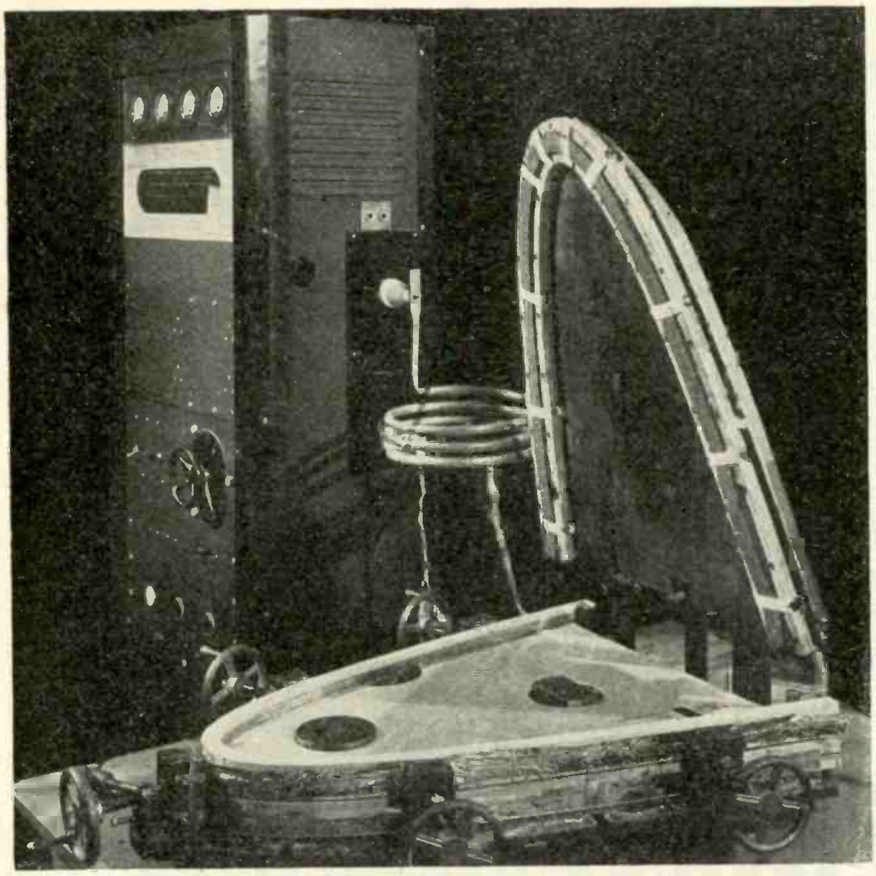
tain in a large piece such as the 25-ft AT-21 spar flange, because the dimensions are comparable to a wavelength at the frequency used, and standing wave effects appear. These cause nonuniform power distribution. This nonuniformity can be minimized to a satisfactory degree by introducing the current to the electrodes at a number of points, to give the effect of breaking the large piece into a number of smaller pieces. Uniform current distribution is essential to uniform heating because the heating effect varies as the square of the current.

Materials containing water, such as wood at high moisture content or wet urea formaldehyde glues, generate more heat from the passage of a high-frequency current than dry materials. For this reason, with a given power, the time required is less with wet glues than with dry glues. If a wet glue line can be placed at right angles to the electrodes there is a concentration of current in the glue line and the relative heating effect in the glue line as compared to that in the wood is further increased. With this arrangement, voltages as low as 200 volts at 5 Mc are used with glue lines 1 inch wide.



Interior of 30-kw r-f generator used in the Fairchild-Burlington plant for molding and curing 25-ft aircraft spar flanges

From the standpoint of cracks due to explosions in the wood from steam or pitch pockets there is a practical top limit of around 230 deg F unless the part is entirely under fluid pressure in which case peak temperatures around 290 deg F can be used.



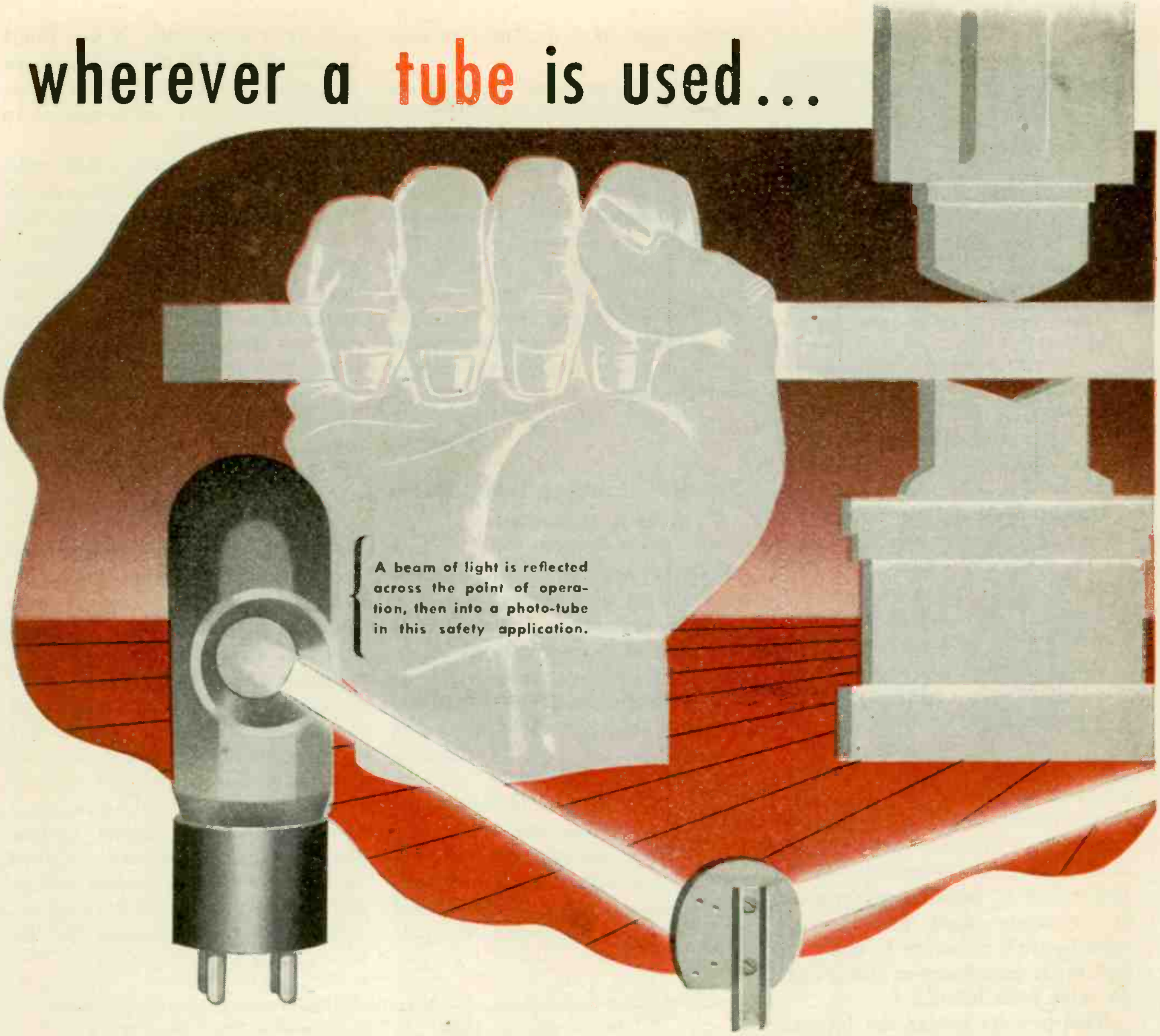
R-F generator and jig used in bonding cap strips to the bulkhead web of a droppable gas tank for Navy Corsair fighters. The jig is equipped with pneumatic pads that maintain fluid pressure and keep glue lines at minimum thickness

The ideal bonding material would be one which could be applied to the work and then set at any convenient time. Most bonding agents, like casein glues or cold or warm setting adhesives, have a fairly short allowable time between applying the glue and getting the glued parts under pressure. This time is called the open assembly time. As the temperature required for setting the bonding agent is increased, the permissable open assembly time is lengthened. One recently developed bonding agent has an open assembly time of days, yet can be set at 205–230 deg F.

Curing 25-Ft. Spar Flanges

The installation at the Fairchild-Burlington plant, used to cure the laminated flanges of the center section spars of the Fairchild AT-21 Gunner consists of a 30-kw r-f generator and a large jig which holds the laminated assembly while it is being set. Thin laminations of wood, smeared with a phenolic resin which has dried, are assembled on their edges to the proper thickness. The flexible blocks on which the laminations rest are made of two pieces joined by a rubber hinge. Since the rubber is under tension, it holds each support open to the

wherever a tube is used...



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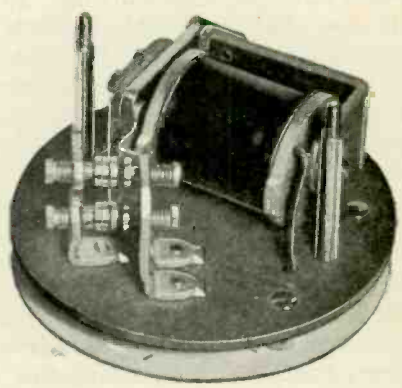

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* Not limited to tube applications but used wherever automatic control is desired for making, breaking, or changing the characteristics of electric circuits.

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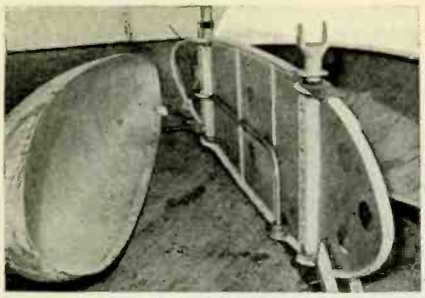


Half shells and the center bulkhead of a light, strong droppable gas tank for the Corsair fighter. R-F heat is used in assembling the bulkhead

full width of the open jig, yet allows for compression as the jig is closed.

When the sides of the jig are clamped together, the thin laminations are pressed into the proper shape. Each side of the jig is lined with a copper plate or electrode, extending from end to end along opposite sides of the spar.

Along one side of the jig, behind the copper plate and its support, is a high-pressure air hose. The use of air pressure not only achieves accurate control, but provides the required uniformity of pressure. The thickness of wood laminations cannot be controlled with the accuracy possible, for example, in the machining of metal. Consequently, if extremely rigid platens were used to apply pressure it would result in crushed fibers or either open or thick glue joints.

This process brings the internal heat of the flange up to the desired temperature in approximately 20 minutes, with remarkably uniform heat throughout the adhesive lines. The whole heating operation is done in approximately 30 minutes, as compared to the 6 or 8-hour curing period under the cold-glue method.

Bulkheads in Droppable Gas Tanks

Curved reinforcing cap strips for the perforated bulkhead used to divide a droppable gas tank into separate cells are cured by high-frequency heating of the laminated assembly then bonded to the web by producing a high-frequency heating effect directly in the glue lines. This was accomplished by applying just enough glue, so that when pressure was applied to the joint a slight excess squeezed out all along either side. Strips of metal foil were placed along opposite edges of the glue lines and held in contact.

Suitable jigs were made to accommodate two sets at a time of each of the three sections of the bulkhead used in expendable gas tanks of the Navy's Corsair fighters. Pneumatic pressure pads are arranged to provide exactly the right amount of pressure as the glue is heated. In a few moments, the glue is brought up to the right temperature for creating a permanent strong bond between the flanges and the web.

Sensitive Carrier-Tone Alarm

By L. H. Appleman
Chief Engineer, WACO

Many of the circuits of carrier-tone alarms that have appeared in various publications do not seem to meet the FCC specifications as set forth in restricted order No. 2. These requirements are met in the receiver used here at WACO and a portion of the receiver circuit is shown in the diagram.

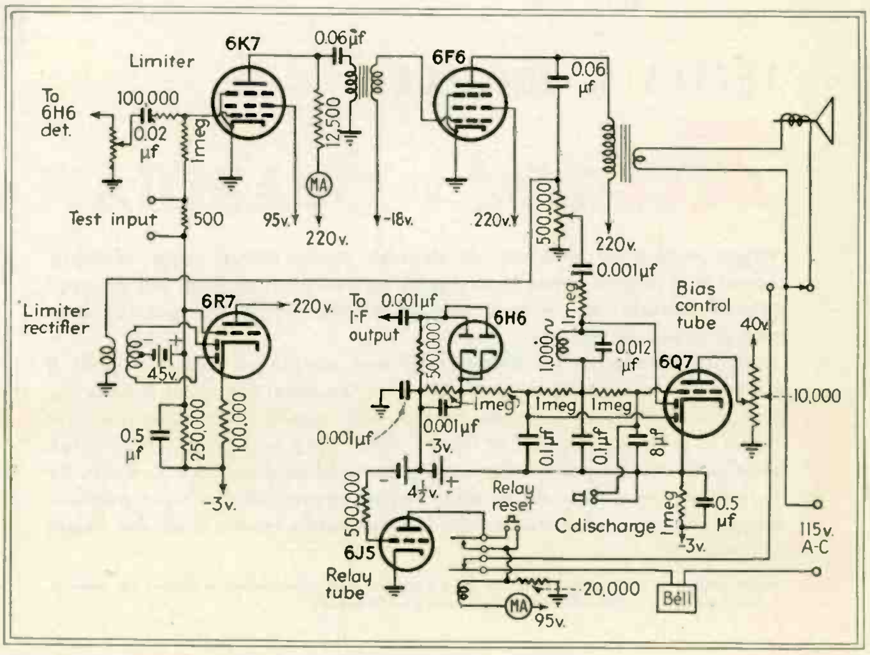
This unit has been in service for over nine months and given very satisfactory performance. It responds to less than 1 percent modulation by a 1,000-cycle tone held for a period of 15 seconds yet music bothers it very little. A test input is brought out to the control room jack panel for feeding 1,000 cycles into the receiver's audio system to check performance.

The circuit contains a 6J5, with zero bias, that holds a relay down. The grid of this tube is connected to a 7½-volt negative bias which is balanced out by an opposing voltage developed across the cathode resistor of a 6Q7. This latter tube also has zero bias and passes plate current to develop the above bucking voltage. There is 3 volts of negative bias in its grid circuit which is balanced out by the rectified carrier from a 6H6 tube.

Operation

When a 1000-cycle tone comes down from the receiver audio output, it is rectified by a 6Q7 diode plate to provide voltage to make the 6Q7 grid negative. The one megohm resistor and 8 μf paper capacitor provide time delay. Of course it follows that if the 6Q7 grid goes negative, the bucking voltage across its cathode resistor is removed, the 6J5 grid goes negative and the relay opens, closing the bell circuit. The bell rings until the toggle switch is thrown, killing the bell and connecting the speaker.

The limiter compresses the in-



Circuit of a portion of the receiver for reception of carrier tone alarms. Reception of a 1,000-cycle tone-modulated carrier of less than 1-percent modulation causes the warning bell to ring

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coming program about 25 to 30 db. It allows a 2½-db rise in output above compression starting point. The limiter rectifier uses a 6R7 with automatic bias control on its diode plates. The diodes are biased by a 45-volt battery plus about 18 volts drop across the 100,000-ohm cathode resistor.

In the usual rectifier, the rectified voltage acts as a negative bias on the rectifier plate, increasing as the signal increases. In this rectifier, for all practical purposes, the rectifier bias does not increase with increasing signal. With no rectification, the 6R7 grid is biased very near cut-off (18 volts) and only about 0.18 ma plate current is flowing. With rectification, the rectified voltage is added to the grid bias and the small plate current is reduced enough to hold the total bias near 18 volts so it won't be cut off. This action increases the compression ratio and causes the knee of the compression curve to break over sharply. This system was used in a limiter designed and built by the writer back in 1938 and in use at WACO since then. The added 45 volt battery bias places the controlled receiver output at the proper level and improves the compression ratio.

A W-E relay was adjusted to close on 12 ma and open on 10 ma. Its current normally is about 13 ma when set for operation. About 5 ma of this is a steady bleeder current going to ground through a resistor. The 6J5 supplies the remainder.

Adjustment

To adjust the receiver, tune in the key station and turn the volume off. Press *C* discharge button and relay reset button. Feed a low level 1000-cycle signal into test input, increasing until input is 1 db above start of compression, which is indicated by a drop in 6K7 plate current. Hold this level and adjust the potentiometer across the receiver output until the relay trips in 15 seconds. Discharge the 8 μf capacitor with its shorting pushbutton each time before adjusting for 15 seconds. After adjustment, the volume can be turned about full on.

After the 15-second adjustment is made, increasing the 1000-cycle


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Research

level 20 db trips the relay in about 12 seconds. If the key station program is allowed to come through for a few minutes before the 12 second test, and the capacitor is not discharged before testing, the time is about 10 seconds.

The program level can rise 35 to 45 db above the 1000-cycle tone level used for the 15 second adjustment, before the relay trips. If 42 db is taken as 100 percent modulation, then the 1000-cycle tone level corresponds to only $\frac{3}{4}$ of 1 percent modulation.

We tuned the set to our station and found the maximum music level without tripping the relay, then fed 1000 cycles to find minimum level for 15-second operation. It was so close to zero on our modulation monitor we could only guess at the reading and call it, "under 1 percent". We then fed 800 and 1200-cycle signals, 100-percent modulated. It did not trip after 30 seconds.

In daily operation, we have found that programs trip the relay an average of once every two days. The 1000-cycle tuned circuit is 4 db down from 1000 at 800 and 1200 cycles. On regular tests from the key station the alarm sounds after about 8 or 9 seconds of tone, and it rings until we switch the speaker on or reset it. If the key station goes off the air, the alarm also sounds.

• • •

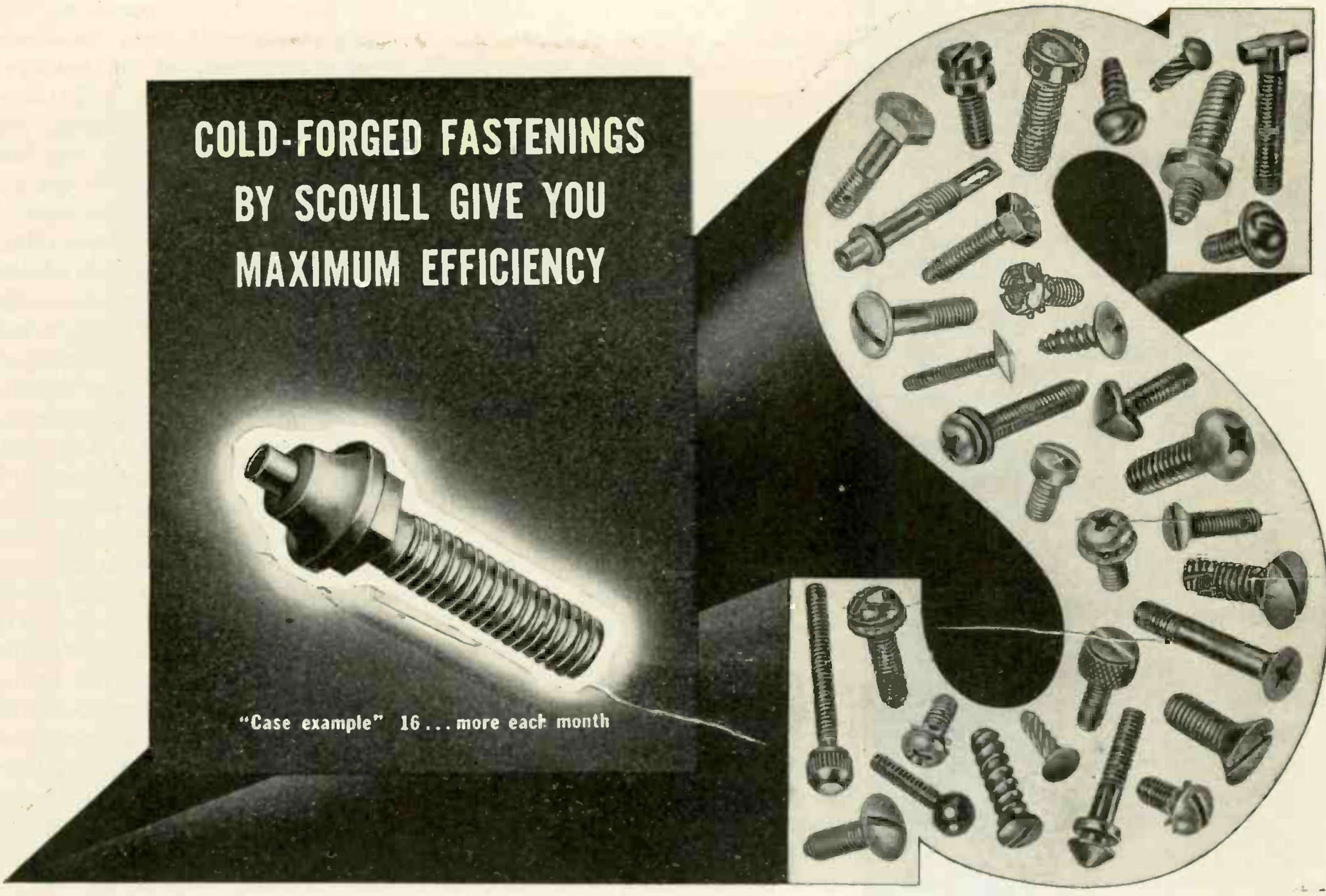
Transmitter Breakdown Alarm

By W. K. ANGUS

Station CFRN
Edmonton, Alberta, Canada

SOME MONTHS AGO, a home-made device was installed on the monitor rack of CFRN to give warning of interruption of program service. A bell rings instantly on failure of the carrier and the same bell also rings, after an appropriate delay of 15 or 20 seconds, if there is any interruption in the audio level from the studio.

The unit has since proved its usefulness. On at least two occasions it gave warning of program interruptions when the operator was talking on the phone with the monitor speaker cut. A description of the device might be of interest



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to other stations where only one operator is on duty at a time.

The circuit finally employed is given in the diagram. The d-c relay should be adjusted to close at 4 or 5 ma and release at 1.5 ma or better. (A less sensitive relay can sometimes be used by bleeding some additional current through it with a resistor.) This relay is in the plate circuits of the 6J7 and the two 6K7 control tubes which are normally biased to cut-off.

The grid of the input stage is fed with a small amount of r-f from some convenient place, or a short antenna can be used. The output circuit is tuned to the operating frequency and coupled to the first half of the 6H6 rectifier. The voltage so developed across the diode load resistor is applied, with minimum time delay, to the grid of the 6J7 control tube. The relay closes instantly when this tube loses its bias.

The audio component from the same source is amplified by the 6C5 and rectified by the second half of the 6H6, thus providing the cutoff bias for the 6K7's. The two tubes in parallel give more reliable operation than one tube used alone. Two 6J7 tubes were tried here but proved to be somewhat temperamental due to their sharp cutoff characteristics.

A good tubular paper capacitor should be chosen for the delay network. Larger paper capacitors of the block type give erratic operation due to leakage. The network arrangement results in high bias voltage from the 6H6. The capacitor charges in a second or two which is desirable from the standpoint of uniformity of time constant with varying program conditions.

On failure of modulation, the time that elapses before the bell will ring is determined by the r-f input, the voltages on the control tubes and the setting of the relay, as well as by the constants of the resistance-capacity network on the grids of the 6K7's. The metering jack for watching the performance of the control tubes when adjusting the unit is almost indispensable.

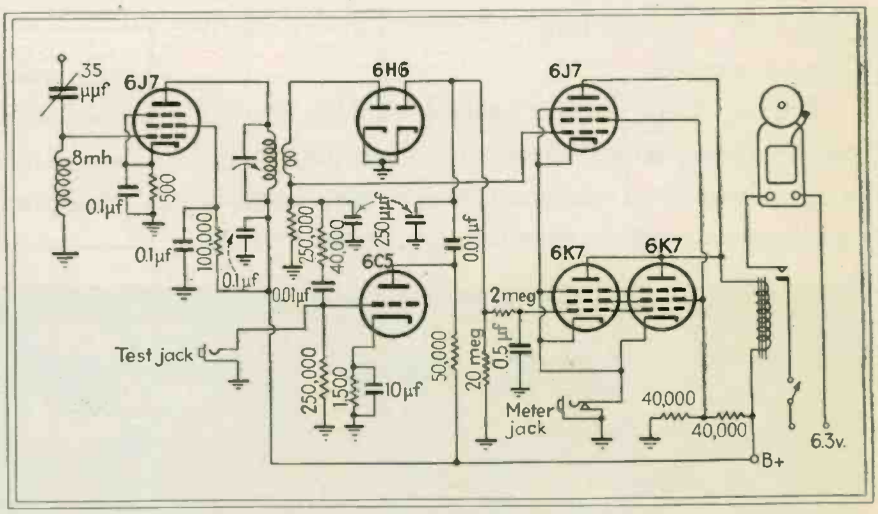
The stand-by switch and the bell itself are the only parts mounted on the front panel. At present we are operating the bell on the filament circuit. This means that the alarm will not function on a power line failure, although the bell will ring about fifteen seconds after the resumption of power if the transmitter does not also come back on.

This condition will be remedied when we obtain another sensitive relay to place in parallel with the first one. Then, with a small bleeder resistor to hold the second relay open and batteries for the bell circuit, the unit will be complete.

• • •

Noise Meter for Planes

AN AUDIO NOISE METER designed for use in quantitative test of noise components in aircraft radio equipment is shown in the diagram. The instrument consists of a vacuum-tube voltmeter that is connected to the regular receiver in the plane. This eliminates switching problems and permits the measurements to



Complete circuit of the transmitter breakdown alarm. The bell rings immediately if the carrier is interrupted, and if the carrier is maintained without modulation for more than about 15 seconds

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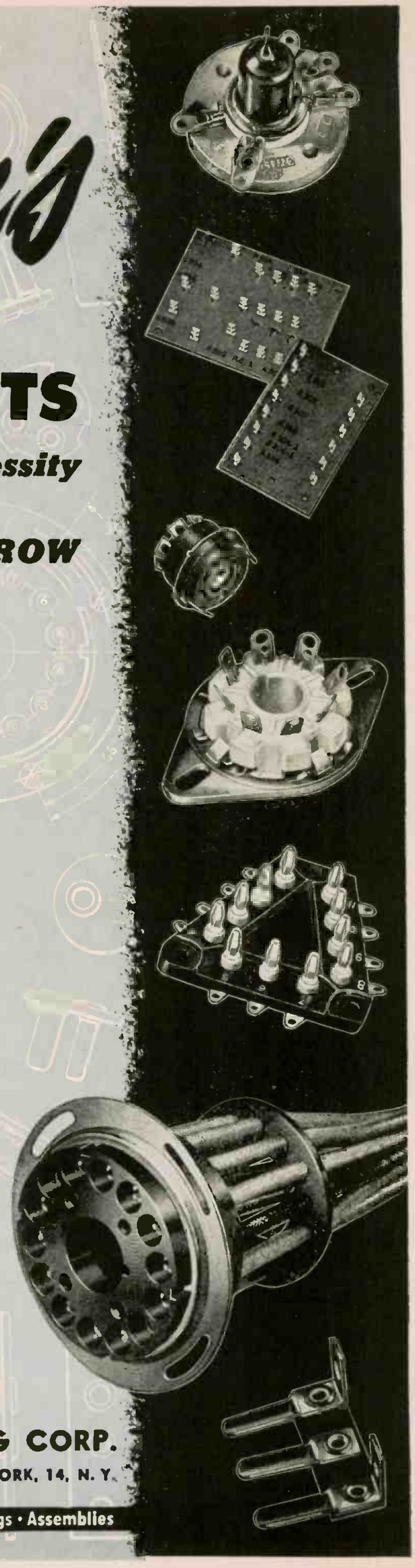

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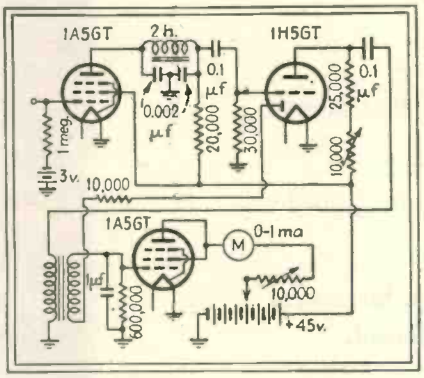
Sockets • Terminal Strips • Plugs • Switches • Plastic Fabrications • Metal Stampings • Assemblies be made from points where interference is being generated, remote from the receiver. The meter is described in a paper by Fred Foulon on the subject of radio noise elimination in all-metal aircraft, and was presented at the AIEE national technical meeting at Salt Lake City in September, 1943.

The instrument indicates the quasipeak value of the noise signal rather than the rms value since only the nuisance value of the noise signal present in the audio output of the receiver is of interest. The proper response is accomplished by the use of a resistance-capacitance network that requires a 10-millisecond charge time and a 600-millisecond discharge time in accordance with the standard time constant for noise-measuring instruments.



Circuit of vacuum-tube voltmeter that connects to the plane's receiver and allows noise measurements at remote points

To prevent a false reading by a signal from a radio station that may be inadvertently tuned in, the audio signal is monitored at the input of the noise meter by headphones inserted in the jack provided. This is also of value in identifying the source of radio noise since certain units of noise-producing equipment in aircraft cause a characteristic audio signal in the receiver.

A starting point in the measurement of radio noise is the evaluation of the background level of the receiver with all noise sources inoperative, the receiver antenna lead disconnected, and the antenna terminal grounded to the receiver chassis through a capacitor whose value equals that of the antenna. The background level is then determined throughout the frequency range of the receiver. The relative

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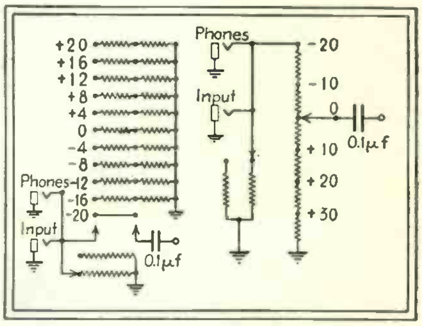
noise output of the various electrical devices in the plane may be measured and steps taken to reduce the coupling paths to the receiver.

For measurement of ignition noise reaching the receiver via the antenna, the background level is measured with the antenna and lead-in connected normally. In this case it must be remembered that the atmospheric noise level is the limiting background level. If noise from equipment inside the plane is reduced to the atmospheric noise level in one location, it may be above the atmospheric noise level in another location.

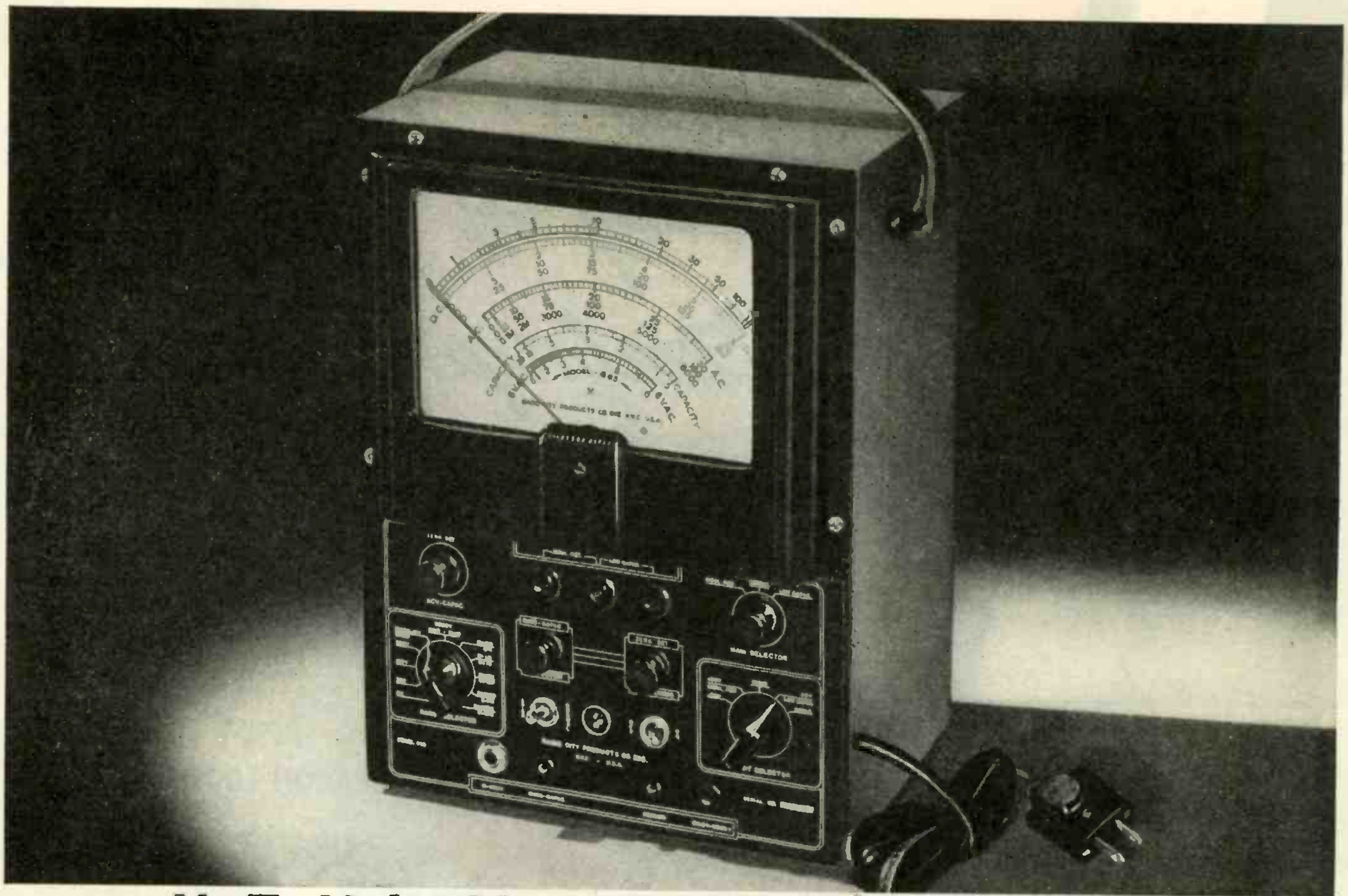


Two attenuator circuits that may be used at the input circuit of the audio noise meter. Phones permit monitoring of the signal

The circuit includes a filter to limit the frequency response of the instrument to the audio range necessary for intelligible transmission of speech. The meter is calibrated in db using a 0-db reference level of one milliwatt in 600 ohms. An input attenuator circuit is shown that extends the fullscale range of the meter in steps of 4 db. An alternative attenuator circuit is also given that provides steps of 10 db. High sensitivity is used to indicate the background level of the receiver used in conjunction with the meter, since this is one factor of the basis on which quantitative audio noise measurements are made.

GLASS FIBERS, bonded together and pressed into wafers, remain resilient and exert even pressure on the metal diaphragn of the noise-canceling lip microphone used by the Signal Corps. The mats from which the washers are cut are a product of Owens-Corning Fiberglas Corp.


Fastest Thing in Fastenings
LIGHTER IN WEIGHT
RESIST VIBRATION LOOSENING
Speed Nuts



V. T. Volt Ohmmegger INSULATION TESTER

MODEL 665

Model 665 provides insulation testing at 500 volts up to 10,000,000,000 ohms (10,000 megohms), with two other unique features—a comprehensive electronic multi-tester, not included in other "megger" types of testers, and a capacitymeter measuring as low as 0.0000025 mfds. (2.5 micro-microfarads) and up to 2,000 microfarads. Direct reading — complete ready to operate — with high voltage test leads. Voltage measurements AC and DC to 6,000 volts. Total of *29 ranges.*

Vacuum Tube Voltmeter on all ranges — input resistance 16 megohms minimum — 160 megohms maximum. V. T. Ohmmeter — 7 ranges to 1000 megohms — no danger of shock.

- ★ High voltage test leads; r.f. lead; signal tracing probe.
- ★ Wide Scale on 8″ D'Arsonval Microammeter with guaranteed accuracy of 2% at full scale. Linear meter movement.
- ★ Foolproof — Maximum protection against burn-out. Meter cannot be damaged by checking a live resistor or using too low a range for making a measurement.
- ★ Has pilot light indicator.
- ★ Matched pair multiplier Resistors accurate to 1%.

- ★ Equivalent of 29 individual measuring instruments in one unit.
- ★ VR 105-30 Voltage regulator tube and its associated circuits, insuring freedom from error due to line voltage fluctuations.
- ★ 13 A.C. and D.C. Voltage scales, measuring from a fraction of a volt to 6,000 volts, at very high sensitivity.

Model 665 has rugged metal case, provides thorough shielding. Complete with 4 leads; large capacity batteries, easily replaceable, tubes and pilot lamp. Size: 9¾″ x 12½″ x 6″. Weight 13 lbs. Code: FIRUS

Net price **\$79.50**

For details of Model 665 and other RCP instruments, send for Catalog 128. Our engineers will gladly advise on unusual test problems.

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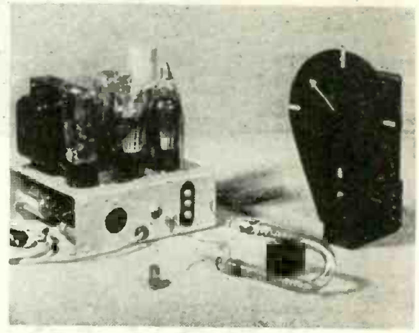
The Vectorscope

By LAWRENCE G. BETZ

Assistant Meter Engineer Public Service and Gas Co., N. J.

ONE OF THE PROBLEMS of instruction in job and vocational training programs is the proper presentation of the vector representation of electrical quantities. The device to be described has been used as a visual aid for this purpose in demonstrations and lectures and has received a favorable reaction from electrical workers studying metering, measurement and distribution. The unit can be readily built by the instructor or experimenter from "junk" material.



Essential components of the vectorscope. The disc is rotated at a speed of 3600 rpm and illuminated by the neon bulb, flashing 60 cps, to create the illusion of stopping the arrow on the disc

Essentially the device consists of a disc, rotating at 3600 rpm, upon which is impinged a light flashing sixty times per second for an extremely short duration. The instant of flash is determined by the phase of the end of the negative half cycle of the quantity being investigated. The recurrent flashing gives the illusion of stopping the disc, an arrow on which takes a fixed position. Various quantities tested in this manner will give approximate phase relations.

Square Waves

The input network is arranged to provide for two voltage ranges, 40 volts and 500 volts. The resistor in the grid lead of the first tube protects the grid during positive pulses by limiting the current to a safe value. The first two tubes are connected to provide trigger operation when acted upon by only three-quarters of one volt, rms. The input sensitivity, including

A New Multiplier Phototube for

VERY LOW LIGHT LEVELS...

RCA-931-A

SENSITIVITY 3 TIMES THAT OF RCA-931

BUY MORE WAR BONDS

SIGNALS are amplified up to 200,000 times and more in this new RCA multiplier phototube—over three times the amplification possible with the famous RCA-931—because manufacturing techniques have been improved materially by RCA engineers.

This really amazing sensitivity is made possible by the skillful use of secondary emission as cathode electrons are impelled against 9 successive dynodes before they reach the plate. At each dynode, secondary electrons are produced to multiply the electron current enormously.

Because this high amplification is accomplished within the phototube itself, extremely low light levels will produce high outputs without the high-gain amplifier stages required with conventional phototubes.

HIGH SIGNAL-TO-NOISE RATIO. Because high-gain amplifier stages are unnecessary with the RCA-931-A, sources of extraneous electrical "noise" (such as grid leaks, etc.) are eliminated, and a favorable signal-to-noise ratio can be obtained for very low light levels.

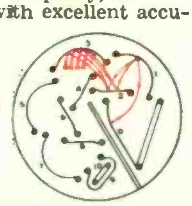
HIGH SENSITIVITY. The 931-A operated at 100 volts per stage has a sensitivity of 2 amperes per lumen; or over 3 times that of the superseded 931 at the same voltage per stage.

CIRCUIT SIMPLICITY. Where light signals are very small and high gain is needed, the 931-A provides a simpler circuit than that for a conventional phototube and its accompanying high-gain amplifier stages; also when the 931-A is used as a d-c amplifier, its zero-reading has excellent stability, and there is no problem of circuit feedback.

COLOR SENSITIVITY. The 931-A—like the 931—employs the S-4 photosurface which is highly sensitive to blue light; peak sensitivity is at about 3750 A°. Frequency response is flat up to a limit determined by transit-time effects, well above 10 million cycles per second. Dark current is very low. Full details are available on request (see coupon).

APPLICATIONS. A typical application of the 931-A is in quantitative spectrographic analysis. The 931-A and its associated circuits are substituted for the photographic plate commonly used in such analyses. This method is speedy, and results can be observed with excellent accuracy. This method of spectrographic analysis is widely used in vitamin measurements.

Cross section of the 931-A, showing electron paths in red.



RCA application engineers will be glad to help you apply the RCA-931-A—or other RCA electron tubes—to the solution of your design problems. Write, outlining your problem, to Commercial Engineering Section, RCA, 585 South Fifth Street, Harrison, N. J.

TECHNICAL DATA. Nine multiplier stages. Cathode photosurface, S-4. Max. seated height, 3⅛". Max. diam., 1-5/16". Base, small shell submagnal 11-pin. Mounts in any position.

MAXIMUM RATINGS (Absolute values): Plate volts (d-c or peak a-c), 1250. Volts between dynode No. 9 and anode, 250. Plate current, 2.5 milliamperes. Plate dissipation, 0.5 watt.

CHARACTERISTICS:

Volts per stage	75	100	Volts
Luminous sensitivity	0.3	2.0	μAmp./μLumen
Current amplification	30,000	200,000	
Sensitivity at 3750 Angstroms	270	1800	Amp./Watt

Order through your local RCA Tube and Equipment Distributor or contact Radio Corporation of America, Harrison, N. J.

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☐ 4-page technical data sheet giving description, ratings, characteristics, typical circuit diagrams, performance curves, and typical circuits for the RCA-931-A.

☐ 16-page booklet entitled "RCA Phototubes," chock-full of valuable tube data, application notes, etc., for RCA phototubes.

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NO Pitting
NO Sticking

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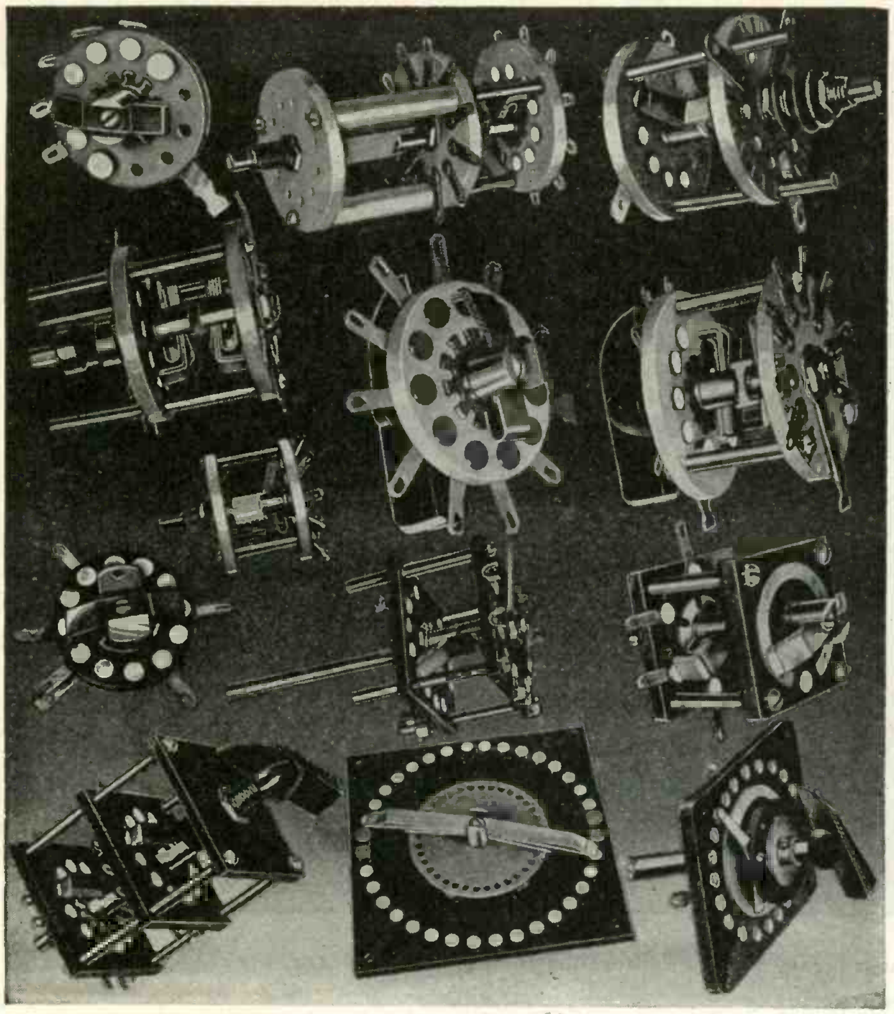

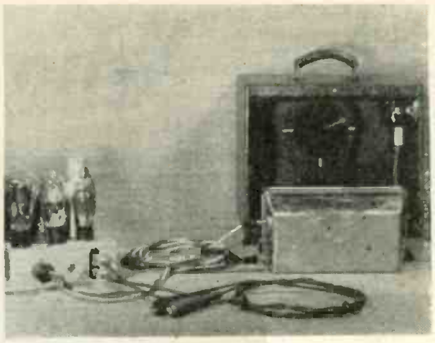

Complete arrangement for classroom demonstration. The carrying case serves as a hood for the disc to permit operation in a normally lighted room

polarity sensitivity, is adjusted by the 24A cathode resistor.

The output derived at the plate of the 57 is nearly a perfect square-wave voltage swinging between −2 and −32 volts. When applied through the coupling condenser C_1 and the grid resistor R, the square-wave produces steep positive and negative pulses of approximately 20 volts amplitude on the grid of the output tube.

The output stage is a conventional audio frequency output circuit with an inductance comprising the load. Chokes, output transformers, and even some interstage AF transformers can be used as the output reactor. It is advisable to connect the plate to the outer turns terminal and to provide extra insulation of strip mica between the outside of coil and core. On the steep negative pulse to this stage, most of the plate current is cut off and the resultant surge across the reactor reaches a value approximating 2500 volts.

Light Source

The light source consists of a neon tube whose diameter and pressure are standard for display purposes. The distance between electrodes is 12 inches; this will vary depending on the supply voltage, 25 volts per inch being approximately optimum. Magnet wire is coiled on the outside of the tube to act as a capacitive firing electrode. This tube can be made to order by local sign makers at a cost below two dollars. Avoid the use of fluorescent-type tubing.

Of importance in the circuit is the gap shown connected in shunt with the output reactor. Set at approximately ten thousandths of an

it's Pre-assembled!

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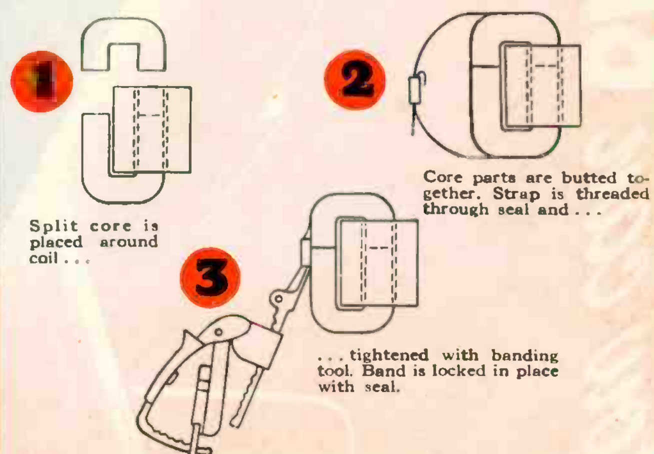
HERE'S HOW TO SPEED COIL ASSEMBLY



Banding Straps, Seals and Tools available from Westinghouse. See Page 9 of B-3223-A.

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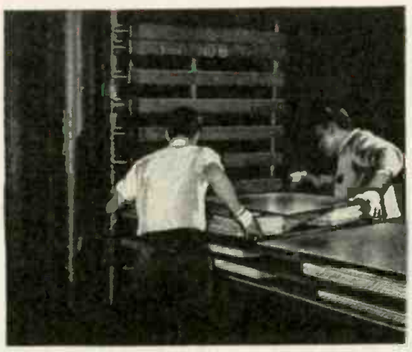
HIPERSIL CORES

How can BAKELITE Plastics

Six years ago, the Formica Insulation Company started development work on aircraft propellers that were light in weight, yet low in cost. Success came shortly before Pearl Harbor. Today, propellers for thousands of training and reconnaissance planes are being made of compreg . . . compressed maple wood veneers impregnated and bonded with BAKELITE Phenol Resin.

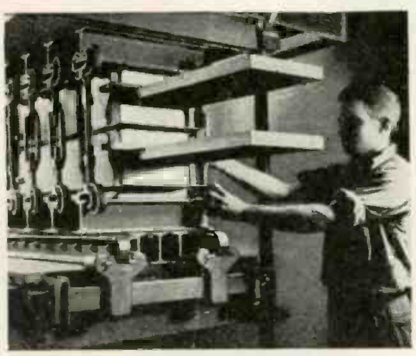
Choice maple veneers are placed in a cage, lowered into a vat of BAKELITE Phenol Resin. Vacuum, then pressure, assures complete saturation into the wood of this thermosetting resin. Later the veneers are removed and stacked to dry.



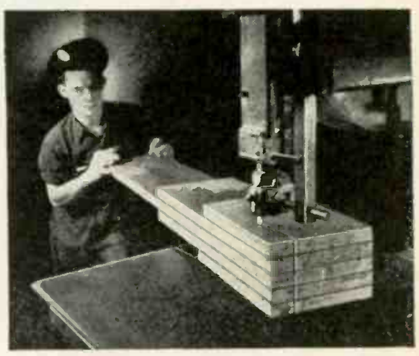
The impregnated veneers are then laid up and placed in a hydraulic hot-press. Here the heat softens the resin, the pressure compresses the wood to one-half its original thickness. Under continued heat, the resin sets. The result is a plank of compreg.

Here a worker is shown planing the densified wood block to assure perfect bonding in later operations. Measured in the grain direction these compreg planks can be said to have a weight-strength ratio of one-half the weight per volume of aluminum.

The planks of compreg are then coated with BAKELITE Phenol Resin and laid up to form the rough shape of the finished propeller blade. The metal plates dividing each unit are electrodes that will carry the high-frequency current used to bond the compreg planks to a single block of densified wood.



In the electrostatic press, high-frequency electrical current is passed through the entire propeller assembly, generating uniform heat throughout its entire depth. This is extremely important since only hot-setting resins can give the necessary bond, and since the tremendous thickness makes it impossible to use the steam platen or oven-heating processes.



After removal from the press, the blocks are rough-cut, then finished to form lightplane propeller blades. Although made of wood, these blades are water-resistant . . . have a tensile strength of 30,000 pounds per square inch, flexural strength of 40,000 pounds, and sheer strength of 8,000 pounds.

improve your products?

Can you produce them faster?... Can you improve them structurally, electrically, mechanically?... Can you build them at lower cost? The answer has been "Yes" for hundreds of products whose manufacturers have investigated BAKELITE Plastics.

Complex shapes are being molded quicker... resulting in sturdy, finished parts at remarkably low cost. Coatings and finishes have been developed with BAKELITE Resin bases that are easier to apply, and that are far more durable and resistant. Wood has been given new strength and endurance... is now being fabricated in curved plywood sections up to 84 feet in length. Cloth laminated with BAKELITE Laminating Varnishes saves 45 per cent in weight of fighter plane ammunition boxes.

These and other examples illustrated on these pages are typical of the scores of applications and developments that you will keep posted on when you are in touch with Bakelite Plastics Headquarters. Our Engineering Staff and Development Laboratories can help you with essential problems. The literature illustrated below can help you with your present and postwar planning.

Write for specific technical literature today. Please address Dept. 7.

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Unit of Union Carbide & Carbon Corporation
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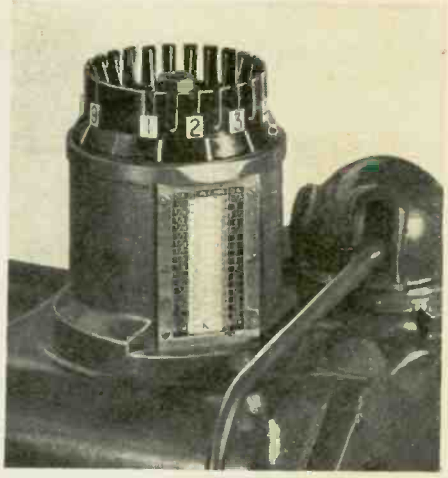
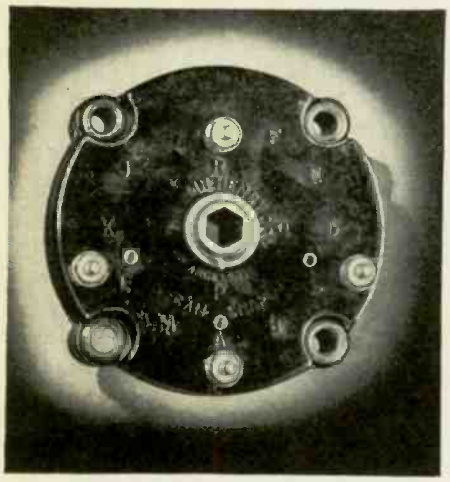
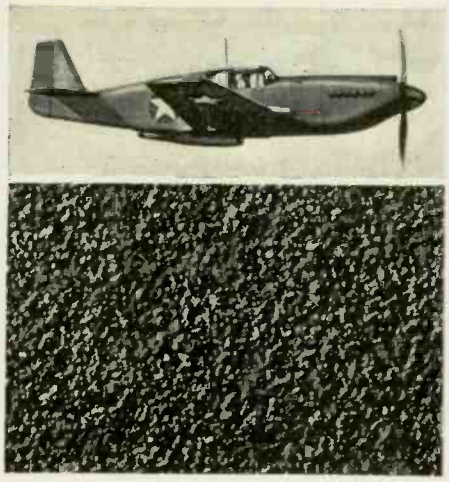


The preselector dial drum that automatically figures the gear ratios and speeds in the use of a No. 5 Warner & Swasey turret lathe was formerly made of metal. It is now molded of a BAKELITE *General Purpose* Phenolic Plastic eliminating several machining operations. The conversion has meant an important savings of metal and a reduction in production costs of approximately 80 percent.



After designing a new type rotary cam selector switch for sequence switching on airplanes, the Paul Henry Company found that simplified production and low cost demanded the use of a molded plastic. But which one? Experimentation pointed to a BAKELITE *Impact-Resistant* Phenolic. Further tests proved this material to have good electrical characteristics, high impact and tensile strengths, excellent heat and moisture resistance. Sales are up, production costs are down 20 percent...because this manufacturer investigated BAKELITE Plastics.



On the steps, catwalks, and cockpit floors of military aircraft, a covering that will withstand wear, yet be skid-proof, is absolutely essential. Rubber is slippery when wet. Other materials wouldn't stand the abuse. The Western States Lacquer Company developed an abrasive coating, particles of hard aggregate suspended in a rubber-like BAKELITE Plastic base. Sprayed or troweled on, this new coating gives a resilient, sandpaper-like surface to the flooring of some of America's leading bombing and fighter planes.

Deck houses for small boats are now being molded of plywood in a single piece. At the Haskelite Manufacturing Company's plant, veneers of wood coated with BAKELITE Resin Glue are laid in diagonal strips over a mold. Then low fluid pressure and controlled heat are applied which forces the plywood assembly to the exact contour of the mold and sets the glue. The finished deck house is 12 feet long, 9⅓ feet wide, and 8 feet high. It is light, strong, and durable.

USEFUL LITERATURE ON PLASTICS

"A Simplified Guide to Bakelite Plastics" gives a summary of the principal BAKELITE Plastics now available. It describes each type briefly, and illustrates typical applications. "Bakelite Molding Plastics" provides further information, and A.S.T.M. data on moldable plastics. "Molding Technic for Bakelite and Vinylite Plastics" is a 224-page manual on the art of molding plastics. It contains comprehensive data that the designer, engineer, molder, and user should have on the design and fabrication of hot-set and cold-set molding materials. Price $3.50 postpaid. Additional pamphlets and booklets describing other types of BAKELITE Plastics are also available. Write to Department 7, requesting these valuable guidebooks.

BAKELITE

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PLASTICS HEADQUARTERS

inch, it protects the tube elements, socket, wiring, and reactor insulation from flash-over. The gap may be constructed by drilling and tapping a small piece of plastic material for 10-32 screws; these should be pointed, inserted to provide the proper gap, and locked with nuts.

Operation

The discharge capacitor C and resistor R must have an RC value that will provide for adequate charging between firing pulses. If a more intense flash is required, the capacitor may be doubled and the resistor halved. This increases the transformer loading and affects the level of direct voltage.

Adjustment of the circuit must not be attempted until at least one minute has elapsed to permit the tubes to warm up. The rheostat in the cathode circuit of the 24-A tube is first reduced to almost zero resistance, then slowly increased until a flash occurs in the neon tube. When set in this manner the circuit is "cocked" by the negative pulse and fired when this voltage returns to zero.

This can be checked by applying voltage from a dry cell; positive polarity to the grid should have no effect, negative polarity should "cock" the circuit and firing should occur when the voltage is withdrawn. Acting at the instant when the negative half cycle becomes zero, the circuit is independent of wave shape and voltage amplitude over a great range. This makes it adaptable for phase determination.

Motor Data

The mechanical components of the device are shown in the illustration. The synchronous disc drive consists of an 1800 rpm motor geared 1 to 2. The motor shown has a two-phase winding, the quadrature voltage being provided by means of a series capacitor. At the time of starting, additional capacity is momentarily added manually in order to bring the disc into synchronism. The motor mounting is concentric with the disc shaft and held in position by friction. The disc can be positioned radially for the reference quantity by means of a key.

Methods of applying various quantities to the input depend upon the problem at hand. For the ap-

It's like driving your car from a dark room —when your windshield frosts over. Dangerous !—that's a weak word for it.

But you flip a switch and a busy little breeze blows Jack Frost off your windshield and keeps him off. You drive safely and with a free mind. And hundreds of thousands of defroster fans are driven so positively, quietly and dependably by "*Smooth Power*" Motors, that you probably never give them a thought.

But *now* we ask you to think about it—perhaps for your own good. These motors can do other jobs—lots of them. They pack an awful lot of smooth power into very small space. They're little huskies.

If your war products need light-power motors, let us know. And if your postwar products are likely to need such power, please write us now, so we can work together, if possible, to keep our respective businesses going after war needs are satisfied.

THE GENERAL INDUSTRIES COMPANY

Smooth Power

THE GENERAL INDUSTRIES COMPANY
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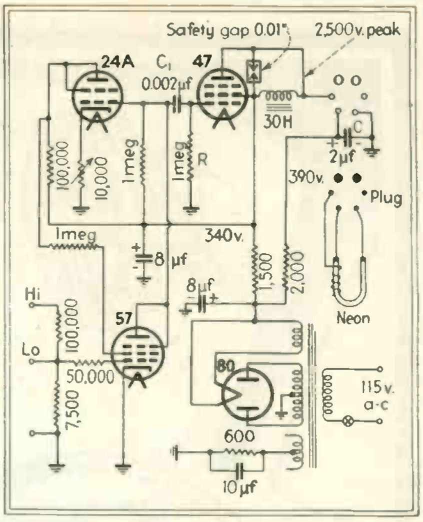


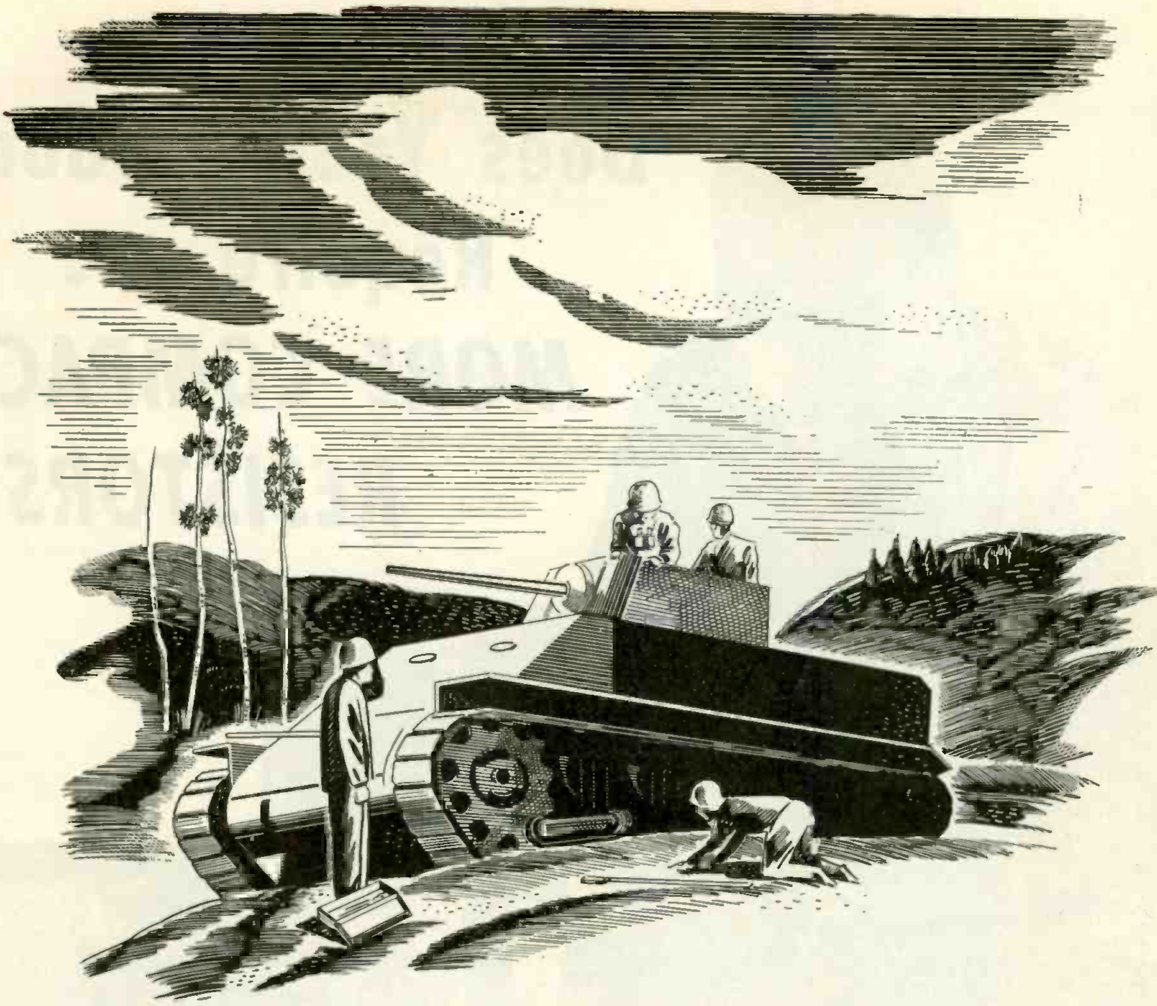
Circuit of the vectorscope, a stroboscopic instrument for visual representation of electrical vectors

plication of currents, shunts must be used which will provide approximately 2 volts. Magnetic fields may be explored by means of air-core coils of physical dimensions appropriate to the problem but it must be remembered that the vector so derived will lag ninety degrees from the actual flux; this can be almost entirely corrected by inserting an 0.01 μf capacitor in series with the search coil providing that the field is strong or that the search coil can be given sufficient number of turns to produce at least 35 volts. Where however, the values to be measured are small, it is advisable to precede the circuit shown with a stage of voltage amplification.

• • •

BRITISH WALKIE-TALKIE

Some British Army troops use this model walkie-talkie for communication purposes. A framework around the operating panel prevents the flexible cover from contacting the controls during transit



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The efficient operation of thousands of parts you can't see makes our war machines the best in the world . . . an unbeatable combination when American boys are behind the guns.

The precision learned in turning out these parts you can't see to wartime close tolerances will make your peacetime products better than ever.

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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.

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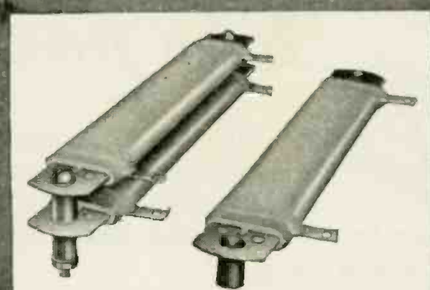
Does Your Product Require . . . *MORE COMPACT RESISTORS?*

The war has proven the importance of compactness in radio, electronic and electrical equipment. Unquestionably the dimensions of many post-war products will reflect the studies that have been made to conserve space. More compact components developed for the war will find great demand for peace-time users.

The Ward Leonard Strip Type Resistor is a typical example. Its flat section permits installation in places where there is not room for a round section resistor of the same value. Other regular Ward Leonard Resistors are available for special purposes.



Strip Resistors may be mounted singly or mounted in any multiples.

The Ward Leonard Resistor Catalog shows resistors of various types, terminals, mountings, enclosures, and resistance values. Send for it.

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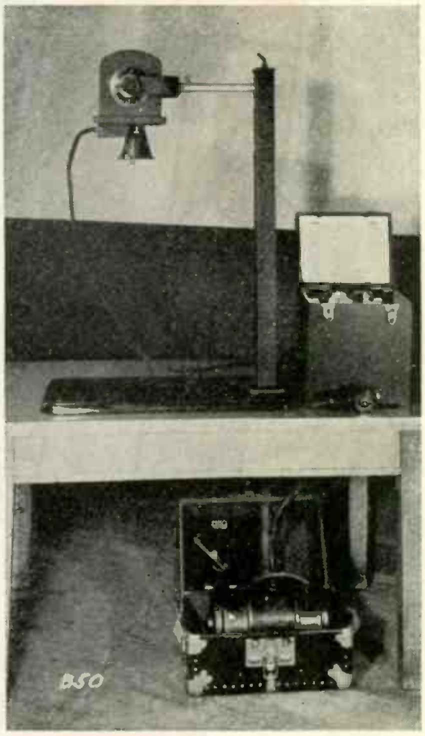
X-Ray for Aircraft Carriers

PORTABLE X-RAY UNITS are being used on the newest aircraft carriers for diagnosis of injuries to wounded airmen operating from the carriers. The use of the compact equipment eliminates risks entailed in delaying treatment until arrival at a shore-based hospital equipped with x-ray facilities.



The new aircraft carriers built by Kaiser are equipped with this portable x-ray unit. Power is obtained from the rotary converter under the table

The compact radiographic equipment may be set up on an ordinary table and takes little space when packed away. The unit is manufactured by the Kelley-Koett Mfg. Co. and includes a rotary converter to operate the x-ray equipment from the d-c line of the ship.

—◆—

MODERN ROUGH *service lamps for Navy ships are designed to withstand the concussion of heavy guns and permit interior lighting during an engagement. Former naval routine called for removal of the bulbs from the light sockets before gunnery commenced. Sylvania Electric Products tests the rough service bulbs by jarring them as violently while mounted on the rim of a heavy steel wheel.*

Leland

IN

Electronics

Assigned the responsibility of furnishing electrical power for outpost and behind the lines communications, Leland engineers developed the generator shown above and many thousands are now in service on all fronts. Other Leland equipment serves as drives on automatic pilots, range finders and sounding equipment.

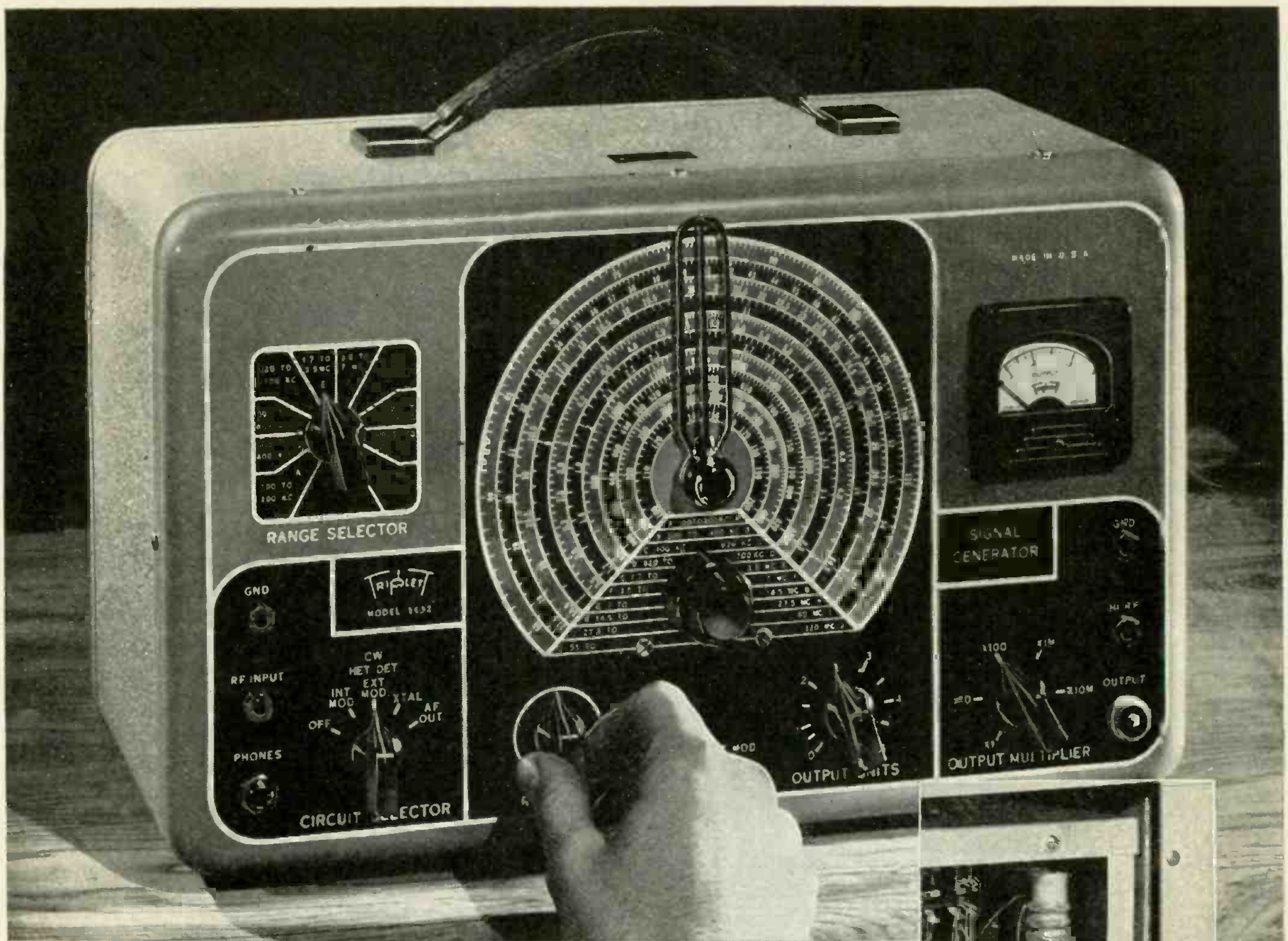
Thus is being acquired a wealth of experience to further the development of motors and generators for electronic industries after the war—engineering in this field already under way.

All types of motors and generators in sizes from ¼ to 3 HP single phase and 5 HP polyphase.

THE LELAND ELECTRIC COMPANY
DAYTON, OHIO

Leland

ELECTRIC MOTORS



MODEL NO. 1632

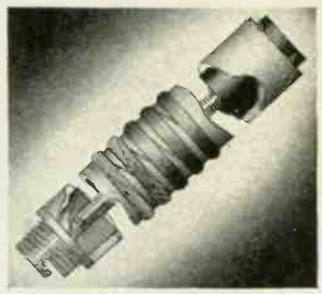
Signal Generator

CONTINUOUS COVERAGE—100 KC. TO 120 MC. • ALL FREQUENCIES FUNDAMENTALS

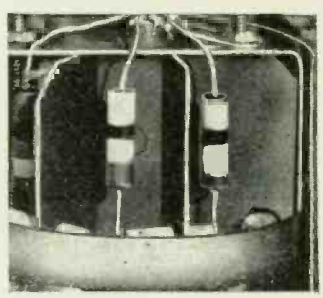
A complete wide-range Signal Generator in keeping with the broader requirements of today's testing. Model 1632 offers accuracy and stability, beyond anything heretofore demanded in the test field, plus the new high frequencies for frequency modulated and television receivers, required for post-war servicing. Top-quality engineering and construction throughout in keeping with the pledge of satisfaction represented by the familiar Triplett trademark.

Of course today's production of this and other models go for war needs, but you will find the complete Triplett line the answer to your problems when you add to your post-war equipment.

• Triple shielding throughout. Steel outer case, steel inner case, plus copper plating.



• All coils permeability tuned. Litz wire wound impregnated against humidity with "high-Q" cement.



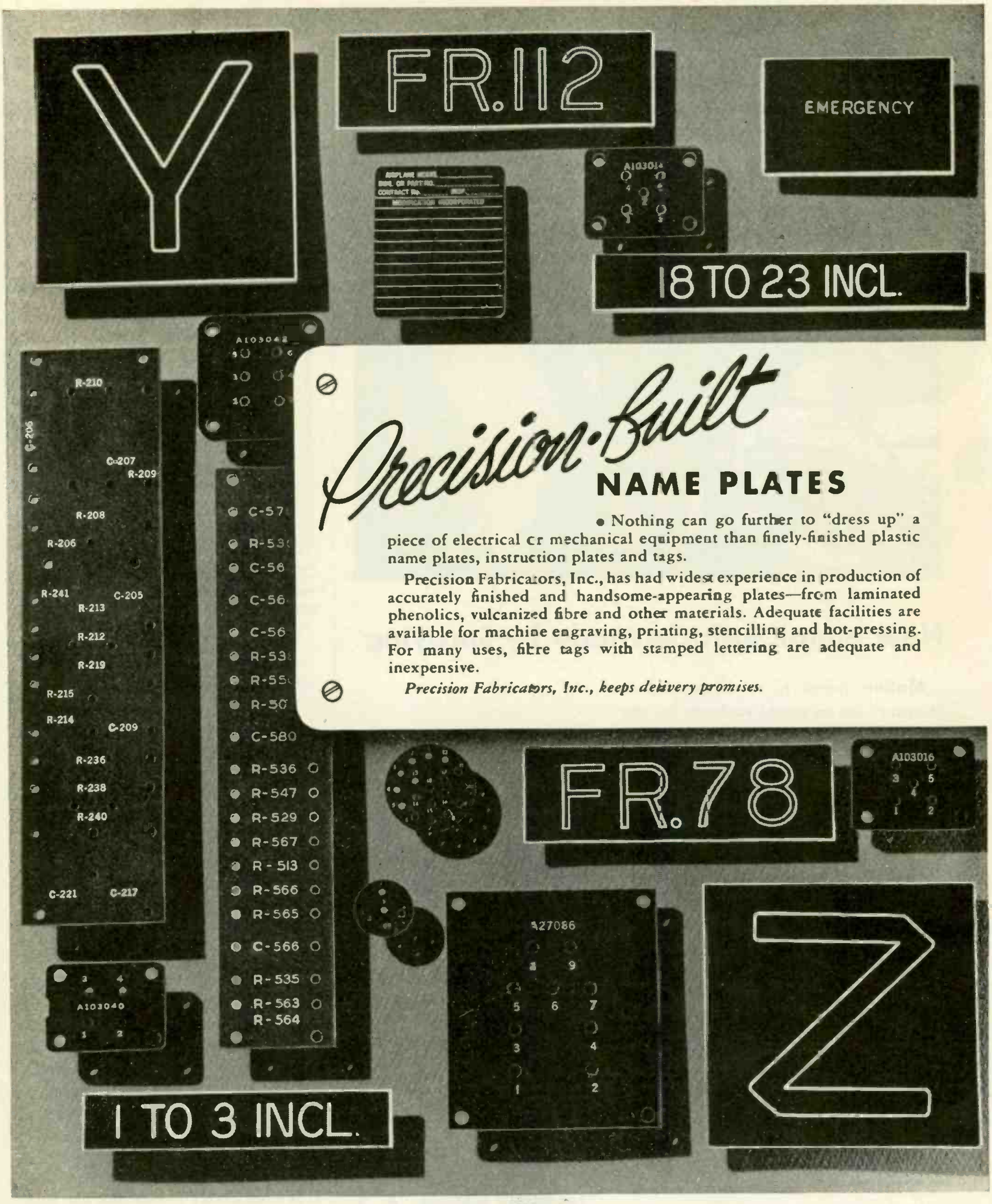
• Note sections individually shielded with pure copper. Entire unit encased in aluminum shield.

Triplett

ELECTRICAL INSTRUMENT CO.

BLUFFTON OHIO ★ ★ ★

STANDARDS ARE SET BY TRIPLETT



Precision-Built

NAME PLATES

• Nothing can go further to "dress up" a piece of electrical or mechanical equipment than finely-finished plastic name plates, instruction plates and tags.

Precision Fabricators, Inc., has had widest experience in production of accurately finished and handsome-appearing plates—from laminated phenolics, vulcanized fibre and other materials. Adequate facilities are available for machine engraving, printing, stencilling and hot-pressing. For many uses, fibre tags with stamped lettering are adequate and inexpensive.

Precision Fabricators, Inc., keeps delivery promises.

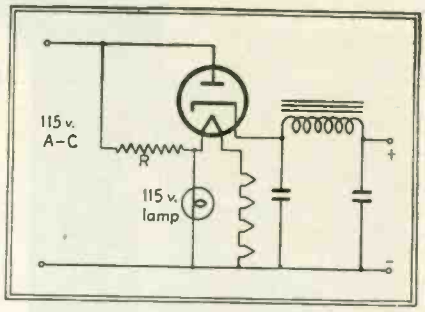
PRECISION *Fabricators* INC.

ROCHESTER, N. Y. NEW YORK: 369 LEXINGTON AVE. • DETROIT: 14319 STRATHMOOR AVE. • PHILADELPHIA: 6710 HOLLIS ST.
CHICAGO: 4317 N. RAVENSWOOD AVE.

SPECIFICATION FABRICATORS OF MYCALEX ★ PHENOL FIBRE ★ VULCANIZED FIBRE ★ RUBBER ★ ASBESTOS AND OTHER MATERIALS

Safe Pilot Lamp Circuit

A CIRCUIT that is designed to prevent the premature failure of pilot lamps in ac-dc receivers is the subject of patent No. 2,325,789 granted recently to A. C. Miller and assigned to Philco. Various expedients have been tried to solve this problem but in the usual circuits the voltage applied to the pilot lamp is high during the time the tubes are heating and they burn out quickly.



Circuit for utilizing the resistance of vacuum tube heaters when cold to prevent too-frequent burnout of the pilot lamp in universal receivers

The invention provides for the use of a 115-volt pilot lamp arranged in a circuit that gives reduced voltage to the lamp while the tubes heat, and more normal voltage during operation of the set. This is accomplished by connecting the lamp in series with the resistor that normally drops the line voltage to the proper value for the series connection of the tube heaters. During the heating period the resistance of the heaters is low and a current of about a half ampere flows through the heaters. Since this current flow takes place through dropping resistor R in the diagram, an IR drop of 25 volts is produced across the resistor and the pilot lamp receives reduced voltage. When the filaments have heated to their normal operating temperature their increased resistance causes the current flow to drop to 0.15 ampere. The IR drop across resistor R is then about 7 volts and the pilot lamp receives a voltage that is close to its normal required value.

PRODUCTION OF ELECTRONIC TUBES by Westinghouse was 11 times greater in 1943 than two years previous. Total sales exceed $22,000,000 as compared with $1,800,000 in 1941.

"Handie Talkie"

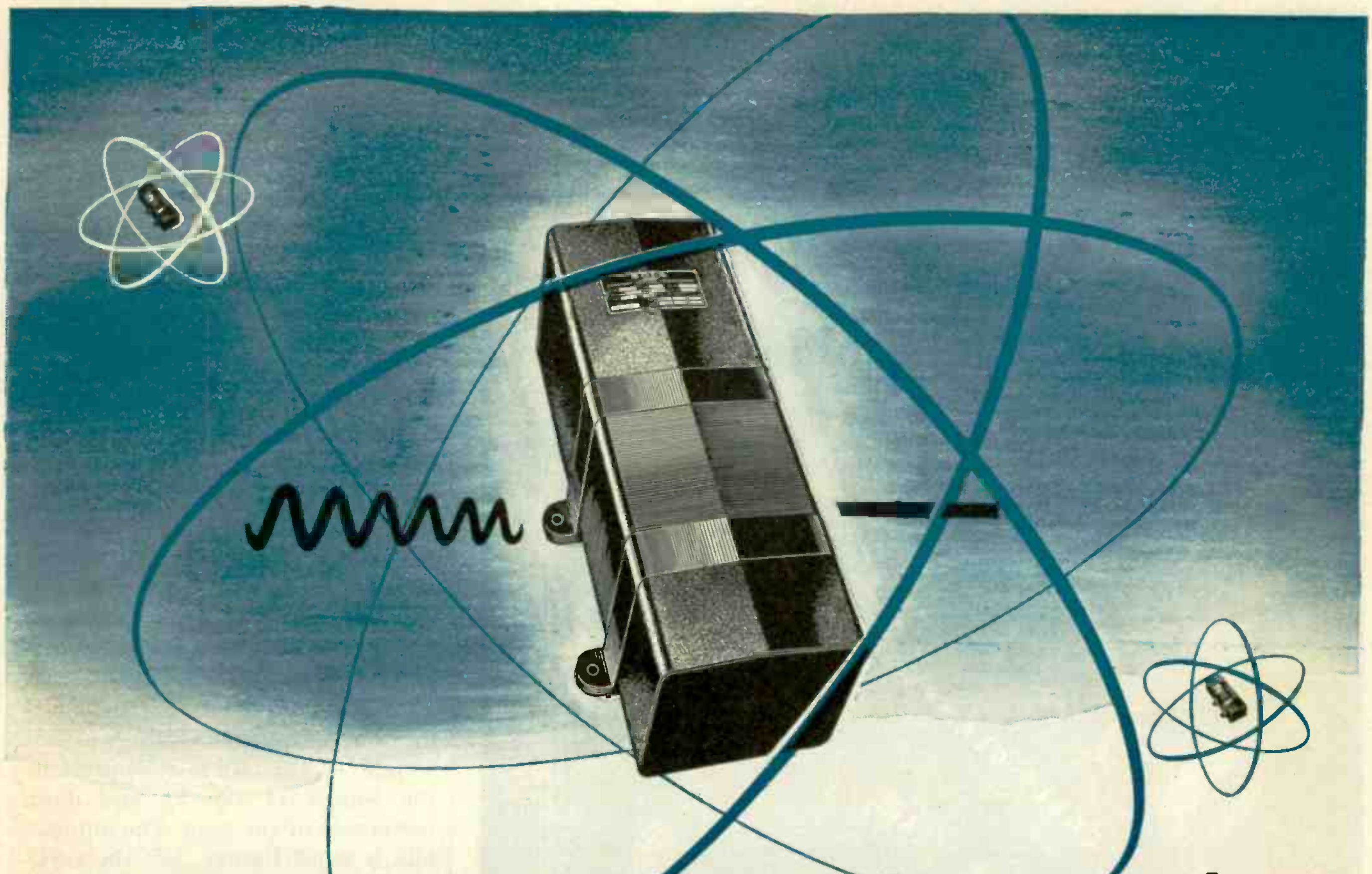
ANOTHER
Motorola Radio 1st ☆

Here is that mighty midget in the U. S. Army Signal Corps' matchless communications equipment arsenal. Pioneered and developed exclusively by Motorola Electronics Engineers it is fighting for Victory on every battle front.

For the continued development and production of Radio Communications and other special Electronic equipment for our Armed Forces, the Motorola organization has been awarded two stars for its Army-Navy "E" Flag. Motorola is proud of the part it has been privileged to play in the speeding of Victory.

ARMY E NAVY

Motorola RADIO
FOR HOME & CAR
GALVIN MFG. CORPORATION · CHICAGO, ILLINOIS



ELECTRONIC PERFORMANCE is always exactly predictable with built-in CONSTANT VOLTAGE

Constant, stable voltage comes first in design consideration if the electronic miracles promised for the post-war world are to be realized.

Perfect performance cannot be guaranteed if delicate electronic devices, too sensitive to tolerate ordinary voltage fluctuations, are left vulnerable to the sags and surges of commercial power lines.

FM and television transmitters and receivers, food sorting and testing devices, scientific instruments, X-ray, sound and projection equipment, precision machinery—these are but a few of the products, once requiring frequent adjustments and constant attention by watchful operators, whose performance is now automatic and exactly predictable with *built-in* Constant Voltage.

Many new products that have not yet progressed beyond the laboratory stage because of critical voltage problems will be available to the post-war world, with built-in Sola Constant Voltage Transformers reducing their operation to a simple "just plug in" basis.

Engineers and sales executives who are responsible for product design should bear this fact in mind—that the precisely controlled voltages of the research laboratory *are not* the voltages that will be encountered once the product reaches the user. An otherwise perfect piece of engineering may be headed for trouble at the hands of less experienced operators.

Dependably close voltage control to within ±1% can be made available to all electronic devices, or electrically operated equipment, with built-in automatic Sola Constant Voltage Transformers.

Without manual adjustments or supervision, they instantly reduce voltage fluctuation as great as 30% to the rated voltage required for successful operation. They protect themselves against short circuit damage. Capacities and sizes are available to meet any design requirements.

SOLA Constant Voltage Transformers

To Manufacturers:
Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications.
Ask for Bulletin DCV-74

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

Post-War Floating Rides

SERVO-MECHANISM PRINCIPLES that enable American tanks to fire on the run with such devastating effect quite possibly will provide "floating" rides in high-speed trains and other vehicles, according to Westinghouse engineers. Actual development work on these applications has been started. Calculations show that the power required to stabilize the vertical movement of a railroad coach is only about three horsepower. The mechanism necessary to accomplish this is small enough to fit into an overnight bag.

Curiously enough the servo-mechanism to stabilize a railroad car will require about the same power and be about the same size as that required for an automobile. Here is the explanation: The equipment required depends on the weight of the object multiplied by the square of the up and down movement of the road. The automobile is much lighter, but the vertical movement is several times that experienced by a railroad car.

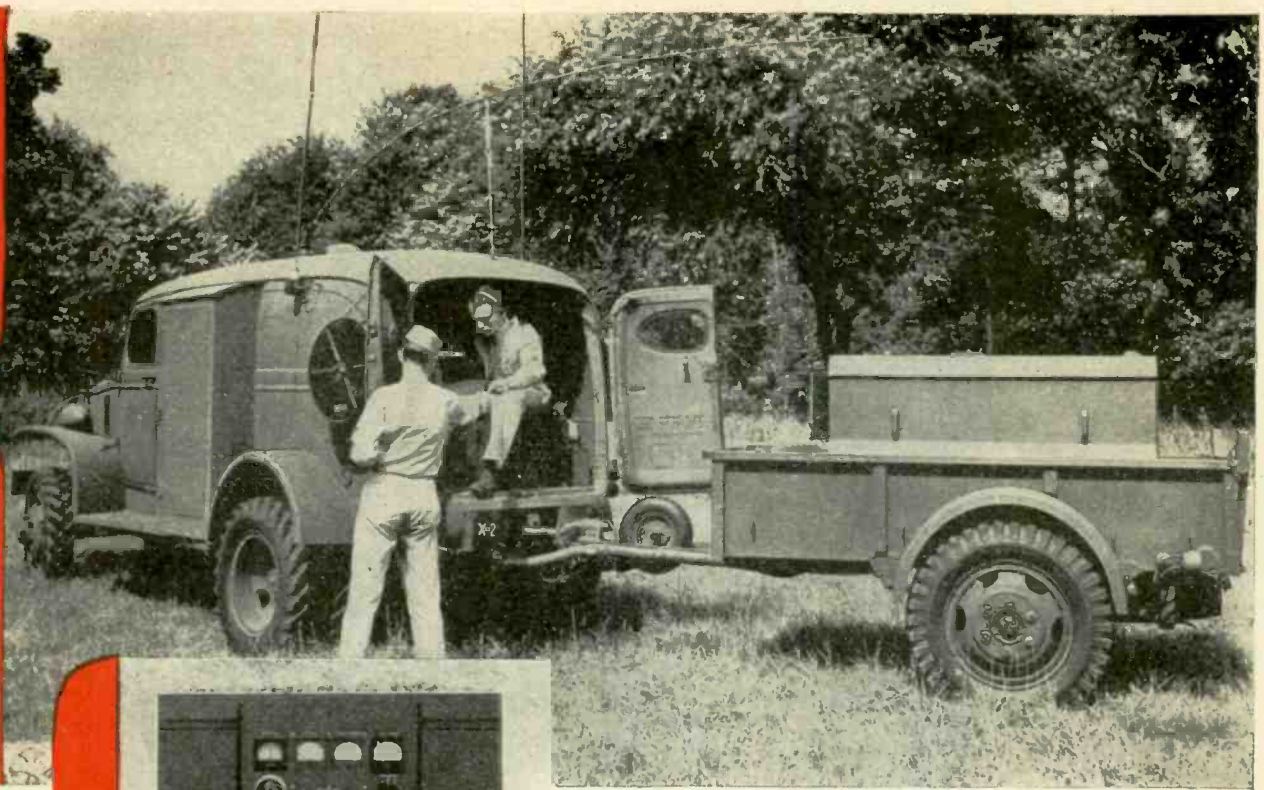
• • •

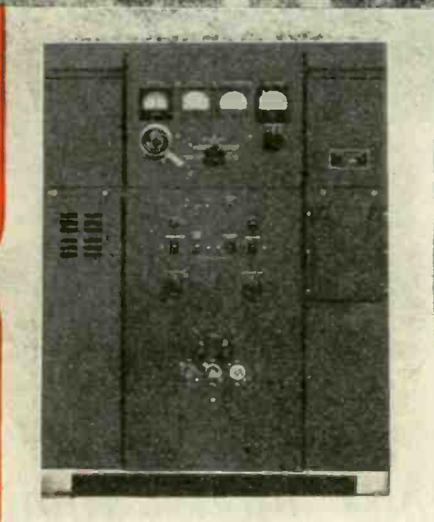
Steel Transmission Lines

TRANSMISSION WIRE for electric power is now made from steel having a coating of zinc for corrosion resistance. Although copper is a better conductor than steel, it does not have the strength which permits spanning long distances. Poles or other supports have to be spaced at comparatively short distances because the weight of the wire plus the added weight of ice or snow causes the wire to break.

In first attempts to use steel wire, one strand of steel was twisted with two strands of copper, the former to provide strength and the latter conductivity. The next development contained two strands of steel with one of copper for still greater strength. A third combination, one strand of steel and one strand of copper, was found to be impracticable. When exposed to a wind running parallel to the conductor, this two-strand wire developed an oscillating propeller motion which resulted in early failure.

Recent experiments have produced a suitable all-steel wire with high electrical conductivity. Although not designed entirely to re-





JOHNSON

Condensers
Tube Sockets
Couplings
Insulators

are used in the famous

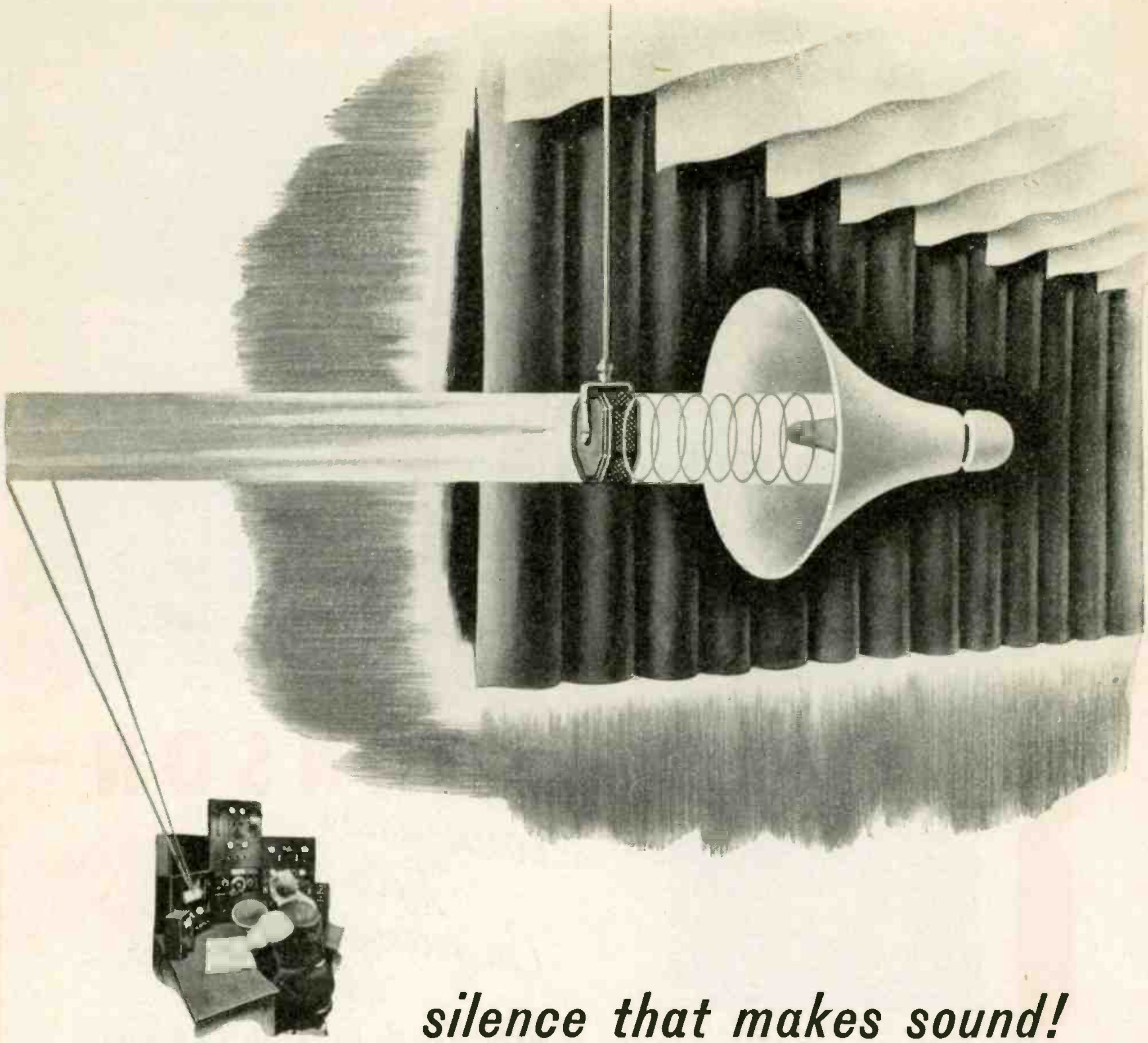
HALLICRAFTER BUILT SCR-299

JOHNSON'S are proud of their part in furnishing many of the important components for this famous transmitter. They are proud to have been selected originally by HALLICRAFTERS to furnish these components for the HT-4—before the pressure of war made price unimportant. They are proud that this same HT-4 was used by the Signal Corps to become a part of the SCR-299—a tribute to the dependability of HALLICRAFTERS equipment and JOHNSON parts. They are proud to have been able to expand production to furnish all of these parts needed in the SCR-299 in addition to the vast numbers of parts needed by other manufacturers. And, we are proud that these are all standard parts made to the same specifications as our "ham" parts before the War.

Write for
CATALOG
967D

JOHNSON
a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA



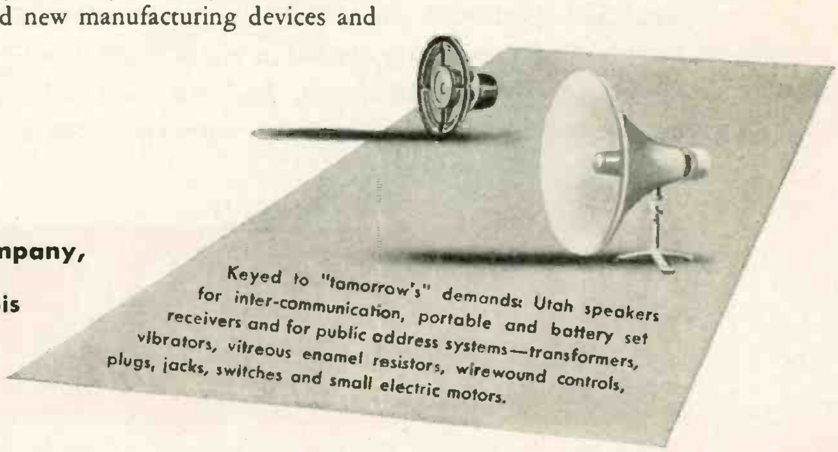
silence that makes sound!

In this "dead" room only the sounds which come out of the speakers are recorded. Sounds which would otherwise bounce back from the walls, ceilings or other objects are trapped and lost forever. The absence of reverberation permits scientifically accurate testing in the sound absorbing room of Utah's *complete* testing laboratory.

In making practical the many war-created radio and electronic improvements—in adapting them to today's needs and for the commercial requirements ahead, Utah engineers have designed new parts and products, developed new manufacturing devices and methods and have instituted new, more comprehensive testing techniques.

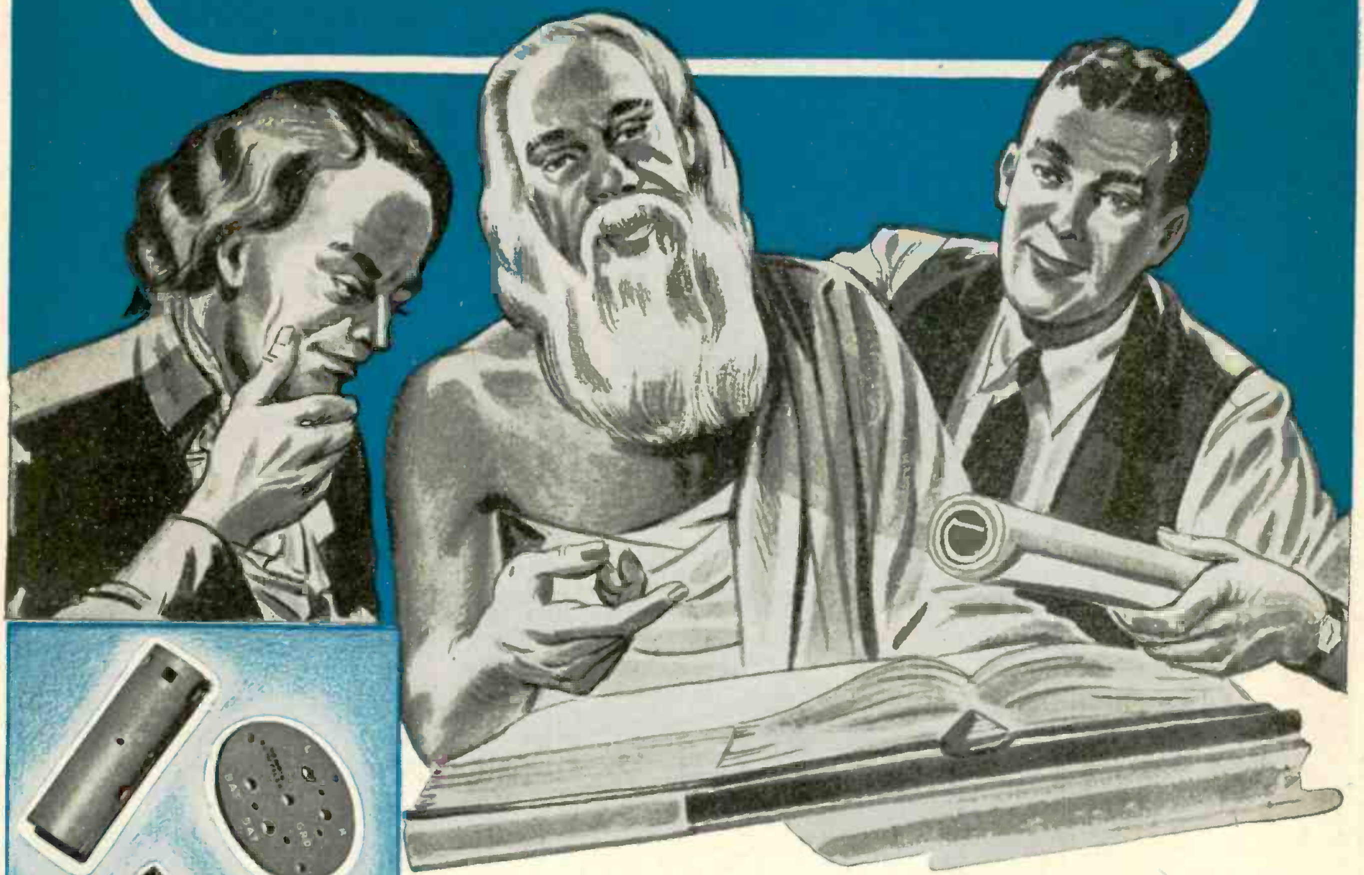
★ ★ ★

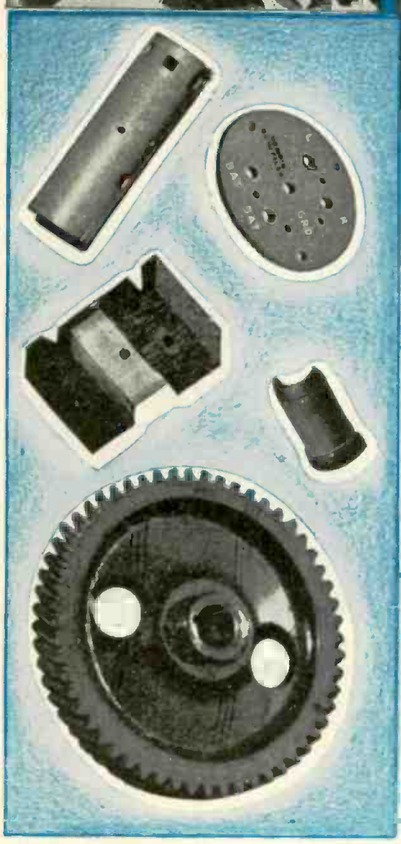
Every Product Made for the Trade, by Utah, Is Thoroughly Tested and Approved



utah Radio Products Company,
837 Orleans Street, Chicago 10, Illinois

CREASEARCH





The Greeks had no word for it and neither do we, more's the pity. Let's coin a word and a definition by starting with Webster's definition of research—"diligent protracted investigation, especially for the purpose of adding to the sum of human knowledge."

Now let's add, "More especially creation of new substances and discovery of special services they can perform better than any previously known substance".

There you have Formica research which has been going on more than 30 years through peace and war.

Formica laminated plastic has been created in various grades suitable for many uses in many industries. Strength, lightness, easy machinability, dielectric properties, acid and moisture resistance and stable dimensions are characteristic properties which vary somewhat according to the purpose of the grade.

Acquaint yourself with the past performance of Formica and its possibilities for your new or improved peacetime product.

"The Formica Story" is a moving picture in color showing the qualities of Formica, how it is made, how it is used. Available for meetings of engineers and executives.

ARMY E NAVY

THE FORMICA INSULATION CO.

4661 SPRING GROVE AVENUE

CINCINNATI 32, OHIO

FORMICA

place copper transmission lines, the steel wire affords definite advantages in specific applications, such as transmitting power economically to isolated rural areas or industrial applications.

The steel wire, a product of American Steel & Wire Co., subsidiary of U. S. Steel Corp., is carefully controlled throughout all stages of manufacture. Especial care is necessary in selecting raw materials and an extremely high degree of control is maintained in making the steel, rolling the rod, and drawing the wire. The finished wire has a high tensile strength and high fatigue resistance.

• • •

Electronic Balance for Gyro Rotors

AN ELECTRONIC INSTRUMENT for the balancing of gyro rotors and measurement of centrifugal forces is shown in the photograph. The machine, called the Electrodynascope, differs from conventional balancing machines in that it directly measures the alternating bearing forces exerted by the unbalance of the rotor rather than tangible displacement of balancing parts.

Test jig and control cabinet of the Electrodynascope, a machine for dynamic balancing of gyro rotors by electronic measurement of centrifugal forces

The rotor to be balanced is mounted on rigid bearing supports and the entire assembly is seismically suspended on springs to eliminate the disturbing influence of floor vibrations. Alternating unbalance forces are transmitted by a practically rigid platform to quartz crystals producing piezo-electric potentials which are magnified by

FIGHTING COMPONENTS *for* FIGHTING EQUIPMENT

B & W COILS *and* ANTENNA TUNERS *for the Hallicrafters-built* SCR-299

In the vanguard of invasion, you'll find the SCR-299 Mobile Radio Unit built by Hallicrafters—and, in this famous unit, you'll find B & W's specialized facilities well represented.

Standard B & W Air Inductors with rugged, armor-type construction take competent care of all amplifier plate coil requirements. Not only is the complete Antenna Tuning Unit a product of the specialized B & W facilities for electronic equipment production, but B & W engineers collaborated closely with Hallicrafters on its design and construction details.

Proud of their part in the SCR-299, B & W engineers welcome similar assignments where the utmost in performance, ruggedness, and dependability are prime considerations.

AIR INDUCTORS • VARIABLE AIR CONDENSERS
ELECTRONIC EQUIPMENT ASSEMBLY

B&W

BARKER & WILLIAMSON
235 FAIRFIELD AVENUE. UPPER DARBY, PA.

Exclusive Export Representatives: Lindeteves, Inc., 10 Rockefeller Plaza, New York, N. Y., U. S. A.

The ignition harness can well be described as an airplane engine's nervous system. One of Connecticut Telephone and Electric Division's latest war assignments is the production of this assembly for the manufacturer of a world-famous aircraft motor.

"Connecticut" war production also includes military field telephones, head sets, switchboards, electronic devices and special ignition parts.

A pioneer in communications and ignition systems, this division of Great American Industries, Inc. is geared for advanced engineering and manufacturing of precision electrical parts and equipment. When you are planning electrical or electronic improvements in your postwar products or manufacturing methods, our development engineers are ready to offer constructive help.

VICTORY AND JOBS AFTER VICTORY

depend on holding the line against inflation. Never bid up a price; never buy what you don't need; make war bonds your investment in tomorrow.

ARMY E NAVY

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

MERIDEN ★ GREAT AMERICAN INDUSTRIES INC. CONNECTICUT

SIMPLICITY OF APPLICATION

. . . and High Degree of Vibration Isolation are Basic Features of ➡ ➡ ➡

LORD
BONDED RUBBER
Shear Type
MOUNTINGS

MILLIONS of Lord Mountings are in use today, providing protection against the harmful effects of shock and vibration on all types of industrial, military, and naval equipment, from light, delicate instruments to heavy, massive machinery.

Providing such protection in modern equipment designs may well be termed "Protective Engineering". To engineers confronted with a problem of vibration control, Lord offers a wide variety of bonded rubber, shear type mountings from the standpoint of function, size, shape, load ratings, and methods of application.

The accompanying photographs show Lord Plate Form Holder Type Mountings being used to float electric generators within the transmitter housing of a marine radio unit manufactured by Federal Telephone and Radio Corporation, at Newark, New Jersey. Simplicity of application is well illustrated. The generators weigh 110 pounds each, and the mountings serve to isolate component equipment from any disturbing forces emanating from this source.

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 in equipment operating at very high frequencies. The remarkable efficiency of Lord Mountings is due to the accuracy, precision, and uniform quality of manufacture.

Lord Mountings are made in two main types, Plate Form and Tube Form, with variations to suit special conditions. Load ratings of standard sizes range from a few ounces to 1500 pounds. They absorb shock, control vibration, and minimize all noise transmitted through solid conduction.

For complete information covering all Lord Mountings, as well as engineering discussion on vibration control, write for Bulletins 103 and 104, or call in a Lord Vibration Engineer for consultation on your vibration problems. There is no obligation.

Back The Attack—Buy War Bonds

IT TAKES RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

SALES REPRESENTATIVES
NEW YORK - - 280 MADISON AVE.
CHICAGO - 520 N. MICHIGAN AVE.
DETROIT - - 7310 WOODWARD AVE.
BURBANK, CAL. - 245 E. OLIVE AVE.

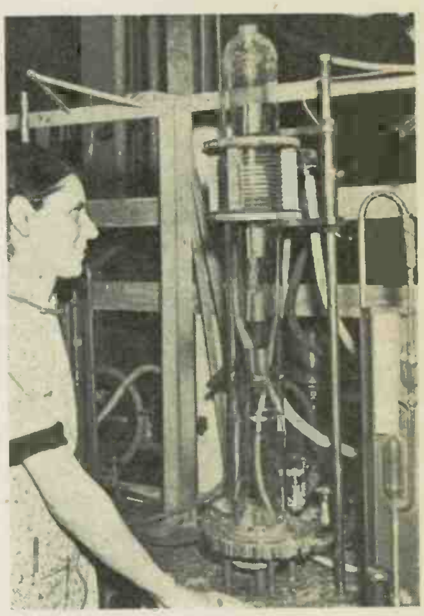
Originators of Shear Type Bonded Rubber Mountings vacuum-tube amplifiers and made visible on the screen of a cathode-ray oscilloscope.

The magnitude of the unbalance, to be ultimately expressed in ounce-inches or depth of drilled or milled holes, is indicated as a sine wave pattern, representing magnitude and location of unbalance. The cathode-ray screen is graduated horizontally into 360 deg for reading the location of unbalance, and vertically into units representing the amount of unbalance.

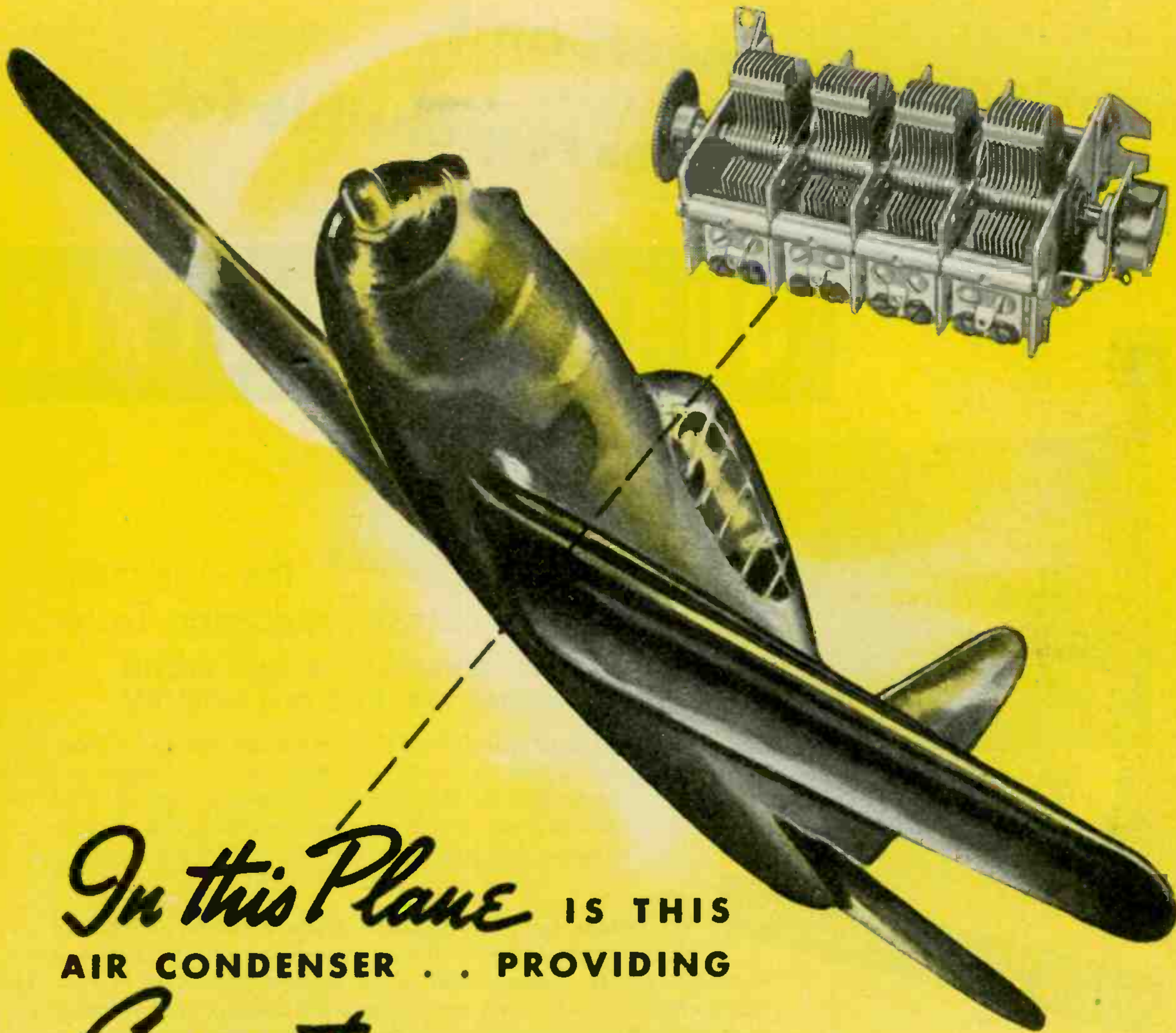
Since centrifugal forces are measured, instead of displacements caused by such forces, and, since the rotor is mounted on rigid supports having a natural frequency considerably above the balancing speed, inertia forces are negligible and indications are independent of the weight of the rotor. Rotor weights up to 75 lb and speeds up to 12,000 rpm may be accommodated by the machine, a product of Sonntag Scientific Corp.

• • •

ANODE TREATMENT

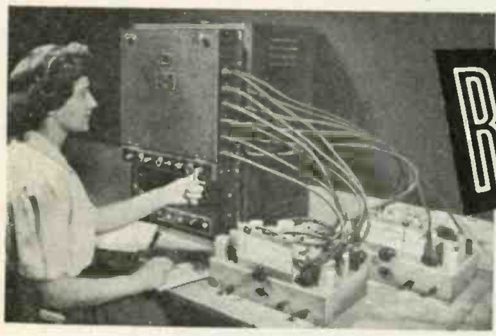


Metal parts of future vacuum tubes have occluded gas particles driven off when they are inserted in this glass container and subjected to an induction heating treatment from the water-cooled coil near the top of the assembly. Control grids are heated to 3,272 deg F in the container, nearly 300 deg hotter than molten iron. The operator is observing graphite plates, under treatment at 2,642 deg F while the gases are pumped from the container



Important to Engineers and Production Executives responsible for

QUALITY CONTROL



ROTOBRIDGE

the Automatic Mass Production Tester

240 WHEATSTONE OR KELVIN BRIDGE CIRCUITS IN 4 MINUTES!

The basic principle of this remarkable testing performance is the motor driven rotary switch. Simple, yet responsible for the revolution in testing methods that has occurred in one short year—and is still growing in scope and size.

TESTING ELECTRONIC EQUIPMENT

The Rotobridge's first application was in testing all types of electronic equipment—for errors in wiring, or resistance and reactance values. Today, most of the leading producers of electronic equipment are using one or more Rotobridge units to check their production. Every circuit is checked—automatically and tirelessly—and with laboratory precision—to tolerances set up by the engineer.

TESTING CABLE HARNESSES

With the adaptation of the Kelvin bridge principle to the Rotobridge, the field of testing complex cable harnesses was opened up. Demands by the Army and Navy for complete 100% tests, instead of spot checks, mean either a larger force of testers using old fashioned methods—or a conversion to automatic methods and the virtual elimination of human error. Aircraft manufacturers are now using the Rotobridge to check harnesses for correct wiring, leakage and proper resistance—three indispensable requirements.

TESTING TRANSFORMERS

Manufacturers of transformers — or companies checking them on incoming inspection—will find the Rotobridge method of testing invaluable. First, because Rotobridge affords a saving of time up to 75%; second, because, with the elimination of human observational errors, greater accuracy is assured.

Rotobridge is an invaluably helpful factor in speeding your wartime production—and it is destined to be one of your most important assets with the return to a competitive peacetime economy. BULLETINS AVAILABLE.

COMMUNICATION MEASUREMENTS LABORATORY
120 GREENWICH STREET, NEW YORK 6, N. Y.

When the curtain goes up on the approaching post-war era, Federal does not propose to perform sleight-of-hand in producing a startling fantasia in broadcast equipment.

But Federal, which built WABC, the 50 Kilowatt key station of the Columbia Broadcasting System and the most modern transmitter in the country, will produce then, as it will discuss now, up-to-the-minute equipment of even greater power to meet individual needs.

Federal's long experience in building transmitters, in both high frequency and standard broadcast ranges, assures equipment that will measure to the highest standards.

Federal's scientific talent, which includes the world's best technical minds, assures equipment that will embody good engineering practices and proved refinements in design.

Federal invites you to discuss your ideas and its facilities for developing transmitting equipment to your particular requirements.

Most of the leading broadcast stations are equipped with Federal transmitting and rectifying tubes — known for their quality and high standard. Use Federal tubes — built with the ultimate of care and workmanship for satisfactory performance.

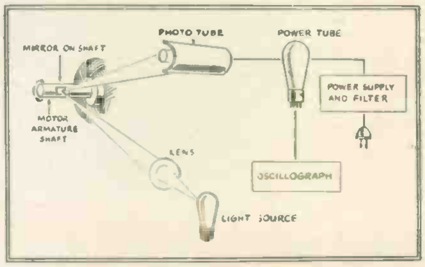
Federal Telephone and Radio Corporation

COMMUNICATION PRODUCTS DIVISION — AN IT&T ASSOCIATE — Newark, N. J.

Phototube Counter

THE COUNTING of the number of revolutions that an armature makes after the current has been cut off is made possible by a phototube and its associated amplifier arranged as shown in the diagram.

Glued to the motor shaft is a tiny mirror that reflects the beam of light every time the armature completes one revolution. The beam is reflected to the phototube and the electrical impulse amplified and fed to an oscillograph galvanometer.



Arrangement of apparatus for electronic counting of motor revolutions during braking with power shut off

The deflections of the galvanometer are recorded on a photographic film and at the same time a visual record of the current is photographed. By examining the film, it is possible to count the number of revolutions the armature makes after the current has been cut off and a brake applied to the motor. The equipment was designed primarily for a special test application on a war project at the Bridgeport Works Laboratory of General Electric.

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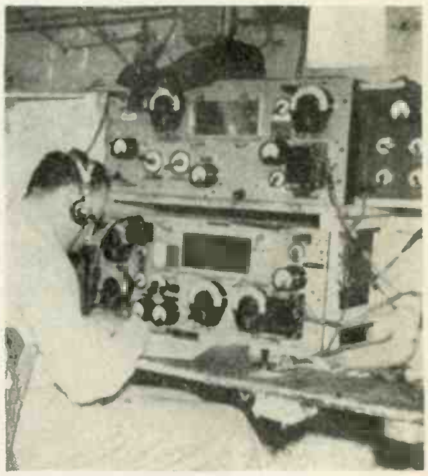
OPERATIONS UNDERGROUND



Communications equipment operated inside the underground British Naval wireless telegraphy station at Famagusta, Cyprus

"NO "SQUARE PEGS" *For Sale*

General Electronics Industries Specializes in Specific Applications of Electronics to Solve Individual Production Problems

● For assistance in your postwar production planning, you are invited to call upon the research engineering skill, experience and facilities of one of the largest organizations specializing in electronics.

General Electronics Industries is prepared at this time to study your electronics requirements and to design or develop the application that will fit your individual purpose. Thus, you will gain a head start in your future postwar production, with the perfect electronic devices General Electronics Industries will be ready to supply as soon as its manufacturing facilities are no longer engaged in all-out war effort.

Write to Engineering Department, General Electronics Industries, 342 West Putnam Avenue, Greenwich, Connecticut.

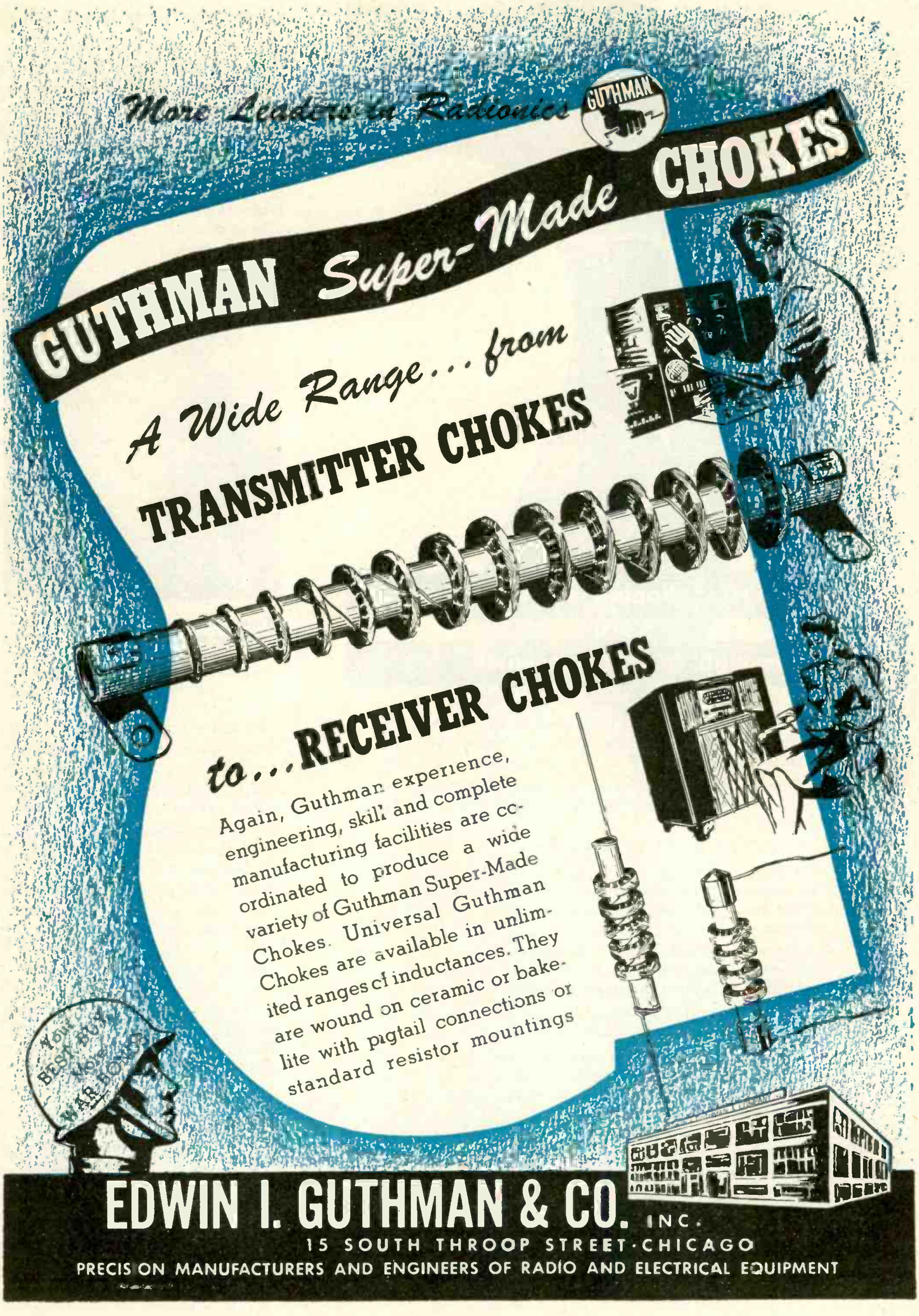
ARMY-NAVY "E" WITH STAR awarded to Auto-Ordnance Corporation for continued excellence in production of "Tommy" Guns.

GENERAL *Electronics* INDUSTRIES

TRADE-MARK REG. U.S. PAT. OFF.

Division of Auto-Ordnance Corporation

GREENWICH • STAMFORD • BRIDGEPORT • NEW MILFORD • NEW YORK


More Leaders in Radionics
GUTHMAN
GUTHMAN Super-Made CHOKES
A Wide Range... from
TRANSMITTER CHOKES
to... RECEIVER CHOKES
Again, Guthman experience, engineering, skill and complete manufacturing facilities are co-ordinated to produce a wide variety of Guthman Super-Made Chokes. Universal Guthman Chokes are available in unlimited ranges of inductances. They are wound on ceramic or bakelite with pigtail connections or standard resistor mountings
EDWIN I. GUTHMAN & CO. INC.
15 SOUTH THROOP STREET · CHICAGO
PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT

Phototube Tests Bomb Fuzes

FRAGMENTATION BOMBS are equipped with safety fuzes installed on the bombs' noses. By timing the release of a firing pin during descent of the bomb, the fuze prevents premature explosion. Revolving of a vane on the tip of the fuze loosens a safety device which, in turn, releases the firing pin to strike explosive portions of the bomb when it hits the ground.

Fuzes for fragmentation bombs are tested in this wind tunnel. The revolving vane releases a safety device that flies off and allows a light beam to strike a phototube

To test a fuze, a laboratory technician places it inside a narrow three-foot long wind tunnel operated by compressed air. Pressing a button starts an automatic timer and opens a magnetic valve. The air blast whirls the vane of the fuze and releases the safety device. As the safety device flies off, it permits a beam of light to strike a phototube which electronically closes the valve and stops the timer. The "arming" time of each fuze is measured by the automatic timer in intervals as small as 1/120 second. The wind tunnel creates 300 to 800-mile-an-hour gales and was developed by Westinghouse engineers.

FISH IN COLORADO lakes and streams can be stunned momentarily by an electrical device so that they can be tagged and released for later identification. The device is exclusively in the hands of the State Game and Fish Department, however.

HANDS that rock the ~~CRADLE~~! AXIS

Awarded to our Hicksville, L. I. plant for outstanding achievement in war production.

PRESS WIRELESS, INC. IS DEVELOPING OR MANUFACTURING

- HIGH POWER TRANSMITTERS
- DIVERSITY RECEIVERS
- AIRCRAFT AND AIRFIELD RADIO EQUIPMENT
- RADIO PRINTER SYSTEMS
- MODUPLEX UNITS "TRADEMARK"
- CHANNELING DEVICES
- RADIO PHOTO TERMINALS
- FACSIMILE MACHINES

AND OTHER TYPES OF RADIO AND COMMUNICATIONS EQUIPMENT

Special radio equipment designed and manufactured by Press Wireless, Inc., is proving its worth on fighting fronts throughout the world. Rugged, high power transmitters and various other units from Press Wireless factories are standing the gaff of war-time duty with maximum dependability, accuracy and extreme simplicity of operation.

Credit for this is due in no small measure to the skilled hands of women workers on Press Wireless production lines. In assembling radio sets as in other war-directed tasks, American women are proving that hands that can rock the cradle also rock the Axis...toward a permanent sleep!

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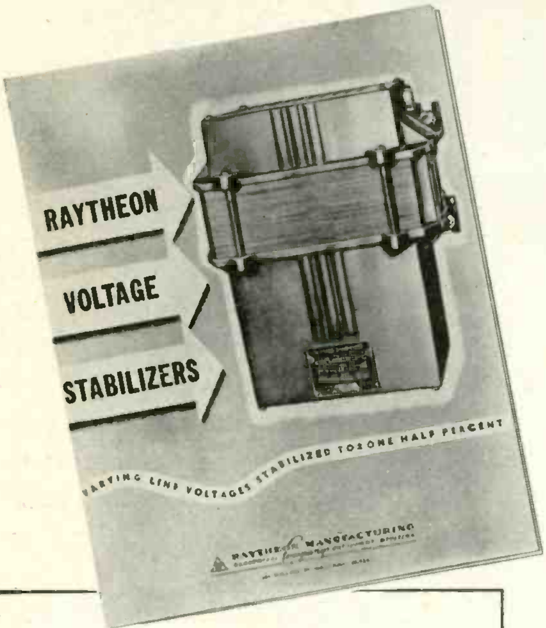
RAYTHEON VOLTAGE STABILIZERS

CONTROL FLUCTUATING VOLTAGE TO ± ½%

A MAGNETIC UNIT WITHOUT MOVING PARTS

Nothing to replace or adjust



JUST OFF THE PRESS

New Stabilizer bulletin DL48-537. Contains operating characteristics, graphs and complete specifications. Write for your copy, today.

Constant AC voltage is essential for reliable, accurate operation of a wide variety of electrical equipment. When these devices are connected to ordinary supply mains, the unstabilized input voltage often varies as much as from 95 to 130 volts thus impairing the accurate operation of the equipment. A Raytheon Voltage Stabilizer, incorporated into the product, overcomes the disadvantages of fluctuating line voltages by providing an accurately controlled source of power held to ± ½%.

Entirely automatic in operation, the Raytheon Voltage Stabilizer has no moving parts . . . nothing to wear out, consequently requires no maintenance. Simply connect it to line and from there on it will take care of itself.

Raytheon Voltage Stabilizers built-in new equipment or offered as an accessory not only improve the performance but also increase the salability of the product.

Users of many types of electrical equipment not having voltage stabilization will find that Raytheon Voltage Stabilizers improve the performance and reliability of their equipment.

Raytheon Voltage Stabilizers are equally suitable for use in equipment for the laboratory, production or unattended locations.

The coveted Army-Navy "E", for Excellence in the manufacture of war equipment and tubes, flies over all four Raytheon plants where 12,000 men and women are producing for VICTORY.

RAYTHEON MANUFACTURING Company

190 WILLOW ST WALTHAM, MASS.

Integrity IN WIRE...?

CAN WIRE be said to have *integrity?* Yes, that is the one quality that, through the years, we have built into Roebling Electric Wires and Cables. So that you can depend on Roebling products...

You need that kind of dependability, when you are buying wire for the products that will bear your name. Whether it's for today's electric motor, tomorrow's appliance...whether it's rubber covered wire for an industrial electric tool or magnet wire for an aircraft radio, you can be sure that the Roebling name guarantees the same fine performance you build into the product in which the wire is used.

JOHN A. ROEBLING'S SONS COMPANY
TRENTON 2, NEW JERSEY
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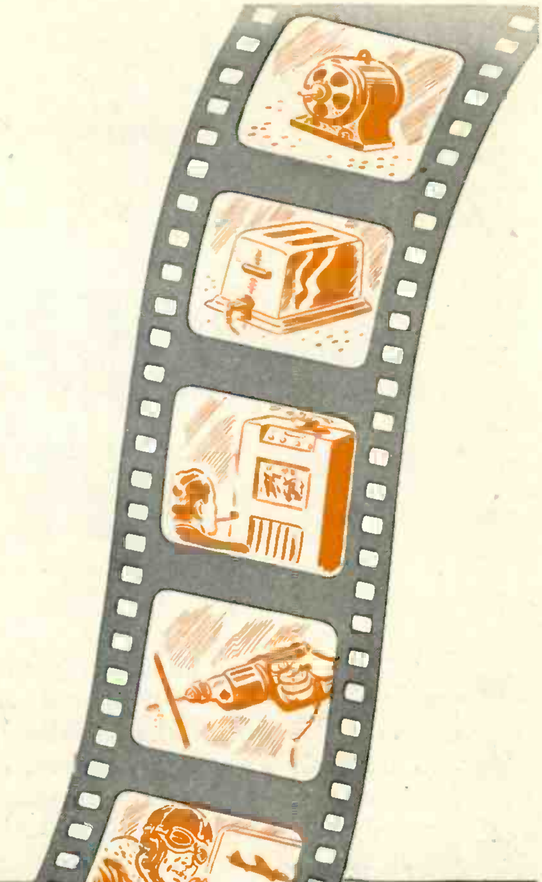
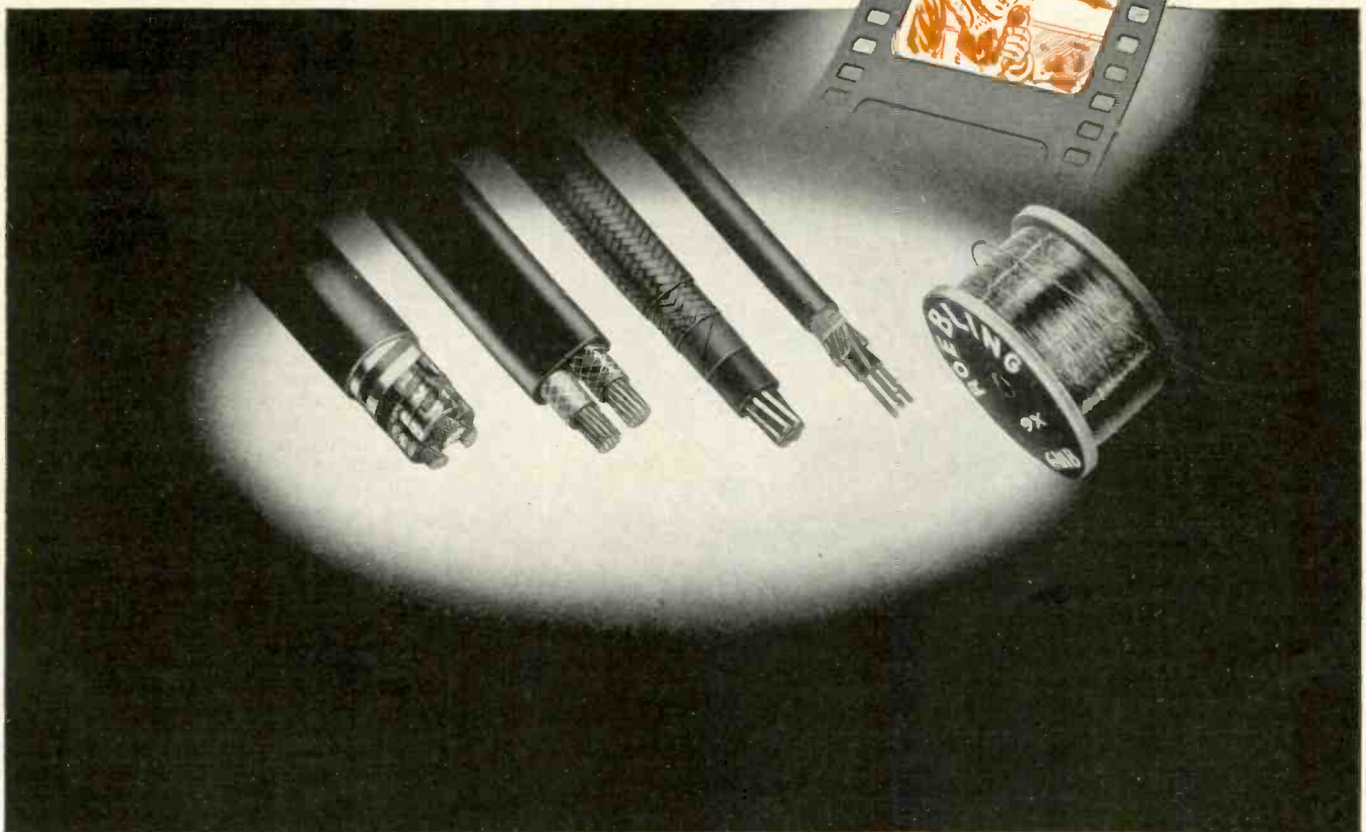




ROEBLING

PACEMAKER IN WIRE PRODUCTS

WIRE ROPE AND STRAND • FITTINGS • AERIAL WIRE ROPE SYSTEMS • COLD ROLLED STRIP • ROUND AND SHAPED WIRE
AIRCORD, SWAGED TERMINALS AND ASSEMBLIES • SUSPENSION BRIDGES AND CABLES • ELECTRICAL WIRES AND CABLES
WIRE CLOTH AND NETTING • HIGH AND LOW CARBON ACID AND BASIC OPEN HEARTH STEELS

Post-War

(*Continued from page 93*)

tions, 800 forestry and 6,500 international radio stations. In homes were 500,000 FM receivers and 10,000 television sets.

Estimates indicate that from 17 to 21 million new receivers may be required from manufacturers during the first 12-month period after war's end. The pressure to get under way on civilian sets will be tremendous and it is highly doubtful if many of the new techniques developed during the war will appear in the receivers produced immediately after the war. With the production indicated above it is possible that some newcomers to the home-receiver business will have a year or two of good going, but competition in this field has always been terrific and well-organized so the marketing job of the neophyte will be anything but a cinch.

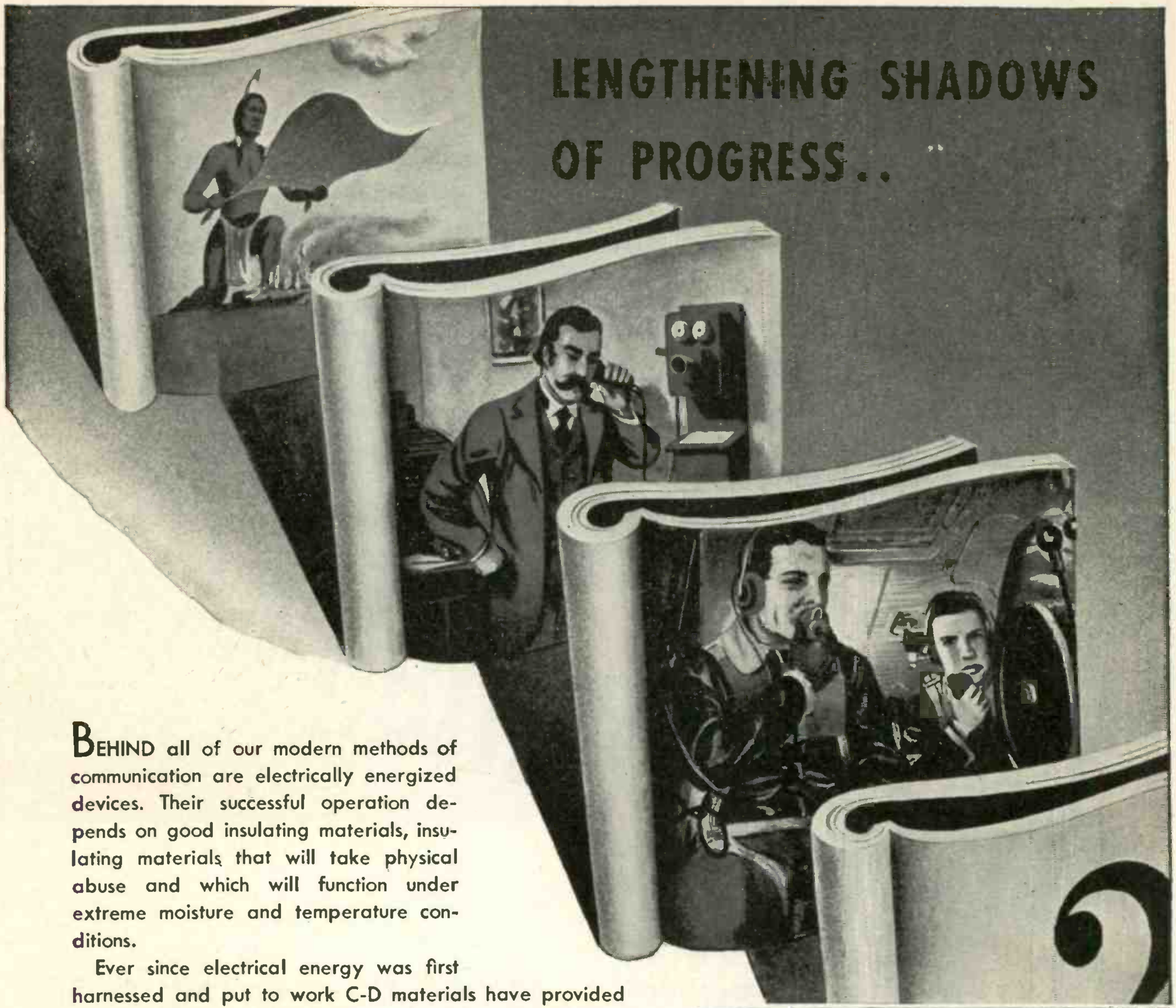
This, of course, is on the encouraging side. So is a statement of Mr. C. I. Stanton, Administrator of Civil Aeronautics, who was quoted before the Senate Interstate Commerce Committee in connection with the White-Wheeler bill (S-814) to revamp the FCC. Said Mr. Stanton:

"We feel that we are on the conservative side in planning for 300,000 aircraft within three years following the war, and half a million by 1950. * * * Fortunately, our air-navigation facilities have been designed for mass traffic. Our radio and traffic-control equipment is of the best and our scientists and inventors can be counted on to keep it so.

"In addition to airports required for this transport work, there must be thousands of inexpensive fields to serve the hundreds of thousands of pilots who will, I believe, be flying their own planes or rented aircraft.. * * *

"CAA radio men and airways engineers are not only improving and extending our domestic skyways, but are cooperating with the armed forces in establishing routes across the seas to all the other continents. * * * We expect to have a dual system of air navigation facilities. At the present time we have in the process of manufacture a large amount of ultrahigh-frequency radio-range equipment. We have not been able to make many installations of this equipment during the war because factories have been occupied with priority Army and Navy orders. * * *

"As soon as the war is over the material will begin to pour out of the factories and we can get down to rapid installation throughout the country. The new ultrahigh-frequency radio-



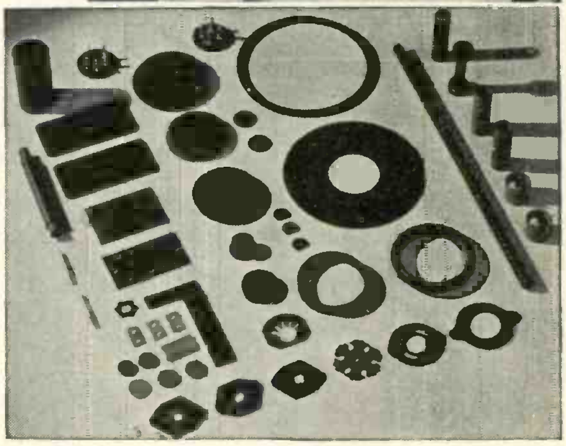
BEHIND all of our modern methods of communication are electrically energized devices. Their successful operation depends on good insulating materials, insulating materials that will take physical abuse and which will function under extreme moisture and temperature conditions.

Ever since electrical energy was first harnessed and put to work C-D materials have provided good insulation. The development of better insulating materials has been the constant goal of the C-D laboratory. The success of C-D's efforts have been the lengthening shadows which have forecast the phenomenal advances which this country has made in the field of communications.

1st DIAMOND Vulcanized FIBRE; then DILECTO, a moisture proof insulation; 3rd VULCOID, which combines to a remarkable degree the desirable properties of both DIAMOND Fibre and DILECTO; 4th MICABOND—Mica insulation in its most usable form and now DILECTENE, a pure resin plastic especially for U-H-F insulation.

C-D engineers have helped solve thousands of insulating problems. They have accumulated a wealth of "know how" which is at your disposal to help solve your electrical insulation problem.

DISTRICT OFFICES: New York • Cleveland • Chicago • Spartanburg, S. C.
West Coast Rep., Marwood, Ltd., San Francisco - Sales Offices in principal cities



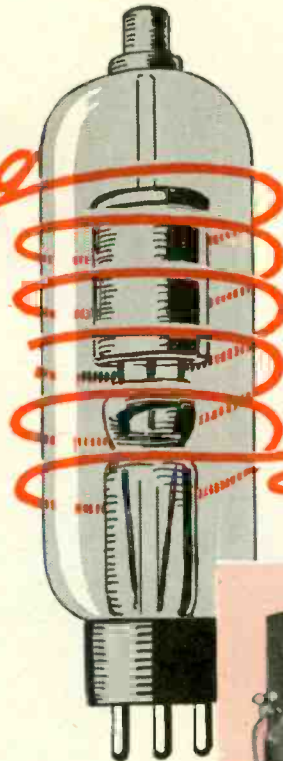
C-D products include THE PLASTICS . . . DILECTO—a laminated phenolic: CELORON—a molded phenolic: DILECTENE—a pure resin plastic especially suited to U-H-F insulation . . . THE NON-METALLICS, DIAMOND Vulcanized Fibre: VULCOID — resin impregnated vulcanized fibre: and MICABOND—built-up mica insulation. Folder GF describes all these products and gives standard sizes and specifications.

CH-43

Continental-Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK • DELAWARE

Electronic Heating



Since 1916

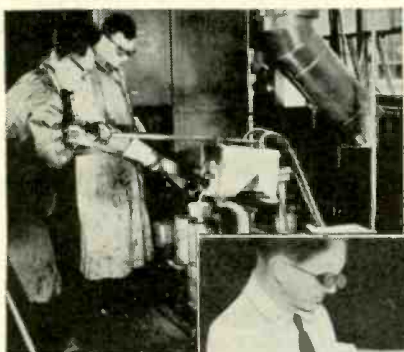
One of electronic heating's first commercial jobs was the degassing of vacuum tube elements.

Dr. Edwin F. Northrup, as early as 1916, proved that high frequency could be used to heat conducting parts in a vacuum to almost any degree desired, with positive and accurate control. When experiments with this Ajax-Northrup theory culminated in vast improvements in commercial tubes, it became an Ajax-Northrup "first" in electronic heating. And that was only the beginning.

Today Ajax-Northrup heat has speeded production, improved quality and lowered unit heating costs of hundreds of jobs — melting, forging, brazing, hardening, annealing, plywood bonding — and in countless other fields.

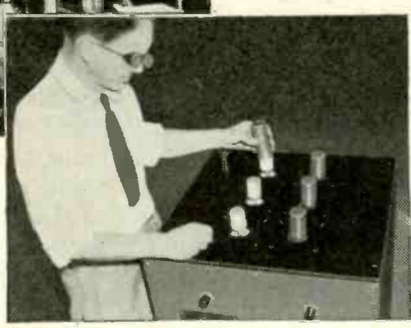
Our experienced engineers stand ready to help you revolutionize your products of today, just as they did a quarter of a century ago for the vacuum tube industry.

Spark-gap power sources from 3 to 40 kw. Shown is 20-kw. set with 17-lb. melting furnace.



Melting

In laboratories like the one shown and in high-production foundries, Ajax-Northrup furnaces give faster melts with greater accuracy and flexibility.



Heating

Six perfect brazed joints per minute with the unit at left! Ajax-Northrup heat can also speed your heat-treating for forging, heat-treating, and countless other jobs.

Tube converters for frequencies above 100,000 cycles. The 5-kw. unit is shown.

Ajax-Northrup motor-generator sets are recommended wherever frequencies below 12,000 cycles and powers above 20-kw. are required. Write for catalogs.

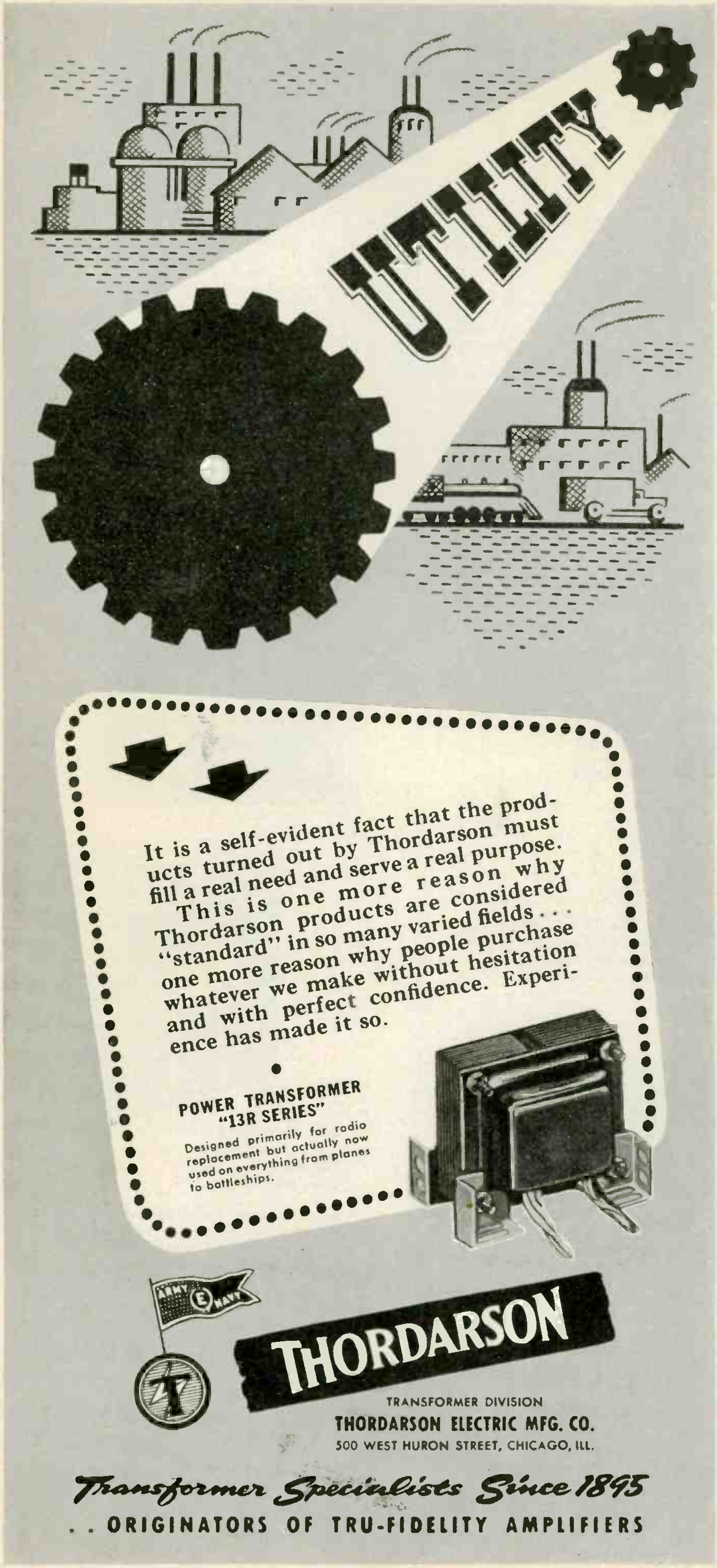
72

AJAX-NORTHRUP HIGH-FREQUENCY HEATING MELTING

AJAX ELECTROTHERMIC CORPORATION • Ajax Park TRENTON 5, N. J.

ASSOCIATE COMPANIES . . . THE AJAX METAL COMPANY. Non-Ferrous Ingot Metals.
AJAX ELECTRIC FURNACE CORPORATION. Ajax-Wyatt Induction Furnaces.
AJAX ELECTRIC COMPANY, INC. Ajax-Hultgren Salt Bath Furnaces.
AJAX ENGINEERING CORPORATION. Aluminum Melting Furnaces.

AJAX



range and instrument-landing system gives signals which do not create interference between stations operating on the same frequency even when they are closely spaced, and perhaps more important, they are almost completely free of static interference. * * *"

Certainly there is going to be business for those now making aviation equipment and who have learned how to make radio sets of the quality required by the war.

Television and FM—What of Them?

If the post-war radio receiver picture is clear, that of television is cloudy. FM is somewhere in between. Enough experience has been had with FM in the rather abortive pre-war days to determine that it is excellent for short-haul service. It is essentially noise-free and this plus the assignment of wide channels can provide high tone quality. There is no doubt that some manufacturers will debauch the tone-quality possibilities in their desire to capture sales in low-priced brackets.

There are now 40 channels for FM, of which 5 are for "non-commercial educational broadcast stations." Mr. Fly, Chairman of the FCC, has indicated that he feels there ought to be many more channels reserved for FM than the present 40. A figure of several hundred has been advanced. O. B. Hanson, Vice-President and Chief Engineer of NBC, speaking before the Senate Interstate Commerce Committee, recently stated that he felt 3000 new FM transmitters could be put on the air under existing rules and technical standards, that this would represent an investment of 150 million dollars. He visualizes the future broadcasting picture as composed of "parallel" AM and FM services, present standard-band stations continuing until surveys show that most people are equipped with FM receivers. Then standard broadcasting will cease except for a certain number of high-power (1000 kw) clear-channel stations with the job of serving the rural districts where the short-haul FM stations would not penetrate successfully. This, of course, is in the distant future.

Mr. Hanson also has optimistic ideas about post-war television, provided "the present frequency allocations and technical standards . . . are not greatly disturbed in the anticipated shuffling of frequency al-

61% SAVING

in critical material for STAINLESS STEEL INSTRUMENT SCREWS

Here is a typical example of the methods "National" has devised to save time, materials, man power and machines.

Formerly, instrument screws were made milled from bar, with cut threads. They are precision parts, full machine finished, with class 3 threads, a closer tolerance than that of commercial screws.

"National" developed a method of manufacture from wire of smaller diameter . . . upsetting the head, machining the blank on noncritical equipment and rolling the thread.

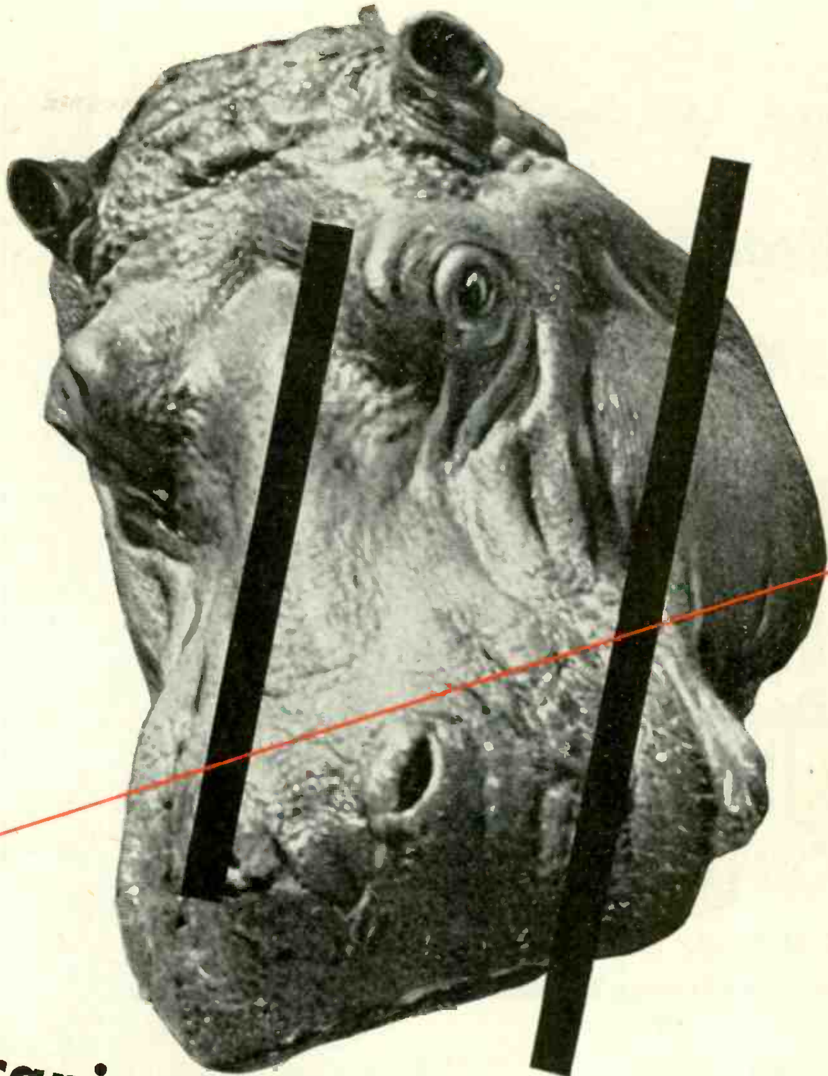
This effected a saving of 61 per cent in stainless steel containing highly critical chrome and nickel, and released a large number of automatic screw machines vitally needed for other purposes.

More than 55 instrument manufacturers have been highly satisfied with the quality of these screws and the savings effected.

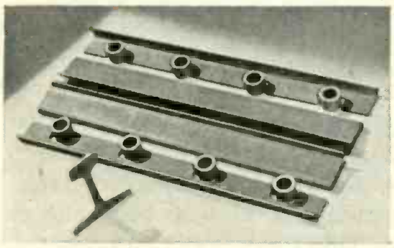
This booklet contains 15 brief stories of important savings on bolts, nuts and special parts. Send for a copy of "SAVINGS."

National
HEADED AND THREADED
PRODUCTS

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



Taylor vulcanized fibre is TOUGH



Complete sets of track insulation for the various weights and types of rail are fabricated by Taylor to A.A.R. specifications. Taylor Fibre has high density. It will not flow under pressure. It has contributed to the success of the automatic block signal system. Taylor railroad track insulation includes everything necessary for complete rail joint insulation—end posts, bottom plates, washer plates, head plates, fish plates, bushings. Whatever your insulation problem may be, Take it to Taylor. Our engineers will be glad to study your blueprints and make recommendations, without obligation.

Tough as the hide of a "hippo," Taylor Vulcanized Fibre is amazing many a skeptical engineer with its ability to stand up under severe punishment.

Between thousands of rail joints, for example, are track-shaped sections of Taylor Vulcanized Fibre insulation. Under the pounding of giant locomotives and heavily-loaded cars that ceaselessly beat and flex the rails, Taylor insulation stands up better than any other material the railroads have ever tried.

Yes, Taylor Vulcanized Fibre is *TOUGH*. And its *quality* is remarkably dependable, too; for it's produced by the Verifibre Process—Taylor's name for quality-control. In the industry's most modern plant, every raw material is produced, checked, and verified under Taylor control and supervision.

If you have a problem that might be solved either by Vulcanized Fibre or Phenol Fibre, it will pay you to Take it to Taylor. Orders are now subject to WPB allocation.

TAYLOR FIBRE COMPANY

NORRISTOWN, PENNSYLVANIA • OFFICES IN PRINCIPAL CITIES
PACIFIC COAST HEADQUARTERS: 544 S. SAN PEDRO ST., LOS ANGELES
LAMINATED PLASTICS: VULCANIZED FIBRE • PHENOL FIBRE
SHEETS, RODS, TUBES, AND FABRICATED PARTS

locations." His optimism runs to the tune of 1000 television stations representing a capital investment of 250 million dollars within a decade after the war; 25 million television receivers having a dollar value of 3 billion dollars in the same period. He feels that few people will prefer to listen and not look in this future period, and that the television receiver with FM will be the rule rather than the exception for the average home.

As is well known, the problem of television as well as all other problems involving frequency allocations are being discussed by an industry planning board, the RTPB, and nothing real can happen to clear up the picture until this board has come to some conclusions. These conclusions must inevitably involve not only television and FM but aircraft-radio, anti-collision devices, facsimile, the requirements of the Army and Navy and all the other services for which radio communication is vitally necessary. The deliberations of the RTPB, therefore, may take quite a time.

In spite of the fact that we have opened up vast new frequency regions during the war (nothing above 300 Mc had been specifically assigned before the war) the optimism of engineers who say that there will be more than enough frequencies to go around is unwarranted.

Industrial Electronics—What about That?

The industrial picture is promising but not all "beer and skittles." The facts are that the industrial electronics has actually been with us for a long time, that it has received tremendous impetus due to the war, that industry will use electronics to a very much greater extent than would have been the case if the war had not stepped-up our normal rate of progress.

The application of electronics to manufacturing processes is not going to create a second industrial revolution, but no industry is going to be immune from electronics. A simplification and a speeding up of many processes, a relief from many drudgeries, a protection against industrial accidents, the distinct possibility of greater leisure—all these may come from the steady application of electronic principles to industry generally.

A typical group of H. F. radio coils insulated with Q-Max A-27 Lacquer

Q-MAX A-27 LACQUER HAS LOW LOSS FACTOR OVER A WIDE FREQUENCY RANGE

The loss factor of Q-Max A-27 Lacquer is very nearly constant as the frequency increases from one megacycle, which is indicative of its excellent performance in the high frequency range. This feature, together with its low dielectric constant and other special characteristics, makes Q-Max A-27 Lacquer an outstanding high frequency coating medium.

In order to give water-repellent protection, minimize oxidation and corrosion, Q-Max A-27 Lacquer deposits a tough, uniformly heavy, and self-leveling film. In spite of the high solids content—45%—which makes such a coating possible, the low viscosity of Q-Max affords ease of application either by dipping or brushing.

Q-Max provides an excellent coating for R. F. solenoid windings and serves as an impregnant on multi-layer or star coils. It is used as a tape saturant, a stiffening and strengthening medium, and a surfacer for wood or porous materials. Because of its low dielectric constant and excellent high frequency insulating characteristics, Q-Max is used widely in treating radio frequency coils.

New descriptive booklet on request.

FOR TODAY . . . AND TOMORROW: H. F. TRANSMITTING SPECIALTIES

The design and manufacture of H. F. transmitting specialties has long been an important part of the production which Communication Products Company, Inc. has offered the radio industry to meet the requirements of a wide range of applications. Our engineering staff and laboratory facilities are available for aid in the solution of your problem.

Communication PRODUCTS COMPANY, INC.
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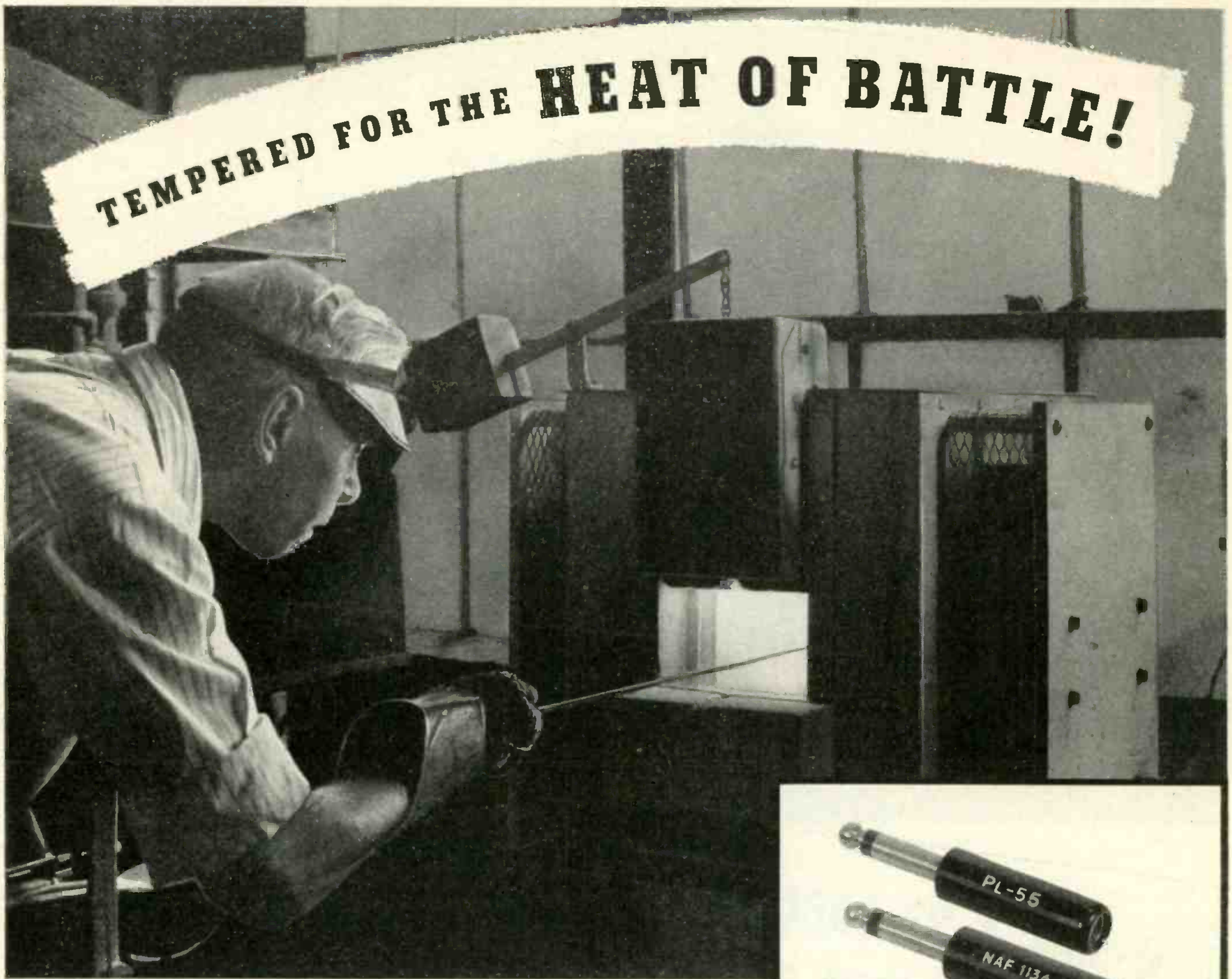
Coaxial Transmission Line and Fittings · Sterling Switches · Auto-Dryaire
Antenna and Radiating Systems · Q-Max A-27 Radio Frequency Lacquer

TEMPERED FOR THE HEAT OF BATTLE!



Remler craftsman heat treats welding and cutting dies and tools for automatic screw machines.

ELECTRONIC TOOLS OF WAR . . . in quantity and on time! There are no delays because Remler has the facilities and experience to do the job from design to finished product—plus the know-how to cut production time which frequently permits quotations at lower prices. This organization of skilled specialists manufactures components and complete electronic equipment for our armed forces and components for *your* application. Inquiries invited.

Wire or telephone if we can be of assistance

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

REMLER

SINCE 1918

Announcing & Communication Equipment

PLUGS & CONNECTORS

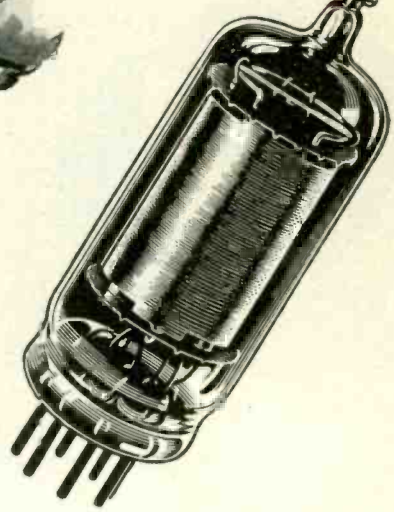
Signal Corps · Navy Specifications

Types:		PL			NAF
50-A	61	74	114	150	
54	62	76	119	159	
55	63	77	120	160	1136-1
56	64	104	124	291-A	
58	65	108	125	354	No.
59	67	109	127		212938-1
60	68	112	149		

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

OTHER DESIGNS TO ORDER

"EASY — HORTENSE FOR ---'S SAKE... GO EASY!"



DON'T WORRY, SOLDIER, TUNG-SOL TUBES IN YOUR SET ARE "*VIBRATION-TESTED*"

TUNG-SOL tubes are built for tough going. They're made to give dependable service under severest conditions.

For example the mount assembly must have rigid support in order to withstand vibration. TUNG-SOL uses a mica disc with sixteen points for contact on the glass envelope. This assures the necessary rigidity even though the glass be irregular.

TUNG-SOL tubes are "*Vibration-Tested.*"

Typical tubes are put in a vibrating machine which tries to shake them to destruction. The proven conditions means a lot to users and makers of electronic devices subject to wartime and to peacetime punishment. TUNG-SOL Vibration-Tested tubes are made for most every electronic application, and TUNG-SOL engineers will be glad to assist you in designing circuits and in selecting the right tubes.

IMPROVED MICA DISC DESIGN

16-point TUNG-SOL disc permits good support under all conditions. *Conventional type disc gives good support only when glass is perfect circle.*

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

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

ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS

It is a most inspiring and significant fact that hundreds of millions of dollars are now going into electronic research, some in industrial plants, some in vast college laboratories where thousands of the country's best brains are working for the war. No one can doubt that much that is potentially of great industrial and social value is being developed in these agencies.

Many of the secrets now kept so well promise much; but only time will tell if they will develop into full-blown, large-scale industrial tools.

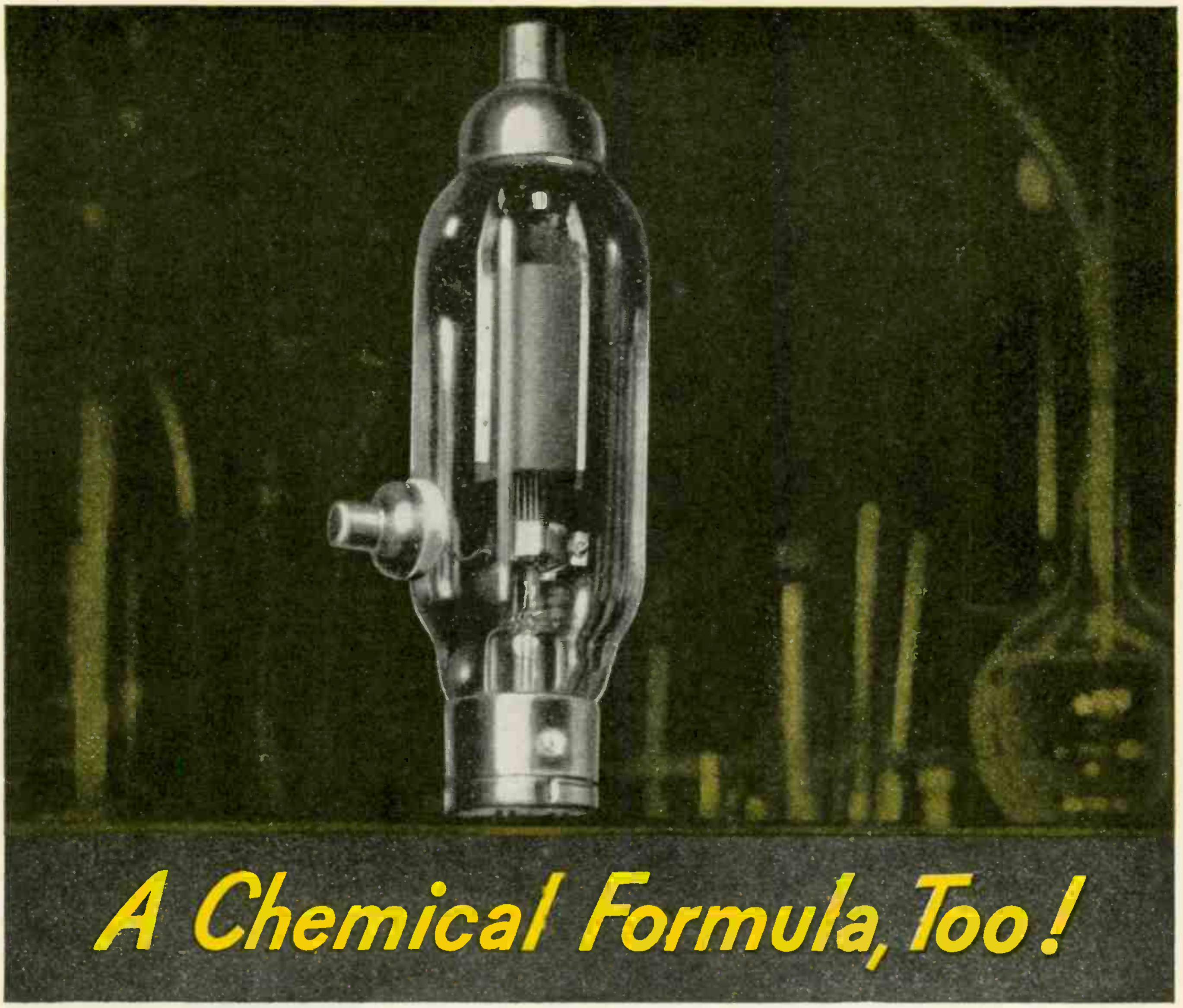
And so, to sum up, the war will not be over quickly; the demand for most items of military electronic gear is still rising; radio and other communications apparatus will be the big end of the business immediately after the war; FM and then television will come along but the demand for regular AM replacement equipment will take up the initial postwar shock; industry will find that it is using electronic devices to an extent thought impossible in the pre-war days but will not go overboard in this direction.

Perhaps some of the new things in the art, as yet clothed in secrecy, will provide an extra spark, but few men "in the know" expect them to usher in a new era of super-prosperity overnight.—K.H.

• • •

PEDAL POWER

Distant lighthouses communicate with each other by radiophone in Australia. Power for the transmitter-receiver is obtained from a pedal-operated generator. Similar sets are used by the Australian Inland Mission for contacting the flying doctor



Chemistry is but one of the many sciences which are collaborating at National Union in the work of producing better electronic tubes for today's vital war assignments. Indeed, our chemists are playing a decisive role in making National Union Tubes *measure up* to the precise standards of scientific instruments.

Thanks to chemical research, we know for example that not only must the formula of a tube's emission coating be *right,* but also the application and processing methods must be rigidly controlled.

To effect such control our chemists, in cooperation with the engineers of our Equipment Division, designed, built and put into production a new type automatic coating machine. Operating in an air-conditioned chamber, this equipment provides exact control of both the coating operation and the chemical processing of the emission coating—free from all extraneous elements.

The fact that tube manufacture *is* such a many-sided scientific job—is a subject to keep in mind when making post-war plans. If you have electronic tube problems—*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

Thermionic Rectifiers

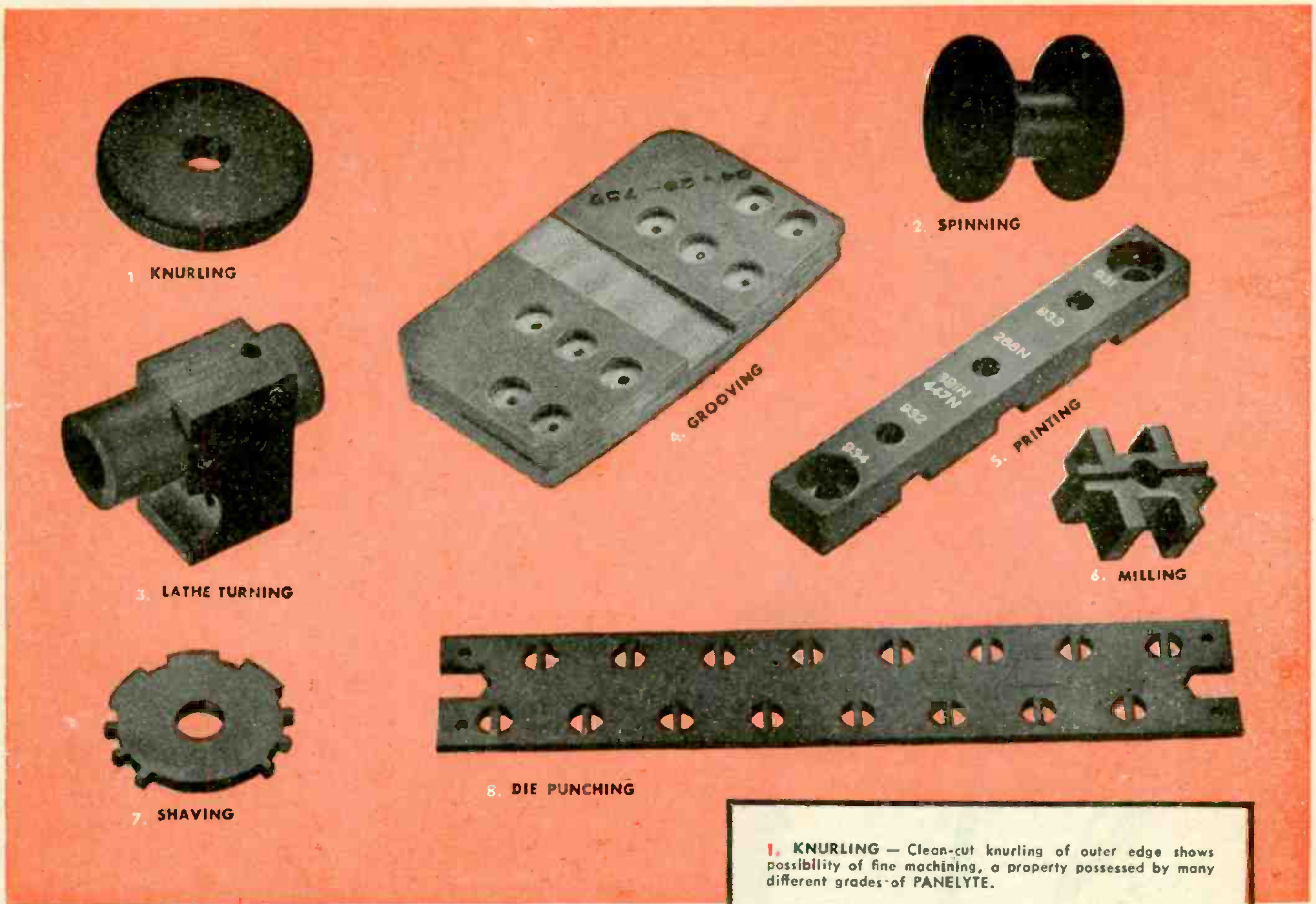
(*Continued from page* 105)

filaments. If type 80 tubes are used, the rating of each of the eight windings is 2 amp at 5 v. Usually such windings can be overloaded, however, for the 5-v, 3-amp filaments of 5Z3 tubes. Tubes 4 and 5 may be connected in parallel to a single secondary of a filament transformer having a double current rating.

While it is normally quite safe to apply plate and filament potentials simultaneously to vacuum tubes, it is perhaps better for this high-voltage device to light the filaments with the Variac set at 0 volts for the plate transformer primary. The primary voltage can then be increased until the desired output is reached. A radio-type transformer is used, the secondary being a 2,000-v winding with a center tap which is not needed for this circuit.

An essential part of the circuit of Fig. 7 is the use of eight resistors, *R*, which parallel each rectifier tube. These are 0.5-meg, 2-w carbon units. They serve the important function of dividing the back emf evenly among the tubes. In the forward direction those resistors

High-voltage bridge rectifier capable of delivering 0.25 amp at 2500 v with eight type 80 tubes. The Variac being adjusted here is connected across the primary of the plate transformer



1. KNURLING
2. SPINNING
3. LATHE TURNING
4. GROOVING
5. PRINTING
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7. SHAVING
8. DIE PUNCHING

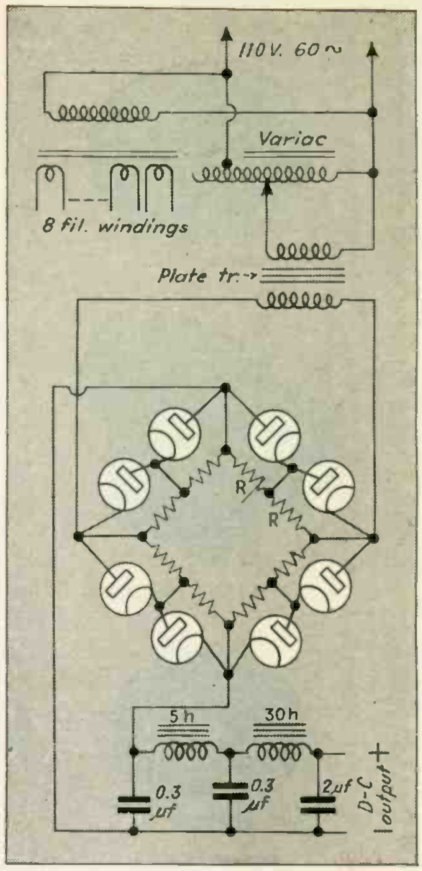


Fig. 7—High-voltage bridge rectifier circuit, using eight receiver-type tubes (type 80 or 5Z3) to provide maximum direct voltage of 2500 v with ample current for cathode-ray tube applications and experimental laboratory use

are largely shunted out by the conductance of the tubes.

Output characteristics are shown in Fig. 8. The dashed lines indicate load resistances of 5,000 to 50,000 ohms. The curved lines are the a-c voltages which are impressed on the primary of the plate transformer as indicated. For instance, with 80 v a-c impressed on the primary, this curve shows that an output of 150 ma at 1,500 v is

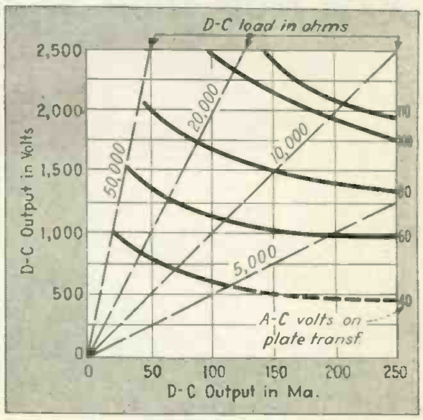
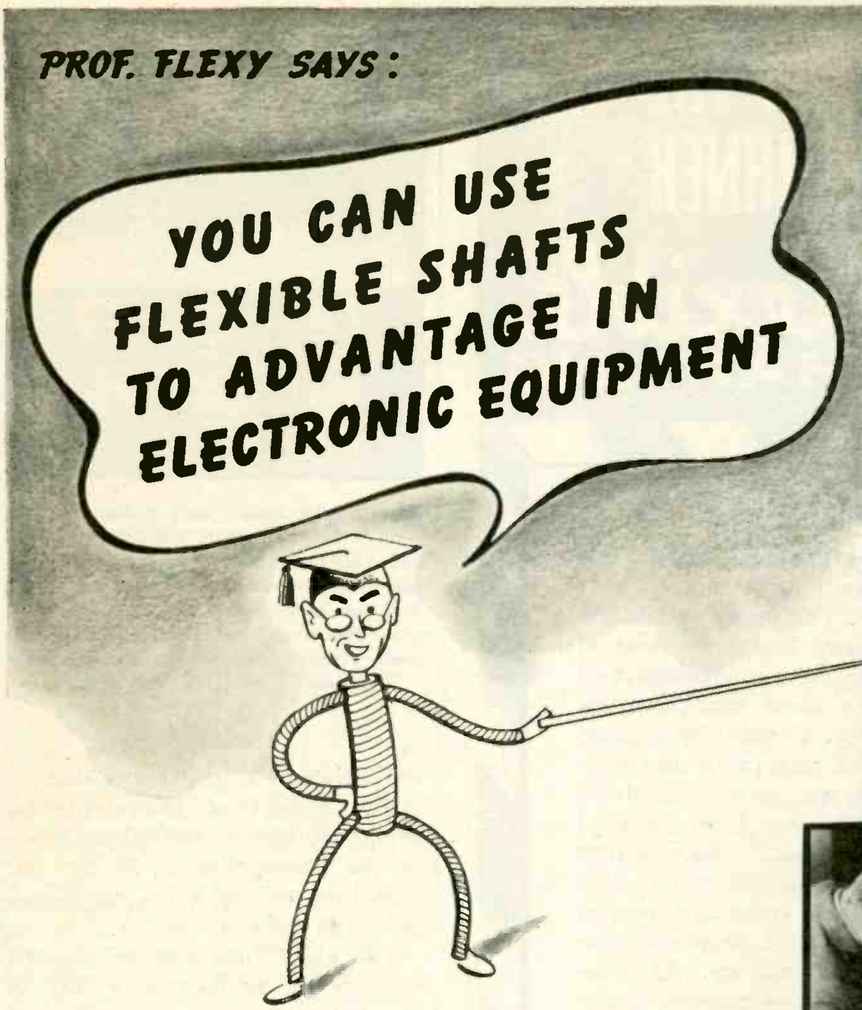
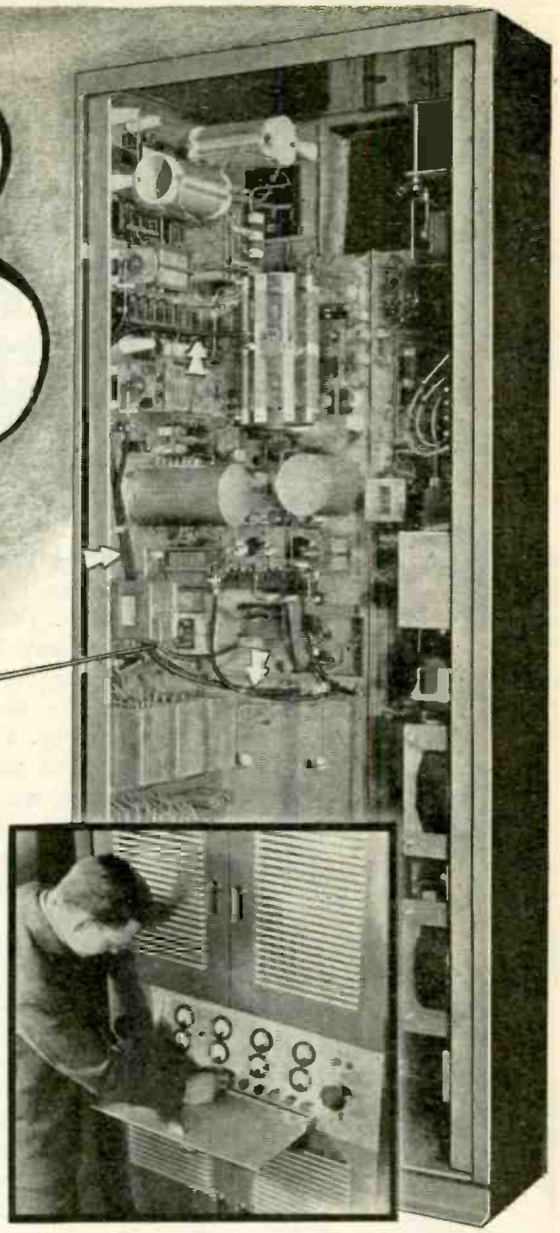


Fig. 8—Operating characteristics of high-voltage bridge rectifier circuit of Fig. 7





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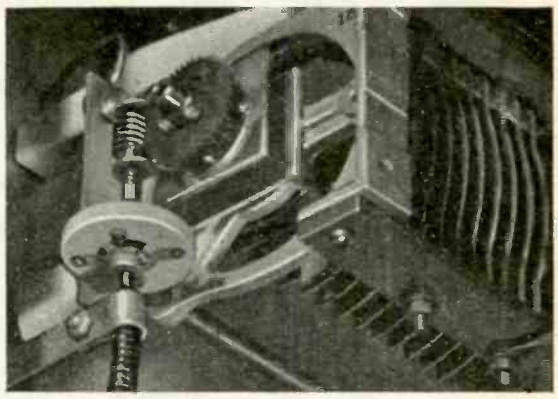

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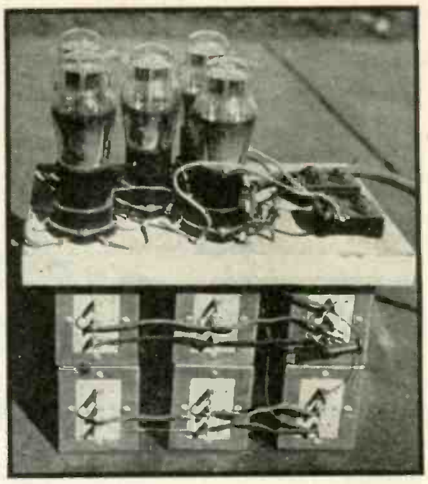

Experimental model used in the development of the half-wave, full-wave doubler, and half-wave doubler circuits. Each of the cans underneath the mounting board is a 4-μf paper capacitor, oil-impregnated with capacitance tolerance of ± 10 percent. Various combinations of these were used during the test runs

available with a 10,000-ohm load.

The weight of the eight-tube bridge rectifier assembled as shown in the photograph is 98 lb. All capacitors are oil-impregnated paper units rated at 3,000 v.

The eight tube sockets may be mounted on an insulating ring in the center of which is the filament transformer, allowing convenient, short leads. To be safe at the potentials used, auto ignition cable is suggested. Isolantite rods support the insulating ring from the metal panel on which all components are fastened.

A miniature switchboard-type voltmeter and ameter may be connected in the d-c output. A 5-ma (full scale) meter calibrated in volts is used in series with an external multiplier of eight 2-watt, 75,000-ohm units. This voltmeter and series resistor also serve to discharge the stored energy in the filter capacitor when the circuit is OFF.

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(1) Waidelich, D. L., The Full-Wave Doubling Rectifier Circuit, *Proc. I R E*, 554–558, Oct. 1941.
(2) Waidelich and Gleason, The Half-Wave Voltage-Doubling Rectifier Circuit, *Proc. I R E*, 535–541, Dec. 1942.
(3) Waidelich, D. L., Voltage Multiplier Circuits, ELECTRONICS, p. 28–29, May 1941.
(4) Gage, S. H., and Gage, H. P., Optic Projection, p. 68, Comstock, Ithaca, N. Y., 1914.
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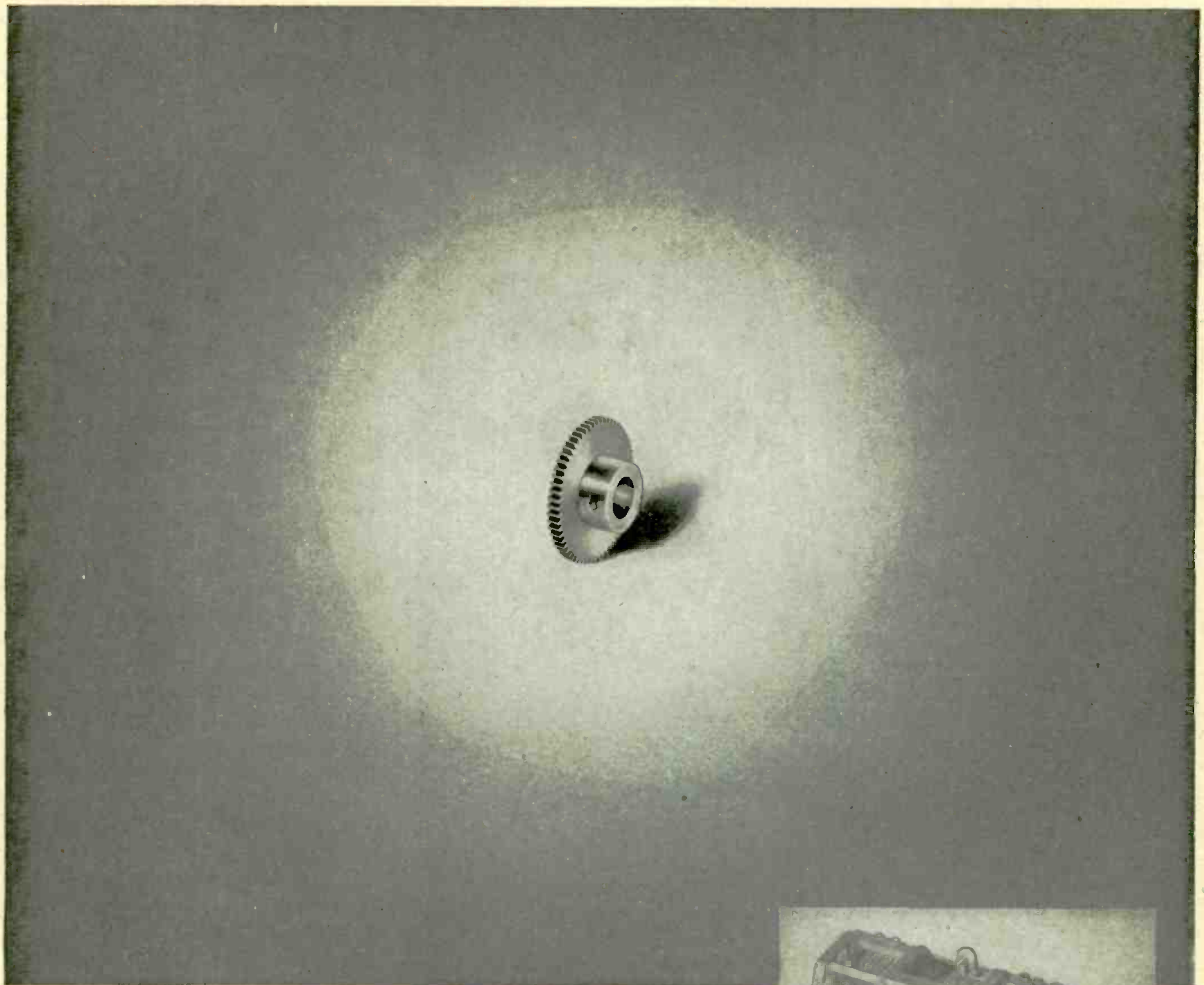
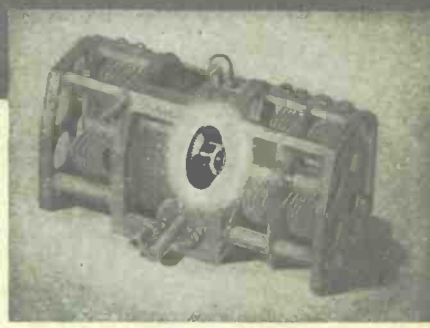
(6) Ref. (5), p. 254.
(7) Ref. (5), p. 26, Fig. 33.
(8) K. Henney (Editor) "Radio Engineering Handbook," p. 501, McGraw-Hill Book Co., 3rd Ed. 1941.





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High-Speed Soldering

(*Continued from page* 117)

forcing all the current to flow through the two pieces of tubing which are connected across the gap in the sheet. By this means the desired concentration is obtained.

Description of Set-Up

The actual construction of the coupling system can be seen in Fig. 8. The rubber hose in the foreground is part of an arrangement for constantly circulating water through the coupling coils. Small copper blocks mounted on the secondary of the current transformer (which is mounted just below the table top) serve as terminals and provide for water connections.

Mounted on the conveyor belt are small Bakelite blocks, each one hollowed out so that the bottom of a capacitor can fits loosely into them. The operator simply places the cans in these blocks and the belt carries them through the applicators. They emerge fully soldered and a few feet further along drop off the belt into a box. The use of the blocks automatically positions the cans, thus making it easy for the operator to feed them.

The applicators are approximately a foot long and the belt travels at somewhat over ten feet per minute. Alterations are under

• • •

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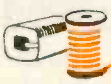

magnet wire and coils

ANACONDA WIRE & CABLE COMPANY

way to speed up the belt. When the necessary changes have been made it is expected that a rate of 4000 cans per hour will be achieved.

R-F Generator

The r-f oscillator used with this setup can be seen in the background of Fig. 1. It is a self-contained unit with an output power rating of 4 kw. Four 833-A's are used in parallel in a Colpitts circuit. The circuits, as well as the construction, are similar to those of the 2-kw unit used for preheating molding materials and previously described. In this case, however, the frequency used is approximately 400 kc.

To date, only about half the power of the r-f unit has been used, but the wisdom of installing units of greater power than required by immediate demand is indicated by the fact that it was hardly installed before plans were made to step up production. This has been the case in almost every r-f heating installation made to date. No better advice can be given to those planning such installations than to guard against figuring r-f power requirements too closely.

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(3) Taylor, John P., Gluing Aircraft Spars With Radio-Frequency Power, ELECTRONICS, January 1944.
(4) Taylor, John P., Radio-Frequency Heating Speeds Plastic Molding Operations, ELECTRONICS, September 1943.
(5) U. S. Patent No. 2,314,865, March 30, 1943, assigned by R. A. Bierwirth to Radio Corporation of America.

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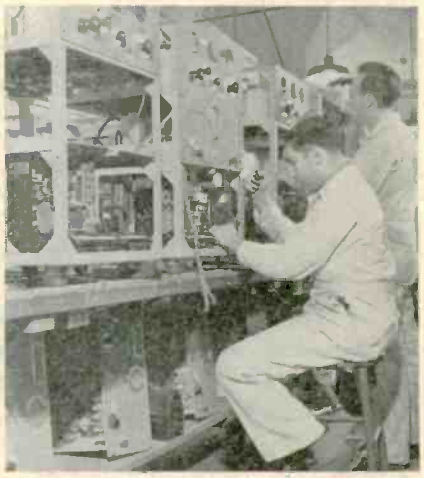
MARINE RADIOPHONES



View of the production line at work assembling radiotelephone units at Radiomarine Corp. of America. These are designed for ship-to-ship and ship-to-shore communication service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THE ELECTRON ART

Electronic Micro-Analyzer Identifies Elements

A MICRO-ANALYZER that reveals a specimen's chemical content by using an "electronic needle" to knock electrons loose from their parent atoms and by measuring the amount of energy lost by the incident electrons in the process has been developed experimentally by Dr. James Hillier of RCA Laboratories.

In the table of chemical elements each atom or element is differentiated from another by the number of electrons surrounding the atom's nucleus. It is known how much voltage is required to displace electrons in their orbits in each atom.

In the micro-analyzer the electrons forming the electronic needle that strike the selected area of the specimen are all moving with the same velocity, say 50,000 volts. After passing through the specimen area, the electrons that struck atoms travel with less velocity or energy. The energy loss suffered by the speeding electron is different for each chemical element and the differences are large enough to be easily distinguished by a method of measuring electron velocities. Thus if an energy loss shows up as 298 volts a carbon atom has been struck; if it is 400 volts the element is identified as nitrogen.

The new instrument permits identification of such tiny objects as the head or tail of a bacterium or virus, according to Dr. Hillier. The vital question, "Of what particular atoms, or chemical elements, are these different particles of matter constructed?" can be answered by the electron micro-analyzer. For the first time, the scientist, using this new instrument, will be able to determine the chemical constituents of a particle weighing only 10^{-15} gram. And, more important still, he will be able to see the relationship of the particles to the rest of the specimen under examination.

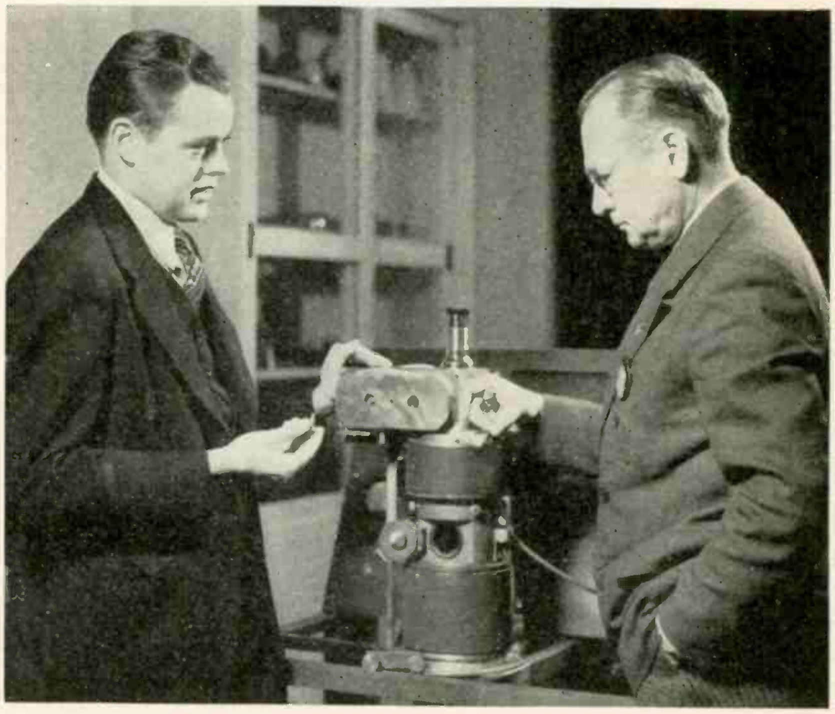
Use With Microscope

"With the new instrument, the image of the specimen may be observed by means of an electron microscope, which is incorporated as a part of the micro-analyzer, and a selection made of the exact portion to be analyzed," Dr. Hillier said. "Then by manipulation of a few controls, a photographic exposure is made of what we call the 'electron velocity distribution.'"

"This results in a series of small marks on the photographic plate, each one of which indicates by its position the presence of a chemical element in the specimen. Thus, with one exposure, information is obtained that would have required weeks or months to obtain by present indirect methods, which too often result in failure.

"If the original specimen was a test tube of bacteria, the scientist knew that it consisted of a number of proteins and other organic materials. But on looking at the electron micrograph, he finds that the bacteria have flagella, cell membranes, and structure in their protoplasm which often includes granules and particles surrounding it which he did not know existed. To find out the chemical structure of these particles, he must perform a number of tests on the bacteria. This procedure is very tedious, and not always successful."

At present, the electron micro-analyzer gives elemental and not compound analyses. Dr. Hillier said that he believes further developmental work on the instrument will enable it to show the amounts of each element in a specimen. He sees very little hope, however, of ever being able to show the way in which they are combined.



The electronic micro-analyzer that identifies the chemical elements in the head or tail of a bacterium or virus is examined by Dr. James Hillier (left) and Dr. V. K. Zworykin

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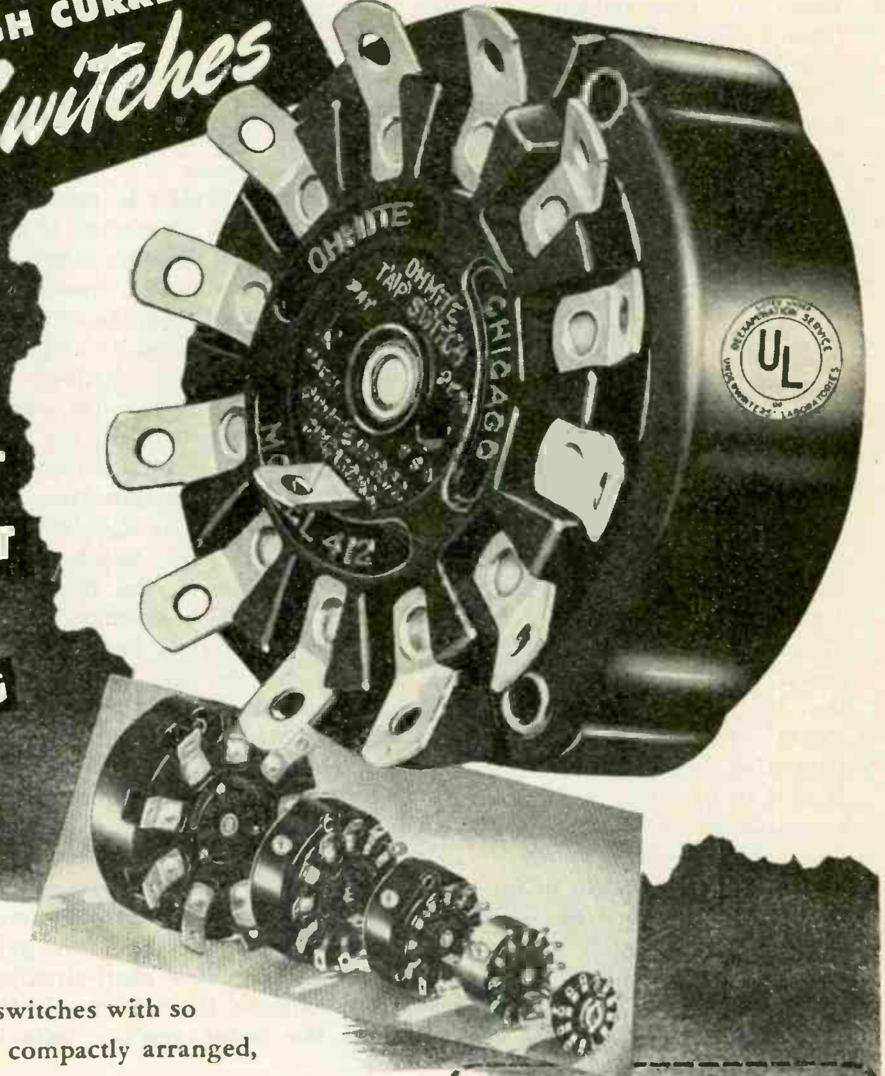

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More Mathematical Tables

THREE ADDITIONS have been made to the series of tables available from the National Bureau of Standards, Washington, D. C. These have been published in the *Journal of Mathematics and Physics* and reprints are obtainable at 25 cents each from the Bureau. The tables are: MT20, a table of integrals

$\int_0^x J_0(t)\ dt$ and $\int_0^x Y_0(t)\ dt$; MT21, a table of

$$Ji_0(x) = \int_x^\infty \frac{J_0(t)}{t} dt$$

and related functions; and MT22, a table of coefficients in numerical integration formulas. Three previous tables were described in the Sept. issue of ELECTRONICS.

Split Detector for Tungsten Wire

AN ELECTRONIC INSTRUMENT for detecting fine longitudinal splits in 1-mm diam. wire by the induction of eddy currents in the wire is described in the September issue of the *Journal of Scientific Instruments* (The University Reading, Berkshire, England). The method is said to be more rapid than examination of the wire under a low-power microscope.

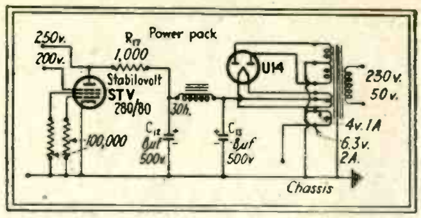
The circuit is shown in the diagram. It contains an oscillator that delivers about 4 watts at a frequency of about 20 Mc to a bridge circuit via the shielded transformer L_2—L_3. The bridge consists of two stable resistors R_3 and R_4, and two inductances, L_5. These are composed of 100 turns of No. 36 SWG (British gage) dsc wire, close-wound on a glass former 2.5 mm. external diameter and 1.25 mm bore. The end of the former of one coil is flared to facilitate insertion of the wire sample. The other coil contains a split-free length of 1-mm tungsten wire, cemented in place.

The whole bridge is made mechanically rigid. A contact is provided to ground the wire sample as it passes through the measuring coil. The output from the bridge is amplified by the tuned r-f amplifier 6J7G, L_6, L_7, and rectified by the diode, which is provided with a delay control R_{10} to offset the normal out-of-balance voltage from the bridge. The d-c output from the rectifier is filtered by $R_{12}C_{11}$ and fed to the d-c amplifier, which has in its anode network the indicating meter, a 0-500 microammeter. A variable resistor R_{16} provides zero adjustment for the meter. The power supply is stabilized by the gas-discharge stabilizer, STV280/80. The chassis should be grounded by the shortest possible route.

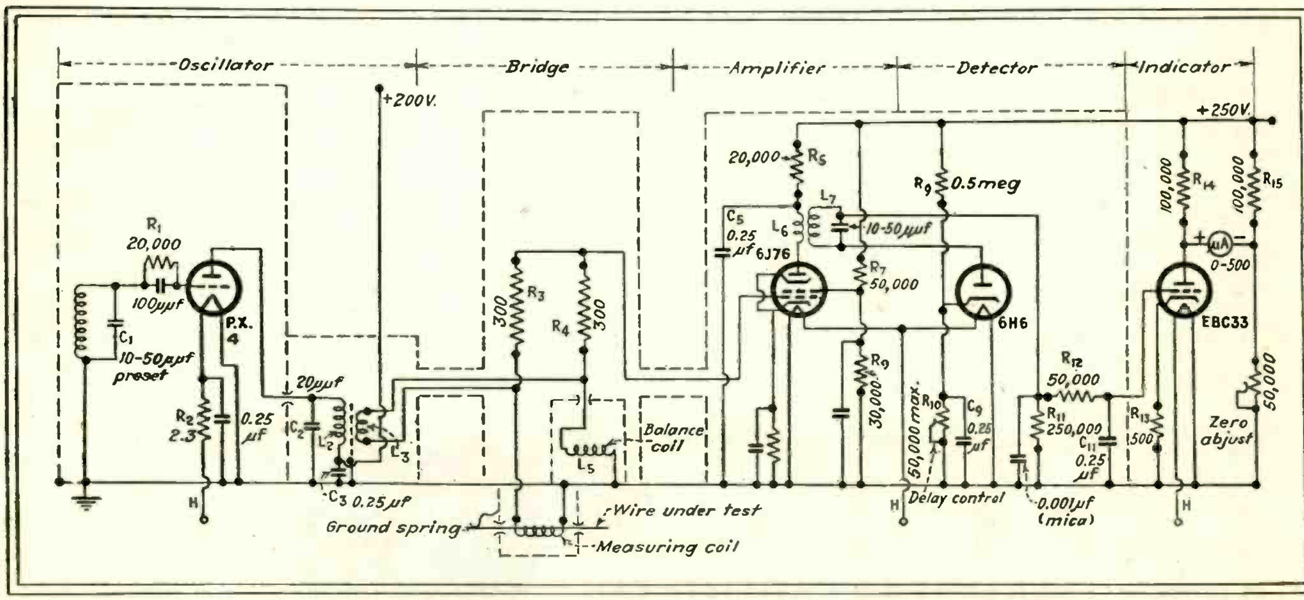
Operating Details

A piece of split-free wire of the diameter to be tested is inserted in the measuring coil, and the grid of the d-c amplifier short-circuited to the chassis, R_{16} is then adjusted until the meter reading falls to zero. The short circuit is then removed, and R_{10} adjusted to give a reading of about 5 microamperes. If a piece of wire containing a split is now substituted for the sound piece, the meter reading should increase steadily as the split part enters the measuring coil. If the reading decreases, or falls to a minimum and then rises, the bridge is out of balance in the wrong sense, and either transposing R_3 and R_4 or varying the value of one of them will correct it. Having set up and tested the apparatus as indicated above, it may be used to test new wire, the wire being passed steadily through the measuring coil at a speed of about 1 cm per second. A sharp rise indicates a split.

It has been found convenient to test wire in lengths of about 10 feet but, with feed and take-up spools attached, much longer lengths could be handled with ease. The apparatus is quite sensitive, and if the r-f amplifier is correctly tuned, the apparatus will detect fine splits barely visible to the naked eye. It has been used with

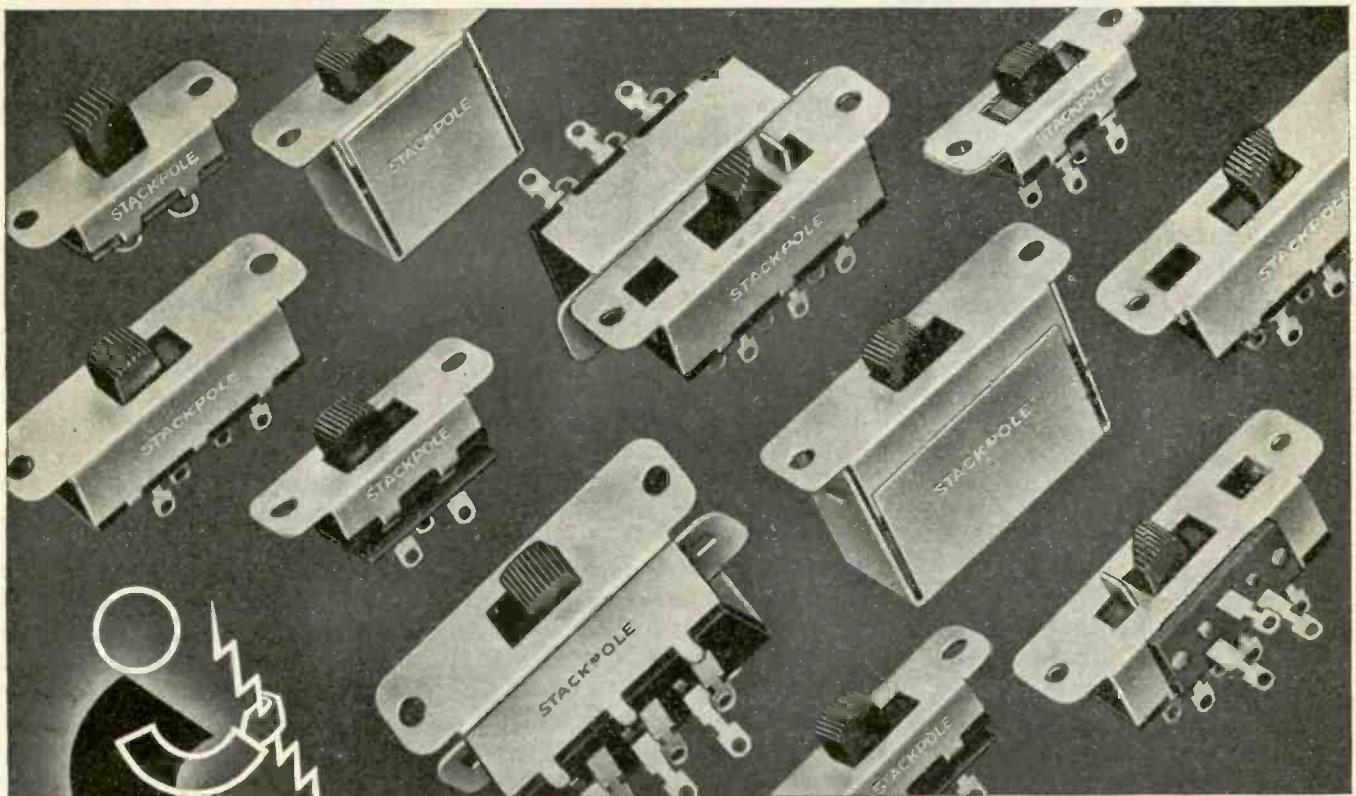


Power supply for the tungsten wire split detector. The STV280/80 is a British gas-discharge voltage regulator tube



Circuit of instrument for detecting fine longitudinal splits in tungsten wire for vacuum tubes. The zero-adjust resistor is R_{16}

SWITCHES LINE · SLIDE ROTARY-ACTION



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success to test samples 1 mm and 0.95 mm in diameter, and will operate with the same coils, although with lower sensitivity, on 0.56 mm wire. Other diameters would merely mean coil redesign.

Graphical Determination of Operating Point of Self-Biased Tube

By ARTHUR SCHACH
Project Engineer
Templetone Radio Co., Mystic, Conn.

IN CHECKING vacuum tube circuits, the problem of finding the proper operating point on the static characteristic curve frequently arises. The circuit of Fig. 1 shows the data usually given: the supply voltage (E_{bb}) applied across the tube, a plate resistor (R), and a cathode resistor (R_k) in series.

The usual method of solution is one of successive approximations. First the load line corresponding to R (or $R + R_k$, if R_k is not negligible in comparison with R) is drawn on the plate characteristic chart. Then a guess is made at a likely plate current, and the voltage drop that this would produce across R_k is computed. Next, there is read from the load line the current which would result from a bias equal to the computed drop. The whole process is repeated several times until a current is obtained which differs only slightly from the previous approximation.

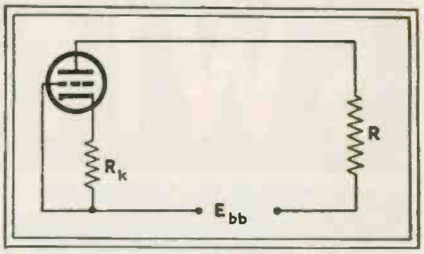


Fig. 1—Essentials of typical self-biased stage

If an error of several ma may be neglected, we might stop at the second current obtained (i.e., the first computed current), and take the mean of it and the initial guess. The error incurred will depend on the accuracy of the initial guess.

But, quite as expeditiously, we can obtain the true limit of the above process, and hence, the exact solution of the problem, by the following procedure for which an example is worked out in Fig. 2.

(1) Note the intersection of the load line with the zero-bias curve (A, Fig. 2) and mark the point A' vertically below it on the voltage axis.

(2) Choose a convenient plate current, I_o, (preferably less than that corresponding to A) and calculate the drop it would produce across R_k.

(3) Locate the point B, on the load line, which corresponds to a grid-bias equal to the drop just

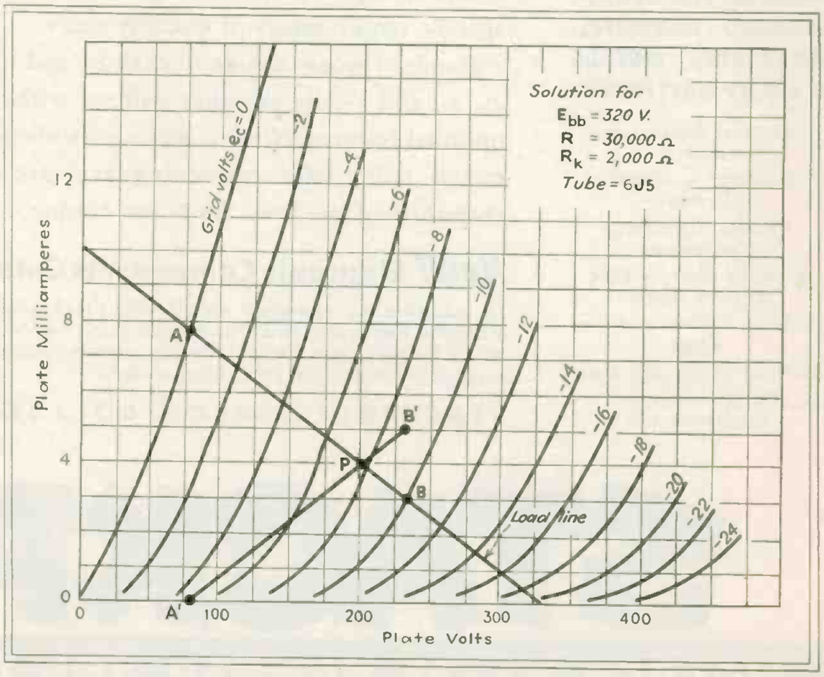
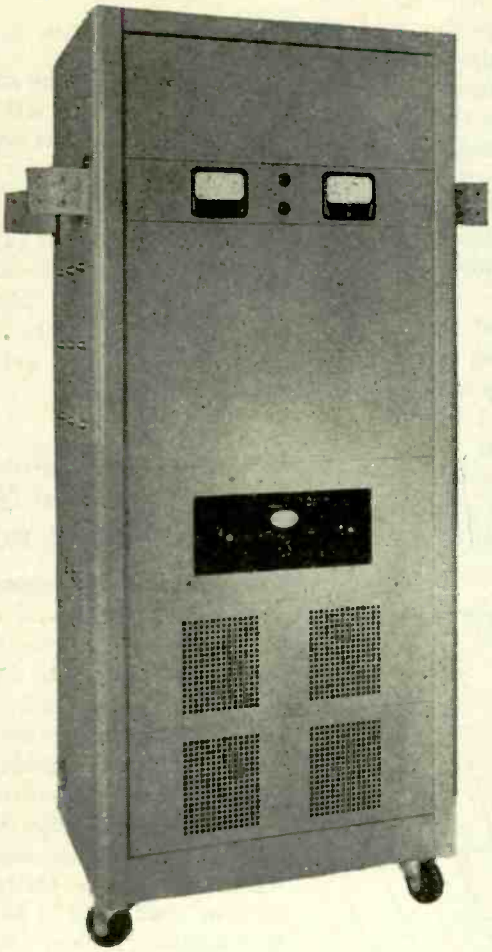


Fig. 2—Graphical solution illustrating the method described in the text. The current, I_{o1} was taken as 5 ma as suggested in step 2

IN PLANNING FOR CONVERSION



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RECTIFIER ENGINEERS

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calculated, and mark the point B' vertically above or below B on the horizontal line corresponding to the chosen current.

(4) Draw $A'B'$. Its intersection, P, with the load line is the required operating point.

If a constant bias is superimposed upon the self-bias, the method of solution is the same if we allow the grid-bias curve corresponding to the constant bias to play the same role as the zero-bias curve plays in the method as outlined above. That is to say, if the constant bias is e_o, the point A will then be the intersection of the load line with the bias curve for $e_c = e_o$.

The correctness of the method just described rests on the assumption that the constant-grid-bias curves, corresponding to equal increments of grid-bias voltage, cut the load line into equal segments. Within the limits of graphical accuracy, this assumption is nearly always justified.

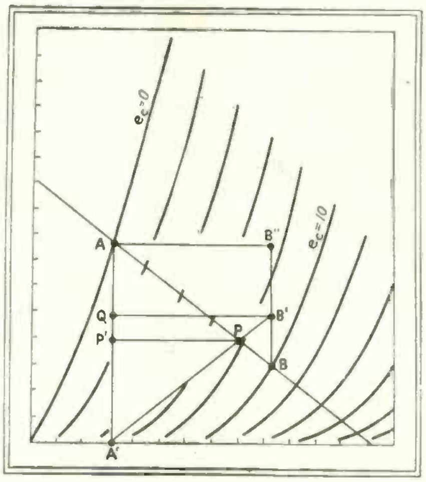

Fig. 3—A portion of Fig. 2 showing the geometrical relationship of the various points discussed in the text

Figure 3 is a repetition of part of Fig. 2 plus the points B'', P', and Q, whose geometrical relationship to the others is made clear in the figure. Now, if I_o is the plate current chosen in step 2, then the current corresponding to P will be

$$\frac{A'P'}{A'Q} I_o$$

In virtue of the similarity of triangles $A'P'P$ and $A'QB'$ this is equal to

$$\frac{P'P}{QB'} I_o$$

and this would produce in R_k a drop equal to

$$\frac{P'P}{QB'} I_o R_k \qquad (1)$$

But, by construction, the bias corresponding to B is $I_o R_k$. Hence, because of the above-mentioned assumption, the bias corresponding to P is

$$\frac{AP}{AB} I_o R_k$$

which, in virtue of the similarity of triangles $AP'P$ and $AB''B$ and because $AB'' = QB'$, is equal to

$$\frac{P'P}{QB'} I_o R_k, \qquad (2)$$

But the equality of (1) and (2) proves that P is the desired solution; i.e., that the plate current corresponding to P produces a drop in R_k equal to the grid-bias corresponding to P.

Geometric Solutions of L-Type Excitation Networks

By Robert C. Paine

The problem of feeding two or more resistive loads from a single source of power at varying currents and phase angles at a given frequency can be solved by the use of an L-type reactive network. One case in which this problem arises is in the excitation of directional antenna arrays. A chart for the solution of these problems has been shown by W. S. Duttera in the October 1942 issue of Electronics. In a specific problem more accurate results can be obtained by graphic solutions on a sufficiently large scale. Such diagrams can also be used to check mathematical solutions based upon them.

The requirements of a given network can be indicated by the ratio of the current required in the load to the current that would flow if the load was directly connected to the source of voltage. This ratio can be expressed by the factor $K\phi$ of which K is the ratio of absolute values of current and ϕ is their relative phase angle.

The network shown in Fig. 1 is designed to change the current by the factor 7/6 (−60°). The graphical solution shown is constructed as follows: Draw the line OD equal to the load resistance R, to any convenient scale, and draw OB equal to K times E at an angle of −60° Connect B to D and draw the line OC

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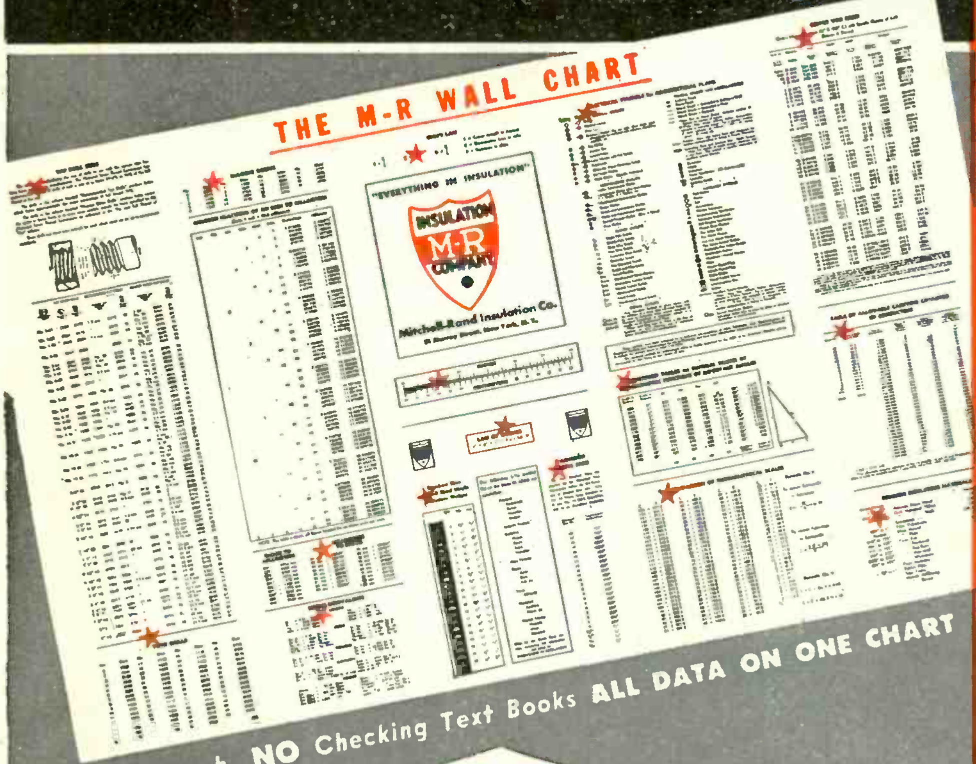

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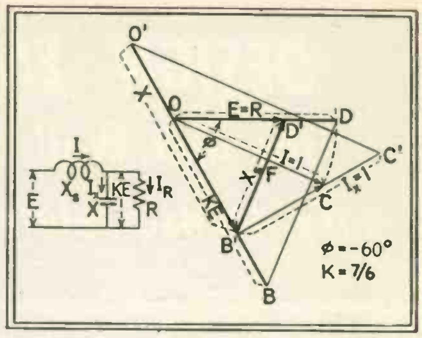


Fig. 1—Geometric solution of the L-type network shown, designed to change the value and phase of the current in a given load R by the factor (7/6 ($-60°$)

equal to R and at right angles to BD. Drop a perpendicular CB' from C to line OB, intersecting OB at B'. Draw $B'D'$ parallel to BD. Lay off $B'C'$ on $B'C$ equal to R. Draw $O'C'$ parallel to OC to meet OB extended at O'. Then $B'D'$ equals X, and $O'B'$ equals X.

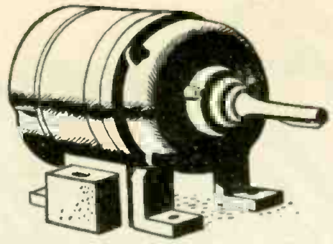
Proof of Graphical Construction

Proof of the above solution is as follows: OD represents the applied voltage, equal to R, which would product unit current in R if directly connected to it. The line OB represents the change which must be made in this voltage as applied to R to obtain the required current. The voltage required to produce this change is the voltage across the reactance X_s, represented by the line BD. The triangle OBD then shows the vector relation of these voltages.

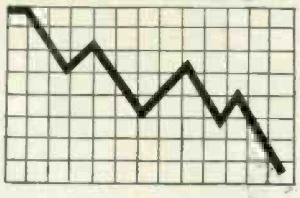
The current diagram is formed by the triangle $OB'C$. Since X_s is assumed to be a pure reactance (practically it can be nearly so), the current thru it will be at 90° to the voltage across it. Therefore, the current line OC is drawn at 90° to the voltage line BD. The current I_R thru resistance R (Fig. 1) is in phase with the voltage across it, hence it lies along the line OB. The current thru X is at right angles to this current, since X is also assumed to be a pure reactance. Then the perpendicular line CB' from C to the voltage line OB represents the current thru X, and its intersection with OB determines the line OB', representing the current thru R. The vector sum of these two currents CB and OB' then equals the total current I represented by OC.

In triangle $OB'C$, we have assumed a condition of current (OC) thru X_s equal to unity (to the scale

1. *Moisture can play hob around electrical equipment.*



2. *It can be absorbed into the insulation and lower its dielectric strength.*



3. *It can eventually result in all sorts of maintenance misery, as every engineer too well knows.*

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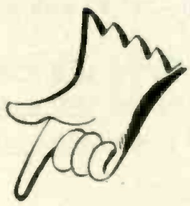

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ELECTRICAL INSULATION

of $R = 1$). Then by drawing the line $B'D'$ parallel to BD we form a new voltage diagram $OB'D'$ for this current condition, in which OB' represents both the voltage across R and the current thru it. Since the voltage $B'D'$ equals IX_s and I now equals unity, $B'D'$ is the required value of X_s. Next we assumed another condition, in which the current I_r thru X is equal to unity, as shown by the line $B'C'$. On this line we formed a new current diagram $O'B'C'$, the line $O'B'$ of which represents the voltage across both R and X as well as the current thru R. The voltage $O'B'$ across X with unit current thru it then becomes a measure of its reactance. Thus the line $O'B'$ represents the value of X.

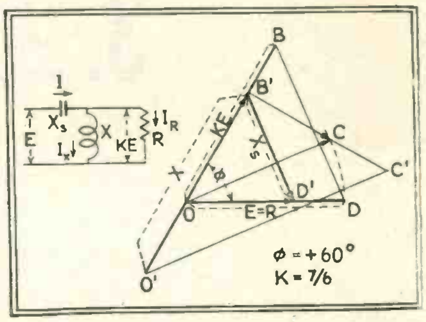
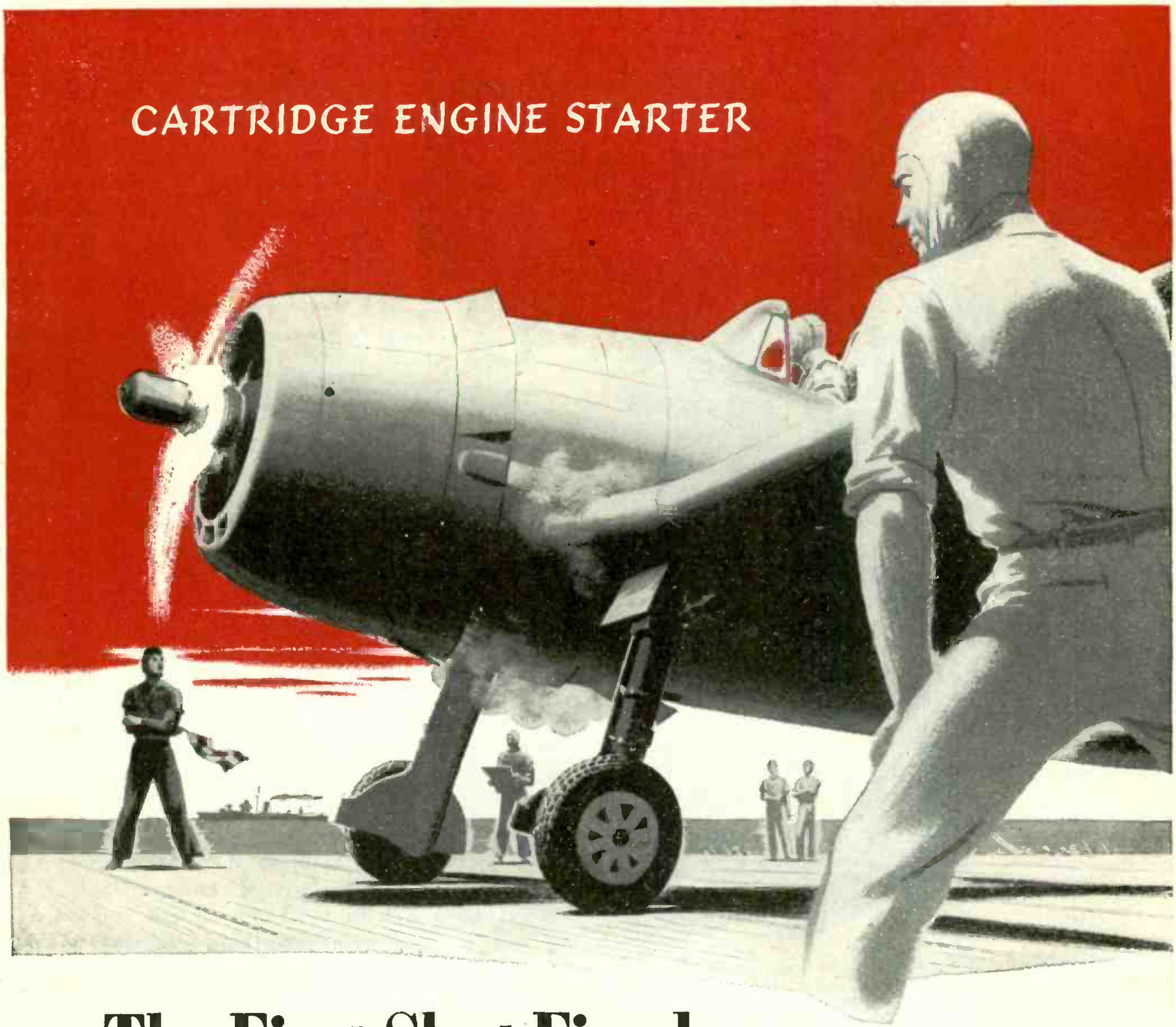


Fig. 2—Geometric solution of the L-type network shown, designed to change the value and phase of the current in a given load by the factor 7/6 (+60°)

To determine the sign of each reactance found as above, consider the relation of the vector of voltage across the reactance to the vector of current thru it. In Fig. 1, the voltage $B'D'$ across X_s leads the current OC thru it, as shown by the line $B'D'$ being rotated counterclockwise with reference to OC. Thus X_s is shown to be inductive in this figure. The voltage OB' across X lags the current $B'C$ thru it and thus X is shown to be capacitive.

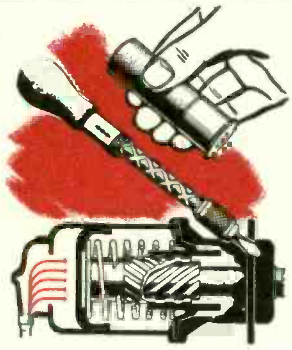
Solutions for Other Values of $K\phi$

Solutions for other conditions are shown in Figs. 2, 3 and 4. In Fig. 2, $K\phi$ equals 7/6 (+60°). The solution of this problem is similar to Fig. 1, but in this case X_s is found to be capacitive and X inductive. This is shown in the corresponding circuit diagram in Fig. 2. In Fig. 3, $K\phi$ equals 0.5 (−30°) and both reactances come out inductive. The opposite condition is shown in Fig. 4, where $K\phi$ equals 0.5 (−30°) and both reactances come out inductive. The opposite condition is shown in



The First Shot Fired

For Lightning-fast Getaways, Navy Fighters Depend on Breeze Cartridge Engine Starters



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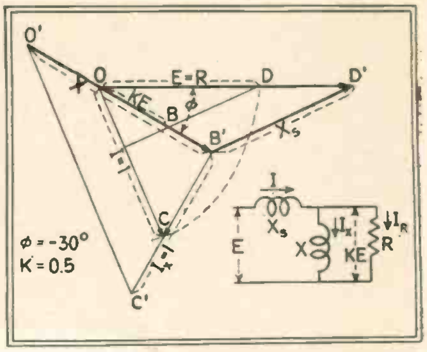


Fig. 3—Geometric solution of the L-type network shown, designed to change the value and phase of the current in a given load by the factor 0.5 (—30°)

Fig. 4, where $K\phi$ equals 0.5 (+30°). Here X_s and X are of the same numerical value as in Fig. 3 but they are both capacitive.

The mathematical solution of these problems, which follows from the geometric construction, depends on familiar formulas of trigonometry. A conventional figure of trigonometry is shown in Fig. 5, in which the capital letters designate angles and lower-case letters the opposite sides. Two of the associated formulas are are: $\tan B = b \sin O/(d - b \cos O)$ and $o = d \sin O/ \sin D$.

Applying these formulas to Fig. 1, we have, in triangle OBD, $\angle B = \text{arc tan } [R \sin \phi/(KR - R \cos \phi)] = \text{arc tan } [\sin \phi/(K - \cos \phi)]$. In the similar right triangles OCB' and OFB', $\angle C = \angle B' = \angle B$ as found above, and $OB' = R \sin B$. In the triangle $O'B'C'$, $\angle C' = \angle B$ and $O'B' = X = R \tan B$. In triangle $OB'D'$, the side $X_s = OB' \sin \phi/\sin D' = R \sin B \sin \phi/\sin (180° - \phi - B)$, since $\angle D' = \angle D$. Substituting values from Fig. 1A we obtain $\angle B = \text{arc tan } 0.866/(1.165 - 0.5) = 52.5°$. Then $\angle D$ of triangle $OBD = (180° - 60° - 52.5°) = 67.5°$ and

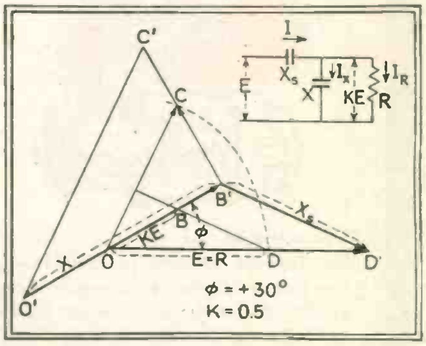


Fig. 4—Geometric solution of the L-type network shown, designed to change the value and phase of the current in a given load by the factor 0.5 (+30°)

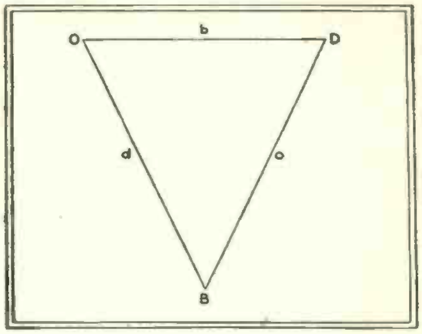


Fig. 5—A conventional figure of trigonometry, used to illustrate the solution of triangles

$\sin D = 0.924$ $OB' = R \sin 52.5° = 0.783R$. Now $X_s = OB' \sin \phi / \sin D = .783\,R\,(0.866)/0.924 = 0.735\,R$, inductive, and $X = R \tan 52.5° = 1.303\,R$, capacitive.

The solution of Fig. 2 is similar to Fig. 1 but the signs of the reactances are reversed. The values for this figure are $X_s = 0.735\,R$, capacitive and $X = 1.303\,R$ inductive.

For the solution of Fig. 3 we obtain $\angle B$ of triangle OBD = arc tan $[R \sin \phi / (KR - R \cos \phi)]$ = arc tan $[0.5/(0.5 - 0.866)] = -1.365 = 126.2°$. Now $\angle D = 180° - 30° - 126.2° = 23.8°$; $OB' = R \sin (180° - B) = R \sin 53.8° = 0.807\,R$; $X_s = OB' \sin \phi / \sin D = 0.807\,R\,(0.5)/0.403 = 1R$, inductive; $X = R \tan (180° - B) = R \tan 53.8° = 1.37\,R$, inductive.

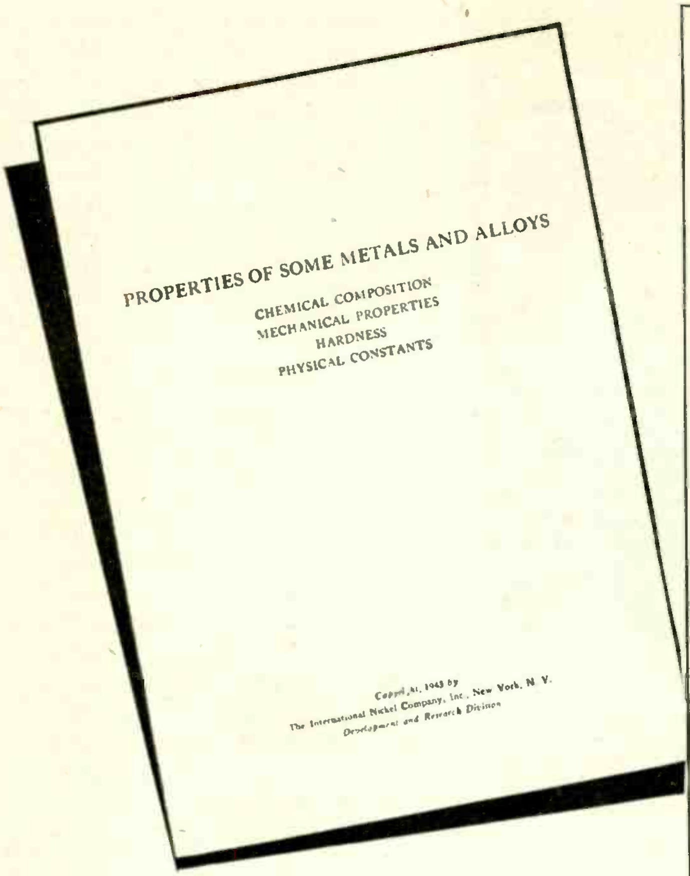
The solution of Fig. 4 is similar, but in this case $X_s = 1\,R$, capacitive, and $X = 1.37\,R$, capacitive.

The four cases shown cover a variety of conditions. Problems involving other values of K can be solved in a similar manner.

• • •

Evaluating Hearing Aids

ONE OF THE PROBLEMS confronting the prospective hearing aid user and the consulting otologist is that of selecting the proper instrument for the individual's needs. In an attempt to fill the need for objective comparison of hearing aids, a hearing aid clinic was established in 1941 at Central Institute for the Deaf, Washington University Medical School, St. Louis. The operation of the clinic and the preliminary findings regarding the performance of various aids in relation to specific categories of defective hearing are described in a booklet published by the Institute, that is a reprint of a paper by B. H. Senturia, S. R.



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- Hastelloy A, B, C, D
- Illium G, R
- Alcoa 2S, 3S, 17S, 52S, 53S
- Alclad 24S
- Alcoa 13, 43, 195, 214, 220
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- Cupro-Nickel 70-30, 55-45
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- Chemical Lead
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- Tellurium Lead
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- Zilloy 15, 40
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- Cast 18 Cr 8 Ni Steel
- Cast 18 Cr 8 Ni 3 Mo. Steel
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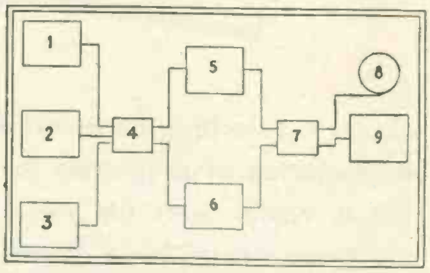
Sheet...Strip...Rod...Tubing...Wire...Castings

Silverman, and C. E. Harrison in the *Annals of Otology, Rhinology and Laryngology*, March, 1943.

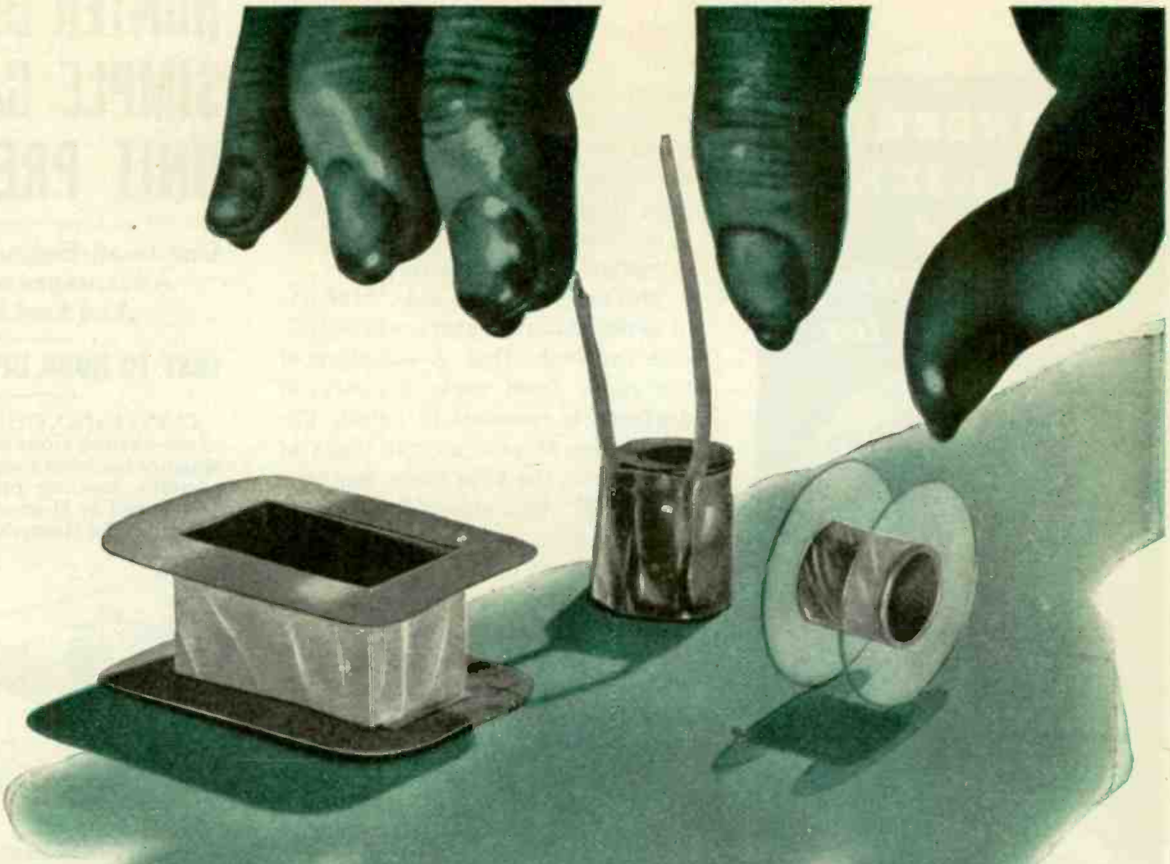
One of the major obstacles in the adequate evaluation of hearing aids has been the lack of satisfactory testing equipment. In many instances coupling the microphone of the hearing aid to the ear piece of an audiometer has been employed for appraising actual performance. Such evaluations are scientifically incorrect since there is an acoustical mismatch and the mechanical contact fails to simulate normal operating conditions of the hearing aid device. At the clinic the room in which hearing air evaluations are conducted simulates the acoustical conditions of the average living room both as to noise level and reverberation characteristics. Reverberation time (the time required for a 1,000-cycle tone to attenuate 60 db) in the laboratory is one second and the noise level averages 35 db above absolute threshold.



Arrangement of apparatus in hearing aid clinic: 1—Western Electric audiometer; 2—transcription turntable; 3—microphone; 4—input selector and equalizers; 5—12-watt amplifier; 6—30-watt amplifier; 7—output selector switch; 8—output volume indicator; 9—dual speakers.

The arrangement of the apparatus used in the evaluation tests is shown in the block diagram. Three sources of sound are available, any one of which may be fed into a special 30-watt amplifier whose frequency characteristics are linear, plus or minus one db, from 60 to 10,000 cycles. One sound source, a Western Electric audiometer, provides pure tone signals, while test sentences are available from a two-speed turntable that plays back electrical transcriptions recorded in the Institute laboratories. The transcriptions were found to have a frequency range from 100 to 9,000 cycles wider than the average phonograph record, and a noise level 25 db less than the newest type record.

The patient to be tested is seated



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Write for Celanese Celluloid Corporation's electrical booklet. It will supply you with pertinent facts regarding Lumarith's electrical advantages. Complete data on dielectric strength, resistivity, etc. are included. Celanese Celluloid Corporation, *The First Name in Plastics*, a division of Celanese Corporation of America, 180 Madison Avenue, New York City 16. Representatives: Dayton, Philadelphia, Cleveland, Chicago, St. Louis, Detroit, Los Angeles, Washington, D. C., Leominster, Montreal, Toronto.

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A CELANESE* PLASTIC

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so that the ears and the hearing aid are two meters from, and at right angles to, the calculated points of sound from two speakers. The output level from the amplifier is monitored by an eight-inch meter and the attenuator is a constant-impedance H pad arrangement to eliminate any reflection that might introduce phase distortion.

Thirteen different aids, products of seven manufacturers, were available for evaluation. A sampling of ten cases from each category of deafness is reported in detail. The evaluation of aids on the basis of response to the pure tones was supplemented by selected sentence tests in most cases. It was noted that a gain of only ten db throughout the range from 256 to 2048 cycles yielded from 25 to 50 percent increase in sentence intelligibility. The authors suggest that this occurs because enough gaps in the auditory pattern are filled to enable the patient to bring into play his ability to synthesize the language stimulus into a meaningful whole. It is possible that an increase of as little as ten db may bridge the gap between intelligibility and unintelligibility of speech.

A 20-item bibliography on hearing aids is included in the reprint.

• • •

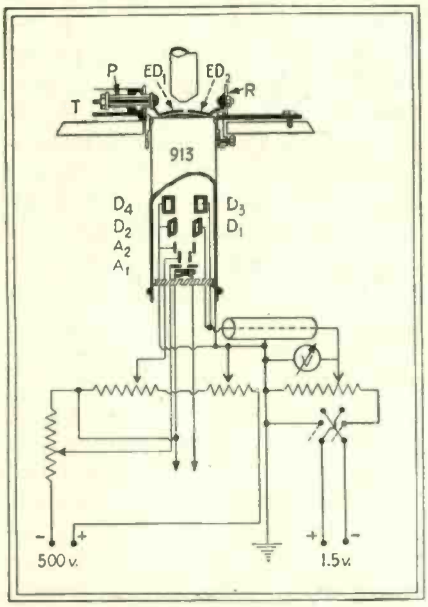
Sensitive C-R Voltmeter

THE USE OF A CONVENTIONAL cathode-ray tube for determining very low potentials caused by a small number of electrons is described by Zabov V. Harvalik in the *Review of Scientific Instruments* for September, 1943. Tubes for this purpose usually have special glass envelopes, quartz supports for the grid structures and are evacuated very carefully. In operation low plate potentials are necessary to prevent the formation of secondary electrons and accidental ionization of residual gas molecules.

For determining low potentials at radio frequencies as well as direct potentials with small electron reserve, a 913 tube is employed in the circuit shown. To overcome the effect of ionization and parasitic electrons, a discharging resistor of 30 megohms is connected across the deflection plates. This keeps the electron beam in the desired position on the screen.

When one volt is applied on the

deflection plates there is a beam deflection of 0.16 mm; the current is 3.0 x 10^{-8} ampere. A microscope with a magnification of 200 times is used to determine this deflection. An eyepiece micrometer of 100 divisions (1 division = 2 mm at the distance of 25 cm) is used to standardize the device. The standardization is performed by applying known potentials to the deflection plates. One division in the eyepiece equals 0.045 volt and a current flow of 1.0 $\times$ 10^{-9} ampere is observed. The fact that this current is not consistent with Ohm's law can be ascribed to the presence of ions in the tube.



Circuit of the cathode-ray voltmeter that measures low-potential sources that can supply few electrons

To increase the input resistance and to improve the reading accuracy, external deflection plates are attached to the structure as shown. The external deflection plates ED_1 and ED_2 are made of copper and insulated from the supporting ring R by Pyrex glass tubing P. They are pressed upon the screen of the tube and are one mm apart. Terminal T is shielded from external influences. A potential of 1.4 volts applied to the external deflection plates causes a displacement of the beam on the screen of 20 divisions at a magnification of 200 times. The input resistance of this system cannot be measured by any galvanometer. It is evident from this measurement that with the external deflection plates the voltage sensitivity is decreased and the input resistance increased.

To reach an exact definition of the deflection of the beam on the screen the following method is used. A bright grain on the fluorescent screen is arbitrarily chosen as reference grain, and the magnification increased to 900 times. By changing the potential on the deflection plates within the tube $(D_1 + D_3 + D_2 + D_4)$ with a potentiometer, the beam is moved to the edge of the reference grain. The grain is still bombarded by electrons and therefore fluorescent. Then a known potential is applied to the external deflection plates. The beam moves, and the reference grain stops fluorescing. By application of a known potential to the deflection plates within tube the deflection caused by the external plates is compensated, and controlled by the reference grain which becomes fluorescent again. The compensating potential is measured by a millivoltmeter. If a magnification of 900 times is used the sensitivity is 0.01 volt with an immeasurably high input resistance.

It is not necessary to use an eyepiece micrometer, as the reference grain fulfills this function. Higher magnifications that 1000 times should not be used since the small focal distance of the objective places the metal parts of the objective close to the external deflection plates, and distorts the field formed between them. Another possible source of distortion of the field can be the polarization of the glass envelope of the screen. A mutual influence is observable if the potential of the anode A_2 is less than 400 volts. The screen apparently becomes strongly negatively charged, and this results in disappearance of the focused ray.

• • •

Matching Speakers of Unequal Impedance

By RICHARD W. CRANE
Concord, N. H.

CONNECTING TWO OR MORE speakers to an amplifier is fairly simple if all the units have identical impedances and all are to share the power output equally. It is a different story, however, if the impedances are unequal and if the various speakers require unequal shares of the power.

Take the most complex case in-

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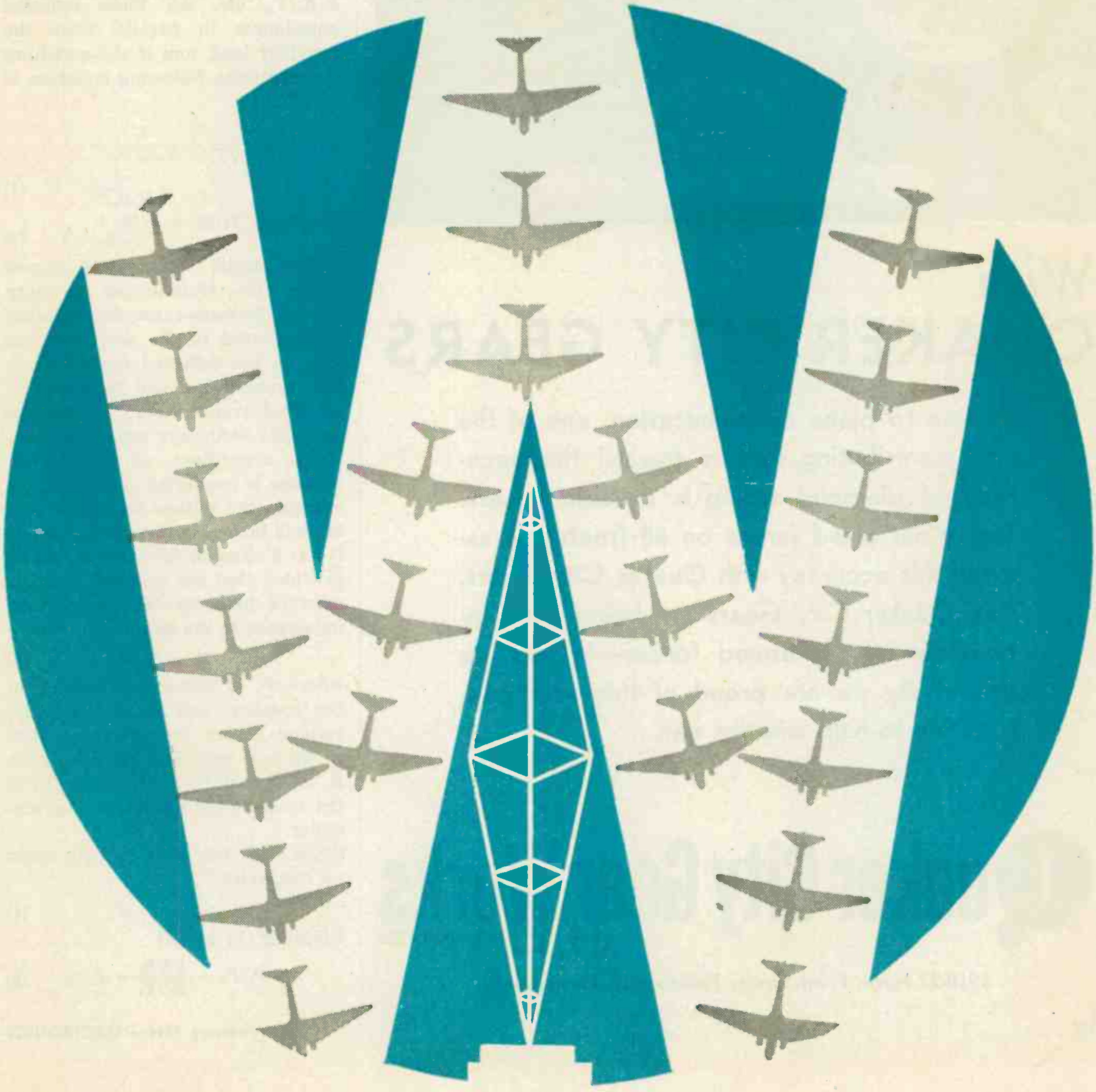


volving n speakers, each of which has a different share of the power, all to be connected to one universal output transformer. Assume that one side of each voice coil is connected to the zero tap, and that the other side is connected to some other tap.

Now, taking speaker 1, and forgetting the others for a moment, the impedance it reflects back to the primary of the transformer is $R_L R_1/T_1$, where R_L is the load impedance the amplifier should see, R_1 is the impedance of voice coil No. 1, and T_1 is the transformer tap to which the speaker is connected. This must be so, since if, for instance, we connected a 4-ohm speaker to a 2-ohm tap, the amplifier would see 4/2 or twice its correct load impedance. Similarly, speaker 2 reflects an impedance of $R_L R_2/T_2$, etc. All these reflected impedances in parallel form the amplifier load, and if the matching is correct the following equation is true

$$1/R_L = \frac{1}{R_L R_1/T_1} + \frac{1}{R_L R_2/T_2} + \cdots\cdots + \frac{1}{R_L R_n/T_n} \qquad (1)$$

Simplifying, $T_1/R_1 + T_2/R_2 + \cdots\cdots + T_n/R_n = 1 \qquad (2)$

The audio voltage developed across the transformer primary will be the same regardless of what is connected to the secondary, as long as the reflected impedance is the correct value, and therefore, in an ideal transformer, the voltage from any secondary tap will be constant regardless of what impedance is connected across it. For example, the voltage across a 2-ohm tap will be nearly the same whether it has 4 ohms or 32 ohms across it, provided that the complete speaker network presents the proper load impedance to the amplifier. Now

$$P_1 = E_1^2/R_1 \qquad (3)$$

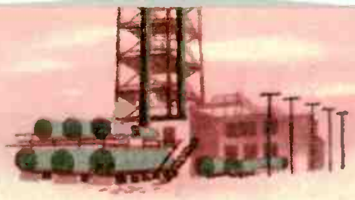
where P_1 is the power desired in the speaker, and E_1 is the audio voltage across the speaker. But, if we had only one speaker, then $R_1 = T_1$ *and* $P_1 = P_T$ where P_T is the total power output of the amplifier.

Since E_1 is the same in both cases we can write

$$P_T = E_1^2/T_1 \qquad (4)$$

Dividing (3) by (4)

$$P_1/P_T = \frac{E_1^2/R_1}{E_1^2/T_1} = T_1/R_1 \qquad (5)$$



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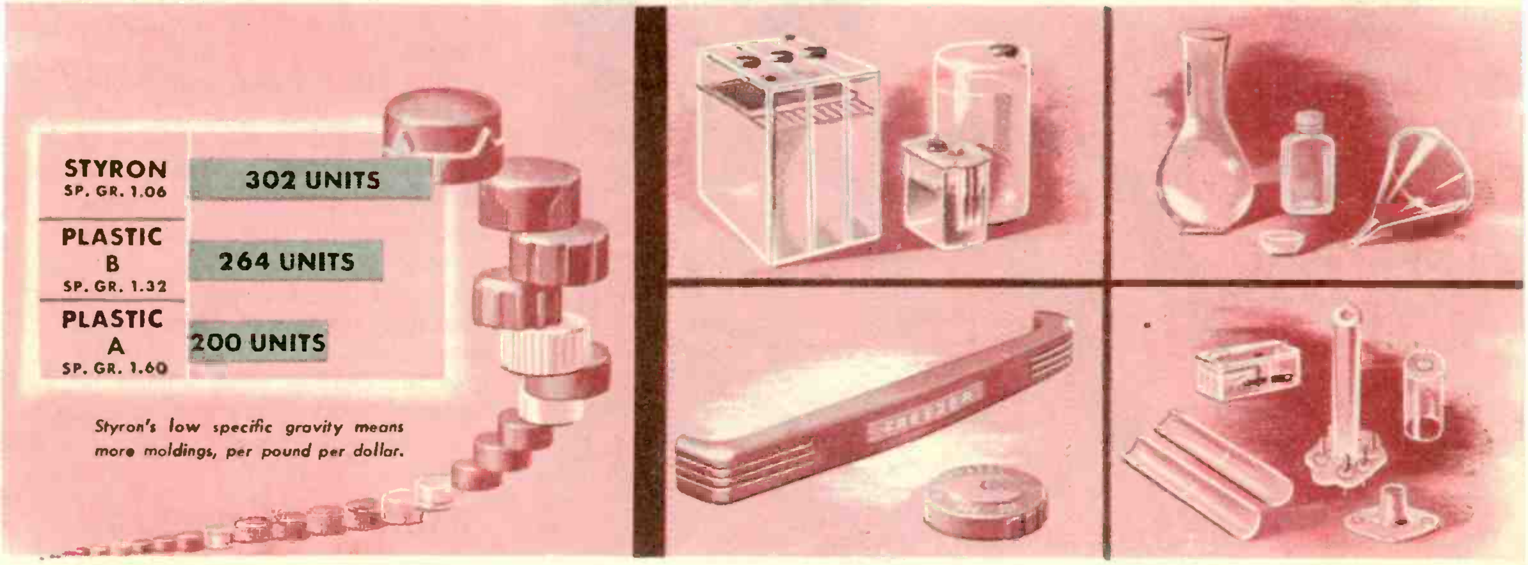

Today, all of us have but one objective—the winning of the war. Tomorrow we also have a great responsibility in the return to a peacetime economy—the responsibility to produce more and better products at a lower price. For these reasons plan now to use Styron (Dow Polystyrene). Large production facilities will make this versatile plastic available in a quantity, of a quality and at a price to meet the exacting needs of a product-hungry world.

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INDISPENSABLE TO INDUSTRY AND VICTORY

Since $P_1 + P_2 + \ldots\ldots P_N$ must equal P_T then

$$P_1/P_T + P_2/P_T + \ldots\ldots P_N/P_T = 1 \quad (6)$$

Substituting Eq. (5) in Eq. (2) we again obtain Eq. (6), which proves our derivation.

Rearranging Eq. (5) we obtain the simple result $T_1 = R_1\rho_1$ where ρ_1 is percent of power output desired in speaker 1, and finally $T_k = R_k\rho_k$ for speaker k. With this equation the most complicated speaker networks can be easily set up. For instance, say we have three speakers, 4, 6, and 8 ohms. The first is to get 50 percent of the power, and the other two 25 percent each:

$T_1 = 4 \times .50 = 2$ ohms; $T_2 = 6 \times .25 = 1.5$ ohms; $T_3 = 8 \times .25 = 2$ ohms.

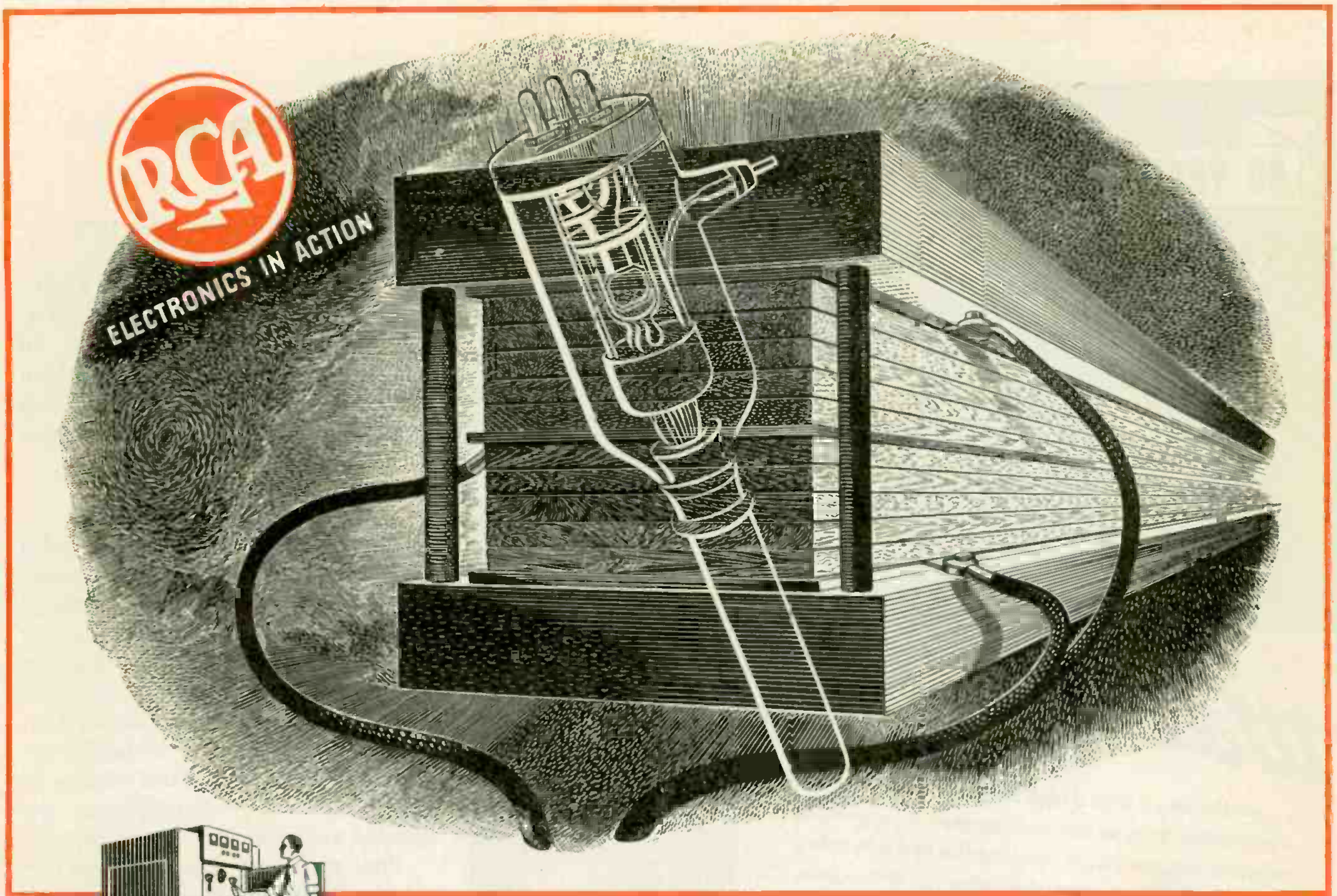
Thus, the 4-ohm and 8-ohm speakers would be connected to the 2-ohm tap, the 6-ohm speaker to a 1.5-ohm tap, the amplifier would be loaded correctly, and each speaker would have the desired share of the power.

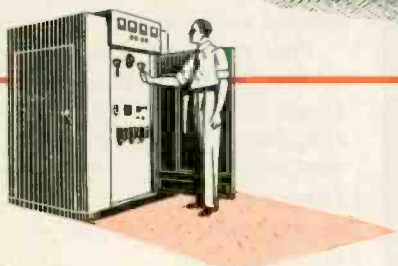
The transformer taps available may not correspond exactly with those calculated, of course, in which case the nearest value should be chosen.

• • •

RADIO RACK MOCK-UP

RADIO rack used at United Air Lines maintenance base at Cheyenne, Wyo. for making studies of possible changes in radio equipment without keeping a plane out of service. The mock-up contains all the radio equipment installed on a Mainliner and permits the transmitters and receivers to be operated as in flight





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.

TUNE IN "WHAT'S NEW?"

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RADIO CORPORATION OF AMERICA

Cathode-Ray Tubes

(*Continued from page* 137)

strates the relation between amplitude, frequency and maximum writing speed for sine waves; Fig. 10 gives the photographic writing speed V as a function of V_{max}, lens aperture F, and object-image ratio M.

Nomographs

Suppose it is desired to record a sine-wave transient having a peak-to-peak amplitude of approximately 6 cm ($A = \pm 3$ cm) and a frequency f of 5 kc. The tube may have a P5 screen with a raster brightness of 2 ft-lamberts. From Fig. 5, V_{max} is determined to be 60 km per sec. for $D_1 = 0.1$. Half of this is taken for safety purposes as explained above, so $V = 30$ km per sec.

The speed of the phenomenon which is to be recorded can be found from Fig. 9 by considering a frequency of 50 kc and dividing the result by ten to give the required frequency of 5 kc. A value of approximately 1 km per sec is obtained for V'.

By means of the nomograph in Fig. 10, we find that recording this speed at $V_{max} = 30$ km per sec permits the use of an aperture of $F = 5.6$ for $M = 1$. If a different ratio of object on screen to image on film is desired, perhaps $M = 10:1$, a line drawn from this value to 1 km per sec on the V' scale crosses the V scale at 3.3 km per sec. Use of $M = 10:1$ permits the recording of speeds 3.3 times higher than with $M = 1$. To confirm this, locate 3.3 km per sec on the V' scale and draw a line to the previous determined aperture $F = 5.6$. The cross point on the V_{max} scale establishes the corresponding increase in V_{max} to 102 km per sec. Since the recorded speed is only 1 km per sec, a line can be drawn from 102 km per sec on the V_{max} scale through $V' = 1$ km per sec, which shows an aperture between $F = 9$ and $F = 11$. Consequently, the phenomenon can be recorded either with an aperture $F = 5.6$ for $M = 1$, with $F = 10$ for $M = 10:1$, or with any intermediate values.

Assume a rectangular wave is to be recorded with a maximum rise

of 5 cm per microsecond. The maximum speed to be recorded is therefore 5×10^6 cm per sec or 50 km per sec.

Recording of Transient Rectangular Wave

The available lens has a maximum aperture of $F=1.9$. The nomograph of Fig. 10 shows that $V_{max}=180$ km per sec. Figure 6 indicates that a P5 screen with $B = 5.6$ ft-lamberts would be satisfactory. Assuming that in this case only 4 ft-lamberts are available from the cathode-ray tube under the given operating conditions, it would probably be advisable to increase the exposure by raising the object-image ratio. For $M=8:1$ the apparent writing speed is increased threefold and a recording of satisfactory density would be secured.

Recording of Recurrent Phenomena

As another example of the use of data given in this article, assume the exposure time for the recording of recurrent phenomena is to be determined.

Let us assume that an amplitude of ±2 cm and a sine wave of 1000 cps, with a sweep frequency of 100 cps, appears on a P1 screen yielding a brightness, B, of 7.5 foot-lamberts. If n is the number of images per second appearing on the screen, t is the exposure time, and V is the maximum writing speed of the phenomenon which has to be recorded, then $V = t\,n\,V_{max}$ or $t = V/(n\,V_{max})$. Referred to a lens with aperture F, $t = VF^2/(n\,V_{max})$.

In this case $n=100$, and $V=2\pi \times 10^3 \times 2 = 12.6 \times 10^3$ cm per sec. From the graph of Fig. 6, $V_{max} = 6 \times 10^5$ cm per sec, and it can then be calculated that $t = 2.1 \times 10^{-4} F^2$ sec. If an aperture of $F=7$ is employed, $t = 1/100$th sec.

Conclusions

As a result of a comprehensive survey of the technique of producing photographic records at maximum writing speed, we may draw the following conclusions:

(1) For high-speed recording, Agfa Triple S Ortho film gives the best results of the films tested for P1, P2, and P5 screens. Recommended development procedure: Develop 8 minutes at 65 deg F in D72.

(2) The P5 screen has the high-

3 steps

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est photographic efficiency.

(3) The maximum photographic writing speed plotted against tube brightness gives an accurate means for determining the exposure time. With standard tubes and high accelerating potentials, phenomena of more than 1000 km per sec have been recorded.

(4) At high accelerating voltages (9.7 kv) all the screens previously mentioned became very efficient for photographic recordings, and the differences, which are quite important at low voltages, become relatively small. At high voltages the brightness differences between individual tubes of the same type seem to diminish.

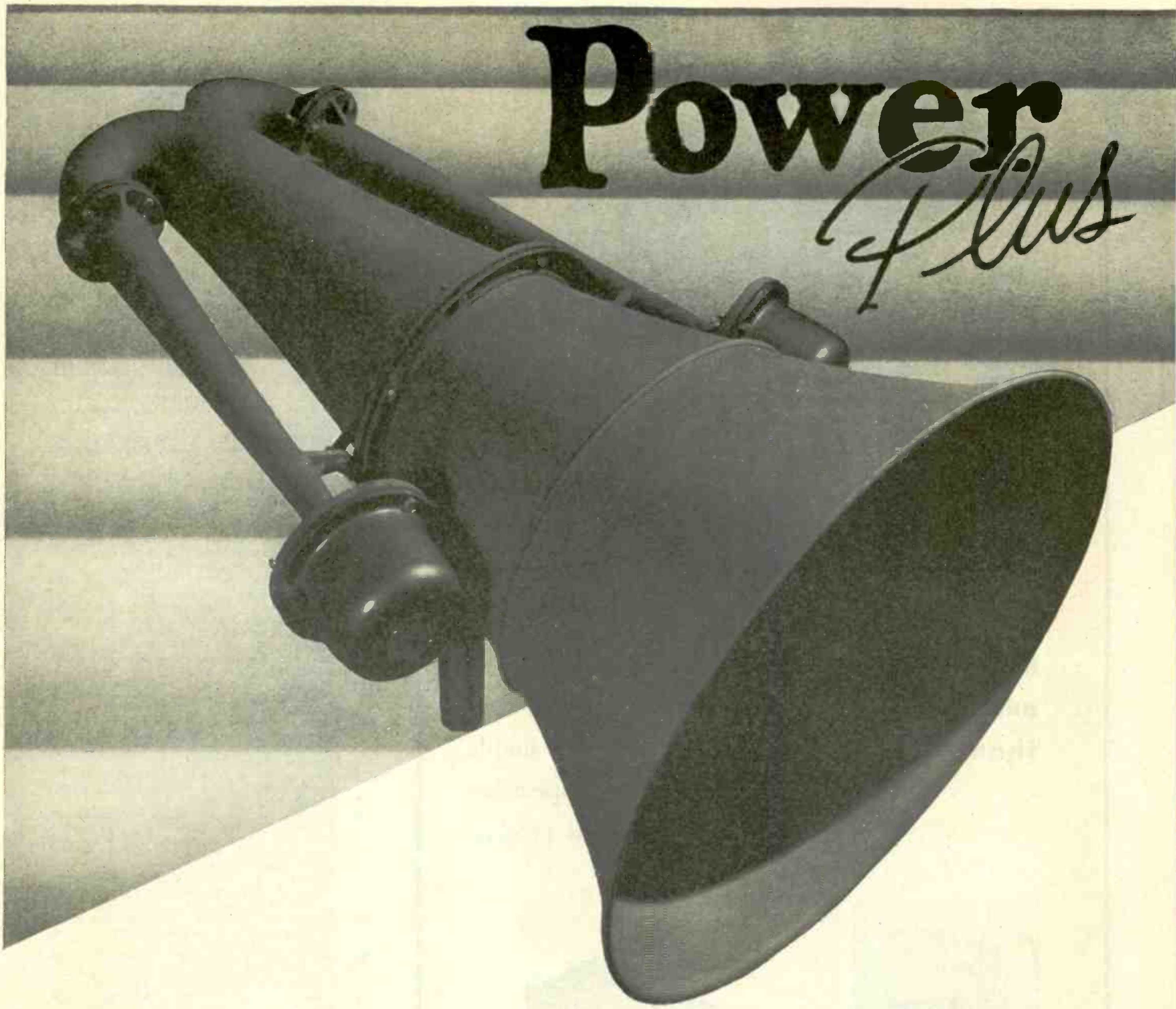
(5) Type P2 screens, which give very poor results at low voltages, show a tremendous increase in efficiency at high voltages and it is desirable to employ this screen at high voltages.

(6) It has been shown that by using synchronized high-speed shutters (1/100 sec) undesirable fogging of the film by background light of the screen can be minimized up to accelerating potentials of about 6 kv. Beam modulation eliminates the necessity for synchroniz-

• • •

PHOTOELECTRIC MAGNIFICATION

Tolerance of precision parts used in fighter plane production are checked on a Comparator, a photoelectric machine that throws an image of precision gages, enlarged 62½ times, on to a screen. The picture above shows bits of dust and lint that accumulated on a gage when left outside an air-conditioned storage room. A Westinghouse Precipitron removes such particles from the storage room



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ing the shutter and permits the use of high accelerating potentials and strong beam currents, without danger of screen burning.

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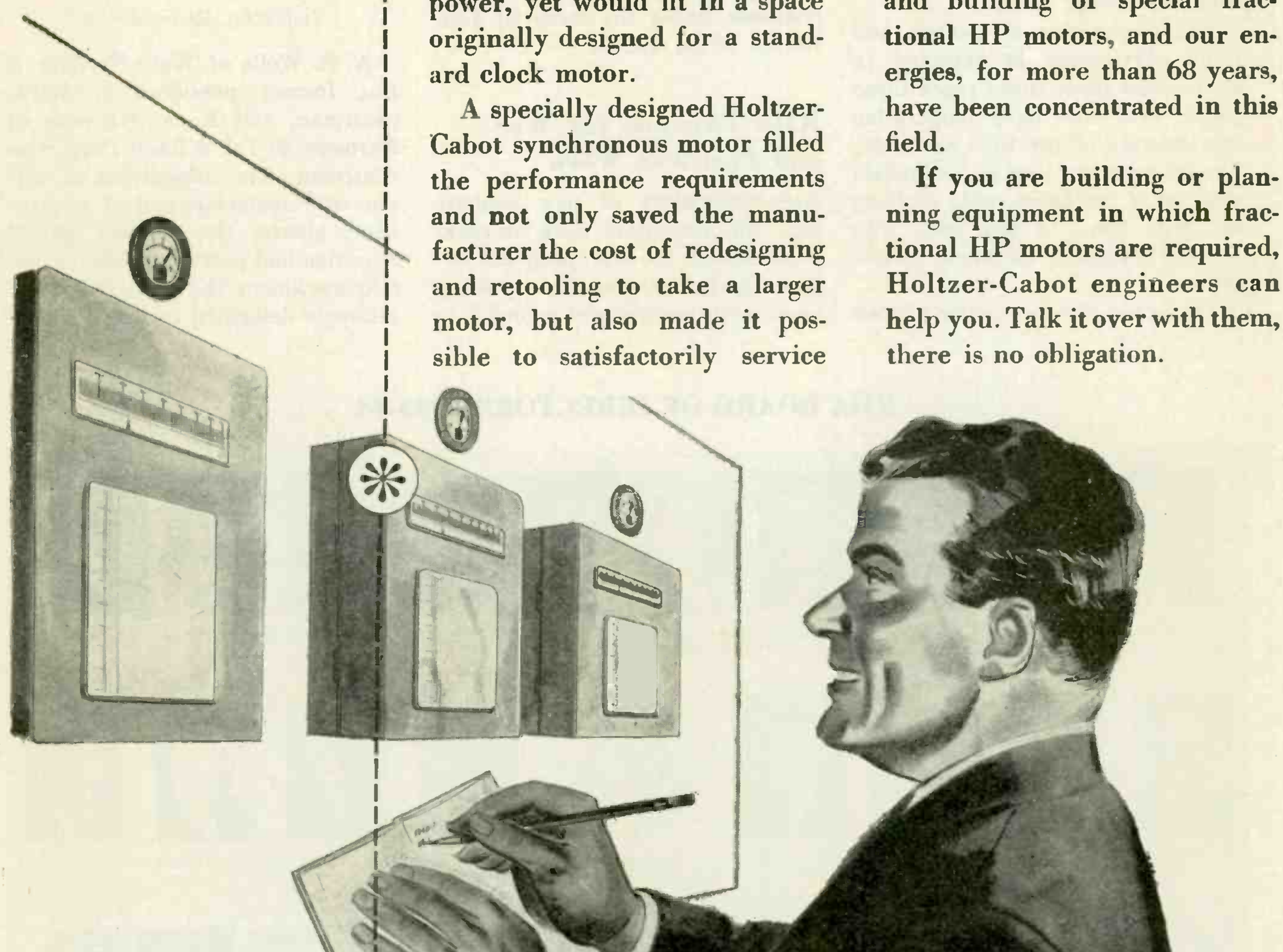

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NEWS OF THE INDUSTRY

New committees for RMA; results of radio survey; Signal Corps on electronic needs; progress of standardization programs; simplified form for Army contracts; London news letter

Tubes for Civilians

TUBES FOR HOME RADIO receivers are being scheduled for production by plants best equipped to produce them, according to the radio and radar division of WPB, in announcing a definite program for manufacturing at least four and a half million radio tubes of critical types for civilian receivers in the first quarter of 1944.

The cooperation of dealers and radio servicemen is expected in seeing that these tubes reach those people first who have inoperative sets because of the tube situation. The program may not be a complete solution of the home radio problem but will serve to put back into service thousands of silent receivers.

The types of tubes being pushed are 12SA7, 12SQ7, 12SK7, 50L6, 35Z5, 35L6, 1H5, 1A7, 80 and other critical types which have not been produced in sufficient numbers, due to military requirements. All the foregoing tube types bear the suffix "GTG", and will be marked "MR" for maintenance, repair and operating supply purposes. They cannot be sold on rated order, preventing diversion from civilian channels, under the terms of Limitation Order L-265.

RMA Expands for War and Post-War Work

ANNOUNCEMENT of new committees, for immediate work on many problems of the war program and also for future plans and conferences with government agencies on post-war problems of the industry, has been made by the Radio Manufacturers Association. The enlarged activities are designed to promote the increased 1944 war program of radio and electronic equipment and will include manpower and employment problems. A comprehensive industry reconversion plan will be included and will be formally presented to and discussed with government officials.

Development of the new RMA program was conducted at the Mid-Winter Conference January 12 and 13 at the Stevens Hotel, Chicago. The special committees and names of their chairmen, appointed by R. C. Cosgrove of Crosley Corp., chairman both of the RMA Set Division and the Association's overall Post-War Planning Committee, follow:

Industry Reconversion

A. S. Wells of Wells-Gardner & Co., former president of RMA, chairman, and E. A. Nicholas of Farnsworth Tel. & Radio Corp., vice chairman. The disposition of surplus war materials and of government plants, the postwar patent situation and postwar product planning are among the many important interests delegated to this commit-

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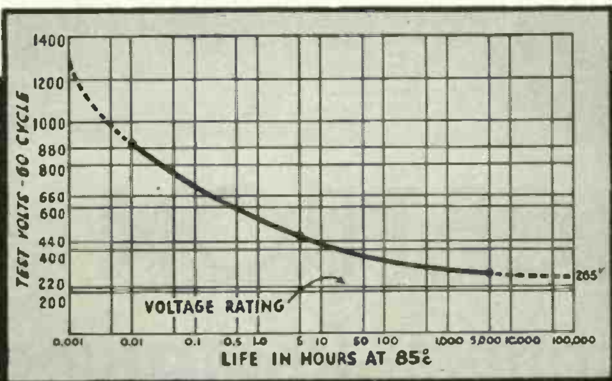

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tee. It will coordinate its work with the Radio Technical Planning Board.

Industry Statistics

Ross D. Siragusa, of Admiral Corp., chairman. This committee will plan development of industry statistics, including data on production and sales, the latter by areas. The future statistics will include tubes, parts and accessories, transmitting apparatus, as well as receivers.

Employment and Personnel

Chairman, A. H. Gardner of Colonial Radio Corp. The committee will handle immediate and also future employment problems, including present manpower, absenteeism, recruiting, absorption of discharged and disabled servicemen, employment stabilization and agreements, and bonus and incentive pay. Under immediate consideration is an RMA survey to secure employment and wage rate data.

Sales Financing

J. P. Rogers of Farnsworth Tel. & Radio Corp., chairman. This committee is to secure data and make recommendations regarding financing problems of distributors, dealers and consumers, as well as manufacturers, including V and VT loans, and problems relating to financing by national and local organizations.

Advertising Committee

The chairman, John S. Garceau of Farnsworth Tel. & Radio Corp. The committee deals with present and future advertising of new radio-electronic apparatus, cooperative advertising, publicity and promotion, etc.

Distribution Costs

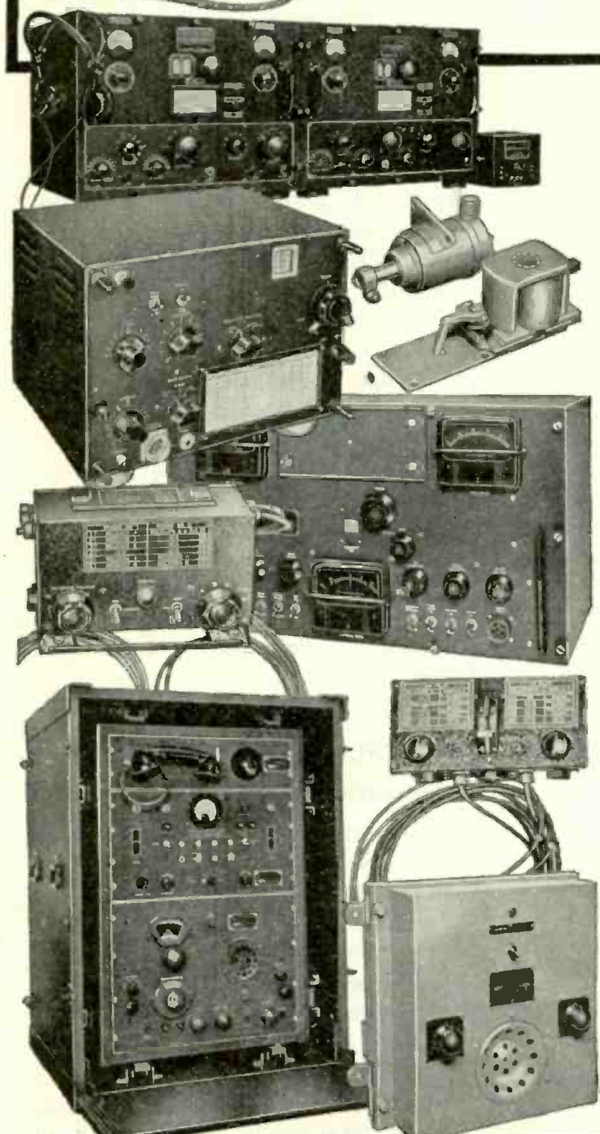
Chairman, Ben Abrams of Emerson Radio & Phono. Corp. The committee will develop data on distribution costs, government control problems and other commercial problems of postwar merchandising.

Export Program

Chairman, W. A. Coogan of the RMA Export Committee is chairman of the special group to consider postwar conditions and problems of postwar export trade,

MAGNAVOX WILL MEAN <u>EVEN</u> <u>MORE</u> TO THE POSTWAR RADIO INDUSTRY

These highly technical instruments—some of the many Magnovox makes for the armed forces—will find their counterparts in peacetime developments.

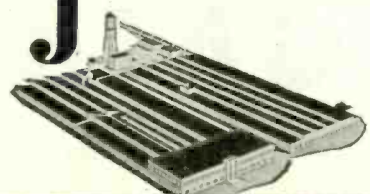


THIRTY-THREE years of pioneering work in radio prepared Magnavox to produce these highly complex precision instruments, ranging from gun firing solenoids to the most intricate radio communication systems.

V-Day will find Magnavox skills and facilities at a new high, because of the miracles of invention and production demanded by the emergency—ready to play a more prominent part than ever in the coming peacetime developments in all phases of electronics. The most advanced engineering and manufacturing facilities are housed in the new, modern six-acre plant. The Magnavox Company, Fort Wayne 4, Indiana.

Magnavox craftsmanship won the first "E" award in this field (1941), now with 3 White Star Renewal Citations.

Magnavox



LOUD SPEAKERS • CAPACITORS • SOLENOIDS • COMMUNICATION & ELECTRONIC EQUIPMENT

including products and merchandising, financing, shipping, trade marks, and promotion in export fields, and also contacts with government agencies concerned with export trade.

Results of Civilian Radio Survey

THE NATIONAL SURVEY of over 5,000 representative households throughout the country, conducted by the Office of Civilian Requirements to ascertain consumer needs, revealed that 89 percent of all families in the United States have one or more radio sets—59 percent have one, 24 percent have two, and 6 percent have three or more radios.

The report stated that 82 percent of all U. S. families have one or more sets in working order—a total of 63 percent have one set, 15 percent have two sets, and 4 percent have three or more sets in working order.

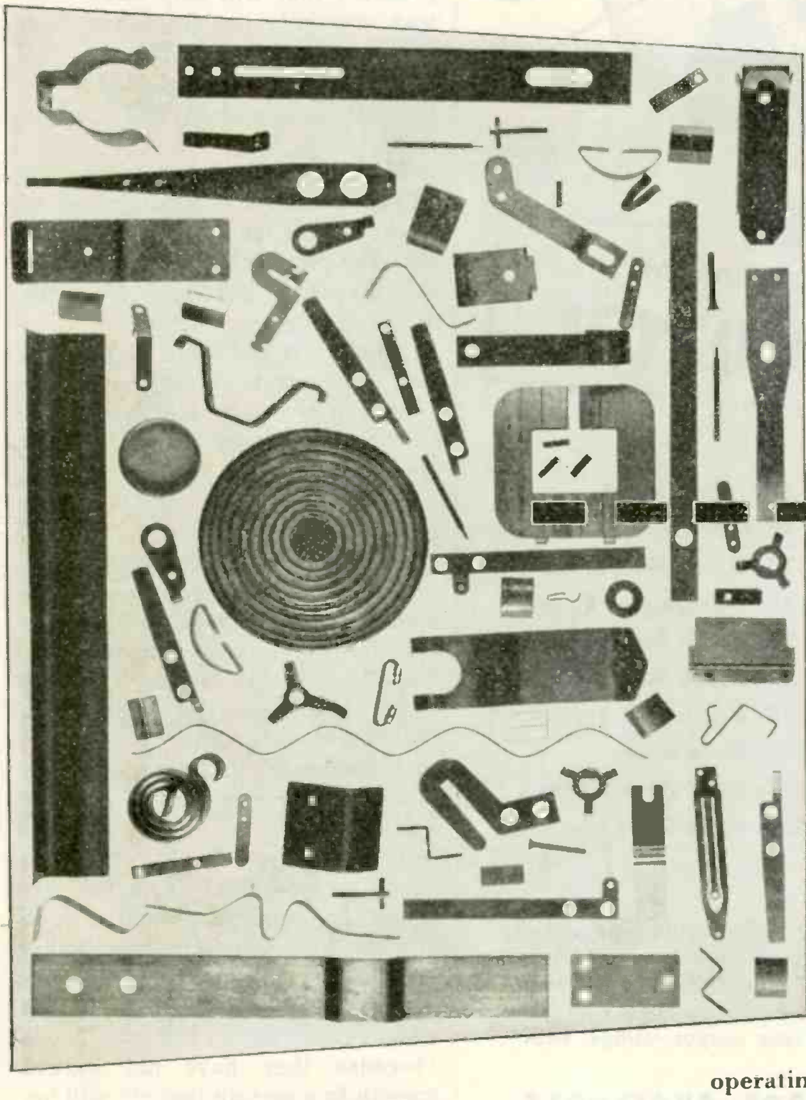
Radio replacement tubes were listed among civilian shortages; also, though not showing as acute shortages, were radio batteries. About 15 percent of farm families reported that they had tried to buy batteries within the last three months and between 7 and 8 percent were successful in obtaining them.

Speaking before the American Marketing Association in New York recently, Frank H. McIntosh, chief of the Domestic and Foreign Branch, Radio and Radar Division of WPB, emphasized that he believed the "low tide (for civilian tubes and parts) has been reached, and that conditions will not be worse but definitely better in the future."

G-E Standards Policy Committee

A COMMITTEE to be responsible for the development and maintenance of sound design engineering and manufacturing standards and practices for use throughout the General Electric Co. has been appointed by executives of the company. The committee will review and determine the adequacy of standards and practices before giving its approval for general use by the company, so that maximum consistency of ap-

"Micro-Processed" Beryllium Copper
FLAT SPRINGS
Hold Proper Shape Indefinitely!



Micro-processing starts with the premise that if you know the characteristics of the beryllium copper strip you are using, know the physical and electrical requirements of the finished spring . . . then the variables of time-temperature involved in heat treat forming can be controlled within the closest of limits.

Flat springs with exceptionally long service life and original accuracy are the inevitable result.

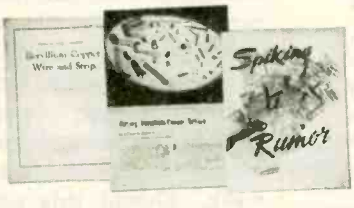
Thus, Instrument Specialties delivers in any desired quantity (from one spring to millions) flat springs Micro-processed to the following tolerances:

Angles: Within ± 1° on bends.
Flatness: Within .001 to .003 in. per inch of length.

Simple or complex designs are equally responsive to Micro-processing; maximum desired properties are also easily attainable. As an example: springs heat treated for minimum drift have unusually high endurance strength. With the Carson Electronic Micrometer developed by I-S, it is a routine matter to measure drift in pilot lots and predict repetition of results in production quantities.

Great savings are possible by incorporating Micro-processed Beryllium copper flat springs in your equipment . . . assembly and maintenance cost is lowered, higher operating efficiency is obtained, and absolute uniformity of characteristics is assured.

Make use of our sample spring and engineering design departments — send drawings, samples, or specifications. We stand ready to prove our statement — on your own springs.



"Making Beryllium Copper Behave"
The story behind the development of micro-processing.

"Spiking A Rumor"
The facts about the greatly increased supply of beryllium copper.

"Predicting Spring Performance of Beryllium Copper Wire & Strip"
Why beryllium copper varies in hardening response and what to do about it.

INSTRUMENT SPECIALTIES CO., INC.
DEPT. D., LITTLE FALLS, NEW JERSEY

FIELD ENGINEERING OFFICES: BOSTON · CHICAGO · CLEVELAND · PHILADELPHIA · NEW YORK pearance, interchangeability, and economy of manufacture will be secured.

American Standards approved by ASA and other nationally accepted standards developed by the AIEE, ASTM, and SAE will continue to be utilized without change insofar as they are applicable.

Post-War Unemployment Compensation Program

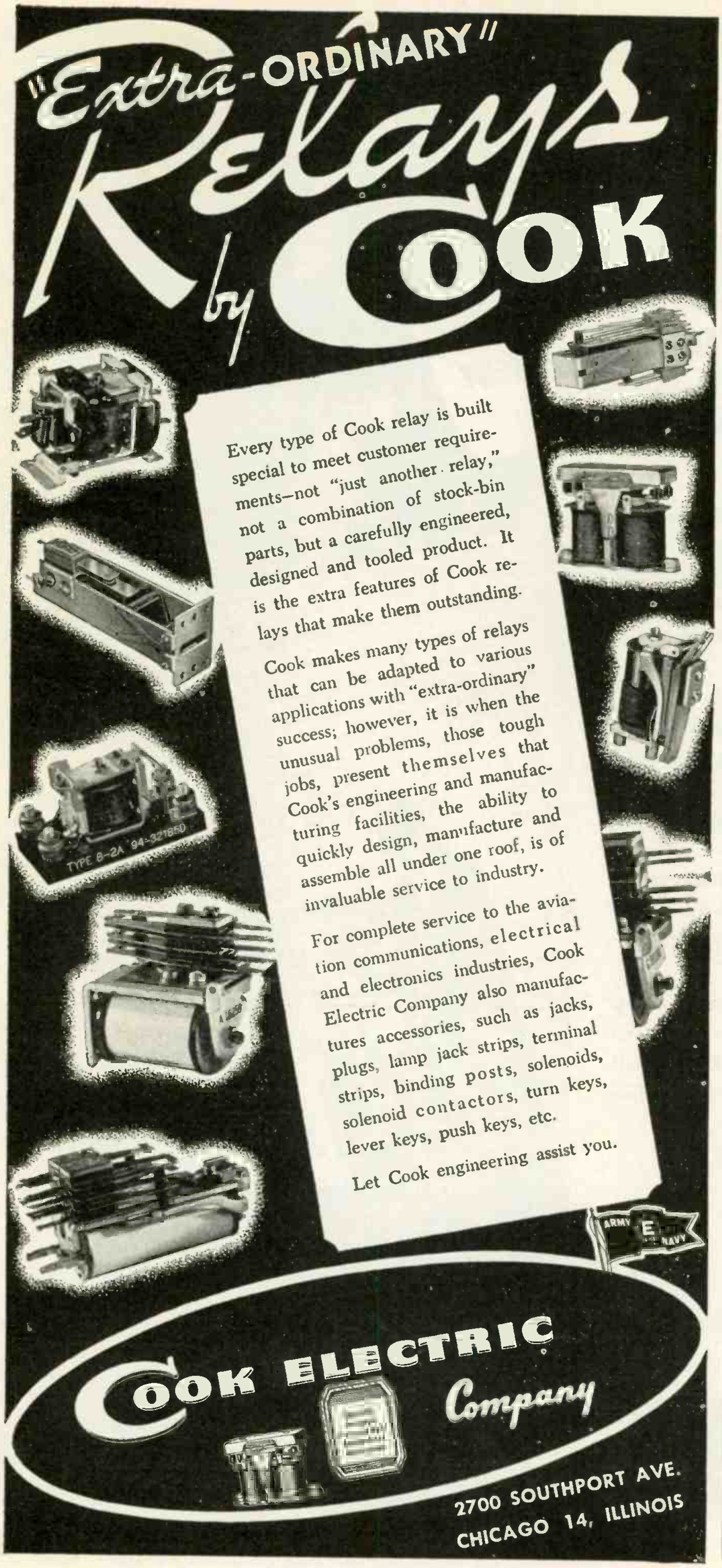
AN UNEMPLOYMENT compensation program that will help solve post-war economic problems has been announced by Sonora Radio & Tel. Corp., Chicago, manufacturers of aircraft communications equipment.

The plan calls for payments of \$20 per week for a maximum of 18 weeks to any employee that is laid off. The payments will begin after the 18 weekly payments from the state. If for any reason the state payments are not made to the employee, payments from the company fund will begin immediately. Cost of the fund is taken care of by the company and no contribution or payroll deduction is required from any employee.

One of the outstanding features of the plan is that employees in the armed forces will be eligible for benefits of the fund upon their release from the service. In the event they have given their lives, the Sonora plan calls for payment of a sum equal to 18 weeks unemployment compensation to next of kin.

The payments begin after the State compensation is ended, because the employee would not be eligible for state compensation if he had any income from the employer. In many cases employees who are not eligible for state funds (because they have not earned enough in a certain period) will become eligible for the state compensation after receiving the company payments, regarded by the State as salary. Under present Illinois statute the unemployment compensation is \$20.00 (maximum) per week. Should this amount be increased, the sum paid from the Sonora fund would be increased.

"If every industry in the nation would promptly adopt a similar plan, I am sure we can avoid any



serious unemployment problem after this war," Jos. Gerl, president of Sonora, said. "It has been our experience that funds contributed by the company are deductible as legitimate expense on war contract negotiations and from corporation taxes.

"We have instituted the unemployment compensation fund to make sure our organization is kept together. The majority of our workers are of the highly skilled type, and we are of the opinion that it is a moral responsibility of Sonora to make certain our employees have a feeling of security.

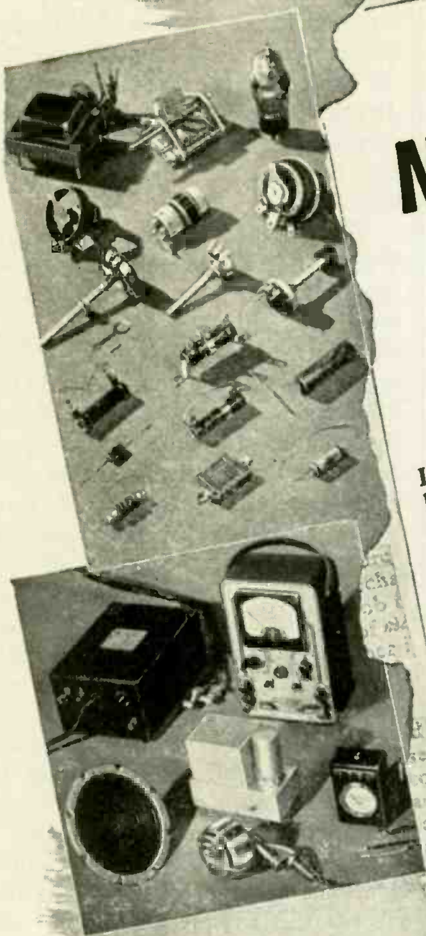
"Although the law requires that a serviceman be given back his job, companies are not required to take back a veteran if his job has been abolished through reasons over which the company has no control. Under our plan, however, all servicemen who were former employees are eligible under the provisions of the unemployment compensation fund."

Simple Bid Form for Army Contracts

MANUFACTURERS doing business with various branches of the Army Service Forces can use a simplified bid form recently announced by the War Department. The form, to be used in the purchase of goods and services under fixed price supply contracts, has been developed and placed in use by the Army.

The form contains a questionnaire section that is elaborate enough to provide for all pertinent information necessary under various circumstances but the contracting officers are expected to request only such data as is needed. This should hold manufacturers' paper work to a minimum, since it is expected that few, if any, cases will require answering all the questions.

Officially designated as Standard Procurement Form No. 1, the new document is in three parts. The first is a form letter requesting potential contractors to bid; the second is a form on which contractors offer to produce goods or provide services, and the third is a list of instructions for completing the second form, which calls for data on a contractor's financial status and other cost and price information.



THOUSANDS OF MAN-HOURS SAVED

Allied's Complete, Centralized Service Speeds Procurement of Everything in Radio and Electronics

It happens every day . . . every hour! . . . From all parts of the Country . . . from the United Nations . . . come urgent calls for vital supplies to keep production humming . . . to hurry development projects . . . to aid men in training, and men in action. For it is a well-known fact that Allied is able to *deliver the goods . . . faster—* and *save precious man-hours all the way down the line!* . . .

Because—here, under one roof are concentrated the largest and most complete stocks of radio and electronic equipment available today!

Because—Allied's procurement experts are in constant contact with all leading manufacturers and have latest "supply data" at their finger tips!

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You, too, can simplify and speed procurement . . . by dealing with this *one central source!* All it takes is *one* call or wire . . . *one* order for everything . . . *one* bookkeeping entry . . . *one* check! Prove it to yourself . . . you'll save many man-hours.

SAVE TIME CALL ALLIED FIRST

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Today's Most Complete, Helpful BUYING GUIDE Send for it now!

NEW Rapid R-F Resonance and Coil Winding Calculator

New, dual-purpose Calculator devised by Allied for fast and accurate determination of resonance factors and coil winding data. Simple, easy to use. Send for it now.
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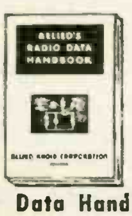

Radio Data Handbook
Formulas, standards, data, tables and charts most commonly used in solution of radio and electronic problems.
Price net, only.....25¢

Over 10,000 Radio and Electronic Items—such as:

Tubes	Batteries	Crystals	Microphones
Condensers	Chargers	Speakers	Headphones
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Resistors	Relays	Training Kits	Intercom
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Coils	Rectifiers	Meters	Converters
Sockets	Wire & Cable	Test Equip.	Generators
Photo Cells	Hardware	Tools	Plugs & Jacks

ALLIED RADIO
Delivers the Goods

Signal Corps View of Electronic Needs

THE TEMPO of military production in the radio-electronic industry was not showing any signs whatever of easing up as 1943 came to a close. On the contrary, there is every indication of continuation and even increase of the present tempo for the first six months of 1944, at least.

This point is emphasized in Washington because there were some elements in the industry that have been thinking in terms of a slow-down in production. Such thinking was completely dissipated by a recent statement from one of the men most competent to speak for military requirements in this field, namely, Maj. Gen. W. H. Harrison, chief of the Procurement and Distribution Service of the Signal Corps. He said, "There is no indication of slowing up in production demands in the radio-electronic industry for the next five or six months, at least. In fact, the monthly output of signal equipment must continually increase in order that this equipment will be available to the combat forces."

In appraising the future of production, manufacturers of radio-electronic equipment would do well to keep in mind two points that are constantly stressed by officers of the Signal Corps: first, the emphasis they place on the continuing need for signal equipment to meet the expanding requirements of our military operations; second, the expectancy of shifts in types of equipment produced on the basis of actual experience on the battlefields, which, in turn, is bound to have an important bearing on the manufacturer's problem of contract termination.

According to Gen. Harrison, contract termination will not result in less overall production in the six months' period ahead. Shifts in kinds of equipment produced will be necessary. For example, a new walkie-talkie has superseded the old model and contracts had to be changed to meet new specifications. Furthermore, certain equipment which does not work out well in actual battle experience will require improvements to be made from time to time. In this sense, Gen. Harrison said, contract term-

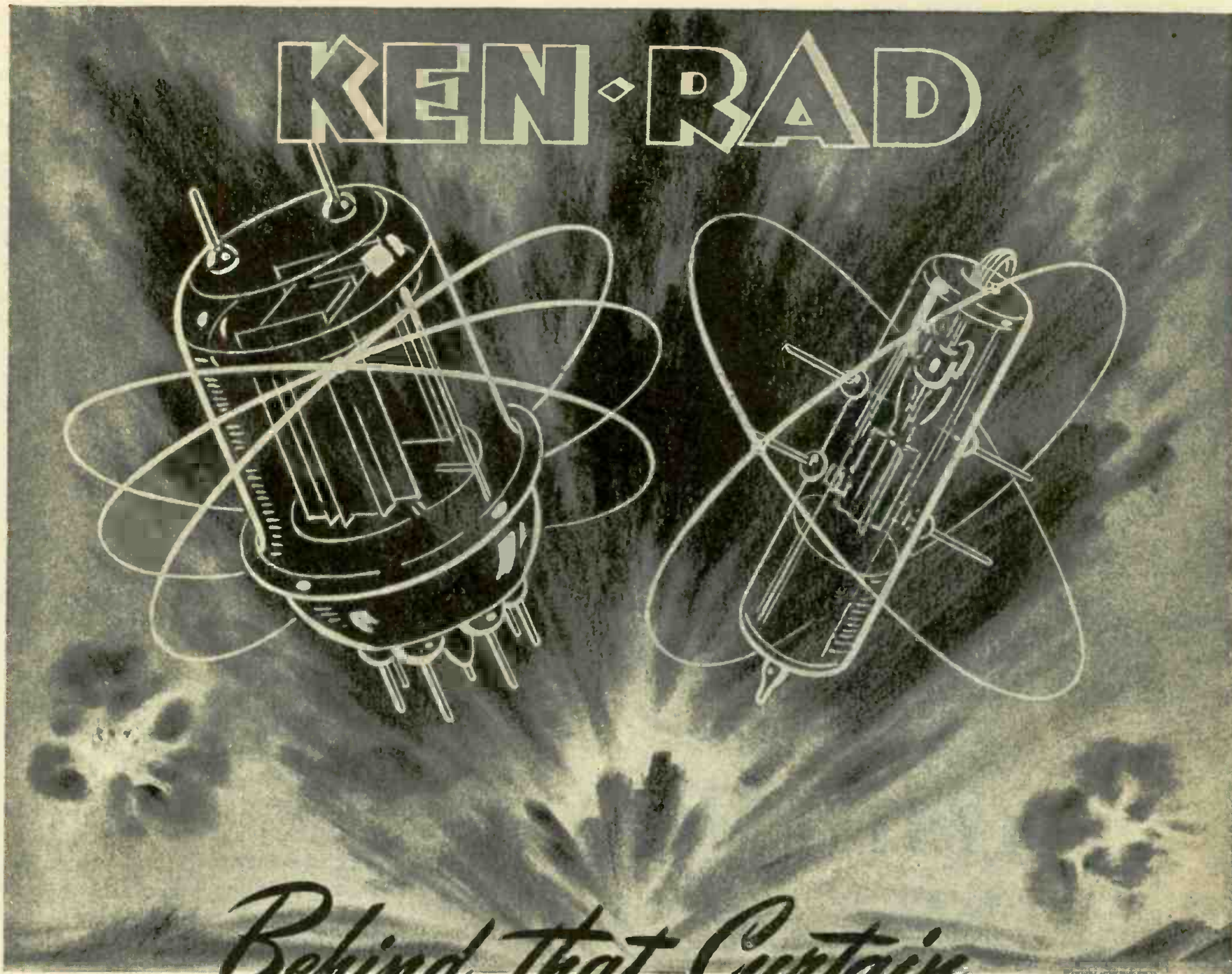
ination may also be expected.

Speaking before the National Business Paper Editors in Washington recently, Maj. Gen. James A. Code, Jr., assistant Chief Signal Officer, stated, "Great offensives are pending and signal communications will play an important part in every battle. The fighting efficiency of our soldiers depends heavily upon adequate communications at all times. But, experience on the battlefields dictates our needs on signal supplies. A piece of equipment which was thought to meet every requirement may become obsolete overnight, due to changing conditions. So, if our men are to have the use of equipment before it does become outmoded, it must be on the spot when needed. It can readily be appreciated, therefore, that delivery schedules by manufacturers must be met, or even surpassed if we are to outfight the enemy."

Government officials have no quarrel with the natural interest of the industry in postwar production and conversion problems. They do look, however, with disfavor on efforts to "beat the gun" or premature undertakings that would interfere with the job in hand. They are confident that there will be so many important postwar uses for present equipment that the manufacturers in this particular industry have no reason to fear the postwar period.

There is a real appreciation in the War Department for the splendid job being done by American manufacturers in the war effort, Gen. Harrison said. The fact that emphasis is placed on the increasing amount of equipment needed is not meant in any sense as a reflection on the industry.

In tribute to the production record of the manufacturers, Gen. Code declared, "It is no boast for me to say that our signal equipment is far and away the finest in the world, the most modern in design and precision, and the best in ruggedness and performance. But it would not be so without the magnificent cooperation, great skill, and untiring efforts of our associates and co-workers of industry. Not only have they produced this equipment in enormous quantities, but production schedules have been generally well maintained."



Behind That Curtain...

Behind the veil of military secrecy are the wonder stories of Ken-Rad electronic tubes   Nearly five thousand of us are now making and sending these tubes which are helping to shatter tyranny   And through Ken-Rad dependable tubes will be worked the *constructive* miracles of the great science of tomorrow

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METAL AND VHF TUBES
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War Solder and Flux

HOUSEHOLD STARCH has broken a bottleneck in soldering steel parts together for assembly in radio equipment. Resin and zinc chloride are the agents most commonly used but zinc chloride causes corrosion unless removed by copious washing with water. Resin, though free of this drawback, is not active. It is almost impossible to wash steel parts after soldering.

Chemical engineers at RCA solved the problem by the use of levulic acid, derived from starch. More active than resin, the acid is blended with it to form a flux that eliminates the post-washing process in its application to certain metals and alloys.

Where a higher tin content is necessary in wartime solders, the War Production Board has relaxed restrictions. Previously higher-content solder could be used only upon the granting of appeal. Under a recent amendment to General Preference Order M-43, specific provisions permit higher tin content, in some cases above 21 percent, for certain solders. Careful survey has shown that the higher tin content solders permitted will actually result in a saving of tin.

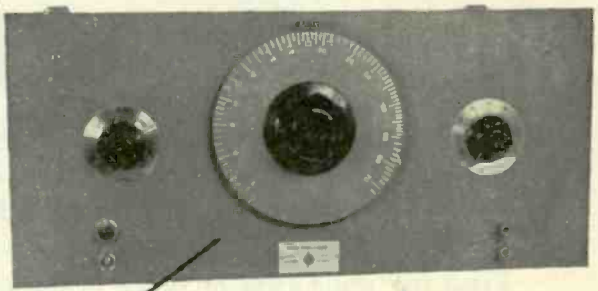
Post-War FM

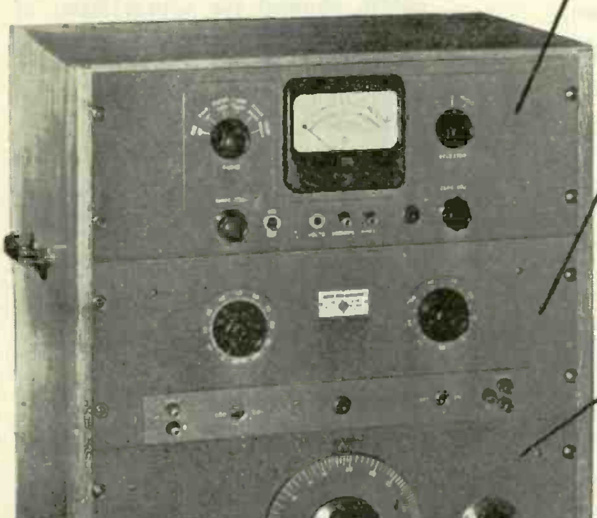
FROM 18 TO 22 million f-m receivers might be expected to be in service by 1950, assuming conclusion of hostilities by the end of 1945, according to J. E. Brown, assistant vice-president of Zenith Radio Corp., in a paper delivered at a meeting of the Chicago section of IRE. He showed that there are 600 trading areas in the U. S. and that f-m stations would probably be allocated on the basis of these trading areas and population centers.

He further suggested that the present f-m bands be extended to 56 Mc. In this extended band, some 1800 f-m stations could be accommodated throughout the country, of which about 750 stations would be required to serve cities having a population of 50,000 persons or less. It was indicated that the number of f-m stations which might be expected to arise would probably be comparable with the number of daily newspapers, which now number 1600.

Mr. Brown asserted that f-m

3 in 1 combination





The complete combination in cabinet measuring 21 x 24 x 14 occupies minimum space on the bench. Note lack of great numbers of knobs and dials which is significant of the simplicity and speed of operation.

Special Vacuum Tube Voltmeter
Model No. 210 AR Square Wave Generator
Model No. 200 DR Audio Oscillator

Most all *-hp-* instruments are available for standard relay rack mounting. Thus several units may be assembled into a special cabinet to make an ideal combination for production line stations or for equipping a small laboratory. The single unit shown at left combines the three standard *-hp-* instruments shown above. With this combination you can measure volts, apply square wave to measure the response of amplifiers and networks . . . make distortion measurements on audio amplifiers, make accurate bridge measurements and all the valuable tests and measurements possible with *-hp-* resistance tuned audio oscillators. Complete technical data sheets are available on these three units which you may obtain without obligation. ★ Just drop a post card in the mail. Also ask for your copy of the 24 page *-hp-* catalog which gives much valuable information about electronic test and measuring equipment in addition to data on the *-hp-* instruments.

HEWLETT-PACKARD COMPANY

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703

broadcasting on the 43–56 Mc band would open up new possibilities in broadcasting which would attract many persons not now in the broadcasting field, as well as those operating stations in the 500–1650 kc broadcast band. It was indicated that the propagation characteristics do not change appreciably throughout this band, and that therefore there would not be the discrimination in frequency assignments which occurs in the standard broadcast band. This fact alone was expected to induce broadcasters, now having unfavorable frequency channel assignments, to enter the new field.

In the discussion which followed the meeting, Mr. Brown said that much had been learned about f-m during the war, that no radio set after the war would be complete without f-m reception, and that the public showed its appreciation of high-quality programs. He felt that while the cost of f-m sets would be appreciably reduced, f-m would continue to provide superior programs of higher qualtiy than is now possible (with existing channel assignments) in the regular broadcast band.

Enemy Communications Equipment

In the past year, the Enemy Equipment Identification Service of the Signal Corps, Army Service Forces, has identified, catalogued and studied more than 10,000 pieces of enemy signal material. Captured equipment, after being studied in Washington and at Signal Corps laboratories, is sent to communications schools for study by men in training. It has been found that German design was frozen five years ago. Although this freezing permitted speed in production, obtained further through interchangeability of parts, the Nazis are unable to keep pace, at least in this line, with the rapid-fire technical developments of the United Nations. The German equipment is sound, but often too bulky for completely efficient field service.

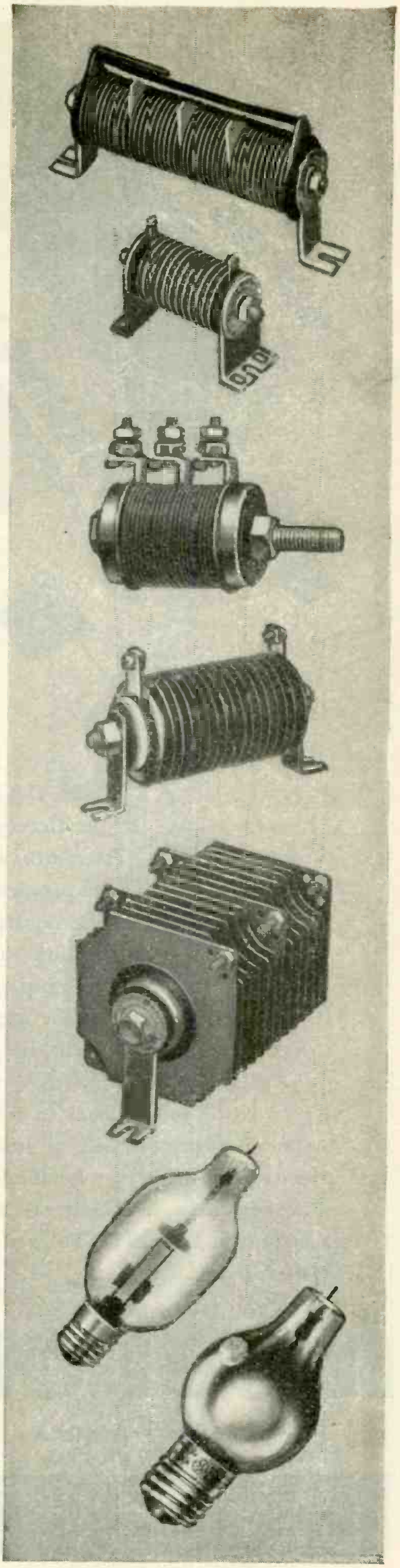
A slant on German psychology is clearly revealed in the equipment handbook furnished each soldier. The book gives minute instructions about each piece of equipment, and

RECTIFIERS

Built to Meet Specific D-c Needs

General Electric is the only designer-manufacturer of Selenium, Copper-Oxide and Tungar Rectifiers. This is important to all who design equipment requiring rectifying units: it means G-E can give completely impartial advice on which type of rectifier will most efficiently, most effectively and most economically do the specific job you require of it. And the stacks . . . whether Selenium or Copper-Oxide . . can be specification-built for that specific job. Address inquiries to Section A-246-119, Tungar and Metallic Rectifier Division, General Electric Company, Bridgeport, Connecticut.

GENERAL ELECTRIC



nothing is left to the German's imagination. He can't make many mistakes if he follows the instructions, but at the same time he is not likely to be able to adapt himself or his equipment to fluid situations.

Most Japanese radio sets are handmade of inferior materials, a large part of the materials having been purchased on U. S. distress markets during the depression. The equipment is generally small and can be carried into jungle action, but as one returning officer remarked: "If the stuff won't work in battle, and often it doesn't, it doesn't matter if it's smaller and easier to handle than ours."

Components Standardization Program to New Agency

THE WAR PRODUCTION Board will transfer electronic component standardization from the Radio and Radar Division to the newly organized joint Army-Navy Electronics Standardization Agency (ANESA).

The standardization of components was instituted under the direction of Col. Sidney K. Wolf, who until recently has been Assistant Director for Production for the Radio Division. It was carried on by the division, the American Standards Association and the War Radio Committee.

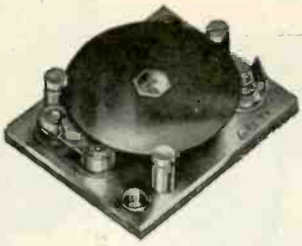
Standards for eleven electronic components have been approved for procurement purposes by the Army and Navy. Drafting of standards specifications for nine more is expected to be completed and turned over to ANESA by March 1. WPB pointed out that the standards on the 20 components, when completed, will make up about three-fourths of the components which reoccur frequently in radios or other electronic equipment.

Components on which American War Standard specifications have been approved are ceramic radio insulating materials, steatite radio insulators, fixed mica dielectric capacitors, ceramic radio dielectric material, external meter resistors, glass-bonded mica radio insulators, fixed composition resistors, electrical indicating instruments, a shock-testing mechanism for electrical

Sensitive as a dog's ear

Rugged as the big rock

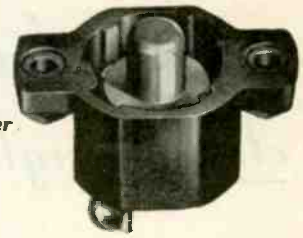
Type C-2851 Series, Used as Roughing Controls on Outer Crystal Ovens



Type B-3120 Crystal Dew Point Control

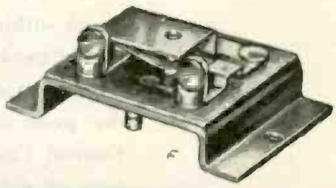
Type RT Adjustable Crystal Temp. Oven Control

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.

indicating instruments, dimensions for external radio-frequency thermocouple converters and glass radio insulators. Components on which standards are expected to be completed by March 1 by WPB include fixed paper dielectric capacitors, porcelain radio insulators, fixed ceramic capacitors, dynamotors, external ammeter shunts, variable wire-wound resistors (low temperature), power-type wire-wound rheostats, and toggle switches.

The Army and Navy have indicated that they will continue the study and application of standard specifications for electronic components not only for the duration of the war but as a peacetime operation through ANESA and the joint Army-Navy Board for Approving Standards. ANESA is located at Red Bank, N. J.

Standards for Allied Nations

AMERICAN PARTICIPATION in an Allied Nations Standards body has been assured by the authorization of the board of directors of the American Standards Association to take part in such an organization. The formation of the body has been discussed informally for some time between the British Standards Institution, the Canadian Engineering Standards Association, the ASA and key governmental agencies in the three countries.

The object of the organization is to secure the maximum possible coordination of standards necessary for the war effort and the immediate post-war period. A skeleton staff will be provided with offices in London and in either New York or Washington.

Standards List

PUBLICATION OF the new list of standards has been announced by the American Standards Association. There are more than 600 standards listed, of which 64 have been approved or revised since the last price list was printed in April, 1943. The standards cover specifications for materials, methods of tests, dimensions, definitions of technical terms, procedures, etc. The new list includes 95 safety standards, and represents the cum-


These are OUR weapons

ulative work of the past 25 years in practically every engineering and industrial field.

Since the war, the ASA has been working very closely with government agencies and with the Armed Services to provide specifications for certain of the materials necessary to our war effort. Because these standards are developed through an accelerated procedure, they are designated as American War Standards. These are listed separately, and to date, there are 40 already completed and many more under development. These war standards have been produced in the field of safety work, machine tools, quality control, photography and radio, just to mention a few.

In each case, the standards approved by the ASA represent general agreement on the part of maker, seller, and user groups as to the best current industrial practice. More than 600 organizations are taking part in this work.

The complete list of American standards will be sent free of charge to anyone interested in this work. Requests should be addressed to the American Standards Association, 29 West 39th St., New York 18, N. Y.

Communications Films for Schools

SCHOOLS, COLLEGES and civic organizations can obtain a 24-minute 16-mm sound film, "Radio at War" upon payment only of transportation charges. The picture is sponsored by RCA in cooperation with the communications branches of the army and navy.

The film traces the activities of two typical American boys, brothers, who enter the Army and Navy shortly after Pearl Harbor. Their progress, through training camp, maneuvers and convoy action in a battle sequence, reveals many phases in the use of electronic communications equipment by the armed forces.

A high point of the film is the sequence of recent official army and navy motion pictures of an invasion in the southwest Pacific and the establishment of a beachhead, with authentic battle scenes of radio's vital part in the operations. Final scenes show Jim

Foreshadowing the Answer to Your Capacitor Problems

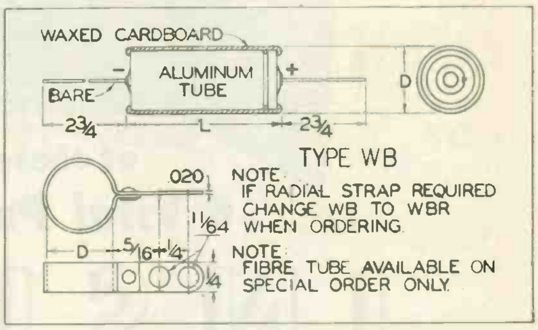
FOR strenuous duty, day after day, month after month—under stress of vibration, in great extremes of humidity and temperature—the Mallory WB Capacitor has proved it can take it.

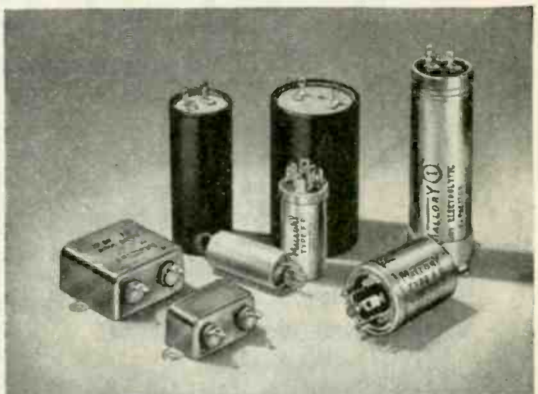
Its size has been reduced to the smallest proportions consistent with good operation and long life, yet it packs from 10 to 50 microfarads, depending on the voltage. It is supplied in a hermetically-sealed tube with waxed cardboard outer sleeve. The ends of this sleeve are spun over the aluminum rim—no chance of "shorts" when leads are bent close to the can.

WB Capacitors are obtainable in 25, 50, 150, 300, 400 and 450 DC working volts, thoroughly aged and individually tested. They can be supplied with radial straps for mounting, if required.

The WB Capacitor is only one of many described in complete detail, with interesting test data, in the latest Mallory catalog. If you do not have a copy, send for one today—and always, when you have a special capacitor problem, call on Mallory technicians. Write Mallory direct or see your nearest Mallory distributor.

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





P. R. MALLORY & CO. Inc.

MALLORY

ELECTROLYTIC, FILM AND PAPER CAPACITORS

Brown, on the beach with his Army Signal Corps outfit, contacting a warship at sea, relaying information on the battle ashore, and the message being received aboard ship by his brother, Joe.

Requests for the film may be addressed either to the Educational Dept. of RCA Victor Division, Radio Corp. of America, Camden, N. J. or William J. Ganz Co., producers of the film, 40 East 49th St., New York, N. Y.

Broadcast Station Employment Data

FULL-TIME EMPLOYMENT of 24,515 persons and part-time employment of 4,862 people was provided by standard broadcast stations during 1943. The figures are compiled by the FCC from data supplied by 815 stations and 10 networks. Some 52 stations had not filed their returns at the time of compilation.

The total weekly compensation paid to all full-time employees amounted to $1,366,687, an average of $55.75 per employee. This is an increase of 6.6 percent over the 1942 figures of $52.32. Average weekly compensation for full-time employees, excluding executives, was $49.50 or an increase of 7.3 percent over the 1942 average of $46.12.

Chinese Facsimile

THE CHINESE LANGUAGE has thousands of characters and the sending of these by Morse code creates a special problem. In that country, the characters are identified by number and the numbers transmitted in Morse. Since there are 9,000 characters that are represented by numbers the coding and decoding of the numbers and characters delays war communications in that theater.

The problem has been solved on two of the long-distance telegraph lines linking four important Chinese cities by the installation of Western Union Telefax facsimile machines. These have been installed by U. S. Signal Corps technicians and by Chinese personnel of the Department of Telegraphs and Telephones of the Chinese Ministry of Communications. Other Chinese cities are to be linked in the system in the near future.

London News Letter

By JOHN H. JUPE
London Correspondent

VHF and Post-War Broadcasting. The first serious plan for the use of VHF in British broadcasting was produced at an IEE meeting in London recently. The main features are applicable, at least in some degree, to the United States and are well worthy of consideration.

It was proposed to use the frequency band 40.5 to 64.5 Mc, arranged in three basic groupings such that the service area of any given station, on say frequency 1, would be surrounded by a ring of six stations alternately on frequencies 2 and 3. These six could in turn be centers of other rings of six, using either frequencies 1 and 2 or 1 and 3.

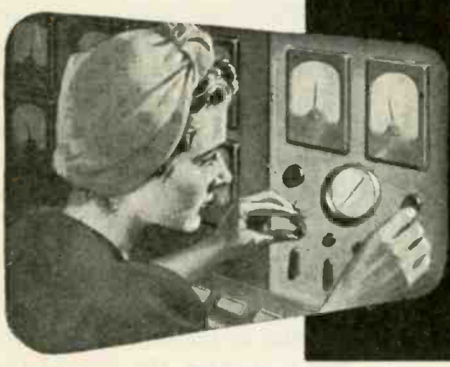
Then assuming a service radius of about 30 miles, the worst case would be that of a receiver 30 miles from one transmitter and about 90 miles from the next nearest using the same frequency. From measurements made in 1938 it has been decided that a simple directional antenna would be ample to eliminate any residual interference.

For television it was proposed to increase the number of lines from the pre-war 405 to 525 and to continue interlaced scanning with a frame frequency of 50 per sec (25 pictures per sec). To overcome the demands of frequency allocations, the form of single sideband transmission known in the United States as "Vestigial Sideband Transmission" was suggested.

The bandwidth judged to be suitable was 5 Mc for vision and 3 Mc for sound. An audio bandwidth of 15 kc was chosen as reasonable for good quality. By using frequency modulation for all sound, with a deviation ratio of 5, the frequency sweep would be 75 kc about the mean carrier frequency. The band occupied in actual practice would have to be much wider, owing to the existence of high order sidebands and the possibility of accidental overmodulation. It was therefore planned to make 250 kc the provisional figure and this would permit at least 12 primary sound channels in each region.

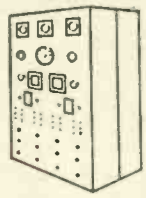
Secondary sound channels are to have a service radius of the order

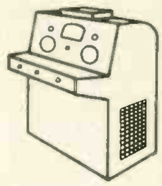
How to be sure that every unit you make is as good as the original design

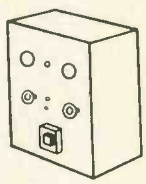


Production TEST EQUIPMENT BY SHERRON

YOUR basic design is probably perfection itself. But what happens to it as it takes shape along the production line? That's what counts. And that's where test equipment, engineered by Sherron to do a specific job, offers positive quality controls. Sherron equipment is now on duty for scores of electronics makers—maintaining constant, *automatic* watch of production standards—assuring the precision of every operation, guaranteeing the smooth flow of standard, top-quality finished products.







Sherron Electronics

A COMPLETE SERVICE FOR MANUFACTURERS

Engineering, design, assembly, manufacturing of quantities or single units.

SHERRON METALLIC CORP., 1201 Flushing Ave., BROOKLYN 6, N. Y.

of half the radius of the region and geographically situated so as to be nearer the adjacent region using another frequency group for its sound channels.

Within each region, the vision channels would have to be kept clear because amplitude modulated vision is particularly susceptible to interference, so the 5-Mc band for vision in adjacent regions could not be used for sound in the complementary area. There would, however, be the possibility of using it with very low power (single city coverage) or in television "off" hours.

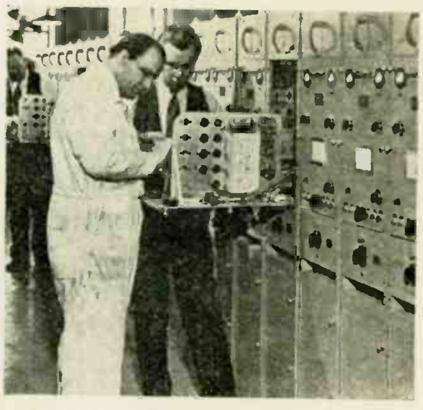
The summary of the proposals was that each region would have 1 vision channel, 12 primary sound channels, 24 secondary sound channels and some 40 restricted sound channels. All within the band from 40.5 to 64.5 Mc.

Color television was ruled out as not practicable on a wide scale within a reasonable time but it is very interesting to note that the cramming of so many stations into such a small bandwidth depends entirely on the interference-reducing properties of frequency modulation.

For a country the size of Great Britain it was estimated that 12 regions, each containing 1 vision channel, etc., would be sufficient to permit broadcasting by concerns other than the British Broadcasting Corp., should Parliament be agreeable. The medium-frequency stations would be left exactly as they are now.

• • •

AUTO ALARM INSPECTION



Automatic alarm receivers for the 500-kc international distress frequency are checked on the inspection line at Radiomarine Corp. of America. They sound the alarm when one-second dashes, spaced four seconds apart, are received from a ship in distress

The "get-it-done-or-else" demands of wartime have brought thousands of production men to see plainly the value of American Phillips Screws:

Speed of assembly often doubled . . . because there are no fumbled starts, or crooked screws to back out and re-drive. Spiral and power drivers are made practical, and the 4-winged bit aligns itself in the tapered recess of the screw head . . . drives automatically straight.

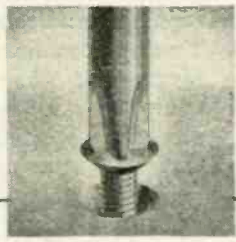
Greater safety . . . both for workers and their work. Driver can't twist out to gash hands, spoil work by gouging or puncturing, or leave any snagging burrs on screw heads.

Lower cost . . . savings of 50% in assembly time are not unusual with American Phillips Screws. Production is increased . . . workers are trained in less time . . . spoiled work and lost-time accidents are eliminated. Uniformly high quality is assured by American's constant research in materials and methods, and by individual inspection of screw head, thread, and point.

Now add the final extras of American delivery service and engineering assistance on special fastening problems . . . then you *know* why everyone who ever tried American Phillips Screws is using them today . . . *and why those who have come to use them in time of war will continue to use them in time of peace.*

AMERICAN SCREW COMPANY
PROVIDENCE, RHODE ISLAND
Chicago: 589 E. Illinois Street *Detroit:* 502 Stephenson Building

1. Fast Starting—Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.



2. Faster Driving—Spiral and power driving are made practical. Driver won't slip out of recess to injure workers or spoil material. (Average time saving is 50%.)

3. Better Fastenings—Screws are set up uniformly tight, without burring or breaking heads. A stronger, neater job results and there are no gouges on work-surface.

Radio Business News

W1XTG, Worcester, Mass., one of the oldest FM outlets, has been granted permission to operate on a commercial basis. Owned by a newspaper, the station has been operating on an experimental status.

FM BROADCASTERS, INC. held its fifth annual session in New York City in January. Most of the events of the two-day meeting were open to anyone seriously interested in FM, whether a paid-up FMBI member or not.

EMERSON RADIO & PHONO. CORP. plans a post-war television receiver with a 3-inch cathode-ray tube. The image will be projected to 15 by 20 inches on a motion picture screen by means of a lens system made of plastics.

AIEE, Los Angeles Section, has organized an electronics division which is holding separate specialized meetings devoted to specific electronic subjects.

GENERAL RADIO CO. has opened an engineering office at 920 South Michigan Ave., Chicago 5, Ill. Lucius E. Packard, in charge of the New York engineering office the past three years, is in charge of the new office. Martin A. Gilman of the factory engineering staff now heads the New York office.

ADMIRAL CORP. is the new name of Continental Radio & Television Corp.

TITEFLEX, INC. is the new name of the Titeflex Metal Hose Co. of Newark 5, N. J. The company manufactures radio ignition shielding for aircraft and automotive engines.

KURMAN ELECTRIC CO. has moved its plant to 35-18 37th St., Long Island City 1, N. Y.

HYTRON CORP. has quadrupled productive facilities by expansion of the plant at Salem, Mass. and addition of a new plant at Newburyport, Mass.

REINER ELECTRONICS CO. has been formed to produce various types of electronic equipment. Headquarters are at 152 West 25th St., New York, N. Y.

ANNOUNCING EBY

MINIATURE TUBE SOCKETS

WITH *Long Life* BERYLLIUM COPPER CONTACTS

This new socket is the result of intensive engineering to produce a unit which combines top electrical performance with assured long service life under the most rigorous conditions.

MICRO-PROCESSED BERYLLIUM COPPER CONTACTS

The close tolerances and high tensile strength of the contacts are made possible by Micro-processing, involving heat-treat forming and control testing by the Carson Electronic Micrometer. As a result, these beryllium copper contacts offer self-alignment and long life with high electrical conductivity. In addition, they are heavily silver plated, giving contact resistance between the socket and the tube pin of less than .01 ohms.

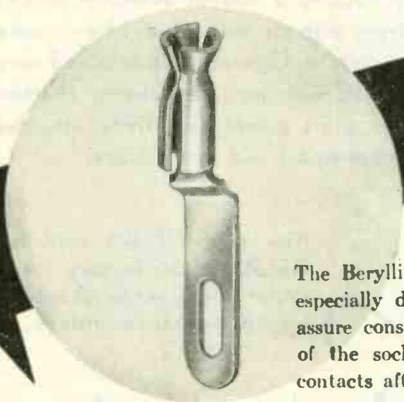
★ THIS SOCKET WAS DESIGNED AND DEVELOPED AT THE SIGNAL CORPS LABORATORIES AT FORT MONMOUTH, N.J.

TWO TYPES AVAILABLE . . .

The low loss type with Navy grade G Steatite Casting having loss factor of .016 or less when tested in accordance with ASTM D 150-42T. Its capacity is 1.5 mmf or less at 10 mc.

General purpose type with mica filled plastic casting having a loss factor of .05 or less when tested in accordance with ASTM D 150-42T. Its capacity is 5 mmf or less at 10 mc.

The new Eby sockets meet required specifications and will withstand the following tests: **humidity cycle; immersion; shock; vibration; and thermal shock.**



The Beryllium Copper Contacts have been especially designed and Micro-processed to assure constant, even pressure on all parts of the socket pin without fatigue in the contacts after continuous use.

HUGH H. EBY INCORPORATED
18 W. CHELTEN AVE.
PHILADELPHIA 44, PA.

We would be glad to send samples and quote prices on this outstanding development in the tube socket field. This socket will give superlative performance in service. Write today.

HALLICRAFTERS Co. produced $34,300,000 worth of equipment for the army, navy and lend-lease in the year ending Dec. 7, 1943. In the year preceding Pearl Harbor the company sold $2,000,000 worth of communications equipment.

Personnel

Ervin James, assistant to FCC commissioner Clifford J. Durr, has been appointed assistant secretary of the FCC.

Lester Via has been appointed to the engineering department of John Meck Industries, in charge of special crystal research.

Jerry Kane, formerly in the research lab of The Turner Co., has become electro-acoustics engineer at Universal Microphone Co.

Frank M. Folsom, recent chief of the procurement branch of the Navy Department, has been elected a vice-president and director of RCA. He will head the manufacturing division of RCA Victor.

Haraden Pratt, vice-president and chief engineer, Mackay Radio & Tel. Co. and vice-president of Federal Tel. & Radio Corp., associates of IT&T Corp., has been awarded the IRE Medal of Honor at the Winter Technical Meeting in N. Y. C. for distinguished service in the field of radio communication. He is secretary and past president of IRE and is the Institute's delegate to RTPB, as well as chairman of the Planning Board's panel on radio communications.

Frank W. Warner has been appointed successor to Henry M. Richardson as chief engineer of the Plastics Divisions of General Electric Co.

Cecil E. Brigham, former chief engineer of C. Brandes, Inc., Kolster Radio Co., Kolster-Brandes Ltd., England, has been appointed general sales manager of Wesley Block & Co., New York. The company employs engineers with specialized training as sales representatives.

Dr. Gregory Timoshenko, associate professor of electrical engineering at University of Connecticut, is doing research development work at Templetone Radio Co., Mystic, Conn.

Sidney K. Wolf, assistant director of production of WPB radio and radar division, has been commissioned a Lieutenant Colonel in the Army Air Force and has been sent to the South Pacific to do research work.

J. W. Bryant, formerly with the radio division of the Missouri State Highway Patrol, has joined General Electric Co. Electronics Dept. at the Chicago office.

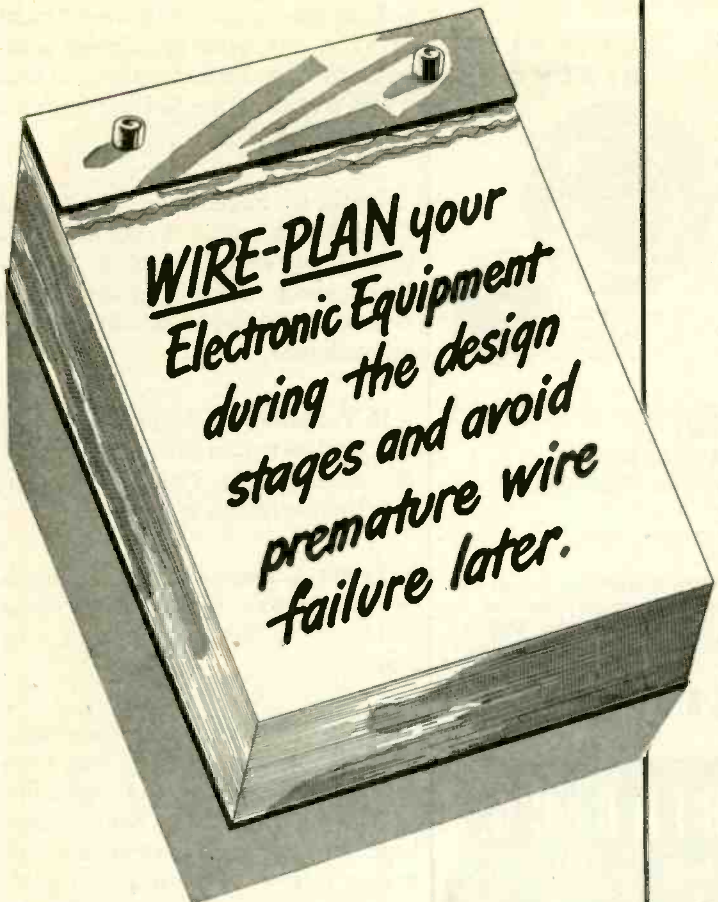
George K. Throckmorton, has retired as RCA vice-president and director and head of RCA Victor for reasons of health. He will continue as a consultant to the company.

Fred J. Vogel, who designed the first single-unit million-volt testing transformer, the first successful installation of cascade-connected transformers in the U. S., has been appointed professor of electrical engineering at Illinois Tech.

Vernon L. Haag has been appointed engineering manager of the electronics plant of Sperry Gyroscope Co. in Garden City, N. Y.

William C. Hancox, sound engineer for World Broadcasting Corp., died at his home at the age of sixty-seven.

Frank W. Curtis has resigned as chief of Van Norman Co. and is now associated with Induction Heating Corp. of New York as development engineer.



USE ROCKBESTOS
Permanently Insulated Wires, Cables and Cords

NOW, while equipment is in the design and experimental stages, is the time to solve wire problems. Because factors such as dielectric strength . . . diameters . . . operating temperatures . . . resistance to destructive elements, etc., are all important. Selecting the right wire for the requirements will prevent many wire-headaches which might arise after the equipment is in service.

The Rockbestos line of 122 standard constructions will meet most of your requirements. For the unusual applications and design problems, Rockbestos Research will develop special wires to meet particular requirements. Whether standard or special, Rockbestos Wires and cables have the *permanent* characteristics that provide resistance to heat, flame, cold, moisture, oil, grease and alkalies . . . each has a *permanent insulation* that assures long-lived service.

It will pay you to consult Rockbestos Research on your wiring problems. Simply outline your requirements and Rockbestos engineers will make their recommendations. Write the nearest branch office or:

ROCKBESTOS PRODUCTS CORPORATION
408 Nicoll Street, New Haven 4, Connecticut
NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, ORE.

ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt.

The first light weight, small diameter, flame-resistant hookup wire, designed in 1937 and widely used since in airborne and ground communication systems, electronic devices, instruments and apparatus. Operating temperatures range from 125° C. to minus 50° C. Also with tinned copper shielding braid and in twisted pair or tripled construction.

ROCKBESTOS THERMOSTAT CONTROL WIRE

Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125", .025" or (for 115 volt service) .031" of felted asbestos insulation and steel armor.

A multi-conductor control wire for low voltage intercommunicating, signal and temperature control systems. Its life-time heatproof and fireproof insulation and rugged abrasion resisting steel armor will give you trouble-proof circuits.

ROCKBESTOS TYPE CA LEAD WIRE

Has high dielectric strength and moisture resistance for use where heat and humidity are encountered. No. 20 to 8 AWG solid or stranded copper, monel or nickel conductors insulated with synthetic tape and various thicknesses of felted asbestos finished in black, white or colors for coding purposes. Also with All-Asbestos insulation only, where high moisture resistance is not required.

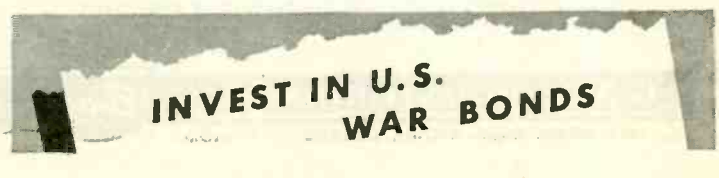
ROCKBESTOS MULTI-CONDUCTOR FIREWALL RADIO HOOKUP CABLE

This type of cable is made up of 1000 V. individual Firewall Radio Hookup Wires (as illustrated at top of column) of required size and number of conductors, cabled, and braided or shielded according to customer's specification. For example, this special 14 conductor #22 AWG cable was taped, shielded with tinned copper braid, then jacketed with a black, glazed cotton braid with a flame-proof finish.

These are but a few of the 122 different wires, cables and cords, designed for severe operating conditions by Rockbestos

PERMANENTLY INSULATED ROCKBESTOS WIRES AND CABLES

ROCKBESTOS RESEARCH
Solves Difficult Wiring Problems



E. F. Russell, first employed by G-E in the engineering department in 1918, has been appointed manager of the Easthampton, Mass., Tube Works of the G-E electronics department.

Louis G. Pacent, Jr. has joined Powers Electronic & Communication Co. of Glen Cove, N. Y. as factory manager. The company manufactures high-power electronic megaphones.

R. T. Pennoyer, first employed by G-E on the test engineering course at Schenectady, has been appointed assistant manager.

Frank A. Ross, senior vice president of Stewart-Warner Corp., died suddenly in Chicago at the age of sixty.

Louise Newton, control operator at WIS, Columbia, S. C., has been appointed chief control operator, first woman chief in South Carolina. Another WIS control room operator is a woman, Anna Burgess.

E. H. Fritschel, who entered G-E as a student engineer on the test course, has been named sales manager of transmitting tubes in the tube division of G-E electronics department.

F. W. Warner has been appointed assistant engineer of the plastics divisions of G-E appliance and merchandise department and will also continue his present work as project engineer.

Rollins H. Mayer, associate radio engineer at the Navy and Sound Labs., Los Angeles, has become electronic engineer in charge of research at The Turner Co. of Cedar Rapids, Iowa.

William S. Paley, president of CBS, has received the Order of Cristobal Colon, highest civilian decoration of the Dominican Republic, in reoognition of the contribution toward better understanding among the Americas by creation of the "Network of the Americas," a radio chain that links twenty Latin-American republics.

STANDARD FREQUENCIES—*Octaves of them*

FREQUENCIES

10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 190

Accuracy: 10 parts in 1,000,000
Output: 30 volts at 500,000 ohms
Input: 105-125V, 50-60c., 40 watts
Weight 50 pounds

Impossible? Well, here it is—

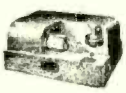
This Multi-frequency generator furnishes the frequencies shown above at the turn of a switch. All frequencies are obtained from a temperature-compensated tuning fork and voltage-stabilized circuit.

With this unit it is possible to calibrate oscillators at many selected points without encountering complex oscilloscope patterns. One of the uncertainties involved in development work on tuned circuits, filters, reeds—and in time measurement can be minimized with the aid of this instrument.

Developed primarily to check frequency meters for precision war work, this Multi-frequency generator possesses a rugged durability and dependability in service that will prove an extra value to many laboratories.

Additional information available on request.

Manufacturer of the
Watch Master



and distributor of
Western Electric
Watch-rate Recorders

American Time Products, INC.

580 Fifth Avenue New York 19, N. Y.

Inductance Bridge

(*Continued from page* 139)

is not affected by that of the other. The resonant frequency may be lowered by the capacitors which are selected by range switch SW_2.

Voltage from the grid circuit of the oscillator is fed to the tapped coil of the voltmeter. When the oscillator frequency corresponds to that of the detector, the detector plate current will be at its maximum. In this way resonance between the two circuits is easily ascertained from the indication of the milliammeter.

Range switch SW_2, provided for extending the resonant frequency range of the detector, is mounted in the center of the panel of the inductance bridge. The operation as already described is that for the switch on position *1*. When the switch is thrown to position *5* an additional fixed capacitance is added to the distributed capacitance of the coil. This additional capacitance is so adjusted to tune the grid circuit to 340 kc. Since the frequency is now one-fifth of the value of that with SW_2 on point *5*, the instrument will measure inductances of five times that measured in position *1*. Thus, SW_2 may be thought of as a multiplier switch. For the third position of the range switch, *D*, a variable capacitor is connected in parallel across the 200-μh coil; this provides for a continuous range of resonant frequencies, and hence of multiplying factors. The dial of this variable capacitor is calibrated in terms of multiplication. With this switch on position *D*, the inductance of the coil inserted at L_x is determined from two dial settings. First it is necessary to determine the inductance from the calibration of standard capacitor C_e, after which it is necessary to multiply this value by the multiplication factor of the dial marked "Frequency" which controls capacitance C_e.

Instrument Construction

A schematic wiring diagram of the complete electronic inductance bridge shown in Fig. 1, together with all important circuit constants. By means of this inductance measuring instrument it has been found

possible to measure small values of inductance with precision and speed suitable for routine laboratory or test methods.

On the photograph showing the panel of the inductance bridge, the left-hand dial, marked INDUCTANCE, controls the calibrated capacitor C_c. In parallel with C_c is a small capacitor C_o of 15 $\mu\mu$f, used to determine the zero setting when coils of known inductance are connected at L_x. The small dial and knob near the bottom of the panel operates C_o. The large right-hand dial, marked FREQUENCY, is a multiplying device used when the switch in the center of the panel is thrown to position *D*. The inductance to be measured is connected to the two binding posts at the bottom of the panel, marked L_x. A switch at the top of the panel controls power, and a pilot lamp operates when power is applied.

Normally the milliammeter reads plate current of T_3, the resonance indicator. However, by depressing the pushbutton at the right of the meter the total plate current of both oscillator tubes may be read on the same meter. In this case the meter has a full scale range of 25 ma.

The instrument can be constructed rather inexpensively of radio parts, which are readily available during normal times.

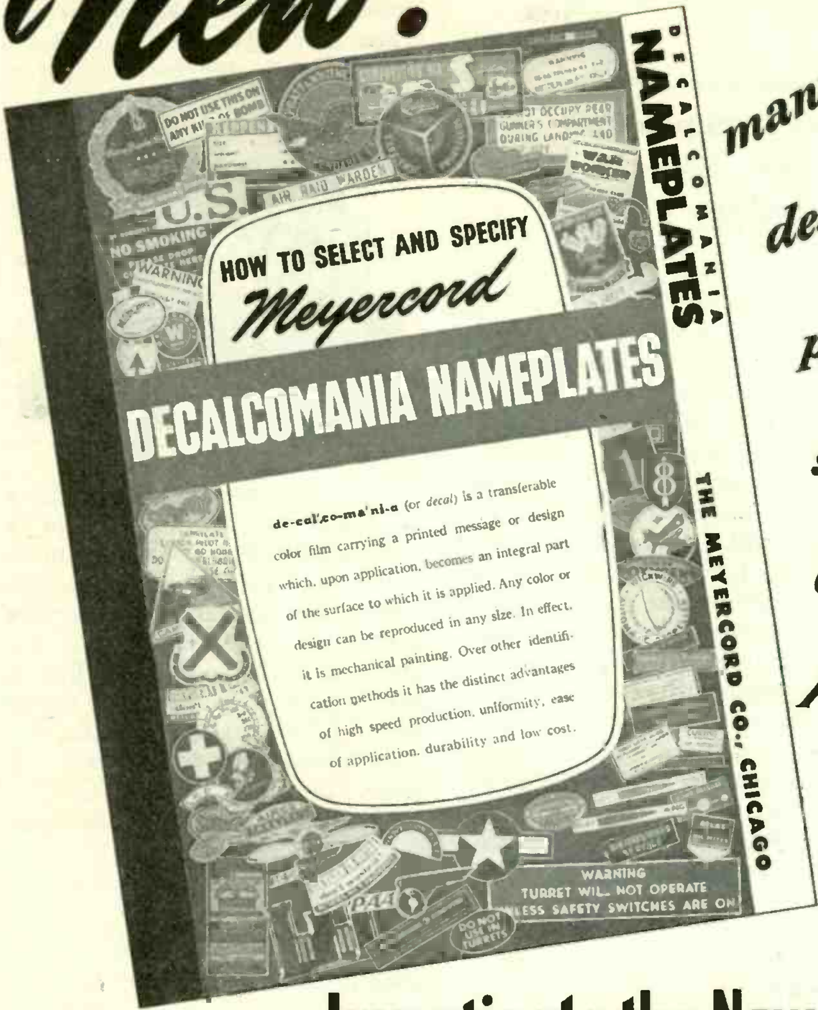
• • •

TUBE PREHEATER

For suggesting the heating of tubes before testing them, Margaret McCarthy was awarded $100. The preheater chassis saves the minute of heating time during inspection at General Electric's West Lynn Works

New!

manufacturers... designers... product engineers... send for this Check-chart on product identification



Investigate the New Developments in

MEYERCORD DECALS

Meyercord research has developed Decalcomania nameplates resistant to acid, petroleum products, alkalis, alcohol, abrasion, moisture and temperature extremes. They provide highly legible product identification, operating instructions, wiring diagrams, etc., with substantial savings in metal, time, labor, weight and cost. Meyercord Decal nameplates are vibration-proof, eliminate sharp edges and require no screws or rivets for application. They are durable, washable and can be produced in any size, colors or design. Easy-to-use solvent or water methods of adhesion permit fast, lasting application to any known commercial surface. Investigate Meyercord Decals for war use...or postwar plans.

Send for a Free Decal Check-Chart

The check-chart tells how to select and apply the right Decal nameplate for 16 different surfaces. In file folder form to hold subsequent data sheets, it also lists 25 Meyercord Decal wartime uses on 34 different types of combat equipment. Address Department 9-2.

DECALS SAVE METAL

Back the Attack—Buy War Bonds

THE MEYERCORD CO.

World's Leading Decalcomania Manufacturer

5323 WEST LAKE STREET • CHICAGO 44, ILLINOIS

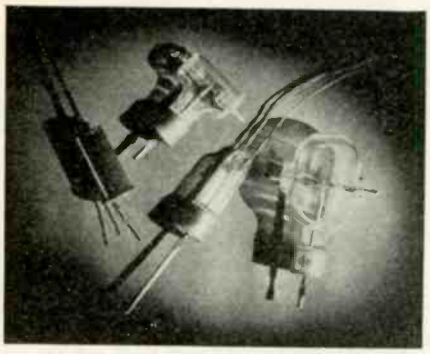
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs

Vacuum Switches

HAVING A WIDE VARIETY of radio and industrial applications, four new vacuum switches can be adapted to oil or water-immersed operation because of their enclosed construction. They are especially applicable for hazardous installations where fire and explosion are a constant risk, as in flour mills, magnesium finishing rooms, and similar dust-laden atmospheres. Two of the new switches are designed for high altitude applications.

Since the contacts of the switches are mounted in a vacuum, they are relatively free from the effects of corrosion and arcing, and are unaffected by dirt or oxidation. Vacuum-type construction gives the switches a high current rating for their size and permits them to handle enough power to operate equipment at greatly reduced voltages.



Operating without auxiliary contactors or relays, the switches can be used on installations where space is at a premium, as in airplanes. No self-contained coil or other operating mechanism is built into the switches. Movement is obtained from the mechanism to be controlled, or from other apparatus to suit the application. This movement can often be provided by a slow-moving cam or by the movement of a thermostat, as in air-conditioning or refrigerating equipment. Air or liquid bellows, a rod-linkage system, or almost any other means can be used to operate switches of this type.

An external fulcrum is eliminated by the use of a flexible diaphragm which transmits movement to the contacts and acts as a natural fulcrum point for the operating arm. The contacts close without vibration, making it possible to mount these switches on or near delicate instruments.

Details as to ratings and other information are available in a free publication, ET-la.

Electronics Dept., General Electric Co., Schenectady, N. Y.

Crystals

A NEW TYPE of low-frequency crystal can be ground to better than one part per million per degree drift, has unusual activity, and has been made to vibrate both on the low and high modes so that dual-frequency crystals of this particular cut can be readily produced, according to its manufacturer. By contour grinding the crystal can be lowered and raised in frequency, and consequently the exact adjustment of frequency is easily accomplished. The crystal can be used in either air-gap mountings or can be plated and clamped at the nodal point. Frequencies as low as 10 kc and as high as 300 kc have been produced with good results.

The James Knights Co., Sandwich, Illinois.

Snap-Action Relay

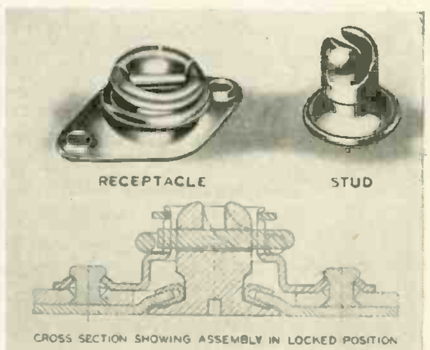
THIS SNAP-ACTION RELAY, Type 79XAX, is designed for use on slowly-varying coil-currents. Contact pressure remains constant despite slow variations in current. Then, when the current reaches a certain point, the contacts operate with a positive snap action.

The relay operates on as little as 10 mw in its coil circuit, and is recommended by the manufacturer for highly sensitive vacuum-tube applications, as well as in detecting overloads at low current levels. Its greatest field of usefulness lies in applications where current varies slowly between various limits, rather than quickly from 0 to rated value.

Struthers-Dunn, Inc., 1321 Arch St., Philadelphia, Pa.

Spring-Lock Fastener

THIS RUGGED SPRING-LOCK fastener is designed expressly for holding the engine cowlings of high-speed war planes and meets Army and Navy specifications. It may also be used for many postwar commercial applications, such as access plates



on farm machinery, radio equipment, panels on motor trucks, home-heating units, and at any point where a quick-acting, vibration-proof, non-rattling fastening is needed.

Elastic Stop Nut Corporation, Union, New Jersey.

TO EXACTING LABORATORY STANDARDS..

Quick and efficient comprehension of the production of laboratory equipment comes naturally to us of ECA. We're rich in the fundamental experiences arising from specialization in the development, design and manufacture of "tailored-to-order" radio and electronic equipment. Our facilities, geared to exacting laboratory standards, permit our engineers and technicians to approach a problem confident that the ultimate result will prove ultimately satisfactory.

An example of the work we do is the ECA Laboratory Oscillograph. This is a 7-inch, direct current, general purpose device built to provide features not ordinarily available in any commercial unit. This Oscillograph has seen continuous service in the ECA laboratory for more than a year, and it has been employed for such varied purposes as photographing transcient phenomena, measuring time delay circuits, checking the fidelity of mechanical recorders and oscillographs, and so on.

INVASION! *This is no time for complacency. It's still necessary to buy War Bonds . . . still necessary to save scrap metal . . . still necessary to be a regular patron of the Red Cross Blood Bank . . . to hasten Victory and save lives.*

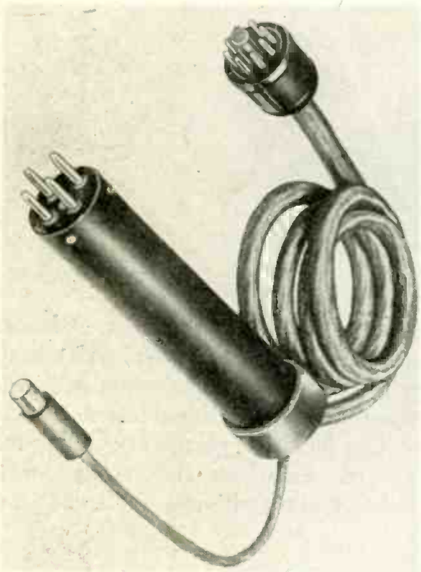
eca

ELECTRONIC CORP. OF AMERICA

45 WEST 18th STREET • NEW YORK 11, N. Y. • WATKINS 9-1870

Sturdy Production Plugs

DEVELOPED FOR USE with the Rotobridge in testing electronic equipment, CML production plugs are now available generally for use by electrical manufacturers. They are 5 in. long and 1¼ in. in diameter, so that the handle will project above the average i-f transformer or capacitor, making it readily accessible. They are made with a heavy steel barrel and are filled with a wooden handle to permit ready removal from socket. All pins are case hardened steel to assure long



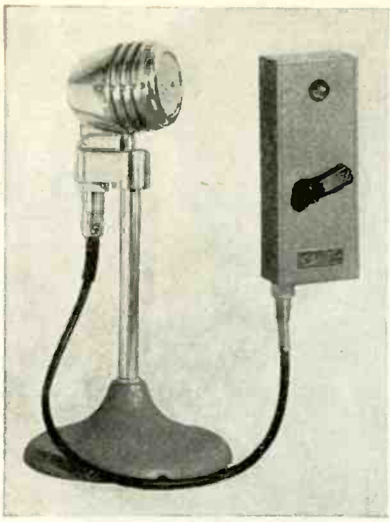
life, yet may be replaced when worn or broken. In both the octal and loktal plugs, center key extends through in form of a threaded rod to permit cable to be fastened firmly in position without strain on pin connections. A flat head machine screw serves the same purpose in the other plugs. In addition to the octal and loktal types, these plugs are available in 4, 5, 6 and 7 pin models.

Communication Measurements Laboratory, 116 Greenwich Street, New York, N. Y.

Microphone Control Box

MODEL P566 RELAY and busy-signal control-box is connected to microphones in Executone's rack and panel amplifier sound systems.

Installed with microphones in such locations as guard houses, reception desks, telephone switchboard and at plant broadcasting



centers, it coordinates the operations of multiple microphones and provides an instantaneous method of cutting in on central plant sound systems. Busy signal light eliminates interruption from other microphones in the same system. Talk-switch prevents accidental broadcasting of unwanted sounds, provides automatic plate voltage relay control, reducing wear on amplifiers, and automatically cuts off music broadcasting when paging is desired.

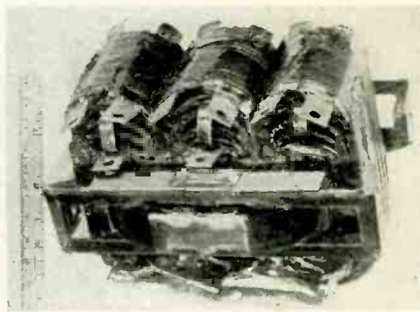
Suitable for wall mounting, the unit is housed in a gray crackle finished metal cabinet, 6½ in. high, 2⅝ in. wide, 1⅜ in. deep. Connections are made to terminal strips located inside the case.

Executone, Inc., 415 Lexington Ave., New York, N. Y.

Midget Aircraft Transformer

THIS TINY 35 kva 400 cps transformer is only about five in. wide and weighs but 25 lb. The ordinary single-phase, 37½ kva transformer weighs 680 lb; even the one with a Hipersil core weighs 430 lb. According to Westinghouse engineers, the most important factor in the creation of this midget is the frequency, 400 cps. Having a rating of 250/30 v, the transformer is a member of a whole new family of 400 cps electrical devices that were on aircraft. This transformer uses class-B insulation, is air-cooled, and could be lighter in weight, except that a compromise is desirable between losses and weight.

Another group of 400 cps transformers displays even greater weight savings. A 7½ kva, three-phase, 208-190/21-26.5 transformer weighs but nine and a third pounds. It is forced air-cooled, and has a regulating winding by which the secondary voltage is maintained constant over a 30 percent range. By added control equipment, constant direct voltage is maintained, compensating for voltage drop in the rectifier, transformer, and supply circuit. Cores are made of new thin-gauge Hipersil steel which provides low losses and lighter weight at this higher frequency. The three-phase core is wound in a novel manner. Two small cores are wound first. Then a third core is wound around these first two, giving the necessary core-type transformer having two windows and three legs for the three-phase windings.



A family of 400 cps, self-cooled auto-transformers is correspondingly small. A five kva, 120/30 v unit weighs eight lb, while a one kva version weighs 2½ lb. Both are capable of operation at 200 deg C temperature rise .Another 1500 w, 180/110 v autotransformer with air blast weighs slightly less than a pound. Thin-gauge Hipersil makes a major contribution to the light weight of all these aircraft designs.

Westinghouse Electric & Mfg. Co., 306 Fourth Ave., P.O. Box 1017, Pittsburgh 30, Pa.

High-Frequency Generator

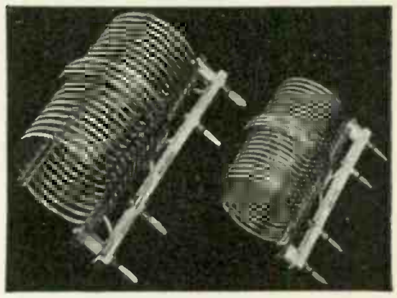
A PORTABLE, WIDE-RANGE calibrated signal generator, HF73, is continuously variable from 200 to 800 Mc. It is hand-calibrated and frequency is read directly in both Mc and cm. Complete with power supply, it is housed in a steel cabinet 15 in. by 7 in. by 7½ in.

Haines Manufacturing Co., 248 McKibbin St., Brooklyn 6, N. Y.


rods
tubes
shapes
tapes
RIGID...to FLEXIBLE...
Compounders and Extruders of Specific Materials for Specific Uses
Synflex Compounds as developed in our own laboratories are produced only in the form of rods, tubes, shapes, tapes and elastics. These distinguished materials meet and surpass the most exacting requirements of the electrical and aviation industries. Many formulations are available, each for a specific job.
Synflex FT 10 is used for the lowest temperature applications, retaining its flexibility to —85°F. * * Synflex FT 11, a transparent material, is effective in a wide range of working temperatures from —60°F. to 188°F. * * Synflex FT 22 has a high dielectric strength and for many applications supplants varnished tubing and sleeving.
Synflex rubber-like Tubings are in continuous lengths from B. & S. #24 (.021 I D.) to 2.000" I.D. Special sizes and shapes upon request.
Inquiries invited. We will gladly submit complete test methods, data and samples.
SYNFLEX
INDUSTRIAL SYNTHETICS CORPORATION
60 WOOLSEY STREET, IRVINGTON, NEW JERSEY

Electronic Heating Coils

STANDARD HEAVY-DUTY coils meet many electronic heating applications up to 1 kw. These air-wound



coils are light in weight and have low dielectric loss.

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.

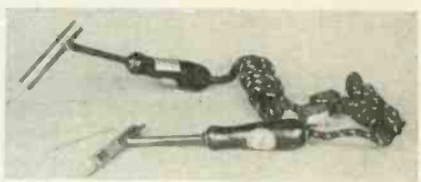
Slide Rules

SLIDE RULES for the professional draftsman, the apprentice draftsman or student, and also a handy five in. pocket rule are now available. All three rules contain A, B, C, D, CI, K, S, L and T scales. With exception of the apprentice rule they are celluloid faced; the apprentice rule has a painted face. They are well constructed, accurate slide rules and come equipped with a case and instruction sheet.

Frederick Post Co., Box 803, Chicago 90, Ill.

Electric Soldering Iron

THIS LIGHT, practical electric soldering iron is equipped with an extendable tip and a heavy balanced pyramid head which can be purchased separately. Approved by the Underwriters Laboratories, Inc., it utilizes a new principle of heat conduction, according to the manufac-

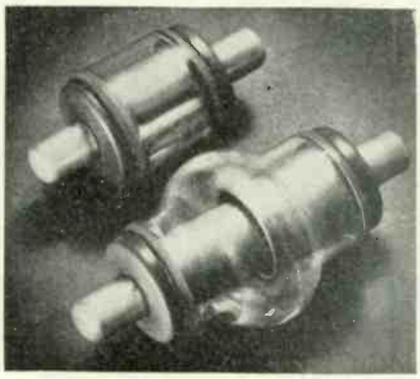


turer. Heating element coils and lead wires are hermetically sealed in ceramic insulation and an air baffle keeps the handle cool. Complete with 6 ft of heater cord, the 60 w, 100 w, and 125 w models sell for a list price of 8, 9, and 12 dollars, respectively. They operate on 110-120 v a.c. or d.c.

Kelnor Mfg. Co., Central Tower, San Francisco 3, Calif.

Compact Vacuum Capacitors

FIVE NEW VACUUM CAPACITORS designed for circuits where the peak voltages range from 7.5 to 16 kv are designated as GL-1L 36/GL-36, which has a peak voltage of 7.5 kv, 25 $\mu\mu$f capacitance. GL-1L 38/GL-38 with a peak voltage of 7.5 kv, 50 $\mu\mu$f capacitance; GL-1L 33/GL-33 with a peak voltage of 7.5 kv, 100 $\mu\mu$f capacitance; GL-1L 22/GL-492 with a peak voltage of 16 kv, 25 $\mu\mu$f capacitance; and GL-1L 23 with a peak voltage of 16 kv, 50 $\mu\mu$f capacitance. Especially important in the design of compact high-frequency circuits is the fact that they are only a tenth the size of similarly rated air-capacitors.

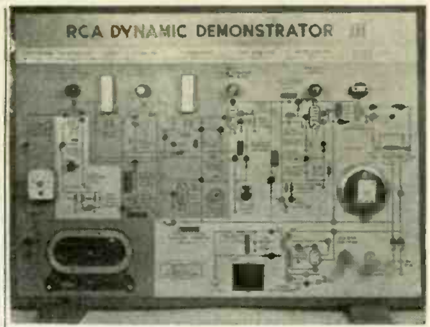


These new capacitors are comparatively loss-free since there are no losses in the vacuum dielectric and because the total capacitance is lumped into a volume of about one cu. in. Vacuum construction insures constant internal voltage breakdown which is independent of altitude, temperature, humidity, and other factors. Details as to ratings and other technical information is available in a free publication, ET-2.

Electronics Dept., General Electric Co., Schenectady, N. Y.

Dynamic Radio Demonstrator

THIS IS AN IMPROVED device intended for laboratory and classroom instruction in radio, and is available on a priority basis. It is a complete, operative, six-tube superheterodyne radio receiver expanded on a plane surface so that all circuits and parts are readily visible and accessible for study. It presents a visual comparison of



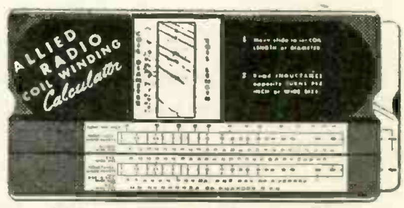
schematic symbols and actual operating parts mounted beside their respective symbols.

The Demonstrator is divided into five principal sections—power, oscillator, r. f., a. f. and i. f. Basic functions of the principal sections of a radio receiver and the character of the signal present are clearly defined by a color-block arrangement which makes possible the tracing of the signal from the time it enters the receiver at the loop or antenna post until it energizes the speaker. Similarly, effects of circuit resonance adjustments and of proper receiver alignment methods may be readily studied. Although thorough studies of radio design, operation and radio servicing may be made without any additional equipment, a more complete understanding of the theory and operation of radio circuits can be obtained by using the Demonstrator in conjunction with other test equipment.

RCA Victor Division of the Radio Corporation of America, Camden, N. J.

Coil Winding Calculator

THIS SLIDE-RULE CALCULATOR permits rapid and accurate determination of inductance, capacitance, and frequency-components of series or parallel-tuned r-f circuits, as



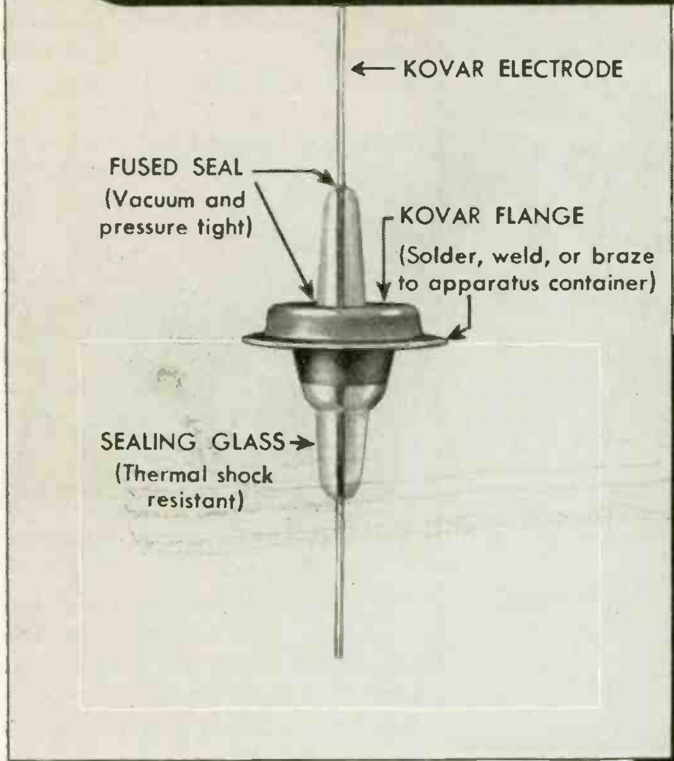
well as inductance, turns-per-inch, wire type, wire size, coil diameter and coil length for single layer-wound solenoid-type r-f coils.

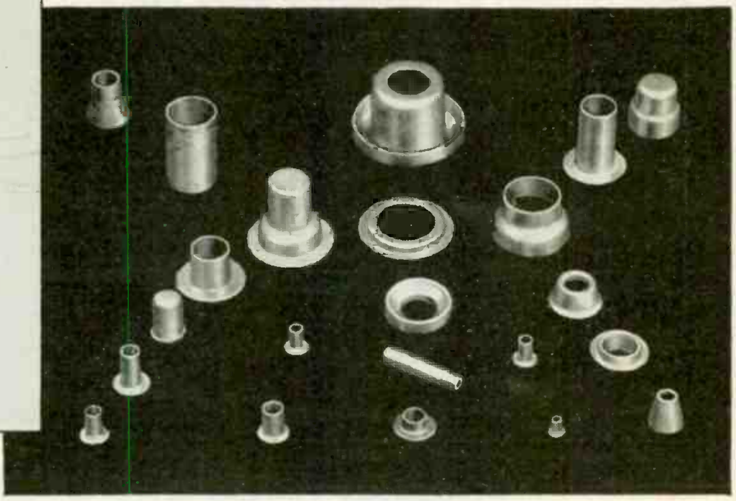
Available for 25 cents from Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7, Ill.

Hermetically Seal . . .

WITH KOVAR

TRADE MARK 337962, REGISTERED IN U. S. PATENT OFFICE





Use KOVAR for sealing

- ELECTRONIC TUBES
- TRANSFORMERS
- RESISTORS
- CAPACITORS
- CONDENSERS
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- SWITCHES
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- INSTRUMENTS
- GAUGES
- METERS
- RECEIVERS
- TRANSMITTERS

A seal is made between Kovar and glass as a chemical bond in which the oxide of Kovar is dissolved into the glass during a heating process. The result, a hermetic seal—permanently vacuum and pressure tight, effective under the most extreme climatic conditions—tropical to stratosphere.

We supply Kovar metal as sheet, rod, wire, tubing or fabricated as cups, eyelets, flanges, etc., also Kovar-glass seals complete ready for soldering, welding or brazing to metal containers.

Kovar IS the answer to permanent vacuum or pressure tight sealing. Let us help engineer YOUR hermetic sealing problems with Kovar.

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ARMY E NAVY "for great achievement"

SINCE 1897

STUPAKOFF

Products for the World of Electronics

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Ionization Gauge

THIS GAUGE measures the degree of vacuum in a system. It is important for the quantity production of quality tubes. Even in the hands of unskilled workers, tubes will come off the pump uniformly accurate when this gauge is used. It gives a continuous reading and will take a variety of tubes with a simple setting. It is designed for economical operation with low priced manometer tubes that can be replaced for less than a dollar.

It is set up by connecting the manometer tube included with each gauge to manifold and plugging in. Left hand meter is for simple setting of ionization current. Right hand meter gives continuous reading of degree of vacuum. Has 4 ranges and measures down to 0.01 micron, 117 v. 60 cps a.c. Stability is maintained by adequate bleeder current and voltage regulators. Set is furnished complete with connecting cables and manometer tube: 1-5Y3G, 1-2051, 2-VR150-30, 2-7B4, or 2-7C7. Available in stationary or portable models.

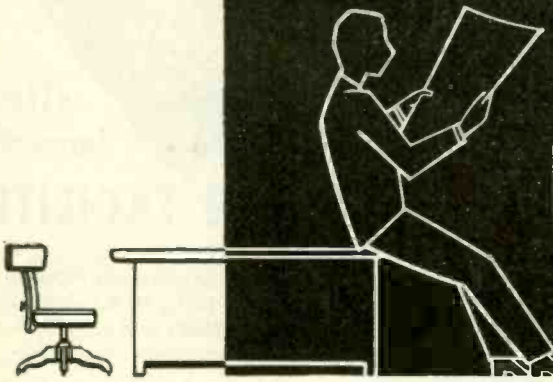
General Electronics, 101 Hazel St., Paterson, N. J.

Synthetic Shellac

A SYNTHETIC SHELLAC which will relieve the shortage of natural shellac, normally imported from India, is being manufactured under the name "Zinlac." It is used in shipbuilding, communications, gas masks, fuses and other military products. According to the manufacturer, practical experience reveals the new synthetic as essentially a duplicate of the natural product, but surpassing it in some properties, such as adhesion to metal as well as wood and subsequent resistance to water.

William Zinsser & Co., 516 W. 59th St., New York 23, N. Y.

GOOD NEWS

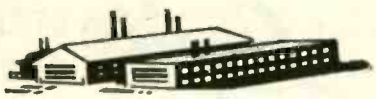


CAN BE A BAD THING, TOO

Victory in North Africa . . . victory in the Solomons . . . victory in Sicily . . .

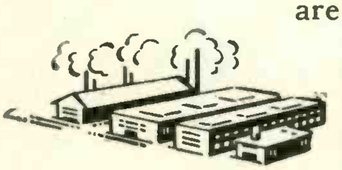
And at home short-sighted workers think a desperate war has become child's play. They relax . . . take a holiday from their jobs . . . chatter idly that the enemy is "done".

What happens then?



Vital production lags . . . production of ships and shells, of tanks and guns and planes . . . young lives in the jungle are snuffed out for lack of material . . . and our friends in Russia and China and Britain suffer because their share is smaller, too.

All because some rosy-eyed people place too much stock in what are only the stepping stones to "unconditional surrender".



No matter how the fortunes of war may turn, Kenyon workers are staying on the job, making good transformers to meet the demands of war plants throughout the nation. This is our modest way of giving thanks to those men who are making the world a safer and happier place in which to live.

THE MARK OF EXCELLENCE

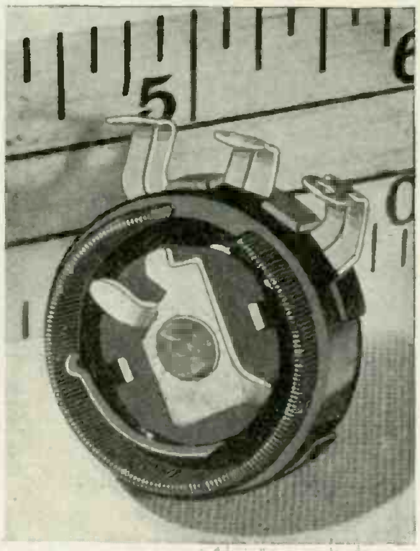
BUY WAR BONDS

KENYON TRANSFORMER CO., Inc.

840 BARRY STREET
NEW YORK, U. S. A.

Midget Control

SPACE-SAVING wire-wound control, Type 43, measures 1⅛ by ⅛ in. The wire winding is curved and held in a concentric slot in the molded Bakelite body. The alloy contact-arm presses against the inside sur-



face of the winding. The control is supplied with or without switch in resistance values up to 10,000 ohms and is rated at 1½ w.

Clarostat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y.

Glass Tube Bottoming Machine

AN IMPROVED GLASS TUBE bottoming machine is available from Eisler Engineering Co., 740 South 13th St., Newark, N. J. The machine is available for the manufacture of telephone switchboard lamps, fluorescent starters, miniature surgical lamps, small electron tubes, hearing aid tubes, medicinal vials, test tubes and small tubular bulbs of all kinds.

Plastic Precision Instruments

IN ELECTRONICS, November 1943 issue, the editors described in this section an alloy plastic called "Emeloid" which is manufactured by The Emeloid Company, 287 Laurel Ave., Arlington, N. J. The manufacturer tells us that they can supply ready-made precision instruments such as slide rules, artillery and navigation charting and calculating instruments, and other precision instruments made of this plastic material.

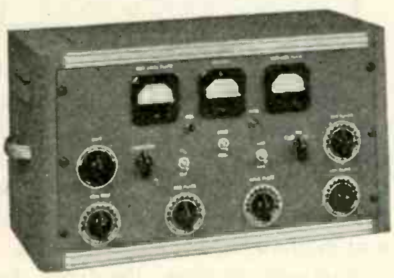
Here is "something new under the sun" —a compact, thoroughly dependable I-F and AUDIO Amplifier in convenient, practical form, all ready to use.

The HARVEY AMPLI-STRIP is built to supply the electrical characteristics you want. Developed by Harvey engineers to meet exacting performance standards, it offers a superb example of the creative and production resources of the Harvey organization.

Whatever your needs in the way of radio or electronic instruments, components or assemblies, present or projected, you will find it to your advantage to get in touch with Harvey of Cambridge.

HARVEY
OF CAMBRIDGE

HARVEY RADIO LABORATORIES, INC.
439 CONCORD AVENUE · CAMBRIDGE 38, MASS.



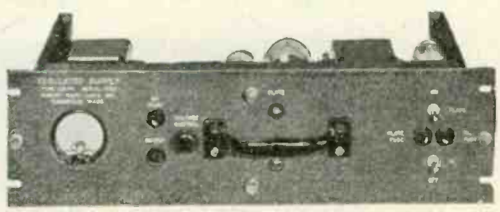
HARVEY UHX-25

A 25-Watt General Purpose Radio Telephone Transmitter

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

HARVEY

106 PA REGULATED POWER SUPPLY
for Laboratory D. C. Source—Range 200 to 300 Volts



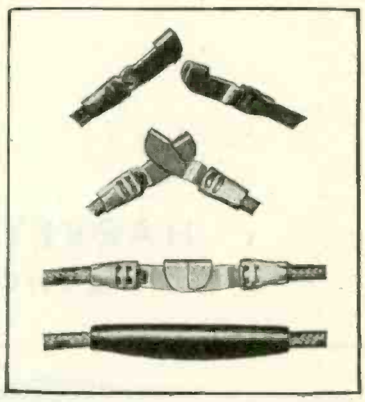
Bushing-Mounted Capacitor

TYPE 817-001 bushing-mounted capacitor in used in high-frequency circuits where both a capacity-ground to a chassis and a lead-through is desired. Capacitance is 55 $\mu\mu$f. Temperature coefficient is -0.00052 $\mu\mu$f/$\mu\mu$f/deg. C. Test voltage is 2,000 v.d.c.; working voltage 1,000 v.

Centralab, Division of Globe-Union, Inc., 900 East Keefe Ave., Milwaukee 1, Wisconsin.

Solderless Splicing Terminal

SOLDERLESS SPLICING TERMINALS (designated as types AMP) have insulation support and are designed to give a quick positive splice for connecting wires until an intentional disconnection is desired. All three crimps are made in one operation. The splice cannot be uncoupled by the wire because the tensile strength of the wire tends to further engage the coupling, although the assembly can be easily and quickly uncoupled when necessary. Two identical parts are used to make a connection and this eliminates the need of stocking or identifying more than one part. A

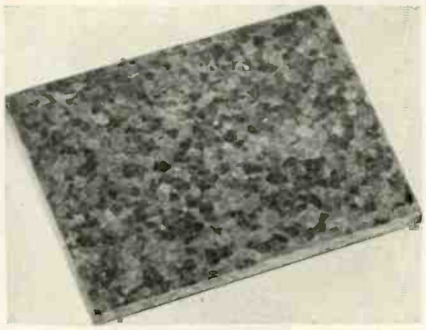


wiping action assures minimum contact drop through the coupling, and gives a good electrical connection even under adverse conditions. Insulation sleeving slips on easily and is then held firmly in place.

Aircraft Marine Products Inc., Dept. B, 1521 N. 4th St., Harrisburg, Pa., or 286 North Broad St., Elizabeth, N. J.

Plastic Insulating Material

"PLASTICERAMIC" is a plastic insulating material closely related to Polystyrene. It is available in sheet form in mottled gray color. The manufacturer states this material has good machining qualities and



the ability to withstand approximately 20 deg. F. higher temperature than Polystyrene, with almost equal electrical characteristics at high frequencies. Characteristics and a dissipation factor chart are available from Printlord, Inc., 93 Mercer St., New York 12, N. Y.

Electrical Insulating Varnish

SYNTHITE PG-4 clear baking varnish is used to insulate high speed armatures by means of vacuum impregnation. According to the manufacturer, it will not throw out nor soften at high temperatures. It is adaptable for use on modern types of polyvinyl acetal coatings of magnet wire. Because of its excellent heat dissipating properties, it is also used on glass insulation for units having high temperature rises. It is resistant to acids and alkalies and can be applied to all types of electrical units as well as textile tapes.

Curing of the varnish takes place through heat-induced chemical polymerization which brings about complete solidification of the entire mass. This type of curing eliminates the possibility of wet spots in the interiors of windings. The degree of hardness can be controlled by altering the baking time and temperature. Generally, this insulating varnish will bake out in 4 to 8 hr at a temperature ranging between 250 to 275 deg F.

John C. Dolph Co., Dept. 22, Newark 5, N. J.

The Home of America's Finest . . .

JAMES *Crystals* KNIGHTS

★ Sandwich, Illinois
(CRYSTAL HEADQUARTERS)

CRYSTALS

DO YOU HAVE A CRYSTAL PROBLEM?

For years, we have specialized in the quantity production of an exceptionally wide variety of quality Quartz Crystals. Recent patents granted to us on new precision cuts and improved mechanical processes have increased still further the accuracy and volume output of James Knights Crystals. We make samples nearly every day for some new customer so that he can design his equipment to fit a crystal that is now a standard of comparison. Why not let us help you?

PRECISION CUTTERS OF QUARTZ
for
COMMUNICATIONS & OPTICAL USES

The JAMES KNIGHTS Company

SANDWICH, ILLINOIS PHONE 65

Porcelain-Clad Capacitor

SOLDER-SEALED porcelain-clad type FPC Inerteen capacitors with mounting studs are used for high voltage d-c applications where space is limited.

From 7,500 v up to and including the 200,000 v class, the capacitor elements are hermetically-sealed in a tubular, wet-process porcelain body with solder sealed end closures. The end closures act as the capacitor terminal by connecting the element leads at opposite ends, utilizing the porcelain tube as insulation.

By eliminating the large metal case and bushings required by metal case capacitors, the new porcelain-clad capacitors help maintain minimum over-all dimensions. Larger types are furnished with or without cast mounting flanges. Where castings are used, the capacitors are solder-sealed, then castings are cemented on with mineral-lead compound.

Westinghouse Electric & Mfg. Co., 306 Fourth Ave., P.O. Box 1017, Pittsburgh 30, Pa.

Square Wave Generator

DESIGNED FOR PRODUCTION testing, this model 530 generator can be made to synchronize with any standard frequency generator or other external frequency source provided that a synchronizing voltage of at least 0.1 v is available. It has a hand-calibrated frequency scale reading from below 10 cps to more than 100 kc. The decade multiplier has four steps. Actual frequency of the output is the dial reading multiplied by the setting of the frequency multiplier. Accuracy of the frequency calibration is 5

More than just sheet steel specialists, ours is an organization where top emphasis is placed upon the men and women responsible for designing and building our products. Working as a team, over a long stretch of years, we've welded together a fine group of exacting, conscientious artisans, supplemented by skilled replacements and additions due to the war.

We build cabinets, chassis, panels and racks for diversified electronic equipment . . . quickly, precisely, economically. The hundreds of different dies available will reduce the cost of the dies needed on your job and may, in many instances, eliminate die-cost entirely. Because of these unique facilities, we manufacture to required specifications at the lowest possible cost. Moreover, we'll go over your plans with you . . . make recommendations if they can be helpful . . . suggest means of expediting deliveries. Briefly, ***ours is an extra pair of hands*** . . . offered willingly as part of a firmly-established policy of unselfish service to our clients.

The services of a Karp engineer are available for a discussion of your problems.

ANY QUANTITIES — ANY METAL — ANY SIZE — ANY FINISH

ARTISANS IN SHEET METAL

KARP METAL PRODUCTS CO., INC.

124 30th STREET • BROOKLYN 31, N. Y.

CABINETS CHASSIS RACKS PANELS

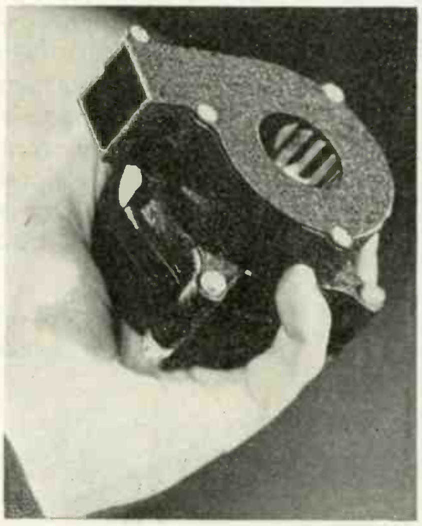
KEEP BACKING THE ATTACK . . . BUY MORE WAR BONDS

percent over extended periods. Output voltage may be varied either in fixed steps or may be continuously varied by means of the variable voltage potentiometer. When the latter is used, the output impedances available are from 0 to 2,000 ohms. If the output voltage is varied in steps, the output impedance is indicated by the output voltage selector setting. Maximum voltage output is approximately 200 v. Power consumption is 30 w; fuse protection, 1 amp. Price, with tubes, is $95 net.

Reiner Electronics Co., 152-6 W. 25 St., New York 1, N. Y.

Blower for Aircraft Radio

THIS SMALL BLOWER unit is designed for cooling aircraft radio sets. It operates on 60 cps at a speed of 3000 rpm and utilizes a new high-efficiency Torrington fan. It is an outgrowth of a motor previ-



ously built by the manufacturer to blow a blast of eight cu ft of cool air through an air-borne radio set and which was operated on either 400 or 800 cps.

Westinghouse Electric & Mfg. Co., 306 Fourth Ave., P.O. Box 1017, Pittsburgh 30, Pa.

"End of the Line" is only the Beginning

• This is the end of the Sylvania Radio Tube production line.

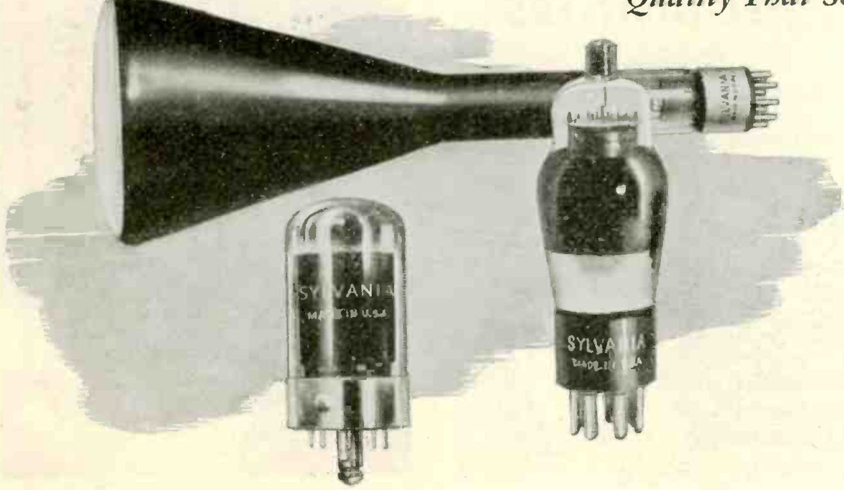
Here trained operators begin a series of tests designed to safeguard high-quality manufacture from any bit of human error.

Standardized precision testing instruments enable them quickly to determine basic radio tube fitness. The slightest defect dooms a tube to instant destruction.

Then come more exhaustive and specialized tests for any deviation at all from specification in the quality inspection and customer inspection departments.

Every Sylvania Radio Tube must pass these rigorous tests — and pass them with a perfect score — before shipment from the factory. This painstaking precision test system is your insurance for Sylvania quality that you can sell with complete confidence.

Quality That Serves the War Shall Serve the Peace



RADIO DIVISION — EMPORIUM, PENNSYLVANIA

SYLVANIA

ELECTRIC PRODUCTS INC.

RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES, INCANDESCENT LAMPS, FLUORESCENT LAMPS, FIXTURES AND ACCESSORIES

Panel Light Assembly

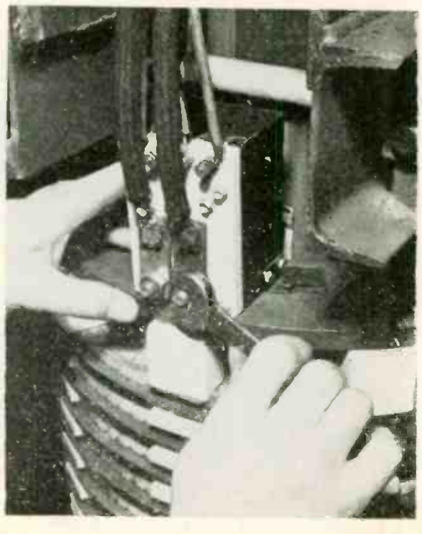
THIS COMPACT and rugged light-shield unit is designed to improve lighting of instrument panels. Its main feature is the knurled head which is rotatable 360 deg and thus casts the light at any desired angle. The lamp housing is made of Navy specification Bakelite sealed with

Bakelite varnish, while the head is made of brass and may be finished with any desired plating. Lamp socket accommodates miniature bayonet base lamp which is easily removable from front of panel. An 11/16 in. panel hole is required for mounting.

Dial Light Co. of America, Inc., 90 West St., New York 6, N. Y.

New Relay for Air-Cooled Transformers

A RELAY for air-cooled transformers makes all possible load capacity available with safety to the insulation. This is accomplished automatically without requiring attention from the plant engineer. The relay takes into account ambient and winding temperatures. How long loads last and conditions exist-



These are the Advantages of PLASKON

TRADE MARK REGISTERED

★ ★ MATERIALS ★ ★

for Electrical Designing

The unusual properties inherent in Plaskon Materials make them especially suitable for the molding of parts for, and assembly of, electrical equipment, both for high utility and decorative purposes. Plaskon Materials are particularly serviceable where high voltages and high frequencies are present, and in parts which are continually subjected to voltage flash-over.

Plaskon Urea-Formaldehyde Compound

1. Wide range of lightfast hues, from translucent natural and pure white to jet black.
2. Smooth surface, eye-catching, warm to touch.
3. Completely resistant to common organic solvents, impervious to oils and grease.
4. Possesses extremely high flexural, impact and tensile strength.
5. Highly resistant to arcing and tracking under high voltages and high frequencies.

Plaskon Grade 2 Compound

1. A Plaskon urea-formaldehyde of good quality, lower in price than regular Plaskon, and adaptable to economy production requirements.
2. High resistance *to*, and retains lustre, surface and color *in*, presence of water, common organic solvents, soaps, etc.
3. Identical unusual dielectric strength and freedom from arcing and tracking as regular Plaskon.

Furnished in one shade of black and brown only.

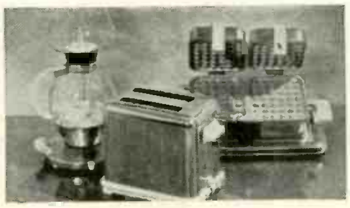
Plaskon Melamine Compound

1. Assures ample protection where water or high humidity prevent the use of urea compounds.
2. Exceptional resistance to acids and alkalies. Non-porous, non-corrodible.
3. Under extreme conditions of heat and humidity, is non-tracking, highly resistant to arcing, and has high dielectric strength.
4. Highest heat resistance of all light-colored plastics.

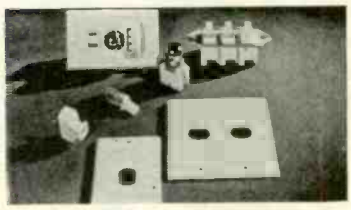
Plaskon Resin Adhesive

1. Materials bonded by Plaskon Resin Glue cannot be separated at glue line—the material fails first.
2. Plaskon glue line is completely moisture-resistant, cannot be weakened by mold or fungi.
3. Maintains its tenacious grip in heavy-duty service for years, under water, on land, in the air.

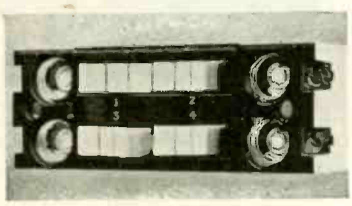
Molded Plaskon is widely used for reflectors because of the high overall lighting efficiency of the material, its light weight, its strength, shatter-resistance, and ability to take unusual forms and shapes economically.



Because it is a non-conductor of electricity, and offers a wide range of beautiful colors, Plaskon is used for decorative purposes on household appliances of every description.



The dielectric properties of Plaskon, plus the wide range of Plaskon colors, make it desirable for color-coded switches, high and low tension circuit breakers and fuse blocks, switchboards, line connectors, plates and plugs.



Molded Plaskon insulators maintain their excellent dielectric properties under high voltages when subjected to continued arcing, high humidities, and long immersion in salt water.

Plaskon provided strength and sturdiness for this delicate radiosonde framework. It permitted higher altitudes, functional improvements, and new accuracy standards in weather signals.

Plaskon "tombstone" sockets for fluorescent lighting provide: mechanical strength; excellent dielectric properties for constant operation; unobtrusive neutral white color.

PLASKON DIVISION • LIBBEY•OWENS•FORD GLASS COMPANY
2130 SYLVAN AVENUE • TOLEDO 6, OHIO

Write for this Manual

The properties and characteristics of Plaskon in molded form, and the proper methods of fabrication, are discussed in detail in this valuable Plaskon handbook. Its contents will be of interest to engineers and fabricators alike.

PLASKON

TRADE MARK REGISTERED

★ ★ MATERIALS ★ ★

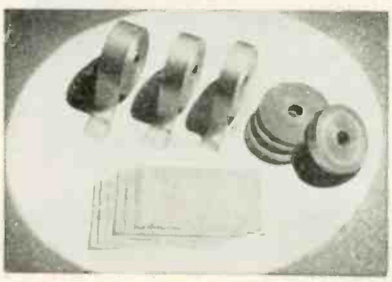
ing prior to overload also influence the relays operation. The design utilizes bimetal elements actuated by changes in air stream temperature and transformer current. Thus, transformer loading is controlled on the basis of both time and temperature. Therefore, maximum safe winding temperature determines the amount of load that can be handled.

Air-cooled transformers — developed a few years before we were plunged into war — have carried loads corresponding to their full name-plate ratings continuously for long periods. On occasion, plant engineers have elected to overload them for short periods. Obviously, there is extra capacity available if the ambient temperature is low or if the overload is of short duration. In such cases, the plant engineer had no means of knowing exactly how much extra load could be carried safely.

Westinghouse Electric & Mfg. Co., 306 Fourth Ave., P.O. Box 1017, Pittsburgh 30, Pa.

New Material for Capacitors

LECTROFILM IS A NEW synthetic dielectric material for capacitors, the development of which was hastened by the shortage of high-grade mica. This new material finds application in the manufacture of fixed r-f blocking and by-pass capacitors used in communications and other electronic equipment. It is available in both rolls and sheets and can be used in present capacitor production lines with very little change in equipment or method of manufacture.

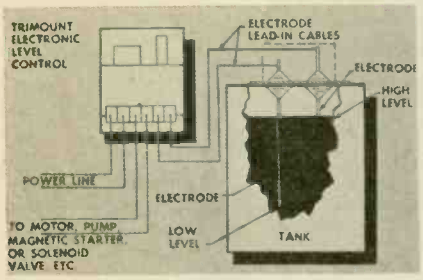


Its strength, chemical stability and flexibility make it suitable for automatic methods of manufacture since it requires little grading or sorting.

General Electric Co., Schenectady, N. Y.

Level Controls

OPERATING ON electronic principles Trimount Level Controls are designed for maintaining or keeping within desired limits the level of conducting solids or liquids within an open or closed tank, hopper or other container and indicating the level.



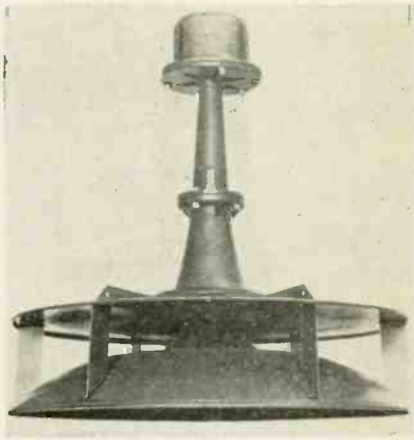
The volume of electrons flowing between electrodes inserted in the tank or hopper changes as conducting solids or liquids make or break contact with one electrode. This change in electronic flow actuates a vacuum-tube relay. The relay actuates motor-driven pumps, alarms, or other equipment.

The control itself is non-mechanical and has no moving parts. It has no chemical or other effect on liquids or solids being controlled and is not chemically or mechanically affected by them. It can be installed in evaporators, freezers, boilers or other containers involving extreme temperatures and can be used for controlling metal chips, acids, brines, chemicals, oil and water.

Trimount Instrument Co., 37 W. Van Buren St., Chicago 5, Ill.

Sound Horn

ANNULAR SOUND distributor, Type L-360, utilizes a different principle of sound distribution in that it combines molecular reflection and collision instead of collision alone. The use of this principle results in a uniformity of sound distribution both as to frequency and power



over a horizontal plane of 360 deg and a vertical plane of approximately 40 deg. It is 23 in. in diam, with an over-all height of 25 in. and will safely handle power input of 20 w when equipped with Jensen U-20 driven unit.

The Langevin Co., Inc., 37 W. 65th St., New York 23, N. Y.

Portable Generator

AIR-COOLED Epcon B-30 generator, designed to meet wartime needs for portable power and light, delivers 3000 w, 110 v a.c., 60 cps; weighs 305 lb. Length, including the base, is 34 in.; height 26 in.

The field ring is high-grade annealed cast steel which produces top electrical efficiency for given weight and at the same time gives maximum support and stability to the generator. Cast iron fittings secure both the generator and the Briggs and Stratton engine to oak sled runners which serve as a strong but light base.

End bells, instead of being solid and heavy, are of open design like a wheel with spokes. Dust covers are of light weight steel spinnings. The V-belt drive makes a big saving in weight over direct drive models on which the generator must be heavy and solid enough to be held exactly in the right position for the direct driveshaft. Pulleys are of cast steel discs instead of solid metal.

Electrical Products Consolidated, Seattle, Wash.

Remote-Control Circuit Breaker

KLIXON D-7229, D-7230 and D-7231 remote-control circuit breakers are designed for aircraft and mobile applications, as well as for the operation and control of any remote electrical load. These breaker-relays indicate circuit operation and can be reset from a control panel

They will carry 115 percent of rated current continuously and will ultimately trip at 125 percent of rated current in an ambient of 25 deg C (77 deg F). The actuating element in the circuit breaker is the snap-acting disc which provides a positive make and break. This disc is unaffected by motion, vibration or shock encountered in aircraft and mobile equipment.

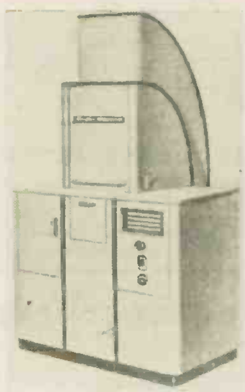
These circuit breakers can be had for trip-free or non-trip-free operation. In the trip-free arrangement, the circuit breaker is free to open irrespective of the maintenance of the handle in the closed position. In the non-trip-free arrangement, the operator can override the action of the circuit breaker-relay from the control panel. They are available in three frame sizes with current ratings from 35 to 200 amp for circuits up to and including 30 v d.c. or 220 v a.c.

Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.

Self-Contained Industrial X-Ray Unit

SEARCHRAY MODEL 150 is the second in a series of x-ray units for industry. The first unit was described in September 1943 ELECTRONICS.

The unit is designed for inspection of parts, assemblies and finished products of metal, hard rubber, plastic, bakelite, ceramics, dielectric and other materials. It takes radiographs quickly without the aid of a skilled x-ray technician or the need of a lead-lined room. Operation of the instrument is made simple by the use of fixed milliamperage over the entire kilovoltage range. An electric interlock, which interrupts the circuit while the radiographic compartment is open, eliminates danger to the operator from x-radiation. A kilovolt regulator permits adjustment (at any point from zero to 150 kv) during the viewing operation.



Current characteristics are 220 volts, single phase, 60 cps, a.c. The unit measures 82 inches in overall height, and weighs approximately 600 lbs. The radiographic compartment measures $25\frac{3}{4}$ x 35 x 25 inches.

North American Philips Co., Inc., Industrial Electronics Div., 100 East 42nd St., New York 17, N. Y.

Lightning Arrester Housing

LIGHTNING ARRESTERS housed in transparent Tenite plastic are used in the communications systems of the Signal Corps and other branches of the armed forces. In the presence of electrical discharges during thunder storms, the glow of a small neon tube visible within the transparent Tenite housing indicates a satisfactory connection between antenna and ground. The

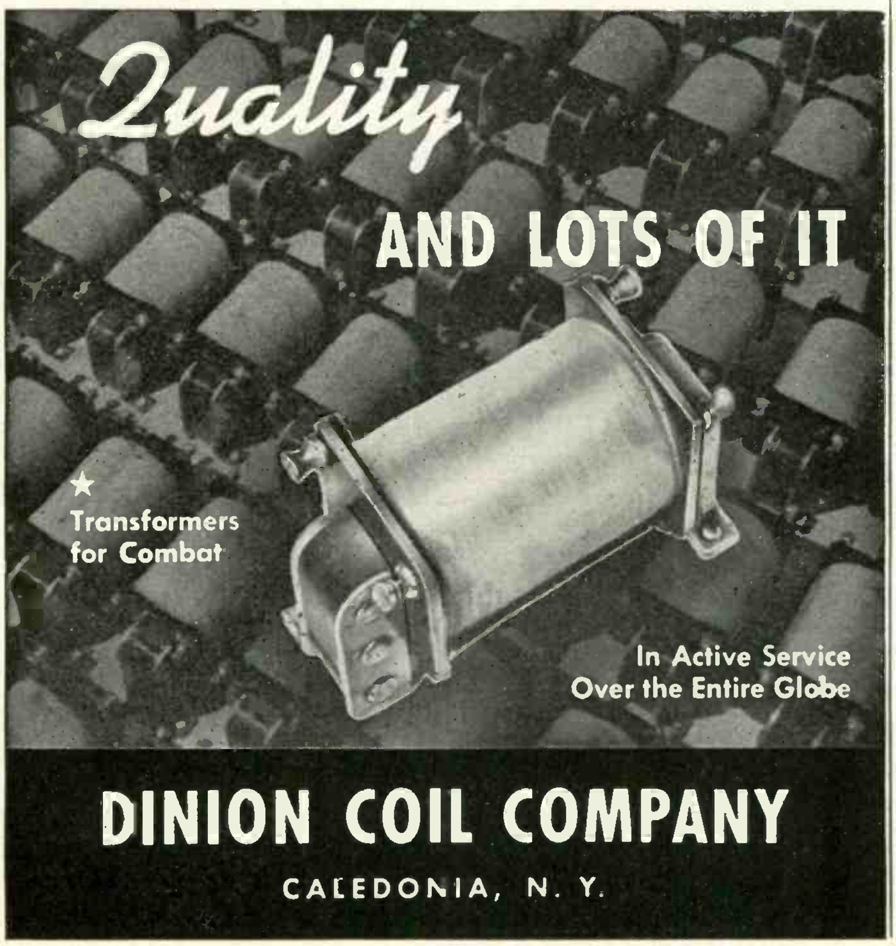
electrodes sealed within the Tenite housing are protected from the effects of the weather, dirt, and insects. Tenite is shatterproof and dirt-resistant.

Lightning arrester housings are molded by Sterling Plastics Company, Union, N. Y., and manufactured by L. S. Brach Manufacturing Corporation, Newark, N. J. Tenite is a product of Tennessee Eastman Corporation, Kingsport, Tenn.

Literature

Special-Purpose Capacitors. Four-page folder No. 721 contains condensed electrical and mechanical data concerning special-purpose capacitors available in production quantities. Types of capacitors included are Numbers 840, 841, 850, 851 and 814-078. Centralab, Division of Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee, Wis.

Communication Systems. A "Catalog-Survey Chart" available from Executone, Inc., 415 Lexington Ave., New York 17, enables the busy executive to analyze his specific communication requirements. The pamphlet also describes a two-way private or amplified communication system for office, factory, institutional and military use.



Timing Apparatus. A 24-page catalog describes timing motors and apparatus in detail. Included is data concerning available engineering service, a-c timing motor and gear units, automatic-reset shift units, instant-stop brake units, manual-reset friction units, standard a-c motor constructional details, standard timers of the elapsed-time indicator, fixed-interval repeat-cycle and fixed-interval automatic-reset types, specially designed timing devices, electronic timers, d-c timing motors and stroboscopic light units. Haydon Mfg. Co., Inc., Forestville, Conn.

Electronics In Industry. A clear-cut exposition of the practical part electronics is playing in various industrial fields is graphically presented in a 44-page booklet illustrated in color and written in non-technical language. RCA Victor Div. of Radio Corporation of America, Camden, N. J.

Electronic Motor-Drive. Bulletin GEA-4025 describes the "Thy-motrol" electronic drive that rectifies and controls power taken from a-c lines for the operation of d-c motors. Forty pages overall, the bulletin describes the device in detail, outlines its functions, lists its advantages and tabulates numerous applications. General Electric Co., Schenectady, N. Y.

Dial-Light Catalog. Catalog No. 43 contains complete information concerning a line of warning and pilot- light assemblies. Accessories of various kinds are also described and pictured. Dial Light Company of America, Inc., 90 West St., New York 6, N. Y.

Speed Nuts. Speed nuts and clips for aircraft and allied applications are cataloged in a new 24-page booklet available from Tinnerman Products, Inc., 2038-2046 Fulton Road, Cleveland, Ohio.

Industrial Instruments. A direct-inking oscillograph using a crystal-actuated mechanism, and a surface-analyzer also using a crystal-actuated mechanism are pictured and described, with complete performance data, in a technical bulletin just released by The Brush Development Co., 3311-25 Perkins Ave., Cleveland 14, Ohio.

Transformers. Catalog 140-F, a 36-page illustrated publication, describes various types and sizes of stock transformers for electronic applications and ac-dc converters, giving complete technical details. Charts designed to facilitate choice of correct units for specific applications are included. Standard Transformer Corp., 1500 North Halsted St., Chicago, Ill.

Beryllium Copper. A folder entitled "Spiking a Rumor" analyzes the present status and the future prospects of the beryllium copper supply and tells how its publisher, a manufacturer of springs made of the material, has kept up deliveries. Instrument Specialties Co., Inc., Little Falls, N. J.

Signal System Data. Three-hole punched to fit into standard data books, a group of twenty-four 4 by 6½-in. looseleaf sheets contains signal system, cable and wire data for engineers, estimators, wiremen and the electrical and electronic industries in general. Included is a standard telephone cable color code, pages tabulating the resistance and current-carrying capacities of various sizes of copper wire, others giving useful information concerning interphone cable, and switchboard telephone cable and wire types used in telephone and signal installations. Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.

Ceramics. Complete specifications on "Centradite", a new ceramic material. are given in Bulletin 720-A. Advantages of the material are given. Possibilities of the material for special applications are explained. Centralab, Division of Globe-Union, Inc., 900 East Keefe Ave., Milwaukee, Wis.

Coil Forms. A booklet on Steatite Coil Forms discusses available sizes, plain tubing, fluted-coil forms, grooving, holes, grinding, spools, glazing, waxing and accuracy. General suggestions for engineers using such forms will also be found helpful, as will also a table suggesting suitable lengths for various o.d., i.d. dimensions and wall thicknesses. Henry L. Crowley & Co., Inc., 1 Central Ave., West Orange, N. J.

Catalog. Catalog No. 94, for 1944, contains descriptions, illustrations and other data pertaining to radio and electronic equipment available from Lafayette Radio Corp., 901 W. Jackson Blvd., Chicago 7, Ill.

Components. A new 36-page catalog just off the press gives full details concerning fixed and variable resistors, inexpensive switches and iron cores for radio and electronic applications. Included is complete technical information relative to high-frequency iron cores. Catalog RC6 also contains a number of useful engineering data charts, such as reactance charts and time-contant charts for series circuits. The Stackpole Carbon Co., Electronic Components Div., St. Marys, Penna.

Noise Primer. A 43-page booklet prepared by engineer H. H. Scott, entitled "The Noise Primer", contains considerable data of practical interest and value to men interested in the subject. Chapter headings include: The Sound—Level Meter; The Decibel—What Is It? How to Use a Sound-Level Meter; Practical Application of the Sound-Level Meter; Analysis of Noise; How to Use the Sound Analyzer; Maximum Accuracy in Noise Measurements; Vibration and Sound; The Vibration Meter; How to Use the Vibration Meter; Analysis of Vibration; How to Use the Vibration Analyzer. Decibel tables are printed in an Appendix. General Radio Co., Cambridge 39, Mass.

Screws. An interesting booklet entitled "Three Generations of Yankee Ingenuity" tells a story of screw-machine products of many types which are playing an important part in the winning of the war. The Waltham Screw Co., Waltham, Mass.

Strain Gage. Complete technical data concerning the SR-4 bonded-resistance-wire strain gage, giving details concerning its design, describing and picturing typical applications, is contained in a new booklet published by the Baldwin Southwark Div., The Baldwin Locomotive Works, Philadelphia, Penna.

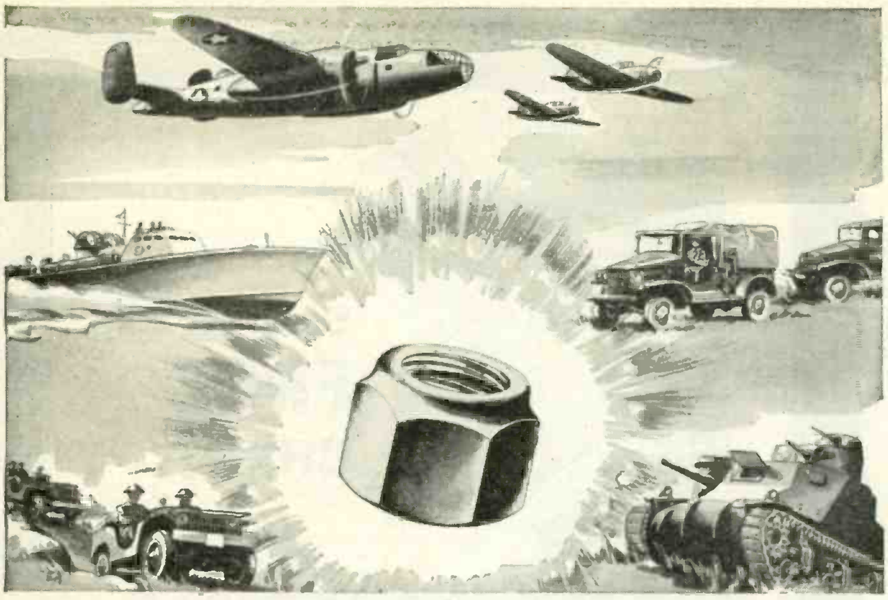
Ignitron Rectifiers. Ignitron mercury-arc rectifiers for 501-kw and higher ratings, 250 to 900 v, are featured in a 36-page bulletin designated GEA-3706. The major portion of the bulletin is devoted to a description of the design and mechanical construction of the rectifiers, their operation and the successive steps involved in manufacture and assembly. Advantages of ignitrons, however, are also listed in connection with the conversion of a.c. to d.c. in mines, railways, steel mills, electro-chemical and other plants. General Electric Co., Schenectady, N. Y.

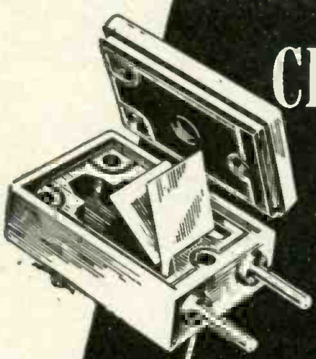
Vibration Control. Various types of vibration-control mountings are described in Catalog G-100. Included is an illustrated chart showing how different types of mountings function and a section covering the theory of vibration control. The Korfund Co., Inc., 48-15 32nd Place, Long Island City 1, N. Y.

Fastenings. A profusely illustrated booklet entitled "Suggestions from Fastening Headquarters" tells how Shakeproof products are aiding the war-effort by solving many assembly problems, gives many suggestions for further utilization of such products in the interest of assembly efficiency. Shakeproof, Inc., 2501 North Keeler Ave., Chicago, Ill.

Electronic Equipment Parts. Catalog No. 220 (45 pages, 1944) illustrates and describes a complete line of electronic equipment parts, accessories and supplies, including test tools, test leads, capacitors, chokes, dials, soldering irons, chassis, cabinets, plugs, antennas, suppressors, hardware, knobs, keys, switches, sockets and jacks. Insuline Corporation of America, 3602 35th Ave., Long Island City, N. Y.

Wave Guides. The Copper & Brass Research Association at 420 Lexington Ave., New York 17, has issued a "Pipe and Tube Bending Handbook" describing practical methods for bending pipes and tubes of copper, brass, and related alloys, which should prove of value in making wave guides.





NEW BOOKS

Electronics

By PAUL R. HEYL, *Ph.D., a series of lectures delivered at the Civic Theater, Indianapolis in 1943. P. R. Mallory & Co., 1943.*

FOR MANY YEARS Dr. Heyl has written and lectured on scientific subjects in layman's language greatly to the edification and enjoyment of his audiences. Recently retired from the National Bureau of Standards, he is now a consultant for P. R. Mallory & Co., under whose auspices the lectures on electrons and what they are now doing in this new world of electronics were given and who have now made available in book form the lectures themselves.

First with an essay on "electrons—nature's building blocks"—and then with the lectures themselves on "an historical introduction, modern theory of electrons," "electrons at work," and finally "electron optics" Dr. Heyl continues his entertaining way with words.

The early lectures deal, naturally, with the work of Avogadro, Perrin, Crookes, Townsend, Millikan, Wilson and the other pioneers who broke up the complacency of scientists at the turn of the 20th century.

Then follows a lecture dealing with modern knowledge of the electron, covering the work of DeBroglie, Lorentz, Swann, Schrödinger, Bohr, Davisson and Germer.

Lecture three starts with Edison, discusses the discoveries or inventions of Fleming and deForest and then tells the reader some of the things electron tubes do in communication and industry.

The final lecture on electron optics deals with the all-important subjects of the cathode-ray tube, the electron microscope, x-rays and other agencies which are possible now that our knowledge of the electron has arrived at the point where it is.

Dr. Heyl has an instructive and interesting approach and this little book is excellent reading for anyone wanting a bird's eye view of electronics.—K. H.

Electrical Engineering—Basic Analysis

By EVERETT M. STRONG, *Prof. of Elec. Eng., Cornell Univ., 391 pages, John Wiley and Sons, Inc., New York, 1943, price $4.00.*

INTENDED, as its title implies, for a first course in electrical engineering—usually in the junior year of college, this book evolved from the introduction of a new course for which existing texts were not suitable.

Most outstanding throughout the text is the careful attention devoted to the true philosophy of engineering, especially in the first chapter. The author instills in the student guidance into the necesary thinking processes so vital to successful engineering practices.

Common obstacles to the application of engineering principles are overcome by the author in a number of ways, the most noteworthy of which are:

(1) The proper handling of dimensional units, and an appropriate use of dimensional analysis

(2) The establishment of basic concepts of *matter*, *energy*, *time* and *space*, free from confusion and ambiguity

(3) The principles of applying formulas by their *creation* resulting from the basic understanding of the phenomena, instead of the malpractice of memorization

(4) The appropriate employment of mathematics, and the preclusion of its misuse, as an engineering tool

(5) The modern concept of the generality existing between analogous physical phenomena—such as electrical and mechanical vibrating systems—and their relationship to the mathematics universally describing the common basic principles.

In the introduction the author presents a pair of diagrams, ingeniously conceived, illustrating the mathematical relationships between the basic entities: *energy*, *momentum*, *displacement*, and *time*, in one; and the electrical analogies of *energy*, *magnetic flux linkage*, *charge*, and *time*, in the other.

In eighteen chapters the established standard requisites in direct and alternating currents are covered. Some departure from past practices is entailed in combining both carefully, on the basis of relative interest and difficulty. Electrical measurements and measuring instruments, electromagnetic induction, magnetic circuits and electromagnets, network analysis and electrostatics, carrying through to completion, with circuits containing combinations of R, L, and C, comprise the principle subject material. Both the transient and the steady-state conditions are considered with the elementary approach consistent with the scope.

Other features include the use of determinants, application of the principle of superposition, and effective application of Thevenin's theorem. The student is indeed fortunate in having an opportunity to learn the power of such organized methods of problem solution at the outset of his training. Fluent use of mathematics, especially integral calculus, conveys ideas directly, without superficial explanations, throughout the book, but only to the extent necessary for completeness and clarity.

The discipline of learning and studying is encouraged on the part of the student, in that questions and problems are provided as a major element in this endeavor. The author feels that the text cannot fulfil its purpose without the liberal use of them. A generous inclusion of references at the end of each chapter lends authoritative support, while the three appendices—*I* on physical tables, *II* on determinants for algebra, and *III* concerning computation, are of self-supporting practical value. The detachable reference graphs at the end of the book (such as B-H curves of various steels) will be found a time-saving convenience in problem solution. The index adequately serves its vital purpose in rendering the material readily accessible.—J.C.A.

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How to Maintain Electric Equipment

By GENERAL ELECTRIC CO., *Schenectady, N. Y., 1943, 372 pages, price $1.75.*

THIS WELL-ORGANIZED book outlines practical methods whereby an industrial plant engineer can obtain the maximum performance and longest life out of General Electric equipment through proper maintenance procedures.

Of particular interest is the 32-page chapter on "How to Maintain Industrial Control," which contains general information, a preventive maintenance schedule, and interesting material on cleaning controls and caring for fuse clips, ferrules, coils, contact tips, types of tips and where to use them, wipe and allowance, thermal relays, and unusual conditions.

But of far greater import is the 13-page section devoted to electronic control, which involves a smaller number of moving and wearing parts, and requires little maintenance because it utilizes resistors, reactors, transformers, and capacitors. Similarly, the electron tubes themselves require inspection and testing at comparatively long intervals. Electronic instruments used for testing high-impedance circuits are also briefly discussed.

An invaluable inspection schedule and trouble-shooting chart is presented, indicating the trouble, cause, and remedy for all types of electronic control. Furthermore, you are told what to inspect, and what to inspect for. Especially emphasized are resistance welding, photoelectric control, and Thy-motrol drive electronic equipment.

Other informative chapters deal with capacitors, electric furnaces, motors and generators, rectifiers, regulators, switchgear, transformers, turbines, welders, insulation, fuse cutouts, battery trucks, lighting, and technical data.—R. E. F.

• • •

Electronic Physics

By L. G. HECTOR, *National Union Radio Corp.*, H. S. LEIN, *Univ. of Buffalo, and* C. E. SCOUTEN, *Univ. of Buffalo. The Blakiston Co., Philadelphia, 1943, 355 pages, price $3.75.*

THE SELECTION of subject matter in this volume has been handled uniquely, and its title is notably apt. It is a basic physics book confined to the electronic field. The subjects covered are necessary to the modern concepts within its scope, with nothing superfluous added. Ordinary light, wireless and x-rays are shown to be closely related and all three to be various aspects of electrical phenomena.

The text is divided into twenty-four chapters. The first eleven are devoted to building up a background in electricity, magnetism, and alternating current theory. Chapters 12 and 13 are on wireless and electron tubes. The succeeding six chapters deal with light and radiation, and are included in a manner that might be called subtle, to give the student groundwork for the modern technique of dealing with ultrashort-wave radiation. Photoelectricity is covered by Chapter 21 in a customary form, placed appropriately in the sequence. The student is introduced to the physical concepts of electromagnetic waves by Chapter 23. The final two chapters bring the student up-to-date in an elementary but not superficial fashion to a comprehension of atomic structure and the composition of matter, so necessary to further understanding of modern developments in electronics.

The style is distinctively attractive—concise and devoid of excess verbiage, yet the entire breadth of its scope is covered with remarkable depth in a mature scientific approach to a thoroughly practical end. The clarity of the illustrations has been enhanced by the use of two-color drawings. Still greater effectiveness of presentation is achieved by the use of an overview

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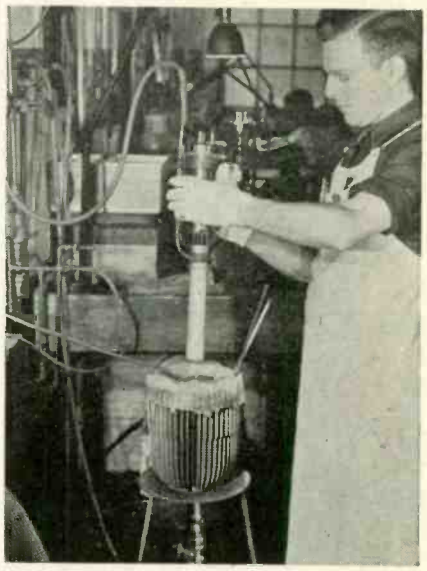
POWER TUBE ASSEMBLY



Soldering heat radiator fins to the plate of a Westinghouse transmitting tube designed for use in 5 to 20 kw stations. Some 1320 watts of power is applied to the filament during operation, enough to heat the plate cherry red unless dissipated by forced air circulation through the copper fins to introduce the reader at the start of each chapter to its contents, and by questions at the end of each chapter to develop the principal ideas. The diversity of student groups that the material will suit is considerably broadened thereby.

The book is suitable for either high school or first-year college students, particularly military personnel requiring a groundwork of physics for training in other technical fields. Certainly it will provide an enjoyable and refreshing review of recent concepts for those who have already completed advanced training in physics and communications, and a *must* book for the serious layman who is satisfied only with authentic material easy to understand.—J.C.A.

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How to Pass a Written Examination

By HARRY C. MCKOWN, *McGraw-Hill Book Co., New York, 1943, 162 pages, price $1.50.*

THIS BOOK offers more than 150 suggestions on how to prepare for written examinations mentally, physically and emotionally; how to answer both objective and essay type questions, and what to do after examinations have been completed. It may be used by high school and college students, civil service applicants, and others who have to take a written examination.—R.E.F.

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Patent Law

By CHESTER H. BIESTERFELD, *John Wiley & Sons, New York, 1943, 225 pages, price $2.75.*

THE PRIMARY INTENTION of this volume is to acquaint engineers, chemists, and students with the basic principles of the patent law.

Since the courts have refused to sustain 80 to 90 percent of the patents coming before them in recent years, those who are developing improvement or other patents will find it valuable to read chapter II dealing with questions of invention and discovery.

Within the past five or six years, a transformation increasing the standard of valid invention has occurred. The reversal or unification of parts in a mechanism, with the function remaining the same, or merely making an apparatus run automatically without changing its purpose, a change of materials or the substitution of parts, a new use for an old machine or material—all these, and more, the courts have considered invalid inventions. In a constructive vein, however, this chapter describes just what improvement patents are likely to be sustained.

Another chapter discusses double patenting—the taking out of a second patent by an inventor who has already obtained an earlier one for the same invention. The law does not permit double patenting and there is no provision for renewal of patents.

Infringement occurs when a party, without license or permission from the owner of the patent, performs some process, manufactures or uses some machine or article, or sells some device, machine, or composition, that falls within the limits of a patent monopoly. A complete chapter is devoted to this subject, and another one to the liability of infringement.

Other chapters consider the large class of inventions that involve the use of a machine, article, or composition of matter, either directly as such or else in some modified or altered form, trade secrets, licenses, reissues, disclaimers, patent litigation, functional claims, and proof of originality.

Each major subject of the essential patent law is discussed and illustrated by citations and quotations taken from recent court decisions.—R.E.F.

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Fundamental Radio Experiments

By ROBERT C. HIGGY, *Assistant Professor, Department of Electrical Engineering, Ohio State University. John Wiley & Sons, Inc., New York, N. Y., 1943. Price $1.50.*

THE TITLE OF this book describes exactly what it is, a series of 32 experiments designed to give the student a grasp of the physical apparatus with which a radio engineer or laboratory technician deals. The experiments are fundamental and could be completed within the time period of the average "pressure" courses now being given to acquaint men with the principles of radio.

Experiments cover reactance determination and effects, vacuum-tube characteristics, oscillators, amplifiers, oscilloscopes, transformers, PA systems, telephone circuits, modulation and detection, transmission lines, vt voltmeters, etc.

The author gives references where desirable to standard texts but includes a sufficient theory so that with the teacher the average student will be able to derive the proper benefit from the experiment. Proper combination of theory and practice, (the latter as exemplified by the work outlined in this book), will better equip students for actual radio practice than many more hours of "book learning" only. —K.H.

• • •

Science at War

By GEORGE W. GRAY, *Harper & Bros., New York, 1943, 296 pages, price $3.00.*

MILITARY IMAGINEERING achieves reality in the fascinating pages of this timely and dramatic portrayal of the role science is playing in our all-out war effort. This book presents a comprehensive panorama of the advances brought about in the various fields of science because of military necessity.

"Today's struggle is a physicist's war," declares George Gray, "in the sense that powerful and spectacular weapons have been introduced through applications of physics. . ." Exciting reading indeed are the descriptions of how degaussing overcame the menace of magnetic mines which were able to detonate ships even at a considerable distance, and how the Battle of Brittain, culminating in the devastating London blitz of 1941, was broken with the aid of radiolocators.

The chapter on electric warfare describes the role of electronics in war industries and on the far-flung battle-fronts of the world. "Everywhere is the versatile lamp of our Western Aladdin—the magic electron tube."

The author vividly traces the mushroom growth of electric warfare from a state of insignificance in 1914 to its emergence in the present conflict as the most important branch of military science. The army and navy are making considerable use of FM radio, particularly for communication with tanks, planes, and other motorized and electrified vehicles and weapons. Systems of electronic control function in innumerable ways in warfare, one of the most remarkable being the apparatus designed to direct antiaircraft gunfire. Three pages are devoted to radar history and development. Of special interest is the section on electronics in war industries, which describes applications in the steel industry, in the electronic chronoscope, and in x-ray machines.

The remaining sections of the chapter on electric warfare are devoted to a discussion of hydrophones employing vacuum-tube amplifiers for submarine sound detection; an electromagnetic locator for detecting ground mines; and developments in radio communication.

Other chapters cover chemical warfare; the problem of aeromedicine; polymers—the world of plastics, synthetic fibers, rubber and gasoline; and a graphic description of the sulfonamides, penicillin and powdered plasma employed so effectively in military medicine and surgery. A brief prologue discusses the moral and social ramifications of global conflict, with the dilemma of conscience which inevitably accompanies it.—R.E.F.

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WAR SERVICE FAMILY

Mrs. Louise Oeser, transmitter calibrator at General Electric Co. Schenectady plant, has two sons in the armed forces, one a lieutenant in the Signal Corps and the other a private in the Marines. A son-in-law is stationed in Hawaii and a granddaughter in the Army Nurse Corps

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronic industry or comment on articles which ELECTRONICS has published

No. 44 Enameled

I might preface this letter with a few all too common remarks about my tenure as a subscriber, how I enjoy your paper, suggested improvements, but I'm magnanimous, all is forgiven and you have a permanent subscriber barring accident.

Remember the Signal Corps "Action" picture you printed in the April 1943 issue? The "G. I." at the extreme left holding the "tommy gun" is your humble correspondent.

Much water under the bridge since that Nov. 8 landing, saw a good bit of Africa, Sicily, and the Italian front.

I have an overtime job as radio repairman with special emphasis on FM and meter repair. We conduct a major repair service within sound of our artillery and sometimes range of those "other people." Never a dull moment.

Would it be difficult for you to enclose perhaps a half-ounce of No. 44 E. Cu wire in an envelope?

Have you any information compiled treating on the repair of D'Arsonval type meters?

FREDERICK LAU
3rd Signal Co.
APO 3, New York, N. Y.

Editor's Note: Can someone oblige with ½ oz. No. 44 wire?

Potentiometer

I THINK IT would be interesting to get some opinions on the use of the term "Potentiometer," by communication or radio engineers.

The A.S.A. Standard C-42 in definition 30-40-080 states as follows.

"A potentiometer is an instrument which embodies part or all of a potentiometer circuit, and by means of which the value of an electromotive force or potential difference, in one of the arms of this circuit, may be measured in terms of one or more other electromotive forces or potential differences and the constants of the potentiometer circuit when the response of a suitable detecting device has been reduced to zero or to an amount which is measurable by the detecting device."

Definition 05-45-095 defines "potentiometer circuit" as follows:

"A potentiometer circuit is a network which is so arranged that, when two or more electromotive forces (or potential differences) are present in as many different branches, the response of a suitable detecting device in one of these branches may be made zero by a suitable adjustment of the electrical constants of the network; and which is characterized by the fact that the detecting device and the electromotive force (or potential difference) under measurement are in the same branch."

Now refer to definition 65-20-555 "voltage divider" especially the last sentence in parenthesis.

"A voltage divider is a resistor provided with fixed or movable contacts and with two fixed terminal contacts; current is passed between the terminal contacts, and a desired voltage is obtained across a portion of the resistor. (The term potentiometer is often erroneously used for this device.)"

It is of interest to note that in the preparation of this A.S.A. Standard on Definitions the Radio and Electronics industries were represented by sub-committees and they presumably passed on these definitions. Yet these industries use the term "potentiometer" in the deprecated sense. Has this been so strongly intrenched in common usage, that the A.S.A. should recognize this fact? Surely it would seem to be a wrong usage, in view of the derivation of the term. It is not in any sense a "meter." Why does this wrong usage persist so strongly among radio engineers? Why also do they persist in calling capacitors condensers?

I feel that the usage of the term "potentiometer" to mean "voltage divider," is on a very low level of intelligence.

PAUL MACGAHAN,
Westinghouse E. & M. Co.
Newark, N. J.

Symbols

I HAVE READ with interest the article "Radio vs. Industrial Symbols" in your September 1943 issue and appreciate the effort made to standardize on our diagram symbols. May I take the liberty of making a few supplementary suggestions to this plan?

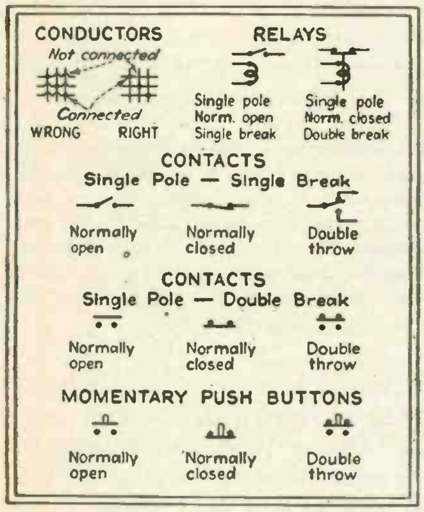
One of the basic problems is to properly indicate wire connections and crossings; I believe there was an article in your magazine six or eight months ago concerning this question. Sketches below show the two ways in which connections and crossings are found in our wiring diagrams today. In my opinion "right" is preferable because

(1) It can be drawn more quickly.

(2) On a poor blue print, loops can be mistaken for connections.

(3) On a small scale diagram with many lines, an accumulation of loops is confusing.

For the elements shown in your article and for terminals, push buttons and signals, I have suggested for use in my own company the symbols as given in attached sketch. You will note that these are a compromise between the symbols under "Communication" and "Power" in your article.



These symbols cover only a fraction of all the symbols currently used in Communication and Power. My proposed symbols are based in part on suggestions made by Dr. George Keinath of Larchmont,, N. Y. at a meeting in Stockholm of the IEC (International Electrotechnical Commission). (See magazine *ATM—Archiv Technisches Messen*—of September 1932, VO6-1).

I think your desire "to avoid perpetuating a ridiculous difference in symbols after the war" should certainly be taken into consideration, not only from a national point of view but from an international standpoint as well. Before I came to the United States (1940) I worked as an Electrical Engineer in Austria, Czechoslovakia, Germany and Switzerland, and my above suggested symbols are based on this experience.

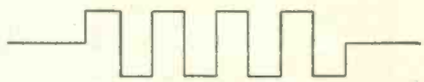
Trusting that my suggestions may be of some value to you in this work of standardizing our symbols, I remain

K. FUERNBERG,
R. W. Cramer Co., Inc.
Centerbrook, Conn.

Symbols

I HAVE JUST READ the article on "Radio vs. Industrial Symbols" in the September, 1943 issue of ELECTRONICS.

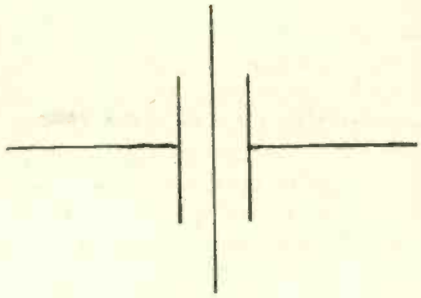
The symbol which you have shown for power resistors seems to be inadequate as a distinctive symbol, hence I believe that the method used by several large companies and as shown on the attached sketch would be preferable. It is



This symbol for a resistor is comparatively easy to draw and is a better pictorial representation of a resistor than a rectangle, which may be mistaken for the fuse symbol. Since it is not greatly different from the "saw tooth" symbol now used in radio, there should be no confusion if the change is made

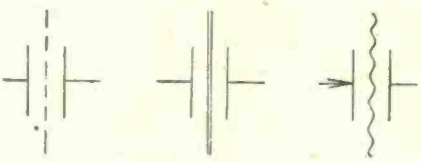
quite easy to draw and cannot readily be confused with any other symbol. Also, it is sufficiently close to the present resistor symbol as used in radio so that there should be no question as to its acceptability in place of the saw tooth design now being used.

The capacitor as shown for power circuits is ungainly and cannot be drawn into diagrams as easily as the present radio symbol. However,



In this basic symbol for a capacitor the central line distinguishes a capacitor from a contactor and may be considered as representing the dielectric, hence several variations are feasible to indicate type of capacitor

since the radio design interferes with the power contactor symbol, we would like to suggest a compromise design also shown on the attached sketch.



We are submitting these ideas on two of the symbols for what use you may wish to make of them in the event you carry this matter to a definite conclusion. We agree that it is necessary to arrange a standard list of symbols which will apply both for communication and for power purposes.

E. W. BREISCH,
Communication Engineer
Union Switch & Signal Co.
Swissvale, Pa.

Symbols

THE WRITER would like to commend you on your article on page 94 of December 1943 ELECTRONICS, under the Title "Now is the Time to Standardize Symbols".

It would appear that the principle of give and take will have to be applied to this problem. There is no doubt that power engineers wish to keep the symbols they have been using for so many years, and the same applies to the electronic engineers as well.

The writer would like to make a proposal that in the case of the symbol for a contactor, the communications type be used as it is more descriptive and does not take up any more drawing board time.

The writer would like to propose that the symbol for a resistor be standardized in the form now used by power engineers as this takes up less drafting time than the symbol now used by the communications men. I see no great objection to the use of the iron core inductor symbol as used by the power engineers but I think that the capacitor symbol should be standardized in the communications manner as this method takes up less drawing board time.

I trust that you will present this proposal to the proper authorities if you think it has enough merit.

G. J. IRWIN,

Chief Engineer
Philco Corporation of Canada Limited

Post-War

AN IMPORTANT POINT has been made by Mr. MacDonald in the article "Post War Planning Problems" (May 1943, p. 72). The undersigned has been repeatedly impressed with the fact that the American people are being led to expect wonders after the war. Promotional matter mainly seems responsible—promising all sorts of gadgets and luxuries afterwards; editorial comment often chimes in. In effect, it seems the American public must be bribed to buy War Bonds and make certain minor sacrifices now by promises of all sorts of fine things they may enjoy soon after.

Such promises are ridiculous—trying to fulfill them would surely lead tn another 1929–1932 debacle. That is, immediate high production of any item to meet a hugh accumulated demand would require operation of large plants and labor and sales forces. If such demand is thus too quickly met, a serious slump will be felt throughout industry, with accompanying unemployment.

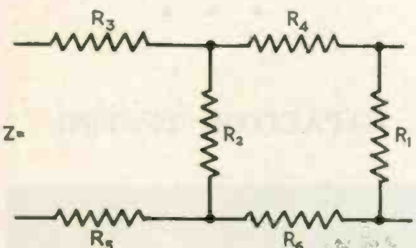
A further question is, shall we distribute our products between domestic needs and the tremendous demand that will exist abroad? Or shall we concentrate on satisfying the cries for the good life and luxury at home while neglecting the great needs abroad? To take the latter course can scarcely contribute to the economic well-being that will be required in a peaceful world.

In the post-war world it will be desirable to meet pent-up demand slowly, thus permitting more even production rates, with competitive improvements added as they come along. It will also be important to recognize the needs of a whole world rather than to foster some "high caste" section exclusively. Progress of all peoples means increased opportunity for all.

JOHN M. SAYWARD
Stamford, Conn.

T Pads

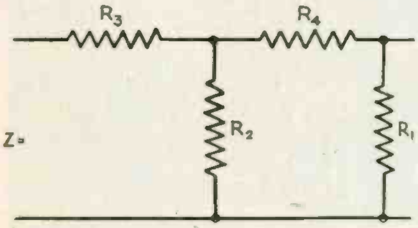
I RECENTLY had occasion to build a 200-to-200-ohm, 5 db T pad. I used information from an ELECTRONICS reference sheet on Page 53, April 1940 issue. The information as given, shows one series leg of 35 ohms, one series leg of 50 ohms and the parallel leg to be 335 ohms. Upon checking, I found the 35-ohm leg should be 55 ohms. This was probably a typographical error and has been called to your attention before; however, in case it has not, I pass this information along for what it is worth.



$$Z = R_3 + \frac{R_2 (R_4 + R_1)}{R_1 + R_2 + R_4}$$

R_1 = input impedance of amplifier

$$Z = R_3 + R_5 + \frac{R_2 (R_4 + R_1 + R_6)}{R_1 + R_2 + R_4 + R_6}$$



Although it is fairly simple to figure the impedance of T and H pads, inclosed are a couple of formulas designed to help one figure such impedances.

H. P. MEISINGER,
Acting Chief Engineer
Radio & Television Section
Dept. of Information
Dept. of Interior, Washington, D. C.

U V Lamps

As you know, existing designs on therapeutic sun lamps are rather complicated, and their costs rather high.

It has occurred to me that a suitable design for sun lamps would incorporate the features of the present-day fluorescent lamp. That is, a long tube, of the proper glass or quartz to pass the beneficient radiations, with the usual type of starter (automatic or hand-operated) and ballast reactor.

The advantages of such a design are immediately apparent: no complicated multi-winding transformer with highly reactive characteristics; more uniform distribution of therapeutic radiations, thus reducing the possibilities of local overexposure such as obtains with a point-source of radiations; simplicity of mechanical arrangement since such units would be light in weight, and nicely adapted to home use.

P. M. Honnell
West Point, N. Y.

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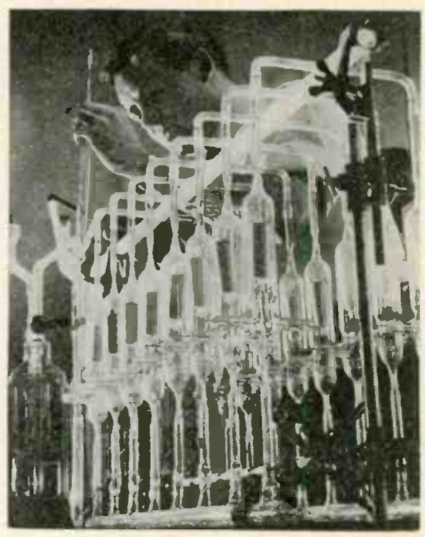
CAPACITOR TESTING



A glass blower worked two weeks sealing 16 capacitors in glass tubes strong enough to stand temperatures from 300 deg below zero F to 250 deg above. The extreme cold was produced by liquid air; the heat came from a burner. Instruments recorded the efficiencies of the various paper dielectrics under test at the Westinghouse Research Laboratories

Multivibrator

(*Continued from page* 145)

(N_1-1)th pulse occurs at time equal to $(N_1-1)/(1-\delta_{d1})$. Further decrease in f_s will permit the (N_1-1)th pulse to synchronize the MV. For the special case of $\delta_{d1}=\delta_{i1}$, this also becomes $N_1-0.5$. Since T_1 is proportional to the logarithm of $k_2\mu_{co1}$, the percentage change in T_1 caused by a given change in $k_2\mu_{co1}$ depends upon its original value. It is apparent from Eq. (1.52)—developed in the January issue of ELECTRONICS—that if $k_2\mu_{co1} > E$, a given percentage change in $k_2\mu_{co1}$ will produce a smaller percentage change in T_1.

$$\frac{dT_1}{T_1} = \left[\frac{d\,(k_2\,\mu_{co1})}{k_2\,\mu_{co1}}\right]\left[\frac{1}{\log_e\,(k_2\,\mu_{co1})}\right] \quad (1.52)$$

In the above example, $k_2\mu_{co1}=9$. Therefore, $dT_1/T_1=0.455\ d(k_2\mu_{co1})/k_2\mu_{co1}$, i.e., the percentage change in T_1 is only 0.455 of the percentage change in $k_2\mu_{co1}$. On this basis, $k_2\mu_{co1}$ must change by 7.7/0.455=17 percent to change the natural period of the MV by 7.7 percent. Hence, if $f, C_{b1}R_1$ and E_{c1} remain constant, N_1 for the MV of Example III will remain at 7 for approximately 17 percent increase and 17 percent decrease in the value of $k_2\mu_{co1}$. Measurements indicate that variations in μ_{co} from tube to tube can be at least 17 percent.

Example IV

A type 6N7 tube is to be used in an MV to divide 300 cps by 8. A 40/60 plate voltage waveshape is desired. It is expected that the greatest changes in the time constants will be in an increasing direction. Provision should be made to allow for a 15 percent increase in each time constant, if this will still permit a reasonable margin for decrease. E_{bb} is 200 v, $E_{co1} = E_{co2} = 10$ v, $R_{L1} = R_{L2} = 60{,}000$ ohms, $R_{b1} = R_{b2} = 28{,}000$ ohms (from the I_b vs. E_b curves).

What percentage decrease in the time constants can be allowed? Give some information on the method of synchronizing this MV.

Solution:

(a) To provide a 40/60 output voltage waveshape, V_1 must divide by $8 \times 4/10 = 3.2$ and V_2 must divide by 4.8.

(b) Reference to Fig. 2.6 indicates that 26 percent is the maximum increase in the value of the time constant that can be tolerated in the section of the MV that divides by 4.8. Because the percentage variation permissible in the time constant increases as the order of division decreases, and because the other section of the MV divides by only 3.2, it is possible to provide for 15 percent increase as well as some decrease from the nominal value of each time constant. Substituting $\delta_i = 0.15$ in (2.8) and solving for the value of δ_d that results in an equality gives $\delta_{d1} = 20.7$ percent for $N_1 = 3.2$ and $\delta_{d2} = 8.75$ percent for $N_2 = 4.8$.

(c) $k_1 = k_2 = 1/(1 + R_b/R_L) = 0.68$.

(d) $\mu_{eo1} = \mu_{eo2} = 200/10 = 20$.

(e) From Fig. 2.7 for $k_1\mu_{eo1} = 13.6$, $N_1 f_s C_{h1} R_1 = 2.61$.

(f) $(N_1/f_s C_{h1} R_1)[0.8(1 - \delta_{d1})] = 2.61 \times 0.8 \times 0.79 = 1.65$.

(g) $(N_2/f_s C_{h2} R_2)[0.8(1 - \delta_{d2})] = 2.61 \times 0.8 \times 0.91 = 1.90$.

(h) Use Fig. 2.8 to solve for A_1 and A_2 from which the values of synchronizing voltage required for V_1 and V_2 can be found. For $N_1/f_s C_{h1} R_1 (1 + \delta_{i1}) = 1.65/1.15 = 1.44$, Fig. 2.8 gives $k_2\mu_{eo1}/(1 + A_1) = 4.22$. Therefore, $A_1 = 2.22$ and $E_{s1} = A_1 E_{co1} = 22.2$ volts. Similarly $A_2 = 1.61$ and $E_{s2} = 16.1$ volts.

(i) Solve (1.9) to find the maximum values of C_{h1} and C_{h2}.

$$C_{h1max} = \left[\frac{T_2}{5}\right]\left[1/\left(R_{L1} + \frac{R_{d1}\,R_{e1}}{R_{d1} + R_{e1}}\right)\right]$$
$$= [4.8/300 \times 5]\,[1/(60 \times 10^3 + 1.5 \times 10^6)]$$
$$= 0.052\ uf.$$

It is apparent that $C_{h2max} = (3.2/4.8)C_{h1max}$. Hence $C_{h2max} = 0.0347$ μf.

(j) Choose $C_{h1} = 0.01$ μf. Then since $N_1/f_s C_{h1} R_1 = 1.65$, $R_1 = N_1/1.65 f_s C_{h1} = 3.2/1.65 \times 300 \times 0.01 \times 10^{-6} = 647{,}000$ ohms.

$$R_{d1} = R_1 - \frac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}} = 647 \times 10^3 - 19 \times 10^3 = 628{,}000 \text{ ohms.}$$

Similarly if C_{h2} is selected as 0.01 μf, then $R_{d2} = 823{,}000$ ohms.

Figure 2.12 is a schematic diagram of the MV. Because the order of division of each tube includes a fraction of a period of the synchronizing frequency, it is necessary to supply the synchronizing pulses to V_1 and V_2 in different phases. By Eq. (2.2) this phase difference must be $360 \times 0.2 = 72$ deg (or $360 \times 0.8 = 288$ deg which is the same result).

Figures 2.13 and 2.14 are plots of the grid voltages of the two tubes of this MV similar to Fig. 2.10 for the symmetrical MV of Example III.

Adjusting the Amplitude of the Synchronizing Voltage

When the design of the MV is completed, the problem becomes that of supplying the calculated optimum value of synchronizing voltage to the circuit. For the reason that with most synchronizing methods some synchronizing voltage finds its way into both the grid and plate circuits of the tube, it is not easy to supply, by direct measurement, the required value of voltage as referred to the grid circuit. A simple and straightforward method of adjusting the synchronizing voltage to its optimum value, and a method which automatically takes into account any discrepancy between the value of μ_{co} for the tube actually in the circuit and the average μ_{co} as used in the calculations is as follows:

By means of a bridge select C_k and R_d. Make a coarse adjustment of the amplitude of the synchronizing voltage such that each section of the MV is dividing by the proper number. Then, if synchronizing voltage is supplied to each tube independently, shunt C_{k1} with a capacity $\delta_{41}C_{k1}$. Adjust the amplitude of the synchronizing voltage to the minimum value for which the MV continues to operate properly. Then remove $\delta_{41}C_{k1}$. Repeat the above procedure for C_{k2}, using a shunting capacity $\delta_{42}C_{k2}$.

In cases where the synchronizing voltage is supplied to both tubes in common, either one or both of the condensers can be paralleled with the capacity δ_4C_k and the synchronizing voltage adjusted to the minimum value required to maintain the proper order of division. In such a case, the same amplitude of synchronizing voltage is provided for both tubes. Therefore, the value used will usually be optimum for only one of the tubes. Independent adjustment of the synchronizing voltage supplied to each tube becomes more desirable with increasing value of N.

Since the exact value of $C_{k2}R_1$ has been shown to be unimportant as long as it is larger than a certain minimum, C_{k1} and R_{d1} can be selected as the nearest standard sizes. In rounding off condenser and resistor values, it is preferable to choose the standard value on the high side of the calculated one. The only modification that this rounding off process necessitates in the MV design is in the amplitude of the synchronizing voltage. The new magnitude of E_{s1} could be easily calculated, but this is not necessary if the synchronizing pulse amplitude is adjusted according to the procedure outlined. Whatever value of C_{h1} is used, it should be shunted with a capacity $\delta_t C_{h1}$ while the synchronizing voltage is being adjusted.

Further, if the amplitude of the synchronizing voltage can be adjusted independently to each tube, then it is not necessary to select equal or exact values for C_{h1} and C_{h2} or R_{d1} and R_{d2}. All that needs to be known is δ_{t1} percent of $C_{h1}R_1$, and this is always δ_{t1} percent of C_{h1}.

The experimental adjustment of the synchronizing voltage could be made by decreasing R_1 to the value $R_1(1 - \delta_{d1})$ instead of increasing C_{h1} to $C_{h1}(1 + \delta_{t1})$. However, with some synchronizing methods the effective amplitude of the synchronizing voltage is a function of R_{d1}.[9] Then too, since δ_{d1} percent of R_1 is not equal to δ_{d1} percent of R_{d1}, this method is not as convenient as paralleling C_{h1}. However, for practical purposes R_{d1} can, in some cases, be considered equal to R_1. To decrease R_{d1} by δ_{d1} percent, parallel it with a resistance of $R_{d1}(1 - \delta_{d1})/\delta_{d1}$ ohms. Increase the amplitude of the synchronizing voltage to the value at which any further increase causes the MV to become unstable or to divide by a smaller number. Then remove the shunt resistor.

If a common amplitude of synchronizing voltage is to be supplied to the two tubes of an unsymmetrical MV, it is possible to make this

[9] This effect is most pronounced in the case where the synchronizing voltage is supplied in series with the ground terminal of R_d. If a synchronizing voltage generator having zero internal impedance and a developed e.m.f. of E_{s2} volts is connected in series with the ground lead of R_{d2}, then (assuming C_{h2} is a zero impedance to the synchronizing pulse) the proportion of E_{s2} that is effective at the grid of V_2 is

$$E_{s2}\left[\frac{\dfrac{R_{b1}R_{L1}}{R_{b1}+R_{L1}}}{R_{d2} \pm \dfrac{R_{b1}R_{L1}}{R_{b1}+R_{L1}}}\right].$$

Also, considerable rounding of the synchronizing pulses may be caused by the shunt capacities which must be charged through R_{d2}.

one value optimum for both tubes. Remember first that, other things remaining the same for both sections, the amplitude of synchronizing voltage required increases with decreasing N. Consequently, the section of the MV which divides by the smaller number will require the greater amplitude of synchronizing voltage. Hence, the section of the MV having the smaller value of N should be designed first to obtain the magnitude of E_s required for it. Using this value of E_s, work backward to obtain the value of N/f_sC_kR which will make this same E_s optimum for the other section. For example, if $k_1\mu_{eo2} = k_2\mu_{eo1}$ and if $A_1 = A_2$ which will be true if the same type of tube is used in each section,[10] it is merely necessary to equate $N_2/f_sC_{k2}R_2(1 + \delta_{i2})$ to $N_1/f_sC_{k1}R_1(1 + \delta_{i1})$. This is apparent from Eq. (2.10).

Note that in every case the factors $(1 - \delta_d)$ and $(1 + \delta_i)$ operate on the product f_sC_kR. Therefore, if C_kR remains constant, the MV will divide by the same number over a synchronizing frequency range of minus δ_d percent and plus δ_i percent. In some cases, when adjusting the amplitude of the synchronizing voltage to its optimum value, it is convenient to change the synchronizing frequency to $f_s(1 - \delta_d)$ or $f_s(1 + \delta_i)$ rather than to alter the time constant of the circuit. Then, depending upon whether $f_s(1 - \delta_d)$ or $f_s(1 + \delta_i)$ is used, the amplitude of the synchronizing voltage is set to the maximum or minimum value for which the desired order of division is obtained. If this method of adjusting the amplitude of the synchronizing voltage is accepted, it must be assumed that, in the circuit used and in the frequency range involved, the amplitude of the synchronizing pulse is not a function of its frequency. It is important to remember in connection with discussions of the maximum allowable variations of C_kR or f_s, that the synchronizing voltage is assumed to be a constant amplitude impulse.

If synchronizing pulses of finite duration are used, the permissible variations from the nominal C_kR products for which reliable synchronizing at a given order of division can be maintained will be decreased. This is due to the fact

[10] Assuming $\mu_{eo1} = \mu_{eo2}$.

that the prolonged synchronizing pulse allows the MV a greater opportunity to trip on the $(N-1)$th pulse. (Quantitative information on the amount of this decrease for the case of rectangular wave synchronizing voltage is developed in Appendix II.) However, if the peak amplitude of the synchronizing pulse is of short duration as compared with the period of the synchronizing wave, and if the amplitude of the pulse decreases more rapidly than E_d is increasing at the ocurrence of the $(N-1)$th pulse, then the values of δ as calculated above can be closely realized in practice.

Another effect of a synchronizing pulse of finite duration is an altering of the discharge rate of the condenser C_k during the time the pulse persists. The reason for this is that the pulse modifies the net voltage active in discharging the condenser. If only one pulse polarity is used, all the changes in the rate of discharge of the condenser will be in the same direction and will introduce some discrepancy between the results expected in the design and those obtained in practice. While this effect is ordinarily of little importance, it can be compensated by a change—usually a decrease—in the value of C_kR. If both pulse polarities are present, the variations in the discharge rate of the condenser cannot always be considered to balance out. The reason for this is mainly that the tube which is passing current will amplify one polarity of pulse considerably more than the other polarity.[11]

Once the design of an MV has been completed for given values of N, f_s and C_kR, the same order of division will be maintained for different synchronizing frequencies provided f_sC_kR is a constant. The optimum amplitude of E_s remains constant for a given order of division as long as f_sC_kR is unchanged.

Magnitude of Synchronizing Voltage vs. E_{bb}

When the plate voltage for the MV is obtained from an unregulated source, it is desirable to know how the optimum magnitude of E_s

[11] By way of example, if the grid of a tube is operating at zero bias, a low impedance source of pulses is required to drive the grid in a positive direction to any important degree. However, the grid is readily responsive to negative pulses.

varies with E_{bb}. The optimum value of E_{s1} as obtained in the design is $A_1 E_{eo1} = A_1 E_{bb}/\mu_{co1}$. A_1 is obtained by reading Fig. 2.8. For a given value on the abscissa of this curve, there corresponds a required value of $k_2\mu_{co1}/(1 + A_1)$. Call this value D_1. Then

$$k_2 \mu_{co1}/(1 + A_1) = D_1$$

and

$$A_1 = [(k_2 \mu_{co1}/D_1) - 1]$$

$$E_{s1} = \frac{A_1 E_{bb}}{\mu_{co1}} = \left[\frac{k_2}{D_1} - \frac{1}{\mu_{co1}}\right] E_{bb} \quad (2.11)$$

In Eq. (2.11), D_1 is not a function of E_{bb}. k_2 and μ_{co1} will, in general, vary somewhat with and in the same direction as E_{bb}. Consequently, a given percentage change in E_{bb} will require a somewhat larger percentage change in E_{s1}, both changes being in the same direction.

Referring to Eq. (2.11), E_{s1}, E_{bb}, k_2 and μ_{co1} are normally fixed. Variations from the nominal value of $C_{b1}R_1$ cause changes in D_1. Therefore the original value of E_{s1} does not remain optimum. Circuits can be developed wherein the bracketed term of Eq. (2.11) is maintained essentially constant even though D_1 varies over rather wide limits. However, it is usually preferable to use several MV stages and gain the additional tolerance in time constants through lower orders of division per stage.

Appendix II

Relations (2.4) through (2.8c) hold for the case of an impulse synchronizing voltage, i.e., a pulse of infinitely short time duration. If the synchronizing pulse is of finite duration, then the factor $(N - 1)$ in (2.4) must be replaced with $N - (1 - \sigma)$, where σ is the ratio of the duration of the synchronizing pulse to the period of the synchronizing voltage. This is illustrated in Fig. 2.31. (Note the similarity between this figure and Fig. 2.3.) Substituting $N - (1 - \sigma)$ for $(N - 1)$ in (2.7), the analagous relations to (2.8) through (2.8c) become:

$$\frac{1 + \delta'_i}{1 - \delta'_d} < \frac{N}{N - (1 - \sigma)} \quad (2.82)$$

$$\delta'_{\sigma - i} < \frac{1 - \sigma}{2N - (1 - \sigma)} \quad (2.82a)$$

$$\delta'_d < \frac{1 - \sigma}{N} \quad (2.82b)$$

$$\delta'_i < \frac{1 - \sigma}{N - (1 - \sigma)} \quad (2.82c)$$

In each case, the allowable variation from the nominal value of C_bR

decreases as σ increases. The ratio of (2.82a) to (2.8a) is

$$\frac{\delta'_{d-i}}{\delta_{d-i}} = \frac{(2N-1)(1-\sigma)}{2N-(1-\sigma)} = \frac{1-\sigma}{1+\dfrac{\sigma}{2N-1}} \qquad (2.83)$$

similarly

$$\frac{\delta'_d}{\delta_d} = (1-\sigma) \qquad (2.84)$$

and

$$\frac{\delta'_i}{\delta_i} = \frac{(N-1)(1-\sigma)}{N-(1-\sigma)} = \frac{1-\sigma}{1+\dfrac{\sigma}{N-1}} \qquad (2.85)$$

For large values of N, all the above ratios approach $(1-\sigma)$. Therefore, the allowable variation of C_kR when synchronizing pulses of finite duration are used is approximately $(1-\sigma)$ as great as for pulses of essentially zero duration. The fact that the rate of discharge of the condenser is altered somewhat for the time that the synchronizing pulse endures introduces some error into these equations. The magnitude of this error decreases as the amplitude and duration of the synchronizing pulse is decreased.

Appendix III

A MV with a natural frequency of 50 cps was built using a 6SN7-GT tube. Type 884 tubes were used in blocking oscillator circuits to supply short pulses of negative polarity in series with the plate load resistor of each MV tube. The single polarity pulses prevented interlocking of the synchronizing voltage controls. The 884's were driven by pulses obtained after limiting the sinusoidal tone supplied by a variable frequency oscillator. Provision was made to provide a zero or 180 deg. phase relation between the trains of pulses supplied to the MV tubes, V_1 and V_2, by the 884 tubes. Thus, the order of division of V_1 and V_2 could be integral, or it could include the fraction 0.5. See Eq. (2.2). The amplitude of the synchronizing pulses was variable from zero to greater than k_1E_{bb} or k_2E_{bb}. If a-c ripple or feedback voltages are superimposed upon E_{bb}, the values of δ_{d1} and δ_{i1} will be reduced. This is especially true in cases where such voltages are not synchronous with the MV frequency. This subject will be covered in Part III. Hence, the plate supply voltage was obtained from a *well regulated and filtered* pack. The amplitude and duration of the synchronizing pulses supplied to the MV was, for practical purposes, independent of frequency in the range employed.

Values of δ_{d1} and δ_{i1} calculated by Eqs. (2.8b) and (2.8c) are tabulated against measured values in Table II. To check δ_{i1}, the synchronizing voltage was adjusted to the maximum value for which V_1 continued to divide by N_1. Then f_s was increased to the maximum value for which the selected order of division (N_1) was maintained.

TABLE II

N_1	$\delta_{i1} = 1/(N_1-1)$ Calculated	$\delta_{i1} = 1/(N_1-1)$ Measured	$\delta_{d1} = 1/N_1$ Calculated	$\delta_{d1} = 1/N_1$ Measured
1.5	2.00	2.11	0.667	0.680
2.0	1.00	0.935	0.500	0.487
2.5	0.667	0.660	0.400	0.392
3.0	0.500	0.487	0.333	0.325
3.5	0.400	0.397	0.286	0.280
4.0	0.333	0.331	0.250	0.238
5.0	0.250	0.243	0.200	0.198
6.0	0.200	0.196	0.167	0.162
7.0	0.167	0.166	0.143	0.140
8.0	0.143	0.140	0.125	0.125
9.0	0.125	0.122	0.111	0.108
10.0	0.111	0.110	0.100	0.099
12.0	0.091	0.092	0.083	0.084
14.0	0.077	0.074	0.071	0.070
16.0	0.067	0.065	0.063	0.060
20.0	0.053	0.050	0.050	0.049

Measured vs. calculated values of δ_{i1} and δ_{d1}. The natural frequency of the symmetrical multivibractor was 50 cps and f_s covered the range of 200 to 3000 cps.

The synchronizing pulses supplied to V_2 were adjusted such that N_2 equaled N_1-1 for the small values of N_1, and N_2-2 for the larger values of N_1. The maximum allowable variation in f_s for a MV is determined by the section with the greater order of division. Thus, the adjustment of E_{s2} did not have to be made with the same care as that of E_{s1}. Further, a better check on the theory was obtained, because only one section of the MV limited the value of δ being measured. To measure δ_{d1}, the synchronizing pulse was adjusted to the minimum amplitude for which V_1 divided by

N_1, and f_s was then decreased to the minimum frequency for which the order of division remained at N_1.

It is apparent that having measured either δ_{d1} or δ_{11}, all the information needed to calculate the other is at hand. For example, in checking either δ_{d1} or δ_{11}, two frequencies, f_{max} and f_{min}, are obtained. Then $\delta_{d1} = (f_{max} - f_{min})/f_{max}$ and $\delta_{11} = (f_{max} - f_{min})/f_{min}$. However, each value in Table II was calculated from an individual measurement, as previously outlined.

In Part II it was found that each time δ_{d1} or δ_{11} entered an equation it operated on the product $f_s C_{k1} R_1$. Consequently, the changes can be in either f_s or $C_{k1}R_1$, i.e., the same percentage variations can be allowed in f_s for a constant $C_{k1}R_1$ as can be allowed in $C_{k1}R_1$ for a constant f_s. It has also been shown that, in a properly designed MV, the maximum value of δ_{d1} and δ_{11} are functions only of N_1, i.e., they do not depend upon the values of f_s or $C_{k1}R_1$.

Appendix IV

To show that all values of $N_1/f_s C_{k1} R_1$ which satisfy Conditions 1 and 3 also satisfy Condition 2, solve (2.4) for A_1

$$A_1 < \left\{ k_2\, \mu_{eo1} \exp \left[- \frac{(N_1 - 1)}{f_s\, C_{k1}\, R_1\, (1 - \delta_{d1})} \right] - 1 \right\}. \quad (2.4a)$$

Substitute this value of A_1 into (2.5).

$$\left\{ \frac{k_2\, \mu_{eo1} \exp \left[- \frac{(N_1 - 1)}{f_s\, C_{k1}\, R_1\, (1 - \delta_{d1})} \right] - 1}{k_2\, \mu_{eo1}} \right\}$$

$$> \exp \left[- \frac{N_1 - 1}{f_s\, C_{k1}\, R_1\, (1 - \delta_{d1})} \right] - \exp \left[- \frac{N_1}{f_s\, C_{k1}\, R_1\, (1 - \delta_{d1})} \right]$$

$$- \frac{1}{k_2 \mu_{eo1}} > - \exp \left[- \frac{N_1}{f_s C_{k1} R_1 (1 - \delta_{d1})} \right]$$

$$k_2 \mu_{eo1} > \exp \left[\frac{N_1}{f_s C_{k1} R_1 (1 - \delta_{d1})} \right]$$

$$\frac{N_1}{f_s C_{k1} R_1 (1 - \delta_{d1})} < \log_e (k_2 \mu_{eo1}) \quad (2.11)$$

Eq. (2.9) which is used in designing the MV requires that

$$\frac{N_1}{f_s C_{k1} R_1} = \log_e (k_2 \mu_{eo1}) \quad (2.9)$$

The value of $N_1/f_s C_{k1} R_1$ obtained from Eq. (2.9) or Fig. 2.7 is then multiplied by $0.8(1 - \delta_{d1})$. Therefore, even without the arbitrary 0.8 factor, (2.11) would be satisfied and would become an equality for δ_{d1} percent decrease from the nominal value of $C_{k1}R_1$.

If (2.11) is satisfied, any value of

$N_1/f_s C_{k1} R_1$ which satisfies (2.4) will also satisfy (2.5). Since the MV design provides a value of $N_1/f_s C_{k1} R_1$ which satisfies (2.4) and (2.6), (2.5) is automatically satisfied.

Symbols Used In This Paper

The numerals 1 or 2 appended to a subscript indicate the section of the circuit in which the component or voltage is located. See Fig.. 1.1.

$A = E_s/E_{co}$.

C_k = Plate to grid coupling capacitor.

E_{bb} = Plate supply voltage.

E_{cc} = Grid supply voltage.

E_{co} = *Magnitude* of d-c grid voltage required for plate current cutoff.

E_s = Peak amplitude of the synchronizing voltage. Except where it is specifically stated to the contrary, E_s is considered positive.

f_s = Frequency of the synchronizing voltage.

$$k_1 = \left[\frac{1}{1 + \dfrac{R_{b1}}{R_{L1}}}\right]\left[\frac{R_{d2}}{R_{d2} + \dfrac{R_{b1} R_{L1}}{R_{b1} + R_{L1}}}\right]$$

$$k_2 = \left[\frac{1}{1 + \dfrac{R_{b2}}{R_{L2}}}\right]\left[\frac{R_{d1}}{R_{d1} + \dfrac{R_{b2} R_{L2}}{R_{b2} + R_{L2}}}\right]$$

MV = Multivibrator.

N = Order of division of *one synchronized section* of multivibrator. See Fig. 1.0.

$N_1 = T_1/T_s$ = Order of division of V_1 and its associated components.

r = Fractional part of N.

r_1 = Fractional part of N_1.

$$R_1 = \left[R_{d1} + \frac{R_{b2} R_{L2}}{R_{b2} + R_{L2}}\right]$$

$$R_2 = \left[R_{d2} + \frac{R_{b1} R_{L1}}{R_{b1} + R_{L1}}\right]$$

R_b = d-c plate resistance of the tube.

R_d = Grid resistor.

R_g = Grid-cathode resistance of the tube.

R_L = Plate resistor.

t = time.

T_1 = Non-conducting time of V_1.

T_2 = Non-conducting time of V_2.

$T_{MV} = T_1 + T_2$ = Period of the multivibrator.

T_s = Period of the synchronizing voltage.

$$\alpha_1 = \frac{1}{C_{k1}\left(R_{d1} + \dfrac{R_{b2} R_{L2}}{R_{b2} + R_{L2}}\right)}.$$

$$\alpha_2 = \frac{1}{C_{k2}\left(R_{d2} + \dfrac{R_{b1} R_{L1}}{R_{b1} + R_{L1}}\right)}.$$

$100\delta_d$ = Percent decrease from nominal value of the product $f_s C_{k1} R_1$

$100\delta_i$ = Percent increase from nominal value of the product $f_s C_{k1} R_1$.

$\mu_{co} = E_{bb}/E_{co}$. Usually $\frac{1}{2}$ to $\frac{3}{4}$ of the rated amplification factor of the tube.

σ = (Width of rectangular synchronizing pulse)/T_s.

Many of the equations are written only for section 1 of the MV. The corresponding equation for section 2 can be obtained in every case by replacing the sub-numeral 1 with 2 and the sub-numeral 2 with 1.

Permanent Magnets

(*Continued from page 129*)

mold, and later removed from the casting. Such holes tend, a good deal more frequently than the first type, to be mislocated, curved, or out of line.

Use of Inserts for Mounting

A second common method of mounting Alnico magnets is to cast soft iron inserts into the magnet (during the pouring process) and to drill and tap or ream these inserts. The inserts are usually coarse knurled to allow the Alnico to grip them tightly. In the case of magneto, motor or generator magnets, the shafts are sometime cast directly into the magnets during the pouring process. Such shafts are rough knurled and/or keyed where the magnet material grips them. It is necessary, of course, to do all finishing operations on the shaft after pouring and heat treatment.

Still a third method of mounting magnets is to cast them into a housing wall. (We are not talking now of the pouring process of the magnets themselves but rather of a process in which the finished magnets are used as inserts in a casting made of a non-magnetic, usually much softer and more easily handled material.) Aluminum and Cerro-Matrix are both suitable for this operation. Other and less frequently used methods of mounting magnets include the use of straps and brackets, clamps, certain cements, and bolts or rods welded to the magnet. (This latter method should be discouraged as the welding process destroys the magnet's characteristics in the vicinity of the weld.)

Mounting the Pole Pieces

Methods of attaching soft iron pole pieces and return members to Alnico magnets are about equal in number to the methods of mounting Alnico magnets, and the problems are quite comparable in nature. The more important of these methods are listed briefly below.

1. A clearance hole with a shoulder may be provided in the Alnico, through which a screw engages a tapped hole in the soft iron member.

2. A counterbored clearance hole may be provided in the soft iron member, through which a screw engages a hole drilled and tapped in a soft iron insert cast into the magnet.

3. The soft iron member may be brazed to the Alnico magnet. Care must be exercised here to see that the temperature of the magnet is not raised too high. The safe maximum limit for this temperature is 1100 deg F, although a temperature value as high as 1200 deg F may be used if it affects only a small portion of the casting and is not maintained for more than two or three minutes.

4. The soft iron member may be soft soldered to the magnet. There are several known methods for doing this, most of them involving a preparation of the surfaces to be soldered by means of an acid.

5. The soft iron member may be cemented or clamped to the magnet.

6. The soft iron member may be welded to the magnet. This is not recommended.

Heat-Treating Precautions

The heat treatment of Alnico puts it through a rather rough temperature cycle. The metal is quenched, sometimes very rapidly, from temperatures which exceed 2000 deg F. One direct consequence of this is the development of severe cracks in magnets of certain shapes or sizes. It is not always possible to set up design principles from the standpoint of avoiding these cracks, and it is not always possible to predict ahead of time just which designs will crack and where. However, certain aspects of the situation are known and are listed below:

1. The more closely a magnet approaches in design a solid sphere or cube, the less likely it is to develop bad cracks.

2. Inserts, large in comparison to the section of the magnet into which they are cast, are very apt to cause cracking of the magnet.

3. Through holes or inserts placed too close to a surface other than the two they connect are apt to cause cracks through to this surface.

4. Rapid changes of section through the magnet should be avoided.

Most engineers are capable of

feeling intuitively if a magnet is of such design that certain sections will experience great stresses if the whole is subject to rapid temperature change. Perhaps it is simply necessary to point out the need for a careful scrutiny of any design with this factor in mind. As an aid to this, certain good and bad designs are shown.

Of course, this whole discussion has been centered about cast Alnico. There is, however, another method of making Alnico magnets of small sizes (less than approximately two ounces in weight) and that is through the process of sintering. The sintering process is one of compressing metal powders under pressure and temperature in a permanent metal mold. In general, magnets having a dimension of less than approximately 3/16 in. are difficult to cast and should be made by the sintering process.

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TESTING RADIO COMPASSES

Test-flying of radio compasses involves simulating radio signal reception during flight and is conducted in a copper-screened room. Here Lt. Arthur Gittelman, U. S. Army Signal Corps inspector, and Helen Picek, graduate physicist, test-fly a radio compass at Bendix Aviation Corp. plant in Baltimore, Md.

R-C Networks

(Continued from page 148)

mum bass-cut of 14 db.

The position of the control has no effect on F_1, since with the driving generator E short-circuited, C always looks into the same resistance no matter where the control is set. This resistance is given by R_1+R_4 in parallel with R_2+R_3, which, for the values given these resistances, equals 200,000 ohms. F_1 is given by Rule 1 as the frequency at which 0.004 μf has a reactance of 200,000 ohms, and from a reactance chart we find this to be 200 cycles.

a_∞ is given as the attenuation of the network when C is short-circuited. This is also independent of the control setting, and is given by $(R_1+R_4)/R_4$; for the given values a_∞ is thus seen to be equal to 6, which corresponds to a value of 15.6 db.

The control setting affects only a_0, and this may be varied from a value of 30, with the control all the way down ($R_3=0$), to a value of 1.2 with the control all the way up ($R_2=0$). These values of a_0 correspond to values of a_0 of 29.6 db and 1.6 db respectively. It is to be noted that for the setting of the control at which $R_2=833{,}000$ ohms, a_0 and a are equal, and the attenuation is constant for all frequencies.

A is given as a_0/a_∞, which, for the maximum bass-boost setting ($a_0=1.2$), equals 0.2, and for the maximum bass-cut setting ($a_0 \doteq 30$), equals 5. From (2), F_2 equals F_1/A, and hence for the maximum bass-boost setting $F_2=1000$ cycles. Similarly, for the maximum bass-cut setting $F_2=40$ cycles.

Substituting these values of F_1, F_2, and a_∞ in Eq. (9) and (10), we obtain the following expressions for a and θ.

$$\left.\begin{aligned}\bar{a} &= 6\sqrt{\frac{f^2+(200)^2}{f^2+(1000)^2}}\\ \theta &= \tan^{-1}\left(\frac{1000}{f}\right)-\tan^{-1}\left(\frac{200}{f}\right)\end{aligned}\right\}\begin{matrix}\text{(Bass-boost)}\\ (A=0.2)\end{matrix} \quad (11)$$

$$\left.\begin{aligned}\bar{a} &= 6\sqrt{\frac{f^2+(200)^2}{f^2+(40)^2}}\\ \theta &= \tan^{-1}\left(\frac{40}{f}\right)-\tan^{-1}\left(\frac{200}{f}\right)\end{aligned}\right\}\begin{matrix}\text{(Bass-cut)}\\ (A=5)\end{matrix} \quad (12)$$

The graphs of these functions,

together with those for two intermediate settings of the control ($A=0.4$ and $A=2.5$), are given in Fig. 2.

Use of Attenuation—Phase-Shift Chart

Given any particular admissible network, it is a perfectly straightforward task to plot its attenuation and phase-shift curves using Eq. (9) and (10). The computations are rather laborious, however, especially if the results are desired in db. These quantities are therefore given graphically in Fig. 3 at intervals of 1 db and 5° for any multiple of the lower turnover frequency from 0.1 to 100, and for any value of A between 1 and 20; if A is less than unity we work with the reciprocal, $1/A$.

Typical Examples

Assuming for the moment that A is greater than unity, let us suppose we wish to find the attenuation of a given network where $A=5.5$, at a frequency equal to seven times the lower turnover frequency, which in this case is F_2. Through the point x ($f=7F_2$, $A=5.5$) passes the solid contour line labelled "2", which means that at this frequency $\alpha=\alpha\infty+2$ db. Keeping the same value of A, we see that at $3F_2$, $\alpha=\alpha\infty+6$ db, and at $0.4F_2$, $\alpha=\alpha\infty+14.1$ db. The attenuation at multiples of F_2 through which contour lines do not pass can be estimated to an accuracy sufficient for nearly all practical purposes.

Returning to the original point x we see that the dotted contour line labelled 30° passes through this point also; hence, the phase-shift at this point is $-30°$ (since when A is greater than unity, θ is negative.) Similarly, for the same value of A, at $3F_2$, $\theta=-42.5°$, and at $0.4F_2$, $\theta=-18°$.

When A is less than unity, we use $1/A$ instead. Thus, had A been given as 0.182, we take the reciprocal, or 5.5, and work with that. Now, however, the attenuation is given in db *below* $\alpha\infty$, and the phase-shifts are positive. We still take the lower turnover frequency, which is now F_1. Thus for $A=0.182$, $f=7F_1$, $\alpha=\alpha\infty-2$ db, and $\theta=30°$. Similarly, for $A=0.182$, $f=3F_1$, $\alpha=\alpha\infty-6$ db, and $\theta=42.5°$.

Tuned Circuits

(*Continued from page* 120)

portional to the spacing of the plates.

Experiments have shown that on a clean polished metal surface, films up to 30 or 40 molecules thick may be formed at 98 percent relative humidity with a temperature around 30 deg C. On a good dielectric material, the films formed under the same conditions were up to 180 molecules in depth. Since oils and greases are dielectrics, capacitor plates should be kept scrupulously free of them.

Coils and Wiring

Impregnation of insulated wires with wax prevents moisture absorption by the insulation covering (thereby decreasing the effective moisture film thickness) and moves the wax-air interface out from the conductor, thus situating the inevitable moisture film in a region of lesser electric intensity where it has less effect on the capacitance of the circuit.

Frequency shift with humidity would seem to be due to surface changes, in view of the relatively short time required for recovery of normal characteristics. This indicates the necessity for keeping the wax-air interfaces out of any region of strong electric field intensity. The foregoing statement applies particularly to coils, which should be covered with a sufficient thickness of wax to keep the interface out of any region of strong electric intensity caused by potentials existing between adjacent turns. It is evident that the greater the spacing of turns, the smaller will be the ratio between coil distributed capacitance and total tuning capacitance, and therefore the less important will be the removal of the wax-air interface. In addition, increased spacing will diminish the electric field between adjacent conductors thereby decreasing the effect of moisture film deposits.

The films build up to depths of 25 molecules on dielectrics at 40 deg C and a relative humidity of 85 percent. A coil wound with flat wire spaced 0.005 in. and with no protective covering other than enamel on the wire would have its distributed capacitance increased

0.01 percent under these conditions.

In view of the fact that moisture films have such large effects when compared with their dimensions, it is interesting to note here that if by some means the interior of a device being tested were maintained 5 deg C above the external temperature, then the interior relative humidity could not exceed 80 percent even though the external temperature might range up to 60 deg C at 100 percent relative humidity.

Conclusions

Listed below are the effects on resonant frequency of each of the variables which are due to dielectric changes only.

1. *Pressure.* For air at 19 deg C the coefficient is -9.125 cps per Mc per in. Hg, or 0.01825 percent change in frequency for altitude change from sea level to 27,500 feet.

2. *Temperature.* For air at 19 deg C, 30 in. Hg., the coefficient is $+0.9375$ cps per Mc per deg C. (This is negligible and need not be considered in design.)

3. *Relative Humidity.* We give below the total frequency shift in cps per Mc, as air at the specified temperature and 760 mm Hg pressure is varied from 0 to 100 percent relative humidity.

deg C.	cps/Mc
−40	−0
−30	−0.4
−20	−1.16
−10	−2.8
0	−6.35
+10	−12.3
+20	−22.65
+30	−39.75
+40	−67.00
+50	−108.5
+60	−170.00
+70	−257.5

4. *Carbon Dioxide.* Mixed with air at 19 deg C and 30 in. Hg pressure, the coefficient is -1.868 cps per Mc per percent of carbon dioxide. Also 53.5 percent of carbon dioxide is required to shift the frequency downward 0.01 percent. This effect becomes greater at lower temperatures.

5. *Moisture Film Deposits.* Deposits at 98 percent relative humidity and 30 deg C on perfectly clean capacitor plates (0.020 in. spacing) are sufficient to lower the frequency 0.0025 percent. The presence of oil or grease films may increase this to 0.015 percent.

6. Wherever wax is used for sealing against moisture, wax-air interfaces must be kept out of strong electric fields.

Transformer Design

(*Continued from page* 109)

impurities. Pressure is then applied to the surface of the hot fluid wax to force it into the coil and between the laminations. The layer paper becomes a framework to support an insulating layer of wax. Each individual wire is fully coated, and the individual laminations are insulated from each other by a coat of wax. The wax chosen for this purpose has a low dielectric constant, lower than any of the plastic films except polystyrene. It is sufficiently plastic at all operating temperatures, even those below zero, to prevent cracking. Long life is assured.

Other Design Details

Figure 8 illustrates an output transformer (TP-204) designed for operation between a single-ended or push-pull tube and a line, in the range between minus 20 db and plus 20 db level. Because this rather small transformer has to handle large signals, many turns of wire per volt of signal were required to keep the flux density low, making it necessary to lengthen the magnetic path to keep the inductance of the windings down to the proper value. In addition, the mean length per turn of the copper circuit was kept low to reduce the series—resistance insertion loss. Since the winding length was quite long, the high-impedance primary winding was broken up into several pies to reduce the developed voltage per layer, and consequently the effective distributed capacitance. Under certain conditions of operation the magnetic flux leakage near the ends of the long legs of the core could become great enough to develop an appreciable leakage reactance. To prevent this and retain good high-frequency performance the tubes surrounding the core, and on which the coils are wound, have built into them an eddy current shield, consisting of a single wrap of heavy sheet copper with an overlapped insulated high-reluctance joint, as shown in Fig. 8A.

The astatically-balanced construction also reduces external hum pickup, which is down about 30 db from an uncased-shell type design of corresponding size. The entire unit is potted in a three-section case which provides an additional 30 db of shielding. The performance of this transformer over a wide range of operating levels is shown in Fig. 9.

(*Continued on page* 388)

FIG. 11—The response of the transformer depicted in Fig. 10 is shown, measured at minus 22 db and minus 65 db

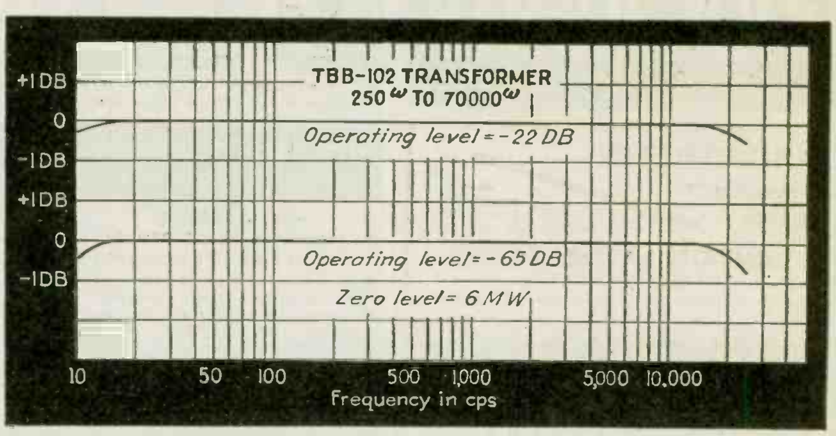
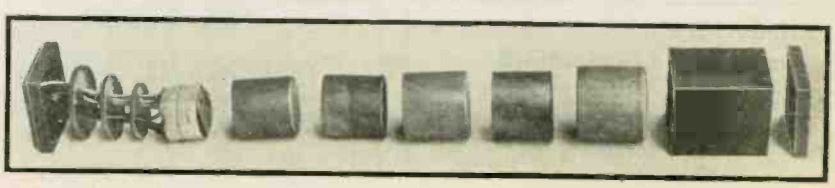


FIG. 12—Exploded view of a high-impedance audio transformer designed to reduce pickup of stray fields



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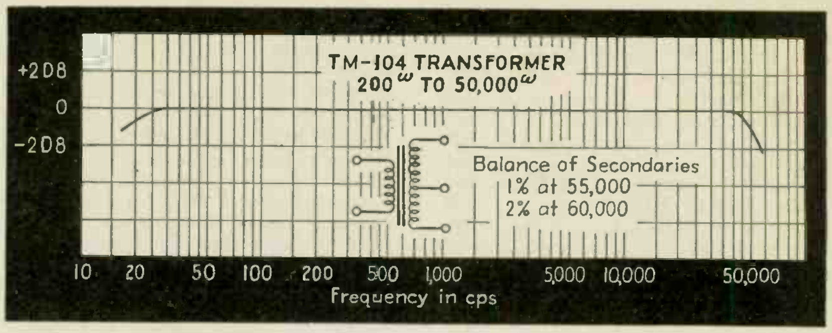

FIG. 13—Graphic illustration of the frequency-response characteristic of an audio transformer discussed by the author

Figure 10 illustrates a small input transformer (TBB-102) designed for operation at a minus 35 db level. The response measured at minus 22 db and minus 65 db is shown in Fig. 11. A core was chosen with a very short magnetic path and with lap joints located near the center of the coil structure. A large core area was chosen to keep the operating flux densities at low values, of the order of gausses rather than hundreds of gausses. The choice of core permitted the winding of a small-sized coil which, even with its small spacing between layers, has a low distributed capacitance. The thickness of the laminations chosen allows the development of a small quantity of eddy current which, acting on this short magnetic length core, effectively limits the high-frequency inductance of the windings, permitting excellent low-frequency response at low core densities without objectionably reducing the high-frequency response. Sheet-copper shielding is used between the primary and the secondary windings, and is so spaced in the coil structure that the capacitances from both ends of every coil to ground are equal.

A transformer of this sort with its high operating impedances, in this instance 70,000 ohms, and its consequent sensitivity to external fields, needs adequate shielding. For this purpose the transformer is cased in a seamless, drawn, round can of high-permeability alloy. Surrounding this high permeability can is a heavy short-circuiting turn of copper. This assembly goes into another can of high-permeability alloy surrounded by copper, and finally into a third high-permeability can. Figure 12 is an exploded view of the assembly, which is then vacuum impregnated and potted in its protective case. This type of shielding is good for about 30 db per can of high-permeability alloy, the entire assembly attenuating external fields about 90 db.

A companion interstage transformer has been developed with the same characteristics and size as the transformer illustrated. It is designed to operate single-ended or push-pull between 10,000 ohms and 40,000 ohms.

Figure 13 shows the frequency-response characteristic of a transformer which is a good example of wide frequency range and balance combined with light weight. It is designed for operation at minus 10 db to zero level, has electrostatic shielding between the primary and secondary windings, and is potted within a 30 db shield can. Excellent high-frequency balance is obtained across the two halves of the secondary, being less than 1 percent at 55,000 cps, and only 2 percent at 60,000 cps. No unbalance at lower frequencies is measurable. The transformer is potted in a case 1¾″x1¾″x2¾″ and weighs 10 oz.

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