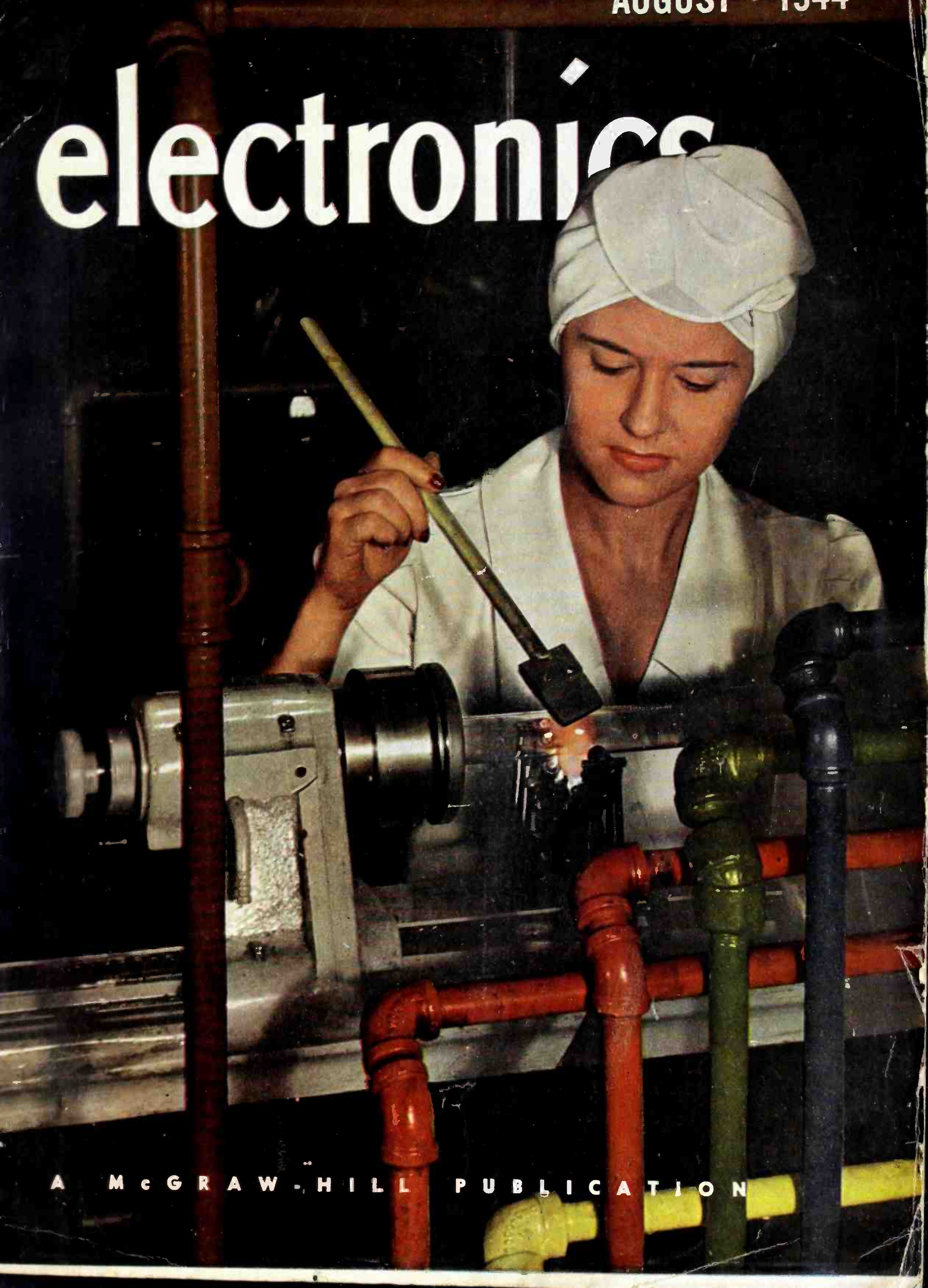
AUGUST · 1944

electronics



A McGRAW-HILL PUBLICATION

electronics

AUGUST • 1944

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330 West 42nd Street, New York 18, N. Y.

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From ....

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To ....

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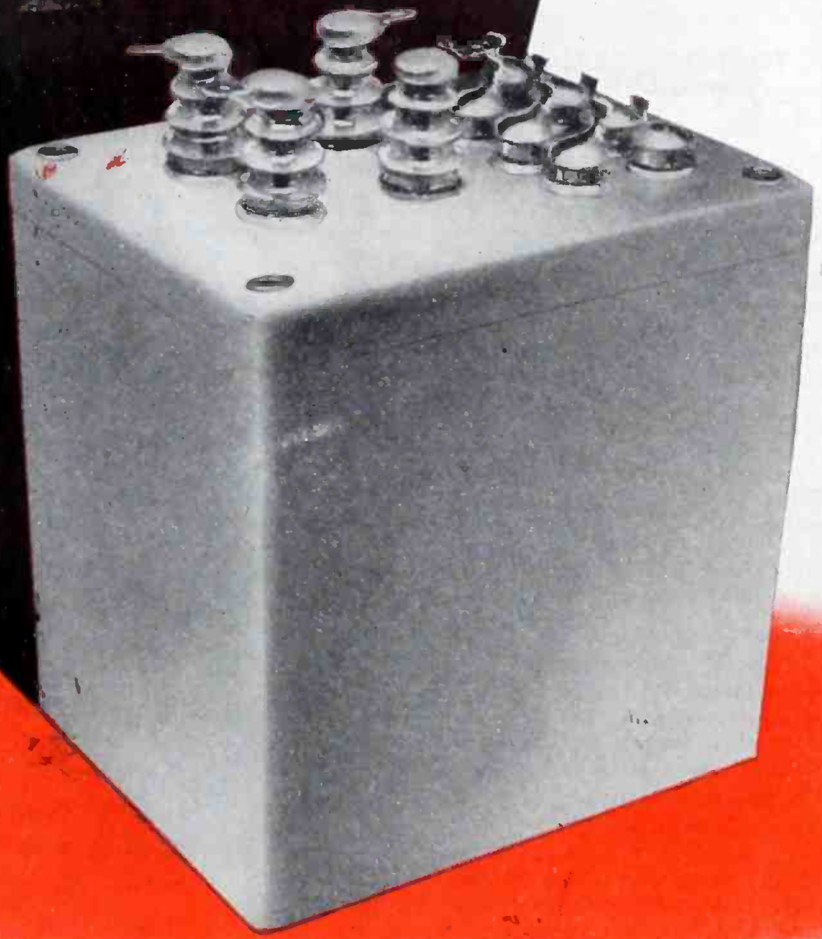
Signed ....

POWER SUPPLY COMPONENTS FOR WAR



The complex power supplies of war apparatus require components of maximum dependability. The unit illustrated is a typical power transformer for cathode ray application. In addition to the tapped primary, this unit provides a low voltage filament winding . . . a 5,000 volt anode supply winding . . . and a filament winding insulated for 15,000 volts peak inverse.

For hermetic sealing this unit employs an all metal enclosure . . . glass seal terminals . . . sealing compound which neither cracks nor flows from –55°C to + 130°C.

May we cooperate with you on design savings for your applications...war or postwar?

United Transformer Co.

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

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EST. 1867

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Quick

LOCAL SERVICE ON INDUSTRIAL ELECTRONIC TUBES

★ HELP SHORTEN
THE WAR . . . BUY
MORE BONDS THAN BEFORE!

The demand for electronic tubes for industrial equipment has jumped by leaps and bounds, as more and more electronic equipment has been used for faster and more accurate production.

Like all tube manufacturers, Westinghouse until recently has been hard pressed to make deliveries.

Today our production is high enough to ease this situation. Many types of tubes are available in limited quantities. We can even deliver spare tubes for many electronic devices.

Looking ahead to continued development of electronic equipment in industry, postwar, we now have a plan to make Westinghouse Electronic Tubes quickly and easily available. Stocks of the most widely used tubes are now available through Westinghouse Electronic Tube Distributors and Westinghouse District Warehouses. As rapidly as possible additional types will be added to local stocks to make a complete line of Quality Controlled Westinghouse Electronic Tubes available to everyone.

Included in this new distribution setup is a plan for surveying the electronic tube needs of individual tube users to better serve their requirements. It will be to your advantage to have your plant included in this survey. Fill in the coupon below and without obligating you in any way, a representative will call and give you complete details and make the survey.

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PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

ELECTRONIC TUBES *at work*

Westinghouse Electric & Manufacturing Co.
Electronic Tube Sales Dept.
Bloomfield, N. J.

Please have your representative call and explain your plan for surveying our Electronic Tube needs.

Name ....

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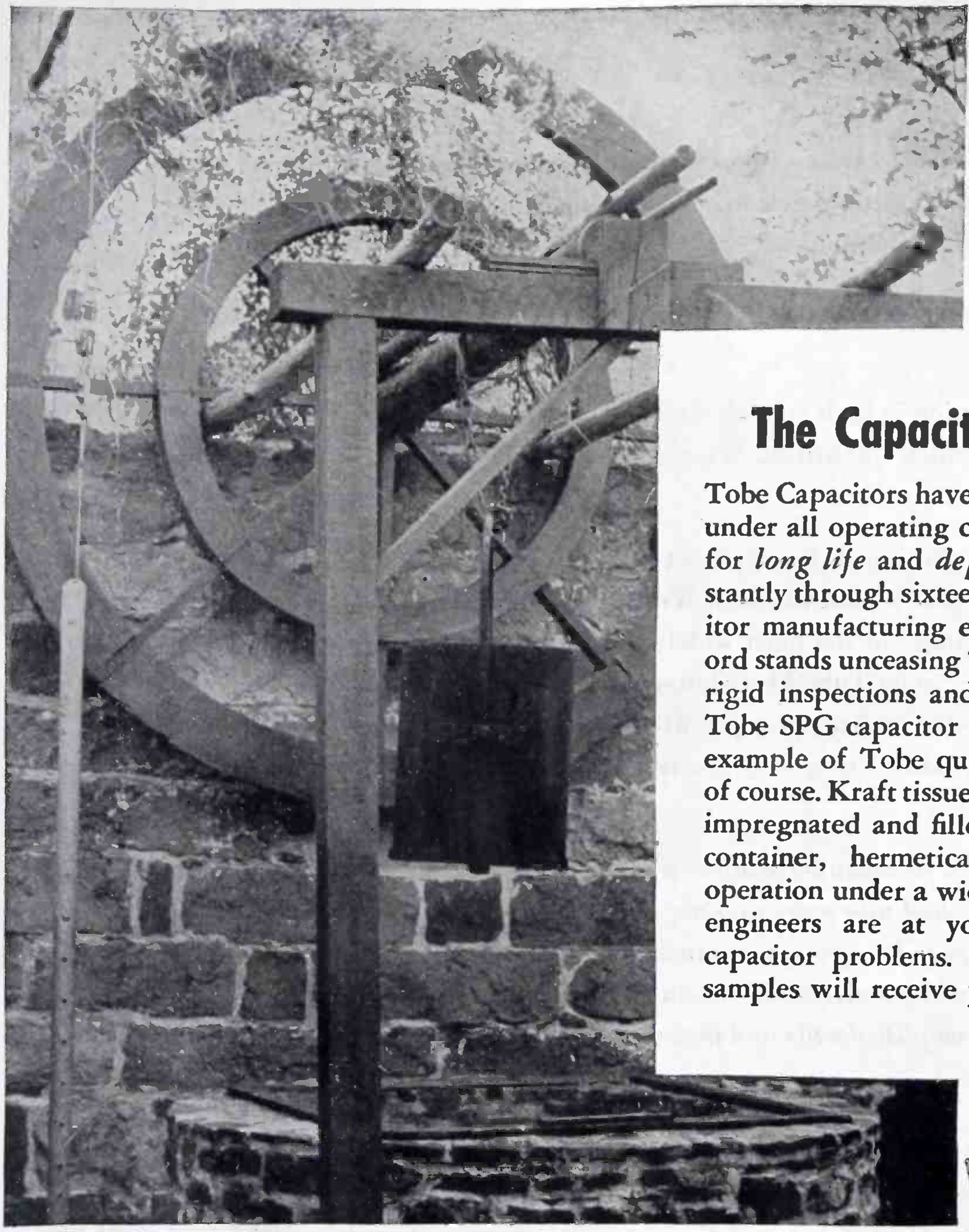


Old Mining Shaft at Newgate Prison in Granby, Conn. The Granby Mines, perhaps the most historic in America, are over 225 years old.

The Capacity to "TAKE IT!"

Tobe Capacitors have proved they can "take it"—under all operating conditions. Their reputation for *long life* and *dependability* has grown constantly through sixteen years of specialized capacitor manufacturing experience. Behind this record stands unceasing Tobe research, frequent and rigid inspections and *conservative ratings*. The Tobe SPG capacitor illustrated below is a good example of Tobe quality. Top grade materials, of course. Kraft tissue, aluminum foil. Mineral oil impregnated and filled, in a streamlined drawn container, hermetically sealed. Designed for operation under a wide temperature range. Tobe engineers are at your ready disposal in all capacitor problems. Inquiries and requests for samples will receive prompt attention.

MIDGET SPG CAPACITOR

SPG CAPACITOR

SPECIFICATIONS

SPG-CAPACITORS

TYPE	SPG*
RATINGS	.05 to 2.0 mfd. 600 V. D. C. .05 mfd. to 1.0 mfd. 1,000 V. D. C.
STANDARD CAPACITANCE TOLERANCE	20%**
TEST VOLTAGE	Twice D. C. rating
GROUND TEST	2,500 Volts D. C.
OPERATING TEMPERATURE	-55° F to 185° F
SHUNT RESISTANCE	.05 to 0.1 mfd. 20,000 megohms .25 to 0.5 mfd. 12,000 megohms 1.0 mfd. 10,000 megohms 2.0 mfd. 5,000 megohms
POWER FACTOR	1,000 cycles—.002 to .005
CONTAINER SIZE	Width ⅝", length 1$\frac{5}{16}$", height 2¼"
MOUNTING HOLE CENTERS	1½"

MIDGET SPG-CAPACITORS

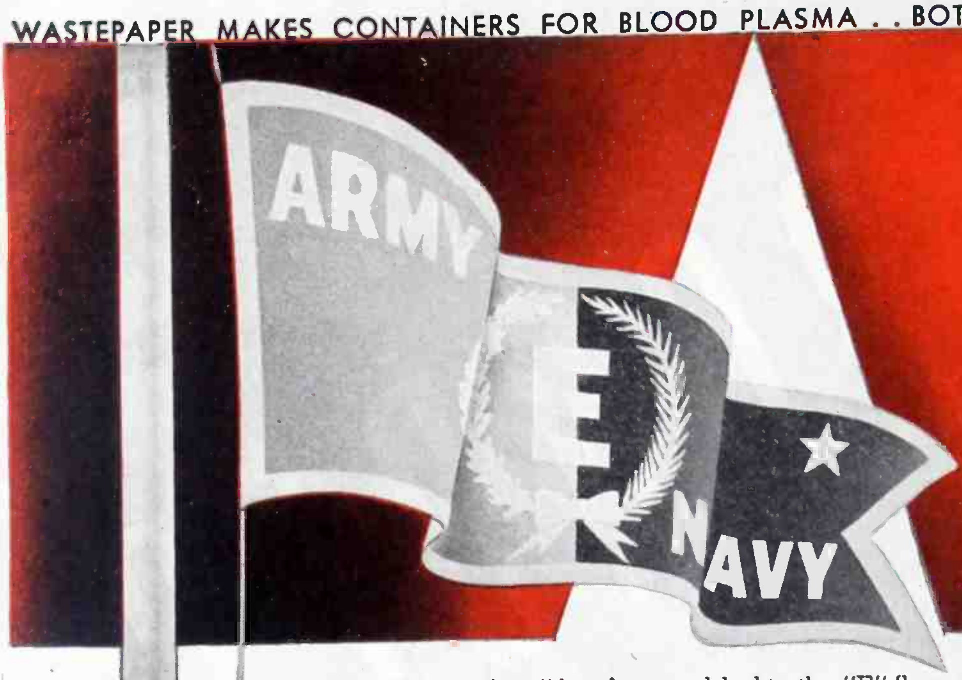
TYPE	SPGM*
RATINGS	.05, .1 and 2 x .05 600 V. D. C. .05 and .1 1,000 V. D. C.
STANDARD CAPACITANCE TOLERANCE	20%**
GROUND TEST	2,500 V. D. C.
OPERATING TEMPERATURES	-55° F to 185° F
SHUNT RESISTANCE	20,000 megohms
POWER FACTOR	At 1,000 cycles—.0075
CONTAINER SIZE	Width ⅝", length 1$\frac{5}{16}$", height 1$\frac{11}{64}$"
MOUNTING HOLE CENTERS	1½"

*Data sheets showing complete code number for units having a specific capacitance value and voltage rating available on request. **Other tolerances available.

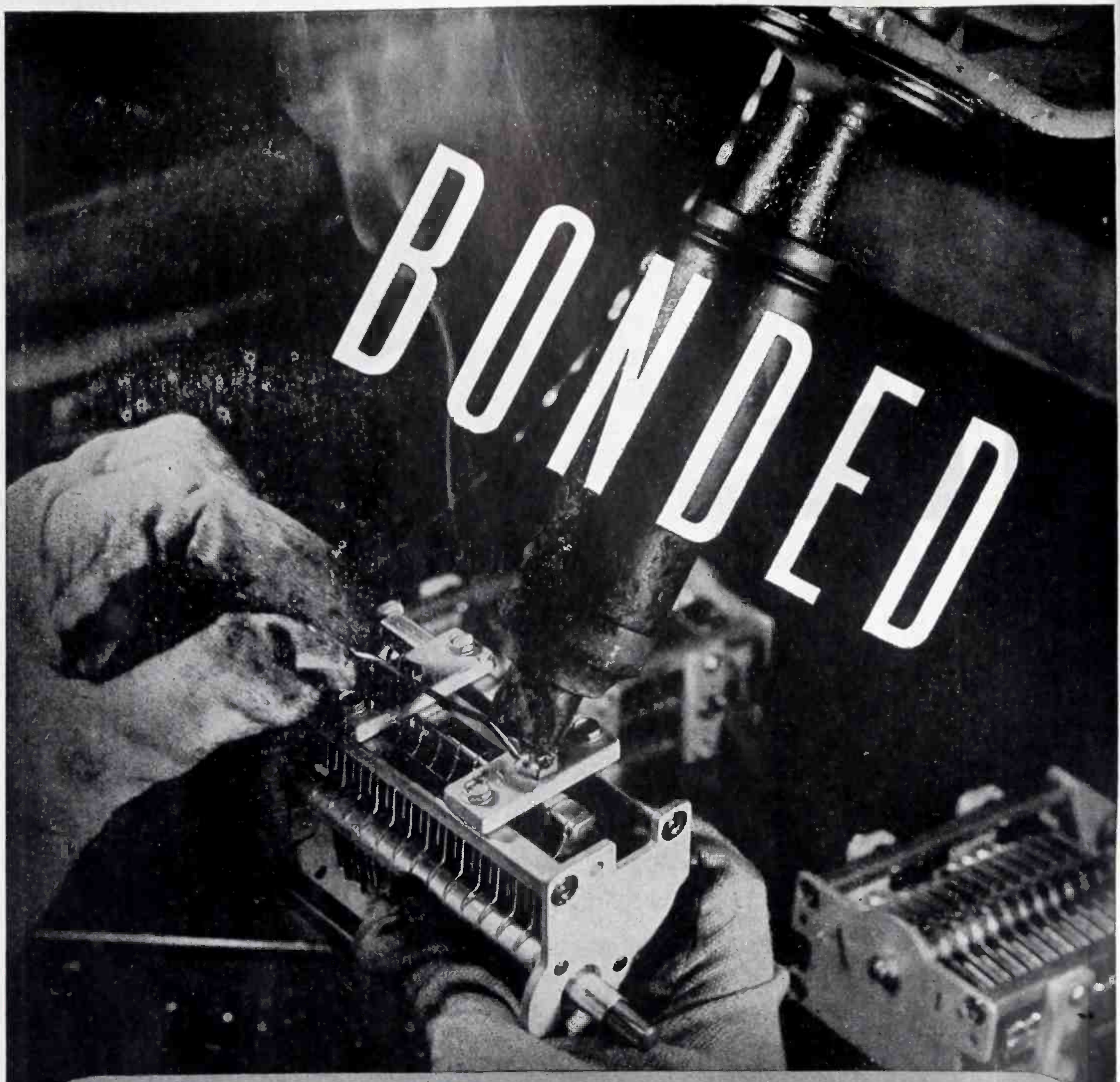
Illustrations show capacitors with terminals on bottom.
Capacitors also available with terminals on top.

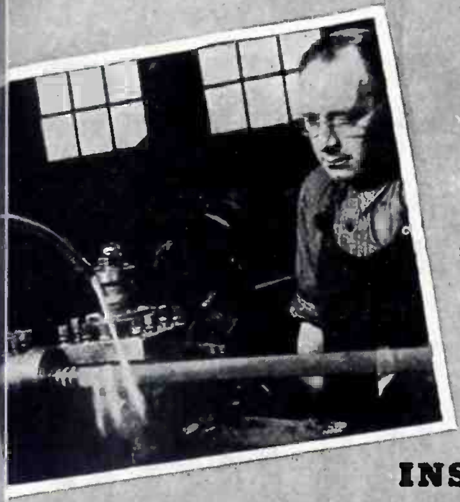
TOBE DEUTSCHMANN CORP.
CANTON · MASSACHUSETTS

A small part in victory today... **A BIG PART IN INDUSTRY TOMORROW**


ARMY
E
NAVY


DOT
SPACE


BONDED



NEW!

MYCALEX 400

(Patent Pending)

THE ONLY HIGH FREQUENCY INSULATION FOR ELECTRONICS COMBINING THESE LONG-SOUGHT ADVANTAGES:

L-4 CHARACTERISTICS

plus

MACHINABILITY TO TOLERANCES AS CLOSE AS ± 0.001 IN.

COIL FORM

SPECIFICATIONS

Power Factor,
1 megacycle 0.0018
Dielectric constant,
1 megacycle 7.4
Loss factor, 1 megacycle....0.013

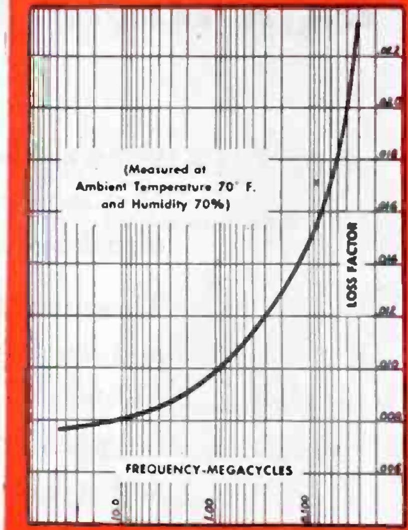
Measured after 48 hours immersion in distilled water in accordance with American War Standard C-75.1—1943 (JAN.-I-10).

Dielectric constant is unchanged from 50 kilocycles to 10 megacycles.

Surface resistance,
megohms 300,000

After 96 hours at 85° F. and 85% relative humidity, with 1 inch electrode spacing.

Specific gravity 3.0
Impact strength, Charpy, ¼ in. x ¼ in. 0.098 ft. lb.



TODAY'S news about low-loss insulation is that MYCALEX 400 is making other glass-and-mica insulation old-fashioned. It is no longer true that "all glass-bonded mica is pretty much the same."

Before the advent of MYCALEX 400, it was impossible to obtain L-4 characteristics plus precise machinability in one and the same insulation. But now MYCALEX 400 combines these long-sought dual advantages. Yet this vastly improved ALL-PURPOSE MYCALEX costs no more.

MYCALEX 400 has a loss factor considerably lower than any other insulation in its class. Its surface resistivity is higher than that of other comparable insulators. This is an important advancement where the application involves high temperature and high humidity, as in the tropics.

Unlike other low-loss ceramic insulators, MYCALEX 400 can be machined with precision . . drilled, tapped, milled, sawed, turned on a lathe and threaded. It has exceedingly low vapor pressure. It makes a perfect seal with metal.

MYCALEX is not a generic term designating a class of materials, but is the *registered trade name* for the low loss insulation manufactured in the Western Hemisphere by the Mycalex Corporation of America

Write for samples. Order any quantities, in sheets or rods – or have us fabricate your component products in Mycalex.

INSULATING BLOCK

MYCALEX
THE INSULATOR
TRADE MARK REG. U. S. PAT. OFF.

MYCALEX CORPORATION OF AMERICA

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GENERAL ELECTRIC

announces the appointment of

GRAYBAR

and GENERAL

IN ADDITION TO G-E DISTRICT

as national distributors of General Electric

General Electric announces the formation of a national network of electronic-tube distributorships.

Three well-known national electrical sales and service organizations: the Graybar Electric Company, the General Electric Supply Corporation, and all G-E district and local apparatus offices.

Each of these national distributors will carry a diversified stock of electronic tubes as soon as priority regulations permit. Now available is a weekly stock and delivery estimate schedule that will tell you when your electronic-tube order will be delivered.

Each distributor will be glad to obtain engineering information on request for any electronic-tube problem.

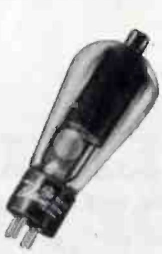
We urge you to take full advantage of this improved electronic-tube service. *Tube Division, Electronics Department, General Electric, Schenectady, New York.*

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

THERE IS A G-E ELECTRONIC TUBE FOR EVERY PURPOSE

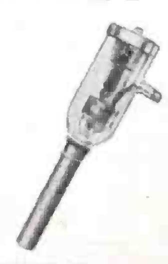
PHANOTRON — *for high-frequency electronic heating*

PHOTOTUBE — *for counting, sorting, grading*



THYRATRON — *for industrial equipment control*

IGNITRON — *for resistance welding and converting a-c to d-c*



PLIOTRON — *for induction and dielectric heating*

PENTODE — *a general-purpose amplifier*

An Open Letter to Executives *of the* Radio Industry

When you find time to consider post war problems, give a thought to what can be accomplished *now* by better industry standardization of components.

Prior to this war, the variety of tubes, resistors, condensers, coils and hardware was limited only by the desires or fancies of hundreds of engineers and by the ability of parts makers to tool and tool and tool. Possibly this haphazard procedure was a necessary adjunct to pioneering and growth.

The automotive industry experienced similar confusion in its early days, but with the advent of stability there also came standardization—of spark plugs, tire sizes, bumper heights, fan belts, sealed beam headlights, etc. Or maybe cooperative standardization helped to bring about industry stability.

Today—while post war radio sets are still in the making—is the time for top radio executives to insist that engineering and commercial departments work with the proper Committees of the Radio Manufacturers' Association to establish industry standards. If it is not done now, the next opportunity may be years away.

Here is an example of what can be accomplished. In one class of component, namely dry electrolytic condensers, there were more than 500 different types, ratings or sizes used as filters in the various radio sets made in a pre-war year. Chief Engineers appear to agree that between 30 to 40 standard units will meet all filtering requirements in 95% of the chasses built.

Should something like 40 electrolytics be adopted as standard type filters, the manufacturers of these condensers can produce in larger quantities and in more fully mechanized departments, furnishing a more uniform product at lower cost. It is probable that metal encased units—with their longer life—can be made so economically that inferior cardboard enclosures can be eliminated as standards. Some production can be maintained in "off-season." Set manufacturers' and service department inventories can be kept lower than heretofore. The public obviously will benefit by cost reduction in both sets and service charges.

Although condensers are used as an example, similar benefits and economies will accrue to the industry and the public by elimination of unnecessary types of other components.

This standardization is a matter which is vital to our industry's growth. If you believe in it, do something about it. Write or confer with the Chairman of the R. M. A. Parts Division, or contact the heads of the various special R. M. A. Committees on components. Only concerted industry effort will bring results. There is great need for leadership. Yours is solicited.

Ordered and paid for by a Capacitor Manufacturer, who, for the sake of industry cooperation, prefers to remain anonymous.

IMPROVE Wiring Harness Methods with IRVINGTON Plastic Tubing and Wire Markers

Wiring harness . . . pre-fabricated wiring sub-assemblies . . . are doing much to speed the manufacture of many war products. They do this by placing the job of wire cutting, stripping, fitting and binding, where it belongs—on a sub-assembly bench.

Conductors used in the assembly of harnesses can be effectively grouped and further insulated with sleeves of Transflex, a transparent plastic tubing which then serves as a flexible, protective conduit. Transflex reduces—often eliminates—the need for lacing; has unusual elongation and may be stretched over lugs, splices and other projections. It withstands attack by moisture, oils, solvents, acids and alkalies, and may be safely used at temperatures as low as —58° F. It does not support combustion.

Irvington Plastic Marker-Insulators are useful in harness construction because they provide both terminal insulation and positive wire identification. Made of the same resistant material as the plastic flexible conduit, they are tough and elastic . . . withstand similar service conditions . . . may be used at operating temperatures up to 170 deg. F. Where continuous higher temperatures are encountered, Varnished Wire Markers are recommended.

For detailed information on these Irvington products, send for technical data sheets describing Transflex and Wire Markers. Please write Dept. 106.

Colored and marked wires are easily distinguishable through Transflex plastic tubing.

Irvington Plastic and Varnished Wire Markers are both available in a variety of sizes and colors; are marked to specifications.

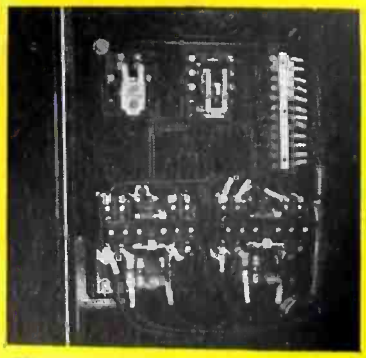
WIRE AND ASSEMBLY TIME SAVED WITH LATEST WIRING HARNESS TECHNIQUES

Better, faster production possible with conductors cut to proper lengths and provided with lugs and identifying markers. Harnesses reduce copper waste; can be bench-fabricated by practically unskilled workers.

❶ Fastening lug and slipping Marker-Insulator into position on wires already cut to size.

❷ Enclosing wires in Transflex plastic tubing conduit eliminates need for lacing.

❸ Connecting harness wires to corresponding equipment terminals.



❹ Completed unit ready for testing. Markers simplify inspection, "in-production" changes, and servicing.

IRVINGTON VARNISH & INSULATOR COMPANY

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MICA CAPACITOR
TYPE E
Sangamo Electric Co.

WHAT HAPPENS TO STEEL WHEN NUT MEETS BOLT?

Blow them up 100 times in the Metalgraph and see why some fasteners fail

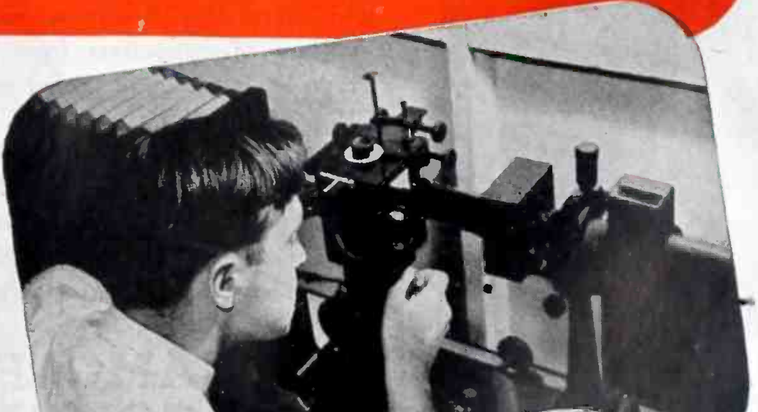
This photograph shows somewhat excessive decarburization in the bolt, and a lap in the thread. Nut is satisfactory. Heat treatment O.K.

Decarburization of bolt satisfactory. Thread form good. Heat treatment slightly deficient. Nut satisfactory.

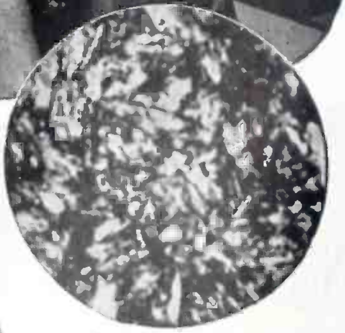
To the naked eye, nuts and bolts are just nuts and bolts. To be sure, surface defects are sometimes apparent, but they are easily detected.

What happens to the granular structure of the metal when the nut has been fastened to the bolt, and then broken in test, is something else again . . . and terribly important.

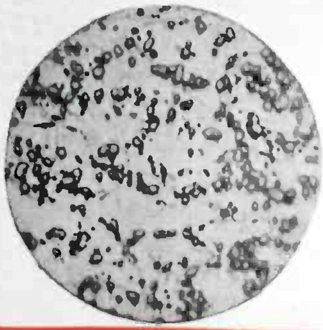
This is just one of the many precautions our metallurgists and engineers take to insure superlative performance . . . an example of the minute attention to details that makes for National Quality.



Operator checking grain structure of steel by means of the Metalgraph.



Heat-treated alloy steel, enlarged 1,000 times.



Spheroidized alloy steel wire, enlarged 750 times.

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PRODUCTS

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

Franklin's $64 Question Gave Electricity a Job

HIGH DIELECTRIC STRENGTH

LOW MOISTURE ABSORPTION
CORROSION RESISTANCE

COMPRESSIVE STRENGTH

TENSILE STRENGTH

FLEXURAL STRENGTH

IMPACT STRENGTH

STABLE OVER A
WIDE TEMPERATURE RANGE

Many More Properties—Combined

Lightning streaked through ages, feared but unchallenged. Then to Benjamin Franklin it flashed the answer to a question that unlocked the future of electricity.

Technical plastics, Synthane for example, have already answered many $1 to $64 questions for people who make things. And may for you. The question, of course, should come before the answer—for only you know, as *you* do, what your requirements are. If whatever you are working on suggests a material of excellent electrical insulating characteristics, resistance to corrosion, mechanical strength, stability at usual temperatures, easy machineability, or a variety of other inter-related properties, our type of technical plastics may readily be indicated. Our latchstring is always out to any inquiry.

Synthane Corporation, Oaks, Penna.

SYNTHANE TECHNICAL PLASTICS

SHEETS • RODS • TUBES • FABRICATED PARTS **SYNTHANE** MOLDED • LAMINATED • MOLDED • MACERATED

Plan your present and future products with Synthane Technical Plastics

A comparison of SYNTHANE TECHNICAL PLASTICS with certain metals, debunking a popular notion that plastics being "magic" can be used indiscriminately

IT IS CHARACTERISTICALLY HUMAN to back a winner . . . to ascribe precipitately to vitamins or sulfa drugs or plastics more powers and claims than sober research can keep up with. Plastics have their possibilities . . . and their limitations. Good design is the reward of knowing both.

Plastics are doing many jobs that metals used to do, especially since certain critical metal shortages have cropped up. But, basically, plastics are not substitute materials. Correctly applied, they should and do stand solely on their own merits.

INTERESTING COMPARISONS TO PROVE the point can be made between our type of plastics—Synthane—and certain metals. Synthane is made by applying heat and pressure to paper or fabric impregnated with thermosetting resins. It is non-metallic, a fact which should at once suggest uses fundamentally different from those of metals. Actually, Synthane is an excellent electrical insulator, and so you find it in hundreds of radio and electrical products and applications, not in place of metal, but to insulate metal. That does not imply Synthane cannot replace metal. As a matter of fact, Synthane has taken over for metals in pulleys, bearings, panels, structural members, scales, dials. The reasons can usually be traced to one or a combination of the many properties of Synthane technical plastics.

ONE OF THE PRINCIPAL REASONS at present is light weight. Synthane has a specific gravity ranging from 1.20 to 1.70, about half that of aluminum, less than magnesium. So in many unstressed parts for aircraft Synthane is a logical consideration.

SYNTHANE LAMINATED PLASTICS GENERALLY have lower mechanical strength than metals for a given cross section. For example, an approximate comparison might read like this:

	Tensile Strength (p.s.i.) ultimate	Compressive Strength (p.s.i.)
Alloyed Aluminum	16,000–60,000	9,000– 47,000 (y)
Brass	40,000–80,000	28,000–126,000 (u)
Cast Iron	16,000–45,000	80,000–200,000 (u)
Synthane	8,000–12,000	30,000– 50,000 (u)

(y—yield strength
u—ultimate strength)

IT IS IMPORTANT, HOWEVER, TO REMEMBER that on a *weight* basis, Synthane may be stronger though redesign of a part for plastics may be necessary.

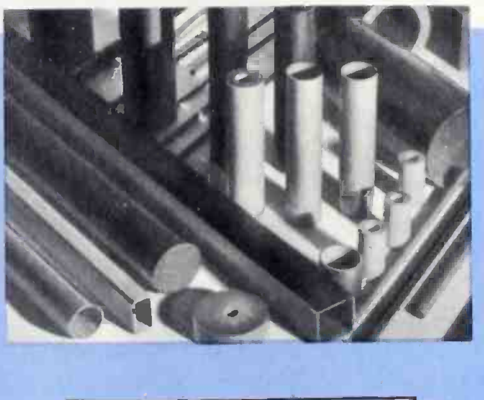
HARDNESS IS A PROPERTY in which another interesting comparison of Synthane with metals can be made. Brinell hardness, tested with 500 Kg. load, 10 mm ball, shows approximately these values: Alloyed aluminum 45–110, Brass 95–150, magnesium (drawn annealed) 29, annealed cast iron 77, Synthane 24–40.

BEHAVIOR UNDER TEMPERATURE CONDITIONS is characteristic of Synthane's non-metallic composition. For instance, whereas the thermal conductivity of aluminum alloys may range from .20 to .54 calories per second per square centimeter per centimeter of thickness per degree C., Synthane's thermal conductivity is about .0005 to .0008. The coefficient of thermal expansion of Synthane is about .0000140 inches per inch per degree F., approximately the same as alloyed aluminum, slightly more than pure aluminum, copper, brass.

CORROSION RESISTANCE IS A SUBJECT of such complications as to temperature, degree of concentration, and type of agent that any comparison with metals would necessarily be lengthy. Synthane does resist corrosion from water, many acids, oils, and salts, and to a greater or lesser extent than metals depending on the metal with which it is compared and the corrosion conditions. Synthane is extensively used as a corrosion resistant material.

APART FROM ITS PHYSICAL, CHEMICAL, electrical and chemical properties, Synthane may be easily and quickly machined by ordinary shop methods, a point which may occasionally influence selection when other factors are the same. And, just as metals are cast for economy in large quantities, so Synthane is available in two molded forms, molded-laminated and molded-macerated, for economy of duplication.

OBVIOUSLY, IN CERTAIN CASES there can be no question of whether to use Synthane plastics or a metal such as when the material must be an electrical conductor or an electrical insulator. In other cases, weight or strength may decide, or corrosion resistance, resilience, hardness, machinability. Or as often happens, the decision may rest upon the extent to which the material required meets many combined specifications. Synthane technical plastics are usually more desired for their combination of properties than for any one specific property for which another specific material or metal may be the only logical answer.



SYNTHANE

PLAN YOUR PRESENT AND FUTURE PRODUCTS WITH SYNTHANE TECHNICAL PLASTICS · SHEETS · RODS · TUBES · FABRICATED PARTS · MOLDED-LAMINATED · MOLDED-MACERATED

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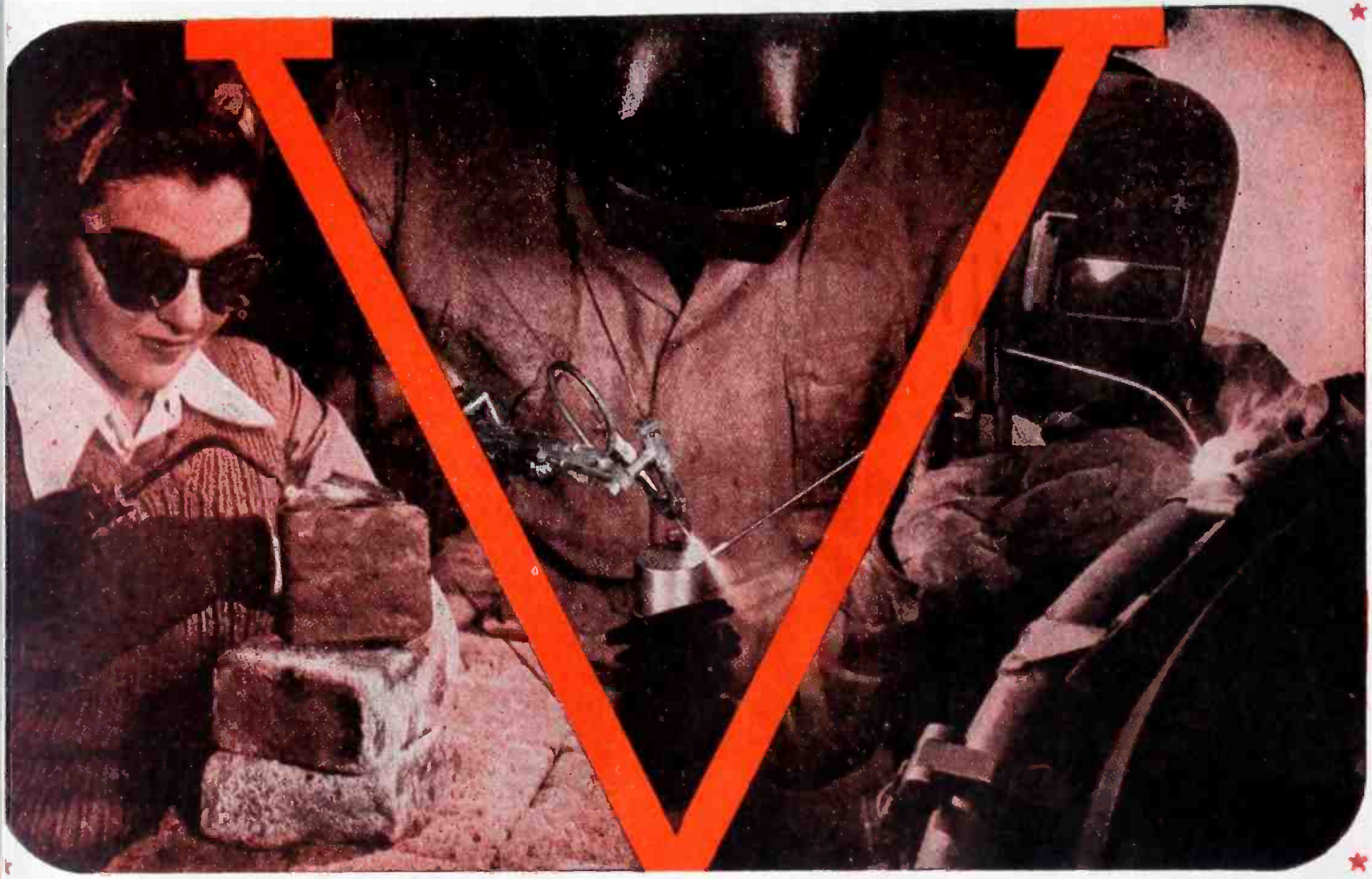
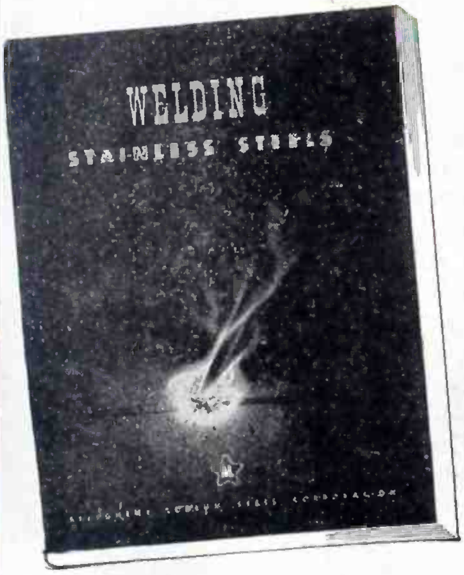
REPRESENTATIVES IN ALL PRINCIPAL CITIES



ARE YOU WELDING STAINLESS STEEL? HERE'S *New Light* ON THE SUBJECT



This book can save you time and void spoilage of vital alloys, both nore than ever essential to the war rogram today. Describes and ilustrates equipment, procedures, recautions. Request copies on our company letterhead, please.

ADDRESS DEPT. E-24

SUCCESSFUL stainless steel welding, as many a shop has found out the hard way, puts a premium not only on knowing what to do, but also what to avoid doing—and why.

That is because the problem, first of all, is a double one as compared to ordinary carbon steel welding, since it calls for maintaining the corrosion resistance of the parent metal across the weld area, as well as its strength. Furthermore, although stainless steel welds easily, the various members of the stainless family differ considerably from carbon steel—and even from each other—in the physical and chemical phenomena they exhibit during the welding process.

Information, clear and complete, is the basic answer. We've supplied it in a new 64-page, full-color booklet, *"Welding Stainless Steels,"* covering all the commonly-used hand or machine methods of welding Allegheny Metal. Employing a new idea in graphic illustration, this book is, we believe, the most complete and understandable coverage of the subject yet published—a welding shop "bible" purposely made so clear and simple that it is also ideal for student training. ● *Write for your copy (see at left).*

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STEEL FOR THE NATION'S WELFARE

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Branch Offices in Principal Cities . . . Allegheny Metal also handled by all Joseph T. Ryerson & Sons, Inc. Warehouses

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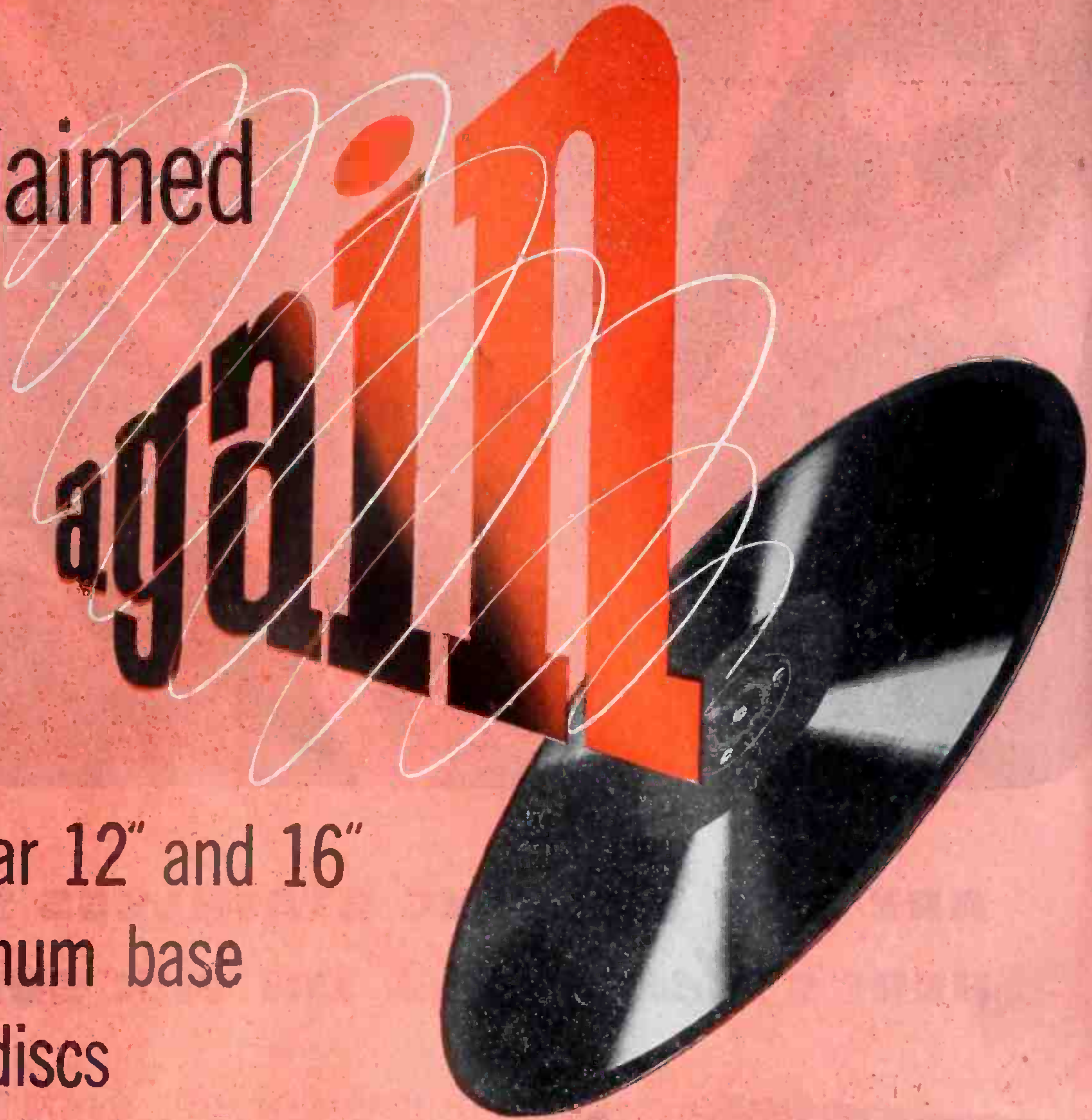

popular 12" and 16"
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also the famous Master Audiodiscs

Once more aluminum base Audiodiscs are available. Once more these discs are acclaimed for their excellent recording properties by professional recordists and radio station engineers.

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Current price lists are now ready and will be sent upon request. Orders will be filled as promptly as possible. Contact your Audiodisc distributor, or address Audio Devices, Inc., 444 Madison Avenue, New York 22, N. Y.

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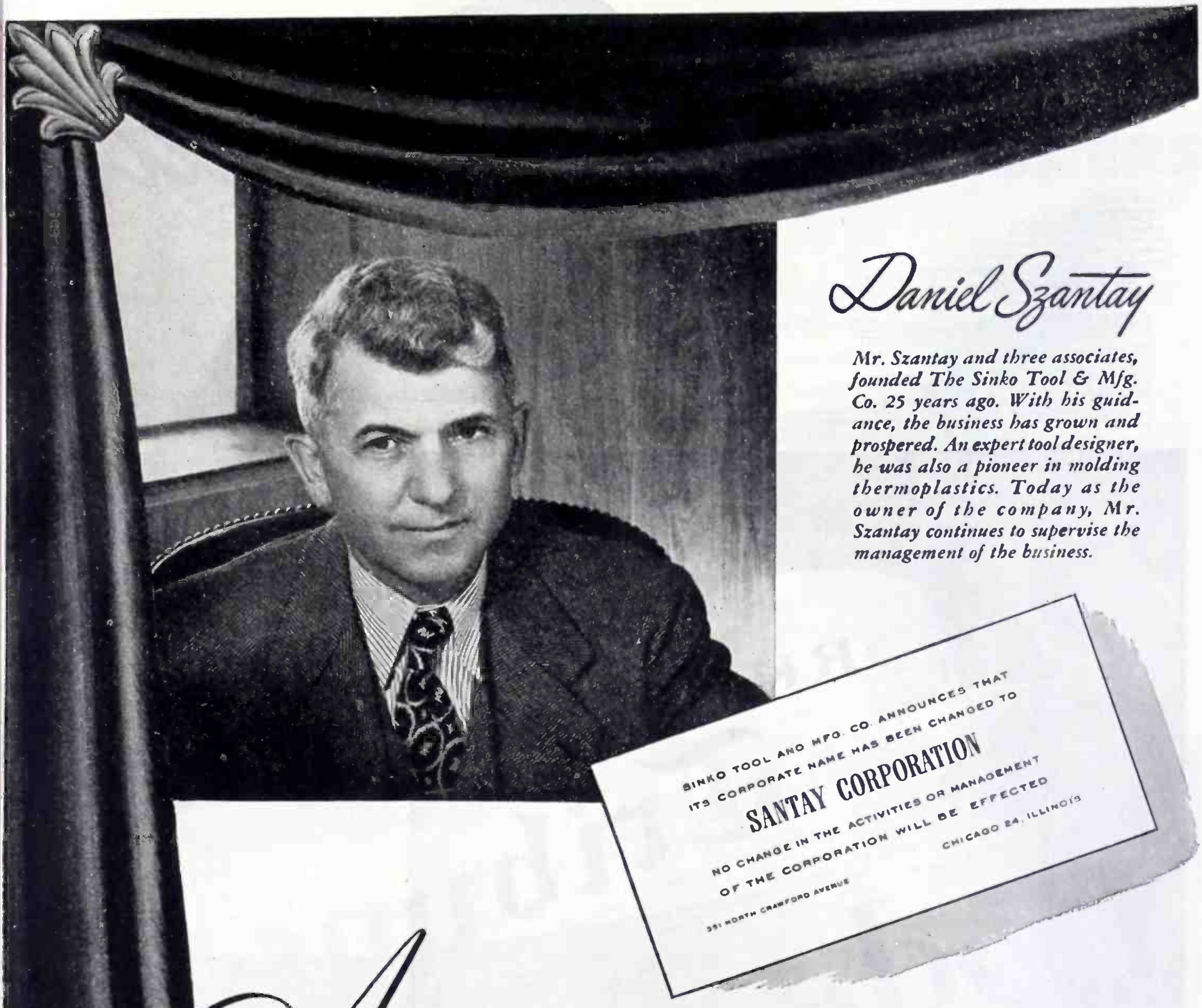

SINKO TOOL AND MFG. CO. ANNOUNCES THAT
ITS CORPORATE NAME HAS BEEN CHANGED TO

SANTAY CORPORATION

NO CHANGE IN THE ACTIVITIES OR MANAGEMENT
OF THE CORPORATION WILL BE EFFECTED

351 NORTH CRAWFORD AVENUE
CHICAGO 24, ILLINOIS

Daniel Szantay

Mr. Szantay and three associates, founded The Sinko Tool & Mfg. Co. 25 years ago. With his guidance, the business has grown and prospered. An expert tool designer, he was also a pioneer in molding thermoplastics. Today as the owner of the company, Mr. Szantay continues to supervise the management of the business.

Announcing

the change *in name* of one of America's leading manufacturers of Injection Molded Plastic parts and products. The Sinko Tool & Manufacturing Company will hereafter be known as SANTAY CORPORATION. For many months, 100% of our facilities have been operating three shifts a day, producing intricate Thermoplastic Parts and Electro-Mechanical Assemblies for the Army and Navy. Invaluable knowledge and experience has been gained, which is bound to be reflected in the products we make in the future. Post-war planners are invited to consult with our master craftsmen on the simplest or most involved metal or thermoplastic part or product.

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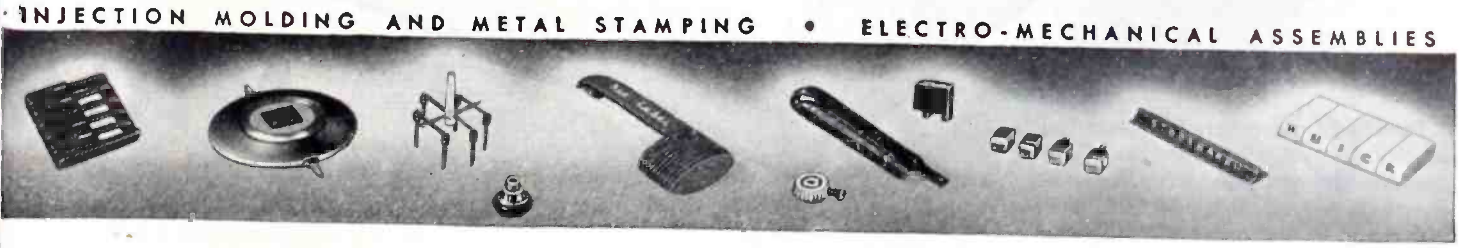
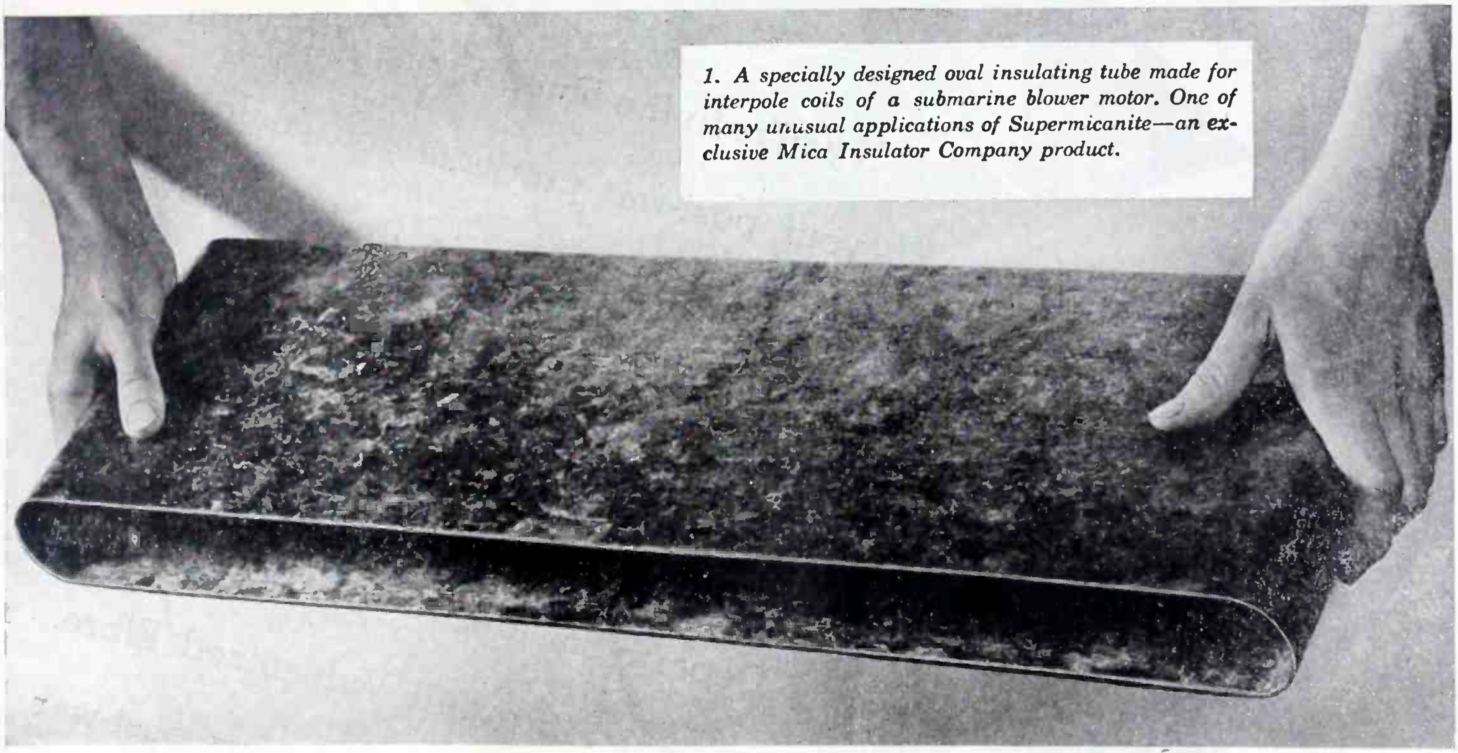


Insulation ...DESIGNED FOR DESIGNERS

Elevated operating temperatures . . . greater speeds . . . higher frequencies . . . compactness of the new functional designs—all mark the trend in re-designing postwar products for civilian use. And all point clearly to the need for "made-to-measure" insulations, which combine the *surety* of time-tested materials with precision fabrication of intricate insulating parts.

Mica Insulator Company brings to this problem a single supply source of diversified materials and an undivided responsibility for their fabrication. With strategically located fabrication facilities and nation-wide distribution of LAMICOID plastic laminates—EMPIRE varnished cloths and tapes—MICA and MICANITE—we are equipped and conditioned by half a hundred years of insulation experience to offer a quick, dependable and complete source of highly specialized insulating materials and products.

Designers and manufacturers of electrical and electronic equipment of all kinds are invited to enlist this service—without obligation—in the solution of insulation problems—present or projected.



1. A specially designed oval insulating tube made for interpole coils of a submarine blower motor. One of many unusual applications of Supermicanite—an exclusive Mica Insulator Company product.

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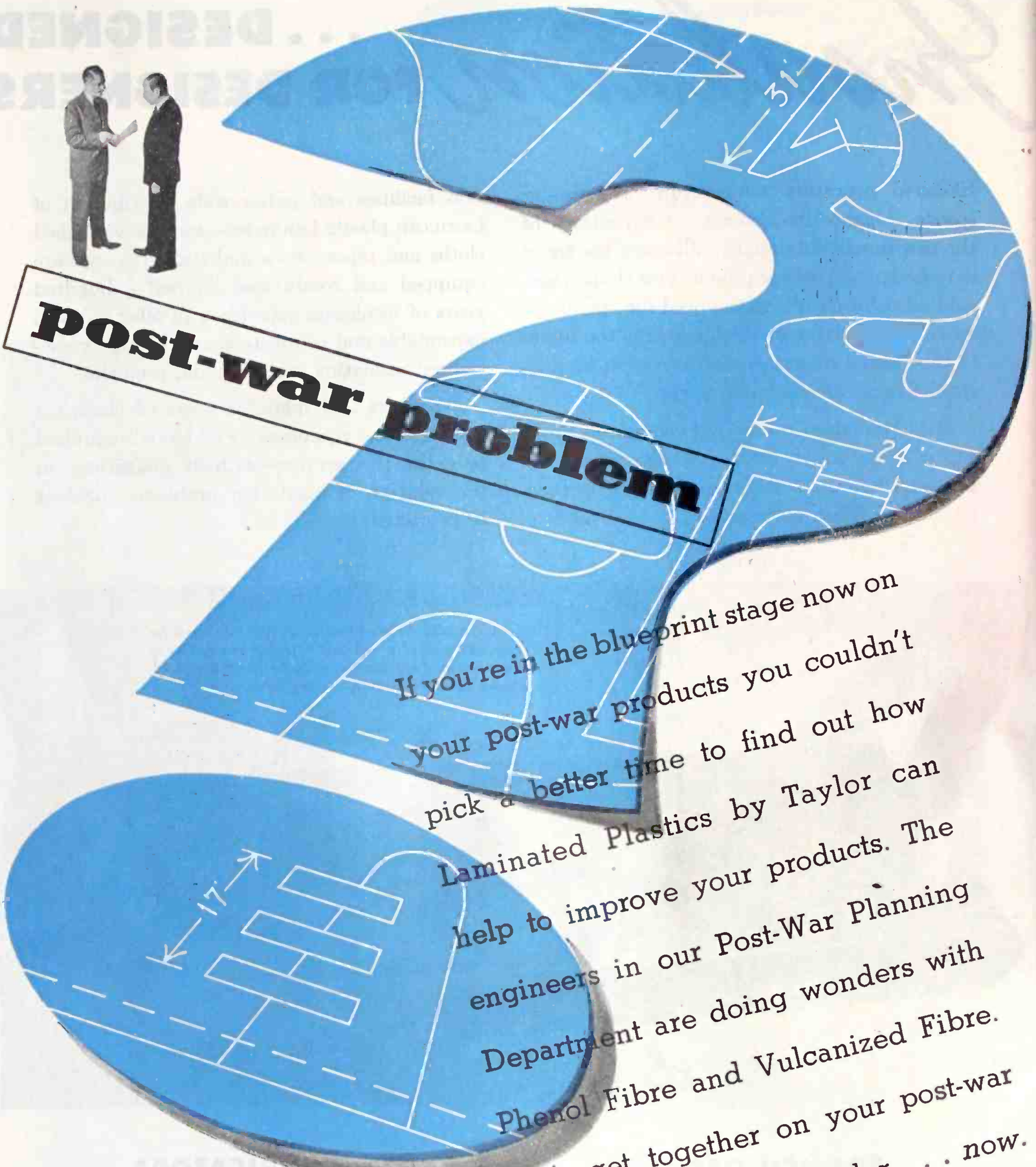

post-war problem

If you're in the blueprint stage now on your post-war products you couldn't pick a better time to find out how Laminated Plastics by Taylor can help to improve your products. The engineers in our Post-War Planning Department are doing wonders with Phenol Fibre and Vulcanized Fibre. Let's get together on your post-war problem. Take it to Taylor . . . now.

POST-WAR PLANNING DEPARTMENT OF

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LAMINATED PLASTICS: PHENOL FIBRE · VULCANIZED FIBRE · Sheets, Rods, Tubes, and Fabricated Parts

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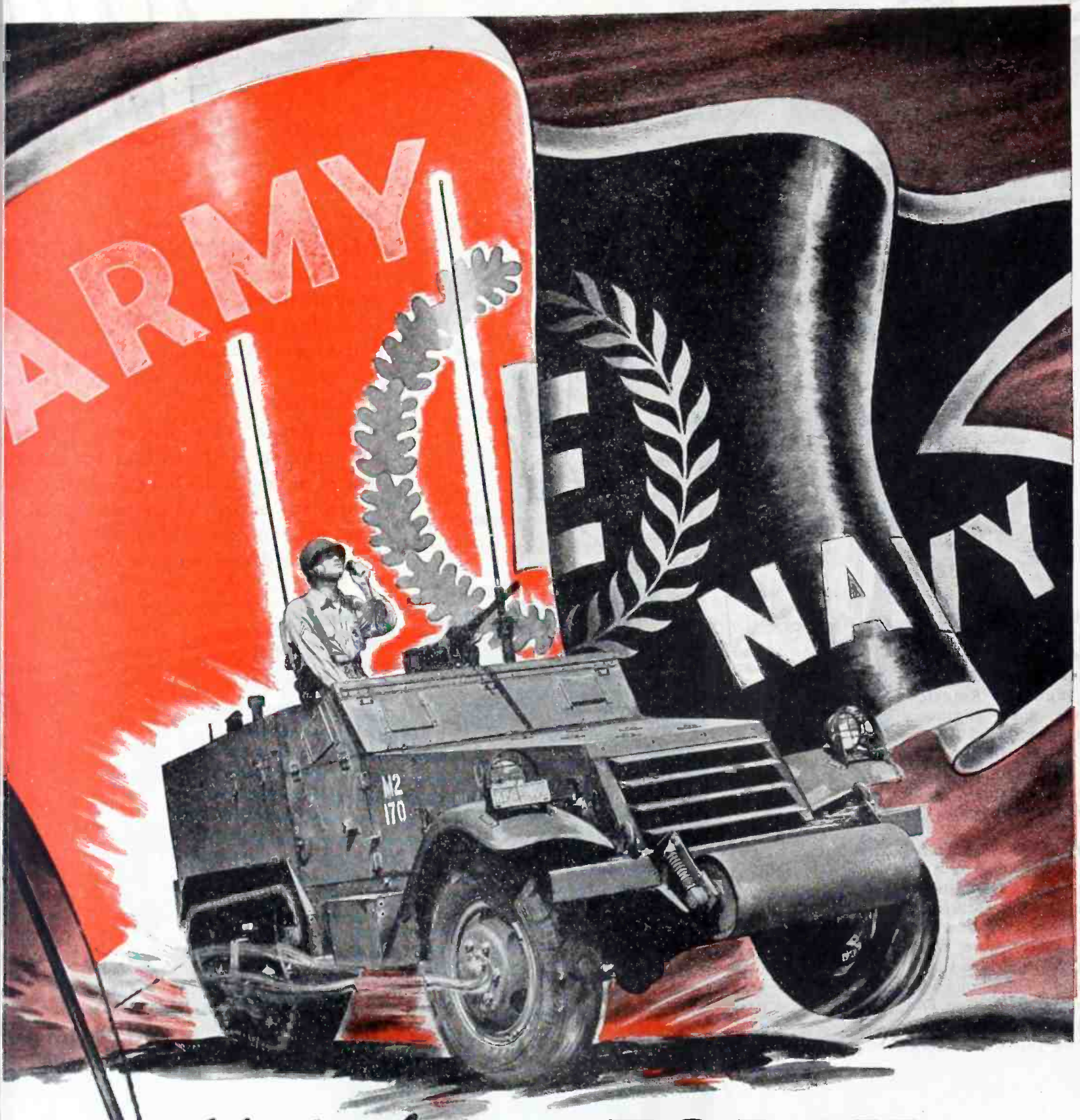
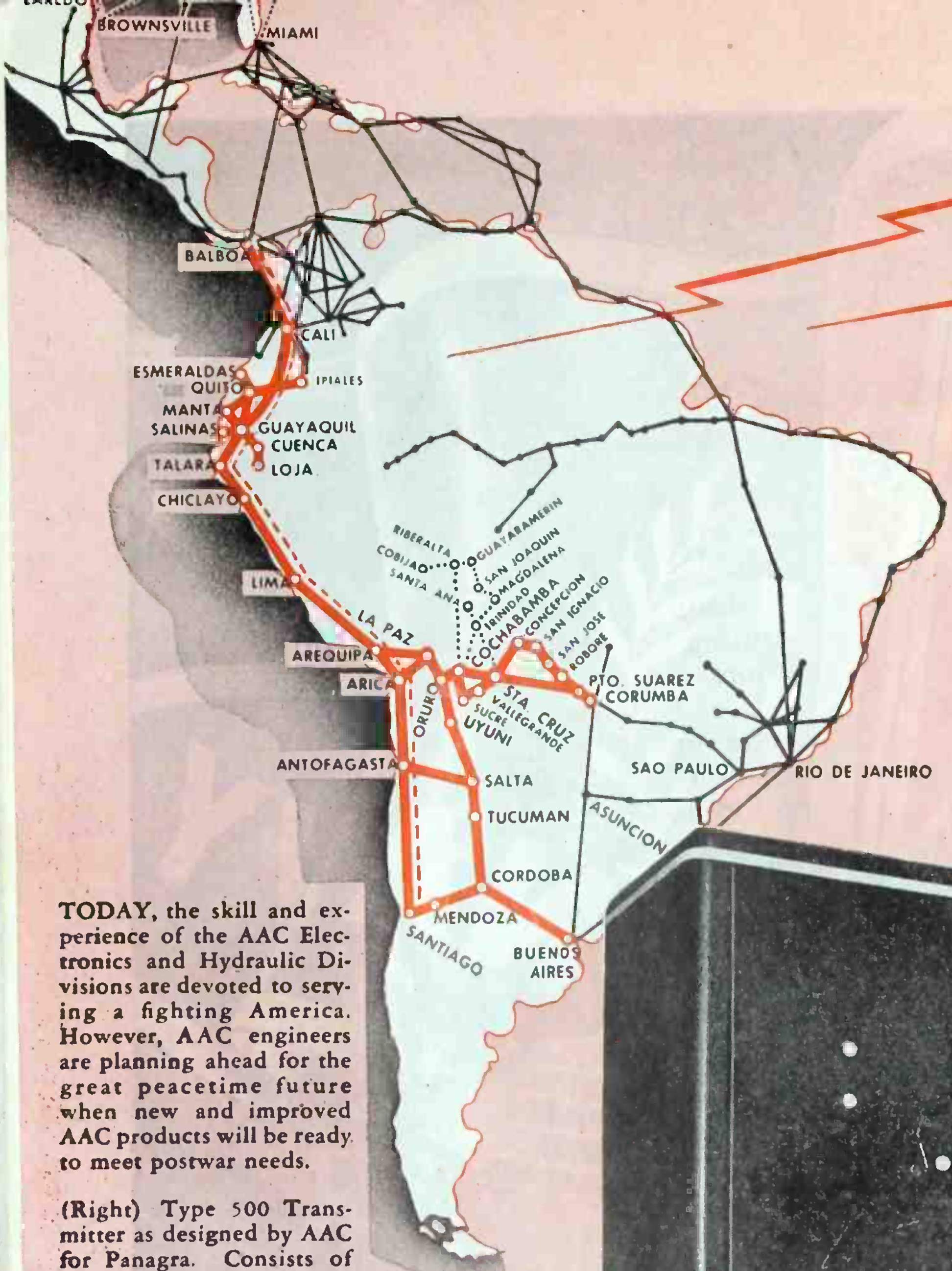


Yesterday and TODAY

The Army-Navy Production Award for outstanding achievement in producing vitally important materials essential to the war effort will be an added incentive to the management and employees of **WARD PRODUCTS CORPORATION** to keep producing more and better equipment for the men who are doing the fighting. While yesterday **WARD** Antennas were accessories for pleasure, today they are implements of War.

WARD *Antennas*

THE WARD PRODUCTS CORPORATION, 1523 EAST 45TH STREET, CLEVELAND, OHIO



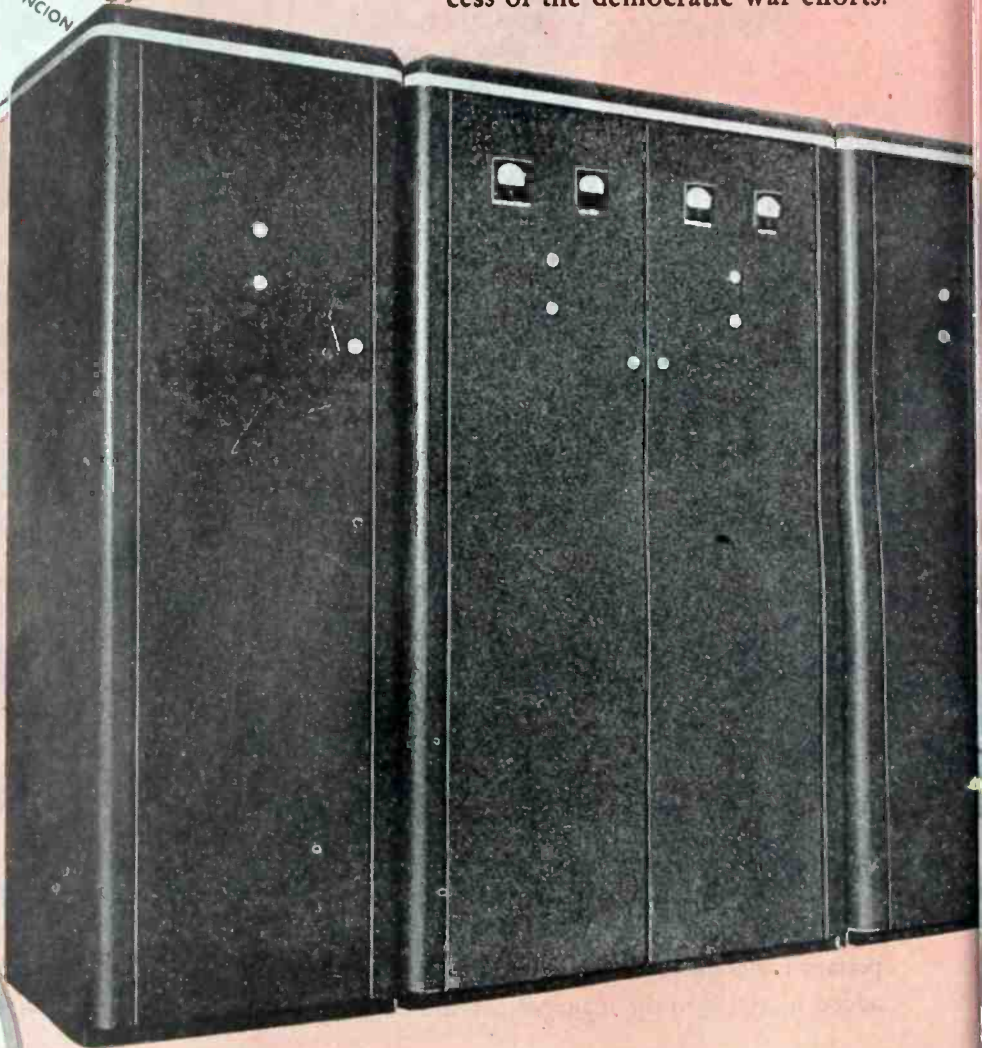
AAC

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

Panagra is today primarily devoting its personnel and facilities to maintenance of aerial lifelines between the Americas, across which are speeding men, mail and materials vital to the suc-

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

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



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Manufacturers of PRECISIO

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TRANSMITTERS

AND OTHER COMMUNICATIONS EQUIPMENT

for

Dependable Operation Of Airlines And Various Communication Services

★ Today, AAC transmitters and other AAC communications equipment play a vital part in dependable operation of warplanes on the fighting fronts, as well as airlines serving the war-busy Americans on the home fronts.

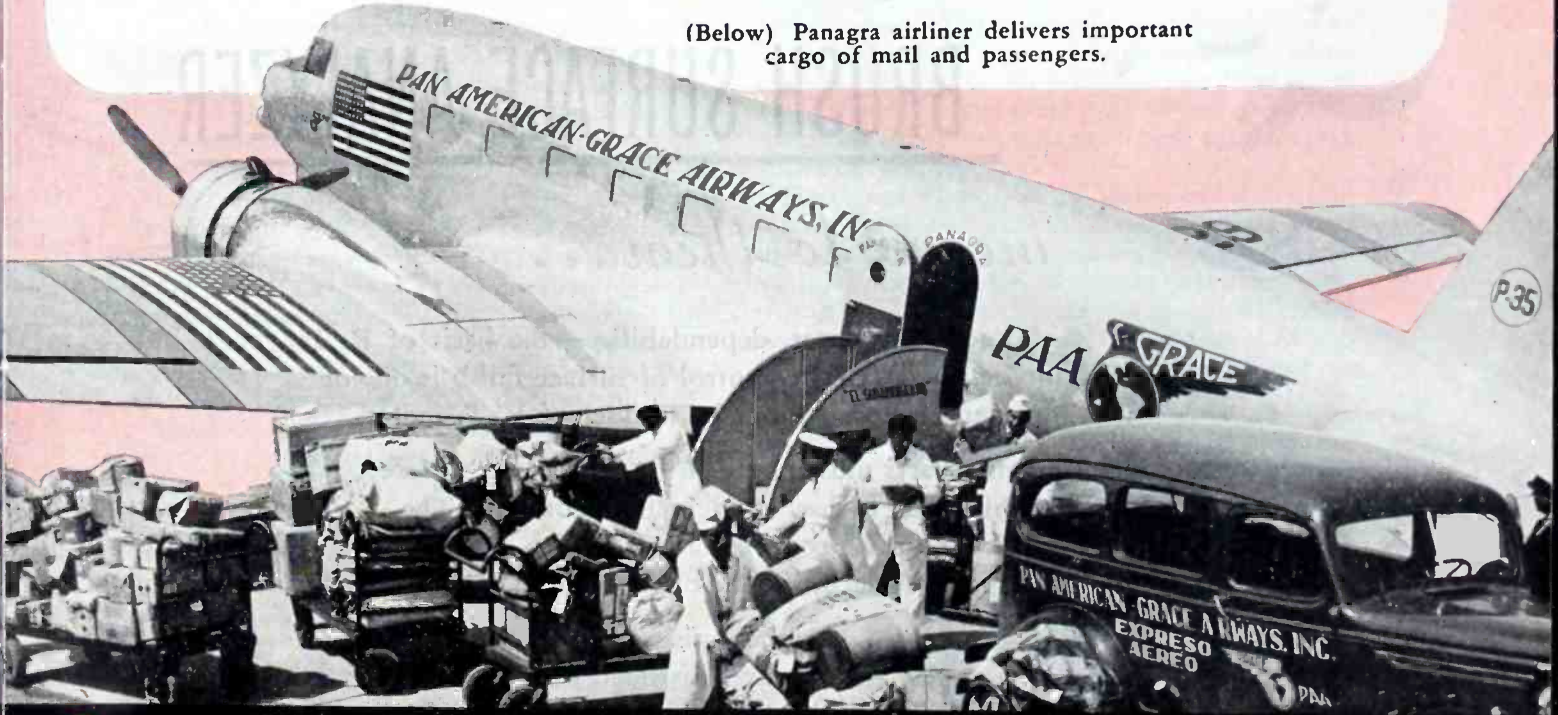
AAC Electronics Division has won distinctive leadership as one of the country's large producers of radio transmitting and receiving equipment. One outstanding example of AAC communications engineering is the equipment designed and built to meet the specified needs of Pan American-Grace Airways, Inc. Consisting of a multi-channel 1,000 watt transmitter, this equipment is used by Panagra for radio homing and communication purposes. It represents one of a complete line of transmitting equipment for use by airlines or services having similar communication needs.

At the present time practically all AAC facilities are devoted to war production. However, your inquiries are welcomed now for commercial equipment which can be supplied in limited quantities if adequate priority ratings are available.

AAC products in transport planes, cargo carriers, troop ships, bombers . . . airport traffic net, police or other services where communications are crucial, can be depended upon as expertly engineered and built to the most efficient performance standards.

Products of **ELECTRONICS DIVISION**

TRANSMITTERS • AIRCRAFT & TANK ANTENNAS • QUARTZ CRYSTALS • RADIO TEST EQUIPMENT



(Below) Panagra airliner delivers important cargo of mail and passengers.

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IN MARINE WARFARE

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Mated, moving parts must be precision made with surface finish accurately held to low microinch smoothness. The Brush Surface Analyzer provides charts which reveal surface irregularities to one millionth of an inch or less.

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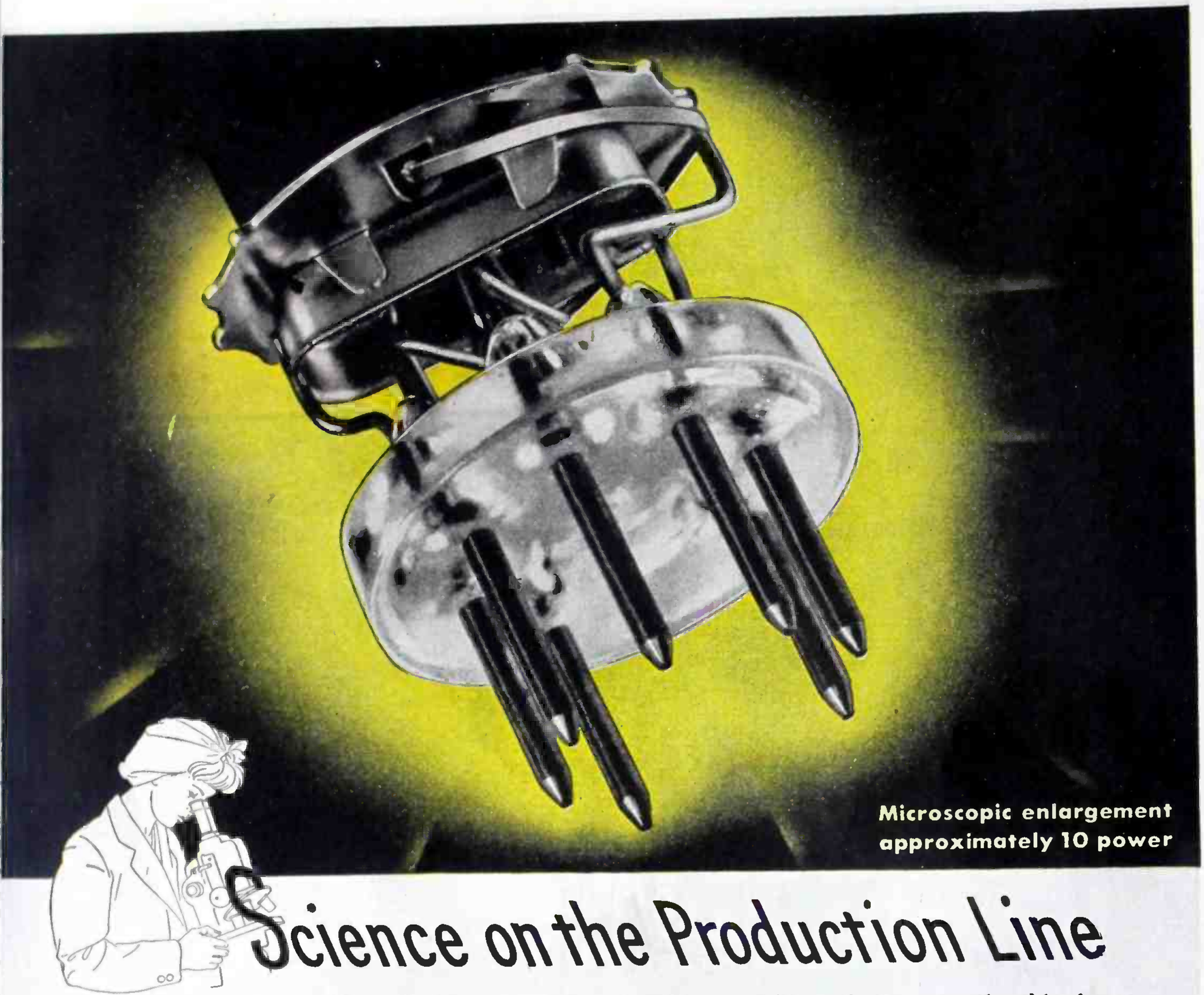

Microscopic enlargement approximately 10 power

Science on the Production Line

Commonly you think of the microscope as a scientific laboratory instrument. But at National Union, these days, you will find it even more extensively used, as a *production* machine, insuring microscopic precision step by step through many processes of manufacture.

With the aid of microscopes, National Union workers accurately check almost invisibly small parts. They *see* to it that welds are sound, clearances are exact and the structure is mechanically perfect. In the photograph above for example, a N. U. 6AG5 miniature tube mount, no higher than your thumb nail is enlarged approximately 10 times, to permit minute examination of important structural factors. Enlargements up to 500 times—making a hair on your head look as tall as a tree—are just as readily obtained, when needed. Moreover, this tube, assembled from 31 individual parts, must pass 40 individual inspections, in addition to thorough examination under the microscope.

Here, again, is one of those unusual techniques developed by National Union engineers to make tube manufacture a more exact science. Such infinite care makes certain that every electronic tube which carries the National Union name will deliver a uniformly high level of performance with long service life. *Count on* National Union.

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

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RADIO AND ELECTRONIC TUBES

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


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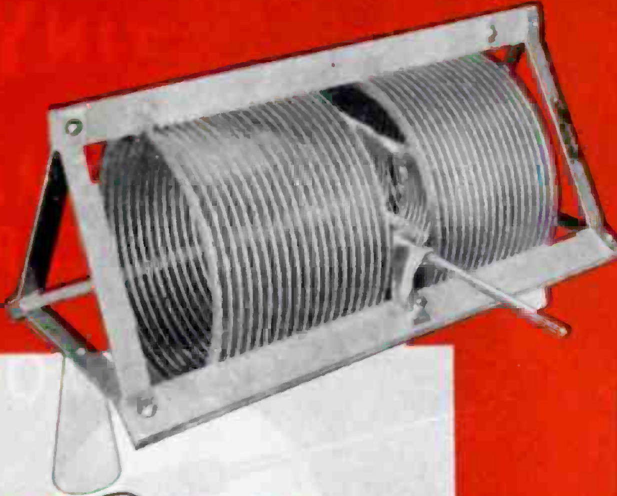

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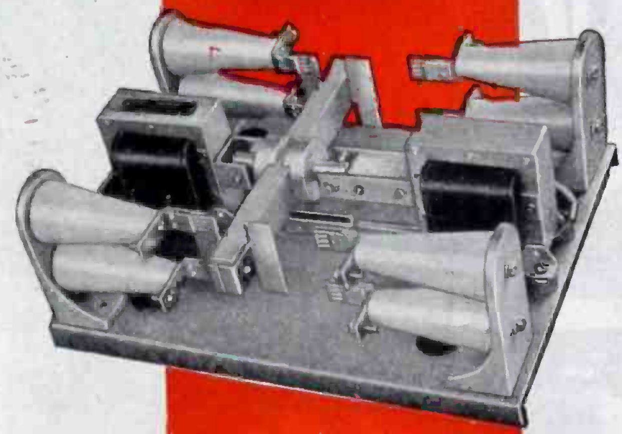
Widely used by discriminating broadcast engineers. Typical is the Phasing Equipment installation by WKBN, Youngstown, Ohio. Variable air condensers, fixed air condensers, gas pressure condensers (for higher voltages), inductors (all kinds), chokes, remote motor driven tuning controls and other components.



Send your specifications or problems for Johnson suggestions and prices -- no obligation.

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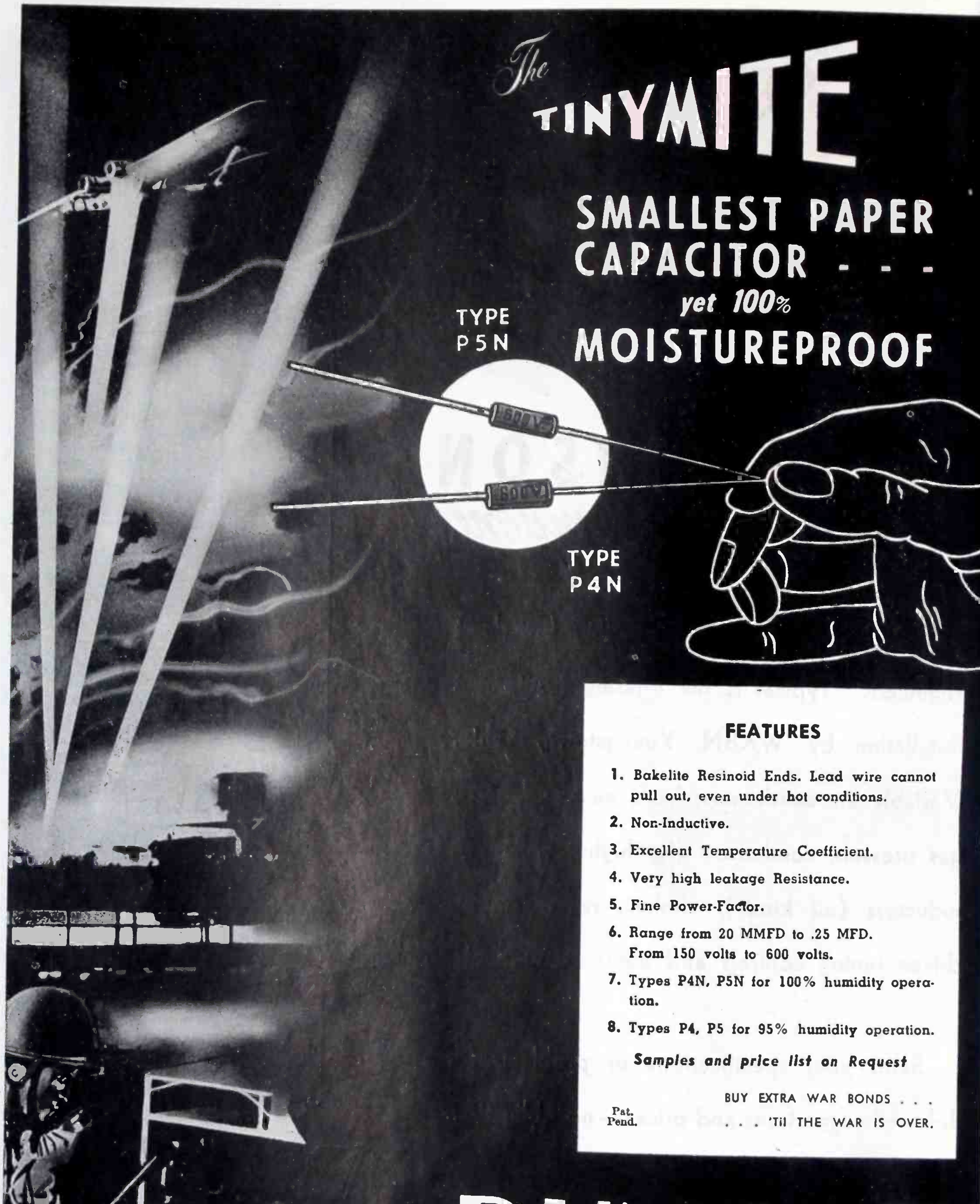
The TINYMITE

SMALLEST PAPER CAPACITOR - - - *yet 100%* MOISTUREPROOF



FEATURES

1. Bakelite Resinoid Ends. Lead wire cannot pull out, even under hot conditions.
2. Non-Inductive.
3. Excellent Temperature Coefficient.
4. Very high leakage Resistance.
5. Fine Power-Factor.
6. Range from 20 MMFD to .25 MFD. From 150 volts to 600 volts.
7. Types P4N, P5N for 100% humidity operation.
8. Types P4, P5 for 95% humidity operation.

Samples and price list on Request

Pat.
Pend.

BUY EXTRA WAR BONDS . . .
. . . 'Til THE WAR IS OVER.

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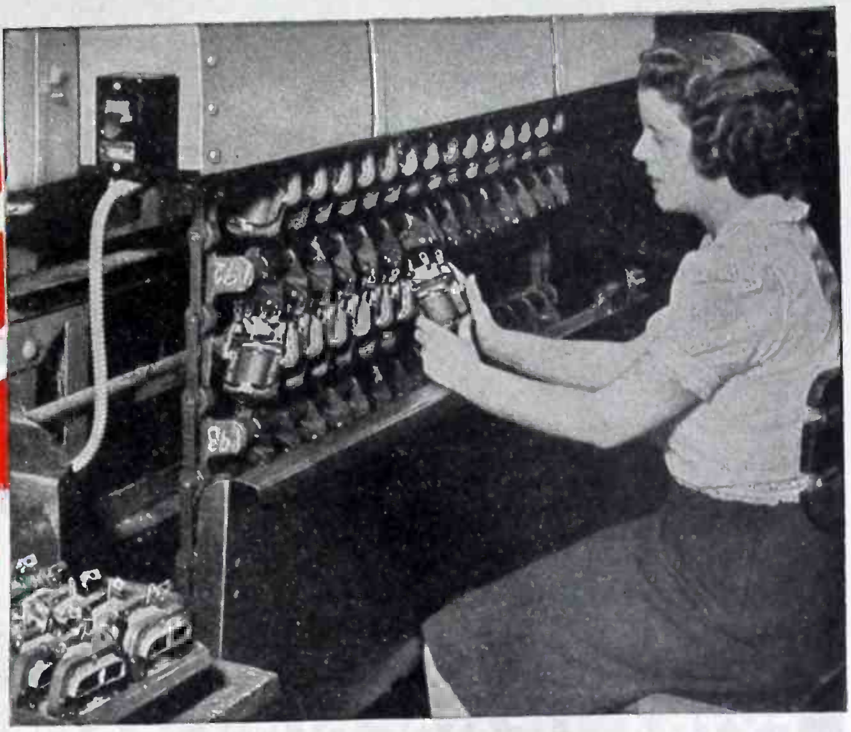
ELECTRIC CO.

MFR'S OF
CAPACITORS FOR EVERY REQUIREMENT
34 HUBERT STREET NEW YORK, N. Y.

1. Solidly BONDED
2. Strongly INSULATED



COILS CAN RATE HIGH ON BOTH COUNTS

If you start with FORMEX magnet wire

● Now you can use the varnishes and baking cycles that will produce solidly bonded coils without risk of weakening the magnet-wire insulation, because FORMEX* magnet wire is strongly resistant to the action of the solvents in varnishes used for bonding.

This tough magnet wire is also highly resistant to heat shock. FORMEX wound assemblies can be exposed to varnishes and temperatures which would cause a fatal percentage of rejects on coils wound with conventional enameled wire.

Because FORMEX is essentially self-sufficient, varnishes can be chosen entirely for their cementing action, thus simplifying the choice of the bonding agent. Stronger and more compact coils are the result.

For more detailed information on how to improve wound assemblies by the use of FORMEX magnet wire and G-E varnishes and thinners, get in touch with our nearest office. *General Electric Company, Schenectady 5, N. Y.*

**Reg. U.S. Pat. Off.*

Resistance to Solvents

Solvent	Heavy Enamel	HF Formex	Solvent	Heavy Enamel	HF Formex
Kerosene	Slight softening	No effect	10% sulphuric acid	No effect	No effect
Petroleum naphtha	Slight softening	No effect	1% potassium hydroxide	No effect	No effect
Toluol coal tar	Fails	Slight softening at 4000 hours	Freon F-12 gas	Fails	No effect
			Cresol, plus alcohol	Fails	Fails
Alcohols (Methyl through octyl)	Fails	No effect	Ammonia	Slight softening	No effect after 72 hours
			Gasoline	Fails	No effect after 5000 hours
Xylol coal tar	Fails	Slight softening at 4000 hours	Asphaltic, or petroleum asphalt	Fails	No effect
Acetone	Fails	No effect	Benzine, plus alcohol, plus gasoline	Fails	Fails
Trichlorethylene	Fails	75% softening			

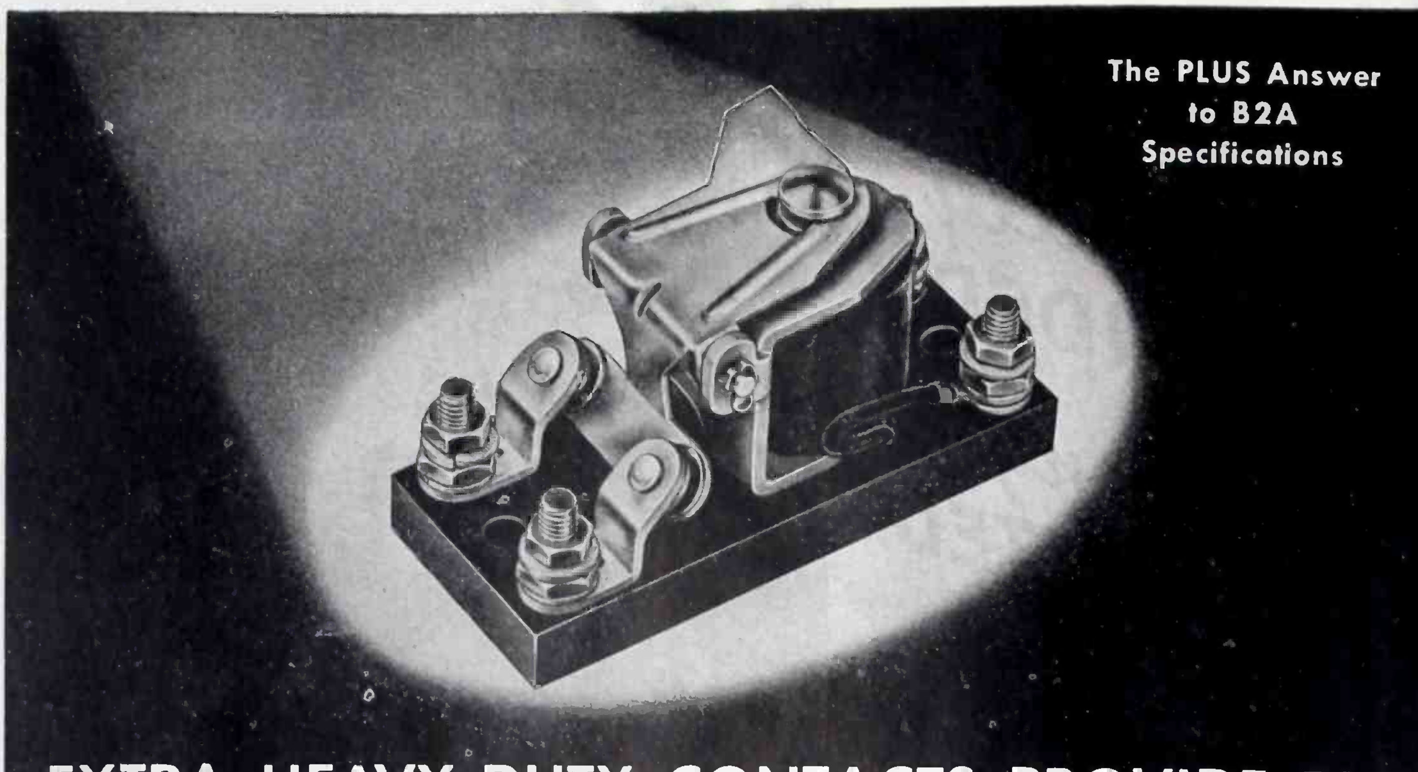
Recommended Baking Practice

Varnish G-E No.	Thinner G-E No.	Specific Gravity at 21 C	Viscosity AV Centipose at 21 C	Minimum baking time, hours			
				110 C	125 C	135 C	150 C
1678	1513	0.930	800	8–10	5–7	3–5	2–4
1679	1513	0.930	950	10–12	6–8	4–6	3–5
9535	9407	0.965	750	8–10	5–7	4–6	3–5
9550	Pet. Spts.	0.915	250	8–10	5–7	4–6	2–5

Baking temperature of 135 C or above is preferred for all of these varnishes. Flash point 60 F.

Buy all the BONDS you can—and keep all you buy

GENERAL ELECTRIC



The PLUS Answer
to B2A
Specifications

EXTRA HEAVY-DUTY CONTACTS PROVIDE BIG SAFETY FACTOR

A SHOCK-PROOF RELAY...THAT'S *Really* SHOCK-PROOF!

If your problem is one of finding a B2A relay on which the contacts stay open or stay closed unfailingly under the most severe conditions of shock and vibration, write for details on Struthers-Dunn Type 17AXX. Small in size, light in weight, it meets and exceeds all specifications for such services.

Struthers-Dunn Nutcracker Type 61HXX100 answers the need for suitable relays for extreme services particularly where severe overloads may cause trouble on units on which contacts have a less generous heavy-duty safety factor. Typical applications include such services as controlling aircraft landing lights, or controlling a number of solenoids simultaneously.

These relays are compact and sturdy, have double-break contacts, and meet the latest 94-32185D specifications with contact safety factor to spare. By a simple system of removable links, they may be converted to meet any one of the earlier 94-32185 or 94-32185A, B, or C specifications—or, they can be supplied in their universal type which enables you to make your own adaptation, quickly and easily for *any* of these specifications.

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

STRUTHERS-DUNN

5,288 RELAY TYPES

DISTRICT ENGINEERING OFFICES: ATLANTA . BALTIMORE . BOSTON . BUFFALO . CHICAGO . CINCINNATI . CLEVELAND
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Toast to Long Life with

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Electrical resistance and heating elements wound with Nichrome* live a longer life of satisfactory service because of *perfected heat and corrosion resistance properties.*

Indeed — Nichrome* is the universally accepted standard of quality in dependable resistance alloys, for this exclusive Driver-Harris nickel-chromium product enjoys an enviable record with leading manufacturers of electrical equipment throughout the world.

Product of unceasing Driver-Harris research Nichrome* is more than a combination of metals. It is the result of 45 years of specialized knowledge and exclusive D-H methods, formulas and quality controls in the production of the *world's foremost resistance alloy.*

Nichrome*. . . is a toast to longer life and improved performance in your post-war products, so specify it and other D-H resistance alloys when buying resistors and heating elements.

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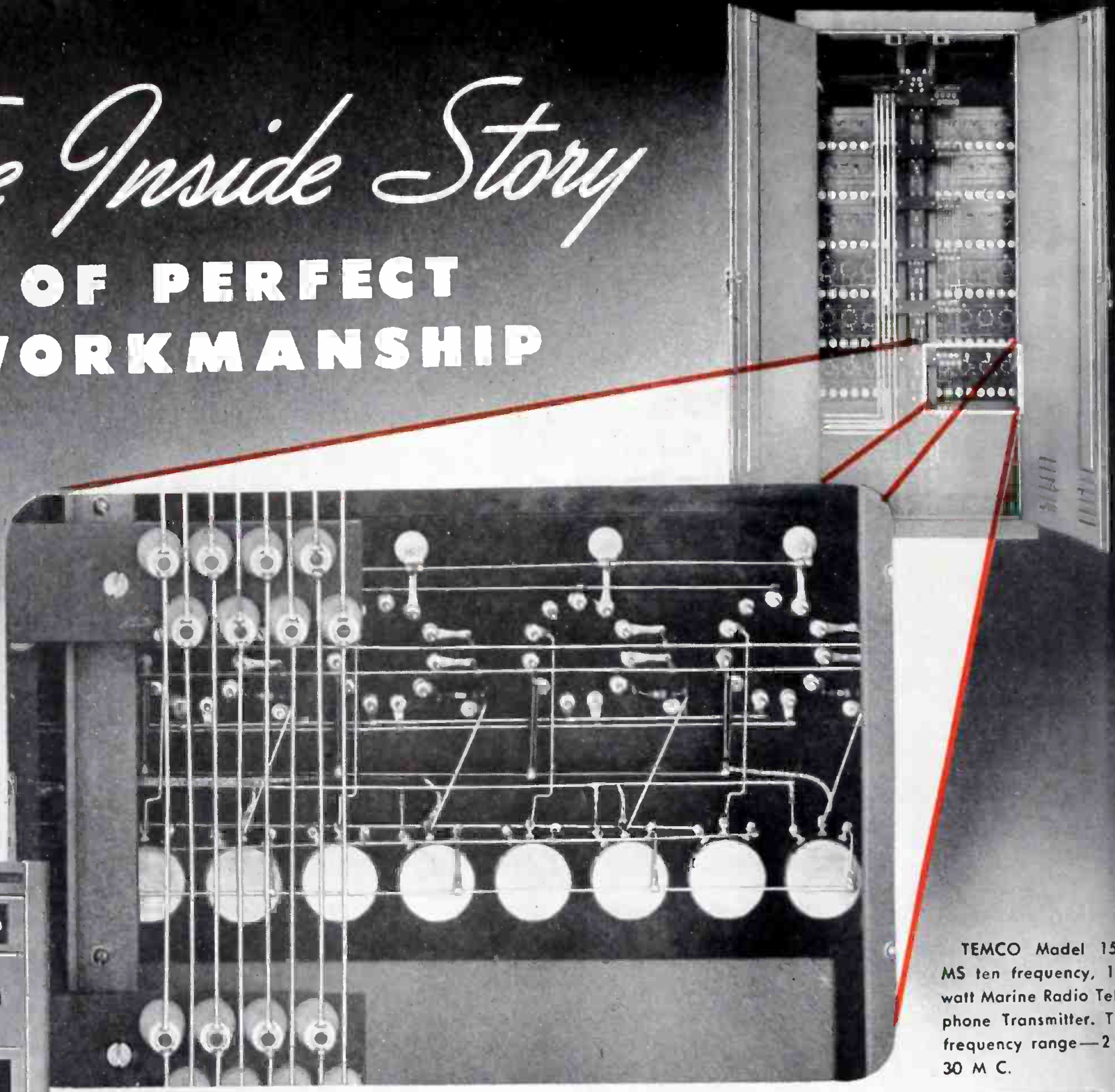
D H
SPECIAL PURPOSE ALLOYS SINCE 1899

Driver–Harris
COMPANY
HARRISON, NEW JERSEY

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

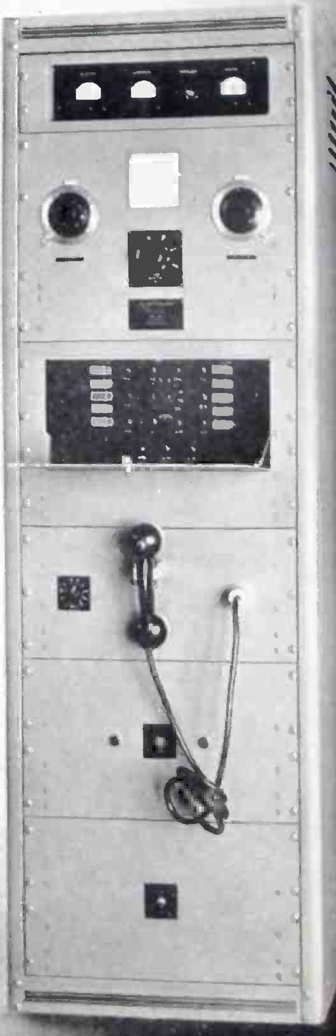
The Inside Story
OF PERFECT WORKMANSHIP



A detail of craftsmanship—from the TEMCO Model 757-BE Cathode Ray Life Test Unit, in upper background; enlarged to show the unusual excellence of inter-wiring.

TEMCO Model 350-BC Radio Telephone Broadcast Transmitter for single frequency operation; power output 350 watts.

TEMCO Model 150-MS ten frequency, 150 watt Marine Radio Telephone Transmitter. The frequency range—2 to 30 M C.



THE story behind TEMCO'S dependable efficiency is a story of higher standards . . in design, in quality of component parts and in painstaking workmanship.

From an engineering standpoint, transmitting equipment built by TEMCO is as handsome "in back" as in front. Behind each TEMCO control panel there is always a job of assembly, wiring and layout of such quality as to meet the most exacting inspection standards — graphically revealing the *plus* in TEMCO performance.

TEMCO

RADIO COMMUNICATION EQUIPMENT

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

High Dielectric Strength

High Mechanical Strength

Low Power Factor

Heat Resistance

High Arc Resistance

They all point to G-E MYCALEX

These important properties are only part of the 21-year success story of G-E mycalex.

In addition, G-E mycalex is easily subjected to all machining operations—drilling, filing, sawing, grinding, polishing—and its stability permits closely held tolerances.

It has high imperviousness to moisture, oils and gases, making it ideal when these conditions are present.

It's unique as a ceramic product . . . because metal parts can be inserted and securely anchored right in it during the process of molding.

Radio, electronic and electrical engineers have found that G-E mycalex meets many of their specialized insulation needs. Let this outstanding all-purpose insulating material help you solve your insulation problems. And help yourself to General Electric's unequaled experience in the application of this amazing material.

For a list of specialists in the fabrication of G-E mycalex—for a free sample of this material and a copy of the data bulletin, "G-E Compression-Molded Mycalex"—please fill out the coupon. . . . *General Electric, Schenectady, N. Y.*

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

FREE—
G-E MYCALEX
BULLETIN

Section 3-D
ELECTRONICS DEPARTMENT
GENERAL ELECTRIC CO.
Schenectady, N. Y.

Please send me a free sample of G-E mycalex and your descriptive bulletin explaining the methods and tools to use in machining G-E mycalex.

(If you wish a list of fabricators of G-E mycalex, check here________.)

*Name*____________________
*Company*____________________
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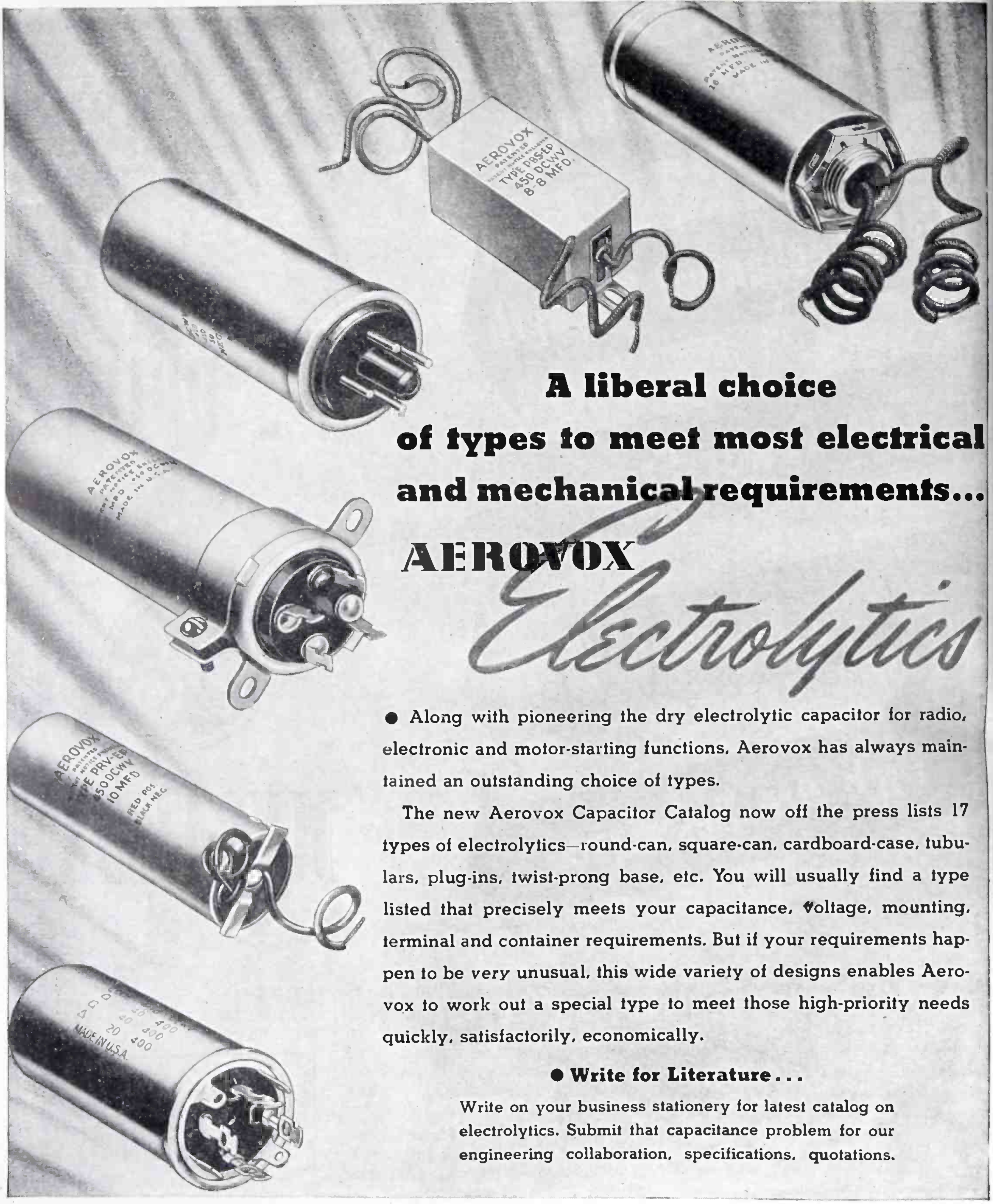
Over 21 Years of Mycalex Experience—Your Assurance of Quality

GENERAL ELECTRIC

177-M-C5-9915



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AEROVOX *Electrolytics*

● Along with pioneering the dry electrolytic capacitor for radio, electronic and motor-starting functions, Aerovox has always maintained an outstanding choice of types.

The new Aerovox Capacitor Catalog now off the press lists 17 types of electrolytics—round-can, square-can, cardboard-case, tubulars, plug-ins, twist-prong base, etc. You will usually find a type listed that precisely meets your capacitance, voltage, mounting, terminal and container requirements. But if your requirements happen to be *very* unusual, this wide variety of designs enables Aerovox to work out a special type to meet those high-priority needs quickly, satisfactorily, economically.

● Write for Literature . . .

Write on your business stationery for latest catalog on electrolytics. Submit that capacitance problem for our engineering collaboration, specifications, quotations.

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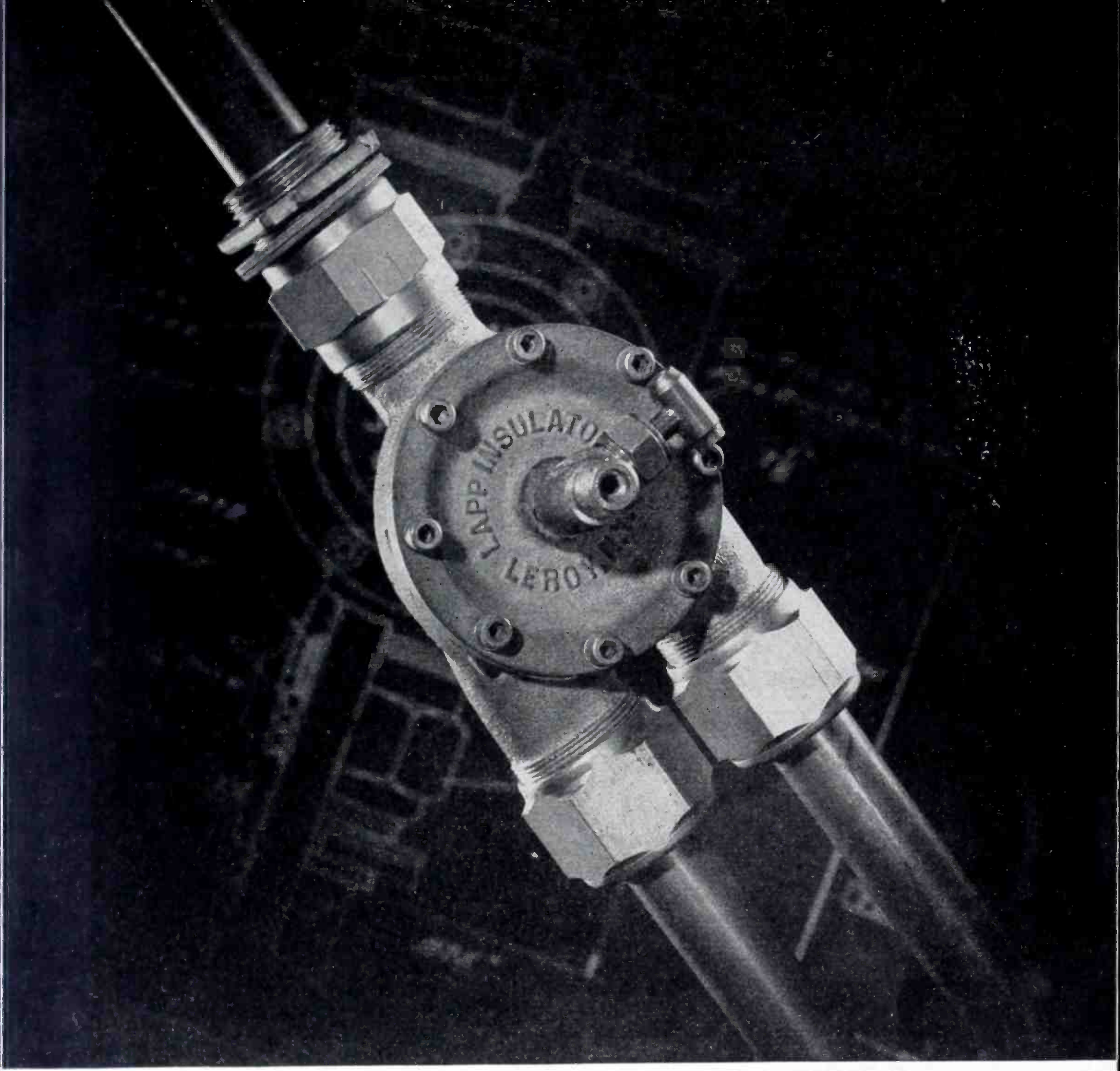


Electronic Parts: ENGINEERING AND PRODUCTION

The gadget above is a junction box for a co-axial gas-filled transmission line. It is one of a series of coupling units, end seals and other fittings for high-frequency transmission—designed and built by Lapp.

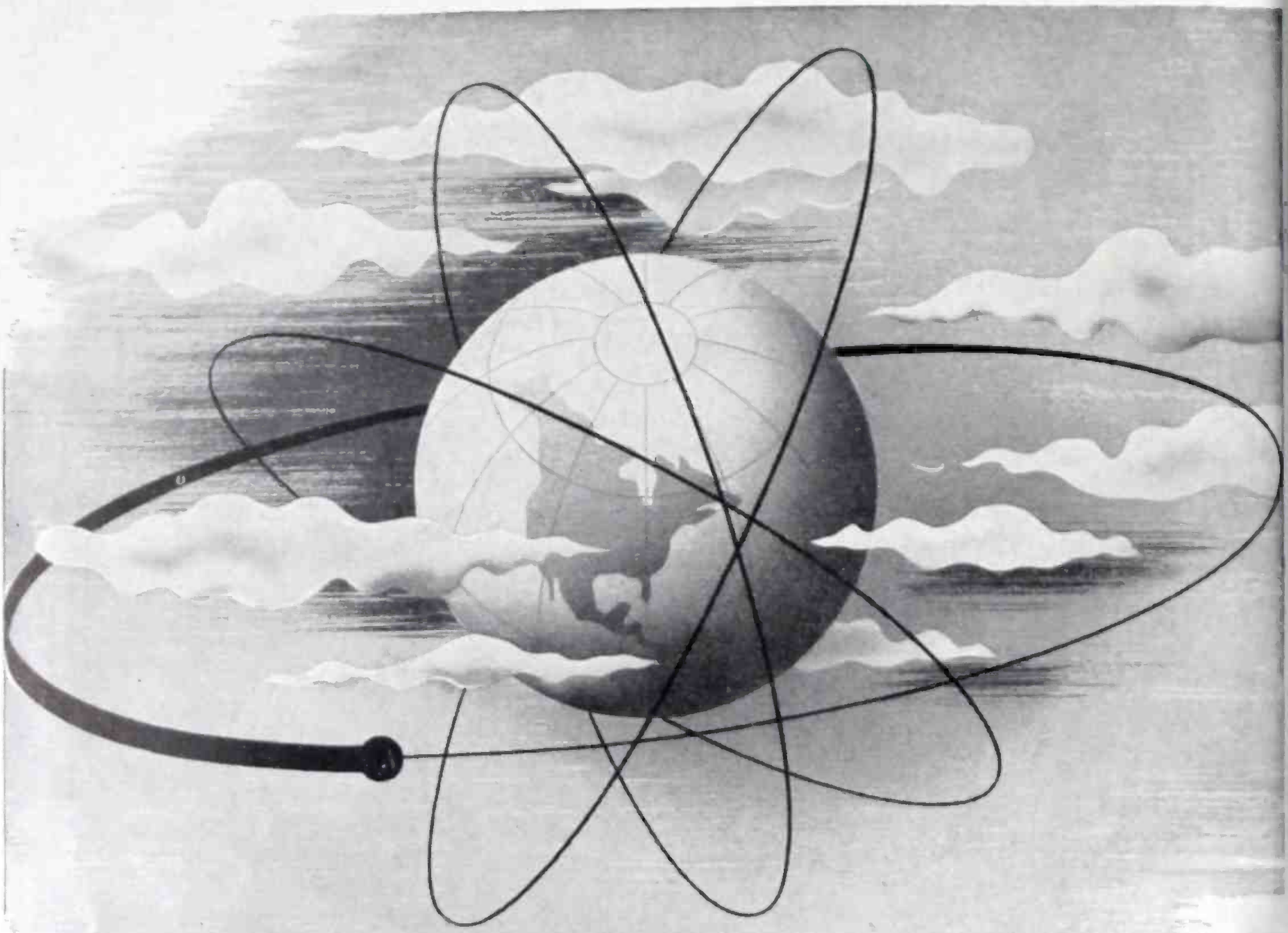
To this type of construction, Lapp brings several innovations and improvements. For example, such a line from Lapp parts is genuinely leak-proof. Every gasket is under spring loading, so there's no leakage created by vibration or thermal change.

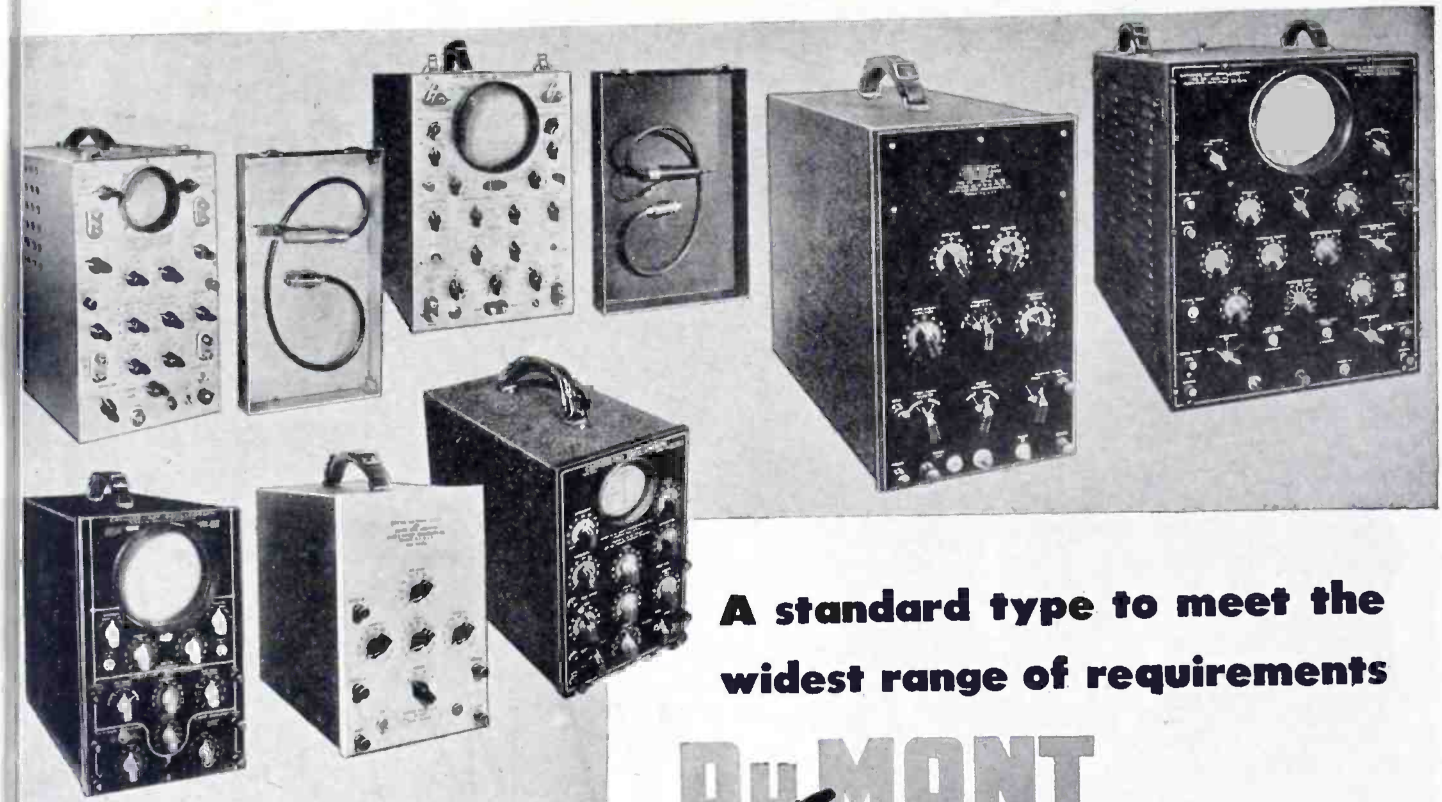
Whether or not you're interested in gas-filled transmission lines, you ought to know about Lapp. Here is an organization of engineers and manufacturers with broad basic knowledge of ceramics and their application. With experience in hundreds upon hundreds of special-purpose electronic parts, we have been able countless times to improve performance, or reduce costs, or cut production time through the application of our specialized skills to design and manufacture of parts involving porcelain or steatite and associated metal parts.

For quick and efficient assistance on a war production subcontract—or for the competitive advantage Lapp-designed and Lapp-built parts will give to you in the postwar battle—an inquiry to Lapp now may pay you dividends. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp

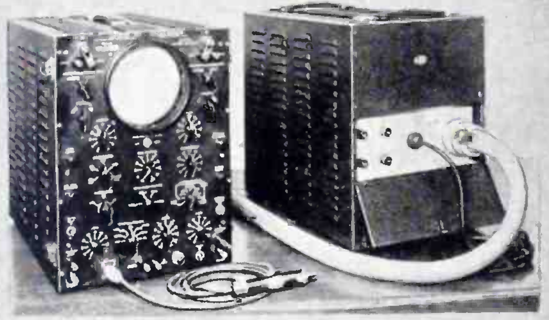
ARMY E NAVY





A standard type to meet the widest range of requirements

DuMONT Oscillographs



➧ The maintenance man in need of a low-cost, simple, portable, rugged instrument; the laboratory technician requiring an instrument covering an exceptionally wide range of frequencies; the instructor demonstrating intricate wave forms to large student bodies—for each of these widely varying applications, and all those between, there is a DuMont cathode-ray oscillograph and cathode-ray tube, as well as accessories, best suited to the precise operating conditions.

Furthermore, as new requirements arise in this rapidly developing technique there become available still more up-to-the-minute DuMont types to fill the bill.

The DuMont Cathode-Ray Manual already lists an outstanding selection of oscillographs, tubes, accessories. New bulletins are constantly being issued on new items, refinements, applications. And for "scoops" on the very latest cathode-ray developments, just follow these monthly DuMont advertisements.

➧ *Write on business stationery for literature . . .*

DUMONT *Precision Electronics & Television*

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

Photo Courtesy Pan American Airways

NEW! Electro-Voice

Model 600-D HAND-HELD MOVING COIL COMMUNICATION MICROPHONE

(REPLACING MODEL 600-C)

FOR MOBILE RADIO TRANSMITTERS AND SOUND EQUIPMENT

- *Resistant to high humidity, wide temperature ranges, mechanical shock and vibration*
- *Frequency curve scientifically designed for highest articulation through interference and background noise*
- *The new Electro-Voice Model 600-D is available in high or low impedance output*
- *Lightweight, can be held for long periods without fatigue*
- *Shock-proof, high impact molded phenolic case*
- *Press-to-talk switch (switch-lock optional) for relay operation, with choice of switching circuits*

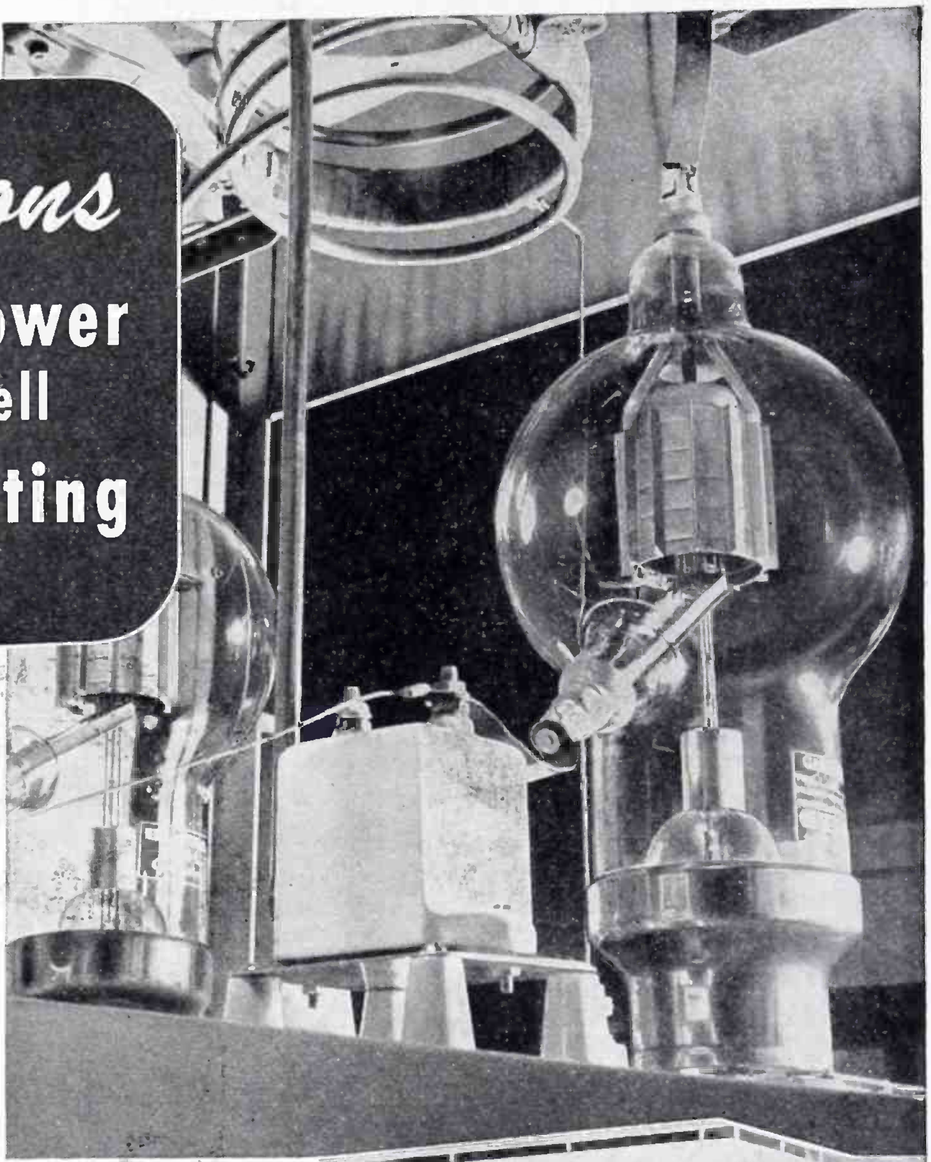
To the growing list of Electro-Voice developments, we now add the Model 600-D which may be adapted to a number of essential civilian applications. Built to rigid wartime specifications, it reflects the painstaking care of the Electro-Voice design laboratory. Electro-Voice Microphones serve you better . . . for longer periods of time.

If your present limited quantity needs can be filled by any of our Standard Model Microphones, with or without minor modifications, please contact your nearest radio parts distributor.

PAPER PACKS A WAR PUNCH . . .
. . . . . SAVE EVERY SCRAP

ELECTRO-VOICE MANUFACTURING CO., INC. • 1239 SOUTH BEND AVENUE • SOUTH BEND, INDIANA
Export Division: 13 East 40th Street, New York 16, N. Y. — U. S. A. Cables: ARLAB

Gammatrons
Provide R-F Power
for Mann-Russell
Dielectric Heating
Generators



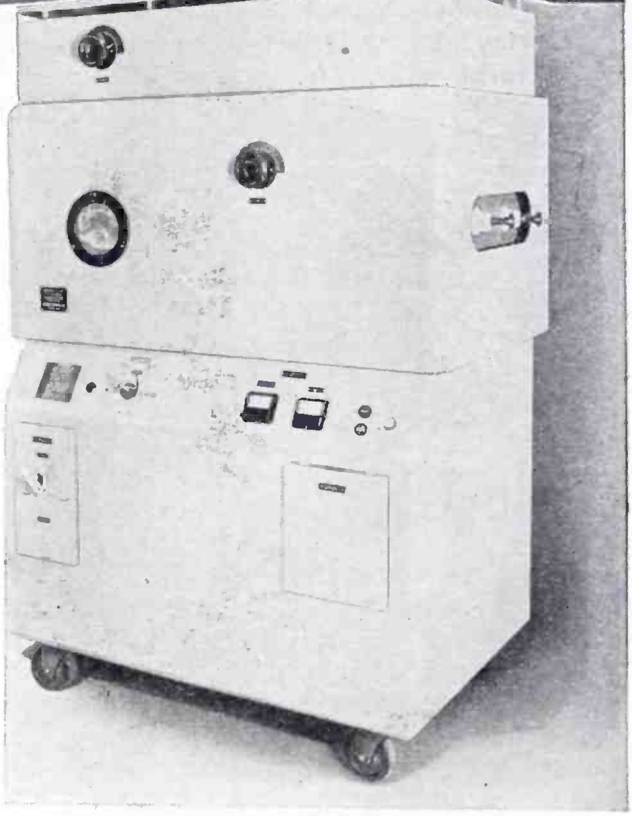
The pair of HK-1054 Gammatrons shown in the master oscillator of a Mann-Russell RF generator at upper right, provide a maximum of 13,300 BTUs per hour at 20 to 30 meters for dielectric heating applications.

0,000 BTU PER HOUR
ROM A PAIR OF HK-1054 TUBES

dio-frequency generators, such as the Mann-Russell unit
ctured here, require tubes capable of producing consider-
le power at high-frequencies, plus remarkable stamina
hen faced with overloading and abuse. Gammatron tubes
e designed to meet such "cast iron" requirements.

For example, the enclosed plate in Gammatrons results
high efficiency at high-frequencies. It traps electrons which
ould otherwise escape, and at the same time eliminates elec-
on bombardment, thus raising voltage limitations.

To designers of high-frequency heating equipment Heintz
d Kaufman, Ltd. offers a type of tube that has the electrical
amina, the efficiency and long life which are so important
the economical operation of h-f generators.



MANN-RUSSELL R-F GENERATOR. High-frequency generators, such as the Mann-Russell unit above, provide a new, cleaner, faster and entirely different method of heating, drying, setting, baking, preheating, sterilizing, and dehydrating non-conducting materials.

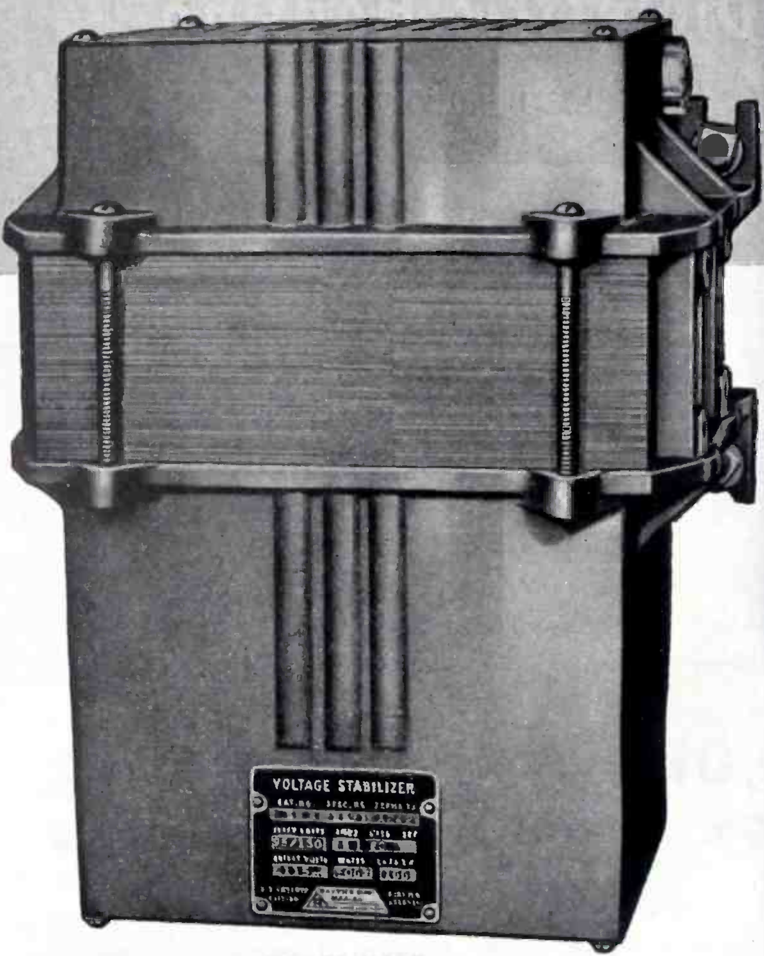
EINTZ AND KAUFMAN LTD.
UTH SAN FRANCISCO • CALIFORNIA, U. S. A.

Gammatron Tubes

UY ANOTHER WAR BOND THIS MONTH

How RAYTHEON VOLTAGE STABILIZERS Assure Dependable Operation of Precision Equipment

- **CONSTANT AC OUTPUT VOLTAGE**
  Raytheon Voltage Stabilizers control fluctuating input voltages and hold constant output voltage to ±½%.
- **WIDE AC INPUT VOLTAGE LIMITS**
  Raytheon Voltage Stabilizers will stabilize input voltages varying from 95 to 130 volts.
- **QUICK RESPONSE**
  Raytheon Voltage Stabilizers stabilize the varying input voltage *within 2 cycles*. Variations cannot be observed on an ordinary volt meter.
- **ENTIRELY AUTOMATIC**
  Raytheon Voltage Stabilizers are entirely automatic in operation. They require no adjustments or maintenance.
- **NO MOVING PARTS**
  Raytheon Voltage Stabilizers have no moving parts . . . Nothing to wear out, thus assuring long life.



ENDBELL MODEL

SEND FOR THIS NEW BULLETIN . . .

It contains a complete description of how the stabilizer operates, its advantages, performance curves, dimensions and other pertinent facts. Simply request Bulletin DL 48-537 and your copy will be promptly mailed.

The coveted Army-Navy "E", for Excellence in the manufacture of war equipment and tubes, flies over all four Raytheon Plants where over 12,000 men and women are producing for VICTORY.

RAYTHEON MANUFACTURING Company
190 WILLOW ST WALTHAM, MASS

WIRE to TOKYO

The Signal Corps is getting it through mile by tortuous mile

COMMUNICATIONS

Must get through . . . in spite of cold, heat, humidity, dryness, or the enemy. Communications is one of the deciding factors in quickly getting the most men and equipment where they can accomplish the greatest good.

RADIO . . . TELEPHONE . . . TELEGRAPH

All have a vital role in the giant web of communications which is the unseen hand guiding the destiny of our fighting men in every sphere of action. All of this communications equipment depends on ELECTRICAL INSULATING MATERIALS for its successful operation.

CONTINENTAL-DIAMOND is making thousands of insulating parts for Military Communications Equipment. Parts fabricated from C-D insulating materials engineered to remain stable from 70°F. below zero to 160°F. above zero.

A few of the many C-D insulating parts being made for War Equipment from C-D products DILECTO . . . DILECTENE . . . VULCOID . . . DIAMOND FIBRE . . . MICABOND . . . CELORON. Complete technical data is available in bulletin GF. Write for it today on your business letterhead.

DISTRICT OFFICES: New York - Cleveland - Chicago - Spartanburg, S. C.
West Coast Rep., Marwood, Ltd., San Francisco - Sales Offices in principal cities

CR-44

Continental-Diamond FIBRE COMPANY

Established 1895. . Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE

Rugged though **tiny . . .**

i-point accuracy plus battle stamina with **CALLITE TUBE COMPONENTS**

fire concussions and tempera- e extremes make ruggedness ential to the Raytheon Type 1A u.h.f. tube. But ruggedness le won't do the job. ually important are iroscopic accuracy and formity. Proof that Tungsten Wire has hse requirements is t the Raytheon Manufacturing Company re- ie on Callite for com- ents in this pentode. our advanced engi- ering methods and pre- ion mass production are entrusted many of the war jobs today requiring the utmost accuracy in tremendous volume. For dependable metallurgical components, investigate our specialized abilities. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, New Jersey. Branch Offices: Chicago, Cleveland.

R/X FOR R*-DAY (Reconversion*)**

Will metallurgical components be important in your post-war product? By consulting us now — you may save design changes and delays later. Our engineers will work with you in advance of R-day — to help you to be ready.

Callite ***tube components***

HARD GLASS LEADS, TUNGSTEN AND MOLYBDENUM WIRE, ROD AND SHEET, FORMED PARTS, AND OTHER COMPONENTS FOR ELECTRONIC TUBES AND INCANDESCENT LAMPS

EASIER, FASTER ASSEMBLIES . . . greater holding power . . . convenient disassembly . . . are the reasons why Bristo Multiple-Spline Socket Set Screws are being used in tremendous quantities now that it is so important to specify the best. To accommodate greatly enlarged demand, manufacturing facilities have again been increased — this time by 25% — and further expansion is being planned.

THE TIGHTEST-SETTING SMALL SCREW ON THE MARKET.

When the fastening point is awkwardly located or so small that it's hard to get at . . . or where vibration will be encountered . . . plan on using Bristo Screws.

The unique multiple spline design *gears* the screw to the key — for convenience in handling . . . and to utilize greater wrenching force without damage. The Bristo screw can be turned fa beyond the point where an ordinary screw would burst or at least round out. Sizes as small as No 4 wire can be set to withstand real vibration. Ye if adjustments need to be made, a flick of the ke will loosen the screw.

Specified by leading aircraft and communic tions equipment manufacturers; ideal for ele trical appliances, cameras, motor assemblie instruments, etc. See other applications listed i THOMAS' REGISTER.

WHY
"BRISTO"
MEANS
"TIGHTER"

Bristo: No expanding pressure; the key pulls the screw around.

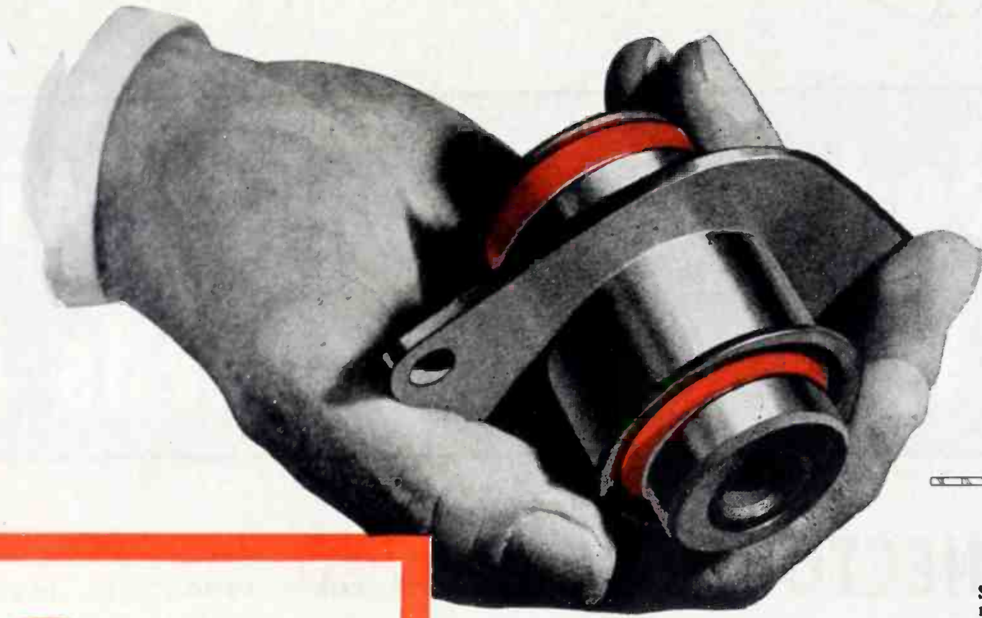
BRISTO MULTIPLE-SPLINE SOCKET SET SCREWS

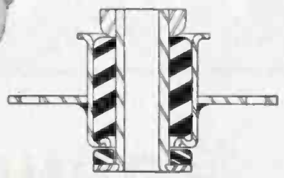
GEARED TO THE KEY — FOR FASTER, EASIER, TIGHTER SETTING

The BRISTOL Company
MILL SUPPLY DIVISIO
[illegible]
[illegible]

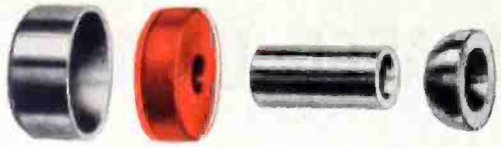
Take the "X" out of Rubber Mounts

(*Where* X *is the* UNKNOWN *Rate of Deflection*)

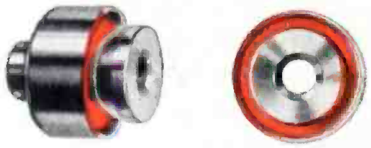




Silentbloc shear-type mounts and bearings are simple to incorporate in designs.



These parts of a Silentbloc, before assembly, show why it is different from all other rubber mountings. Rubber ring is inserted under high pressure into outer tube. Inner sleeve (or solid shaft) is "shot" with extreme force through inner diameter of rubber. All parts can be varied to achieve exact performance needed.



Comparison of this completed Silentbloc with unassembled parts shows how rubber is elongated and compressed. Any kind of rubber, synthetic, natural or reclaimed, and any kind of metal can be used. Inner metal member can be sleeve or bearing type, or solid shaft threaded or grooved. Natural pull of live rubber makes adhesion of rubber-to-metal virtually indestructible.

Design with Engineered
GENERAL SILENTBLOC

Of course rubber is resilient. But *how* resilient—what's the rate and direction of deflection?

You can remove that X with General Silentbloc. These shear-type rubber mountings, bearings and couplings can be *engineered* by our skilled staff to give the exact performance your job requires. If you know the rate of deflection needed, we can design a Silentbloc to *match* that curve.

Such precise control is made possible by the patented Silentbloc principle of elongation and confinement of rubber. By variation of size and design of the fitting, kind of rubber, the degree of elongation of the rubber and distortion of its outer and inner diameters, Silentbloc mountings and bearings can be engineered to:

—Provide soft cushioning for axial load but maintain rigidity to radial or conical loads, or vice versa
—Snub at either or both ends for shock loads
—Allow a wide controlled amplitude of torque action
—Exert greater pressure on the outer or inner diameter
—Control deflection under increasing load.

These are a few examples—the variations of Silentbloc are almost unlimited. They are used today in many fields—automotive, aviation, industrial and domestic machinery, electrical and electronic equipment, marine equipment and others.

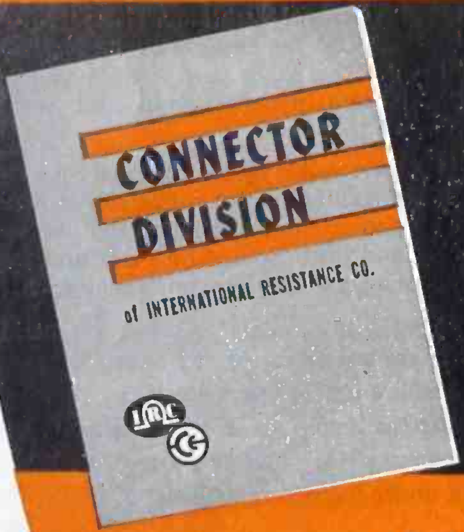
You can improve your products with Silentbloc to control vibration, isolate parts, insulate against foreign vibration, give torque action, correct against bearing or mounting misalignment. For factual literature, write The General Tire & Rubber Company, Dept. 91, Wabash, Indiana.

The
GENERAL
SILENTBLOC
MOUNTINGS . . . BEARINGS
COUPLINGS

THE GENERAL TIRE & RUBBER CO.
Mechanical Products Division, Wabash, Indiana

A Good Firm to Connect With For Your Postwar Needs in:

CONNECTORS—such as coaxial cable connectors, multiple contact connectors, cable plugs **AND RELATED UNITS** and such other small components to which our experience, manufacturing facilities and volume production in this field can be applied.



CONNECTOR DIVISION

of INTERNATIONAL RESISTANCE CO.

Write for Your Copy of our Catalog

Illustrated and described in this catalog are the types of connectors we are now producing. . . . A member of our Engineering Staff is available for consultation on other types of connectors for industrial use.

*CONNECTOR DIVISION OF

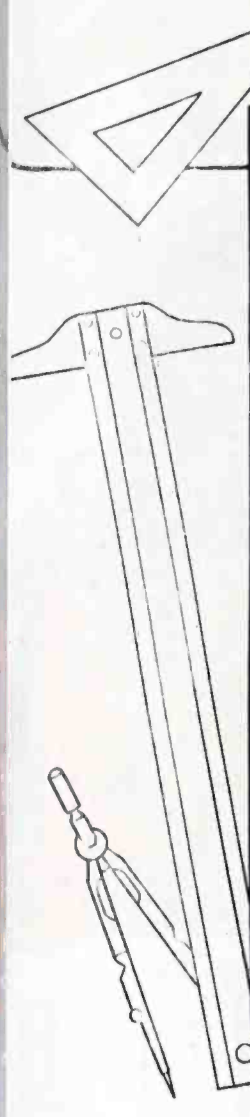
INTERNATIONAL RESISTANCE CO.

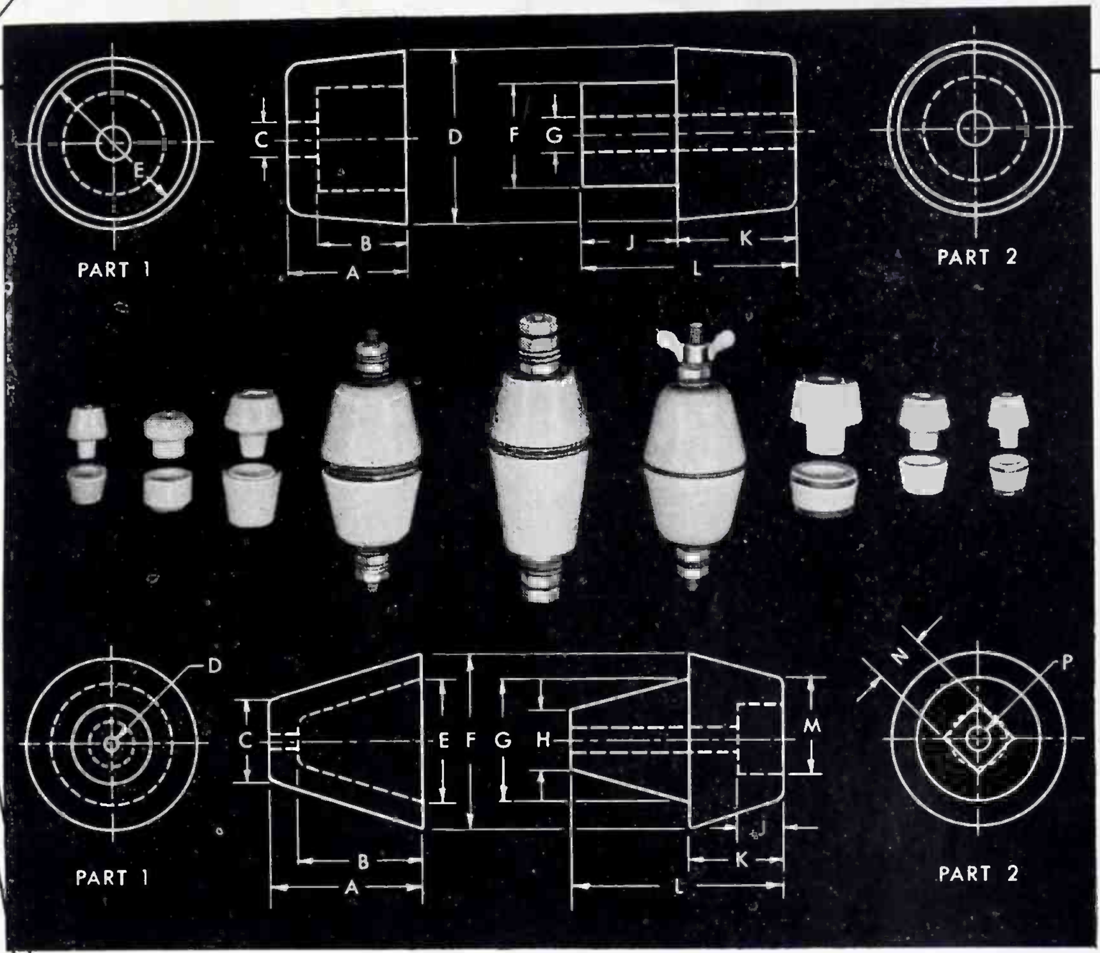
401 N. BROAD ST., PHILADELPHIA 8, PA.

*FORMERLY CONNECTOR CORPORATION

From Drawing Board to Final Products

STEATITE BUSHINGS





For TRANSFORMERS · LEAD-INS · ANTENNAS

BUSHINGS are but one of thousands of items which we produce for the electronic industry. Attention to every design detail, plus the Stupakoff precision method of manufacture, produces bushings of maximum mechanical strength and minimum electrical losses.

Stupakoff bushings are stocked in many sizes and styles—singly—in pairs, consisting of male and female—assembled with hardware; also bushings with metal bands for solder sealing. Special styles will be made promptly to your design.

Knowledge gained through years of experience, engineering ability and modern manufacturing facilities enable Stupakoff to produce millions of ceramic insulators daily. Your inquiries will receive prompt attention.

ARMY E NAVY

"FOR GREAT ACHIEVEMENT"

STUPAKOFF
Steatite
INSULATORS

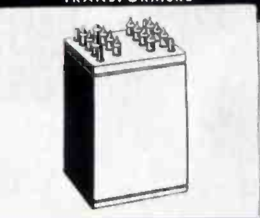
Do More Than Before—Buy EXTRA War Bonds

Products for the World of Electronics

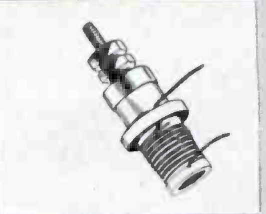
STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

TOMORROW

HERMETICALLY SEALED TRANSFORMERS



R. F. COILS



I. F. COILS

CHOKE COILS

Two years ago, when production of civilian radio was put aside for the duration, we stopped our Mica Trimmer Condenser assembly lines.

Today our efforts are devoted entirely to production of R. F. and I. F. coils, hermetically sealed transformers, assemblies and equipment for our armed services. But we haven't lost our "know how" on products for peacetime use — in fact, the pressure of all-out war work has added much to our store of knowledge.

Tomorrow, when the war is won, we will again be at your service with all our former products. *We* are planning for tomorrow NOW, and anything *you* can tell us NOW about *your* plans will help us prepare to serve you better when tomorrow comes.

Right now — we have open facilities for war work!

KEEP BACKING
THE ATTACK!
BUY MORE
WAR BONDS

AUTOMATIC
WINDING CO., INC.

COMPLETE ELECTRONIC ASSEMBLIES & COMPONENT PARTS

900 PASSAIC AVE. EAST NEWARK, N. J.

NO SUBSTITUTE NEEDED!

USE HYTRON 6AL5

VERY-HIGH-FREQUENCY TWIN DIODE

The 6AL5 fills the need for a high perveance twin diode with the low voltage drop required for many special r.f. circuit applications. WPB and the Services consider diode connection of the 6J6 twin triode (and other triodes) to be a wasteful misuse. With minor changes of socket wiring, the 6AL5 easily replaces the diode-connected 6J6.

Specifically manufactured and rated as a diode, the 6AL5 is tested as a diode. Close production control keeps within a narrow range the cutoff characteristic in the contact potential region. Designed throughout for efficiency on high and very-high radio frequencies, the 6AL5 has a separately connected shield which may be grounded to isolate the two diodes and their associated circuits. A midget miniature bulb permits extra space savings.

Possible uses include: Detector and AVC, clipper, limiter, FM frequency discriminator, special high-frequency diode, power rectifier.

TYPE 6AL5
(Developmental Hytron D27)

BASING
Pin 1 — Cathode 1
Pin 2 — Plate 2
Pin 3 — Heater
Pin 4 — Heater
Pin 5 — Cathode 2
Pin 6 — Shield
Pin 7 — Plate 1

CONSTRUCTIONAL FEATURES

1. Rugged mount is supported by short, heavy stem leads as well as by top mica.
2. Close cathode-to-plate spacing gives high perveance. (Note plate cooling fins.)
3. Electrostatic shield connects to pin 6.
4. Baffle mica shields the elements from getter spray.
5. Miniature stem permits negligible lead inductance and minimum interelectrode capacitances.

HYTRON TYPE 6AL5

Very-High-Frequency Twin Diode

ELECTRICAL CHARACTERISTICS

Heater potential (AC or DC)	6.3 volts
Heater current	0.3 amperes
Peak inverse potential†	460 max. volts
Heater-cathode potential†	350 max. volts
Peak plate current per plate†	60 max. ma.
Average plate current per plate†	10 max. DC ma.

INTERELECTRODE CAPACITANCES

Plate 1 to plate 2	0.015 mmf.
Plate to cathode*	2.8 mmf.
Cathode to all*	3.8 mmf.

Capacitances are averages with close-fitting shield.

PHYSICAL CHARACTERISTICS

Bulb	T-5½ midget
Base	Miniature button 7-pin
Height overall	1.82 inches max.
Diameter	0.75 inch max.

† Maximum ratings shown are absolute; design maximums should be approximately 10% lower to allow for line voltage variations.
• Value is for one of the two twin diode sections.

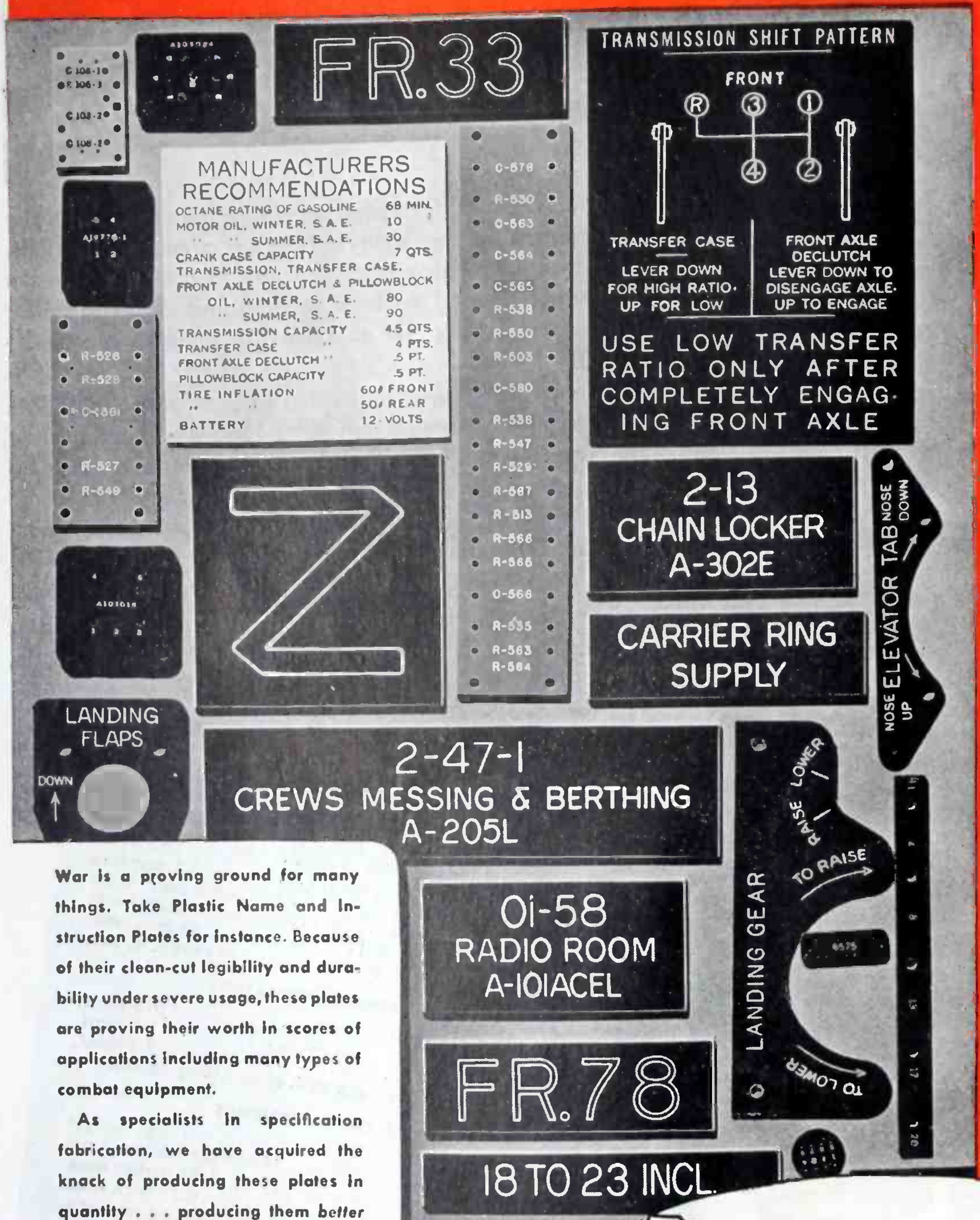
OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

BUY ANOTHER WAR BOND

Plastic NAME AND INSTRUCTION PLATES



ENGRAVED
EMBOSSED
LITHOGRAPHED
PRINTED
HOT PRESSED

from

LAMINATED PHENOLIC
WHITE CORE-BLACK SURFACE
COLORED SURFACES
MELAMINE
LUCITE
PLEXIGLASS

and other Plastic materials as specified

War is a proving ground for many things. Take Plastic Name and Instruction Plates for instance. Because of their clean-cut legibility and durability under severe usage, these plates are proving their worth in scores of applications including many types of combat equipment.

As specialists in specification fabrication, we have acquired the knack of producing these plates in quantity . . . producing them *better* . . . *faster* . . . and *more economically!*

Let us prove this to you. Send us the specifications for your next requirements.

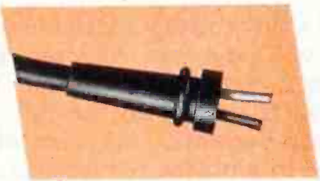
Specification Fabricators of
GLASS BONDED MICA, PHENOL FIBRE, VULCANIZED FIBRE, RUBBER, ASBESTOS, CORK, CORPRENE AND OTHER MATERIALS

Precision FABRICATORS, INC.
112 N. FITZHUGH ST., ROCHESTER 4, N. Y.

Branch Offices: NEW YORK: 420 LEXINGTON AVE., DETROIT: 14319 STRATHMOOR AV
PHILADELPHIA: 6710 HOLLIS ST., CHICAGO: 4317 RAVENSWOOD AVE.

A GOOD ELECTRIC DRILL *PLUS* A GOOD CORD

Nationally advertised identifying mark of a corditis-free electrical tool or appliance—the Belden unbreakable plug.



One of the many Belden Strain Reliefs may simplify assembly problems—lower production costs—and add longer service life to the product.

Belden Plugs, Cords, Strain Relief—in a wide range of combinations—make up complete corditis-free cords for every electrical requirement.

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

Most Belden-equipped electrical machines are still running today, when failure can mean loss of service for the duration.

For years the identifying mark of a good appliance, Belden electrical cords and plugs are an indication to the purchaser that the manufacturer was careful in the selection of the parts for his product. The buyer has confidence that Belden cords assure freedom from Corditis, irritating disease that ruins cords and plugs.

When designing your post-war products take advantage of the plus values of Belden electrical cords, perfected through years of experimenting, testing, controlled production, and cooperation with industry. Specify Belden.

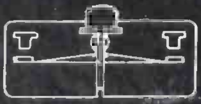
Belden Manufacturing Company
4625 W. Van Buren Street, Chicago 44, Illinois

Belden

Corditis-free CORDS

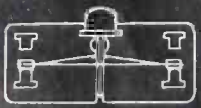
Don't Handicap Important Designs for Lack of a SMALL Electric Switch

3 basic contact arrangements



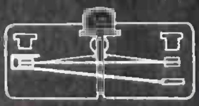
single-circuit, normally open

single-circuit, normally closed

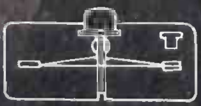


double-circuit, one normally open and one normally closed

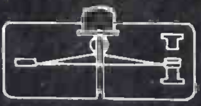
And many special forms. For example:



three-point structure



single-break, normally open

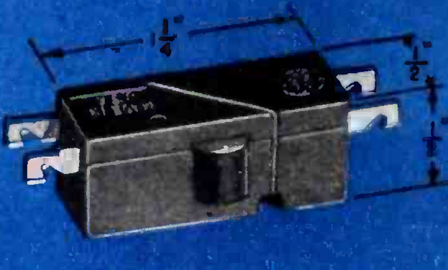


single-break, double-throw

SWITCHETTES

BUY WAR BONDS

THE G-E SWITCHETTE IS ONLY THIS BIG



(This one is ACTUAL SIZE)

WHEREVER you need a tiny contact mechanism in ratings up to 10 amperes at 24 volts d-c—an enclosed, self-contained unit that's light and compact, yet can withstand thousands of operations—there's a G-E Switchette to do the job.

This tiny switch weighs only 9 grams, and is suitable for use at altitudes up to 50,000 feet and in ambient temperatures from 200 F to −70 F. It's corrosion-proof—meets 50-hour salt-spray tests. It's vibration-resistant. The contacts will not chatter when subjected to mechanical frequencies of 5 to 55 cycles per second at 1/32-inch maximum amplitude (1/16-inch total travel), or to a linear acceleration of 25 g in any direction.

Two terminal arrangements are available—out the ends of the case as shown above, or out the top through the cover. This makes for easy mounting in any position.

More than 200 design modifications of the G-E Switchette are available to provide for a wide variety of electrical and mechanical arrangements.

SHIPMENT FROM STOCK

Some forms are now available from warehouse stocks in substantial quantities, to give you quick delivery for your important war jobs.

For your copy of our new catalog (GEA-3818B) which gives dimensions, ratings, and ordering directions for both standard and modified Switchettes, call our local office. *General Electric Co., Schenectady 5, New York.*

GENERAL ELECTRIC

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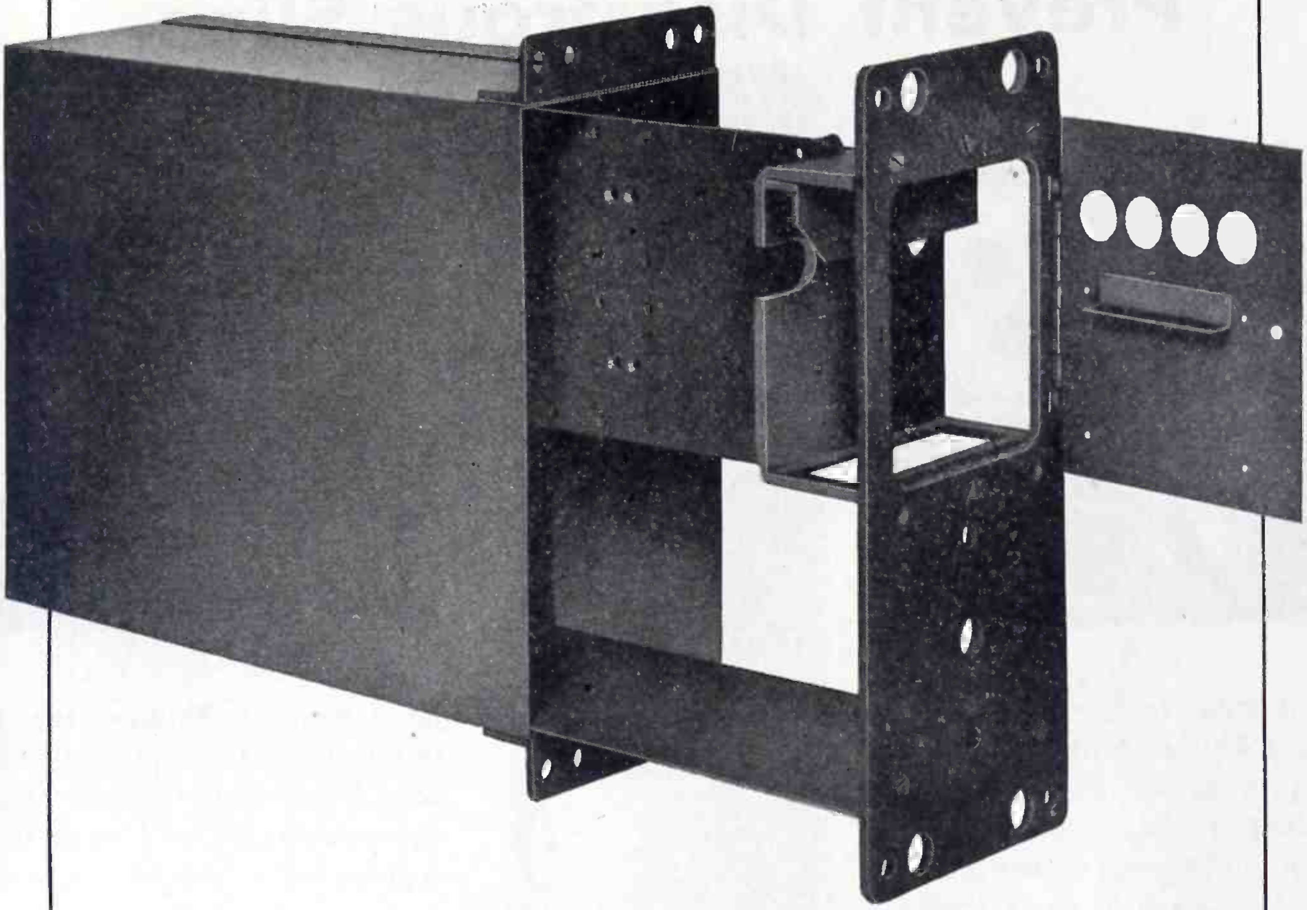
What is your sheet metal fabrication problem?



IS IT DELIVERY?
IS IT QUALITY?
IS IT PRICE?

The arithmetic is simple:

KARP'S production and engineering techniques plus tools, equipment, personnel and hundreds of stock dies ADD UP TO . . .

KARP'S savings for you in time, labor and expense and . . .

KARP'S universally praised quality and delivery at competitive prices.

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IT'S IMPORTANT TO BUY WAR BONDS . . . MORE IMPORTANT TO HOLD ON TO THEM

AMERICAN *Phillips* SCREWS

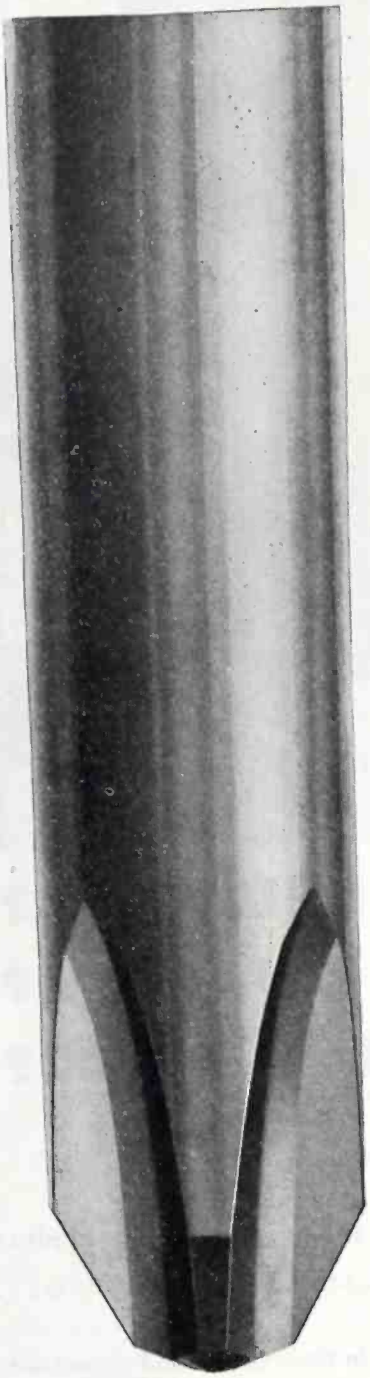
Prevent Disastrous Slips

... in assembling planes

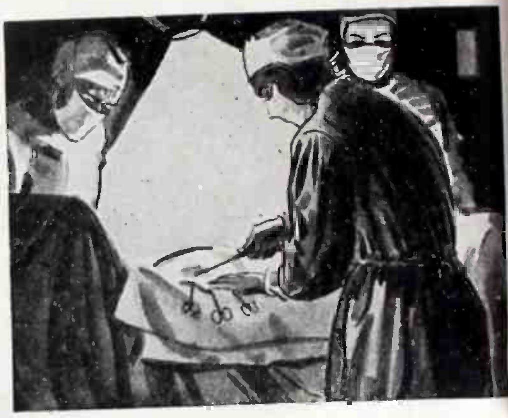
Firm, 4-point engagement of the American Phillips Driver with the recessed American Phillips Screw *is positive prevention* of the driver slipping out, and ripping up the plane's "skin" . . . on which not a scratch is permissible.

American Phillips Screw and Driver align themselves automatically into a single unit that can't drive any way but straight. That's why American Phillips Screws are so easy to handle, so quick to drive, so untiring even to women workers.

And that's why, in all applications from airplane manufacturing to bone surgery, the total time they save often adds up to 50%.



... in setting fractured bones

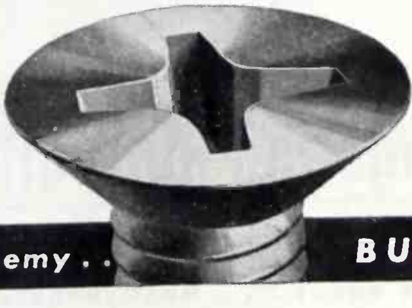


Just as American Phillips Screws protect against slashes on an airplane's skin, so they protect fracture-patients against wounds caused by the driver slipping out of slotted-head screws.

A western surgeon writes: "We have had a Vitallium metal driver and screws cast on this (Phillips) principle, and have been highly gratified by their use. Time of driving is much less. Driver never slips and jabs the patient. Actual asepsis (freedom from germs) is better because the surgeon is not tempted to use his free hand to steady the driver".

No matter what *your* fastening problem, you will profit equally by using American Phillips Screws.

AMERICAN SCREW COMPANY

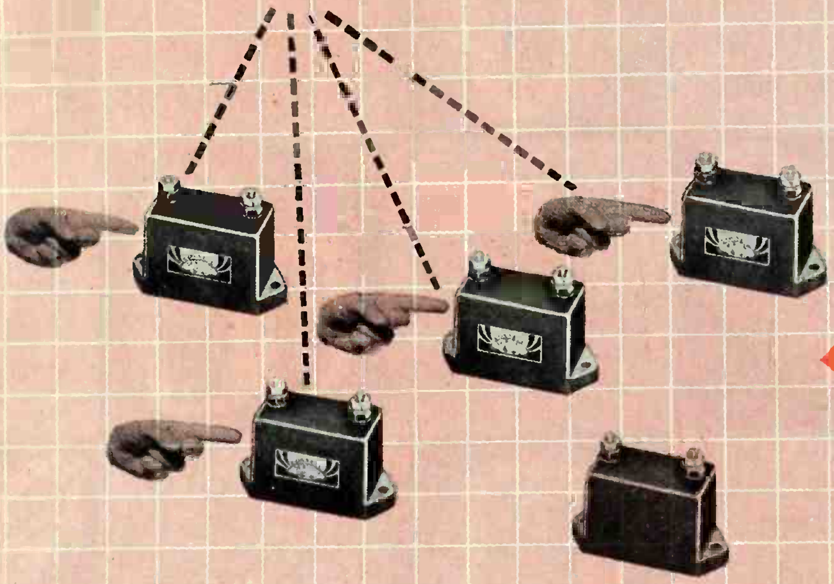


PROVIDENCE 1,
RHODE ISLAND

CHICAGO 11: 589 E. Illinois Street
DETROIT 2: 502 Stephenson Building

Put the screws on the enemy . . BUY WAR BONDS!

4 out of 5



engineers choose C-D . . .

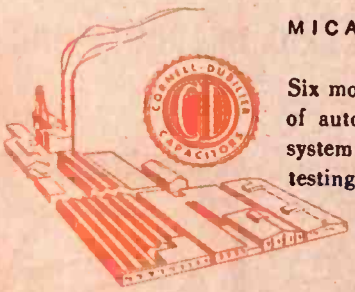
From the engineer's blueprint to the finished product, Cornell-Dubilier Capacitors are planned to give maximum operating efficiency and trouble-free long life. Electronic engineers rely on the quality and stamina of C-D Capacitors with the confidence of long association. They know that C-D has developed and built good capacitors for 34 years. For information about them, write to the world's largest manufacturer of capacitors. Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey.

Another famous C-D development

TYPE 6K ideal for high stability tuned circuits where constant capacity is required.

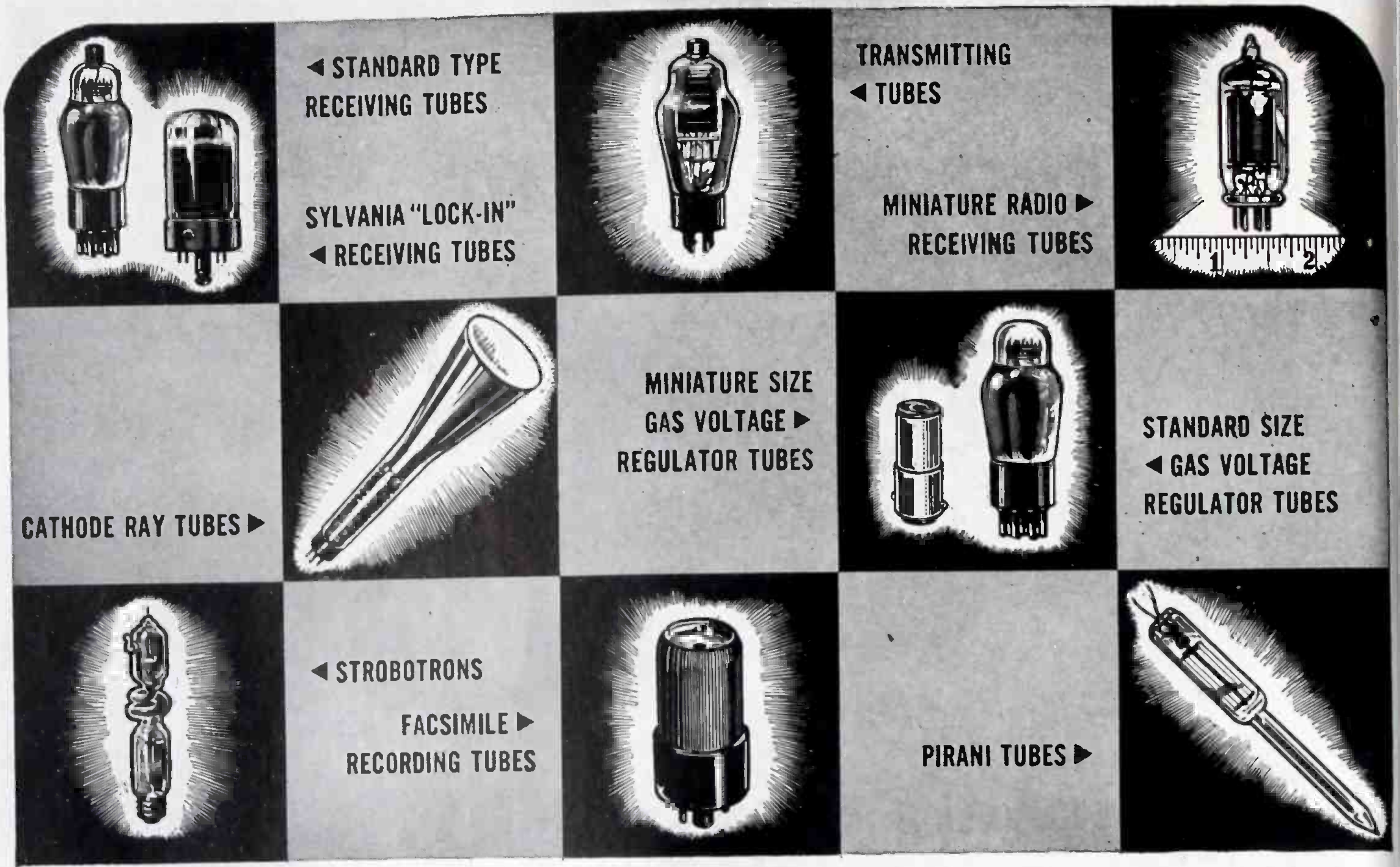
A compensated unit which can be made having any temperature coefficient between the limits of + .003% to – .005% per degree C. (tolerance ± .001% per degree C.) over a temperature range of from –40° C. to +70°C., made in a wide variety of capacity and voltage ratings.

MICA • DYKANOL • PAPER • WET AND DRY ELECTROLYTICS



Six modern Cornell-Dubilier plants have every facility for mass production. Huge batteries of automatic machines, moulding presses, and the largest radio capacitor impregnating system in the world, are ready to serve your requirements. Up-to-the-minute precision testing devices, including high power oscillators for overload tests at any frequency, hold production to exacting laboratory standards.

Cornell-Dubilier Capacitors



ELECTRON TUBES

in Search of an Inventor

Whether the inventor is an individual or the research laboratory of a great corporation, Sylvania offers a wide variety of electron tubes. A few of them are shown here, together with components—as a sample of our manufacture to one standard —the highest anywhere known. There are many more, some of which are on the restricted list. For information about Sylvania electron and radio tubes, write Sylvania Electric Products Inc., 500 Fifth Avenue, New York 18, N.Y.

One Standard — The Highest Anywhere Known

SYLVANIA ELECTRIC PRODUCTS INC.

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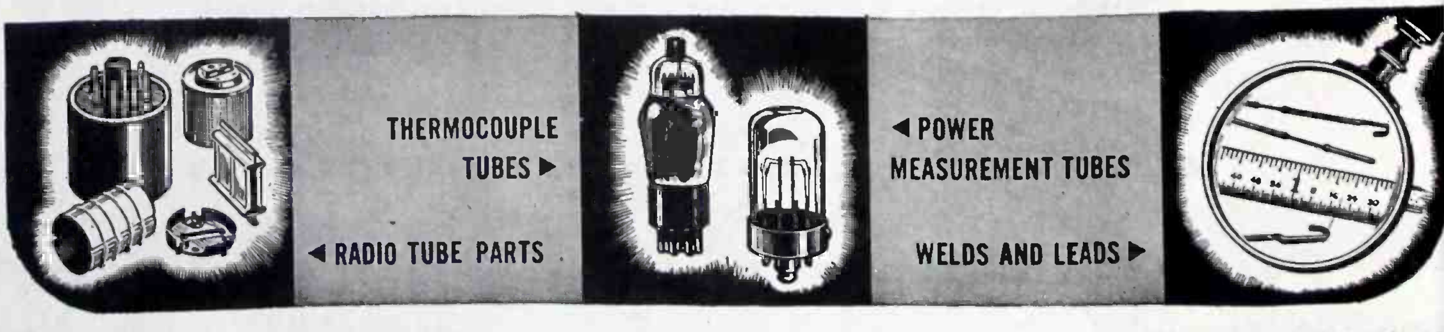
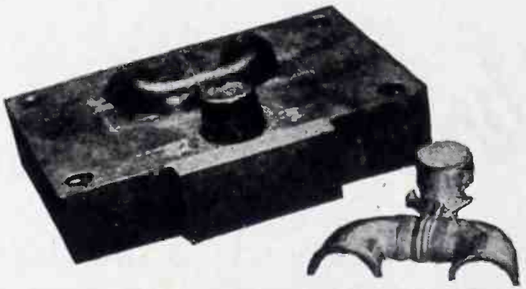
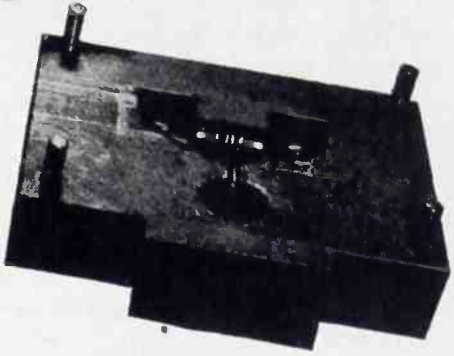




WE CAN'T BUY 'EM — SO WE BUILD 'EM



Cannon Quality Control requires tools and dies of exceptionally close tolerances. So to meet our standards we make our own.

That's doing it the hard way but it's worth it. For now we have a tool and die manufacturing plant second to none in precision, accuracy and general excellence of product.

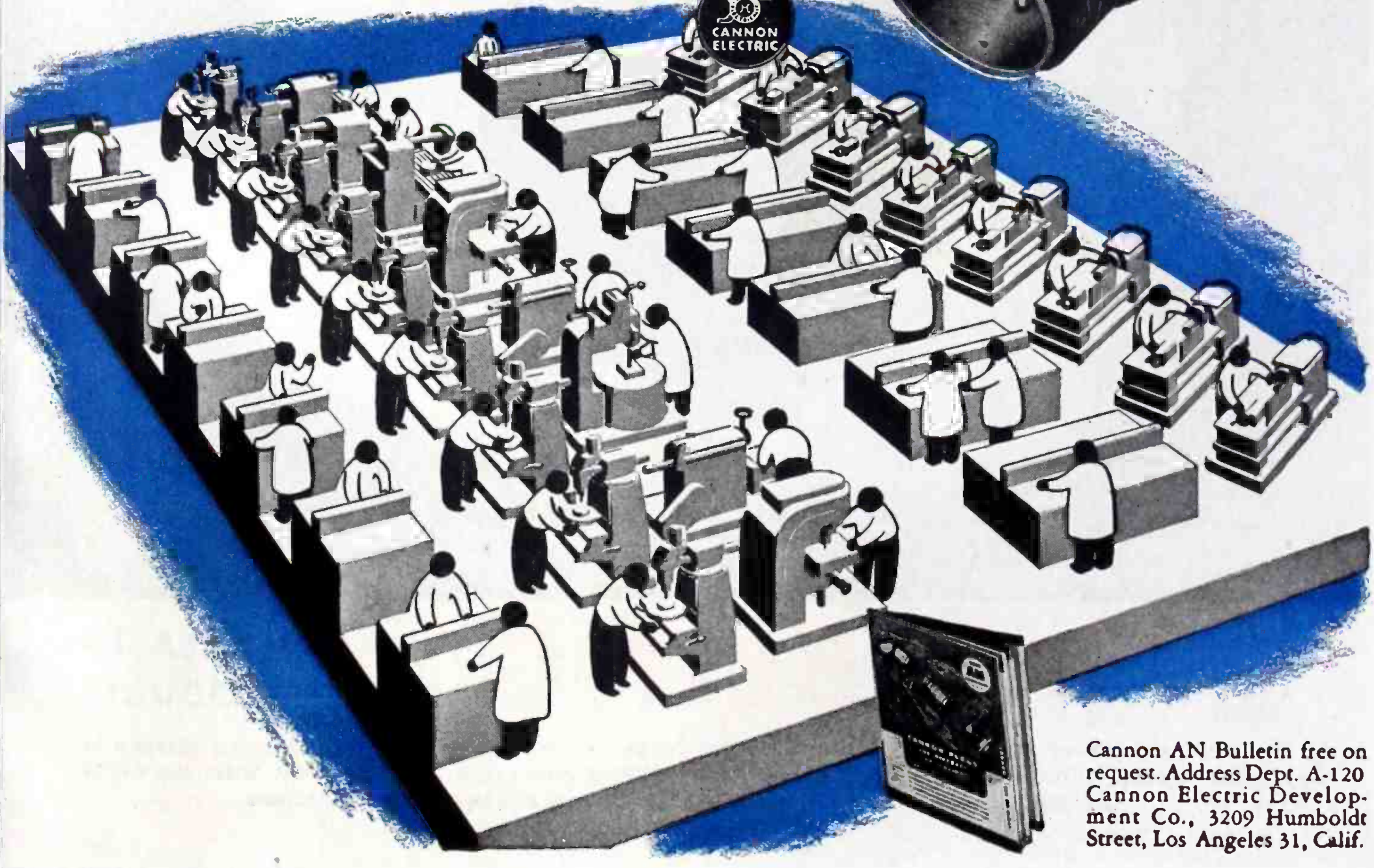
It's an organization of skilled tool makers, none with less than seven years experience. These expert craftsmen work with the best equipment and the finest materials. It is a big plant with a capacity many times our ordinary needs. But this production margin means better tools, more efficient machines, replacements long before exhaustion and thus, of course, connectors we're proud to identify with the Cannon trade mark.

CANNON ELECTRIC

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

Canadian Factory and Engineering Office: Cannon Electric Co., Ltd., Toronto

Representatives in principal cities — Consult your local telephone book



Cannon AN Bulletin free on request. Address Dept. A-120 Cannon Electric Development Co., 3209 Humboldt Street, Los Angeles 31, Calif.

Wire AND NOTHING ELSE!

Making wire—that's the full time, all time job of Roebling *wire specialists*. Wire Specialization—that's the secret of Roebling quality.

When you see the name Roebling on a reel or coil—you know it has real significance. It stands for *integrity* in electrical wires and cables—integrity that has been the watchword of generations of Roebling wire specialists.

Give your product the *plus* in safety and dependability which Roebling electrical wires and cables assure. Available in types for all purposes—from portable cords and magnet wire to heavy power cables.

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TRENTON 2, NEW JERSEY
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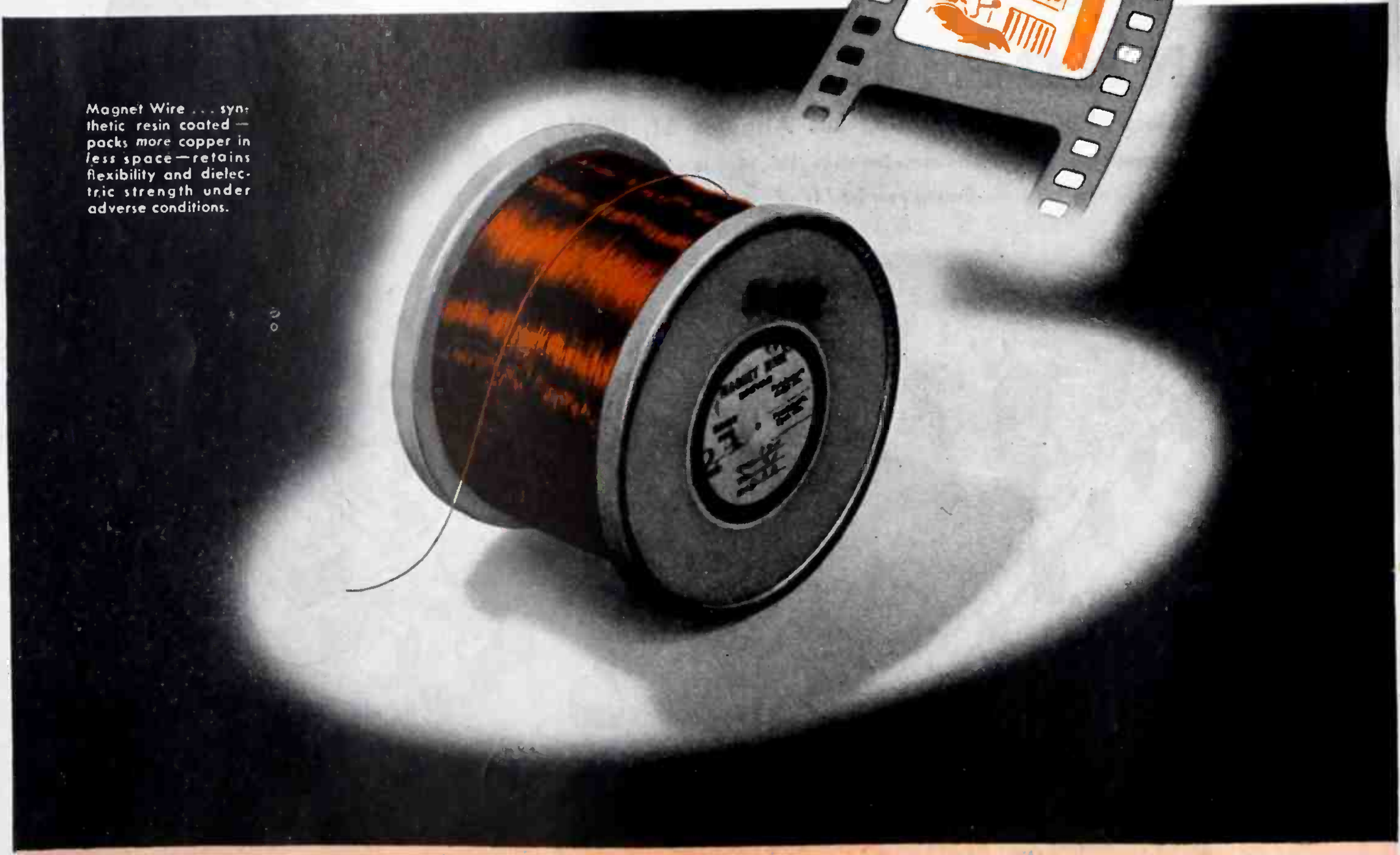

Magnet Wire . . . synthetic resin coated—packs more copper in less space—retains flexibility and dielectric strength under adverse conditions.

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Obvious Quality

VISUAL

Clean cut mechanical nicety literally radiates from these UNITED mercury rectifiers. It is only natural that their eye appeal impresses the exacting minds of so many government and commercial engineers.

TEST

The physical ruggedness and sterling workmanship in these tubes reveal the kind of care and precision that has entered into the electrical phases of their design. They are criterions, rather than ordinary conformers to the constantly stiffening Army and Navy test specifications—*both* mechanical and electrical.

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Representative service records maintained over a period of 10 years by large users prove an average of many thousands of hours satisfactory operating life.

THERE IS NO SPECULATION IN CHOOSING UNITED MERCURY RECTIFIERS

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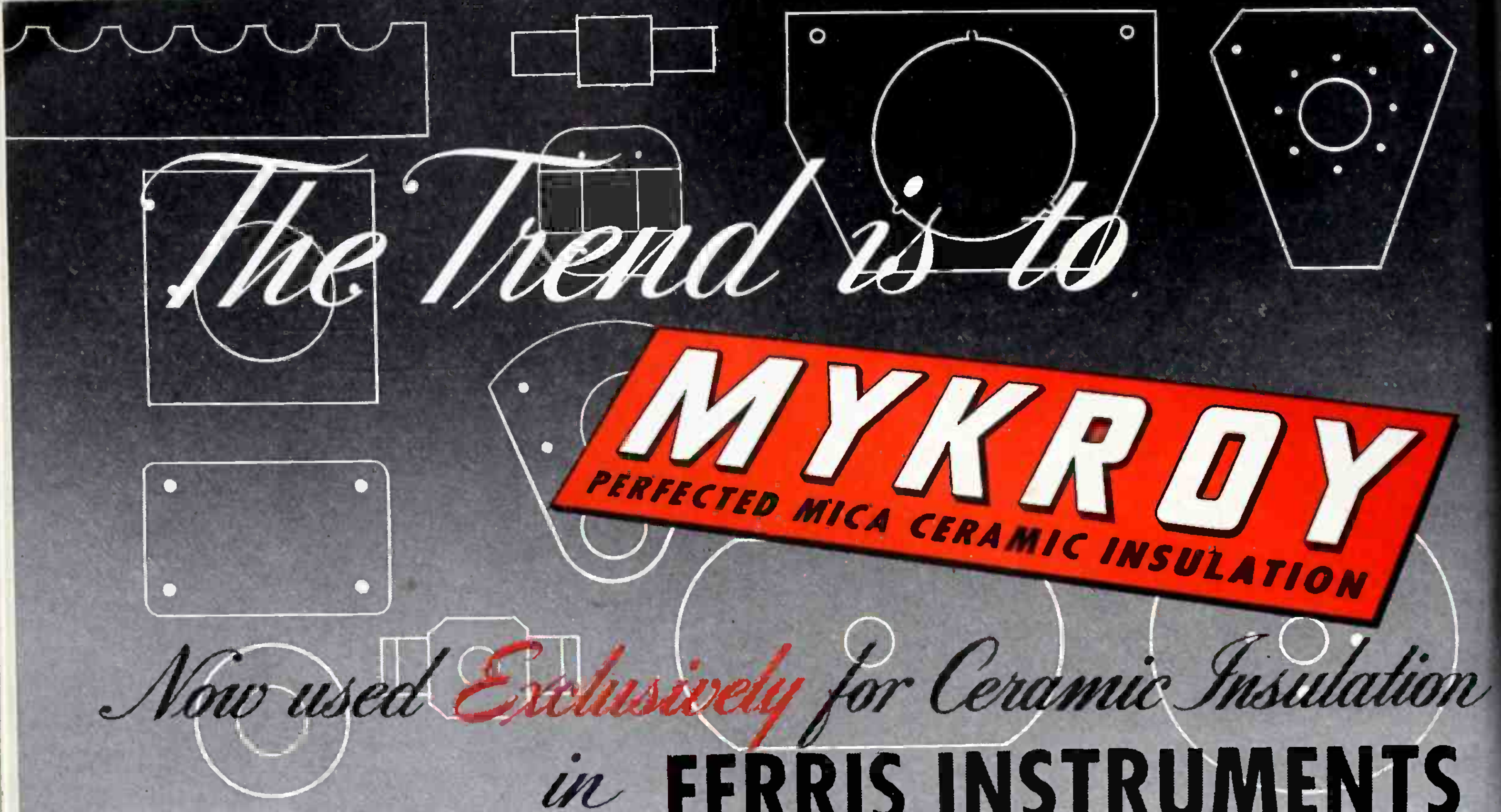
Transmitting tubes exclusively since 1934

ARMY E NAVY

The UNITED types illustrated will interchange with and replace other type tubes as follows:

USE UNITED TYPE 967 to replace FG-17
" " " 972-A " " 872-A
" " " UX-973 ....
" " " 973 (Not illustrated) 873



The Trend is to

MYKROY

PERFECTED MICA CERAMIC INSULATION

Now used *Exclusively* *for Ceramic Insulation*

in **FERRIS INSTRUMENTS**

Ferris Instruments, world famous signal generators, set the standard for the entire electronic industry by maintaining accuracy to within *0.01 percent*. Insulation specifications for an instrument of Ferris' perfection are consequently of the highest order.

4 REASONS WHY FERRIS ENGINEERS SELECTED MYKROY

(1) Despite wide temperature swing, the insulation must unfailingly maintain low loss factor.

(2) No change in dielectric constant can be tolerated.

(3) Physical stability must be assured to prevent changes in inductances and capacitances.

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For these most exacting insulation specifications MYKROY "fills the bill" dependably.

Ferris engineers are particularly satisfied with MYKROY because it can be machined to closest tolerances permitting them to make spot changes in structural design rapidly and easily in their own shop. Though *your own* H-F designs may not embrace such critical standards, it is wise to use MYKROY for dependably high results.

(Illustrated) 20-250 Megacycle Ferris Standard Signal Generator

SEND FOR YOUR FREE COPY OF THE MYKROY ENGINEERS MANUAL containing the newest facts about the improved insulation. A request on your letterhead will bring your copy by return mail.

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

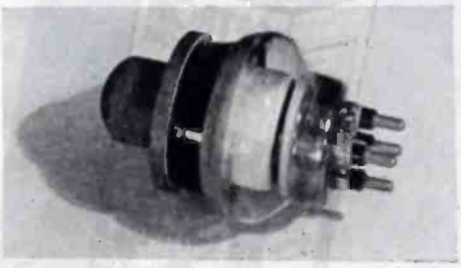
MADE EXCLUSIVELY BY **ELECTRONIC MECHANICS INC.**
70 CLIFTON BOULEVARD • CLIFTON, NEW JERSEY
Chicago 47: 1917 NO. SPRINGFIELD AVENUE . . TEL. Albany 4310
Export Office: 89 Broad Street, New York 4, N. Y.

This is how an electron behaves

designing a new electronic tube, athematical calculations are invalu- le, but as every designer knows, they e but preliminaries. After them, there ually come many tests of various perimental tubes. Machlett thought e cut-and-try method not only waste- l, but not productive of the best sults. So we shortened and simplified e procedure by what our laboratory eople call the "rubber model."

Here is a stretched rubber sheet. At e high end is a model of the cathode lectron emitter) of a proposed tube, nd at the other end the anode, or rget of an X-ray tube, plate of an scillator or rectifier. The slope between the two is proportional to the desired potential difference. By means of an electro-magnet, a steel ball can be held in any position along the cathode, then released to roll under gravity to the anode, where the point it strikes can be observed and measured. *This is an electro-mechanical analogy.*

By means of this rubber model technique, months have been shortened into days, weeks into hours. More than that, new and higher performance has been achieved in the final product, so that when you buy a Machlett tube, you are assured of precise results, longer life, greater economy . . . Machlett Laboratories, Inc., Springdale, Connecticut.

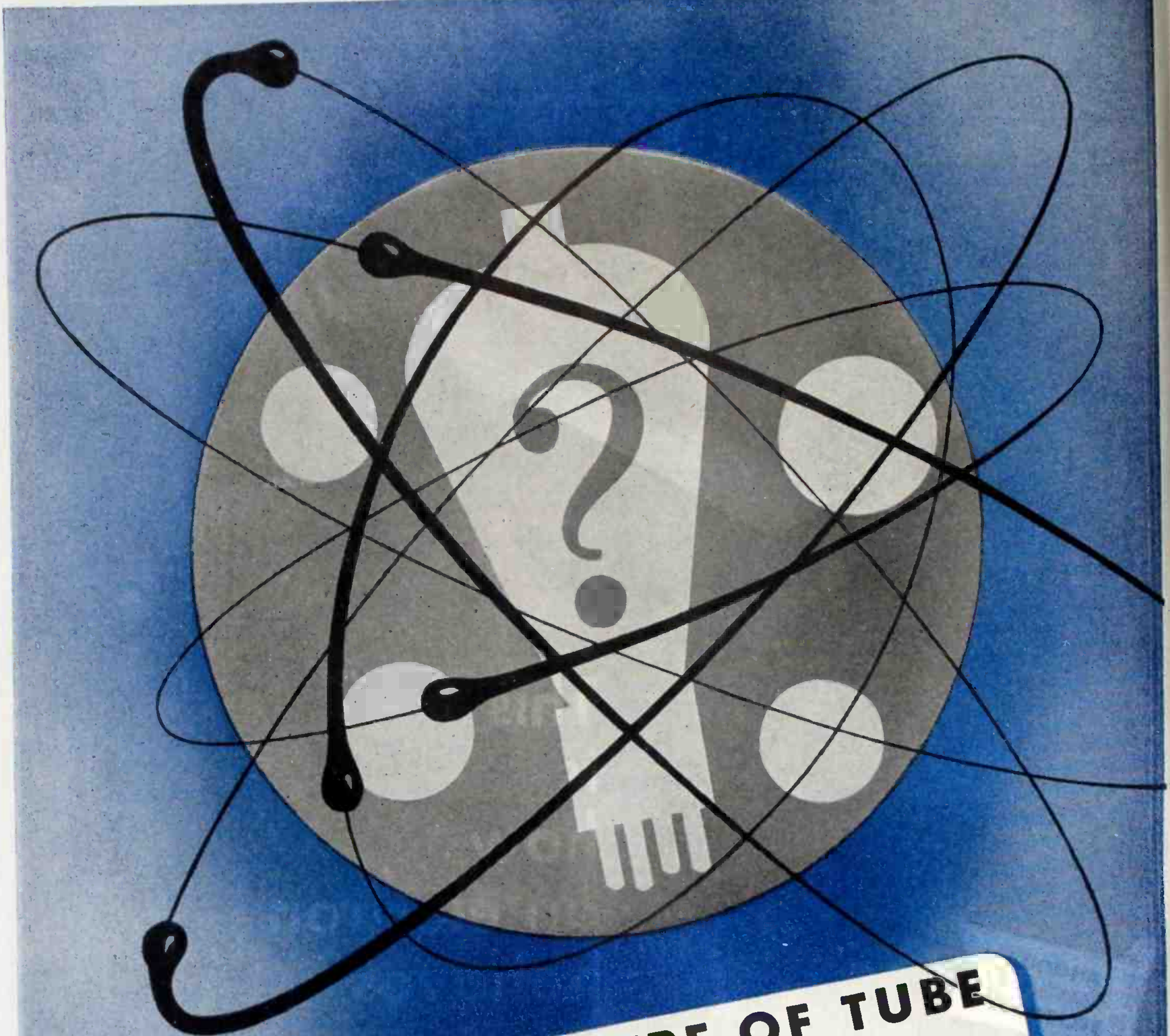


The Machlett 880 is a radio oscillator tube for use in transmitters, and has a maximum output of 60 KW.

MACHLETT

X RAY TUBES SINCE 1898

TODAY THEIR LARGEST MAKER



WHAT TYPE OF TUBE DO YOU NEED?

You can probably find the answer in the great variety of tubes we make. But if not, write us what sort of tube you need . . . what you wish it to accomplish . . . how it is to be used. Our engineers will study your problem and, without obligation, tell you if such a tube is practicable. Further, you will receive complete information on what Continental, with their exceptional laboratory facilities and long experience, can do to help you solve your problem. Write today: remember, there is no obligation!

CETRON

Electronic Tubes · Rectifiers · Phototubes

Set New Quality Standards

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SPECIALIZED SKILLS A DIME A DOZEN

BUT what makes Lewyt "different" is the ability with which we use our specialized skills for *your* benefit . . . especially when you've got your eye on post-war cost-conscious buyers.

Will there be many sub-contractors in wartime products bidding for your work? Be cautious, then, with those of only war-born experience . . . whose production education is largely limited to the lush years of "Cost-Plus" operations.

But in the period of re-conversion to a civilian economy, cost-sensitive production will be an imperative *must*. There will be no place or time for carelessness, or laxity, or indifference to costs.

Lewyt is *not* a war baby. Lewyt is a "Manufacturer's Manufacturer" with 56 years of widely diversified production experience . . . with highly developed skills for making things better at less cost. We are doing it for many of the greatest names in American Industry. Perhaps we can "whet your appetite" for some of these skills, too.

It costs nothing to consult us. Even if present conditions preclude figuring on the job *now*, we *can* quote on WAR BONDS. They start at $18.75.

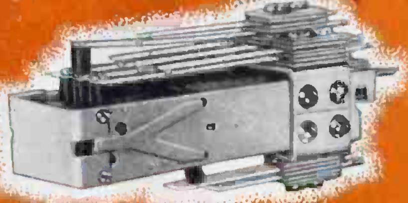
CHECK THESE OPERATIONS FOR IMPORTANT SAVINGS

We specialize in electric and electronic instruments, chassis and housings; mechanical and electrical assemblies; highest precision machine work; sheet metal fabrications; all types of welding, product finishing, etc. Write on your business stationery for illustrated 48-page book, "Let Lewyt Do It" . . . postage paid, no charge, no obligation. See Lewyt listings in Thomas' Register. LEWYT CORPORATION, 62 BROADWAY, BROOKLYN 11, N. Y.

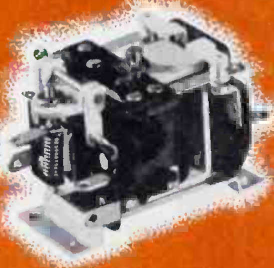
Lewyt

LET LEWYT DO IT

Specify-RELAYS



RIGHT—Step Relay—Combines lever operated and cam operated contact pile-ups. Lever action contacts operate only when the coil is energized, cam operated contacts operate until another impulse is received.

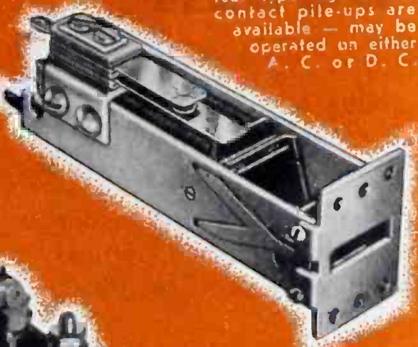


BELOW—Type 200—A double pole, double throw, latching relay arranged with two interlocking armatures. Either coil operates with a single impulse and contact remains until the other coil is energized.

ABOVE—Type 301—A double pole double throw aviation type relay with 10 ampere contacts featuring a pin type bearing, adjustable residual and back-stop.

BELOW — Annunciator Relay—Combines relay contacts and a visual leaf type signal. Two contact pile-ups are available — may be operated on either A. C. or D. C.

ABOVE—Type M-3—Small, single pole, single throw relay available with coil resistance from 150 to 1500 ohms. Can be mounted in a 1" cube. Contacts handle maximum of 5 amperes.



ABOVE—Type B-2A—Conforms to Army Air Force specifications for a 25 ampere contactor. Features pin type bearing double break contact arrangement which eliminates the necessity for current carrying pigtails. Adjustable residual and back-stop.

ABOVE — Differential Relay—A two coil sensitive relay with a balanced armature to make it less susceptible to vibration and shock. Can be made to balance with 3MA in each coil and to operate with 4MA in one coil and 2MA in the other coil for 60 volt operation or the equivalent in ampere turns.

LEFT — Differential Relay with Switches — Similar to standard Differential Relay, but equipped with small switches to obtain greater contact ratings.

Whether your requirements are for a standard type relay or a special relay for an unusual application, you can rely on Cook engineering to give you those "plus" features that make all Cook relays "extra-ordinary."

Here are some facts about Cook relays for you to consider when planning your relay requirements.

- Carefully designed to the high standards of Cook engineering.
- Tooled and fabricated completely under one roof.
- Precision manufactured with modern equipment.
- Assembled and tested with exacting care by skilled workers.
- Highest grades of all materials are used in all parts of Cook relays.
- Manufactured in a model plant with efficiency that provides capacity to produce in quantity.
- Cook Electric Company has been engaged in the manufacture of precision electrical apparatus since 1897.

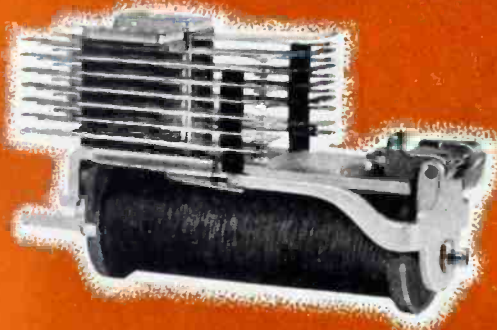
Illustrated here are a few of the standard types of Cook relays. Your requirements may be supplied with a standard type relay; however, it is when you have an unusual problem that Cook's engineering and manufacturing facilities, the ability to quickly design, manufacture and assemble all under one roof are of invaluable service. Cook special relays are built to meet customer requirements—not "just another relay"—not a combination of stock-bin parts, but a carefully engineered, designed and tooled product.

Cook's engineering staff is at your service to help you solve those unusual problems. A staff of field engineers located in various key cities throughout the United States is also available to you.

For complete service to the aviation, communications, electrical and electronics industries, Cook Electric Company also manufactures accessories, such as jacks, plugs, lamp jack strips, terminal strips, binding posts, solenoids, solenoid contactors, turn keys, lever keys, push keys, etc.

A new catalog of the complete line of Cook relays and accessories is now in preparation. A request on your letterhead will bring one to you immediately upon its completion.

by COOK - *All* Cook Relays, whether special or standard type, are *"Extra-ordinary"*

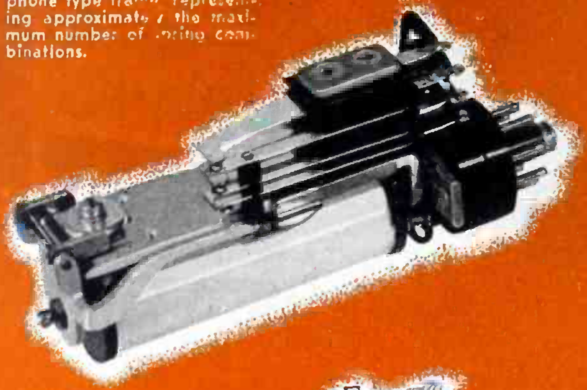


ABOVE—Type 142—Double pile-up relay on large telephone type frame representing approximately the maximum number of spring combinations.

RIGHT—Type 124—Special keying relay using silicon steel armature and heel piece with a laminated silicon steel core enabling operation on direct current at keying speeds up to 40 words per minute.

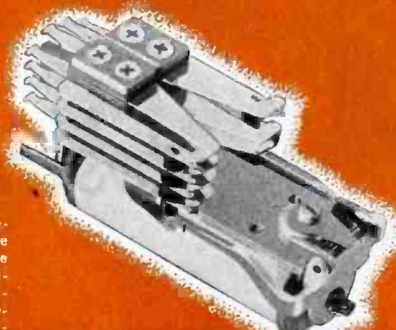
ABOVE — Type 400 — New, small, telephone type relay, approximately ½ size of former small, telephone type relays. Available in single and double pile-ups and special spread terminals.

BELOW—Type 128—A standard short frame telephone type relay with bakelite impregnated, Air Corps approved coil.

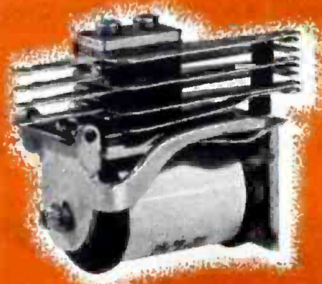


ABOVE—Type 113—An A.C. relay having a laminated core, heavy Oilite bearing yoke, special silicon steel armature and heel piece, and plug-in base.

LEFT—Small Time Delay Relay—Slug type on a short telephone type frame, a maximum of 125 milliseconds delay in operation can be obtained.



LEFT — Type 107 — A large type telephone relay used for keying and antenna switching. Keys satisfactorily at 20 words per minute—Mycalex insulation in the antenna switching pile-ups.



ABOVE—Type 100—Represents a typical contact pile-up combination on the short telephone type relay frame.

ABOVE—Type 107—Time delay relay of the slug type. Pure copper slug on heel end of core provides maximum of 300 milli-seconds delay in contact opening after circuit is broken

ABOVE—Type 109—Antenna switching contact combination with Mycalex insulation. Has a side contact mount to reduce capacity between antenna circuit and ground

COOK ELECTRIC Company

Specially
Designed
Precision Built
Aeronautical
Accessories

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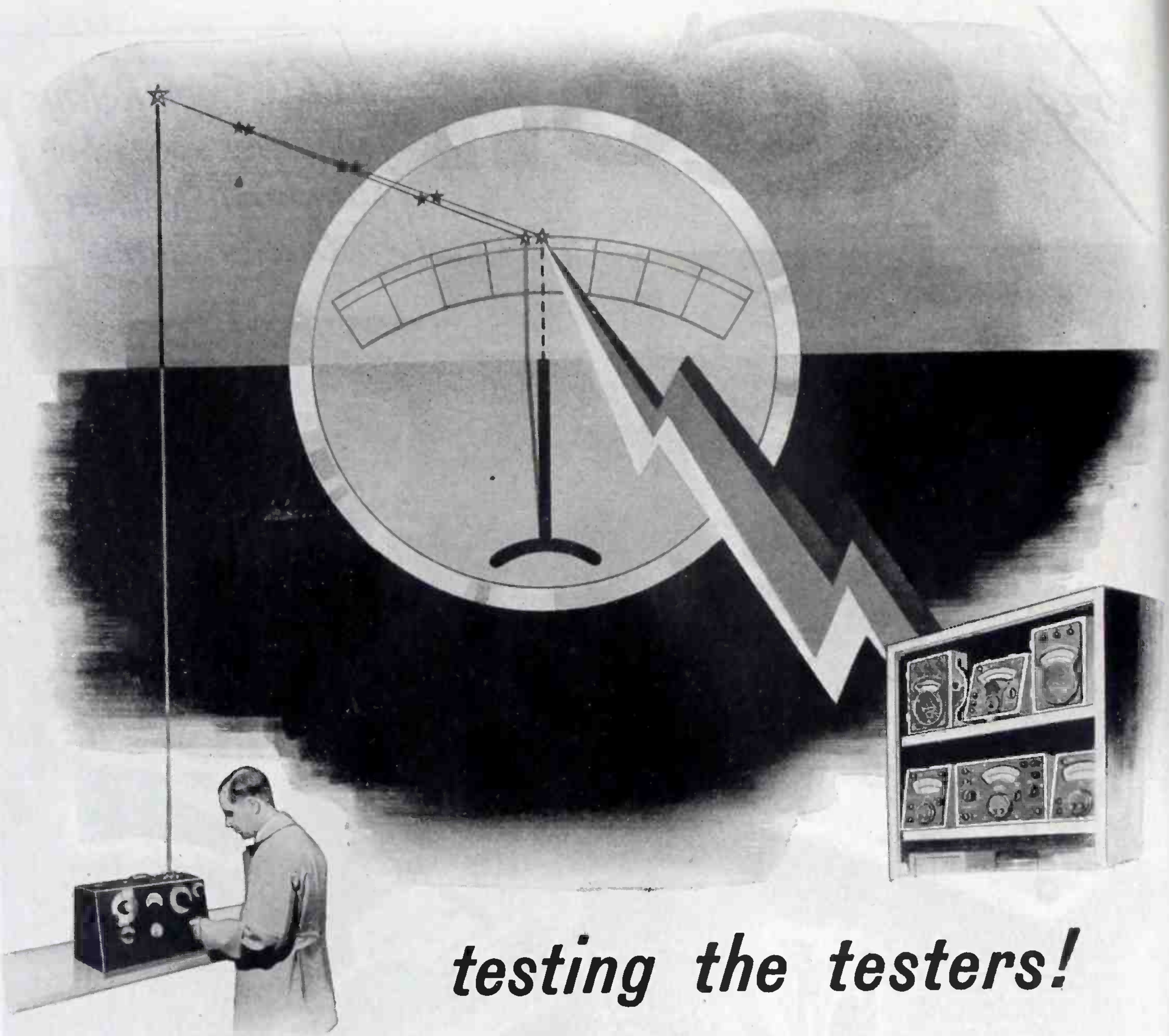

testing the testers!

Tests are meaningless unless the testing equipment is accurate. Utah's "bureau of standards" is kept under guard to assure absolute accuracy . . . these special testing devices, used to check the testing equipment on the line, are operated only by specially trained men and are never allowed to reach full-scale reading.

Because of this testing of testing equipment, the results of Utah's *complete* testing laboratory can always be relied upon—failures due to inadequate, inaccurate testing are avoided.

These comprehensive testing techniques which have been developed by Utah engineers are playing an important part in the adaptation of the many new radio and electronic ideas to military needs today—and will play an equally vital part in meeting commercial requirements tomorrow.

★ ★ ★

Every Product Made for the Trade, by Utah, Is Thoroughly Tested and Approved

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

utah

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

MORE small and medium

TRANSFORMERS

AVAILABLE

because production facilities have been expanded AGAIN

More rapid delivery is now possible because an additional expansion of production facilities has made possible the increased manufacture of Consolidated's well-known small and medium transformers. These transformer types include Pulse Transformers, Power Transformers, Solenoid Coils and Search Coils. Other products include Range Filters and Headsets.

Consolidated engineers will also design transformers for special applications or will build to your specifications.

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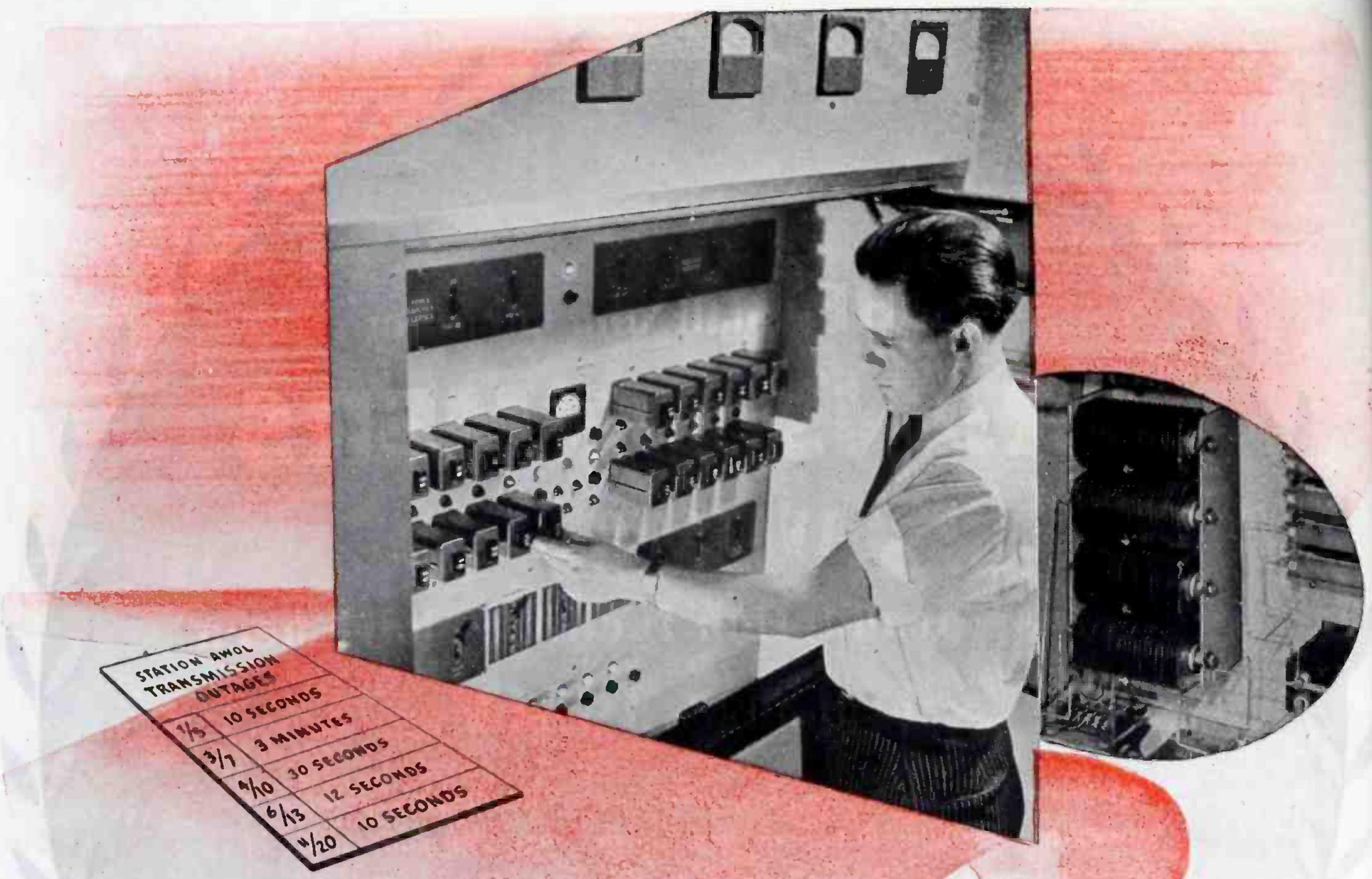

CONSIDER *Continuity of Operation* WHEN YOU SELECT A NEW TRANSMITTER

Off the air, right in the middle of a program—that's the nightmare of operating a radio station. That's when seconds seem like hours, and minutes like eternities. As though you didn't know!

Westinghouse Transmitters have been designed to cut program outage down to an almost unbelievable point. For example:

1. *Indicator Lights* show at a glance which circuit suffered an overload—even though the transmitter has returned to the air . . . making circuit checkup easy.
2. *Conservative Operation of All Tubes*—greatly increases reliability . . . lengthens tube life.
3. *Air-Cooled Tubes*—eliminate complicated and unreliable water cooling equipment.
4. *Surgeproof Metal Rectifiers* eliminate low voltage rectifier failures.
5. *Tube Life Meter* indicates the end of reliable tube life.
6. *Circuit Breakers* supply full overload and undervoltage protection automatically reducing length of outage.

We'll gladly give you complete information on these features, as well as other important advantages of Westinghouse Transmitters, such as: ***Low Operating Cost, Simplicity of Control, High Fidelity Signals, Ease of Maintenance.***

PLACE YOUR ORDER NOW FOR YOUR POSTWAR TRANSMITTER

By placing your order today for a Westinghouse Transmitter, you assure yourself of the fastest possible delivery following the lifting of wartime manufacturing restrictions. We are scheduling deliveries in the sequence in which orders are received. For details, write Westinghouse Electric & Mfg. Company, Dept. 1NB, P. O. Box 868, Pittsburgh 30, Pa.

J-0807

Westinghouse RADIO DIVISION
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

AM • ELECTRONICS • FM

Miracle in a handful

..so much done by so little

How large or small must a mounting be to fill the twin duties of efficiently absorbing shock and vibration, and also possess long functional life? All Lord Mountings are compact, light-weight units, based on long-term studies of the mechanical properties of natural and synthetic rubber when stressed in shear. Lord Bonded Rubber Mountings can be literally termed "a miracle in a handful". The mounting illustrated above has a load-carrying capacity of 100 pounds at 1/16" deflection, yet is only 1" in diameter, 1½" long, and weighs less than 3 ounces.

In every line of industry . . . in every type of structure in motion, the use of Lord Mountings will prolong equipment life, lower maintenance costs, insure greater accuracy of operation, reduce material weights by eliminating the necessity for inertia masses, increase personnel efficiency by eliminating nerve-wearing noise and vibration transmitted through solid conduction.

Whether you are an engineer or financier, production manager or operator of equipment, you should be interested in eliminating harmful vibration. Send for literature on vibration control or call in a Lord Vibration Engineer for consultation on your vibration problems. There is no obligation.

LORD
BONDED RUBBER
Shear Type
MOUNTINGS

IT TAKES RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

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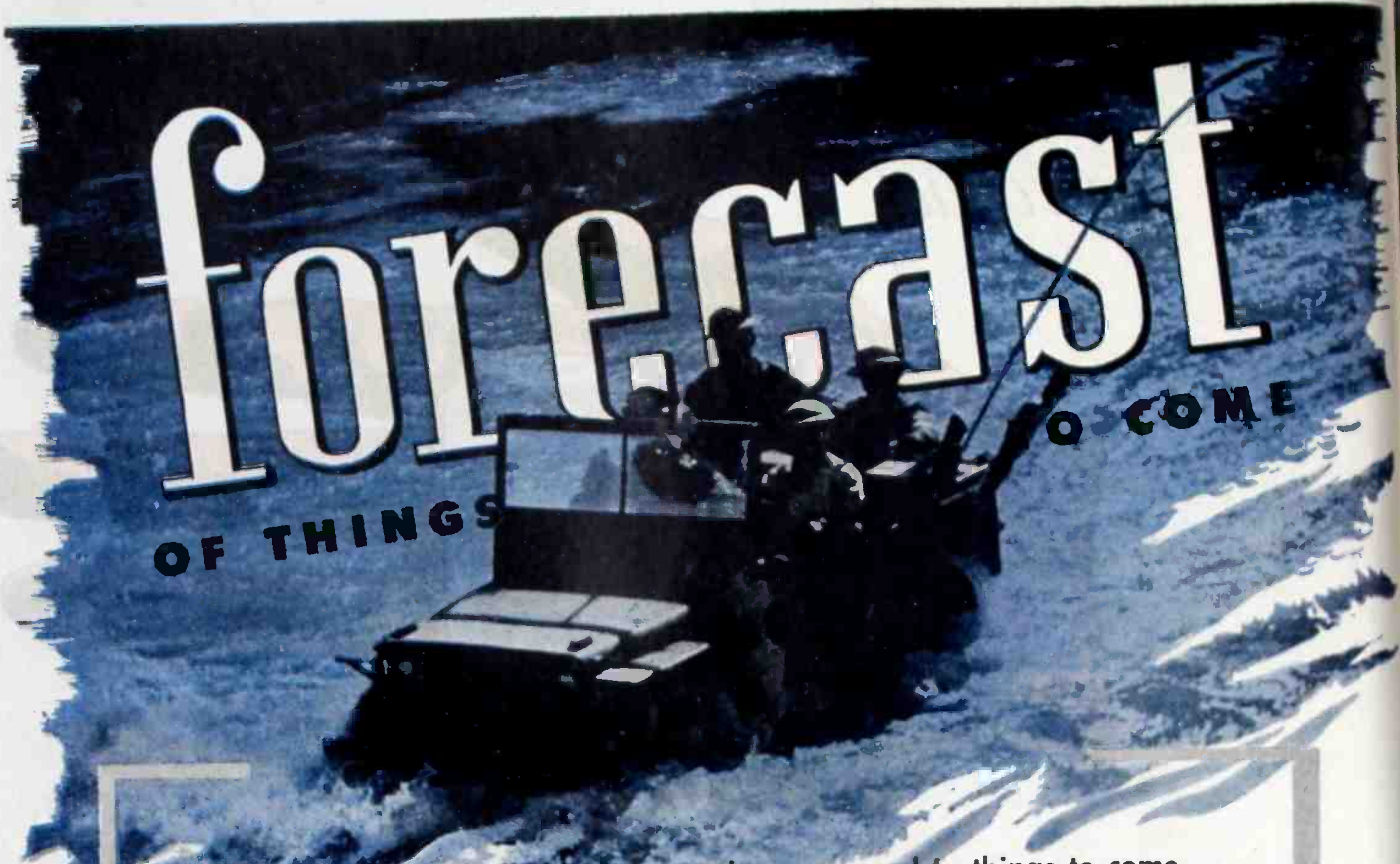
CANADIAN REPRESENTATIVES
RAILWAY & POWER ENGINEERING CORP., LTD.
TORONTO, CANADA

Originators of Shear Type Bonded Rubber Mountings



forecast

OF THINGS O COME

Our ability to call all ships, contact all planes, talk with every party on reconnoiter, forecasts the impact of electronics on future progress. Today's accomplishments in electronics are as nothing compared to things to come. To current war time triumphs in this field Leland engineering has contributed a full share. To tomorrow's great strides Leland will also contribute in full measure.

THE LELAND ELECTRIC CO.
DAYTON 1, OHIO

Leland Carbon Pile Voltage Regulator—control device on air-borne electronic equipment component.

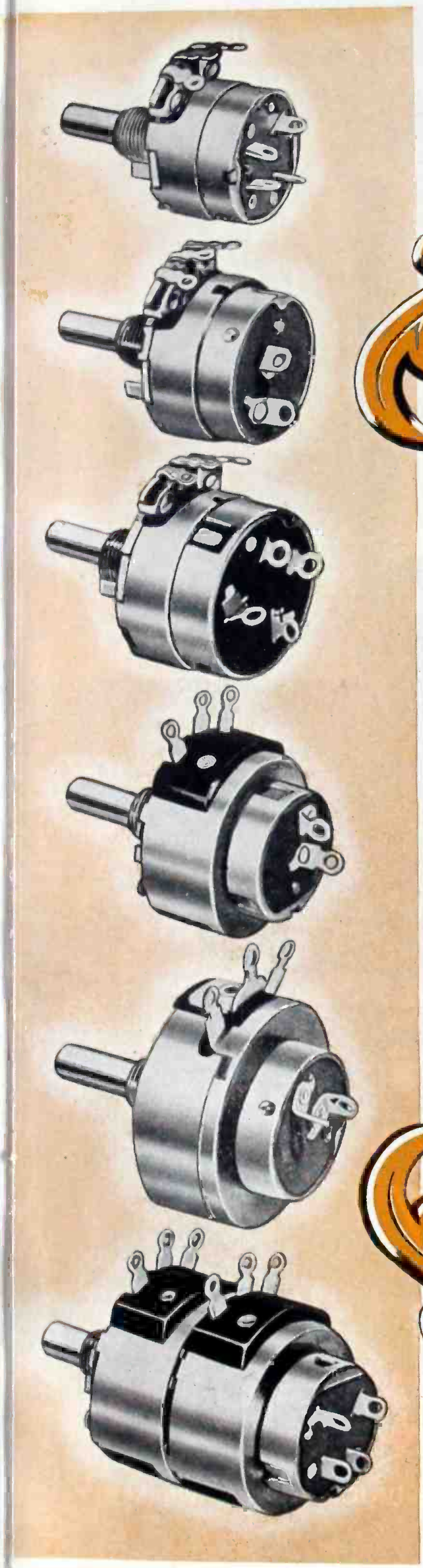
The Leland line includes motors, generators, motor generator sets, inverters and voltage regulators.

Consult Leland. They may be able to supply or design, exactly what you require.

Leland
ELECTRIC

CREATIVE
ELECTRICAL
ENGINEERING

YOUR MOST IMPORTANT OBLIGATION—THE PURCHASE OF WAR BONDS



Intensive research, creative engineering and precision mass production are the factors diligently followed in the development and manufacture of Chicago Telephone Supply Company variable resistors, both wire wound and carbon.

Manufacturers of Quality
Electro-Mechanical Components Since 1896

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CHICAGO TELEPHONE SUPPLY
Company

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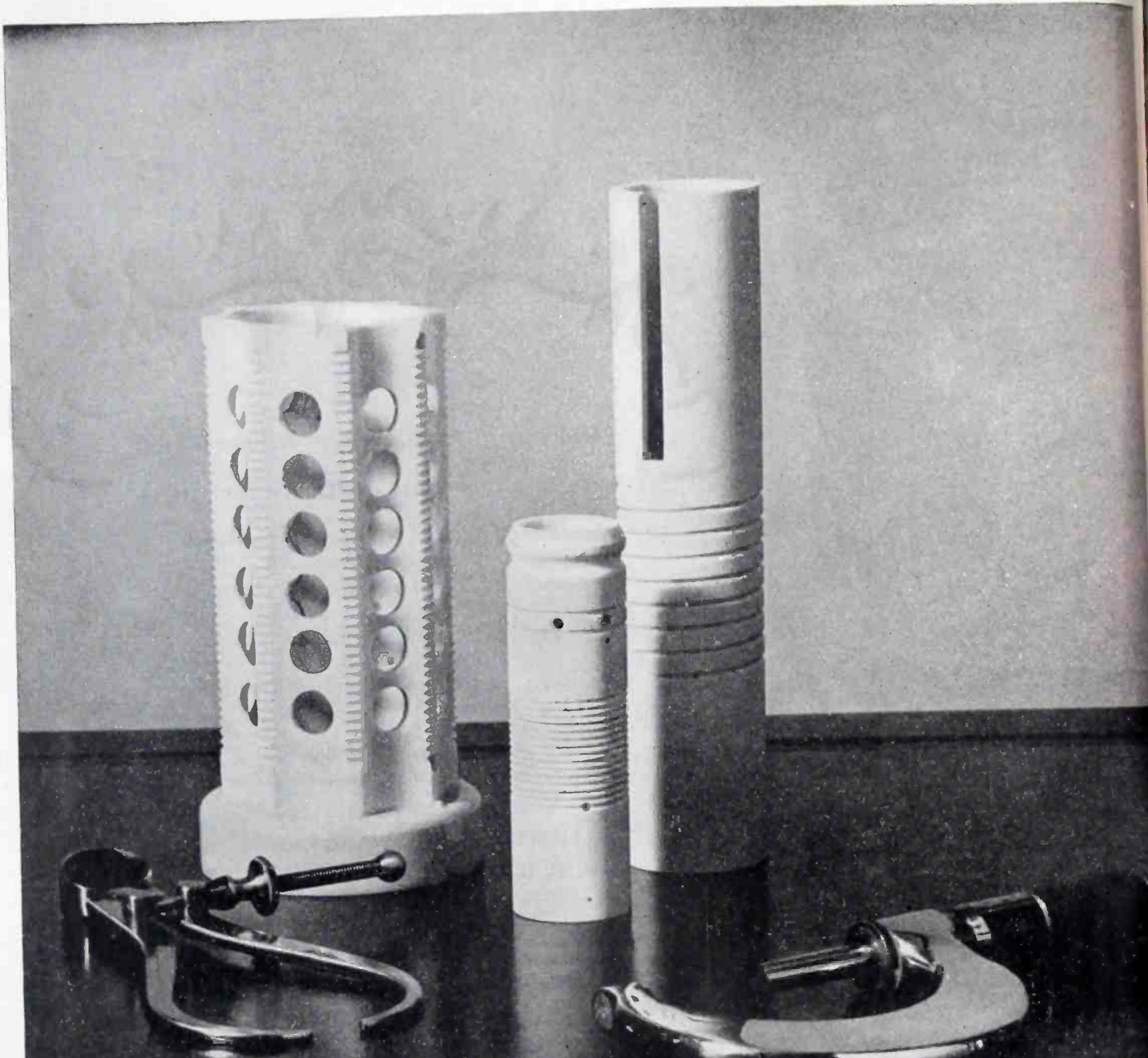
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ARMY E NAVY
Centralab
CRL
Division of GLOBE-UNION INC., Milwaukee

TURBO

. . . FOR HIGH FLASH POINT!

SATURATED SLEEVING

VARNISHED TUBING

This TURBO insulation sleeving copes with the wide divergency in operating conditions in present day applications. It embodies all the major essential factors responsible for above-par functional efficiency.

The ability of TURBO Saturated Sleeving and Varnished Oil Tubing, to protect circuits at all times, is corroborated by its great dielectric strength. Extreme resistance to heat is emphasized by its high flash characteristic.

The imperviousness of TURBO insulation tubing to moisture, alkalis, rot, corrosion, oils and acid fumes, assures dependability under all conditions. Inside impregnation and non-projecting properties add to its long, efficient service life, while smooth bore and uniform diameter assure rapid snaking and fishing when installing. Write for free specimen board and list of standard sizes today.

WIRE IDENTIFICATION MARKERS:

● The facilitating of production and assembling operations, with corresponding increases in functional efficiency, are effected with this TURBO insulation product. Available in any size, length or color, these TURBO markers are strictly in accord with Army, Navy and Air Corps.

VARNISHED GLASS TUBING: resistant to extremely high heat

● The extensive use of this TURBO product is directly attributable to its excellent characteristics under high heat conditions. Heavy duty operating conditions, confined areas where ventilation is minimized and other similar problems are solved

FLEXIBLE VARNISHED OIL TUBING:

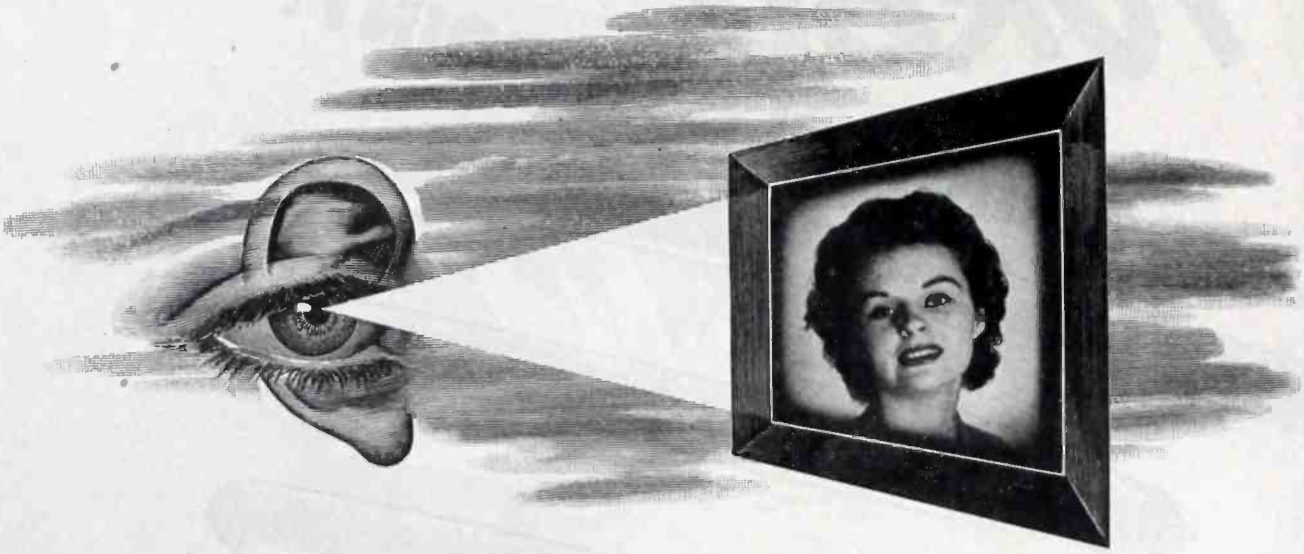
● This TURBO insulation meets the diversity of requirements necessary to stand up against general break-downs, impairment through moisture absorption, and the general deteriorating influences caused by acids, alkalis, etc.

EXTRUDED TUBING: resistant to sub-zero temperatures

● Where the effects of extreme low temperatures are apt to induce insulation embrittlement, TURBO Extruded Tubing is especially suited. Sudden climatic changes, wide fluctuations in temperature, or refrigerant operating conditions will not affect the dependability.

WILLIAM BRAND & CO.

276 FOURTH AVENUE, NEW YORK, N. Y.
325 W. HURON STREET, CHICAGO, ILL.



S + S = $

The dollar sign is the answer. It completes the well-used television formula S + S, or Sight plus Sound, and it's a rather dramatic way of saying that television will bring profit to you.

S + S = $ has been just a promise for a long time. But it's due to become a reality shortly after victory.

You're informed on television, of course, or you wouldn't be reading this publication. But is "being informed" enough? Isn't it high time for action... for constructive planning?

DuMont will fill this need for planning—with the DuMont Equipment Reservation Plan. There are other prospective telecasters in your area, so send for this plan. It contains cost estimates ...offers our arrangement for *reserving* and custom-building your transmitting set-up; for training your personnel.

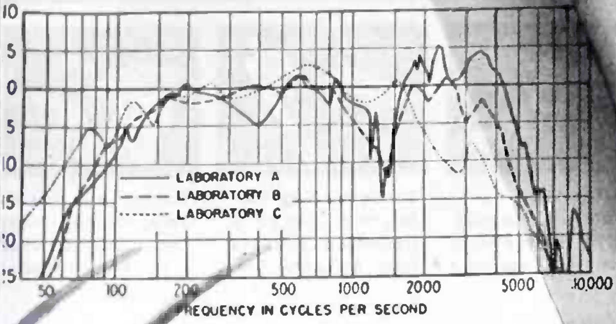
The demand for television time will soar after victory. There'll be a peacetime scramble to be "first with television," because S + S = $.

DuMont's extensive specialized experience in precision electronics, in television station construction and management is at your command...in the DuMont Equipment Reservation Plan.

DUMONT *Precision Electronics and Television*

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

The graph shows only one of the interesting points of discussion: "Frequency response curves of the same loud speaker as measured in three different laboratories."



How to judge Loud Speakers from Frequency Response Curves

For years we at Jensen have keenly felt the need of dependable and useful information to guide both the professional and the layman in their selection, purchase, installation and use f loud speakers. Now we are going to meet that need by a series of informative technical Monographs prepared by the Jensen Technical Service Department. ¶ The first Monograph in the series deals with one of the most interesting and controversial subjects in the field of acoustics, "LOUD SPEAKER FREQUENCY RESPONSE MEASUREMENTS." It discusses thoroughly the practical aspects of this subject in such a way that the material is unhesitatingly recommended to the whole profession: the engineer, the trade, the student, and even the layman. The first Monograph is ready now. Copies are available from Jensen jobbers and dealers everywhere, or fill out the coupon below and send it with 25c to

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Gentlemen:
I am interested in the monograph, "Loud Speaker Frequency Response Measurement." Enclosed is 25c for my copy.

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Watch for the rest of the series to be announced later. Other Monographs will deal with equally important and interesting subjects.

FREE to men in the Military Services, to Military Technical Training Centers, and to Technical Schools and Libraries. Just write and request a copy.

CLARE
TYPE "C" RELAY

. . . For Applications Where Rapid Opening and Closing of Circuits is Required.

★

FEATURES

1. Contacts are made from precious metals and alloys, such as silver, palladium, palladium-iridium, tungsten and elkonium. They can be furnished in sizes from .062" silver, rated at 1 ampere, 50 watts, to .1875" tungsten, rated at 4 amperes, 500 watts. Various types can be incorporated in one relay.

2. Pile-up assembly is locked together under hydraulic pressure. Projecting wafer insulators which provide creepage path of ¼" between contact springs can be furnished. The entire assembly withstands very heavy breakdown tests.

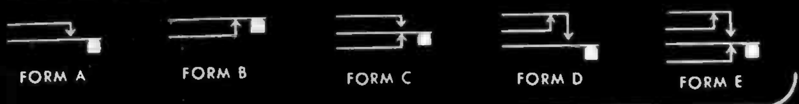
3. Heelpiece, coil core and armature assembly are of magnetic metal, carefully annealed. Where sensitivity and timing are important factors, a *special magnetic* metal is recommended to provide permeability.

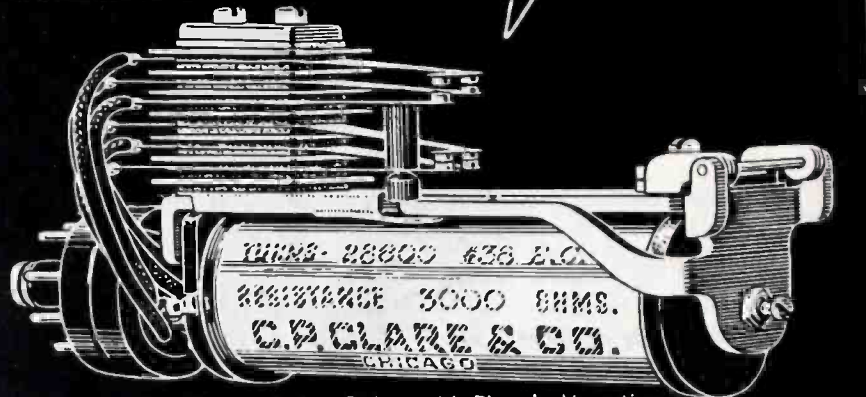
4. Spring bushing insulators of Bakelite rod give excellent service where heavy contact pressures are employed, where vibration exists, or heavy duty service is desired.

5. Coils are carefully wound to exact turns on precision machines. Lead out wires are securely soldered. Coils impregnated with special varnish are available. The coil is protected with a transparent acetate covering.

6. Relay illustrated is arranged for octal base plug mounting which makes for easy service and replacement. Other types of mounting, such as individual angle bracket, strip or panel can be furnished. Easy to handle slip-on Bakelite covers for individual mounting or metal covers for group mounting can be supplied.

Contact springs employing any of these forms can be furnished.

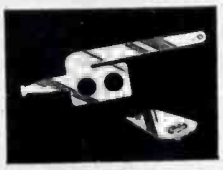




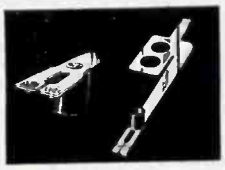
Clare Type C d. c. Relay with Plug-In Mounting

Data regarding turns and resistance appears on all coils—protected by transparent covering.

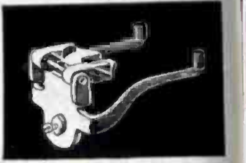
High voltage pile-up insulation withstands heavy break-down tests.



Contacts of rare metals and special alloys, welded to nickel silver springs.



Spring bushing insulators made by a patented process from Bakelite rod.



Double arm armature, stainless steel shaft in brass yoke can be furnished.

THE Clare Type "C" d.c. Relay is especially desirable for applications which require rapid opening and closing of circuits. It may be used for control of up to 12 circuits.

Special adjustment and special coil selection is necessary where operation of the relay involves limited coil current, extremely high speed operation, or other unusual requirements. In cases where unusually close operating limits are required, we recommend that complete data be submitted to Clare engineers.

Because of the wide range of contact arrangements possible with the Clare Type "C" Relay, Clare can "custom-build" you a relay that will most exactly fit your requirements. Standard spring assemblies may be equipped with any combination of the forms shown. Many different standard and special sizes of contacts may be provided.

So, whether your production problem involves sequence control of machine tools, electric eye controls, counting equipment, alarm systems, radio, radar or other electronic controls, it will pay you to know all about Clare "Custom-Built" Relays and what they can mean to you in the reduction of relay costs.

While the Type "C" is designed to be mounted in a horizontal position, it will operate satisfactorily in any position. Spring assemblies may be located on either the right or left hand side for convenience in mounting.

Let Clare engineers know your specific relay problem. Send for the Clare data book and catalog. Write to C. P. Clare and Co., 4719 Sunnyside Avenue, Chicago (30), Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

CLARE RELAYS

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

W. J. HALLIGAN, President,
Hallicrafters Radio . . .

Mr. Halligan says, "Those of us who are building radio communications equipment in this war anticipate a tremendous demand in the future for radios and radio telephones for plane to ground, ship to shore use, and many other applications."

"COMMUNICATIONS EQUIPMENT IS ONLY AS GOOD AS ITS POWER SUPPLY"

adio equipment needs an efficient, reliable power supply," continues Mr. Halligan,
nd for that reason, the radio industry is constantly on the alert for new and better
ver supplies and devices for adapting current for radio use. Such power supplies and
h devices are of inestimable value to the communications equipment manufacturer."

ctronic Laboratories has vibrator power supplies for use wherever current must
changed in voltage, frequency or type, or will engineer one to fit specific space,
ight and voltage requirements. E·L Vibrator Power Supplies offer many advan-
ges for all current conversion requirements up to 1500 watts as a result of devel-
ment in circuits and design pioneered and perfected by Electronic Laboratories.
L Power Supplies are definitely more efficient, and give substantially longer
vice life. In addition, they are highly versatile, permitting multiple inputs and
tputs, any needed wave-form, great flexibility in shape and size, and a high de-
ee of voltage regulation when needed. They are economical in price and require
nost no attention or maintenance. Their dependability is being demonstrated every-
y on the fighting fronts. E·L engineers offer consultation on power supply problems.

E-L STANDARD POWER SUPPLY MODEL 307

For the operation of standard 110 volt AC equipment, such as radios and small motors, from a 6 volt battery. Characteristics: Input voltage, 6 v. DC; Output voltage, 115 v. AC; Output power, 100 watts: Output frequency, 60 cycles.

Dimensions: 7½x8¼x10¾ in. *Weight:* 23½ pounds.

Write for further information of this and other models of the extensive E-L line.

Electronic LABORATORIES INC.
INDIANAPOLIS

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

NEW LETTER CONTEST for SERVICEMEN!

ELEVEN 1st PRIZE WINNERS IN 5 MONTHS IN CONTEST No. 1!

Yes sir, guys, the hundreds of letters received were so swell that *double* first prize winners had to be awarded each of the first four months and there were *triple* first prize winners the fifth and last month . . .

SO–HERE WE GO AGAIN!

Get in on this NEW letter contest—write and tell us your *first hand* experiences with *all* types of Radio Communications equipment built by Hallicrafters including the famous SCR-299!

RULES FOR THE CONTEST

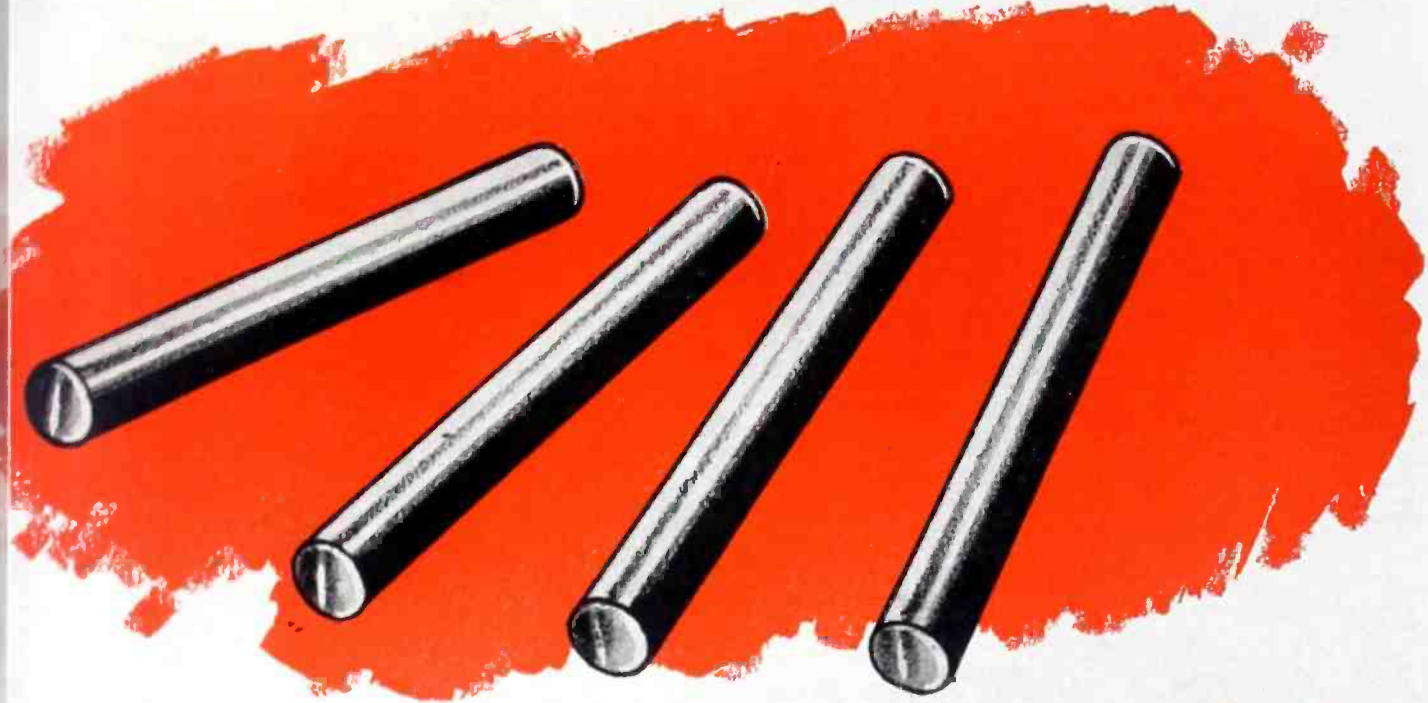
Hallicrafters will give $100.00 for the best letter received during each of the five months of April, May, June, July and August. (Deadline: Received by midnight, the last day of each month.) . . . For every serious letter received Hallicrafters will send $1.00 so even if you do not win a big prize your time will not be in vain. . . . Your letter will become the property of Hallicrafters and they will have the right to reproduce it in a Hallicrafters advertisement. Write as many letters as you wish. V-mail letters will do. . . . Military regulations prohibit the publication of winners' names and photos at present . . . monthly winners will be notified immediately upon judging.

BUY A WAR BOND TODAY!

hallicrafters RADIO

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT, CHICAGO 16, U. S. A.

HREE OF THESE PLASTICS OULD FAIL ON YOUR PRODUCT!



– do you know which one is right?

ly one of the above four widely known astic materials is suited to your product. he other three, while ideal for other uses, ght be costly failures to you. Creative uses four of these plastics — and many others. e have no interest in pushing any of them.

When you decide that you might like a astic material on your product, don't worry urself searching through lists of plastics anufacturers, and then trying to judge be- een materials. Instead, *call on Creative* and let an expert, with no particular material to sell, study your problem and advise you which type of plastic, *if any*, will do your job best.

What is more, you may be pleasantly surprised to learn that your product can be produced by us without the cost and delays of molds. Possibly the very item that you want is carried in our stock for immediate delivery.

In any case, get the habit of applying our "know-how" . . . Call on Creative

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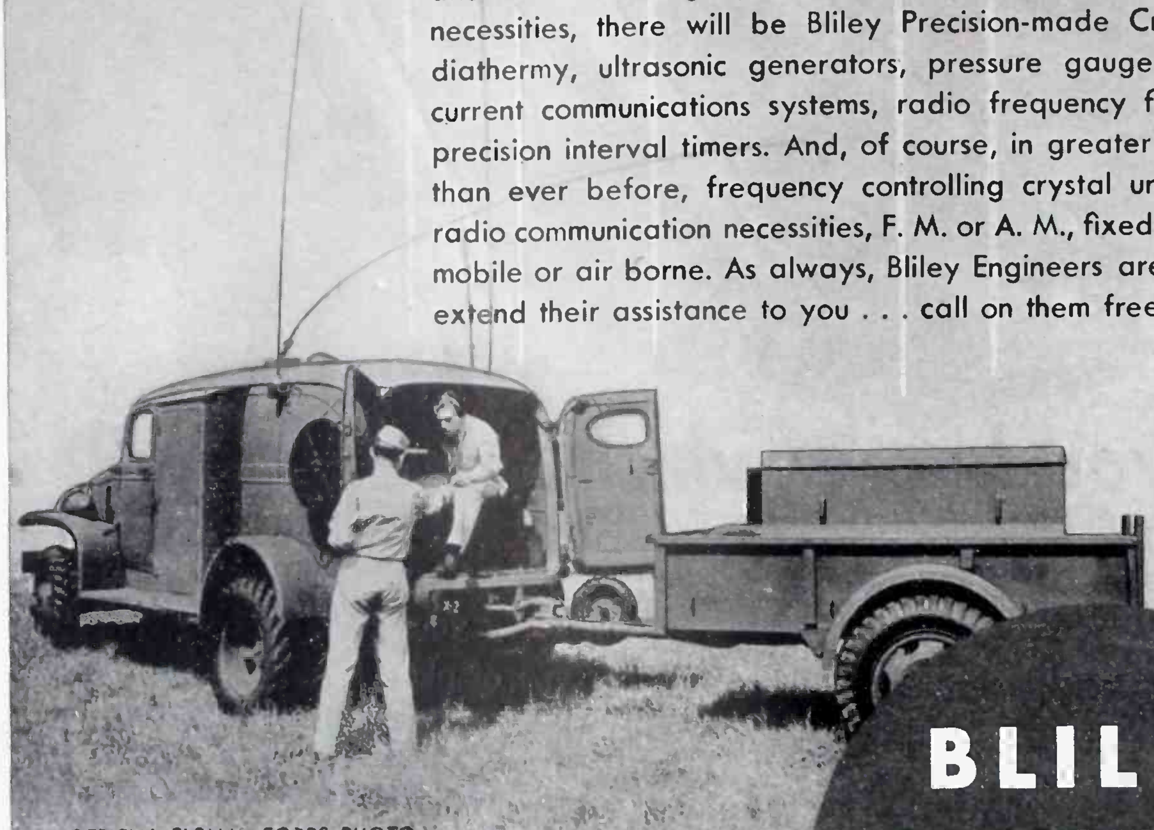
CP PLASTICS CORP.

978 KENT AVE, BROOKLYN 5, NEW YORK

Standard of Excellence

Bliley Crystal Units are doing a great wartime job. Increased engineering knowledge, expanded facilities, and improved production techniques have emerged from this effort. This wartime experience will be reflected in peacetime application.

Bliley Crystals will again take their rightful place with their pre-war record of dependability, accuracy and user acceptance. Not counting applications covered by wartime secrecy necessities, there will be Bliley Precision-made Crystals for diathermy, ultrasonic generators, pressure gauges, carrier-current communications systems, radio frequency filters, and precision interval timers. And, of course, in greater quantities than ever before, frequency controlling crystal units for all radio communication necessities, F. M. or A. M., fixed, portable, mobile or air borne. As always, Bliley Engineers are ready to extend their assistance to you . . . call on them freely.



OFFICIAL SIGNAL CORPS PHOTO
SCR-299 MOBILE RADIO STATION

BLILEY CRYSTALS
Accurate
Dependable

BLILEY ELECTRIC COMPANY - - - ERIE, PA.

Bliley Crystals


MPHENOL -
FRIEND OF YESTERDAY'S "HAMS"...
...Now Radar Radio Experts
Depend upon
AMPHENOL
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Connectors
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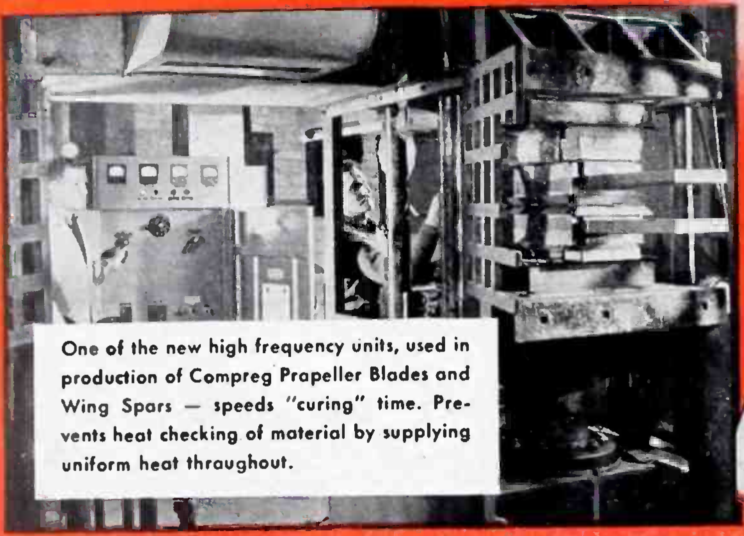
Cable
Radio Parts
Synthetics
AMERICAN PHENOLIC CORPORATION
1830 S. 54th Avenue, Chicago 50, Illinois

Electronic Heating Increases Use and Extends Applications of PANELYTE* COMPREG

PANELYTE Compreg Propeller Blades — rotary cut veneer impregnated with phenol-formaldehyde. It possesses extremely high tensile, compressive and flexural strength. Carving is done by Engineering Research, Riverdale, Md.



One of the new high frequency units, used in production of Compreg Propeller Blades and Wing Spars — speeds "curing" time. Prevents heat checking of material by supplying uniform heat throughout.

This popular R.C.A. advertisement featured electronic heating apparatus used in manufacture of Compreg.

*Mass production of sheets, rods, tubes, molded forms and fabricated parts in paper, fabric, wood veneer, fibre glass and asbestos base thermo-setting plastics.

This laminated resinous plastic with wood veneer base is superior to wood in dimensional stability, strength uniformity and resistance to moisture and decay. Panelyte Compreg is superior to light alloys in weight saving and resistance to fatigue failure, erosion and corrosion.

"Gluing by radio waves" cuts "curing" time from hours to minutes — saving production time and costs.

Compreg is preeminently suited to all structural beam applications, within sizes available in the material. Compreg's early use in circuit breaker rods indicates its adaptability in electrical design. Compreg is also a good heat insulating material, and this, coupled with its high strength, makes it ideal for supports in magazines and cold storage units in ships. It prevents heat conduction from deck plates and bulkheads, which occurred when steel supports were used.

Samples and full technical data immediately available.

PANELYTE *the structural plastic*

PANELYTE DIVISION
ST. REGIS PAPER COMPANY
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NEW YORK 17, N. Y.

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

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

Towers that Talk!

American Airlines Photo

VASHINGTON NATIONAL AIRPORT

he nation's own, at the Capitol City—Operated by CAA.

Delta Airlines Photo

NEW ORLEANS AIRPORT

Modern airport terminal at the Crescent City—an architectural gem.

American Airlines Photo

LOUISVILLE'S BOWMAN FIELD

Pride of the Blue Grass State.

Braniff Airways Photo

HOUSTON MUNICIPAL AIRPORT

ateway to Mexico and Central America.

Delta Air Lines Photo

ATLANTA MUNICIPAL AIRPORT

Serving the metropolis of Southeastern U.S.

American Airlines Photo

LA GUARDIA AIRPORT, NEW YORK

One of the world's largest and busiest airports.

Sentinels of the Sky

• • • the control towers of the nation's airports that stand guard night and day. Each safe arrival and departure at these busy terminals rests on the vigilance of their skilled staffs and the reliability of their radio equipment. Each must function with never failing dependability—in peace as in war.

Radio Receptor airport traffic control radio equipment, examples of which are to be found throughout the nation in leading civil airports, and around the world in army airfields, is noted for its rugged construction and reliability in operation.

Specify **Radio Receptor** radio equipment for your airport and you may rest assured that your equipment will be equal to the best.

It is not too early to plan for that postwar airport for your municipality. Let **Radio Receptor** aid you. Send for our Airport Radio Questionnaire—no obligation.

Highways of the Air—a review of fact and opinion on the importance of radio in aviation—sent on request to those interested in airport design, construction and operation.

COOPERATION OF ARCHITECTS, CONSULTANTS AND CONTRACTORS INVITED

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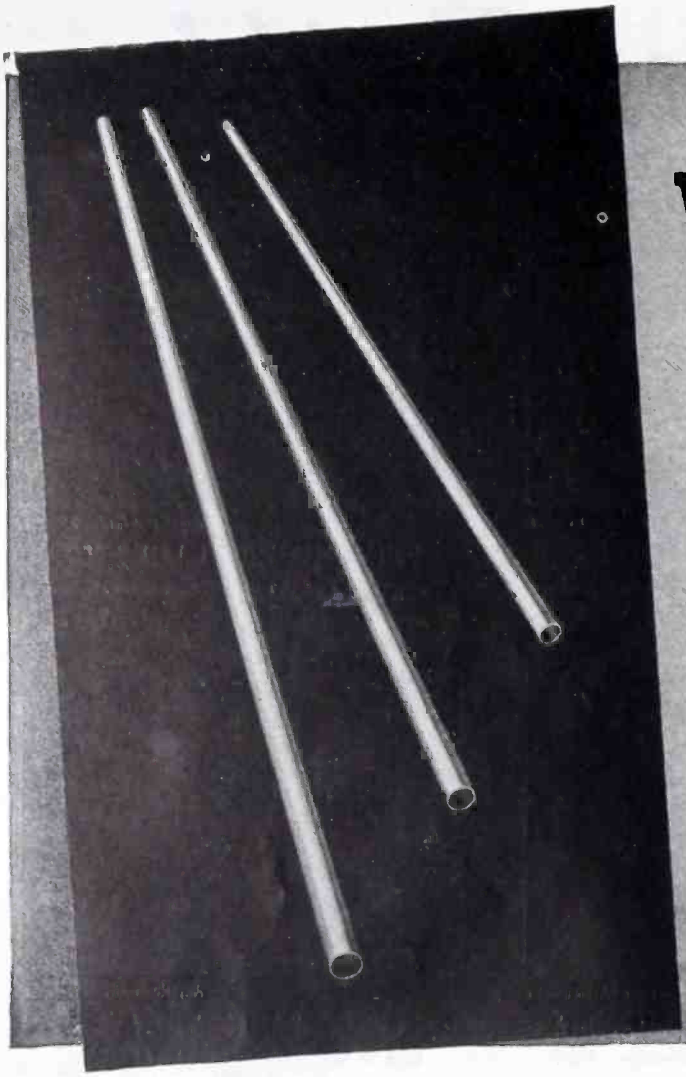
Engineers and Manufacturers of Airway and Airport Radio Equipment • Communications Equipment • Industrial Electronics • Electronic Heating Equipment

SINCE 1922 IN RADIO AND ELECTRONICS



WILCO ANNOUNCES

Larger Plant

New Equipment

Increased Facilities

for producing

TUBING

The demand for Wilco tubing, wire and other products used in various electronic applications for the Army and Navy has caused the H. A. Wilson Company to increase its manufacturing facilities and develop new products and techniques. Both present and future customers will find these new Wilco developments of great advantage.

The H. A. Wilson Company manufactures and is interested in receiving inquiries regarding the following products—

WILCO RADIO TUBING

Silver Tubing (Fine, Coin, Sterling)
Gold Tubing (any karat)
Gold on silver (on one or both sides)
Gold on bronze (on one or both sides)
Silver on copper (on one or both sides)
Tubing made to order from special materials or any combination of materials.

WILCO RADIO WIRE

Silver (Fine, Coin, Sterling)
Silver-jacketed Invar
Silver-jacketed Brass and Bronze
Silver-jacketed Copper
Gold Wire
Gold on silver
Gold-jacketed Bronze and Brass
Any other type of jacketed wire desired

Let us analyze your problems. Write

THE H. A. WILSON COMPANY

105 Chestnut Street, Newark 5, N. J.
Branches: Detroit • Chicago

Centralab

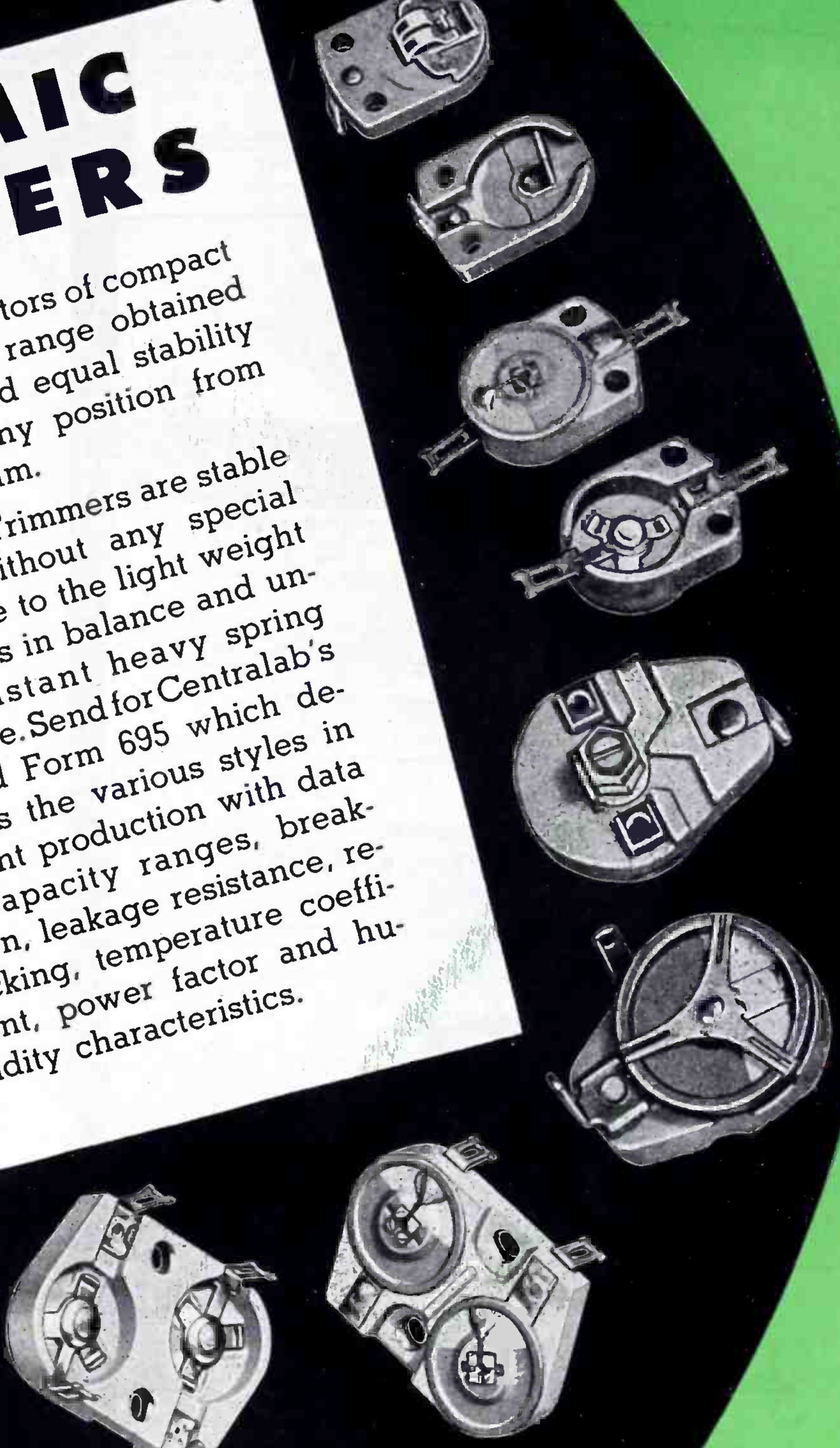
CRL

CERAMIC TRIMMERS

Here are trimmer capacitors of compact size . . . full capacity range obtained with 180° rotation, and equal stability . . . maintained at any position from minimum to maximum.

Centralab Ceramic Trimmers are stable under vibration without any special locking device, due to the light weight rotor that is always in balance and under constant heavy spring pressure. Send for Centralab's revised Form 695 which describes the various styles in current production with data on capacity ranges, breakdown, leakage resistance, retracking, temperature coefficient, power factor and humidity characteristics.

CENTRALAB'S CERAMIC TRIMMERS are easily adjusted by means of a screw driver.



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Division of GLOBE-UNION INC., Milwaukee

Producers of Variable Resistors • Selector Switches • Ceramic Capacitors, Fixed and Variable • Steatite Insulators.

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Meet our 9 best salesmen for Pyrex Metallized Bushings

WE could never pay these "salesmen" what they're worth! For it's companies like these who have discovered for you all the savings that Pyrex metallized bushings can bring. This unique method features a metallized layer that solders easily yet gives you a positive seal against leakage of oil, water, or air. With fewer parts and operations you save time and money on assembly. Best of all, Corning type metallizing can be applied to a wide range of glasses offering extreme resistance to thermal, mechanical, or electrical shock as needed.

This new metallizing method is just one of many ways Corning Research in Glass can help you. Let us send you full details of hermetic metallizing on glass plus a new booklet, "There Will Be More Glass Parts in Post-war Electrical Products." Write Electronic Sales Department E-8 Bulb and Tubing Division, Corning Glas Works, Corning, N.Y.

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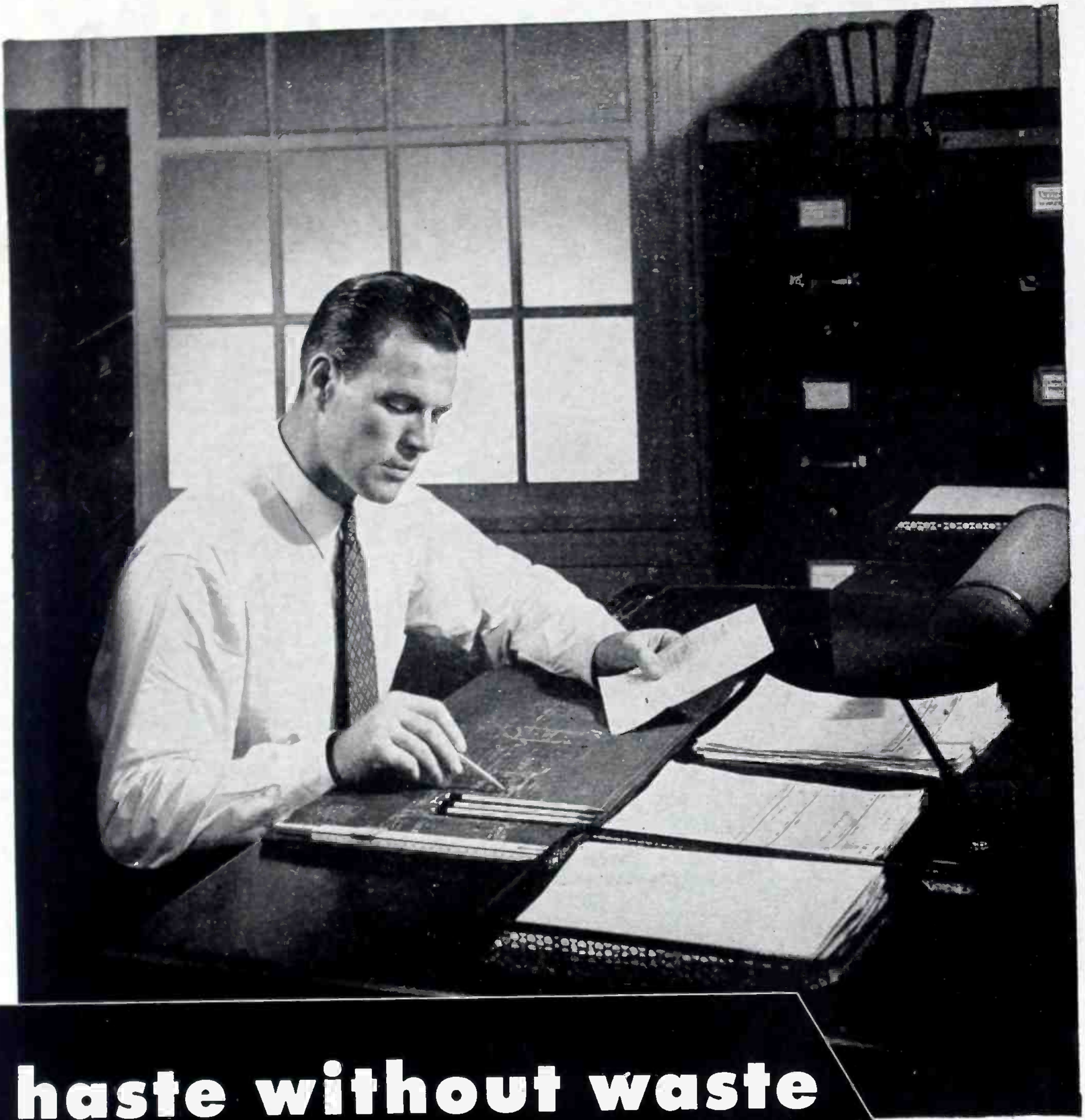

haste without waste

The electronic engineer has been doing a tremendous job. The increasing importance of advanced electronic equipment in modern warfare has multiplied his task a hundredfold. But, the special training and vitally important knowledge of the electronic engineer enables him to tackle each day's job regardless of its magnitude and get it out of the way. The electronic engineer is living proof that *haste without waste* is possible.

Advanced electronic tubes and equipment are playing a role of immeasurable importance in the Allied Nations' drive for Victory. When the war ends, the results of Raytheon's intensive research and manufacturing experience will be utilized to meet advanced electronic tube requirements.

ARMY-NAVY "E" WITH STARS
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Raytheon Manufacturing Company
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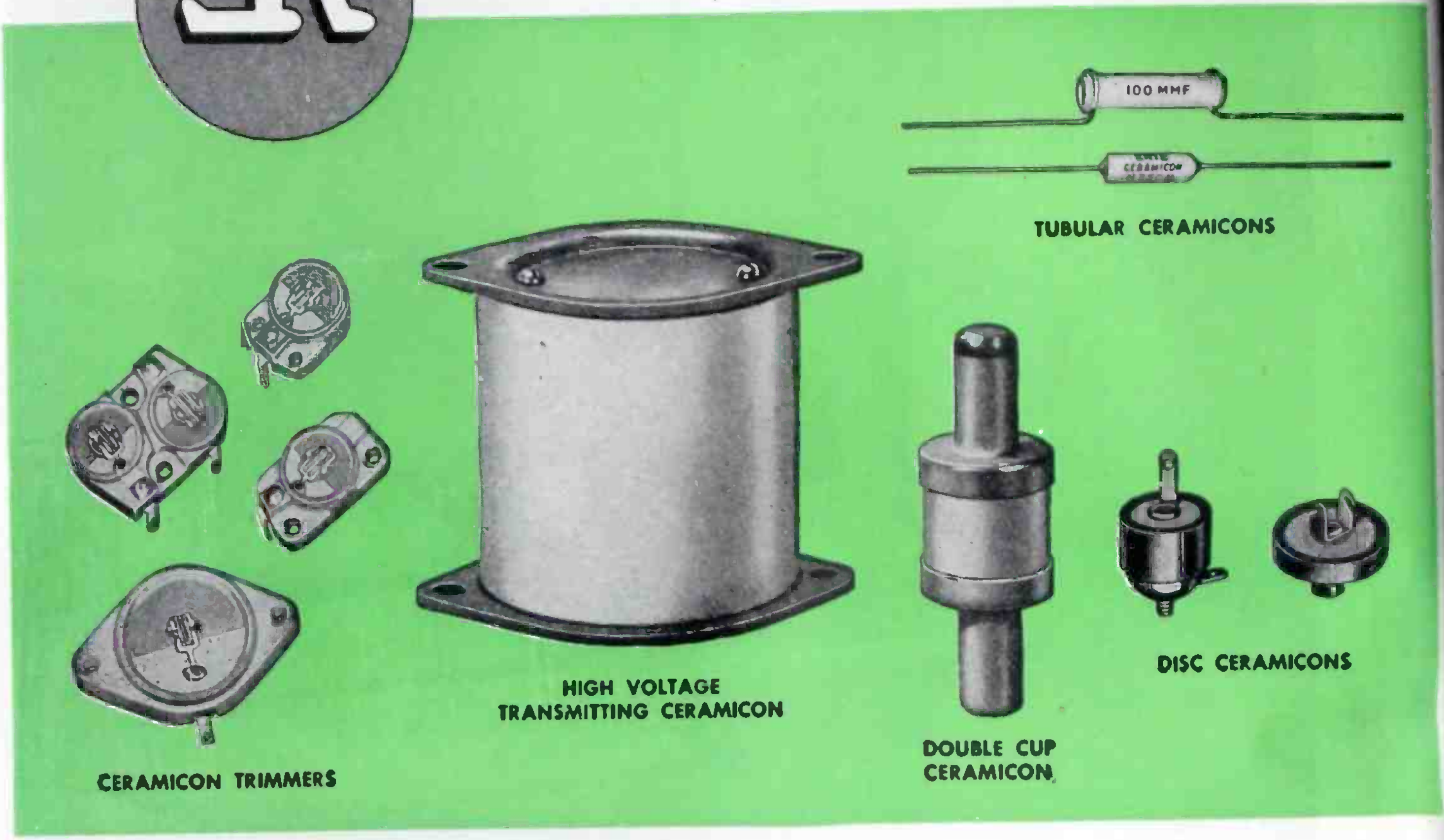
DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES AND EQUIPMENT FOR THE NEW ERA OF ELECTRONICS

FIRSTS in Ceramic Condenser Design

by Erie Resistor



HERE are illustrated five types of ceramic condensers that are playing a vital part in today's wartime electronic apparatus and that will greatly effect the functioning of future electronics. Each is built around a basic design first created by Erie Resistor.

The first silver-ceramic condenser made in this country was an insulated tubular unit designed and produced by Erie Resistor over seven years ago. These popular temperature-compensating Ceramicons have fully proved themselves under severe wartime conditions. A few years later Erie Ceramicon Trimmers gave the U. S. radio industry an entirely new type of padder with hitherto unobtainable characteristics.

For obtaining relative high capacities in compact, low-loss units for high frequency applications, Erie Resistor engineers originated disc-type Ceramicons.

The original Erie double-cup design for high voltage applications has overcome many problems that formerly limited the expansion of ceramic condensers for high voltage, high KVA applications.

Large, high voltage transmitting condensers are now a reality with the characteristic stability of silvered ceramic construction, thanks to another pioneering Erie Resistor Ceramicon design.

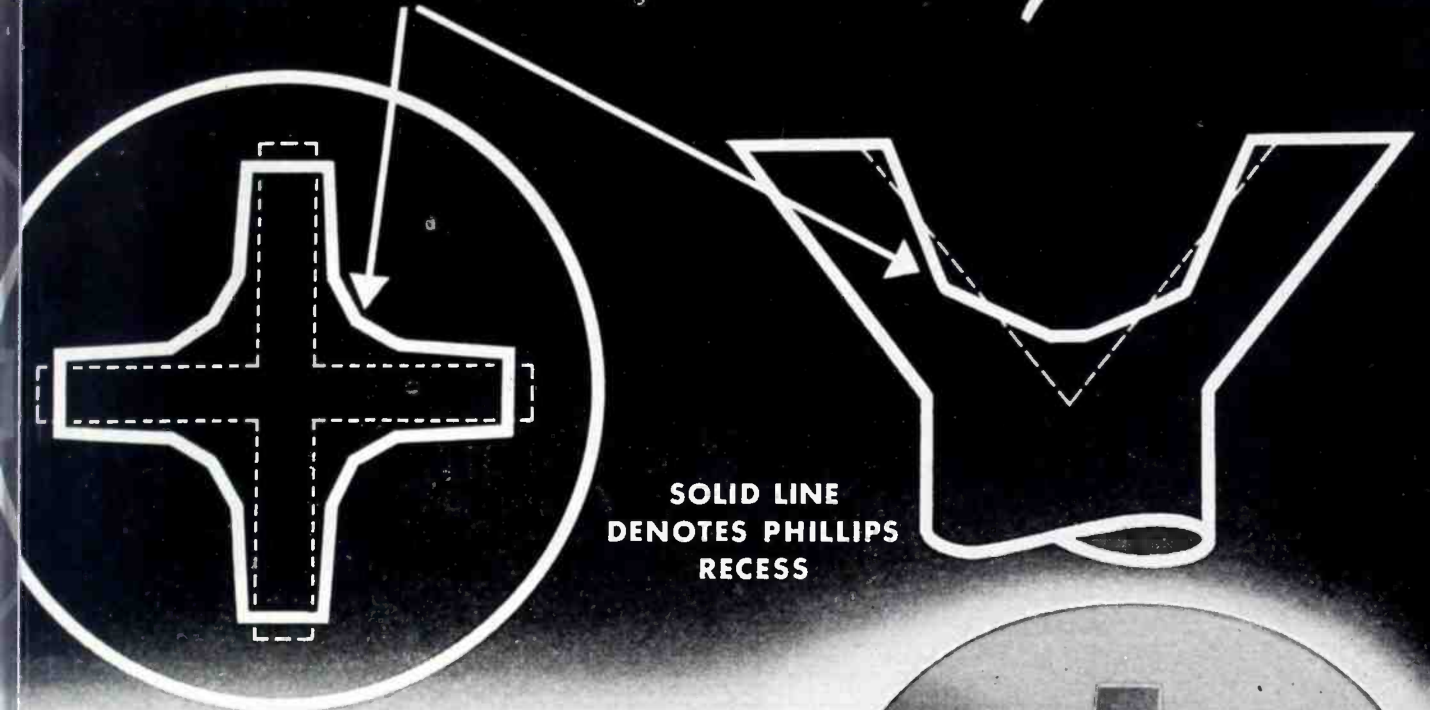
We believe that existing Erie Ceramicons, and other Erie Ceramicon designs to come from our development laboratory in the future will play an important part in the progress of the electronic industry.

ARMY E NAVY
FOR HIGH ACHIEVEMENT IN WAR PRODUCTION

Back The Attack—With War Bonds

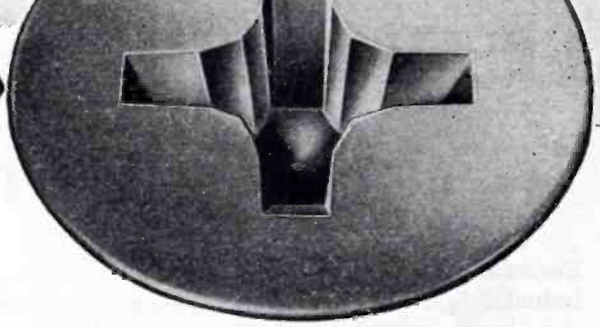
ERIE RESISTOR CORP., ERIE, PA. LONDON, ENGLAND · TORONTO, CANADA.

NLY ONE *Recessed Head Screw*
as these 2 *Trouble-Saving Features...*



SOLID LINE
DENOTES PHILLIPS
RECESS

PHILLIPS.. *the Engineered Recess*



eft-hand drawing shows how scientifically the center corners of
llips Recess are *engineered.* Instead of being squared, these
re *rounded* in a series of flat planes, with every angle and every
on making a definite contribution to driving efficiency.
makes it possible for workers to utilize full turning power –
danger of burring or reaming out the heads of Phillips Screws.
examine the right-hand drawing. This shows *more* scientific
ring. Instead of being tapered to a sharp point that would
the screw shank, the Phillips Recess has a nearly flat bottom.
makes it possible to set screws up uniformly tight without fear
heads shearing off. The flat bottom also permitted design of a
, longer-lasting driver point.
the *Phillips* Recess is engineered this way. Only when you
screws with the Phillips Recessed Head can you get the freedom
ouble . . . the strength and driving speed these features make
. You can get Phillips Recessed Head Screws in any head style,
size.

TO MAKE WARTIME QUOTAS AND PEACETIME PROFITS-- USE PHILLIPS SCREWS AND DRIVERS

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

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

Easier Driving: Able to utilize their full turning power, workers can maintain speed without tiring.

PHILLIPS *Recessed Head* SCREWS

SCREWS · MACHINE SCREWS · SELF-TAPPING SCREWS · STOVE BOLTS

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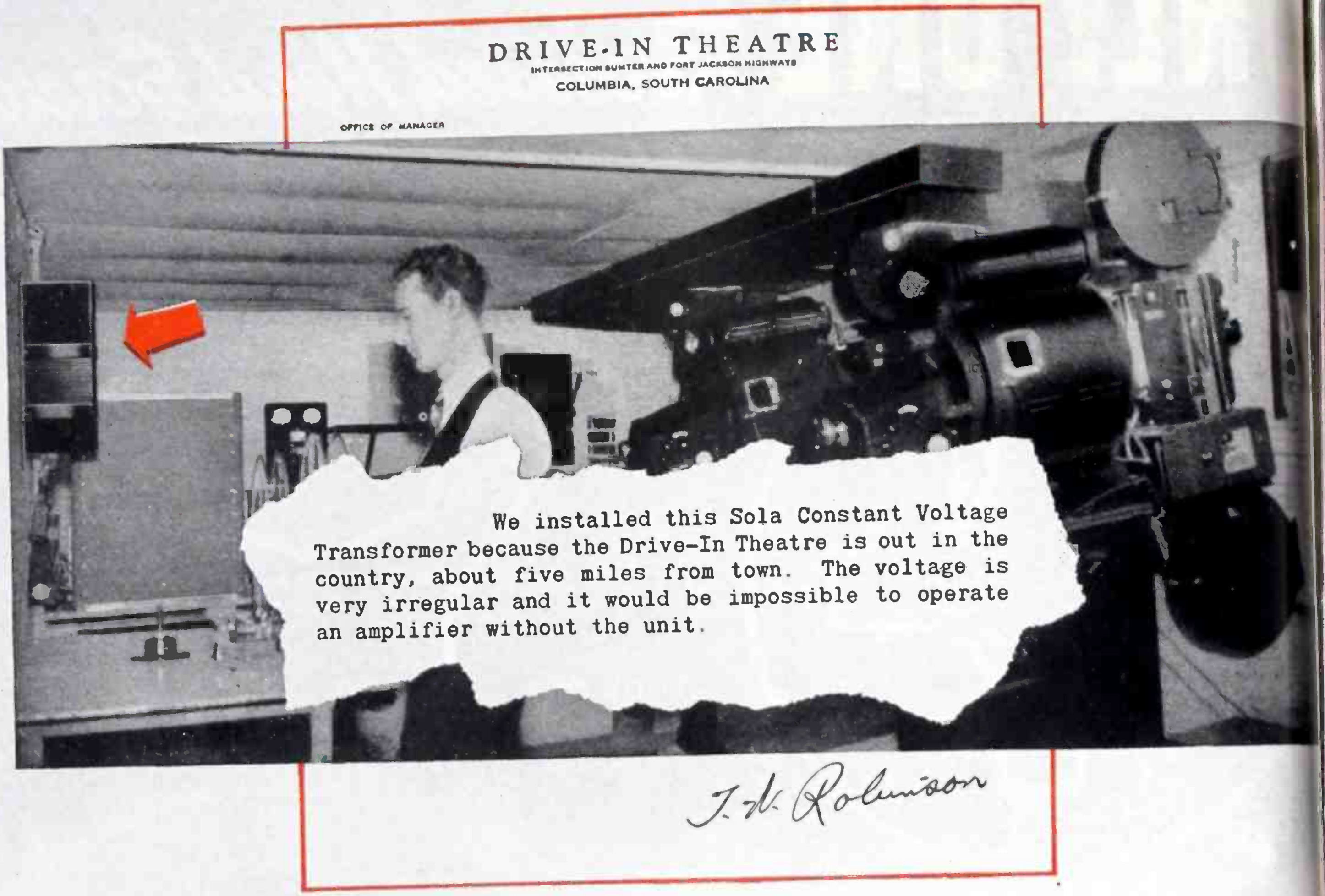
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
General Screw Mfg. Co., Chicago, Ill.
The H. M. Harper Co., Chicago, Ill.

International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
Manufacturers Screw Products, Chicago, Ill.
Milford Rivet and Machine Co., Milford, Conn.
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.

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.
Wolverine Bolt Co., Detroit, Mich.



DRIVE-IN THEATRE
INTERSECTION SUMTER AND FORT JACKSON HIGHWAYS
COLUMBIA, SOUTH CAROLINA

OFFICE OF MANAGER

We installed this Sola Constant Voltage Transformer because the Drive-In Theatre is out in the country, about five miles from town. The voltage is very irregular and it would be impossible to operate an amplifier without the unit.

J. H. Robinson

GREATER FIDELITY in sound projection is accomplished with built-in CONSTANT VOLTAGE

Because of the heavy demands for industrial power, stable voltages are practically non-existant on America's power lines.

These fluctuating voltages are noticeable in the operation of anything electrical. But where they affect the greatest part of the American public is in the operation of sound and communication equipment.

Even before Pearl Harbor the Drive-In Theatre of Columbia, South Carolina found it impossible to operate its amplifying system with the irregular voltages available from its power source. Only through the installation of a SOLA Constant Voltage Transformer were they able to correct this situation and deliver an acceptable performance to their public. Many other theatres have followed this example.

The lessons learned before Pearl Harbor, and greatly amplified by the increased tempo of industrial production, will contribute towards the future enjoyment of entertainment and communication facilities.

But SOLA Constant Voltage Transformers are now at war and further improvements in theatre entertainment must wait until the guns are stilled. SOLA Constant Voltage Transformers are figuring prominently in blue prints of the post-war world.

When victory is complete SOLA Constant Voltage Transformers wil be available as a built-in part of motion picture and sound projection equipment, they will add to you enjoyment of FM and television, they will transmit your voice wit greater clarity to distant parts o the globe, they will guide you safel through the air, and in hundreds o other ways contribute to the usefulness of all things electrical.

Custom-made units can be designed to exact specifications. Standard units are available in capacities from 10VA to 15KVA.

To Manufacturers:

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

Ask for Bulletin DCV-74

SOLA Constant Voltage Transformers

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

Uniform, Synchronous Speed at Every Station

Teletype Machine powered with a Holtzer-Cabot motor

Electric motors driving the intricate mechanisms of machines that transmit and record messages verbatim must have identical operating characteristics at every station. Since standard "off-the-shelf" motors cannot meet the strict performance requirements, such as uniform, synchronous speed, quietness, load cycles, etc., the solution is a special motor designed to exactly meet the particular operating conditions.

For over 50 years Holtzer-Cabot has designed and built special motors to fit the application. Many machines such as teletype machines, and other sending and receiving equipment are Holtzer-Cabot powered.

Although, today, all of our plant facilities are being utilized for building special fractional H.P. motors for military use, our motor development engineers will gladly discuss your post-war motor requirements with you. No obligation of course.

SPECIAL MOTORS DESIGNED TO FIT THE APPLICATION

HOLTZER-CABOT

Division First Industrial Corporation

Designers and Builders of Special Fractional HP Motors and Electrical Apparatus

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MOVING COIL ASSEMBLY
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- *Aircraft type bracket as well as aircraft type jewels and pivots; ruggedly built; unaffected by vibration or humidity and temperature extremes*
- *Specially built apparatus winds the armature on a precision coil form; the number of turns and the internal resistance of the armature are held to close tolerances*
- *Low resistance bronze torque springs are adjusted and tested before assembly; high torque to weight ratio; damping factor as prescribed by American Standard Association war standards*
- *Pivots are microscopically inspected before assembly; balance weights, made of selected beryllium copper wire, are permanently fixed in place*
- *DeJur Meters are characterized by their ruggedness, close tolerances, and highest quality materials*

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MANUFACTURERS OF DeJUR METERS, RHEOSTATS, POTENTIOMETERS AND OTHER PRECISION ELECTRONIC COMPONENTS
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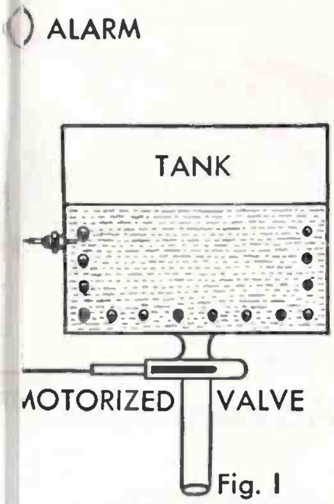


Fig. 1

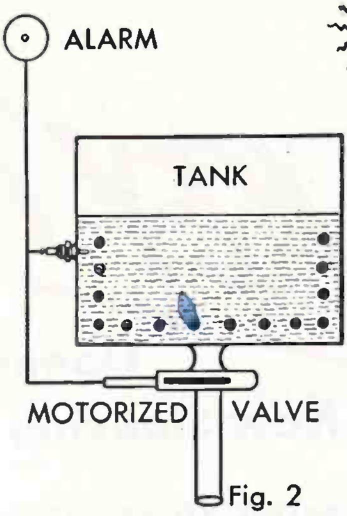


Fig. 2

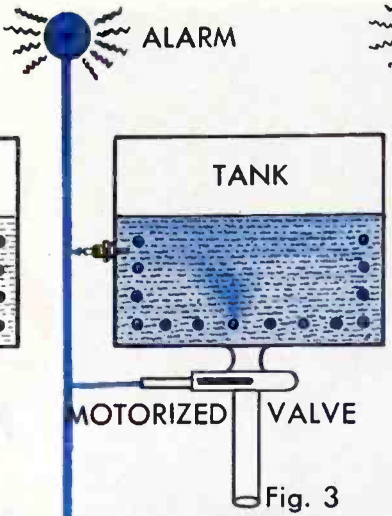


Fig. 3

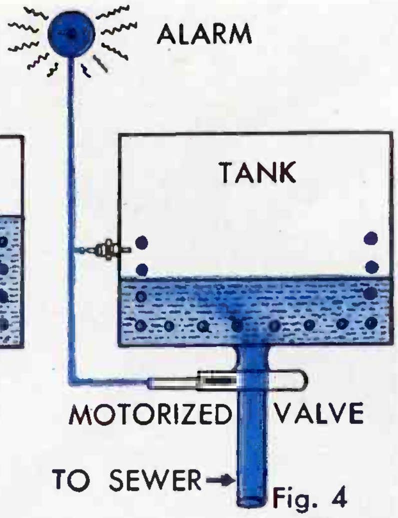
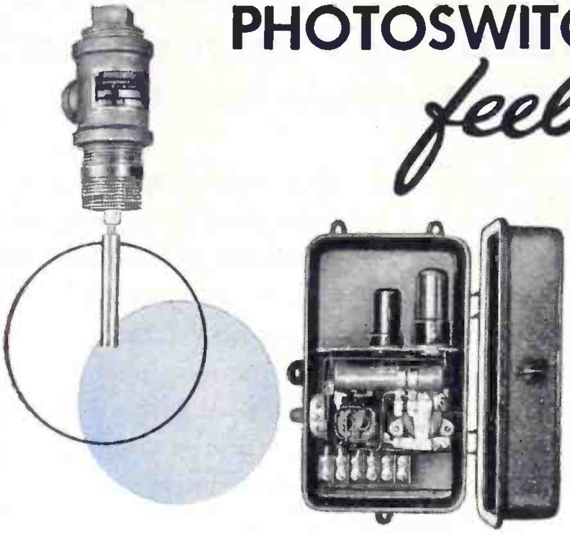


Fig. 4

PHOTOSWITCH CONCENTRATE CONTROLS *feel* LIQUID MIXTURE CHANGES *Electronically*



Photoswitch Concentrate Controls — electronic teammates of Photoswitch Level Controls — check liquid mixtures, detect changes and contamination, and act *instantly* to sound alarms, operate signal lights, start pumps, open or close valves . . . as required.

☆ ☆ ☆

ow Photoswitch Detects ontaminated Condensate

1. This tank contains hot condensate water, used heat coils through which flows an electrolyte con- ing acids. Photoswitch Concentrate Control P25N, n horizontal probe fitting permanently installed in the k wall, guards against contamination of the conden- by the acid, should a leak develop in the coils.

2. A leak develops in the electrolyte coils.

3. Concentration of acid leaking into the conden- has reached the critical low solution point at which highly sensitive Photoswitch Electronic Control is de- ed to operate. A microcurrent passes through the id at the probe, and is amplified by the Photoswitch trol to operate a signal and a three-way, motorized e which cuts off flow of condensate from the tank to boilers, and dumps the contaminated water into the er.

4. Exhaust valve empties tank so that coil leak be repaired.

The installation pictured here is used in a large smelting plant for automatic detection and control of contamination in hot condensate, used to heat coils through which an acid electrolyte flows. Coil leaks permit the acids to mix with the condensate, rendering it unfit for use in the boilers. Electronic detection and automatic control provide the surest, simplest and most economical solution of the problem.

This is another example of the electronic versatility and economy of Photoswitch Level Controls for liquids and powders. Their magic fingers are also handling single level indication and control, on and off pump control at two levels, or boiler feedwater control in thousands of plants and industries throughout the country. They are *floatless, efficient, maintenance-free,* and have no moving parts to wear out.

Write today for Bulletin 1100.

☆ ☆ ☆

Photoswitch Incorporated also manufactures photoelectric and electronic equipment for Turbidity Control, Smoke Density Indication, Counting, Automatic Inspection, Conveyor Control, Machinery Safeguards, Property Protection, and similar industrial applications.

L-2

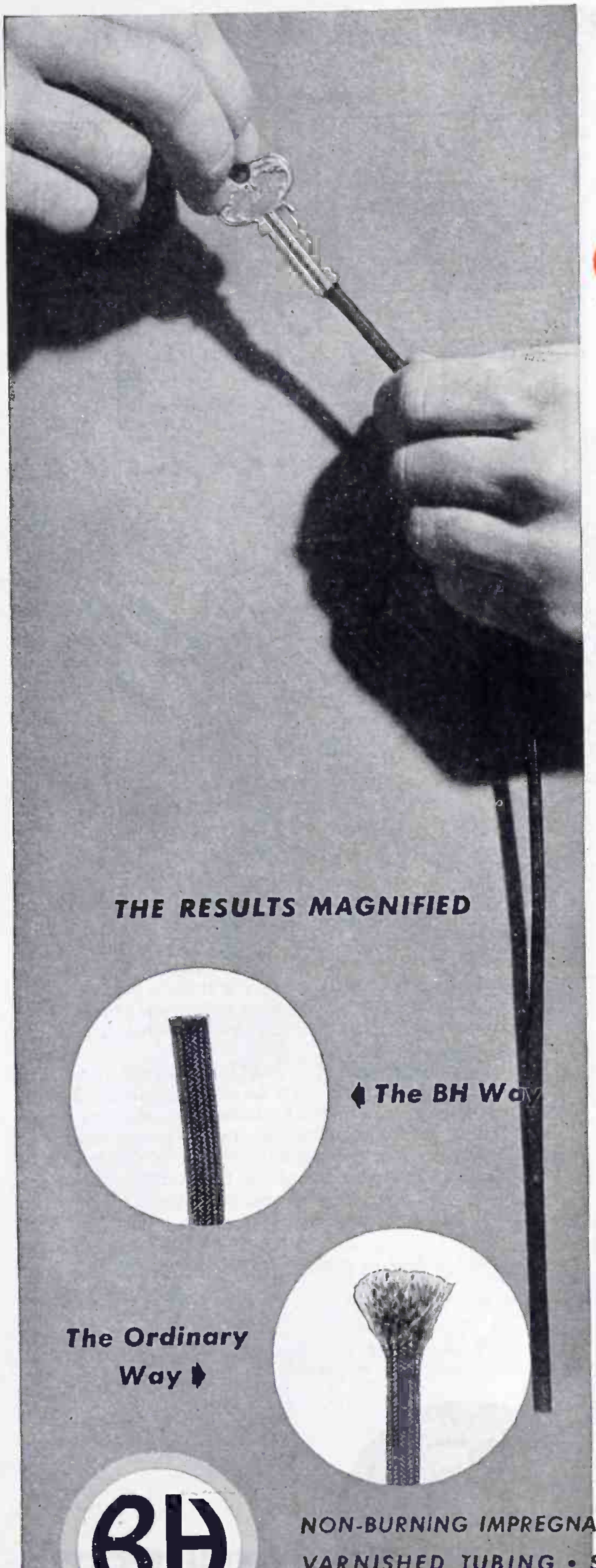
Electronic

EVEL CONTROLS

OTOELECTRIC AND ELECTRONIC CONTROLS
FOR EVERY INDUSTRIAL PURPOSE

PHOTOSWITCH
INCORPORATED

CAMBRIDGE 42, MASSACHUSETTS
District Offices in All Principal Cities



KEY TEST

Opens Up New Sleeving Advantages

PROVE TO YOURSELF THE NON-FRAYING, FLEXIBLE QUALITIES OF BH *EXTRA FLEX* FIBERGLAS SLEEVING

MAKE THIS simple test right at your desk and you'll see that here at last is a truly non-fraying, flexible sleeving. Just take a length of BH *Extra Flexible* Fiberglas Sleeving and jam an ordinary key into one end. Turn it around and push it up and down in the sleeving. Notice how the sleeving spreads but doesn't fray. Now do the same with a similar size piece of your present saturated sleeving. It breaks and frays. Further abuse unravels it. But BH Sleeving stands up under rough handling and severe service alike.

BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

NON-FRAYING • FLEXIBLE • HEAT-RESISTANT • NON-INFLAMMABLE • WATER-RESISTANT • VERMIN-PROOF NON-DETERIORATING • HIGH DIELECTRIC AND YARN STRENGTH • NON-CRYSTALLIZING at LOW TEMPERATURES

BH Sleeving is woven from choicest continuous-filament Fiberglas yarns and treated by an exclusive BH process that gives it stamina and pliability. Natural properties of Fiberglas as an insulator are virtually unequalled. So why be content with any less efficient sleeving? You'll want to try the BH test yourself. BH Sleeving is available in all sizes from No. 20 to 5/8", inclusive. Write for samples of specific sizes *today* and be convinced. 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.

THE NATIONAL DEBT—
and Your Postwar Job

Coming upon the heels of a ruinous ten-year depression, this war has once more made it clear to us that the strength of our country depends upon our ability and willingness to produce. Until the world conflict eclipsed the depression, we saw what failure to use our productive capacity can do — even to a country potentially as rich as ours.

The stark reality of war finally shocked us out of our economic lethargy. The necessity of supplying our Armed Forces with almost unlimited quantities of goods unleashed our inventive genius and revealed to us our real capacity to produce. It indicated what our standard of living might be if, in time of peace, we used our full productive capacity.

Today we are producing more than all the other nations combined, half again as much as in 1940. Today our production is insuring victory to our fighting men.

But what of the future?

Already our national debt has reached astronomical proportions, and it is going higher. The depression years' fear of insecurity that all but paralyzed our spirit of enterprise, our inventive genius, and our natural instinct for expansion, appears likely to return promptly if industrial activity again is curtailed for long because of unwise public policies.

This war is being fought to make men free. But our economy cannot be kept free through military conquest alone. There is another responsibility which we on the home front cannot avoid any more than we can build walls around our future. That is the problem created by our frightening public debt.

This is a two hundred billion dollar war. It affects the lives of every one of us. At the end of this war, the public debt of the United States will be at least ten times the twenty-five billion dollars that it was at the end of the first World War. It will be almost twice the present annual national income of the country. The interest charge alone will be about 4 per cent of the national income. If the burden were spread evenly, interest alone would take at least $80.00 of every worker's income per year, or approximately $1.60 out of each and every weekly pay check.

Some people fear that the heavy taxes required by the debt will keep the country poor by obstructing employment and limiting the output of goods.

Others believe that the size of the debt does not matter because we owe it to ourselves. They reason that if A is taxed $100 to pay $100 interest to B, A has $100 less to spend and B has $100 more, but both together have the same amount. They, therefore, hold that the demand for goods and the volume of employment remain unchanged.

Which view is correct?

Is our huge debt bound to be a crushing burden which limits employment and lowers the nation's standard of living, or will it simply redistribute income? May the public debt under certain conditions even be used to help increase employment and raise our living standards?

Most people, rich and poor alike, find it difficult to believe that the national debt "just doesn't matter". They know that the interest alone on this huge debt will be almost equal to the total amount of taxes ever raised before by the government for all purposes in any peacetime year. They find it difficult to follow the kind of reasoning that suggests increasing the already mammoth debt year by year in order to maintain full production and employment. They fail to see how this "debt raising" can go on indefinitely.

On the other hand, the records show that other nations have more than once successfully managed even greater debt burdens than will confront the United States after the present war. The interest on the British debt after the Napoleonic Wars was nearly 8 per cent of the national income, and after the first World War was over 7 per cent. But despite heavy taxes and some unfortunate mistakes in economic policy (such as restoring the prewar pound), per capita real income in Great Britain rose about 31 per cent between 1920 and 1929. In fact, it rose as rapidly as it did in the United States. The world depression was far less severe in Britain than it was in the United States; and, by 1936, when industrial production still was 6 per cent below 1929 in the United States, it was nearly 16 per cent above 1929 in Britain. Britain's heavy debt burden proved less of a handicap to her during the depression than our weak banking system did to us.

Whether the debt becomes a crushing burden or whether we use it to further our progress depends upon who holds the debt and how the money is raised to pay the interest.

Here are the important possibilities:

1. If the expenses of the government, including the interest on the debt, are met largely by heavy taxes upon business profits—i.e., by taxes upon job-giving—then they will reduce employment, output, and our standard of living, regardless of who holds the debt. Heavy taxes on profits prevent enterprise from expanding current operations or enlarging the capacity of its plants, unless the prospects for profit seem certain and the prospects for loss are slim. Hence the jobs that might be created to take advantage of long chances will not come into existence, and the country as a whole will be poorer.
2. If the expenses of the government are met largely by stiff surtaxes upon the incomes of persons who do a considerable amount of saving, and the debt is, in the main, owned by millions of small investors, then the net effect of the debt upon the volume of employment and output will be fairly neutral. The stiff surtaxes, while reducing the savings of the well-to-do, will cause them to avoid risky investments and to hold part of the savings of each year in the form of cash. This will limit the demand for goods and the volume of employment. But this effect will be partially offset if millions of small holders of the debt are led by their savings in government bonds to spend a larger part of their current income.
3. If the expenses of the government are met largely by sales taxes or other taxes on small incomes, and if the debt is held largely by the well-to-do or by business corporations, then the effect of the debt will be unfavorable to employment and production. The limitation to the spending power of the small-income group will reduce the volume of investment opportunities, and the transfer of income to the well-to-do will increase the volume of investment-seeking funds.
4. If the debt is widely distributed among millions of small holders, and the expenses of the government are met largely by taxes on individuals, if substantial exemptions from surtaxes are given for all income invested in new plant or equipment, and if there are liberal offsets for losses, then the debt will help increase employment and raise the standard of living. The millions of small holders will gain a sense of security from their accumulated savings and hence be encouraged to spend a larger portion of their current incomes. The stiff surtaxes will reduce the savings of the well-to-do; liberal exemptions for income put into new plant and equipment, and generous treatment of losses, will cause the well-to-do to invest their savings in job-giving enterprise rather than to hold them in idle cash.

But what is the situation today?

Today, non-banking corporations own nearly half of the Federal debt, commercial banks about one-fourth, and individuals less than one-fourth. Not more, and probably less, than one-tenth of the debt is held by persons earning less than $5,000—although these persons receive three-fourths of all income.

Today, about half of the revenues of the Federal government come largely from taxes which must be regarded as *taxes upon the creation of new jobs*. If these conditions continue, we may be sure that the debt will be a disastrous obstacle to a rising standard of living after the war.

What can be done to change this situation?

To begin with, vigorous steps should be taken to get much more of the debt into the hands of individuals, particularly of those in the small-income group. During the last three years, the incomes of individuals, after taxes, have exceeded the supply of consumer goods by $74.2 billion. In other words, individuals have been compelled, by the sheer scarcity of goods, to save over $74 billion. Of this amount, only $27.4 billion, or 37 cents out of every dollar, has gone into government bonds. Indeed, individuals have saved more in the form of cash and bank deposits than in the form of government bonds. The sale of war bonds to individuals was most disappointing in the recent drive. It was so disappointing, in fact, that I would favor a special drive *for individuals only,* to be scheduled before the next general drive. During 1944, when the supplies of civilian goods are severely restricted and when the fighting is at its climax, the Treasury will have its best opportunity to persuade individuals to buy more bonds. This opportunity should not be lost. An increase of at least twenty-five billion should be the goal for the next year. Every citizen should be made to understand that by buying war bonds now, he is not only helping to win the war; he is helping to make possible a more prosperous and stable America after the war.

The efforts to sell bonds to individuals should be vigorously continued throughout the shift from war production to civilian production. During this period, corporations which, up to now, have been the largest buyers of government bonds, will need all their depreciation allowances and undistributed profits to pay for new equipment, and to restore their own dealers' inventories. The government, however, will still have large bills to settle and will need to sell as many bonds as it can for some months after the end of hostilities. During this period, the demand for most types of goods is likely to exceed the immediate productive capacity of industry. Hence, the sale of bonds by the government will make for economic stability.

The huge expenses, including interest on the debt, which the government must meet after the war, require that the tax system be drastically reformed. Today, taxes fall most heavily upon those incomes which are the reward for increasing production and employment, because profits are taxed first as corporate profits, and taxed again as dividends to owners of the corporation. Surtaxes are so stiff and offsets for losses so meager that the well-to-do capitalists cannot afford to encourage and help promising young businessmen to start new enterprises.

A nation whose expenses are as large as those of the United States will be after the war must be sure that its tax system provides incentives, not penalties, for increasing production and employment.

Should the debt be repaid? Some people fear that any reduction of the debt would have a deflationary effect and cause unemployment. An opposite view was expressed by Mr. Morgenthau recently: "We have a big public debt that must be paid off, and the quicker we do that the better." Both of these views are extreme. Repayment of part of the debt during a period of depression would increase unemployment. Every period of high prosperity, however, would give the government an opportunity to pay off part of the debt without limiting employment. During these periods of prosperity, business corporations will sell government bonds in order to buy equipment; and many individuals will redeem war savings bonds in order to purchase houses, automobiles, and other goods. If the government budget runs a surplus during periods of high prosperity, and if this surplus is used to retire some of the bonds sold by corporations or redeemed by individuals, the country will be protected against a disorderly and speculative rise in prices. Thus, reduction of the debt can be made a device for stabilizing our economy.

There are two other reasons why reduction of the debt will be desirable.

In the first place, it will help prepare the country financially for a possible third World War. Determined as we are that this war shall be the last one, common sense tells us not to count on this. At any rate, we must be prepared for any eventuality.

In the second place, gradual reduction of the debt would stimulate employment by creating the expectation of lower taxes. It is not generally appreciated how much the willingness of individuals and business concerns to spend money is affected by the prospects of higher or lower taxes. One of the best ways to make individuals and enterprises spend more freely is to convince them that taxes will become a little lower, year by year.

Many people have difficulty in visualizing the day when there will be a substantial reduction in the burden of the national debt. And yet, if the country pursues wise economic policies, there is no reason why the debt burden should not be cut in half during the next generation.

The days of technological progress and economic expansion are not over. They are, in fact, only well begun. During the Twenties, the national income in dollars of constant purchasing power increased by well over 50 per cent. Between 1929 and 1939, it increased by less than 6 per cent. Perhaps the rate of the Twenties cannot be maintained indefinitely; but scientific research and development work in industry are laying the foundation for very large advances in national income. Suppose that the national income increases 33 per cent in the first decade after fighting stops (say, hopefully, 1945), 25 per cent in the next decade, and thereafter at the rate of 20 per cent a decade. In 1955, the national income (at present prices) would be about $173 billion; in 1965, about $216 billion; and in 1975, about $257 billion. By 1970, the burden of the debt would be reduced by nearly half, even if not a cen of it were repaid!

A huge public debt is a test of the character, the common sense, the foresight, and the equally important technical and engineering skill of a nation. *It requires that tens of millions of small income earners be willing to become substantial holders of the debt. It requires that the nation be willing to tax itself heavily, but in ways which increase the attractiveness of job giving or self-employment relative to job-holding; it requires that the nation be willing to pursue policies of expansion and to put a rising income for the nation ahead of the pleas of self-seeking groups in labor, agriculture, and industry.*

A huge debt may so draw out the hidden powers of a people that it makes the nation wealthier rather than poorer, stronger rather than weaker.

Up to now, Americans have not met the test of a big public debt too well. Individuals have saved more in cash than in government bonds, and the country has shown little interest in avoiding the kind of taxes that reduce the demand for labor. These shortcomings, I am sure, stem largely from the fact that the American people never have had the problems of debt and taxation honestly and adequately explained to them.

I have confidence in the American people. I believe that Americans have the intelligence to understand this problem of the public debt, the character to face their responsibility regarding it, and the common sense to accept the challenge and make the most of it.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc

Many complex glass structures go into a modern vacuum tube

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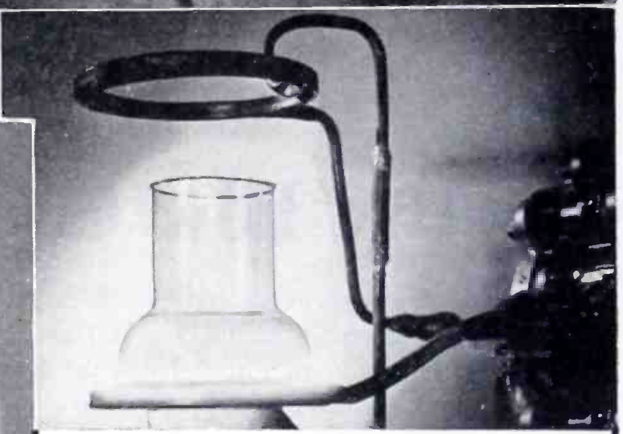
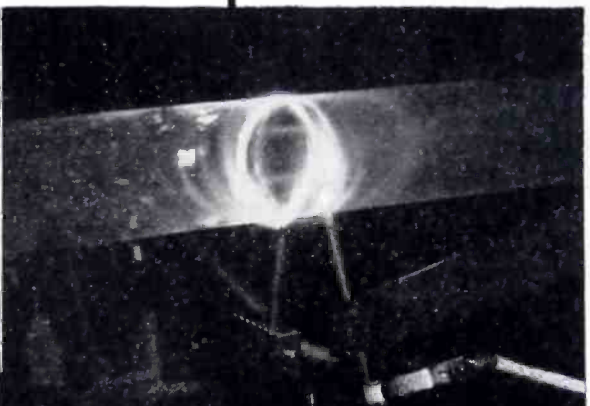
I vacuum tubes many complicated sapes, large and small, must be mde within very close tolerances. Enac's know-how of handling glass is just one reason why electronic egineers throughout the world smit their special problems to Enac with complete confidence in Enac's ability to do a superior job.

There are four complicated glass to metal seals in this vacuum tube part



The use of R. F. heat in making glass to metal seals simplifies and speeds many such sealing operations

Making very large glass seals requires expert handling. Two 17" glass cylinders are being joined



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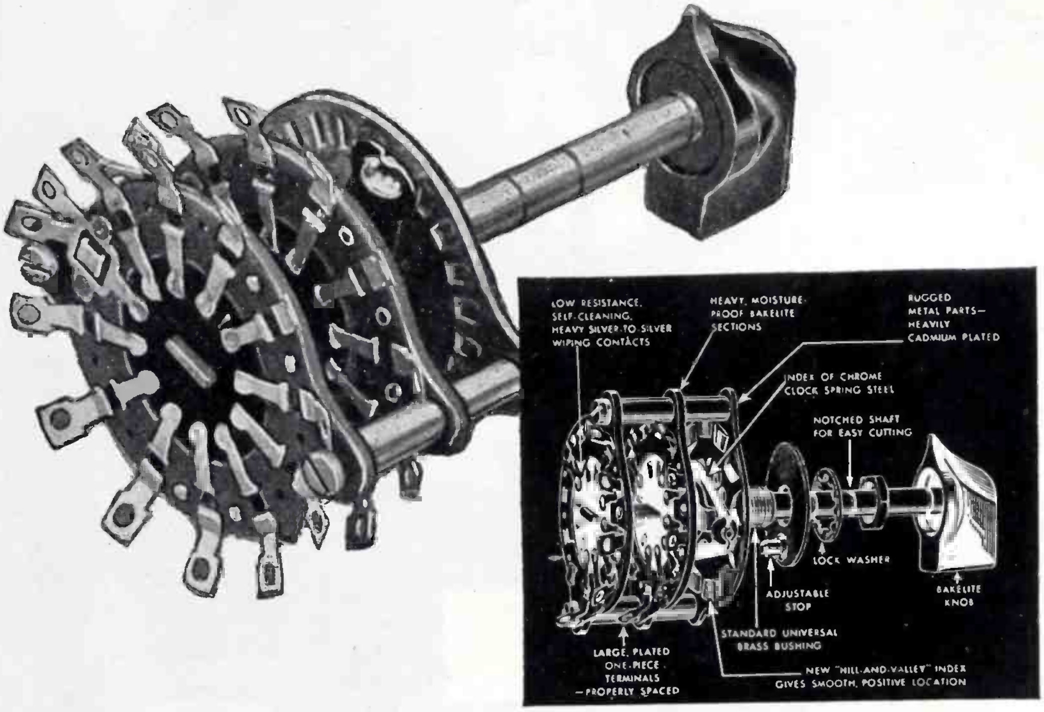

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CROSS TALK

RIDE . . . At the close of the New York Phil-h monic concert on June 25, the United States Rub-b Company stated over the CBS network that "there c ld be no rubber industry without chemists." This ws a very fine acknowledgment from one of Amer-ic's large industrial concerns that its business was dendent upon its technicians. It is a fact, of crse, but it is no more true of the rubber industry t n it is true of the radio industry. Yet—has there er been a member of the radio industry who had t grace to make a similar public statement?

or some reason the role played by radio engineers hs never been played up; never glamorized; seldom acnowledged. In fact large elements of the radio reeiver business have felt that its engineers were neessary evils, payroll names to be unloaded in bad ties when company policies and company politics g in a turmoil.

adio engineers today are in a different situation. Teir work is properly assayed by the war agencies wich make such good use of them; engineers are in gat demand; they have a big share in big things. Teir ego must have improved. It is difficult to esti-mte too highly, however, the betterment of the aver-a radio man's morale if the radio companies sud-dly realized the fact that "there could be no radio iustry without engineers" and began to tell that ft to the public; began, in truth, to take some pride itheir technicians.

MATEURS . . . In spite of the fact that every-o admits the value of the radio amateur in time of pce or war, disquieting rumors get about that he is tbe liquidated.

his seems highly undesirable from every stand-pnt. As he has demonstrated time and again, the aateur is an essential element of the radio industry, an essential part of our national life. This is not true, alone, because he pounds brass and can help out in time of distress; nor is it true because he builds radio apparatus and, therefore, is an engineer; nor is it true, alone, because he is a member of the amateur game where he has learned the value of a high esprit de corps. The amateur is all of these—he knows his equipment, he can build it and maintain it in operation; he has enough theory, and lots of practical experience and knowledge.

Within the past few months, the Editor of ELECTRONICS has had his hands full of a high-priority job for one of the armed services. Many men have been hired. It is only fair to state, right now, that the best men on his staff are those who have had amateur experience. This testimony is available anytime, anywhere that it may be useful in keeping the amateur in radio after the war.

► **FUN** . . . Within the last year much has been made of the electronic method of flowing tin on tinplate. The plate is first coated with tin in an electroplating process; then by induction heating, the tin is flowed so that it goes into all the little crevasses of the material coated. Very nifty system. Now comes one Craig Walsh, ex-Associate Editor of ELECTRONICS, and states that he has a much simpler process. He simply boils the coated plate in Crisco!

OPA cracked down on the black market in radio sets in New York City recently. Seems the boys were buying up junk parts, old auto sets, components, etc., putting them together for a few dollars, selling the assembly for many dollars more than the ceiling price for sets of similar numbers of tubes etc., permitted. Sounds just like the good old pre-war days!

MD., DD., LLD . . . Mairzie-Doates, Dozy-Doates, Little-Lamsie-Divy.

Technical Plan For POST-WAR

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Boston	1, 2, 4, 6, 8, 11, 12, 14, 16, 18	0	0	10	10
Washington, D. C.	1, 2, 4, 6, 11, 12, 14, 16	1	2	5	8
Baltimore	8, 18, 20, 22	0	0	4	4
Providence	10, 19, 21	0	0	3	3
Hartford	5, 9, 15	0	0	3	3
Schenectady, Albany, Troy	3, 7, 13, 17	1	0	3	4
Scranton, Wilkes-Barre	10, 26	0	0	2	2
Springfield, Holyoke	24	0	0	1	1
New Haven	25	0	0	1	1
Worcester	23, 25	0	0	2	2
Allentown, Bethlehem, Easton	24, 25	0	0	2	2
Lowell, Lawrence	25	0	0	1	1
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Note: This tabulation is only one of many possible allocation plans. Channels could be assigned anywhere in the general area of the designated market.

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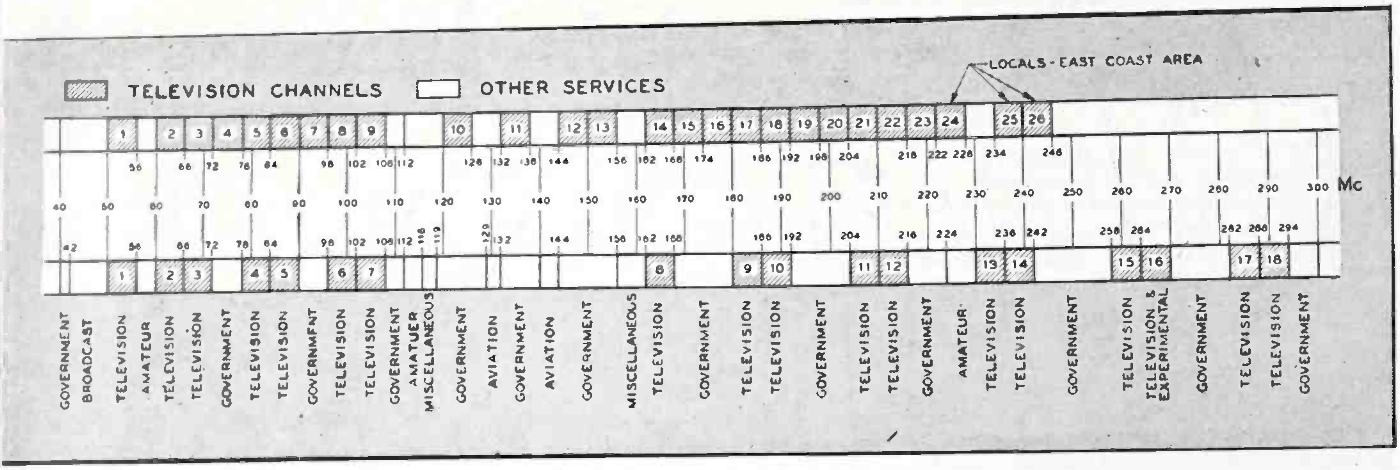
TELEVISION



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The justification for this large mount of ether space is found in he requirements for a national allocation of television service. The irst 30 metropolitan markets, defined by the U. S. Department of Commerce and roughly spotted in Fig. 2, are used as the basis of the Panel's plan. The most critical region from the allocation standpoint is the eastern seaboard from Boston to Washington, within which nine of the thirty markets are located. Figure 3 shows a possible allocation of one station to each of these nine markets, using four channels. The interference radius is shown as 170 miles.

To provide more than one station per city, and to offer service in smaller cities in the same region, a large number of additional channels are required. Table I shows a possible allocation of the 26 proposed channels to the eastern seaboard which would allow 12 stations in New York, 10 stations in Boston, nine stations in Philadelphia and eight stations in Washington (the primary markets). The table shows a total of 65 stations in 15 market areas. (The same allocation plan would provide 12 stations in Chicago, nine in Detroit, eight in Pittsburgh, seven in Cleveland, and a smaller number in the nearby smaller communities.)

This is television service on a scale not thought of before the war. In view of the present level of production and employment in the industry, supplying the equipment for such a system should prove easy, provided only that the public is willing to pay for it. Public acceptance depends not only on the technical excellence and availability of service, but also on the quality and quantity of program material.

Relaying and Experimental Channels

The cost of television programming is such that network connections are considered essential, so that several stations may share the cost.

To prepare for relaying requirements, as well as to permit studio-to-transmitter service and outside pick-up, the RTPB Panel has proposed allocations for commercial television relay service. The channels are classified in three groups: Group B, consisting of a number of 12-Mc channels from 162 to 294 Mc (which will eventually be displaced by assignments to television broadcasting); Group C consisting of twenty 10-Mc channels in a continuous band somewhere between the limits 300 and 1000 Mc; and Group D consisting of twenty 20-Mc channels in a continuous band somewhere between the limits 1000 and 3000 Mc. Proposed assignments for relaying constitute 600 Mc in all, or about 22 percent of the space between 300 and 3000 Mc. The remaining 78 percent is more than sufficient to take care of other needs, including post-war radar and similar wideband services.

The final allocation proposal has to do with experimental stations. The Panel is on record to the effect that an improved system of television should be investigated by ex-

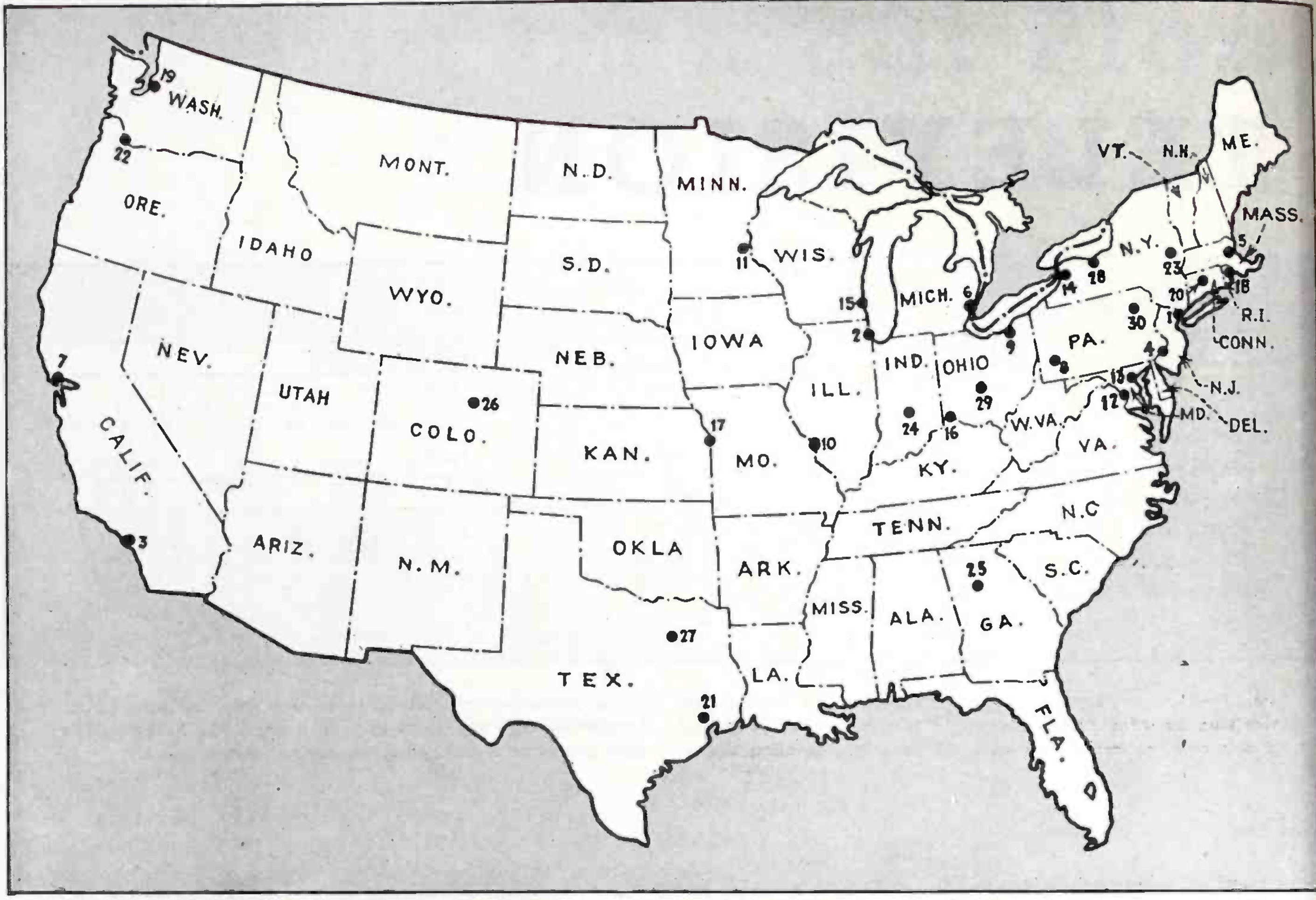


FIG. 2—Basis of the RTPB Television Panel's plan is the assignment of channels to stations in the first 30 metropolitan markets, as defined by the U. S. Department of Commerce. Markets roughly spotted on the map include: (1) New York; (2) Chicago; (3) Los Angeles; (4) Philadelphia; (5) Boston; (6) Detroit; (7) San Francisco; (8) Pittsburgh; (9) Cleveland; (10) St. Louis; (11) Minneapolis; (12) Washington; (13) Baltimore; (14) Buffalo; (15) Milwaukee; (16) Cincinnati; (17) Kansas City; (18) Providence; (19) Seattle; (20) Hartford; (21) Houston; (22) Portland; (23) Albany; (24) Indianapolis; (25) Atlanta; (26) Denver; (27) Dallas; (28) Rochester; (29) Columbus; (30) Scranton

perimentation. To provide for such experimental work, it was recommended that 30 channels, each 20-Mc wide, should be assigned in a continuous band between 600 and 2000 Mc. Although it is recommended by the Panel that no standards for use in such channels be set up at present, calculation shows that a 20-Mc channel (maximum video sideband 18.25 Mc) is capable of accommodating a picture of 1100 lines, possessing detail comparable to professional 35-mm motion pictures.

The experimental stations to some extent may occupy the same channels as relay stations. Allowing 50 percent duplication, the allocation of experimental facilities adds 300 Mc of space to the previously mentioned 600-Mc requirement for relaying and lifts the total requirement for television space to 33 percent in the region from 300 to 3000 Mc.

Additional allocations for experimentation are suggested in the region above 3000 Mc, including a continuous band of sixty 20-Mc channels in the region from 3000 to 10,000 Mc, and an unspecified number of 20-Mc channels above 10,000 Mc. The channels above 3000 Mc are desired primarily for experimentation with television relaying, rather than for experimental broadcasting. Here

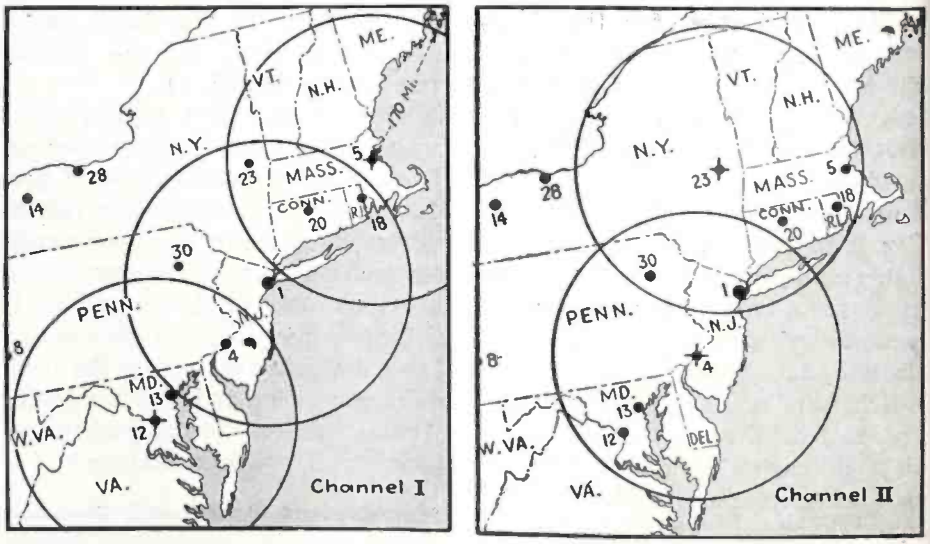


FIG. 3—The most critical region, from a television allocation standpoint, is the eastern seaboard from Boston to Washington, within which nine of the 30 major

agin the requirements for space ar great, but the percentage of the avilable space is not excessive.

IPB Proposed Television Standards

'he RTPB Panel has reviewed th standards governing commerci television broadcasting (NTSC-FC standards) and has reaffirmed mst of them. Two basic changes hre been made. The alternative u: of frequency modulation for the piture and synchronizing signals h: been eliminated, and the speeications for frequency modulatin of the associated sound signal hre been modified. In all other respcts, including the scanning speeications, the RTPB recommendatins coincide with the existing sndards.

'he complete list of standards is gen in Table II. The explanation oeach standard has appeared previcsly in an ELECTRONICS report (ebruary 1941, p. 17) on the NSC proceedings. They have also bn described in detail in the book "levision Standards and Practi" (McGraw-Hill, New York, 1:3). In the interest of completens in this report; a brief discussin of the standards is presented.

The first four standards have to d with the 6-Mc television channel, sown in Fig. 4. These standards a identical in all respects to the NSC-FCC values. The 6-Mc chann permits vestigial sideband pictre transmission with a maximum vleo sideband of about 4.25 Mc. Te sound carrier is spaced 4.5 Mc fm the picture carrier, rather than 1.25 Mc (which would be possible if the sound carrier were moved from the right edge of the diagram to the left edge) because the effect of cross-modulation between carriers is not noticeable with the wide spacing and would be visible with the narrower spacing.

The next four standards, on scanning specifications, are also identical with the NTSC-FCC values. The picture scanning figures remain at 525 lines, 30 frames per second, interlaced two-to-one. It was the concensus of Committee 3 of the Panel, which investigated the matter, that these values represented the best values with which to employ the full capabilities of the

TABLE II—PROPOSED STANDARDS

(1) The width of the standard television broadcast channel shall be 6 Mc.

(2) It shall be standard to locate the visual carrier 4.5 Mc lower in frequency than the unmodulated aural carrier.

(3) It shall be standard to locate the unmodulated aural carrier 0.25 Mc lower than the upper frequency limit of the channel.

(4) The standard visual transmission amplitude characteristic shall be that shown in appended Drawing I (Fig. 4)

(5) The standard number of scanning lines per frame period shall be 525, interlaced two-to-one.

(6) The standard frame frequency shall be 30 per second and the standard field frequency shall be 60 per second.

(7) The standard aspect ratio of the transmitted television picture shall be 4 units horizontally to 3 units vertically.

(8) It shall be standard, during active scanning intervals, to scan left to right horizontally and from top to bottom vertically, at uniform velocities.

(9) It shall be standard in television broadcasting transmission to modulate a carrier within a single television channel for both picture and synchronizing signals, the two signals comprising different modulation ranges in amplitude.

(10) It shall be standard that a decrease in initial light intensity cause an increase in radiated power.

(11) It shall be standard that the black level be represented by a definite carrier level, independent of light and shade in the picture.

(12) It shall be standard to transmit the black level at 75 percent (with a tolerance of plus or minus 2.5 percent) of the peak carrier amplitude.

(13) It shall be standard to use frequency modulation for the television aural transmission, with a maximum frequency swing of 25 kc.

(14) It shall be standard to pre-emphasize the aural transmission in accordance with the impedance-frequency characteristic of a series inductance-resistance network having a time constant of 50 microseconds.

(15) It shall be standard in television broadcast transmission to radiate a signal in conformity with the appended drawing "Television Synchronizing Waveform," Committee 2, Panel 6, RTPB, March 15, 1944 (Fig. 5), as modified by vestigial sideband operation as specified in Drawing I of the FCC "Standards of Good Engineering Practice," dated April 30, 1941.

(16) The time interval between the leading edges of successive horizontal pulses shall vary less than one half of one percent of the average interval.

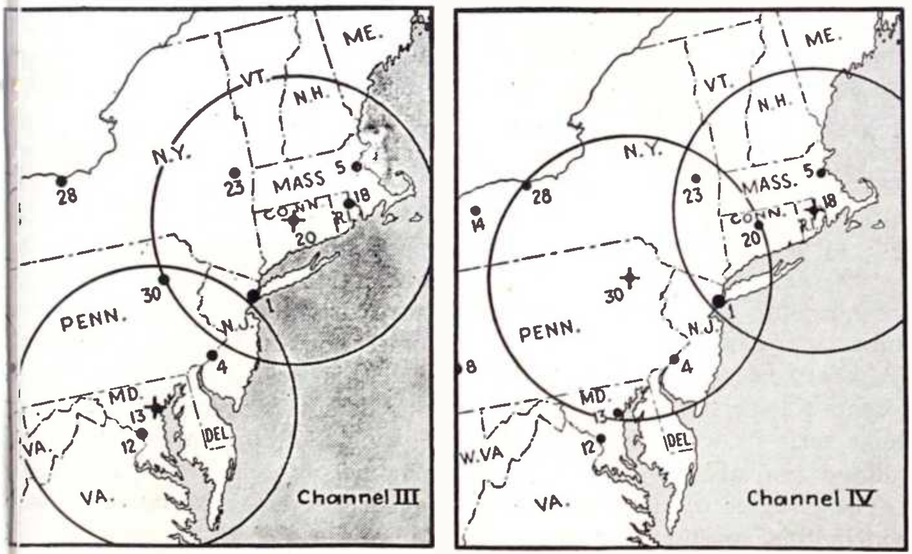
(17) It shall be standard in television transmission that the rate-of-change of the frequency of recurrence of the leading edges of the horizontal synchronizing signals be not greater than 0.15 percent per second, the frequency to be determined by an averaging process carried out over a period of not less than 20, nor more than 100 lines, such lines not to include any portion of the vertical blanking signal.

(18) It shall be standard to rate the visual transmitter in terms of its peak power when transmitting a standard television signal.

(19) Modulation of the visual transmitter, the radio-frequency signal amplitude shall be 15 percent or less of the peak amplitude, for maximum white.

(20) It shall be standard to employ an unmodulated radiated carrier power of the aural transmission not less than 100 percent nor more than 150 percent of the peak radiated power of the picture transmission.

(21) It shall be standard in television broadcasting to radiate signals having horizontal polarization.



markets shown in Fig. 2 are located. Assuming an interference radius of 170 miles, each of the nine could have a station by using four channels as shown here

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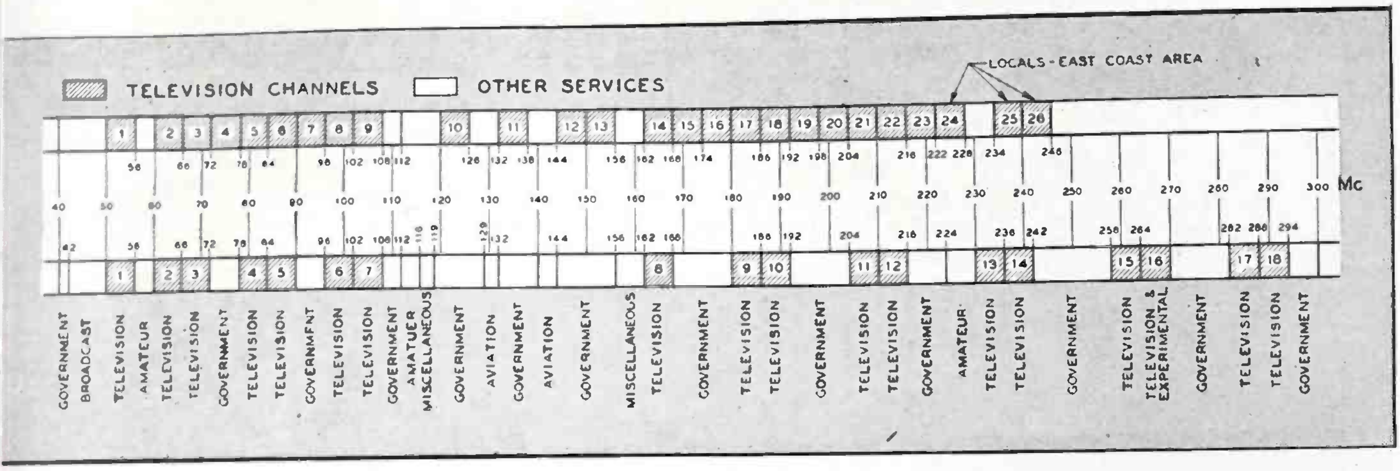

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ercial broadcasting is shown in ig. 1. The present allocation lower bar in the figure) consists f 18 six-megacycle channels from 0 to 294 Mc. The proposed allocaion (upper bar) suggests the addiion of 8 six-megacycle channels, naking 26 channels in all, extendng from 50 to 246 Mc. According o this proposal, television would ccupy about 80 percent of the pace from 50 to 246 Mc. Gaps are eft for the present amateur bands nd for aviation, government, and niscellaneous services.

The justification for this large mount of ether space is found in he requirements for a national alocation of television service. The irst 30 metropolitan markets, defined by the U. S. Department of Commerce and roughly spotted in Fig. 2, are used as the basis of the Panel's plan. The most critical region from the allocation standpoint is the eastern seaboard from Boston to Washington, within which nine of the thirty markets are located. Figure 3 shows a possible allocation of one station to each of these nine markets, using four channels. The interference radius is shown as 170 miles.

To provide more than one station per city, and to offer service in smaller cities in the same region, a large number of additional channels are required. Table I shows a possible allocation of the 26 proposed channels to the eastern seaboard which would allow 12 stations in New York, 10 stations in Boston, nine stations in Philadelphia and eight stations in Washington (the primary markets). The table shows a total of 65 stations in 15 market areas. (The same allocation plan would provide 12 stations in Chicago, nine in Detroit, eight in Pittsburgh, seven in Cleveland, and a smaller number in the nearby smaller communities.)

This is television service on a scale not thought of before the war. In view of the present level of production and employment in the industry, supplying the equipment for such a system should prove easy, provided only that the public is willing to pay for it. Public acceptance depends not only on the technical excellence and availability of service, but also on the quality and quantity of program material.

Relaying and Experimental Channels

The cost of television programming is such that network connections are considered essential, so that several stations may share the cost.

To prepare for relaying requirements, as well as to permit studio-to-transmitter service and outside pick-up, the RTPB Panel has proposed allocations for commercial television relay service. The channels are classified in three groups: Group B, consisting of a number of 12-Mc channels from 162 to 294 Mc (which will eventually be displaced by assignments to television broadcasting); Group C consisting of twenty 10-Mc channels in a continuous band somewhere between the limits 300 and 1000 Mc; and Group D consisting of twenty 20-Mc channels in a continuous band somewhere between the limits 1000 and 3000 Mc. Proposed assignments for relaying constitute 600 Mc in all, or about 22 percent of the space between 300 and 3000 Mc. The remaining 78 percent is more than sufficient to take care of other needs, including post-war radar and similar wideband services.

The final allocation proposal has to do with experimental stations. The Panel is on record to the effect that an improved system of television should be investigated by ex-

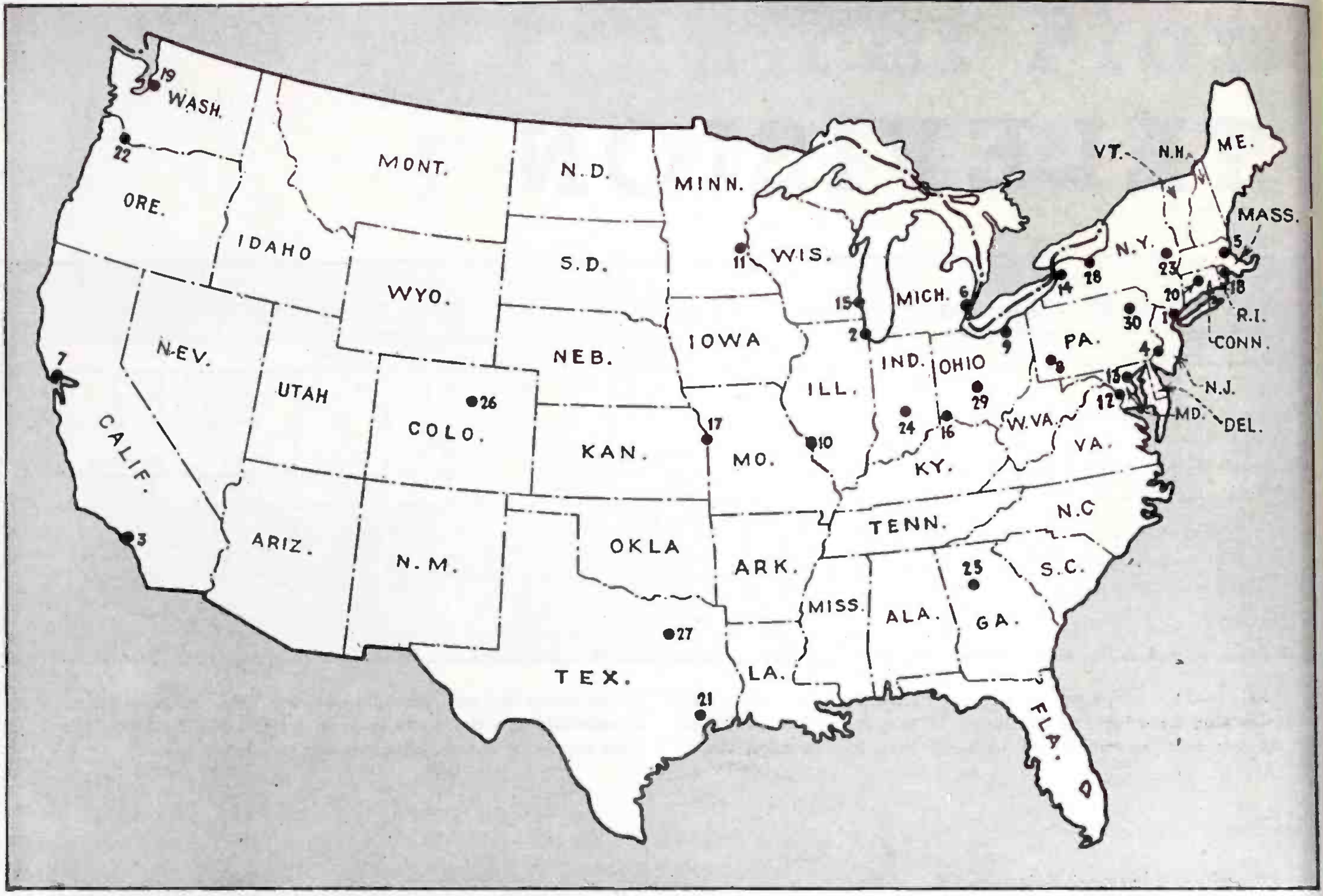


FIG. 2—Basis of the RTPB Television Panel's plan is the assignment of channels to stations in the first 30 metropolitan markets, as defined by the U. S. Department of Commerce. Markets roughly spotted on the map include: (1) New York; (2) Chicago; (3) Los Angeles; (4) Philadelphia; (5) Boston; (6) Detroit; (7) San Francisco; (8) Pittsburgh; (9) Cleveland; (10) St. Louis; (11) Minneapolis; (12) Washington; (13) Baltimore; (14) Buffalo; (15) Milwaukee; (16) Cincinnati; (17) Kansas City; (18) Providence; (19) Seattle; (20) Hartford; (21) Houston; (22) Portland; (23) Albany; (24) Indianapolis; (25) Atlanta; (26) Denver; (27) Dallas; (28) Rochester; (29) Columbus; (30) Scranton

perimentation. To provide for such experimental work, it was recommended that 30 channels, each 20-Mc wide, should be assigned in a continuous band between 600 and 2000 Mc. Although it is recommended by the Panel that no standards for use in such channels be set up at present, calculation shows that a 20-Mc channel (maximum video sideband 18.25 Mc) is capable of accommodating a picture of 1100 lines, possessing detail comparable to professional 35-mm motion pictures.

The experimental stations to some extent may occupy the same channels as relay stations. Allowing 50 percent duplication, the allocation of experimental facilities adds 300 Mc of space to the previously mentioned 600-Mc requirement for relaying and lifts the total requirement for television space to 33 percent in the region from 300 to 3000 Mc.

Additional allocations for experimentation are suggested in the region above 3000 Mc, including a continuous band of sixty 20-Mc channels in the region from 3000 to 10,000 Mc, and an unspecified number of 20-Mc channels above 10,000 Mc. The channels above 3000 Mc are desired primarily for experimentation with television relaying, rather than for experimental broadcasting. Here

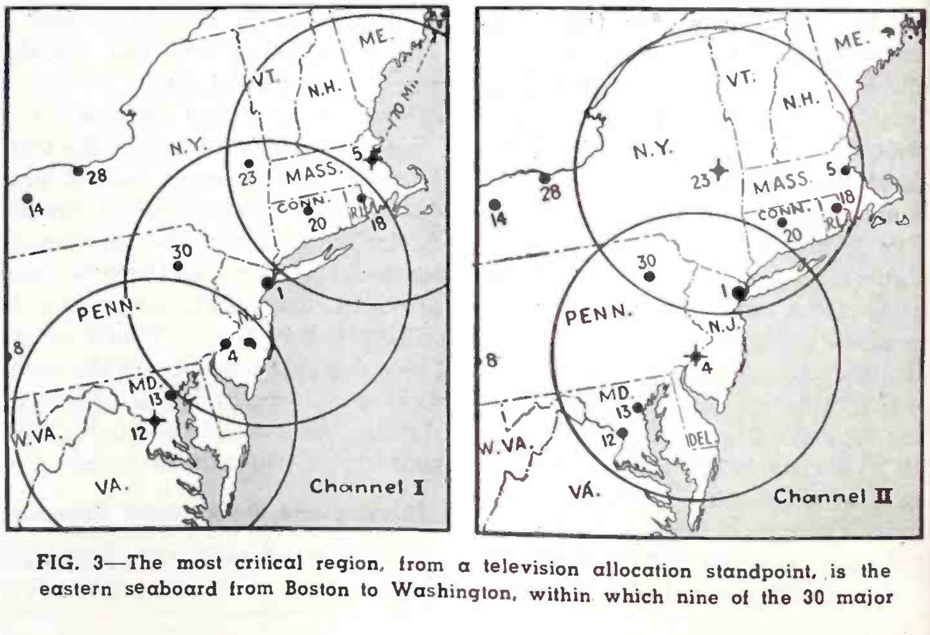


FIG. 3—The most critical region, from a television allocation standpoint, is the eastern seaboard from Boston to Washington, within which nine of the 30 major

ain the requirements for space e great, but the percentage of the ailable space is not excessive.

RTPB Proposed Television Standards

The RTPB Panel has reviewed ie standards governing commeral television broadcasting (NTSC-CC standards) and has reaffirmed iost of them. Two basic changes ave been made. The alternative se of frequency modulation for the icture and synchronizing signals as been eliminated, and the speifications for frequency modulaon of the associated sound signal ave been modified. In all other repects, including the scanning speifications, the RTPB recommendaons coincide with the existing tandards.

The complete list of standards is iven in Table II. The explanation f each standard has appeared prevously in an ELECTRONICS report February 1941, p. 17) on the TSC proceedings. They have also een described in detail in the book Television Standards and Pracice" (McGraw-Hill, New York, 943). In the interest of completeess in this report; a brief discusion of the standards is presented.

TABLE II—PROPOSED STANDARDS

(1) The width of the standard television broadcast channel shall be 6 Mc.

(2) It shall be standard to locate the visual carrier 4.5 Mc lower in frequency than the unmodulated aural carrier.

(3) It shall be standard to locate the unmodulated aural carrier 0.25 Mc lower than the upper frequency limit of the channel.

(4) The standard visual transmission amplitude characteristic shall be that shown in appended Drawing I (Fig. 4)

(5) The standard number of scanning lines per frame period shall be 525, interlaced two-to-one.

(6) The standard frame frequency shall be 30 per second and the standard field frequency shall be 60 per second.

(7) The standard aspect ratio of the transmitted television picture shall be 4 units horizontally to 3 units vertically.

(8) It shall be standard, during active scanning intervals, to scan left to right horizontally and from top to bottom vertically, at uniform velocities.

(9) It shall be standard in television broadcasting transmission to modulate a carrier within a single television channel for both picture and synchronizing signals, the two signals comprising different modulation ranges in amplitude.

(10) It shall be standard that a decrease in initial light intensity cause an increase in radiated power.

(11) It shall be standard that the black level be represented by a definite carrier level, independent of light and shade in the picture.

(12) It shall be standard to transmit the black level at 75 percent (with a tolerance of plus or minus 2.5 percent) of the peak carrier amplitude.

(13) It shall be standard to use frequency modulation for the television aural transmission, with a maximum frequency swing of 25 kc.

(14) It shall be standard to pre-emphasize the aural transmission in accordance with the impedance-frequency characteristic of a series inductance-resistance network having a time constant of 50 microseconds.

(15) It shall be standard in television broadcast transmission to radiate a signal in conformity with the appended drawing "Television Synchronizing Waveform," Committee 2, Panel 6, RTPB, March 15, 1944 (Fig. 5), as modified by vestigial sideband operation as specified in Drawing I of the FCC "Standards of Good Engineering Practice," dated April 30, 1941.

(16) The time interval between the leading edges of successive horizontal pulses shall vary less than one half of one percent of the average interval.

(17) It shall be standard in television transmission that the rate-of-change of the frequency of recurrence of the leading edges of the horizontal synchronizing signals be not greater than 0.15 percent per second, the frequency to be determined by an averaging process carried out over a period of not less than 20, nor more than 100 lines, such lines not to include any portion of the vertical blanking signal.

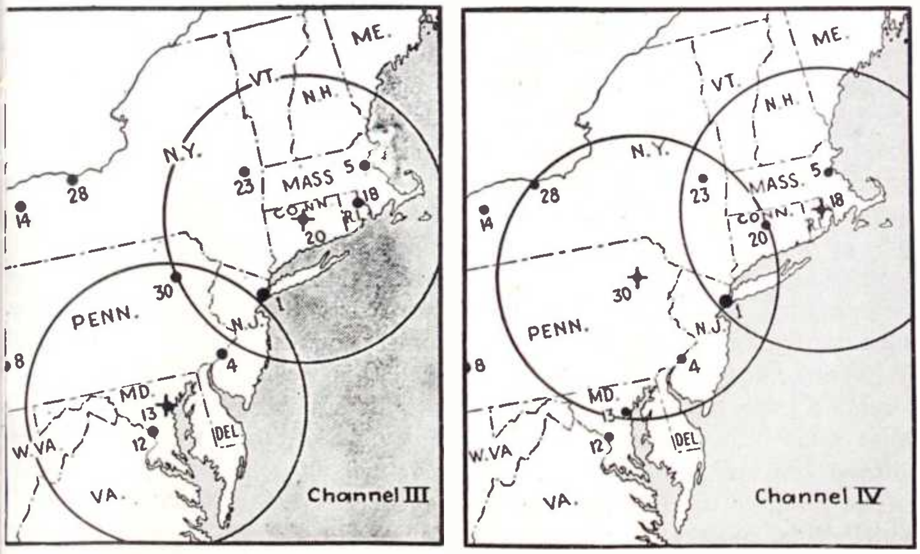
(18) It shall be standard to rate the visual transmitter in terms of its peak power when transmitting a standard television signal.

(19) Modulation of the visual transmitter, the radio-frequency signal amplitude shall be 15 percent or less of the peak amplitude, for maximum white.

(20) It shall be standard to employ an unmodulated radiated carrier power of the aural transmission not less than 100 percent nor more than 150 percent of the peak radiated power of the picture transmission.

(21) It shall be standard in television broadcasting to radiate signals having horizontal polarization.

The first four standards have to o with the 6-Mc television channel, hown in Fig. 4. These standards re identical in all respects to the TSC-FCC values. The 6-Mc chanel permits vestigial sideband picure transmission with a maximum ideo sideband of about 4.25 Mc. he sound carrier is spaced 4.5 Mc rom the picture carrier, rather than 1.25 Mc (which would be possible if the sound carrier were moved from the right edge of the diagram to the left edge) because the effect of cross-modulation between carriers is not noticeable with the wide spacing and would be visible with the narrower spacing.



markets shown in Fig. 2 are located. Assuming an interference radius of 170 miles, each of the nine could have a station by using four channels as shown here

The next four standards, on scanning specifications, are also identical with the NTSC-FCC values. The picture scanning figures remain at 525 lines, 30 frames per second, interlaced two-to-one. It was the concensus of Committee 3 of the Panel, which investigated the matter, that these values represented the best values with which to employ the full capabilities of the

4.25 Mc video sideband previously mentioned.

F-M Video Not Permitted

Standard number 9, relating to the type of modulation to be used in transmitting the picture, has been changed to permit amplitude modulation only. The NTSC-FCC version of this standard permitted the use of either amplitude or frequency modulation for picture and synchronizing signals. Experience has shown, since the NTSC investigation, that frequency modulation has serious limitations in broadcasting the picture, due to the effects of multipath transmission.

When multipath effects are present, the direct wave and a wave reflected from a structure off the direct path tend to cancel or reinforce each other by wave interference, depending on the relative phases of the signals. When frequency modulation is employed, the arrival of one value of the carrier frequency may be delayed in the reflected path just enough to interfere with (and possibly cancel) the same value of the carrier frequency transmitted by the direct path. The effect is particularly pronounced when frequency modulation is used for the sync signals, since the maximum and minimum amplitudes of the sync correspond to two discrete carrier frequency values. Demonstrations showed that multipath transmission may result in total loss of the sync signal when f-m is used, whereas no such serious effect occurs when a-m is used.

The effect of multipath transmission is also serious in the picture itself. In this case, the effect of multipath transmission is to produce a beat-note pattern which has no evident relationship to the picture content and flickers over the screen in a distracting fashion. The same multipath conditions, when a-m is employed, produce a ghost image displaced from the true image but similar to it in form. Such a-m ghosts, while troublesome, are much less annoying than the f-m ghosts. Hence it was concluded by Committee 2 of the Panel, which studied the matter, that frequency modulation was impractical for picture broadcasting. (It should be noted, however, that f-m is highly suitable for *relay* picture transmissions, where the use of directive transmitting and receiving antennas eliminates the effect of reflected signals.)

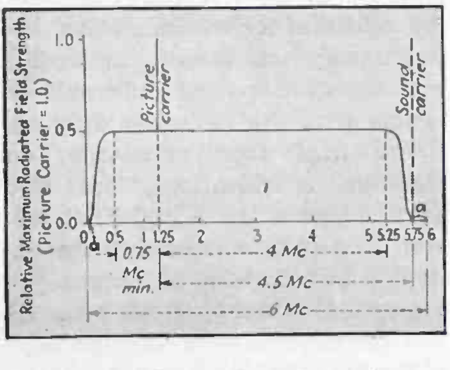


FIG. 4—Idealized picture transmission amplitude characteristic. The relative field strength outside the picture side bands (at *a*) is not to exceed 0.0005. Details are discussed in the text

The next three standards, relating to the polarity of transmission, d-c transmission, and the percentage of carrier amplitude devoted to sync signals, are identical with the NTSC-FCC standards. Here again Committee 2 agreed that these methods of transmission represented the best practice known to the art, and should be preserved for post-war use. The numerical values stated in the standards are illustrated in the sync-signal waveform, shown in Fig. 5.

Audio Standards Substantially Changed

The next standards, numbered 13 and 14, relate to the transmission of the associated sound signal. Strangely enough it is only in these standards, which do not relate to the television problem proper, that any substantial changes appear. The NTSC-FCC standards specify frequency modulation with a maximum deviation of plus or minus 75 kc, and frequency pre-emphasis in accordance with a 100-microsecond time constant. The RTPB Panel standards specify frequency modulation with maximum deviation of plus or minus 25 kc. and pre-emphasis according to a 50-microsecond time constant. The most important change relates to the frequency deviation, which represents a lowering of the signal-to-noise ratio by a factor of three in voltage (9.6 db).

The minutes of Committee 3, to which this matter was referred, show that considerable discussion centered on this question. The NTSC had standardized on a deviation of 75 kc with the tacit understanding that only the Group A channels (up to 108 Mc) would be available for broadcasting in the initial stages. The RTPB, as shown earlier in this report, was faced by the definite prospect of using channels as high as 250 Mc. Between 100 Mc and 250 Mc there has been found to exist a dividing line above which the frequency drift of the receiver local oscillator becomes a serious factor. It has been appreciated for some time that frequency-modulated sound transmission requires more precise tuning than amplitude-modulated signals, because the wider spectrum of the f-m transmission occupies fully the bandwidth allotted to it in the receiver and because full noise suppression is obtained only when the f-m signal is centered on the discriminator characteristic. Thus the receiver drift problem operates against proper reception of f-m sound signals on the channels above 100 Mc.

Two proposals were offered to solve the problem. One was to revert to amplitude modulation for the sound channel, while retaining the receiver bandwidth at the 200-kc value. This would permit the receiver oscillator to drift plus or minus 80 kc (about 0.03 percent at 250 Mc) without affecting the strength or quality of the sound transmission. The other alternative was to reduce the deviation of the f-m transmission, but likewise retain the full bandwidth at 200 kc. The 25-kc deviation permits the receiver oscillator to drift about 60 kc (0.02 percent at 250 Mc) before serious difficulties with the quality of the reproduction ensue. If 75-kc deviation were used, the allowable drift in a 200-kc bandwidth is only 10 kc (0.004 percent). The members of Committee 3 stated that present best practice in the control of 250-Mc oscillators would not assure drift less than 0.02 percent, unless crystal control were used, and this was deemed uneconomical for domestic equipment, especially in view of the large number of channels to be covered. Consequently it was deemed inadvisable to retain the 75-kc deviation and 25-kc was substituted for it.

Another problem encountered in

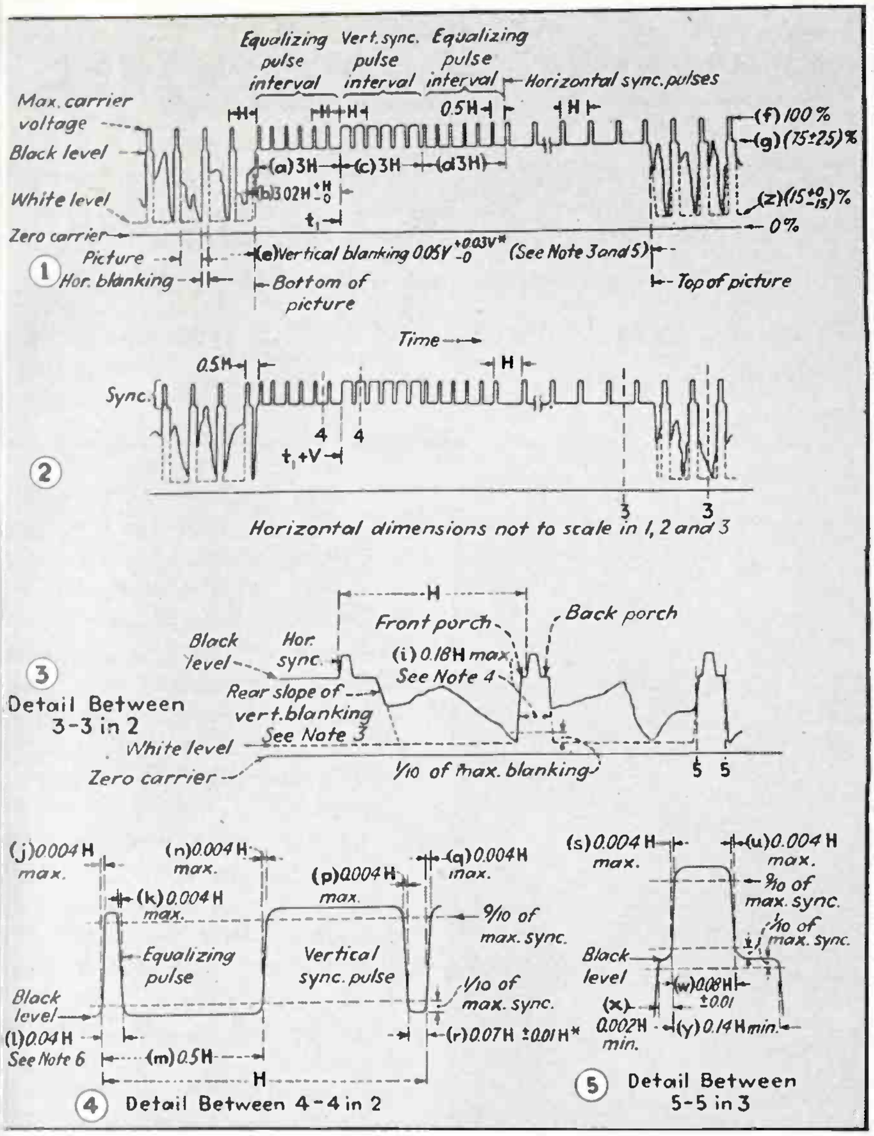


FIG. 5—Recommended television synchronizing waveform

Notes: (1) *H* equals time from start of one line to start of next line; (2) *V* equals time from start of one field to start of next field; (3) Leading and trailing edges of vertical blanking should be complete in less than 0.1 *H*; (4) Leading and trailing slopes of horizontal blanking must be steep enough to preserve minimum and maximum values of $(x+y)$ under all conditions of picture content; (*5) Dimensions marked with an asterisk indicate that tolerances given are permitted only for long time variations, and not for successive cycles; (6) Equalizing pulse area shall be between 0.45 and 0.5 of the area of a horizontal sync pulse.

f-m transmission is the audio distortion which can be produced when multipath effects are present. Such distortion arises from the cancellation of two components of the carrier signal, one arriving directly, the other by a reflected path. When the reflected signal is comparable in strength to the direct signal, noticeable distortion may occur. This problem was thoroughly discussed by Committee 3. This effect was considered to be of small importance compared with the receiver-drift problem.

The reduction of the time constant from 100 to 50-microseconds was recommended on the advice of the broadcasters, who indicated that the 100-microsecond characteristic introduces somewhat excessive peaking of the high frequencies, causing the studio operator to ride gain at a low value to avoid overmodulation on high-frequency peaks. It was believed that the lower value of 50 microseconds would permit the studio gain control to be set safely at a higher value, and thus obtain more efficient use of the sound transmitter.

Standard number 20, which states the relative power of the picture and sound transmission, was changed to take into account, in part, the reduced deviation in the sound transmission. The NTSC-FCC standard specifies that the sound radiated power shall be from 50 to 100 percent of the picture radiated power. The RTPB Panel recommendation is that the sound-radiated power be increased to a value from 100 to 150 percent of the picture power. This amounts to maximum increase of 3 times in power (about 3 db), which compensates partly for the 9-db loss due to lowered deviation. It was believed that the noise-reduction inherent in f-m transmission was sufficient to take care of the 6 db difference in all parts of the service area.

Sync Signal Waveform

The next three standards (15, 16 and 17) specify the synchronizing signal waveform and certain tolerances. The only change here is another elimination of an alternative.

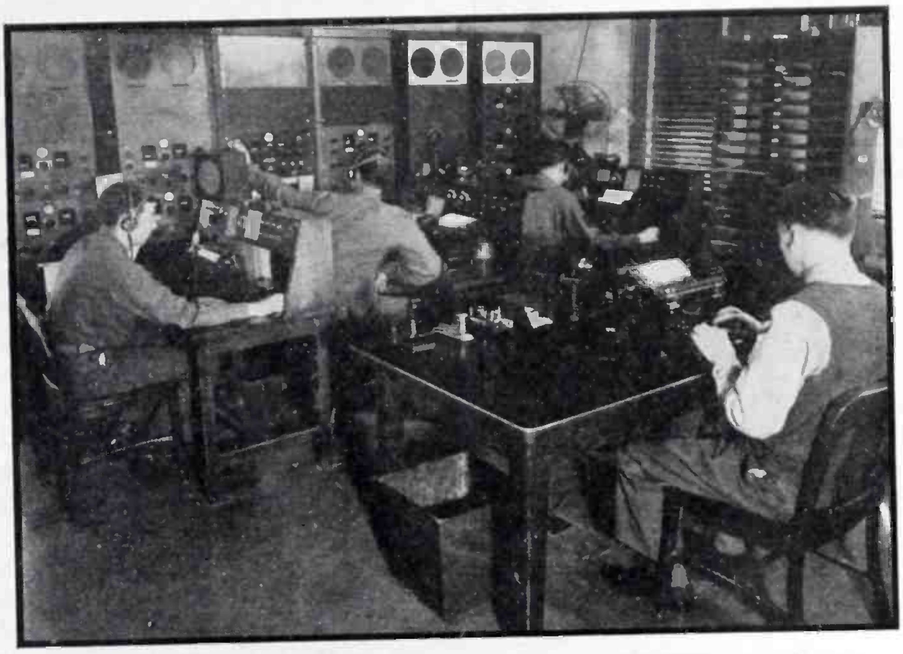
The NTSC-FCC standards specify the serrated vertical synchronizing waveform of Fig. 5, but they also permit an alternative form, the so-called 500-kc vertical sync. The deliberations of Committee 2 revolved about the relative merits of the two systems. It was brought out that the resonant band-pass circuit used to separate the vertical pulses in the 500-kc signal have twice the band-width of the low-pass integrating circuit used with the serrated pulses of Fig. 5, and that the noise accepted by the former circuit might therefore be greater, depending on the noise spectrum actually present. But the principal factor favoring the serrated pulse was the fact that it offered excellent performance when used with a newly developed a-f-c vertical sync circuit, which so improves the general performance of the synchronization system as to provide solid synchronization even when the signal strength is so low that the picture is barely recognizable. In possession of such a satisfactory solution of the sync problem, the Committee voted to eliminate the alternative form of sync pulse in the interest of simplification of the standards.

The synchronization waveform shown in Fig. 5 is identical in all numerical values and shapes to the standard NTSC-FCC waveform. Minor corrections and additions to the dimensions have been incorporated in the interest of greater precision and to clarify the meaning of the specifications. The tolerance standards 16 and 17 were set up by

(*Continued on page* 164)

Army Airways

Army Air Force affiliate provides point-to-point service, weather information, aeronautical navigational aids and coordination at various landing fields in domestic and foreign theaters, facilitating military flying and pointing the way for post-war development of international air travel



Typical AACS radio station at major AAF airdrome. The operator at the left exchanges weather data with other bases, the one in the center handles arrival and departure messages, the man at the right maintains contact with aircraft enroute and the man in the foreground is the supervisor

REFLECTING the rapid rise in military aviation, and foreshadowing the future development of air travel together with the communications system which will make it possible, is the Army Airways Communications System with headquarters in the City Hall Building at Asheville, North Carolina.

The AACS, a worldwide organization, is part of the Army Air Force. Its immediate objective is to make military flying as safe, foolproof and reliable as is humanly possible in wartime. To this end the organization operates a vast array of wire and radio communications facilities, direction-finding and range-beacon stations, weather stations and other radio-facilities and also coordinates many similar services at various landing fields.

The activities of the AACS will have definite value in peace-time military aviation and, despite the fact that military airways do not necessarily follow routes desirable for commercial service, should also prove useful in re-establishing commercial and civilian aviation in the post-war period.

Organization

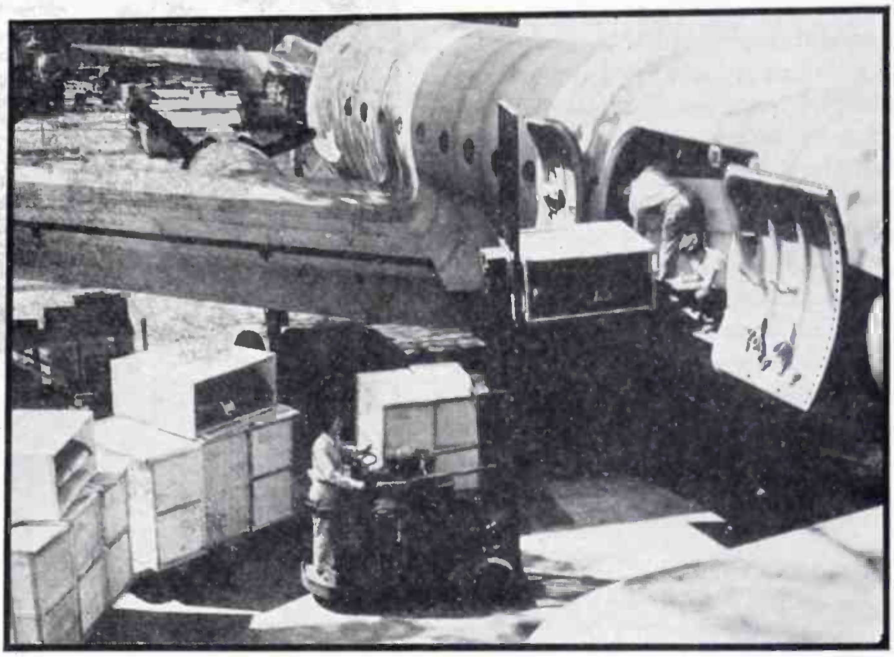
The AACS is primarily an operating or service organization in which field activities are of paramount importance. The administrative headquarters are unobtrusive and practical; those responsible for administration are level-headed aviation or communications men who know what field conditions are beause they have flown planes and operated communication systems. Some have extensive experience in commercial communications and many have built and maintained their own stations as amateur radio operators.

Beause of the importance which is attached to field operations, a high degree of decentralization is desirable. Men operating control towers or, perhaps, portable marker-beacons, are "on their own" to a large extent. At the same time the high degree of specialized knowledge which these men require, the fact that they often have very severe responsibilities, and that they are called upon to produce results regardless of the circumstances in which they find themselves calls for particularl dependable, resourceful and reliabl personnel.

As a result of necessary decentralization, the usual array o "echelons" has been streamlined the point where the remotest de

This ugly duckling, consisting of a few boards, some rusty nails, a signal-light gun, a field telephone, a cot, a receiver and a transmitter served as a control tower at a Chinese field until more elaborate equipment arrived

Communications System



Flying freights find cargoes waiting, thanks to rapid exchange of information between AACS radio stations. Minimum delay at stops spells efficient operation

achment is only a few layers re-noved from the top man. The eadquarters in Asheville is the erve center of the entire system. t is largely an administrative unit nd coordinates its activities with hose of the Army, Navy, the Civil eronautic Administration and our llies. It establishes policies for he overall system.

So far as the AACS is concerned, he world is divided into 8 Wings or purposes of administration. In nost instances, Wing Headquar-ers are located near the terminals f the various air-ferry and air-ransport commands. In general, Ving Headquarters is responsible or the supervision and inspection f installations and equipment and or the establishment of policies re-ting to operations within the Ving. Each Wing is divided into roups, of which 24 exist at the resent time. Of these, four are lo-ated in the continental United tates and the balance in foreign ountries.

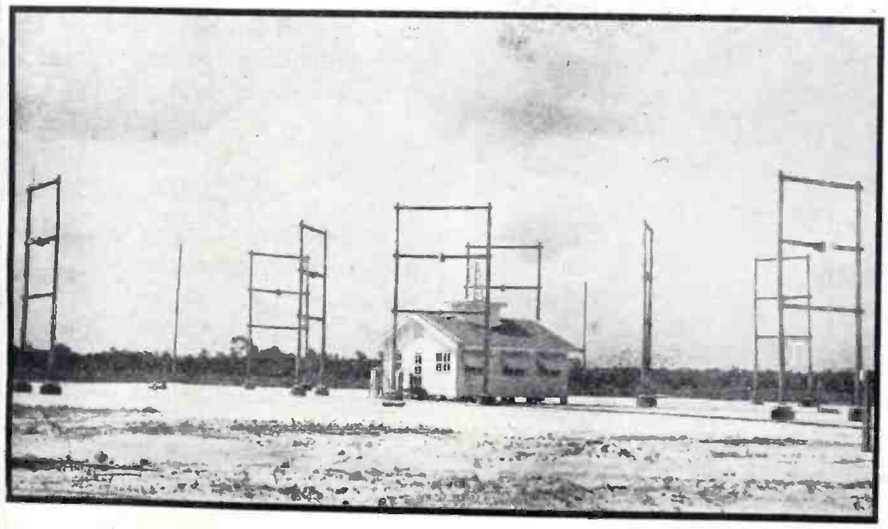
A Detachment is a field operat-ng unit charged with the responsi-ility of operating and maintain-ng one of the many AACS stations hich may be located almost any-here throughout the world. The etachment is set up to provide op-rating and maintenance services nly. However, in many cases mem-ers of a Detachment are required perform additional services, such installing and even constructing ntrol towers and communications equipment, usually beause of their remoteness from normal facilities for such purposes.

Such a streamlined organization is well adapted to carry out the activities in which the AACS is primarily engaged. Broadly speaking, these activities are three-fold: (1) to provide point-to-point communiations throughout the world, especially with ground stations along military airways, (2) to collect, coordinate and disseminate weather information along military airways, and (3) to provide aeronautical navigational aids and various types of flight controls for aircraft operating between ground stations.

Problems

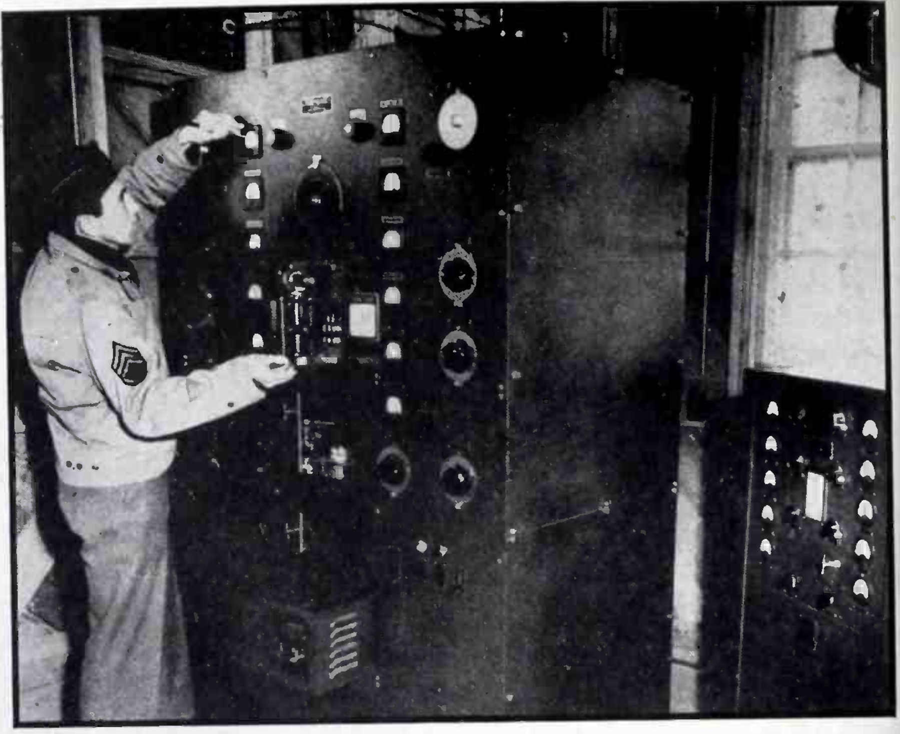
Numerous unusual and interesting problems confront the AACS and in each case a satisfactory answer must be found promptly. For example, the organization must maintain a continuous watch throughout the world for all military airways for whose operation it is responsible. It must establish communications quickly in war theaters and this may be a task of considerable proportions and difficulties in a war of a high degree of mobility. Although the Signal Corps is charged with the installation and major repairs of equipment, conditions sometimes make it necessary for AACS personnel to install and service equipment as well as to maintain it.

While it is necessary to be sure that our own personnel is adequately informed of weather and other conditions in which they are interested, it is equally important to keep such information from the enemy. This requirement imposes



Direction-finding stations like this, set up all over the world, give bearings to military aircraft hundreds of miles away certain restrictions on the system, which do not exist to the same extent in commercial installations. To provide adequate weather information, it is necessary to operate weather stations throughout the world. The Weather Wing of the Army Air Force makes the observations from which weather reports are prepared, but the AACS serves as the transmission agency in disseminating this data.

These various requirements make it mandatory to have personnel resourceful in the field, for many improvisations may be required. The system is constantly in a state of change to cope with new conditions or to expand its service.



Radio-range transmitter in the far north, being checked by an AACS maintenance technician

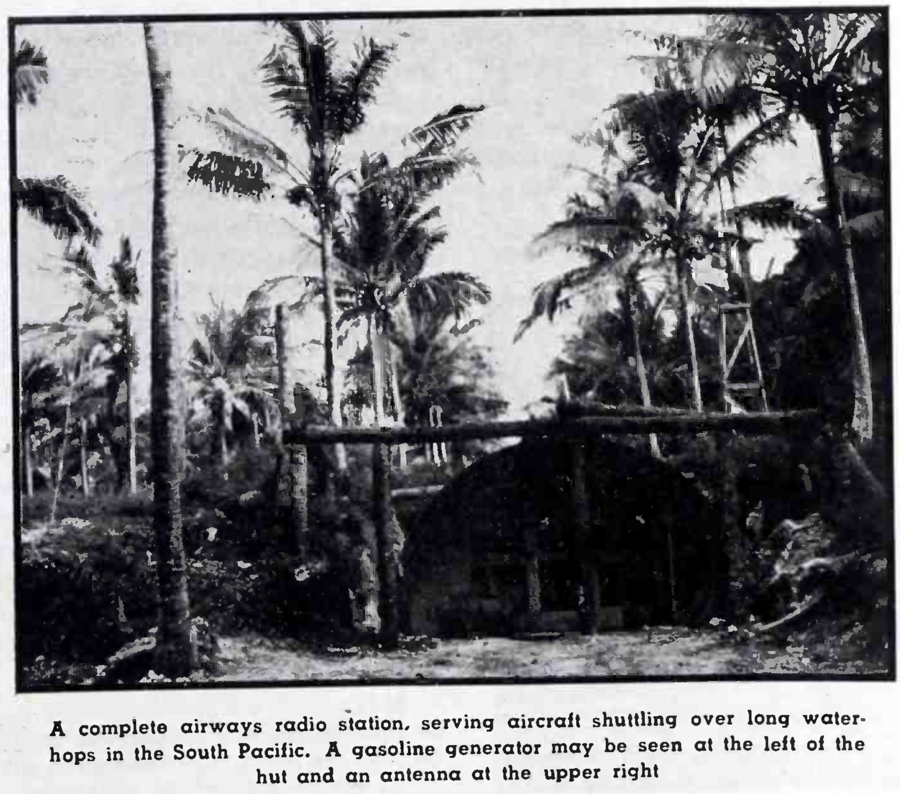
Facilities

The wide variety of services rendered by the AACS requires that it employ practically all known means of communications.

In outpost detachments, where a new installation is just getting under way or where traffic is light, manually-keyed radio circuits are usually adequate. Such circuits are most useful where the traffic does not exceed about 100,000 words per month.

As traffic increases, manually-keyed radio circuits give way to automatic-keyed, high-speed radio circuits. This type of facility is used in stations at major terminals and generally handles from a million to a million-and-a-half words per month. Should point-to-point communications be limited to a few hours a day, due to ionosphere characteristics, automatic keying is particularly useful as it is often permissable for traffic to pile up while circuits are inoperative and then to push it all through during the period in which transmission characteristics are desirable.

Point-to-point communication is used to send dispatcher notices to planes, for identifying planes, for location of planes during flight, to indicate to the next airport when planes are expected to arrive and to assure that the point of arrival has adequate facilities for feeding, housing, and otherwise taking care of the mission. Such point-to-point service is in continuous operation; periodic schedules are not adequate. In the average ground stations, radio operators customarily monitor and guard more than one frequency, although this service is not available in all installations. Communication is frequently carried on by means of 10-channel transmitters, and frequently multiple transmissions are made to insure the safety of crews and to check reports.

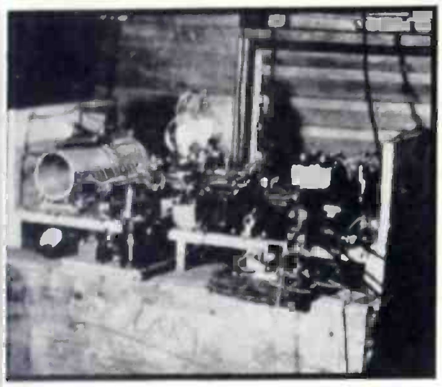


A complete airways radio station, serving aircraft shuttling over long water-hops in the South Pacific. A gasoline generator may be seen at the left of the hut and an antenna at the upper right

Teletype

Where the volume of traffic is appreciably greater than a million words per month radio-teletype systems replace automatic tape circuits. Teletype transmissions can take place at 60 words per minute and additional personnel and time are not required to code messages sent in this manner.

The extensive use which the ACS makes of teletype service nd the rapid expansion which nany of the communications centers undergo has produced some eal problems in design and contruction. To alleviate this trouble nd, so far as possible, to relieve he field personnel of the responsiility for the engineering and planiing of large permanent installaions, Headquarters has undertaken he task of designing many teleype communication centers.



In the best amateur tradition, captured Jap parts are pressed into service to build an emergency transmitter

Upon being advised of the local acilities available for communicaions, Headquarters plans an adeuate center and submits floor plans or the installation. Asheville even rovides its field personnel with erspective photographs indicating eneral appearance and layout. These photographs aid field personel in visualizing what the center hould look like when it is built. This is accomplished by means of nodels of various pieces of teletype quipment and office furniture, uilt to scale and arranged to best neet requirements.

Facsimile

Facsimile picture transmission is mployed not only to speed transmission but also to conserve the ime of key personnel.

Since the number of well-trained veather-forecasters is limited, it is ot possible to have a forecaster t each landing field. However, veather observers can be placed t the various landing fields. These nen make continuous observations nd transmit their meteorological lata to a central station, at which a weather forecaster is located. On the basis of information sent to him, the weather forecaster can make his predictions and prepare a weather map. By means of facsimile such weather maps are transmitted from the key station to other stations in its region. By this method, the usefulness of trained weather forecasters is considerably increased.

Radiophone

Radio-telephone service is installed in airplanes primarily to enable them to communicate with control towers. Few point-to-point services employ radiophones since these are wasteful of frequency as compared to continuous-wave transmission. (Radio-telephone service is used to some extent in a number of Canadian Detachments.) Furthermore, the lack of secrecy of such equipment very definitely restricts the use which can be made of this class of service for military application.

Of course, both commercial-telephone and teletype-wire facilities are used to maximum advantage wherever these are available. Commercial services are used in the United States or other countries where such facilities exist.

Private Wire Facilities

At the various communication centers and airfields, private-wire facilities are used to supplement general or commercial facilities. For example: interphone or intercom equipment is often used, over a private wire line, to connect the engineering department, control tower, base hospital, commanding officer, fire house and crash crew. The purpose of such an emergency line is to provide reliable instantaneous service in the event of crash landing, fire, or other emergencies, without having to depend on commercial circuits. Interphone systems are set up so that stations are connected together throughout all hours of the day and are ready for immediate operation from any one of the interconnected stations. Any station can communicate immediately with any other station on the interphone system.

In addition to interphone or intercom private lines, a special crash-alarm is used at all permanent bases. This connects the tower, fire house, hospital and similar emergency services and important centers. This alarm system is set up so that all interconnected stations can be connected together simultaneously to receive the same message. This system is employed only for crash landings or similar emergencies.

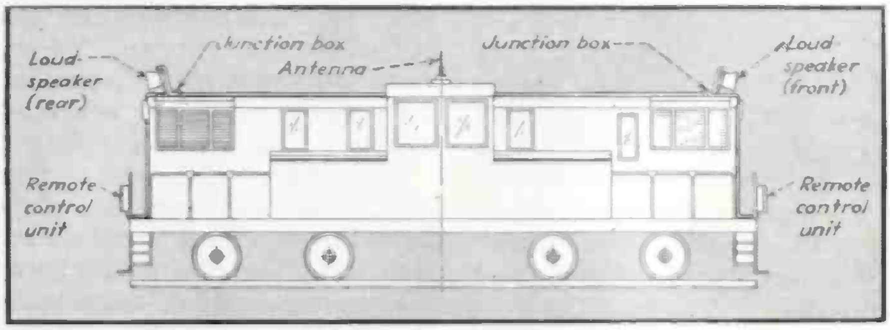
Equipment for the location, con-

(*Continued on page* 204)

Modern AACS control tower, perched like an eagle's nest on top of a hangar at a permanent Army air base

Electronic Communication

Description of typical radio, rail carrier and induction systems used for maintaining two-way telephonic contact. Advantages and disadvantages of each. Discussion of safety devices designed to indicate equipment failures



Space radio telephone equipment on a Diesel-electric locomotive, showing location of whip antenna, auxiliary remote-control units and loudspeakers. The installation may be operated by personnel on the ground or by trainmen

In applying radio and other electronic signaling principles as a means of increasing efficiency and safety in the railroad field, engineers have developed a number of practicable train communicating methods. While the various methods have as a common denominator the electronic tube, and incorporate basic circuits known to the majority of communications engineers, modes of operation differ widely. Each method has certain technical and operational advantages and disadvantages, and practical experience on American railroads has indicated the advisability of considering all methods carefully when selecting a system to meet a specific requirement.

The available train-communicating systems may be grouped under three general classifications, according to the signal propagation method employed:

(1) *Space Radio Systems*, in which radio wave energy is propagated into space by non-directional or directional antenna systems.

(2) *Rail Carrier Telephone Systems*, in which carrier signals, at frequencies usually below 10 kc, are applied primarily to the rails. Reception on mobile units is ordinarily by an inductive method, with pickup coils located in proximity to the rails.

(3) *Induction Radio Systems*, which utilize the combined induction and radiation fields generated by radio-frequency carrier-signal energy impressed on wayside conductors, such as electric power, telephone, or telegraph wires. Carrier signal energy may be inductively impressed on wayside conductors by loop antennas installed in mobile units, or by use of inductive or capacitive line-coupling methods at fixed stations.

Space Radio Systems

Space radio systems, by virtue of their inherent ability to operate without the use of wayside wires or other conductors extending along railroad right of ways, provide the most flexible and versatile means of train communications. As metallic signaling circuits are not required,

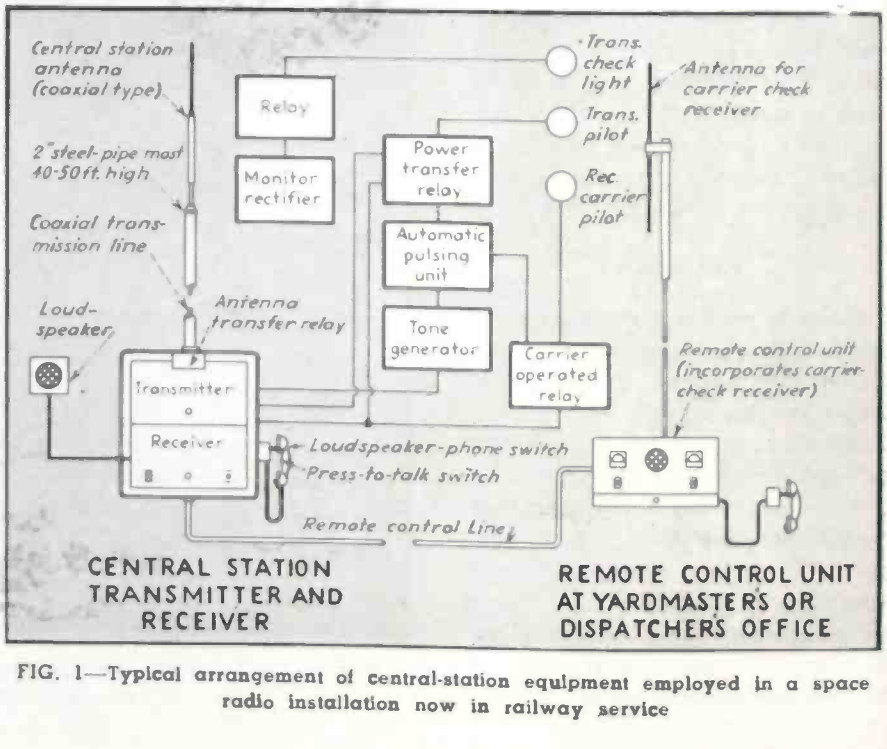


FIG. 1—Typical arrangement of central-station equipment employed in a space radio installation now in railway service

for TRAINS

By WILLIAM S. HALSTEAD

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pace radio system will continue 'unction with full efficiency when yside wires or tracks are damd by storm, floods, or other ses and maintenance of positive imunications along railroad ht of ways is most urgently ded.

n the majority of railroad radiophone installations now in use, quency-modulation equipment igned for operation at frequens above 30 Mc is employed. In ny instances, notably on the rail- systems of government-owned nance plants, operation has been ducted in the 30–40 Mc band, h output power ratings of locotive transmitters ranging from to 50 watts. These installations the most part utilize coaxial liators at central stations to eft relatively uniform propagation radio wave energy in all horital directions, thereby providing nplete coverage of yards extend- over comparatively wide areas.

Many of the railroad radio inllations now in use comprise a ral-station transmitter having ninal power output ratings rang- from 25 to 50 watts, although plitude-modulated transmitters ed as low as 15 watts have been cessfully used for yard operas. The transmitter, its associd central-station receiver, and coaxial antenna are usually inlled at an elevated point or other table location near the center of railroad yard, with telephone e connections to a remote control it at a yardmaster's or dispatchs office as indicated in Fig. 1.

Receiving equipment on locomoes is cooperatively associated with transmitting equipment and normally is mounted in the same case, as shown in Fig. 2. A relay is employed to transfer the antenna from receiver to transmitter. In order to provide an audio signal of good intelligibility within the cab, an audio amplifier having a power output rating of at least 3 watts is ordinarily used in the receiver, while the loudspeaker employed in locomotive cabs is usually of the re-entrant type. Flexible "whip" antennas are employed, as far as is known, in all locomotive radiotelephone installations, so the antenna will not be damaged in entering roundhouses or passing under power lines and other overhead structures.

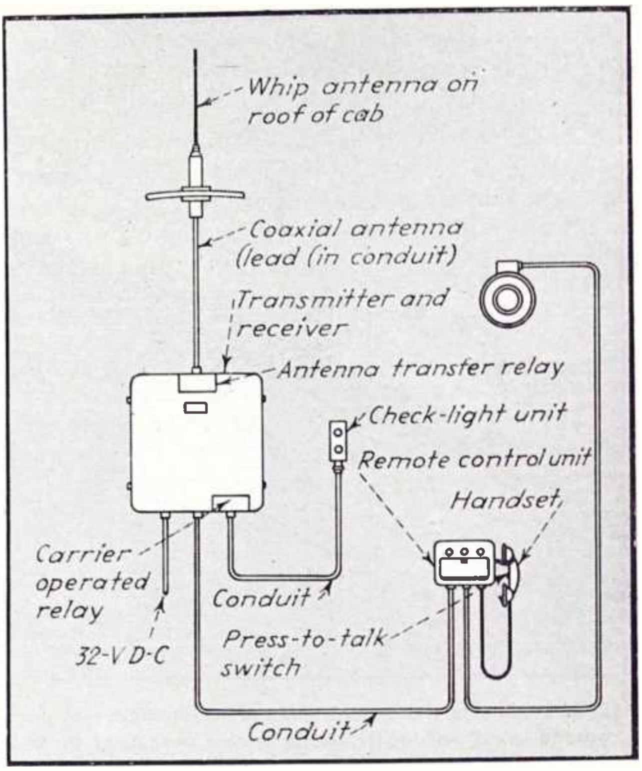


FIG. 2—Equipment used in the cab of a locomotive in a typical space radio installation

Power Supplies and Shock Mounts

Much of the railroad radiotelephone equipment now installed on Diesel-electric locomotives in ordnance plants and elsewhere is operated on a separate 6-volt storage battery, with a belt-driven generator being employed to charge the radio battery during periods in which the Diesel motors are in operation. Voltage regulators are used to maintain proper charging rate, as in the conventional electrical systems of automobiles.

Because of the prevalence of 32-volt d-c power sources on practically all steam locomotives and on many locomotives of other types, it is often desirable to provide radiotelephone equipment designed for 32-volt d-c operation.

All mobile transmitting and receiving units must be protected against the shock and vibration of locomotive service by means of shock mounts of suitable type. On steam locomotives employed in yard areas, proper shock-mount design is of considerable importance as both shock and vibration are of relatively great amplitude and of three-dimensional character. The impact experienced when a yard locomotive moves against a long string of loaded freight cars is often of considerable magnitude and may cause serious damage to components if adequate cushioning of shocks is not afforded.

In addition to the need for adequate protection against shock and vibration, it is important that locomotive radio equipment, on steam engines especially, be properly housed in order to protect components from the damaging effects of water and dampness, as well as from such trouble makers as carbon particles and corrosive gases.

Fail-Safe Provisions

The circuits employed in railroad radio equipment now in service in ordnance plants and at other locations are similar, in general, to

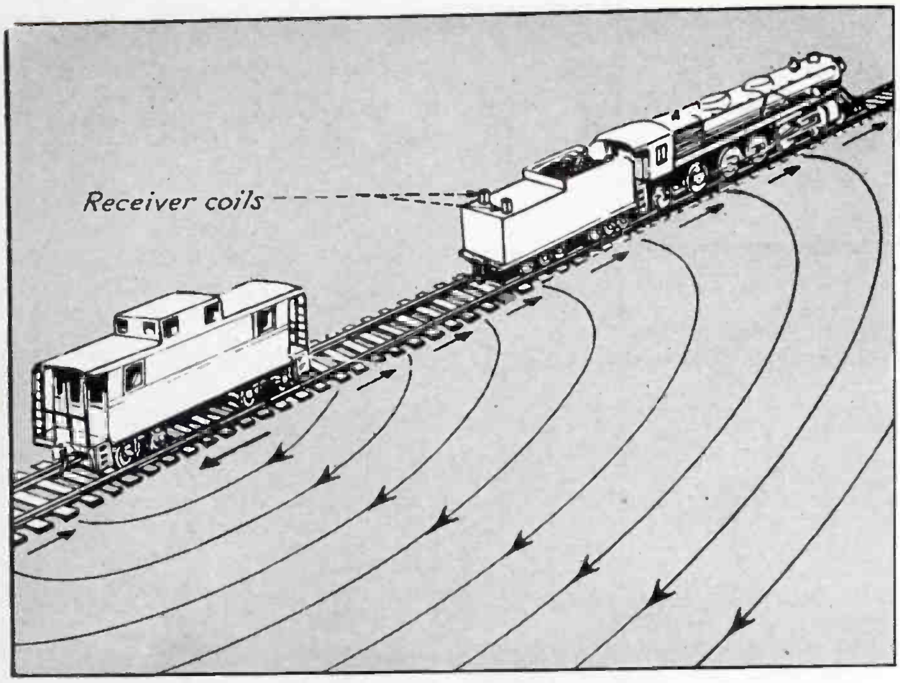


FIG. 3—Current flow from caboose to locomotive through rails and back through ground in rail carrier telephone system developed by Union Switch and Signal Co.

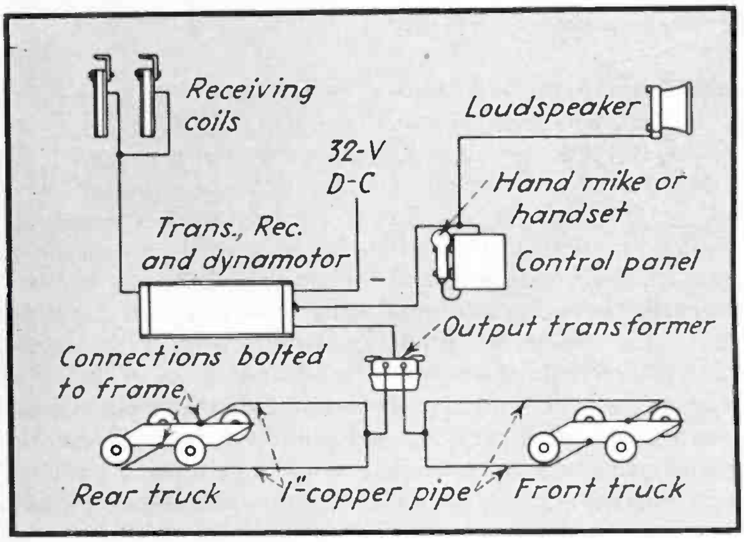


FIG. 4—Block diagram of two-way rail carrier telephone system used on caboose by Union Switch and Signal Co.

those utilized in conventional police radio apparatus. However, in certain instances, protective checking circuits have been incorporated in order to provide an equivalent of the normally closed-circuit principle employed in railway signaling practice. An example is the standard semaphore arm, which drops by gravity to the "stop" position when power fails; the engineer of an approaching train must then follow a precautionary procedure.

Instructions given by radiotelephone to an engineer must be followed in minute detail unless they are countermanded. Should central-station equipment fail after issuance of orders, or should locomotive receiving apparatus become inoperative for any reason, the engineer, if not advised of such failure, would proceed to follow the original instructions regardless of attempts by the dispatcher to change these orders.

Typical Audio-Visual Checking System

In railroad radiotelephone systems developed by engineers of the Halstead Corporation, checking signals are continuously transmitted from the central station or other control station at intervals of several seconds. In locomotive cabs, these signals are reproduced by cab loudspeakers and control the operation of visual indicators to provide audio-visual indication of proper operation of the system.

In a system of this type, which has been successfully utilized in some ordnance plant installations over a period of two years, carrier wave energy is transmitted from the central station at periodic intervals by means of an automatic pulsing device which momentarily keys the transmitter at predetermined intervals. Concurrently with emission of the carrier, a tone signal is impressed on the input circuit of the transmitter. In locomotive cabs, the recurrent pulse signal actuates a check light, while the tone signal is reproduced by the cab loudspeaker. The frequency of the tone signal is such that it may be heard above normal background noise within a cab. In some government-owned ordnance depots, such as the Kingsbury Ordnance Plant, a tone signal of 1000 cycles is utilized. In other installations, frequencies ranging from 180 to 1000 cycles have been employed.

In order to prevent interference between the automatically-transmitted checking signals and voice signals from mobile units or secondary stations operating on the same carrier frequency, a carrier-operated lock-out relay in the central-station receiver automatically suspends pulse transmission during periods in which signals are being transmitted by mobile units or secondary stations.

An overall carrier-check is also utilized at the central-station control point to provide an indication of proper emission of checking and voice signals by the central-station transmitter. In some of the railroad radio installations now in service, this check is provided by means of a meter and a carrier-operated signal light incorporated in a carrier-check receiver located at the remote-control point.

A system of this general type provides a check on overall operation of the radio control system. In event of failure of the central-station transmitter, or any portion of the locomotive receiver, including the loudspeaker, the audio-visual signals are not repeated in the cab, thereby warning the engineer that the radio system is inoperative.

In some locomotive radiotelephone installations in which the dio-visual checking system is emloyed, a carrier-operated relay, orinarily connected in the audio gate r squelch circuit of the receiver, is tilized to control operation of the heck light. In other instances, the heck light is selectively controlled y a relay actuated by rectified sigal energy of predetermined audio requency. In this case, an audiorequency filter having suitable andpass characteristics is emloyed in connection with the audio utput circuit of the receiver to acept the checking signal of predeermined frequency, such as 180 ycles, and to reject voice or other ontrol frequencies. A signal rectier, usually of the selenium or coper-oxide type, is then utilized to onvert the audio-frequency checkg signal into direct-current enrgy for operation of a relay, which ontrols the operation of the check ght.

Protective radio control techiques are of particular value durg freight classifying operations hen a locomotive is pushing a ng string of cars over a "hump" here freight cars are uncoupled, sually one at a time, and allowed coast down to a particular track the classification yard. Inasuch as the engineer is freuently out of sight of critical ard operations in this case it is nportant for the engineer to now that he is in constant touch ith the control point at the "hump" and that in event of equipment failure a positive indication will be given.

In applying radio communicating techniques on mainline trackage, several engineering problems are presented.[1] The substantially line-of-sight propagation characteristics of ultrahigh-frequency radio wave energy, particularly at frequencies above 300 Mc, will probably necessitate the use of automatic repeaters at certain points in urban areas and in mountainous country where obstructions in the transmission path, such as steel-frame buildings and hills, produce objectionable shielding effects. While the use of repeaters in this manner may involve a comparatively large number of wayside units, this equipment should also prove to be of value to wayside personnel who may be expected to utilize the repeater equipment for localized zone communications functions, thus sub-dividing the longitudinal radio-telephone network into a series of zones, each under local control as well as centralized control.

Automatic Repeaters on Main Lines

In repeater networks intended for operation at frequencies above 300 Mc, directional antenna systems with extremely high front-to-back ratios will probably be used for zone to zone work.

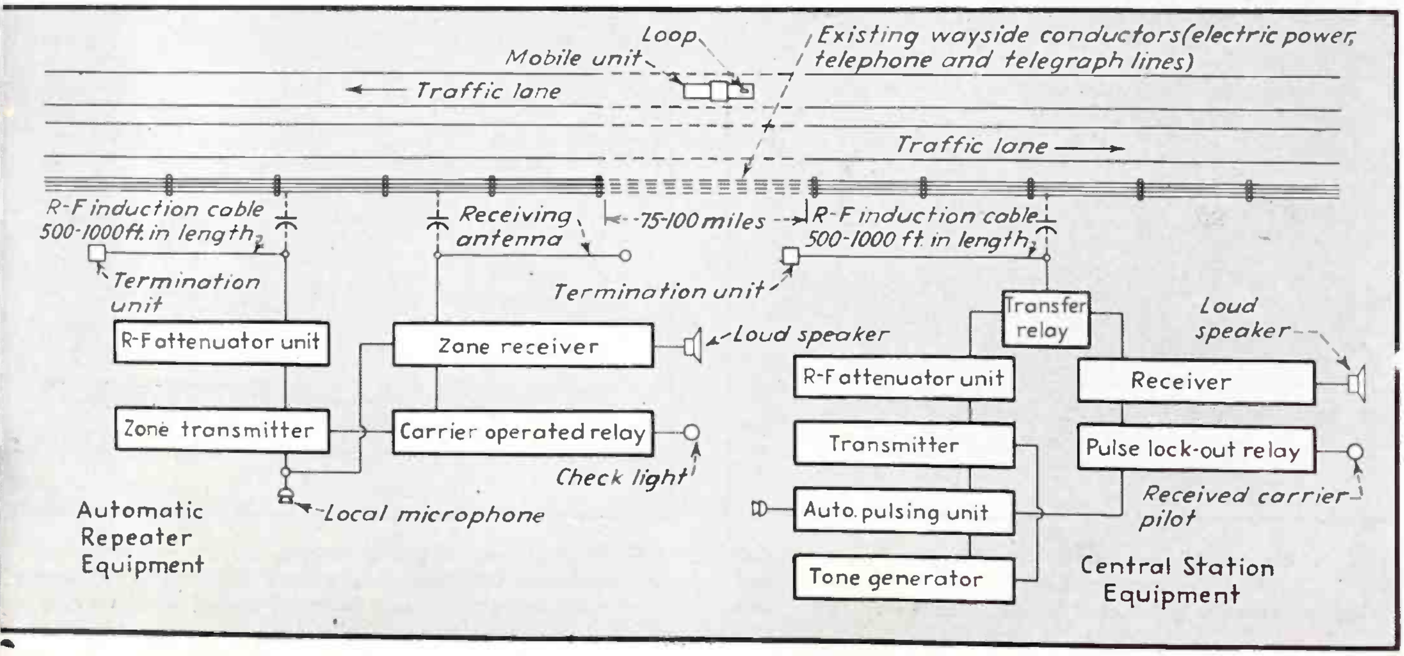
Radiotelephony is also expected to be of particular value in intra-train communications services, such as cab-to-caboose signaling. In this type of service, where distances are relatively short (ordinarily in the neighborhood of 7000 feet or less), the use of frequencies above 100 Mc and especially above 300 Mc appears logical.

Intra-train radio services are aided by the extended metallic ground path offered by the rails, as well as by the wave reflecting media presented by sides of hills and elevated wayside wire circuits where these are present. These factors are of particular importance at curves in railroad right of ways where hills and other obstructions in the line-of-sight transmission path between cab and caboose might otherwise cause objectionable suspension of communications.

Disadvantages of Space Radio

While space radio systems have maximum flexibility and are not dependent on wire and rail conductors along right of ways, the use of space radio, in the opinion of some railroad people, presents a serious problem in that the portions of the radio frequency spectrum where existing commercial equipment may be operated are already overcrowded. Also, any comprehensive use of radio equipment by the railroads must allow for the fact that most of the nation's principal rail transportation systems operate over

FIG. 5—Induction radio system for use on extended railway trackage requiring automatic repeater equipment, showing both inductive and capacitive methods of coupling to wayside conductors paralleling the tracks



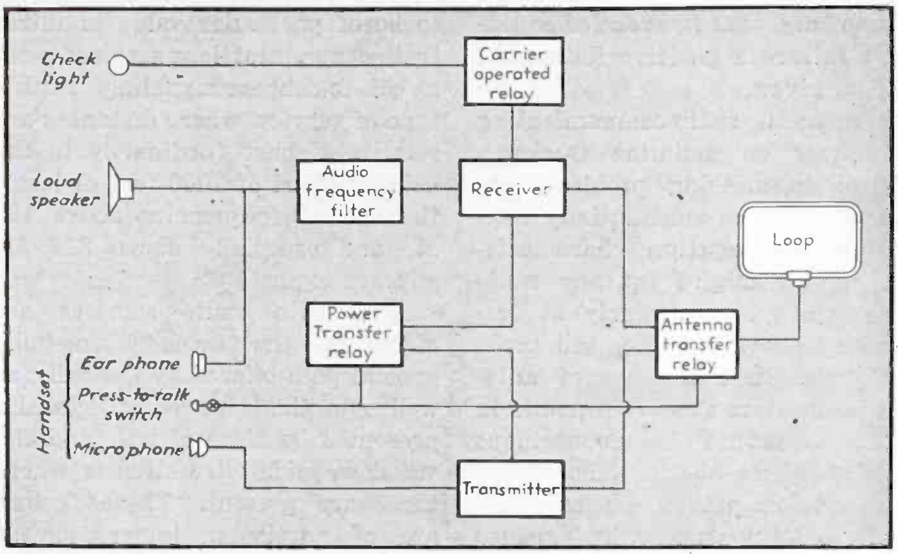


FIG. 6—Block diagram showing units employed on a locomotive in an induction radio system

long distances on an interstate basis, and in some instances a single railway system will span half a continent.

Unlike most other high-frequency radio services, therefore, allocation of frequencies for railroad use cannot be made on a limited-area basis as is the case in the majority of municipal, county, or state police radio installations. Studies now being made by the Federal Communications Commission and other governmental agencies, the Radio Technical Planning Board, the Association of American Railroads, and other groups should result in an intelligent, long-range solution to the allocation problem.

It is likely that full consideration will be given to the possible use of frequencies above 300 Mc, where service assignments have not yet been made, since there is an apparent dearth of available frequencies below 300 Mc. As an aid in this direction, development programs are now being conducted by capable engineering groups to determine the service capabilities of railroad radio equipment operating at frequencies above 300 Mc as well as at lower frequencies.

A relatively large number of automatic repeater stations, plus multichannel operation, will probably be required for use in main line operations. The cost of such repeater equipment, while it may not be prohibitive, does present an economic problem of considerable importance from the railroad operator's point of view.

Rail Carrier Telephone Systems

In rail carrier or induction telephone systems, in which carrier signal energy is fed directly to the rails (and sometimes secondarily to wayside wires), current flow is through the rails, with return through ground as shown in Fig. 3. The concentrated induction field produced by the rail current is utilized in reception by means of pick-up coils, usually located in proximity to the track.

Rail carrier telephone communication systems are useful only within a short lateral distance of rail circuits. As appreciable radiation of radio wave energy does not occur, such systems do not require Federal licensing or frequency allocation. As signals are confined substantially to railroad property, a degree of privacy exists which is not ordinarily obtainable with space radio systems. Rail carrier telephone systems offer means for effecting transmission of signals over comparatively long distances, sometimes in excess of 100 miles between wayside stations and trains and over distances of 10 miles or

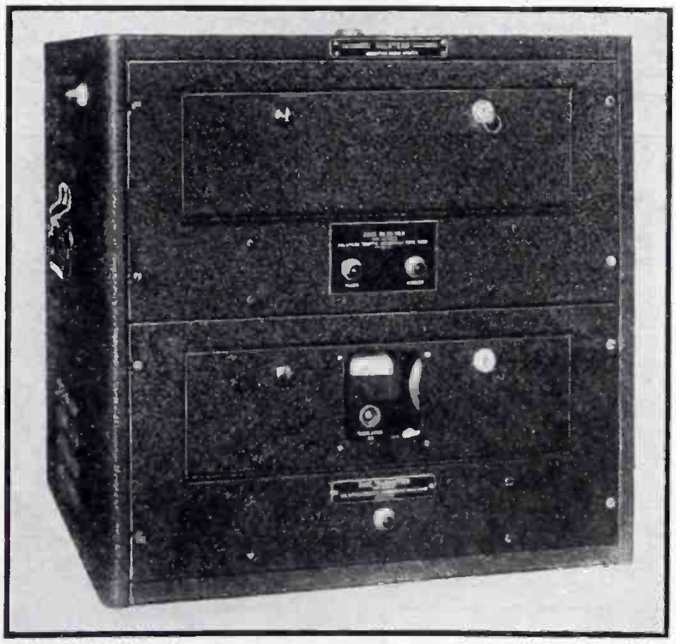


FIG. 7—Induction radio unit for fixed-station use, containing an f-m receiver, a zone transmitter, and a carrier-operated relay to provide automatic repeater functions. Power output is 10 watts

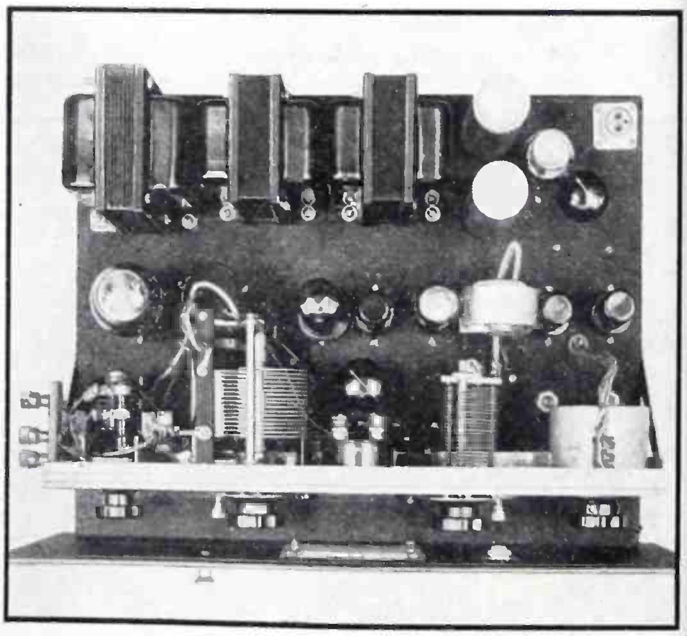


FIG. 8—Top view of the chassis of the f-m transmitter employed in the induction radio unit of Fig. 7. Tuning controls and other adjustments are behind a locked panel having a window for the meter at the center

more between trains, with relative alence of "dead spots" at bridges, tunnels, and other obstructions to normal space radio propagation.

Representative rail carrier telephone equipment now installed and in operation, such as that employed in a train communication system developed by the Union Switch and Signal Company,[2] ordinarily employs the upper side band of a relatively low-frequency rier, such as 5700 cycles. Although frequencies below 10 kc are employed in rail carrier equipment now in operation on railroad systems, it is understood that frequencies as high as 250 kc and above may be utilized.

Carrier signal energy is supplied to the rails by direct metallic connection between the output circuit of the transmitter and the rails, usually by means of a connection from the output transformer to the insulated trucks of the locomotive or caboose. Signals normally are received on mobile units by inductive pick-up from the rails. At fixed stations, carrier signal energy ordinarily is applied between a wire line and a track as ground connection, although in some instances it is understood that signals are applied between tracks.

In rail carrier telephone installations now in service, mobile transmitting equipment with primary power input rating of approximately 500 watts is employed, with four 6L6 tubes in parallel push-pull connection in the power amplifier stage of the transmitter. Signal energy is applied to rail circuits by conductive connection between the output transformer of the transmitter and the rails, usually through the wheels of an insulated truck of the vehicle as indicated in Fig. 4.

The output transformer of the mobile transmitter is connected to a loop of one-inch copper pipe, extending from the insulated truck at one end of the vehicle through the secondary of the output transformer (with which a tuning capacitor is associated) to the truck at the other end of the vehicle, with the loop completed through the running rails between the wheels to which connections are made. The voltage drop across the impedance presented by the running rails between the wheels is the transmitting rail voltage, this voltage being produced along both rails in parallel.

Protective Checks on Rail Carrier Systems

Signal pick-up in mobile units is accomplished ordinarily by means of coils located beneath the mobile units and in proximity to the rails. The signal is then amplified and demodulated, with subsequent audio amplification after filtering and peak-limiting, for operation of the cab loudspeaker.

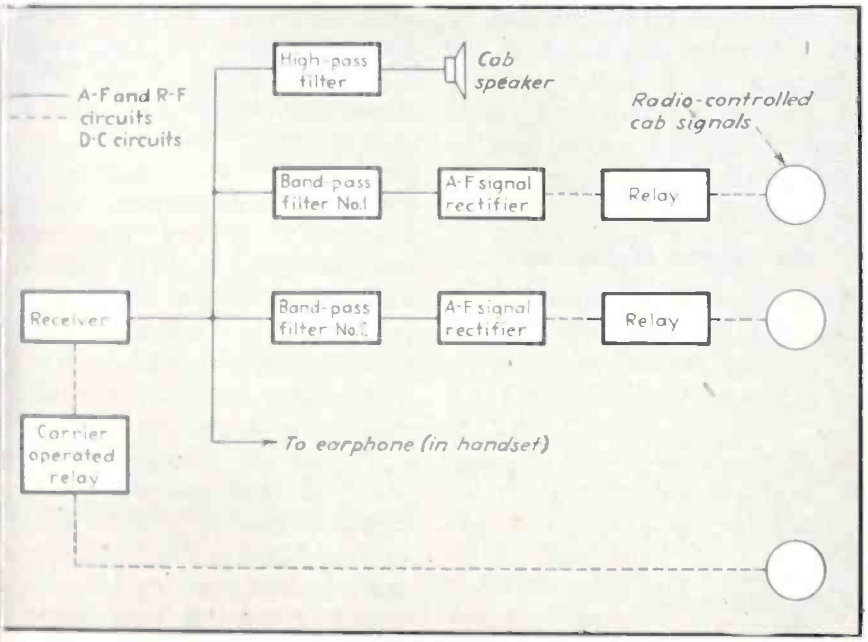


FIG. 9—Block diagram showing a-f signal selector units used in providing one form of automatic cab signal control.. Operation invalues reception of tone signals of predetermined frequencies, each related to a given traffic control signal. Voice signals may be received concurrently without interfering with control functions

An indicating light is provided on a control box associated with the mobile transmitter and receiver, to serve as a check on emission of a modulated carrier. This light flickers with modulation of the carrier, thereby indicating to the user that an effective modulated carrier signal is being transmitted to the rail circuit. A signal selector unit may also be connected with the receiver to control the operation of a bell during calling operations, in which a 1050-cycle tone signal is impressed on the carrier at the station where the call originates. The same selector unit may also be used to control the operation of red and green cab signals. In this procedure, the green, or "proceed," light is energized as long as the 1050-cycle "calling" signal is being received, while the loudspeaker is disconnected. When the tone signal is terminated, the red, or "stop" light is energized, the bell is operated, and the loudspeaker is connected for speech reception. The "proceed" indication is thus given in accordance with the normally closed-circuit principle utilized in other forms of railway signaling.

The range of a rail carrier system is extended considerably when wire lines run parallel to main-line trackage, due to inductive coupling between the rails and the lines.

Disadvantages of Rail Carrier Telephone Systems

Rail carrier or induction telephone systems, in which signal energy is impressed primarily on the rails, require good electric connections or bonding between the rails, which, in some instances, may entail considerable expense. As rail circuits rapidly attenuate carrier signal energy, transmitting equipment is of relatively large power-output rating and size as compared with space radio apparatus. Installation of rail carrier telephone equipment now in operation on some railways also requires the insulation of trucks of both the locomotive and the caboose from the body. If a locomotive is derailed, or in case of actual rail

(*Continued on page* 262)

Synchronized Oscillators as F-M Receiver Limiters

An oscillator stage following the i-f amplifier and synchronized to a subharmonic of the i-f signal gives voltage gain, adjacent-channel selectivity, quieting sensitivity, and good amplitude-limiting action. Synchronizing voltage can be injected in several ways

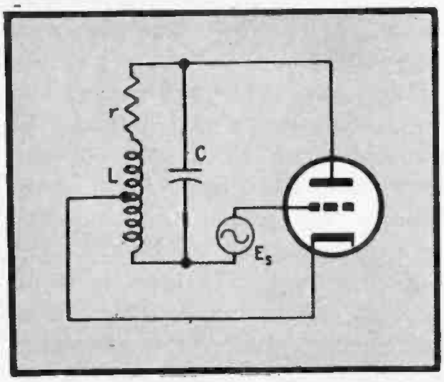


FIG. 1—Impedanceless generator in series with grid injects a synchronizing signal into a simplified Hartley oscillator

IN prewar f-m receivers the only nonlinear element was the amplitude limiter. Distortionless amplification of an f-m signal is independent, within limits, of the amplitude characteristic of the r-f and i-f amplifiers. Accordingly, it was thought that some of the nonlinear but extremely sensitive amplifiers used in the early days and long abandoned for a-m reception might prove useful as limiters in f-m receivers.

Following this line, the Zenith Laboratories in 1941 started a study of the possible advantages of synchronized oscillators in f-m reception. As used in an f-m receiver, the application comprises an oscillator stage following the i-f amplifier, with the oscillator frequency synchronized to the frequency of the i-f signal, or to a subharmonic of it. Thus, if frequency of the i-f signal deviates over 150 kc with a center frequency of 8.3 Mc, the synchronized oscillator may operate over the same range, or at a subharmonic such as 4.15 Mc, with a deviation of 75 kc. The practical application of subharmonic synchronization for frequency division is well known.[1]

Because of the priority of military work, research and development of this type f-m receiver have been on a limited scale. Unconventional ways have been found for using a synchronized oscillator to advantage, but these developments will have to wait for publication until practical application can be realized.

Interest in the phenomena exhibited by synchronized oscillators goes back to the early days of vacuum tubes and references are extensive. Several hundred papers, largely of a theoretical nature, have been written on the behavior of oscillators. Of these, a substantial fraction have dealt with synchronization and frequency division. A few of the best representatives of these references are listed in the bibliography at the end of this article. Papers on actual applications are scarce, for the reason that up to the present, the field has been relatively limited.

Some Actual Applications

There have been several suggested and actual applications to f-m receiver technique. Among these is British Patent No. 163,462, issued to Eccles and Vincent in 1920. It covers the use of an oscillator synchronized at the carrier frequency for the reception of narrow-band f-m, code and phone transmissions. The inherent selectivity of a synchronized oscillator seems to have been realized at this early date. Some work was also done about this time by H. G. Moller[7], who used a synchronized oscillator for f-m code reception

The idea then seems to have languished until the middle thirties In 1935, Armstrong[8] obtained a patent on the use of a synchronized oscillator at the intermediate frequency in an f-m receiver, with a limiter following the oscillator to remove amplitude variations. In 1938, the Japanese[9] described the use of a synchronized oscillator to separate the f-m component from a signal which contained both frequency and amplitude modulation. Their oscillato was adjusted so that it acted simultaneously as a fair amplitude limiter. Synchronization on a subharmonic of the received signal was tried, but unfavorable results were obtained.

In 1940 two Russian workers Kisselgof and Knazev[10], suggested and built a synchronized amplifier for f-m receivers. The oscillator was synchronized at the intermediate frequency, and amplitude limitation was achieved by loading the oscillator with a pair of shunt connected diode clippers. These investigators showed that norma amplifier gains could be obtained in an oscillator stage. The problem of injecting the synchronizing signa from the high-impedance circuit of a preceding amplifier was met by employing a pentagrid tube, the 6L7, with the i-f signal applied to the first grid and the oscillatio circuit connected between the third grid and plate. By thus allowing only electron coupling between the source of injected voltage and the oscillator circuit they minimized interaction between the two cir circuits and thereby eliminated a major feedback problem.

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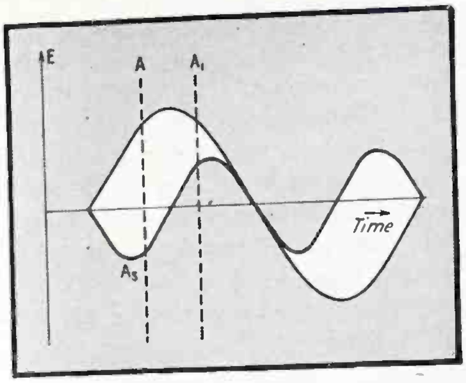
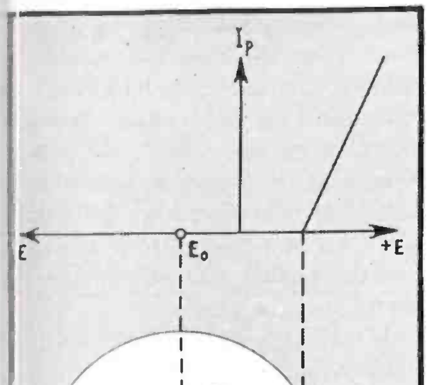


FIG. 3—Phase relations between oscillation and synchronizing voltage when the latter is of twice the former's frequency. Time lapse here represents the amplification period of the tube, during which the effect is that of a synchronizing wave of identical frequency but double amplitude

Practically all the references on the synchronized oscillator are theoretical in nature, and highly mathematical, due to the non-linear differential equations involved. While a simplified explanation may lack rigor, at least it has the advantage of presenting a physical picture of the mechanism of synchronization for both fundamental and subharmonic operation.



IG. 2—Plate current of oscillator in Fig. 1 a function of instantaneous voltage ross tank circuit, which appears as the ojection of vector *A*. For a free-running cillator, (a) angular velocity is assumed nstant. In (b), angular velocity of the synchronizing signal is greater and A_s is the nk-voltage component due to synchronizing voltage

This analysis is based on a consideration of the actions occurring over one cycle of a synchronized oscillator. Such a treatment has been published recently for a free-running Hartley oscillator[11]. Referring to Fig. 1, consider a simplified Hartley oscillator with the tank circuit connected between plate and grid, and with the synchronizing signal injected by an impedanceless generator in series with the grid lead.

Theory of the Synchronized Oscillator

Figure 2(a) shows the plate current of the tube as a function of the instantaneous voltage across the tank circuit. The oscillator is assumed to operate class C without plate-current saturation. Figure 2(a) shows instantaneous oscillator voltage as the projection of a vector A of variable length, rotating in a counter-clockwise direction. For a free-running oscillator, i.e., $E_s = 0$, the angular velocity of this vector may be assumed constant over the cycle. From A_1 to A, the g_m of the tube is zero, the damping factor of the oscillation is positive, and the vector amplitude decreases exponentially.

From A to A_1, the amplitude must increase exponentially to its original value if oscillation amplitude is to remain stable. During this amplification period, when the tube is conducting, the damping factor is negative. The condition for stability in a free-running oscillator is that the loss in amplitude during the cut-off period, when the tube is not conducting, must be just equal to the gain in amplitude during the amplification period.

We have assumed that for a free-running oscillator the angular velocity of the amplitude vector is constant, and equal to the resonant angular velocity of the tuned circuit. Actually, angular velocity during the amplification period will differ from this, because of the changed circuit conditions during this period, with the result that the *average* angular velocity of the amplitude vector of a free-running oscillator over one cycle will, in general, not agree exactly with the resonant angular velocity of the tank circuit.

The possibility of a change in angular velocity during the amplification period gives the clue to what occurs during synchronization. For if E_s is not zero, and has an angular velocity not equal to that of the free-running oscillator, stable synchronization means that the average angular velocity of the oscillation amplitude vector must change until it is equal to that of the injected signal.

During the cut-off period, synchronizing voltage E_s can have no effect on the oscillation vector, the angular velocity of which during this period is, say, ω_o, the resonant angular velocity of the tuned circuit. During the amplification period, however, E_s causes a component of plate current which may change the phase angle of the oscillation vector. Thus the angular velocity of the oscillation vector during the amplification period may be decreased or increased, depending on whether the phase of the plate current produced by E_s is lagging or leading the phase of the free-running oscillation current at the start of the amplification period.

If the angular velocity of E_s is

greater or less than ω_o, synchronization occurs only when the A vector rotates through 2π radians in exactly one cycle of E_s. The condition for stable synchronization is that the gain or loss in relative phase angle between A and E_s during the amplification period shall exactly balance the loss or gain in relative phase angle during the cut-off period.

Vector Relations

In Fig. 2(b), are shown the vector relations existing when the angular velocity of the synchronizing signal is greater than ω_o, the free-running angular velocity. Here A_s is the component of the tank voltage due to the synchronizing voltage E_s. This component is added in quadrature with the oscillation vector during the amplification period, so the angular velocity, ω_1, of the resultant is increased during this period. If ω_s is the angular velocity of the synchronizing signal, the average value of angular velocity of the resultant over a complete cycle must be equal to ω_s, for stable synchronization.

For a given difference between ω_o and ω_s, the angular velocity of E_s, the phase angle between E_s and A at the start of the amplification period will be 90 deg for the minimum amplitude of E_s required for synchronization. If the magnitude of E_s is less than this critical value, the gain in phase during the amplification period will not balance the loss in phase during the cut-off period, and the effect of E_s during the next conductive period will be reduced due to the discrepancy in correct phasing at the start. Thus the phase conditions never stabilize, and no synchronization exists.

If the magnitude of E_s is greater than that required at optimum phasing, the gain in phase during the amplification period will be greater than required, and the phase at the start of the next amplification period will be less than 90 deg, thus reducing gain in this period. This process will continue until the relative phase at the start of the amplification period is reduced to a value which remains stable with the given magnitude of E_s.

The phenomenon of stable synchronization is thus due to the fact that the oscillation vector can slip in relation to the synchronizing vector until stable phase and amplitude conditions are reached. If E_s is variable in frequency, but always of sufficient amplitude, the oscillator will adjust itself almost instantaneously to every change in frequency of E_s.

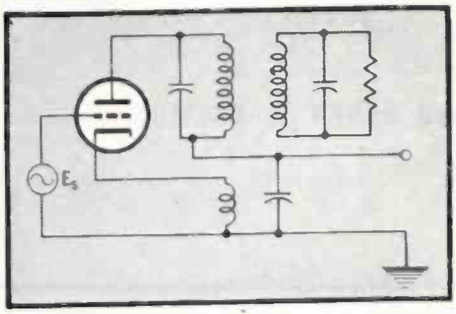


FIG. 4—Addition of a tuned secondary to the tank-circuit inductance increases synchronization sensitivity by reducing phase-angle variation of the primary impedance

Synchronization with an injected signal whose frequency is a multiple of the free-running frequency can be explained in a similar manner. Figure 3 shows the phase relations which might exist during the amplification period and between the oscillation voltage and a synchronizing voltage of twice the frequency. During the active period the double-frequency synchronizing wave is practically equivalent to a synchronizing wave with the frequency of the oscillator but twice the amplitude of the double-frequency wave. It is clear that if the amplification period extended beyond the boundaries marked in Fig. 3, the effect of the injected voltage at double frequency would be to decrease the desired change in oscillation vector phase, since the added portions would produce a reactance change in the opposite direction.

For subharmonic operation, the fraction of the oscillator cycle comprising the amplification period should be limited to a half cycle (or an odd multiple of a half cycle) of the synchronizing voltage.

Sensitivity of Synchronization

While the method of injecting synchronizing voltage shown in Fig. 1 cannot generally be realized in a practical f-m receiver, it can be used to illustrate the factors affecting synchronization sensitivity of the amplifier-limiter in practical circuits, since the same gener principles hold for all.

Synchronization sensitivity ma be defined roughly as the amplitu of the injected voltage required synchronize the oscillator over given frequency range of the sy chronizing voltage, for a given o cillator frequency and amplitude.

Since the synchronization pro ess is essentially that of adding reactive component of current du ing a fraction of the oscillat cycle in order to slow down or spee up the angular velocity of the osci lation vector during this perio the action is similar to that of frequency modulator of the rea ance tube type. Factors affectin sensitivity are the same in bo cases.

The L/C ratio of the tank ci cuit should be as high as possibl since then the reactive voltage d veloped across the tuned circuit is maximum for a given amplitude reactive plate current. The g_m the tube during the amplificatio period should be as high as possibl to secure the required reactive pla current with the least injected vol age.

With the single-circuit oscillat shown in Fig. 1, sensitivity ca usually be increased for low osci lator voltages by damping th tuned circuit. If damping is i creased, the amplitude of the r quired reactive plate current r mains the same for a given devi tion from the resonant frequenc

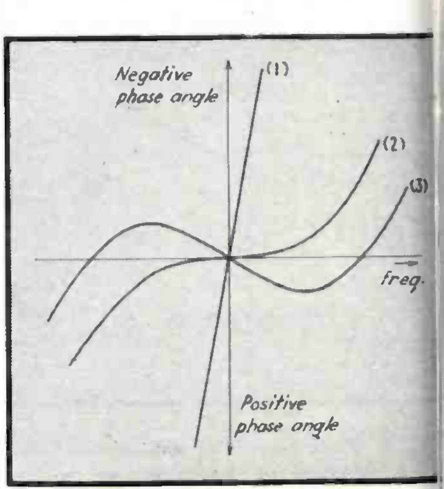


FIG. 5—Phase characteristics of primar impedance in Fig. 4 for a single circuit (1 two circuits critically coupled (2) and tw circuits over-critically coupled (3). In curv (3), synchronization sensitivity in the cente is largely lost

since the decrease in impedance of the tuned circuit is balanced by a decrease in the phase angle of the impedance. However, the g_m of the tube during the amplification period must be increased to maintain the same oscillator voltage, and hence the required synchronizing voltage on the grid of the tube is decreased. For optimum adjustment, damp the tuned circuit until, for a desired oscillator voltage, the plate current and the g_m of the tube are as high as possible.

In a single-circuit oscillator the required reactive current varies linearly with frequency deviation for a small range on either side of resonance, since it varies with the sine of the phase angle of the tuned circuit impedance. This phase-angle variation may be reduced by a large factor over a small range, and synchronization sensitivity correspondingly increased, by adding a tuned secondary to the tank circuit inductance, as shown in Fig. 4. If circuit Q factors and coupling are adjusted to give a band-pass characteristic over the desired frequency range, the phase angle variation of the primary impedance can be easily reduced by a factor of five or more, with a corresponding increase in the synchronization sensitivity.

Figure 5 shows the phase characteristics of the primary impedance for (1) a single circuit, (2) two circuits critically coupled, and (3) two circuits over-critically coupled. Even a moderate degree of coupling will provide considerable improvement of the sensitivity. This increase in sensitivity with a band-pass tank circuit was first noted by Sterky.[12] If the two circuits are over-critically coupled, giving the phase characteristic (3) of Fig. 5, the free-running frequency of the oscillator tends to rest on either side of the double bend in the characteristic, and synchronization sensitivity to a signal in the center is largely lost. This condition may also occur unintentionally through regenerative coupling to a preceding high-Q i-f circuit, and is to be avoided at all costs.

Difficulties with Subharmonics

All the factors discussed above, namely High *L/C* ratio, high g_m, and two-mesh tank circuits, which make for high synchronization sensitivity at the fundamental, also hold for synchronization at a subharmonic of the injected voltage. This is because, as discussed above, the action of the injected signal at a higher frequency than the oscillator, over a limited period of amplification, is exactly analogous to the action of a signal at the same frequency as the oscillator. There is, however, some loss in sensitivity over operation at the fundamental, due to the restriction of the amplification period, and the only justification for subharmonic operation is that it avoids the practical difficulties of feeding an oscillator from a high-impedance source, and minimizes difficulties in oscillator alignment due to overall regeneration.

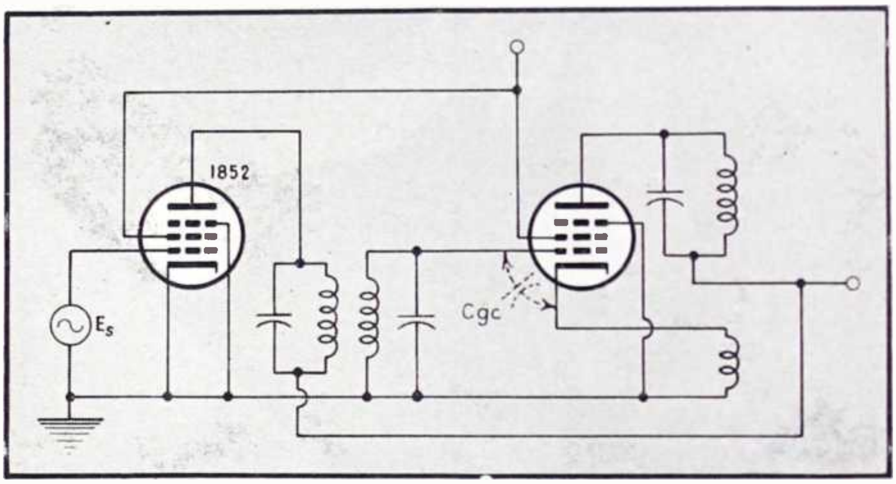


FIG. 6—Typical synchronized-oscillator circuit having synchronizing voltage developed in the grid circuit of the type 1852 tube while oscillation is maintained by a cathode tickler winding

Some of the loss in sensitivity entailed in subharmonic operation can be recovered by a proper adjustment of bias on the oscillator, since this determines the length of the amplification period. In general, however, fixed bias on the oscillator grid makes it difficult to start at the desired level of 5 to 10 volts, and not much latitude exists in bias voltage.

Suppression of Subharmonic Oscillations

An unpleasant feature which is associated with high sensitivity for subharmonic operation is the long-known fact that oscillations at the subharmonic frequency are suppressed if the injected signal rises to the same order of magnitude as the oscillator voltage. This is sometimes not recognized at first if a demodulated signal is viewed on an oscilloscope.

Distortion caused by suppression of the subharmonic at the center of the band then has a similar appearance to distortion caused by insufficient synchronizing signal and the consequent loss of synchronization over part of the modulation cycle. The effect appears to be due to upper bend saturation in the tube characteristic, so that too much injected voltage lowers the effective g_m of the tube to the point where the lower-frequency oscillations can no longer be sustained. While this effect is analogous to i-f overloading in an a-m receiver, the resulting audio distortion is much worse, and cannot be tolerated.

If minimum synchronizing voltage, delivered by the i-f amplifier, is of the order of a volt, suppression of the subharmonic oscillation by stronger signals can be satisfactorily overcome with a complete automatic gain-control circuit deriving voltage from rectification in the last i-f grid circuit before the limiter. If, however, full advantage is taken of the gain in a synchronized oscillator, the required minimum synchronizing voltage will be much less than one volt, and generally there will not be enough gain in the i-f amplifier to provide satisfactory gain control. Fortunately, special circuit means exist that will not suppress the oscillation until the voltage on the last i-f amplifier is high enough to cause this stage

(*Continued on page* 332)

Carrier Communication

Orders go to crane operators by wireless means in this installation and all transmissio is cleared through a central desk. Inherent disadvantages of telephone systems are ove come while control and coordination are improved

Experimental model of special-design receiver for carrier-current signal reception fits into the corner of a crane cab at plant No. 2 of GM's Fisher Cleveland Aircraft Div. At the controls is R. B. Jones, who had charge of construction and testing on the installation

By M. L. SNEDEKER *Radio Section General Foreman, Fisher Cleveland Aircraft Div., General Motors Corp., Cleveland, Ohio*

DIRECT audio communication with crane operators has been provided in many industrial plants by telephone. The utility of such systems has often suffered from delays in transmission of orders because of a busy line and confusion because several individuals might call the cabman concerning the same job of lift.

Clearing of all instructions to the crane operators through one central desk is highly desirable since it enables the operations foreman always to know just where each of the several cabs is operating. There are also occasions when two cabs must operate from the same bridge for lifting heavy pieces. In addition to requiring no special conductors, a carrier-communication system held the promise of greater flexibility than telephone service.

Power Distribution System

As is usually the case, working out the idea required considerably more effort than its formulation did. An investigation was first made of the power distribution system of the plant. Several interesting points came to light—chief among which was the fact that it consisted, for the most part, of three-conductor sheathed-in-lead cable having a very high capacitance to ground.

From the 132-kv high-line, two banks of transformers feed tw 4800-volt busses to the various sub stations throughout the plant. I each sub-station is located a 480 440-volt step-down transforme connected delta-delta.

Line Coupling Unit

An attempt was made to feed th 160 kc carrier frequency into th 440-volt service mains. As ex pected, there was little or no suc cess—variations in the power loa were very great, with the resul that transmitter loading was als changed.

The r-f energy was next fed int the 4800-volt side of one of the sub-stations through a 0.001 μf blocking capacitor. Considerable difficulty was experienced in coupling the transmitter output to the power mains; impedance of the power system was such that satisfactory loading of the transmitter could not be achieved. A number of schemes were tried, the final result being the tapped vario-coupler shown in Fig. 1.

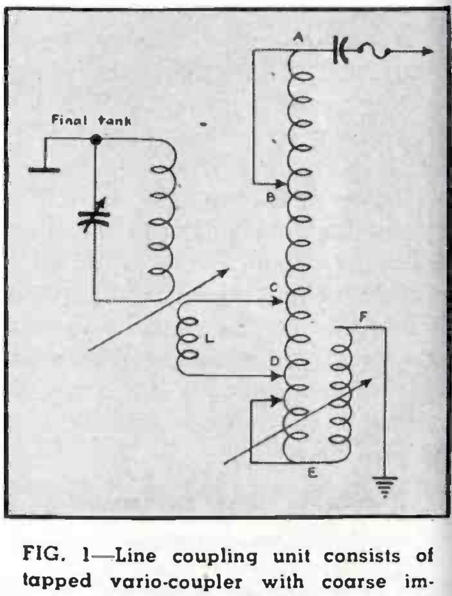


FIG. 1—Line coupling unit consists of tapped vario-coupler with coarse impedance-matching adjustment by taps

to Crane Cabs

Between *C* and *D* the winding is tped every turn: this allows the ipedance of the link *L* to be csely matched. The winding beteen *A* and *B* is tapped every senth turn. This provides a carse adjustment of inductance ile fine adjustment is made with te rotor *EF*. The entire vario-upler *AE* consists of 272 turns of o. 16 wire on a four-inch diamer form.

In the rotor are 34 turns of No. wire on a three-inch diameter frm. Inductance is 0.07 mh. The k *L* consists of 12 turns of No. 1 enameled wire, wound on a 3½-i diameter form. This is coupled ncentrically to the final tank circit of the transmitter. With this arangement it is possible to load te transmitter to any desired aount, and power-load variations sem to have no effect.

Using this set-up with an r-f wer of approximately 50 watts, ecellent coverage throughout the ant was achieved, even though sme of the runs through the lead-seathed 4800-volt cables were seval hundred feet in length. Car-r-frequency traps in the load es adjacent to the feed point re not used since there was satisctory signal strength without tem.

Comprising a 6F6 electron-upled oscillator operating at 160 kc, a 6V6 buffer and two 807's in parallel as the final amplifier, the transmitter circuit is quite conventional.

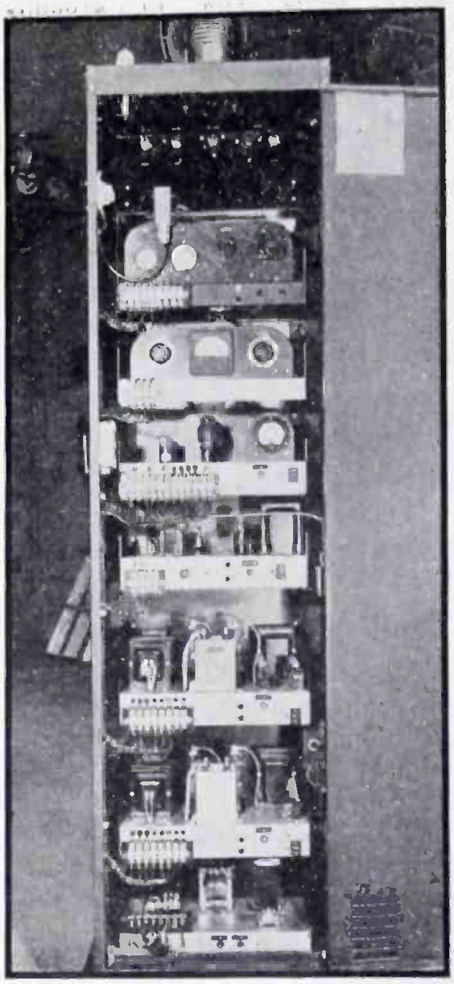
Transmitter for Minimum Maintenance

Push-pull 6L6's are used in the modulator unit. While the circuit of the transmitter is more or less standard, there are two special features. Every component of the transmitter, and particularly of the power supply units, was designed to operate considerably below its maximum rating since the system is in operation 24 hours a day. This over-design has paid dividends by providing almost zero maintenance.

The entire transmitter is housed in a cabinet with a thermostatically controlled blower set to operate when the ambient temperature exceeds 130 deg. F. A block diagram is shown in Fig. 2.

Special Receivers Required

Initial tests, made with a commercial receiver in a crane cab, indicated that special receiving equipment would be necessary. The electrical noise level in the plant was so high that ordinary noise suppression circuits were useless. It was evident therefore that a signal of considerable strength would have to be available at the receiver and also that a highly effective squelch circuit must be employed.



Cabinet of carrier-current transmitter contains, from top to bottom, line matching unit, final amplifier, oscillator-buffer, modulator, local speech amplifier, modulator power supply, final power supply, and control elements. Thermostatically-controlled ventilating blower has intake through elbow on top

With these requirements in mind, an r-f power of 50 watts was decided upon, and a great deal of experimenting was done with all sorts of noise-reducing circuits.

The receiver used in the crane installations was designed by E. T. Rosenberg and is diagrammed in Fig. 3. Of special interest is the squelch circuit.

Employing a straightforward t-r-f circuit, the receiver uses three 6SK7 tubes as r-f amplifiers, a 6SQ7 tube as diode detector and first audio amplifier, a 6F6 as power amplifier, a 6SJ7 in a squelch or carrier-operated noise-suppressor circuit, and a type 80 rectifier. Ordinary 175-kc i-f transformers tuned to approximately 160 kc are utilized as interstage transformers T_1 to T_4.

Bias for the first two r-f amplifiers is obtained through a 500-ohm resistor in each cathode, both re-

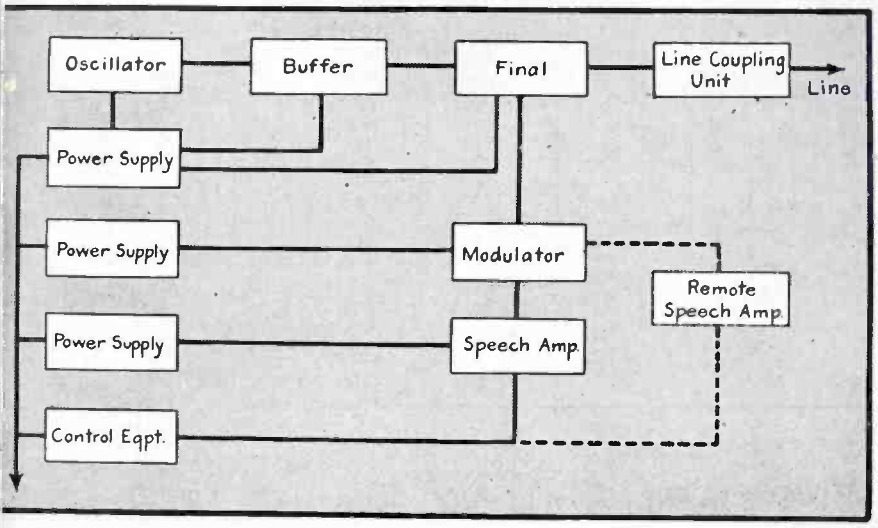


FIG. 2—Block diagram relates functions of units in transmitter rack illustrated. Remote speech-amplifier is located at the dispatcher's desk, with duplicate in cabinet for test purposes

sistors being run to ground through a common 25,000-ohm sensitivity control. In ordinary operation this control is left in the extreme counter-clockwise position, of maximum resistance. The cathodes are then approximately 13 to 15 volts above ground. The third r-f amplifier has a cathode bias of 2.5 to 3 volts, obtained by means of a 500-ohm resistor from cathode to ground.

Screen voltage for the r-f amplifiers and the squelch tube is obtained from a voltage divider consisting of a 15,000-ohm resistor and a 10,000-ohm resistor in series across the power supply. This arrangement supplies approximately 100 volts to the screens.

Incorporated in the plate supply lead to each r-f amplifier is a filter consisting of a series 10,000-ohm resistor and a 0.05-μf by-pass capacitor. Voltage, measured at the plates of the 6SK7 tubes, will be from 225 to 285 volts, with the voltage at the third r-f tube plate being somewhat lower than the others, due to the lower bias and higher plate current.

The type 6SQ7 tube is connected as a conventional diode detector and audio amplifier; the diodes being tied together to form a half-wave rectifier. Rectified r-f voltage appears across the load resistors, 50,000-ohms and 250,000-ohms connected in series from the cathode to the low side of the r-f transformer secondary.

Audio voltage is picked off at the junction of the resistors and applied across the 250,000-ohm volume control through a 0.004-μf capacitor. The arm of the potentiometer goes directly to the grid of the triode, which is resistance coupled to the 6F6 output tube. Bias for the 6SQ7 is obtained by means of a 5,000-ohm resistor from cathode to ground. The 10,000-ohm squelch control is in parallel with this resistor. Since the cathode of the 6SJ7 squelch tube is tied to that of the 6SQ7, the total plate current of both tubes flows through this parallel combination.

Squelch Circuit

Operation of the squelch circuit is as follows: The control grid of the 6SJ7 is tied through a 0.5 megohm filter-resistor to the low side of the diode load resistor. With no signal, there is no diode current and no voltage drop across the diode load resistor. Since the 6SQ7 and 6SJ7 cathodes are connected together, there is no bias on the 6SJ7 tube, which, therefore draws 6 or 7 ma of plate current. This causes a large drop across the paralleled 5,000-ohm resistor and 10,000-ohm squelch control, biasing the 6SQ7 beyond cutoff and rendering the receiver inoperative.

When a carrier is received, a d-c voltage appears across the diode load resistor and biases the 6SJ7 to cutoff. The only current now flowing through the paralleled bias resistor and squelch control is the plate current of the 6SQ7, the bias of which is now at the correct operating value, and the receiver functions normally. Obviously, the receiver should never be operated with the squelch in the maximum clockwise, or minimum resistance, position as this will remove all bias from the 6SQ7 and cause excessive current to flow. Bias on the 6SQ7, without signal, is 15 to 17 volts; with signal, 1.5 to 2 volts.

Voltage at the plate of the 6SQ7 is approximately 200 to 250 volts. Voltage at the plate of the 6SJ7 is 285 to 300 volts, the same as that at the screen of the 6F6 since both are connected directly to the output of the plate supply filter. Plate voltage on the 6F6 is 275 to 290 volts and grid bias, about 17 volts, is obtained by means of a 500-ohm resistor from cathode to ground.

Designed for 110-volt 60-cycle operation, the receiver power supply consists of an ordinary, commercial power transformer, full wave rectifier, and single-section capacitor input filter. For operating the receiver from the 440-volt 3-phase power source in the crane cabs, the primary of the power transformer is connected in series with a bank of four 50-watt, 115-volt, rough-service lamps across one phase. A separate fuse and switch-box is provided for the receiver which is independent of the interlock and manual safety switches in the crane cab. The antenna lead from the receiver is connected to all three phases

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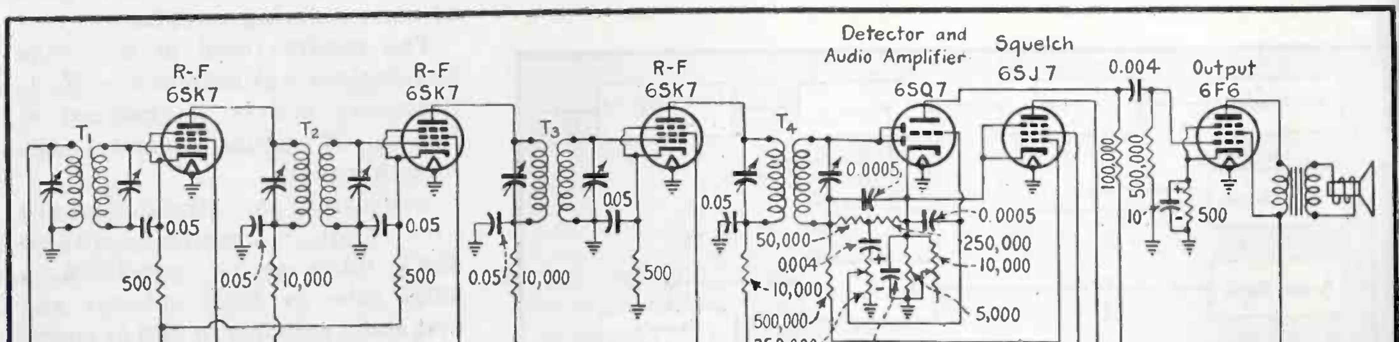
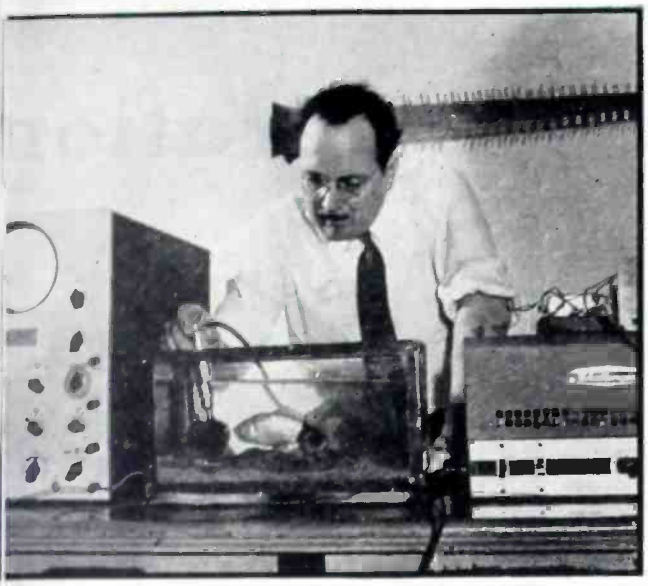
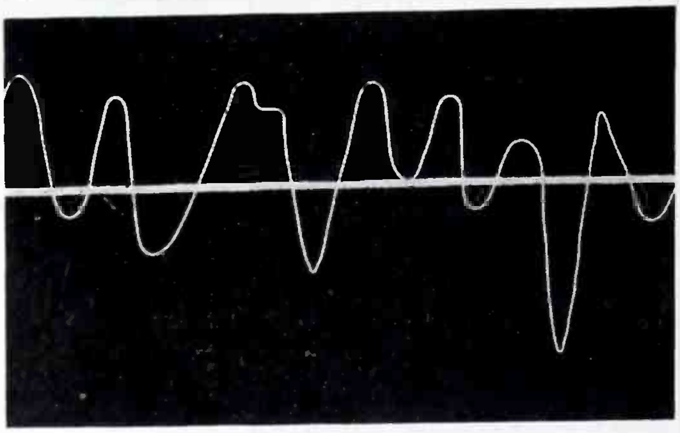


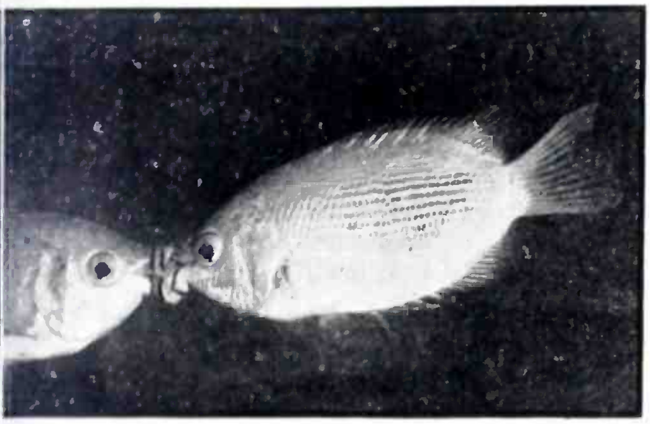
FIG. 3—Schematic diagram gives details of special receiver designed and built for carrier-current crane communication. Controls include sensitivity, volume, and squelch

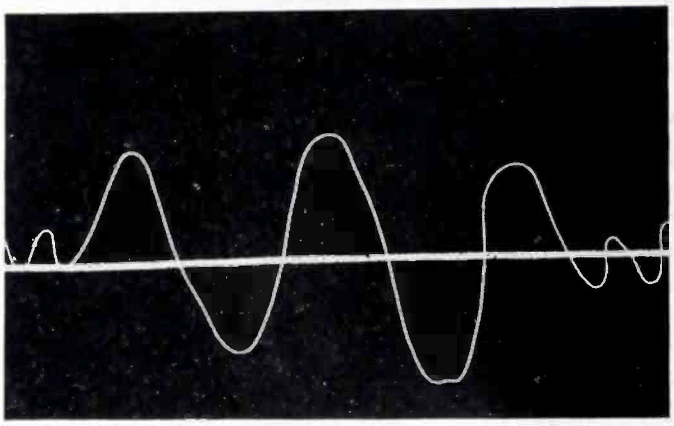
FISH TALK



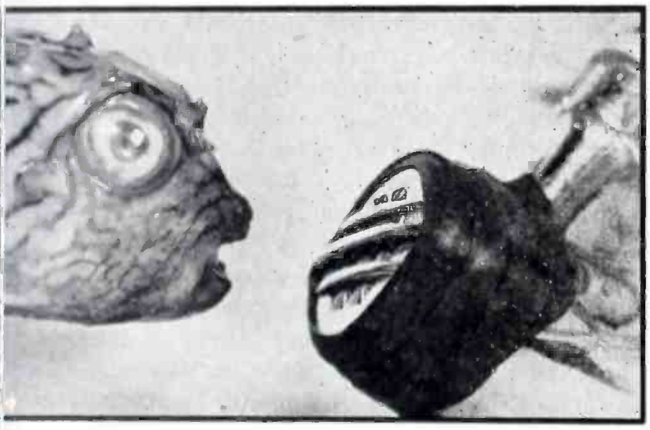


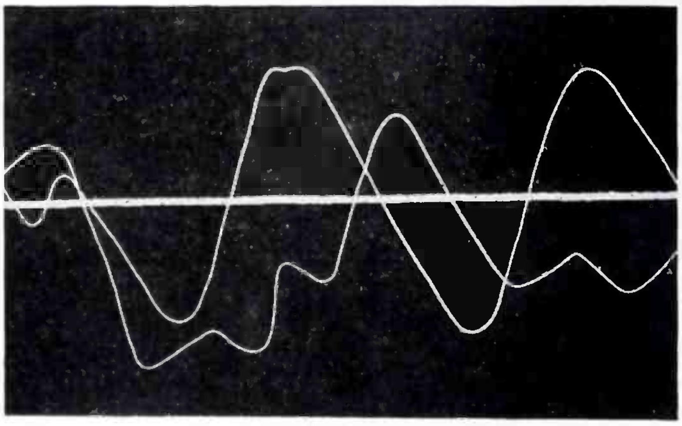
Working with the set-up above, Dr. Christopher Coates of the New York Zoological Society Aquarium has classified fish moods and their corresponding audible manifestations. Trace at right represents the sounds of feeding goldfish



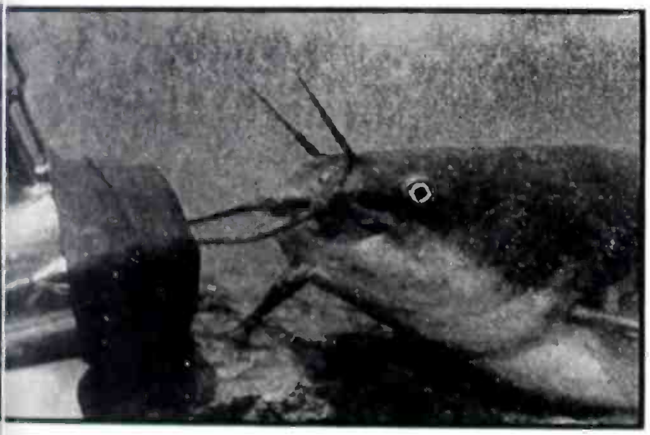


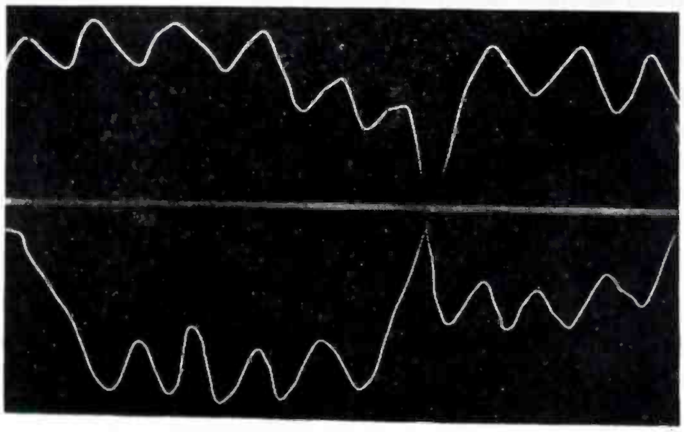
Osculation at left and corresponding oscillation at right, above, characterize an amorous pair of Malayan gouramies. Many fish make sounds by grinding their teeth, while others blow air from swim bladders to make croaking noises





No political implications, just an angry boxfish, above, expressing indignation after having been jabbed with a pencil. Grunts of annoyance form agitated, uneven curves. Happy catfish, below, produces purring sound pictured at the right





28-Volt Operation of Receiving Tubes

By C. R. HAMMOND, E. KOHLER and W. J. LATTIN

Ken-Rad Tube & Lamp Corporation, Owensboro, Kentucky

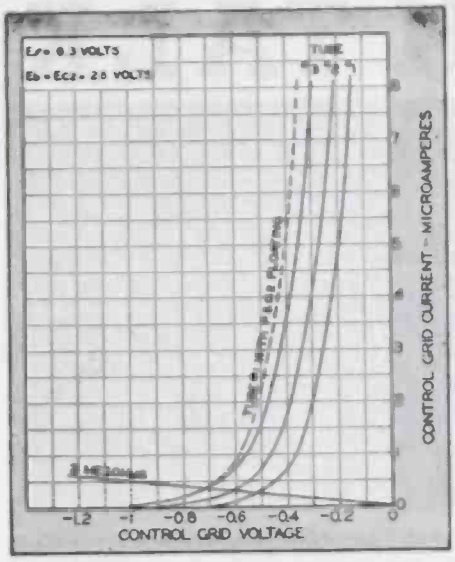


FIG. 1—Typical grid current characteristics of type 9003 pentode in contact potential region

THE APPLICATION of receiving tubes at plate and screen voltages of 28 volts enables the designer of aircraft radio and related equipment to effect substantial simplifications. The direct use of the aircraft primary battery for the B supply permits elimination of high-voltage generating components with consequent reduction in size, weight, cost, maintenance, and power requirements of the equipment. Improved reliability and efficiency are also obtained.

Heretofore there has been a lack of published data and performance ratings covering operation of available tube types from a 28-volt B supply. This paper attempts to provide this data for typical operation of standard r-f pentodes, triodes, and voltage amplifier types. Single-ended 12-volt metal types were chosen, mainly because they have been the accepted standard of the Services and of the majority of leading aircraft radio manufacturers. Miniature tube types are included because they will exhibit advantages in vhf equipment. Data on several GT double-triode types are given, since it is thought they may find application as phase inverters, multivibrators, or oscillators.

Operating Problems at 28 Volts

Operation of electron tubes with plate and screen voltages obtained directly from the primary 28-volt aircraft battery offers a few difficulties which must be recognized in establishing design practices, equipment performance tolerances, and choice of tube types. These difficulties are principally:

1. Variation of grid contact potential between tubes of a given type.
2. Greater percentage variation of transconductance and other characteristics, for certain types (tube-to-tube) than is experienced with the same tubes at maximum voltage ratings.
3. The wide range of battery voltage (occurring in the aircraft) over which satisfactory tube performance must be obtained.

Tube operation at 28 volts plate and screen supply makes it necessary to employ the lowest possible bias. At zero bias with low grid circuit resistance, an obvious difficulty with grid current loading of tuned circuits arises. At low orders of fixed or cathode bias difficulty is experienced with many tubes of a large lot drawing grid current because the bias is not high enough to overcome the contact potential. If the bias is made high enough that no tubes draw grid current the average gain for all tubes is at an undesirable low level. A good compromise is to employ grid-leak bias which evens out the variations of gain from tube to tube. Tubes which tend to run high in grid contact potential also tend to run high in transconductance, and vice versa, so that tubes with high G_m will bias themselves back further than tubes with low G_m.

Effective Grid Bias

We define grid contact potential, as employed in this discussion only, to be that grid potential at which the grid current characteristic (in the absence of gas or positive ion current) intercepts the zero grid current axis. The grid current characteristics of several type 9003 tubes are shown in Fig. 1. The grid contact potential values are approximately −0.7 volt for tube 1 and −1.0 volt for tube 3. The values are usually found to lie between −0.2 and −1.2 volts for most vacuum tubes of the classes discussed herein. Since the potential depends on such items as the work functions of emitting materials, mean

TABLE I—CHARACTERISTICS OF R-F PENTODE AMPLIFIER TYPES WITH 28-VOLT B SUPPLY

TYPE	TRANS-CONDUCTANCE	PLATE RESISTANCE	PLATE CURRENT	SCREEN CURRENT	CUTOFF BIAS *
6AG5	1300 μ MHOS	OVER 1 MEG.	.40 MA	.10 MA	-2 V.
12SF7	1075 μ MHOS	OVER .4 MEG.	2.0 MA	.60 MA	-9 V.
12SG7	1325 μ MHOS	OVER .75 MEG.	.75 MA	.35 MA	-5 V.
12SH7	1200 μ MHOS	OVER 2 MEG.	.35 MA	.15 MA	-2 V.
12SJ7	1350 μ MHOS	OVER .75 MEG.	1.0 MA	.30 MA	-3 V.
12SK7	1350 μ MHOS	OVER .3 MEG.	2.0 MA	.60 MA	-10 V.
9001	1150 μ MHOS	OVER .7 MEG.	.65 MA	.30 MA	-3 V.
9003	1250 μ MHOS	OVER .3 MEG.	1.6 MA	.70 MA	-10 V.

---

* Cutoff bias for transconductance of 10 micromhos. Data in this table was obtained with rated heater voltage, plate and screen voltage of 28 volts and grid bias of zero volts through 2 megohms

erformance of pentodes and triodes operated directly from an aircraft battery as B sup-ly. Grid leak bias is recommended to minimize effects of grid contact potential and G_m variations. Tables show performance of RC-coupled amplifiers in 28-volt service

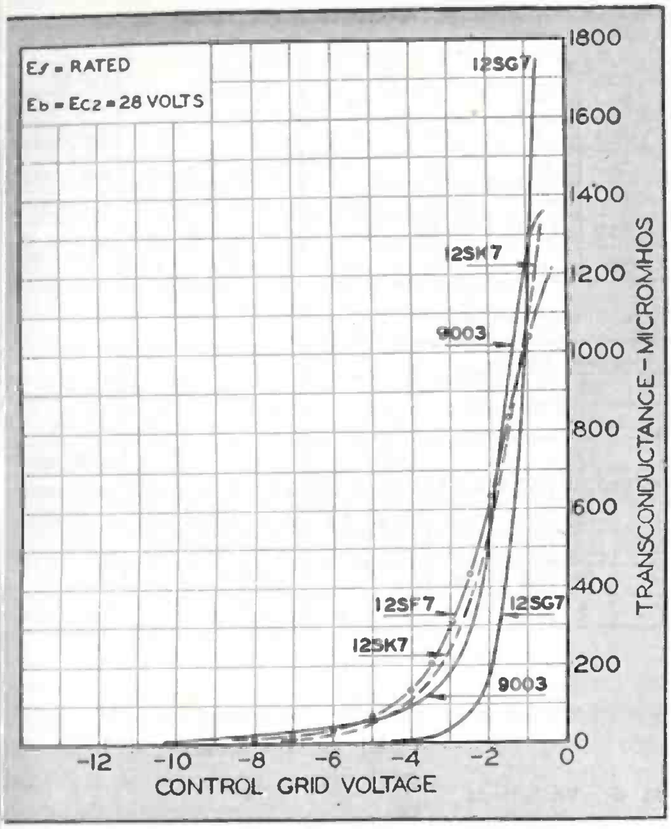


FIG. 2—Transconductance vs. control grid bias for remote cut-off pentodes

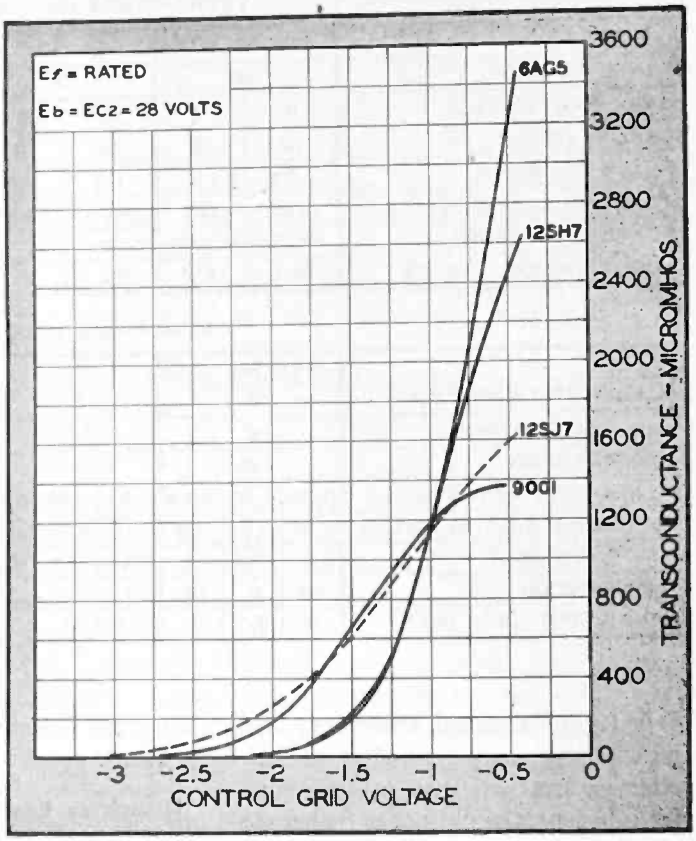


FIG. 3—Transconductance vs. control grid bias for sharp cut-off pentodes

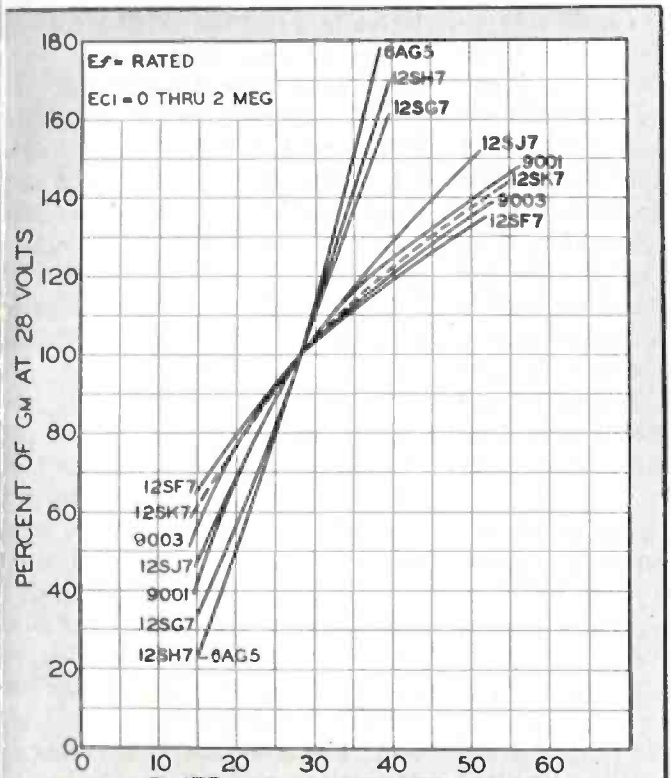


FIG. 4—Percentage variation of transconductance of r-f pentodes with B supply voltage

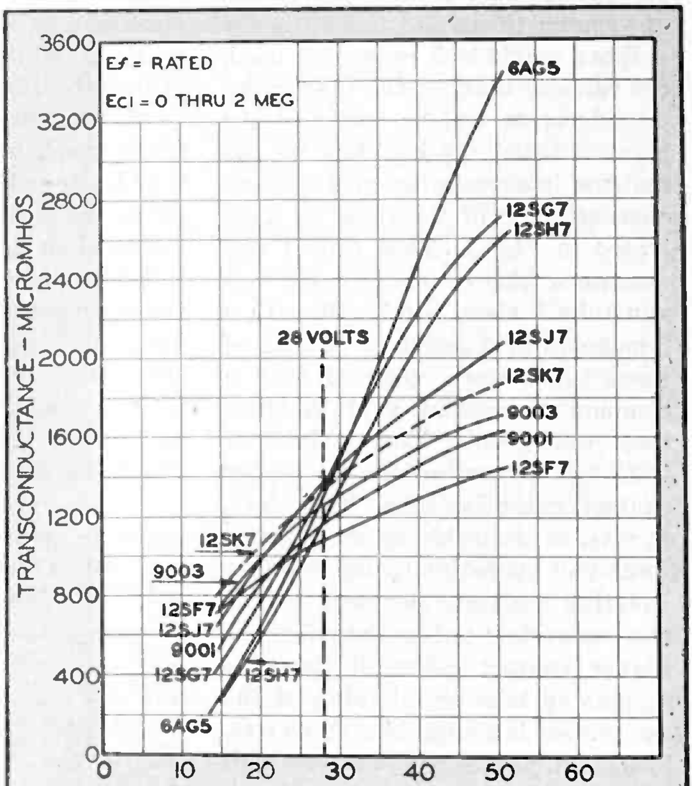


FIG. 5—Transconductance of r-f pentodes vs. B supply voltage, for eight different tube types

TABLE II—TYPICAL AUDIO AMPLIFIER OPERATION OF TRIODES AT 28 VOLTS

TUBE TYPE	12AH7GT			12J5GT			12SN7GT			12SR7			9002			
HEATER VOLTAGE	12.6			12.6			12.6			12.6			6.3			VOLTS
HEATER CURRENT	0.15			0.15			0.30			0.15			0.15			AMPS
TRANSFORMER OR CHOKE FED A-F AMPLIFIER																
	(PER SECTION)						(PER SECTION)									
PLATE VOLTAGE	28			28			28			28			28			VOLTS
GRID BIAS VOLTAGE	0	-1		0	-1		0	-1		0	-1		0	-1		VOLTS
GRID RESISTOR	10	0		10	0		10	0		10	0		10	0		MEGOHMS
PLATE CURRENT	1.25	1.0		1.2	1.0		1.2	1.0		1.0	0.75		0.50	0.50		MILLIAMPS
TRANSCONDUCTANCE	1200	1100		1625	1450		1625	1450		1150	1000		1150	1100		MICROMHOS
PLATE RESISTANCE	14,000	15,000		12,250	14,500		12,250	14,500		15,750	18,000		17,750	21,000		OHMS
AMPLIFICATION FACTOR	16.8	16.5		20	21		20	21		18	18		20.5	23		
RESISTANCE COUPLED A-F AMPLIFIER																
	(PER SECTION)						(PER SECTION)									
PLATE SUPPLY VOLTAGE	28			28			28			28			28			VOLTS
GRID BIAS VOLTAGE	0			0			0			0			0			VOLTS
GRID RESISTOR	10			10			10			10			10			MEGOHMS
PLATE LOAD RESISTOR	0.05	0.10	0.22	0.05	0.10	0.22	0.05	0.10	0.22	0.05	0.10	0.22	0.05	0.10	0.22	MEGOHMS
FOLLOWING GRID RESISTOR	0.10	0.22	1.0	0.10	0.22	1.0	0.10	0.22	1.0	0.10	0.22	1.0	0.10	0.22	1.0	MEGOHMS
PLATE CURRENT	275	150	75	225	150	75	225	150	75	250	150	75	175	100	50	MICROAMPS
AMPLIFICATION	9.5	11	12	11	12	13	11	12	13	9	11	12	10	11.5	13	
MAX OUTPUT (5% DIST)	3	3.5	5	2.5	3	4	2.5	3	4	2.5	3	4	1.5	2	3	RMS VOLTS

velocity of emitted electrons, area of effective electron emission, cathode temperature, grid-cathode spacing, potentials on other tube elements, etc., it is impossible to hold the value to that degree of uniformity achieved in the control of other parameters during the manufacture of vacuum tubes.

When a grid leak resistor is used, the value of bias for the tube under consideration will be found at the point at which the load line for the resistor intersects the grid current characteristic of the tube, as illustrated in Fig. 1. Thus tube 1 will assume a bias of about −0.5 volt and tube 3 about −0.7 volt with a 2-megohm grid resistor. If both of these tubes were operated with a common 2-megohm grid resistor, they would both have a bias of −0.7 volt determined by the higher contact potential tube. Therefore, it may be desirable in many cases of 28-volt operation to use separate isolating resistors for each tube in the avc system unless the effects of higher contact potential tubes in increasing bias on all tubes of the avc system is acceptable. Of course, in some instances where a very high value of d-c diode load is employed, the diode contact potential may establish the bias for the tubes on the avc line and the use of separate isolating resistors would not be important.

Minimizing Effects of G_m Variations

Since the minimum bias for maximum gain for each tube of a lot is established by the grid leak, this method of bias is recommended instead of cathode bias for 28-volt operation. While cathode bias tends to smooth out tube variations, it can be shown that cathode bias will not minimize G_m variations except when the bias is so large that the average G_m is reduced more than can be tolerated in 28-volt operation. Grid leak bias is almost as effective for smoothing tube variations and is inherently available in most avc systems. For this reason all tube ratings published herewith are made with a 2-megohm grid leak (with the exception of voltage amplifiers which employ a 10-megoh leak) at zero external bias. Th grid signal employed is 0.10 volt rms.

TABLE III—TYPICAL RESISTANCE-COUPLED AUDIO AMPLIFIER OPERATION OF PENTODES AT 28 VOLTS

TUBE TYPE	12SF7		12SJ7		9001	
HEATER VOLTAGE - VOLTS	12.6		12.6		6.3	
HEATER CURRENT - AMP.	0.15		0.15		0.15	
PLATE SUPPLY VOLTAGE - V	28		28		28	
GRID BIAS VOLTAGE - V	0		0		0	
GRID RESISTOR - MEGOHMS	10		10		10	
SCREEN GRID RESISTOR "	0.33	0.82	0.22	0.47	0.068	0.27
PLATE LOAD RESISTOR "	0.10	0.22	0.10	0.22	0.10	0.22
FOLLOWING GRID RES. "	0.22	1.0	0.22	1.0	0.22	1.0
PLATE CURRENT - μA	180	90	180	85	170	70
SCREEN GRID CURRENT - μA	60	25	60	35	90	36
AMPLIFICATION	23	35	34	47	38	52
MAX OUTPUT (5% DIST.) - V	3	4	4	4.5	3.5	4

This signal is standard on the G test line of the tube plant and i employed in the laboratory so tha data are directly useful for translation into test limits. For the condition of zero grid circuit resistance at 28 volts B supply the value of G_m observed varies negligibly as the grid signal is reduced from 0.1 v. For the condition of 2 megohms grid circuit resistance some grid current rectification occurs and biases the grid back somewhat Therefore higher measured value of G_m will be observed for grid signals less than 0.1 volt.

"High" G_m types show mor change in G_m with signal level tha "medium" G_m types. "Low" G tubes of a given type tend to show more change than "high" G_m tubes For example, when the grid signa is reduced from 100 millivolts to 5 millivolts for type 12SH7 the highest tubes increase their observed G_m about 5 percent, while the lowest tubes increase it about 9 percent. For type 12SG7 the respective differences are 3.5 percent and percent, and for type 12SK7 they are 1.2 percent and 1.5 percent Thus the following data indicate lightly lower values and less uniormity than might be obtained in ircuit practice.

The average characteristics of everal pentode types for 28-volt operation are shown in Table I. The mutual conductance curves for remote cut-off pentodes are given in Fig. 2, and for sharp cut-off pentodes in Fig. 3. These curves are or the condition of zero grid circuit resistance, and the high value f G_m shown for some types at bias alues less than about -0.75 volt will not be realized in r-f amplifier pplications with 2-megohm grid eak bias (see Table I).

ransconductance Variations at 28-Volt Design Center

It is of practical interest to note he percentage variation in transonductance which occurs as the B upply voltage is varied. Some airraft radio equipments must operte over a range of 22 volts minimum to 32 volts maximum, or -21 ercent and $+14$ percent from a deign center of 28 volts. From a athode temperature standpoint ubes cannot be rated for supply oltage variations greater than ±10 ercent for continuous operation. However, if equipments are to be measured for performance at extremes of voltage variation, Fig. 4 and 5 show the order of variation in stage gains to be expected for each tube type as the B voltage is varied (heater voltage constant). The disadvantage of "high G_m" tubes such as types 6AG5, 12SG7, and 12SH7 is apparent.

Typical transconductance variations as a function of heater voltage (B voltage constant) are illustrated in Fig. 6. Both effects must be tolerated and allowed for in equipment performance test specifications. Figure 6 also demonstrates that contact potential bias is to be preferred over fixed or cathode bias if variation in transconductance over a range of heater voltage is an important consideration.

There is one point which should be emphasized in connection with 28-volt operation of standard receiving tubes. It is that a tube rated for a very high transconductance at higher voltages will not necessarily exhibit a higher transconductance at 28 volts than the medium transconductance tubes such as the types 12SJ7, 12SK7, etc. The curves of Fig. 4 and 5 demonstrate this fact. Furthermore, many of the very high transconductance types are rated with -1.0 volt bias at maximum plate and screen voltage ratings, and no appreciable reduction in bias is obtained with grid leak bias. For tubes like types 12SJ7 and 12SK7 which are rated with -3.0 volts bias at maximum voltage ratings, it is possible to reduce the bias sufficiently for 28-volt operation that a value of transconductance is obtained equal to or better than that of the "high G_m" types. In addition, the "medium G_m" types exhibit tube-to-tube uniformity at 28 volts comparable to that obtained at maximum voltage ratings, while the "high G_m" types do not.

Selection of Tube Types

The comparative average transconductance and the typical range of variation between tubes of a given lot are illustrated in Fig. 7 for several types. This figure should assist the designer who is critical of product variations in the selection of types to be used. Figures 2 and 3 should be useful in the choice of types for a particular application. For most r-f and i-f applications with avc the 12SK7 appears to be a good selection both from the standpoint of average characteris-

(*Continued on page* 379)

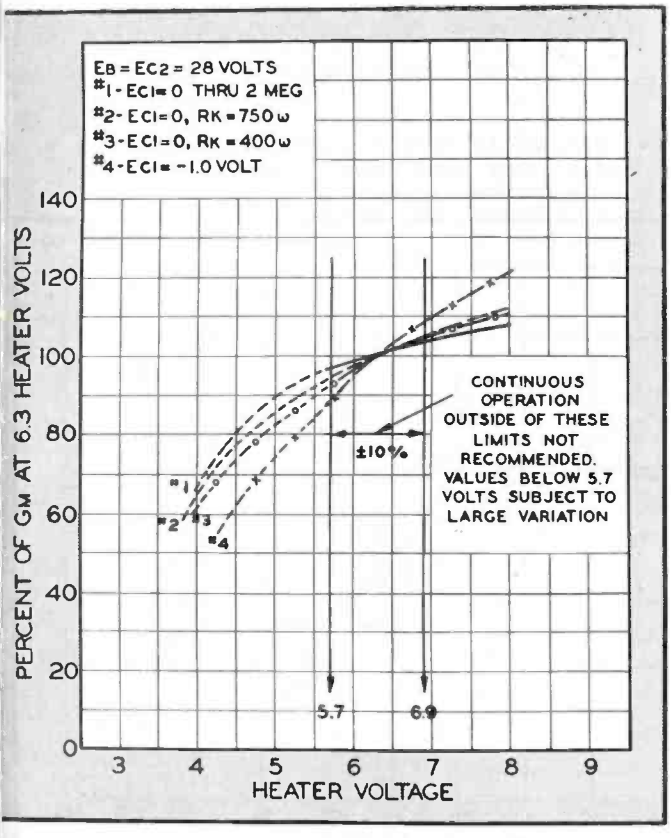


FIG. 6—Percentage variation of transconductance of type 9003 pentode heater voltage

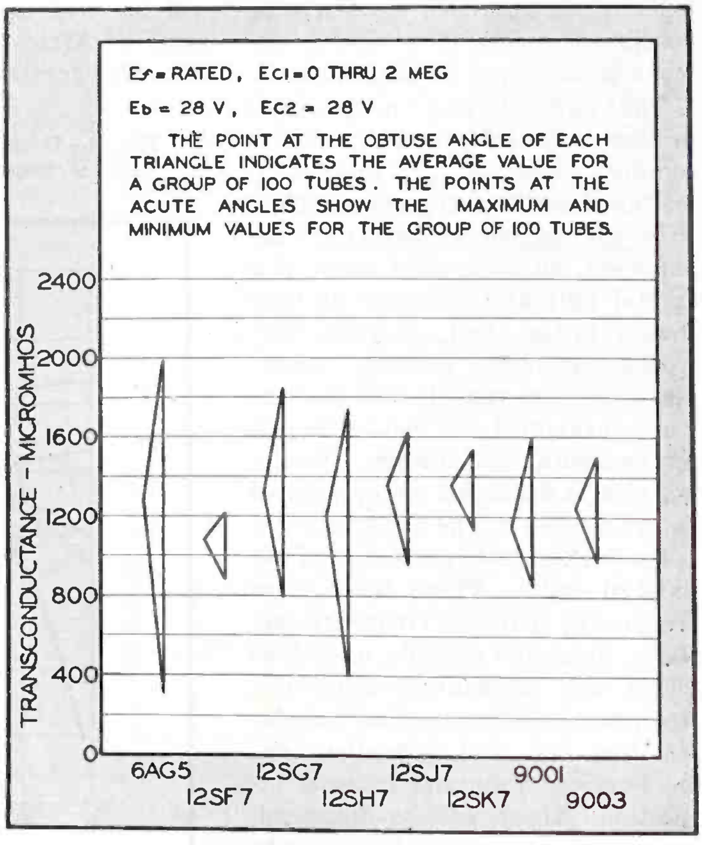


FIG. 7—Transconductance variation of r-f pentodes with 28-volt B supply

CRYSTAL

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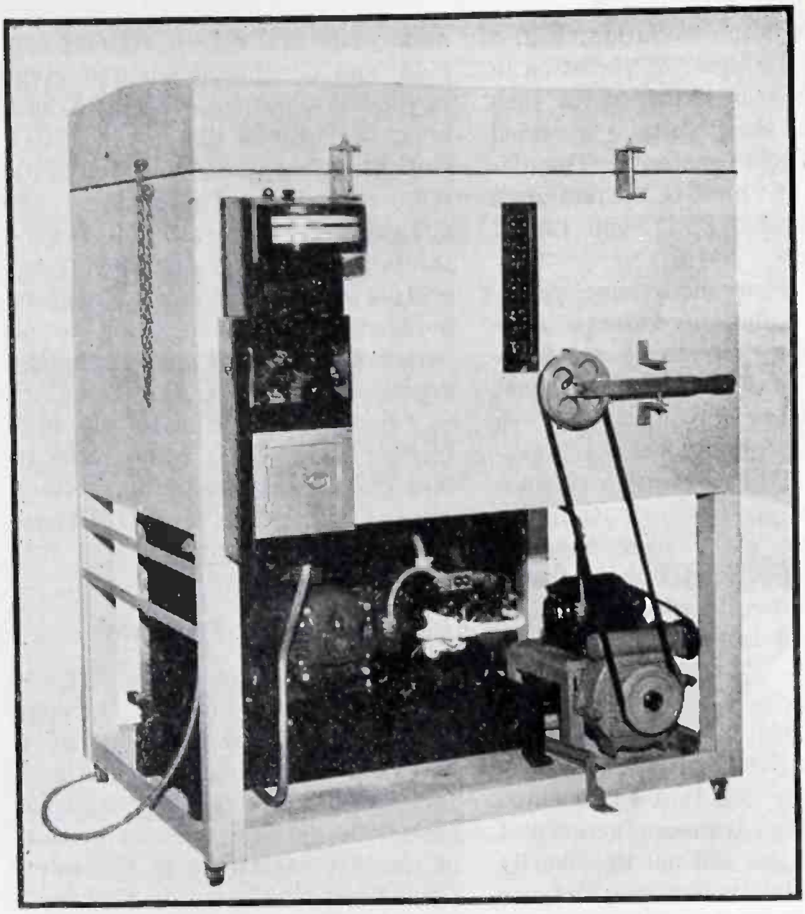


Temperature-controlled testing box accommodates as many as 600 crystal units at a time. Manual checks are made at two-deg intervals over required temperature range. For resulting data, see Fig. 3

BEFORE CRYSTALS are shipped from the laboratory, they are put through a series of exacting tests which approach as nearly as possible the conditions and treatment encountered in actual use.

The daily testing program is broken up into three parts: (1) incoming inspection, (2) production testing, and (3) acceptance testing.

In the incoming inspection department, all component parts of a crystal unit are examined as they come into the plant. Holders, electrodes, springs, gaskets, nameplates, etc. are visually and mechanically examined to insure proper workmanship and design. Faulty material is discarded or reprocessed before it goes to the assembly line.

Production tests are made on the finished units. These tests cover frequency, spurious frequency, activity, drop, and altitude, as well as visual and mechanical inspection. Acceptance testing routine includes starting, full load, vibration, immersion, cleaning, and internal inspection. These will be discussed.

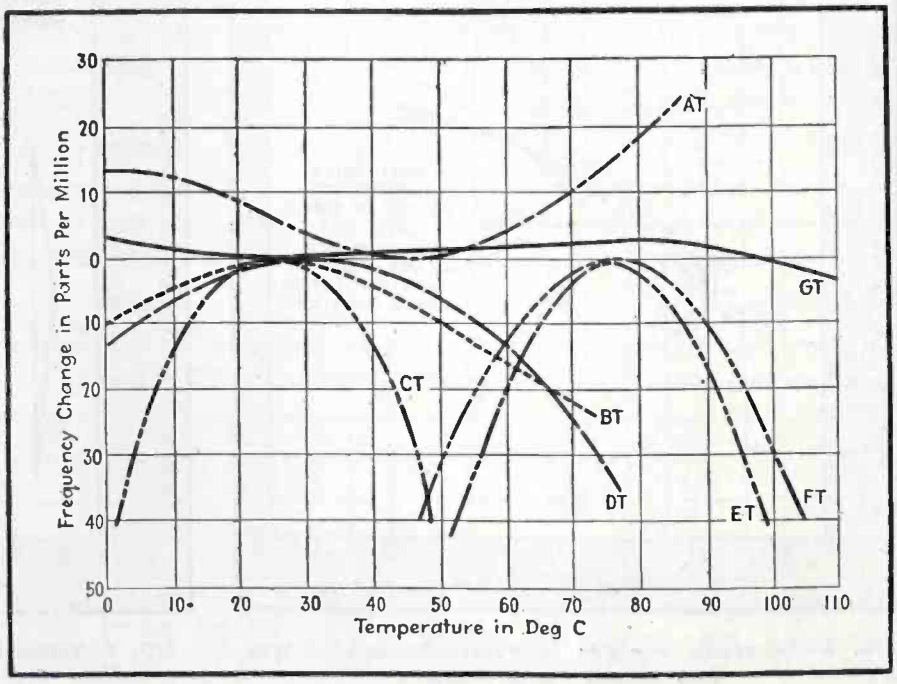
Crystals are expected to operate efficiently at widely different temperatures. Some, for instance, will be used in the frigid climates of Alaska and Siberia, while others will be used in the equatorial regions of Africa and the South Pacific. One crystal, in a bomber, may pass from equatorial ground temperatures to the sub-zero temperatures of the stratosphere in a few minutes. A good crystal must work efficiently, no matter what the temperature.

Crystal Tests

For the above reasons each crystal is tested, both for frequency and activity, over the entire temperature range of its anticipated use. A minimum activity and an allowable frequency deviation are set up and crystals which do not conform over the established temperature range are rejected.

Variation in frequency with a change in temperature, or temperature coefficient[1], is characteristic of the type of cut made. Frequency-temperature curves of some of the more common cuts are shown in Fig. 1. These curves show that every type has a turning point at some temperature. To hold the crys-

FIG. 1—Temperature coefficients for different crystal cuts are indicated in terms of frequency change. Each curve reveals a turning point at some characteristic temperature



TESTING TECHNIQUES

ep-by-step account of characteristic production and acceptance hurdles in the path of crystal oscillator plate before its final approval, with details on procedures, interpretation of results, and methods of reclaiming initially faulty units

t within frequency tolerances set in the specifications, it is impor-t at that the turning point be at te middle of the temperature range t utilize the symmetry of the rve.

Turning point can be changed by icreasing or decreasing the B Z′) angle. This is shown graphilly in Fig. 2. The A and C angles so affect the turning point but to much lesser degree. By way of example, assume that a 5000 kc, -cut crystal is being tested from 90 deg C to −50 deg C. Suppose e specifications call for a maxium frequency deviation of not ore than 0.02 percent. This means at the allowable deviation is 1000 cycles. In Fig. 3 are shown veral cases encountered in checkig.

Case (1) is that of a good crystal ving its peak in the middle of the mperature range and being thin tolerance at both ends of the rve. No. (2) is mounted too high d is out of tolerance at room mperature. Some such crystals can be repaired and brought within tolerance by decreasing the air gap between crystal and electrodes. Usually, however, the crystal must be ground to the next higher frequency.

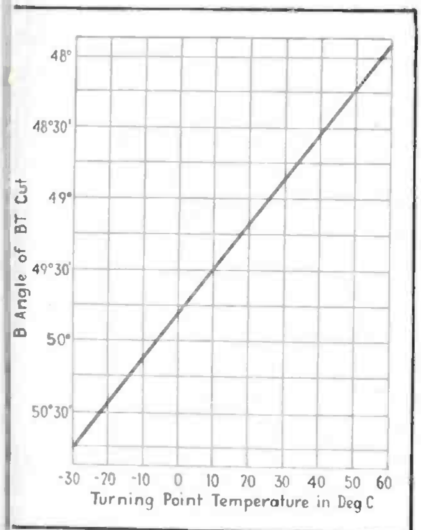
Example (3) is cut at the wrong angle, making it peak at the wrong temperature, so it cannot be used for this particular temperature range. No. (4) is mounted too low at room temperature and goes out of tolerance at both ends. This crystal can be repaired by very slight grinding and a thorough washing. No. (5) has a spurious frequency caused by coupling.[1] This crystal can be repaired by a slight change in dimensions of the blank.

Current Must Hold Up

Activity of a crystal is required to remain above a certain minimum over the entire temperature range.[2] First of all, activity is a function of the contour and geometric dimensions of the crystal blank. By leaving the thickness and length of a blank constant but changing the width, one can make activity go through a number of maxima and minima. A typical activity curve is shown in Fig. 4.

Contour of the faces of the blank is equally important—affecting the activity in a similar manner. In manufacture it is imperative that the geometrical dimensions and flatness required for obtaining maximum activity at a given frequency be determined experimentally before putting that frequency into actual production. Even though finishers have both the dimensions and contour as perfect as possible and have maximum activity of the crystal at room temperature, activity dips may occur at some point in the temperature range which will cause a crystal to fall below the activity minimum. In Fig. 5 are shown several common dips found in checking crystals.

In No. (1) the sharp dip over a small temperature range is usually caused by improper dimensioning of the blank, resulting in interfer-



IG. 2—Turning point temperature of specific crystal cut depends in this anner on the B (ZZ′) angle. This roperty is used to maintain tolerance

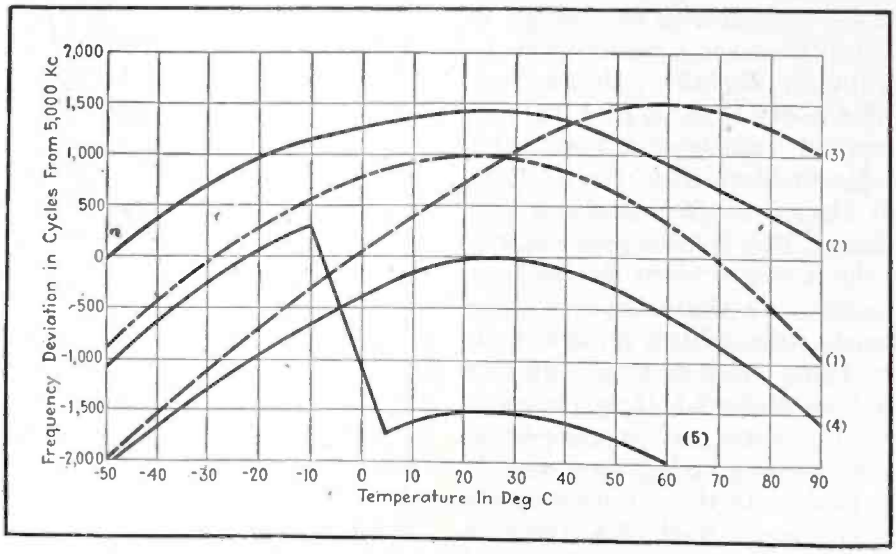
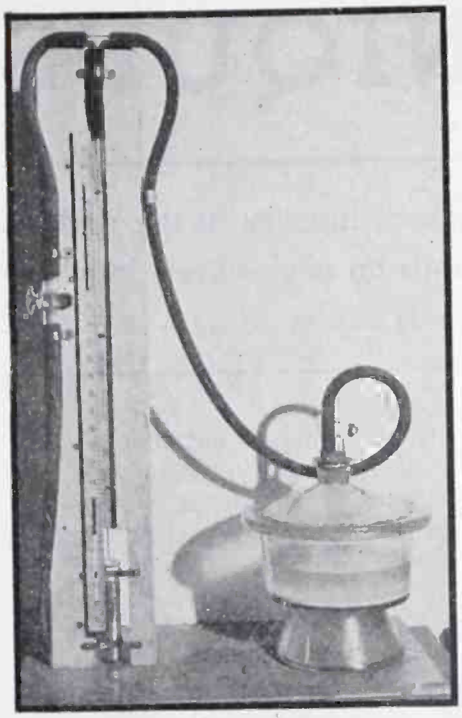


FIG. 3—Studies of five crystals under frequency-temperature test shows only No. 1 to be satisfactorily within 1000-cycle tolerance. Some of the others can be adjusted to requirements, some must be reprocessed by further grinding to another, higher frequency



Bell jar serves in altitude test when pressure is reduced to ½ in. of mercury. Ability of crystals to resist atmospheric penetration is vital in aircraft application

ing modes of vibration or coupling. A crystal of this sort is repaired by changing the dimensions of the blank slightly so as to eliminate interfering modes. There appears to be a correlation between the spurious frequencies mentioned previously and these activity dips. Where one occurs, the other is also present. Where the dip is a gradual one over a wide temperature range, as No. (2), it is termed a mechanical dip. This is usually caused by slippage of electrodes or change of spring pressure. Sometimes the crystal is slightly undersize and shifts in the case. Repair for such a crystal consists of changing the spring or electrodes. No. (3) and (5) dip out at the temperature extremes. This means poor contour on the crystal or electrodes, or both. Changing of electrodes will often remedy this situation, but it is sometimes necessary to lap the blank to the next higher frequency. No. (4) dips out completely at 0 deg, which reveals water vapor in the holder. In this circumstance, a new holder is used. No. (6) is a good crystal showing only slight variations due to slippage of the spring used to hold the electrodes in contact with the crystal.

Two other factors which affect overall activity of a crystal in the holder are size of air gap and condition of contact points on the electrodes. In the former case, resonance occurs at a certain relationship between frequency of the crystal and size of the air gap. When component motion of the faces of the crystal takes place in the direction of the electrodes, a supersonic air pulse is set up. This pulse travels across the air gap and is reflected back to the crystal.

Supersonic Interference

When the total path traveled by the air pulse is equal to the wavelength of the supersonic wave, interference occurs as the pulse returns to the crystal surface. Thus, for any particular frequency, there is a certain size of air gap at which interference occurs and causes a decrease in activity. The dimensions of a resonant air gap can be calculated, for any frequency, from the formula

$$g = \frac{v}{2f} \qquad (1)$$

where g is dimension of the air gap in thousandths of an inch, v is velocity of the supersonic pulse (sound) at a particular temperature, and f is frequency of crystal.

By way of illustration, consider an 8 Mc crystal at 20 deg C. Velocity of sound at this temperature 1130 fps. Substituting in Eq. (

$$g = \frac{1130 \times 12}{2 \times 8 \times 10^6} = 0.00084 \text{ in.}$$

Air gap resonance has much le effect in thickness-shear oscillato than in pure thickness oscillato

Friction Resists Activity

The second factor, condition the contact points of electrodes, important because friction betwe the electrodes and the crystal creases activity. Electrodes are l ped perfectly flat and then polish on very fine carborundum paper with optical powder. Reducing fr tion increases activity.

Too much spring pressure often decrease activity since it hibits vibration of the crystal. Ho ever, the spring has to prevent sl page of the crystal so the probl becomes one of having precis the right pressure.

Types of Apparatus

Testing equipment, for mak the temperature runs, varies wid in design. However, there are t general types: (1) equipment test each crystal continuously o the entire temperature range a (2) equipment in which the temp ature can be held constant at int vals over the temperature ra while a large number of crystals

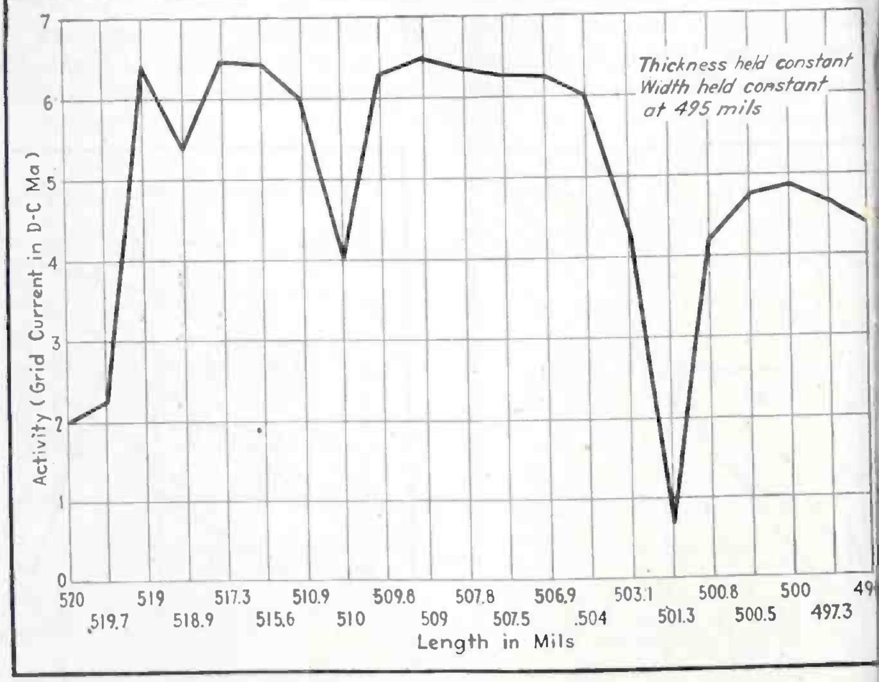


FIG. 4—Electrical activity, at constant thickness and width of crystal, relates to length in accordance with this typical curve. Satisfactory crystal must not have an activity dip going below the established minimum anywhere in temperature range

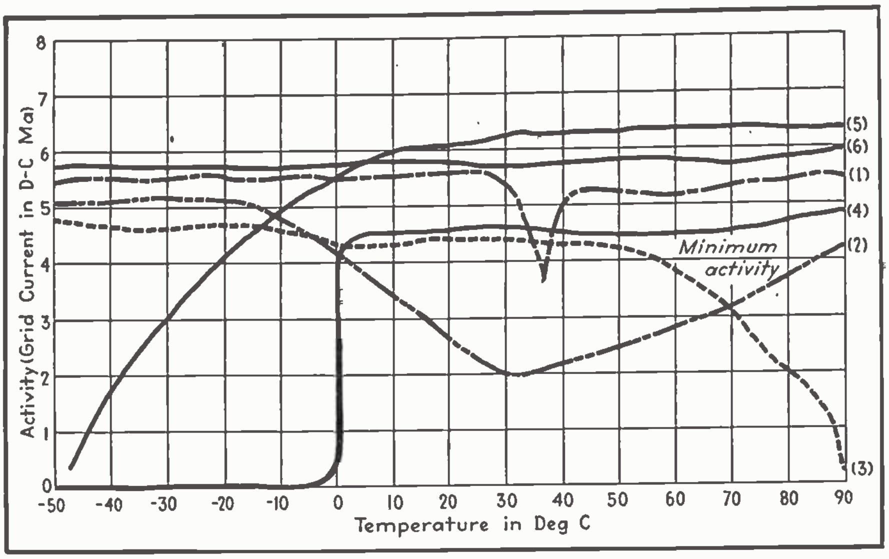


FIG. 5—Activity dips in production-tested crystals take these forms, each of which reveals some characteristic trouble. For instance, No. 4 exhibits presence of water vapor which halts activity at freezing point

ecked at each interval for activity
ad frequency. Recording of fre-
ency and activity may be either
anual or automatic. The auto-
atic self-recording test apparatus
of course, the most convenient to
e. But it does not adapt itself
mass production so well as man-
l means—the reason being that it
tails prohibitive cost to have
ough testing units to care for
rge numbers of crystals. Most
boratories use a simple insulated
x, similar to that illustrated,
hich will accommodate from 50–
0 crystals at a time. These are
aced in an indexed wheel inside
te box and the crystals checked at
tervals of two degrees over the en-
re range.

In the general run of crystals ap-
roximately 85 percent pass the ac-
vity and frequency tests on the
mperature run. Of the 15 percent
ilures, about 14 are activity and
frequency rejects. Rejected crys-
ls go to the repair department
here they are reworked. About
percent of the repaired crystals
ss upon being retested. Those
rown out on the second run are
ain reworked, being checked for
ntour, twinning, and flaws and on
e next temperature run, about
percent pass. General practice is
discard those failing on the third
n.

Shock, Frequency, and Sealing

Another production test is used
r determining the mechanical sta-
lity of a crystal. Each unit is per-
itted to fall five times from a
ight of eight inches to a horizon-
l two-inch oak plank (most plants
ve substituted several sharp taps
an oak plank for the drop test).
ter the drop test, there must be
resulting damage to the unit and
tivity must not have changed
ore than 10 percent nor fre-
ency more than 0.002 percent.

Crystals are tested at room tem-
ature for spurious frequencies.
is is done by placing the unit in
tuned-plate oscillator and tuning
plate circuit over the frequency
nge (5–10 Mc). The crystal must
cillate at a single frequency.

For testing the seal on aircraft
ystals, a reduced pressure test is
ed. Each unit must be sealed so
at when subjected to an absolute
ternal pressure of ½ in. of mercury, ten minutes is required for the pressure inside the unit to drop to ¼ atmosphere. Testing is done with a device as illustrated which measures the ion current through each crystal when a d-c potential of 1000–2000 volts is applied to the crystal unit in series with a high resistance.

Here is the purpose of this test. If a crystal has an air leak, internal pressure decreases, due to a decrease in atmospheric pressure, as the plane carrying it ascends. When the plane is in a dive, or descends, atmospheric pressure on the outside increases—forcing air into the holder. If the plane goes through a cloud where humidity is high, the entering air is moist. This moisture condenses in the holder, short-circuiting the unit.

Examination Ends Production Checks

Close, visual external inspection of the finished product is the last production test. Causes for most common rejections are bad prongs, scratches or chips in the Bakelite case, and poor lettering or stamping. In each circumstance these are set aside to be repaired. Bad prongs are caused by faulty soldering of the tips or scratches exposing the brass. Prongs are made of nickel- or chrome-plated brass. If the brass is exposed the crystal is rejected because brass tarnishes. In these cases, the prongs are resoldered, smoothed down, and replated electrolytically. Scratched or chipped holders are replaced with new ones. If the stamping is bad, it is usually buffed off and re-done. In some cases addition of whiting will remedy the situation.

Acceptance Tests

At this point, crystal units are submitted to inspectors for acceptance. These inspectors do not check every crystal through all their tests. In most cases, they make a spot or type test. This involves taking at random a group of 30 crystals out of each thousand. These are submitted to visual and mechanical inspection; frequency, activity, starting, spurious frequency, full load, drop, seal, vibration, and immersion tests; cleaning; and internal inspection.

The manufacturer submits crystals in groups of 1000. Inspectors select 30 at random from the group of 1000 and run them through the various tests. If more than one crystal fails out of the group of 30, another 30 crystals is selected from the original 1000. If 3 or more units fail out of the two groups of 30, (60 crystals) the original 1000 crystals are rejected and cannot be shipped.

At this point, the manufacturer may rework the thousand crystals and re-submit 30 for another spot check, or he may submit the entire 1000 units, *without* reworking, to be run through all the acceptance tests.

Acceptance tests are primarily the same as the production tests with these exceptions: In the starting test, a crystal is measured for

(*Continued on page* 380)

EFFICIENCY OF Induction Heating Coils

Examination of the action occurring in induction heating of metals, including analy of current distribution in work coil and load, relation between frequency and coupli efficiency, impedance considerations and discussion of factors affecting choice of frequen

In induction heating of metals, the object to be heated is placed in the field of a suitably designed coil which is carrying an alternating current. Currents are then induced in the object, generating heat without contact. The action is that of a transformer with the secondary short-circuited.

Equivalent Circuit for Induction Heating

In the circuit of Fig. 1,* a coil of inductance L_1 and resistance R_1 is placed across the terminals of a generator which is developing a voltage V_1. The generator may be a rotating machine, a spark-gap oscillator, or a vacuum-tube oscillator. A piece of metal to be heated may be represented as the shorted secondary turn with a resistance R_2 and an inductance L_2. The circuit equations are

$$V_1 = [R_1 + j\omega L_1]\, I_1 + j\omega M I_2 \qquad (1)$$

and

$$0 = j\omega M I_1 + [R_2 + j\omega L_2]\, I_2 \qquad (2)$$

where f is the frequency in cycles per second, ω equals $2\pi f$, and M is the mutual inductance in henrys. Elimination between these two equations gives the impedance presented to the terminals of the generator.

$$V_1/I_1 = R_1 + j\omega L_1 + \frac{(M)^2}{R_2 + j\omega L_2}$$
$$= R_1 + \frac{(\omega M)^2 R_2}{R_2{}^2 + (\omega L_2)^2} + j\omega\left\{L_1 - \frac{(\omega M)^2\, L_2}{R_2{}^2 + (\omega L_2)^2}\right\} \qquad (3)$$

Thus we see that the primary resistance is increased by the presence of the load or shorted turn, while the inductance of the work coil has decreased.

Let $Q = \omega L_2/R_2$. Then the increase in resistance due to the presence of the metal to be heated is

$$\triangle R_1 = \left(\frac{M}{L_2}\right)^2 R_2 \frac{Q^2}{Q^2+1} \qquad (4)$$

and

$$\triangle L_1 = -\left(\frac{M}{L_2}\right)^2 L_2 \frac{Q^2}{Q^2+1} \qquad (5)$$

Equations for Efficiency

The efficiency of the heating circuit, that is, the ratio of the power transferred to the work to the total power supplied is

$$\text{Efficiency} = \frac{\triangle R_1}{R_1 + \triangle R_1} = \frac{\left(\frac{M}{L_2}\right)^2 R_2 \frac{Q^2}{Q^2+1}}{R_1 + \left(\frac{M}{L_2}\right)^2 R_2 \frac{Q^2}{Q^2+1}} \qquad (6)$$

The Q of the secondary circuit is generally much larger than unity for most of the frequencies used for induction heating. The variation of the factor $Q^2/(Q^2+1)$ as a function of Q is shown in Fig. 2. It is seen that as Q becomes large, the factor in question approaches unity. If we make this limiting sumption, Eq. (6) becomes

$$\text{Efficiency} = \frac{\left(\frac{M}{L_2}\right)^2 \frac{R_2}{R_1}}{1 + \left(\frac{M}{L_2}\right)^2 \frac{R_2}{R_1}}$$

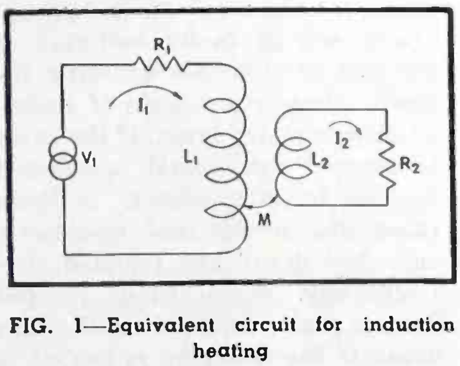


FIG. 1—Equivalent circuit for induction heating

At high frequencies, the curr flowing in a conductor tends to c centrate near the surface. The c rent density drops off exponentia with the depth. A depth, s, may defined as the thickness of a la of metal which, if it carried u form current, would present same resistance as the total me sheet carrying the exponentia decaying current. Then

$$s\ \text{(centimeters)} = \frac{1}{2\pi\sqrt{10^{-9}\mu_r\sigma f}}$$

where

μ_r = the relative permeability of the m
σ = the conductivity of the metal (m for a centimeter cube)
f = frequency (cycles per second)

Since this layer varies inversely the square root of the frequency may be shown that the resista varies directly as the square r of the frequency. The preced statements are predicated on assumption that the metal in qu tion has a thickness several ti greater than the skin thickness

Now, if the metal which is pla in the work coil has a thickness a diameter which satisfies these quirements, the resistance R_2 wh appears in Eq. (7) will vary as square root of the frequency. H ever, the same statement holds t for the resistance of the work c R_1. In this case, the ratio R_2/R_1 be simply a constant which is in pendent of frequency, and the

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* This is the circuit treated briefly by C. B. Kirkpatrick, Magnetic Induction Field of Air-Core Coils, *Wireless Engineer*, XX, No. 239. August, 1943, p. 378.

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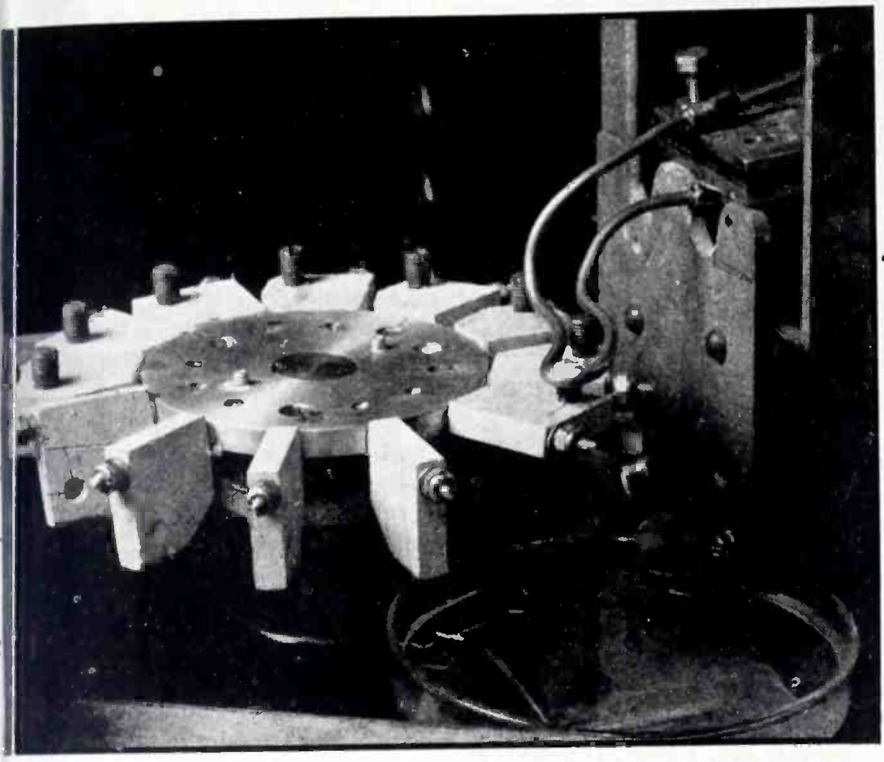

Single-turn work coil being used for localized hardening of the slotted tops of set screws. The rotating jig automatically dunks each screw in the cooling tray

cy also becomes independent of quency.

t should be remembered that we e assumed that Q is large, and t the skin thickness is small pared to thickness or diameter he conductors in question. Also, hould be noted that this reason- cannot be extrapolated into the remely high frequencies where acitance effects must be taken o account.

Factors Affecting Choice of Frequency

ince the efficiency is independ- of frequency, it is interesting to mine other factors which may uence the choice of frequency. a vacuum-tube oscillator, the ver is limited by the characteris- of the particular vacuum tubes d in the oscillator. Then, for a d power and large values of Q, current in the primary is

$$\sqrt{\frac{P}{R_1 + \Delta R_1}} = \sqrt{\frac{\mathrm{P}}{R_1 + \left(\frac{M}{L_2}\right)^2 R_2}} = \frac{1}{\sqrt{R_1}}\sqrt{\frac{P}{1 + \left(\frac{M}{L_2}\right)^2 \frac{R_2}{R_1}}} \quad (9)$$

R_2/R_1 is a constant ratio inde- dent of frequency, the current he primary for a constant power inversely proportional to the are root of the primary resis- ce. But this resistance is directly proportional to the square root of the frequency, so that

$$I_1 \propto 1/f^{0.25} \quad (10)$$

Under the assumption we have been making, the inductance at the input terminals is independent of frequency. Also, the reactance at these terminals is generally large compared to the resistance, so that the voltage at the terminals is

$$V_1 = \omega(L_1 + \Delta L_1)\, I_1 \quad (11)$$

Taking Eq. (10) into consideration, we see that

$$V_1 \propto f^{0.75} \quad (12)$$

We may thus sum up our observations, remembering the assumptions that have been made during the course of the development:

1. The efficiency of power transfer is independent of frequency.
2. The reactance at the input terminals of the work coil varies directly with frequency.
3. The resistance at the terminals of the work coil varies with the square root of the frequency.
4. The current in the work coil, for a constant power input, varies inversely as the one-fourth power of the frequency.
5. The voltage in the work coil, for a constant power input, varies directly as the three-fourths power of the frequency.

To test the foregoing conclusions, experimental data was assembled

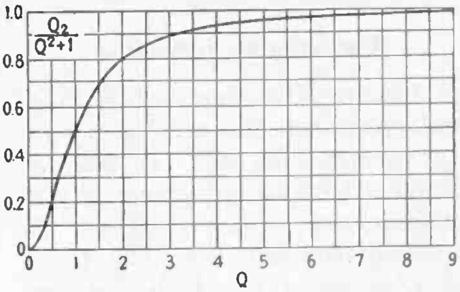

FIG. 2—Variation of factor in Eq. (6) with Q of induction-heating secondary circuit

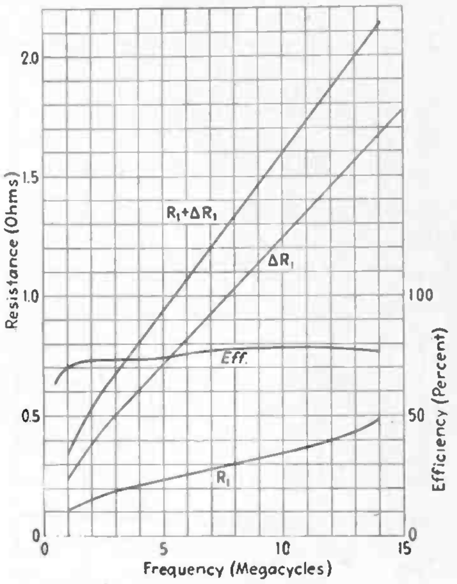

FIG. 3—Resistance and efficiency data for a work coil used in inductively heating an RCA-6A6 vacuum tube

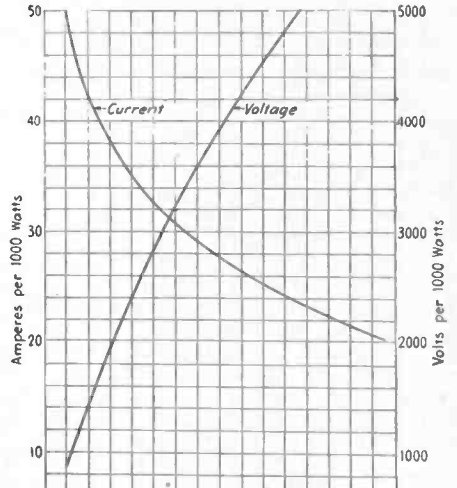

FIG. 4—Current and voltage values on the work coil used to heat the RCA-6A6 vacuum tube when coil power is 1000 watts

concerning a coil placed around a vacuum tube. The coil in question was a helix or solenoid, consisting of copper tubing which had a diameter of 5/32 inch, wound to form eleven turns which were 2½ inches in diameter. The length of the coil was 3¼ inches. The work or object to be heated was an RCA-6A6 vacuum tube†.

Experimental Verification

Measurements were first made of coil resistance and reactance with the vacuum tube out. The coil was found to have an inductance of 2.76 microhenries, which remained essentially constant over the range of frequencies at which measurements were made. The resistance R_1 varied with frequency as shown in Fig. 3. Then the vacuum tube was inserted in the coil and the measurements repeated. The inductance decreased only about one one-hundredth of a microhenry. The new resistance $R_1 + \Delta R_1$ is shown in Fig. 3.

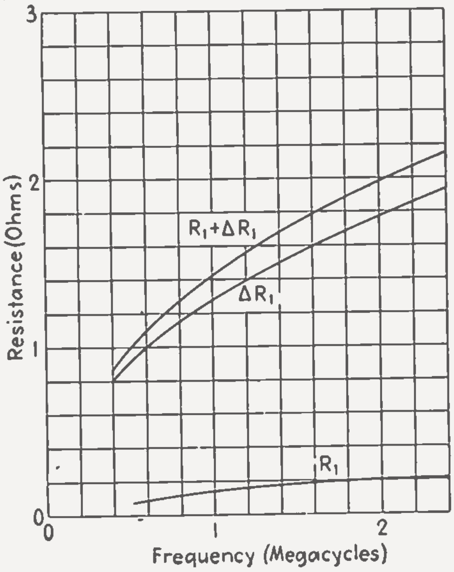

FIG. 5—Resistance values of multi-turn work-coil closely coupled to steel load

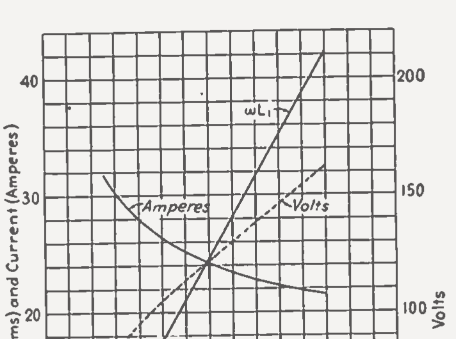

FIG. 6—Reactance, voltage and current of multi-turn work-coil closely coupled to steel load

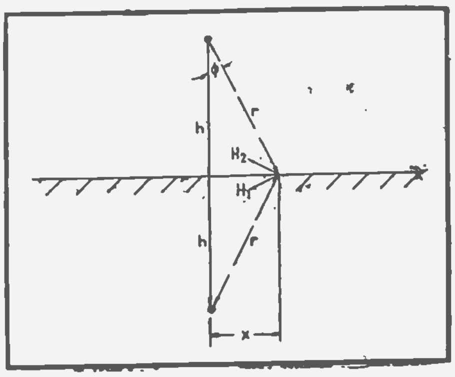

FIG. 7—Current-carrying conductor above and parallel to a conducting sheet

Efficiency of power transfer is also shown in Fig. 3. This curve was computed directly from the measured values of resistance. We see that the efficiency lies between 72.0 and 78.5 percent for all frequencies between 1 and 15 Mc.

The current in the coil under load conditions and the voltage across the terminals of the coil are shown in Fig. 4 for the case where the available power is 1000 watts. The coil current is approximately 50 amp at a frequency of 1 Mc, and decreases to about 20 amp when the frequency has increased to 15 Mc. Since Fig. 3 shows that the efficiency is approximately the same at the two frequencies, the coil will not get any hotter with the increased current at the low frequency than it will at the higher frequency with less current. On the other hand, the voltage is less than 1000 volts at the low frequency while it rises to more than 5000 volts at 15 Mc.

Heating a Steel Cylinder

The high voltages shown here are due to the loose coupling. Closer coupling to the work will make ΔL_1 have a greater numerical value, so that the total reactance will be decreased. This important effect of close coupling will be illustrated by means of another example. Th work coil was very similar to th one used for coupling to the RCA 6A6 tube. Copper tubing whic had a diameter of 5/32 in. wa wound to form 11 turns. The tot length of the coil was 3¼ in., an the inside diameter of the coil wa 4.92 cm. This coil was placed aroun a steel cylinder which had a diam eter of 4.76 cm. Thus the spacin between the coil and the steel cylin der was 0.08 cm.

The measured values of R_1 an $R_1 + \Delta R_1$ are shown in Fig. 5, to gether with the calculated values c ΔR_1. The efficiency calculated fro Eq. (6) is exactly 90 percent ove the range of frequencies at whic measurements were made so ther is no need to show the results i curve form.

The measured values of reactanc with and without the steel cylinde are shown in Fig. 6. Because c the close coupling, the reactanc drops a great deal when the cylin der is inserted. The effect of thi is remarkable when the voltag across the coil is considered. Figu 6 shows that this voltage lies b tween 80 and 160 volts when th operating frequency is between 0 and 2.4 Mc. The current in the co as a function of frequency is als shown in Fig. 6.

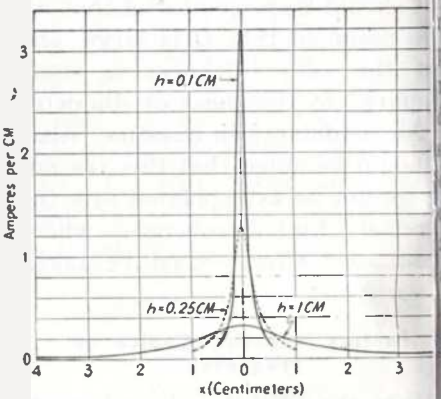

FIG. 8—Current distribution in the sheet f a filamentary conductor at various heigh above the sheet

Analysis of Single-Turn Coupling Coil

At times, it becomes necessary t couple to a cylinder of metal wit a single-turn coil closely space to the work. Then the coil impe ance is very low and transforme must be used to obtain efficient o eration. This is true in many so

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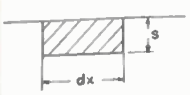
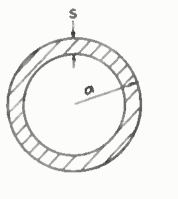
† An RCA-6A6 tube was chosen as a convenient load for obtaining these data, but this heating operation was simply a laboratory experiment which had no connection with the manufacture of this type of tube.





I. 9 (above, left)—Current-carrying patch
n the surface of a conducting sheet

I. 10 (above, right)—Current distribution
a cylindrical conductor far removed from sheet

ing operations and in the prac-
of scanning for case-hardening
steel by self-quenching. Before
sidering the transformers which
be used in this operation, it
ms desirable to examine the ac-
of the single-turn coupling coil.
the cylinder to be heated is of
ge diameter, the case may be
plified by treating the problem
a straight conductor parallel to
at sheet of metal of great thick-
s.

n Fig. 7, we see a long conductor
allel to a conducting layer and
nits above the layer. This fila-
tary conductor is carrying cur-
t into the paper. For the pur-
e of computing fields above the
al layer, we place another con-
tor or image h units below the
face of the layer. This image is
ctively a conductor carrying
rent out of the paper. At a point
nits along the conducting layer,
shown in Fig. 7, the current-
rying conductor above the metal
et sets up a magnetic intensity
tor H_1 which is at right angles
the line r drawn from the con-
tor to the point in question. The
gnitude of this magnetic inten-
is

$$H_1 = I/2\pi r \tag{13}$$

re $r = \sqrt{h^2 + x^2}$. The magnetic
nsity due to the image is H_2 and
xactly equal to H_1 in magnitude
points in the direction shown in
. 7. The vector sum of these two
ors is parallel to the surface of
layer and has a magnitude
ch is

$$H = 2H_1 \cos \phi = 2h\ H_1/r \tag{14}$$

if the layer is a good conduc-
the current in the layer will be
centrated near the surface. Then
current density J in amp per
in the little patch shown in Fig.
here the patch is of unit width
x and h are in cm, is

$$J = H = \frac{I}{\pi}\frac{h}{h^2 + x^2} = \frac{I}{\pi h}\frac{1}{1+\left(\frac{x}{h}\right)^2} \tag{15}$$

Current Distribution in Metal Sheet

Figure 8 shows the current distribution in the sheet for a number of values of h, with the current I in the conductor, and flowing out of the paper, equal to one ampere. We see that as the conductor is placed closer to the layer or sheet, the current density increases directly below the conductor, but drops off quickly in a lateral direction.

To sum up all of the current in the sheet, integrate Eq. (15) from $x = -\infty$ to $x = +\infty$. Then

$$\int_{x=-\infty}^{x=+\infty} J\,dx = \frac{2hI}{\pi}\int_{x=0}^{x=\infty}\frac{dx}{h^2+x^2}$$

$$= \frac{2}{\pi}hI\frac{1}{h}\tan^{-1}\left(\frac{x}{h}\right)\Bigg|_{x=0}^{x=\infty} = I \tag{16}$$

The total current flowing in the sheet is thus equal to the current assumed to be flowing in the single conductor.

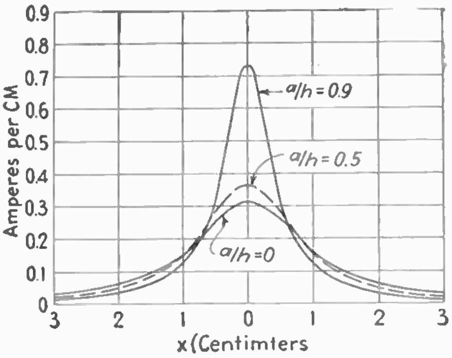


FIG. 11—Current distribution in the conducting sheet when the conductor has a finite radius and $h = 1.0$ cm

We will now proceed with a consideration of the losses in the sheet. The current density J flows out of the paper in a small patch of unit lateral width and of thickness s. This dimension s (Fig. 9) is the skin thickness given by Eq. (8). The current flowing out of the patch shown in Fig. 9 is $J\,dx$. The resistance of the patch shown, with a length of one centimeter into the paper, is

$$dR = 1/\sigma s\,dx \tag{17}$$

The watts lost (I^2R) in this small element is

$$(J\,dx)^2\,dR = \frac{J^2\,dx}{\sigma s} \tag{18}$$

If we now substitute Eq. (15) in (18) and integrate from $x = -\infty$ to $x = +\infty$, we have the power lost in the sheet in a slice taken at right angles to the cylindrical conductor, where the thickness of the slice in the direction along the conductor is one centimeter. If P_m equals the power lost in a 1-cm slice of the metal sheet,

$$P_m = \frac{1}{\sigma s}\int_{x=-\infty}^{x=+\infty} J^2dx =$$

$$\frac{2h^2I^2}{\pi^2\sigma s}\int_{x=0}^{x=+\infty}\frac{dx}{(h^2+x^2)^2} \tag{19}$$

But

$$\int_{x=0}^{x=\infty}\frac{dx}{(h^2+x^2)^2} =$$

$$\frac{1}{2h^3}\tan^{-1}\left(\frac{x}{h}\right)\Bigg|_{x=0}^{x=\infty} = \frac{\pi}{4h^3} \tag{20}$$

so that

$$P_m = \frac{I^2}{2\pi\sigma sh} = \frac{I^2}{h}\sqrt{\frac{10^{-9}\mu_r f}{\sigma}} \tag{21}$$

Finite Cylindrical Conductor

Since the cylindrical conductor generally has a conductivity and relative permeability different from the metal sheet, we should distinguish between the quantities. Let

σ_m = conductivity of the metal sheet
σ_c = conductivity of the current-carrying conductor placed parallel to the sheet
μ_m = relative permeability of the metal sheet
μ_c = relative permeability of the current-carrying conductor

Then Eq. (21) should be

$$P_m = \frac{I^2}{h}\sqrt{\frac{10^{-9}\mu_m f}{\sigma_m}} \tag{22}$$

If the conductor of radius a is placed far enough from the sheet so that the presence of the sheet does

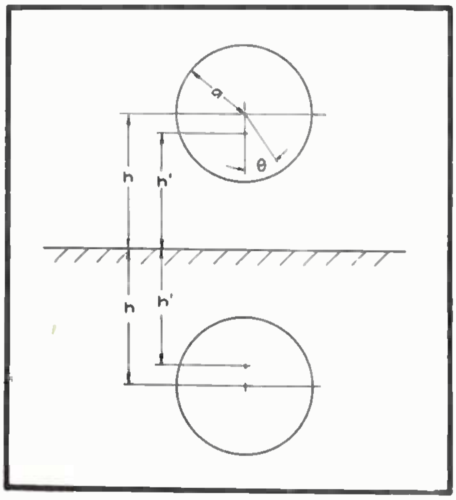


FIG. 12—Cross-section of cylindrical conductor and image in the sheet

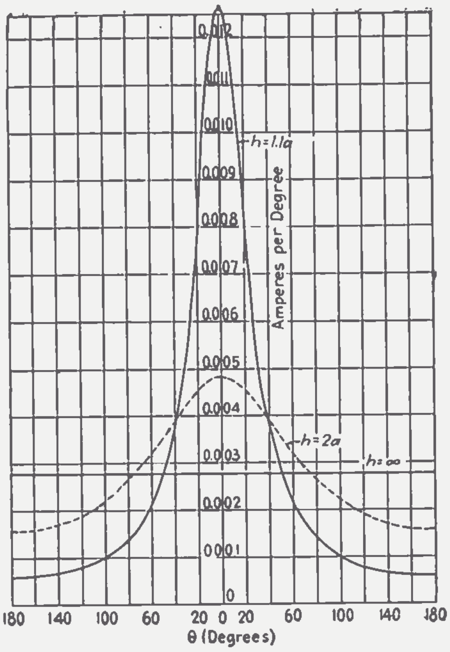


FIG. 13—Current distribution on the cylindrical conductor occasioned by the presence of the metal sheet

not alter the current distribution on the conductor, the current on the conductor will flow in a thin layer s equal to the skin thickness (Fig. 10). Then the power lost in a centimeter of conductor is

$$P_c = \frac{I^2}{.2\pi\, a s_c \sigma_c} = \frac{I^2}{a}\sqrt{\frac{10^{-9}\mu_c f}{\sigma_c}} \qquad (23)$$

and the ratio of the power spent in the metal sheet to the power lost in the conductor is

$$P_m/P_c = \frac{a}{h}\sqrt{\frac{\mu_m \sigma_c}{\mu_c\, \sigma_m}} \qquad (24)$$

Before interpreting Eq. (24), examine the effect of the altered current distribution on the sheet and on the conductor due to close spacing.

When the conductor has a finite radius, a, with the axis of the conductor a distance, h, above the metal sheet, the fields external to the conductor may be computed by replacing the cylindrical conductor by a filament carrying the current I at a new height, h', where

$$h' = \sqrt{h^2 - a^2} = h\sqrt{1 - \left(\frac{a}{h}\right)^2} \qquad (25)$$

The effect on the current density in the metal sheet may be studied by substituting h' for h in Eq. (15). Then

$$J\,(\text{amp per cm}) = \frac{I}{\pi h}\,\frac{\sqrt{1 - \left(\frac{a}{h}\right)^2}}{1 - \left(\frac{a}{h}\right)^2 + \left(\frac{x}{h}\right)^2} \qquad (26)$$

The current density distribution is shown in Fig. 11 for a number of values of the radius, where the height of the conductor is equal to one centimeter. Increasing the radius of the cylinder has the same effect as bringing a thin filament closer to the metal sheet.

The power loss in the metal sheet may be obtained by substituting h' for h in Eq. (22), with the result that

$$P_m = \frac{I^2}{h}\sqrt{\frac{10^{-9}\mu_m f}{\sigma_m}} \cdot \frac{1}{\sqrt{1 - \left(\frac{a}{h}\right)^2}} \qquad (27)$$

Current Distribution in Cylinder

The current distribution around the surface of the cylindrical conductor may be obtained by using the construction of Fig. 12. By means of a tedious algebraic construction, it may be shown that the current density on the surface of the conductor, confined to a layer s_c centimeters in thickness, is

$$J\,(\text{amp per radian}) = \frac{I}{2\pi}\,\frac{\sqrt{1 - \left(\frac{a}{h}\right)^2}}{1 - \frac{a}{h}\cos\theta} \qquad (28)$$

By substituting 360° for 2π radians in Eq. (28), we may express the current density in amperes per degree. This has been done in constructing the curves of Fig. 13. The current density distribution depends only upon the ratio of radius to height. When the conductor is brought very close to the metal sheet, the current on the conductor crowds around to the side closest to the sheet.

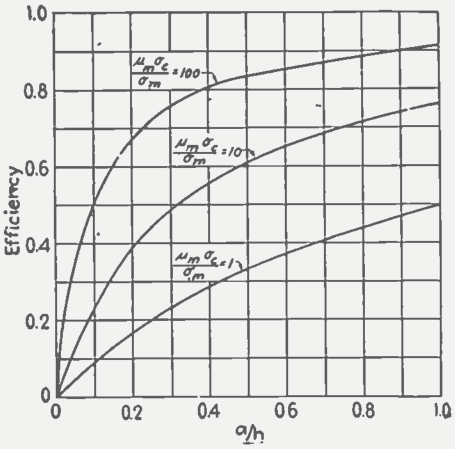


FIG. 14—Coupling efficiency of cylindrical conductor parallel to a metal sheet

The power loss in the conductor is found by integrating the I^2R loss around the circumference of the conductor. Then

$$P_c = 2\int_{\theta=0}^{\theta=\pi} \frac{(J\,d\theta)^2}{\sigma_c s_c a\, d\theta}$$

$$= \frac{I^2}{2\pi^2 a\, \sigma_c s_c}\left[1 - \left(\frac{a}{h}\right)^2\right]$$

$$\int_{\theta=0}^{\theta=\pi} \frac{d\theta}{\left[1 - \frac{a}{h}\cos\theta\right]^2} \qquad (2$$

The integral itself is equal to

$$\frac{\pi}{1 - \left(\frac{a}{h}\right)^2}\,\frac{1}{\sqrt{1 - \left(\frac{a}{h}\right)^2}}$$

so that

$$P_c = \frac{I^2}{2\pi a s_c\, \sigma_c}\,\frac{1}{\sqrt{1 - \left(\frac{a}{h}\right)^2}}$$

$$= \frac{I^2}{a}\sqrt{\frac{10^{-9}\,\mu_c f}{\sigma_c}}\,\frac{1}{\sqrt{1 - \left(\frac{a}{h}\right)^2}} \qquad (3$$

If we now divide Eq. (27) by E (30), we obtain

$$P_m/P_c = \frac{a}{h}\sqrt{\frac{\mu_m\, \sigma_c}{\mu_c\, \sigma_m}} \qquad (3$$

It is a somewhat surprising fa that this result is identical wi the result shown in Eq. (24) whic was deduced from simple assum tions which did not take into a count the redistribution of curre due to the finite conductor size.

Since in inductive heating t coupling coil is usually made of co per, the relative permeability may be set equal to unity for sin plicity. The efficiency is obtain from Eq. (31) in the followin manner.

$$\text{Efficiency} = \frac{P_m}{P_m + P_c} = \frac{1}{1 + \frac{P_c}{P_m}}$$

$$= \frac{1}{1 + \frac{h}{a}\sqrt{\frac{\sigma_m}{\mu_m\, \sigma_c}}} \qquad (3$$

Efficiency Curves

Figure 14 shows the variation efficiency with the ratio a/h. T need for close conductor spacing

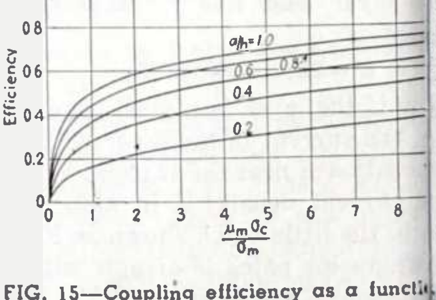


FIG. 15—Coupling efficiency as a functi of conductivity

adily seen. Figure 15 shows the iciency curves replotted as a function of $\mu_m\sigma_c/\sigma_m$. The conductivity the conductor is important in determining the coupling efficiency. here a copper conductor is used to cuple to iron, the coupling efficiency may become high. However, is sometimes necessary to heat a cpper article by induction. At the srt of the heating cycle, the ratio σ_m is unity ($\mu_m = 1$ for copper). om Fig. 15, we see that the best ssible efficiency is 0.5 when the dius of the conductor is equal to e height above the sheet. However, for practical purposes a/h is s than unity, so that the coupling iciency will be less than 50 percnt at the start of heating. Fortnately, the picture does not conue to be so gloomy. The coupg coil or conductor is usually holv tubing through which cooling ter flows, so that the conductiv- of the conductor does not change time passes. The load begins to at so that its conductivity deeases. This results in an improvement in efficiency so that the nductivity decreases still faster, d soon the efficiency assumes reaable proportions.

If the heating coil is wrapped ound a cylindrical load which has a radius many times larger than the diameter of the conductor which makes up the coil and large compared to the spacing between the coil and the work, we may use these results obtained for a conductor parallel to a flat sheet. If the circumference of the load is C centimeters, the resistance of a single-turn coil may be obtained from Eq. (27) and (30). This resistance is

$$R = \frac{C}{a}\frac{\sqrt{\frac{10^{-9}f}{\sigma_c}}}{\sqrt{1-\left(\frac{a}{h}\right)^2}}\left[1+\frac{a}{h}\sqrt{\frac{\mu_m\,\sigma_c}{\sigma_m}}\right] \quad (33)$$

Characteristic Impedance of Load

To obtain the reactance, we must first have available the expression for the characteristic impedance of the conductor over the flat sheet. This is

$$Z_c = 60 \log_\epsilon\left[\left(\frac{h}{a}\right)\left(1+\sqrt{1-\left(\frac{a}{h}\right)^2}\right)\right] \quad (34)$$

SUMMARY OF DATA IN EXAMPLE FOR THREE VALUES OF h

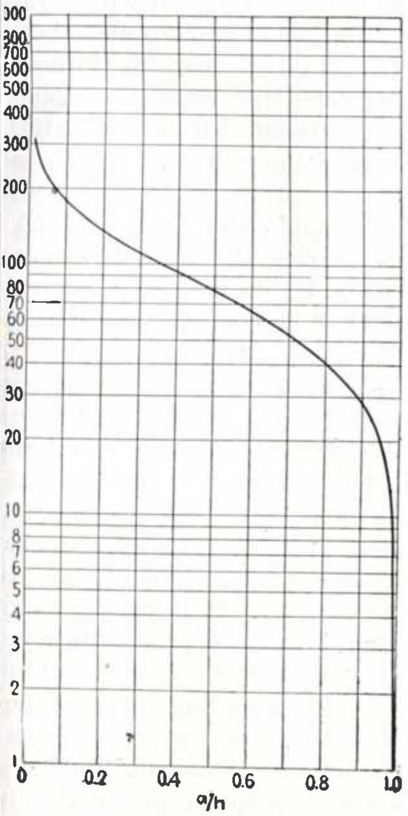
h (cm)	0.44	0.54	0.64
Efficiency (%)...	84.2	81.4	78.5
R (ohms)	0.0195	0.0156	0.0131
Z_c (ohms)	73	87	97
X (ohms)	0.23	0.273	0.304
I (amp for 1000 w)	226	253	276
V (volts for 1000 w)	52	69	84
I (amp for 100,000 w)	2260	2530	2760
V (volts for 100,000 w)	520	691	840

This characteristic impedance as a function of a/h is shown in Fig. 16.

The single-turn coil around the load is usually fed in push-pull. Then the mid-point of the coil is at ground potential. The reactance between one terminal of the coil and the work is then the characteristic impedance multiplied by the tangent of the electrical length of the semi-circumference. The total reactance is twice this value. That is,

$$X = 2Z_c \tan\left(\frac{2\pi}{\lambda}\frac{C}{2}\right) \cong \frac{2\pi C Z_c}{\lambda} = \frac{2\pi f Z_c C}{3\times 10^{10}} \quad (35)$$

Thus we have at hand the necessary formulas for computing the efficiency, resistance, reactance, current and voltage. A casual inspection of these equations will reveal that the five conclusions reached early in the paper are sustained, within the limits of the restrictions placed on dimensions.



. 16—Characteristic impedance of cylinder parallel to metal sheet

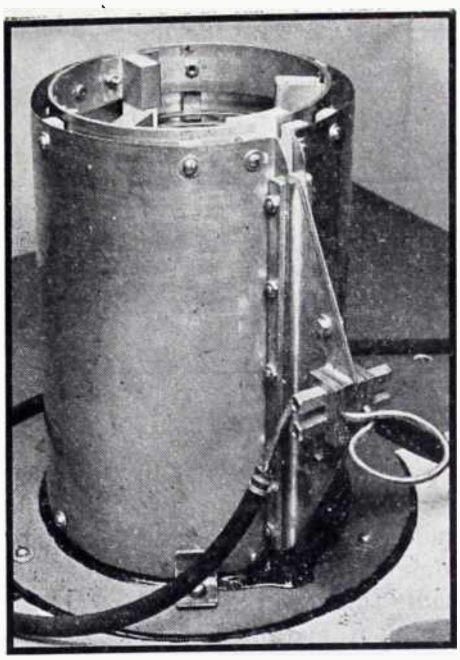


FIG. 17—A current transformer which is useful for inductive heating

Practical Example

The magnitude of values encountered when a single-turn coil is used will be shown by means of an example. The following constants will be used:

C = 15.0 cm
a = 0.24 cm
h = 0.44 cm
σ_c = conductivity of copper coil = 580,000 mhos for a cm cube
σ_m = conductivity of hot steel — 6000 mhos for a cm cube
μ_m = unity for steel above the Curie point
f = 10^6 cycles per second

From Eq. (32), we find that the efficiency is 84.2 percent. Substituting the numerical values in Eq. (33) gives a resistance of 0.0195 ohm, with a current of 226.0 amp for a power of 1000 watts.

Since a/h is 0.545, Fig. 16 gives 73 ohms for the characteristic impedance. Then Eq. (35) shows that the reactance is 0.23 ohm. This reactance multiplied by the current gives a voltage across the terminals of the coil of 52 volts.

The table gives a summary of this numerical data for a few values of h. It may be seen that increasing h results in a slight increase in the current to be handled and a sharp increase in the voltage appearing at

(Continued on page 382)

COMMENTS ON

Discussion of technical, economic and human considerations involved in high-fidelity sound reproduction for post-war radio receivers and broadcasting systems

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THE term "high fidelity", as used at present in the general radio and sound reproduction field, has come to mean an extension of the audio range to the upper frequency limits of audibility of the human ear, as contrasted with a range limited to the usual 4000 or 5000 cycles. In reality, the term "high fidelity" is comparative, and it would be more correct to think of it as "higher fidelity".

Today there is available to the public a new system of program transmission, using frequency modulation of the very high frequency radio spectrum, where suitable channel spacing has been allocated by the FCC so that a wide audio band can be transmitted. In the interest of providing the public with a better radio broadcasting service, every advantage should be taken of frequency modulation toward establishing improved standards of transmission and reception. However, in determining these standards, it is quite important to take a practical view of what constitutes *realizable* high fidelity, bearing in mind that, in the overall result, various practical mechanical and electrical limitations, some physiological and psychological phenomena and, last but not least, the actual program content, are elements fully as important as a theoretically complete sound spectrum, or perhaps more so.

Fidelity implies a faithful reproduction of the original, a condition which in audio systems cannot actually be attained but, at best, only approached. True fidelity would require that:

1. The system not discriminate in any of its component parts against any frequency within the range under consideration.
2. No component part of the entire system introduce false harmonics.
3. There be no amplitude limitation of any portion of the spectrum in either transmission or reception.
4. The system be free from phase distortion.
5. The system be free from extraneous noise.
6. The loudspeaker and its driving amplifiers be capable of reproducing without distortion the full frequency range at loudness levels suitable for all listeners.
7. The acoustics of both the pick-up and listening spaces be suitable.
8. The spatial relationships of the sources of sound be transmitted and reproduced. This last probably requires some form of binaural or stereophonic system, neither of which is economically feasible for general public service at this time.

A system as described above, with the exception of binaural or stereophonic transmission, is not too difficult of realization from a transmitting standpoint. It might be closely approached in a receiver reproducing system, but the cost would probably be beyond the value which would be placed upon it by the purchasing public, particularly if the receiver were required to reproduce frequencies from 30 to 15,000 cycles.

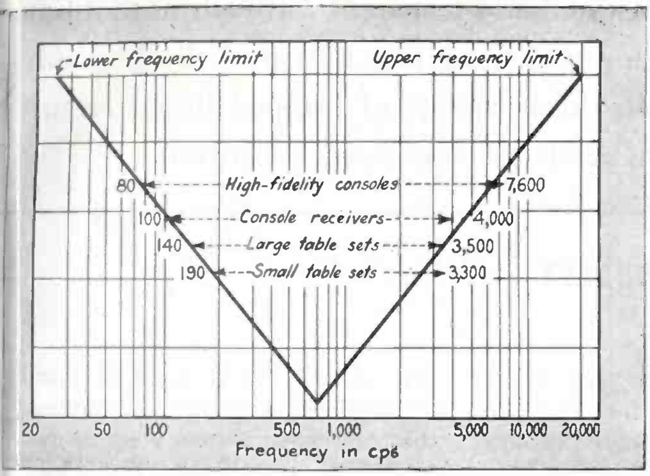
Balanced Frequency Response

It is curious that the emphasis in general discussions of high fidelity thus far has been on an extension of the upper portion of the sound spectrum, and little has been said about the required balance between said upper portion and the lower frequencies. Actually it has been discerned on the basis of much observation that a balanced fre quency response is quite essential to program enjoyment, although this balance factor has not yet been reduced to a rigorous mathematica formula. One authority has said and our experience has confirmed this general statement, that th product of the lower and upper fre quency limits should equal a num ber in the vicinity of 500,000. A sim ple example will show the approxi mate validity of this hypothesis a indicating the importance of bal ance. A system having frequenc response limits of 50 to 8,000 cycles or a total range of 7,950 cycles, i conceded as satisfactory by mos authorities. If we retain this sam range and compare it with a rang of from 250 to 10,500 cycles, there i little question that the former i preferable for reasons of genera "naturalness" but particularly be cause of the reproduction of a sub stantial range below 250 cycles Note that with a range of 50 t 8000 cycles the bulk of progra energy is in the band centerin about a point at approximate 700 cycles.

Figure 1 shows preferred lowe and upper frequency limits in whic the balance is properly maintaine It will be noted that the product the upper and lower frequency lin its, as has been specified, is approx mately 500,000. Many of the bette home radio receivers of conve tional type seem to fit surprising well within these frequency limit

An extension of the frequen range to 17,000 cycles and down 30 cycles would encompass the e tire audible spectrum, but at only small percentage of the total ti would there be any appreciable e

HIGH FIDELITY



3. 1—Preferred lower and upper frequency limits for bal-
ced frequency response in radio receivers. For any given
ceiver, the product of the lower and upper frequency limits should equal approximately 500,000

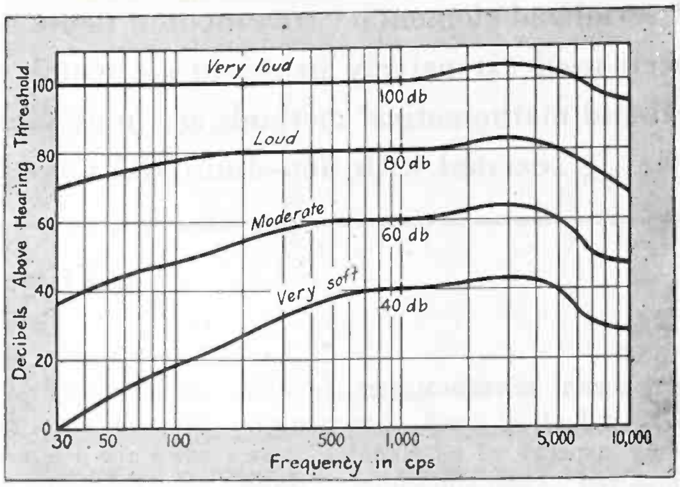


FIG. 2—Frequency response curves for normal ears at 20 years of age, for four different loudness levels at which radio receivers may be operated. At low levels, low-frequency sounds can barely be heard

ey in the region above 10,000 cles. Reproduction of frequencies ave 10,000 cycles adds only to the eoyment, if that is the word, of sh things as key jingles, footsps, handclapping and various extneous noises (non-musical) from msical instruments, such as resin seaks, air rush from wind instrunts, and the like. These "sound ects" can hardly be considered eential or worth high cost to attan!

Tone Control Settings

Experience and various surveys ave shown that, even when listen have receivers capable of reproing frequencies up to 5,000 cy, they usually operate the tone trol to restrict the audio range an upper frequency cut-off someere between 2,500 and 4,000 les. Reasons given for this are t the "tone is mellower", "more asant", "less obtrusive", etc. ny listeners who are musically ined and who appreciate symny and opera are, strangely ugh, numbered in this class, inating that this procedure does stem from uncultivated tastes has some other, more general, is.

t has been claimed that, if distion and noise were eliminated m the higher-frequency band, public would then prefer the extended upper range. Perhaps so, if the higher range is properly balanced by adequate bass reproduction. Distortion and noise are unpleasant at any portion of the sound spectrum.

Present-Day Receivers

Receivers which at present provide millions of listeners with many hours of enjoyment seem generally adequate for reproducing the intelligence and entertainment contained in the program material. The witticisms of Charlie McCarthy, for example, are just as humorous on a receiver whose frequency range is 200 to 3,000 cycles as on a higher-fidelity system.

In this connection, it should not be overlooked that the entertainment and attention-engaging factors in musical listening are not concerned with quality alone. Such matters as appreciation of technique, melody itself, rhythm and the like, are of great importance to the musical ear and all these of course can be reproduced satisfactorily within a reasonably restricted frequency range.

The average radio listener purchases the table model receiver rather than the console. The former type of receiver cannot adequately reproduce bass frequencies, the fundamental reason being lack of sufficient physical size. It is only in the console type that adequate reproduction in the low-frequency range can be approached, but few even of this type have provided really good bass response free from noticeable cavity resonance. The higher frequencies, however, may be reproduced with properly designed smaller receivers, but generally at the expense of an undesirable directional characteristic. This varies with frequency in the preponderant majority of loudspeakers, so that reproduction of these higher frequencies is accentuated in front of the speaker and decreases with the increase in angle from the loudspeaker axis. The response at 45 deg is substantially less than optimum, even at frequencies as low as 3,000 cycles. A true higher-fidelity receiver must so distribute the higher frequencies that, within a specified solid angle, the response at all frequencies is substantially uniform.

Acoustic Limitations

The acoustic conditions of the studio and listening space can be controlled only over a frequency range of approximately 64 to 8,000 cycles, as design data and experience with materials and completed rooms is available only within those limits. At frequencies of 4,000 cycles and higher, the absorption

(*Continued on page* 385)

INTRODUCTION to

A serialized elementary treatment of the non-sinusoidal and transient wave forms that hav been used extensively in recent electronic developments. In this first part, both graphi cal and mathematical methods are used to explain the behavior of lumped linear circuit excited with non-sinusoidal wave forms under steady-state conditions

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By BEVERLY DUDLEY
Western Editor

RECENT DEVELOPMENTS in the industrial and communications aspects of electronics have employed non-sinusoidal wave forms and transients in greater and greater degree. Indeed, it would appear that the requirements of modern electrical technology have reached the stage where our concepts must be generalized and expanded beyond conventional alternating current theory to account for the behavior of circuits when subjected to periodic and non-periodic excitation of a wide variety of wave forms.

It will be the purpose of this series of articles to discuss, in elementary fashion, the behavior of a few simple electric circuits composed of linear elements (in which current is directly or inversely proportional to voltage for any frequency), where non-sinusoidal and transient voltages and current wave forms play an important role. An attempt will be made to outline electric circuit behavior under steady-state as well as transient conditions. To this end both mathematical and graphical methods will be employed. The mathematical approach appears to be most suited for use when exact numerical results are desired, or where general laws are to be formulated. On the other hand, graphical methods lend themselves quite admirably to an interpretation of some of the fundamental processes with which we must deal.

It is proposed to discuss three phases of the general topic: (1) the general voltage-current relations which exist for linear circuit elements and their applications to steady-state and transient non-sinusoidal wave forms, (2) a mathematical and graphical interpretation of the behavior of simple circuits, composed of linear elements, under steady-state conditions with non-sinusoidal wave forms, and (3) the analysis of simple circuits under transient conditions, with emphasis on the physical interpretation of the method of solving the circuit equations.

The combination of transient and steady-state conditions leads, of course, to the complete solution of the behavior of the electric circuit. The transient solution represents that phase of circuit behavior which transpires from the time the circu is subjected to an initial impulse t the time when a steady equilibriu condition is attained. The stead state condition is that equilibriu state of affairs which exists aft the transient "cushion" has decay to a negligibly small magnitude.

Fundamentals of Circuit Behavior

The fundamentals of linear ele tric circuit theory are equally a plicable to transient or steady-sta conditions. With emphasis plac on the physical interpretation, tho fundamental concepts which w be employed may be stated as fo lows:

(1) The instantaneous volta across a resistor is equal to t product of its resistance in ohm and the instantaneous value of th current in amperes flowing throug it.

(2) The instantaneous value the voltage drop across an induct is equal to the product of its indu tance in henries and the time ra of change of the current flowi through it in amperes per seco

(3) The instantaneous value the current flowing through a c pacitor is equal to the product its capacitance in farads and t time rate of change of the volta across its electrodes in volts p second.

(4) A magnetic field surroun ing an inductor is produced wh an electric current flows through i

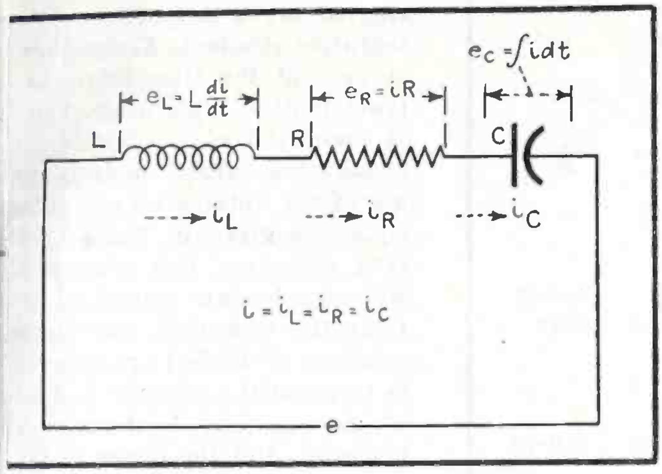
(5) An electric field is esta lished between the two conducto of a capacitor when a difference potential exists between them.

(6) A finite amount of time required to establish an electric a magnetic field.

TABLE I—Voltage-Current Relations for Linear Circuit Elements

Circuit Element	Voltage Equation	Current Equation
Resistance, R	$e_R = Ri_R$	$i_R = \frac{e_R}{R}$
Self-Inductance, L	$e_L = L\frac{di_L}{dt}$	$i_L = \frac{1}{L}\int e_L\,dt$
Capacitance, C	$e_C = \frac{1}{C}\int i_C dt$	$i_C = C\frac{de_C}{dt}$

TRANSIENTS...Part I



IG. 1—General type of series circuit consisting of linear elements *R, L, and C*

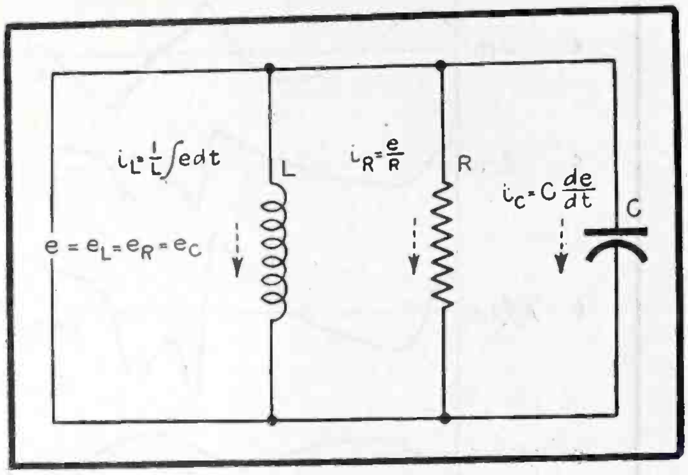


FIG. 2—General type of parallel circuit composed of linear elements *R, L, and C*

(7) The superposition theorem ay be applied to circuits composed linear circuit elements, that is, circuit elements whose properties e independent of the voltage ross or the current through them. he superposition theorem states at in a network composed of linar circuit elements, each electrootive force produces a current inpendent of any other electromove force, the electromotive forces d currents of which may be added gebraically to obtain the resultt. The ability to superpose curnts and voltages of a given freency, independently of those of her frequency and of transients, a direct consequence of the reriction that only linear circuit ements are under discussion. The perposition theorem does not apy (at least, not without extenon) to non-linear elements.

(8) For circuits employing ries connections, Kirchhoff's volte law applies. This law states at the total voltage drop across electric circuit is equal to the m of the voltage drops across ch of its circuit elements, and is ual to the sum of the voltage ses or impressed electromotive rces.

(9) For circuits employing parlel connections, Kirchhoff's curnt law is valid. This law states at the current flowing to any ncture is equal to the sum of the rrents flowing away from the ncture. (It may be noted that th forms of Kirchhoff's laws are merely specialized forms of conservation of energy.)

The first three of these statements relates the voltage and current for the three different linear circuit elements, all of which are assumed to be ideal. An ideal circuit element is one which is presumed to behave physically in strict accordance with the mathematical prediction of its behavior; all losses are assumed to be zero (except the resistance of a resistor) and distributed capacitance, inductance and resistance are assumed absent.

When expressed in mathematical form, the first three statements (and their inverse) give rise to the six equations of Table I. The voltage-current relations expressed by these six equations are derivable not only from experimental observation but also from definitions of fundamental electrical concepts. All six relations are of paramount importance to the study of linear circuit behavior. However, the mathematical expressions in one column are merely alternative forms of the equations in the other, so there are only three, instead of six independent relations. When dealing with voltages and currents in *L* and *C* elements, we are involved not only in algebraic operations, but in rates of change and inverse rates of change, treated, respectively, in differential and integral calculus. Calculus, dealing with quantities which vary, introduces mental concepts which may be difficult to grasp at first, just as it might be difficult to play, at first, a ball game in which the number of players is constantly varying. While no one can hope to be completely free to carry out independent thinking on electric circuits who does not have at least a rudimentary knowledge of elementary calculus, it is the aim here to present the fundamental concepts in graphical form so that a formal acquaintance with this branch of mathematics may be dispensed with.

We may obtain experimental verification of the relation given in Table I. However, since it is not possible to obtain ideal circuit elements, no experimental verification can be more than an approximation to the ideal state of affairs. The approximation may be exceedingly good, and with well-designed circuit elements it will be good. However, it can be shown that the voltage-current relations of Table I have a true theoretical foundation.

Derivation of Voltage-Current Relations

From a study of elementary electricity, the charge (the number of electrons or ions) on a capacitor q is proportional to the product of the voltage e between the capacitor plates and the capacitance C of the capacitor. Quantitatively, this yields the result

$$q = eC \tag{1}$$

Since charged particles are the fundamental building-blocks of electricity, all electrical effects are explainable in terms of them, as for instance, the concept of an electric

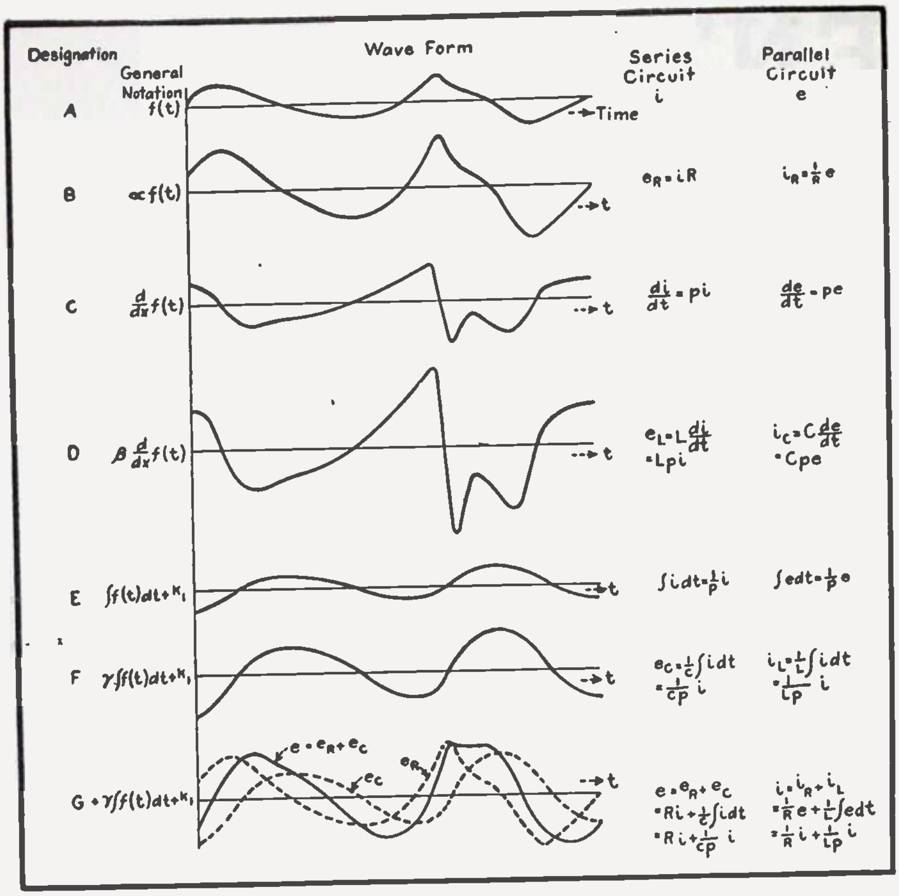


FIG. 3—General type of wave form impressed on a series or parallel *RLC* circuit (curve A) and resulting wave forms existing in other portions of the circuit

current. From the study of the flow of an electric current, we learn that an electric current is the time rate of change of charge. Expressed analytically we have the result

$$i = dq/dt \tag{2}$$

If we substitute the first of these equations into the second, and keep in mind that C is a constant (since we are dealing with circuit elements which are constants) the current can be expressed in terms of the capacitance and the voltage by means of the equation

$$i = \frac{dq}{dt} = \frac{d}{dt}(eC) = e\frac{dC}{dt} + C\frac{de}{dt}$$
$$= 0 + C\frac{de}{dt} = C\frac{de}{dt} \tag{3}$$

If we multiply this equation through by dt, divide by C, and integrate both sides of the resultant equation, the voltage across a capacitor is expressed in terms of the current through it by means of the equation

$$e_C = \frac{1}{C}\int i\,dt + K_C \tag{4}$$

The constant K_C is required to account for any residual charge which may appear on the capacitor at the time for which $t = 0$.

Similarly we may develop analytical reasoning to support the equation connecting voltage and current in an inductive circuit. From the laws of electromagnetism, the voltage is related to the magnetic flux by means of the experimental result stating that the voltage is proportional to the number of turns, and also to the time rate of change of flux. The total flux is the product of the number of turns, N, assumed to be constant, and the flux, ϕ, per turn. The total flux $N\phi$ is produced by the current, i, and the resultant voltage may be written in the form

$$e_L = \frac{d}{dt}(N\phi) = N\frac{d\phi}{dt} + \phi\frac{dN}{dt}$$
$$= N\frac{d\phi}{di}\frac{di}{dt} + 0 = L\frac{di}{dt} \tag{5}$$

The last is permissible since the inductance, L, is defined as the flux linkages per unit time or the number of turns times the derivative of the flux with respect to the current, or $L = Nd\phi/dt$. Again, multiplying by dt, dividing by L and integrating both sides of the equation we obtain the result

$$i = \frac{1}{L}\int e\,dt + K_L \tag{6}$$

Using the results of Table I and Kirchhoff's law we can build up general analytical expressions whic support (and in fact are essentiall the same thing as) the graphica evaluation of wave forms which ar carried out in this article. The integration constant, K_L specifies th current at the time taken as th lower limit of integration. The fac is sometimes overlooked tha steady-state circuit analysis make use of the differential and integra equations given in Table I. It i true, of course, that when dealin with steady-state sinusoidal cond tions the somewhat awe-inspirin relations of Table I are expressib in terms of the familiar $j\omega$ facto which can then be treated alg braically. But the terms in $j\omega$ a merely the result of applying t more general equations of Table to a special case; when we no long deal with a fortuitious special cas we must revert to thinking in tern of fundamentals. These fund mentals involve time rates change (and their inverse), a since these change for each ne type of wave form, they also invol a completely new solution of t circuit relations. Essentially, t same kind of generalization is ca ried out when we proceed from sin wave to non-sinusoidal wave for as is involved when we make t jump from d-c to a-c theory.

Voltage-Current Relations Hold Fc Transient and Steady-State Conditic

The fundamental voltage-curre relations given in Table I are co pletely general for linear circu elements, and therefore may be a plied to steady-state and transie currents and voltages of any phy cal realizable wave shape. Befo we may proceed it is necessary build up a thorough understandi of these voltage-current relatio This could be done by discussin individually, the voltage-current r lations of each separate circuit e ment, and subsequently applyi this reasoning to circuits compos of various combinations of circu elements. We may combine both these steps, and study the volta current relations of the vario elements when combined in ser or parallel circuits.

In the analysis of series circui it will be convenient to assume t current of specified wave form a then ascertain the magnitude a

ve forms of the voltage drops
ross each of the circuit elements
well as that of the impressed
ltage. The voltage across each of
e circuit elements is determined
terms of the equations given in
e third column of Table I. By
irchhoff's voltage law the im-
essed voltage will be equal to the
m of the voltage drops around
e circuit. Such an analysis (in
ich the current is regarded as
e independent variable) may
carried out for any combina-
n of the three fundamen-
l circuit elements connected
series. Likewise, for parallel cir-
its composed of any combination
the three circuit elements, the
agnitudes and wave forms of the
impressed voltage will be assumed and the magnitudes and wave forms of the total and branch currents will be required.

Series Circuit

Consider the circuit of Fig. 1 composed of *R*, *L*, and *C* in series and in which a current, *i*, flows as a result of an impressed electromotive force, *e*. For this case, Kirchhoff's current law takes the form

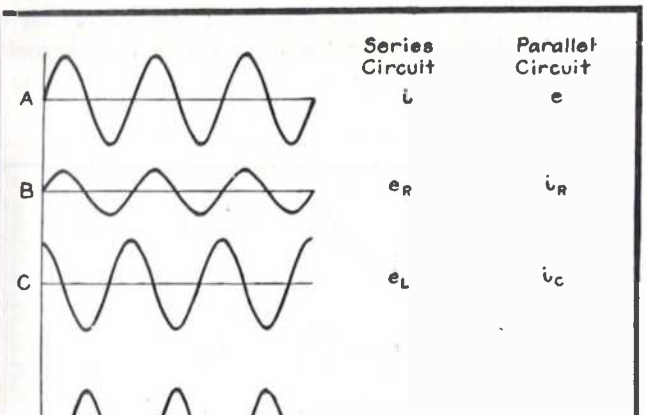
$$i = i_L = i_R = i_C \qquad (7)$$

The voltage law becomes

$$e = e_L + e_R + e_C = L\frac{di}{dt} + Ri + \frac{1}{C}\int i\,dt \qquad (8)$$

By means of the second circuit equation, the steady-state voltage drops across portions of the circuit can be determined as soon as the magnitude and wave form of the current flowing through it are known. Since the voltage across a constant resistance is proportional to the current through it, the current and voltage wave forms for a resistance will be identical functions of time.

The voltage-current relations for inductance and capacitance are expressed by more complicated equations and dissimilarity of current and voltage wave forms may therefore be anticipated. In general, for each different wave form of current flowing through the series circuit we may expect completely dissim-



IG. 4—Current and voltage wave forms in series and parallel rcuits with sinusoidal excitation. As applied to series circuits e significance of the curves is as follows: (A) Current through rcuit; (B) Voltage across *R*; (C) Voltage across *L*; (D) Voltage ross C; (E) Voltage across *R* and *L*; (F) Voltage across *R* d *C*; (G) Voltage across *L* and *C*; (H) Voltage across *R*, *L*, d *C*. All wave forms have the same frequency and nusoidal type of variation, but differ in amplitude and phase

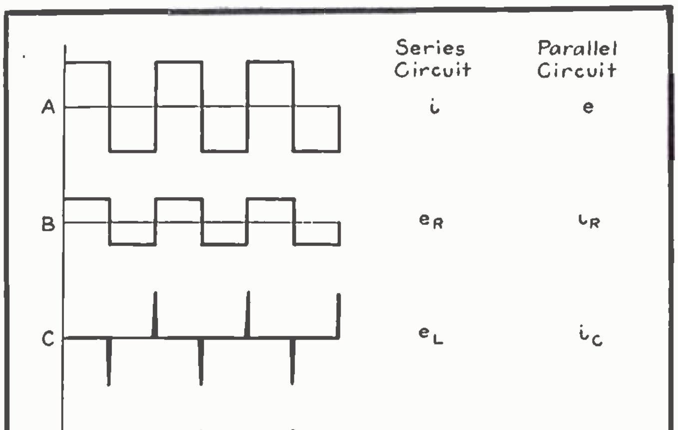


FIG. 5—Current and voltage wave forms in linear circuits with square wave excitation. As applied to parallel circuits, the curves have the following significance: (A) Impressed voltage; (B) Current through *R*; (C) Current through *C*; (D) Current through *L*; (E) Current through *R* and *C*; (F) Current through *R* and *L*; (G) Current through *L* and *C*; (H) Current through *R*, *L*, and *C* connected in parallel. The only wave form resembling the impressed excitation is that for *R*

ilar wave forms of voltage across the circuit as a whole as well as across L and C. Indeed, when we come to consider the matter carefully it would appear quite remarkable that we should ever obtain voltage drops across different kinds of circuit elements, whose wave forms were similar to one another or (except in the case of the resistance) similar to that of the current flowing through the circuit.

Parallel Circuit

Next consider the general parallel circuit of Fig. 2 composed of the three different circuit elements, L, R, and C in parallel, across which an electromotive force, e, is applied. From Kirchhoff's voltage law, the voltage drop across each circuit element is equal while from Kirchhoff's current law the total current taken from the generator will be equal to the sum of the three branch currents. Making use of the circuit relations of Table I, Kirchhoff's laws may be expressed quantitatively in the form

$$e = e_C = e_R = e_L \qquad (9)$$

for the voltages and in the form

$$i = i_C + i_R + i_L = C\frac{de}{dt} + \frac{e}{R} + \frac{1}{L}\int e\,dt \qquad (10)$$

for the currents. While the physical interpretation of Eq. (8) is different from that of Eq. (10) the forms of the two equations are identical. The two circuits for which differential equations of the same form exist are said to be duals.

Although representing exceedingly important electric circuit relations, Eq. (8) and (10) can be regarded thus far merely as mathematical abstractions. To use these results we need to know the true significance and physical interpretation of the mathematical expressions di/dt, $\int i\,dt$, de/dt, and $\int e\,dt$ which are associated with varying values of current and voltage. This is especially important since these symbols do not represent algebraic quantities, in the usual sense of the word, but designate types of operations which must be carried out. They are directives, if you will, telling us how we must perform a particular job in order that a desired end result may be achieved. The symbolic notation, di/dt, indicates that we are to carry out the operation of differentiating the current, i, with respect to time, t. The notation $\int i\,dt$ calls for the process of integrating the current i with respect to time t, just as the symbol j calls for a 90-degree rotation in a counter-clockwise direction of the vector with which it is associa-

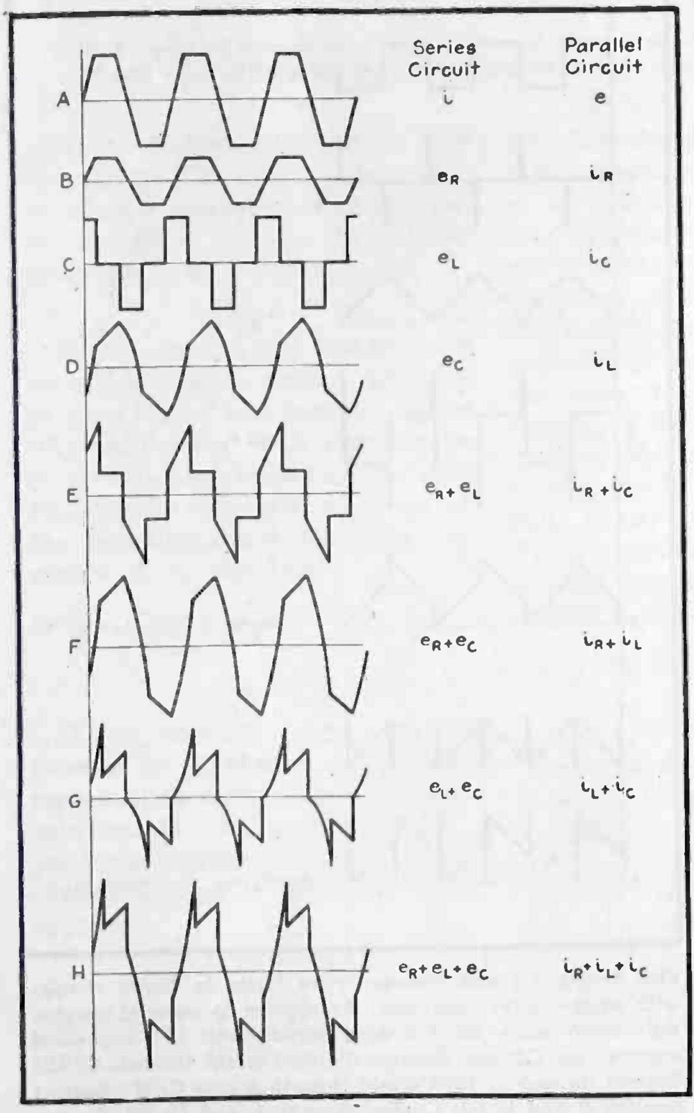


FIG. 6—Current and voltage wave forms for series and parallel *RLC* circuits with trapezoidal wave form excitation

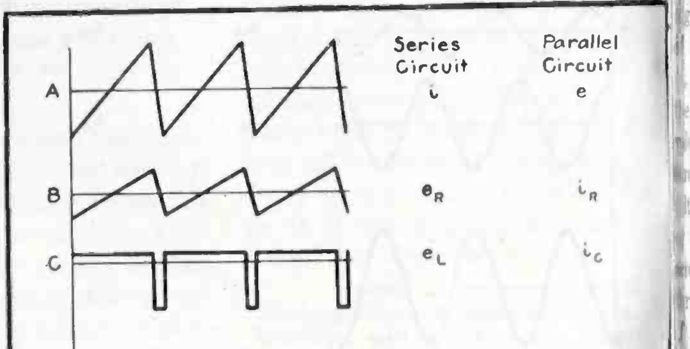


FIG. 7—Current and voltage wave forms for series and parallel *RLC* circuits with triangular wave form excitation

It should be noted that differenation, indicated by the notation *dilt*, and integration, indicated by the notation, $\int i\,dt$, are inverse oprations just as are those of sqaring and extracting a root.

ince the derivative commonly taes the form of a time rate of chnge, the corresponding integral my be regarded as the inverse tie rate of change. Graphically, raes of change are indicated by th slope of a graphical plot, while ingrals are represented by areas uer a curve. The fundamental ocepts involved in differentiation ar integration are really quite siple, but a slight detour will be in oer to review the physical intertations underlying these mathenical operations.

'he process of differentiation is nolved when we desire to dernie the voltage drop across an intor whose current is known ($= L\,di/dt$) or when it is necesay to ascertain the current flown through a capacitor in terms of the voltage across its plates ($= C\,de/dt$). On the other hand, h process of integration is inved in determining the current hough an inductor in terms of the age across it, $i_L = (1/L) \int e\,dt$, n in determining the voltage oss a capacitor when the current hough it is known: $e_c = (1/C) \int i\,dt$. Thus, both the processes o differentiation and integration a not mere mathematical abstracns, but represent exceedingly imtant conditions of behavior of various electrical circuit elents.

raphical Approach to Analysis of Voltage-Current Relations

A formal treatment of the proc- of differentiation and integra- may be found in any standard tbook on differential and integral culus. A graphical interpreta- will be substituted here for the re formal mathematical approach the belief that in an elementary atment this procedure results in learer understanding of the estial physical principles. The thematical operations will be inpreted in terms of electric cirt behavior.

Suppose that time-varying curve of Fig. 3, $f(t)$, represents the ve form of current flowing in the series circuit of Fig. 1 or the voltage across the parallel circuit of Fig. 2. The following analysis can be carried out for either type of circuit, according to the relations given at the right of this diagram. To be specific, we shall apply the analysis to the series circuit of Fig. 1. Since $e = iR$ (where R is a constant) the voltage across the resistor will be exactly of the same wave shape (except for scale factor of the ordinates) as that of the current. Hence it may be represented by curve B.

Wave Form of Voltage Drop Across Inductor

With the current wave form as shown at A in Fig. 3 it will be necessary to differentiate this current and multiply it by the inductance L to obtain the voltage across the inductor through which the current flows. Graphically it is therefore necessary to determine the derivative (or slope) of the given current wave (represented by curve A) to obtain the rate of change (curve B) and then to multiply the result by L to obtain the voltage across L (curve C). The derivative of curve A at any point along the t axis is given by its slope at the point in question. Accordingly, if we measure the slope of curve A at each point and plot, as ordinates in curve C, the magnitudes of these slope determinations at the corresponding values of t, the resultant curve, C, will be the derivative of curve A. The derived curve, C, will be positive (above the zero axis) when the slope of curve A is positive—that is, when a line tangent to the curve runs from the lower left-hand to the upper right-hand region. The magnitude of the derived curve will be zero when the slope of the original curve is zero or when a line drawn tangent to the curve (at the value of t in question) is horizontal. The magnitude of the derived curve will increase as the slope of the original curve increases and vice versa. A little study will show the relation existing between the original curve, A, and the derived curve, C. The reader will understand, of course, that the graphical operations are merely representations, or ways of indicating, the fundamental physical phenomena taking place.

The absolute value of the voltage across the inductor is obtainable by multiplying the time rate of change of current, represented by the derived curve C by a suitable constant, L, equal to the inductance of the circuit. If the ordinates of curve C are multiplied by L, curve D will now represent the wave form of the voltage across an inductance.

To ascertain the voltage across a capacitor through which a known current flows, it is necessary to integrate the current and divide by the capacitance, C. If the current is represented graphically by curve A, then the integral of the current may be represented graphically by the area under the current curve (A), as is shown in any text on integral calculus. This area represents what we have chosen to call the inverse rate of change. To illustrate the fundamentals, it is now necessary to carry out the process of graphical integration.

Wave Form of Voltage Across Capacitor

If we plot, point by point, the area inclosed between curve A and its zero axis, the resultant curve will be as shown at E in Fig. 3. At any point along the abscissa, the height of curve E represents the area under curve A. The integrated curve, E, increases as the area of curve A above the zero axis increases, whereas curve C decreases when the area under curve B is negative.

In deriving curve E as the area under the original curve A, a certain amount of arbitrariness is involved until the beginning and end points are specified on the original curve whose area is to be ascertained. These end points are called the limits of integration. The arbitrariness resulting from failure to specify the limits between which the original curve A is integrated, makes it necessary, in general, to add a constant, K_1, to the integrated curve F. In the graphical plot, the need for inserting such a constant was not apparent since we began finding the area under the curve at a specific point, $t = 0$, thus establishing one limit of integration. The other constant of integration is that value of t for which the process is discontinued. For purposes

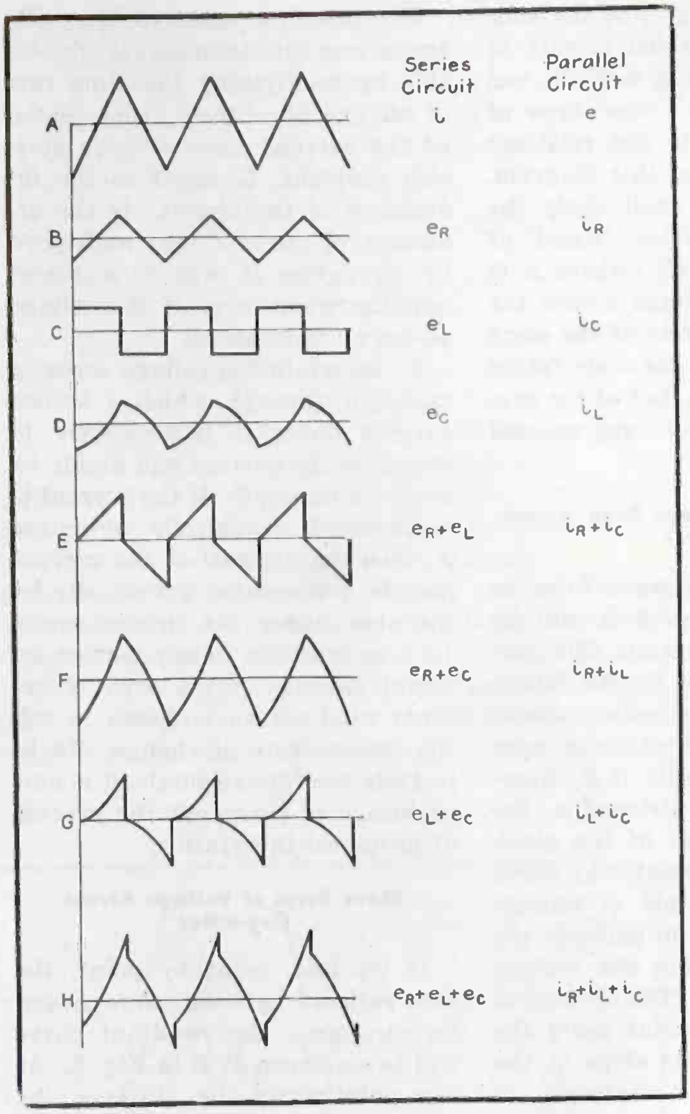


FIG. 8—Current and voltage wave forms for series and parallel *RLC* circuits with saw-tooth wave form excitation. This wave form is used extensively in sweep circuits of cathode-ray tubes used in television transmitters, television receivers, oscilloscopes and newly-developed cathode-ray equipment

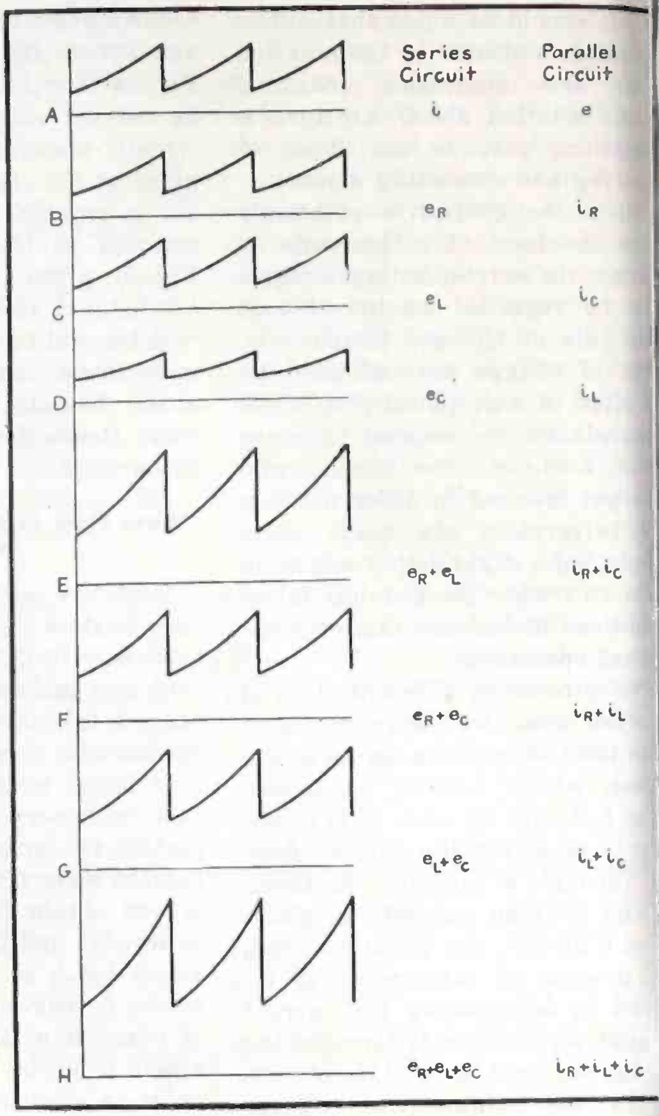


FIG. 9—Current and voltage wave forms for series and parall *RLC* circuits with excitation which is a recurrent portion of exponential wave form. All wave forms are identical exce for amplitude, because the exponential function has the san shape as its derivative and integral

of generality the integration constant, K_1, has been retained in the column marked General Notation. Physically, the integration constant represents the voltage across the capacitor (for the series circuit) or the current in an inductor (for the parallel circuit) when $t = 0$. If we assume, as we shall, that the voltages and currents are initially 0, the constant may be dropped. This has been done in writing the electrical equations at the right of the wave form diagrams.

In obtaining the derivative or the integral of the given time-varying function, we have carried out an operation of inversion on the original function representing the given current. In obtaining the derivative of the current this inversion has been obtained by means of the operator, di/dt, whereas the operator $\int i\,dt$ has been used in obtaining the integral curve of the current. The mathematical directives which indicate how these conversions are to be made are called inversion operators.

Inversion Operators

We have now illustrated, by graphical methods, the inversion of wave forms by means of the inversion operators, $df(t)/dt$ and $\int f(t)dt$, and it is now necessary to apply Kirchhoff's laws to solve the voltage-current relations for simple circuits. Consider, for example, a series circuit composed of *R* and *C* or a parallel circuit composed of *R* and *L*, the necessary voltage and current conditions of which are shown by curves B and F. By adding curves B and F graphically, we carry out the necessary algebraic operations requir by Kirchhoff's law. Thus, the f line of curve G (representing t algebraic sum of curves B and represents the wave form of vo age across an *RC* series circuit the wave form of current for a c cuit of *R* and *L* in parallel. T curves are lettered to apply only a series *RC* circuit. The graphic addition is in accordance with t superposition theorem.

It will be observed that all of t curves of Fig. 3 are single-valu functions of time, without disco tinuities. A single-valued functi of time is, of course, some relati having a single value at any giv instant, and a continuous functi is one having no breaks or disco tinuities. Since we have chosen perfectly arbitrary function f purposes of discussion, the gener ocedure which has been developed applicable to sinusoidal wave rms which may be encountered in actice, since these are single-lued and continuous. In general, ese conditions will be fulfilled in actice.

raphical Method Applied to Sinusoidal Waves

We shall apply the method out-ied above to an analysis of the miliar sinusoidal time variations the first application of the graph-al procedure. Since there exists a ial relation between the series and rallel RLC circuits, it will be cessary to analyze only one such rcuit. For purposes of illustra-on, the series circuit will be eated.

The voltage-current relations ex-ting in series RLC circuit are iven by Eq. (7) and (8). For the articular application in question, sinusoidal current is assumed so iat the instantaneous value of the irrent may be expressed graphi-lly by curve A of Fig. 4 or mathe-iatically as

$$i = I_m \sin \omega t \qquad (9)$$

y inserting Eq. (9) into Eq. (8), ie impressed voltage and the volt-ge drops will be given by

$$= e_L + e_R + e_C = L\frac{d}{dt}(I_m \sin \omega t)$$

$$+ RI_m \sin \omega t + \frac{1}{C}\int I_m \sin \omega t \, dt \qquad (10)$$

ince the voltage drop across the esistor is proportional to the cur-ent through it, we have immedi-tely

$$e_R = RI_m \sin \omega t \qquad (11)$$

raphically this voltage drop is ob-iined by multiplying curve A of ig. 4 by R to obtain curve B. For ie remaining voltage drops we iust now differentiate and inte-rate the sine function in order to iake use of Eq. (10).

Since the derivative of the given me-varying (sine) function is its ope—or its time rate of change— is evident that the derivative will e proportional to the frequency or ω = 2πf since the slope varies yclically with frequency. There-ore ω will be a multiplying actor. It is also evident that within ny cycle, or period, the time rate f change is equal to the slope of ie given curve. Now the slope of he sine curve yields a cosine curve. Therefore, the derivative of the sinusoidal current is curve

$$\frac{di}{dt} = \frac{d}{dt}(I_m \sin \omega t) = \omega I_m \cos \omega t$$

$$= \omega I_m \sin\left(\omega t + \frac{\pi}{2}\right) = j\omega I_m \sin \omega t = j\omega i \qquad (12)$$

The third step in the above equation is justified since there is a 90-deg phase shift between the sine and cosine function. We may indicate this 90-deg phase shift by the added angle, π/2 radians, or by any other generally accepted notation which will be understood as indicating a 90-deg phase shift. Such a device is the operator j. Accordingly we may multiply the final results by j (instead of adding the angle π/2) to indicate the desired shift. By means of this artifice we have achieved the very important advantage of being able to express the voltage across the inductance as a sine function (instead of a cosine function) which is also the expression used to designate the time variation of current. The voltage across the inductance is

$$e_L = L\frac{di}{dt} = j\omega LI_m \sin \omega t = j\omega Li \qquad (13)$$

obtained by multiplying the final form of Eq. (12) by L. The result is shown graphically as curve C of Fig. 4. It will be noted from Eq. (12) and (13) that for a-c theory involving sine waves, the inversion operator, di/dt, can be replaced with the expression $j\omega$.

The graphical and geometric significance of the integral of a sine wave is slightly more difficult. Since the integral is represented graphically by the area under the given curve, the area under the curve, for each full cycle or period, will decrease as the time interval of the period decreases, or as the frequency increases. The inverse time rate of change is inversely proportional to frequency, just as the time rate of change was found to be proportional to frequency. Thus the integral is inversely proportional to ω = 2πf, or is proportional to 1/ω = 1/2πf. Also, within any cycle or period the integral is proportional to the negative of the cosine wave. Hence we have the result

$$\int i \, dt = \int (I_m \sin \omega t) \, dt = -\frac{1}{\omega} I_m \cos \omega t$$

$$= -\frac{I_m}{\omega} \sin\left(\omega t - \frac{\pi}{2}\right) = -j\frac{I_m}{\omega} \sin \omega t$$

$$= -j\frac{i}{\omega} \qquad (14)$$

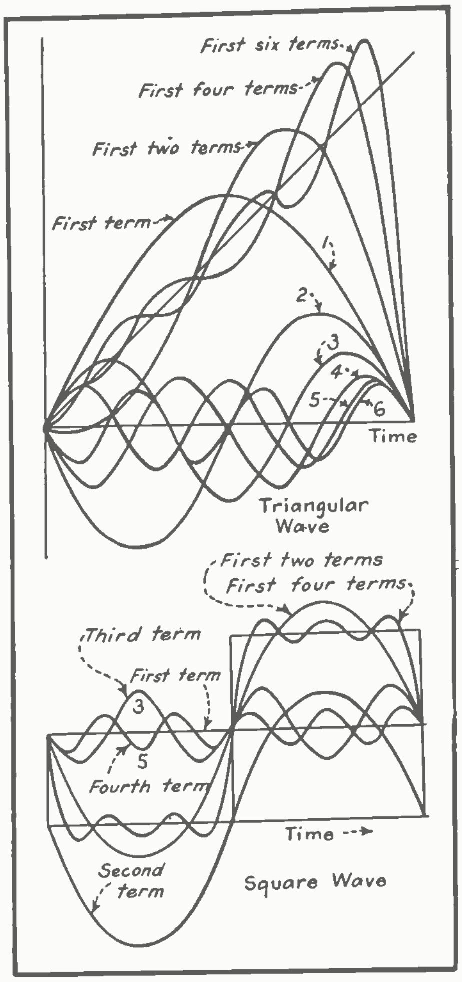


FIG. 10—Two diagrams illustrating the manner in which recurrent wave forms may be constructed from a series of sine waves of appropriate amplitude, frequency and phase. The order of the harmonics is indicated by the numerals. Successive stages in the early development of the desired waves are shown

The justification of the $-j$ is based upon the same reasoning as that already described above. The voltage across the capacitor is

$$e_C = -j\frac{I_m}{\omega C} \sin \omega t = -j\frac{1}{\omega C} i \qquad (15)$$

obtained by multiplying Eq. (14) by $1/C$. Again, through the use of the j operator we have been able to express the voltage drop across the capacitor in terms of a sine curve which is used to express the time variation of current.

Using Eq. (11), (13) and (14) and Kirchhoff's voltage law,

$$e = j\omega LI_m \sin \omega t + RI_m \sin \omega t - j\frac{1}{\omega C} I_m \sin \omega t$$

$$= \left(j\,\omega L + R - j\frac{1}{\omega C}\right) I_m \sin \omega t$$

$$= \left(j\,\omega L + R - j\frac{1}{\omega C}\right) i \qquad (16)$$

Since L, R, and C are constants, this equation shows that the instantaneous value of the impressed volt-

(*Continued on page* 392)

PI NETWORKS as Coupled Tank Circuits

A development of the theory of pi networks as they apply to r-f output circuits of tra mitters. A design procedure is outlined and curves are given to simplify matching t output stage directly to the transmission line or antenna, without an output transform

By **FREDERIC D. SCHOTTLAND** *Consultant Forest Hills, N. Y.*

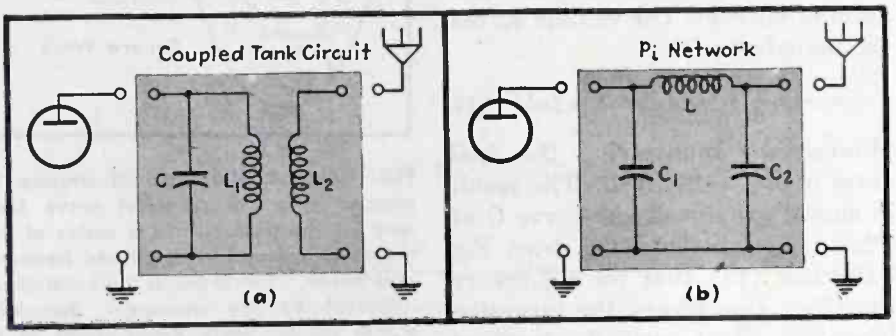


FIG. 1—Simplified representation of a class C r-f output stage feeding a transmission line or antenna at resonance through a coupled tank circuit (a) and through an equivalent pi network (b)

THE use of a π configuration of reactances to couple a class C power amplifier to its load is not new. However, the proper handling of such a network in this application is far from being common knowledge to engineers who design or operate transmitting equipment. This lack of knowledge generally results in a circuit containing few of the obtainable advantages, and one whose harmonic attenuation leaves much to be desired.

New Approach Needed

Unfortunately for the transmitter engineer, design information on π networks is to be found principally in texts concerning themselves with filter and transmission-line theory. As a consequence, the subject is not approached in such a manner as to apply directly to the problem at hand. When following the customary design procedure, an infinite number of solutions are indicated. Cut-and-try methods of adjustment are extremely laborious, and modifications appear to give totally uncorrelated results. The underlying theory as presented in texts is in such form as to give little help, since the means for imposing the further conditions necessary to obtain the single desired solution are by no means apparent.

If the π network is to replace the coupled tank circuit, obviously it must perform the same functions. In general, the basic requirements of the circuit are:

1. It must transform the load to some predetermined impedance.
2. It must deliver a prescrib amount of energy at so maximum or required e ciency.
3. It must provide a preselect degree of harmonic atten tion.

Review of Matching Problem

Figure 1(a) is a simplified sc matic of a vacuum tube coupl through a plate-tuned transform to a load which may be an anten at resonance or a properly term ated transmission line. Figure (b) accomplishes the same coupli through the use of a π netwo Both will perform the functic listed above.

In the coupled tank circuit of F 1(a), the first function is controll by correctly choosing the turns tio of L_1 and L_2 and the amount mutual inductance. The seco function is accomplished by havi the proper ratio of L_1 to C. Final we obtain sufficient harmonic att uation by keeping the circuit ab some minimum value of Q. In oth words, we couple in a resistar with a definite relationship to eit reactance. All of these points well covered in existing literatu and this knowledge is basic to t transmitter engineer.

Inspection of the π network Fig. 1(b) does not immediately how all this is accomplished. We know that a π network will transform impedances and act as a coupling device, but how to control the efficiency and the Q of the circuit is not indicated, nor is this design information available in convenient form.

Reduction of π to L

In any actual circuit we are not concerned with the internal impedance of our tube as such, but rather with the impedance into which it must work. As a limiting case it becomes that impedance which will give the maximum transfer of radio-frequency power under the specific operating conditions of grid bias, excitation and plate voltage employed, without exceeding the rated plate dissipation of the tube. In the circuit of Fig. 2, therefore, R_G will be taken to mean the impedance with which we wish to terminate our generator, and not the internal impedance of the generator itself.

The values of X_T and X_C to match R_A to R_G are obtained from the relations*

$$X_T = \frac{-R_G X_L}{R_G \pm \sqrt{R_G R_A - X_L^2}} \quad (1)$$

$$X_C = \frac{-R_A X_L}{R_A \pm \sqrt{R_G R_A - X_L^2}} \quad (2)$$

To avoid an imaginary value for X_T or X_C,

$$X_L^2 \leqq R_G R_A \quad (3)$$

To make X_C infinite in value so the output capacitor will drop out, we must choose the negative sign for the radical and use a value of R_A such that

$$R_A = \sqrt{R_G R_A - X_L^2} \quad (4)$$

This in no way changes the performance of the network, but the circuit simplifies to the *L* network of Fig. 3, which may be more easily analyzed.

The *L* network shown in Fig. 3 is of extreme interest. It is not only the equivalent circuit of a π network, but if R_A is taken as the reflected resistance of the load, it is the equivalent circuit of a coupled tank network as well. Here, then, is common ground and a means of correlating the two circuits. At resonance, X_T is equal to X_L. R_G was defined as the impedance into which we are to work. That is, it is the image impedance of the network, so

$$X_L = X_T = R_G/Q \quad (5)$$

$$R_A = X_L/Q \quad (6)$$

From Eq. (5), at any desired Q the value of X_L is fixed, and consequently the value of X_T is also fixed. The value of R_A is given by Eq. (6). From Eq. (5) and (6) we see that

$$R_G = X_L^2/R_A \quad (7)$$

Limitations of L Network

We formerly intended to find a network which would match R_G to whatever antenna we had. Because of the restriction of Eq. (4), however, we must now match our antenna to our network. This by no means destroys the usefulness of the network, for the value of R_A which has been obtained is the minimum impedance into which we may work under the given operating conditions. This minimum is entirely independent of the restrictions of Eq. (4).

If the actual load has an impedance greater than R_A it can be made to look like R_A so far as its resistance is concerned, by shunting it with the proper value of reactance. Naturally we shall choose a capacitance for this purpose, since it will act to increase the harmonic attenuation. If the actual antenna has an impedance smaller than R_A, there is nothing we can do about it. Obviously, to increase the impedance we must insert a reactance in series with R_A. If this is a capacitance, it will subtract from X_L, and if an inductance it will add. We may, therefore, view the addition of a series reactance as a change in the value of X_L. If we reduce X_L to obtain the required Q, the QX_L is reduced and R_G is not matched. Similarly, if X_L is increased, we again obtain a mismatch.

Fortunately, it is seldom necessary to couple into an antenna whose impedance is much below that usually found to be the proper terminating impedance of the network. At low radio frequencies, of course, this difficulty may very well be encountered. Although the normal antenna in this case may be so short electrically as to have low resistance, its capacitance in general will also be quite low. To resonate such an antenna, considerable inductance will be required in the loading coil. The resistance of such a coil will be comparable to the antenna itself, and added to it, will bring the resistance into which the network is coupled to a higher value. Of course, this added resistance represents a loss, but that loss was inherent in the circuit and not added by the coupling network. The whole matter may be resolved as follows:

At low frequencies (such as radio

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*Everitt, W. L., Output Networks for dio Frequency Power Amplifiers. *Proc.* .E., 19, No. 5, p. 725-737. May 1931.

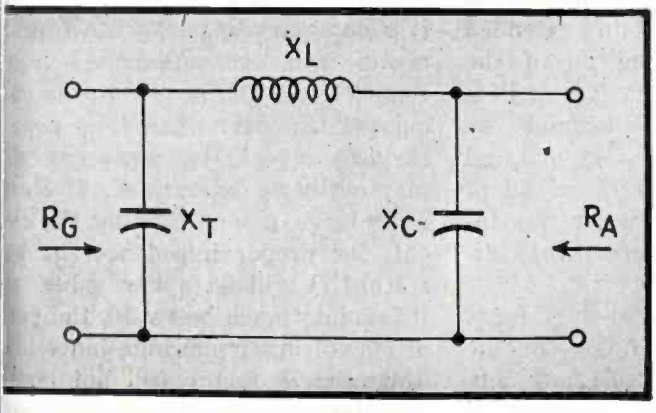


FIG. 2—Pi section used as a low-pass coupling network

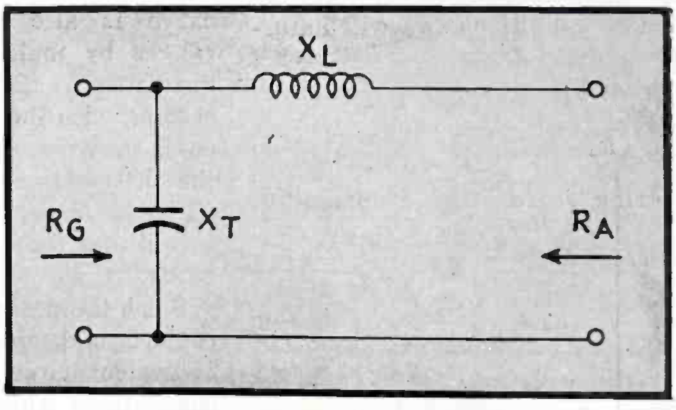


FIG. 3—Equivalent circuit of pi coupling network

beacon frequencies below the broadcast band), it is desirable to use a class C amplifier whose generator impedance is as low as possible, such as a low-voltage, high-current tube or tubes in parallel. This will make R_G and consequently R_A lower. If R_A is still greater than the effective antenna resistance, the resulting circuit would have a higher Q than required, and would, in effect, be undercoupled.

When the actual load, which we shall call R_L, is greater than R_A, the problem has a complete solution. A reactance in parallel with R_L will give a circuit whose impedance is lower than R_L. By properly choosing this reactance, the resistive component may be made equal to R_A, something which was impossible to do with additions of series reactances. This reactance should be capacitive, to increase harmonic suppression.

Development of π Circuit

It is interesting to note that we are throwing off the yoke of Eq. (4), since we are now resynthesizing the original π network of Fig. 2. However, for simplicity, and to maintain the analogy to coupled tank circuits, we shall continue to use the L network of Fig. 3. We shall treat this newly formed parallel circuit as an entity in terms of its series equivalent.

Figure 4(a) shows this parallel circuit, where R_L is a load greater than R_A, and X_C is the compensating capacitive reactance necessary to make the total circuit resistance look like R_A. Figure 4(b) is the series equivalent, where X_E becomes the effective series reactance of Fig. 4(a). It will be as though X_L had been reduced. To compensate, either X_L or the tuning capacitance must be increased. To maintain the original conditions, we will naturally increase X_L.

From Fig. 4(b),

$$R_A - jX_E = \frac{-jR_L X_C}{R_L - jX_C} \qquad (8)$$

Clearing j from the denominator,

$$R_A - jX_E = \frac{R_L X_C^2 - jR_L^2 X_C}{R_L^2 + X_C^2}$$

$$R_A = \frac{R_L X_C^2}{R_L^2 + X_C^2} \qquad (9)$$

$$X_E = -\frac{R_L^2 X_C}{R_L^2 + X_C^2} \qquad (10)$$

Solving Eq. (9) for X_C now gives

$$X_C = -R_L\sqrt{\frac{R_A}{R_L - R_A}} \qquad (11)$$

Equation (11) gives the value of compensating capacitive reactance X_C which will transform R_L into R_A. Figure 5 is a family of curves for this relationship, where R_L is plotted versus X_C for selected values of R_A.

In using Fig. 5, the range may be extended by multiplying all of the quantities by the same factor. For example, assume that it is required to find the reactance which will transform an actual resistive load R_L of 60 ohms into one of 20 ohms. Since there is no curve in the range of $R_A = 20$, we will use the $R_A = 2$ curve and assume that R_L and X_C are also ten times their given values. We enter the graph from the left at the point $R_L = 6$. Traveling to the right we find that the intersection with $R_A = 2$ occurs at $X_C = 4.2$. Multiplying by ten, our answer is 42 ohms.

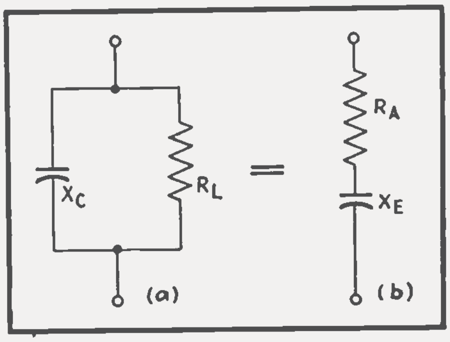


FIG. 4—Load with reactance in parallel (a), and its equivalent series circuit (b)

Equation (10) gives the series equivalent reactance introduced by X_C, this being the value by which X_L will have to be increased to compensate. Figure 6 is a family of curves for this relationship. This curve is also used in extended ranges by multiplying all of the quantities by the same factor. Proceeding with the above example, we enter the curve at $X_C = 42$, and find the intersection with $R_L = 60$ at $X_E = 28$ ohms. No factor was involved and the answer is read directly.

Since the design procedure for a coupled tank circuit holds for the equivalent circuit of Fig. 3, any calculations which the engineer is accustomed to make to determine the proper reactances to use for a coupled tank circuit hold equally well for the π network. Of course, in most cases only X_C would remain the same, while X_L would have to be increased by an amount equal to the value of X_E. Knowing X_C and Q, R_A could be readily obtained.

Terminating Impedance

At best, the calculation of the generator impedance of a class C power amplifier is only an approximation. An actual measurement under operating conditions is much to be preferred. While we cannot do precisely that, we are able to do what is even more to the point. The circuit lends itself admirably to a measurement of R_G, the resistance with which we actually wish to terminate the vacuum tube.

The circuit of Fig. 3 is set up with sufficient metering to obtain plate current, plate voltage and load current. In place of R_A we may use any convenient value which we shall call R_X. The circuit is then tuned by means of X_T and the output and input powers calculated. If we have not exceeded or equaled the rated power dissipation capabilities of the tube, X_L is reduced and the circuit retuned. This procedure is continued until, at resonance, either maximum or required power output is obtained within the limitations of tube power dissipation. In the case of pentodes, the screen as well as plate dissipation must be watched, particularly if the ratio of X_L to R_X is large. Having adjusted the circuit we have terminated it with the proper R_G. Since we know R_X or can measure it, by measuring X_L or X_T we are able to calculate R_G. From this data R_A i fixed according to the circuit Q which is to be used.

If R_X is much different from R it is necessary to repeat the adjustments and measurements using some value of R_X nearer to the calculated R_A. Just when it is necessary to repeat the measurements may easily be determined. If R_X is quite large, upon adjusting the circuit for proper impedance the resulting Q will be a low value. If it becomes much below 10, the conditions of maximum impedance and unity power factor will not occur simultaneously, and the harmonic generation will be appreciable.

Consequently, erroneous measurements will result. If, on the other hand, R_x is too low, X_L will be large in order to bring R_o to its proper value. This will result in a condition of undercoupling. The tube will be delivering full output possible under the conditions, but that output will be low as will be the input power. Since the internal impedance of a vacuum tube is a function of the operating conditions, R will be different from that under the required load conditions.

Antenna Measurement

In many cases, the actual antenna resistance R_L is not known. This may be found experimentally. Since we already know R_o, by replacing R_x with the actual antenna, adjusting for the required power, and measuring X_L or X_T we have sufficient data to calculate the unknown load resistance. Here again we should have comparable values of load, and the first measurement will generally have to be repeated using a value of R_x more nearly the same as R_L. Of course, if equipment is available, the measurement may be made by the substitution method. This means, in most cases, having available power resistors, continuously variable, and with negligible or tunable reactance. The first method is quite accurate and more adaptable to the equipment of the normal laboratory or transmitting plant.

Note that for the antenna measurement, we are not concerned with R as it will finally exist, but simply wish to keep it constant for the two measurements, the one with R_x and the other with R_L. To be most accurate, therefore, all meter readings should be the same for both measurements. Low power may, of course, be used in this antenna resistance measurement.

Design Summary

The following outline summarizes the procedure to be followed in the design of a π coupling network.

1. Set up the circuit of Fig. 3 with any value of R_A, such as R_x. Adjust X_L until when tuned by X_T the required power output within dissipation limits is obtained. Measure R_x and X_L or X_T. The required load impedance R_o is given by Eq. (7).

2. Select a value of Q for the required harmonic attenuation and calculate X_L and X_T from Eq. (5).

3. Find the value of R_A from Eq. (6).

4. Replace R_x by R_L, the actual load, and adjust the circuit for the required power output. Measure X_L or X_T, and using the value of R_o found in step 1, calculate R_L from Eq. (7) solved for R_A, which in this case is R_L.

5. Replace this value of R_L by an R_x of approximately the same value and repeat steps 1 and 4.

6. If neither the value of R_x used in step 1 nor the value in step 5 is approximately equal to R_A, repeat steps 1, 2 and 3 using an R_x more nearly the same as that of R_A as found in step 3.

7. Find X_C from Fig. 5 or from Eq. (11).

8. Find X_E from Fig. 6 or from Eq. (10).

9. Increase X_L by X_E.

If reasonable care has been exercised, the circuit will be found to tune within a small percentage of the calculated X_T, and the final adjustments will be easy to make.

If X_T was varied very much in achieving tuning, this will alter the Q and should be corrected. Let us examine the case where X_T was increased for tuning, knowing that if it were decreased the reverse procedure would hold. In order to decrease X_T (increase the capacitance), either X_E must be increased or X_L decreased. The effect on the power output will clearly indicate which is required. An examination of Fig. 6 will show whether X_C is to be increased or decreased to cause the proper change in X_E. It will be seen that up to the point where X_C is equal to R_L an increase in X_C will cause an increase in X_E. When the value of X_C is greater

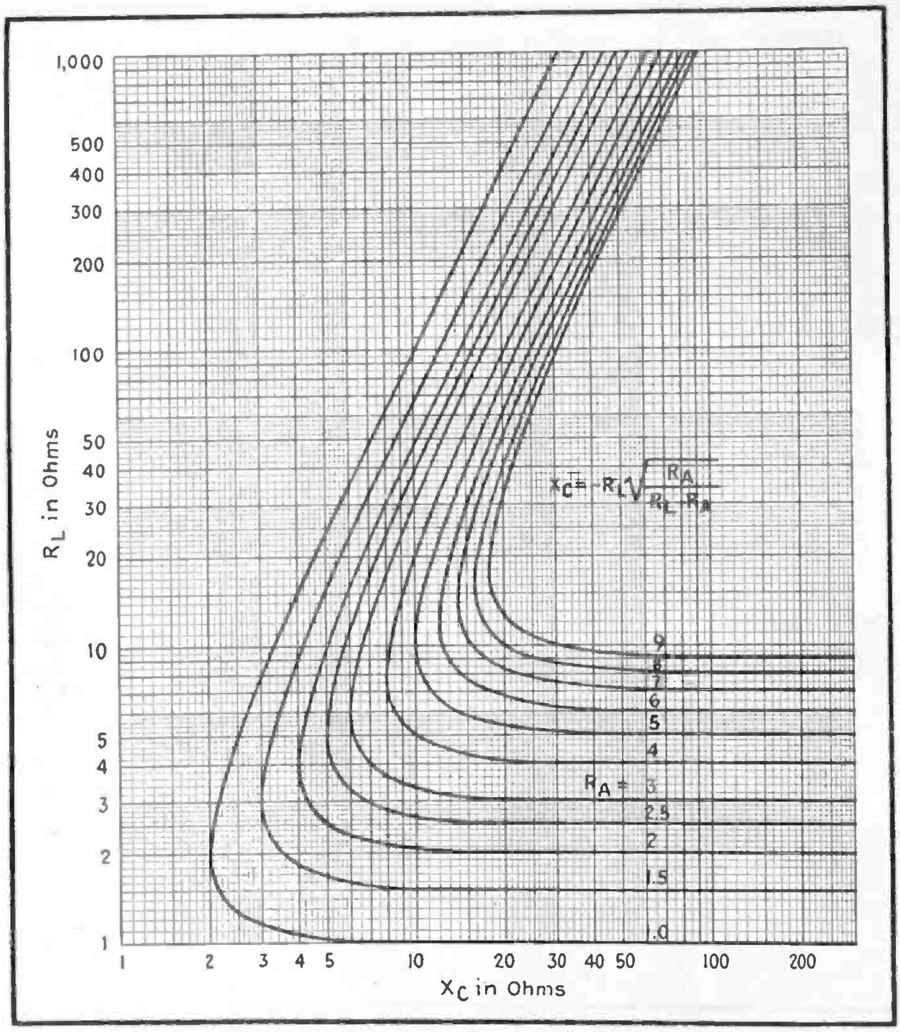


FIG. 5—Chart giving value of compensating capacitive reactance X_C required to make load circuit have correct resistance for matching purposes

than R_L a decrease in X_C is needed to cause an increase in X_E. Incidentally, it is just this effect that makes the adjustment of a π network by cut-and-try methods so confusing to the uninitiated. Not only can tuning be accomplished by any of the three reactances, but the change in the direction of the effect of changes in X_o produces apparently uncorrellated results.

Example

Probably the best method of explaining the design procedure is to work out a typical design. The following example is actual observed data.

1. The circuit of Fig. 3 is set up, choosing initially for R_A the value $R_x = 60$ ohms. X_L is adjusted for maximum power output, then measured and found to be 308 ohms. From this, $R_o = X_L^2/R_X = 94{,}900/60 = 1580$ ohms.

2. Using a Q of 12, $X_L = X_T = R_o/Q = 1580/12 = 132$ ohms.

3. $R_A = X_L/Q = 132/12 = 11$ ohms.

4. Inserting the actual antenna and readjusting for maximum power output, X_L is found to be 413 ohms. From this, $R_L = X_L^2/R_o = 171{,}000/1580 = 108$ ohms.

5. Steps 1 and 4 are repeated using $R_X = 108$ ohms. Upon readjustment, X_L is found to be 425 ohms, and $R_o = X_L^2/R_X = 181{,}000/108 = 1660$ ohms. Replacing R_X by R_L and again readjusting, X_L is measured as 417 ohms, and $R_L = X_L^2/R_o = 174{,}000/1660 = 105$ ohms.

6. Since R_A and both values of R_X are quite different, we will repeat steps 1, 2 and 3 using $R_X = 15$. When adjusted now, $X_L = 149$ ohms, and $R_o = X_L^2/R_X = 22{,}200/15 = 1480$ ohms. At a Q of 12, $X_L = X_T = 1480/12 = 123$ ohms, and $R_A = X_L/Q = 123/12 = 10$ ohms.

7. Using Fig. 5, we enter at $R_L = 10.5$ ohms, and the intersec tion with $R_A = 1$ occurs at $X_o = 3.4$ Since a factor of 10 has been used $X_o = 34$ ohms.

8. Using Fig. 6 we enter th curve at $X_o = 340$ and, assuming curve $R_L = 105$ to exist slight above $R_L = 100$, we can estima the intersection to occur at X_E 30. Since a factor of 0.1 was used $X_E = 3$ ohms.

9. X_L is, therefore, increased 126 ohms.

Our final circuit has $X_T = 12$ ohms, $X_L = 126$ ohms, and $X_o = 3$ ohms. It properly terminates ou tube when loaded by a resonant an tenna of 105 ohms, yielding a cir cuit Q of 12. In actual practic this tuned almost perfectly as ca culated, and the change in X_T produce exact tuning was too sligh to warrant any further changes.

Conclusion

The foregoing assumes th means for making reactance and re sistance measurements are at han In the field, particularly usin emergency equipment, this will n be so. However, it is hoped th sufficient light has been thrown c the subject to enable "blind" tu ing to be accomplished logical and rapidly.

As a suggestion, start with an network, resonate the antenna, an then add output capacitance as re quired. Up to a point, increases i capacitance and inductance wi bring up the antenna curren Thereafter, the current will sta to drop off. In other words, at fir R_L is too large to achieve a lo enough R_o. As X_o reduces the effe tive R_L the current will increase the point of overcoupling and exce sive power output, as evidenced b excessive plate current. Further re duction of R_L or increase in X_L wi be in the direction of low couplin and high Q, which is, of cours more desirable. For safety, the adjustment is continued in this d rection until the plate meter ind cates that not too great a plate in put is being delivered to the tub With a little experience, one wi easily learn the "feel" of π networ adjustments, and will work ou rapid and surprisingly accura methods of tuning without an equipment other than the transmi ter meters.

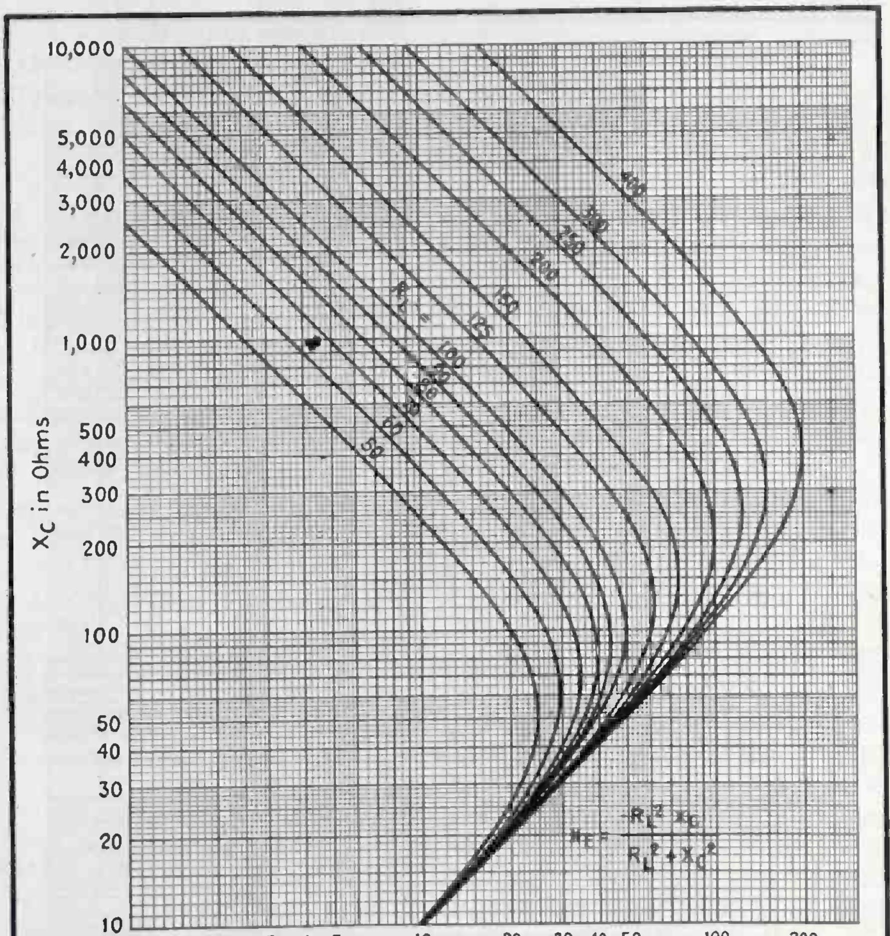


FIG. 6—Chart giving reactance value X_E by which the inductive reactance X_L in the network must be increased to give correct tuning

Now may be an appropriate time to direct attention to leadership that has proven itself under the most severe war demands and conditions: Cinch, alert and anticipating electronic socket requirements, presented to the industry a complete line of miniature socket assemblies—long before general wide spread manufacture. ★

CINCH MANUFACTURING CORPORATION, 2335 W. Van Buren St., Chicago 12, Ill.
SUBSIDIARY OF UNITED-CARR FASTENER CORPORATION, CAMBRIDGE, MASS.

INDUSTRIAL CONTROL

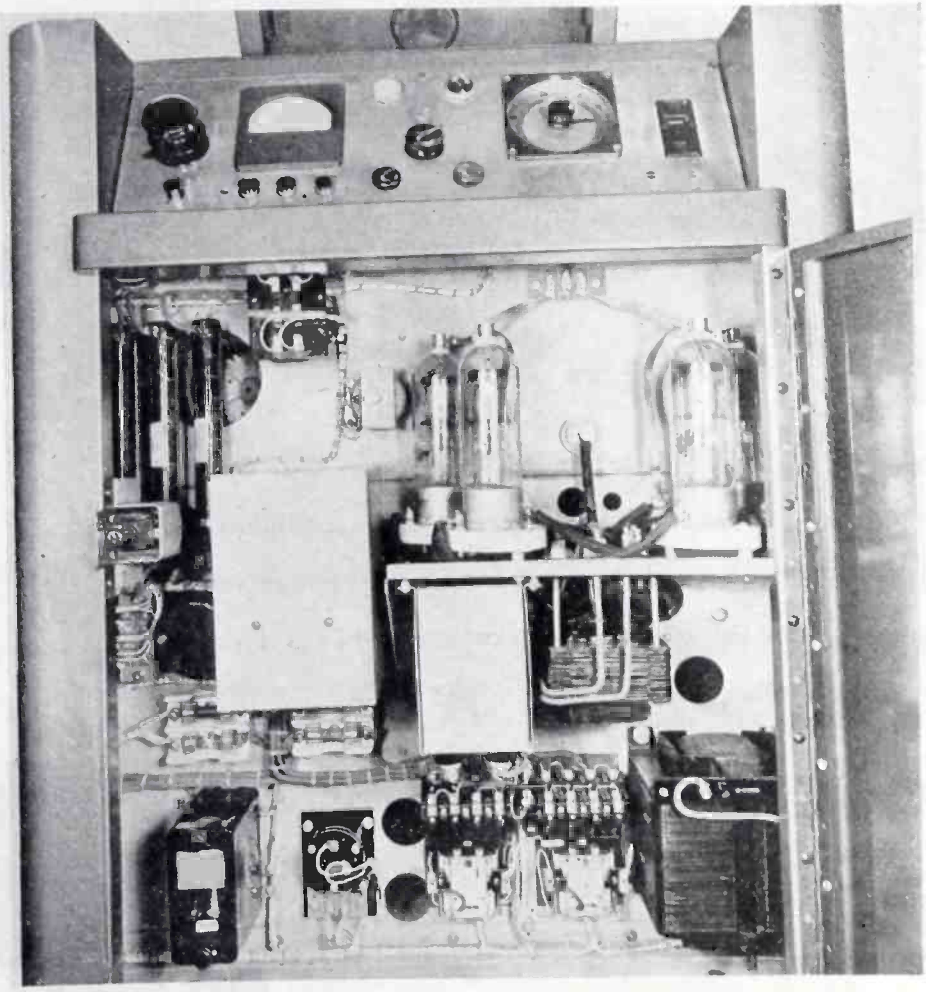
Close-up of the control panel and hea
ing chamber of the RCA r-f generato
The open-mesh cover permits gases t
escape during heating of the preforn
while two infrared lamps provide ra
diant heat to prevent cooling of the pre
form surface by surrounding air

Electronic Heating of Plastic Performs

In the manufacture of plastic products, uniform and rapid preheating provided by dielectric heating softens the entire preform to an easily moldable state and eliminates gases before molding. This action greatly reduces the chance of warping or blistering the work piece in the mold and virtually eliminates the risk of damage to the mold. Since the molding cycle is cut from hours to minutes in some applications, production time is also saved.

Especially designed for heating plastic preforms, a new RCA r-f generator is a package unit that delivers up to 2000 watts of power, or 6800 BTU per hour, into a dielectric load of average characteristics. An operating frequency of approximately 27.4 Mc permits rapid heating of a wide variety of materials without danger of arcover between plates.

To pre-heat plastic preforms for molding, the operator places the preform on the bottom electrode, then closes the counter-balanced lid, automatically bringing the retracting upper electrode into co
tact with the work, and presses t
starter button. The top electro
mounting and operating mecha
ism is designed to permit the ele
trode to seat flat and exert unifor
pressure on any thickness of pr
form within its operating rang
At the end of the heating cycle,
pre-set timer automatically ope
the lid and shuts off the power.



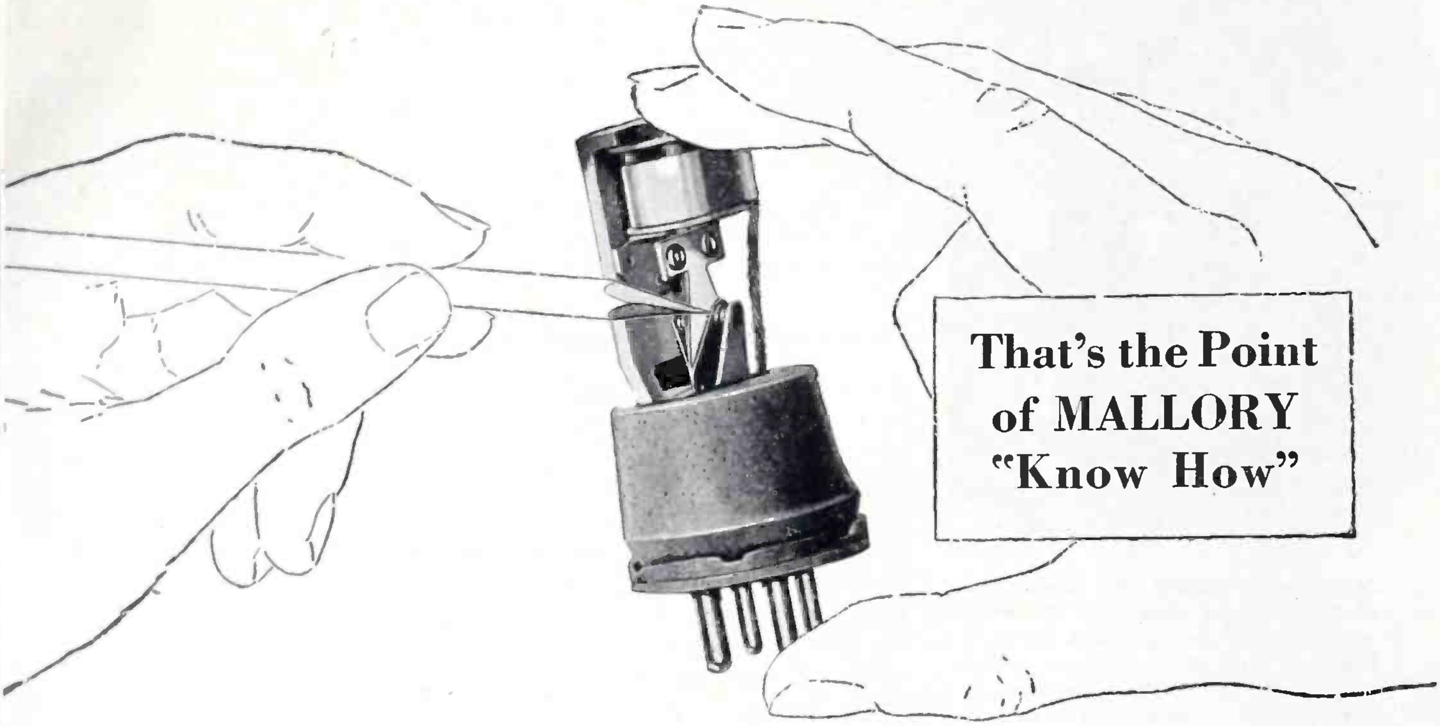
The electronic power unit of the RCA model 2-B dielectric heating unit for heating plastic preforms

Controls

Timer, power controls, and inc
cators are mounted on a contr
panel, placed just below the lid a
tilted for visibility and conve
ence. Access to tubes and comp
nents of the generator equipme
for servicing and replacements
provided by front and rear doo
in the body of the cabinet, bo
equipped with power disconne
switches and key locks to preve
entry except by authorized main
nance personnel. Changes in op
ating setup are quickly made
means of the front panel contr
without requiring access to the i
side of the cabinet.

Once the best treatment is
termined for a given type prefor
each successive one is heated to t
proper temperature for moldi
The generator, shown in the pho
graphs, contains an electronic r
ulator which maintains the heati
rate constant at a predetermin
value, irrespective of normal var

CONTACTS
Can Make or Break a Vibrator



That's the Point of MALLORY "Know How"

Contacts in a vibrator take a lot of punishment. They must operate under widely varying conditions of temperature and must "make and break" 115 times a second. Small wonder that alert engineers think of contacts first when selecting a vibrator!

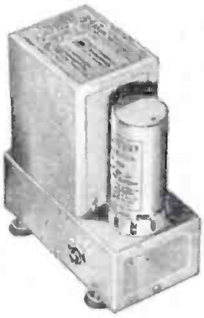
For over 20 years, Mallory has been industrial headquarters for every type of electrical contact. It has introduced new contact compositions . . . evolved better designs . . . formulated improved surface finishes.

As a result of this wide experience, Mallory equips its vibrators with special grade tungsten contacts which are cut in its own plant from material made to its own specifications. They give longer life, are subject to a minimum of erosion and transfer.

Mallory is ready to apply its special vibrator "know how" to your specific applications.

For Perfect Portable Power . . .

MALLORY Vibrapack*



The preferred vibrator power supply in planes, boats and mobile equipment of our armed forces. Operates under great extremes of heat, cold and humidity; withstands an abnormal amount of vibration, jolts and jars.

**Vibrapack is the registered trademark of P. R. Mallory & Co., Inc., for vibrator power supplies.*

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

War Bonds Are Your Personal Investment in Victory

P.R.MALLORY&CO.Inc

MALLORY VIBRATORS

AND VIBRATOR POWER SUPPLIES

In the photo above, the operator is shown placing a preform on the lower electrode. When the mesh cover is lowered, the upper electrode makes contact with the plastic material. The cover pops open and power is shut off at the end of a predetermined heating interval

tions in preform shapes or chemical and physical changes which occur during the heating cycle.

A synchronous motor timer, adjusted by means of a knob on the front panel, may be set for time cycles from two seconds to 120 seconds, depending on the size of the work piece and other factors involved in a specific application. The unit will heat up to one pound of molding material per minute. An additional feature consists of two infrared lamps, installed in the heating chamber, to provide auxiliary radiant heat to prevent cooling of the preform surfaces by the surrounding air.

Equipment Safety

In addition to safety features designed to protect operators, the equipment itself is thoroughly protected. An r-f filter is included to guard against r-f radiation via the power circuits. The unit is completely shielded to minimize the possibility of direct radiation.

Automatic overload relays guard against tube overloads, and an automatic time-delay relay prevents damage which might otherwise result from starting the unit without an adequate filament warm-up. An automatic voltage regulator, capable of handling a line voltage range of 190 to 260 volts, supplies constant filament voltage.

Although designed for heating plastic preforms, the unit can be connected to remote electrodes for other types of operations, such as heating assemblies of wood veneers to set or cure the glue lines.

Close-coupled external loads having suitable electrical characteristics can be handled by the installation of an appropriate fitting fo passage of a short transmissio line.

Equipment beneath the heatin chamber is cooled by air from built-in blower system that contains dual filters to insure maximum cleanliness of the cooling air The unit is equipped with two RC 833A oscillator tubes, four 800 rectifier tubes, and two 2050 contro tubes, and weighs about 80 pounds. It is mounted on ball-bearing casters and may be installed b plugging into a 220-volt a-c line.

Electronic Vulcanizing of Tires for Army Trucks

A TIRE LIFE of 100,000 miles after the war may be provided by commercial development of an electronic dielectric heating method of vulcanizing rubber now being used by the Army as a mobile means of quickly effecting tire repairs. Heretofore, heat for vulcanizing has been provided by means of conduction from either steam or electrical resistance metal molds or open steam chambers. This type of equipment as used by the Army permitted a total of about ten repairs per hour. An example of the weight involved is suggested by the weight of an open steam repair unit which, with its tanks, weighs about twelve thousand pounds. It is flexible as to tire sizes but not portable on a standard size Army truck permitted near the front lines. In comparison, the electronic unit, in addition to a generatin unit, weighs about 500 lb.

An example of the heating tim

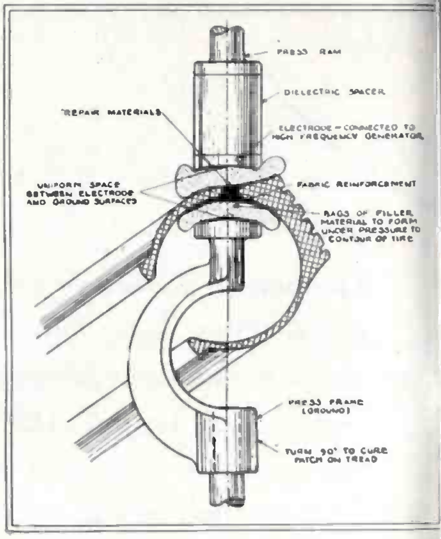


Fig. 2—Bags of filler material act as flexible molds for curing tire patches with dielectric heating

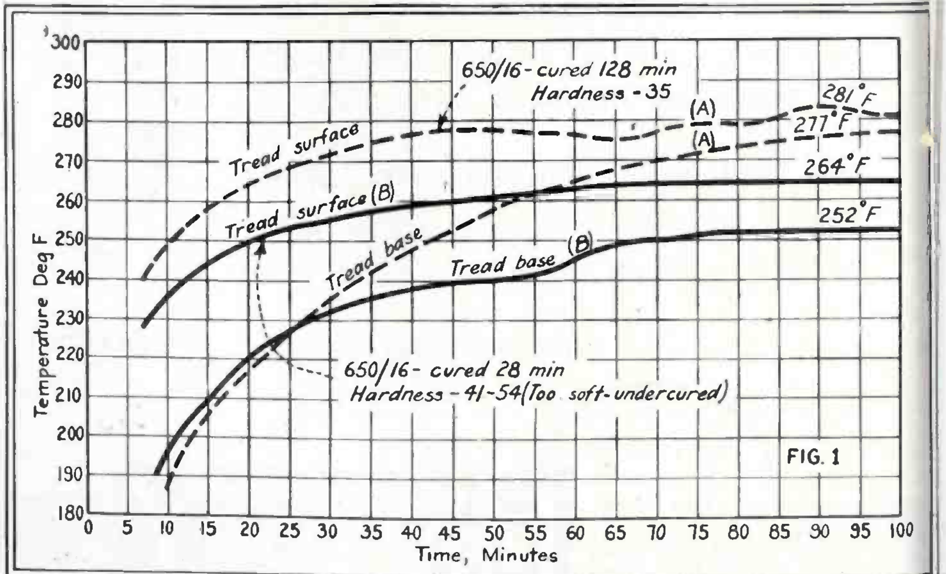


Fig. 1—Curing curves of steam pressure method of vulcanizing as shown by thermocouples placed at the tread surface and tread base. The curves marked *A* were obtained from one mold. A different mold was employed when curve *B* was plotted

for example:

ELECTRONIC TIMING

Industry is making increasing use of electronic timers in timing or controlling intervals that are beyond the accuracy and scope of mechanical measurement. Such applications as measurement of the speed of a camera's shutter, welding control, plastic molding, photographic exposure and measurement of turbine speeds are typical.

Series 175 Relay

THERE'S A JOB FOR *Relays* BY GUARDIAN

The above diagram of an electronic timing circuit shows a capacitor and an adjustable resistor connected to the grid of a thyratron or "trigger" type of tube. As the capacitor discharges, the grid potential reaches a point where the tube becomes conductive and energizes a relay.

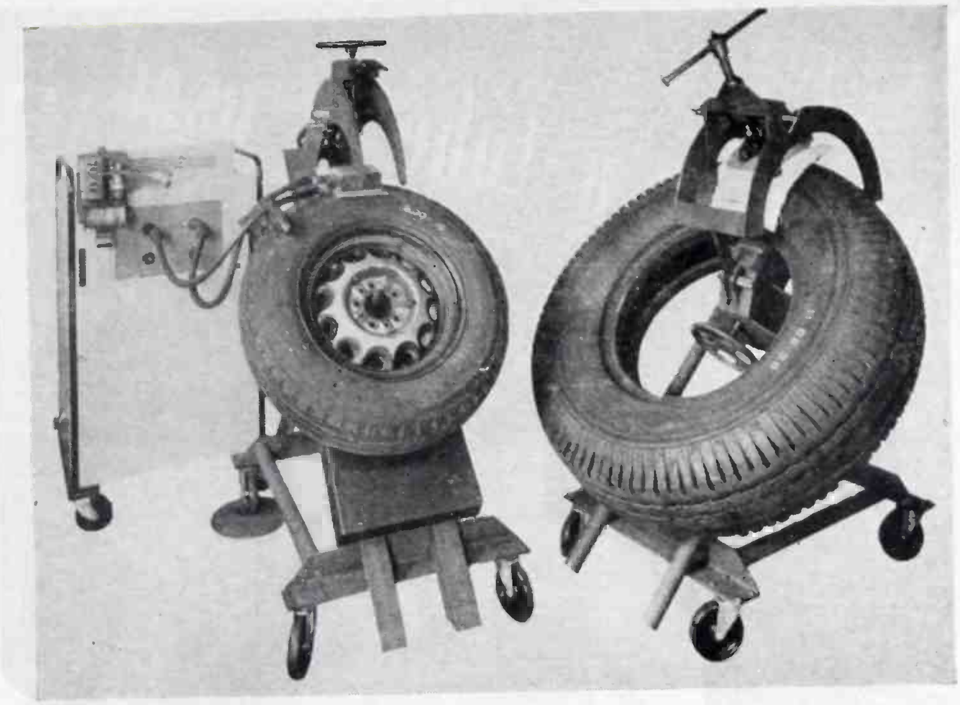
The relay is generally a fast-acting type such as the Guardian Series 175 operating at a speed which minimizes interference with the timing interval. Coil operating voltages range from 6 to 110 volts D.C. (Also available for A.C. in Series 170). Contacts are rated at 12½ amps. at 110 volts, 60 cycles, non-inductive in combinations up to D.P., D.T. Bakelite base is molded to reduce surface leakage. Has binding post terminals in place of solder lugs. Write for Bulletin 175.

Consult Guardian whenever a tube is used—however—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

GUARDIAN G ELECTRIC

1625-J W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY



The r-f generator and two fixtures of the Vulcatrone development for repairing tires by means of dielectric heating. The fixture at the right is designed to vulcanize small sectional and spot repairs, the one at the left handles spot repairs only but also cures sidewall, corner or tread patches to cord depth without removing the tire from the rim

of the older method of vulcanizing is given in Fig. 1 where the curves represent temperatures at tread surface and tread base of tires during cures in molds. A variation of from 12 to 50 deg on the outside tire surfaces between the top and bottom of tread is also shown.

Development work on the dielectric heating project was instigated by Lt. Col. C. W. Vogt, Chief of the Technical Staff for Supply, Transportation Corps of the Army. He worked in conjunction with the Lakso Company of Fitchburgh, Mass. Test apparatus was made up and tried out at Forest Products Laboratory, Madison, Wis. where several sizes of high frequency generators were available. The tests showed that a type bag, filled with pulverulent material arranged as in Fig. 2, would:

1—Adjust itself readily to variations in shape and thickness of tires at shoulder, sidewalls, and treads.

2—Make possible spot and sectional cures in a few minutes and with a minimum of temperature differences throughout these varying thicknesses of sections.

3—Maintain satisfactory sharp shoulder edges to correspond with edges of the tires adjacent to the area of cures.

Since the tests at Madison, numerous experimental tire repairs have been made and some of these tires have been tested to destruction and found entirely satisfactory. Tests using thermocouples at various points show that even at ten times the speed of temperature rise in the center of area cure, temperature variations are considerably less than that obtained on present day conventional repair apparatus. Figure 3 shows that practically uniform temperature is maintained throughout the tire thickness.

Flexible Mold

The sectional repair unit is based on the principle of having the material to be heated placed between two spaced electrodes. The variation in thickness between the tread corner and sidewall is compensated for by a bag containing a flowable noncompressible material, this bag automatically forming a mold of the proper shape and enabling uniform pressure to be applied to the patch area.

The fixtures to hold the tires are designed so that a minimum of labor is involved in the setting up operation. The tire is laid into the fixture and from then on is positioned by handwheels. The high frequency generator shown in the photograph is the laboratory model, the field units being of more rugged construction and having a minimum of dials and controls.

At a meeting of the Society of Automotive Engineers at Philadelphia in June, Colonel Vogt delivered a paper on the electronic vulcanizing process and included excerpts from an official report of Aberdeen Proving Ground. The report stated that repaired tires were subjected to road tests which the Automotive Section has regarded as highly satisfactorily. The report went on to say that, with present standard equipment the average time for individua cure of a spot or section may ru over two hours. With the experimental electronic equipment, curin is accomplished in ten minutes.

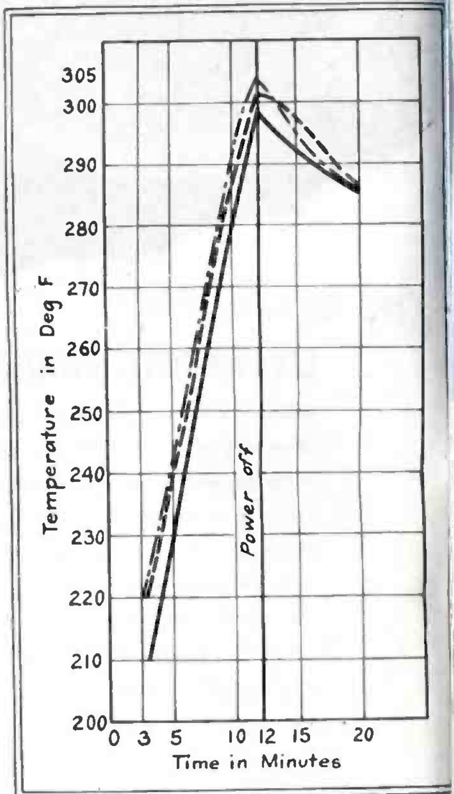


Fig. 3—Curing curves of dielectric heating for tire repair as shown by themocouples placed at several points. The solid curve represents temperature at surface of lining; dotted curve, at center of tire; dash-dash curve, at tread surface. All were recorded at point of axis of the press

Radiation

Colonel Vogt said that because o the possibility of radio interferenc with other electrical systems, suc as radar and communication

IRC WILL BE READY

with TYPE MW WIRE WOUND RESISTORS

Just as quickly as Allied Arms put an end to the hideous holocaust, I R C again will assume its rightful position as industry's number one source for *all* types of resistors. That greater quantities... at lower costs than ever, can be offered is established by the fact that I R C is operating on a mass production basis, the world's largest resistor plants.

ENGINEERING COUNSEL AVAILABLE

I R C's engineering staff will be glad to share with interested executives its knowledge and experience gained through years of specialization in the manufacture of resistance devices for practically every kind of application.

It is quite possible a parallel case to your own may have been already studied and solved, in which event you can save valuable time. No obligation is entailed, and, of course, your confidence will be respected.

FEATURES OF MW WIRE WOUND RESISTORS

1. *Provide light weight, low temperature rise power-type resistors for use where space and weight are vital factors.*

2. *Allow as many as six sections in a single molded resistor for flexibility of design needs.*

3. *Flat, wire wound resistor strip is insulated for mounting to chassis by high pressure molding in special asbestos-filled phenolic compound.*

4. *Permanently attached metal bracket with mounting feet permits attachment of resistor to any flat metal surface to increase heat dissipation.*

5. *Rating established at a common-sense temperature rise of 100° C.*

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FIXED & VARIABLE RESISTORS

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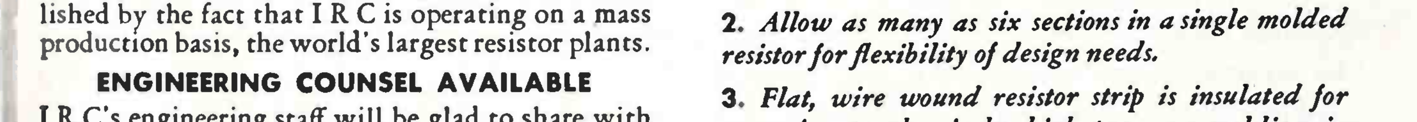
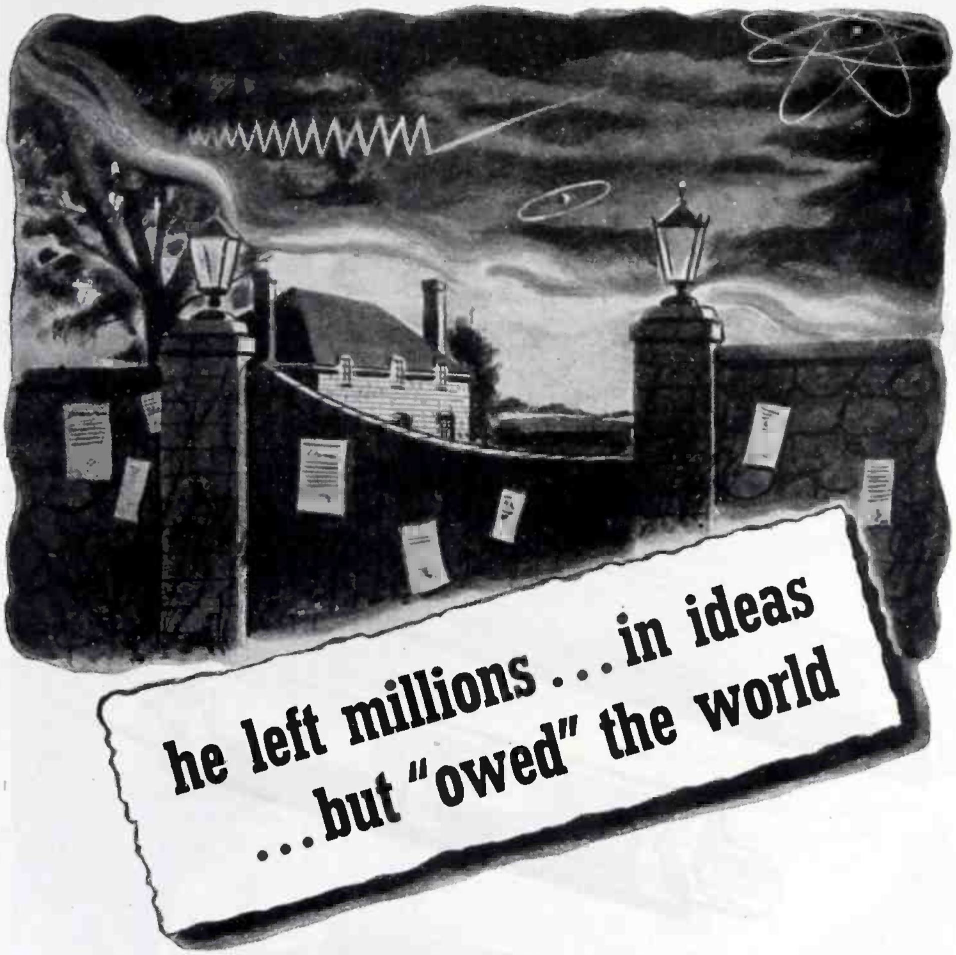
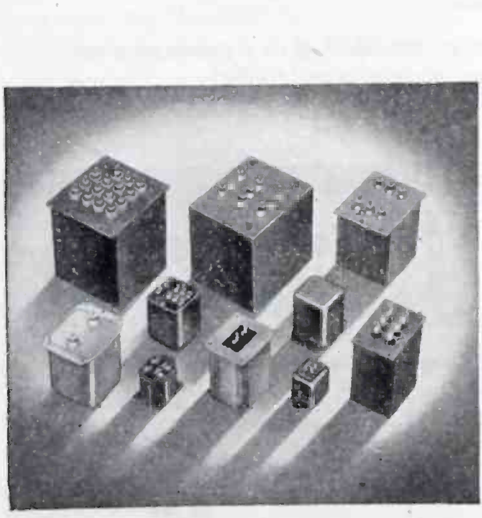
IRC makes more types of resistance units, in more shapes, for more applications than any other manufacturer in the world.







equipment, the Signal Corps sent one of their mobile testing sets to determine the extent of this interference so that the necessary provisions could be made to prevent harmful interference. A simple screening with the usual interlocks can be applied without slowing down or adversely affecting the speed, flexibility or operation of the electronic heating tire repair unit.

"Another little known fact," said Colonel Vogt, "which has bee learned during our developmen work is that livelier cures are made by the few minutes application o 'internal' heat as contrasted to a hour or more of impressed or external heat. Contact with the heated molds for an hour or more causes a heat embrittlement of this outer tire surface resulting in appreciably reduced mileage from this embrittled and case-hardened rubber.

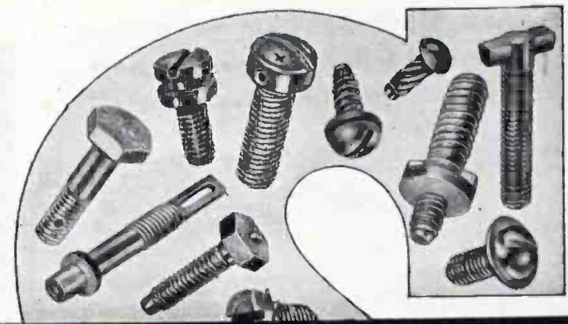
"In order to produce the proper heat in the center of the rubber tire mass, an excessive heat has been necessary, time and temperature wise, on the outside of this mass. This applies not only to repairs and recapping but also to new tir manufacture. Probably the reaso that this condition is not mor widely known is that apparently n means has been available heretofore to overcome excessive surfac heat in order to produce prope internal temperature at the core o the rubber.

"While our tests indicate tha both recapping and new tire production may advantageously utiliz methods we have evolved durin these last months, we have studiously avoided branching out commercially into these phases, keeping in mind our primary purpos of making available as quickly a possible to the armed forces, a ligh weight, highly mobile unit, for effecting tire repairs on a wide rang of tire sizes."

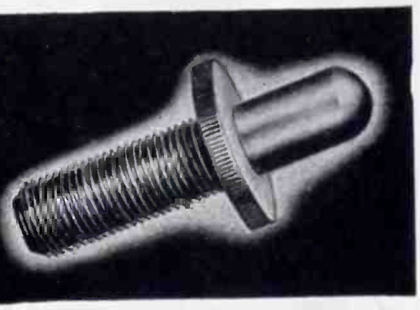
• • •

X-Ray Ceramic Products

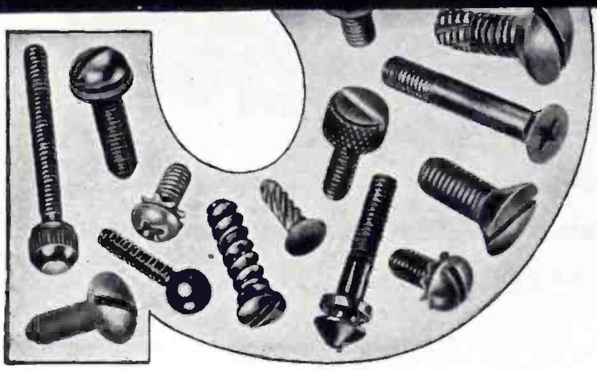
THE RESULTS of an investigatio of problems in the manufacture o ceramic materials, insulators, glass refractories, crucible and chinaware were announced by John E Nielson, application engineer o North American Philips Co., at th annual convention of the America



SCOVILL SPECIALIZES IN COLD-FORGED FASTENINGS TO FILL YOUR SPECIFIC REQUIREMENTS



"Cold-forging"— proof #22
. . . more each month



LD-FORGING skill mastered that job illustrated above—it was cold-forged by Scovill special-s. Many buyers of special designed fastenings ieved their job could not be cold-forged il they were shown just what cold-forging enuity could accomplish.

hat is where Scovill comes in. It is our job Scovill, not only to serve you effectively by ping select the exact cold-forged fastenings t will best fill your specific requirements, also to advise you just what fastenings can l should be cold-forged.

o serve you effectively—we must understand r particular problems thoroughly—help you to choose between "standard" and "special" fastenings—advise you candidly whether cold-forging can and should be employed to obtain the best results—design, or help you design, the fastening device most advantageous to your assembled product—deliver your job for minimum money—materials—motions.

Save time, trouble, money—as many Scovill customers have done—by calling in one of our Fastenings Experts from our nearest office to plan your fastenings when the product is still in the design stage.

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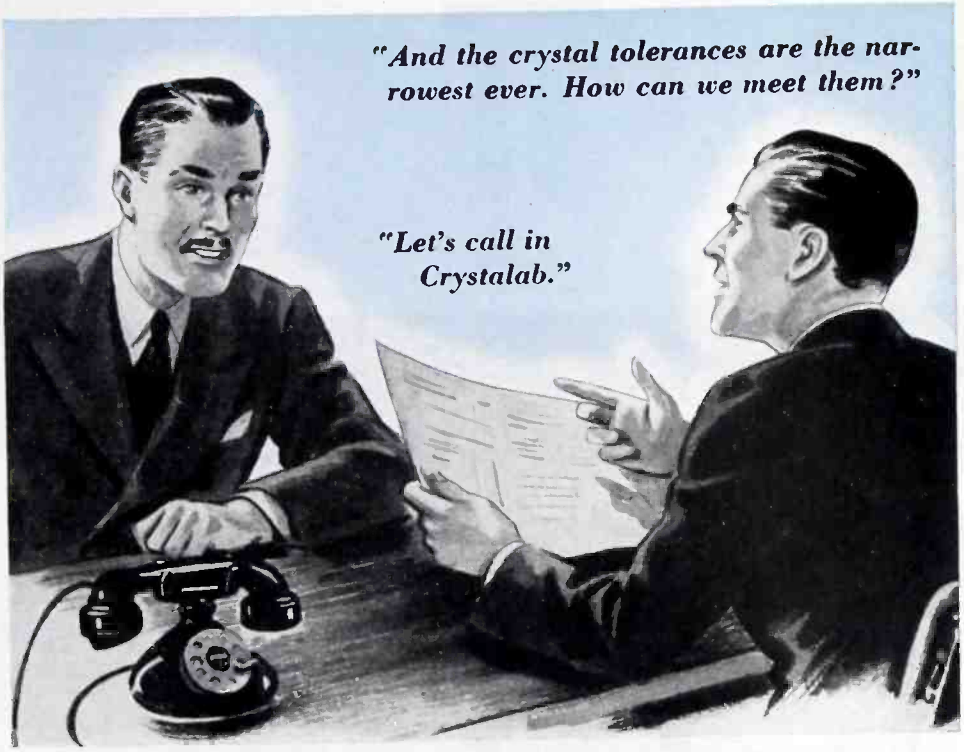

AS CRYSTAL specifications become more and more rigid, more and more communication equipment builders are meeting the "specs" by acting on the suggestion, "Let's call in Crystalab."

There are good reasons for this fact:

1 From the beginning, Crystalab has been meeting the rigid specifications set by the U. S. Coast Guard, the U. S. Signal Corps, and other branches of the armed services . . . the standards which are the basis of specifications now used by most of the industry.

2 Crystalab testing equipment, much of it designed and built by our own engineers, is unsurpassed in the industry. It includes instruments for testing the performance of crystals under all temperature and frequency conditions. Thus, when a crystal leaves Crystalab, it is accurate to highest precision standards.

Crystalab service goes far beyond crystal manufacture and testing, however. Our laboratory is available for special work in the design and calibration of new electronic circuits of all kinds. Our engineers are experienced in all phases of communications research, design and building.

Whether your need is crystal supply, or specialized help in the solution of electronic problems, there is an excellent possibility that you will find the answer in the words . . .

"Call in Crystalab"

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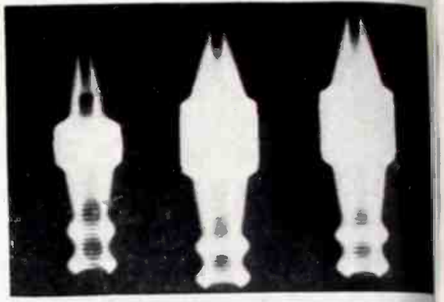


X-ray photograph of spark-plug porce- lains that failed under test. The original picture shows small cracks in two units and a metal particle embedded in the third

Ceramic Society in Pittsburgh, Some twenty ceramic companies cooperated in the investigation.

Radiographs, taken with Norelc Searchray equipment, of a numbe of different products were shown These included spark-plugs (show in the illustration), firebrick, re fractory furnace orifice rings, an plate and lead glass. In all cases the x-ray photographs showed hid den defects such as internal cracks voids and foreign matter, that wer not visible externally.

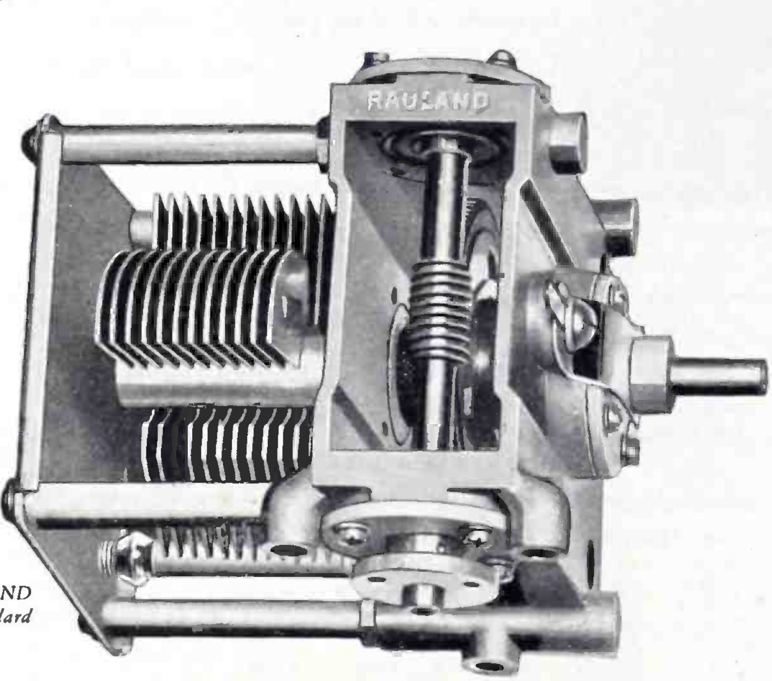
Bread plates that were x-raye before and after glazing showed th uneven distribution of the glaz after firing. The glaze materi contains substances of high atomi weight that cause a high ray ab sorption and, although thin layer of the material are usually applie uneven layers show up the radi graphs. Pieces of plate glass an lead glass that appeared identic to the eye were shown to be quit

Rayproof and shockproof. A girl opera tor adjusts the controls of the Norelc Searchray model 150. Made by Nort American Philips Co., the unit has built-in indirect fluoroscope and a po tential limit of 150 kvp

Master testing instruments are required to be unfailingly accurate at all times. Comparable, for example, to the U. S. Master Clock which regulates all government time is the RAULAND Frequency Standard which makes possible the *almost unbelievable* control accuracy of *1/100th of 1%!* Its maximum backlash is *.007 of one degree* or *one part in fifty thousand* . . . and this precision control is maintained throughout the entire range of minus 30° C. to plus 50° C! A typical example of RAULAND engineering thoroughness and craftsmanship.

Trademarks of Craftsmanship

Above: Master Government Clock located at U. S. Bureau Standards, Washington, D. C.



Right: RAULAND Frequency Standard

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Electroneering is our business

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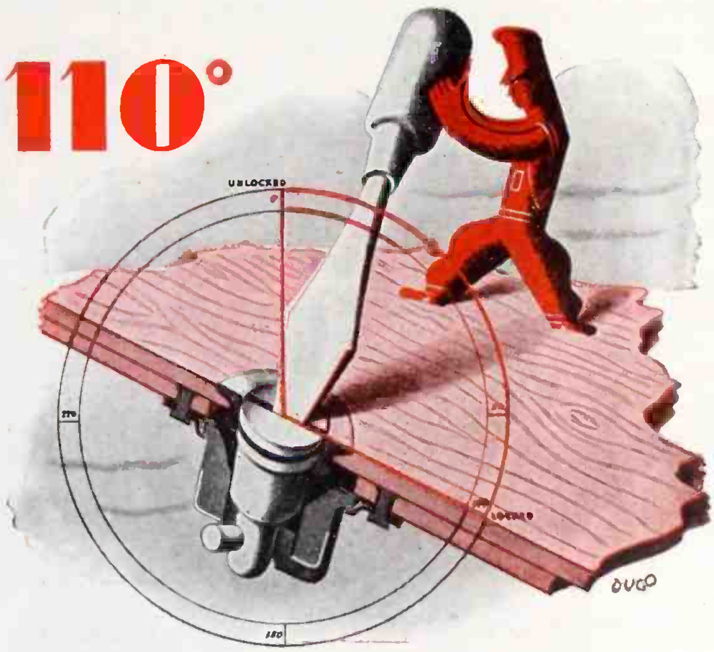
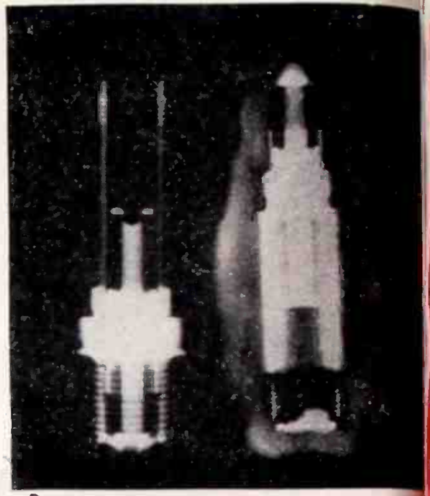
War Bonds and Stamps! Rauland employees are still investing 10% of their salaries in War Bonds





Two assembled spark-plugs for air craft are shown in this radiograph 200 plugs may be x-rayed at a tim on one film

different when radiographed. Th greater absorption of the ray b the lead makes it possible to d termine small differences in lea content of lead glass.

• • •

Production Tester for Mic Capacitors

In the Manufacture of mic capacitors, a method of rapi measurement of capacity is nece sary for sorting and other oper tions. Bridge balancing metho are useful and capable of high a curacy and are used where gradin to narrow tolerances must be don Where less accuracy is require more rapid direct capacity readin arrangements recommend them selves.

The equipment to be describ was developed for sorting mi capacitors within the range 10 1200 $\mu\mu$f and is calibrated direct for this range. The unit possess the qualities needed for producti test equipment as it is small a compact, simple to use and to ser ice, and supplies sufficient accura for the purpose for which it w intended.

For mica capacitors, it is sati factory to measure capacity terms of impedance, neglecting t effect which capacitor losses ha on this impedance. Capacitors bad power factor will be reject by other tests and, for the accura of capacity required in sorting, t impedance modification effected the loss factor is not significant.

Capacity accuracy to a few pe cent is usually satisfactory and t

Stop INACCURACIES with the New DoALL COMPARATOR GAGE

Widest range of utility of any Comparator Gage. Does the work of four separate Comparators. The only one providing magnifications from 5000 to 100,000. Graduated to read directly to one millionth of an inch.

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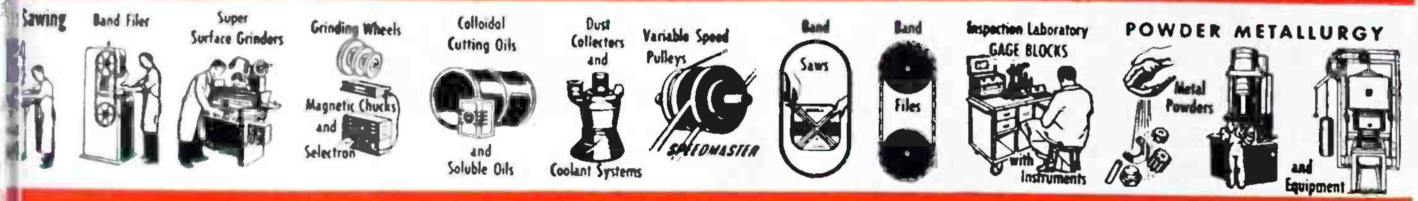
QUALITY CONTROL. Send for this free 64-page Handbook on Scientific Inspection. You'll find it interesting and helpful.



DoALL

INDUSTRY'S NEW SET OF TOOLS

CONTINENTAL MACHINES, INC.
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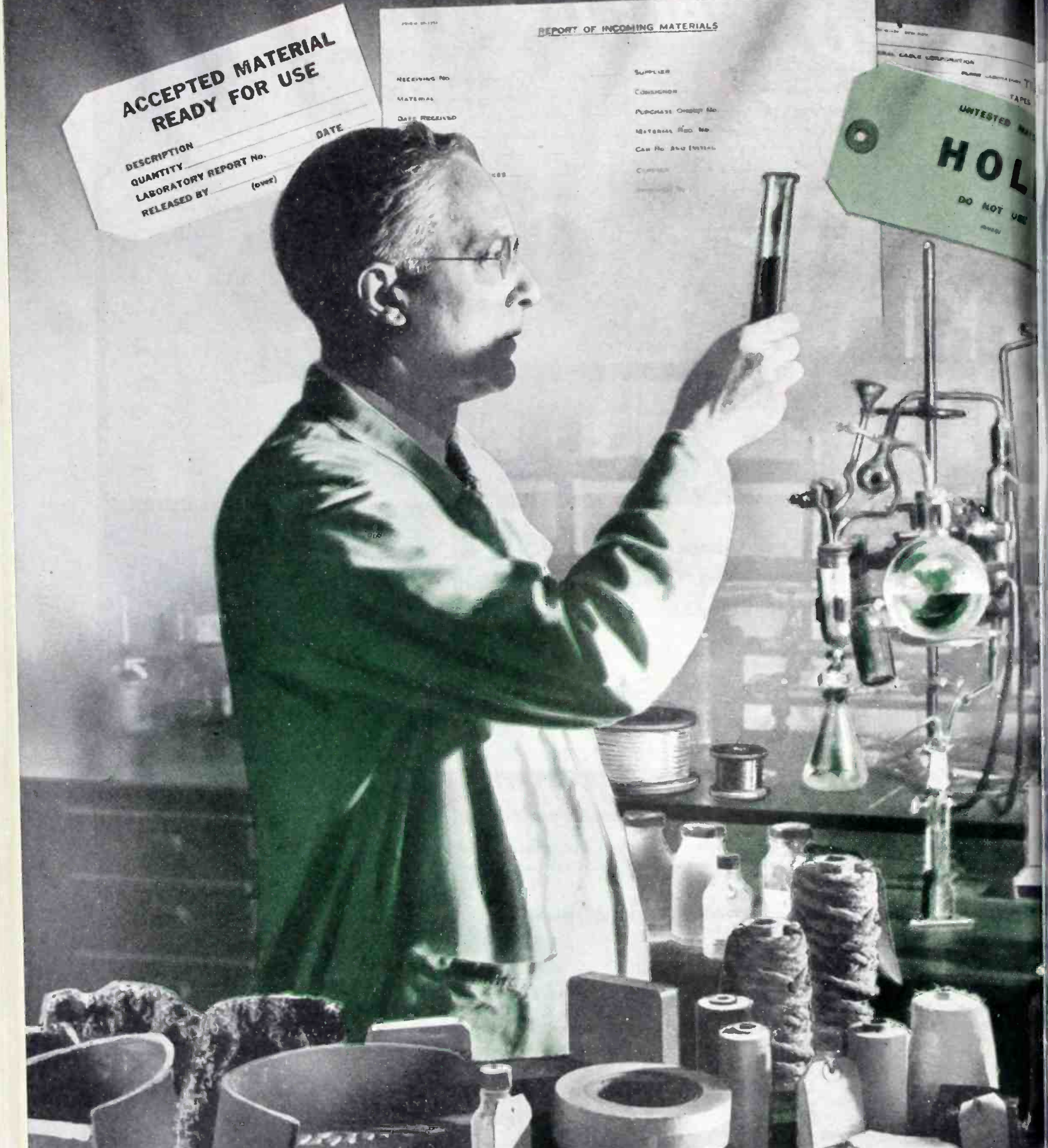
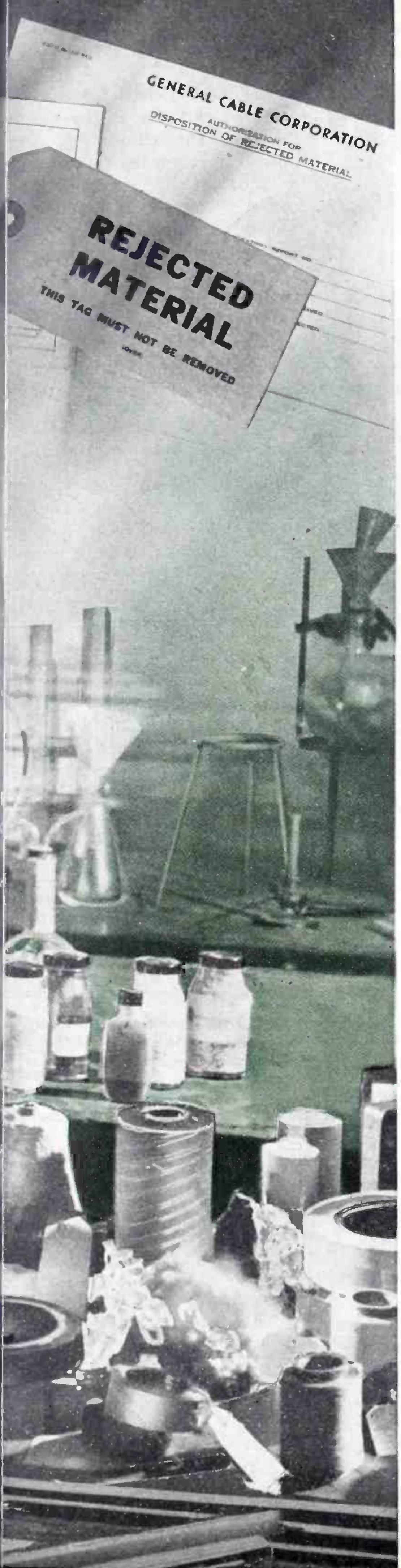
QUALITY CONTROL . . . . . BY GENERAL



Literally hundreds of materials—among them metals, fabrics, lacquers, asphalts, synthetic polymers—are used in making modern wire and cable. The chemical, physical, metallurgical tests of all incoming raw materials for each plant are "double-checked" in the Control Testing Laboratory located at that plant. All 9 of these laboratories operate, however, under direct and close supervision of the General Cable Research Laboratory—the largest, it has been said, "in the world" devoted exclusively to wire and cable research.

CABLE'S OWN "BUREAU OF STANDARDS"

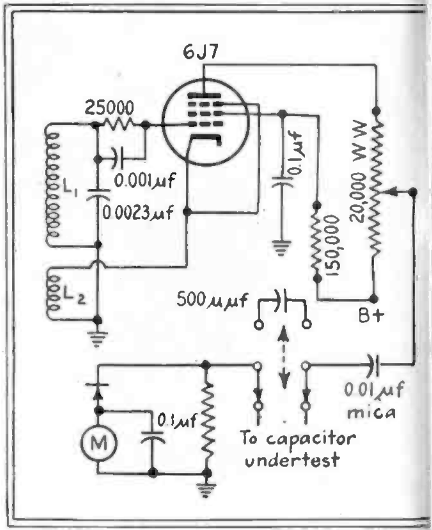


effect on impedance of a power fa tor even of 0.5 percent would n affect the nominal capacity of th capacitor.

The method used for the evalu ation of capacity is the measur ment of the alternating curren flowing through the capacitor fro a substantially constant voltag source. The utmost simplicity wa aimed at and for this reason th use of stabilized alternating cu rent generators or negative fee back amplifiers was dispensed wit and, instead, a rapid check meth was incorporated in the tester wit a screwdriver adjustment for com pensation.

Circuit

The diagram shows a 6J7 tu connected as an electron-couple oscillator operating on a frequenc of 25 kilocycles. The output this oscillator is taken by means a wire-wound potentiometer to th



Circuit for rapid measurement of mica capacitors. Coil L_1 consists of three pies, each containing 500 turns of No. 40 SWG on a ½-inch form. Feedback coil L_2 contains 200 turns of No. 36 SWG wound between the pies of L

terminals of the capacitor unde test. In series with this capacito a 1000-ohm resistor is connected t ground. Across the 1000-ohm re sistor, a half-wave copper-oxid rectifier and a 0-1 d-c milliammete are used to give a measurement o the current flowing through the re sistance by measuring the voltag across it. The milliammeter scal is calibrated in 100-μμf steps fron 100–1200 μμf. Towards the en of the scale there is a tendency fo the 100-μμf steps to be closer to gether than on the 0-600 μμf part of the scale.

A switch with spring return is ncorporated to switch the test erminals to an internal standard 600-μμf capacitor to which reference can be made whenever desired. The oscillator, due to the grid leak ias arrangement, tends to maintain a constant amplitude of oscillation but any variations due to alve ageing, etc., are compensated or when required by a screwdriver djustment of the output potentioeter.

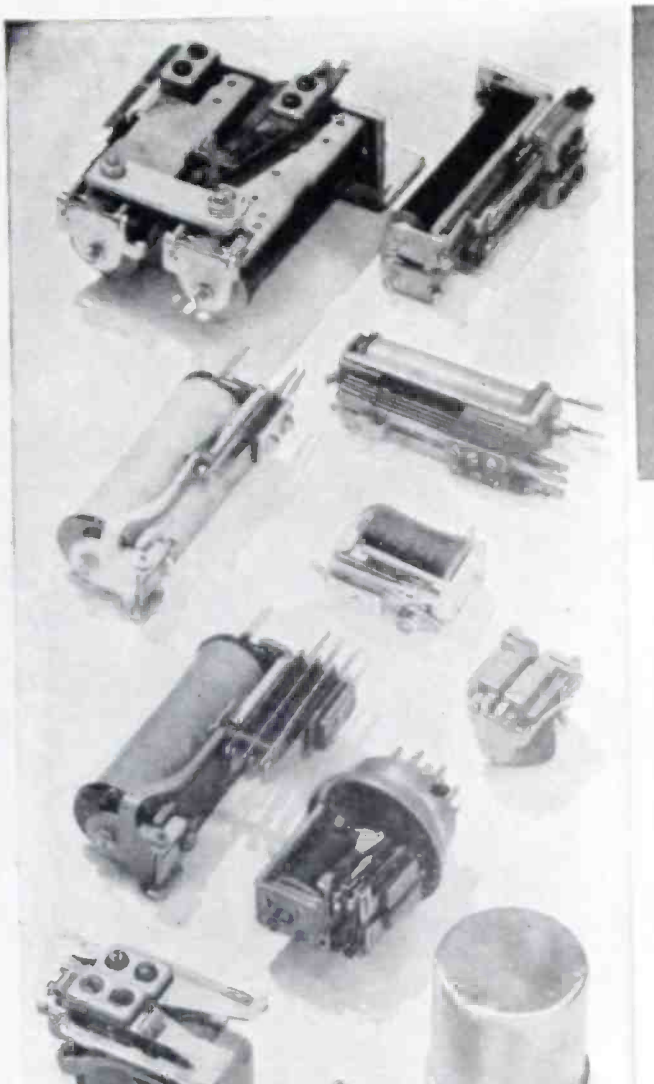
The same principle can be used or other ranges of capacity. For easonable linearity of the scale, he capacitor impedance should be everal times that of the other impedances in series with it, i.e., the 000-ohm resistance and rectifier nd the section of the output pontiometer across which the voltge being used is developed.

Other uses for the tester than e one for which it was developed ggest themselves. Among these e thickness, moisture and other aluations which can be made by easurement of capacity or dietric constant.

• • •

FREE FRENCH OP

erating at an airfield on Gibraltar. deline Portalis, member of the ench Service Feminines de la Flotte, es landing instructions by radio m the control tower to an incoming pilot



TO SELECT THE *Right Relay* TAKE THESE TWO STEPS

The *right* relay, of course, is the one which will exactly fit your needs, and give you the longest, most dependable service at lowest cost. Here's how you can get it:

1. Write for the Automatic Electric catalog. It lists over forty basic types of relays, providing every combination needed for modern electrical control. All technical facts are clearly tabulated for your guidance.

2. If you want help in applying this information to your problem, call in our field engineer. He will be glad to put his experience to work for you.

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FOR SPEED AND ACCURACY

RCP

QUALITY TESTING INSTRUMENTS

CP ADVANCED DESIGNS put control t your fingertips with quality testrs simple to operate, flexible and ast. Behind each design is the sound ngineering reflected in superior erformance and unfailing accuracy.

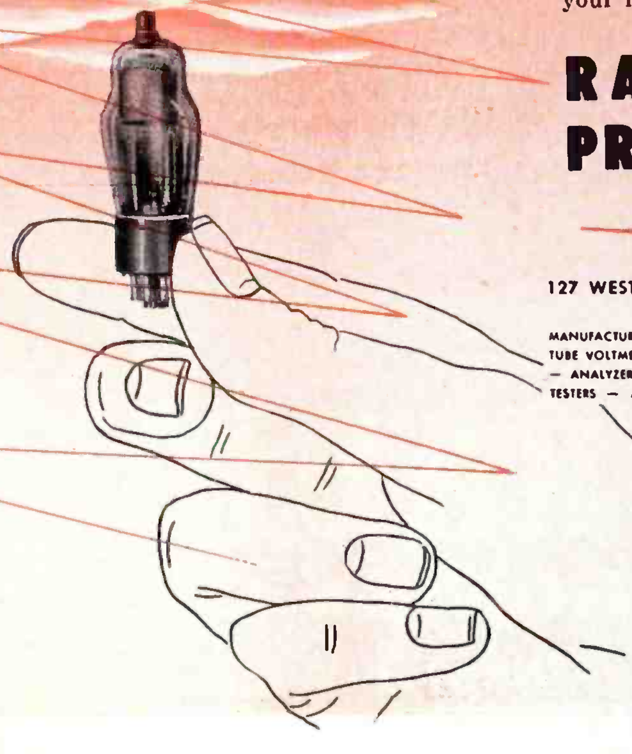
ur new Tube Tester Model 314 xemplifies many technical improveents. It is designed for faster esting of Octal Loctal, Bantam r., Miniature, Midget, and all acorn tubes. Model 314 tests all present filament voltages from 1.1 to 117 volts — a range that anticipates voltages of the near future. Has sockets for all receiving tubes, no adapters required; individual connections for each element.

Lever type switching controls each tube prong, checks roaming filaments, dual cathode structures and multi-purpose tubes. Separate plate tests on diodes and rectifiers. Neon short tests detect leakage between elements while tube is hot. 4½" rectangular meter with "Poor-Good" scale. Pilot Lite indicator; double fused plug protects transformer. In durable oak case—14¼x13x6 inches. Weight: 12¼ lbs. Code: Atlas.

MODEL 314

Complete for operation on 60 cycles, 110 V.	$48.50
50-60 cycles, 220 V.	$49.95

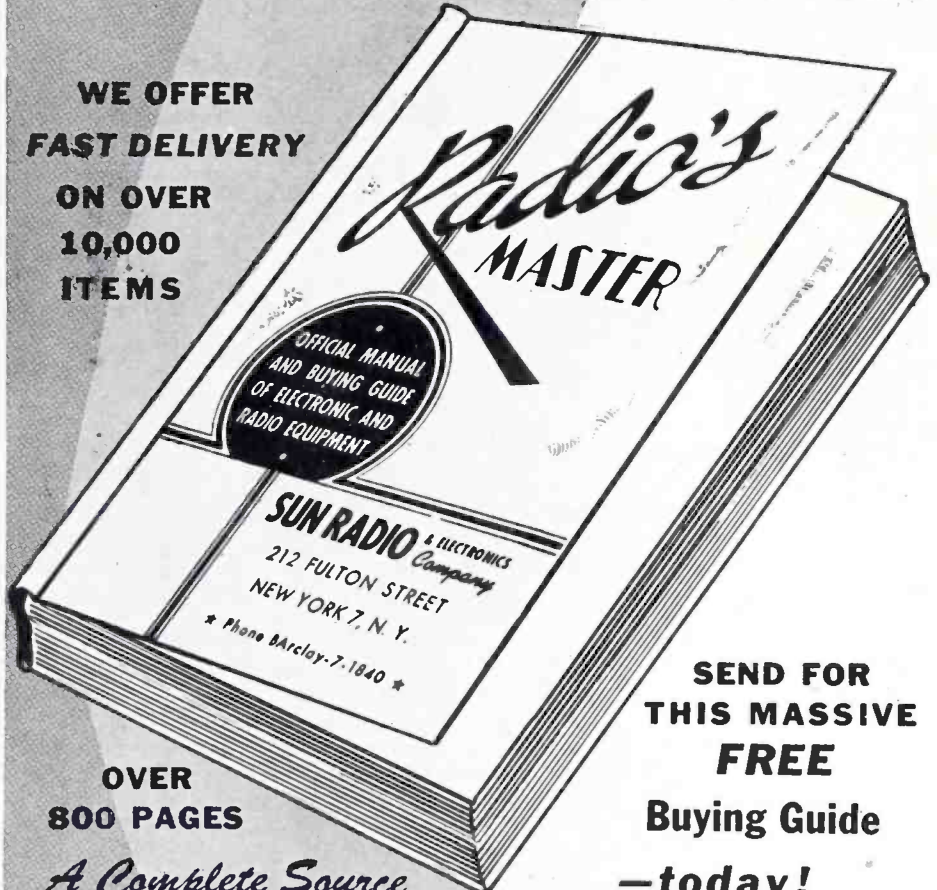
Other RCP instruments are described in our Catalog No. 128. These are instruments which conform with Government specifications or are recognized as "standard". Our engineers, keenly aware of the complex problems created by the development of new products, are ready to assist you by designing special instruments for your requirements.



RADIO CITY PRODUCTS CO.
INC.

127 WEST 26th ST. NEW YORK 1, N. Y.

MANUFACTURERS OF PRECISION ELECTRONIC LIMIT BRIDGES—VACUUM TUBE VOLTMETERS — VOLT-OHM-MILLIAMMETERS — SIGNAL GENERATORS — ANALYZER UNITS — TUBE TESTERS — MULTITESTERS — APPLIANCE TESTERS — AND SPECIAL INSTRUMENTS BUILT TO SPECIFICATIONS.



Television Standards

(*Continued from page 97*)

the NTSC to permit the use of chanical scanning devices in th ceiver, should such prove ad tageous. The RTPB Panel mad changes in these standards.

The remaining standards 19 and 21) relating to the me of rating television transmitter maximum white level, and the larization of the emitted waves identical to the previous re mendations of the NTSC.

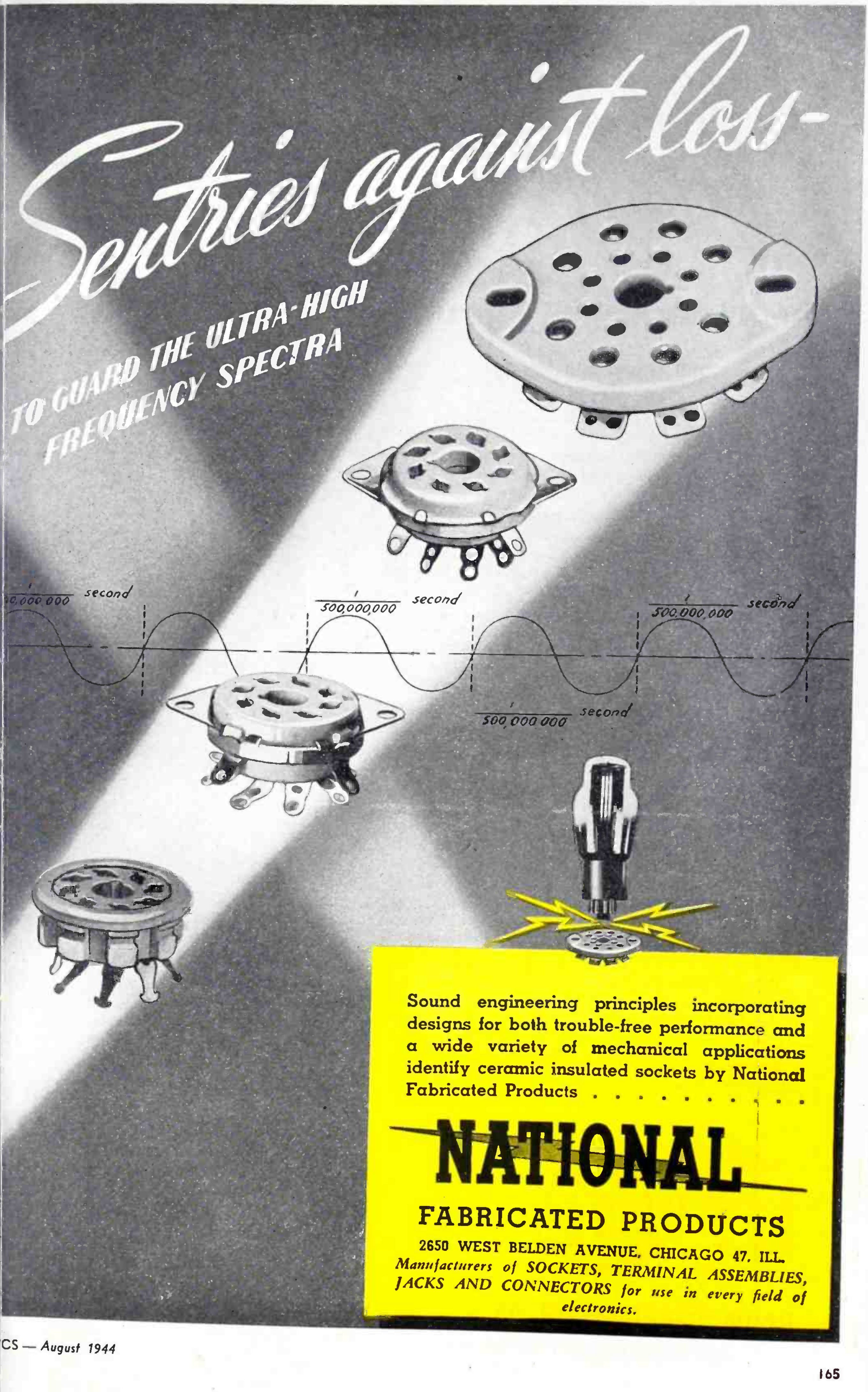
In summary, the RTPB Panel modified the NTSC-FCC stand in one respect (reducing the m mum deviation of the freque modulated sound signal and incr ing the sound signal radi power) to permit easier use on higher frequency channels, and tightened the standards in tw spects (by the elimination of a ternative method of picture m lation and an alternative ver sync signal which is believed have no particular merit). Ot wise, the standards remain as up and adopted in 1941. This i itself a tribute to the work of NTSC and of its predecessor, RMA Committee on Television.

Standards of Good Engineerin Practice

In addition to the primary sta ards of television transmission described, proposed "standards good engineering practice" w studied by Committee 5 of Panel. These include toleran (such as those expressed in sta ards 15, 16, and 17 of Table certain transmitter operating ch acteristics, and methods of me urement which relate to the ba standards.

Strict specification was deem impractical in many cases. For ample, the linearity of sweep c cuits in the camera was discuss and a method of measuring it scribed, but no strict tolerances l down. The "dynamic character tic" of the transmitter (the re tionship between subject brightn in the studio and transmitter o put voltage), is recommended to "substantially logarithmic". Ho ever, no tolerances are set up, pen ing further studies.

Methods of measuring the sid


Sentries against loss-
TO GUARD THE ULTRA-HIGH FREQUENCY SPECTRA
1/0,000,000 second
1/500,000,000 second
1/500,000,000 second
1/500,000,000 second

In High Quality Microphones

for AM Broadcasting, FM Broadcasting and Television Sound

TWELVE years ago, RCA engineers startled the industry by announcing the development of a revolutionary new microphone, "the microphone without a diaphragm."

That microphone was the first velocity microphone—and, back in 1932, it was a daring innovation. There was some shaking of heads over the fact that it looked different, worked differently, and moved the pre-amplifier from the microphone case to the equipment rack.

But, the broadcasting industry—which was just then moving into high gear—quickly found out that the Velocity Microphone was more convenient, more dependable and of far better quality than the condenser microphones then in use.

With one accord, broadcasters adopted the RCA Velocity Microphone for all high-quality pickups, and they have been using them in constantly increasing numbers ever since.

Meantime, RCA engineers, not content with the first velocity microphone, have gone on improving it. They designed new mountings, used new materials to achieve higher output, added new finishes. In 1935 they brought out the Uni-directional Microphone, a velocity-type microphone which has a single-sided pickup (as contrasted to the two-sided pickup of the standard velocity microphone). And in 1939, the "Combination" Microphone—a model which provides uni-directional, bi-directional or non-directional pickup at the turn of a switch.

Today RCA broadcast microphones are the standard of the industry. Used by NBC, CBS, the BLUE and nearly all regional networks—as well as by most of the independent stations, large and small.

For the best in microphones—and the best in all radio equipment—look to RCA!

RCA

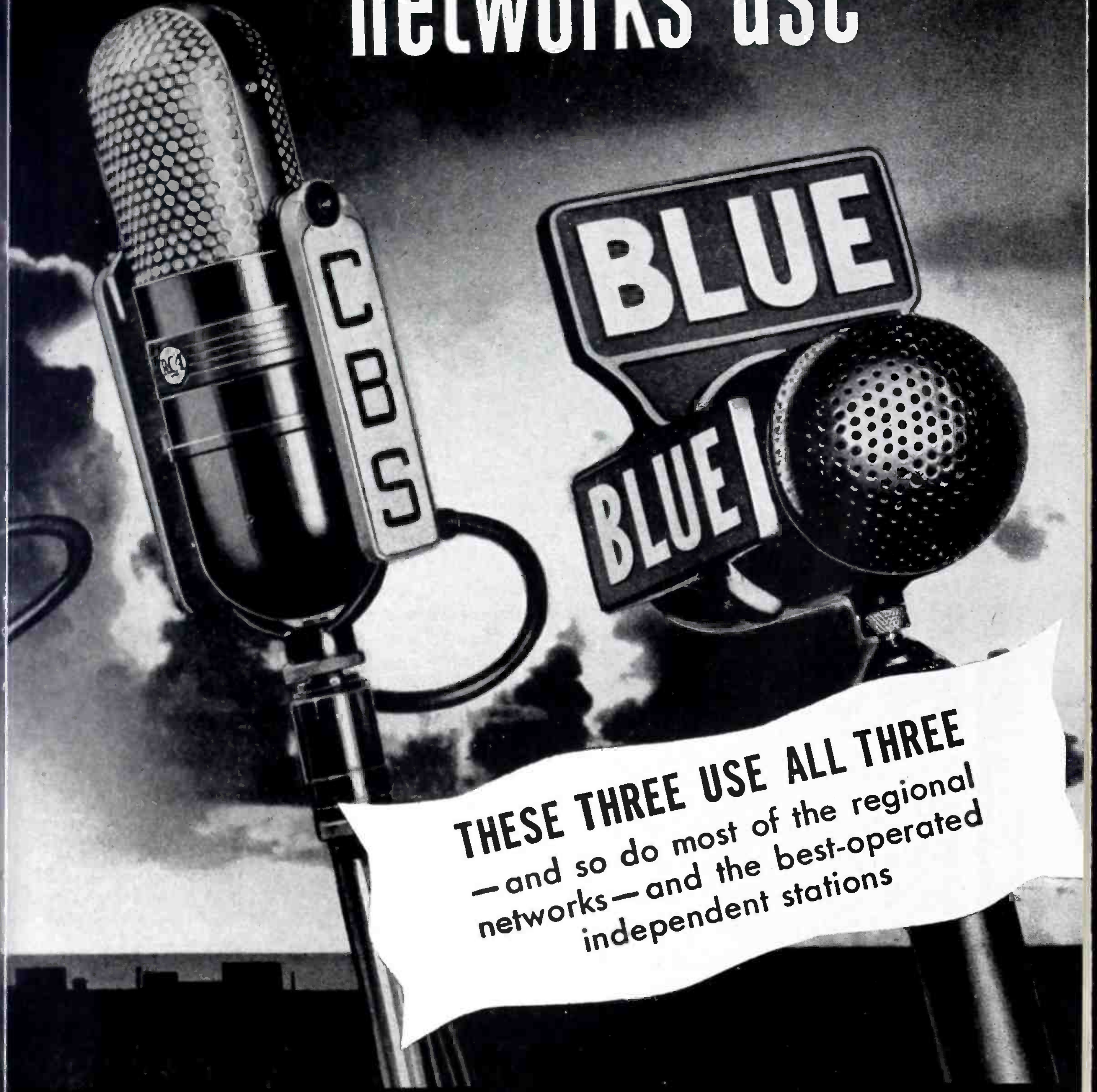
BUY MORE
WAR BONDS

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION • CAMDEN, N. J.

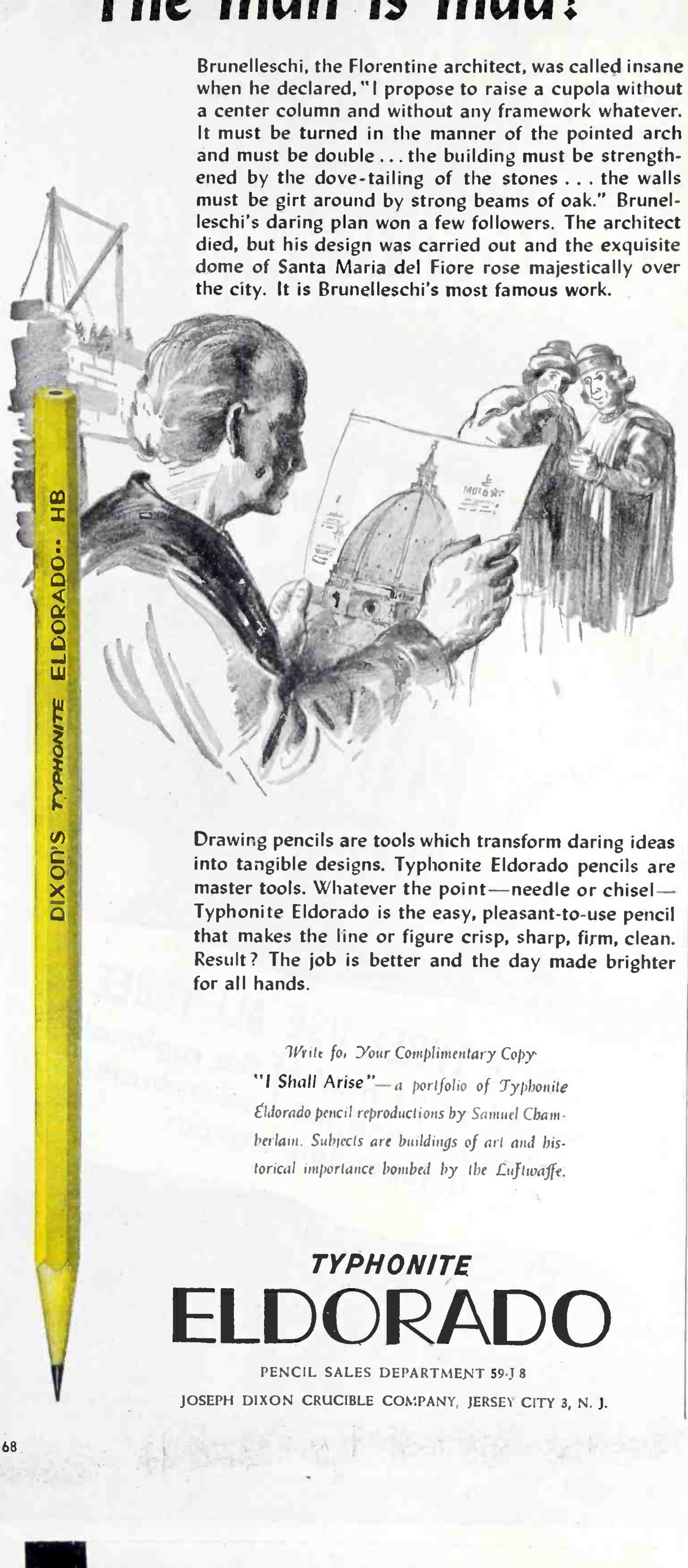
The RCA 44BX Velocity Microphone
high-quality studio pickups. A freque
which (when used with RCA pre-amp
form from 30 to 15,000 cycles, makes
ideal microphone for FM broadcasting
quality AM broadcasting.

microphones the networks use"



The RCA 77-C1 Special-purpose Microphone. Provides a uni-directional, bi-directional or non-directional response as desired. Change from one to another by turn of a switch. Frequency, response constant through entire operating angle. A combination of flexibility and quality which is unequaled.

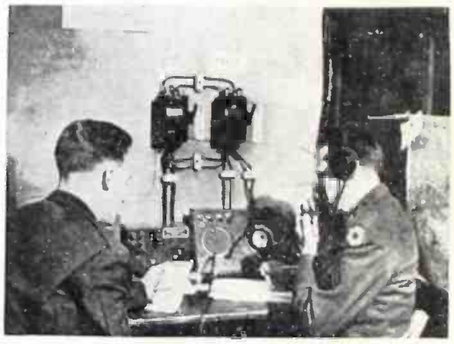
The RCA 88-A Pressure Microphone. A rugged, non-critical unit — especially suited for remote pickups. Weighs only a pound, provides a high output level, has a moisture-proof, molded styrol diaphragm and a protecting wind screen. Response of 60 to 10,000 cycles makes it suitable for many studio uses as well as remotes.



uniform with the standard shown in Fig. 4, are also proposed. The modulating signal consist of sync pulses and variable-frequency sinewaves whose peak-to-peak amplitude is 0.5 the peak sync-pulse amplitude. The sinewave frequency is varied throughout the video range and the field strength radiated by the transmitter measured, against the 100-kc sideband as a reference. In case field strength measurements are not sufficiently reliable, measurements of r-f voltage developed across a resistive dummy load may be used in conjunction with the measured characteristics of the transmitting radiator. The attenuation tolerance recommended is that the field strength so measured be down at least 20 db from the 100-kc value at values lower than 1.25 Mc and higher than 4.5 Mc from the carrier. Within the sideband regions, the characteristic is to fall not more than 2 db up to a modulating frequency of 1.25 Mc and not more than 6 db up to a frequency of 3 Mc. In the low frequency range it is recommended that the variation in transmitter

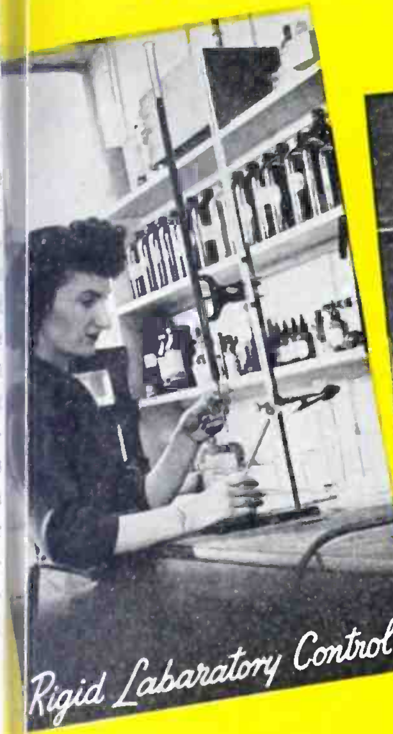
• • •

POLICE RADIO IN LONDON



An efficient radio net is operated in London by American MP's. As shown above, men in cruising jeeps report incidents by radio to headquarters of Provost Control via a central station

PRECISION PLATING
IN GOLD and SILVER
To Performance Specifications


Rigid Labaratory Control


Large-volume Solutions


Critical Over-all Inspection

HECK THESE TWO CASE HISTORIES

It had started simply enough . . . just an order to gold-plate a small, precision-machined part to withstand a severe
lt spray test. Then a sudden shift in the tide of war
mped the demand 500% . . . with high-rate deliveries needed
once. With the celerity possible only when sure knowledge
rects large-scale facilities, deliveries were doubled — over-
ght — with full-scale production reached in only three days.
d this with no deviation from the specification for precision
ting, established by DICO engineers on the basis of the
rformance requirement.

2 Another problem met by DICO engineers is the application of an adherent gold plate on a molybdenum wire only .008" in diameter. Since the plating must not only be able to withstand extreme deformation but must also "preserve the original physical characteristics and limits of the wire", extremely close tolerances are involved. To meet the tolerances and to handle the many miles of wire required to be plated each month, special machinery had to be designed and built to DICO specifications for use by men skilled in precision plating.

These are but two of the widely divergent problems in precision plating that are daily submitted to DICO. We believe our facilities and skills are unique. We offer them for the solution of your plating problems.

DICO

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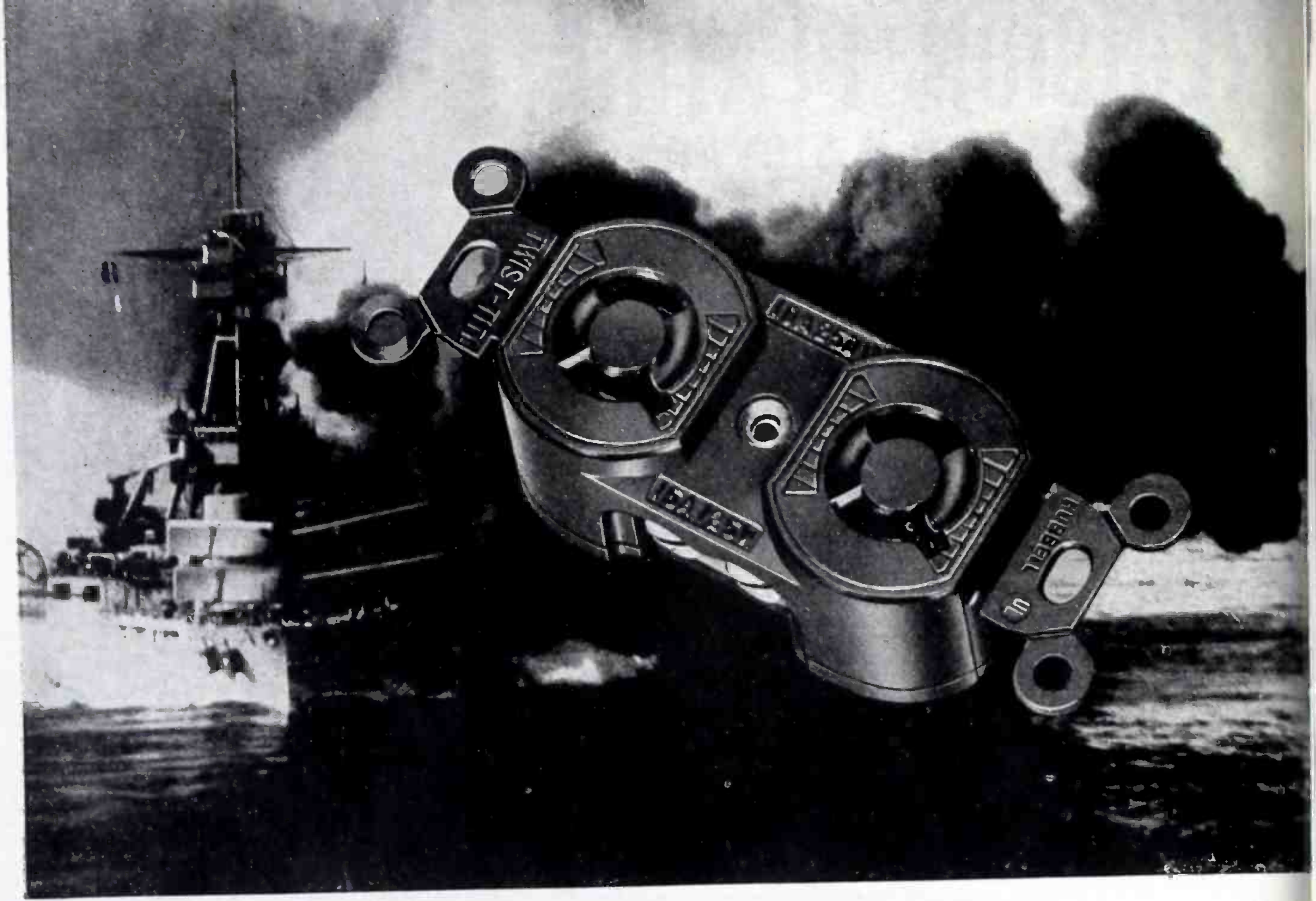
- ASSEMBLING



EVEN A BROADSIDE DOESN'T JAR THE PLUG OUT OF THIS RECEPTACLE

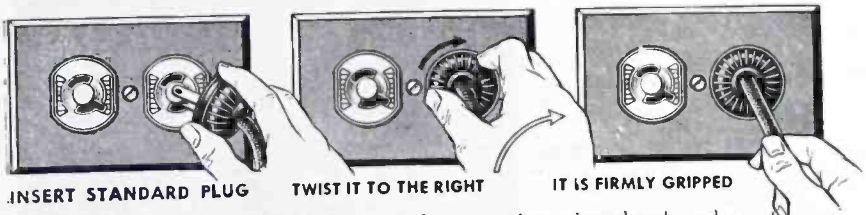
Another Engineering Accomplishment of The Hubbell Development Laboratory

ELECTRICAL connections aboard modern warships must withstand the shock of gunfire as well as the normal vibration of operation. When ordinary outlets were used for plugging in portable electrical equipment, considerable trouble was experienced with plugs working loose, or being ejected by the recoil of a broadside. This problem was solved with a product of the Hubbell Development Laboratory.

The Hubbell Twist-Tite Receptacle now used on various classes of Naval vessels firmly grips all standard parallel-blade plugs. This is an enormous advantage. It assures the Navy of vibration-proof connections withou necessity of putting special plugs on the extension of all the clocks, fans, vacuum cleaners, radios similar equipment used on every ship.

The function of the Hubbell Development Labo is to help industry meet its ever-changing need for e cal connectors, switches, sockets and receptacles. Mos devices on the market today originated in, or hav improved by the Hubbell Laboratory. If you have a lem within the scope of the Laboratory, let us know it. We will gladly have a local technical adviser call o

HOW THE HUBBELL "TWIST-TITE" WORKS



INSERT STANDARD PLUG

TWIST IT TO THE RIGHT

IT IS FIRMLY GRIPPED

Besides the advantage of the elimination of accidental plug disconnection, TWIST-TITE always assures a continuous, uninterrupted flow of current. The Laboratory has also developed a complete line of TWIST-LOCK connectors used extensively by industry where an absolute locking device is desired.

TRADE HUBBELL MARK

HUBBEL
DEVELOPMENT LABORAT
OF HARVEY HUBBELL,

1523 STATE ST., BRIDGEPORT 2,

Need a Motor that can lift 500 times its own weight?

THIS electric motor weighs only a pound. But more power is packed in that one pound of motor than has ever been before.

With Lear gearing it can handle a quarter-ton load.

And it has to be ready to do that in an instant. Because this motor moves control flaps, and heater shutters on warplanes. And air pressures mount high at the speed these ships fly.

On aircraft, even the weight of a coat of paint has to be considered. So this motor had to be light.

There's little room in an airplane. So it had to be small.

Designing it meant starting from scratch. There was no precedent for this kind of engineering.

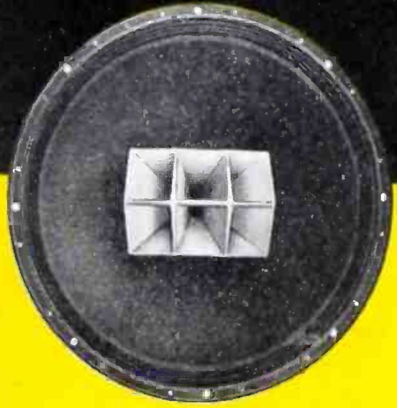
You may never need a motor like this. It may cost more than you might want to pay.

But if you are looking ahead toward manufacturing some peacetime product, we want you to know that such a motor has been developed along with 250 other Lear products.

And equally important, we want you to know that there is available the kind of engineering thinking that could conceive and produce it.

PLANTS: Piqua, O., and Grand Rapids, Mich. BRANCHES AT: New York, Los Angeles, Chicago, Detroit, Cleveland, Providence.

LEAR AVIA
INC.
PIQUA · OHIO



output from frame to frame be not more than five percent, due to all causes, including hum, noise and low-frequency response.

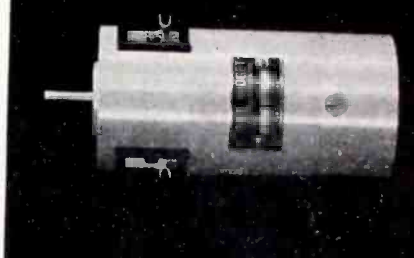
The peak power output of a transmitter is defined as 1.73 times the average power measured in a resistive dummy load (resistance equal to the transmission line) when the transmitter is transmitting a standard black television image. Various definitions of rated power, maximum peak power, and operating peak power are stated. The carrier frequency stability recommended is plus or minus 0.005 percent, compared with 0.01 percent required by the FCC at present. Finally, it is urged that the esr (effective signal radiated) now used by the FCC as a basis for licensing television stations, be dropped in favor of a more complete specification of transmitter coverage shown on a contour map.

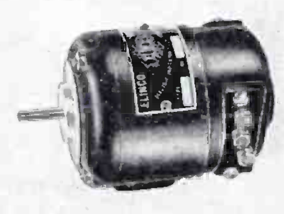
In conclusion, it is appropriate to quote the RTPB Panel Report, which expresses the unanimous opinion of members concerning the validity of the proposed standards and their suitability for immediate postwar use:

"It is understood that expansion of commercial television activity must await availability of materials and personnel. Prior to the resumption of full-scale operations it is important that the proposed standards be periodically re-examined in the light of technical developments. Panel 6 agrees that the proposed standards are the best on which to resume television activity, based on all presently available information, and, moreover, Panel 6 agrees that the standards do not in any way restrict the use of classified developments now individually known to the Panel and its Committee members."

◆

RECORDINGS OF THE OLD and New Testaments have been completed on 169 phonograph discs, each playing a half hour, and have been issued by the American Foundation for the Blind as a Talking Book. The foundation had the financial assistance of the Library of Congress, the American Bible Society and the New York Bible Society. All Talking Books are sent to sightless persons at no cost.





One reason for the outstanding acceptance of ***LEXEL** Tape as primary insulation for wire and cable is its good insulation resistance. This quality has enabled manufacturers of communications systems to supply equipment with the absolute minimum of interference or "cross talk".

Can't you imagine the staggering losses in lives—materials—or both, if orders were jumbled or unintelligible?

***LEXEL** provides this protection with extremely light, thin material—a marked saving in space and weight as compared with most insulation for low tension circuits. This is especially important in compact, portable equipment.

In dielectric strength ***LEXEL** tests high; it has very low moisture absorption and is flame retardant. It performs efficiently at extreme temperatures.

The conductor is CENTER-SEALED in a continuous helical tube of ***LEXEL**—sealed by the heat which disperses the lacquer solvents. It is furnished in sizes for all gauges of wire and cable, in rolls to fit standard serving machines.

Let us send additional information, samples for testing and the names of manufacturers supplying ***LEXEL** insulated wire.

CUSTOM-MADE INSULATION!

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

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

THE **DOBECKMUN** COMPANY

CLEVELAND, OHIO • OAKLAND, CAL

TUBES AT WORK

Convenient Remote Amplifier

By Alvin H. Smith
Chief Engineer KSCJ

Many broadcast stations have need of an inexpensive single channel remote amplifier for convenience in handling remotes. Such an amplifier has been in daily service at KSCJ for over a year and has proven quite satisfactory.

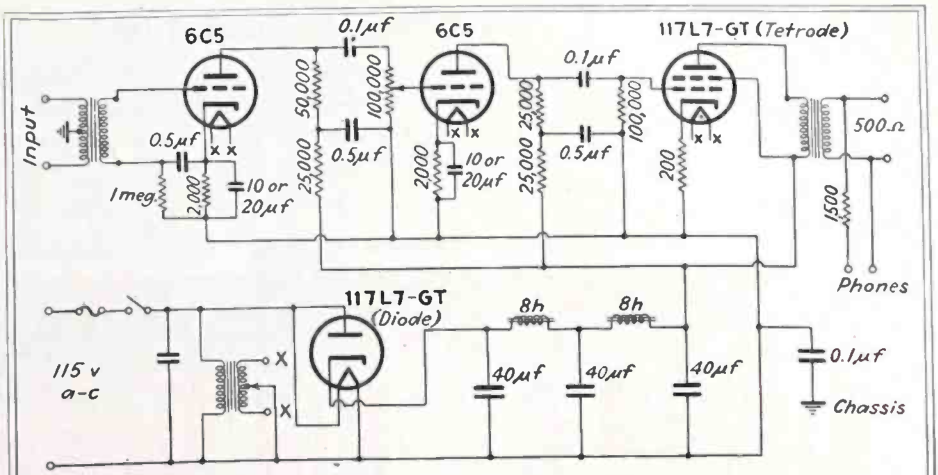
The manner of solving the problem of maintaining a low noise level, due to the proximity of the power supply to the low-level high-impedance audio circuits, will be of interest to other engineers.

Only one a-c transformer is used, a low-wattage 6.3-volt filament transformer. This is mounted as far from the microphone input transformer as possible, and positioned for minimum a-c pickup in the input transformer. The latter transformer has more effect on hum than any other single item in the amplifier.

To keep the filter chokes well away from the audio-frequency circuits, they were mounted on the opposite side of the chassis from the a-f transformers. All high-impedance leads were kept very short or completely shielded. The shells of the 6C5 tubes were grounded to the chassis to prevent oscillation.

An ideal output transformer was not available, so an inexpensive public address type transformer was used. This did not provide the proper loud impedance for the 117L7-GT but, due to the low power output required, this was found to be unimportant. Distortion is reduced somewhat by omitting the cathode bypass capacitor on the output stage to introduce degeneration.

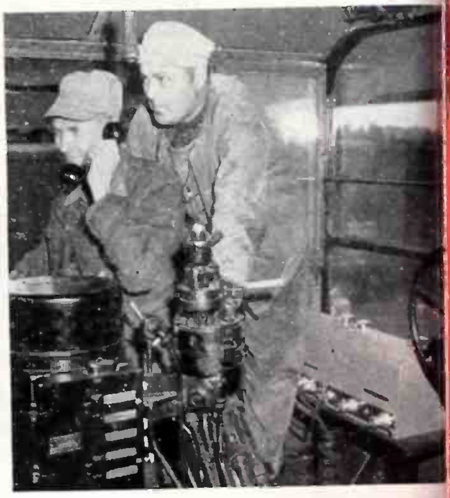
The frequency response was found to be plus or minus 2 db from 50 to 17,000 cps. At voice frequencies, the distortion was approximately 1 percent with 6 milliwatts of output. The noise level was found to be down 55 db from a reference level of 6 milliwatts. while the overall gain was 90 db.



Circuit of the inexpensive remote amplifier that was constructed of spare parts at KSCJ. The overall gain is 90 db

Two-Way F-M Units Installed in Freight Yards

F-M communication between trains was inaugurated June 5, at the freight yards of the Rock Island Lines in Chicago. The installation consists of two locomotives equipped with portable f-m transmitting and receiving equipment and a master control unit incorporating transmitter and receiver at the freight yards at Blue Island and interconnected with the incoming and outgoing freight stations. The equipment is used primarily to increase efficiency of operation and speed up service as well as to minimize delays in th routing of freight traffic.

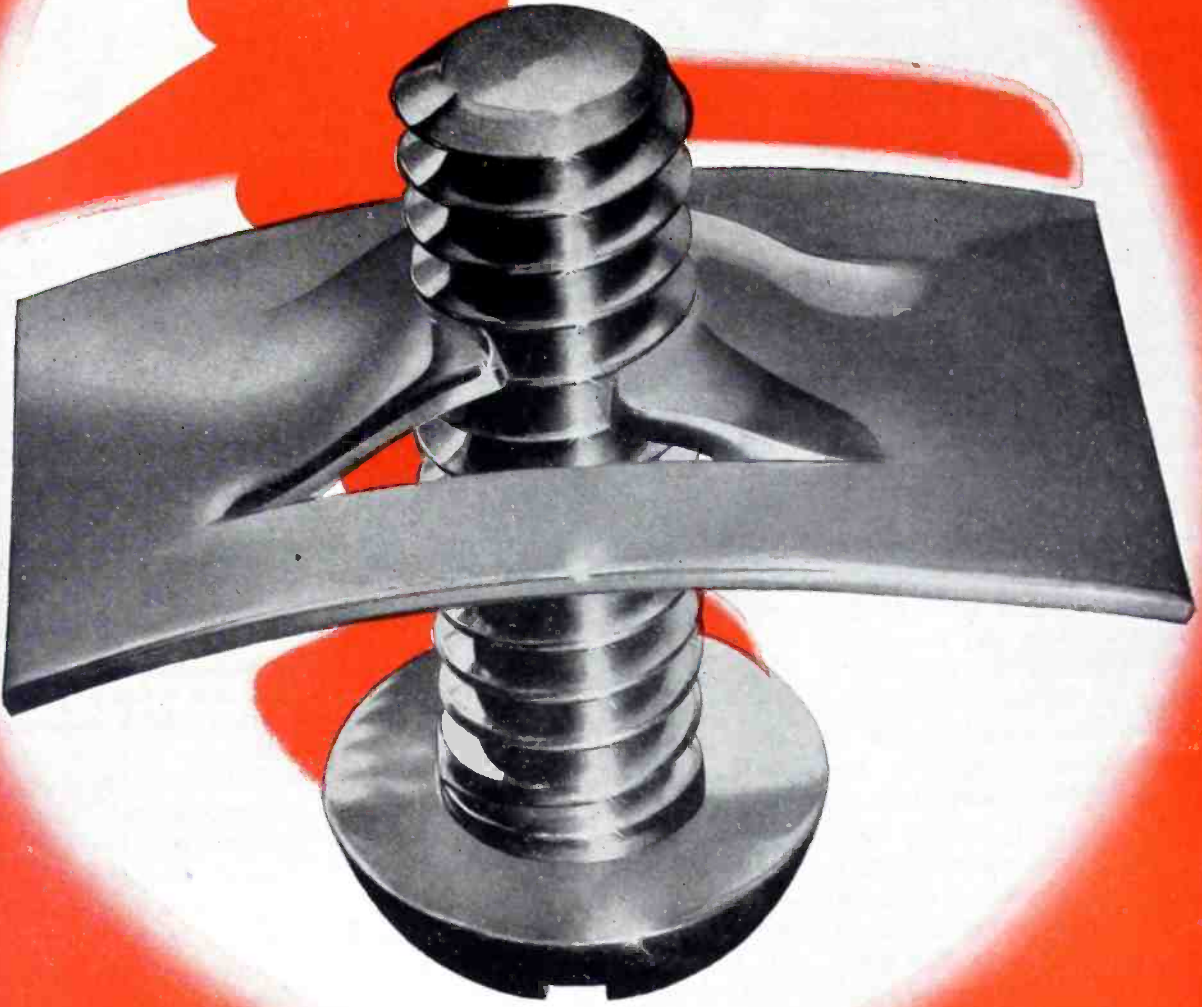


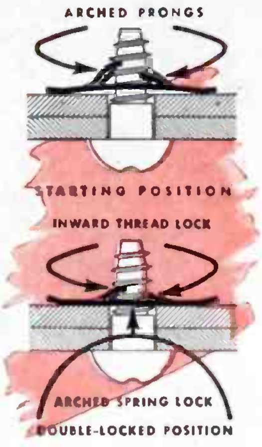
On approaching the railroad yards, train crews can now receive instructions from the train dispatcher via Motorola f-m equipment mounted behind the engineer

The f-m radio equipment used i fundamentally that described o page 102 of the January 1944 issu of Electronics, and manufacture by the Galvin Mfg. Co. of Chicag Several modifications have been incorporated in order to adopt th Motorola standard unit for trai use.

Technical Features

Provision is made to communicate by means of a hand telephon set, while a loudspeaker is used fo calling purposes. Wire telephon links from two freight yards connect with the master radio contr unit and thence by radio links t either of the two radio-equippe locomotives. The master contr equipment is located at the base o a 90-ft lighting tower which sup




ARCHED PRONGS
STARTING POSITION
INWARD THREAD LOCK
ARCHED SPRING LOCK
DOUBLE-LOCKED POSITION

ports a conventional whip antenna.

A selective tone system of calling has been developed so that the desired train may be called without interfering with other radio-equipped locomotives. This operates by means of a resonant system which actuates the relays in the appropriate locomotive when the call system is actuated at the freight yard. Provision is made for calling any one of ten locomotives at will and the system may be expanded for any number of units. All radio-equipped trains can be called for a general broadcast.

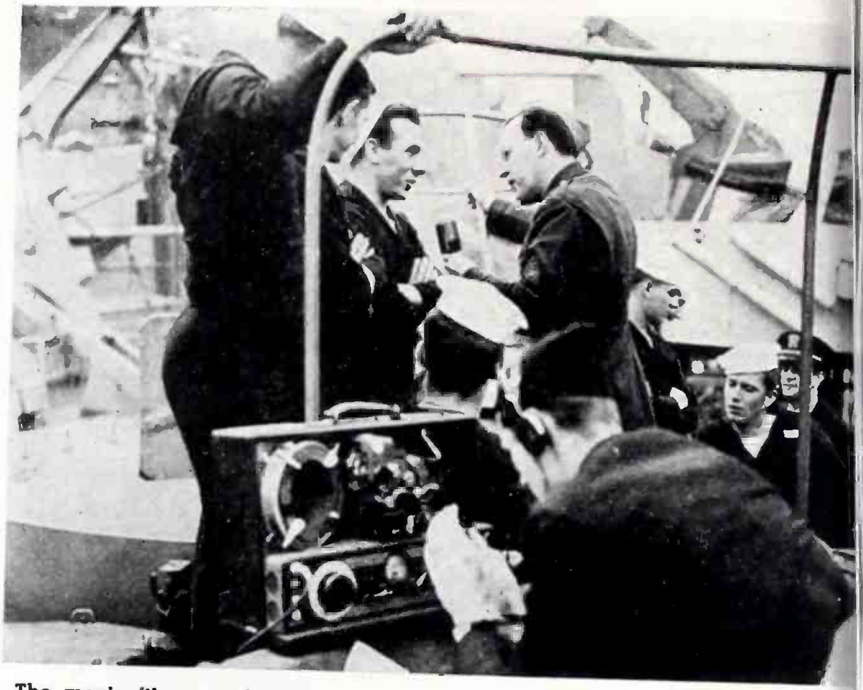
Each locomotive contains a whip antenna, loudspeaker and hand set, f-m receiver, f-m transmitter, and power generating units. At present, all communication is at 39.95 Mc, but plans are under way to operate about 250 Mc after the war.

Another application of f-m equipment which was demonstrated by the Rock Island Lines is an f-m system for duplex operation in the event of failure of railway telephone lines. In operation, one portable radio unit is used at each end of the line where a break occurs. Provision is made for feeding audio energy from the telephone line into the radio unit. Two such units replace the damaged wire circuits and permit an operation over a distance of 15 miles. Operating under the call letters KBPK on frequencies of 30.66 and 39.54 Mc, this duplex equipment has already seen useful service when storms damaged wire communications facilities.

New Film Recorder in Invasion

THE NOW FAMOUS BROADCAST by George Hicks, Blue Network correspondent, (an eyewitness account of a Nazi aerial attack on Allied ships in the first stages of the invasion) was made on a recorder using 35-mm movie film.

The machine embosses a sound track on blank film and can record 120 lines across the width of the strip. This provides a 12,000-ft sound track on a 50-ft film, about five hours of steady recording. The embossing is made with a sapphire stylus mounted in a magnetic head that presses against the film when it is supported by a resilient pad. A second sapphire in a magnetic head is used for playback.



The movie film recorder in action with George Hicks, Blue Network correspon while he interviews Navy men aboard an LST just prior to D-Day. The recorder both sides of a 50-ft film to accommodate a 12,000-ft sound track

An important feature of the machine is that starting and stopping are controlled by either a manual switch, electrical impulses or voice or sound. An automatic volume control circuit is used to prevent overmodulation and resultant overlapping of the sound grooves. Made by Amertype Recordgraph Corp. of New York.

Censoring of Hicks story was accomplished by feeding the o of the original film into an machine and breaking the ci when censoring was necessary. this process, it was discovered syllables of words could be del In one recording, the censor jected to a word that was pl The next word was singular, bu form a sentence it had to be pl so the sibilant sound of the 's' taken off the first word and pu the second word.

Blind Landings with Electronic System

AN INSTRUMENT which permits pilots to make blind landings on runways within fifty feet of a preselected spot is now being built into combat planes and trainers. The instrument, shown in the photographs, is used as the indicator of an electronic system that is the result of seven years of continuous research and development by Westinghouse Elec. and Mfg. Co. and the Washington Institute of Technology, which worked with the U. S. Navy to originate a simplified device for taking the guesswork out of blind landings.

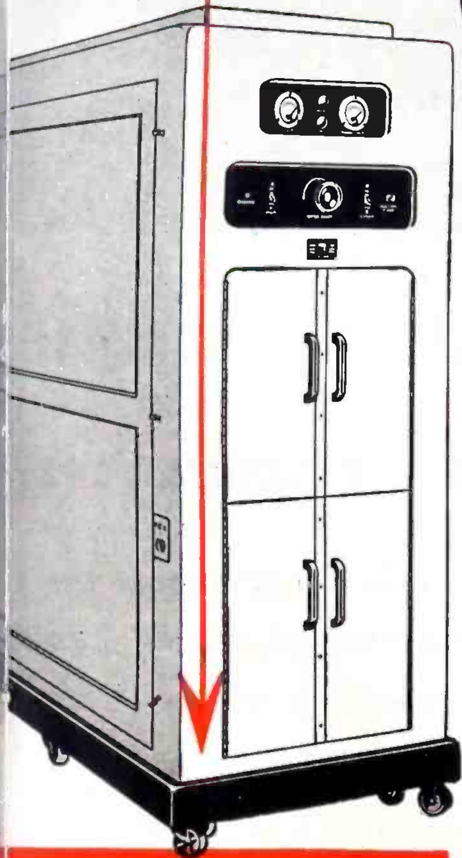
In the electronic system, the pilot gets all directions for descent by watching two crossed pointers and two signal lamps on the instrument. These are actuated by two radio receivers in the plane which are tuned to the directional beams transmitted by the gro equipment. One receiver respo to the localizer, or on-course bea and moves the vertical pointer the instrument dial. The sec receiver responds to altitude s nals and operates the horizo pointer.

Transmitters

Four radio transmitters and t antenna systems at and near t airport comprise the ground rad equipment. These produce bea which first indicate the pilot's a proach to the field and then ma the field's boundary; establish t invisible glide path which leads the runway; and signal directio for keeping the glide to the fie neither too shallow nor too stee

Vertical guidance is provided b three of these transmitters. On

There's no ONE-MAN-BAND in Electronic Heating



Although it is possible to construct an electronic heater that will generate a great range of high frequency currents, it will not perform *all* heating jobs efficiently and it would be very costly in use.

Virtually every application of electronic heating requires a specific FREQUENCY AND POWER combination. Therefore, to realize the maximum advantages of this improved heating method, *each installation should be designed and built for its particular application.* For example: when a heating operation can best be done at 5 kw and 22 megacycles it would be *wasteful* and *inefficient* to use a machine that delivers 20 kw at 500 kc.

Many first-time users of electronic heating are induced to buy "misfits" when they try to find an all-purpose machine. Our extensive line of equipment offers you the broadest range of power and frequency combinations at *prices lower* than other makes of comparable quality.

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00 megacycles —
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- 5 Kw
- 7½ Kw
- 10 Kw
- 12½ Kw
- 15 Kw
- 18 Kw
- 25 Kw
- 40 Kw
- 100 Kw

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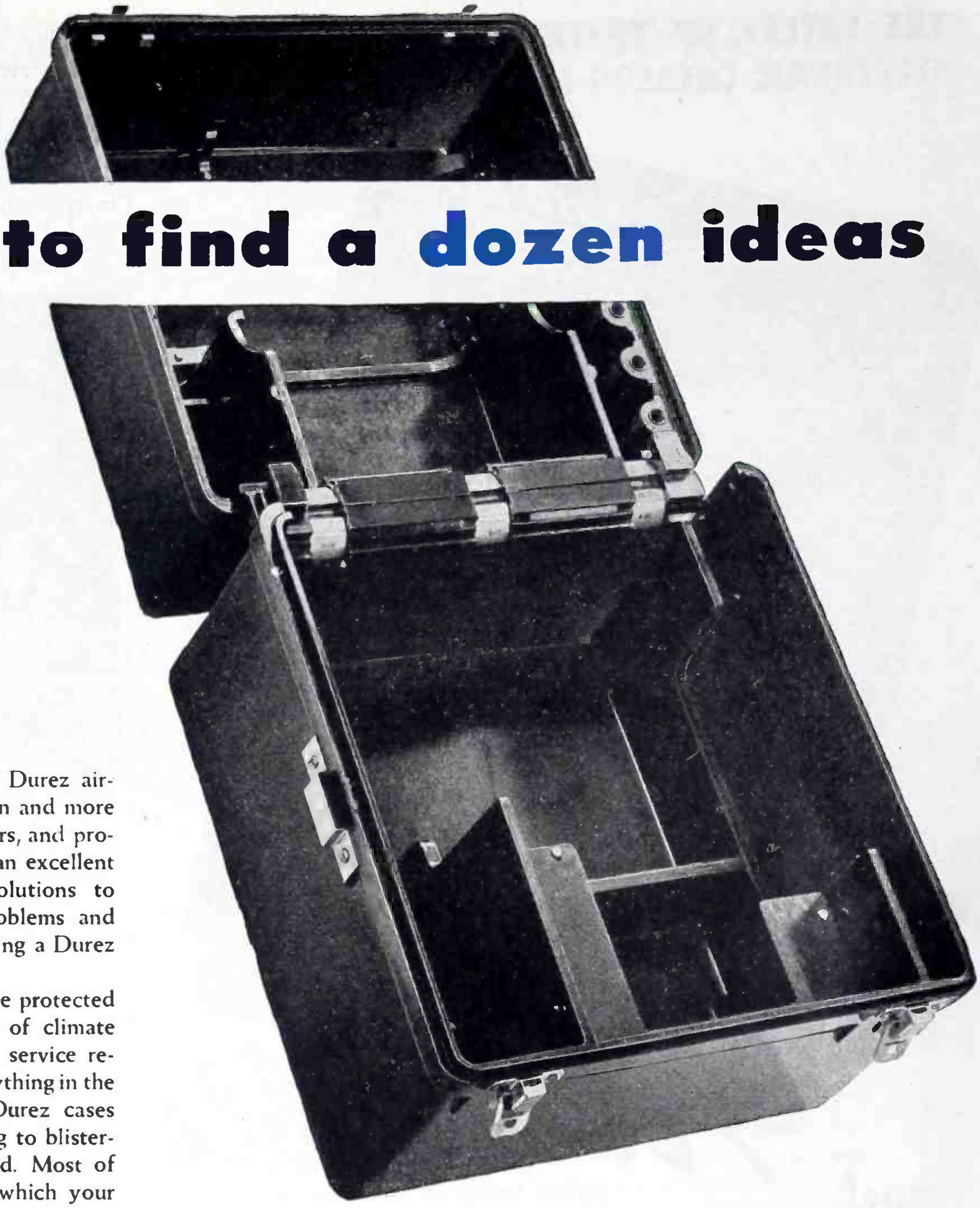

How to find a dozen ideas

They're all in this molded Durez aircraft sextant case...a dozen and more ideas for designers, engineers, and production men. The case is an excellent example of ingenious solutions to many difficult molding problems and of the reasons for specifying a Durez phenolic.

Sextants, of course, must be protected from the bitterest moods of climate and geography. As far as service requirements go, almost everything in the book is thrown at these Durez cases—from salt spray and fog to blistering heat and freezing cold. Most of the service conditions to which your own products may be exposed are probably part of the daily life of the sextant case.

Versatility is the outstanding property of Durez. Check off a few of its characteristics. There's light weight, yet tensile strength is very good. There's impact strength which can take plenty of punishment. There's the fact that extreme temperatures affect neither inherent properties nor dimensional stability. There's powerful resistance to the corrosive attacks of chemicals, oils, mild acids and alkalies. And, there's a series of electrical properties which make Durez a first choice for that industry.

In the versatility of Durez may lie at least part of the answer to your production and merchandising problems. For instance, ease of moldability, another characteristic of Durez compounds, provided part of the answer to the highly complicated molding problem of the sextant case. We suggest that now is the time to start talking it over with your custom molder. And we are always ready with valuable data and personal assistance in answering plastic materials questions. Write to Durez Plastics & Chemicals, Inc., 88 Walck Road, North Tonawanda, New York.

DUREZ

PHENOLIC MOLDING COMPOUNDS AND RESINS

PLASTICS THAT FIT THE JOB

furnishes the glide path, a ra
beam similar to the funnel-sha
ray thrown by a flashlight.
other two transmitters are mark
whose beacon signals, transmit
vertically, light the lamps on
instrument panel via the plan
marker receivers. The first fl

The two crossed pointers on the instru ment above the control post remain i alignment with dotted lines on the panel face as long as a pilot's descen to an unseen runway is precisely o course. Signals from transmitters on the ground actuate the pointers

tells the pilot he is a few mile
from the airport and that he shoul
prepare for the glide path by maintaining an altitude of 1500 feet.
When a similar beam from the second marker lights the other lamp
the pilot knows he has reached th
boundary of the field.

Operation

The homing path, or localizer is produced by ultrahigh frequency radio transmitters feeding tw sharply directional loops. Signa strength emanating from the loops is almost equal if the plane is on course and flying in directly between them. This the vertical pointer of the instrument interprets by assuming an upright position. Should the plane wander to the left or right of the course, the corresponding signal predominates and the vertical pointer veers in that direction in an amount roughly proportional to the distance the ship has flown off course.

The horizontal pointer remains in position across the center of the

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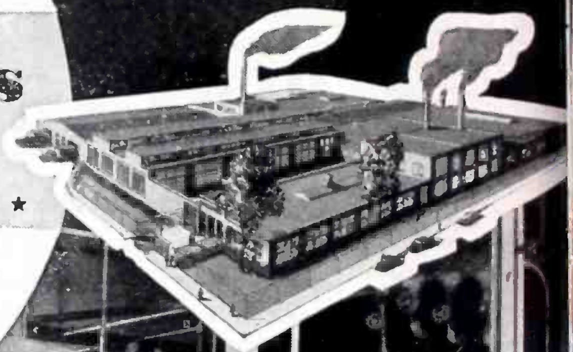

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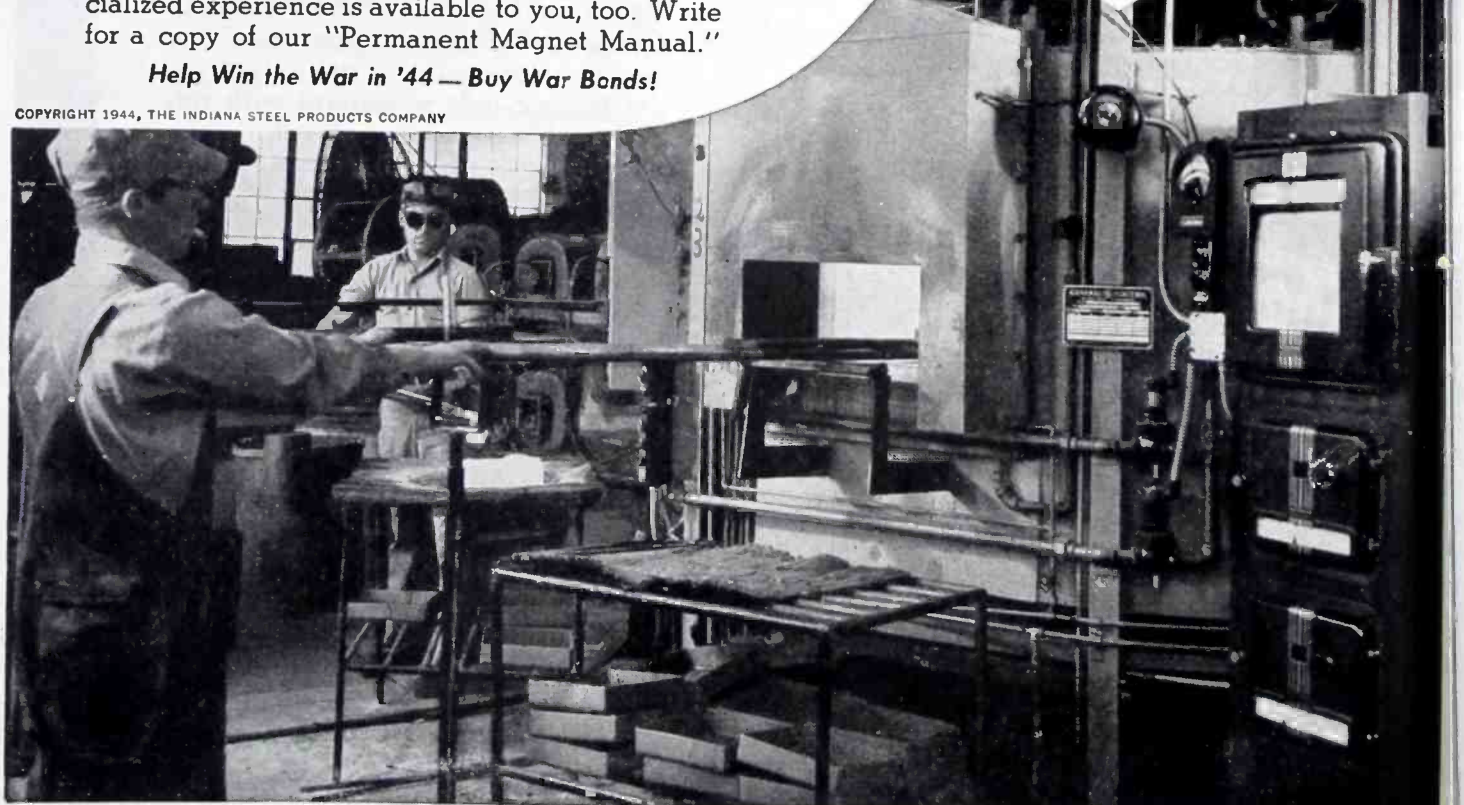

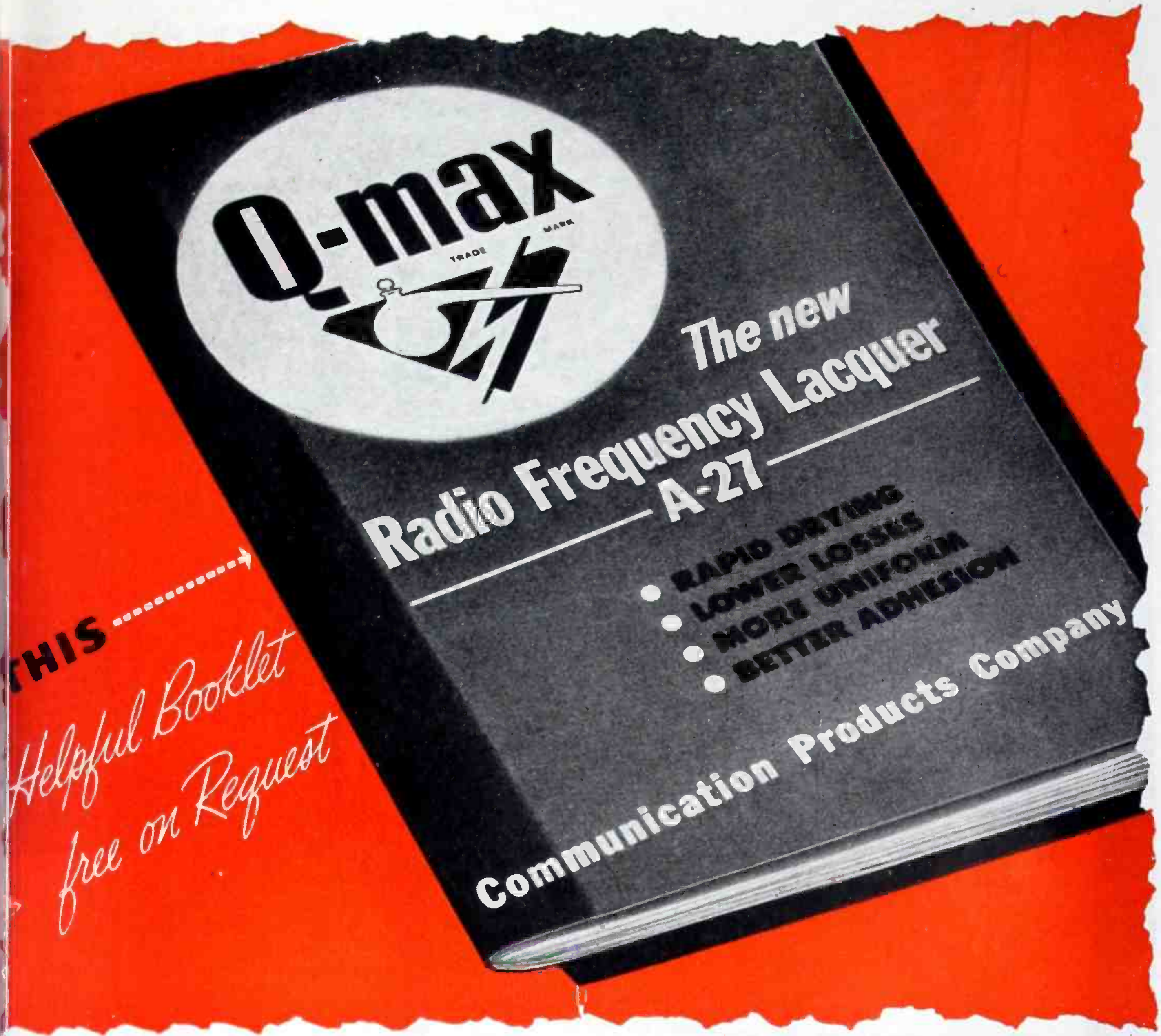

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dial while the plane is descendi at the correct angle. If the gli is too shallow, the pointer ris if it is too steep, the pointer mo downward.

The electronic landing system in daily service at Indianapo and several other commercial a ports as well as on Army and Na flying fields. Pilots learn quick how to use it and thousands our Army and Navy pilots ha learned to use and depend on it modern flight technique.

Cross pointer indicators for blind landing of aircraft are checked in the Westinghouse Meter Division at Newark, N. J. The instruments operate on a current change as small as 12 microamperes

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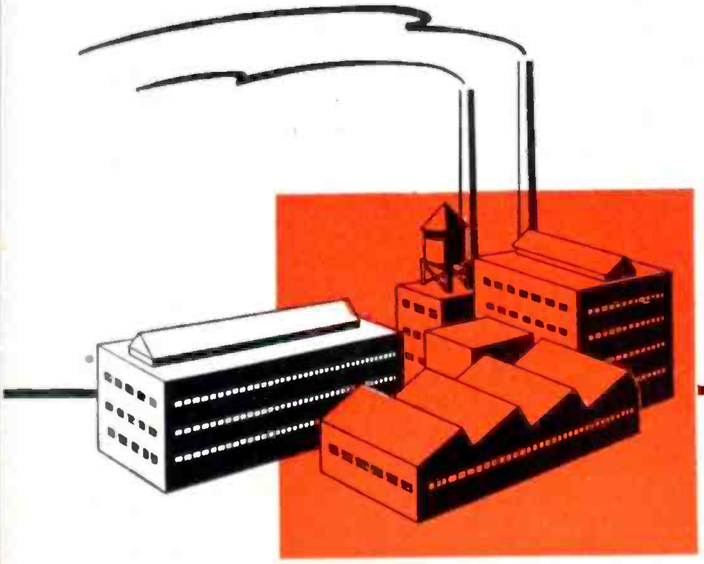

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Columbia Broadcasting System

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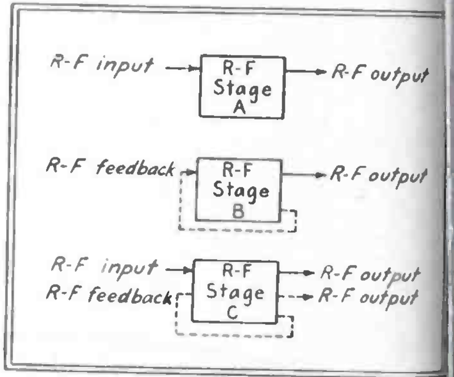

FIG. 1—Typical conditions of operation of an r-f stage in a transmitter

Figure 1 illustrates the conditio under investigation while tunin the r-f amplifier. At *A* is a bloc diagram of a neutralized amplifier the r-f input to the grid circuit alone being used to obtain the power output. Almost the same condition exists at *B* of the same figure, an r-f oscillator. It is merely an r-f amplifier with some of its own plate power fed back, usually in the neighborhood of 5 percent of the output and in proper phase for sustained oscillations. Thus in the grid circuits of *A* and *B* only one r-f current flows to vary the bias voltage. In *C* of Fig. 1, we have the case of the unneutralized amplifier, where r-f is fed from a preceding stage, but some r-f is also fed back from a spurious frequency in the plate circuit. This is really a combination of an r-f amplifier and an oscillator that results

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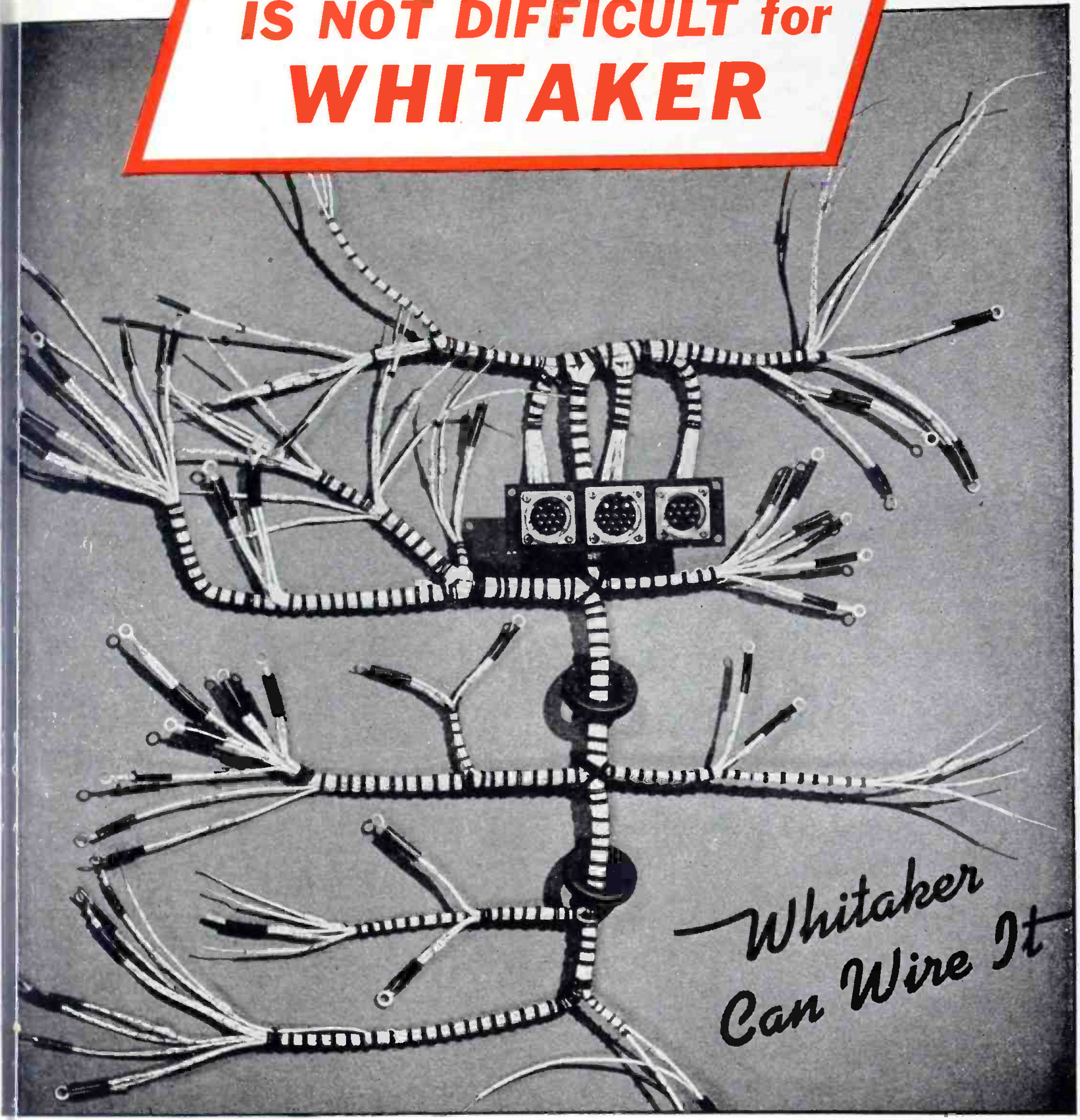

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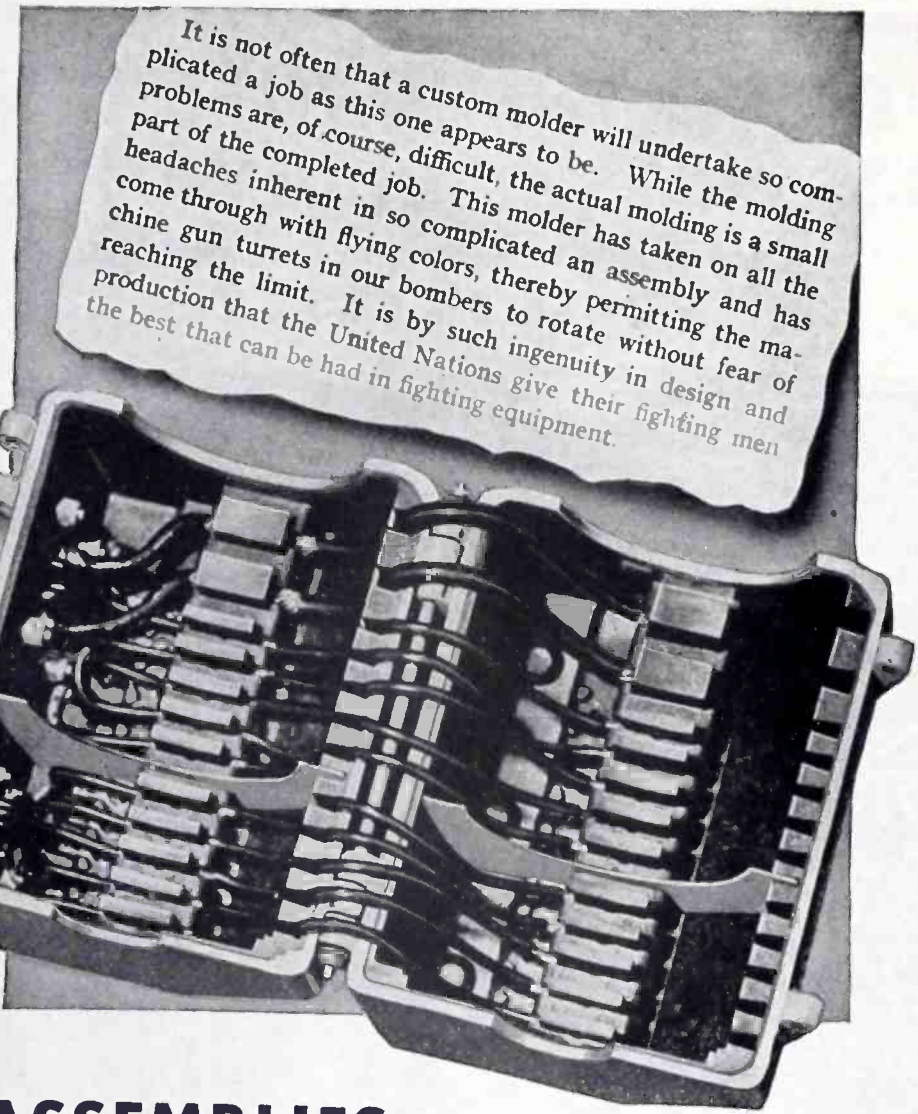

It is not often that a custom molder will undertake so complicated a job as this one appears to be. While the molding problems are, of course, difficult, the actual molding is a small part of the completed job. This molder has taken on all the headaches inherent in so complicated an assembly and has come through with flying colors, thereby permitting the machine gun turrets in our bombers to rotate without fear of reaching the limit. It is by such ingenuity in design and production that the United Nations give their fighting men the best that can be had in fighting equipment.

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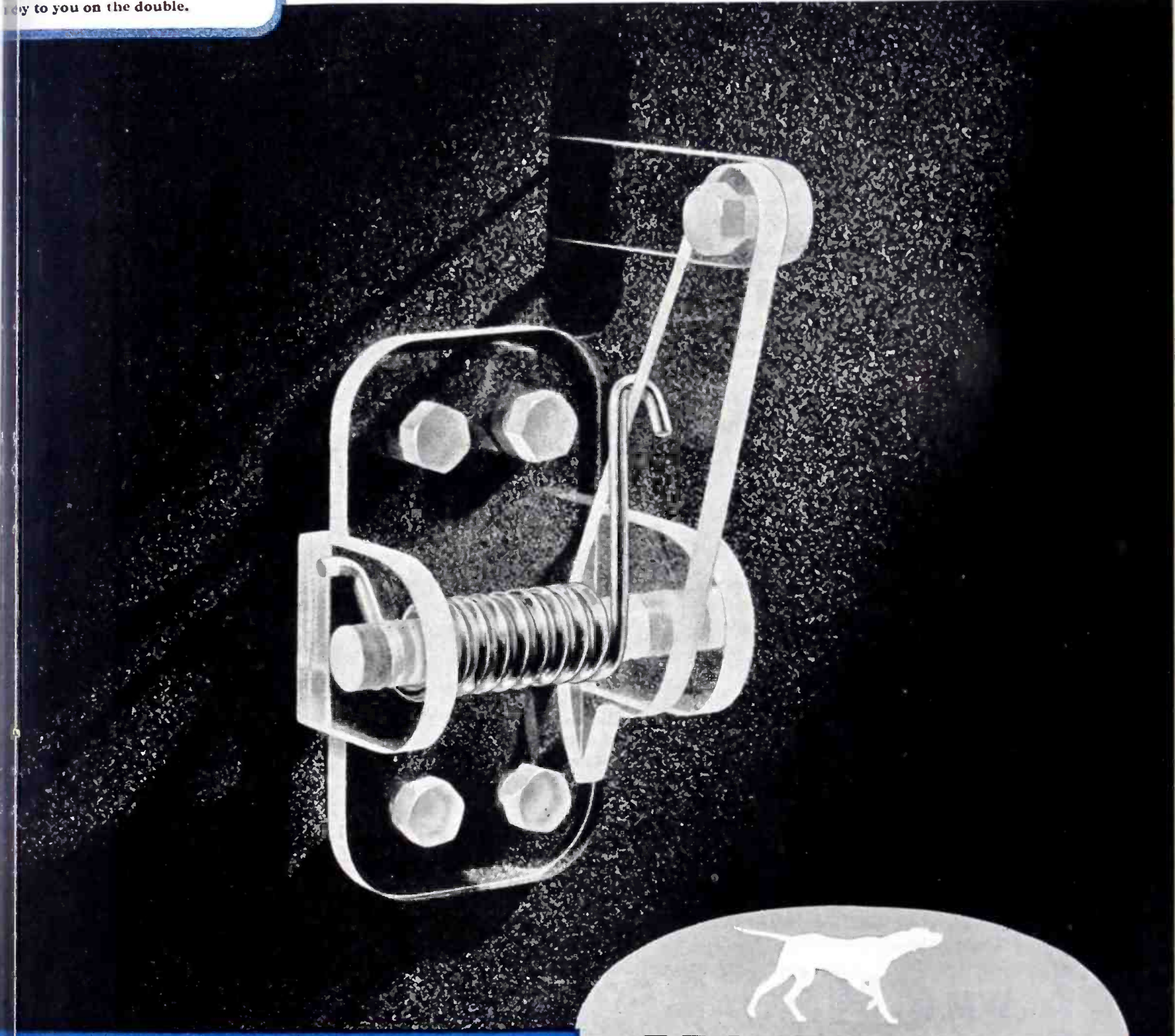


HUNTER

Science in Springs

NTER PRESSED STEEL COMPANY, LANSDALE, PENNA.

not only in poor efficiency but duces undesirable frequencies

With cases illustrated at A B, an ammeter in the grid c will show the current flowing ing resonance, and this curren fall off in about the same d either side of resonance, as trated by curve AA of Fig.

Some operators prefer to v plate and grid ammeters at same time, the one rising an other falling about the same d either side of resonance. How in tightly coupled circuits, cially at high frequencies, these relationships may not hold though the amplifier is perf neutralized.

Instability

When another current is pre in the grid circuit due to extran oscillations, the current will not off at the same angle, but one will have a steeper dip than other. Thus, if in tuning fron to F_1 and F_2, the curve AC res and may be an indication of un ance, possibly caused by bad tralization. Curve AC might i

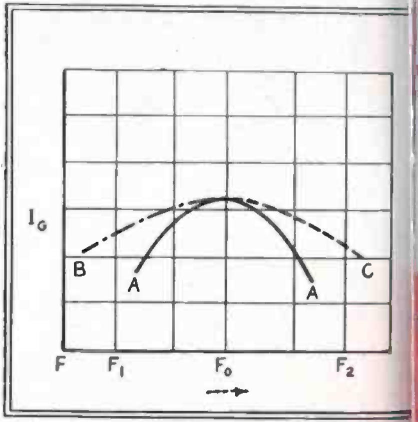
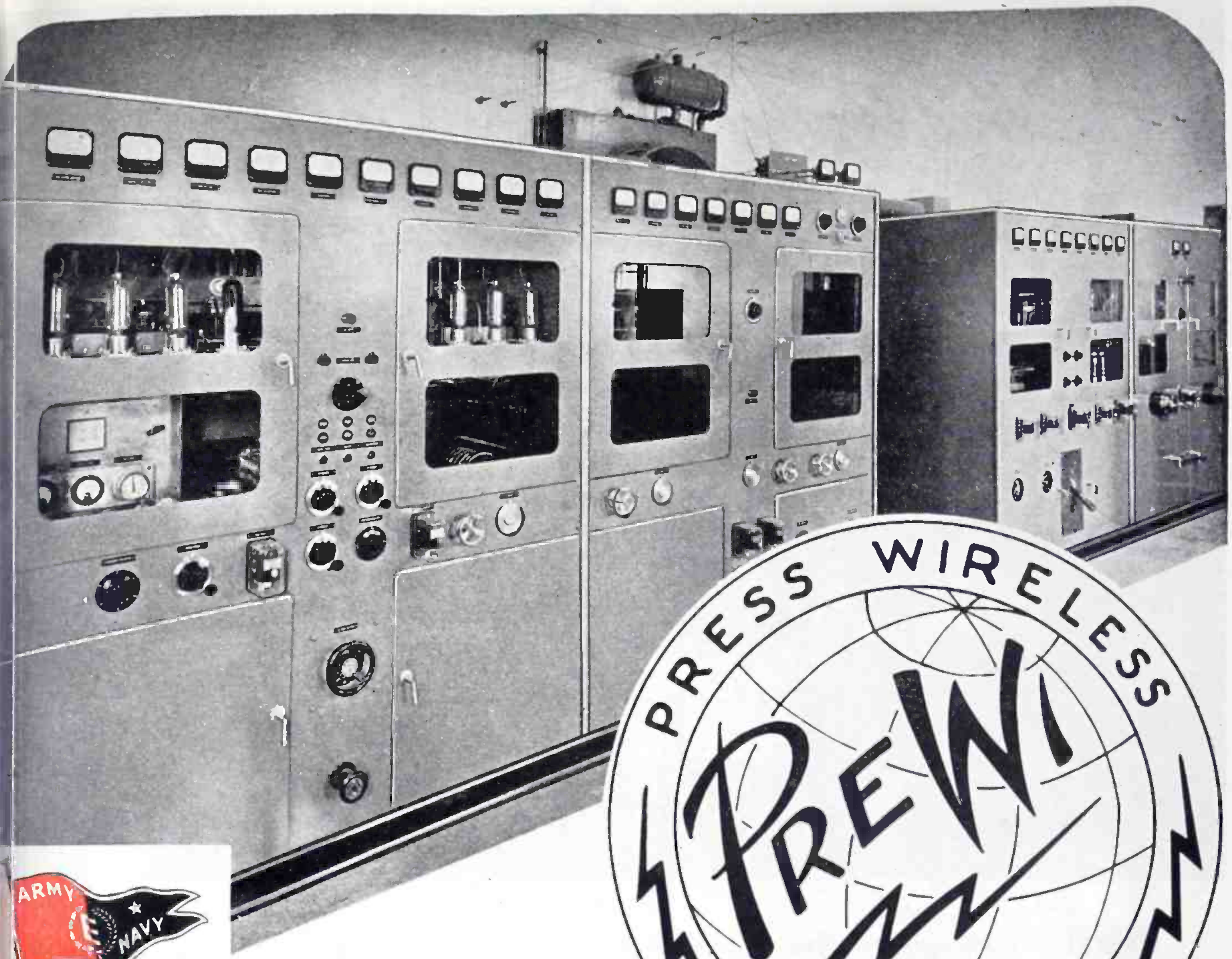


Fig. 2—Graph showing the possib changes in grid current of an r-f ampl fier when the plate tank circuit is tun through resonance

cate instability at frequencies abo resonance, which would call for r duction of inductance (in indu tance neutralization). Curve B would show possible instability b low resonance, requiring more i ductance or capacitance in the ne tralization circuit.

While this system may indicat an unbalance in the tank circuit, is not to be used to obtain neutral ization. Even if an unbalance i noticed, it is no assurance that th circuit is not neutralized. Further more, only operators thoroughl



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For years, "via PREWI" has been identified with international radio communications of increasing volume and importance. PREWI is now incorporated in the trademark appearing on radio transmitters and other units Press Wireless is manufacturing for our armed forces. PREWI thus has become a symbol of outstanding service, not only in the interchange of world-wide radio communications but also in supplying instruments which make such interchange possible.

ales Office, Manufacturing Division
14 BROADWAY, NEW YORK 18, N. Y.

PRESS WIRELESS, INC.

Executive Offices
435 N. MICHIGAN AVENUE, CHICAGO

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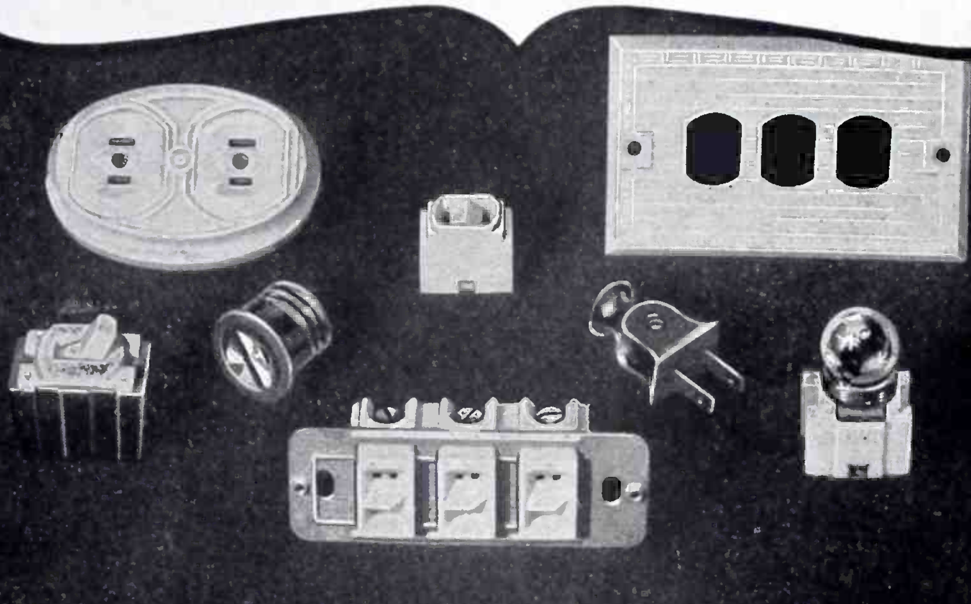
This is why PLASKON is chosen for these electrical service parts



PROTECTION against arcing, flash-over and uncontrolled high-voltage electrical currents is assured by the unusual dielectric properties of Plaskon. Under these conditions extremely condensed chemical residues, high in insulation value, form on the surface of the molded Plaskon unit. And long exposure to high humidities, even immersion in salt solution for 24 hours, fail to destroy the resistance of Plaskon to arcing.

Plaskon is available in a wide range of colors, for decorative and utility use in switch plates, plugs, color-coded controls, high and low tension circuit breakers and fuse blocks, heavy duty switchboards, line connectors, and many other electrical control duties.

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Plaskon Urea-Formaldehyde Compound

1. Wide range of lightfast hues, from translucent natural and pure white to jet black.
2. Smooth surface, eye-catching, warm to touch.
3. Completely resistant to common organic solvents, impervious to oils and grease.
4. Possesses extremely high flexural, impact and tensile strength.
5. Highly resistant to arcing and tracking under high voltages and high frequencies.

Plaskon Grade 2 Compound

1. A Plaskon urea-formaldehyde of good quality, lower in price than regular Plaskon, and adaptable to economy production requirements.
2. High resistance *to*, and retains lustre, surface and color *in*, presence of water, common organic solvents, soaps, etc.
3. Identical unusual dielectric strength and freedom from arcing and tracking as regular Plaskon. Furnished in one shade of black and brown only.

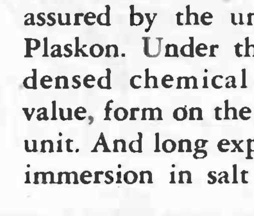
Plaskon Melamine Compound

1. Assures ample protection where water or high humidity prevent the use of urea compounds.
2. Exceptional resistance to acids and alkalies. Non-porous, noncorrodible.
3. Under extreme conditions of heat and humidity, is non-tracking, highly resistant to arcing, and has high dielectric strength.
4. Highest heat resistance of all light-colored plastics.

Plaskon Resin Glue

1. Materials bonded by Plasko Resin Glue cannot be separate at glue line—the material fails fir
2. Plaskon glue line is complet moisture-resistant, cannot b weakened by mold or fungi.
3. Maintains its tenacious grip heavy-duty service for years, und water, on land, in the air.

PLASKON DIVISION, LIBBEY • OWENS • FORD GLASS COMPANY
2136 SYLVAN AVENUE • TOLEDO 6, OHIO
Canadian Agent: Canadian Industries, Ltd., Montreal, P. Q.



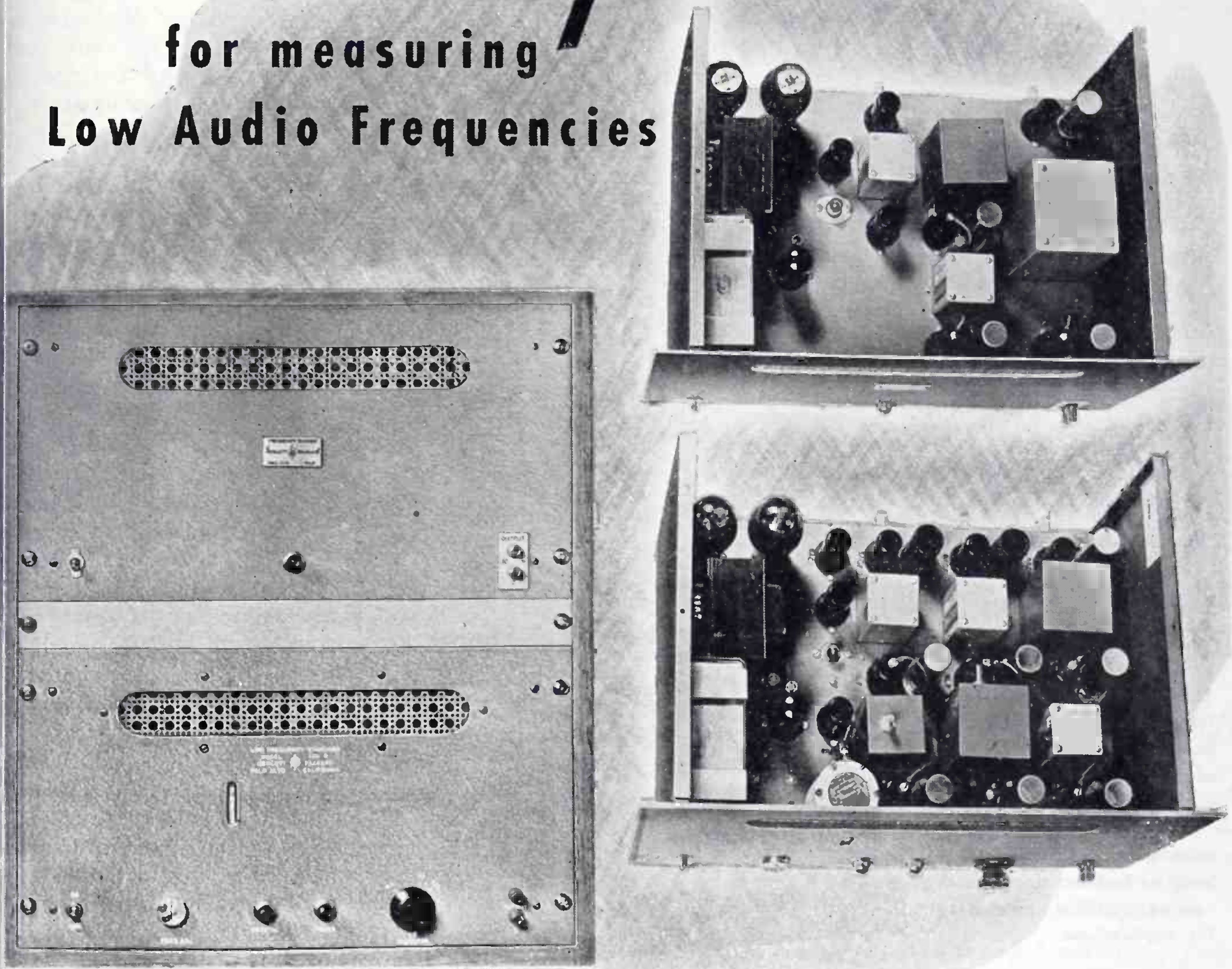
Write for this Manual

The properties and characteristics of Plaskon in molded form, and the proper methods of fabrication, are discussed in detail in this valuable Plaskon handbook. Its contents will be of interest to engineers and fabricators alike.

PLASKON
TRADE MARK REGISTERED
★ ★ MATERIALS ★ ★

new, versatile *hp* instruments

for measuring Low Audio Frequencies

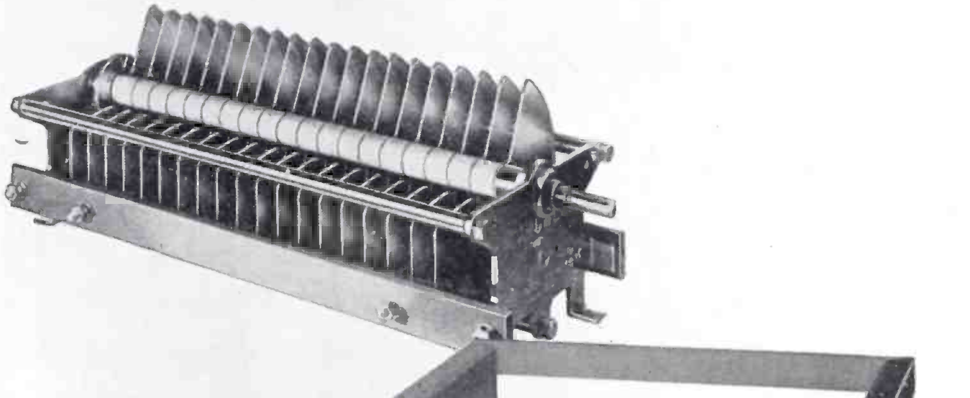


The problems of measuring low quncies usually require a great deal of flexibility in rumcnts and in such work it is generally desirle make measurements by lissijou pattern method. -h offers a simple solution to such problems with e odel 100B Frequency Standard in conjunction thi 10 cycle frequency divider. This combination lu:ated) will give an output of 10, 100, 1000, ,00 and 100,000 CPS with accuracy within us r minus .001%. To provide a large number of harmonics for measuring frequencies above 100KC, generators and mixing panels can be supplied. These additions will provide the means for measuring frequencies up to 50 megacycles. *-hp-* can also supply standardization and measurement equipment for much higher frequencies.

Ask for more detailed data and information. Give us details of your problem so we can provide an intelligent answer. There is, of course, no cost or obligation. Write us today.

HEWLETT-PACKARD COMPANY

Box 880A • Station A • Palo Alto, California



familiar with their transmi
should use this method, since
resonance operation can raise
plate current to the point wher
overload circuits would operat
would then be difficult to bring
trols back to normal to get
transmitter back on the air.
serving the grid ammeters sh
be used only to determine no
conditions, with any unu
changes warning the operato
some kind of irregularity.

Another Method

Another way of checking
tralization rapidly is by cutting
excitation. (This may requir
recording of a carrier break
the transmitter log.) This is d
by shutting off the auxiliary o
lator's plate supply and then swi
ing the oscillator transfer swi
to the dead oscillator, killing
to all succeeding tubes. If
tubes are all biased to cut-off
beyond, the grid and plate
meters should all drop to zero i
perfectly neutralized transmi
and the carrier should go off
air. Any flow of plate and g
current will indicate possible os
lation in the earliest stage a
should be checked through regu
neutralization procedures.

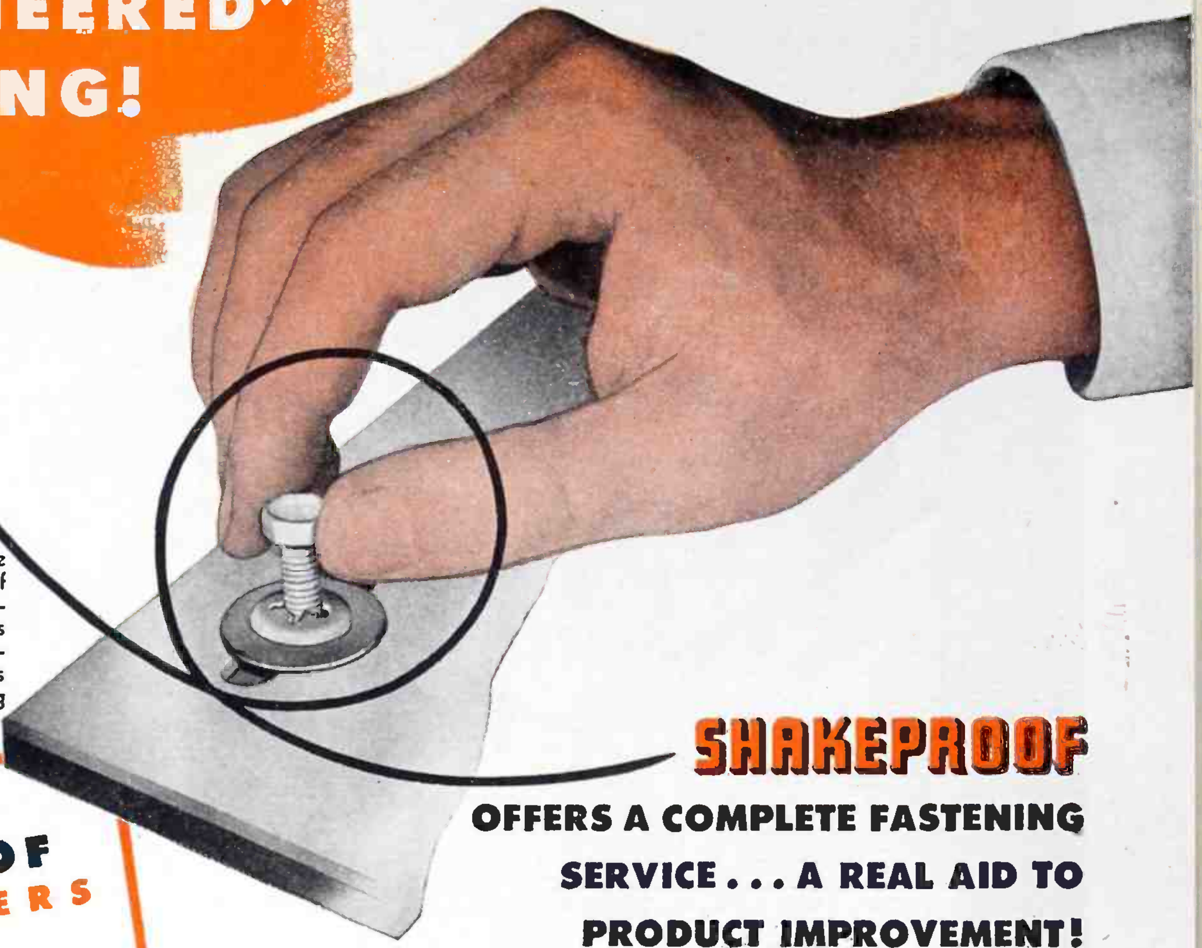
This process of checking ta
only a couple of seconds, lo
enough for the technician to
serve that the particular ammete
read zero, while plate and gr
voltmeters remain at normal rea
ings. Amplifiers with self-bias a
so biased that, with all excitati
removed a safe amount of pla
current flows. Such a stage wou
seem to have regeneration or o
cillation, but the skilled technici
will be familiar with his circui

Where plate current flows wi
excitation off, the difficulty may
traced not only to improper ne
tralization but to spurious oscilla
tions, caused generally by simila
r-f chokes resonating in the plat
and grid circuits at some far re
moved low frequency. Parasitic
of high frequency due to long r-
leads may also cause irregula
operation and may show up wit
this check.

Checks After Shutdown

If the operator has more time
available and his transmitter is off
the air he has two other easy ways

TRY "ENGINEERED" LOCKING!



tion showing Shakeproof Type
ne Lock Washer. Shakeproof
Lock Washers with plain peri-
are particularly advantageous
sed to span oversize or elon-
clearance holds. Pressure is
d to the outer rim, distributing
d over a large area.

HAKEPROOF
CK WASHERS

TYPE 11 EXTERNAL TOOTH
For U. S. Standard Hex Nuts; Square Nuts; Hex Washer Head Screws; Binding Head Screws; Truss Head Screws.

PE 12 INTERNAL TOOTH
S.A.E. Hexagon Nuts; Round
ad Screws; Fillister Head
rews; Hexagon Head Screws.

TYPE 15 COUNTERSUNK TOOTH
For Flat Head Screws; Oval Head Screws.

TYPE 40 EXTERNAL-INTERNAL TOOTH
For Electrical Bonding Applications.

WRITE FOR FREE TEST KIT No. 21

SHAKEPROOF

OFFERS A COMPLETE FASTENING SERVICE . . . A REAL AID TO PRODUCT IMPROVEMENT!

Modern fastening techniques, such as those developed and recommended by Shakeproof Engineers, have led to the improved utility of countless products. These engineers, with their thorough knowledge of fastenings and the materials with which they are used, are well qualified to help you in obtaining the most efficient locking for your particular applications. Shakeproof offers you this service in the interest of product improvement—without obligation.

There's a "plus" value to the Shakeproof service . . . providing you with the choice of six standard lock washer styles . . . all incorporating the exclusive Shakeproof tapered-twisted tooth locking principle. Such a combination assures locked-tight, vibration-resisting efficiency. Call in a Shakeproof engineer—let him analyze your products and show you how these fastenings will help give them a longer life and more satisfactory performance. Write today!

SHAKEPROOF inc.
"fastening Headquarters"

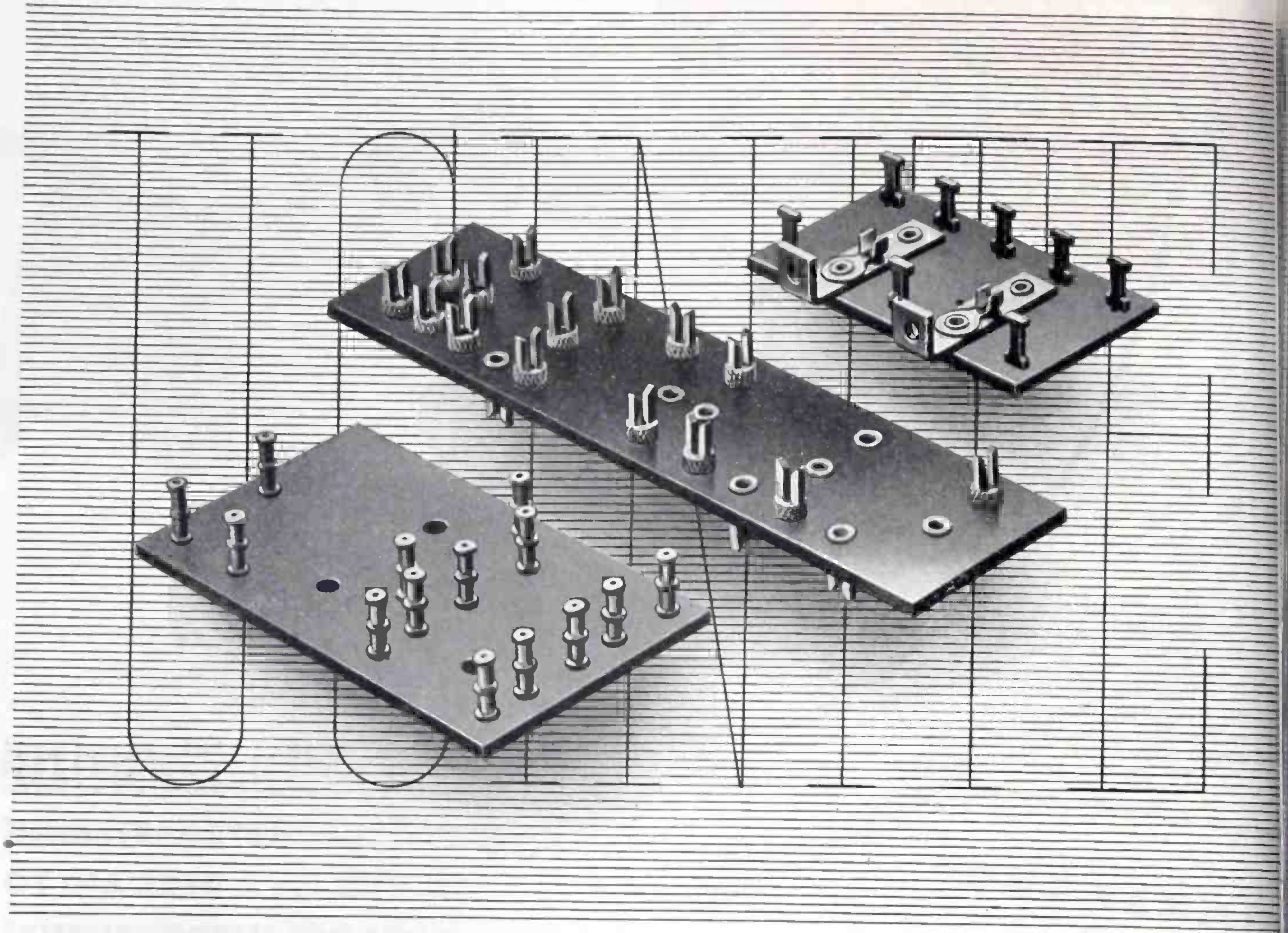
Distributor of Shakeproof Products Manufactured by ILLINOIS TOOL WORKS
2501 North Keeler Avenue, Chicago 39, Illinois
Plants at Chicago and Elgin, Illinois
In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario

Type 1
ing Screws
etals

Shakeproof
Type 25 Thread-Cutting
Screws for Plastics

Sems Fastener Units
Pre-Assembled Shakeproof Lock
Washer and Screw

Shakeproof Cowl
Fasteners . . . "The Quick-
Opening Lock"



We don't care

We make all kinds of insulated assemblies at Ucinite. But we have no special preferences . . . and play no favorites in manufacturing them.

It's the customer that calls the turn. We don't care whether the order is for laminated or molded bases. We don't care whether the lugs and metal parts need to be made by punch presses or screw machines. Tell us what type of assembly you require and we will produce it the way you want it.

It is a matter of professional pride, with us, to make our specialized skill and varied equipment count in getting things done in strict accordance with specifications . . . and time schedules, too.

The UCINITE CO.
Newtonville 60, Mass.
Division of United-Carr Fastener Corp.

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

LOOKING FOR A HIGH VALUE OF...

WATTS PER OUNCE?

This Little Giant Has It, And At 200 Mc, Too!

Imagine getting 90 watts continuous output* from a tube that weighs only 1.5 oz. and at 3 meters! Even at 1.5 meters (200 Mc) the output is still high, 65 watts. A couple of years ago such a tube was a dream, now it's a reality.

In spite of its small size and weight, GENERAL ELECTRONIC'S DR-24G triode is conservatively rated. Its superb performance results from the teamwork that goes into its manufacture . . . teamwork of design engineers who give careful attention to details and skilled hand craftsmen experienced in precision glassblowing and in the other steps of production and testing.

There are no insulators or supports here to evolve gas on the first overload, no exposed filament to spray the envelope with energy-wasting electrons. The plate dome is just one of those details which distinguishes the DR-24G. A tantalum plate and grid eliminate the flashed-film type getter and allow the tube to run cooler, particularly at high frequencies.

TECHNICAL DESCRIPTION

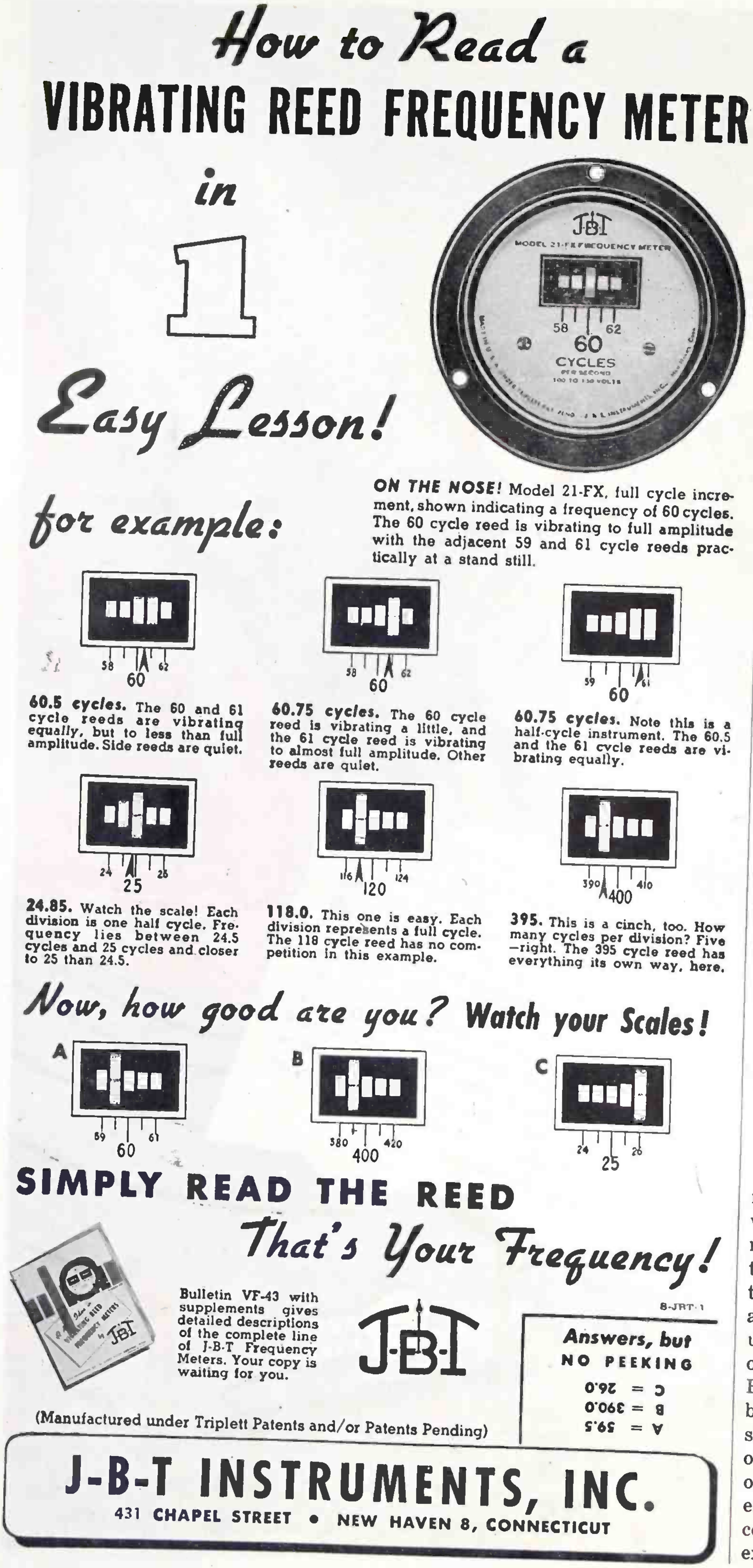
Filament. . Thoriated Tungsten
Volts 6.3
Amperes 3.0
Max. Plate Voltage
100 Mc ...... 2000 v
200 Mc ...... 1500 v
Max. Av. Plate Current .... 75 ma
Max. Av. Plate Dissipation . 25 w
Max. Av. Grid Current .... 25 ma
Amplification Factor 25
Capacities
Grid to Plate. . 1.7 uuf
Grid to Filament 2.5 uuf
Filament to Plate 0.4 uuf
4⅜" Overall Height, 1½" Diameter
Nonex Glass Envelope
Base Standard Small 4 prong

* As a Class C, Unmodulated UHF Ampifier

GENERAL ELECTRONICS INC.

101 HAZEL STREET, PATERSON 3, N. J.

LES OFFICE, NEW YORK 23, 1819 BROADWAY   EXPORT DEPT., 85 BROAD STREET, NEW YORK 4, N. Y.   CHICAGO 47, 1917 NO. SPRINGFIELD AVE.



of checking roughly for neutra
tion. With the filament of
amplifier tube lit, but the plate
age off, r-f voltage is fed to
amplifier. While observing
grid current meter, the plate
tuning capacitor is rotated thr
resonance (with no plate volta
In a perfectly neutralized st
the grid ammeter reading sh
remain steady, since the plate
cuit is supposed to have no reac
upon the grid circuit.

In a badly neutralized st
there will be a violent dip of the
meter while tuning through res
ance. There will generally be s
slight reaction on the meter, es
cially on the higher frequenc
even though the amplifier is n
tralized, but the operator will eas
recognize this flutter of the nee
from the more pronounced
caused by poor neutralization.

Another quick check is good
all but the final stage. This
quires that two stages have no pl
voltage while checking, althou
the filaments remain on. With
preceding stage tuned to resonan
(but no plate voltage) the succe
ing amplifier is likewise tuned
resonance and its plate meter o
served for current. The presen
of current will be a fairly sure sig
of r-f leaking through the prece
ing amplifier tube and being rect
fied in the succeeding stage.

Obviously the final stage cann
be checked in this manner sinc
there is no following stage b
which to detect the presence of r-
At higher frequencies or due t
stray couplings, some r-f may stil
feed through but the engineer i
conscious of these peculiarities.

Other Effects

It must be stressed that the technician must be fully acquainted with the circuits he tests by these methods, to avoid damage and trouble. These checks should serve to indicate that everything is operating normally, any deviations from usual readings only warning the operator for more careful checking. Even after these tests, there may be extraneous oscillations due to shock excitation, transients, or other strays developed by long operation of circuits, which will escape these tests. Such special conditions require treatment with extensive and elaborate equipment.

NOW A *New*

"TH" TRANSTAT

SMALLER AND LIGHTER THAN EVER BEFORE!

NOMINAL LOAD 300 VA, 50/60 CYCLES, 115 VOLTS INPUT, 0 TO 115 VOLTS OUTPUT

MAXIMUM LOAD 340 VA, 50/60 CYCLES, 115 VOLTS INPUT, 0 TO 130 VOLTS OUTPUT

MAXIMUM BRUSH CURRENT 2.6 AMPERES

ith this new model, many smaller communications and ustrial applications can have Transtat's smooth con- l, high efficiency and ruggedness. An ideal compo- it, this transformer—type a.c. voltage regulator is one-half the size and less than one-half the weight the smallest previous TH Transtat.

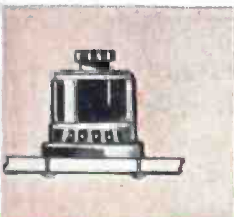
UNIFORM—Interchangeable Bakelite Bases

addition to the well-known Bakelite closeness of toler- ce, these bases have insulating barriers between ter- als to prevent shorting of leads.

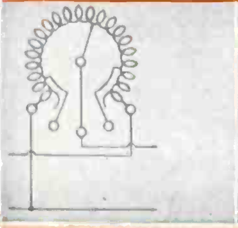
FLEXIBLE—New Brush Assembly Facilitates Mounting Changes

The unique brush arm shaft mechanism provides ease of change from table mounting to back of panel mounting or ganging. Die cast brush arm permits quick brush changes, improves heat dissipation and has generous brush contact area. Other features include extra wire insulation and impregnation of core and coil with special synthetic phenolic varnish. For complete details write for bulletin.

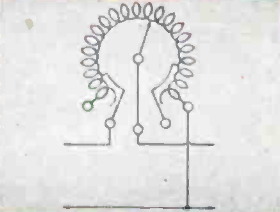
AMERICAN TRANSFORMER COMPANY, 178 Emmet St., Newark 5, N. J

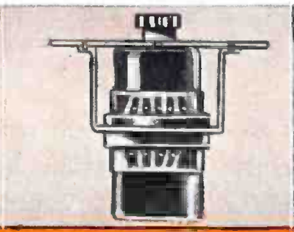


ckwise rotation of hand- eel increases the voltage en table-mounted unit is nnected as shown below.

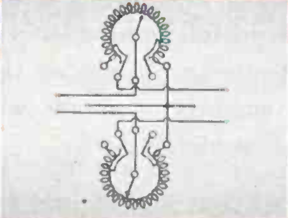


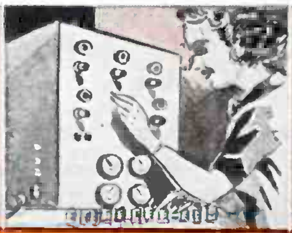
For back of panel mounting, connect Transtat as shown and reverse shaft to provide voltage increase on clockwise movement.



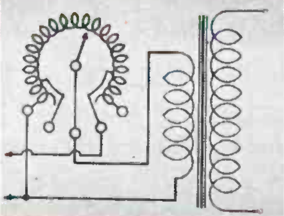


Many circuits are possible when the new Transtat is ganged for polyphase or simultaneous single phase control.

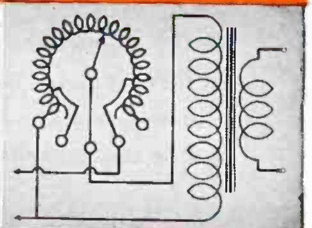




For fuse testing, spot welding, soldering, etc., an adjustable low voltage can be furnished as shown.



For rectifier plate supply, and other h.v. applications, the new Transtat may be connected thus.



Pioneer Manufacturers
f Transformers, Reactors
d Rectifiers for Electronics
and Power Transmission

AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

WHERE TOMORROW MEETS TODAY

Up there above the clouds the Dreams of Tomorrow are being proven today

SOARING COMBAT PLANES sing a song of the future! In equipment and efficiency they far outstrip normal peace-time ambitions. They are born of the grim challenge of war for new and ever-improved electrical design.

Vision and inventive genius are required to originate such new developments, and in this field Small Electric Motors (Canada) Limited have been privileged to make important scientific contributions. Out of the experience gained today by forward-looking firms like this, substantial benefits will accrue to the world of tomorrow.

At the moment, Small Electric Motors is in full production for Victory but in the post-war field of electrical equipment the influence of this aggregation of creative engineering minds will also be recognized for specialized services of a high order.

DESIGNERS
AND MANUFACTURERS
Of All Types of Precision
Electrical Apparatus
Including:

D.C. & A.C. Motors for
Specialized Purposes
Aircraft Generators
Aircraft Engine Starters
Alternators
Motor Generators
Electric Pumps
Motors with Governors
Gyros, etc.

3-44

SMALL Electric Motors
(CANADA) LIMITED

LEASIDE • TORONTO • CANADA

Communication Systems

(*Continued from page* 101)

trol and direction of aircraft tak
a variety of forms. In all cases t
aim is to provide reliable servi
under any and all conditions, wi
adequate alternatives provided
case of failure of the primary sy
tem.

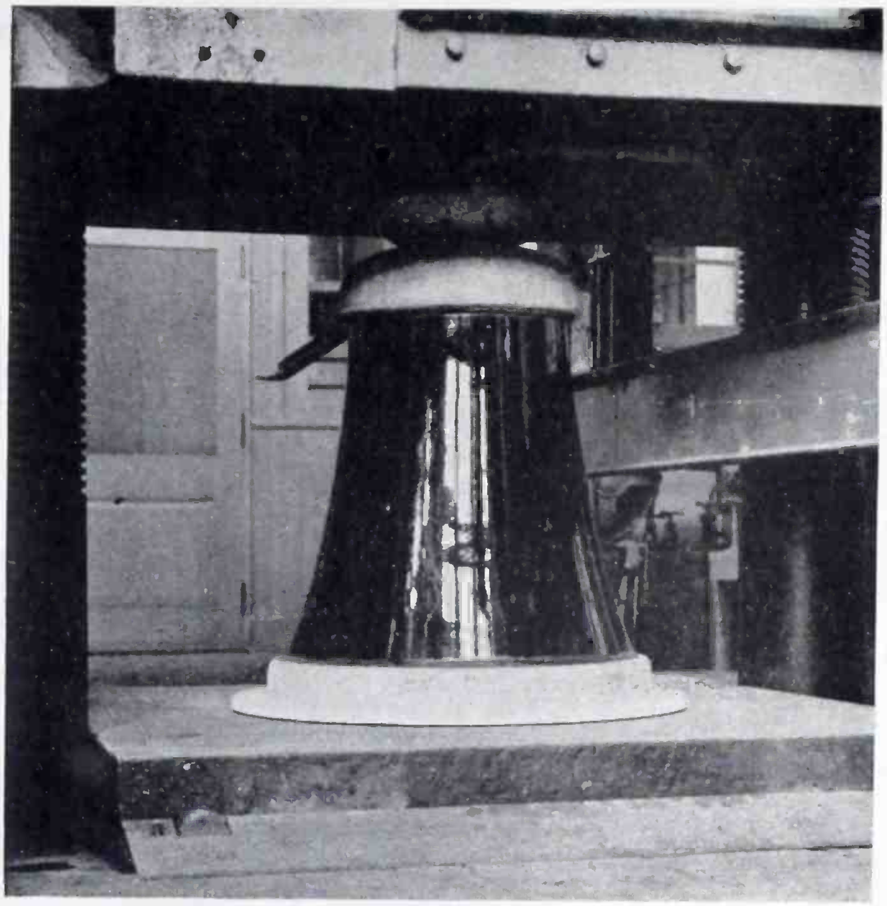
The most elementary type
equipment for use in planes is t
compass receiver which enables t
pilot to ascertain his own locatio
Such a receiver permits broadca
stations to be used as homing be
cons.

Range-Beacons

Various types of radio-range be
cons are in use. Loop-type radi
range-stations were originally in
stalled and in some cases these ar
still in operation. They are, how
ever, subject to considerable nigh
error and consequently are bein
replaced by Adcock antennas wher
ever feasible. These are virtuall
free from this undesirable charac
teristic. Such radio ranges provid
the well known A and N homing
beams.

Beacons are supplemented by fan markers, usually several miles from the airfield. The purpose of the fan markers is to give a definite indication to the pilot that he is a specified distance from the field and to permit him to make necessary adjustments before landing. In addition to the fan markers a 75-Mc Z marker is used to provide a definite indication that the pilot is over the beacon station. This Z marker provides a signal which operates a flashing lamp on the instrument panel of the plane. The electrical characteristics of the system are such that the Z signal takes the place of the cone of silence which would otherwise occur when the pilot is directly over the antenna of the radio range-beacon. Thus, a definite position indication is substituted for an absence of signal when the pilot has reached his objective.

The Z marker is also used to indicate a change in course, since the Z marker signal is received at the intersection of two range-courses. Such an intersection, or turn, is usually indicated by keying the Z



An armchair for a two million pounder

Those were the requirements for the base insulator of one of America's great stations. And this insulator is the one that met them.

The insulator you need may be only a tiny standoff or entrance insulator with practically no mechanical requirement at all, but at Locke these get just the same attention to engineering and manufacturing detail that is given spectacular developments such as this two million pound insulator.

Because your requirements are small, don't hesitate to call on us. You will get the same consideration and service as the biggest jobs get.

A COMPLETE "CLAY"RAMIC SERVICE

for every electrical, chemical and mechanical application.

Locke has unrivalled facilities for the production of fired clay pieces by every known method.

(1) Dry Process — Porcelain and Steatite

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

(2) Vacutite Process—Porcelain and Steatite

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

(3) Wet Process — Porcelain and Steatite

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

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

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

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

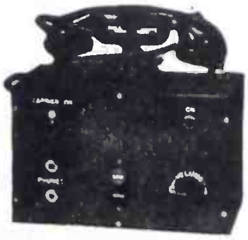
Other clayramic products will be available in the future to meet special conditions. Whatever your problem, our experienced electrical, mechanical and ceramic engineers will be glad to help. Their services have resulted in material savings in money, time and critical materials to other manufacturers.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

Locke **INSULATOR CORPORATION**

BALTIMORE, MARYLAND

"Leaders in Clayramics"

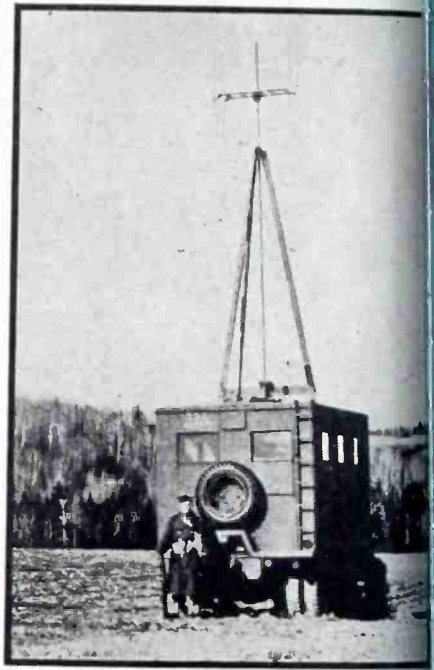

Straight Furrows



marker in a specified manner. Z markers are also used to indic clearance to the pilot to proceed the next fan marker. When used this way, the Z markers are used traffic lights to indicate a clear passage on the next leg of the jo ney.

Combined Voice and D-F

While these facilities are use in directing a plane, experience shown that it is often desirable necessary to talk to the pilot wh he is flying a course. Early instal tions made provisions for such arrangement by transmitting voi modulation in place of the rad range beacon signal. Such a pr cedure made it necessary to shut of the A-N signals when voice com munication was desired. This was undesirable since it temporarily denied the homing device to pilots flying the course.



AACS v-h-f direction-finder on wheels, used to guide fighter aircraft to emergency fields

To overcome this objection, a simultaneous radio-range beacon was devised. This permits the operator in the control tower to speak to pilots in flight at the same time that the pilot makes use of direction-finding signals. Simultaneous radio-range stations are used to transmit weather data to pilots while flying, and to direct traffic near the control tower. Ordinarily, these simultaneous radio-range stations operate 24 hours a day except in

SILICONES

one Insulating Materials

Available in Production Quantities

W
ORNING RESINS

orning Resins—utstanding high temperature are specially designed for use with heat stable ical insulating materials. These products possible operating temperatures as high °C. They combine heat resistance and ure-proofness with exceptional ion of electrical properties.

Corning 993—A silicone resin for hing Fiberglas served magnet Fiberglas or asbestos cloth, tape and ng; impregnating motor stators, transformer and other electrical equipment. Operating rature, 150°C. to 200°C.

Corning 2052—A silicone resin for impregnating rotating equipment. Operating rature, 125°C. to 75°C.

Corning Silicone Products Include:

s—Inert liquids, with viscosity little affected perature changes; for operation zero as well as elevated temperatures.

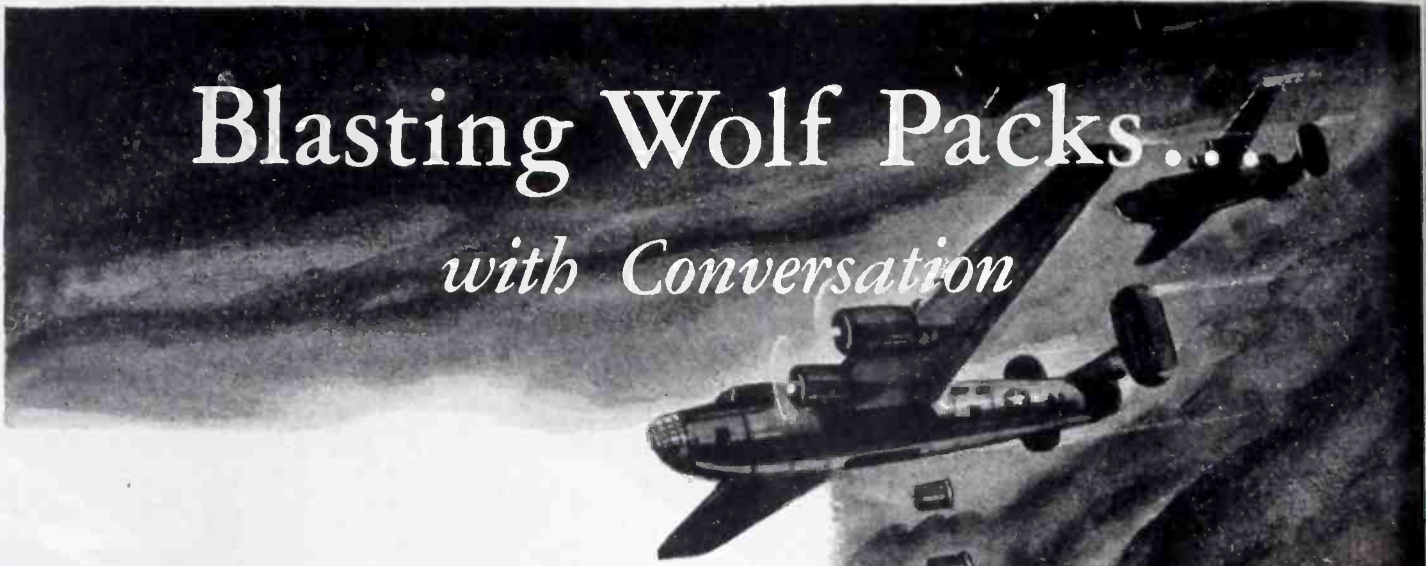
es—For lubrication of valves in high temperature or ive chemical services. lug Cock Grease—For metal valves ck Grease—For glass and ceramic valves.

DOW CORNING
CORPORATION
BOX 592
MIDLAND MICHIGAN

DOW CORNING

Blasting Wolf Packs...

with Conversation

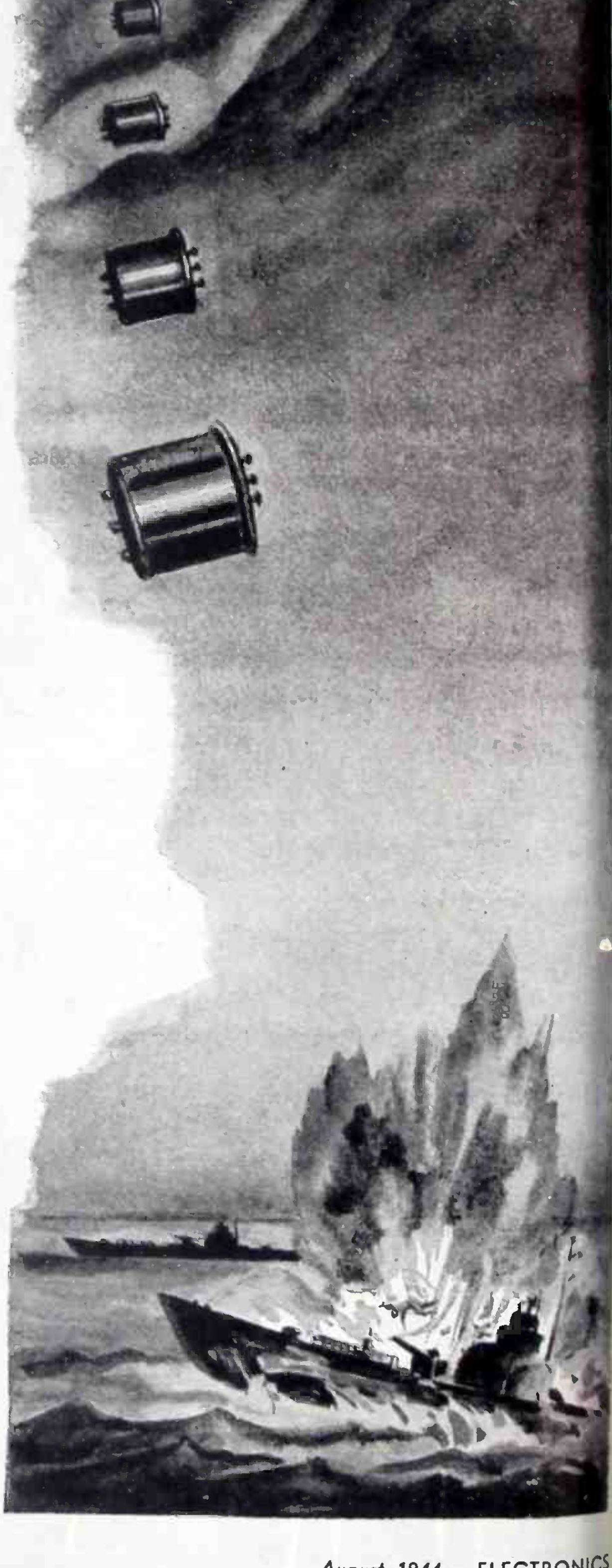


Sinking U-boats . . . blasting enemy planes . . . silencing hostile batteries . . . these are but a few of the many "missions" now being carried out by Transformers, the "bombs" that are activated by TALK instead of TNT.

Thus Transformers, along with the other important components that make up the Communications Systems for our armed forces, are doing their "talking" where it really counts . . . which is a fine example for us at home to follow.

THE ROLA COMPANY, INC., 2530 Superior Ave., Cleveland 14, Ohio

Let the man with the "Mike" do the talking



ROLA

Help Shorten the War — *Buy More War Bonds*

MAKERS OF THE FINEST IN
SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

THE LITTLE THINGS ON WHICH SO MUCH DEPENDS!

M-R

Friction and Sealing Tapes

M-R FASTHOLD FRICTION TAPE

Double Coated With Rubbery Compounds . . . Tensile Strength more than 44 pounds . . . Adhesive Strength more than 50 Pounds

In the manufacture of FASTHOLD FRICTION TAPE the best procurable cotton sheeting (long staple 56/60) is first dried to eliminate moisture . . . then the fabric is thoroughly impregnated with a filler coat of insulating, waterproofing and preserving compound . . . after several days of drying a second coat, exceptionally heavy in rubber content, is forced through the fabric by means of enormous rollers . . . then follows another period of drying out before cutting and wrapping in tin foil for protection.

The materials used and the precision and control exercised in the manufacture of FASTHOLD FRICTION TAPE enables it to meet all known electrical tests and requirements . . . and to Guarantee it against Unraveling or Drying Out.

FASTHOLD FRICTION TAPE is New York warehouse stocked in widths of 3/8—1/2—3/4—1—1 1/2 and 2 inches.

M-R ANHYDROUS SEALING TAPE

IMPROVES WITH AGE AND SERVICE

25.58% Cotton Sheeting
74.42% M-R Insulating Compounds

Weatherproof . . . Waterproof . . . Acid, Alkali, Oilproof . . . Permanently Flexible . . . Will not Vulcanize or Dry Out . . . Tensile Strength 30 Pounds . . . Dielectric 1,000 volts

ANHYDROUS SEALING TAPE contains nothing which will injure fabrics or metals. It is made of the best procurable cotton sheeting and special M-R Bituminous Compounds. A wrapping of ANHYDROUS TAPE gradually becomes one solid mass (glass hard on the outside and soft inside) that excludes air, moisture, vapors, etc. It can be used to great advantage under conditions which disintegrate ordinary tapes; inside work where acids or alkali fumes or spray prevail; outside for cable joint insulation in conduits, transformer connections, extreme high or low temperatures, etc.; mines and damp places where atmospheric conditions and constant friction demand maximum wearing qualities.

A joint, properly taped with ANHYDROUS, is absolutely waterproof even after complete submergence for many weeks.

ANHYDROUS SEALING TAPES are New York warehouse stocked in widths of 3/4 and 1 1/2 inches . . . other sizes are available, as ordered.

REE FOR THE ASKING

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combat zones. In such cases t operate only at the request o pilot.

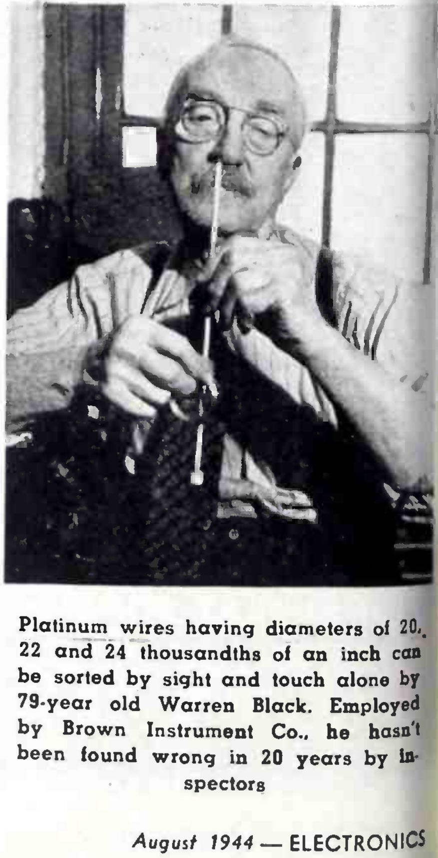
Direction-Finding Methods Provid Bearings for Pilots

While radio range-beacons are lied on as much as possible, these cilities may not always be depen upon. This is particularly true combat areas where equipment m be damaged as a result of ene action, where fighter pilots are too well trained in radio ran beacon methods, or where bla outs may be encountered. In su cases, radio direction-finding me ods are used to advantage.

Of course, bearings must be t ken at several positions from tra missions sent out from the pla requesting its bearings. Bearin from several stations are then co municated to a central or key st tion where the position of the pla is determined. The plane's positi is then communicated to the pil By taking sucessive bearings at va ious time intervals, the pilot can kept advised of his position.—B.

• • •

SORTING PLATINUM WIRES IS FINE WORK



Platinum wires having diameters of 20, 22 and 24 thousandths of an inch can be sorted by sight and touch alone by 79-year old Warren Black. Employed by Brown Instrument Co., he hasn't been found wrong in 20 years by inspectors

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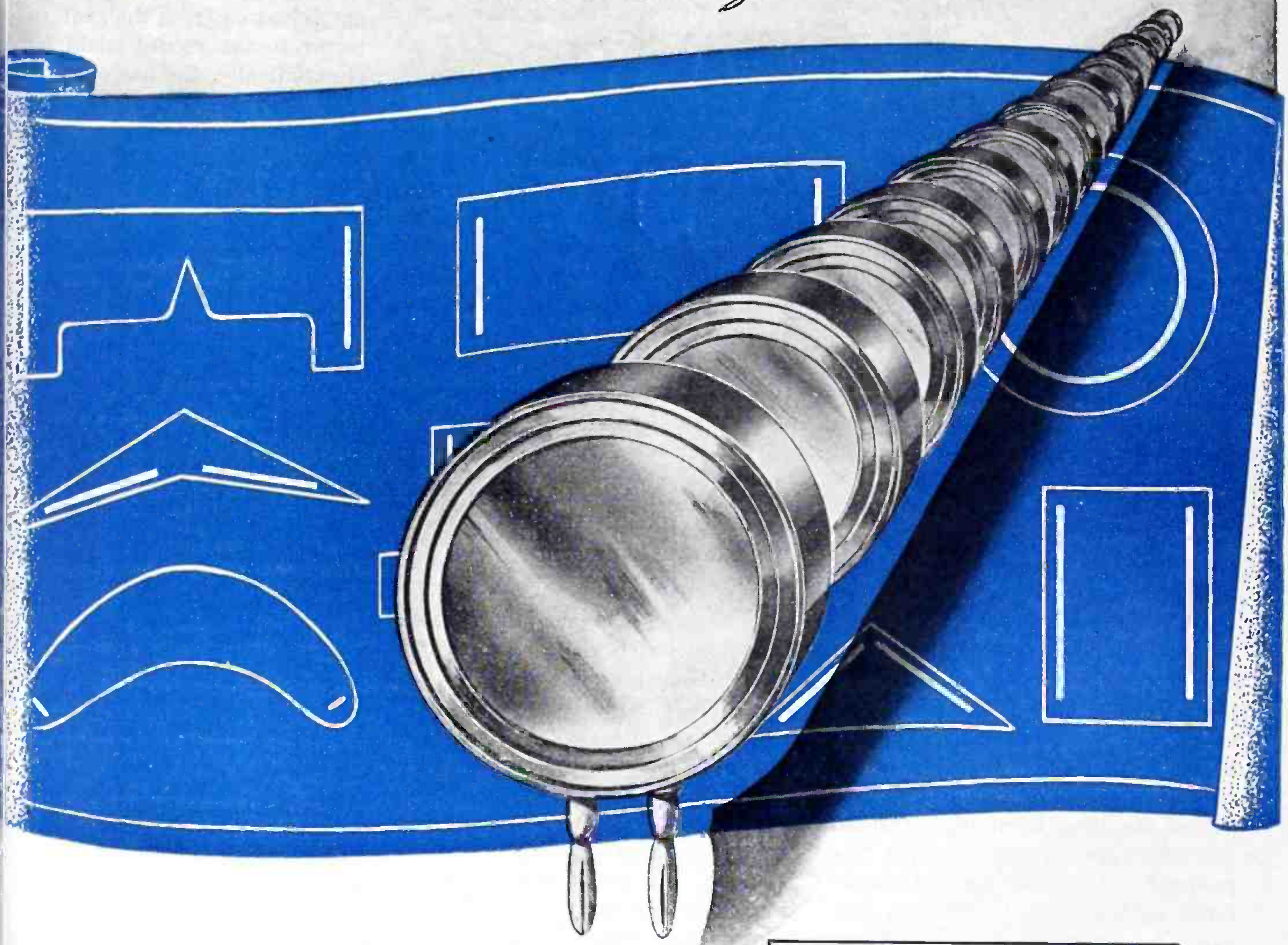

Selenium Corporation of America photo-electric cells are of the self-generating type and are manufactured to highest sensitivity and permanence standards. All S. C. A. self-generating cells can be used in a range from −70° C. to +70° C. and are rendered permanently stable by a special forming process. The most modern methods and equipment available are used in the manufacture of S. C. A. products. All cells and types, thoroughly inspected and matched with regard to sensitivity, spectral response, etc., are available.

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THE ELECTRON ART

Infrared Spectroscopy in Industry

THAT THE USE OF INFRARED spectroscopy in industry has passed through its first phase in which the fundamental work has been done is pointed out in a recently published book, "Infrared Spectroscopy" by Barnes, Gore, Liddel and Williams, of American Cyanamid Co. (Reviewed in July, 1944 ELECTRONICS, p. 370) The authors review the preliminary work of spectroscopists in developing their own methods of quantitative analysis and suggest ways in which the new technique may be further improved as an industrial tool. A condensation of their views follows.

Industrial infrared spectroscopy is now entering its second phase—the development from proving potentialities under ideal research conditions to widespread applications under any practical conditions which might occur. It has passed the stage of hiring a trained infrared spectroscopist with the general instruction that he should build an instrument and then proceed to demonstrate its utility. Neither sufficient time nor trained personnel is available to permit such an approach. With the large number of companies now conducting infrared research, it is necessary that commercial spectrometers be available, that there be sufficient background information in the literature so that an operator may produce results immediately without spending a long time acquiring basic data.

The infrared spectroscopist already at work in the field was called upon to study the possibility of performing analyses which were difficult or tedious by chemical methods. Once a satisfactory analysis had been established, his research instrument was generally tied up for a month or more on routine work while research on further exploratory problems suffered. For his own protection, the spectroscopist developed simple, compact instruments having sufficient resolving power to handle the majority of the analytical problems encountered. With such instruments available, the role of the research spectrometer in analysis may be restricted to obtaining the pure spectra of the components involved. From these spectra, the analytical frequencies can be chosen and the rest of the analysis performed by means of the small spectrometer. For convenience in setting to these frequencies, mechanical stops are provided. These small instruments can be operated in the laboratory or moved to the site of the chemical reaction.

There are at least two important advances in the instrumentology of research spectrometers which must be made. Most infrared spectra are obtained today as records of frequency vs galvanometer deflection superimposed upon the radiation background. To obtain full significance from these results it is necessary to convert them to frequency vs percent transmission or log of percent transmission. This conversion now involves considerable tedious labor and it is highly desirable that the instrument make this conversion automatically. In short, infrared needs a spectrophotometer to replace its present spectrometer.

Most infrared recording is done by means of a very sensitive galvanometer amplifier. Unless the stability conditions of the building in which the instrument is used are favorable, such a mechanically sensitive device is not satisfactory. An improved detecting system is required and it is highly desirable that a means of electronic amplification of thermocouple output be
devised to replace the present u
of galvanometers. There is a gro
ing tendency to use pen recorde
rather than photographic metho
for recording the galvanomet
deflections. This means that
electronic stage must be interpos
between the galvanometer bea
and the actual record. If the enti
amplification from the radiation d
tector to the record could be do
electronically, the use of some ty
of a split beam instrument wou
answer the instrumental proble
of the infrared spectroscopist.

Radial Beam Tubes

A NEW TYPE of vacuum tube, i
which a flat radial beam of electro
in a cylindrical structure may b
made to rotate about the axis, is d
scribed by A. M. Skellett in th
Bell System Technical Journal fo
April, 1944. Features of the tub
are its absence of an internal focu
ing structure and resultant simpli
ity of design, its small size, low op
erating voltage and high beam cu
rent.

Several designs and variations o
the fundamental idea exhibited i
this tube are possible. In its mos
elementary form, as illustrated i
Fig. 1, the tube consists of a cylin

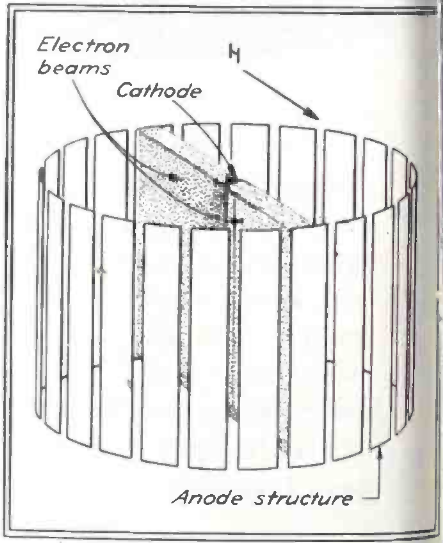

Fig. 1—Metal plates arranged cylindrically about the cathode form separate anodes in this new type of vacuum tube

drical cathode surrounded by a cylindrical anode structure which is divided into a number of parallel strips or separate rectangular anodes. When the potential of the

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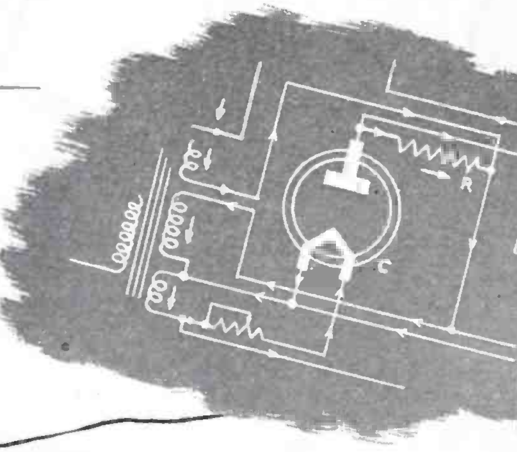

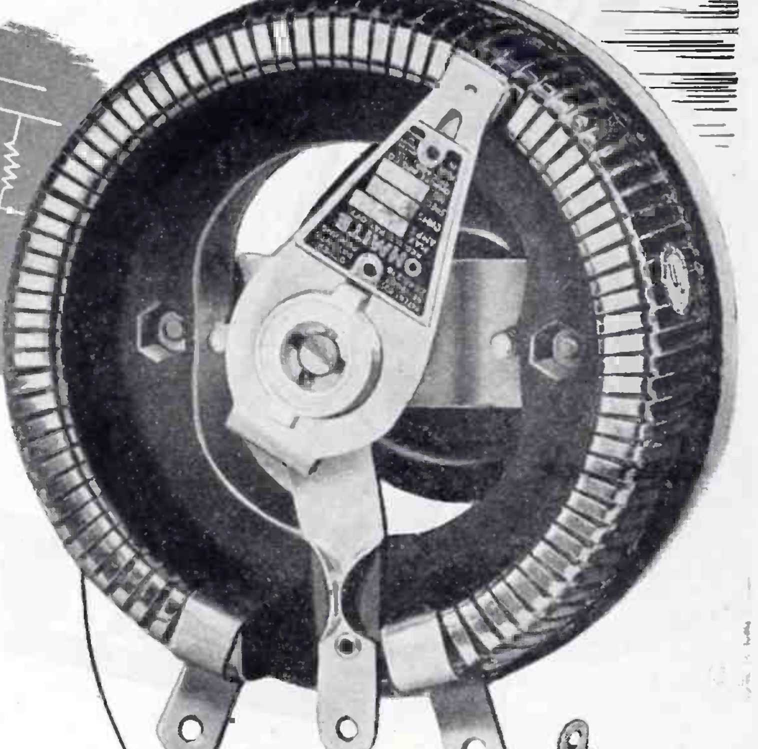

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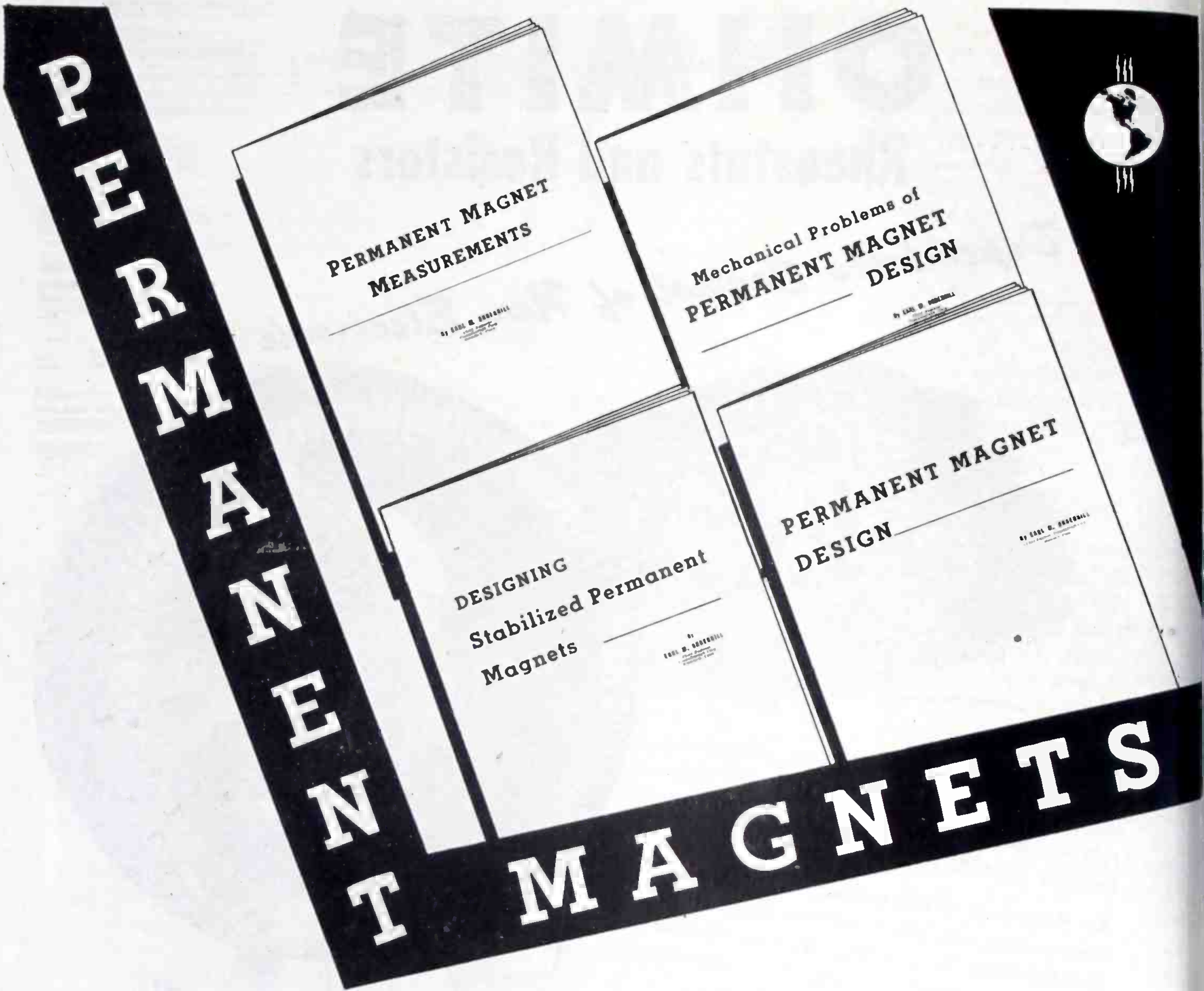

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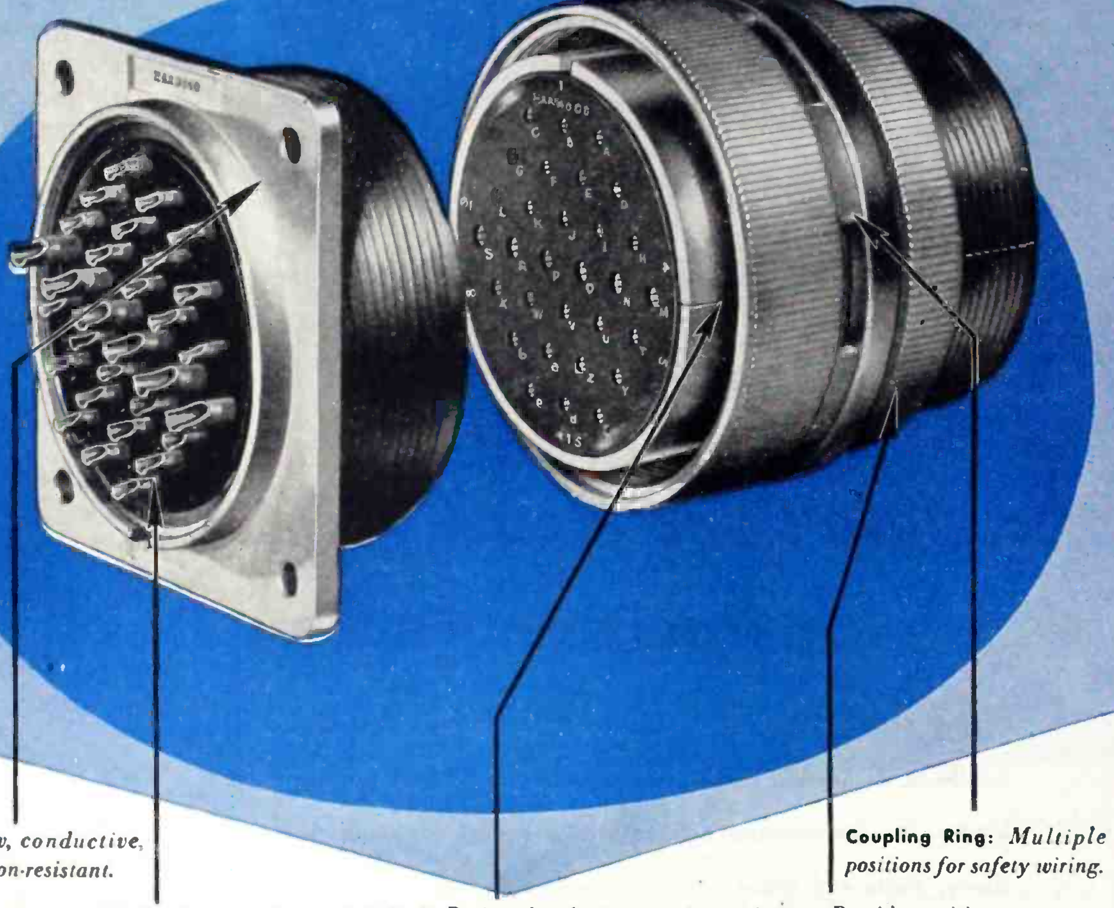

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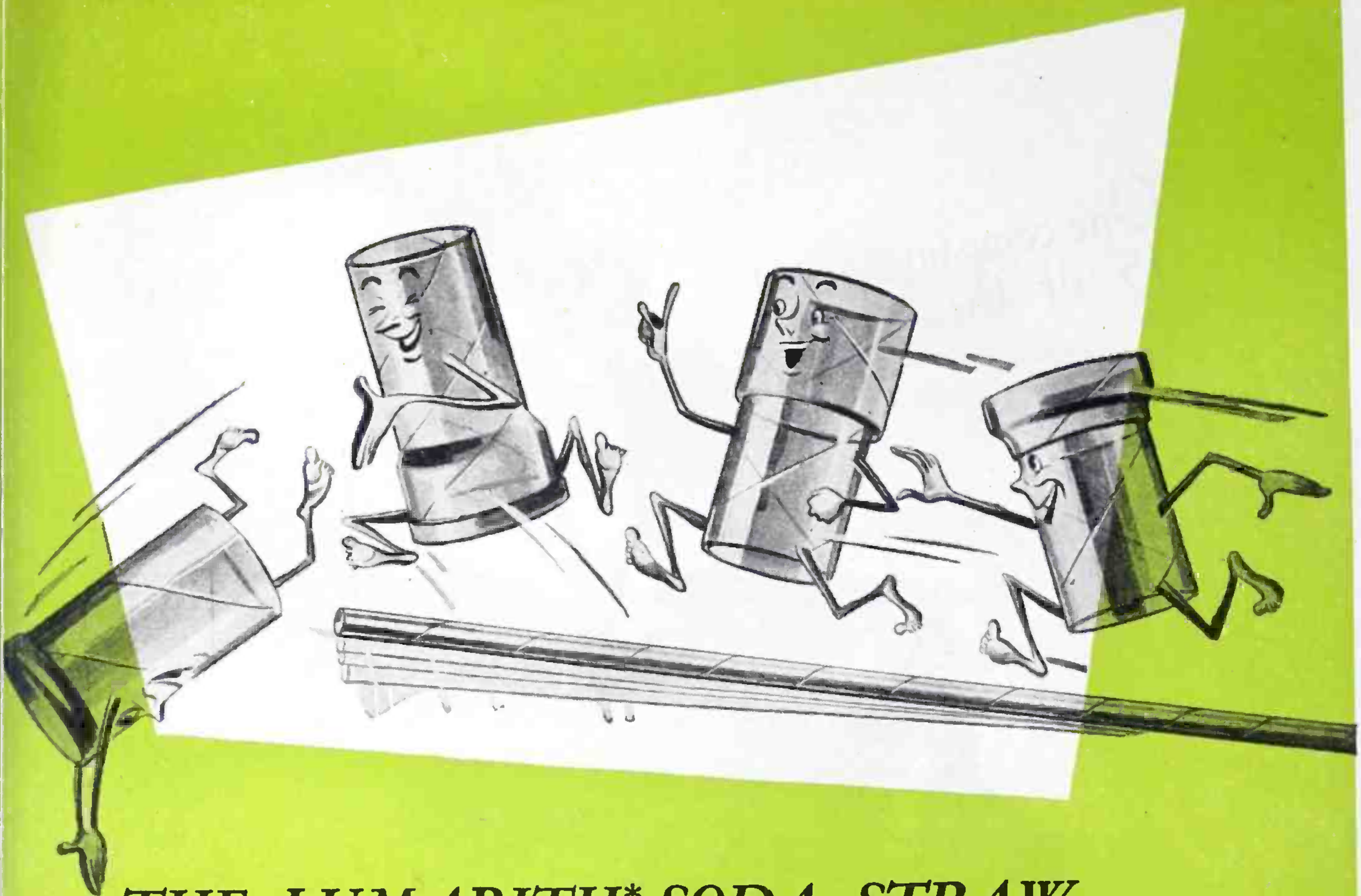
various anodes is made posit
with respect to that of the catho
electrons are drawn to each of th
segments. When a uniform m
netic field is applied, with its dir
tion at right angles to the axis
the tube, the electrons are focus
in two diametrically opposite bea
as shown, the direction of the ma
netic field being indicated by t
arrow marked *H*.

The beams are parallel to t
lines of force of the magnetic fi
so that if the field is rotated t
electron beams move around t
tube with it. In this way, the ma
netic field serves both to focus t
electrons and to direct the resultir
beams to different elements of t
anode structure.

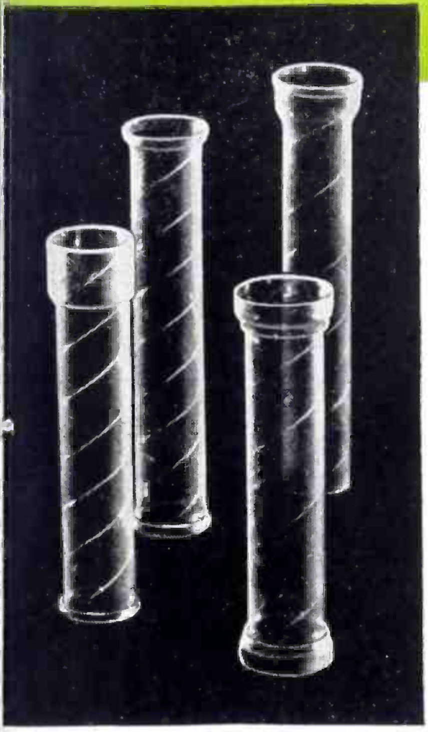
Single Beam

For some applications it is desi
able to eliminate one of the tw
beams and this may be accon
plished by substituting a unifor
electrical field in the tube for th
cylindrical field which results whe
all anode segments are at the sam
potential. The uniform field may b
obtained by applying to the anod
elements a series of potentials whic
vary according to the sine of th
angle taken around the axis. Th
line joining the maximum poten
tials (+ and −) is maintained
parallel to the magnetic field so that
on one side of this cathode the po
tentials are all negative and the
beam on that side is suppressed.
The remaining beam will have
somewhat less current than the
corresponding one in the cylindrical field but the magnetic field strength required for focusing is reduced.

The magnetic field may be conveniently provided by inserting the tube in place of the armature in the stator of a two-pole polyphase alternating current motor. The rotation of the magnetic field in the stator of the motor determines the rotation of the electron beams within the tube. Permanent magnets may also be used for applications where the electron beams within the tube are not required to rotate continuously. A rotating field for the stator of the motor may be produced from a single-phase power supply by inserting a capacitor in series with each winding of a split single-phase stator so that the current through one phase



THE LUMARITH* SODA STRAW *was just a* SPRINGBOARD...



A utstanding development, by one fabricator, is the spirally-w nd grommet of Lumarith—supplied with one end spun. Af r the grommet is in place, the other end is spun on standa drill press equipment, making a tight-fitting, permanent in allation. The Lumarith won't crack or come out despite clim c changes

Note these new electrical uses for spirally-wound LUMARITH!

You'll find the old Lumarith soda straw idea doing business all over the war-front these days—precision grommets, for one thing, of spirally-wound Lumarith, and doing a real job. Spirally-wound units are also serving in aircraft hydraulic controls, on small motors, in lamps, push button tuning coils, coil forms and as "spaghetti."

These transparent Lumarith parts are efficient performers wherever light weight, toughness, good insulating qualities are important, plus Lumarith's well-known resistance to the "black hand" of corrosion.

Fabricators producing spirally-wound tubing of Lumarith offer a range of lengths, diameters and wall thicknesses, suitable to many types of applications in the electrical field. What new uses can you visualize in your products?

You'll also want to be posted on the excellent insulating qualities and corrosion-resistance of Lumarith foils, films and molding materials. Send for "Lumarith for the Electrical Industry," a comprehensive booklet. *Celanese Celluloid Corporation*, The First Name in Plastics, a division of the Celanese Corporation of America, 180 Madison Avenue, New York 16.

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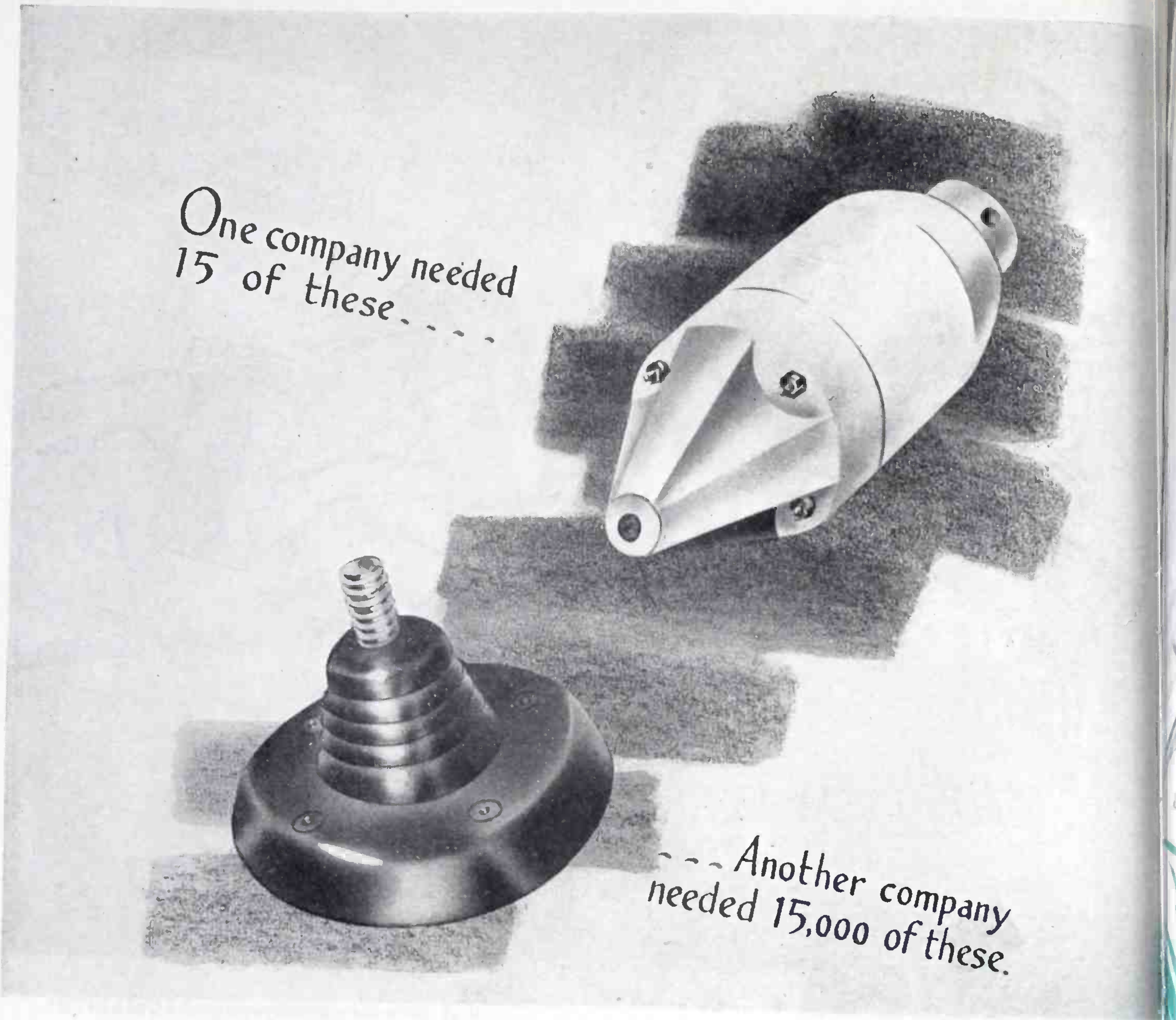
One company needed 15 of these....
---Another company needed 15,000 of these.

STOP "Leap-Frog" Corrosion

"Leap-Frog" Corrosion damages underground pipes and cables.

Pipes or other metal structures are in places electro-positive in relation to the soil and due to natural galvanic action corrosion results. Metal is taken away from one section of pipe and deposited somewhere else along the exposed pipe.

By using Federal Cathodic Protection Rectifiers, "Leap-Frog" corrosion is foiled. On constant guard is a direct current charge which cancels the harmful electrolytic corrosive action on oil, gas and water pipelines and underground cables.

These Federal units have no moving parts, so they last indefinitely — with the absolute minimum of attention. In desert heat or torrid dampness they keep on the job day and night.

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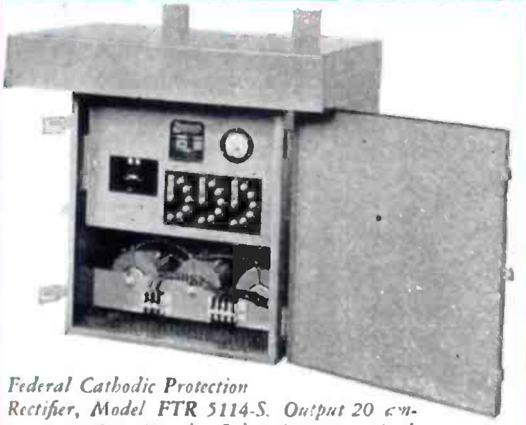

Federal Cathodic Protection Rectifier, Model FTR 5114-S. Output 20 amperes at 10 to 40 volts. Other sizes as required.

Federal Telephone and Radio Corporation

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winding lags by 45 deg and through the other leads by an angle.

Construction

The fundamental principles in this type of tube may be mod and elaborated, depending upon application for which the tub intended. The diagram of Fi shows the arrangement of the ternal elements of a tube ha 30 anodes and various auxil elements.

Surrounding the cathode is a trol grid which modulates the tron beams in much the same as any control grid. The cr patched structure with 30 slot maintained at a positive poten with respect to the cathode an analogous in its operation to screen grid of a tetrode or pent

Behind each window of the scr is a pair of paraxial wires wh because of similarity in funct to the fourth element of a pento is called a suppressor grid. In b

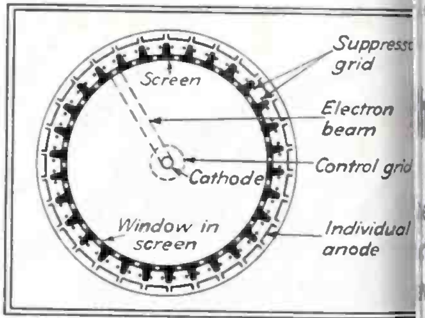

Fig. 2—This mechanical arrangemen of electrodes permits a radial electro beam to be directed to each set of el ments by a magnetic field

of each suppressor is a separat anode. Projection-like gear teet in back of the screen elements ar employed to prevent electrons, des tined for one anode, from reachin an adjacent one.

As shown in Fig. 2, the scree consists of only one element. However, it may be split into a number of elements, if necessary to provide a separate screen for each individual anode. Likewise, the grid action of the suppressor grid may be increased by means of lateral wires across the window of the screen grid tube. The curves of Fig. 3 shows the characteristics of the tubes represented in Fig. 2. Curve B is obtained with lateral wires previously mentioned whereas curve A is obtained with simply the two

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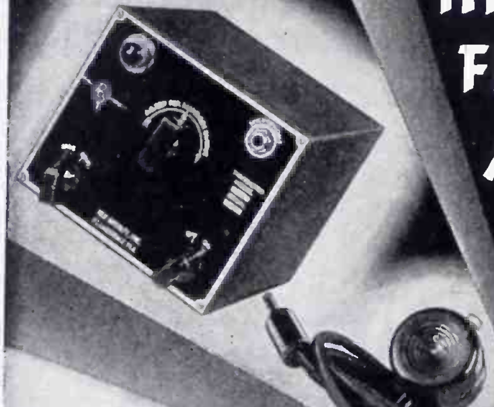

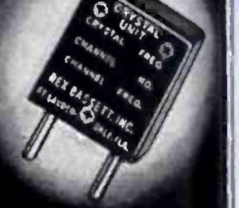

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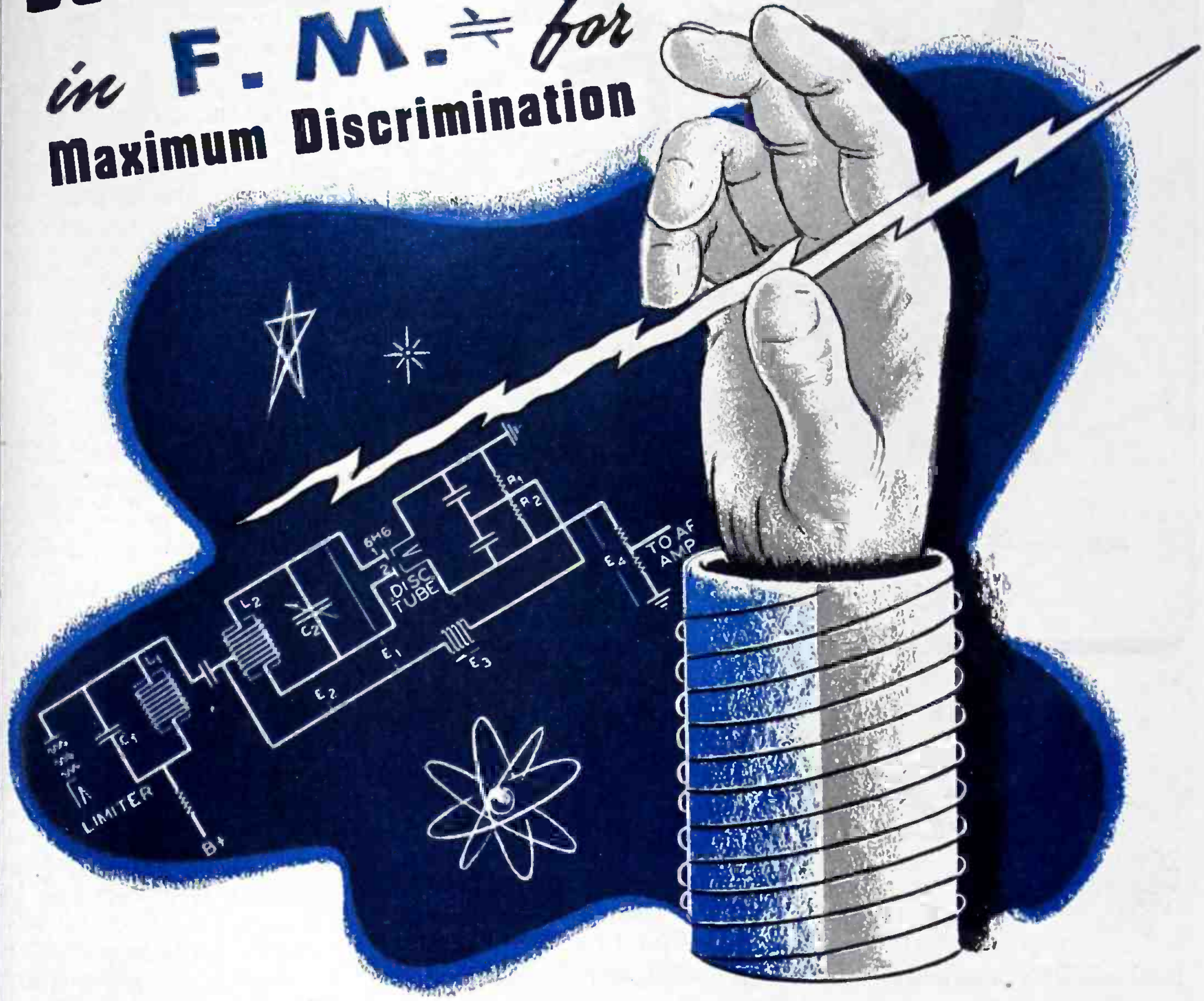

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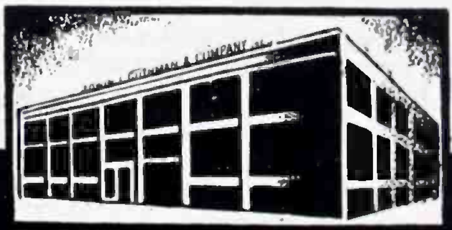

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paraxial suppressor grid wir Measurements on this tube show it to have the following charact istics:

	Without Laterals	With Later
Transconductance (micromhos)	100	25
Anode Resistance (ohms)	30,000	64,00
Amplification Factor	3.5	16
Cut-off Voltage	−80	−

It should be noted that the da in this table, as well as the gra of Fig. 3 shows the transfer ch acteristic with respect to the su pressor grid, rather than with spect to the control grid as usually the case. It is apparent th amplification of signals applied the individual suppressors may readily obtained. The article giv

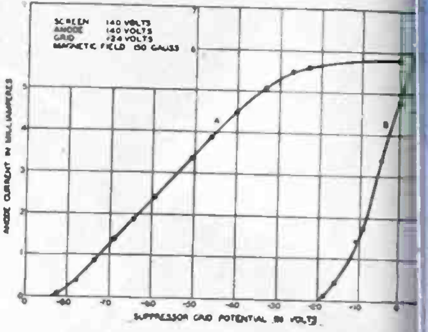
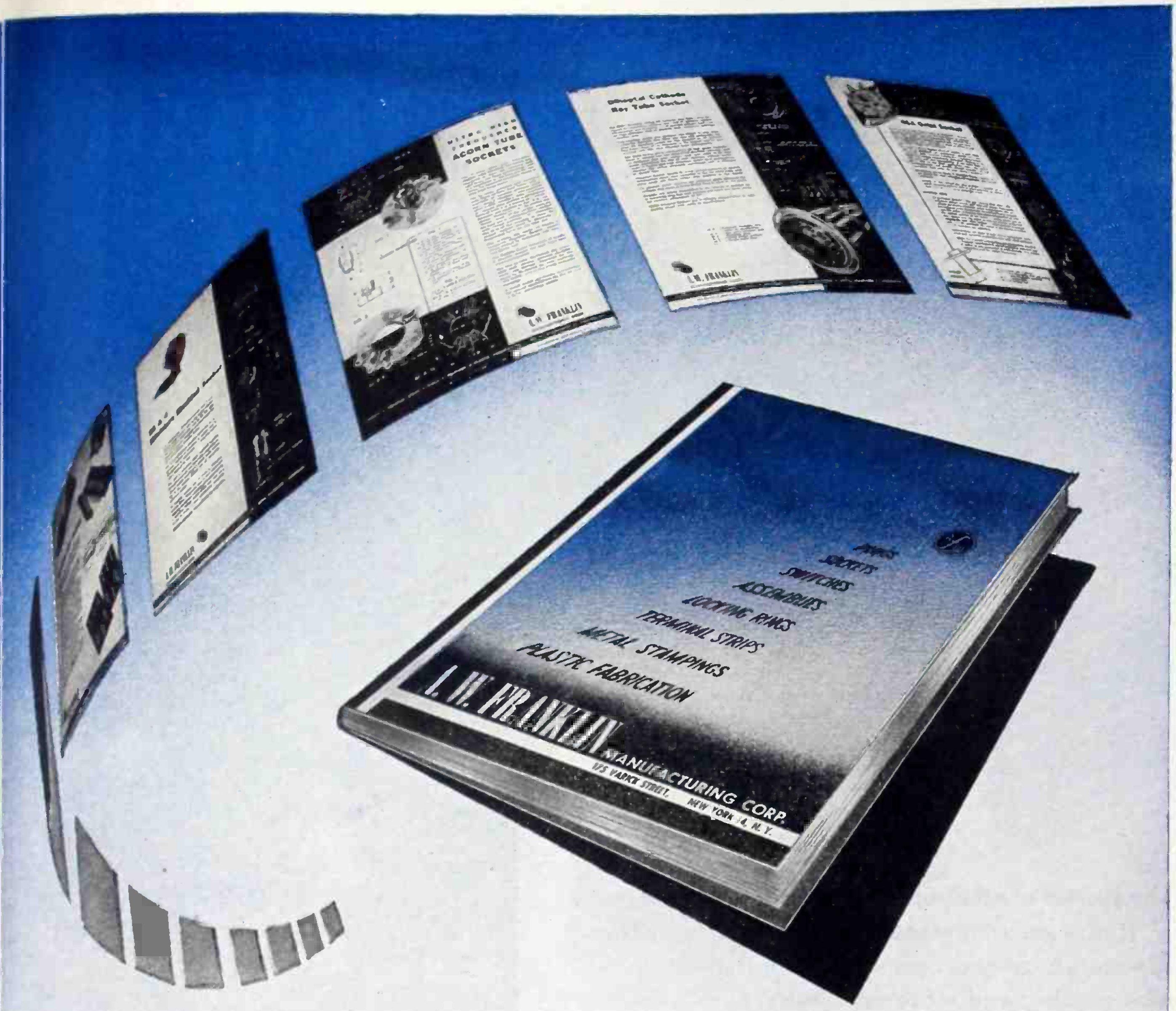


Fig. 3—Suppressor grid characteristics of the new tube. Curve *A* was obtained with lateral wires, curve *B* with lateral wires

no data concerning the transfe characteristics as determined b the control grid but there are n indications to believe that this con trol grid would behave differently from that of any other tube struc ture.

The article gives drawings and photographic reproductions of the formation of electron beams under varying magnetic fields and provides a mathematical analysis for the case of a cylindrical electrical field as well as a uniform electrical field.

While a tube of this general type should obviously be expected to lend itself to many useful and interesting applications, Dr. Skellett's article limits discussion to the use of this tube as an electronic commutator and the application of the tube to multiplex telegraphy. It is stated that a 30-channel multiplex system for signalling using two of the 30-anode tubes has been successfully tested over short distances in New York City.



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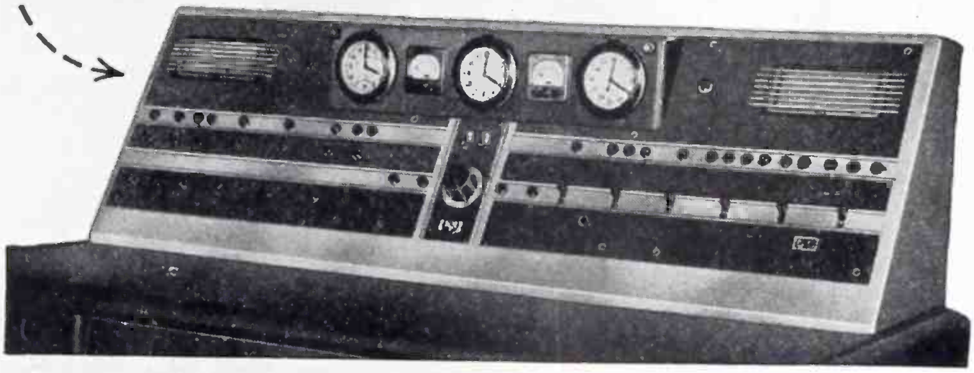

This radio control panel, 54" x 27" is a "prize package" of precision production and versatility—76 *accurately positioned, machined holes and slots, 3-tone enamel finish and color inlay, combination metal etching, a number of artistically produced escutcheons and bezels, and easy-to-read dials with sharply defined calibrations.*

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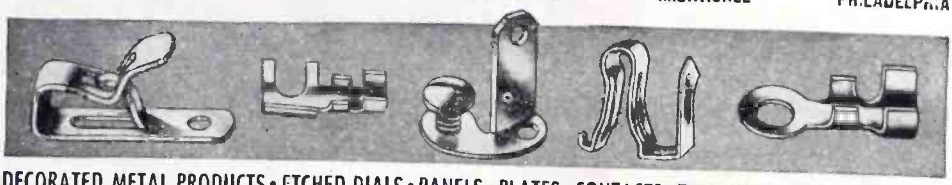


DECORATED METAL PRODUCTS • ETCHED DIALS • PANELS • PLATES • CONTACTS • TERMINALS • CLIPS • LUGS • ETC.

Control of Radium Poison

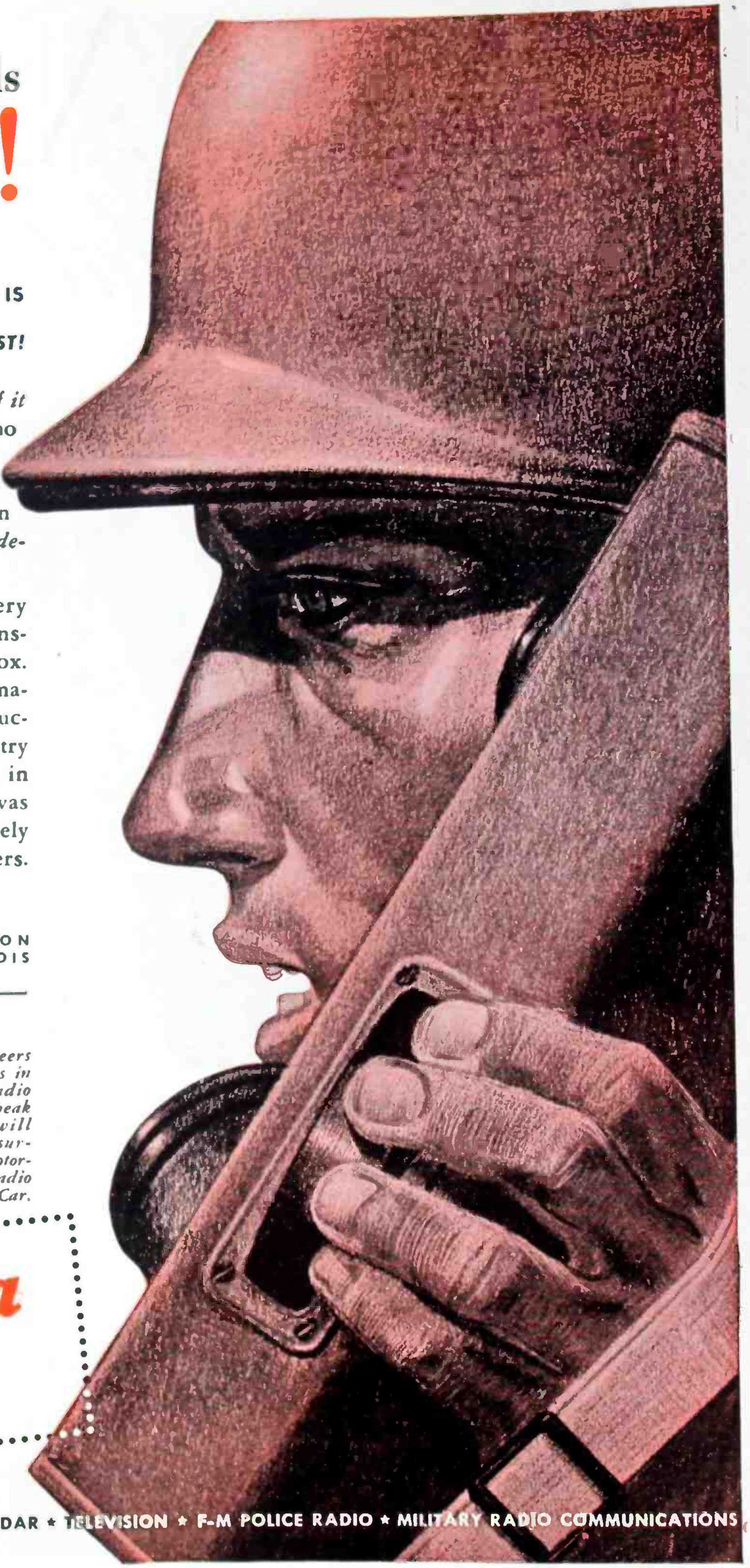
RECENTLY INTEREST has revivec
the problem of preventing poi
ing and other injuries from rad
in plants engaged in paint
luminous dials. This is a nat
result of the great increase in
type of work for the manufact
of military equipment. Altho
the principles of protection
now well known, many new wo
ers under foremen who have
cently entered this field are
gaged in applying radioactive pa
and there is, therefore, an
creased possibility of inj
through ignorance.

In controlling this type of haza
two important physical measu
ments are required. The rad
content of the workroom air a
of the expired breath of the
dividual workers must be det
mined. With these measuremen
it is possible to ascertain wheth
the workroom air contains su
cient radon to constitute a haza
and whether workers are taki
any of the radium paint into th
bodies.

Apparatus previously used
measurements of radon consist
of a sensitive string electromet
connected to an ionization cha
ber, in which the sample of a
was placed to measure the strengt
of the ion current which the rado
in the sample produced. This io
current is proportional to th
amount of radon present. To sav
time, it was necessary to mak
this electrometer record its read
ings automatically. This require
a special camera and the result
were not known until the film wa
developed and interpreted. Many
other disadvantages combined t
reduce the rate at which tests
could be made, such as failure of
insulators in humid weather and
the necessity for adjusting the
sensitivity of the electrometer to
the strength of each sample.

Electronic Method

To speed up these tests and also to improve their accuracy, a new method was developed by L. F. Curtiss and F. J. Davis and described in the September, 1943 *Journal of Research*. To make clear the principle employed, it should be explained that radon is a radioactive gas which emits alpha par-



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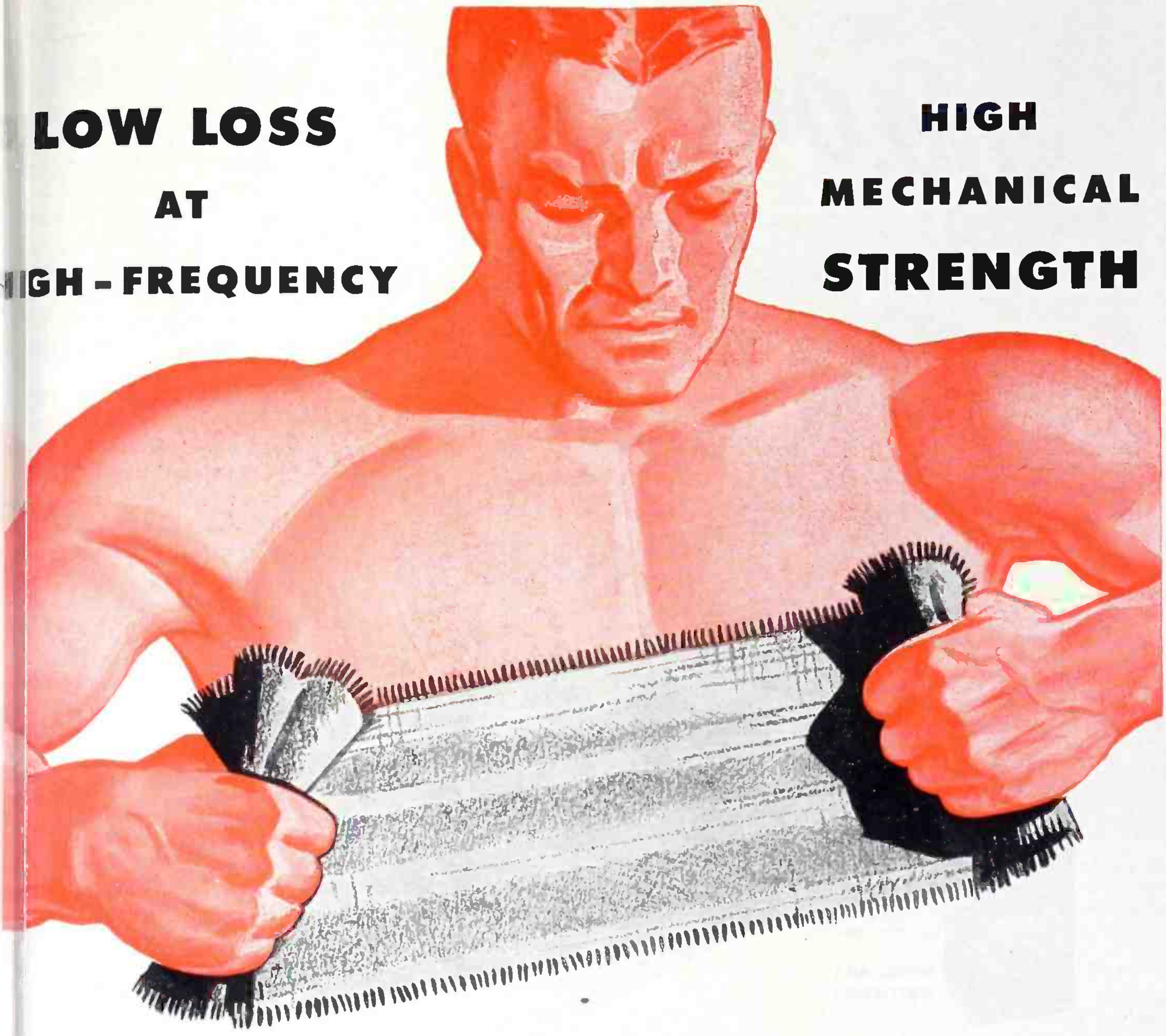
HIGH MECHANICAL STRENGTH



Until now most of the better high frequency insulators have been either brittle or subject to deformation at elevated temperatures. With the development of glass mat base Formica there is available an insulator that allows only minimum losses at high frequencies and at the same time retains the mechanical strength and machinability that is characteristic of other grades of Formica.

For low losses at high frequencies we suggest that you test Formica Grade MF 66 which has been found to be the answer for antenna insulators and coil forms on airborne and ground installations. It withstands the vibrations and mechanical stresses to which military radio equipment is subject. This material is resistant to attacks of fungus growth and can be used in the tropics.

Sample on request. "The Formica Story" is a moving picture showing the qualities of Formica, how it is made, how it is used. Available for meetings of engineers and business groups.

ARMY E NAVY

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Cincinnati, 32, Ohio

ticles, helium atoms, traveling high speeds. It is these al particles that produce the ion c rents in an ionization chaml Therefore, a method of count the number of alpha particles hour from a sample gives a va proportional to the amount radon present in the sample. T authors have devised equipment means of which this may be d and the number per hour prin automatically on adding-mach paper.

First, all oxygen is remo from the sample, since this hinders the production of a sh electrical pulse in the ion counti chamber. The gas sample, mi oxygen, is introduced into chamber, which is a large can w an insulated rod projecting i the center. The can is connec to a source of voltage of ab 1,000 volts.

Under the conditions just scribed, each alpha particle resu in a sharp voltage pulse on the ce tral rod as the ions it produces shooting through the gas a driven to the central rod by t voltage applied to the can. Th occurs in an extremely short tim less than 0.001 second. This sha pulse is amplified by a vacuu tube circuit until the current strong enough to operate a traf recorder, such as is used to cou vehicles on a highway. This d vice automatically prints the da of the week, the hour of the day and the number of alpha particle that have passed through th chamber at that hour. This pr vides the necessary data for com puting the amount of radon pres ent.

Operation

A diagram of the comple system for counting alpha par ticles from radon is shown in th illustration. In use, system i evacuated as far as stopcock T with all other stopcocks in the position shown. With reduced copper in tube C, heated to a dull red, T_7 is closed and T_3 turned to admit a moderate stream of nitrogen from the cylinder through the furnace and drying bulbs into the ion chamber. When the open manometer M shows that atmospheric pressure has been established in the ion chamber, T_6 is closed. The

Penicillin Production Speeded by RCA Electronic Heat

Drying Time Cut from 4 Hours to 30 Minutes

v York, June 26—To aid in increasing pduction of the drug penicillin, RCA oratories, Princeton, N. J., developed a iew electronic method for the bulk-uction of the purified penicillin solu-. *The new system, using electronic t, completes in 30 minutes a process uiring 24 hours by conventional thods!*

he achievement was announced jointly b RCA Laboratories, Inc., and E. R. ibb & Sons, manufacturing chemists to t medical profession, under whose pices extensive tests have just been pleted.

h RCA electronic heating apparatus l concentrate in 24 hours enough icillin to treat 4000 patients requiring ,000 units each.

er Benefits: Squibb scientists completed re than 1000 tests to compare the elec-nic method with the conventional thod of concentrating penicillin. The antages of electronic heat, in addition speed, included:

Reduction of operating costs. One ton of dry ice (costing $65) is saved every 24 hours.

Reduction in maintenance costs through elimination of complicated freezing apparatus and high-vacuum pumps.

Smoother flow of production with less chance of shut-downs due to mechanical difficulties.

4. Reduction of floor space by about 90%.
5. Large savings in initial plant investment, compared with installations using "freeze-drying" process.

How Penicillin Is Made: Penicillin is produced by a special type of mold (either by surface or submerged fermentation) in containers holding up to several thousand gallons. The penicillin-containing broth is then separated from the mold by filtration, and the crude penicillin extracted from the broth with an organic solvent. It is next given an elaborate series of chemical treatments which removes most of the impurities and reduces the bulk about 600 times.

This is the point where the final bulk-reduction must begin. The potency of the solution must be increased from about 40,000 units per cc to about 100,000 units per cc. The penicillin is then "freeze-dried" to its final powder form.

Much painstaking research in the Squibb Laboratories has contributed to the perfection of these processes and to the designing of equipment to carry them out on a large scale.

How Electronic Heat Is Used: Since evaporation by ordinary heat methods would destroy the effectiveness of the drug, bulk-reduction has been achieved through "freeze-drying"—a process in which the liquid is caused to evaporate from the penicillin solution in a high vacuum at temperatures below the freezing point of water.

In the electronic bulk-reduction method developed at RCA, the solution is boiled, under low pressure, at about 50°F. A series of three glass bulbs is used in the process, the high-frequency power from the 2000-watt RCA electronic generator being applied to the solution in the lower bulb, which holds about 200 cc.

- This is the new RCA 2000-watt electronic generator especially designed for the plastics industry and other applications requiring power at frequencies up to 27 megacycles.

High-frequency electric current passes through the solution, raising its temperature to 50°F.—the boiling point under the vacuum used. Evaporation into the two upper bulbs takes place at the rate of about 2000 cc per hour. Provision is made for supplying penicillin solution to the lower bulb on a continuous basis.

The electronic generator, which was built for this particular application, takes about 15 square feet of floor space, and stands about 7½ feet high.

According to Mr. Horace A. Holaday, Associate Director in charge of Squibb Biological Laboratories, who supervised the tests, "The RCA apparatus offers an important contribution in facilitating the evaporation of the final purified penicillin solution. It greatly simplifies the operation, and eliminates the necessity of using much more elaborate equipment."

RCA Equipment Availability: RCA electronic generators suitable for bulk-reduction of penicillin will be available through RCA on priority. Other RCA electronic generators for a wide variety of industrial heating applications are also available. If you have a practical problem which RCA electronic heat might solve, please write, stating your problem, to Radio Corporation of America, Electronic Apparatus Section (70-48x), Camden, N. J.

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RCA

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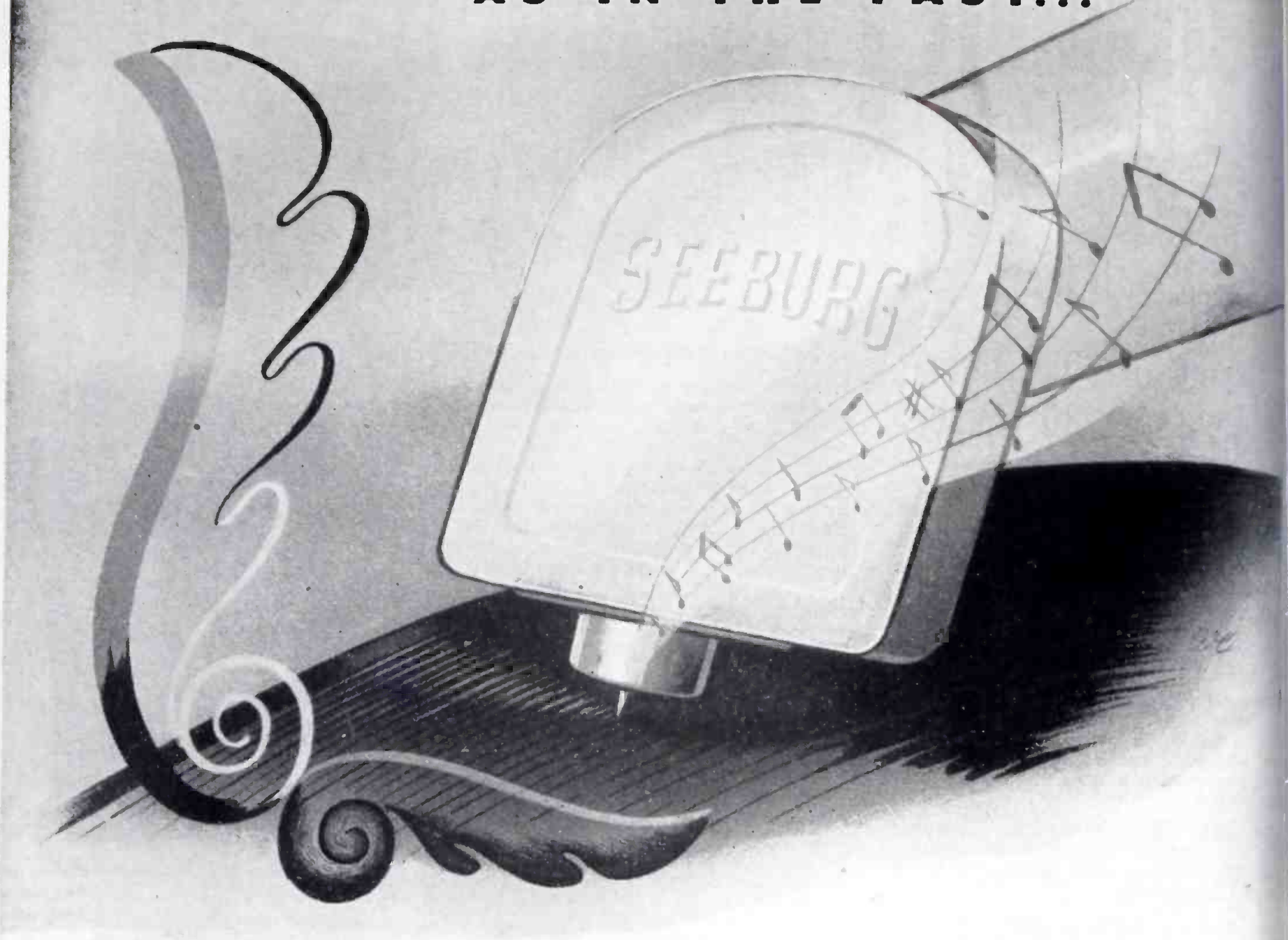

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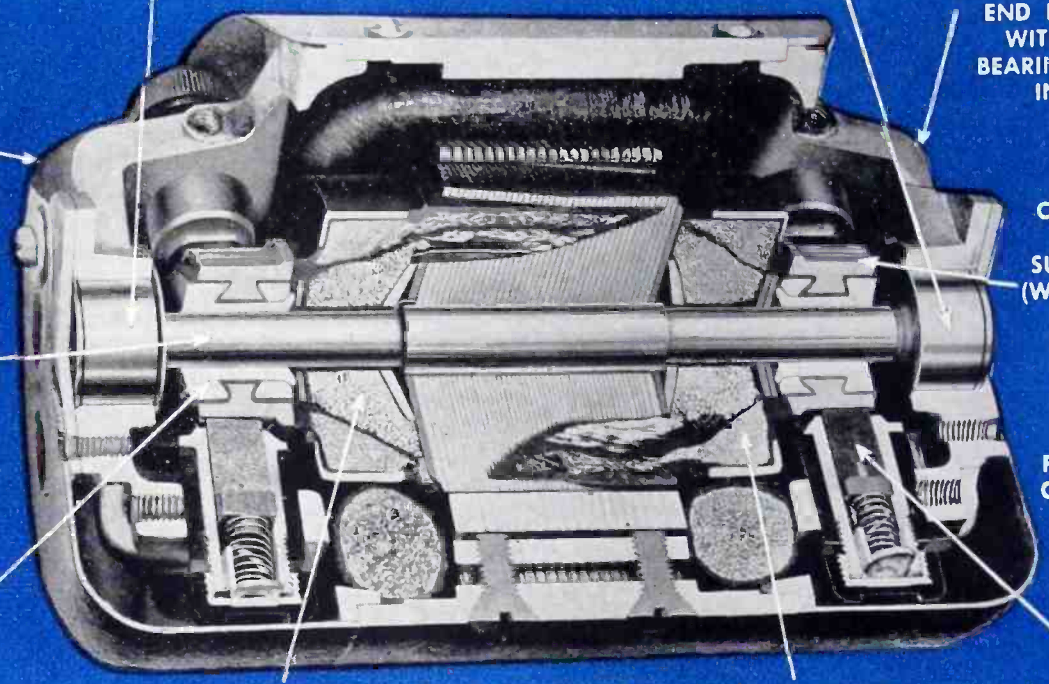

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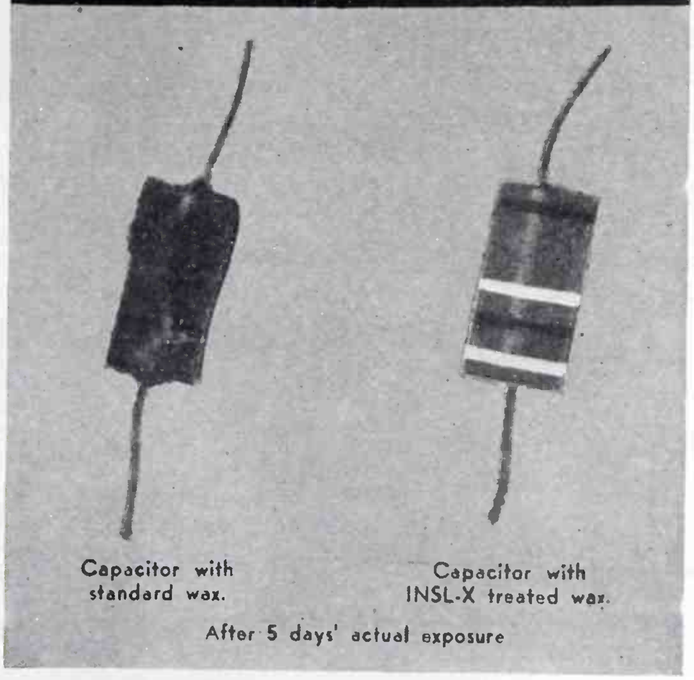
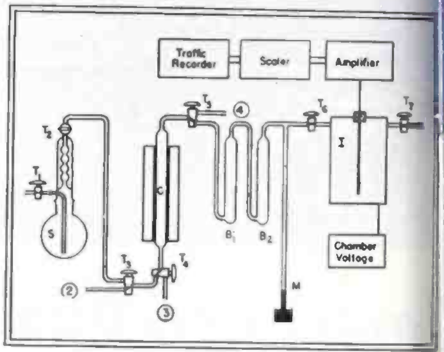


voltage is then applied to the i chamber and the counting proce started.

When a sufficient number pulses have been recorded for satisfactory determination of t background, the chamber may l calibrated by admitting a know quantity of radon from the stan ard radium solution stored in bu S. This is accomplished by agai evacuating the system up to sto cock T_2 with the furnace hot. The nitrogen from the cylinder is a mitted slowly through T_1 into th bulb S with T_2 and T_6 open to th chamber and T_7 closed. At the sam time, sufficient heat is applied t bulb S to cause the solution to boi

Nitrogen is admitted until th pressure in the ion chamber i again atmospheric. This transfe to the ion chamber the quantity o



Complete system for determination of radon. At I is the ion-counting chamber; S is the standard radium solution; C, reduced copper; B_1, Drierite; B_2, P_2O_5; M, open mercury manometer.

radon accumulated in the standard solution since it was last removed. This can be computed from the known quantity of radium in the solution and the elapsed time.

The measurement of an unknown may now be made by evacuating the chamber as before and attaching the flask containing the unknown at T_3. Stopcock T_3 is turned to connect the flask to the furnace and a flushing tube is connected to the supply of nitrogen from the cylinder. By closing T_7 and opening T_6, the ion chamber is filled to atmospheric pressure with oxygen-free nitrogen, since the oxygen originally in the sample flask is removed in the furnace. At the same time, the radon in the sample flask is also transferred to the ion chamber. Then T_6 is closed and the

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ELYRIA, OHIO

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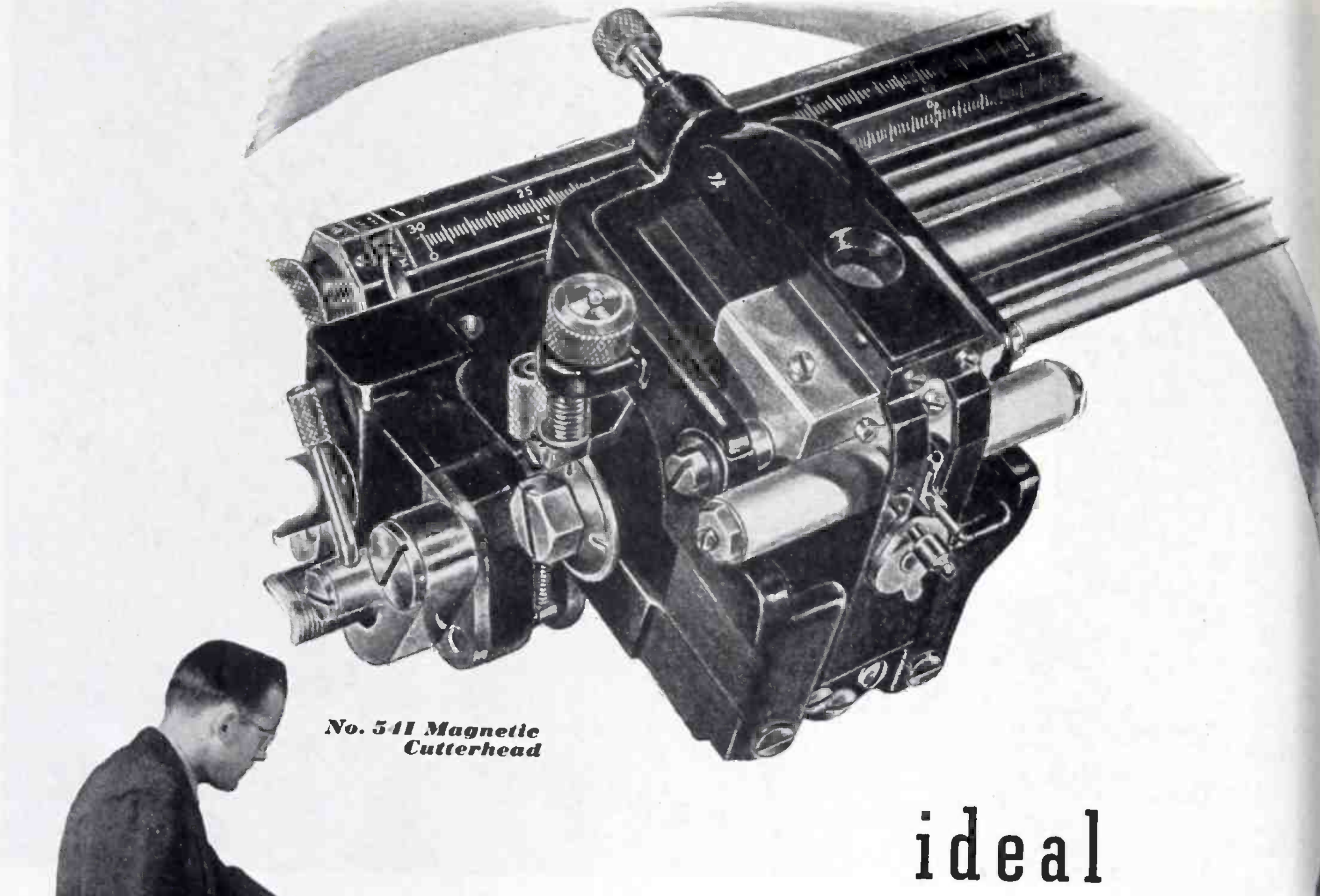
Smooth Power



No. 541 Magnetic Cutterhead

ideal frequency response

— flat within ± 2 db. to 9,000 cycles, with an exceptionally low distortion content.

Measured by the "light" method, the Fairchild Magnetic Cutterhead reveals an ideal curve for instantaneous recording.

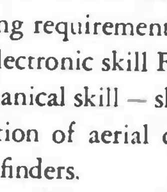
And mechanically, it offers exclusive features that damp the moving armature; that permit its accurate adjustment without disassembly of the cutterhead; and that fully modulate the groove at 98 lines per inch with a minimum of distortion — a feature extremely desirable in making masters for pressing.

Standard with the No. 539 Fairchild Recorder, the No. 541 Magnetic Cutterhead is easily adapted to any recorder.

With professional use in mind, all Fairchild recording instruments are built to meet the exacting requirements of the radio and communications fields. To electronic skill Fairchild has added the plus of exceptional mechanical skill — skill long practiced in .0002" tolerance production of aerial cameras, electronic devices and radio direction finders.

The result of persistent research to provide unusually high volume level recording with exceptionally low distortion content is the No. 541 Magnetic Cutterhead. Descriptive and priority data are available.

SOUND EQUIPMENT



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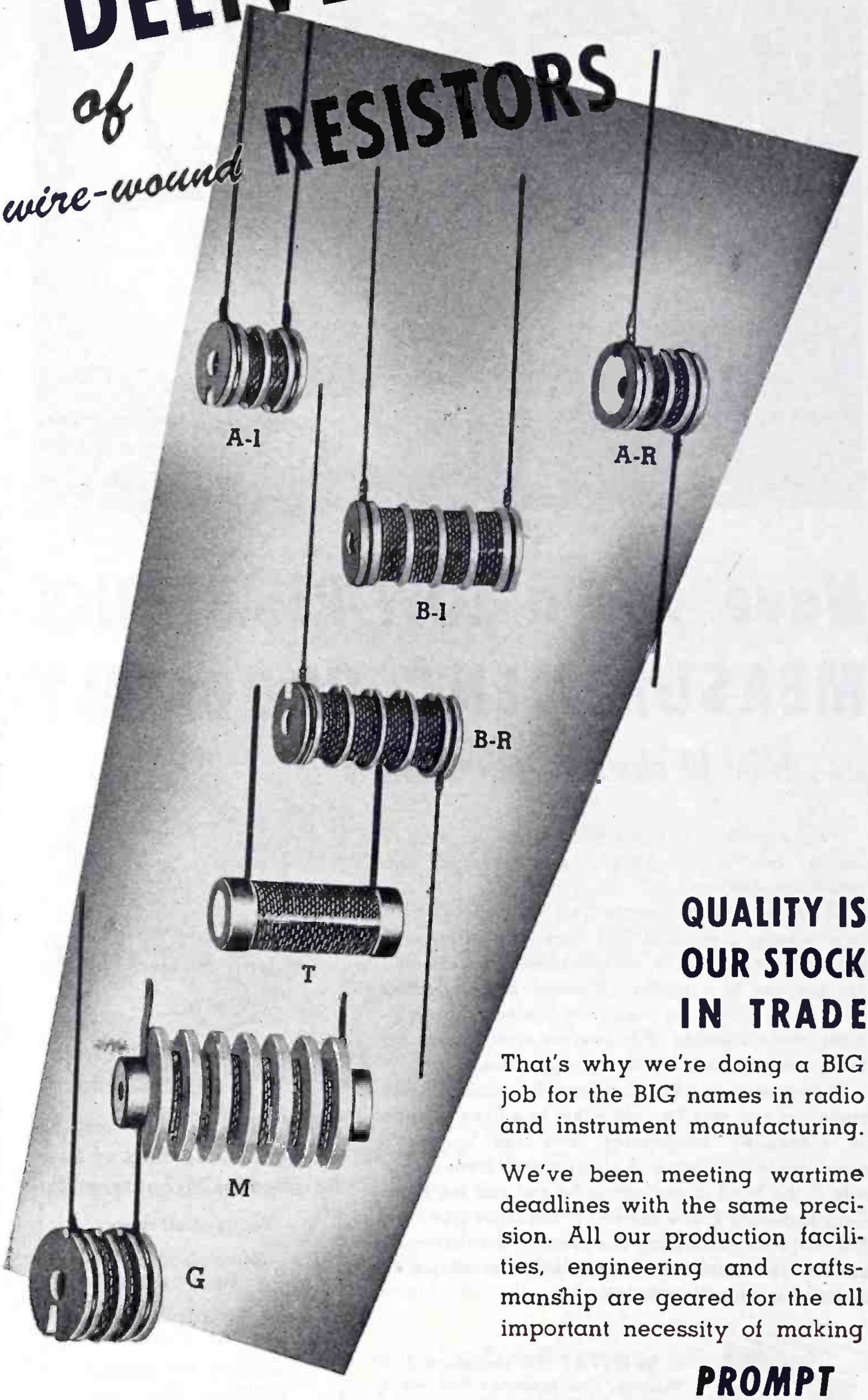

SPECIFICATIONS:

"A'—15/32 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—½% standard accuracy—non inductive pie wound—½ watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A'—Same as A-1, with leads reversed.

'B —15/16 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—½% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B'—Same as B-1, with leads reversed.

'—1-1/32 long x 7/16" dia.—Inductively wound—⅛ x .015 strap terminals—35 to 35,000 ohms—2 watts, 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

—1-13/32 long x ¾" dia.—Mountable with 6-32 screw—⅛ x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy. Baked varnish finish.

—15/32 long x ½" dia.—Mountable with 6-32 flat or filester head screw: No. 21 tinned copper wire leads. 1 to 500,000 ohm value. ½% standard accuracy—non inductive pie wound .8 watts, 30° temperature rise in free air. 100° C. maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.

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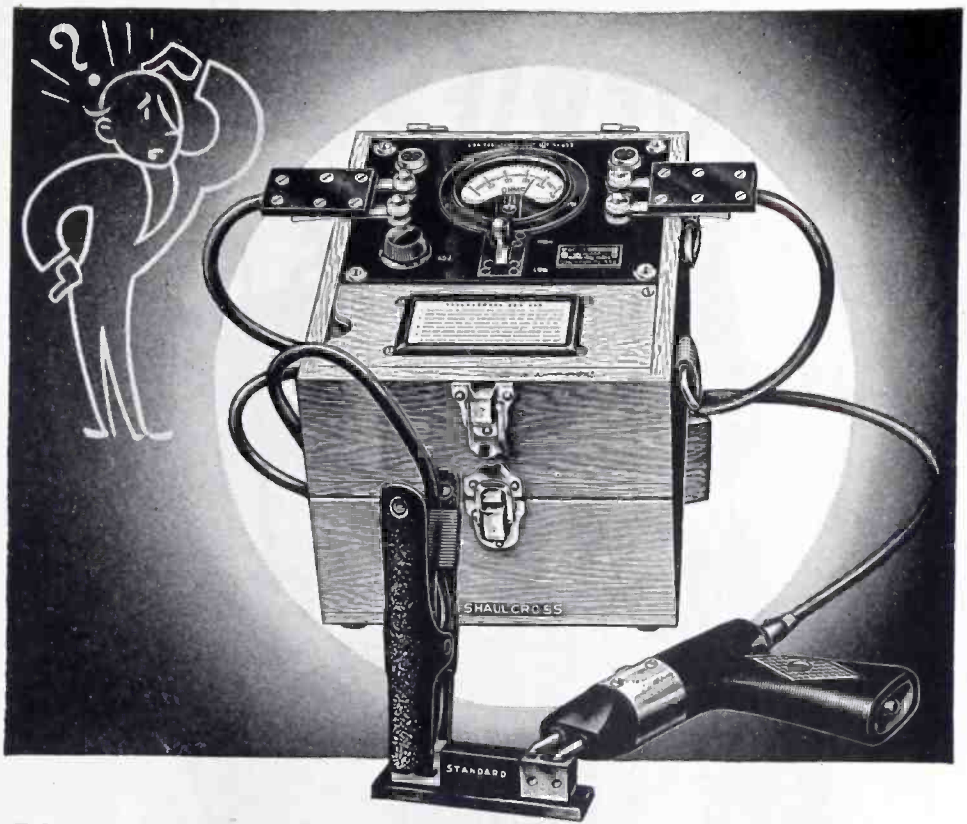
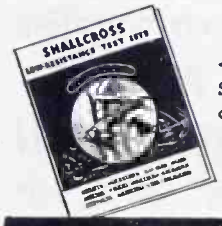




alpha particles from the sampl may be counted.

The new arrangement is so compact that six ion chambers can b operated in the space required fo one ionization chamber with it electrometer and camera. No photographic process is involved and th final record is immediately available, thus saving considerabl time. Insulation of moderate quality may be used throughout th new equipment, because it is onl important that the current be larg enough to insure its being counted.

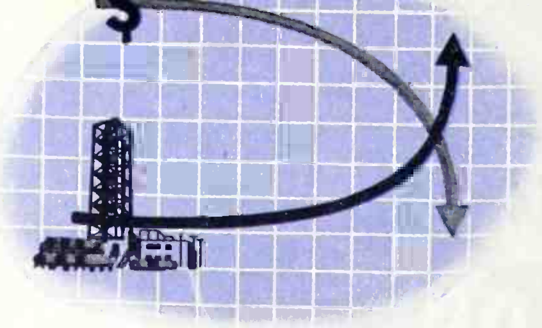
• • •

Phase-Indicating Null Indicator for Bridges

THE USE OF A-C operated bridges i often severely limited by the fact that the usual methods of detection of balance do not indicate the direction of deviation. Thus, in the simplest case of a four-arm bridge with resistive elements, a balance detector sensitive to alternating current will not indicate whether the balancing resistor should be made larger or smaller to reach balance. This makes it practically impossible to use an a-c operated bridge for automatic control purposes because a signal originating in the balance indicator would not indicate, to whatever correcting element is being used, the direction it will have to move in order to obtain balance.

There are several schemes available which will obtain, on a zero-center d-c instrument, deflections to the right or to the left if the deviation of an a-c operated bridge from balance is in opposite directions. An analysis follows of the action of one of the balanced detector circuits for a-c bridges which has recently been used very successfully on the commercial strain gage indicator described in the December 1943 issue of ELECTRONICS.

Consider the simple Wheatstone bridge arrangement shown in Fig. 1. With the bridge in balance, there will be zero voltage between points A and B. When unbalanced with X larger than R_3, point A will be positive with respect to point B on the half cycle during which C is positive with respect to D. That is, the alternating voltage E_{AB} will be in phase with the a-c voltage E_{CD}. With X smaller than demanded by



Production up—Price down
Reason enough to plan on Styron

Add all the other well-known advantages of polystyrene and you get a clear picture of Styron's place in plastics

The individual qualities of Styron (Dow polystyrene) are well known. One reason for this recognition is the surprisingly wide variety of products that are made possible, or made better, by the use of these qualities.

In the fluorescent-light fixture shown above, as one example, Styron's exceptional clarity and high refractive index are peculiarly valuable. Its unique dimensional stability under extremely low temperature, its freedom from odor and its complete lack of water absorption are but a few of the properties which account for its success in the refrigeration field. The brilliant crystalline beauty of Styron, its resistance to acids and alkalies, and the ease of its moldability make it both decorative and practical for use in products for the home.

Now, to polystyrene's own characteristics and versatility can be added the advantage of huge war-keyed production. As a result, Dow, pioneer and major producer of this outstanding thermoplastic, has been able to reduce substantially the base price—a trend of vast significance to the plastics industry. These facts are reason enough to plan on Styron.

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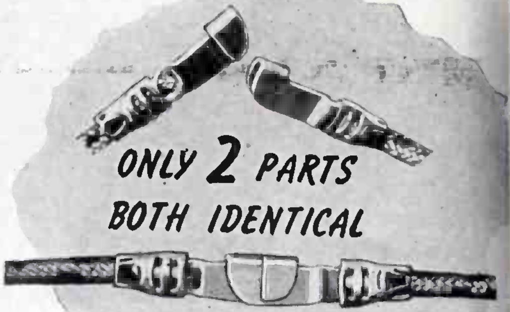
THE AMP *Solderless* KNIFE-DISCONNECT SPLICING TERMINAL



STAY TOGETHER UNTIL INTENTIONALLY TAKEN APART

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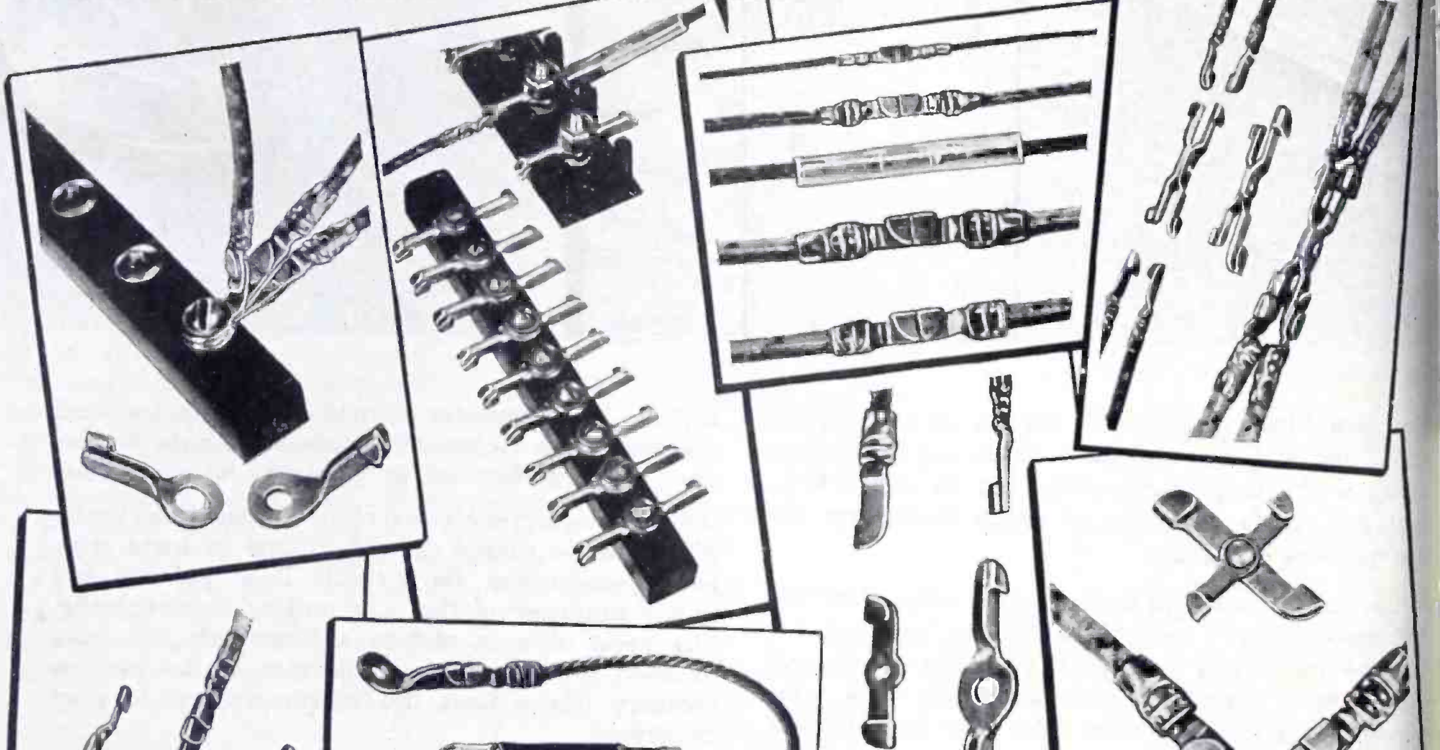
The basic design of the AMP Splicing Terminal, using identical ends with a knife-switch wiping action, has proven so superior to conventional splicing methods that AMP now introduces a disconnect splicing system to cover a wide variety of adaptations. Typical examples are shown here. Each of these incorporates the same exceptional electrical and mechanical characteristics inherent in the basic design. All current carrying parts are integral stampings of pure electrical copper, having minimum weight. No reduced conductivity alloys.

Write today for your copy of AMP Bulletin 31



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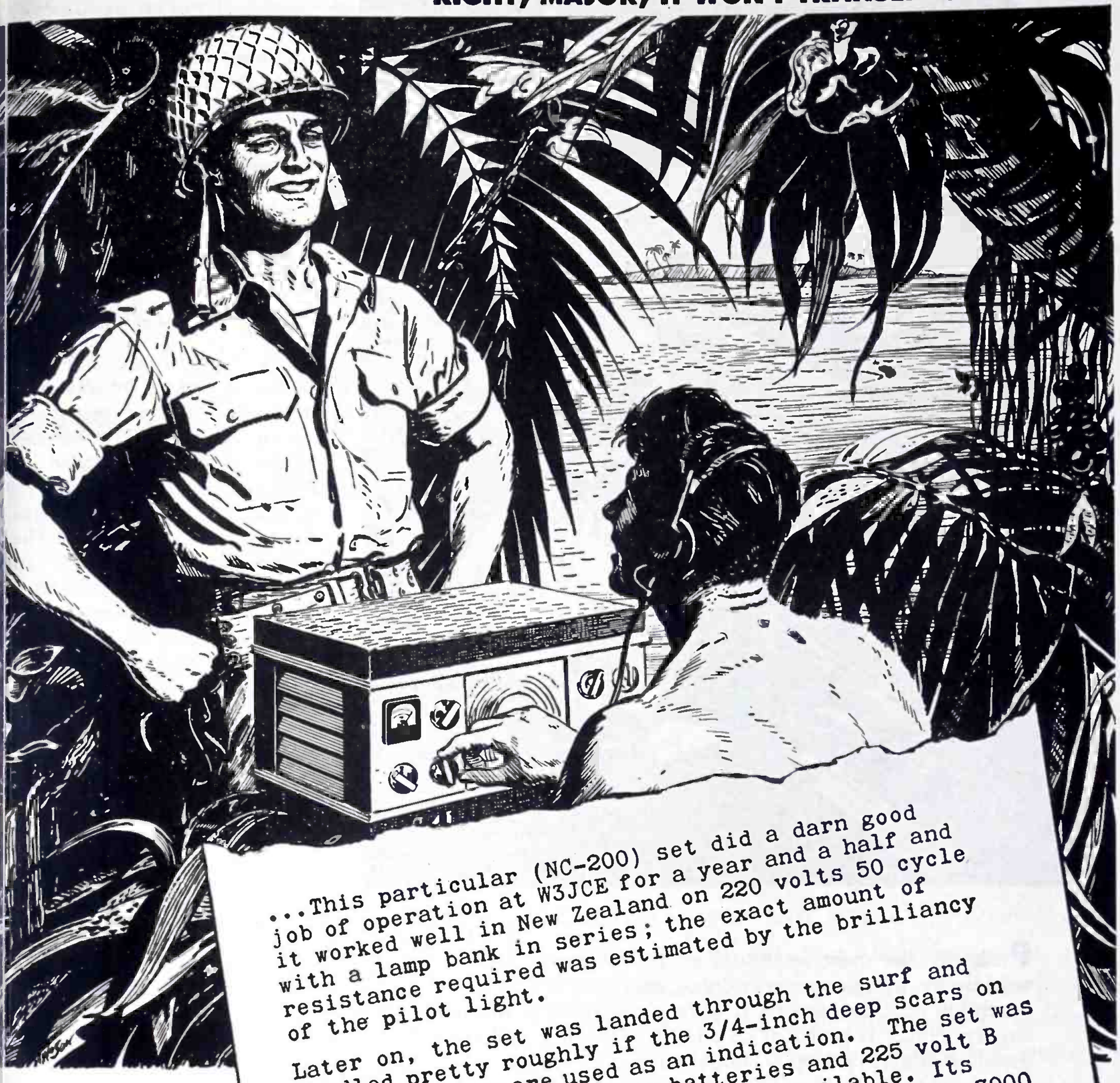
RIGHT, MAJOR, IT WON'T TRANSLATE JAPANESE



...This particular (NC-200) set did a darn good job of operation at W3JCE for a year and a half and it worked well in New Zealand on 220 volts 50 cycle with a lamp bank in series; the exact amount of resistance required was estimated by the brilliancy of the pilot light.

Later on, the set was landed through the surf and handled pretty roughly if the 3/4-inch deep scars on the packing box are used as an indication. The set was operated on 6 volt storage batteries and 225 volt B for several weeks until AC became available. Its reception of broadcast programs from the States 7000 miles away was excellent. In fact, the only thing it wouldn't do was translate Japanese. The NC-200 was by far the best radio on the island except for one 'RAS' and I guess you know who built that.

When I received my orders to come back to this country, it almost broke my heart to part with 'Baby', but I sold it because a good radio means a lot out there.

(Excerpt from a letter from a Major of Marines in the Pacific)

NATIONAL COMPANY

MALDEN **MASS, U. S. A.**

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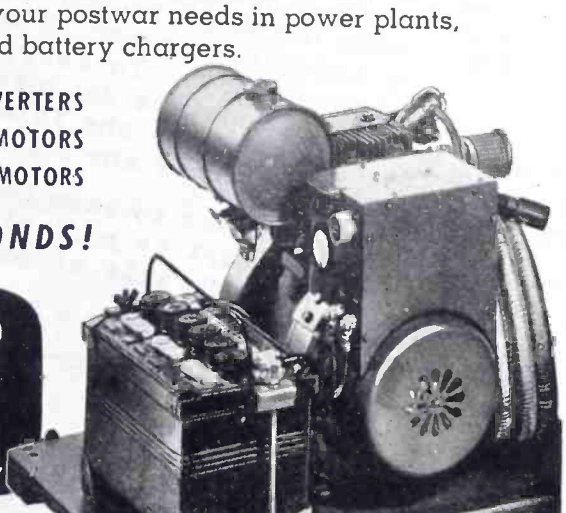

balance, A will be negative with r
spect to B during the half cycle th
C is positive with respect to D, a
the voltage E_{AB} will consequen
be 180 deg out of phase with t
voltage E_{CD}. It is evident that a b
ance detector for the voltage E
which at the same time would i
dicate its phase relation with r
spect to the voltage E_{CD}, would be
valuable addition to the tools of t
electrical engineer.

Indicator Circuit

The strain gage indicator r
ferred to uses an unusual arrang
ment of small dry-type rectifiers
shown in Fig. 2. A 1000-cycle alte
nating voltage is applied to t
bridge and the unbalanced volta
existing between points A and B
fed through an amplifier. The a
plified output voltage is appli
through a transformer to one dia
onal of a four-element rectifi
bridge arranged so as to short-ci
cuit itself. The other diagonal
connected to a winding on the tran
former furnishing the voltage fo
the bridge. This voltage is cons
quently in phase with the voltag

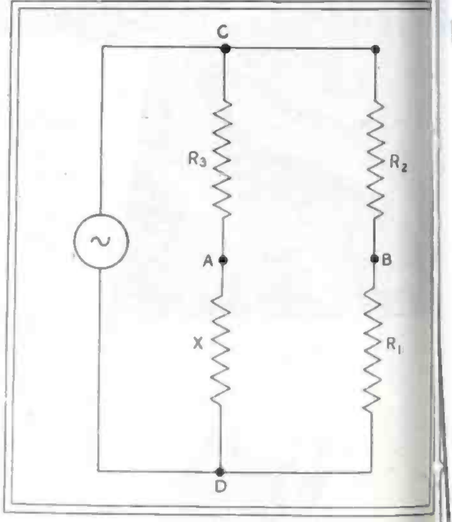

Fig. 1—Wheatstone bridge circuit in which the polarity of the voltage between points A and B changes when the value of X is above and below the value required for balance

E_{CD}. The d-c indicating instrument is connected as shown between the centertaps of the transformer windings connected to the diagonals of the bridge.

To analyze the performance of the circuit, the essential voltage sources and rectifiers are redrawn in fig. 3 where vacuum-tube rectifiers are shown, simply for the con-

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ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt.

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This unusually small diameter, light weight, high-dielectric No. 26 AWG three conductor cable was designed for an electronic device in which three No. 22 AWG single conductor aircraft circuit wires previously used had proved too bulky. It is made to a nominal diameter of .125" (smaller than a No. 14 AWG single conductor 1000 volt Rockbestos Firewall Radio Hookup Wire). Also in 4-conductor construction — and with No. 20, 22 and 24 AWG individual conductors.

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Sizes No. 22 to 4 AWG solid or stranded copper, monel or nicke conductors insulated with .031" or .040" of impregnated felted asbestos in black, white or colors.

Heatproof and flame-resistant, this lead wire will not bake brittle and crack under vibration, won't rot, swell or flow when in contact with oil or grease, and has ample moisture resistance for most applications.

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This type of cable is made up of 1000 volt rated individual Firewall Radio Hookup Wires of required size and number of conductors, cabled, and braided or shielded according to customer's specification. For example, this special 14 conductor No. 22 AWG cable was taped, shielded with tinned copper braid, then jacketed with a black glazed cotton braid with a flame-resistant finish.

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Illustration of
Type 8020, Half Wave
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Peak Inverse Voltage 40,000
Peak Plate Current 0.5 Amp.

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EXPORT DIVISION 25 WARREN STREET, NEW YORK, 7 NEW YORK
CABLE ADDRESS SIMONTRICE NEWYORK

ELECTRONIC e ENTERPRISES

venience of being able to refer their terminals as cathode a anode. Resistances are shown series with the tubes, to illustr the fact that copper-oxide rectif elements have appreciable res tance in the forward direction.

One of the voltages can be c sidered as a reference voltage; th would be the voltage existing b tween *H* and *F*. Assume this to an alternating voltage of consta value and considerably larger th the voltage *RT* which we wish indicate. It will also be convenie to assume the two voltages *HF* a *RT* as square waves.

When the voltage *RT* is zer voltage *HF* will produce curren alternately through rectifiers *a* a *b*, when *H* is positive with respe to *F*, and through rectifiers *c* a *d*, when *F* is positive with respe to *H*. Assuming equal rectifier cha acteristics and series resistance winding *HF* then forms a balance bridge circuit alternately with branch *a-b*, and then with branch *c-d*. When no voltage exists across winding *RT*, points *R*, *S* and *T* are always at equal potential, and consequently no current will flow in the meter *I*.

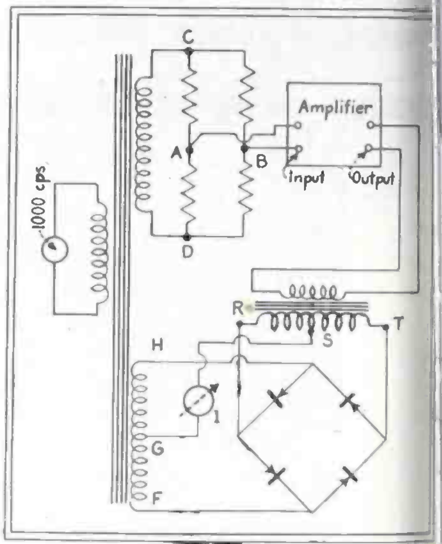


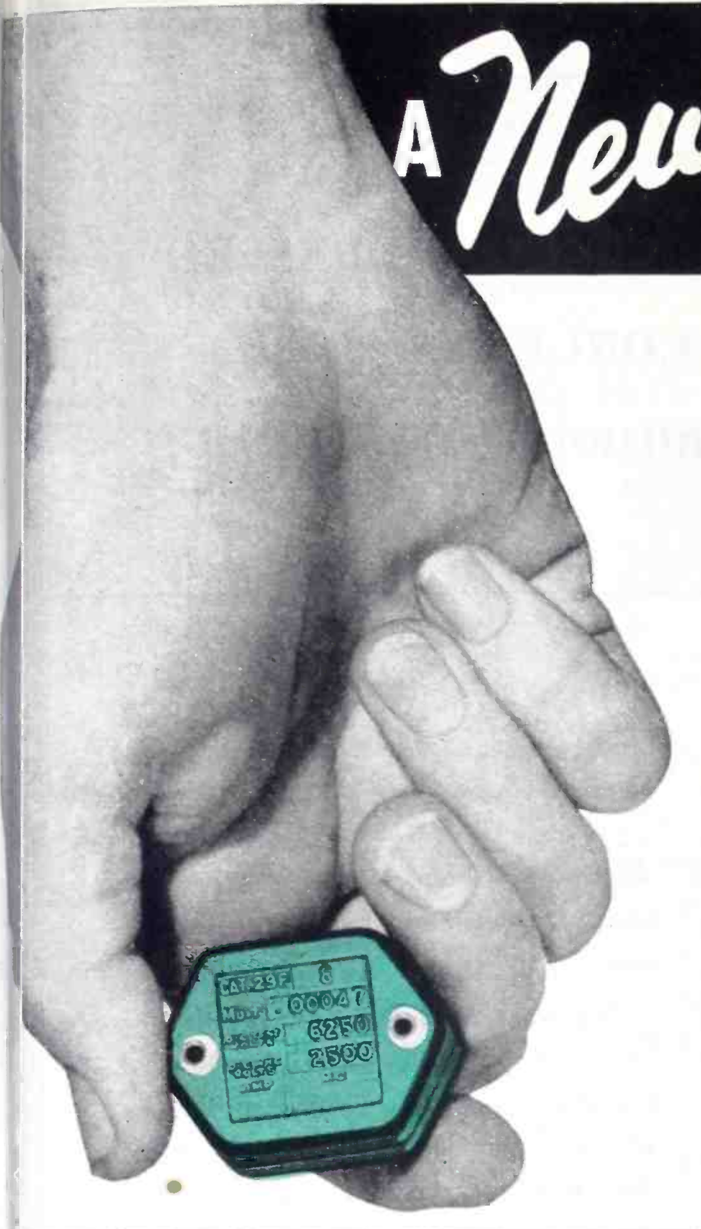
Fig. 2—Circuit of a strain gage indicator containing dry-type rectifiers and an electronic amplifier

Inoperative Branch

To consider what happens in that branch of rectifiers which is not carrying current at a particular instant, let *R* be just midway between *H* and *F* in potential. Since *G* is also midway between *H* and *F*, no potential exists between *R* and

A *New* G-E COMPONENT

LECTROFILM CAPACITORS



Their high dielectric strength assures dependability

Lectrofilm* capacitors are excellent for radio-frequency blocking and by-pass applications where "Q" and temperature coefficient are not critical. Many thousands have been proved in G-E radio equipment now in use on every battle front. Among their outstanding features are the following:

Wide operational margin insures dependability—note the high ratio of d-c test voltage to d-c working voltage shown in table.

Dependable operation over a wide range of ambient temperatures—from minus 55 C to plus 85 C.

Mechanically interchangeable with mica capacitors of the same ratings built to American War Standards (C-75.3—1942) in case sizes CM 60, 65, and 70.

Dense, strong, and moisture-resistant cases made of a distinctive-green, low-loss plastic. The case-60 type is molded under high pressure and high temperature; the case-65 and case-70 types are potted with a special G-E compound, selected for its moisture resistance and stability at high temperature. Lectrofilm capacitors will pass the above American War Standards thermal-cycle tests without difficulty.

For information on "Q," temperature coefficient, and r-f current-carrying capacity, ask for Bulletin GEA-4295, General Electric Company, Schenectady 5, N. Y.

RATINGS CURRENTLY AVAILABLE IN CASE-60 TYPE SHOWN ABOVE

icromicro-farads †	D-c Working Voltage	D-c Test Voltage	Cat. No.
100	2500	6250	29F21
150	2500	6250	29F22
220	2500	6250	29F23
330	2500	6250	29F24
470	2500	6250	29F8
680	2500	6250	29F9
1000	2500	6250	29F10
1500	2500	6250	29F11
2200	2500	6250	29F12
3300	2500	6250	29F13
4700	2500	6250	29F16
6800	1200	3000	29F25
10000	1200	3000	29F26

†C acitance tolerance ±10 per cent. Capacitance temperature coefficient approxima y 700 parts per million per degree C. as measured at 1000 cycles over a te erature range of minus 40 C to plus 85 C.

Lectrofilm is General Electric's new synthetic dielectric made from materials that are available in he United States.

Illustration shows case 65 or 70 type. Bulletin GEA-4295 lists ratings available

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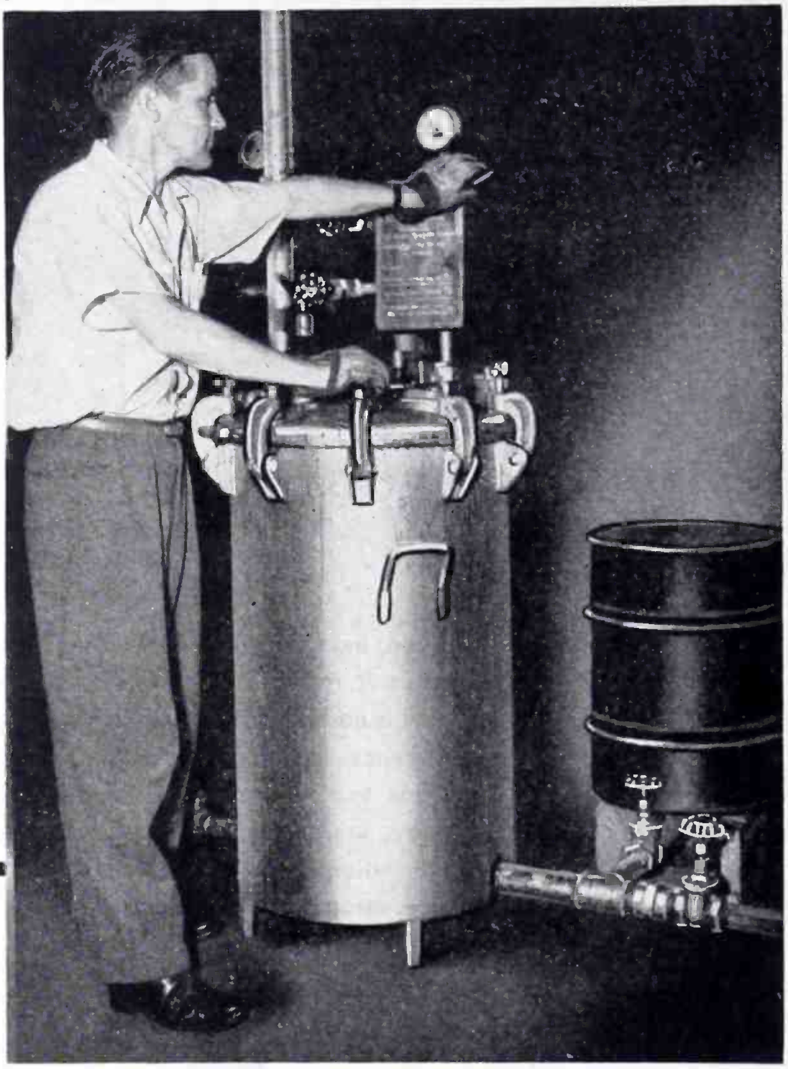
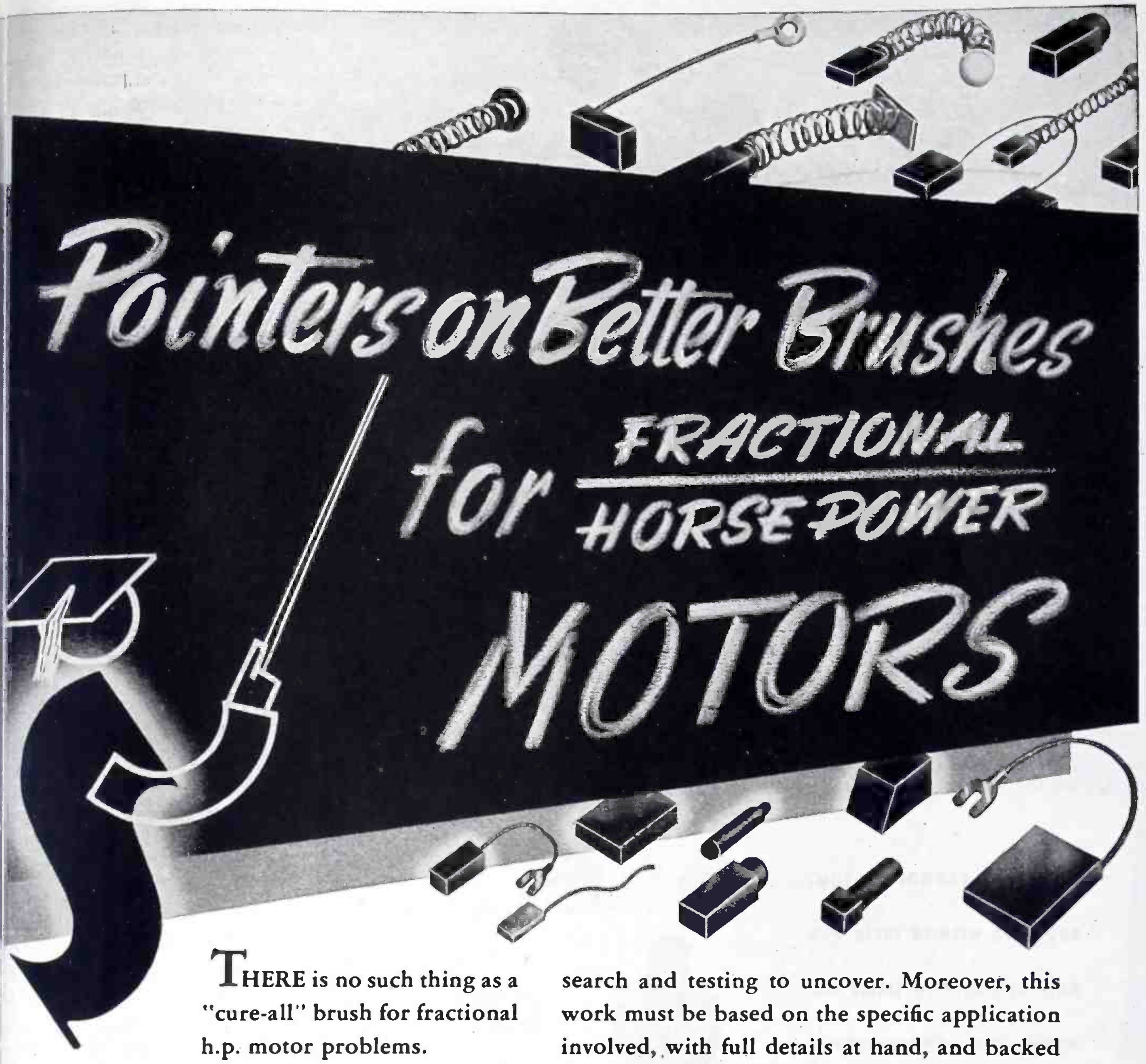


G. In either of the two rectifie and d, no current can flow as l as point T does not become posi with respect to H, in which rectifier d would begin to conc since its anode would then be p tive with respect to the cathode as long as point T does not bec negative with respect to F, in wh case rectifier c would become ducting. Therefore, during the cycle when H is positive with spect to F, branch c-d could be c sidered as absent, as long as th are no voltages trying to m point T positive with respect to or negative with respect to F. D ing the half cycle when F is po tive with respect to H, similar r soning applies to branch a-b a point R.

When H is positive with resp to F, point R is midway betwe them in potential and the potent of point T is then determined the voltage appearing at this stant across winding RT. If th voltage is less than half of the vo age HF, the conditions for consi ering branch c-d as absent, as o lined above, are fulfilled. Assu that the voltage TR is 4 volts wi T positive, when voltage HF is volts with H positive. Point S m then be 2 volts positive with resp to R. If the meter resistance high compared to the resistances i the rectifier branches, point S wi be also 2 volts positive with respe to point G, and current will flo through the meter in the directio from S to G.

During the next half cycle, F wil be positive with respect to H. Current will flow through branch c-d establishing point T midway in potential between F and H. Branc a-b can now be considered as absent. If the voltage RT is in phase with voltage HF, its polarity will also be reversed, that is, R will now be 4 volts positive with respect to T, and S will again be 2 volts positive with respect to G. Current will again be flowing through the meter from S to G. It is obvious that current would flow through the d-c meter in the opposite direction if the phase of the voltage RT would have been assumed opposite, that is, if T were negative with respect to R during the half cycle when H is positive with respect to F.

Suppose the two waves are 90 deg out of phase, considering them still



THERE is no such thing as a "cure-all" brush for fractional h.p. motor problems.

That's the big point about small, universal-motor problems in general. They're as alike as peas in a pod—*which means they're not alike at all.* They only seem alike superficially, and that's why brush problems begin to pile up.

This becomes more understandable when it is realized that a brush which works best on one make of, say, vacuum cleaner, probably won't work best on another. There are too many points of difference requiring painstaking research and testing to uncover. Moreover, this work must be based on the specific application involved, with full details at hand, and backed by a COMPLETE line of brush types permitting adaptations to any one of hundreds of widely varying conditions that may be indicated.

Stackpole's facilities in this direction are entirely adequate, our record of achievement in solving small-motor brush problems is unsurpassed.

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as square waves. During the cycle when H is positive with spect to F, the voltage RT cha its polarity, resulting in two e but opposite impulses of cur through the meter, which w therefore read zero. If the p displacement is less than 90 the impulse in the one direction be longer than in the other, the meter will indicate.

Voltage HF has been called reference voltage; it might also called the "exciting" voltage of measuring circuit. It does not tribute anything to the reading the meter, as long as it is at le

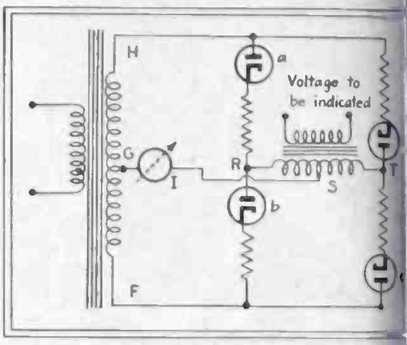


FIG. 3—This simplified circuit of t units shown in Fig. 2 has been draw with vacuum tube symbols replaci the dry rectifiers for convenience terminology

twice as much as the voltage which is to be measured, or tected. In practical applications should not be difficult to bri about this condition, so that meter reading will then be propo tional to the voltage RT to be mea ured.

Sinusoidal Waves

If a sinusoidal wave shape is a sumed, no change in operation sults as long as voltage RT is eith in phase, or 180 deg out of pha with the reference voltage, and less than half of the reference vol age. The meter reading will the be determined by the average valu of the voltage RT.

If a phase displacement betwee two sinusoidal voltages exists, ther will be periods when the instantaneous value of the voltage RT wil be higher than half of the voltage HF (most obviously near the time and at the instant when voltage HF passes through zero). During this period, the original basis that branches a-b and c-d can be considered alternately as absent is not

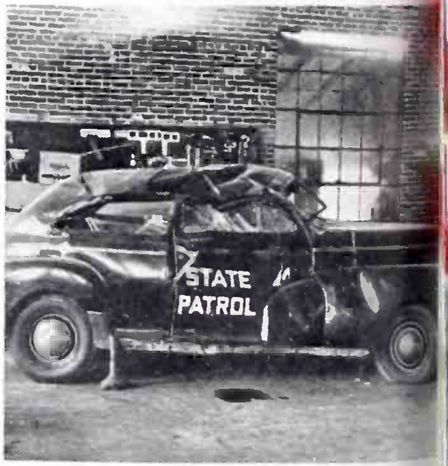
true any more. In the original
alysis, rectifiers d and c were
tirely inoperative during the h
cycle when H was positive, provid
the voltage RT was less than h
of the voltage HF. If this is not t
case, current will flow in one of t
two rectifier elements, in d for
ample when T is more positive wi
respect to R than H is positive wi
respect to G, or in other words,
the voltage RT is more than ha
of the voltage HF. Regardless
this additional current in eleme
d, S will still be positive with r
spect to G, and current will flo
in the meter I the same as und
our original assumption. Only th
proportionality factor between th
indication of the meter and th
voltage RT will change the mome
that rectifier d becomes activ
Qualitatively nothing will chang
when our original assumption (vol
age RT less than half of voltag
HF) is not fulfilled any more. Wit
exactly 90 deg phase displaceme
between the two voltages, the me
ter will read zero; with a phase di
placement less or more than 90 deg
the current through the meter wi
be in one or the other direction.

Application

In control circuits, the meter ma
be replaced by a polarized d-c relay
As possible applications, phase re
versal relays, control operatio

• • •

FREAK ACCIDENT



After an accident, the driver of this Missouri State patrol car was pinned in the wreckage. A Motorola f-m transmitter was torn from its mounting and the antenna bent back almost flat against the side of the car. In spite of the damage, the patrolman made contact with his home station forty miles away to request assistance

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Produced in Stainless Steels (various analyses), and "Monel."

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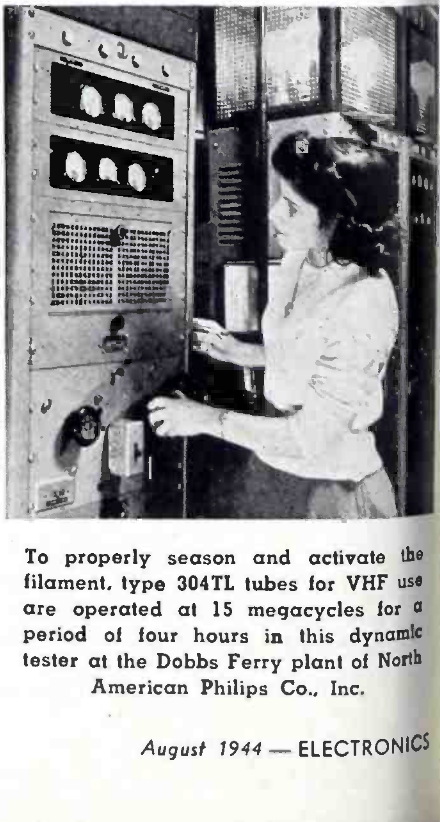
SEAMLESS and Patented LOCKSEAM Cathode Sleeves from a-c operated bridges (res tance thermometers, for instanc come to mind. Another highly val able feature of this circuit is th a voltage differing in frequen from the reference voltage will n cause any reading on the met This means that a 60-cycle ma netic pick-up in the leads will n cause any deflection in the met as it would if the balance indicat would simply indicate the presen of any alternating voltage. Th frequency discriminating action the circuit may provide other e tremely interesting possibilities. the reference voltage has, for e ample, a frequency of 300 cps, meter reading will be obtained on if the voltage RT is also of 3 cycles, or has a component of th frequency, and if this 300-cyc component has in turn a componen in phase (or 180 deg out of phas with the 300-cycle reference vol age.

If the reference voltage is 6 cycles while voltage RT is 59 cycles these two voltages beat together t produce a frequency of one cps. Th d-c meter will then swing from positive to a negative indicatio and back once every second; a max imum positive indication would fo instance be a sign that the two volt ages are in phase, and a polarize relay in place of the meter migh be used for automatic synchroniza tion of a-c generators.

• • •

DYNAMIC TUBE TESTER



To properly season and activate the filament, type 304TL tubes for VHF use are operated at 15 megacycles for a period of four hours in this dynamic tester at the Dobbs Ferry plant of North American Philips Co., Inc.

GOAT is Stamping Grounds for Small Tough Jobs. Shown are a few typical electronic tube parts that have been stamped, drawn and formed on GOAT machines, dies and presses.

We can't juggle . . . but we are pretty versatile in our own way. During the past 15 years we have been called upon to handle a great variety of tough jobs requiring skill, precision, efficiency and versatility. Because of experience gained throughout the years, GOAT has been able to meet the demands of the electronic industry for greater quality, durability and quantity production. Today, GOAT serves almost every electronic tube manufacturer with a tremendous variety of stock and special parts, made of any metal . . . to any required degree of accuracy.

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314 DEAN STREET, BROOKLYN 17, N. Y.

Communication for Trains

(*Continued from page* 107)

breakage, the communications s tem may be rendered inoperat

From a service point of vi rail carrier systems, which r mally operate at low carrier f quencies, utilize portions of the f quency spectrum where many c rier circuits of telephone, telegr and electric power companies n operate. This means that the nu ber of available communicat channels is relatively small, p sibly limiting the use of rail carr systems to operational communi tions only, without provision various passenger services.

Induction Radio Systems

Induction radio systems combi many of the features employed space radio and rail carrier te phone systems. Although ind tion radio systems of the type u der discussion operate at ra frequencies, use is made of combined r-f induction and radi tion fields existing in close proxi ity to loop radiators and waysi wires on which radio-frequency si nal energy is impressed.[3, 4, 6]

Induction radio systems are di tinguished from normal space r dio systems for the reason that i induction radio techniques use made of the localized and highl concentrated r-f induction and r diation fields which exist in clos proximity to loop and other rad ators. These fields are usually co sidered to be within the distanc of 157,000/f feet where f is in k while space radio systems utili the radiation field existant in spa at distances considerably beyon those at which the induction field i effective.

Induction radio techniques diffe from those employed in rail carrier telephone communication systems, in that signal energy at radio frequencies is impressed primarily on wayside wires rather than on rail circuits, while the combined induction and radiation field surrounding these wires is utilized for communication purposes. No conductive connections are required to rail or wire circuits.

Inasmuch as induction radio signaling methods do not employ low-

AFTER THIS WAR
WHAT'S THE RADIO AND TELEVISION BUSINESS
GOING TO LOOK LIKE?

Let's look at television first—everybody else is! Our own deep confidence in the ultimate success of television is founded on long, practical experience. As early as 1938, we were producing television receiving sets commercially. In March of this year we applied for a license to operate our own television broadcasting station. But confident as we are, we try to view television realistically, and with sound business judgment.

HERE'S HOW WE SEE... THE TELEVISION PROSPECT

1. Television has a *great* future.

2. There is tremendous public interest in television. wever, it will be several years after the war before eough television stations can be built to provide full nional coverage.

3. As television broadcasting facilities develop—terrory by territory—good business opportunities will b presented to you . . . and to us.

Wen television broadcasting develops in your terriy, Stromberg-Carlson will have a full line of teleion receiving sets which will bring to this rich field t 50-year-old fact: "There is nothing finer than a Stmberg-Carlson!"

HERE'S OUR VIEW OF... THE RADIO FORECAST

1. There always has been—always will be—a profite demand for a good radio and radio phonograph fine musical instrument.

2. For the immediate post-war years, the expanding rket for FM receivers and phonograph combinans will provide your greatest profit opportunity.

3. We believe that such instruments must have surlative tone quality and an appearance in keeping th the best in furniture design.

AND HERE'S OUR PLEDGE TO HELP YOU TO A PROFITABLE POST-WAR BUSINESS!

1. We will have—soon after Victory—a fine line of Stromberg-Carlson FM and AM radios, phonograph combinations and television receivers in a wide range of prices.

2. We will have a policy of distribution planned to give every Authorized Dealer a good profit opportunity on the Stromberg-Carlson line.

3. And the Stromberg-Carlson name will be even more widely and more favorably known than ever before.

STROMBERG-CARLSON

ROCHESTER 3, NEW YORK

RADIOS, TELEVISION, TELEPHONES
AND SOUND EQUIPMENT

impedance rail circuits which r pidly attenuate signal energy frequencies above 10 kc, relativ low-power equipment, comparab in power output rating, size, weig and cost to space radio equipmen can be utilized for two-way co munication between mobile uni and wayside stations over distanc of 100 miles where normally-exis ent wayside lines are present.

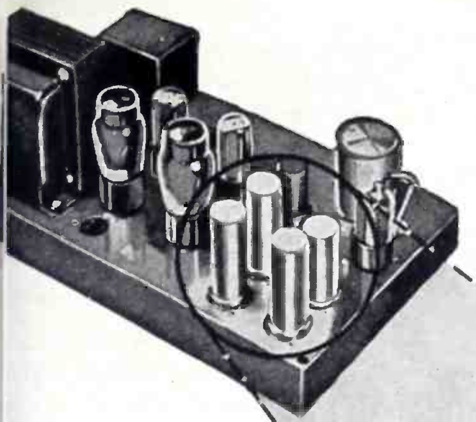
Induction radio systems also hav a desirable characteristic possesse by rail carrier telephone system with respect to restriction in later extent of the signal zone, so tha relative privacy of communication as compared with normal space radio systems, is maintained. Further, at the lower radio frequencies equipment may be operated without Federal licensing providin that such operation is in compliance with FCC regulations.

Since telephone, telegraph, o electric power lines follow closel most all railroad trackage, the extensive wire network required fo operation of induction radio systems on a comprehensive national basis is already largely existent. In the limited number of instances where wires leave the vicinity of the railroad right of way for distances greater than several hundred feet, inexpensive installations of one or two wires across the gap will carry the r-f carrier signals to the points where the normal wire circuits again are in proximity to the tracks.

Induction radio techniques appear to be well-adapted for use in various urban and mountainous areas through which railroads operate. Signals impressed on wayside wires will follow the curvature of trackage in sections where space-radiated signals cannot readily be received without the aid of repeating equipment.

As induction radio techniques are not dependent on rail circuits, damage to the tracks does not prevent effective functioning of the system. Communications may usually be maintained in event of line breaks even though at reduced efficiency (as is commonly the case in carrier telephone installations of electric power companies), because adjacent lines or tracks themselves will often provide an inductive bridge across a break in a line.

The use of radio-frequency car-



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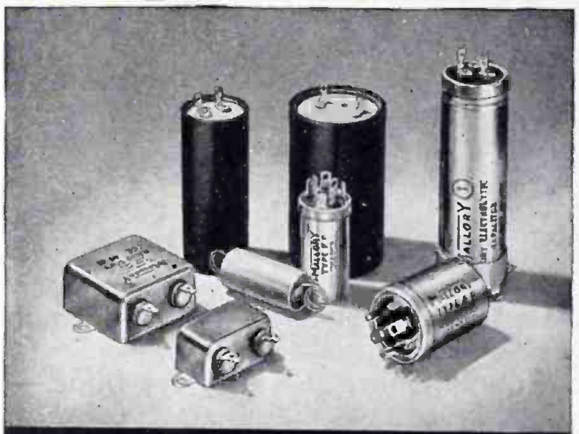

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FILM AND PAPER
CAPACITORS

riers and frequency-modulati techniques also provides relativ high signal-to-noise ratios at rece ing stations where electric no levels are of considerable mag tude, as in electric or Diesel-elect locomotives.

Induction Radio Equipment

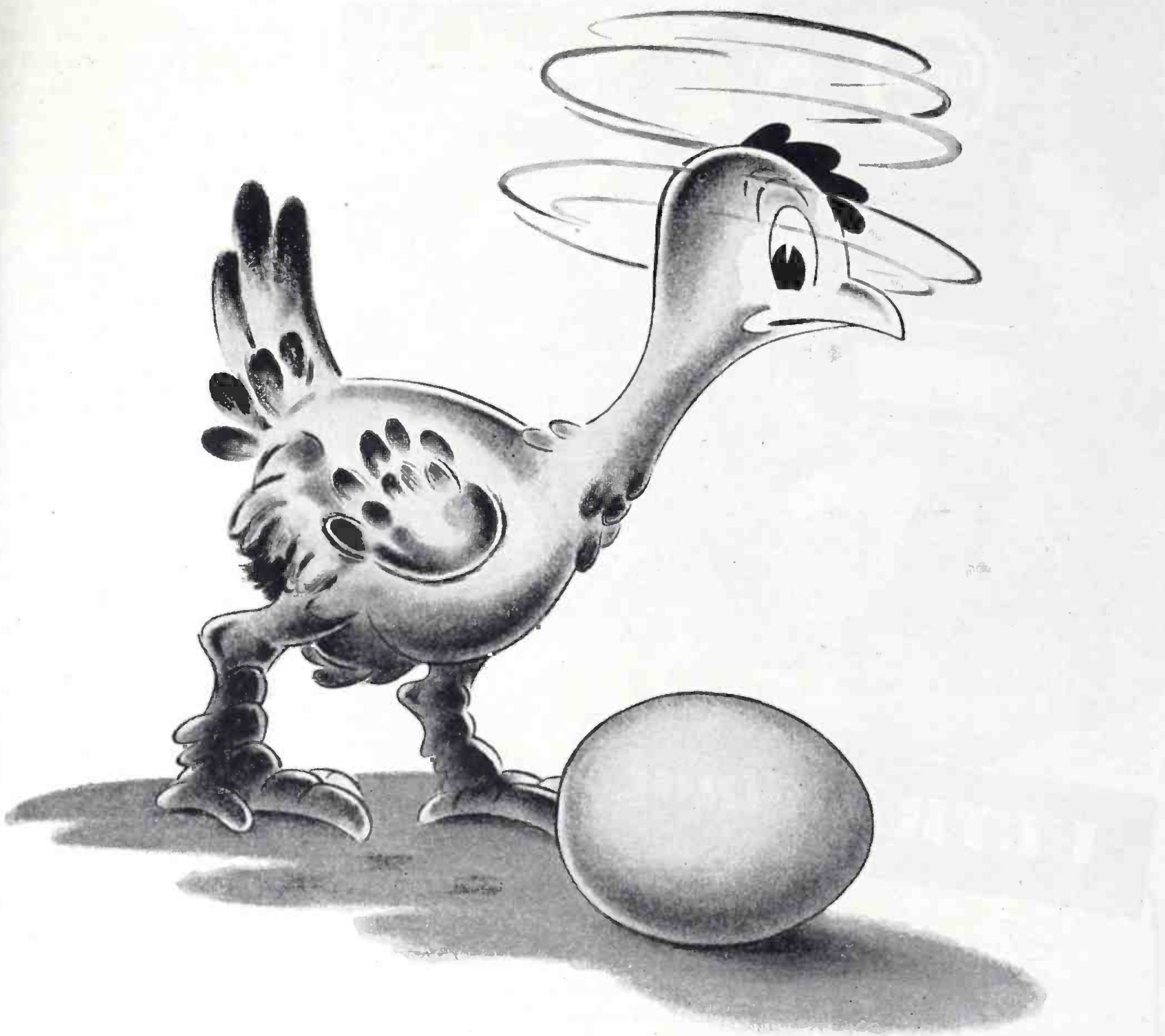
Induction radiotelephone equ ment utilized in railroad and oth traffic communicating servic usually employs central station wayside transmitters with pow output ratings ranging from 3 to watts. Frequencies used are no mally in the portion of the radi frequency spectrum extending fro 50 to 200 kc, although lower higher frequencies may be utilize

Signal energy may be impress on wayside wire circuits throug inductive coupling between th wire circuits and an r-f transmi sion line extending parallel to an in close proximity to such wires, o by means of capacitive coupling be tween the output circuit of th transmitter and the one or mor existing wayside wires which ex tend along traffic lanes. In th former case, the transmission lin or induction cable is usually locate parallel to and several feet from ex isting wayside wires. The line i terminated in its characteristic im pedance to reduce standing waves and resultant excessive radiation from the line.

In induction radiotelephone systems developed by the Halstead Corporation an r-f attenuator unit, usually adjustable in 2-db steps, is sometimes employed in the power output circuit of the transmitter to facilitate regulation of the amount of r-f power impressed on wire circuits without requiring a change in the output loading circuit of the transmitter. This unit also aids non-technical personnel in maintaining optimum field intensity under varying weather conditions, when moisture on line insulators may cause greater attenuation of r-f signal energy than when insulators are dry.

Receiving equipment may be coupled to the r-f transmission line or to one or more wayside wires through suitable capacitors, as shown in Fig. 5.

Although amplitude-modulated induction radiotelephone equipment has been successfully employed in



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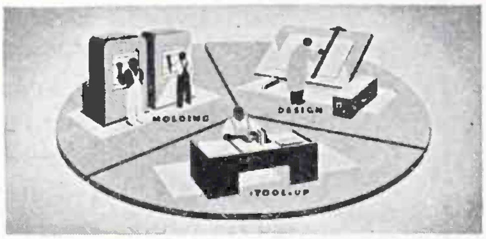

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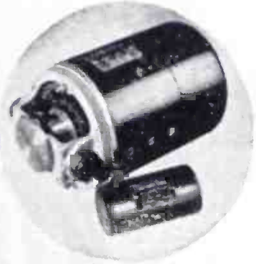


two-way communication service tween wayside stations and locon tives at distances of more than 1 miles, the use of frequency modu tion results in appreciably great signal-to-noise ratios, better over signal quality, and reduction power requirements of mob transmitting equipment. Tests f-m induction radiotelephone sy tems have shown that voice signa of good intelligibility may be r ceived when electrical noise level of such magnitude as to complete over-ride amplitude-modulated si nals of equivalent signal intensit

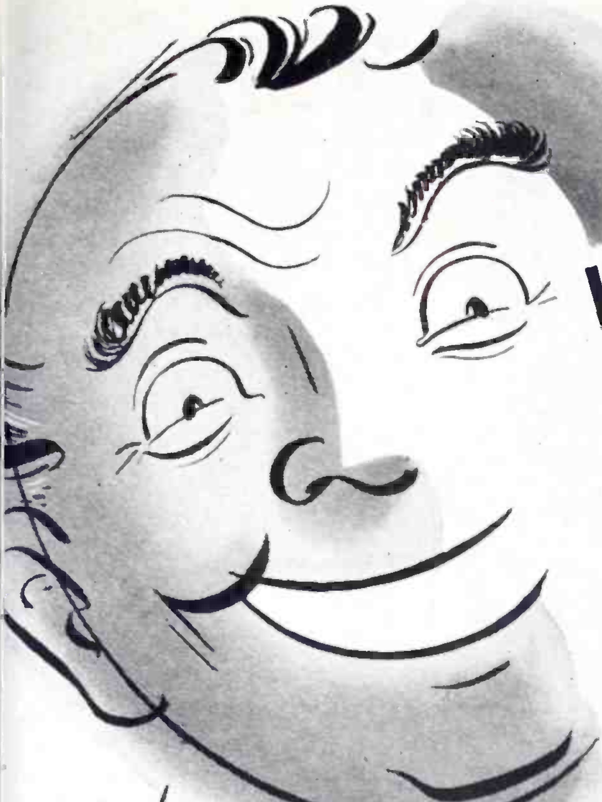
Equipment employed on locom tives and other mobile units usual incorporates transmitters, recei ers and control units similar in ge eral design to that used in conve tional radio practice at the low frequencies, with the exception th a loop antenna is utilized. In som installations the loop is located o the tender or another convenien and electrically-efficient point.

Arrangement of Induction Equipment

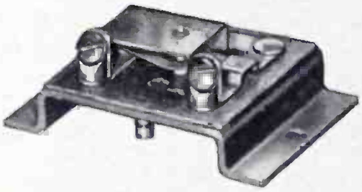
The general electrical arrang ment of transmitting and receivin units employed in induction radi telephone equipment of mobile typ is shown in Fig. 6. Mobile trans mitters having power output rat ings of 10 to 25 watts have been successfully utilized, with power rating usually being dependent upon the size and overall electrical efficiency of the loop radiator.

Receiving equipment normally employs an electronic squelch circuit to effect silencing of the audio-output system except during periods in which an effective carrier signal is being received. A carrier-operated relay is incorporated in the squelch circuit of the receiver to operate a check-light, as in some space radio systems designed for railway service.

Operation of locomotive equipment is such that an intense r-f field is developed in proximity to wayside conductors by the combined induction and radiation fields existent in the vicinity of a loop antenna. The signal energy induced on wayside wires is then utilized for communications purposes, attenuation per unit length of line being sufficiently low to permit maintenance of satisfactory signal-to-noise ratios at receiving loca-

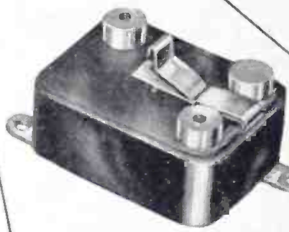


Klixon Snap-Acting Controls can solve your control headaches

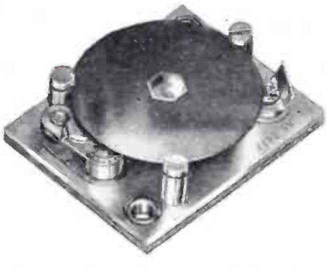


Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

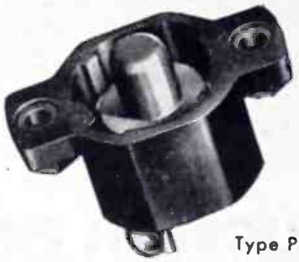
Type ER Series. Ambient Compensated Time Delayed Relays



Type C-7220 Precision Snap Switch. 12 amps. 30 Volts D.C., 125 Volts A.C.

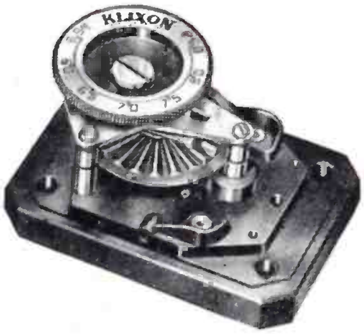


Type B-3120 Thermostat and Heater, Crystal Dew Point Control



Type PM (NAF-1131) Circuit Breaker

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



Type RT Thermostat. Adjustable Temperature Control

If you have a control problem—such as motor or transformer overheat protection, electrical circuit overload protection, thermal time delays or temperature control for radio equipment—there's a Klixon Snap-Acting control that will solve your particular control problem.

Small, compact, light in weight, Klixon controls provide positive, accurate action under all operating conditions. The simple, foolproof actuating element . . . the scientifically calibrated Spencer thermostatic disc . . . snaps to a clean "break" or solid "make". And furthermore, the accurate performance of Klixon Controls is not affected by motion, vibration, shock or altitude.

Klixon snap-acting controls are available in many standard types, such as those illustrated, to fit most control requirements. Write for complete information.

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SPENCER THERMOSTAT COMPANY, ATTLEBORO, MASS.

tions along railroad right of way

In order to expand the usef range of induction radiotelephon systems along longitudinally-e tending lanes of traffic such as rai way tracks and highways, aut matic f-m repeater equipment ha been developed. A representati repeater unit of this type is illu trated in Fig. 7 and 8. This equi ment includes an f-m receiver an associated repeater or zone tran mitter. A carrier-operated rela employed in the receiver is utilize in applying transmitter plate powe during periods in which carrier sig nal energy is received from a pre ceding repeater, central station, o mobile transmitter. The contr circuits are such that the transmit ter may also be locally controlle to permit its use in such waysid points as signal towers and othe selected locations along railroa right of ways.

Repeater Operation

Through the use of automatic repeater systems of this type, signals from a mobile unit or wayside transmitter operating on a given carrier frequency may be received at a repeater station and thence retransmitted automatically at a second carrier frequency to any point along extensive railroad right of ways. In such repeater installations, the audio-visual checking system is of operational value in establishing the integrity of the entire connecting network. A master checking signal is transmitted from the primary control station and is relayed along the repeater network to its termination. Reception of the recurrent checking signal in all locomotives or other mobile units provides aural as well as visual indication of proper operation of the entire system, while the carrier-operated pulse lock-out method prevents interference between the checking signals and voice signals from mobile units or secondary stations.

Operating Cab Signal Lights

An adaptation of the signaling method employed in the checking system provides a practicable and relatively simple means for effecting selective operation of red, green or amber lights within locomotive cabs when supplementary signal in-

Unique research, engineering, tool design 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.

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1/50 H.P. CAPACITOR MOTOR

TYPE J-70

SEVEN weeks from inquiry to delivery . . . 3 weeks to engineer final sample . . . 4 weeks to production.

60 Cycles, 115 Volts • Single Phase-3400 R.P.M. • Low temperature rise • High efficiency: Diameter 3 5/16", Overall length 3 1/8", Shaft diameter 5/16", Weight 3 lbs. Applications are for driving blowers in high ambient temperatures and for powering small control devices of all types.

We Invite Inquiry

This motor can be supplied to deliver 1/25 H.P., can be wound for 2 or 3 phase and also furnished for 400 cycle applications at higher speeds and H.P.

dications of this type are desir Audio-frequency band-pass filte signal rectifiers and relays are co nected with the locomotive receiv to effect selective control of the si nal lights, as shown in Fig. 9, wi relay interconnections being su that failure of carrier signaling ci cuits will cause a red light to energized.

In this application of radio tra fic control techniques, tone signa of definite audio frequency, corr lated with and indicative of su traffic control signals as "stop "proceed", and "caution", are tran mitted to the locomotive cab by low-power wayside transmitter wi an associated r-f transmission li disposed in proximity to the trac for the length of a desired signalin zone. The control signals are als reproduced by the cab loudspeake thereby serving as an aural aid an supplementary check on the visu control indication. Units of thi type may prove to be of particula value on trackage leading to th "hump" of classification yard where substantially continuou control indications are desirable.

Disadvantages of Induction Radio

While induction radio system will undoubtedly be utilized in man important railway services, ther are several important factors to b considered in determining to what extent this type of signaling should be employed.

At points on main line trackage where wayside wires may be buried, installed in lead-sheathing, or where wires run at substantial distances from trackage, as in freight yards, supplementary wires must be installed. While this may be a relatively inexpensive matter in most instances, it does involve some complications.

In the event of floods or severe storms, during which wire lines may be destroyed or damaged for considerable distances, the system is likely to be made inoperative within the damaged area.

As in rail and other carrier telephone services, the number of available communications channels is not great. However, as the effective signaling zone extends only for a limited distance from track areas, this problem may not be of sufficient magnitude to prevent extensive use of induction radio tech-

CHECK TRANSMITTER FREQUENCY IN LESS THAN A MINUTE

THE BROWNING FREQUENCY METER, used by police and other emergency radio facilities for the past five years, is still the best meter for such services — because it was specifically designed for them. The design, which permits determination of any five frequencies from 1.5 to 120 Mc., makes for simplicity of operation which requires less than one minute to check one frequency. All Browning development work aims at specific, rather than broad, uses. Thus, all Browning equipment is best for its particular job. Furthermore, Browning Laboratory facilities are available for study and solution of your own, specific electronic engineering problems. Write for data.

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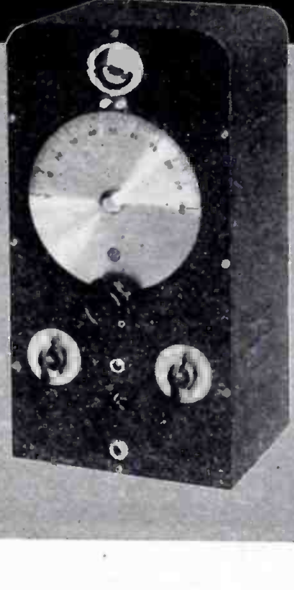

niques, especially along main li trackage.

Conclusions

Although no one at the prese time can predict with any degree certainty the extent to which a of the systems described above w be applied to railroad operation, is believed that comprehensive tes now being conducted will indica to what extent each of the thr systems can best serve the ra road industry.

It is probable, therefore, th within the coming year there w be sufficient technical data and o erational experience to guide ra road operators in properly evalua ing the respective merits of th various systems. Test installatio should likewise provide railroad o erators with tangible evidence the extent to which the variou train communications techniqu can increase the efficiency a safety of rail operations.

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(4) Tune 550—Highway Radio Ahead ELECTRONICS, p. 32, Sept. 1940.
(5) *Proc. I.R.E.*, 29, p. 95, March 194

• • •

ELECTRONIC COLOR RECORDER

In two minutes, this electronic instrument does more accurately what a trained man formerly did in two weeks. The machine is a recording spectrophotometer, used by RCA for testing luminescent materials for cathode-ray tubes, and produces a characteristic curve for each variation of color

CALENDERING

Calendering is a process combining heat, friction and pressure to iron out the surface and produce a desired smoothness of finish.

Rough

Means a grainy, slightly irregular surface comparable to cement smoothed with a wooden trowel.

Smooth

Means an even semi-gloss surface with a flown out, unbroken film.

Friction Glazed

Means a glossy surface rubbed to a high polish. The degree of gloss may be varied to suit use.

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Cloth as woven, is a structural base in or upon which may be built many colorings, finishes and coatings.

Cloth is flexible, has high tensile strength and is very durable. By special processing, cloth serves many purposes. Combining cloth with plastic types of fillings and coatings opens up many new industrial use possibilities.

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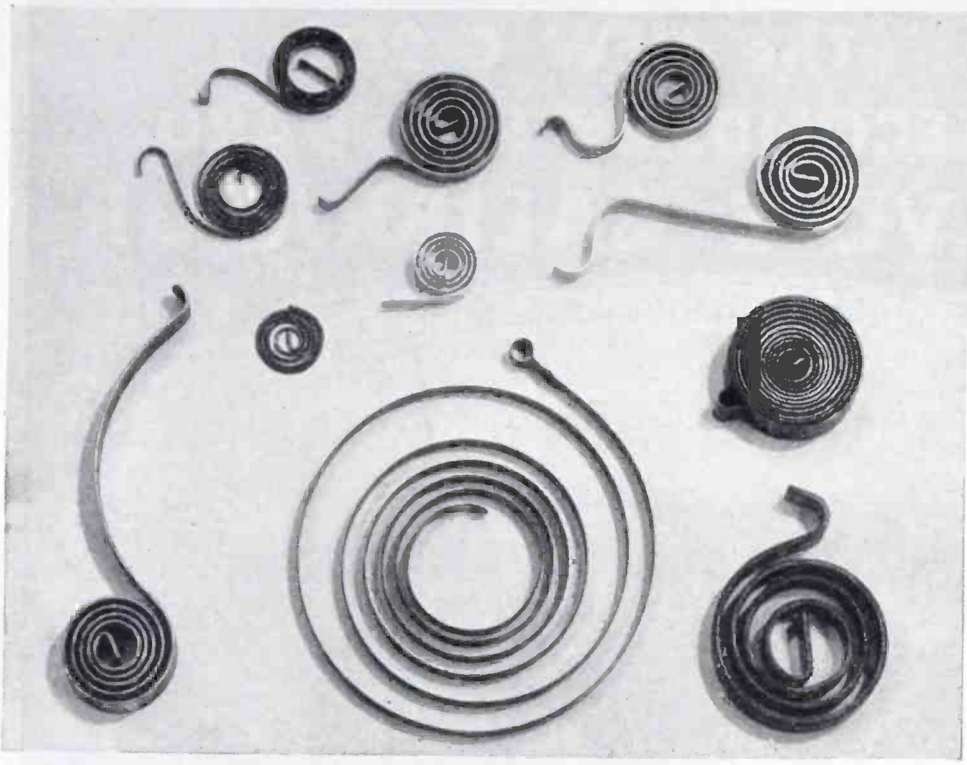
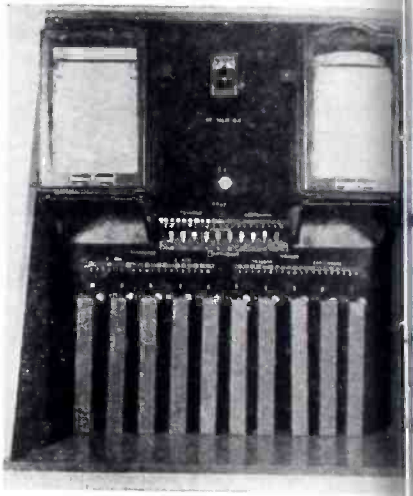


dimensions, initial drain, disch schedule, initial service life, service life after storage.

It is obvious that since mult cell batteries are combination different sizes, numbers, and rangements of cells, an almost limited variety of batteries is sible. It is also obvious that e battery added to the already siderable list of standards creases the difficulty of proc ment, stock keeping, assignmen equipment, shipment, storage, distribution at places of use. T combined with the fact that all batteries have a limited shelf l depending to some extent on



Automatic battery test set provide choices between continuous and pro gram loads with panel-light indicatio and moving-chart records of results

conditions of storage, makes it e tremely desirable that the standa list be kept to the absolute mi mum consistent with the fulfillme of all necessary requirements. T this end it has been arranged th no additions can be made to t standard list until necessity h been proved and proper authorit secured.

The latest specification in use Signal Corps Tentative Specifica tion 70-21-P—Bureau of Ships A Interim Spec. 17-B-7 (Int.), wa formulated by representatives of the Army, Navy, and industries under the direction of the SCSA. This specification provides standards for both the Army and the Navy and facilitates procureme of batteries for all services by one agency. This original specification is to become a joint Army-Navy specification to be know as JAN-B-18.

Recent studies have resulted in

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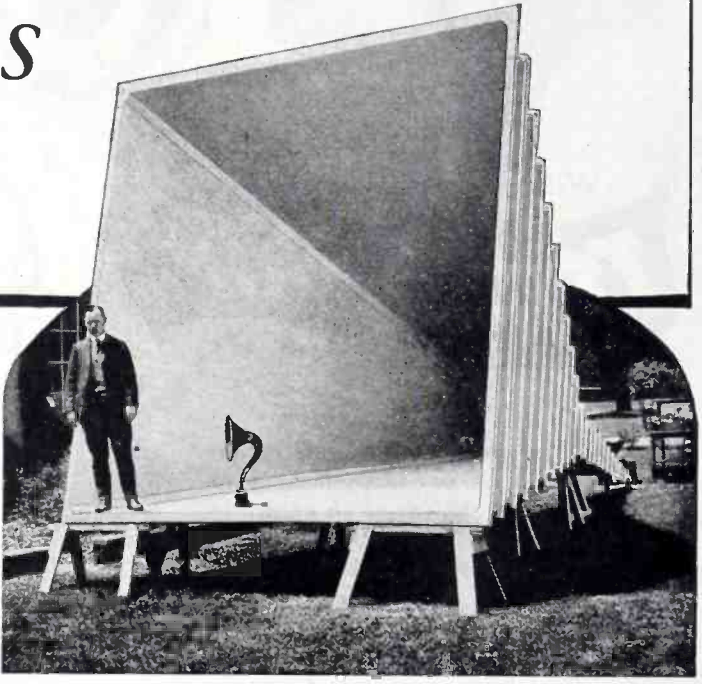


Largest loud speaker ever built—heard 9 miles. Built for Idora Amusement Park, Oakland, Cal., in 1922. Standing in the speaker is E. S. Pridham, now a vice-president, one of the founders of Magnavox, and co-inventor of the electro-dynamic speaker.

THIS GIANT SPEAKER was a Magnavox development of twenty years ago . . . an early example of the pioneering by which Magnavox has produced so many outstanding contributions to the radio industry. Among those contributions was the electro-dynamic speaker, the "voice" of all modern electronic sound reproduction.

Present wartime experience will enable Magnavox to serve the peacetime needs of the radio industry even better than before. With stepped-up efficiency and the excellent facilities of the modern six-acre plant, Magnavox will again supply components for radio manufacturers, and will figure prominently in the coming peacetime developments of electronics. The Magnavox Company, Fort Wayne 4, Ind.

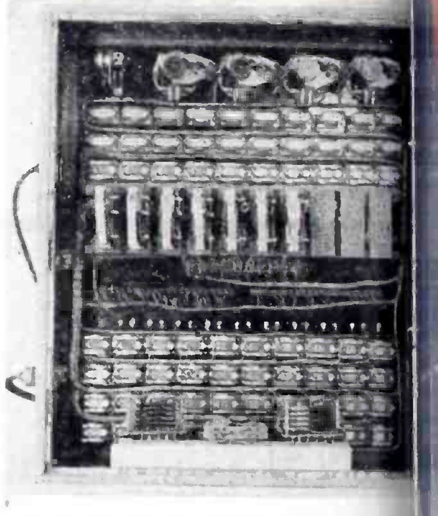
Magnavox craftsmanship won the first "E" award in this field (1941), now with 3 White Star Renewal Citations.

Magnavox

LOUD SPEAKERS • CAPACITORS • SOLENOIDS **COMMUNICATION & ELECTRONIC EQUIPMENT**

the adoption of standard proc ures and materials for moistu proofing assemblies and jackets dry batteries to meet the se climatic conditions prevailing tropical areas. This treatme now generally followed by batt manufacturers, consists of impr nating and coating assembly ma rials and jackets with a suita moisture resistant wax.

A standard packaging specifi tion has been formulated under rection of the Signal Corps Stor and Issue Agency in Philadelph and is now generally followed manufacturers. This specificati



Rear view of test set illustrated show how interchangeable resistor bank plug in on banana-pin base mount

requires that batteries be package in vapor proof bags which give pro tection from moisture and fungu during shipment and in storage These steps are expected to b effective in protection during shipment, storage, and service regard less of the area in which batteries are to be used.

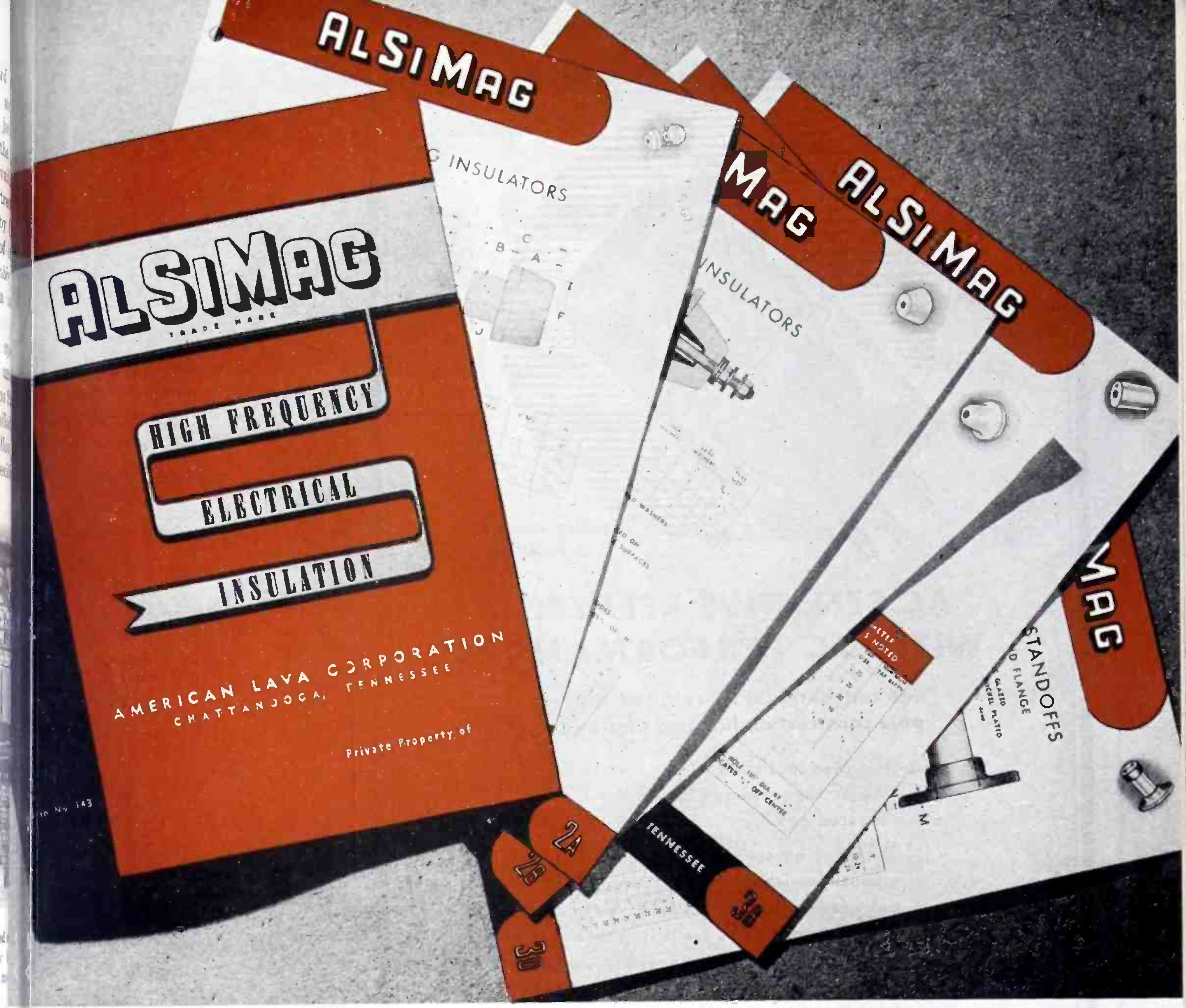
Practical Benefits

Benefits which accrue from th program of testing, specification writing, and standardization are many, among which are the following:

(a) Procurement of batteries for Signal Corps use is restricted to a reasonable number of standards.

(b) Very large numbers of the major types are ordered and used, permitting continuous-quality manufacture on assembly lines in the most efficient manner possible.

(c) Various services utilize the



ANNOUNCING BULLETIN NO. 143

Every engineer in the electronic field will appreciate the concise method in which the Electrical and Mechanical properties together with the design and dimensions of AlSiMag High Frequency Insulators have been arranged and tabulated for easy and quick reference in new Bulletin No. 143.

The AlSiMag insulators described are those most commonly used in high frequency applications. *Deliveries can now be made within a reasonable period.*

Note: *When requesting copies please include name and position of others in your organization to whom we should send Bulletin No. 143 so that you may retain your own copy.*

The insulators described in Bulletin No. 143 represent only a small portion of our output. Specially made insulators to customer's specifications are our principal products. Our Engineering Staff will be glad to cooperate on your designs.

AMERICAN LAVA CORPORATION
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ARMY E NAVY

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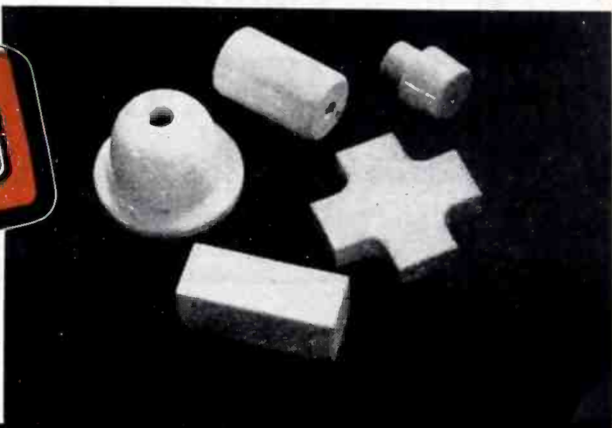


AC SENSITIVE RELAYS...
WITH DC PERFORMANCE

The conventional AC relay of shaded pole construction has two limitations.

(1) Its power sensitivity is only a small fraction of that afforded by the same relay operated on DC.

(2) It cannot be successfully operated on a gradually variable voltage or current without passing through states of instability and chattering. This limits its usefulness to circuits in which the input is sharply changed from one level to another and rules it out for sensitive control on continuously variable AC.

SIGMA has perfected a complete unit which is an adaptation of most SIGMA Sensitive relays to AC operation with neither of the above disadvantages, by incorporating within the relay housing a midget selenium rectifier of the full wave type, with or without a filter condenser as circumstances dictate. Operation is attained on continuously variable AC with no instability or chatter, and at practically the same power sensitivity afforded on DC. Unit is more compact and saves space.

Suggested Operating Ranges: higher voltages may be used with series resistors mounted with the relay enclosure.

Type 4 MBR
4.0—12.0 volts
5.0—35.0 ma.

Type 5 MBR
4.0—12.0 volts
0.5—10.0 ma.

SIGMA

Sigma Instruments, INC.
Sensitive RELAYS

NEW ADDRESS
62 CEYLON STREET
BOSTON 20, MASS.

In this push-button test kit, standar battery types BA-42 and BA-59 an shown in relation to their means o connection. This unit is part of tes set IE-10

same standards, permitting simpl fication of placing orders by o agency for all requirements.

(d) As a result of the intensiv program of testing, research, an standardization, there has been marked improvement in quality an performance of batteries.

(e) Groundwork has been lai for further advances and modifica tions as may be required for batter ies for use in tropical and arcti areas. Already improvements along these lines are well under way.

(f) Stock keeping and issue of batteries is simplified in depots and using areas.

(g) A mass of technical data and experience has accumulated, providing a more definite and scientific approach to the application of batteries for services of all kinds.

The accomplishment of this standardization under the direction of SCSA has included the utilization of much previous work done by such organizations as the National Bureau of Standards and

Besides miscellaneous tools and transceiver handset, case CS-79 contains batteries BA-39 and BA-40. Unit is power source for radio set SCR-509

The American Standards Associ tion. It has also been aided b efforts of the battery manufactu ers and by personnel of the arme forces.

Before the issuance of the spec fication it had been customary t design each type of battery to th equipment with which it was to b used. Current practice is to desig the equipment to use an approve Signal Corps type battery. Signa Corps dry batteries are not standardized for general Signal Corp use but rather for use with individual equipment. The Standard Agency is charged with approva of batteries for each particular us intended and manufacturers ma not use other batteries than thos so approved.

Prosperity Among Broadcasters

ON THE FIRST ANNIVERSARY of effectuation of FCC chain broadcasting regulations, Chairman James L. Fly announced that broadcasting stations as a whole earned 50 percent more, before income taxes, in 1943 than in 1942.

Specifically, NBC's earnings went up from 137 to 190 percent of the value of its property, CBS from 97 to 158 percent, Blue from 8 percent to 149, and Mutual 59 to 84 percent.

For 1943, 723 stations reported income, while 73 reported losses. Total income was $46,850,189, while total losses were $368,792.

Research for Communications and Radar Leadership

CONTINUOUS RESEARCH is an activity which is keeping this country in the lead in military electronics, according to Major General Harry C. Ingles, Chief Signal Officer, who appeared before a House Committee to discuss his 1945 budget.

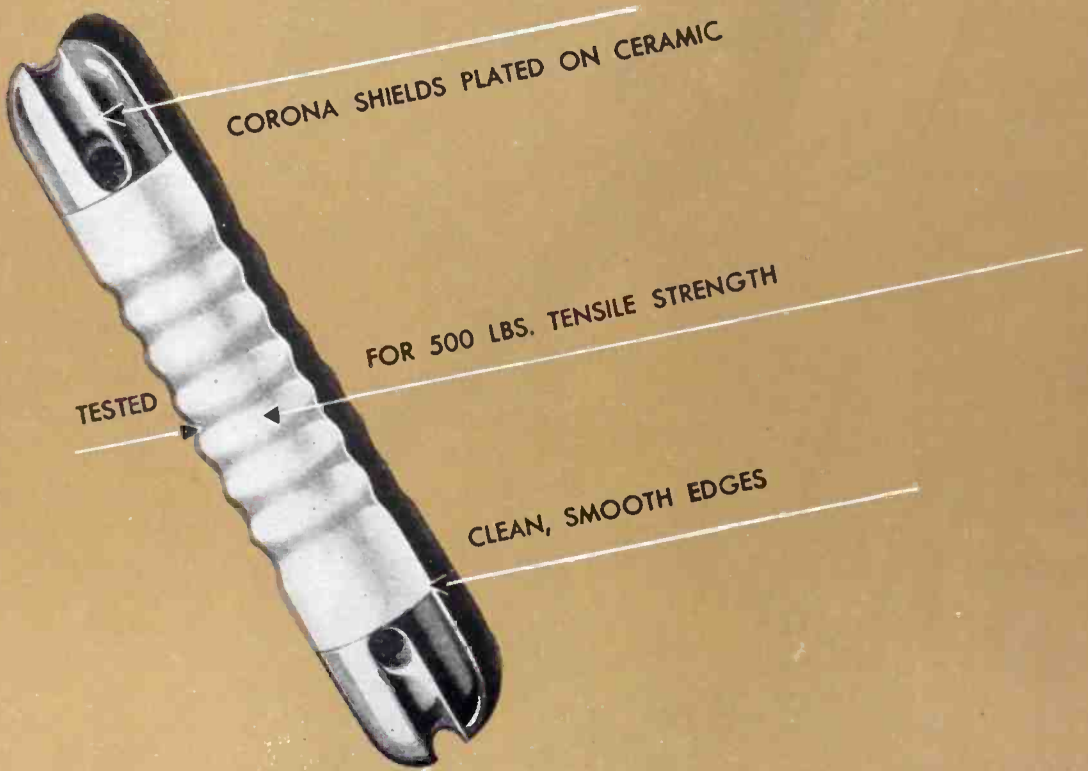
The $50,000,000 requested was characterized as essential to development work on low- and high-level blind bombing, blind landing, other air navigational equipment, control equipment for guided missiles, radio counter-measure equipment, radio relay systems and equipment for front line use.

He described American signal equipment as the equal of German

Presenting

A BASICALLY BETTER

ANTENNA STRAIN INSULATOR



A development of Bendix Radio* Creative Engineering, this new antenna insulator effectively removes the dangers attendant on loosening of corona shields. The shields *cannot* come loose because they are plated directly on the ceramic—so insolubly bonded as to make a single unit of ceramic and metal. Careful manufacturing processes provide a clean, point free edge on the metal shield to further reduce the tendency of corona discharge.

The result? Well, tested in a pressure chamber duplicating 40,000 feet altitude the Bendix Insulator forced a spark jump of 10 inches between the transmitter and chamber wall without allowing current to cross the insulator.

Baffle-designed to reduce flashover—*and tested to 500 lbs. tensile strength*—this performance-proved Bendix development is now available for general use.

*TRADE-MARK OF BENDIX AVIATION CORPORATION

Bendix RADIO DIVISION

BENDIX AVIATION CORPORATION • TOWSON, MARYLAND

TANDARD FOR THE AVIATION INDUSTRY

apparatus in every way and fa superior to Japanese. He sai American radar is better than tha of Germany.

Savings during the next fisc year have been made possible b contract terminations and price renegotiations and savings. He observed that signal equipment price have been reduced approximately 1 percent. Quantity production an increased experience among manufacturers were credited. Price estimates are being made more accurately by the Signal Corps, too, he said.

One type of combat radio had been reduced from $6,370 to $3,729 while one piece of radar equipment, after having been built in considerable number, was cut from $40,000 to $20,000. Component prices have been similarly reduced.

American Transmission to Europe

RADIO ACTIVITIES of the Psychological Warfare Branch of OWI include the establishment and operation of radio facilities to spread our messages on the continent of Europe.

Four 50-kw medium-wave transmitters and at least four powerful shortwave transmitters are beamed to the Continent from points in America, England, North Africa, and Italy.

Thus, reception is practically assured for any listener with a short or medium-wave receiver in any part of Europe. Additional transmitters are in readiness for installation on the Continent.

No listener surveys have been made, but indication of effectiveness is given by the fact that originally severe penalties for listening have been made even most drastic by German occupation authorities.

Conventions to Come

Aug. 29-Sept. 1. Pacific Coast Technical Meeting, Los Angeles, Calif. **American Institute of Electrical Engineers**, H. H. Henline, secretary, 29 West 39 St., New York 18, N. Y.

Sept. 18–20. Eleventh Annual National Conference, Toledo, Ohio. **Associated Police Communication**

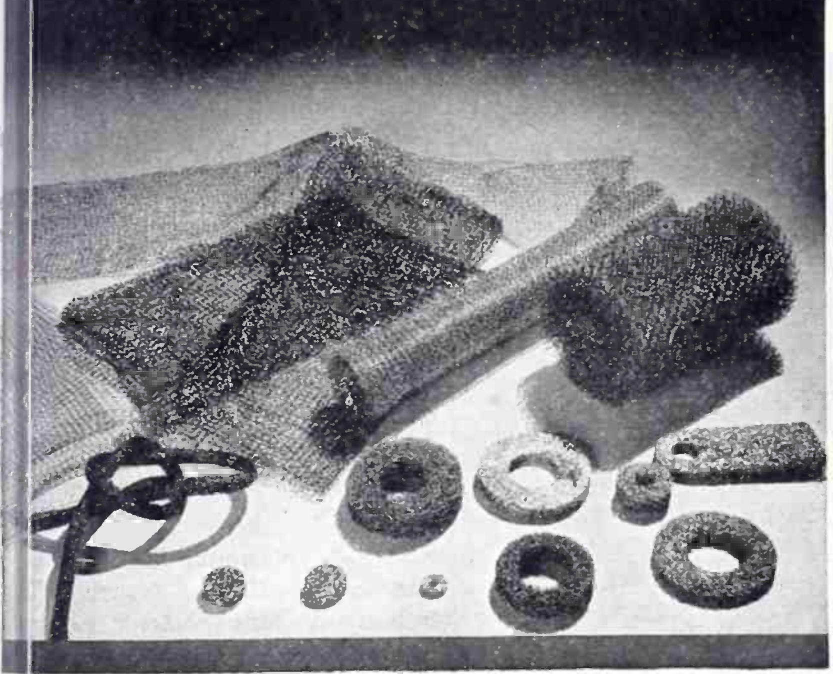
"I want A FLEXIBLE GASKET TO WITHSTAND 2000° F." said the airplane part maker

"I want A RUSTLESS, DURABLE PRESSING PAD" said the laundry operator

"I want A FINE TUBE GRID THAT WON'T SAG" said the electronic tube maker

"I want A LASTING WICK FOR AIRPLANE HEATERS" said the cabin heater maker

They found what they wanted in KNIT MESH made of INCO Nickel Alloys



Today, metal mesh knit from INCO Nickel Alloys does *all* these varied jobs.

Tomorrow? Perhaps it's the answer to an electronic problem now on *your* drafting board.

For Knit Metal Mesh, product of the Metal Textile Corp., Orange, N. J., has many properties that point to its wide future use in electronics.

Knit from Monel, Nickel or Inconel, it is rustless corrosion-resistant, tough, strong, able to withstand high temperatures. In addition, its special *linked-loop* design is flexible, highly resistant to breakage, unusually strong on the bias. It offers, for instance, a firm fabric for grids because the linked loops allow normal expansion when the grid is heated, and return the fabric to its original shape as the grid cools.

The knit fabric holds together even when made of very fine wire (.0045 diameter), and with as few as 4 or 5 openings to the inch.

For further information about mesh knit from the INCO Nickel Alloys . . . and for other technical service on metal problems . . . address: The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

"I want A BETTER AIR FILTER MEDIUM" said the filter manufacturer

"I want A FLEXIBLE STRAP THAT WON'T JIGGLE LOOSE" said the magneto maker

NICKEL INCO ALLOYS

MNEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • "Z" NICKEL • NICKEL • Sheet . . . Strip . . . Rod . . . Tubing . . . Wire . . . Castings

Officers, Sgt. C. H. Knudel, chai man, 720 Jefferson Ave., Toledo Ohio.

Oct. 2-5. Forty-Ninth Annual mee ing, Boston, Mass. **Internation Municipal Signal Associatio** Irwin Shulsinger, secretary, East 41 St., New York, N. Y.

Oct. 5–7. **National Electroni Conference,** Chicago, Ill. B. Du ley, secretary, 520 N. Michiga Ave., Chicago, Ill.

Oct. 12–14. Fall Meeting, Buffal N. Y. **Electrochemical Societ** Colin G. Fink, secretary, Columbi University, New York 27, N. Y.

Oct. 16–18. Fifty-Sixth Semi-Annual Fall Conference, New York N. Y. **Society of Motion Pictur Engineers,** W. C. Kunzmann, vic president, Hotel Pennsylvania New York, N. Y.

Oct. 16–19. Twenty-Fifth Annua Meeting, Cleveland, Ohio. **American Welding Society,** M. M. Kelly secretary, 33 West 39 St., Ne York 18, N. Y.

Oct. 19–21. Electronic Parts and Equipment Industry Conference, Chicago, Ill. **Association of Electronic Parts and Equipment Manufacturers; Eastern Div., Sales Managers Club;** and **National Electronics Distributors Association.** H. W. Clough, chairman, PO Box 5070-A, Chicago 80, Ill.

Nov. 2–3. National Time and Motion Study Clinic, Chicago, Ill. **Industrial Management Society.** C. S. Becker, vice president, 205 West Wacker Drive, Chicago 6, Ill.

Nov. 13–14. Annual Receiver- and Tube-design Meeting, Rochester, N. Y. **Radio Manufacturers Association** and **Institute of Radio Engineers;** Bond Geddes, secretary RMA, 1317 F St. N.W., Washington, D. C.; Haraden Pratt, secretary IRE, 330 West 42 St., New York 18, N. Y.

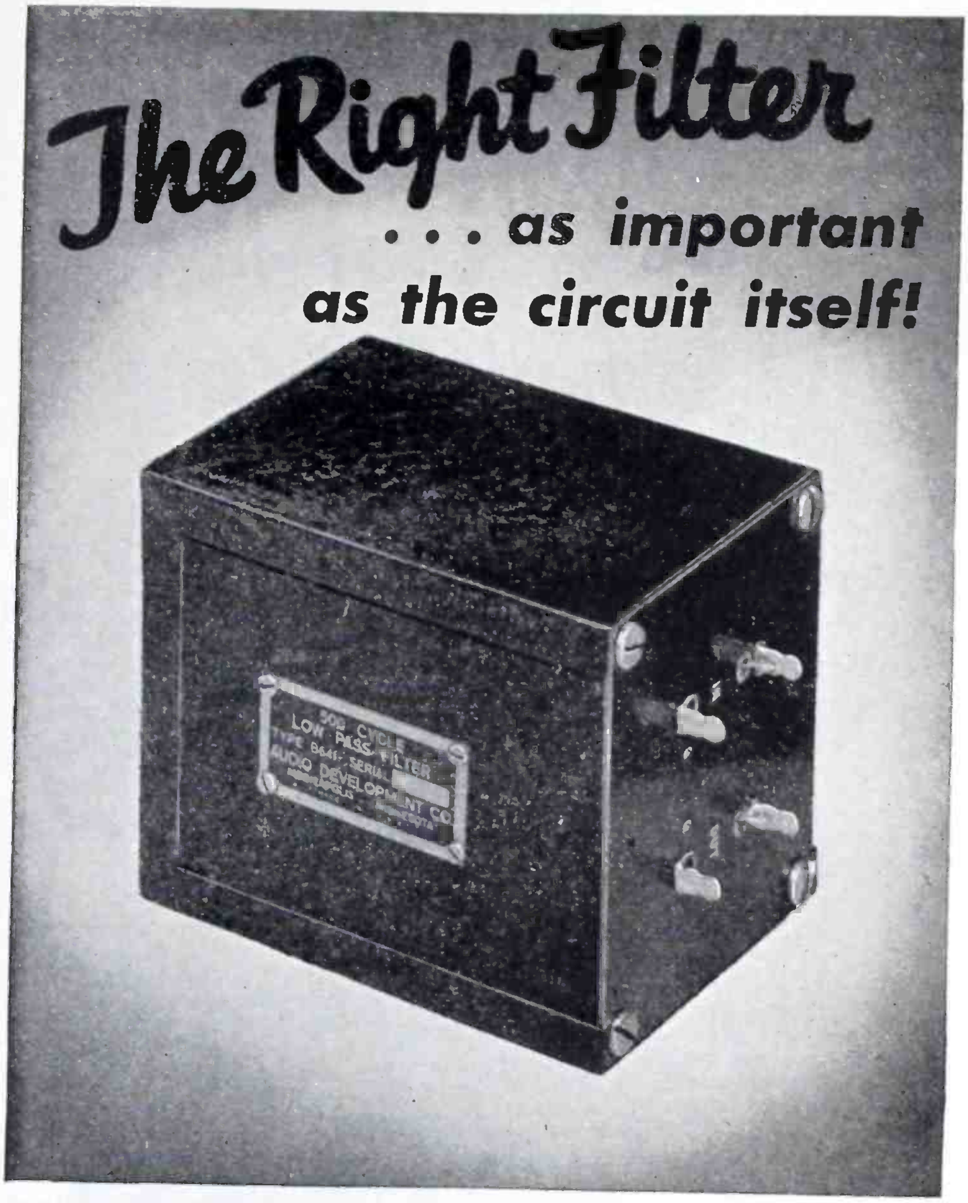
Signal Corps Is Pleased

NOTHING HAS BEEN MORE striking than the achievement of the electronic design and manufacturing groups, in the opinion of Major General William H. Harrison, chief of the Procurement and Distribu-

STION: Has your company considered selection of
War radio air condensers?

It isn't too soon to plan. And in planning, take into consideration the importance of the air condenser. Recall how very much our armed forces today depend upon communication sets, and the necessity of accurate tuning to get every message distinctly. It is significant that variable air condensers of Radio Condenser Company are used by our armed forces. Why wouldn't they continue to be a good bet after the war? Plan — and use — our air condensers and push button tuning devices in your post-war manufacture of radios.

RADIO CONDENSER CO.
CAMDEN, N. J.
RADIO CONDENSER CO. LTD., TORONTO, CAN.



tion Service of the Signal C He was conveying the thanks o organization to the industry talk before RMA in Chicago cently.

In addition to creating a s tion where our invasion forces lacked no essential signal eq ment, the industry is credited supplying complete equipment French and Italian units. He stantiated the belief that all of equipment outstripped that of enemy in dependability, flexibi range, and general performanc

Electronic Production Of

WPB ANNOUNCES that communi tion and electronic equipment fe percent below the level of Ma production during April and wa percent behind schedule. Radio declining program, fell 5 perc short. Airborne equipment, a r ing program, was 6 percent beh and ship communication and el tronic equipment was 4 percent while ground equipment was 1 p cent ahead.

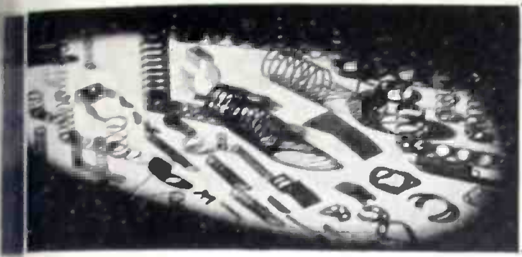
LONDON NEWS LETTE

By John H. Jupe
London Correspondent

Recording High Speed Transient At a lecture recently delivere before the Association for Scie tific Photography some interes ing data was disclosed, togeth with records taken from a cr screen at frequencies up to 41 M In this case the maximum writin speed was 3,800 km per sec—1/8 the speed of light—yet the recor was quite clear and occupie about 8 complete cycles.

The lenses used were a 2-i focus with an aperture of f/1.9, and a series of 1-in. focus, with apertures ranging from f/1.9 to f/1.4 There was also a special lens constructed by Taylor, Taylor and Hobson for the Kodak research department with a 2½-in. focus and an aperture of f/1.

In the opinion of W. Nethercot, who conducted the work for the Electrical Research Association, the fastest films were orthochromatic, Kodak R.55 or Ilford 5.G.91. The very slight increase in speed obtained by using panchromatic emulsions was not judged to out-



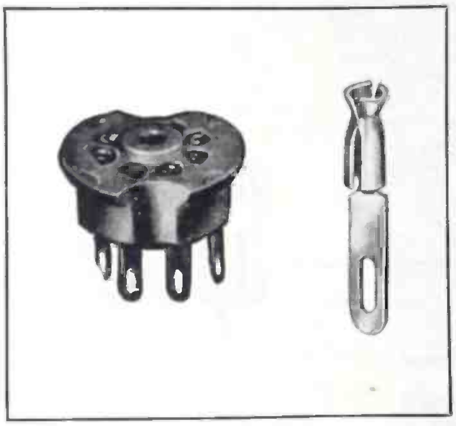
The I-S SPRINGBOARD

VOL. 1 NO. 1

Published by **INSTRUMENT SPECIALTIES CO., INC.**
258 BERGEN BOULEVARD LITTLE FALLS, NEW JERSEY

EWORTHY FACTS ABOUT MICRO-PROCESSED BERYLLIUM COPPER

OUTSTANDING TUBE SOCKET PERFORMANCE DIRECT RESULT OF MICRO-PROCESSED BERYLLIUM COPPER

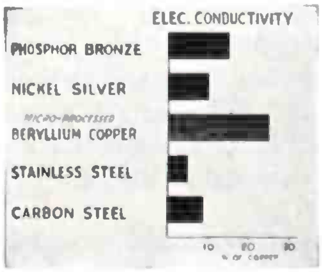


Instrument Specialties is producing in large quantities a new tube socket contact which assures uniform, constant pressure on the tube pins under conditions of extreme vibration and temperature. This contact was designed to take full advantage of beryllium copper, permitting intricate forming prior to heat treatment, and SELECTIVE HARDENING, a new heat treating technique. The spring end of the contact is hardened to a tensile strength of 180,000 lb. per sq. in. (Rockwell 15N-80) for maximum stability, and the tab end is heat treated to 50,000 lb. per sq. in. (Rockwell 15N-40) for ductility and ease of soldering leads.

These micro-processed beryllium copper contacts have maximum vibration stability, minimum drift under load, and high conductivity, giving low electrical losses.

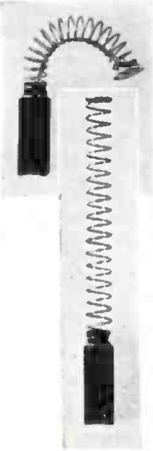
The entire socket, produced by H. H. Eby, Inc., Philadelphia, was made to specifications and designs of the Signal Corps Laboratory, Ft. Monmouth, N. J.

Micro-Processed Beryllium Copper Has Highest Conductivity Of all Spring Materials



Before heat treatment, the conductivity of Beryllium Copper is the same as phosphor bronze. Conductivity increases during heat treatment, and response varies with each lot of material. Micro-processing is the only sure way of obtaining the value shown above, and at the same time reaching maximum overall spring properties. Still higher conductivity values are obtainable at [illegible] sacrifice in other properties.

BRUSH SPRINGS WITHOUT SHUNTS SAVE UP TO 30% ON ASSEMBLIES



Beryllium Copper^{mp}, with its high conductivity (see chart) and ability to stand 100°F higher working temperature, plus closer tolerances on the ID has eliminated the need for pigtails on brush springs in many light duty applications. I-S unshunted brush springs are far easier to assemble, give longer service life at peak loads, and assure constant, even pressure at all times. Send drawings to I-S or write for I-S brush spring data sheet.

One order for 1,250,000 contact coil springs is being micro-processed by I-S at the rate of 250,000 per week.

WHAT DOES 200,000 LB. PER SQ. IN. TENSILE STRENGTH MEAN IN SPRING PERFORMANCE?

The higher strength of Certified "Silvercote" Beryllium Copper wire used in I-S coil springs allows a 25% increase in design stress over ASTM spec. wire. This makes it possible to design a satisfactory spring in a smaller space, and also greatly increases life under endurance service. Resistance to drift is increased 5 to 20 times, an important advantage in a variety of every-day spring applications.

LITERATURE

DO YOU HAVE ON FILE?
Recent technical article by Sheldon Klock, I-S Field engineer, points out contributions of Micro-processing in improving performance of electronic equipment, and accomplishing results impossible with conventional spring materials. Write for your copy today.

FROM THE I-S LABORATORY

Cleaning Beryllium Copper Springs in Preparation for Soldering and Electro-Plating

Two standard cleaning methods that give excellent results on Beryllium Copper:

1. Sulphuric-Bichromate Pickle

sulphuric acid	1 gal.
water	4 gals.
sodium bichromate	3 ozs. per gal.
temperature	140°-180° F
time	½ to 10 mins.

Parts should be agitated in solution to insure uniform attack. Time should be kept to the minimum needed to prevent loss of spring pressure and to avoid pitting. Rinse with cold water.

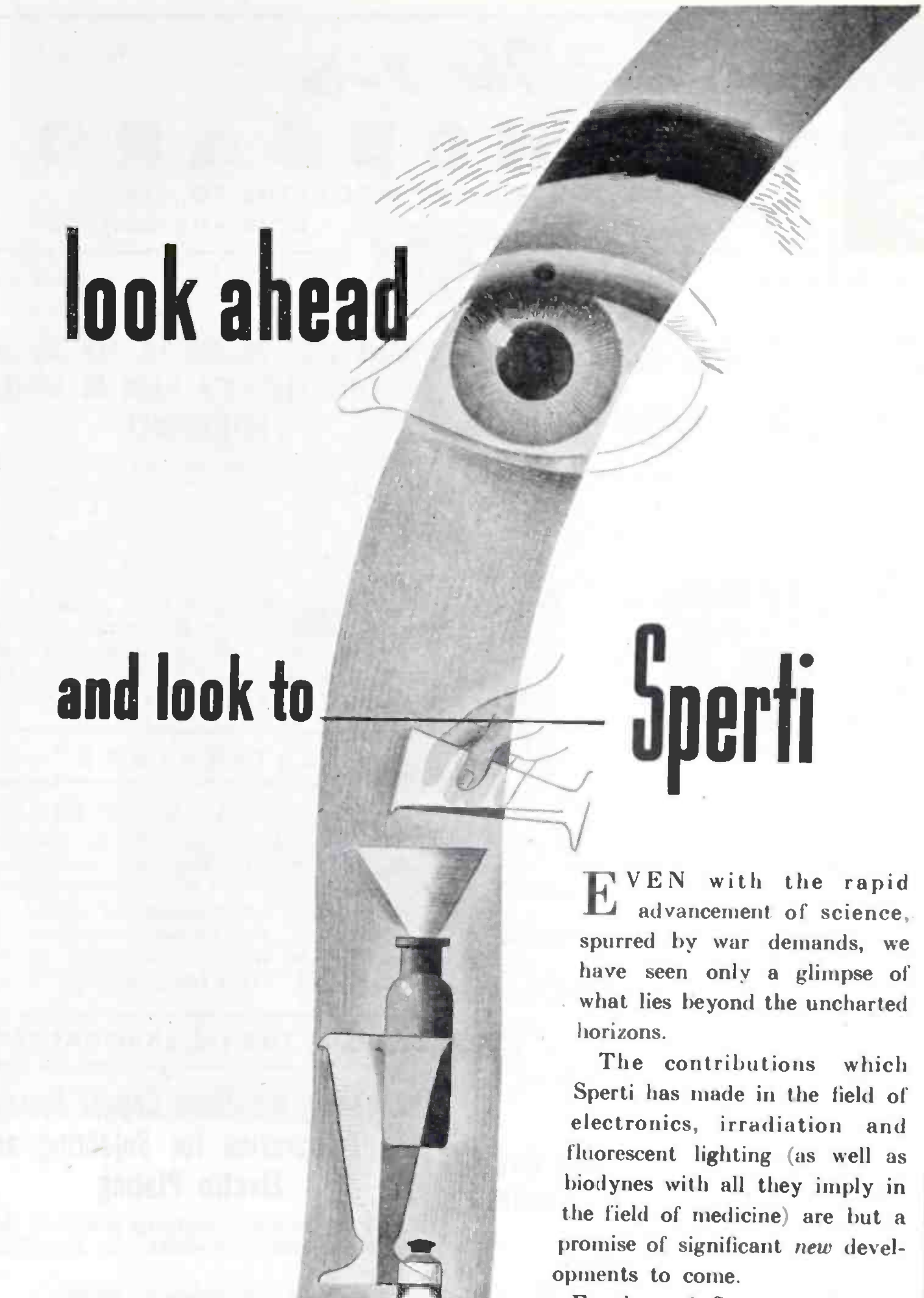
2. Bright Dip

Solution #1 may be used cold as a bright dip or a typical bright dip as follows may be used:

sulphuric acid	2 gals.
nitric acid	1 gal.
water	1 qt.
hydrochloric acid	1 oz. per 5 gals.
temperature	cold
time	5 seconds to 5 mins.

Rinse in cold water followed by a hot water rinse to aid in rapid drying.

Parts having a very light oxide surface such as results from salt bath heat-treatment, may be satisfactorily cleaned by using only the bright dip solution. Such parts will then readily electro-plate or solder.



weigh the additional difficul encountered. Recommended velopers were Kodak D.19b a Ilford I.D.33, followed in so cases by treatment with urani intensifiers. For paper pri high contrast papers such Kodak BG.4 or 5, or Velox VG were used with very good resul

Needless to say, only small n atives could be obtained, as, wit out very bulky camera equipme the lens must be near the oscil graph screen, with consequent r duction in its depth of focus. D focussing due to curvature of t screen and distortion due to t trace being at the edge, set furth limits but a 5-in. screen was fou to have a useful working ar about 4 in. in diameter.

Placing the film in direct co tact with the screen produc fairly satisfactory results up about 6 Mc but the results usin a camera were far better. Th method was adopted for most the work, which represents a bi advance in the recording of hig speed transients at reasonabl cost and without undue difficult

Police and Fire Radios Separated

CITIES WHOSE FIRE DEPARTMENT serve a population of 150,000 o more and smaller localities with special problems are eligible fo special municipal fire frequencies independent of their police channels, according to the terms of a recent act by FCC.

Available frequencies are 1630, 35580, and 37740 kc. Although only one vhf will normally be assigned to any locality, additional ones can be considered in the light of special needs.

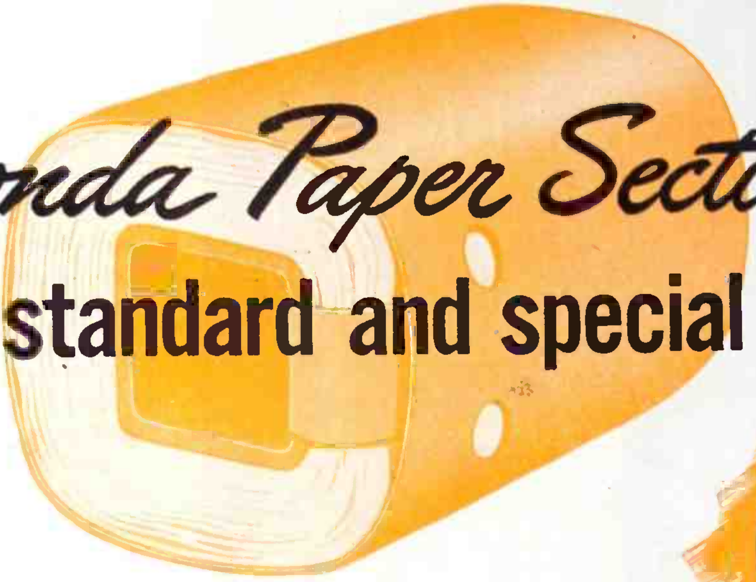
Power, in general, is restricted to 250 watts, while authorized types of emission are: A-1, A-2, and A-3 on 1630 kc; A-1, A-2, A-3, A-4, and special emission for fm on 35580 and 37740 kc.

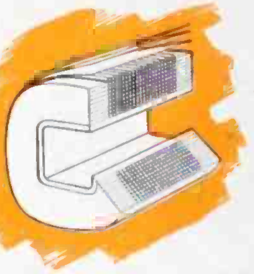
How Television May Grow

AUDIENCES FOR FUTURE TELEVISION entertainment may get their first taste by blind listening to the audio components of television broadcasts if the predictions of Leonard

Anaconda Paper Section Coils

...all standard and special types





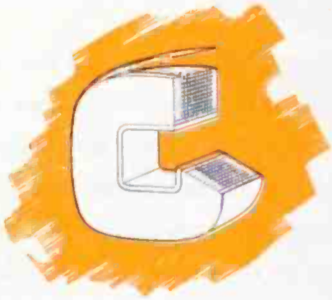
THE PAPER SECTION construction used by Anaconda is exceedingly flexible and a wide variety of coils can be made by this method. Standard Paper Section Coils may be wound on round, square or rectangular cores. The thickness of the inner layer of the paper is especially selected to suit the size of wire used for the winding.

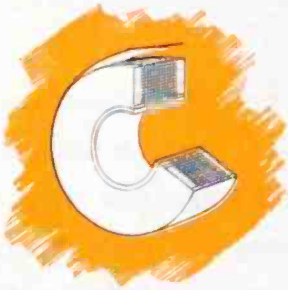
In addition, special types of Paper Section Coils are designed for high voltages, ranging up to 85,000 volts or more, such as in the case of X-ray transformers.

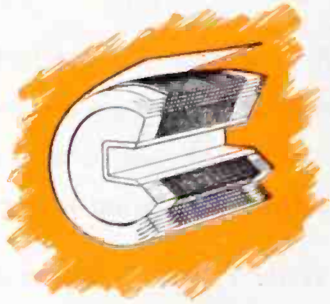
Anaconda High Voltage Paper Section Coils are made with special methods of insulation and construction to accommodate high potentials. For example, the paper margin is substantially larger; the number of inter-layer paper wraps is graded throughout the coil; the inner and outer layers of wire are usually wound with increased pitch to separate the individual turns; the type of paper used is carefully selected to meet specific conditions.

Paper Section Coils are one of the many fine *engineered* products of Anaconda. Any of our sales offices will be glad to refer inquiries to our coil engineering staff.

44238





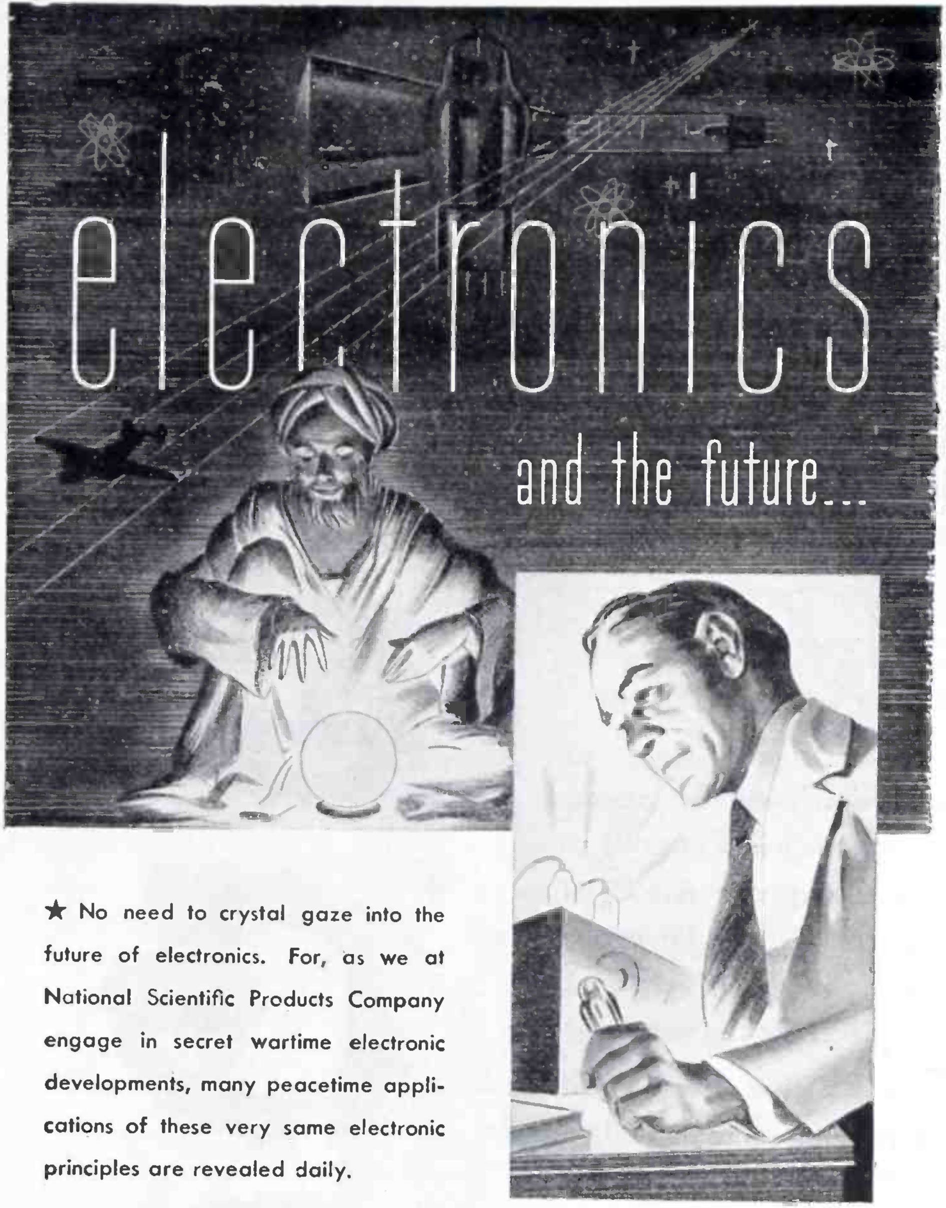


magnet wire and coils

ANACONDA

ANACONDA WIRE & CABLE COMPANY

GERAL OFFICES: 25 Broadway, New York 4
Subsidiary of Anaconda Copper Mining Company
CHICAGO OFFICE: 20 North Wacker Drive 6 • Sales Offices in Principal Cities



Cramer, vice president of Du M Laboratories, come true.

Speaking at a recent meeting the Television Press Club of N York, he suggested that many the present differences of opini might be settled through the mou tain-into-molehill effect of a tu ing device which permits cont uous tuning over a wide frequen range. This development, the M lory-Ware Inductuner, makes feasible for immediate postwar f sets to cover the television auc channels as well as their own.

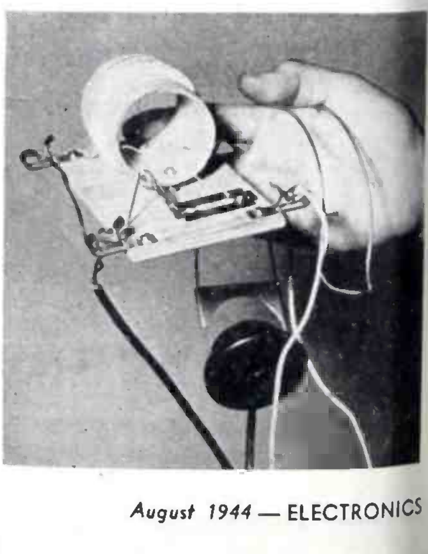
Then, having had a taste of te vision, the listener would aspire add a separate video unit whic could be made available for $ or less. Future development such as the addition of color, a changes of standards would th be more easily and inexpensive achieved. Mr. Cramer envision the final top-bracket receiver as unit combination of television sig and sound, fm, am, and phon graph with a price somewhere b tween $500 and $1000. Such device would be the evolutiona outgrowth of the piecemeal syste and would be considerably longer coming.

Razor-Blade Radios

IN NEW YORK RECENTLY, Marli Firearms Co. was startled to hea that its blued-steel razor blade were in considerable demand on th Italian front as components fo portable radio receiving sets.

In a letter from Lt. Maxie L. Ru pert, Anzio, details of the receiver were provided, together with a wir ing diagram.

Further development is apparently under way as engineers of Na



INVASION BY..
TELEPHONE

According to War Department records, rehabilitation of 49,176 wire miles of communications was accomplished by the Signal Corps in Sicily alone.

The magazine, "Steel", comments on the fact that wire communication remains basic in this zone. It enjoys the advantage of a degree of security not enjoyed by other mediums. The editor of "Steel" points out that the demand for wire field communications will continue to be heavy until the wars in both major zones are won.

Imagine the demand for field telephone equipment with the whole continent of Europe under invasion, and Pacific operations constantly expanding!

The men and women of Connecticut Telephone & Electric Division, commended personally by War Manpower Commissioner McNutt for their splendid record in turning out field telephones and other basic communications equipment, realize their ever-increasing responsibilities. They are determined to fulfill this obligation to our armed forces and those of our allies.

CONNECTICUT
TELEPHONE & ELECTRIC
★ DIVISION ★

GREAT AMERICAN INDUSTRIES, INC.

MERIDEN CONN.

G.A.I. divisions are producing for the war effort: Military Trucks, Fire Apparatus, Communications and Electronic Equipment, Aircraft Ignition Components, Cellular Rubber Products.

tional Broadcasting Co. made a unit from details of the letter, gesting that improved recep might be brought about by sub tuting a short piece of pencil l for the steel contact point of safety pin detector. The receive lustrated here is the latter, Mode

Study of Automobile Interference

WORKING IN COOPERATION with Society of Automotive Engine the Engineering Department RMA is undertaking a series tests to determine details of au mobile interference with televis and f-m reception. Five thous dollars has been appropriated the project.

Soviet Electronic Plant

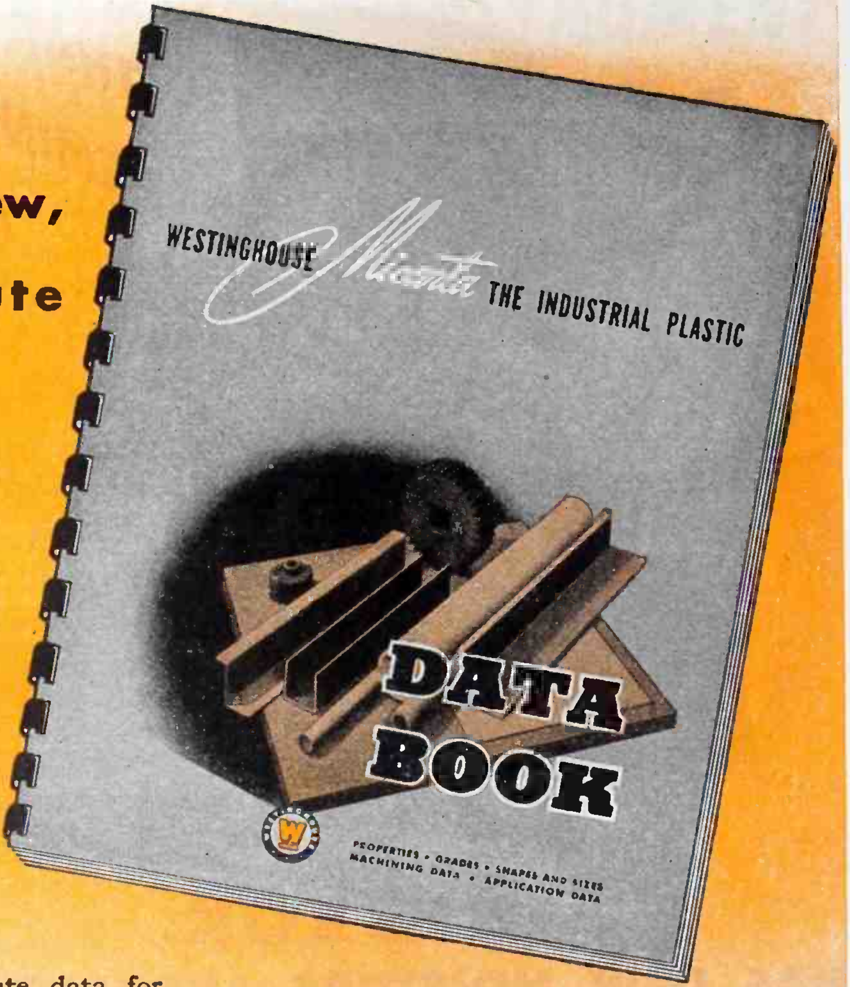
PRODUCTION AND ENGINEERING partments of some of the new Russian electronic plants are doi work which compares very fav ably with some large American ganizations, in the opinion of R C. Ellis, director of the Radio a Radar Division of WPB, who cently returned from a two mont visit to the Soviet Union. Speaki before the Third War Producti Conference of RMA in Chicago cently, he gave an account of som of the impressions he had receive

The Russian radio industry b fore the war was very small, wit sets and parts produced in abou fifteen factories. Development wor originated with a central gover ment planning agency, which wa primarily interested in high-powe transmitters, television, and special tubes. There were two experimental television stations in operation.

Little work was done on receiving tubes, shortwave sets, high fidelity, fm, loudspeakers, or component parts. Foreign contact by their engineers was kept to a minimum and few outside radio men were allowed inside Russia.

Between June and October, 1941, because of the German invasion, all of the radio industry was evacuated from western Russia to central Siberia, over 2,500 miles away. Here temperatures vary more than anywhere else in the world, changing from 100 deg F in summer to −50 in winter. Despite this and compli-

40 pages of new, up-to-the-minute *facts* FOR COMMUNICATIONS ENGINEERS



Here's new and up-to-the-minute data for designers of communications and electronics equipment in concise, easy-to-use form.

Forty pages of property tables, performance curves and design suggestions provide working data for selecting the proper grade of Micarta for any communications application. Data covers both laminated, molded, and formed Micarta. Grades include those designed for severest wear and high dielectric strength. Micarta terminal blocks, commutators, bases, coil forms, switch spacers and tube sockets, are now standard in the industry. In these successful applications, you may find the basis for an improved design.

Reserve your copy of the new Micarta Data Book today. Write Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N. J-06354-1B

GET THIS HELPFUL DATA:

Grades of Micarta—their characteristics . . . corresponding Army and Navy types.

Properties of Micarta — electrical . . . mechanical . . . chemical . . . how they compare with other materials.

Designing Help—machining data . . . how to apply directional loads . . . molded and formed Micarta design suggestions.

Forms Available—standard shapes and sizes . . . plates, rods, tubes, angles, channels, zees.

Westinghouse Micarta
THE INDUSTRIAL PLASTIC

PLANTS IN 25 CITIES . . . WESTINGHOUSE OFFICES EVERYWHERE cations involved in housing sh ages and plant inadequacies, a ments of equipment began 1 months after the move.

One tube plant employs 2,000 sons and makes several typ metal tubes. Glass tubes are made, including glass power tu acorn tubes, water-cooled po tubes up to 100 kw, rectifiers x-ray tubes. All are skillfully h built, including the glass blowi

Test equipment of all types lacking, lighting facilities were p and safety devices meager. Nev theless, the spirit with which p duction quotas are strived for ceeded the sort of thing genera demonstrated in American pla About 85 percent of the employ are characterized as a serio minded group of women, rangi from 14 to 55 years of age.

Recently some of the plants we moved back to the west into mode buildings which incorporate lat production knowledge. These buil ings include elaborate precautio against bombing and gas attac In one particular plant visited, t organization followed closely tho principles accepted in Americ While production and engineerin activities compared favorably wi ours, personnel and incentive d partments are considerably ahea of those in many of our plants.

Television Picture Quality

EVEN IF THERE were no basi change in television standards im mediately after the war, ther would be possible an appreciab improvement in the quality of th picture produced, in the opinion o Allen B. DuMont. Speaking befor one of the sessions of the Television Seminar of Radio Executive Club in New York, Mr. DuMont pointed out that most of the receivers in existence are of rather old vintage and not capable of translating more than 250 lines of the transmitted 525 into a useful picture.

Contrasting television details with those of motion pictures, he showed that from the viewpoints of flicker frequency (60 to 48 per sec.) and intensity (20 to 12 foot lamberts), television had the advantage. As for comparative numbers of picture elements, 35 mm film has

A PRECISION LABORATORY INSTRUMENT

EDERAL

U. H. F.

SIGNAL

GENERATOR

MODELS

804-CSI

Also 804-CS2

R MORE DETAILED INFOR-
ATION WRITE TO DEPT. E-8

Carefully and difficultly acquired experience enabled **Federal** to produce more Ultra High Frequency Test Signal Generators than were ever thought possible—and quickly, too.

Breaking the tightness of demand by the Army and Navy, these high quality laboratory precision instruments are available to research laboratories and industrial manufacturers engaged in the production of electronic equipment.

Your inquiries are invited.

CARRIER FREQUENCY RANGE: 7.6 to 330 megacycles plus or minus 2%, direct-reading in 5 bands, 6th band available for use with blank coil form supplied.

OUTPUT VOLTAGE RANGE: Calibrated Attenuator continuously variable from 1 to 20,000 microvolts, accuracy plus or minus 10%.

MODULATION: Internal Modulation 1,000 cycles; external modulation up to 20,000 cycles; 0 to 60% direct-reading modulation meter.

STRAY FIELD LEAKAGE: Held to a minimum by Improved shielding and R.F. Filters.

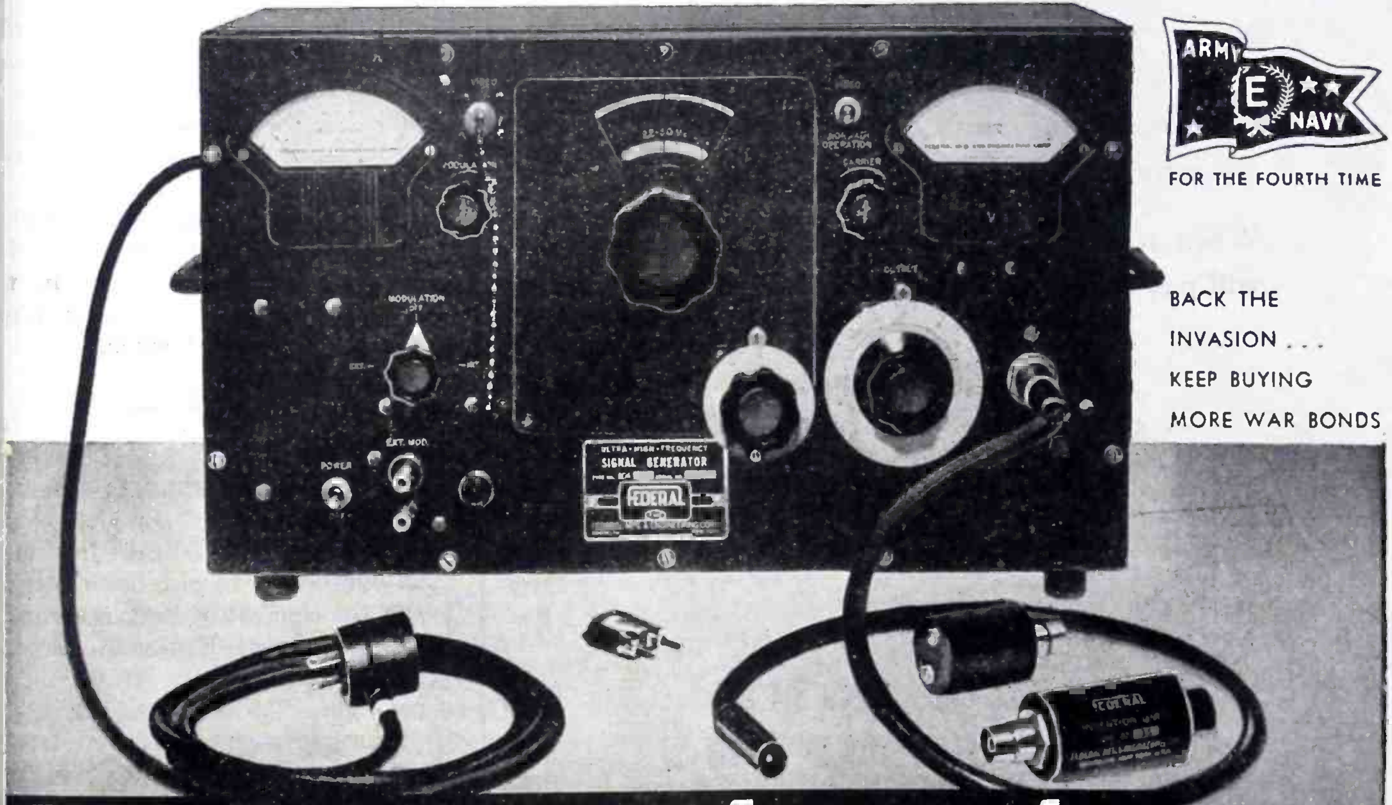
VIDEO OR PULSE MODULATION: Can be pulse modulated externally with signals having very steep wave fronts.

VOLTAGE REGULATED POWER SUPPLY: 115 or 230 volts, 40 to 60 cycles, single-phase.

Manufactured by arrangement with the General Radio Company of Cambridge, Massachusetts, and in accordance with their designs.

ARMY E NAVY

FOR THE FOURTH TIME

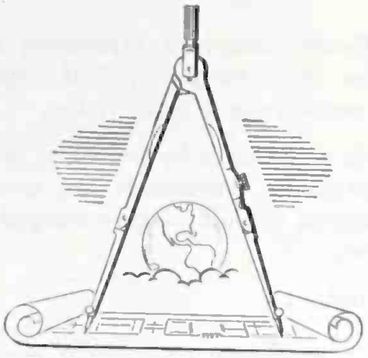


BACK THE
INVASION . . .
KEEP BUYING
MORE WAR BONDS

Federal Manufacturing and Engineering Corp.

Manufacturers of Federal Photographic Equipment and Federal Electronic Devices

BROOKLYN 5 NEW YORK



about ½ million while 525 line t vision has about half as ma However, only theater projection the television picture might t full advantage of additional defi tion.

Two of the recent developme which will make better reception television pictures possible are fl faced tubes, which aid contra and tubes with black screens, wh reduce halo effects. Referring the probable size of screen in po war receivers, Mr. Dumont thoug that 20-in. would be the maximu with the flat-type, 16-in. a mo popular top size because of its mo practical aspects with regard cabinet mounting.

Beachhead Press Communication

FOR THE FIRST TIME in history, t press has its own radio communic tion service directly behind t battle lines in Normandy. Speci equipment previously prepared b Press Wireless is capable of sen ing and receiving all varieties radio traffic, including broadca services.

Besides a semi-permanent sta tion, the European press crew ha a truck with transmitting and r ceiving sets and a unit for genera ing electric power to operate it. I this unit are both radio-telephon and radio-telegraph equipmen which can be operated separatel or simultaneously.

Transmission is possible either directly to the eastern receiving terminal of the company in the United States or to their high-speed channels in London.

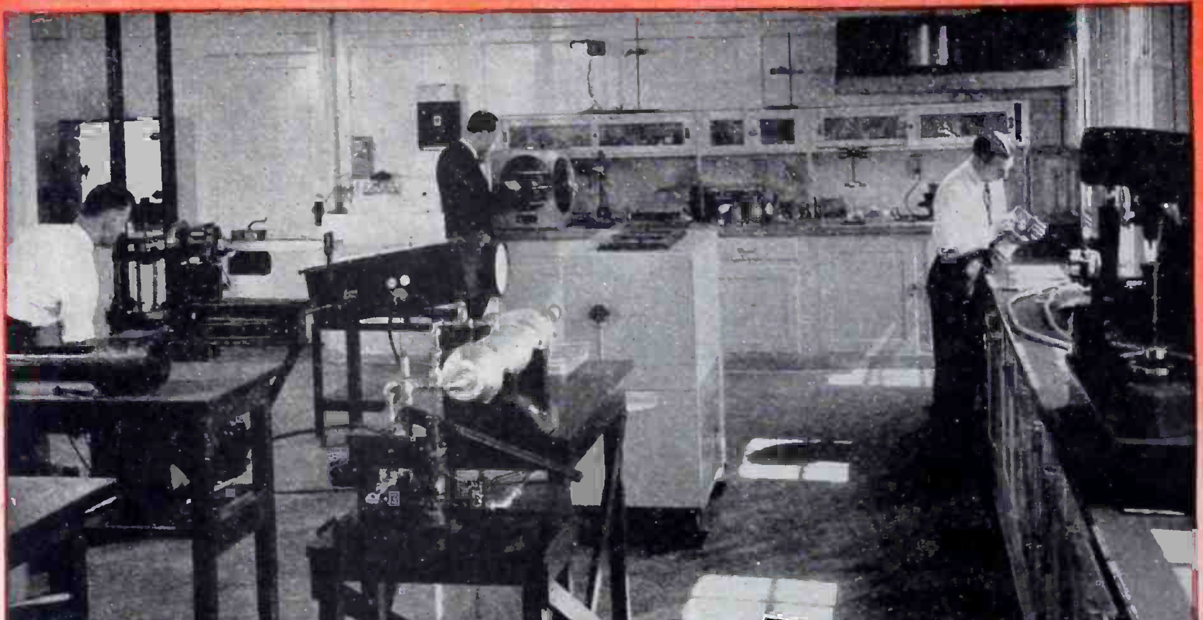
Electronics and the Automatic Age

MODERN, MULTI-ENGINED bombers constitute the most complete examples of complex, delicate jobs done automatically to eliminate fatigue and the element of human error, in the opinion of Ernest R. Breech, president of Bendix Aviation Corporation. "More varied tasks are performed by scientific means inside the compact airframes of military aircraft than in any other space of comparable size," he stated, in the course of a display of Bendix-engineered apparatus at Teterboro, N. J., recently.

At the same time, intensive train-

Relentless RESEARCH

FOR BETTER ELECTRICAL CONNECTORS

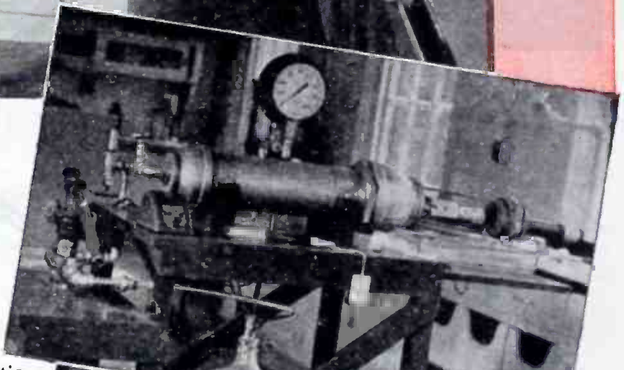


Section of Burndy's test laboratory

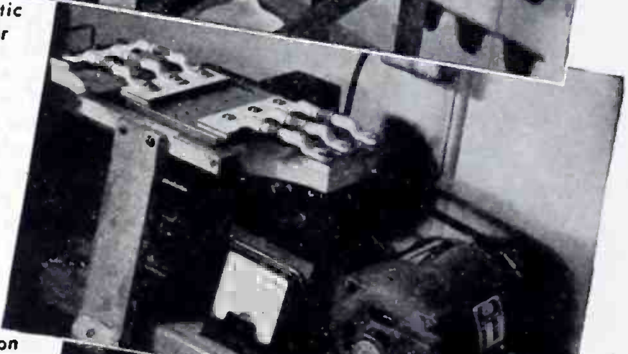
...FOUNDATION FOR Burndy's LEADERSHIP

At Burndy, the development even of a small, special connector, means more than mere drawing board technique. It starts right from *bed-rock* . . . because only through complete laboratory findings on materials, design, and performance, can service efficiency be assured.

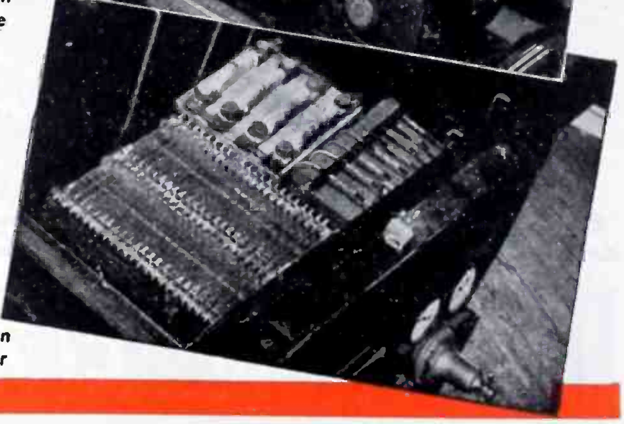
The constant, relentless research here in Burndy's completely equipped laboratory explains why so many outstanding connector developments stem from this source . . . and why industry relies on Burndy for the correct solution to any connector problem. Feel free to use this service at any time!



Hydrostatic Chamber



Vibration Machine

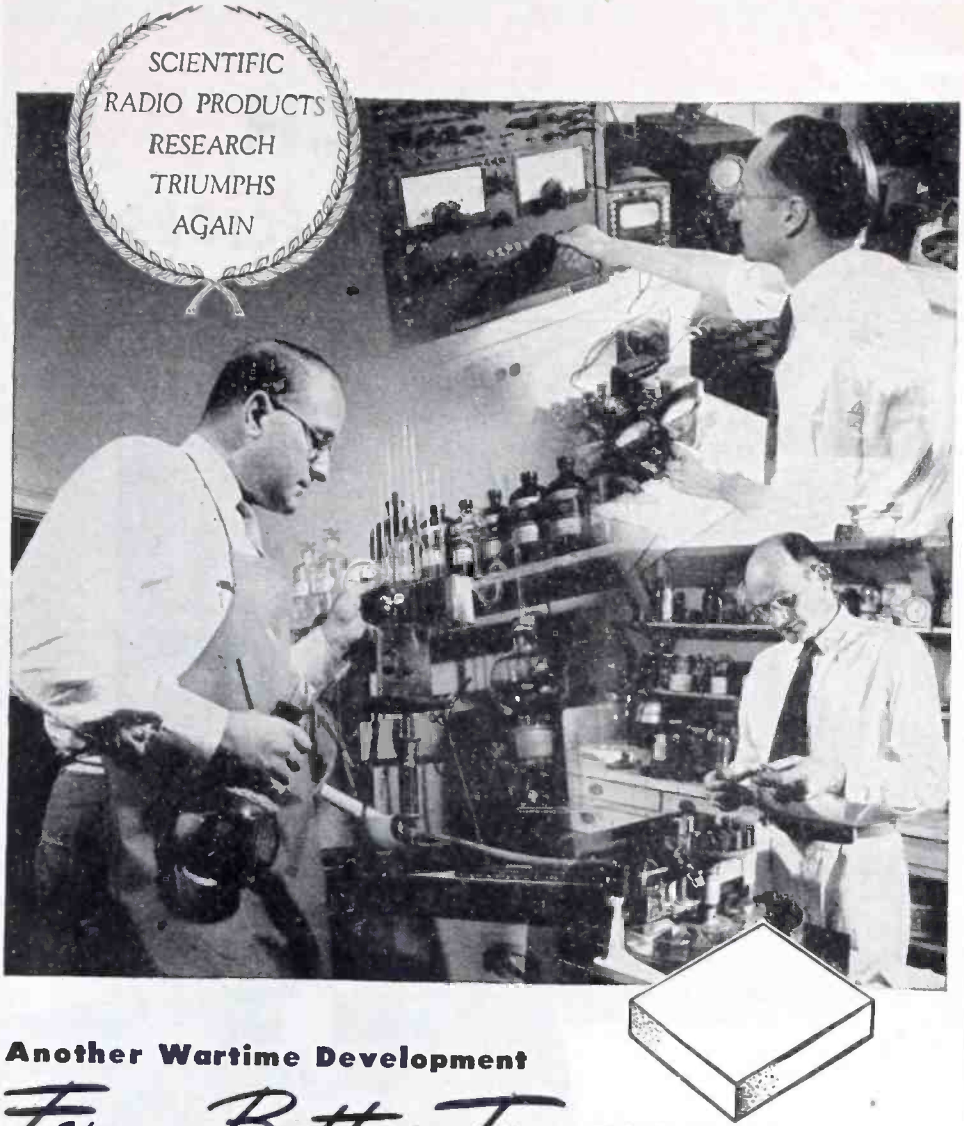


Corrosion Chamber

Headquarters for
CONNECTORS

Burndy

BURNDY ENGINEERING CO., INC.
107 BRUCKNER BOULEVARD, NEW YORK 54, N. Y.
IN CANADA: Canadian Line Materials, Limited, Toronto 13



ing has given large numbers
Americans new education in el
tronics and other forms of scien
He feels that this combination m
herald a remarkable advance f
technology as applied to priva
lives after the war.

Substantial Radar Researc

PROJECTS PLANNED for 1945 by t
Office of Scientific Research and D
velopment (OSRD) total 23 speci
developments for the armed ser
ices with a total allotment of $105
625,000. Of this, radar work r
ceived $35,300,000, within $100,0
of expenditures for 1944. Radio c
ordination rated $12,700,000—$1
000,000 less than 1944, and electr
cal communication was allotte
$500,000, one-half the previou
figure.

Terminations to Accelerate

PREVIOUS FIGURES show that case
of Signal Corps contract termina
tions with claims to exceed $10,000
average 8.7 months for settlement
Of this time, six months is require
by the contractor to submit his claim.

Speaking at a luncheon meeting during the recent RMA Convention, Colonel William M. Mack, Director of Procurement, Army Signal Corps, said that efforts will be made to reduce this time to something like 90 days from termination notice to final agreement.

Activities in January covered 140 contracts involving a value of about $19,000,000, while in May, 255 contracts valued at $50,000,000 were closed.

Radio in Europe

EVEN THOUGH the German authorities have made strenuous efforts to confiscate radio receivers from the people of Europe, appreciable numbers of sets are still known to be in the hands of patriots.

All sorts of subterfuges have been followed. Old radios have been turned in while good ones were kept, and conspicuous outside antennas have largely given way to bed-spring aerials.

Allied broadcasts to Europe have provided specific instructions on construction, maintenance, and repair of sets. For instance, a recent OWI broadcast in French sug-

THE WAR WILL END ON

____

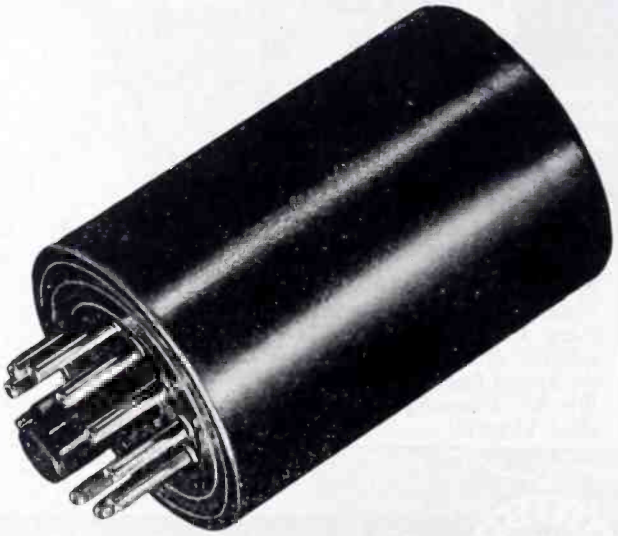
(YOU FILL IN THE DATE)

Think of it! You as a civilian have the power to decide when the war will end. Use that power to the utmost—NOW—by

1. Buying war bonds to the limit of your capacity.
2. Working harder, longer, and uninterruptedly turning out implements of war.
3. Donating your blood to the Red Cross to save lives on the battle field.
4. Collecting waste paper and other scrap for which the government is asking.
5. Avoiding black markets as you would the plague. (Black markets cause the plague of inflation.)

All of these are weapons of war—weapons that strike terror in the hearts of our enemies. Use them.

We, the management and employees alike, at Kenyon, are building better transformers than we ever built before—and building them faster for the armed forces.



THE MARK OF EXCELLENCE

KENYON TRANSFORMER CO., Inc.

840 BARRY STREET
NEW YORK, U. S. A.

gested the organization of coll tive listening groups including least one radio technician and p sessing at least one receiver. was also suggested that tubes a parts of old sets be kept for a co munity stockpile. Then, whene anyone is compelled to turn ove radio receiver to the authorities can take out the good tubes and p bad ones in their place before (ing so.

Standardization of Hook-up Wire

ATTENTION OF EQUIPMENT manufa turers is directed to the two ne specifications which cover rad hook-up wire. Published by the Si nal Corps of the Army and the B reau of Ships of the Navy, the tw standards do not differ from ea other greatly. Both are performance specifications broad enough t permit the development of oth types of insulations, and also to a low the use of several differer kinds of materials now availabl

Copies of the Signal Corps standard can be obtained from the Sign Corps Standards Agency, 12 Broa St., Red Bank, N. J. Preliminar drafts of the Navy standard hav been sent out for industry comment only.

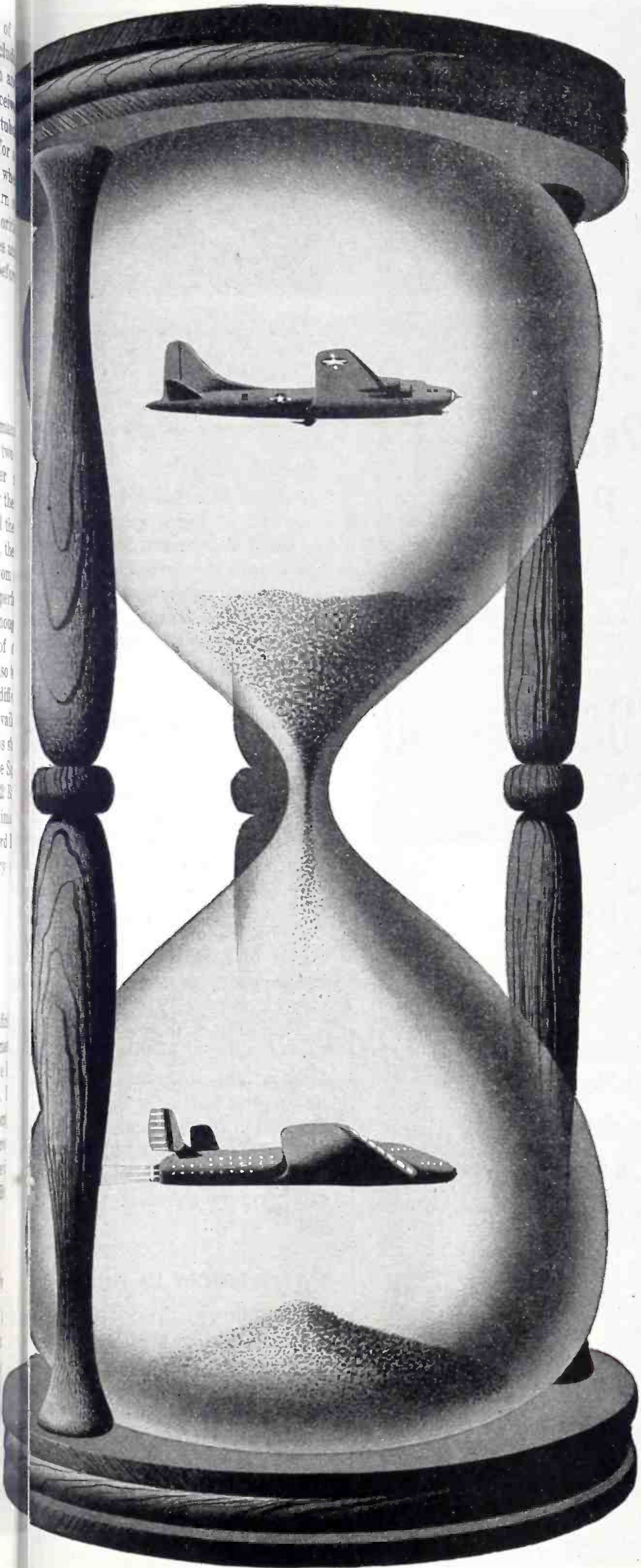
British Television Standards

IMAGES WITH 800-line definition and color are being recommended for English television by one British manufacturer, Pye, Ltd. Television activities of this company were formerly under the direction of Dr. Peter Goldmark, television specialist of the Columbia Broadcasting System here.

Women Engineers Ready

RANGING IN AGES from 18 to 29, a group of 33 women have just finished a special nine-month engineering training course at Carnegie Institute of Technology. They are prepared to act as engineering assistants, participating in the design of electrical equipment, in research work, in analysis and testing, writing specifications, and compiling engineering reports.

Selected from 275 candidates,



WILCO facilities Expanded to Meet Wartime Needs!

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

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

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

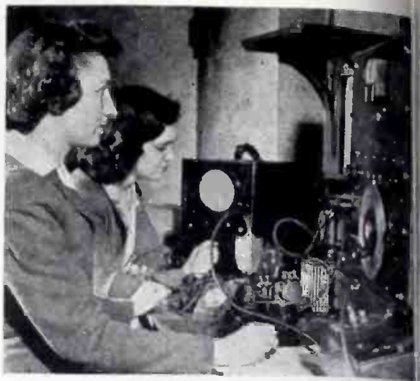
At the coming of peace, the skill and experience gained in the development and application of these new Wilco products and techniques will mean much to automotive, electrical appliance and many other types of manufacturing customers. No company will then be better equipped to meet individual requirements for Thermostatic Bimetals and Electrical Contacts on any desired scale than the H. A. Wilson Company, pioneers in this field.

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

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

WILCO

Thermometals—Electrical Contacts
Precious Metal Bimetallic Products



Two of thirty-three women engineers to finish a nine-month Westinghouse-sponsored course at Carnegie Institute o Technology. Evelyn Work and Betty Haynes determine the characteristics o an amplifier tube with a cathode-ray oscilloscope and a wave analyzer

these graduates are being placed i engineering and research labora tories of Westinghouse Elec. & Mfg Co. plants in various eastern cities The company sponsored the train ing program. During the course, th students had all expenses paid and in addition, received $50 a month

More Accurate Broadcast Data

BECAUSE MANY BROADCAST licensees have, in the past, been filing re newal applications with gross er rors which are repeated time and time again, FCC has established two new forms which require that the chief engineer or technical director of a station swear or affirm the accuracy of contained information.

This step is to prevent the copying of data from previous renewal applications without reexamination by anyone having knowledge or information of the facts. One of the two forms applies to stations using non-directional antennas, while the other refers to those using directional types.

CAA Alaskan Radio

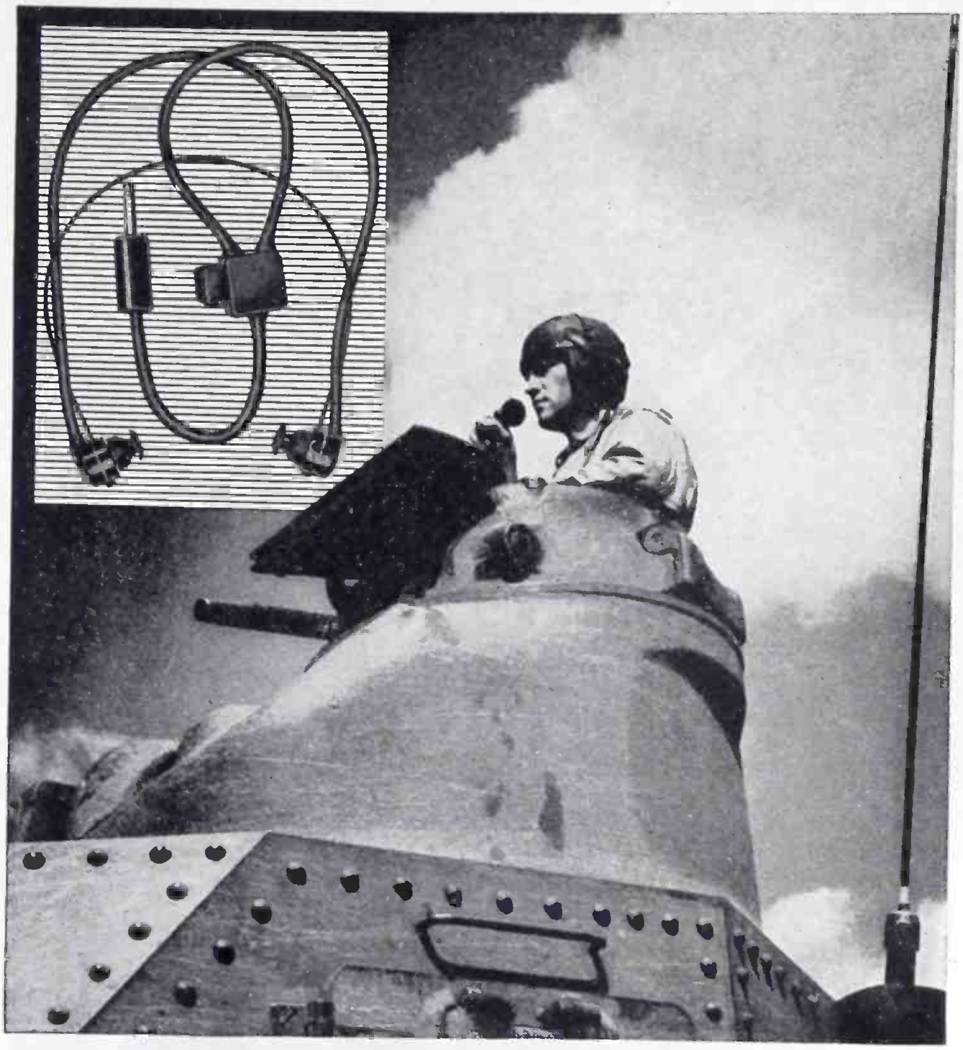
ALTHOUGH THE ARMY is operating most of the aircraft communication facilities in the Aleutians, Civil Aeronautics Administration operates three radio services throughout territorial Alaska.

Of the three, one provides communication with the actual aircraft in flight, another operates and maintains radio aids to navigation, and the third collects and dis-

O hasty development or Chinese copy f the units of some other manufacturer, he popular Types 214–314 Rheostats ave been made by us for many years. he Type 214 was first brought out in s present general form in 1919. As aterials improved . . . better wire . . . etter insulation . . . more accurate inding-methods . . . better mechanical esign of molded form, winding cards nd contact arms . . . the Type 214 radually reached its present stage. hey are being turned out just as uickly and in just as large volume as e are able. After the war we may have me radical improvements in our entire eostat line. In the meantime when rdering rheostats that look like G-R, hy not *buy* G-R, if our present deliv- ry schedules meet your requirements.

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts
NEW YORK CHICAGO LOS ANGELES



tributes meteorological inform tion.

When the radio installation pr gram was started in 1940, point-t point ground communication w served by medium-high frequenc while ground to aircraft conta was maintained over the voi channel of the radio range whe these services existed. More r cently, communication faciliti have been added with operatio located in the low-frequency ban

Because of frequent unfavorab conditions of the ionosphere i northern latitudes, high frequenc transmission is hampered. Thu low-frequency facilities are mor dependable, even though operatin speed cannot be as high.

While the meteorological an point-to-point communication i continental United States has fo some time depended on land line and teletypewriter transmission the vast distances and scarcity o civilization make it likely tha Alaskan aircraft will depend o radio for some time to come.

Survey of FM Activities

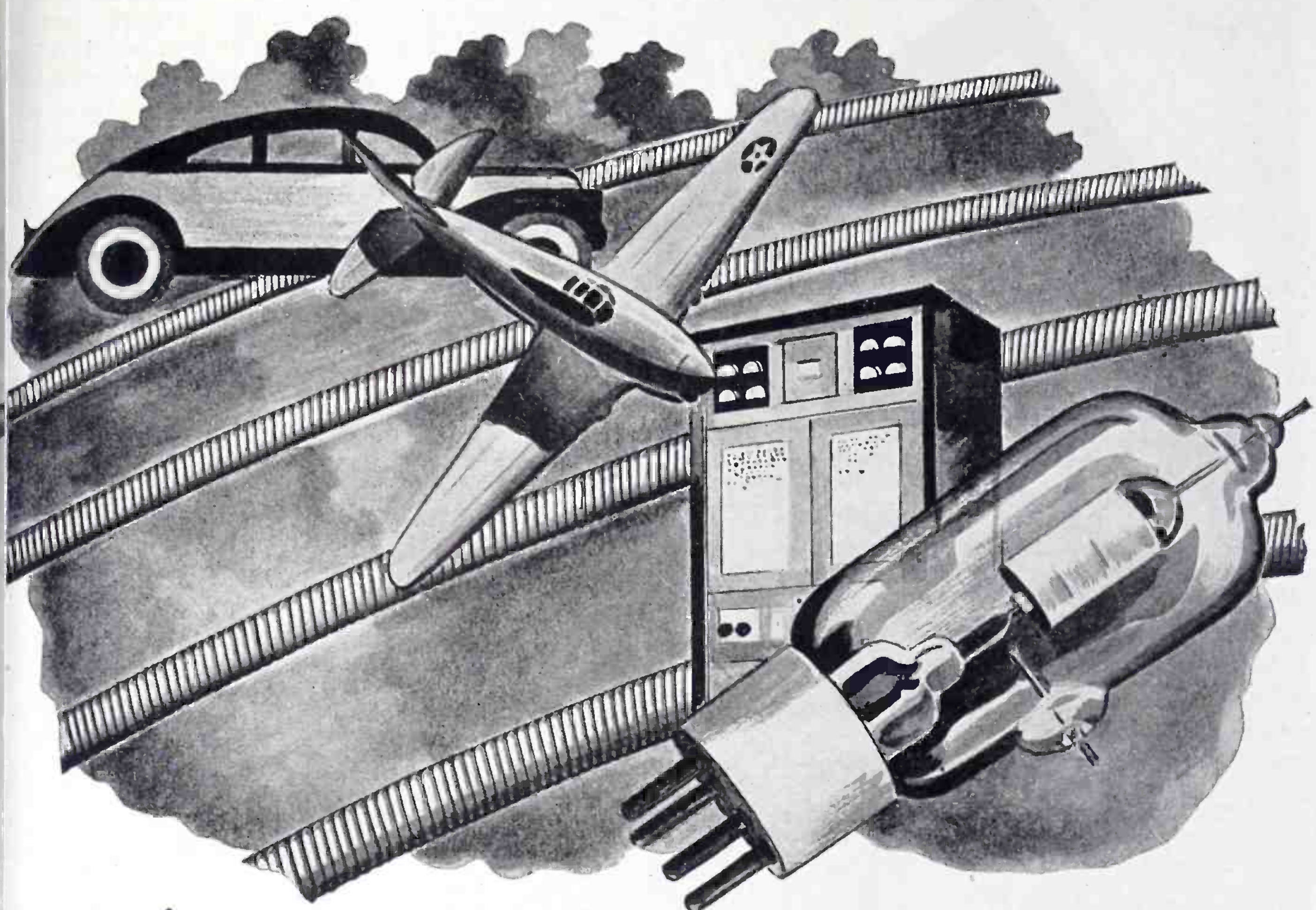
COMMENTS REGARDING the extent to which present and proposed policies of f-m broadcasters conform to the consideration of public interest, convenience, and necessity have been requested by FCC. A letter requesting such information has recently been dispatched to all national and regional networks.

Quoting from regulations, FCC points out that it is authorized to consider, in addition to the minimum technical requirements, the extent to which the station has made or will make use of its facilities to develop a distinct and separate service from that otherwise available in the service area.

Civilian Essentialities

IT IS ESTIMATED that 12,000,000 radio tubes above present production would be needed to put the civilian economy on a basis of unrestricted supplies. William Y. Elliott, vice chairman for civilian requirements has established three theoretical levels and supplied to WPB estimated figures for meeting each in a long list of commodities.

Level No. I is designated as mini-



Know THE RANGE AND SCOPE OF *S.S.White Flexible Shafts*

Because there are many places in electronic equipment where a *power drive* is needed for instruments or other auxiliaries, and many more that call for *remote control* of parts requiring operational adjustment, every engineer-designer should be familiar with the possibilities of S. S. White Flexible Shafts. For S. S. White shafts serve these two functions with the following decisive advantages.

1. **SIMPLICITY**—With a single, easily applied shaft you can transmit power or remote control around turns, past obstructions or through congested areas. This means fewer parts, simplified assembly, faster production, lower costs.

2. **BETTER DESIGNS**—Flexible shafts give you complete freedom in placing driving and driven or controlled elements wherever you want to put them to best satisfy circuit requirements, space conditions, ease of assembly, convenience of operation and servicing.

3. **ECONOMY**—In addition to the economy of simplicity, flexible shafts make accurate alignment of connected parts unnecessary, further reducing assembly costs.

FOR BASIC DATA on S. S. White Flexible Shafts for power drives and for remote control ask for Bulletin 43. Your copy mailed on request.

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO.
DEPT. E 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS
AIRCRAFT ACCESSORIES
MOLDED PLASTICS
MOLDED RESISTORS
FLEXIBLE SHAFT TOOLS

mum essential requirements, wi distribution through rationin Level No. II represents minimu essential requirements without co trol on distribution. Level No. I means an unrestricted supply products.

Therefore, while the 4,500,0 vacuum tubes estimated to be pr duced in the third quarter of th year will fill the requirements Level I, 10,000,000 would be need for Level II and 16,500,000 f Level III. Farm radio batteri are estimated at 45,000,000 cells f the third quarter, while 91,200,0 would be required for Level II ar 121,600,000 for Level III.

Training in Electronics

SPECIAL FREE COURSES in radio an electronics will start during Augus in major war production center throughout the state of Californi Offered by University of Cal fornia, these classes are designe for full-time workers who are abl to devote two hours a week to le tures and an equal amount to hom study.

Training is offered at both ele mentary and advanced levels. Prerequisites are employment in a war industry plus high-school graduation or equivalent. To facilitat attendance, OPA regulations permit application for supplementary gasoline allowances.

Detailed information can be obtained from U of C war training centers in Berkeley, Los Angeles or San Diego. Courses are part of the Engineering, Science, and Management War Training Program of the U.S. Office of Education.

Postwar Prognostications

SURVEYS OF POTENTIAL MARKETS for the months after the war are being made in large numbers by government agencies, commercial concerns, and publications. Sample findings:

Among the many appliances covered in a recent survey made by WPB, radios placed sixth in consumer demand. Out of 4,488 households interviewed, 154 would buy a radio first if such commodities were readily available, and 89 would buy radios second. Estimated on the same basis, U. S. totals for first and second pur-

chases would amount to 2,030,5

Ranking radios in potential po ularity, and in order, were was ing machines, electric irons, m chanical refrigerators, cooki stoves, and electric toasters.

Meanwhile another survey, r off by McCall's magazine, indicat a very striking preference f modern over traditional styles radio cabinets. Questions asked women in all parts of the coun and from all age, income, and o cupational groups were designed indicate choices among conso type radios, table models, radi phonograph combinations, telev sion sets, and pianos.

Depositors at the Frankli Square National Bank of Nassa County, Long Island, N. Y., ha participated in a plan in which the make deposits earmarked for sp cific postwar purchases. Televisio receivers head the list. And if th figures of the bank are extended t a national average, there are 1,600 000 people in the country ready t utilize $652,000,000 for the sam purpose. Funds of $400 are se aside by the depositors for thi purpose.

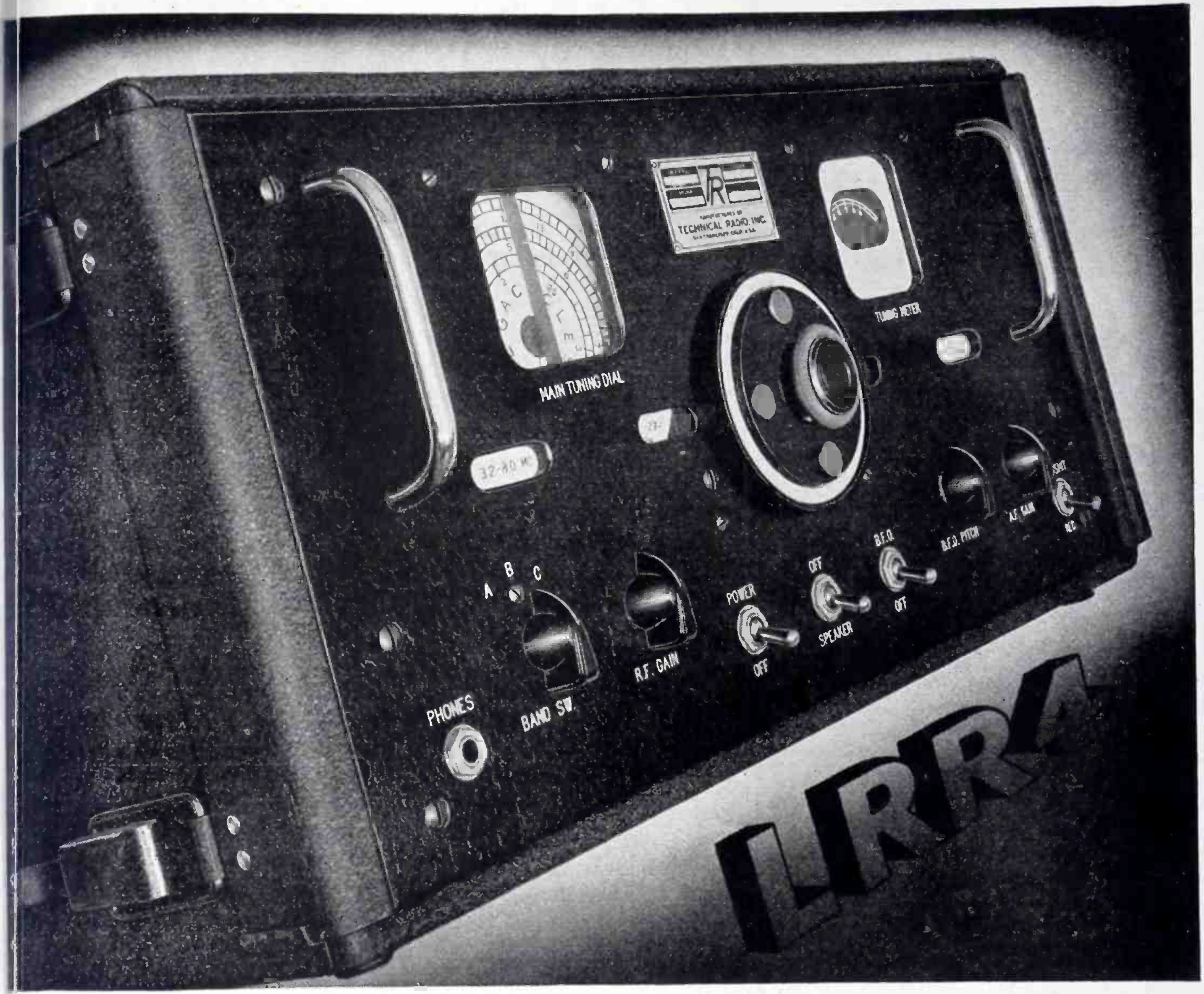
Pent-up demand for radio receivers is estimated at a potentia of 20,000,000 sets by J. H. Rasmussen, Crosley Corp., who recently addressed the Advertising and Sales Executive Club of Kansas City. He pointed out that the radio industry produced 13,000,000 receivers in its peak year and that during the current year it will produce about ten times the value of that year's output.

Surplus Electronic Goods

BESIDES BASIC COMPONENT PARTS like bolts, nuts, screws, rivets, and the like, the Surplus War Property Division of U. S. Treasury Procurement is doing business in such surplus war properties as radio tubes, professional and scientific instruments and apparatus, coin operated machines, radio broadcast receivers, and battery charging generators.

To keep posted on merchandise available, write to the nearest regional office and ask to be put on the appropriate mailing list. Requests should be accompanied by a statement of the specific merchandise lines normally manufactured

Built to take it . . . *anywhere . . . anytime!*



● ● ● Techrad LRR-4 is built to take it under y and all conditions. This Techrad receiver has F.C.C. proval for low radiation, but there are many more sons why it is winning such general acceptance.

Techrad LRR-4 is built to insure uninterrupted per- rmance under the most drastic condi- ons of service . . . *anywhere in the world.* ecause of its massive and rugged con- ruction, it can be counted on to get ere, and to get there intact. It will stand ansshipment on the bang-slam carriers und in remote places and be ready to go to service upon arrival at its destination.

Techrad LRR-4 will work in any climate. It offers a high degree of resistance to tropical humidity and to tropical organisms because *LRR-4 transformers are hermetically sealed* . . . and *LRR-4 wiring and terminal boards are completely* ˙*Anti-Fungus treated.* It will also stand up under severe duty at sea, because *LRR-4 is capable of withstanding the Salt Spray Test.* Techrad LRR-4 is available in a number of different models which cover a variety of frequency ranges.

• • • •

MASTER ENGINEERING TAKES NOTHING FOR GRANTED.

TECHRAD

Technical Radio Company
Over ten years of continuous experience
275 Ninth Street · San Francisco 3, California
Export Agents: Frazar & Hansen, 301 Clay St., San Francisco 11, California, U.S.A.

or bought for resale. Regional offices are located in Boston, Washington, Chicago, Atlanta, Kansas City, Seattle, New York, Cincinnati, Denver, Fort Worth and San Francisco. Capital and producer's goods are being distributed by Reconstruction Finance Corp.

Brazilian Radiophone Network

THE CAPITALS of all states and territories of Brazil will be linked together into one comprehensive radiotelephone network, under the terms of a decree recently issued by President Getulio Vargas.

Existing internal radio and wire lines are to be supplemented by new equipment built and operated by a subsidiary of International Telephone & Telegraph Corp.

Since Brazil has no connections between the central sections of the country around Rio de Janeiro, Sao Paulo, and Santos by land-wire telephone to the south, north, and west areas of the Republic, the new facilities will fill a long-felt need.

Communication in the Navy

MORSE CODE is featured heavily in the communication procedures of our Navy according to comment made by Rear Admiral Joseph R. Redman, Director of Naval Communications, during recent ceremonies marking the anniversary of the telegraph.

He pointed out that it is not even

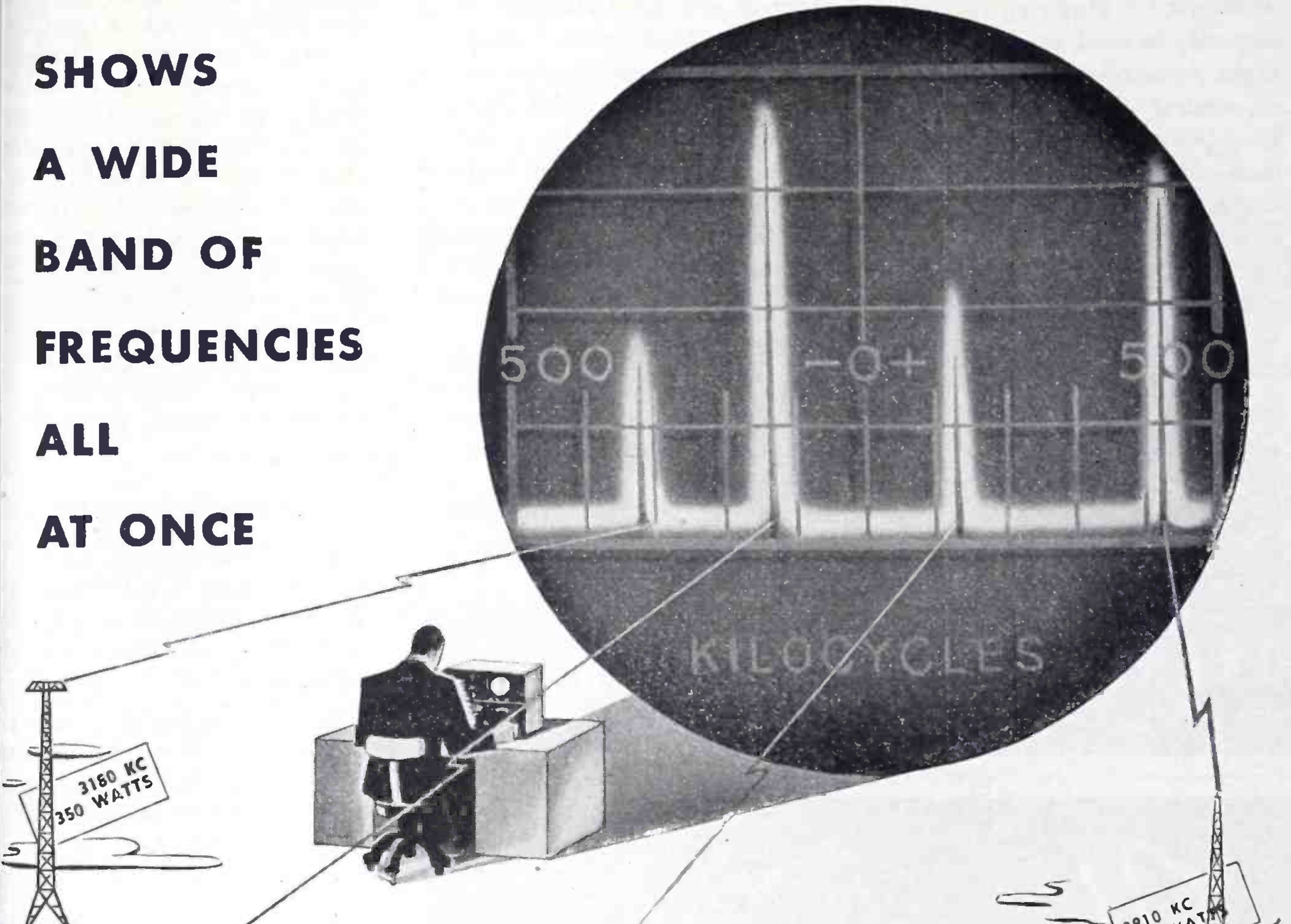
• • •

ON THE AIR FROM A DUCK

Launched from an LST at Anzio beachhead, a duck similar to this bore the first radio station to speak to the American public from a front line position. It was designated by the call JJRP and soon became known as Jig Jig Roger Peter to the Army. The transmitter used was an SCR-299, made for the Signal Corps by Hallicrafters Co., Chicago, Ill.

PANORAMIC

SHOWS A WIDE BAND OF FREQUENCIES ALL AT ONCE

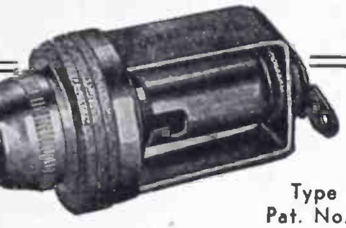


Panoramic reception is defined as the SIMULTANEOUS VISUAL reception of a multiplicity of radio signals over a broad band of frequencies. It is a technique that literally allows you to see what you are missing. In **communications,** for example, while ordinarily only one station may be received at one time, with Panoramic reception, the presence and characteristics — signal strength, frequency stability, modulation, etc. — of a number of stations may be seen concurrently.

In other applications, as well, Panoramic reception permits you to see what you're missing. In ***direction finding,*** signals too weak to give an aural indication can be made to give a satisfactory bearing with its use. In ***transmission,*** field strength and frequency of transmitter can be accurately compared with a standard signal. And in ***production,*** Panoramic reception may be utilized to compare components with a standard.

Why not let one of our engineers explain to you the principle of Panoramic technique, and how it may be used to your advantage.

PANORAMIC RADIO CORPORATION
THE MARK OF THE ORIGINAL PANORAMIC
242-250 WEST 55TH ST., *New York 19, N.Y.*



possible to maintain peacetime sp of transmission since the weal link in the chain must be con ered. Also, since radio silence r be in effect, a repeat or verificat cannot be requested. Theref transmission goes on at a rate about fifteen words a minute.

Certain unspoken agreements ist within radio communication. though, as he pointed out, effect jamming methods for enemy tra missions have been developed, v little of it has been done because the fear of retaliatory tactics. F quency assignments are still reg tered with the Berne Bureau, a not long ago our State Departm received via that organization objection to some proposed f quency restriction from the G man Government.

BUSINESS NEWS

Federal Telephone & Radio Co converts 3000 sq ft of space at 3 North Michigan Ave., Chicago, I to the purposes of its midweste activities.

Name of radio and electron equipment making **Phil-Americ Inc.**, New York, N. Y., is chang to **Philharmonic Radio Corp.** Ne location is 528 East 72 St., Ne York 21, N. Y.

In Chicago, Ill., a new company formed as **Electronic Mfg. Co.** to make transformers, chokes, an wave filters, besides providin consultation on apparatus desig

Colonial Radio Corp. Buffalo, N. becomes a wholly-owned subsi iary of **Sylvania Electric Product Inc.** by purchase of capital stoc No personnel changes are in volved.

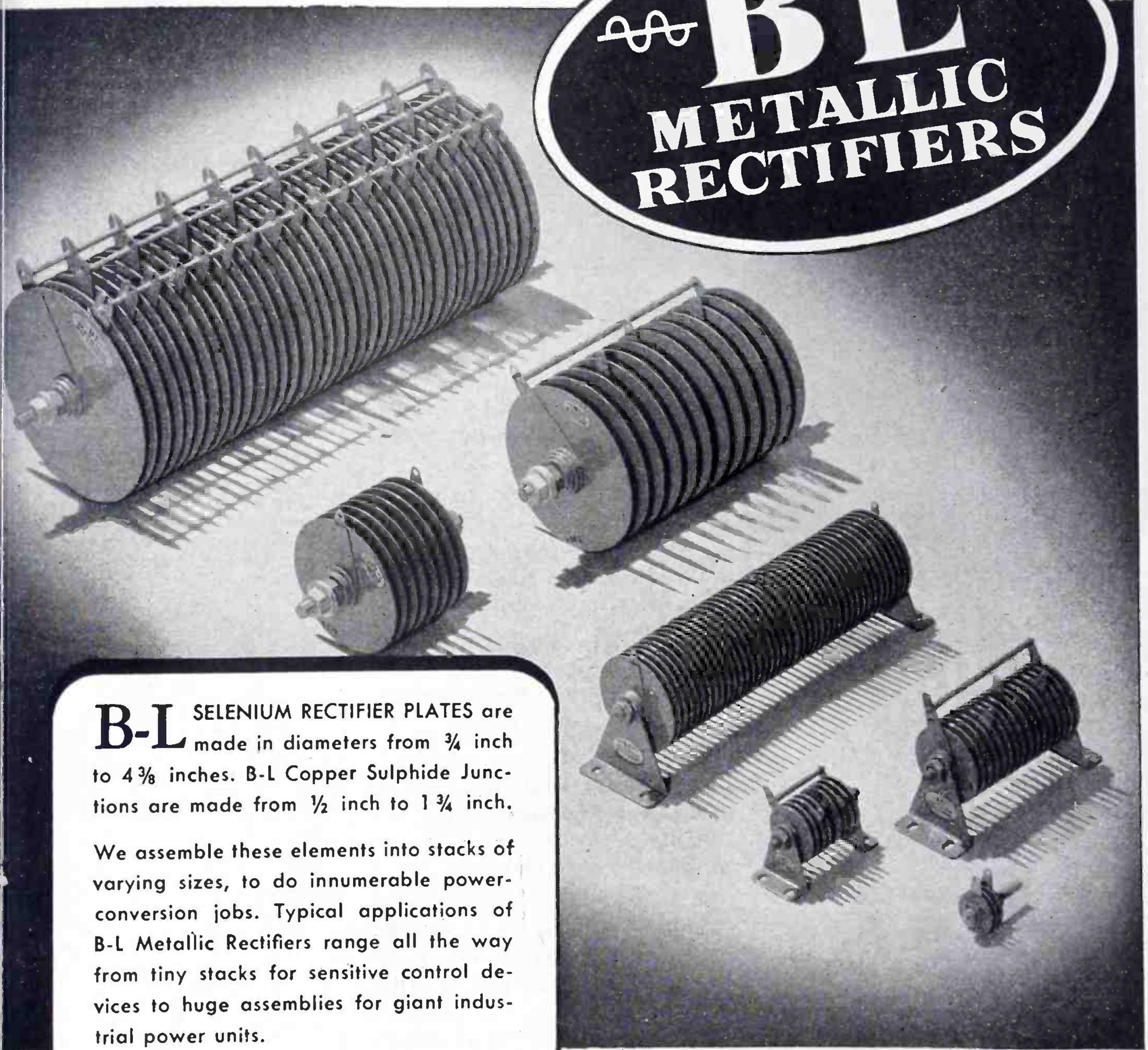
Partial ownership of **Progressiv Welder Co.**, Detroit, Mich., i transferred to the employee through a stock purchase an ownership sharing program.

At **Machlett Laboratories**, whos first radio transmitter tube were recently put into service in NBC broadcasts to Europe, free electronics courses are offered to all employees both in Springdale and Norwalk, Conn., location of the company's two plants.

To meet increased war production demands, **United States Rubber Co.** is establishing new manufac-

IN EVERY NEEDED SIZE --

for Every Needed Purpose!



BL
METALLIC RECTIFIERS

B-L SELENIUM RECTIFIER PLATES are made in diameters from ¾ inch to 4⅜ inches. B-L Copper Sulphide Junctions are made from ½ inch to 1 ¾ inch.

We assemble these elements into stacks of varying sizes, to do innumerable power-conversion jobs. Typical applications of B-L Metallic Rectifiers range all the way from tiny stacks for sensitive control devices to huge assemblies for giant industrial power units.

No matter what rectifier applications you are considering, B-L will be glad to work with you. Selenium and Copper Sulphide Rectifiers for all needs are available.

Write for Bulletin No. 98

BL

THE BENWOOD LINZE CO. • ST. LOUIS 3, MO.

Designers & manufacturers of Copper Sulphide & Selenium Rectifiers, Battery Chargers, and D. C. Power Supplies for practically every requirement.

turing facilities in a number of eastern and midwestern states. Among them are Signal Corps wire operations at Lowell, Mass.

Grayhill is the brief name of a new company organized in Chicago, Ill., with general offices at 1 North Pulaski Road and manufacturing establishment in La Grange, Ill. Products are to include mechanical and electrical switching devices.

In Boston, Mass., **General Control Co.** removes to a new office and plant at 1200 Soldiers Field Road. Facilities, which occupy several times the space available at the previous location, include an enlarged engineering department, new laboratory equipment for the development and testing of electrical and electronic products, and an assembly hall for engineering meetings.

Radio station KEX, Portland, Ore., is sold, subject to FCC approval, by the *Portland Oregonian* to **Westinghouse Radio Stations Inc.** Price was $400,000.

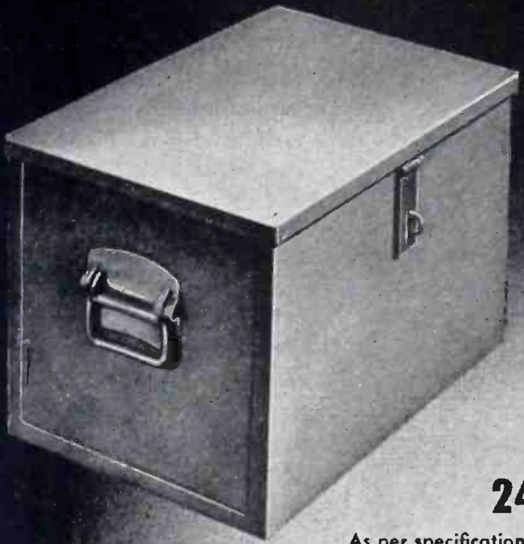
Raytheon Production Corp. changes its name to the Radio Receiving Tube Div., **Raytheon Mfg. Co.**

With the formation of a subsidiary company, **RKO Television Corp.**, **Radio-Keith-Orpheum Corp.** relates its production and programming facilities to video.

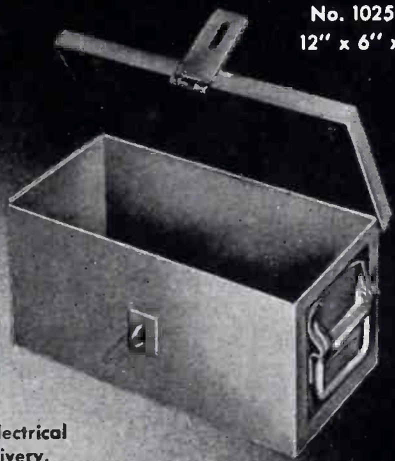
Carbonyl iron powder, used in the making of cores for inductive devices, is being made in this country by **General Aniline & Film Corp.**, New York, N. Y. The company, seized from German ownership, is supplying the entire demand for the material which was formerly imported from Germany. Other products include Polectron resins used in the manufacture of paper capacitors.

Addition of twelve RMA members results in a peak record of 210. New affiliates are **Consolidated**

SPARE PARTS BOXES



No. 1025—6
18" x 9" x 9"



No. 1025—1
12" x 6" x 6"

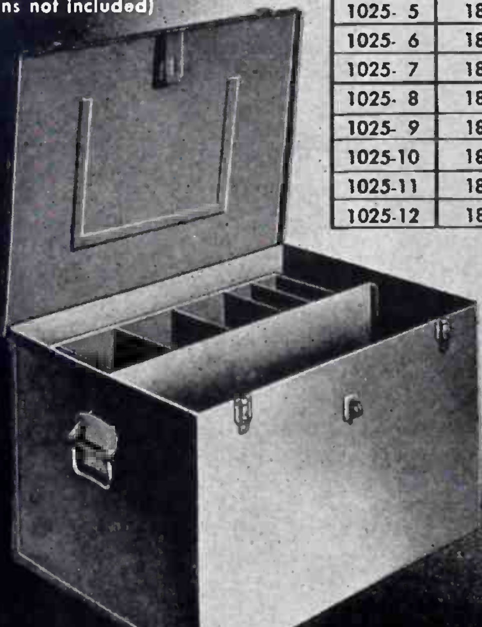
24 STOCK SIZES

As per specification 42 B 9 (Int) for shipboard use, Electrical and Mechanical. Navy grey finish. Immediate Delivery.

— WRITE FOR PRICE LIST —

Number	Length	Width	Height	Number	Length	Width	Height
1025- 1	12	6	6	1025-13	18	18	12
1025- 2	12	9	6	1025-15	24	15	12
1025- 3	12	12	6	1025-16	24	15	15
1025- 4	12	9	9	1025-17	24	18	12
1025- 5	18	9	6	1025-18	24	18	15
1025- 6	18	9	9	1025-19	24	18	18
1025- 7	18	12	9	1025-20	24	12	9
1025- 8	18	6	6	1025-23	30	15	9
1025- 9	18	15	9	1025-14	30	15	12
1025-10	18	12	6	1025-22	36	12	9
1025-11	18	15	12	1025-21	42	9	9
1025-12	18	12	12	1025-24	42	12	9

No. 1025—14
30" x 15" x 12"
rtitions not included)



Cole steel office equipment
will again be available after the war

COLE STEEL EQUIPMENT CO.

349 BROADWAY, NEW YORK 13, N. Y.

FACTORY: BROOKLYN, N. Y.

Radio Products Co., Chicago, Ill. **Crystal Research Laboratories** Hartford, Conn.; **Electronic Laboratories**, Indianapolis, Ind.; **Electronic Engineering Co.**, Chicago, Ill.; **Electronic Tube Corp.**, Philadelphia, Pa.; **General Electronics Inc.**, New York, N. Y.; **Selenium Corp. of America**, Los Angeles Calif.; **M. Simons & Son Co.**, New York, N. Y.; **Mark Simpson Mfg Co.**, New York, N. Y.; **Universal Microphone Co.**, Inglewood, Calif. **Viewtone Co.**, New York, N. Y. and **Winters & Crampton Corp.** Grandville, Mich.

PERSONNEL

At Summit, N. J., **F. H. Shepard, Jr.** opens his new office and laboratory for consultation on such electronic specialties as industrial control, servo mechanisms, special amplifiers, and photoelectric applications.

Permoflux Corp., Chicago, Ill. gives responsibility for development on acoustic transducers to new chief engineer, **Raymond C. Bierman**, former studio field engineer with NBC.

Louis Dolinko joins the engineering staff of United Electronics Co., Newark, N. J. He has been an instructor in radio engineering at Scott Field, Ill.

In Brooklyn, N. Y. Amperex Electronic Products adds to its engineering staff **John F. Dryer Jr.**, previously chief of the electrical research department, Duramold Div., Fairchild Engine & Airplane Corp.

The Rochester, N. Y., section of AIEE elects to chairmanship **Oliver L. Angevine**, radio-telephony engineer of Stromberg-Carlson Co. Manager of research and engineering at the same company, **Dr. George R. Town** becomes treasurer of the section.

Caxton Brown succeeds **Edward F. Weston** to the presidency of Weston Electrical Instrument Co., Newark, N. J. Mr. Weston becomes chairman of the board.

In the electronic apparatus section of RCA Victor Div., Radio Corp. of America, Camden, N. J., **Walter L. Tesch** becomes application engineer while **Thomas F.**

BROADCASTING STATIONS!
RECORDING STUDIOS!
SCHOOLS!

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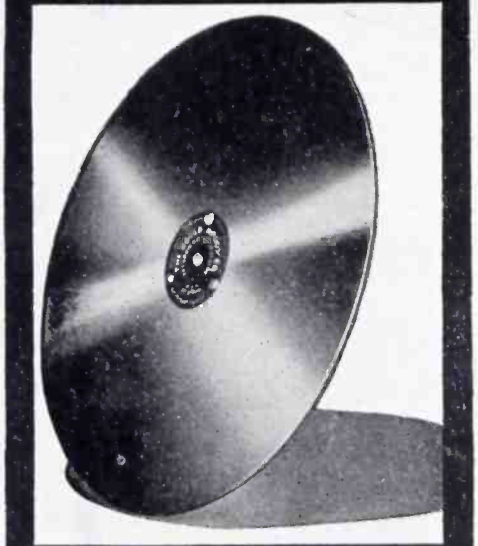
Without Delay!



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"Black Seal"
GLASS BASE
INSTANTANEOUS
RECORDING BLANKS

The tributes paid to "Black Seal" discs by many leading engineers have been earned by distinguished service on the turntable. Your ears will recognize the difference in quality of reproduction, and the longer play-back life will prove the superiority of "Black Seal" construction. Choice of two weights — thin, flexible, interchangeable with aluminum, or medium weight — both with four holes.

An AA-2X rating is automatically available to broadcasting stations, recording studios and schools. Enclosure of your priority rating will facilitate delivery

Old Aluminum Blanks Recoated with "Black Seal" Formula on Short Notice

THE
GOULD-MOODY
COMPANY

RECORDING BLANK DIVISION
395 BROADWAY · NEW YORK 13, N. Y.

EXPORT DEPT. ROYAL NATIONAL COMPANY, INC.
89 BROAD STREET, N. Y.

Kenna becomes commercial engineer on high-frequency induction heating equipment. Mr. Tesch has been manager of the record engineering department. Mr. Kenna comes from Van Norman Machine Tool Co.

At Lord Mfg. Co., Erie, Pa., **Leon Wallerstein Jr.** advances to development engineer in charge of the development laboratory. **Paul C. Roche** becomes chief field engineer and **R. C. Henshaw** takes over the function of chief engineer.

E. J. Rehfeldt (above) is manager of planning and production, and **Harry Holubow** (below) chief engineer of Electronic Mfg. Co., Chicago, Ill. Both have been with Thordarson Electrical Mfg. Co.

Electrical
Papers

ARE INCLUDED I
THIS *NEW* BOOKLE
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This colorful new book tells how paper is being employed to improve products, lower costs and increase production. It explains what Electrical Papers and other Industrial Papers are, how their physical properties can be controlled to fit an amazing variety of purposes, and contains a list of 68 Industrial Papers, their characteristics and uses in industry.

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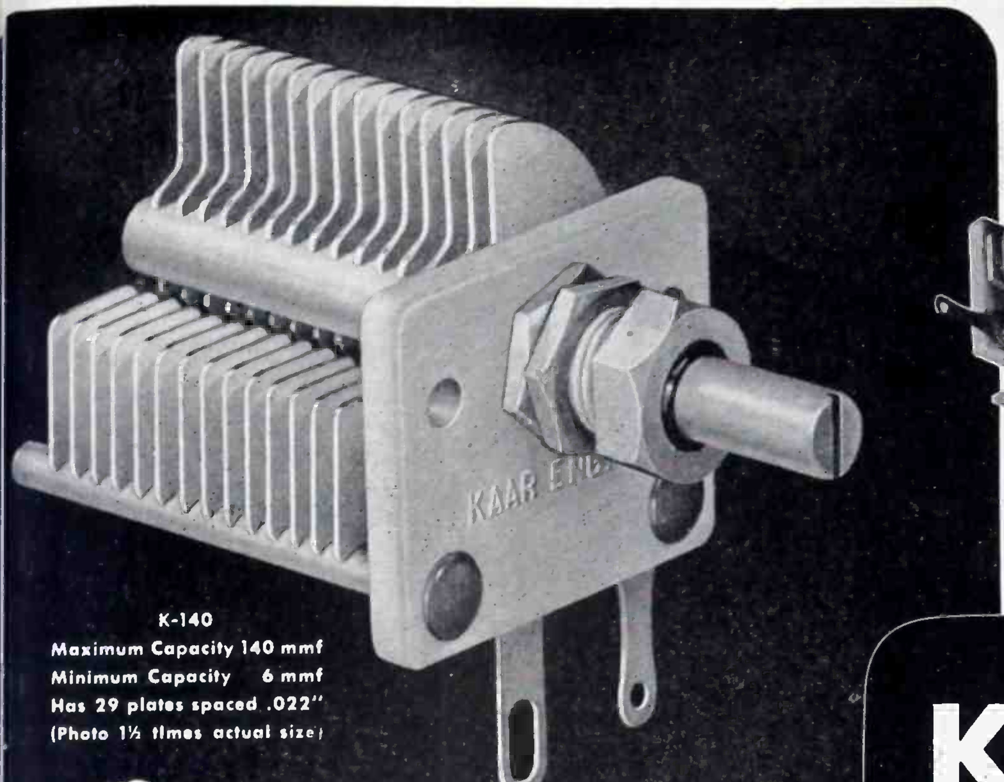
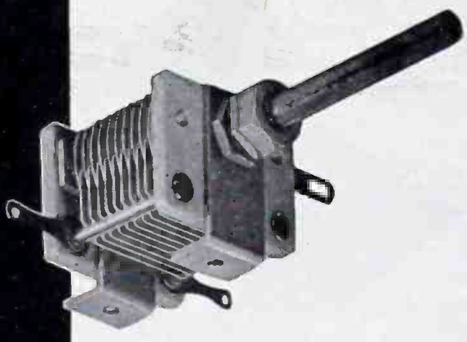
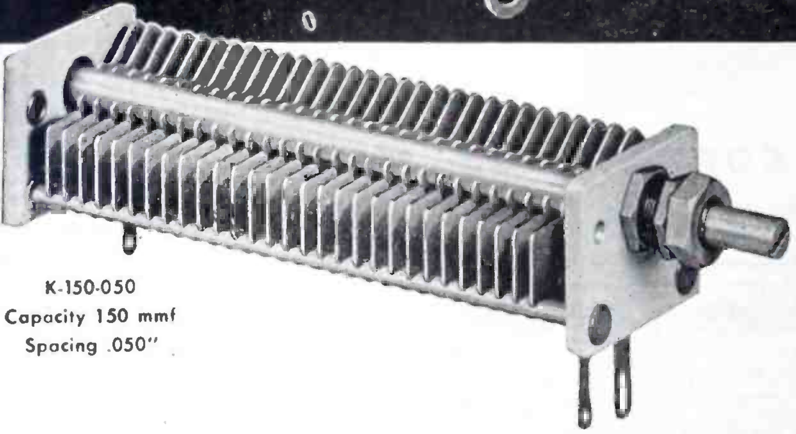


K-140
Maximum Capacity 140 mmf
Minimum Capacity 6 mmf
Has 29 plates spaced .022"
(Photo 1½ times actual size)



K-100-2B
Capacity 100 mmf
Spacing .022"



K-150-050
Capacity 150 mmf
Spacing .050"

KAAR

VARIABLE AIR CONDENSERS

FOR TANK CIRCUIT AND ANTENNA TUNING

Use this reliable West Coast source for Variable Air Condensers

Kaar Engineering Company now offers prompt delivery of standard and special types of variable air condensers suitable for many applications in radio transmitters and receivers. They are particularly useful as tank and antenna tuning capacitors in low and medium power transmitters.

The small cross-section of Kaar condensers allows a number of them to be assembled in multi-channel radio equipment in a minimum amount of space. Every Kaar capacitor is substantially constructed with soldered and plated brass rotor and stator plates. Shafts can be furnished slotted for screwdriver adjustment, and tapered lock nuts and split bushings assure positive locking without disturbing the adjustment.

Special types are available with very wide air gaps, double rotors and stators, high maximum capacities or special mounting brackets. Further information will be gladly furnished upon request.

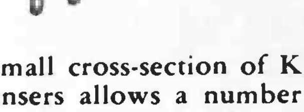
KAAR
ENGINEERING CO.
PALO ALTO, CALIFORNIA

***Export Agents:* FRAZAR AND HANSEN**
301 Clay Street • San Francisco, Calif.

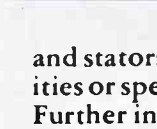
MOBILE RECEIVERS — Crystal controlled superheterodynes for medium and high frequencies. Easy to service.

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

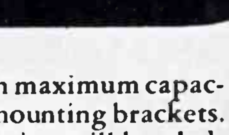
TRANSMITTERS — Mobile, marine, and central station transmitters for medium and high frequencies. Instant heating, quickly serviced.

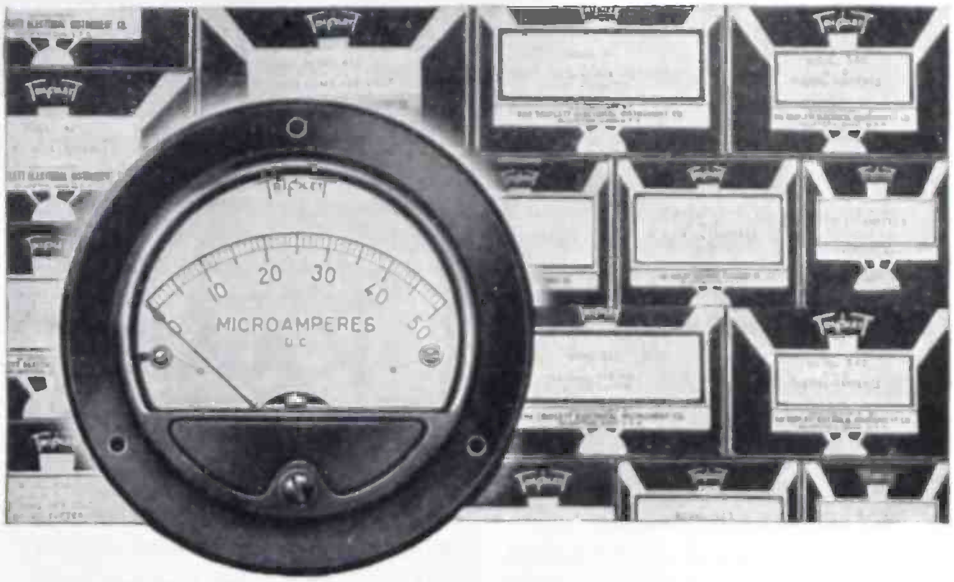


MICROPHONES — Type 4-C single button carbon. Superb voice quality, high output, moisture-resistant.



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





Walter T. Hopewell joins Lavoie Laboratories, Morganville, N. J., as general manager. He has been with ANEPA, and before that, U. S. Rubber Co.

At Eutectic Welding Alloys Co., New York, N. Y., **Clinton E. Swift** joins the organization as assistant manager in the engineering and research department.

New manager of the switchgear and control division, Westinghouse Electric & Mfg. Co., is **J. R. MacNeill**, former manager of switchgear engineering. He succeeds **R. A. Neal**, now vice president.

From the Montana School of Mines, where he has been professor of physics, Dr. **Daniel Q. Posin** goes to the Radiation Laboratory of Massachusetts Institute of Technology as a physicist and staff member concerned with war project research on high-frequency techniques.

Within the Signal Corps, Brigadier Generals **William S. Rumbough**, chief signal officer in the European theater of operations, and **George L. Van Deusen**, commanding general of the Eastern Signal Corps Training Center at Fort Monmouth, are nominated to the temporary ranks of major general.

In Bridgeport, Conn., **H. R. Kreutter** becomes acting supervisor of the technical service section, receiver division, General Electric Co. He has been serving as a design engineer of military equipment. Another appointment makes **C. G. Fick** receiver engineer responsible, among other activities, for production.

L. R. Thomas, system telegraph engineer of the Atcheson, Topeka, and Santa Fe Railway, is appointed electronics engineer.

Succeeding Captain **Maurice Edwin Curtis**, **Captain William Bronley Ammon** assumes the post of communications officer at the headquarters of Commander-in-Chief of the U. S. Fleet, Admiral **Ernest J. King**.

Frederick A. O'Leary becomes chief of the radio and radar section of the production department

NINE SEALED METAL-CLAD MICRO SWITCHES

used by REHNBERG-JACOBSON MANUFACTURING COMPANY to control operation of this automatic drilling and reaming machine

hnberg-Jacobson Company of Rockford, Illi-
is, use nine sealed metal-clad Micro Switches at
ategic points to control the operation of their
tomatic Drilling and Reaming Machine. This
chine drills and reams 20 holes in sequence in
e reduction gear pinion carrier for an aircraft
gine. The Type RN Micro Switches used are
aled against the entrance of oil, dirt, and chips.

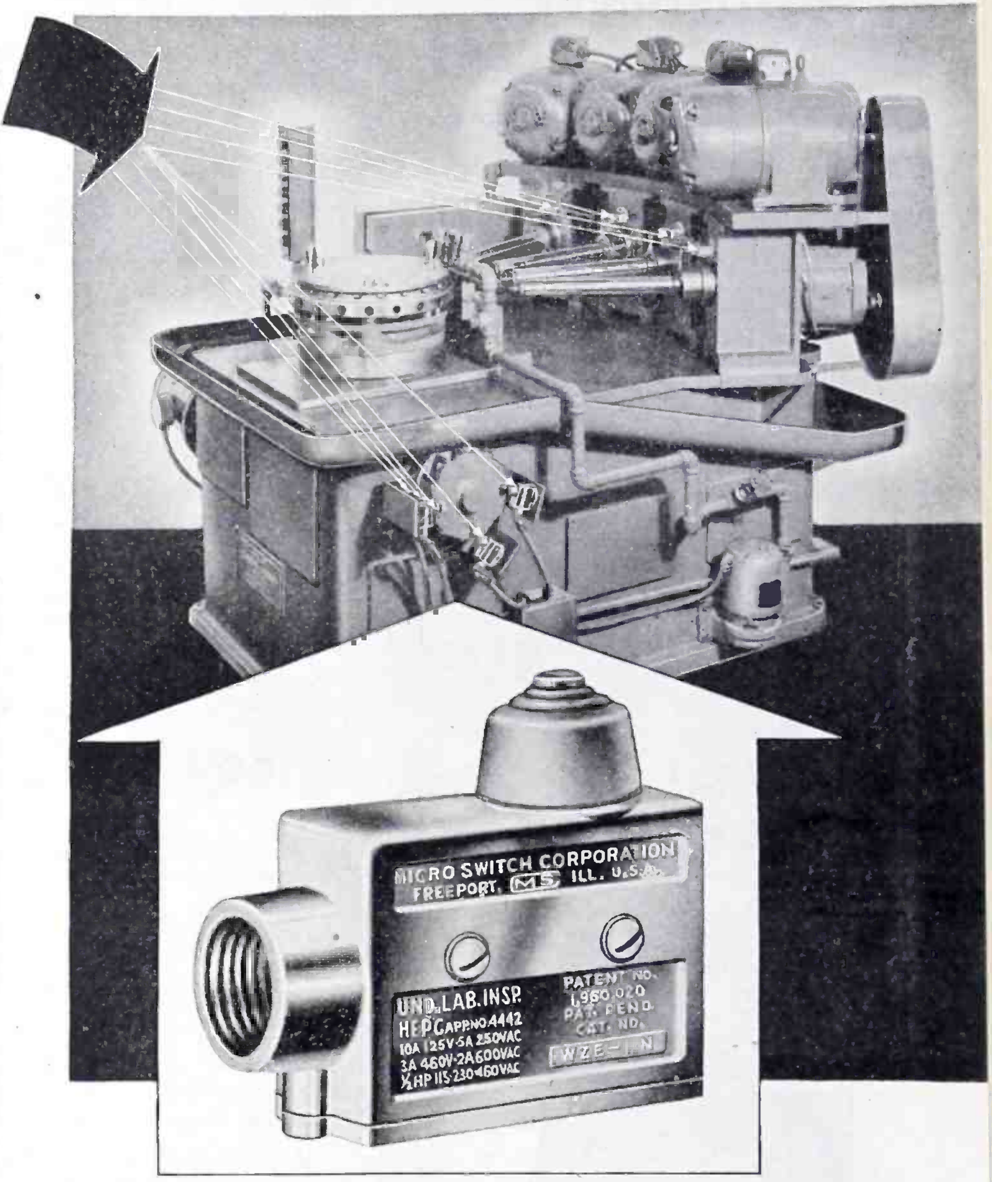
e piece is held in a fixture mounted on a stand-
d Rehnberg 20" automatic index unit which is
ntrolled by an 11-step program wheel. On the
st step, the reamers rest; on the last step, the
lls rest. There are four horizontally-mounted
ads, two for drills and two for reamers, paired
ke to drill two holes and ream two holes si-
ultaneously.

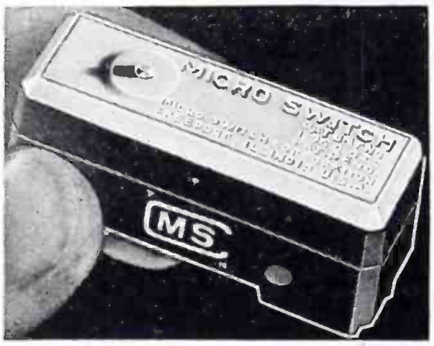
e five metal-clad Micro Switches, shown on the
nt of the machine, control the electrical circuit.
e two innermost switches of the left hand group
ntrol the program of the drilling and reaming
its. The third switch of the group, directly in
nt, terminates the machine cycle after all drilling
d reaming operations have been completed. The
er right hand switch stops the automatic index
tor after each index cycle is completed. The
per right hand switch permits the machine cycle
be started only at the proper position of the
exed table.

e four Micro Switches mounted above each of
e four units of the machine electrically interlock
e machine in such a way that should either the
lls or the reamers fail to retract from the work,
e automatic index table will not index and break
tools.

hnberg-Jacobson Company's use of Micro
itches for this important operation is typical of
e many uses which design engineers are finding
this tiny, accurate, snap-action electric switch.
ey find that, more than any other, it meets mod-
needs for a switch to control substantial amounts
power yet operate in small space.

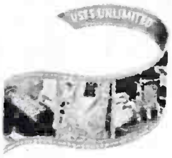
ousands of special housings, actuators and elec-
cal characteristics . . . more than 2700 . . . are avail-
e to meet almost every design problem. Send
Micro Switch Handbook-Catalog No. 60 today
full particulars. If your design is for aircraft,
d for Handbook-Catalog No. 70 also.

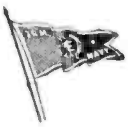




The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V.A. at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate repeat performance is experienced over millions of operations. Wide variety of basic switches and actuators meets requirements varying from high vibration resistance to sensitivity of operating force and motion as low as 2/1000 ounce-inches. Many types of metal housings are available.

s Unlimited"—a dramatic talking motion pic-
of Micro Switches, in color, is available to
strial groups, training classes, schools and
eges, through Y.M.C.A. Motion Picture Bu-
u, New York, Chicago, San Francisco. Size:
nm. Length: 40 minutes. Write us for details.





Let's All Back the Attack—
Buy EXTRA War Bonds

Micro Switch Corporation, Freeport, Ill.
Branches: 43 E. Ohio St., Chicago (11) • 4900 Euclid Ave., Cleveland (3)
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Sales & Engineering Offices: Boston • Hartford • Portland, Ore. • Dallas, Tex.

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

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MICRO MS SWITCH

TRADE MARK

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

in the regional office of WPB, Boston, Mass. He was previously assistant chief and formerly with Raytheon Mfg. Co.

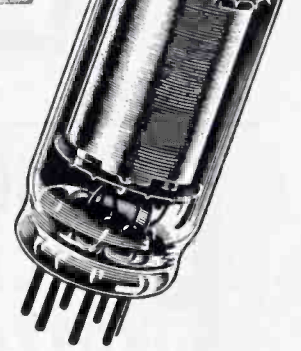
Andrew Co., Chicago, Ill., puts **Walter F. Kean** in charge of a new division which will supply field engineering and allocation service to a-m and f-m broadcasters. Mr. Kean has been in charge of testing on radio and radar projects for Western Electric Co.

Within RMA, **Raymond C. Cosgrove,** vice president and general manager of Crosley Corp., becomes president to succeed **Paul V. Galvin.** Expansion of the board of directors from 27 to 34 involves the election of **Herbert A. Bell** of

Raymond C. Cosgrove, right, receives the gavel from retiring RMA president, Paul V. Galvin

DIRT–

INSIDE ELECTRONIC TUBES CAN CAUSE TROUBLE TOO

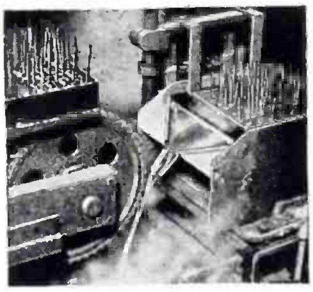


Foreign matter within an Electronic Tube was always a hazard. Now, with the tendency toward miniature tubes and smaller parts with less distances between them, even a tiny thread of lint free in the glass enclosure can prove very damaging.

The TUNG-SOL regular procedure of washing and baking all mounts and glass enclosures just before sealing has proven a more than worth while precaution. It not only removes all dirt and dust and lint from component parts but at the same time removes any deposit of harmful salts that might poison the emission of electrons from the filament.

This final cleaning is just one of the innumerable practices instituted by TUNG-SOL research and development engineers, who have given TUNG-SOL Electronic Tubes their ruggedness, long life, efficiency and uniformity. These characteristics are important to both manufacturers and users of electronic devices. These engineers are available to you to assist in the designing of circuits and in the selection of the tubes that will do your job most efficiently.

EVERY DAY IS WASH DAY . . .



A continuous flow of hot water is introduced through the bottom of the washing tank and is discharged out the top floating the lint and foreign matter out with it. This prevents contamination of water. After washing, both mounts and enclosures travel through a high temperature oven, thoroughly clean and ready for exhaust.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

ARMY E NAVY

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

LSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS

Packard-Bell Co., **Joseph Gerl**
Sonora Radio & Television Co
(set division), **Fred R. Lack**
Western Electric Co., **Geo**
Lewis of Federal Telephone & R
dio Corp. (transmitter divisio
Ernest Searing of Internatio
Resistance Co., **S. I. Cole** of Ae
vox Corp., and **Monte Cohen**
F. W. Sickles Co., (parts divisio
Frank M. Folsom of RCA Vic
Div. was elected to succeed
C. B. Jolliffe; **R. E. Carlson**
Tung-Sol Lamp Works, to succe
Roy Burlew; and **G. Richard F**
ling of Erie Resistor Corp., to su
ceed **George R. Blackburn.**

At WABD, DuMont Television st
tion in New York, N. Y., **Sal Pat**
mio advances from operating eng
neer to acting chief.

As an application engineer, **A.**
Kruger joins Wheelco Instrumen
Co., Chicago, Ill. He has be
identified with industrial heatin
and processing for a number
years.

Dr. Ellis R. Ott, recently associa
professor of mathematics at th
University of Buffalo, becomes ex
ecutive engineer and assistant

the director of engineering at National Union Radio Corp. His headquarters will be at the research and development laboratories, Newark, N. J.

◆

ABOUT 25 PERCENT of the prewar personnel of broadcasting stations and networks are in uniform.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Associated Spring Corp.
  The Wallace Barnes Co.
  Rolling Mill Div.
  Forestville, Conn.

Burgess Battery Co.
  United States Battery Div.
  Freeport, Ill.

Hercules Powder Co.
  Badger Ordnance Works
  Baraboo, Wis.

Insuline Corporation of America
  Long Island City, N. Y.

Markem Machine Co.
  Keene, New Hampshire

Universal Microphone Co.
  Inglewood, Calif.

Ward Products Corp.
  Cleveland, Ohio

CHIEF SIGNAL OFFICER'S CERTIFICATES OF APPRECIATION

These awards are testimonials to the contribution of individuals and organizations not eligible for Army-Navy recognition

Dr. Edwin H. Armstrong

Western Union Telegraph Co.

American Telephone & Telegraph Co.

RCA Communications Inc.

Mackay Radio & Telegraph Co.

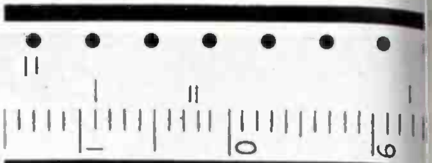
Commercial Cable Co.

National Association of Broadcasters

• • •

JUST LIKE A WOMAN

Girl operators of the Women's Division of the RCAF take six months training in the Wireless School at Montreal. They find that the easiest letter to learn in Morse is "Q", which reminds them of the first four notes of the "Wedding March"



The tape is graduated in hundredths of a minute — Values accurate to .0025 minutes are read easily and directly.

Authentic, Printed, Unassailable Record Invaluable in Labor Relations . . .

THE NEW
MARSTO-CHRO
GATHERS

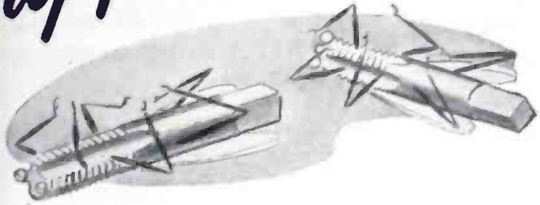
- ✓ elemental time quickly and curately.
- ✓ saves time because fewer obs vations are necessary.
- ✓ no need to combine elements - every motion recorded at th instant of recurrence.
- ✓ increases confidence betwe management and labor.

No watch to read . . . nothing t write down . . . time values accura up to .0025 can be read directly, easily and accurately. Postwar competitio will demand greater individual operating efficiency based on new methods and more comprehensive time studies. Now is the time to get set.

Write today . . . learn how the Marsto-Chron time study method will give you more efficient production.

BAY PRODUCTS CORP.
171 CAMDEN ST.
BOSTON 18, MASS.

P-K ASSEMBLY ENGINEERS "BLITZ" TWO TROUBLESOME *Tapping "Bugs"*



—prove the simpler P-K Fastening Method is a short cut to stronger instrument assemblies

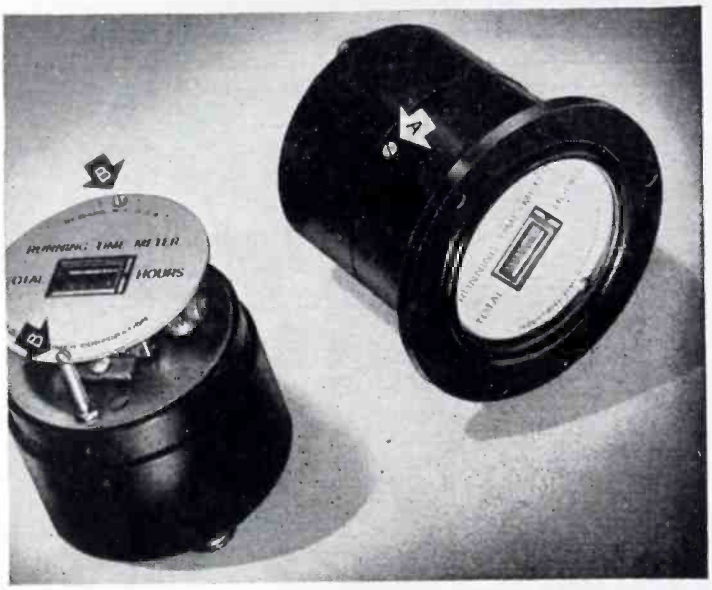
Industrial Timer Corporation, N. J., makes numerous timing devices widely used by the armed forces and by war plants. When planning the assembly of a newly designed Running Time Meter, they first tried machine screws for two "tricky" fastenings. The result was costly tapping delays and unsatisfactory holding power.

Familiar with the advantages of P-K Self-tapping Screws from use in metal assemblies, they called in a P-K Assembly Engineer. By following his suggestions, the bothersome "bugs" were eliminated, along with both the tapping operations.

Talk to a P-K Assembly Engineer about your fastening problems. He has specialized in all types of plastic and metal fastenings, and is well-prepared to show you how to save tapping time, prevent breakage, improve strength. He'll call at your request, – or, if you prefer, send assembly details for recommendations. Parker-Kalon Corp., 208 Varick St., New York 14, N. Y.

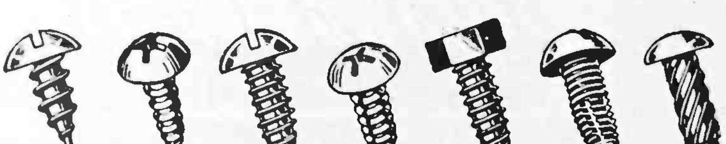
PARKER-KALON
Quality-Controlled
SELF-TAPPING SCREWS
Give the Green Light to War Assemblies

TOUGH JOB TILL TAPPING GETS GO-BY. Fastening the plastic cover (A) to the plastic body was a tough job because a brass part lay between. When tapped for machine screws, brass chips fouled the plastic threads, holding power was poor. P-K Type "F" Screws eliminated both tapping and chip problem, assured a strong assembly.



NO FIXTURES – NO FAILURES, now that P-K Type "Z" Screws are used to fasten the brass dial plate (B) to the small hollow brass tubes that have been molded into the plastic case. With machine screws, a complicated fixture would have been necessary to hold the tubes for tapping, also tapping the tiny holes would have given constant trouble. Girls now drive the P-K Screws easily, without fixtures, into plain, untapped holes.

• P-K SCREWS ARE SOLD BY GOOD DISTRIBUTORS EVERYWHERE •



SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

U. S. A. Signal Corps
Communication
EQUIPMENT and COMPONENTS
PROMPT DELIVERY

Complete units or any component parts now available on the following:

NOW IN PRODUCTION

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CD-874 PL-54 BC-366
JK-26 PL-55 BC-347-C
PE-86 PL-58 SW-141
JB-47 TD-3

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RADIO AND TELEVISION CORPORATION
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ENAMELED MAGNET WIRE

• Much of the success of this Hudson Wire product is due to a new coating method that gives a smooth, permanently-adherent enameling. Mercury-process tests guarantee perfect uniformity; great tensile strength assures perfect laying even at high winding speeds. Especially adaptable for reduction in coil dimensions without sacrificing electrical values.

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HUDSON WIRE COMPANY
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WINSTED CONNECTICUT

Synchronized F-M Oscillator

(*Continued from page* 111)

to act as a limiter and so pre a further rise.

Advantages of the System

At this point, the advantage using a synchronized oscillato an f-m receiver can be summar as follows:

1. Selectivity to adjacent chan —at least equal to the selecti of two i-f stages.
2. If properly designed—a chronization sensitivity cient to give a voltage gain an amplifier) considerably ter than the conventional amplifier.
3. An amplitude-limiting act better than that of a conv tional limiter.
4. A quieting sensitivity invers proportional to frequency dev tion of the received signal.

The fact that overall regene tion is decreased as a result of s

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A compact, sturdy terminal strip with Bakelite Barriers that provide maximum metal to metal spacing and prevent direct shorts from frayed wires at terminals.

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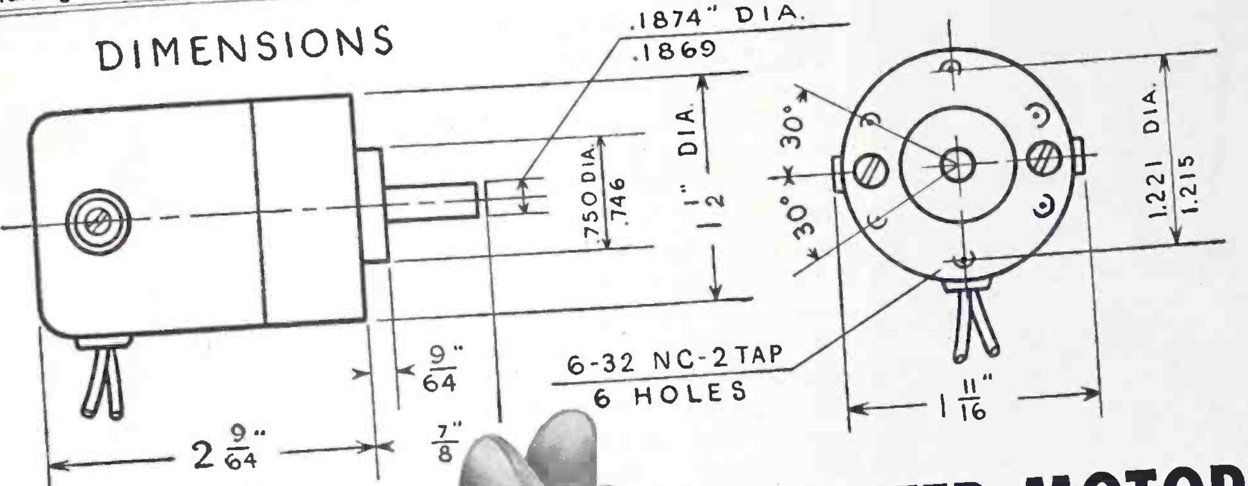
R.P.M.	11,000	8,500	5,000
Amps. Input	.480	.450	.300
Starting torque in % of full load torque	250 min.	250 min.	250 min.



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M-17

FEATURES OF TYPE A-16A OSTER MOTOR

HOUSING — die cast aluminum, totally enclosed.

FINISH — black anodized.

WEIGHT — 7 ounces.

BEARINGS — high quality single shielded ball bearings, lubricated with grease suited for any specific application. Bearing housings fitted with steel inserts.

MOUNTING — standard 3/4" diameter air corps rabbet.

BRUSHES—high grade metal graphite of ample size to assure unusually long brush life.

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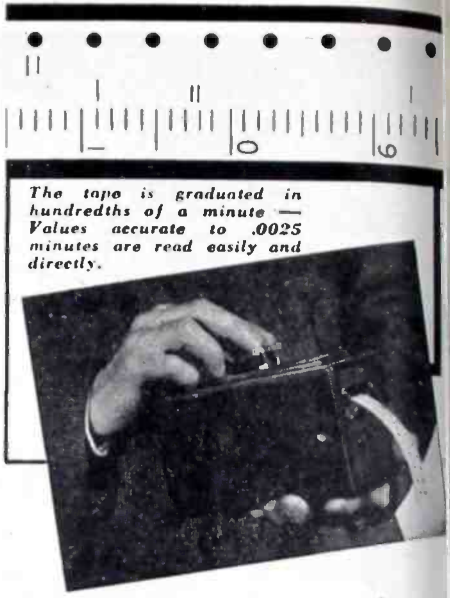
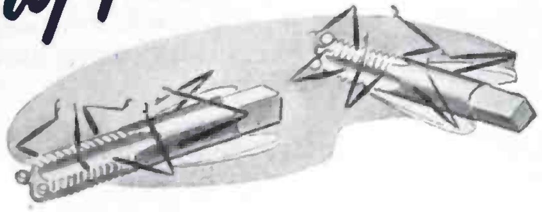


K ASSEMBLY ENGINEERS "LITZ" TWO TROUBLESOME

Tapping "Bugs"



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dustrial Timer Corporation, N. J., makes numerous ti ing devices widely used by the armed forces and by w plants. When planning the assembly of a newly de gned Running Time Meter, they first tried machine sc ws for two "tricky" fastenings. The result was costly ta ing delays and unsatisfactory holding power.

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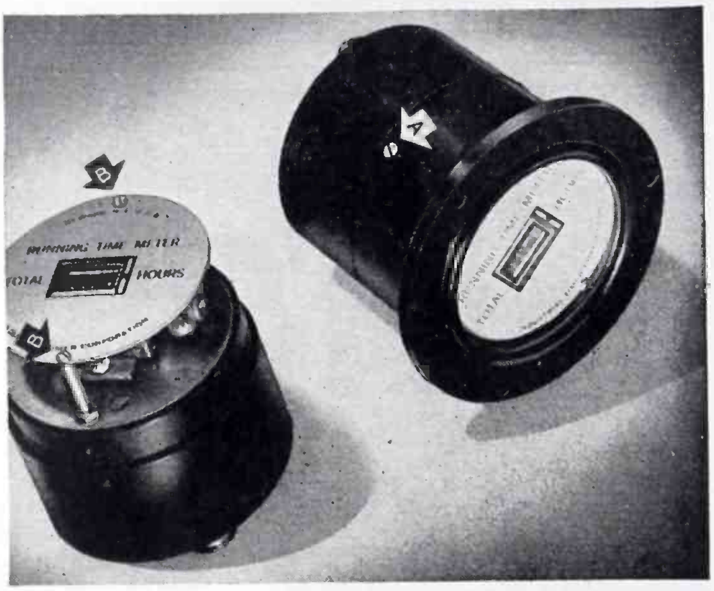
TOUGH JOB TILL TAPPING GETS GO-BY. Fastening the plastic cover (A) to the plastic body was a tough job because a brass part lay between. When tapped for machine screws, brass chips fouled the plastic threads, holding power was poor. P-K Type "F" Screws eliminated both tapping and chip problem, assured a strong assembly.



NO FIXTURES – NO FAILURES, now that P-K Type "Z" Screws are used to fasten the brass dial plate (B) to the small hollow brass tubes that have been molded into the plastic case. With machine screws, a complicated fixture would have been necessary to hold the tubes for tapping, also tapping the tiny holes would have given constant trouble. Girls now drive the P-K Screws easily, without fixtures, into plain, untapped holes.

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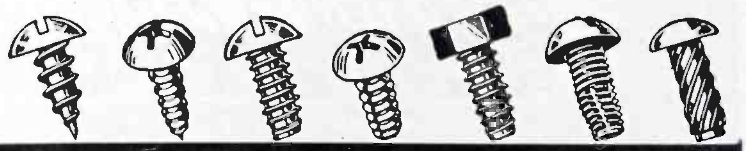

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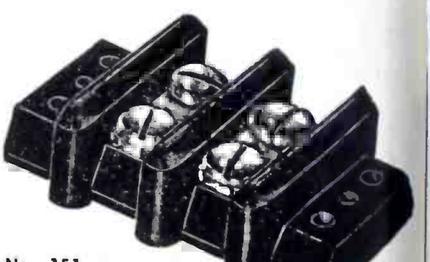

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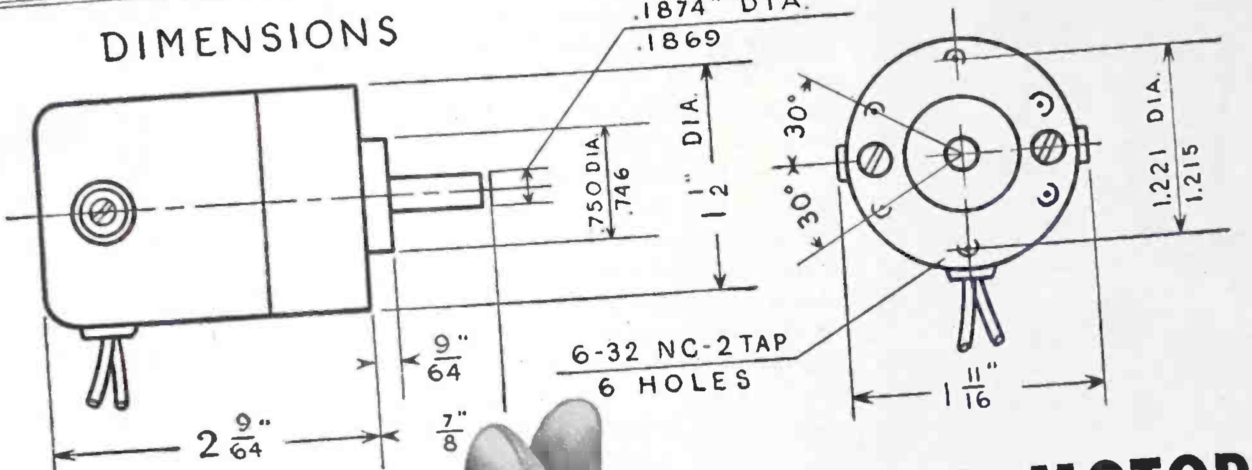

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Department L-17 **Genoa, Illinois**

harmonic operation cannot be fairly counted as an advantage, since operation on the fundamental is practically impossible, and subharmonic operation may add to the receiver cost by requiring an automatic gain-control string.

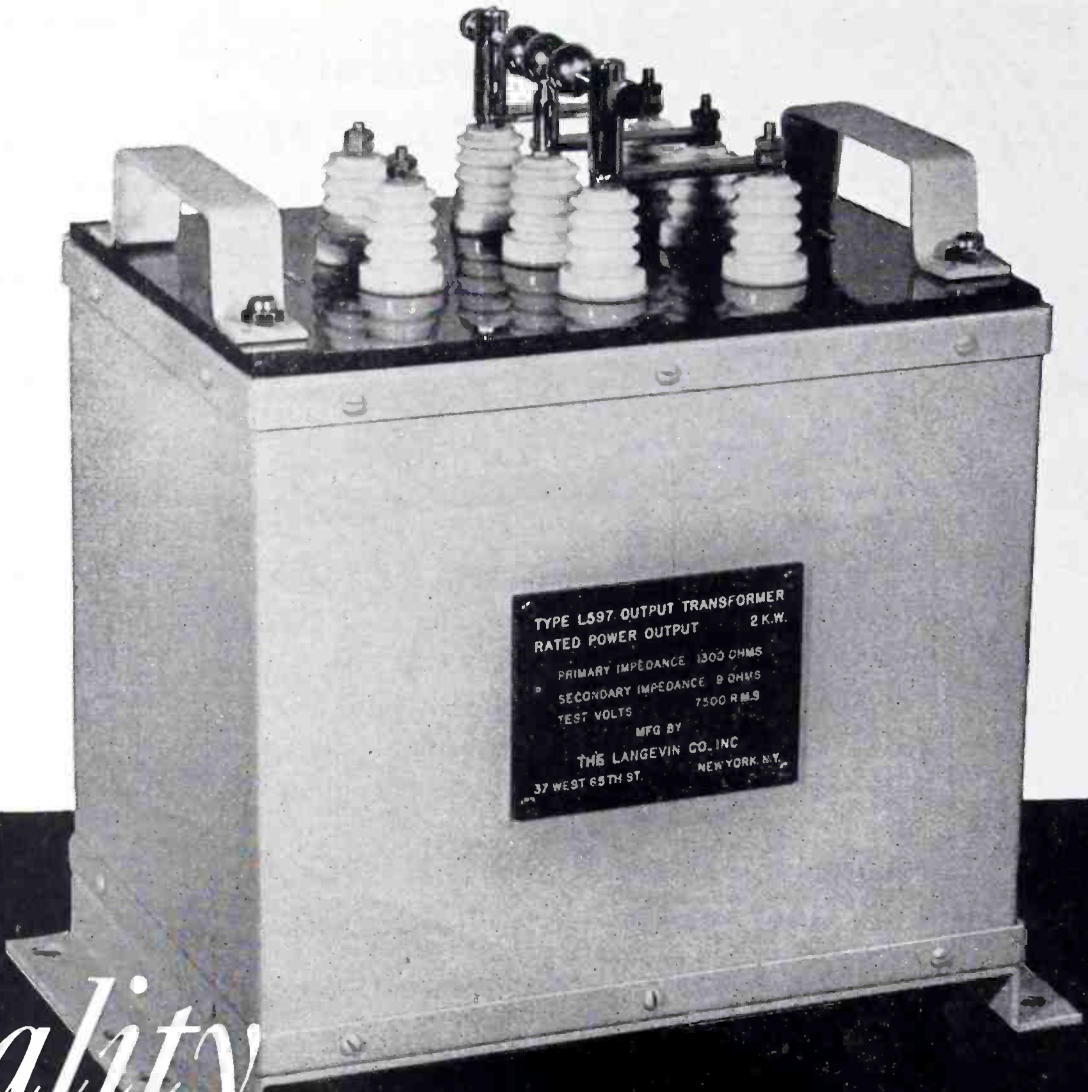
Of the features listed, the first—selectivity—is an inherent property of any synchronized oscillator. It can be shown mathematically[13] that if two equal voltages, one lying within the synchronizing range of an oscillator, and one without, are injected into the oscillator so that it is synchronized by the first signal, the amplitude of the second signal will be greatly reduced. Physically, the explanation of this is that the effective g_m of the oscillator tube for the interfering signal is considerably reduced, since it can produce an effect only during the amplification period, which is not synchronous with the interfering signal.

With subharmonic operation, the only effect of an adjacent-channel signal is a very slight frequency modulation which may occur during the amplification periods. While the desirability of good adjacent-channel selectivity will be enhanced as the f-m band is filled up, it is doubtful whether this advantage alone is sufficient to justify the use of a synchronized oscillator, if it is used following an i-f amplifier

• • •

GIRL AND GONIOMETER

Airwoman "Petie" Houston, of Hamilton, Ont., operates a direction finder with which she traces planes in flight. She is one of a class of RCAF Women's Division students at No. 1 Wireless School in Montreal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which already has a good selectivity.

At present, no known oscillator limiter circuit combines perfec amplitude limiting with high synchronization sensitivity and voltage gain. While it is possible t adjust an oscillator for a hig amplitude, 20 volts or more, so tha it limits very well for a signal a the center of the band, the amplitude still shows a variation ove the band, and the sensitivity usually drops by a factor of ten o more.

On the other hand, an oscillator with a lower amplitude level, and designed for maximum sensitivity and voltage gain, can be followed with a very simple limiter stage o the usual type, the combination giving excellent limiting action over the entire band. The use of a conventional limiter following the oscillator has the further advantage that the oscillator is separated from the frequency detector. If a conventional diode discriminator is connected directly to the oscillator

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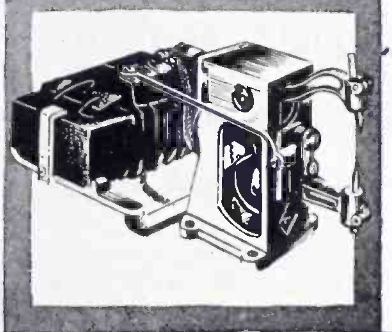

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through a secondary on the oscillator tank coil, the oscillator and discriminator alignments become interdependent, with consequent difficulties in production.

The last feature—a quieting sensitivity inversely proportional to frequency deviation—is of importance in the application of the synchronized oscillator-limiter to f-m services other than broadcast. These services generally employ a low deviation ratio, and a small quieting voltage on the limiter is very desirable because the r-f and i-f gains can be kept low and stable.

Injection of Synchronizing Voltage

In most of the previous applications of the synchronized oscillator, injection has been accomplished from low-impedance sources. Since the source of synchronizing voltage in a practical f-m receiver is the last i-f stage, problems arise because of the high impedance of this circuit. Coupling between the oscillator tank circuit and the synchronizing input circuit must be reduced to a minimum in order to ob-

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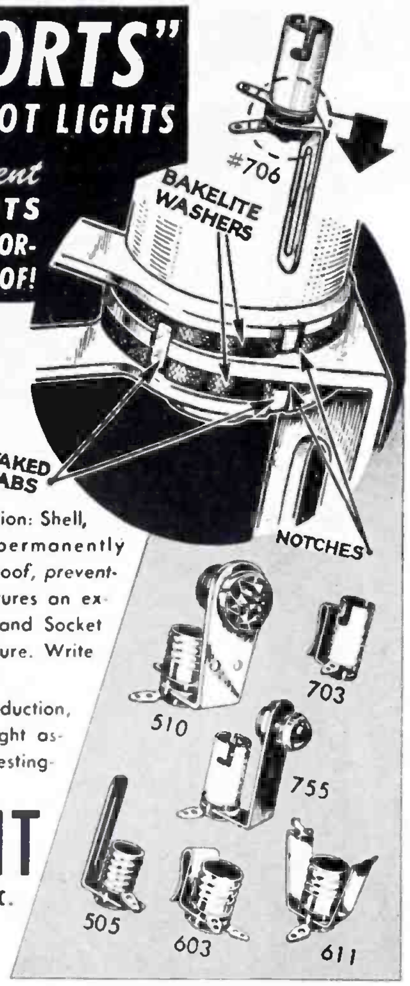

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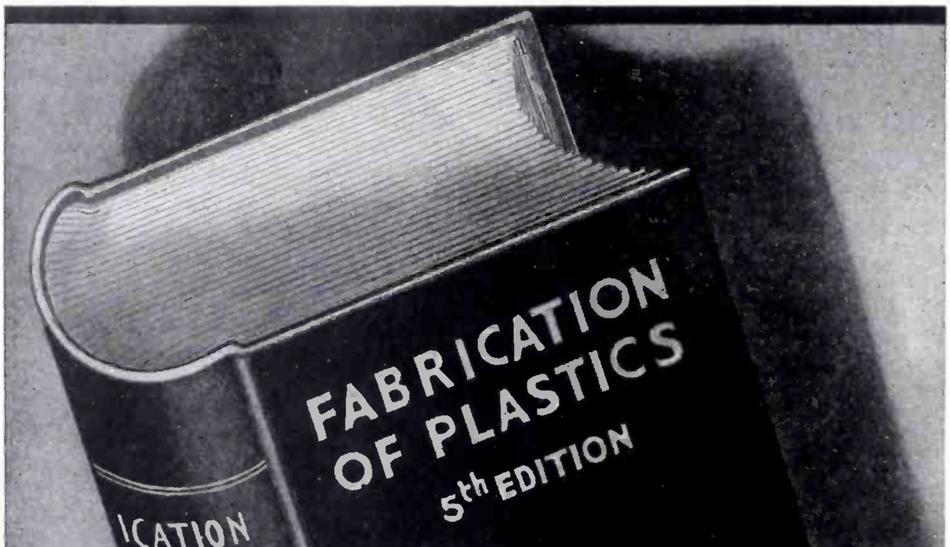

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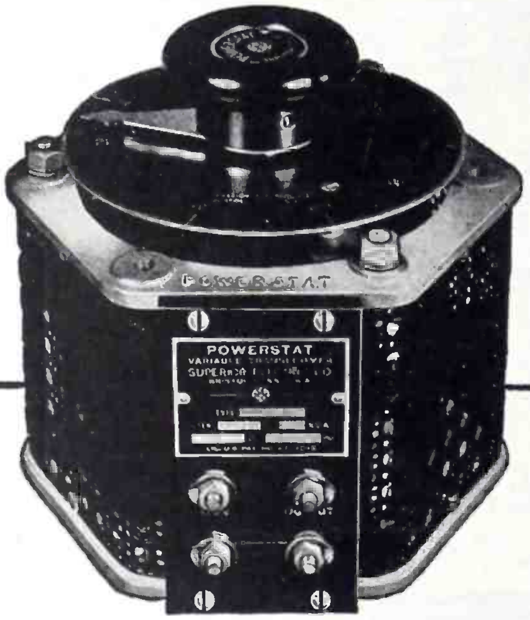

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tain normal gain from the i-f stage.

Figure 6 shows a typical synchronized-oscillator circuit using a type 1852 tube with the synchronizing voltage developed in the grid circuit. Oscillation is maintained by a cathode tickler winding. Because of the grid-to-cathode capacitance, part of the oscillator voltage across the tickler is developed across the input tuned circuit which at the same time works as the plate load for the last i-f amplifier.

Normal gain of an i-f amplifier is $g_m Q\omega L$, which might be 50 for an f-m i-f amplifier. If the oscillator operates at the fundamental, the loading effect due to the reflected oscillator voltage is so great that the amplifier gain practically disappears. With subharmonic operation, a gain of 10 in the preceding i-f amplifier is obtainable. Thus most of the gain in the oscillator itself may be lost by the reduction of gain in the preceding stage.

As mentioned, the Russian solution to this problem was the use of a pentagrid mixer, in which the first section acted as a buffer be-

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TECHNICAL NOTES

Excerpts from New Home Study Lessons Being Prepared under the Direction of the CREI Director of Engineering Texts

Phase Inverter Circuit

In the August issue of its monthly magazine, CREI NEWS, The Capitol Radio Engineering Institute continues its series of interesting technical articles. The coming issue deals with an interesting type of phase inverter circuit, particularly suitable for wide band operation, such as for a cathode-ray oscilloscope.

Part I, which appears in the August issue, describes the circuit, compares it with other types of phase inverter circuits, and analyzes its basic action.

A second article on the phase inverter circuit will appear in the September issue of the CREI NEWS. It will evaluate its gain and its stability under variable operating conditions.

We are making these technical articles available to every interested radioman. If you want to receive these articles on the phase inverter circuit, and other articles to follow, merely write to the Capitol Radio Engineering Institute, and ask for the August issue of the CREI NEWS containing this article. This and other future issues will be sent to you free and without obligation.

★ ★ ★

The subject of "Phase Inverter Circuit" is but one of many that are being constantly revised and added to CREI lessons by A. Preisman, Director of Engineering Texts, under the personal supervision of CREI President, E. H. Rietzke. CREI home study courses are of college calibre for the professional engineer and technician who recognizes CREI training as a proven program for personal advancement in the field of Radio-Electronics. Complete details of the home study courses sent on request. . . . *Ask for 36-page booklet.*

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PUNCH IN HOLES INDICATED

tween the input circuit and the oscillator. Unfortunately, with present tube structures this method has two disadvantages. First, it is impossible to obtain the desired g_m in the oscillator section if the electron stream is already limited by the first grid. Second, because of the low g_m, suppression of subharmonic oscillations occurs at a considerably lower level than is the case with high g_m pentodes. It is expected that by using different injection methods and tube structures, these difficulties will be overcome.

Even though the loading effect in the oscillator input circuit is reduced to a negligible amount, enough coupling may still exist between the oscillator and the i-f circuits to introduce hysteresis into the oscillator. The worst offender in this connection is stray coupling between the oscillator and the input to the i-f amplifier. An amount of coupling which ordinarily is acceptable in production will cause the oscillator to jump suddenly from one frequency to another during alignment, and make its correct adjustment impossible in production. Subharmonic operation overcomes this to a large extent, since the harmonic content of the oscillator is not large without an injected signal. Normal precautions must be taken to reduce overall feedback from the oscillator, however, even with subharmonic operation.

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A METHOD of producing pile fabrics, by applying cut fibers to a suitable backing material by an electrostatic process, was halted temporarily by the war.

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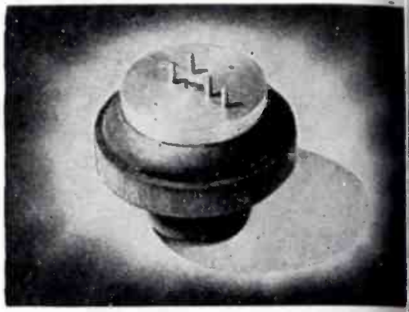
And cut rejections and costs with STEDMAN precision-made dummy tubes, tube-pin straighteners, etc.



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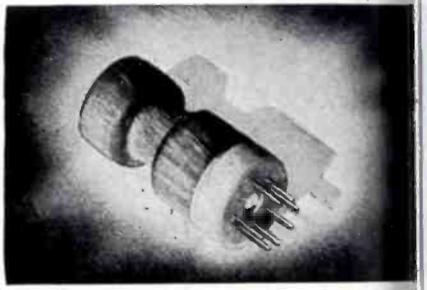
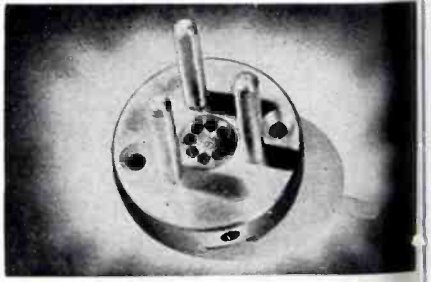


DUMMY MINIATURE TUBE
Precision made. Stainless Steel Pins. Used to hold socket clips in correct alignment during wiring.
Meets requirements of WPB subcommittee on miniature tubes.



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Used with hardened tool steel insert for factory use. Also stainless steel insert when resistance to corrosion is desired. Precision made. Body and posts cadmium plated. Inserts replaceable.
Illustrated above are a few of the products we are now delivering to leading equipment manufacturers. Standard items available. Special items to fit your particular requirements.

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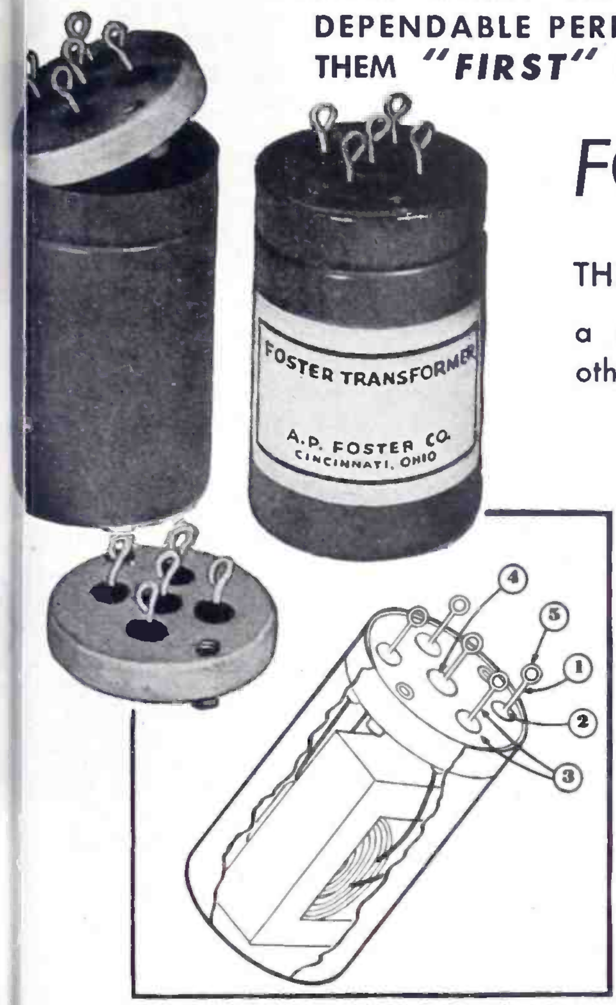

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a development that has definite advantages over other types of hermetic seals for tropical use.

❶ The electrode can be bent at an angle 90° from the upright position without breaking the glass in the seal. In fact, it can be bent and straightened several times and then the terminal will break *before* the glass is damaged.

❷ Extremely high resistance to thermal shock.

❸ The metallic parts are cold rolled steel, rather than expensive alloys.

❹ The terminals are fused directly into the metal in multiple. Ordinary seals are made up individually and are soldered into holes in the transformer case.

❺ A loop is provided for easy hook-up.

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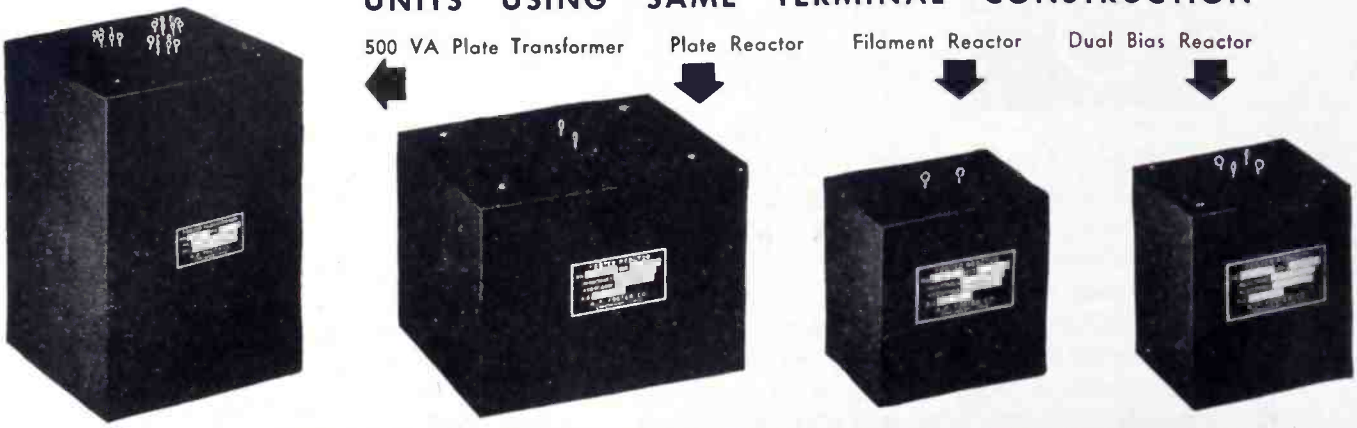

SPECIALISTS IN BUILDING TRANSFORMERS SINCE 1938

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TRANSFORMER ENGINEERS & MANUFACTURERS
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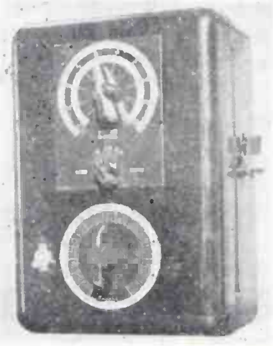
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

General Electric Products

THREE NEW PRODUCTS are available from General Electric Co., Schenectady, N. Y.

THE FIRST OF THESE, available from the Industrial Control Division, is a new tempering attachment, (CR7503-D149), for use with G. E. synchronous spot-welding controls which incorporate the phase-shift method of heat control. The attachment is particularly suitable for use in the spot-welding of air-hardenable steels, since it permits tempering the weld while the work is still in the machine. The attachment consists of a heat-control and a time-control adjuster for tempering, and the relays which automatically transfer the additional heat-and-time adjustment from the spot-welding control with which the attachment is being used. The attachment is enclosed in a metal case designed for wall mounting. The calibrated adjustment dials are mounted on the hinged door of this case, together with an on-off switch for preventing the relays from being energized when ordinary spot or pulsation welding is being done. Bulletin CEA-4201 is available on this unit.



FORMEX ribbon-rectangular magnet wire is now available as thin as 0.004 inch and can be applied where round wire previously had to be used. It increases the winding-space factor and may be used in place of larger size, rectangular magnet wire to increase magnetic effect or to reduce coil size. The wire is smooth, strong, flexible, and able to withstand high-speed winding without damage to insulation. The manufacturer states that its dielectric strength and the wire's resistance to abrasion, heat-shock, and solvents, is greater than that of other enameled wire.

FOR AIRCRAFT electric systems there is available standard dust-tight enclosures which come in various lengths. They are designed to house combinations of contactors, relays, and other devices usually required in control systems for airplanes. The enclosures are light in weight and provide ready accessibility to devices. They may also be used as junction boxes.

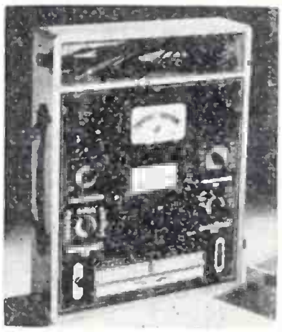
Radio City Products

THE FOLLOWING THREE new products are available from Radio City Products, Inc., 127 West 26th St., New York 1, N. Y.

MODEL 422 Supertester is for general circuit testing. Its features include current measurements in both a.c. and d.c. up to 25 amperes; voltage measurements in both a.c. and d.c. up to 5,000 v; high voltage is not applied to the selector switch nor to general test circuits. It has a 3-inch sq meter with movement of 200 microamps, or 5,000 ohms per volt sensitivity on d.c. voltage measurements. Resistance measurements can be made up to 10 megohms. The batteries are replaceable without the use of a soldering iron.

MULTITESTOR MODEL 420 is compact and rugged and measures 6⅜ x 3½ x 3 in, open faced, and weigh 25 oz. The meter movements ar guaranteed to be accurate within percent. The voltage multipliers ar a metallized matched pair of resistors having a tolerance of 1 percen The basic meter is rated 0.400 microamps. D-C meter, output mete milliammeter and ohmmeter provide a total of 23 ranges. A-C an d-c voltmeter is rated up to 5,000 at 1,000 ohms per volt sensitivity It comes supplied with batteries.

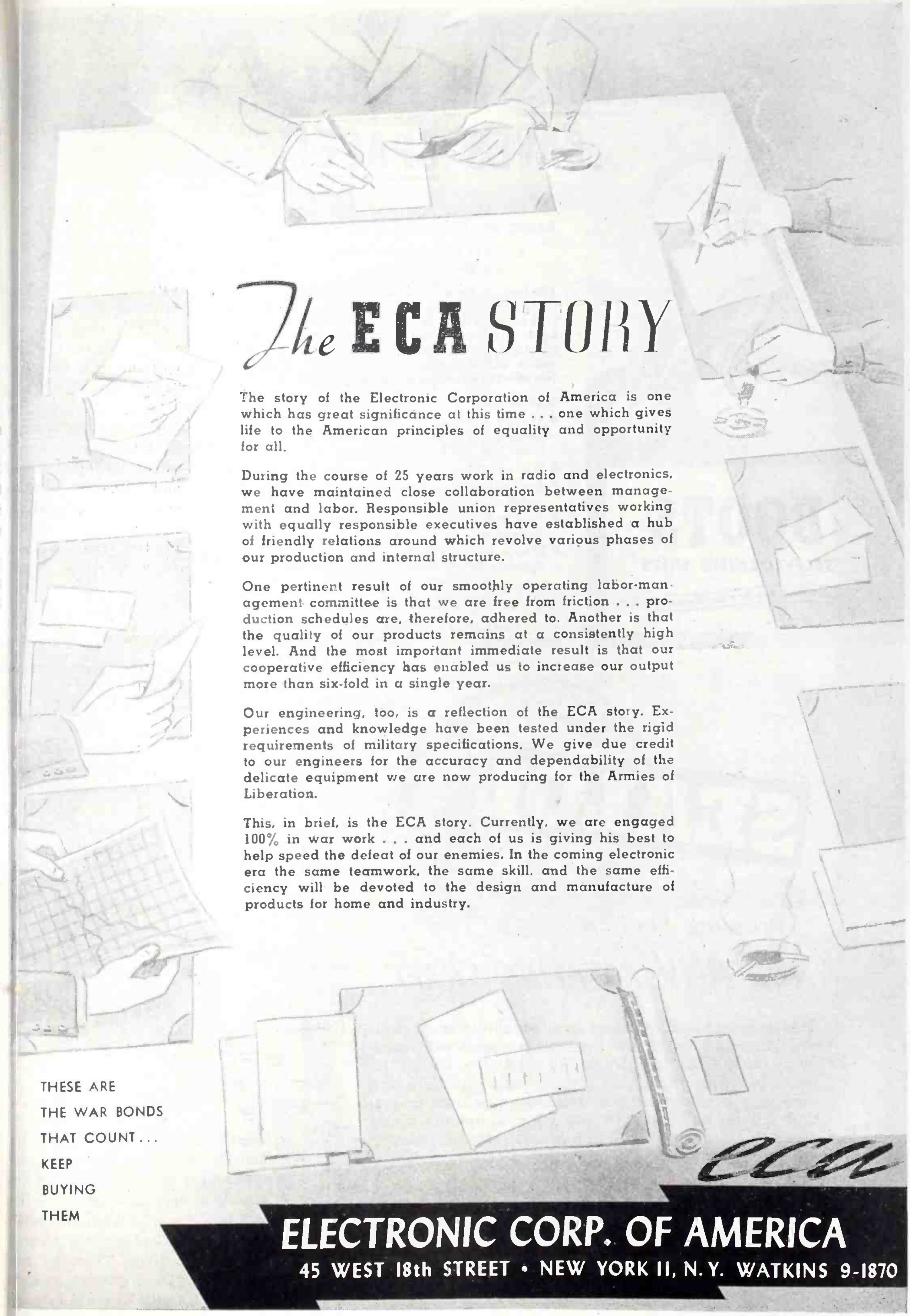
MODEL 314 is a tube tester. Th filament voltage switch is designe to test all present filament voltage from 1.1 to 117 volts. Lever type switching individually controls each tube prong, checks roaming filaments, and dual cathodes. The instrument provides separate plate tests on diodes and rectifiers and has a neon short test. The meter is rectangular and measures 4½ inches and has a poor-good scale. A pilot light indicates on-off.



New Electron Tubes

EQUIPMENT manufacturers may now obtain against WPB rated orders two new electron tubes.

The first of these is designated RCA-1P28 which is an ultraviolet-sensitive, high-vacuum. 9-stage multiplier phototube utilizing electrostatic focusing. It is similar in size and appearance to type 931-A but is constructed with a special



The ECA STORY

The story of the Electronic Corporation of America is one which has great significance at this time . . . one which gives life to the American principles of equality and opportunity for all.

During the course of 25 years work in radio and electronics, we have maintained close collaboration between management and labor. Responsible union representatives working with equally responsible executives have established a hub of friendly relations around which revolve various phases of our production and internal structure.

One pertinent result of our smoothly operating labor-management committee is that we are free from friction . . . production schedules are, therefore, adhered to. Another is that the quality of our products remains at a consistently high level. And the most important immediate result is that our cooperative efficiency has enabled us to increase our output more than six-fold in a single year.

Our engineering, too, is a reflection of the ECA story. Experiences and knowledge have been tested under the rigid requirements of military specifications. We give due credit to our engineers for the accuracy and dependability of the delicate equipment we are now producing for the Armies of Liberation.

This, in brief, is the ECA story. Currently, we are engaged 100% in war work . . . and each of us is giving his best to help speed the defeat of our enemies. In the coming electronic era the same teamwork, the same skill, and the same efficiency will be devoted to the design and manufacture of products for home and industry.

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The locking device is an integral part of this all-metal nut. Assures permanently tight, vibration-proof connections. Locks anywhere on bolt. Can be re-used effectively many times. Simplifies assembly and maintenance. Saves weight. Not affected by temperature or corrosion.

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FOR ANY ROTATING SHAFT

This compact seal operates in either direction of shaft rotation and seals fluids (including gases) with minimum power loss and frictional heating. "Sealol" is available with or without retainer cup and is adaptable to special conditions; requires minimum space, and is easy to assemble into your equipment. Send blueprints and complete information for recommendations. Descriptive bulletin on request.

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glass bulb which transmits radian energy in the ultraviolet regio down to about 2,000 Angstrom Featuring small size, rugged co struction, freedom from distortio low noise level, and extremely lo dark-current, the tube is intende for scientific research and specia ized applications where very lo ultraviolet radiation levels are i volved.

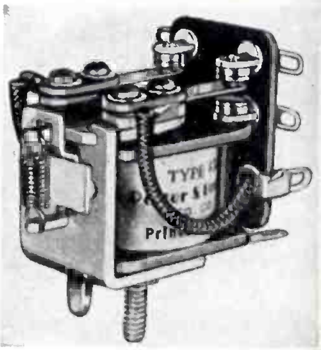
The other tube is 6AQ6, which a miniature multi-unit tube co taining two diodes and a high-m triode in one envelope. Many of i electrical characteristics are sim lar to those of the metal type 6Q but it requires only half the heate current and has appreciably lowe grid-cathode and plate-cathode ca pacitances. The tube is designed fo use as a combined detector, amplifier, and automatic-volume-contro tube. Its small size facilitates th design of small, compact receive units.

RCA Victor Div., Radio Corporation of America, Harrison, N. J.

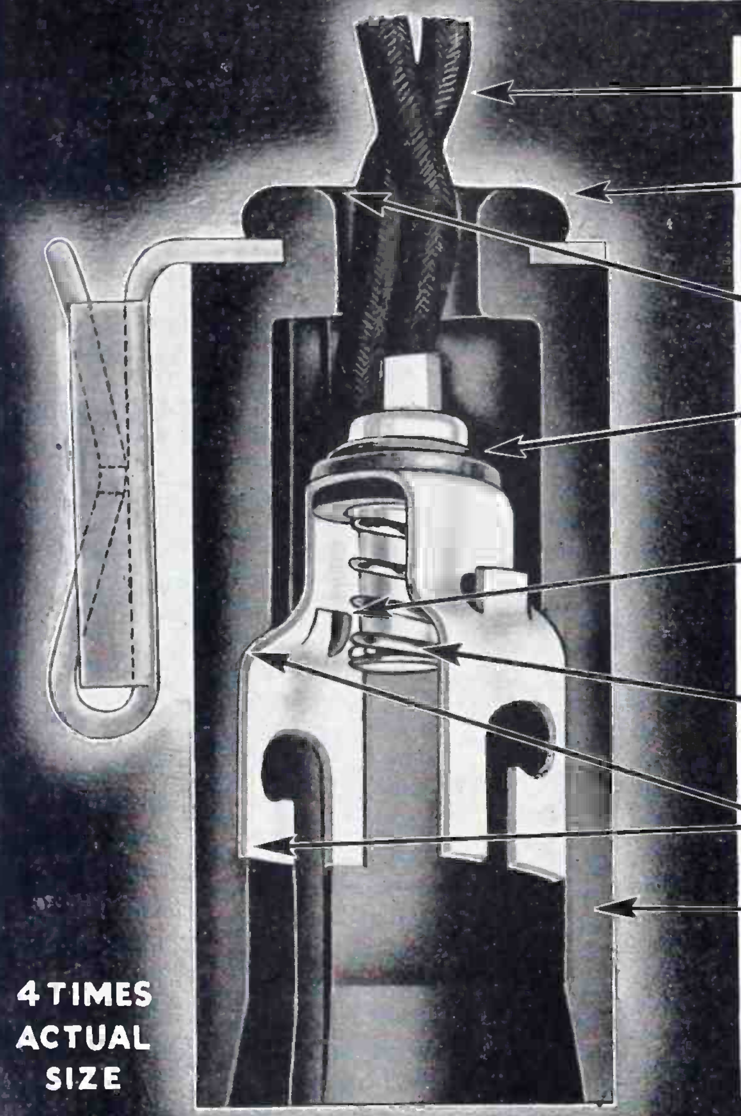
Aircraft Relays

SERIES KR AND KL are two new types of relays designed for circuit switching in aircraft radio applications.

The KR Series are sturdy relays designed for applications where size and weight are important factors. Where current is not too limited, the d.-c. types can be adjusted to withstand the vibration encountered in most aircraft applications. The relays can be provided with a mechanism for easy adjustment of armature spring where a critical pull in value of current or voltage is required. Contacts are normally supplied in silver. They are rated at 3 amp, 110 v, 60 cps, noninductive load. Coils are available for



a New and Superior DIAL LIGHT SOCKET



Tensile strength of leads and connections far in excess of requirements.

Tough, plastic shell molded around bracket providing a secure bond with mechanical strength far beyond any normal requirement.

Rounded edge will not cut or fray wire insulation.

Voltage Breakdown between contacts—1200 Volts. Voltage Breakdown to ground —5000 Volts.

Lug on contact fits in groove in shell so that contact cannot be turned or twisted when inserting lamp.

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Plastic shell is recessed for contacts, which cannot be pushed or pulled out of position.

Stronger, tougher, neavy walled plastic shell.

A variety of different mounting bracket styles available, suitable for practically any mounting.

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This year Lenz celebrates its 40th year of service to the communications industry.

Lenz Dial Light Sockets have always been known for their superior mechanical qualities and electrical characteristics.

Now these sockets are still further improved, with even greater mechanical strength. A stronger, tougher plastic shell is attached to the bracket with a new type of construction that provides a virtually unbreakable bond between shell and bracket. Its excellent electrical characteristics are maintained.

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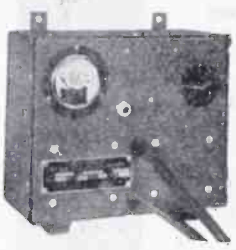

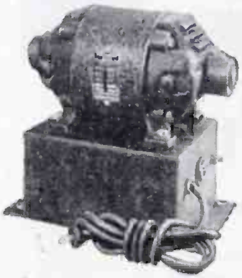

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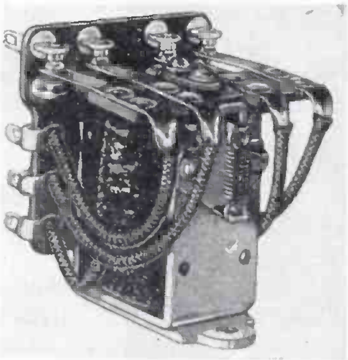
voltages up to 110 v, 60 cps, or 60 v, d.c. Contact arrangements may be had up to and including DPDT. In this series is included Type KRD-4 which measures 1$\frac{11}{16}$ x 1$\frac{1}{4}$ x 1$\frac{3}{16}$ in., not including the mounting stud. The unit weighs 1$\frac{3}{4}$ to 2 oz and is designed to mount in two holes.

The KL Series have approximately twice as much coil space and a larger number of poles than the KR Series. These relays will operate on values as low as 0.2 watts. The contacts are normally supplied in silver, and are rated at 3 amp, 110 v, 60 cps non-inductive load. Coils are supplied for voltages up to 220 v, 60 cps, or 110 v, d.c. Contact arrangements are available up to and including 4 pole DT. Type KLD-1 of this series measures 1$\frac{13}{16}$ x 1$\frac{13}{16}$ x 1$\frac{13}{16}$ in., and weighs 3$\frac{1}{2}$ to 4 oz.



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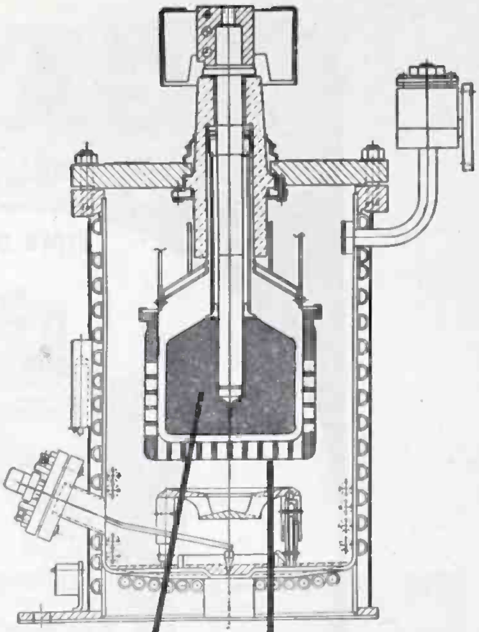

THAT'S AN UNWRITTEN LAW in many laboratories today. Because "National" graphite's purity—99.979%—could be expressed as a number, the manufacturer's engineers knew what its performance characteristics would be when used as the anode and anode shield material in this Ignitron Rectifier.

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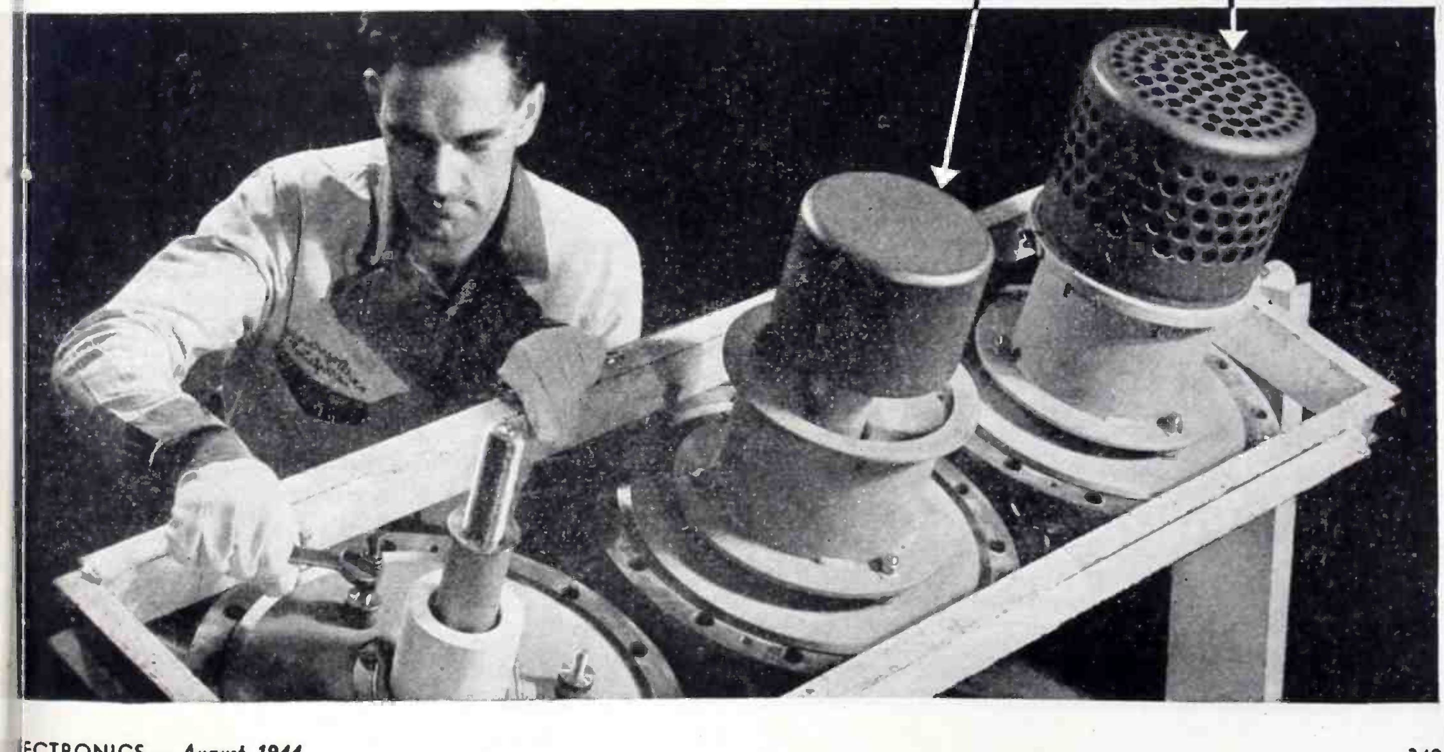

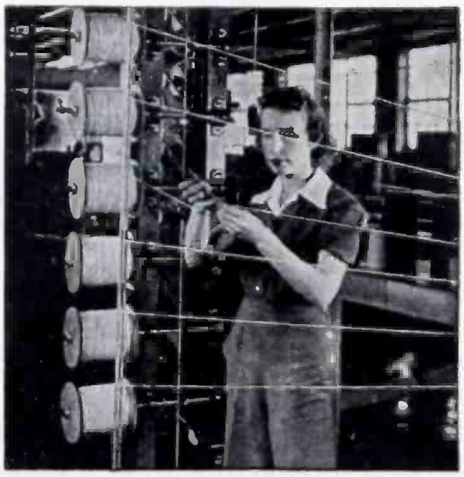

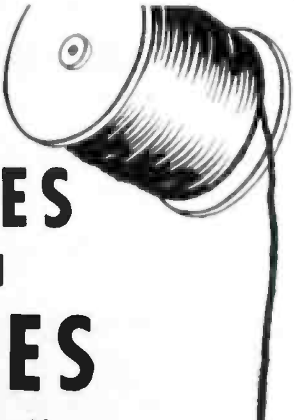

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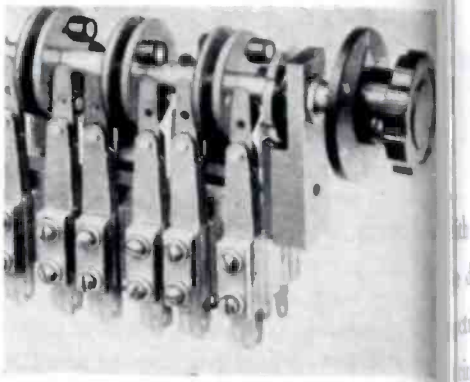
THE NEW ROTARY cam lever switch is designed for one to six index positions. Any combination of spring-leaf contact assemblies is available for each of the six positions. Practically any number of circuits in sequence (or repeat) can be opened or closed by the use of a single control knob. One hole is required in the panel for mounting, and contact assemblies in any section can be removed from the frame by removing one bolt. Other features of the unit include spring-type actuators, cast aluminum frame, Bakelite cams and rollers, static-shielding nickel-plated phosphor bronze contact springs, solid silver contacts, circular cams for locating up to 12 low-friction spring-type actuators, and contact build-ups assembled under pressure. The switch is rated at 10 amp, 125 v a.c., and is built to meet Government specifications.



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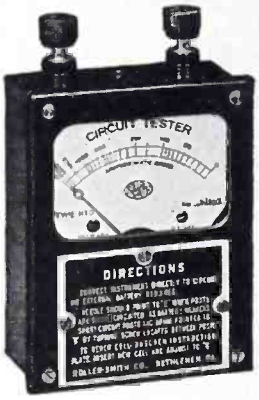

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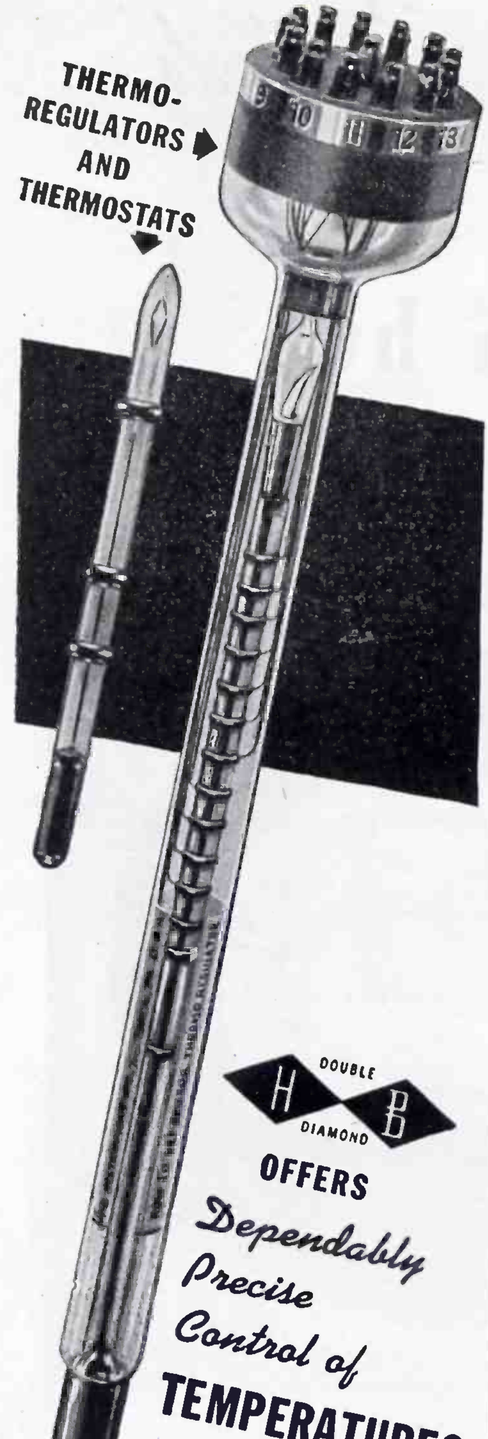

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Electronic Power Co., Inc., 18 West 44th St., New York 18, N. Y.

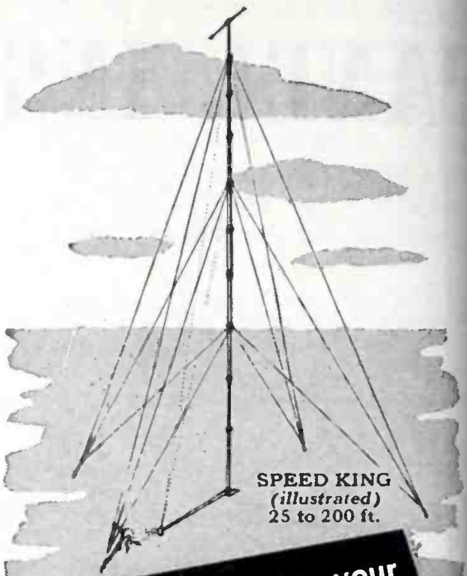
Timing Devices

SERIES 5900 comprises synchronous motor-operated automatic reset time delay and interval timers for time delays of one second to five minutes with fixed or adjustable intervals. The units are available with various assemblies of actuating arms, reset springs, terminal mountings and precision snap switches, NC, NO, and DT. For applications involving shock and vibration, the motors can be equipped with a shift-counterweight assembly. The motors are also available with special plating and other protection against high humidity, corrosion and fungus growth. These same units, designated as 5148 series, are available for d.c. operation.

Haydon Mfg. Co., Inc., Forestville, Conn.

HARCO

RADIO MASTS and TOWERS



are the solution to your PROBLEMS (present or post-war)

because-

1. **LOW TRANSPORTATION COST.** Shipping expense reduced to a minimum because total weight and shipping space is extremely small. Also low storage and handling costs.
2. **MINIMUM ERECTION COST.** Speedy erection insured—due to elimination of Bolts and because customary erection labor expense has been reduced by shop fabrication. All connections reduced to simplest form.
3. **CAN BE ERECTED WITH INEXPERIENCED LABOR.** HARCO MASTS AND TOWERS are easy to put up. Emphasis placed on portability—no sections are too heavy for one man. No skill required for making connections. None of the usual hazards exist. Ground assembly optional.
4. **CAN BE ERECTED UNDER ADVERSE CONDITIONS.** Erection accomplished under all weather conditions and extreme temperatures by men wearing gloves. Rigid construction is the result of all sections having a high strength-weight ratio, and the type of connections and bracing used. Every safety precaution possible has been taken.

Whatever your problems may be, HARCO can solve them from every Engineering angle. If none of our 16 Standard Designs meet your requirements, we can give you a "Custom Built" job.

Please send complete design specifications when inquiring for detailed information.

HARCO

STEEL CONSTRUCTION CO., Inc.
Elizabeth 4, New Jersey

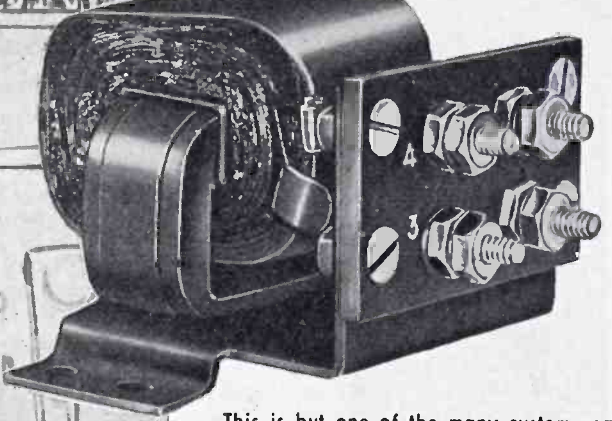
Giving Eyes to War Birds

.. AT 50,000 FEET AND — 57.4 DEG. F

To the combat pilot, high up in the inky blackness of night, the glowing instruments are more than a mechanism . . . they're his security, his strategy and his return ticket! These lights must not fail!

To further this dependability in aircraft lighting systems, the N-Y-T Sample Dept. has produced the 8 ounce transformer illustrated—lighter in weight by 40% than any component of the same output previously used.

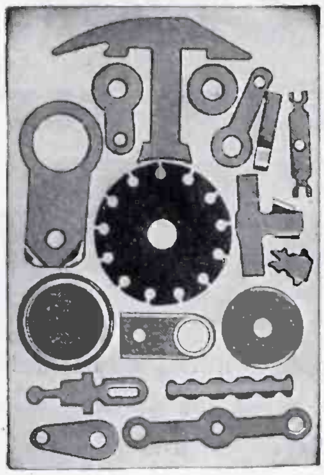
Conservative, from the standpoint of electrical and mechanical characteristics, this N-Y-T unit has a temperature rise of only 30 deg. C. and permits operation over all ambient from minus 65 deg. C. to plus 70 deg. C. Its diversity of application is illustrated by the fact that output voltages and currents may be varied without affecting size and weight, if the output is held to 30 V.A.



This is but one of the many custom-engineerings executed by N.Y.T. technicians, in hastening Victory through electronics; similar transformer products will aid immeasurably in the fulfillment of peace-time advancements.

NEW YORK TRANSFORMER CO.

26 WAVERLY PLACE
NEW YORK 3, N. Y.



Pocket-Type Circuit Tester

THIS TESTER is designated as Type HTD. It is designed to determine the resistance of an electrical circuit with the scale reading directly in ohms. It is available with a range from zero to 10,000 ohms, or with two ranges from zero to 5,000 and zero to 50,000 ohms. The unit weighs 19 oz, and measures 4½ x 3 x 1½ in. It consists of a small d'Arsonval, type d.c., voltmeter which is connected in series with a standard flashlight battery. Terminals are provided for connecting to the circuit under test. The plate on the front can be removed to replace the dry cell battery and also gives access to the internal zero adjuster. Catalog No. 123-b on this instrument is available from Roller-Smith Co., Bethlehem, Pa.

Chest Set

THIS CHEST SET, designated as TD-3, is a Signal Corp item designed for use between a microphone and a transmitter and consists of a chest unit, equipped with a switch; a junction box; two cotton webbing straps; and two cords for connecting a throat or lip mike to a transmitter. It has a three-way toggle switch (on, off and momentarily on). The complete unit or any component part is available from Trav-Ler Karenola Radio & Television Corp., 1036 W. Van Buren St., Chicago, Ill.

New Power Supply Units

SELENIUM RECTIFIER power supply units of 1, 5 and 10 amps capacity at 115 v d.c. constitute a new line of such units designed for use in the operation of magnetic equipment, d-c motors, relays, circuit

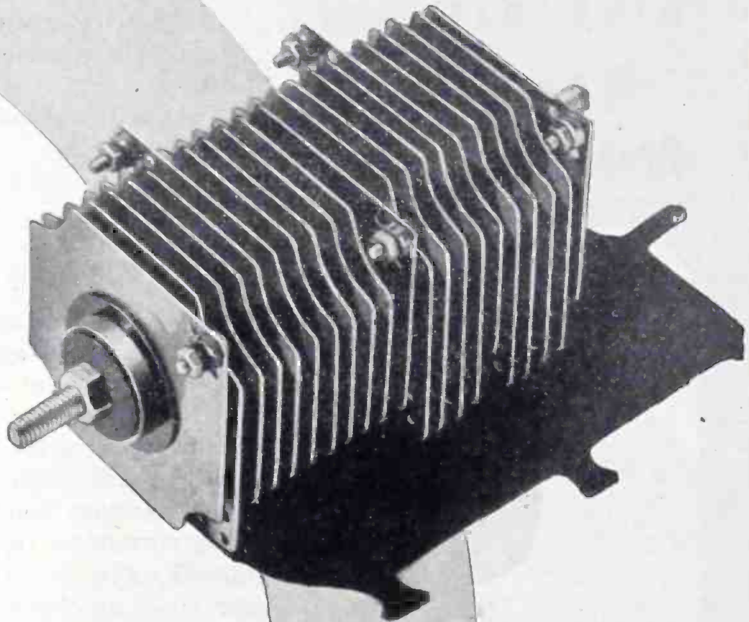
Only Offers All Three

Low-voltage Rectifiers

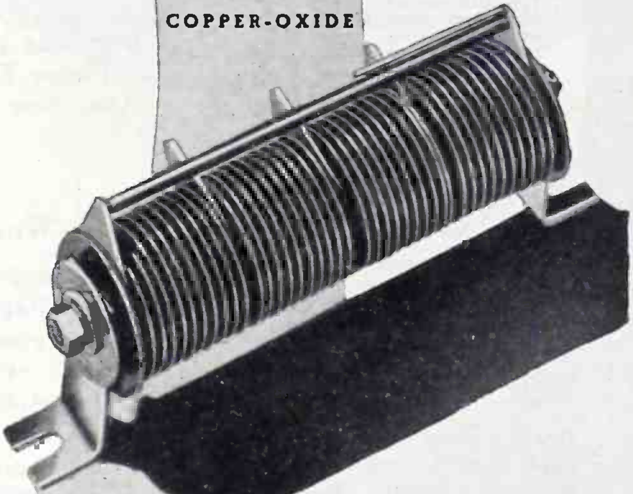
Where other manufacturers offer one or two of the three standard types of low-voltage rectifiers, General Electric is alone in supplying all three—an important fact to remember when next you need a rectifying unit. The reason: The most efficient type in one application may be least efficient on the very next application. It is in determining which type to use in each instance that G.E. can help you most—having all three types it can give impartial engineering advice on which one you should use. Full details from Section A844-119, Tungar & Metallic Rectifier Division, General Electric Co., Bridgeport, Conn.

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news, every weekday 6.45 P.M. EWT, CBS.

GENERAL ELECTRIC



COPPER-OXIDE



SELENIUM

TUNGAR

breakers, carbon arc lamps, battery chargers, and other similar devices. Other capacities are available on request from the manufacturer. The units are designed for wall or bench mounting and require no special connections. They are equipped with a 6 ft input lead with male connector and a standard convenience receptacle for the output. The 10 amp unit is furnished with an 11-point selector switch for maintaining 115 v from no load to full load.

Federal Telephone & Radio Corp., Newark, N. J.

Industrial X-Ray Unit

Model 50 KV industrial x-ray unit is for low kilovoltage x-ray inspection of light metal alloys, spot-weld control, micro-radiography, thin sections of heavier metals and articles of low density such as plywood, plastics, leather, glass, textiles, porcelains, ceramics and biological specimens. The unit is self-contained, shockproof, rayproof and is rated for continuous operation over long periods of time.

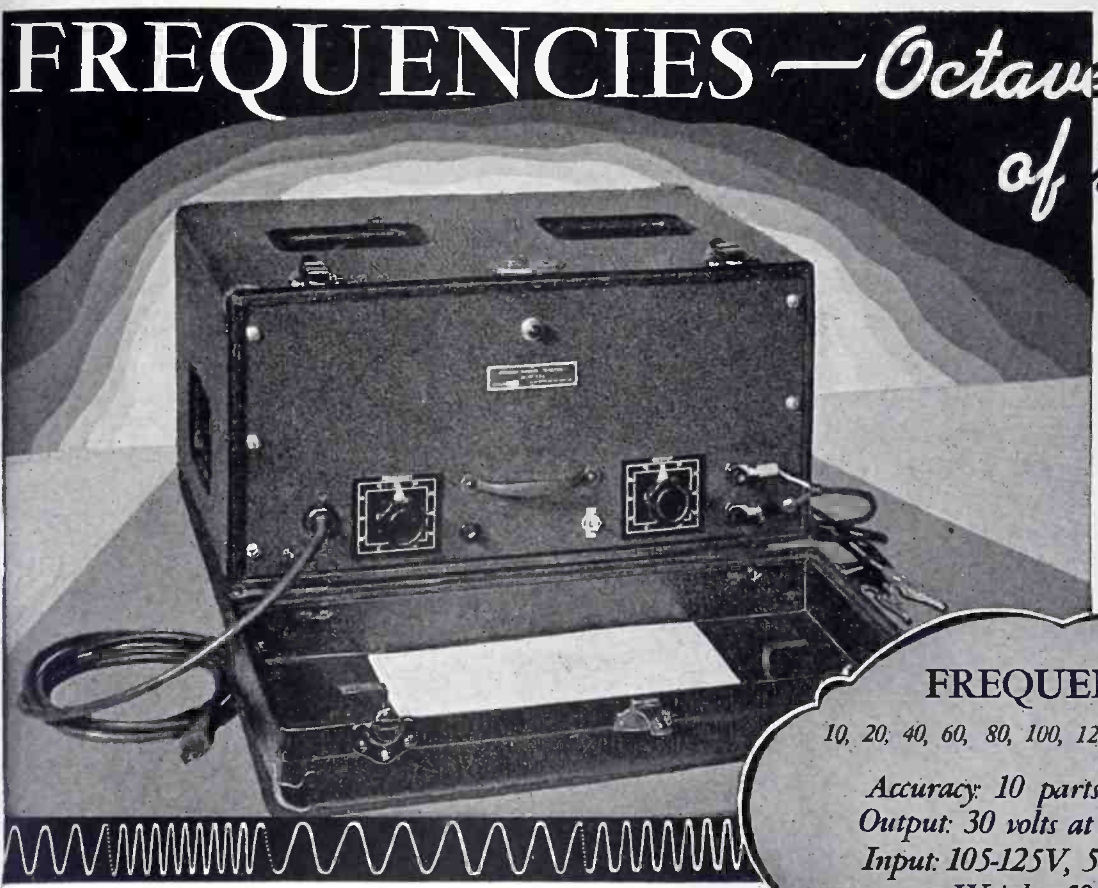
Picker X-Ray Corp., 300 Fourth Ave., New York 10, N. Y.

Wire-Wound Surge Resistors

Developed for x-ray and other high-voltage applications, Type 290 wire-wound surge resistors are capable of handling high voltage, and dissipating normally 200 watts. The resistors are wound on high-grade, non-hygroscopic ceramic forms with insulated Nichrome wire, single layer space-wound. The wire is protected with a finish which re-insulates and resists heat and operates on 450 deg F. Any resistance from 1,000 to 3,000,000 ohms is available. The manufacturer cites as a typical application of these resistors their use in the constant potential d.c. output of a high-voltage Kenetron rectifying system to stabilize the performance of the apparatus to which this high potential is being applied, with the resistors operating either as bleeders or as voltmeter multipliers.

Shallcross Mfg. Co., Jackson and Pusey Aves., Collingdale, Pa.

STANDARD FREQUENCIES—*Octaves of them*



FREQUENCIES

10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 190

Accuracy: 10 parts in 1,000,000
Output: 30 volts at 500,000 ohms
Input: 105-125V, 50-60c, 40 watts
Weight: 50 pounds

Impossible? Well, here it is—

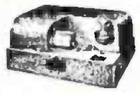
This Multi-frequency generator furnishes the frequencies shown above at the turn of a switch. All frequencies are obtained from a temperature-compensated tuning fork and voltage-stabilized circuit.

With this unit it is possible to calibrate oscillators at many selected points without encountering complex oscilloscope patterns. One of the uncertainties involved in development work on tuned circuits, filters, reeds—and in time measurement can be minimized with the aid of this instrument.

Developed primarily to check frequency meters for precision war work, this Multi-frequency generator possesses a rugged durability and dependability in service that will prove an extra value to many laboratories.

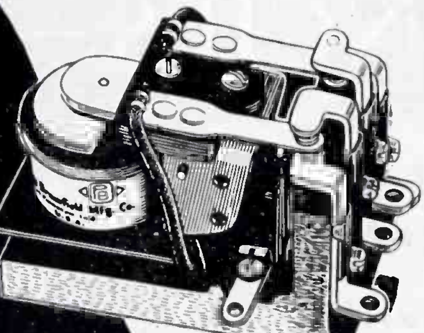
Additional information available on request.

Manufacturer of the
Watch Master



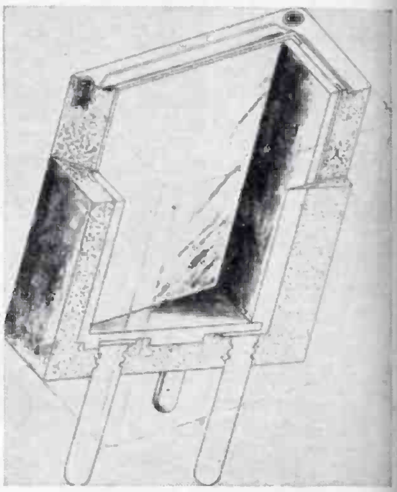
and distributor of
Western Electric
Watch-rate Recorders

American Time Products, INC.
580 Fifth Avenue New York 19, N. Y.



Quartz Crystal Holder

SP-3A HOLDER for quartz crystals is suitable for use with certain aircraft and Navy crystals, and is designed so that it contains no crevices, strands of wire, or hollow pins which can hold foreign material. The surfaces of the holder may be washed clean before sealing. Solid pins, imbedded in plastic, are used to make the holder strong and act as an added precaution against foreign material. Pins and contact plates are made of stainless steel to prevent corrosion under adverse conditions.



Henry Mfg. Co., 2213 Westwood Blvd., Los Angeles 25, Cal.

Fungicidal Concentrate for Waxes

THIS CONCENTRATE is the newest development in a line of fungicides developed in collaboration with military engineers. The concentrate may be used in various insulation and sealing waxes. It does not volatilize or lose potency at bath temperatures, and it is non-toxic to humans and therefore will not cause dermatitis.

Insl-X Co., 857 Meeker Ave., Brooklyn, N. Y.

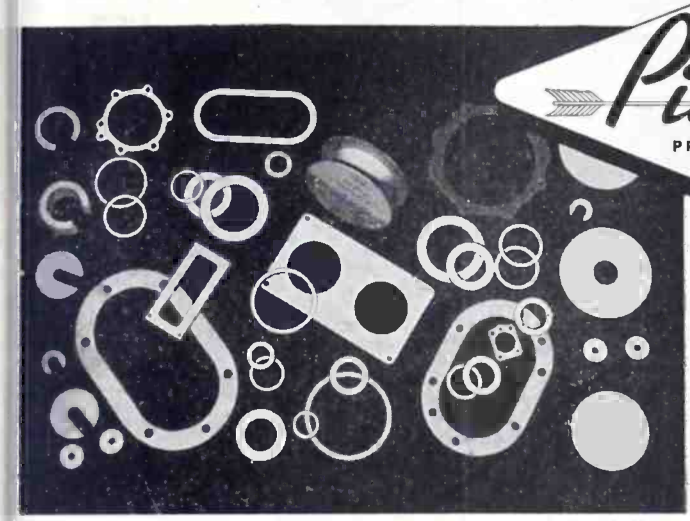
Extruded Tubing

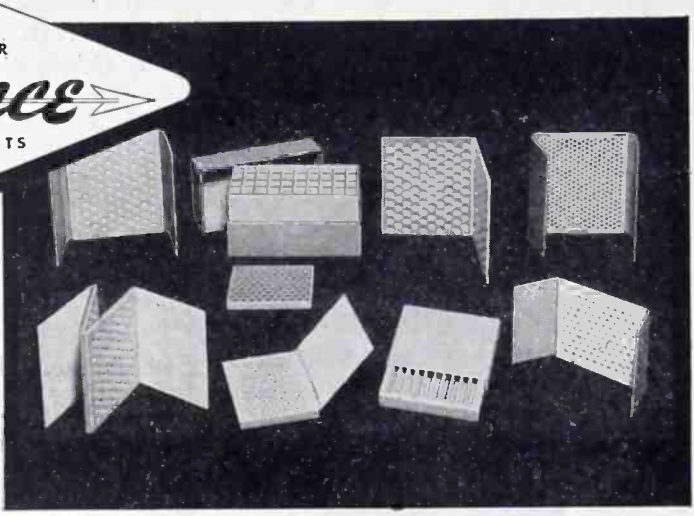
THOUGH THIS newly developed vinyl tubing, designated Natvar 400 Series, has the same electrical properties as conventional tubing, the manufacturer states that it has better heat endurance characteristics, resistance to oil embrittlement and resistance to gasoline-benzol. Wires insulated with it may be soldered without special care or technique

We Can Make *These* For You... *Now*

SEND US YOUR SPECIFICATIONS ON STANDARDIZED ITEMS, OR LET US HELP DEVELOP NEW USES TO MEET YOUR NEEDS. WE ARE EXPERIENCED PAPER CONVERTERS . . . HAVE A NEW, UP-TO-DATE PLANT . . AND ARE IN A POSITION TO SERVE YOU WELL AND PROMPTLY

PAPER
Pierce
PRODUCTS





NDUSTRIAL GASKETS; DIE CUT SPECIALTIES

ierce industrial gaskets: manufactured to precision dimenons from paper, felt, cork, asbestos, synthetic rubber, leather r special compositions; meet specifications for resistence to il, water, gasoline, heat, pressure. Die-cut specialties: prouced by rotary press, platen press, punch press, or drawing ethods from paper, felt, cork, special compositions.

ACKAGING AND SHOP PRODUCTION ENVELOPES

ierce packaging envelopes for holding small flat parts; etal-top envelopes for secure fastening and convenient repening; waterproof and greaseproof envelopes to meet all pecifications; duplex shop-order envelopes — with protective lassine panels: the modern method of keeping blueprints and roduction orders together during work in progress.

NEW...SAF-T-PAK BOXES FOR SMALL PARTS

Pierce Saf-T-Pak Boxes: specially designed to individual requirements for the protection of small precision parts and other fragile items easily damaged in shipment. Can be produced from kraft, chipboard, or special compositions in a wide variety of forms with die-cut cells, cushion liners, partitions, other construction features of protective packaging.

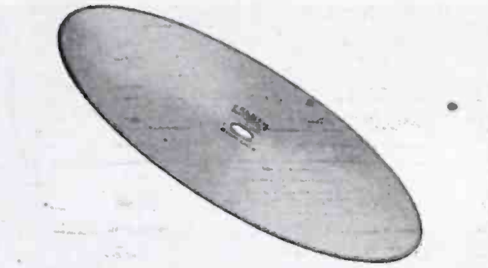
SPIRAL-WOUND PAPER TUBES AND CANS

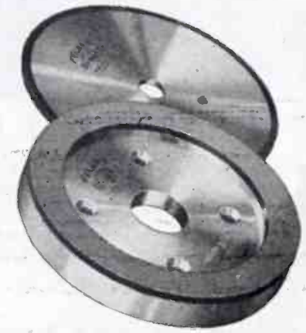
Pierce spiral-wound tubes and cans: in diameters from 3/8" to 6" — any required length — from waterproof paper, kraft, chipboard, special compositions. Also, Pierce Saf-T-Pak tubes with felt liner for protection of fragile parts in shipment. Pierce protective caps and tubes for male and female threads: made in any size, waxed or plain.

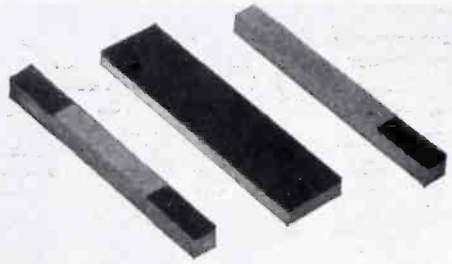
PAPER
Pierce
PRODUCTS

★ ***WRITE FOR SAMPLES AND COMPLETE INFORMATION***

Manufactured by **PIERCE PAPER PRODUCTS CO., 2726-B AUBURN STREET, ROCKFORD, ILLINOIS**







and without flow or opening of the tubing near the point of soldering. It is tough, resistant to tear, and has tensile strength in excess of 3000 psi, with elongation from 170 to 410 percent depending on the type of tubing. It remains flexible down to −80 deg F. The tubing is chemically inert and is suitable for oil lines, sheathing and other protective coverings in applications where adverse oil, solvent or acid conditions are severe, and where protection from chemicals or vibration is required over a wide temperature range.

The National Varnished Products Corp., Woodbridge, N. J.

Molded Mica Capacitors

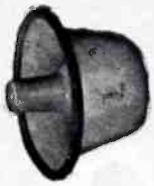
THREE TYPES OF capacitors have been added to the manufacturer's line of "El Menco" capacitors. Type CM-20 comes in two types which include No. 503J and 603J.

Both of these have cases which measure $\frac{11}{16}$ x $\frac{7}{16}$ x $\frac{7}{32}$ inches, with wire terminals measuring 0.032 inches in diameter and $1\frac{1}{4}$ in. long, thinned brass. No. 503-J (foil) is rated at a capacity range from 2.5 to 1500 $\mu\mu$f, maximum working volt from 800 to 300, and minimum tolerances rated from ± 10 percent to ± 5 percent. No. 603J (silver) has a capacity range of 2.5 to 1000 $\mu\mu$f, maximum working v of 500; and a minimum tolerance of ± 2 percent. The third type is designated CM-40 (604L silvered). Case dimensions are $1\frac{1}{32}$ x $\frac{41}{64}$ x $\frac{11}{32}$ in. Wire terminals measure 0.040 inches, in diameter and $1\frac{3}{8}$ in long, thinned brass. Capacity range is from 470 to 10,000 $\mu\mu$f; maximum working voltage is 500; and ± 2 percent minimum tolerances.

The Electro Motive Mfg. Co., Willimantic, Conn.

Precision Welding Timer

SUITABLE FOR WELDING small objects of high conductivity such as aluminum or copper, a new precise welding timer, designated as SP-18, is available with heat control for timing intervals of one-half cycle or less. The timer is designed for welding of such items as radio tube parts and sockets, pig-tail resistors



000 B.C.

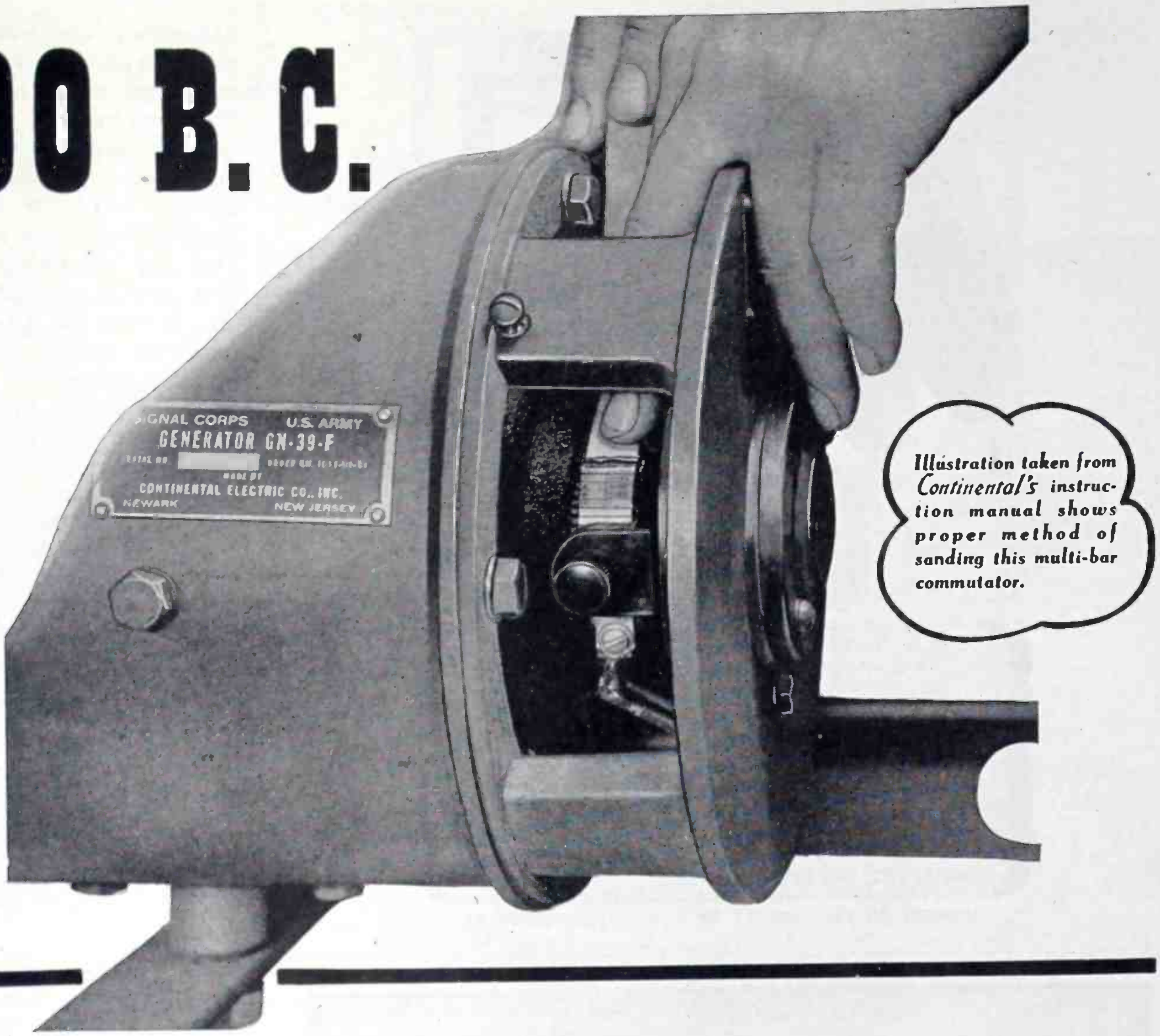


Illustration taken from Continental's instruction manual shows proper method of sanding this multi-bar commutator.

00 Volts Between Coils is the operating voltage of these engine ven generators being built for the Signal Corps by *Continental ctric Co., Inc.* of Newark, N. J.

hey are tested at 3000 volts—three times their normal voltage. et compact design allows only minimum clearance between coils!

atvar varnished acetate and Natvar varnished silk were chosen *Continental* for this important application because they are *thin*, cause they have *high dielectric strength*, and because they are *iform.*

hat are your insulation problems? Write, wire or phone us for liveries, either from stocks located near you, or from our own.

Natvar

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished cellulose acetate
- Varnished Fiberglas cloth
- Varnished papers
- Varnished tubings and sleevings
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded Vinylite tubings
- Extruded Vinylite identification markers

THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE
RAHWAY 7-2171

CABLE ADDRESS
NATVAR: RAHWAY, N. J.

201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

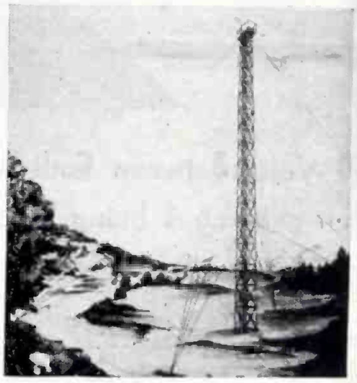
8-NVP-6

to terminal lugs, watch and instrument parts, contact tips on electrical relays and other small part The instrument is furnished as separate control for use with existing small bench welders in combination with a small weldin transformer. One control tube i used, and this thyratron serves th dual purpose of rectifying alternating current to charge a firin capacitor and also firing the smal ignitron power tube. Heat contro is accomplished by a phase-shif method, the adjustment dial fo which is mounted on the cabine door. The timer is rated at 230, 460 volts, 50/60 cps.

Department 7-N-20, Westinghouse Electric & Mfg. Co., Eas Pittsburgh, Pa.

Radio Tower

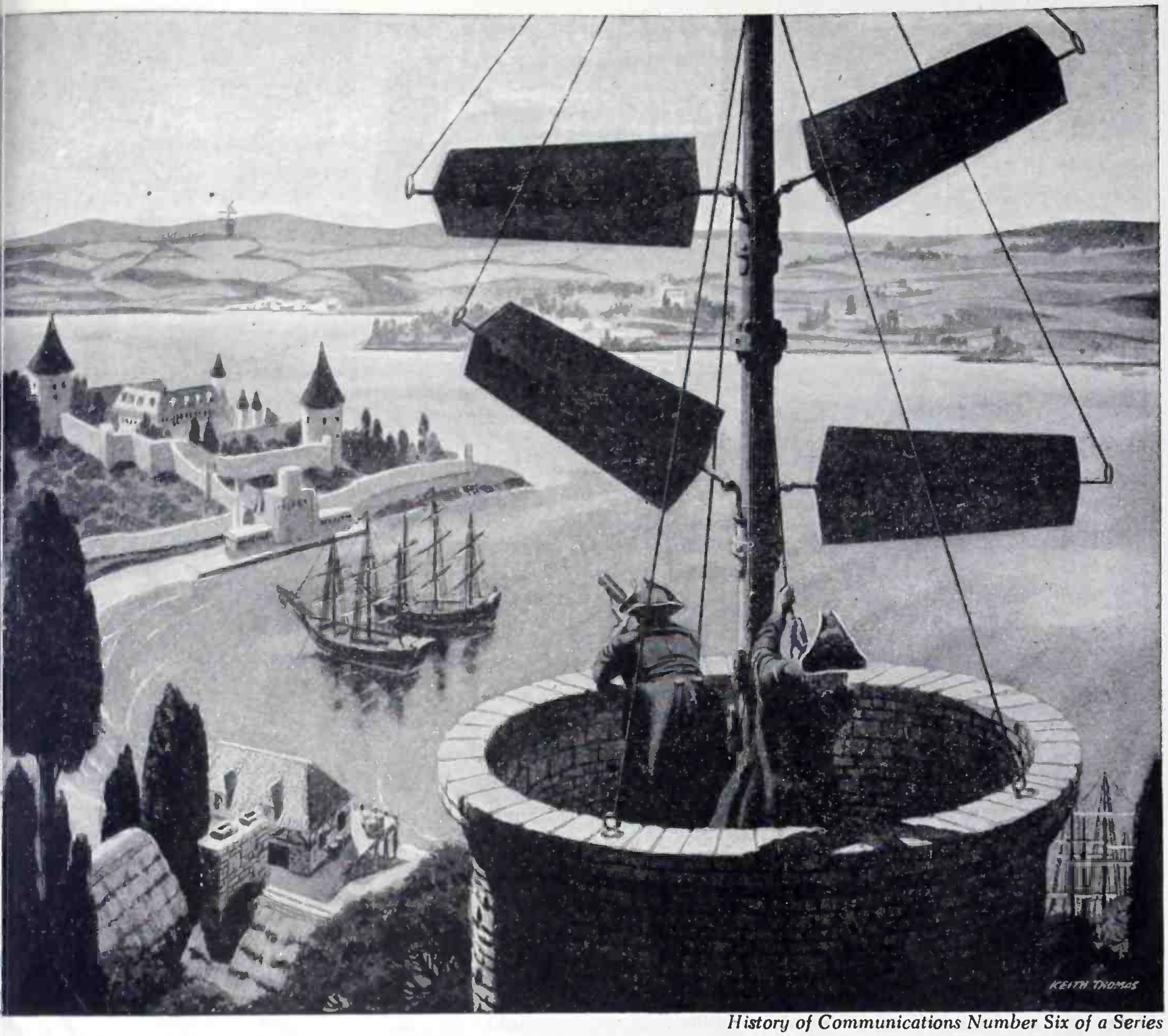
BANTAM KING is the name of 30, 50 and 100-ft steel towers made of interchangeable four-foot sections each six feet in height. The towers are easily and quickly installed, and may be used as a portable or permanent units. They may be used for vhf and fm radiators, rotary or stationary beam antennas, or for radio-range and radio beacon systems.



Harco Steel Construction Co., Inc., 1180 East Broad St., Elizabeth 4, N. J.

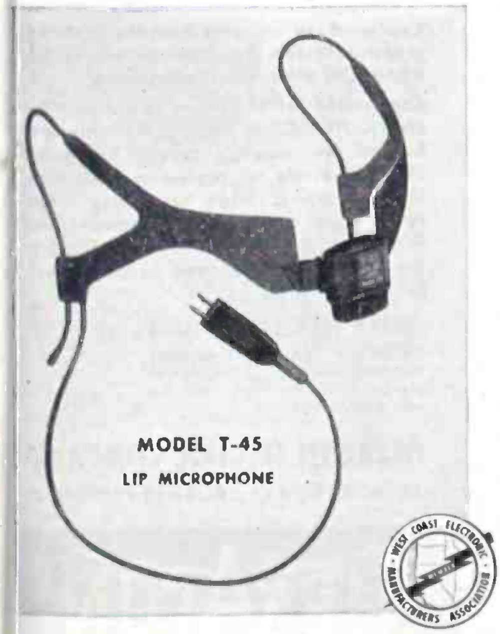
Fungus Resistant Coatings

THESE FOUR NEW moisture and fungus resistant coatings for war equipment have been approved by the Signal Corps. They include: Tuf-On No. 74-F Bakelite resin varnish which takes 12 min to set, and 1 hr to dry hard; Tuf-On No. 74-M which is also a Bakelite resin varnish. It takes 5 min to set and 45



History of Communications Number Six of a Series

COMMUNICATION BY SEMAPHORE



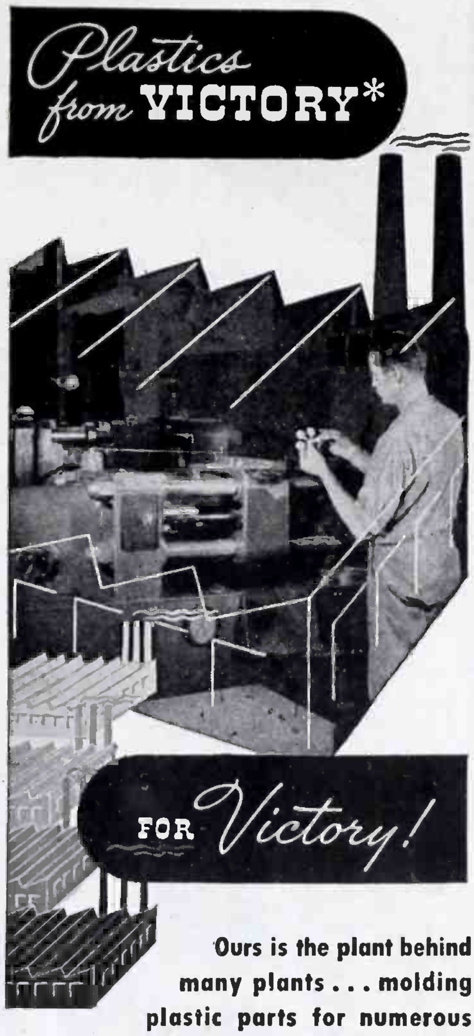
The Semaphore, as a means of communication, met first commercial acceptance in France under the authority of Napoleon in 1792. Restricted by "line of sight" and low power eye pieces, excessive numbers of relay stations, as pictured above, were required for "directional broadcasting" over rough terrain. Weather conditions, too, were a handicap. Because of the code used and its necessary translation, delays and errors were continually encountered.

Today, in the era of applied electronics, Universal microphones are being used to expedite messages on every battle front in the service of the Allies. Universal is proud of its contribution in the electronic voice communications and its every effort to our ultimate Victory.

Model T-45, illustrated at left, is the new Lip Microphone being manufactured by Universal for the U. S. Army Signal Corps. Shortly, these microphones will be available to priority users through local Radio Jobbers.

UNIVERSAL MICROPHONE COMPANY
INGLEWOOD, CALIFORNIA

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



Ours is the plant behind many plants . . . molding plastic parts for numerous contractors who are supplying the Navy, the Army Air Forces, and the Signal Corps.

Molding millions of precision plastic parts for the Armed Forces is still our big job, but we have the time, the equipment and a highly skilled staff to handle a limited number of new contracts—and do a better molding job, *on time.*

Whether for production now, or after the War, our engineers are ready to work with you immediately. Write us today and let us know your molding problems.

Member: Society of the Plastics Industry

Automatic Injection Molding
Small and large parts
UP TO 17-OZ. SHOTS
Lumarith, Tenite, Fibestos, Plastacelle, Crystallite, Lucite, Ethyl Cellulose, Polystrene, Lustron, Styron, Vinylite, Loalin, Cellulose Acetate and others . . . all molded to your exacting specifications.

*VICTORY
MANUFACTURING
COMPANY
1724 W. Arcade Place, Chicago 12, Ill.
ESTABLISHED 1930

min to dry hard; Tuf-On No. 58-F coating which dries very hard in 10 min, and takes 5 min to set; and Tuf-On No. 58-M coating which also takes 10 min to dry hard, and 5 min to set. The drying times are based on testing methods as given in Signal Corps Specifications.

The manufacturer recommends the varnish types No. 74-F and No. 74-FM for the protection of rigid parts and assemblies because of their high moisture resistance, dielectric strength and good adhesion. No. 58 is for use where considerable flexibility in the coating is required such as for wire, and where a good fire retardant quality is desirable. This coating is also for use in applications where better protection has to be sacrificed for speed of production.

Wipe-On Corp., 105 Hudson St., New York, N. Y.

Wide-Range Oscilloscope

TYPE 248 oscilloscope is a wide range, portable instrument which consists of two units, namely the oscilloscope and the power supply connected by a 6 ft plug-in, shielded cable. A removable cover protects the oscilloscope panel when the instrument is not in use. The power supply unit weighs 80 lb and the oscilloscope unit weighs 30 lb. Each unit measures 14 x 18 x 21 in. The vertical amplifier is usable to 10 Mc. A delay network in the vertical channel permits observation of the entire wave shape of short-duration phenomena.

Allen B. DuMont Laboratories, Inc., Passaic, N. J.

Exponential Rule

THIS RULE ATTEMPTS to give a graphical presentation of natural and common logarithms, exponentials and reciprocals; giving direct and without interpolations the characteristics and mantissas of numbers ranging from 1. up to 100,000, and from 1. down to 0.00001. It is an improvement over the rule released in 1932.

Louis B. Sklar, 816 North Sixth St., Philadelphia, Pa.

TYPE P-100
Tip Dia. 3/8"
Ship. Wt. 1¼ lbs.
Equal to 1½ lb.
Old Style Copper,
100 watts.

HEXACON
ELECTRIC SOLDERING IRONS

Light-weight!

Less operator fatigue . . . easier manipulation . . . rapid, uniform heat—these are a few of the features responsible for the wide popularity of HEXACON electric soldering irons.

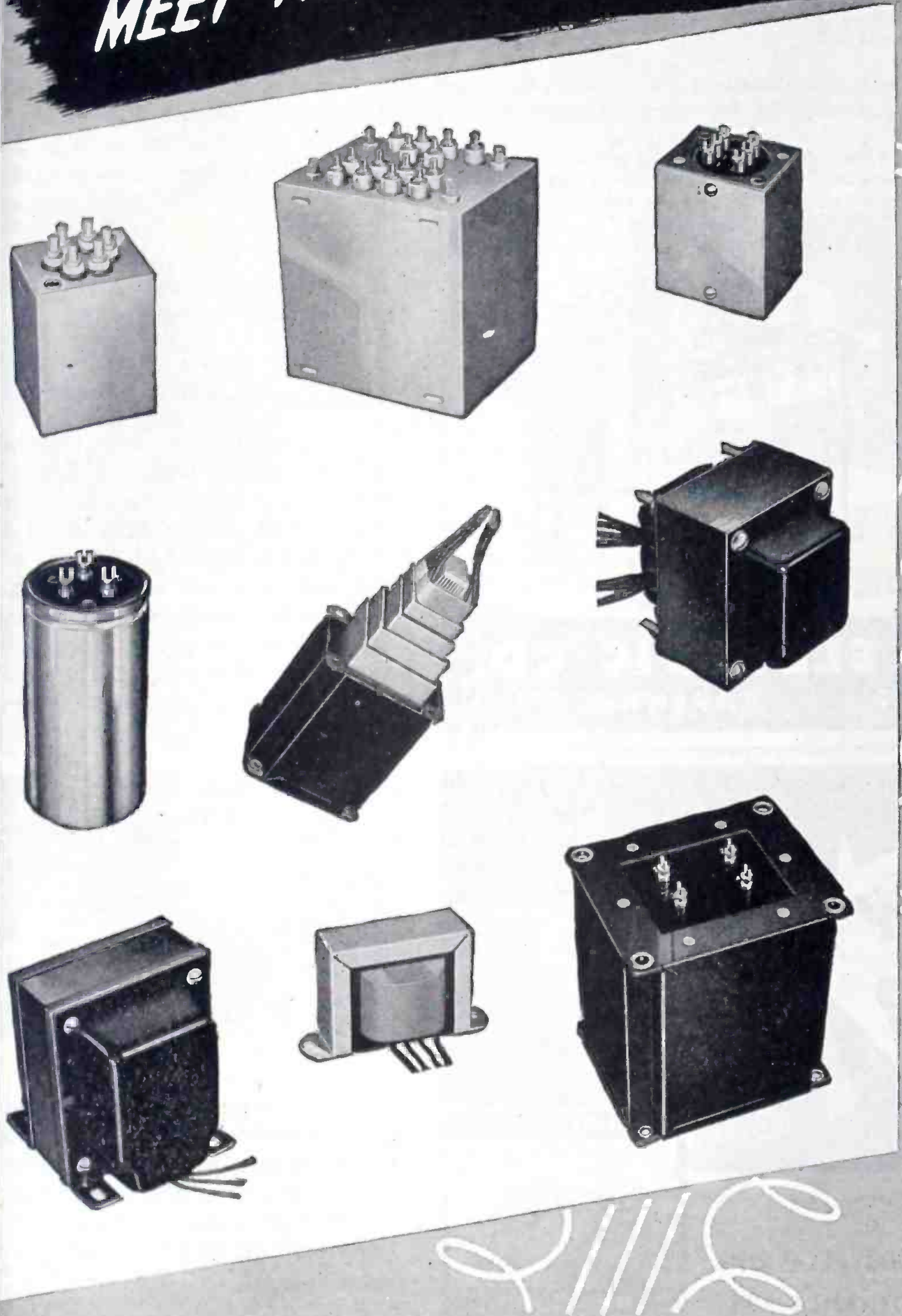
Constructed for maximum operating efficiency, HEXACON heating elements are housed in damage-proof, hexagon-shaped barrels for protection from mechanical injury. High heat alloy cores resist scale and prolong element life. Insulation breakdown tested for twice the requirements of the Underwriters' Laboratories.

WRITE FOR LITERATURE
Descriptive bulletins, describing the complete line of HEXACON electric soldering irons, will be sent on request.

HEXACON ELECTRIC COMPANY
130 W. CLAY AVE., ROSELLE PARK, N. J.

HEXACON

MEET THE FREED TRANSFORMER FAMILY



This is the first in a series of advertisements designed to inform you about Freed Transformers. The spectacular wartime developments originating in the Freed Laboratories are worthy of a page in Electronic History! The ingenious applications; the engineering efficiency; the reliable, unfailing performance of Freed units — all built to exacting specifications — are tributes to the resourcefulness and sound, basic knowledge of our engineering staff. . . . This staff is available to assist you, and we urge any engineer struggling with an intricate problem to submit it without delay.

FREED TRANSFORMERS

FREED TRANSFORMER COMPANY · 74 SPRING STREET · NEW YORK CITY

"RE-CONVERSION LAG"
. . . will it hit you *hard*?

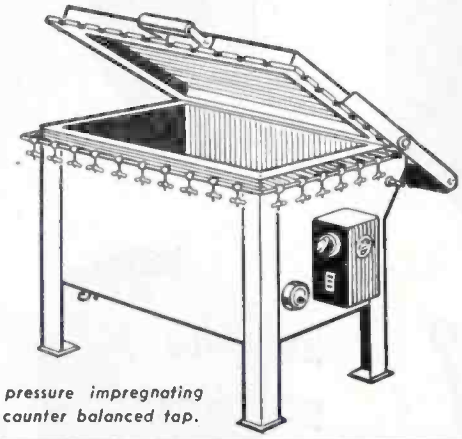
Your company's race to capture post-war markets will depend greatly upon the speed with which key production men can shift from war to peacetime manufacturing and assembly.

This critical transition time can be materially shortened if plans for your production include knowledge of preferred equipment, tools, methods, sources and specifications.

Where, for instance, would you turn for newest methods of impregnating with heated compounds under pressure or vacuum? Or, for spraying heated compounds from a pressure spray tank? Or, melting Korogel? Or, spraying Nylon?

You'll find the Sta-Warm Production Engineering Service Department well stocked with ready answers to these and other similar questions. Use of Sta-Warm electrically heated tanks, kettles and pots before the war, plus greatly expanded applications by war contractors, provides a backlog of data now available to you. For factual information about melting, conveying or dispensing heated compounds and soft metals, write to Sta-Warm.

Have you latest bulletin no. 036? Ask for it today.



100 gal. pressure impregnating tank with counter balanced top.

STA-WARM ELECTRIC CO.
1000 N. CHESTNUT ST. • RAVENNA, OHIO

SEND TODAY for THIS FOLDER

TELLS HOW TO QUICKLY AND EASILY CODE WIRES

Save Time on
• NEW INSTALLATIONS
• WIRE ASSEMBLIES • MAINTENANCE JOBS

E-Z CODE Wire Markers come on handy cards. They are simple to use, stick quickly, no moistening, stay on and stand abuse.

Our standard types fit most coding requirements, although special codes, sizes and arrangements can be made to your specifications. Prompt deliveries.

Write today to

WESTERN LITHOGRAPH COMPANY
Dept. A4, 600 East 2nd St., Los Angeles 54, California

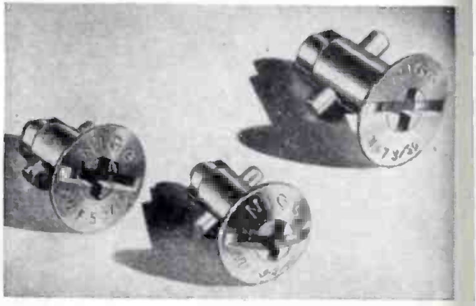
E-Z Code WIRE MARKERS

Electronic Heating Unit

HEATER UNITS for electronic heating in such applications as brazing and soldering, melting metals, bombarding tubes, surface hardening, sealing packages, and glass bonding to metals are available for frequencies up to 300 megacycles, and in power ranges of 3, 5, 7½, 10, 12½, 15, 18, 25, 40 and 100 kw, with stepless control from zero to full load. The heater units are especially designed for their particular applications.

Scientific Electric, Div. of "S" Corrugated Quenched Gap Co., 119 Monroe St., Garfield, N. J.

Fastener Studs



ONLY A QUARTER turn is required to lock or unlock these new fastener studs which can accommodate total sheet thicknesses of from 0.021 to 0.500 inches, and which have an adjustable range of nearly one-half inch. Adjustment is accomplished from the outside to any desired tension and locking torque. The studs are available in standard dimensions, are interchangeable with all snap or spring-type fasteners and will fit existing pin-type receptacles. Badly damaged or bent surfaces can be securely fastened immediately. Illustrated (from left to right) are types NU-F-5, NU-V-5 and NU-7.

Nigg Engineering Co., Covina, Cal.

Silicone Resins

NEW ORGANO-SILICON polymers, designated as "Silicones" are now commercially available for applications essential to the war effort. The manufacturer states that these silicone resins, when used for electrical insulation, extend the range of operating temperatures possible in

HERE'S A NEW RELAY

RO-TROL

The ROTARY RELAY that withstands SHOCK and VIBRATION!!

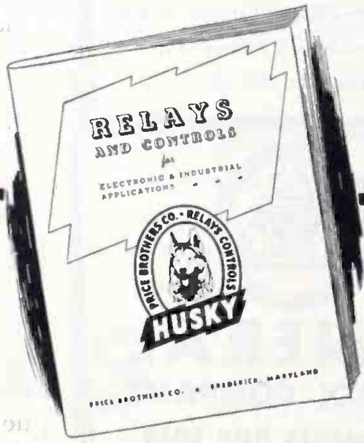
Ro-Trol is a new basic relay unit, operating on a rotating balanced principle, instead of the conventional method. It was developed especially to withstand the severe shocks and vibration of war planes, tanks, ships, etc.

WIDE ADAPTABILITY

The basic Ro-Trol unit is adaptable to a wide variety of Wafer and Multiple contact arrangements. It is most compact, the basic unit measuring: 2½" x 1½" x 1¾". Electronic engineers in both military and private fields have proclaimed "Ro-Trol" a great advance in Relay Engineering.

SEND FOR CATALOG RE-48

This portfolio gives complete engineering data about Ro-Trol and other types of Relays we manufacture. It should prove useful whenever you have need for Relay applications. Get a copy today.



The "HUSKY" Line

includes many other styles of Relays and Controls . . .

ARMY E NAVY

As a result of 30 years of experience we have also developed a complete line of relays for radio transmitter and general control applications, including: Time Delay Relays, Motor Starting Relays, High-speed Keying, and Power Contractors.

PRICE BROTHERS CO. ★ RELAYS CONTROLS HUSKY

30 YEARS OF "KNOWING HOW"

We manufacture in our own plant practically everything that goes into our products. We are equipped to furnish a standard diversified line as well as to manufacture equipment built to particular specifications.

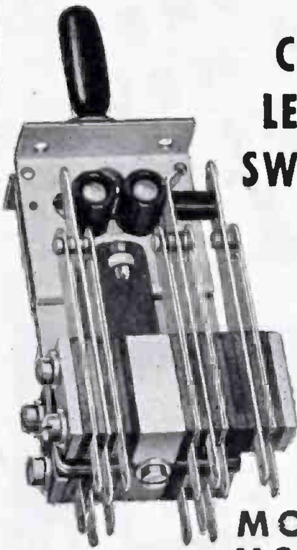
RICE Brothers Co.

★ ★ ★ ★ FREDERICK, MARYLAND

LAYS, CONTROLS, AND MAGNETIC DEVICES ★ 30 YEARS EXPERIENCE

Master

CAM
LEVER
SWITCH



MODEL
MCL-FS

The Model MCL-FS is designed for switching applications requiring long life and dependability. Due to its ability to control multiple circuits, it is used by the thousands for electronics and communications equipment. Roller cam action eliminates contact bounce — single bolt secures or releases contact assemblies — contact possibilities are unlimited. If you're thinking of switching, think of the original cam lever switch specialist, General Control Company!

*Single Bolt Assembly.
*Static Shielding.
*No Side Thrust.
*Government approved.
*Mechanically stronger.
*Rating — 10 amps. 125 V. A. C.
— 2 amps. 125 V. D. C.
*Breakdown — 2500 V. Between Springs
—4500 V. Springs to Frame.
*Write for Catalog No. MCL-20.

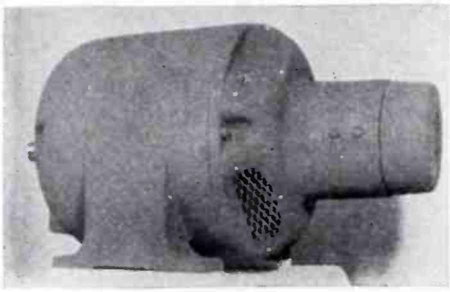
GENERAL
CONTROL COMPANY
1202 SOLDIERS FIELD ROAD
BOSTON 34, MASS.

electrical equipment beyond the limit of thermal stability of conventional organic materials. One of the resins is available as a coating and impregnating varnish which may be applied to Fiberglas cloth, asbestos cloth, asbestos paper and Fiberglas service wire and similar products by conventional dipping and drying methods. It requires baking at a temperature of 250 deg C for one to three hours to cure to a non-tacky state. Another resin is an impregnating varnish which sets with heat at 200 deg C. Neither of these materials carbonize or darken when subjected to prolonged heating at the curing temperatures.

Dow Corning Corp., Midland, Mich.

Revolving Field Generators

KATOLIGHT REVOLVING field generators are built in sizes 5, 10, 15 and 25 kw, 4 pole (1800 rpm). These generators can be furnished as independent two-bearing generators suitable for belt or coupling drive or as single bearing generators designed to fit standard SAE engine bell housing. They are conservatively rated and will carry 25 percent overload without exceeding allowable temperature rise. Voltage regulation is approximately 10 percent with 2 cycle speed change. Illustrated is Model 49EG04 which is a 10 kw, 110 v a.c. motor.

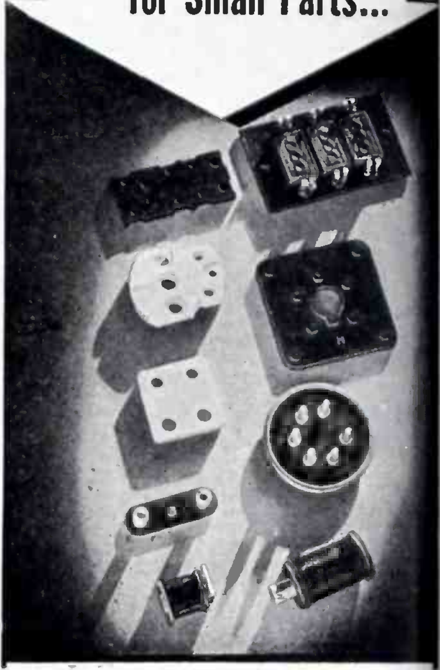


Kato Engineering Co., Mankato, Minn.

Rectifier

MODEL No. 869B rectifier tube is for use in broadcasting or induction heating equipment. It is designed to withstand rough usage, vibration and high peak-inverse voltages with no arc back. The carbon anode of the unit is a large, heavy-duty type. Protection is provided against loose

A Complete
Fungicide
treatment
for Small Parts...



Wax or Varnish

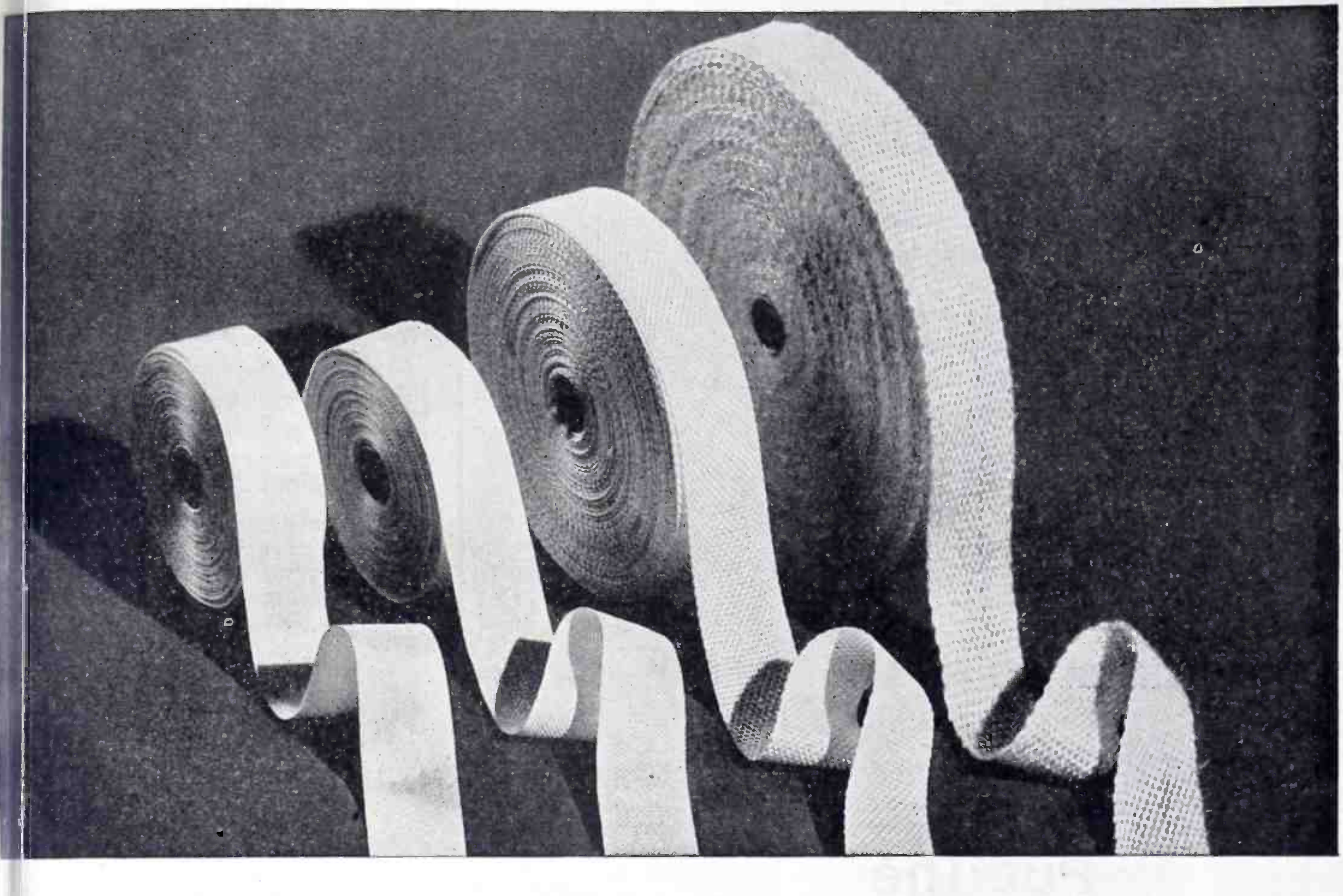
In accordance with government specifications, we can render a FUNGICIDE treatment along with our complete moistureproofing service. Small parts are thoroughly dehydrated for the length of time needed to thoroughly extract moisture. Parts are waxed and varnished according to specifications and all areas are thoroughly coated. Sufficient time is allowed to thoroughly impregnate all materials to the full extent of their porosity. All surplus wax is removed by this operation leaving all machined surfaces and counter bores clean and smooth. All smooth surfaces are polished to a dust-free hard finish.

Daily
PICK-UP AND DELIVERY
in METROPOLITAN AREA

★

PRODUCTION
ENGINEERING CORP.
666 VAN HOUTEN AVE.
CLIFTON, N. J.

FIBERGLAS* Electrical Tapes...



... inorganic ... strong ... wide range of sizes ... can help solve your electrical insulating problems

Many complicated electrical design and repair problems have been solved by the use of Fiberglas Tapes. One of the many advantages is their availability in a wide range of widths and thicknesses.

Fiberglas Tapes are as thin as .003" and as thick as .015", with intermediate thicknesses of .005", .007" and .010"... Standard widths range from ⅜" to 1½".

But, you can also add to this feature the extraordinary tensile strength of Fiberglas Tape! Fiberglas Tape—½" x *.003"*—has an approximate breaking strength of 80 lbs.! Compare this breaking strength with those of *.007" organic tapes!*

Fiberglas Tapes, being glass, have many properties which make them most desirable for use in the insulating of electrical equipment . . . resistance to high temperatures, moisture, oil, corrosive vapors. In combination with suitable varnishes, the result is longer-lasting and more efficient electrical insulation.

Fiberglas is available in all of the standard untreated forms, together with varnished cloth, mica-Fiberglas combinations, varnished sleeving, pressure-sensitive tapes and Fiberglas laminates.

So, whether you manufacture, service, buy or use electrical equipment—Fiberglas is worth knowing about, in every detail.

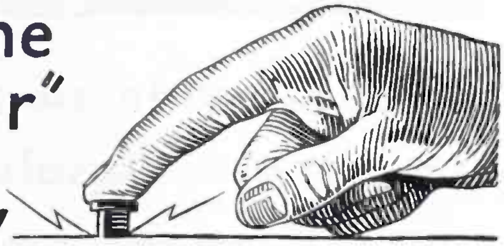
Fiberglas electrical insulating materials are now IMMEDIATELY AVAILABLE in quantity from distributors' stocks.

When you write for complete information, include a request for your copy of booklet "What Keeps the Wheels Turning" . . . *Owens-Corning Fiberglas Corporation, 1860 Nicholas Bldg., Toledo 1, Ohio. In Canada, Fiberglas Canada, Ltd., Oshawa, Ontario.*

FIBERGLAS ...A BASIC MATERIAL

*T. M. Reg. U. S. Pat. Off.

YARNS • TAPES • CORD • SLEEVING • CLOTH AND OTHER FORMS



anodes. The cathode shield is made with an edgewise-wound ribbon filament of a new alloy which provides emission reserve and longer life The tube has the following rated characteristics: Maximum peak-inverse anode current (25–150 cycles) 10 amp; average anode curren 2.5 amp (in-phase filament excitation); typical conditions in a single-phase, full-wave circuit (tubes); a.c. input voltage 707 (RMS per tube); d.c. output voltage 6360; maximum d.c. load current 5 amp.

Arpin Mfg. Co., 422 Alden St. Orange, N. J.

Water-Seal Electrical Connectors

CONNECTORS WHICH SEAL cable ends against water are available in several types, some of which include Hysealug for single conductor cables and Hysealinks, Hysealplugs, etc., for cables from No. 4 to 2000 mcm. The connectors are made from pure copper and are silver plated. The barrel of the connectors is indented onto the conductor while the shroud is compressed over insulation to form a watertight cable end seal.

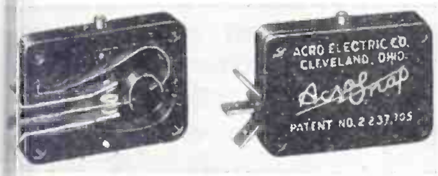
Burndy Engineering Co., Inc., 107 Eastern Blvd., New York 54, N. Y.

Pilot Light Assembly

"TRIO-LIGHT" pilot light assembly is a unit designed to aid in the control of multiple co-ordinated circuits. It is available in any size bank, in multiples of three pilot lights to each assembly. The silver plated terminals of the assembly are secured to insure perfect contact under severe stress. The lamp sockets of the pilot lights accommodate bayonet base lamps which are easily removable from the front of the panel. Features of the assemt include color-coded flat lenses ch etched numbers, letters or rds; choice of lens colors in either l, green, amber, blue, yellow, il, white or clear; and the use of f-round lenses. The unit may be ained grounded or ungrounded. ial Light Co. of America, Inc., Broadway, New York 3, N. Y.

ap Switch

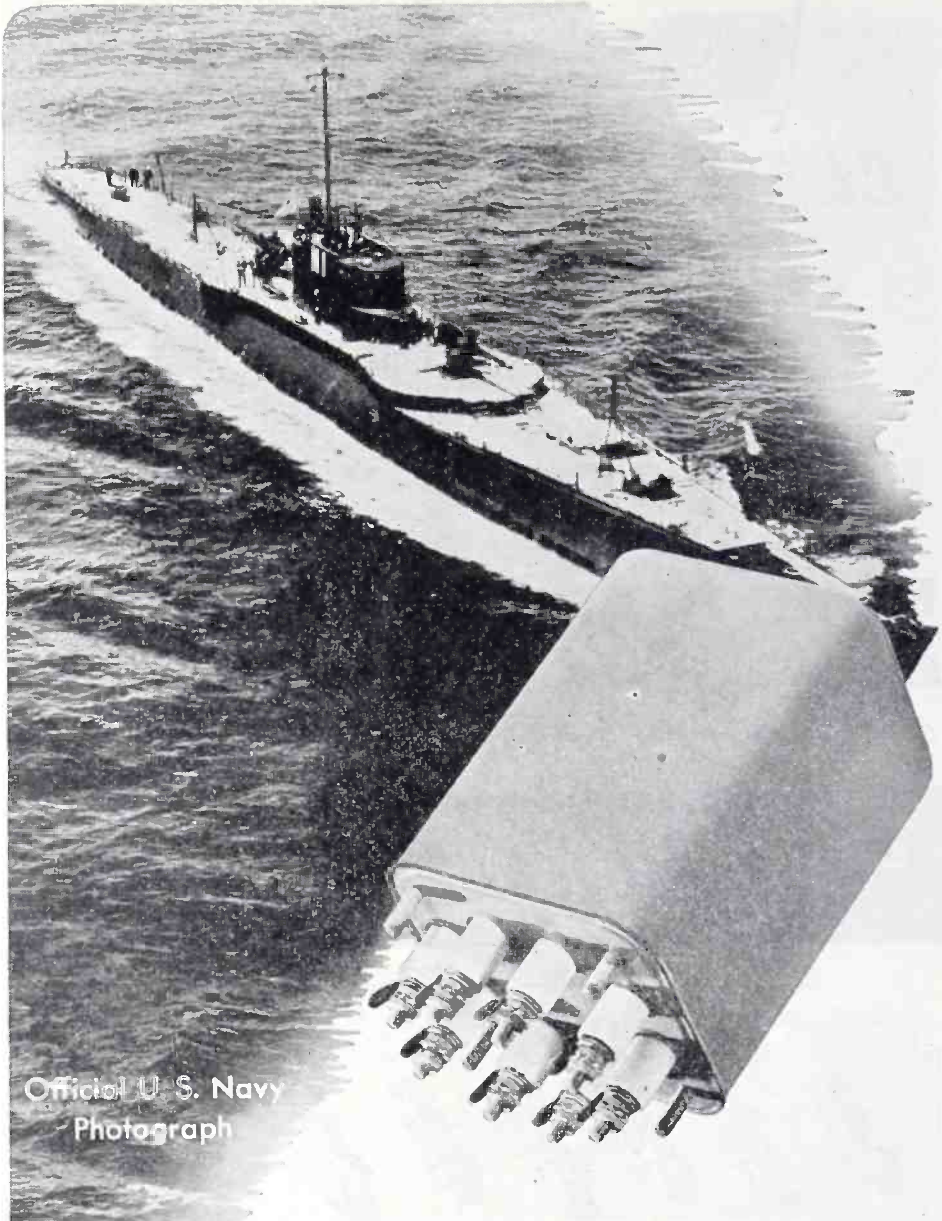
NIAC DESIGNATES a snap-action ich measures $\frac{13}{16}$ in. high, $1\frac{13}{16}$ in. g, and $\frac{17}{64}$ in. thick. It is fully en- sed in a Bakelite case which con- ns four mounting holes measur- $\frac{3}{32}$ inches in diameter. Leaf- e or overtravel-plunger-type uators may be attached to the e if desirable. Actuation is made a stainless-steel pin plunger. All



rts of the switch are non-cor- sive and all contacts are made of ver. The main and contact des and rolling spring are made beryllium copper. The switch is ailable in SP, normally open, rmally closed, and DT types, and rated at 15 amp, 115 v a.c. Acro Electric Co., 1316 Superior e., Cleveland 14, Ohio.

ectangular Oil-Type pacitors

NEW AND COMPLETE line of rec- ngular oil-type capacitors (desig- ted as Capacitrons and available types BC, EC and CC) are avail- le in standard container sizes and voltage ratings up to 6000 volts . working. These new Capaci- ons will meet Army and Navy ecifications, including total salt- ter submersion tests. Capacities, ltage ratings, container sizes, pes of terminals, and mounting rangements are given in Bulletin . 104 available from The Capaci- on Co., 318 W. Schiller St., Chi- go 10, Ill.


Official U. S. Navy Photograph

Time Delay Relay

A COMPACT, TWO CIRCUIT time delay relay, designated as Type TDSA and TDSB, which provides a definitely varied operation of one circuit in relation to the second circuit. The relay is arranged for surface mounting for either front or rear connections and is especially designed to withstand momentary shock conditions.

R. W. Cramer Co., Inc., Centerbrook, Conn.

Literature

Resistance Welding. Bulletin GET-1189 contains a series of reprinted articles written by R. T. Gillette. The book contains sections devoted to resistance-welding methods and equipment, the selection of equipment for best welding results, welding-electrodes and their maintenance, material and its preparation for welding, and a master chart of welding processes. General Electric Co., Schenectady, N. Y.

ompany Brochure. This booklet
lls of the development of Elec-
ical Testing Laboratories, Inc.,
company which deals in elec-
ical and general testing, inspec-
ons and research of electrical
oducts. The name of the broch-
re is "Independent Laboratory
rvices." Electrical Testing Lab-
atories, Inc., 2 East End Ave. at
th St., New York 21, N. Y.

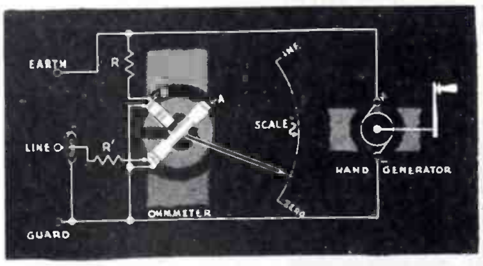
ompany Background Data. An-
ther brochure available gives
ckground data of North Ameri-
n Philips Co., Inc., a manufac-
rers of Norelco electronic prod-
ts. North American Philips Co.,
c., 100 East 42nd St., New York
, N. Y.

ransmitter. A new 100 kw short-
ave transmitter is illustrated
d described in a 4-page folder.
esign, performance and operat-
g features are included in this
lletin entitled "G-E Preview of
New 100 KW Transmitter".
lectronics Dept., General Elec-
ic Co., Schenectady, N. Y.

esins and Plastics. "Geon" resins
d plastics for calendar and solu-
on processing are described in
echnical Bulletin PM2 which has
en prepared especially for those
ho are concerned with the coat-
g of fibrous material. Tables of
mparative properties, and a sec-
on on mixing and milling, calen-
ering and solution coating, are
cluded in the bulletin. The B.
. Goodrich Co., Chemical Div.,
kron, Ohio.

strumentation Magazine. This is
e name of a new house-organ
ublished in the interest of
easurement and control of in-
ustrial processes. The house-
rgan is devoted to electronic,
neumatic and mechanical in-
trumentation. Vol. 1, No. 2 con-
ains several articles of interest to
lectronic equipment manufactur-
rs. Brown Instrument Co., a di-
ision of Minneapolis-Honeywell
egulator Co., Philadelphia 44, Pa.

ubular Ceramic Capacitors. Bul-
etin No. 819 describes tubular
eramic capacitors (types 920,
23, 924, 930, 931, 932 and 933) with
xial leads. The wire leads of



these capacitors are attached parallel with the body. Dimension drawings and a capacity chart for the various temperature coefficients are given in the bulletin as well as data on power factor, tolerance, voltage rating and humidity. These capacitors are mainly for use in temperature compensation application to stabilize critical circuits, and in applications where stability of capacitance is especially important. Centralab, Div., of Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

Cerium Alloys. "Some Facts About Cerium" is a 6-page leaflet which serves as an introduction to cerium. The manufacturer states the material may be used in electronic applications as a constituent of getters, filament, electrode and magnetic materials. Cerium Metals Corp., 522 Fifth Ave., New York 18, N. Y.

Tube Characteristics. Essential characteristics of metal, glass, miniature, cathode-ray and trans-ing tubes are contained in a bolet (EED-44-1). Electronics Eineering Department, Ken-Ra Tube & Lamp Corp., Inc., Ownsboro, Ky.

Crtal Catalog. Nine types of crtals are illustrated and de-scribed in a booklet entitled "Cstals for the Critical". The Jaes Knight Co., Sandwich, Ill.

inental - Diamond Bulletins. bulletins available from Con-inntal - Diamond Fibre Co., Nwark, Del.) include Bulletin 3 which is devoted to the de-ig and fabrication of laminated molded phenolic plastics and anized fibre parts, and Bulle-inDN-44 which describes Dilec-, a low loss insulation for uhf pications.

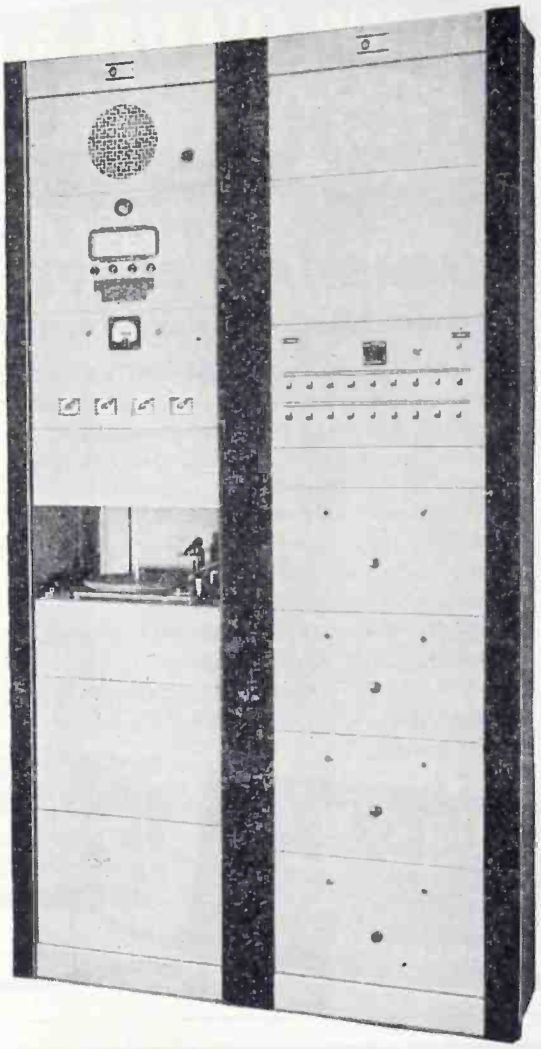
tener Catalog. A 16-page cata-profusely illustrated with htographs and drawings and deribing the improvements and to which the manufacturer's Simlock fastener can be put, alled "Simlock, the Fastener ofToday with the Design of To-mrow". Simlock Div., Simmons hine Tool Corp., Albany, N. Y.

lation Tester. Bulletin No. 48 describes Model B-5 Megoh-m, which is a battery-vibrator tye of insulation tester. The Hman H. Stricht Co., Inc., 27 k Place, New York 7, N. Y.

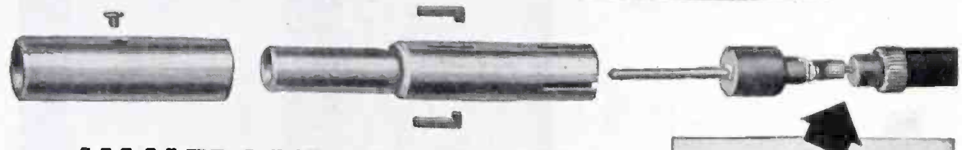
Rlio Components. Sockets, ter-m al strips, connectors, plugs, jks and fittings are all described inCatalog No. 441, available from Nional Fabricated Products, 2 W. Belden Ave., Chicago 47, Il

Sf Tapping Screws. Tables, dia-gms and factual data on the sject of P-K Self-tapping Sews is available in a handy rs' guide. Cost of the booklet is 50 cents and it is available fm Parker-Kalon Corp., 204 ick St., New York 14, N. Y.

Rlio Components. Catalog Sup-plment No. 95 contains a listing o a wide assortment of radio a electronic parts. Lafayette Rdio Corp., 901 W. Jackson Blvd., Cicago, Ill.



ANDREW COAXIAL PLUGS AND JACKS



IMMEDIATE DELIVERY

in moderate quantities from stock

ANDREW coaxial plugs and jacks are used as connectors for flexible coaxial lines, and fit many of the standard Army and Navy approved cables. They are especially useful where a simple panel mounting plug-in type of connector is required.

Machined from brass bar stock, these sturdy plugs and jacks provide a positive connection between the outer conductors and between the inner conductors. Inner conductor contacts are silver plated to obtain maximum conductivity. Insulation is the best grade of Mycalex. Patch cords are made of low-loss flexible coaxial lines of 72 ohms surge impedance. Patch panels consist of 24 jacks mounted on a 19" relay rack panel.

WRITE FOR BULLETIN NO. 31

ONLY ANDREW offers this easy accessibility for soldering.

You don't have to solder through a window to install on ANDREW plug or jack. Just remove one screw, slide the sections apart with your fingers and solder. This is a new improvement invented and used exclusively by ANDREW.

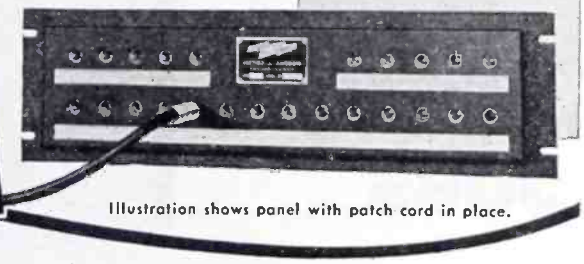
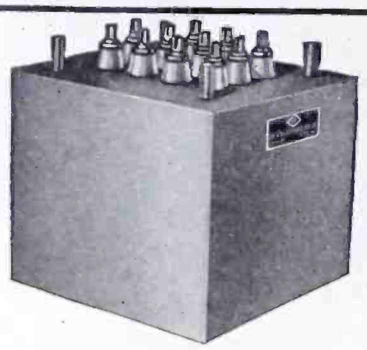


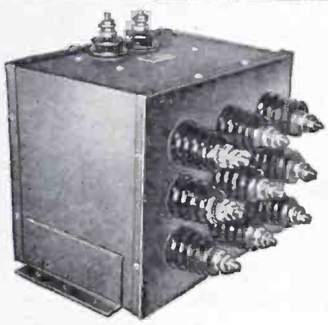
Illustration shows panel with patch cord in place.

ANDREW CO.

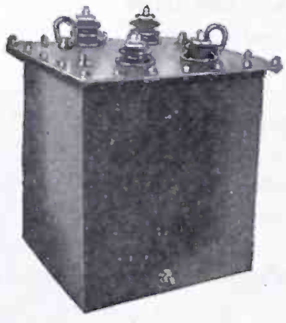
363 East 75th Street
Chicago 19, Illinois



HERMETICALLY SEALED TRANSFORMERS



FILAMENT TRANSFORMERS



OIL-COOLED PLATE SUPPLY TRANSFORMERS

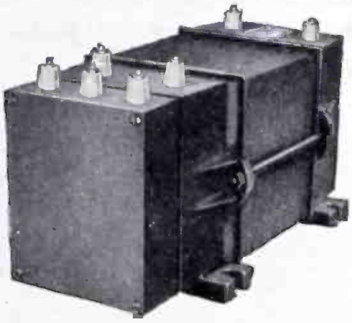


PLATE MODULATION TRANSFORMERS

THE ACME ELECTRIC & MANUFACTURING CO. • CUBA, N.Y. • CLYDE, N.Y.

Acme Electric

Panel Instruments. Panel instruments with bridge type construction and with soft iron pole pieces are illustrated and described, together with cased models, in a 16-page folder. O. B. McClintock Co., Minneapolis, Minn.

Luminescence. "The ABC of Luminescence" is the title of a 24-page book which tells in simple language the principles of luminescence, and includes a discussion of the practical applications of these principles in the form of activated fluorescent and phosphorescent pigments. A number of simple tables and charts are included to illustrate terms applicable to this particular industry. The New Jersey Zinc Co., 160 Front St., New York 7, N. Y.

◆

SOLDIERS ON GUADALCANAL report that they can receive some American standard broadcast stations with fair regularity.

110-VOLTS A. C. from DIRECT CURRENT

with KATOLIGHT ROTARY KONVERTERS for operating radio and electronic equipment, moving picture projectors, sound apparatus, A.C. appliances, etc.

225 WATT CONVERTER

Available in sizes 110 through 2500 watts, 1800 and 3600 r.p.m. ball bearing designs. Furnish standard 110-volt 60 cycle A.C. from 32, 110 or 220-volts direct current. Quiet in operation. Can be furnished with special filtering equipment for sentitive radio work.

PIONEERS IN THE BUILDING OF SMALL ROTARY CONVERTERS

At present Kato's entire production must be directed to furnishing converters on high priority orders. Wire us if you need this kind of equipment for orders.

Also manufacturers of A.C. and D.C. generators ranging from 350 watts through 25 K.W.; power plants; Frequency changers; high frequency generators; and Motor Generator Sets.

KATO ENGINEERING CO.
72 ELM ST. MANKATO, MINN.

Carrier Communication

(Continued from page 114)

hrough 0.002-μf, high-voltage, nica capacitors.

Signaling and Control Circuits

Located on the dispatcher's desk s a speech amplifier including an scillator to give a 1000-cycle tone. mplitude of this note is considerbly higher than that of the averge voice input. This tone is used s an attention signal. It is fed nto the amplifier through a monentary contact switch, thus enbling the dispatcher to secure the ttention of all crane operators beore transmitting orders which night apply to any one of them. The output of this amplifier is fed o the carrier current transmitter ia a telephone line which is simplexed. On the amplifier, a "press-o-talk" key completes the circuit hrough this simplex and actuates relay in the transmitter—applyng plate voltage.

The speech amplifier is dupliated in the transmitter cabinet nd by means of a "local-remote" witch can be used instead of the mplifier located on the dispatcher's lesk. This allows the transmitter o be modulated when making tests on it.

A time-delay relay is provided so plate voltage cannot be applied imultaneously with filament voltge. This protects mercury vapor ectifier tubes in the event of inerruption to the a-c supply voltage. Plate voltage is applied to the ransmitter by means of the relay described previously.

Operating Problems

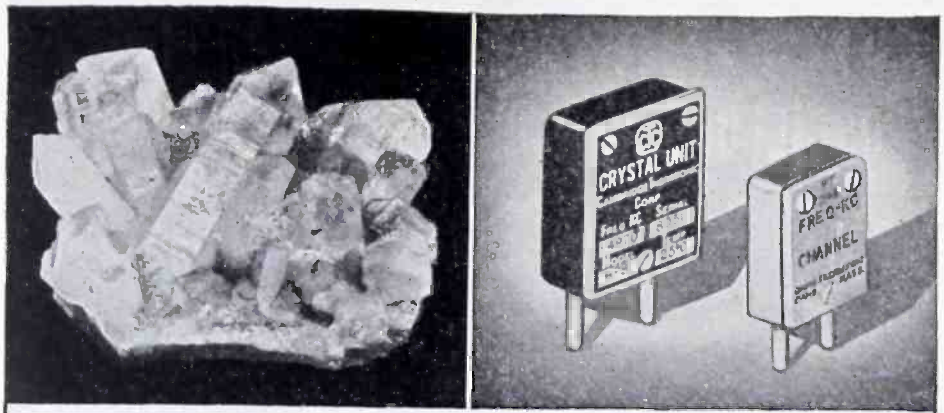
Considerable difficulty has been experienced with the contactor shoes of the cranes. Operation of the receiver while the crane is in motion is not entirely satisfactory; noise produced by the arcing of the shoes on the trolley is sufficiently high to trip the squelch circuit. This results in a continuous sputtering noise, and since the audio output of the receiver is quite high, this is very distracting to the crane operator. Some improvement has been effected by reshaping the contact shoes and resurfacing portions of the trolley bus throughout the plant.

Located, as it is, in the center of a production area, the dispatcher's desk has an extremely high acoustical noise level and it was found necessary to provide an enclosure so background noise would be reduced during transmission.

The system has been in continuous operation for six months and has already demonstrated its value as a means of speeding production by saving time. Special credit is due R. B. Jones, under whose direction all experimental testing as well as construction work was done.

Tests made outside the plant indicate complete absence of radiation.

Transmitters are now being installed in the crane cabs to provide two-way communication. Experiments indicate that this will increase the utility of the system considerably. Eight cabs are in use at present, with plans being made for the addition of others at an early date.



From QUARTZ to QUALITY...

C. T. C. Crystals are Carefully Controlled

X-RAY ORIENTATION — predetermination of the crystallographic axes to assure correct cutting . . . Four individual lapping operations, plus edge lapping . . . Soap washes and clear water rinses . . . Filtered compressed air drying . . . insure the constant frequency, high activity and dependability of every C. T. C. Crystal.

For complete information, quotations and delivery estimates on C. T. C. Crystals—"the Crystals you can count on"—write, phone or wire

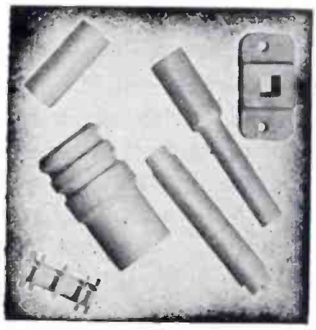
CAMBRIDGE Thermionic CORPORATION
439 CONCORD AVENUE CAMBRIDGE 38, MASSACHUSETTS

Quality
AND LOTS OF IT

★ Transformers for Combat

In Active Service Over the Entire Globe

DINION COIL COMPANY
CALEDONIA, N. Y.



Lavite STEATITE CERAMIC

CHARACTERISTICS
Specific gravity of only 2.5 to 2.6
Water absorption S. 1.5-0.001 per cent. Per cent power factor.
S. 1.5 to 60 cycles was only 0.0165.
Dielectric constant at 60 cycles was 5.9-1000 KC 5.4.

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8-Volt peration

(Continued from page 119)

:s and minimum tube-to-tube vari-
ions. For vhf use, the 9003 should
ove very satisfactory.

The types most satisfactory for
sistance-coupled voltage ampli-
rs with 28-volt B supply are pen-
des and low-mu triodes. High-mu
iodes cannot be used successfully
cause the bias developed in the
id resistor by the grid contact
tential will cause the tubes to
erate at or near plate current
t-off. The cut-off bias of a triode
approximately the ratio of plate
ltage to mu. For the type 12SQ7,
hich has a mu of 100, the approxi-
ate cut-off bias would be 28/100,
−0.28 volts. Since the bias de-
loped by contact potential in the
id resistor may vary from −0.2
−1.2 volts, the impracticability
using high-mu triodes is appar-
nt. They will not only produce
ss amplification than a low-mu
iode at 28-volt B supply, but will
roduce much less maximum volt-
ge output, with large gain varia-
ons between tubes of a given type.

28-Volt Amplifier Performance

Data on resistance-coupled audio
mplifier gain and maximum out-
ut voltage (for 5 percent distor-
on) are given for triodes in Table
, for three different values of
ate load and following grid resis-
or. Information on transconduc-
nce, plate resistance, and mu is
lso given which will be applicable
the case of transformer or choke-
ed amplifier stages. Resistance-
upled amplifier data for several
entodes is presented in Table III.
ny of the tubes shown in these ta-
les should prove very satisfactory
28-volt service, the selection de-
ending on the gain requirements
nd use of auxiliary diode or triode
ections.

It is probable that in the future
ubes designed especially for low-
oltage applications will be added to
he many tube types already avail-
ble. However, it appears that most
f the present standard types will
rove satisfactory, and the design
f new types for 28-volt service
hould be limited to tubes for appli-
ations in which present standard
ypes are not entirely suitable.

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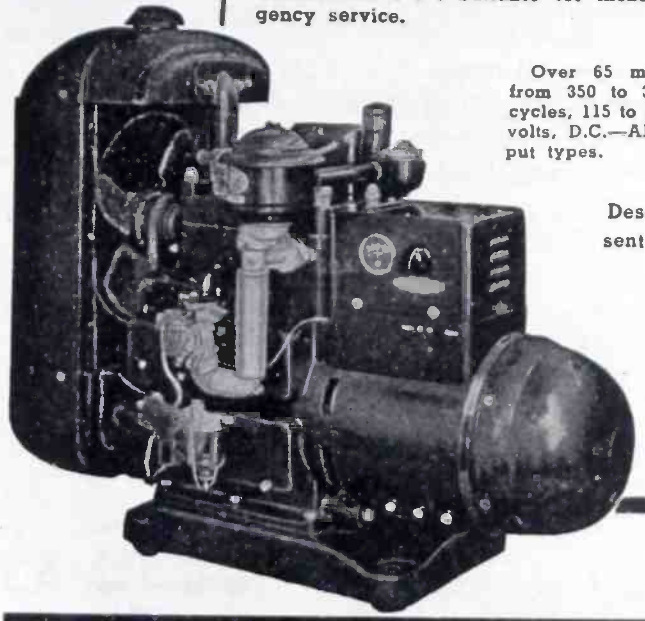

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Crystal Testing

(*Continued from page 123*)

starting time in a production-type test oscillator over the temperature range. The crystal must reach the minimum acceptable activity within ½ sec.

The full load test consists of operating the crystal at room temperature in a standard test set for a period of not less than 15 sec with the plate circuit of the set tuned to give maximum activity. Crystal activity must pass a certain minimum.

In the vibration test, crystals are mounted by the pins in random directions on the platform of a vibration machine. Units are subjected to a simple harmonic motion of a certain amplitude and frequency and left for two hours. This treatment is intended to simulate the shock and jar that crystals will receive in severe service. At the end of two hours, frequency must not have changed more than 0.002 percent and activity more than 10 percent from the values registered before the tests.

Another test involves immersing

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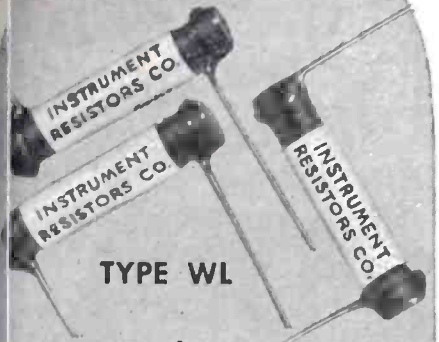

the units in water at room temperature and heating them to 90 deg C during a period of 30 min. The units are held at this temperature for an hour. They are then dried and set aside for 30 min. Frequency must not change more than 0.002 percent, the activity must change less than 10 percent, and the d-c resistance, measured between the prongs, must not be less than 10 megohms.

In the cleaning and internal inspection tests, crystals are disassembled and examined. Crystals are scrubbed with nylon toothbrushes in soap and water. Electrodes and crystal blanks are then rinsed in clear water and dried by evaporation. Units are then reassembled; at no time during the entire procedure are the crystals touched by hand. After this, frequency should not change more than 0.006 percent and activity more than 10 percent.

After satisfactory spot tests, each unit is tested for frequency, activity, and full load at room temperature. Those passing are given the official stamp and are ready for shipment.

Effects of Age

After the rigid inspection and testing procedures through which crystals are run to weed out the bad ones, it would appear that the units should last indefinitely. Yet crystals often go dead on the shelf before they are actually used. These defections are due to a phenomenon called aging. Caused by an action on the surface of the quartz, this phenomenon resembles common erosion.

Under high magnification, the surface of a crystal, although finished with the finest optical powder, is revealed as being covered with microscopic hills and valleys. Traces of moisture within the holder combine with changes in temperature to cause chipping and cracking of these hills. This raises the frequency of the crystal, at the same time usually decreasing activity. This is explained by the fact that chipping decreases the thickness of the crystal—to raise the frequency—at the same time depositing a film of quartz powder in the valleys—to lower activity. Thorough cleaning of a finished crystal seems to lessen aging.

Another solution consists of ac-

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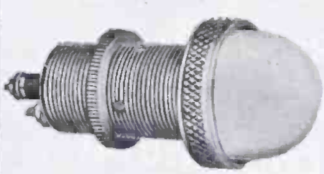

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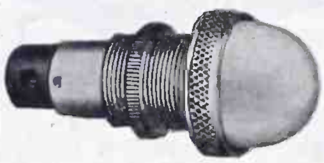

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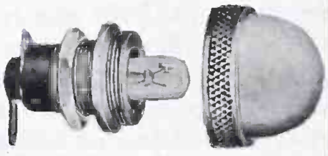

The T3 D/E Unit, List Price, (less lamp) $1.80.

Specifications: Mounting hole 11/16" diameter; overall depth behind the front of the panel 1"; length of threaded area 7/16"; (our SCB type socket).

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celerated aging by subjecting crystals to a series of hot and cold cycles. If the temperature treatment and a very thorough cleaning are combined, further aging is very slight. The effect is also materially reduced by using an evacuated holder or placing a chemical inside the holder to absorb moisture.

Another recent attempt to prevent aging involved coating the surface of the crystal with water glass which sets to a silicate chemically similar to quartz. This fills up all the valleys and excludes air and water vapor. However, it has been found that the material flaked off after standing several months.

One way to preventing aging is to plate the surface of the crystal with such a metal as gold or silver. This coating, at the same time, can be used as electrodes for the crystal and has promising possibilities. The only difficulty appears to be that tarnish appears on the metal. If this difficulty is overcome, perhaps all future crystals will be plated.

REFERENCES

(1) Elbl, L. A., Quartz Crystal Cuts, ELECTRONICS, July 1943.
(2) Elbl, L. A., Quartz Crystal Finishing, ELECTRONICS, January 1944.

• • •

Induction Heating

(Continued from page 129)

the terminals of the coil. Values of current and voltage for an operating power of 100,000 watts are also shown in this table. The current is far in excess of the values of tank circuit current that may be obtained so that it is virtually impossible to place this coil directly in the tank circuit.

Output Transformer

A transformer that has been extremely useful in working into low-impedance loads of the type being considered here is pictured in Fig. 17. This transformer consists of a multi-turn primary which is part of the tank circuit and a single-turn secondary which is really a sheet of copper wrapped around the primary with as close a spacing to the primary as is consistent with voltage requirements. Where the single-turn coil presents resistance values of the order of a few hun-

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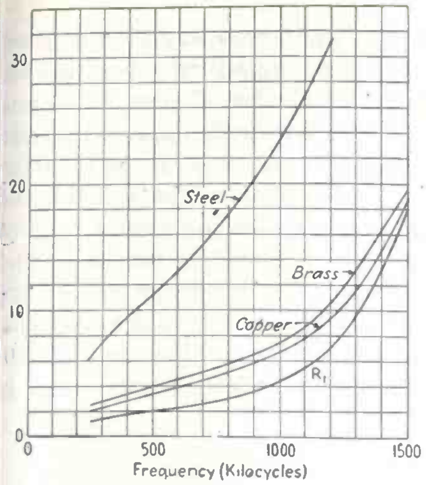

IG. 18—Input resistance of transformer ith copper, brass, and steel loads. The ırve marked R_1 is the no-load resistance

redths of an ohm and reactance alues of a few tenths, the resisance looking into the primary of ne transformer may be several hms, while the input reactance may e several hundred ohms.

Measurements of input resistance nd reactance as well as efficiency ere made on a transformer similar o the one shown in Fig. 17. The rimary consisted of thirty-one

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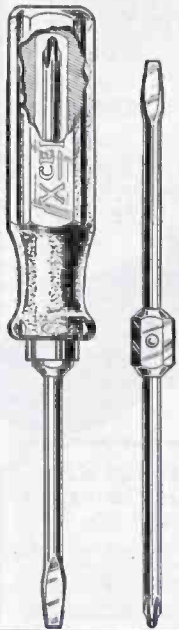

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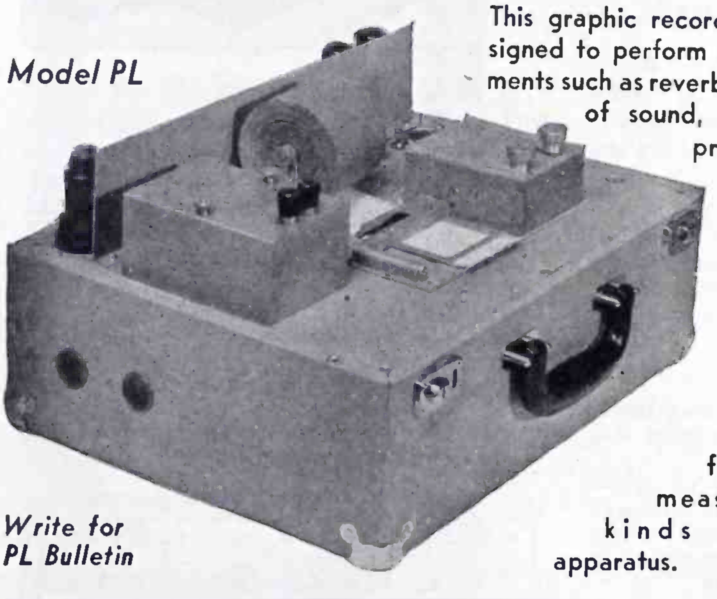

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turns. The secondary copper sheet fed into a single-turn coil which encircled a cylinder. Copper, brass and steel cylinders were used. Figure 18 shows the values of resistance for the three cylinders as well as the resistance measured when no cylinder was in the single-turn coil. The accompanying reactance values are shown in Fig. 19, while the efficiency curves are given in Fig. 20. The efficiency into a steel load is

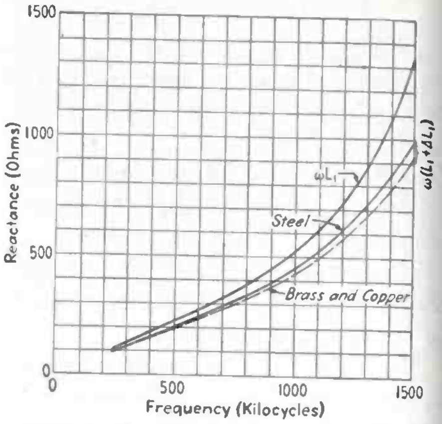

FIG. 19—Input reactance of transformer with copper, brass, and steel loads. The curve marked ωL_1 is the no-load reactance

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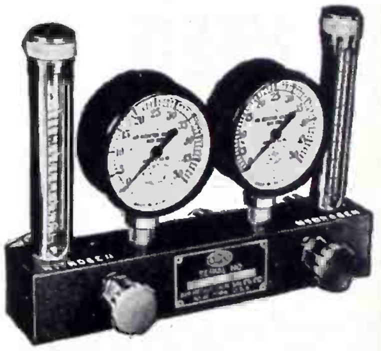

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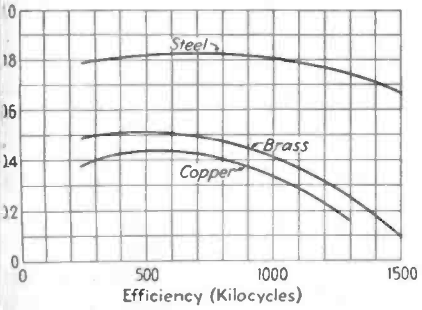
ry good, while the efficiencies th copper and brass loads approach the maximum values that ay be expected. The dropping off efficiency at the higher frequencies is due to resonance effects the transformer, brought about distributed capacitance. The iciency at the higher frequencies n be improved by the proper ange in the design of the transrmer. However, there is really ry little need for this redegn because of the fact that in ost metal heating applications ere is no point in using freencies higher than a few huned kilocycles.



G. 20—Efficiency of coupling to copper, ass, and steel by means of a transformer

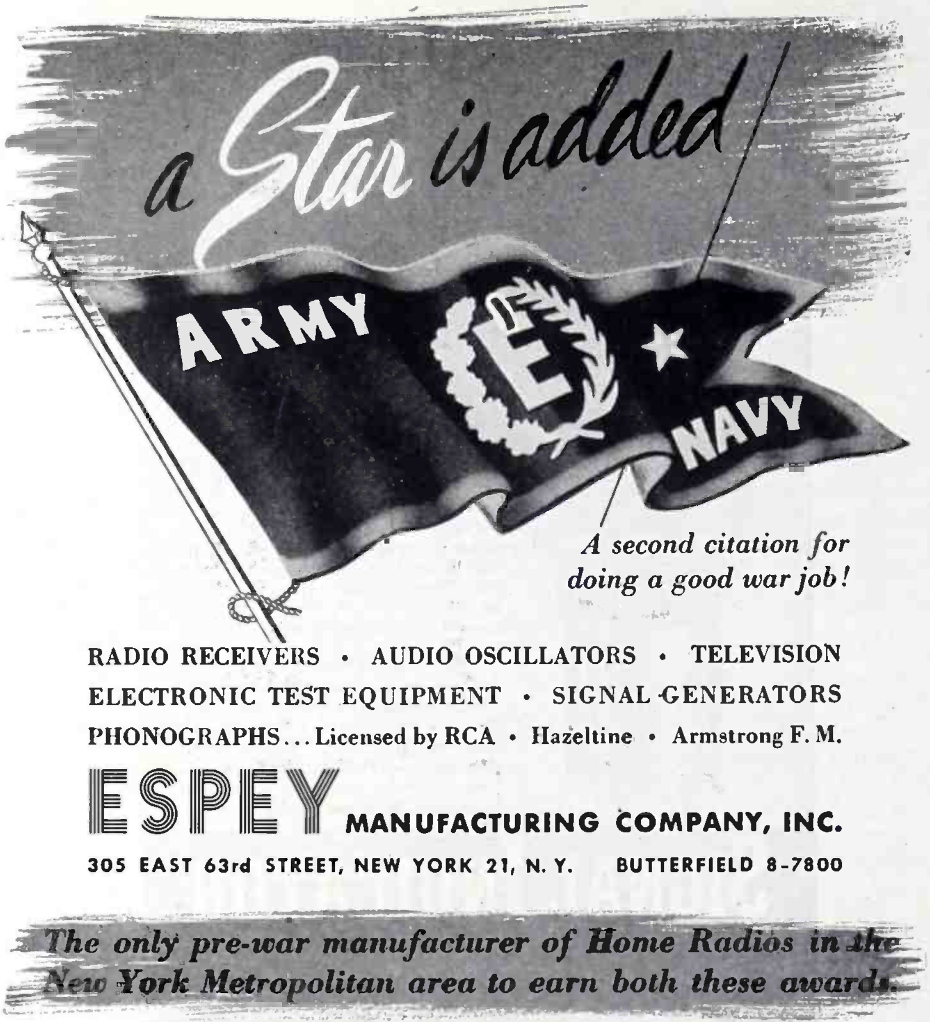
In conclusion, it may be well to state that while the simplifying sumptions made in this paper ow that the efficiency of coupling metal loads is independent of equency, factors such as distribed capacitance come into play at e higher frequencies. At the wer frequencies, the skin thickss may be of the same order of agnitude as the dimensions of the ject to be heated, with a consement sharp reduction in efficiency. his latter effect is partially exained by a consideration of Eq.) and Fig. 2.

• • •

High Fidelity

(*Continued from page* 131)

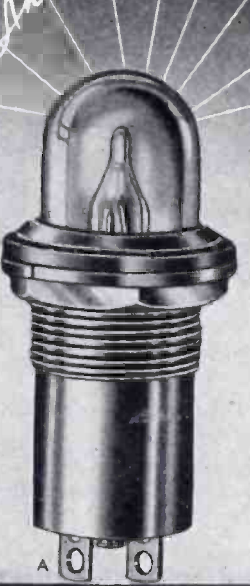
ntributed by the air itself, at ual values of relative humidity, ecomes of increasing importance. t 10,000 cycles and a relative umidity of 50 percent, the absorpon of the air limits the reverberaon time to about 1.5 seconds even ough the walls, floor and ceiling re perfectly reflective; at 12,000 cles the limit is approximately 2 seconds and at 15,000 cycles



about 0.9 second. This factor should not be overlooked as it is one relatively fixed limit which certainly must affect consideration of higher fidelity, not only in the studio but also in the home.

Frequency, Loudness and Hearing

The ear, the final criterion of judgment, is also to be taken into account, as the higher frequencies can only be detected by relatively young listeners, since hearing loss at the higher frequencies increases with age. Results obtained by the U. S. Public Health Service in this field (in Bulletin No. 5, 1938) show that above about 2,000 cycles, hearing loss increases rapidly as a person grows older. For males, the average loss in db at 8192 cycles for age 25 is 9 db; for age 35, 16 db; for age 45, 22 db; and for age 55, 32 db. For females the loss is considerably less, being uniform from 64 to 8192 cycles up to age 25, then dropping to 8 db for age 35, to 12 db for age 45 and to 21 db for age 55. Although few measurements have ever been made above 10,000



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cycles, indications are that the hearing loss curves do not trend upward!

Program fidelity is also determined by the loudness level at which the loudspeaker is operated. Curves in Fig. 2 show the frequency response of normal ears at four listening levels, "normal" ears being those of young people about 20 years of age. Note that only at the "very loud" and "loud" listening levels, 100 db and 80 db above the hearing threshold, respectively, is the low-frequency response of the ear substantially flat. The decreased response of the ear at 50 cycles, 100 cycles and 200 cycles, as compared with 1,000 cycles, is tabulated below for four db levels above the threshold of hearing:

Condition	Frequency (cycles per second) 50	100	200	1,000
Very Loud (100db)	0	0	0	0
Loud (80db)	–6	–2	0	0
Moderate (60db)	–17	–11	–6	0
Very Soft (40db)	–30	–22	–12	0

In the case of the "very soft" listening condition the response would further tend to be obscured at the low frequencies by local airborne noises as this listening level compares with average residential noise. Any decrease of more than 10 db or so below this level will generally be obscured or masked by said noise. The response of a young listener seated at 45 deg from a radio receiver having a reasonably

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uniform response up to about 10,000 cycles, operated at a loudness level of 60 db which is a "moderate" listening level, shows at 9000 cycles a drop of 42 db from the peak response occurring at about 450 cycles. In the bass direction, the drop-off in response increases gradually from this peak to a value of 26 db down at 40 cycles.

Thus it is apparent that the higher-fidelity receiver should include compensation for listening level effects in the volume control used with the receiver to provide uniform loudness at low frequencies. This device could also be used to compensate partially for the directivity curve of the loudspeaker, where adequate distribution cannot be attained in loudspeaker design. As volume is lowered, such a tone-compensated volume control will then discriminate against the middle frequencies in favor of the low frequencies and, to a lesser degree, the higher frequencies. The effect to the ear will be more pleasing reproduction at the usual listening levels, which are commonly in the "moderate" classification.

Other Distortion Factors

The preponderant majority of sound systems are now, and will be for years to come as far as can now be visualized, mon-aural systems, whether they are utilized for recordings or for radio broadcasting. This fact alone indicates a fundamental departure from perfection because of the absence of true space consciousness of the sound sources.

Some other factors occurring in the general high-fidelity problem, such as random noise and distortion, may also be mentioned. Since distortion components are multiples of fundamental frequencies, and since many audio devices, particularly recordings, have varying degrees of inherent distortion, difficult to eliminate, a wider band will increase the effect of same. This causes much of the upper-frequency "fuzziness" generally in evidence on most attempts at wide-band reproduction. The phase distortion introduced by most sound systems is not believed to be a serious problem, as the ear is apparently not sensitive to moderate phase changes. The phase characteristics should, however, be uniform. Distortion must be kept to the lowest possible value and more attention should be directed to investigation and elimination of cross-modulation products as compared with present stress on the more simple harmonic distortion effects.

Multi-path effects resulting in distortion are observable in reception on both amplitude and frequency-modulation systems. This form of distortion, when it occurs, can be more noticeable with frequency modulation, and this effect has been observed in certain instances. It is possible that some listeners will be subject to this distortion, the effects of which increase with an extension of the audio range and deviation. However, good limiting in a frequency-modulation receiver should minimize this form of distortion.

Random noise is directly proportional to band width and any increase in the latter will increase the amount of noise passed. This imposes stringent design conditions on all the units in the line-up and would be particularly difficult to get and to maintain, at a reasonable price, in the case of a practical home receiver.

Standard radio broadcasting is at present limited to an upper modulation frequency of 5,000 cycles as a result of the 10,000-cycle spacing of radio channels, but most

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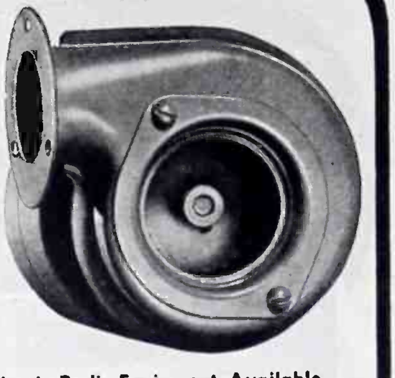

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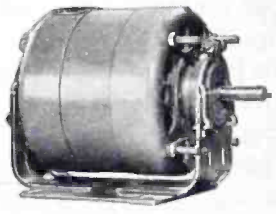

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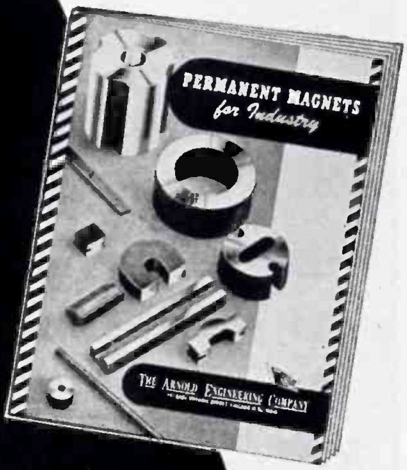

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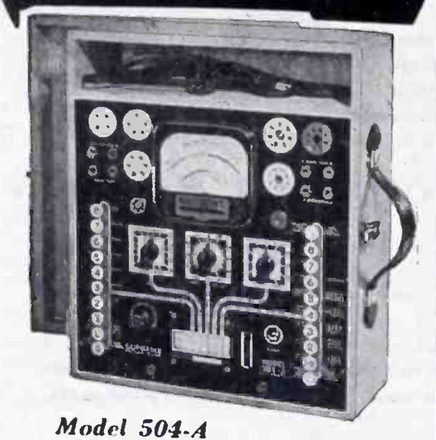
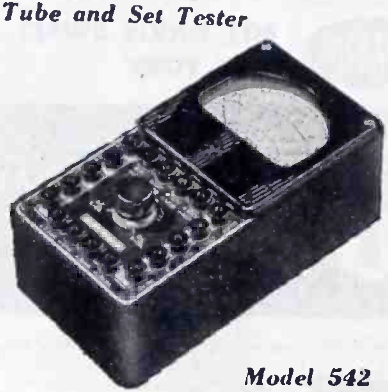
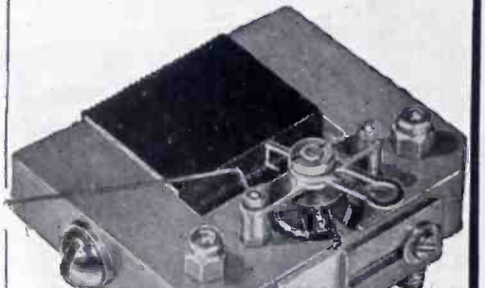






studio equipment and transmitters are capable of transmitting up to 10,000 cycles or higher. However, satisfactory reception with this wide band is not generally possible in the evening because of "monkey chatter" from adjacent-channel stations, so that a restriction in frequency response in the receiver is in such case actually desirable.

Whether or not we can make full use of a complete audio spectrum depends, in the final analysis, upon the ability of the manufacturers to provide receivers which will satisfactorily reproduce the lower frequencies. Only when this is possible in the average marketable receiver can we make full use of the higher portions of the frequency spectrum and can refer to the system as one of higher fidelity. The average price of a broadcast receiver in 1940, of which many millions were sold, was about $35, and at this price satisfactory reproduction of 50 to 15,000 cycles is not to be expected. It must be stressed that power-handling facilities in all models were quite limited at the lower frequencies due to loudspeaker design, so that the lower limits indicated in Fig. 1 do not actually have the full meaning implied.

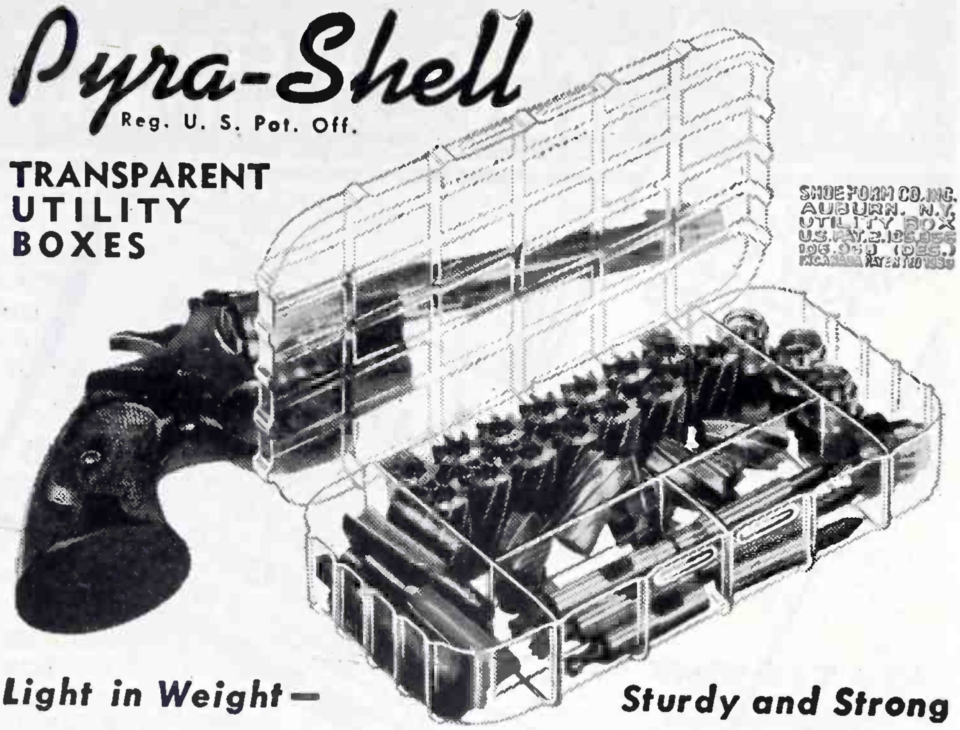
Recommendations

In an appeal to common sense and practicability in the matter of fixing an audio band width for receiver it is suggested that the range, from 60 to 8,000, or possibly 50 to 10,000 cycles be considered for all types of broadcasting, including frequency modulation. There is little question, in the opinion of those who have devoted their lives to the problems of sound reproduction, that good reproduction over a practical band will provide a better service to the listener than one of controversial and indefinite quality over a theoretically complete audio spectrum. Our efforts should be directed towards the provision of a balanced system of reproduction as fine as we can possibly design and build it, rather than solely toward extending the upper frequency limits beyond 10,000 cycles with the possible neglect of other more important factors. It is especially stressed that reproduction at the lower frequencies be investigated and improved, because it is in this

rection, the direction of balance , compared with present trends, at we can best provide what un- ased observation and listeners' eference demands.

How can publicizing and creating demand for 15,000-cycle receivers · systems be possibly justified, hen a good 10,000-cycle receiver at can be made available to the reater part of the public has not t been designed? For the sake technical integrity and the fu- ıre of the radio industry let's get wn to earth in the matter of high lelity. We are faced with the pros- ect of a post-war era in which it is ery likely that many claims for ew materials, techniques and over- ll improvements will face the spot- ght of public test—and fail. Let s not, therefore, in our enthusi- sm make claims that are too diffi- ult, if not impossible, to realize.

Acknowledgement. Appreciation ; expressed for the cooperation of ne following NBC engineers in the reparation of this paper: G. M. ixon, Assistant Development En- ineer and C. A. Rackey, Audio- ideo Facilities Engineer.



Transients

(*Continued from page* 139)

age can be expressed as a sinusoidal voltage which is the sum of the three sinusoidal voltages across the circuit elements. Therefore the shapes of the current and voltage waves are identical, except for the amplitude and a phase displacement indicated by the j terms.

Since the instantaneous value of the impressed voltage varies sinusoidally with time and has a phase displacement (which we shall designate as ϕ), the impressed voltage may be written as

$$e = E_m \sin(\omega t + \phi) \tag{17}$$

where E_m is the maximum or amplitude value. Comparing Eq. (16) with Eq. (17) it is evident that

$$E_m = \left(j\,\omega L + R - j\frac{1}{\omega C}\right) I_m \tag{18}$$

Each of these component voltages can be considered to be generated by means of a rotating vector, all vectors of which rotate at the same angular velocity. By means of such a vector diagram, it is easy to show that

$$\phi = \tan^{-1}\frac{\left(\omega L - \frac{1}{\omega C}\right)}{R} \tag{19}$$

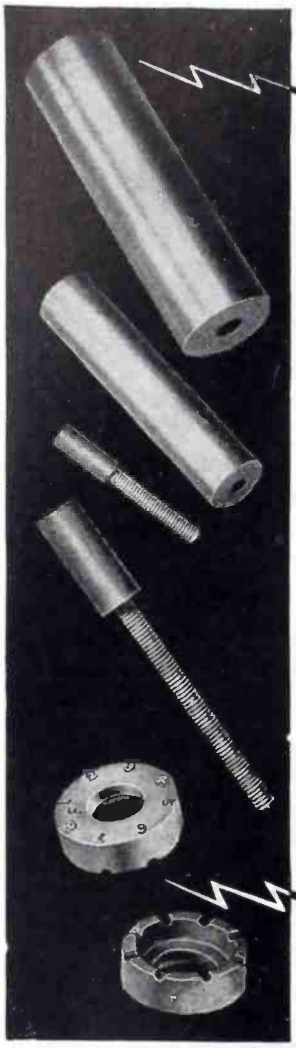
Graphical Representation of Wave Forms

The curves of Fig. 4 represent the current and voltage of a series circuit with sinusoidal current flowing through it. Curve A represents the current which flows through the circuit. Curve B represents the voltage across the resistor R. Curve C represents the voltage across inductance L, and curve D represents the voltage across capacitor C. The voltage impressed across a series circuit consisting only of R and L in which the sinusoidal current, i, flows is shown at E, while curve F represents the voltage across a series circuit consisting only of R and C. Curve G represents the idealized case in which there is no resistance in a series circuit consisting of L and C. Curve H represents the voltage impressed across R, L, and C through which a sinusoidal current flows. By means of the graphical addition employed in deriving curves D to H, the dependence upon the magnitude of the circuit constants of shift in phase between impressed voltage and current may be easily visualized.

The curves of Fig. 4 provide visual indication that for linear circuits in which the current is sinusoidal, the voltage drops and the applied voltage have the same general form as that of the current. Similarity of wave forms results from the peculiar property of sine waves which makes their derivative and integral of the same shape as the given sine wave, except for phase displacements. This state of affairs, which greatly simplifies the study of alternating current theory, does not exist in general. If waves of other shape had been employed, this state of affairs would not exist.

Graphics for Non-Sinusoidal Waves

There is no end to the variety of wave shapes which might be treated, but there is little need to analyze more than a few simple and typical wave forms in order to illustrate the essential behavior of circuits with non-sinusoidal wave forms. Accordingly, discussion will be limited to a graphical treatment



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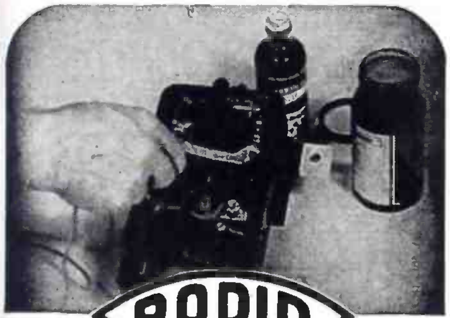

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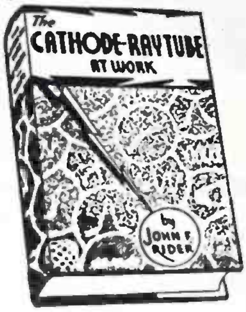

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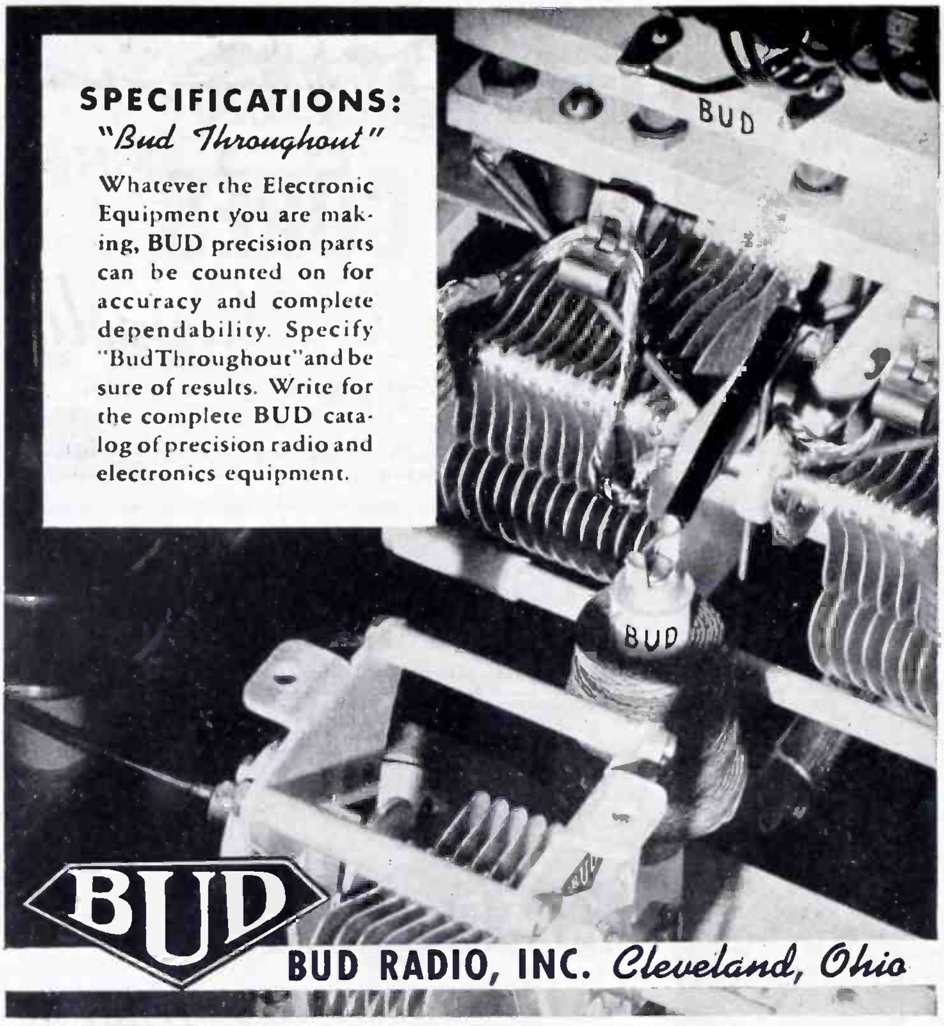
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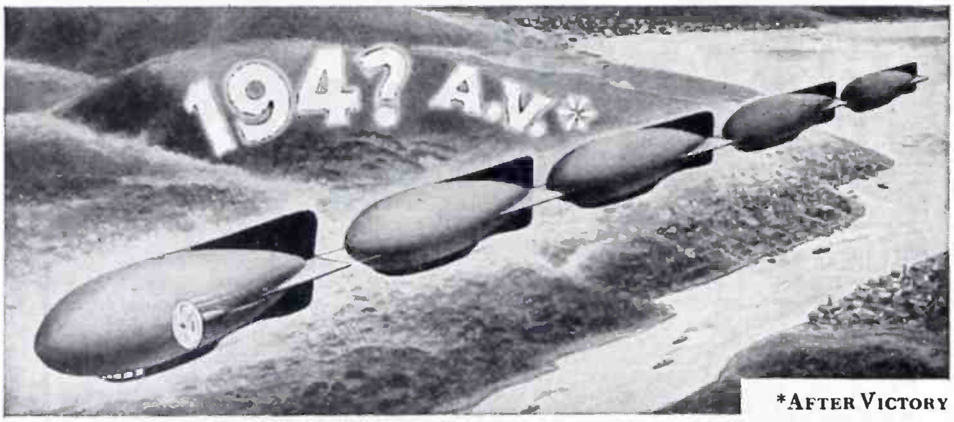

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of square waves, triangular waves, saw-tooth waves, trapezoidal waves and exponential waves, as well as the sine waves which have already been treated. The analysis of the exponential wave is included because it is the only wave variation in which all voltage and current wave forms are identical, except for scale factor. There is not even a phase shift, as in the case of sine waves. Because of this remarkable condition, exponential functions are of great theoretical and practical importance, and much use will be made of exponential functions when transients are treated.

Square Waves

Next consider the case in which the current flowing through a series circuit may be represented by a square wave as shown in Fig. 5. In this and all following cases, the original curve will be differentiated and integrated by graphical methods alone. Curve A of Fig. 5 represents the current flowing in a series circuit, while curve B represents the voltage across a resistor in

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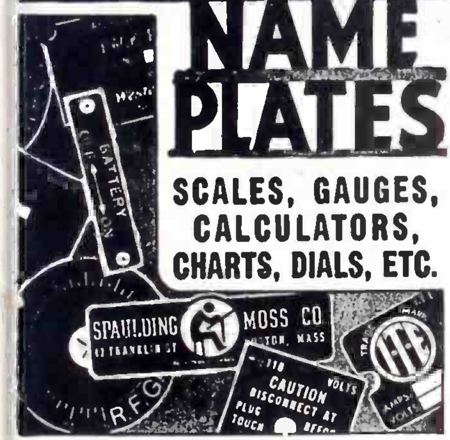

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which the current flows. To obtain the voltage across an inductor, curve A of Fig. 5 must be differentiated (that is, its slope at all points must be ascertained) and the result multiplied by L.

The slope of curve A is zero at all points except the points of transition. At these points the slope is theoretically infinite if the sides of the original wave shape are truly vertical. In practice, the slope has a finite value and is so indicated in curve C of Fig. 5. Curve C represents the voltage across an inductor through which a square-wave current flows. Curve D represents the voltage across a capacitor C through which the square wave of current flows and is therefore proportional to the area under curve A. Note that the wave shapes of curves C and D do not resemble that of the original curve A, nor do they resemble one another.

In order that a square-wave current may flow through the circuit, the wave form of the applied voltage will now depend upon the configuration of the circuit network. If the series circuit is composed of resistance and inductance, curve E (which is the sum of waves B and C) represents the wave form of the voltage required to produce the required square wave of current. Likewise curve F is the voltage required to produce a square wave of current in an RC circuit. If the circuit consists only of inductance, L, and capacitance, C, the required voltage wave shape is given by the sum of curves C and D, shown as curve G. The curve at H represents the voltage wave required in an RLC circuit to produce a square wave of current, but the type of time variation will be as indicated. This example tends to illustrate one very important point. Whereas a harmonically varying current is produced by an applied voltage which is also harmonically varying, identity of voltage and current wave forms does not exist in general. It is for this reason that attention must be given to the wave forms of a number of more important elementary circuits and current wave shape.

Trapezoidal Waves

If we assume that the current wave shape is trapezoidal, as shown in curve A of Fig. 6, then the volt-

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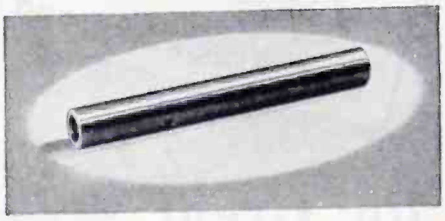

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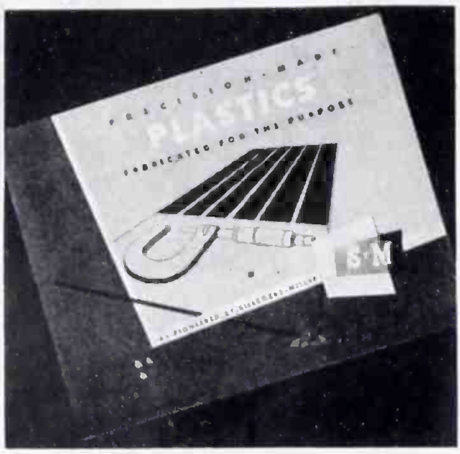
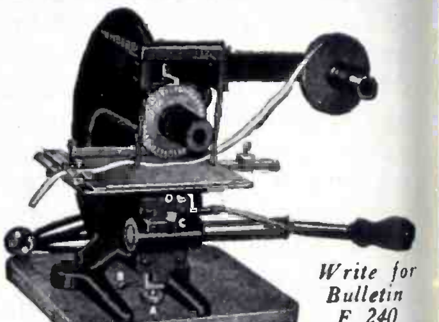


forms are more difficult to express than those in which the wave forms are sine or cosine waves. Furthermore, while we have simple trigonometric expressions which enable us to express the sinusoidal time variation of a voltage or current with great simplicity and ease, we have, in general, no equally satisfactory method of obtaining analytical expressions for non-sinusoidal wave forms. It has been possible to show these wave forms graphically, of course. However, if we wish an analytical expression for those wave forms, it will be necessary to break each wave form down into its fundamental, recurrent cycles. In some cases (as in all of those selected for treatment here, except the wave of Fig. 3 which does not include a complete period or cycle) it is possible to break down the wave still further, expressing each segment as a single-valued continuous function of time. Several expressions, one for each segment, will then be required to specify the wave, and we must find some means of expressing the fact that these wave segments recur at cycle intervals. With this procedure, the problem is always messy, lacks generality, and is difficult of application.

It can be shown (see any text on Fourier series) that any recurrent wave form can be expressed as a series of simple sine waves of appropriate amplitude, frequency, and phase. Hence, it is possible to build up any of the recurrent waves shown here (among others) by means of sine waves which, we found, were the simplest to handle. The manner in which saw-tooth and square waves may be constructed of a series of sine waves is illustrated in Fig. 10.

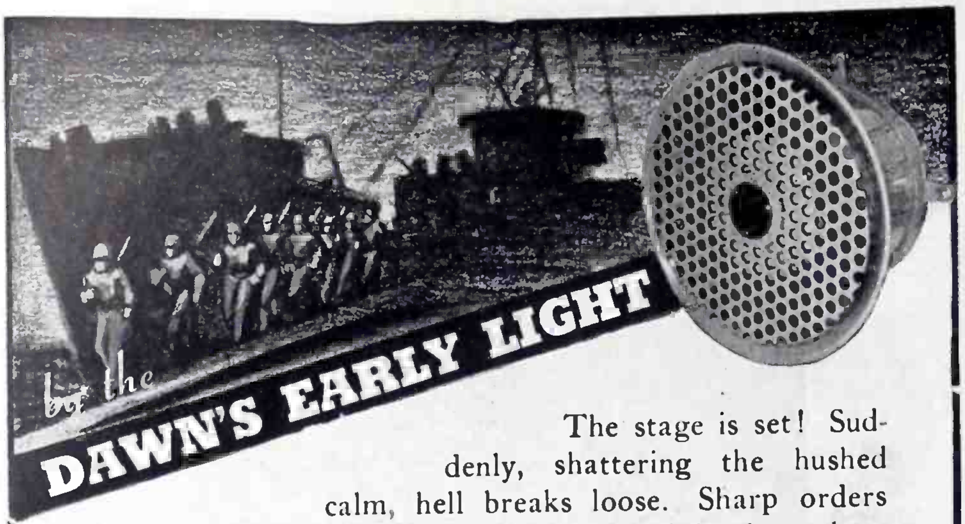
Frequently a non-sinusoidal wave form requires an infinite number of sinusoidally varying terms to express the desired wave shape exactly. But sufficiently good approximations to the desired wave shape may also usually be obtained with a finite number of terms since the terms of higher harmonics usually have small amplitude and consequently make little contribution to the wave shapes. Hence, by including a sufficient number of terms, we can approach the desired wave form as closely as we like. The frequency of the last term retained in the

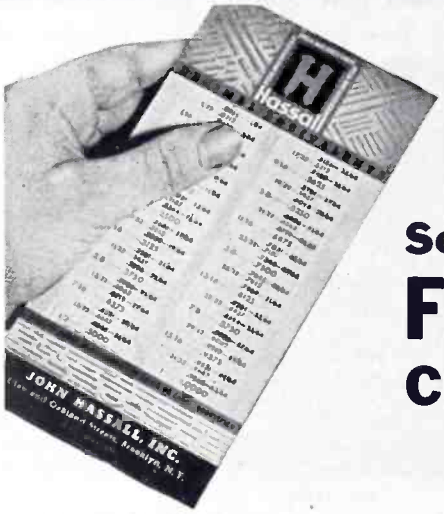


series indicates the highest frequency for which the communication system should be designed.

We may summarize the important conclusions as follows:

1. For linear circuit elements, the fundamental voltage-current relations (given in Table I) are the general ones employed when dealing with transient or non-sinusoidal steady-state wave forms.
2. In general, the wave forms of steady-state voltages and currents in linear electric circuits do not resemble one another, except that all have the same period or time interval of periodic variation.
3. For the special case of sinusoidal waves, the general derivatives and integrals of Table I are replaceable by terms involving $j\omega$.
4. For the special case of exponential wave form, all voltage and current forms are alike.
5. The graphical methods used in this article have aimed to provide a basis for understanding the fundamental phenomena, rather than for obtaining numerical values of current and voltage.





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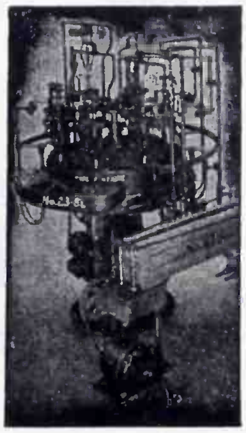

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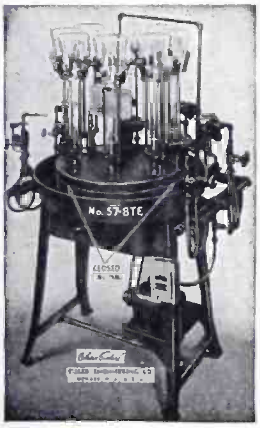

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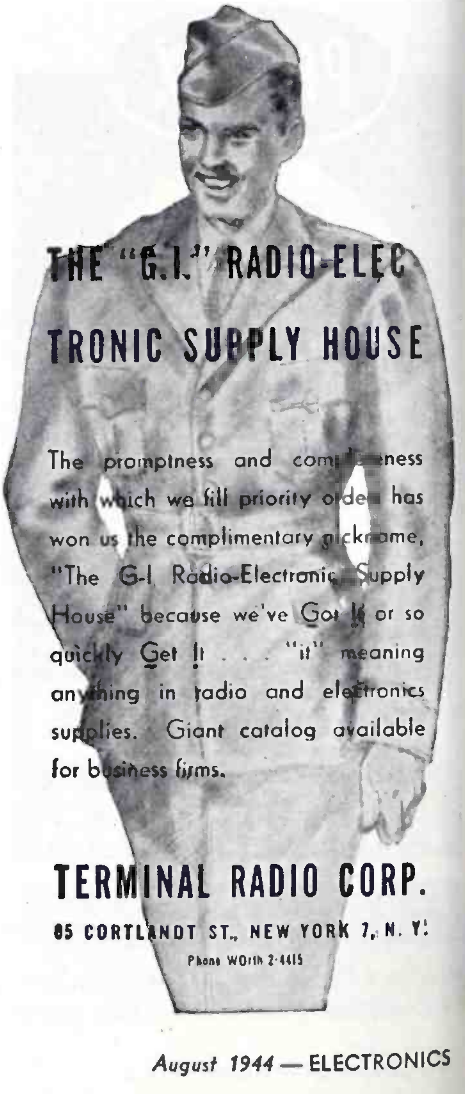
By ROBERT N. AUBLE, *Instructor in Radio, Arsenal Technical Schools, Indianapolis, The Macmillan Co., New York, 1944, 134 pages 8½ x 11 size, punched for standard binder and with cardboard covers, price $1.50.*

THIRTY JOB SHEETS, designed to provide a practical working knowledge of the electrical fundamentals of radio when used by instructors having access to a variety of good textbooks and having well-equipped shops for students. The jobs are a distinct improvement over the average experiments found in textbooks.

Each job starts with a list of its objectives and specific page references to such textbooks as Everitt's Fundamentals of Radio, Henney's Principles of Radio and Radio Engineering Handbook, Ghirardi's Radio Physics Course, RCA's Tube Manual, etc. Topics for classroom discussion before the shop work are then listed in two groups, one on re-



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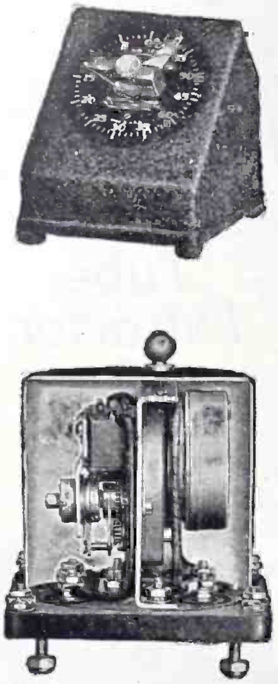
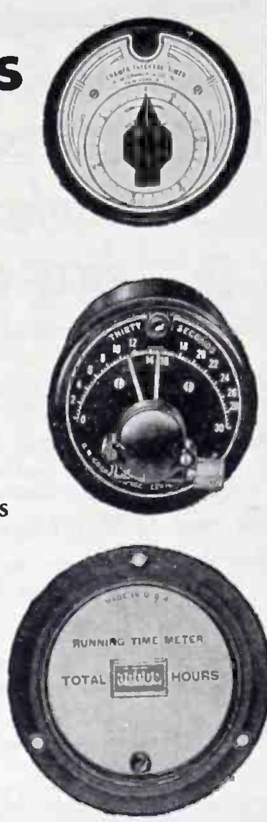
ated knowledge and the other on related skills. Numbered steps tell what to do and provide spaces for recording results or answering questions. Blank tables are printed for tabular data in many cases, and blank graphs are provided when results are to be plotted. Optional added procedures are often given. Finally, careful selected and worded questions test the student's understanding of the principles involved, with spaces again being provided for writing the answers in the book. Some of the questions are of the missing-word type, which simplifies the work of the instructor who must grade each student's book regularly.

The first five job sheets cover soldering, wiring, chassis drilling, use of circuit symbols, checking continuity and replacing defective parts. The next five deal with magnetism. No. 11 covers laws of electric charges; three are on fundamental measurements and three more on measuring instruments, while two deal with Ohm's law. Induced currents and the transformer





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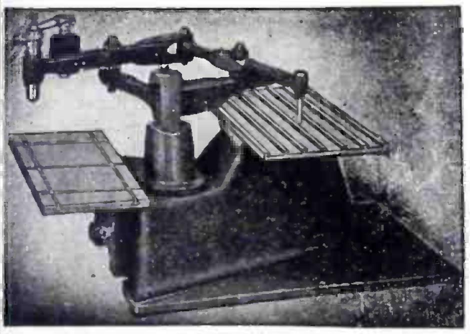

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take three job sheets; No. 23 is on the use of the wire gauge, No. 24 on coil winding, and No. 25 on building a crystal set. Two cover capacitance, one deals with a.c., No. 29 is Construction of an Audio Oscillator, and No. 30 is Action of a Rectifier Tube.

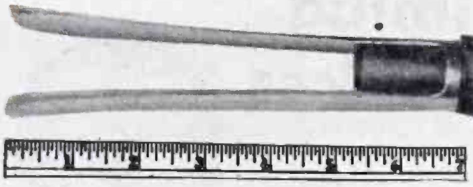
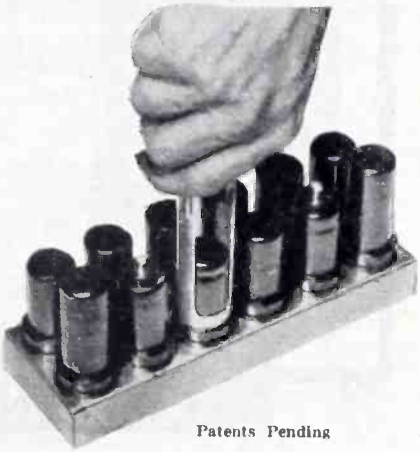
The book is highly recommended for use in radio shop classes.—J.M.

• • •

Table of the Bessel Functions $J_0(z)$ and $J_1(z)$

WPA Mathematical Tables Project, *conducted under Sponsorship of National Bureau of Standards. Published by Columbia University Press, Morningside Heights, New York 27, N. Y., 1943, 406 pages, $5.00.*

Bessel functions of orders zero and one are encountered in the general solution of boundary value problems arising in the theory of potential, heat conduction, and wave motion, when the domain is bounded by a circle or a circular cylinder. In particular, they occur in the problem of propagation of electromagnetic waves with a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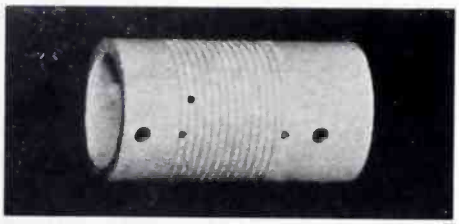
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traight wire as a guide (in an isoropic medium), the theory of the kin effect for poorly conducting vires, the problem of oscillatory notion of a sphere in a viscous nedium, the vibration of a heavy hain in a resisting medium, and n many other boundary value roblems.

In spite of their great imporance in theory and application, Bessel functions have scarcely been abulated for complex arguments. Aside from tables for purely imagnary arguments and for argunents in the form $r\sqrt{i}$, Hayashi's hort tables of $J_0(z)$ and $J_1(z)$ are the only ones in existence. To meet he need for more adequate tables, these functions are tabulated in the present volume for argumentpoints defined in polar coordinates. Along each of the rays = 0°, 5°, . . . 90°, ten-place values of the real and maginary parts of $J_0(z)$ and $J_1(z)$ are given for moduli ranging from 0 to 10 at intervals of 0.01.

• • •

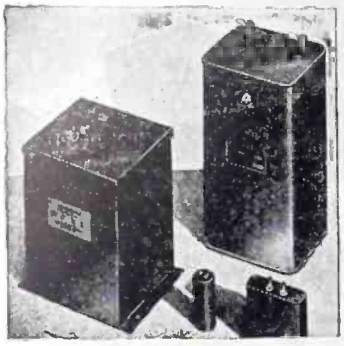
Fundamentals of Radio Communications

By Austin R. Frey, *Lehigh University, Longmans Green & Co., New York, 393 pages, $4.00, 1944.*

This small, compact volume, intended to "present in as concise a form as possible, the fundamental principles of radio communication" provides an introduction to the principles of radio for those familiar with calculus. Since the entire scope of radio communication is covered in 400 pages or less, each topic is developed rapidly and it is impossible to provide an exhaustive treatment of any topic.

The 9 chapter headings deal with: (I) Resonant Circuits, (II) Thermionic Emission and Diodes, (III) Grid - Controlled Vacuum Tubes, (IV) Voltage Amplifiers, (V) Power Amplifiers, (VI) Oscillators, (VII) Modulation and Demodulation, (VIII) R-F Transmission Lines, and (IX) Radiation.

For the most part, concepts of ultra high-frequency operation are omitted. There is no treatment of wave guides or electromagnetic horns, and only very brief mention of some of the more recently developed uhf oscillators. A section on transients which appears in Chapter VI is introduced by a dis-



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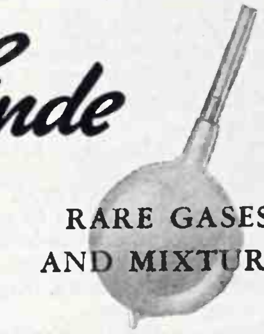

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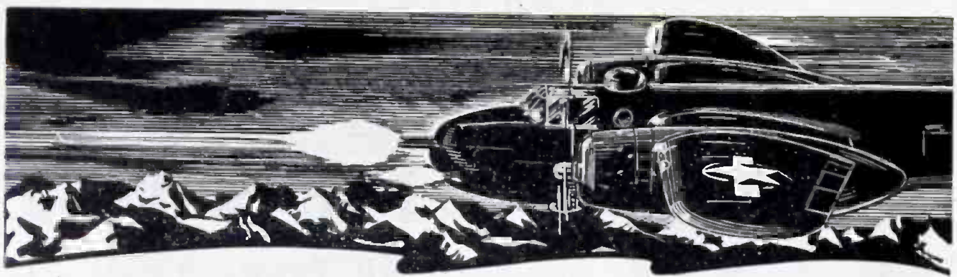
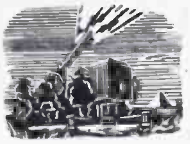
cussion of spark transmitters. It seems unfortunate that this type of transmitter is not permitted to die its natural death. Throughout, emphasis is placed on fundamental principles rather than on commercial practice.

The physical interpretation of the operation of radio circuits is well done and only a moderate amount of mathematics is used. For the most part the mathematical derivations are rather concise and compact. On page 219 an error occurs in the expansion of sinh βt as $\beta t \rightarrow 0$. Although the expansion is incorrectly carried out, the final result, for the current in an RL circuit for critically damped conditions, is correctly given.

The volume is certainly more advanced than the practical texts on radio which aim to present only a qualitative descriptive picture of communications. But it is not sufficiently elaborate or exhaustive to be a text or reference for the communications engineer. As the author states, the main feature of this book is its compact presenta-





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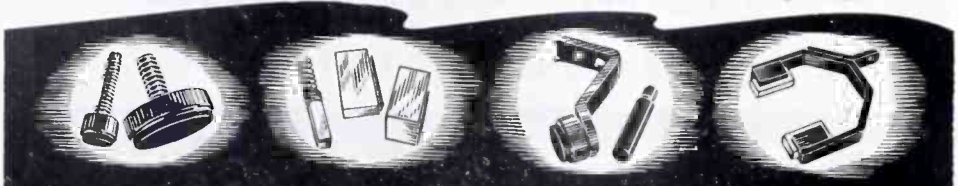

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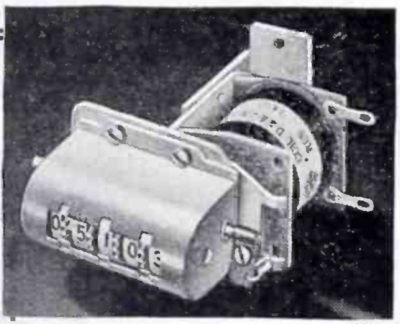

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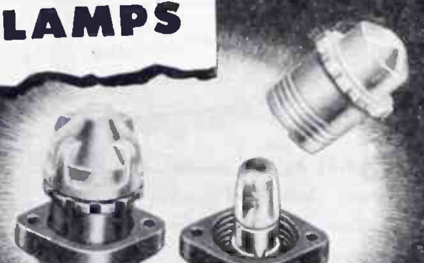

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tion of a quantitative concept of radio communication.

The volume can be recommended as an introductory volume for those who possess training in science or general engineering but are not familiar with the principles of radio.—B.D.

• • •

Principles of Powder Metallurgy

By Franz Skaupy, *Philosophical Library, Inc., 15 E. 40th St., New York; 1944, 80 pages, price $3.00.*

This translation of what apparently was originally a German report on developments in powder metallurgy was written when the author first recognized the importance of the method in the manufacture of bearings, cutting tool tips, and machine parts. It is based on previous successful applications to electric lamp filaments, electrical contact points, anodes for x-ray tubes, magnet cores, and small crucibles.

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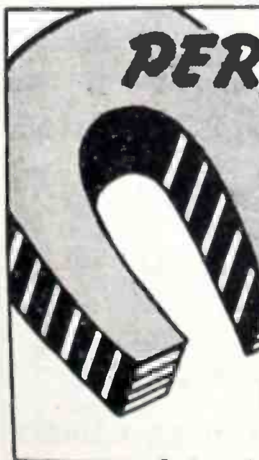

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laboratory research point of view, describing first the production of metal powders and their properties, then the production and properties of powdered metal or "ceramic metal" parts with and without binding agents. Particular attention is given to the metals tungsten, molybdenum, and tantalum and relatively little to bearing metals and powdered iron parts.

The discussion of methods is largely confined to laboratory technique and methods but contains details of manufacturing procedure that are not found in other books and technical publications. The language is often more scholastic in tone than that of an industrial metallurgist.—M.G.V.

• • •

20th Century Engineering

BY C. H. S. TUPHOLME, *Philosophical Library, 15 E. 40th St., New York, N. Y., 1944, 201-xi pages, price $3.*

ACHIEVEMENTS OF THE PAST decade in many branches of engineering are briefly explained in this book, with emphasis on British developments since the author is British and the book was written in England. The author's aim was to select and digest a number of interesting engineering developments for the benefit of engineers and members of the armed forces who wish to keep abreast of what has been happening. However, because it was written two or three years ago many of the most recent developments that one would look for are missing.

Chapters cover mechanical power, shop processes, air conditioning and refrigeration, chemical and metallurgical engineering, electric engineering, traction, marine engineering, aircraft and physics. Engineers who are interested in European developments in engines and power systems will find the opening chapter helpful. The section on shop processes is limited chiefly to oxy-acetylene cutting and hardening, chromium plating to extend life of tools and parts and to build up worn parts, precision machining and finishing, and methods of inspection and testing.

The chapter on chemical and metallurgical engineering covers plastics, a gas hyper-compressor for

(*Continued on page* 412)

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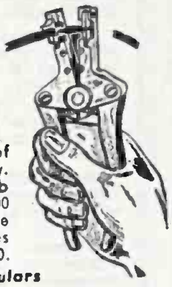

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Small 3-Stage AMPLIFIER

Only 2⅛" by 3" by ⅝"

DOES YOUR PRODUCT REQUIRE A MORE COMPACT AMPLIFIER?

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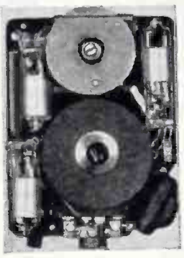

PARAPHONE HEARING AID INC.
2056 East 4th Cleveland 15, Ohio

J. L. A. McLAUGHLIN
Designer of
Communications Receivers
P. O. Box 529, LaJolla, Calif.

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ELECTRONIC EQUIPMENT
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FINE RIBBONS OF TUNGSTEN MOLYBDENUM

Making a modest but effective contribution in Electronics' War accomplishments.

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for checking transmitters from 1.5 to 56 mc., within 0.01 per cent

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Consulting Engineers
Industrial Electronics
& Communications
Earle Bldg., Washington 4, D. C.

SEARCHLIGHT SECTION

(Classified Advertising)

UNDISPLAYED RATE: 15c a word, minimum charge $3.00; Positions Wanted (full or part time individual salaried employment only) ½ the above rate. **DISPLAYED:** The advertising rate is $7.50 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

POSITIONS VACANT

RADIO DESIGN engineers thoroughly experienced on design of radio receivers. Position offers an excellent permanent opportunity with a well established New York company for war and post-war work. Write giving full particulars, background and experience. P-696, Electronics, 330 W. 42nd St., New York 18, N. Y.

EMPLOYMENT SERVICE

SALARIED POSITIONS — This advertising service of 34 years' recognized standing negotiates for high salaried supervisory technical and executive positions. Procedure will be individualized to your personal requirements and will not conflict with Manpower Commission's. Retaining fee protected by refund provision. Identity covered and present position protected. Send for details. R. W. Bixby, Inc., 278 Delward Bldg., Buffalo, N. Y.

EMPLOYMENT AGENCY

ELECTRONICS—More positions are coming in daily for well qualified men in Electronics. Our service is Nation wide and covers all branches of Engineering. More than 51 years at the same address. The Engineering Agency, Inc., 53 W. Jackson Blvd., Chicago 4, Illinois.

POSITIONS WANTED

ENGINEER-PHYSICIST, with fifteen years of experience; desires position in research or development. Familiar with high vacuum technique, glass blowing, x-rays and related applications. PW-700, Electronics, 330 W. 42nd St., New York 18, N. Y.

REPRESENTATIVE WANTED

MANUFACTURERS REPRESENTATIVE wanted by a midwestern manufacturer of metal stampings in small lots. Some very desirable territory still open on a protected commission basis. Die stamping knowledge an advantage. Reply Room 209, 549 Washington Boulevard, Chicago, Illinois.

REPRESENTATIVE AVAILABLE

SUCCESSFUL NEW YORK firm of electronic representatives with an established trade of twenty years continuous contact with distributors, industrials, laboratories and government agencies wishes to add additional lines such as tubes, capacitors, resistors, relays, meters or allied electronic parts. RA-691, Electronics, 330 W. 42nd St., New York 18, N. Y.

MANUFACTURERS REPRESENTATIVE at present selling components to radio manufacturers, government agencies and jobbers in the eastern territory. Will consider high type lines with post-war future. RA-701, Electronics, 330 W. 42nd St., New York 18, N. Y.

MECHANICAL ENGINEER with thorough technical training and experience in the handling of men to take charge of a small research model room and drafting department of well-known, long established company. Work is principally in the design of light mechanisms. Some knowledge of electrical circuits and electronic devices desirable.

P-705, Electronics
330 West 42nd St., New York 18, N. Y.

REPRESENTATIVE AVAILABLE

Do you want representation in Texas and Southwest? Technical and Practical manufacturers representative, long identified with Radio and Electrical Industry. Write:

JAMES A. DUPREE
130 Belden Ave., San Antonio 4, Tex.

ENGINEERS

For design, development and production of

Electrical Measuring Instruments or Radio Test Equipment or Both

If you are thinking about your post-war future
If you want a position of permanence

Here is your chance to become associated with a long established and progressive manufacturing concern, well known in the industry for the quality for its products.

This company has been successful in manufacturing pre-war equipment identical with that now provided in the war effort. We will have a continuing program of post-war engineering development assuring peace-time security and permanence of employment in a major field.

We need men well grounded in the fundamentals of electronic engineering and who have substantial experience in electrical measuring instrument or test equipment design. Practical production experience also is desired. Salary commensurate with previous experience and ability.

Our engineering staff is a congenial, capable team of technicians with whom you will enjoy working. Modern plant buildings provide pleasant working conditions, and this small Northwestern Ohio College town is an ideal place to live and enjoy life.

Write to

The Triplett Electrical Instrument Co.
333 Harmon Road Bluffton, Ohio

WANTED

PRODUCTION MANAGER

LEADING ELECTRONIC TUBE MANUFACTURER has opening for production manager with wide experience in tube manufacturing. Excellent opportunity for right man. Apply by letter stating experience, education, etc. Reply

P-695, Electronics
330 West 42nd St., New York 18, N. Y.

OPPORTUNITIES TO "*GROW*"

A leading organization in New England with extensive present and postwar development program in commercial electronics wants mechanical and electrical engineers of proved talent for engineering and development work. Company now producing mechanical, electrical and electronic instruments for war purposes. Permanent positions for right men. Reply by letter giving complete outline of education, experience, and personal statistics. Address:

P-702, Electronics
330 West 42nd St., New York 18, N. Y.

FOR SALE

2 High Frequency Generators

2 k.w. output, 3 phase, up to 50 megacycles, suitable for experimental work only.

Forest Products Engineering Co.
Manhattan Building Chicago, Ill.

BEST QUALITY, USED ELECTRON TUBE MACHINERY

Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

AMERICAN ELECTRICAL SALES CO., INC.
65-67 East 8th St. New York, N. Y.

WANTED

ENGINEER

EXPERIENCED IN THE MANUFACTURING OF

TRANSFORMERS

GOOD FUTURE WITH GROWING CONCERN

Our employees have been informed of this Ad

LOCATION CHICAGO

P-703, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

WANTED

AC-DC MOTOR ENGINEER

Thoroughly experienced in development of small fractional H/P DC Aircraft motors and similar electro-mechanical devices. Good post-war opportunity. State age, education, complete experience, draft status, salary. Replies confidential.

F. A. Smith Manufacturing Co., Inc.
P. O. Box 509 Rochester 2, N. Y.

TECHNICAL MANUSCRIPTS
INSTRUCTION MANUALS
CONSULTATION SERVICE

In All Phases of Electronics

INDUSTRIAL ELECTRONICS, INC.
21 Henry St. Detroit 1, Mich.

WANTED

SURPLUS RADIO & ELECTRONIC PARTS and EQUIPMENT

of every description

Screws—Nuts—Bolts—Washers & Lockwashers—Solder Lugs—Rubber Grommets, Bushings & Feet—Solder Lug & Screw Terminal Strips—Fibre & Bakelite Washers—Push on & Set Screw Knobs—Push Button Switches & Knobs—Iron Cores—Momentary & Toggle Switches—Steel, Brass & Bakelite Spacers—Leather Handles & Loops—Slide Lever Hinges—Expansion & Compression, Etc. Springs Of Every Description—Connection Wire—Battery, Speaker Plugs & Receptacles—Magnet Wire—Tubular & Mica Condensers—Resistors—Short Lengths Fibre Glass Wire (all gauges)—Bakelite Handles—Flexible Shaft Cables—and 1001 other Items.

Mr. Manufacturer: What are your Buying requirements? We carry huge stocks of above type material on hand—how can we serve you?

LOUIS GANCHER CO.

50 West Broadway, New York 7, N. Y.

"In Radio Since 1921"

MOTORS

Fractional H.P. Motors/Armatures Rewound-Rebuilt

Ship at our expense. All work guaranteed. Highest grade materials used throughout.

IMPERIAL ELECTRIC COMPANY
100 Blackstone St., Woonsocket, R. I.

(Additional Employment Advertising on pages 383, 395, 409, 410 & 411)

WANTED

PRODUCT DESIGN ENGINEERS

by a long established manufacturer of electrical equipment — electro-magnetic relays — solenoids — switches. Located in small midwestern city, convenient to Chicago.

Relays, solenoids, switches, and related items to be designed, are primarily for

Automotive
Farm
Radio
Aircraft and
Industrial Control Equipment

Write, giving complete resumé of past experience, salary desired etc. to

P-694, Electronics
520 North Michigan Ave., Chicago 11, Ill.

ENGINEERING OPENING

Project Supervisor

Permanent position with an established concern manufacturing communications equipment.

Prefer top-notch man with UHF experience who can take charge of development or design project.

Salary commensurate with ability. Additional compensation for assignment of patents to company.

Pleasant working conditions.

W.M.C. rules observed.

Address
DALE POLLACK
Engineering Director
TEMPLETON RADIO COMPANY
Makers of Temple Radios
MYSTIC, CONN.

WANTED

SENIOR Radio Engineers

Executive type with thorough practical and educational background in radio and electronics. Must have substantial experience and demonstrated initiative in design, research, and development. Capable of supervising development and production engineers. Excellent working conditions. Permanent positions with ample opportunity for advancement. Outline complete details of qualifications, experience, and when available. Salaries open. Confidential inquiries respected. Write.

Personnel Director
AIR COMMUNICATIONS, INC.
Kansas City 10, Missouri

ELECTRONIC

ENGINEERS
TECHNICIANS
DESIGNERS
DRAFTSMEN
TUBE TECHNICIANS

EXCELLENT OPPORTUNITIES IN A MAJOR POST-WAR FIELD!

Openings available at our Research Laboratories and Electronics Manufacturing Unit. Leaders in the design and development of vital electronic equipment for the Armed Forces.
Essential workers need release.
Write, stating Experience, Education, Draft Status, Salary. Include snapshot if available. Or apply to

SPERRY
GYROSCOPE COMPANY, INC.
RESEARCH LABORATORIES
STEWART AVE. & CLINTON RD.
GARDEN CITY, NEW YORK

SENIOR RADIO ENGINEERS

Top bracket midwest radio-electronics manufacturer has present and postwar positions for one chief mechanical engineer, two research, three development, two production, one specifications and standards. Salaries open. Confidential inquiries respected. Write

P-699, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

WANTED

GRADUATE MECHANICAL ELECTRICAL ENGINEERS AND STRESS ANALYSTS

Excellent immediate and post-war opportunity for qualified engineers having experience on small electro-mechanical devices. Apply by letter only, giving experience and training resume and draft status.

Must comply with W. M. C. Regulations.

LEAR, INC.
PIQUA, OHIO
R. J. Biggs, Special Representative

WANTED

DESIGNER

A central New England Manufacturer employing over 1000 people needs Draftsman-Designer on telephone and signaling (mechanical) apparatus.

Knowledge of die-casting and plastic applications desirable.

WMC Regulations Prevail.

P-681, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED

Top-Flight Distribution Manager

by one of America's leading manufacturers of small electrical parts, extensively used in radio servicing and in industry. Products enjoy excellent acceptance but management is of opinion that present distributional system is in need of revision to gear it to post-war competitive markets. If you have an outstanding promotional record, are chock-full of ideas and are stirred by the challenge of a big job you may become part of the executive "family" of a company that is "going places". The matter of salary will depend entirely on you and what the government will allow to be paid. Write complete background data and enclose photo with your first letter.

P-697, Electronics
330 West 42nd St., New York 18, N. Y.

TECHNICAL MANUSCRIPT WRITER

TO ASSIST ENGINEERS WITH PREPARATION OF MANUSCRIPTS FOR PUBLICATION, AND TO SUPERVISE PREPARATION OF INSTRUCTION BOOKS FOR RADIO EQUIPMENT. SALARY COMMENSURATE WITH ABILITY AND EXPERIENCE. SEND COMPLETE DETAILS OF EXPERIENCE, DRAFT STATUS, AND RECENT PHOTOGRAPH IN FIRST LETTER. STATE SALARY EXPECTED, AND IF NOW EMPLOYED IN WAR INDUSTRY, STATE CONDITION OF AVAILABILITY.

ADDRESS: DALE POLLACK,

CHIEF ENGINEER

TEMPLETONE RADIO COMPANY

MYSTIC, CONNECTICUT

WANTED

ELECTRONIC ENGINEER

to work 100% on the job—rather than 25% actual work and 75% "holding the job."

The Engineer we need must have substantial experience and demonstrated initiative in design, research and development.

The position offers an excellent opportunity with a well-established company in western New England, employing over 100 personnel. This company's 5 years pre-war industrial background assures a continued program of postwar advancement.

P-686, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED

ENGINEER

with

ELECTRONIC or ELECTRICAL

Experience for Research
and Development in our

TOCCO HEAT TREATING INDUSTRY

Post War Future
Good Salary for Right Applicant

OHIO CRANKSHAFT
3800 Harvard Cleveland, Ohio

WANTED

SENIOR ENGINEER

with at least seven years industrial experience in important electronic research and development work. Capable of executing important assignments from development to finished products.

JUNIOR ENGINEERS

with sound educational background and at least one year's experience in factory or engineering departments.

RADIO TECHNICIANS

with factory or model shop experience in building test equipment on production testing electronic equipment.

MECHANICAL ENGINEER

preferably experienced in electronic field.

PRODUCTION MAN

experienced in setting up and supervising production lines.

These positions offer unusually good permanent opportunities—top compensation commensurate with qualifications—congenial, progressive organization with new and one of the best equipped laboratory and factory facilities in the industry. Interesting work on most advanced type of military communication equipment now and broad field of quality radio-phonograph and industrial electronics after V-Day. Please write detailed qualifications, including availability, if not occupied to full extent of ability in war work, to Dept. F.

THE MAGNAVOX COMPANY
Fort Wayne, Indiana

Permanent Employment

ELECTRONIC DEVELOPMENT ENGINEERS

Well-established Eastern Massachusetts concern desires graduate electronic engineers with flair for research and eye to future. Permanent position concerned at present with important development work for government with increased opportunities after the war. Unusual openings for men with capacity and initiative. Must be U. S. Citizens.

P-670, Electronics
330 W. 42nd St., New York 18, N. Y.

WANTED

ENGINEERS—DESIGNERS

ELECTRICAL, MECHANICAL
RADIO, ACOUSTICAL

For Research and Development Laboratory of established company engaged in war work. Activity includes electronic control equipment, continuous recorders, special radio devices, and aircraft accessories. Excellent post-war opportunities. Laboratory located in central Manhattan. All replies strictly confidential. Write full details.

P-651, Electronics
330 W. 42nd St., New York 18, N. Y.

FIELD SERVICE ENGINEERS

For domestic and foreign Service
Also instruction book writers.
Good knowledge of Radio and/or experienced in technical writing.
Essential workers need release.

HAZELTINE
ELECTRONICS CORP.
58-25 Little Neck Parkway
Little Neck, Long Island

RADIO EXECUTIVE

Medium size midwest radio-electronics manufacturer seeks assistant chief engineer capable of wider responsibilities. Salary open. All queries confidential. Write

P-698, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

WANTED

ENGINEERS

ELECTRICAL
MECHANICAL
ELECTRONIC

There is an excellent opportunity for several men in our comparatively small organization located in the Midwest. Our plant is now devoted entirely to war work, but we have extensive post-war plans and large resources.

Our staff knows of this advertisement, so have no hesitancy in writing. Give complete information of education, experience, age, salary desired, and telephone number.

P 684 Electronics
520 North Michigan Ave., Chicago 11, Ill.

WANTED

SALES MANAGER

Long established mid-western manufacturer of electrical equipment—electro-magnetic relays — solenoids—switches—selling principally to manufacturers in the following industries:

Automotive
Farm Equipment
Radio
Aircraft
Industrial Controls

Man selected for this position must have sufficient engineering knowledge of our products and their uses to be able to discuss them intelligently with engineers; to visualize potential markets, to suggest new products, and developments.

Write, giving complete resumé of past experience, salary desired etc. to

SW-693, Electronics, 520 North Michigan Ave., Chicago 11, Ill.

SYLVANIA ELECTRIC PRODUCTS, INC.

has openings for

ELECTRICAL ENGINEERS
MECHANICAL ENGINEERS
MACHINE DESIGNERS
RADIO TECHNICIANS

to work on the design, development and production of radio tubes, fluorescent lamps, electronic equipment and devices.

We want men who have the "know how" of getting things done under pressure, and who would like to become associated with a company whose post-war future is indeed encouraging.

Reply giving age, education, and experience to our

INDUSTRIAL RELATIONS DEPARTMENT
500 Fifth Avenue New York (18) N. Y.

WANTED

DEVELOPMENT ENGINEERS

Mechanical and electrical. Graduate or equivalent training. Required for development work in the following branches:

1. Electro-mechanical devices, communication systems. Must be interested in development and familiar with magnetic circuits.
2. Measuring and control instruments. Background should be in electrical engineering, including electronics.

Statement of Availability Required.

P-682, Electronics
330 West 42nd St., New York 18, N. Y.

ENGINEERS DRAFTSMEN

POST WAR OPPORTUNITY

Progressive New York Electronic Manufacturing Company is now seeking additional personnel. Require two (2) transmitter, five (5) receiver and two (2) special equipment engineers, as well as four (4) draftsmen and two (2) laboratory technicians.

This is not a "Duration" program. Personnel of proven capabilities assured a post war position, comparable current status. Transportation will be paid to New York. Salaries commensurate with experience and ability and current earnings. All negotiations confidential. Address replies to

ELECTRONICS, SUITE 411
280 BROADWAY NEW YORK, N. Y.

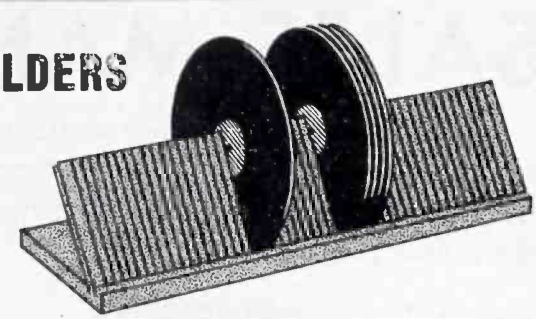
WANTED

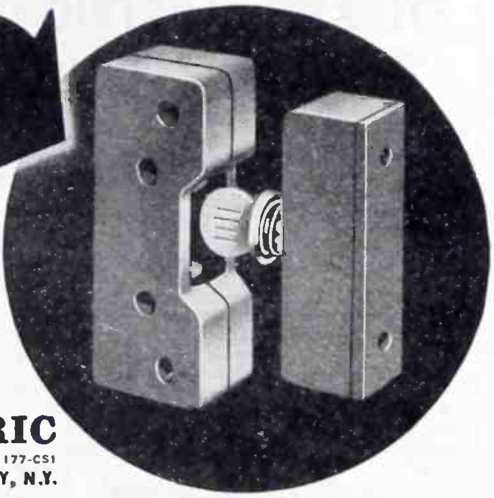
PHYSICISTS and ELECTRICAL ENGINEERS

Needed in connection with the manufacture of a wide variety of new and advanced types of communications equipment and special electronic products. Openings for Electrical Engineers available in St. Paul, Minn., Eau Claire, Wisc., and Chicago. Apply or write, giving full qualifications and furnish snapshot.

D.L.R.—Employment Dept.

WESTERN ELECTRIC COMPANY
Hawthorne Station Chicago 23, Ill.





making nitrogen for ammonia, alumimum, magnesium, stainless steel, lead-bearing steel, the Lindeweld process of gas welding, recent types of electric welding, electromagnetic crack detection, radiographic examination of metals, induction hardening and controlled-atmosphere heat treating, the Dewey process for forming metal tubing and electroforming.

The photoelectric cell and some recent uses, fluorescence and fluorescent lighting, infrared baking of finishes, electric feeler control, automatic interlocking control for moving bridges and automatic control of processing operations are included under electrical engineering.

Many types of military aircraft and their features and equipment are described in the aircraft chapter, but all of the models have now been superseded. No mention is made of the de Havilland Mosquito, a 110-percent British developed and manufactured plane. Only two pages are devoted to physics, covering the electron microscope, ultrahigh-speed X-ray photography and the chloral hydrate treatment for restoring burned documents. Radar is given two paragraphs at the end of the aircraft discussion.—K.S.P.

• • •

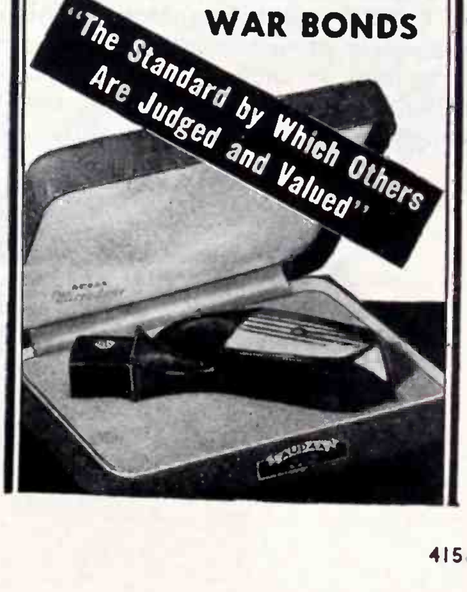
How to Pass Radio License Examinations

By Charles E. Drew, *John Wiley & Sons, Inc., New York, Second Edition, 1944, 320 pages, price $3.00.*

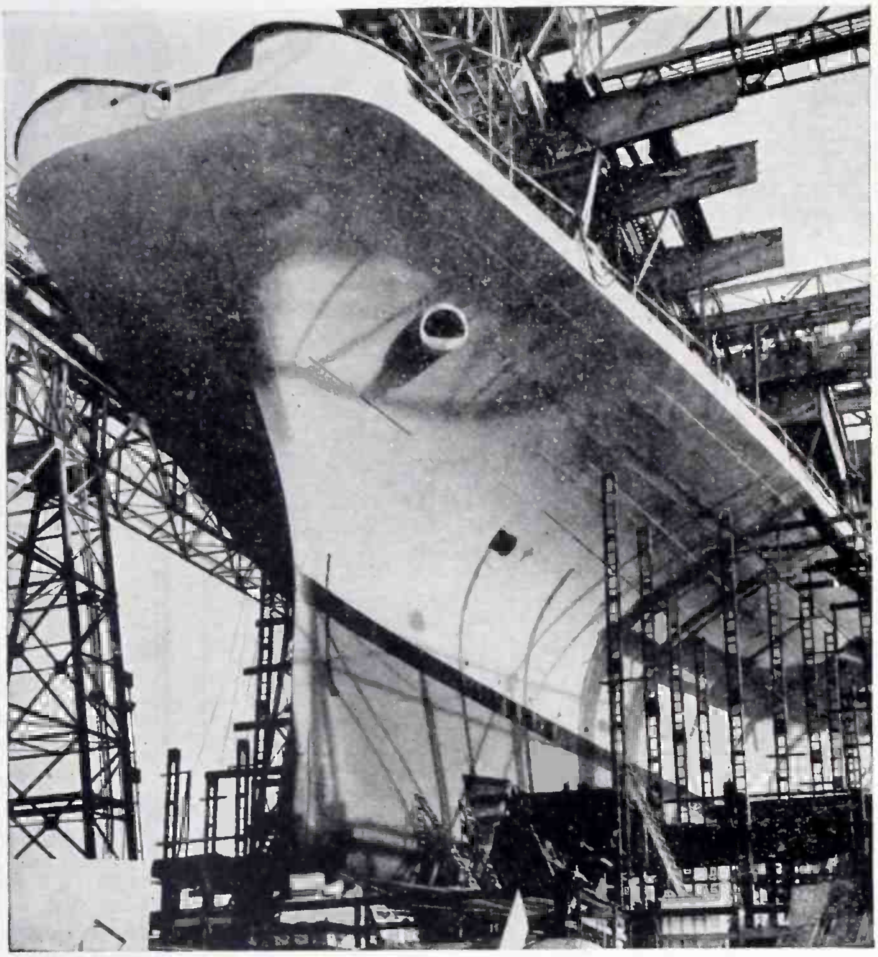
A revised version of the collection of answers to some 1300 questions in the FCC Study Guide. Discussion material has been added in small type after some answers to clarify reasons for answers. New material includes data on operation of circuits to provide maximum frequency stability in transmitters and extra data on modulation, oscillators, classes of amplifiers and rectifier power supplies. The six chapters of the book correspond to the six elements in FCC examinations: Basic radio laws; basic theory and practice; radiotelephone; advanced radiotelephone; radiotelegraphy; advanced radiotelegraphy. The new edition, like its predecessors, provides a valuable and efficient means of refreshing theorectical knowledge in preparation for the examinations.—J.M.

INDEX TO ADVERTISERS

(Continued)



"The Standard by Which Others Are Judged and Valued"
AUDAX



Today warships are structurally stronger because of Geon, the *new* electrical insulation material

THE bulkheads of a modern fighting ship are honeycombed with holes to permit passage of the miles of electrical wire and cable needed to control it. Each hole is a weakening factor in the ship's construction; the larger the hole, the greater the weakening effect. Those thousands of holes are smaller now — enough smaller in their overall effect to have actually *increased the structural strength of the ship,* according to a letter from the office of the Secretary of the Navy now in our files.

That's because of the unusual electrical properties of GEON insulation material. This new flexible thermoplastic permits materially thinner insulation coatings, and so makes possible smaller diameter holes. GEON is flame resistant, too, and so eliminates the danger of quick-spreading fires like the ones that resulted when rubber insulation acted like a flaming fuse once it caught on fire.

Various compounds of GEON Plastics are used as jacketing for power cables; insulation for flexible, power and communications cables; jacketing for portable and flexible wire. Other compounds can be made which will combine many of the following characteristics in a wide variety of combinations: resistance to acids, alkalies, almost all other chemicals; resistance to heat, cold, light, aging, abrasion; easy to process, light weight, can be easily colored for quick identification; and many others.

Right now GEON is available to industrial users subject to allocation under General Preference Order M-10. However, limited quantities can be had for experiment — and our research staff and laboratory facilities are available to help you work out any special problems or applications. For more complete information, write Department F-3, Chemical Division, The B. F. Goodrich Company, Rose Building, E. Ninth and Prospect, Cleveland 15, Ohio.

Geon
Vinyl Resins & Plastics

CHEMICAL DIVISION
THE B. F. GOODRICH COMPANY
ROSE BUILDING E. NINTH & PROSPECT CLEVELAND 15, OHIO

FIXED ATTENUATORS ENGINEERED by DAVEN

DAVEN Fixed Attenuators are available in any desired impedances, and any loss from minimum for the selected impedances upward. Extensively used in major broadcasting and motion picture sound studios, and for laboratory standards of attenuation, DAVEN Fixed Attenuators are backed by years of experience and skill. Our engineers will gladly cooperate on special problems.

RECTANGULAR:	TYPE 153 . . . 3⅜" high x 1½" long x 1⅝" wide (overall), height of standard key-lever switch. TYPE 154 . . . 1¾" high x 1½" long x 1⅝" wide (overall), approx. half height of key-lever switch.
CYLINDRICAL:	TYPE 950 . . . 11/16" diameter x 1⅝" long, for use in small space; mounts with No. 6 screw through center hole. TYPE 1030 . . . 1⅜" diameter x ⅞" long, type for tapped fixed attenuators; mounts with No. 6 screw through center hole.
PLUG-IN:	TYPE 691 (octal tube base) . . . 1⅜" diameter x 3" long; provides convenience in interchanging fixed value networks.
CIRCUITS:	"T" or Bal. "H", and where required, "L", "U", "O", "π".

DAVEN Fixed Attenuators are precision-built of accurately adjusted, card-type resistors, non-inductively wound on bakelite strips. Standard accuracy ± 2% (type 691, ± 1%), closer tolerances available on request. Properly aged to retain accurate characteristics. Mounted in metal shielding. Wattage, maximum dissipation 1 watt (type 950, 0.6w), special units to 20 watt.

DAVEN *SPECIAL FIXED ATTENUATORS:* Multiple output networks (size of type 153)
Medium wattage networks (up to 20w, type 153) Tapped fixed networks (type 1030)

YOU CAN HELP SPEED V-DAY BY BUYING WAR BONDS

THE DAVEN COMPANY
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

All MINIATURES All ON THE ARMY-NAVY PREFERRED LIST AND All DEVELOPED BY RCA!

The 17 RCA Miniatures shown on this page—all of them on today's Army-Navy Preferred List of Vacuum Tubes—are:

1A3—H-F diode
1L4—R-F amplifier pentode
1R5—pentagrid converter
1S5—diode-pentode
1T4—R-F amplifier pentode
3A4—power amplifier pentode
3A5—H-F twin triode
3S4—power amplifier pentode
6AG5—R-F amplifier pentode
6AL5—twin diode
6AQ6—Duplex-diode High-Mu triode
6C4—H-F power triode
6J4—U-H-F amplifier triode
6J6—twin triode
9001—Sharp cut-off U-H-F pentode
9002—U-H-F triode
9003—Super-control U-H-F pentode

TINY tubes like these—*every single one of them developed by RCA*—were destined for the spotlight—thanks to your recognition of their possibilities.

The spotlight picked them up first in June, 1940, when the "Personal Radio" was announced—the history-making portable designed around RCA's staunch little quartet, Miniatures 1R5, 1S4, 1S5, and 1T4.

War found Miniatures instantly available for overseas service—for example, in such equipment as the paratrooper's air-borne "Handie-Talkie."

Once Victory is won, it will be our privilege to work with you designers so that, together, we may play our continuing parts in miniature tube type development and use for peace-time purposes. We look forward to that day. And we will gladly advise you now which tubes—Miniatures, and others—will most likely be on RCA's post-war list of "Preferred Tube Types," if you will write to RCA Commercial Engineering Section, 720 South 5th St., Harrison, N. J.

The Magic Brain of all electronic equipment is a Tube and the fountain-head of modern Tube development is RCA.

BUY
WAR
BONDS

RCA

RADIO CORPORATION OF AMERICA
RCA VICTOR DIVISION • CAMDEN, N. J.