W B Gould

electronics

AUGUST · 1943

ELECTRONIC SEWING MACHINE

HELLS BELLS, THESE TUBES MUST BE BUILT ON A FOUR-LEAF CLOVER . . .

Amperex transmitting and rectifying tubes have longer operating life packed into them than most hardened engineers anticipate. Now, this isn't a matter of luck . . . rather, it's the result of unceasing laboratory research and new production methods.

Amperex tubes are extremely precise . . . They're tank tough . . . They keep going at rated efficiency up to the very end. Wherever used, in civilian and military communications or in industrial applications—Amperex tubes are as constant and dependable as mathematical formulae.

BLOOD DONORS ARE URGENTLY NEEDED . . . MAKE A DATE WITH THE RED CROSS

AMPEREX ELECTRONIC PRODUCTS

79 WASHINGTON STREET • BROOKLYN, N. Y.

electronics

AUGUST • 1943

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From ....

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To ....

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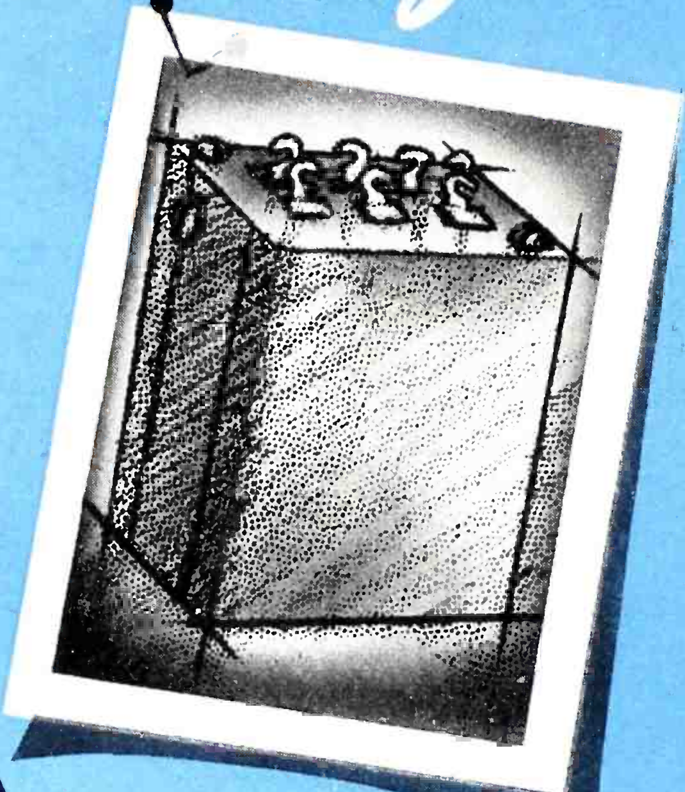
Signed ....

Savings in DESIGN



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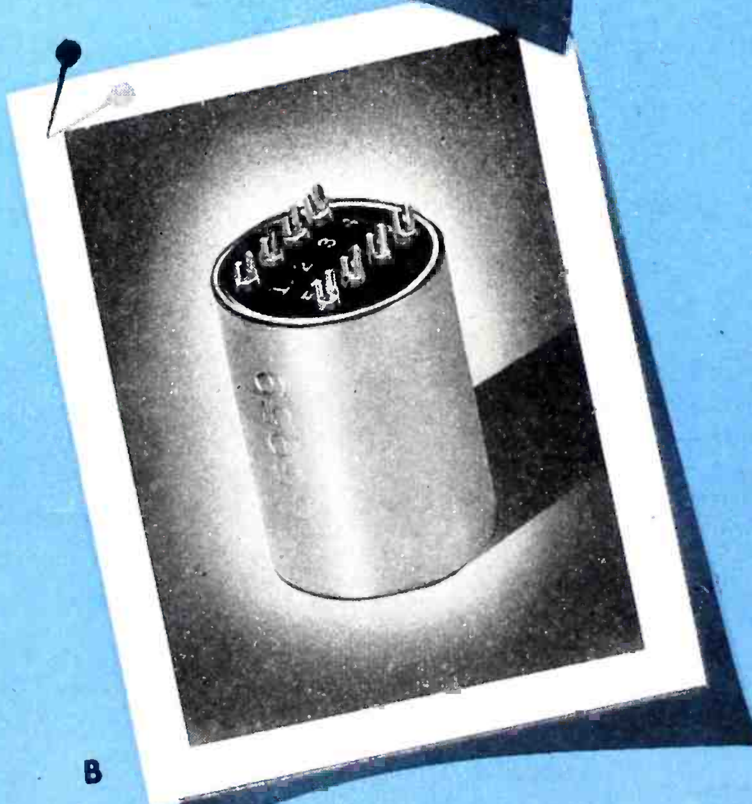


B

PREVIOUS UTC ads have illustrated the importance of engineering design in the saving of critical materials, machine time and man hours. The engineer's responsibility in our war effort is tremendous. We can win or lose the war because the winner will be that group of nations which gets there first with the most. We illustrate the functioning of this viewpoint at UTC by a highlight design for the month, as below.

A . . . *Contemporary transformer as brought to UTC for duplication.*

B . . . *UTC final design, illustrating design savings.*

VOLUME REDUCTION 80% . . . This represents a vital reduction in critical material.

WEIGHT REDUCTION 78% . . . Used in portable apparatus, weight reduction is important.

PRICE REDUCTION 84% . . . This means more war units for the same cost . . . Quicker.

DEPENDABILITY --% . . . Considerably more efficient electrically and *submersion proof.*

May we design a war unit to your application?

UNITED TRANSFORMER CO.

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

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

★ **STABILIZED** to keep its toughness and transparency — that's Albanene Tracing Paper. Because it is treated with crystal-clear Albanite, a new synthetic solid developed in the K&E laboratories—Albanene will not oxidize, become brittle or lose transparency with age. Albanene's improved drawing surface takes ink or pencil fluently, erases with ease . . . Ask your K&E dealer.

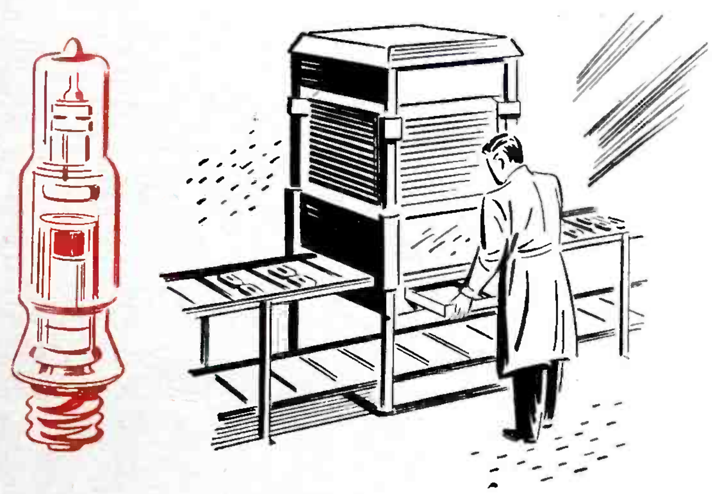
TRADE MARK K+E

KEUFFEL & ESSER CO · *Est. 1867*

CHICAGO · **NEW YORK · HOBOKEN, N. J.** · MONTREAL
ST. LOUIS · SAN FRANCISCO · LOS ANGELES · DETROIT

. . . at Work

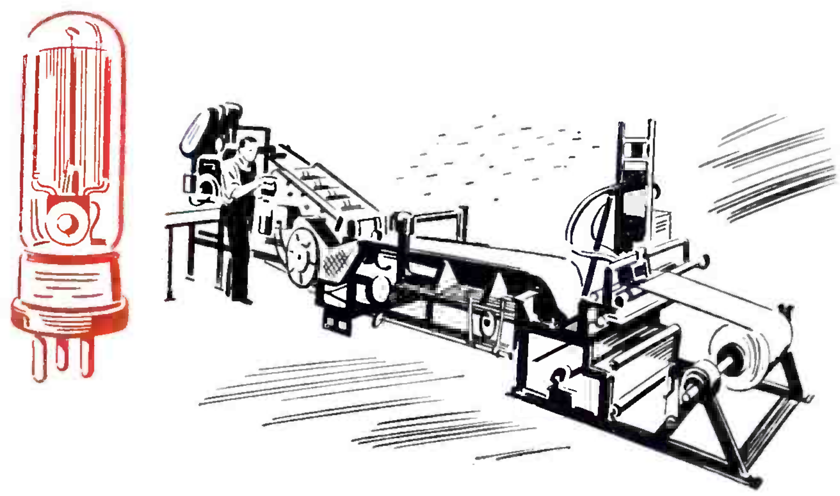
Through the new and improved industrial techniques it makes possible, electronic science is helping America to win its wartime production battles. Here are some of the scores of important ways Westinghouse electronic devices are being used to improve products, speed production, cut costs.



Automatic X-ray Units, built into a conveyor line, speed inspection of vital aircraft castings in a midwest plant. Controls for the units are interlocked with the conveyor drive. When the parts are positioned beneath the x-ray unit, a protective hood lowers, exposure is made, the hood rises and parts pass on. Operation is continuous and largely automatic.

The Stroboglow Lamp makes rapidly rotating objects appear to "stand still". Electronic tubes deliver a light flash each time the object reaches a given point in its motion cycle. Through "persistence of vision", the image is carried over to the next flash, making the rapidly rotating object appear as though standing still—so its operating characteristics may be studied.

Faster Than Lightning is no exaggeration in describing the Westinghouse Electronic Oscillograph. By means of cathode ray tubes, it records electrical phenomena at speeds of *1/100 of one-millionth of a second*. Widely used in studying methods of power line protection, it is now being used to provide important data on internal combustion engine performance.



Electronic Register Regulators accurately control the register in the cutting of paper. A beam of light from a phototube, directed at the paper web, detects even the slightest out-of-register condition, causing the regulator to operate, bringing the paper back into perfect register with respect to the printed material. Thus waste due to improper printing is eliminated.

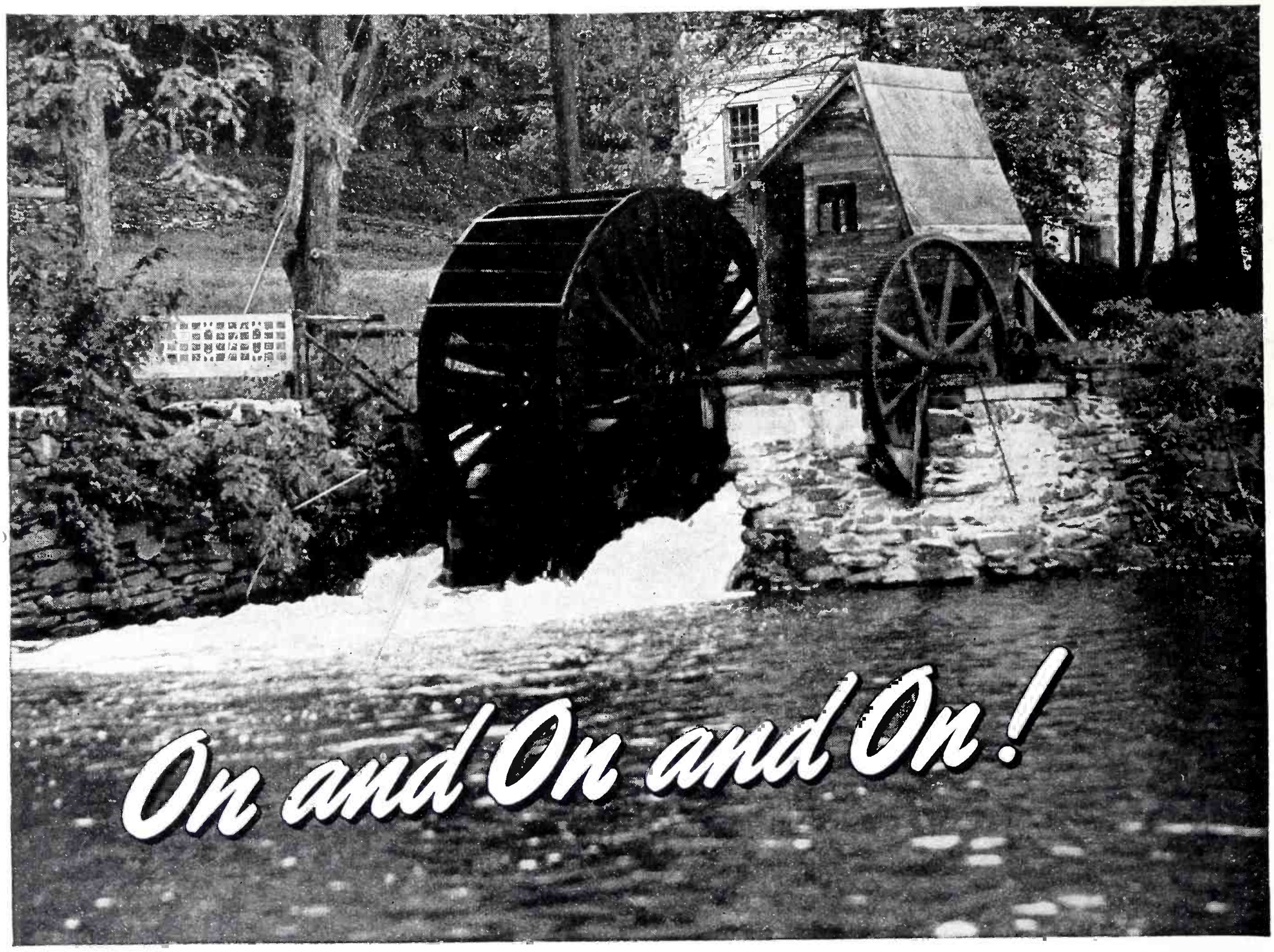
J-91032-A

For further information on Westinghouse "Electronics At Work", write for Booklet B-3264. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

WESTINGHOUSE

Westinghouse ELECTRONICS

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE



Long, uninterrupted service is called for in a capacitor and to fulfill that requirement three things are necessary:—intensive experience . . . advanced engineering . . . rigid production standards. This combination has given Tobe Capacitors a proud record, with almost complete absence of "returns."

The Tobe Oil-Mite Capacitor, shown here, has consistently lived up to an established reputation for long life. This capacitor, impregnated and filled with mineral oil, is most carefully made and most conservatively rated. It is performing day-in, day-out duty as a filter condenser in war equipment. Inquiries in connection with your condenser problems will receive our prompt attention.

LONG LIFE ASSURED

CHARACTERISTICS OF TOBE OIL-MITE CAPACITORS

STANDARD CAPACITY TOLERANCE.	= 10%
TEST VOLTAGE..............	Twice D.C. rating
SHUNT RESISTANCE...........	.05 to 0.1 mfd. 20,000 megohms. .25 to 0.5 mfd. 12,000 megohms. 1.0 to 2.0 mfd. 12,000 megohms
RATINGS....................	.05 mfd. to 2.0 mfd. 600 V.D.C. .05 mfd. to 1.0 mfd. 1,000 V.D.C.
GROUND TEST..............	2,500 Volts D.C.
POWER FACTOR.............	At 1,000 cycles—.002 to .005

TOBE DEUTSCHMANN CORP.
TOBE
CANTON · MASSACHUSETTS

A SMALL PART IN VICTORY TODAY
A BIG PART IN INDUSTRY TOMORROW

"CONSTANT AS THE PLANETS IN THEIR ORBITS"

If you are a manufacturer of controls . . . or, if you are giving consideration to the manufacturing opportunities in this field, here is an announcement of importance to you.

The successful application of electronic principles to the problem of control, as exemplified by the Thordarson Flashtron, has resulted in lightning-fast action (and hence extreme accuracy) giving new meaning to the word control itself.

The Thordarson Flashtron is not a complete control "system". But it is literally the electronic "heart", around which may be designed a control set-up making full use of several years of intensive research pointed towards one objective . . . ±O tolerance in regulating temperature, pressure, flow, speed, frequency, light, and a host of other factors involved in almost every field of human endeavor.

The Thordarson Flashtron is not "new" in the sense of being merely a unit fresh from the laboratory, without practical usage to back up its claims. On the contrary, the Thordarson Flashtron has served as the heart of control systems operating in widely diversified fields, for a number of years. It has not only proved its uncanny precision characteristics, but it has also demonstrated its ability to achieve results heretofore thought impossible, with continuous dollar and cents savings to the user over a long period of time.

We invite interested manufacturers to write for descriptive folder today.

ARMY E NAVY

THORDARSON

ELECTRIC MFG. COMPANY
500 WEST HURON STREET, CHICAGO, ILL.

"Transformer Specialists Since 1895"

CONTACT PRESSURE LIFTS 15 TIMES THE RELAYS' WEIGHT!

DUNCO'S LITTLE GIANT OF THE RELAY FIELD

Ordinary relays weighing, say, one pound, may give a contact pressure of 3 or 4 ounces.

By comparison, the Struthers-Dunn Series 61 D.C. Relays give 7 *pounds contact pressure in a unit weighing only 8 ounces!* Moreover, these famous Dunco "Nutcrackers" are especially designed to withstand shocks and vibration, and to operate faithfully without an enclosure in dirty or dusty places.

Although designed for D. C. use, their contacts will also handle A.C. They are supplied in various single and double pole types and are specifically recommended for any low-voltage d-c service where exceptionally strong contact pressure is desirable to secure maximum resistance to shock.

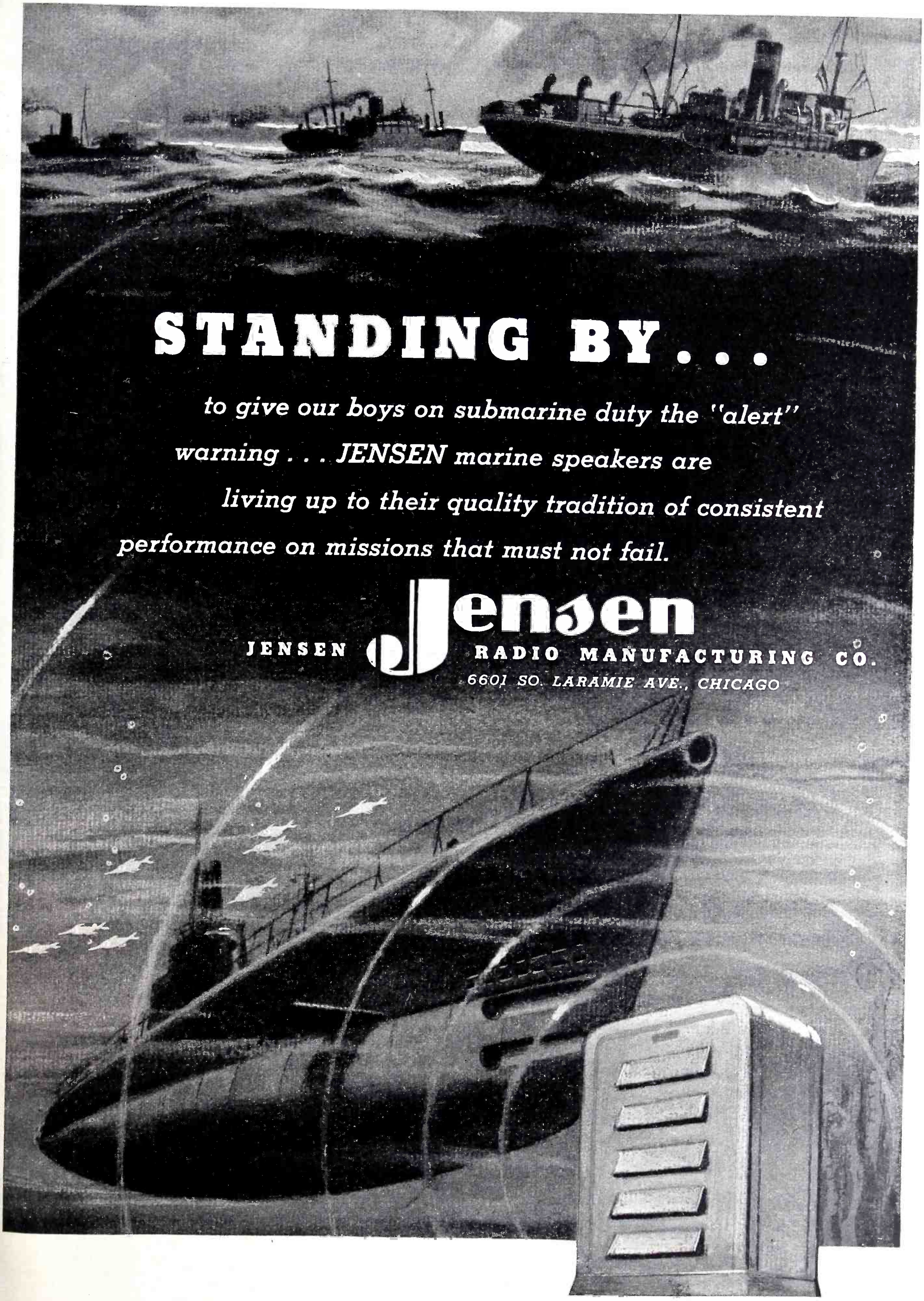
RELAY GUIDE SENT ON REQUEST

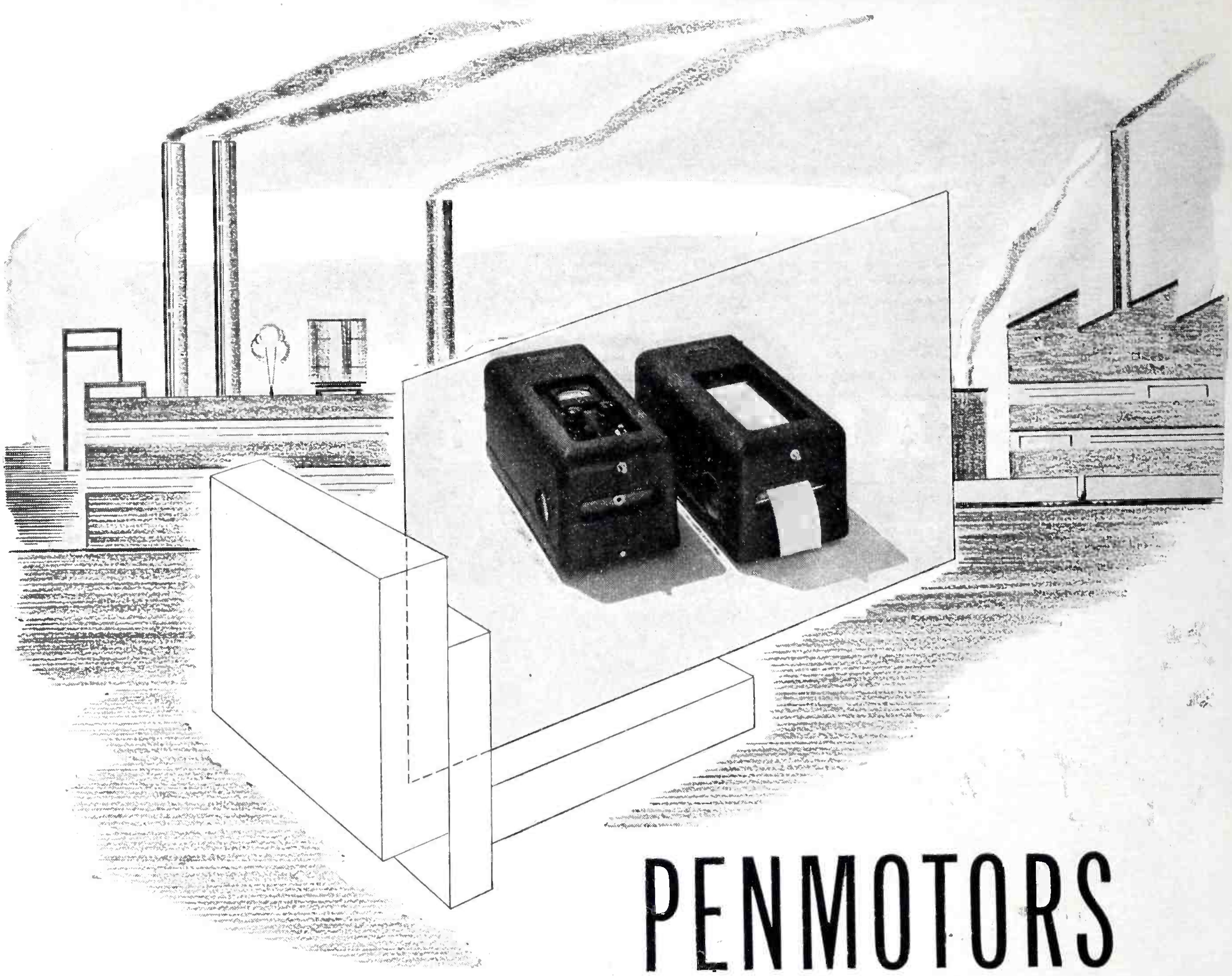
You'll find these Series 61 Relays described on Page 29-F of the Dunco Catalog and Relay Data Book. Copy gladly sent on request to interested users.

STRUTHERS-DUNN, Inc.

1321 ARCH STREET, PHILADELPHIA, PA.

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


STANDING BY...
to give our boys on submarine duty the "alert" warning . . . JENSEN marine speakers are living up to their quality tradition of consistent performance on missions that must not fail.
Jensen
JENSEN RADIO MANUFACTURING CO.
6601 SO. LARAMIE AVE., CHICAGO



PENMOTORS

for War . . and the Peace to come

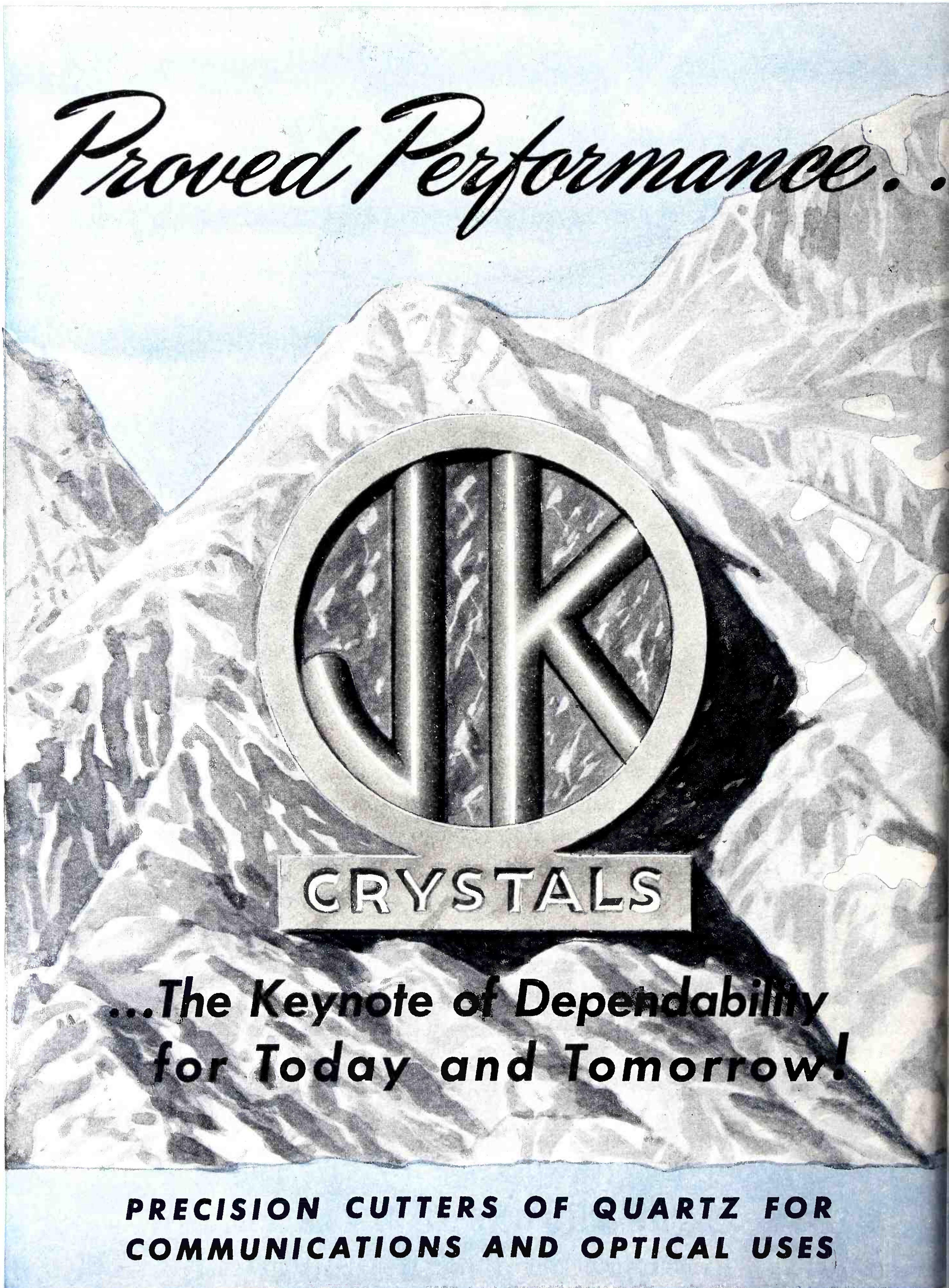
● We continually hear of the exploits of motors in this war. Motors that dart thru space on wings of destruction. There are motors that strain and tug over wild terrain. Motors that lurk in deadly silence far below the ocean's surface or ply through high seas to "deliver the goods". Each has its own job — to do well.

Motors must build motors. These motors must be flawless, smooth-running and precision built. More motors are needed . . . to record vibrations, strains, pressures and smoothness of polished bearing surfaces. This is the job of the penmotor, a small crystal that drives the recording pen of the Brush Direct Inking Oscillograph. It is designed to insure precision in war and the peace to come when motors will be built for construction not for destruction.

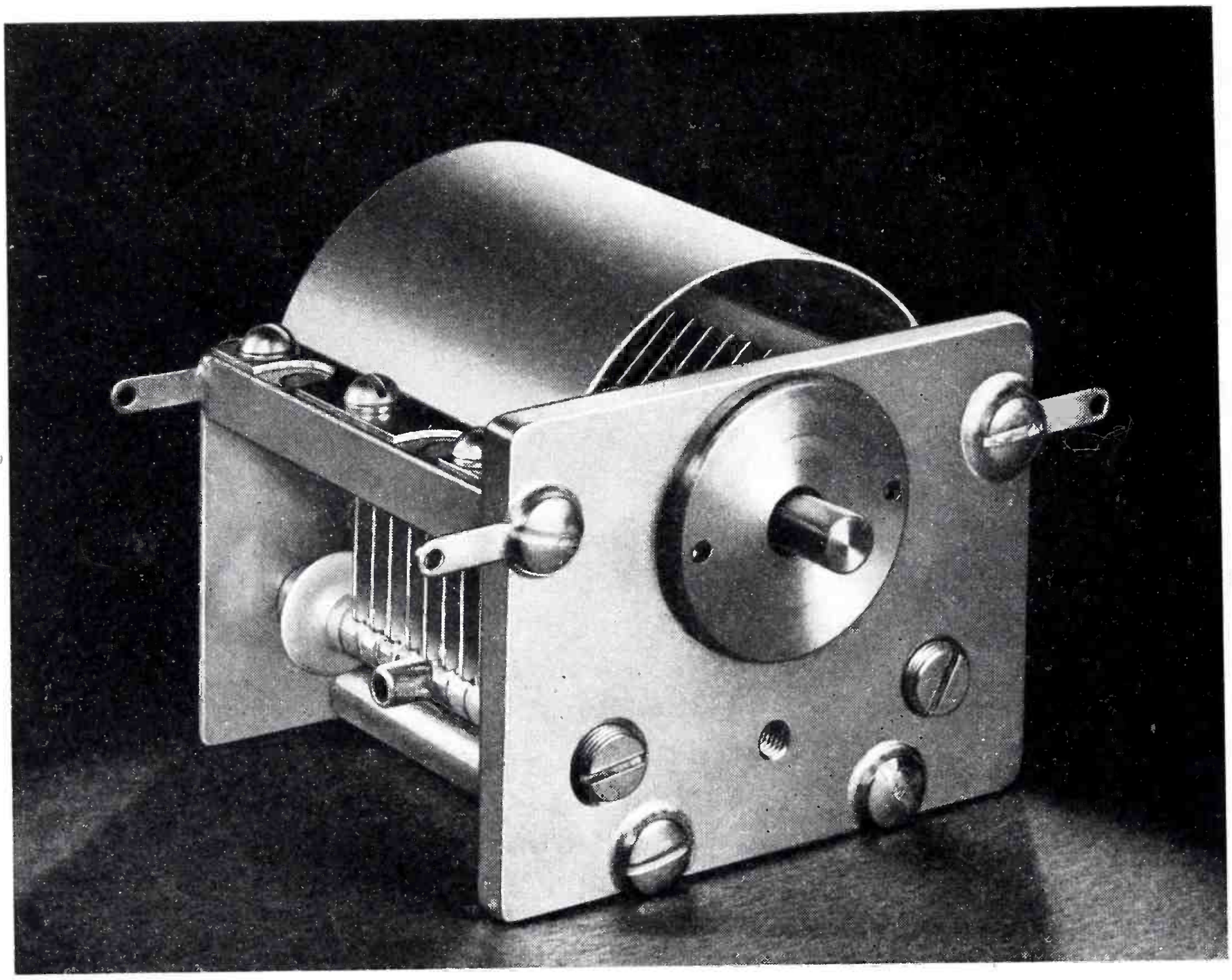
THE BRUSH DEVELOPMENT COMPANY

3311 Perkins Avenue • • • Cleveland, Ohio

BRUSH CRYSTAL PRODUCTS


Proved Performance...
CRYSTALS
...The Keynote of Dependability for Today and Tomorrow!
PRECISION CUTTERS OF QUARTZ FOR COMMUNICATIONS AND OPTICAL USES

CONDENSER TROUBLE?



Perplexing Problem Solved!

IN THE YEARS we have spent designing and building variable condensers we have learned that a great many equipment limitations can be overcome by proper condenser design. Our engineering and laboratory facilities are available to work out *YOUR* condenser problems regardless of the technicalities involved.

THE SIGN OF QUALITY IN RADIO

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

HAMMARLUND

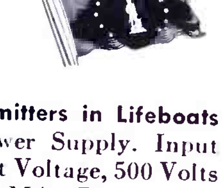
SH-H-H-H! THE ENEMY IS LISTENING!

● Sailors at sea couldn't listen to their favorite radio programs until one of our foremost radio manufacturers was commissioned to build a special sea-going receiver. It was found that ordinary radios "rebroadcast" and tipped off the ship's location. And without any radio, morale suffered.

Now, it's different! Sailors around the world are listening to radio programs from home through this low-radiation receiving set. The speed with which it was produced and put in service is a tribute, in part, to the *E·L* engineers asked to provide a suitable power supply. They did it—fast, and well.

This is just one of the many contributions to America's war effort which *E·L* research and specialized knowledge of vibrator power supplies and electronic circuits has made possible. You'll find *E·L* Vibrator Power Supplies on the job in all types of service, and on every front where the United Nations are fighting.

Wherever electric current must be changed, in voltage, frequency or type, *E·L* Vibrator Power Supplies and Converters offer a wide range of advantages, for peace, as well as for war.



For Operating Radio Transmitters in Lifeboats —E·L Model S-1229-B Power Supply. Input Voltage, 12 Volts DC; Output Voltage, 500 Volts DC; Output Current, 175 MA; Dimensions, 7½" x 5½" x 6¼".

For Operating AC Radio Receivers from DC Current—E·L Model 262 Marine Power Supply. Input Voltage, 110 Volts DC; Output Voltage, 110 Volts AC; Output Power, 250 Volt-Amperes; Output Frequency, 60 Cycles; Dimensions, 10½" x 7⅝" x 8¼".

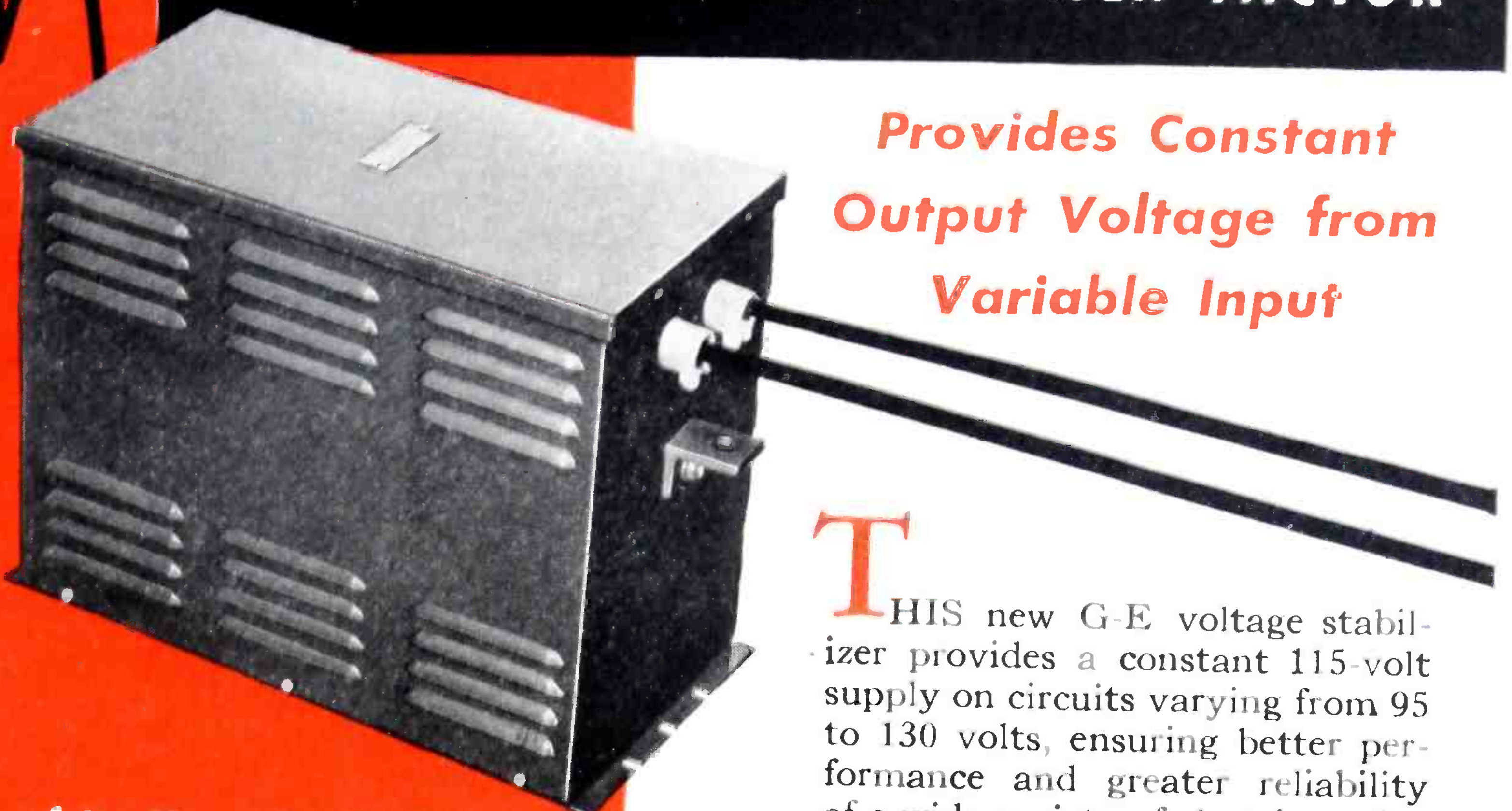
Electronic LABORATORIES, INC.

INDIANAPOLIS

***E·L* ELECTRICAL PRODUCTS**—Vibrator Power Supplies for Communications . . . Lighting . . . Electric Motor Operation . . . Electric, Electronic and other Equipment . . . on Land, Sea or in the Air.


Hide and Seek
..A DEADLY GAME IN RADAR!
When the bombardment of radio pulsations contacts a foreign object—whether it is in the air, or on or beneath the surface of the ocean—the recoil of this electronic wave is instantaneous.
More than merely registering the presence of the enemy in size or force . . . RADAR accurately and precisely visualizes distance and range, height or depth of the target. The bombardment that follows is tangible . . . cold steel!
Electronic Enterprises power and transmitter tubes are an integral part of the strategic and communications systems of our military forces. Ingenuity of design, 'know-how' in engineering, and understanding of the basic problems involved, are all instrumental in the culmination of Victory.
Your post-war involvements will receive comparable research and effort; inquiries are invited.
ELECTRONIC ENTERPRISES, INC.
ELECTRONIC e ENTERPRISES
GENERAL OFFICES: 65-67 SEVENTH AVE. NEWARK, N. J.

HERE'S A VOLTAGE STABILIZER THAT'S INSENSITIVE TO LOAD POWER FACTOR



Provides Constant Output Voltage from Variable Input

THIS new G-E voltage stabilizer provides a constant 115-volt supply on circuits varying from 95 to 130 volts, ensuring better performance and greater reliability of a wide variety of electric equipment. On such circuits, wherever close voltage regulation is requisite to good operation, these stabilizers fill the bill.

Maintenance costs are negligible. This voltage stabilizer is completely automatic, and because there are no moving parts, practically no maintenance is necessary. It is not affected by variations in load from no load to full load or by changes in power factor from unity to 0.8 lagging. Moreover, it will operate continuously throughout the range from open circuit to short circuit without damage.

Wide range of ratings. Ratings from 50 to 5000 va are available; "specials" will be built to order.

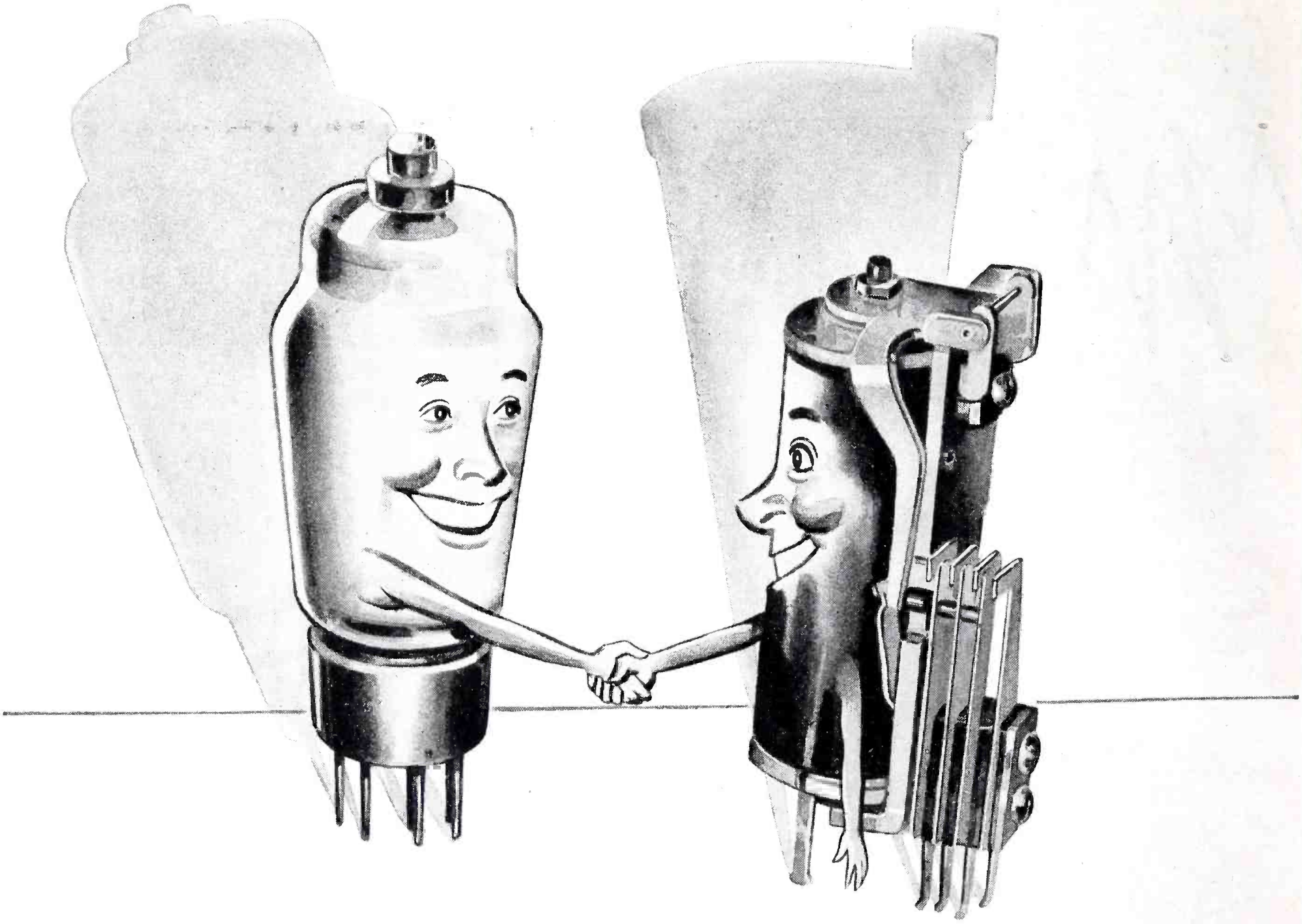
For details on this stabilizer's unique circuit, write for Bulletin GEA-3634. *General Electric Co., Schenectady, N. Y.*

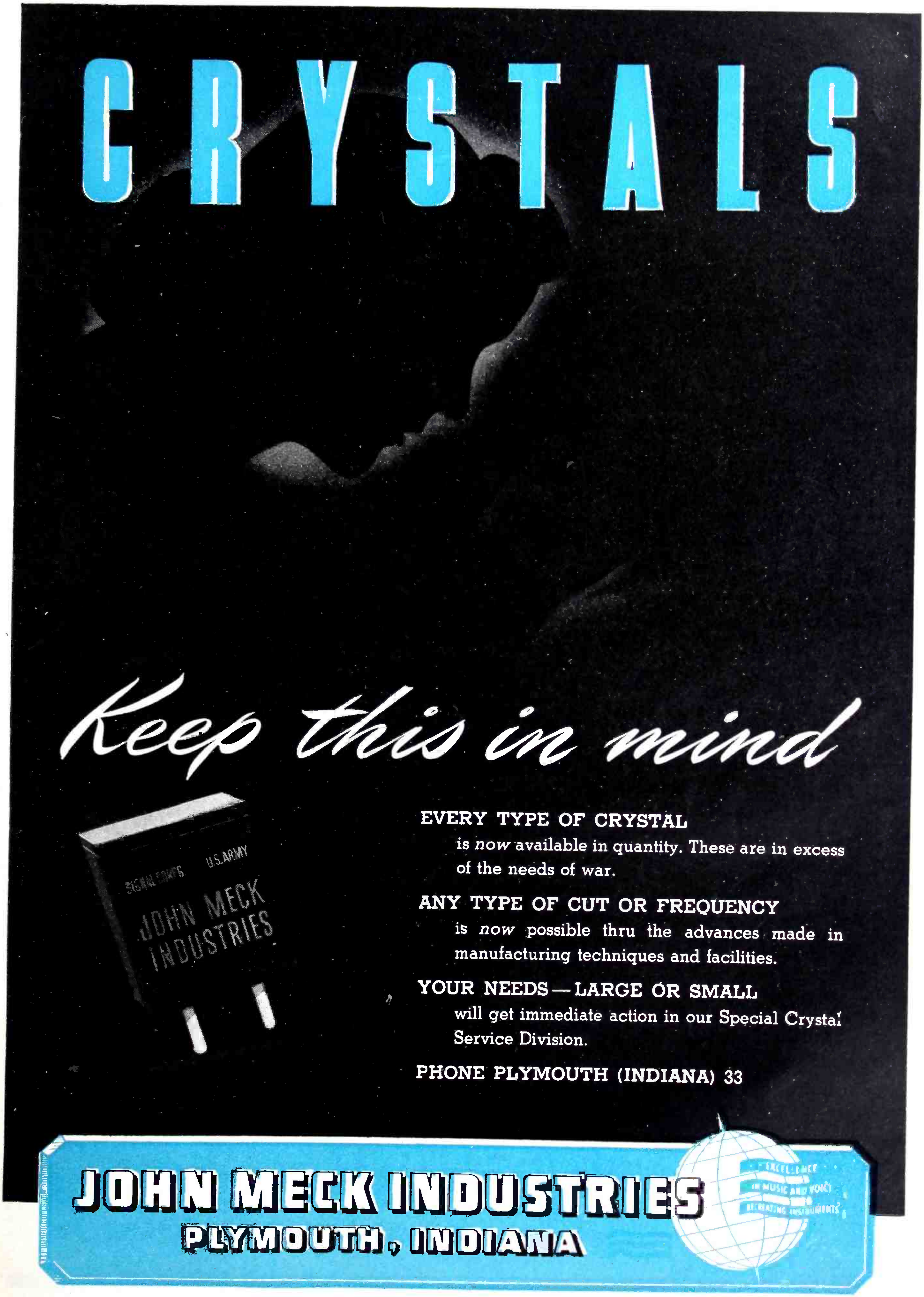
A Few of Its Many Applications:

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

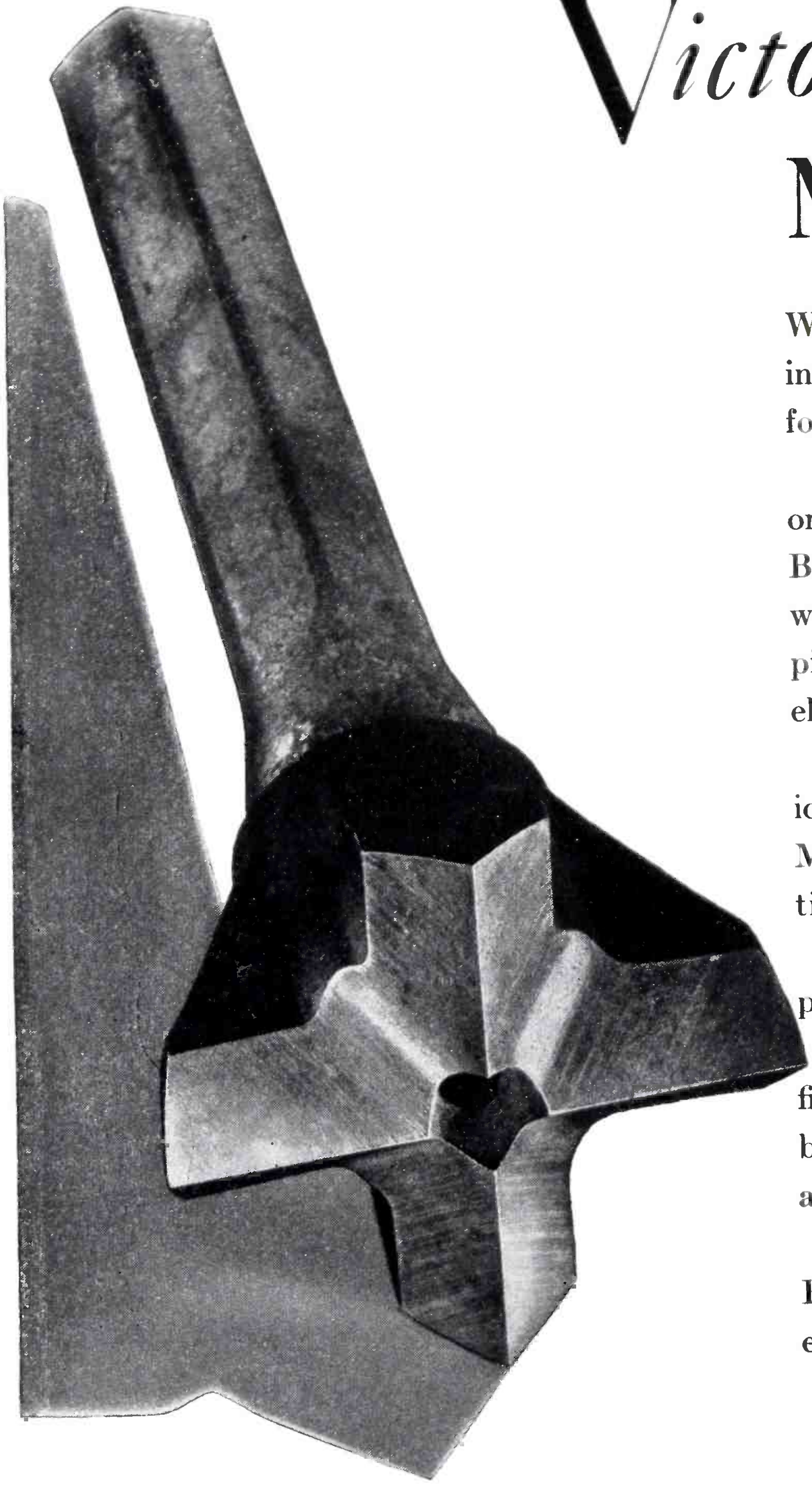
GENERAL ELECTRIC

408-47 5205




CRYSTALS
Keep this in mind
SIGNAL CORPS U.S. ARMY
JOHN MECK INDUSTRIES
EVERY TYPE OF CRYSTAL
is *now* available in quantity. These are in excess of the needs of war.
ANY TYPE OF CUT OR FREQUENCY
is *now* possible thru the advances made in manufacturing techniques and facilities.
YOUR NEEDS—LARGE OR SMALL
will get immediate action in our Special Crystal Service Division.
PHONE PLYMOUTH (INDIANA) 33
JOHN MECK INDUSTRIES
PLYMOUTH, INDIANA
EXCELLENCE IN MUSIC AND VOICE RECREATING INSTRUMENTS


EVERY
TAYLOR TUBE
IS Custom Built!
Individual Treatment Assures Uniform Dependability....
The performance of a high power transmitting tube depends largely on the purity of the metals used. Metals vary — each requires more or less or even different treatment if the utmost in uniform dependability is to be attained. That's why every Taylor Tube is Custom Built!
Individual heating, evacuating, bombarding and flashing must be scientifically perfect to insure a perfect tube. A final "OK" on a Taylor Tube is never given lightly. It is a token of our sense of responsibility. Where tubes get hard service and a chance to be overloaded, it's the Custom Built tube that can be depended upon to "deliver the goods".
Taylor
HEAVY
CUSTOM BUILT
DUTY
Tubes
TAYLOR TUBES, INC., 2312-18 WABANSIA AVE., CHICAGO, ILLINOIS



Victory's ...—
Magic Wand?

When the war is won, and victory is reckoned in terms of its contributors, save a pat of praise for a slender shank of steel—the rock drill.

The rock drill bites off the tungsten-tin ores of Bolivia's Chojlla region, chews out Brazilian zirconia, Cuban manganese, and wrests from our own and many another picturesque land, dozens more of the earth's elements essential to victory.

A considerable tonnage of these rarer, critical ores and minerals finds its way to Foote Mineral Company for grinding, beneficiation, or processing by our chemical division.

Yet our sights are not fixed only on supplying and improving the world's mineral treasures. Every day Foote researchers are finding, or helping others to discover, newer, better ways to put ores, minerals, metals and chemicals to work.

If you are interested to know whether Foote products, processes or research can benefit you, make a point of writing to us today.

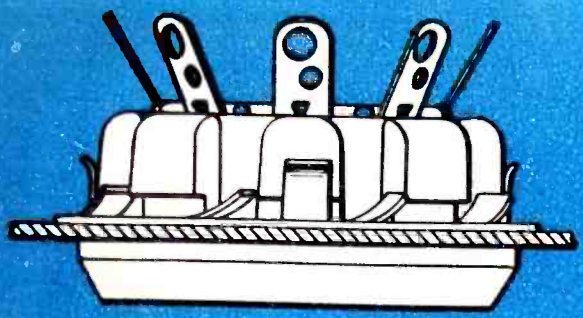
ZIRCONIUM, THE METAL THAT MADE GOOD

Zirconium had long been regarded as an excellent "getter" for vacuum tubes. Trouble was, other more volatile metal impurities were not being removed by manufacturing processes. Foote tackled the job and licked it early in 1942, when the United States sorely needed zirconium. Foote "G" Grade Zirconium Metal was their answer, a pure grade which eliminates rejections for mirroring and leakage, improves tube quality and life, diminishes secondary emission, and makes possible smaller transmitting tubes. To this achievement, Foote now adds Ductile Zirconium which has all the desirable properties of the powder and, in addition, can be machined, formed or welded into structural tube elements. Experimental quantities of Ductile Zirconium sheet, wire, rod are now obtainable. Write for information.

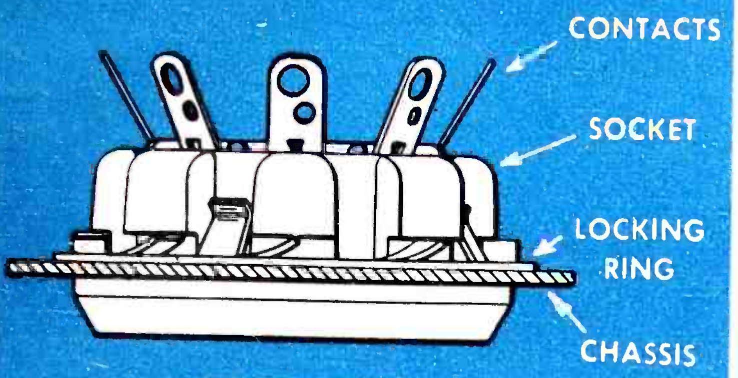
Foote
MINERAL COMPANY

A Step Ahead in Industrial Ores and Chemicals

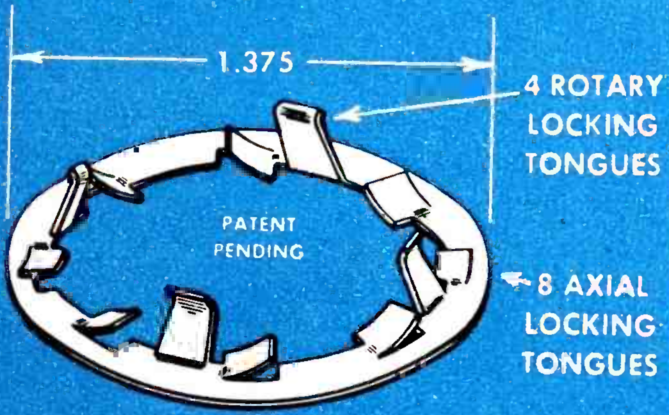
PHILADELPHIA • ASBESTOS • EXTON, PENNSYLVANIA
Home Office: 1617 SUMMER STREET, PHILADELPHIA, PA.
West Coast Representative: GRIFFIN CHEMICAL CO., San Francisco, California
English Representative: ERNEST B. WESTMAN, LTD., London, England



LOCKING RING IN
UNLOCKED POSITION



LOCKING RING
IN LOCKED POSITION

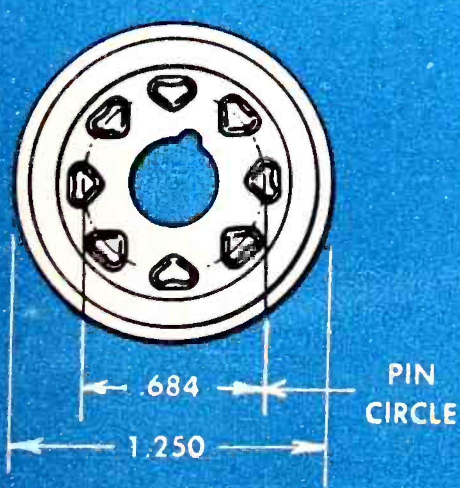


NEW TYPE LOCKING RING

Assures POSITIVE LOCK to Chassis.

1/8 turn with simple tool
permits assembly or removal

Assembly part No. 65-3



OCTAL CERAMIC SOCKET

Assembly part No. 65A-1

Grade G Steatite body

Phosphor Bronze, Silver
Plated, Contacts

THE NEW FRANKLIN LOCKING RING is much more than a labor saving device. In addition to its labor saving feature it assures a POSITIVE LOCK of components to chassis.

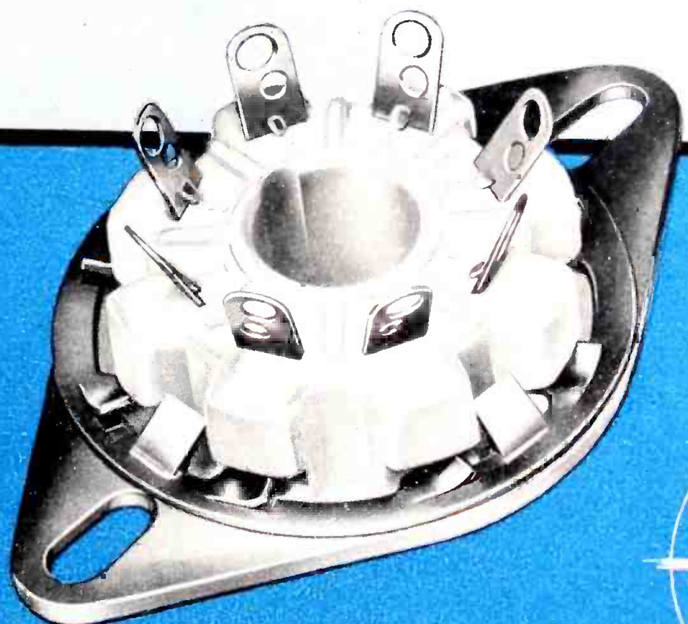
The Franklin Locking Ring fits between the chassis and the component to be locked; a simple tool is placed over the component and a 1/8 inch turn of the tool, by wrist action, does the locking — a further 1/8 inch turn does the unlocking.

While the Franklin Locking Ring was developed to lock sockets to chassis for the Radio and Electronic industries the use of this Locking Ring need not be confined to this work. The Franklin Locking Ring can be applied throughout industry, wherever components need to be locked to parent bodies.

Illustrated are various features of the Franklin Locking Ring.

A. W. FRANKLIN MANUFACTURING CORP.

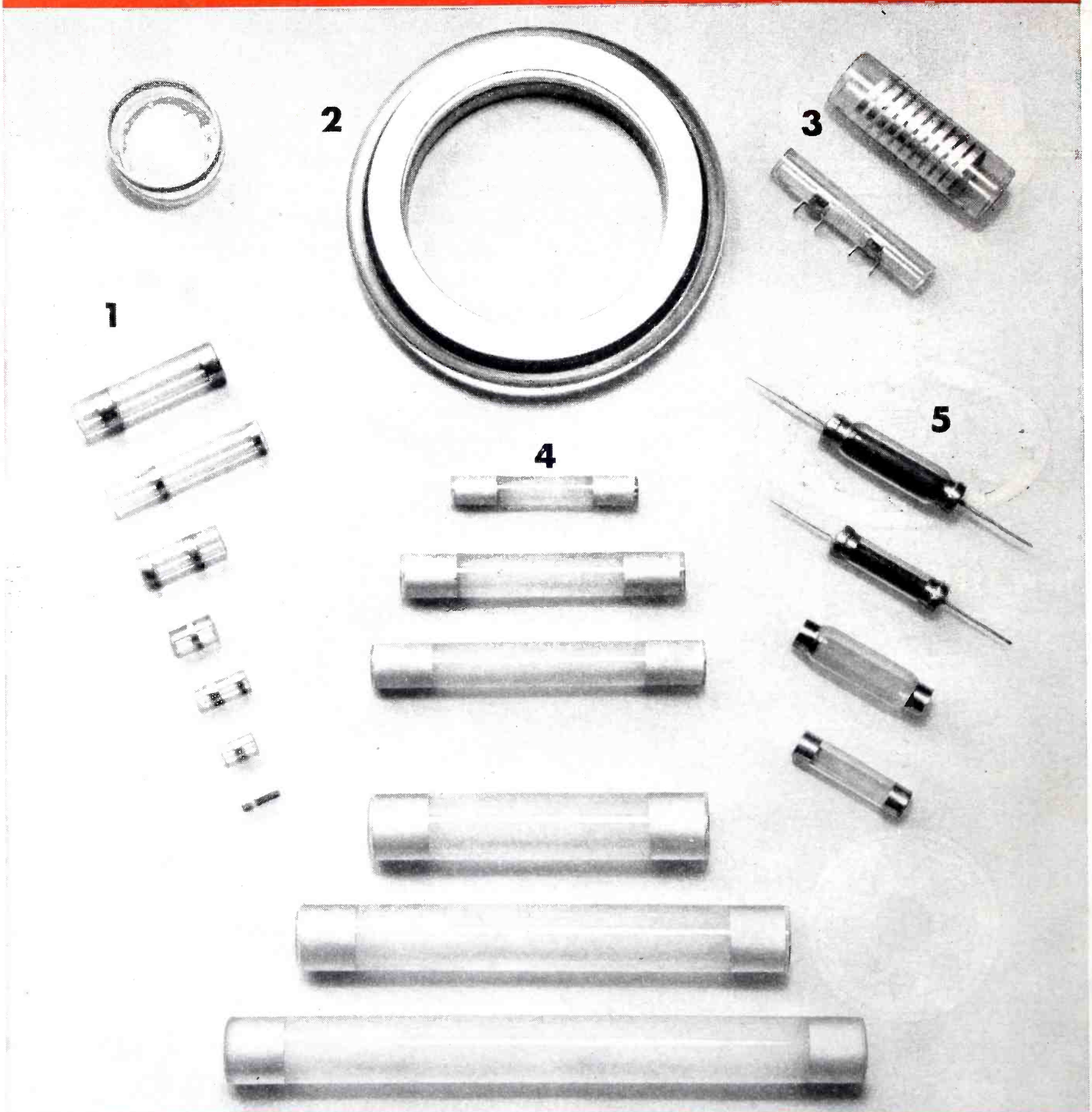
175 VARICK STREET, NEW YORK 14, N. Y.



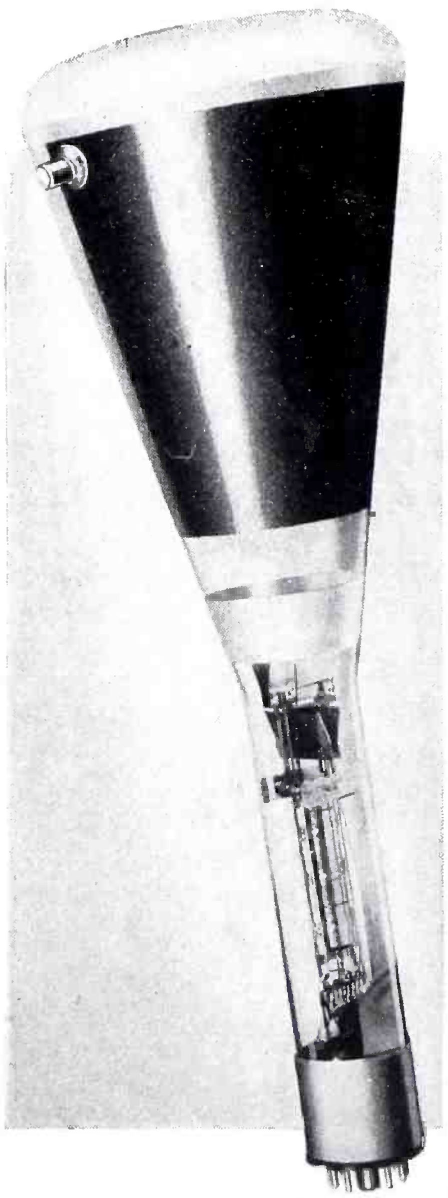
The one piece Ceramic Socket, illustrated, has been designed to embody the Franklin patented Bow Spring Action Contact. This Contact is a feature of Franklin Sockets which enjoy such favor throughout the Radio industry.

CORNING GLASS
RESEARCH
ANNOUNCES
NEW

HERMETIC



1. Radio Apparatus Bushings. 2. Ring Insulator. 3. Coil Forms. 4. Envelopes for Condensers and Power Resistors. 5. Small Envelopes for Condensers and Resistors.



Their guns were loaded and aimed...yet

ELECTRONICS FIRED THE FIRST SHOT

On Sunday, November 8, in North Africa, the sound which broke the peaceful stillness of that eventful night was not the booming of allied guns, nor the throbbing engines of countless landing barges. It was a VOICE—the friendly voice of the President of the United States saying "We come among you to repulse the cruel invaders—Have faith in our words—Help us where you are able."

At many points where our boys landed along the North African coast there was little, if any, resistance because electronics had already won the day. By short wave radio America's motives had been made clear. Days of fighting were avoided. Thousands of lives were saved.

Distinguished service on many fronts has won the electronic tube a place among the great weapons of modern warfare. Yes, electronic tubes can *fight!* And to supply these fighting tubes for our fighting forces the men and women of National Union have doubled and *redoubled* production. We know the day is coming when these tubes and the knowledge which builds them will be reconverted to the needs of peace. In National Union's plans for this new age of electronics, there is to be a comprehensive industrial service . . . to aid engineers and production men in applying the miracle of electronics to their production, testing and packaging processes. Today, to the extent that present war work will permit, National Union invites consultation with producers of war goods regarding their electronic tube problems.

NATIONAL UNION RADIO CORPORATION • NEWARK, NEW JERSEY • LANSDALE, PA.

NATIONAL UNION

RADIO AND ELECTRONIC TUBES

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

PLUG PL-55 JACK JK-26 JACK J-310 JACK JK-34A

For more than 46 years the products of the Chicago Telephone Supply Company have been the standard for high quality workmanship. From their inception in the engineering laboratories to the craftsmanship of the finished article, Chicago Telephone Supply products are planned for maximum performance and trouble-free long life. If you are a manufacturer of electronic equipment—all of the engineering skill and great production facilities of Chicago Telephone Supply Company are at your service.

Plugs, Jacks, Switches, Variable Resistors

Telephone Generators and Ringers

CTS

Representatives
R. W. Farris
127 E. Thirty-first St.
Kansas City, Mo.
Phone: Logan 0234

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

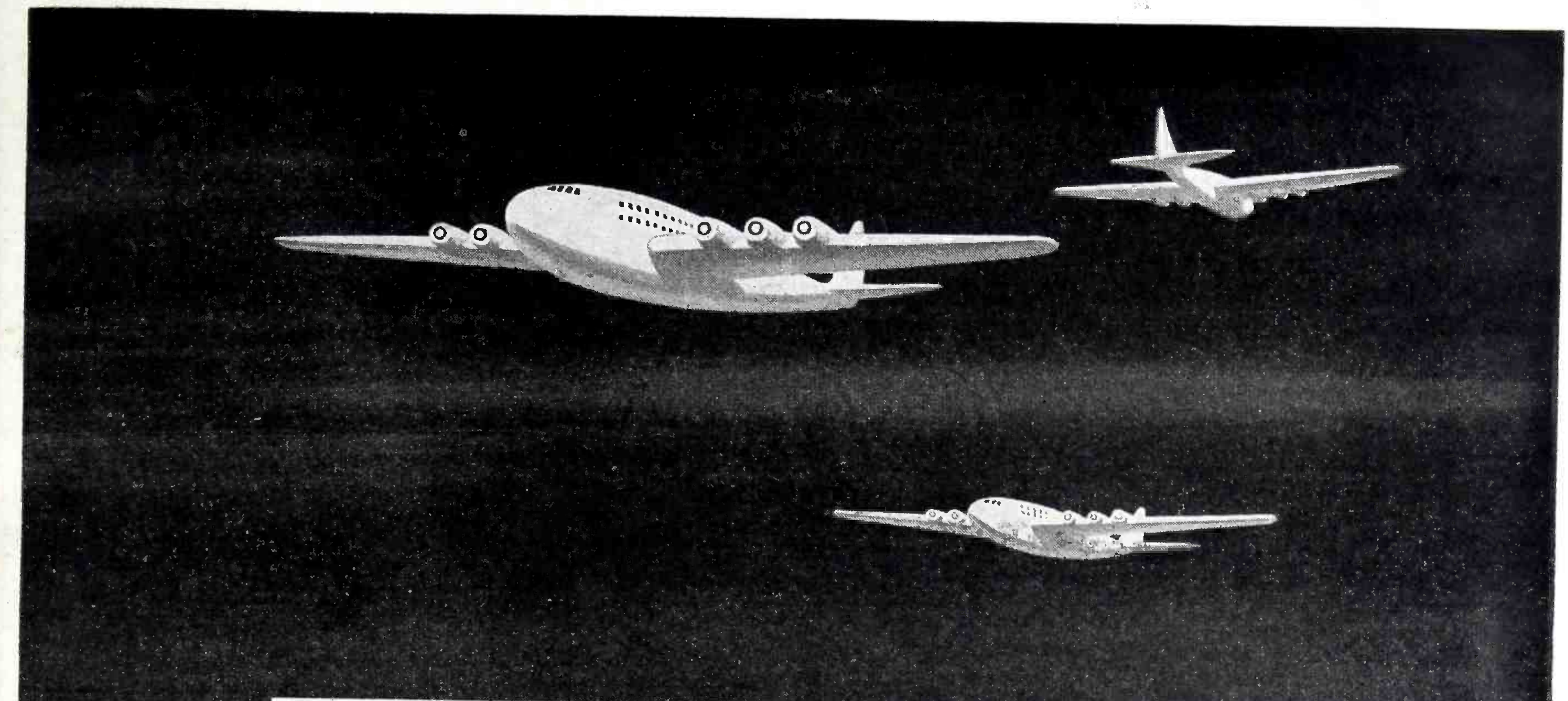
CHICAGO TELEPHONE SUPPLY
Company

Branch Offices
S. J. Hutchinson, Jr.
401 N. Broad St.
Philadelphia, Pa.
Phone: Walnut 5369

In Canada:
C. C. Meredith & Co.
Streetsville, Ontario

ELKHART ★ INDIANA

Manufacturers of Quality Electro-Mechanical Components Since 1896



Crossroads of the world

When Lieut. Commander Richard E. Byrd made his memorable round-trip flight with Pilot Floyd Bennett from Spitsbergen to the North Pole in 1926, his tri-motored Fokker plane carried a short-wave transmitter designed by Ralph M. Heintz, co-founder of Heintz and Kaufman, Ltd.

Two years later Sir George Hubert Wilkins flew a similar transmitter over the Pole while determining the feasibility of establishing weather stations in the Far North, and while proving the efficiency of planes at polar latitudes. Taking off from Pt. Barrow, Sir Hubert crossed the top of the world in a successful 2100-mile flight to Dead Man's Island.

The forecasts of these scientific pioneers are becoming a reality as Great Circle routes to distant countries lead our bombers and transports over Arctic regions. Today an air-minded generation speaks of the North Pole as "the crossroads of the world."

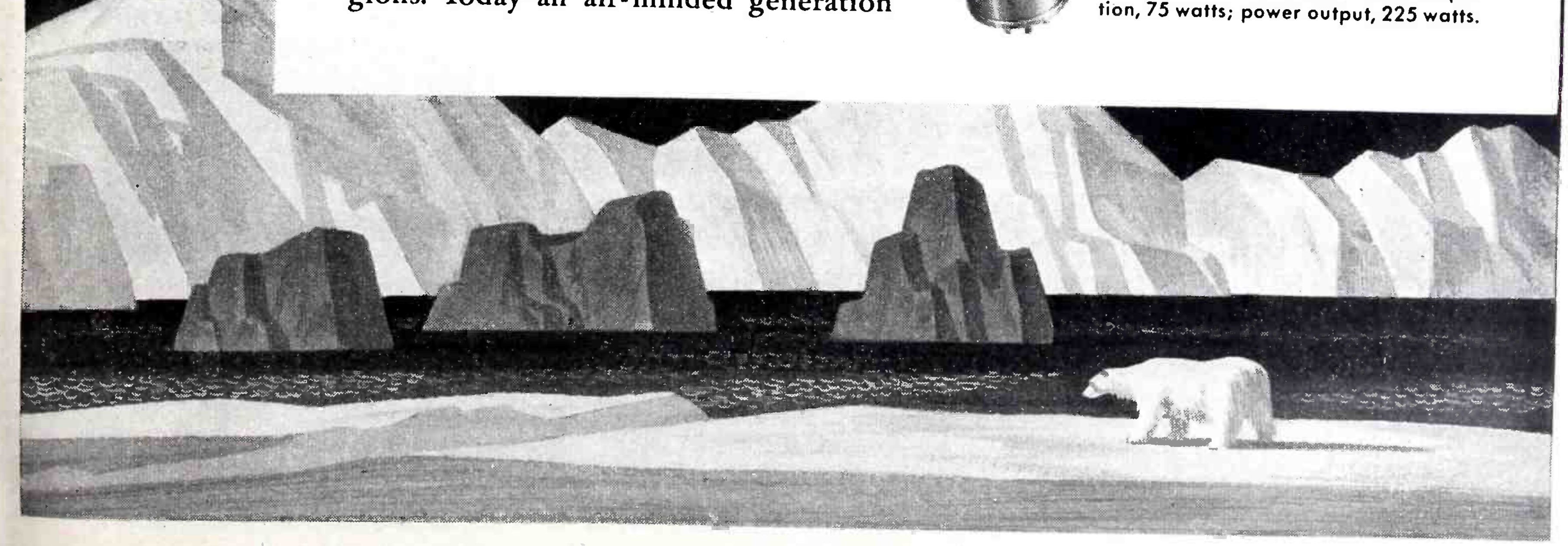
The polar flights of Byrd and Wilkins are part of the heritage of Heintz and Kaufman, Ltd., and are reflected in the many types of Gammatron tubes our engineers have designed especially for aviation transmitters.

In the Heintz and Kaufman plant and in our laboratories, Gammatrons are being ceaselessly perfected to safeguard planes and their crews as they soar over the top of the world.

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

Gammatron Tubes

HK-257—Highly popular Gammatron beam pentode of advanced design, made with tantalum elements. It has high voltage and power capabilities, needs no neutralization even at high frequencies, and requires very low driving power and screen current. Plate dissipation, 75 watts; power output, 225 watts.

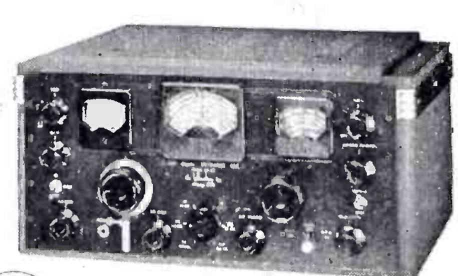


"MY BOY OWNS THIS PLACE!"

Some time ago I retired, just a good, old-fashioned, real-American retirement . . . thought I had served my time and done my share.

When the war started I went back to work . . . a good tool maker can do a lot to help lick those fellows, you know. And it is fun to work for my boy. I'm proud of him and proud of America that makes men like him possible. He had the same start I had only now he owns this shop. And that is one of the things we are all fighting for—to preserve that American FREEDOM of opportunity.

Pardon me, I've got work to do now. When the war's over look me up—on the front porch.



BUY MORE BONDS!

hallicrafters

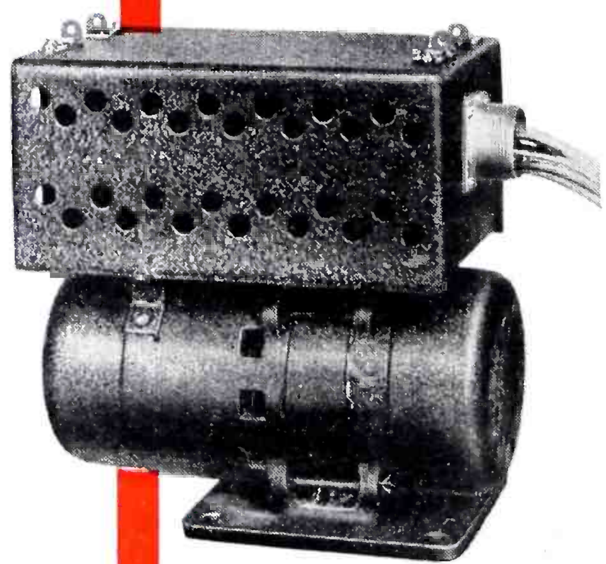
CHICAGO, U. S. A.

"LELAND ELECTRIC REPORTING, SIR!"

"Your order has been executed, sir, and Leland motors, generators, dynamotors, alternators and voltage regulators have reported for duty. Installations have been made and are being made, to power field radio and phone equipment, airplane instruments, automatic pilots, fathometers on ships, etc. Reports received, sir, indicate successful operation on electronic equipment everywhere...on land...on sea...under the sea...and in the air. Any further orders, sir?"

Yes, many Leland designs, some of them exclusively Leland, are serving in all branches, Army...Navy...Air Services...Merchant Marine...Coast Guard. In fact, around 98% of the Leland output is being channeled for war duty—Leland's contribution in time of crisis.

Leland production largely earmarked for armed services, but Leland engineers for consultation on post-war needs immediately available.



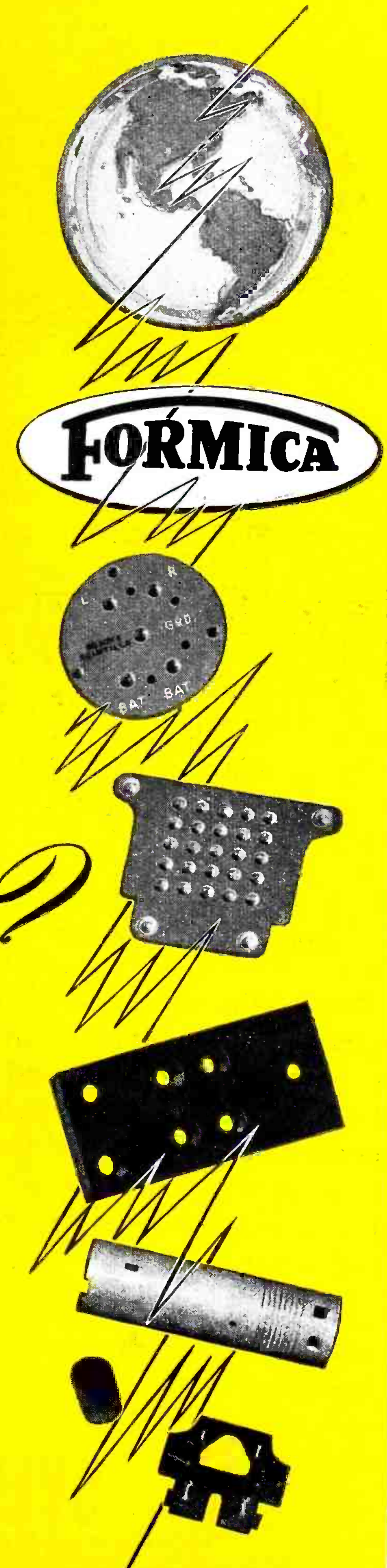
SPECIAL LELAND POWER INVERTER

Leland

WAR DUTY MOTORS

THE LELAND ELECTRIC COMPANY • DAYTON, OHIO

POOR COMMUNICATIONS COST 2000 LIVES



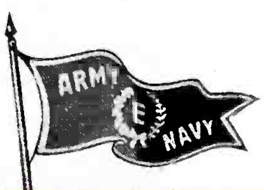
What about Ours Today?

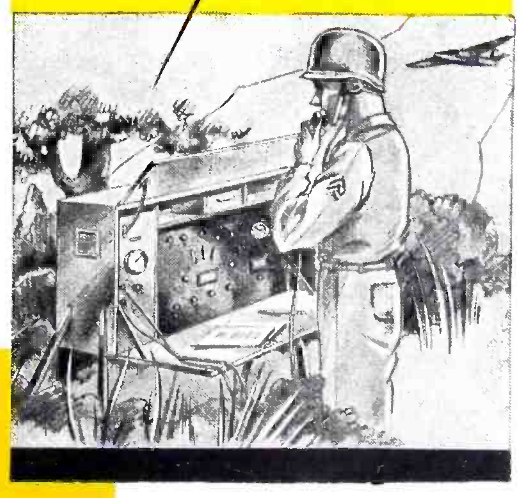
THE unnecessary war of 1812 was declared two days after Lord Castlereagh announced in England that the "Orders in Council" (which caused the quarrel) would be repealed — but the Congress of 1812 didn't get the news in time.

The final battle of New Orleans, costing 2,000 lives, was fought fifteen days after peace was signed at Ghent — but the armies hadn't heard the news.

Today news, propaganda, and battle orders can girdle the globe in a second if communications equipment is functioning perfectly.

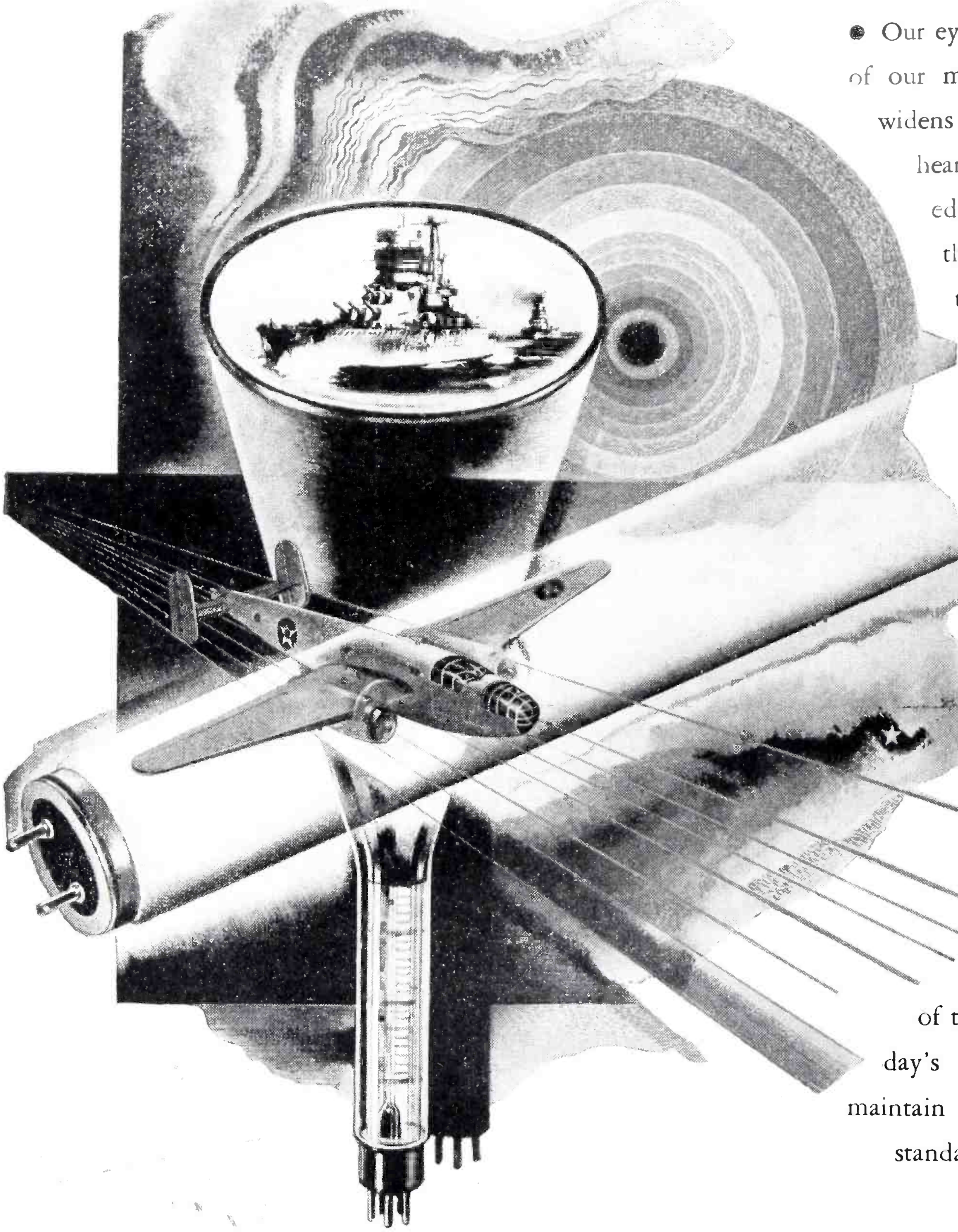
Radio parts made of Formica help civil and military communications function perfectly because of Formica's excellent insulating qualities at radio and audio frequencies. In addition, Formica is light, strong, tough, moisture resistant, and readily machined. A material possessing such properties will have many new uses in the close knit world of tomorrow, some uses in your product no doubt.





THE FORMICA INSULATION COMPANY
4661 Spring Grove Avenue, Cincinnati, Ohio

To see and hear beyond the beyond

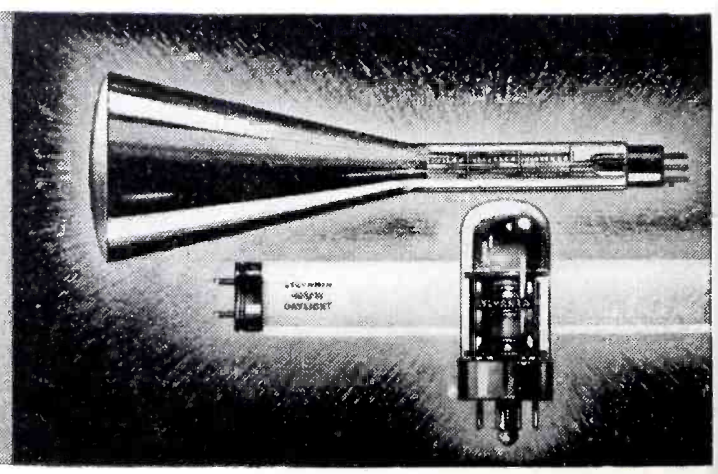


● Our eyes and ears are the advance guards of our mind's march forward. Whatever widens the horizons of human vision and hearing, reveals new vistas of knowledge. So our chosen work for more than forty years has been exploration of uncharted realms of sight and sound. Starting with the humble incandescent lamp, progressing to radio and electronic tubes, fluorescent lamps and equipment, we are today busy with ventures which are contributing vitally to the winning of the war. And important as these may be to Victory, their full flower will come as enduring boons to better living in the years beyond. How could anyone, glimpsing the rich promise of the future, be content to do each day's work with a firm resolve to maintain anything less than the highest standards known!

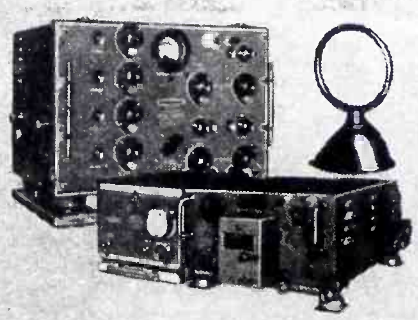
SYLVANIA ELECTRIC PRODUCTS INC., EMPORIUM, PA.

MAKERS OF INCANDESCENT LAMPS, FLUORESCENT LAMPS, FIXTURES AND ACCESSORIES, RADIO TUBES, CATHODE RAY TUBES AND ELECTRONIC DEVICES

VITAL TO VICTORY is the ever-increasing number of electronic devices that miraculously bridge the gap between man and the machine tool in war industry. Electronic contributions to technology make inspection and processing more automatic and foolproof. From long experience, Sylvania has developed and applied electronic tubes to industrial as well as military uses.



"SEEING" through Fog and Darkness



RADIOMEN OF "THE INVISIBLE CREW"

These "Radiomen" have the ability to withstand extreme service conditions due to the painstaking efforts of Bendix Radio Engineers. No detail is too small to escape the grueling tests that insure unfailing performance. Electronic research continually steps up already high performance to exceed every standard previously reached.

BENDIX RADIO

Superhuman Vision with "THE INVISIBLE CREW"

Superhuman range, far into space . . . superhuman penetration, through darkness, cloud or fog . . . this is the electronic "vision" that Bendix Radio, through Radar, gives the pilot of U. S. combat aircraft.

With special electronic devices developed by Bendix Radio, he "sees" what lies ahead. He talks with fellow pilots, and keeps in touch with comrades on the ground. He picks up distant radio stations to guide him on his course.

Daily, as routine practice, he uses Radar and other electronic applications of Bendix Radio too confidential to talk about now. Through these members of "The Invisible Crew" he senses secrets of the future . . . the future that awaits his triumphant return.

More than 25 Bendix plants are speeding "The Invisible Crew" to world battle fronts.

THE INVISIBLE CREW
Precision
Equipment by
Bendix
AVIATION CORPORATION

BENDIX RADIO DIVISION

ELECTRONIC PRECISION PARTS

MACHINED FOR ACCURACY

HAYDU BROTHERS are playing a vital part in the important and strenuous war efforts of the Electronic Industries . . . supplying this field with over twenty-two million precision parts daily.

No matter how large the quantity, how close the tolerance, how impossible the problem, we have always arrived at a solution that saves time, money and materials . . . and waste of time, money or materials is criminal in these war times.

Additional space, extra equipment permits us to serve more clients . . . faster, better, at greater economy. We have the experience, engineering staff, the men and the machines to undertake your difficult problems. Consult us at once.

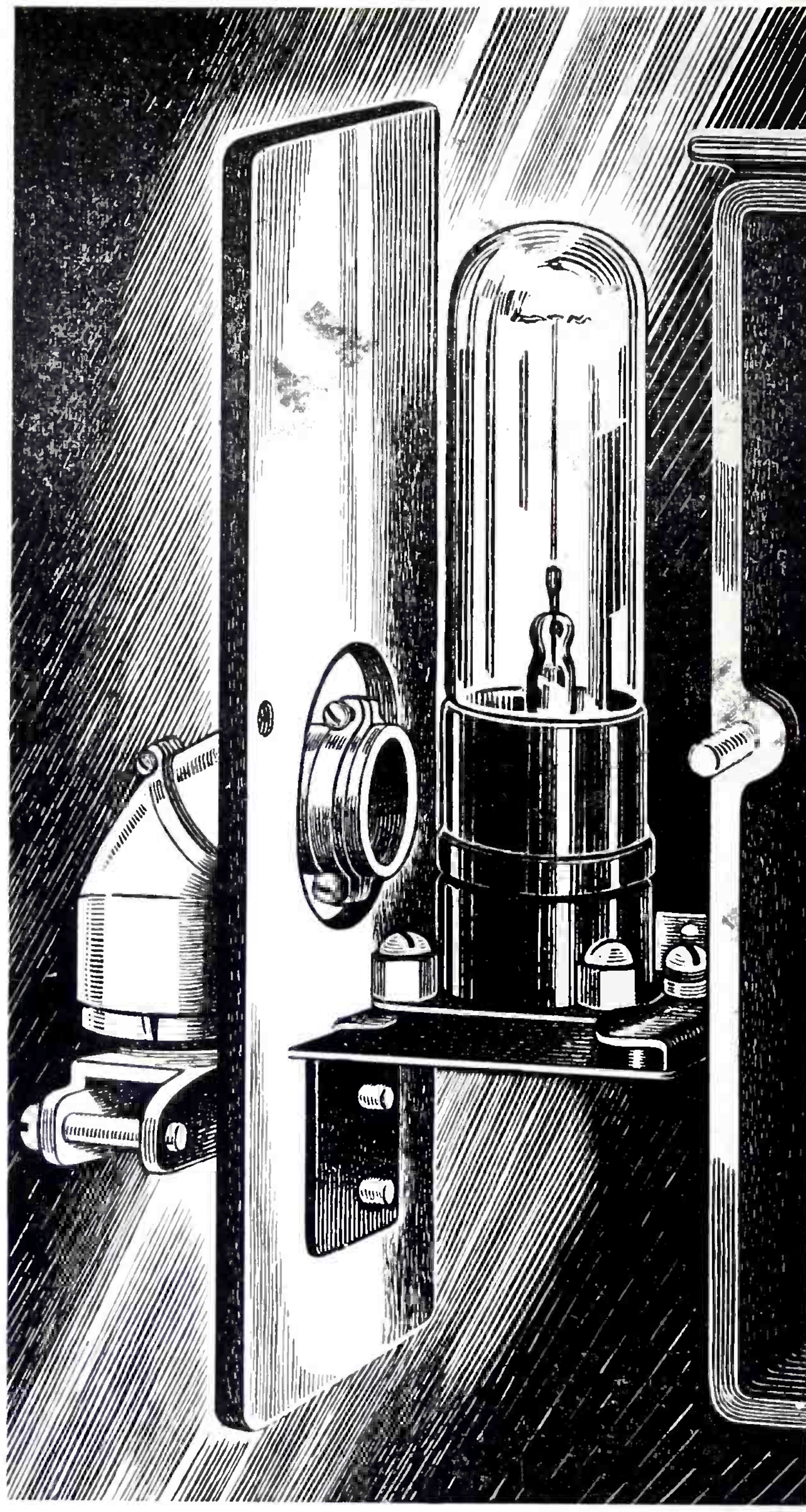
HAYDU Bros.

A MEMBER OF THE RADIO MANUFACTURERS ASSOCIATION

Mt. Bethel Road, Plainfield, N.J.

SPECIALISTS IN BURNER TIPS

TUBE PARTS, WIRE FORMS, METAL STAMPING FOR RADIO, ELECTRICAL, AVIATION AND INSTRUMENT MANUFACTURERS



WE REMEMBER!

. . . it seemed an impossible job, but it was our country asking for help! Raytheon laboratories went on an "all out" basis . . . time went on and there were no "clock watchers." Power tubes for intricate new electronic applications had to be developed immediately and there was no pattern, no precedent to follow. The results depended solely upon the skill of Raytheon's corps of specially trained engineers.

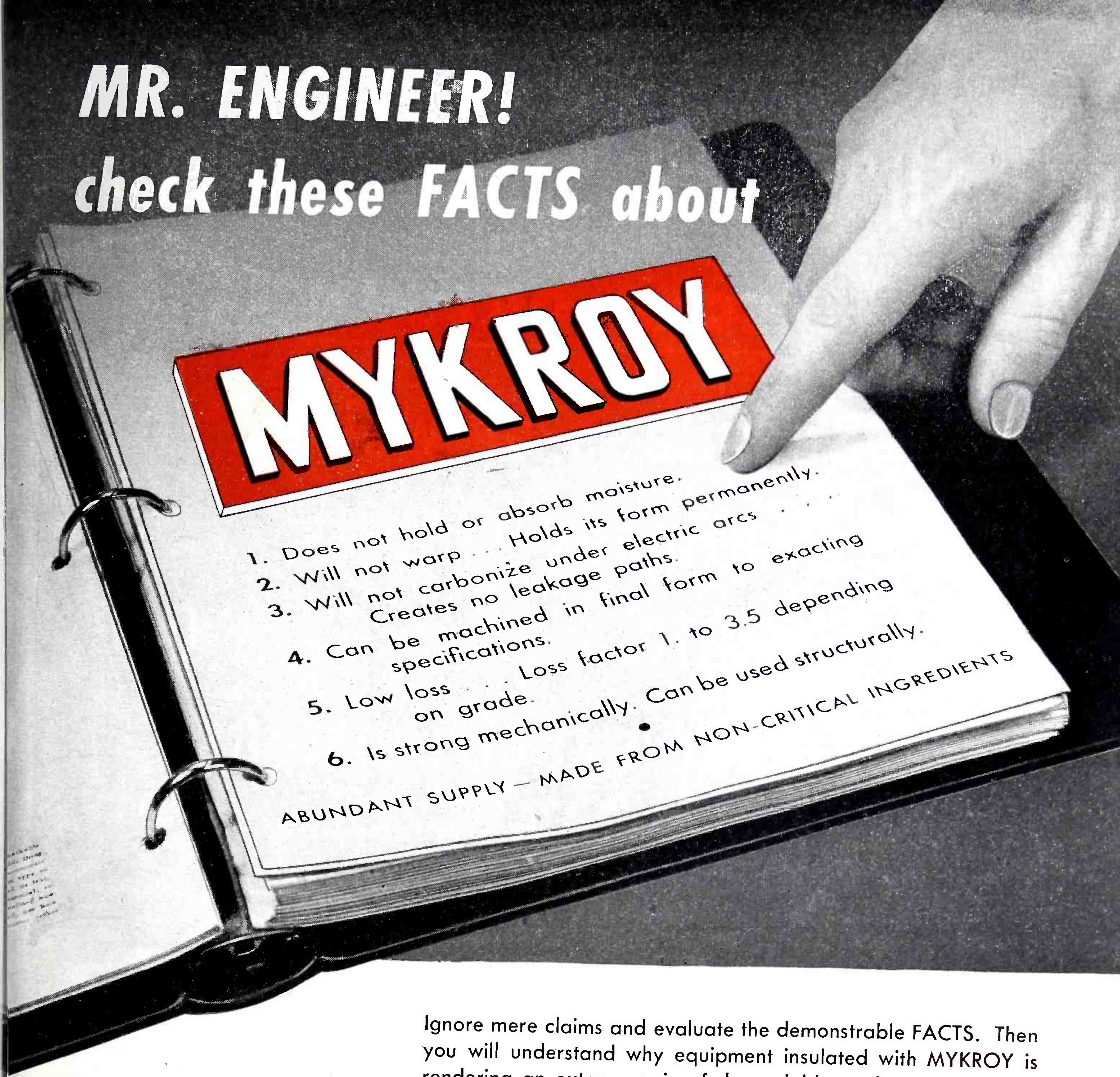
Just how well Raytheon's power tube division has succeeded in delivering these intricately designed tubes in quantities heretofore unknown, is evidenced by the production increases that have enabled Raytheon to be an important factor in the successful operations of our military forces. *Look to Raytheon for your postwar power-tube requirements.*

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

RAYTHEON

Raytheon Manufacturing Company

WALTHAM AND NEWTON, MASSACHUSETTS



TYPICAL EXAMPLES OF MYKROY APPLICATIONS

- Stand-off Insulators
- Variable condensers
- Tube and Crystal Sockets
- Mounting strips
- Structural supports for radio circuits
- Plug-in bases
- Antenna reel insulators
- Insulated couplings
- Relay bases and arms
- Motor generator brush holders
- Padding condenser supports
- High voltage arc shields
- Oscillator circuits
- Fixed condensers
- Impregnated resistors
- Radio frequency coil forms
- Radio frequency panel assemblies
- Radio frequency switches
- Lead-in insulators

Ignore mere claims and evaluate the demonstrable FACTS. Then you will understand why equipment insulated with MYKROY is rendering an extra margin of dependable performance . . . on land, on sea and in the air.

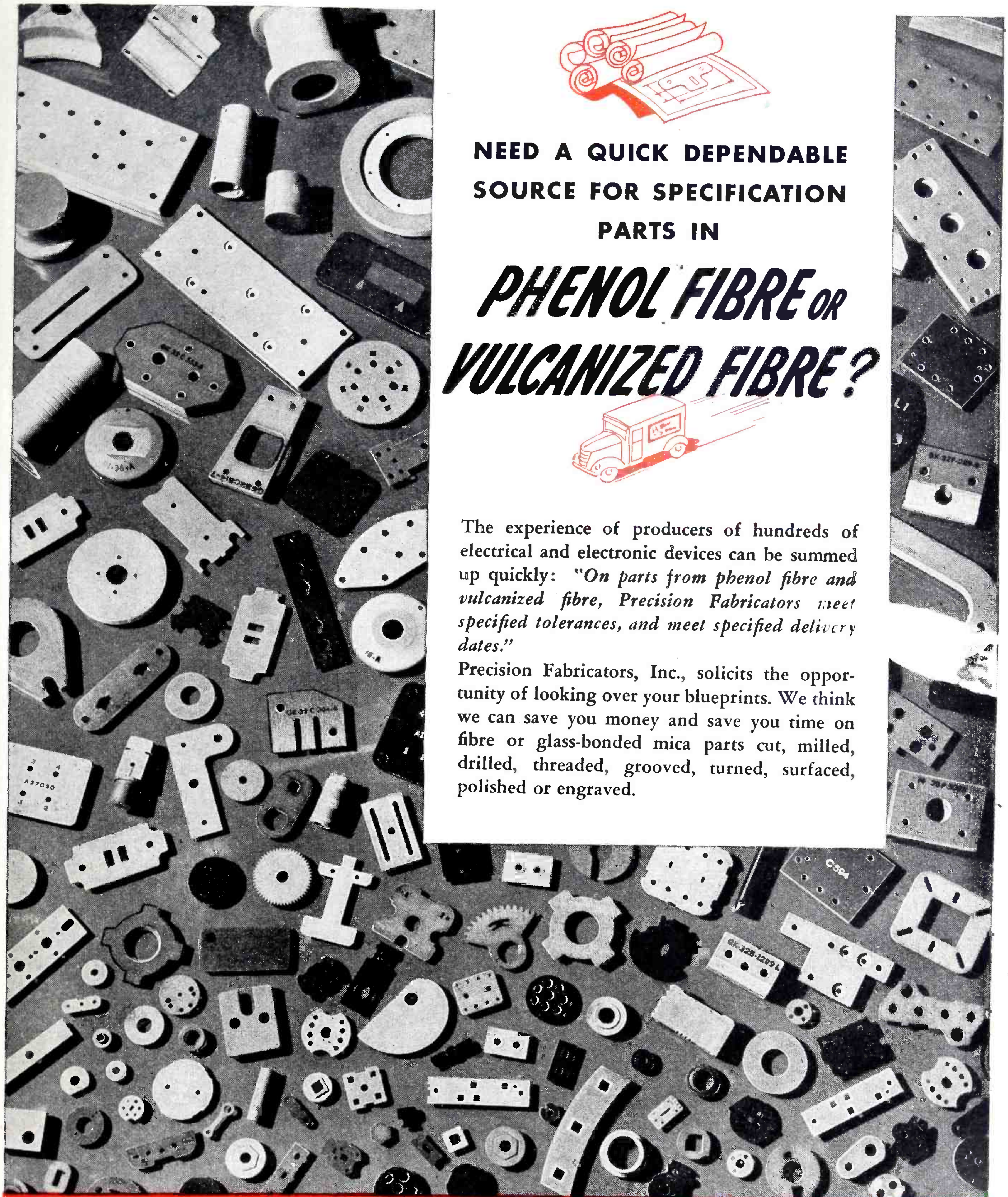
On blazing desert sands, in humid, dripping jungles, amid Grand Banks fog or arctic frost, MYKROY steadfastly retains its fixed electrical and mechanical properties.

With each new advancement in electronics engineering, the standards and requirements for insulating materials become more exacting. MYKROY meets and anticipates these needs. For more efficient insulation today and in the post-war progress of electronics, investigate MYKROY. Write or phone us for detailed information.

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

MADE EXCLUSIVELY BY ELECTRONIC MECHANICS INC.

70 CLIFTON BOULEVARD • CLIFTON, NEW JERSEY
Chicago: 1917 NO. SPRINGFIELD AVENUE . . . TEL. Albany 4310



NEED A QUICK DEPENDABLE SOURCE FOR SPECIFICATION PARTS IN

PHENOL FIBRE OR VULCANIZED FIBRE?

The experience of producers of hundreds of electrical and electronic devices can be summed up quickly: *"On parts from phenol fibre and vulcanized fibre, Precision Fabricators meet specified tolerances, and meet specified delivery dates."*

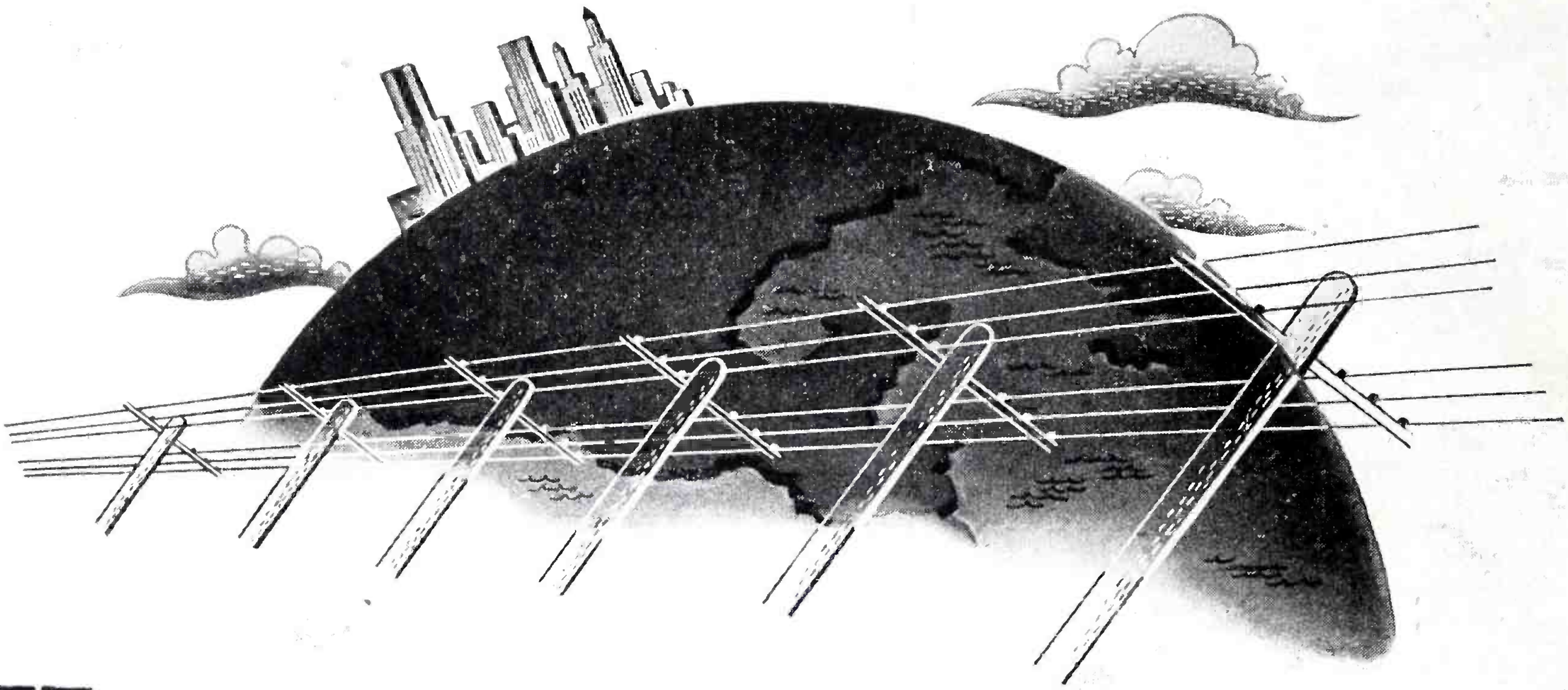
Precision Fabricators, Inc., solicits the opportunity of looking over your blueprints. We think we can save you money and save you time on fibre or glass-bonded mica parts cut, milled, drilled, threaded, grooved, turned, surfaced, polished or engraved.

PRECISION *Fabricators* INC.

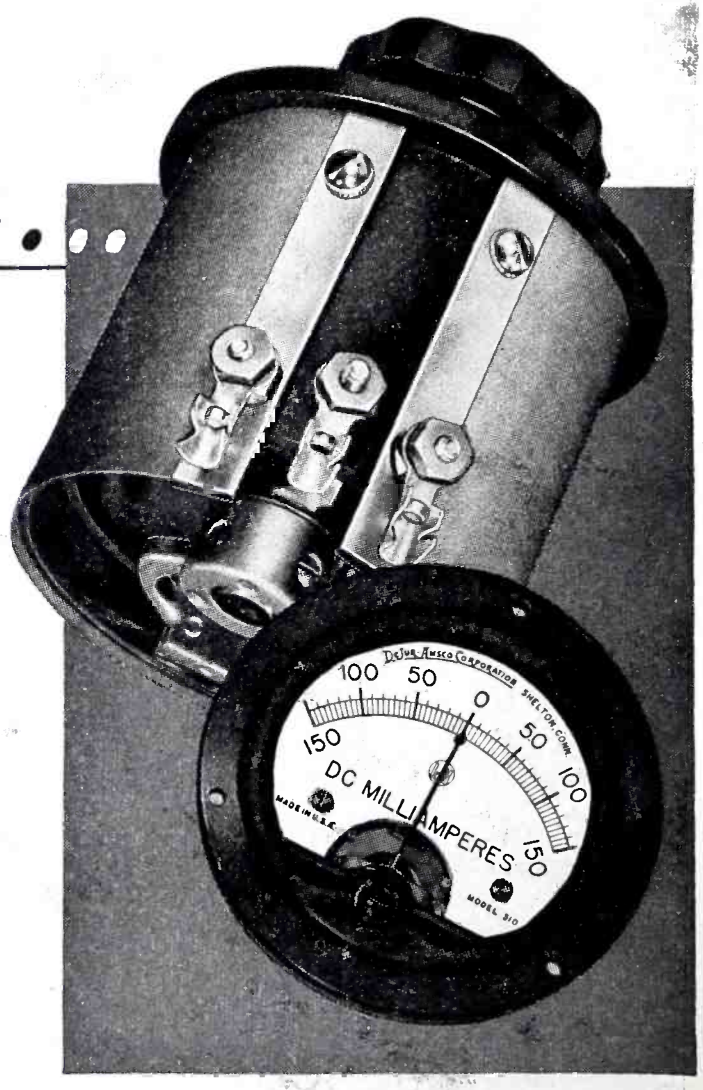
ROCHESTER, N.Y. NEW YORK: 369 LEXINGTON AVE. • DETROIT: 14319 STRATHMOOR AVE. • PHILADELPHIA: 6710 HOLLIS ST.

SPECIFICATION FABRICATORS OF MYCALEX ★ PHENOL FIBRE ★ VULCANIZED FIBRE ★ RUBBER ★ ASBESTOS AND OTHER MATERIALS

ONE OF A SERIES OF ADVERTISEMENTS SHOWING DeJUR PRECISION PRODUCTS IN ACTION ON THE HOME FRONT



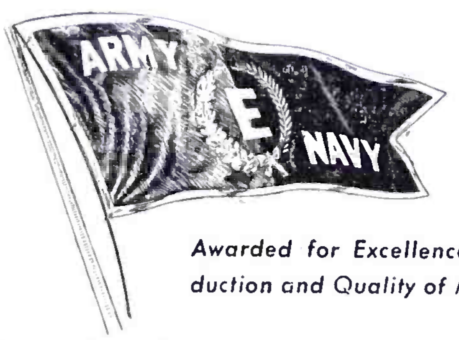
Keeping them open. . . .



Imagine what would happen if the electric power lines in your community broke down as you're reading this. Thanks, however, to the Public Utilities and their vigilant band of crack trouble-shooters, the possibilities are indeed slim.

Aiding in tracking down trouble in power stations, factories, fields, homes and shops are instruments incorporating dependable DeJur Components. Standing faithfully, they have proved their worth in innumerable cases . . . have helped head off disaster, pointed unerringly to the causes of breakdowns, kept lines open and current moving. On the home front as well as the battle front, DeJur Products deliver satisfactory service.

KEEP BUYING
WAR BONDS AND STAMPS



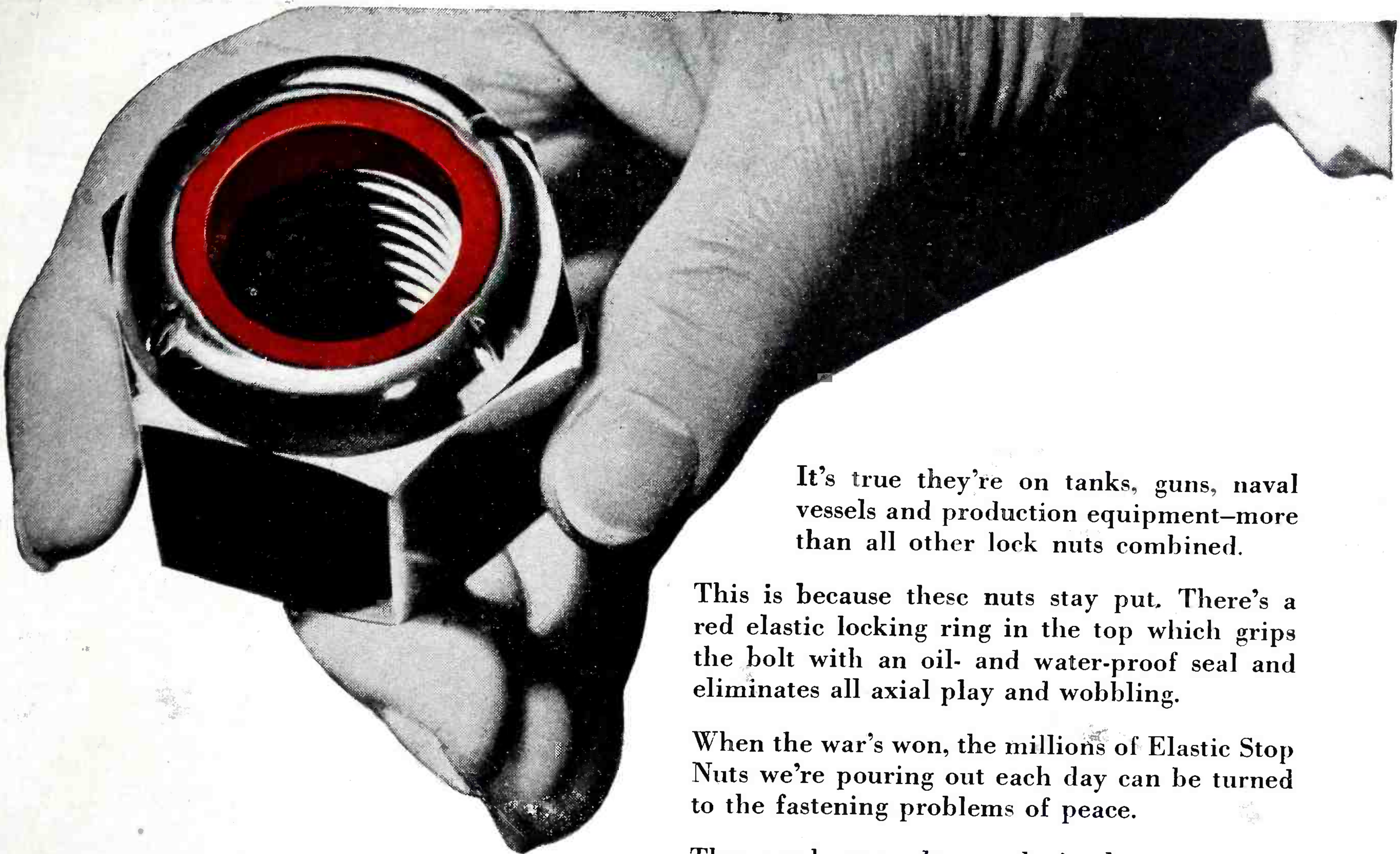
Awarded for Excellence in Production and Quality of Material

DeJUR-AMSCO CORPORATION

SHELTON, CONNECTICUT

MANUFACTURERS OF DEJUR METERS, RHEOSTATS AND POTENTIOMETERS

NEW YORK PLANT: 99 Hudson Street, New York City ◦ **CANADIAN SALES OFFICE:** 560 King Street West, Toronto



It's true they're on tanks, guns, naval vessels and production equipment—more than all other lock nuts combined.

This is because these nuts stay put. There's a red elastic locking ring in the top which grips the bolt with an oil- and water-proof seal and eliminates all axial play and wobbling.

When the war's won, the millions of Elastic Stop Nuts we're pouring out each day can be turned to the fastening problems of peace.

They can be turned to producing better products and equipment that will save time and expense for maintenance engineers.

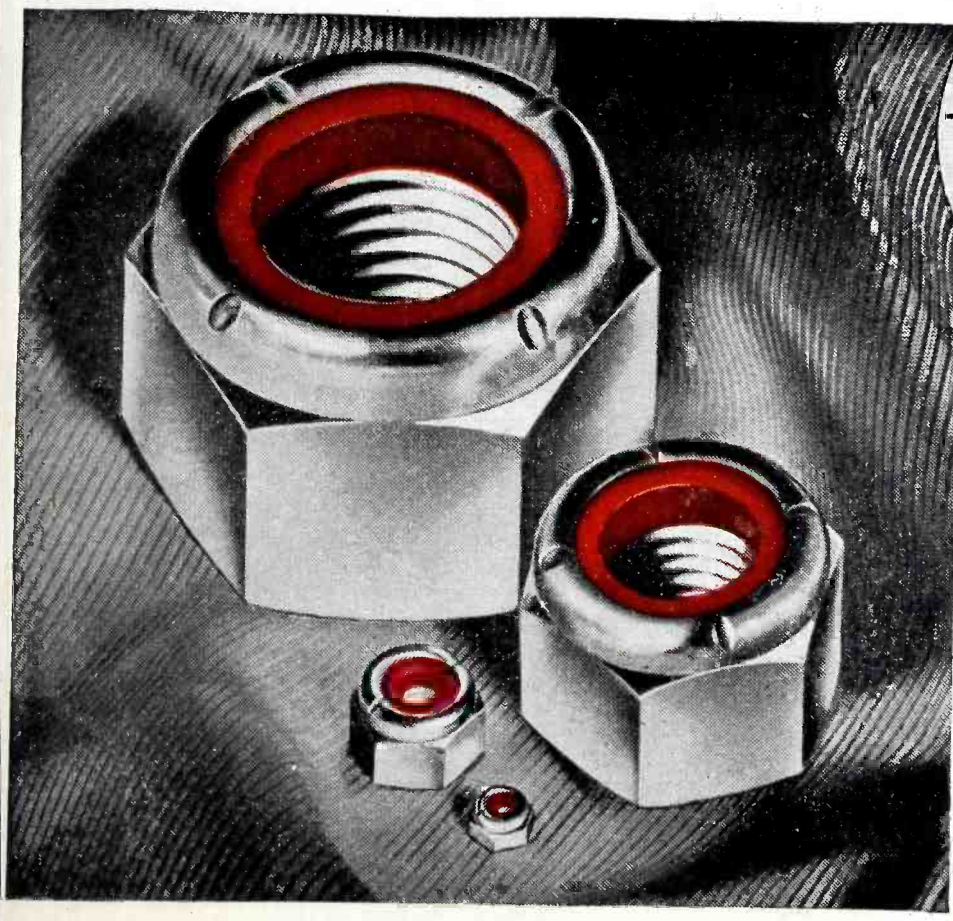
Whatever your fastening problems might be, our engineers, experienced in the work of both war and peace, will be glad to help cope with them.

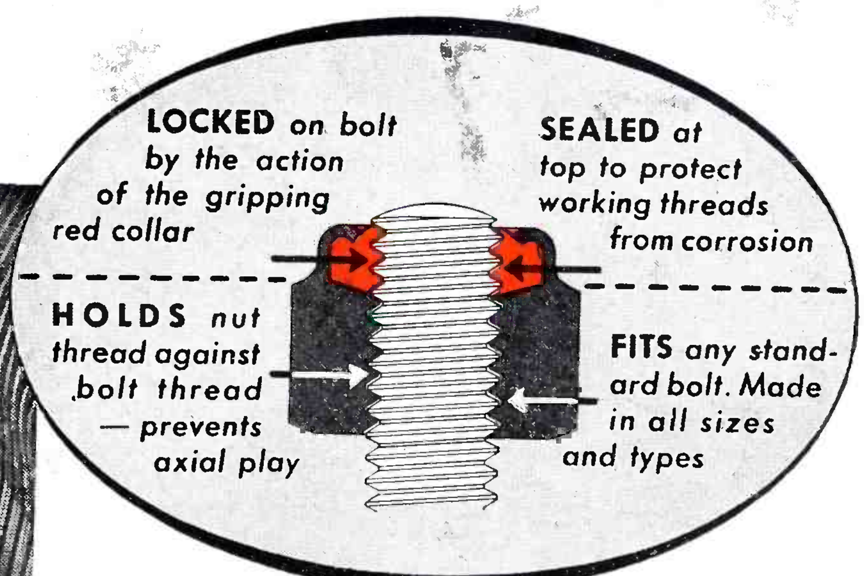
Feel free to call upon them. They'll work with you and suggest the proper Elastic Stop Nut to lick the job.

THEY'RE THE NUTS FOR POSTWAR PLANNING

It's true that now we can't supply all the Elastic Stop Nuts Uncle Sam wants – even with three big plants running 24 hours a day.

It's true that Elastic Stop Nuts are flying in every American plane – sometimes 50,000 of them in a single ship.



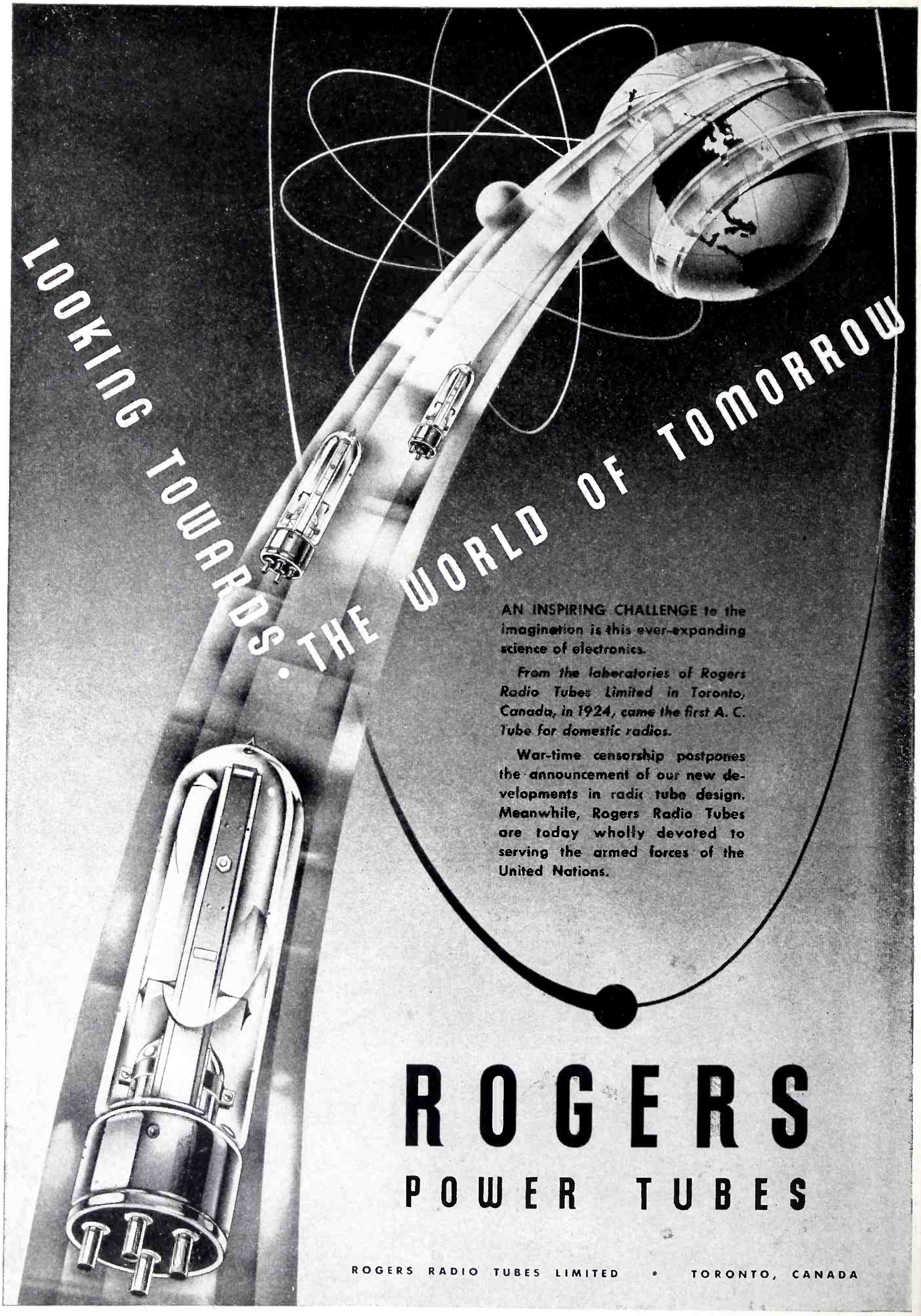


ELASTIC STOP NUTS

Lock fast to make things last

ESNA TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA
Union, New Jersey and Lincoln, Nebraska


LOOKING TOWARDS · THE WORLD OF TOMORROW
AN INSPIRING CHALLENGE to the imagination is this ever-expanding science of electronics.
From the laboratories of Rogers Radio Tubes Limited in Toronto, Canada, in 1924, came the first A. C. Tube for domestic radios.
War-time censorship postpones the announcement of our new developments in radic tube design. Meanwhile, Rogers Radio Tubes are today wholly devoted to serving the armed forces of the United Nations.
ROGERS
POWER TUBES
ROGERS RADIO TUBES LIMITED • TORONTO, CANADA

Control Devices

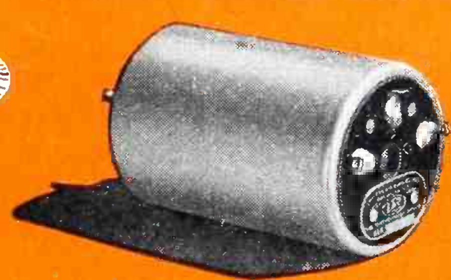
FOR SUCCESSFUL PERFORMANCE IN "BIG LEAGUE" AVIATION...

When the situation calls for something special in control devices . . . whether it be a tiny 400 cycle induction or synchronous motor, a miniature DC control generator, a special selector switch, a vibration proof relay, or any other electric, electronic or mechanical control device . . . EASTERN AIR DEVICES, INC., can design and build it.

Unique research, engineering, tool making and production skills combine, not only to build control devices that fulfill the most exacting requirements, but also to build special purpose devices for which no specifications exist. Our list of customers . . . the most exacting in government, aviation and manufacturing . . . attest to these skills.

EAD

400 CYCLE SYNCHRONOUS MOTOR



We were asked to develop a small synchronous motor with .3 inch-ounce pull in torque. Size, weight and cold test requirements were severe. Yet, in a short time, we were in production with the above motor which develops .6 inch-ounce pull in torque and carries these specifications: 115 volts; 400 cycles; 3 phase; weight 14½ oz.; length 2 11/16"; diameter 1¾".

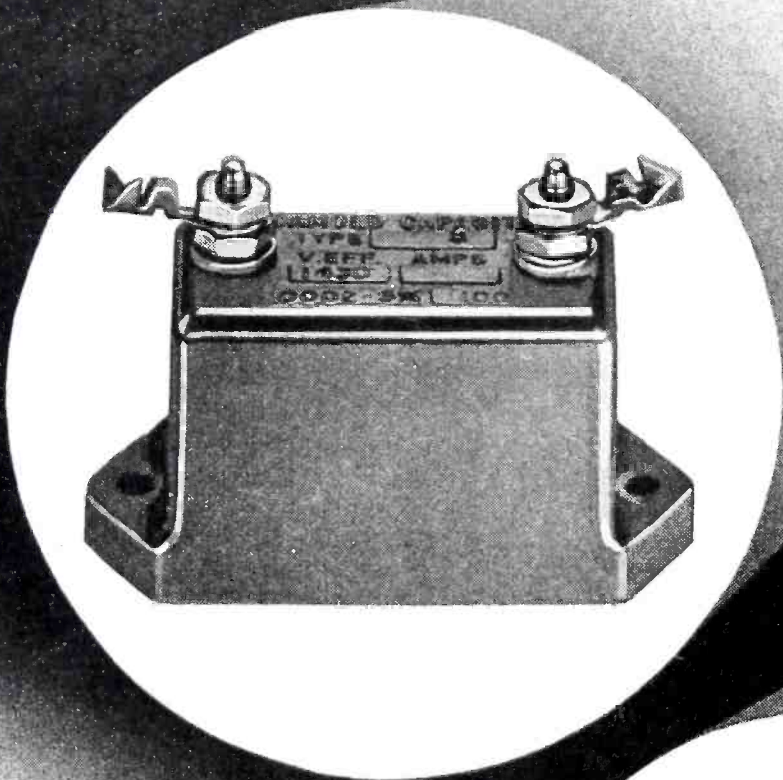
POST WAR PLANNING?

That new product . . . will it need a special control device? Why not let us design it and produce it economically? We invite your inquiry

EASTERN AIR DEVICES, INC.

314 DEAN STREET • BROOKLYN, N. Y.

An Affiliate of THE FRED GOAT CO. INC., Special Machinery Specialists Since 1893



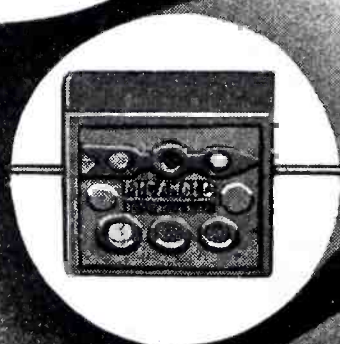
Micamold

Introduced

MICA CAPACITORS MOLDED IN BAKELITE

19 years ago, *Micamold* developed the first mica capacitor molded in bakelite. From this start grew many developments resulting in the large variety of useful types and specifications available today. From the exclusive type "Q" capacitor (smallest made) to the big bakelite enclosed transmitting mica capacitors, we provide units in many sizes and shapes . . . each one built to critical standards. *Micamold* was first and *Micamold* still is first.

Greatly expanded facilities permit the handling of large production schedules with reasonable promptness. We invite your inquiry.



REMEMBER . . . there's a Micamold Capacitor for every Communications and Electronic Application.

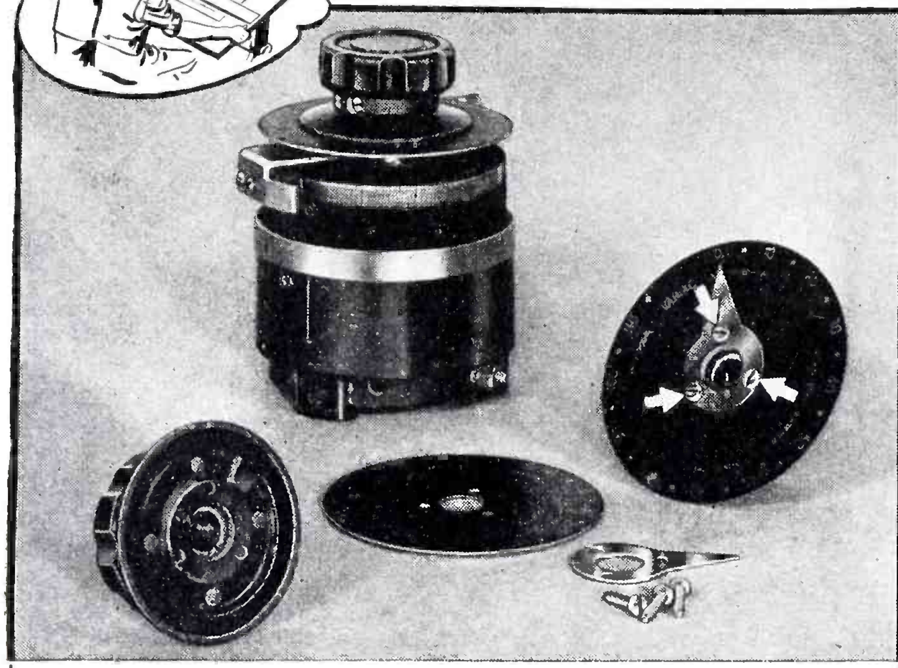
Receiving and Transmitting Mica Capacitors
Molded Paper Capacitors ★ Oil Impregnated Capacitors
Dry Electrolytic Capacitors ★ Molded Wire Wound Resistors

MICAMOLD RADIO CORPORATION 1087 FLUSHING AVE. B'KLYN 6, N. Y.

Question every fastening job

...at the DRAFTING BOARD!

...at the PRODUCTION LINE!



GENERAL RADIO COMPANY design engineers saved a lot of production work and money by giving a little extra thought to fastening methods. They might have written the common specification – "machine screws in threaded brass inserts" – to fasten the metal dial to the Bakelite knob of their Variac Transformer. That would have meant extra expense for inserts . . . extra work and time in molding knobs.

But they considered the P-K Self-tapping Screw method, too . . . found that stronger fastenings could be made with ONE simple operation, without inserts. And they solved the problem of making fastenings to some knobs that did not allow room for inserts.

STRUTHERS-DUNN production men considered P-K Self-tapping Screws as a possible means of simplifying a complicated job of attaching terminals to the Dunco Relay. With a machine screw, the fastening required 5 operations . . . drilling through the plastic base . . . drilling a recess in the bottom of the base for the screw head . . . inserting the screw from the bottom . . . filling the recess with wax . . . and finally, locking the screw in place.

The job became a cinch, with a special screw that combined a Type "U" Self-tapping Screw on one end and a standard machine screw on the other end. The screw is simply driven into a hole drilled into the top of the base . . . the Self-tapping Screw threaded section anchoring securely into the plastic base. One operation instead of five!

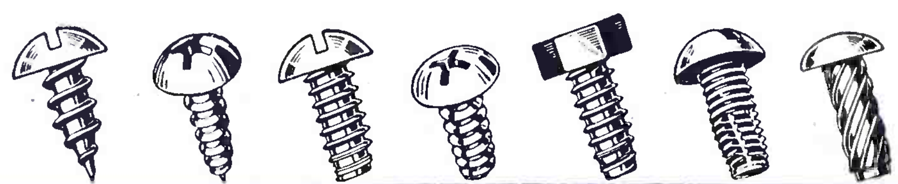
Hundreds of Jobs Prove You Can Save Man-Hours

. . . with Parker-Kalon Self-tapping Screws

These are two of hundreds of products, important to the war effort, which are being turned out faster, with a saving of precious man-hours, because the makers questioned their fastening methods.

"Can it be done with P-K Self-tapping Screws?" . . . is a question that uncovers opportunities to save time and labor. It is a wise standard practise at the drafting board, and on the production line. For a very large percentage of metal and plastic fastening jobs, these Screws offer a combination of ease, speed and security that no other fastening device or method can match.

Call in a P-K Assembly Engineer to check over fastening jobs with you. Whenever he finds a place for a Self-tapping Screw you can make the fastening in one easy operation . . . just drive the Screw into a plain hole! Without interrupting production, without special tools or skilled help, you eliminate tapping and tap maintenance . . . stop fumbling with bolts and nuts . . . do away with inserts . . . cut out riveting and welding in hard-to-get-at-places. Write for a P-K Assembly Engineer, or, send assembly details for recommendations. Parker-Kalon Corp., 192-194 Varick Street, New York.

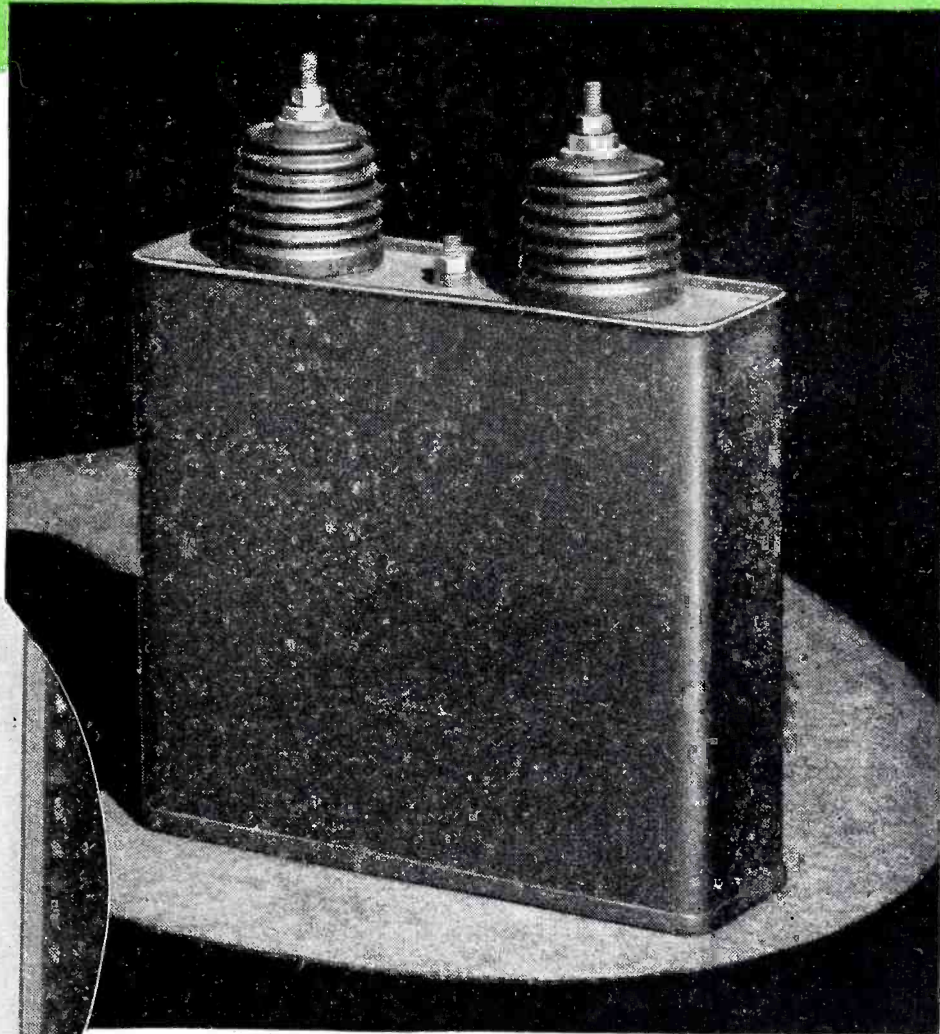


SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

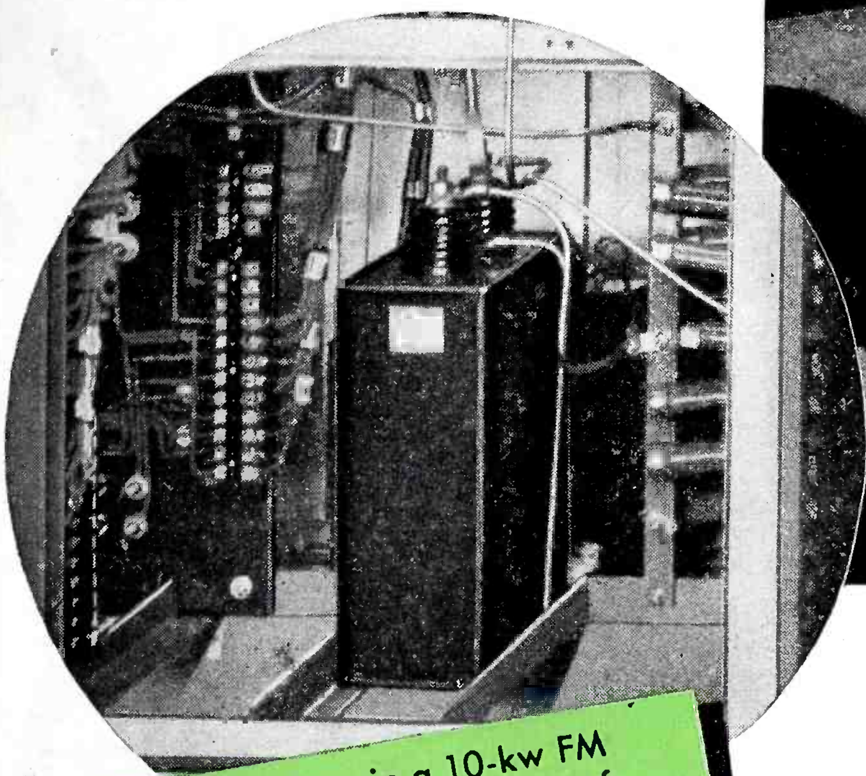
PARKER-KALON
Quality-Controlled
SELF-TAPPING SCREWS

Quick Delivery

PYRANOL CAPACITORS



for High-voltage D-c Service



Used as a filter in a 10-kw FM transmitter. This is one of many applications.

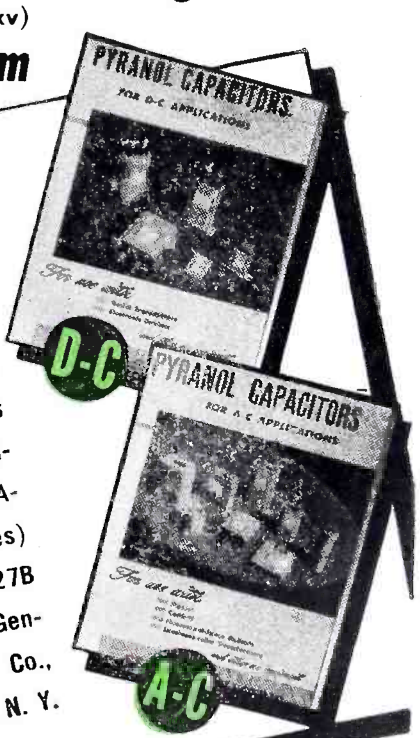
30 *Standard Ratings* (5–75 kv) *to choose from*

FILTER problems take a beating when you install Pyranol* capacitors for high-voltage d-c service. Here are other useful facts to remember about Pyranol capacitors:

- They can be mounted in any position.
- Reliable performance is ensured by superior materials and individual testing.
- Substantially increased manufacturing facilities now enable us to make prompt deliveries.

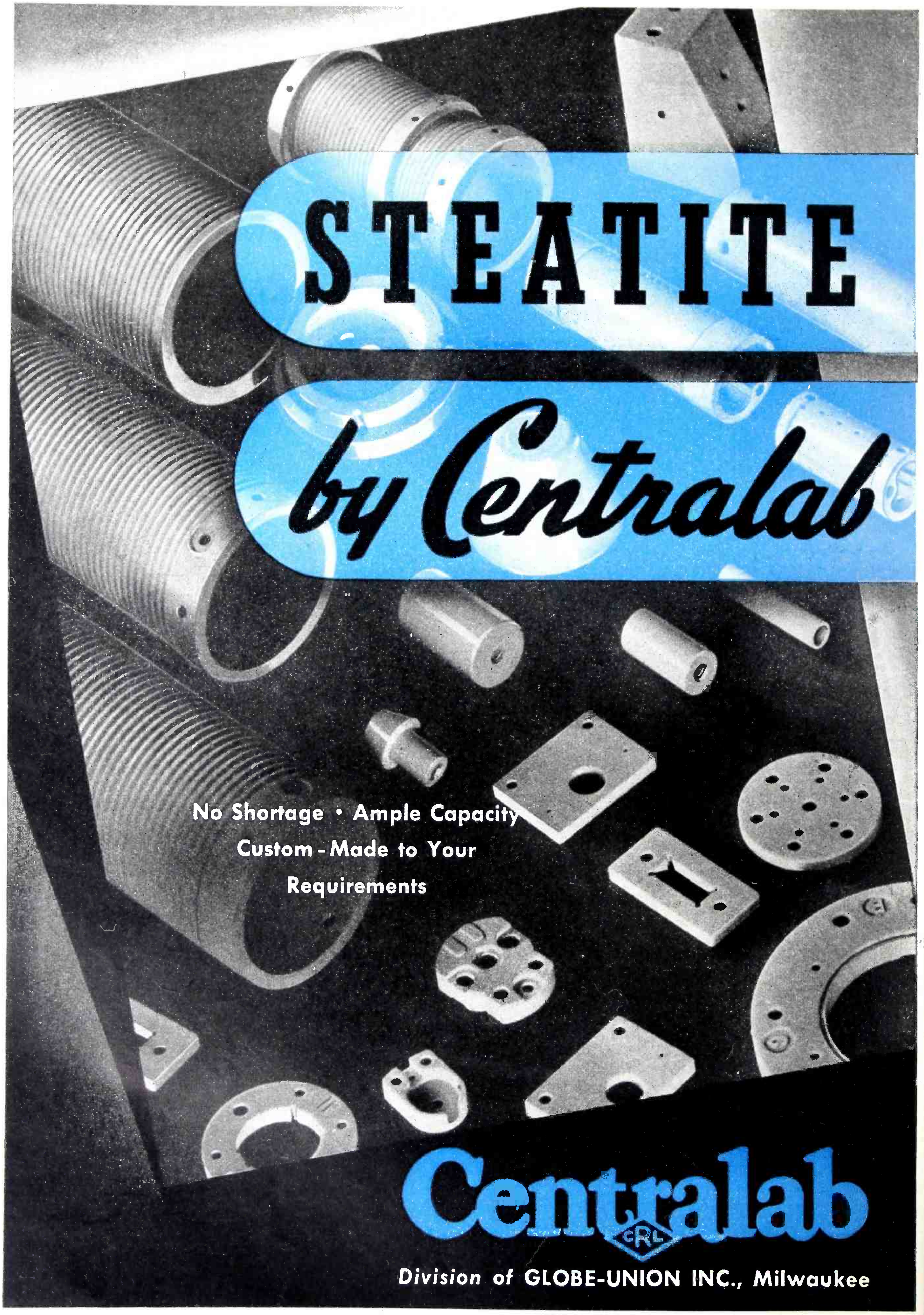
**Pyranol is the G-E trade mark for capacitors and for askarel, the synthetic, noninflammable liquid used in treating G-E capacitors.*

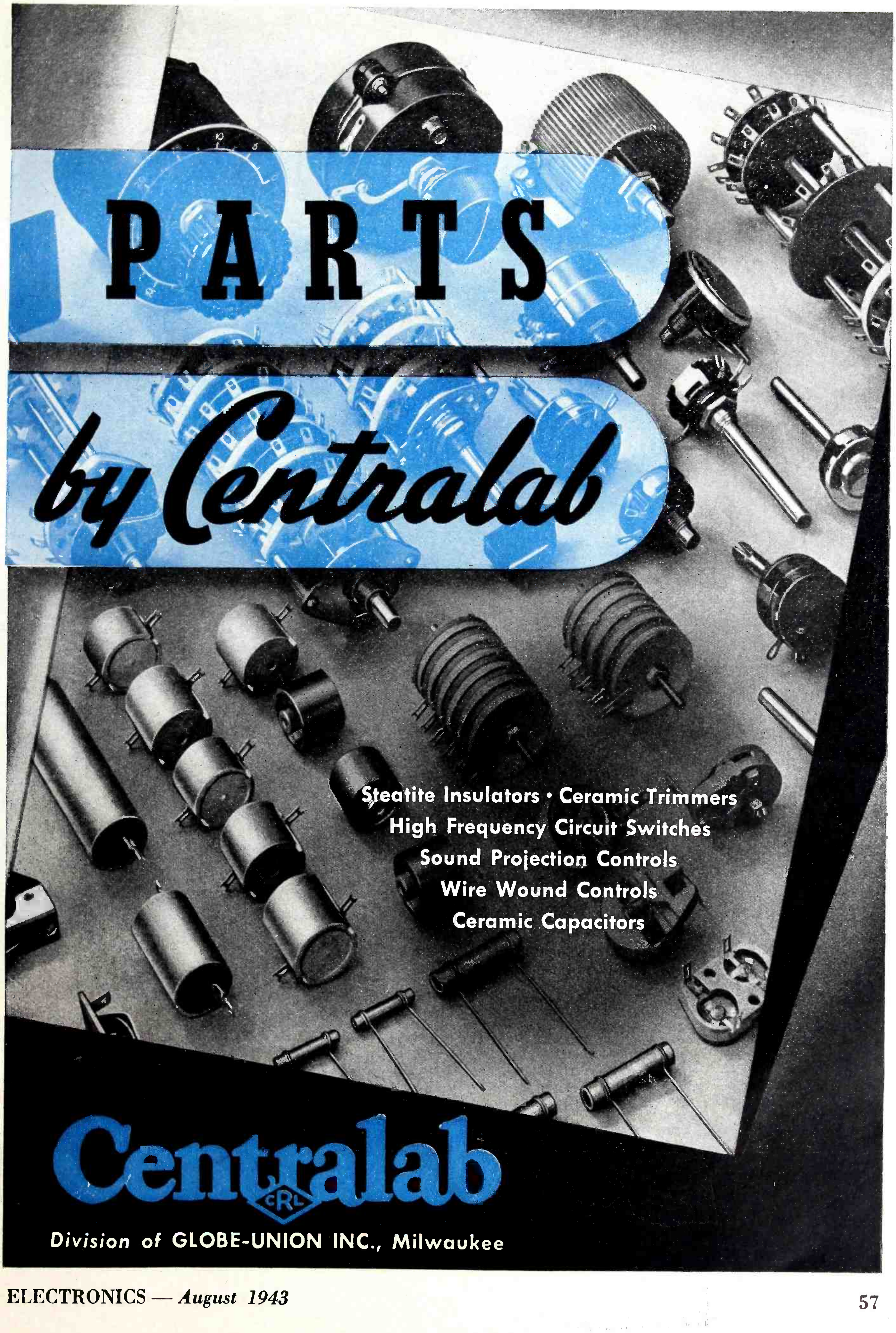
BE SURE TO GET your copies of these time-saving catalogs on our complete line of Pyranol capacitors for built-in applications. Ask for GEA-2621A (d-c types) and/or GEA-2027B (a-c types). General Electric Co., Schenectady, N. Y.



GENERAL ELECTRIC

407-59-5700


STEATITE
by Centralab
No Shortage • Ample Capacity
Custom-Made to Your
Requirements
Centralab
CRL
Division of GLOBE-UNION INC., Milwaukee



PARTS
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Steatite Insulators • Ceramic Trimmers
High Frequency Circuit Switches
Sound Projection Controls
Wire Wound Controls
Ceramic Capacitors
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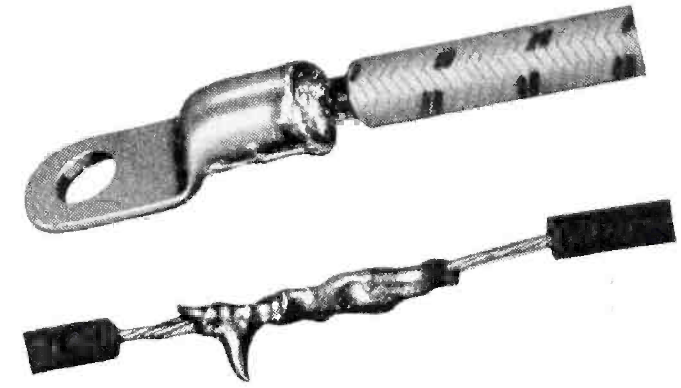
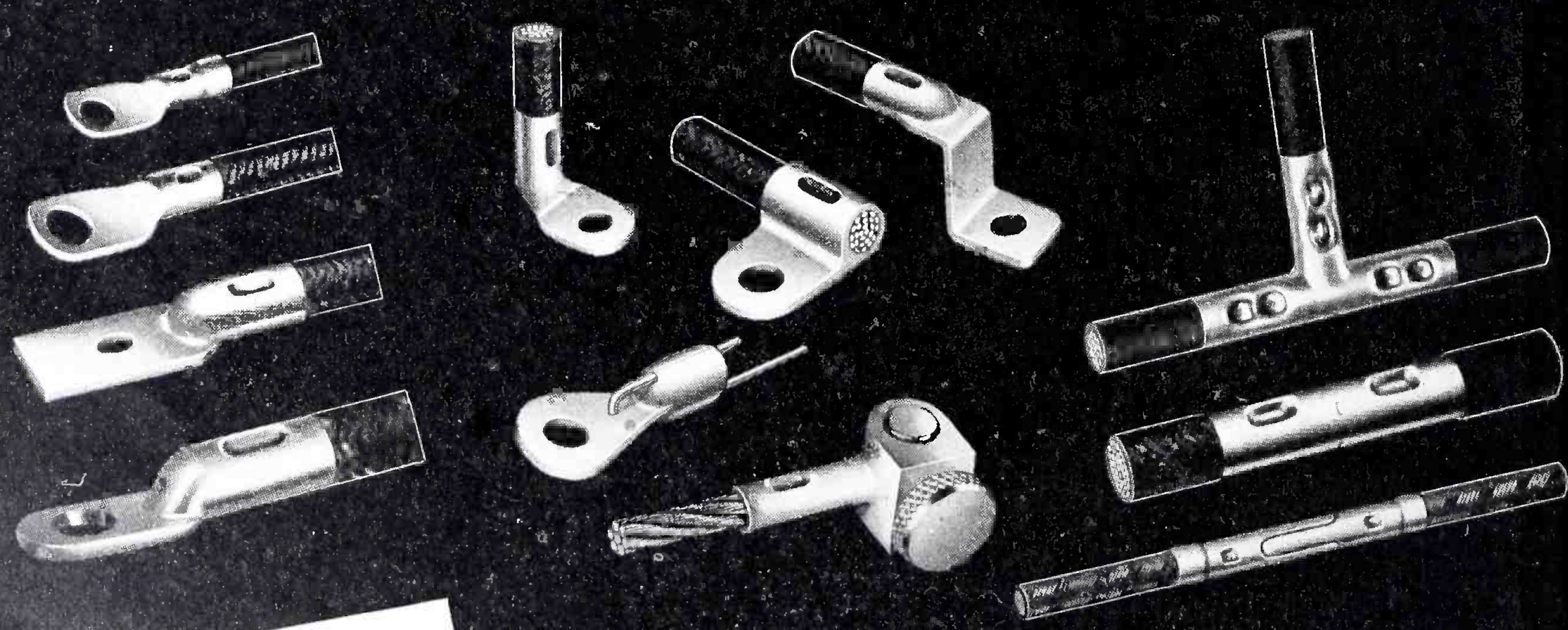
REMEMBER...

When most electrical connections looked like this?



solder was piled on,
***hoping* for a sound, efficient connection**

A few of the many types of Burndy HYLINE connectors (indent type).



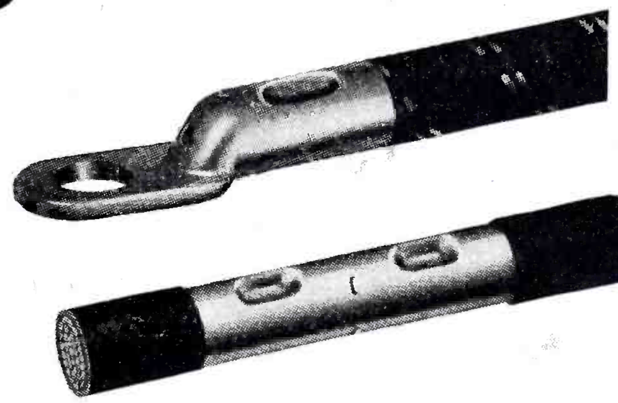
Pat. No. 2,109,837

The **BURNDY INDENT** . . . the mark of a sound and efficient electrical connection!

Burndy

BUT TODAY...

electrical connections look like this!



electrically efficient, mechanically strong, and workmanlike in appearance with Burndy HYLINE Connectors (indent type)

Whether you are using #29 wire in a sensitive electronic circuit, or 1000 mcm cable in a power circuit, HYLINE connectors (indent type) will improve circuit efficiency, eliminate circuit troubles due to faulty connections, lower your connection costs, and add clean, workmanlike appearance to the circuit.

Increased electrical efficiency is assured because HYLINE connectors are compactly formed from *pure copper* in *one piece* . . . and are permanently attached to the conductor by the famous Burndy *indent* method. The exclusive *one-piece* construction of HYLINE connectors eliminates any possibility of added resistance from extra contact surfaces.

High mechanical strength is assured because indenting with simple Burndy HYTOOLS permanently *locks* the connector to the conductor. It's the same proved Burndy principle which utilities have used for years in connecting vital networks!

Lower connection costs are assured because Burndy has specially designed HYTOOLS for rapidly indenting connectors, regardless of the quantities inolved. There are hand pliers for indenting small sizes singly or in small quantity; automatic bench presses for mass production; and portable hydraulic or pneumatic presses for the larger sizes. In many plants, connections are being made in *one-tenth* the time, the Burndy indent way!

• • •

No matter what your connection problem, Burndy engineers will gladly assist in adapting proved HYLINE connectors to your circuits or products. Simply acquaint them with your problem, or write today for the new illustrated HYLINE catalog. Burndy Engineering Co., Inc., 107 Eastern Boulevard, New York 54, N. Y.

ELECTRICAL CONNECTORS

NEED HELP? *Use Electronic Production Aids*

SHAKE 'EM TO PIECES

How tough is your stuff? New G-E vibration motors shake materials, and with amazing speed—to discover how much abuse they'll take. Compresses years of wear into a few minutes' test. Vibration frequency, up to 20,000 per sec. Learn scientifically how much wear your products will stand. Several types available. Facts in Bulletin GEA-4091. Also tells about vibration meters.

Electronically Controlled SPOT WELDING *Speeds Production* 540%

We know it's good; we use it ourselves. Spot-welding frames for G-E switchgear enclosures speeded production 540% over riveting; 375% over bolting. Saves time, materials, man power. ARE YOU RIVETING where you should be SPOT WELDING? Switch now! And to get the best results from spot-welding, use G-E electronic control. G-E engineers will be glad to help you with any control problem. Write to your G-E office or to Electronic Control Section, General Electric Company, Schenectady, N. Y.

SYNCHRONOUS MOTOR USERS...

Have you heard about the new G-E electronic synchronous-motor exciter? Can be used in place of rotating exciters to save space, materials. Takes standard a-c power and electronically gives you steady, easily controlled d-c. Quiet. Dependable. Low-current control circuit for easy automatic control if desired. Small, single control, like radio volume control, adjusts voltage. Ties in with standard synchronous-motor controls. Uses long-life G-E phanotron rectifier tubes. Any G-E office can quote. Ask about CR7501-B.

SIMPLIFY VARIABLE-SPEED DRIVE *ELECTRONICALLY*

New G-E Thy-mo-trol drive gives you full, stepless speed control on a single dial. Operates from a-c power. No gears, clutches, or belts needed to vary speed. Smooth, shockless acceleration at maximum permissible rate. No current peaks on line. Dynamic braking for quick stops. Holds speed within plus or minus 2% from no load to full load at any speed up to basic. Full torque at low speeds! It pulls and pulls and pulls. Compact. Easy to install. Motor is only major moving part. Ask about CR7507. Bulletin GED-972A. Standard ratings up to 10 hp. Special forms and ratings if you need them.

Rx — REDUCE RIVETING REJECTS

If exact timing would improve your riveting results, install G-E electronic timers. They take the guesswork out of timing. One Detroit manufacturer found they cut rejects for new operators—improved results for old operators. They use simple circuit, yet provide exact timing. Several ratings available, covering time ranges from 1/20 second to two minutes. Good for millions of operations. Low cost. Sturdy. Knob on front for easy adjustment. Many other applications, too.

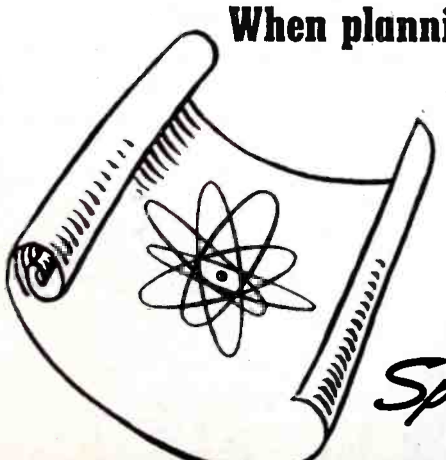
TOO MUCH RACKET IN YOUR FACTORY?

Too much noise fatigues workers, cuts down production. Have you too much noise in your factory? Find out with a G-E sound-level meter. Accurately tells you *how much* noise and where it's coming from. No guesswork. This high-precision instrument gives quantitative measure of sound as it affects the human ear. Small, portable, battery-operated. Easy to use; requires no special training. Full instructions given. Many companies have purchased sound-level meter for multitude of purposes. See Bulletin GEA-3151.

PHOTOELECTRIC RELAYS IN STOCK!

Limited quantity of high-speed relays (CR7505N100). More than 450 operations a minute. Operates on light-intensity change of ½ foot-candle. Time delay up to ½ second for holding relay closed after light impulse, which may be as short as .001 second. Excellent for simple register-control jobs. Automatic seal-in circuit if desired. Relay contacts handle up to 10 amp at 230 volts. Operates on 115 or 230 volts, a-c; 50/60 cycles. Power consumption, 30 watts. Many special features.

When planning new machines, processes, buildings— LOOK TO ELECTRONICS

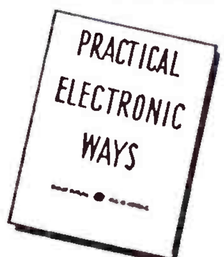


Electronic production aids, like these on this page, offer real opportunities for improvements and economies. Come to General Electric for electronic answers to your problems. ***General Electric, Electronic Control Section, Schenectady, N. Y.***

Speed Production Electronically

GENERAL ELECTRIC

FREE!



A book of examples of electronic production aids. No. GEA-3891

General Electric, Sec. C 676-101
Schenectady, N. Y.

In addition to "Practical Electronic Ways," Bulletin GEA-3891, please send me the bulletins checked.

- ☐ GEA-4091—Vibration motors and meters
- ☐ GED-972A—Thy-mo-trol drive (electronic motor control)
- ☐ GEA-1755E—Photoelectric relays
- ☐ GEA-2791C—Electronic control for resistance welding
- ☐ GEA-3151—Electronic sound-level meter

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Flying blind . . . but not deaf

HIGH over obscuring clouds, through the murk of fog and the black of night, the "blind" pilot speeds to his mission . . . and returns . . . almost completely dependent upon what he hears through his headphones. A tremendous responsibility for any piece of equipment.

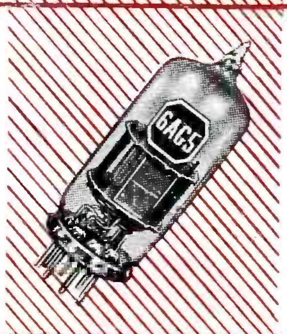
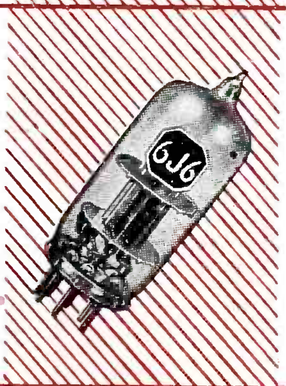
Making headphones to the exacting standards of the Army and Navy Air Force is one of the wartime tasks of Rola. A pioneer in Radio and later in Electronics, the technical knowledge and the manufacturing skill of this seasoned organization now is devoted exclusively to giving our Fighters in the Air the best, most effective equipment of any in the world. THE ROLA COMPANY, INC., 2530 Superior Avenue, Cleveland, Ohio.

In addition to complete headsets, Rola manufactures transformers and coils of all kinds for aerial communications. If your problem involves Electronics . . . and is important to the war effort . . . why not discuss it with a Rola engineer.

★ ROLA ★

MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

4 NEW RCA TUBES!

TYPE		MECHANICAL DATA	ELECTRICAL DATA	APPLICATION DATA
2C22 AMPLIFIER TRIODE		Max. overall length......3¼″ Bulb .... T-9 Caps (2): Skirted miniature Base: Intermediate shell octal 8-pin Mounts in any position	Heater volts..........6.3 AC or DC Heater amps ....0.3 Max. plate volts...............300 Plate dissipation..........3.3 watts Plate milliamps..................11 Mu......20 Rp......6600 ohms Transconductance...3000 micromhos	Designed for special high-frequency applications including transmitter service. Approx. resonant frequency of grid-cathode circuit is 335 megacycles.
6AG5 MINIATURE R-F AMPLIFIER PENTODE		Max. overall length......2⅛″ Bulb .... T-5½ Base: Miniature button 7-pin Mounts in any position	Heater volts..........6.3 AC or DC Heater amps ....0.3 Max. plate volts...............300 Plate dissipation...........2 watts Transconductance...5000 micromhos	Sharp-cut-off type designed for compact, light-weight equipment as an r-f amplifier, and as a high-frequency intermediate amplifier.
6J6 MINIATURE TWIN TRIODE		Max. overall length......2⅛″ Bulb .... T-5½ Base: Miniature button 7-pin Mounts in any position	Heater volts..........6.3 AC or DC Heater amps..................0.45 Max. plate volts...............150 Max. plate dissipation.....1.5 watts* Max. plate milliamps...........15* Class C telegraph service: At 15 volts: Output watts......3.5 Driving watts ....0.35 Cathode is common to both triodes. *Each triode	Designed for either push-pull or parallel operation up to 600 megacycles. With push-pull grid circuit and plates in parallel, the 6J6 makes a good mixer at frequencies up to 600 megacycles. Also useful as an oscillator.
5R4-GY FULL-WAVE HIGH-VACUUM RECTIFIER		Max. overall length...5-5/16″ Bulb ....ST-16 Base: Medium shell octal 5-pin, Micanol Mounts vertically, or mounts horizontally with pins 1 and 4 in vertical plane.	Filament volts...................5.0 Filament amps...................2.0 Max. peak inverse volts (No-load conditions)........2800 Peak plate milliamps per plate...650 Max. DC output amps..........0.25 at 2400 peak inverse volts.	

FREE

RCA ELECTRON TUBES

(RCA Victor Division)

RADIO CORPORATION OF AMERICA

Camden, N. J.

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

RCA Commercial Eng. Section
Radio Corp. of America
448 So. Fifth St., Harrison, N. J.
Gentlemen:
Please send me your handy 16-page booklet (Form 1275B) which shows "Characteristics and Socket Connections of RCA Receiving and Allied Special Tubes" in easy-to-read tabular form.

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Street.................................

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AMERTRAN

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

"Devise scouts that will travel 186,284 miles per second—pierce fog, gloom, and clouds—and report accurately the location of our enemies." Such, in effect, was a pre-war assignment given to those associated with ultra high frequency radio. Among the concerns honored by this task that culminated in RADAR, was the American Transformer Company.

We have every reason to believe that we fulfilled this assignment capably, because AmerTran equipment was not only accepted under the original specifications, but has been retained as improvements have been accomplished progressively.

Our work in RADAR has been a source of gratification to us as our contribution to an epoch-making development in the field of electronics.

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AMERICAN TRANSFORMER COMPANY

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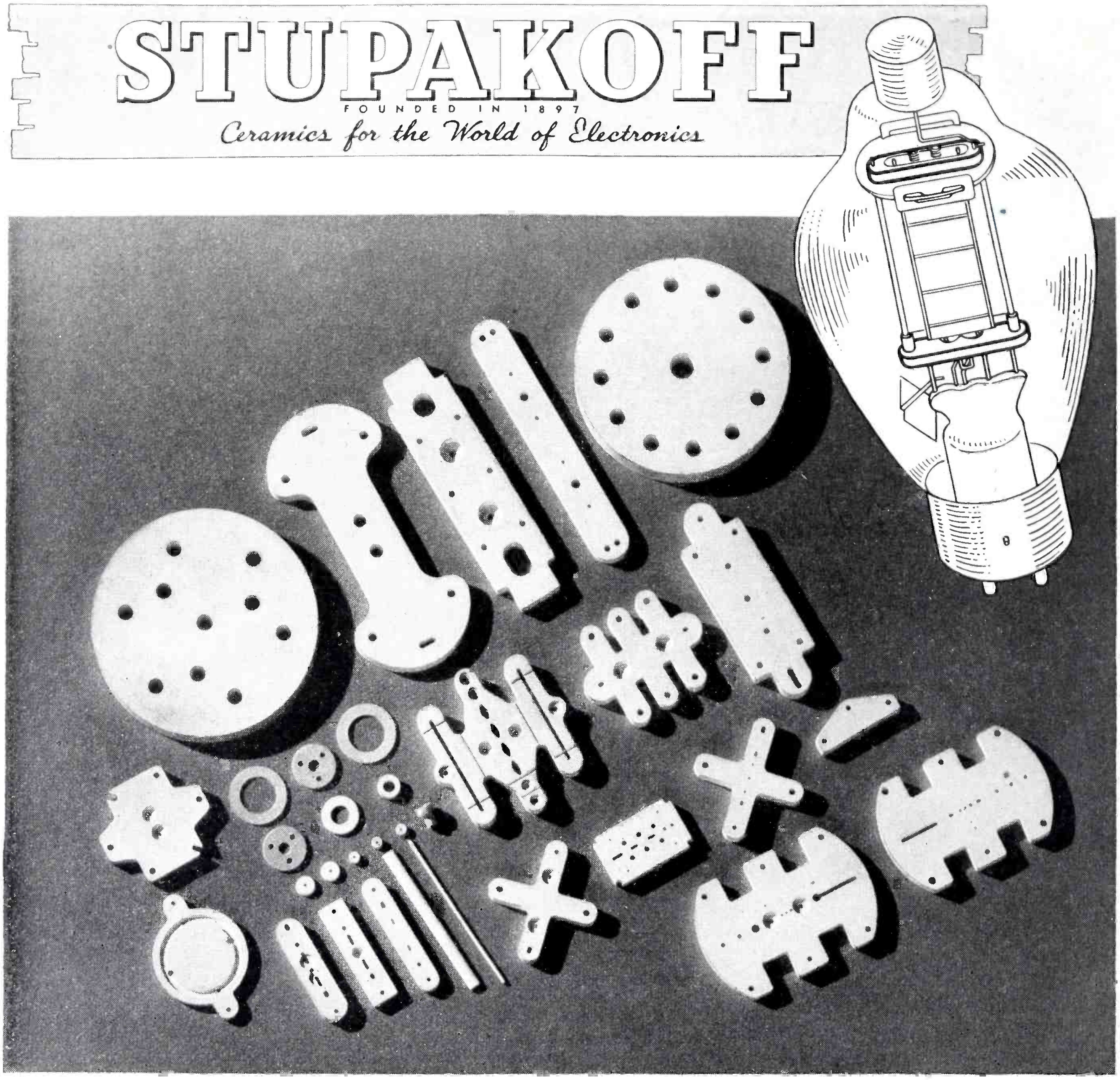
MANUFACTURING SINCE 1901 AT NEWARK, N. J.

STUPAKOFF

FOUNDED IN 1897

Ceramics for the World of Electronics

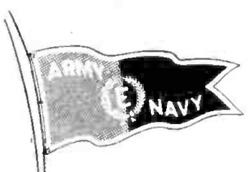


20 Years' Experience...

ENGINEERING AND MANUFACTURING INSULATORS FOR *Radio Tubes*

STUPAKOFF ceramics were used as heater insulators in the first A. C. radio tube. In the years following we have been directly associated with practically every change and improvement and have developed many materials which have contributed to the progress of the radio tube industry.

Insulators vary in specifications, depending upon their application. We have the experience necessary to prescribe the correct material for a given application and the manufacturing facilities to produce extremely large quantities of precision made ceramic insulators to your specifications.



"for great achievement"

STUPAKOFF
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INSULATORS

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Your boat will have a 'phone!

After the war...

. . . the two-way radiotelephone will be employed by American industry as a convenience, a safeguard and a business requirement. This modern method of communication has many proven applications in the following fields:

Aviation	Railroading
Marine	Public Utilities
Police, Patrol	Fire Fighting
Trucking	Engineering
Mining	

If you think you may be able to employ two-way radiotelephone communication in your field, we would be pleased to discuss your problem without cost or obligation. We have nothing to sell since our entire output has been placed at the disposal of the United Nations all over the world!

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Requests for information and literature from responsible parties may be addressed to Jefferson-Travis Radio Manufacturing Corporation, 380 Second Avenue, New York.

YES, sir—when peace comes any water-faring craft from an ocean liner to a runabout can have two-way radiotelephone equipment for the pleasure, convenience and safety that it spells. The amazing wartime development of this unusual form of communication gives definite promise it will be used in scores of ways in the social and industrial life of the nation after the war.

As pioneers in the field of two-way radiotelephone equipment it gives us satisfaction to know that our entire output is effectively serving the United Nations in every sphere of conflict and hastening the day when Jefferson-Travis again will be making this equipment for you and your peacetime purposes in Tomorrow's World!

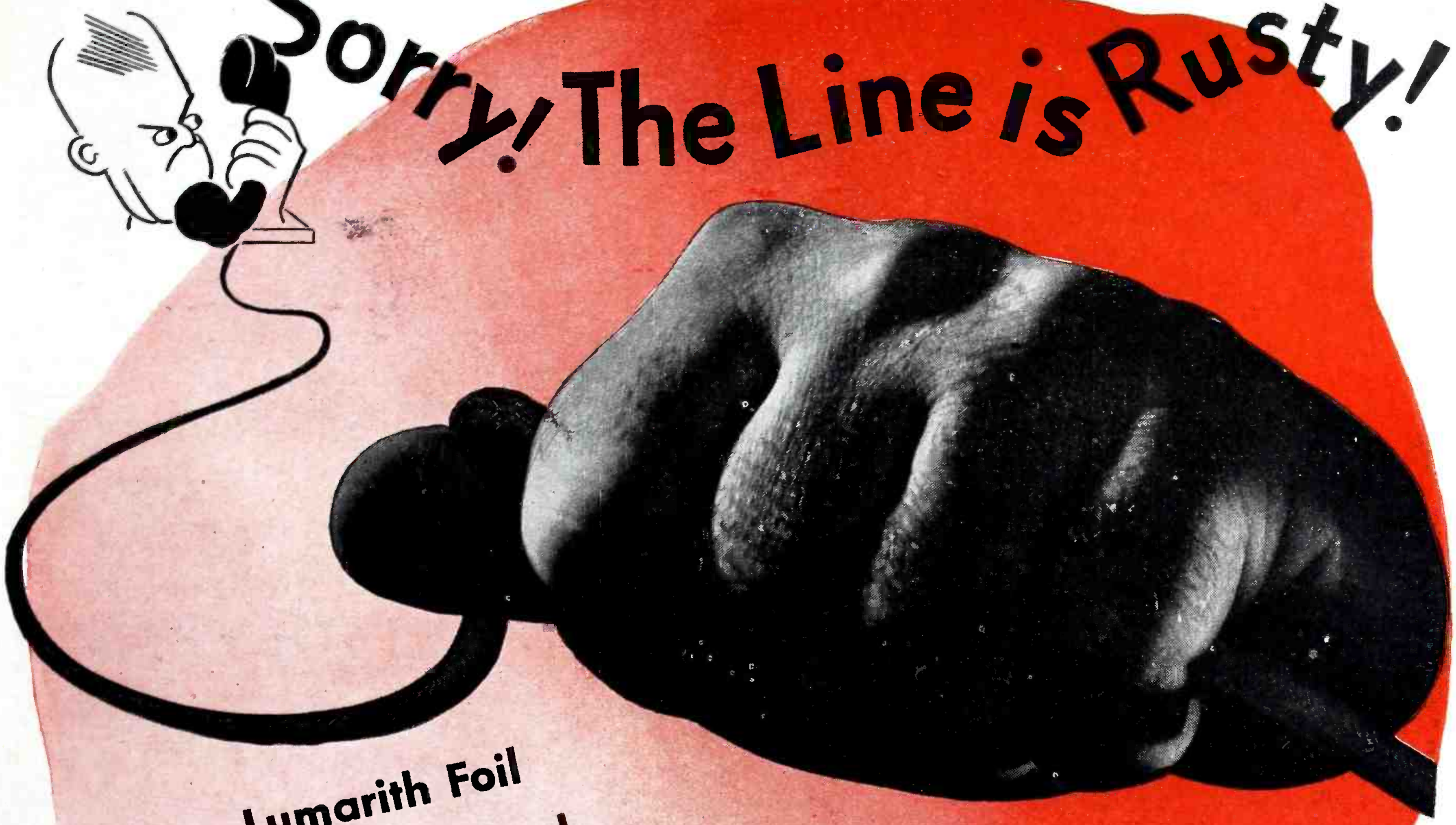
RADIO COMMUNICATION EQUIPMENT

JEFFERSON-TRAVIS

RADIOTELEPHONE EQUIPMENT

NEW YORK • WASHINGTON • BOSTON

Sorry! The Line is Rusty!



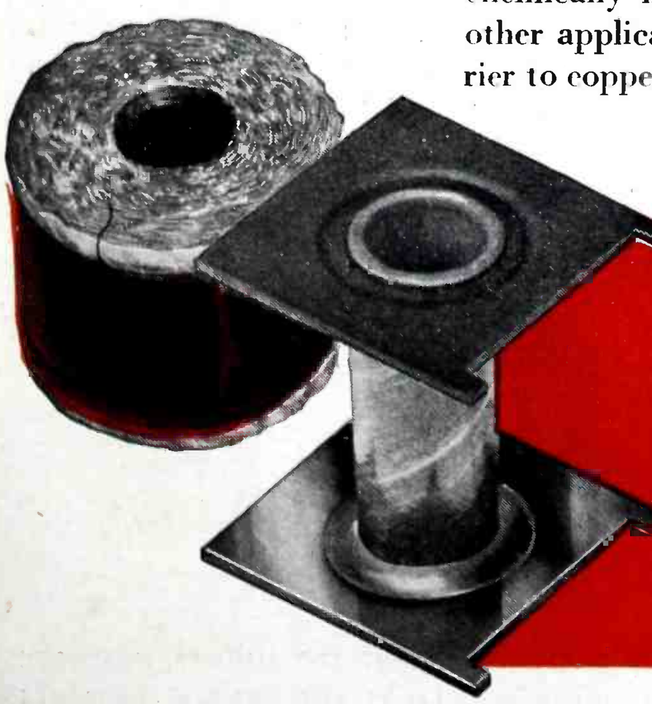
Lumarith Foil Keeps Out The Black Hand of Electro-Chemical Corrosion

To possess fixed insulation value, a dielectric should remain chemically stable. Electro-chemical oxidation can affect efficiency and operation of electrical circuits when insulation coils are not resistant to changing climatic conditions. The corrosion induced may progress to the point where the copper wire windings break.

Lumarith foil (or molded Lumarith) is chemically inert. In bobbins, coils and other applications, it forms a vital barrier to copper wire corrosion. The dielectric strength of Lumarith is high—its operational life, long.

The possibilities of Lumarith in the electrical field are limitless. If you have a problem involving insulation or protection of equipment, make use of the Celanese Celluloid Corporation's research department. It is prepared to offer you suggestions and advice.

Celanese Celluloid Corporation, *The First Name in Plastics*, a division of Celanese Corporation of America, 180 Madison Avenue, New York City 16.



LUMARITH* *Foil*

A CELANESE* PLASTIC

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

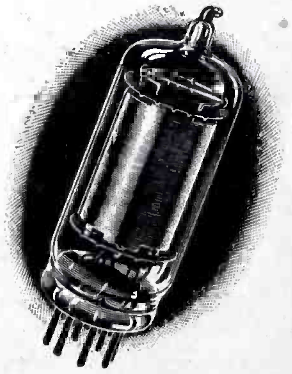
BUT OUR FEET ARE ON THE GROUND

Here at Tung-Sol we are doing a lot of looking ahead to the wonderful new post-war world. We see new comforts and pleasures in the home . . . improved manufacturing methods in industry . . . great advancements in medicine and in communications . . . all brought about by the science of electronics.

But our feet are on the ground. We know that most of the future benefits to be derived from electronics will result from the improvement of devices and equipment already in existence, and we are doing some very realistic work and planning to bring about these changes.

When the war is won we will have ready a greater vastly improved line of Tung-Sol tubes for transmission, reception and amplification. Our staff of research engineers, with their knowledge of war-time advancements in electronics, will be available to help you make your post-war products better.

TUNG-SOL
vibration-tested
RADIO TUBES



TUNG-SOL LAMP WORKS INC., NEWARK, N. J., *Sales Offices:* ATLANTA, CHICAGO, DALLAS, DENVER, DETROIT, LOS ANGELES, NEW YORK
ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND THERMAL SWITCHES

"Who says a War Job is Tiring? ...WHEN IT'S SO EASY TO DO GOOD WORK!"

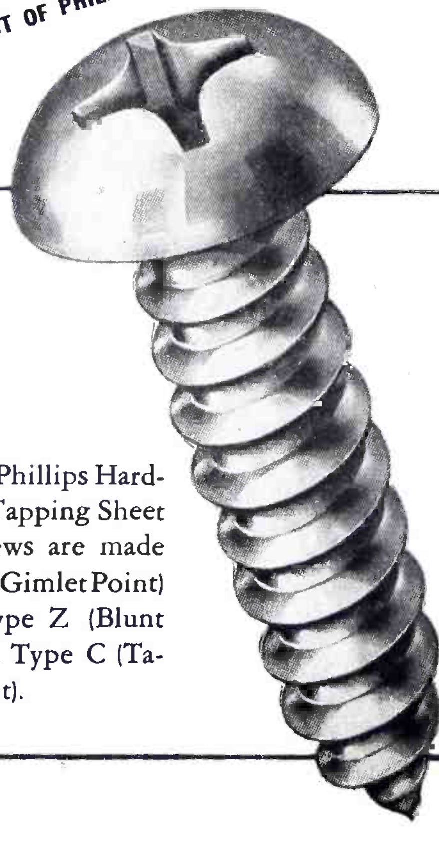
Fatigue is the Chief Absentee where Assemblies are made with AMERICAN PHILLIPS SCREWS

War jobs are *not* tiring when assembly work is done with *automatically straight-driven* American Phillips Screws. Even inexperienced hands catch on quickly to the simple routine of aiming and driving with one hand, while the other hand braces the work. No nerve-strain . . . because there's no chance of fumbling starts and wobbly, crooked driving . . . hence no undue weariness that slows production. Instead, always the stimulating incentive of work well done . . . because the non-slip connection between the 4-winged driver and the tapered recess of the American Phillips screw-head means that operators literally *can't miss.* Hour after hour, each American Phillips fastening duplicates all others, with a screw-head that sets up tight and plumb-level. No burred or broken heads, no gouged work-surfaces.

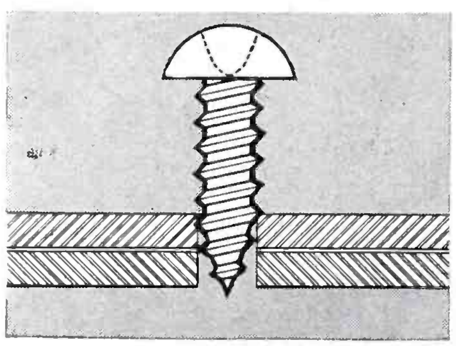
That's why women who drive American Phillips Screws can outwork men who drive slotted screws . . . *by 50% or more.* And that's why plants that tried American Phillips Screws continue to use them. You can bank on American for all types and sizes of Phillips Screws . . . every order piece-inspected for conformance to American standards of quality. Let American help *you* to "put the screws on the Axis"—*faster.*

4-WINGED DRIVER CAN'T TWIST OUT OF PHILLIPS RECESSED HEAD

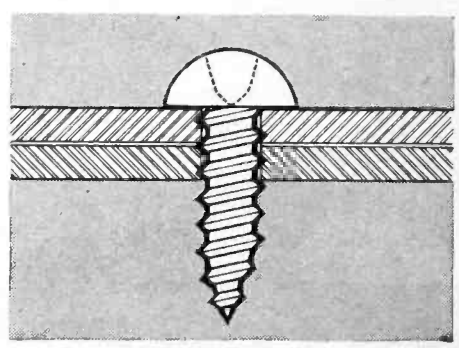
AMERICAN SCREW COMPANY
PROVIDENCE, RHODE ISLAND
Chicago: 589 E. Illinois Street *Detroit:* 5-267 General Motors Building



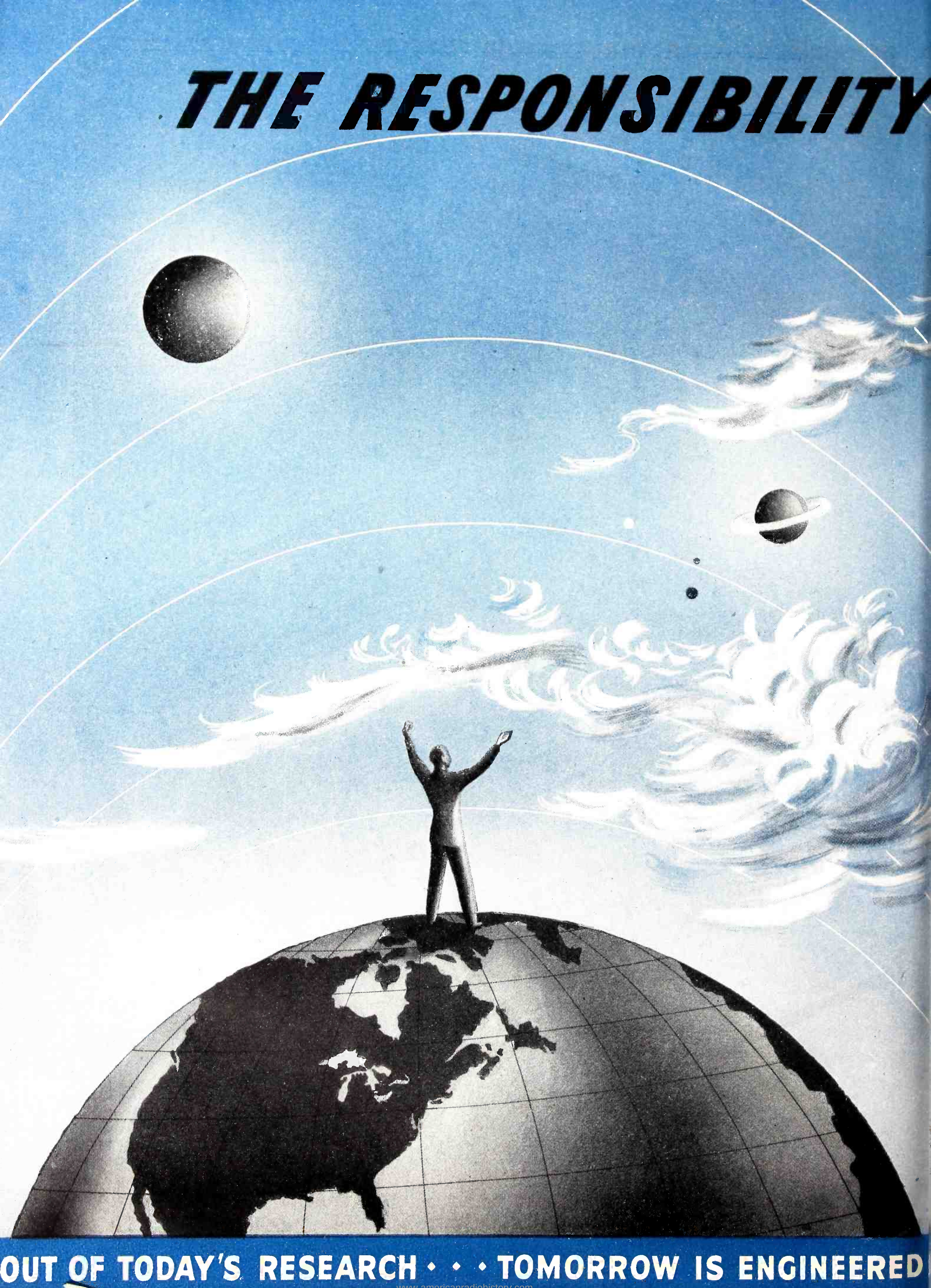
American Phillips Hardened Self-Tapping Sheet Metal Screws are made in Type A (Gimlet Point) shown, Type Z (Blunt Point), and Type C (Tapered Point).



American Phillips Driver and Screw form a single, straight-line driving unit . . . and stay that way until screw is completely driven in.



American Phillips Hardened Self-Tapping Sheet Metal Screw sets up tight and straight in drilled or clean-punched holes.


THE RESPONSIBILITY
OUT OF TODAY'S RESEARCH · · · TOMORROW IS ENGINEERED

OF LEADERSHIP

Constant pioneering . . . the unceasing search beyond present horizons for a Better Way . . . this is the responsibility of Leadership.

As man reaches for the stars, through the science of electricity . . . the miracles of Radio and Television . . . the amazing new world of Electronics, we at American Lava Corporation have paced each new achievement with insulation engineered to the new requirements.

When war came upon us with its demands for tremendously expanded production . . . its requirements for higher performance in Communications . . . we were ready with the KNOW HOW gained from 40 years' experience in pioneering, developing and perfecting steatite ceramic insulation.

Our research and engineering staffs will gladly cooperate on today's blue print . . . tomorrow's production.

AMERICAN LAVA CORPORATION

CHATTANOOGA, TENNESSEE

ARMY E NAVY

AWARDED JULY 27, 1942

here stability is an important
quirement, AlSiMag Steatite
ramics are unsurpassed for lend-
g rigidity and permanence of
ignment to electronic circuits.

ALSIMAG

TRADE MARK REGISTERED U. S. PATENT OFFICE

STEATITE CERAMIC INSULATORS

CHARACTERISTICS TAILORED TO YOUR REQUIREMENTS

READY...WILLING...
ABLE TO DELIVER

We are tooled up and in production on these and many other inter-communication items. Increased capacity enables us to accept additional orders for prompt delivery. Write for details.

INCHES AWAY—YET MILES APART

Linked by Interphone Equipment

Pilot and crew, separated by deafening flak and engine throb, explosions and noisy ack-ack fire, are *linked together* completely by interphone communication equipment. Where split-second timing depends on perfect intra-plane communication, Trav-Ler Karenola equipment fights right along with front-line American Air Forces . . . relaying orders and messages to every man aloft with maximum clarity and dependability . . . forging a link that strengthens the fighting airship.

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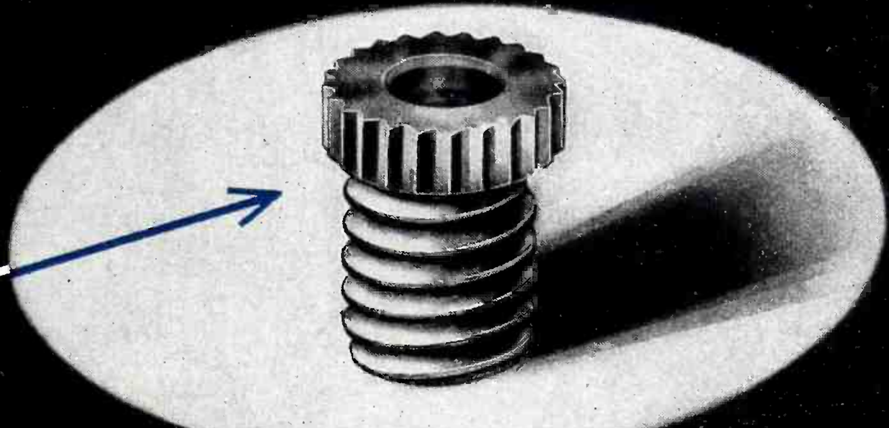
MANUFACTURERS OF QUALITY RADIO AND COMMUNICATION EQUIPMENT

RADIO MANUFACTURERS ASSOCIATION MEMBER

NOW IT CAN BE DONE!

A Molded-in One-Piece Insert Can Be Replaced Without Special Tools or Damage to the Material



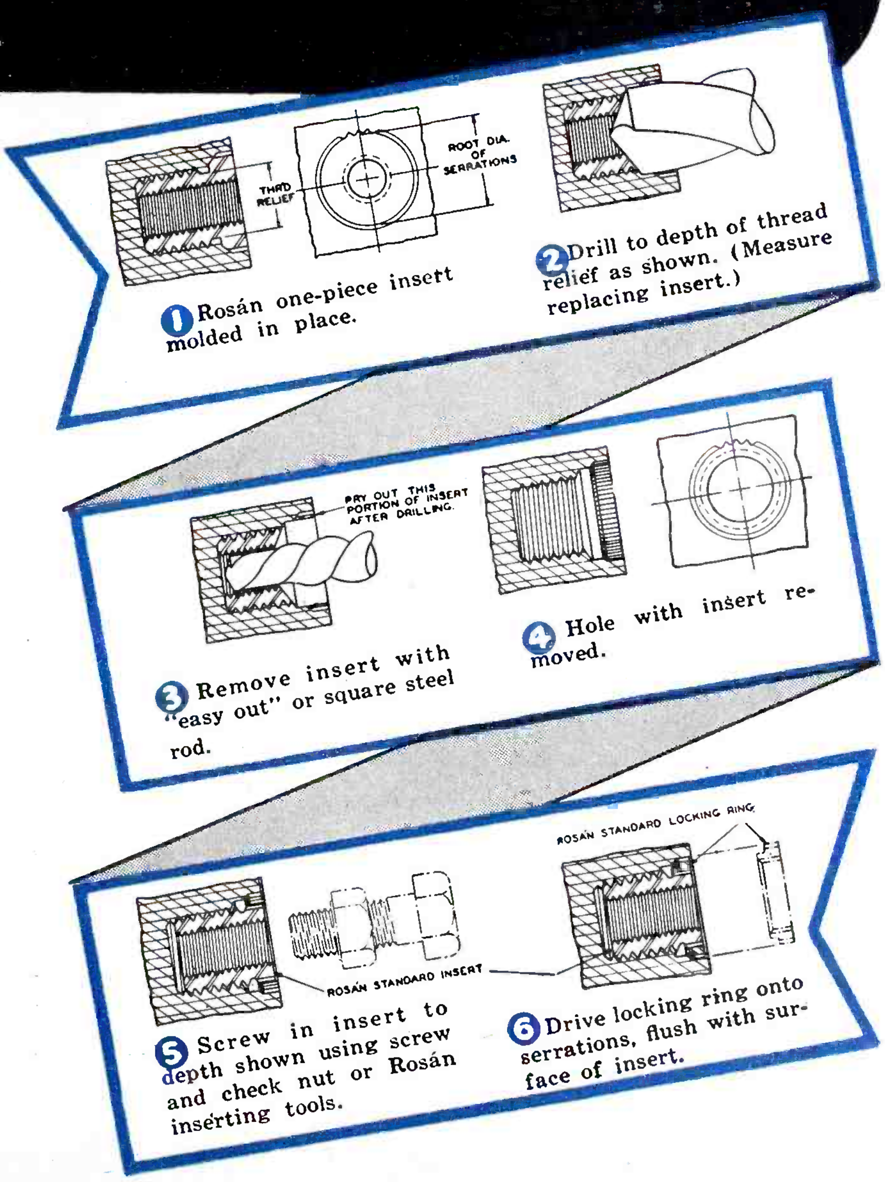
Patents Pending

The Rosán One-Piece Molded-in Insert not only may be removed without disturbing the parent material, but it leaves a threaded, counterbored and serrated hole into which a standard Rosán Threaded Insert may be screwed and locked by the regular process of the Rosán Locking System.

The principle of the Rosán Locking System, which furnishes this solution to fastening problems, is very simple and ingenious. On the standard Rosán Insert, there is a serrated collar. The Rosán Locking Ring, which is serrated both inside and out, engages its inner teeth with the serrations on the collar while its outer teeth, or splines, broach their way into the parent material at the wall of the counterbore. The pressure of the surrounding material causes the Locking Ring to close in upon the collar enough to eliminate all tolerance and make a permanent, solid installation. The diagrams at the right show the method of removing the Rosán One-Piece Molded-in Insert and replacing it with a Rosán standard unit.

There is also the Rosán Molded-in Stud which is locked in the material, but replaceable like the Insert.

Manufacturers are invited to submit their fastening problems to our Engineering Department. No obligation. Write for full information and descriptive literature.



THE ROSÁN LOCKING SYSTEM

BARDWELL & McALISTER, INC.

7636 Santa Monica Boulevard, Hollywood 28, California

Small, compact and lightweight

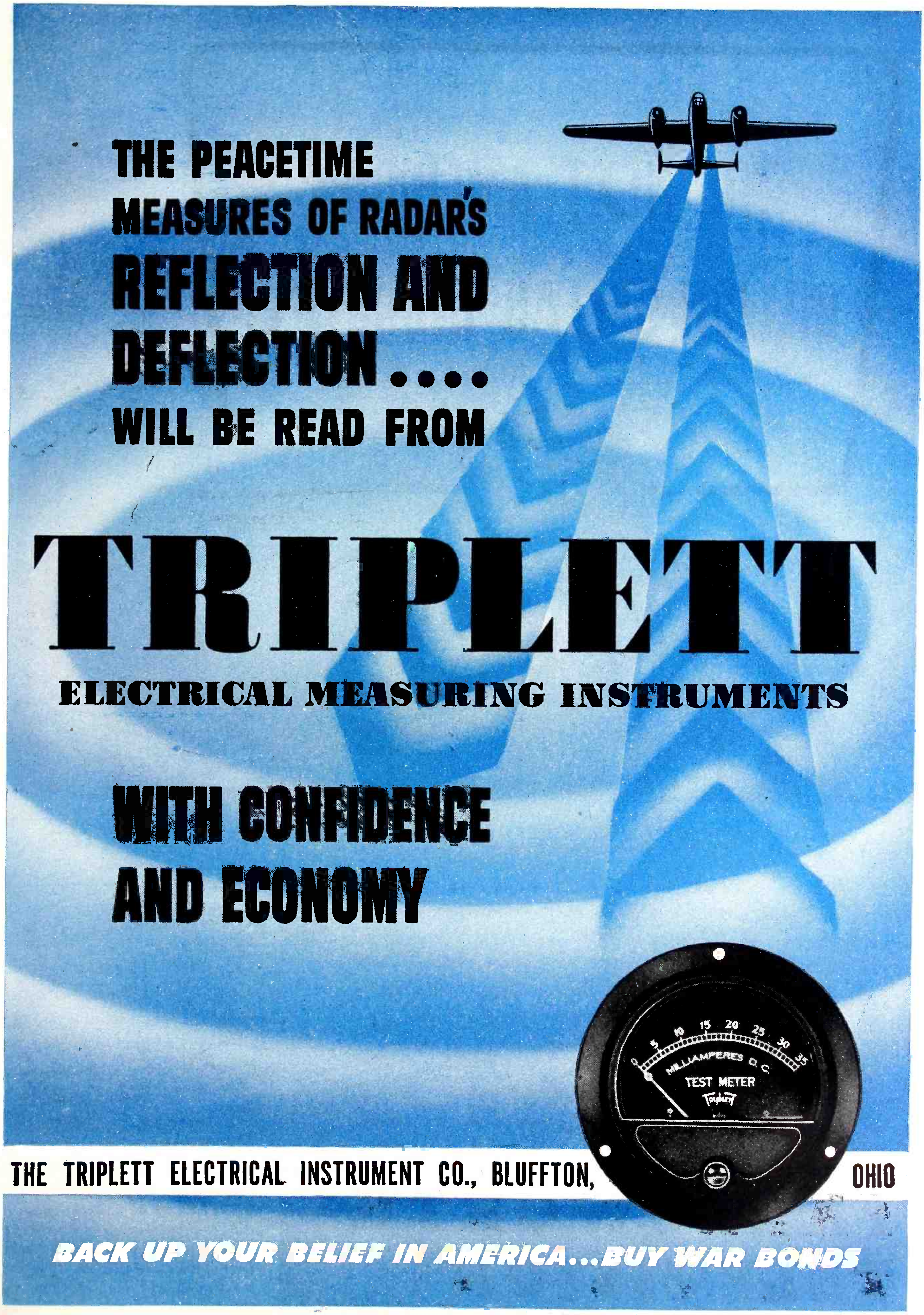
... yet highly efficient!

For example, take this hermetically-sealed unit designed by the N-Y-T Sample Department. While it weighs only five ounces and measures but 1⅜″ in diameter by 1¾″ high, it is both immersion proof and shock-proof. The moisture pouring off an icy transformer, which has just dived from a sub-zero temperature in the stratosphere to a few thousand feet above a steaming tropical zone, may well be imagined. Protection must be assured in all phases of modern warfare; equally important to functional efficiency and accuracy are size and weight.

This is but one of the innumerable solutions for vital Army, Navy and Air Corps requirements achieved by N-Y-T. Unceasing research and testing are embodied in every transformer problem by our engineers.

NEW YORK TRANSFORMER COMPANY

26 WAVERLY PLACE NEW YORK, N. Y.


THE PEACETIME
MEASURES OF RADAR'S
REFLECTION AND
DEFLECTION....
WILL BE READ FROM
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ELECTRICAL MEASURING INSTRUMENTS
WITH CONFIDENCE
AND ECONOMY
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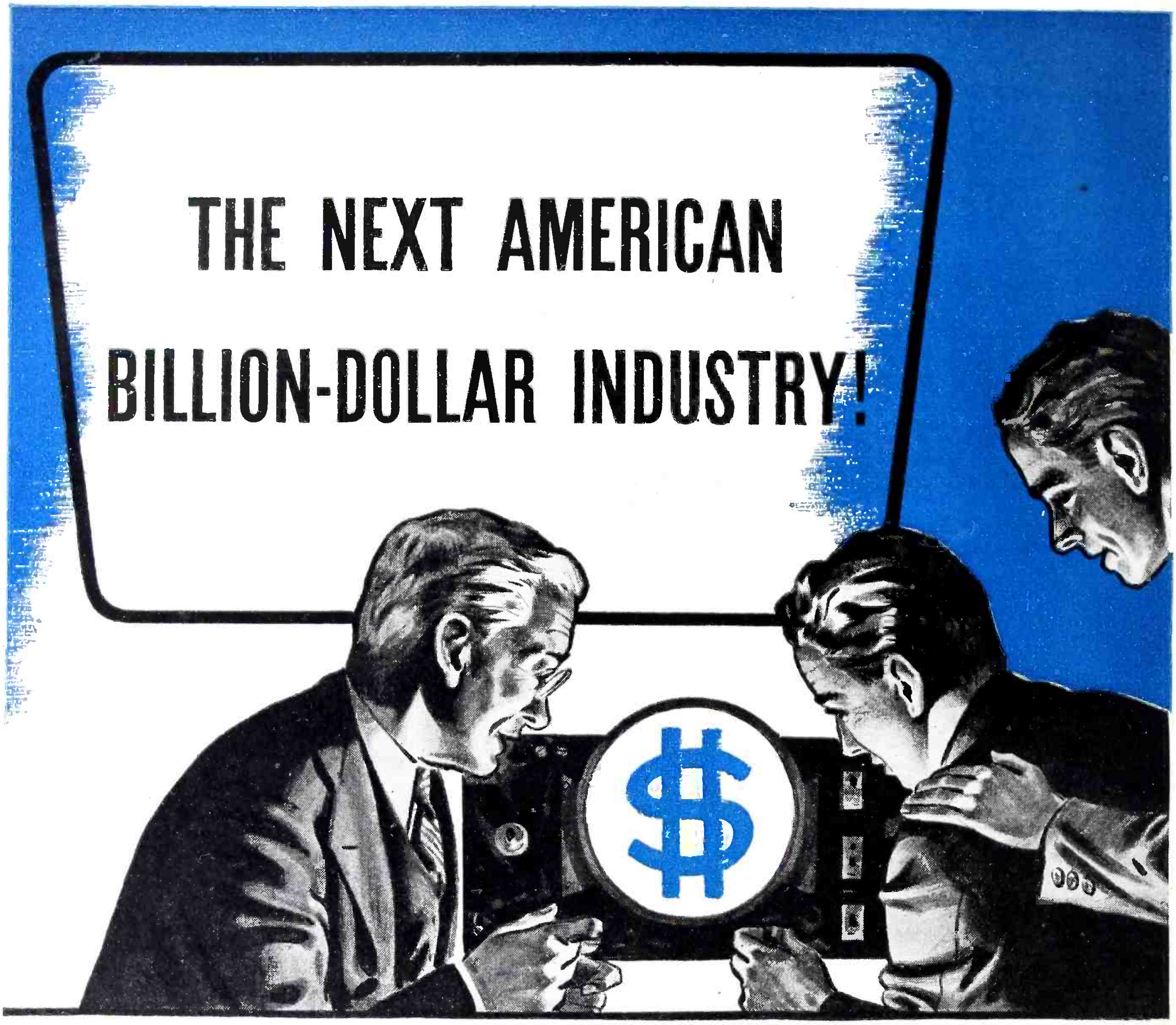
TEST METER
THE TRIPLETT ELECTRICAL INSTRUMENT CO., BLUFFTON, OHIO
BACK UP YOUR BELIEF IN AMERICA...BUY WAR BONDS



Many men with a sound background in radio are looking forward to television as the next great industry to present outstanding opportunities.

Television techniques have advanced a long way since modern electronic television was demonstrated in the then small Farnsworth laboratory 17 years ago. Farnsworth's original Dissector Tube, cathode ray tubes, circuits, synchronizing devices — all the original equipment — have been perfected. *Electronic television* has grown up . . . at war's end, television is confidently expected to rapidly become a major influence in the world.

Ever since Farnsworth experiments created electronic television, our research has stressed both electronic tubes and circuits, for the correlated development of *both* proves more fruitful of results.

Our primary interest has always been television and allied electronic development. Farnsworth, pioneer of electronic television, continues in this field during wartime. Our current production is entirely military, of course. But after Victory, we'll be ready to help you with your television problems.

FARNSWORTH TELEVISION

ARMY E NAVY

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

Management
—Heart of America's Industrial Progress

In Peace and War, Management Men and Methods Steer Production on a Steady Upward Course

WHEN the Allied armada of 2,000 ships, protected by a vast umbrella of planes, struck the coast of Sicily, Axis leaders once more had reason to wonder how "that decadent, pleasure-loving America" had swung from the manufacture of automobiles, refrigerators and costume jewelry to equipments of war, and had out-produced such mighty plants as the Krupp, the Fiat and the Skoda works — and had done it so quickly.

America at war is in the lead just as it has led a world at peace. Super-performing planes are taking to the air at the present rate of nearly 100,000 per year. Ships, to carry the war to our enemies, slide down the ways at the rate of two a day. Tanks, trucks, guns, ammunition are pouring out of our "peace" plants in far greater volume than the entire Axis effort can possibly equal. War expenditures in 1943 alone will reach the staggering figure of approximately $83,000,000,000 — an amount equal to our entire national income for 1929. Added to this is the rock-bottom output of essential civilian goods — a very considerable item.

This unprecedented production is taking place while some 9,000,000 men and women, those physically best equipped, have been called to the armed forces. Many of them were taken from industry, and their loss could be repaired only by more efficient equipment and more effective methods.

Rigorous training programs had to be superimposed upon many other abnormal problems facing industry in its high-speed conversion from stoves to boats; from printing machines to guns; from automobiles to airplane engines; from fishing tackle to bomb sights.

This phenomenal task was further complicated by the need for rapid expansion. A modest machine tool industry had to be expanded to handle a volume many times its normal capacity. Steel production had to be increased by 20%, and that of aluminum and magnesium multiplied over and over. From almost nil, the demand for high octane gasoline soared to unbelievable quantities. The creation of synthetic rubber and electronic industries was necessary almost overnight.

Who deserves credit for these accomplishments? All industry! The engineers, chemists, designers, skilled workers, common laborers. But over and above all it belongs to *management*.

In industry it is mandatory to have a directive force to coordinate the efforts of men in the use of materials and the application of power toward the production of goods and services. The application of this directive force is the function of management, and only because we had today's kind of management were we able to transform ourselves, almost overnight, from a peace-loving nation to the world's greatest producer of implements of war. As a nation, we had been preparing for a long time to play our part in world affairs. This preparation, certainly not planned for today's objectives but none the less effective, began some four decades ago.

With the advent of the twentieth century, the character of industry in the United States, and, therefore, the character of American living, began to change. Scientific management was born. Frederick W. Taylor brought into focus and showed how to use effectively those processes and procedures upon which our present-day mass production is based. He was followed by Harrington Emerson, who made the industrial world acquainted with efficiency in manufacture and the remarkable progress to be gained therefrom in the field of production, with its consequent price reductions and wider distribution of industry's products. There followed, in industry, an alert management, a capable management, a management with vision. Without it, the work of Taylor and Emerson would have gone for naught.

It is because of this early work of management — and the extraordinary developments it produced — that the country as a whole, and particularly those employed in industry, were not over-awed by the seemingly impossible job of quick conversion to all-out war production. But let us look back four decades and examine some of those preparatory accomplishments which have proven so vital to the progress and welfare of the nation.

From 1900 to 1939 (the last pre-war year), total employment of all kinds increased 52 per cent; in the manufacturing industries alone the increase was 84 per cent. *The nation became definitely industrial.*

In 1900 the average wage earner was able to spend only 20.2 per cent of his income for things other than necessities; in 1930 his buying power for non-essentials had increased to 34.8 per cent. *The average man acquired confidence in what industry could do.*

In 1900 the average work week was 56 hours; in 1930 it was 48 hours. *The burden of production was being transferred from man to machine.*

In 1939 the United States possessed 30 per cent of the world's railroads, 72 per cent of its automobiles, 49 per cent of its telephones. *The nation's production equipment had grown to formidable proportions.*

In 1939 nearly half of the families in the United States owned their own homes, 64 million individuals carried life insurance policies and 45 million had savings accounts. National income had increased 300 per cent from 1900 and during the same period the proportion of national income paid out in salaries and wages increased from 58 to 70 per cent. And in less than this period (1914—1939) the purchasing power of the wage rate increased by 60 per cent. *There had been evolved the kind of living for which men will work — and fight.*

Since 1900, factories increased their output of goods from $11,000,000,000 to $60,000,000,000 in 1939. This increase of nearly 450 per cent was accomplished while the country's population rose only 60 per cent. In this same span of years, technological developments and improvements in methods had increased the value added by manufacture per wage earner by 200 per cent, and the horsepower per factory worker had been multiplied by 2½. *The nation's production plant was ready to assume its gigantic wartime job.*

During this period of industrial and national evolution, management itself had changed. Prior to the advent of scientific management, our goods and services were the product of several kinds of directive activities, varying from the strictly paternalistic to the ruthless. There was little conception of the responsibility that industry now broadly acknowledges — the responsibility of trusteeship in the interest of stockholders, employees and the public — specifically; in the interest of our national economy — generally. Acceptance of this stewardship is acceptance, also, of the belief that, in the long run, no industry, and no unit of industry, that does not serve society can live.

Have the actions of management caused the times to change? Or has an alert management been successful only because it has changed with the times? Certainly, the industrial concern of 1900 would not thrive under the conditions of today. Just as certainly the new things that industry has in store for a waiting postwar world will have a far-reaching effect upon the times.

Management today seldom owns the factory or the business it manages. It is hired to perform the coordinating, directive functions. It is free to change — of itself, or with the times. Management therefore exercises its power through leadership in executing ideas . . . not through ownership.

This is the fourteenth of a series of editorials appearing monthly in all McGraw-Hill publications, reaching more than one and one-half million readers. They are dedicated to the purpose of telling the part that each industry is playing in the war effort and of informing the public on the magnificent war-production accomplishments of America's industries.

Good management can be sustained only in an environment sympathetic to its aims. It has an undeniable obligation to society, because it must be a compatible part of the social structure or be rejected by that structure as a whole.

An environment sympathetic to its aims means, also, that industry, in the very serious reconstruction period ahead, will not be at full effectiveness if it is subjected to attacks by government no matter what the underlying reasons may be — over-zealous devotion to a cause, lack of understanding or just plain politics. It was to industry — to industrial management — that the government turned when our existence as a free nation was threatened; it is to industrial management that government must turn in order to win the peace.

This statement is made in the sincere conviction that what has made America strong is industry's ability to produce consistently more and more goods and services for more and more people. It is only by actually creating them that we built up our stockpiles of the necessities of life. And it is only by creating them that we can have more of those things that make life worth while. These become available to more people as industry succeeds in getting greater output of goods and services for a given input of human energy, materials and power.

And what of the physical jobs ahead? In this country alone, there will be an immense demand upon industry to supply the things people have been unable to purchase during the war. Today the nation is wearing out not only its automobiles, refrigerators, vacuum cleaners and radios, but its very houses, its roads, railroads, and airline equipment. It is saving its money while whetting its appetite. Truly, the calls the American people will make upon industry in the postwar period will be many and insistent.

This demand can be viewed in another light. Economists say there will be 56,000,000 persons seeking gainful employment after the war. The Committee for Economic Development has estimated that $140,000,000,000 worth of goods and services will be required each year for those people. Compare that with our actual output of $97,000,000,000 worth of goods and services in 1940 when gainful employment was 46,000,000.

These future jobs will be done if industry's management is not too much hampered by government management. Management in industry performs its function in the field of *doing* things. Management in government performs its function in the field of *regulating* things. The best cooperation of the two kinds of management will be necessary in the postwar period. Certainly, too much of the regulatory kind will interfere seriously with the kind that does things.

Industrial management must improve, too. If it is too selfish, if it does not recognize definitely the trusteeship inherent in its job, if it does not understand and live up to its social responsibilities, then it will be risking all for which we are fighting. The following suggestions are made to indicate the direction that management's self-improvement can take.

Evolution in management has been too slow in some respects. Management in industry has been too prone to see the advantages in technological development while being blind to its evils. Looking at industry and social progress as a whole, there can be no doubt as to the value of technological improvement. It creates jobs. It elevates the standard of living. But that economic fact is of no satisfaction to the individual who loses his job because a new machine or a new method required one less man. By and large, this is an evil that management can do something about.

Management has been too careless of its opportunities with regard to labor. On that account the pendulum of social readjustment has swung too far. Labor has been given extensive privilege without corresponding responsibility.

Industrial management has been too slow to abandon its policy of letting the buyer beware. As a result of this, industry today is over-regulated.

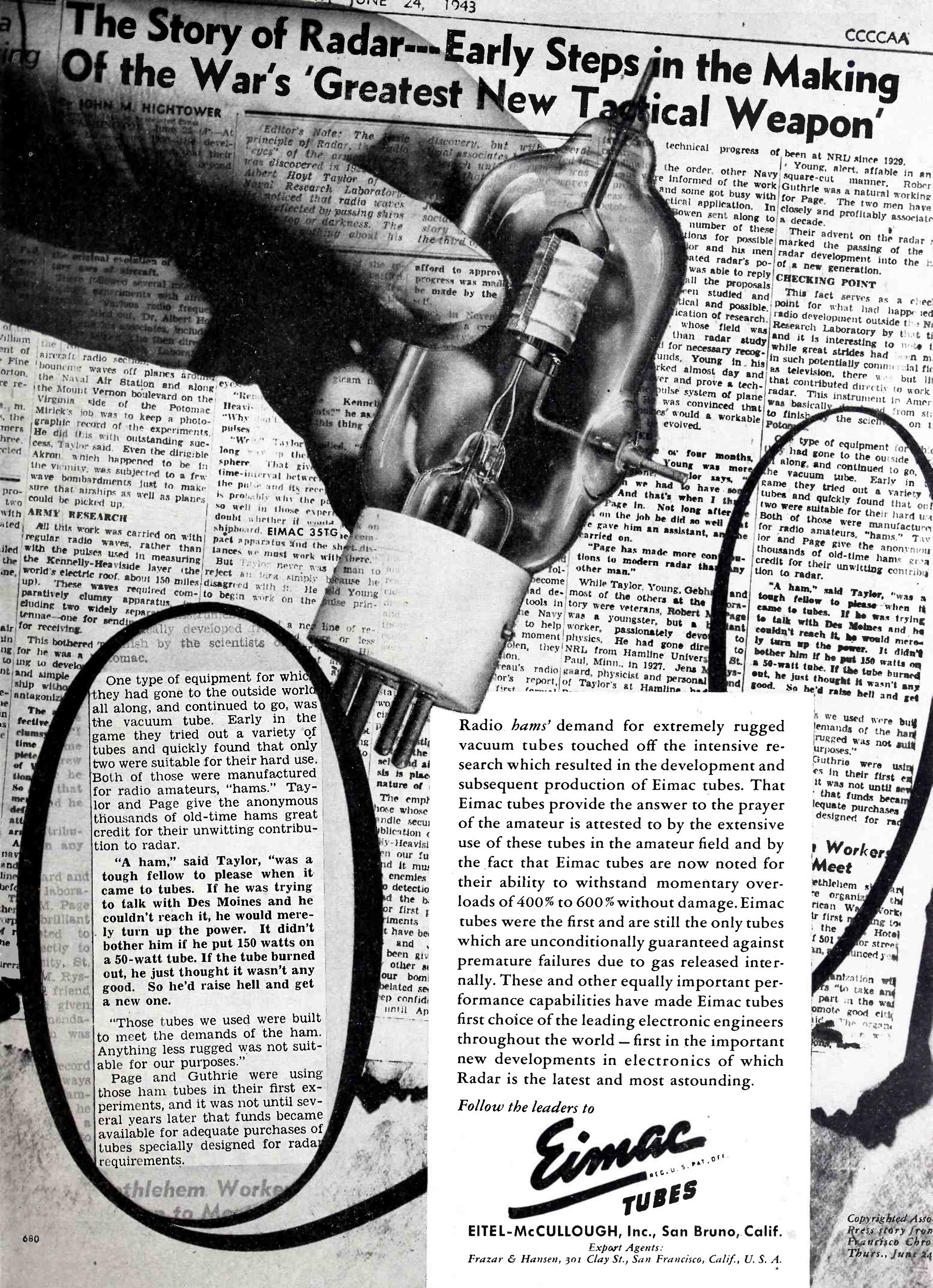
Management has been too slow in recognizing its responsibility to promote the economic philosophy that a society cannot have for consumption what it does not produce. A companion educational item too long neglected is management's obligation in the field of public relations.

In these years since 1900, industrial management has been growing. Perhaps many of its experiences have been but growing pains. Management has learned, among other things, the absolutely vital need for capital at the right time and in the right amount. It has learned to use some of its earnings as "seed-money" in the introduction of new products and the use of new processes. It has learned to invest more and more in research. It has learned of the interdependence of industry and agriculture. And it has learned much about the eternal triangle of industry, labor and government.

With such a history and such experiences behind it, I have every faith that management is going ahead to even more glorious accomplishments in the winning of the war, and I believe that its peacetime accomplishments to come are beyond the prediction of any of us — even management itself.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.



Radio *hams'* demand for extremely rugged vacuum tubes touched off the intensive research which resulted in the development and subsequent production of Eimac tubes. That Eimac tubes provide the answer to the prayer of the amateur is attested to by the extensive use of these tubes in the amateur field and by the fact that Eimac tubes are now noted for their ability to withstand momentary overloads of 400% to 600% without damage. Eimac tubes were the first and are still the only tubes which are unconditionally guaranteed against premature failures due to gas released internally. These and other equally important performance capabilities have made Eimac tubes first choice of the leading electronic engineers throughout the world — first in the important new developments in electronics of which Radar is the latest and most astounding.

Follow the leaders to

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

EITEL-McCULLOUGH, Inc., San Bruno, Calif.

Export Agents:
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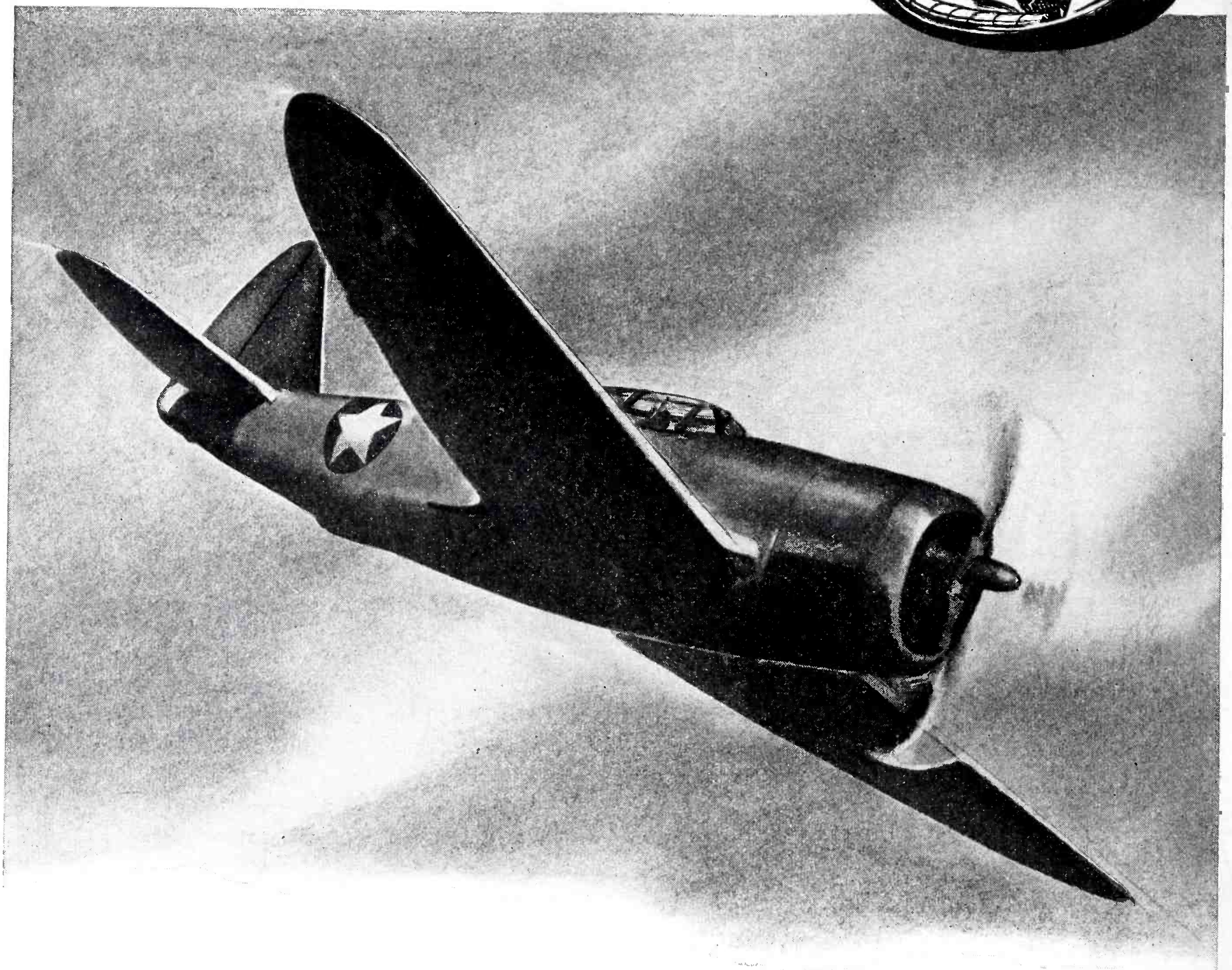
It gave Jenny a voice in '17



. . . and it's in the Army now!

PEACETIME SOUND-TRANSMISSION PRODUCTS BY WESTERN ELECTRIC INCLUDE:

Bell Telephones, switchboards and cable—broadcasting apparatus—aviation, marine and police radio telephones—public address systems — sound picture equipment—aids for the hard of hearing — audiometers for testing hearing—sound measuring equipment.

In August, 1917, Western Electric engineers demonstrated to the Army the *first* two-way radio telephone between plane and ground. It led to the communications which helped make possible the tremendous growth of air transport.

Through the years, Western Electric radio has been standard on the nation's major airlines.

Today, Western Electric command sets fly and fight with Army planes on every front. All our facilities are devoted to making communications equipment for war—for use in the air, on the ground, at sea.

Tomorrow, count on Western Electric for continued pioneering and leadership in fields where sound-transmission plays a part.

Western Electric

ARSENAL OF COMMUNICATIONS EQUIPMENT.

WASHINGTON FEEDBACK

President Roosevelt has now submitted to Congress the long awaited report of the National Patent Planning Commission. The findings of the Commission, which will be the basis of legislation, are generally regarded as a guarantee against hasty and piecemeal tinkering with the basic patent system of the country.

The report strongly attested to the overall soundness of the patent structure. The exchange of scientific information gathered by industrial laboratories was made possible only because of the protection afforded under the patent system, the Commission pointedly observed.

Conceding that patents had in some instances been abused, the report advanced several major recommendations, as follows: that all patent agreements be recorded with the U. S. Patent Office in order to expose secret or improper agreements; that patent owners suing for infringement be limited to reasonable compensation without prohibiting use of an invention when its manufacture is necessary for the public good; that Congress set up test standards to determine the patentability of inventions; that a single court of patent appeals be established; that the patent term should not exceed 20 years after the application is filed.

FCC—Against a background of feuding and personal bickering, a special House Committee headed by E. E. Cox (D-Ga.) has now launched its investigation of the Federal Communications Commission. The opening session was chock full of explosives, with counsel for the committee setting the stage with perhaps the longest list of alleged sins of commission and omission ever leveled at any agency of the Federal Government.

The charges ran all the way from that of the exercise of an all but absolute dictatorship over radio communications by the Commission and particularly its chairman, James L. Fly, to that of endangering national security and the war effort through the Commission's carrying on of radio intelligence work that should be left exclusively to the armed services.

To the list of charges, FCC Chairman Fly countered immediately with a declaration that, given a fair opportunity, he would disprove them. He claimed that the investigation was a combined attempt by "Cox, the radio monopoly and the military" to wreck the commission and "set up monopolistic control by commercial interests of the Nation's most significant mechanism of free speech."

WPB—The War Production Board has been concerned during the past month with ways and means to alleviate two embarassing shortages in the electronic field—mica for capacitor manufacture and radio tubes for civilian use.

To alleviate the present shortage of high grade mica, the Board plans to import more mica and to encourage increased production in this country. The writer was told that under certain conditions, miners of domestic mica may receive aid from Colonial Mica Corporation (the only government buying agency) in the form of low-rent machinery and a training program for employees selecting and grading mica.

Domestic interests believe that a much larger percentage of their mica could legitimately pass as top grade if a mica testing machine developed by Bell Laboratories was used by Colonial to test electrical qualities of mica, in place of the eye-appeal method. This was brought out in a heated two-day session of hearings conducted recently by the Senate Truman Investigating Committee. At present there is, apparently, only one such machine in existence, but several are being built for WPB to use in further experiments.

WPB has two plans under consideration for dealing with the civilian tube shortage. One would set up a definite number of tubes to be produced for civilian use, allocating individual types to different manufacturers and so permitting long, specialized production runs. The other, which is more likely to be adopted, would schedule the whole production of tubes, both civilian and military, without specifying any definite number of tubes for civilian production. Under the second plan, civilians would get any excess over military demands and would have the benefit of special runs squeezed in whenever possible.

INSTRUMENTS—The standardization of electrical indicating instruments has been encouraged by an amendment to WPB's Limitation Order L-203, which is expected to raise output 10 percent.

The amendment permits manufacturers to accept without preliminary approval purchase orders for less than 500 instruments which conform to standards published by the American Standards Association, or to specifications of the Armed Services. Automatic approval is also given on orders for less than 500 instruments any dimension of which exceeds 3½ inches and on orders for any number of polarized-vane non-jeweled instruments, the most familiar of which is the ammeter on an automobile dash board.

Instruments governed by L-203 are redefined to exclude portable instruments which measure more than one electrical quantity. The definition thereby differentiates between "meters" administered under L-203 and "test equipment" covered by General Scheduling Order M-293.

WERS—At the request of OCD, the Federal Communications Commission has issued an order amending its regulations so as to permit war emergency radio stations to go into action "during emergencies endangering life, public safety, or important property, for essential communications relating to civilian defense or national security."

Previously, WERS had been limited to operation during or following air raids, impending air raids, or other enemy military operations or acts of sabotage.

Mallory Distributors Can Save You Time When Time is Important

Quick, complete information and prices for your purchasing department.

Lack of a few parts can wreck almost any production schedule. But when the needed parts are Mallory electronic products, the Mallory distributor is the man to turn to for help.

For example—one manufacturer discovered, just the day before scheduled use, that a number of selector switches required for the launching apparatus of a new aircraft carrier were missing. Something had gone wrong somewhere. But a wire to a Mallory distributor found him with the exact circuit arrangement in stock. The switches went out via air express and the carrier was launched on time.

Application data for your engineering and design departments.

Example Number Two—Navy Code Schools in two universities urgently needed a number of electronic products, among them Mallory switches and jacks, in order to inaugurate training of code operators on schedule. Something inexplicable had gone wrong and the parts were missing. Again, a Mallory distributor stepped into the breach to save the day in jig time.

Service from stock.

Nothing very dramatic about this, it is true. But it demonstrates how Mallory distributors are geared to save time in furnishing essential electronic parts for essential uses . . . especially where small orders are concerned.

Where essential electronic parts are required—for maintenance, laboratory and testing devices, pre-production models—in short, where small quantities are involved, the Mallory distributor stands by to help. We are doing our level best to keep his stocks adequate. Proper ratings are needed? Certainly!

A copy of the Mallory catalog for ready reference.

But make his acquaintance. He can be of service in many ways. If you do not know the name of the Mallory distributor nearest you, we will be glad to tell you.

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

P. R. MALLORY & CO. Inc
MALLORY
APPROVED
PRECISION PRODUCTS

CROSS TALK

▶ **RADAR** . . . Just a few months ago nobody could mention the word radar without a look around to see if the FBI were within earshot. Nobody, that is, except the recruiting posters of the Navy, the Radio and Radar Branch of the WPB, a certain laboratory down in a middle Atlantic state and certain other people who didn't know it was off the record.

Now the word seems to be on everybody's lips. The papers state that bombers have knocked off Germany's radar plant at Friedrichshafen, that we landed in the Aleutians by radar, that a certain battleship was bumped off cold by radar-directed guns; and scarcely a day passes without some new evidence of the marvels of the great secret weapon. In spite of our being publishers, it is our considered opinion that there is altogether too much being said and printed about radar at the present time.

▶ **SUPERSONICS** . . . Do you know how bats fly? Before the New York Institute of Science, John Mills of the Bell Laboratories described the research that led to our present knowledge of the interesting phenomenon which keeps bats from batting their brains out while flitting about at night, seemingly without much control but actually with very superior control. It is an excellent example of the scientific method whereby quantitative data is desired, where each variable is studied at a time and all others are excluded.

A certain number of bats were got into the laboratory of two Harvard biologists, Donald R. Griffin and Robert Galambos. Across the room was stretched a series of vertical wires set far enough apart so the normal bat could fly back and forth from one side to the other between the obstacles. The average bat collided with wires about 30 percent of the time. This was taken as the norm.

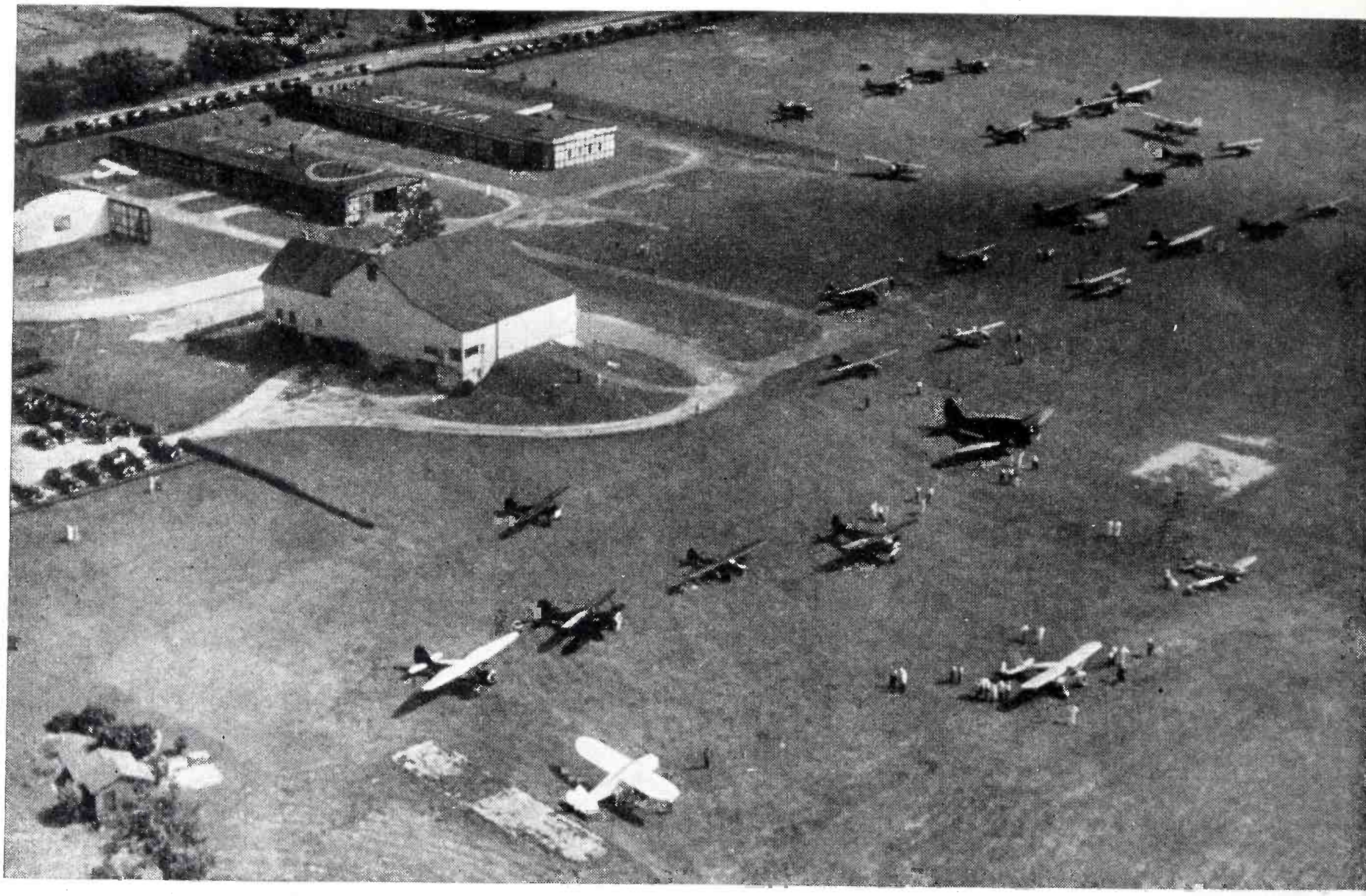
The bats had their eyes covered with collodion and they got through just as well as before. Then their ears were plugged and the collision percentage went up to a figure which represented pure chance. The fact that there were no sounds in the room indicated the possibility that the bats were making their own sounds—but nothing could be heard. When the bat's mouths were taped shut, the collision average went up even though the animals could see and hear.

Supersonic apparatus brought to the laboratory indicated the remarkable fact that bats generate, transmit and receive, superaudible sounds which are reflected from nearby objects, giving the bat an accurate picture of his surroundings by the good old reflection or echo technique. He squeaks 30 to 50 times a second, listening for the return signal, estimates distance and direction in time to swerve and avoid collision.

Man must be pretty smart to imitate a bat.

▶ **MANPOWER** . . . Much sympathy is wasted on some outfits who are continually losing men to other companies when they could keep them, or hire new ones, by paying what the traffic now requires. There is a fellow in the east who needs a lot of men but he says "the government won't let him pay over $1 per hour" and so he is not filling up his payroll very fast. There are others who believe they are still in the depression days when engineers were a dime a dozen, when you could hire them for three months, pump them dry, kick them out.

Post-War CIVILIAN AVIATION



The end of the war will bring new opportunities for the radio industry and for trained radio personnel. One of the best will involve the design, production, distribution and maintenance of new equipment for non-commercial civilian planes and the airports serving them. Radio men with an eye to the future would do well to keep this in mind.

Communications, navigation, and traffic-control at airports will be major post-war problems. The Army and Navy have made tremendous strides in the development and application of electronic gear for such purposes but their equipment will not, considered generally, fit civilian needs. One exception may be low-frequency range transmitters. These were commonly used by commercial airlines before the war and will probably continue to serve aircraft of all kinds for some time after it.

Let us not lose sight of the fact that military equipment is designed for the highly specialized business of war. Private Doe doesn't hop into a B-25 or a P-38 and fly a hundred miles to see his girl. Yet civilian Doe may want to do just that. Neither a bomber nor a fighter can readily be rendered suitable for such service.

Military Gear Unsuitable

Harry Diamond, physicist for the National Bureau of Standards, points out that military aviation radio gear, similarly, is not particularly suitable for commercial airline use, much less civilian flying.[1] He states that it is intended for service over large geographical areas of widely varying topography, instead of along fixed routes involving relatively uniform terrain. Flexibility, simplicity and ruggedness required to meet the peculiar needs of global warfare are not precisely the same kind that is needed for civilian service.

Even if military aviation radio equipment could be easily modified to meet civilian needs it would probably cost too much for this market. A civilian who buys a plane for $1500 will not care to spend a like amount for radio equipment. Yet in the future he will have to have radio equipment in order to fly with maximum safety and to meet government requirements. This will inevitably stimulate the design of gear specifically suited to civilian use.

Opportunity for Manufacturers

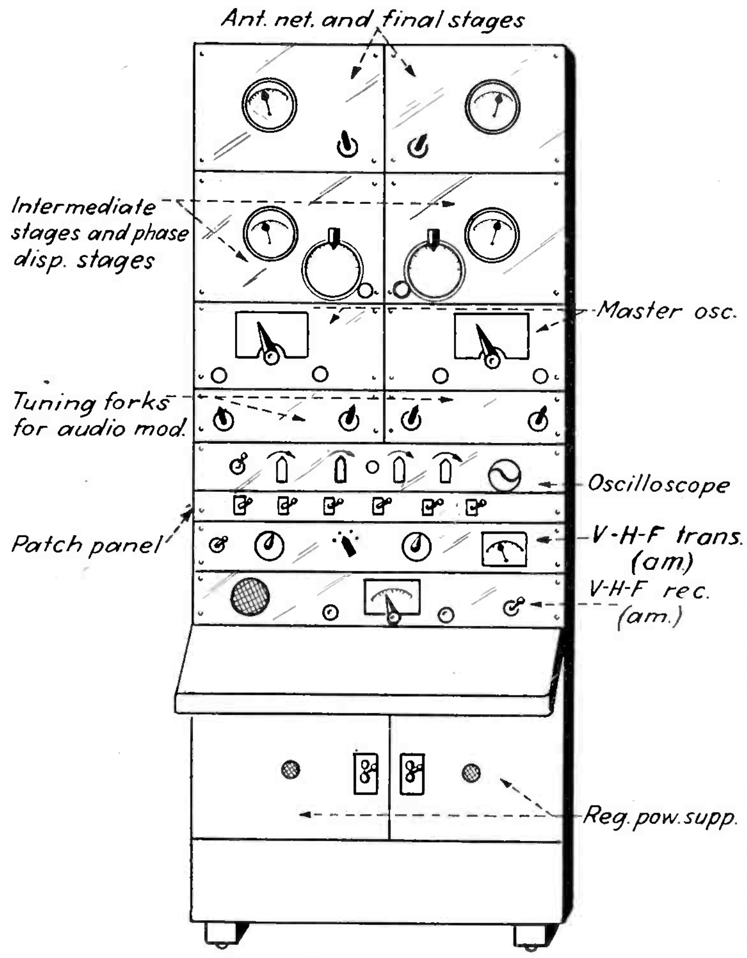
The large companies at present making military aviation radio apparatus will not necessarily be in a better position to supply such gear than smaller firms. While the market will eventually prove very extensive indeed it cannot reach full potential overnight. Thus it may be difficult for big companies to tap it initially because of their initial need for mass-production items.

During the anticipated transition period it is believed that small manu-

RADIO Prospects

A rapid increase in the number of small airports is anticipated, with attendant demand for communications, navigation and traffic-control gear. Military equipment is not readily convertible. The opportunity for small manufacturers is particularly evident

By ROBERT E. RICKETTS



Layout of compact v-h-f ground station range and communications bay of a type the author considers ideal for future small civilian airport use

facturers will be able to operate favorably. The author has spent considerable time studying problems which are likely to arise during this period and finds the prospects interesting indeed. Several wide-awake automobile dealers of his acquaintance, for example, have ear-marked aircraft and aircraft accessories for inclusion in their post-war plans. They intend to open showrooms at existing airports or to build small airports of their own, handling both planes and cars. Used cars may even be taken in trade on new plane sales.

A few months ago one of these dealers had already purchased land and was beginning to build his showrooms and level off his runways.

Status Before the War

Let us quickly review the status of civilian aircraft radio equipment immediately before the war.

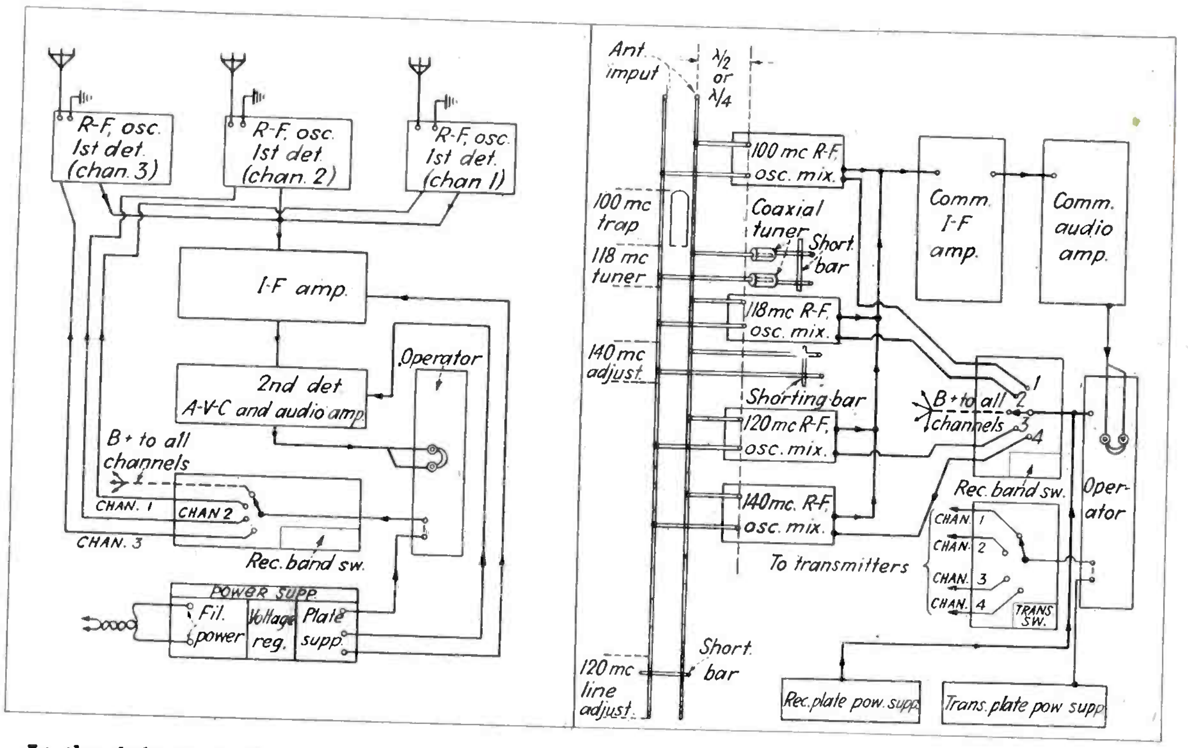
The larger airports were fairly well equipped but the smaller airports frequently had no apparatus other than one communications receiver for weather reports. Even where additional gear was available it was not universally satisfactory.

In the control towers of typical large airports low frequencies were used for navigation transmissions, particularly for the A-N ranges. In the years 1939 and 1940 the trend toward high and very-high-frequencies started to make an appreciable dent in other airport services.[2] After research by the large airlines, v-h-f amplitude-modulated equipment designed to operate on about 140 Mc was ordered for delivery in 1941 and 1942. (Frequency-modulation equipment and quantitative data concerning its efficacy in aviation service was not yet readily available.)

Different airlines usually used different calling frequencies. Civilian planes used other frequencies for communications. Distress calls were made on two separate channels. The airlines had stations about every 200 miles, while the CAA maintained its

TENTATIVE CAA-FCC ALLOCATION PLANS

Band	Frequency (Mc)	Service
(1)	33.4— 39.0	Aviation Instruction
(2)	60.1— 65.8	Radio Teletype (Weather)
(3)	75.0	Fan Marker Beacons, Field-Approach Markers
(4)	93.3—110.3	Landing Beams, Runway Localizers
(5)	123.0—127.0	Radiophone Weather Transmissions, Range Transmitters
(6)	129.3—131.48	Airport Traffic Control
(7)	140.1	National Calling, Itinerant Aircraft
(8)	140.24—143.88	Plane-to-Plane, Plane-to-Ground



At the left, typical receiving setup used by airlines for simultaneously monitoring several channels. Similar systems are recommended for civilian airport use. At the right, transmission-line network scheme suggested for use where only one efficient v-h-f antenna is available

own weather-reporting stations and stations for the handling of air-traffic and distress calls.

One can readily see that many different channels were, of necessity, monitored by the larger airports. Transmitters, tuned or tunable to a large number of frequencies, had to be ready for operation as long as such airports were in service, usually 24 hours a day. A large number of fixed-frequency receivers as well as additional tunable receivers, involving extensive switching and complicated remote-controls, were also necessary.

Recent Equipment Trends

The operators on each channel used their transmitters only intermittently but the receivers had to be running constantly. It is interesting to bring our information up to date on this point.

Originally, the airlines had need for just a few channels. A few fixed-frequency transmitters and receivers met requirements. As business warranted it, additional channels were added.

Now, it is obvious that transmitters used only intermittently may employ band-switching to cover many frequencies. But in the past few years the number of channels added has reached such proportions that for efficiency it has been necessary to employ a multiplicity of band-switching transmitters. In order to keep the required number of transmitters within bounds a group-frequency system of communications was adopted. Where airports and planes originally transmitted and listened on the same frequency during a given contact, separate frequencies were soon employed for transmission and reception, bringing about less frequent need for changing airport transmitter frequencies.

Receiving equipment was simultaneously designed so that two or more frequencies could be monitored by one airport operator. Separate crystal-controlled superheterodyne oscillators were used for each frequency to be monitored. Separate r-f stages and first-detectors were, similarly, used for each frequency. First-detector outputs were fed, in parallel, to a common i-f amplifier. The i-f amplifier was used to drive a common second-detector, noise-limiter and/or a-v-c system and audio amplifier.

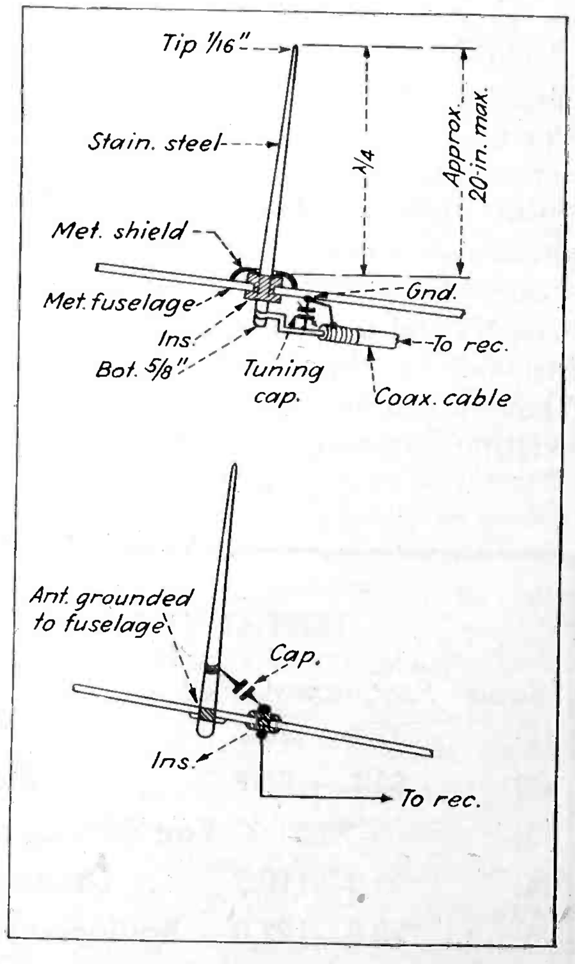
Small Airport Needs

To make civilian flying safe for the anticipated large number of small planes after the war, many small municipal and private airports will have to be in operation.

Obviously, airlines will continue to have their own scheduled routes and airports, so that the smaller airports will not have to serve the larger planes, except in emergencies, at least until such a time as the airlines begin to run a lot of "whistle-stop" locals. Any civilian aviation radio equipment design should, however, undoubtedly take into consideration the future plans of the airlines as well as those of CAA. The airlines and the CAA furnish weather reports and other information of value to the civilian pilot. Aside from this, the ability to contact all other planes and any kind of ground station is a safety-factor not to be considered lightly when designing gear intended to meet demands of the future.

It is reasonable to assume that airports primarily serving civilian flyers will some day be from 40 to 70 miles apart. Thus a potentially large number of airports is involved. The bands allotted for air communications have already become over-crowded. The high, very high and ultrahigh-frequencies, therefore, seem logical places for civilian aviation service.

The first group of frequencies to be more extensively utilized for aviation service will be between 75 and 150 Mc, in the high and very-high-frequency bands. It seems probable that 750 Mc may be the maximum frequency used for conventional purposes for several years. Still higher frequencies, in the ultrahigh and possibly in the super-high, brackets will probably come into use for spe-



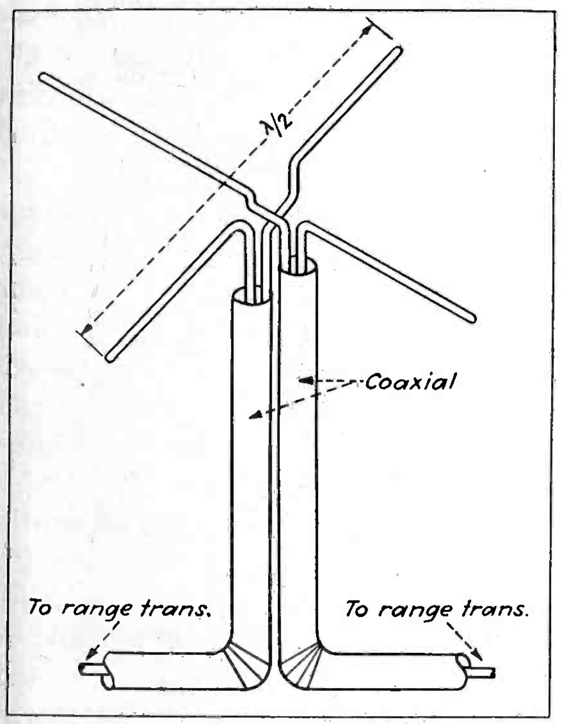
Use of v-h-f gear simplifies installation of antennas on small planes. The top drawing shows a method of shunt-feeding a typical antenna and the bottom drawing illustrates a series-fed system

cial applications in the more remote future.

Within the first-mentioned range, equipment which will be available soon after the war will serve small airports, particularly, very well indeed. At an altitude of 1200 ft or more a 300-watt v-h-f ground station appears to put out a very strong signal up to 100 miles and distances considerably beyond may be covered with reasonable reliability.

Probable New Frequencies

Marker beacons operating on 75 Mc were installed in 1938 by the CAA. In 1941, Chicago and New York airports placed v-h-f range



Range transmitters operating on the very-high-frequencies may employ extremely simple antenna arrays. This one delivers horizontally polarized waves

transmitters in continuous service. This equipment has worked out very well and its success marks the turn of a new aviation radio era. So it is well that we look into the future and examine tentative plans regarding frequencies.

A chart included in these pages outlines what the author believes to be a good composite picture of CAA and FCC proposals, complete insofar as it is possible for tentative plans to be so under present circumstances, if not in every detail.

The first group of frequencies shown in the chart, from 33.4 to 39.0 Mc, is proposed for aviation instruction, with four separate channels available.

The second group, involving the very-high-frequencies between 60.1 and 65.8 Mc, may be used for radio teletype dissemination of weather data and comparable information, probably to be transmitted by CAA stations.

The third allocation, already in use, will undoubtedly continue to be employed for fan marker beacon transmissions. (This channel has also been used for some time for field-approach markers, used in conjunction with the altimeters of planes to constitute a blind-landing system, and will no doubt continue to accommodate such systems also until all-radio systems are substituted.)

The fourth band, having spot frequencies on 93.3, 93.9, 94.3, 109.5 and 110.3 Mc, is tentatively proposed for instrument landing service, the first three frequencies to be utilized for landing beams and the last three for runway localizers.

The fifth band is apparently to be taken up eventually by radiophone weather broadcast transmitters shifted from lower frequencies and operating between 123 and 126 Mc, with 31 exclusive frequencies, and by similarly shifted range transmitters operating between 126 and 127 Mc, using 10 shared frequencies.

The sixth group, proposed for airport traffic-control service, will involve spot frequencies on 129.3, 129.78, 130.3, 130.86, 131.42 and 131.48 Mc.

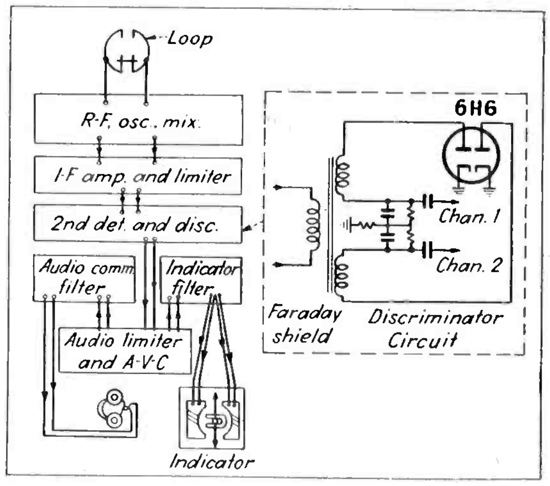
The seventh allocation, on 140.1 Mc, is evidently to be used for national calling and itinerant aircraft service.

The eighth group, between 140.24 and 143.88 Mc, with 28 spot frequencies available, seems destined to be given over to plane-to-plane and plane-to-ground two-way communications.

Design and Production Suggestions

Aircraft communications equipment has always presented peculiar design difficulties and the use of higher frequencies introduces additional problems of no small magnitude. The design of h-f and v-h-f gear for civilian aviation service requires a particularly high order of ingenuity for here it is not only necessary to conform with CAA and FCC requirements but this must be done without running the price of the equipment beyond the relatively limited capacity of the customer to pay.

The subject of design is so ex-



Block diagram of plane receiver suitable for both communications and navigation, embodying a modified discriminator circuit devised by the author

tremely broad that only a few pertinent points can be mentioned here. For example, one method of obtaining production economy may be to manufacture one piece of equipment that is flexible enough to fulfill many functions when used with suitable accessories. Additional savings could possibly be effected by reducing the required number of cables, remote-drives, relays and coaxial lines, for which there will be a considerable demand anyway because of the expansion of the overall market. In this connection the author believes that automobile radio manufacturers have already shown aircraft equipment designers the way.

Another thought that comes to mind is that it may be possible to economically meet demands for light weight plus ruggedness by the increased use of aluminum, which should be available in many new varieties as a result of wartime experiment and may even now be satisfactorily welded.

Possibilities for Expansion

In a survey made by one of the large airlines it was recently observed that 60 percent of its radio operators' time was spent directing airport landings and controlling airport traffic. Thus it might seem that all a small civilian airport really needs is one h-f or v-h-f transmitter for communications, a transmitter turning out a homing signal and a receiver tunable over a wide band of frequencies. This sort of a setup might, indeed, "get by" for a short time after the war ends but it will certainly prove quite inadequate when civilians really begin to fly.

For one thing, homing signals

(*Continued on page* 276)

An ELECTRONIC "SEWING

Thermoplastic sheets of the type used to make raincoats, tobacco-pouches, food packages and inflatable articles are bonded by means of radio-frequency heating. Rotating electrodes and h-f currents are substituted for needle and thread to make firm, moisture-proof seams

RESEMBLING a conventional sewing machine in appearance, a recently-developed electronic "sewing machine" replaces customary needle and thread with a pair of rotating electrodes and a high-frequency current. Designed to make firm seams in new thermoplastic sheet materials that have emerged from the laboratories of the plastics industry, it employs to advantage a phenomenon that has long been the annoyance of radio engineers. Here the heating of dielectrics by a strong high-frequency field finds useful industrial application in the controlled softening of thermoplastics.

There are a number of synthetic-resins which become soft as temperature is elevated and may thus be classed as thermoplastics. Among them are the typical materials listed in Fig. 1. These, and similar synthetic resins are readily extruded, pressed or rolled into sheet form and possess valuable properties such as chemical inertness; imperviousness to water, moisture, or gas; light weight; high strength, and transparency.

Conventional Fabricating Methods

Three distinct methods are commonly employed at present for fabricating articles from thermoplastic sheeting. The most widely used is ordinary sewing, which is rapid but tends to weaken the material at the seams due to the perforations of the needle and requires the use of cement before as well as after if the seams are to be completely moisture-proof. Threadless bonds are sometimes made by the use of a solvent and pressure. Or bonds may be made by the application of heated rollers or plates. The two latter methods are frequently combined to produce moisture-proof seams but where solvents and/or externally applied heat is used there is generally some weakening due to the action of the solvent or some distortion due to the method of applying the heat.

The use of hot rollers or platens as a source of heat for bonding thermoplastic layers encounters some definite limitations. When the hot plates A and B in Fig. 2 are placed on the outside surfaces of sheets (a) and (b), which are to be bonded along the surface (c), the plates must be maintained at a sufficiently high temperature P so that the interfacial temperature will be high enough above room temperature R to make the material plastic in the region to be bonded. The temperature distribution across the material

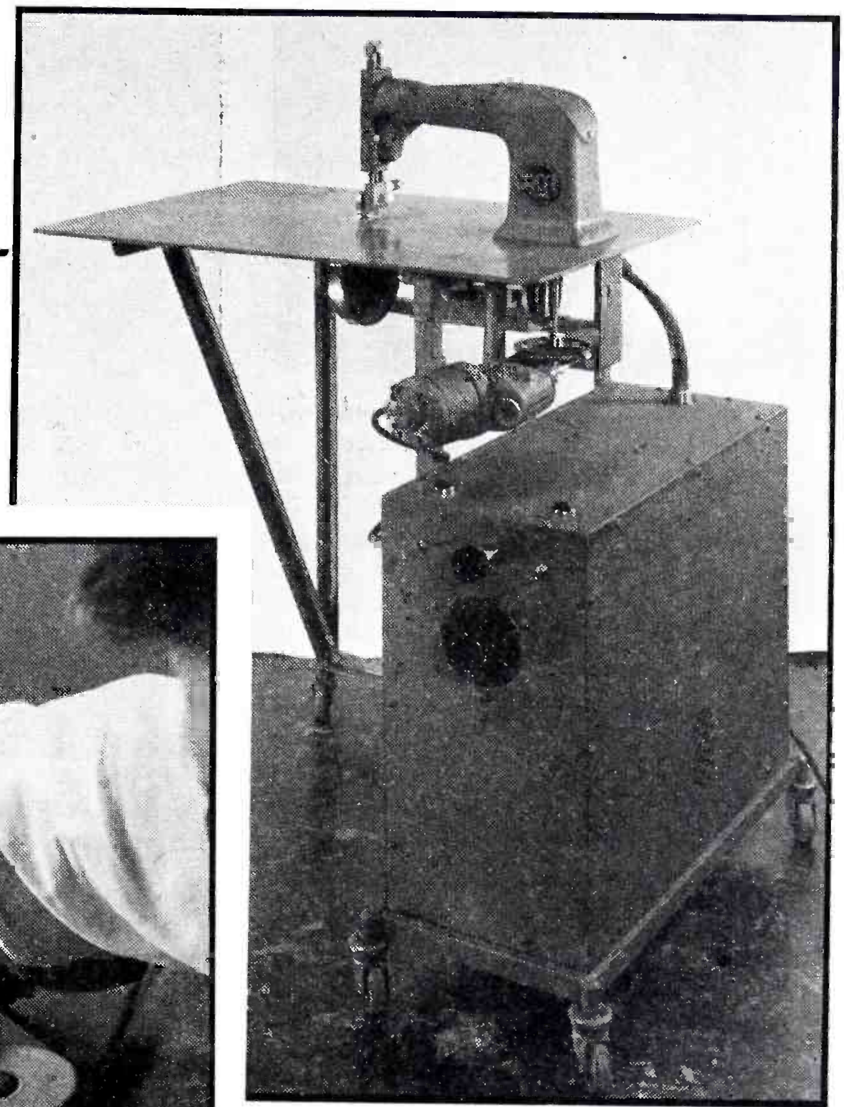
MATERIAL	*Pliofilm*	*Vinylite*	*Koroseal*	*Saran*
MANUFACTURER	Goodyear Tire & Rubber Co.	Carbide & Carbon Chemicals Co.	B. F. Goodrich Co.	Dow Chemical Co.
CHEMICAL FAMILY	Rubber Hydrochloride	Vinyl Resin	Plasticized Polyvinyl Chloride	Vinylidene Chloride
THICKNESS	0.001 in. to 0.0018 in.	0.0045 in.	0.001 in. to 0.0018 in.	0.0015 in. to 0.005 in.
BOND OBTAINED BY R-F HEATING	Excellent *	Excellent *	Excellent †	Excellent †
R-F BREAKDOWN RESISTANCE	Excellent	Excellent	Fair, Improving With Thickness	Fair, Improving With Thickness
SPEED OF SEALING	5 ft. per min.	5 ft. per min.	5 ft. per min.	4 ft. per min.
THERMAL CONDUCTIVITY	3.0×10^{-4}	3.9 to 4.0×10^{-4}	3.9 to 4.0×10^{-4}	2.2×10^{-4}
SPECIFIC HEAT	0.39 to 0.43	0.30 to 0.50	0.32 to 0.51	0.32
DENSITY	1.64	1.2 to 1.6	1.2 to 1.6	1.68 to 1.75
SOFTENS	80 to 110 deg. C.	90 to 150 deg. C.	90 to 110 deg. C.	110 to 140 deg. C.

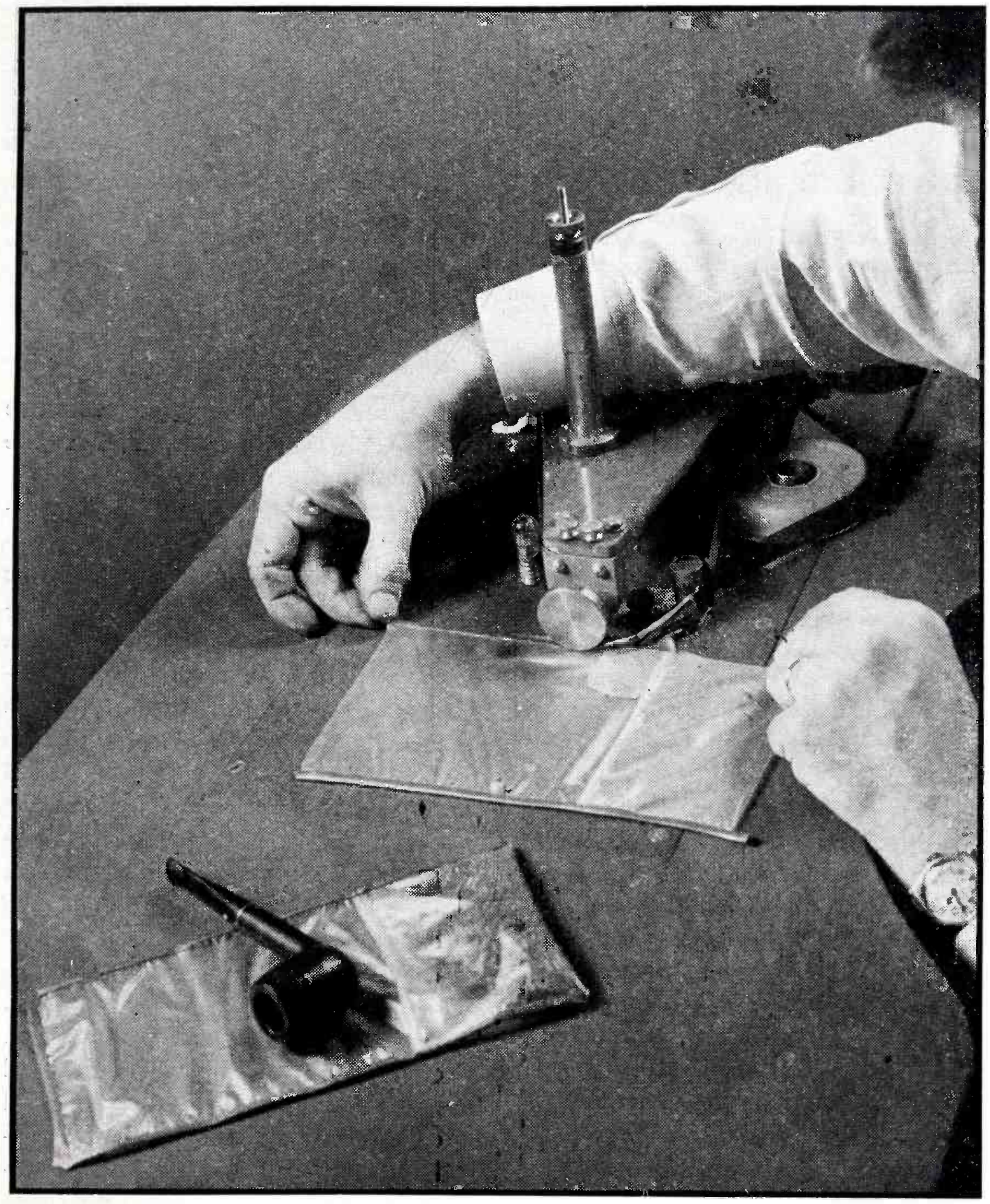
* At 60 Mc. † In combination with tapes of other materials, or at higher frequency

FIG. 1—Four typical thermoplastic sheet materials and data pertinent to fabrication in the electronic sewing machine, as determined experimentally by the author

MACHINE"

By CYRIL N. HOYLER
RCA Laboratories
Princeton, N. J.





Latest model electronic sewing machine

Experimental unit in use, fabricating thermoplastic tobacco-pouch. Binding attachment permits simultaneous decoration with contrasting-color tape

under these conditions is shown by the dotted curve *HP*, which also indicates the relative plasticity of the material between its external faces.

It is apparent that the hot plates will produce excessive softening of the outer surfaces, with consequent extrusion of the material when pressure is applied, as indicated by Fig. 3. The greatly softened surface is weakened along the seam by extrusion and also becomes gummy and sticks to the hot plates, which must frequently be cleaned during production. In addition, the low thermal conductivity of most thermoplastic materials limits the speed at which sealing may be done.

Advantages of R-F Heating

When a radio-frequency field is applied across the seam, heat is generated uniformly by dielectric loss. When sufficient power is used, the temperature of plasticity may be attained in a very short time. Referring again to Fig. 2, consider *A* and *B* as the electrodes between which an electric field is established, while (*a*) and (*b*) represent, as before, the thermoplastic sheets to be bonded along line (*c*). The good heat conductivity of the metal electrodes keeps the outer layers of the material comparatively cool so that the temperature distribution across the material is that shown by the curve *RF*, which also represents the relative plasticity of the material between the plates.

It is apparent that the highest temperature is in the central region, where thermoplastic softening must occur for the two layers to be properly fused. When the electrodes are made to exert a slight pressure during the application of the radio-frequency field, the softened interfacial surfaces will bond as shown in Fig. 4, with negligible deformation of the outer surfaces.

So that the sealing process may be made continuous, the fixed electrodes of Fig. 2 are conveniently replaced

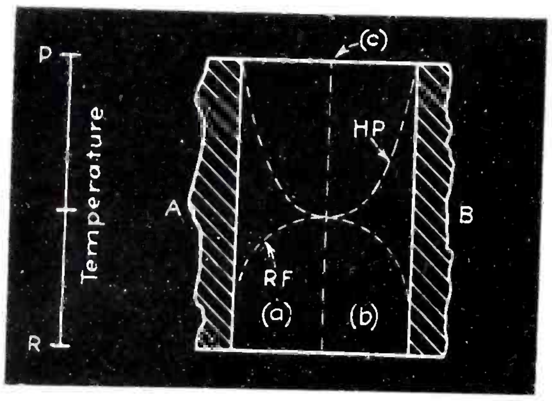
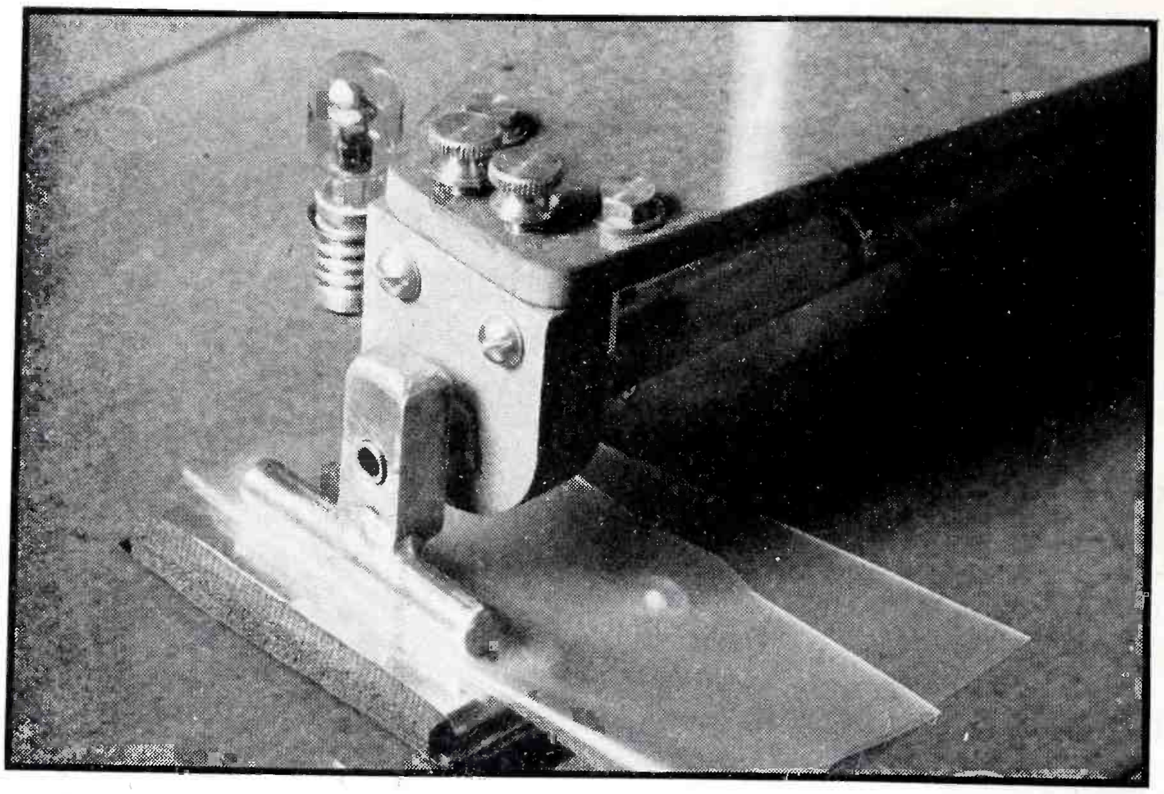


FIG. 2—Curves showing temperature distribution across thermoplastic material to be bonded. *HP* shows distribution with conventional hot-plate heating. *RF* shows distribution with r-f heating. *A* and *B* are cross-sectional views of portions of the plates or electrodes, *(a)* and *(b)* are cross-sections of the sheets to be bonded and (c) is the contact surface



Close-up of "business-end" of experimental model, illustrating use of bar instead of driven roller electrodes where, as in the packaging of foodstuffs, it may be desirable to form a whole seam or seal in one shot

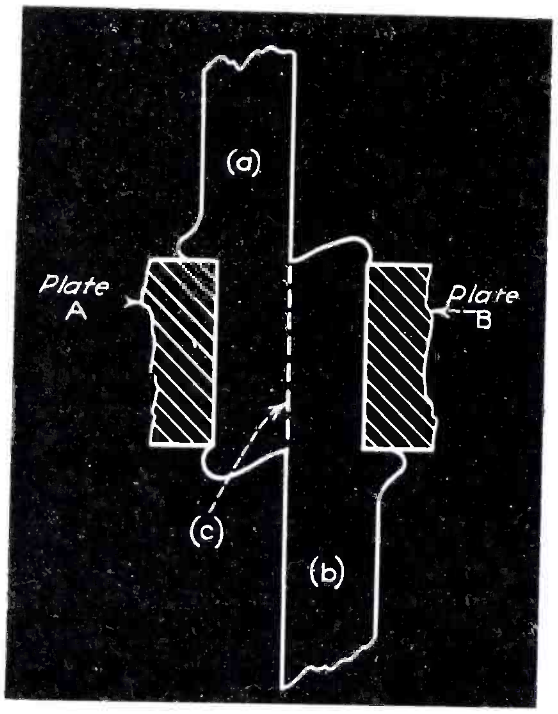


FIG. 3—Drawing showing result of typical hot-plate bond. Note extrusion at surfaces contacted by plates, caused by excessive softening of the outer surfaces of the material

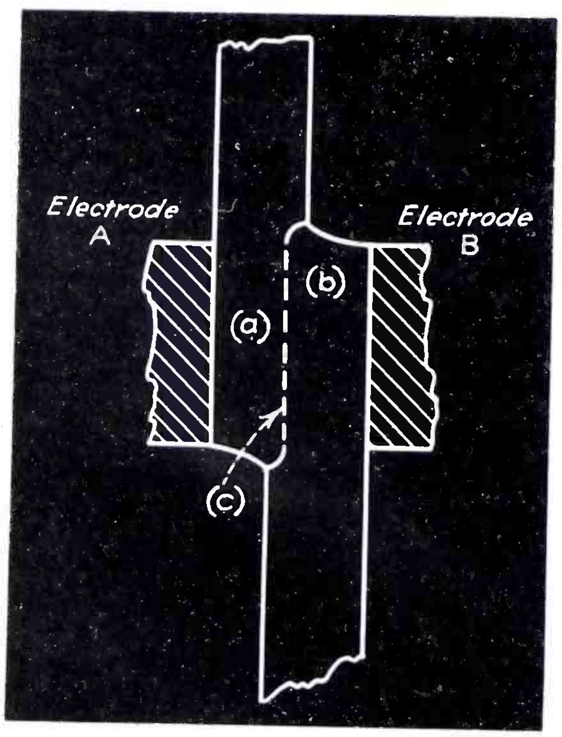


FIG. 4—Result of r-f bond, with electrodes operating under slight pressure. Heat is generated uniformly throughout the material. The electrodes rapidly conduct heat away from the outer surfaces of the material so these surfaces remain cool

by rotating electrodes between which the material to be bonded may pass in the manner in which it passes through a sewing machine. Uniform feeding of the material is accomplished by gearing the electrodes together in such a way that their peripheral speeds are the same. Unless this is done there is considerable slippage between layers on long seams, with consequent improper registry, or wrinkling.

The radio-frequency field may be readily established between the electrodes by coupling them to the output of a small oscillator through a suitable transmission line. An outstanding advantage of this method of electronic heating lies in its flexibility. Having once determined suitable operating parameters such as speed, power and pressure, the controls can be instantly adjusted to reproduce any desired condition. There is no period of waiting for plates to heat up or cool off; no testing of a solvent's potency; no drying period for cement.

Machine Design Details

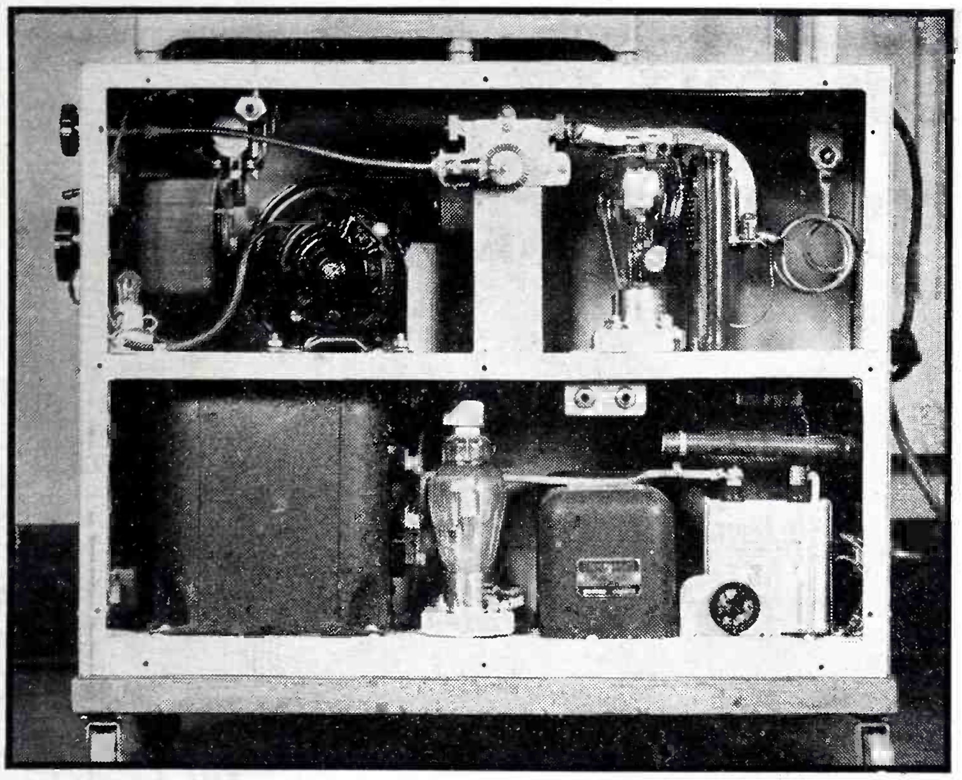
Construction of the most recent model of the electronic sewing machine, assembled as a complete operating unit, may be described as follows: A framework supports the rotating electrodes and work table at convenient level, with the oscillator and its power supply housed in an integrally associated metal cabinet. Power and tuning controls are mounted on the front panel of the metal cabinet.

The radio-frequency power is conducted from the oscillator to the rotating electrodes by a concentric line of such a length that the electrodes are effectively at the end of a quarter-wave transmission line. Under this condition, maximum voltage is placed across the material to be bonded. The oscillator is tuned until its operating frequency is such that this condition is realized, as indicated by maximum brilliance of a small neon lamp mounted near the high-potential electrode.

First experimental tests were conducted at a frequency of 15 mc, with improved operation noted at 45 mc. The final choice of 60 to 70 mc used in the latest model was dictated largely by convenience of power generation, together with ease of conducting energy to the electrodes through a length of quarter-wave line that could be conveniently used. The actual power required to make a serviceable bond is very low so the oscillator used provides ample output reserve for heating even unusually thick sections efficiently.

R-F Power Requirements

Under one set of operating conditions a seam one-eighth of an inch wide was made at the rate of five feet per minute, which was equivalent to heating every point along the



Arrangement of r-f oscillator, associated controls and cooling blower (top shelf) and power-supply (bottom shelf). A foot-switch controls the rotating electrode driving motor and oscillator output. A panel-switch permits the motor to be stopped where it is desirable to move the material by hand and merely "baste" it together at spaced intervals

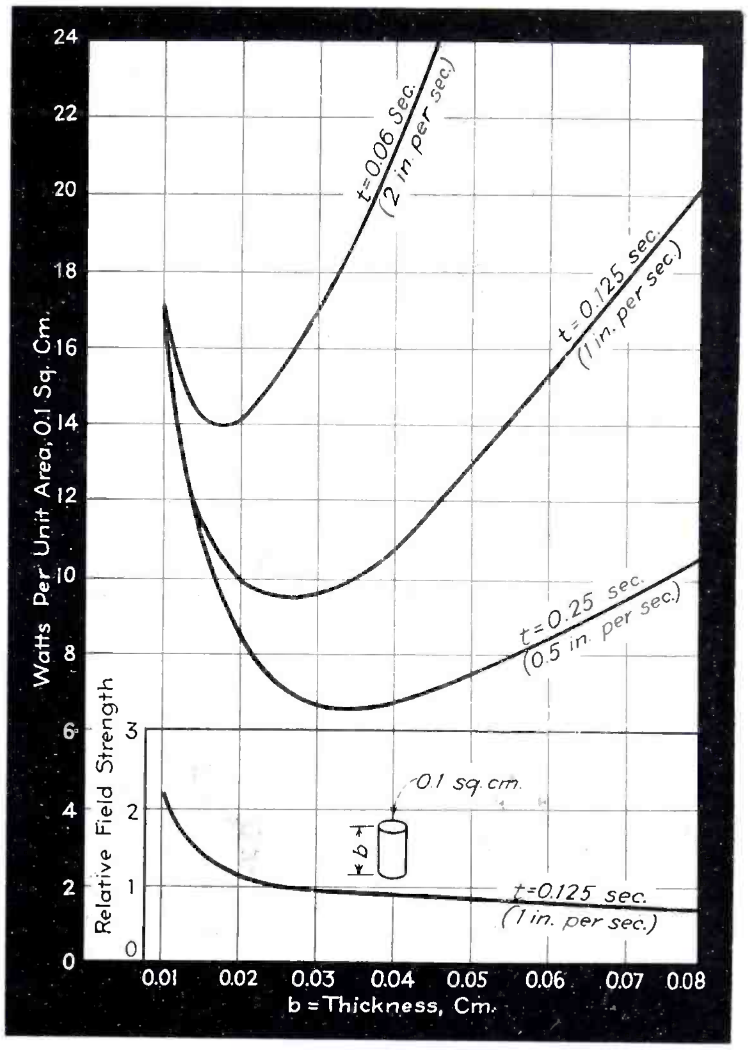


FIG. 5—(Right) Curves showing power requirements and field strength as functions of Vinylite thickness and speed of bonding

seam for 0.125 second. Using Vinylite as an illustration, the power requirements for making a seal under these conditions may be calculated. This material has a softening point between 90 deg and 150 deg C, a specific heat of about 0.4 calories per gram and a density of approximately 1.5 grams per cubic centimeter. Neglecting heat conduction into the electrodes, the power required to elevate the temperature of one cubic centimeter of Vinylite from 20 deg to 150 deg C in a second is:

$$P = J \rho c \Delta T = 326 \text{ watts} \qquad (1)$$

where J is the mechanical equivalent of heat,
ρ is the density in grams per cubic centimeter,
c is the specific heat in calories per gram, and
ΔT is the temperature increment in degrees Centigrade.

For sealing two sheets each 0.004 inch thick, the volume to be heated is roughly equivalent to 0.002 cubic centimeter and the time is 0.125 second, which makes the actual power necessary to heat this small volume only 5.2 watts.

To account for the heat conducted into cold electrodes G. H. Brown has developed a theoretical solution for dielectric heating by radio-frequency power, based on an analogy between the solution of a transmission line with series inductance and shunt leakage conductance and the solution of the heat-flow equation. ("Heat-Conduction Problems in Presses Used for Gluing Wood", scheduled for early publication in the *I.R.E. Proceedings.*) He shows the following expression, which gives the temperature at the center of the dielectric material being heated. Values used in the accompanying example apply to dielectrics of glue and wood:

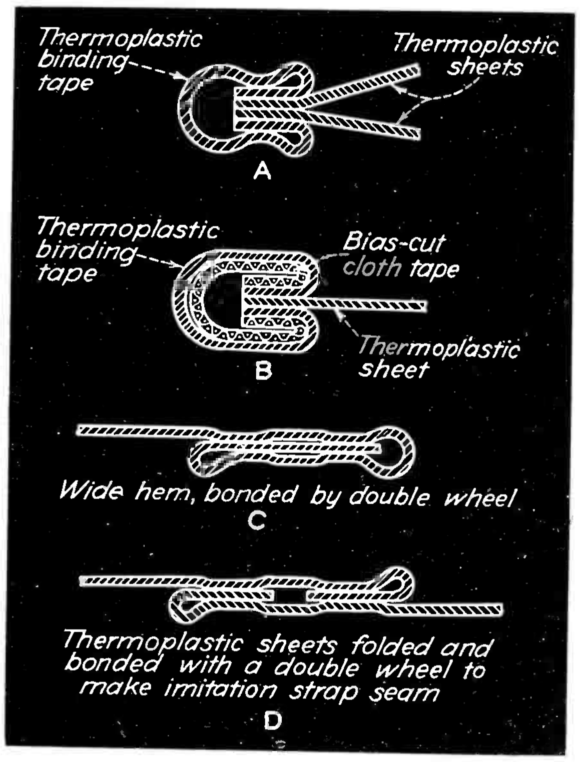


FIG. 6—Special thermoplastic sheet bonds which may be made by using binding, hemming and other electronic sewing machine attachments

$$u_c = \frac{4Hb^2}{\pi^3 k}\left[\left(1-\epsilon^{-\frac{\pi^2 a^2 t}{b^2}}\right) - \left(\frac{1-\epsilon^{-\frac{3^2\pi^2 a^2 t}{b^2}}}{3^3}\right) + \left(\frac{1-\epsilon^{-\frac{5^2\pi^2 a^2 t}{b^2}}}{5^3}\right) - \cdots\cdots\right] \qquad (2)$$

u_c = temperature increment at the center in degrees C (150 − 20 = 130 degrees C)
H = gram-calories per second per cubic centimeter,
b = total thickness of material between plates (0.02 centimeters),
k = thermal conductivity: 0.0004 gm-cal/(sec.) (sq. cm.) (deg. C per cm.),
t = time (0.125 seconds).
c = specific heat (0.4 calories per degree C per gram),
ρ = density (1.5 grams per cubic centimeter),
a^2 = thermal diffusivity $= \frac{k}{c\rho}$ (0.00067 square centimeters per second),

Solving Eq. (2):

$$130 = 0.13H\left[\left(1-\epsilon^{-2.06}\right) - \left(\frac{1-\epsilon^{-18.51}}{27}\right) + \left(\frac{1-\epsilon^{-51.50}}{125}\right)\right]$$

or, H = 1180 gram-calories per second per cubic centimeter.

Since power in watts = 4.187 x gram-calories per second and the volume actually to be heated is 0.002 cubic centimeters, the power required for this volume is:

$$4.187 \times 1180 \times 0.002 = 9.88 \text{ watts}$$

On the basis of similar calculations, curves have been drawn in

(*Continued on page* 160)

Power Output of
A-C OPERATED AMPLIFIERS

For many industrial applications amplifiers can be operated advantageously from an a-c source of power. Rapid and comparatively simple graphical methods of determining the power output of a-c operated triode and pentode amplifiers are given

By
WARREN A. SCHWARZMANN
Cambridge, Mass.

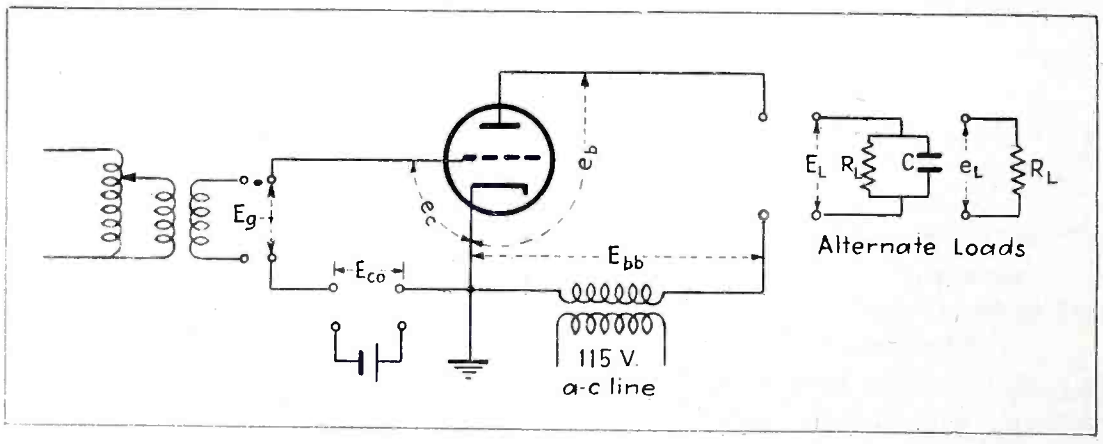
THE operation of electron tubes in communication circuits, with few possible exceptions, requires the application of direct voltages between the various electrodes. These electrode voltages establish the quiescent points or operating conditions. The path of operation can then be determined from a knowledge of the manner in which the control grid voltage varies, and from a knowledge of the static characteristics of the tubes. The analysis of this type of circuit operation has been rather thoroughly covered in technical literature.

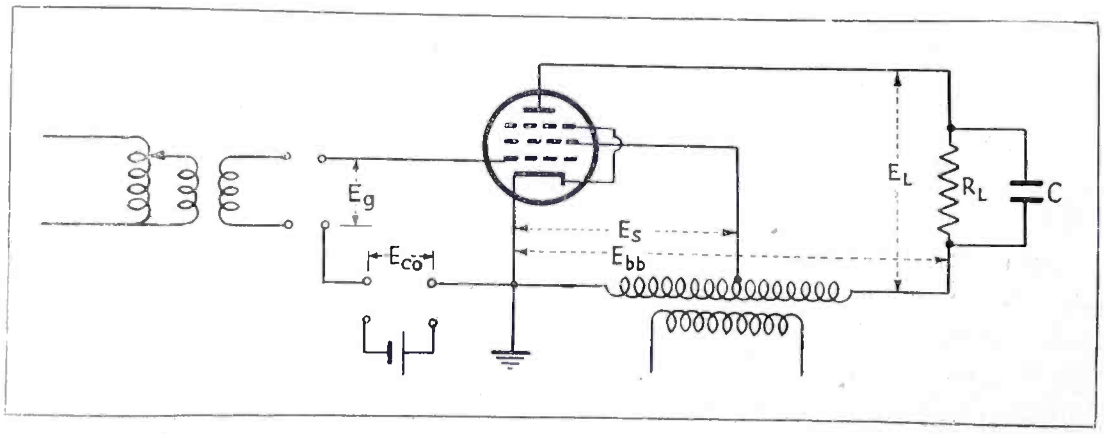
In the industrial application of electron tubes the need for direct operating electrode voltages is not so important. Indeed, it is frequently possible (and many times convenient) to operate the tubes from an a-c source of power. Such operation is not suitable for those applications which require the instantaneous and continuous flow of plate current, but it is suitable for those control operations which need not take place more quickly than every cycle of the alternating current supply.

The prediction of the power output of a-c operated amplifiers is usually of major consideration in this method of operation. It is the purpose of this article to outline methods for calculating the output power of alternating current operated amplifiers using tubes having triode or pentode characteristics. The results presented here are based on theoretical calculations as well as upon laboratory measurements, using either a purely resistive load or a plate load consisting of a resistor and capacitor in parallel. The methods given here are intended to provide approximate results quickly, using the average plate characteristics of the tubes as given in any tube manual. It is hoped that the method of calculation presented here will make unnecessary the use of experimental methods of design which may be tedious and time-consuming.

The schematic diagrams for which the data given in this article applies, are shown in Fig. 1 and 2. In these diagrams and in the analysis to follow, the following symbolic notation has been used:

The practical determination of the power output of a-c operated amplifiers is condensed from the author's thesis, "Prediction of the Output of Alternating-Current-Operated Amplifiers" in partial fulfillment of the degree of Bachelor of Science at the Massachusetts Institute of Technology





ABOVE

FIG. 1—Schematic diagram for triode, for two different types of loads, illustrating the notation with respect to voltage and load

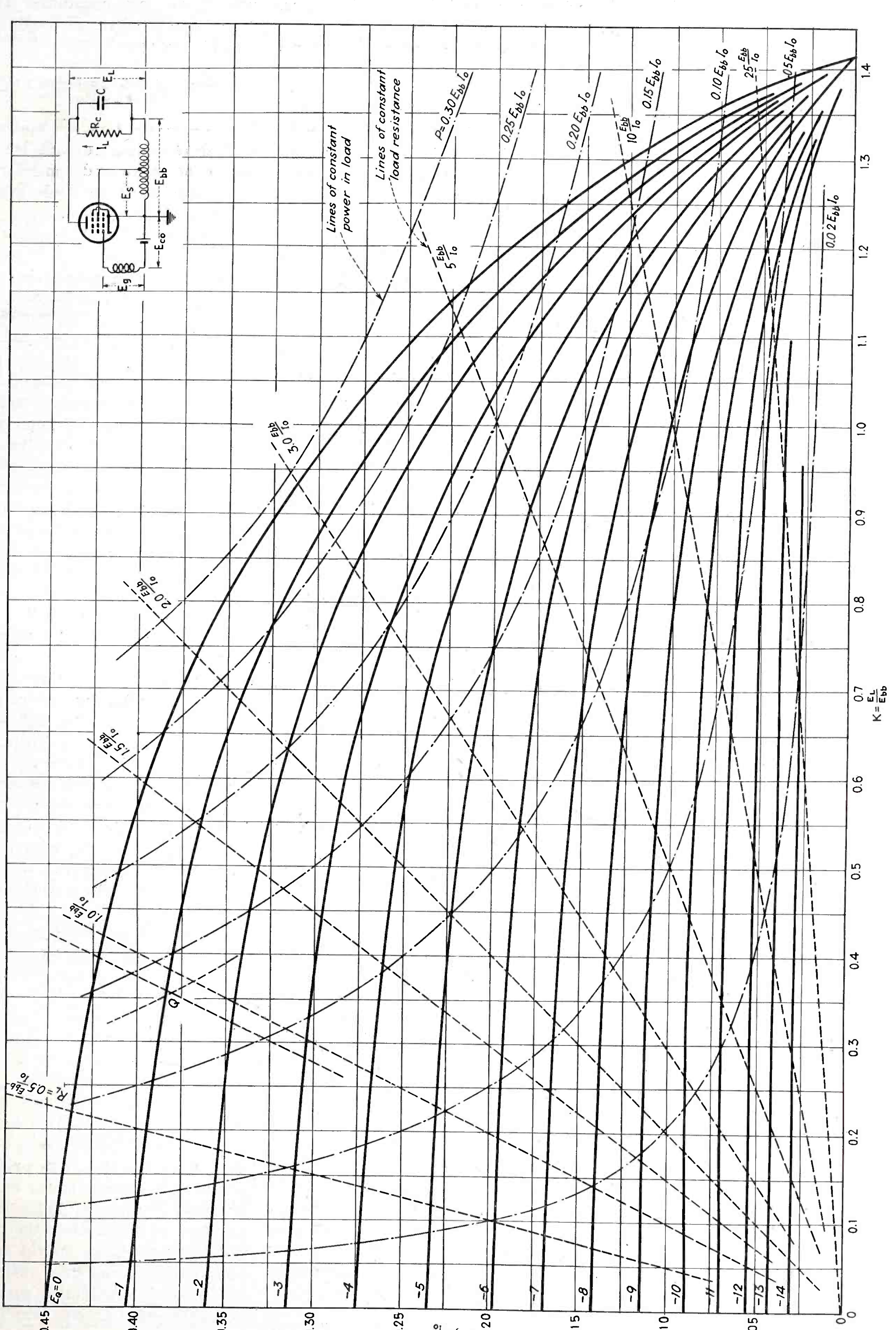
LEFT

FIG. 2—Diagram of connections for pentode and load for which the graphical diagram of power output is determined

RIGHT

FIG. 3—Load current, load voltage chart for pentodes operated with a-c power supply and having RC load

ALTERNATING CURRENT OPERATED AMPLIFIER LOAD CURRENT-LOAD VOLTAGE CHART FOR PENTODES



E_{bb} r.m.s. value of alternating plate supply voltage
e_c $= E_{co} + E_g$ r.m.s. value of cathode-grid voltage
E_{co} steady grid bias voltage
E_g r.m.s. value of alternating component of cathode-grid voltage; E_g is considered to be positive when in phase with E_{bb}, and negative when 180 deg. out of phase with E_{bb}
E_L r.m.s. value of voltage across RC load for triode or pentode
e_L r.m.s. value of voltage across resistive load for triode
E_o value of plate voltage (on plate-voltage plate-current family) obtained at the axis, $I_b = 0$, when the straight portion of the curve, $E_c = 0$, is extended to intersect this axis
E_{sg} screen grid voltage for which tube ratings or static characteristic curves of tube are available
E_{sg} actual screen grid voltage at which tube is to be operated
I_L average value of the current flowing through load resistor R_L
I_o calculated plate current at zero grid bias and zero plate voltage and for screen voltage for which static curves or tube ratings are available, obtained by projecting the saturated curves to left axis
I_s calculated plate current at zero bias, zero plate voltage, and for screen grid voltage at which tube is operated
P power delivered by tube to its load
R_L resistance of external plate load resistor
r_p internal plate resistance of tube
μ amplification factor

The behavior of a triode can be predicted with reasonable accuracy from relatively simple equations which express the load current in terms of tube parameters and operating voltages. In the case of the tubes having pentode characteristics, investigations have shown that graphical methods are more convenient and accurate than mathematical equations.

It can be shown that, for a triode with a pure resistance load, the average plate current is:

$$I_L = \frac{1.35(E_{bb} + \mu E_g) + \mu E_{co} - E_o}{3r_p + 3R_L} \qquad (1)$$

This equation expresses the average value of the plate current when the tube parameters and operating voltages are known. It should be observed that r_p and μ are to be determined in the usual manner for the root-mean-square values of the operating voltages. Of course, these values will vary throughout the cycle, but the published values can usually be used for engineering purposes.

If the resistance load is shunted by a capacitor of sufficient capacitance so as to keep the load voltage essentialy constant throughout a complete cycle, then the average load current may be obtained from the expression:

$$I_L = \frac{1.35(E_{bb} + \mu E_g) + \mu E_{co} - E_o)}{(3r_p + R_L)} \qquad (2)$$

where the symbols have the values previously given.

Both of the above equations are based on the assumption that the alternating components of the grid and plate voltage are in phase. If there is a phase shift between the plate supply voltage and the sinusodial component of grid voltage, the numerators of equations (1) and (2) become:

$$1.35[E_{bb}^2 + 2E_{bb}\mu E_g \cos\phi + \mu^2 E_g^2]^{1/2} + \mu E_{co} - E_o \qquad (3)$$

where ϕ is the angle of phase shift and E_g is considered to be positive.

If μE_g is much less than E_{bb}, the numerator simplifies to:

$$1.35\,(E_{bb} + \mu E_g \cos\phi) + \mu E_{co} - E_o \qquad (4)$$

Once the average value of the plate current and the resistance of the load are shown, the average voltage across the load can be determined as can also the power dissipated in the load resistor, provided the resistor is a linear device. Experience has indicated that these equations can usually be used to produce results which are accurate to within 5 or 10 percent, although occasionaly errors as high as 25 percent may be encountered. The equations are derived on the following assumption:

1. The static plate characteristics are straight, parallel, equidistant lines, which assumes that the amplification factor is constant. If high negative grid bias is used, the approximation is not too good because of the curvature of the plate characteristic.

2. E_o is the value of the plate voltage when $E_c = 0$ and no plate current flows. For constant-μ triodes $E_o = -\mu E_c$, where E_c is the negative bias voltage.

MAXIMUM RATINGS FOR 6G6-G CONNECTED AS PENTODE

Plate voltage	180 max. volts
Screen voltage	180 max. volts
Plate dissipation	2.75 max. watts
Screen dissipation	0.75 max. watts

Typical Operation and Characteristics — Class A_1 Amplifier

Plate voltage	135	180	volts
Screen voltage	135	180	volts
Grid voltage	−6	−9	volts
Peak A-F grid voltage	6	9	volts
Zero-signal plate current	11.5	15	ma
Zero-signal screen current	2	2.5	ma
Plate resistance	0.170	0.175	megohm
Transconductance	2,100	2,300	μmhos
Load resistance	12,000	10,000	ohms
Total harmonic distortion	7.5	10	%
Maximum signal power output	0.6	1.1	watts

Output of A-C Operated Pentode Amplifier

The power output of tubes having pentode characteristics are most conveniently and accurately determined through the use of the graphical chart of Fig. 3. The chart of Fig. 3 can be used with any pentode type of tube once its static characteristics are known. The results have been applied only for a load consisting of a resistor and capacitor combination in parallel as the load circuit.

It will be noted that the coordinates of Fig. 3 are given either as a current ratio or as a voltage ratio and hence the diagram is applicable to any voltage and current at which the tube can be operated. For example in order to obtain the load current the ordinates of Fig. 3 must be multiplied by I_o; likewise to obtain the load voltage the abscissa must be multiplied by E_{bb}. Rather than give the theory underlying the construction of the chart of Fig. 3, it seems more practical to limit discussion to a use of this chart.

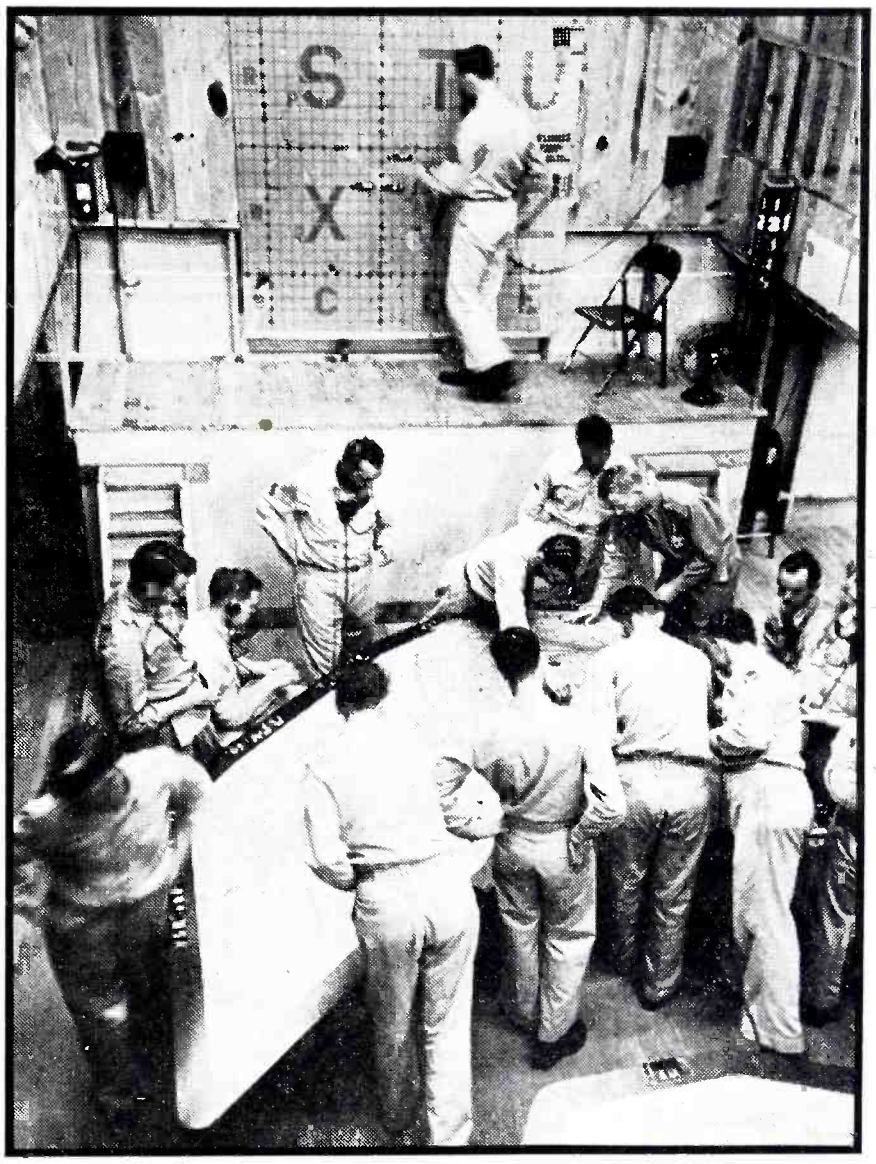
Let us take a specific problem. We have a relay which we desire to open and close. A capacitor will be used across it to prevent chattering. The current required to close the relay is 8 milliamperes, the release current is 7 milliamperes, and the relay resistance is 5,000 ohms. A voltage of 2 volts is available for actuating the relay (or its amplifying tube), and a 115-volt, 60-cycle power source is available.

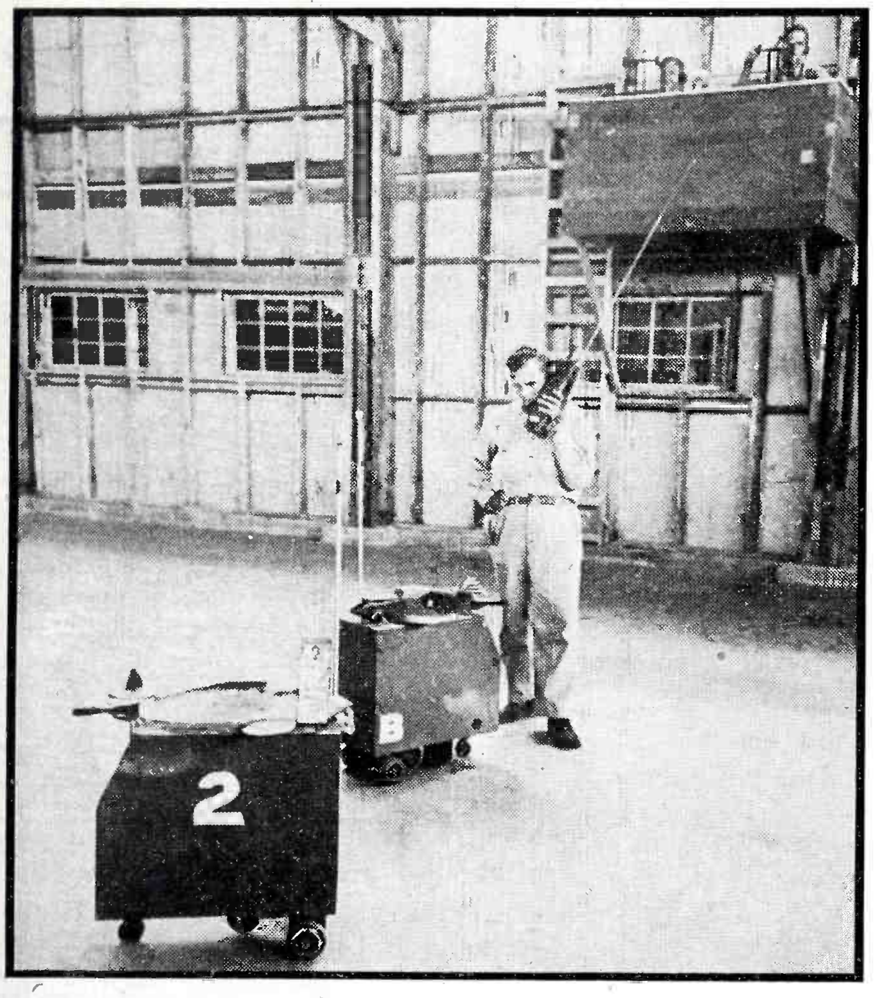
The power required to close the relay is $P = I^2R = (8\text{x}10^{-3})^2\text{x}5\text{x}10^3 = 0.32$ watt. The voltage required is $E_L = I_LR = 8\text{x}10^{-3}\text{x}5\text{x}10^3 = 40$ volts. Since only 2 volts are available for control of the relay, an amplifying tube is required, and one capable of operating from the 115-volt line should be selected. A 6G6 pentode will be selected since this has more than adequate power output at its rated voltages, and gives promise of producing sufficient power output at electrode voltages of 115 volts. For purposes of illustration, the problem will be worked out on the assumption that only the tube ratings are available; if the static curves are available, more precise results could be obtained.

(*Continued on page* 277)

Radio-Robot Battle

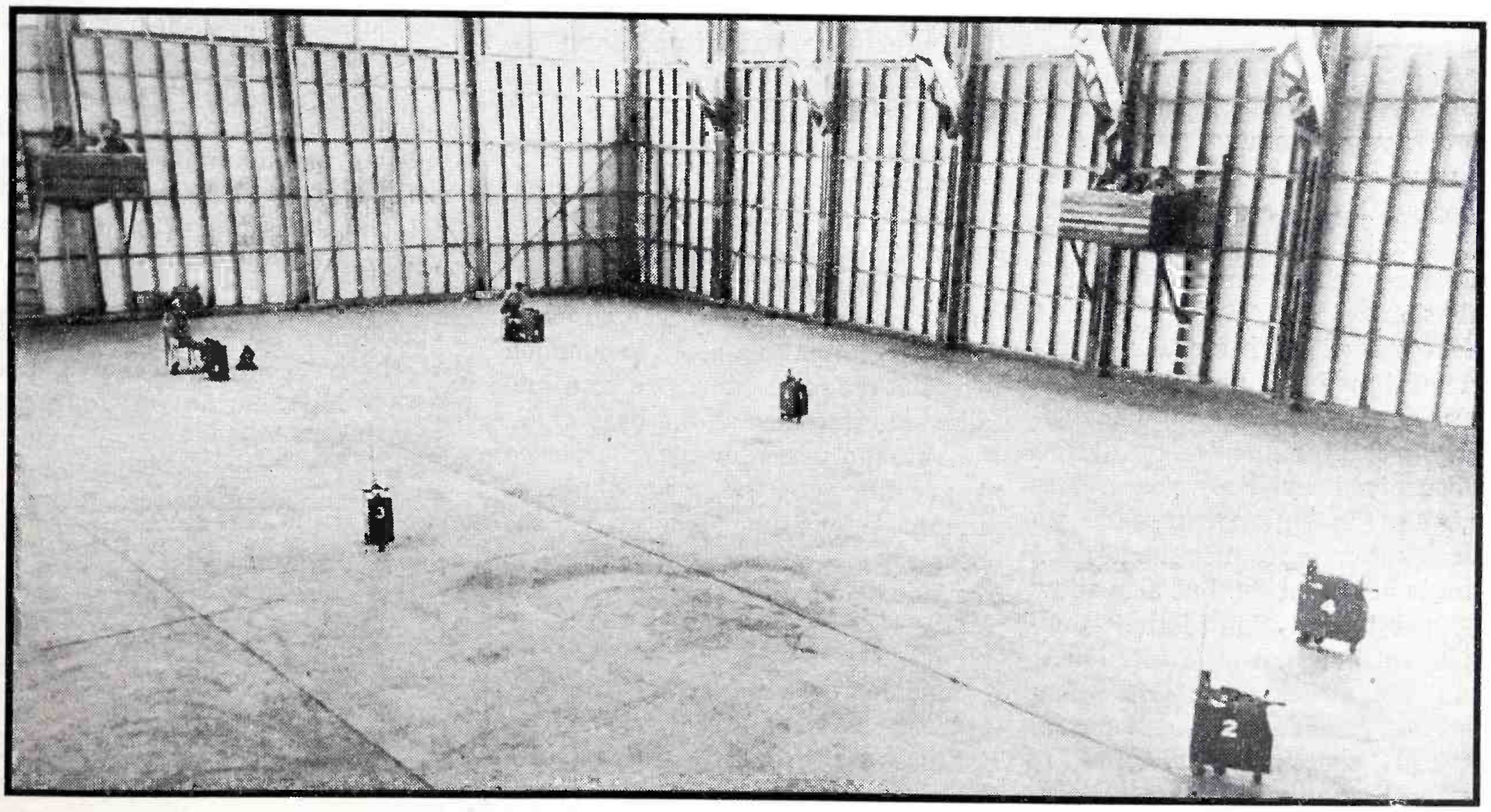
Electric cars controlled by radioed instructions go through maneuvers of raiding and defending air squadrons while trainees at an Army Air Force school in Orlando, Florida handle communications equipment





WARNING—Approach of enemy raiders is reported by wire. Position, progress and probable course are quickly plotted on a map here at operations headquarters and instructions for interception dispatched by radio to strategically located fields

CONTACT—Out on the floor of a building serving as a simulated combat area in miniature, instructions from operations headquarters are received on walkie-talkies. Models representing raiders (2) and defending planes (B) are guided into position



RESULT—Observers in balcony-boxes high up on the sides of the battle building check the positions of models constantly and report the progress of maneuvers for position by wire to operations headquarters

Design Data for

By H. W. HASENBECK

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San Diego, Cal.

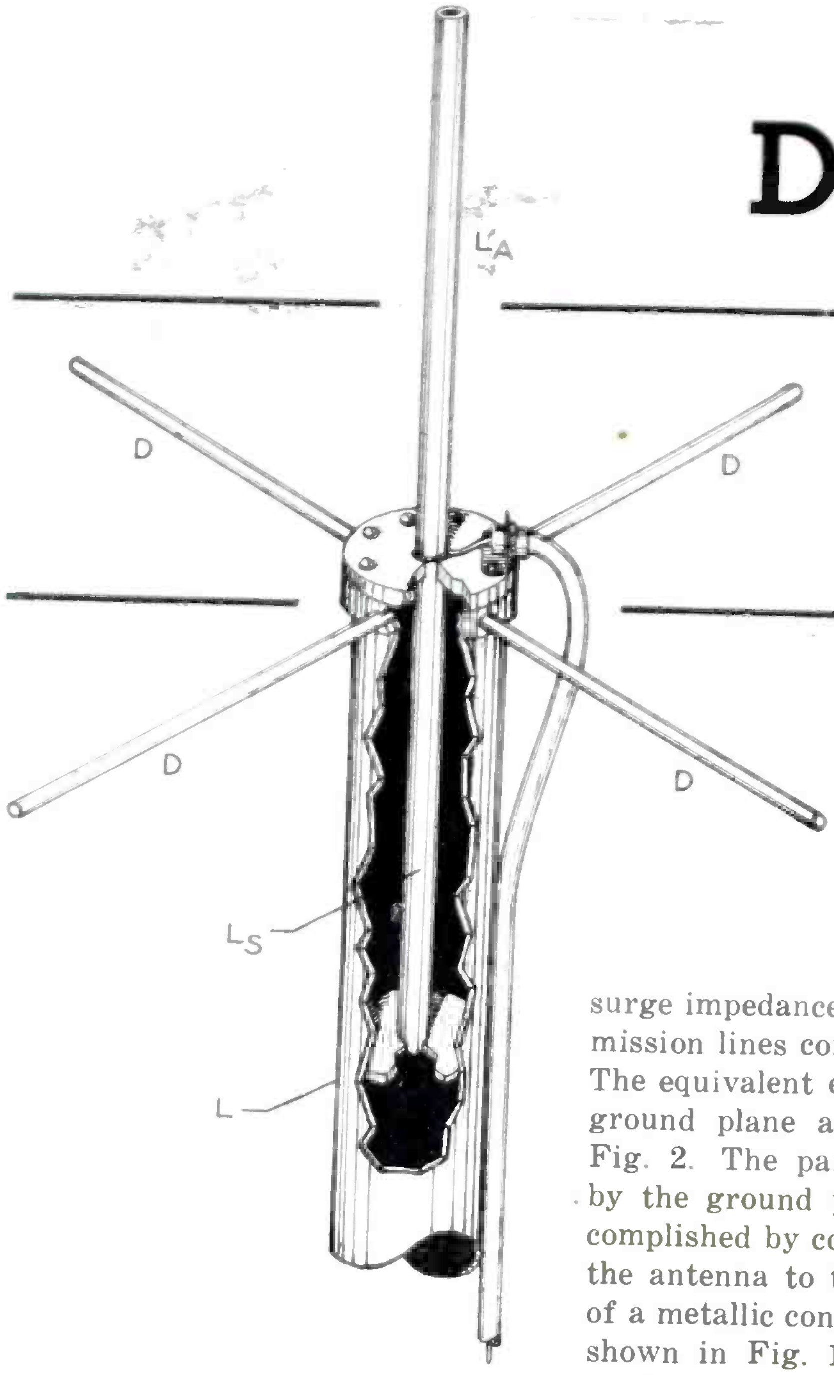

FIG. 1 — Constructional details of ground plane antenna. L may be any convenient length provided it is at least as long as L_s

A VERTICAL antenna located several wavelengths above ground does not display the low angle of radiation expected unless certain features are included as an integral part of the installation.

One type of high-frequency antenna designed to produce a low vertical angle of radiation is the so-called "ground plane." Its design was conceived by Brown and Epstein,[1] and is unique in that its features not only produce the desired low angle of radiation, but also allow for proper termination of the transmission line and place the antenna at ground potential. Figure 1 illustrates the mechanical construction.

Basically, the antenna assembly is so designed that a parallel circuit is formed, whose impedance can be made to match the characteristic surge impedance of concentric transmission lines commercially available. The equivalent electrical circuit of a ground plane antenna is shown in Fig. 2. The parallel circuit formed by the ground plane antenna is accomplished by connecting the base of the antenna to the center conductor of a metallic concentric base support, shown in Fig. 1 as L. This center conductor, shown as L_s in Fig. 1, acts as an inductance, and is shunted at the top by the antenna base impedance, composed of capacitive reactance and radiation resistance. If the inductance, capacitance and resistance are of the proper values, the parallel circuit thus formed will act as a pure resistance at the operating frequency.

As illustrated in Fig. 1, the outer conductor of the coaxial transmission line is connected to the outer conductor of the antenna base support. Since the inner conductor is common to the outer conductor, due to a metallic shorting disc at the base of L_s, the antenna assembly may be placed at ground potential, providing the antenna supporting structure or the outer sheath of the coaxial line is grounded.

Design Data

Consider the circuit shown in Fig. 2. If the values of reactance and resistance are properly proportioned, the circuit can be made to act as a pure resistance, practically equal to the surge impedance of coaxial transmission lines in common use. Proof of this fact is demonstrated by

$$\frac{j53.3\,(25 - j36)}{25 + j53.3 - j36} = 77 \text{ ohms} \qquad (1)$$

The term $j53.3$ represents the reactance of L_s in Fig. 2, and the term $(25—j36)$ represents the resistance and reactance of L_a. The combined branches of the circuit equal 77 ohms and form the termination of the coaxial transmission line.

The four arms extending out from the top end of the outer sleeve of the concentric base support, labelled D, are ground radials. These radials are necessary to lower the radiation resistance and decrease the effect of high-angle interference radiation originating on the supporting structure or coaxial feed line.

The terms found on the left side of Eq. (1) are entirely possible to obtain in actual practice, and the resulting parallel impedance should be satisfactory for terminating coaxial lines having a characteristic surge impedance between 60 and 90 ohms.

It can be shown mathematically that the base impedance of a quarter-wave antenna, having four radi-

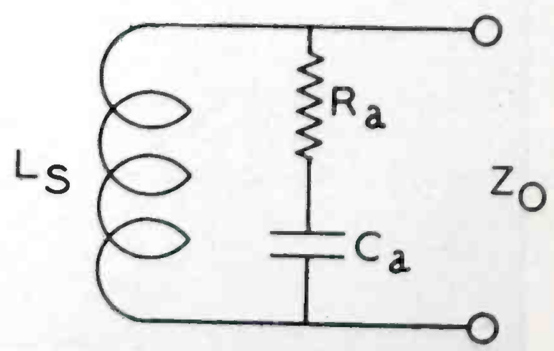

FIG. 2—Equivalent electrical circuit of ground plane antenna

Ground Plane Antennas

The addition of a turnstile element to a high-frequency vertical antenna lowers the angle of radiation. This paper develops the basic formulas for designing such a ground plane antenna. An example is worked out for a 78-ohm termination at 33.78 Mc

als extending from its base, is approximately 30 ohms. Since Eq. (1) indicates that the antenna must offer a capacitive reactance at its base equal to $-j36$ ohms, the antenna must be made slightly shorter than a quarter-wave. Obviously, if the antenna is shortened, the radiation resistance will decrease. Measurements indicate that when the antenna offers $-j36$ at the base, the radiation resistance decreases to 25 ohms as required by Eq. (1).

The $j53.3$ term of Eq. (1) is easily obtainable by properly proportioning the length of the concentric base supporting structure. Once the surge impedance of this section has been determined, the reactance of the center conductor can be calculated quite accurately by

$$jX = Z_o \tan Y \qquad (2)$$

Since jX must equal 53.3,

$$\tan Y = 53.3/Z_o \qquad (3)$$

Z_o may be calculated once the material has been chosen from which the antenna base support is to be constructed.

$$Z_o = 138.15 \log b/a \qquad (4)$$

where b is the inside diameter of the outer conductor and a is the outside diameter of the inner conductor.

The number of electrical degrees which the tangent value represents, as calculated by Eq. (3), may be obtained from a table of trigonometric functions. The length in inches which represents one electrical degree at the operating frequency f in Mc is

$$L = 32.8/f \qquad (5)$$

The total length of the concentric antenna base supporting section L_s (as measured from the top of the shorting disc to the top of the outer conductor) is

$$L_s = LY \qquad (6)$$

where L is the length of one electrical degree in inches, and Y is the number of electrical degrees necessary to form 53.3 ohms reactance.

Each of the ground radials should be one quarter-wave in length, and may be calculated by

$$d = 85.5\,L \qquad (7)$$

For those who do not have the necessary equipment to measure the characteristics at the base of the antenna so as to determine when the antenna length is properly adjusted to fulfill the term (25—$j36$) given by Eq. (1), the following equations may be of interest:

$$\pm jX = Z_{oa} \tan \left\{ (2\pi h/\lambda) + (1.5\pi) + 0.01\,[\sqrt{2.86\,(\log \lambda/a) - 4.6} + 3.4] \right\} \qquad (8)$$

where

$\pm jX$ is reactance of antenna
Z_{oa} is characteristic impedance of antenna
h is length of antenna
λ is electrical length of one cycle at the operating frequency
a is radius of antenna element
$Z_{oa} = K_1 + K_2$
$K_1 = 138.15 \log h/a$
$K_2 = -(60 + 69 \log 2h/\lambda)$

The reactance of the antenna can be calculated quite accurately by the use of Eq. (8). Since the length of h must be assumed in solving for Z_{oa}, several trial values may be necessary before the exact length is ascertained. Previous calculations indicate that the length of h is usually between 87 percent and 90 percent of the true 90 deg. electrical length. Several values of h should be chosen between these limits and the reactance calculated. The values should then be plotted as a function of h to obtain the exact length for a reactance of —$j36$ ohms at its base.

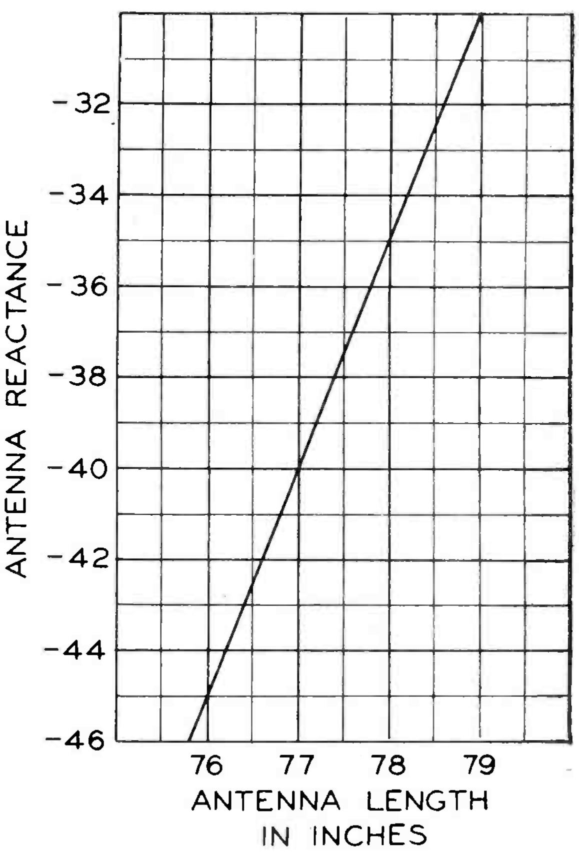

FIG. 3—Reactance as a function of length h for the hypothetical antenna design given in the text

Example of Calculations

A practical example may help in making the included data more easily followed. Assume it is desired to design a ground plane antenna to operate on a frequency of 33.780 Mc. The characteristic impedance of the transmission line is 78 ohms. The material available for the antenna base support is a section of copper tubing with an inside diameter of 2 inches and a center conductor having an outside diameter of 0.625 inches. The antenna section is to be a continuation of the center conductor of the antenna base support.

If the various sections of the an-

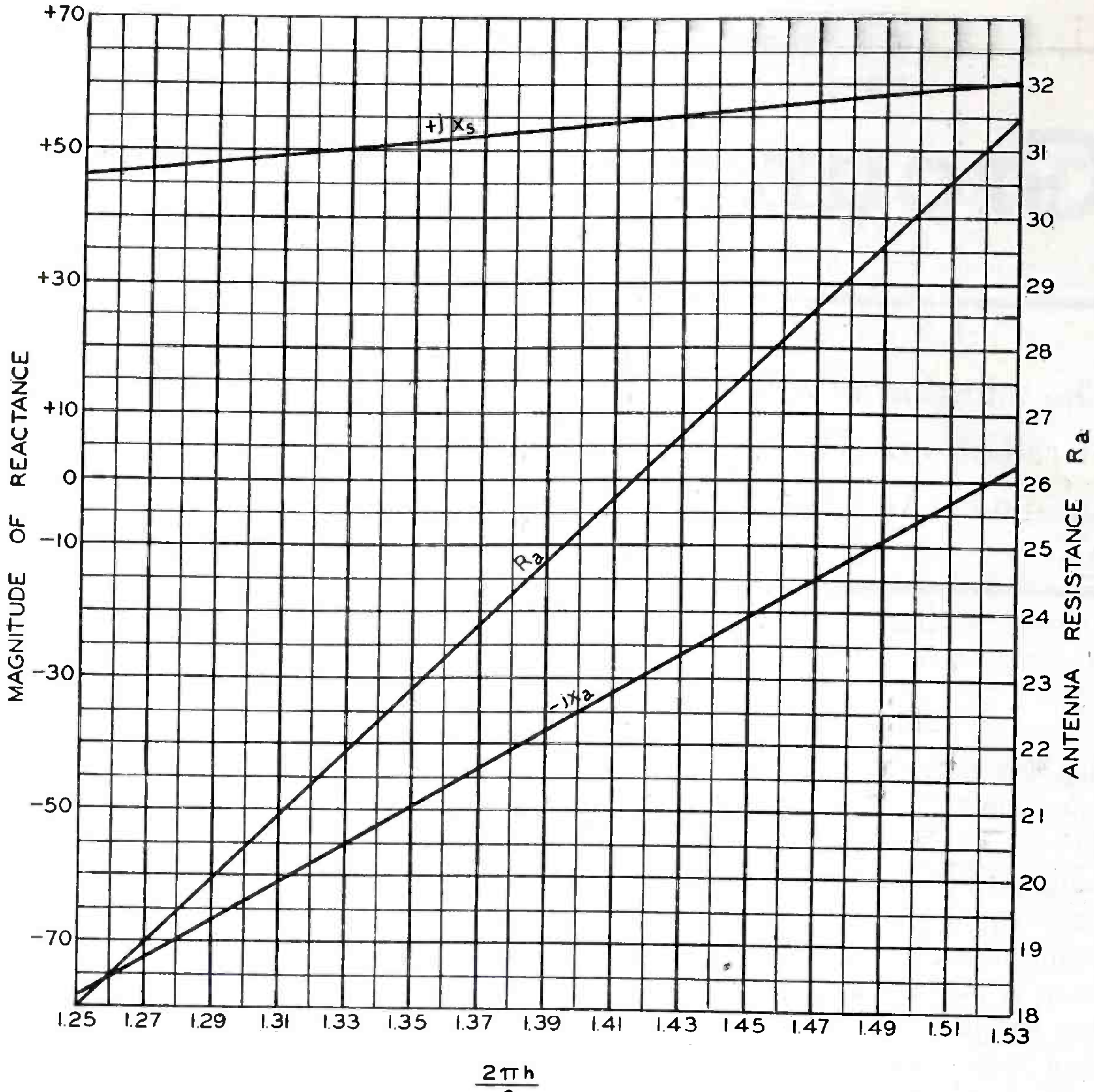

FIG. 4—Antenna reactance, antenna resistance and antenna base reactance as a function of $2\pi h/\lambda$

NOTE: The frequency range covered by the curves in Fig. 4 and 5 is approximately 30 to 37 Mc, with h being the correct value of 77.8 inches for 33.78 Mc

tenna system satisfy the terms given on the left side of Eq. (1), the 78-ohm transmission line should be satisfactorily terminated.

Since the antenna base support L_s is to offer the required 53.3 ohms reactance to the base of the antenna, the length of this section must be calculated. First, it is necessary to calculate the Z_o of this section by the use of Eq. (4). $Z_o = 138.15 \log 2/0.625 = 70$ ohms.

Substituting known values in Eq. (3), we get $53.3 = 70 \tan Y$, or $\tan Y = 53.3/70 = 0.76143$. Then $\tan^{-1} 0.76143 = Y = 37° 17'$.

From Eq. (5) the length of one electrical degree may be calculated: $L = 32.8/33.780 = 0.973$ inches. From Eq. (6), $L_s = 37.2833° \times 0.973 = 36.28$ in.

The next operation solves for the length of the ground radials. The length is measured from the outer wall of the outer conductor of the concentric antenna base support to the tip of the radial: $d = 85.5 \times 0.973 = 93$ in.

The antenna must offer $-j36$ at its base. The proper length may be calculated by the use of Eq. (8) and (9). As mentioned, the length usually will be between 87 percent and 90 percent of the true 90 deg. electrical length. The 90 deg. length is $90°L = 90° \times 0.973 = 87.5$ in. The correct length of h should be between 0.87×87.5 in. and 0.9×87.5 in. or between 76 in. and 78.8 in.

If the reactance of the antenna is calculated for the lengths 76 and 78.8 in. and these reactive values plotted as a function of h, the proper value may be ascertained.

The characteristic impedance of the 76 in. element is $Z_{oa} = K_1 + K_2$.

$$K_1 = 138.15 \log 76/0.3125 = 330$$
$$K_2 = -(60 + 69 \log 152/350) = -35.7$$
$$Z_{oa} = 330 - 35.7 = 294.3 \text{ ohms.}$$

The characteristic impedance of the 78.8 in. element is

$$K_1 = 138.15 \log 78.8/0.3125 = 331$$
$$K_2 = -(60 + 69 \log 157.6/350) = -36$$
$$Z_{oa} = 331 - 36 = 295 \text{ ohms}$$

From Eq. (8), the reactance of the 76 in. element is

$$\pm jX = 294.3 \tan \{6.28 \times 76/350 + 4.71 + 0.01 [\sqrt{2.86 (\log 350/0.3125) - 4.6} + 3.4]\}$$
$$\pm jX = 294.3 \tan 6.073 + 0.0555$$
$$= 294.3 \tan 6.1285$$
$$\pm jX = 294.3 \tan 351.3 \text{ deg.}$$

Since 351.3 deg. is in the fourth quadrant, the tangent value is negative and the reactive component of the antenna will be $-jX$.

$$-jX = 294.3 \tan 8.7 \text{ deg.}$$
$$= 294.3 \times 0.153 = 45 \text{ ohms}$$

The reactance of the 78.8 in. element is

$$\pm jX = 294.3 \tan \{6.28 \times 78.8/350 + 4.71 + 0.01 [\sqrt{2.86 (\log 350/0.3125) - 4.6} + 3.4]\}$$
$$\pm jX = 295 \tan 6.1785$$
$$\pm jX = 295 \tan 354 \text{ deg.}$$

Since 354 deg. is also in the fourth quadrant the tangent value is negative and the reactive component is $-jX$.

$$-jX = 295 \tan 6 \text{ deg.} = 295 \times .1051$$
$$= 31 \text{ ohms}$$

When these two values are plotted as a function of h as shown in Fig. 3, the correct value of h to produce $-j36$ ohms is 77.8 in.

Thus, to construct a ground plane antenna to operate on a frequency of 33.78 Mc, which will properly terminate a 78-ohm transmission line, the antenna must be ⅝ in. diameter and 77.8 in. long. The antenna base support must have a surge impedance of 70 ohms and a length of 36.28 in. The lengths of the four ground radials, extending out at right angles from the top of the antenna base support, must be 83 in. each.

The curves in Fig. 4 and 5 illus-

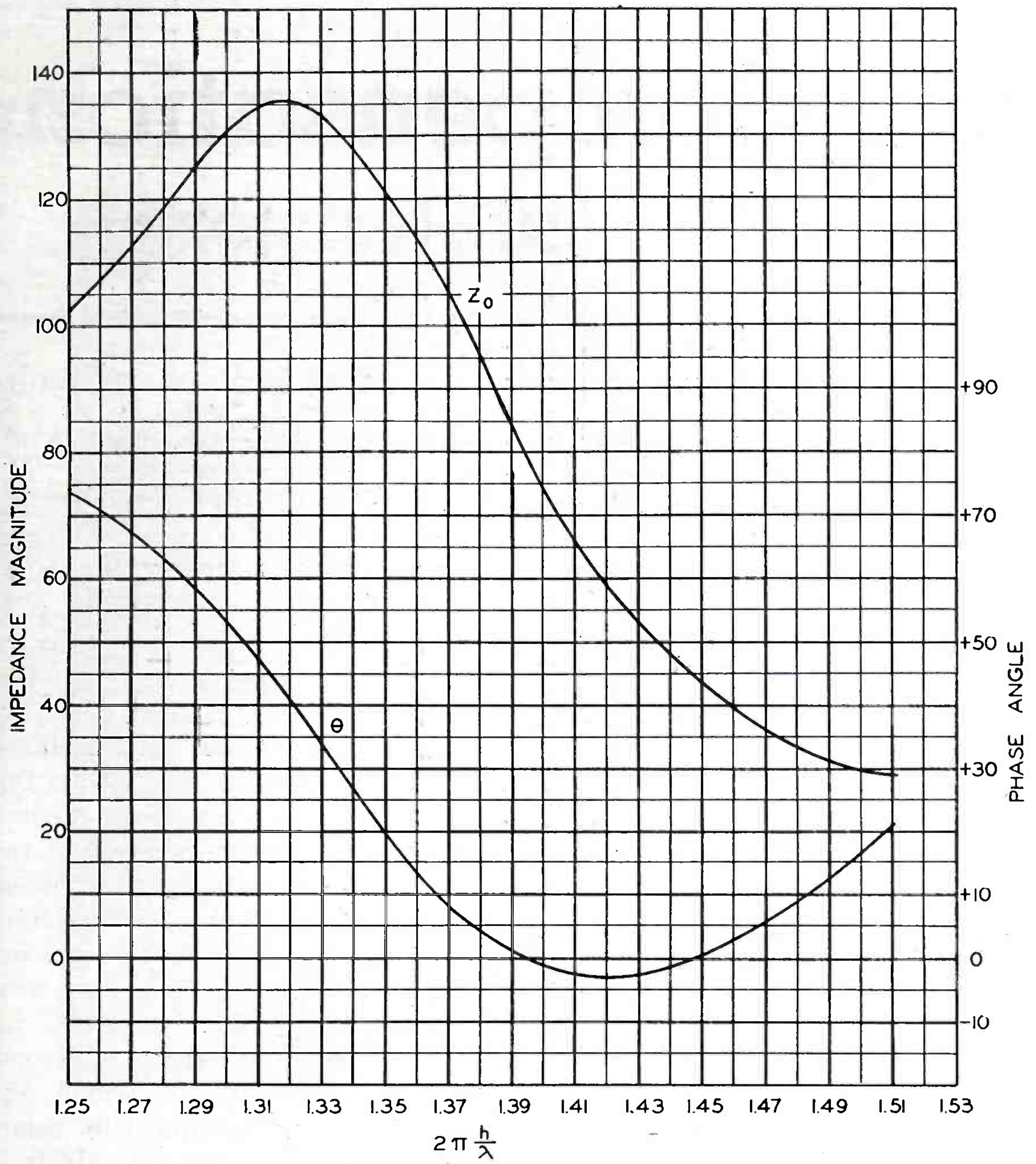

FIG. 5—Antenna terminating impedance and its phase angle as a function of $2\pi h/\lambda$

trate the variation of reactive and resistive component parts of the antenna when the operating frequency is varied from the proper operating frequency of 33.78 Mc. The frequency range represented by both curves is approximately 30 to 37 Mc. Figure 5 combines the reactive and resistive components to illustrate the variation in magnitude of the antenna terminating impedance and its phase angle.

The author wishes to acknowledge the cooperation of the technical staff of the Radio Section of the Electrical Division of the City of San Diego in aiding with construction and measurements of the antenna described in this paper.

APPENDIX

The constant 32.8 in Eq. (5) was derived from

$$\lambda_{meters} = 3 \times 10^8/f_{cycles} = 3 \times 10^2/f_{Mc}$$
$$\lambda_{inches} = 39.37 \times 3 \times 10^2/f_{Mc}$$
$$L = 39.37 \times 3 \times 10^2/360\, f_{Mc} = 32.8/f_{Mc}$$

Measurements indicate that the length of the ground radials is not critical providing they are equal to 90 deg. electrical length or longer. The constant 85.5 when multiplied by L gives the approximate 90 deg. electrical length, after allowance has been made for "end-effect". (85.5 is 95 percent of 90 deg.)

In computing the resistance and reactance at the base of the antenna, the antenna was considered as an open-circuited transmission line. The methods used in obtaining the characteristic impedance Z_{oa} of the antenna were developed by Morrison and Smith.[2] (For a complete derivation, refer to p. 693 of their paper.[2]) The accuracy of Morrison and Smith's methods of calculation seems to be substantiated by the correlation between the reactance values calculated by the use of Eq. (8) and the results obtained by the more rigorous formula given by King and Blake.[3]

By including the 1.5 π term in Eq. (8), a rotation of 270 deg. is produced, making it possible to multiply the Z_{oa} term by the tangent value without regard to the antenna length, up to $\lambda/2$.

The square root term in Eq. (8) corrects for "end effect" which is influenced by the relationship between the antenna radius and operating wave length.

Over the range of $2\pi h/\lambda$ under consideration for this investigation (1.25 to 1.53), the reactance values calculated by Eq. (8) are in complete agreement with those calculated by the formula given by King and Blake.[3]

The values of resistance used in formulating curve R_a in Fig. 4 and calculation to obtain the impedance and phase angle curves of Fig. 5 were derived from the data given by King and Blake.

Several methods of calculating the antenna resistance were investigated, and the results indicate that the values obtained are not in perfect agreement. The formula cited by Brown and Epstein gives a resistance of 21.159 ohms at $\lambda/4$, while the transmission line formula given by Morrison and Smith yields a resistance of approximately 36 ohms. The rigorous method of King and Blake gives a value of approximately 32.5 ohms.

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(3) King, R., and Blake, Jr., F. G., The Self-Impedance of a Symmetrical Antenna, *Proc. I.R.E.*, **30**, p. 335–349, 1942.

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Temperature Compensation with Negative Coefficient Resistors

Use of semi-conducting materials as series neutralizers. Early experiments with d-c millivoltmeters, shunted and thermocouple ammeters, a-c voltmeters, ohmmeters of the ratio type, recording voltmeters and ammeters. Commercial diesel engine pyrometer application

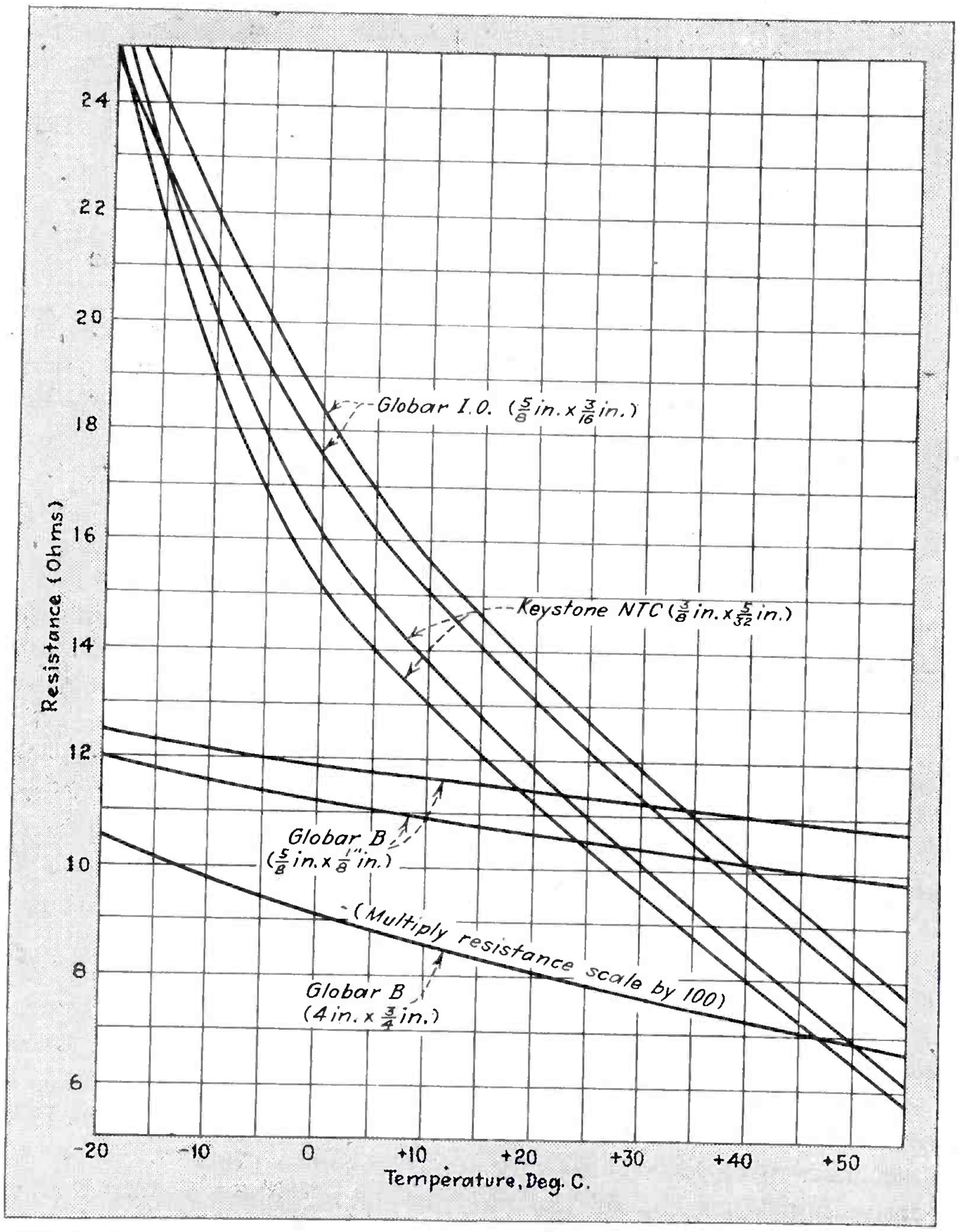

FIG. 1—Temperature-resistance characteristics of three types of neutralizers

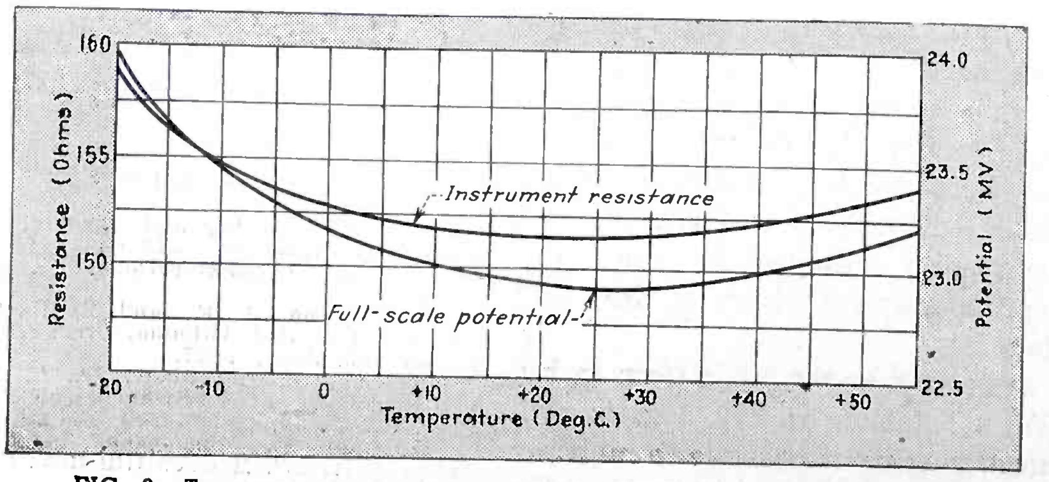

FIG. 2—Temperature characteristics of experimental millivoltmeter

IT IS WELL KNOWN that electromagnetic and thermal voltmeters and wattmeters measure potential in terms of current. Obviously the ratio of potential to current is determined by the impedance of the instrument circuit. This impedance is to an important degree a function of the temperature of the coils and other instrument elements. Many engineers who use voltmeters and shunt ammeters, but do not design them, fail to realize how serious ambient temperature errors can be. The writer has repeatedly come across instruments in which the range has been multiplied by someone not skilled in the art. If it is correctly done the results will be good. But it is frequently accomplished in such a manner that if the sun shines on the instrument its calibration changes several percent.

The resistance of copper or aluminum changes about 0.2 percent per deg. F. This means that if a voltmeter employs circuit elements consisting entirely of these metals and is calibrated at 70 deg. F. it will read 1 percent low at 75 deg.

Effect of Temperature Variation

In an electrical instrument, the most important effect of temperature variation is to change the resistance of the coil or coils. The temperature coefficient of control spring elasticity, which is negative, is ordinarily about one tenth the magnitude of the positive co-efficient of resistance, and in a d'Arsonval mechanism is partly balanced by the coefficient of the permanent magnet.

In d-c voltmeters of more than a few volts full scale, temperature compensation virtually takes care of itself. D'Arsonval mechanisms are so efficient that full-scale deflection can readily be obtained with only 50 to

# of Instruments

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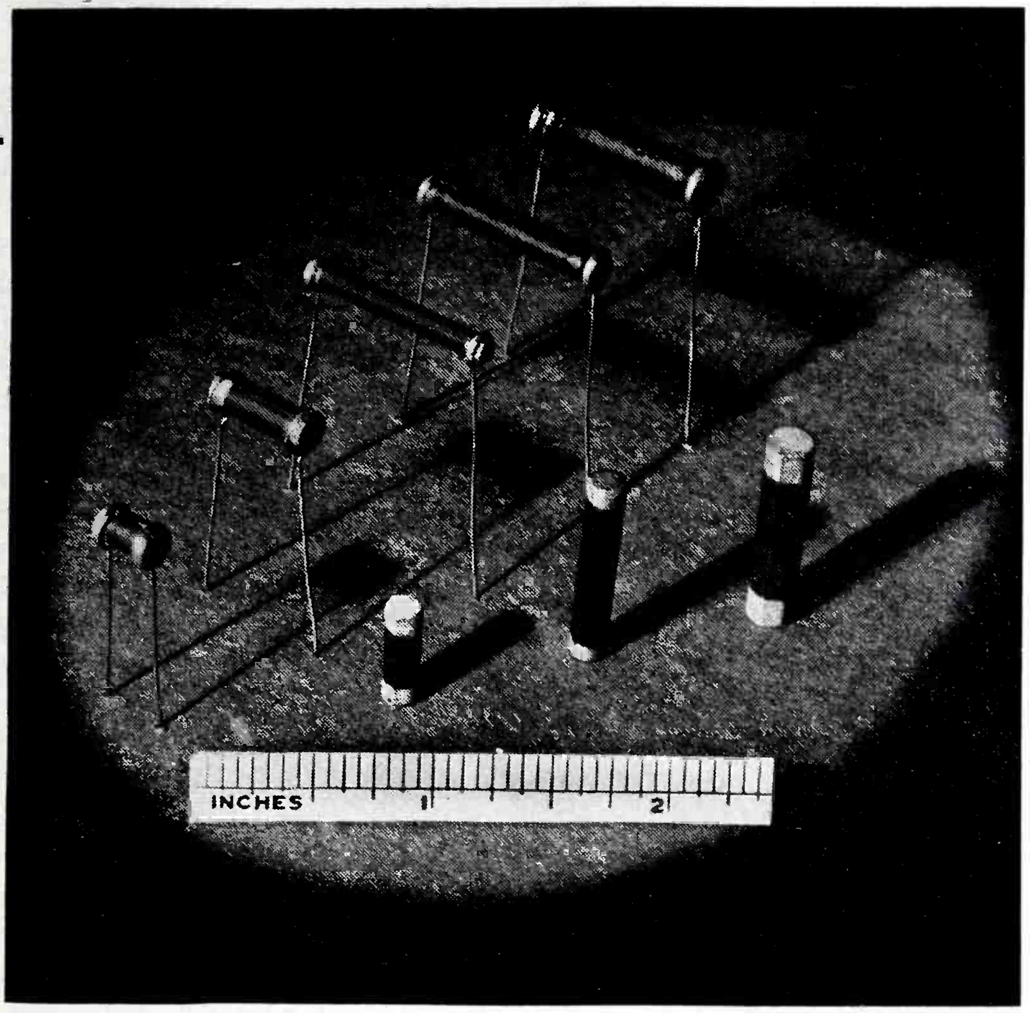


Typical negative temperature coefficient resistors of the type used by the author as instrument neutralizers

100 millivolts applied across the moving element. Nothing practical is to be gained by increasing the potential across it beyond 200 millivolts. If a 0.05-volt mechanism is used to make a 5-volt voltmeter, 99 percent of the resistance will be in manganin or constantan, and the temperature coefficient of the instrument will be only one hundredth that of the wire (neglecting the influence of temperature on the hairsprings and magnet). But if this same mechanism is to be used for ranges below one volt, it is time to guard against temperature errors.

Other instruments in which the reduction of temperature influence is a problem are millivoltmeters, including pyrometer indicators; shunted ammeters and thermocouple instruments; a-c voltmeters, in which the burden is much higher than in d-c instruments; ohmmeters of the ratio type, in which the calibration is determined by the resistance of one of the instrumnt circuits; and recording voltmeters and wattmeters. Pen-writing recorders require roughly a thousand times the power consumed by corresponding indicators to traverse a given length of scale.

With all these instruments the problem is to get as much of the available voltage across the active magnetic coil as possible, without giving the instrument an inadmissible temperature coefficient.

Commercial Compensation Practice

In 1936, Brooks described a method of fully compensating a millivoltmeter by shunting it with iron or nickel, metals having high positive temperature coefficients, and adding manganin in series.[1] The principle was based on an earlier method of Swinburne. According to Brooks' analysis, to obtain complete compensation eight-ninths of the millivoltage must be consumed in the series resistor and a considerable part of the current must be lost in the shunt. Therefore, perfect compensation is gained but only at the expense of a large quantity of power consumed in the compensating resistors compared to that in the moving element.

The usual commercial practice has been to make the series resistor of manganin or constantan, both of which have substantially zero temperature coefficients. Its resistance has to be at least five times that of the coil to give fair compensation over a moderate range of temperature. If the instrument is to be very precise, or if it is to be completely reliable outdoors and particularly in aviation service, the ratio must be several times higher. The result is that more precious microwatts are wasted in the series resistor than are used in the coil.

Negative T.C. Series Resistors

The ideal series resistor would have a high negative temperature coefficient rather than a zero t.c. which merely "dilutes" both the temperature error and the efficiency of the instrument. The required change in resistance (equal and opposite to that of the mechanism coil) would preferably be obtained by virtue of the ideal resistor's inherent characteristics, permitting the compensating job to be accomplished without the necessity for a wastefully high series resistance value.

Carbon in some forms has a negative coefficient. The author understands that it has been successfully employed to compensate electrical instruments but has seen no data on its performance in this application.

There does not appear to be any ductile metal having entirely suitable properties. (Manganin, constantan and a few other alloys have very small negative t.c. at high temperatures. Driver-Harris' Ohmax is stated to have a t.c. of −0.00035 per deg C.) However, in 1937, Faus of General Electric published a description of resistors made of tellurium and tellurium-silver alloys.[2] They are

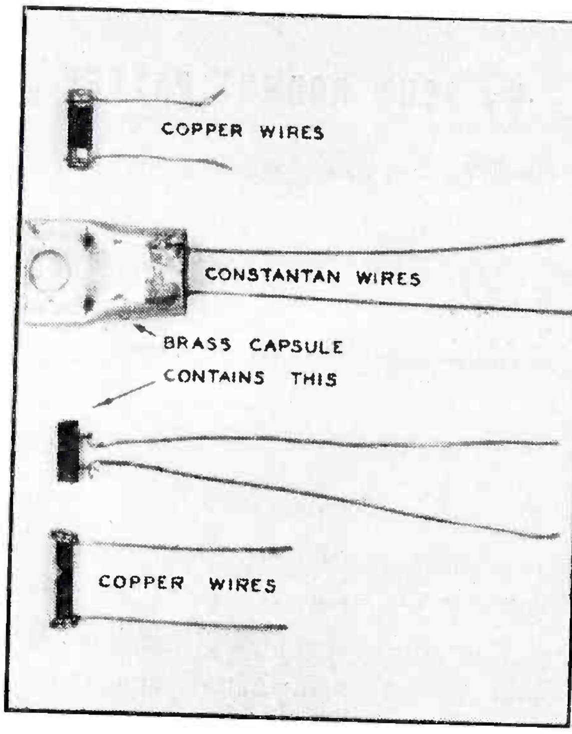


FIG. 3—Neutralizers arranged, from bottom up, in the order in which they have been employed in diesel engine pyrometers

remarkable in several ways. Tellurium, so far as the author of the present paper knows, is the only element besides carbon which, in elemental form, has a useful negative temperature coefficient. The coefficient of the resistors described is −1.2 percent per deg C. This is three times that of copper (and opposite in sign), and many times higher than that of carbon. The resistance-temperature characteristics are shown to be linear from +70 deg C to −10 deg C for tellurium and from +70 deg C to −70 deg C for a 15 percent silver and 85 percent tellurium alloy. But resistors of the variety described appear to have relatively low current-carrying capacity. (Faus also has patented a cadmium-antimony compound having similar characteristics.[3])

Characteristics of Semi-Conductors

It has long been known that most insulators become conductors at high temperatures, and that the conductivity of many semi-conductors increases with temperature. Among the latter may be mentioned the carbides of silicon and boron and oxides of uranium, manganese and copper. In general, semi-conductors are oxides, carbides, sulphides and nitrides of polyvalent metals. It is the adaptability of such materials to the compensation of electrical instruments which is our chief concern in the following discussion.

In 1940, Pearson described three types of negative temperature coefficient materials and called resistors made of them "thermistors".[4] It was stated that some forms would be suitable for instrument compensation. The three types were uranium oxide, with a t.c. of 3 percent per deg C, a mixture of nickel oxide and manganese oxide, with a t.c. of 4.2 percent per deg C, and silver sulphide, with a t.c. of 4.9 percent per deg C. The nickel and manganese oxide composition was said to be suitable for d-c circuits, the other two compounds being subject to polarization.

A number of years ago The Carborundum Company began manufacturing for general-purpose use silicon carbide resistors called Globar B, having negative coefficients. They were not specifically designed for instrument compensation at that time but it is known that the Weston Electrical Instrument Company experimented with these resistors soon after they were made available. Tests were made but to the author's knowledge the results of this work were not published.

Early Silicon Carbide Studies

Knowing that the resistors were not specifically designed for this purpose, the author nevertheless also undertook, about two years ago, an extended study of Globar B resistors as possible "neutralizers" for instrument compensation. (The word neutralizer is desirable when describing resistors used for this purpose as it avoids confusion with the cold-end "compensator", which is a bimetallic spiral used in pyromillivoltmeters to compensate for the potential of the reference junction. In order to obtain the precise information necessary to apply such resistors as neutralizers to instruments of diverse characteristics, it was found desirable to measure the resistance of a quantity of them at various temperatures between −45 deg C and

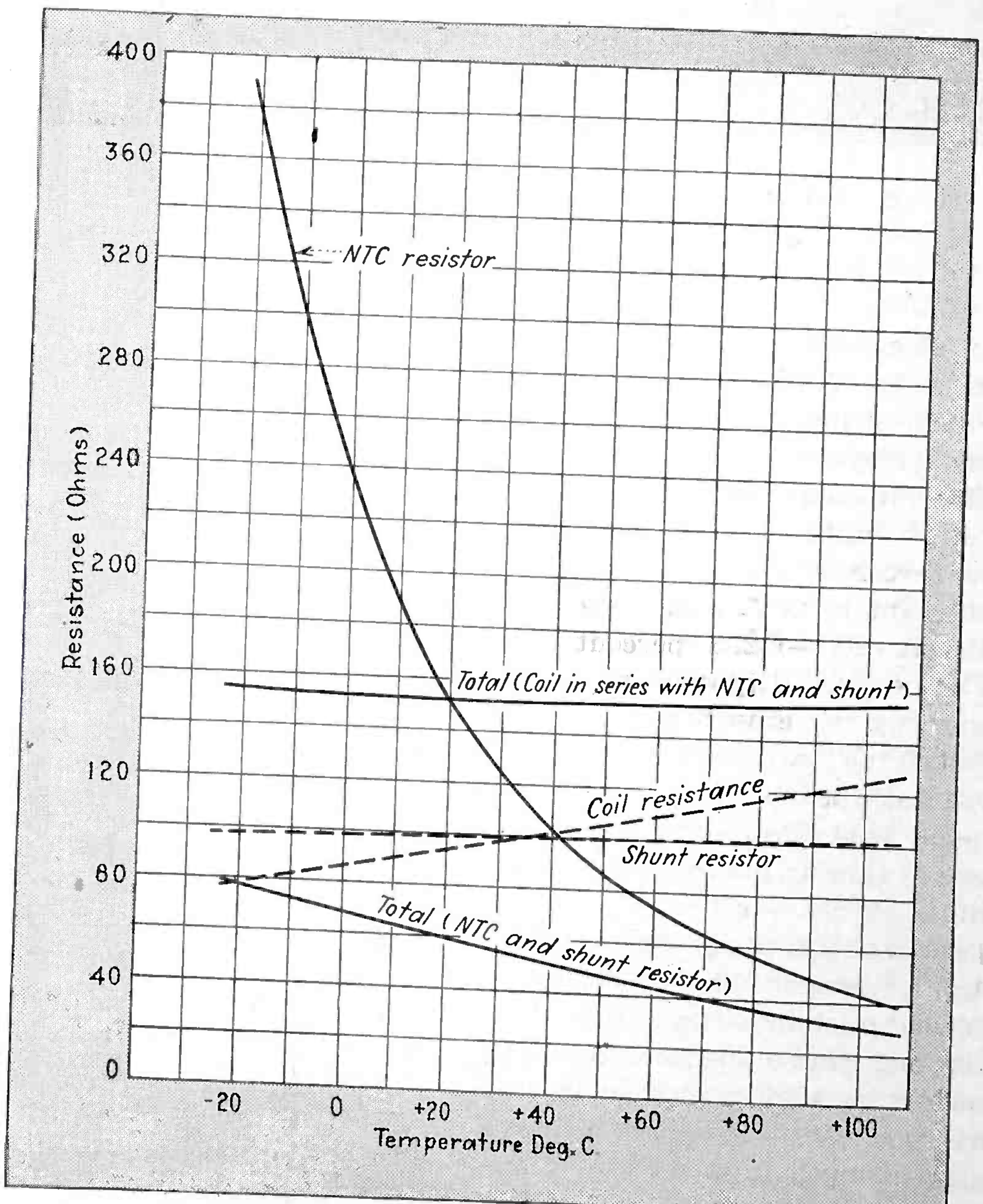


FIG. 4—Graphs suggesting method of obtaining temperature compensation of an instrument coil over a wide range by using a neutralizer consisting of a negative temperature coefficient resistor shunted by another resistor having a slightly positive coefficient

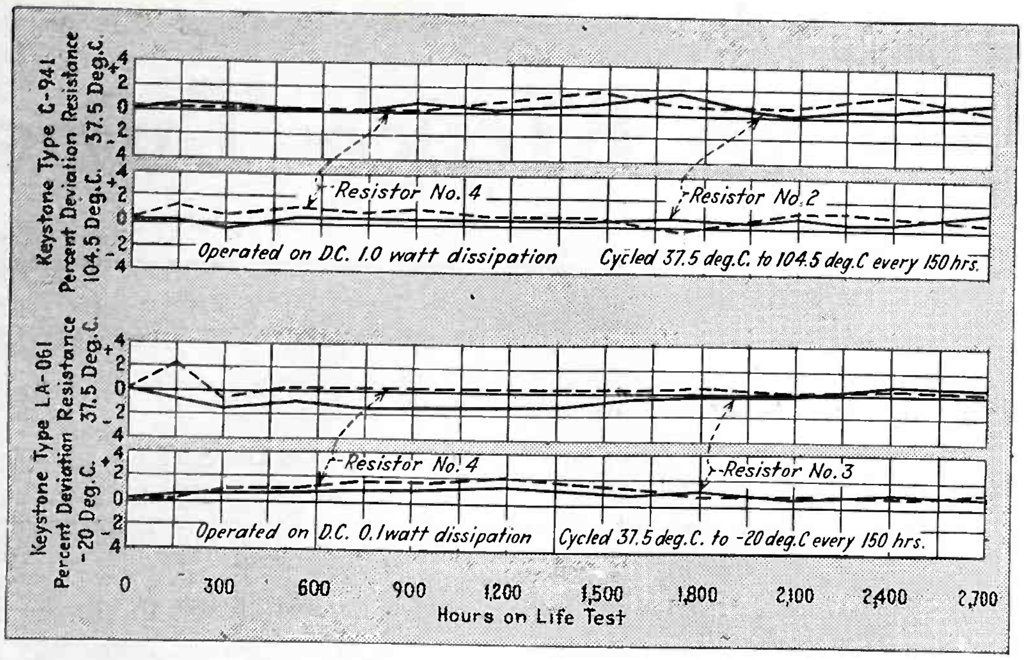


FIG. 5—Curves showing NTC resistor life-test performance

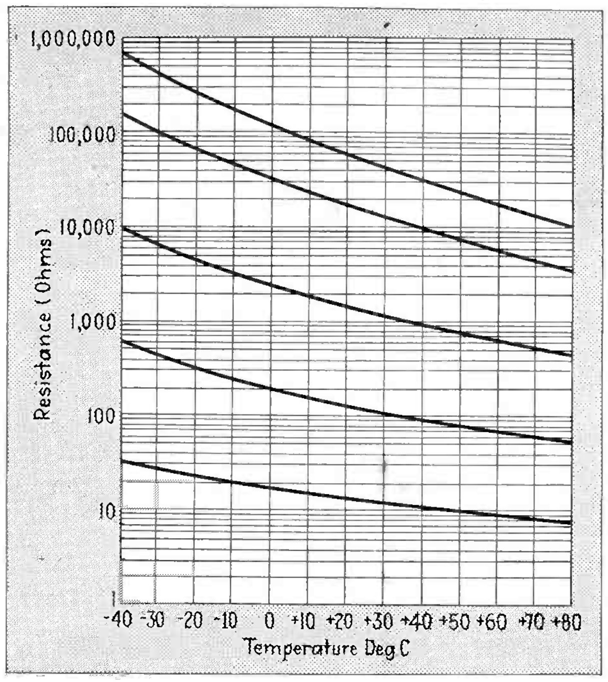


FIG. 6—Typical characteristics of type LA Keystone negative t.c. resistors

+70 deg C. The samples were production units ranging from 1 ohm to 860 ohms at room temperature. In physical size they ranged from $\frac{1}{8}$ in. x $\frac{5}{8}$ in. to $\frac{3}{4}$ in. x 4 in. They fell into two main groups: Small neutralizers, ranging in resistance from 1 to 100 ohms and having coefficients numerically smaller than that of copper; and $\frac{3}{4}$ in. x 4 in. ones, of about 800 ohms, and having a coefficient of −0.6 per deg C. This is roughly —1½ times that of copper. (Ordinarily, temperature coefficients are stated in ohms per ohm per degree, but in instrument compensation work it is more convenient to state them in percent per degree, because instrument errors are customarily stated in these terms.)

Among the small neutralizers, temperature coefficients varied from —0.19 percent to —0.576 percent per deg C. Out of 20 tested, one half were between −0.235 percent and —0.270 percent. Eighteen were between −0.232 percent and —0.386 percent. There was little correlation between coefficients and resistance values. Some neutralizers which were intended to have the same resistance (and did at one particular temperature) had different coefficients. There was some evidence of change in characteristics with age. A few had sinuous characteristics. In general the small resistors seemed to have very useful properties for the specialized work of instrument compensation but it looked as if in order to apply them it would be necessary to measure the change of resistance of each individual resistor. The large resistors were more uniform. The resistances of four samples ranged from 780 ohms to 856 ohms at 20 deg C. The resistance change per deg C was −4.31 ohms, ±0.26 ohms.

Use As Instrument Neutralizers

In a neutralizer, the *amount* of change of resistance per degree is more important than the *percentage* of change, and more important than the initial resistance value itself. (The author has coined a symbol for it. The symbol is *DR*. In mathematics, it is customary to use a capital delta, preceding a letter signifying a variable, to designate a change in the variable. The letter delta does not occur on conventional typewriters, so for convenience in writing specifications the letter *D* is used.)

The change of resistance per degree, *DR*, is considered of prime importance, because a given coil will have a definite positive *DR*, which must be balanced by the negative *DR* of the neutralizer. Besides these two components, any production instrument will include in series a small amount of zero t.c. resistance for calibrating, because it is not practical to adjust either the coil or the neutralizer. The tolerance on *DR* should be close, because, unless selective assembly is applied, the *DR* of the instrument, which should usually be close to zero, will carry a tolerance equal to the sum of the tolerances of the coil and the neutralizer.

The *DR* of a coil of wire is αR, where α is the temperature coefficient of resistivity, and R the resistance of the coil. The factor α may be considered constant throughout the atmospheric temperature range (for wire but not for neutralizers). It is given as 0.393 percent per deg C for copper and 0.403 percent per deg C for aluminum.[5] Since in a production lot of standard coils R is likely to vary 10 percent or 15 percent, we find it practical to use the simple formula $DR = 0.004R$ for both metals.

Experimental Recording Voltmeter

In 1940, an experimental recording voltmeter was built, based on one of our standard models. One of the $\frac{3}{4}$ in. x 4 in. neutralizers mentioned above was used in series with a solenoid having twenty times the resistance of the standard type. The burden was 6.3 watts at 110 volts, compared with 35 watts in a standard voltmeter. The temperature coefficient was substantially zero over a wide range of ambient temperatures. The model was in almost constant operation for three months, at temperatures fluctuating between 55 deg C and −9 deg C, with a final test at —42 deg. Results obtained were very promising.

Somewhat later, a recording wattmeter using neutralizers was designed. But the war has so changed the requirements for instruments that neither of these developments has since been put into production.

Tests on More Recent Materials

In February, 1941, the Keystone Carbon Company announced negative temperature coefficient resistors with coefficients ranging from —0.7 to —2 percent per C. The latter value is quite high. These resistors were not, of course, designed specifically for the critical job of instrument compensation. One of the first samples

(*Continued on page* 190)

Training Girls to Make Tubes

Proper oral instruction starts women out in the right frame of mind for production of equipment needed in the war effort. Manual instruction in a training room shows up special aptitudes. Streamlined course cuts training time from four weeks to one

By L. A. YODER *Instructor, Electronic Tube Training Section, General Electric Co., Schenectady, N. Y.*

New employees have a get-acquainted talk with an instructor

TO SPEED UP the process of training girls for electronic tube manufacture, particularly necessitated by the war, we are using a special course for new employees.

That the course successfully serves its purpose was demonstrated recently when it was necessary to start another assembly line with newly trained workers. The work involved both fine and rough assembly, and the trained but inexperienced operators were assigned to the respective stations on the basis of their performance in the training room. Every girl made good. They reached production requirements in a little over one week, whereas it formerly required at least four weeks to "break in" unsorted, untrained workers on this work.

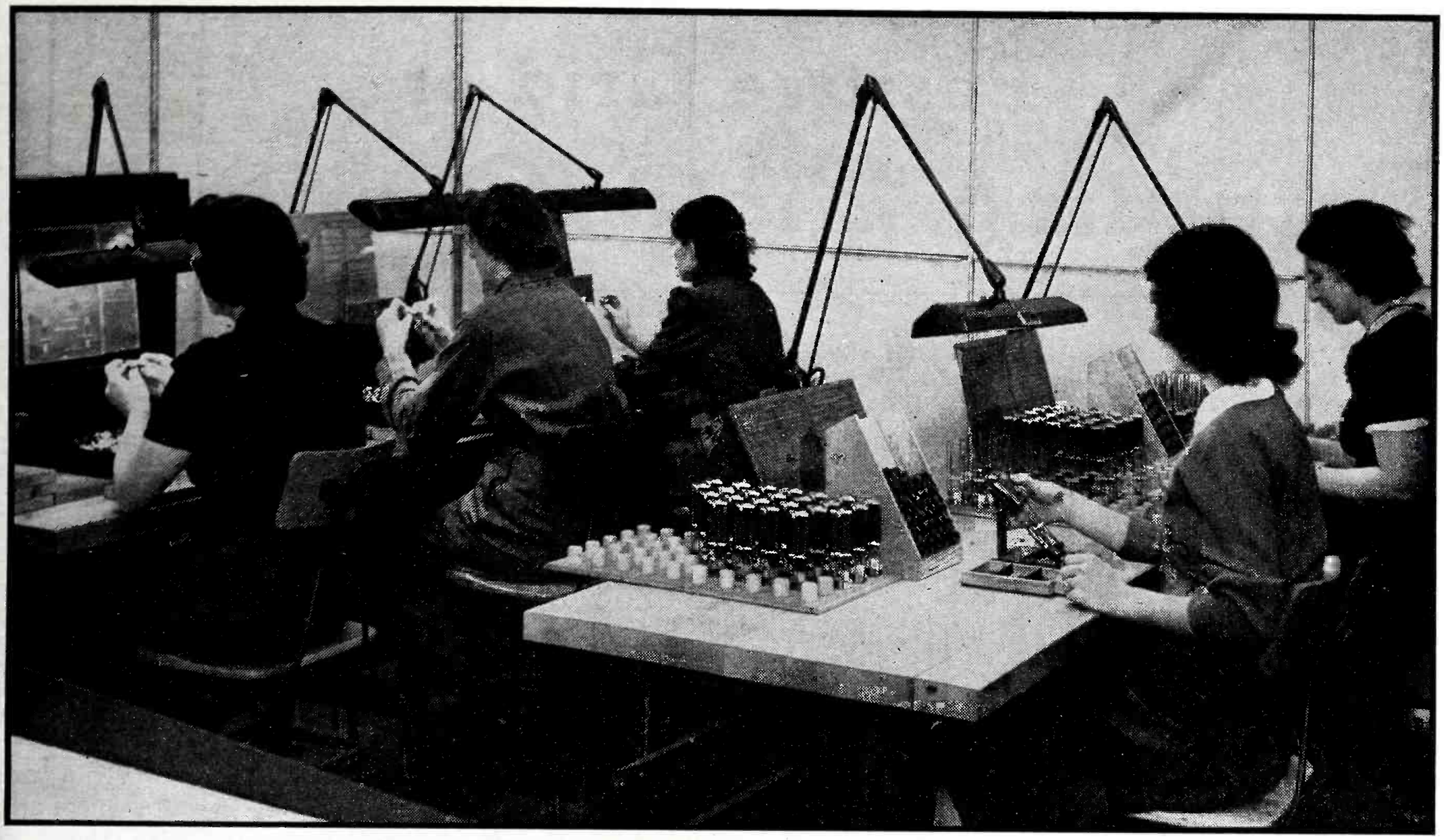
Wartime Worker Types

Most prospective female employees now applying for work have had no previous factory experience. Some formerly worked as sales clerks, beauty shop operators, or clerical workers, or were engaged in other occupations bearing no relation to factory work. Many of them are young girls or housewives who have never been gainfully employed. They all want a job, but very few care what kind of a job they get and practically none know what kind of work they can learn to do. They have no knowledge of factory life.

In normal times this type of worker may be readily absorbed into industry. A foreman would have ample time to instruct her in the work and coach her through the first few tough days. He could help her adjust herself to a new way of making a livelihood. But in war times the foreman is very busy; he has many pressing production problems

Operating test sets in the training room, beginners learn to read meters and manipulate controls

Training period assignments, such as splicing glass tubing, show up special aptitudes of new workers



Girls have an opportunity to try all kinds of work in the training room

and only limited time to devote to individual workers.

Our training program takes these things into consideration and has been carefully planned to aid both the new employee and the foreman. It benefits the new employee because it equips her for a job in the factory. It aids the foreman because he receives a girl whom he knows has demonstrated her ability and has a reasonable chance to succeed in performing the job on which she will be placed.

Oral Instruction

There are two major phases of the training program: oral instruction, and manual instruction. The purpose of the oral instruction is to impress the new employees with the importance of their work, and to help them get along with their foreman, their fellow workers and their job.

After being interviewed and accepted by the personnel department and general foreman, the new employees report to the training room. Here they are met by the training room supervisor, are seated as groups around a conference table and the first of three talks is given.

The purpose of this talk is to relieve first day nervousness and to interest employees in their future work. During this talk they are put at ease and are told:

1. That the company is glad to have them as new employees.
2. That the purpose of the training room is to help them get a good start.
3. That they will be expected to observe certain routine in regard to time clock registration, relief periods, etc.

We have found that employees who have some knowledge of the uses of the product they are helping to make are better workers. The realization that they are actually playing an important part in winning the war, particularly, acts as a stimulus to the quality and quantity of their work. Therefore, another part of the first day talk is designed to impress new employees with the importance of the job they are going to do. This is done by:

1. Showing them several types of tubes and describing the part these play in sending and receiving military messages and orders.
2. Explaining why every unit of our Army and Navy must have its electronic "weapons".
3. Stressing the fact that many types of tubes are secret and are used for secret purposes, and cautioning them to say nothing about their work outside of the factory.

After this talk they are taken on a tour through the factory by an instructor. They see tube parts made; they see these parts put together by the assembly line operators; and they see the assembled parts sealed into glass bulbs. They see machines that exhaust the air from the bulbs and they see the tubes being based and tested. In fact, they see the tubes grow before their own eyes and most of them show considerable interest in all the operations.

In the second talk, given the following day, the supervisor covers the following topics:

(A) *General Safety Rules*

1. Tells of the attention given to safety and the expense to which the company has gone to make all jobs as safe as possible.
2. Explains that most accidents are caused by carelessness and thoughtlessness.
3. Reads the most important rules from a safety booklet issued to each new employee and tells of accidents that resulted from disobeying these rules.

(B) *Company Benefit Plans*

1. Explains Employees' Mutual Benefit Association.
2. Discusses company group and free insurance.
3. Outlines relief and loan plan.
4. Talks about Athletic Association.
5. Mentions vacations with pay.

(*Continued on page* 228)

Positive Grid or Retarding Field Oscillators

Ability to produce oscillations up to 5,000 Mc gives importance to retarding field oscillators, of which Barkhausen-Kurz and Gill-Morrell oscillators are typical examples, in spite of limited efficiency. Microwaves can often be produced with ordinary tubes

By ROBERT I. SARBACHER and WILLIAM A. EDSON

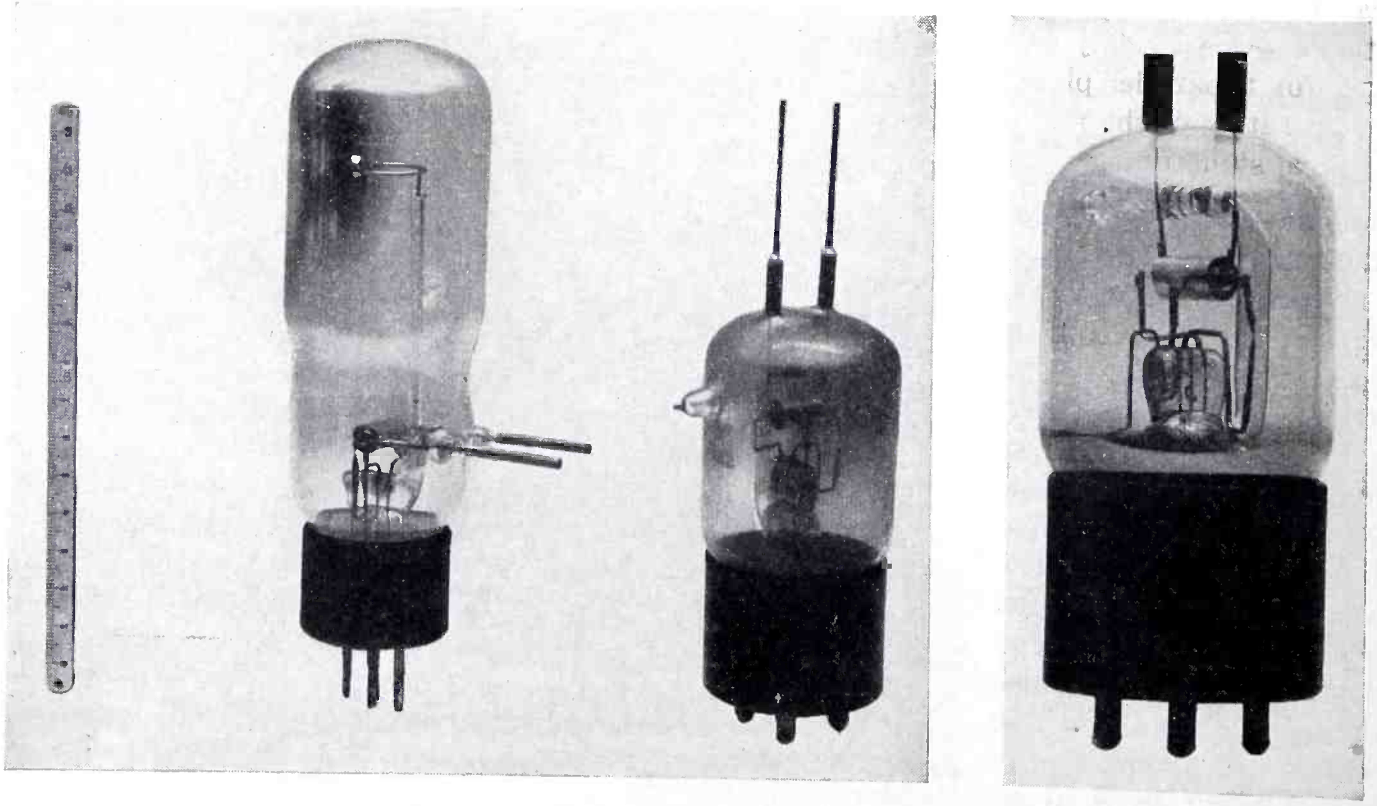
Illinois Institute of Technology Chicago, Ill.

A TRIODE oscillator, in which the grid is maintained at a high positive bias while that of the plate is at or near the cathode potential, is referred to as a positive grid or retarding field oscillator. The Barkhausen and Gill-Morrell oscillators were the first oscillators of this type to be described, and these names are still probably more familiar than the term retarding field oscillator. Positive grid oscillators are of considerable importance in ultrahigh frequency applications even though limited in power output and efficiency. Provided that suitable voltages are applied to the electrodes, many commercial triodes have been found capable of generating these oscillations. In general, tubes with concentric cylindrical electrodes have proved to be the most satisfactory, although other electrode configurations can also be used.

This article presents a brief resume of the operation of such oscillators. The mechanism of oscillations is given not only in terms of electric circuit theory but also by means of a mechanical analogy. Several useful tables and constants for determining the frequency of oscillation in terms of electrode dimensions and applied voltages are also given.

Retarding field oscillators usually operate with negligible space charge. Consequently, the emission of electrons from the cathode is random with respect to time and does not vary in synchronism with the period of electronic oscillations about the grid. Thus, although it is true that electronic oscillations occur in any tube in which the grid is positive and the plate is negative with respect to the cathode, it is also true that no effect is produced in a circuit external to the tube unless the random electronic oscillations are, in some manner, turned into synchronous oscillations. This process of converting the random motion of electrons into synchronized oscillations is of fundamental importance in the operation of all retarding field oscillators. Consequently the mechanism by which this is accomplished will be examined.

This material is a condensation, by the authors, of a chapter of their forthcoming book, "Hyper and Ultra-High Frequency Engineering." Its presentation in this form is by courtesy of the publishers, John Wiley and Sons.



Typical retarding field tubes for the production of ultra-short waves. Courtesy, "Electrical Communication"

The common characteristic by which retarding field oscillators are identified is that electrons oscillate or vibrate back and forth through the meshes of the positive grid. The electric field present between the electrodes may be thought of as the sum of the fixed field determined by the battery voltages and the alternating field due to the voltage of oscillation. Because the electron is negatively charged, it is forced in the direction opposite to that conventionally assigned to the field. Therefore electrons whose instantaneous velocity is in the direction of the alternating field give up energy to that field whereas the electrons whose velocity is opposite to that of the alternating field absorb energy. If, on the average, more electrons vibrate in phase with the alternating field than in opposition to it, a new power output will result which will support the alternating field and drive an external load. That such is the case will be shown in the following paragraphs.

By means of retarding field tubes, oscillations may be produced in the grid circuit, in the plate circuit, in the cathode circuit, or in the cathode-plate circuit. The frequency of oscillations is determined by the transit time of flight of electrons and this in turn depends upon the electrode dimensions and the voltages at which they are operated. The operation of positive grid tubes is most easily explained in terms of a parallel plane structure. The operation of the more practical cylindrical structure differs only in numerical details. The coefficients applicable to both structures are presented in the table.

FREQUENCIES AND WAVELENGTHS GENERATED BY RETARDING FIELD OSCILLATORS

	Plane Structure	Cylindrical Structure
Wavelength, in meters, associated with oscillations in anode circuit or in grid circuit if $\lambda_k = \lambda_a$	$\lambda_a = 2000\, d_a V_k^{1/2}/V_a$	$\lambda_a = 2000\, r_g G(y)/V_k^{1/2}$
Wavelength, in meters, associated with oscillations in cathode circuit or in grid circuit if $\lambda_a = \lambda_k$	$\lambda_k = 2000\, d_k/V_k^{1/2}$	$\lambda_k = 2000\, r_g F(x)/V_k^{1/2}$
Wavelength, in meters, associated with oscillations in the cathode-anode circuit	$\lambda_t = 2000\dfrac{V_a d_k + V_k d_a}{V_a\sqrt{V_k}}$	$\lambda_t = 2000\, r_g[G(y) + F(x)]/V_k^{1/2}$
Frequency, in Mc, associated with oscillations in anode circuit or in grid circuit if $\lambda_k = \lambda_a$	$f_a = 0.15\, V_a/d_a V_k^{1/2}$	$f_a = 0.15\, V_k^{1/2}/r_g G(y)$
Frequency, in Mc, associated with oscillations in cathode circuit or in grid circuit if $\lambda_a = \lambda_k$	$f_k = 0.15\, V_k^{1/2}/d_k$	$f_k = 0.15\, V_k^{1/2}/r_g F(x)$
Frequency, in Mc, associated with oscillations in cathode-anode circuit	$f_t = 0.15\dfrac{V_a\sqrt{V_k}}{V_a d_k + V_k d_a}$	$f_t = 0.15\dfrac{V_k^{1/2}}{r_g[G(y) + F(x)]}$

V_k represents grid-cathode potential in volts
V_a represents grid-anode potential in volts
d_k represents grid-cathode distance in meters
d_a represents grid-anode distance in meters
r_g represents radius of grid in meters
$F(x)$ and $G(y)$ are given in Fig. 4

Oscillations in the Grid Circuit

One of the most common types of operation for retarding field oscillators is that in which oscillations occur in the grid circuit. To determine the behavior of such operation, consider a tube with plane electrodes, as shown in Fig. 1. The grid-anode distance is d_a and the grid-cathode distance is d_k. With respect to the grid as reference point, the cathode and anode voltages are V_k and V_a volts, respectively. It will be assumed that d_a and d_k are equal. Initially it will also be assumed that no potential difference, alternating or direct, exists between anode and cathode. This condition requires that $V_a = V_k$. Let us now assume that an alternating voltage of perhaps a few volts is impressed upon the grid (with respect to anode and cathode) and that the frequency is such that one full cycle is described in the time required for an electron to travel from cathode to anode.

Consider an electron which leaves the cathode when the alternating component of the grid voltage is zero and is changing in the positive direction. During the entire time that the electron is traveling from cathode to grid the accelerating field is stronger than normal so that the electron arrives at the grid with a velocity higher than that corresponding to the steady voltage V_k. Assuming that the electron does not strike a grid wire, it proceeds into the retarding field of the grid-anode space. At the same time the grid voltage reverses so that the retarding field is now of less than normal intensity. As a result the electron will not come to rest before reaching the plate but will strike the plate with some velocity corresponding to the alternating voltage applied to the grid. Evidently this energy, which was supplied by the alternating voltage, is dissipated as heat. This electron has then absorbed power from the applied voltage.

Now consider an electron which leaves the cathode one-half cycle later. Because the accelerating field is weaker than normal, it arrives at the grid with less energy than that corresponding to V_k. Again the alternating voltage reverses as the electron passes through the grid plane, so that the retarding field is stronger than normal during the transit toward the plate. The electron is then brought to rest somewhat in front of the plate and returns once more toward the grid. Again, however, the voltage has reversed, so that the field

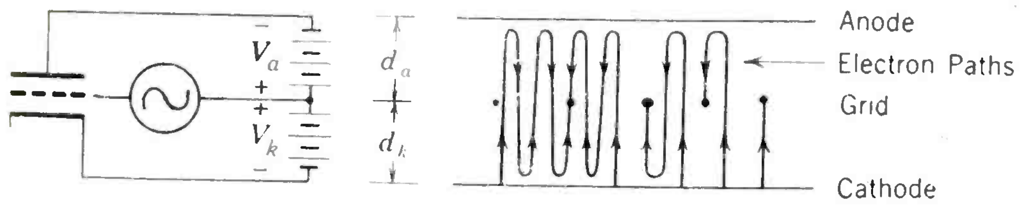


FIG. 1—Diagram of electrode voltages in retarding field oscillator (left) and path of travel of electrons within tube having plane electrodes (left)

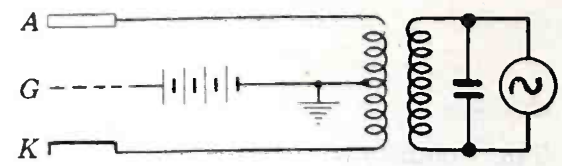


FIG. 3—Schematic diagram illustrating the connections for the production of oscillations between plate and cathode of positive grid oscillators

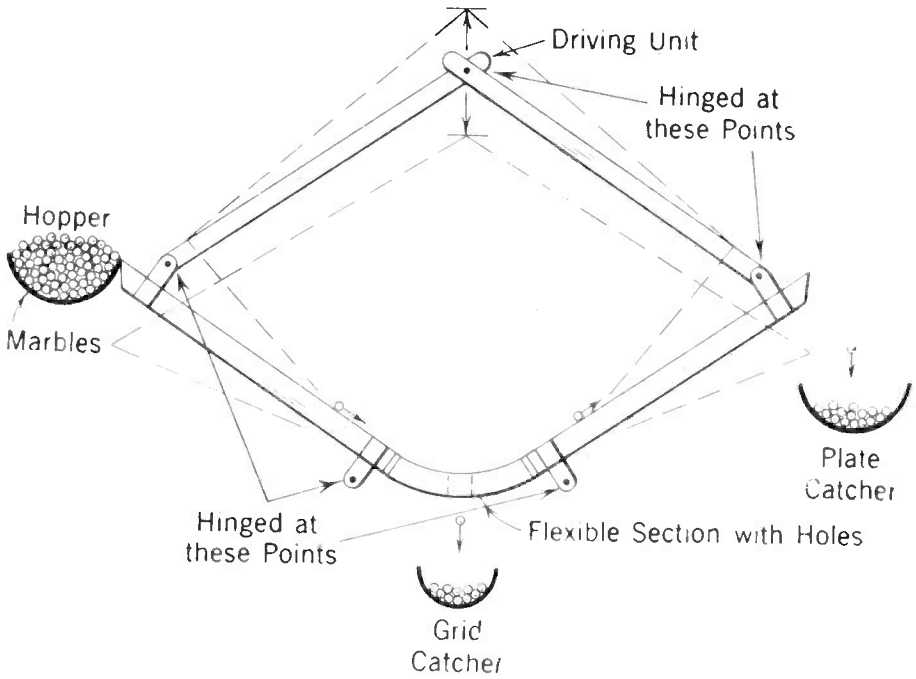


FIG. 2—Mechanical model analog illustrating the operation of a positive grid oscillator

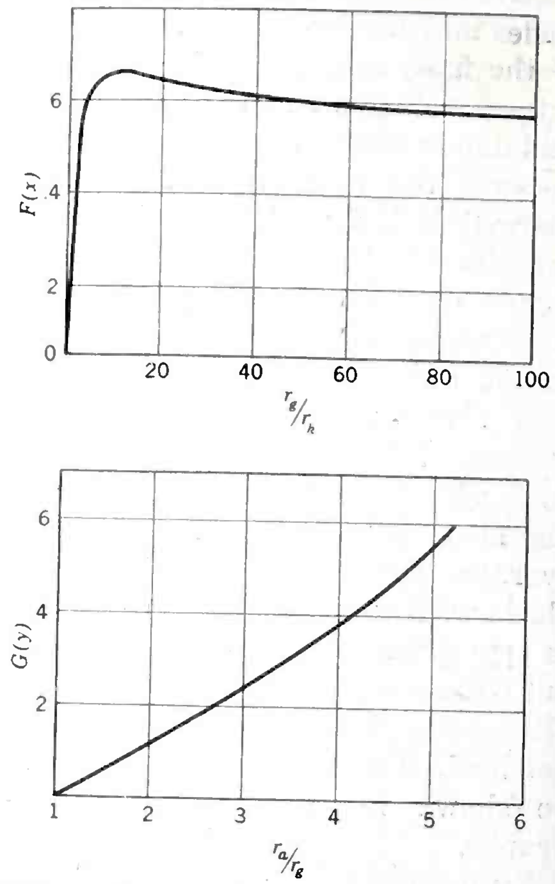


FIG. 4—Plot of Schiebe functions, used in determining the wavelength or frequency of oscillations of tubes with cylindrical electrodes

accelerating the electron is less than normal, and the electron returns to the grid with less energy than it had upon leaving it.

With each successive oscillation the electron returns to the grid with a lower energy and moves a shorter distance away from the grid. The kinetic energy originally derived from the direct voltage, V_k, is converted into power at high frequency and is delivered to the external circuit. Ultimately, of course, the electron strikes a grid wire and is lost. But on the average those electrons which deliver power to the external circuit execute several oscillations while those which absorb power travel only once from cathode to plate. Thus a net positive power output is available.

This mechanism is known as amplitude selection. Those electrons with unsuitable phase are rejected from the system by the excess of velocity which they acquire in one transit. Those electrons with suitable phase are retained in the system for several oscillations. It can be shown that all electrons emitted over one-half cycle produce, to varying degrees, loss of power, and they are ejected after one transit. Likewise all electrons emitted during the other half-cycle deliver useful output and are retained in the system until captured by the grid.

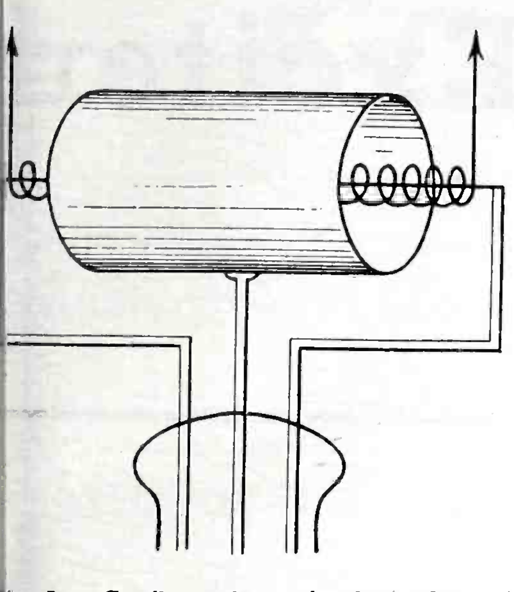
The frequency specified in this development is such that one full cycle corresponds to the transit time from cathode to plate or from grid to plate to grid. As shown in the table, the wavelength of generated oscillations is

$$\lambda_k = \lambda_a = 2000\, d_k V_k^{-1/2} \text{ meters} \quad (1)$$

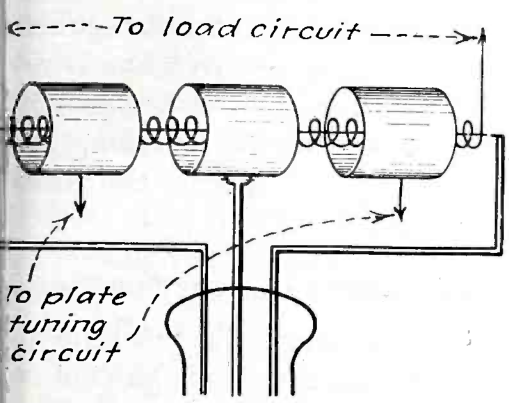
where distances are measured in meters and potentials in volts. If, for example, $d_k = 0.001$ meter (0.1 cm) and $V_k = 100$ volts, the generated wavelength is approximately 0.2 meter (20 cm), a very short wave.

Mechanical Analogy

Figure 2 shows a mechanical device which illustrates many of the characteristics of the positive grid oscillations just described. Let us assume that marbles are discharged at a uniform rate from the hopper and roll down the inclined side, across the flexible section, and up the other side. Suppose that the unit is driven as shown so that the driving bar makes one full cycle up and down in the time required for a marble to roll down from the hopper and up the other side. Marbles may be lost from this system either by rolling over the edge into the plate



. 5 — Configuration of electrodes of spiral grid retarding field oscillator



6—Spiral grid oscillator tube with di-d plate. For clarity in illustrating con-ction, the spacing between plate sections is exaggerated

atcher trough or by falling through hole in the flexible section.

A marble which emerges from the opper when the system is as shown y the solid lines, and when the edges re rising, rolls down an incline that s always steeper than normal. Dur-ng the time that it crosses the flex-ble section the displacement is re-ersed and the marble finds the sec-nd incline less steep than normal. t is thus able to roll over the edge nd escape to the plate catcher.

A marble which enters the system alf a cycle later finds its original ncline always less steep than nor-al and arrives at the flexible sec-on with a velocity below normal. he second incline is now steeper an normal and the marble is thus nable to reach the far edge. The isplacement of the system from ormal again passes through zero as the marble reverses and the velocity with which it again reaches the bottom is still further reduced. This marble oscillates back and forth in the system, losing more and more energy with each cycle. It ultimately is lost through a hole in the flexible section.

The similarity of this device to the electronic one just described is very great. Marbles or electrons which enter the system at times of unfavorable phase are ejected after one full transit. Marbles or electrons which enter the system at times of favorable phase gives up energy to the system and remain for several cycles of oscillation. Since the marbles are discharged at a uniform rate, as many electrons or marbles enter in favorable as in unfavorable phase, and the power contributed by those in favorable phase outweighs that absorbed by those of unfavorable phase.

Phase Selection

Both the positive-grid oscillator and the mechanical model just described display an effect known as phase selection. It is most easily visualized in terms of the mechanical model. In their initial movement marbles require some definite time to roll from one edge of the mechanism to the other. Marbles of favorable phase give up energy to the system and roll through successively shorter distances. In this device the time required for one full oscillation decreases as the distance traveled decreases. Therefore an operating frequency which corresponds to the time required for the first oscillation is too low for later oscillations.

The operation of the positive-grid tube is affected in the same way. The actual generated frequency is a compromise corresponding to some intermediate amplitude of electron motion. Electrons which remain in the system for several complete cycles tend to advance from favorable to unfavorable phase. The low efficiency characteristic of positive-grid oscillators is due largely to the effects of phase selection.

Review of Oscillations in Grid Circuit

It has been shown that oscillations can exist in a plane parallel triode having equal electrode spacings and no cathode-anode voltage. The oscillations appear from grid to cathode (or anode) and are of quite high frequency. It is clear, in reviewing the performance, that the success of the arrangement depends upon the fact that cathode and anode are at the same potential and that the transit times from grid to cathode and from grid to anode are equal. Serious failure of the equality of transit times is fatal to this mode of oscillation since the impulses cannot become synchronized. Equality of plate and cathode voltage, although very desirable, is not essential since the amplitude selection mentioned before can take place at the cathode after one full cycle of electron oscillation. Electrons which leave the cathode in unfavorable phase are accelerated during one full excursion from cathode to plate and back, and are then lost at the cathode. Electrons which leave the cathode in favorable phase continue in their oscillation, as shown above, until they strike a grid wire and are lost.

It may be shown that the grid-cathode and grid-anode transit times are equal in the parallel plane case if $d_a/V_a = d_k/V_k$. Many experimenters have reported strong oscillations with large negative plate voltages, probably in fulfillment of this condition. Such oscillations exist provided only that some impedance is present in the grid lead to cause a voltage drop and that the transit times are suitable. Power is delivered to the external circuit of an appropriate resistive load such as a tuned circuit.

Oscillations in the Plate-Cathode Circuit

A different sort of oscillation results if the load is applied between cathode and plate as shown in Fig. 3. An electron moving from the cathode toward the plate constitutes an elementary electric current whose direction is opposite to the motion because of our convention as to current flow. Evidently the motion from cathode toward the plate causes the plate to become momentarily negative and the cathode positive with respect to the bias values.

The operation of this circuit is similar to that of Fig. 1. It is most conveniently explained by assuming a voltage to be introduced by an external generator of appropriate frequency. It is then shown that

(Continued on page 232)

Electronic Exciter

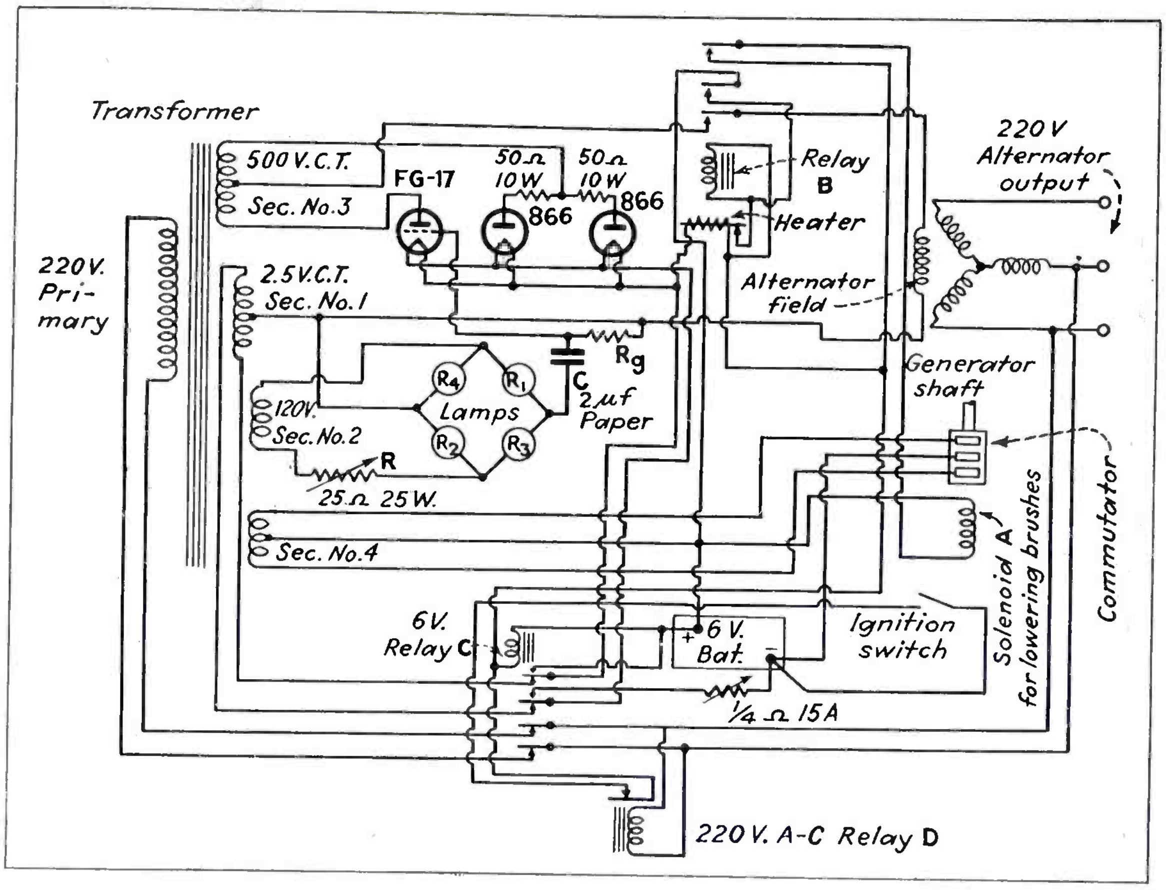


FIG. 1—Circuit diagram of an electronic voltage regulator which also replaces the exciter on small and medium-size a-c generators

THE rapid expansion of the manufacture and sale of small commercial diesel engine-driven generating sets for private commercial power supplies just prior to the outbreak of the war points the way to a much more intensive invasion of the power-generating field by such sets as soon as victory is achieved and materials are again obtainable.

Motor-generator sets which deliver an alternating voltage normally require a d-c exciter and a voltage regulator. High speed of response to load changes is one of the primary requirements for a regulator for these sets, due to the comparatively large fluctuations in load when motors are started. A suitable voltage regulator has been described on page 104 of the April 1943 issue of ELECTRONICS and will be referred to in this description.

Further research into the problem, conducted at the University of Denver, has led to the development of a regulator which also replaces the exciter. Since the total cost for this apparatus is very little more than for the regulator alone, a distinct savings will be realized due to elimination of the exciter. Further advantages lie in the more rapid response to load changes and in the elimination of brush and V-belt maintenance on the exciter.

Description of Circuit

Referring to Fig. 1, it will be seen that the circuit is essentially the same as for the voltage regulator previously described, except that the regulator feeds directly into the field of the alternator. The development work was done on a 5-kva, three-phase, 220-volt, 1800-rpm machine.

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Secondary No. 3 is 500 volts center-tapped. The grid control tube is an FG-17 thyratron. The two type 866 rectifier tubes employ 50-ohm, 10-watt resistors to divide the load between them.

Storage Battery Used for Starting

In order to allow the machine to build up in voltage when started, a rotary reversing switch mounted on the shaft of the alternator is used in conjunction with a 6-volt battery and secondary No. 4. The secondary is 14 turns of No. 12 wire, center-tapped.

A development of the reversing switch is shown in Fig. 2. The switch is made up of two slip rings with alternate interleaved segments forming an elementary commutator 1½ in. in diameter and 2 in. long. Ford starter brushes are used. The brushes are normally held off the commutator by a spring mechanism, and are lowered in contact with the commutator only when solenoid *A* is energized by the ignition switch of the engine upon starting.

Three relays are used, labeled *B*, *C*, and *D*. Relay *B* prevents the plate voltage from being applied to the tubes until the heater has caused the bimetallic strip to energize the operating coil of relay *B* from the 6-volt battery, thus giving a heating time of 20 seconds for the tube filaments. Relay *C* is energized from the 6-volt battery when the ignition switch is closed. Relay *D* opens its contact when its coil is at about 25 percent of rated voltage. This al-

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lows relay C to de-energize and open its top contacts, closing its bottom contacts.

To start the machine, the ignition switch is closed and the filament voltage adjusted to 2.5 volts by means of the series rheostat. The engine is then started. When the thermal delay closes after the 20-second interval required to heat the filaments, solenoid A is energized, lowering the brushes on the commutator. Secondary No. 4 is then energized on first one half and then the other by the commutator-type reversing switch. This causes the generator to build up in voltage.

When about 25-percent voltage is reached, relay D picks up and releases relay C, whose top contacts open and bottom contacts close. This energizes the transformer primary from the generator, and also de-energizes solenoid A and raises the brushes on the rotary switch. The filaments are also transferred from the battery to secondary No. 1. All this is accomplished in a little less than two seconds after the thermal delay on relay B trips. The generator immediately builds up in voltage to the value for which rheostat R is adjusted, and remains constant. The rate of response is extremely rapid, and the circuit is very stable. No elaborate anti-hunting device is needed. Hunting is prevented by proper adjustment of R_g, which for the machine used was 500 ohms. The wave form of the generator is not changed by the use of this type of excitation, as was verified by oscillographic tests.

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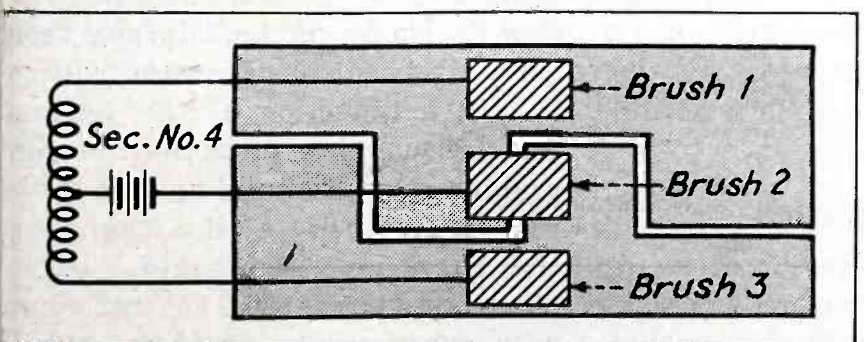

FIG. 2—Development of the elementary commutator used to apply battery voltage alternately to the two halves of secondary No. 4 to make the alternator build up its voltage when started

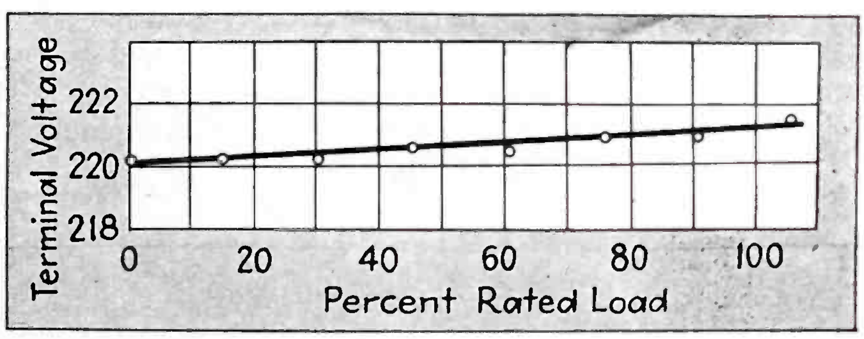

FIG. 3—Variation of output voltage with load for a resistance load. The slight rise in voltage with load is due to the drop in bridge voltage when the transformer furnishes more field current

Electronic Exciter

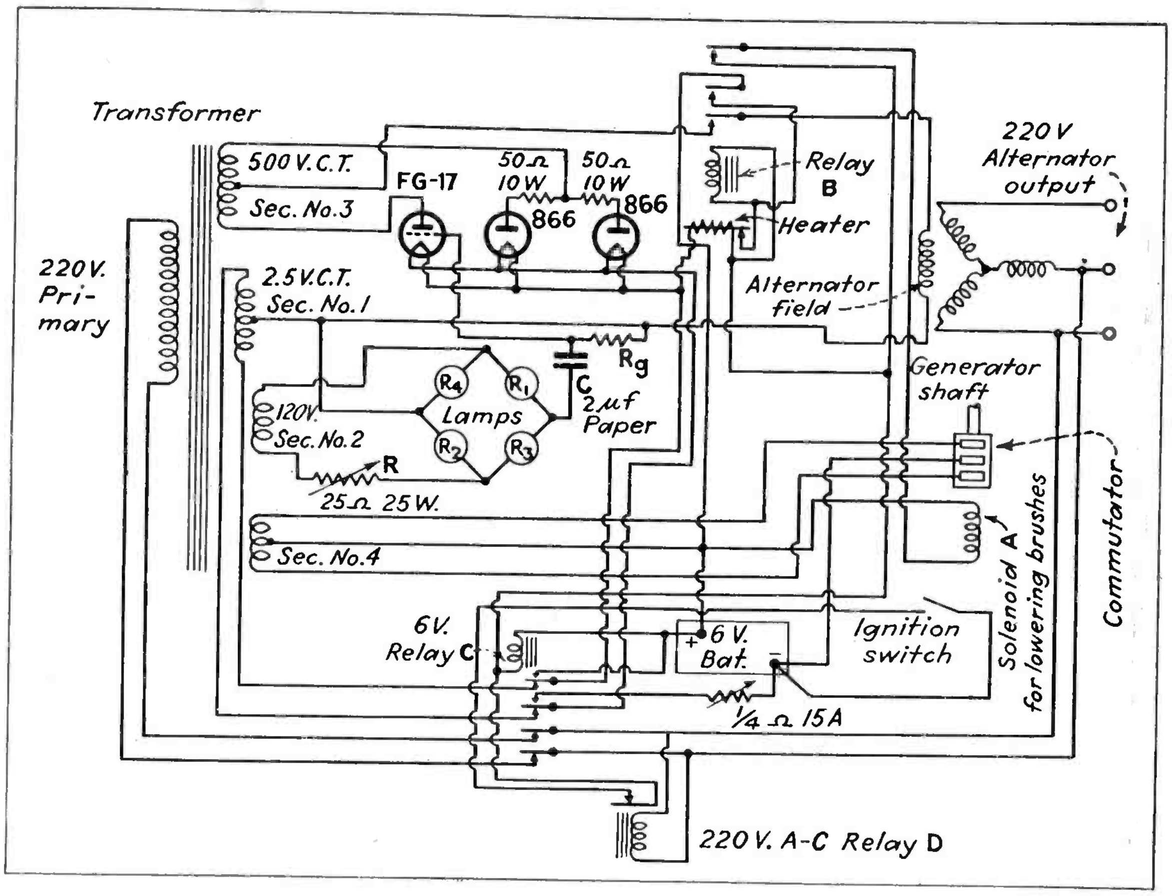

FIG. 1—Circuit diagram of an electronic voltage regulator which also replaces the exciter on small and medium-size a-c generators

THE rapid expansion of the manufacture and sale of small commercial diesel engine-driven generating sets for private commercial power supplies just prior to the outbreak of the war points the way to a much more intensive invasion of the power-generating field by such sets as soon as victory is achieved and materials are again obtainable.

Motor-generator sets which deliver an alternating voltage normally require a d-c exciter and a voltage regulator. High speed of response to load changes is one of the primary requirements for a regulator for these sets, due to the comparatively large fluctuations in load when motors are started. A suitable voltage regulator has been described on page 104 of the April 1943 issue of ELECTRONICS and will be referred to in this description.

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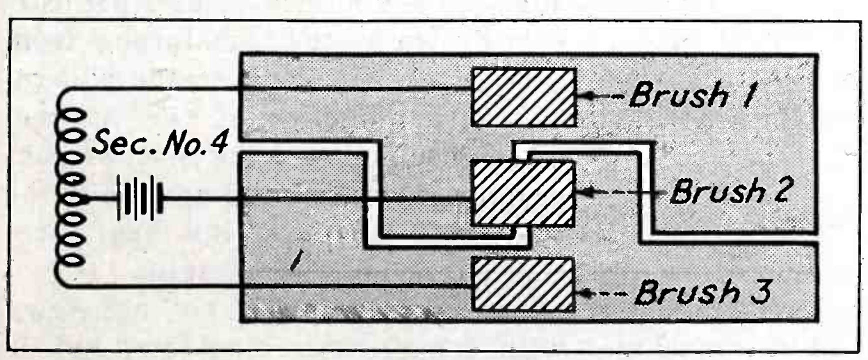

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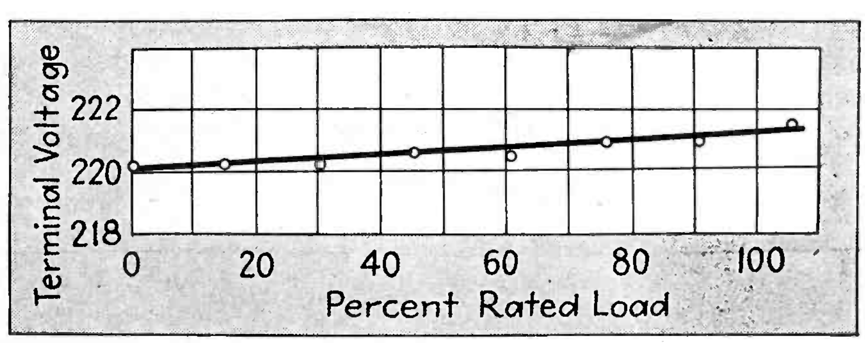

FIG. 3—Variation of output voltage with load for a resistance load. The slight rise in voltage with load is due to the drop in bridge voltage when the transformer furnishes more field current

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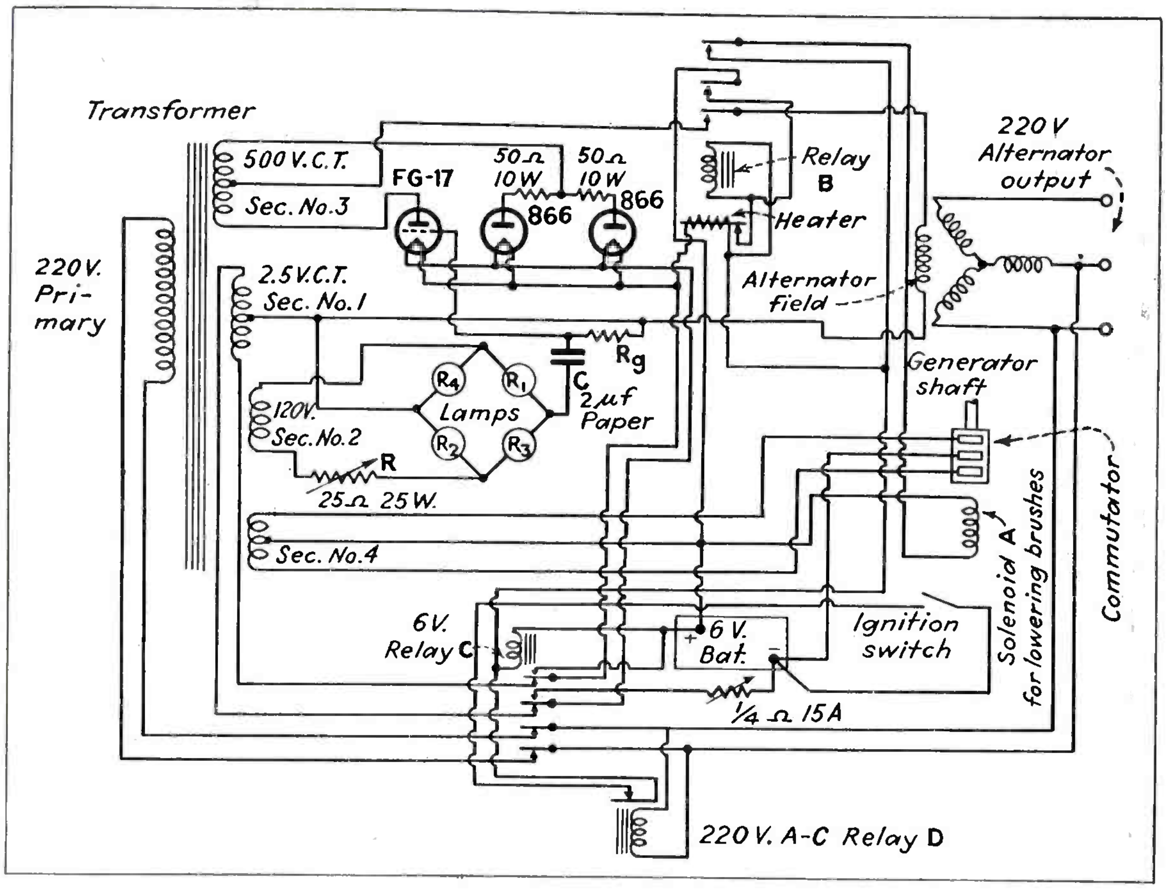

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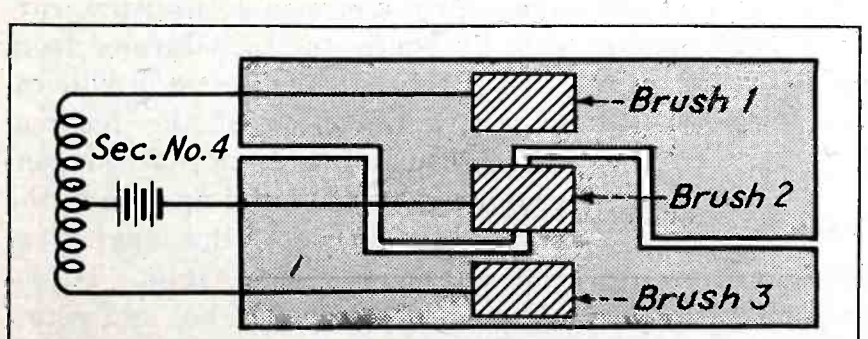

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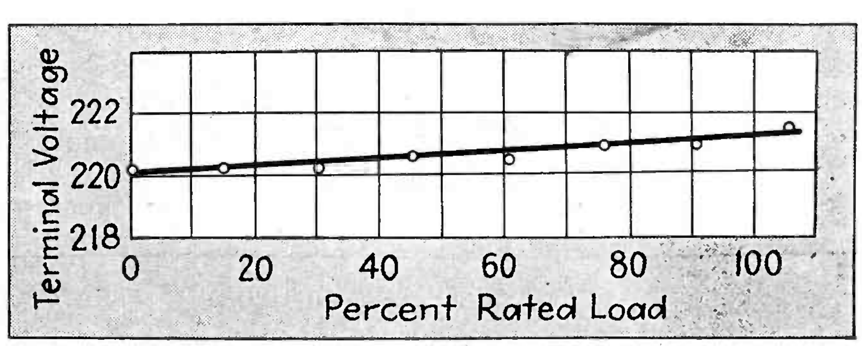

FIG. 3—Variation of output voltage with load for a resistance load. The slight rise in voltage with load is due to the drop in bridge voltage when the transformer furnishes more field current

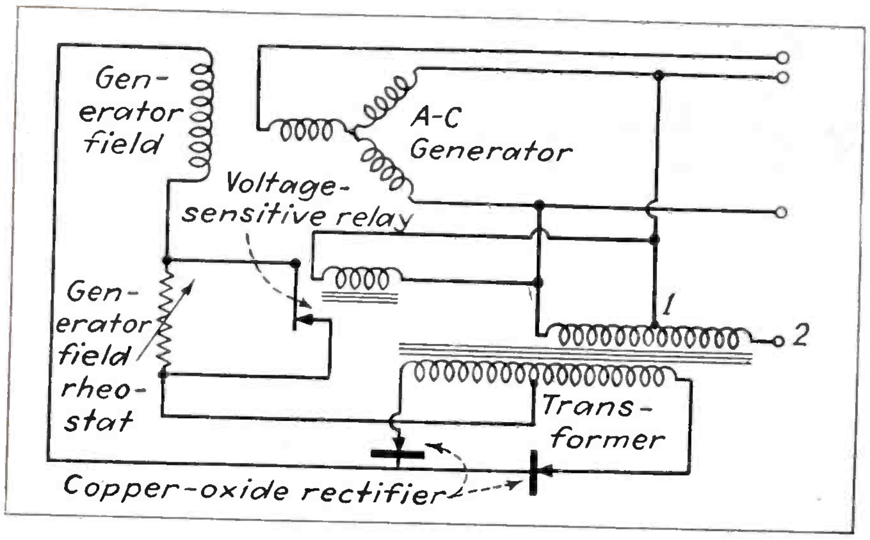

FIG. 4—Method of using copper-oxide rectifiers to make the alternator build up its voltage from residual flux without a battery

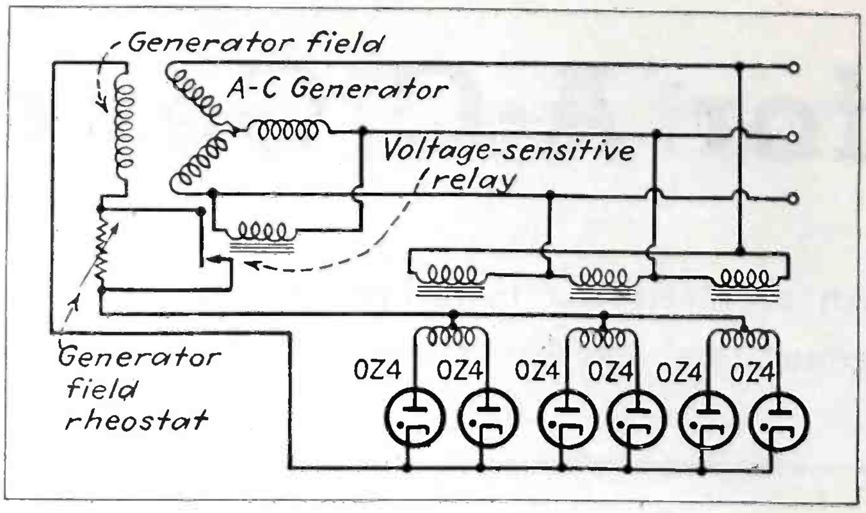

FIG. 5—Method of using six cold-cathode rectifier tubes to make the alternator build up its voltage from residual flux

machine will function under excitation from the battery circuit until the short is cleared, when the voltage will again build up to normal and close the relays to the a-c side.

Effect of Load Changes on Tube Outputs

The division of current between the grid control tube and the non-controlled rectifiers depends upon the voltage drop in the field and upon the voltage of the transformer plate supply (secondary No. 3). For example, if the voltage of the supply transformer is 125 volts on either side of center tap, and the field *IR* drop is 100 volts, the thyratron and the 866 tubes would carry approximately equal currents as measured on a d-c ammeter. If the secondary voltage is doubled to about 250 volts, then most of the current would be carried by the 866 tubes, the thyratron being operative during only a short period of each cycle.

Types of Tubes Required for Various Sizes of Generators

With standard generators designed for 125-volt nominal d-c excitation, the field requirements usually lie between 4 and 6 percent for small machines and 2 to 3 percent for machines of 100 kva or thereabouts. This is usually at 100 volts applied to the field. With the standard 125-volt d-c field winding, the current for a 25-kva machine would then be about 10 amperes, assuming 4 percent field loss.

The division of current between the grid-controlled tube and the straight rectifier tubes depends upon the voltage required for the field and upon the secondary plate voltage supplied from the transformer. By proper choice of the secondary supply voltage, the size of grid-controlled tube can be kept down within the lower price range and a major part of the current can be carried by non-controlled rectifiers, for which the replacement cost is comparatively low. Using 350 to 400 volts rms on each side of the center tap for the 25-kva generator mentioned above, the grid-controlled tube would carry current about one-fifth of the time, or an average of 2 amperes, while the non-controlled tubes would carry the other 16 amperes. Thus an FG-57 thyratron could be used as the grid-controlled tube, and three FG-104 phanotron tubes in parallel can be used for the non-controlled tubes. The average capacity of an FG-57 is 2.5 amperes, while the maximum is 15 amperes, both values being larger than the actual load on the tube.

Special field coils designed for operation at 500 volts would allow excitation of a generator five times the size of that with a 100-volt winding, using the same size tube. Insulation difficulties at 500 volts are not too great, although it has been found by experience that high surges are sometimes present in rectifier circuits, so that better field insulation would be required for this type of supply than for a field excited by a d-c generator.

Economic Factors

The cost of such a regulator-exciter as has been described, not including the battery, for a 25-kva machine with 125-volt field is less than $125. Prior to the war, a reasonably good regulator cost about $100 and an exciter for this size generator, rated at 1200 rpm, cost $150. Electronic excitation thus gives substantially lower first cost along with much more rapid response characteristics, and should receive serious consideration by the various manufacturers of small generating sets when peacetime markets are again available.

Two possible methods for self-excitation of a-c generators from their residual flux will be described.

Use of Copper-Oxide Rectifiers

The generator may be caused to build up from its residual flux by the use of copper-oxide rectifiers, a transformer and relays as shown in Fig. 4. A relay is used to change the primary from terminals 1 to 2 as soon as the generator starts to build up. The voltage-sensitive relay maintains the voltage fairly constant at 10 to 25 percent of rated value while the mercury vapor rectifier tubes warm up. The necessary relays for changing over to the regulator are not shown.

Experiments have shown that the transformer must be carefully proportioned so as to obtain a maximum of output with a minimum of exciting current at the low residual voltage. Any appreciable exciting current drawn by the transformer from a relatively small generator will result in a reduction of the residual flux to such a low value that the generator refuses to build up, due to the reverse curvature of the magnetization curve near the origin. Three-phase rectification is not necessary with copper-oxide rectifiers, but is desirable in order to insure building up from a low residual flux.

(*Continued on page* 261)

Iron-core Components In Pulse Amplifiers

A discussion of the rate of voltage change in the "leading edge," "flat top" and "trailing edge" portions of square-wave or flat-top pulses when impressed on iron-core reactors

By REUBEN LEE

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Westinghouse Electric & Manufacturing Co.,
Baltimore, Md.

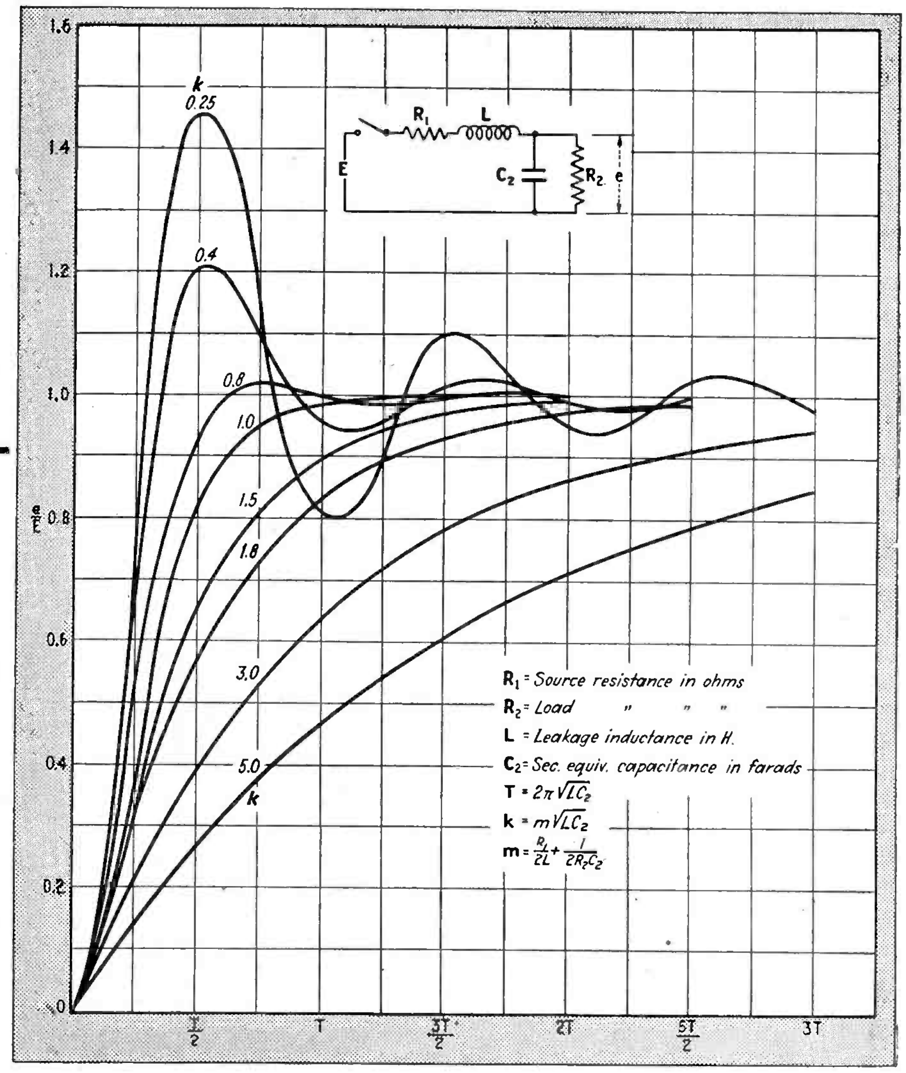
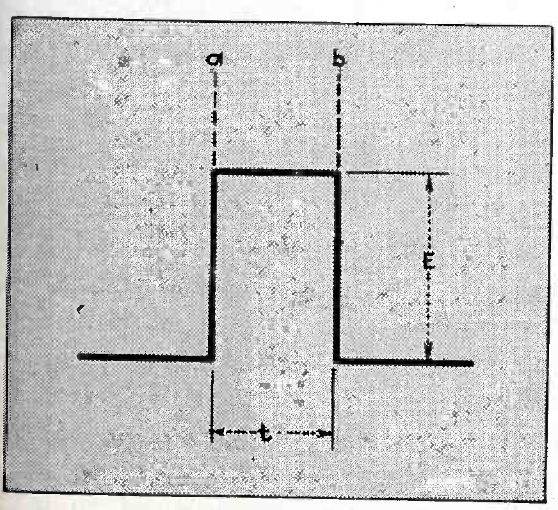


Fig. 3 — Influence of transformer constants on front edge of pulse

Square or flat-topped pulses of steep wavefront have come into considerable use of recent years, particularly in television and allied techniques. They may be impressed on iron-cored transformers by a vacuum tube, a transmission line, or even a battery and a switch.

The analysis to follow discusses the rate of rise of the front edge, the extent of the flat top and the rate of decay of the trailing edge as functions of circuit constants. The mathematical expressions for these portions of the wave, which describe the transient conditions producing these waves, are not given, in the interest of economy of space. All the essential data necessary for one to understand these rates-of-voltage change are given, however.



◀ Fig. 1—Square-top pulse to be studied

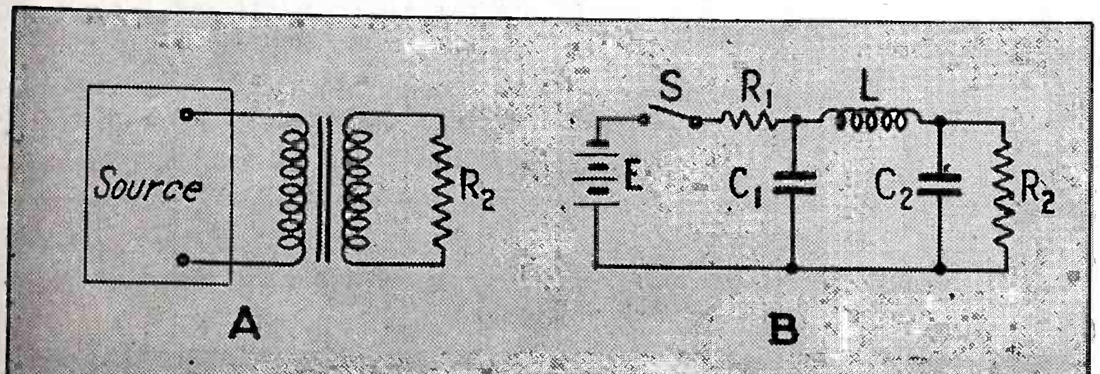


Fig. 2—Pulse amplifier and equivalent circuit. *L* is transformer leakage inductance. R_1 is the source resistance, R_2 is the load resistance, C_1 and C_2 are primary and secondary winding capacitances

The pulse itself is given in Fig. 1 and a generalized circuit for the amplifier is given in Fig. 2A with the equivalent so far as the transformer is concerned in Fig. 2B.

During the front edge period when the pulse voltage e is rising abruptly to its final value E, the transformer open-circuit inductance presents practically infinite impedance to the voltage change and is omitted in Fig. 2B. The leakage inductance, however, has considerable influence on the wave shape and appears as L. Other quantities are defined on the figure. Quantities in the secondary circuit are all referred to the primary by multiplying them by $(N_P/N_S)^2$ or, if it were more convenient to treat the transformer entirely from the secondary, the primary quantities would be referred

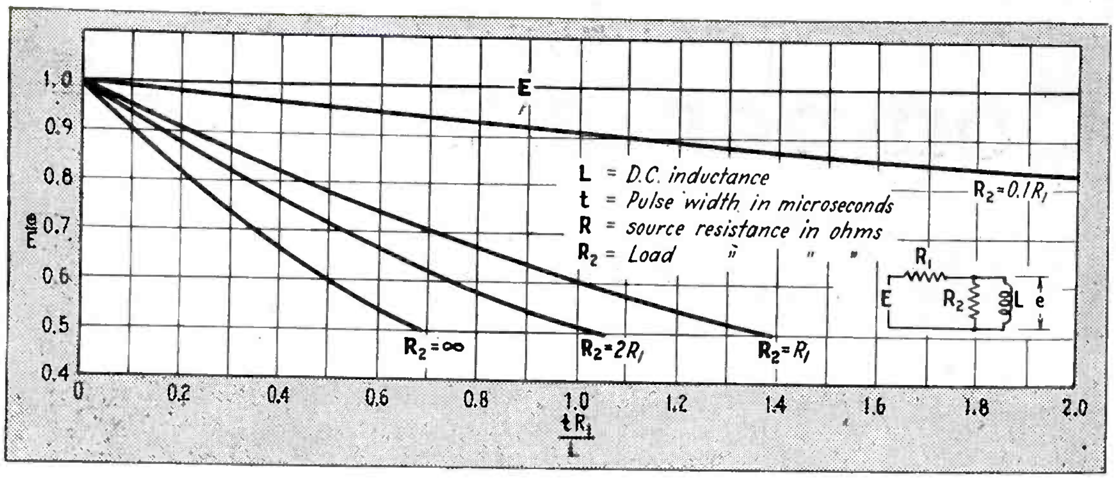


Fig. 4—Influence of transformer open-circuit inductance on flat-top portion of pulse. The inductance in this case is in microhenrys

to that side by a reciprocal multiplying factor.

Since there are two capacity terms C_1 and C_2 then for any considerable deviation of the transformer turns-ratio from unity, one or the other of these capacitances will become preponderant. Turns-ratio and therefore voltage-ratio affect these capacitances in such a way that for a step-up transformer, C_1 may be neglected and for a step-down transformer, C_2 may be neglected. The discussion here will be confined to the step-up case, although the step-down and the 1 to 1 ratio cases are not markedly different.

Front-edge Conditions

When the front of the wave is impressed suddenly on the step-up transformer, Fig. 3, as by closing a switch, the initial voltage e and current entering from the battery are zero. The rate at which the voltage rises is given in Fig. 3. The final value $E\left(\frac{R_2}{R_1 + R_2}\right)$ indicates that the amplifier will be more efficient the smaller R_1 is. In Fig. 3, R_1 is considered negligibly small. If the value E for the top of the pulse is multiplied by $\frac{R_2}{R_1 + R_2}$ the curves are reasonably accurate. Note that the abscissas are not time but percentage of the time constant of the transformer.

The rate of voltage rise is governed by the leakage inductance L, the secondary capacitance C_2 and markedly by another factor, k, which is the product of the decrement and the angular velocity of an oscillatory circuit, but which has the same form for a circuit which is not oscillatory. Other things remaining equal, the greater the transformer leakage inductance and distributed capacitance, the slower the rate of voltage rise. R_1 and R_2 also are important since they affect factor k. Note that if a slight amount of oscillation can be tolerated, the wave rises much faster than if no oscillations are present.

If the circuit is far removed from oscillation, the rise is very slow. If the circuit is damped very little, the oscillation may reach a maximum initial value of two times the steady-state voltage E and often such marked peaks would be objectionable. The values for k given on the curve appear to be those which fall within the most practicable range.

"Flat-top" Conditions

Once the pulse top is reached, the value E is dependent upon the transformer open-circuit inductance for its maintenance at this value. If the pulse stayed on indefinitely at the value E, it would require an infinite inductance to maintain it so, and of course this is not practical. Therefore, the top of such a pulse always has a tendency to droop. The equiva-

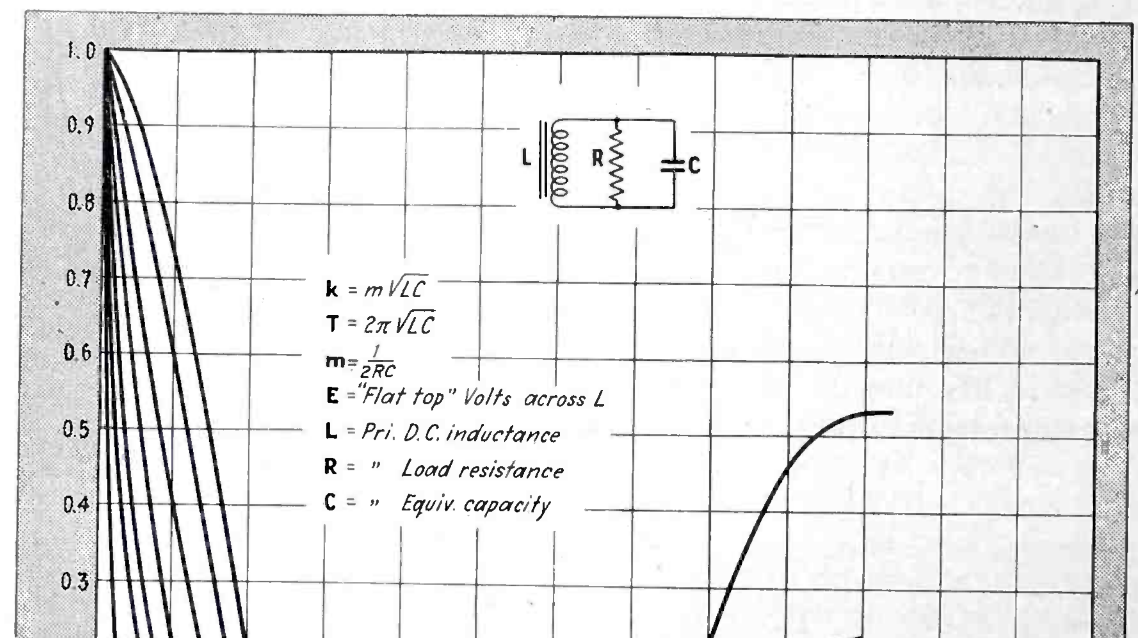


Fig. 5—Effect of transformer constants on trailing-edge of pulse

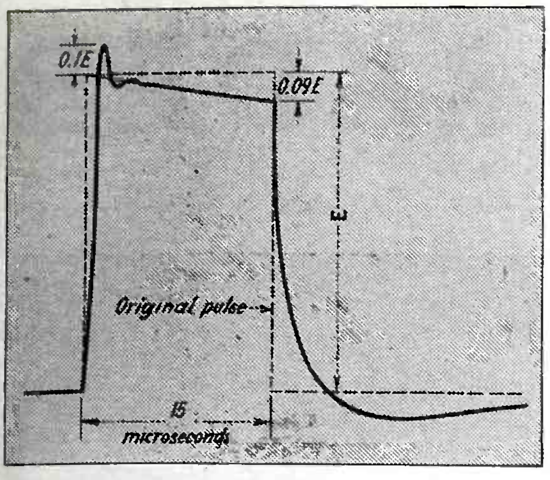
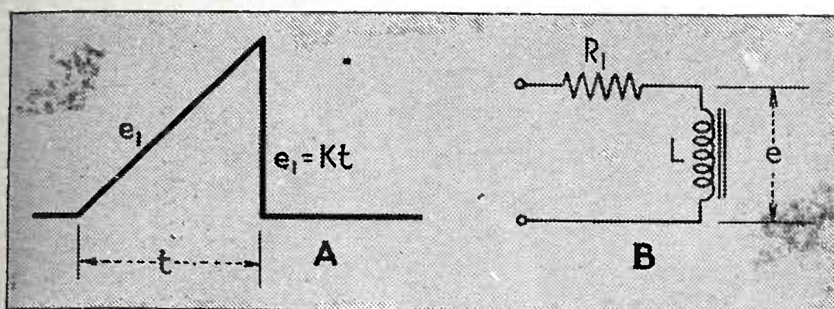


Fig. 6 — (left) — Actual pulse delivered by typical case treated in text

Fig. 7 — (below) — Typical saw-tooth pulse and circuit analyzed in text



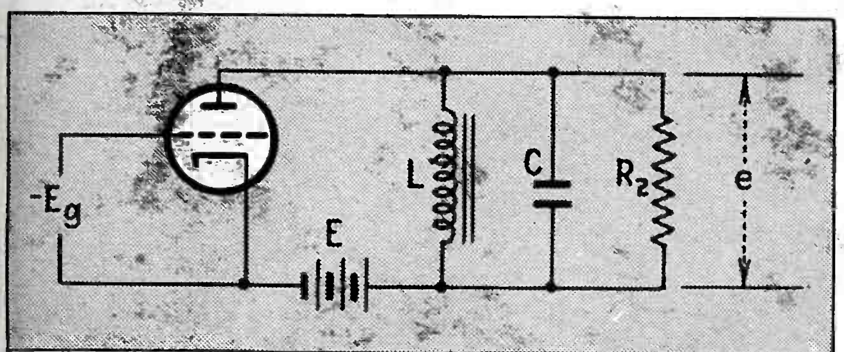


Fig. 8—Circuit for developing high voltages by interrupting a current through a reactor

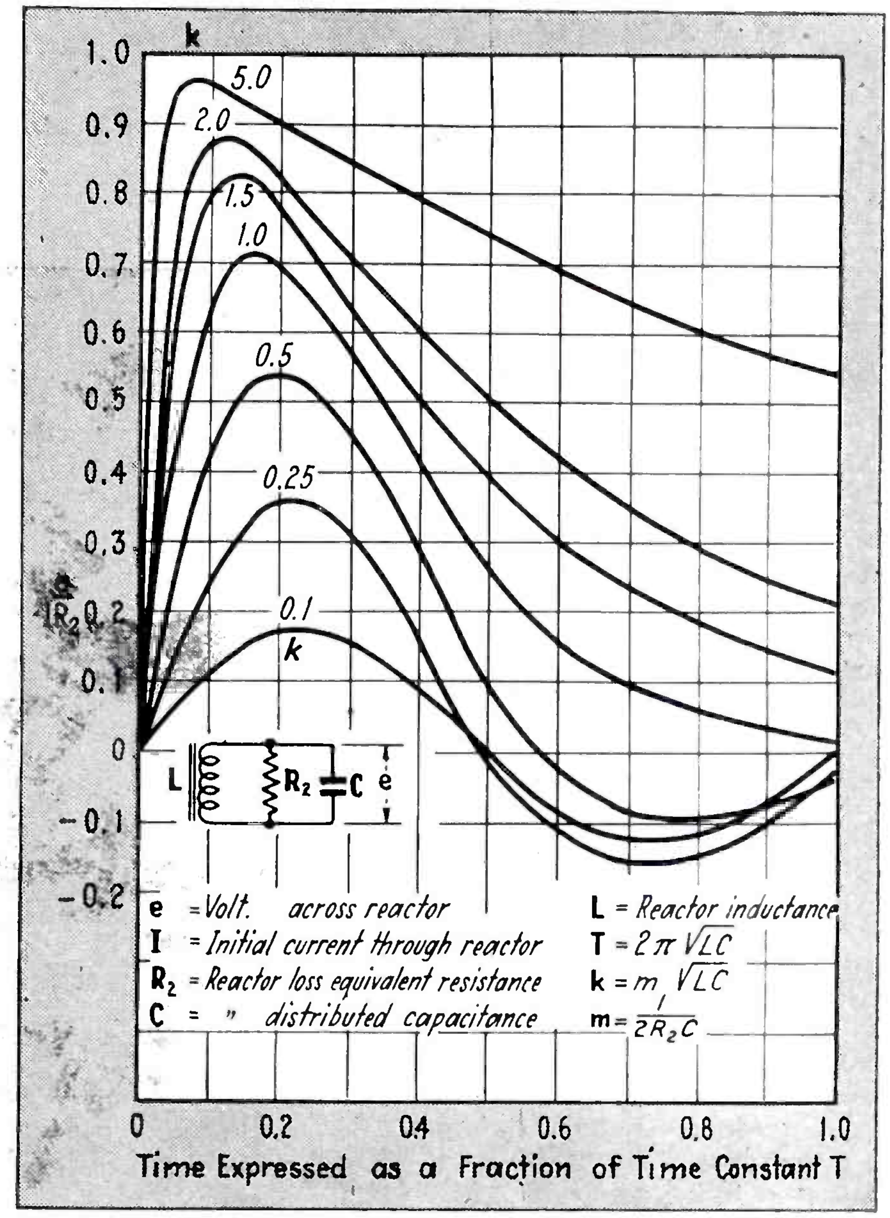


Fig. 9—Curves of voltage rise across a reactor

lent circuit during this time is shown in Fig. 4. Since the rate of voltage change is relatively small during this period, C_1 and C_2 disappear from the picture. Since the leakage inductance is usually small compared to the open-circuit inductance, it is neglected. When the circuit (Fig. 4) is first closed, the e is assumed to be at the steady value E, which is strictly true only when R_1 is negligibly small. Therefore, the curves for the top of the wave need to be corrected the same as those for the front of the wave, in that e should be multiplied by the ratio $R_2/(R_1+R_2)$. Several curves are given, representing several types of pulse amplifiers ranging from a pentode where the source resistance is very high (R_2 is 1/10th of R_1), to an amplifier whose load resistance is infinity or whose output power is zero. In the latter case, e need not be multiplied by any ratio of resistances; its final value is the same as that of the battery. All the curves are exponential, having a common point at 0, 1. The abscissas are not time, but are the product of time and ratio R_1/L the time being the duration of the pulse between points a and b in Fig. 1. Obviously, the greater the inductance L the less deviation from a flat top pulse there is during this amount of time.

"Trailing-edge" Conditions

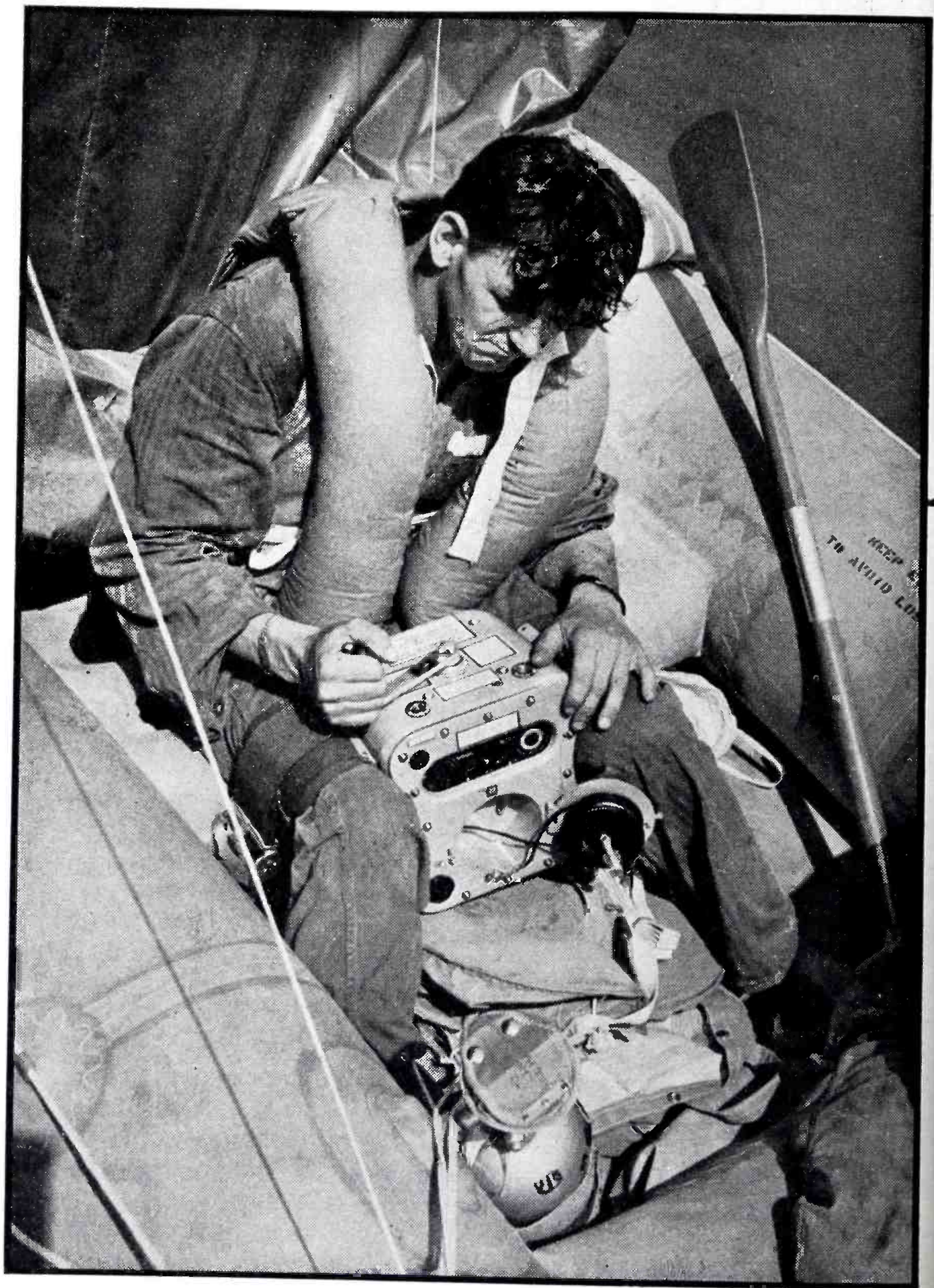
At time instant b in Fig. 1, we will assume that the battery circuit in Fig. 4 is suddenly opened. The circuit now becomes that of Fig. 5, in which L is the open circuit inductance. Secondary capacitance (C), is again present to an appreciable extent. It will be assumed that the current through L has not increased to an appreciable amount, and therefore the flat top wave was practically unimpaired at instant b; but if this is true, it is the same as saying that there is no initial current in inductance L, so when the switch is open, C_2 supplies all the load current momentarily. This is the basis upon which Fig. 5 is drawn. The time constant is now determined by the open-circuit inductance L and capacity C rather than by leakage inductance and capacity C_2 as was the case in Fig. 3. The constant k is again the product of decrement and angular velocity for the oscillatory case, but the decrement now has a different meaning. Lest it be assumed that the time constant is so great in this case that it precludes satisfactory performance, attention is drawn to the fact that higher open-circuit inductance L results in higher values of k, and the curves with higher values of k drop much more rapidly than do the smaller values, but only with reference to the time constant, T.

This does not mean that such a wave will drop more rapidly in time, but only with reference to the time constant which is determined by open-circuit inductance and capacitance. It does mean, however, that the slope of the trailing edge can be kept within tolerable limits, provided the transformer capacitance can be kept small enough. The accurate predetermination of this capacitance is therefore of first importance. The measurement and evaluation of the trans-

(*Continued on page 262*)

RADIO and RADAR

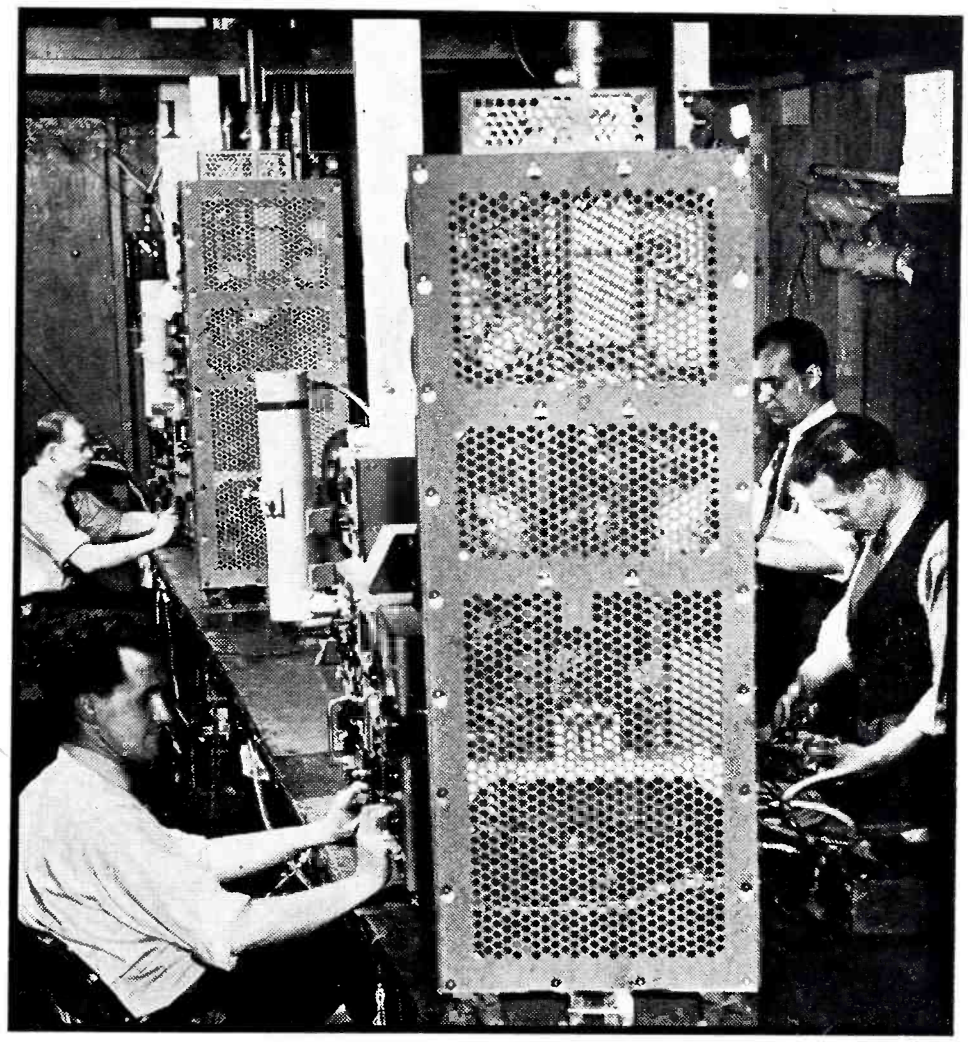
Conveniently held between the knees because of its "hour-glass" figure, and cranked like an old-fashioned coffee-mill to generate power, this Bendix transmitter designed with the help of the Signal Corps and Wright Field automatically transmits a coded call for help from U. S. Army airmen forced down at sea. It operates in the 500 kc "SOS" band where, under average conditions, it covers a 100,000 square-mile area



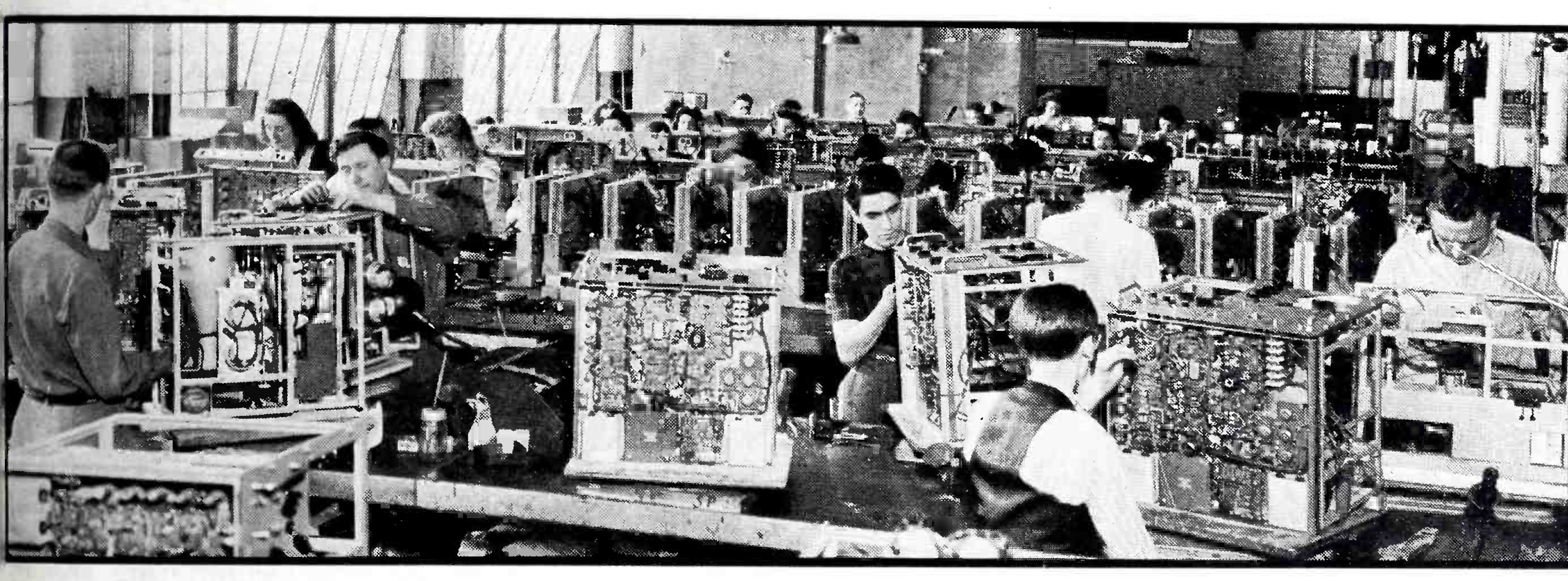
Rescue-raft transmitter, with complete complement of accessories including the bag in which it is packed, weighs 33 lb and floats nicely if it is necessary to toss it from a plane and pick it up later. An antenna wire, normally nested on a reel in a front-panel compartment, is carried up as high as 300 ft. by a 5-ft. hydrogen balloon in calm weather and a box-kite when the wind is blowing

at WAR

Automatic transmitter included as part of Army airmen's emergency gear brings help to fliers forced down at sea. Navy aircraft and ship-locating equipment pictured in production. Electronic sound apparatus, shown on Attu beach, aided American landing



Radar transmitters undergoing test in a General Electric plant just before shipment to the U. S. Navy (right)

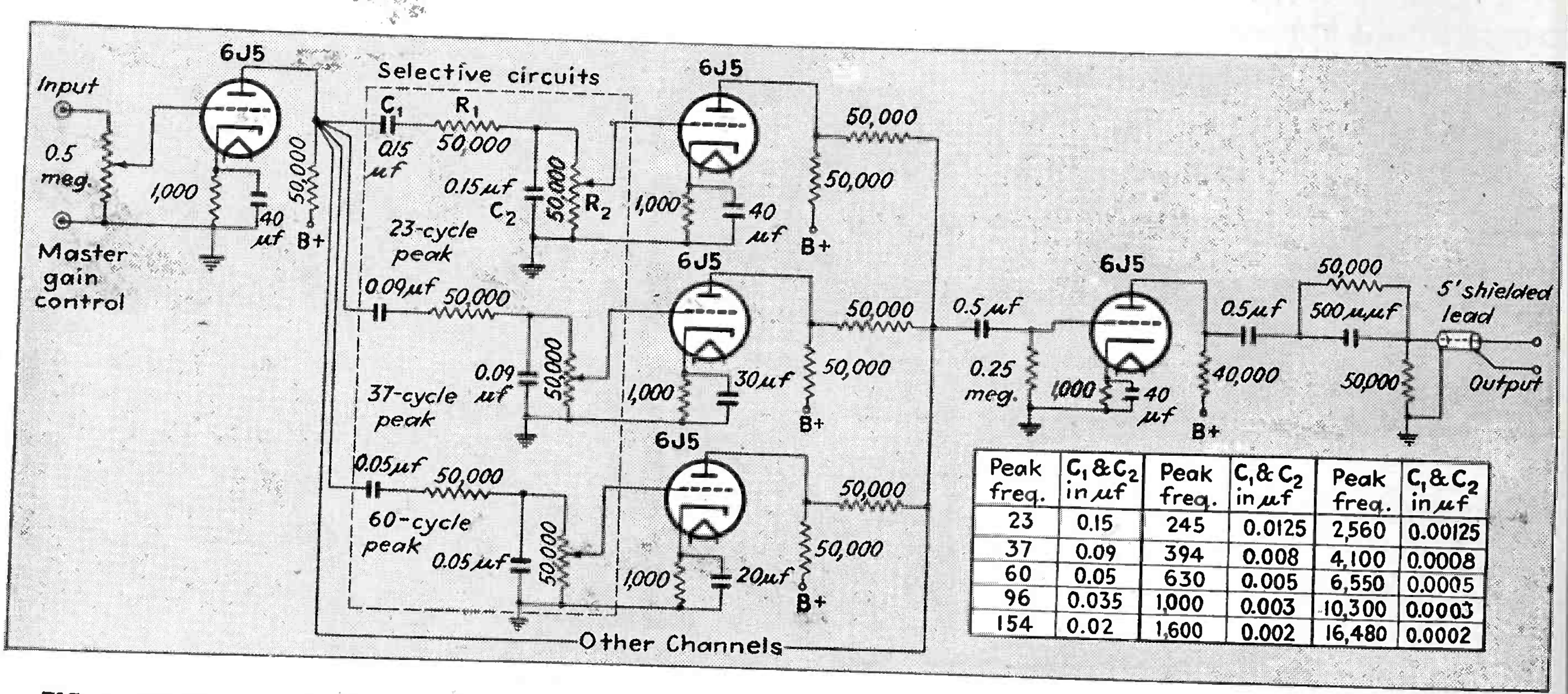


Other radar equipment in production. Discussing such apparatus recently, Army's former Chief Signal Officer, Maj. Gen. Dawson Olmstead, said that during the Attu landing weather was so bad that men could have been put ashore successfully only with the aid of radar (above)

A microphone, amplifier and University loudspeaker mounted on a "dog-cart" guided landing boats ashore at Attu once the shock-troops had established themselves on the beach, as shown by this official U. S. Navy photo (right)

Universal Equalizer Provides A-F Amplifier Design Data

Complete details of an instrument which, when inserted in an audio amplifier system and adjusted to satisfy listeners, automatically provides on its panel a response curve from which required equalizer circuit constants to improve response characteristics can be determined



Peak freq.	C_1 & C_2 in μf	Peak freq.	C_1 & C_2 in μf	Peak freq.	C_1 & C_2 in μf
23	0.15	245	0.0125	2,560	0.00125
37	0.09	394	0.008	4,100	0.0008
60	0.05	630	0.005	6,550	0.0005
96	0.035	1,000	0.003	10,300	0.0003
154	0.02	1,600	0.002	16,480	0.0002

FIG. 1—Tonalizer circuit, with values of parts for a 15-channel arrangement. Fewer or more channels may be used if desired, by appropriately spacing the peak frequencies. By-pass capacitors for cathode resistors in remaining channels can be 10 μf each

IN AUDIO WORK, there are many uses for an instrument which makes it possible to change the response curve of an amplifier at will. Such an instrument is the "Tonalizer" developed by Paul H. Thomsen of Silver Spring, Md. It consists essentially of 15 separate calibrated tone control channels connected in parallel but acting independently, each controlling a different portion of the audio spectrum.

To determine the overall response requirements of an audio amplifier intended for high-fidelity sound reproduction the tonalizer unit is inserted in the circuit of the amplifier to be tested, at some point where the signal voltage is about 2 volts. The 15 channel controls are adjusted until the output of the amplifier is the same at all audio frequencies. The response curve then shows on front panel, since the positions of control levers forming the visual curve are calibrated directly in db.

Typical Uses

The response of a theater sound system or public address system can be adjusted to suit various acoustic conditions in much the same manner. The tonalizer is inserted in the amplifier at some convenient point, usually at the input of the single-tube stage which precedes the output stage. The channel controls are set to give the desired tone balance, as determined by listening at various positions in the audience while the system is in use. From the response curve indicated by these control settings, the required compensation can be determined and the necessary permanent equalization inserted later with assurance that the results obtained with the tonalizer will thereby be duplicated.

Response characteristics of microphones, loudspeakers and phonograph pickups can be determined with the tonalizer by using signal sources and amplifiers having reasonably flat response characteristics. Almost any combination of equip-

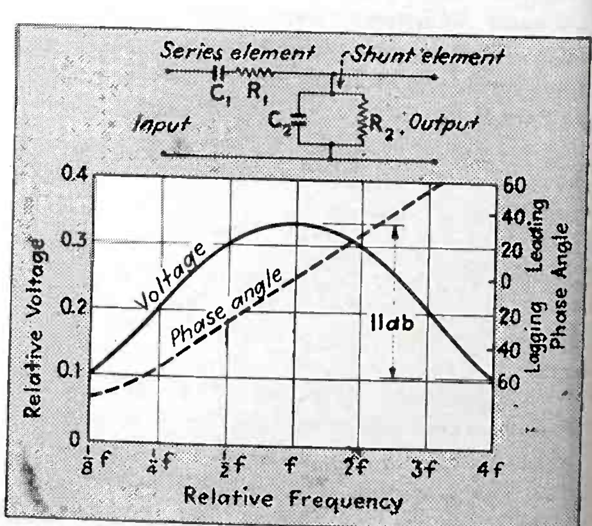
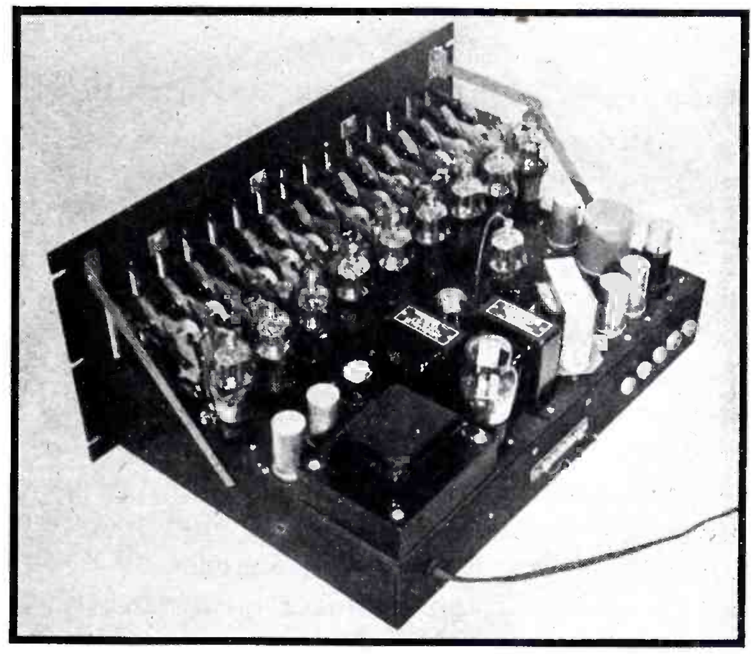


FIG. 2—*RC* selective circuit used in tonalizer, with voltage response curve it provides

LEFT: Front panel of 15-channel tonalizer. The levers move up and down through the vertical slots in the panel, with their ends tracing the response curve to which the instrument is set

BELOW: Rear of 15-channel tonalizer, showing gear arrangements used for channel gain control potentiometers. Double-triode 6F8G tubes, each serving two channels, can be used in place of individual 6J5 tubes, as was done in the model shown here, but experience has indicated that individual tubes are to be preferred



ment can be used. With the assistance of the tonalizer it is possible to improve the acoustic characteristics of any type of sound amplification system.

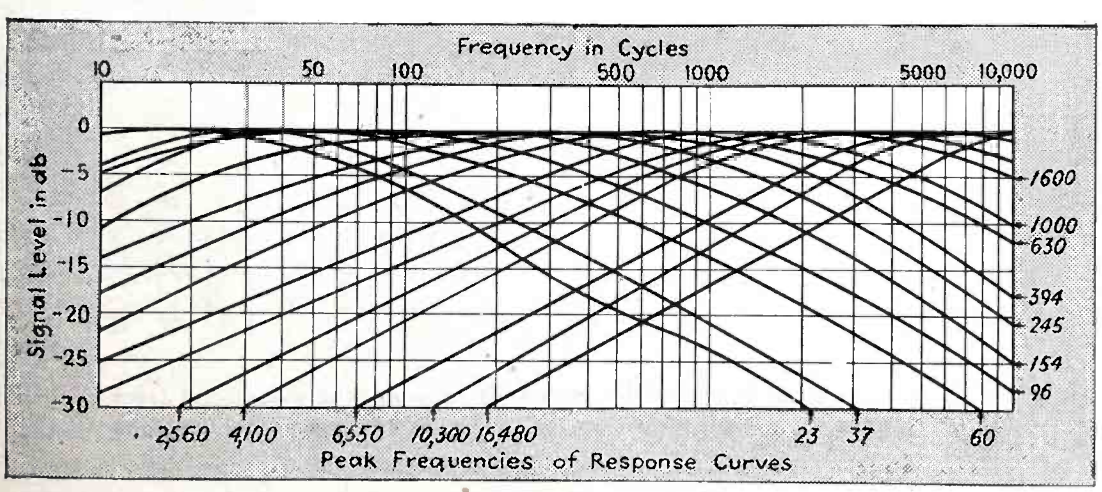
Frequencies responsible for overloading are readily determined. By lowering the gain at these frequencies with suitable equalizing networks, it is often possible to increase the effective or apparent output of an audio amplifier system a considerable amount without feedback and with hardly noticeable loss of fidelity. In the same manner, audio frequencies which cause overmodulation of a transmitter can be determined and suppressed, making it possible in some instances to more than triple the effective radiated power of a communications transmitter without overmodulating.

Another application is in connection with re-recording of old phonograph records. The controls can be adjusted quickly to get the best possible fidelity from each record in turn.

The tonalizer is fundamentally a test instrument, due to its multiplicity of tubes and circuits, and is not ordinarily left in a circuit. It may, however, be used permanently as a near-ideal tone control in applications where cost is not a limiting factor.

The basic circuit is shown in Fig. 1. The input voltage amplifier stage with its master gain control permits adjusting the overall gain of the system and has a sufficiently high input impedance for a plate circuit connection to any stage when the signal level is about 2 volts in the amplifier to be tested. The plate circuit of the 6J5 input stage feeds each of the 15 selective channels in parallel (for simplicity, only three channels are shown in the diagram).

FIG. 3—The individual responses of all 15 channels combine to give a flat response, as shown here, when all controls are set at maximum



Circuit Details

RC circuits are used as a-f filters to eliminate phase distortion and other drawbacks of tuned LC circuits. Each *RC* circuit is broadly peaked at a particular frequency, and has its own individual gain control. The gain control levers for the 15 channels are so arranged on the control panel that their ends trace the over-all response curve to which the instrument is set.

The output matching circuit and shielded cable are optional, and are used only when it is inadvisable for some reason to connect the 0.5-μf output capacitor directly to the grid of a tube in the amplifier being tested.

A conventional, well-filtered, full-wave powerpack makes the tonalizer an independent unit operable directly from an a-c line. A 5Y3G tube is used with a transformer providing 375 volts on each side of the center tap. Two 15-henry chokes and three

(*Continued on page* 269)

ELEMENTARY PARTICLES

During the past decade, rapid strides have been made in our knowledge of the basic particles of physics, and several new and fundamental "building blocks of the universe" have been discovered. Dr. Stranathan brings the reader up to date on these recent advances, in a summary of interest to users and designers of electronic devices

By J. D. STRANATHAN

University of Kansas

KNOWLEDGE of the more fundamental particles of matter encountered in nature is so fascinating to those even casually interested in the subject of physics that it seems worthwhile occasionally to summarize for the general reader the present state of knowledge concerning these particles. Electrons, protons, photons, positrons, and mesotrons are not products of the conjurer's imagination; their existence is unquestioned. They can be produced in the laboratory. They are found associated with the penetrating cosmic rays coming to us from interstellar space. Some of them are involved in the transmutation of the elements, the changing of one element into another. Some are involved in artificial radioactivity. Let us inquire briefly concerning the existence and the properties of these particles.

Forty years ago we began talking about electrons, minute electrical charges, although it was not until 1913 that it was demonstrated conclusively that electrical charge exists only in whole multiples of some unit called the electron. At that time accurate measurements of many different small charges were made, and it turned out that each of these charges was 1, 2, 3, 4, 5, or etc., times the smallest charge ever found. This smallest charge, the electron, is 1.60 x 10^{-19} coulomb. This is the charge that would move past a given point in a wire in one second if there was flowing in the wire a current of one ten-millionth of a millionth of a microampere. These electrons are negatively charged electrically, have a mass 1/1837 that of the hydrogen atom, and constitute one of the essential building stones of which all matter is constructed. They are the particles emitted from the hot cathode in the radio tube. Due to their negative charge they are attracted to the positively charged plate, and thereby given velocities of the order of 5,000 miles per second. Although the mass of the electron is extremely small, the large number of these small masses moving at such high speed gives up sufficient energy upon striking the anode to heat the plate perceptibly and sometimes disastrously.

Early Knowledge of Atomic Physics

Revealing information concerning the general structure of atoms dates back also some 25 years. Many experiments show that the atom of a particular material is made up of a very small centrally placed and positively charged part called the nucleus. This nucleus, which accounts for nearly the entire mass of the atom, is surrounded by a number of so-called planetary electrons arranged in shells at various distances from the nucleus. The number of these planetary electrons in each atom varies from one kind of atom to another; it is 1 for hydrogen, 2 for helium, 3 for lithium, and on up to 92 for uranium. In any given atom the electrons prefer to rotate about the nucleus in those shells nearer the nucleus. It is possible, however, to displace an electron outward temporarily. The atom gives out light when this electron moves back from an outer to an inner shell. The nucleus always has a positive charge, 1 for hydrogen, 2 for helium, 3 for lithium, and on up to 92 for uranium. Thus the positive nuclear charge just balances the total negative planetary electron charge; the atom as a whole is neutral. The structure of the nucleus, along with the appropriate number and arrangement of planetary electrons, is what distinguishes one atom from another. All properties of matter must therefore be determined fundamentally by the structure of the atom, the grouping of these atoms into molecules, and the arrangement of these molecules in a particular material.

In an electrical discharge tube in

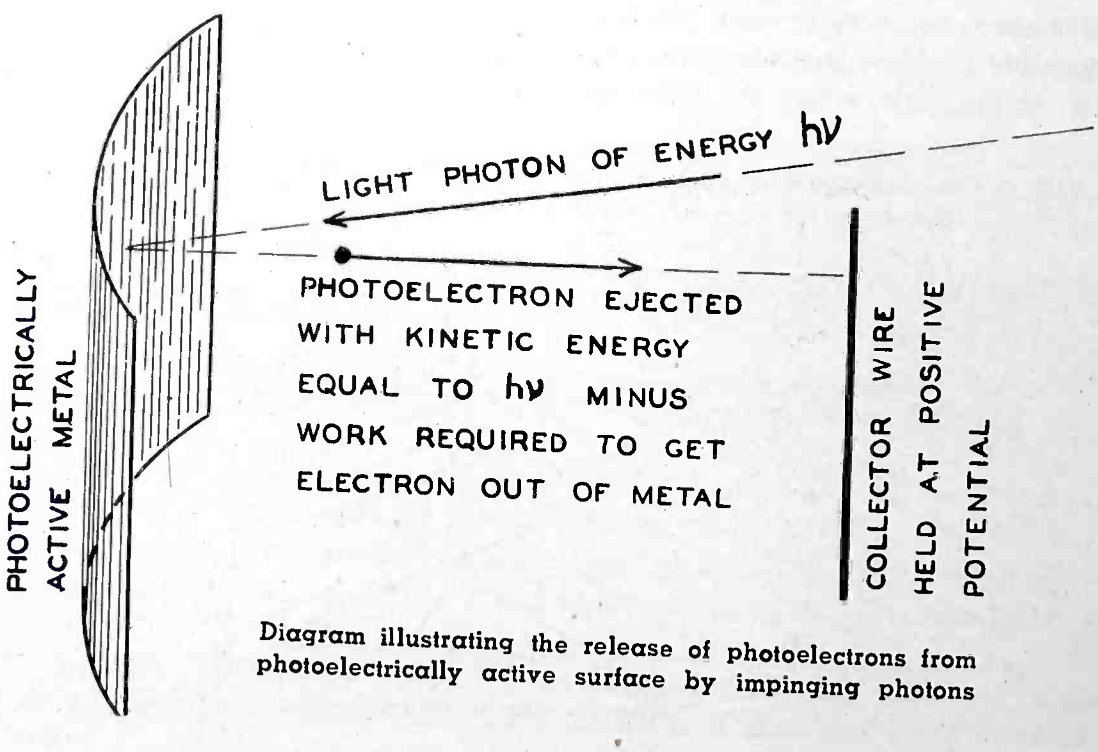
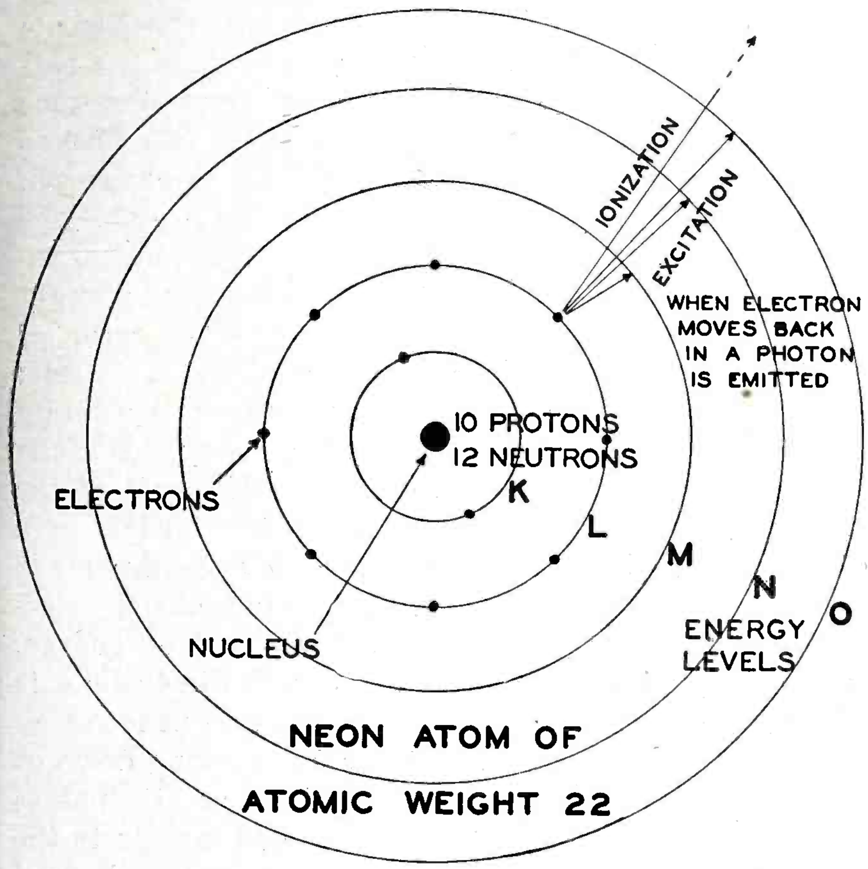


Diagram illustrating the release of photoelectrons from photoelectrically active surface by impinging photons

OF PHYSICS

At the request of the editors of Electronics, Dr. J. D. Stranathan, Chairman of the Department of Physics and Astronomy at the University of Kansas, has prepared this article on the fundamental building blocks of all matter. It has been written to summarize recent advances in atomic physics and to bring the reader up to date regarding those elementary particles underlying the physics of electronics.



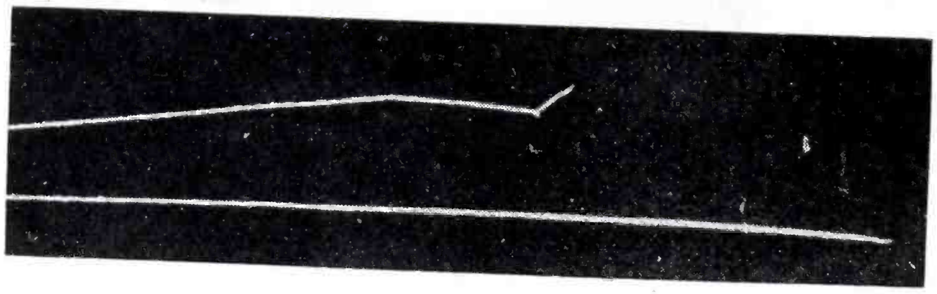
Schematic representation of protons in nucleus, and electrons in energy level orbits for neon atom. Excitation occurs when electrons move to outer energy levels. Ionization occurs when electron is completely removed from the atom

which an appreciable amount of gas has been left, such as a neon sign tube, some of the gaseous atoms are ionized. Ionization of an atom consists simply of tearing away from that atom one or more planetary electrons. This leaves a positively charged ion only inappreciably lighter than the original atom. In a discharge tube the electrons move from cathode to anode, while the positive ions move toward the cathode. If a small hole is drilled in a disc-shaped cathode in the gaseous discharge tube, a stream of these positive ions proceeds through the opening. This stream can be bent by electric or magnetic fields. Thus information regarding the velocity and the ratio of charge to mass of the particle can be obtained. Since the mass of this ion is that of the atom less one electron, the masses of atoms can be compared in this way. In fact this has proved to be a very accurate method of determining the atomic weights of the chemical elements, much more accurate in general that any of the methods more commonly used by chemists. It was through studies of these positive ions that the existence of isotopes was discovered. In general the atoms of a given element, say neon, are not all alike; some are heavier than others. Some neon has an atomic weight 20, some 21, and some 22. These three kinds of neon are called isotopes. The three isotopes of neon exist in nature in such proportions as to give an average atomic weight 20.2. Nearly every element is composed of isotopes. As will be remarked later, some of these isotopes are stable and some are radioactive. The several isotopes of any given element differ only in the structure of their nuclei; they have the same number and arrangement of planetary electrons. The simplest nucleus is that of hydrogen. This nucleus is known as a proton. It bears a positive charge of one unit, and has a mass only slightly less than that of the hydrogen atom. All other nuclei are apparently constructed of varying numbers of protons and neutrons. The neutron, to which we shall shortly return, is a particle discovered only ten years ago.

The Photon—Particle or Wave?

Another "particle" which has been known for many years is the photon. The word particle is here placed in quotes because under some conditions this photon exhibits clearly the properties of a particle whereas under other conditions it behaves definitely as a wave. In this respect it is no different from other particles we shall discuss, but this dual character has been recognized longer and studied more thoroughly for photons. Heat radiation, light, x-rays, and gamma rays given off by radioactive materials, all of which are electromagnetic waves of the same type as but of much higher frequency than radio waves, are emitted and absorbed only in discrete amounts of energy. That is, radiant energy is not emitted or absorbed continuously, but only in bundles of predetermined size. This discrete amount of energy, called a quantum or a photon, depends upon the frequency of the radiation; it is given by $h\nu$ where h is a universal constant and ν is the frequency. This photon, possessing an energy $h\nu$, travels through space with the velocity of light. Experiments show that the photon possesses momentum and mass; it possesses no electrical charge.

The existence of the photon is made evident from several types of studies, one of the most common being the photoelectric effect. It is common knowledge that photoelectric cells are used for a wide variety of purposes; they are used whenever it is desired that a change in light intensity produce a change in electric current. The active surface of the cell is made of a material which emits electrons from its surface when the surface is illuminated with light of sufficiently high frequency. The number of electrons emitted per



Cloud chamber photograph of tracks left by two alpha particles given off by radium

second, and hence the current to a nearby collector held at a positive potential, is proportional to the intensity of light falling on the surface. The individual electrons are emitted with some velocity, of the order of a few hundred miles per second, a velocity which is rather small for an electron. One might suspect that the velocity with which the electron is emitted would be larger when the surface is illuminated with intense light, but such is not the case. The more intense light ejects more electrons per second, but each electron is ejected with the same velocity as for light of low intensity. The velocity with which the electron is ejected from the surface depends upon the frequency of the incident light; it is larger for blue than for red light. In fact measurements show that the velocity of the fastest electron ejected is just that which allows the electron to have a kinetic energy exactly equal to the energy $h\nu$ of one of the photons of incident light, less a certain amount of energy required to get the electron out of the surface emitting the photoelectrons. The higher frequency associated with blue light thus accounts for the greater energy of an electron ejected by blue light than for one ejected by red light. Experiments of this and similar character show definitely that light, including not only visible light but also infrared, ultraviolet, x-rays, and gamma rays, is absorbed by matter and emitted by matter in energy bundles of size $h\nu$. It is this energy bundle that is called the photon.

The electron, the proton, and the photon have been known for some time. As a consequence one even casually interested in science knows something of them. No other fundamental particles were known before 1932. Since 1932, however, the existence of several other particles has been established. The neutron, the positron, and the mesotron are firmly established. The neutrino has a rather solid theoretical foundation, but as yet we lack conclusive experimental evidence for its existence. With the recognition of these additional particles has come also the realization that mass is just another form of energy. Without any question it is possible today to convert mass into energy, or to convert energy into mass. We shall shortly say more of this. Let us first see just how the discoveries of the neutron, the positron and the mesotron came about.

The Neutron—An Uncharged Particle

In 1932 several observers found that if radiation from certain natural radioactive materials was allowed to fall upon light elements such as beryllium, boron and lithium, there was emitted from these elements a very penetrating radiation. It was of course known that x-rays, and the gamma rays given off from natural radioactive materials, were extremely penetrating, far more penetrating than any other known type of radiation. Furthermore, it was known that in general the higher the frequency of such radiation the greater was the penetrating power. It was therefore quite natural to suppose at first that this new radiation was of the same character as x-rays and gamma rays except that it was of a still higher frequency. Since x-rays and gamma rays are absorbed as photons it was presumed that this new radiation was constituted also of photons. Studies of the absorption of this new radiation in matter soon showed, however, that such was not the case. Among other things it was found that this new radiation was absorbed more rapidly in water or paraffin than in an equivalent mass of lead. Any matter containing hydrogen is a much better absorber of this new radiation than is a material which does not contain hydrogen. On the other hand, photons are absorbed much more rapidly by lead and other heavy elements than by the light elements.

It soon became apparent that this penetrating radiation consisted of a previously unrecognized particle, a particle now called the neutron. A variety of convincing experiments has shown that this neutron is a particle having a mass almost the same as the proton; its mass is 1.0090 as compared to 1.0081 for the hydrogen atom and 1.0076 for the proton. This difference is so small that one not familiar with the experiments might suspect that it is due to error of measurement. Definitely it is not; the mass of the neutron is slightly larger than that of the proton; it is even slightly larger than that of the hydrogen atom, which consists of a proton as nucleus and one planetary electron. The neutron has no electrical charge. This lack of charge, coupled with its small dimensions, is responsible for its great penetrating power. The gradual slowing down of a charged particle as it passes through matter is due largely to the electrical forces between the charged particle and the planetary electrons of the atoms of material. The energy of the charged particle is gradually spent in knocking these planetary electrons from atoms, that is, in ionizing the atoms. The neutron, having no electrical charge, does not produce this ionization. Hence it loses its energy slowly; it is very penetrating.

The fact that the mass of the neutron is essentially the same as that of the hydrogen atom is responsible for the relatively rapid absorption of neutrons in any material containing hydrogen atoms in its structure. Let us think for a moment of the behavior of two billiard balls or of two marbles. Let us assume that the balls are perfectly elastic. Assume also that there is no friction between the balls and the table; the ball cannot then behave peculiarly because of its spin. Let one ball be stationary. Let a second ball be shot directly at the first. If the second ball has the same mass as the first, it will stop dead after the collision, while the struck ball will proceed forward with a velocity equal to that originally possessed by the striking ball. If the second ball (the striking ball) has a mass greater than the ball originally at rest, then after the collision both balls will proceed forward, the second ball at a somewhat reduced velocity. If the second ball has a mass less than that of the ball originally at rest, then the struck ball proceeds forward and the striking ball bounces backward. It is only when the striking and the struck balls have equal masses that the striking ball is brought to a dead stop. This behavior can be deduced from the known laws of mechanics; or it can be observed experimentally. Now if neutrons lose their energy by making collisions with the nuclei of atoms, then a neutron would be brought to rest most rapidly if it were allowed to strike particles of its own mass. Hydrogen nuclei have essentially this same mass. Hence any material containing hydrogen atoms is relatively an absorber of neutrons.

Discovery of the Positron

Another fundamental particle called the positron was discovered in 1932. This positron has the same mass as the ordinary electron. It has an electrical charge the same as the electron except that it is positive whereas that of the electron is negative. Experimental evidence for the existence of the positron can be understood only after a few words regarding a widely used method of studying charged particles. When a high speed charged particle is allowed to pass through an enclosed space filled with air and saturated with water vapor, the particle ionizes many atoms along its path. Many ions are therefore left along the path of the particle. If immediately after passage of the particle the mixture of air and water vapor is expanded, perhaps by withdrawing a plunger, the water vapor cools and small droplets of water condense on the ions. With proper illumination one can see or can photograph these water droplets. Thus one sees or photographs the path along which the charged particle just passed. The apparatus for making these tracks evident is called a cloud chamber. This method has been used for over thirty years.

One of the early cloud track photographs taken is shown on the opposite page. In this case the charged particle responsible for the track was an alpha particle. The alpha particle, which is given off by many radioactive materials, is really a helium nucleus. It has a mass four times that of the proton, and possesses a positive charge of two electron units. The alpha particle leaves a very dense track, due in part to its double charge and in part to its relatively large mass. The droplets of water condensed on the many ions are so close together as to present the appearance of almost a continuous track. Any charged particle leaves a similar track, though usually not so intense. The lighter and less highly charged proton leaves a less dense track than the alpha particle. The still lighter electron, with its single negative charge, leaves a much less intense track than the proton, a track in which the individual water droplets can be distinguished.

Before evidence of the positron is shown, it is necessary to recall one further fact. If a high speed charged particle is made to pass through a magnetic field, the particle's motion being perpendicular to the field, the particle is deflected to one side. A positively charged particle is deflected one way in a given magnetic field while a negatively charged particle is deflected in the opposite direction. The greater the velocity and the mass of the particle, the less is the deflection.

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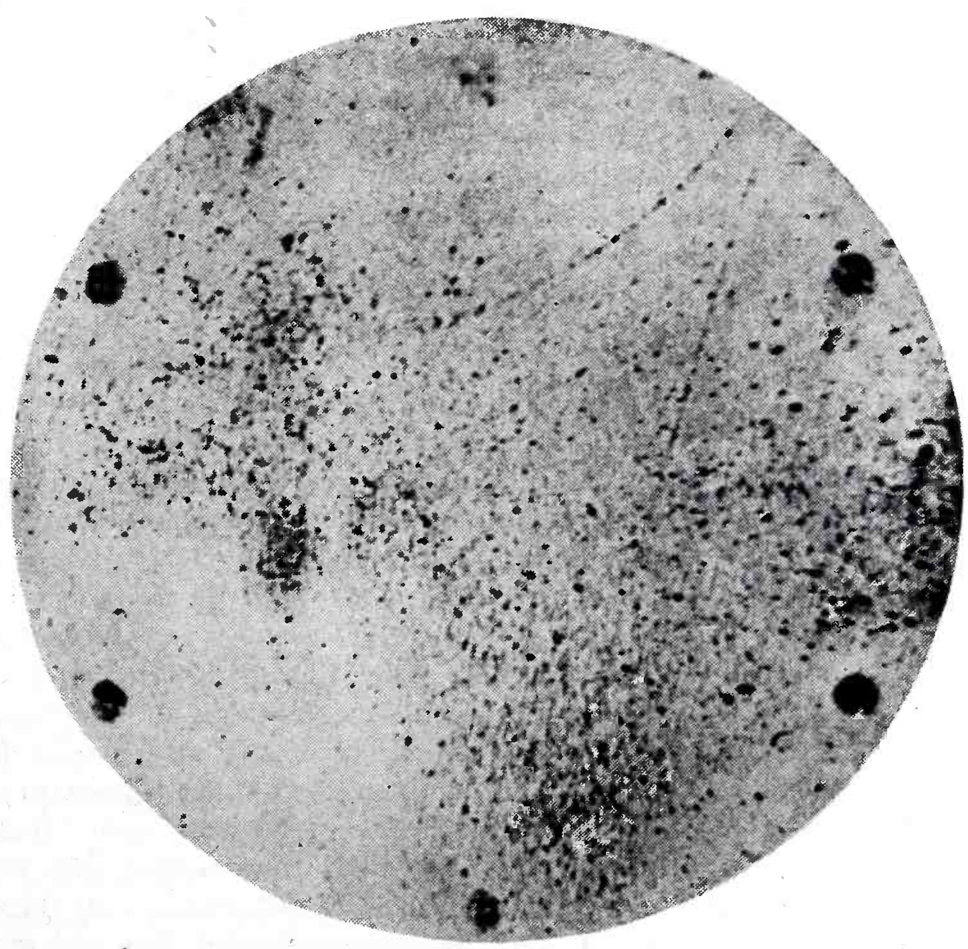
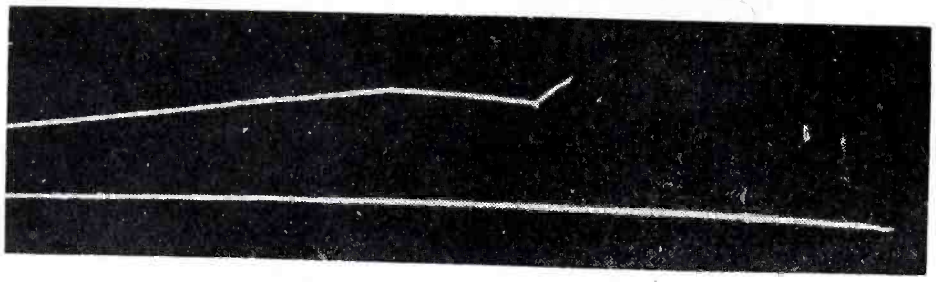


Photographic traces of a pair of tracks originating from a common point, the two particles responsible for these tracks producing equal specific ionizations. The track of greater curvature is produced by an electron. The track of less curvature is produced by a positron. Both half-tones are from the author's book, "Particles of Modern Physics" published by Blakiston



Cloud chamber photograph of tracks left by two alpha particles given off by radium

second, and hence the current to a nearby collector held at a positive potential, is proportional to the intensity of light falling on the surface. The individual electrons are emitted with some velocity, of the order of a few hundred miles per second, a velocity which is rather small for an electron. One might suspect that the velocity with which the electron is emitted would be larger when the surface is illuminated with intense light, but such is not the case. The more intense light ejects more electrons per second, but each electron is ejected with the same velocity as for light of low intensity. The velocity with which the electron is ejected from the surface depends upon the frequency of the incident light; it is larger for blue than for red light. In fact measurements show that the velocity of the fastest electron ejected is just that which allows the electron to have a kinetic energy exactly equal to the energy $h\nu$ of one of the photons of incident light, less a certain amount of energy required to get the electron out of the surface emitting the photoelectrons. The higher frequency associated with blue light thus accounts for the greater energy of an electron ejected by blue light than for one ejected by red light. Experiments of this and similar character show definitely that light, including not only visible light but also infrared, ultraviolet, x-rays, and gamma rays, is absorbed by matter and emitted by matter in energy bundles of size $h\nu$. It is this energy bundle that is called the photon.

The electron, the proton, and the photon have been known for some time. As a consequence one even casually interested in science knows something of them. No other fundamental particles were known before 1932. Since 1932, however, the existence of several other particles has been established. The neutron, the positron, and the mesotron are firmly established. The neutrino has a rather solid theoretical foundation, but as yet we lack conclusive experimental evidence for its existence. With the recognition of these additional particles has come also the realization that mass is just another form of energy. Without any question it is possible today to convert mass into energy, or to convert energy into mass. We shall shortly say more of this. Let us first see just how the discoveries of the neutron, the positron and the mesotron came about.

The Neutron—An Uncharged Particle

In 1932 several observers found that if radiation from certain natural radioactive materials was allowed to fall upon light elements such as beryllium, boron and lithium, there was emitted from these elements a very penetrating radiation. It was of course known that x-rays, and the gamma rays given off from natural radioactive materials, were extremely penetrating, far more penetrating than any other known type of radiation. Furthermore, it was known that in general the higher the frequency of such radiation the greater was the penetrating power. It was therefore quite natural to suppose at first that this new radiation was of the same character as x-rays and gamma rays except that it was of a still higher frequency. Since x-rays and gamma rays are absorbed as photons it was presumed that this new radiation was constituted also of photons. Studies of the absorption of this new radiation in matter soon showed, however, that such was not the case. Among other things it was found that this new radiation was absorbed more rapidly in water or paraffin than in an equivalent mass of lead. Any matter containing hydrogen is a much better absorber of this new radiation than is a material which does not contain hydrogen. On the other hand, photons are absorbed much more rapidly by lead and other heavy elements than by the light elements.

It soon became apparent that this penetrating radiation consisted of a previously unrecognized particle, a particle now called the neutron. A variety of convincing experiments has shown that this neutron is a particle having a mass almost the same as the proton; its mass is 1.0090 as compared to 1.0081 for the hydrogen atom and 1.0076 for the proton. This difference is so small that one not familiar with the experiments might suspect that it is due to error of measurement. Definitely it is not; the mass of the neutron is slightly larger than that of the proton; it is even slightly larger than that of the hydrogen atom, which consists of a proton as nucleus and one planetary electron. The neutron has no electrical charge. This lack of charge, coupled with its small dimensions, is responsible for its great penetrating power. The gradual slowing down of a charged particle as it passes through matter is due largely to the electrical forces between the charged particle and the planetary electrons of the atoms of material. The energy of the charged particle is gradually spent in knocking these planetary electrons from atoms, that is, in ionizing the atoms. The neutron, having no electrical charge, does not produce this ionization. Hence it loses its energy slowly; it is very penetrating.

The fact that the mass of the neutron is essentially the same as that of the hydrogen atom is responsible for the relatively rapid absorption of neutrons in any material containing hydrogen atoms in its structure. Let us think for a moment of the behavior of two billiard balls or of two marbles. Let us assume that the balls are perfectly elastic. Assume also that there is no friction between the balls and the table; the ball cannot then behave peculiarly because of its spin. Let one ball be stationary. Let a second ball be shot directly at the first. If the second ball has the same mass as the first, it will stop dead after the collision, while the struck ball will proceed forward with a velocity equal to that originally possessed by the striking ball. If the second ball (the striking ball) has a mass greater than the ball originally at rest, then after the collision both balls will proceed forward, the second ball at a somewhat reduced velocity. If the second ball has a mass less than that of the ball originally at rest, then the struck ball proceeds forward and the striking ball bounces backward. It is only when the striking and the struck balls have equal masses that the striking ball is brought to a dead stop. This behavior can be deduced from the known laws of mechanics; or it can be observed experimentally. Now if neutrons lose their energy by making collisions with the nuclei of atoms, then a neutron would be brought to rest most rapidly if it were allowed to strike particles of its own mass. Hydrogen nuclei have essentially this same mass. Hence any material containing hydrogen atoms is relatively an absorber of neutrons.

Discovery of the Positron

Another fundamental particle called the positron was discovered in 1932. This positron has the same mass as the ordinary electron. It has an electrical charge the same as the electron except that it is positive whereas that of the electron is negative. Experimental evidence for the existence of the positron can be understood only after a few words regarding a widely used method of studying charged particles. When a high speed charged particle is allowed to pass through an enclosed space filled with air and saturated with water vapor, the particle ionizes many atoms along its path. Many ions are therefore left along the path of the particle. If immediately after passage of the particle the mixture of air and water vapor is expanded, perhaps by withdrawing a plunger, the water vapor cools and small droplets of water condense on the ions. With proper illumination one can see or can photograph these water droplets. Thus one sees or photographs the path along which the charged particle just passed. The apparatus for making these tracks evident is called a cloud chamber. This method has been used for over thirty years.

One of the early cloud track photographs taken is shown on the opposite page. In this case the charged particle responsible for the track was an alpha particle. The alpha particle, which is given off by many radioactive materials, is really a helium nucleus. It has a mass four times that of the proton, and possesses a positive charge of two electron units. The alpha particle leaves a very dense track, due in part to its double charge and in part to its relatively large mass. The droplets of water condensed on the many ions are so close together as to present the appearance of almost a continuous track. Any charged particle leaves a similar track, though usually not so intense. The lighter and less highly charged proton leaves a less dense track than the alpha particle. The still lighter electron, with its single negative charge, leaves a much less intense track than the proton, a track in which the individual water droplets can be distinguished.

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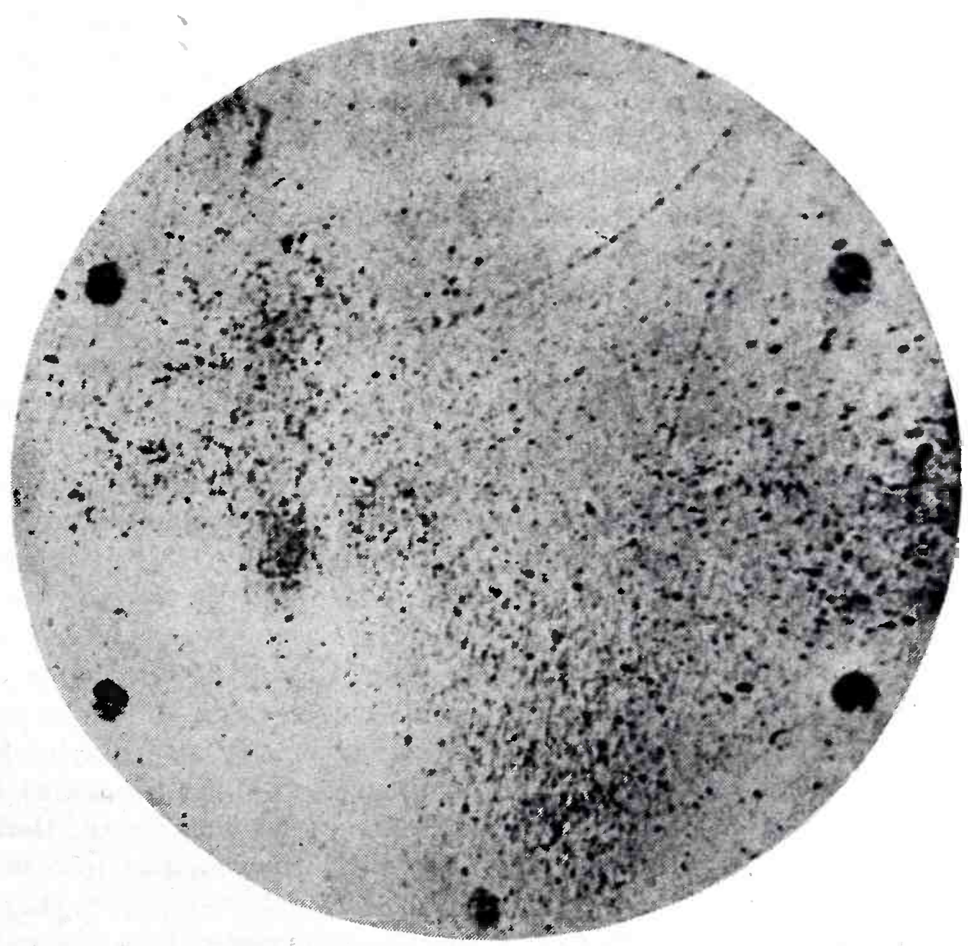


Photographic traces of a pair of tracks originating from a common point, the two particles responsible for these tracks producing equal specific ionizations. The track of greater curvature is produced by an electron. The track of less curvature is produced by a positron. Both half-tones are from the author's book, "Particles of Modern Physics" published by Blakiston

SUMMARY OF PROPERTIES OF ELEMENTARY PARTICLES

Name of Particle	Mass ($O_2 = 16$)	Charge	Relative Power of Penetration	Relative Abundance as Individual Particles	Produce Tracks
Electron........	1/1837	−1	Intermediate	Many	Yes
Positron........	1/1837	+1	Intermediate	Few	Yes
Proton.........	1.0076	+1	Low	Intermediate	Yes
Neutron........	1.0090	0	Very high	Few	No
Photon........	$h\nu/c^2$	0	High	Many	No
Mesotron.......	1/10 (approx)	±1	Very high	Very few	Yes

for the tracks on page 125 were no doubt formed by cosmic rays as these were absorbed in matter above the cloud chamber. The production of these electron-positron pairs is a common phenomenon. They can be produced either by cosmic rays or by the penetrating gamma rays emitted by some radioactive materials. A photon of radiation, $h\nu$, is apparently converted into an electron-positron pair. Mass is truly created from the radiant energy represented by the photon. The reverse process is also observed. An electron and a positron often disappear, and in their place appears a photon of radiant energy. Mass is thus converted into radiant energy. This interchange of mass and energy is a very important discovery, one which may well play an important role in the future. Not only do we know that mass can be changed into energy, or energy into mass, but we know just how much of one should result from a given amount of the other. We shall shortly indicate just how well we know this.

The Mesotron—A "Heavy Electron"

Still another particle, the mesotron, was discovered in 1936. It was first recognized by Dr. Carl D. Anderson of California, the same man who discovered the positron. Dr. Anderson had been investigating the tracks left in a large cloud chamber by the cosmic ray particles. Occasionally he found a particle which left a track very much like those left by electrons, but which appeared to have other characteristics differing from those of an electron. These new particles were unusually penetrating; they did not knock electrons out of matter as readily as the usual electron; they often proceeded through thick lead plates without producing perceptible secondary effects. Various subsequent experiments showed that this new particle possesses the same charge as the ordinary electron, except that it is sometimes negative and sometimes positive, and that its mass is intermediate between that of the electron and that of the proton. Many experiments indicate that its mass is roughly 180 times that of the usual electron, or roughly 1/10 that of the proton. This particle was originally called a "heavy electron". Later it was called the barytron. It is now called the mesotron.

Some of the cosmic radiation originating in interstellar space is exceedingly penetrating. Some is fairly easily absorbed. The penetrating component has been observed in mines after penetrating a quarter mile of the earth's crust. It has also been observed after penetrating to a depth of one-fourth mile below the surface of a deep lake or sea. It now appears that this extremely penetrating component of cosmic rays consists of mesotrons. High speed mesotrons are found throughout the atmosphere; they are more numerous as one goes to higher altitudes. One might at first suspect that the mesotrons themselves constitute the primary cosmic rays coming to us from interstellar space. Such cannct be the case, however. Experiments have shown that the mesotron does not live long. It is unstable, or radioactive as we say. After existing for a short time it disintegrates into an ordinary electron or positron. One might properly ask what happens to all the extra mass possessed by the original mesotron over that possessed by the electron into which it turns. The answer is that this excess mass is converted into energy. This is just another example that mass and energy are interchangeable, two forms of the same thing. Experiments have shown that on the average the mesotron lives for only about two millionths of a second before disintegrating into an ordinary electron. It is for this reason that the mesotrons observed in cosmic rays cannot have come from interstellar space. Although they travel with a velocity barely smaller than the velocity of light, 186,000 miles per second, they cannot go many miles before disintegrating. Hence they could not have traveled to us from interstellar space. They are no doubt formed high in our atmosphere by some component of the primary cosmic rays, apparently protons, as these primary rays strike our atmosphere. They then proceed downward toward the earth's surface, some of them disintegrating on the way, others reaching the earth and penetrating far into it. This makes clear why more mesotrons are observed at high altitudes; many have disintegrated before reaching the earth.

It should not be thought that mesotrons constitute the main part of cosmic rays. Many other particles are observed, electrons, positrons, protons, photons and occasional neutrons. Most of the particles observed at the earth's surface are of secondary character; they are not the particles which came from interstellar space. The secondary particles arise in our atmosphere as atoms are knocked apart by the incoming primary rays. The secondary particles then proceed to produce additional secondaries. The nature of the primary rays coming from interstellar space is not entirely known. It seems certain that at least most of them must be charged particles. It also seems that some of these must be protons. The primary rays probably consist largely of electrons, positrons and protons. The cosmic ray particles possess extremely high energies, often as high as 10 billion electron-volts. (An electron-volt is the energy which an electron would acquire in moving freely through a difference of potential of one volt. If the plate of a radio tube is held at a potential of 250 volts positive with respect to the cathode, then electrons striking the plate have an energy of 250 electron-volts.) Although in recent years development of the Van de Graaff machine and the cyclotron have allowed us to give charged particles suprisingly high energies in the laboratory, energies of the order of those possessed by cosmic ray par-

(*Continued on page* 272)

Chart for Determining

Square Root of a Complex Number

The tedious and time-consuming calculations required in finding the square root of a complex number in transmission line and filter calculations can be greatly simplified through the use of the graph given in this reference sheet

By ROBERT G. NISLE

Ensign, U. S. N. R.
Cambridge, Mass.

In designing certain types of electrical networks, and particularly in making transmission line or filter calculations, the need frequently arises for evaluating the square root of a complex number such as an impedance. If the impedance is expressed in polar coordinates, any root can be quickly and easily found, but if the expression is originally given in rectangular coordinates, the required operations are tedious and time consuming. The impedance must first be converted from rectangular to polar form, the square root is then determined, and finally the result is reconverted into rectangular coordinates, thereby requiring three separate and distinct operations. It is the purpose of this Reference Sheet to present a method by which the square root of any complex number which is expressed in rectangular coordinates can be easily and quickly determined, also in rectangular coordinates.

The chart presented here is based on sound mathematical reasoning, but it is believed that the reader is not primarliy interested in the mathematical basis upon which the design rests. Greater interest may be expected to be attached to the practical use of the chart, and the errors and magnitudes for which it is most useful. As reproduced, the errors which may be expected are simply those which would be expected in reading any graph, and these may be considered to be negligible for most engineering purposes. The range of variables covers those quantities usually encountered in practical engineering work. However, if it is necessary to consider ranges outside that covered by the graph, this can be done by multiplying the original complex number by some suitable scale factor (such as 0.01 or 100) so that the problem may be fitted into the range for which the chart is drawn. The final result will then have to be multiplied by the reciprocal of this original scale factor (for example, 100 or 0.01, respectively).

If the original complex number is

$$Z = a + jb$$

the problem before us is to determine

$$Z^{\frac{1}{2}} = x + jy$$

The double set of coordinates relate the quantities x, y, b, and $K = a/b$ so that when any two are known, their intersection determines a position or point on the chart from which the remaining two quantities may be determined. To use the chart, first determine $K = a/b$. Then, knowing K and b, find the intersection of these two coordinates on the vertical and horizontal axes. The point of intersection thus found will also be the point of intersection for the desired values of x and y, read off from the slanting scale.

It should be noted that $Z^{\frac{1}{2}}$ has two roots, a positive root and a negative root. Geometrically, these two possibilities are indicated in graphical form by means of vectors which are directed in opposite directions, or, are 180 deg. apart. The physical requirements of the problem must be considered when deciding which of the two roots is to be used.

It is believed that the use of the chart can be best illustrated through the solution of several representative examples.

Example 1: Assume that we have an impedance

$$Z = a + jb = 15 + j20$$

and that it is required to determine

$$Z^{\frac{1}{2}} = x + jy$$

First determine $K = a/b = 0.75$. Locate the intersection of the coordinates, $K = 0.75$ and $b = 20$. At this point read $x = 4.46$ and $y = 2.25$. The desired result is then

$$Z^{\frac{1}{2}} = x + jy = 4.46 + j\,2.25$$

or its negative value,

$$Z^{\frac{1}{2}} = -x - jy = -4.46 - j\,2.25.$$

Example 2: If the complex number is

$$Z = -15 + j\,20$$

the result is

$$Z^{\frac{1}{2}} = x + jy = 2.25 + j\,4.46$$

or, alternatively

$$Z^{\frac{1}{2}} = -x - jy = -2.25 - j\,4.46.$$

Example 3: If the impedance is

$$Z = -15 - j\,20$$

the final result is

$$Z^{\frac{1}{2}} = -2.25 + j\ 4.46$$

or

$$Z^{\frac{1}{2}} = 2.25 - j\ 4.46.$$

Example 4: If the impedance is

$$Z = 15 - j\ 20$$

the final result is

$$Z^{\frac{1}{2}} = -4.46 + j\ 2.25$$

or

$$Z^{\frac{1}{2}} = 4.46 - j\,2.25.$$

Example 5: If the impedance is

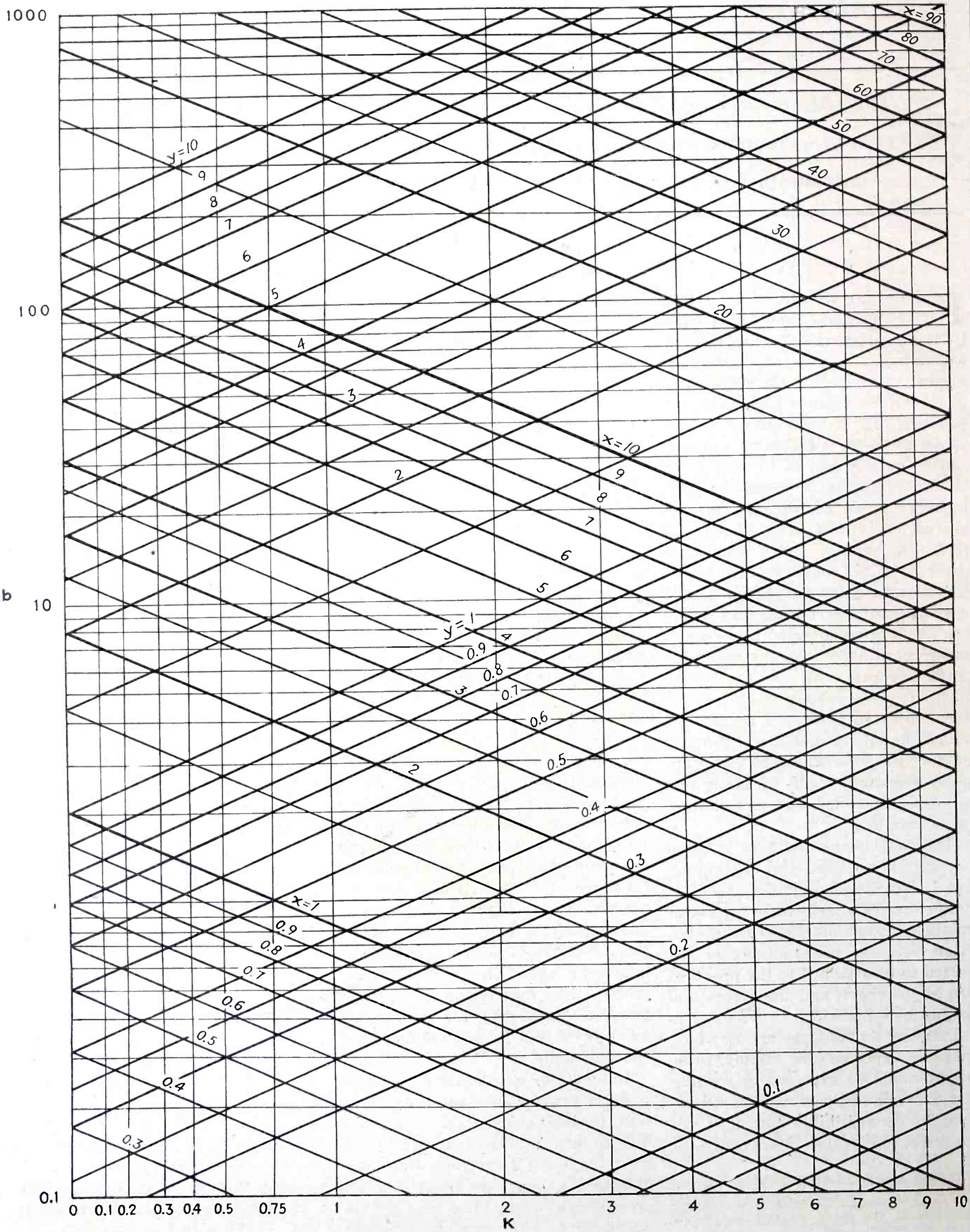
$$Z = 150 + j\ 200$$

we find that $K = 0.75$, $b = 200$, $x = 14.2$ and $y = 7.1$. The result is

$$Z^{\frac{1}{2}} = 14.2 + j\ 7.1.$$

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the view of the Navy Department or the naval services at large.

Chart for Determining
SQUARE ROOT OF A COMPLEX NUMBER



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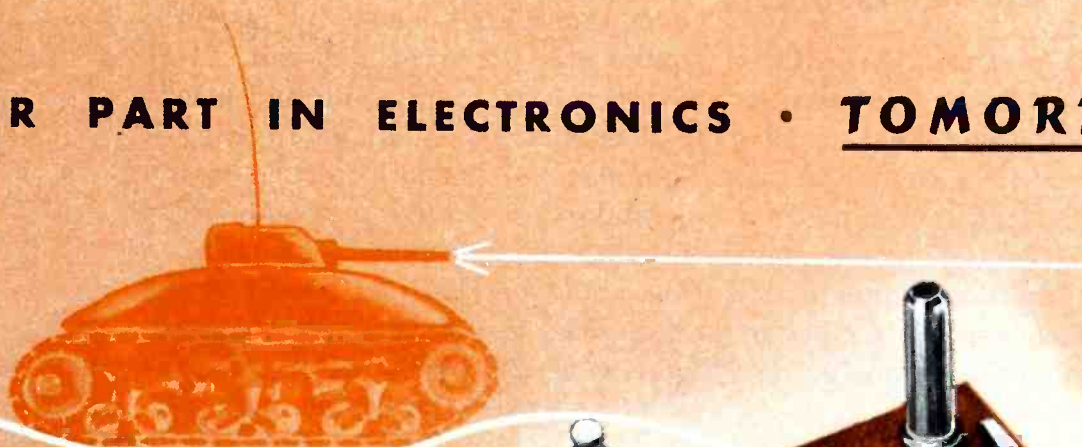

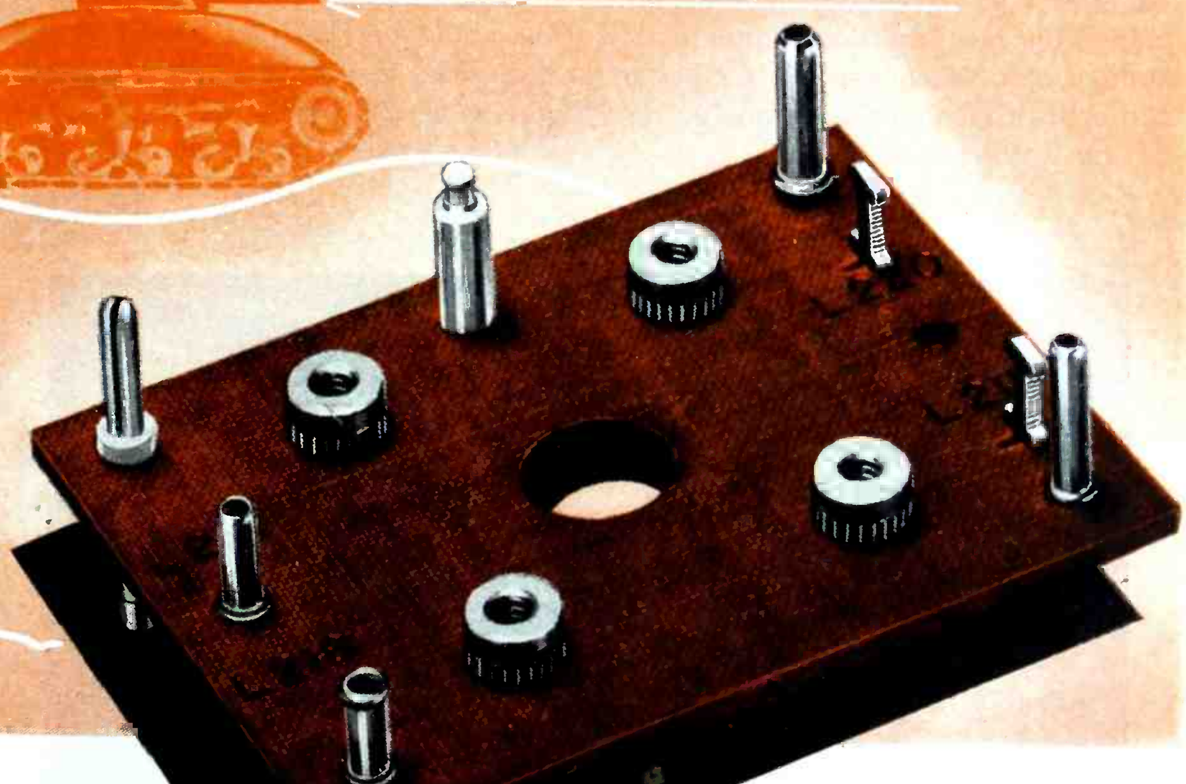

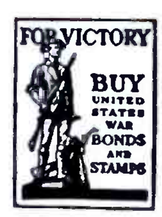

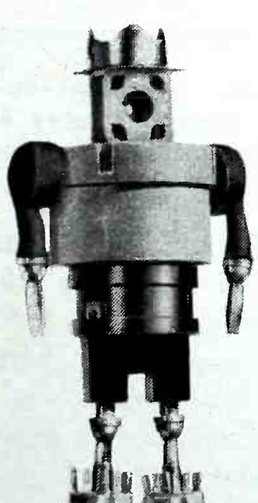

THIS panel illustrates many possible combinations of lugs, bushings, tube pins, printing, etc., on CINCH'S own laminated material Ucinite. Consult our engineering staff to develop the proper terminal board for your own particular applications.

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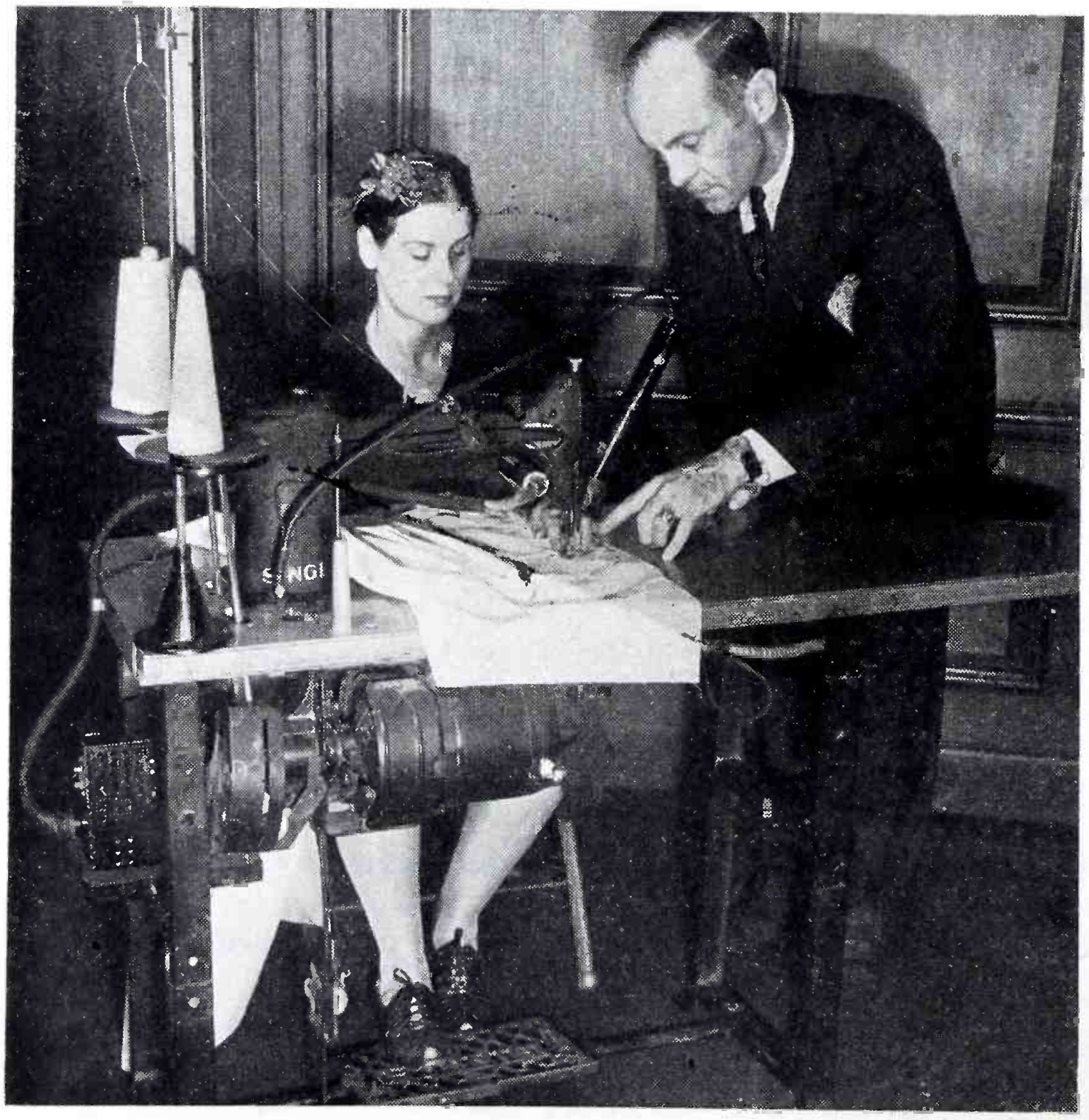
TUBES AT WORK

Photoelectric Safety Control For Electric Sewing Machines

To protect the fingers of sightless workers operating electric sewing machines, a photoelectric safety system has been developed by J. O. Kleber of the American Foundation for the Blind. The control system brings the machine to a complete and sudden stop whenever the fingers of the operator come dangerously close to the needle.

From the left side of the machine a beam of light is projected onto the chromium-plated shoe by a light source consisting of a 6-volt, 21-cp automobile stoplight bulb and a lens in a tubular housing, as in Fig. 1. The reflected beam is picked up by a standard phototube in a housing at the right of the shoe. The beam is thus about half an inch ahead of the needle, in a region through which the fingers of an operator might normally approach the needle.



First electric sewing machine equipped with photoelectric safety control for sightless workers. J. O. Kleber, developer of the control, demonstrates to Helen Scherer, a totally blind operator, that the machine will stop automatically before her finger can get in the path of the needle

Twisted leads in a half-inch diameter braided copper shield are used to connect the phototube to the amplifier box mounted under the machine. The amplifier circuit is shown

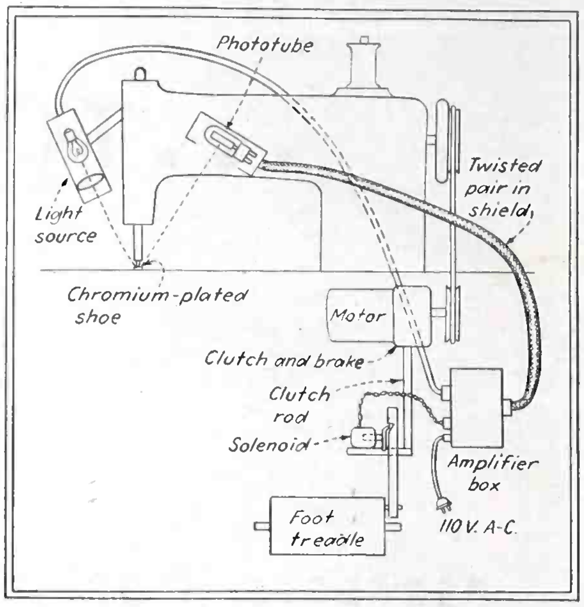


Fig. 1—Basic arrangement used to make a sewing machine safe for sightless operators

in Fig. 2, and involves operation of a pentode directly from the a-c line, with a stepdown transformer providing 6.3 volts for the tube filament and for the lamp in the light source.

All connections to the amplifier housing are made through four

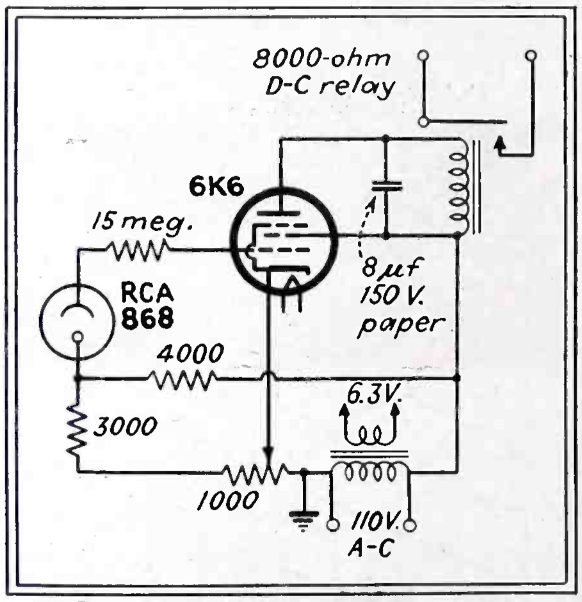


Fig. 2—This circuit, operating directly from an a-c line, closes the relay when the phototube light beam is interrupted

plugs, making it possible to install a new amplifier unit in a few minutes if trouble develops. This is a highly desirable feature when workers are paid on a piece-work basis.

The sewing machine is a standard commercial model, in which the motor runs continuously. Pressure on a foot treadle connects the motor to the machine through a clutch and

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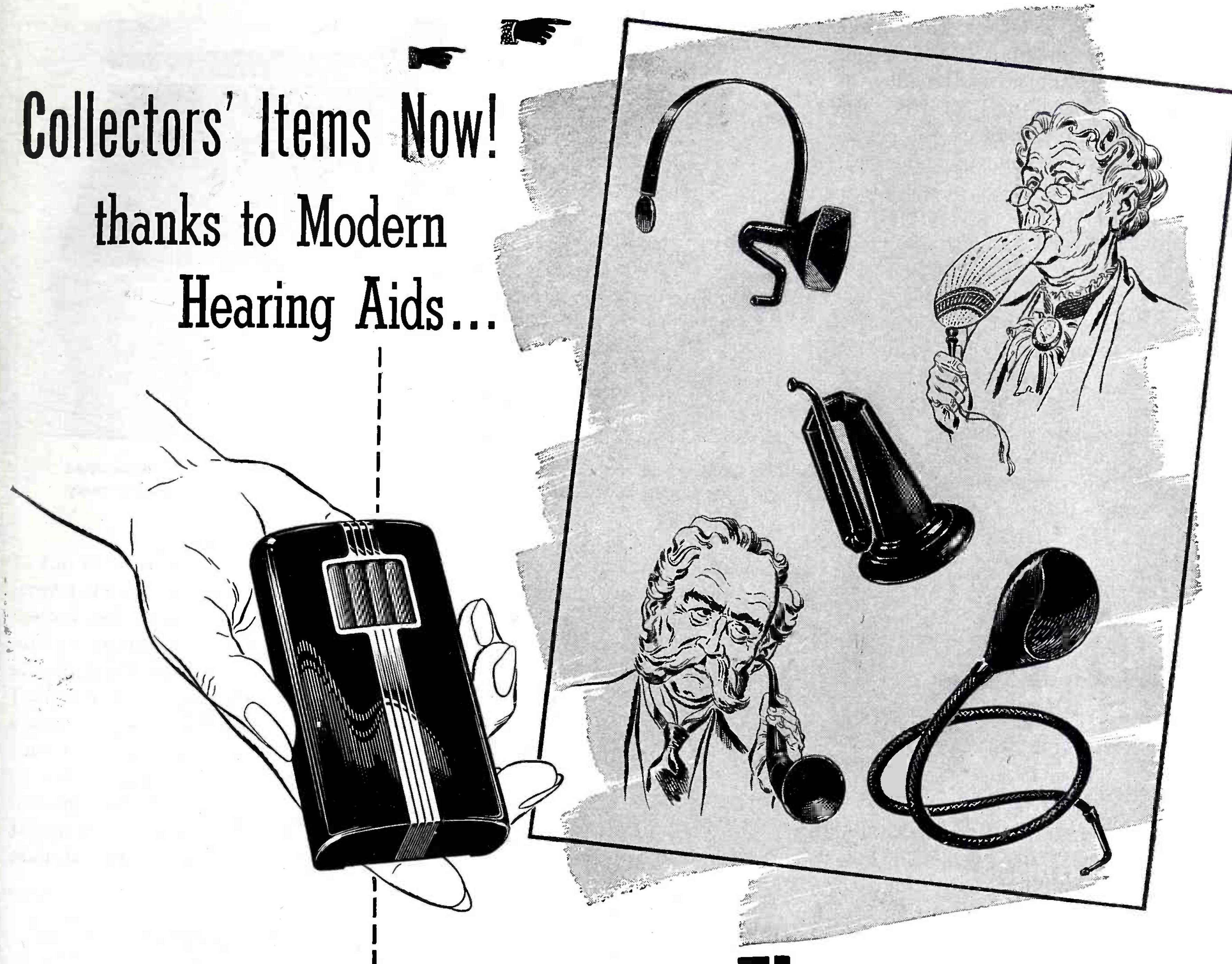

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For millions with impaired hearing a new avenue of hope was opened when scientists applied to this field the amplification of sound by means of the vacuum tube. From that point on, manufacturers directed their efforts toward instruments combining increased effectiveness with reduction in both size and weight.... Because volume and tone control plays an extremely important role in these small amplifying sets, it is only natural that I R C should have been consulted in the design of this sensitive part. The tiny Volume Control units used by many manufacturers not only employ special Resistance Elements as developed by I R C but also utilize the multi-finger contact and spiral clock-spring connector ideas originated and perfected by I R C. Marvels of compactness and efficiency, these midget controls constitute still another tribute to the ingenuity of I R C's engineering staff.... Perhaps you, too, are faced with a problem requiring expert resistance counsel. If so, we welcome your inquiry and will be glad to apply our research facilities toward its solution.

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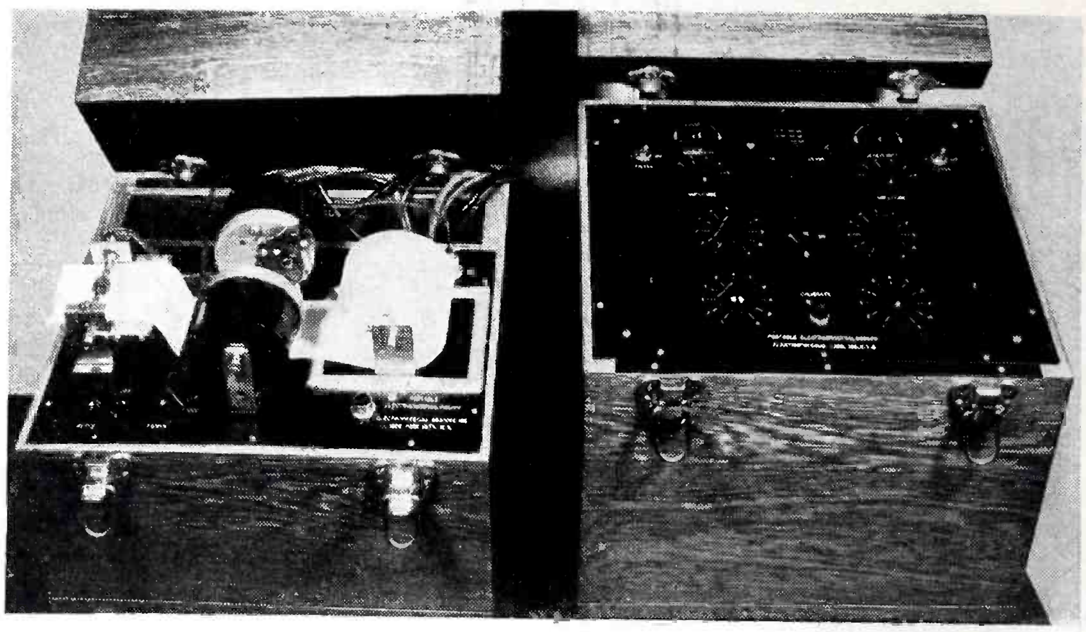
simultaneously releases the brake acting on the machine. Releasing of pressure on the foot treadle or equivalent "breaking" of the rod which links the treadle to the clutch will therefore disconnect the motor and apply brakes to the machine.

The relay in the plate circuit of the amplifier tube controls a solenoid which, when energized, "breaks" the clutch rod and thus stops the machine. As soon as the obstruction is removed from the light beam, the clutch rod can be restored by momentarily removing foot pressure from the treadle. The solenoid can be energized from the a-c line, but quieter operation was obtained by using a Rectox unit taken from a pinball machine. The solenoid likewise was obtained from a pinball machine, and requires about 8 v.



Recorder and amplifier units of the portable electroencephalograph developed by Eletcrophysical Laboratories, New York City. One person can easily carry the complete equipment

Electroencephalograph Design

By Paul Traugott

Chief Engineer
Electro-Physical Laboratories, Inc.
New York, N. Y.

One major difficulty encountered in working with the high-gain, low-frequency amplifiers used for encephalography (measurement and recording of brain potentials) is due to input tube troubles in the form of high fluctuation noise (probably chiefly shot effect) and microphonics.

Microphonic disturbances can be kept within reasonable limits by proper shock-proof mounting of tubes. Noise can be minimized by using special low-noise tubes such as the RCA 1620 or the Western Electric 547-A. Sometimes a special low-noise tube has low noise only in a range above 20 cycles, which is above the frequencies commonly used in encephalography, and may even show more noise disturbance at lower frequencies than is created by a well-chosen standard type of tube.

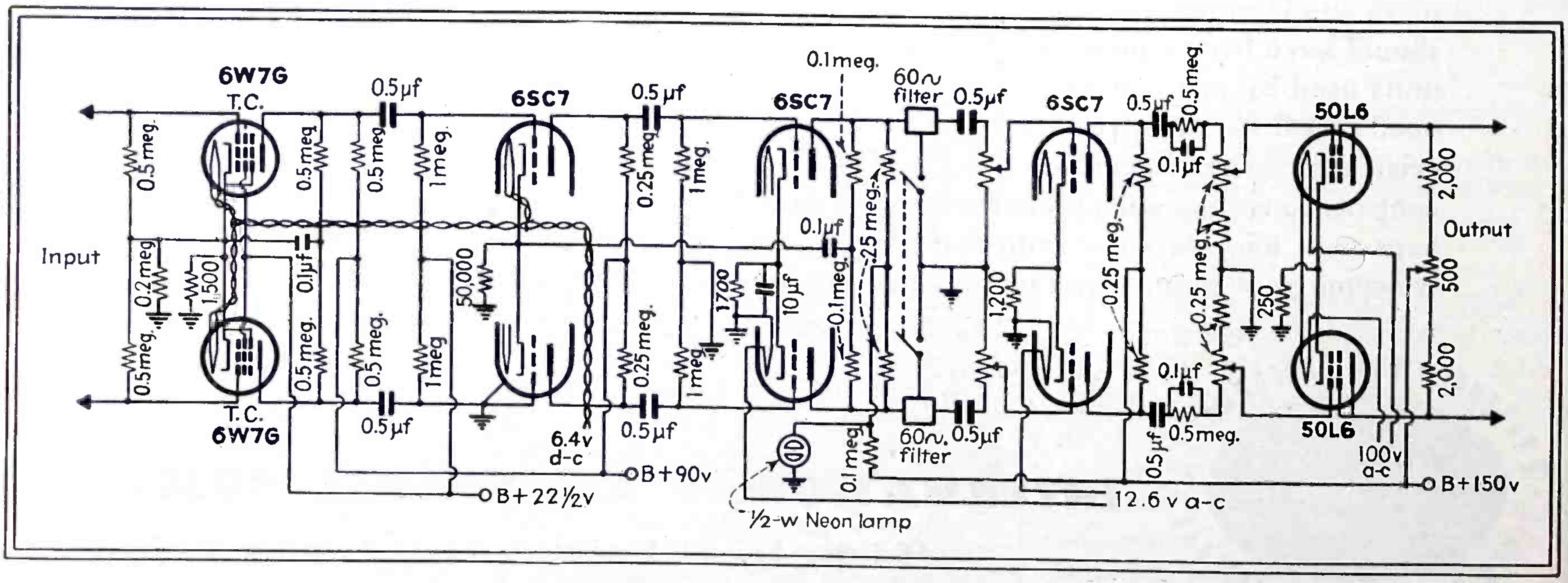
Input Impedance Affects Signal-Noise Ratio

There are certain operating adjustments in the input stage of an amplifier of this kind which result in greatly improved signal-noise ratios, but these high ratios are obtainable only at the expense of fairly low input impedance because the grid bias and screen voltage values for the input stage must be so low that the tubes operate in the grid current region.

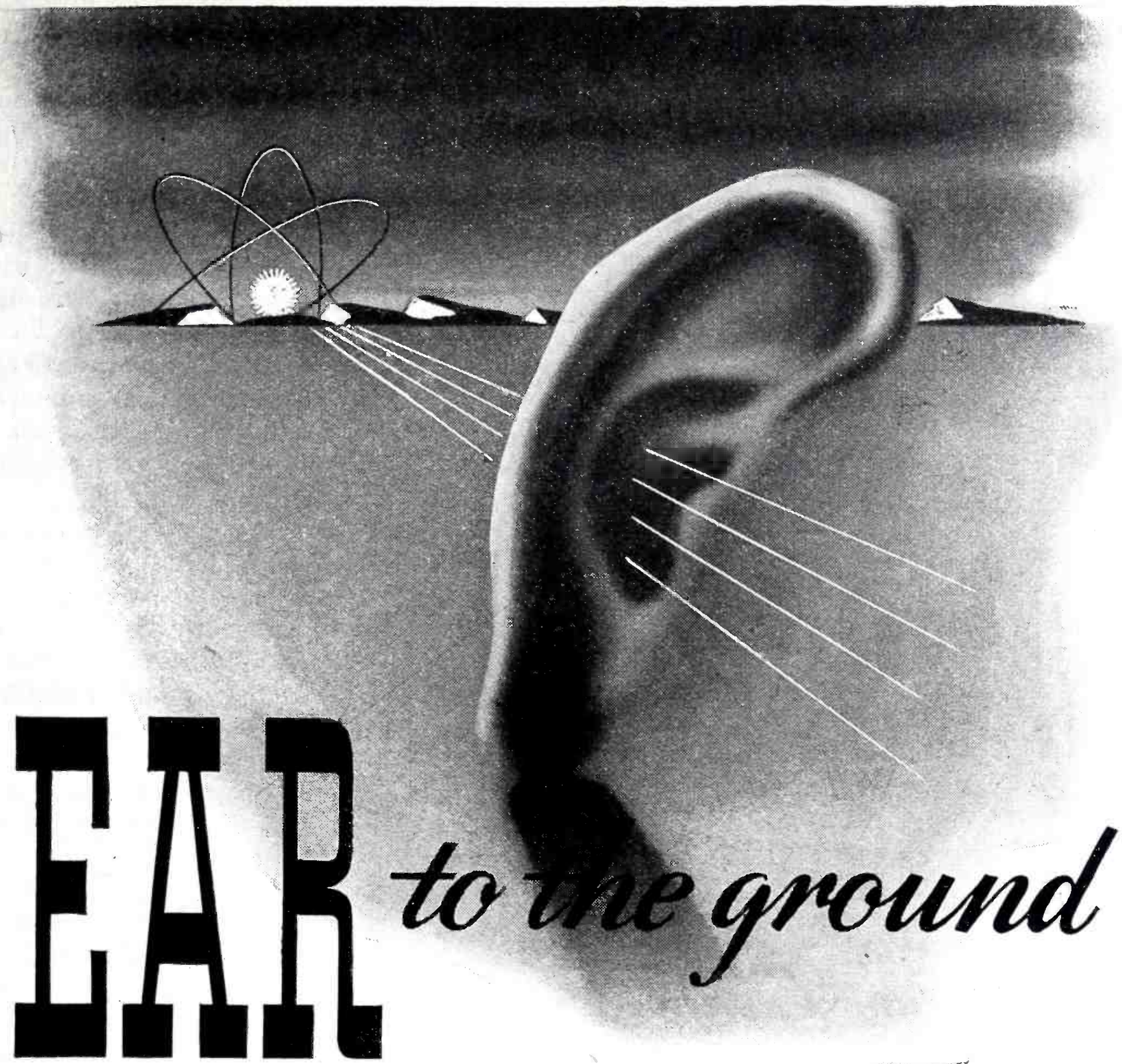
For ordinary encephalography, where the electrode resistance out of which the amplifier operates is a variable quantity but where the impedance of the calibrating circuit is constant, a low input impedance upsets the validity of the calibrating circuit values and thereby causes inaccurate results. The possible gain in signal-noise ratio is of the order of five to one, however, so that for special cases the low input impedance might be tolerated to secure the highest possible signal-noise ratio.

Calibration Problems

Electroencephalograph amplifiers are generally calibrated by applying a d-c pulse of the requisite voltage (usually 10, 20, 50, or 100 microvolts) to one grid of the push-pull input stage, with the opposite stage grounded. For most operating adjustments the cathode inversion that



Special hum-free push-pull amplifier circuit used in each channel of the portable electroencephalograph


EAR to the ground

takes place in the input stage makes the amplifier gain the same in this connection as it is for the push-pull, ungrounded condition under which encephalograms are usually made.

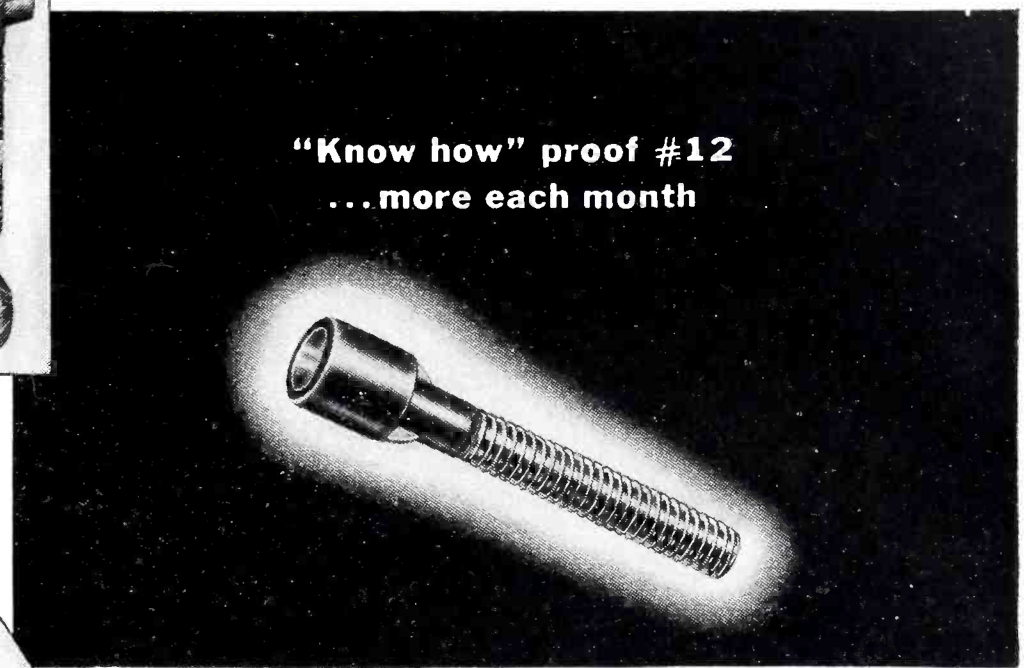
In order to simulate the operating conditions of these amplifiers as closely as possible during calibration, a small 8-cycle rotating-field magnetic generator was constructed, using an armature having a capacity of less than 5 $\mu\mu$f to ground, and its voltage output was determined by comparison on a d-c oscilloscope. With this generator a completely ungrounded signal can be applied to the amplifier either with signal-ended input (one grid grounded) or with push-pull input.

Low armature capacity to ground is essential because this capacity shunts the attenuator network used to reduce the measured generator output to the extremely low voltage actually used for calibration. Shunt errors of this type become very large even at very low frequencies when working at low voltage levels (of the order of 0.00001 volt) with ungrounded input.

It was found that under certain conditions the single-ended input did not give correct inversion and the d-c calibrating pulse did not accurately correspond to an equivalent a-c input signal. By a simple adjustment in screen potential on the input pentodes, the d-c calibrating pulse between grid and ground can be made to produce just twice the equivalent a-c voltage applied in push-pull. This makes the gain of the amplifier appear to be twice its actual value, and makes the amplifier appear to have twice as good a signal-noise ratio as it actually possesses. Uniformity in calibrating procedures is thus highly essential to fair comparison of different amplifiers for encephalographic work.

Frequency Response Considerations

Electroencephalographic amplifiers are usually said to be flat from 1 cycle up to some quite high frequency, often up to 10,000 cycles. Fortunately, it is quite unnecessary to have anything like this response. It is impracticable, with any reasonable use of space and money, to get this great frequency range in a high-gain push-pull, resistance-capacity coupled amplifier having suitably low fluctuation noise. A brief considera-



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You know what you need in special or standard fastenings. The Fastenings Expert at the nearest Scovill office knows how to help you find the answers promptly for both present and postwar requirements. Like most large, skilled metal-forming plants, we are largely engaged in war work, but you can count on a prompt, frank answer as to what we can do for you—and when. Call on the nearest Scovill office today.

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tion of the fundamental factors involved will show this.

RC networks are ordinarily used between the plates and grids of the amplifier stages. For all the well-known reasons the grid resistor values cannot greatly exceed 1 megohm, and in the stage feeding the output tubes it must be about half this value. The coupling capacitors, especially in the early stages, must have extremely low leakage since any leakage current will appear in the output as fluctuation. The capacitors must be reasonably small in size if their capacity to ground is to be low enough to make high-frequency response possible. To produce flat response down to 1 cycle requires about 10 μf, an impractical value for a paper capacitor having low leakage. Even 2-μf capacitors will give a response which is down about 0.9 db at 1 cycle, and these units must be mounted well up above the chassis to keep the response up at 5000 cycles.

The suggestion is often made that high-frequency response up to some very high point is desirable because the apparatus might be used for oscillographic studies with a cathode-ray tube. It is not generally realized that to photograph even 5000 cycles with any degree of interpretability requires a film or paper speed of around 16 feet per second, a fast-screen tube and a high-speed photographic lens. This type of equipment is not likely to be in the hands of the average encephalograph user. Experience has shown that a flat response up to about 30 cycles is more than adequate for ordinary encephalographic work.

Interference Problems

The problem of eliminating interfering fields at the input of an electroencephalograph amplifier consists partly in eliminating in-phase voltages at the input and partly in using selective filters having a simple structure along with high attenuation.

A 60-cycle interfering field picked up by a subject connected to the amplifier in the usual way may measure as high as 0.3 volt from each grid to ground, but the desired signal may average only around 0.00003 volt. The interfering voltage has approximately the same phase at both input grids, while the desired signal is out of phase at the grids.

Unless means are taken to reduce

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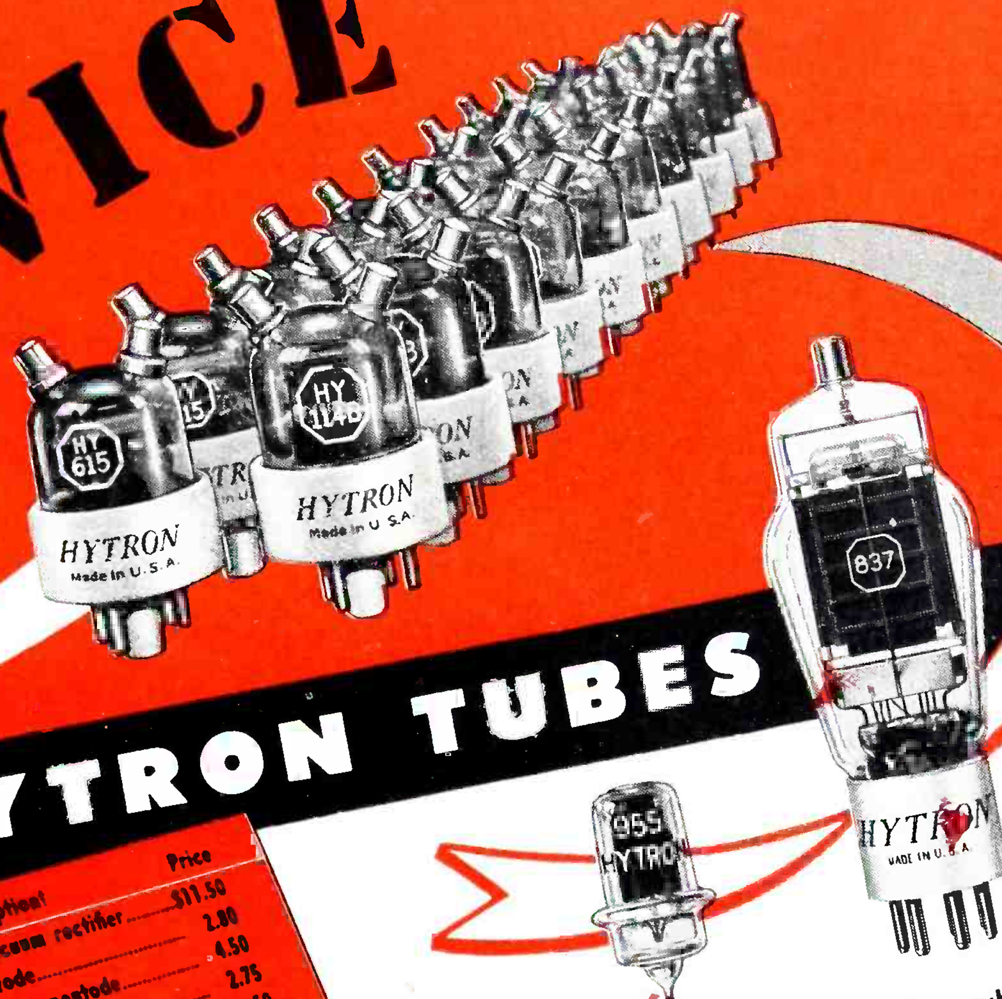

NEW HYTRON TUBES

Type	Description†	Price
836	Half-wave, high-vacuum rectifier	$11.50
837	12-watt, r.f. pentode	2.80
954	Sharp cut-off, acorn pentode	4.50
955	Acorn triode	2.75
956	Remote cut-off, acorn pentode	4.50
1616	Half-wave, high-vacuum rectifier‡	5.75
1625	25-watt, r.f. tetrode (12-v. heater)	3.50
1626	5-watt, triode oscillator	2.50
E1148	3.5-watt, u-h-f triode	2.25
VR105-30	Gaseous voltage regulator	1.25
VR150-30	Gaseous voltage regulator	1.25

OTHER POPULAR HYTRON TUBES*

Type	Description†	Price
2C25	15-watt, medium-mu triode	$3.00
2C45	7.5-watt, triode (modulator)	2.50
10Y	15-watt, general-purpose triode‡	1.50
801A/801	20-watt, general-purpose triode‡	2.50
HY61/807	25-watt, r.f. beam tetrode	2.25
841	15-watt, high-mu triode‡	2.25
864	Non-microphonic voltage-amp. triode	1.00
HY24	2-watt, power triode‡	1.50
HY31Z	30-watt, high-mu twin triode‡	3.50
HY65	15-watt, r.f. beam tetrode‡	3.00
HY69	40-watt, r.f. beam tetrode‡	3.95
HY75	15-watt, u-h-f triode‡	3.95
HY1148	(2C24) 1.8-watt, u-h-f triode‡	2.25
HY615	3.5-watt, u-h-f triode	2.25

*This is not a complete list.
‡Instant-heating filament.
†For complete characteristics consult Government specifications. Wattage ratings indicate maximum plate dissipation.

On this list of tubes which have recently joined the growing legions of Hytron types already marching on to Victory, you may find just the ones you want for your War equipments. Whether you choose the tiny "acorns" or the husky 1616 rectifier, you will discover the same high quality and design refinements which have made other Hytron tubes famous. If you place your orders well in advance, you will also be pleased by Hytron's on-schedule deliveries. Not too infrequently, deliveries are made from stock.

HYTRON RADIO TUBES

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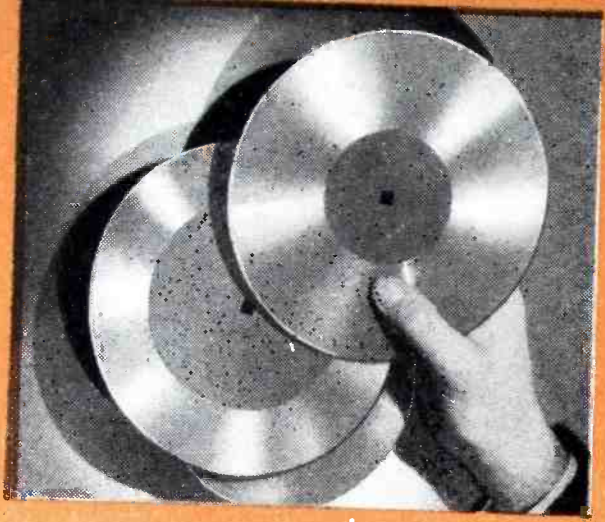
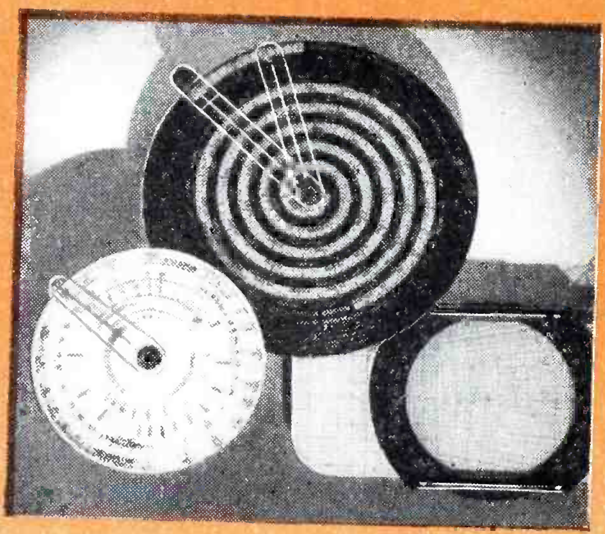
Vinylite* Plastics



LIGHT WEIGHT AND STRENGTH are important characteristics of records made from VINYLITE Rigid Sheet for sound recording and transcribing purposes. Although wafer-thin, these records are virtually unbreakable. Their exceptional dimensional stability provides high fidelity in transcribing, and prevents warping and distorting under normal changes in temperature and humidity.



DIMENSIONAL STABILITY and unfailing accuracy are assured for calculating instruments used in aircraft navigation when VINYLITE Rigid Sheets are used. One manufacturer claims calibrations can be printed to even closer tolerances on these materials than on metal sheets. Moreover, the plastic sheets require no finishing as do metal sheets.

THERE ARE three major reasons why VINYLITE Plastics are outstanding among thermoplastic materials now available to industry . . . their unique combinations of properties, their varied forms that are suited to many fabricating techniques, and the vast opportunities they present for improving the design and performance of a wide range of products.

In VINYLITE Plastics you will find materials that are basically odorless, tasteless, non-toxic, non-flammable, and highly resistant to moisture, oils, and chemicals . . . types that can be rigid or flexible . . . transparent, translucent, or opaque . . . colorful or colorless . . . as desired.

These valuable properties are obtainable for a diversity of products, since VINYLITE Plastics can be either injection or compression molded, extruded into tubes or rods, or used as the basis for coatings on cloth, metal, paper, or concrete. They can be compounded into adhesives. Rigid sheets of VINYLITE Plastics can be formed into a wide variety of flat or three-dimensional shapes.

The developments described on these pages are typical of hundreds of applications of VINYLITE Plastics that are helping to meet today's critical needs better, faster, and frequently at lower cost. A further indication of what *you* can gain with these materials can be obtained by writing for Booklet 18VE, "Vinylite Resins—Their Forms, Properties and Uses."

Plastics Division

CARBIDE AND CARBON CHEMICALS CORPORATION

Unit of Union Carbide and Carbon Corporation

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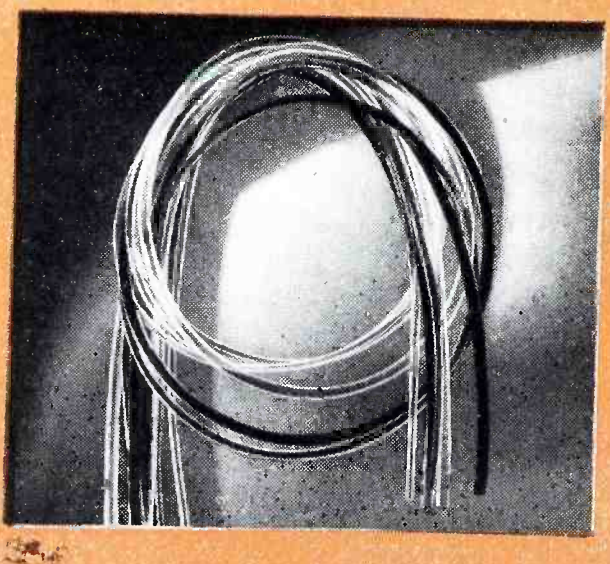
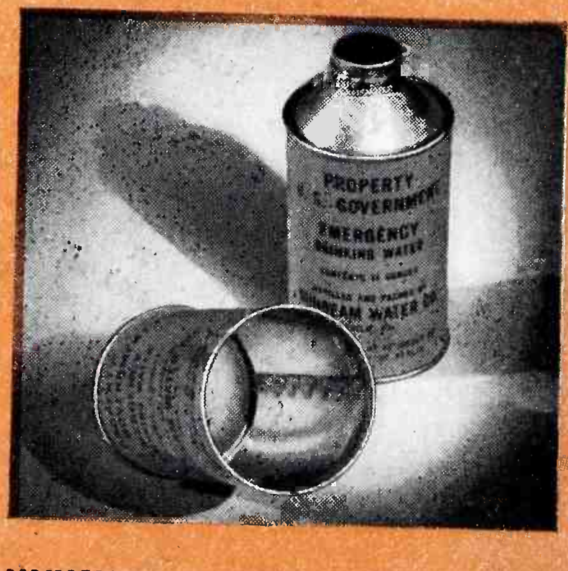
30 EAST 42ND STREET, NEW YORK, N. Y.

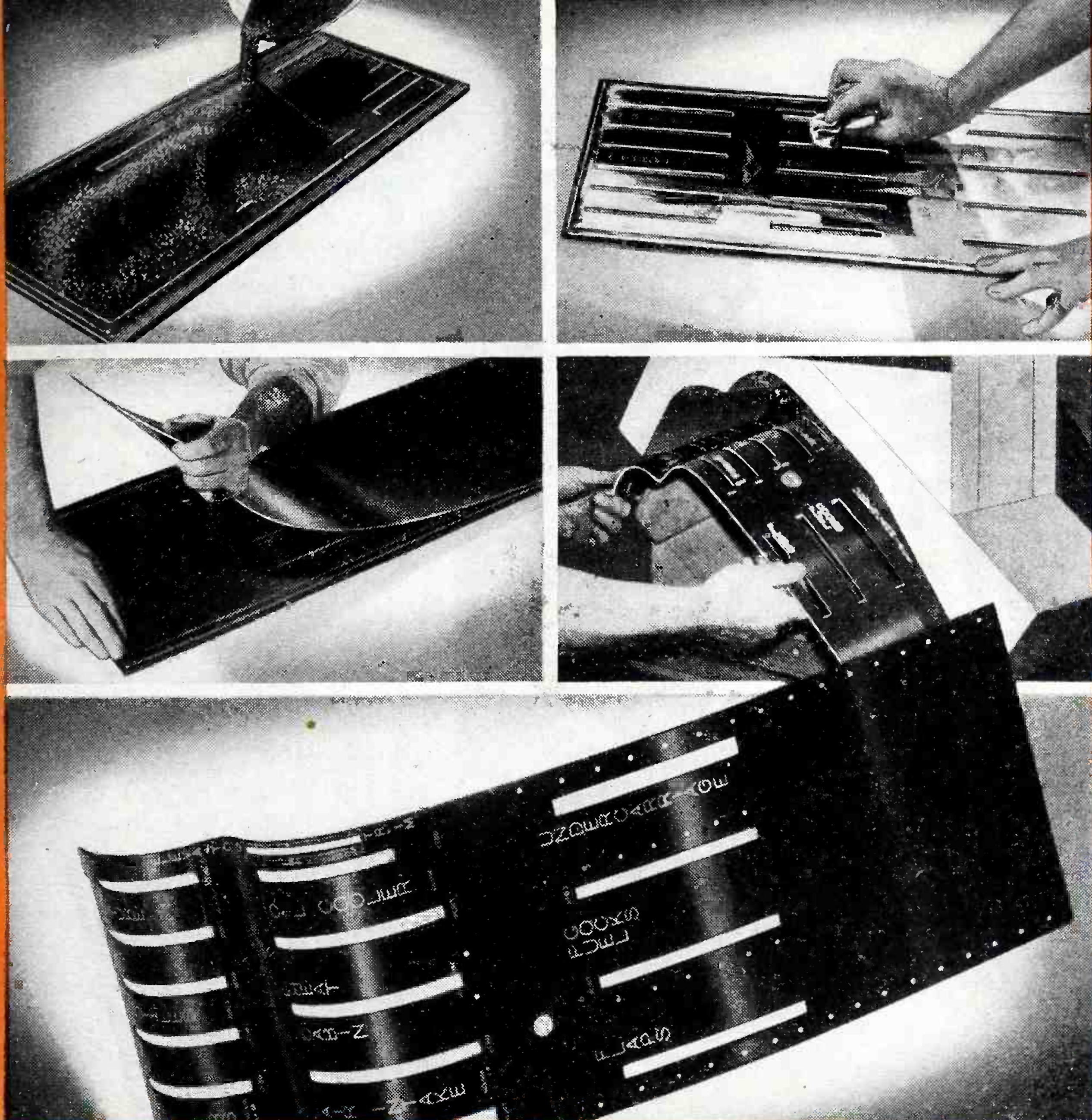


ACID AND ALKALI RESISTANCE of VINYLITE Elastic Plastics are employed to excellent advantage for flexible hose used in chemical service. Aging and constant exposure to light will not cause these plastics to deteriorate. Transparent extruded tubing of this type, serving as abrasion-resistant conduit for electrical wiring, simplifies inspection of vital light and power lines.

FLAME AND ABRASION RESISTANCE are outstanding qualities of wire and cable insulation made from VINYLITE Elastic Plastics. Because it is non-oxidizing, this improved insulation is more highly resistant to aging than rubber compounds formerly used. Primary insulation is extruded directly around the wire. Jacketing for outer protection is provided in the form of extruded tubing or tapes made from VINYLITE Flexible Sheeting. A wide color range facilitates color coding.



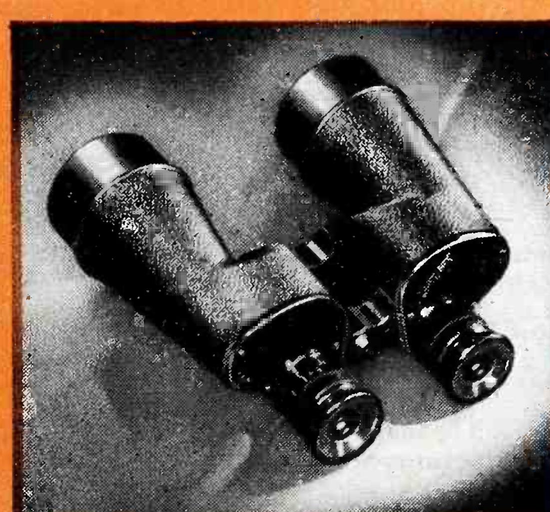
UNUSUAL CORROSION RESISTANCE for the interiors of emergency drinking water containers is provided by linings based on VINYLITE Resins. These coatings are applied by the American Can Company and are similar to those used by that company for beer cans. These impervious linings prevent interaction of can and contents. They are baked to a glasslike finish, but are highly resistant to impact shocks even at extremely cold temperatures. Because of these characteristics, the sterile water is protected against contamination during prolonged storage.



SIMPLIFIED PRODUCTION — The control panel illustrated is typical of the production economies made possible by VINYLITE Plastics. In this instance, the panel is formed, complete in every detail, by a simple molding operation. The technique employed is an adaptation of the plastic printing plate development that makes it possible to conserve substantial quantities of precious metals, and to save even more precious man-hours on the production line.

There are two fundamental steps. First, a matrix of BAKELITE Phenolic Material is made from an etched copper pattern. Second, the phenolic matrix or mold is used to form any number of duplicates from a special VINYLITE Plastic molding compound. Slots, holes, and markings, including intaglio lettering, are incorporated in the panel in this molding operation. A simple pigment "wipe" accentuates the markings and lettering. Then, the flat panel is curved to final shape under heat and pressure on a wooden mandrel. This simple technique eliminates many operations that were formerly necessary with metal plates, such as drilling, engraving, slotting, anodizing, and polishing.

(Panels Molded by Theo. Moss & Co., Inc.)



WATERPROOFNESS AND TOUGHNESS for the coverings used on Navy binoculars, which formerly demanded highly cured rubber, are now provided by an embossed sheeting of VINYLITE Elastic Plastics. This plastic covering requires no curing or vulcanizing . . . withstands the corrosive action of salty spray, and prevents penetration of water vapor which would fog the lenses.

Vinylite*

TRADE MARK

ELASTIC PLASTICS • RIGID PLASTICS
RESINS FOR ADHESIVES
RESINS FOR SURFACE COATINGS

**The words "Vinylite" and "Vinylseal" are registered trade-marks of Carbide and Carbon Chemicals Corporation.*

"VINYLITE" ELASTIC PLASTICS

Rubber-like materials produced in a variety of forms, ranging from soft to semi-rigid. Possess great toughness and good resistance to continuous flexing, and to severe wear and abrasion. Tensile strength greater than that of most rubber compounds. Have excellent electrical insulating properties, and do not oxidize. Can be made non-flammable and highly resistant to water, oils, and corrosive chemicals by correct choice of plasticizer.

Available in a wide range of translucent or opaque colors, or in colorless types. Supplied as sheeting, compounds, for calendering onto cloth, molding and extrusion compounds, or as powdered resins for industries that have compounding equipment, such as the rubber industry. No curing or vulcanizing is required.

"VINYLITE" RIGID PLASTICS

Produced from unplasticized vinyl resins, these various forms of plastics possess a combination of properties not found in other thermoplastic materials. Having extremely low water absorption, they remain dimensionally stable under widely varying atmospheric conditions. Outstanding in resistance to alcohols, oils, and corrosive chemicals. Have high impact and tensile strengths. Odorless, tasteless, and non-toxic. Do not support combustion.

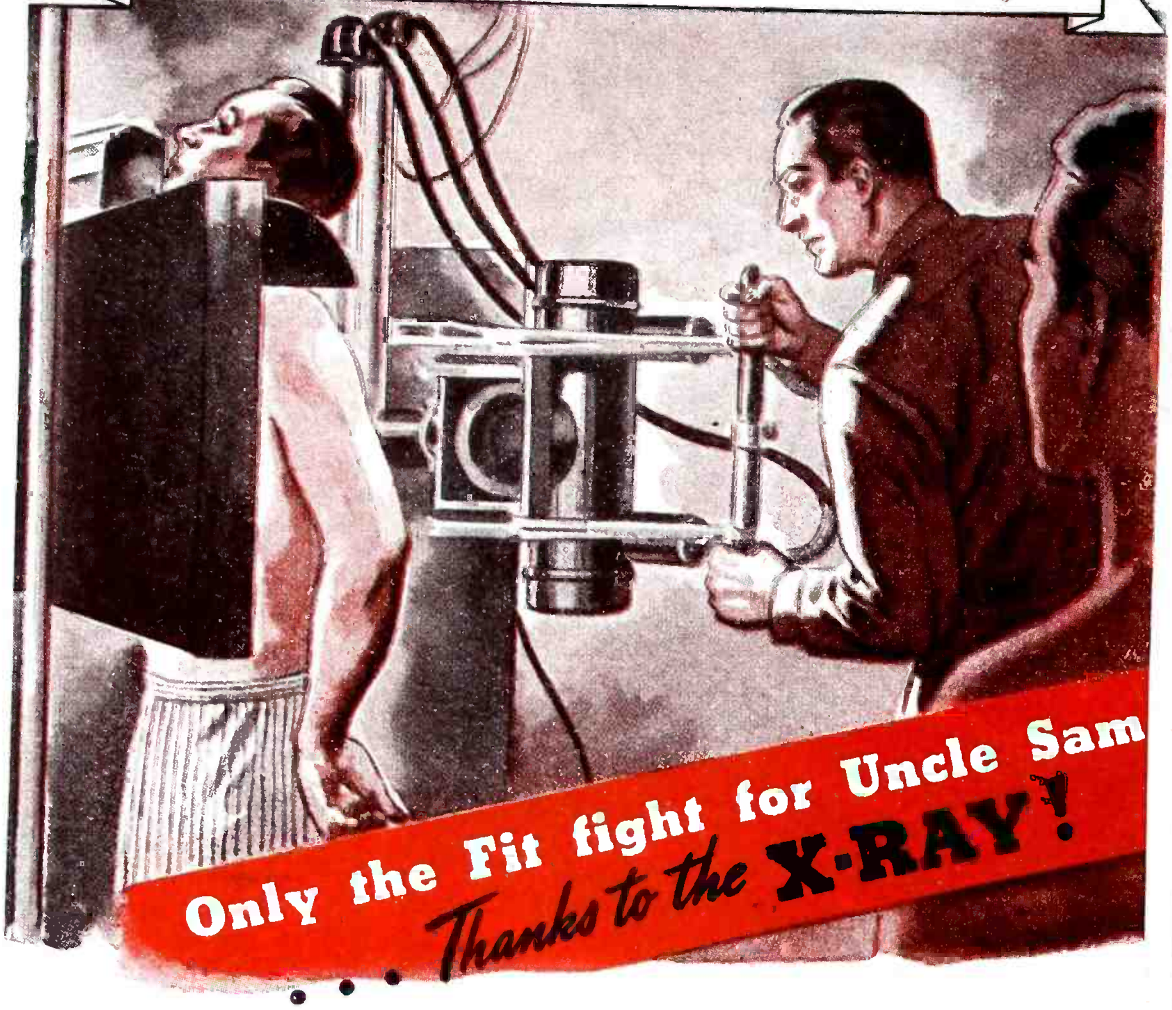
Available in natural transparent, as well as transparent, translucent, and opaque colors. Supplied as rigid sheets, or as molding and extrusion compounds. Rigid sheet can be fabricated by forming, drawing, blowing, spinning, or swaging, and can be punched, sheared, sawed, or machined with metalworking tools. Molding compounds adaptable to both compression- and injection-molding processes.

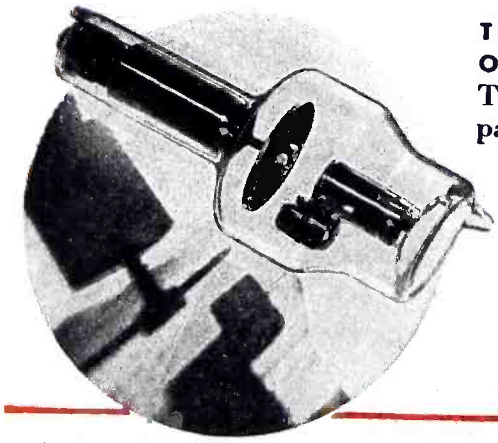
"VINYLITE" RESINS FOR SURFACE COATINGS

When correctly formulated and applied, these resins yield finishes of unusual toughness, gloss, adhesion, and chemical resistance. Can be applied by spraying, knife-coating, or dipping to a wide variety of surfaces, such as metal, cloth, paper, and concrete. Prepared by dissolving resins in organic solvents, these finishes can be modified with different pigments, dyes, and plasticizers. The resins are generally not employed with other film-forming bases, thus coatings formulated from them exhibit the desirable features of VINYLITE Resins alone. Drying is solely by solvent evaporation. Finishes can be either air-drying or baking types.

"VINYLITE" RESINS FOR ADHESIVES

Unusual toughness, resiliency, and impact resistance are characteristic of adhesives made from these resins. They are widely used as bonding agents for such materials as cellophane, cloth, paper, cardboard, porcelain, metal, mica, stone, leather, wood, and plastic sheets and film. Available as granules for the compounding of adhesives, or as solutions sold under the trade-mark "VINYLSEAL." The latter are especially recommended for bonding impervious materials, such as metals, and the urea and phenolic plastics. Their bonding strength is comparable to that obtained with soft solder.





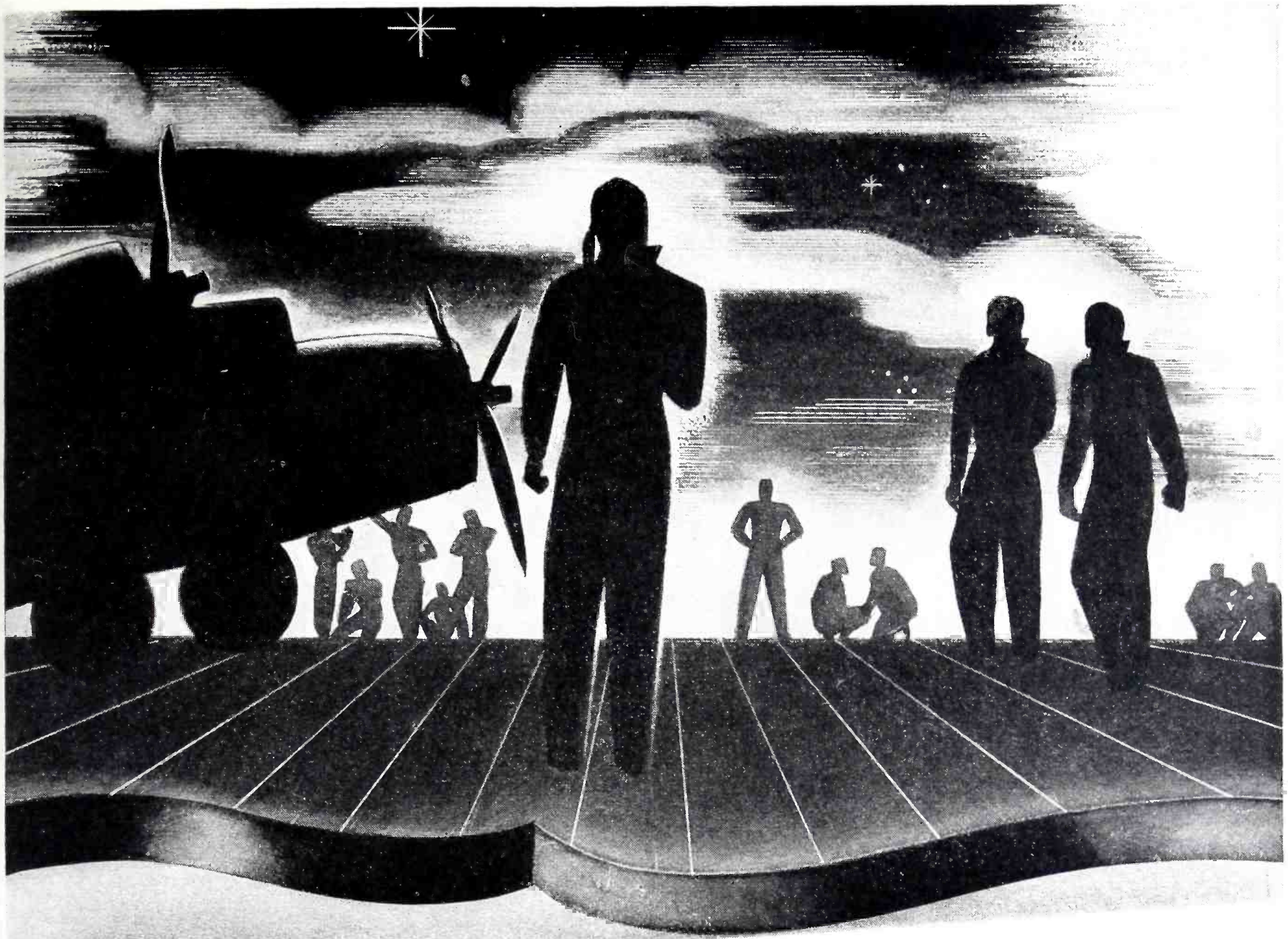
the in-phase gain in the input stages, no practical amount of selective filtering will be satisfactory. It is true that a perfectly balanced push-pull amplifier will give zero response to an in-phase signal, but it is also true that such a perfectly balanced amplifier will also give zero response to an out-of-phase signal when a large in-phase signal is applied to its input grids. There will be a sufficiently large signal between grids and ground in the second and third stages to block every succeeding grid and render the entire amplifier inoperative. Thus, even if the commercially difficult task of perfectly balancing a push-pull amplifier is accomplished, such a simple solution is not possible.

The means usually employed involves eliminating the in-phase signal or reducing its effect by degeneration which is effective only for in-phase signals. One of the simplest means for doing this is by use of a high-value cathode resistor common to both input tubes, with the resultant high negative grid voltage reduced by an opposition voltage or by returning the grids to ground through a suitable positive potential. This is the so-called Tönnies circuit.

Where the noise level is not important, the Tönnies circuit is fairly effective for in-phase cancellation, but it has some series disadvantages when a low noise level is required. Placing the cathodes of input tubes of a high-gain, low-frequency amplifier at some large resistance above ground increases all heater-cathode disturbances by a large factor and results in a much higher fluctuation noise. This effect can be eliminated only by having the random fluctuations perfectly identical in time and magnitude in the two input tubes, a condition rarely obtainable in practice unless a large number of tubes is tested to secure a perfectly matched pair.

Description of New Portable Electroencephalograph

The electroencephalograph described here incorporates recent and important design features meeting the requirements just described and permitting fully portable operation without the use of a shielded room. It consists of a 17-tube, two-channel amplifier and a high-speed writer or recorder in separate carrying cases,



operating from a 115-volt a-c line and from small B batteries in the amplifier unit.

Hum-Suppressing Input Circuit

Each amplifier channel consists of a five-stage push-pull resistance-capacity coupled amplifier like that shown in Fig. 1. In-phase hum components in the input stage are greatly attenuated by degeneration introduced in the grid circuits by a 0.2-megohm resistor, with the tube cathodes nearly at ground potential. The amount of degeneration increases with input impedance, thus providing a certain amount of automatic control over the hum input which also increases with input impedance.

Not all of the in-phase signal can be removed by the first stage, hence in-phase degeneration is provided in the second and third stages also. In the second stage, a 50,000-ohm cathode resistor provides degeneration, while a 22½-volt section of a B battery is connected in series with the grids to counteract some of the excessive bias developed across this resistor. In the third stage, a 0.1-μf capacitor provides a feedback path from the plates of the tube to the cathode of the second stage.

Any small unbalance in the first stage will make some of the in-phase input signal appear as an out-of-phase signal at the second stage, and this may be greater than can economically be suppressed by the 60-cycle filter following the third stage. Other input circuits which provide more complete in-phase degeneration are in the process of development.

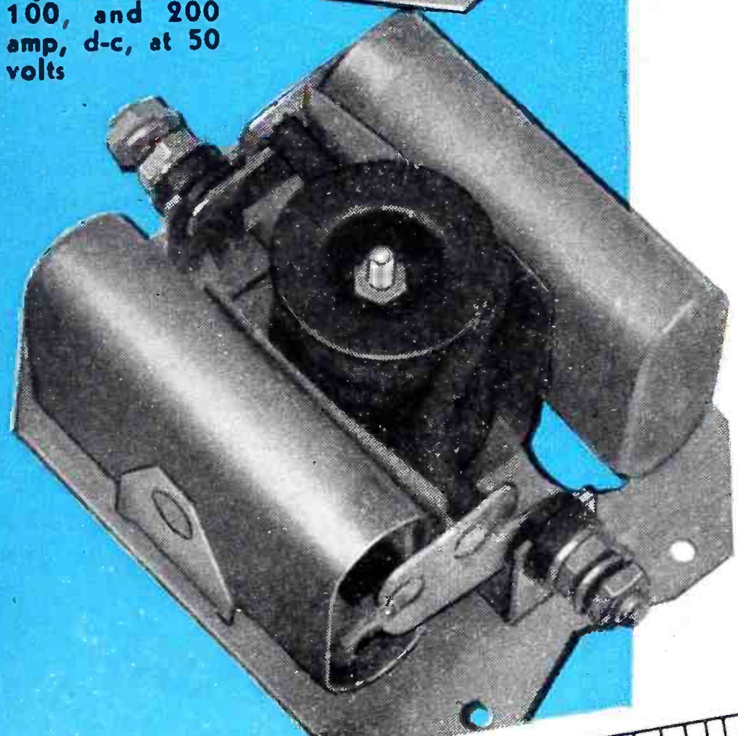
Hum Filters

The filters used after the third stage are noninductive, employing only resistors and capacitors, and may be removed entirely from the circuit by means of a dpst switch. With the filter in, the band of frequencies from 30 to 80 cycles and all frequencies above 400 cycles are greatly attenuated. With the filter out, all frequencies from 1 to 4000 cycles are amplified within 3 db, for possible oscillographic and other amplifier uses.

When used with bipolar connections to both input grids, 60-cycle hum voltage at the output is so low that useful encephalograms may be

NEW G-E RADIO-NOISE FILTERS *for Aircraft*

Available in ratings of 25, 50, 100, and 200 amp, d-c, at 50 volts



They provide excellent noise suppression —especially from 200 to 20,000 kc

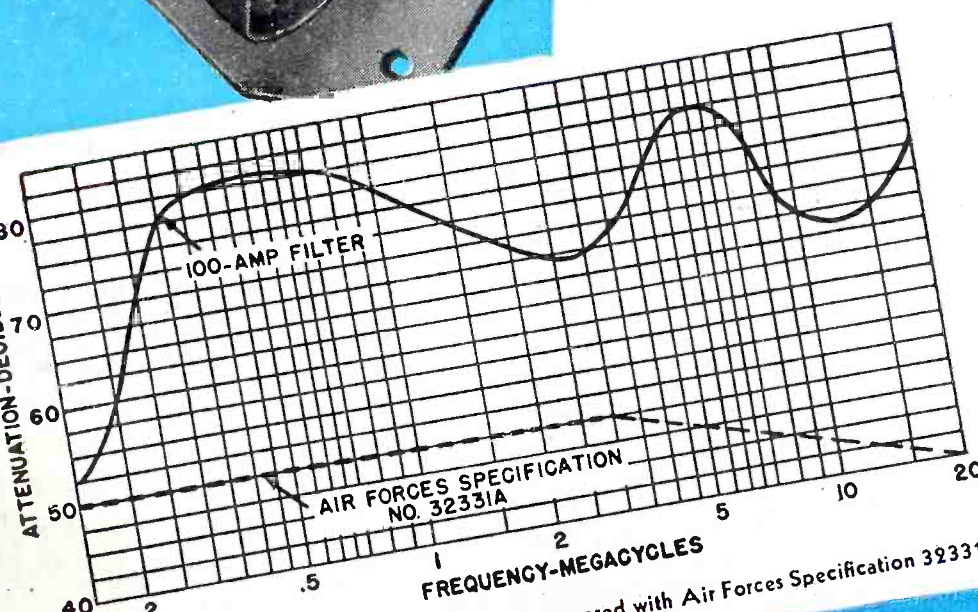
THESE filters help immeasurably in providing the high-fidelity radio reception so important in aerial warfare. They attenuate radio-noise voltage on aircraft electric systems (on circuits with such equipment as generators, amplidynes, inverters, and dynamotors). They are particularly helpful in systems where open wiring is used to save weight.

FEATURES

- High attenuation characteristic results in excellent noise reduction
- Compact and lightweight (For 100-amp rating, shown at left, approx 2 1/5 lb, measuring approx 5 by 4 by 2 1/2 in.)
- Can be mounted readily in any position
- Operate efficiently over a wide temperature range (— 50 C to 50 C)
- Comply with U.S. Army Air Forces specifications, including the stringent requirements as to vibration and acceleration

★ ★ ★

FOR FURTHER DATA Ask your G-E representative for Bulletin GEA-4098, or write to General Electric, Schenectady, New York.



Attenuation characteristic of G-E 100-amp filter compared with Air Forces Specification 32331 A

GENERAL ELECTRIC

407-92-6700

taken in nearly all locations without any screening. Even in locations having strong hum fields due to a-c machines, a simple wire screen at a strategic point near the subject is usually adequate. With a unipolar connection, the resulting automatic grounding of the subject makes hum-free records even easier to obtain.

Performance Data

The fourth and fifth stages are conventional in design, with the 50L6 output tubes feeding one of the electrodynamic writers. A deflection of at least 1 cm is obtained when a 10-microvolt d-c pulse is applied to the input of the amplifier in a conventional manner, and the stylus deflection due to noise and hum under this condition is less than 2 mm.

The two amplifier channels are identical throughout. Four 11-point selector switches and a 12-point Jones receptacle on the panel (not in the diagram shown in Fig. 1) permit selection of all possible combinations of 1 to 11 electrodes.

Power Supply

The heaters of the tubes in the first two stages are operated from the a-c line through a highly filtered rectifier arrangement paralleled by a voltage-stabilizing 6-volt dry battery. Plate voltages for the first two stages are obtained from a set of three small portable B batteries having a life of 4 to 12 months, while the remaining stages are supplied by a more or less conventional voltage-regulated power pack operating from the a-c line.

• • •

Carrier Current Coupling Circuits for Civilian Defense Networks

TECHNICAL DATA on the wired wireless or carrier current communication system being used in Prince George's County, Maryland for Civilian Defense purposes has been released by the two radio engineers who designed and installed the system, namely Perry E. Wightman, Radio Aide for Prince George's County, and Henry H. Lyon, Chief Engineer of station WOL in Washington.

Transmitters for two-way com-

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RCA

RCA ELECTRON TUBES

RCA Victor Division, **RADIO CORPORATION OF AMERICA**, Camden, N. J.

munication are located at the Control Center in Hyattsville and at a Report Center in Mt. Rainier, 10 miles away by wire line ($1\frac{1}{2}$ miles airline), using frequencies of 150 and 160 kc. Receivers for one-way communication were also installed in a number of Report Centers and Fire Houses in surrounding localities. The frequencies chosen are sufficiently low to minimize line radiation, yet pass readily through the distribution transformers at each station, and do not interfere with established broadcast systems, telephone or power company systems.

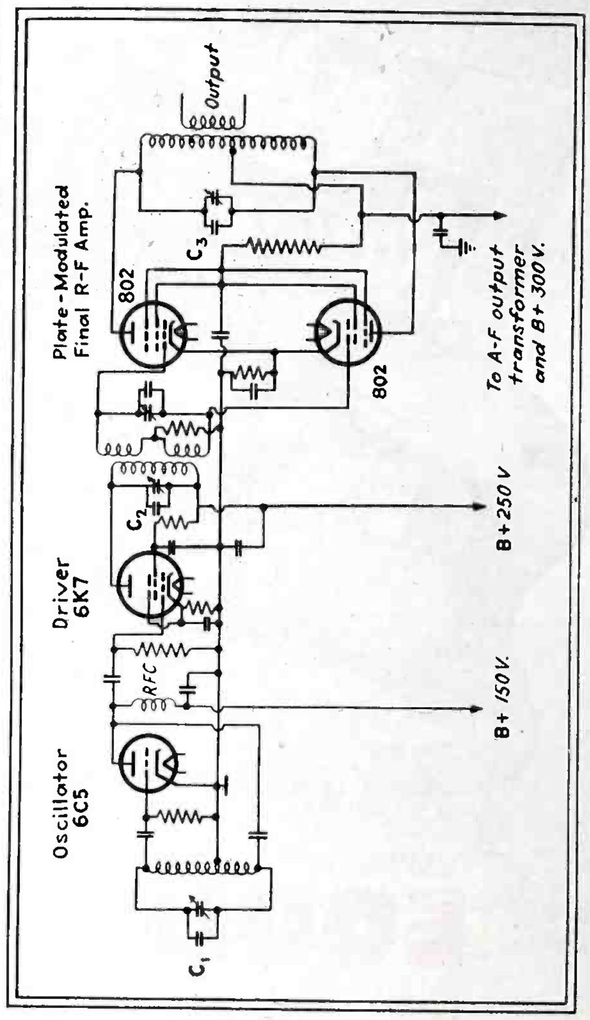
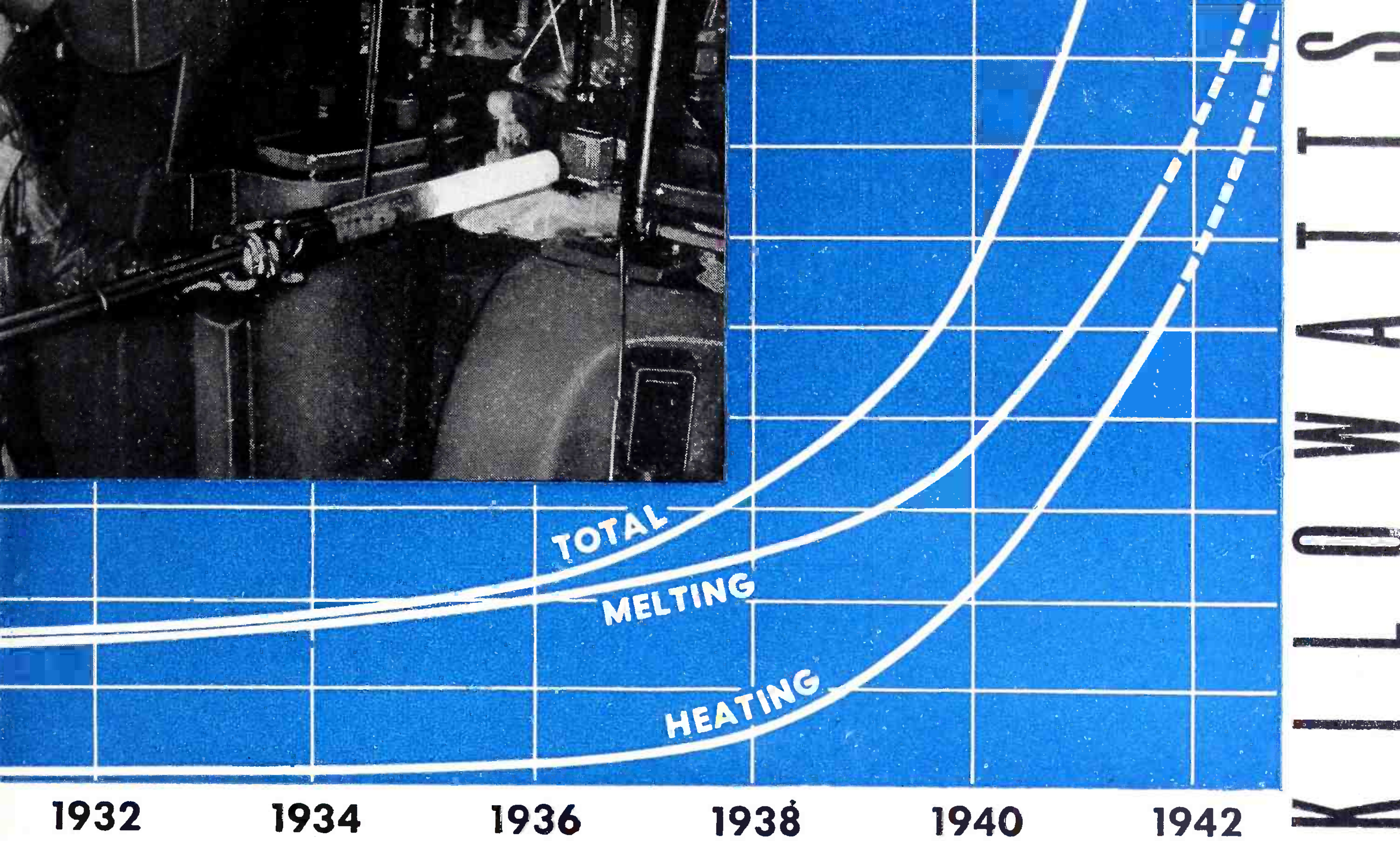


Fig. 1—Transmitter arrangement used for 150-kc wired wireless operation. The modulator (not shown) consisted of a pair of 6L6 tubes in push-pull, driven by a 6C5 and a carbon microphone

The transmitter circuit is conventional, and is shown in Fig. 1 chiefly to give the tube line-up and to indicate the types of circuits found most suitable for 150 kc.

Ordinary superheterodyne receivers were converted for operation on 150 kc by making simple changes in the oscillator stage and the first r-f stage. The changes required in a conventional circuit arrangement are shown in Fig. 2. A new antenna coil was wound according to the specifications given, with the primary



HIGH FREQUENCY HEATING AND MELTING

... are here to stay!

jax-Northrup Melting Furnaces vary in size rom the laboratory types rated in ounces the pilot plant outfits rated in pounds and e final batteries of larger units whose daily utput of special alloys may be rated in tons.

•

Ajax Oscillators, tube converters or motor generators provide the power.

High frequency heating has been greatly accelerated by the combination of current events. Quantity production floating on conveyors provides an ideal setup. The urgency for speed, maintenance of uniformity and conservation of man power are the deciding factors.

In fact, although little heating equipment had been installed previous to 1936, the sales curve of Ajax-Northrup High Frequency Heating Equipment may soon equal that of the melting equipment which has been used extensively since 1918.

Continued growth is assured because high frequency heating covers the range of advantages from high-speed production to top quality and competitive costs.

The unusual flexibility of Ajax-Northrup High Frequency Equipment may easily be its greatest asset, for you can quickly convert from heating to brazing, or melting at any time for a fraction of the original investment. Inquiries from manufacturers desiring to incorporate electronic heating in their post-war products are particularly welcome.

58

AJAX HIGH FREQUENCY FURNACES

NORTHRUP AJAX ELECTROTHERMIC CORPORATION, AJAX PARK, TRENTON, N.J.

ASSOCIATE COMPANIES: THE AJAX METAL CO. *Non-Ferrous Ingot Metal for foundry use.*
AJAX ELECTRIC FURNACE CORPORATION. *Ajax-Wyatt Induction Furnaces for melting.*
AJAX ELECTRIC CO., INC. *Ajax-Hultgren Salt Bath Furnace and Resistance Type Electric Furnaces.*
AJAX ENGINEERING CORPORATION. *Aluminum Melting Furnaces.*

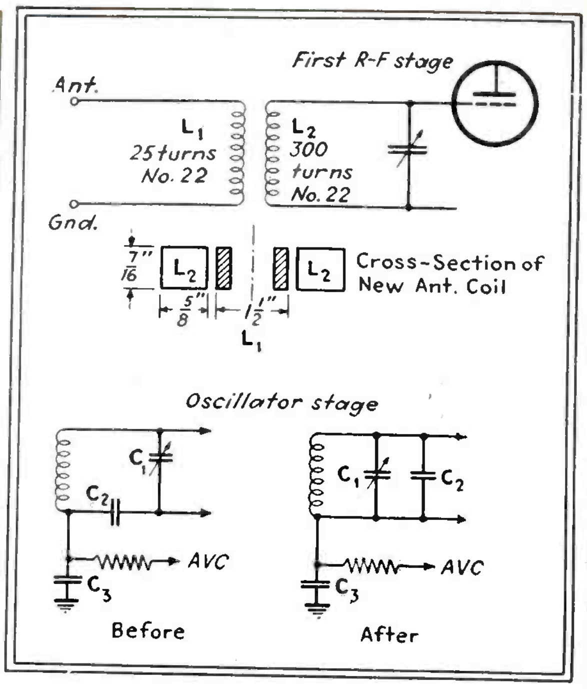


Fig. 2—Essential changes required in a conventional superheterodyne receiver for 150-kc reception

placed inside the secondary. The finished coil was boiled in wax, then wrapped with cotton tape. In the oscillator circuit, series tracking capacitor C_2 was removed and connected in parallel with oscillator tuning capacitor C_1.

Coupling Methods and Circuits

Two methods of coupling a receiver to the power line are shown in Fig. 3. One method involves connecting the antenna lead to the hot side of the line through a small capacitor, and connecting the ground lead to the neutral or grounded side of the line. These connections may ordinarily be made at any convenient wall outlet. The other method involves connecting one side of the line (whichever side gives best results) to the receiver chassis through a capacitor and connecting the antenna lead to a good external ground.

Methods of coupling a transmitter to the line are shown in Fig. 4. C_3

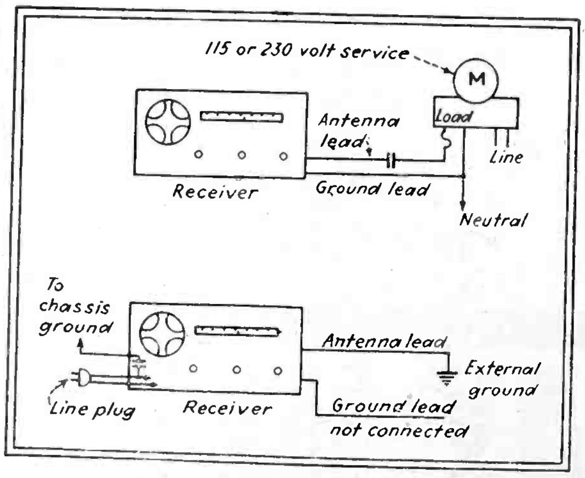
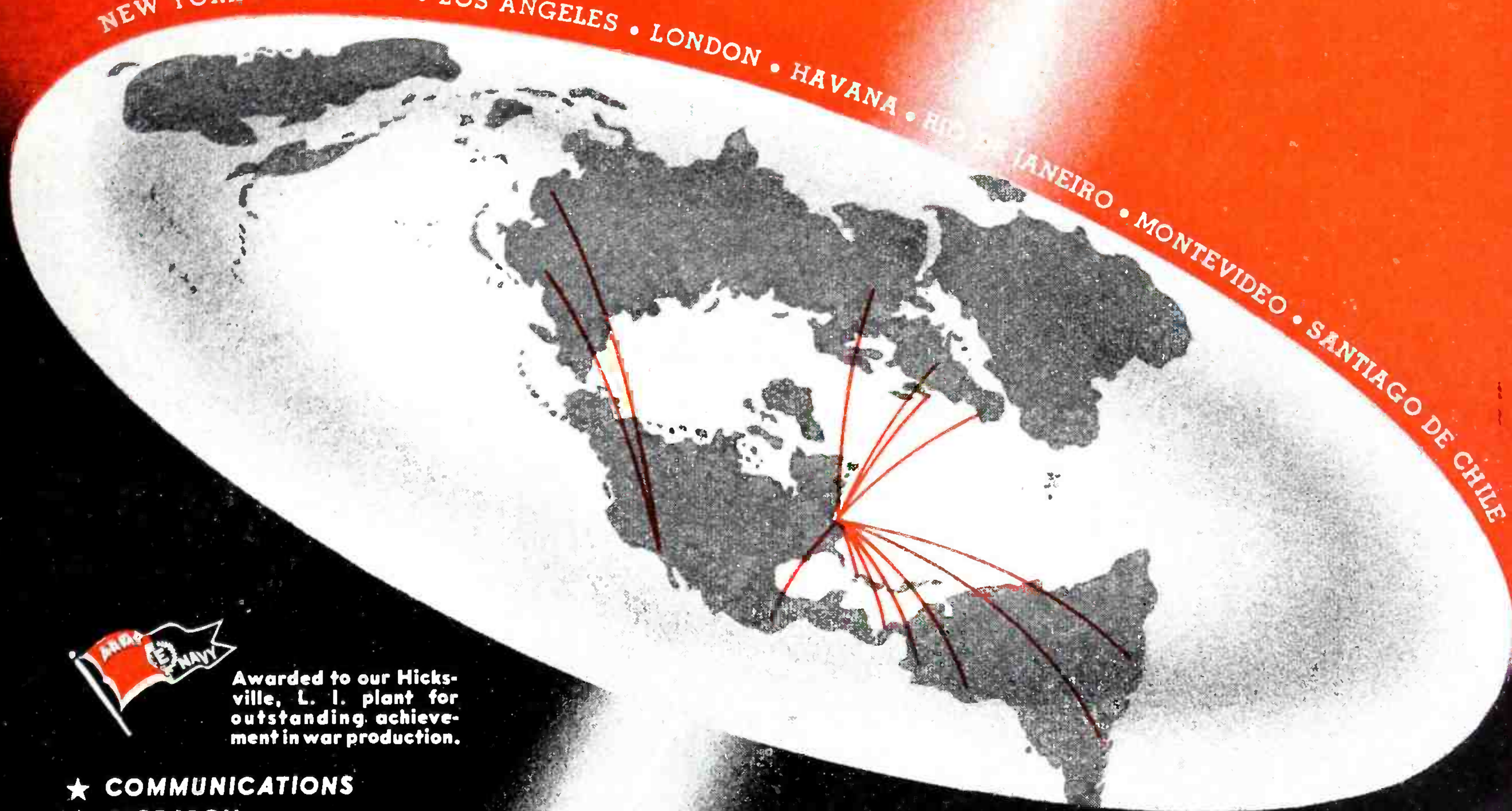


Fig. 3—Two methods of coupling a receiver to a power line for carrier-current reception

PRESS WIRELESS Inc. AND *Post-War* PLANS



Awarded to our Hicksville, L. I. plant for outstanding achievement in war production.

★ COMMUNICATIONS
★ RESEARCH
★ DEVELOPMENT ENGINEERING
★ MANUFACTURING

In the formulation of plans for the post-war world, extensive use already is being made of Press Wireless and its international network of radio communications.

Execution of these plans will require still further employment of Press Wireless facilities.

We are gratified to have this opportunity to serve. For over twenty years we have been planning, installing, and operating large-scale radio communications systems and manufacturing the equipment their functioning requires.

Today the manufacturing, design, and engineering resources of Press Wireless are devoted entirely to supplying our armed forces with vital radio units. The work we are doing now, added to our more than two decades of communications and manufacturing experience will, we believe, further fit Press Wireless for public service when the war ends.

PRESS WIRELESS Inc.

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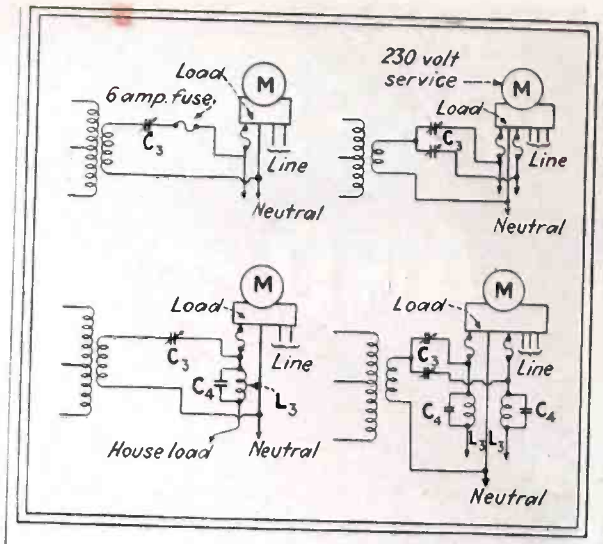


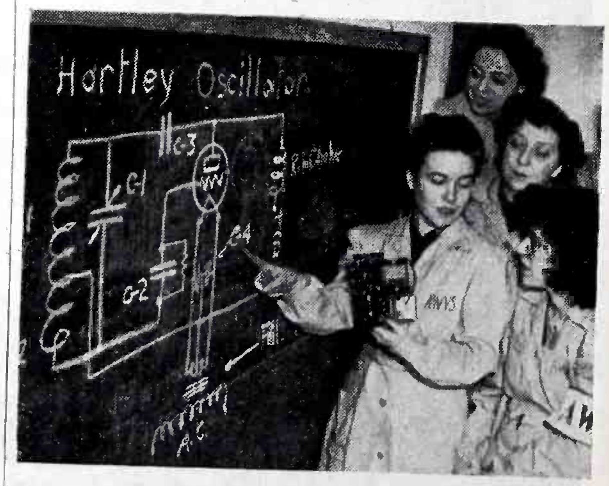
Fig. 4—Four methods of coupling a transmitter to a power line

is here serving both as blocking capacitor and as tuning capacitor for the line circuit, and will generally give resonance at some value between 0.01 and 0.05 μf.

While it is possible to get along without load-isolating filters, considerably better results are obtained if filters are used to prevent r-f signal power from being expended in the shunt load connected to the house side of the meter, as in the two lower circuits in Fig. 4. The coils used must have sufficient current-carrying capacity to handle the total connected load without serious voltage drop at the line frequency. C_4 can have a low voltage rating but should be of high quality and of the correct size to tune L_3 to the operating frequency.

• • •

AWVS ESTABLISHES RADIO SCHOOL



The American Women's Volunteer Services have established a radio laboratory for training women to replace men wherever they may be needed in wartime communications work. The women will be taught all phases of radio construction and repair. The school will turn out radio engineering aides, repair women and technicians. This photo shows members of the class in theory

M-R

EXTRUDED PLASTIC TUBINGS

HAVE ALL THE QUALITIES TO MEET TODAY'S INSULATION REQUIREMENTS!

Mitchell-Rand Extruded Plastic Tubings are fast making friends with the progressively difficult insulation tubing problems and applications generated by today's advances in electrical and electronic developments.

Their properties make them ideal for today's insulation tubing applications. Mitchell-Rand Extruded Plastic Tubings are made in four grades; MIRAFLEX, MIRATEN, MIRAGLAS and MIRADIE. Miraglas and Miradie are transparent. Miraflex and Miraten are made in six colors.

If Extruded Plastic Tubings don't apply to your particular applications bring your tubing problems to Mitchell-Rand "The Electrical Insulation Headquarters" for the specific tubing to meet your needs.

	MIRAFLEX	MIRATEN	MIRAGLAS MIRADIE
Dielectric Strength 020 Wall Dry Wet	750 VPM 350	1000 VPM 1000	850 VPM 815
Water Absorption after 34 hours	1.5%	0.5%	0.4%
Tensile Strength lbs. per sq. in.	2,150	4,000	3,000
Life at 105° C.	400 hrs.	1,000 hrs.	
Resistance to Brittleness	Does not become brittle or shatter at −40° F.	−58° F.	−50° C.
Wemco Oil Test 48 hours.—100° C.	All grades passed satisfactorily		

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GREAT TENSILE STRENGTH
SOLDERS SUCCESSFULLY
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THIN OR THICK WALLS
MOISTURE PROOF
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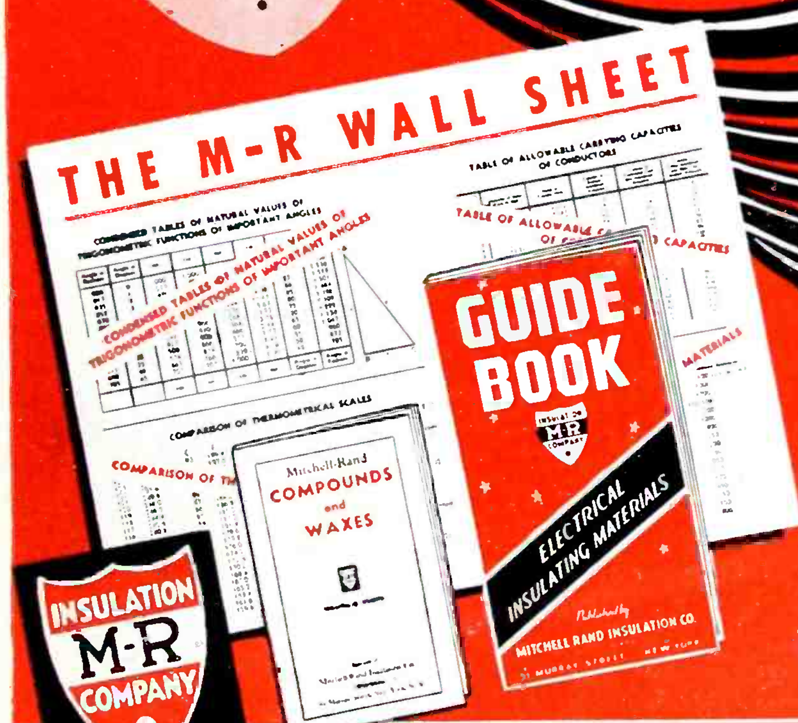

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Impregnated Varnish Tubing
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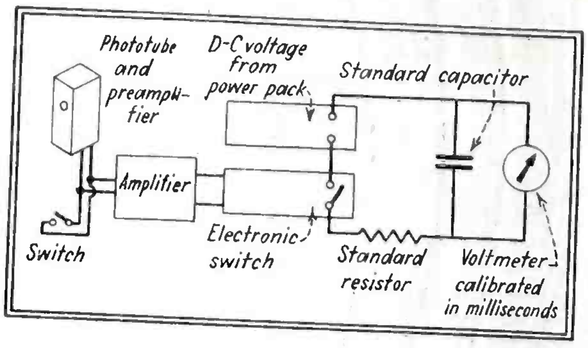
Fiberglas Saturated Sleeving and Varnished Tubing
Asbestos Sleeving and Tape
Extruded Plastic Tubing
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth and Tubing

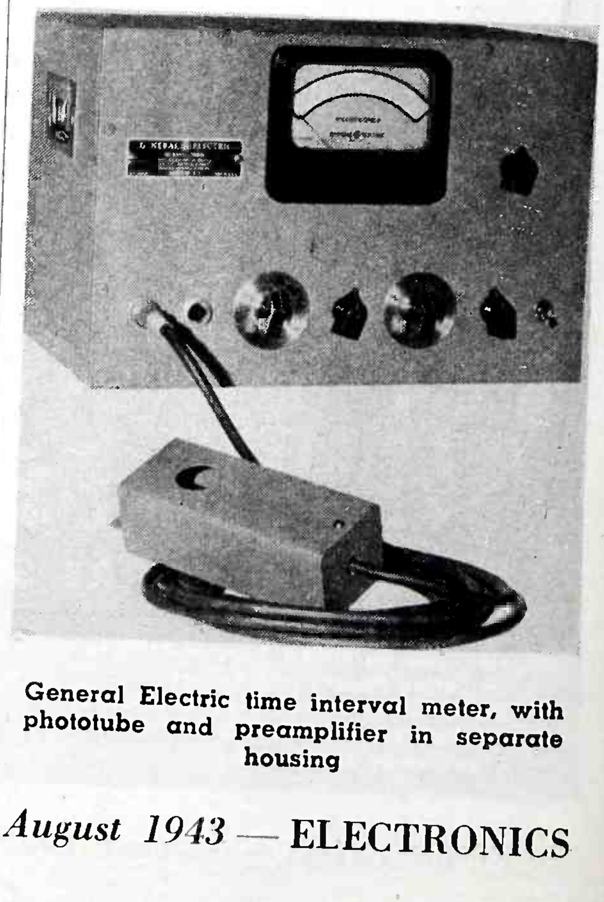
Electronic Interval-Measurer

TIME INTERVALS as short as 100 microseconds between any two events which can be converted into electrical impulses are measured accurately with a new G-E electronic meter. The impulses can be those produced by a phototube due to two interruptions of a light beam, by controls which are operated in sequence, or by any combination of any means for obtaining electrical impulses at the beginning and end of the event to be timed.



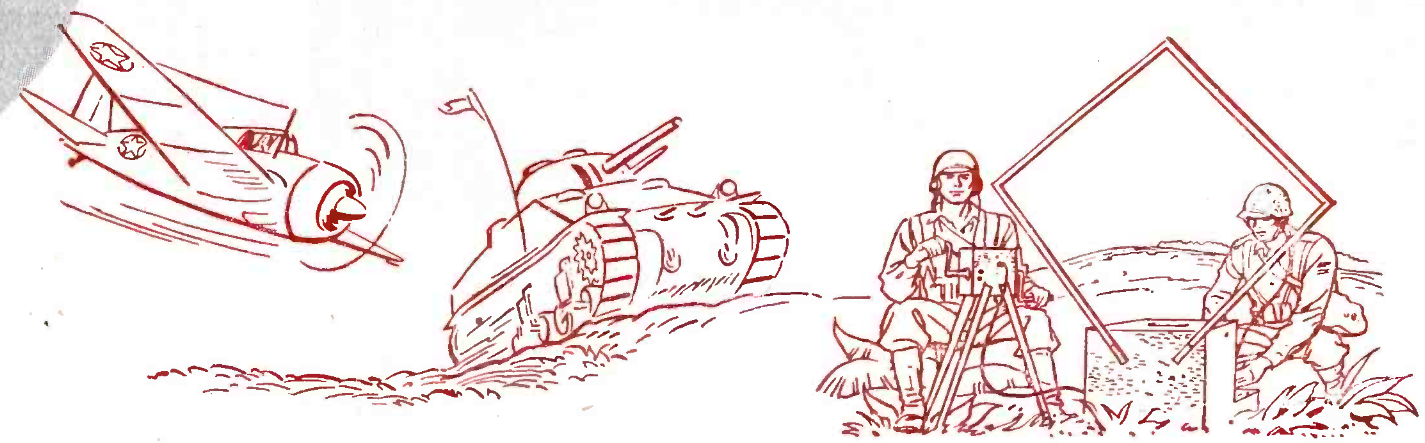
Block diagram of electronic time-measuring meter

The impulses are fed into an electronic switch which is used to control the time in which a standard capacitor is charged through a standard resistor, as shown in the block diagram. The voltage across the capacitor is proportional to the time of charging, hence the voltmeter can be calibrated directly in units of time rather than voltage. The meter will continue indicating the time interval after measuring, with a drift of less than one division per minute. Shorting the capacitor with a push-button switch clears the meter for another reading.



General Electric time interval meter, with phototube and preamplifier in separate housing

Where size is important!



Hipersil* Cores save space

More from less . . . lighter weight . . . smaller size . . . but *more* flux-carrying capacity. That's why Hipersil Cores are being specified for a steadily increasing variety of communication applications . . . in radio transformers, chokes, relays, reactors and loading coils.

Hipersil Cores release designers from the limitations of ordinary steel cores. They are the only commercial cores that combine these advantages:

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

SIMPLIFIED TRANSFORMER ASSEMBLY

Hipersil Cores eliminate hard-to-handle tiny transformer laminations. Wound from one strip and then cut in two pieces, they save valuable man-hours because there are only 2 pieces per loop.

For better, more efficient, lighter and smaller communication equipment — QUICKER . . . ask your Westinghouse representative about . . . and use in your equipment . . . *standard* Hipersil Core sizes.

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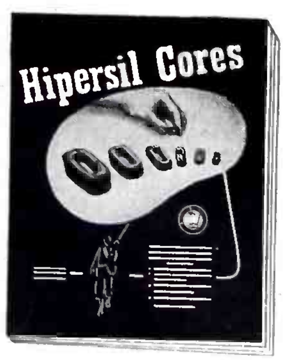
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

HIPERSIL



GET THE FACTS ABOUT HIPERSIL

Write for B-3223, the new data book filled with application and performance facts about Hipersil. Address: Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., Dept. 7-N.

* Registered Trade-mark, Westinghouse Electric & Mfg. Co., for HIgh PERmeability SILicon steel.

Electronic Control on Drill Press

THE FIELD OF USEFULNESS of an ordinary small drill press at the Schenectady plant of General Electric Co. was greatly increased by the addition of a $\frac{1}{3}$-hp G-E Thy-mo-trol drive. Operating speeds can now be adjusted from 25 rpm to 1750 rpm simply by rotating a knob, and the direction of rotation can be changed by pressing a button. Independent

Changing speed on this drill press is as easy as tuning in a new station on a radio receiver, for motor current is furnished by a pair of thyratrons controlled from the push-button station at the left

speed adjustments are provided for both forward and reverse rotation, permitting preselected speeds for both tapping and backing out. The wide range of speeds makes it possible to use the drill press for a wide variety of hard-to-drill materials ranging from molded compounds to the hardest steel pieces without changing pulleys.

• • •

FIRST HAND TRAINING

A unit from the Royal Corps of Signals demonstrates a portable radio set to Cadets at Eton College, England

CANNON *Visual Aids*

TO HELP YOU LICK THE MANPOWER SHORTAGE BY MAKING YOUR WORKERS MORE EFFICIENT

TRAINING FILM—Ready now! A slide film with sound, produced to aid the men servicing fighting aircraft in the field, or the men and women building all types of electrical equipment where AN Connectors are used. Clears up confusing terminology. Explains assembly techniques. Shows how AN part numbers are established and facilitates ordering of replacements.

CATALOGS—Your engineering department, production executives and service men need the basic information clearly presented in the new catalogs covering many types of Cannon Connectors used in any industry employing electrically operated devices.

WALL CHARTS—One chart gives insert arrangements and shell sizes on AN specification connectors at a glance. The other gives catalog numbers of all AN fittings. Both charts aid the designer, and the man in the field who is servicing any type of equipment on which AN electrical connectors are used.

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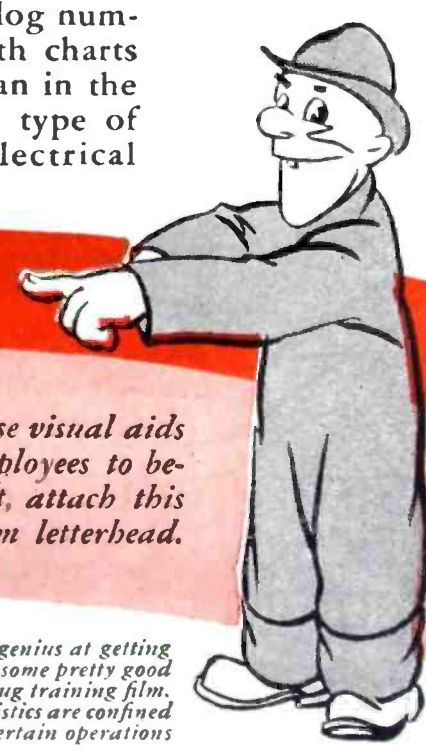

CANNON ELECTRIC

Cannon Electric Development Company
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Please send us more information on the visual aids checked below:
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If any or all of these visual aids will help your employees to become more efficient, attach this coupon to your firm letterhead.

Short-Circuit Sammy is a genius at getting into trouble, but he raises some pretty good questions in the Cannon Plug training film. His pedagogical characteristics are confined to showing how not to do certain operations

Audio Perspective System for Home Radio Receivers

By Ignatius Volpe

WITH THE ELECTRONIC ARRANGEMENT presented here, perspective sound effects aproximating those in Walt Disney's production "Fantasia" can be obtained in the home during radio reception of symphonic programs. Listeners can experience the sensation of sitting before the actual orchestra, with violin strains coming from the left and percussion instruments from the right.

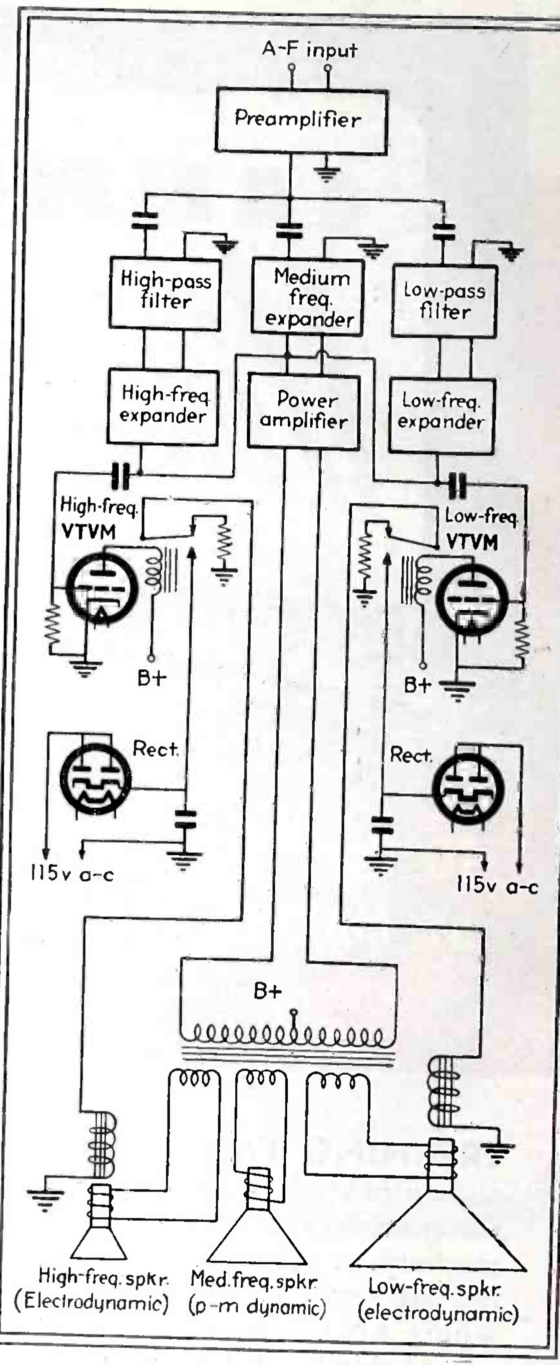
The system replaces the audio section of an ordinary high-quality receiver, preferably an FM receiver which can receive programs incorporating the full range of audio frequencies up to 15,000 cycles.

The arrangement is shown in block form in the accompanying diagram. Parts values and detailed circuits are purposely avoided since the entire system is intended solely to be suggestive and promote experimentation with audio perspective.

The audio signal from the discriminator or second detector of the receiver is applied to the preamplifier, which contains a conventional volume control and may have one or more voltage amplifier stages. The preamplifier feeds into three channels at all times, but the number of channels which are effective in producing sound at any instant depends upon the extent to which strong low-frequency and high-frequency components are present in the received program.

The center channel in the diagram is operative at all times. Here signals go through a conventional volume expander and power amplifier to an output transformer and p-m dynamic loudspeaker. The output transformer has two other secondaries, serving the two additional loudspeakers, but these are effective only when their field coils are energized by the other two channels.

The left-hand channel in the diagram has a filter which attenuates the lower frequencies. The resulting high-frequency portion of the program passes on to the high-frequency expander. This expander and the medium-frequency expander both feed a vacuum tube voltmeter stage in the high-frequency channel. When the combined input to the vtvm reaches a predetermined level, the plate circuit relay closes and applies field excitation to the high-frequency loudspeaker.



Suggested method of obtaining audio perspective in home radio receivers

Similarly, the right-hand channel applies field excitation to the low-frequency loudspeaker when the program contains strong low notes.

The power amplifier should be of highest quality and have an extended range of from about 20 cycles to 15,000 cycles, and the response of the high-frequency loudspeaker should go up to 15,000 cycles. For best effect, the loudspeakers should be positioned as far apart as possible. It is placement that determines the degree of perspectiveness provided by the system.

The use of a dial tone every three minutes on local telephone calls brought a 14 percent reduction in average time per conversation in Rochester, N. Y.

Airport Traffic at *all* CAA airports controlled by *Air Associates'* low and ultra high frequency transmitters

Design features . . . Four unit file cabinet construction with ball bearing "pull out" mechanism, simplifying maintenance and inspection. Identical power supply and modulator units employed on both types. The TMO is easily convertible to the TUI, at a later date, by replacing the radio frequency units.

Built for 24-hour continuous operation . . . Each component of the Air Associates CAA Airport Traffic Control Transmitter is designed and built for continuous operation. Electrical and mechanical standards, not exceeded by any other government service, are maintained—to insure absolute reliability.

Standardization by the Civil Aeronautics Administration upon Air Associates transmitters—for the vital job of controlling all traffic at airports—is evidence that the electronic engineers, laboratories and shops of Air Associates *deliver* equipment that thoroughly meets today's needs and anticipates tomorrow's requirements.

In addition to these transmitters, Air Associates' Radio Division also manufactures a complete line of receivers and transmitters for light planes and transports, police motorcycle receivers and receiver-transmitters, interphones, and complete ground stations—also accessory equipment such as automatic antenna systems, selector boxes, loading coils and relays, headphones and microphones.

★ Developed expressly for the Civil Aeronautics Administration . . . Built to their rigid specification CAA-509, Air Associates has produced the Type TMO low frequency, and the Type TUI, ultra high frequency airport transmitters, which *fully meet* the requirements of extreme temperature and humidity conditions specified. The original order has been increased by more than 60%.

★ Type TMO low frequency transmitter . . . A 50-watt, 200-400 kc, voice and tone modulated equipment which operates into practically any antenna suitable for Airport installation.

★ Type TUI Ultra high frequency transmitter . . . A 50-watt, 126-132 MC voice and tone modulated equipment, for operation into a 70 ohm transmission line.

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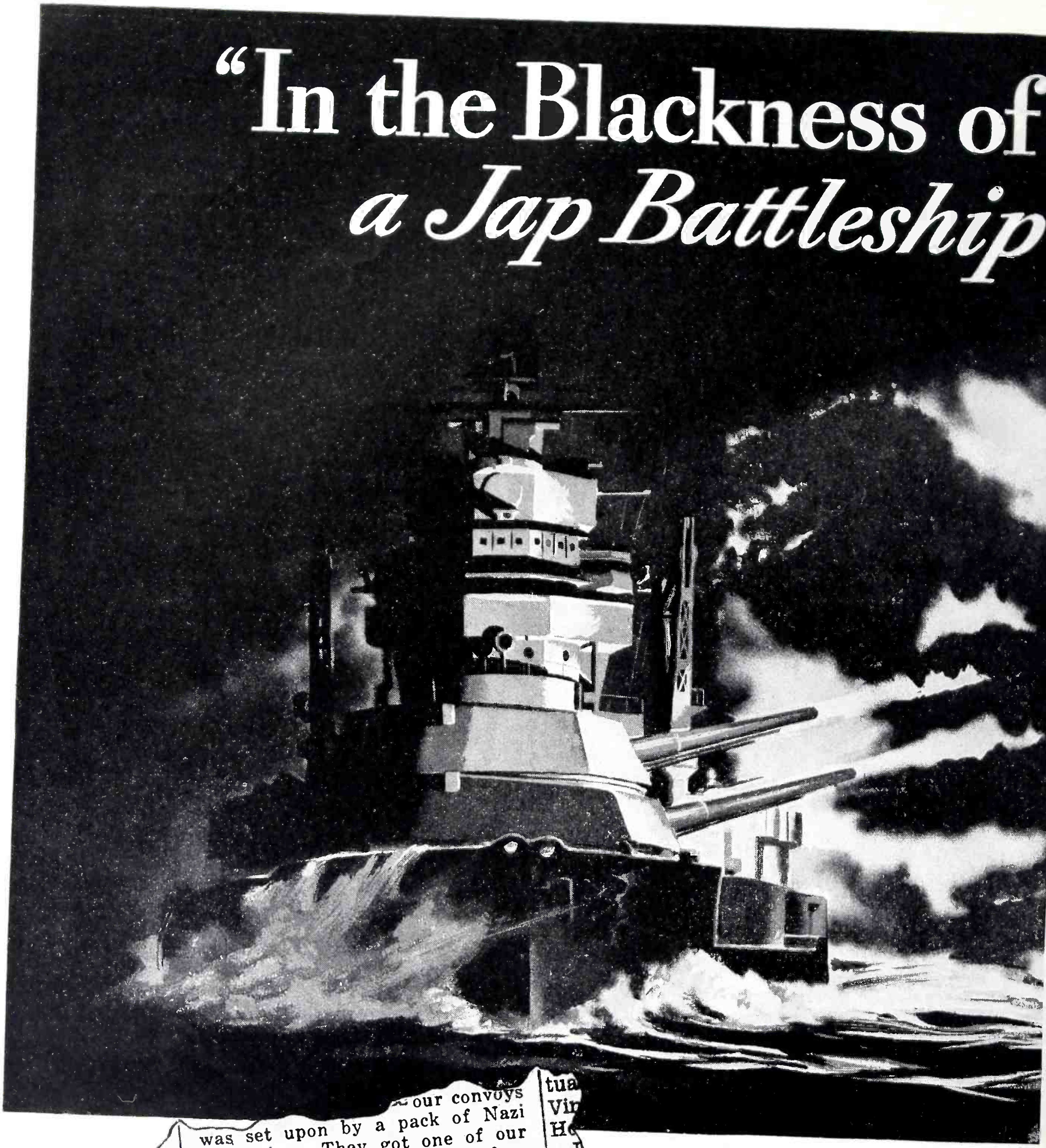


...our convoys was set upon by a pack of Nazi submarines. They got one of our merchant ships, but we got four of their submarines.

History will some day record the part radio and the radar have played in giving us fighting superiority over the Axis. But let me give you one instance. On the night of Nov. 14, off Guadalcanal there lay a Japanese battleship. It was a stormy night. Eight miles away was a ship of our fleet. With the use of the radar our ship with its second salvo, sank the Jap battleship in the blackness of night, eight miles away. Is there any wonder that the...

EXTRACT *from address by James F. Byrnes, Director of War Mobilization, at Spartanburg, S. C., May 31, 1943, broadcast over the Blue Network.*

Radar principles were first applied to aviation by RCA through equipment built and installed in its own plane in 1937, in connection with a study of collision prevention.

In 1938, RCA built an experimental Radar installation for the U. S. Navy. As the result of tests, in October, 1939 the Navy placed with RCA its first order for service Radar equipment. Since then, vast strides in the development of Radar in RCA Laboratories

RADIO

Electronic Sewing Machine

(*Continued from page* 93)

Fig. 5 showing power requirements for various thicknesses of Vinylite at several bonding speeds. It is assumed that power is confined to a cylindrical volume having a cross-sectional area of 0.1 square centimeter and a height of b centimeters ranging, in this case, from 0.01 centimeter to 0.08 centimeter. It is instructive to note that there is an optimum thickness, for a given rate of speed, at which the power requirement is a minimum.

Heat Conduction Losses

Inspection of the calculations for power requirements with and without heat-conduction loss may lead the casual observer to an erroneous conclusion. Since the cold electrodes require nearly twice the power that is needed when no conduction losses are entailed, it appears inefficient to use a method which conducts so much heat away. But the fact that the outside layers of the material being fused are kept cool prevents the surface from becoming gummy and thus the distortion that would otherwise appear is greatly reduced.

The power dissipated in a cylindrical volume of unit cross-section is expressed by the relation

$$P = E^2G/b \text{ watts} \qquad (3)$$

where E is the voltage,
G the conductivity, and
b the thickness.

In terms of voltage (3) becomes

$$E = \sqrt{b}\sqrt{\frac{P}{G}} \text{ volts} \qquad (4)$$

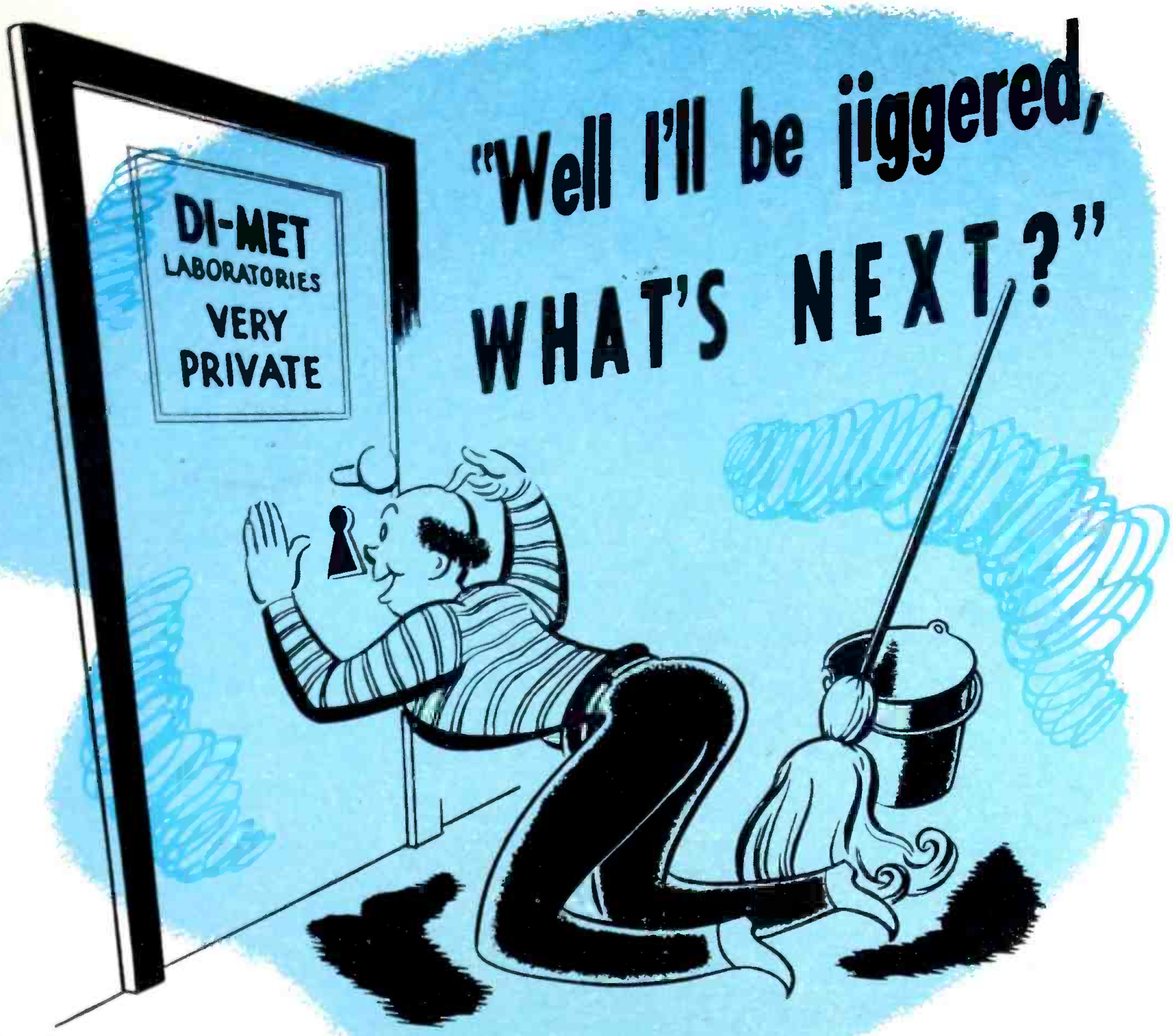
Since the field strength $F = E/b$, (4) may be written

$$F = \frac{1}{\sqrt{b}}\sqrt{\frac{P}{G}} \text{ volts per unit thickness} \qquad (5)$$

Using a subscript 1 to designate the values which apply to the minimum ordinate in the curves in Fig. 5 and a subscript 2 for values at any other point, Eq. (5) yields this relationship:

$$\frac{F_2}{F_1} = \sqrt{\frac{b_1}{b_2}\frac{P_2}{P_1}} \qquad (6)$$

which is plotted in Fig. 5 by the curve showing relative field strength versus thickness at a sealing rate of 1 inch per second. Note that as the thickness becomes less than that at the minimum ordinate the power



"Well I'll be jiggered, WHAT'S NEXT?"

SINCE the very beginning of the quartz cutting program, DI-MET engineers have constantly endeavored to improve quartz cutting results through better blade and machine performance. Their success in these efforts has been substantial, starting with the first DI-MET Rimlock blade offered to the quartz industry.

The Rimlock was developed by a radical departure in bonding procedures* which greatly increased the blade life and cutting speed. For the delicate dicing operation the DI-MET Resinoid Bonded Wheel proved highly efficient producing smooth, polished surfaces.

Latest developments in DI-MET laboratories include the "green-rim" resinoid bond for increased life, and Dynamic Tensioning—a process that puts cutting rims of metal type wheels under balanced tension—makes blades run flat during actual cutting operations and tends to *keep them flat* for the life of the blade!

Undoubtedly new and even better DI-MET developments are in store for quartz operators. And you can bet your share will come from DI-MET laboratories, since continuous effort and experimentation here are constantly improving existing quartz cutting techniques, producing *more* blanks per pound of quartz and eliminating unnecessary wastage. For any cutting problem—for every cutting operation—look to DI-MET!

FELKER DI-MET

FELKER MANUFACTURING CO.
1116 Border Ave. • Torrance, Calif.

TYPE C R
Bond: Copper
SIZES
Cut Off Wheels:
3", 4" and all even diameters up to 16"
Thick body Wheels:
Diameters: Up to 6"
Thicknesses: 1/16" to ½"

RIMLOCK
Bond: Copper
SIZES
Cut Off Wheels:
3", 4" and all even diameters up to 16"
Thick body Wheels:
Diameters: 1" to 6"
Thicknesses: 1/16" to ½"

RIMLOCK
Bond: Steel
SIZES
Cut-Off Wheels:
3", 4" and all even diameters to 24"

RESINOID BONDED
Straight Wheel, Type D1T
Diameters: 3", 4", 6"
Thicknesses: 1/32" to ½"

CUP WHEEL
Resinoid Bonded Plain Cupwheel, Type D6W
Diameter: 6"

MANUFACTURERS OF DIAMOND ABRASIVE WHEELS

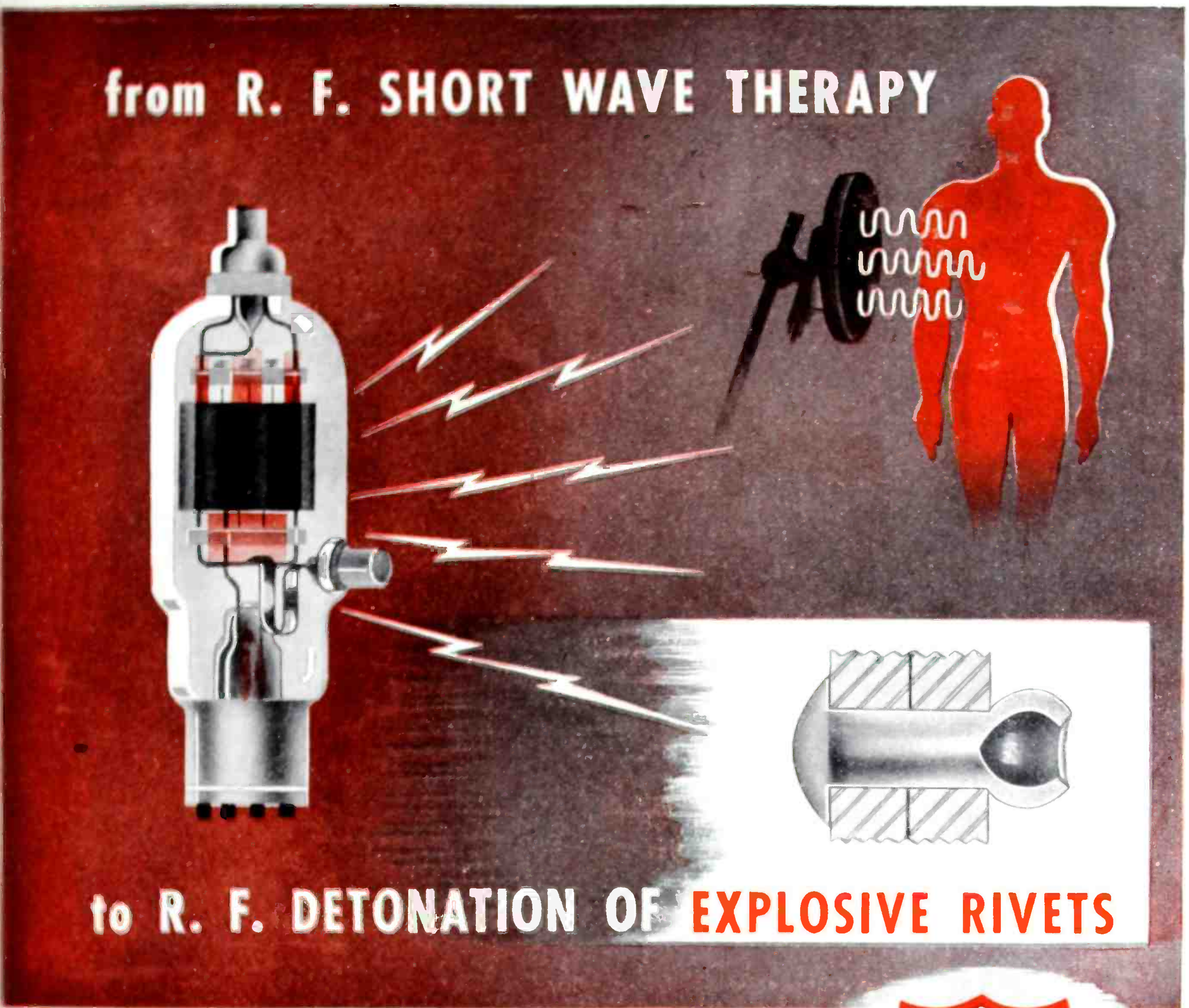
rises rapidly and the possibility of electrical breakdown becomes great. This prediction is strikingly corroborated in the experience with Koroseal, as described later.

Useful Machine Attachments

Some of the attachments designed for conventional sewing machines may be effectively adapted to the electronic model. One such device is a binding attachment which folds a plastic tape upon itself to bind a raw edge of thermoplastic material and thus enhance its appearance and/or increase its strength. The attachment is also helpful for reinforcing and finishing a seam made by joining two layers of material together and to a strip of thermoplastic tape, as suggested in Fig. 6A. Such a taped-seam is particularly useful in the assembly of bags or containers which must hold liquids or gases under pressure.

A bias-cut cloth tape may be folded-in simultaneously with plastic tape to obtain a color contrast, or to provide additional reinforcement of the edge. When a bias-cut cloth tape is used in conjunction with a thermoplastic tape an unusual result can be achieved, as may be seen by reference to Fig. 6B. With the layers of cloth acting as a heat insulator, only the three inner thicknesses of thermoplastic material will attain the temperature of plasticity and bond together. In effect, this is equivalent to bonding or "sewing" on the inside only.

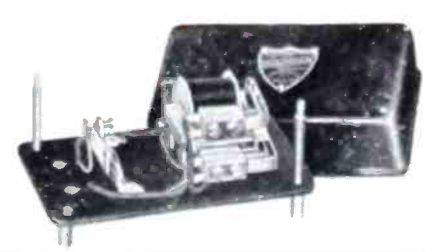
Hemmers are used to fold-over raw edges of material to produce a finished edge. In conventional sewing, a hem is usually secured by single stitching, although where wide hems are desired double or triple stitching may be used. For double or triple stitching a two or three-needle machine is frequently used. A similar result may be realized with the electronic sewing machine desribed by using a grooved or double wheel as one of the electrodes to make two bonds simultaneously. When sewing cloth, operators assist the hemming attachment by starting the fold by hand, but for plastic sheeting such a method is not suitable since the material does not crease easily and is somewhat more slippery when in contact with itself than cloth. Experience indicated that thermoplastic sheeting needed a longer folding channel than those

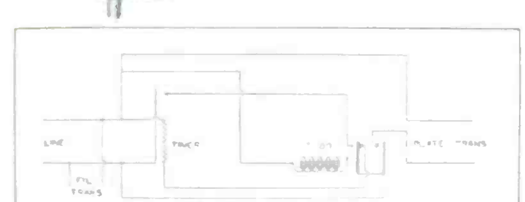


RELAYS BY GUARDIAN

From rebuilding human bodies—to riveting aircraft structures . . . from case hardening of metals to plywood glueing . . . wherever a tube is used, there you will usually find a relay. Oscillator tubes such as are used to generate radio frequencies in diathermy machines and detonators for explosive rivets usually require a "warm up" of 20 to 30 seconds to allow the tube filaments to heat. The Guardian Time Delay Relay T-100 is frequently used in applications of this type.

The time delay is adjustable for any period between 10 and 60 seconds and is accomplished by means of a resistance wound bi-metal in series with a resistor, not shown. The contact capacity of the T-100 is 1500 watts on 110 volt, 60 cycle, non-inductive AC. The power consumption of coil and time delay during closing of thermostatic blade is approximately 10 VA; after closing, 5.5 VA. Other types of relays commonly used in conjunction with oscillator tubes are the B-100 Break-In Relay for power supply control, and the X-100 Adjustable Overload Relay for power supply and tube protection. These and other R.F. relays are described in Bulletin R-5. Send for it. No obligation.





T-100 Time Delay Relay

GUARDIAN ELECTRIC

1625-J WEST WALNUT STREET CHICAGO, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY ordinarily provided in commercial hemming attachments. When such a folding channel is provided a uniform hem can readily be made. A cross-section of a wide hem, bonded with a double wheel, is shown in Fig. 6C.

It is frequently desirable to join two sheets of material by a lapped or imitation strap seam, in which a double stitch is ordinarily utilized. Attachments available for doing this precisely assist the operator of the electronic sewing machine in making such a seam with thermoplastic materials as shown in Fig. 6D. It is apparent that a double wheel is desirable for this operation.

Experience With Various Materials

A summary of our experiences with four synthetic sheet materials is given in Fig. 1. Pliofilm and Vinylite proved easiest to use in the particular machine under discussion. Most of the experimental work on Koroseal, which was done on material 0.001 inch thick, indicated that it did not seal completely in the electronic sewing machine since the cold electrodes conducted heat too rapidly away from the interface. This necessitated excessive voltages across the seam in order to supply the conduction losses and, consequently, there was frequent arcing through the material. This experience was predicted by the theoretical curves of Fig. 5, which show that power concentration and field strength rise sharply for thin materials. It was particularly noted, however, that the use of a narrow Vinylite tape between layers of Koroseal made an excellent bond with all tendency to arc eliminated. The same satisfactory result was also accomplished by using the binding attachment with Vinylite tape. There may be distinct advantage in the use of two materials for some applications.

When fabricating materials that break down easily, the use of higher frequencies should be considered. Saran, for example, is a valuable material because of its chemical inertness. However, it has a relatively low power factor, hence higher voltages must be generated across a seam to get sufficient heating in the material. Its voltage resistivity is also low, so that electrical breakdown occurs and no satisfactory bond is possible at 15 megacycles. At 60 megacycles, great improvement was noted and excellent

Illustrated above is a 15-inch Cathode Ray Tube

THE HEART OF TELEVISION
IS A TUBE!

Successful Television came into view with the development of the cathode ray tube which gave it definition—translating millions of electrical impulses per second into animated reproductions of scenes occurring at other points. ★ RAULAND tubes played a major part in this epochal achievement by making possible practical television projection on 15 foot x 20 foot screens. Significant facts like these point the way to effective post-war planning.

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

Electroneering is our business

THE RAULAND CORPORATION . . . CHICAGO, ILLINOIS

Buy War Bonds and Stamps! Rauland employees are still investing 10% of their salaries in War Bonds seams were possible for a total thickness greater than 0.005 inch. For sheets one or two thousands of an inch thick the results were erratic, which indicated that the use of a still higher frequency should solve the problem of bonding this or other material of similar characteristics.

Typical Manufacturing Uses

Some general categories of use for thermoplastic sheeting of the types referred to are briefly discussed:

Wearing Apparel—Raincoats and protective coverings are not necessarily completely moisture-proof when sewed together by conventional means. For the sake of emphasis it is desirable to repeat that it is frequently necessary to cement seams both before and after stitching to make them completely impervious to moisture. Also, the perforation of needles through the material weakens it and permits high concentration of force around the needle holes. With radio-frequency bonding this is not the case so that, in addition to obtaining tight seams, the strength of the finished article is improved.

Packaging—Most thermoplastic sheet-materials are particularly useful in that they are highly impervious to gases, are chemically inert as well as physically strong. The packaging industry has become conscious of these advantages and from trends already noted it appears likely that widespread use will be made of such materials in the packaging field in the future. The reliable seal that can be made when in-

• • •

FUNDAMENTALS OF ELECTRICITY

This group of WACs at an electrical institute in Newark, N. J., are working out preliminary experiments to get acquainted with some electrical properties of circuit components used in a-c electrical circuits. It sounds technical—but these WACs are Corporal Technicians

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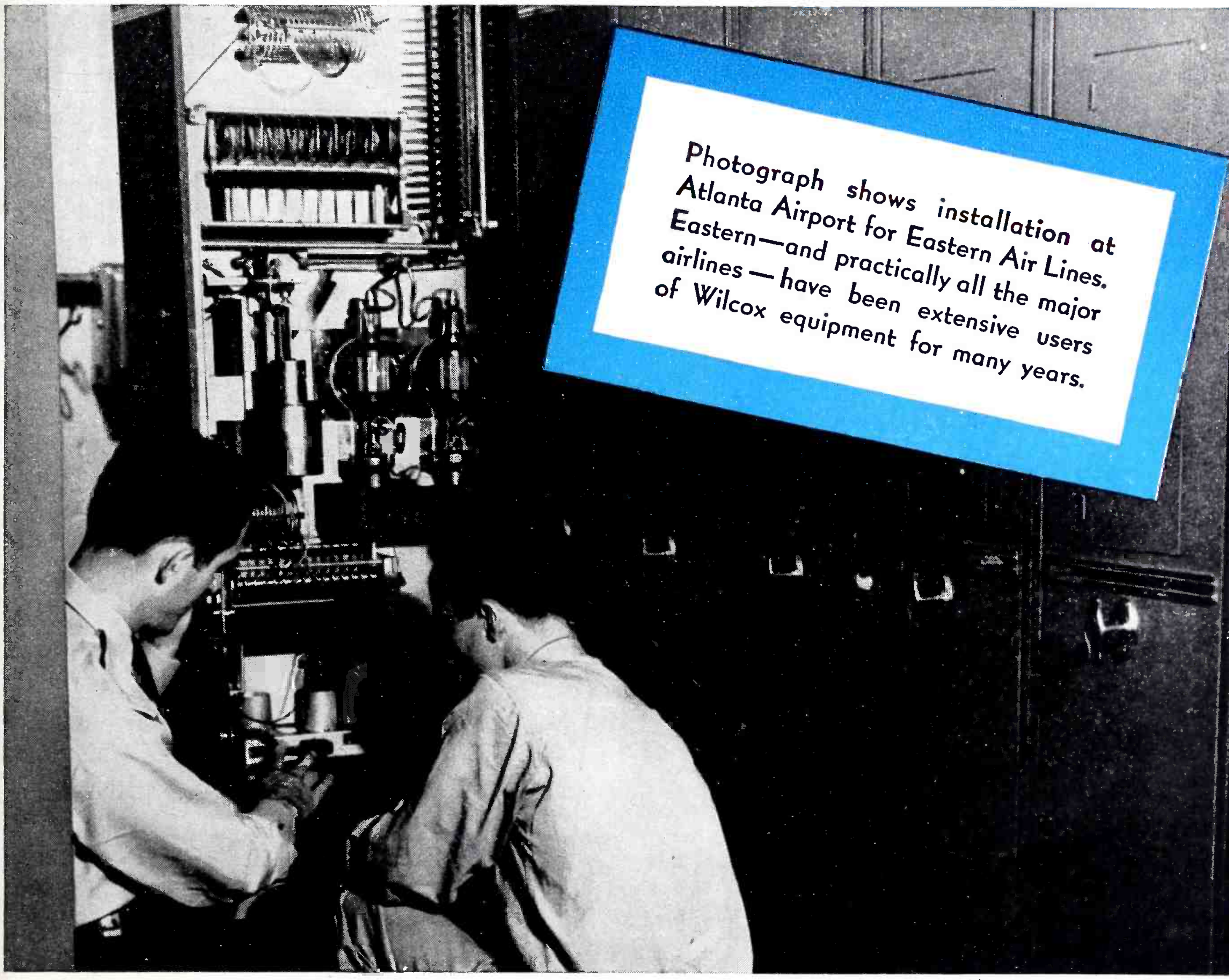

Photo, Courtesy Eastern Air Lines

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WILCOX ELECTRIC COMPANY

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THERE MUST BE DEPENDABLE COMMUNICATIONS

terfacial surfaces are heated is of utmost importance where foodstuffs are concerned. Radio-frequency bonding appears to be practically adapted for vacuum closures. It is probable that use of a "bar sealer" will be more important for this application than the use of rotating electrodes as the entire seal may often be made in one operation.

Inflatable Articles—It has been found that the diffusion rate of gas is extremely low and that resistance to deterioration by ultraviolet rays is high for some kinds of vinyl-resin sheeting, which suggests the use of thermoplastic sheeting for the construction of balloons. Also, bladders to be enclosed in a covering of cloth or other material may be effectively fabricated with the aid of radio-frequency bonding. Such devices may well be adapted as a form of "water-wings", may even be used to the extent of making inflatable life rafts and similar devices.

Coated Materials—Cloth may be coated or impregnated with thermoplastic resins and, in such form, will respond to electronic sewing. Cloth may also be woven from thermoplastic threads, or from coated strands, so that dielectric heating may serve to bond such fabrics. Ravelling which occurs at cut edges of some materials has been eliminated in a number of cases by applying a thermoplastic binding with the electronic sewing machine.

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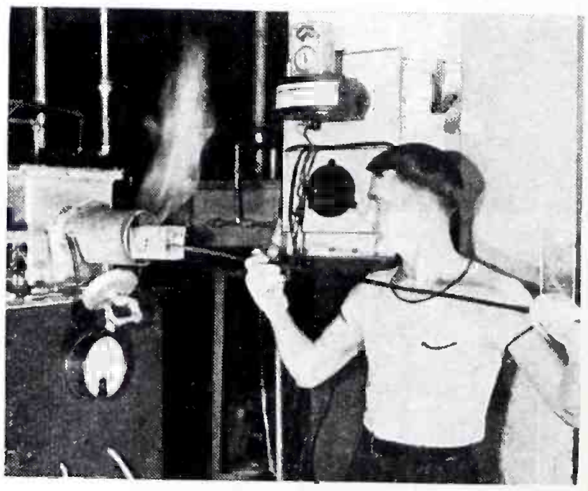
HYDROGEN FURNACE



Parts of radio transmitting tubes are heat treated in this hydrogen furnace at the Westinghouse Lamp Div., Bloomfield, N. J., to drive out any traces of gas which may be imprisoned within the metal. Burning hydrogen prevents oxidation and provides temperatures around 2100 deg. F. After this treatment and unless the parts are to be used immediately in manufacture, they are placed in a vacuum storage container to guard against their reabsorbing air or other gases

THE ELECTRON ART

Case Hardening with R-F Energy

UNIFORMLY HARDENED CASES 0.005 to 0.030 inch deep and controllable to within 0.001 inch have been produced on steel objects with 5-Mc r-f energy generated by power vacuum tubes, using techniques described by V. W. Sherman in Vol. 21, No. 2 of *Electrical Communication.*

Common faults of r-f surface heat treatment, namely excessive penetration of heat and nonuniform heating of the metal to be hardened, are generally due either to too low a frequency or to a heating rate so low that the heating period must be 15 sec or more. Heating power should therefore be equivalent to several times the conduction loss, and the time of treatment must be kept short enough to minimize conduction drastically. Since there is usually no excuse for hardening to a depth much in excess of allowable future wear, except possibly where impact load is high, it appears that the cost of heat-treatment is justified only in a layer up to about 0.030 inch deep.

Freedom from scaling or severe oxidation can be secured through reduction of time just as readily as through reduction of temperature. When the heat treatment is completed in one second or less, there is no scaling even in ordinary atmosphere, and the time is just barely sufficient to produce a blue oxide color. With r-f heating methods, it is thoroughly practical to conduct the treatment in a controlled atmosphere like hydrogen and thus prevent oxidation.

Process of Heat Generation

An induction heating work coil enclosing an iron object constitutes a transformer in which the surface layer of the object is a single-turn short-circuited secondary. The current I induced in this secondary flows through a resistance R and develops heat at a rate equal to I^2R. If a given coil has say 10 turns and the equipment can send 100 amp through these turns, the maximum ampere-turns available for heat-treating purposes is 1000. Since the secondary has one turn, the theoretical maximum secondary current cannot exceed 1000 amp in this example.

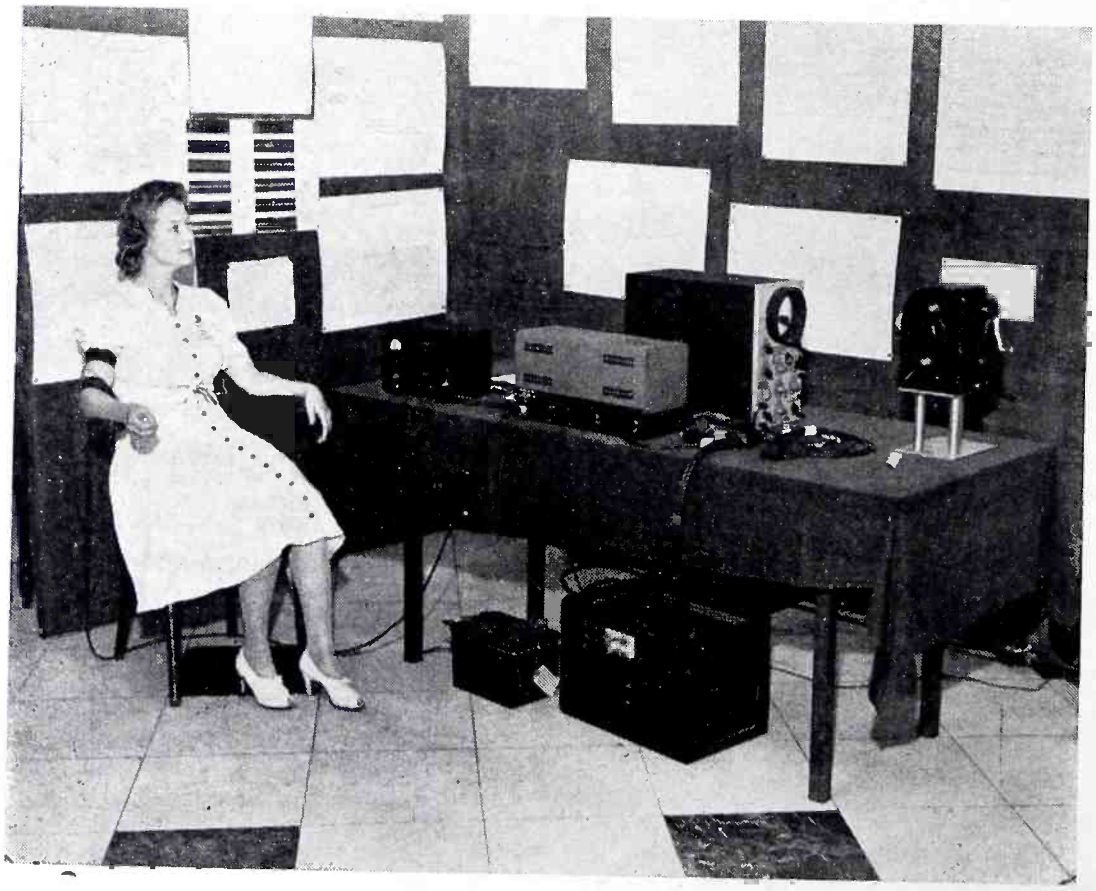
Not all of the primary flux will thread the secondary, however, because of the need for insulation and mechanical clearance between coil and work. If only 50 percent of the primary flux links with the surface of the work, only 500 amp would actually be available for generating heat in the work. It follows, then, that the rate of heating in the metal can under given conditions be increased only by increasing the resistance of the surface layer in which the current is confined.

Resistance versus Frequency

The thickness of the layer in which the current is confined can be shown to vary inversely as the square root of the frequency. Thus, if frequency is increased from 1 to 4 Mc, the thickness is reduced to one-half, the secondary resistance is doubled, and the heat developed by the available current is also doubled.

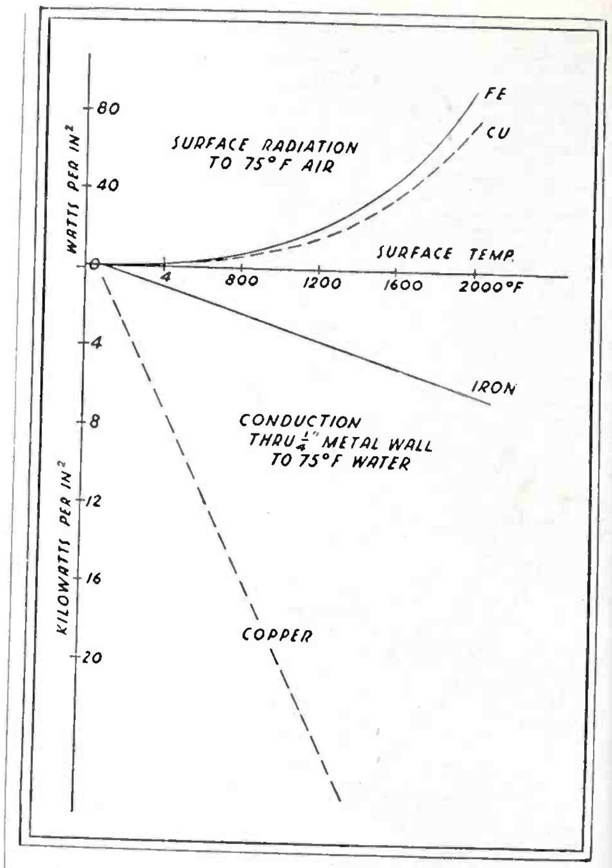
The problem of keeping the resistance high becomes increasingly im-

DEVICE RATES PARALYTICS



Mrs. Dorothy Hampton is shown with the electrode of a new device affixed to her arm. The instrument, developed under a grant of the National Foundation for Infantile Paralysis, tests the paralyzed muscles to determine immediately whether there is any chance of restoring them to normalcy. The device was recently demonstrated in Washington, D. C., and is interesting in that, apparently, traces of the muscle potential are shown on a cathode-ray tube screen


OHMITE



Heat loss curves for two representative metals with surfaces heated by radio-frequency energy. The loss of heat through conduction is sufficiently great to permit self-quenching of the surface (without immersion in a liquid after heating) in many types of objects

portant as the diameter of the work becomes smaller. For example, the resistance of the current-carrying path in a $\frac{1}{4}$-inch diameter piece is only 25 percent of that in a 1-inch diameter piece. With definite limitations on the output of the induction heating unit, on the current-carrying capacity of the work coil, on the number of turns in the coil, and on the coefficient of coupling, there thus remains only the control of secondary resistance by exploitation of high-frequency skin effect.

The rates of loss of energy from a heated metal surface to air and to an inner mass of metal are shown in the accompanying graph for two representative metals, iron and copper. These curves indicate that for all practical purposes the radiation loss is negligible compared to the conduction loss of heat. The curves also indicate that the minimum heating rate in kw per sq in should be at least double that of the conduction loss if nonuniform deep heating of the work is to be avoided.

The paper contains a number of excellent macrophotographs and microphotographs of specimens having surfaces heated by radio-frequency energy, with interpretations of results in each case.

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Send for Bulletin 8

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U.S.A.

Light Source for Photoelectric Radiometry

DETAILED CONSTRUCTION DATA for a tungsten-filament-in-quartz lamp suitable for precision filter radiometry, such as for calibration of the spectral and total radiation sensitivity of phototubes, is given in a research paper by R. Stair and W. O. Smith in the June 1943 *Journal of Research of the National Bureau of Standards.*

About 18 inches of 8-mil tungsten wire is arranged in four evenly spaced hairpin loops, with blackened tungsten shields over the loop ends and the supporting hooks so as to block radiation from cooler areas of the filament. The entire lamp envelope is constructed from high-quality fused quartz. Wavelength values from 2300 A to 3500 A are obtainable with a filament temperature range of 2500 to 2900 deg K, with wavelength corresponding to each temperature being found from the table in the paper or from a more complete table available from the Bureau of Standards.

The lamp is used in calibrating individual phototubes for the specific purpose to which they are to be applied, as well as for calibrating the portion of phototube surface that is to be used.

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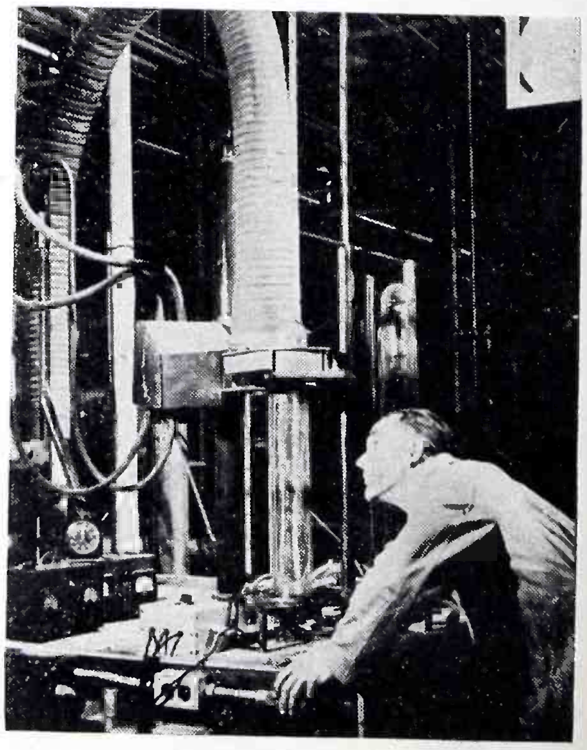
PREPARING FOR THE FUTURE



Canadian industry is now planning to create peace time jobs and luxuries in the conversion of war time industries. Cathode-ray tube parts are shown being cleaned in a vacuum firing machine which drives all gases from metal. This equipment is vital to fighting men

Exploding old assembly methods..

The spring tension principle of the SPEED NUT SYSTEM has revolutionized assembly methods everywhere. Now, in many cases, one SPEED NUT performs multiple functions, reduces number of parts, eliminates handling operations and drastically cuts weight and production costs.

For example: Our complete line of SPEED NUT angles combines the angle bracket and fastener into a single part. Self-retaining SPEED NUTS for all types of conduit clamps speed up assembly by eliminating unnecessary handling of parts. SPEED NUT retainer rings cut riveting operations to a minimum and save both in material and weight. SPEED NUT strips replace extruded gang channels. And our triangular nut plate for attachment of running lights, cuts riveting operations from 6 to 1. These are only 5 out of dozens of SPEED NUT designs that have virtually exploded conventional assembly methods. Write for our new summary catalog No. 185.

TINNERMAN PRODUCTS INC. • 2106 Fulton Rd., Cleveland, Ohio

IN CANADA: Wallace Barnes Co., Ltd., Hamilton, Ontario **IN ENGLAND:** Simmonds Aerocessories, Ltd., London

Speed Nuts

FASTEST THING IN FASTENINGS!

Tristimulus Colorimeter

THE DEVELOPMENT AND USE of precision photoelectric methods for evaluating the appearance of materials is described in 46-page Bureau of Standards Circular C429, "Photoelectric Tristimulus Colorimetry with Three Filters", by Richard S. Hunter (obtainable from Supt. of Documents, Washington, D. C. for 10 cents coin).

A tristimulus colorimeter measures a color stimulus in terms of three selected stimuli called primaries. The ideal source-filter-phototube combination for the photoelectric tristimulus colorimeter are those spectrally equivalent to the 1931 ICI standard observer for colorimetry in combination with an appropriate illuminant. Although the best available combinations do not quite meet this requirement, there are many problems of color measurement to which this direct and rapid color measurement procedure may be advantageously applied.

The Circular reviews the use of photoelectric cells for color measurements, gives a 3-page list of terms, symbols and definitions applying to the subject, and analyzes the problems involved in measuring color differences as small as those which trained inspectors of paint, textile, plastic, paper and ceramic products can see. Possible errors are taken up, and instructions are given for converting photoelectric tristimulus data to eight different usable forms for various industrial purposes. The bibliography contains 51 references.

• • •

High Harmonics of Quartz Crystals Control VHF Oscillator Circuits

THE DEVELOPMENT of a circuit that permits utilization of crystal harmonics at least as high as the 23rd now makes possible the construction of a crystal-controlled oscillator circuit operating at frequencies as high as 150 Mc, using crystals with fundamental frequencies below 10 Mc.

The theory of the new circuit is presented by I. E. Fair in the April 1943 *Bell Laboratories Record*. Practically all circuits used for quartz crystal oscillators require that the reactance of the crystal be positive at the operating point. The equivalent circuit of a crystal, making up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Don't cramp your style by trying to stick too rigidly to the "straight and narrow path" in remote control and light power transmission. With WALKER-TURNER FLEXIBLE SHAFTING you can take your choice between going through or going around. Oftentimes it offers the only practicable solution to knotty problems in mechanical design, as many aircraft builders—among others—have learned. Maybe you are struggling with some application today on which you could use a little of our experience. Take it up with us.
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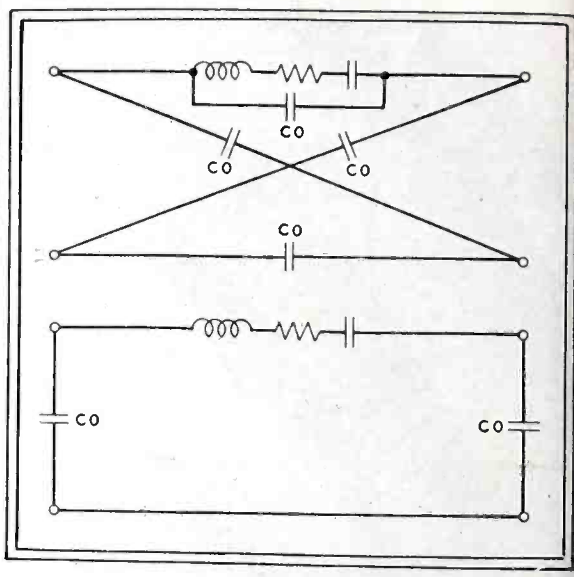


Fig. 1—Lattice network (above) and equivalent circuit (below) for placing the undesirable static capacity of a crystal unit at the ends of the lattice where it can become part of the associated oscillator circuit

this reactance, consists of *R*, *L* and *C* in series, with the combination shunted by a capacity *CO* representing the static capacity obtained if the crystal were removed from its holder and some other insulating material placed in the holder. It is this capacity which tends to make the combined reactance negative.

Since a crystal may be represented electrically by two impedances in parallel, a lattice network including a crystal in one of its series arms could be represented as shown in the upper part of Fig. 1. This in turn is equivalent to the circuit just shown underneath, wherein the shunting effect of *CO* is brought to the ends of the lattice where it can be combined with other elements of the circuit.

If the network of Fig. 1 is placed in a crystal oscillator circuit as shown in the upper part of Fig. 2, the effective circuit is as shown in the lower part of Fig. 2. Capacities *CO* are not

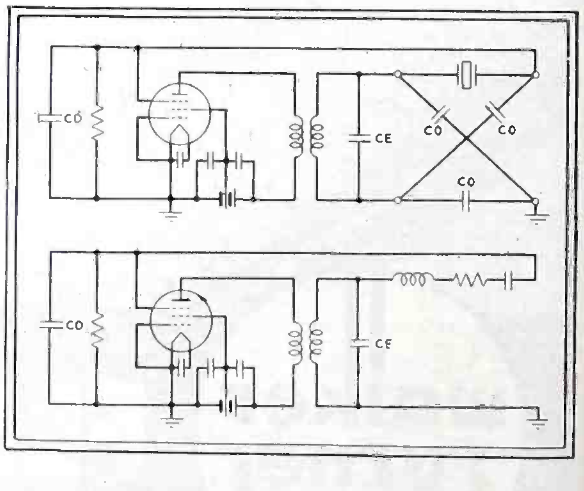
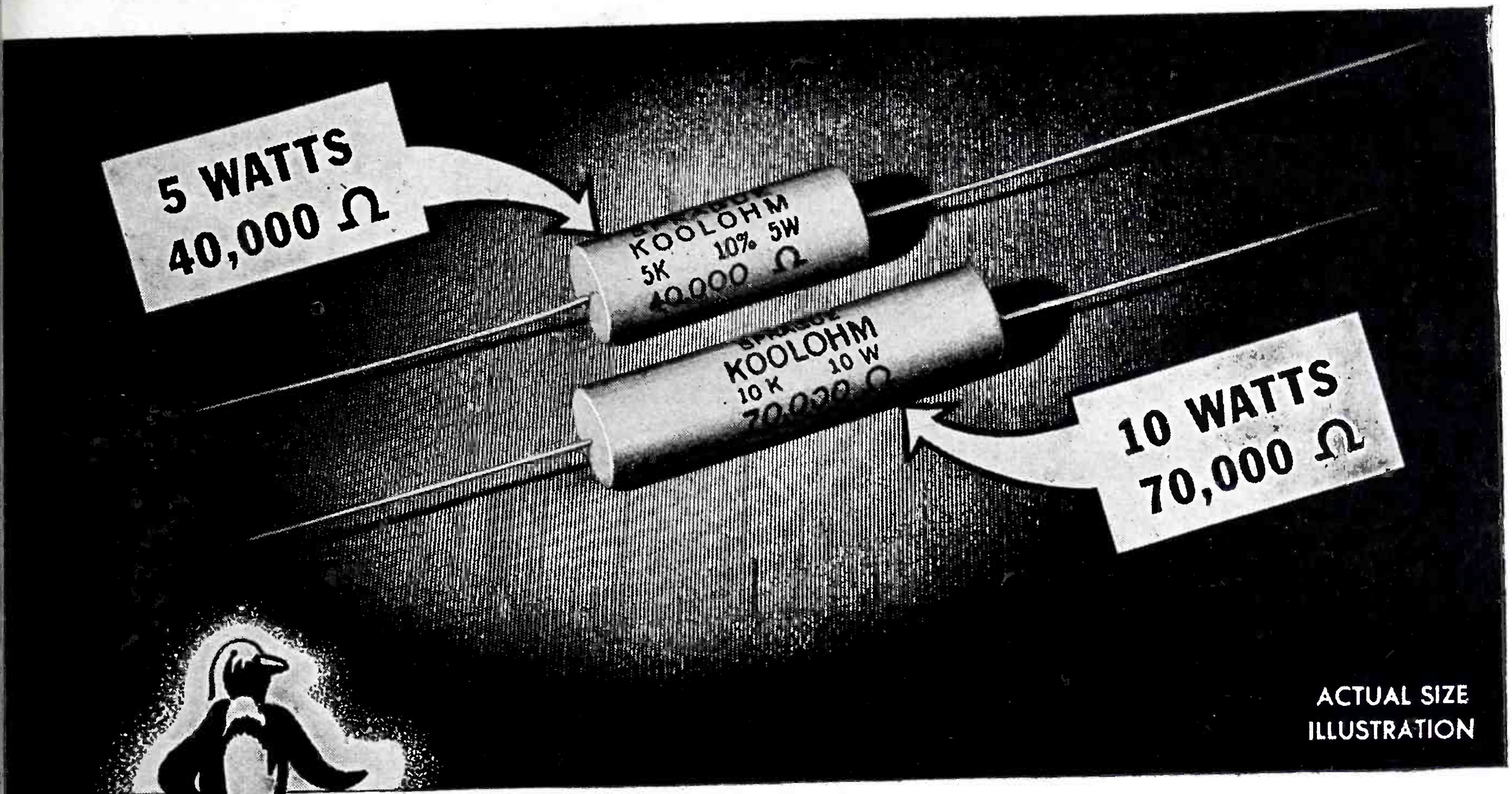


Fig. 2—New oscillator circuit (above) and equivalent circuit (below) for obtaining quartz crystal control at frequencies up to 150 Mc

THESE RESISTOR WATTAGE RATINGS MEAN WHAT THEY SAY



...Regardless of the ohmic values

If it's a 5-watt Koolohm, use it at its full 5-watt rating—regardless of whether it has a 1 ohm or a 40,000 ohm value! If it's a 10-watt Koolohm you can count on it dissipating a full 10 watts whether the resistance value is 1 ohm or 70,000 ohms!

In brief, there's no need to "play safe" with Koolohms. You don't have to use a larger resistor than you actually require. You can forget your worries as to whether the wire size is big enough to carry the current and the resistor body large enough to withstand the temperature rise involved. *You can use any Koolohm at its full wattage rating—any time, anywhere!*

This freedom of use is made possible because Koolohm design is based upon a time-tested, inorganic insulating material. This is sintered on the wire *before it is wound*—at 1000° C.! The insulation is flexible, and has a dielectric strength of 350 volts per mil at 400° C.!

Samples free to industrial users. Catalog on request to all who are interested in better, more dependable resistors.

SPRAGUE SPECIALTIES CO., Resistor Division, North Adams, Mass.

KOOLOHM WIRE IS 2¼ TIMES LARGER

Although Koolohm Resistors themselves are no larger—often smaller—than ordinary resistors, their wire is 2¼ times larger in actual cross-sectional area! This is especially important in the high resistance values where very fine wires so often fail to carry the currents involved in power resistor operation, or to withstand the corrosive effects of operation in high humidities *Play safe* with Koolohms!

KOOLOHM

REGISTERED TRADEMARK

POWER WIRE WOUND RESISTORS AND METER MULTIPLIERS

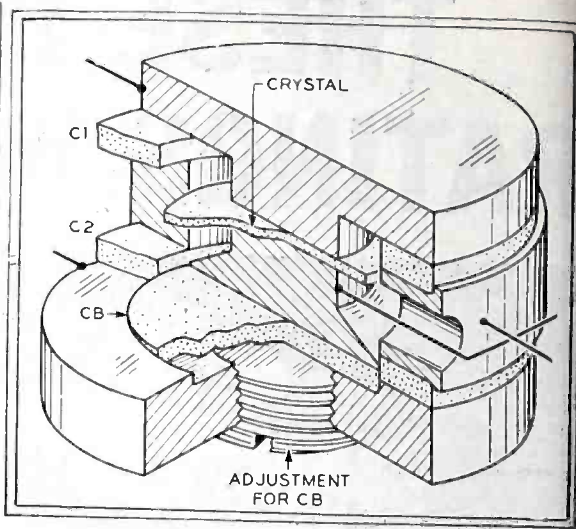


Fig. 3—Constructional details of the crystal lattice unit. It is small enough to be mounted on a standard vacuum tube base

shown since they now form parts of capacities *CD* and *CE*. With the effect of the shunting capacity *CO* removed from the crystal, positive reactance is obtained even at high harmonic frequencies.

The capacities comprising the crystal and those associated with it in the lattice network are very small. It is possible, therefore, to assemble the crystal and the three capacitors in a compact unit which can be mounted on a tube base. The construction of this crystal-capacitor network is shown in Fig. 3. One capacity is adjustable, being changed by means of a threaded screw.

• • •

Supersonic Research Abroad

THE PROPAGATION of supersonic waves in wires is analyzed in a 5-page article by E. Czerlinsky in the Jan. 1942 *Akust. Zeitschr.* Where the wavelength is of the order of the wire diameter, the propagation velocity falls steadily as frequency is increased. At higher frequencies, the velocity reaches a constant value which is essentially independent of frequency.

The use of a Poulsen arc generator to drive a magnetostriction oscillator from which considerable supersonic power must be obtained is described by H. H. Zschirnt in Nov. 1942 *Hochf: tech. u. Elek: akus.* A commercial 20.8-kc magnetostriction oscillator for submarine signalling, consisting of nickel stampings with two rectangular slots through which the thick rubber-covered exciting turns were wound, was used in the first tests. The arc was operated in a coal-gas atmosphere, with a water-

cooled copper anode and a rotating carbon in a transverse magnetic field, using a 700-volt d-c generator as the power source. Considerable attention is given in the article to methods of recording the frequency and amplitude fluctuations of the Poulsen arc oscillations, and to means for reducing inherent fluctuations in arc frequency.

A modified air-jet generator for generating supersonic intensities of the order of 1 watt per sq cm in gases rather than liquids is described in a 21-page paper by Ehret and Hahnemann in *Zeitschr. f. tech. Phys.*, 23, No. 10, 1942. Two ways of separating the supersonic field from the flow of air are given. In the method adopted, the base of the resonator is replaced by a diaphragm having a transverse natural frequency equal to the Hartmann frequency. The authors conclude that perfected apparatus would be useful also for excitation of liquids.

Abstracts of the above-described papers were compiled by the Radio Research Board (Great Britain) and published in the May 1943 issue of *Wireless Engineer*, from which the foregoing paragraphs were compiled.

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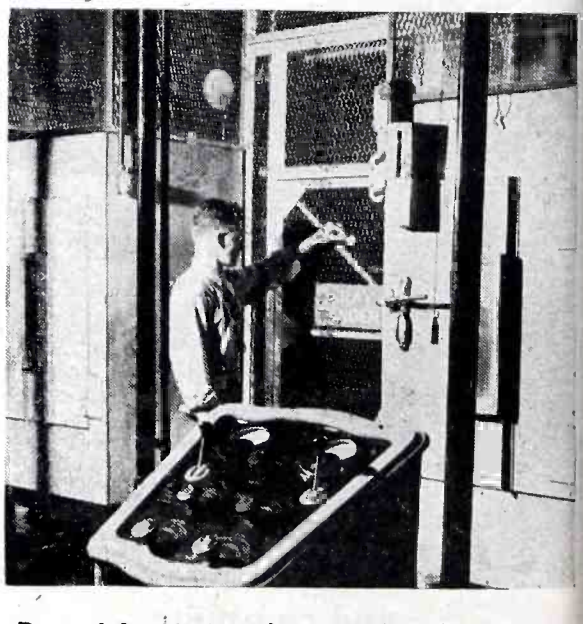
X-RAY PROVING GROUND



Powerful x-ray tubes produced at the Westinghouse Lamp Division for use in industry and medicine are tested in this laboratory "proving ground". The tubes are placed in lead chambers, and operated from the control panel in the foreground. Safety switches make it impossible for the doors of the lead chambers to be opened without cutting off the power. The test operator is shown placing a small white envelope containing unexposed film on the door of the test area. Such films are carried by operators as a precaution against exposure to x-rays. The films, which are developed regularly, would show any such exposure

Data on New Acoustic Stethoscope

By HARRY F. OLSON

RCA Mfg. Co., Camden, N. J.

THE EMPLOYMENT of a reversed taper tube in a new stethoscope developed in RCA Laboratories promises to widen considerably the study of sounds produced within the human body, such as normal heart sounds, heart murmurs, breathing sounds, respiratory rales and rattles, and peristaltic squeaks or groans.

The new instrument transmits all frequencies over the range from 40 to 4000 cycles without discrimination or appreciable attenuation, whereas an ordinary stethoscope has an effective range of only 200 to 1500 cycles. So many new sounds are heard that a filter controlled by a knob has been built into the instrument to permit limiting its range until the meanings of the new sounds can be determined by further study.

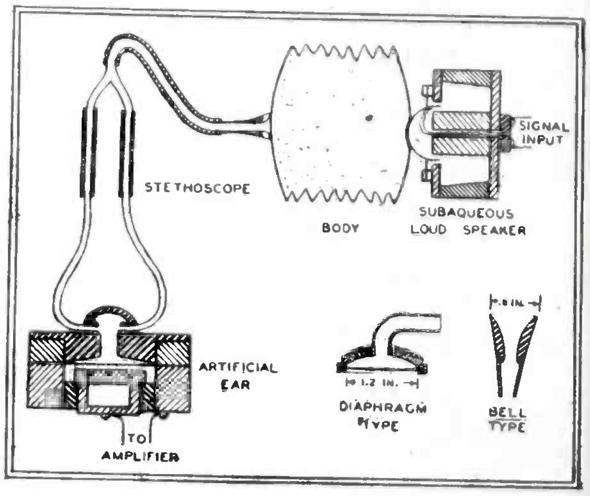


Fig. 1—Arrangement used to obtain the frequency response characteristic of a stethoscope

The arrangement used for comparing response characteristics of stethoscopes is shown in Fig. 1. Sound vibrations were developed in the human body by means of a subaqueous loudspeaker fed by an audio amplifier and audio signal generator. An artificial ear was first held directly against the opposite side of the body to secure a reference characteristic, and different stethoscopes in turn were then introduced between the artificial ear and the body. The resulting frequency response characteristics are shown in Fig. 2 for the new acoustic stethoscope and two other types.

The output of the acoustic stethoscope is essentially flat, and is

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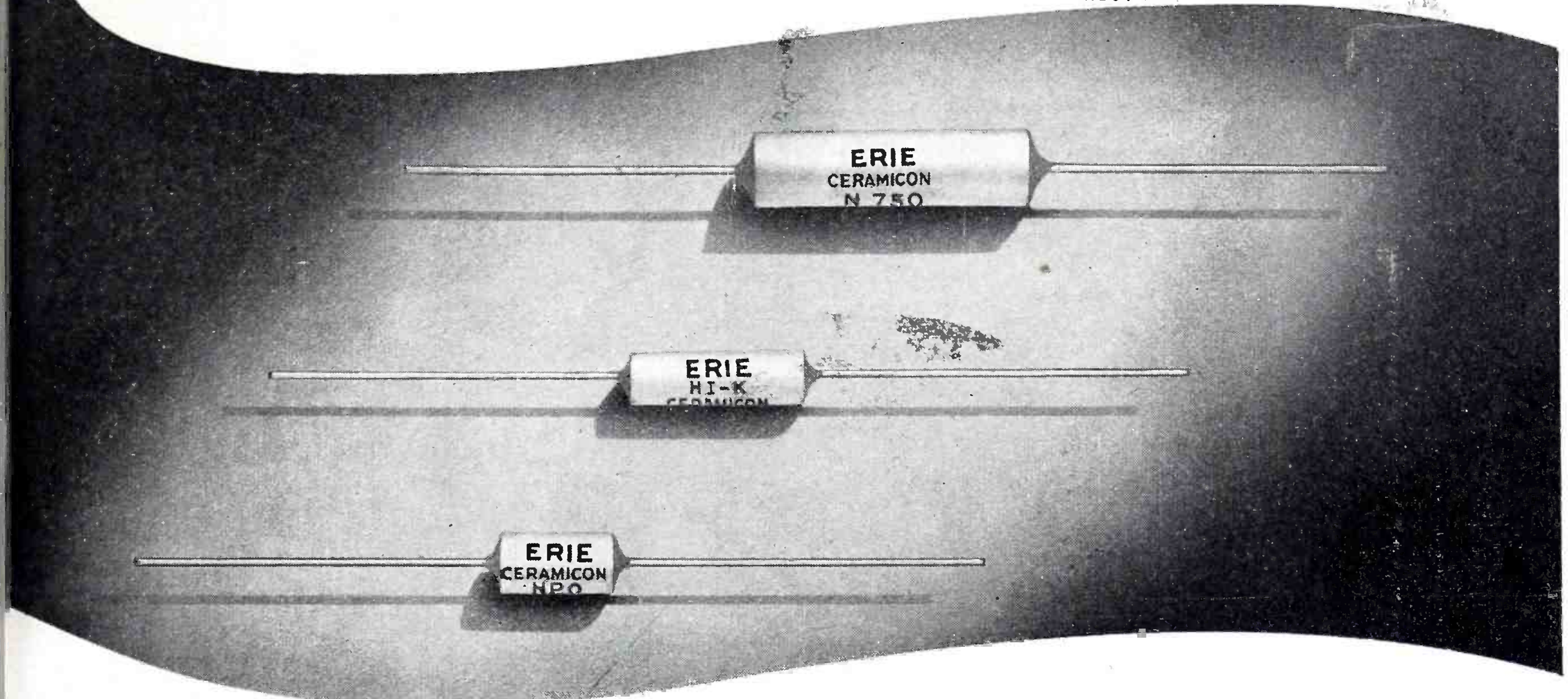

Have 5 Inherent Advantages

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★ INVEST TODAY IN ★ BONDS FOR VICTORY

WHAT do the five advantages of Insulated Ceramicons listed here mean to you? From the standpoint of design, they mean a more compact, efficient lay-out. Insulated Ceramicons can be located *anywhere* in the chassis without regard to the proximity of other components. They make possible shorter leads which are *musts* in higher frequency circuits. They mean greater protection against humidity . . . so important in today's military equipment. They provide extra insurance against breakage in handling on the assembly lines or damage from shock and vibration in actual service. The method of attaching wire leads to the silver electrodes provides a more uniform and direct electrical path.

Erie Insulated Ceramicons, for temperature compensating applications, are made in three sizes and in capacities up to 375 mmf. Erie "Hi-K" Insulated Ceramicons, for by-pass and blocking condensers, are available up to 5,000 mmf.

Where your specifications call for capacities within the above ranges, specify Erie Insulated Ceramicons.

For complete information covering operating characteristics of Erie Insulated Ceramicons, write for data sheet.

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

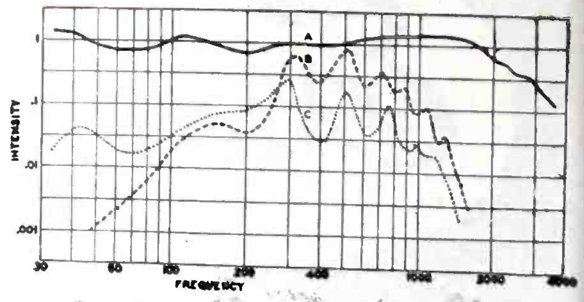


Fig. 2—Frequency response curves for the new acoustic stethoscope (*A*), a diaphragm-type stethoscope (*B*) and a bell-type stethoscope (*C*)

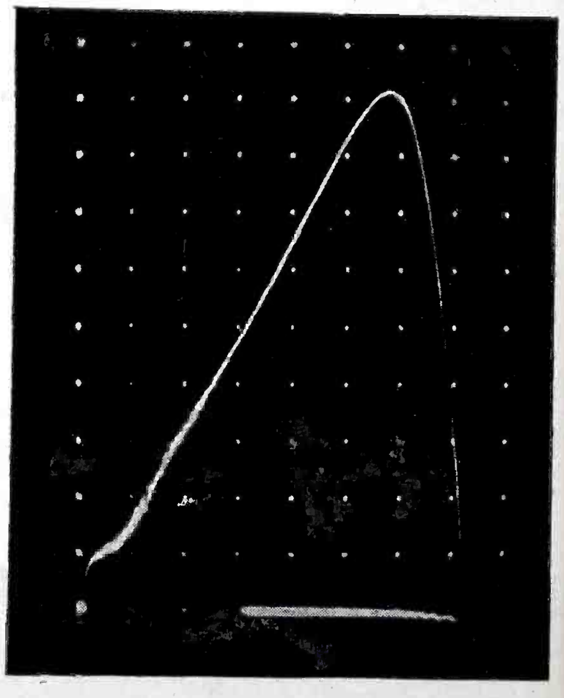
about 12 db higher than that of the bell-type unit. The uniform response is expected to be a great aid in diagnosis since this depends entirely upon the character of the sound heard. The new stethoscope is insensitive to air-borne noise due to the high mismatch between the air and the stethoscope, hence extraneous noise will not mask weak desired sounds.

• • •

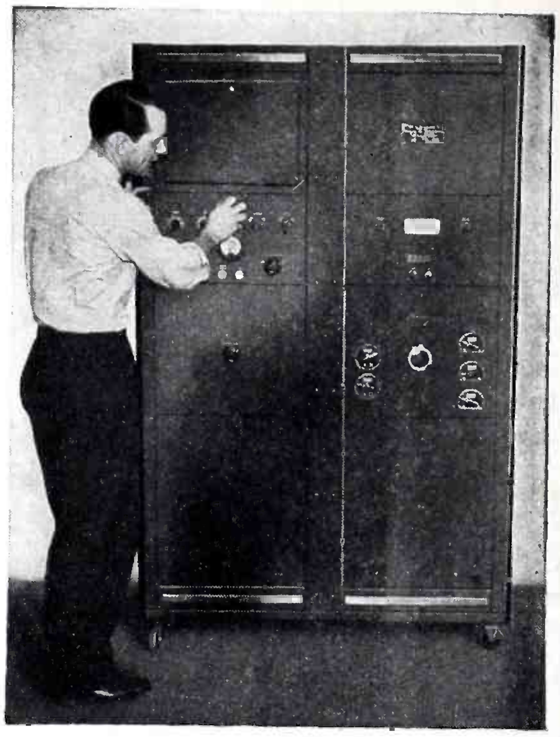
Pressure of Exploding Gunpowder Is Recorded with Oscillograph

To INSURE UNIFORMITY of powder in production runs and thereby eliminate errors in fire-control calculations due to variations in propelling charges, a Dumont type 235 cathode-ray oscillograph is being used in conjunction with testing of powder.

A powder sample is exploded in a strong sealed container, and the voltages derived from pressure elements affected by the explosion are applied to the horizontal and vertical plates of a cathode-ray tube through suitable amplifiers. This causes the beam



Example of ballistic graph obtained



Dumont oscillograph and associated equipment used to check powder charges electronically

to move in a path that constitutes a graph of pressure variations. This oscillogram is photographically recorded and later analyzed.

Calibration is secured in a novel manner through application of a series of luminous dots arranged in a matrix on the screen, so that both graph and matrix are photographed simultaneously. Each luminous dot is electronically positioned on the screen so that the horizontal or vertical distance between any two adjacent dots is a constant known factor. Readings can be duplicated to within ½ percent by this method.

The entire process is automatic once the closed container or bomb has been charged and the circuit voltages adjusted. Pressing a plunger then automatically opens the camera shutter, turns on the cathode-ray beam, fires the charge, switches the input of the deflection amplifiers from bomb chamber to matrix generator so as to produce the matrix of dots, turns off the electron beam and closes the camera shutter. A short-persistence blue fluorescent screen is used in the 9-in. diameter cathode-ray tube.

When porcelain insulators of a radio transmitter were broken during unloading somewhere in Africa, an Army dental officer made a satisfactory repair with the cement used in artificial dentures.

Temperature Compensation

(Continued from page 105)

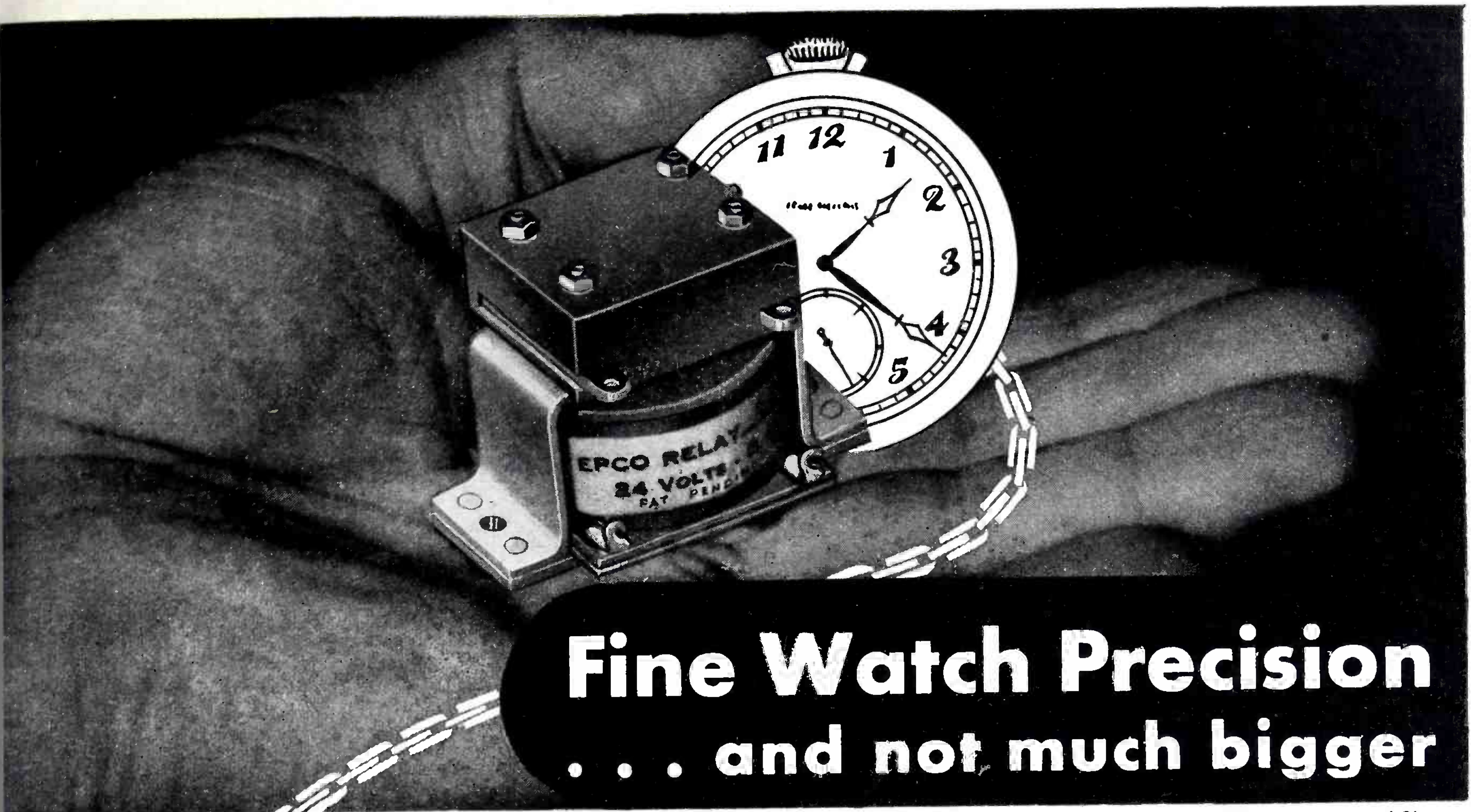
received, which was a 1 in. x $\frac{3}{32}$ in. unit and had a resistance of 675 ohms at 20 deg, was tested from −30 deg C to +41 deg C, starting at the low temperature. At first it showed an erratic characteristic, and on cooling again, didn't follow the original curve. There seemed to be an aging phenomenon. Several days later it was tested again. A smooth characteristic was obtained this time, with resistances about 14 percent higher than originally. This indicated the desirability of giving resistors to be used as neutralizers an accelerated aging or "cooking" treatment. (The manufacturer has since made a practice of aging such resistors.)

Figure 1 illustrates typical resistance-temperature curves, obtained by the author, of three types of neutralizers. The two curves marked Keystone illustrate the characteristics of the resistors discussed in the preceding paragraph when compounded to produce the highest possible coefficient and pertain to neutralizers now used in standard Diesel engine pyromillivoltmeters.

There are three curves pertaining to the silicon carbide Globar resistors previously described and two pertaining to a new material of unstated composition, labelled I.O. The curves were obtained from two out of a number of samples prepared by the manufacturer for this test.

It is important to notice that all the curves are concave upwards. The negative temperature coefficient increases as the temperature decreases. The upturn is especially pronounced below 0 deg. This is obviously undesirable. The *DR* of the coil to be compensated is substantially constant, while that of the neutralizer varies. The curves for the Keystone neutralizers show that at 20 deg $DR = 0.173$ ohms per degree, at 50 deg $DR = 0.145$, and at −10 deg $DR = 0.515$ ohms per degree. The exact result of these variations will be illustrated later.

It is only fair to say that a large proportion of electrical measuring instruments are not operated at 10 deg below zero C, and that neutralizers are therefore rendering good service in large numbers, having made possible the design of more



(Photograph Actual Size)

NEW *"Sealed"* MIDGET RELAY

Explosion Proof! Dust Proof!

Sealed Chamber—Makes Relay Explosion Proof and Dust Proof; serves as effective arc quench.

Excess Capacity—Rated at 25 amperes; operates satisfactorily at 50 amperes; tested without failure at 120 amperes high inductive load.

Light and Compact—Standard model above (S47D) weight only 4.7 ounces; overall dimensions as follows: Height, 1 9/16"; Width, 1 21/64"; Length (less base), 1 7/16"; Overall of base, 2 1/16"; Mounting holes, center to center, 1 3/4".

Positive Action—Overtravel spring insures positive contact pressure and instant "break" release.

Tamper Proof—Factory adjusted and sealed; protection against unauthorized re-adjustments.

Reversible Contacts— If worn from excessive use contacts may be reversed in the field, thus providing new surfaces without disturbing adjustment.

Electrical
PRODUCTS CORPORATION
General Office:
1128 Venice Blvd. Los Angeles, Calif.

Specifications:

Normal Coil Rating. 24 volt - 150 m. a. - 3.6 watts.

Contact Rating. 25 amps. inductive load at 30 volts.

Unit has withstood Army tests, including overload; vibration 55 cycles per second with .06" excursion; acceleration of 10 gravity units; salt spray tests of 240 hours duration.

rugged and better-compensated instruments.

Figure 1 shows that a random pair of Keystone resistors had closely parallel characteristics. This is also true of the pair of Globar I.O. resistors. It is important that neutralizers for a specified application have parallel resistance-temperature characteristics, because *DR* is the slope of the curve representing these characteristics.

Laboratory Model Millivoltmeter

Early in 1941 we were giving special attention to the problem of producing more rugged marine diesel engine pyrometers having requisite high resistance. High resistance is desirable to avoid the necessity of accurately adjusting the resistance of the leads to the thermocouple. But increasing the circuit resistance ordinarily means decreasing the torque corresponding to a given millivoltage.

A model millivoltmeter was built to see what improvements could be achieved. It differed from our existing designs in several ways, so a direct comparison cannot be made. The author designed a special magnet, using Nipermag, producing twice the flux of the commercial unit magnet, and used a moving coil of different proportions. A composite neutralizer was made with assorted samples at hand. Five Keystone neutralizers, with a combined resistance of about 82 ohms, and one Globar B of 108 ohms were connected in parallel. The *DR* of the combination just matched that of the 105 ohm coil, which, according to the formula above, was assumed to be 0.42 ohms per degree.

During the first temperature test to which the instrument was subjected, inconsistencies in total resistance were noticed. The cause seemed to be that the neutralizers, which were not mounted very close to the machanism, did not maintain a temperature equal to that of the moving coil during changes in ambient temperature. To overcome this condition, the bundle of neutralizers was insulated and clamped against the magnet. The resistance then followed a smoother curve.

The instrument was made into a pyromillivoltmeter without cold-end compensator. A calibrating series resistor of manganin was substituted for the customary constantan resistor. These modifications were made

to facilitate accurate tests with a potentiometer. The millivoltmeter was calibrated to a range of 0-1200 deg F, for use with an iron-constantan thermocouple. Full-scale potential was 34.8 mv. The resistances were then as follows at 21 deg C:

Moving coil and springs	104.8
Six Neutralizers in parallel	46.6
Manganin calibrating resistor	91.3

Had the desired calibration been 0-800 deg F, the 91.3-ohm calibrating resistor could have been reduced to a few ohms (which would not seriously affect the compensation) and this low range obtained without altering any other components. The instrument would under these conditions have been a remarkably efficient compensated millivoltmeter, because two-thirds of the available millivoltage would have been applied across the moving coil.

Figure 2 shows the influence of temperature on the instrument, without the 91.3 ohm manganin calibrating resistor. Both the resistance and the milivoltage required to produce full-scale deflection are plotted. The omission of the fixed manganin resistor facilitated the precise observation of variations in the millivoltmeter characteristics.

Figure 2 also demonstrates several interesting characteristics. The resistance and full-scale millivoltage fall to a minimum at approximately room temperature. At low temperatures the neutralizer resistance rises faster than the resistance of the aluminum coil falls. At high temperatures, it is the coil resistance which rises too fast. The minimum full-scale millivoltage occurs at the same temperature as the minimum resistance, demonstrating that the influence of temperature on all factors combined (other than resistance) in an instrument of this type is negligible. Obviously, as long as commercial neutralizers have curved characteristics, it will be necessary to specify the temperature at which the required *DR* is to be obtained.

Commercial Diesel Engine Pyrometer

Following the construction of this experimental model, Bristol undertook to improve the design of its commercially available diesel engine pyrometers. The required changes in specifications seemed relatively small. The design already included the best materials known at the time it was made so as to obtain the highest pos-

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The scientifically designed Phillips Recess automatically centers the driving force and eliminates all driving troubles . . . fumbling, wobbly starts . . . slant-driven screws . . . burred and broken screw heads . . . and dangerous screw driver skids.

Screw and driver "become one unit", making such efficient use of turning power that driving is much easier and faster, regardless of driving method. And, power driving is made practical in most cases.

They cost less to use! Compare the cost of driving Phillips and slotted head screws. You'll find that the price of screws is a minor item in your total fastening expense . . . that it actually costs less to have the advantages of the Phillips Recess!

KEY TO FASTENING SPEED AND SAFETY

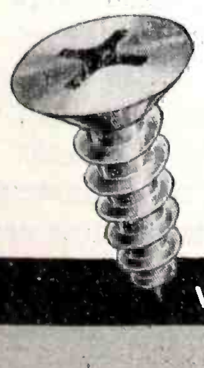
The Phillips Recessed Head was scientifically engineered to afford:

Fast Starting – Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.

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%.)

Easier Driving – Turning power is fully utilized by automatic centering of driver in screw head. Workers maintain speed without tiring.

Better Fastenings – Screws are set-up uniformly tight, without burring or breaking heads. A stronger, neater job results.



PHILLIPS *Recessed Head* SCREWS

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

21 SOURCES

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

sible spring torque modulus, together with a circuit resistance of about 100 ohms and good temperature compensation. The best way to make the desired improvements (especially lengthening the scale) appeared to be the use of a neutralizer with a higher co-efficient. In this way the existing specifications of the electrical mechanism could be retained and the overall circuit resistance could be kept at a desirably high value while greater accuracy of calibration was obtained.

Manufacturing tolerances were such that some of these pyrometers had circuit resistances as low as 90 ohms (total circuit, consisting of moving element, neutralizer, calibrating resistor, thermocouple and connecting leads) while some coils alone were as high as 57 ohms. The thermocouple and leads were standardized at 10 ohms. That left the low resistance of 23 ohms, under the worst conditions, for ambient temperature compensation and calibration.

The moving coils were of aluminum wire, and had a resistance of 52 ohms ±10 percent. Therefore: $DR = 0.004 \times 52 = 0.208$ ohms per deg C. The minimum temperature coefficient that could be used was $-0.208 \div 23 \times 100 = 0.91$ percent per deg C. This was well within the range of coefficients available in negative t.c. resistors.

The preliminary specifications for the neutralizers for this application were:

$DR = -0.2$ ohms per deg C
Resistance as low as possible.

As may be seen in Figure 1, the resistance (NTC type unit at room temperature (20 deg C) was between 11 and 12 ohms. DR was -0.173 ohms per deg C, which was a little low.

Mechanical Mounting Problem

The original resistors were provided with short, stiff leads of molybdenum wire imbedded in the ends. It was difficult to solder extensions to them. Constantan leads were spot welded to the molybdenum wires. But the latter were so brittle and fragile that neutralizer and leads had to be imbedded in a brass capsule. The capsule was bolted to the instrument mechanism. At present these neutralizers are being supplied with sprayed metal ends, to which tinned copper wires are soldered.

Figure 3 illustrates, starting at

How to Select a RECTIFIER

To say one type of rectifier is better than any other type would be as fatuous as saying a bomber is better than a fighter plane. Each is better than the other when accomplishing the specific results for which it is designed.

Thus, the manufacturer of a product employing rectifiers must first determine the results to be obtained and the conditions under which the rectifier will function. Such data are essential when deciding whether Selenium, Copper Oxide or Tungar type of rectifier will do the most efficient, most economical and most satisfactory job.

Since General Electric makes all three — Selenium, Copper Oxide and Tungar — it has no reason to prefer one to the other. It can give you unprejudiced advice on which type is best for your particular requirements.

When next you need a rectifier, why not let G-E Tungar and Metallic Rectifier Engineers analyze your needs and offer their recommendations? Naturally, this engineering consulting service entails no obligation. Address inquiries to Section A-836-119, Appliance and Merchandise Dept., General Electric Company, Bridgeport, Connecticut.

GENERAL ELECTRIC

the bottom, the history of neutralizers used in our diesel engine pyrometers. At the time the change in production was made from imbedded molybdenum terminals to metal sprayed ends, the manufacturer found it necessary to increase the room temperature resistance to 14.5 ohms to obtain the full rate of change $DR = -0.2$ ohms per deg C. It appears that in the neutralizers of low resistance now used the maximum practical temperature co-efficient is 1.4 percent per deg C, rather than 2 percent.

Possible Future Neutralizer Refinement

Some resistance-temperature curves taken recently on sample diesel engine pyromillivoltmeters were similar in character to the one shown in Fig. 2, except that curvature was somewhat more pronounced. A typical example had a resistance of 92.0 ohms at 47 deg C and −15 deg C, and a minimum resistance of 90.8 ohms at 20 deg C, which is an increase of 1.32 percent for 27 deg above normal or 35 deg below. This is excellent performance, considering that the resistance of the aluminum coil, accounting for 56 percent of the total resistance, increased 10.5 percent at 47 deg and decreased 13.5 percent at −15 deg.

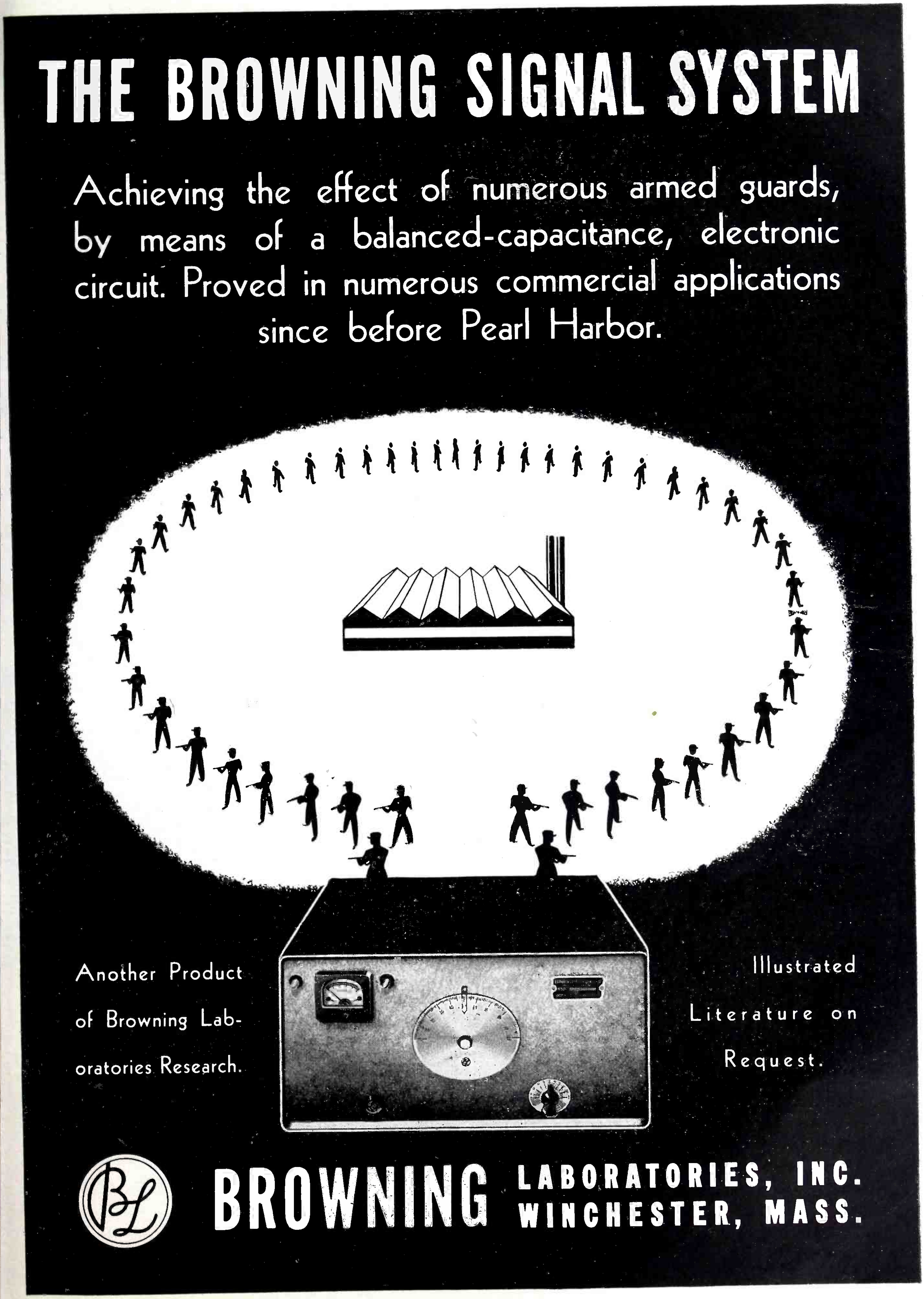
R. R. Hoffman, chief engineer of Keystone Carbon Company, has suggested an interesting method of straightening the resistance-temperature characteristic of a resistor. The principle, illustrated by him in Fig. 4, consists of shunting an NTC unit with a resistor having a very small temperature coefficient. A negative coefficient resistor of sufficiently high resistance must be selected to produce the required DR in the combination and the combination will have a higher resistance than a pure neutralizer. But if the total circuit resistance can be increased about 15 percent without seriously impairing its operation the improvement in accuracy of compensation over a wide temperature range seems well worth while.

The shunt resistor chosen by Mr. Hoffman for his example has a small positive constant temperature coefficient.

Negative T. C. Resistor Stability

The author is also indebted to Mr. Hoffman for Fig. 5 and Fig. 6.

Figure 5 gives the results of a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Achieving the effect of numerous armed guards, by means of a balanced-capacitance, electronic circuit. Proved in numerous commercial applications since before Pearl Harbor.
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Illustrated Literature on Request.
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BROWNING LABORATORIES, INC. WINCHESTER, MASS.

stability test lasting almost four months, recently performed on three NTC resistors. The temperature of the samples was swung cyclicly between two temperatures, as given in the figure. Upon reaching the high or the low temperature level, the resistance of the samples was measured with a wheatstone bridge. The graphs show by what proportion the resistance of the samples departed from the resistances they had the first time they reached the high and low temperatures respectively, each time they returned to those temperatures. The tests on the Type LA-061 (lower half of Fig. 5) are of special interest to instrument designers because at 0.1 watt dissipation self-heating would be negligible. The maximum departures of 2 percent indicated would not, in most instrument compensation applications, be very serious, because the neutralizer would usually not have more than 20 percent of the total circuit resistance.

Figure 6 gives the resistance-temperature characteristics of typical samples. The two lower curves are in the resistance range most likely to interest the instrument designer. The lowest curve pertains to the neutralizer used in the diesel engine pyrometer.

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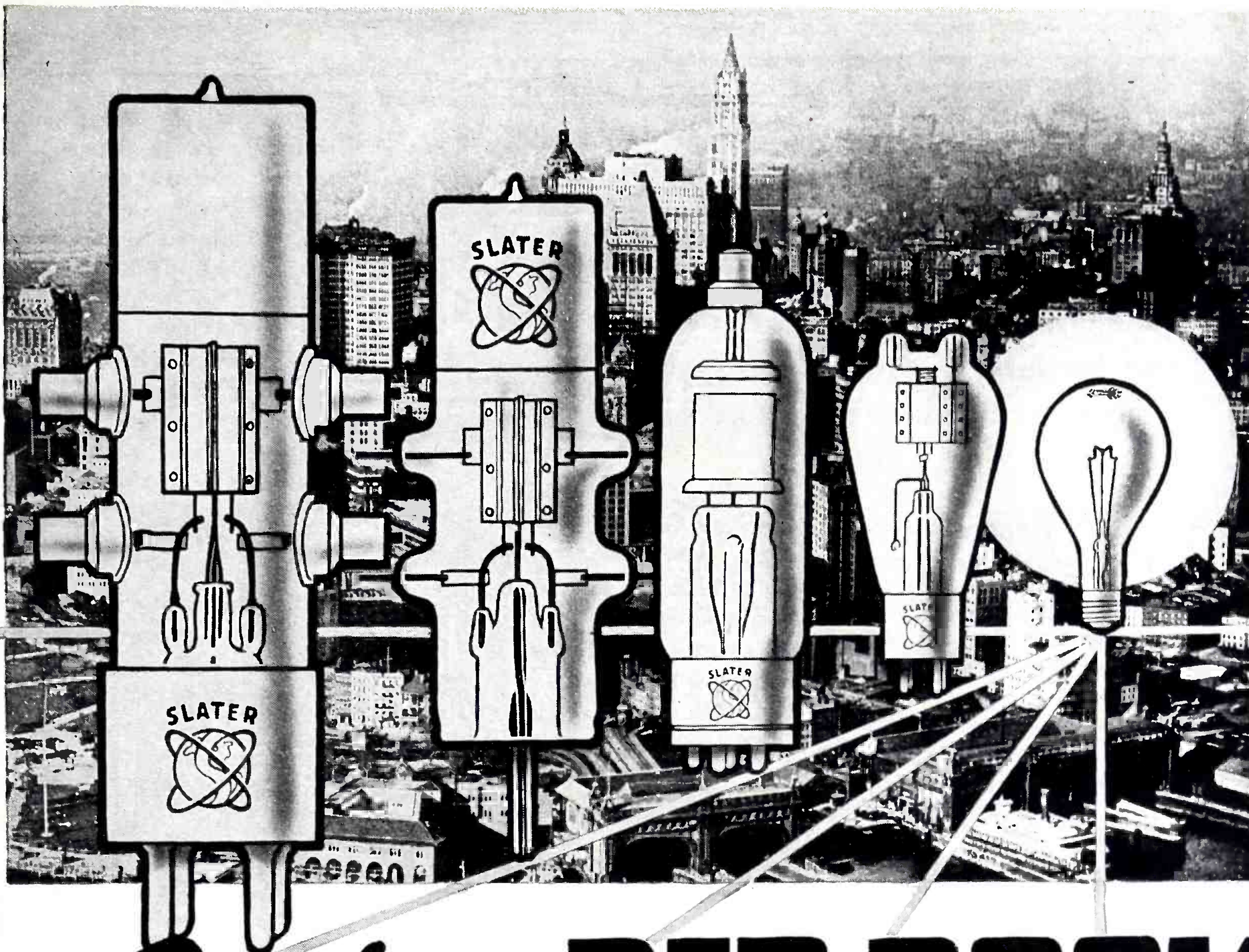

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In the links in the chain of electronic research . . . the study by scientists of tungsten for lamp filaments, and other discoveries related to the lamp, such as the "Edison Effect," were among the milestones of progress toward the electron-tube development. It was, therefore, only natural that Slater's long experience in the manufacture of *incandescent lamps provided a *firm foundation* for making electronic tubes. With engineers versed in the science of vacuum tube manufacture . . . with one of the most modernly equipped plants and laboratories . . . with expert craftsmen skilled in the building of vacuum tubes . . . the Slater organization was ready to keep pace with electronics progress. How well we have done this is evidenced by the broad acceptance of Slater Electronic Tubes by the intra-industries and their use by our Government.

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NEWS OF THE INDUSTRY

Signal Corps gets new Chief, and is reorganized; President congratulates NRL on 20 years of research; engineers needed to fill jobs of physicists; Wall St. hears more about electronics; personnel news

General Ingles Becomes New Chief Signal Officer of Army

MAJOR GENERAL HARRY C. INGLES has been nominated by President Roosevelt to succeed Major General Dawson Olmstead, who retired June 30 at his own request after having held this post for nearly two years.

General Ingles, who is 55, graduated from West Point in 1914 and entered the Infantry, but transfered to the Signal Corps during the first World War. He has held a wide variety of posts, many as an instructor, culminating in responsible positions giving an intimate knowledge of combat operations in two theaters of the present global war. From 1924 to 1926 he was Director of the Fort Monmouth Signal School. He has held important Army General Staff assignments, and was Deputy Commander in the European theater under the late Lieutenant General Frank M. Andrews.

General Olmstead, with an expert staff having decentralized responsibility, carried the Signal Corps through its vast expansion of personnel and operation, including utilization of radar, perfection of wire and radio communications for modern warfare, and the Alcan telephone system, longest carrier system in the world. Only recently he returned from an extended inspection trip covering Signal Corps installations in Alaska, Africa, China, England and South America. General Olmstead will take over a less strenuous assignment as Military Representative on the Telecommunication Board set up under the Secretary of State to guide postwar communications planning.

New Standards for Transformers

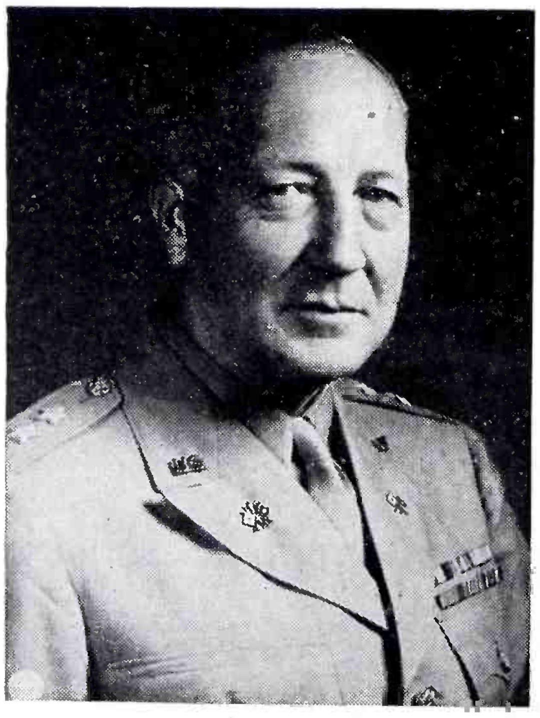
A 90-PAGE VOLUME issued recently by ASA constitutes the most complete set of electrical standards yet published on transformers, regulators, reactors and related induction apparatus. There are six pages of definitions, a 23-page section presenting the new test code for transformers and giving instructions for making acceptance tests to demonstrate that the requirements of the standards have been fulfilled, and a 7-page section giving permissible continuous and short-time loading during operation of transformers and regulators.

These standards represent the culmination of ten years of cooperation and concentrated work on the part of the industry. They supersede numerous other publications and constitute a veritable handbook of data for manufacturers and users of transformers. By specifying that apparatus shall be in accordance with American Standards, the purchaser of equipment is saved much effort in preparing detailed specifications.

The American Standards for Transformers, Regulators and Reactors (Including Test Code and Guides for Operation) may be obtained from the American Standards Association, 29 W. 39th St., New York at $1.25 per copy.

Another new transformer standard, Power and Audio Transformers and Reactors, Home Receiver Replacement Type, covers performance and quality requirements for a simplified list of 14 such units deemed sufficient to service about 90 percent of the radio sets in use. It is obtainable from ASA for 25 cents.

Major General Dawson Olmstead
RETIRED June 30, 1943



Major General Harry C. Ingles
NEW CHIEF SIGNAL OFFICER

Naval Research Laboratories Celebrates 20th Anniversary

IN COMMEMORATION of the formal opening on July 2, 1923 of a laboratory "To increase the safety, reliability and efficiency of the Fleet by application of scientific research and laboratory experimentation on naval problems", celebration ceremonies were held on July 2, 1943 at Naval Research Laboratory in Anacostia, D. C.

After the address of welcome by Rear Admiral A. H. Van Keuren, Director of the Laboratory, addresses were given by Honorable James V. Forrestal, Under Secretary of the Navy, Captain Thomas L. Gatch, former Commanding Officer of Battleship "X", and Dr. Charles F. Kettering, Chairman of National In-

ventors Council and General Motors executive.

In extending congratulations by letter on this twentieth anniversary, President Franklin D. Roosevelt emphasized the importance of the work done by the Laboratory in these words: "Your staff of scientists have engaged upon research problems with the indomitable spirit of the Navy. Sometimes these problems have seemed insurmountable, particularly in the field of detection of the enemy. Our success is proven since we are now able to meet the enemy in the air and on the sea with unsurpassed battle intelligence."

Laboratory Activities

Much of the work at the Laboratory is basic research, fundamental to improvements in the years to come. This has included long, arduous studies of standards for measuring underwater sound vibrations in absolute units, thus establishing the basic principles and design of our modern submarine detectors, and the study of high-frequency radiation and precise methods for their measurement, culminating in our modern radar for detection of the enemy.

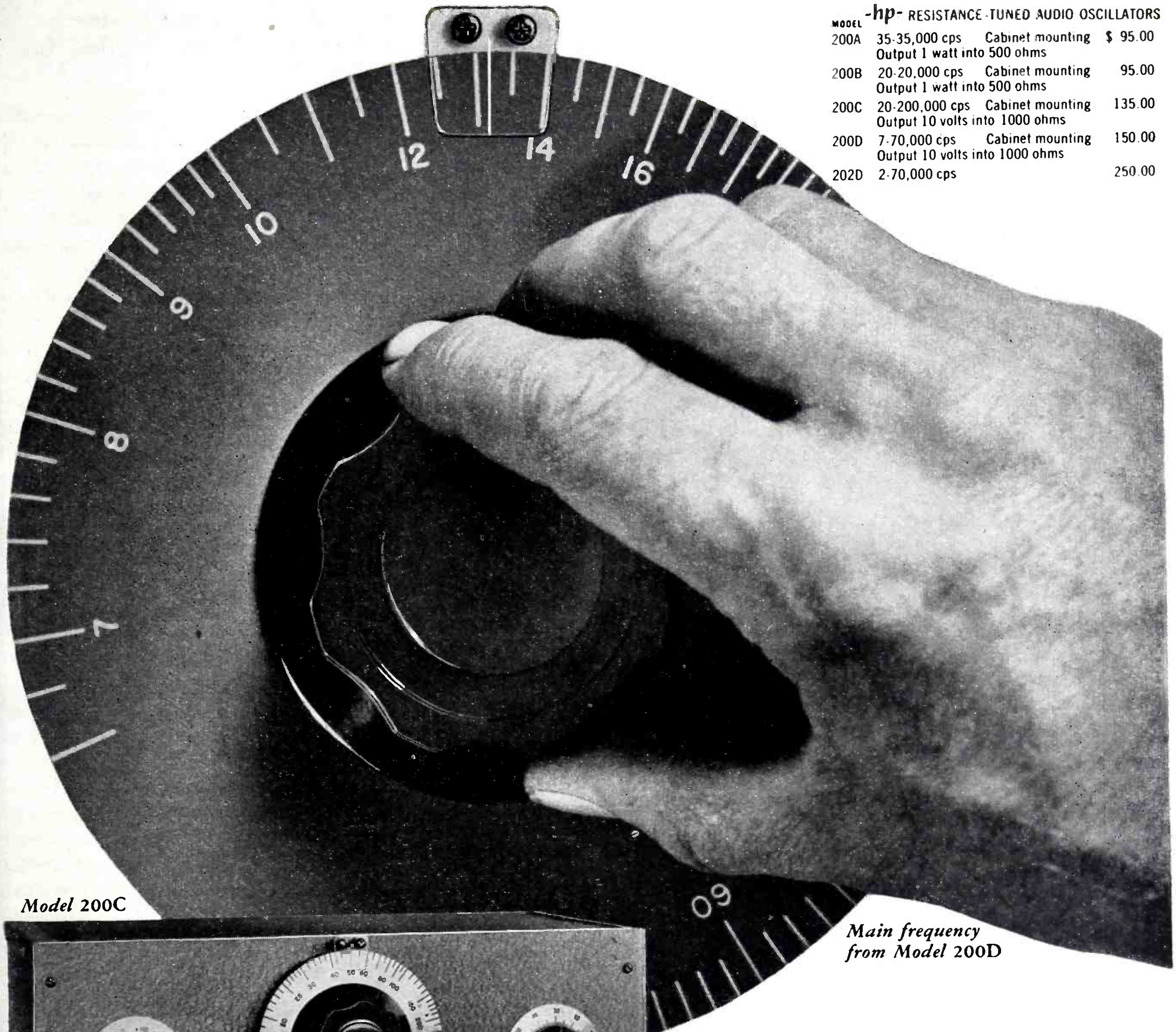
The staff is a permanent civilian organization of scientists, with many Naval officers in administrative posts. These latter are periodically exchanged for other officers in the Fleet, in order that experience with latest Naval developments will be carried back to the Fleet and the immediate problems of the service afloat will be brought into the Laboratory for inspection.

The Radio Materiel School, established in 1929 as a part of the Laboratory, has grown to be one of the major centers for training enlisted personnel in the maintenance of shipborne radio and radar equipment.

The Laboratory has grown to many times the size of those first few buildings on the bank of the Potomac River in 1923, and an annex of several major buildings has recently been built on Chesapeake Bay for tests of radio-locating equipment.

Each development is carried to the point where its application to service requirements has been fully demonstrated, and building specifications have been drawn up for its manufacture by private industry. Activity on a project terminates only when a manufactured model has been developed that passes Navy tests.

MODEL	-hp- RESISTANCE-TUNED AUDIO OSCILLATORS		
200A	35-35,000 cps Output 1 watt into 500 ohms	Cabinet mounting	$ 95.00
200B	20-20,000 cps Output 1 watt into 500 ohms	Cabinet mounting	95.00
200C	20-200,000 cps Output 10 volts into 1000 ohms	Cabinet mounting	135.00
200D	7-70,000 cps Output 10 volts into 1000 ohms	Cabinet mounting	150.00
202D	2-70,000 cps		250.00



Main frequency from Model 200D

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no zero setting

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Just three dials on this audio oscillator: range selector, output voltage control and the main frequency dial. This simplicity of design makes for utmost speed in operation and yet there is no sacrifice in accuracy. Of outstanding importance is the fact that no zero setting is required even during the first few minutes of operation. The frequency stability can be depended upon over long periods as well as the accuracy of the calibrations which are for direct reading.

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Engineers with Physics Training Badly Needed for War Research

THE HEAVIEST DEMANDS for research workers and teachers made upon the Office of Scientific Personnel of the National Research Council are in the field of physics. The supply of persons whose chief training has been in this field is exhausted and persons who can do the work of physicists, either in war research or in teaching, must be sought from other fields. There are large numbers of persons in other fields whose scientific and technical training includes sufficient physics so that they can do work ordinarily requiring physicists. Several hundred such persons are already substituting for physicists in research and in teaching.

Reports of the National Roster upon the shortages of physicists indicate that several hundred more emergency-physicists will be needed. All persons who feel that they may be able to serve in the capacity of physicists, either in research or as teachers of beginning physics in the training programs of the armed forces, should at once communicate with Dr. Homer L. Dodge, Director of the Office of Scientific Personnel, National Research Council, 2101 Constitution Avenue, N. W., Washington 25, D. C.

New Fees for Alien Patents

BEGINNING AUG. 1, 1943, licenses to use enemy-owned patents held by the Alien Property Custodian will be issued for a flat fee of $15 per patent. According to Leo T. Crowley, this arrangement will make it easier for small manufacturers to put single patents to work promptly, and will more equitably compensate APC for work involved in searching out contractual agreements that already exist on specific patents.

The old fee was $50 for the first patent, plus $5 for each related patent in the same license. Class similarity of patents covered by an application will no longer have to be considered, thus speeding up issuance of licenses.

Information on the 40,000 patents and patent applications held by APC can be obtained from Office of Alien Property Custodian, Field Bldg., Chicago, Ill.

Signal Corps is Reorganized

IN PLACE OF the old Signal Supply Services and Signal Operating Services, Major General Harry C. Ingles has as new Chief Signal Officer instituted an organizational setup providing five services:

1. *Procurement and Distribution Services,* headed by newly-promoted Major General W. H. Harrison.
2. *Engineering and Technical Services,* under Major General Roger B. Colton, who will direct all development, research and maintenance activities of the Signal Corps.
3. *Army Communications Service,* under Brigadier General Frank E. Stoner.
4. *Personnel and Training Service,* headed by Brigadier General J. V. Matejka, recently returned to Washington after having served as Chief Signal Officer under General Eisenhower for the Allied Forces Command in North Africa.
5. *Army Pictorial Service,* under Colonel Kirke B. Lawton.

Major General James A. Code, Jr., who was Assistant Chief Signal Officer under retiring General Olmstead, retains that capacity under General Ingles.

Wall St. Watches Electronics

THE PRESENT ACTIVE role of electronics in industry and the postwar prospects in this field were discussed in the last two lectures presented in the Governing Room of the New York Stock Exchange under the auspices of the Institute of Finance. (Previous lectures were reported in the July issue of ELECTRONICS.)

Electronics at Work in Industry

A. C. Monteith, Manager of Westinghouse's Industry Engineering Dept., introduced his resume of rectifiers, carrier current relaying, precipitrons, welding controls, fluorescent lighting and high-frequency heating in industry with the statement that the position of electronics today is somewhat like that which existed when President Jefferson invested 15 million dollars in the Louisiana Purchase. The people vaguely knew they had something potentially great, but didn't dream of its true significance for a good many years

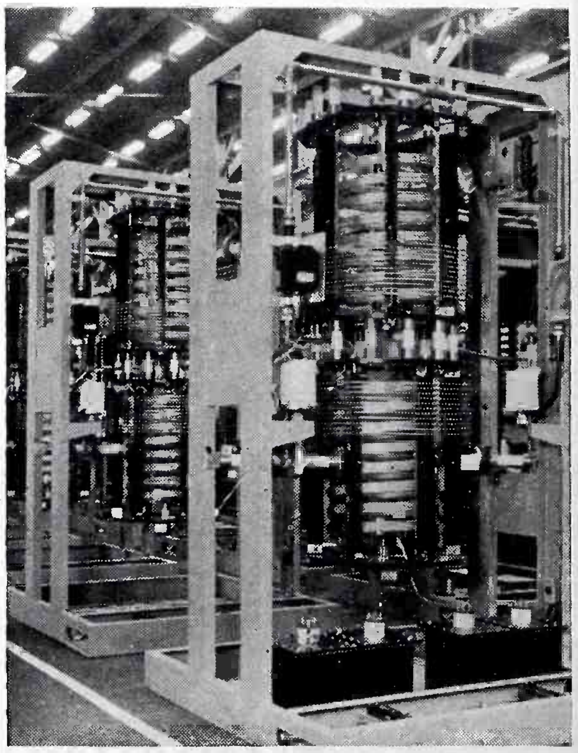
afterward. His conclusion indicated what the nature of this future might be:

"One of the difficulties encountered by the electronics industry in the early thirties was the fact that it was ahead of industrial acceptance at that time. In the meantime, there has been considerable educational work done in the schools; most of the schools have electronics courses now. Industry also has done quite a bit of educational work. Certainly the large number of men in the armed forces who are dealing with electronics and staking their lives on electronics are going to come back with a much better appreciation of the limitations and uses of electronics. And I think we are going to find a greater acceptance of electronics in industry than we have seen displayed in the past.

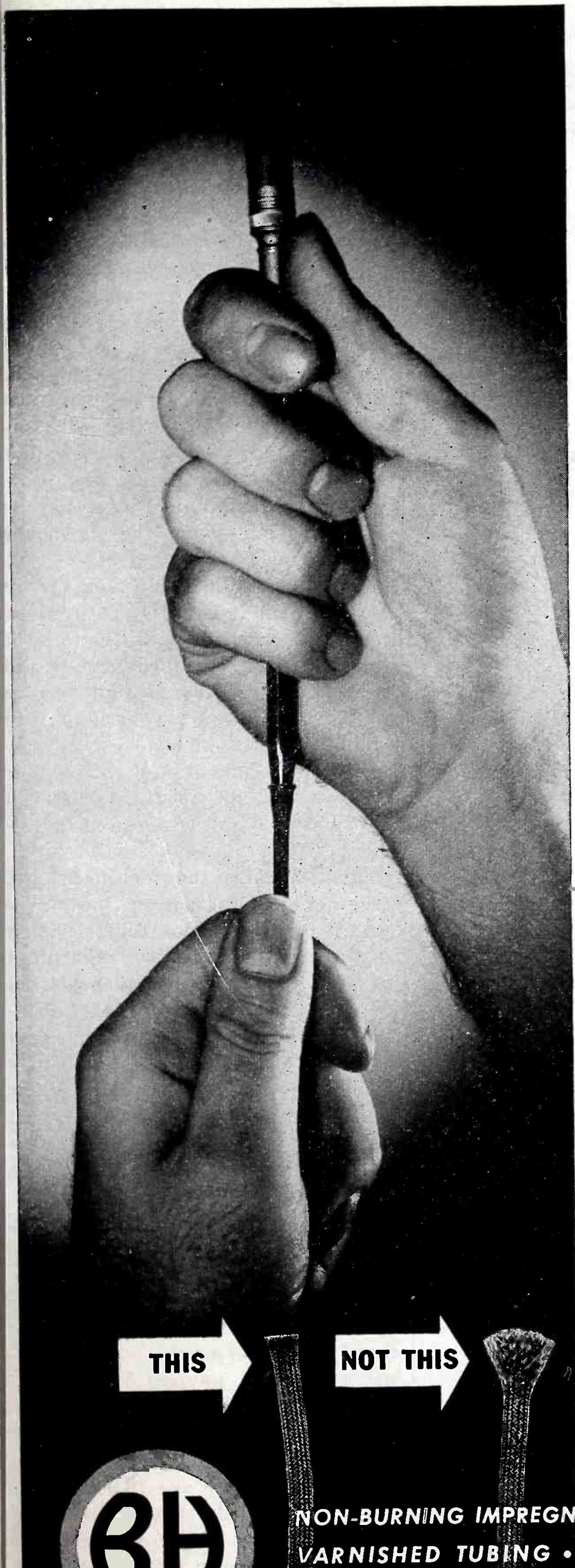
"However, I want to issue one word of caution, as far as the introduction of electronics to industry is concerned. As engineers, we don't want to try to do everything electronically just because electronics is a popular subject at the present time. Let's keep it on a good, sound basis. Let's be sure that the thing we are doing in industry electronically is

• • •

200-KW TUNING UNITS FOR ELECTRONIC FUSING OF TIN



Tuning units for Westinghouse induction heating equipment to be used in fusing tin plate on steel strip. Each unit handles the 200-kilowatt output of a vacuum tube oscillator operating with a d-c plate voltage of 17,000 volts and generating a frequency of 200 kc.



TOUGH TEST

You can easily make proves new "extra flex" Fiberglas sleeving is non-fraying

A new sleeving which we have just developed is as flexible as a piece of string and also non-fraying. A buyer of thousands of feet of sleeving was convinced of its flexibility, but skeptical of our non-fraying claims until he applied a tough test of his own, which you can easily duplicate—this way:

Secure from us a sample of new BH extra flexible Fiberglas Sleeving equal in size to the saturated sleeving you now use. Insert the end of a mechanical pencil into the ends of both the new BH extra flexible Fiberglas Sleeving and your present saturated sleeving and push *hard*. BH extra flexible Fiberglas Sleeving will spread slightly *but without breaking*. The usual saturated sleeving will break down at the edges and separate. As an added test, tap the ends of both pieces of sleeving with your finger. Continued manipulation will produce only the slightest fuzz on the BH extra flexible Fiberglas sample, 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.

doing it better than the mechanical way of doing it at the present time."

Future Thinking about Electronics

Dr. W. R. G. Baker, General Electric vice-president, classified electronics into three broad fields—entertainment, the transfer of intelligence, and the industry and home market—and discussed future prospects of each.

"Probably the thing that today confuses consumers and the public is that they feel another business as big as radio should be developed out of electronics. Maybe that will happen; but today, so far as the public is concerned, electronics represents the mass entertainment business, and to us as businessmen the big money is here too."

Dr. Baker foresees a big future for FM and television, with radar paying back television in the form of improved and simplified circuits and tubes, but believes facsimile to be very, very much in the distant future simply because we don't know how to use the technical possibilities that are now available in a way that will give a return on the required investment.

He advocates that engineers get together and agree on best allocation of frequencies for television and other services now, regardless of what it means to what has been done and to sets now in use. If nothing is done until the war stops, the pressure of keeping labor gainfully employed will probably be so great that there will not be time to do an intelligent job of reallocation. The decisions made may affect us for the balance of our lives. If the problems are not met intelligently now, we may be forced into standards that are not the most desirable.

Commenting on the economics of radar in aviation and in the merchant marine after the war, to permit full-speed navigation in fog, darkness and bad weather, he warns against becoming too romantic about the amount of business to be obtained. If there are 10,000 ships after the war, the market will be saturated after 10,000 obstacle detectors have been manufactured. Likewise, if there are 10,000 transport planes, there will be a good market here only until saturation is reached unless engineers bring out something new. In the mass-production end of communications,


FIRST in Custom-machined PLASTICS
CANVAS BAKELITE
POLYSTYRENE
DUREZ
CATALIN
BAKELITE
MATERIAL: LUCITE
O. D. ½" + .0005 − .0000
INTERSECTION OF CROSSLINES WITHIN .001 OF CENTER.
WIDTH OF LINES .004
LAMINATED BAKELITE
EBONY ASBESTOS
PLEXIGLAS
VULCANIZED FIBRE
FIBRE
LUCITE
SOLVED by BRILHART
TENITE
LINEN BAKELITE
BRASS AND POLYSTYRENE MOLDED TOGETHER
Daily the BRILHART Company through its wide experience and engineering skill breaks new bottlenecks on the war production front in PLASTICS.
In addition to creating new high standards of perfection in machining we also do specialized injection molding of small parts and inserts.
Whether your requirements are design ~ production ~ experimental ~ problematical ~ ...if it's plastic... take it to BRILHART...
First in Custom-Machined Plastics
ARNOLD BRILHART CO.
435 MIDDLENECK RD. GREAT NECK, N.Y.
Phone: GREAT NECK 4054

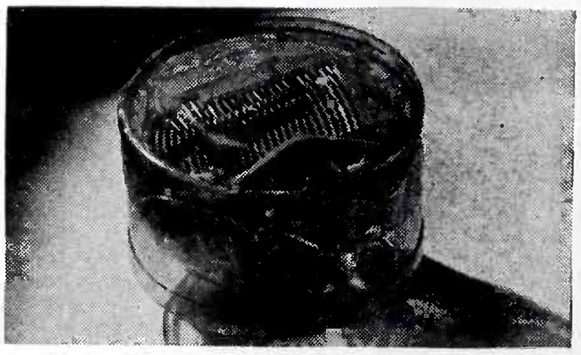
then, we will be dealing with a lot of small markets which, however, can constitute a lot of business taken as a whole.

Electronics as applied to industry is exactly like the science of chemistry. Chemistry is an industrial technique, and so is electronics. In radio, electronics created an industry, but in industry itself, electronics is an adjunct like chemistry.

In conclusion, Dr. Baker advocated serious consideration of merchandising problems so as to avoid repetition of the tremendous discounts, free cruises for distributors who bought so many sets or tubes, dumping of sets, artificial obsolescence of sets through style changes, and the questionable advertising practices in the radio industry in the early thirties. We must face the fact that some of the small companies are doing ten times more business than they did before the war, and they are not readily going to return to their original status.

Tropic-Bound Replacement Parts Are Sealed in Plastic Containers

REPLACEMENT RADIO and radar parts destined for troops in the tropics are being protected against moisture and fungus growths while awaiting use by means of modern "glamour" packaging materials. Each part is wrapped and sealed individually in transparent packaging material, then packed in a rigid transparent plastic container made by Celanese Celluloid Corp. under the trade name Lumarith. Final sealing of the container with moisture-proof tape gives protection against water, grease, mold, poison gas, and extremes of temperature and humidity.



Plug-in coil for a transmitter, packaged for a tropical destination

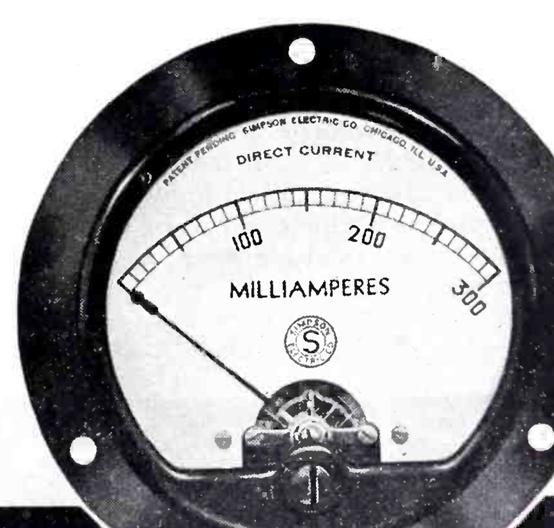
KEEPING THINGS UNDER CONTROL

A WAR MACHINE is an intricate and complicated mechanism, with all its planes, tanks, ships and guns. To keep it functioning smoothly and efficiently requires split-second timing, and precise coordination.

In this vital task of keeping things under control, Simpson Instruments and testing equipment are playing an important part. So our part, here at Simpson, is to produce all the instruments we can, and to make them the best that skill and ingenuity can devise. This we are doing wholeheartedly.

Our only aim is the common cause that today unites all industry and all American workers. If we can make our weapons as good, and as tough, as the men who wield them, victory will be well in hand.

SIMPSON ELECTRIC COMPANY
5200-5218 Kinzie Street, Chicago 44, Illinois



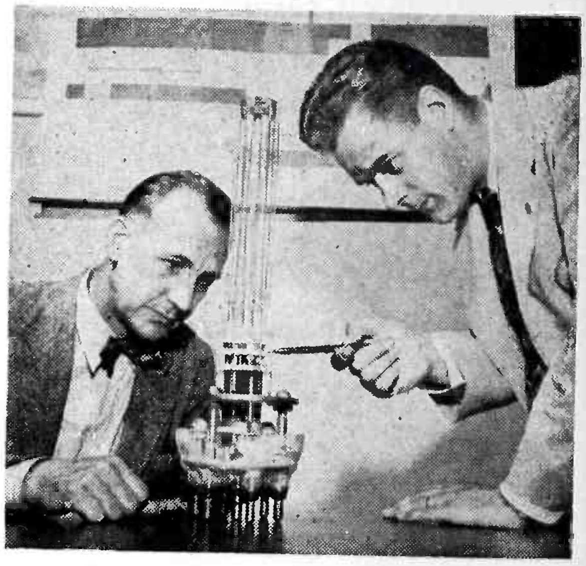
Simpson

INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory

New Electronic Consulting Group

To EXPEDITE present wartime applications of electronic devices, utilize present developments to the fullest extent in postwar applications, and make immediately available to all industries the electronic developments found practical in one industry, Westinghouse has established a group of electronic engineers to serve as consultants and coordinate developmental work on new electronic methods of doing specific jobs.



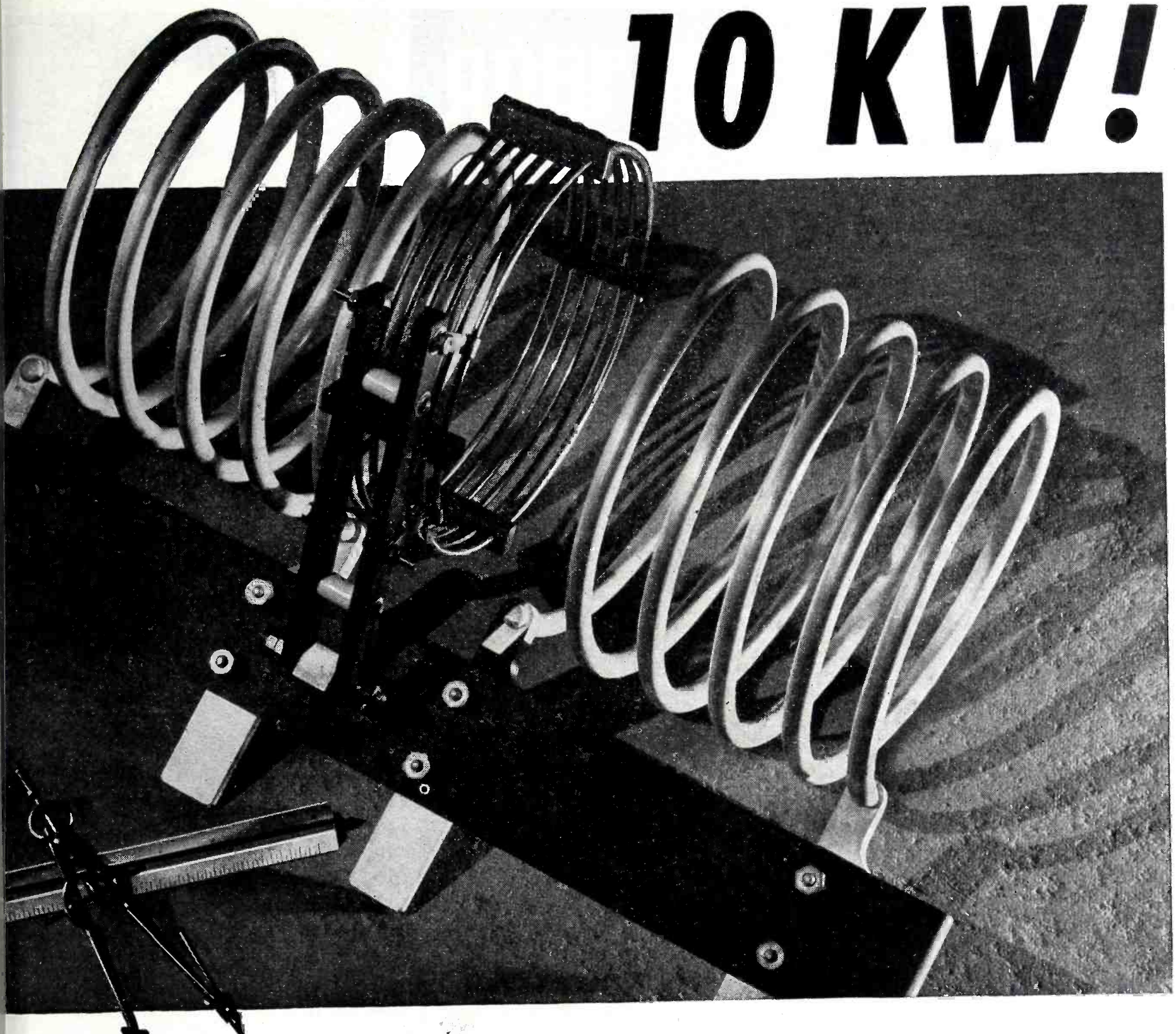
Gordon F. Jones (left) and Carl J. Madsen, senior electronic engineers in the new Westinghouse consulting group, shown examining the elements in a partially dismantled 100-kw oscillator tube

Two senior engineers, Gordon F. Jones and Carl J. Madsen, will head this Industry Engineering group. Mr. Jones has been with Westinghouse for 24 years, with the most recent of his various positions being in Central Station Engineering. Mr. Madsen has had 17 years of electronics experience with Westinghouse, and was recently Section Engineer in the Baltimore plant. He will act as consultant on application work in connection with electronic methods in process and speed control, induction and dielectric heating, and will coordinate educational work in electronics.

Amos Germain, with Westinghouse since 1929 and recently a meter and electronic specialist in the Northwest District, will direct the commercial relations of this electronic group.

In announcing the new setup at a luncheon in New York City attended by editors of technical papers, A. C. Monteith, Manager of the Industry Engineering Department, empha-

10 KW!



...a typical B & W high-power coil

Over 10" in diameter by 20" long, and designed for 10 KW. service, this variable-link final amplifier, plate coil, is a good example of B & W engineering at work on the job of matching modern inductor requirements. B & W Inductors of this general type are available in all standard frequency ranges. Coils are bolted in place, and may be switched for band-changing with a minimum of time and effort. Connections are silver-soldered, and all metal parts, including coils, are heavily silver-plated. Coils in the unit illustrated are of ⅝ copper tubing. Other B & W Air Inductors of this type utilize tubing as large as 1".

FAST DELIVERIES on all B & W Air Inductor types are assured by our greatly expanded facilities, and straight-line production on most smaller types. Engineering data on any type upon request.

BARKER & WILLIAMSON, 235 Fairfield Ave., Upper Darby, Pa.

Air Inductors

"BABIES AND JUNIORS" *(25 to 75 watts)*

STANDARD TYPES *(100 watts to 1 KW.)*

SPECIAL HIGH-POWER TYPES *(to 10 KW. and above)*

B&W

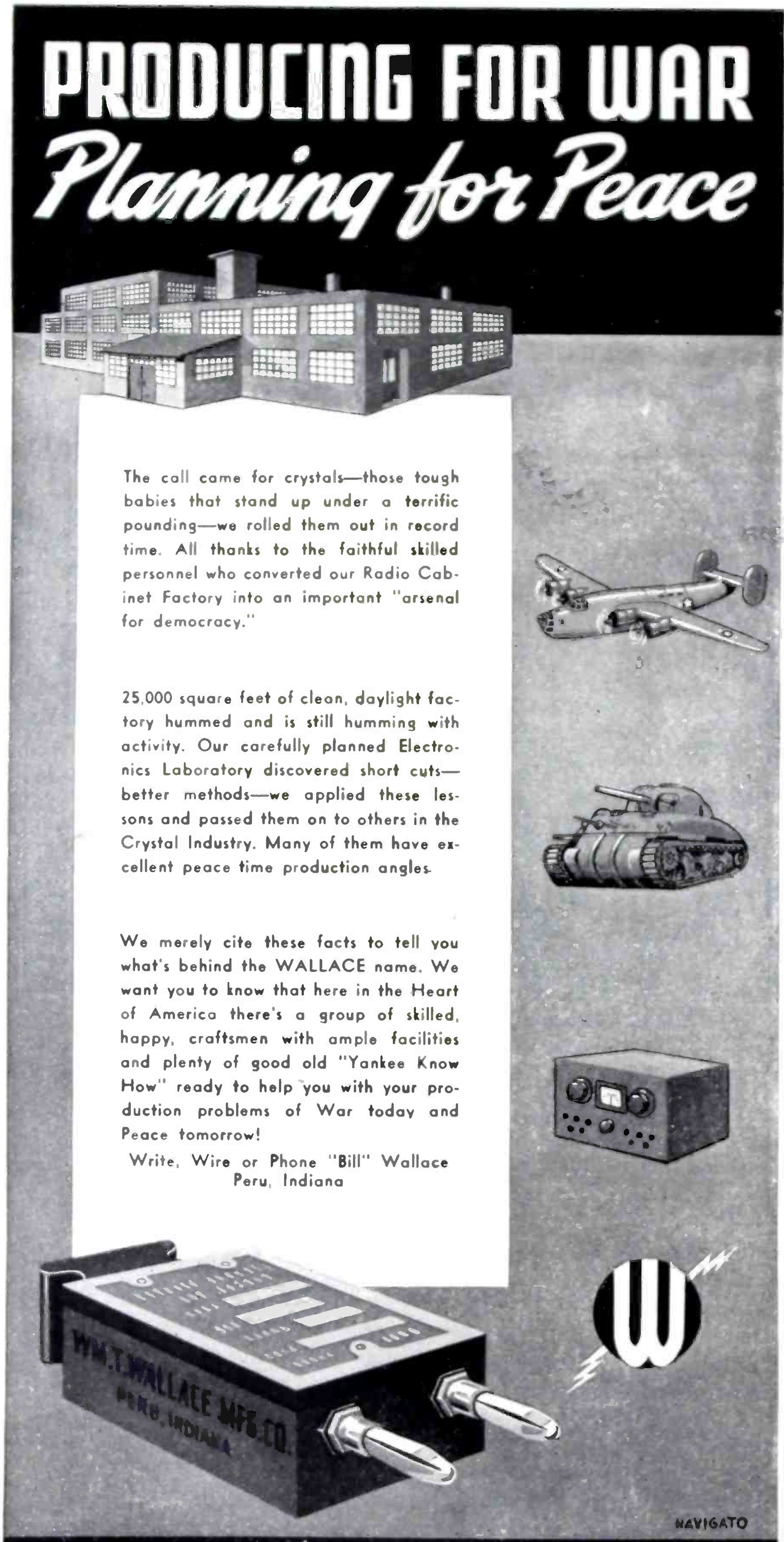
TURRETS — BAND HOPPERS — SWINGING LINK ASSEMBLIES, ETC.

SPECIAL RADIO AND ELECTRONIC EQUIPMENT ASSEMBLIES

Variable Air Condensers

(Integral neutralizing types)

MANUFACTURERS OF QUALITY ELECTRONIC COMPONENTS FOR OVER A DECADE



Amos J. Germain, in charge of commercial relations in the Westinghouse group set up to guide industrial electronic work

sized the importance of appraising each possible electronic application and comparing it with time-tried mechanical methods. With electronics growing so fast, the danger of being swept off our feet increases correspondingly. It will be the duty of this new group to recommend the best method when analyzing industrial applications, regardless of whether or not it is an electronic method.

Movie Shows Electronics At Work

A NEW 20-MINUTE SOUND film in 16 mm print has been made available by Westinghouse for free loan to war plants and engineering and technical societies. Animated drawings show tube construction, explain the six basic functions of electronic tubes, and give operating principles of important electronic applications. Many scenes show actual equipment in use. The chief purpose is to explain electronics in a clear, visual manner to the army of technicians whose wartime duties now include operation of electronic devices.

The film can be obtained by writing to Dept. 7-N, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Light-sensitive devices installed on the new War Department Building in Arlington, Va. reduce fuel consumption by lowering heating system temperatures automatically in a section being warmed by the sun.

FM News

TREE FOLIAGE surrounding an FM receiving antenna can reduce signal strength as much as 50 percent, according to Walter J. Damm, president of FM Broadcasters Inc. Sudden increases in signal intensity were observed in various locations last fall when leaves fell off trees, and careful measurements at regular intervals this spring by Phil Laeser, chief engineer of W55M in Milwaukee, definitely established a relationship between foliage and signal strength.

Signal Corps to Train Women as Inspectors in Radio Factories

UNDER A PROGRAM being launched by the Signal Corps, women are being trained as civilian inspectors for duty in factories producing military radio, radar and telephone equipment. The salary of $1752 a year starts at the beginning of the 6-week training period. Selections of applicants are to be made at local Civil Service Commission offices through interviews and simple aptitude tests. High-school graduation is preferred but equivalent education and experience is acceptable. Those selected will receive training in their home areas. Men are also sought, but must be outside Selective Service age brackets or physically unfit for military service.

Personnel

Major General W. H. Harrison, AT&T vice-president and chief engineer on leave, received his promotion from Brigadier General simultaneously with a transfer from the Army Service Forces to the Office of the Chief Signal Officer.

Raymond F. Guy, speaking at the recent joint IRE-AIEE conference in Cleveland, revealed that the first patents on transmission and reception by FM were applied for in 1902. His talk on FM vs AM emphasized possibilities of program transmission between stations by u-h-f relays.

S. I. Cole, president of Aerovox Corp., was elected a member of the RMA Executive Committee.


DAWN

George M. Muschamp has been appointed to the newly created post of vice-president in Charge of Engineering at Brown Instrument Co. He has directed development of several Brown electronic devices including the flight recorder.

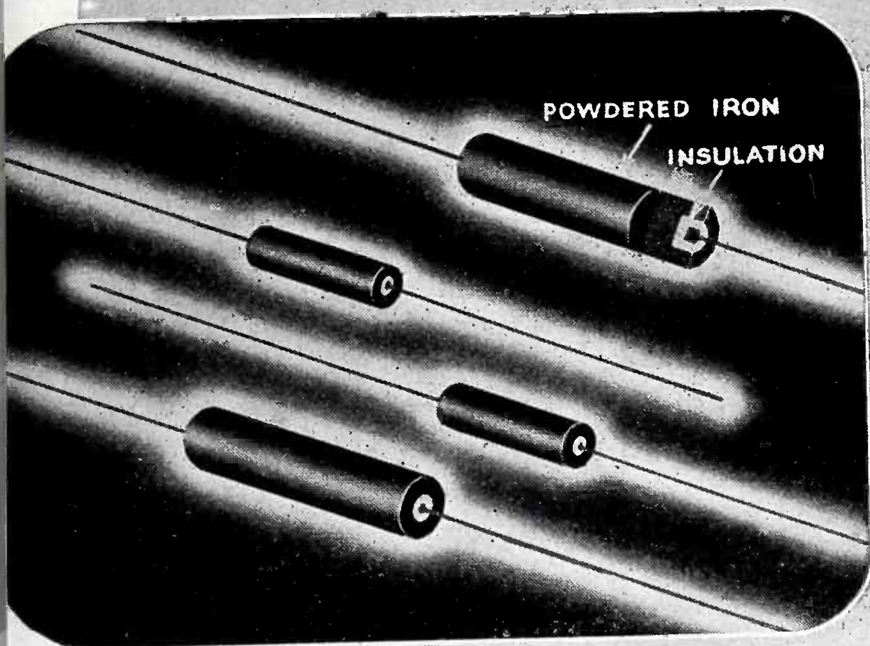
Dr. Joseph Slepian, associate director of Westinghouse Research Labs, was selected as the 14th winner of the gold Lamme Medal, for his contributions to the development of the ignitron, the de-ion circuit breaker and other current-interrupting and rectifying apparatus.

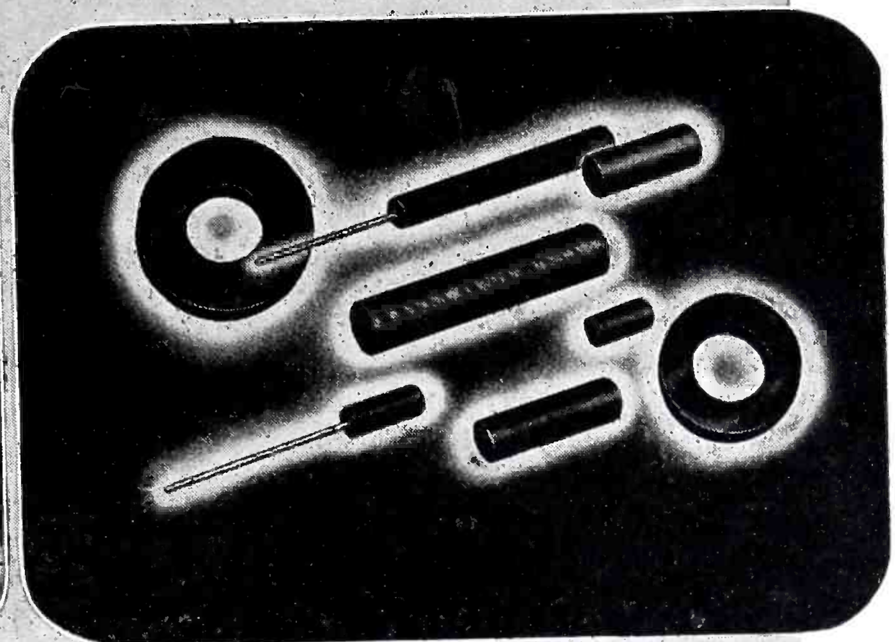
Though receiving thus one of the highest AIEE honors, he has never taken formal training as an electrical engineer. Instead, mathematics predominated in his studies at Harvard, with electrical knowledge being obtained from study of books at night.

Dr. Ettore Bellini, who in collaboration with Commandant A. Tosi produced the Bellini-Tosi system of direction finding, died in January, presumably in Italy.

John Stone, holder of more than 120 radio and telephone patents and past president of IRE, died in San Diego on May 20 at the age of 73. His early patents include a system of radio telegraphy which maintains secrecy of messages automatically, and a radio bearing-determining system for ships.

TWO IMPORTANT NEW IRON CORE DEVELOPMENTS





IRON CORES FOR CHOKE COILS

HIGH-RESISTIVITY CORES

These little units have been designed for use with audio chokes, "hash" chokes, R-F chokes and various others They consist of an iron core having insulated leads and resembling the axial lead-type resistors. These cores reduce the physical dimensions of the choke coil, and the iron serves to increase the "Q". The insulated leads serve as connections to the coil and permit point-to-point wiring. Available in a complete line for present day requirements.

* * *

OTHER STACKPOLE IRON CORES include a complete line for modern high frequency equipment from 40 meg. to 175 meg. and higher; insulated cores, high-resistivity cores; molded iron transformer cores, and various others. Samples to your specifications gladly submitted

STACKPOLE MAKES:

Brushes for all rotating equipment
Carbon, Graphite, Molded Metal and Composition Contacts
Powder Metallurgy Components
Bearings • Anodes
Electrodes
Power Tube Anodes
Brazing Blocks
Welding Rods, Electrodes and Plates
Rheostat Plates and Discs
and various other molded items.

Where cores having high unit resistivity are needed, Stackpole offers a special material showing resistance of practically infinity. Cores of this material are recommended for applications where a resistance of 150 megohms or greater is required, and where voltages do not exceed the breakdown value. The insulation reduces leakage currents and their resultant noise troubles when coil is located on or touching this high resistance core; possibilities of voltage breakdown between coils and cores are greatly reduced; and, in applications using cup cores, this material avoids the necessity for heavily insulated lead wires.

STACKPOLE CARBON CO.
St. Marys, Pennsylvania

STACKPOLE

MOLDED METAL POWDER AND CARBON PRODUCTS

William H. Knight has been appointed director of sales and market research for the Elastic Stop Nut Corporation. The Elastic Stop Nut Corp., manufacturers of self-locking nuts, has plants in Union N. J., and Lincoln, Neb.

Henry Dressel, a member of the engineering staff of Stackpole Carbon Co., has been appointed supervisor of Electronic Components Engineering. He was previously associated with Oak Mfg. Co. of Chicago.

Frank D. Tellwright succeeded F. R. Lack as Director of ANEPA. He is on leave of absence from his position as first vice-president of Pacific Telephone and Telegraph Co., and has been with ANEPA since Feb. 1 of this year.

W. A. Mann has been made assistant manager, Industrial Division, of G-E's Central District, Chicago.

R. M. Cherry is now assistant manager of G-E's Industrial Heating Division. He joined General Electric in 1919 after graduation from the University of Arkansas.

Captain Stanley F. Patten, Assistant Director of the Radio Division of the Bureau of Ships, has been assigned to command duty at sea. He entered Naval service in 1917, has held a variety of radio posts at sea as well as on shore, and was in command of the destroyer USS Alden from 1938 to 1940.

Harrison E. Merkel recently joined the Office of War Information as Officer in charge of its Wire and Overseas Communications Facilities Division. He was formerly manager of the Newspaper Division of Western Union, and has had considerable experience with AT&T, the Navy Bureau of Navigation and as director of wire services for banking firms in New York City.

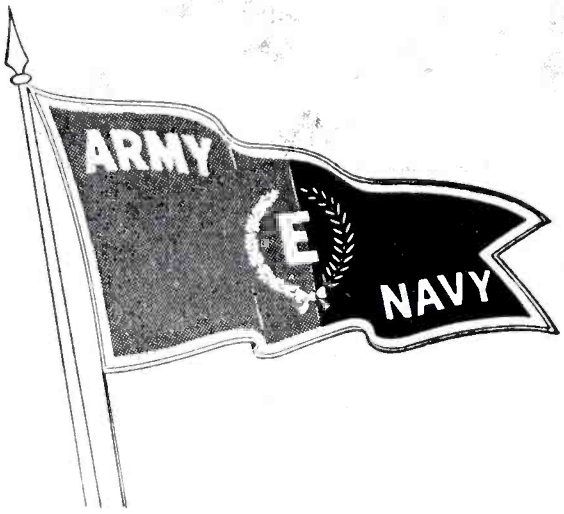
Dr. Ralph L. Power has been promoted to the grade of Senior Inspector in the Signal Corps. He was formerly a radio advertising counsellor, and has been in radio since 1922.

Austin Ellmore is now vice-president in charge of Engineering at Utah Radio Products Co. He has been with Utah for 14 years, and has been chief engineer since 1938.

William J. Knochel is responsible for coordinating the manufacture of electronic tubes in his new position as assistant superintendent of Electronic Manufacturing at Westinghouse.

Carlton Mellick has been appointed sales manager of Goat Metal Stampings, Inc. He recently served in Washington as special WPB representative for the Tin Conservation Division.

Lionel B. Cornwell has joined United Cinephone Corp. as general manager. He was formerly chief engineer for Bendix-Westinghouse Automotive Air Brake Co.



Ace Mfg. Corp.,
Philadelphia, Pa.

Blaw-Knox Co.,
Blawnox, Pa.

Felker Mfg. Co.,
Torrance, Cal.

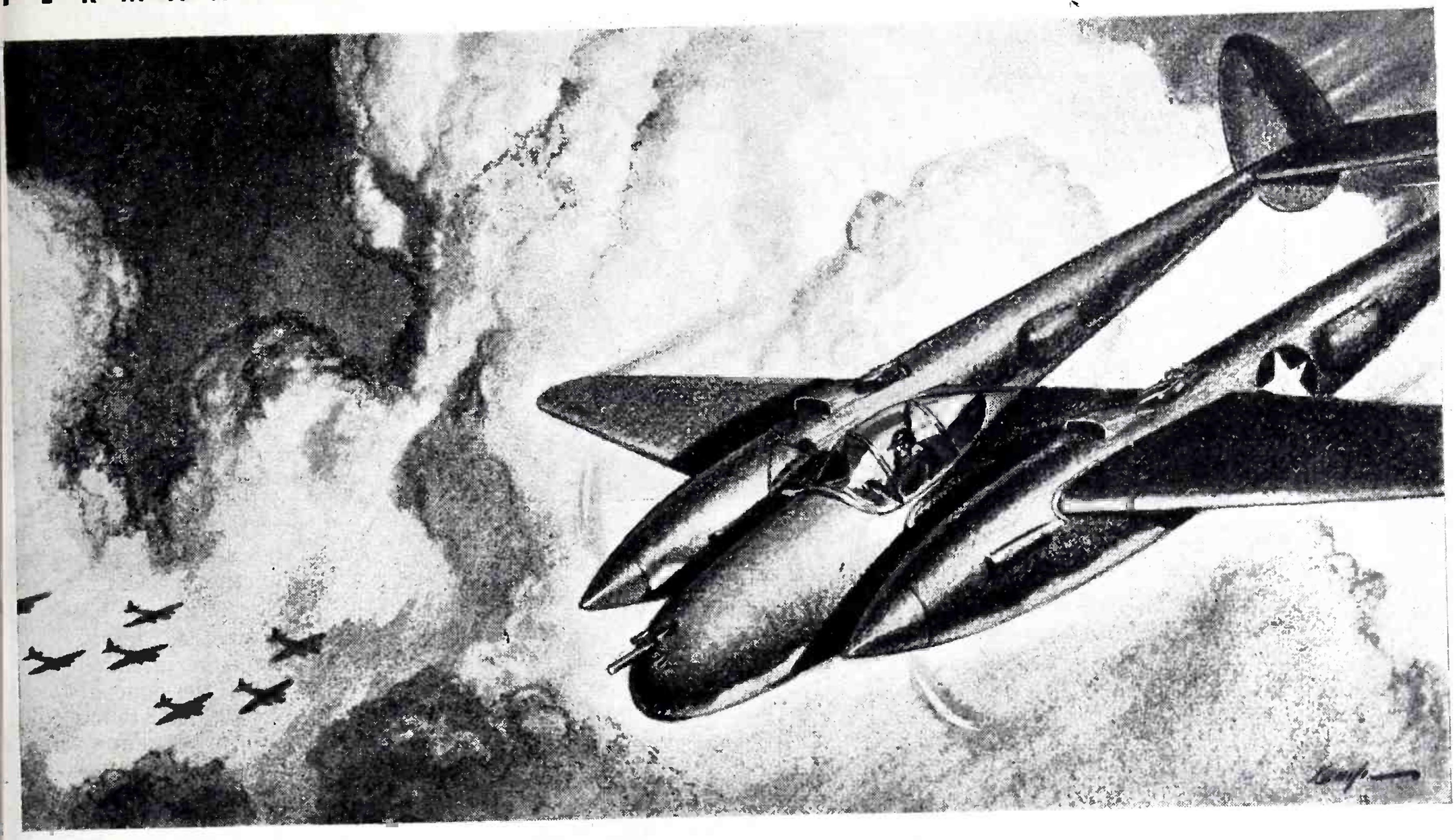
General Cable Corp.,
New York, N. Y.

General Electric Co.,
Plastics Dept., Plant No. 1,
Pittsfield, Mass.

General Instrument Corp.,
Elizabeth, N. J.

Heintz & Kaufman, Ltd.,
South San Francisco, Cal.

Westinghouse Electric & Mfg. Co.,
Meter Div.,
Newark, N. J.



Training Girls

(*Continued from page* 107)

6. Explains profit sharing plan.
7. Discusses method of buying and paying for war bonds.

The third talk is given after the employee has finished the training room Course. In this talk the supervisor covers the following subjects:

1. Explains that in order to insure successful manufacturing it is necessary for any large factory to have a number of closely cooperating departments. He names the departments — engineering, production, planning and wage rate, cost and inspection, and quality control. He also gives a brief and simple explanation of the function of each department.
2. Talks about the factory personnel, the superintendent and his assistant, the general foreman and his assistants, the foremen and leaders and workers. He explains the need for cooperation and stresses, especially, the close relationship of the foremen and the worker.
3. Discusses pay days, and methods of payment, and explains how to make out time reports.

Manual Instruction

The manufacture of tubes covers a variety of different types of work. The requirements of an operator needed to perform different operations satisfactorily vary considerably. Some assembly work is very delicate and requires an operator possessing good eyesight and a high degree of natural skill and dexterity. Ordinary assembly and machine work can be performed by operators possessing average dexterity and skill. The same holds true for glass workers, and these can be roughly divided into the same two types.

Some trainees may have minor deformities or may not possess average skill and dexterity, but they may be good workers if placed on rough work where they are not greatly handicapped by their deformities or lack of natural skill. Naturally, to place this type of operator in an assembly line or other position requiring a fast accurate worker would be a mistake.

All the girls are given manual work practice under the guidance of instructors to teach the elements of motion economy and to impress them with the importance of doing a job in


A Great Family
A GREATLY magnified picture of a few Stewart parts—vitally important although small in size, as practically all assemblies would be useless without them. A "Great" Family in every sense. Great in coverage—meets almost every Terminal requirement in the electrical field. Great because every part is made to highest precision standards—accurately dimensioned and to full standard gauge. Great by reason of the quality of the metals used, assuring maximum strength, durability and long life.
Odd shaped pieces stamped and formed from wire or strip on high speed machines.
Hundreds of items in stock.
Complete Hot Tinning and Plating facilities for handling large orders.
Send for samples and quotations.
Let us have your prints and specifications.
Quick Response to Inquiries
STEWART STAMPING COMPANY
621 East 216th Street, 67, New York
BUY MORE WAR BONDS!
STEWART TERMINALS

the correct way. This also enables us to find out what natural ability each girl possesses and to place her on the type work commensurate with her ability.

Each girl is sent through a series of four different types of work; assembly, inspection, test and glass work. There are three work stations for each of these operations, making it possible to accommodate twelve operators at a time.

The assembly work performed is that of partly assembling one of the many tube types manufactured. It is a combination of rough and fine work. Here the operator is taught the importance of doing the job right and of having an orderly and carefully arranged work place so as to avoid wasteful motion. She is taught how to properly use small tools such as cutters, pliers, and tweezers. She also learns how to make welds with small bench spot welders which are used in nearly all tube assembly operations.

The inspection work is very simple, and the trainee as well as the instructors inspects parts for defects. The work place is laid out in such a manner that the work may be inspected by using symmetrical motions.

The test work is that of operating a simple test set. Here the operator learns to read meters and to set voltages, using controls such as rheostats. The test set is so constructed that switches must be closed and opened in a given sequence or it becomes inoperative. The girl is told of safety features such as safety switches, guards, and lights.

The glass work is that of making a simple splice in hard glass tubing, and it requires a knack to do the job. Some trainees may learn in a short time while others may spend a whole day trying and not succeed.

A record is kept of each trainee's performance at each work station. Grading on all work is done on the basis of accuracy and number of pieces done in a given time after the girl has had sufficient practice.

The training room supervisor and one instructor closely observe and check trainees. Lack of natural ability quickly becomes evident. If a girl shows unusual aptitude for one type of work she is placed on that type of work in the factory. If she is handicapped in any way she is placed on some job within the range of her capability.

They wanted **WIRE**

1/3 *the thickness of* **HUMAN HAIR**

. . . and here you see a magnified photograph of this 0.0009-inch Nickel Alloy Wire knotted around two thick-looking bars which are really two strands of human hair

The strength, toughness and corrosion resistance of INCO Nickel Alloys are available in almost any size product you could name . . . from giant forgings as big as the gate stems in Boulder Dam to wire of split-hair fineness.

The use of the wire illustrated here must be kept secret, but this information can be given. The wire is so fine that a pound of it would stretch more than 80 miles. It is so nearly invisible that the workmen at Driver-Harris Co., who produce it, work by *feel* more than by sight as they draw it through the diamond dies.

Nickel, Monel, "K" Monel, Inconel . . . all can be drawn into wire as fine, or heavy, as you require . . . and, of course, are available in many other forms. All have high strength, toughness and resistance to corrosion. In addition, each alloy has individual properties that make it superior for special uses.

. . .

If you are interested in detailed information about the great range of sizes and forms produced in INCO Nickel Alloys, write for the booklet "Tremendous Trifles." A copy is yours for the asking.

INCO NICKEL ALLOYS

MONEL · "K" MONEL · "S" MONEL
"R" MONEL · "KR" MONEL
INCONEL · "Z" NICKEL · NICKEL

Sheet . . . Strip . . . Rod
Tubing . . . Wire . . . Castings

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK 5, N. Y.

Positive Grid Oscillators

(*Continued from page* 111)

power is delivered to, rather than drawn from this generator so that it may be replaced by a suitable load circuit.

Let the frequency be such that one cycle corresponds to a round trip of the electron, half as high as the frequency previously assumed. Consider an electron which leaves the cathode at an instant when the applied alternating voltage is zero and when the cathode potential is changing in a positive direction. This electron will reach the grid 90 deg later when the cathode potential is a maximum (grid to cathode potential a minimum), and its velocity will be correspondingly reduced. During the following quarter cycle the electron will be decelerated by the retarding field of the plate, which by our assumption is at a maximum because the plate potential is now a minimum. The third quarter cycle finds the electron returning toward the grid, with the plate at its positive maximum so that the electron is again slowed down. During the last quarter cycle the electron approaches the cathode against a retarding field that once more exceeds its normal value. This electron does work upon the external system and will continue to do so through several oscillations.

Now consider an electron which leaves the cathode one half cycle later. This electron arrives at the grid with greater than normal velocity. Since the plate is now swinging in a positive direction the additional velocity will help the electron to strike the plate and remove itself from the system.

Again we generalize to say that all electrons emitted over one half cycle are able to do work upon the external circuit until they are captured by the grid. The electrons emitted during the other half cycle are quickly removed from the system at the grid or plate.

It is important to note that the frequency generated in this case is only half as great as that developed when the grid voltage is allowed to oscillate. This disadvantage is compensated by the fact that oscillations

Precise Load Rating OF LORD BONDED RUBBER MOUNTINGS

RESULTS IN HIGH EFFICIENCY OF VIBRATION ISOLATION

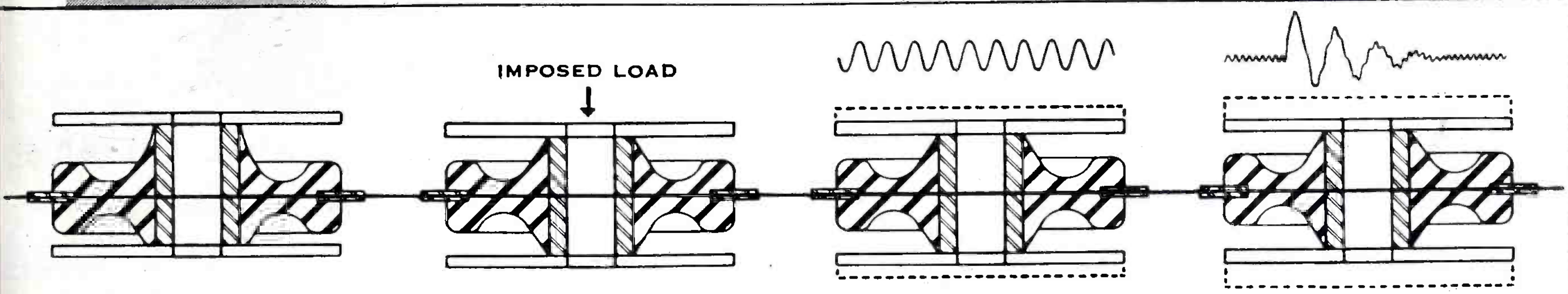


FIG. 1 FIG. 2 FIG. 3 FIG. 4

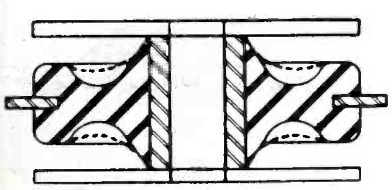


FIG. 5

Operation of Plate Form Mountings

ALL Lord Mountings are designed to operate on the principle of having the rubber "stressed in shear" when load is applied in the direction of the main axis of the mounting. This mounting design provides the required softness and deflection in the direction of the disturbing forces, and stability or resistance to movement in directions normal to the major thrusts, thereby obtaining the highest degree of vibration isolation efficiency.

The proper deflection of a mounting under a given static load is of paramount importance in selecting a suitable means of flexible suspension, and every Lord Mounting is designed to have a definite static deflection under its rated load. Lord Plate Form Mountings (non-snubbing type) are designed to deflect 1/16 inch when rated load is applied.

Illustrations above show a Lord Plate Form Mounting in the various positions it assumes while static or in action:

Fig. 1—Under no load (as shipped from factory). Note extension of center sleeve. Fig. 2—Under rated load; note that center sleeve has deflected 1/16 inch. Fig. 3—Operating in zone of free shear action under normal vibration. Fig. 4—Operating momentarily under sudden shock or in zone of resonance. *(see footnote)

Lord Plate Form Mountings are designed to cover a wide range of applications in every field of industry. They are made in four shapes (round, square, diamond, and holder types) and four sizes, with load ratings ranging from a few ounces to 300 pounds. Load ratings of each size can be varied by:

1—Utilizing different rubber compounds of varying degrees of stiffness to meet specific spring-rate requirements.

2—Changing dimensions of rubber element at flexing point. (See Illustration No. 5)

The remarkable efficiency of Lord Plate Form Mountings is due to the accuracy, precision, and uniform quality of manufacture.

Various factors must be considered when choosing mountings for individual installations. Through proper mounting selection, isolation efficiencies ranging from 75% to 85% reduction of disturbing forces may be expected, although reductions up to 97% are not unusual on equipment operating at very high frequency.

Write for bulletins 103 and 104. They give complete information on all Lord Mountings as well as an engineering discussion on vibration control. Better still, call in a Lord vibration engineer for consultation on your design problems. There is no obligation.

INVEST TODAY IN BONDS FOR VICTORY

**Where frequent shock loads or operation in resonance zone are encountered, the use of Lord Vertical Snubbing Type Mountings is recommended. See Bulletin 103.*

LORD MANUFACTURING COMPANY . . . ERIE, PENNSYLVANIA

Originators of Shear Type Bonded Rubber Mountings

SALES REPRESENTATIVES • NEW YORK, 280 Madison Ave. • CHICAGO, 520 N. Michigan Ave. • DETROIT, 7310 Woodward Ave. • BURBANK, CAL., 245 E. Olive Ave.

are generated even though the grid-plate and grid-cathode transit times are not equal.

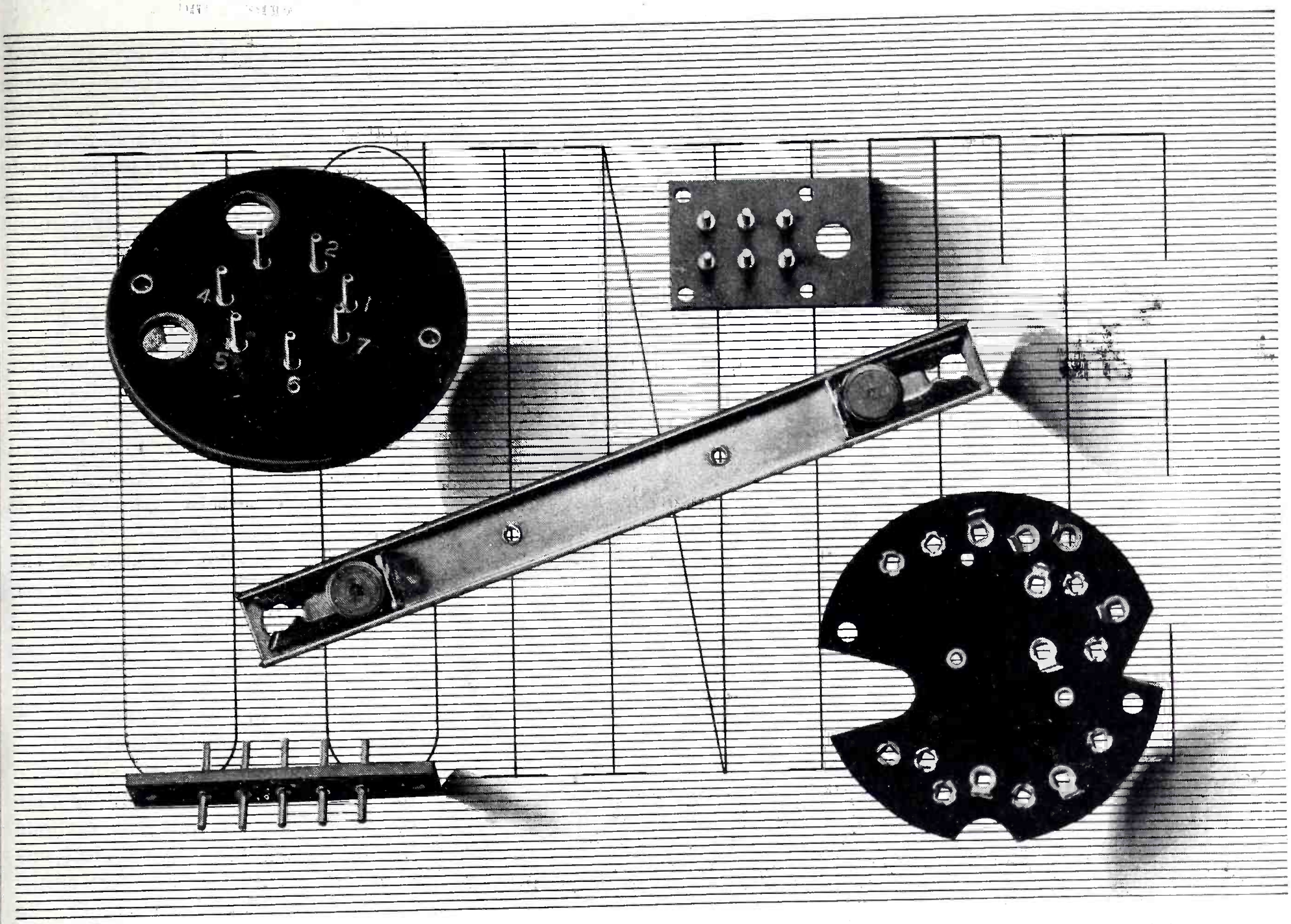
The mechanical model previously described is easily modified to suit these conditions. The two inclined sides now bear a fixed angle to each other, and the trough so formed is merely tipped from side to side at half the frequency previously used. Marbles which emerge from the hopper when the trough is level and the hopper is moving upward are in unfavorable phase and arrive at the bottom of the trough with relatively large speeds by means of which they overrun the far edge and escape to the plate catcher. Marbles which emerge from the hopper a half cycle later give up work to the system and remain for several cycles.

Oscillations in Plate Circuit or Cathode Circuit

Oscillations may also be produced if the grid and cathode have no alternating voltage and the anode voltage is allowed to vary. The demonstration that such oscillations are self-sustaining is similar to the previous ones. All electrons which leave the cathode and pass through the grid have the same velocity at the grid plane because no alternating field exists in the grid-cathode space. Let us assume that the plate voltage oscillates at a frequency such that one full cycle is executed in the time required for the electron to travel from grid to plate and return.

An electron which leaves the grid mesh at a time when the alternating plate voltage is zero and is changing in a positive direction is retarded by a less than normal field during its transit to the plate, and therefore strikes the plate and is lost. An electron which leaves the grid mesh half a cycle later is retarded by a more than normal force and therefore is unable to reach the plate and comes to rest somewhere near the plate. The alternating component of the plate voltage now reverses so that the electron is less than normally accelerated in the return to the grid. Evidently the operation outlined above is adequate to support oscillation, provided that virtually all the electrons returned to the grid are lost, for the electrons of favorable phase react upon the plate twice as long as those of unfavorable phase.

Actually, however, a considerable number of the electrons returned



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The laminated bakelite assemblies that we are turning out in such large quantities at Ucinite are on a made-to-order basis. We make them all types, kinds and sizes. And every order gets the same care in designing, the same precision in fabricating and assembling, the same thoroughness of inspection.

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from plate to grid pass into the grid-cathode region and again return through the grid mesh toward the plate. These will be in a phase to aid the oscillation if the grid-cathode transit time is equal to or is an integral multiple of the grid-anode transit time. If this relation is not approximately correct the number of electrons in unfavorable phase at the plate is increased and the chance of oscillation is greatly diminished.

Here, as before, it is desirable but not absolutely necessary that no direct voltage difference shall exist from cathode to anode. The selection of favorable vs. unfavorable phase is much better effected at the plate than at the cathode. In this case the generated wavelength is given by the equation of the Table

$$\lambda_a = 2000\, d_a V_k^{-1/2} \quad (2)$$

with provision that

$$\lambda_k = 2000\, d_k V_k^{-1/2} = n\lambda_a \quad (3)$$

where n is some small integer.

An oscillation extremely similar to the one just described may be produced by allowing only the cathode voltage to oscillate. Again electrons of unfavorable phase are best eliminated at the plate. If $V_k = V_a$ the wavelength is given by the relation

$$\lambda_k = 2000\, d_k V_k^{-1/2} \quad (4)$$

with the provision that

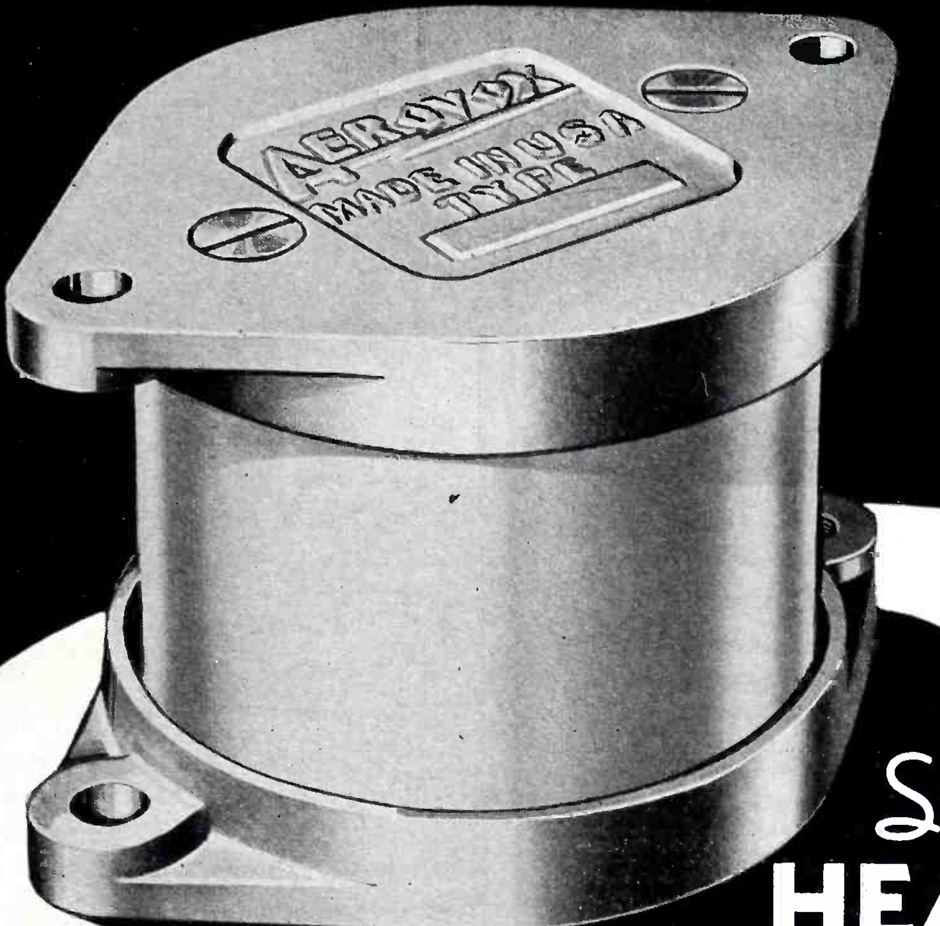
$$\lambda_a = 2000\, d_a V_k^{-1/2} = n\lambda_k \quad (5)$$

where n is again a small integer. The symbols used are those of the Table.

It can be shown that all these different modes of oscillation may exist in tubes with either cylindrical or plane electrodes. The processes of amplitude selection and phase selection are not essentially affected, and the wavelengths are not greatly different. In general the cylindrical arrangement is more convenient in manufacture, and the fact that it yields somewhat higher frequencies than the plane structure for given spacings is in its favor.

For cylindrical structures the mode of oscillation in which only the plate voltage swings is attractive in that a small grid-plate spacing may be achieved without an excessively small grid area. A very high resulting frequency is indicated. For d = 0.0005 meter (0.5 mm) and V = 100 volts the value of λ is approximately 0.1 meter (10 cm).

The mechanical model corresponding to these last two modes of oscil-



AEROVOX 1940 SERIES

Type 1940: 8" dia. x 10" tall. .00001 mfd. 35000 v., to .01 mfd. 15000 v.

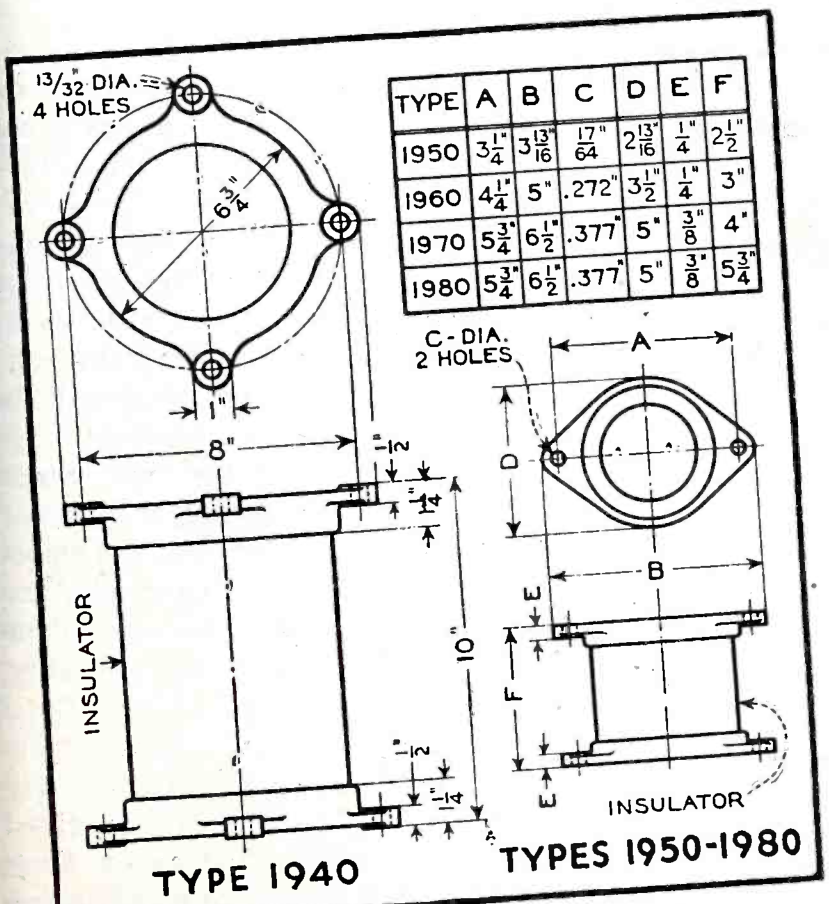
Type 1950: 3¼" dia. x 2½" tall. .00001 mfd. 6000 v., to .02 mfd. 3000 v.

Type 1960: 4¼" dia. x 3" tall. .00001 mfd. 15000 v., to .25 mfd. 1000 v.

Type 1970: 5¾" dia. x 4" tall. .00001 mfd. 20000 v., to .5 mfd. 1000 v.

Type 1980: 5¾" dia. x 5¾" tall. .00001 mfd. 35000 v., to .05 mfd. 5000 v.

Stack-Mounting HEAVY-DUTY Mica Capacitors



TYPE	A	B	C	D	E	F
1950	3¼"	3 13/16"	17/64"	2 13/16"	¼"	2½"
1960	4¼"	5"	.272"	3½"	¼"	3"
1970	5¾"	6½"	.377"	5"	3/8"	4"
1980	5¾"	6½"	.377"	5"	3/8"	5¾"

● Climaxing an outstanding selection of mica receiving and transmitting capacitors—from tiny "postage stamp" molded-in-bakelite types to the extra-heavy-duty micas—Aerovox offers its stack-mounting or 1940 series as standard items (subject to priorities, of course). Heretofore made in limited quantities, these capacitors are now in regular and large production. Note these quality features:

Special cylindrical low-loss glazed ceramic case. Long creepage path between terminals. Design eliminates corona losses inside and out, and provides uniform voltage gradient. Cast-aluminum terminals insure low contact resistance between units.

Sections of finest grade India ruby mica dielectric, made to very close tolerance to equalize loading of series-connected sections.

Units conservatively rated to withstand surge voltages above rated values. Extremely low power factor to handle heavy kva. loads without overheating. Vacuum-impregnated sections imbedded in low-loss filler, reducing stray-field losses and safeguarding against moisture entrance. Mica stacks rigidly clamped in low-loss non-magnetic clamps, and heat-treated for maximum capacity-temperature stability.

• Ask for DATA . . .

Engineering data on these stack-mounting and other extra-heavy-duty transmitting capacitors, available on request.

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lation has one side permanently fixed. The swinging side oscillates at the frequency given in the initial description of the model. The process of eliminating the marbles which are introduced in unfavorable phase is accomplished as before, and the entire operation is very similar to that previously described.

Frequency and Wavelength of Oscillation

The frequency of an alternating current is the number of complete cycles described per second and is therefore equal to the reciprocal of the time required for one cycle. This time, called the period, is usually designated T. Thus

$$f = 1/T \qquad (6)$$

The length of the wave produced in free space by a given frequency is often useful. It is understood that the wavelength in free space is meant whenever the term wavelength is used. The wavelength is defined by the identity

$$c = f\lambda \qquad (7)$$

where c is the velocity of light in meters per second and λ is the free-space wavelength in meters. Combining the two we have

$$\lambda = c/f = cT \qquad (8)$$

It has been shown that oscillations may occur at any of several frequencies corresponding to the different transit time involved. These frequencies, together with the associated wavelengths, are presented in the Table. The subscript a refers to the grid-anode transit time, the subscript k refers to the grid-cathode transit time, and the subscript t refers to the sum of the two. Since $G(y)$ and $F(x)$ are less than 1 for typical cases it is seen that the wavelengths for cylindrical electrodes are typically less than those for plane electrodes of comparable spacing. Numerical values for $F(x)$ and $G(y)$ for dimensions of cylindrical structures encountered in practice are given in Fig. 4. For any specified tube structure the values of $F(x)$ and $G(y)$ are taken from the curves and inserted in the equations for cylindrical grid tubes.

The Spiral Grid Tube

The Barkhausen oscillator as ordinarily constructed is not satisfactory for frequencies much above 600 Mc per second. In order to obtain higher frequencies the spacings must be reduced and the voltages increased. Both steps are disadvantageous in

that a smaller structure is called upon to dissipate a larger amount of power. The spiral-grid tube as described by A. G. Clavier* is useful to much higher frequencies, in the order of 5000 megacycles.

In this tube the grid takes the form of an open (unshorted) helix surrounding an axial filament. The plate, a concentric cylinder, is ordinarily supported at the middle and is maintained at a high negative voltage with respect to the filament. The output is taken from the two ends of the grid, which is maintained at the usual high positive potential. The generated frequency is much higher than that predicted by the simple theory of free electron oscillations. Experiment shows that it is primarily dependent upon the resonant properties of the grid and associated load, and is essentially independent of the applied voltage. The exciting mechanism is entirely dependent upon transit time effects. The construction of one of these tubes is shown in Fig. 5. The filament, usually of pure tungsten, is supported in tension between two end supports. The grid, formed of tantalum or some other highly refractory metal, is an open spiral concentric with the filament. The ends of the grid are supported by two relatively heavy rods which form the output terminals. They pass directly through the hard-glass envelope to the load circuit, which is usually a parallel-wire or Lecher system. Evidently, then, these rods are themselves part of the output line. The plate, which forms no part of the high-frequency circuit, is supported at the middle by a single rod or bar. Thus the entire structure is very symmetrical and simple in comparison with conventional receiving tubes.

Fay and Samuel* describe extensive tests on some seventy different experimental tubes of this sort. The frequency range from 500 to 2000 megacycles was covered. The most significant result of this work is a relation between the expanded length of the grid coil and the frequency at which optimum oscillating conditions exist. The ratio of expanded length

* Clavier, A. G., The Production and Utilization of Micro-Rays, *Electrical Communication,* 12, 3, 1933.

* Fay, C. E. and Samuel, A. L., Vacuum Tubes for Generating Frequencies above One Hundred Megacycles, *Proc. I.R.E.,* 23, 199, 1935.

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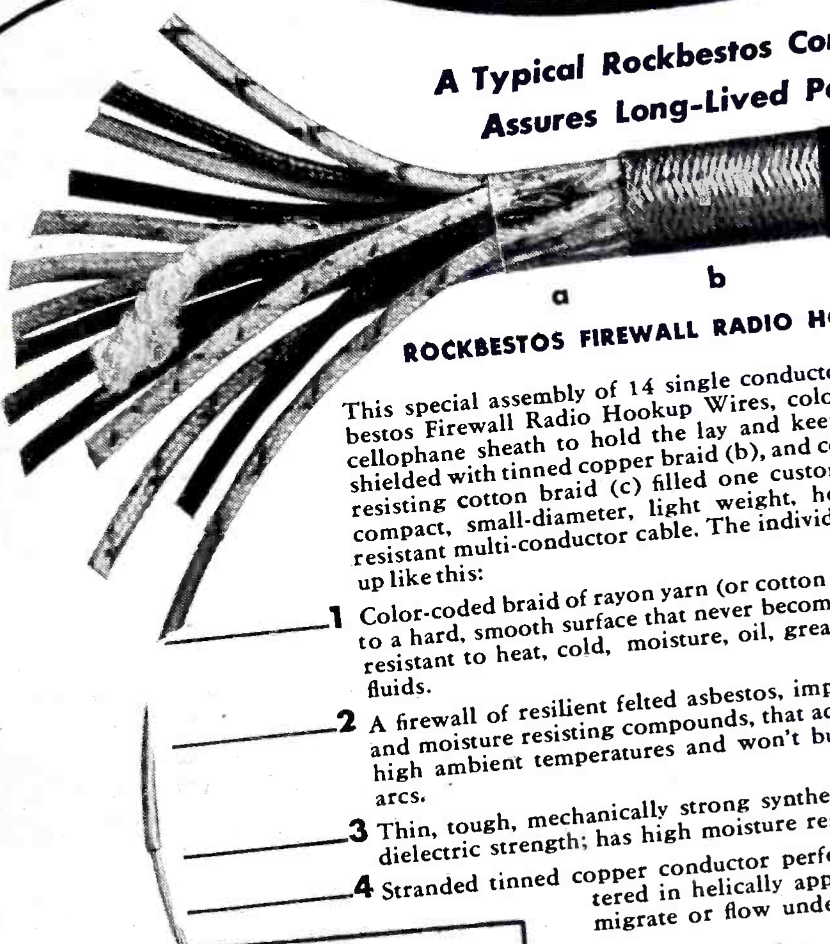
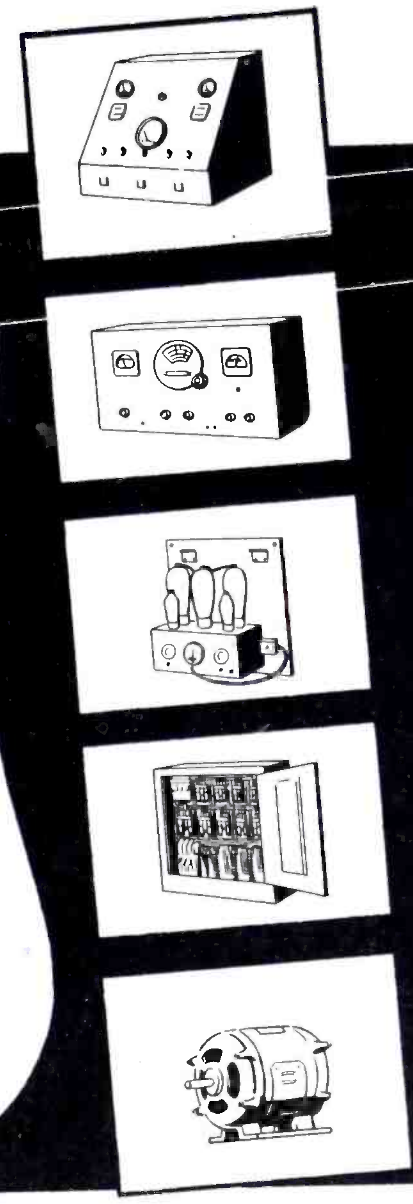




ROCKBESTOS FIREWALL RADIO HOOKUP CABLE

This special assembly of 14 single conductor No. 22 AWG Rockbestos Firewall Radio Hookup Wires, color-coded, cabled with a cellophane sheath to hold the lay and keep the braids clean (a), shielded with tinned copper braid (b), and covered with an abrasion-resisting cotton braid (c) filled one customer's requirement for a compact, small-diameter, light weight, heat, flame and moisture resistant multi-conductor cable. The individual conductors are made up like this:

1 Color-coded braid of rayon yarn (or cotton or glass) lacquer-finished to a hard, smooth surface that never becomes gummy or tacky and is resistant to heat, cold, moisture, oil, grease, gasoline and cleaning fluids.

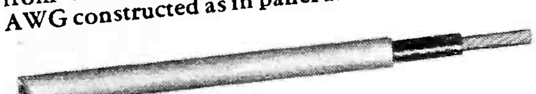
2 A firewall of resilient felted asbestos, impregnated with heat, flame and moisture resisting compounds, that acts as a heat-barrier against high ambient temperatures and won't burn under copper-melting arcs.

3 Thin, tough, mechanically strong synthetic tape for uniform high dielectric strength; has high moisture resistance.

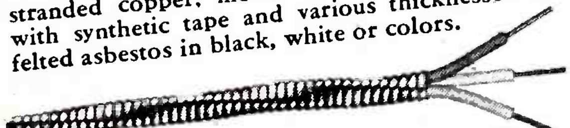
4 Stranded tinned copper conductor perfectly and permanently centered in helically applied insulation that will not migrate or flow under heat.

**One of more than 122 different wires and cables developed for severe operating conditions by Rockbestos.*

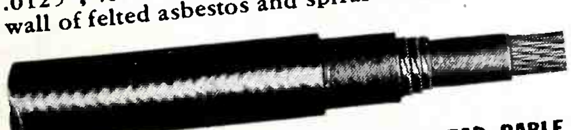
ROCKBESTOS FIREWALL RADIO HOOKUP WIRE
The first light weight, small diameter, flame resistant hookup wire, designed in 1937 and widely used since in aircraft radio, ground installations and instruments. Operating temperature range from 125°C to minus 50°C. Sizes No. 22 to 4 AWG constructed as in panel above.



ROCKBESTOS TYPE CA LEAD WIRE
Has high dielectric strength plus high moisture resistance for use where heat and humidity is encountered. Sizes No. 20 to 8 AWG solid or stranded copper, monel or nickel conductors with synthetic tape and various thicknesses of felted asbestos in black, white or colors.



ROCKBESTOS THERMOSTAT CONTROL WIRE
For low voltage signal and intercommunicating systems and heat control devices. Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125", .025" or (for 115 volt service) .031" wall of felted asbestos and spiral metallic armor.



ROCKBESTOS A.V.C. 600 VOLT MOTOR LEAD CABLE
A heat, flame, oil, grease and moisture resistant cable for coil connections and motor leads. Sizes No. 18 AWG to 1,000,000 CM insulated with laminated felted asbestos and varnished cambric and covered with a rugged asbestos braid.

In step with the electronic developments of today are the 122 standard types of *permanently insulated* wires, cables and cords developed by Rockbestos to give dependable performance under severe or unusual operating conditions. Each and every one has built-in *permanent* characteristics that provide resistance to heat, flame, cold, moisture, oil, grease, alkalies, caustics and corrosive fumes . . . *a permanent insulation* for long-lived service.

The Rockbestos line includes wires that are unaffected by insulation-baking temperatures up to 125°C or frigid cold as low as minus 50°C . . . wires that are small in diameter, light in weight, yet possessing unusually high dielectric strength. A few of the standard constructions are illustrated and others are available in sizes ranging from No. 30 AWG to 2,500,000 CM in voltages from 300 to 5000.

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of the grid to the wavelength of optimum performance was found to be closely equal to 1.2 with few significant deviations. The ratio of plate diameter to grid diameter was approximately 2.5. In all tests a rather high negative voltage was applied to the plate, and in all cases the efficiency was low, in the order of 0.5 to 1 percent.

Spiral-grid Barkhausen oscillators are subject to a certain amount of trouble due to parasitic oscillations. That is, undesired oscillations of a frequency far removed from that of the desired oscillation may result if the load tuning or applied voltages are distributed by a small amount.

The Divided Plate Oscillator

A very interesting and important variant of the spiral-grid tube was developed by W. D. Hershberger.* This tube, which is illustrated in Fig. 6, differs from the normal spiral-grid tube only in that the plate is divided into three equal sections by transverse cuts. Two important advantages are made possible by this division. The various sections of the plate may be operated at different direct potentials, and resonant circuits may be connected between them.

The operation of this tube is not essentially different from that of the normal spiral-grid tube. In fact, it is essentially an idealization of that operation. The central portion of the grid and plate contribute little to the operation, while the end sections oscillate in a pure push-pull or symmetrical fashion at or very near the natural frequency of the grid spiral. Since the central section of the structure does not contribute to the useful operation it should be rendered inactive in order to avoid unnecessary power dissipation. This is accomplished by applying a suitable higher negative bias to the central portion of the plate. When this voltage is properly chosen the central grid section draws little or no current. The electrostatic field pattern which results tends to crowd the current toward the outer portions of the end sections where it is most effective.

A very marked improvement in performance results if suitable reso-

* Hershberger, W. D., Modes of Oscillation in Barkhausen-Kurz Tubes, *Proc. I.R.E.*, 24, 964, 1936.

nant lines are connected to the two plate sections as well as to the grid ends and if these lines are coupled together. It is found that the plate line is several times as effective as the grid line in setting the frequency of oscillation and that the frequency is virtually independent of the grid voltage. In one test, the frequency was observed to change by only 0.1 percent for a 10 percent change of grid voltage. Since high frequency-stability is very important and is generally difficult to achieve at these frequencies this feature is of great interest.

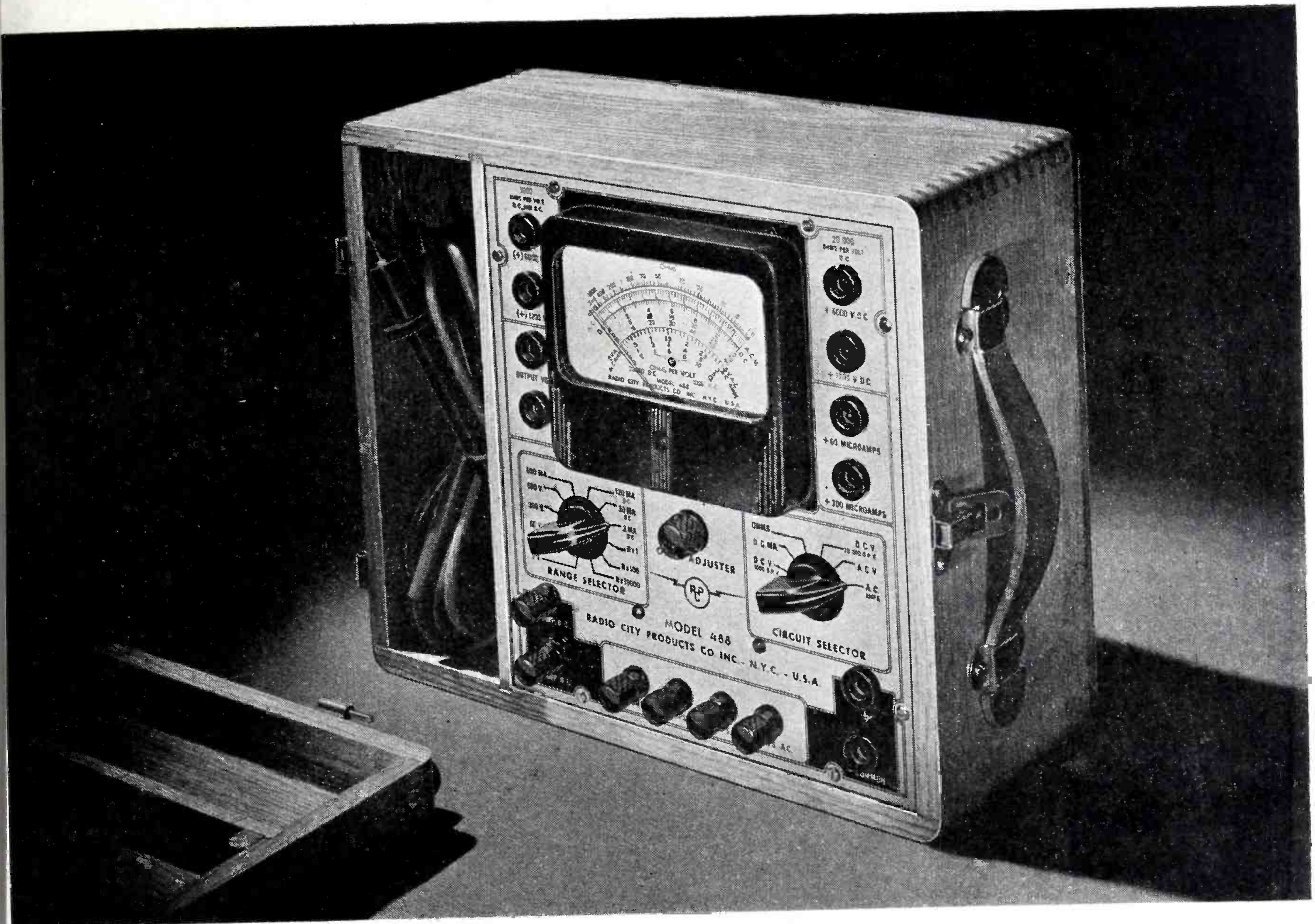
Another feature of this arrangement is the freedom from parasitic or spurious modes of oscillation. With the grid and plate circuits properly turned only one frequency of oscillation is produced. Wide deviations of grid, plate, or filament voltages affect the output but do not introduce new frequencies or seriously affect the frequency in question. This again is in sharp contrast to ordinary Barkhausen oscillators, which are relatively sensitive to this trouble.

The efficiency to be expected from this arrangement is somewhat better than that characteristic of the standard spiral-grid tube. The improved efficiency results from the large negative bias applied to the central portion of the plate. Thus the electron current is concentrated at the ends of the tubes where the maximum voltage swings exist. An efficiency of 1 to 2 percent is characteristic of well-built tubes of this design.

• • •

MASS PRODUCTION OF CATHODE-RAY TUBES

Many cathode-ray tubes are exhausted simultaneously on sealex machines in Canadian factories



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CHECK THESE FEATURES:

Dual D. C. sensitivity of 20,000 ohms per volt and 1,000 ohms per volt. A. C. sensitivity of 1,000 ohms per volt.
Wide-scale 4½" meter with movement of 50 microamperes.
Readings as low as 1 microampere.
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A.C. Voltmeter . .	0-3-12-60-300-600-1,200-6,000 volts.
Output Voltmeter .	0-3-12-60-300-600-1,200-6,000 volts.
D.C. Microammeter	0-60-300 Microamperes.
D.C. Milliammeter	0-3-20-120-600 milliamperes.
D.C. Ammeter . . .	0-12 amperes.
A.C. Ammeter . . .	0-3-6-12 amperes.
Ohmmeter	0-3,000-300,000 -30,000,000 ohms.

Model 488 is supplied ready to operate, complete with self-contained battery, test probes and a convenient carrying case with removable cover. Overall dimensions of case: 12½" x 10⅞" x 6½". Net: $71.50

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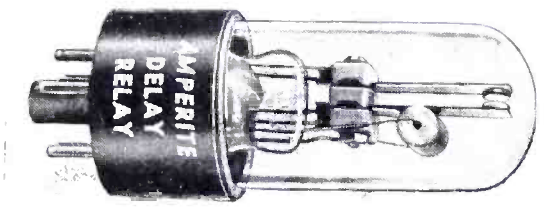
Thermostatic Delay Relay

DELAYS FROM 1 TO 100 seconds can be obtained with this relay which fits any standard octal tube socket. The relay is compensated for ambient temperature changes of −40 to +100 deg F and is available as a single pole device with either nor-



mally open or normally closed contacts. The contacts are capable of handling up to 12 amps, 115 volts, a.c. or d.c. Hermetic sealing in inert gas keeps contacts clean. Replacements are easily made.

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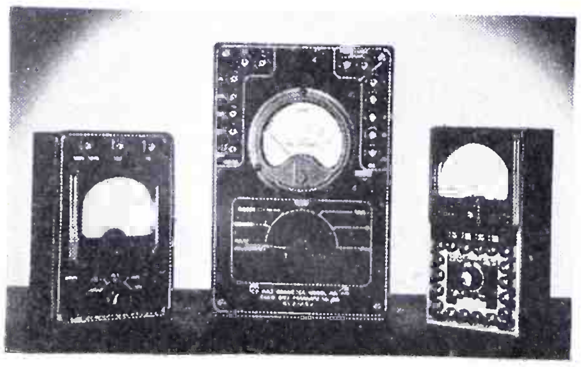
Test Instruments

THREE TEST INSTRUMENTS are announced by Radio City Products, Inc., 127 West 26th St., New York, N. Y.



Model 471 output meter has a constant impedance of 4000 ohms, and is a rectifier type a-c voltmeter. The resistors used within the instrument are precision wire wound with an accuracy rating of within 1 percent. Five voltage ranges of 0–1.5, 6, 15, 60, and 150 are available by turning a selector switch. A self-contained condenser for blocking d-c components is connected to separate terminals.

Model 481 volt-ohmmeter is a test meter with a sensitivity of 50 microamps. Internal precision wire wound resistors are accurate to 1 percent. D-c voltmeter readings range from 0.1 to 1000 volt. D-c milliammeter readings range from 0 to 100 milliamps. Resistance measurements range from 0.1 ohms to 10 megohms. Energy for resistance measurements is supplied from self-contained batteries.

Model 442 pocket-size multimeter is a compact multitester with a 200 microamp movement and a sensitivity of 5000 ohms per volt. The instrument has four d-c milliammeter ranges of 0–0.3, 6, 30 and 150 (with a first scale division of 5 microamps; four d-c voltmeter ranges of 0-6, 150, 300, and 1500 (with a first scale division of 0.1 volt; four a-c voltmeter ranges of 0-6, 30, 150, and 600 (with a first scale division of 0.1 volt; five output voltmeter ranges of 0-6, 30, 50, 150 and 600; four decibel ranges from —6 to +50.

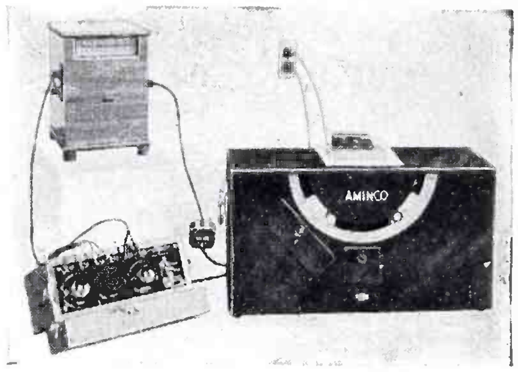
Gloss Measuring Instrument

THE NEW AMINCO-SCOTT Glossmeter (Goniophotometer) measures high, medium and low gloss (from zero to 100 percent) of plane surfaces of materials over $2\frac{1}{8}$ x 3 inches in size, such as paint finishes, enamels, lacquers, metals, wood, paper, plastics, glass, etc. Results are in terms of I.C.I. Normal Observer and I.C.I. Illuminant C.

The illuminator uses a barrier-type photocell which is mounted adjacent to the lamp. It acts as a compensating voltage supply in the measuring circuit. The amount of light striking the photocell is controlled by means of a circular disk which has graduated apertures.

Illumination is adjustable from −30 deg. to +70 deg. from the normal. The receptor is adjustable from +30 deg. to −70 deg. from the normal. Angles may be read to 1 minute of arc. Measurements of relative apparent reflectance from zero to 100 percent (in steps of 0.01 percent) can be made.

It operates on 110–120 volts, 60 cps (controlled frequency) single-



phase a.c., and is unaffected by fluctuations in line voltage. It need not be operated in a darkened room. Renewal of the lamp is the only upkeep cost involved. The Glossmeter consists essentially of four main components—a goniophotometer, reference plate and sample holder, control and measuring unit, and galvanometer. A standard glass reference plate is supplied. The outfit weighs approximately 55 lbs.

Complete description and specimen surves are given in Bulletin DB2115, which is available from the manufacturer, the American Instrument Company, Silver Spring, Maryland.

Radiosonde Test Chamber

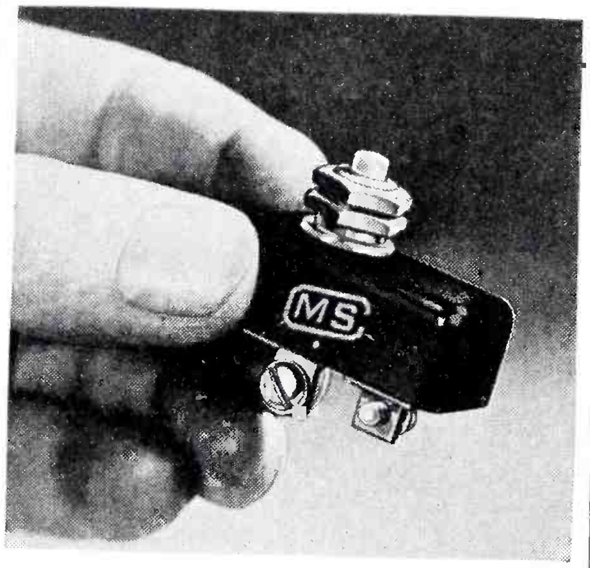
A FREE TEST SPACE measuring 18 x 18 x 12 inches is provided in Model NEL 212 radiosonde test chamber which reproduces elemental conditions of air density, temperature and humidity, controlled by a transformer-type voltage regulator. The instrument has both manual and automatic control. Temperature gradients on the automatic cycle can be held to a tolerance of ±1 deg C. An artificial heat load can be applied to approximate the adiabatic lapse rate of radiosonde ascensions to ±1/10 of 1 deg C. Humidity can be controlled to ±5 percent RH from 10 percent to 95 percent, and is provided by a steam generator which is auto-

matically controlled. An indicating-controller (manufactured by C. J. Tagliabue Mfg. Co., Park & Nostrand Avenues, Brooklyn, N. Y.) is incorporated on the control panel with an open-well type mercury manometer. An indicator-recorder-controller called Tag-Celectray (also manufactured by Tagliabue) which provides a wet and dry bulb record is also available with the chamber. By using a psychometric chart, RH can instantly be determined.

Northern Engineering Laboratories, 50 Church St., New York, N. Y.

Tiny Precision Switches

"PEANUT" MICRO SWITCHES said to be more rugged, lighter and resistant to vibration than larger models are available with or without an enclosing case. When used without a case, actuating movement can be applied anywhere over a large portion of the upper spring. When a case is used, a convenient mount-



ing stem is provided. The contact gaps (for d-c loads) measure up to 0.085 inch but can be varied. Contacts are 99.95 percent silver and are formed with a knurled surface to provide high unit pressure for low voltage applications and to minimize the effects of dirt on the contacts when an enclosing case is not used.

Micro Switch Corp., Freeport, Ill.

White Pencil Tracing Cloth

WHITEX IS THE NAME of a tracing cloth which is moisture resistant on both sides. It takes a jet-black image from a hard pencil. The cloth itself is quite transparent.

The Frederick Post Co., Box 803, Chicago, Ill.

matically controlled. An indicating-controller (manufactured by C. J. Tagliabue Mfg. Co., Park & Nostrand Avenues, Brooklyn, N. Y.) is incorporated on the control panel with an open-well type mercury manometer. An indicator-recorder-controller called Tag-Celectray (also manufactured by Tagliabue) which provides a wet and dry bulb record is also available with the chamber. By using a psychometric chart, RH can instantly be determined.

Northern Engineering Laboratories, 50 Church St., New York, N. Y.

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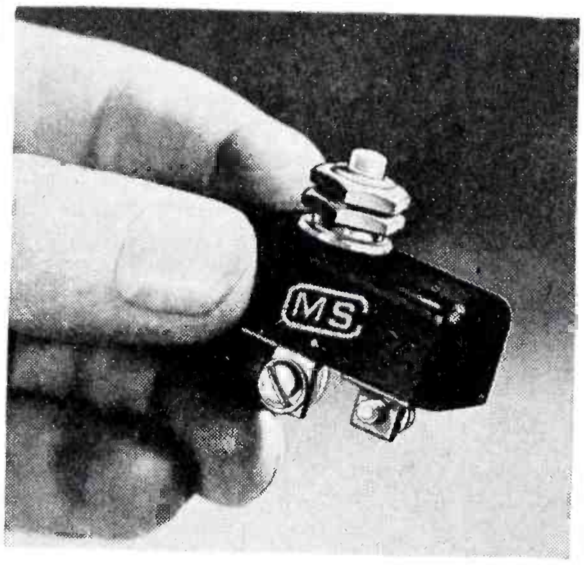

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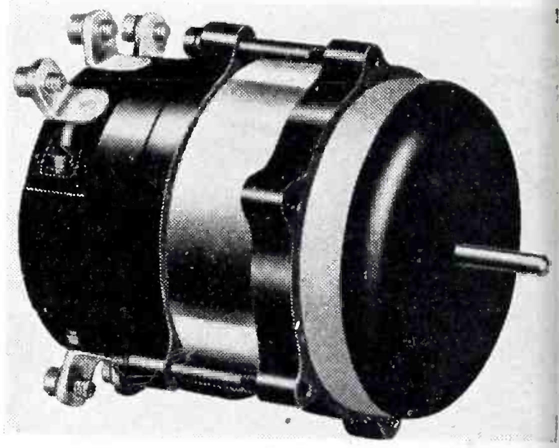
Rotatable Transformer

ILLUSTRATED IS TYPE 787 rotatable transformer which is light in weight and is for use in electronic devices. It operates on either 32 volts, 60 cps, or 110 volts, 400 cps, a-c current and may be continuously rotated at speeds up to 1800 rpm. With 110 volts input the voltage varies from

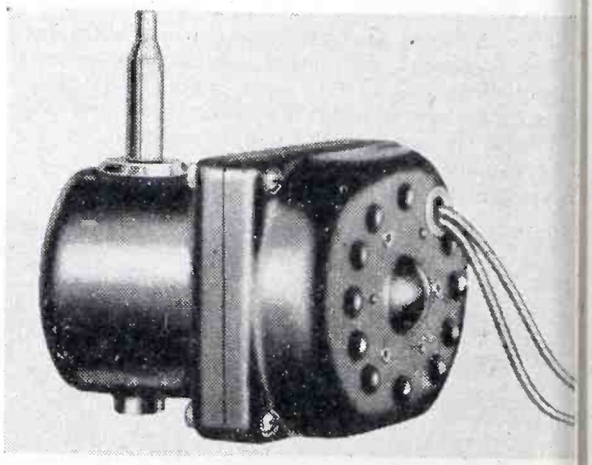


zero to 193 volts according to the position of the rotor. With a weight of 10 oz and an overall length of less than 3 inches the unit may be incorporated into units where compactness and lightweight are essential.

Kollsman Instrument Division of Square D Co., 80–08 45th Ave., Elmhurst, N. Y.

Constant Speed Motor

A SELF-STARTING, CONSTANT speed motor, which maintains speed regulation under variations of voltage, load, and temperature, measures $4\frac{3}{8}$ x $3\frac{1}{8}$ x $3\frac{1}{4}$ inches. It is available for operation on 110 and 220 volts, 50 or 60 cps at 14 watts input. The



gears, which are made of helical-cut laminated Bakelite, operate quietly, are completely enclosed and protected. The motor has forced ventilation for cool operation, large bearings and ample oil reserves and is precision assembled.

Rotom Mfg. Co., Alhambra, Cal.

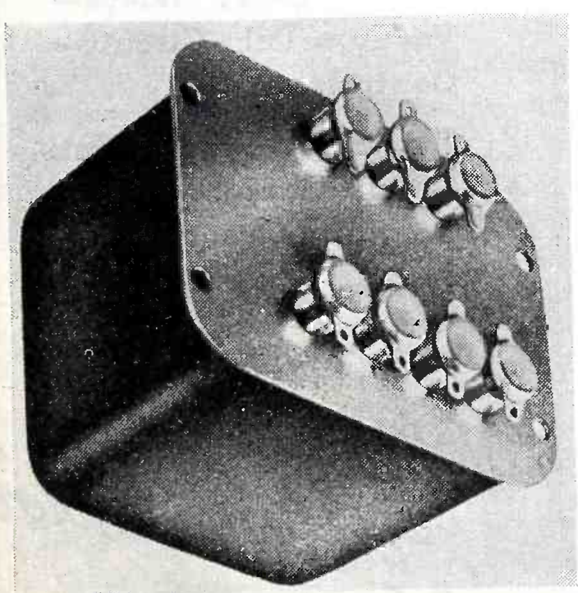
Mica Capacitor Alternates

TYPE 38 OIL TUBULARS, designed as metal-cased alternates for mica capacitors, are for use in assemblies where space and weight are at a minimum. They meet standard specifications for paper dielectric capacitors used as mica alternates. The metal case is capped with a double-rubber Bakelite terminal insulator assembly. Units are available with both terminals insulated or with one terminal grounded to the case. The units have pigtail terminals and come in two sizes (1 inch long x 5/16 inch diameter and and 1 3/16 inch long x 7/16 inch diameter), and are normally supplied without an outer sleeve but can be had with an insulating jacket which adds 1/16 inch to the diameter. Impregnant and fill are available in either castor (Hyvol) or in mineral oil. Ratings are from 300 to 800 volt d.c. The capacitance range is from 0.001 to 0.01 mfd.

Aerovox Corp., New Bedford, Mass.

Hermetically-Sealed Transformer

GLASS OR PORCELAIN INSULATORS with metal bands are used in these transformers to make them especially suitable in applications where dust and dampness prevail. The insulators are soldered into a transformer case which is made of cold drawn

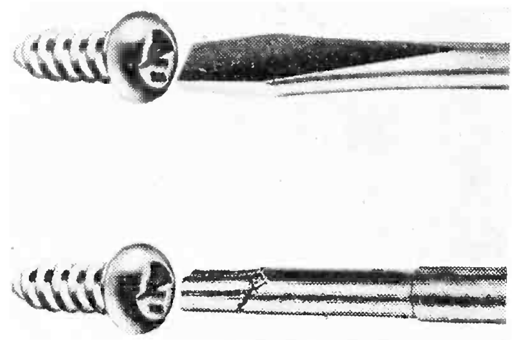


copper-plated steel. The transformers meet Navy specifications for hermetic sealing. Impregnation process used is the manufacturer's own process called "vac-sealing".

Peerless Electrical Products, 6920 McKinley Ave., Los Angeles, 1, Cal.

Clutch Head Screws

THESE SCREWS CAN BE operated with an assembly bit or with a standard type screwdriver when used out in the field, or in an emergency with a piece of steel rod flattened to the approximate semblence of a screwdriver. The clutch of the screw head is deep and is easy to get at. The center pivot of the assembly bit is rugged and free from sharp fins. The manufacturer states that actual tests



show that the center pivot bit can go through approximately 200,000 operations without failure. Worn down bits may be renewed by applying them for a short period to a grinding wheel. The clutch head feature of these screws is adaptable to a wide range of head designs.

A bulletin which more thoroughly describes and illustrates this product is available from the manufacturer, United Screw & Bolt Corp., Chicago, Ill.

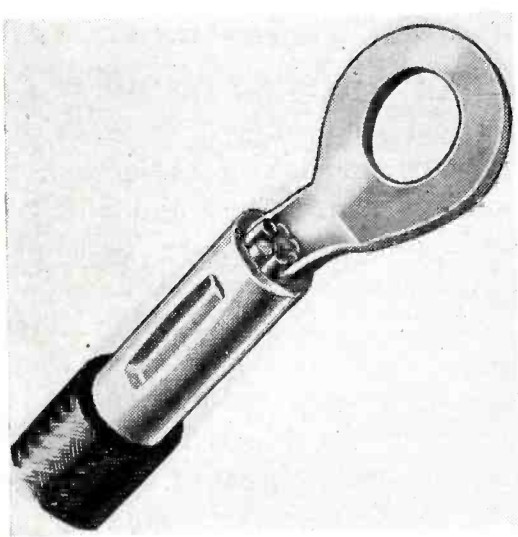
Rubber-Like Flexible Tubing for Electrical Insulation

TWO TYPES OF THIS TUBING are available. The first is designated as "Synflex FT-11" and it is a transparent, flexible tubing developed for extreme sub-zero applications. The range of working temperatures for continuous operation is -60 deg F to $+188.6$ deg F. Its dielectric strength is 1000 VPM. Its transparency facilitates circuit and wire code identification and permits inspection of soldered points or connectors without having to remove the insulating sleeve. The second type of tubing is designated as "Synflex FT-22" which is a rubber-like synthetic for both electrical and non-electrical applications and may be used to replace varnished tubing and sleeving, rubber, tin, aluminum, copper, etc. It has a temperature resistance of $+194$ deg F and a dielectric strength of 1200 VPM. Neither of these types will support combustion and both have high chemical resistance and low water-absorption characteristics. Either of them will stretch and fit tightly over lugs and splices. They may be blown over flexible or rigid metal conduit and used for water-proofing and sealing cable ends. Sizes available range from B & S No. 24 (0.021 inches I.D.) to 2.000 inches I.D. Special sizes and shapes are available on request.

Industrial Synthetics Corp., Irvington, N. J.

Solderless Terminals and Connectors

Sta-Kon pressure terminals are available for wire sizes from No. 22 to 250 M.C.M. (Commercial A.W.G.). They are small and compact, and provide a secure, vibration-proof grip that is derived by a long indenture (which does not damage the strands) and runs parallel to the wire strands, resulting in a highly con-



ductive electrical connection. Also available are 2-way, 3-way, 4-way and disconnect splices. The terminals and connectors meet corrosion and fatigue tests and can be installed by means of either manual, electric, pneumatic or hydraulic power.

Thomas & Betts Co., Inc., Elizabeth, N. J.

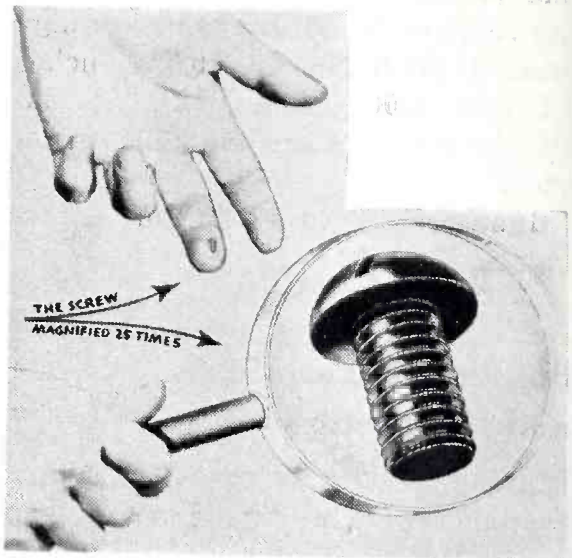
Plant Broadcasting Unit

"Plant Broadcaster" is a simplified low-cost unit for voice-paging and music broadcasting in smaller war production plants. It operates 20 to 40 loudspeakers and covers an area of up to 100,000 sq. ft. It requires 22 inches of floor space to install and comes ready to plug in.

Operadio Mfg. Co., St. Charles, Ill.

Tiny Screws

PRECISION-MADE SCREWS which measure 0.072 inches in diameter are available for use in aviation head-



phones, microphones and other similar devices. Illustrated is No. 1-72 screw.

Manufacturers Screw Products, 216 W. Hubbard St., Chicago, Ill.

Electrical Connectors

TYPE DP-B10C2 (of the DP Series) electrical connector is a rack type connector for use in radio rack assemblies, transmitters and any general applications where both plug and receptacle must be fixed permanently. It is rectangular shaped and is designed to fit rack equipment. The shell (of die-cast aluminum alloy) is tapered to effect a close fit when engaged. The two units of the complete connector are self aligning but are dependent upon the accuracy of the equipment it connects. The insert insulation is made of molded phenolic, having eight standard contacts of silver-plated brass, and two coaxial contacts, with isolantite insulators. The diameter of the four mounting holes is 0.144 inch, countersunk for No. 8 flat head machine screws. Weight of the receptacle is 0.276 lbs. and the plug 0.266 lb.

Cannon Electric Development Co., 3209 Humboldt St., Los Angeles, Cal.

Synthetic Rubber Sponge

THE B. F. GOODRICH CO., Akron, Ohio, have developed a synthetic rubber sponge which will stay soft and compressible at —40 deg F. Slabs or molded shapes (in black color) are available in medium density.

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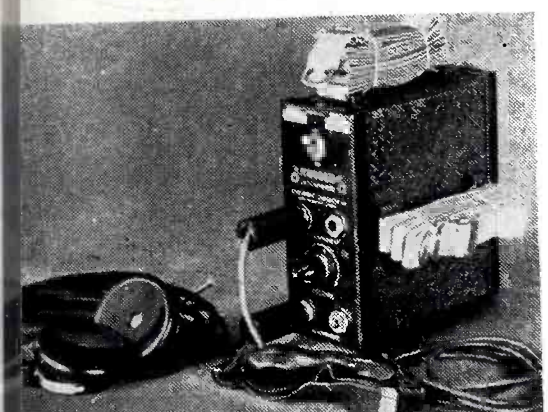
NGER MODEL No. 404 is a portable, -contained interphone which may used as a means of two-way comnication between two workers in sy factory assembly lines. The inment is carried on a waist-belt h a strap for the user's shoulder. interphone amplifier case is reed for two-way operation and ween the two persons is a single d, of any desired length, for one- communication, or two cords for



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Electronic Specialty Co., 3456 endale Blvd., Los Angeles, Cal.

igh Altitude Test Chamber

AMCOIL" DESIGNATES a high altide test chamber which consists of a por-proof automatic mechanical reigeration cabinet and an enclosed acuum chamber with insulating air pace surrounding it. The chamber rovides low temperatures quickly nd under actual ambient temperture conditions. The manufacturer tates that the outstanding advange of the unit for laboratory work that any changes in test procedure, equiring holes, shafts, electrical eads, etc., affecting the construction f the vacuum chamber, can be made ithout disturbing the refrigeration quipment. The chamber can be renoved intact, revamped or changed, nd then re-inserted in the cabinet ithout extensive repairs.

Exterior overall measurements of 'Amcoil" Model RAC-11 are $72\frac{1}{2}$

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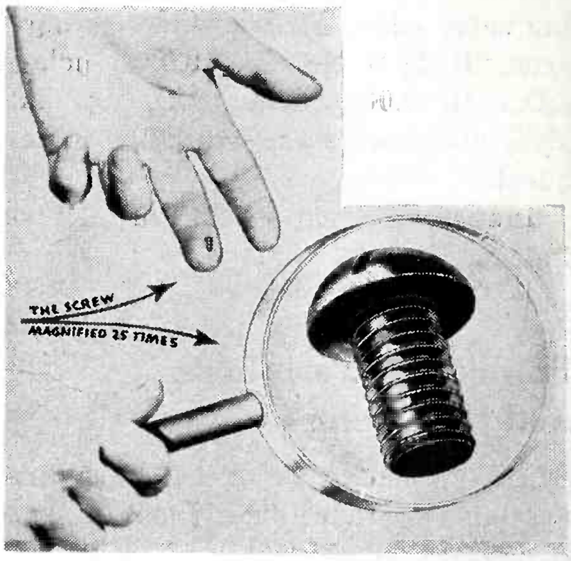

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Cannon Electric Development Co., 3209 Humboldt St., Los Angeles, Cal.

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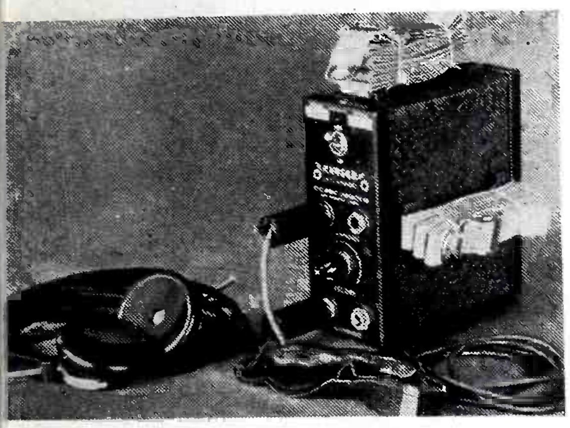
Interphone

RANGER MODEL NO. 404 is a portable, self-contained interphone which may be used as a means of two-way communication between two workers in noisy factory assembly lines. The instrument is carried on a waist-belt with a strap for the user's shoulder. One interphone amplifier case is required for two-way operation and between the two persons is a single cord, of any desired length, for one-way communication, or two cords for two-way service. A throat type microphone (which frees the worker's hands) and regular headphones come with the unit. The volume can be adjusted to the desired level. An audio output of 180 milliwatts is available. The overall size of the interphone amplifier unit is 4½ x 2¼ x 5⅛ inches. The weight of the unit is 2 lbs 10 oz complete with tubes, batteries and belts.



Electronic Specialty Co., 3456 Glendale Blvd., Los Angeles, Cal.

High Altitude Test Chamber

"AMCOIL" DESIGNATES a high altitude test chamber which consists of a vapor-proof automatic mechanical refrigeration cabinet and an enclosed vacuum chamber with insulating air space surrounding it. The chamber provides low temperatures quickly and under actual ambient temperature conditions. The manufacturer states that the outstanding advantage of the unit for laboratory work is that any changes in test procedure, requiring holes, shafts, electrical leads, etc., affecting the construction of the vacuum chamber, can be made without disturbing the refrigeration equipment. The chamber can be removed intact, revamped or changed, and then re-inserted in the cabinet without extensive repairs.

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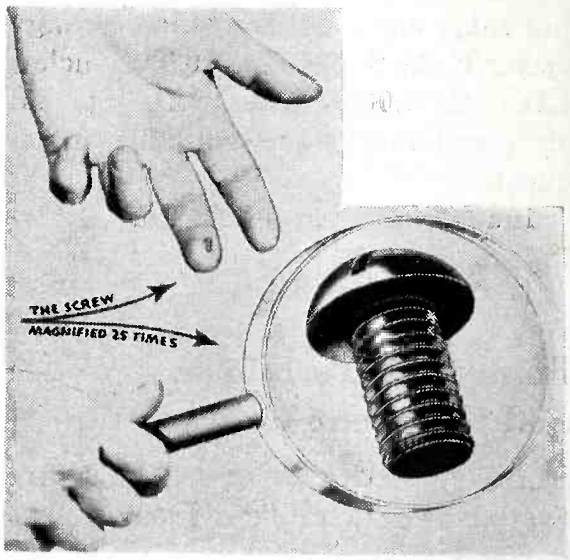

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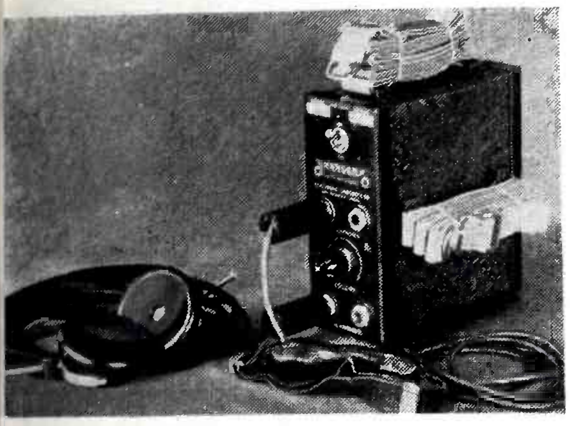

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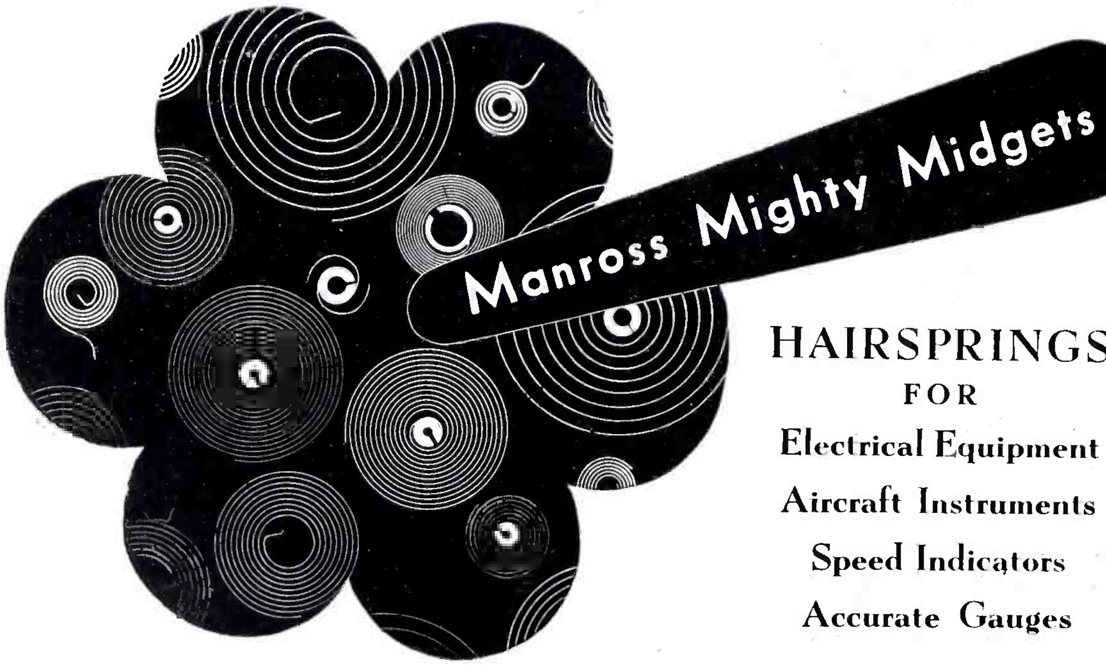


inches wide x 101½ inches high x 49 inches deep, including the stand. The height of the cabinet is 66½ inches. The switch panel extension is 12 inches. Interior (usable space) is 30 inches wide x 24 inches high x 18 inches deep; cubical content is 8 cu ft. (Model RAC-22 is 44 inches wide and has 11 cu ft of usable interior.) Temperature range is −70 deg C or −55 deg C to +70 deg C. Pressure is rated from atmospheric to 60,000 ft.

A descriptive data sheet is available from American Coils Co., 27 Lexington St., Newark, N. J.

Selenium Stacks

SMALL, LIGHTWEIGHT SELENIUM rectifier stacks have been added to the tunger and copper oxide rectifier line of General Electric's Appliance & Merchandise Dept., Bridgeport, Conn. The electrical characteristics of these rectifiers have been improved so that a.c is converted to d.c more efficiently. Better forward current characteristics and low leakage provide higher operating efficiencies than were previously available.

Literature

Sound Equipment. Precision sound equipment is described and illustrated in a 28 page booklet. Attenuators, resistance devices, attenuator frames, resistors, tap-switches, volume indicator units, transmission measuring sets, decade resistance boxes, jack mountings, cords, plugs, relay racks, telephone switchboard type keys are among the equipment described. Technical data on mixer attenuation curves, mixer circuits, loss calculations of mixer circuits, voltage ratio table, pad formulae, dimensions of double ganged attenuators and dimensions of attenuator frames is also included. Booklet available from Cinema Engineering Co., 1508 W. Verdugo Ave., Burbank, Calif.

Measuring and Control Instruments. Bulletin Z6200, superseding Z6100, is a condensed listing of equipment manufactured by the below company. The features, construction, scale ranges, universal models and price list for temperature controllers are given. Portable potentiometers, series 300, are described and illustrated. Radiation heads, straight type thermocouples, angle type thermocouples, remote controllers, remote controller auxilliaries, flame control units and auxiliaries and several other instruments are covered. Bulletin Z6200 available from Wheelco Instruments Co., Harrison and Peoria St., Chicago, Ill.

Metallic Tubing. Catalog 113 describes the types of flexible metallic tubing used in the conveyance of oils, gasses and liquids. Data is given on available fittings, both industrial and S.A.E. Complete pressure charts and charts showing radius of bend are included. Catalog 113 available from Titeflex Metal Hose Co., 500 Frelinghuysen Ave., Newark, N. J.

Zinc Plated Steel. Facts about zinc plated steel are presented in this 4 page folder. This metal can be bent, stamped, formed, drawn, soldered and spot welded to meet many production necessities. A suitable substitute for vital metals. Available in sheets up to 36 x 96 inches in most gauges. Folder available from American Nickeloid Co., Peru, Ill.

Safety. "Safety Speeds Production" was prepared to meet the needs of executives who face the current shortage of experienced supervisory employees. The booklet has been reviewed for accuracy and usefulness by safety engineers in large war plants. Bulletin 10 available from Division of Labor Standards, U. S. Department of Labor, Washington, D. C.

Absenteeism. "Controlling Absenteeism" summarizes the experience of management in 200 outstanding war plants dealing with absenteeism. The booklet tells of the methods of control tried at the plant level and the degree of success which might possibly be attained if these methods were used throughout the country. Bulletin 12 available for ten cents from United States Department of Labor, Division of Labor Standards, Washington, D. C.

Welding and Cutting. To aid users of the oxy-acetylene welding and cutting process, a booklet "Handbook for welding and Cutting Operator" has been prepared. This booklet gives a list of do's and don'ts and suggestions on the care and maintenance of blowpipes, regulators and welding and cutting accessories. Available from International Acetylene Association, 30 E. 42nd St., New York, N. Y.

Vacuum Pumps. Bulletin 10 describes bellows type vacuum pumps. These pumps designed for production and laboratory applications are available in three standard sizes. The construction features and a table of specifications for each model is included. Bulletin 10 from American Automatic Typewriter Co., 614 N. Carpenter St., Chicago, Ill .

Insulation. Bulletin 143 describes ten insulating mediums which are known as "Thermobonds". They are produced for application to such units as high speed armatures, high cycle drill and grinder motors, heavy duty motors and transformers and marine engine magnetic coils. Bulletin 143 available from Sterling Varnish Co., 181 Ohio River Blvd., Haysville, Pa.

Gage Blocks. Four 35-mm sound slide films describing the use of gage blocks are now available. The following subjects are covered: Theory of Gage Blocks; How Gage Blocks are Used; How Gage Blocks are Made; The Use of Gage Instruments. The history of how gage blocks came into being is graphically shown by the evolution of the system of measurement. The care of gages and their many uses in machining operation is also given. These films may be obtained from Savage Tool Co., Minneapolis, Minn.; use company letterhead.

Testing Instruments. Special testing instruments for automotive and aircraft industries are given in Bulletin 740. Air flow measuring equipment, recording and indicating engine indicators, direct pressure engine indicators, indicating and recording balanced pressure indicators, piezo-electric pressure indicators, fuel flow indicators, magnetic thickness gages, piezo-electric equipment, rail car test equipment, slow motion study equipment, sound study equipment and many miscellaneous testing instruments are briefly described. Bulletin 740 available from Commercial Engineering Laboratories, 4612 Woodward, Detroit, Mich.

Radio-Noise Filter. Bulletin Gea-4098 describes filters for the suppression of radio noise in aircraft applications, on circuits with generators, amplidynes, inverters, dynamotors and other equipment. These filters meets the requirements of U. S. Army Air Forces Specification No. 32331A. The performance, attenuation, electrical and mechanical characteristics are given. Bulletin GEA-4098 available from General Electric Co., Schenectady, N. Y.

Radio Education. The booklet "Radio-Electronics in Education" presents the various types of aid radio contributes to the trend of education. The booklet covers such subjects as; broadcasting an aid to modern education; recordings find wide use in teaching field; radio widens musical culture of America; school sound systems heighten efficiency; women and children hear special programs; sound motion pictures aid group instruction; television is new educational medium; RCA electron microscope explores unseen worlds; the Inter-American university of the air; radio and phonographs for schools; RCA Institutes offers technical radio courses; training devices developed for schools, service organization maintained in field; tube information service available. Booklet available from Dept. of Information, Radio Corporation of America, 30 Rockefeller Plaza, New York, N. Y.

Phosphor Bronze and Brass Design Chart. The June 1943 issue of *The Mainspring* controls a design chart for phosphor-bronze and brass extension or compression helical springs. Section 1 covers safe loads from one tenth pound to ten pounds. Booklet available from Wallace Barnes Co., Bristol, Conn.

Electrical Rectifiers. Catalog sheets 300 and 301 describe new models of magnesium-copper-sulphide industrial electrical rectifiers. The characteristics of each are explained and a price list is included. Catalog sheets 300 and 301 available from McColpin-Christie Corp., Ltd., 4920 S. Figueroa St., Los Angeles, 37, Calif.

Welding Alloy Chart. A welding chart of welding alloys containing details relative to the low temperature welding alloys is available from the Eutectic Welding Alloys Co., 40 Worth St., New York, N. Y. The physical properties of the various metals are given and the method of operation for each.

Resistor-Condenser Wall Chart. A new and compact color code wall chart, which presents in both pictorial and convenient tabular form the complete RMA resistor and condenser color code marking arrangements used by many resistor and molded mica condenser manufacturers. Also available is a four page illustrated folder describing the contents of the new 3rd Edition Radio Troubleshooter's Handbook by A. A. Ghiradi. Both available from Radio & Technical Publishing Co., 45 Astor Pl., New York, N. Y. Enclose a three cent stamp.

ELECTRONICS Buyers' Guide. The Buyers' Guide of the June 1943 issue of ELECTRONICS, containing names of manufacturers who are supplying the electronic industry with parts, accessories, materials, instruments and complete electronic units, has been reprinted as a separate bound booklet by A. W. Franklin Mfg. Corp., 175 Varick St., New York, N. Y. for distrubution. A limited number of copies are available directly from this firm.

Electronic Exciter

(Continued from page 114)

Instead of copper-oxide rectifiers, six type 0Z4 cold-cathode tubes may be used in a three-phase full-wave rectifier circuit, as shown in Fig. 5. Three-phase rectification is necessary in this case because the individual loops of current for single-phase rectification do not overlap, and the 0Z4 tubes do not fire until a certain minimum voltage is reached. The field circuit is operating near the origin on the hysteresis loop, where large change in magnetizing force results in a relatively small change in the flux density, and hence little choking or smoothing action is obtained.

Use of Cold-Cathode Rectifiers

A generator which builds up from its residual flux in this manner has the same general characteristics as a self-excited d-c generator with a straight-line magnetization curve. In a-c generators the magnetization curve is a straight line well beyond rated voltage, and hence the generator will not reach a point of stable operation anywhere near its rated voltage. Some device such as a voltage-sensitive relay (shown in Fig. 4) must be used to keep the voltage at some value, say 10 to 25 percent of normal operating voltage, while the filaments of the mercury vapor rectifiers are warmed up. This necessitates an extension of the filament winding on the main transformer to give the required filament voltage when the alternating voltage is at say 25 percent of the rated value. It is not feasible to operate the generator at rated voltage during this warming-up period, due to the relatively large field current required from the copper-oxide rectifiers or the 0Z4 tubes.

The extra equipment required in order to allow the generator to build up from the residual voltage will cost more than the reversing rotary switch, and is not as dependable as the switch and battery.

Iron-core Components

(*Continued from page* 117)

more detail later.

A Numerical Case—a 5Mc I-F Transformer

By means of the three sets of curves we can now construct the pulse shape delivered to load R_2. Suppose a transformer with the following measured constants be required to deliver a flat top pulse of 15 microseconds duration.

Leakage inductance L (secondary short-circuited)	$= 1.89 \times 10^{-4} H$
Primary open-circuit inductance	$= 0.1\ H$
Primary secondary turns ratio N_P/N_S	$= 1.3$
Source Resistance R_1	= 800 ohms
Load Resistance (Primary equivalent)	= 5000 ohms
Capacitance C_2 (calculated)	$= 388\ \mu\mu f$

From the expressions given in Fig. 3, we find

$$m = 2.38 \times 10^6$$
$$T = 1.7 \text{ microsecond}$$
$$k = 0.65$$

The front of the wave will follow a curve between those marked $k = 0.4$ and $k = 0.8$ in Fig. 3. The value E will be reached in $0.5T$ or 0.85 microsecond, and a peak of about 10 percent occurs in 1 microsecond.

The top of the wave will slope down to a value determined by the product $tR_1/L = 0.12$, and by a curve between those for $R_2 = \infty$ and $R_2 = 2R_1$ in Fig. 4. The value is evidently $0.91E$.

The trailing edge is given by Fig. 5. Here

$$m = 0.258 \times 10^6$$
$$T = 39.1 \times 10^{-6}$$
$$k = 1.6$$

so that the load voltage reaches zero in $0.115T$ or 4.5 microseconds. There is a slight negative loop of 7 percent at $0.3T$ or 11.7 microseconds beyond the pulse edge b.

The pulse delivered to load R_2 as shown in Fig. 6 is a combination of these three curves.

Saw-Tooth Transformers

Probably the most common application of saw-tooth transformers is to provide a linear sweep to elements of a cathode-ray oscillograph. In such a circuit, the load on the transformer can be regarded as negligible. Therefore we will assume a linearly increasing voltage as shown in Fig. 7A to be

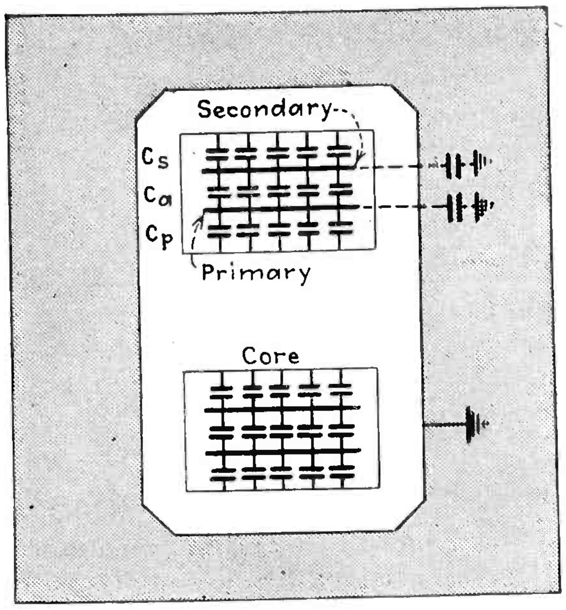


Fig. 10—Cross section of transformer with concentric windings showing interwinding capacitance

applied to the circuit of Fig. 7B. Analysis shows that the voltage e across the inductance L has the same slope as the applied voltage times an exponential term determined by the resistance R_1 of the amplifier, the open-circuit inductance of the transformer, and the time between the beginning and the end of the linear sweep. Under the conditions assumed, the value of the exponential for any interval of time can be taken from the curve marked $R_2 = \infty$ in Fig. 4. For example, suppose the sweep lasts for 500 microseconds, the tube plate resistance is 800 ohms, and the transformer inductance is 10 henries. The value of the abscissa is 0.04, and since the slope of this exponential curve equals its ordinate, the slope of the voltage applied to the plates of the oscillograph will be, at the end of the time interval, 96 percent of the slope which it had at the beginning of the time interval.

Let us assume that at the end of the time interval t, Fig. 7A, the tube is cut off. Then the sweep circuit transformer reverts to that of Fig. 5, in which R includes only the losses of the transformer, which were neglected in the analysis for linearity of sweep. That is, the voltage does not immediately disappear, but follows the curves of Fig. 5 very closely, the same as the trailing edge of the flat-top pulse.

Voltage Rise in Reactors

Numerous circuits have been devised for the development of relatively high voltages by interrupting the current through a reactor. We will here discuss only one, namely, that of Fig. 8 which is typical.

Battery E is supplying current

through choke L to the tube, when suddenly a negative voltage $-E_g$ is applied to the grid of the tube. This interrupts the current through L, forcing it to discharge into its own capacity and loss resistance R_2. There is this difference in the assumptions made for choke L compared to those that were made in previous analyses for the open-circuit inductance of transformers: the initial current through L is not negligible, but is the current drawn by the tube itself. We will assume that the series resistance of the choke is zero, so that the initial voltage across C and R_2 is also zero. This analysis, therefore, applies only where the choke is shunted only by a high resistance such as its own losses. The case where a voltage *drop* is produced has already been covered by the analysis for the trailing edge of a flat top pulse transformer.

The performance of this choke is shown in Fig. 9. The ordinates on the curve are the voltage rise divided by the IR drop consisting of the choke initial current and the loss resistance R_2. The effect of high inductance is seen by the fact that for high values of k the voltage rise is quite steep and great. Low capacitance is also important to attain such steep voltage rises. Close observance will show that the choke voltage rises up to its peak value in about the same length of time that the voltage on the trailing edge of the transformer decreased to its minimum value. There is this difference, however, that for small values of k the voltage amplitude is small. Usually in the operation of such chokes, only the rela-

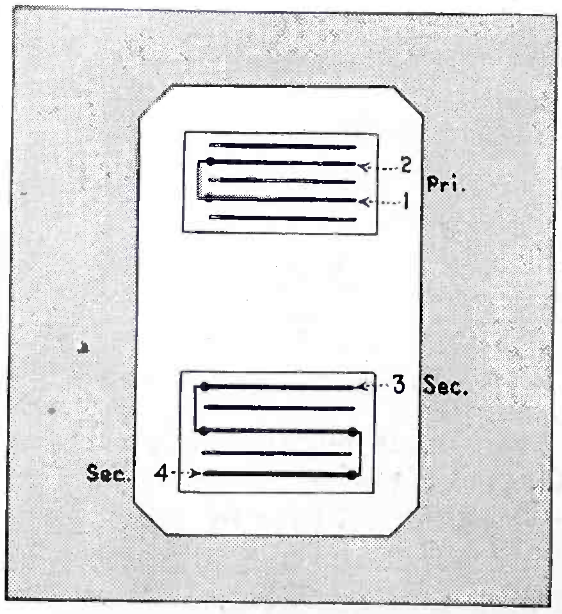


Fig. 11—Placement of primary and secondary windings

tively linear portion of the voltage rise curve is used. Figure 9 shows that with proper values of k it may be possible to utilize considerably more of such a pulse. For example, where $k = 5$ the pulse could be allowed to continue unchanged up to some value approximately 25 percent of the time constant T, instead of being cut off at much smaller values of T and voltage rise. This again requires low capacitance in the choke, but it has the advantage of requiring less subsequent amplification for the final pulse.

Transformers and reactors designed in accordance with the principles here formulated are entirely practicable; they have been built with fairly small dimensions for pulses of ½ to 2700 microseconds duration.

Capacitance Evaluation

Capacitances C_1 and C_2 must be evaluated in terms of voltage gradients in the windings; i.e., C_1 and C_2 are not the ordinary measurable capacity between primary and core, or secondary and core, or primary and secondary, but usually exceed these values if the transformer is step-up and are less than these values if the transformer is step-down. In any transformer, regardless of turns-ratio, voltage gradient must be considered for proper evaluation.

For example, in the transformer whose cross-section is shown in Fig. 10 the primary and secondary are each wound in a single layer concentrically, and will be assumed as wound in the same rotational direction, and in the same traverse direction (right to left). It will further be assumed that the right ends of both windings are connected to ground (or core) through large capacitances, as shown dotted, so that the right ends are at substantially the same a-c potential. Capacitance C_1 is composed of many small incremental capacitances C_p and C_2 of many small incremental capacitances C_s each of which has a different voltage across it. Likewise, there exist many small incremental capacitances C_a between primary and secondary which have different potentials across them. If the transformer is step-up

$$C_1 = 1/3\Sigma C_p \text{ and } C_2 = 1/3\left[\Sigma C_s + \left(\frac{N_s - N_p}{N_p}\right)^2 \Sigma C_a\right]$$

If the transformer is step-down,

$$C_1 = 1/3 \left[\Sigma C_p + \left(\frac{N_p - N_s}{N_p} \right)^2 \Sigma C_a \right] \text{ and}$$

$$C_2 = 1/3\, C_s.$$

If the ratio is 1:1,

$$C_1 = 1/3 \left[\Sigma C_p \right] \text{ and } C_2 = 1/3 \left[\Sigma C_s. \right]$$

For transformers with opposite angular rotations of primary and secondary windings, or with opposite traverse directions, (but not both), the factor $\left(\frac{N_p - N_s}{N_p} \right)^2$ and $\left(\frac{N_s - N_p}{N_p} \right)^2$ in the foregoing equations become $\left(\frac{N_p + N_s}{N_p} \right)^2$; Add $4/3 \Sigma C_a$ to C_1 and C_2 for 1:1 ratio: there is no other change. For transformers with *both* angular rotations and traverse directions opposite there is no change at all in these equations. If there is a shield between primary and secondary, omit terms containing C_a in these equations, and make ΣC_s and ΣC_p include the capacity of secondary and primary to shield, respectively. Note that ΣC_s is the measurable capacity of the short-circuited secondary to ground (or core), and ΣC_p the measurable capacity of the short-circuited primary to ground (or core).

For more interleaving of primary and secondary windings, more elaborate evaluation of capacitance is necessary. This will be illustrated below by the description of an actual transformer (the pulse shape of which is given in Fig. 6.)

As shown in Fig. 11 the primary

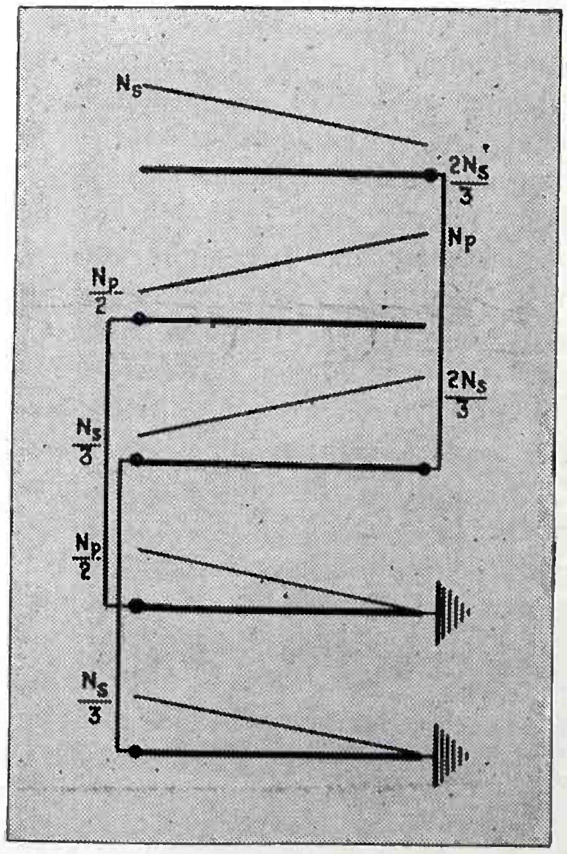


Fig. 12—Voltage gradients along the windings in terms of turns

is wound in two layers, interleaved between three secondary layers. This interleaving is done to reduce leakage inductance. The secondary winding is wound in a 2-layer "bank" fashion, in each of the 3 layers above mentioned. This is done to reduce its own capacitance. The transformer is used to couple a type 2A3 tube to a pair of cathode-ray tube plates. The plates are an open circuit; hence R_L would be infinite, but the transformer has sufficient iron loss to give R_L a finite value. The measurable constants are:

N_p = 112 turns (56 per layer)
N_s = 360 turns (120 per layer)
R_1 = 800 ohms
R_2 = 5000 ohms

The capacitance from secondary to core is 100 $\mu\mu$f. The capacitance (average) between primary and secondary layers is 46 $\mu\mu$f. Leads 1 and 3 are at a-c ground potential. All windings are wound in same direction of rotation, but the directions of traverse are:

Secondary Section			Primary Section	
1st	2nd	3rd	1st	2nd
L to Rt.	Rt to L.	L to Rt.	L to Rt.	Rt. to L

Designate these winding sections, in the order above as, S_1, S_2, S_3, P_1, P_2. The voltage gradients along these windings are as shown in Fig. 12 except that turns are used instead of volts. This is permissible since e_p/e_s N_p/N_s.

In the space between	Turn gradient is
S_1 and core	0 to $N_s/3$
S_1 and P_1	0 to $N_s/3 - N_p/2$
P_1 and S_2	$N_s/3 - N_p/2$ to $2N_s/3$
S_2 and P_2	$N_s/3 - N_p/2$ to $2N_s/3 - N_p$
P_2 and S_3	$2N_s/3 - N_p$ to $N_s - N_p/2$
S_3 and core	$2N_s/3$ to N_s

The transformer is so constructed that there is 10.3 $\mu\mu$f from S_3 to core. The secondary-to-core capacitance is mostly S_1 to core. The primary effective value of this capacitance is $\Sigma C_s/3N_p^2 \times (N_s/3)^2$. Putting the $C_a/3N_p^2(\Delta n_1^2 \div \Delta n_2^2 + \Delta n_1 \Delta n_2)$. Thus numerical values of N_s and N_p in this expression form the above table we have $\frac{(100 - 10.3) \times (120)^2}{3 \times 112^2} = 38$ $\mu\mu$f for the effective value when referred to the primary. For the inter-winding spaces we can use the equation $C_e = C_{-a}3N_p^2(\Delta_1^2 + \Delta n_2^2 + \Delta n_1 \Delta n_2)$. Thus we get for S_1-P_1, $\Delta n_1 = 0$

$$\Delta n_2 = N_s/3 - N_p/2 = 120 - 56 = 64 \text{ turns.}$$

$$Ce = \frac{46 \times (64)^2}{3 \times (112)^2} = 5.0\ \mu\mu\text{f}$$

for P_1-S_2, $\Delta n_1 = 64$

$\Delta n_2 = N_s/3 = 240$

$$C_e = \frac{46}{3 \times (112)^2}\left[(64)^2 + 240^2 + 64 \times 240\right] = 84\ \mu\mu f$$

for S_2-P_2, $\Delta n_1 = 64$

$\Delta n_2 = 2N_s/3 - N = 240\text{-}112\text{-}128$

$$C_e = \frac{46}{3 \times (112)^2}\left[(64)^2 + (128)^2 + 64 \times 128\right] = 35\ \mu\mu$$

for P_2-S_3, $\Delta n_1 = 128$

$\Delta n_2 = N_s - N_p/2 = 360\text{-}56 = 304$

$$Ce = \frac{46}{3 \times (112)^2}\left[(128)^2 + (304)^2 + 128 \times 304\right] = 178\ \mu\mu f$$

for S_3-core $\Delta n_1 = 2N_s/3 = 240$

$\Delta n_2 = N_s = 360$

$$C_e = \frac{10.3}{3 \times (112)^2}\left[(360)^2 + (240)^2 + 240 \times 360\right] = 75\ \mu\mu f$$

Thus, because of the high voltage across it, the small S_3-core capacity becomes appreciable.

Since the secondary winding intervenes between any primary winding section and the core, $C_1 = 0$. C_2 is the sum of all the layers C_e's plus C_e of S_1-core. It has already been referred to the primary side in the above calculations, and hence the multiplier $(N_s)^2/(N_p)$ is unnecessary.

Hence $C_2 = 75 + 38 + 5 + 84 + 35 + 178 = 415\ \mu\mu f$. Adding another 25 $\mu\mu f$ for tube, load and incidental capacity, $C_2 = 440\ \mu\mu f$. If it had been referred to the whole secondary winding, this value would have been $440 \times \left(\frac{112^2}{360}\right) = 42\ \mu\mu f$.

The measured value of capacity from secondary to primary and core is 240 $\mu\mu f$. Contrast this value with 42 $\mu\mu f$, and the importance of the above calculations becomes apparent.

• • •

TUBES FOR NAVY

High-power transmitting tubes for a modern war of communications, made for the U. S. Navy by Westinghouse Lamp Division

Universal Equalizer

(*Continued from page* 121)

10-μf electrolytics comprise the powerpack filter.

The response curve for an individual selective *RC* circuit is given in Fig. 2. The value of the peak frequency of this curve depends upon the values of *R* and *C* employed, and is determined by the formula

$$f = \frac{1}{2\pi \sqrt{R_1 R_2 C_1 C_2}}$$

If R_1 is made equal to R_2 and C_1 is made equal to C_2, the equation becomes

$$f = \frac{1}{2\pi\ RC}$$

This equation shows that the peak frequency is inversely proportional to capacity, instead of being inversely proportional to the square root of capacity as in tuned *LC* circuits.

Theory of Selective Circuit

Each selective circuit consists of a series element C_1R_1 and a parallel element C_2R_2, forming a voltage divider as shown in Fig. 2. R_1 and R_2 are 50,000 ohms for all channels, but C_1 and C_2 are equal in individual channels only.

At low audio frequencies, most of the signal voltage is dropped across the series element, and only a relatively small voltage is available across R_2 for transfer to the amplifying portion of the channel.

At high audio frequencies (above 4*f* in Fig. 2), the impedance of the shunt element is much lower than that of the series element, and again the voltage across R_2 for transfer to the amplifier tube is relatively small.

As the frequency is decreased from a high value, the impedances of both the series and shunt elements increase but at different rates. The peak response occurs at the point where the two impedances increase at the same rate, for the two impedances are then increasing at the same proportional rate and giving a high constant output voltage across R_2, corresponding to the peak of the response curve.

Performance Data

The lowest peak frequency employed in a 15-channel tonalizer is 23 cycles. Successive peaks are each approximately 1.6 times the preceding value, namely 37, 60, 96, 154, 245, 394, 630, 1000, 1600, 2560, 4100, 6550, 10,300, and 16,480 cycles. This gives considerable overlap of response curves, with smooth changes in response and with a maximum possible variation of about 5 db between adjacent peaks.

When all 15 channel controls are set for equal or maximum gain, the response curves combine to give essentially flat over-all response, as shown in Fig. 3. Here the signal levels are plotted in db and cover a much greater range than the voltage ratios of Fig. 2.

The width of each individual response curve and the amount of overlap together make it impossible to cut out a frequency completely with one channel control. The maximum possible variation from one channel to the next is about 5 db, hence essentially complete suppression (30 db below the original level, from a practical standpoint) can be obtained at the lowest peak of 23 cycles by setting the first six channel controls to zero.

The channel control potentiometer shafts are each fitted with a small gear pinion engaged with a segment of a large gear formed integral with a small rod. This rod projects through a front panel which is engraved with horizontal (abscissa) db lines and vertical (ordinate) frequency lines. The ends of the rods trace points on a response curve, and could serve as anchor points for a flexible bar which actually would take the shape of the complete response curve of the tonalizer.

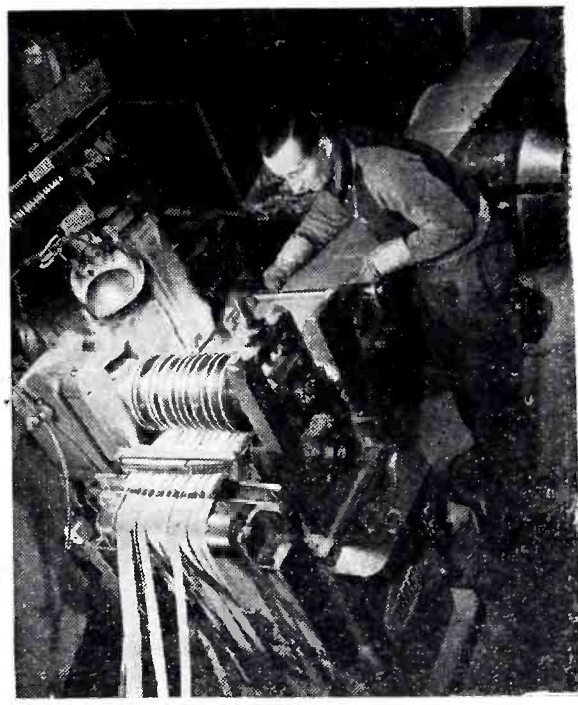
If the channel controls were not calibrated in db, the response curve could still be obtained with one additional run after the controls were set. To determine response in this manner a db meter is connected to the output of the amplifier under test, with the tonalizer in the system. The a-f input from the a-f signal generator is then varied over the frequency range. The actual db variations are then read on the meter and plotted to secure the response curve. Due allowance must, of course, be made if the amplifier itself is not flat, but most amplifiers are designed to have reasonably flat response.

The tonalizer input and output impedance values can be considered as over 50,000 ohms for all practical purposes. Input voltages in the range of 0.25 to 5 volts will give the maximum output voltage of 10 volts at all frequencies. The input level can be adjusted with the input volume control to prevent overloading of the amplifier stages in the tonalizer. Shielded input and output leads, each five feet long, are used.

Many factors must be taken into consideration in the design of a tonalizer in order to meet the obvious requirement that it must introduce neither frequency nor waveform distortion. Some of the design problems are discussed in U. S. patent 2,298,987, "Audio Frequency Signal Transmission Circuit", issued to Paul H. Thomsen Oct. 13, 1942 and covering the tonalizer. Simplicity of operation and sufficient stability to permit duplication of control settings are also among the important requirements.—J. M.

* * *

FEATHERWEIGHT TRANSFORMER CORE



Half the nickel and ten percent of the copper formerly required in transformer cores is being saved by a featherweight, compact radio transformer core designed for war communications duty by the Westinghouse Transformer Division. The material conservation plus a 30 to 50 percent saving in weight was accomplished by reconstructing the core and using Hipersil steel. This steel is highly magnetic, requires less copper wire and eliminates the use of nickel and the slow hand work formerly required. Here a workman is cutting Hipersil strip into ribbons of various widths to be wound into cores which are impregnated with a plastic compound and baked. The tiny cores are used in portable "walkie-talkie" field radios and for communications equipment in tanks, airplanes and submarines, where space is at a premium

Particles of Physics

(*Continued from page 126*)

ticles have not even been approached.

Properties of Elementary Particles

Now that we have discussed some of the properties of the fundamental particles known to exist in nature it might be well to summarize these. Properties of the several particles are shown in Table I. It will be noted that all charged particles produce tracks in a cloud chamber. The photon and the neutron, which have no charge, do not. These two particles do not produce ionization along their paths. All electrical charges indicated in the table are given in terms of the electron as a unit. Except for the photon all masses are given on the physical atomic weight scale for which the most abundant isotope of oxygen is arbitrarily given a mass exactly 16. The equivalent mass of the photon depends upon the frequency; it is $h\nu/c^2$ where c is the velocity of light. The relative penetrating powers and the relative abundances should not be taken too literally. Any particle can have a low or a high energy. A high energy proton would be more penetrating than a very low energy electron. The relative penetrating powers indicated in the table are what we expect when dealing with particles of essentially equal energies. Likewise the abundance of free particles depends upon conditions, and the values indicated represent only average conditions.

One somewhat familiar with the particles of modern physics might wonder why still another particle has not been listed in the table. In attempting to interpret certain aspects of radioactivity, both natural and artificial, it seems necessary to assume the existence of a particle which is called the neutrino. It certainly has no charge, for it leaves no track in the cloud chamber; and it is supposed to have an extremely small mass. There are several experiments which seem to show that such a particle exists, but they are not as direct as we might wish. Although the neutrino probably does exist, it is by no means as certain as are the particles listed in the table. I have omitted it because we are not certain.

Combinations of Elementary Particles

One often hears mentioned other particles also, particles which most certainly do exist. There is, for example, the deuteron. This is a heavy hydrogen nucleus; it has a mass 2 and a charge +1. There is also the alpha particle, one of the particles ejected by many radioactive materials as they disintegrate. This is a helium nucleus; it has a mass 4 and a charge +2. These and other heavier atomic nuclei certainly exist. We often work with high speed deuterons and alpha particles in the laboratory. They have not been included in the table because they are only combinations of protons and neutrons. The deuteron is made from one proton and one neutron; the alpha particle is made from two protons and two neutrons. Other heavier nuclei consist of greater, and usually not equal, numbers of protons and neutrons.

Role of Cyclotron and Van de Graaff Generator

Development of the Van de Graaff machine and of the cyclotron approximately 10 years ago has allowed us to learn a great deal concerning the structure of nuclei, the artificial disintegration of the elements, and the conversion of mass into energy. Both of these pieces of apparatus are designed for the purpose of giving extremely high energies to light atomic nuclei, protons, deuterons and alpha particles. Protons with 8 to 10 million electron-volts have been produced with the cyclotron. Deuterons with 15 to 20 million electron-volts have been produced. The same cyclotron is capable of producing alpha particles with 35 to 40 million electron-volts energy. Although neither the Van de Graaff machine nor the cyclotron is suitable for giving electrons high energies, a third instrument called the betatron, and developed very recently by Kerst, is capable of giving electrons an energy of 20 million electron-volts. None of these instruments can produce high energy neutrons directly, for the neutron has no charge. High energy neutrons can be produced indirectly, however, by bombarding certain materials with protons, deuterons or alpha particles. The bombarded material ejects neutrons.

We can now disintegrate almost any of the known elements, actually turn them into other atoms. This disintegration is accomplished by bombarding the element with protons, deuterons, alpha particles, neutrons or photons. Some atoms can be changed into any one of a number of different atoms. For example, aluminum of atomic weight 27 can be made into seven different things, phosphorus, two kinds of silicon, two kinds of magnesium, sodium, or aluminum of atomic weight 28. Similarly, a given atom can often be made in several different ways. Aluminum of atomic weight 28 is an example. This can be made in five different ways, starting with magnesium, silicon, phosphorus, or aluminum of atomic weight 27. We now recognize nearly 600 different kinds of atoms. Slightly less than 300 of these are stable. Approximately 300 are radioactive, disintegrating in the same manner as the natural radioactive elements. They are said to be artificially radioactive, because they have been produced artificially in the laboratory. Most of these eject an electron or a positron as they disintegrate.

Nothing So Practical as a Good Theory

Before closing I should like to bring out more clearly just how certainly we know that mass and energy are interchangeable. It was predicted theoretically some years ago that they should be interchangeable; and there was predicted a definite amount of energy that would appear for every gram of mass destroyed. If mass and energy are interchangeable as one expects theoretically, then in the disintegration of any material there should appear 931 million electron-volts energy for every atom disintegrating when the disintegration produces a loss of one unit in atomic weight. Let us consider a particular example. When lithium of atomic weight 7.01822 is bombarded with high energy hydrogen nuclei (protons) of atomic weight 1.00813, the lithium nucleus absorbs the proton and then splits into two helium nuclei. Helium has an atomic weight 4.00391. We actually observe in the cloud chamber tracks of the two helium nuclei as they fly off at high speed from the point of disintegration. The combined mass of the two particles with which we started (7.01822 + 1.00813) is 8.02635. The combined mass of the two particles resulting from the disintegration (4.00391 + 4.00391) is 8.00782. Thus there has been a loss of 0.01853 mass units in atomic weight. If this mass has been turned into energy there should appear $931 \times 0.0153 = 17.25$ million electron-volts energy for each atom which disintegrates. Now we can measure experimentally the energy of the bombarding proton and the energies with which the two helium nuclei fly off. We actually find that the helium nuclei have 17.28 million electron-volts more kinetic energy than the incident proton. Where has this energy come from? It is almost exactly that which would result from the loss of mass. The inference is strong that this mass has been turned into energy.

One might quote dozens of examples similar to the above. In some disintegrations there is a loss of mass and a gain in energy. In others there is a gain in mass and a loss in energy. In every case the gain or loss of energy can be accounted for almost exactly by the loss or gain in mass. All of these experiments make certain the fact that mass can be turned into energy, or energy into mass. We all recognize that heat can be turned into mechanical work, or work into heat. We do it every day on a large scale. Heat is just another form of energy. It is equally certain that mass and energy are interchangeable; mass is just another form of energy. It is true that we have so far not succeeded in converting mass into energy on a large scale. Perhaps we shall some day. If we ever do, we shall have available a very concentrated source of energy. If it could all be converted into energy, a small mass which could be carried in the hand would provide sufficient energy to run a large battleship across the ocean.

We can make artificial radioactive materials for medical purposes. A number of artificially produced atoms are used for important studies of plant and animal growth. A great deal of money is being spent to further knowledge and application of the conversion of mass into energy. Who could have foreseen thirty years ago that the basic knowledge we had gained in electronics would ever lead to the important applications it now has in radio, television and numerous other everyday appliances? Perhaps one living thirty years from now will marvel also at many still newer developments of which we at present can only speculate.

Aviation Radio Prospects

(*Continued from page* 89)

often involve much loss of time and extra travel due to their inability to take the bending or drifting effects of crosswinds upon a plane's course into consideration. And small planes have little gas to spare. Furthermore, a homing signal doesn't tell the pilot how far off-course he is flying and several of them operating in one locality could easily confuse a flier attempting to find one specific field.

The author believes that even small airports must furnish more positive means of navigation and that transmitters installed for this purpose should later be useful in establishing "stepping-stones" for short hops between such airports. A chain of small fields with adequate radio facilities might thus constitute a civilian air-highway across a State, or from one State to another.

It is possible that it may be desirable to use a compact range transmitter employing FM and providing a field-pattern somewhat similar to that of the conventional A-N range transmitter, while using a separate, band-switched AM transmitter on other frequencies for airport control and calling services.

Certainly even small civilian airports should have a multi-channel receiver of the type currently used by the airlines, capable of simultaneously monitoring two or three channels, and a tunable receiver for receiving weather reports and monitoring distress and itinerant calling channels.

This is the future's minimum equipment.

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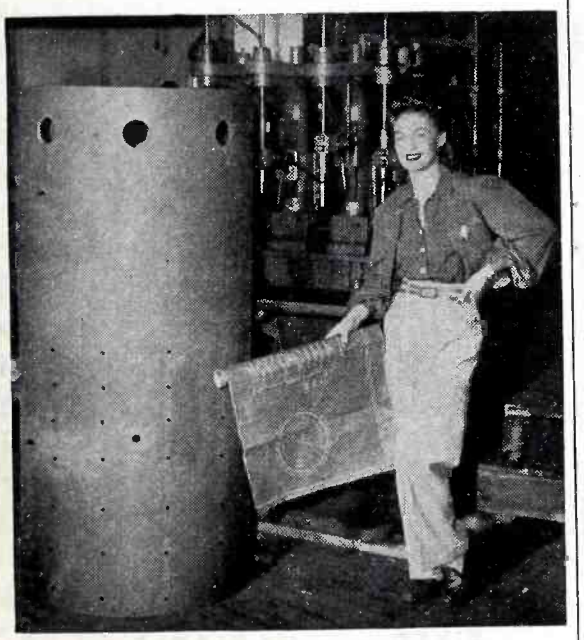
(1) Henney, K., "Radio Engineering Handbook", McGraw-Hill Book Co., New York.
(2) Sandretto, P. C., "Principles of Aeronautical Engineering", McGraw-Hill Book Co., New York.

A low-cost three-tube radio receiver made by mass-production methods and using a minimum of critical materials is to be produced in Great Britain for home use. It was found more economical to produce new utility sets than to make unstandardized replacement parts for the many existing receivers.



A-C Amplifiers

(*Continued from page 96*)

To use the chart of Fig. 3, it is necessary to determine the scales for the chart. The load voltage on the abscissa is found by multiplying the scale factor K, by E_{bb}. This gives us a new voltage scale for the abscissa, representing the voltage across the load, E_L.

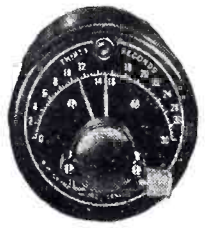
To find the scale for the ordinate, f, we must determine I_o, the current which would flow when no grid bias is applied, when the plate voltage is zero, and when the screen voltage is at its operating value. If the tube characteristic curves are available, we can determine this current (for the screen voltage for which the curves are plotted) by extending the linear portion of the $E_{c1} = 0$ curve to the left axis for which $E_p = 0$.

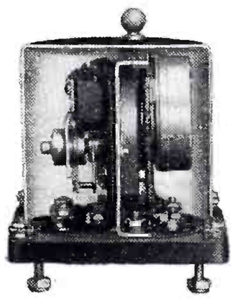
If we make use of the published ratings of the 6G6 used as a pentode, we see that for plate and screen voltage of 135 volts and a control grid bias of -6 volts, the plate current is 11.5 milliamperes. To obtain operating conditions for a 115-volt supply, it is necessary to assume that the pentode characteristics are horizontal, and equally spaced; this is a good assumption for our purpose. If we assume the plate current is independent of plate voltage, we can say as an approximation that 11.5 milliamperes of plate current flows at zero plate voltage, when the screen voltage is 135 volts and the control grid voltage is -6 volts.* The plate current at zero control grid voltage can then be calculated as $11.5 + g_m \Delta E_c$, where g_m is the published transconductance and ΔE_c is the change in grid voltage, in this case from -6 or $+6$ volts. Thus, the plate current at zero control grid voltage is

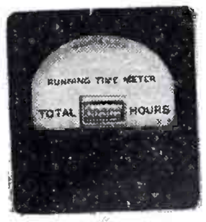
$$I_x = 11.5 \times 10^{-3} + 2100 \times 10^{-6} \times 6 = 24.1 \times 10^{-3} = 24.1 \text{ ma.}$$

If a value of screen voltage different from that for which the tube data is given is to be used, the current I_x will have to be modified to take account of the new screen grid voltage. If E_{sg}' is the actual screen grid voltage and E_{sg} is the screen grid voltage for which the tube data applies, the desired current is $I_o =$

* This fictitious plate current is determined by extrapolating the curves of saturation to the zero plate voltage abscissa. It is a value which is convenient for purposes of calculation rather than a value actually encountered in tube operation.







$I_x E_{sg}'/E_{sg}$. In our particular case

$$I_o = 24.1(115/135) = 20.53 \text{ ma}$$

This current, I_o, multiplied by the scale factor, f, gives the load current, I_L. Whereas we ordinarily find the third or E_c scale graphically, it is necessary to make some assumptions as to the characteristics of the tube in the absence of static curves. The chart of Fig. 3 gives grid bias values necessary to cause a 10 percent reduction in plate current. For this reason it is necessary to determine the bias necessary to reduce the plate current to 90 percent of its value at $E_c = 0$. If the value of I_o is put in the equation $E_g = I_p/g_m$, and the difference in E_g between $I_o = 20.53$ ma. and $0.9I_o = 0.9\text{x}20.53 = 18.5$ ma is found, this will be the bias required to produce a 10 percent change in plate current. Thus,

$$E_{cx}' = (I_o - 0.9I_o)/g_m = (20.5 - 18.5)/2.1 = 0.953 \text{ volts}$$

This calculation takes into account the compensation required by virtue of the fact that the actual plate voltage is 115 volts instead of the rated value of 135 volts, since the current I_o, rather than I_x, was used in this calculation. If the scale E_Q of Fig. 4 is multiplied by E'_{cx}, the bias for tube operation is also determined.

The resistance of the relay is $R_L = E_L/I_L$, or, in terms of the operating voltage and current, $R_L = nE_{bb}/I_o$, where n is the scale factor for the resistance lines. In this example, $R_L = 5{,}000$ ohms, $E_{bb} = 115$ volts, and $I_o = 0.0205$ ampere. The scale factor is

$$n = I_o R_L/E_{bb} = 0.0205 \times 5000/115 = 0.892.$$

We interpolate on the load resistance curves between $R_L = 0.5E_{bb}/I_o$ and $R_L = 1.0E_{bb}/I_o$ and determine the line of operation at 5,000-ohm load.

The power required is 0.32 watt. This power may be expressed as

$$P = E_L I_L = mE_{bb}I.$$

where m is a scale factor:

$$m = P/E_{bb}I_o = 0.32/(115 \times 0.0205) = 0.134.$$

Interpolating between the hyperbolic curves $P = 0.1E_{bb}I_o$ and $P = 0.2E_{bb}I_o$, we can determine the intersection of the resistance and power curves. This is the point of operation for the relay, and is designated by the letter Q on Fig. 3.

For these operating conditions, the grid voltage change which is required to operate the relay is

$$E_Q = E_c/E'_{cx} = 2/0.953 = -2.20 \text{ volts.}$$

Since we are at about -0.8 volt already, relay operation will occur for $E_Q = -3$ volts.

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

Incentives to Inventors

I HAVE BEEN MEANING to write to you for some time, especially since reading one of your articles in ELECTRONICS on suggested changes in our patent system.

In most of the cases the argument seems to revolve around the point that inventions are made primarily because the inventor works under a certain incentive to do so, especially in the expectation of a certain great or small material reward. I think anybody who is familar with the industrial setup will tell you that this argument is entirely beside the point. I do not think that in modern times any important invention was made or initiated because the man who invented it set out to make an invention in order to make money. Inventions come about because a certain problem arises in a scientific or industrial field and it is the character of research that a solution must and will be found for it, irrespective of whether or not obtaining that solution is accompanied by some material advantage to the one who contributes that solution.

I think the best proof of my argument is that in all industrial laboratories all inventions are assigned against a nominal value—usually one dollar—unless some other arrangements were made, which to my knowledge is rather the exception. And still all the laboratories over the country keep on inventing, which according to the theory that an incentive is required for the invention as such, should not be possible at all.

It seems to me that there is some confusion in mixing up the incentive for the invention with the required help to commercialize the invention. Any invention will be successful only if the contribution answers a certain social necessity. If it is not important enough for Society to provide the necessary means to put the invention into actual practice, no outside help will be able to do so.

EUGENE MITTELMANN
Consulting Engineer
Illinois Tool Co.
Chicago, Ill.

Three-Trace Cathode-ray Tubes

YOU PROBABLY KNOW of the difficulties which research men have had in obtaining multiple-trace cathode-ray tubes. The Western Electric Co. is no longer building three-trace tubes, and they are not being manufactured by any other company to my knowledge. There is a possibility that if there is enough demand for the 330-C or a closely similar tube, their manufacture will be undertaken by a Chicago corporation now making mostly 12-inch television tubes. The undersigned would appreciate hearing from anyone who needs a tube for replacement or original use in war research, giving priorities and stating how many tubes would be wanted.

W. E. GILSON, M.D.,
Department of Physiology
The University of Madison
Madison, Wisconsin

All-Electronic Sound Reproducer

FOR SOME TIME I have been toying with an idea for building a system of recording and playback in which there are no moving parts. Today I hit on a plan which I believe has good prospects, although it is not entirely practical at present.

A cathode-ray tube, phototube, lens and film are arranged as shown in the sketch, so that a spot at any point on the screen of the cathode-ray tube is focused on the phototube. There is no moving time base; in other words, the film which contains the sound track of a musical rendition or other recorded sounds remains stationary for the duration of the selection.

The sound track is recorded initially on the film in a zigzag manner. A saw-tooth oscillator connected to the horizontal deflecting plates sweeps the electron beam and its spot horizontally back and forth across the screen at a speed comparable to that of an ordinary phonograph record, while a vertical sweep oscillator having an extremely low frequency (about one cycle per three minutes) moves the spot slowly downward. The combined deflections would make the spot trace exactly the same zigzag pattern as the sound track on the film.

The light reaching the phototube at each instant would then be proportional to the density of the sound track area opposite the moving spot at that instant. The spot on the screen would of course be focused sharply enough so that its illumination affected only one sound track at a time.

With this arrangement, recordings could be individual squares of film, or a continuous length of film which is moved downward one frame at the end of each selection by an electromagnetic device.

Some of the problems I foresee are those of keeping the deflecting system in exact synchronism with the zigzag film track, eliminating inter-

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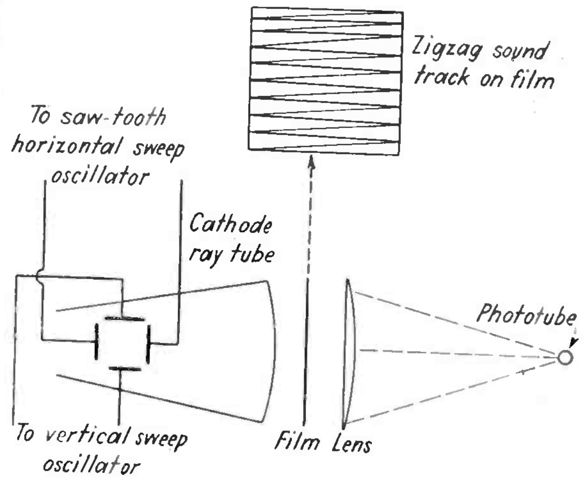
SENTINELS OF THE SKIES

Barrage balloons are a comparatively new branch of the U. S. Army, but they are already protecting many vital American installations against hostile aircraft. These "rubber cows" carry no crew, have no fire power nor armor. Enemy pilots avoid these balloons because their cables cut through the wings of a plane very easily. The Army's barrage balloon training center is situated at Camp Tyson, located off the regular airlines and in the northwestern wooded section of Tennessee. The 317th Battalion control room, which directs 54 balloon sites in the vicinity of the camp, is shown here. From this point telephoned directions are given for the lowering and raising of the balloons



Proposed arrangement of parts for an all-electronic sound reproducer

ruptions of sound at the beginning and end of each line, and positioning the film accurately with respect to the spot.

Any comment which readers of ELECTRONICS care to make on this idea will be appreciated.

FREDERICK M. PARRY,
Radio Station KTKN
Ketchikan, Alaska

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PORTRAITS OF WATER DROPS

Samuel Gilman, research engineer at the Westinghouse Research Labs. is shown with the camera which he uses to take "portraits" of water droplets so that the tiny particles of water can be measured accurately. A high intensity flash, produced through use of electronic circuits and lasting for only ten millionths of a second, shines into the camera through a water spray and the droplets are recorded on the photographic plate as white dots without distortion. The apparatus may be useful in analyzing fuel spray, as in automobile carburetors

CONTACTS

For the Field of Electronics

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INDEX TO ADVERTISERS

Postwar Radio

"CROSSTALK" for June observes that "Once the war ends and set manufacturers tool up for mass production of the pre-war variety of receivers, it will be too late."

How right you are!

If my 1942 Phono-combination and '42 Auto Radio (and even my '42 automobile too, for that matter) are fair samples for spot checks, why resurrect such things

Manufacturers who insist on prostitution of their art by post-war production of '42 models had better count on herding their most ingenious talent into the sales department. It will come in handy there to 'invent' outstanding features which have been military secrets these long years.

Convention cry of the future may well be:

"Time Marches Backwards!"

RICHARD S. LEVY
Signal Corps
Buffalo, N. Y.

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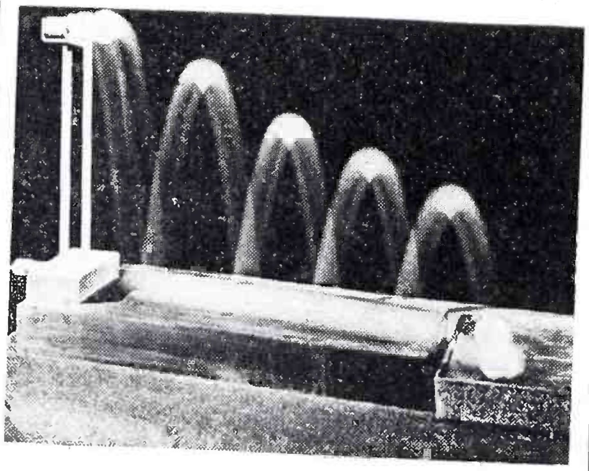
BOUNCELESS BALL



Engineers at Westinghouse have found that a steel ball half-filled with metallic powder will not bounce, as this time exposure photograph illustrates. Two balls of the same weight, one empty and one containing powder, were dropped simultaneously from the top of the posts, left. The empty ball left a looping trail of light as it bounced four times on the steel plate. The ball containing the powder rolled without bouncing, as shown by the straight streak of light on the plate. Rough surfaces of the metal powder particles created frictional heat, as they slid over each other, dissipating the energy the ball would have used in bouncing. This discovery has been used to prevent poor connections by eliminating bouncing and chattering in electrical relays and swiftly acting switching devices used in communications systems. The relay contacts are made hollow and partly filled with powder or hollow powder containers are attached to the contacts