JANUARY • 1944

electronics

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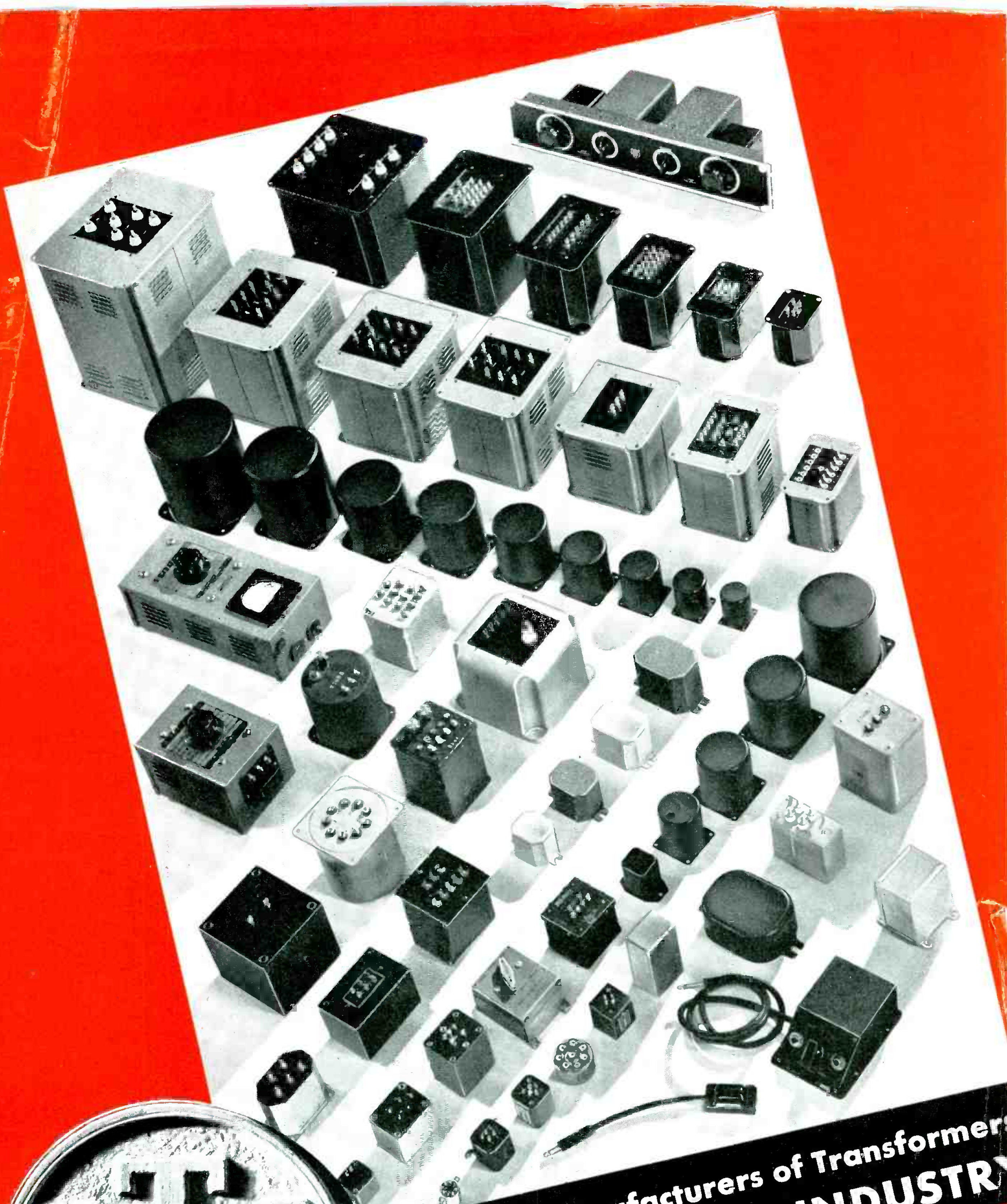

electronics

JANUARY • 1944

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To ....

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Signed ....

Day in and day out

LONG, UNINTERRUPTED SERVICE is the characteristic you want most in a capacitor. And that's the reputation of Tobe Capacitors, earned through an almost complete absence of "returns"! • Lasting stamina is built into Tobe Capacitors through every careful step in their manufacture... checked and cross-checked by frequent, rigid inspections. For your further assurance of complete satisfaction, every Tobe Capacitor is rated ultra-conservatively. • The Tobe Oil-Mite Capacitor shown below is oil-impregnated and oil-filled. It meets Army and Navy immersion tests. • The ingenuity of Tobe engineers is at your ready disposal in all capacitor problems. Inquiries will receive prompt attention.

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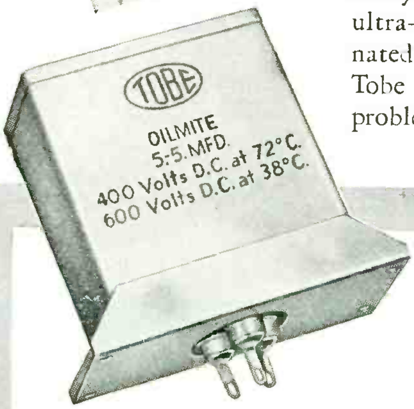

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SPECIFICATIONS—TYPE RAL 300 CAPACITOR

SHUNT RESISTANCE
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WORKING VOLTAGE
400 Volts D. C. at 72° C.
600 Volts D. C. at 38° C.

INSULATING RESISTANCE—
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DIMENSIONS . . . 2" x 3⅜" x 3¾"

Meets Army and Navy Immersion Tests
Oil Impregnated—Oil Filled

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

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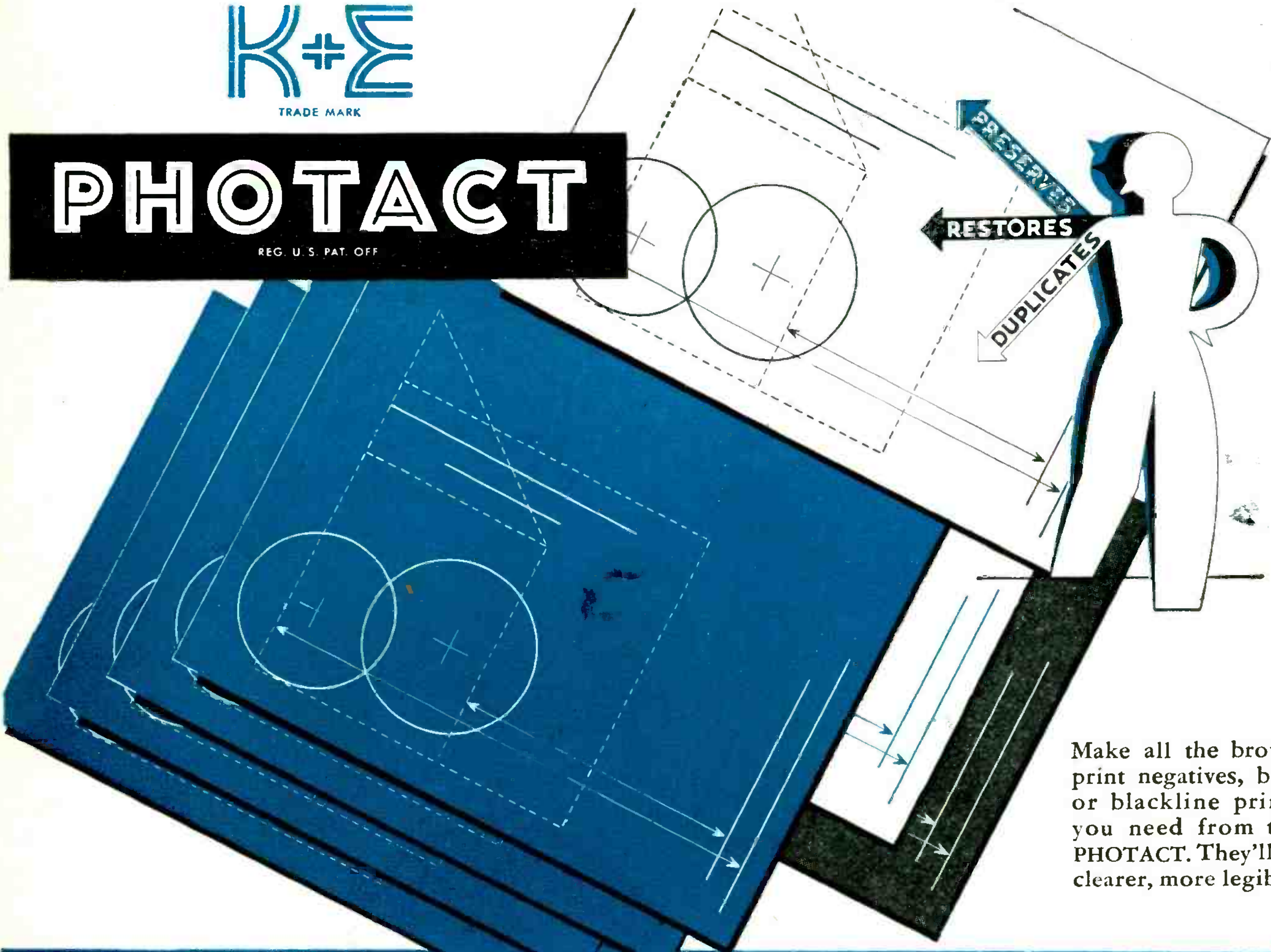

Make all the brown print negatives, blue or blackline prints you need from the PHOTACT. They'll be clearer, more legible.

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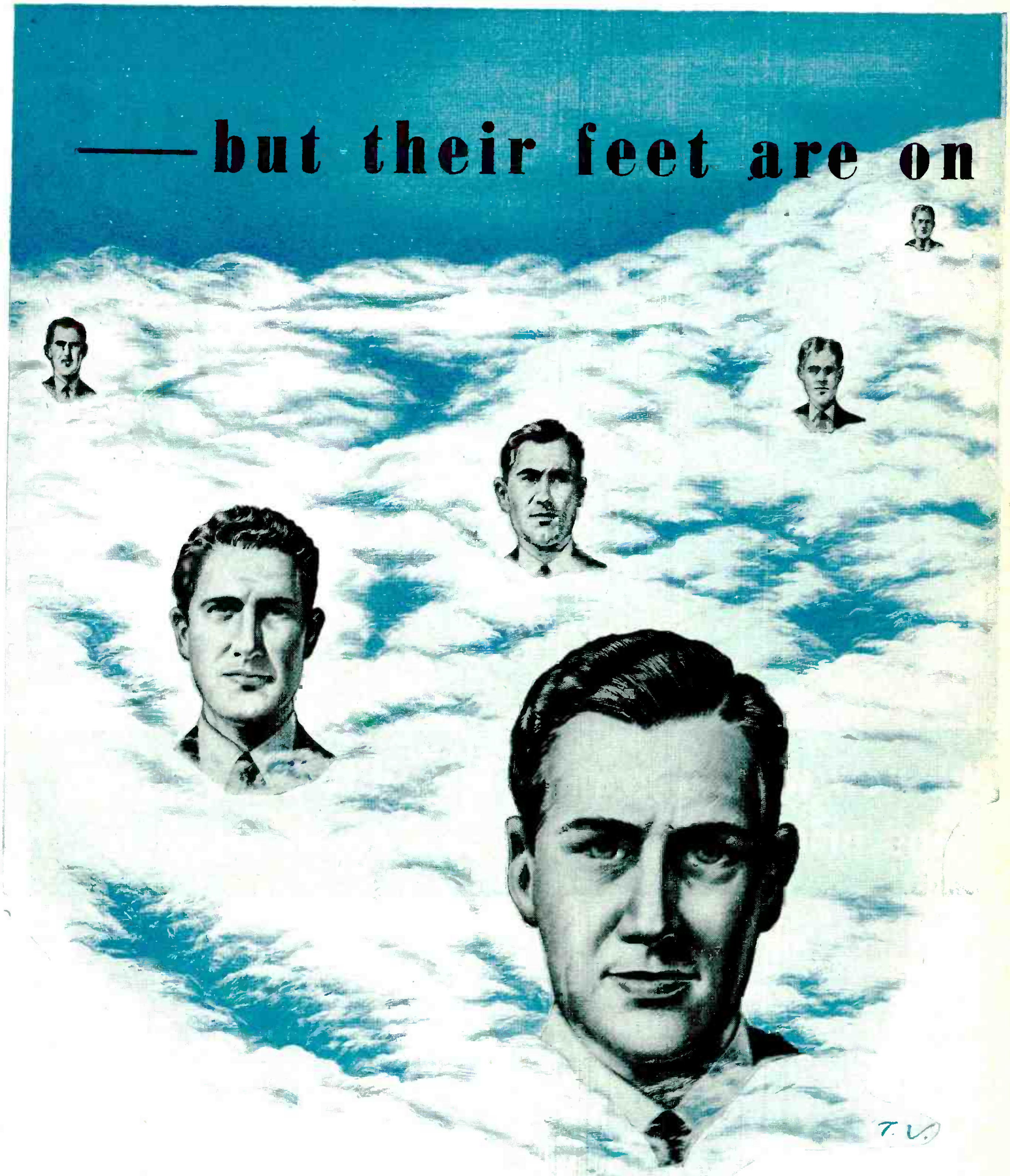


Westinghouse

Electronic Tubes *AT WORK*

the ground . . .

TODAY there's scarcely a problem that doesn't have its electronic answer.

Electronics sees all, hears all, knows all!

From trapping microscopic dust particles . . . to welding giant girders . . . or sewing together metal skins that surface airplanes . . . electronic tubes perform a multiplicity of special tasks and daily duties that stagger even present day imaginations.

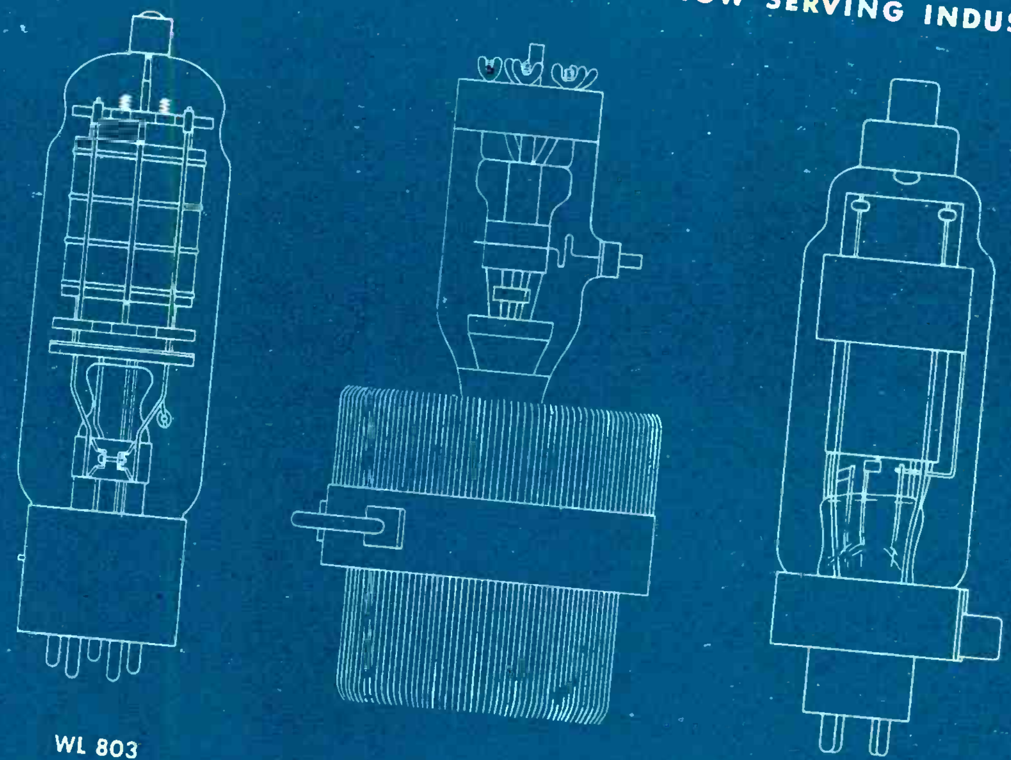
In this field of modern magic Westinghouse has an outstanding record.

On a thousand fronts, military and industrial, Westinghouse Electronic Tubes are doing a thousand jobs. Soundly designed and engineered they are all true products of Westinghouse "know-how"!

Include electronics in your post-war planning . . . but before you carry your plans too far, make sure they are practical *electronically*. Take advantage of the technical assistance Westinghouse has to offer.

Westinghouse engineers have their heads in the clouds but their feet, you'll find, are on the ground. Westinghouse Electric and Manufacturing Co., Bloomfield, N. J. *Plants in 25 cities . . . offices everywhere.*

A FEW OF THE WESTINGHOUSE TUBES NOW SERVING INDUSTRY



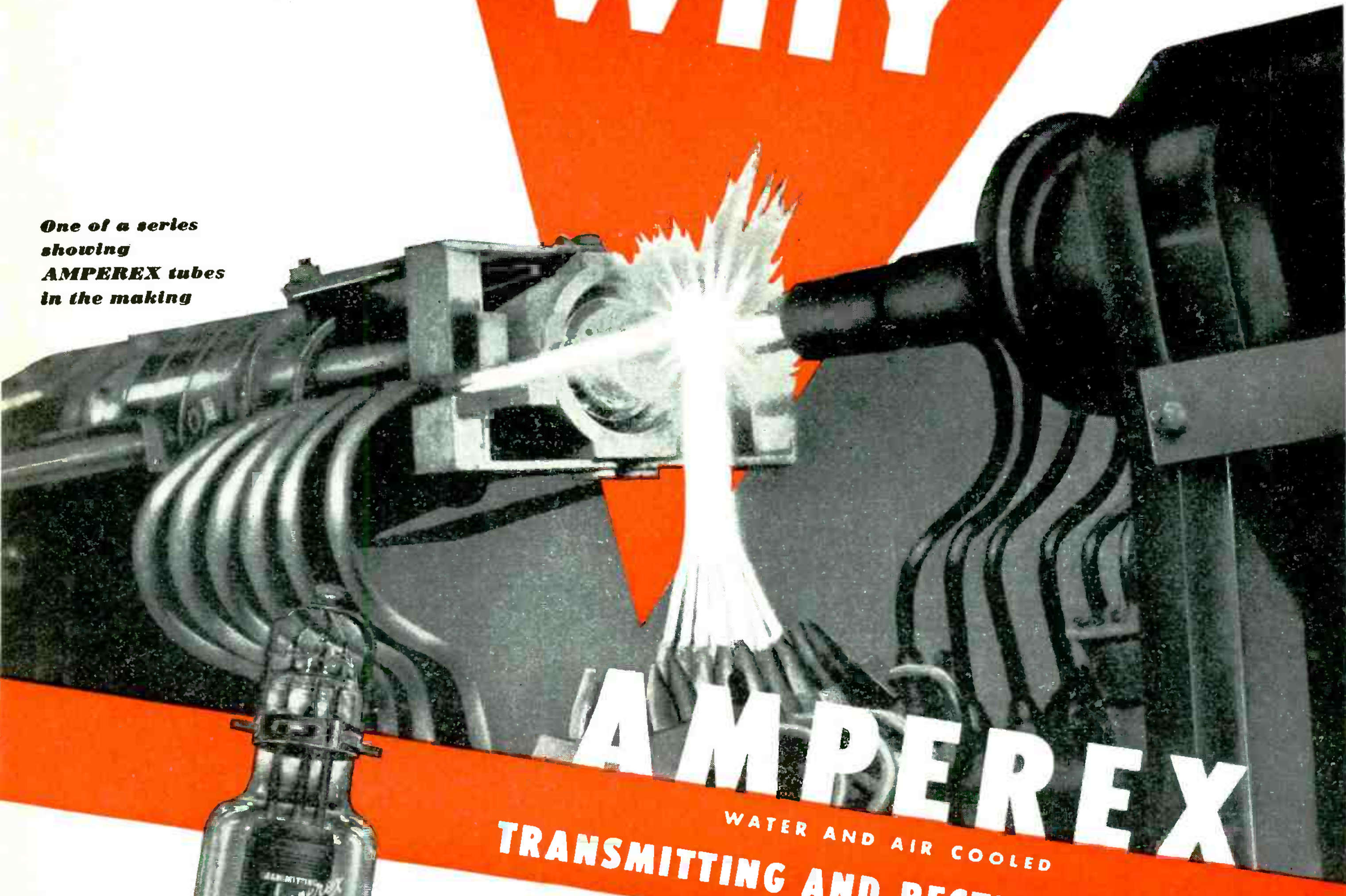
WL 803
Pentode RF Power Amplifier and Oscillator. Used in aircraft and ground communication service. Ask for Bulletin SP-150.

WL 895
Class "C" Oscillator used for broadcasting, tin re-flow and other induction heating applications. Ask for Bulletin SP-195.

WL 632A
Thyratron. Used in circuits requiring high speed, sensitive relays and controlled rectifiers. Ask for Bulletin SP-128.

WHY

One of a series showing AMPEREX tubes in the making



AMPEREX

WATER AND AIR COOLED

TRANSMITTING AND RECTIFYING TUBES

AMPEREX ... the high performance tube

Amperex "key" men have been associated with the vacuum tube art ever since its inception. Working against a background unique in the field, our engineers and production people are given free rein to conduct independent research and experimentation. Unhampered by mass production limitations, their high standards have resulted in advanced designs, greater efficiency, lower cost and longer life. Such "Amperextras" have carried our tubes to a commanding position in communications, ultra high frequency transmission, electro medical apparatus, high voltage rectification and many industrial applications.

START THE NEW YEAR WITH EXTRA PURCHASES OF WAR BONDS

ARMY E NAVY

AMPEREX ELECTRONIC PRODUCTS

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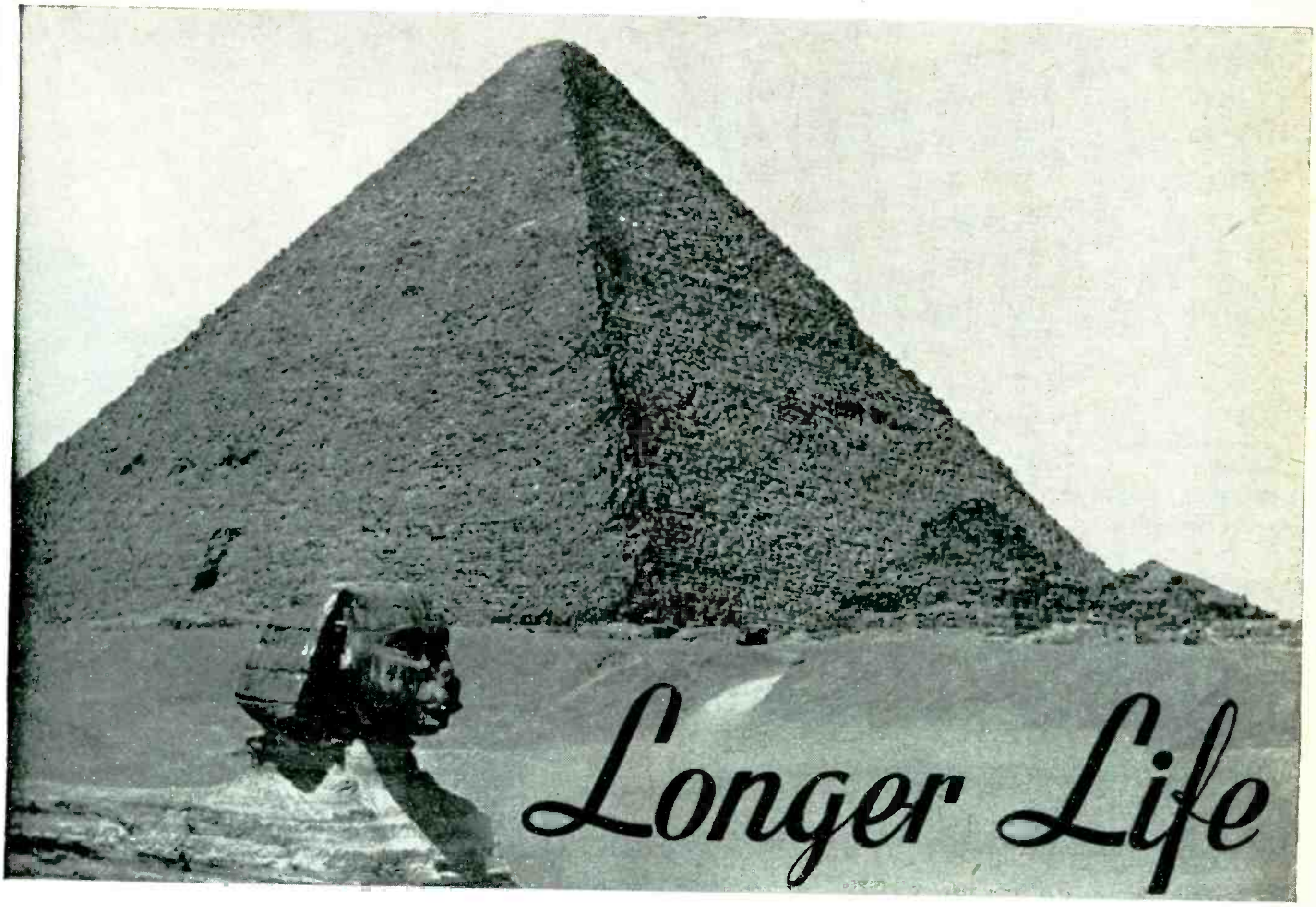

Pat. Pending

- ★ *Oil Impregnated - Oil Filled*
- ★ *Oil Sealed*
- ★ *Ceramic or Bakelite Tubes*
- ★ *Bakelite Cement Ends (Oil Proof)*
- ★ *Suitable for Operation 75° to 100° C*
- ★ *Ideal for Extreme High Altitude Duty*
- ★ *No Danger of "Flash Over"*
- ★ *No Metal for "Body Capacity"*
- ★ **No Internal Corrosion**

DUE TO ITS CONSTRUCTION

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

DUMONT

ELECTRIC CO.

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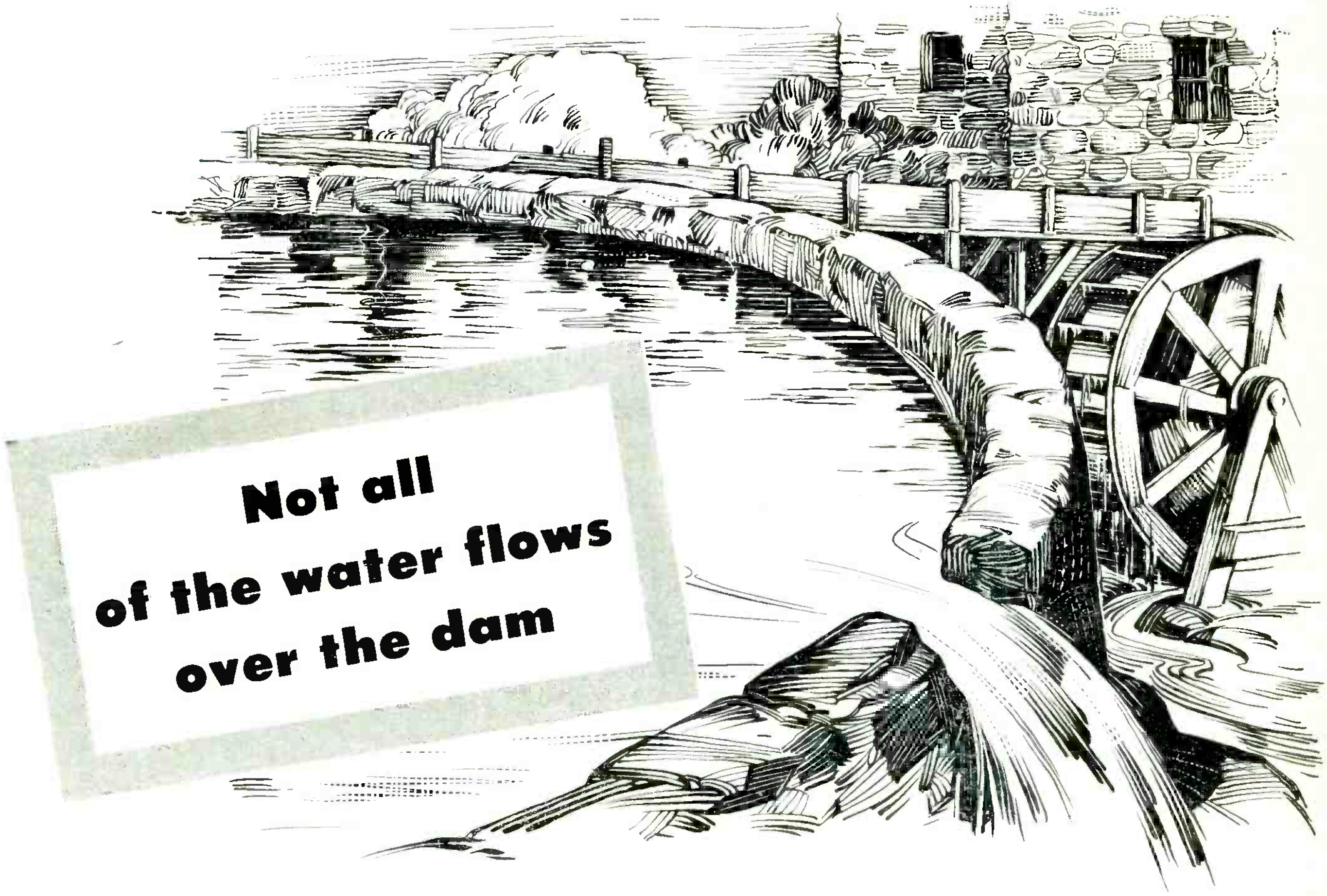
CAPACITORS FOR EVERY REQUIREMENT
34 HUBERT STREET NEW YORK, N. Y.

BUY BONDS NOW

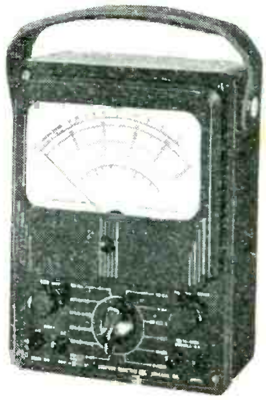


BEFORE it becomes just "water over the dam", every working hour, every problem solved, contributes in some measure to the reservoir of practical knowledge we call experience.

There is a wealth of such experience behind Simpson instruments and testing equipment. Into their making has gone all the knowledge acquired during the more than 30 years which Ray Simpson has devoted to the design and manufacture of electrical instruments—all the experience and know-how of a group of men who have long been associated with him.

The important thing today, of course, is that this enables Simpson to build instruments of proven accuracy and stamina, at a rapid rate. Each one has a full bridge type movement with soft iron pole pieces. For the first time this admittedly finer design has been made a matter of mass production —with all the resulting economies and speed.

When it comes time to apply the many things learned under the impetus of war, remember that true progress has its roots in the past. For the utmost in lasting accuracy, and value, look to Simpson.



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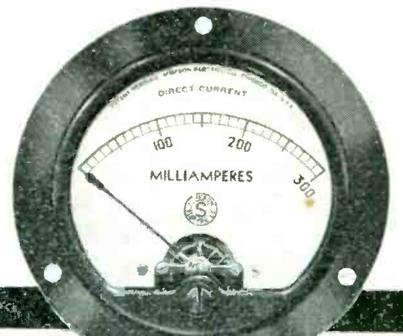
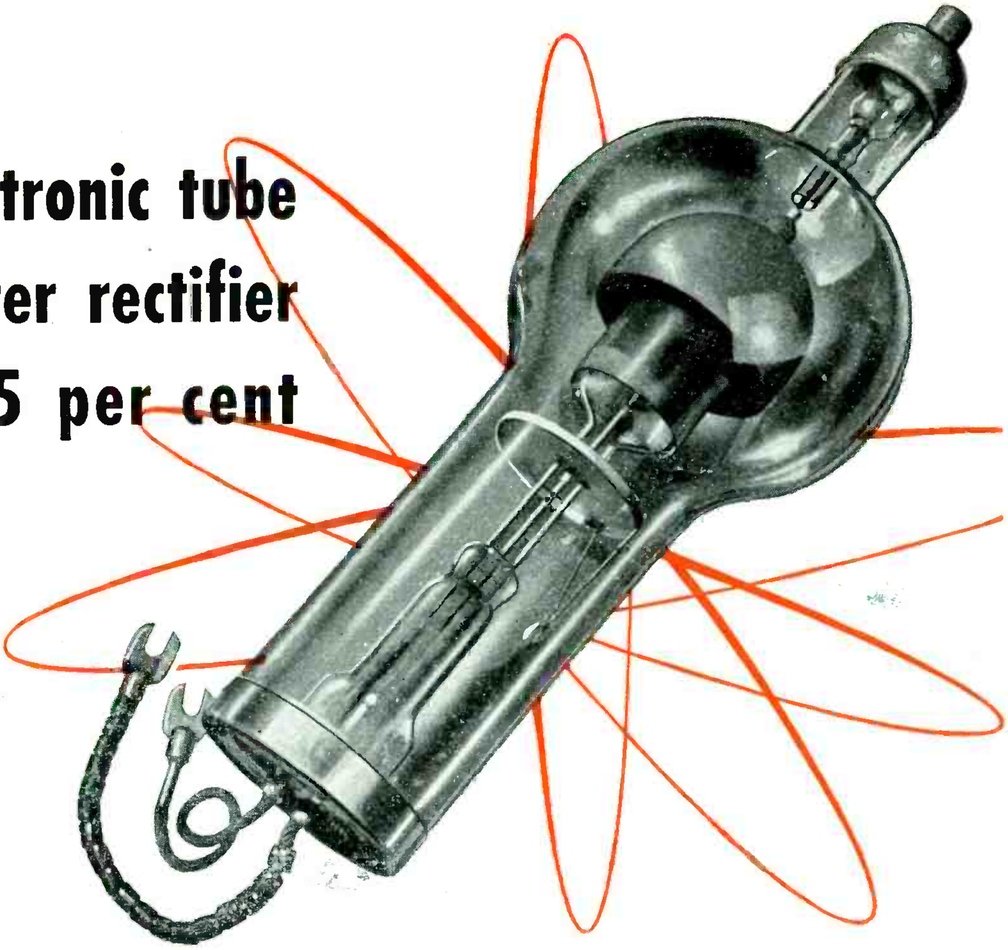


INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory

This G-E electronic tube cut transmitter rectifier losses by 95 per cent



another G·E electronic FIRST!

TODAY'S complete line of G-E transmitting and industrial tubes includes many basic electronic "firsts."

For example, G. E. developed the hot-cathode mercury-vapor rectifier tube, the tube which has cut rectifier losses to a twentieth of what they were with high-vacuum rectifiers and reduced over-all transmitter power costs by 15 per cent. Moreover, the mercury-vapor rectifier has a lower first cost and longer life than the high-vacuum rectifiers that it has replaced. And by making it possible to use less expensive transformers and filters, over-all transmitter costs have been appreciably reduced.

ALL G-E transmitting tubes are designed and built to provide the greatest efficiency, longest service, and maximum operating economy possible.

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

FREE BOOK—"How Electronic Tubes Work." Address Electronics Department, General Electric, Schenectady, N. Y.

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

G-E TUBES ARE "FIRST" IN INDUSTRY, TOO!

Many modern methods of manufacture could not have been achieved if G-E electronic tubes had not been developed to do the job. The G-E steel-clad ignitron and the G-E thyratron, for instance, made today's high-speed welding of aluminum and stainless steel both possible and practical.

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

GENERAL ELECTRIC

161-C1-8850

G-E Antennas . . .

→ **G-E TELEVISION RELAY ANTENNA.** This relay type of television antenna, developed exclusively by G.E., is in use at General Electric's television "workshop" station WRGB at Schenectady. It has had a remarkable record of performance and reliability since its installation.

This antenna is completely enclosed and contains four horizontal bays. It is highly directional and is especially designed to permit the wide band operation which is so necessary to successful television transmitting. This G-E antenna is so efficient that no relay link should be built without it!

↑ **G-E FM CIRCULAR ANTENNA.** Measurements to date on this horizontally polarized circular antenna show such decisive electrical and mechanical advantages that it has clearly outmoded the conventional types.

Simple, rugged, compact, and pleasing in appearance, the design of this antenna makes it easy to mount on a pole of any diameter. It is grounded to the pole for lightning protection . . . easily adapted for sleet-melting . . . *and easy to tune.* Its wide frequency range and its lower coupling between bays are two of its strongest features. The latter permits optimum power gain per bay, compared to existing designs as evidenced by these figures:

	One-bay	Two-bay	Four-bay
POWER GAIN	.602	1.66	3.47

G-E FM circular antennas are being operated with surpassing success in six of the nation's important stations.

TO RULE THE WAVES

G-E VERTICAL RADIATOR FOR AM. The WGY antenna illustrated is a 625-foot, all-steel, uniform cross-section tower. It is of the most modern and rugged type. Its installation improved the coverage . . . reduced fading . . . and provided generally more reliable performance for General Electric's Station WGY.

G-E S-T FM RELAY ANTENNA. A multiple-dipole antenna easily mounted on a single pole. Its housings (appearing as dipole tubes in the photograph) are completely sealed and pressurized to keep out moisture. One bank of enclosed dipoles is the antenna while the other acts as a reflector, and permits extremely sharp-focus directional beaming in a powerful, narrow, horizontal pattern. This gives a power gain of 10 at the studio transmitter and, if also used at the receiver, it provides an additional and second power gain of ten.

# of AM, FM, and TELEVISION

AMONG the important recent G-E contributions to broadcasting, broadcast and relay antennas are especially outstanding. Illustrated are four types of G-E antennas, for four distinct uses. All four are proving their high efficiency in present broadcast use . . . all four are unique in their performance . . . all four are rugged in construction and easy to install. G-E can supply all these types of antenna with the station equipment.

The operating characteristics of these antennas enable the broadcaster to put out *more radio frequency power*, and to radiate that increased power with more *effective coverage*. G-E antennas, properly co-ordinated with their transmitters, give greatly improved performance . . . profitably . . . by more efficient and economical distribution or radiation over broader areas.

G-E electronic engineers can provide the antenna best suited to your needs whether AM, FM or TELEVISION, or, indeed, can help you equip your station with any equipment you may need from microphone to antenna.

A PLAN THAT WILL SECURE YOUR PLACE IN RADIO BROADCASTING POST-WAR

General Electric offers you "The G-E Equipment Reservation Plan". . . a plan designed to enable you to complete your post-war plans *now*. It will enable you to establish a post-war priority on a broadcast transmitter and associated equipment. It will enable us to plan definitely for large-scale post-war production, thereby giving you the fastest possible post-war delivery and the savings of planned production. Investigate this plan today and assure your place in radio broadcasting post-war. *Electronics Department, General Electric, Schenectady, New York.*

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

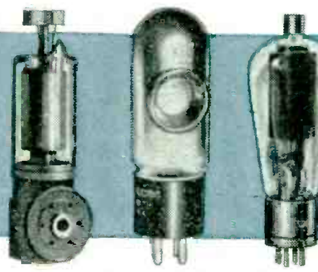
BACK THE ATTACK — BUY WAR BONDS!

Complete Station Equipment • Studio Equipment • Transmitters • Antennas • Electronic Tubes • Receivers

GENERAL ELECTRIC 160-C2 **FM • TELEVISION • AM**

See G.E. for all three!

No. 9 IN A SERIES EXPLAINING THE USES OF ELECTRONIC TUBES IN INDUSTRY



A G-E X-ray tube (1), a G-E phototube (2), a G-E thyratron tube (3), and several G-E amplifier tubes are the "eyes and brains" of this ingenious machine.

To safeguard our fighting men, hand grenades must be flawless—*every* fuse must be timed to split-second accuracy.

From the engineering laboratory of General Electric has come an automatic X-ray inspector—the first of its kind—which checks time fuses at the incredible rate of 4000 an hour . . . with the unerring accuracy no other inspection method can even approach.

A movable belt carries the fuses through the penetrating beam of a 100,000-volt G-E X-ray tube which casts its glow on a fluorescent screen. A G-E phototube, or "electric eye," inspects the glow. If constant, verdict is "O.K." If intensity changes, powder charge is inadequate for proper timing. Instantaneously, a four-way alarm is given . . . a bell rings; a red light flashes; the imperfect fuse gets a dab of red paint; a photo-electric meter chart records the "dud."

It is the purpose of G-E electronic tube engineers to aid any *manufacturer* of electronic devices in the application of tubes. Through its nation-wide distribution system, G. E. is also prepared to supply *users* of electronic devices with replacement tubes.

FREE BOOKLET ON ELECTRONIC TUBES

Send us the names of interested men in your plant. We will mail them, without charge, an illustrated, easily understood book on "How Electronic Tubes Work." Address *Electronics Department, General Electric, Schenectady, N. Y.*

• *Tune in* "The World Today" *and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E* "All Girl Orchestra" *at 10 P.M. E.W.T. over NBC.*

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

GENERAL ELECTRIC

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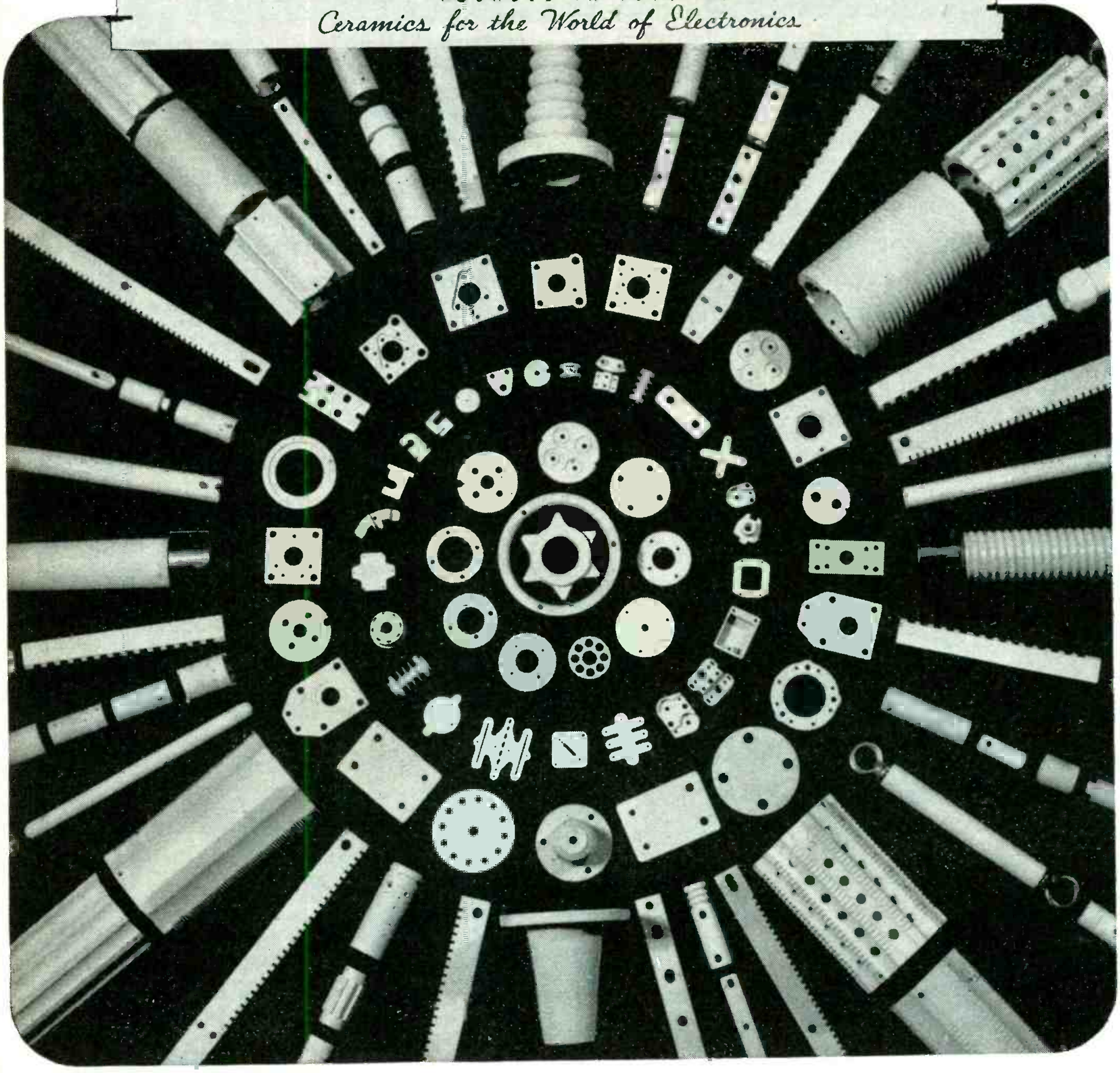
STUPAKOFF

FOUNDED IN 1897

Ceramics for the World of Electronics



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Engineered with the proper material
for your particular application

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- TUBULAR—SINGLE OR MULTIPLE HOLE
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- ELECTRONIC TUBE
- SPREADER
- ENTRANCE
- COIL FORM
- SPECIAL

ARMY E NAVY

"for great achievement"

STUPAKOFF
Ceramic
INSULATORS

Buy War Bonds

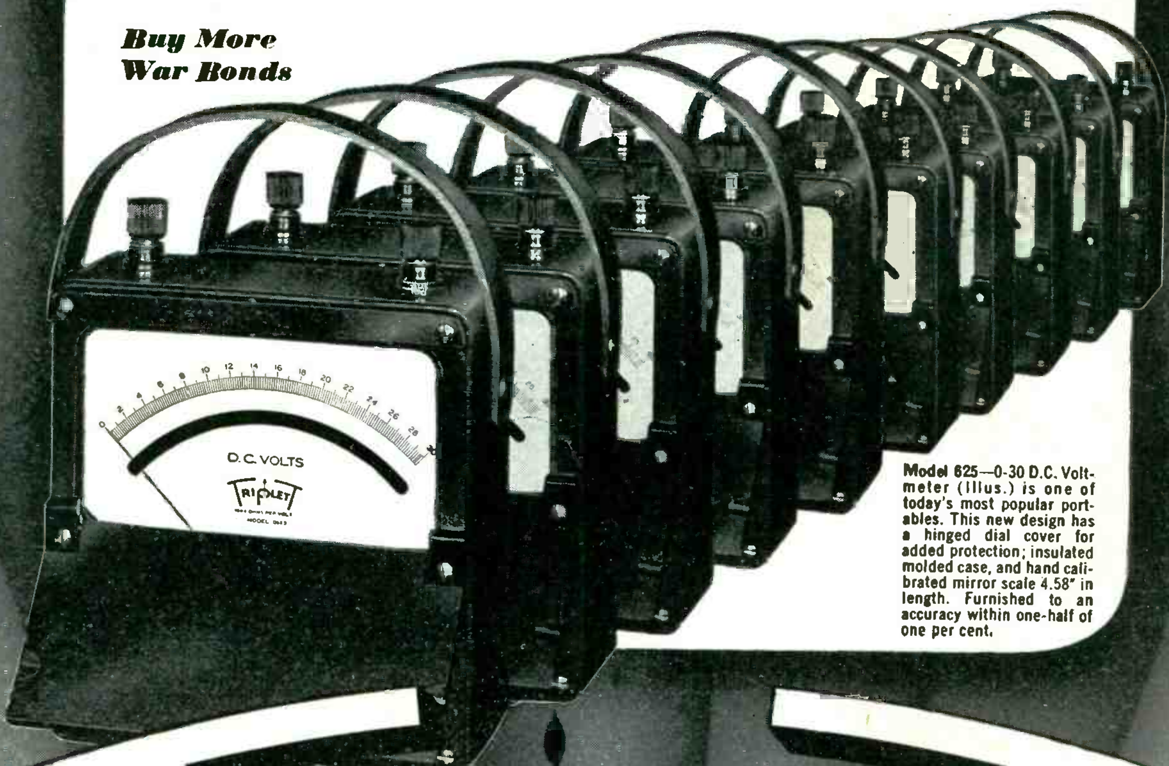
STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Faithfully Yours

The familiar Triplett trademark stands as a pledge of long service for those who require instruments that *faithfully* retain their accuracy over the years. Engineers realize the importance of Triplett contributions in making better instruments. In Triplett laminated magnet construction, for example, exclusive methods give permanency and provide for uniform scale linearity. Scientific heat-treating in automatic furnaces, followed by peening of each lamination, and the use of selected "cut-off" segments insure uniform standard printed scale accuracy. Careful ageing of all magnets follows to provide unchanging permanency of strength.

THE TRIPLETT ELECTRICAL INSTRUMENT CO. • BLUFFTON, OHIO

Buy More War Bonds



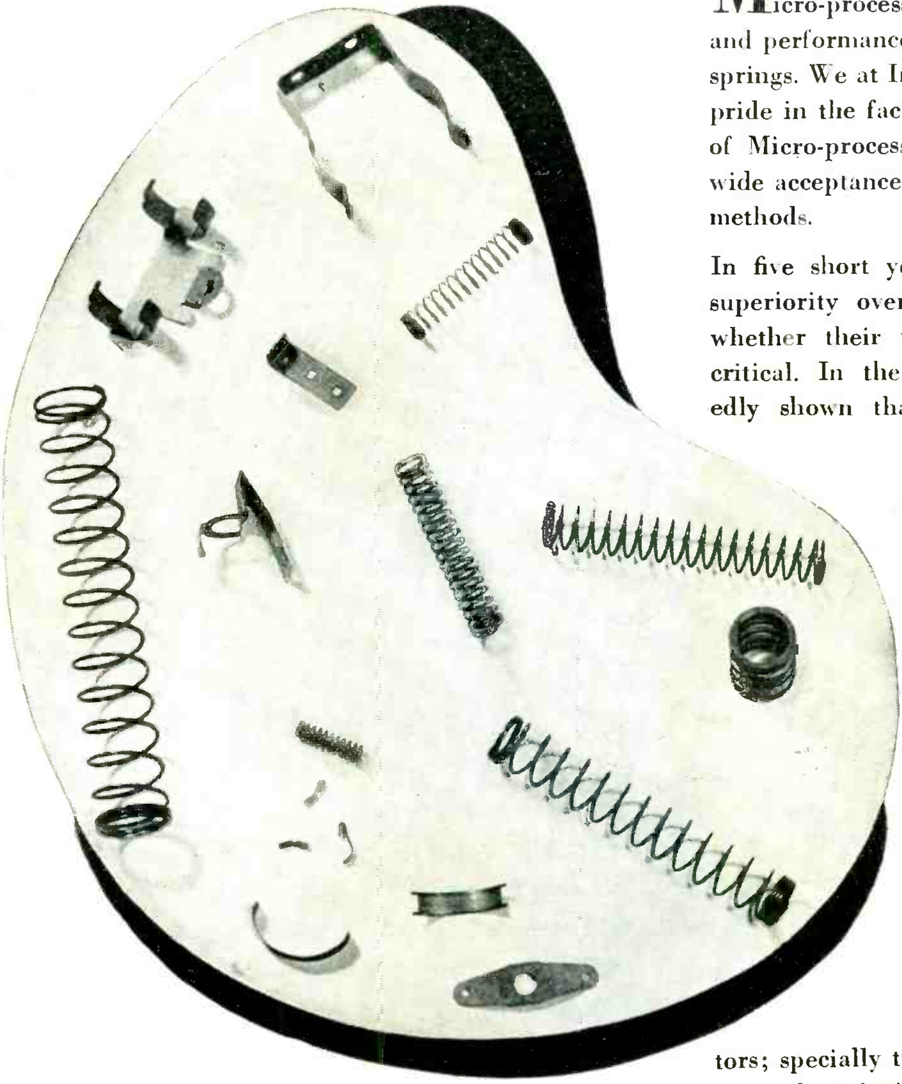
Model 625—0-30 D.C. Voltmeter (Illus.) is one of today's most popular portables. This new design has a hinged dial cover for added protection; insulated molded case, and hand calibrated mirror scale 4.58" in length. Furnished to an accuracy within one-half of one per cent.

TRIPLETT

ELECTRICAL MEASURING INSTRUMENTS
RADIO AND INDUSTRIAL TEST EQUIPMENT

"But he that is greatest among you shall be your servant"

Matt. 23:11



"Micro-processing" sets new standards of design and performance for beryllium copper coil and flat springs. We at Instrument Specialties Company take pride in the fact that the service record of millions of Micro-processed springs has resulted in nation-wide acceptance of our unique precision production methods.

In five short years I-S springs have proved their superiority over *any* beryllium copper springs — whether their ultimate use is average or highly critical. In the same five years we have repeatedly shown that only Micro-processed beryllium copper can achieve certain desired physical and electrical characteristics. Every step in our progress is backed up in fact — on your own springs, designed and Micro-processed to meet your particular need.

How does I-S attain mass production when orders range from 1,000,000 to 10 springs with simple or complex requirements? The answer is plain to see. Special "spring grade" wire, drawn to specifications set up by the I-S production control laboratory; coiling, heat treatment and electronic micrometer inspection is directed by routine control methods based upon known factors; specially trained tool and die makers skillfully apply the principles of Micro-processing to flat spring work; and in addition, Instrument Specialties Company has in the field, resident engineers in major industrial areas who are ready to discuss with you and act upon your spring problems.

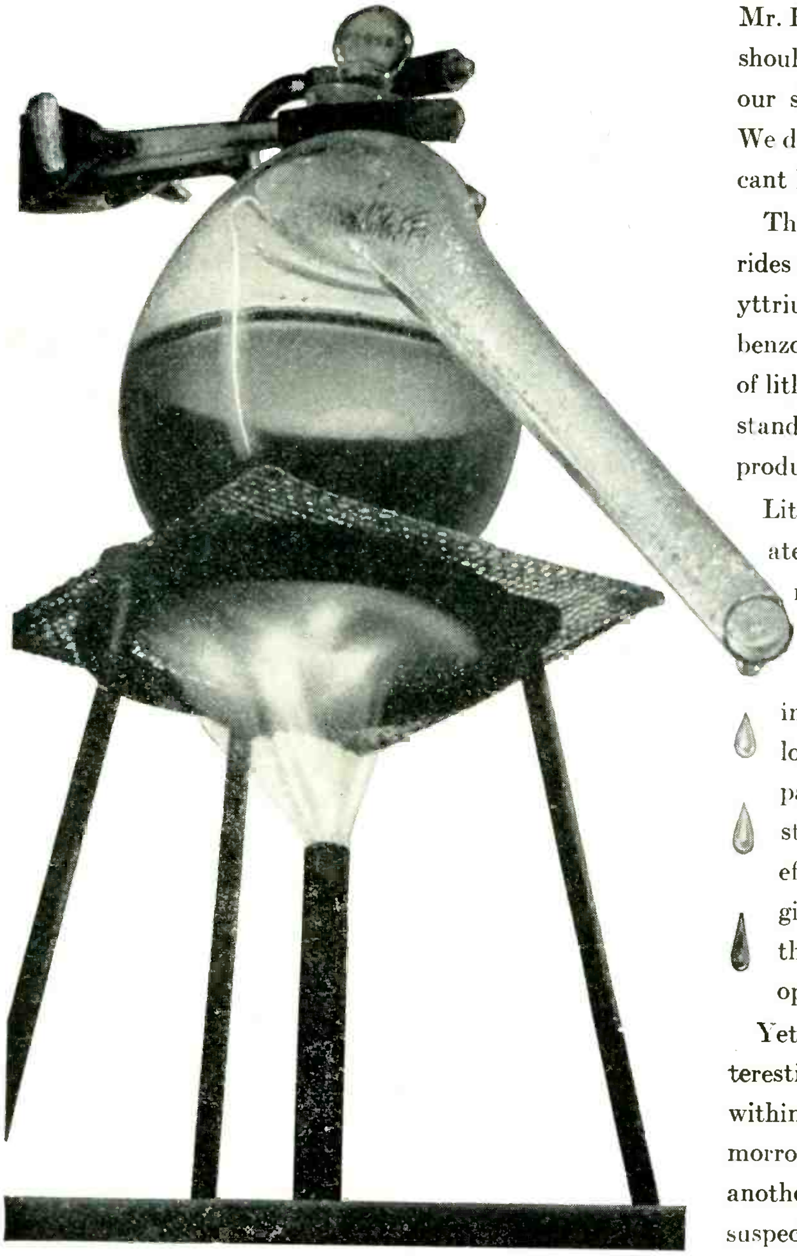
By re-defining the possibilities of spring performance we have opened new avenues for the use of beryllium copper springs — *Micro-processing, more than ever before, is a servant to the nation's industry.*

INSTRUMENT SPECIALTIES CO., INC.

DEPT. D., LITTLE FALLS, NEW JERSEY

FIELD ENGINEERING OFFICES: BOSTON · CHICAGO · CLEVELAND · PHILADELPHIA · NEW YORK

Is this the beginning of a miracle?



Mr. Ernest G. Enck, our technical director, thinks we should put greater emphasis in our advertising on our sizing and beneficiation of ores and minerals. We do, he emphatically reminds us, prepare a significant list of chemicals from these ores and minerals.

There are, for instance, the carbonates and chlorides of lithium and strontium; the nitrates of lithium, yttrium, caesium, thallium and zirconium; and the benzoate, chloride, hydroxide, fluoride, and stearate of lithium . . . to mention only a few. A better understanding of these underemployed chemicals is already producing startling discoveries.

Lithium stearate is a case in point. Lithium stearate or "metal soap", was just what petroleum researchers needed to compound for our fighting planes *one* grease which tames the biting cold of Reykjavik as easily as it does the scorching heat of Tunisia. Will the automobile industry look into the post-war possibilities of this Foote patented product? Probably! Another example is strontium. Strontium salts, now vital to the war effort, are intriguing the interest of ceramic engineers and, after the war, may well influence the making of whiteware, glazes, lustres and optical glasses.

Yet, this is only a beginning. Much of our most interesting exploratory work is still quietly bubbling within the retorts of our laboratory. Today or tomorrow it is just possible we may help you achieve another miracle of chemistry, or to start one. If you suspect we can help you now, please write us.

FOOTE DUCTILE ZIRCONIUM NOW IN PRODUCTION!

Here is real news for every one of you in the radio and electronics industries, news we have been waiting to give you for months. *We are now in production on ductile zirconium.*

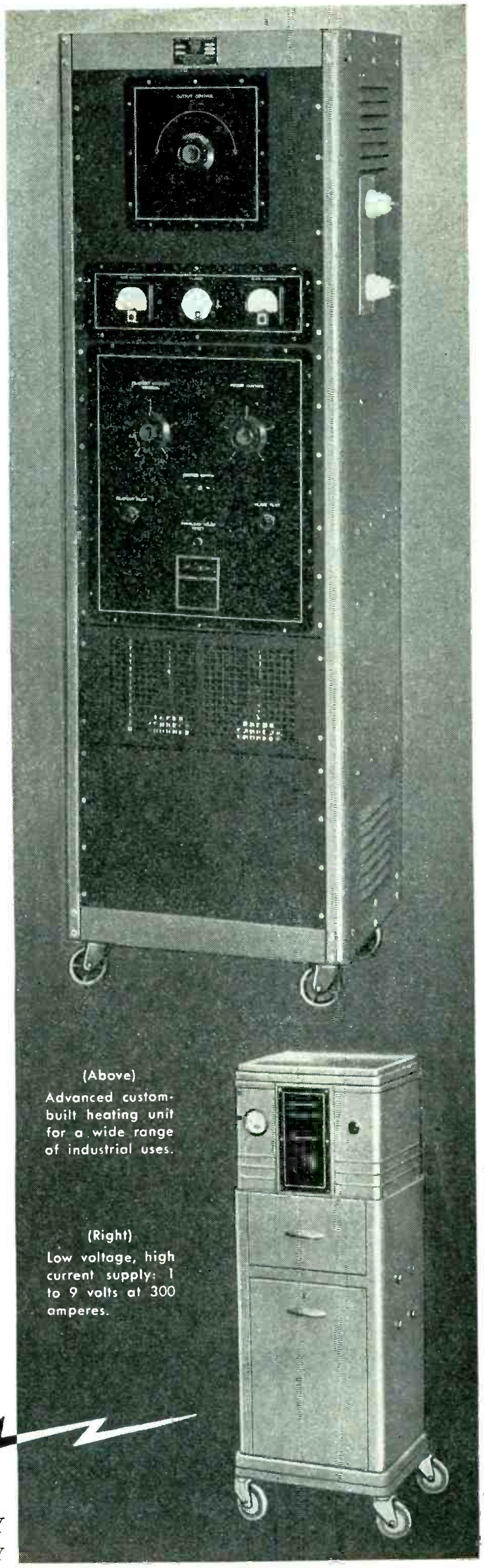
You are, of course, well acquainted with zirconium metal powder and its advantages for vacuum tubes. Ductile zirconium, like the powder, is an active "getter" at elevated temperatures. However, ductile zirconium is doubly useful, since—because of its structural strength—it may be shaped into vacuum tube elements. In fact, the metal may be spot-welded, butt-welded or machined. Experimental quantities are available as wire, sheet, rod, and woven screen. Other special forms can be made on request. Your inquiries are invited.

Foote
MINERAL COMPANY

A Step Ahead in Industrial Ores and Chemicals

PHILADELPHIA • ASBESTOS • EXTON, PENNSYLVANIA
Home Office: 1617 SUMMER STREET, PHILADELPHIA, PA.
West Coast Representative: GRIFFIN CHEMICAL CO., San Francisco, California

Since 1921
Designers and Builders
of
ELECTRO-STATIC
or
ELECTRO-MAGNETIC
High Frequency Units



(Above)
Advanced custom-built heating unit for a wide range of industrial uses.

(Right)
Low voltage, high current supply: 1 to 9 volts at 300 amperes.

For more than two decades, leading manufacturers of electronic, neon, X-Ray and (more recently) fluorescent tubes, have used our apparatus for such operations as degassing, sealing glass to glass or glass to metal (Kovar or copper).

Use of our apparatus always has afforded highly satisfactory results plus economy.

As dielectric and induction heating equipment, our better-built units are showing many points of superiority in metallurgical, plastics, plywood and dehydration applications.

It will pay you to let us supply the unit of proper frequency and power output for your particular needs. Write for further information today.

S. E. D.
LAZCSIKS

Scientific Electric

Division of

"S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE STREET **GARFIELD, NEW JERSEY**

CONTENTS OF MANUAL

The Cathode-Ray Oscillograph: introduction, general description, high-voltage power supply, amplifiers, linear time-base generator, intensity modulation, low-voltage power supply, mechanical considerations, conclusion.

• • •

Oscillograph Design Considerations: power supplies, amplifier design, time-bases or sweep generators.

• • •

DuMont Cathode-Ray Equipment: description, specifications, accessories, oscillograph type comparison list, specialty products.

• • •

DuMont Cathode-Ray Tube: general information, installation notes, type specification sheets, tube type comparison list.

• • •

Sales and Service Information: how to order, patent notice, price list, etc.

• • •

Instrument and Tube Application Notes: frequency and phase determination, photographic measurements, observation of relay rebounce, etc.

Cathode-Ray Tubes

... and how they are applied

For a dozen years past the Allen B. DuMont Laboratories have specialized in the development, production and application of cathode-ray tubes.

DuMont was the first to introduce the *commercialized* cathode-ray tube as a practical tool for research worker, production engineer and technician. Not only have DuMont tubes and oscillographs resulted in savings in time required to investigate the many problems to which they are applicable, but they have also revealed truths in man's laws of the working forces of nature.

And now, as a further service, DuMont engineers have compiled a manual of pertinent data, together with detailed descriptions of DuMont tubes and associated equipment. This data is in loose-leaf form. The binder permits constant revision to keep pace with the fast-moving cathode-ray technique. Each manual bears a serial number so that the name and address of its recipient may be duly registered. Additional pages are mailed from time to time.

• • •

Write on your business stationery for your copy. Our Engineering Department is interested in aiding you with your cathode-ray application problems.

DUMONT *Precision Electronics & Television*

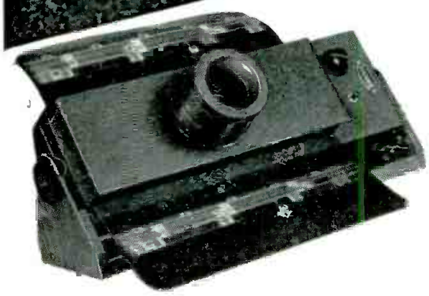
ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: WESPEXLIN, NEW YORK

In this new *Picker Magnifying Illuminator* the industrial radiographer will find a practical instrument for the magnification inspection and study of critical film areas.

for the critical study of industrial radiographs

A magnifying factor of 2½X provides ample power for minute study of spot weld radiographs, or those exhibiting porosity, shrinkage cracks, gas inclusions, and similar faults. Picker Bulletin 1143 gives details, specifications, prices.

PX



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Telescopic lens mount adjustable to individual vision...variable intensity fluorescent illumination . . . sliding baffle hood . . . adjustable viewing angle . . . takes any length film up to 14" wide...operates on AC or DC.

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DeJur wire-wound potentiometers provide maximum service and efficiency. Rugged, durable and dependable . . . engineered to meet rigid government requirements. There's a type to fill your bill . . . or we'll build to special resistances. Technical data sent upon request. Our engineers will gladly assist you.

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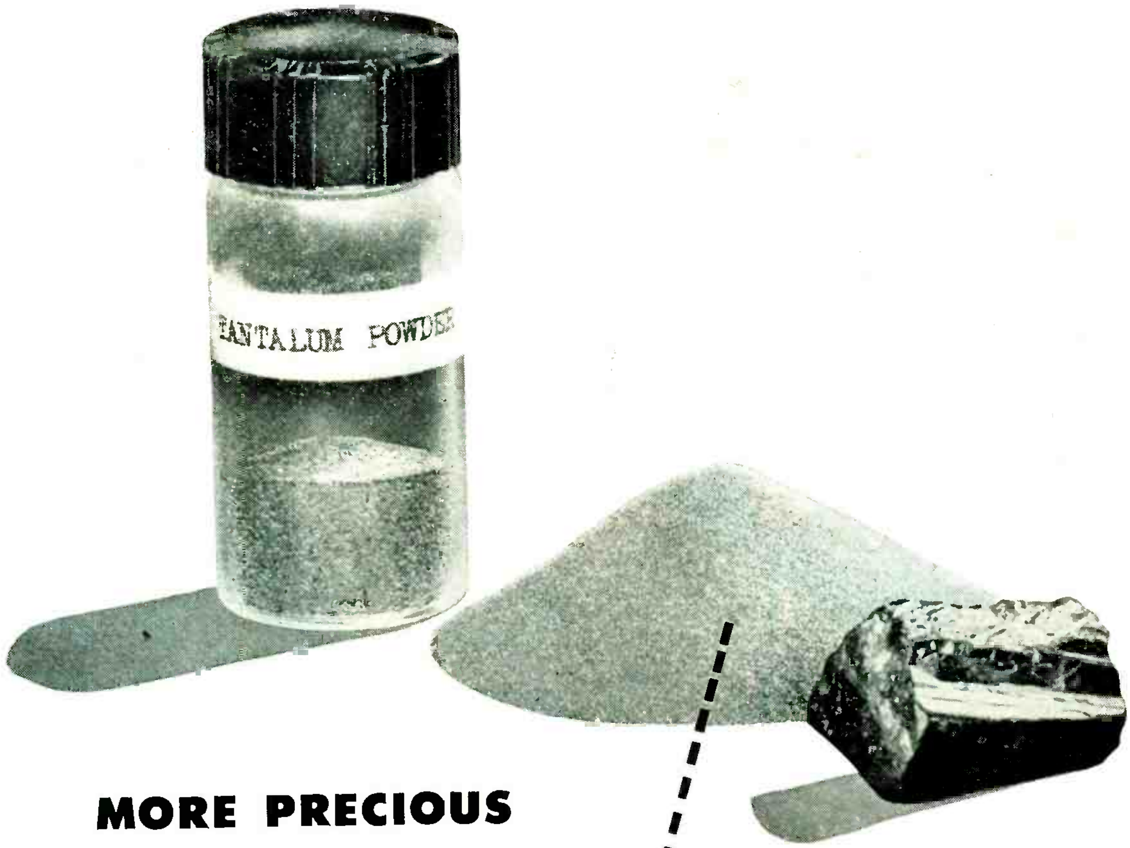
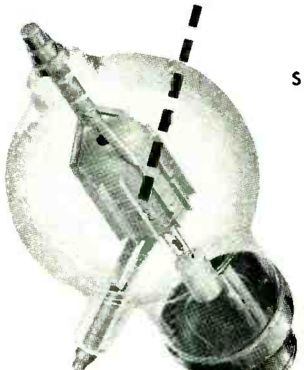

TANTALUM POWDER

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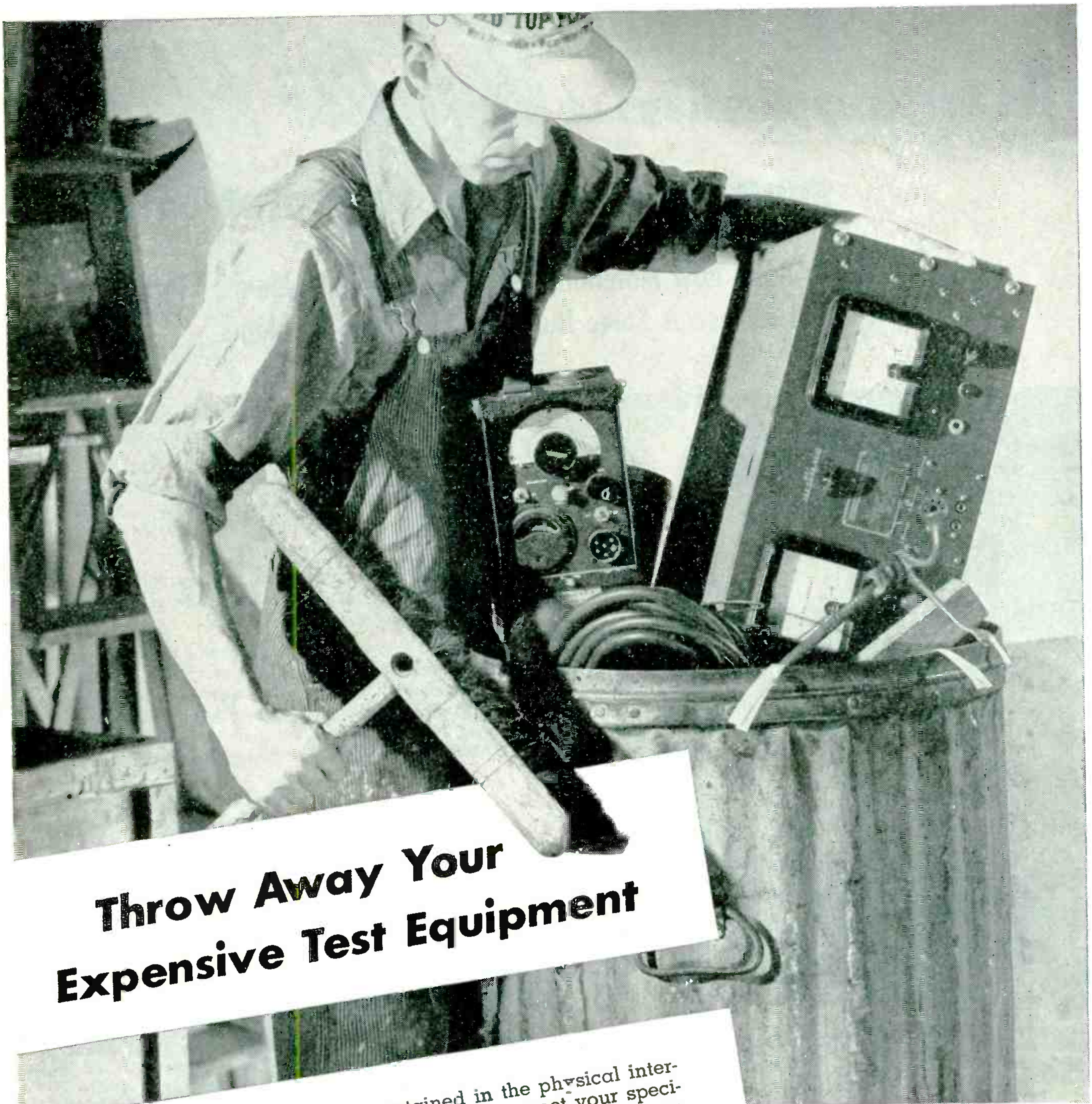
High Mechanical Strength
Good Machinability!



Throw Away Your Expensive Test Equipment

that is . . . if the components contained in the physical interpretation of your engineering designs do not meet your specifications. Be sure that the final product incorporates the same high quality components that you tested in your original model.

There's no guesswork when your specifications include Raytheon Tubes. Regardless of the intricacies involved in the designs of your electronic devices, you can rely on Raytheon Tubes to perform with a high degree of perfection the functions demanded of them.

Raytheon's leadership is proved through unfailing tube performances under the most severe military applications. When peace comes, Raytheon ingenuity will afford users many new and important advancements in tube engineering to meet the requirements of their new radio-electronic devices.

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RAYTHEON

RAYTHEON MANUFACTURING COMPANY
Waltham and Newton, Massachusetts

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

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suggest answers to your problems?

As Basic Raw Materials, VINYLITE Sheets, Moldings, Coatings, and Adhesives Solve Hundreds of Critical Problems

VINYLITE Plastics have taken a major role on two important fronts ... the battle front and the industrial front ... for these reasons:

First, they are supplied, or can be fabricated, in a wide variety of forms ... rigid sheets, elastic sheeting and film, rigid and elastic moldings and extrusions, or bases for coatings and adhesives.

Then, too, VINYLITE Plastics are strong, lightweight, dimensionally stable, non-flammable, resistant to water, oils, and chemicals.

Because they have found such wide application in essential uses, these plastics are restricted to high-priority applications. Our Field Engineers and Development Laboratories will be glad to help you with such problems. Get in touch with them, now, or write for Booklet 18, "Vinylite Resins—Their Forms, Properties and Uses."

Plastics Division

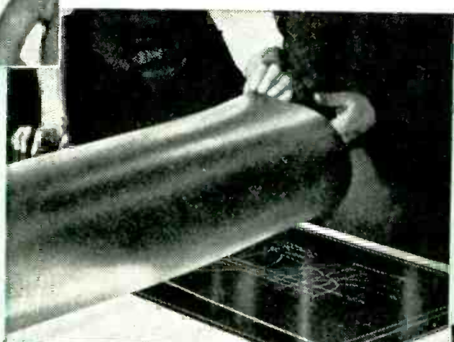
CARBIDE AND CARBON CHEMICALS CORPORATION

Unit of Union Carbide and Carbon Corporation

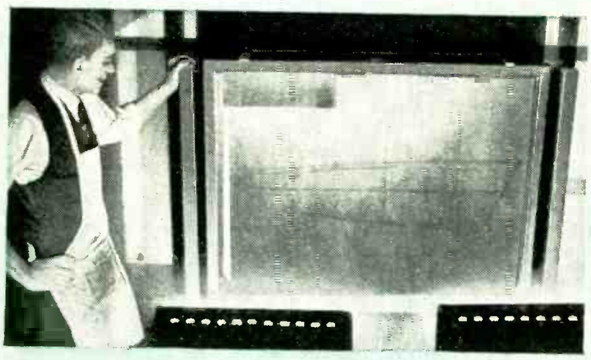
UCC

30 EAST 42ND STREET, NEW YORK 17, N. Y.

To speed the making of templets for complex aircraft parts, one of America's leading fighter plane manufacturers uses an ingenious method of photographing tracings directly on steel plates. The original drawing is carefully traced on a sheet of VINYLITE Rigid Plastic. The result is an extremely clear, plastic negative.

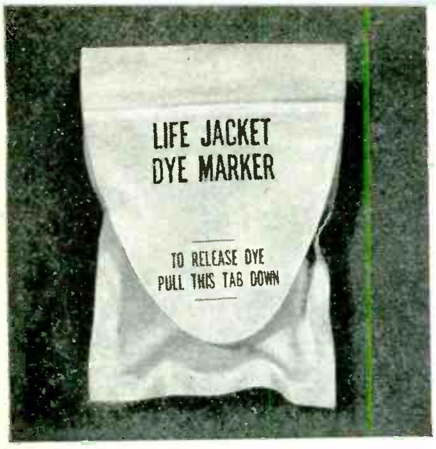


The final steel print is developed by applying acid and friction. When compared against the tracing on the VINYLITE sheet, it proves to be a perfect reproduction.



This plastic negative is then sandwiched between a sheet of light-sensitized steel and the glass door of a special printing box. Vacuum draws the three into perfect contact. Then arc lights make a contact print of the templet drawing directly on the steel. Because VINYLITE Plastics are dimensionally stable, no distortion occurs under this sharp temperature change, permitting the image to maintain the absolute accuracy required in the final part.

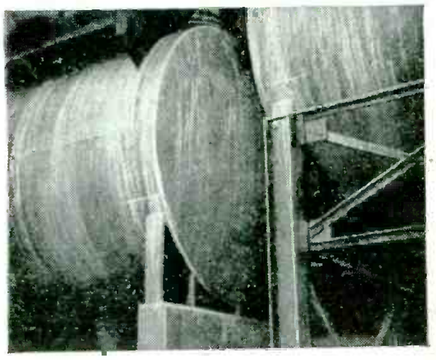
After checking the steel plate against the original drawing, it is cut to shape. The entire process, from drawing to templet is completed in only one hour.



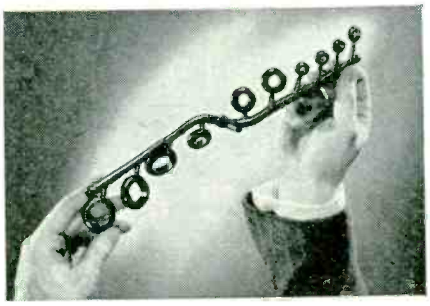
Survivors of sea casualties are easier to spot from a rescue plane now that both the Army and Navy are providing life jackets with special packets containing a "tea-bag" of fluorescent dye. In times of emergency the dye is readily released to spread quickly over a large area of the sea. One problem in the manufacture of these packets was to find a coating and an adhesive that were strong, waterproof, and that would protect the dye at extreme temperatures. The answer was found in a VINYLITE Plastic. Cloth is coated, then instructions are printed on it. The "tea-bag" is inserted and the packet edges are heat-sealed, using the coating as the adhesive.

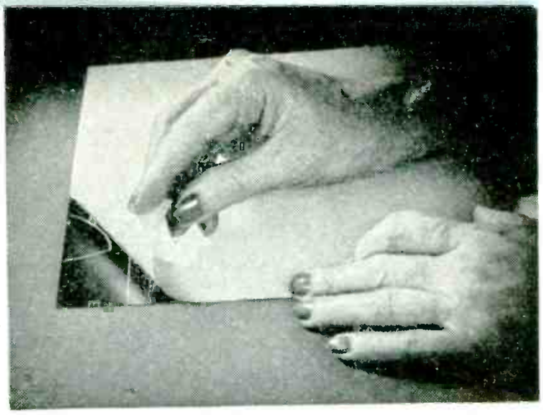
A manufacturer of machine roll coverings experimented with an extruded tube of VINYLITE Elastic Plastic applied over the metal core. But, with vulcanizing impossible, how could this new material be successfully bonded? The answer came in the form of an adhesive made with VINYLITE Resins. And because VINYLITE Plastics do not oxidize the new platen is proving to be superior to its rubber predecessor.

These two storage tanks contain concentrated sulfuric acid. The temperature of the metal is usually between 90 and 100 degrees F. There is considerable spillage. Under these conditions, ordinary coatings broke down in less than a month. One year ago the tanks were refinished with VINYLITE Resin VMCH air-dry coating. Today, although stained by spilled acid, this coating is unharmed.

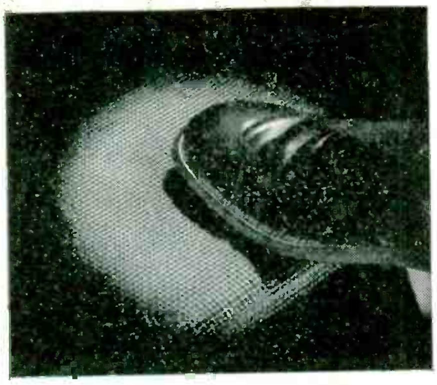


Tiny grommets must be made by the thousands to supply the needs of American military planes and trucks. Today these grommets are injection molded of a VINYLITE Elastic Plastic. This conversion saves large quantities of critical rubber, but even more important, it cuts molding time to a fraction of that formerly needed. Scrap and trim can be remolded immediately without costly reprocessing.





Important blueprints became oil stained, wrinkled, and torn in war-plant shops. How could they be made more durable to eliminate this waste? Now a thin sheet of VINYLITE Elastic Film, backed with paper, is laid over the print . . . then ironed on at moderate temperature. The thermoplastic film softens . . . adheres to the print. As soon as it cools the backing paper is stripped off, leaving a strong, glossy, water- and oil-proof coating.



Bomber floor mats and catwalk mats must be skidproof and unaffected by oil. A prominent rubber company, using standard rubber - processing equipment, calendered VINYLITE Elastic Plastics on a cloth base . . . embossed the surface for maximum traction. Since VINYLITE Elastic Plastic requires no curing or vulcanizing these sturdy, skidproof, oilproof mats are made at low cost.

PROPERTIES OF "VINYLITE" ELASTIC PLASTICS—These are a relatively new group of VINYLITE Plastics with rubber-like or elastomeric properties. They are produced in a variety of forms, ranging from soft to semi-rigid. They possess great toughness, and excellent resistance to continued flexing, and to severe wear and abrasion. Tensile strength is higher than that of most rubber compounds. Their electrical insulating properties are outstanding. They are not subject to oxidation. By correct choice of plasticizer, they can be made non-flammable, and highly resistant to water, oils, and corrosive chemicals. They are available in a wide range of colors, either translucent or opaque, or can be supplied in their natural, colorless, transparent state. Since all VINYLITE Elastic Plastics are thermoplastic, no curing or vulcanizing is required. They are more affected by temperature changes than is rubber, but their operating range is wide, some types remaining flexible at —50 deg. F., yet tack-free at 200 deg. F.

VINYLITE Elastic Plastics are supplied as sheeting and as compounds for calendering onto cloth, and for molding and extrusion.

PROPERTIES OF "VINYLITE" RIGID PLASTICS — Produced from unplasticized vinyl resins, VINYLITE Rigid Plastics possess a combination of properties found in no other thermoplastic material. Because of their extremely low water absorption, these plastics remain dimensionally stable under widely varying atmospheric conditions. They have exceptional resistance to alcohols, oils, and corrosive chemicals. They have high impact strength and tensile strength. They are odorless, tasteless, and non-toxic. They do not support combustion. They are available in a wide range of colors, translucent or opaque, and also in colorless, transparent forms. They are supplied as rigid sheets or as molding and extrusion compounds. Rigid sheets can be fabricated by forming, drawing, blowing, spinning or swoging, and can be punched, sheared, sawed, and machined on standard metalworking tools. Molding compounds are suitable for both compression and injection molding. Extrusion compounds give highly finished continuous rigid rods, tubes, and shapes directly from the die.

PROPERTIES OF "VINYLITE" RESINS FOR SURFACE COATINGS—Correctly formulated and applied, VINYLITE Resins yield finishes of unusual toughness, gloss, adhesion, and chemical resistance. They can be applied by spraying, knife-coating, or dipping to a wide variety of surfaces, such as metal, cloth, paper, and concrete. Prepared by dissolving resins in organic solvents, these finishes can be modified with a wide variety of pigments, dyes, and plasticizers. These resins are generally not employed with other film-forming bases, therefore, coatings formulated from them exhibit the desirable features of VINYLITE Resins alone. Drying is solely by evaporation of solvent, and finishes can be either air-drying or baking types.

PROPERTIES OF "VINYLITE" RESINS FOR ADHESIVES—Unusual toughness, resiliency, and impact resistance are characteristic of adhesives made of VINYLITE Resins. These resin adhesives are widely used as bonding agents for such materials as cellophane, cloth, paper, cardboard, porcelain, metal, mica, stone, leather, wood, and plastic sheets and film. They are available as powders for the compounding of adhesives, or as solutions sold under the trade-mark VINYLSEAL. The latter are especially recommended for bonding impervious materials, such as metals, and urea and phenolic plastics. Their bonding strength is comparable to that obtained with soft solder. By the addition of plasticizers, adhesives based on VINYLITE Resins can give almost any degree of flexibility desired.

Vinylite
TRADE MARK

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

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

QUAKE-PROOF CONSTRUCTION

In a few cubic inches of space National Union tube designers plan and build their electronic skyscrapers. Many fragile parts of these intricate mechanisms are precisely balanced, buttressed and welded fast.

For N. U. engineers well know the *rough sailing* that's ahead for these tubes—the shocks, concussion, vibration—relatively far more shattering than the impact of an earthquake on a modern steel and masonry building. So their war job is to build tubes which will stand up and take what comes—whose parts will *stay* in precise alignment—whose exact clearances will not be altered—whose air seal will not be broken.

To master this complicated construction problem calls for precision engineering of the first order—and a minute knowledge of the strength, rigidity and other characteristics of many metals. The point is—modern electronic tubes are scientific instruments. And to be sure of getting the tubes which will best handle your post-war work—you'll want to seek sound technical advice. Call 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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PERFECTED IN WARTIME
DEPENDABLE IN PEACETIME
Immediate and sustained communications are now playing the greatest role in the world's history. Precision crystals are a vital part of communications on all fronts . . . enabling the Allies to establish and maintain superiority in the present world struggle.
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Producers of Approved Precision Crystals for Radio Frequency Control


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A product of the
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Typifying the broad advances possible through close collaboration between the Army, Navy and N·Y·T engineers, this unit conforms to the most exacting requirements of modern military equipment.
Embodying the very latest in design, its proportions have been engineered to permit maximum performance, while utilizing only a minimum of space.
The immersion-proof case has been custom-built to do a specific job, further illustrating the policy of the N·Y·T Sample Department of meeting individual mechanical and electrical requirements. Your inquiries are invited.
NEW YORK TRANSFORMER COMPANY
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DR 24 G

Suitable for pulses of instantaneous high power at high frequencies. Also for ultra high frequency work.

VACUUM CONDENSER

A permanent capacitance. Protected by vacuum from moisture, dirt, changing characteristics and mechanical injury. 50 mmf. 5,000 volt.

IONIZATION GAUGE

A very sensitive instrument for determining degree of vacuum in a system. Convenient, stable, trouble free. Indispensable for production of quality vacuum tubes.

DR 872 A

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

DR 873

Similar to 872 A except that it's grid controlled. Can be used for the very smooth control of rectified DC voltage.

DR 17

Grid Control Rectifier similar in characteristics to 866.

DR 300

A rugged tube for rugged service. Made by pioneers in the use of graphite anodes which protect against excess anode temperature. 300 watt capacity.

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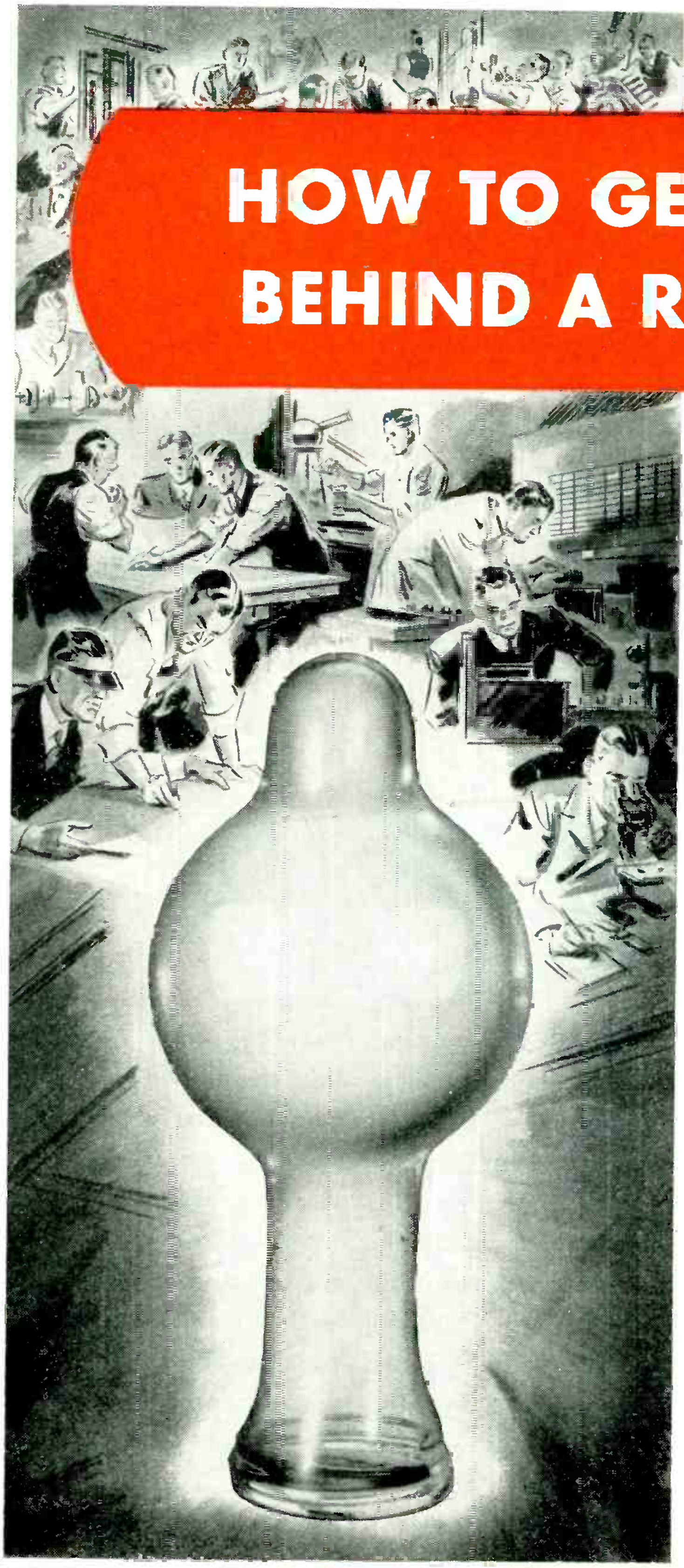
EXPERIENCED heads, which among other things, pioneered the graphite anode and carburizing thoriated filament, have joined in this young and virile company to develop and manufacture the finest in vacuum products for electronic applications . . . with no prejudices, no preconceptions, no antiquated equipment or methods to hinder their creative and productive abilities. The products shown are modern in design and construction and represent use of the latest knowledge in the electronic field.

GENERAL ELECTRONICS INC.

101 HAZEL STREET, PATERSON, N. J.

HOW TO GET 250 MEN BEHIND A RADIO TUBE



IT sounds like a big order—but we do it at Corning. And for any user of electronic glassware, big or little, this is a service mighty hard to equal.

Behind every radio tube, x-ray bulb, cathode ray bulb, resistor tube, every one of the hundreds of electronic glassware products made by Corning Glass—stand 250 glass experts. Planners, research workers, engineers, production men—each a specialist in his own right, backed by one of the largest, most modern laboratories in the United States.

This unmatched reservoir of glass-making experience is one of the factors which make Corning's position unique in the industry. In its 75 years of pioneering, for example, Corning has developed more than 25,000 glass formulae. It has made Pyrex brand heat resistant glasses a practical fact instead of a dream; it has developed glasses with an expansion coefficient practically equal to that of fused quartz, and which can be formed in a variety of intricate shapes which only recently were impossible in glass.

To the manufacturer of electronic equipment—Corning's "know-how" in glass is particularly important. It means that here, under one roof, you too can find helpful, expert advice on any glass problem. If you are interested in a detailed study of electrical glassware, write for "Glass in the Electrical Industry." Address Electronics Sales Dept. E-1, Bulb and Tubing Division, Corning Glass Works, Corning, N. Y.

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Electronic Glassware

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

Hallicrafters peacetime communications equipment is meeting the wartime qualifications and demands of the Military!

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

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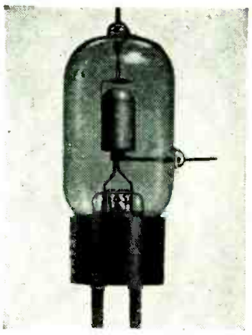
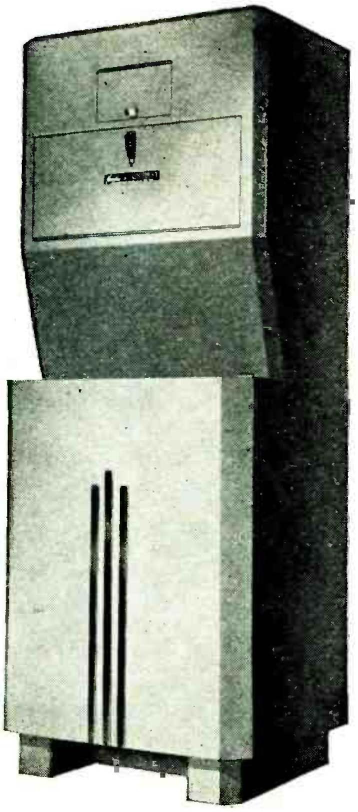
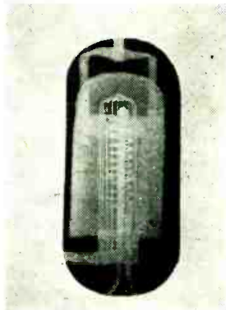
World's largest exclusive manufacturer of short wave radio communications equipment... First exclusive radio manufacturer to win the Army-Navy Production Award for the third time.

Norelco Searchray
Saves Manufacturing Trouble



Above is a photograph of a vacuum tube as the inspector's eye — and the camera — see t. A certain defect in manufacture is hidden to the eye. But Searchray, the new self-contained X-ray unit, shown in center, can spot it. See illustration at right.





Same tube as seen radiographically by Searchray. Note defect. The filament is too close to the grid, which will cause the tube to heat up. Searchray saves time, money and labor by checking products before assembly.

If you manufacture lamps, tubes, electrical parts, rubber, ceramics, light alloys or plastics—Norelco Searchray can pay for itself many times over by acting as an X-ray inspection tool at every step of manufacture or assembly.

Shockproof, rayproof, foolproof and readily mobile, Searchray, the self-contained X-ray unit, is so simply devised that anyone can operate it safely. It examines objects both fluoroscopically and radiographically; it is as useful in the laboratory as on the assembly or production line.

The Searchray Model 80, illustrated above, is an 80 KvP, 5MA unit which operates on 110 volt A.C. simply by plugging into an outlet. Another Searchray — Model 150, likewise a self-contained, rayproof, shockproof, X-ray unit for fluoroscopic and radiographic examination, permits use of any kilovoltage up to 150 KvP, 10MA. It operates on 220 volts A.C.

Searchray may be of help in *your* product inspection problems. Write today to North American Philips. Let us tell you more about Searchray—and other Norelco products.

For our Armed Forces we make Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes for land, sea and air-borne communications equipment.

For our war industries we make Searchray (X-ray) apparatus for industrial and research applications; X-ray Diffraction Apparatus; Electronic Temperature Indicators; Direct Reading Frequency Meters; Tungsten and Molybdenum in powder, rod, wire and sheet form; Tungsten Alloys; Fine wire of practically all drawable metals and alloys: bare, plated and enameled; Diamond Dies; High Frequency Heating Equipment.

And for Victory we say: Buy More War Bonds.

Norelco ELECTRONIC PRODUCTS

NORTH AMERICAN PHILIPS COMPANY, INC., 100 EAST 42ND STREET • NEW YORK 17, N. Y.

Factories in Dobbs Ferry, N.Y.; Mount Vernon, New York (Philips Metalix Corporation); Lewiston, Maine (Elmet Division)
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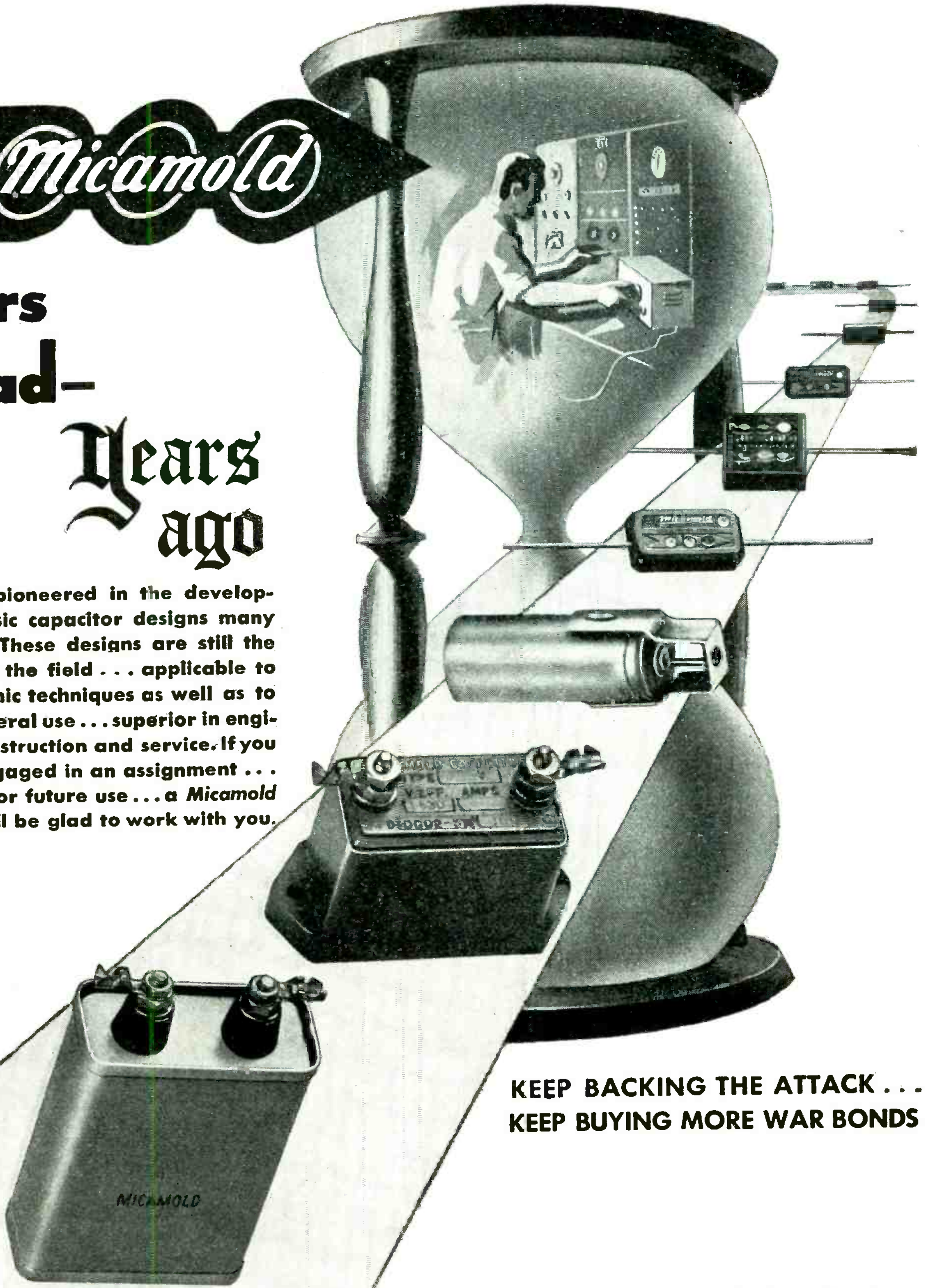
Micamold

Years ahead— Years ago



MICAMOLD pioneered in the development of basic capacitor designs many years ago. These designs are still the standards in the field . . . applicable to new electronic techniques as well as to those in general use . . . superior in engineering, construction and service. If you are now engaged in an assignment . . . for present or future use . . . a *Micamold* engineer will be glad to work with you.

**KEEP BACKING THE ATTACK . . .
KEEP BUYING MORE WAR BONDS**

There's a Micamold Capacitor for All Radionic and Electrical Applications:

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

MICAMOLD RADIO CORPORATION
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A PLANET *Not a Meteor*

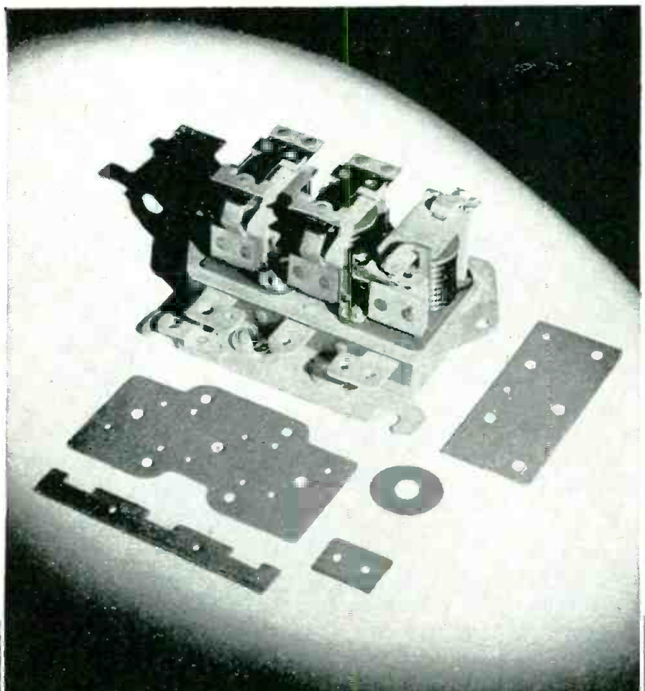
Ever notice how a meteor streaks across the heavens in a blaze of fiery splendor? It's a beautiful sight . . . while it lasts. But most meteors burn themselves out long before striking the earth. Not so a planet . . . though much less brilliant, it's there to stay. That's how we like to think of I. C. E. Here to stay . . . Born of the war . . . yes, but acquitting itself well, and all the better to serve you in the post-war future.

Electronics
. . . the promise of great things to come

ICE

INDUSTRIAL & COMMERCIAL ELECTRONICS
BELMONT, CALIFORNIA

GREASED LIGHTNING STREAKS IN FOR THE KILL



National Vulcanized Fibre and Phenolite, laminated Bakelite parts, because of their lightness in weight, high dielectric strength, exceptional wearing and other qualities, are playing a vital part in everything of Uncle Sam's that "flies, floats or shoots."

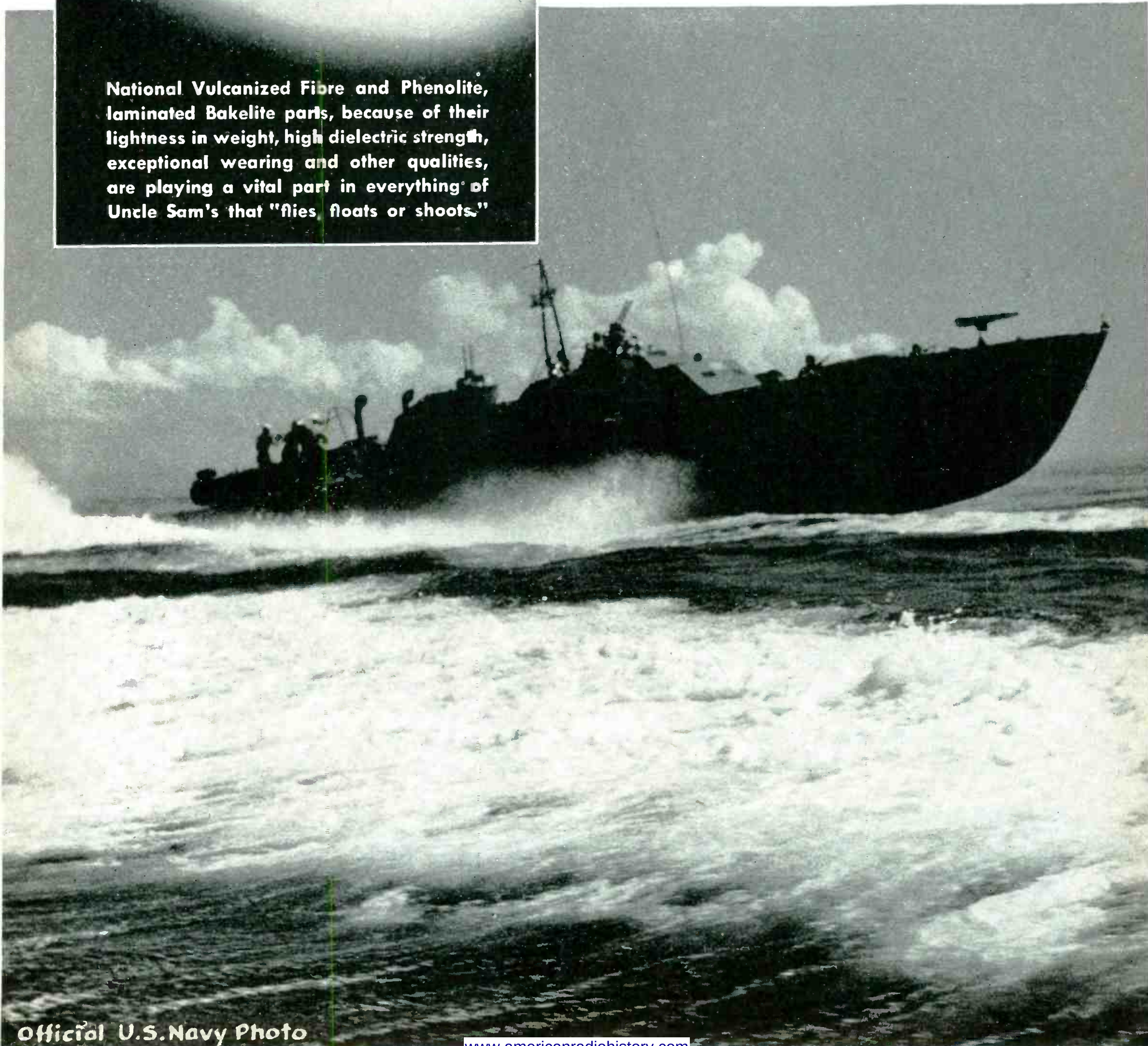
THE bigger they are, the harder they fall! That's the slogan of the PT's. There's nothing the NIPS can show that PT's won't take on and send to the bottom. The record proves it.

In the production of PT boats, lightness in weight and exceptional strength are important factors. That's why there is found in their construction and insulation—strong, lightweight plastics like National Vulcanized Fibre and Phenolite, laminated Bakelite. We salute the Naval architects who gave our fighting men at sea the lightning striking panther, the PT boat.

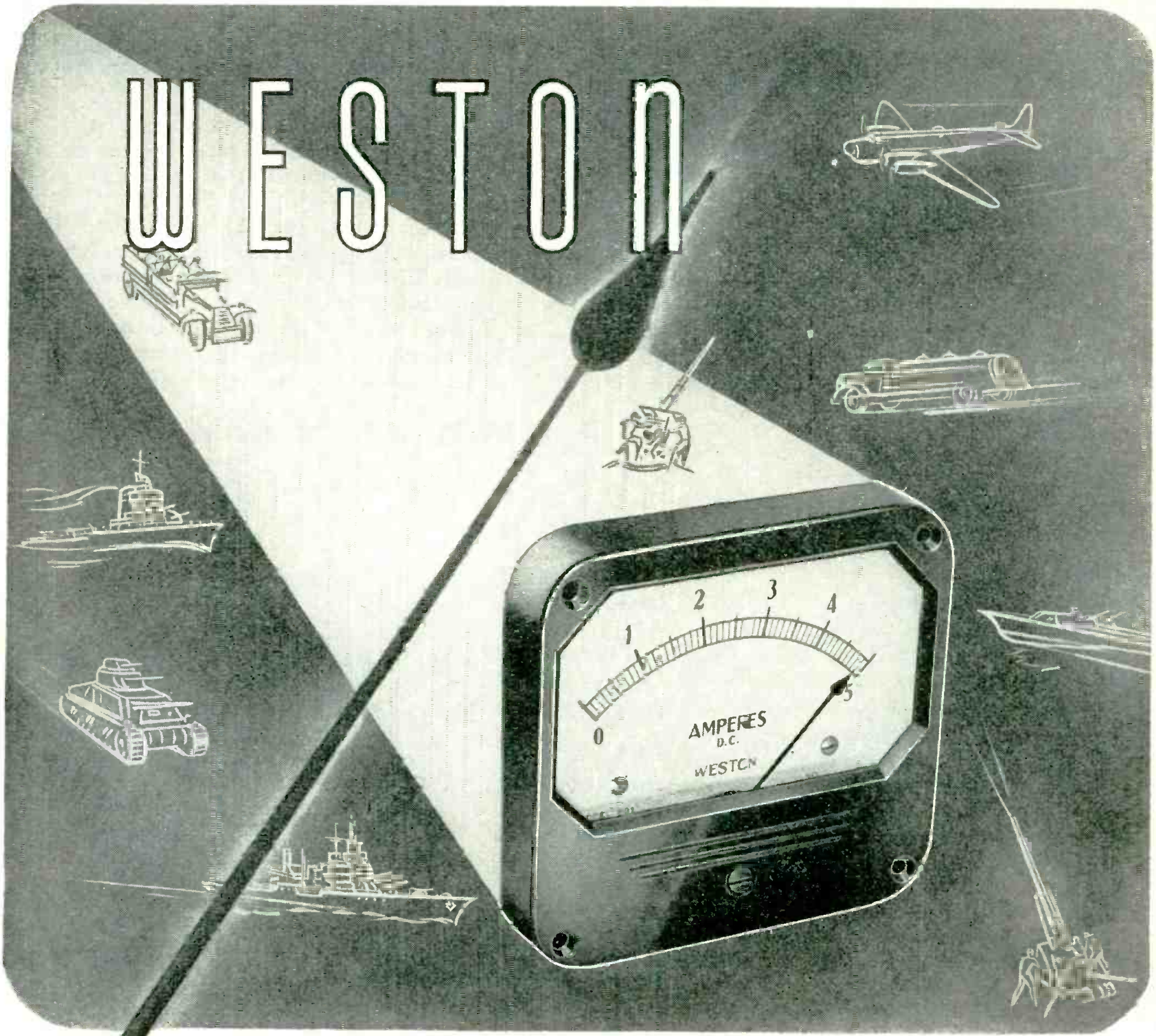
NATIONAL VULCANIZED FIBRE CO.

WILMINGTON DELAWARE

Offices in Principal Cities



Official U.S. Navy Photo



CONTINUING LEADERSHIP

. . . through the war and beyond!

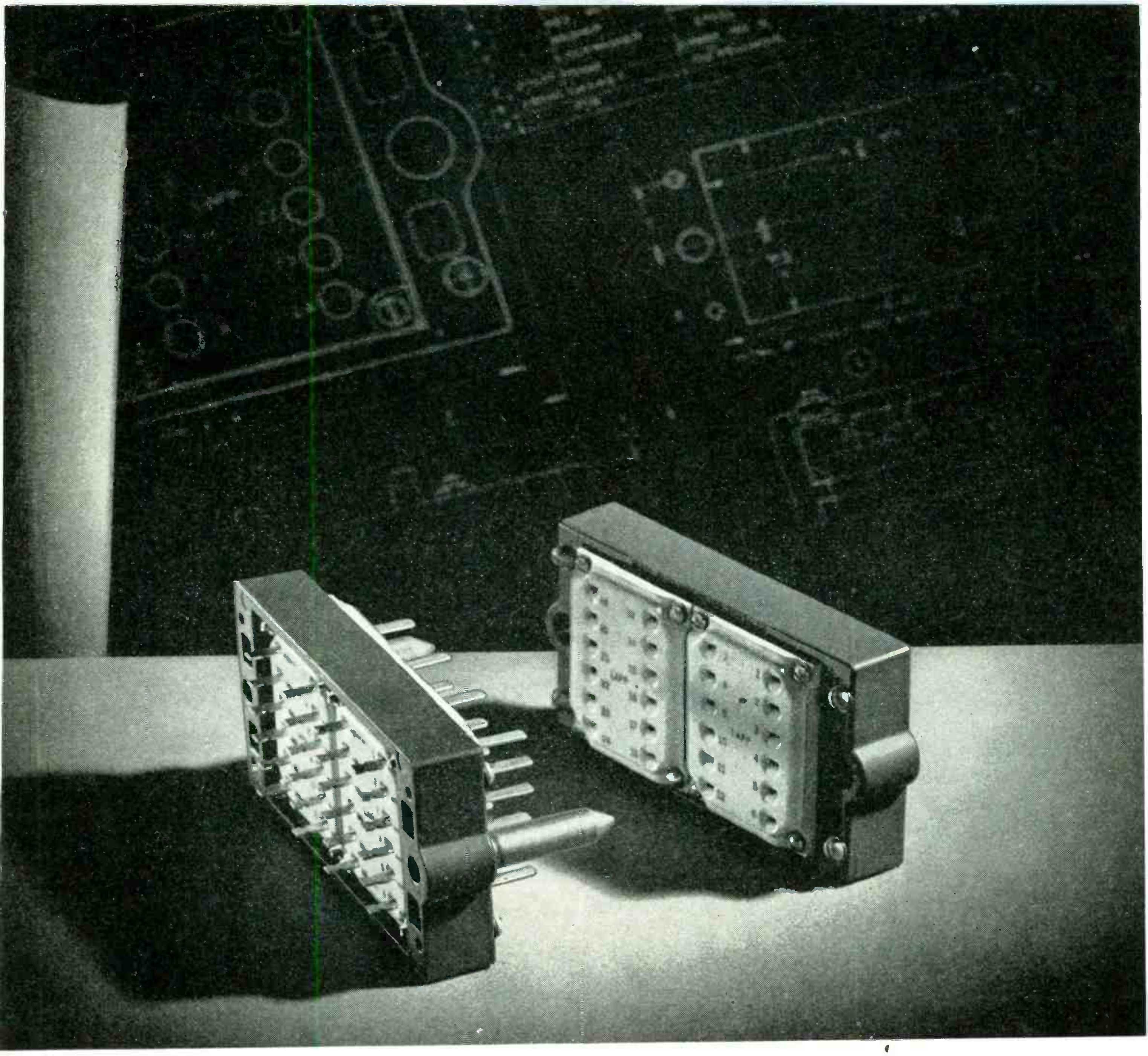
The start of the new year finds instrument headquarters still *busy at it* in the final drive for victory. Dependable WESTON instruments, in all familiar types, continue flowing in unprecedented quantities to every battle front. *In new types, too;* for all during this period of stress WESTON development laboratories also have *led the way* . . . continually meeting the new measurement problems of this mechanized war. Thus when instrument priorities are relaxed, WESTONS will continue as industry's *standards* for all measurement needs. For, *new* measurement tools as well as *old* will be available in their most *trustworthy form* . . . here at instrument headquarters. Weston Electrical Instrument Corp., 618 Frelinghuysen Ave., Newark 5, N. J.

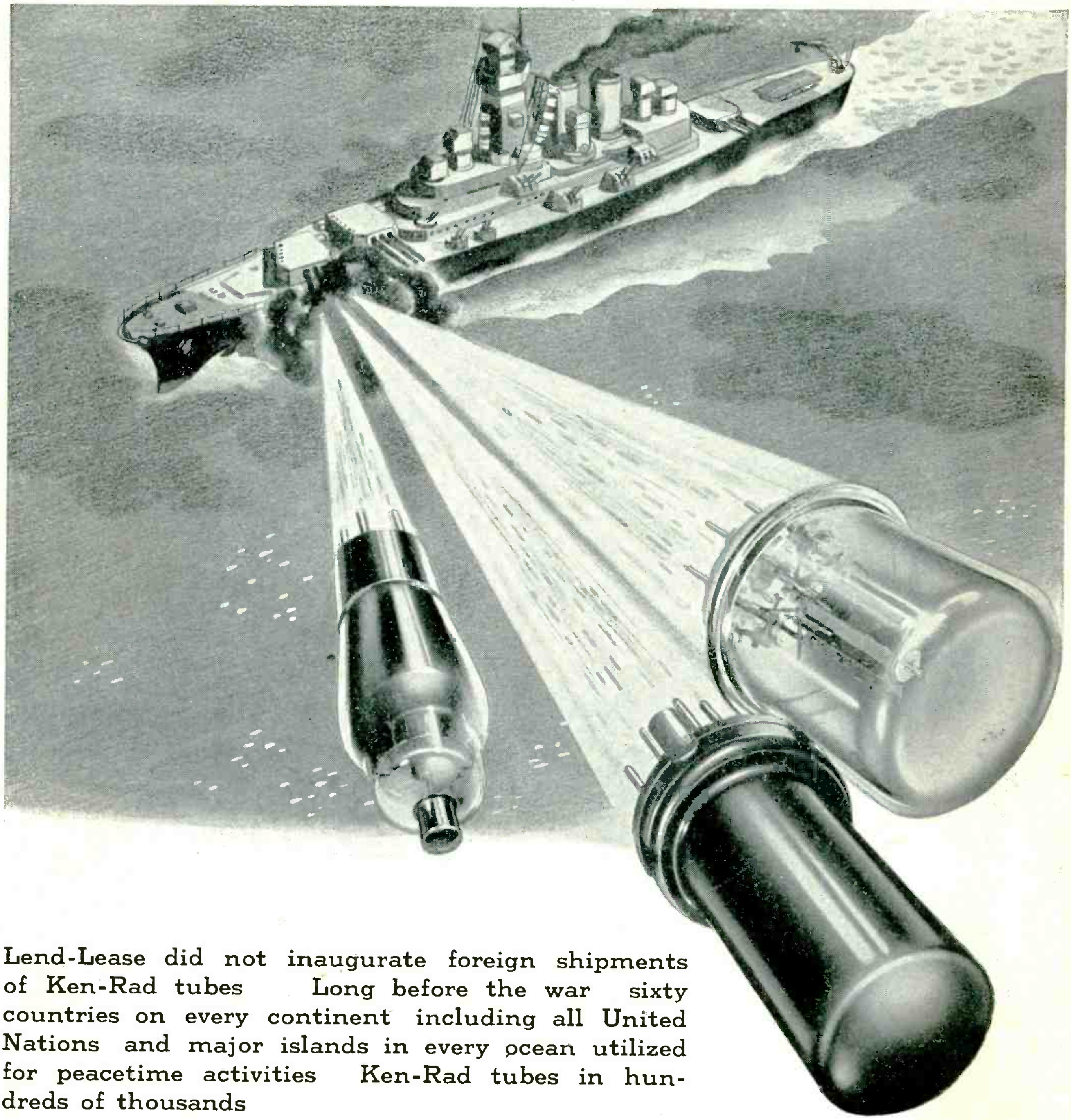
Laboratory Standards . . . Precision DC and AC Portables . . . Instrument Transfomers . . . Sensitive Relays . . . DC, AC, and Thermo Switchboard and Panel Instruments.

WESTON

Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters...Aircraft Instruments... Electric Tachometers...Dial Thermometers.

FOR OVER 55 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS





Lend-Lease did not inaugurate foreign shipments of Ken-Rad tubes Long before the war sixty countries on every continent including all United Nations and major islands in every ocean utilized for peacetime activities Ken-Rad tubes in hundreds of thousands

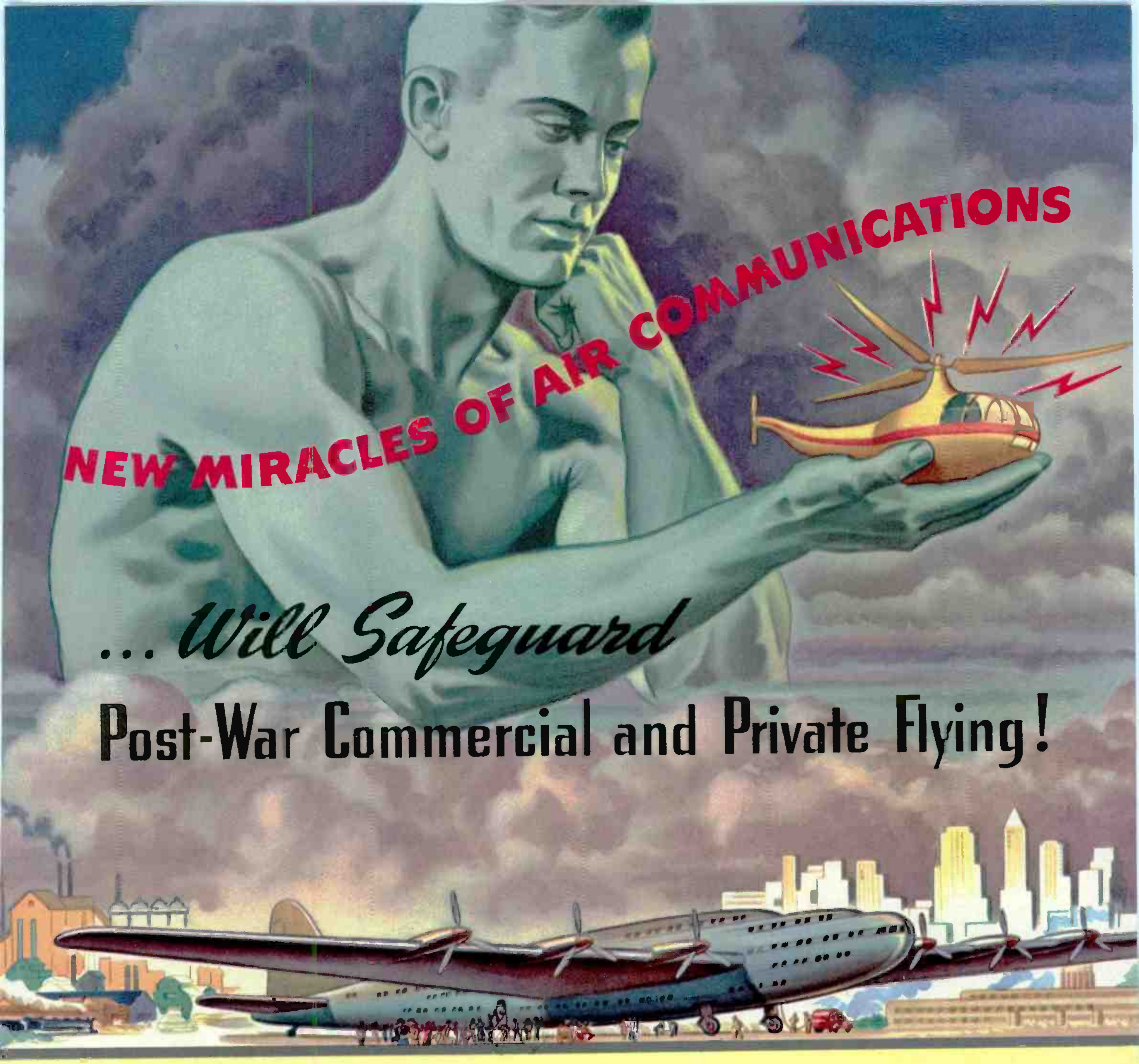
Today millions of Ken-Rad tubes serve every battle front and we are proud that in war or peace the entire military world and civilians alike recognize Ken-Rad dependability

TRANSMITTING TUBES
CATHODE RAY TUBES
INCANDESCENT LAMPS

KEN-RAD

FLUORESCENT LAMPS
SPECIAL PURPOSE TUBES
METAL AND VHF TUBES

EXECUTIVE OFFICES
OWENSBORO · KENTUCKY
EXPORTS 116 BROAD STREET NEW YORK



Designing, Engineering and Building for Victory...and the Future...

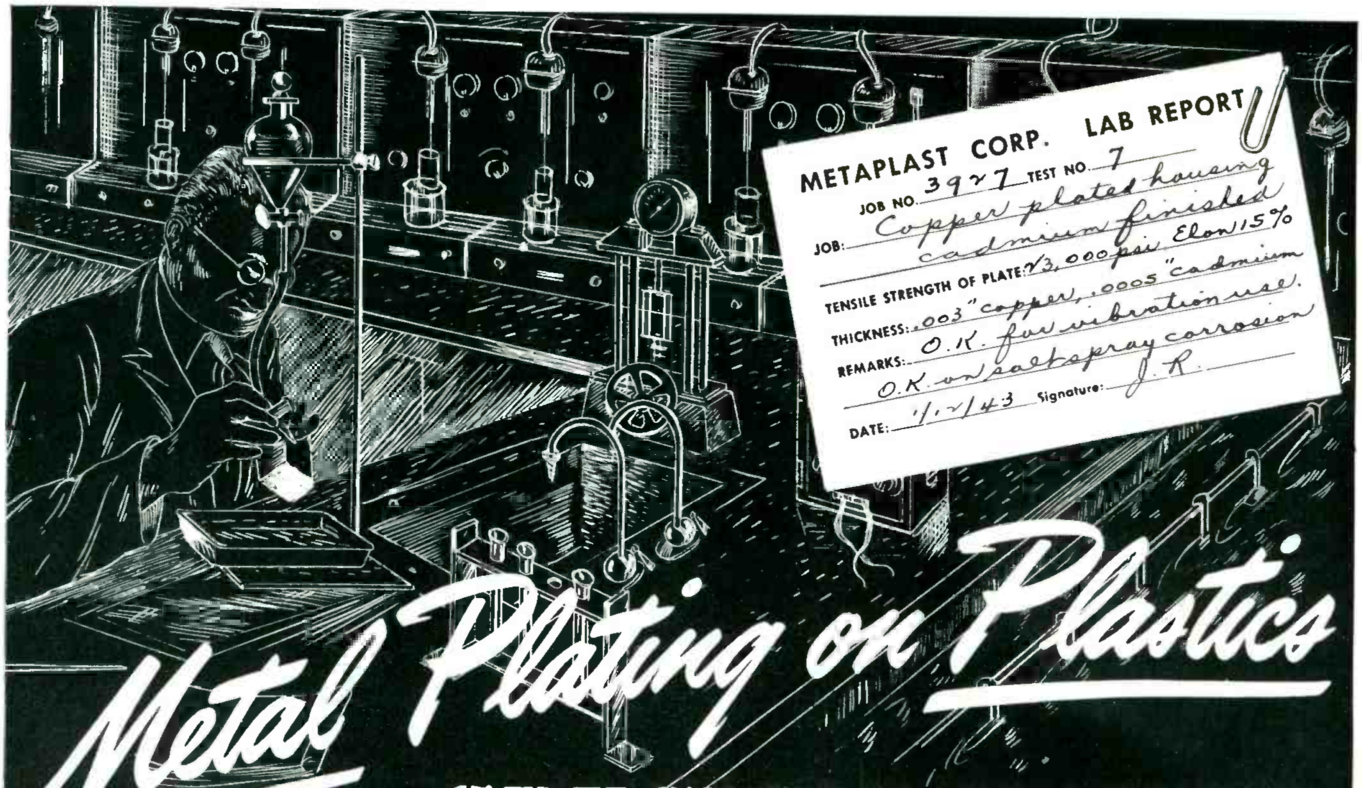
Air Communications Products include: Radio Range Receivers, Glide Path Receivers, Marker Beacon Receivers, Aircraft Automatic Direction Finders, Aircraft Transmitters, Command Receivers, Command Transmitters, Small Transmitters up to 1 K.W., Interphone Equipment, Radio Telephone Equipment, Adaptors for Radio Compasses. Out of their achievements for war, Air Communications engineers will bring you new knowledge and experience of value in peacetime aviation development. *Cooperative engineering available.* Let us help you solve your engineering problems of the future.

★ The skyways of tomorrow will be paved with new safeguards resulting from new and amazing developments in air communications. Private planes as well as great commercial airliners will pierce the veil of fog, clouds and darkness with an ease and accuracy undreamed of only a few short years ago! Startling advancements already made in electronic communications, and assured developments yet to come, give us this portent of the future . . . *and Air Communications plans are directed toward that future!*

Now, Air Communications precision-built Products are being used to increase the operating efficiency of America's warplanes. After victory, Air Communications skilled organization will be at the service of America's great post-war aviation industry...ready with the advanced engineering and designing ability needed to produce *everything for the safety, convenience and economy of flying.*

AIR COMMUNICATIONS, INC.

KANSAS CITY 8, MISSOURI



Metal Plating on Plastics *to* SPECIFICATIONS

. . . Thousands of Antenna Masts of copper plated compreg wood for Combat planes

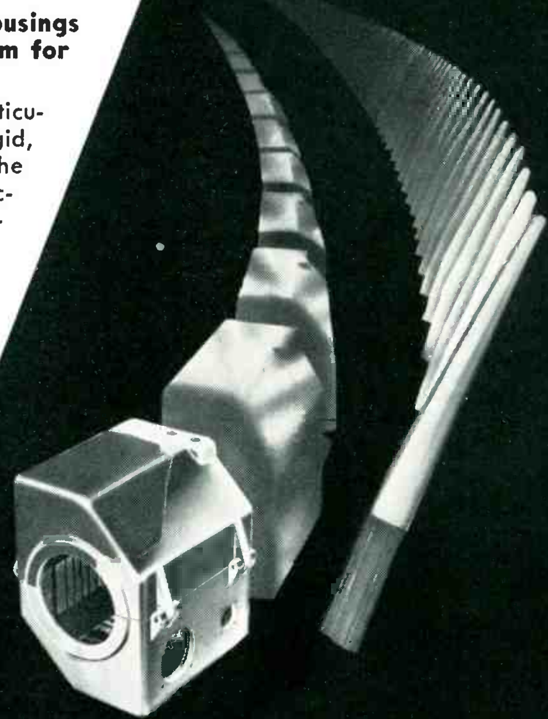
. . . Thousands of Plastic Housings plated with copper and cadmium for our Bombers.

Each and every non-conductive unit meticulously electroplated to meet the usual, rigid, ultimate-in-precision specifications of the Army and Navy. That's the unheralded record of Metaplast and its group of laboratory technicians, chemical engineers, and highly skilled electroplaters.

Metaplast is the accepted precision-tested method for electro-depositing a smooth, non-porous, adhesive, metal coating in any desired thickness on non-conductive surfaces.

May we work with you on your problems. War work or post-war planning are of equal interest to us.

METAPLAST CORPORATION
205 WEST 19th STREET • New York 11, N. Y.



Metaplast

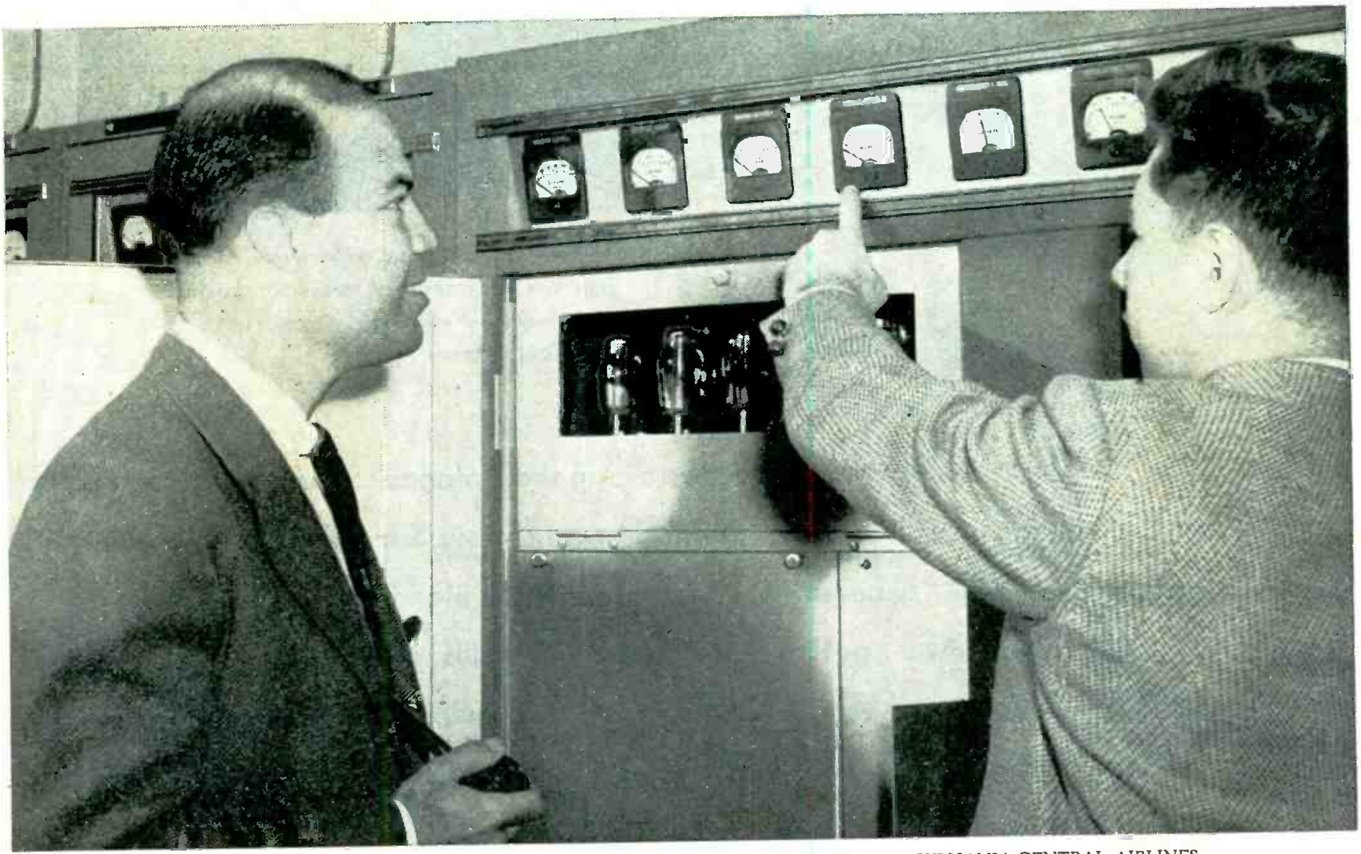
Metal Plating on Plastics

U.S. Patents 2,214,646-2,303,891 U.S. and Foreign Patents

COPPER • SILVER • CADMIUM • GOLD • NICKEL • CHROME • LEAD • PLATINUM

WILCOX IS IN SERVICE

...Along the Route of The Capital Fleet



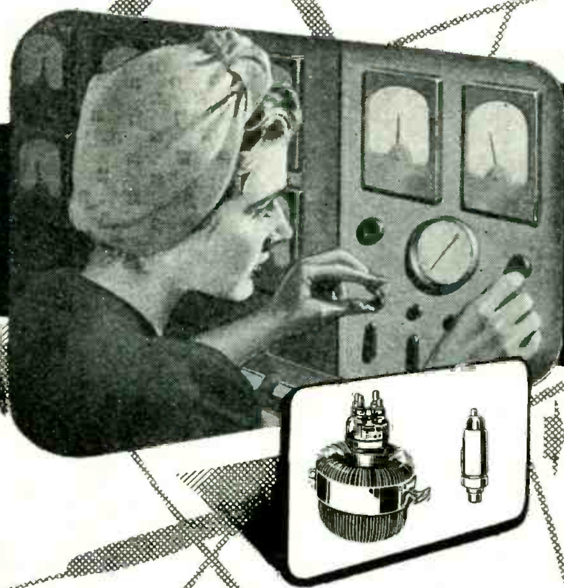
Photograph, courtesy PENNSYLVANIA-CENTRAL AIRLINES.
(left) B. J. Vierling, Supt., Maintenance, (right) Earl Raymond, Chief, Ground Station Maintenance.

"Installation of Wilcox transmitters, at many of our points, has given our communications the high degree of dependability so necessary for airline operations," states Mr. Earl Raymond of Pennsylvania-Central Airlines. In addition to installations on major airlines throughout the United States, Wilcox radio equipment is being used now in connection with world-wide military aircraft operations.

WILCOX ELECTRIC COMPANY

MANUFACTURERS OF RADIO EQUIPMENT • FOURTEENTH & CHESTNUT, KANSAS CITY, MO.

– Assuring Today's Production Perfection
– Insuring Tomorrow's Product Prestige



VACUUM TUBE TEST EQUIPMENT

Sherron facilities and experience encompass the full range of vacuum tube test equipment — from the "peanut" size to the giant transmitter type.

Today, when lives and battles are in the balance, Sherron Test Equipment is helping manufacturers maintain reputations for perfection. Existing standards are high, necessarily. They'll be equally high in the postwar tomorrow when they will be spotlighted by vigorous sales competition. Manufacturers of vacuum tubes, as well as other precision instruments, can insure postwar acceptance now — with production testing equipment that assures superior product performance.

MANUFACTURERS: We offer an unusual combination of facilities to companies contemplating design, development, or production of test equipment.

ENGINEERING DESIGN, MANUFACTURING, ASSEMBLY — COMPLETE PRODUCTION (INDIVIDUAL UNITS OR QUANTITIES) TO SPECIFICATIONS.

Sherron Electronics

SHERRON METALLIC CORPORATION

1201 Flushing Avenue Brooklyn 6, New York

THERE IS ONLY ONE MYCALEX

This building houses MYCALEX which, in the opinion of reputable engineers, is ". . . the most nearly perfect electrical insulator known today". Developed and perfected more than twenty-five years ago, MYCALEX has been improved to such an extent that it now possesses advantages which make it superior to other types of glass bound mica insulation.

In any number of military and industrial applications . . . in any weather and climate . . . the unique properties of Leadless MYCALEX have been tried and tested, and found more than satisfactory. A few desirable properties are high dielectric strength combined with mechanical strength, heat and arc resistance, low moisture absorption, low power factor and low loss. Furthermore, MYCALEX meets all standards for close tolerances. Leadless MYCALEX is adaptable, too . . . it can be cut, tapped, machined, drilled, ground, polished . . . or *moulded.** And in any of these assignments it will prove to be extremely dependable. *Sheets and rods are immediately available for fabrication by us or in your own plant.*

MYCALEX THE INSULATOR

Trade Mark Reg. U. S. Pat. Off.

Remember . . . MYCALEX is not the name of a class of materials, but the registered trade-name for low-loss insulation manufactured in the WESTERN HEMISPHERE by the Mycalex Corporation of America.

Keep Buying More and More War Bonds

***If you have a special job where moulded parts are needed, we invite your specifications**

MYCALEX CORPORATION OF AMERICA

Exclusive Licensee under all patents of MYCALEX (PARENT) CO., Ltd.

60 CLIFTON BOULEVARD — **CLIFTON, NEW JERSEY**

Stepping up to TEN MILLION VOLTS

X-Ray and Impulse Generator Capacitors

AEROVOX TYPE '26

Applications:

- X-ray filter capacitors
- Impulse test generators
- Carrier-current coupling capacitors
- High-voltage laboratory equipment
- Many other high-voltage applications

Ratings:

50,000 v. D.C.	.005 to .1 mfd.
75,000 v. D.C.	.001 to .05 mfd.
100,000 v. D.C.	.001 to .05 mfd.
150,000 v. D.C.	.001 to .03 mfd.

● Charged in parallel, discharged in series, these capacitors provide for voltages up to ten million and over for certain deep-penetration X-ray and impulse generator applications. For usual X-ray work, single units operate up to 150,000 volts.

Aerovox Type '26 capacitors are designed for just such service. Multilayer paper sections, oil-impregnated, oil-filled, housed in sturdy tubular bakelite cases. Choice of metal cap terminals facilitates stack mounting and connections. Sections of matched capacitance insuring uniform voltage gradient throughout length of capacitor.

Behind these capacitors stand those giant Aerovox winding machines handling dozens of "papers" at a time for highest-voltage paper sections. Likewise batteries of Aerovox vacuum tanks insuring thorough impregnation even to the last paper fibre. Such facilities spell Aerovox—the last word in oil capacitors—safeguarded by thorough inspection and testing from raw materials to finished units.

● New catalog, listing an outstanding line of heavy-duty capacitors for radio, electronic and industrial functions, sent on request to individuals engaged actively in professional engineering or production. Submit your capacitance problems and requirements.

AEROVOX *Capacitors*

INDIVIDUALLY TESTED

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"The Inspector and I Get Along OK"

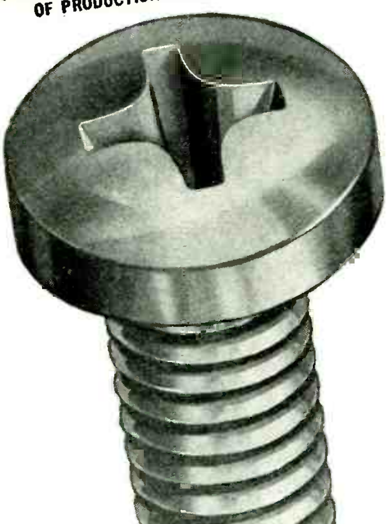
... since we changed to

AMERICAN

PHILLIPS SCREWS

that drive straight and set up tight ... with no burred heads or scarred work

WORLD'S EASIEST, FASTEST, SAFEST METHOD OF PRODUCTION SCREW DRIVING

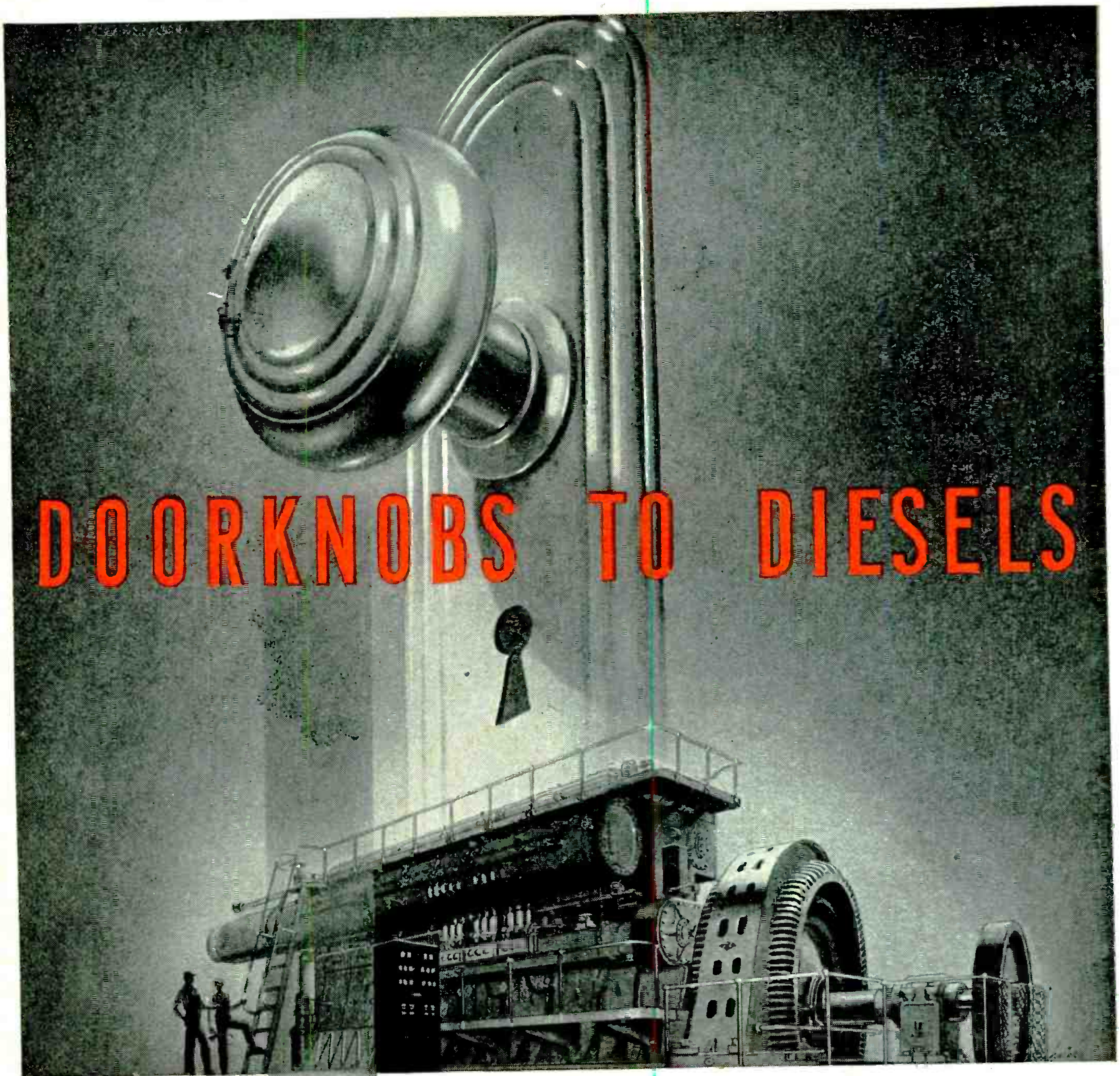


Every fastening made with American Phillips Screws is a clean, strong fastening ... *the first time it's made.* No crooked screws to be re-driven. No burred and broken screw-heads to be backed out and replaced. No holes to be re-tapped.

Neither are there any gouges on the work-surface, to cause rejection of finished material. For the Phillips Driver engages the American Phillips Recessed Screw Head in a firm contact, making one single, self-aligned driving unit *that stays put until the screw is turned up tight and flush.* There's no wobbling at the start, no physical strain in the driving operation. So women and inexperienced men can keep up the work-pace, without difficulty or undue fatigue. And output increases as time-per-fastening is cut ... as much as 50%.

In addition, there are special advantages to American's brand of Phillips Screws: *Full Value,* assured by automatic weigh-count. *Piece Inspection* of head, thread, and point. *Delivery Service,* maintained by high-speed production. *Engineering Service,* at *your* service on any special fastening problem. That's why more and more buyers of screws specify: "American brand".

AMERICAN SCREW CO.
PROVIDENCE, RHODE ISLAND
Chicago: 589 E. Illinois Street
Detroit: 502 Stephenson Building



The Western Brass that went into doorknobs and a myriad of peacetime items is flowing into diesel engines and battle equipment of every description. • • The output of our mills at East Alton, Ill., and New Haven, Conn., now many times multiplied, is helping our boys to blast the foes of Freedom—speeding the day when we can serve you. We are ready now to help with your post-war plans.

Western BRASS PRODUCTS
WESTERN CARTRIDGE COMPANY EAST ALTON, ILLINOIS, U.S.A.

Western BRASS MILLS
TRADE MARK REG. U. S. PAT. OFF.
Division of WESTERN CARTRIDGE COMPANY, *East Alton, Ill.*

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

AMERTRAN

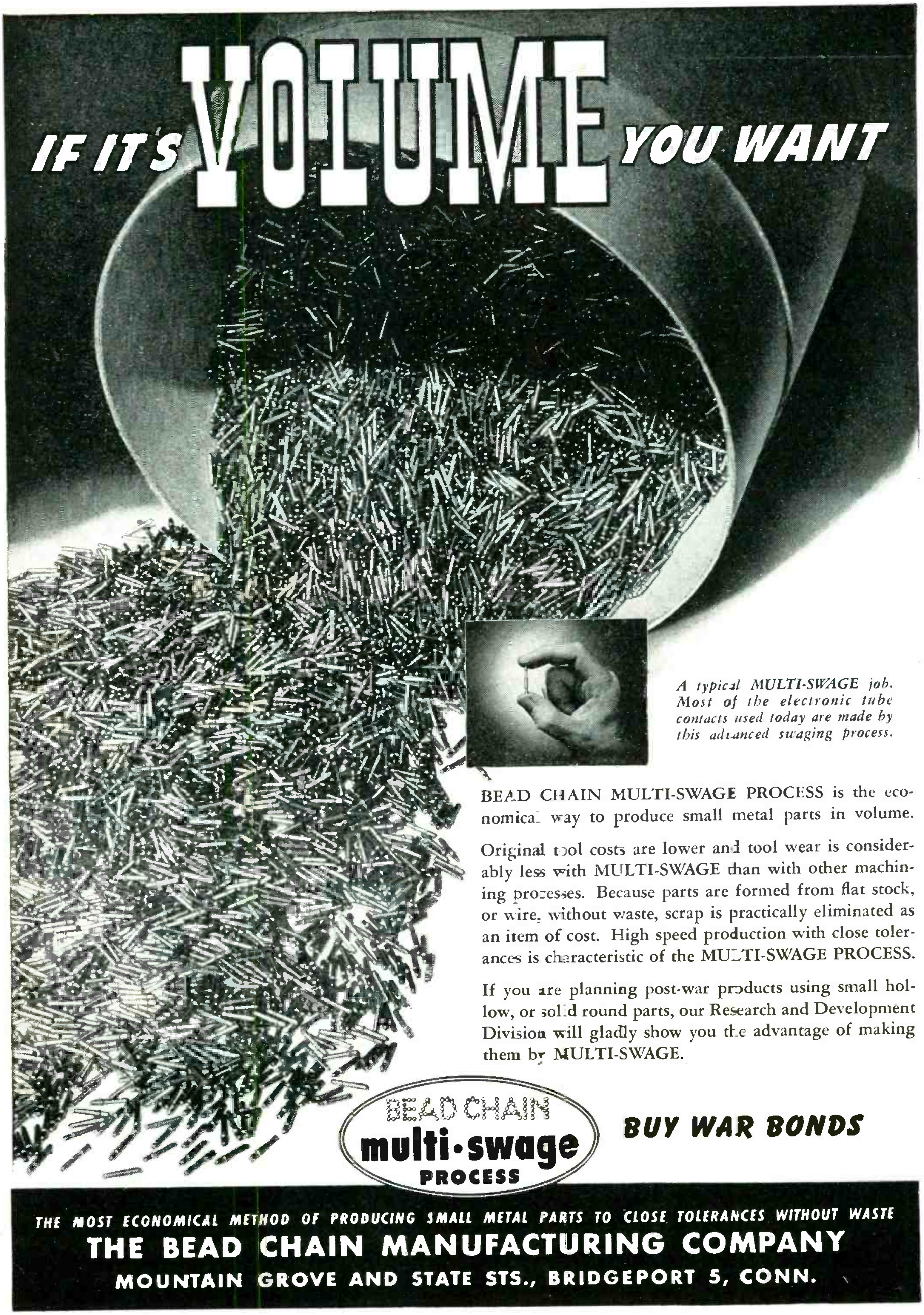
IT IS SAID that no chain can be stronger than its weakest link, and this is equally true of a rectifier. All three magnetic components are important, and the design of each should be coordinated to the other two units for best results. AmerTran Plate Transformers, Reactors and Filament Transformers, operating together, insure optimum overall performance.

These economical dry type, self-cooled units are wound and treated to withstand wide climatic changes and operating conditions. Adequate insulation — well above minimum requirements — and rugged construction provide trouble-free operation. Compound-filled, adequate bushings, electrostatic shields, are a few items of construction that denote the high quality of these units. The three components are designed to meet all the usual, and some of the unusual, requirements common to such applications.

AMERICAN TRANSFORMER COMPANY
178 Emmet Street, Newark 5, New Jersey

AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.


IF IT'S VOLUME YOU WANT
A typical MULTI-SWAGE job. Most of the electronic tube contacts used today are made by this advanced swaging process.
BEAD CHAIN MULTI-SWAGE PROCESS is the economical way to produce small metal parts in volume.
Original tool costs are lower and tool wear is considerably less with MULTI-SWAGE than with other machining processes. Because parts are formed from flat stock, or wire, without waste, scrap is practically eliminated as an item of cost. High speed production with close tolerances is characteristic of the MULTI-SWAGE PROCESS.
If you are planning post-war products using small hollow, or solid round parts, our Research and Development Division will gladly show you the advantage of making them by MULTI-SWAGE.
BEAD CHAIN multi·swage PROCESS
BUY WAR BONDS
THE MOST ECONOMICAL METHOD OF PRODUCING SMALL METAL PARTS TO CLOSE TOLERANCES WITHOUT WASTE
THE BEAD CHAIN MANUFACTURING COMPANY
MOUNTAIN GROVE AND STATE STS., BRIDGEPORT 5, CONN.

Safety Zone

FREE FROM THE BLACK HAND OF ELECTRO-CHEMICAL CORROSION

UNLIKE many dielectrics, Lumarith (cellulose-acetate base), when in contact with current-carrying copper wire, remains unaffected in the presence of moisture, and does not promote corrosion of the wire. In foil and film, it is used as an extra covering for bobbins and spools and as between-layer insulation in wire-wound coils—wherever the black hand of corrosion threatens.

A-78 finished Lumarith foil—matte-surfaced on one side—eliminates the need of talc or lubricants required by ordinary foil when it is slit and wound into cops. A-78 finished foil has good elongation—making it ideal for use in automatic machinery. You are invited to write for booklet of facts about Lumarith plastics and their special electrical applications. Celanese Celluloid Corporation, *The First Name in Plastics*, a division of Celanese Corporation of America, 180 Madison Avenue, New York City 16. *Representatives:* Cleveland, Dayton, Philadelphia, Chicago, St. Louis, Detroit, Los Angeles, Washington, D. C., Leominster, Montreal, Toronto, Ottawa.

LUMARITH PLASTICS IN FILM . . . FOIL . . . MOLDING MATERIALS AND OTHER FORMS

LUMARITH*

A CELANESE* PLASTIC

*Reg. U. S. Pat. Off.

When she drops her nickel in the juke box, she never thinks about the motor that turns the table or changes the records. All she wants is her money's worth, in music.

How dependably she gets it rests largely on the small motors that furnish the power. If they're "*Smooth Power*", neither she nor the maker of the juke box need worry.

THE GENERAL INDUSTRIES COMPANY

G I

Smooth Power

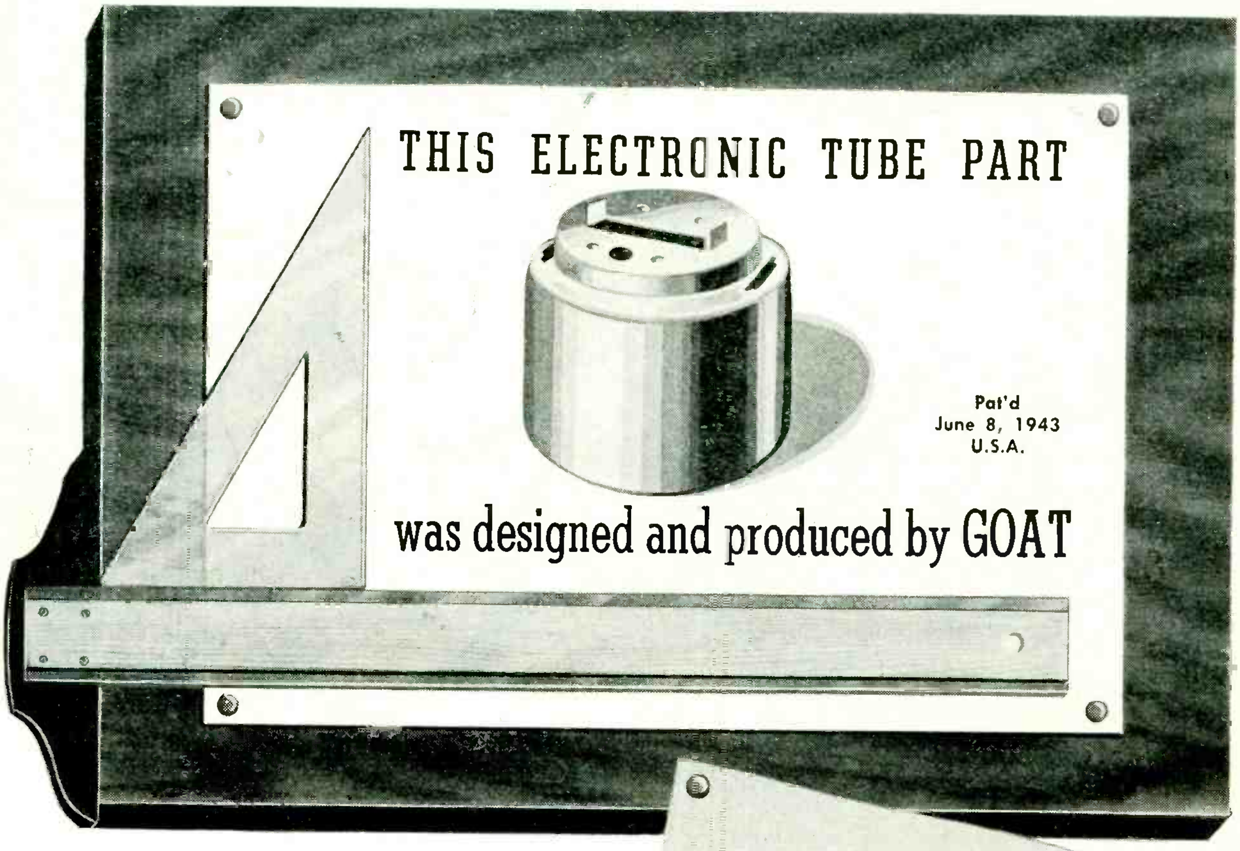
"*Smooth Power*" motors start instantly, attain speed quickly and run as smooth as silk.

We've been making these powerful, compact motors for years. They're driving such varied devices as record changers, tape recorders and intricate control systems. Whatever type of service they're doing, you can be sure they answer promptly to every order.

Right now, War demands take all of our manufacturing capacity. But our engineers have time available to study your present or future needs, and make suggestions for the right "*Smooth Power*" motor for your particular job. Let's talk it over.

THE GENERAL INDUSTRIES COMPANY
Elyria Ohio

INGENUITY?



Since the days of radio infancy GOAT has been able to meet the demands for greater quality, durability and quantity production. Throughout the years, GOAT has proved its ability to design and handle tough jobs requiring skill, precision and efficiency. Today GOAT serves almost every electronic tube manufacturer with a tremendous variety of stock and special parts made of any metal to any specified degree of accuracy.

GOAT METAL STAMPINGS, INC.

A DIVISION OF THE FRED GOAT CO., INC...EST. 1893

314 DEAN STREET • BROOKLYN, N. Y.

The Sta-Kon* Way

FOR rapid, permanent installations of STA-KON Pressure (Solderless) Wire Terminals, correctly engineered T&B STA-KON Tools are indispensable. • All T&B Tools are quick and easy to operate. • There are different models for whichever type of power you prefer: manual, air, hydraulic or electric. • In fact, the STA-KON Way has been called the speed way of assembly line production by many electronics manufacturers who have changed over from solder. • The electrical joint made by the staking tool is vibration and corrosion proof and is today performing on fractional current, high frequency circuits. • STA-KONS are made in hundreds of shapes and wire capacities, with and without Insulation-grip. • Under the T&B Plan, STA-KONS and STA-KON Tools are sold only through T&B Distributors, who reduce the manufacturer's selling costs, thereby reducing the cost of all electrical equipment to the user.

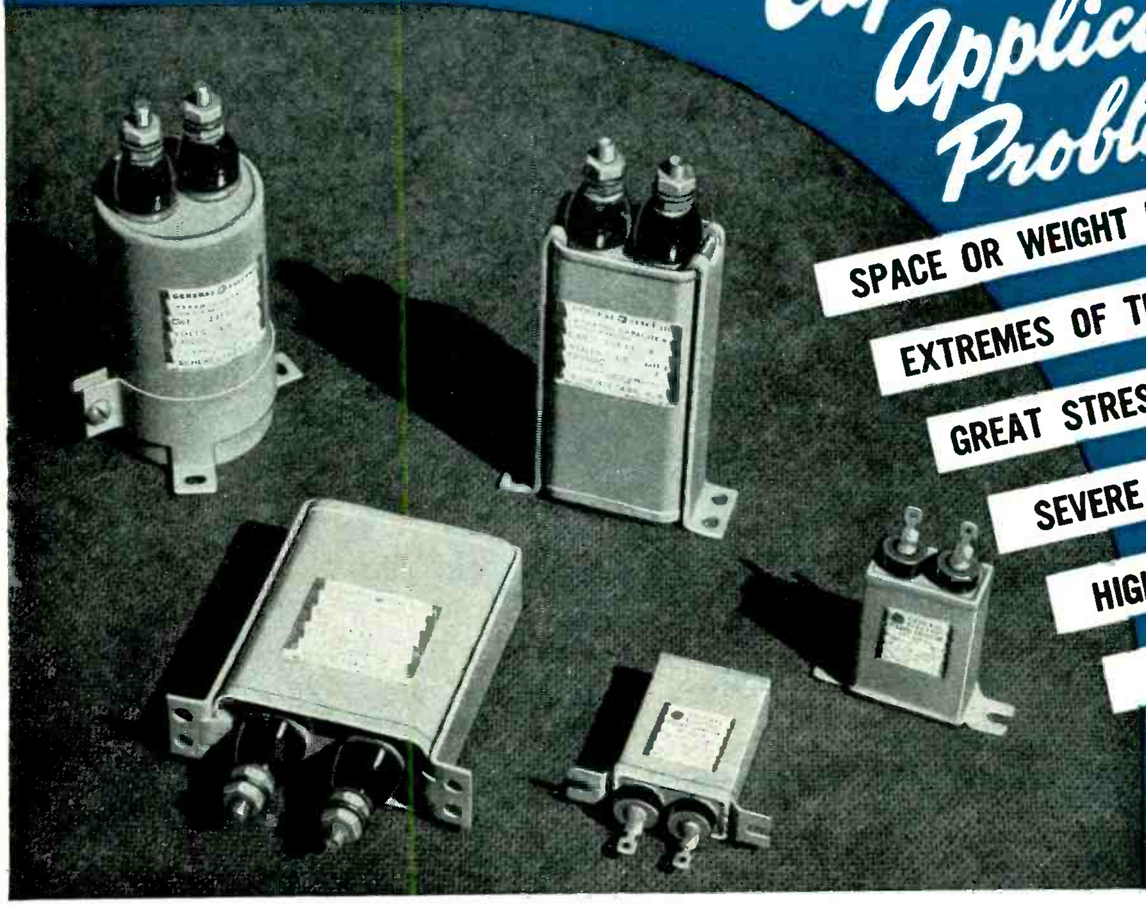
WRITE FOR ILLUSTRATED STA-KON BULLETIN 500

* Patented STA-KON: Reg. U. S. Pat. Off.

THE THOMAS & BETTS CO.
INCORPORATED
MANUFACTURERS OF ELECTRICAL FITTINGS SINCE 1899
ELIZABETH 1, NEW JERSEY
In Canada: Thomas & Betts Ltd. Montreal

E Flag awarded April, 1943
White Star awarded October, 1943

HAVE YOU ANY OF THESE *Capacitor Application Problems?*



- SPACE OR WEIGHT LIMITATIONS
- EXTREMES OF TEMPERATURE
- GREAT STRESS OR SHOCK
- SEVERE VIBRATION
- HIGH ALTITUDE
- HUMIDITY

Whatever your specifications, we're likely to have the answer

WE are in an excellent position to provide you with hermetically-sealed capacitors for wartime applications. Our extensive engineering, research, and manufacturing facilities are at your service.

In some cases there will be no need to look further than our standard line of Pyranol* capacitors for built-in applications.

The line includes more than 350 ratings in space-saving shapes and sizes. Many of the ratings are available in three shapes—oval, cylindrical, rectangular—to make your design problems easier. And they can be mounted in any position.

BE SURE TO GET your copies of our time-saving catalogs on d-c (GEA-2621A) and a-c (GEA-2027B) types. Ask your G-E representative for them by number, or write to General Electric, Schenectady, New York.

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

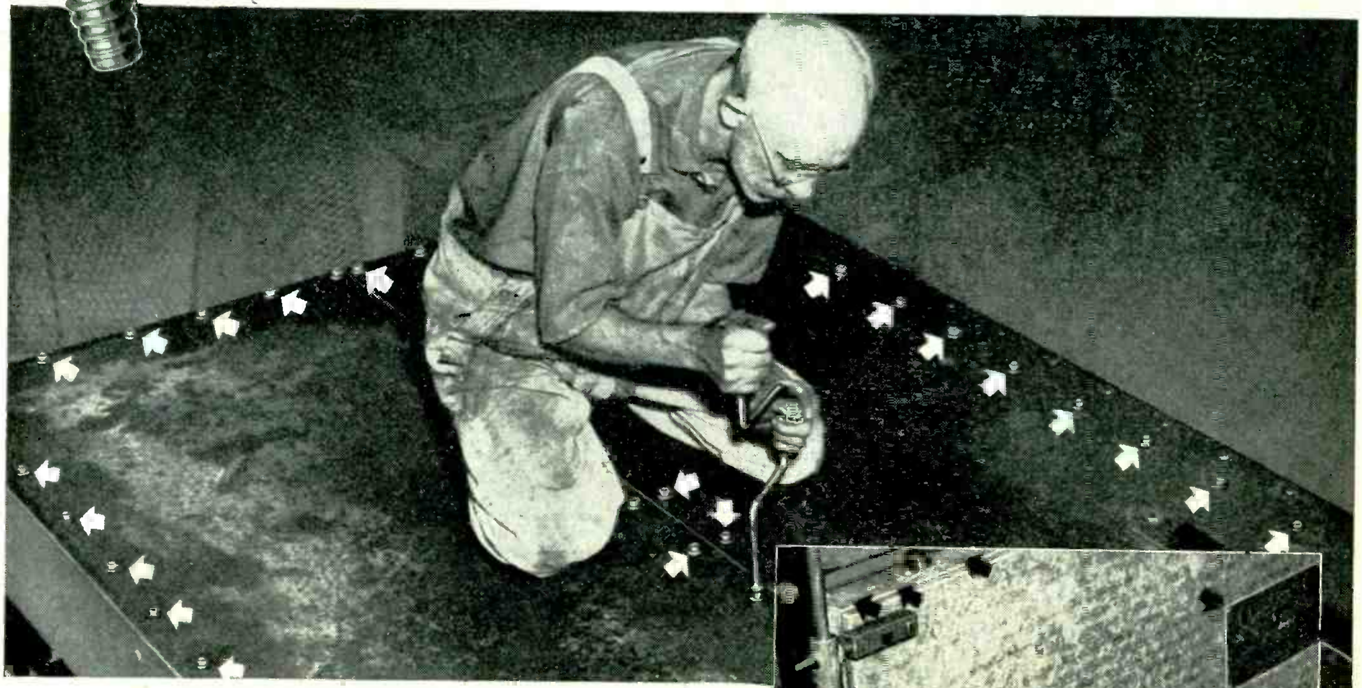
BUY WAR BONDS

PYRANOL CAPACITORS

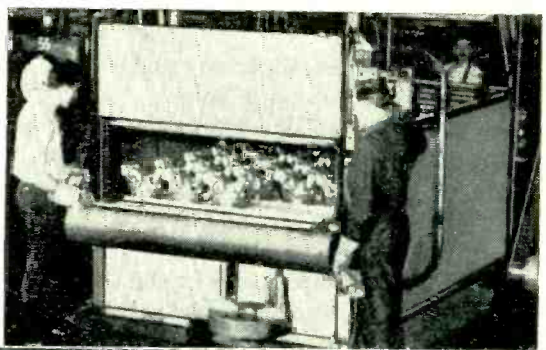
GENERAL ELECTRIC

407-60-5700

..."it Relieves Our Manpower Shortage"



Ample Holding Power for Heavy Assemblies. The Gehnrich Corp., Long Island City, N. Y., uses P-K Type "Z", Hex Head Cap, and Type "A" Self-tapping Screws for a large number of fastenings in heavy units (one oven door weighs 1500 pounds), evidence of dependable holding power. P-K Screws fasten: the 1/8 in. steel cover plate to the 3/6 in. angle iron frame of oven door; the 1/4 in. steel frame to oven; the asbestos door-seal; the base pan to the front panel; the name plate to door. Below, a Gehnrich oven heat-treating airplane engine cylinder heads.

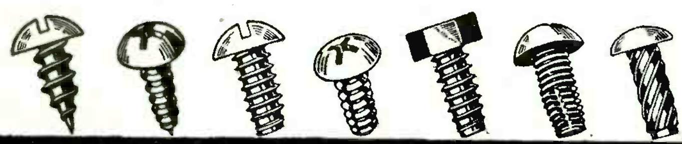


With the *Simplest* Fastening method... P-K Self-tapping Screws... Gehnrich spreads scarce Manpower further!

"Especially in times like these," says a Gehnrich Corporation executive, "with the shortage of labor so severe, we appreciate the simplicity which Parker-Kalon Self-tapping Screws bring to assembly work. If we had to tap holes and put up with tap breakage and maintenance as we once did with machine screws, we would probably have to divert manpower from other vital production, or take much longer to do a given assembly job."

Hundreds of concerns, like this well-known maker of industrial ovens and dryers, are finding that the P-K Self-tapping Screws which they adopted to cut costs in peacetime, are an important help in meeting the rush schedules of war. The simplicity of making fastenings with Self-tapping Screws means that fastening work gets done from 25 to 50 percent faster . . . releasing men for other duties. It means that "green hands" can equal the performance of experienced assembly workers.

Question every fastening job . . . on the drafting board . . . in production. In 7 out of 10 cases you'll find that P-K Self-tapping Screws will save operations . . . salvage vital man-hours . . . speed production . . . cut costs. At your request, a P-K Assembly Engineer will call and help you uncover all opportunities to apply this simplest fastening method. Or, send details of your assembly for recommendations. Parker-Kalon Corporation, 192-194 Varick Street, New York 14, N. Y.

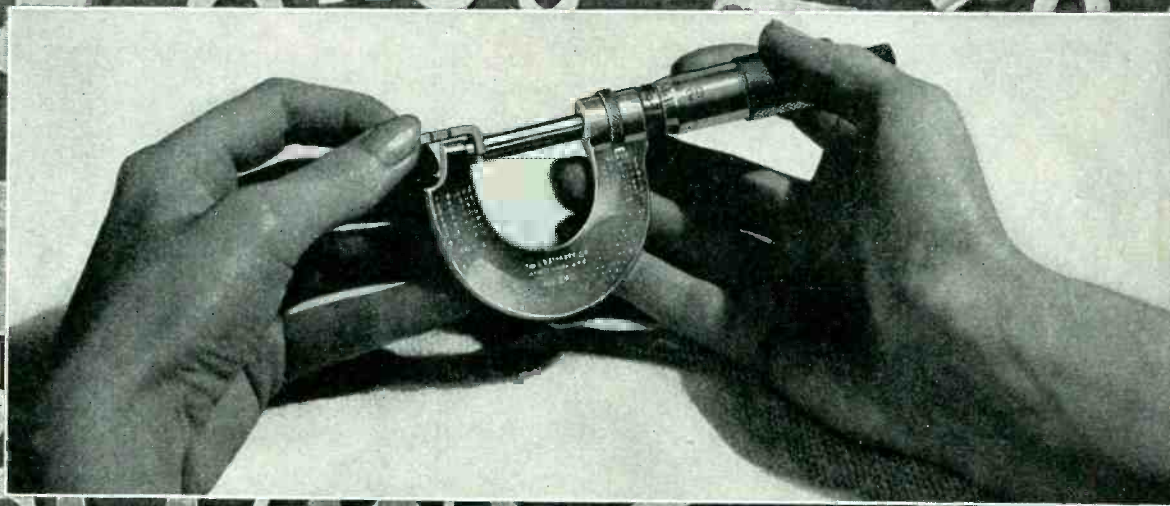


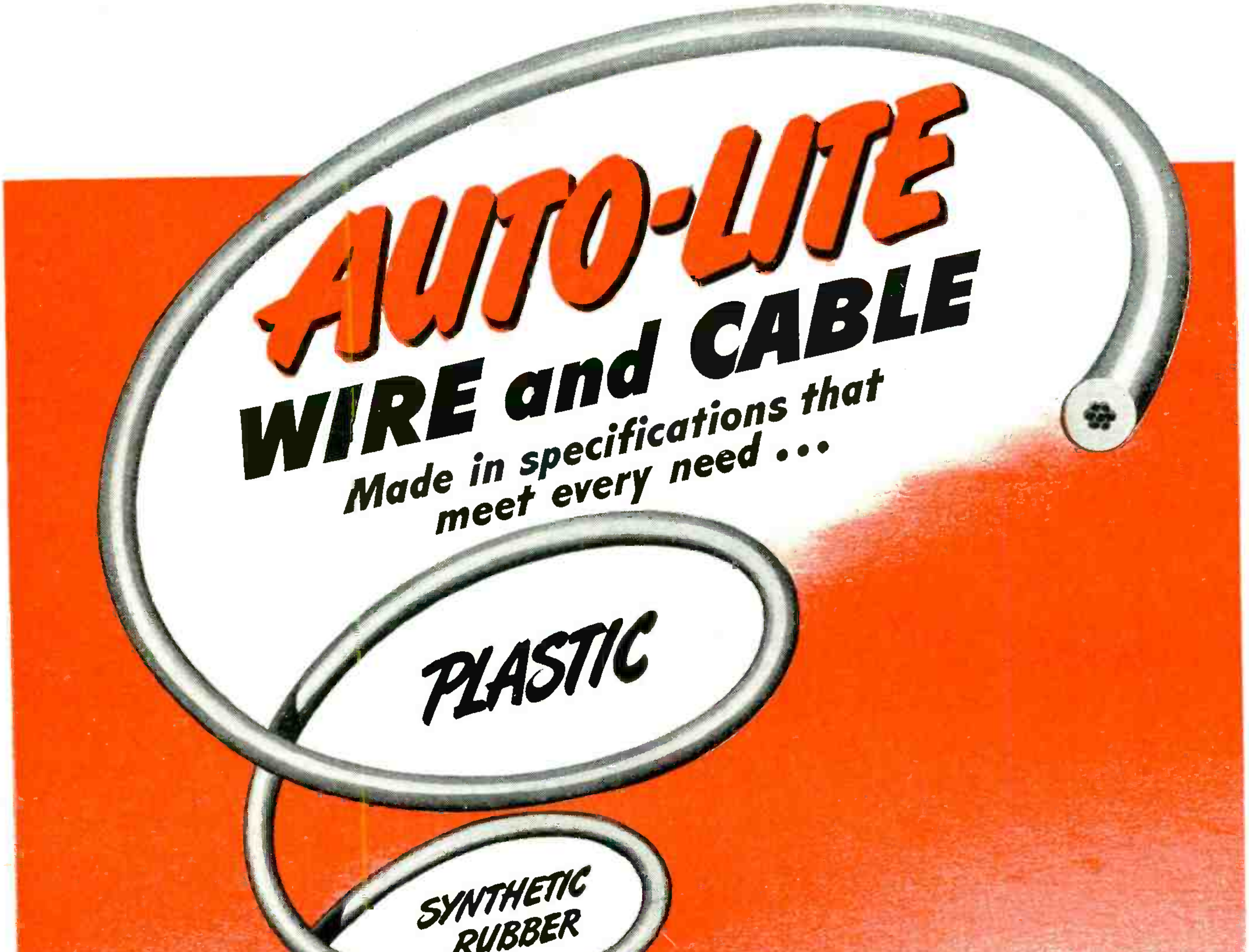
SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

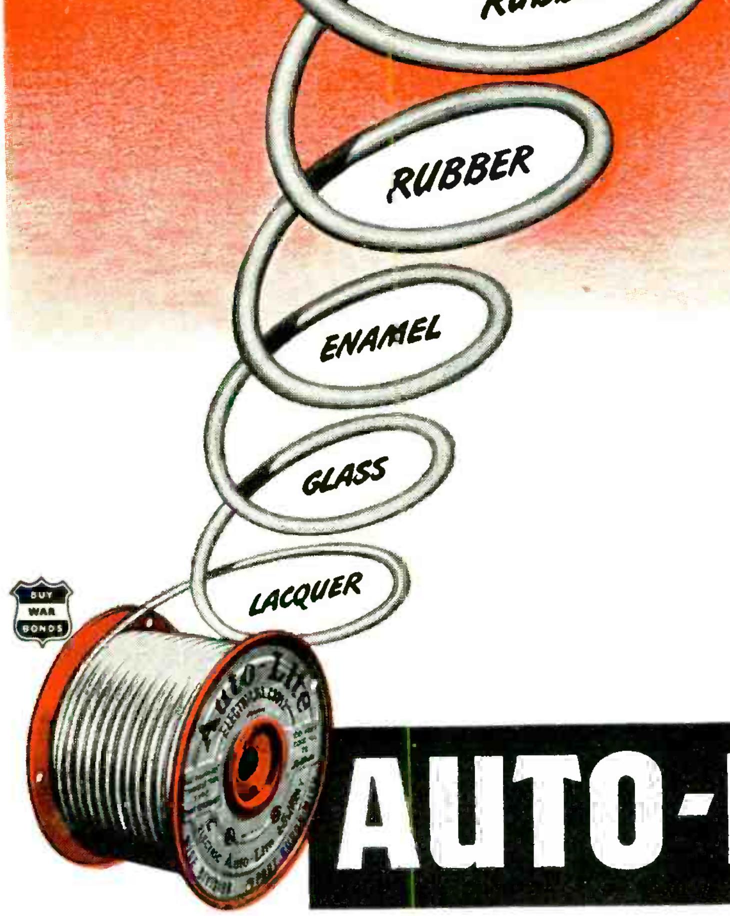
PARKER-KALON

Quality-Controlled

SELF-TAPPING SCREWS







Auto-Lite Wire and Cable can meet the electrical need of your product. Wire is supplied in a full range of sizes, shapes and materials. Insulations of all types are available including special developments like Auto-Lite's Vega Chromoxide Enamel, an insulation of decided advantage where resistance to heat is of paramount importance.

Equally revolutionary advances in other types of wire and cable have helped manufacturers perfect products with increased heat resistance, improved performance characteristics...and often at decided savings in cost.

For further information on your specific problem, write to

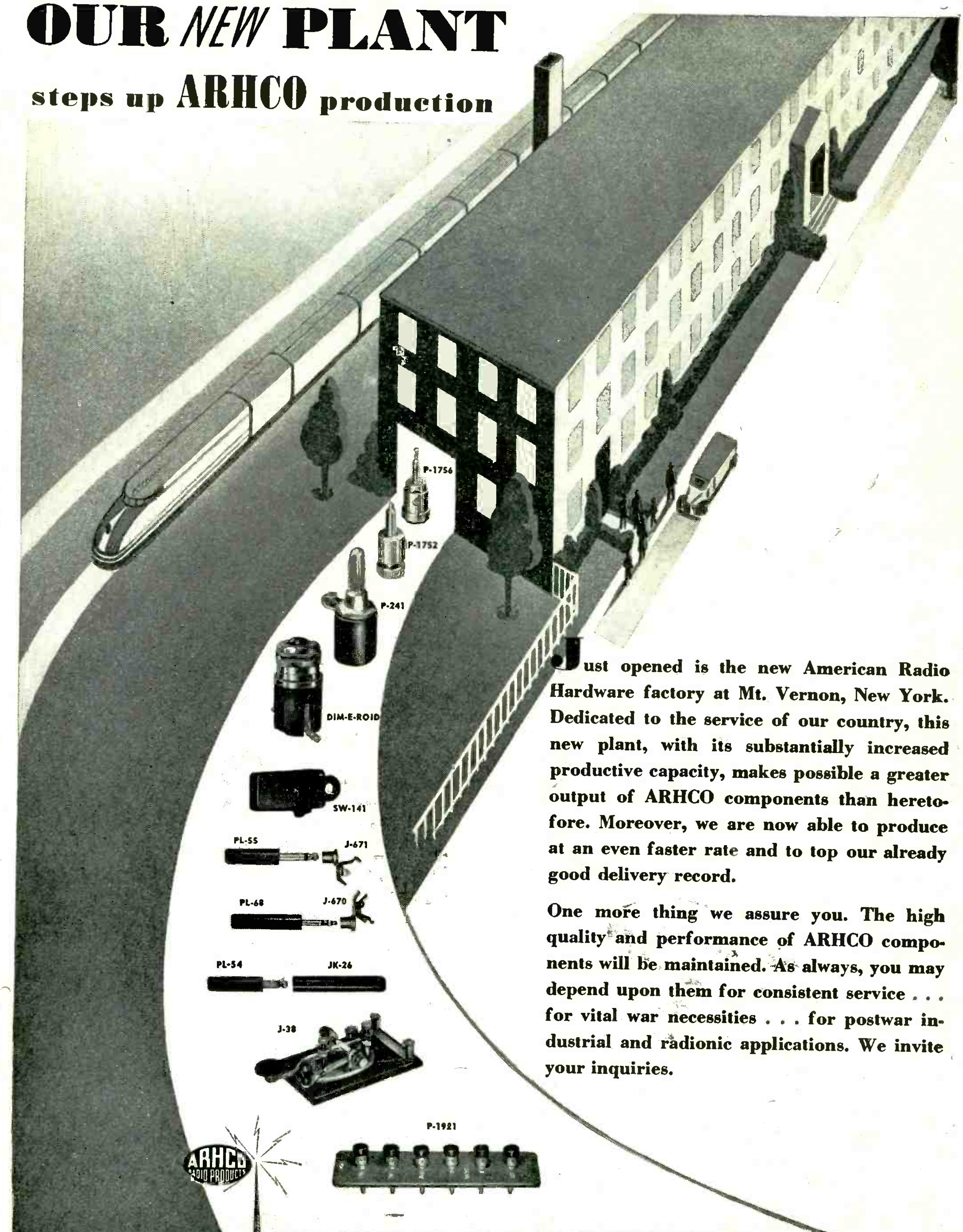
THE ELECTRIC AUTO-LITE COMPANY

SARNIA, ONT. *Wire Division* PORT HURON, MICH.

AUTO-LITE *ELECTRICAL* **WIRE and CABLE**

OUR *NEW* PLANT

steps up ARHCO production



Just opened is the new American Radio Hardware factory at Mt. Vernon, New York. Dedicated to the service of our country, this new plant, with its substantially increased productive capacity, makes possible a greater output of ARHCO components than heretofore. Moreover, we are now able to produce at an even faster rate and to top our already good delivery record.

One more thing we assure you. The high quality and performance of ARHCO components will be maintained. As always, you may depend upon them for consistent service . . . for vital war necessities . . . for postwar industrial and radionic applications. We invite your inquiries.

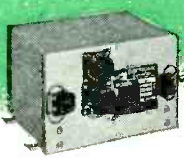
American Radio Hardware Co., Inc.

152-4 MacQuesten Parkway South, Mount Vernon, N. Y.

MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT

How BIG

This E·L Power Supply (Model S-1374) is a high-powered unit, putting out 750 volt-amperes. Input voltage is 115 volts DC, and output voltage is 115 volts, 60 cycles AC. Efficiency is 70%. It weighs 50 pounds.



◄ OR HOW LITTLE

Here is a low-powered E·L Power Supply (Model S-1361). Its output power is 10 watts. Input voltage is 24 volts DC, and output voltage is 350 volts DC at 25 ma. It weighs only 5 pounds.

Can You Build a Vibrator Power Supply?

We don't know. Right now, we build them *this* big and *this* little. And the limit has not yet been reached — in either direction.

Only *E·L* VIBRATOR POWER SUPPLIES Offer All These Advantages:

1. CONVERSION—DC to AC; DC to DC; AC to DC; AC to AC.
2. CAPACITIES—Up to 1,000 Watts.
3. VARIABLE FREQUENCIES—A power supply may be designed to furnish any frequency from 20 to 280 cycles, or a controlled variable output within a 5% range of the output frequency.
4. MULTIPLE INPUTS—For example, one E·L Power Supply, in quantity production today, operates from 6, 12, 24, 110 volts DC or 110 volts AC, and 220 volts AC, with a single stable output of 6 volts DC.
5. MULTIPLE OUTPUTS—Any number of output voltages may be secured from one power supply to suit individual needs.
6. WAVE FORMS—A vibrator power supply can be designed to provide any wave form needed for the equipment to be operated.
7. FLEXIBLE IN SHAPE, SIZE AND WEIGHT—The component parts of a vibrator power supply lend themselves to a variety of assembly arrangements which makes them most flexible in meeting space and weight limitations.
8. HIGHEST EFFICIENCY—E·L Vibrator Power Supplies provide the highest degree of efficiency available in any type power supply.
9. COMPLETELY RELIABLE—Use on aircraft, tanks, PT boats, "Walkie-Talkies," jeeps, peeps and other military equipment, under toughest operating conditions has demonstrated that E·L units have what it takes!
10. MINIMUM MAINTENANCE—There are no brushes, armatures or bearings requiring lubrication or replacement because of wear. The entire unit may be sealed against dust or moisture.

Increasing wattage limitations from 100 up to 1,000 in two years is no accident. It is the result of many years' specialization in the technique of vibrator power supplies, and the most extensive research ever conducted on power supply circuits.

For radio, lighting, communications, and other current needs, *E·L* Power Supplies will bring you a dependability and service life far beyond anything we would have dared prophesy even a few years ago. This is being proved every day, all over the world, under the toughest operating conditions of war.

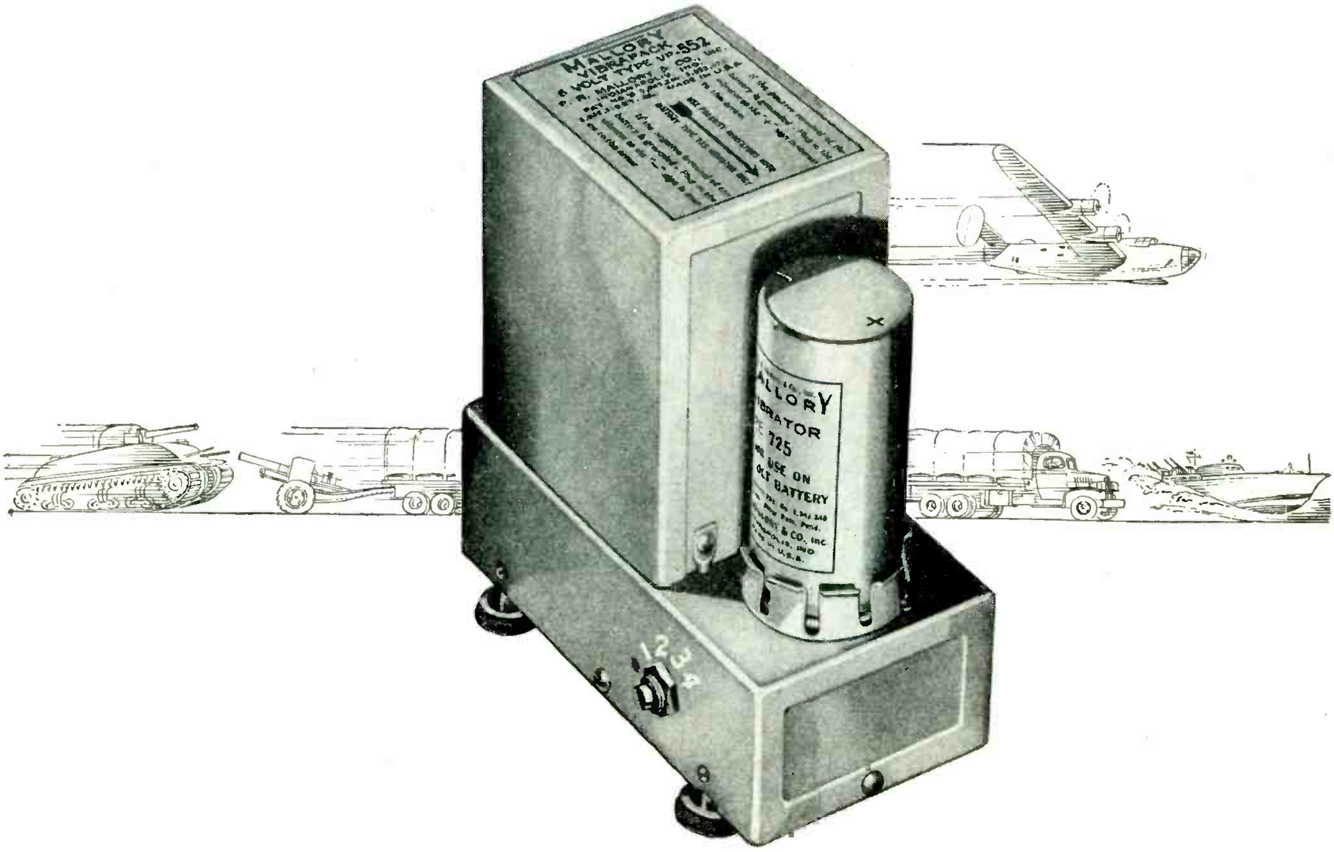
No matter what your power supply problem may be—whether it's primarily one of size . . . weight . . . input . . . output . . . efficiency . . . or whatever—the chances are that *E·L* engineers will be able to provide you with the best solution.

Electronic LABORATORIES, INC.

INDIANAPOLIS

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

Our Wartime Worries Are Your Peacetime Profits



This fast-moving mechanized war is a terribly exacting proving ground. It often crowds into a few hours the normal wear of months and years.

Take vibrator power supplies, for instance. They take a lot of punishment going over rough terrain in tanks and trucks. The stress and strain of operating in dive bombers is almost unbelievable. And in all instruments of war—from planes, to boats, to submarines—they are subject to extremes of temperature and atmospheric pressure as widely different as our far-flung battle lines.

To build vibrator power supplies to master these conditions involved many an engineering headache. But, by new designs and constructions, by better materials and imaginative experiments, Mallory succeeded in building them.

**Vibrapack is the registered trademark of P. R. Mallory & Co., Inc., for vibrator power supplies.*

Today they serve on land and sea—above the clouds and below the waves—thoroughly tested, and completely dependable.

Born in the crucible of war, these same Mallory Vibrapacks* are ready to further your peacetime profits tomorrow. Write us about your application requirements.

MALLORY "Know How" Serves Your Vibrator Needs

Fully protected against corrosive fumes, extremes of atmospheric pressure and moisture-laden air, Mallory hermetically-sealed vibrators operate under ideal conditions for economy and long life.

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

It's Your War Too—Buy Bonds and Stamps

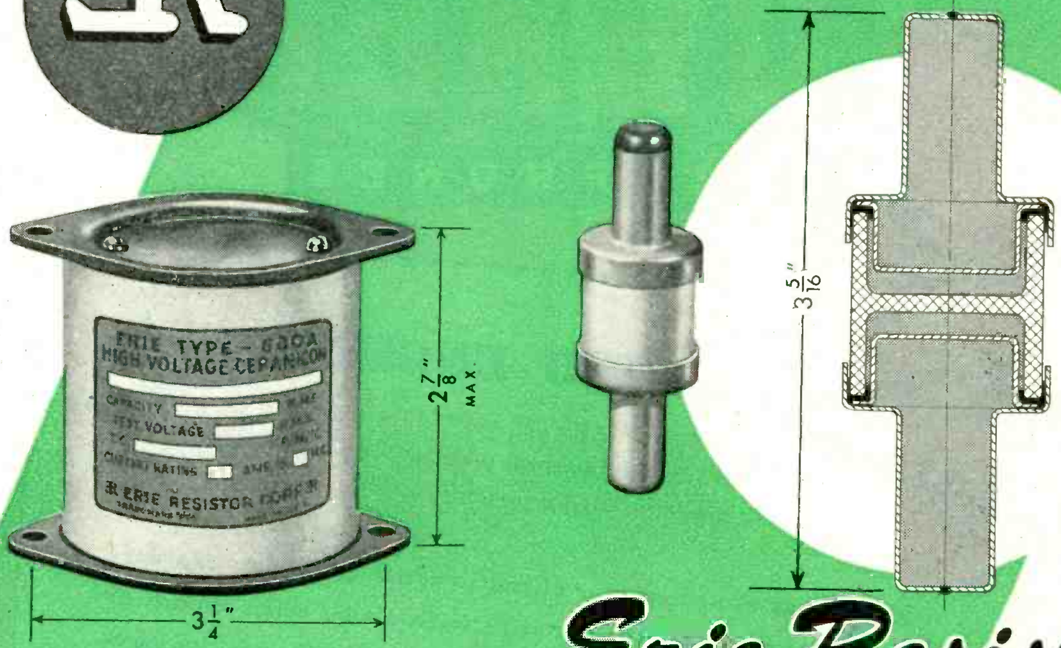
P.R. MALLORY & CO. Inc.

MALLORY VIBRATORS AND VIBRATOR POWER SUPPLIES

Ceramicon Designs

REG. U.S. PAT. OFF.

FOR HIGH VOLTAGE AND HIGH KVA APPLICATIONS



PIONEERED BY Erie Resistor

THE two condensers illustrated above are examples of two basic ceramic condenser designs developed by Erie Resistor for high voltage, high KVA applications.

Shown at the left is the Erie Type 680A transmitting condenser that is designed for 6000 volts RMS test voltage. This unit consists essentially of a number of silvered ceramic discs, each having the well known stability and temperature retrace characteristics of compensating Ceramicons, and in addition are designed to safely withstand high voltages required in this type of condenser.

The Antenna Coupling Ceramicon illustrated at the right employs the double cup design originated by Erie Resistor. In developing this unit Erie engineers successfully overcame the problems of eliminating corona and dissipating internal heat while retaining small size and simplicity of design. The specifications of this condenser, given at the right, show the high degree of perfection it has now reached.

Erie Resistor is working further on the development of similar Ceramicon designs for other applications. If you have a condenser problem connected with present day equipment, or for postwar applications involving high voltage, high KVA units, we would like to discuss Erie Ceramicons with you. Our wide experience, beginning in 1935 with the first development of ceramic condensers in this country, gives us a comprehensive background on which to base recommendations.

CHARACTERISTICS

Left: Type 680A Transmitting Ceramicon Maximum capacity 400 MMF in zero temperature coefficient, 2000 MMF in -750 P/M/°C. 10,000 volts D. C. test voltage.

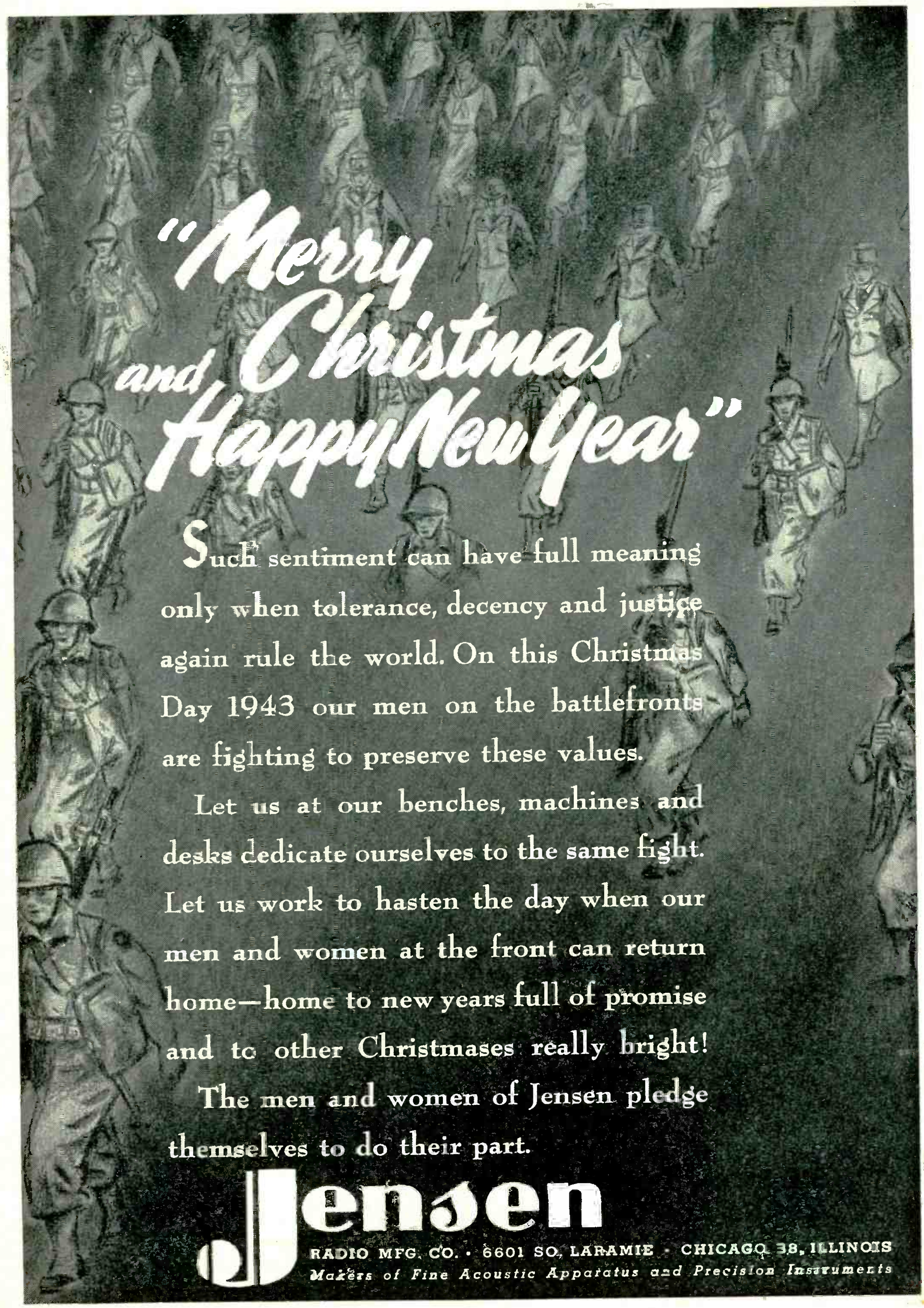
Right: Erie Antenna Coupling Condenser: Maximum capacity 50 MMF in zero, 250 MMF in -750 P/M/°C temperature coefficient. Typical rating in zero coefficient, maximum R. F. current 3 amps at 3 MC and 5 amps at 9 MC at 65°C. Test voltage 6000 volts D. C.

ARMY E NAVY

FOR HIGH ACHIEVEMENT IN WAR PRODUCTION

Back The Attack—With War Bonds

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

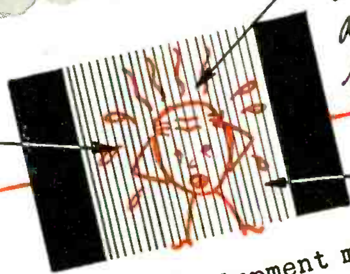

"Merry Christmas and Happy New Year"
Such sentiment can have full meaning only when tolerance, decency and justice again rule the world. On this Christmas Day 1943 our men on the battlefronts are fighting to preserve these values.
Let us at our benches, machines and desks dedicate ourselves to the same fight. Let us work to hasten the day when our men and women at the front can return home—home to new years full of promise and to other Christmases really bright!
The men and women of Jensen pledge themselves to do their part.
Jensen
RADIO MFG. CO. • 6601 SO. LARAMIE • CHICAGO 38, ILLINOIS
Makers of Fine Acoustic Apparatus and Precision Instruments

MEMO TO J. Smith
chief engineer

RE: Heating non-metallic materials with "Cold heat"

Westinghouse Thermo-electronic equipment

Jim: this is any non-metallic material like plywood, paper, plastic etc.



electron getting batted around 10,000,000 times a second by radio frequency field — and that makes him hot!

300° F. throughout material

Jim: This Westinghouse development may be the answer to our heat-curing problems. Imagine putting stuff like plywood between two plates, and heating it uniformly to 300 deg. F. in 3 minutes, with radio waves!

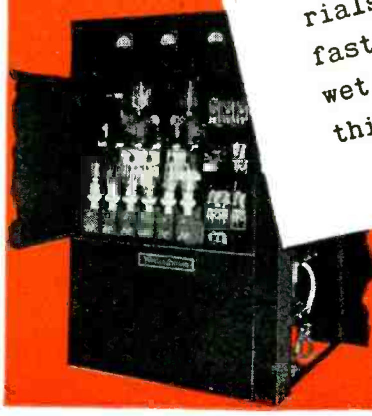
This thermo-electronic heating equipment generates heat uniformly throughout the material—like the "artificial fever" you read about. Best of all, there's no overheating of the outside surface and underheating in the center.

This cuts heating time as much as 95%, they claim, because you don't wait for heat to penetrate to the center—it's already there! This speeds up chemical reactions, too.

As I understand it, Jim, there are some limitations. Some materials with low "heat loss factor" like hard rubber just won't heat as fast as others. Size of surface and degree of dryness required from wet materials are other limiting factors. But aside from these, I think we should check into this. Why don't you give this thing a look?

Joe

J-08055



20-kw Westinghouse high-frequency unit.

For information on Westinghouse high-frequency heating equipment, write Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

Westinghouse
PLANTS IN 25 CITIES... OFFICES EVERYWHERE

Electronic Heating

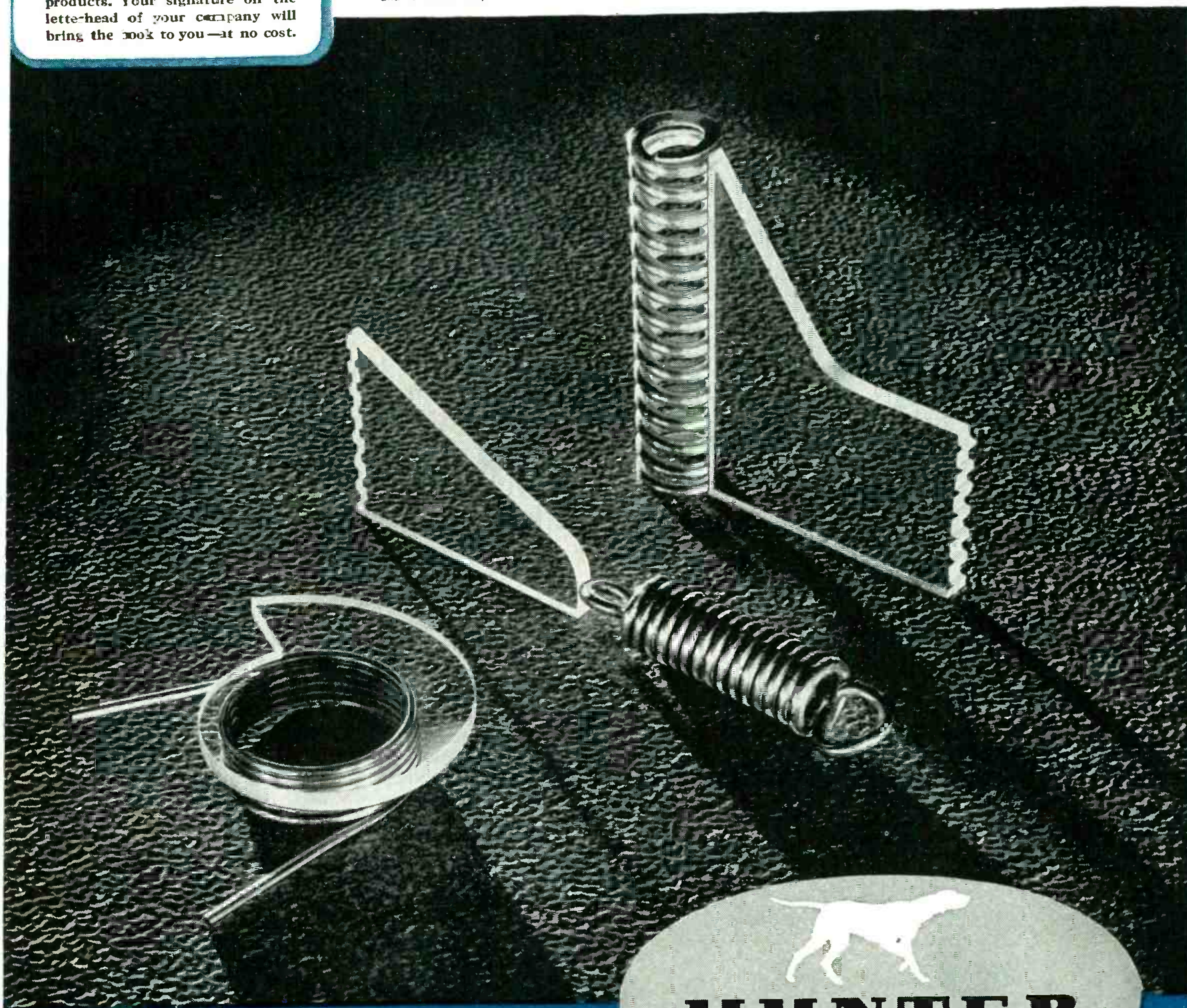
You Can't Build the Future on a Flaw!

SMOTHER THE BUMS!

Right now most copies of "Science in Springs" are being used to develop war products. The manual is filled with helpful engineering data on the design and manufacture of springs—information that can be most helpful in planning your own products. Your signature on the letterhead of your company will bring the book to you—at no cost.

THOSE PRODUCTS of yours which are being planned now to compete in a competitive future era are being planned with great care. But one flaw in the design or construction of any part of that product . . . and your plan can fail. Consider, for example, one of the smallest parts of any machine . . . a spring. You depend on that spring to do its job, yet, some people are willing to call any piece of coiled wire a spring. There's one flaw right there—a flaw that Hunter stands ready to correct. With Hunter and other good springmakers, the design and construction of a spring to do the job calls for an engineer's mind and experience, for knowledge of mathematics, chemistry, metallurgy, research, testing and inspection. It may involve the conception of new research instruments, or a detailed report like the one which Hunter prepared to cover the design and performance of a mechanism and a spring, the spring weighing only .000053 lb. These are some of the reasons why your springs, at least, *will* perform—if Hunter designs or makes them . . . why they won't let you down.

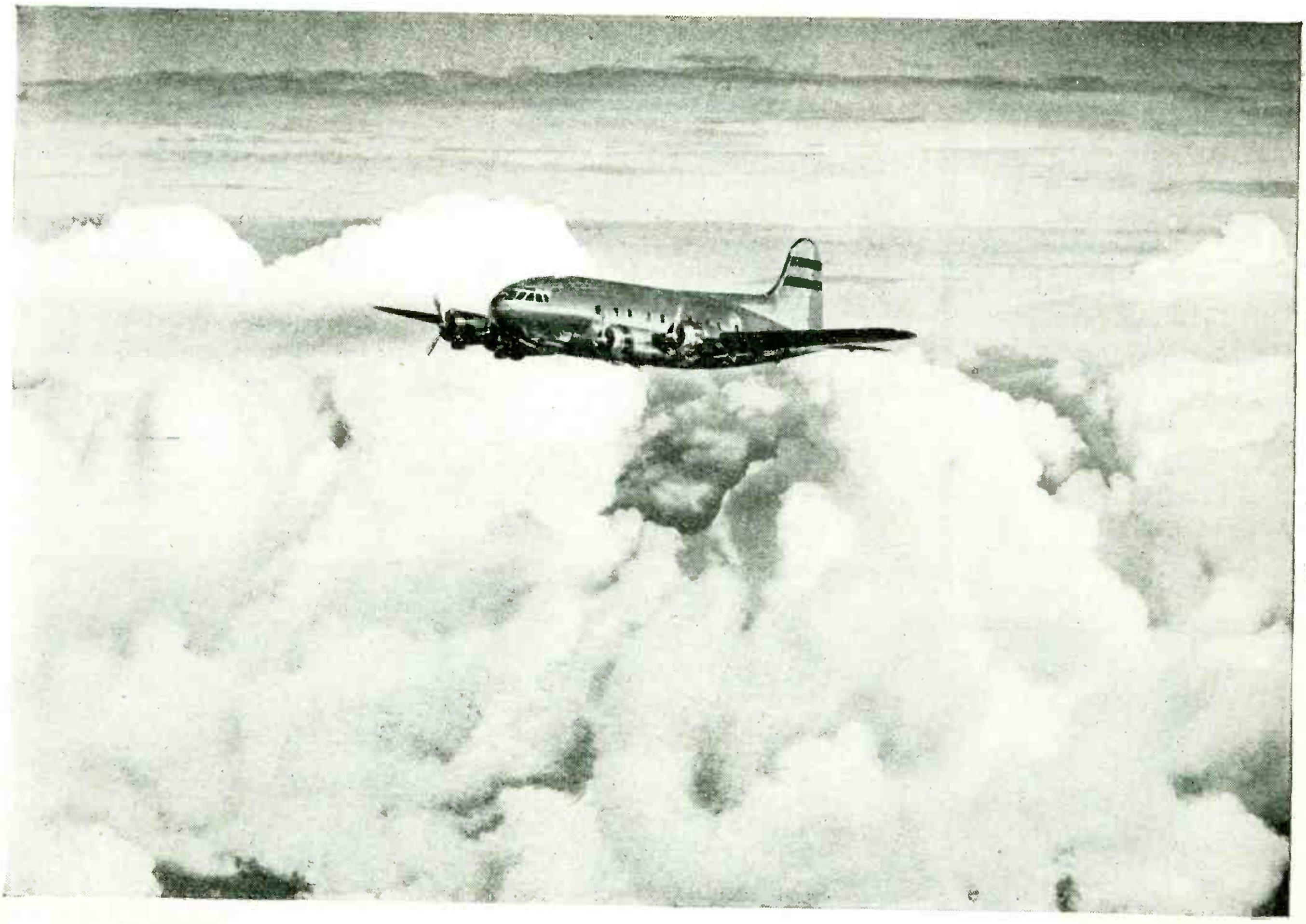
FORCE DEFLECTION CHARACTERISTICS OF 3 BASIC TYPES OF SPRINGS *In designing springs (in this case an extension, a compression, and a torsion spring) Hunter has long recommended the drawing of a pressure diagram in order to record the specifications graphically, and to reveal simple errors which may represent serious faults in performance. The force deflection characteristics of these three springs are represented by the plexiglass curves. Note that in the case of the torsion spring, a polar diagram is represented instead of the usual linear diagram commonly employed. Construction and use of these diagrams are explained in detail in the Hunter Data Book.*



HUNTER

Science in Springs

HUNTER PRESSED STEEL COMPANY, LANSDALE, PENNA.



ARMY E NAVY

"...A SYMBOL of CONTRIBUTION to AMERICAN FREEDOM..."

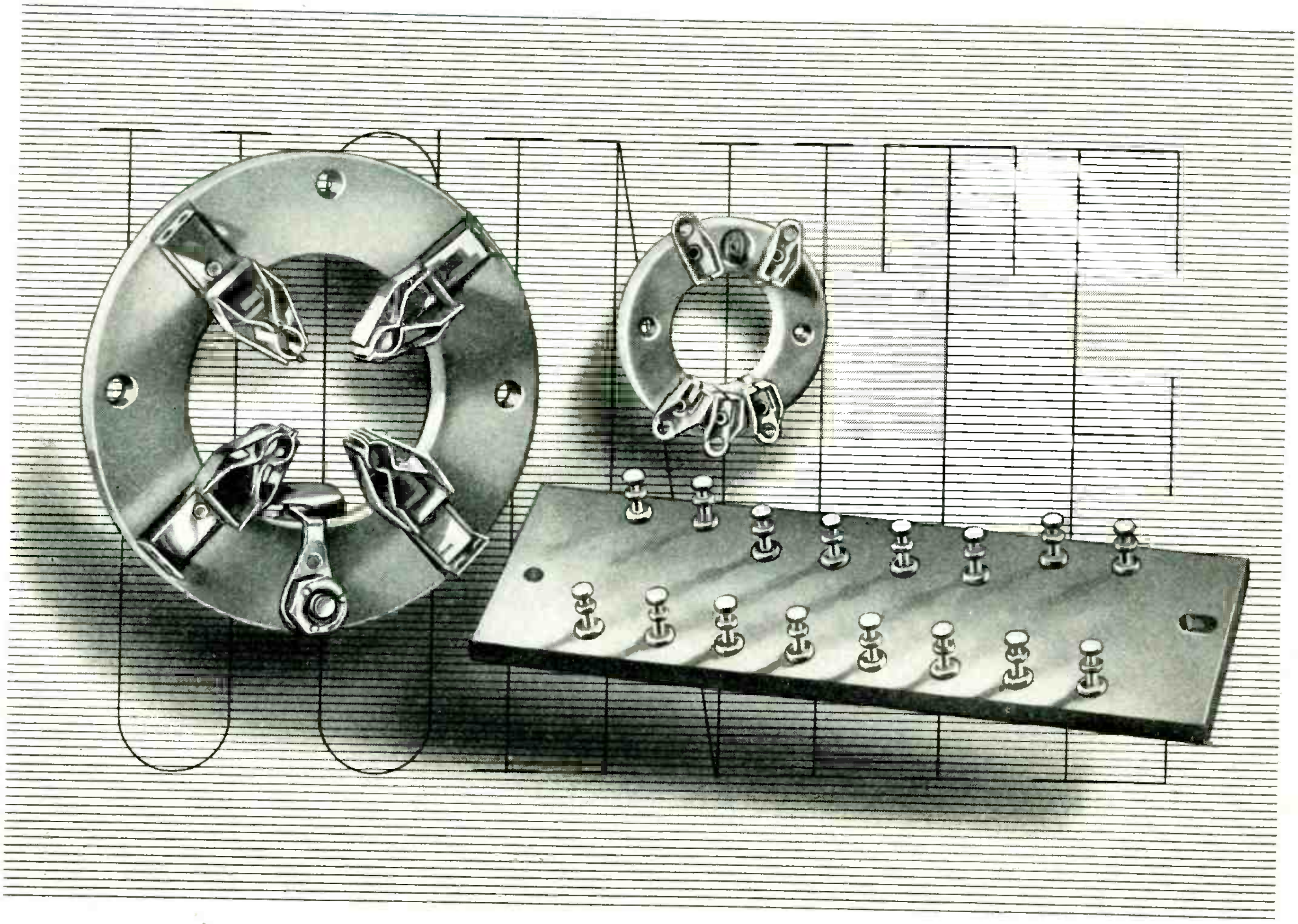
LAURELS HAVE BEEN WON!
WE SHALL NOT REST ON THEM . . .

Bestowal of the coveted ARMY-NAVY Production Award upon ELECTRONIC ENTERPRISES conveys to us a solemn sense of responsibility. The power transmitting and rectifying tubes that we produce—glistening magic bottles of glass and metal—these are the vocal cords of the voice of freedom. We are determined that for your sake and for our own sake these voices shall ring loud and clear. Our accomplishments will increase. The high quality—the rugged, precise construction of these electronic components will be maintained while at the same time production soars to ever higher levels. In planes and tanks and on the battle wagons E-E electronic vacuum tubes shall continue to serve their country well.

ELECTRONIC e ENTERPRISES

ELECTRONIC ENTERPRISES • INC

GENERAL OFFICES: 65-67 SEVENTH AVENUE, NEWARK, 4, N. J. — EXPORT DEPT. 25 WARREN STREET, NEW YORK CITY, N. Y., CABLE ADDRESS: SIMONTRICE, N. Y.



Rings, Octals, Flats

Ceramic sockets are a specialty of ours. We know all about them, from long experience. Ring mounts, octal mounts and flat types of many kinds and sizes go through the assembly lines at Ucinite on a streamlined schedule.

We do our own fabricating of metal parts, plating, heat-treating and assembling . . . all under one roof and one management. And if you want us to start from scratch and produce a new design, we have the engineering talent to do that, too. Ucinite offers you the kind of planning and production that can relieve you of many a connector problem so that you can forget about it until it's all done.

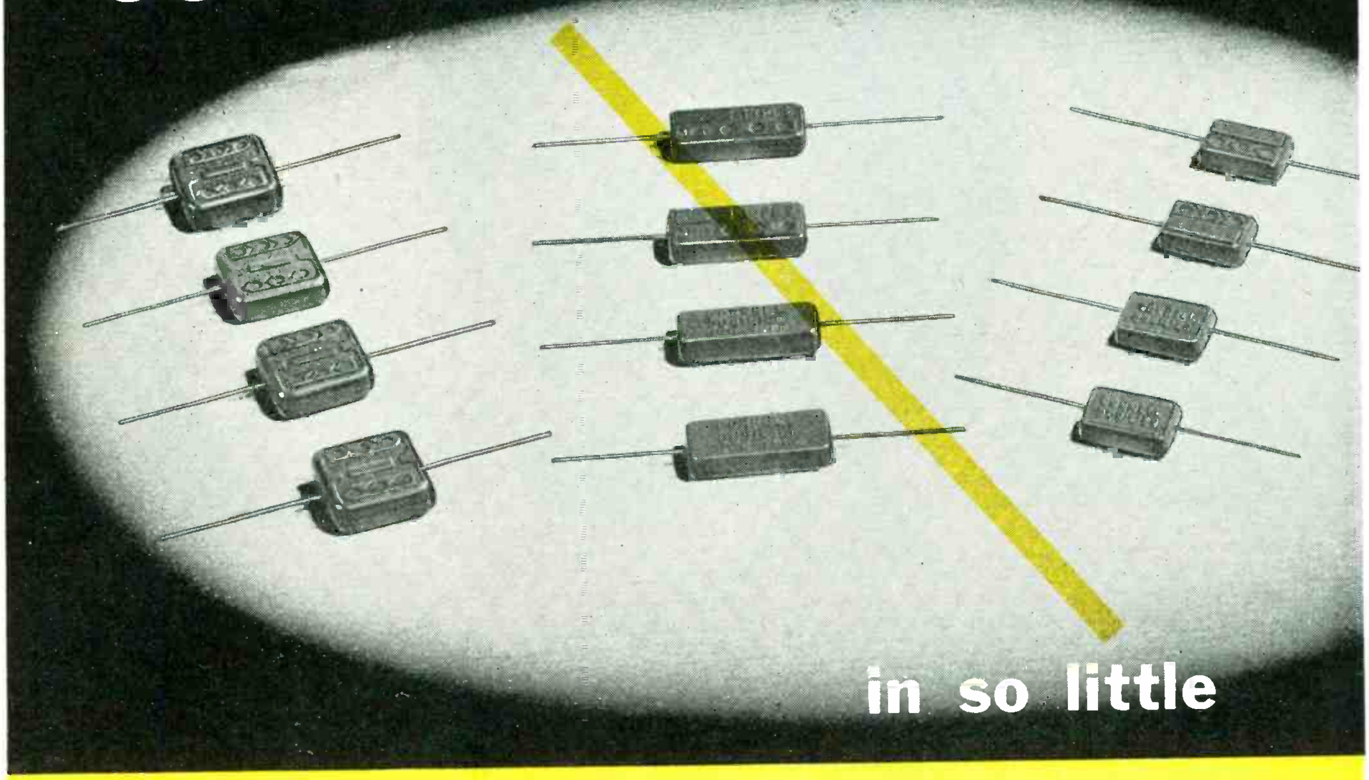
The UCINITE CO.

Newtonville 60, Mass.

Division of United-Carr Fastener Corp.

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

SO MUCH



in so little

One of the great products to come from the world's oldest and largest capacitor manufacturer is the type 1R mica capacitor—the now famous "Silver-Mike." At the other extreme of the scale from its big brothers, huge capacitors for power distribution systems, yet comparable to them in reliability of performance and in comparative life span, this tiny featherweight represents an achievement for which C-D engineers can well be proud. Type 1R is fully described in our Catalog. Cornell-Dubilier Electric Corporation, So. Plainfield, N.J.

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

TYPE 1R SILVERED MICA CAPACITORS

Suited for use in circuits where the LC product must be kept constant. Here are some of the C-D features that make 1R outstanding among silvered mica capacitors:

SILVER COATING THOROUGHLY BONDED TO MICA—Uniform and low capacity-temperature coefficient (+.002% per degree C.)—excellent retrace characteristics.

EXTRA-HEAVY SILVER COATING — Practically no capacity drift with time.

STANDARD UNITS MOULDED IN LOW-LOSS RED BAKELITE — Protection against physical damage and change of electrical characteristics —exceptionally high Q (3000 to 5000).

TINNED BRASS WIRE LEADS—Prevent breakage —easily bent in any direction without affecting characteristics of unit.

COMPLETELY WAX - IMPREGNATED — Assures excellent humidity characteristics.

Cornell Dubilier capacitors

more in use today than any other make

1910 CORNELL-DUBILIER CAPACITORS C-D 1944

MICA • DYKANOL • PAPER
WET AND DRY
ELECTROYLTIC CAPACITORS

"The difficult we do immediately, the impossible takes a little longer." —*Army Service Forces*

Electro-Voice DIFFERENTIAL MICROPHONES

Developed by our Engineering Department in close collaboration with the Fort Monmouth Signal Laboratories, and hailed as an accomplishment in the science of speech transmission, the *Differential Microphone* effectively shuts out all ambient noises and reverberation . . . permitting voice to come through clearly and distinctly . . . while rejecting the terrific din in tanks and the roar of gunfire.

In its present form, the *Differential Microphone* is produced as the T-45, a "Lip Mike," for use in battle by our Armed Forces and those of our Allies. Postwar developments will provide a variety of models with advantages that will be felt in many phases of civilian life.

- Frequency response substantially flat from 200-4000 cps.
- Low harmonic distortion
- Cancellation of ambient noise, but normal response to user's voice
- Self-supporting, to free both hands of the operator
- Usable when gas mask, dust respirator or oxygen mask is required
- Uniform response in all positions
- Unaffected by temperature cycles from —40° F. to +185° F.
- Ability to withstand complete immersion in water
- Physical strength to withstand 10,000 drops
- Weight, including harness, cord and plug, less than 2 ounces

Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC. • 1239 SOUTH BEND AVENUE • SOUTH BEND 24, INDIANA

Export Division: 13 East 40th Street, New York 16, N. Y. — U. S. A. *Cables:* ARLAB

"In recognition of Service beyond the call of duty . . ."

In this grim business of war, the men in uniform take the risks; they deserve the decorations.

We tube manufacturers don't expect medals. When, however, credit *does* come our way . . . and when it comes from such a man as Paul V. Galvin, President of RMA . . . it makes us mighty proud and happy.

"Let me take a moment for special mention of the tube engineers. Too often they are not fully recognized. We see fine accomplishments in apparatus, but we fail to appreciate the important work that has been done behind the scenes by the tube engineer. Hats off to you—your accomplishment has been most extraordinary. But you, also, you cannot as yet rest upon your oars. The job is not finished, and new and additional accomplishments are required before we are finished with this war." *

Hytron engineers realize fully that "the job is not finished", and they continue to strive for "new and additional accomplishments" needed to win the war. Their aim is to develop better tubes to make possible better fighting equiment—let the decorations fall where they may.

* Excerpt from address of Paul V. Galvin, president of the Radio Manufacturers Association at the Institute of Radio Engineers' Rochester Fall Meeting, November 9, 1943.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

HYTRON RADIO TUBES

BUY ANOTHER WAR BOND

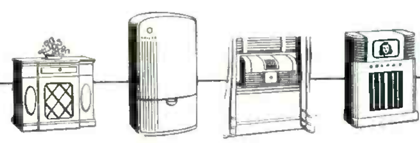
TWO-MAN TORNADO!

THE BAZOOKA . . . ANOTHER SPECTACULAR AMERICAN "SECRET WEAPON" . . . ANOTHER DRAMATIC STORY OF PHILCO AT WAR

TWO MEN AND A BAZOOKA . . . more than a match for sixty tons of steel! Yes, that's the latest story of American ingenuity and productive skill.

A single soldier carries and fires it, his teammate loads it . . . and 60 ton enemy tanks, concrete pill boxes, brick walls and bridges wither under the fire of its deadly rocket projectile. It's an amazing achievement of ordnance design, conceived and developed by the Ordnance Department of the United States Army. And it's another stirring chapter in the fascinating story of Philco at war.

The men and women of the Philco *Metal* Division, whose huge presses produce the metal parts of peacetime Philco radios, have played a leading part in the final perfection and production of the Bazooka. With their colleagues in the Philco *Radio* Division, they are turning out miracles of war equipment. After victory, their new knowledge and skill will bring you the newest achievements of modern science in radio, television, refrigeration, air conditioning and industrial electronics under the famous Philco name.



After victory Philco peacetime products will offer the highest achievements of modern science for the homes and industries of America.

PHILCO CORPORATION

utah V-NEWS

RADIO INDUSTRY NOW PRODUCES FOR WAR—BUT PLANS FOR PEACE

UTAH EMPLOYEES BREAK PRODUCTION RECORDS FOR UNCLE SAM

FRED R. TUERK

Month by month, production records have been broken as Utah has gone "all out" for Uncle Sam, according to Fred R. Tuerk, President.

He points out that experience gained during the war period will be ably utilized in efficient peacetime production.

With emphasis on quality, the dependability of Utah parts, long a by-word in the radio and sound equipment industries, will be maintained.

YOU ARE PART OF UTAH'S POSTWAR PLANS

ODEN F. JESTER

"We're working for Victory and planning for peace now," stated Oden F. Jester, Vice-President in Charge of Sales of the Utah Radio Products Company, when queried recently on Utah's postwar plans. "Our experts are hard at work, developing plans for the future—plans that take utmost consideration of the needs of industrial concerns. Better products are on the way. In the Utah laboratory rapid strides have been made in adapting new electronic and radio developments for war uses—and making them available for the requirements of tomorrow."

CARTER DIVISION IN FULL SWING FOR WAR PRODUCTION—AND POSTWAR PLANNING

FRANK E. ELLITHORPE

Frank E. Ellithorpe, Sales Manager of the Carter Division of the Utah Radio Products Company, declared in a recent interview that Utah Jacks, Switches, Vitreous Enameled Resistors, Plugs, Wirewound Controls and other Utah-Carter parts are seeing service on wide fronts—in the air, on the sea and on the ground. They are playing an important part in adapting the new electronic and radio developments—in making them militarily and commercially usable.

Mr. Ellithorpe went on to state that Utah-Carter parts are proving that the engineering which created them and the manufacturing methods which are turning them out in ever-increasing quantities are worthy of the fighting men who depend on those parts. This same engineering staff and these same manufacturing facilities, Mr. Ellithorpe went on to say, will be converted to the development and production of the Utah products to meet the demands of industry for "tomorrow."

WAR DEVELOPMENTS AND THEIR PEACETIME MARKETS

The war has speeded discoveries and improvements in many fields, said W. A. Ellmore, Vice-President in Charge of Engineering of the Utah Radio Products Co. "Nowhere," he went on, "has this been more true than in the radio and communications fields. Today, electrical and electronic miracles are enlisted in the armed forces—but tomorrow they will be at the service of peacetime America." Mr. Ellmore further pointed out that because of the wartime research and improvements now going on at Utah, there will be greater enjoyment and convenience in the American home—greater efficiency in the American factory.

W. A. ELLMORE

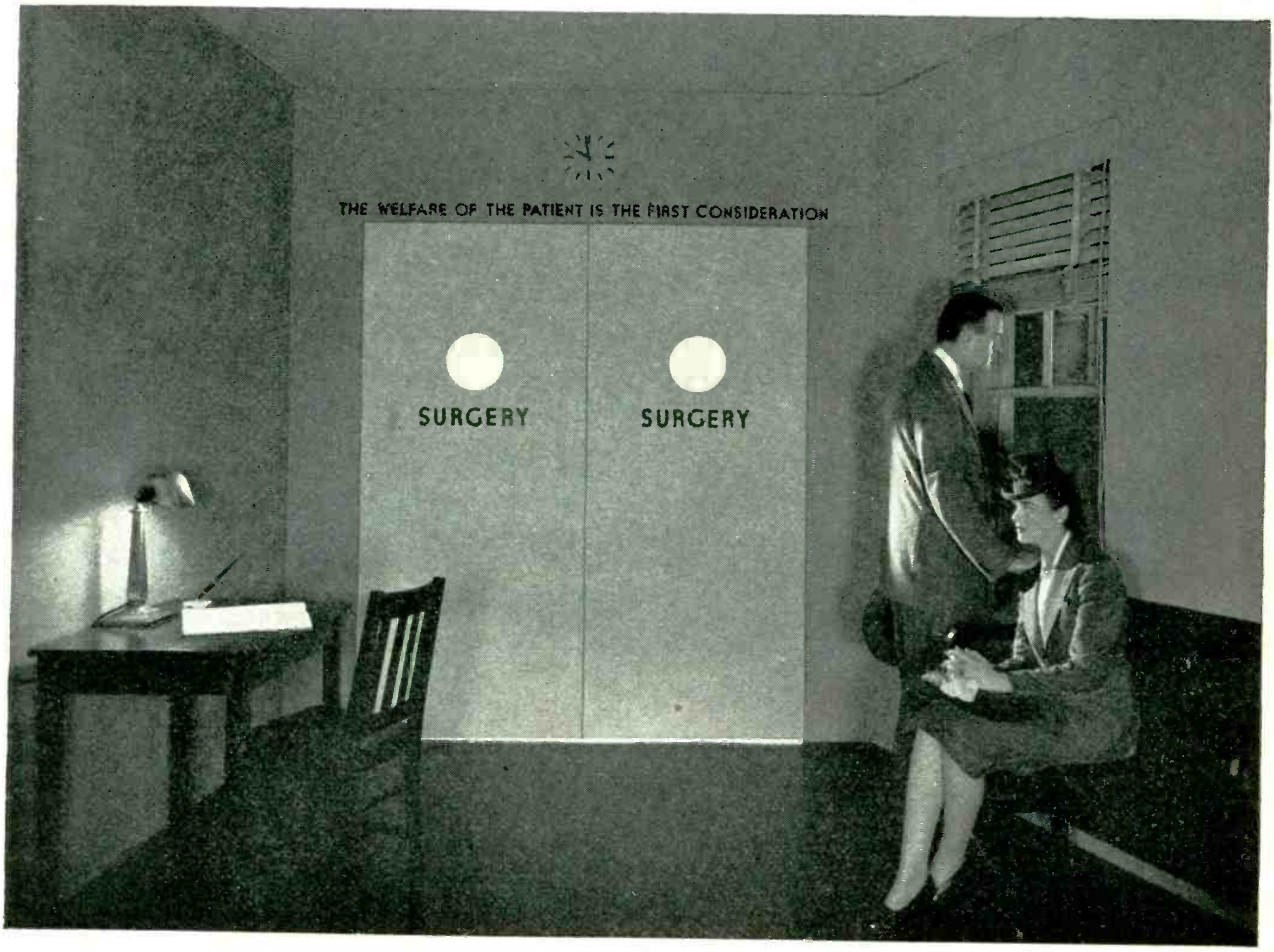
UTAH RADIO PRODUCTS CO., 837 *Orleans St., Chicago, Ill.*

When life and death ride on a slender needle . . .

If you have ever walked into the white hush of a modern operating room you have seen the metered instruments on which the surgeons depend as the age-old battle of life and death is fought across the operating table. These meters must be true. They must be unfailingly precise. Life itself depends upon them.

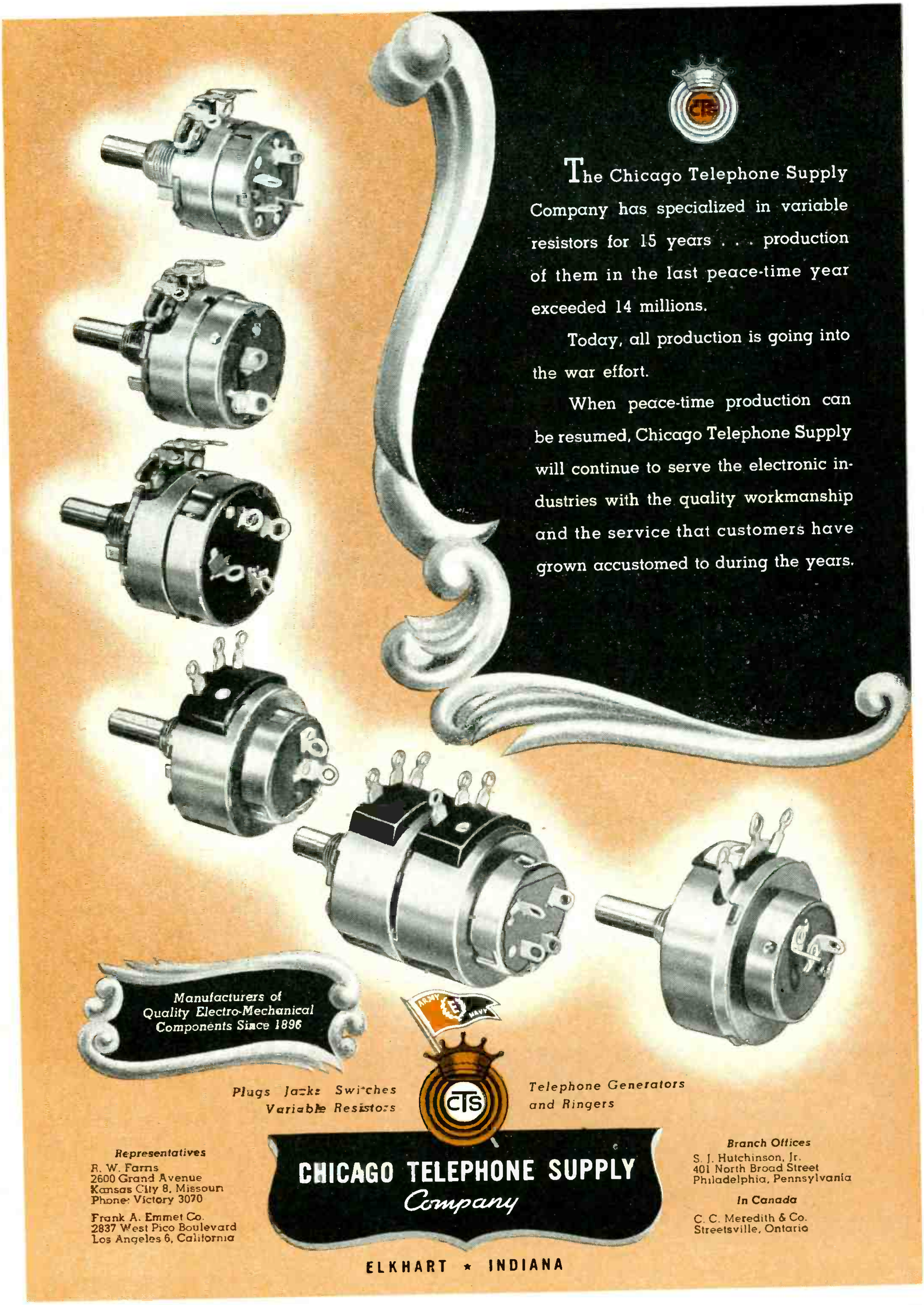
It is measuring, metering, and testing equipment of this kind—equipment that accepts the responsibility of *sustained accuracy**—that is built by Boes. Whether it be for the professions, the sciences, or for production, a Boes-made instrument is worthy of the work that it must do.

* **SUSTAINED ACCURACY** is not an easy quality to achieve. It must take into account all factors of use—must then employ the design, the alloys, the construction that infallibly protect an instrument against all threats to its reliable performance. Such instruments, obviously, must be built with performance—not price—in mind. We invite the inquiries of those who are interested in such standards.

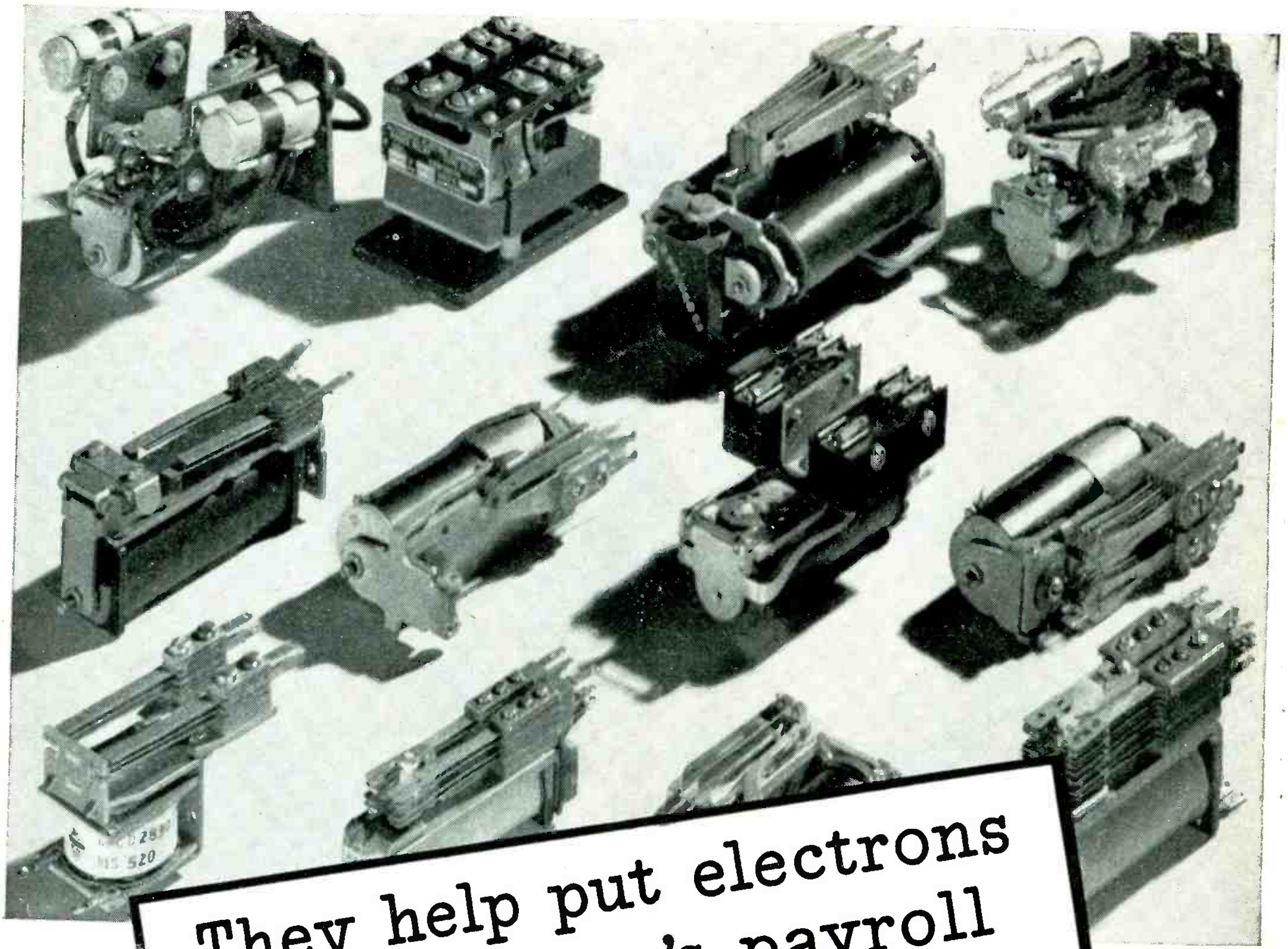


Boes *instruments*

for Measuring, Metering & Testing Equipment ☆ The W W Boes Co., Dayton, Ohio



The Chicago Telephone Supply Company has specialized in variable resistors for 15 years . . . production of them in the last peace-time year exceeded 14 millions.
Today, all production is going into the war effort.
When peace-time production can be resumed, Chicago Telephone Supply will continue to serve the electronic industries with the quality workmanship and the service that customers have grown accustomed to during the years.
Manufacturers of Quality Electro-Mechanical Components Since 1896
Plugs Jacks Switches
Variable Resistors
CTS
Telephone Generators and Ringers
ARMY E NAVY
Representatives
R. W. Farris
2600 Grand Avenue
Kansas City 8, Missouri
Phone: Victory 3070
Frank A. Emmet Co.
2837 West Pico Boulevard
Los Angeles 6, California
CHICAGO TELEPHONE SUPPLY
Company
ELKHART ★ INDIANA
Branch Offices
S. J. Hutchinson, Jr.
401 North Broad Street
Philadelphia, Pennsylvania
In Canada
C. C. Meredith & Co.
Streetsville, Ontario



They help put electrons on Industry's payroll

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

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

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

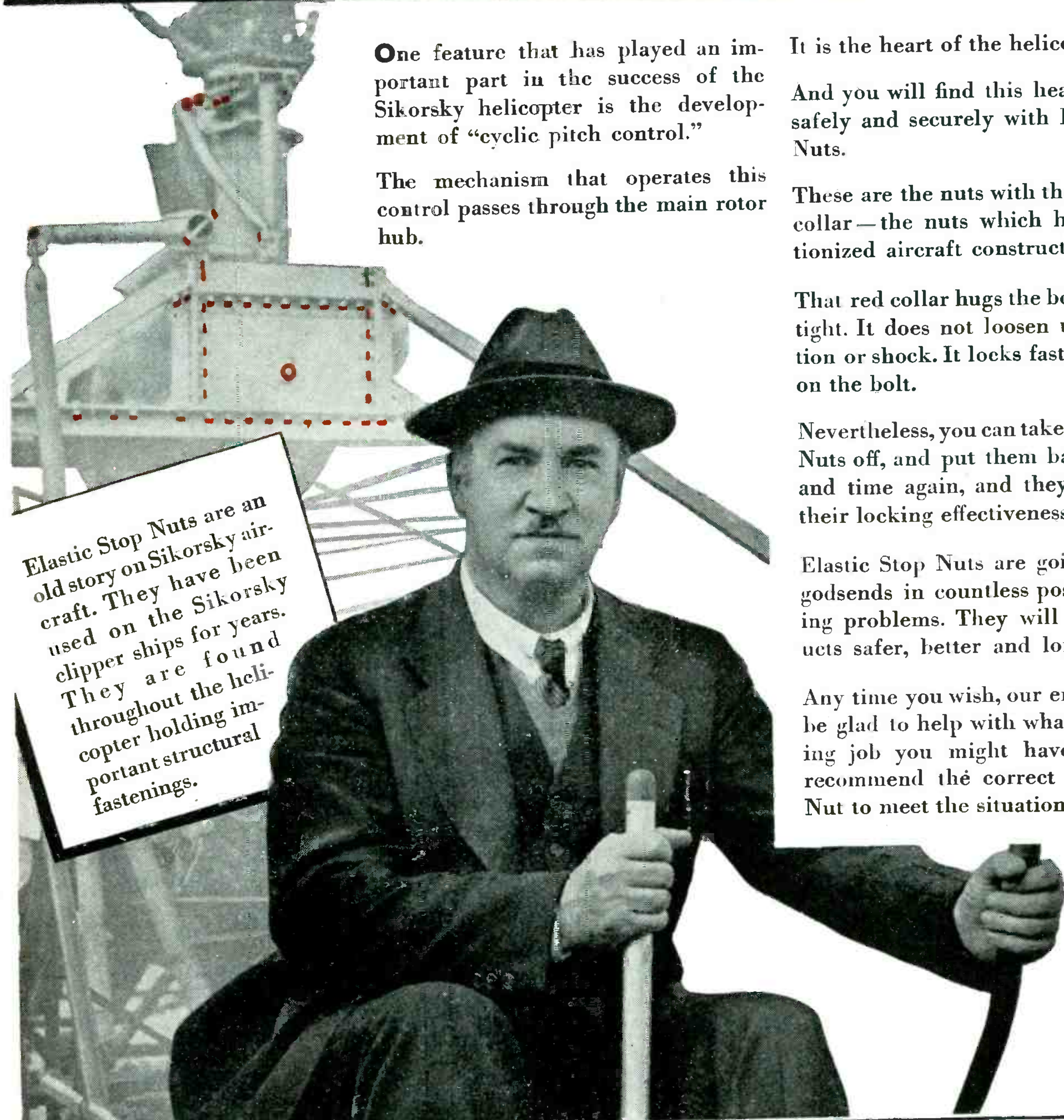
Relays
AND OTHER CONTROL DEVICES
by **AUTOMATIC ELECTRIC**

ARMY E NAVY

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

MUSCLES FOR THE MIRACLES OF ELECTRONICS

SAFEGUARDING THE HELICOPTER'S HEART



Elastic Stop Nuts are an old story on Sikorsky aircraft. They have been used on the Sikorsky clipper ships for years. They are found throughout the helicopter holding important structural fastenings.

One feature that has played an important part in the success of the Sikorsky helicopter is the development of "cyclic pitch control."

The mechanism that operates this control passes through the main rotor hub.

It is the heart of the helicopter.

And you will find this heart fastened safely and securely with Elastic Stop Nuts.

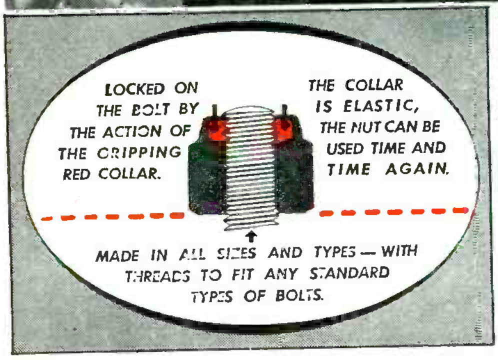
These are the nuts with the red elastic collar—the nuts which have revolutionized aircraft construction.

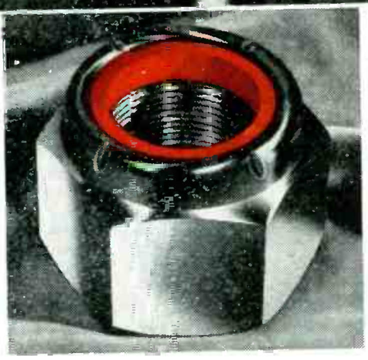
That red collar hugs the bolt and grips tight. It does not loosen under vibration or shock. It locks fast—anywhere on the bolt.

Nevertheless, you can take Elastic Stop Nuts off, and put them back on, time and time again, and they still retain their locking effectiveness.

Elastic Stop Nuts are going to prove godsends in countless postwar fastening problems. They will make products safer, better and longer lasting.

Any time you wish, our engineers will be glad to help with whatever fastening job you might have. They will recommend the correct Elastic Stop Nut to meet the situation.





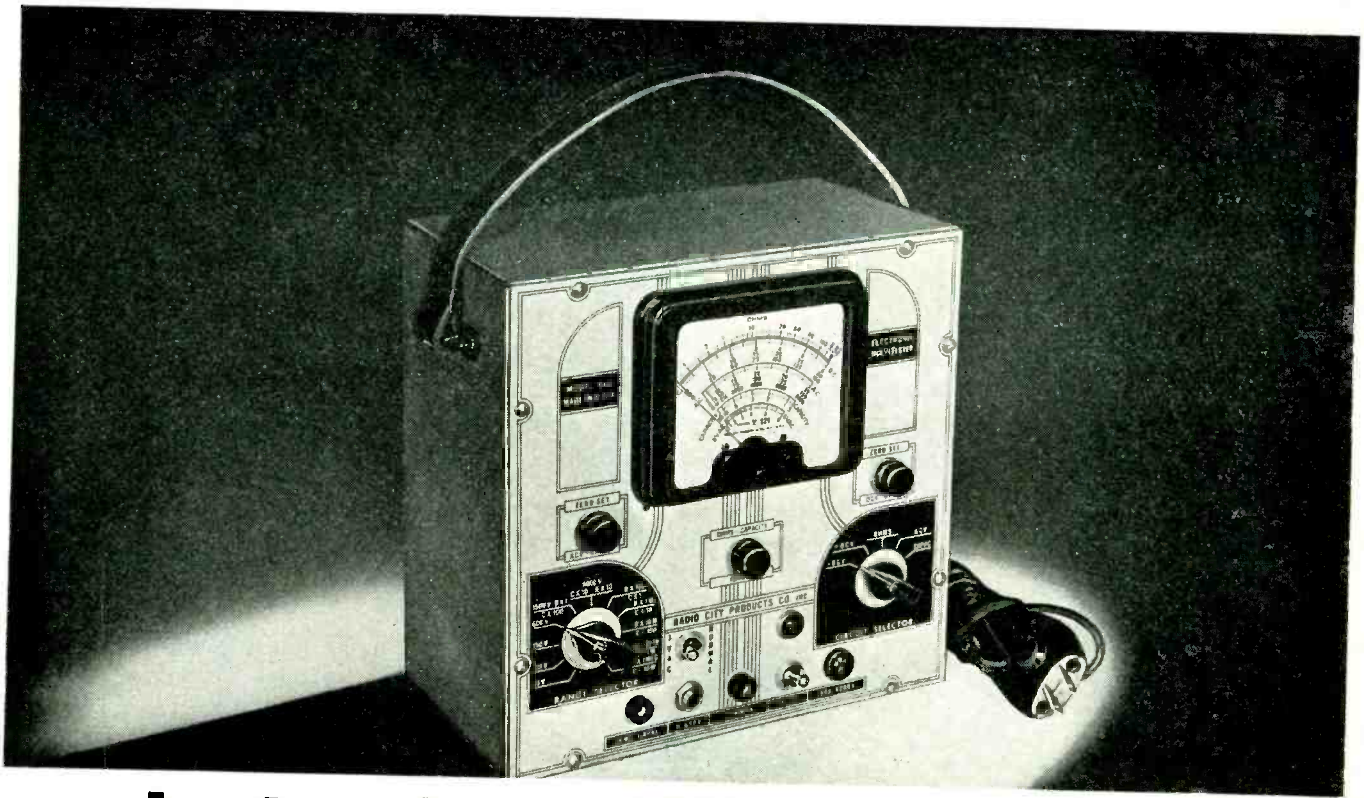
ESNA

TRADE MARK OF

ELASTIC STOP NUT CORPORATION OF AMERICA
UNION, NEW JERSEY AND LINCOLN, NEBRASKA

ELASTIC STOP NUTS

Lock fast to make things last



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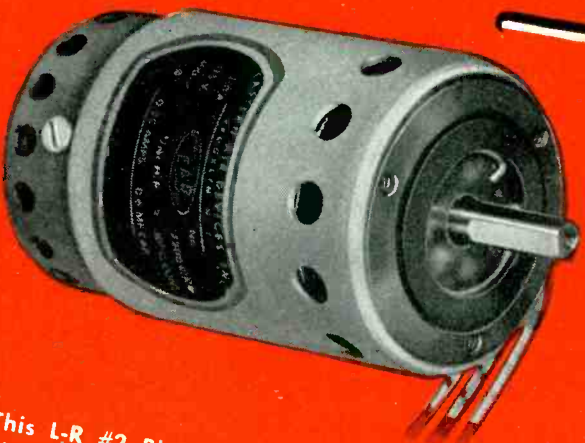

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Reconversion *and* Contract Termination

American industry is dedicated to an all-out effort to achieve victory, and its good faith in this direction is amply demonstrated by the results.

American industry also is dedicated to making democracy work effectively after the victory. And it is toward this objective that industry must prepare itself to guide the processes of demobilization and reconversion in order to minimize the dislocations and chaos which too easily can result from so tremendous a task.

We exercised foresight from the very beginning of the war mobilization program. Let us now exercise foresight in the approaching changeover from a wartime to a peacetime economy.

The first step in converting American industry from military to civilian production is the termination of contracts between the government procurement agencies and the producers. There are now in force war contracts amounting to tens upon tens of billions of dollars. As the demand for weapons of war decreases, the Armed Services will undertake to cancel contracts. With the emphasis shifting from weapons of one category to weapons of another category, many billion dollars worth of contracts already have been terminated. It is hoped that the experience now being gained in this work will provide the basis for effective and sound procedures when an avalanche of cancellations comes later.

Many complex problems involved in the termination of contracts will materially influence the success of the entire reconversion program. Once war demands fall off sufficiently to permit the renewal of civilian production, we will have to act with great speed if we are to avoid large-scale unemployment. Prompt financial settlements of contracts and the rapid clearance of plants are of immediate and great significance. In many cases the removal of equipment and raw materials will be more important than money payments. The allocation of raw material for civilian production will be of paramount importance.

Government agencies obviously must exercise great care in spending the people's money and in protecting the interest of the public against excessive payments. Unjust enrichment at the expense of the people will not be condoned nor will it reflect favorably upon management to present inflated claims. But long-delayed negotiations, which will retard the initiation of civilian production, likewise must be avoided.

The contracting agencies and the manufacturers both know that the greatest losses in the reconversion period will result from delays in getting peacetime production under way. The greatest potential wastes lie in unemployment and in idle plants. The magnitude of such losses to the public can be far greater than the money spent in liberal settlements; to the manufacturer, these losses can represent vastly more than the extra funds that might result from interminable litigation. Policies must be firmly established *now* whereby the manufacturers, including subcontractors and suppliers, will receive substantial settlements immediately in order that ample funds be available for reconverting plants and accumulating necessary inventories of peacetime goods. Nor must we overlook the fact that the uncertainty of long drawn-out disputes will have a stifling effect on enterprise and that final settlements, therefore, should be made as promptly as possible.

Plants that are equipped largely with special wartime tools and machines and that are fully stocked with materials, components, and finished military products will not be able to undertake any substantial degree of conversion until this machinery and this inventory are removed. Advance arrangements are essential for the prompt clearance of great numbers of plants the country over. Adequate warehousing facilities must readily be available so that the changeover to civilian production will not be hampered.

As war demands decline, civilian output will be resumed; and while we recognize that the demands for munitions must vary as the strategy of the military leaders is changed, it is hoped that the Armed Services already have or soon will develop schedules of their continued needs under different strategic assumptions. If we know in advance the probable curtailment in war requirements we are in position to estimate the timing and the quantities of raw materials, the number of workers, and the industrial facilities which will be available for peacetime purposes. It will then be possible to integrate the lifting of restrictions on civilian production with the drop in war production.

Needless unemployment and idle plants will prevail if restrictions on the output of civilian goods are removed at a slower rate than available manpower, materials and plants permit. On the other hand, if the controls on civilian production are removed prematurely or too freely, then the production of military requirements will be hampered correspondingly. There will be great clamor and pressure for eliminating all restrictions as soon as any measurable quantity of materials and numbers of workers are freed from war work. It will react adversely on industry as well as on government if these pressures are heeded indiscriminately, thereby retarding the production of munitions for our boys who still will be fighting and dying at the front. The coordination of declining war demands with increasing civilian production probably is the most difficult and at the same time the most important task in our entire reconversion problem. Advance planning and sound judgment are essential.

An order of priority for initiating non-war or civilian production must be prepared beforehand. The schedule of resumption of peacetime production should be governed by the amounts of materials, manpower and facilities that are available as well as by the relative needs or importance of different products. There will be strong competition for priority among the various kinds of consumer goods, equipment needed for reconversion, producers goods required for expansion and modernization, and export demands. Relative need obviously is the most compelling criterion. But because of the importance of expediting reconversion, earliest consideration is urged for the tools and fixtures and models which will expedite large-scale civilian production when adequate labor and materials are available. In any case, advance schedules will be needed to avoid a makeshift, piecemeal lifting of controls on the basis of who shouts the loudest.

Another difficult problem of the reconversion period will be to keep to a minimum the distortion of inter-industrial and intra-industrial relationships. Many varieties of consumers goods compete for the consumer dollar, and some industries will offer strong resistance if the green light is given first to industries whose products may thereby acquire a time advantage.

Even more difficult will be the matter of competition between companies producing the same products. Some manufacturers may find themselves tied up with continuing war contracts with restrictions on their peacetime products suddenly lifted and their competitors free to take advantage of the situation. The declining need for different kinds of war materiel will vary greatly, and some producers inevitably will be available for peacetime production considerably in advance of some of their competitors.

This raises the question of victory models or nucleus plants to eliminate competitive advantages among producers of identical products pending the time when all are on an equal footing again. Policies controlling this should take into account the degree or the extent of competitive advantage which reconversion might bring, and also upon the time interval during which these advantages will prevail. Such programs necessarily mean increased government control, hence they should be adopted only under the most pressing circumstances.

There is the important question of termination as between large and small plants. Fairness must be exercised, and undue advantage to either group must be avoided in extending opportunities to continue receiving profitable war orders or in getting back into civilian production. The problems of small manufacturers must not be neglected in this period. Likewise, any restraints on new ventures and on more vigorous competition must meticulously be avoided.

There also is the question of communities which have been greatly enlarged and others which actually have been brought into being by the war. It might be advisable to terminate contracts in these areas first in order that the workers might be encouraged to migrate elsewhere while employment prospects are most favorable. Also, if continued production of some armaments is contemplated after the war, it might be well to concentrate this production in communities which otherwise would be stranded.

If the process of terminating contracts is to be geared into meeting continued demands for munitions and also expediting reconversion, then the Armed Services must accept broad policy considerations as criteria for cancelling contracts. Procurement officers might be inclined to cancel contracts with all high cost producers first. Or they might be inclined to cancel small producers first so as to reduce the administrative burden. Then again, they might cancel the newer producers of specific products rather than the older, time-tried manufacturers.

These procurement criteria may all be highly desirable and efficient but other important considerations such as those mentioned above must be given proper attention. *Demobilization cannot be a separate process from reconversion.* They must be united. The termination of contracts is a demobilization task, but I am confident that the procurement agencies appreciate the importance of this operation in facilitating reconversion and that they will take full cognizance of the policies necessary for giving every assistance to initiating peacetime production.

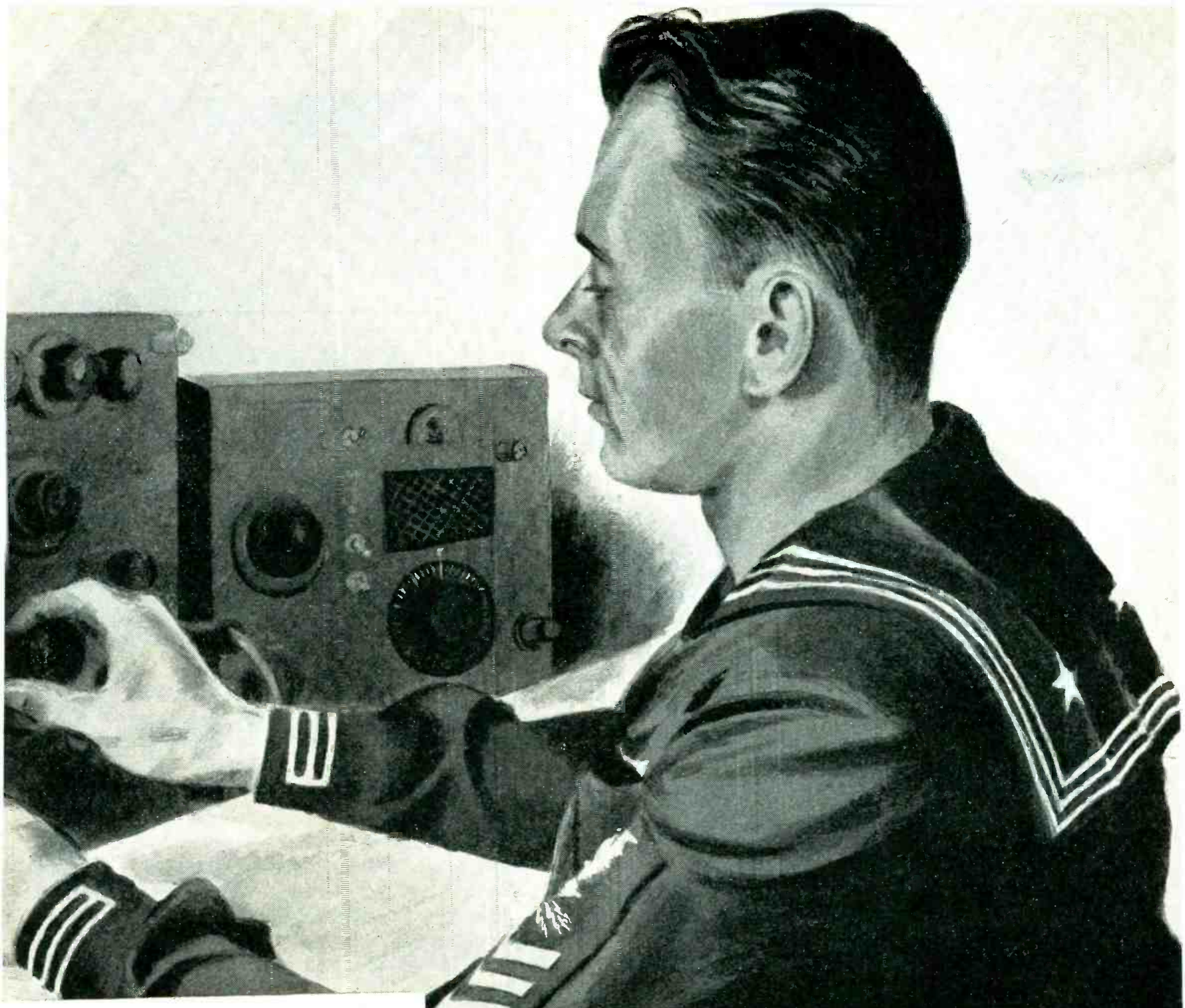
I have not attempted to raise all the important policy questions in terminating contracts, nor do I propose specific solutions for each major problem. Rather it has been my purpose to indicate the complexities of the task which faces us and to urge that intelligent and sound plans be developed now while there is time. By so doing, we can avoid the dislocations and economic disorder which otherwise might characterize the reconversion period. The better we are prepared, the more rapid will be the resumption of full employment and good business after the war is won.

This job of changing America's industrial pattern from war to peace speedily and efficiently, is one which will tax the talents and knowledge of the ablest business men of the country. These men can, and I am sure that they will, attack this task with the same energy and determination that characterized their efforts in the period of mobilization for war.

Industry advisory committees were established to cooperate with governmental agencies in the great task of conversion to a full war economy. These committees are the means through which industry has the opportunity to play a major role in the solution of the problems of reconversion. It must assume that responsibility or accept the consequences in the form of enforced government control. Industry must take a renewed interest in these committees and make certain that our best minds and strongest men are available for the challenging job of conversion which we face now. It is a job that must be done well if we are to have a good start on the road to a greater democratic and free enterprise nation

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.



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Eimac tubes created and developed with the help of radio amateurs, possess superior performance characteristics and great stamina. They will stand momentary overloads of as much as 600% and they are unconditionally guaranteed against premature failure due to gas released internally. These are good reasons why Eimac tubes are first choice among leading electronic engineers throughout the world.

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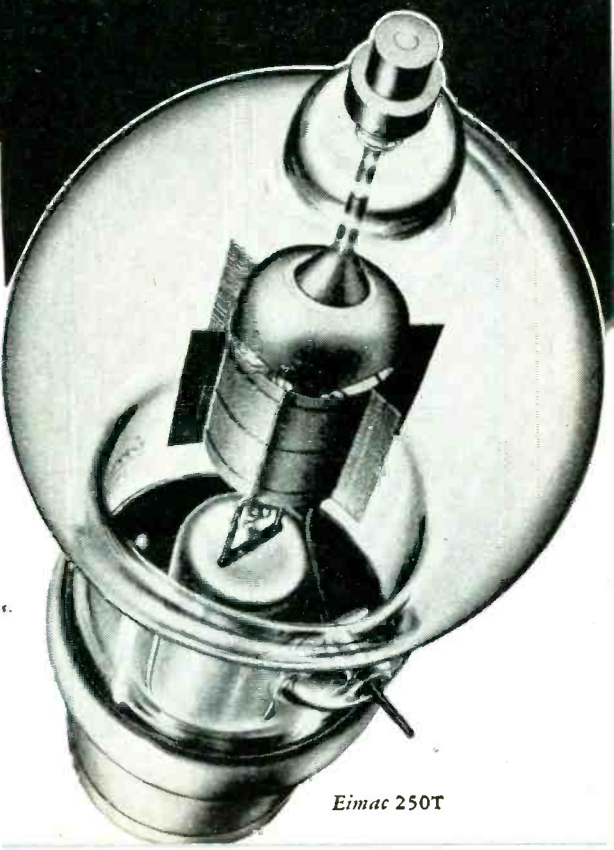

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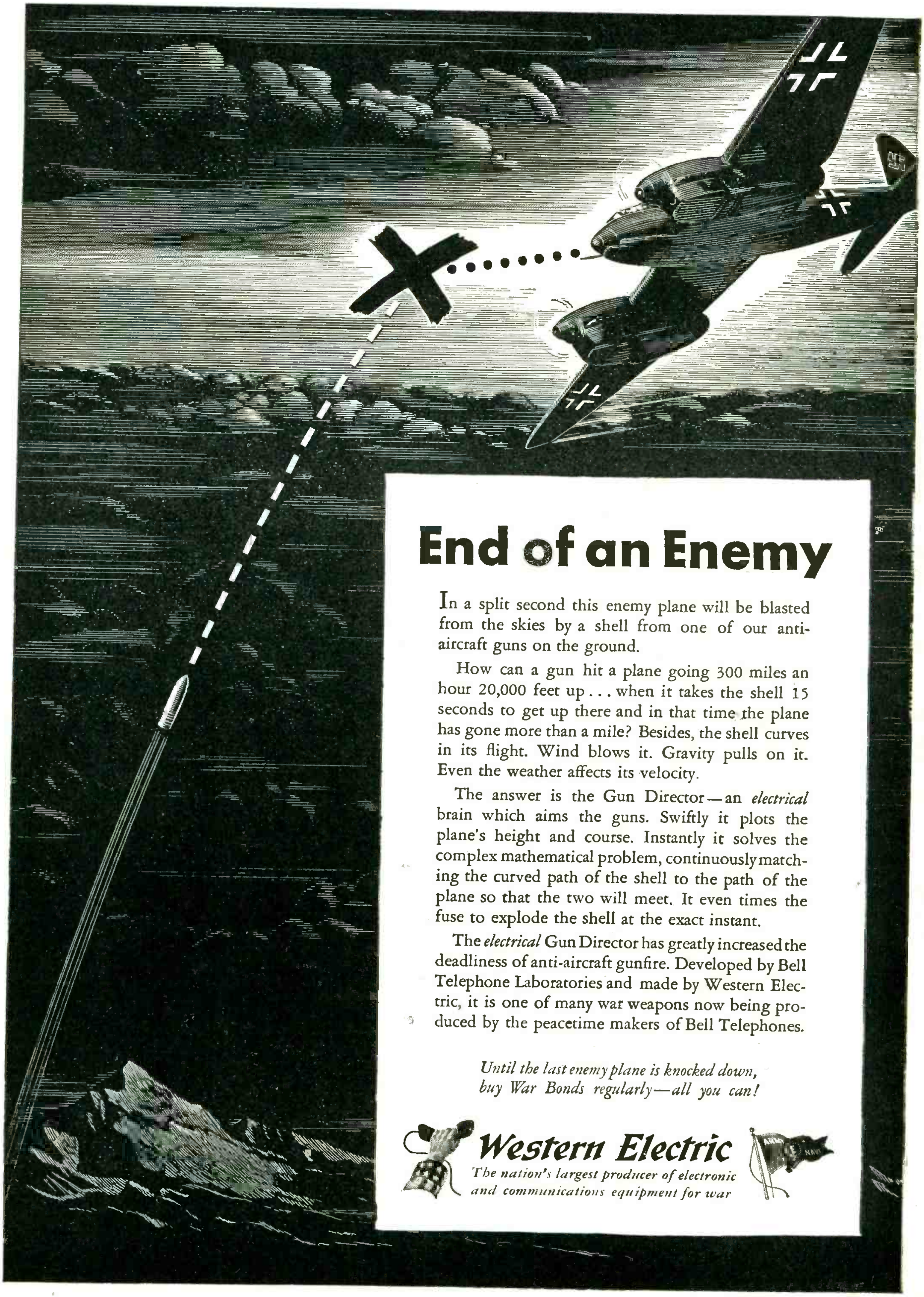

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The *electrical* Gun Director has greatly increased the deadliness of anti-aircraft gunfire. Developed by Bell Telephone Laboratories and made by Western Electric, it is one of many war weapons now being produced by the peacetime makers of Bell Telephones.

Until the last enemy plane is knocked down, buy War Bonds regularly—all you can!

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WASHINGTON FEEDBACK

Postwar Planning — Carrying along his often-voiced theme of "So little time and so much to be done," FCC chairman Fly stressed the urgency of studies of technical problems vital to the future of radio in his remarks before an important postwar planning conference in Washington. In attendance were members of the Radio Technical Planning Board, the Interdepartmental Advisory Committee (composed of 13 government agencies), the Board of War Communications and the Federal Communications Commission. It was generally agreed that allocation studies should be speeded, subject to priorities of war work, even though characteristics of the higher frequencies are not fully known.

Various panels of RTPB and government groups will consider major changes which may be necessary in services such as standard broadcasting, FM, television, international point-to-point, etc.; changes to be made in FCC's present standards of good engineering practice and other technical rules; and the possibilities of utilizing frequencies above 300 mc. It was suggested that the studies be completed as soon as possible so that manufacturers can be ready with plans to produce equipment when materials are again made available.

The group was informed of studies that FCC is making to determine the possibility of long-distance skywave interference in the present FM and television bands. There was also some discussion of international television transmissions.

Patents—The exchange of patent rights and technical information between the United States and Great Britain is expected to be greatly facilitated by the setting up in London of a Legal Agency, which will operate as a field division of the Legal Section of the U. S. Signal Corps.

Experience has demonstrated that even where agreements for joint use of patents have existed there has been such a lack of understanding that full advantage has not been taken of them. It has, for example, been difficult to know when British-owned patents are being used by American manufacturers in such a way that licenses are needed. It has also been hard to keep track of the ultimate user of licenses and technical data transferred to the British.

The new Legal Agency maintains direct contact with British industry and patent owners. It should be able not only to get complete details of the requisitions involved, but also to bring together the interested parties. Another service it performs is in connection with British patents on inventions relating to classified material. Applications for use of such patents are affected by the Espionage Act, Army regulations on security, and the patent law on publication of data which might be detrimental to public safety or defense. The result of the various regulations has been that some companies have sacrificed their foreign rights rather than take the responsibility of filing their applications abroad. The Legal Agency will take such applications, sent to the Signal Corps, and clear them through the proper channels.

Production Figures—Donald M. Nelson, chief of WPB, in a recent production report, pointed to the 9 percent increase over September in communication and electronic equipment as "one of the brightest spots of the month."

That the electronics production program must, nevertheless, show a continued increase was stressed by Ray C. Ellis, director of the Radio Division of WPB, when he told a group of his field representatives meeting in Washington recently that production must move from a $250,000,000 monthly basis to over $300,000,000 per month. This will consist of about 50 percent radio, 42 percent electronics, and 8 percent telephone and telegraphic requirements, according to Frank S. Horning, chief of the division's Field Service, as compared with the 1943 volume of 60 percent radio, 31 percent electronics and 9 percent telephone and telegraphic equipment. In 1942, the volume was given as approximately 70 percent radio, 17 percent electronics and 13 percent telephone and telegraphic equipment.

There are now, it appears, 161 prime contractors, with approximately 1000 "direct contributors" of electronic component parts, according to an official statement from the Radio Division.

Radio Census—Radio shortages are being checked in a nationwide survey of consumer needs which the Bureau of Census is conducting for WPB's Office of Civilian Requirements. Visiting 7000 households to ascertain shortages in more than 100 types of goods and services, census enumerators are gathering information regarding shortages in radio sets (excluding automobile sets), radio tubes, farm-radio batteries and also radio repair service.

Replies to a number of set questions will be tabulated by OCR as quickly as possible so that production of any items critically needed by civilian consumers may be planned.
—G. T. M.

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CROSS TALK

►**EXPERTS** . . . How best to learn what electronics offers an industrial company interested in applying tubes to its own processes is a question that faces every wideawake concern today. Now that electronic experts are virtually unobtainable without stealing them from someone else, the next best (and perhaps the very best) plan is to look around one's own plant. What is required is a man who has a good mechanical background and who in the pre-war days was an amateur radio operator or, going further back in time, a home-set builder.

Old-line electrical engineers may have trouble grasping electronics. For them a vacuum tube is an open circuit; to them the concepts of wave guides in which electric energy is piped over a single conductor will prove most troublesome.

Every industrial plant should have someone appointed, now, to begin learning electronics. If possible he should be given a place to work, some money for books, so he may learn what has been done, and some apparatus, to enable him to get the feel of the equipment. This man, in time, could advise the company on the merits of electronic apparatus on the market and, given the proper encouragement and ability he could soon learn where and how electronics could be applied to his own plant processes.

Waiting until after the war to get a start may prove to be waiting much too long.

►**SOS** . . . According to the New Yorker, much of whose contents we enjoy but do not believe, one of the lifeboat transmitters pictured on ELECTRONICS' September cover was shipped to someone around New York City for some experimental work. The office secretary opened the bundle, and seeing the handle of the radio transmitter, gave it a couple of good whirls, as who wouldn't?

Within a short while, they got a call from the Coastal Command, who wanted to know who the hell was lost at sea on lower Madison Avenue.

►**RTPB** . . . With the complete roster of panel chairmen appointed and placed before the industry by Chairman W.R.G. Baker, work is already under way on the many important problems to be discussed by this board. One of the major conflicts, according to Dr. Baker, is the desire of television and FM enthusiasts for ether space. As we remember the earlier conflict the FM people wanted the lowest television channel and would have been satisfied if they had secured this additional waveband. Whether still more channels are now deemed necessary for FM expansion, is not known. Mr. Fly has stated that he believes the existing 16 to 17 channels available for television is not sufficient. Six months ought to see the answer to this dispute, according to Dr. Baker.

Since a 1-kw FM transmitter complete with mike, turntable and antenna costs only $10,000 approximately, there will undoubtedly be a big demand for permission to broadcast by FM. Many agencies not now in the broadcast business will want to break into it in this manner. The scramble for frequencies will remind old-timers of the days when all broadcast stations were on 360 meters.

As a matter of fact (the reader may sense that we are now warming up to the subject) there is really no reason why any existing broadcast station which is really performing a service, and which wants to keep on with this job, should not have an FM outlet. There is no reason why there should not be several hundred channels and not just a dozen. This would immediately remove broadcasting time from the realm of the hard-to-get, with the result that politicians might not try so hard to get it.

The broadcasters, however, seem to be least wideawake to the portent of frequency modulation, at least in New York. Here it is treated as a sort of ugly stepchild to be killed, if possible, with hour after hour of recordings, many with loud needle scratches. CBS, for instance, does not put the New York Philharmonic on its New York FM outlet, although the NBC big-time event, the NBC Symphony, now provides FM listeners with the big treat of the week.

COMPONENT PARTS

UP IN THE ALEUTIANS an army plane took off on an emergency patrol with its direction-finding gear inoperative for lack of a replacement capacitor. Fog closed in and, probably because the d-f equipment was not functioning, the ship and its crew were lost at sea. Technicians later discovered that a suitable replacement capacitor was available all the time in a nearby navy stockpile. When tested, the part proved to be electrically identical but it was, unfortunately, dissimilar in shape and differently marked.

Aside from the obvious desirability of employing standard identification codes and so conserving shipping facilities to and storage space on the fighting fronts, there is good reason for universal adoption of physical and electrical component parts standards in wartime. It appears that a 30 to 35 percent increase in production of electronic equipment will be required for military purposes in 1944. Labor is at a premium and factory facilities are already taxed to the utmost. Standardization can help produce the required production increase.

The Objectives of Standards

Advocates of component parts standardization list the major objectives of the present program as follows:

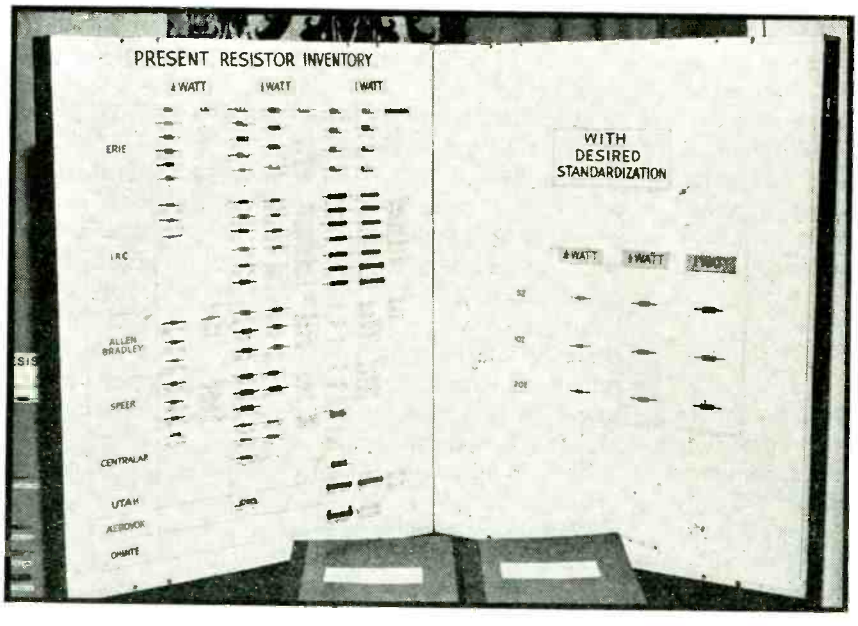
Concentration of component parts manufacturers upon fewer types can increase production by utilizing labor, machinery and even materials to better advantage. More efficient operation will carry right on down through testing and packaging.

Availability of standard parts from more sources of supply will insure continuous production of finished gear by prime contractors. Here too, the testing and handling problems will be simplified.

Standards have already been written and approved for ten component parts, accessories and associated testing devices.* The ten include fixed mica-dielectric capacitors, 2½ and 3-inch round flush-mounting panel-type electrical indicating instruments, ceramic radio insulating materials intended primarily for use as insulators, ceramic radio dielectrics intended primarily for applications where capacitance is the prime consideration, shock-testing mechanisms for 2½ and 3-inch round flush-mounting panel-type electrical indicating instruments, ferrule-terminal style external meter resistors, glass-bonded mica radio insulators, steatite radio insulators, fixed composition resistors and 120-milliampere to 10 ampere-type external radio-frequency thermocouple converters. Approval dates range from November 12, 1942 for the first to October 19, 1943 for the tenth.

Standards have been proposed on limited sizes of fixed molded paper-dielectric capacitors, dynamotors (third draft), porcelain radio insulators (third draft), glass radio insulators (fourth draft), low operating-temperature variable wire-wound resistors (seventh draft. Originally entitled "wire-wound potentiometers and rheostats"), one crystal unit involving a piezo-electric element in a sealed holder and designed for non-keying applications in aircraft (fourth draft), power-type wire-wound rheostats (third draft. Originally entitled "high-power variable wire-wound resistors") and 600-volt rms low-tension radio and instrument hook-up wire employing thermoplastic synthetic insulation (third draft). Some dozen or so more proposed standards are in preparation.

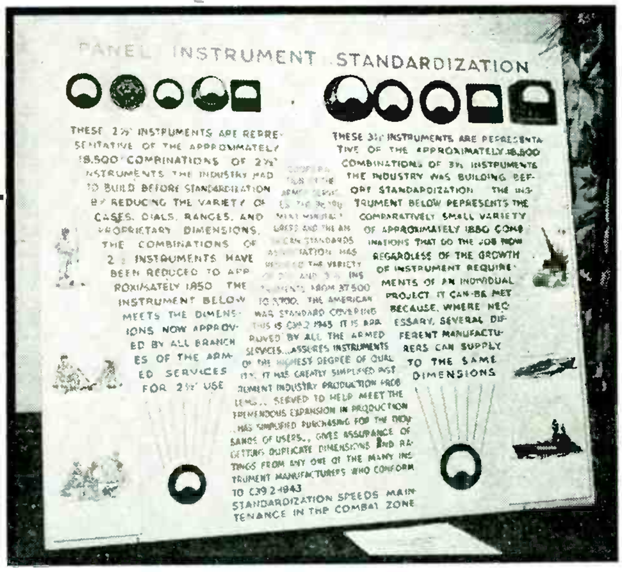
Progress is being made but the chief standard-bearers for the program say that lack of genuine enthusiasm on the part of some agencies and outright opposition by certain individuals involved in the



One standardization objective. Left, multiplicity of resistors in a typical prime-contractor's stock. Right, actual requirements

* American Standards Association, 29 West 39th St., New York 18, N. Y.

STANDARDS



Another example. Standardization of the cases, dials and ranges of the 10 instruments at the top permits their compression into the two at the bottom

work renders speed consistent with the requirements of the war effort difficult.

More complete cooperation is clearly required between the various groups and companies necessarily involved in the component parts standardization program if wartime objectives are to be obtained. Generalizations are rarely accurate in every detail but it is believed that the following editorial observations constitute a fair overall picture of the major obstacles in the path of the program.

Some Program Obstacles

Standardization must stem from the Army and Navy. Neither branch of the service is entirely consistent in its own component parts specifications. Moreover, while some effort has been made to dovetail the specifications of various branches of the service one gets the distinct impression in the field that much more might be done in that direction.

WPB, utilizing the facilities of ASA, is the guiding spirit in the program. The agency, it appears, is currently endeavoring to speed up standardization by inducing prime contractors to insist upon standard parts rather than by means of directives. This may be considered weak or it may be considered strong, depending upon where the reader sits. One obvious weakness is the fact that it provides little centralized direction for the program and less enforcement "teeth."

Prime contractors, for the most part, appear willing enough to specify and use standard parts. They will not, however, hold up a production line when they themselves are under pressure to meet contract delivery dates, where standard parts are not quickly available and where other parts will pass the required tests.

Component parts manufacturers, similarly, are cooperatively inclined, with some few exceptions, up to the point where the demand for standardized designs makes it necessary to even temporarily shut down machines in production in order to make the required changeovers. Insistence upon rapid changeovers, they point out, could easily disrupt factory operations and defeat the very purpose of the program. Where a component parts manufacturer's attitude toward standardization is completely negative it will often be found that he has his eye on the immediate post-war competitive objective rather than present wartime necessity.

Summing up the above analysis, it might be said that a lot of people like the general idea of wartime component parts standards but too few are doing something about it.

Specifications and Symbols

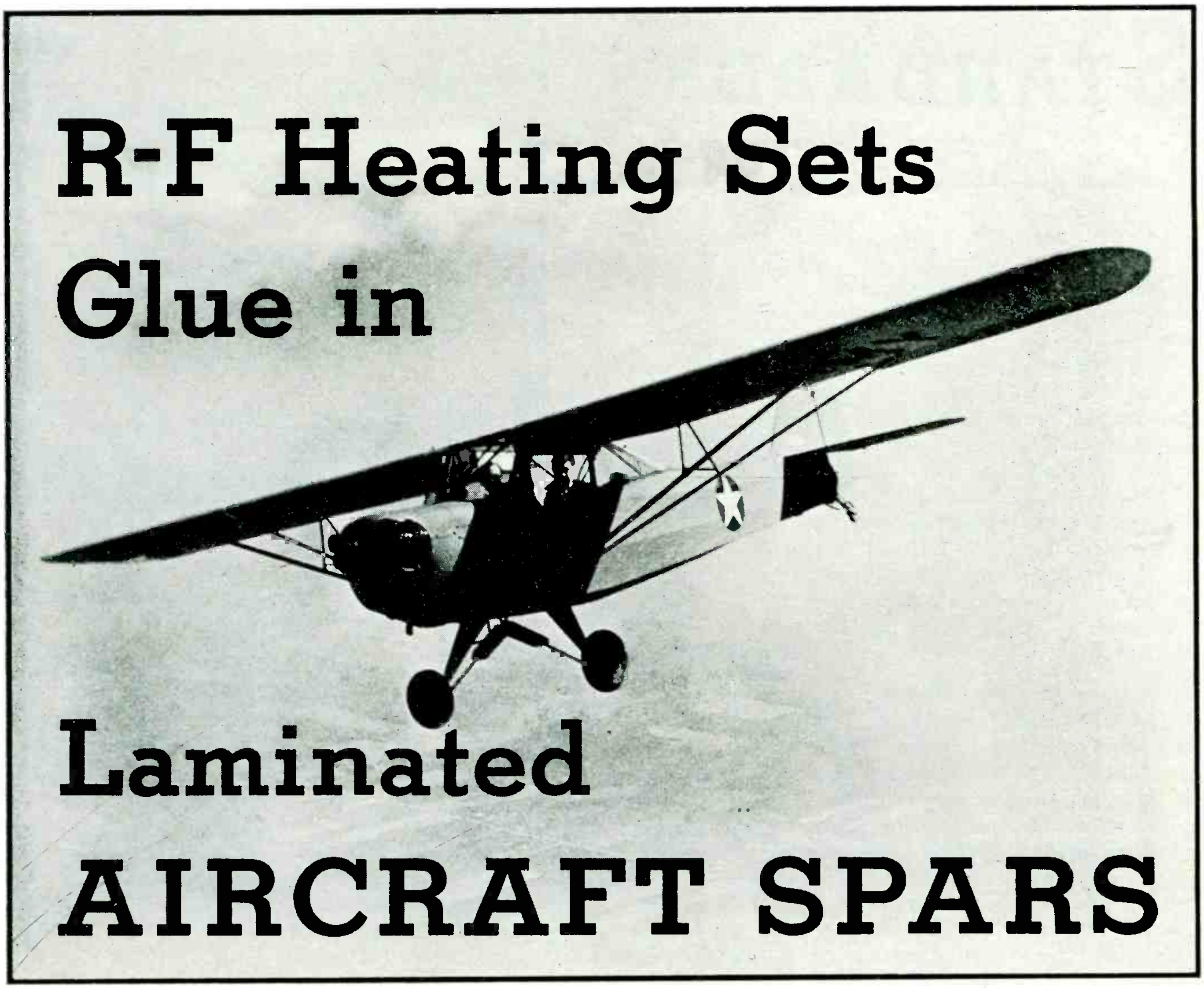
The need for wartime component parts standards goes right down to the tap-roots of the industry and even affects paper work. Many difficult design drawings have had to be duplicated, with resultant bottlenecks in drafting departments, because of minor differences which could have been resolved by closer cooperation between the Army and the Navy, or between various groups within each service. Similarly, many change-orders and other forms have had to be turned out in duplicate, triplicate, quadruplicate and quintuplicate for one agency or group or customer, civilian as well as military, and then done all over again with minor variations for another.

ELECTRONICS has for some time agitated for one set of standard component parts symbols, and this subject too should be part and parcel of the present standardization program. There is an international set of circuit symbols. There are the radio symbols. There are power symbols. And now there is a fourth set of symbols, involving differences, in use to designate electrical or electronic component parts in the aircraft field.

The symbols situation has become so complicated that one of the best-known companies in this industry has designed its own set of symbols, into which all other symbols are resolved before drawings coming from outside sources are placed in the hands of engineers. We don't know how much of the component parts standardization program can be carried over into peacetime practice but it does appear safe to say that virtually all work done now in connection with symbols could readily carry over. It is felt, furthermore, that unless symbol standards are straightened out now, under pressure of wartime exigencies, there is little likelihood that they will be later. As this is written there is some indication that meetings now in progress may soon resolve the situation and come up with one set of symbols, to be used at least for the duration.—W. MACD

FIG. 1—Type L-2 plane, built by Taylorcraft. Multi-laminar spars are being used successfully in ships of this type

R-F Heating Sets Glue in Laminated AIRCRAFT SPARS



Use of electronic gear reduces glue-setting time from eight hours to twenty minutes, increases output of typical small plant from 25 to 200 spars per day and cuts lumber cost 40 percent. Spars so produced are stronger than those made from a single piece

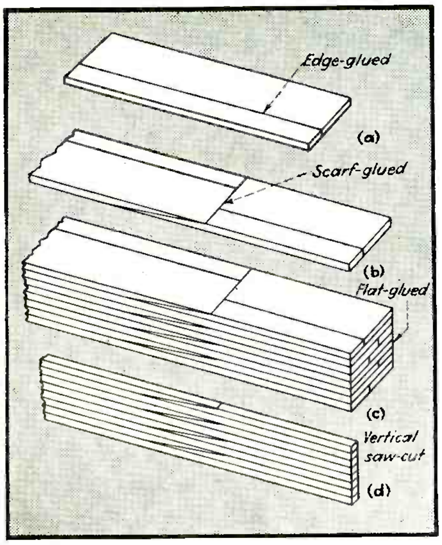
RADIO-FREQUENCY HEATING is being employed to advantage in setting the synthetic-resin glues used in assembling laminated aircraft spars. During the past year the multi-laminar spars used in the Taylorcraft Type L-2 plane have been made by this method and the advantages of using radio-frequency heating are considered to have been well proved.

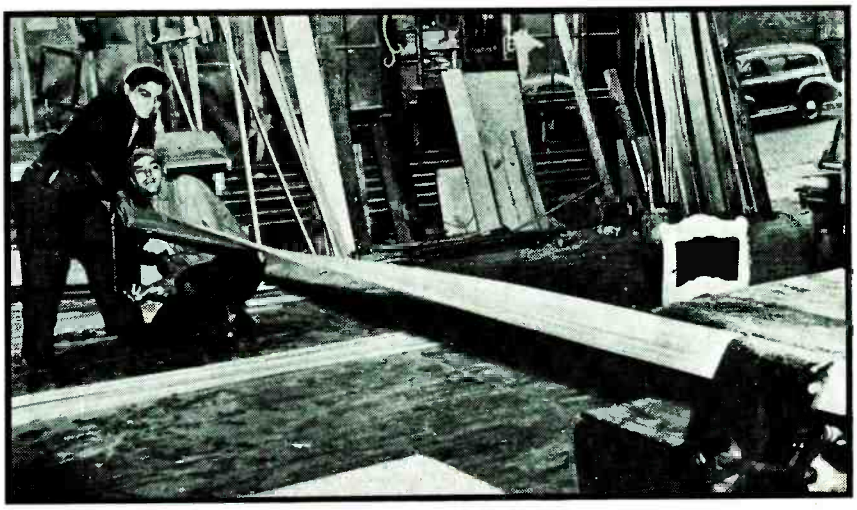
Time for complete setting of the glue has been reduced from eight hours to twenty minutes. Production capability of a single small plant has been upped from 25 spars per day to 200 spars per day. Even more important—the use of r.f. has made it feasible to use smaller pieces of wood, thus overcoming a critical shortage of full-size lumber and, incidentally, permitting a 40-percent saving in the cost of lumber. The laminated spars made by this method are stronger than spars cut from a single piece; in fact, some tests have indicated they may be stronger than the metal spars used before the war.

Use of Laminated Spars

Planes such as that shown in Fig. 1 formerly made use of a fabric-covered metal-frame type of wing construction. The main spars were usually of extruded aluminum or nicralumin.

Sometime before Pearl Harbor it became apparent that aluminum would not be available for this purpose. Aircraft manufacturers then turned to spars cut from solid wood planks, usually spruce. However, as Grade A spruce of the kind specifi-





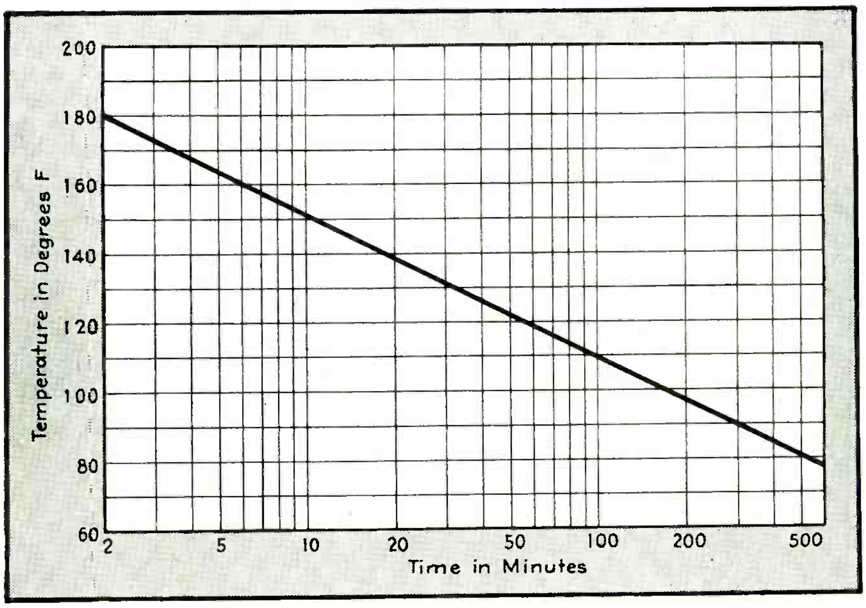


FIG. 2 (above)—Steps in the construction of multi-laminar spar showing (a) narrow boards edge-glued to obtain 6-in. widths, (b) short boards scarf-glued to obtain 16½-ft length, (c) ¾ x 6-in. boards flat-glued to obtain 6 in. x 6 in. x 16½-in. block, (d) block sawed vertically to obtain edge-grain laminated spars ¾ in. x 6 in. x 16½ ft

FIG. 3 (above at right)—Multi-laminar spar ¾ in. x 6 in. x 16½ ft size) made by radio-frequency gluing can be twisted through 180 deg. without damage

FIG. 4 (right)—Approximate time required for setting resin glue used in making multi-laminar spar, plotted against temperature at the glue line

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cally designated for aircraft use constituted only about one-half of one percent of all of the standing timber of this type, the total usable supply was strictly limited. Manufacturers therefore turned to making spars by gluing several thin boards together to obtain the necessary thickness. The next step was to use up short lengths by scarf-jointing these together, and eventually to use narrower widths by edge-gluing. By this means the amount of usable lumber was greatly increased, although at the cost of adding several steps to the process of turning out spars.

At about the same time poplar was approved for use as an alternative to spruce. Unfortunately, poplar was not available in edge-grain cut, so that still another gluing operation was involved when it was used. This is best explained by describing the steps in the construction of a typical spar.

Multi-Laminar Construction

The sketches in Fig. 2 illustrate the evolution of a multi-laminar spar such as those used in the Taylorcraft L-2. Other methods of assembly are used at times, according to the material available, but the one shown illustrates all of the steps ordinarily required.

The lumber as received is about ¾ in. thick. It comes in various widths, specified as "4 inches and over," and in various lengths "4 feet and over". The first step is to select two boards of approximately the same length and to edge-glue these as shown in Fig. 2a. The result is a board which can be trimmed to a 6-in. width.

The second step is to scarf-joint two or three lengths of the 6-in. wide boards together to obtain the required length of 16½ ft, as shown in Fig. 2b. If the material is poplar, the wood will be flat-grain (i.e., grain roughly parallel to the face of the board), whereas the specification

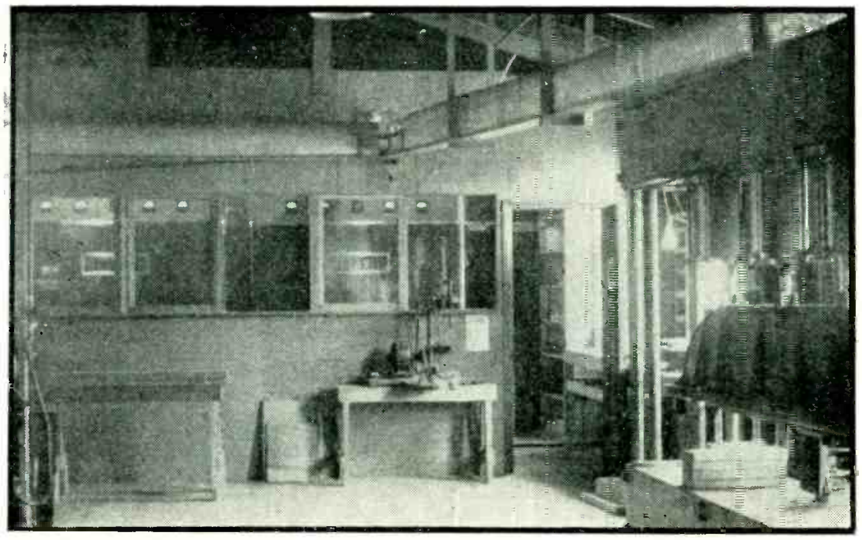


FIG. 5—Radio-frequency equipment installed at Tolerton Lumber Company, Alliance, Ohio, for making laminated spars. The r-f generator is located in the room in the background. Transmission lines consisting of sheet-metal outer conductors and copper tubing inner conductors can be seen running around the top of the room to the edge-gluing press just barely visible at the left and the big flat-gluing press at right

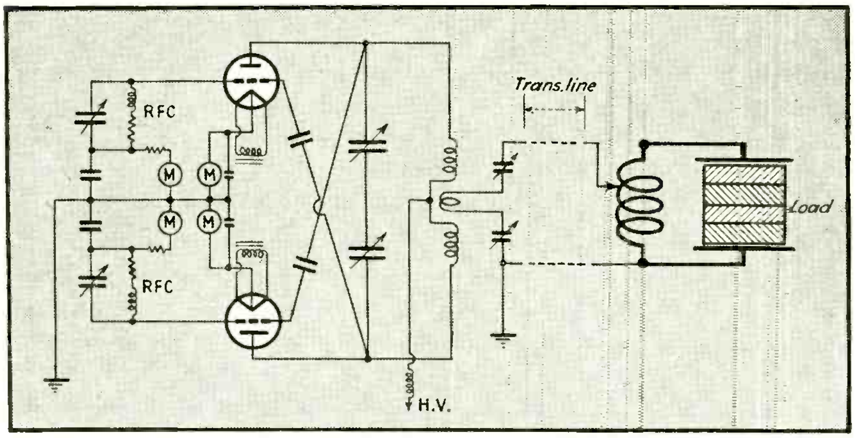


FIG. 6 (above)—Simplified schematic of the r-f generator used in the installation pictured in Fig. 5. The load is tuned by means of inductances in parallel, facilitating the use of transmission lines between generator and load

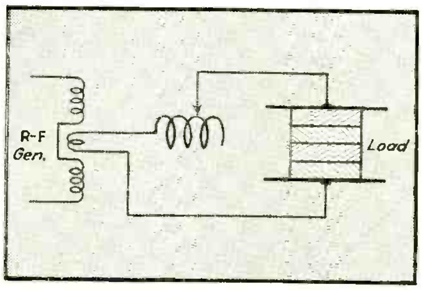


FIG. 7 (right)—An alternative load tuning circuit using series inductance. This arrangement can be used only when the r-f generator is close to the load

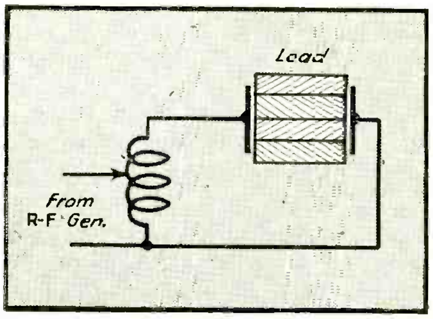


FIG. 8 (below at right)—Arrangement for gluing by concentrating flow of current through the glue lines

calls for the wood in the spar to be edge-grain (i.e., grain roughly perpendicular to the face of the board). To get around this two additional steps are required.

Six to eight of the flat pieces, made up as described above, are assembled and glued together as shown in Fig. 2c. The result is a single block of wood about 6 in. x 6 in. x 16$\frac{1}{2}$ ft long. This block is then sawn vertically into six strips, each $\frac{3}{4}$ in. x 6 in. x 16$\frac{1}{2}$ ft as shown in Fig. 2d. This laminated plank, which looks as though it had been assembled from a number of $\frac{3}{4}$-in. squares, is the piece from which the desired spar is shaped and finished.

While a spar which has been made as described may consist of as many as twenty separate pieces (if $\frac{3}{4}$-in. thick boards are used), it is in some ways actually stronger than a spar made from a single plank. Such a spar, $\frac{3}{4}$ in. x 6 in. x 16$\frac{1}{2}$ ft in size, can be twisted through 180 deg. as shown in Fig. 3, a test which few solid spars can pass.

Need for Heat Curing

In order to appreciate the advantages of heat in curing glued aircraft assemblies, it is first necessary to realize the important difference between the resin adhesives now used and the animal and hide glues used in the wood airplanes of the twenties.

Animal glues and other early types obtain their set by the evaporation of moisture. Strong joints may result but these joints are generally not water or fungus-resistant and hence deteriorate in time. Resin adhesives, on the other hand, obtain their set by chemical reaction under heat and pressure. They are at least water-resistant, and can be made completely waterproof.

The time required to set resin glues is an inverse function of the temperature and, in the working range, is approximately logarithmic. This is shown in Fig. 4. The type used in the spars under discussion will polymerize or set in about eight hours at a temperature of 80 deg. If, however, the temperature is increased to 180 deg. it will set in two or three minutes. Thus, by providing some means of heating, the curing time can be enormously reduced as compared to drying in air.

Moreover, when this is done fewer fixtures are required, space is conserved, and multiple-step laminating processes become practical, since the time required for the individual operations is not excessively long.

Advantages of R-F Heating

Various methods of providing the heat needed to expedite the setting of resin glues are in use.

Thin resin-bonded plywood (often referred to as "aircraft-quality plywood") is usually made in hot-plate presses, that is, presses in which the platens are heated by steam piped through them. However, for thicknesses greater than an inch, the time required for the heat to penetrate to the center glue-lines is excessive. The wood is a very poor thermal conductor, and the maximum outer temperature must be limited to not much over 300 deg. if charring is to be avoided. Approximate calculations indicate that about four hours would be required for the center of a 6-in. thick assembly to reach 200 deg. F when the platens are maintained at 300 deg. F.

Another method which is sometimes used is to clamp the laminations as in cold-gluing and place the whole assembly in a heated kiln. This requires about the same time as the hot-plate press but has the advantage of not tying up press facilities.

In addition to the time required and the tying up of scarce equipment, there is in both these methods an added disadvantage in that some drying-out of the wood, particularly near surfaces, is almost certain to occur. Since the moisture content of aircraft woods is specified within close tolerances, this often necessitates reconditioning of the wood after gluing.

R-F heating has been in use in the manufacture of the spars under discussion only a little over a year and in only a very few installations. Nevertheless, it is already evident that the advantages which it offers are considerable.

The wood, with r-f heating, is actually heated from the inside out. This follows from the fact that while heat is generated uniformly throughout the wood, there is always some loss by conduction from the outside,

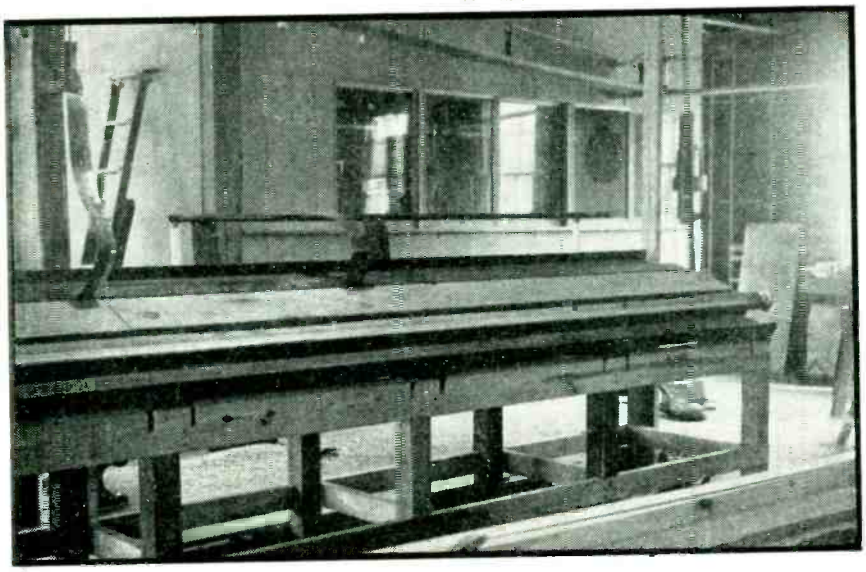


FIG. 9—One end of a special press used for edge-gluing. The fire-hose at the front of the press is utilized to provide fluid pressure along the length of the boards to be edge-glued

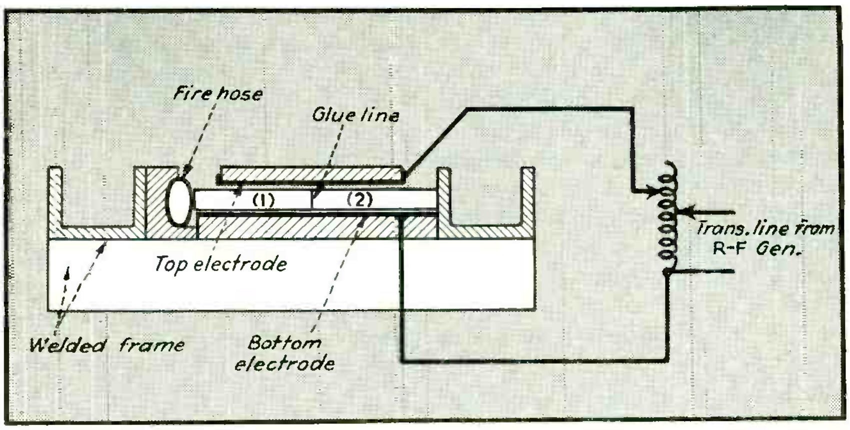


FIG. 10—End view of the edge-gluing press, showing how two boards (1) and (2) are edge-glued by the use of electrodes arranged so that the current flows through the glue line

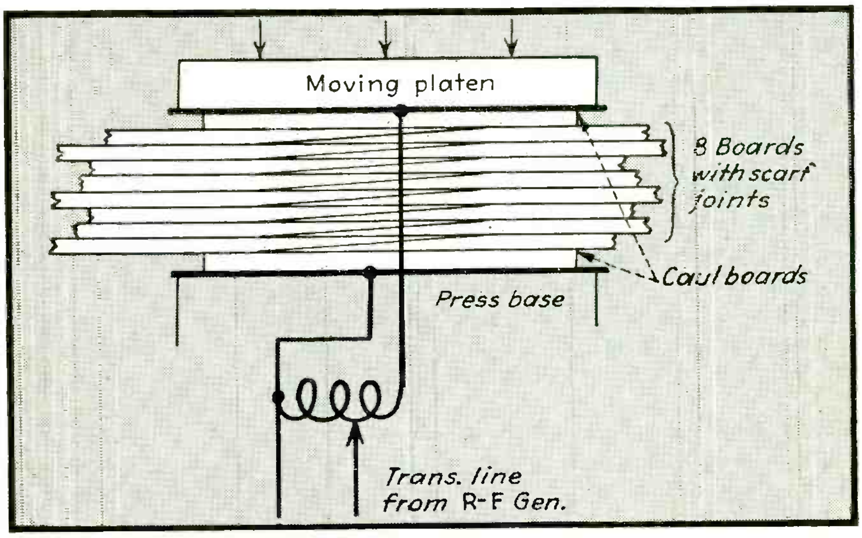


FIG. 11—Arrangement of electrodes for gluing scarf joints in a number of short boards to make up the required 16½-ft lengths

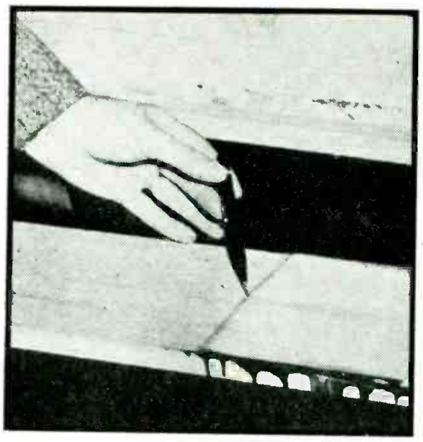


FIG. 12 (above)—Scarf joint in a ¾ x 6-in. board made by the method illustrated in Fig. 11

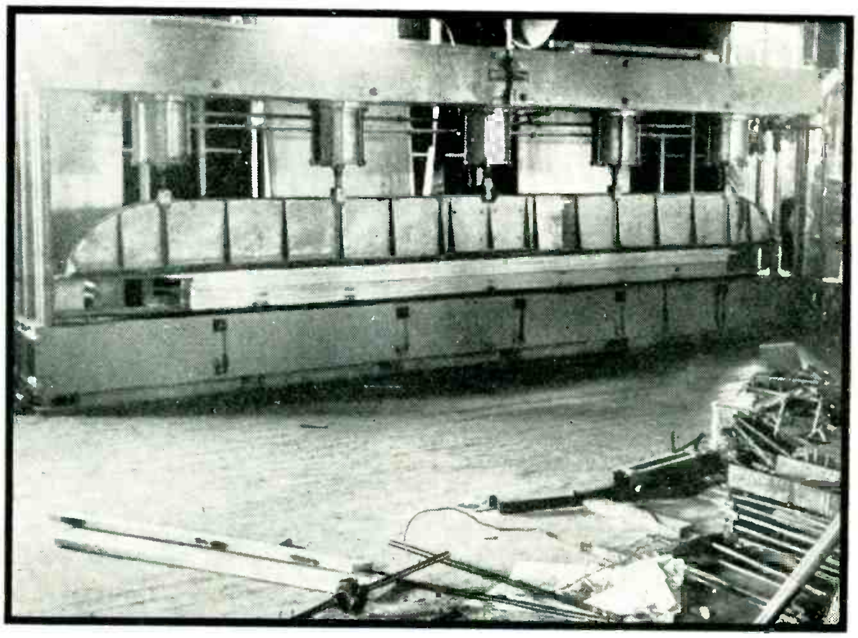


FIG. 13 (right)—Large press used in gluing up the 6 in. x 6 in. x 16½-ft blocks from which multi-laminar spars are sawed

so that the center ordinarily will be somewhat hotter than the surface. As a result, there is more heat at the glue lines, where it is wanted, and less at the surface, where it is of no use. Moreover, the time required to reach curing temperature is not dependent on thickness and can, within the limits set by allowable inter-electrode voltages, be made as short as desired.

A 6-in. thick assembly requiring four hours in a hot-plate press (or eight hours at room temperature) can be cured in twenty minutes with ease by means of r-f heating. It could be done in ten or even five minutes if the greater power required could be economically justified. Because of the short curing time involved, little loss of moisture occurs. The joints made in this way are at least as strong as those obtained in other ways.

Equipment for R-F Heating

The theory of r-f heating as applied to wood has been presented in an earlier article.[1] This discussion of equipment will, therefore, stress the application angles. The equipment to be described is that installed at the Tolerton Lumber Company, Alliance, Ohio, where the spars described above are manufactured.

The r-f generator used in making these spars is a 15-kw (output power rating) device of modified radio transmitter design. This unit is housed in a small room which is provided with several windows looking out into the operating area. The room was found desirable to protect the equipment from the hazards of lumber-mill operations.

Emanating from this "r-f room" is a transmission line. Branches in the line, with appropriate switching arrangements, allow power to be fed to any one of three press positions. Some idea of the arrangement of the equipment can be obtained from Fig. 5.

A simplified schematic of the r-f unit is shown in Fig. 6. The circuit is that of a Colpitts push-pull oscillator. Output coupling is by means of a two-turn pickup loop, the position of which, relative to the split tank inductance, can be varied by a motor which is push-button controlled from the panel.

The load coupling arrangement used is also shown in Fig. 6. Ordinarily, a load of this type represents a fairly high capacitance and at the frequency used (approximately 8.5 Mc) only a small inductance is required for resonance. By making this inductance of large current-carrying capacity (usually copper pipe) and locating it near the load, it is possible to keep copper losses low while at the same time allowing the r-f unit itself to be located some distance from the press.

An alternative series tuning arrangement, shown in Fig. 7, is often used in heating plastic preforms[2] and sometimes in wood heating, but is practical only if the r-f unit can be placed very close to the press. Where it is desired to feed power to several locations, as in the present case, it is almost always necessary to use transmission lines, and since these must usually run overhead, the minimum lengths are likely to be 20 ft or more even for very compact layouts. This makes the parallel tuning arrangement of Fig. 6 the logical choice.

Another load arrangement is shown in Fig. 8. Its usefulness is limited to special cases. In this setup the electrodes are placed at the sides of the assembly rather than on the top and bottom. With such an arrangement the current, instead of flowing uniformly through the wood, tends to concentrate in the glue lines, due to the moisture which they contain. As a result, the glue rises quickly in temperature to about the boiling point and curing is almost immediate (providing the glue used ordinarily sets rapidly at 210 deg. F or lower). Since the only power required is that necessary to heat the glue lines and the immediately adjacent wood, the action is many times more efficient than when all the wood must be heated. There are several practical drawbacks which limit the usefulness of this method. However, where it can be used, as in one case noted below, the results are outstanding.

The actual arrangements of electrodes are worth noting, since they illustrate the approach to several common application problems.

Connecting R-F to Presses

As noted above, a transmission line from the r-f generator is arranged so that power may be fed to any of three press positions. This line consists of an inner conductor of one-half inch copper tubing, mounted on 4-in. standoffs, and an outer conductor of sheet metal in the form of an inverted U. A 1 x 6-in. board supports the line through its entire length. This type of line has the mechanical and safety advantages of a concentric type line without the voltage-flashover problem involved in the use of standard concentric lines of relatively small diameter. Moreover, it is easily constructed from readily available parts and easily changed when necessary.

Switching is accomplished by knife-blade switches mounted on standoffs directly in the line. In Fig. 5 one of these switches may be seen at the right-angle junction of the lines to two of the presses.

Spar Manufacturing Procedure

The first of three presses to be used in the spar-manufacturing operation is the edge-gluing press. This is a press which was built on the location for this particular job. An end of it can be seen at the left in Fig. 5 and part of the length (it is 25 ft. overall) in Fig. 9. The retaining members of this press are U-shaped channel irons welded to form a rigid framework and supported by a wood frame in a convenient working position. An end view diagram is shown in Fig. 10.

Boards to be edge-glued are placed side by side, with the outer edge of one board pressing against the retaining frame and the outer edge of the other board pressing against a length of deflated fire-hose. Pressure is applied by filling the fire-hose with water at 100 lb pressure. As the fire-hose expands it presses the two boards firmly together and holds them for as long as required, after which a valve at the far end is operated to release the pressure.

The arrangement of electrodes used with this edge-gluing press may be seen in Fig. 10. The top electrode is about 8 in. wide, so that the joint to be glued can fall anywhere within this width. The electrodes are nearly 25 ft long, allowing boards as long as the press will accommodate to be glued in one operation. Gluing in this case is accomplished by making most of the current flow through the glue line.

Using only part of the available power, edge joints in boards 16½ ft long are securely set in two minutes. Temperature measurements show that the glue comes up to a temperature of over 200 deg. in a period of ten to fifteen seconds. The joints made in this press have been carefully tested by several laboratories and found to exhibit strength which in all cases is above specifications, and in most cases is greater than that of the wood itself.

The second press position, in the ordinary sequence of operations, is the scarf-jointing press. Several different presses have been used for this purpose, the most satisfactory of which, from the r-f viewpoint, was an all-wood press using two lengths of fire-hose to obtain the necessary pressure on the top caul board.

The arrangement of electrodes is shown in Fig. 11. In this instance the whole body of the wood is heated (experiments with heating only through the glue line having yielded questionable results). For most operations a number of scarfs are done at one time since plenty of power is available and a saving in handling time is effected. Making eight scarf joints as shown usually requires about ten minutes. A scarf joint made in this manner is shown in Fig. 12.

The third press operation is that of assembling the several layers to make the 6 x 6-in. block. This is done in a large press which originally was used in making simple laminated

(*Continued on page 196*)

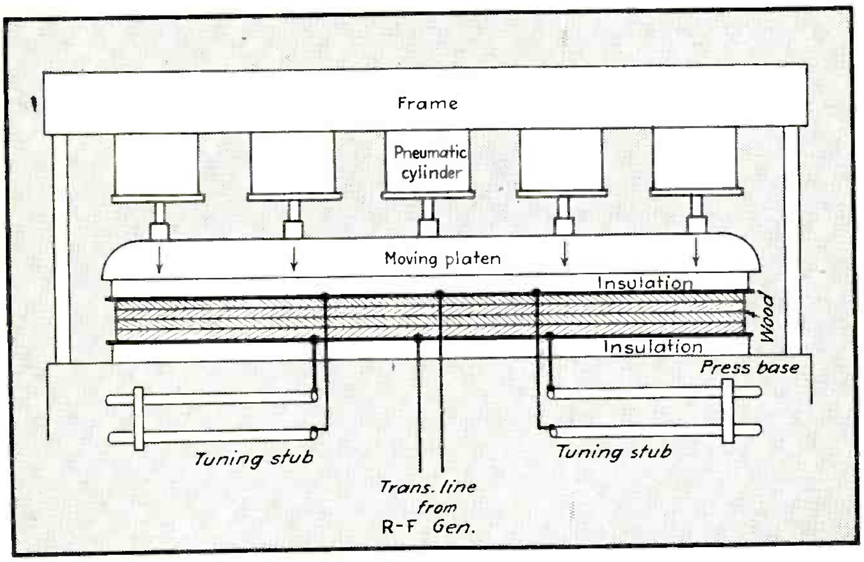


FIG. 14—Arrangement of electrodes and tuning inductances (stubs) on the large press. Two tuning inductances are used in order to reduce voltage variation due to the standing wave along the platen

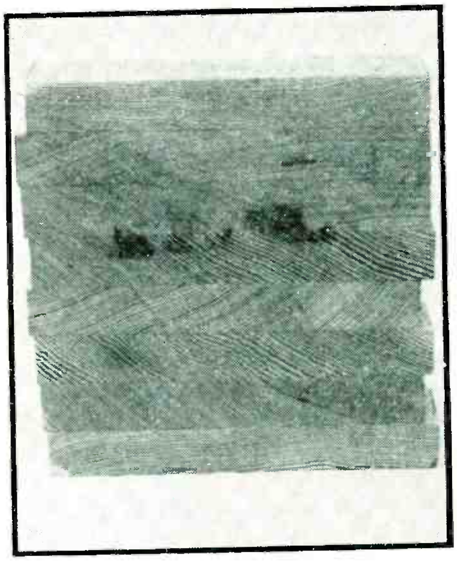


FIG. 15—Piece cut from the end of the 6 in x 6 in. x 16½-ft block from which the multi-laminar spar is cut

P-M Communication System for CHICAGO SURFACE

LEFT: Battery of squad cars equipped with mobile p-m communication equipment

BELOW: Control panel for mobile radiotelephone set is mounted at base of dashboard in squad cars

Forty-four mobile units with two-way phase-modulated radio equipment and seven supervisory cars with receivers keep streetcars and buses operating smoothly under all emergencies, proving the effectiveness of low-power p-m in covering 190 square miles of territory

The phase-modulated radio communication system which is being used by the Chicago Surface Lines to provide city-wide coverage for emergency operation now has a background of a year and one-half of successful operation.

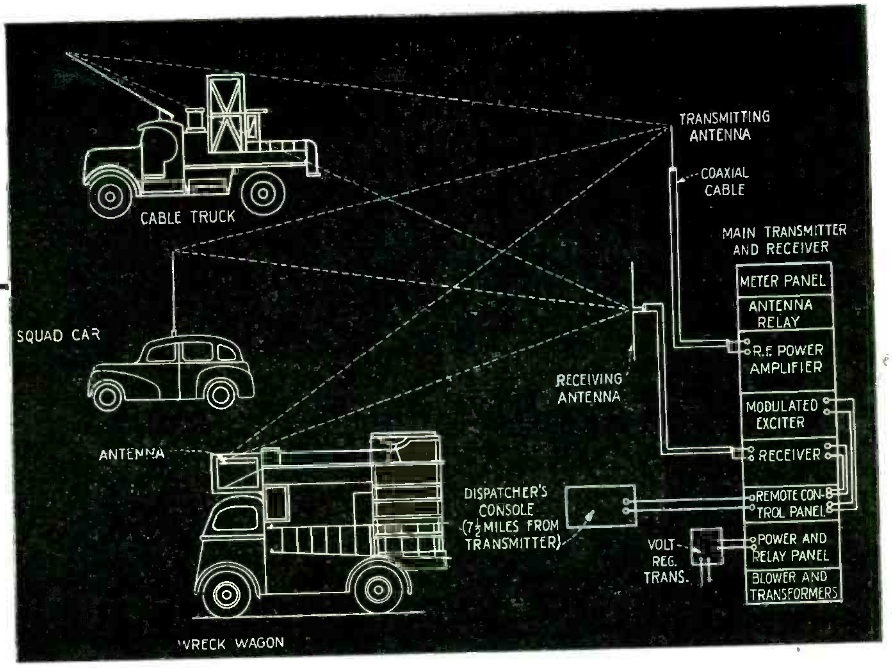
The system fulfills an important need when fires, floods, accidents or other emergencies endanger life and property and normal communication is not readily available. It has even been called upon to obtain medical attention for streetcar passengers suddenly taken ill, and in at least one case a squad car became an emergency maternity ward. Furthermore, by bringing squad cars to accidents promptly, the system has materially aided in adjustment of claims and reduction of losses.

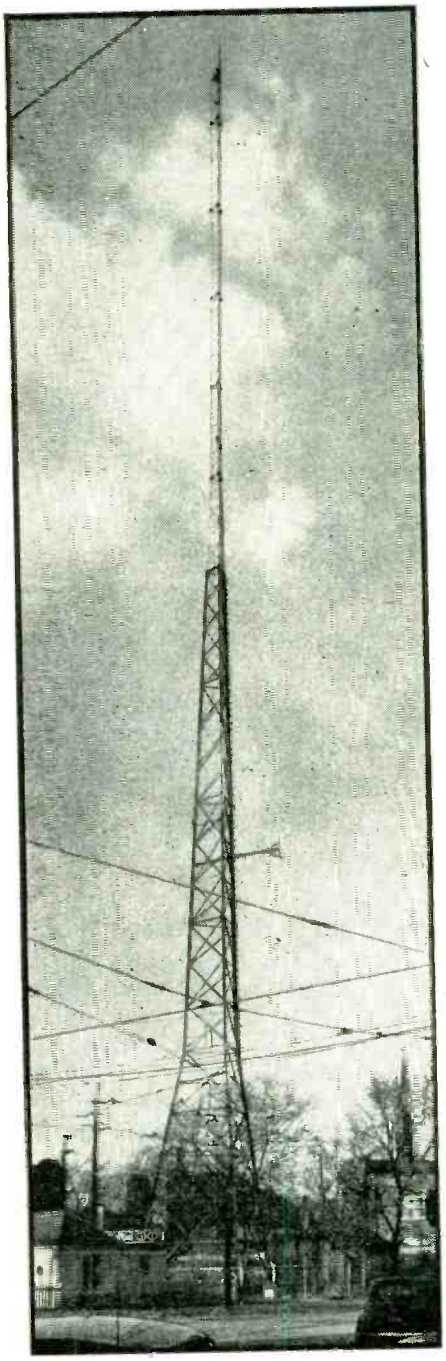
With an area of some one-hundred square miles, Chicago has a population of approximately three and one-half million persons served by several transportation systems, of which the largest is the Chicago Surface Lines. This system provides approximately four million passenger rides per day by means of approximately 3500 streetcars, electric trolley buses and gasoline-powered buses, of which the latter are used primarily in outlying sections of the city as feeders to the main streetcar system.

The operation and maintenance of so vast a transportation system requires an elaborate means of communication which in the past has been provided largely by telephone service. Telephone service, however, has been found inadequate for meeting the various emergencies which must necessarily be expected to arise when several thousand mobile units are in constant use, for a telephone communication system operates satisfactorily in only one direction. While it is possible for streetcar operators to phone the

LINES

By
BEVERLY DUDLEY
Western Editor





ABOVE: FIG. 1—Functional diagram illustrating operation of p-m radio system used by Chicago Surface Lines

LEFT: Main antenna tower. Receiving dipole can be seen at the 86-foot level on the 267-foot tower

RIGHT: Interior view of Motorola transmitter and receiver unit at main station. The tank in the corner maintains dry atmosphere of nitrogen in coaxial cables. On wall at left are a Weston photoelectric control unit for tower lights and a Sola constant-voltage transformer

central office in the event of emergency, it is not possible for the central office to get in touch with the public transportation units or squad cars, wrecking wagons or line trucks whose positions vary constantly.

Outline of System

The radio system which has been installed provides two-way communication between a dispatcher's office located in the loop and 44 mobile units distributed throughout various sections of the city. In addition, seven automobiles are provided with receivers for one-way communication and are used by executives of the company for supervisory control. All transmitters and receivers operate on the same carrier frequency. Since all receivers are in continuous operation, each mobile unit is kept in constant touch with other units and with the dispatcher's desk.

Of the 44 two-way mobile units, 18 are installed in Chevrolet passenger automobiles which tour the entire city throughout the day for approximately 18 hours. Only three of these cars are used during the

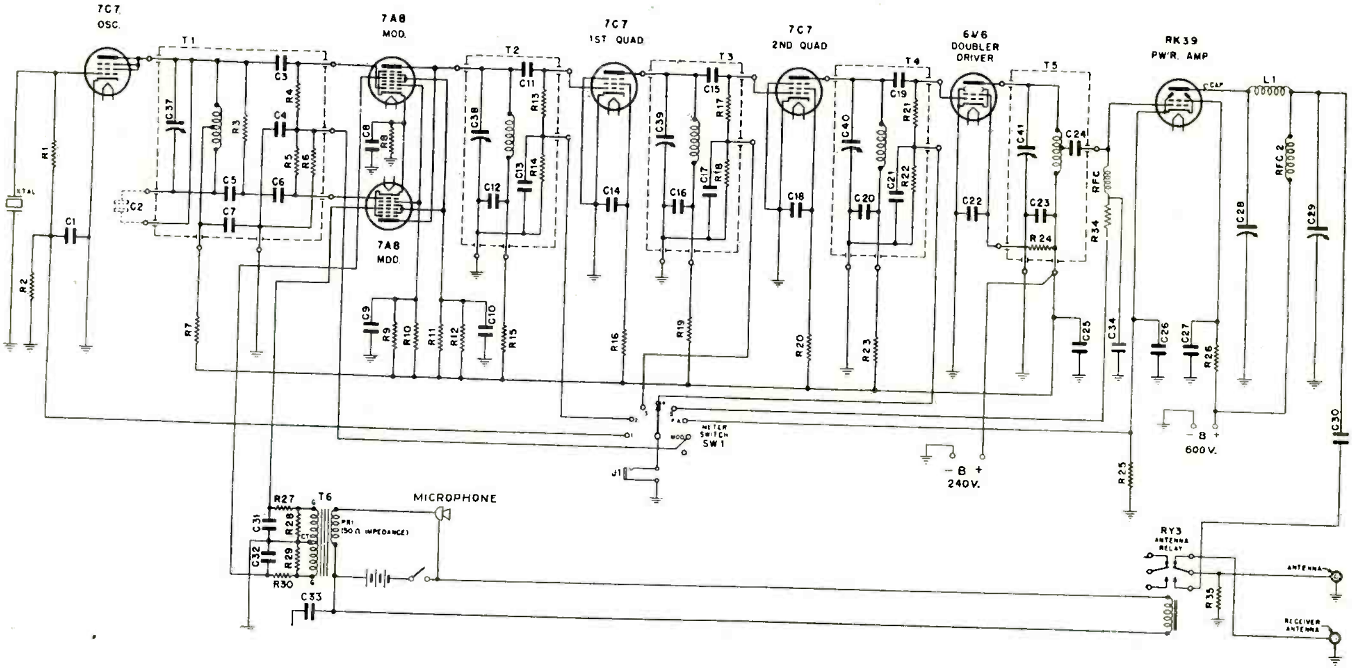


FIG. 2—Simplified schematic wiring diagram of p-m mobile transmitter delivering 30 watts. A similar unit, but with two 807 (or RK39) tubes in parallel in the final r-f stage, and powered from a rectifier-filter system rather than from storage batteries and a generator, is used as the exciter unit for the remotely-controlled main transmitter. For purposes of simplicity, numerous protective, remote control and interlocking circuits have been omitted from this diagram

C1 —5,000 μμf, 300 v
C2 —50 μμf, 400 v
C3 —100 μμf, 400 v
C4 —2,000 μμf, 500 v
C5 —10 μμf, 400 v
C6 —100 μμf, 400 v
C7 —5,000 μμf, 300 v
C8 —20 μf, 25 v
C9 —0.05 μf, 600 v
C10—0.05 μf, 600 v
C11—100 μμf, 400 v
C12—5,000 μμf, 300 v
C13—2,000 μμf, 500 v
C14—2,000 μμf, 500 v
C15—100 μμf, 400 v
C16—2,000 μμf, 500 v
C17—2,000 μμf, 500 v
C18—2,000 μμf, 500 v
C19—100 μμf, 400 v
C20—2,000 μμf, 500 v
C21—2,000 μμf, 300 v
C22—5,000 μμf, 300 v
C23—2,000 μμf, 500 v
C24—50 μμf, 400 v
C25—0.05 μf, 600 v
C26—5 to 44 μμf
C27—50 μμf, 200 v
C28—50 μμf, 400 v
C29—500 μμf, 400 v
C30—0.05 μf, 600 v
C31—0.05 μf, 600 v
C32—0.05 μf, 600 v
C33—5 to 44 μμf
C34—50 μμf, 200 v
C35—50 μμf, 200 v
C36—5 to 44 μμf
C37 to C41—trimmers
R1 —470,000 ohms
R2 —1,000 ohms
R3 —10,000 ohms
R4 —47,000 ohms
R5 —47,000 ohms
R6 —100 ohms
R7 —4,700 ohms
R8 —330 ohms
R9 —100,000 ohms
R10—100,000 ohms
R11—33,000 ohms
R12—33,000 ohms
R13—220,000 ohms
R14—100 ohms
R15—1,000 ohms
R16—150,000 ohms
R17—220,000 ohms
R18—100 ohms
R19—1,000 ohms
R20—150,000 ohms
R21—220,000 ohms
R22—100 ohms
R23—1,000 ohms
R24—2,200 ohms
R25—½ ohm
R26—20,000 ohms
R27—22,000 ohms
R28—220,000 ohms
R29—220,000 ohms
R30—22,000 ohms
R31—470 ohms
R32—5,000 ohms
R33—18 ohms
R34—22,000 ohms
R35—27,000 ohms

remaining six hours. Effective coverage of all of the company's transportation units is provided by these squad cars. Fifteen wreck wagons equipped with two-way units are located throughout the city in the company's garages, which are connected by telephone lines to dispatcher's office. These wreck wagons serve to remove stalled vehicles from the right of way, clear collisions between vehicles when these occur at locations which would block the passing of the company's passenger-carrying units; guard fallen wires and feeder cables while awaiting arrival of regular repair crews; cooperate with the fire department at fires to maintain regular transportation and to safeguard life and property and perform similar emergency functions.

The remaining 11 two-way mobile units are located on trucks equipped to handle the installation and repairs of overhead contact wires and feeders. These trucks are also available for emergency service.

Communication from a central dispatcher's office in the centrally located business district with the 51 mobile units is made possible by a remotely controlled transmitter and receiver combination operating under the call letters WAYH. The transmitter and receiver are located in a small tile building at the base of a 267-foot triangular steel tower at Madison Street and Austin Boulevard.

This site marks the western city limits and the dividing line between the north side and the south side of the city. This site was determined by Motorola engineers after a complete survey of the city for a suitable location. It offers a low noise level to facilitate the reception of signals from the mobile units located at any point in the city and provides complete coverage of the city with the 250-watt, 39.86-Mc phase-modulated transmitter located in the small building at the base of the tower. The transmitter and receiver are connected to a vertical half-wave antenna.

Figure 1 indicates the functional arrangement of the communication units of the system.

Although the origination of a satisfactory communication system is in itself a design problem of appreciable magnitude, the organization and proper administration of the operating personnel requires the services of several hundred employees. Each of the men in the squad cars and the foreman of the wrecking wagons and cable trucks are required to possess restricted radio telephone licenses in order to operate the radio equipment in the automobiles. In all, some 250 employees of the Chicago Surface

Lines have radio licenses for operating such equipment. This number includes a sufficient number of men for maintaining 24-hour operation of the system and for relief personnel to replace those on vacations.

It is estimated that during a normal day's operation, between 100 and 200 messages per day are transmitted over this system. This is approximately an average of four calls per mobile unit each day.

Although all components of the system have been found to operate in a highly satisfactory manner, a maintenance and repair shop is operated at one of the storage barns and garages owned by the surface lines. Several spare units are always kept available in this shop for immediate replacement should this become necessary. By according proper service to the transmitters and receivers in the mobile units, major repairs are reduced to a minimum.

Mobile Units

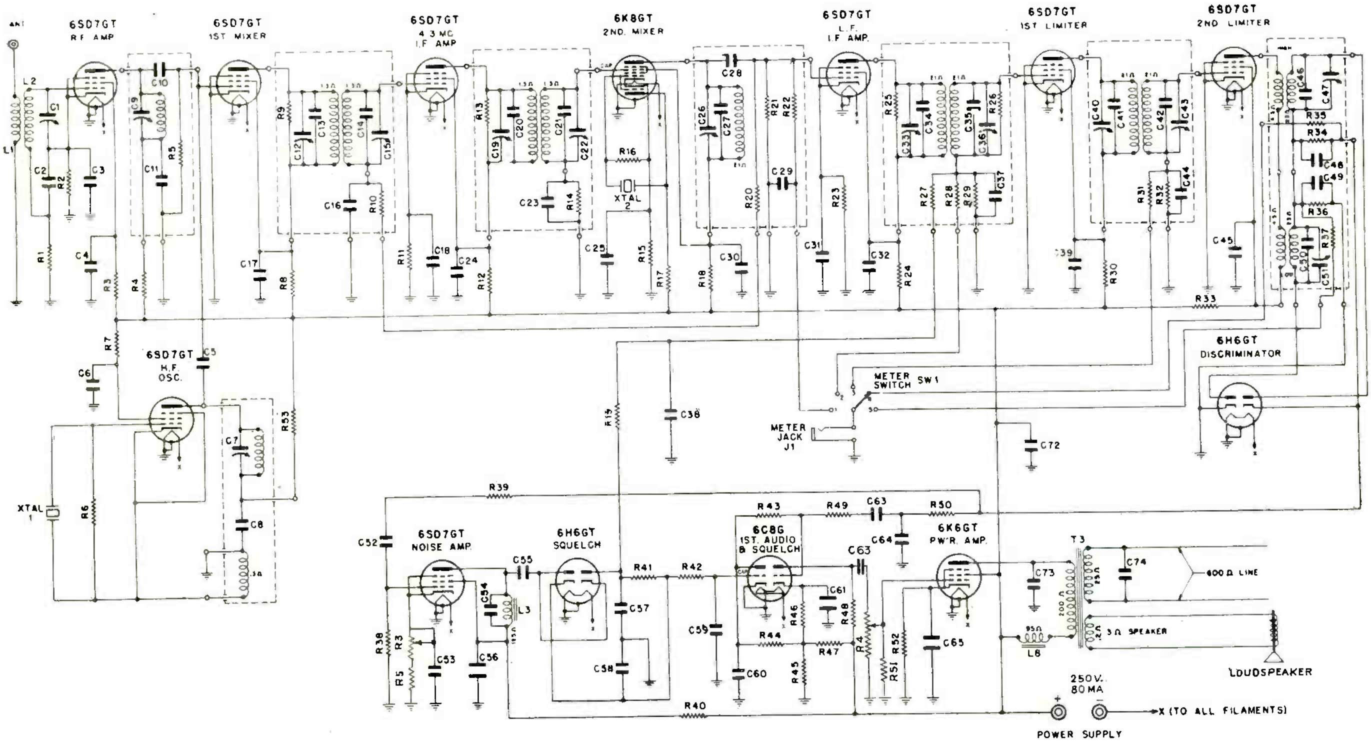
Flexibility of operation has been one of the foremost design characteristics in establishing this radio system. Not only is the equipment of one mobile unit interchangeable with that mounted on any other mobile unit, but with minor modifications which may be easily effected, the same equipment is used in the main transmitting and receiving station. Such a system makes possible the ready replacement and servicing of units which may not perform as well as may be expected or which may become damaged in service. Accordingly, a description of the equipment in the mobile unit will likewise constitute a description of the major part of the transmitting and receiving equipment of the main station.

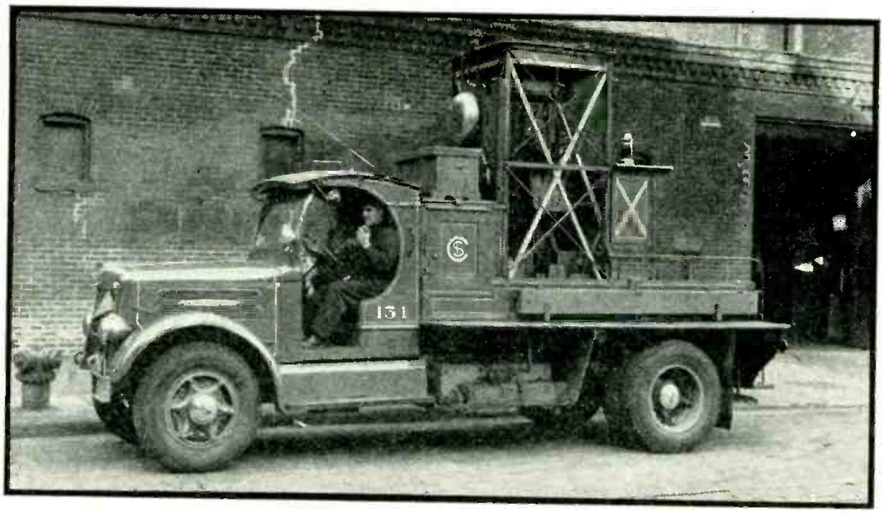
A complete installation for a mobile unit includes the following equipment: (1) antenna; (2) receiver; (3) transmitter; (4) control head; (5) microphone; (6) connecting cable; (7) accessory kit and instruction-service manual.

The antenna is customarily

FIG. 3—Wiring diagram of the p-m receiver used in mobile units. An input stage of r-f amplification, two limiters, and squelch circuits are features of this double superheterodyne, both oscillators of which are crystal controlled. Receivers for mobile units employ battery and vibrator power supply. Similar units with supply from rectifier-filter systems are used at the main station

C1 —3.5 to 50 μμf
C2 —500 μμf, 400 v
C3 —5,000 μμf, 400 v
C4 —5,000 μμf, 400 v
C5 —2 μμf
C6 —2,000 μμf, 400 v
C7 —5 to 44 μμf
C8 —5,000 μμf, 400 v
C9 —5 to 44 μμf
C10—100 μμf, 400 v
C11—5,000 μμf, 400 v
C12—5 to 44 μμf
C13—10 μμf, 500 v
C14—10 μμf, 500 v
C15—5 to 44 μμf
C16—500 μμf, 400 v
C17—5,000 μμf, 400 v
C18—5,000 μμf, 400 v
C19—5 to 44 μμf
C20—10 μμf, 650 v
C21—10 μμf, 650 v
C22—5 to 44 μμf
C23—500 μμf, 400 v
C24—5,000 μμf, 400 v
C25—0.05 μf, 600 v
C26—5,000 μμf, 300 v
C27—2,000 μμf, 500 v
C28—35 μμf max.
C29—140 μμf max.
C30—0.01 μf, 2500 v
C31—2,000 μμf, 500 v
C32—2,000 μμf, 500 v
C33—40 μf, 25 v
C34—2,000 μμf, 500 v
C35—6 μf, 10,000 v
C36—2 μf, 1,000 v
C37—100 μμf, 400 v
C38—0.05 μf, 600 v
C39—0.05 μf, 600 v
C40—5 to 44 μμf
C41—50 μμf, 200 v
C42—50 μμf, 200 v
C43—5 to 44 μμf
C44—100 μμf, 400 v
C45—0.05 μf, 600 v
C46—40 μμf, 200 v
C47—5 to 44 μμf
C48—500 μμf, 400 v
C49—500 μμf, 400 v
C50—40 μμf, 200 v
C51—5 to 44 μμf
C52—2,000 μμf, 400 v
C53—0.05 μf, 600 v
C54—2,000 μμf, 400 v
C55—5,000 μμf, 400 v
C56—15 μf, 250 v
C57—5,000 μμf, 400 v
C58—5,000 μμf, 400 v
C59—0.05 μf, 600 v
C60—0.05 μf, 600 v
C61—15 μf, 250 v
C62—5,000 μμf, 400 v
C63—5,000 μμf, 400 v
C64—100 μμf, 400 v
C65—20 μf, 25 v
C72—2,000 μμf, 400 v
C73—0.02 μf, 600 v
C74—0.25 μf, 100 v
R1 —100,000 ohms
R2 —270 ohms
R3 —68,000 ohms
R4 —4,700 ohms
R5 —4.7 megohms
R6 —47,000 ohms
R7 —47,000 ohms
R8 —27,000 ohms
R9 —470,000 ohms
R10—100,000 ohms
R11—330 ohms
R12—15,000 ohms
R13—470,000 ohms
R14—27,000 ohms
R15—330 ohms
R16—47,000 ohms
R17—150,000 ohms
R18—10,000 ohms
R19—1 megohm
R20—1 megohm
R21—100,000 ohms
R22—1 megohm
R23—560 ohms
R24—27,000 ohms
R25—100,000 ohms
R26—47,000 ohms
R27—1 megohm
R28—1.5 megohm
R29—100,000 ohms
R30—27,000 ohms
R31—1.5 megohm
R32—100,000 ohms
R33—27,000 ohms
R34—100,000 ohms
R35—470,000 ohms
R36—100,000 ohms
R37—1 megohm
R38—1 megohm
R39—470,000 ohms
R40—15,000 ohms
R41—1 megohm
R42—1 megohm
R43—1 megohm
R44—270,000 ohms
R45—6,800 ohms
R46—4,700 ohms
R47—47,000 ohms
R48—270,000 ohms
R49—820,000 ohms
R50—220,000 ohms
R51—2.2 megohms
R52—1,000 ohms
R53—4,700 ohms





Cable truck equipped with radio facilities. The steel rod antenna mounted on roof of driver's cab is at a 45-deg. angle pointing forward, and the two radio units are mounted in the wooden case below the large gong. Microphone, loudspeaker, and control panel are mounted inside roof of driver's cab

mounted in the center of the roof on squad cars. In the case of wrecking wagons or cable trucks suitable space is at a premium. The antenna is mounted above the driver's seat and out of the way of ladders, cable reels, or other equipment.

At the frequency of 39.86 Mc, the quarter-wave antenna is approximately 5½ feet tall. This roof-type antenna is sufficiently rigid to be self-supporting under ordinary conditions of operation. At the same time, sufficient flexibility is provided so that the antenna may bend over should it strike the limb of a tree or other obstructions lower than approximately 12 feet above street level. The roof-top antenna is supported by a cone-shaped helical spring. The antenna is cut to the exact length for the operating frequency. A V-shaped antenna is used on the wrecking trucks due to lack of space for the usual type of antenna.

Transmitters for Mobile Units

The transmitters for the mobile units are phase-modulated and operate at a carrier frequency of 39.86 Mc with a maximum rated carrier power of 30 watts. They are designed for 100-percent phase modulation at 15 kc deviation. The oscillator is crystal-controlled and is guaranteed to maintain its frequency to within ±0.02 percent of its assigned value without temperature control. Except for antenna, storage battery power supply and microphone with its accessory control circuit, the transmitter is self-contained in a gray crackle-finish steel cabinet. Most of the circuits in the transmitter operate at low power and employ receiving-type tubes and receiver construction. The 30-watt output amplifier uses heavier coils and exhibits the constructional features of a low-powered transmitter.

Power for operation of the mobile transmitter is obtained from a heavy-duty storage battery. This is used to operate the filaments of the transmitter tubes. It also supplies power to drive the dynamotor, which provides 160 ma at 600 volts for the final power amplifier, as well as 240 volts for the supply of the oscillator and exciter amplifiers.

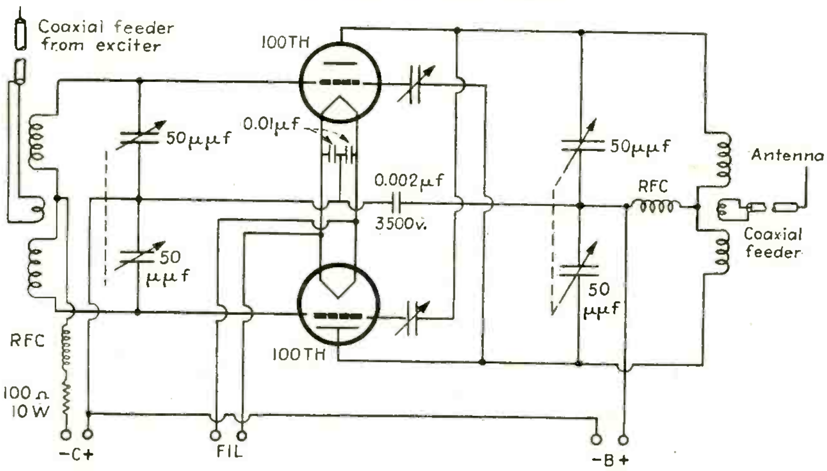
A simplified schematic wiring diagram of the mobile transmitter is shown in Fig. 2. The transmitter employs a 7C7 oscillator connected as a triode, two frequency quadrupling stages each using a 7C7 tube, and a frequency doubler using a 6V6 beam power tube whose power output is fed to the grid circuit of the final stage employing one 807 or one RK-39 beam tube as the power amplifier. In addition, two 7A8 tubes in a push-pull arrangement are used simultaneously as r-f amplifiers at the crystal frequency and as a push-pull modulator. It will be seen that the frequency is multiplied 32 times in the various amplifying stages, and accordingly the quartz crystal operates at $\frac{1}{32}$ of the assigned carrier frequency, or at 1,245.6 kc.

The first r-f amplifier, operating at the crystal frequency, is also the modulator and makes use of a pair of 7A8 tubes in a push-pull arrangement. R-F energy from the crystal oscillator is fed through a phase-splitting circuit to the first grid of each of the 7A8 tubes, whereas the audio voltage from a split-phase microphone transformer is fed to the second control grid of the 7A8 tube to provide phase modulation. Either a military type microphone or a cradle type hand set may be used interchangeably if the receiver in the hand set is not to be used.

The schematic wiring diagram does not show the details of the var-

(*Continued on page* 238)

FIG. 4—Schematic wiring diagram of push-pull neutralized final r-f power amplifier delivering 250 watts output



Post-War INDUSTRIAL EQUIPMENT Distribution

There are three types of electronic gear—devices which will probably have to be sold by their manufacturer, products which can be merchandised by "middle men" and component parts. Education of industry rather than engineering is the key to the future

By S. S. EGERT

INDUSTRIAL electronics, in the author's opinion, will develop less rapidly than many people think, immediately after the war, due to several factors:

First: The demand for new home radios and other communications equipment will to some extent dominate the initial post-war activities of the industry.

Second: Many circuits needed to practically adapt electronic principles to industry are being developed during the war period and it will take time to convert them to peacetime use.

Third: Education of industry to the use of electronic equipment must be more widespread. It must also be based on sound economic facts and will require time and effort to devise and execute.

Fourth: A complete new distribution plan must be developed to sell many newly-created industrial items.

Three Types of Gear

In spite of these initial difficulties the industrial electronics field is destined to become one of our largest industries. Speed of market development will depend to a considerable extent upon solution of the distribution problem.

Unfortunately, industrial electronics has no precedent on which to base a distribution plan. Its wide scope requires a plan which reaches and informs people with such widely divergent interests as scientists, teachers, design engineers, production managers, service engineers, sales engineers and other personnel in many fields and industries.

Industrial electronic equipment may be divided into three main groups, as follows:

Group 1—Devices which require direct selling by the manufacturer.

Group 2—Devices which may be sold by "middle men" but which require specialized knowledge for installation.

Group 3—Basic component parts.

A short discussion of each of these groups may help the reader's thinking.

Direct Distribution

Group 1—Items of direct sale will require highly specialized selling knowledge. Each sale will have large dollar value. In areas where the volume of business warrants it, factory branch offices may be maintained. In areas where there is insufficient volume the work would have to be handled direct from the home office.

One industrial item which at present appears to be in this group is the electronic heating unit. Even though the actual basic units may be similar for many varied applications, only trained specialists thoroughly familiar with the equipment and its application can sell, install and service it. This is due to the highly specialized knowledge necessary for applications involving processes of welding, melting, brazing, plating, etc., on varied products such as metals, wood and plastics.

In merchandising this type of equipment, literature, advertising and sales effort must be based principally on cost-saving thoughts.

Jobber Distribution

Group 2—This group includes industrial electronic devices which can be packaged and sold through jobbing outlets with trained sales and service-engineering personnel. Examples of such items are packaged photoelectric relays, capacity relays and specialty test equipment.

From present indications the bulk of the items in this group will first be distributed by electrical or electronic-radio jobbing houses. As the volume of the individual items increases some distribution will be taken over by other jobbers serving specific fields, such as those handling mill supplies.

Jobbers can obtain technical help

(*Continued on page* 200)

ONE MAN'S OPINION

THE AUTHOR is a salesman of electronic apparatus, with a technical background and considerable practical experience in the field. His future business prospects depend largely upon careful planning for things to come

THE PREDICTIONS advanced here, nevertheless, represent just one man's opinion. He may be right or he may be wrong in his thinking concerning the post-war industrial market. Comment is invited

Electron Bombardment in TELEVISION

A detailed analysis of actions occurring in an Iconoscope when an elemental area of the mosaic is bombarded by the scanning electron beam under conditions varying from dark to light. The sticking effect, important in projection kinescopes, is explained

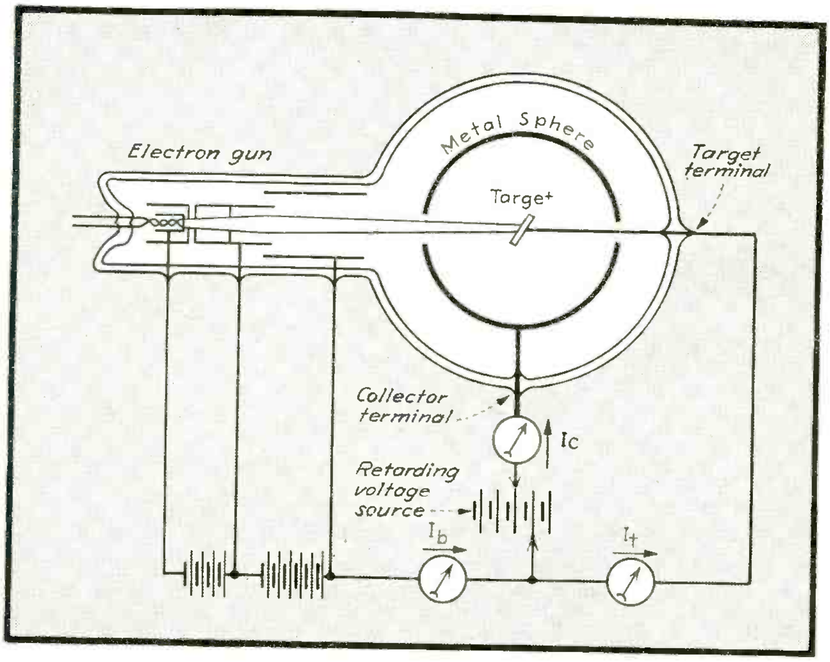
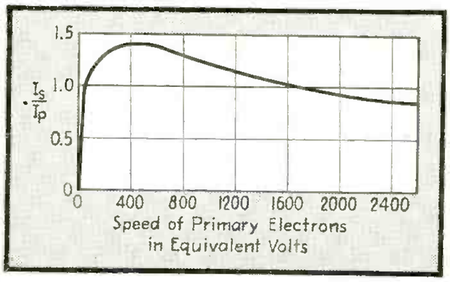


FIG. 1 (above)—Essential features of special cathode-ray tube developed for studying electron bombardment of target surfaces

FIG. 2 (right)—Ratio of secondary electrons to primary electrons as plotted against speed of primary electrons when using a pure nickel target in the tube of Fig. 1



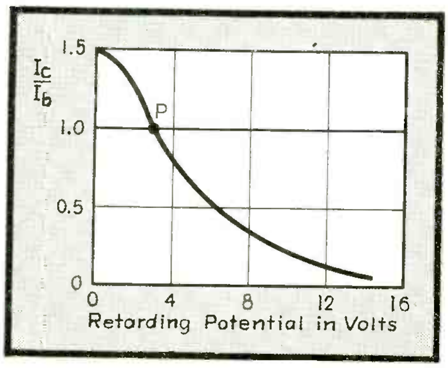


FIG. 3 (left)—Ratio of collector current to beam current as plotted against negative retarding potential (collector negative with respect to target) when using a pure nickel target and a fixed primary electron speed of 500 equivalent volts in the cathode-ray tube of Fig. 1

IN AN ORDINARY VACUUM TUBE there are two main effects—the controlled unidirectional flow of electrons from cathode to plate, and the bombardment of the plate by these electrons. The controlled unidirectional conduction is in these tubes the desired effect, and the electron bombardment is generally undesirable because it heats the collecting electrode and results in energy losses.

While modern all-electronic television makes use of a great number of ordinary radio vacuum tubes, its actual functioning depends mainly on cathode-ray tubes at the transmitting and receiving ends of the television system. In television cathode-ray tubes the same two main effects exist, but with an important difference—the electron bombardment is utilized, while the unidirectional conduction is incidental to the operation of the tubes. Electron bombardment of targets and the resulting secondary emission make possible the operation of both the Kinescope (receiving tube) and the Iconoscope (camera pickup tube).

There is another distinction between the ordinary vacuum tube and the television cathode-ray tube. In ordinary tubes the plate acts as both the target and the collector, whereas in television tubes the target is either an insulator or an insulated conductor, with the collection of electrons being done by another electrode. This collecting electrode is usually the second anode.

When a surface is bombarded by electrons of considerable velocity, the incident electrons may impart to the electrons near the surface sufficient

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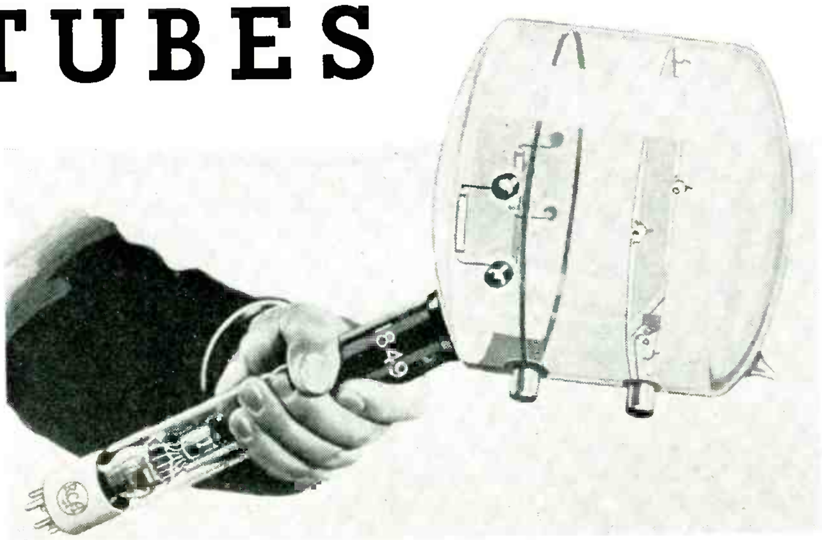
TUBES



energy to escape from the surface. The incident electrons are called the primary electrons, while the electrons leaving the surface are called the secondary electrons. The number of secondary electrons emitted for each primary electron, and the velocity of the secondaries, vary with the velocity of the primary electrons and with the chemical nature and physical condition of the surface.

Bombardment Research Tube

In Fig. 1 a typical tube for studying electron bombardment of a given surface is shown. The target is located at the center of a metallic sphere and is kept at a desired potential with respect to the cathode, thereby assuring a definite velocity of the bombarding primary electrons. The electron beam is produced in a conventional electron gun and enters the sphere through a small hole in its wall. Provisions are made for varying the potential of the sphere with respect to the target, as well as for reading the currents to the target, the sphere and the beam current.

For a conducting target, such as pure nickel, the target current I_t is equal to the beam (primary) current I_b minus the collector current I_c ($I_t = I_b - I_c$). A negative value for target current I_t indicates that the ratio of secondary current to primary current (I_s/I_p) is greater than unity. When I_t is positive, the ratio is less than unity, and when I_t is zero the ratio is unity. A curve of variation of this ratio for pure nickel target as a function of velocity of primary electrons is shown in Fig. 2. (For a contaminated metal surface the secondary emission ratio is generally greater than for the clean surface shown.)

Equilibrium Potential of Target

At a given voltage difference between the target and the cathode one may apply increasing negative or retarding voltages on the collector with respect to the target. When this is done, the collector current will gradually drop to zero.

For pure nickel and a 500-volt beam, the curve of the ratio of collector current to beam current as a function of the retarding voltage is shown in Fig. 3. At point P, where the curve goes through a ratio value of unity, the target current I_t is equal to zero. This is an important point on the curve. Since there is no current flowing to the target, the lead to the target may be cut under the conditions at P without disturbing either the electrode potentials or the currents to them.

Since the potential of the target is not changed when the target lead is cut under the conditions at P, the

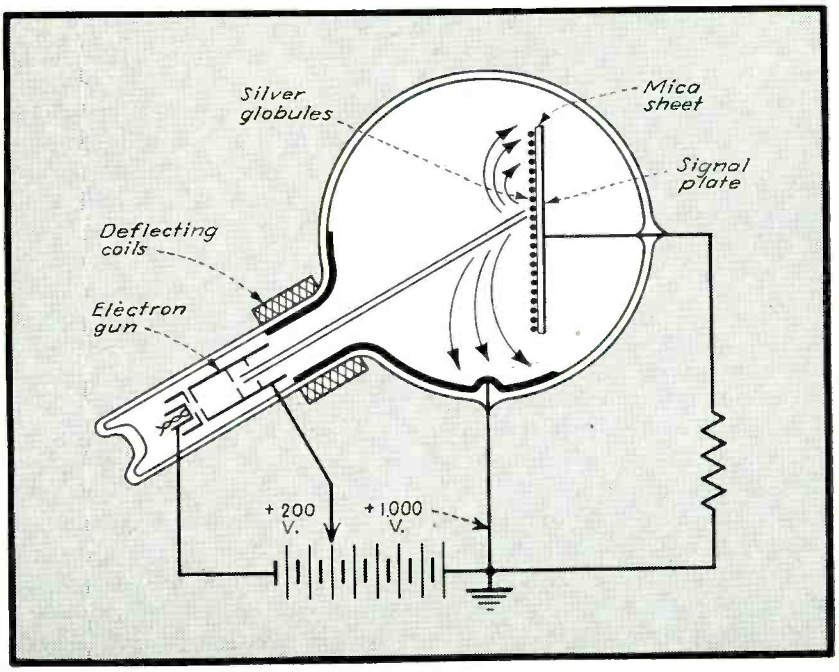


FIG. 4—Essential features of a standard Iconoscope for electronic television cameras

target potential is still equivalent to the beam velocity. The collecting sphere, however, is at −3 volts with respect to the target. A conclusion follows: an *insulated* nickel target will assume a potential of 3 volts higher than the collector for 500-volt primary electrons. (The collector has to be at 497 volts.) Or, generally speaking, when the secondary emission ratio is higher than unity, an insulated metal target will assume a potential of a few volts positive with respect to the collector. This potential is called the equilibrium potential of an insulated target under electron bombardment. The velocity of the primary electrons will of course be equivalent to the sum of the collector voltage plus the voltage between the insulated target and the collector.

Sticking Effect

Now let the nickel target float and increase the collector potential to 1700 volts. The secondary emission ratio of pure nickel at this voltage is unity and the target will float to the same potential as the collector, so that the difference of potential between the two is zero.

If the collector potential is further increased, the insulated target will stay at the same potential with respect to the cathode. In other words, it will be getting more and more negative with respect to the collector. This phenomena is called the "sticking effect" in television vernacular. To observe how it happens, make a metallic connection between the target and the collector and raise both to 2000 volts with respect to the cathode. The secondary emission ratio at 2000 volts is nine-tenths, and while meter I_b will measure the current flowing to the target and collector together, nine-tenths of it will flow to the collector and one-tenth to the target.

If the target is now disconnected and left floating, more electrons will be arriving at it than departing from it, charging it negatively with respect to the collector. At the same time the arriving primary electrons slow down to the velocity equivalent to the actual voltage between the target and the cathode.

With primary electrons slower than 2000 volts, the secondary emission ratio increases, and finally, when the target is at exactly 1700 volts positive with respect to the cathode, and 300 volts negative with respect to the collector, the ratio becomes unity. In other words, the target here "sticks" at an equilibrium potential of 1700 volts, and any increase in the voltage on the collector will not increase the potential of the floating target.

The two cases just described play a very important part in the performance of television cathode-ray tubes and have to be clearly understood before an analysis of their performance can be undertaken. Sticking is especially important in projection kinescopes when it is desired to use high voltages on the second anode to get more light. Before using these high voltages, such as 20 to 70 thousand volts, one must make certain that the luminescent material does not "stick" below the value chosen.

Mosaic is Target in Iconoscope

The action of electron bombardment in a standard Iconoscope is somewhat similar to the case of bombarding an insulated metal target with electrons having a velocity at which the secondary emission ratio of the target is greater than unity.

Figure 4 shows the arrangement of the essential parts in a standard Iconoscope. Generated by a conventional electron gun, an electron beam of approximately 1000-volt velocity enters a nearly equipotential space in the bulb portion of the tube, where it strikes the photosensitive mosaic. The mosaic consists of a multiplicity of minute silver globules, oxidized and caesiated (in other words, photo-sensitized), uniformly distributed on a 9 x 12-cm sheet of mica only 0.0025 cm thick. The back side of the mica sheet is platinized to form a capacitor between the globules and the platinum coating, having a value of 122 $\mu\mu$f per sq cm.

The secondary emission characteristics of oxidized and caesiated silver vary greatly, depending on the condition and method of preparation of the surface. These variations however are restricted to the maximum value of the secondary emission, while the relative velocity or energy distribution of secondaries changes little.

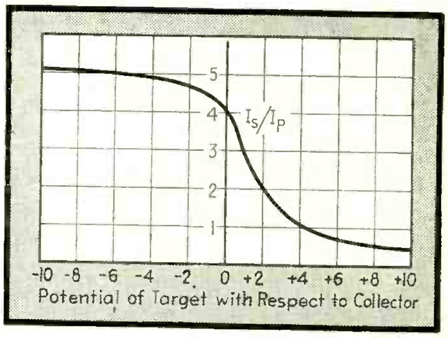


FIG. 5—Secondary emission characteristic of photosensitized silver

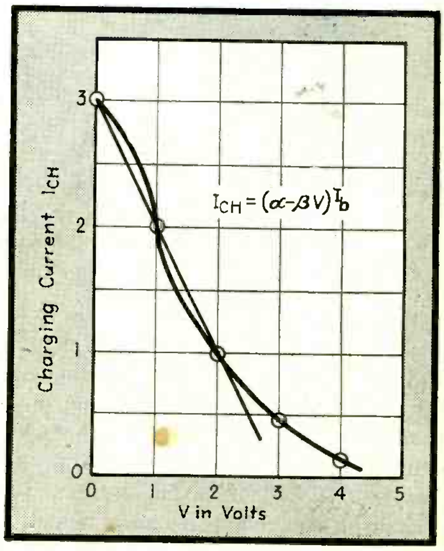


FIG. 6—Charging current characteristic of an Iconoscope mosaic

A typical energy distribution curve of secondary emission of photosensitized silver for 1000-volt primaries is shown in Fig. 5. As may be seen from the curve, the secondary emission characteristics of a complex surface differ from those of pure metals. In the case under consideration two important characteristic features attract attention at once. The first is the fact that the secondary emission ratio reaches a very high value of 5.1, compared with slightly more than one for pure nickel.

The second feature is that, with the collector at zero potential with respect to the target, not all the electrons from the target are collected. Apparently either there are some

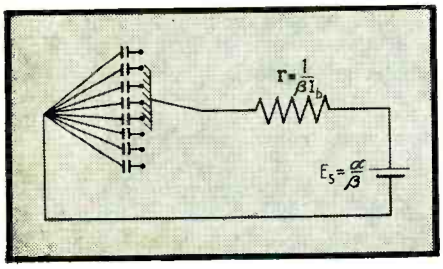


FIG. 7—Equivalent circuit of a dark mosaic undergoing scanning

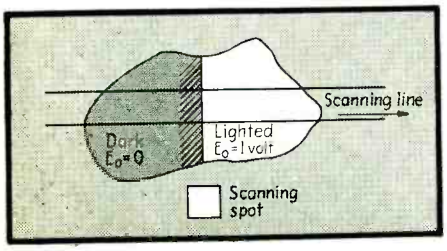


FIG. 8—Scanning from a dark area into a lighted area

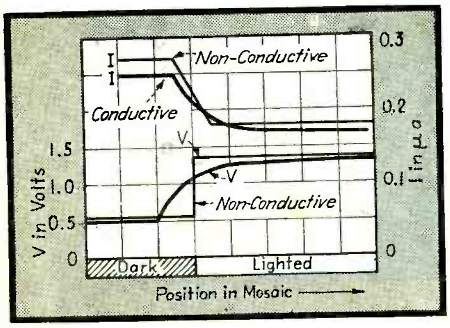


FIG. 9—Transient charging current I and mosaic potential V during scanning

electrons hidden in the crevices of the surface, or some electrons are emitted with "insufficient" velocities to reach the collector. They may be drawn to the collector by applying positive potentials to the collector with respect to the target. The second feature, while interesting, is of little importance to us since the collector is seldom positive with respect to the mosaic. Our interest lies, therefore, in the portion of the curve to the right of the line of zero collector potential.

Scanning Action

In actual Iconoscopes, the primary beam may be used with electron velocity between 500 and 2000 volts. Usually however, the velocity is 1000 equivalent volts. The beam is focused at the mosaic to an area of approximately one picture element. Therefore, at any one instant the area under electron bombardment is that of one picture element. The scanning spot, however, moves along the mosaic at a very high speed, bombarding a point on the mosaic for only 1.28×10^{-7} sec. for every frame of a 441-line picture.

If light falls on a portion of the mosaic, photoelectric emission takes place, and by losing some electrons that portion of the mosaic acquires a positive charge. Suppose a portion of the mosaic is charged to one volt positive, and consider what happens when this mosaic is scanned, first the part of it having no charge, then the boundary between the dark, the uncharged mosaic and the positively charged lighted mosaic, and finally when the lighted area is scanned.

The scanning spot may be considered as a square brush having an area of one picture element. The charges on the globules or sub-elementary capacitances under the spot are instantaneously equalized, so that one may talk of the potential of the spot and the charge on the spot. The charge on the spot is affected by the charging current, which is equal to the difference between the secondary current and the primary or beam current.

The charging current characteristic shown in Fig. 6 is easily derived by subtracting the beam current (unity) from the secondary emission characteristic. In the interval from 0 to 2 volts the charging characteristic is represented very closely by the straight line: $I_{CH} = (\alpha - \beta V) I_b = (3 - 1V) I_b$, where V is the potential of the target with respect to the collector.

Scanning a Dark Area

Now suppose the spot is moving in a normal scanning manner along the uncharged portion of the mosaic. If a steady state has been reached, the current to the signal plate, the potential of the moving spot, and the potential of elements already scanned are all steady and constant. The charging current is therefore

$$I_{CH} = (\alpha - \beta V) I_b \qquad (1)$$

The mosaic elements after scanning are all charged to the same potential V. Since the capacitance charged per second by the spot is nNC, the charge left by the spot on the mosaic is $nNCV$ coulombs per second, where n is the number of elements per frame, N is frames per second and C is the capacitance of a picture element. Coulombs per second is current in amperes; therefore, the two currents must be equal:

$$I (\alpha - \beta V) I_b = nNCV \qquad (2)$$

Solving this for V gives

$$V = \frac{\alpha I_b}{nNC - \beta I_b} = \frac{\alpha}{\beta} \cdot \frac{1}{\frac{nNC}{\beta I_b} + 1}$$

Now letting $1/nNC = R$, letting $1/\beta I_b = r$ and letting $\alpha/\beta = E_s$ gives

$$V = E_s \frac{R_1}{r + R_1} \qquad (3)$$

The solution in Eq. (3) is an exact equivalent of a simple charge of capacitors by a commutating brush in the arrangement shown in Fig. 7. The brush, covering a number of capacitors of a total capacitance C and commutating nNC farads per second, charges them through a resistance $1/\beta I_b$ from a battery of α/β volts.

Scanning a Boundary

If at time $t = 0$ the leading edge of a rectangular scanning spot or brush reaches the boundary between dark and lighted portions of the mosaic, a transient condition will prevail until some later time, when a new and different steady state will be reached. As shown in Fig. 8, before the leading edge of the spot reached the lighted portion, the current to the mosaic and voltage to which its elements are charged are both steady and of values given. Thus, before $t = 0$, $V = E_s R_1/(r + R_1)$ and $I_o = E_s R_1/(r + R_1) r$.

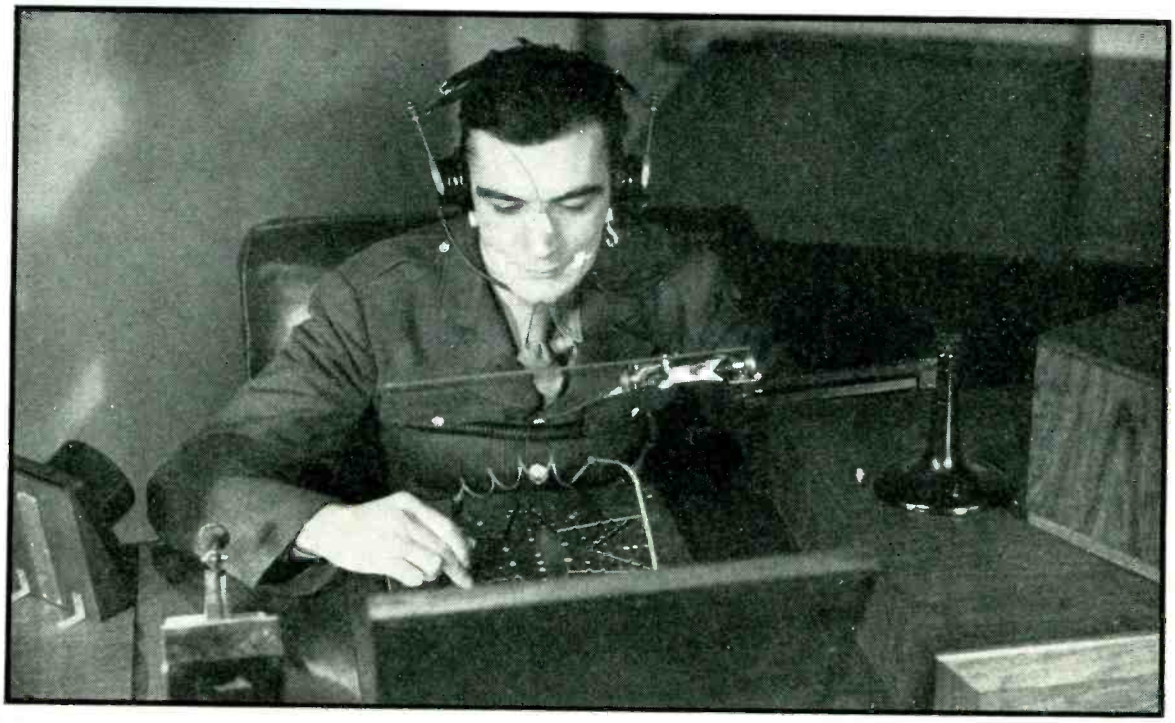
After $t = 0$ the charge coming under the spot is $nNCE_0$ coulombs per second, the charge left over on the mosaic after scanning is $nNCV$ coulombs per second, and the secondary emission charging current is $(E_s - V)/r$. These quantities should satisfy the following equation at all times:

$$VC = \int_0^t \left(nNCE_0 + \frac{E_s - V}{r} - nNCV \right) dt \qquad (4)$$

Equation (4) reduces to a linear

(Continued on page 327)

Electronics In The Study of HEAD INJURIES



Pickups are attached to the patient in a manner involving minimum discomfort. The left hand is attached to a unit under the table containing the pickups for arterial pulse, sweating of the palm and tremor of the fingertips. The patient is here performing an assigned mechanical task (moving a metal electrode through grooves of a star-shaped maze as rapidly as possible without touching the sides of the groove). The task is later repeated under more difficult conditions such as viewing the maze in a mirror while listening to disagreeable sounds in phones

THE APPLICATION of electronic methods to allied fields of technology and science has already become a commonplace fact. Under the impetus of global war, research in all fields has surged forward on a broad front. No more powerful tool has arisen to the hands of investigators in the allied technologies than the application of electronics. And hardly a more fertile field for such application exists than the field of medicine.

The ensuing discussion will describe qualitatively an example of such application. Although containing nothing that can be construed as a development in electronic science per se, the special configuration and application of known circuits and devices will (it is hoped) be instrumental in solving one of the important medical problems arising from the war.

The apparatus to be described was constructed and is now being used for psychophysiological research by the Head Injury Project in the Department of Neurology at the College of Physicians & Surgeons of Columbia University, New York City.* The main purpose is to provide a means for the differential diagnosis of certain types of head injury cases which are common among the casualties of modern warfare.

The Medical Problem

In particular these are the cases of service men who have experienced concussion without severe penetrating wounds of the skull and in which there exists doubt as to the actual presence or extent of brain damage. Such cases may be classified roughly into three groups. In the first, called the organic group, there is actual damage to the brain as an organ, but it is not severe enough to be clearly recognizable as such by ordinary clinical examination. The second group has no actual brain damage but, as a consequence of shock, has suffered a mental disability, the so-called "traumatic neuroses." The third is a mixed group in which there is injury to the brain as well as aberrations of the normal mental processes.

Among the most common symptoms resulting from such head injuries are headaches, dizziness, emotional irritability and personality changes, loss of memory, and a

*The work described in this paper represents a partial report on research done under a contract (Head Injury Project No. OEM-CMR148) recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Columbia University. This project is directed by Dr. Tracy J. Putnam and Dr. John G. Lynn.

Psychophysiological research has evolved a promising electronic instrument for indirect diagnosis of brain damage in concussion cases. Technical features include use of FM carrier amplification, differentiating circuits and trigger circuits that provide constant-amplitude pulses for time-axis recording of 20 variables

By CHARLES SHEER and JOHN G. LYNN, M. D.

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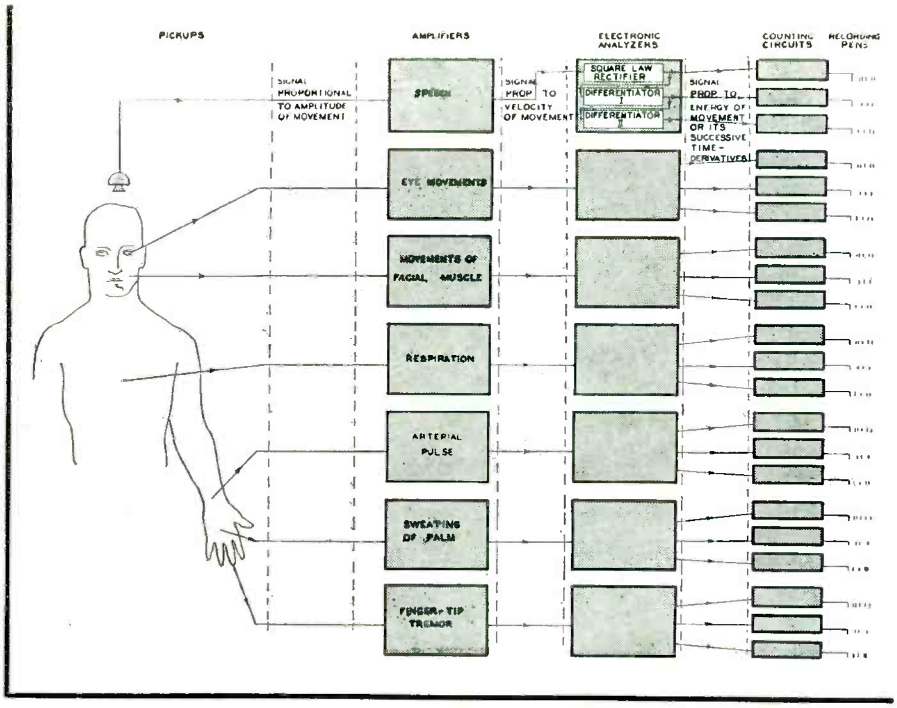


Fig. 1—Block diagram showing seven indicators attached to various parts of the patient, and the successive amplifying, analyzing, counting and recording stages for each indicator

general lowering of physical and mental efficiency. These symptoms are common to all three groups, making it almost impossible to determine the origin of the disability by ordinary medical examination.

The efficacy of medical treatment and rehabilitation of these men, however, depends chiefly on an exact knowledge of the relative weights of the organic and mental causal factors operating in each case. Hence the development of an accurate and dependable means for making such a diagnosis represents an important problem in war medicine.

Method of Approach

In view of the present inadequacy of standard clinical methods and ordinary diagnostic instruments, such as x-ray, brain-wave records, etc., a different approach to the problem was formulated and adopted for this study. The latter involves an indirect evaluation of brain function by the measurement and analysis of the activity of certain other parts of the body over which the brain exerts control. This constitutes the fundamental precept of the branch of science known as psychophysiology.

The idea that the dynamical characteristics of the activity of a particular organ, muscle, or gland is directly related to the condition of the nerve center which controls it has gained considerable credence among psychophysiologists at the present time. Hence the basic concept of this research is to measure accurately and simultaneously the activity of certain so-called indicator organs, chosen specifically with regard to their control centers in the central nervous system. Furthermore, any abnormalities in the nervous system can be exaggerated by placing the individual under stress. The abnormalities thus accentuated by induced stressful situations are reflected in the correspondingly amplified changes in the activity of the various indicator organs being measured.

If the measurements are of a sufficiently high order of accuracy and the analysis of the records suf-

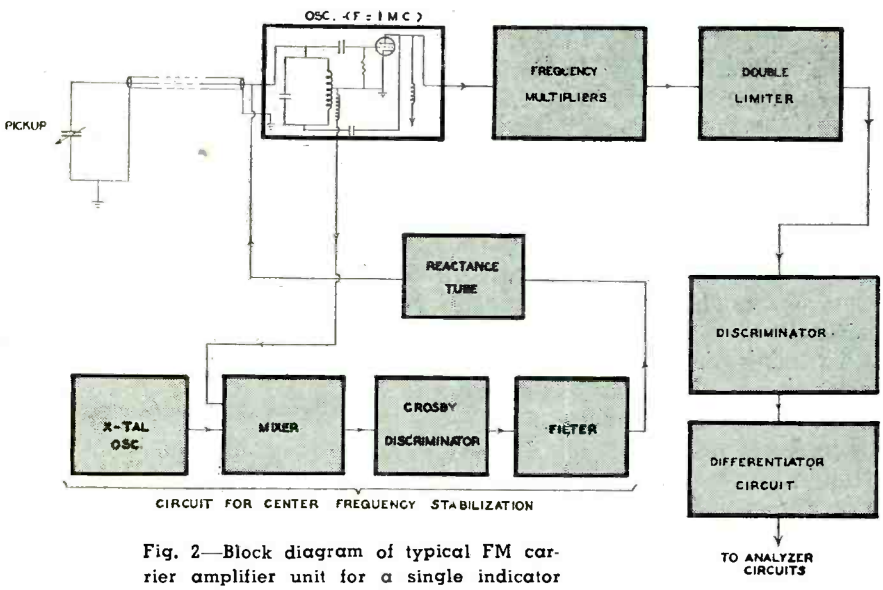


Fig. 2—Block diagram of typical FM carrier amplifier unit for a single indicator

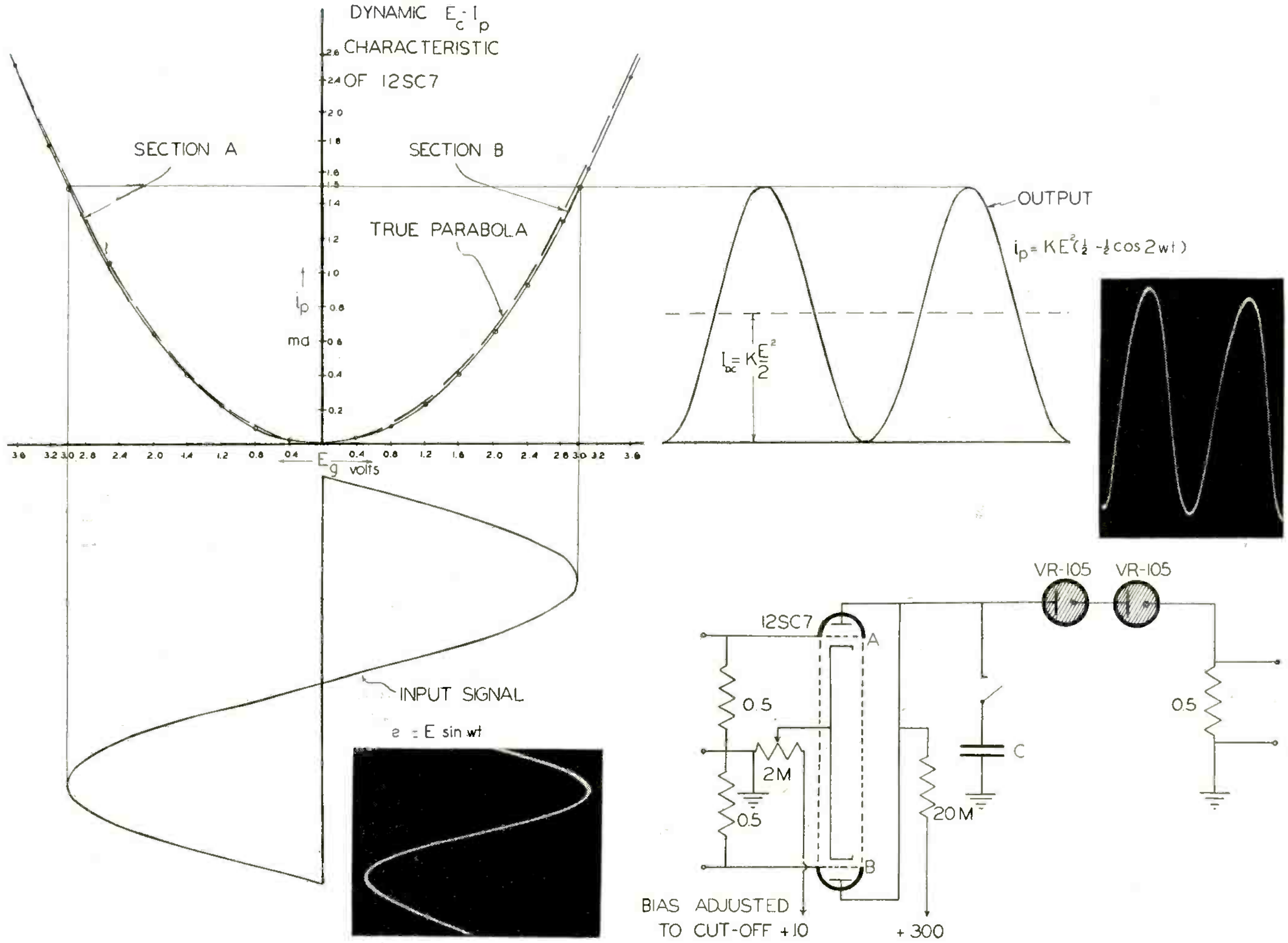


FIG. 3—Square-law rectifier circuit for converting the velocity-time signal into an energy-time signal, and characteristic operating curves. Curves for sections *A* and *B* are plotted back to back in order to show the operation of a stage having push-pull input and parallel output. Projection of the total input signal on the combined characteristic gives the output signal. Alongside the input and output signal curves are corresponding oscillograms obtained, showing the fidelity of the square-law operation

ficiently fine, it is expected that even slightly abnormal patterns of response will be distinguishable from normal records. This viewpoint further presumes that the nature of the deviations will correlate with their causes and thus designate unequivocally the cause of the abnormality, so that the method may be of practical value in a clinical diagnosis.

It seems apparent at present that the success of this method devolves largely upon the technique of measurement and analysis. Instruments wherewith to perform the latter were lacking and the early work of the Head Injury Project clearly indicates the inadequacy of the existing methods. The manifest needs for newer and more accurate instruments led to the decision which culminated in the construction of the apparatus to be described below.

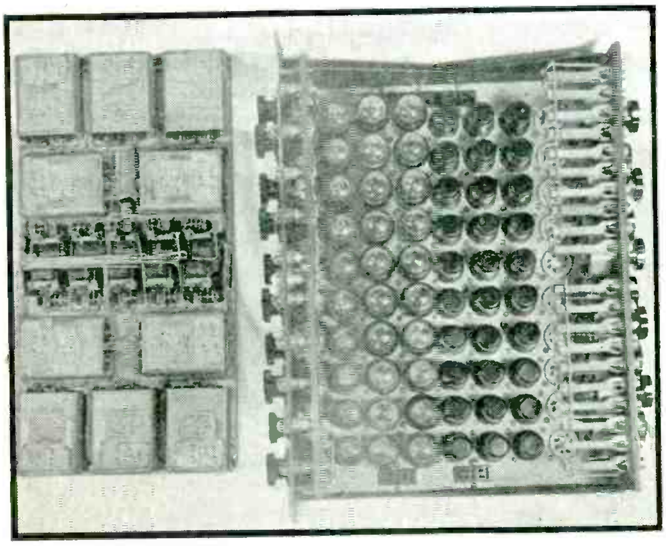
The Technical Problem

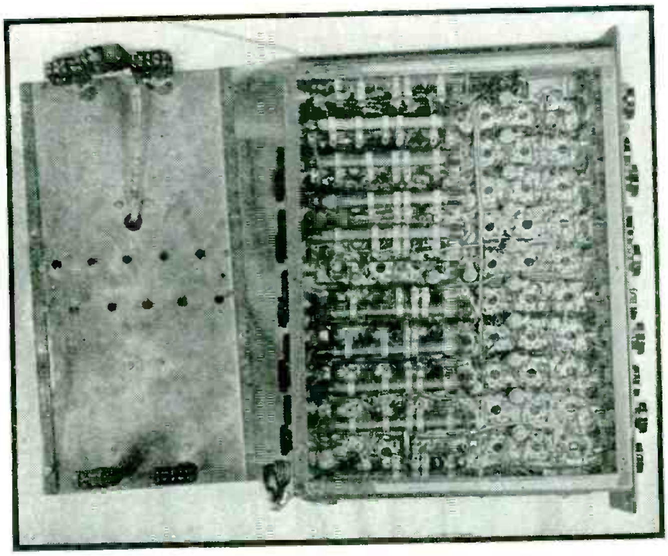
The problems facing the engineer engaged in such work are, on the whole, somewhat different from the average development work in communications. One is soon impressed with the fact that a precise analysis is to be attempted of perhaps the most complex mechanism in existence, of which an almost random variability is a chief characteristic.

A further complication lies in the fact that no one, as yet, has clearly demonstrated exactly what must be measured in order to obtain the desired "index" of nerve center control. For example, the "indicators" measured in this study are respiration, heart action, eye movements, contractions of the facial muscles, sweating of the palm, finger-tip tremor, and speech. Nearly all of these involve movement of one form or another. Previous investigators have recorded this motion as the instantaneous displacements of the various indicator organs during activity. However, the amplitude-time functions were found to be at best only vaguely correlative with nerve center control. The weight of experimental evidence emphasizes the fact that this is not the most desirable criterion for the measurements.

Choice of Measurements

Any study of this kind which makes even a pretense of being quantitative must establish a logical working criterion of exactly what must be measured. It is commonly accepted





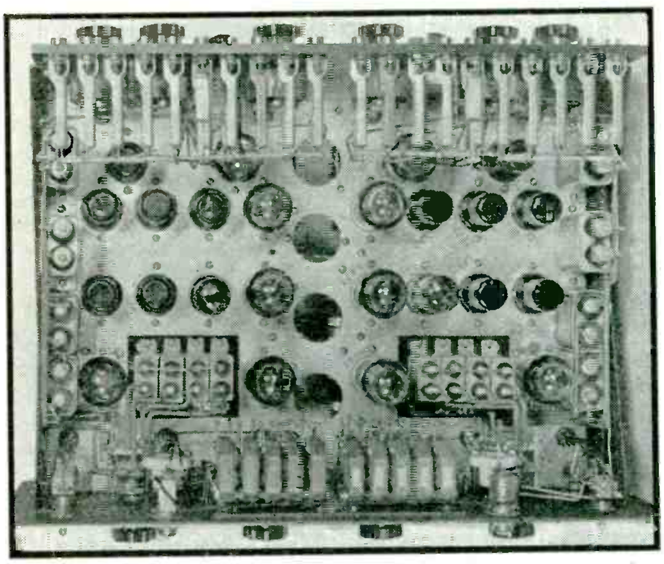
Top and bottom views of the chassis containing ten of the counter circuits of Fig. 5. With 60 tubes on a single chassis (10-35L6, 20-VR-105, 20-12SJ7 and 10-12SC7), a top deck (at left in each view) had to be provided for some of the parts

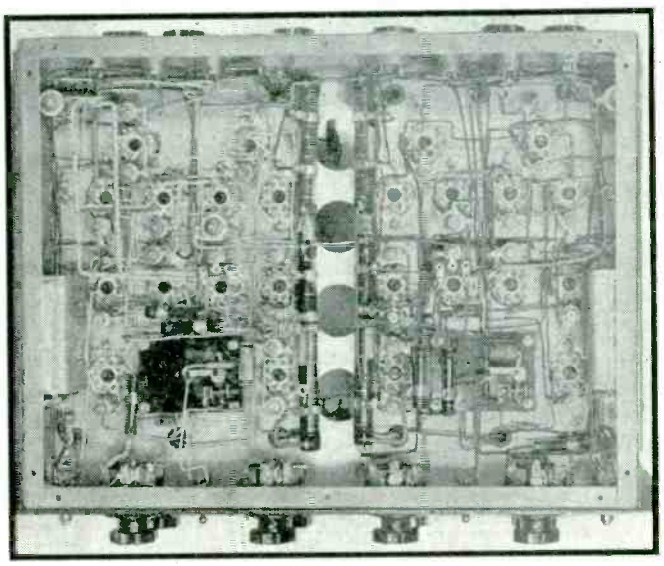
that the degree of control that the nerve centers have on a given organ may be related directly to the average rate at which nerve impulses are dispatched to and received by the organ. There is no way this can be measured at present in a clinically applicable manner. But we may seek some aspect of the activity of the organ in response to the controlling impulses which relates in the simplest possible manner to the rate at which they are received. This, if known, would constitute the most logical criterion on the basis of which the measurements would be made.

In view of the impossibility of measuring nerve impulses directly, we are forced to use a trial-and-error procedure, measuring the response in terms of external activity and evaluating the results in terms of how clear-cut a manner the measurements thus obtained serve to distinguish between carefully selected and matched groups of pure brain damaged, pure neurotically maladjusted, and normal control subjects.

A survey of previous work yields scant information that is helpful in indicating a definite choice. One can deduce, for example, that the amplitude-time functions of movement, or the bioelectric potentials which accompany the acivity, although related to nerve center control, are not related simply enough for this problem. However, out of the agglomeration of reported facts, there appears an orientation which seems somewhat more likely to be a better criterion than any heretofore considered. This is the amount of work done or mechanical energy output during activity. It does not necessarily purport to describe the total energy transitions involved in the functioning of any organ or muscle.

The *total* energy-time function would not be a practical criterion because it is almost impossible to measure. But some evidence exists that the mechanical aspect of the energy involved in activity is the





Top and bottom views of a chassis containing two units each of square-law rectifiers. Each unit contains a selection of filter capacitors for C_1 of Fig. 6 and four of the diffentiator circuits of Fig. 4

quantity most simply related to changes in the central system. Furthermore, the mechanical aspects are relatively easy to measure. The heart and lungs, for example, may be treated as pumping engines, fingertip tremor may be treated as a vibrating rod, while the rate at which fluid is produced may be taken as a measure of the mechanical work in sweat secretion, and so forth.

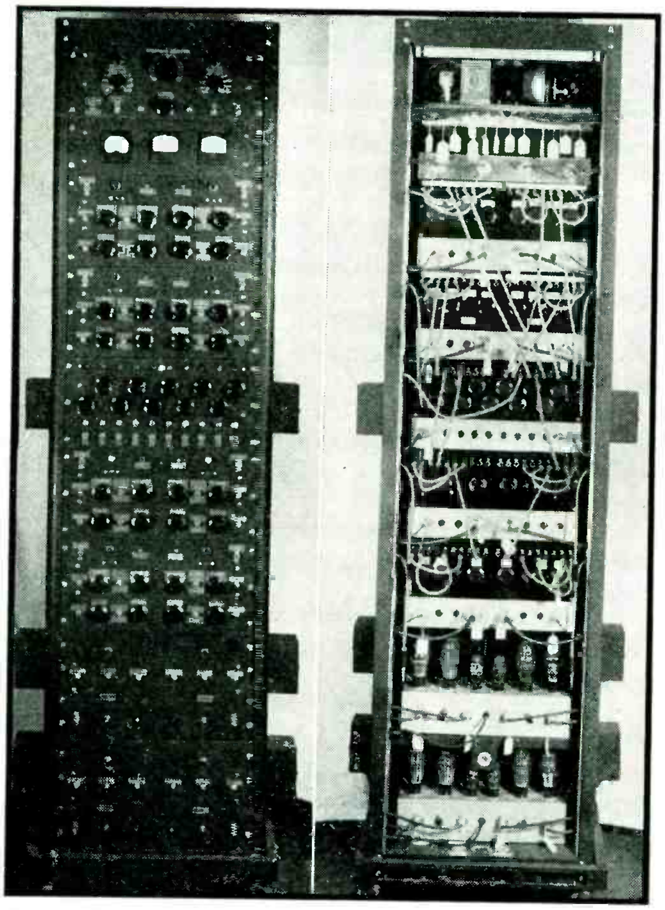
This orientation is, of course, necessarily over-simplified, but accurate measurements are meaningless on the requirements of the apparatus itself.

Use of Carrier System

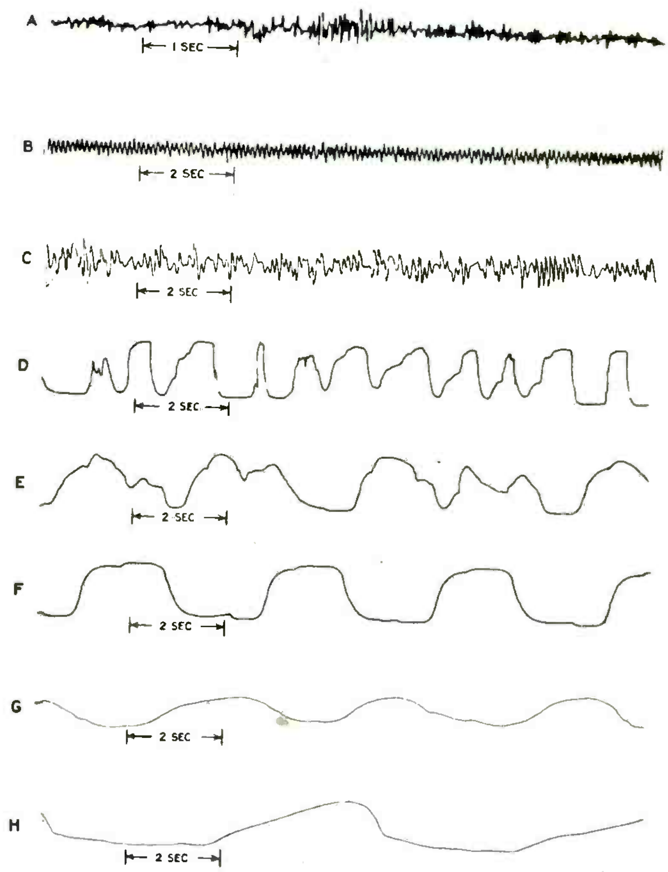
The instrumentation designed for use in this study is subject to many restrictions of both a technical and practical nature. The variations (except in speech) occur at sub-audio frequencies ranging from about 20 cps down to 0.05 cps, with the majority occurring in the neighborhood of 1 cps. Amplifiers involving conductive coupling to accommodate such plifying stages, such as the Miller cathode control amplifier.[1] The application of these circuits to this work has proved eminently successful.

Overcoming Thermal Drifts

The necessity for quantitative measurements imposes severe restrictions on the quality and construction of the component parts. In d-c circuits sensitive to changes of a few millivolts, thermal drifts of circuit parameters are a serious problem. It was found necessary to dispense



Front and rear views of the analyzer rack. Each chassis has a rear panel with jacks and patch cords to provide a maximum of flexibility in interconnection of the various units. Protruding boxes on the sides contain air-circulating fans. This and two other racks of similar size constitute the bulk of the equipment



Examples of representative types of signal inputs. *A*—Muscle contraction record; *B*—Record of fingertip movements under normal or calm state; *C*—Fingertip movements under agitation or excitement; *D*, *E* and *F*—Various types of eye movement records (blinking, rolling and lateral movement respectively); *G*—Normal breathing record; *H*—Deep breathing record

any other basis. We may therefore state as a working hypothesis that the instantaneous kinetic energy (or some similar quantity from which the mechanical energy may be derived) is to be measured as the criterion of psychophysiological activity. Recognizing that this orientation is based on presumption, and in the hope of proving its validity, we may proceed to the consideration of signals are troublesome, especially where high-gain circuits are required. For this reason the carrier system was adopted for the major part of the amplification. The technique of handling the signal after demodulation involves the use of exceptionally well regulated power supplies, of constant-voltage gas tubes as "d-c capacitors" for both coupling and by-passing, and of stabilized am- with all carbon resistors and potentiometers, as well as all electrolytic capacitors. The potentiometers used were of the General Radio wire-wound type. Nearly all the resistors were IRC precision units (because of their very low temperature coefficient). The capacitors were GE pyranols for the large values, and Cornell-Dubilier low-loss micas for the small values. The excellent construc-

Fig. 5 (at right)—Counting circuit, consisting essentially of a vacuum-tube bridge (*A, B, C* and *D*) in which the input signal causes an unbalance which charges the 4-μf capacitor C_1 through constant-current tube 12SJ7(2). When a critical voltage is reached, the Eccles-Jordan trigger circuit (in shaded area) is tripped, causing section A of the 12SC7 to pass current, operating the micro-relay which in turn discharges C_1, reinverts the trigger circuit and activates the 35L6G driver tube momentarily. This tube drives the writing pen whose field coil is connected between X and Y

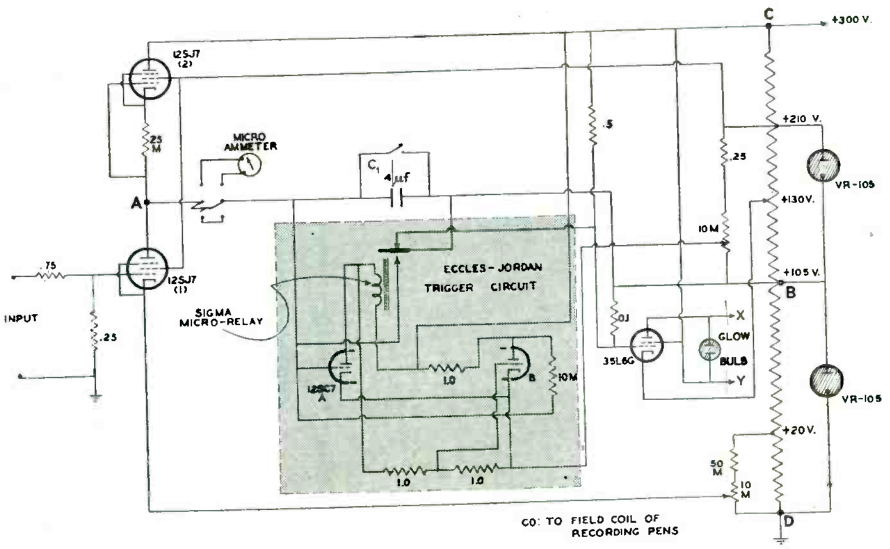
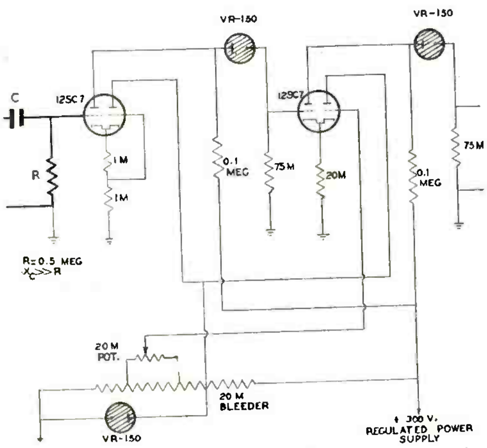


Fig. 4 (below)—Differentiating circuit (*R-C*) and amplifier circuit for very low-frequency signals to compensate for the insertion loss of the *R-C* circuit



tion of Western Electric jacks, plugs and switches was made use of in eliminating contact troubles. For the many other component parts employed, a careful selection was made in each case, based on an investigation of performance characteristics.

Types of Pickups Used

A block diagram indicating the multiplicity of the channels and the successive treatment of the signal from the pickup on the patient to the final record on the paper tape is shown in Fig. 1. Three of the pickups are electro-mechanical transducers involving linear variations in capacitance proportional to the amplitude of movement (respiration, finger-tip tremor, and pulse movement); one is a fixed capacitance (sweating); two are direct electrical contacts (eye movements and movements of the facial muscles); and one is an ordinary microphone (speech). For the latter the acoustic energy of the voice output is taken as a measure of the mechanical energy output of the vocal cords. Therefore, a microphone and standard audio amplifier provide the necessary equipment for the speech channel. (The value of the voice mechanism as an indicator is still obscure and its usefulness in this respect is under investigation.)

Eye-Movement Pickup

The measurement of the movements of the eyeballs and facial muscles is subject to the restriction that the pickups must be small and provide no discomfort to the patient. In the past the amount of muscular

(*Continued on page 338*)

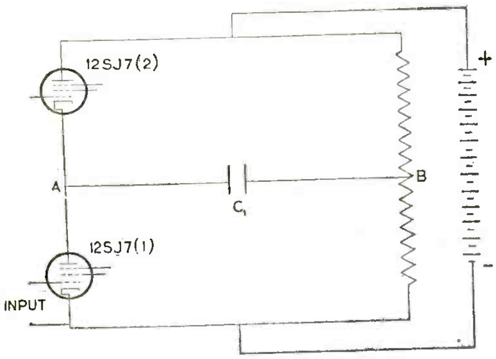
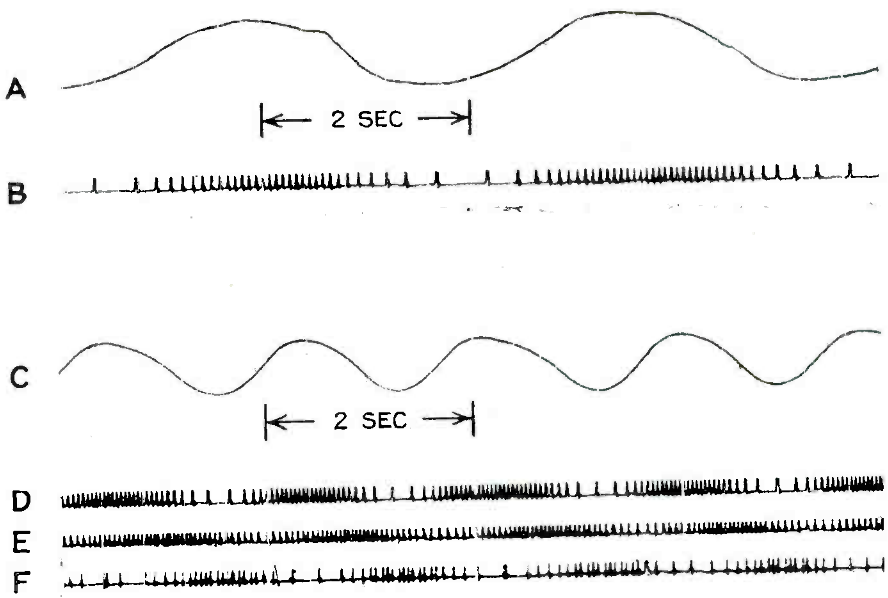
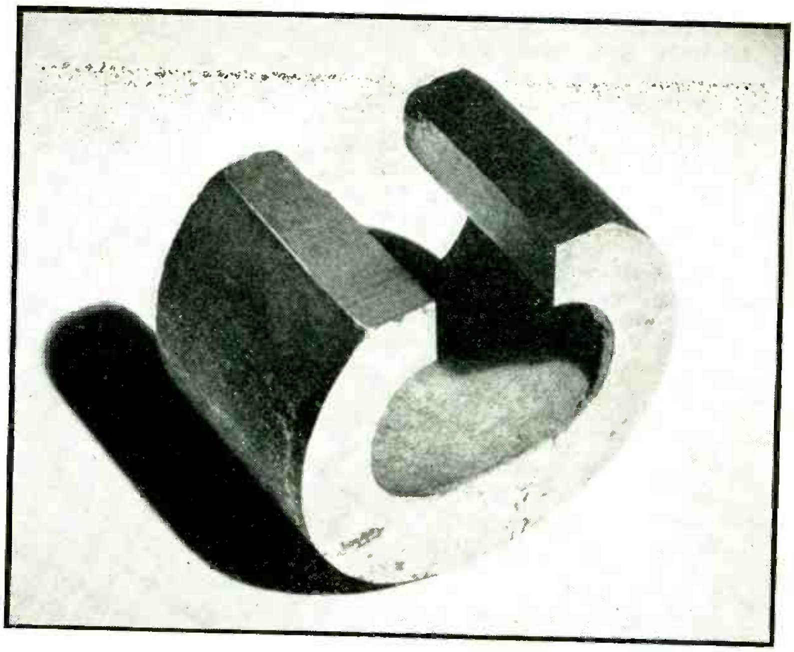


Fig. 6 (above)—Simplified diagram of vacuum-tube bridge in counter circuit of Fig. 5

Fig. 7 (at right)—Examples of pulse patterns obtained in time-axis recording. *A* and *B* represent a normal breathing amplitude record with its corresponding time-axis record. *C* is an artificial amplitude signal, and *D*, *E* and *F* are respectively its time-axis record, the first time derivative and the second time derivative



Alnico permanent magnet with air gap. Its cross-sectional area and total length for a particular purpose can be estimated quite accurately by following the instructions in this article



DESIGNING Stabilized Permanent

Having covered fundamental design equations of permanent magnets in a previous article,* the author here considers motor, generator, magneto and similar applications where demagnetizing influences exist and provide stabilization of flux density in air gaps

By

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In a previous article fundamental concepts and units of permanent magnet theory were defined, fundamental design equations were developed, and a method for the determination of the leakage constants was discussed. Finally, using the methods developed, certain elementary problems were set up and solved in which the only demagnetizing influence exerted on the magnet was that of the working air gap itself. The problems neglected the stabilization of the magnets as a protection of their calibrations from stray fields, load fields, shock and other demagnetizing influences.

It is proposed in this present article to further develop the theory of permanent magnet design, including the cases omitted or excepted in the first article. This involves first, however, the necessity of becoming familiar with minor hysteresis loops in general, and with the phenomenon of stabilization in particular. A consideration of the problems involved in the design of permanent magnets for motors, generators, magnetos, and other devices, the operation of which impose demagnetizing influences (in addition to the influence of the gap) upon the magnet, will then logically follow.

Minor Hysteresis Loop

Suppose that the magnet of Fig. 1 (a) has just been magnetized, fully saturated, and then removed from the influence of the magnetizing field. This procedure is performed with a soft iron keeper in the gap of the magnet, and the flux density in the magnet is now at the point B_r of Fig. 1 (b). When the keeper is removed, the magnet operating point will move down the curve to the point x in accordance with the laws developed in the previous article.

Now, what happens if the keeper is put back into the gap? The operating point does *not* move back up to the B_r point as might be expected, but starts off on a new curve as indicated by the arrows of Fig. 1 (b), and arrives at the point y. Thus, in the single removal and replacement of the keeper, the magnet has suffered in flux density the difference between B_r and y. When the keeper is again removed, the operating point travels back to x over the upper curve as indicated. The loop thus formed by the two curves between x and y is known as a minor hysteresis loop.

In handling minor hysteresis loops, two approximations are usually

* Underhill, Earl M., Permanent Magnet Design, ELECTRONICS, p. 126, Dec. 1943.

made, both of second order effect. First, it is assumed, as stated above, that the loop closes itself at the points x and y. This is not strictly the case. The operating point, on its return trip from y towards x, actually crosses its outbound path (near x) and intersects the major hysteresis loop slightly below x.

Theoretically, also, this same phenomenon happens to a smaller and smaller extent each time the keeper is replaced and removed. Actually, however, the difference becomes almost entirely unmeasurable after about two or three cycles. For the purposes in mind in this article we can forget this and assume, as above, that the loop closes itself at the points x and y.

which acts as the path of the magnet operating point in both directions.

Effect of Demagnetizing Field

Let us now take our two design equations and write them in the form:

$$B_g = \frac{A_m}{FA_g} B_m \qquad (1)$$

$$B_g = \frac{l_m}{f\, l_g} H_m \qquad (2)$$

If these two equations are plotted against coordinates B_g and H_m, as in Fig. 2, Eq. (1) will be identical in shape to the demagnetization curve (B_m vs. H_m) but multiplied by the constant factor A_m/FA_g, and Eq. (2) will be a straight line passing through the origin and of slope l_m/fl_g. Obviously, the intersection of these two

netizing field may be an a-c field, a d-c field in opposition to the magnetization of the magnet, heat, etc.) When the additional demagnetizing field is removed, the operating point will run up the minor hysteresis loop xy until it reaches the point z, the intersection of xy with the straight line of Eq. (2).

This process has resulted in the loss of flux density in the air gap of amount $B_{g1} - B_{g2}$ but it has given us a stable magnet. To show this, let us imagine that the magnet we have just stabilized is put into service and that in the field it encounters a demagnetizing field of strength ΔH_1. The operating point will run down the minor hysteresis loop xy till it reaches the point p. Here a state of

Magnets

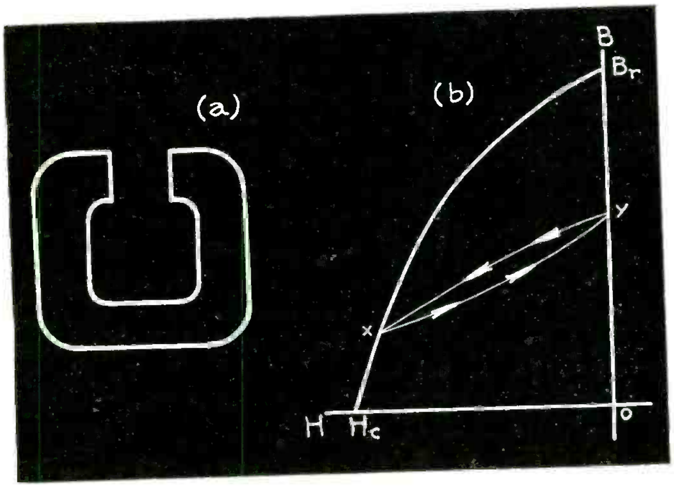


FIG. 1—Basic magnet shape considered in this article, and demagnetization curve showing minor hysteresis loop between x and y

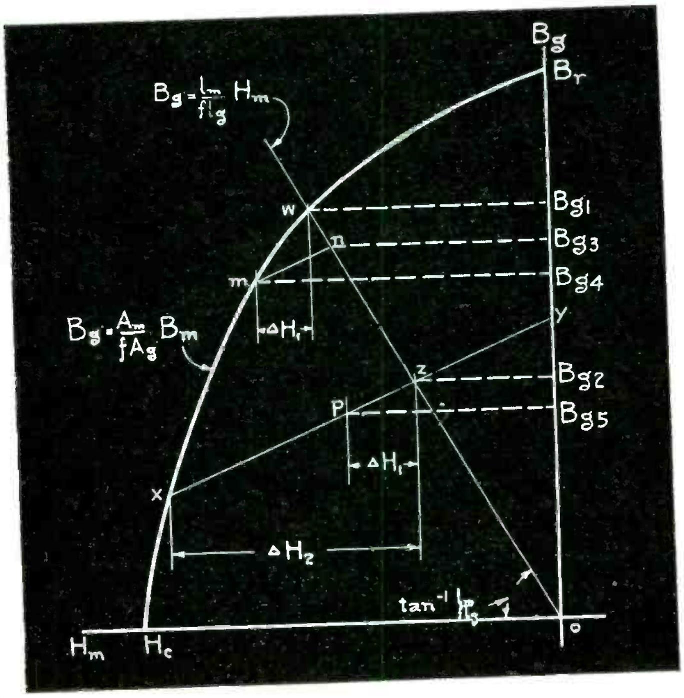


FIG. 2—Plot of Eq. (1) and (2), with minor hysteresis loops represented by straight lines x-y and m-n. This type of graph permits determining stabilizing effect of a demagnetizing field

The second approximation made relative to this type of minor hysteresis loop is that it is not a loop at all, but rather a straight line. This approximation is permissible because of the extreme narrowness of the loop, and inaccuracies thus introduced into our calculations are negligible. Henceforth, therefore, we shall think of and handle the minor hysteresis loop as a single straight line (between the points x and y of Fig. 1 (b), for instance)

curves at the point w is the graphical solution for B_g of the two simultaneous equations. This, of course, is the flux density in the gap (of size l_g, A_g) of a magnet (of size l_m, A_m) having leakage constants f and F and having been completely saturated and its keeper withdrawn.

Let us now deliberately apply an *additional* demagnetizing influence to the magnet in question, forcing the operating point down the curve to the point x. (This additional demag-

balance is again reached, and as long as ΔH_1 persists the magnet will supply a flux density of B_{g5} to the air gap. Of course, as soon as ΔH_1 is removed, the operating point returns to z and the flux density in the gap again becomes B_{g2}.

Now, let us suppose that we had not stabilized the magnet before putting it into operation and that the magnet was again subjected to the demagnetizing field ΔH_1. The operating point would move down the major hysteresis loop from w to m, where it would remain for the duration of the demagnetizing influence. The flux density in the gap would change from B_{g1} to B_{g4}, a far greater change than $B_{g2}-B_{g5}$. Furthermore, when ΔH_1 is removed, the operating point will *not* return to its original position, but will move up the minor hysteresis loop mn to the point n, its intersection with the straight line of Eq. (2). Thus, the unstabilized magnet not only suffered more during the application of ΔH_1, but, upon its removal, presented the air gap with a *permanent* change, $B_{g1} - B_{g3}$, in flux density.

It is evident, then, that any apparatus requiring a gap flux of *constant* calibration *must* employ a stabilized magnet. Of course, there are limits to the demagnetizing field which any stabilized magnet can stand and the limit in the case under discussion is shown by ΔH_2. If the demagnetizing field exceeds this limit, the operating point will drop further down the major hysteresis loop and, upon removal of the demagnetizing field, come back up on a different minor hysteresis loop.

The more a magnet is demagnetized from the point w (Fig. 2), the more stable it becomes. The designer must take into consideration the maximum adverse field his magnet has to stand before specifying the amount of stabilization it is to receive.

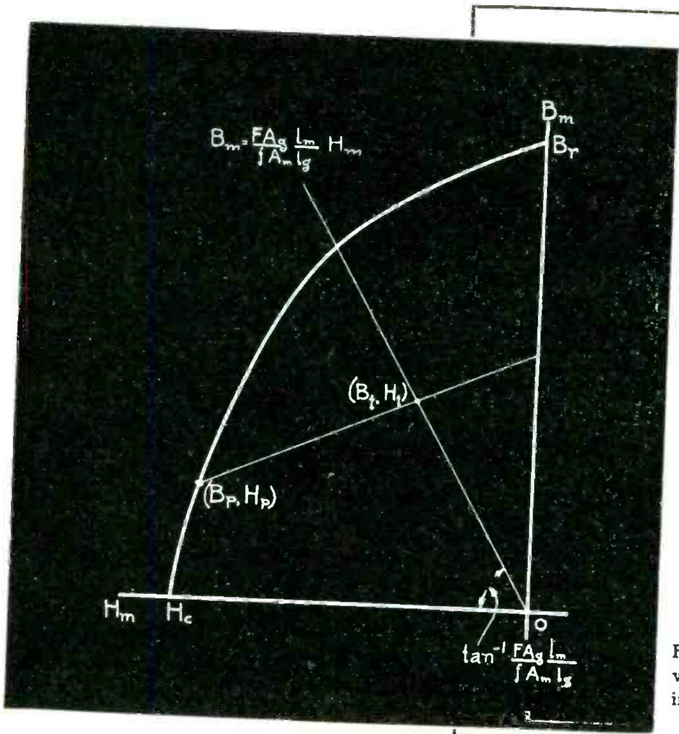


FIG. 3 Graph showing open-circuit condition for same problem as in Fig. 2

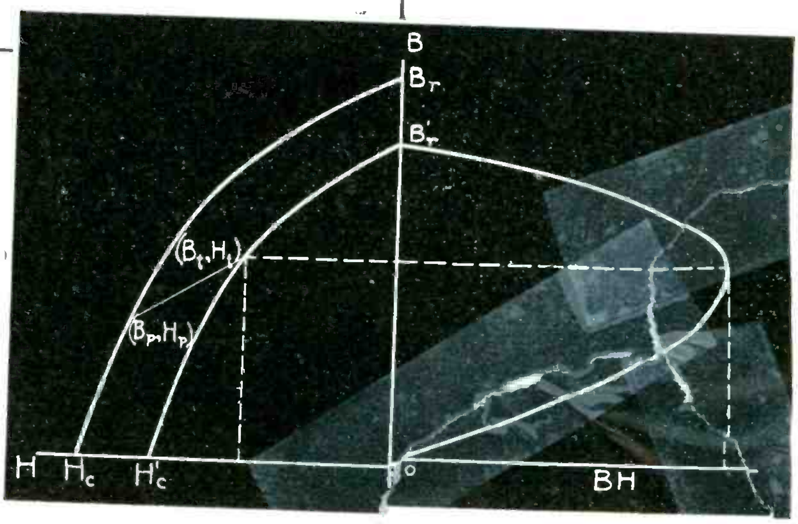


FIG. 4 Final graph, from which the operating point can be determined

Demagnetization Curves

Having thus familiarized ourselves with minor hysteresis loops and having reviewed briefly the phenomenon of stabilization, let us pass on to design considerations for a motor or magneto magnet.

Since the demagnetization curve is an important factor in these considerations and since it is desirable in many cases to do our work analytically rather than graphically, the first job is that of writing an equation for the demagnetization curve. This may be done in many ways but perhaps the two most useful methods of expressing B as a function of H are either by a power series or an equation of a parabola.* (It must be borne in mind that although the demagnetization curve is in the second quadrant of the major hysteresis loop, we will refer to H as positive, not negative.) At the moment we are interested in the parabolic relation between B and H. Within very close limits the following equation may be made to approximate the demagnetization curve of any properly heat-treated alloy:

$$B = \frac{B_r (H_c - H)}{H_c - aH} \qquad (3)$$

where: B = dependent variable
H = independent variable
B_r = residual flux density (gauss)
H_c = coercive force (oersteds)
a = a constant for the particular curve under consideration.

This equation may also be written:

$$\beta = \frac{1-\theta}{1-a\theta} \qquad (4)$$

where:

$$\beta = B/B_r$$
$$\theta = A/H_c$$

In this θ may also be expressed as

$$\theta = \frac{1-\beta}{1-a\beta} \qquad (5)$$

Now, multiplying Eq. (4) and (5) together, differentiating with respect to θ, and setting $d(\beta\theta)/d\theta = 0$, we get

$$\frac{d\beta}{d\theta} = -1 \qquad (6)$$

* The fact that the demagnetization curve may be very closely approximated by a parabola was pointed out by Watson.

Differentiating Eq. (4) with respect to θ and substituting Eq. (6) into the result, we get

$$\beta = \theta \qquad (7$$

This establishes a very important point, that $B/B_r = H/H_c$ at the point of maximum energy product, B_oH_o.

The form of Eq. (3) shows that only three points are necessary to establish fully the complete demagnetization curve. These points may be any three points along the course of the curve, but upon occasion it may be desirable to specify a curve by the three cardinal points, B_r, H_c, and the point of B_oH_o. B_r and H_c fit directly into Eq. (3), and the point of B_oH_o is introduced through the constant, a. Transposing Eq. (4):

$$a = \frac{\beta + \theta - 1}{\beta\theta} \qquad (8)$$

At the point of B_oH_o, $\beta = \theta$. Hence, combining Eq. (7) with Eq. (8), we have

$$a = \frac{2\beta - 1}{\beta\theta} = \frac{2\theta - 1}{\beta\theta}$$

Multiplying these two equations together and taking the square root of the result:

$$a = \frac{2\sqrt{\beta\theta} - 1}{\beta\theta} = \frac{2}{\sqrt{\beta\theta}} - \frac{1}{\beta\theta}$$

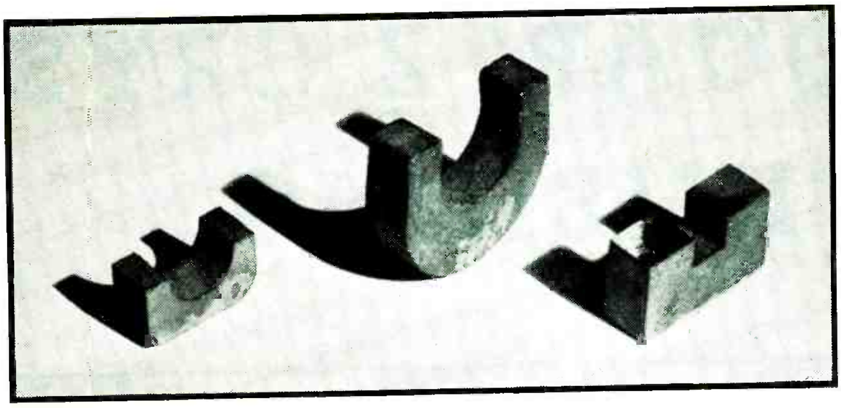
And thus we obtain a value for a, in terms of B_oH_o:

$$a = 2\sqrt{\frac{B_r H_c}{B_o H_o}} - \frac{B_r H_c}{B_o H_o} \qquad (9)$$

Stabilization of Magnets

Before going deeper into the analytical work involved in the design of a magneto magnet, let us pause momentarily to get a glimpse of the path to be followed.

As stated earlier, the primary difference (from a design standpoint) between a magneto magnet and, let us say, a loudspeaker magnet is the fact that the former is subject to heavy demagnetizing influences over and beyond the demagnetizing influence of the air gap itself. The magneto manufacturer long ago discovered that if he assembled his instrument completely and then magnetized the magnet (which would be the proper procedure in the case of the loudspeaker), the instrument when placed upon test would deliver an output that would be high initially but would fall off rapidly at first and then asymptotically approach some much lower value. This phenomenon is due, of course, to the demagnetizing effect of the current in the coils of the magneto, and the only possible practical remedy is the use of a stabilized magnet right from the beginning.



Examples of Alnico permanent magnets to which design data in this article applies

The next question, then, is: How much shall the magnet be stabilized in order that the magneto's initial output shall remain constant with time? This question, of course, is related to the magnitude of the demagnetizing forces present in the operation of the machine. These forces may be computed, if necessary, on the basis of the machine's maximum load or even on the basis of short-circuit (if a generator or magneto) or stalled (if a motor) conditions. Most manufacturers, however, have found this computation to be unnecessary. They have learned from experience that, in general, a machine magnet is sufficiently stabilized if it is fully magnetized prior to inserting it in its magnetic circuit. This is true whether the magnet be part of the stator or the rotor.

To better picture exactly what happens in this process, let us take a look at Fig. 3. This is similar to Fig. 2 except that we now have H_m plotted against B_m instead of against B_g as previously. This means that the slope of the straight line of Eq. (2) is multiplied by the factor FA_g/A_m, and the equation of this line becomes

$$B_m = \frac{FA_g\, l_m}{fA_m\, l_g} H_m \qquad (10)$$

Now, when our magnet is magnetized to (or beyond) its saturation point, the operating point runs up the normal magnetization curve (not shown on Fig. 3) to some point high up on the major hysteresis loop and remains there until the current in the magnetizer is turned off, at which time it drops to the point B_r of Fig. 3. When the magnet is removed from the magnetizer it is "open-circuited", i.e., operating in no magnetic circuit other than that formed of itself and a return path of unit permeability, and this condition is invariably one in which the pole faces of the magnet exert a self-imposed and very severe demagnetizing influence.

Of course, the severity of this demagnetizing force is a function of the dimensions and shape of the magnet, being much greater for short, fat straight rods than for long, thin horseshoes, for instance. But for practical magneto and motor magnets made of a practical alloy (such as one of the Alnicos) the demagnetizing influence of the open-circuit condition is large, and the operating point of Fig. 3 will run down the demagnetization curve from B_r to some point (B_p, H_p).

If, now, the magnet (regardless of whether it be part of the rotor or stator) be encased in its housing, and the magnetic circuit completed, (working air gaps in such machines run of the order of 0.010" in total length) the severe demagnetizing influence of the open-circuit condition will have been removed, and the only demagnetizing influence then exerted on the magnet (until the machine starts operating) is that of the working air gap itself.

(*Continued on page 310*)

QUARTZ CRYSTAL FINISHING

By L. A. ELBL
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Initial and intermediate stages in crystal production are generally accomplished by machines, but final adjustments for frequency and activity still involve much hand work. Some of the problems encountered are discussed, and mechanical and chemical methods of minimizing the use of highly skilled labor are described

FIG. 1—Individual finishing position and operator. Test gear may be seen in the background, with a heavy, circular metal block and light copper plate constituting electrodes projecting from it for rapid and convenient frequency and activity checks. The girl is lapping a crystal on a flat glass plate smeared with abrasive

QUARTZ CRYSTAL PRODUCTION, in its initial and intermediate stages, is generally accomplished by automatic or semi-automatic machines. Final finishing is still largely a hand operation.

While several methods of speeding up the finishing operation have been devised in recent years and are briefly described here, highly-skilled operators continue to play an important part in most plants because physical dimensions of the order of sub-millionths of an inch are involved. Furthermore, the extremely sensitive electronic apparatus used to check final frequencies and other factors does not readily lend itself to full automatic control.

Procedure and Equipment

While there are many hand finishing procedures in use in different plants, common practice is as follows: The finisher is furnished with a work position as shown in Fig. 1. A portion of a finishing department is pictured in Fig. 2. Necessary gear includes frequency-checking equipment, a flat glass plate, fine abrasive (No. 125 optical powder or its equivalent), water, bowls, brush, cleaning solutions, several lint-free towels, a micrometer, an optical flat, and a small square.

The test equipment in use in different plants varies in detail. Usually, however, it consists of two comparison oscillators built to the same design. A standard crystal of the desired frequency is placed in one oscillator and this frequency is matched by that of the crystal under test and installed in the second oscillator. The crystal under test is repeatedly lapped until its frequency zero-beats with that of the standard.

For matching crystals whose frequencies differ appreciably a calibrated variable oscillator is sometimes used until the crystal under test is within 15,000 cps of the standard crystal. When the crystals are within 15,000 cps of each other an audible beat note is produced. This beat note can be detected in phones. The note can then be measured by

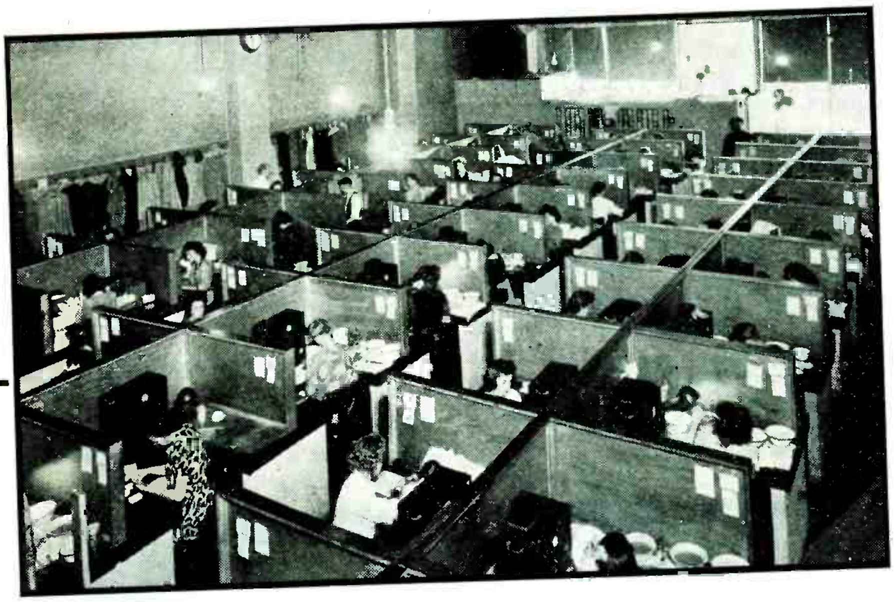

FIG. 2—A portion of the crystal-finishing department in the author's plant

matching it with a calibrated audio oscillator. Another way is to apply the beat-note audio-frequency voltage to a visual audio-frequency meter which the operator can read directly. Such an arrangement is called a deviation meter or cycle counter.

The activity or oscillating strength of a crystal is usually measured by reading the rectified grid current on a milliameter placed in the grid circuit of the oscillator in which the crystal under test is placed.

The finisher receives the crystals as they come off the mechanical lapping machines. Such crystals have been pre-dimensioned to proper length and width and have usually been brought to within ten kc of the desired frequency. A mixture of abrasive and water about the consistency of syrup is prepared on the glass plate. The finisher then takes a crystal and removes all chips and cracks from the edges by stropping successive edges on the plate. This procedure is called beveling or edge-rolling. It is continued until the activity of the crystal has been brought to a maximum and all visible imperfections have disappeared from the edges.

A preliminary frequency check is made by comparing the frequency of the crystal with that of a standard crystal whose frequency previously has been accurately determined. The finisher is now ready to reduce the crystal to the proper thickness, which is accomplished by grinding with a rotary or figure-eight motion on the flat plate, keeping faces as flat and parallel as possible.

At frequent intervals the crystal is checked for activity and frequency. This is done by thoroughly cleansing and drying the crystal and placing it between a heavy metal block (a typical circular block may be seen projecting from the lower right side of the test oscillator in Fig. 1) and a small copper top electrode. The activity is checked, and then the frequency. The activity must remain at a certain minimum while the frequency is brought within the desired limits. If activity is lost, additional beveling is required.

When both activity and frequency are within required limits the crystal is ready to mount. Usually around 1200 to 1500 cps are allowed for a normal change in frequency in the holder. The procedure of placing the crystal between electrodes in a holder is called "mounting." * Final activity and frequency adjustments are made in the holder.

Frequency and Activity

On the surface, the job of finishing crystals appears rather simple, but it is difficult for several reasons. No hard and fast rules for finishing a crystal can be set down because no two crystals finish exactly alike. Each is an individual problem.

Certain suggestions can be given but it is largely up to the finisher to determine through a process of trial and error the particular steps which will give the desired results on a given crystal. Experienced finishers

* Eibl, L. A. Crystal Holder design, ELECTRONICS, October, 1943.

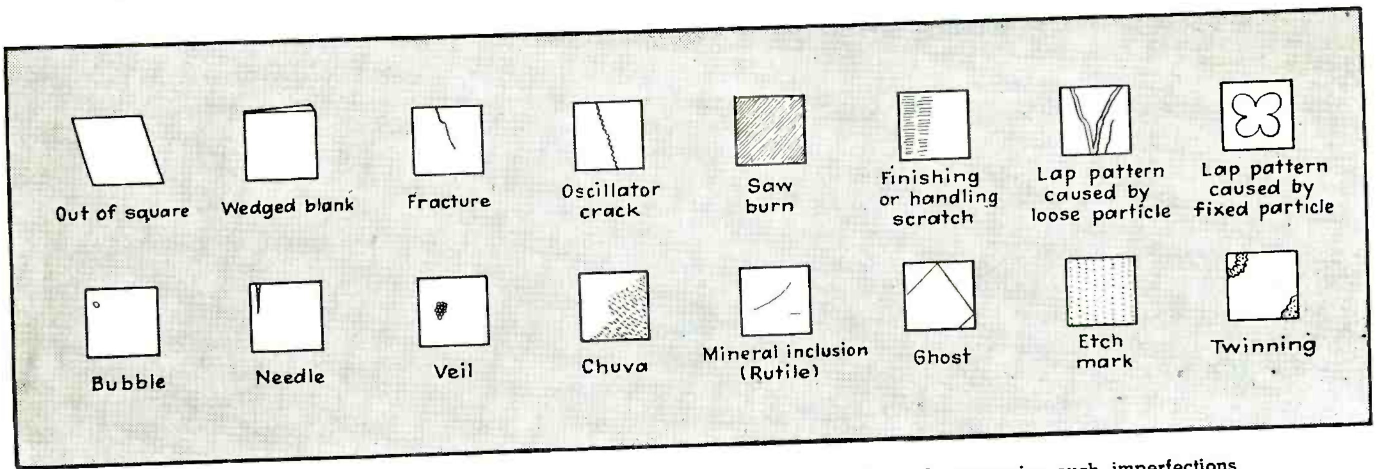

FIG. 3—Examples of imperfections in finished crystals. Finishers must instantly recognize such imperfections

cannot be taught by instruction alone. They gain proficiency only by practice and experience over a considerable period of time.

Let us consider a little further this process of crystal finishing. As mentioned previously, a finisher has two chief concerns: (a) bringing the crystal to the desired frequency, and (b) maintaining sufficient activity to pass the minimum activity test.

As far as is known now, the activity of a crystal is determined by its geometric dimensions, its flatness, absence of flaws, and cleanliness. To raise the activity, the finisher is told to (1) make the faces as flat and parallel as possible, (2) remove all flaws such as chipped edges, broken corners, etc., (3) check dimensions and change if necessary, (4) make crystal perfectly square, and (5) be sure the crystal is surgically clean. Consequently, when the finisher encounters a crystal of low activity these steps are successively tried until activity is satisfactory. Whether to reduce the width or the length, increase the bevels of the edges or round a corner is something that can be told only by judicious and careful "feeling out".

To change the frequency, the finisher grinds on the faces of the crystal, reducing the thickness. Also, each time that the finisher works on the edges, he changes the frequency at the same time. Dimensional ratios have been worked out for thickness vs frequency but the exact value varies with the quartz structure and other conditions. As the final frequency is approached, extreme care must be exercised, for if the crystal is ground a few millionths of an inch too thin, it will be over-frequency. A crystal cannot be made thicker, but by working perpendicular to the electric axis the frequency may be lowered a small amount (a few hundred cycles). Usually, however, a crystal ground five hundred cps or more over frequency is a crystal lost beyond chance for salvage.

Final frequency grinding may involve merely touching the crystal to the glass. To bring a crystal in at the proper activity and at the same time maintain its activity is truly a delicate job. Some crystals may be finished in five minutes, others may require as much as thirty minutes. Sometimes, after trying every suggestion known, the finisher is still unable to bring the crystal to specifications.

Imperfections and Ageing

A crystal which has perfect activity on the block may have very poor or no activity when it is placed between electrodes and pressure is applied. In most cases changing the dimensions of the crystal will remedy this. In other cases the electrodes have to be flattened. If neither of these methods remedy the situation, the crystal probably has some impurity in it or is out of flat, and is discarded.

Numerous imperfections may be found in a finished crystal blank. Some of these are shown in Figure 3. A finisher must be able to recognize such imperfections.

Another difficulty which must be considered in finishing is that of "ageing." This phenomenon, not too well understood, has to do with the change in frequency of a crystal with age. It is thought to be due to the working out of microscopic dirt particles from the pores in the quartz or to the rearrangement of molecules on the surface which were disturbed or thrown out of their original arrangement by finishing.

Whatever the cause, ageing may cause the frequency of a crystal to rise as much as 500 to 1,000 cps, depending upon the frequency of the crystal. A finisher must allow for this frequency change in finishing because if it is not done, the crystal may age out of tolerance. To complicate matters, ageing is not uniform. It varies with the frequency, the cleanliness of the crystal, and even the electrodes between which the crystal has been placed and the holder in which it has been incorporated. Recent experiments prove that accessory parts also go through an ageing period.

FIG. 4—Finishing crystals by "tumbling." They are placed in glass jars, along with abrasives, and the jars are rotated by means of a motor

Importance of Cleanliness

Another difficulty in finishing a crystal is that of getting the finished crystal perfectly clean. Considerable experimenting has been done on cleaning crystals, the criterion being the condition at which further cleansing with various solvents causes no rise in frequency.

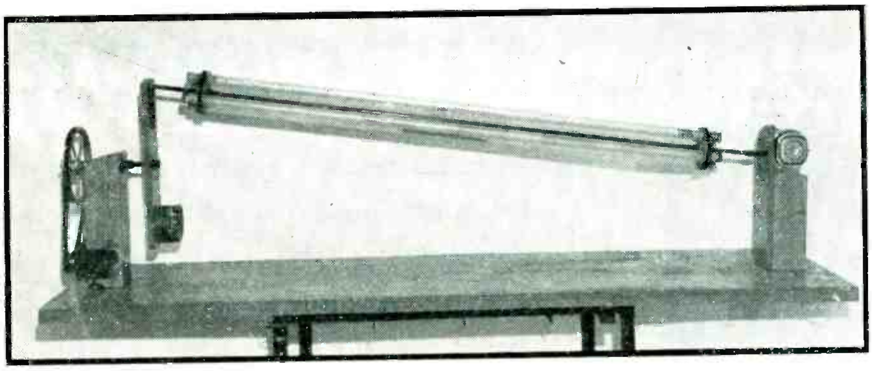

FIG. 5—An automatic "beveling" machine. Crystals and abrasives are placed in glass tubes equipped with baffles. The tubes are rotated and at the same time tilted up and down by means of a motor-driven eccentric

Cleaning a crystal will frequently cause its frequency to rise as much as 1,000 to 1,500 cps. This too, must be taken into account in finishing. It has been found that crystals are rarely thoroughly clean unless scrubbed with a brush and soap. Accepted procedure is to scrub the crystal thoroughly with soap and then rinse it in a series of solvents such as ammonia, water, and chemically-pure alcohol or carbon tetrachloride. Crystals are then dried in a blast of air. Even drying on a towel gives trouble, due to the lint deposited. Accessory parts must be cleansed as well.

Keeping Crystal Clean

One of the chief difficulties of keeping a crystal clean is to prevent the finisher from getting oil on it from the fingers. In final stages, crystals must be handled with tweezers or rubber gloves to eliminate this factor. (In final assembly, they must be mounted in an enclosed dust proof room. The air in this room is filtered and all precautions are taken to keep the interior surgically clean. The crystal blank is given a final cleaning and all parts of the crystal unit are thoroughly "blown out" with compressed air.)

After all these precautions, as much as 15 percent of all finished crystals may be thrown out during final checking because of activity or frequency variations. The cause for rejected crystals may be found in any of the difficulties discussed above. They must be reprocessed or repaired by altering dimensions, further grinding, cleaning, or changing electrodes and holders. Approximately 60 percent are eventually salvaged.

Last of the difficulties to be mentioned in finishing is the fact that the personality of the individual creeps into his work. This introduces an element of uncertainty. No two people finish a crystal alike. Sometimes little personality traits are beneficial while in other cases they are detrimental. This accounts for the fact that some finishers can finish 70 good crystals a day, while others working and trying just as hard reach a peak at 25.

For the past ten years crystal manufacturers have been attempting to produce a machine for finishing crystals, thereby eliminating the human element. Many of these have been tried and some have been reasonably successful in reducing if not eliminating hand work.

Machine Finishing

One machine method of finishing is called "tumbling". When using this process, shown in Fig. 4, semi-finished crystals are placed in candy jars along with coarse abrasive and water. The jars then are placed on long shafts which cause them to rotate. Crystals and abrasives slide over each other in random rotation. There is very little pressure on the crystals so the rate of grinding is very slow. As little as one to three kc can be removed in one hour. This is equivalent to one small sweep across plate glass by a finisher. As many as 1,000 crystals can be ground at once by such a machine and the crystals remain perfectly flat.

A machine has also been designed for beveling crystals. It is shown in Fig. 5, and is a tubular affair. Crystals are placed in the tubes along with a small amount of abrasive. The tubes rotate slowly, at the same time running on an eccentric so that they are tipped first towards one end and then toward the other. The crystals ride on the abrasive in the lower part of the tubes and are frequently

(*Continued on page* 288)

FIG. 6—Mass etching of crystals, latest innovation in the chemical method of finishing. Harmless fluorides less difficult to handle than hydrofluoric acid have recently been developed for such work

ELECTRON

Description of a typical electron diffraction camera for study of surface reactions at elevated temperatures, with the technique of analyzing the characteristic ring patterns and several examples of the use of the instrument in oxidation and corrosion research

By EARL A. GULBRANSEN

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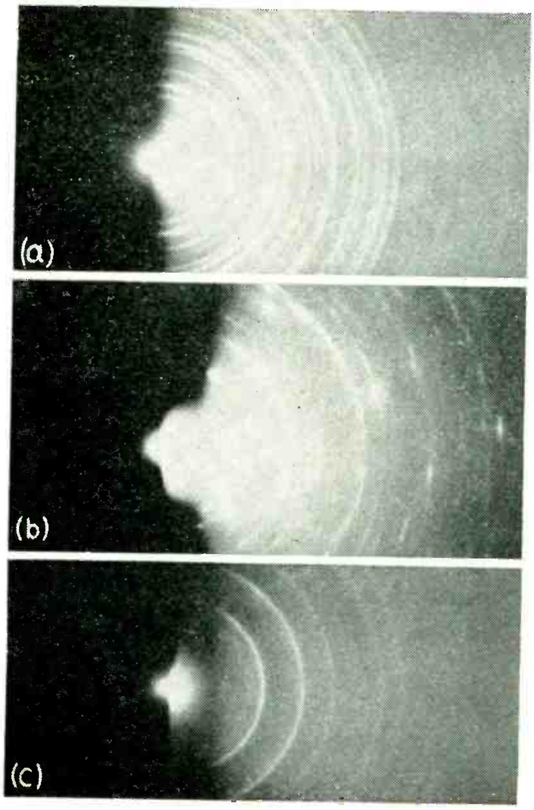


Typical diffraction pictures: (a) Electrolytic iron oxidized; 1 cm of air for 15 minutes at 600°C—Fe_3O_4; (b) Electrolytic iron oxidized in a vacuum of 2×10^{-4} mm of Hg at 850°C—FeO lattice; (c) Aluminum oxidized in 1 cm of air at 500°C—Al lattice

THE DEVELOPMENT of the electron diffraction camera as a tool in chemistry and physics arose from the prediction by de Broglie in 1924 that a wave system is associated with particles in motion. According to this prediction the wavelength λ of the associated wave system of a particle in motion is given by $\lambda = h/mv$. Here v is the velocity of the particle, m is the mass and h is Planck's constant.

One of the important developments in the techniques of electron diffraction was the discovery by Matukawa and Shinohara and by Thomson in 1930 that electrons impinging at grazing angles on plane polycrystalline specimens would give diffraction rings characteristic of the material in question. In this case only half-circles were obtained on the photographic plate. Two main types of diffraction analysis are in use today, namely: (1) transmission patterns obtained by passing the electron beam through thin sections of the material, and (2) reflection patterns obtained by impinging the electron beam at grazing angles.

X-ray and electron diffraction techniques differ as a result of the charge characteristic of the electrons and as a result of the wavelengths of the radiation. Electrons are scattered a million times more effectively than x-rays, which fact limits the thickness of the films in the transmission technique to 300 Angstroms or less. In the case of the reflection technique it is evident that at grazing angles, the first few atomic layers only are effective in the diffraction. This fact makes the electron diffraction camera extremely useful for the study of surface phenomenon.

The wavelength of electrons of 50 kv energy is 0.0533 Angstrom. For x-rays the wavelengths run from 0.5583 Angstrom for the $K\alpha_1$ line of silver to 2.2850 for the $K\alpha_1$ line of chromium. This difference in wavelength decreases the angle of scattering and the diameter of the diffraction rings for a given distance from specimen to film for the use of elec-

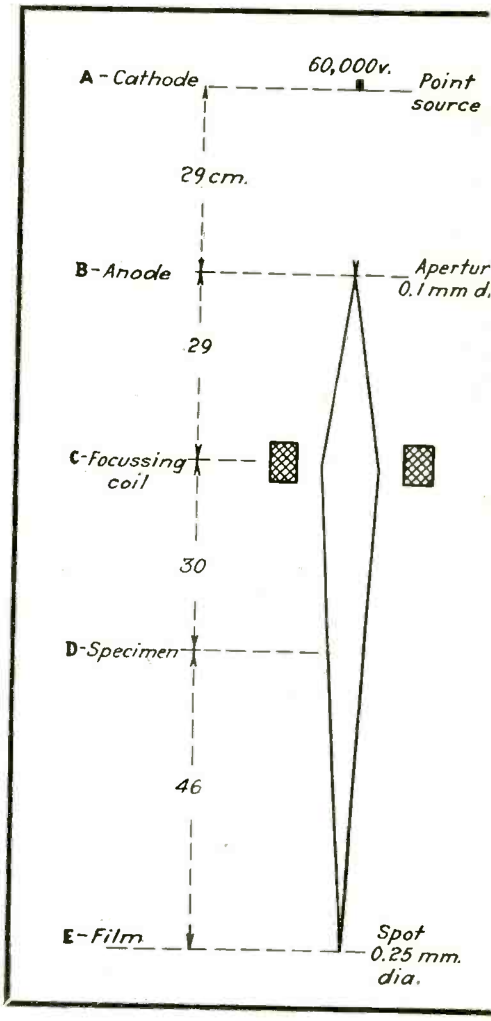


FIG. 1—Optics of electron diffraction camera

DIFFRACTION ANALYSIS of Surface Films

tron diffraction techniques, as contrasted to x-ray techniques.

The intensities of the diffracted patterns for the electrons are much greater than those obtained with x-rays. Thus, exposures of from 1 to 20 seconds are common in electron diffraction analysis, and the patterns can usually be seen on a fluorescent screen.

Electron diffraction analysis is not to be thought of as a substitute for the usual x-ray analysis because of the difficulty of preparation of the specimen for the general case. However, in its special field of surface phenomenon, it shows utility.

Among the many problems which have been studied by the electronic diffraction technique are:

1. Thin films of inorganic and organic materials
2. Oxide and other corrosion films
3. Polished surfaces
4. Crystal growth
5. Electrodeposited materials
6. Surface catalysis
7. Thermionic emission
8. Colloidal state
9. Photoelectric emission
10. Wear and lubrication
11. Impurities on surface
12. Running in of bearings

The electron diffraction camera in use at our laboratories consists of a source of homogeneous high-voltage electrons of 30 to 60 kv energy, a magnetic focussing system, a sample holder and manipulator and a camera section. The optical diagram of the electron diffraction camera is shown in Fig. 1, and a schematic diagram of the apparatus with some auxiliary equipment is shown in Fig. 2.

Apparatus

The high-velocity electrons are formed in the cathode discharge tube using hydrogen gas. After the beam passes through the 0.004-inch anode hole, it is collimated by a magnetic lens and brought to a focus on the fluorescent screen or photographic film. The reflection or transmission samples are placed between the magnetic lens and the photographic film. The specimen holder and manipulator allow movement of the specimen relative to the beam. At the same time the beam can be moved through small angles in order to graze the specimens mounted for reflection pictures.

For proper operation of the camera, a vacuum of about 10^{-5} mm of Hg is maintained in the main section of the camera, while a pressure of about 0.01 mm of Hg is maintained in the gas discharge tube. The pressure in the discharge tube is regulated by a well designed needle valve operating with a constant pressure drop across the valve. With constant high direct voltage, the current in the discharge tube is dependent on the pressure. Using a current of 50 microamperes in the discharge tube, exposures of the order of 1 to 10 seconds are necessary. The voltage is maintained constant to about 0.1 percent by a well regulated input source and high-capacitance filter.

The specimens for transmission patterns are thin sections of material

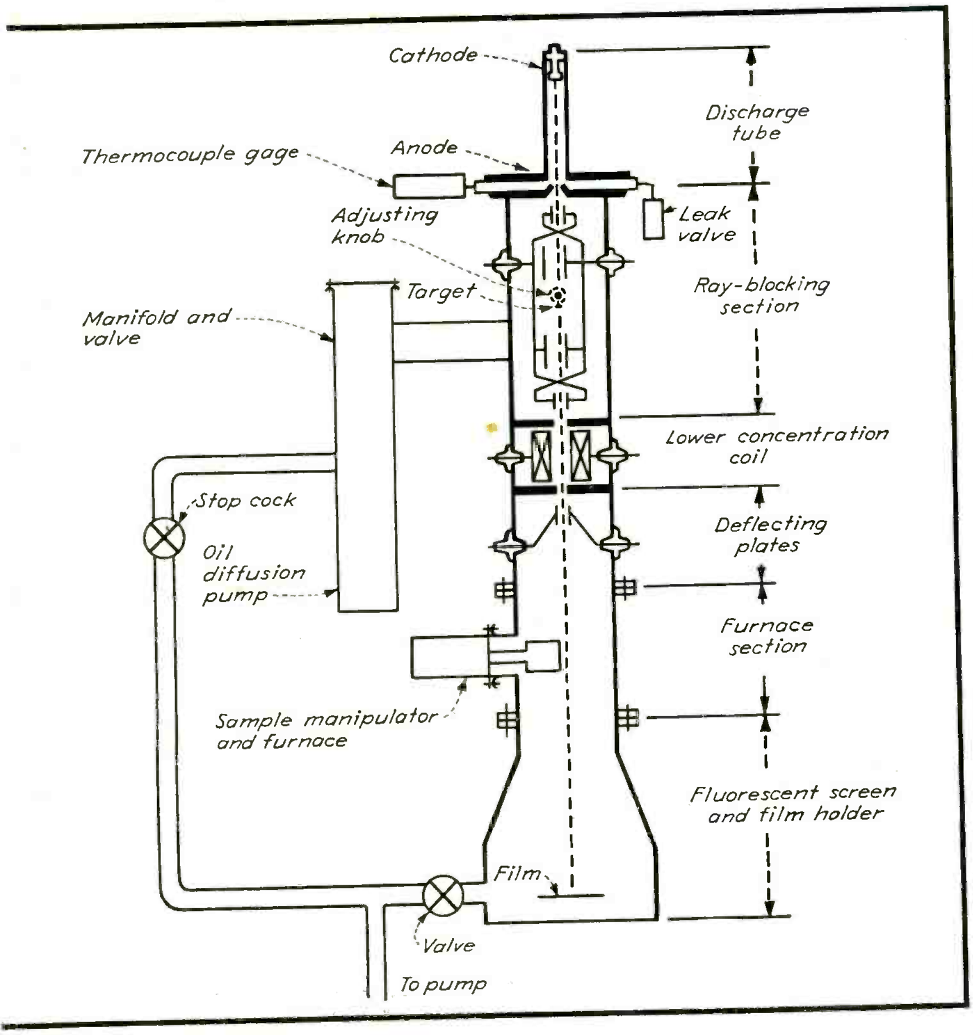


FIG. 2—Schematic diagram of electron diffraction camera

DIFFRACTION PATTERN OF EVAPORATED ALUMINUM

Electron Diffraction			X-Ray Tables	
Radius in cm	d_{hkl} in A	Intensity	d_{hkl} in A	Intensity
1.09	2.31	strong	2.33	strong
1.25	2.015	strong	2.02	strong
1.78	1.415	strong	1.43	strong
2.07	1.215	strong	1.219	strong
2.17	1.16	weak	1.168	weak
2.73	0.922	weak	0.928	weak
2.81	0.895	weak	0.905	weak
3.08	0.820	weak	0.826	weak
3.29	0.765	weak	0.778	weak

30 to 200 Angstroms thick. The usual technique involves evaporation of the material on to a thin organic film. Other methods, such as film stripping techniques, are used depending upon the particular problem. In general, the transmission technique suffers from the considerable difficulty of preparing specimens.

Technique

The reflection technique is more versatile since the only requirements are that the material be plane crystalline and of a certain area. The area and the surface preparation are important factors in regard to the overall intensity of the pattern. Usually the surfaces are made smooth with various types of polishing paper before subjecting them to the experimental procedures. Care must be observed to prevent organic and other films from contaminating the surface.

Analysis of Patterns

Figure 3 shows schematically the variables involved in the analysis of reflection patterns. The poly-crystalline specimen at a distance L from the film diffracts electrons giving rings of radii, R_{hkl}. In the case of single crystals or specimens in which orientation effects are present, spots or lines may be obtained instead of rings. The undiffracted beam is shown striking the film behind the shadow edge. The angles of scattering correspond to those which are predicted by a simplified form of Bragg's law applicable only to small angles

$$R_{hkl} = \frac{\lambda L}{d_{hkl}}$$

Here λ is the wavelength of the electrons and d_{hkl} is the lattice spacing effective in producing the diffraction *hkl*. Thus, by measuring the radii of the diffraction rings, the corresponding crystal spacings can be determined when L and λ are given. A knowledge of the values of the radii of the various rings and their relative intensities leads directly by comparison with tables to the identification of the material or film.

The instrument can be calibrated either by directly determining the voltage or by making diffraction patterns of known materials and calculating the value of λ. The table shows a typical comparison of the lattice spacings of evaporated aluminum, as determined by electron diffraction, with the spacings listed in Hanawalt, Rinn and Frevel's tables* obtained by x-ray analysis. The agreement is good to about 1 percent. This order of agreement is to be expected because of the uncertainty in the specimen to plate distance. The width of the specimen is about 1 cm while the specimen to plate distance is 48 cm.

Application to Surface Film

One of the interesting applications of the electron diffraction technique has been the study of oxidation and corrosion products of the various metals in different gas atmospheres. The apparatus in our laboratories is fitted out to study surface reactions and allows the diffraction picture to be taken at the temperatures in question. This is done by enclosing the specimen in a silver furnace whose temperature is carefully controlled. The samples can be cleaned by treatment with hydrogen. The behavior of the metal in various gas atmospheres can then be studied by admitting the gases to the camera for specified time intervals at various pressures. At the conclusion of the experiment the camera is evacuated and the diffraction picture taken at the temperature in question.

The photographs show three typical diffraction pictures obtained by the reflection technique. At (a) is the diffraction pattern obtained by subjecting pure electrolytic iron to an air atmosphere of 1 cm of mercury pressure for 15 minutes at 600°C. The structure is found to be Fe_3O_4. At (b) is the pattern obtained when pure electrolytic iron is heated to 850°C in a quartz tube in a vacuum of 2×10^{-4} mm of Hg. The structure is FeO and shows evidence of preferred orientation as indicated by the spots. At (c) is the result of heating aluminum in air at 1.5 cm of Hg for 2 minutes at 500°C. The pattern is that of aluminum and shows that the aluminum oxide film that is formed is noncrystalline in nature.

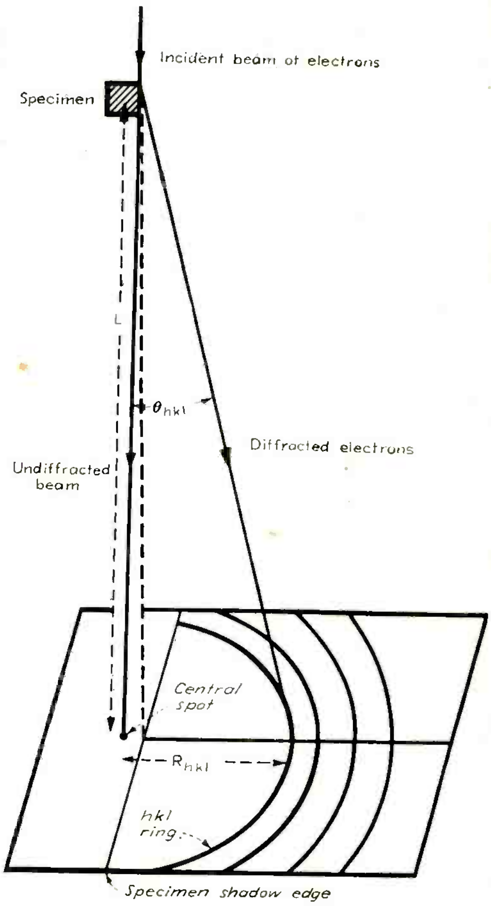


FIG. 3—Schematic diagram of variables involved in reflection patterns

* Hanawalt, Rinn and Frevel, *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 10, p. 457–512 (1938).

Electronic Locator for
Salvaging Trolley Rails

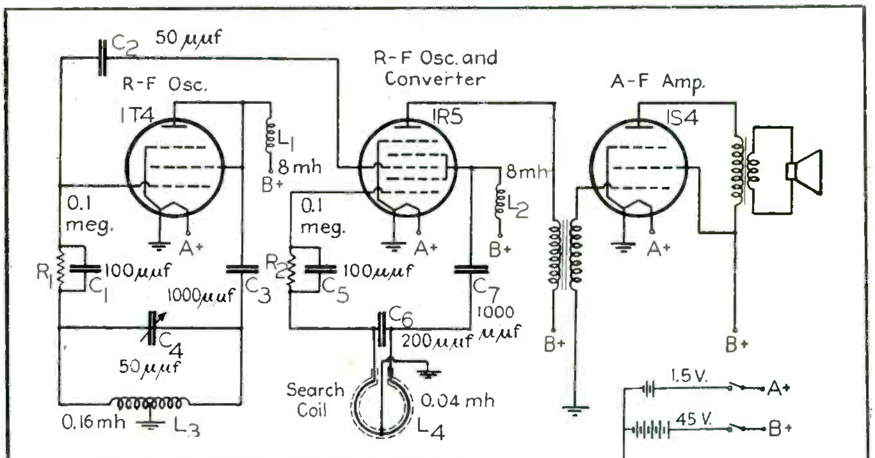


FIG. 1—Complete circuit of locator

By **JAMES G. CLARKE** and **CHARLES F. SPITZER**

Asst. Prof. in Elec. Eng. Yale University

Instructor in Elec. Eng. Yale University

DUE TO THE SHORTAGE of steel, a New England city decided to salvage trolley rails from abandoned routes. In parts of the city, the two rails were tied together beneath the pavement with steel cross-ties consisting of ½ x 2-in. straps placed on edge at a depth of about one foot. To avoid destruction of the pavement between the rails as they were lifted, it was desired to locate these cross-ties so that they could be cut off with an acetylene torch.

A simple electronic locator was devised using a circuit which depended upon the changes of inductance of a search coil when metal was brought into its vicinity. This change resulted from eddy currents in the metal, which established a flux opposing the flux from the coil.

Figure 1 illustrates the circuit used to detect this very small change in inductance. The search coil, L_4, was made the inductor of the tank circuit in one of two r-f oscillators which were operated at slightly different frequencies. These frequencies were mixed in the 1R5 and detected. The difference frequency was amplified in the 1S4 and fed to a speaker.

A fairly high radio frequency was used in the oscillators, since this produces a large change in cycles per second for a given percentage change in inductance. Also, the effect of eddy currents is more pronounced at high frequencies.

If the operating frequency selected is too high, the disturbing influence of stray capacitances and ground currents may become appreciable. A frequency of 2 Mc was found to be a satisfactory compromise between these effects.

To minimize the influence of stray capacitances, a comparatively large capacitance and small inductance was used in the tank circuit containing the search coil, and a Faraday electrostatic screen was placed between the search coil and the ground. Increase of capacitance and decrease of inductance reduces the impedance of the tank circuit. This reduction results in a poor impedance match with the plate resistance of the tube.

Since the length of the cross-ties which were to be located was great compared to their thickness, it was expected that a long narrow coil would be more sensitive than a circular coil. This assumption was found to be incorrect. The shape of a coil was changed, and the minimum distances permitting detection were plotted in Fig. 2 against the ratio of coil width to coil length. This showed a circular coil was most sensitive.

Miniature-type tubes with button-base sockets were used. The filaments of these tubes were supplied from a flashlight battery, and the plates from a 45-volt hearing-aid battery. The functions of one oscillator, the mixer and an amplifier were combined in the pentagrid tube. A small p-m loudspeaker was used.

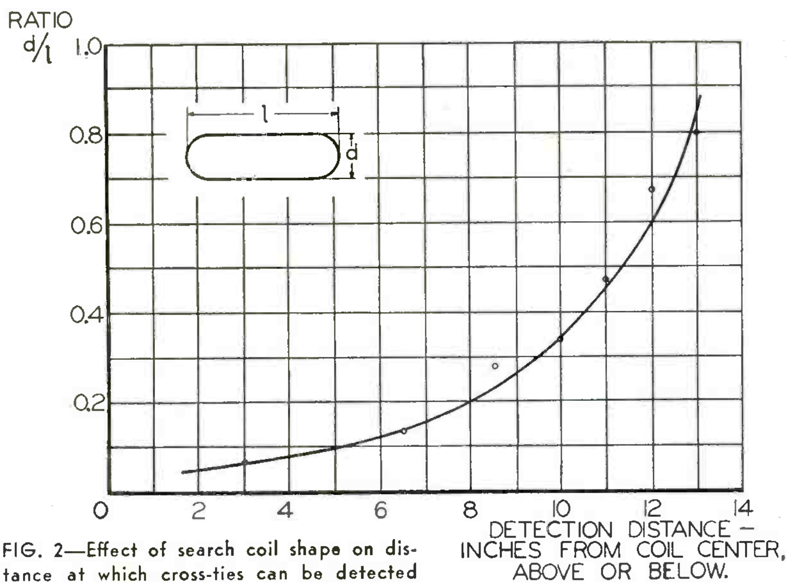


FIG. 2—Effect of search coil shape on distance at which cross-ties can be detected

An Improved
TRANSMISSION LINE CALCULATOR

An extension of the "calculator" originally published in ELECTRONICS in January 1939. New parameters have been added and accuracy has been improved

THERE was developed and has been in use in the Bell Telephone Laboratories for a number of years a particularly useful form of calculator for solving radio transmission line problems. The calculator was originally described in ELECTRONICS* where it was presented in "cut-out" form. The impetus given to radio development by the war has promoted considerable interest in this calculator among engineers and research workers, particularly in the field of u-h-f technique where electrical measurements must be made indirectly. Accordingly, it has been felt desirable to again present at this time a comprehensive description of the device. Several new and useful parameters have been added to the original design and the entire calculator has been redrawn to improve its accuracy and facilitate reading the coordinates.

The calculator is, fundamentally, a special kind of impedance coordinate system, mechanically arranged with respect to a set of movable scales to portray the relationship of impedance at any point along a uniform open wire or coaxial transmission line to the impedance at any other point and to the several other electrical parameters. These other parameters are plotted as scales along the radial arm and around the rim of the calculator, both of which are arranged to be independently adjustable with respect to the main impedance coordinates. All of the parameters are related to one another and specific solutions to a given problem are obtainable through the use of an adjustable cross-hair index along the radial arm, which extends to intersect the scales around the rim. The parameters which are plotted on the calculator include:

I. Impedance, or admittance, at any point along the line. (a) Reflection coefficient magnitude. (b) Reflection coefficient angle in degrees.

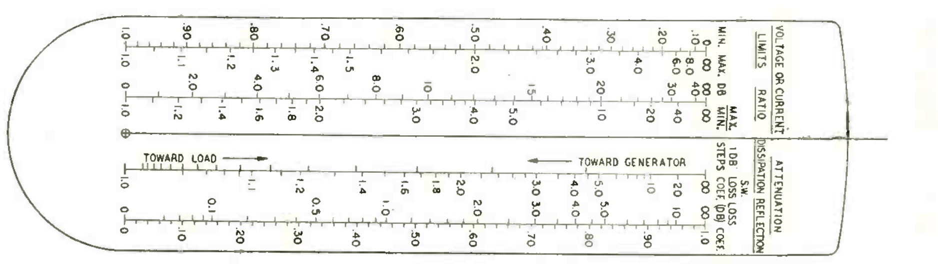
II. Length of line between any two points in wavelengths.

III. Attenuation between any two points in decibels. (a) Standing wave loss coefficient. (b) Reflection loss in decibels.

IV. Voltage or current standing wave ratio. (a) Standing wave ratio in decibels. (b) Limits of voltage and current due to standing waves.

A brief discussion of each of the several parameters and the manner in which they may be evaluated from the calculator will be given.

The impedance at any point along a transmission line is, unless otherwise defined, normally considered to be that impedance which would be measured if the line were cut at that point and measurements were made looking into the line section which is connected to the load.



Impedance—General Considerations

The impedance at any point along the line and the power reaching this point from the generator completely determine the magnitude of the current and voltage and their phase relationship at that point. For a steady state, the generator impedance itself, as well as the impedance looking towards the generator from any point along the line where it may have been considered to have been cut, can in no way affect the *distribution* of current or voltage along the transmission line to which the generator is connected.

In other words, the generator impedance can have no effect upon the standing wave position or amplitude ratio or upon the relation of the standing wave to the impedance dis-

* Smith, Phillip H. Transmission Line Calculator, ELECTRONICS, January 1939.

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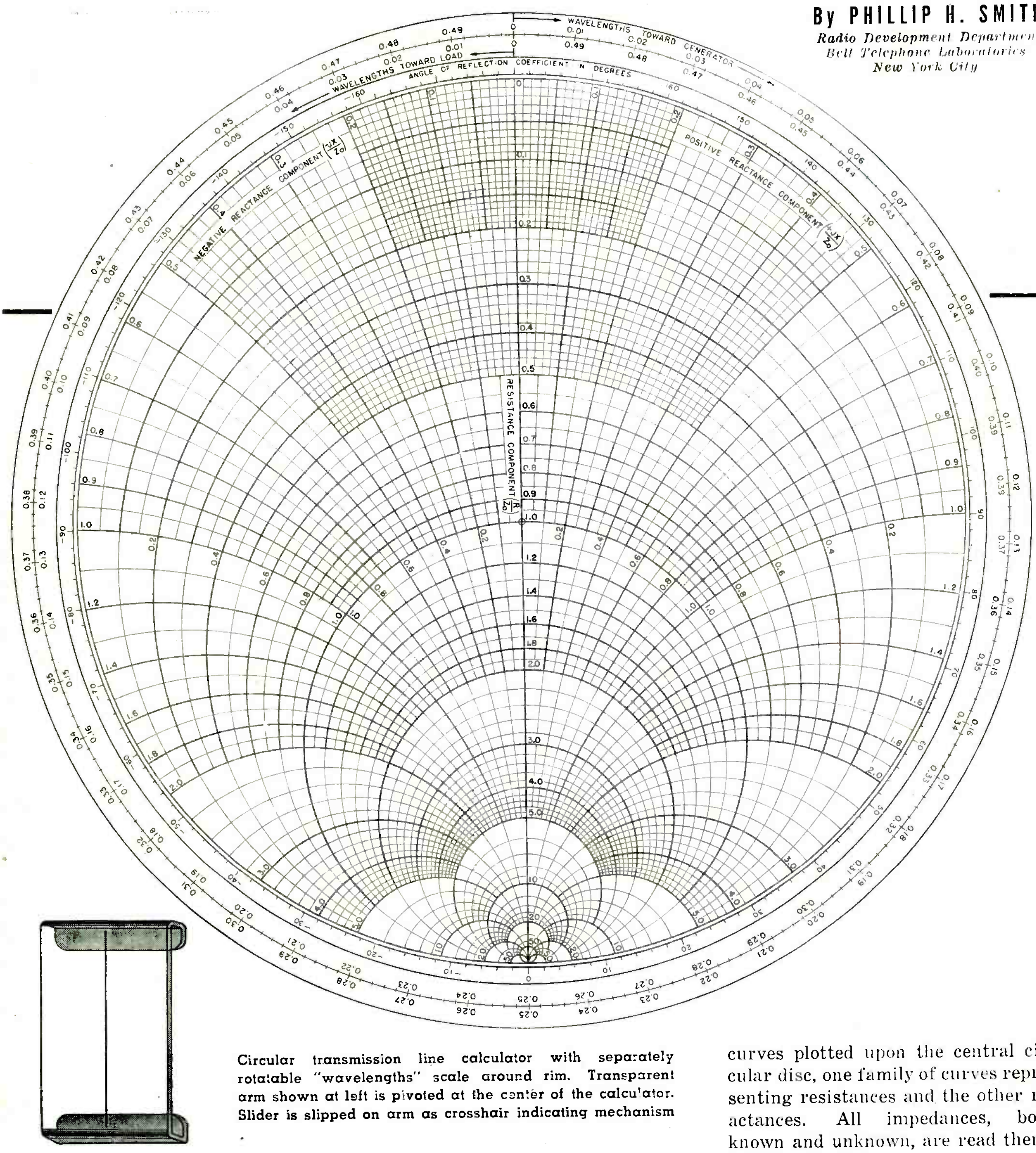


Circular transmission line calculator with separately rotatable "wavelengths" scale around rim. Transparent arm shown at left is pivoted at the center of the calculator. Slider is slipped on arm as crosshair indicating mechanism

tribution (locus of impedances) along the line. The generator impedance can affect *only* the power delivered to the transmission line and consequently the amplitude of the current or voltage all along the line, proportionately. The calculator relates the series components of the impedances thus considered at any point along a transmission line to a number of other parameters which will be discussed individually.

Impedance Coordinates—Central Area of Calculator

The series impedance components are represented on the calculator as two orthogonal families of circular curves plotted upon the central circular disc, one family of curves representing resistances and the other reactances. All impedances, both known and unknown, are read thereupon. To make the calculator of general application, these impedance coordinates are labeled as a fractional part of the characteristic impedance of the line (a fixed parameter in any given problem which may be evaluated from the physical dimensions of the line.)*

* Morrison, J. F., Transmission Lines, *Pickups* (Western Electric Co., New York), December 1939. See also "Radio Engineers Handbook," Terman, p. 174.

It is therefore necessary when using the calculator for solving problems involving the impedance at any point to first divide the components of all known impedances by the characteristic impedance of the line, then obtain a solution from the calculator which, if an impedance, will be expressed as a fraction of the characteristic impedance of the line, and finally to multiply this solution by the characteristic impedance to obtain the answer in ohms. The characteristic impedance is usually a "real" number, i.e., a pure resistance, for radio transmission lines, which makes this procedure a relatively simple one.

The relation between the impedance of the line at any point and the other parameters listed above is evaluated with the aid of the cross-hair index line on the radial arm as described later.

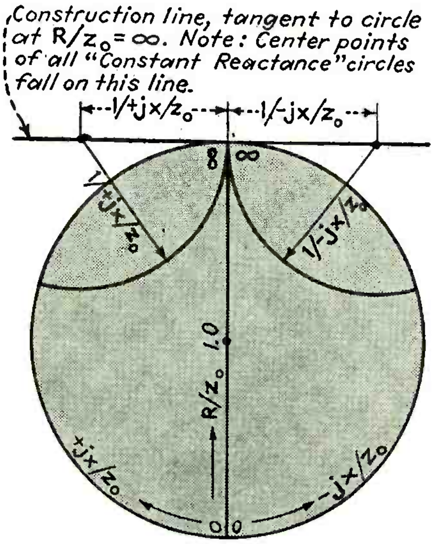
Equivalent Parallel Components of Impedance

The calculator also provides a means for converting the series components of impedances to their equivalent parallel resistance and parallel reactance components. This is accomplished by setting the series components under the cross-hair index line on the radial arm and then moving the latter to the diametrically opposite point on the calculator and taking the reciprocal of the values read at that point as the equivalent parallel resistance and parallel reactance. (A reciprocal scale is provided along the radial arm.) The equivalent parallel component of resistance is useful in problems where it is desired to evaluate the magnitude of the voltage and to avoid converting the problem to one involving admittances.

Admittance Coordinates

The calculator relates the series components of admittances, as well as impedances, to the various other parameters listed above and accordingly the coordinates may be considered to be admittance coordinates if preferred. In this case the coordinate axis (real) labeled "Resistance Component (R/Z_o)" becomes the Conductance Component (a/Y_o) axis, the scale units then indicating a fractional part of the characteristic admittance of the line. Likewise, the coordinate axis (imaginary) labeled "Positive Reactance Component $(+jX/Z_o)$" becomes the Positive Susceptance Component $(+jb/Y)$ axis and in the negative direction the Negative Susceptance Component $(-jb/Y)$.

Admittance is defined as $Y = a + jb$ and it is important to remember that capacitance is considered to be a positive susceptance and inductance a negative susceptance. The direction of rotation indicated on the calculator in moving from one point to another is the same whether impedance or admittance coordinates are considered.



Construction of "constant reactance" curves $\pm jx/Z_o$

Converting Impedances to Admittances

Impedances may be converted to admittances, or vice versa, by going to a diametrically opposite point on the calculator, as described above for obtaining the equivalent parallel resistance components, and reading the values at that point as conductance and susceptance.

Reflection Coefficient

The impedance (or admittance) at any point along a uniform transmission line is completely defined by the amplitude and phase angle of the "reflection coefficient" at that point. It is often convenient to think of transmission line phenomena in terms of the magnitude and phase relationship of reflected and incident traveling waves, i.e., the reflection coefficient of the transmission line under consideration.

The magnitude of the reflection coefficient is expressed by a number between 0 and 1.0, which represents the ratio of reflected to incident voltage at the point under consideration. If the attenuation of the line is negligible the magnitude of the reflection coefficient will be a constant at all points along the line for a given load impedance resulting in a given standing wave amplitude ratio along the line.

The magnitude of the reflection coefficient is plotted as a scale along the radial arm. The phase angle of the reflection coefficient is directly related to the impedance and accordingly is indicated on the calculator as a scale around the rim of the impedance coordinate system.

All impedances radially in line have a constant reflection coefficient phase angle. This phase angle is the angle by which the reflected wave lags the incident wave at the point along the line under consideration. Where these two waves add in phase to give a maximum voltage the impedance is resistive and greater than the characteristic impedance of the line, and the angle of the reflection coefficient is zero degrees. Going towards the generator from this point, the departure from zero phase angle is linearly related to the distance traversed. The reflected voltage wave at first lags the incident voltage wave (having the longer path to traverse) and the phase angle of the reflection coefficient is considered to be negative for the first quarter wavelength from the voltage maximum point in the direction of the generator. The reactive component of the impedance in this region is negative.

At the exact quarter-wavelength (90 deg.) point the incident and reflected voltage waves are exactly out of phase and the angle of the reflection coefficient is ± 180 deg. Continuing in the same direction towards the generator, the two waves become increasingly more in-phase and in this region between one-quarter and one-half wavelength from the voltage maximum point towards the generator, where the reactive component of the impedance is inductive, the reflected wave leads the incident wave and the reflection coefficient has a positive angle.

The relationship between the magnitude of the reflection coefficient and the standing wave amplitude ratio may be derived from the fact that at the voltage maximum point the incident and reflected waves add in phase, whereas, at the voltage minimum point they are exactly out of phase, thus

$$\frac{E_{max}}{E_{min}} = \frac{V_I + V_R}{V_I - V_R} = \frac{1 + \frac{V_R}{V_I}}{1 - \frac{V_R}{V_I}} \quad (1)$$

$$\text{Since } \frac{V_R}{V_I} = k,$$

$$\frac{E_{max}}{E_{min}} = \frac{1 + k}{1 - k} \quad (2)$$

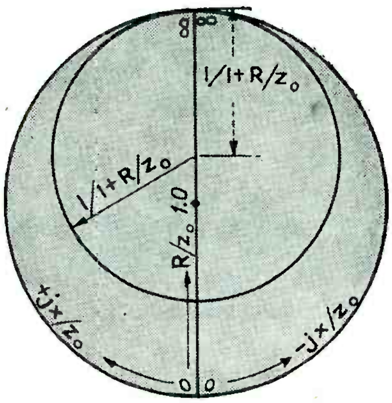
k = magnitude of the voltage reflection coefficient
V_R = reflected voltage
V_I = incident voltage

Length of Line—Movable Distance Scale Around Rim

Impedances along a uniform transmission line vary cyclically, repeating every half wavelength if the line has negligible attenuation. Thus, for any given termination the impedance locus path in going along the line in either direction from any initial starting point will close upon itself in exactly one-half wavelength effective length. The circular calculator is arranged so that one trip around the impedance coordinated disc at any constant distance from the center corresponds to a movement of just one-half wavelength along the transmission line. The length scale around the rim of the calculator is linear and its zero position may be adjusted so that measurements can be started from a point radially in line with any known impedance point on the coordinates and carried in either direction, i.e., either "towards the generator" or "towards the load" to a point where it may be desired to know the impedance.

Uniform transmission lines with air dielectric and negligible attenuation have an "effective length" equivalent to the length of the wave in free space and no correction is required for the length scale. However, any solid dielectric material in the field of the conductors causes a reduction in the length of the standing wave which is proportional to $1/\sqrt{K}$ where K is the dielectric constant. This applies to lines where the entire field is confined to a homogeneous dielectric such as rubber-insulated coaxial lines. In coaxial lines, for example, where bead insulators are used, if the beads are spaced closer than about 1/36th wavelength, the line may be considered to have a uniform effective dielectric constant. The length scale refers to the "effective length" of the line.

As further discussed in the section entitled "Standing Wave Ratio," the relation between impedance and current distribution (standing waves), especially with respect to their position along the line, is often conveniently referred to the pure resistance



Construction of "constant resistance" curves R/Z_0

points and length measurements are often made with reference to one end or the other of the "real" axis, at which points the maximum and minimum current and voltage points occur.

Any line length in excess of one-half wavelength can be reduced to an equivalent shorter length to bring it within the scale range of the calculator by subtracting the largest possible whole numbers of half wavelengths therefrom.

Scales Along Radial Arm

A number of the parameters are uniquely related to one another as well as to the magnitude of the reflection coefficient previously described. These parameters are conveniently plotted as scales along the radial arm in nomograph form. Their relationship may be evaluated through the use of the sliding index line which permits reading any or all of the several scales at the intersection of the slider index line. A given set of such values are also related to a given impedance locus which is traversed upon the impedance coordinates at the cross index line intersection when the radial arm is rotated once around the calculator. The several related parameters plotted along the radial arm in nomograph form include the following:

(1) Attenuation in 1-db steps (due to loss resistance of line, leakage, and dielectric loss).
(2) Standing wave loss coefficient (due to increased average current and voltage).
(3) Reflection loss (or gain) in decibels.
(4) Reflection coefficient magnitude (voltage).
(5) Standing wave ratio (*SWR*) of maximum to minimum current or voltage.
(6) Standing wave ratio expressed in decibels ($20 \log_{10} SWR$).
(7) Relative voltage or current at maximum and minimum points for constant power.

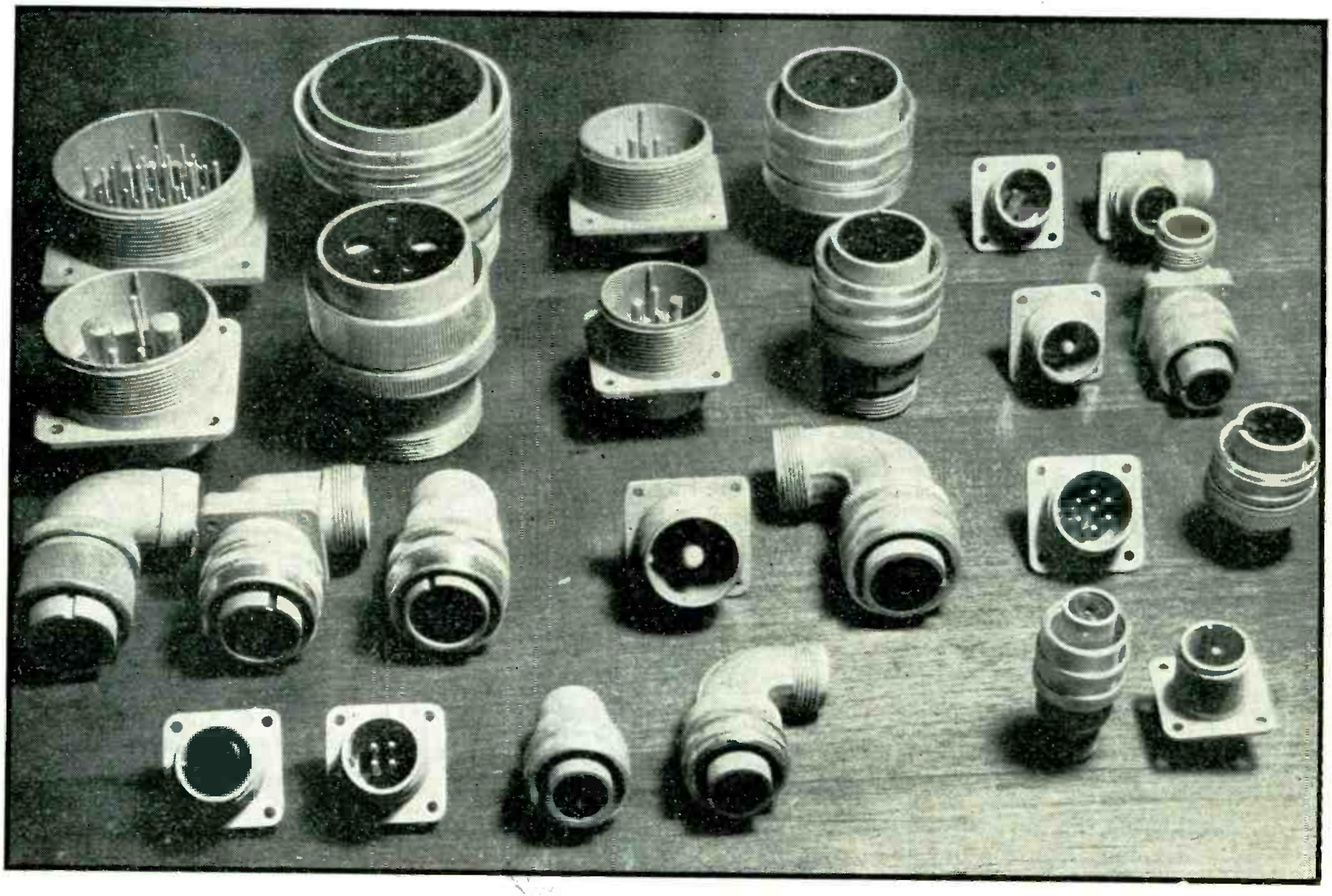
Attenuation

Attenuation causes the impedance locus along a uniform transmission line to spiral inward toward the center of the calculator from the initial starting point when going from the load end of the line "toward the generator", and to spiral outward toward the rim when going from an initial starting point "toward the load". The rate at which this spiral locus approaches the center (or the rim) depends directly upon the attenuation per unit length of line as well as upon the initial starting point.

Impedances near the rim (encountered along a line bearing a large standing wave) are altered to a greater extent by a db unit of attenuation, for example, than impedances near the center. The attenuation scale is conveniently plotted along the radial arm since it is a measure

(*Continued on page* 318)

AIRCRAFT RADIO



Typical aircraft electrical disconnect plugs made to Army and Navy specifications by various manufacturers. Corresponding types are interchangeable

TOP ROW, left to right: Cannon AN-3102-40-1P; Cannon AN 3106-40-1S; Cannon AN-3102-28-2P; Aero AN-3106-28-2S; Amphenol AN-3102-14S-1P; Amphenol AN-3108-14S-1S. SECOND ROW: Amphenol AN-3102-32P-1P; Aero AN-3108-32-1S; Amphenol AN-3102-22-4P; Cannon AN-3106-22-4S; Amphenol AN-3102-14-3P; Amphenol AN-3108-14-3S. THIRD ROW: Harwood AN-3108-18-4S; Amphenol 97-3108J-18-4S; Amphenol AN-3106-18-4S; Amphenol AN-3102-18-6P; Cannon AN-3108-18-6S; Amphenol AN-3102-16S-1P; Cannon AN-3106-16S-1S. BOTTOM ROW: Amphenol AN-3102-14S-2S; Amphenol AN-3102-14S-2P; Cannon AN-3106-14S-2S; Cannon AN-3108-14S-2S; Amphenol AN 3106-12-5S; Amphenol AN-3102-12-5P

BEFORE ANY ITEM is made a part of an airplane, someone must prove that it will pay its own way during the life of the airplane.

There are many ways in which a component of a plane can pay its way. For example, it may add to the speed of the plane or otherwise improve performance. It may add to the pay load or increase the safety of flight. It may enable the manufacturer to turn out planes quicker and cheaper or enable the operator of an airline to speed up the overhaul of such a plane.

Interest, taxes and depreciation go on whether or not a plane is flying and earning revenue, and these expenses may amount to $100 per day or more. In addition, a plane on the ground is not earning revenue, and a successful transcontinental airline can reasonably expect an income of somewhere around $1,000 per day from each plane in its fleet. Broken down into loss per hour, we find that the airline loses approximately $40 for every hour a plane spends on the ground. Therefore, anything that speeds up the periodical overhaul and repair adds to income.

The electrical or radio disconnect plug is a good example of an aircraft part that can speed up overhaul. For instance, one of its many uses is for plug-in instrument panels, as illustrated in Fig. 1. Here the change to plugs resulted in a saving of about 4 hours in changing instruments in the plane, besides the intangible benefit of not having so many men working in the cockpit at the same time.

One usually supposes that plugs add weight and thus counteract the benefit derived from facility in overhaul. If sufficient forethought is given to the installation this is not necessarily true. In the case of the aforementioned plug-in instrument panel, enough wire and terminal strips were removed to save 4½ lb over the weight of the plugs which were substituted. At a conservative estimate, a pound is worth $20 a year per plane in revenue*, hence the plugs earned $90 in revenue for each plane on which the conversion was

*Under wartime conditions, about ten times this amount.

Disconnect Plugs

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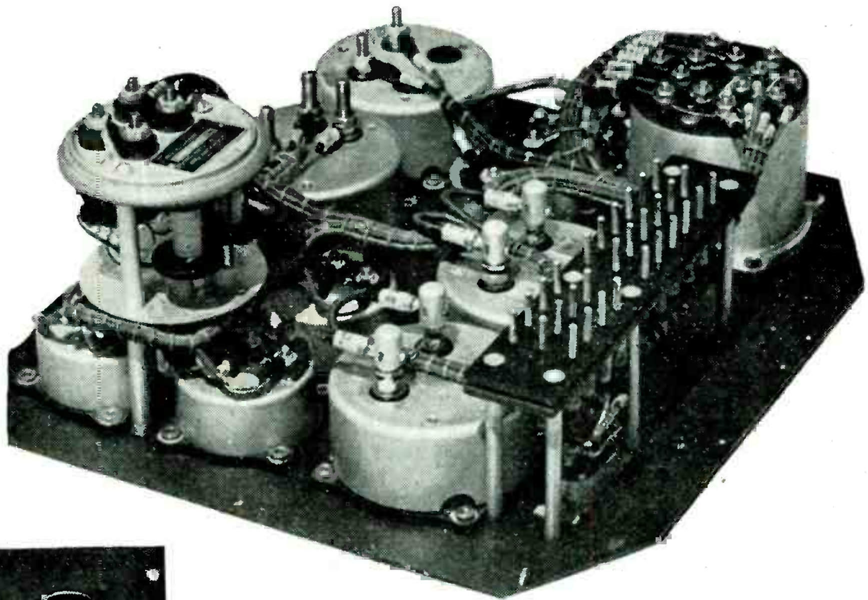
Properly used, electrical disconnect plugs can boost earning power of commercial aircraft by reducing total weight of radio and electrical equipment, minimizing overhaul time, and speeding emergency replacements. Some planes have over 2000 connections through plugs



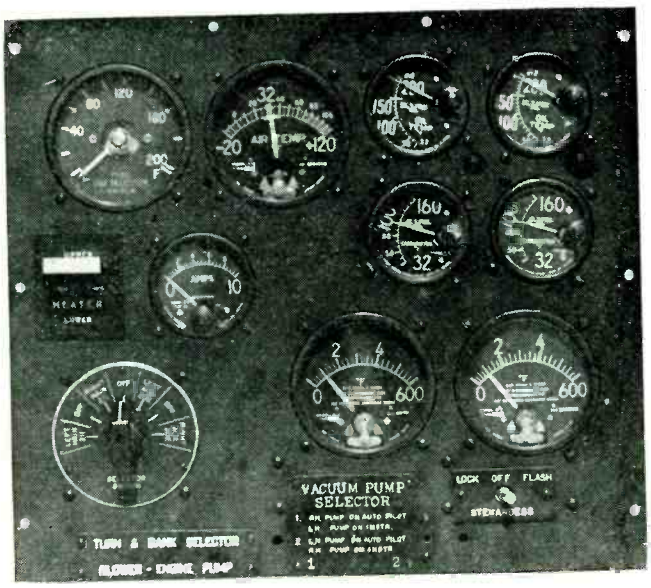


FIG. 1 — Front and rear views of an aircraft instrument panel group equipped with a 30-pin electrical disconnect plug

made. For a fleet of 100 planes, $9,000 is added to the yearly income.

Uses for Plugs

In spite of the most careful attention during periodic overhauls of an airplane, some parts may require repair or attention between the periodic overhauls. Radio and electrical parts are no exception. If it were necessary to make such repairs in the plane, costly delays of scheduled departures would frequently result. In the case of radio and electrical equipment, such delays are generally prevented by quick replacement of the defective unit by a serviceable unit. Quick replacement is greatly facilitated by the use of disconnect plugs.

Electrical disconnect plugs are used throughout airplanes, sometimes in the most unlikely locations. Electrical connections to each engine nacelle are made through plugs to starters, generators, generator control boxes, booster coils, full-feathering propeller pumps, electrical instruments, magneto leads, etc.

Other parts of the plane are also made quickly removable through the use of plugs and receptacles. Some examples are as follows: wing tips, wings, center sections, tail cones, stabilizers, instrument boards, individual instruments, electrical switch panels, radio control panels, radio receivers and transmitters, batteries, electric ovens for keeping food hot, battery carts, interphone stations, ground telephones, electrical cabin temperature controls, deicing equipment, etc.

All in all, in some planes as high as 2000 or more connections are disconnected through plugs. If such connections were removed and remade by unsoldering and soldering it would probably take one man about two weeks.

Types of Plugs

Currents may range from a fraction of a milliampere to 500 amperes and from a few millivolts to 1000 volts or more. A plug may have one contact or rows and rows of contacts of all sizes. The plug shown in Fig. 2, having a total of 180 contacts, will be used to disconnect the radio con-

(Continued on page 236)

The MULTIVIBRATOR Applied Theory

This first part of a three-part paper is devoted largely to the multivibrator operating at its natural frequency. The wave shape of the synchronizing voltage and its point of application to the multivibrator are considered

IN this article* the analysis of the multivibrator is developed on the basis of simple capacitor-resistor time constants. An equation relating the natural frequency of the multivibrator to the characteristics of the tubes and circuit components is derived and discussed. The waveform of the synchronizing voltage is considered, as well as the conditions that determine the phase in which this voltage must be supplied to each tube. Equations are given which relate the variations permissible in the time constants of the circuit to the order of division of the stage. Three conditions which must be satisfied in the design of a synchronized multivibrator to allow for the above variations are stated and illustrated. A method of designing the multivibrator so as to fulfill these requirements is developed, together with a practical method for adjusting the amplitude of the synchronizing voltage to the calculated optimum value. The application of either positive or negative pulses to only one tube and to both tubes is discussed. Percentage variations in the frequency and amplitude of the synchronizing pulses over which a given order of division can be maintained are presented. Equations and curves are included which facilitate the design of both synchronized and unsynchronized multivibrators.

* List of symbols is at end of paper.

General Multivibrator Considerations

To familiarize the reader with the author's concept of the operation of the multivibrator, a preliminary explanation is given. The multivibrator circuit described by Abraham and Bloch consists of two resistance-capacitance coupled amplifier stages with the output of each stage connected to the input of the other. This is illustrated in Fig. 1.0.

If V_2 is thought of as a switch which closes a circuit and applies a negative step of voltage to terminal 2, it is a simple matter to write the equation that describes the voltage across R_{d1}. When the switch closes, the voltage across R_{d1} will decrease instantaneously from zero to the value of the negative step and will thereafter increase exponentially toward zero. Finally this voltage will become less negative than that required to prevent the flow of current in V_1.

Due to the regenerative action of the circuit, an infinitesimal current through V_1 will be rapidly amplified and will result, according to the above logic, in closing switch V_1, thereby applying a negative step of voltage to terminal 3. When this switch closes, it simultaneously opens switch V_2, i.e., the plate current of V_2 is stopped. Now the previous cycle of operations is repeated with the functions of the two sections of the circuit interchanged. The sum of the nonconducting times of V_1 and V_2 is one period of the multivibrator frequency.

It is apparent that the natural fre-

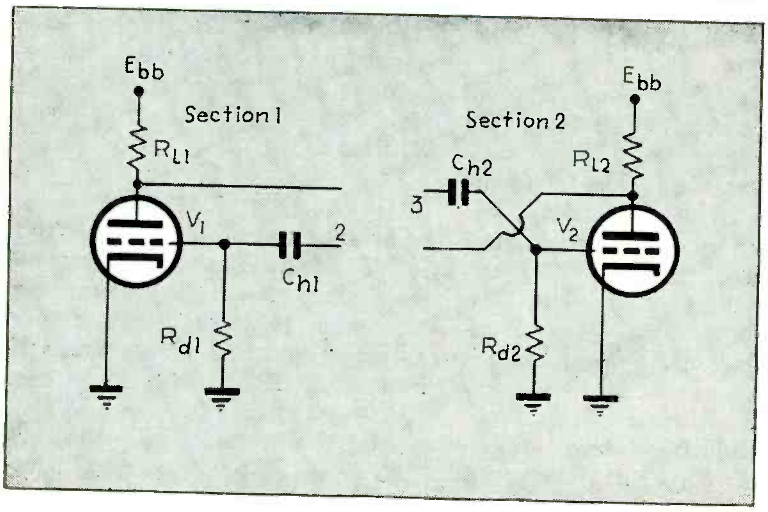


FIG. 1.0—This Abraham and Bloch multivibrator circuit consists of two resistance-capacitance coupled amplifier stages. The output of each stage is connected to the input of the other stage.

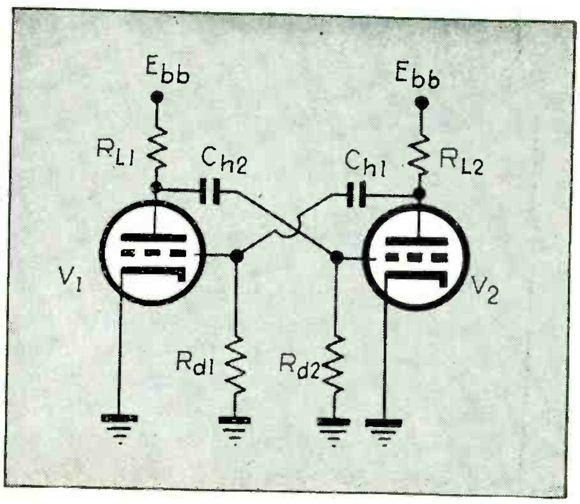


FIG. 1.1—(below at right)—Basic two-triode multivibrator circuit

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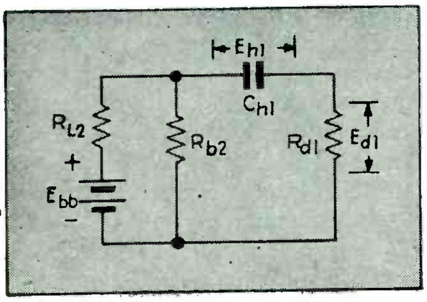
and Design . . . Part I



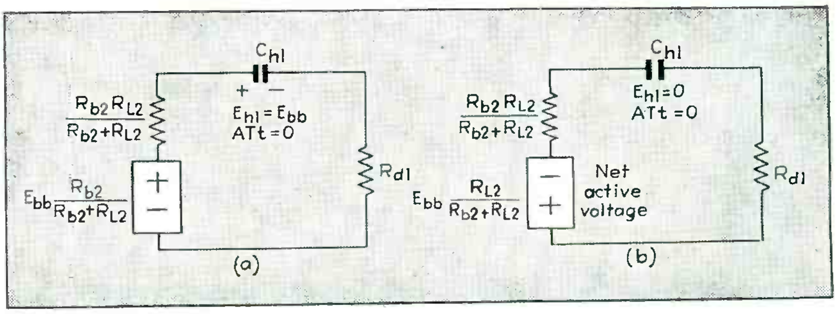


FIG. 1.2—Equivalent discharge circuit of C_{h1} in the multivibrator of Fig. 1.1. V_2 is conducting, and V_1 is nonconducting. $E_{h1} = E_{bb}$ at $t = 0$. Time is measured from the instant V_2 becomes conducting. **FIG. 1.3** (above at right)—Simplification of Fig. 1.2 by the use of Thevenin's Theorem

quency of the MV (multivibrator) is determined by the characteristics of the tubes, the values of the circuit time constants and the magnitude of the change of voltage applied to these time constant circuits when the tubes change from the nonconducting to the conducting state.

The Unsynchronized Multivibrator

During one portion of the MV cycle, section 1 generates a step function of voltage which is applied to the time constant circuit of section 2. The duration of this portion of the cycle depends only upon the magnitude of the voltage step, the value of the time constant $C_{h2}R_{d2}$ and the critical grid voltage of V_2. In practice, the internal resistance of the generator is not zero. Consequently, the resistive component of the above time constant is larger than R_{d2}.

It should be noted that section 1 would continue to supply the step of voltage indefinitely, but that this portion of the cycle is terminated when the grid voltage of V_t reaches the critical (cut-off) value $-E_{co2}$. For the other portion of the cycle, section 2 becomes a generator of a voltage step which is applied to V_1.

Thus, it is seen that both tubes are in a static condition except for the extremely short time during which they are in the process of interchanging their conduction states. The present paper assumes that the time involved in these changeovers is negligible in comparison with the MV period. For this reason, static values of plate resistance and amplification factor are used in developing equations for the period of the MV.

Referring to the MV circuit of Fig 1.1 the equivalent discharge (decreasing potential difference across the capacitor terminals) circuit of C_{h1} is as indicated in Fig. 1.2[1]. By the use of Thevenin's theorem, Fig. 1.2[1] can be simplified to Fig. 1.3a. For the solution of the transient voltage across R_{d1}, Fig. 1.3b is equivalent to Fig. 1.3a. The difference between

FIG. 1.4—Plot of Eq. (1.2). Starting from the value $-k_2E_{bb}$, the grid voltage of V_1 increases exponentially toward zero

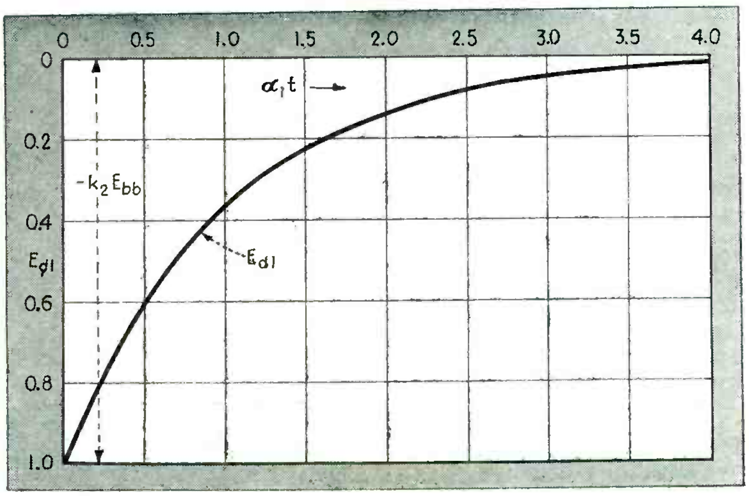
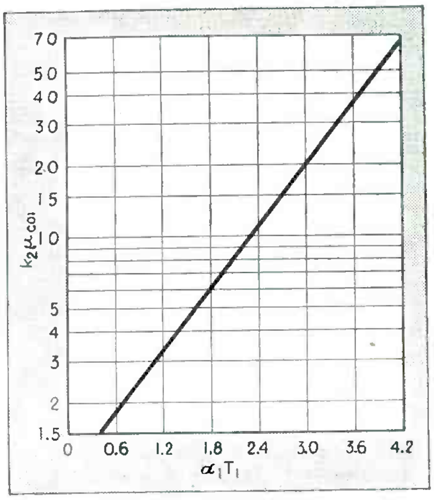


FIG. 1.5—Plot of Eq. (1.5a). By means of this curve, the multivibrator can be designed to operate at a given natural frequency



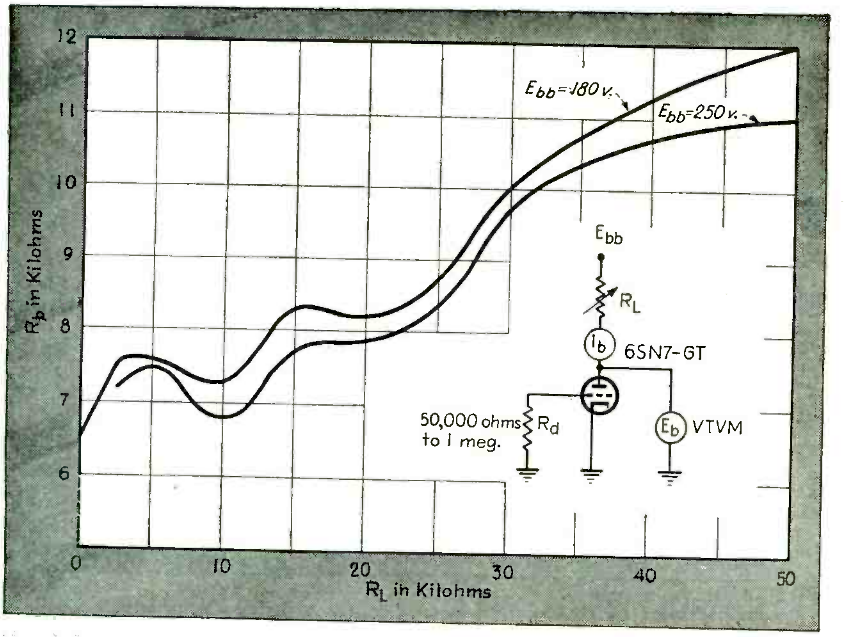


FIG. 1.6—Measured average d-c plate resistance (R_b) of type 6SN7-GT at zero bias as a function of the plate load resistor. R_b is practically independent of R_d for values of R_d in the range of 50,000 ohms to 1 megohm. $R_b = E_b/I_b$

these figures is that in Fig. 1.3b the net active voltage has been indicated as the only voltage in the circuit. This net voltage is readily obtained from Fig. 1.3a by taking the difference between the voltage across the capacitor and the voltage applied to the circuit.

It is apparent from Fig. 1.1 also that the magnitude of the active voltage is equal to the drop across R_{L2}, since it is by this amount that the charging voltage for C_{h1} has been reduced. The same current will flow in the circuit of Fig. 1.3b as in the circuit of Fig. 1.3a. The actual voltage across the capacitor and the voltage applied to the circuit are as indicated in Fig. 1.3a.

From Fig. 1.3b

$$E_{d1} = -\left[E_{bb}\frac{R_{L2}}{R_{b2}+R_{L2}}\right]\left[\frac{R_{d1}}{R_1}\right]\exp\left[-\frac{t}{C_{h1}R_1}\right] \quad (1.1)$$

$$= -k_2 E_{bb}\exp[-\alpha_1 t] \quad (1.2)$$

Where $k_2 = \left[\frac{1}{1+\frac{R_{b2}}{R_{L2}}}\right]\left[\frac{1}{1+\frac{1}{R_{d1}}\left(\frac{R_{b2}R_{L2}}{R_{b2}+R_{L2}}\right)}\right]$ (1.3)

and $\alpha_1 = \frac{1}{C_{h1}R_1}$ (1.4)

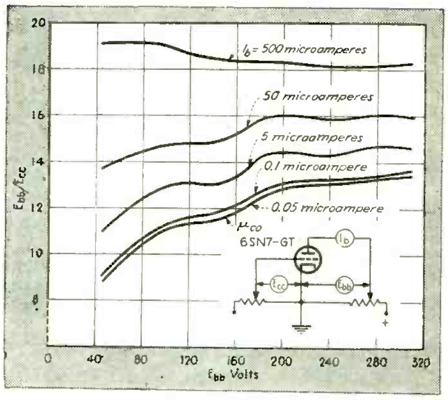
and $R_1 = \left[R_{d1} + \frac{R_{b2}R_{L2}}{R_{b2}+R_{L2}}\right]$

Equation (1.2) is plotted in general terms in Fig. 1.4. From this curve it is noted that when V_1 first becomes nonconducting ($t = 0$) its grid voltage is equal to $-k_2E_{bb}$. As time increases, this grid voltage increases exponentially toward zero. When E_{d1} reaches the cut-off value $-E_{co1}$, the tube will become conducting. Suppose $-E_{co1}$ is equal to $-0.1k_2E_{bb}$. Then from Fig. 1.4 the tube will become conducting when $\alpha_1 t$ is equal to 2.3.

Eq. (1.2) can be written

$$\frac{E_{d1}}{-k_2E_{bb}} = \exp[-\alpha_1 t]. \quad (1.2)$$

FIG. 1.8—Measured average values of the ratio E_{bb}/E_{cc} required to provide various values of plate current as a function of plate voltage for the type 6SN7-GT tube. Note that μ_{co} is considerably less than the rated dynamic mu which is 20



[1] R_{b2} of Fig. 1.2 is defined as the ratio of plate voltage to plate current at zero grid voltage. A resistance somewhat smaller than this would be more accurate as an average value, due to the fact that for a portion of the cycle the grid voltage is positive rather than zero.

It will be noted that E_{b1} of Fig. 1.2 is assumed to be E_{bb} at time equal to zero. This assumption can be validated by proper selection of the resistance associated with C_{h1} during its charging time. This charge time constant is considered later.

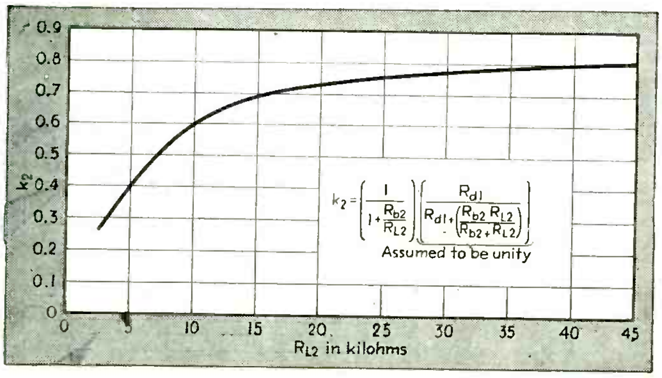
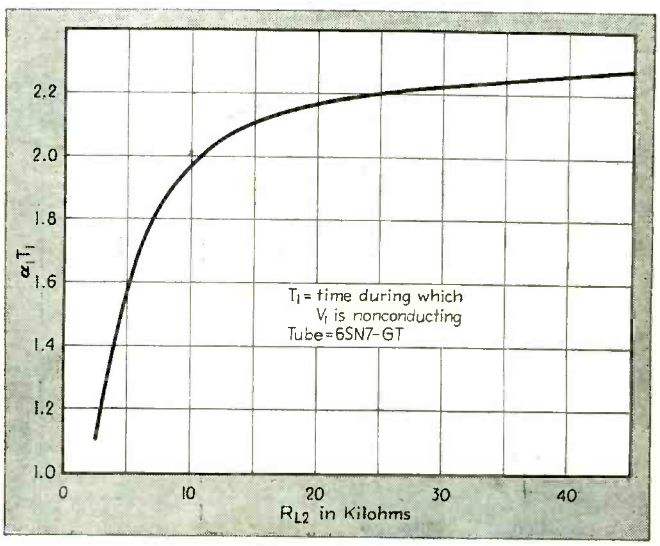
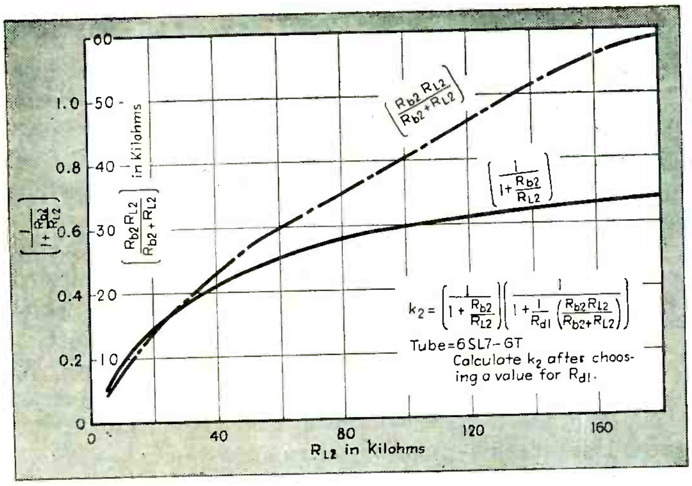


FIG. 1.7—If the second bracket in the expression for k_2 is assumed equal to 1; then, by reading from Fig. 1.6, average values of k_2 can be plotted as a function of R_{L2}. This curve is for type 6SN7-GT in the E_{bb} range of 150 to 250 volts

FIG. 1.9 (at right)—For a given tube type, α_1T_1 can be plotted as a function of R_{L2}. This type of curve simplifies multivibrator design





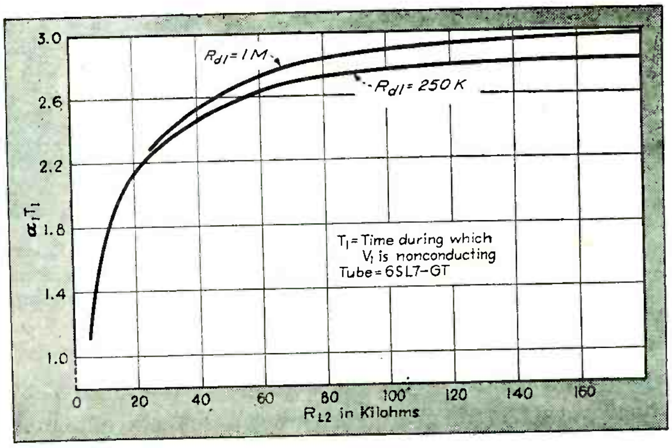


FIG. 1.10—A method of plotting the information necessary to compute the value of k as a function of R_L in cases where the value of the second bracket in the expression for k cannot be considered equal to unity. Measured average values for type 6SL7-GT in the E_{bb} range of 150 to 250 volts. FIG. 1.12 (above at right)—Similar to Fig. 1.9, but applicable to type 6SL7-GT tubes

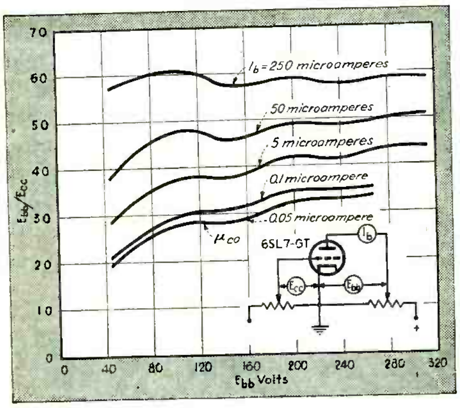


FIG. 1.11—Same as Fig. 1.8, but applicable to type 6SL7-GT tubes. The curve designated μ_{co} is useful in multivibrator design

Substituting the specific values $-E_{co1}$ for E_{d1} and T_1 for t, (1.2) becomes

$$\frac{E_{co1}}{k_2 E_{bb}} = \frac{1}{k_2\,\mu_{co1}} = \exp\left[-\alpha_1 T_1\right] \quad (1.5)$$

$$\alpha_1 T_1 = -\log_e\left[\frac{1}{k_2\,\mu_{co1}}\right] = \log_e\left[k_2\,\mu_{co1}\right] = 2.30\log_{10}\left[k_2\,\mu_{co1}\right]. \quad (1.5a)$$

(A modification of this equation for use with pentodes is given later in this paper.) Usually μ_{co1} is ½ to ¾ of the rated amplification factor of the tube and equals E_{bb}/E_{co1}. T_1 is directly proportional to $C_{h1}R_1$ and to the logarithm of $k_2\mu_{co1}$. Therefore, a 2 to 1 change in the value of $C_{h1}R_1$ will produce a 2 to 1 change in T_1. A 2 to 1 increase or decrease in $k_2\mu_{co1}$ will add or subtract $\log_e 2 = 0.693$ to the value of the logarithm term. The percentage change that this represents depends upon the original value of $k_2\mu_{co1}$. The variation in T_1 introduced by a given percentage change of $k_2\mu_{co1}$ decreases as the value of this factor increases. (See Appendix 1.) If $k_2\mu_{co1} = \epsilon = 2.718$, the log term of Eq. (1.5a) becomes unity. If, in addition, $R_{d1} >> R_{b2}R_{L2}/(R_{b2} + R_{L2})$, the equation reduces to the frequently mentioned "order of magnitude" form, i.e., $T_{mv} = C_{h1}R_{d1} + C_{h2}R_{d2}$.

For $k_2\mu_{co1} = 1$, the log term of Eq. (1.5a) becomes zero, making T_1 zero. The explanation for this is that if $k_2\mu_{co1} = 1$, then $k_2 = 1/\mu_{co1}$ and $k_2E_{bb} = E_{bb}/\mu_{co1} = E_{co1}$. It is apparent from Eq. (1.2) and Fig. 1.4 that blocking oscillations cannot be maintained for values of $k_2E_{bb} < E_{co1}$, i.e., for $k_2 < 1/\mu_{co1}$. Consequently, k_2E_{bb} must be greater than E_{co1}. Thus a minimum value for E_{bb} is fixed at E_{co1}/k_2. If E_{bb1} and E_{bb2} are the plate supply voltages for V_1 and V_2 respectively, then E_{bb1} must be greater than E_{co2}/k_1 and E_{bb2} must be greater than E_{co1}/k_2. (The loop gain of the circuit can be $1\angle 0°$ at some frequency even though $k\mu_{co} < 1$. The chief reason for this is the dynamic value of μ is always greater than μ_{co}. While *blocking* oscillations cannot be sustained in such cases, an essentially sinusoidal output voltage will be obtained.)

Figure 1.5 is a plot of Eq. (1.5a). For a given k_2 and μ_{co1}, this curve gives the value of α_1T_1 at which the tube will become conducting. Knowing α_1T_1, the value of α_1 required to keep V_1 nonconducting for a time T_1 can be calculated.

The portion T_2 of the MV period is calculated by using Eq. (1.6).

$$T_2 = \frac{1}{\alpha_2}\log_e\left[k_1\,\mu_{co2}\right] \quad (1.6)$$

The period of the MV is then T_{MV} where $T_{MV} = T_1 + T_2$ (1.7)

Note that as long as $\mu_{co} = E_{bb}/E_{co}$ remains constant, the period of the MV is independent of the plate supply voltage.

The quantity k is a function of the d-c plate resistance and associated load resistor of one tube and the resistor in the grid circuit of the other tube. If $R_{d1} >> \frac{R_{b2}R_{L2}}{R_{b2}+R_{L2}}$ then k_2 is very nearly equal to $1/[1 + (R_{b2}/R_{L2})]$. Since R_b is a function of the plate current through the tube, it will depend upon the values of R_L and E_{bb}.

Measurements

The measured values given in Fig. 1.6 for type 6SN7-GT twin triode are somewhat lower than those obtained from static characteristics given in tube data books. While making these plate resistance measurements, R_d was varied from 50,000 ohms to 1 megohm with essentially no change in plate resistance. For lower values of R_d the plate resistance is less than that given in Fig 1.6. The decrease in R_b for R_d equal to zero is as much as 10 to 40 percent of the values on Fig. 1.6 the greater percentage decreases taking place at the higher values of R_L.

From the information on Fig. 1.6, the value of k as a function of R_L can be obtained. Figure 1.7 is such a plot for the type 6SN7-GT tube. Because k vs. R_L varies most rapidly for values of R_L less than about 20,000 ohms, the natural frequency of the MV will change more for a given percentage variation of R_L in this range than it will with higher values of R_L.

Figure 1.9 is a plot of $\alpha_1 T_1$ vs. R_{L2} (or $\alpha_2 T_2$ vs. R_{L1}) for type 6SN7-GT. This curve is for average values of $k_2 \mu_{co1}$ for various tubes and E_{bb} values in the range of 150 to 250 volts.

The ratio E_{bb}/E_{cc} for several values of plate current is plotted against E_{bb} for the type 6SN7-GT tube in Fig. 1.8. Variations of this ratio for different tubes, particularly between different brands, were as great as 20 percent for each current value plotted on this figure. The average for several brands of tubes is shown. The curve for 0.05 microampere of current has been designated μ_{co}.

For a given tube and plate supply voltage there is a corresponding value of μ_{co}. Also if $R_{d1} >> \frac{R_{b2} R_{L2}}{R_{b2} + R_{L2}}$, a given R_{L2} will provide a definite value of k_2. Therefore, when a tube and plate load resistor are selected, the value of $k_2 \mu_{co1}$ is fixed. This is sufficient information to solve for $\alpha_1 T_1$ by Eq. (1.5a) or Fig. 1.5.

Figures 1.10, 1.11 and 1.12 are curves for the type 6SL7-GT tube, similar to Figs. 1.7, 1.8 and 1.9 for the type 6SN7-GT.

The only assumption that has been made in the development of Eqs. (1.1) through (1.6) is that C_{h1} charges to E_{bb} during the time T_2 (the discharge time of C_{h2}) and that C_{h2} charges to E_{bb} during T_1. Figure 1.13 is the equivalent charge circuit for C_{h1}. The time constant of this circuit is

$$C_{h1}\left(R_{L2} + \frac{R_{d1}\, R_{g1}}{R_{d1} + R_{g1}}\right) \qquad (1.8)$$

A steady-state analysis shows that

$$\text{if} \quad C_{h1}\left(R_{L2} + \frac{R_{d1}\, R_{g1}}{R_{d1} + R_{g1}}\right) \leq \frac{T_2}{5} \qquad (1.9)$$

and if

$$C_{h2}\left(R_{L1} + \frac{R_{d2}\, R_{g2}}{R_{d2} + R_{g2}}\right) \leq \frac{T_1}{5} \qquad (1.9)$$

then the voltage across the capacitors will be equal to or greater than 0.993 E_{bb} at the ends of the charging intervals. If the 5 in (1.9) is decreased to 2.5, the capacitor voltage will be equal to or greater than $0.91 E_{bb}$.

As long as (1.9) is satisfied, Eqs. (1.1) through (1.6) are accurate for frequencies at which the shunt capacities of the circuit can be neglected. The upper frequency limit is influenced by the same factors that determine the high-frequency response of an amplifier stage. (The effects of shunt capacities are discussed later in this paper.)

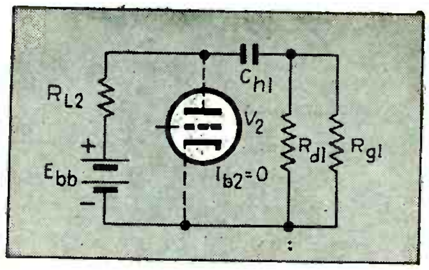


FIG. 1.13—Equivalent charge circuit of C_{h1} in the multivibrator of Fig. 1.1. V_2 is nonconducting, and V_1 is conducting

Note that in (1.9) R_d is shunted by the relatively small R_g. A reasonable average value for R_g in (1.9) is 1500 ohms. Therefore R_d can be increased and C_h decreased to maintain the necessary product $C_h R_d$ of Eq. (1.5a) and at the same time satisfy (1.9). See Appendix I for a discussion of the relative importance of fully satisfying (1.9).*

The Synchronizing Voltage

Equations relating the natural period of a MV to the characteristics of the tubes and associated circuit parameters have been developed and discussed. If the MV is to be uncontrolled, the information already provided is sufficient to complete the design. If the MV is to be synchronized with a controlling frequency, additional design formulas are needed. Before considering the synchronizing problem, some attention will be given to the wave form of the synchronizing voltage and the point of its application to the MV stage.

Of the three common wave shapes, the sine wave, the square wave and the impulse, the impulse is preferable as the synchronizing voltage for several reasons.

Considering first the case of the sine wave, any variation from the nominal values of the time constants will result in a variation of the phase of the output voltage from the MV. The reason for this is that the sine wave requires a finite time to change amplitude. Mathematically,

$$-\Delta E \exp\left[-\frac{t}{CR}\right] + E_s \sin \omega_s t = -E_{co} \qquad (2.1)$$

The MV will synchronize at a value of time just greater than that which satisfies Eq. (2.1). From this equation it is apparent that any variation of ΔE, CR or E_s, or a tube with a slightly different value of E_{co} will cause a change in the time at which the MV synchronizes.

For the case of rectangular-wave synchronizing voltage of sufficient amplitude, phase variations cannot occur in the output voltage. However, due to the time duration of the square wave, the percentage decrease from the nominal value of CR that can be tolerated without the MV dividing by a smaller number is less than for an impulse synchronizing voltage. The sine wave suffers from this disadvantage to a considerable extent also.

With an impulse synchronizing voltage the MV is given only a momentary opportunity to trip. If it does not trip on a given impulse, it will wait for the next one. (If the MV is not properly designed, it is possible that its natural period will lie between impulses.) Thus there is no possibility of phase variations in the output voltage.

Applying the Synchronizing Voltage to the MV

The synchronizing voltage can be applied in the grid, plate or cathode circuit of either tube or both tubes or in any combination of these places.[2] If both polarities of synchronizing voltage are present at any of these points, one polarity will be amplified by the tube that is passing current and will be coupled into the grid circuit of the other tube.

Figure 2.1 illustrates one method of applying the synchronizing voltage to a MV. The synchronizing voltage is supplied, in proper phase, to the grids of limiter tubes V_3 and V_4. The relation between ϕ_1 and ϕ_2 is determined by whether each tube of the MV is to divide by an integer or an integer plus a fraction. (This is explained later in conjunction with Fig. 2.2.) The time constants of which C_1 and C_2 are parts should be small as compared with the period of the synchronizing wave. This will

---

* Two examples of MV design precede Appendix I.

[2] Wherever the synchronizing voltage is applied to the circuit, the effect of the impedance of the synchronizing voltage generator upon the operation of the MV should be considered.

result in pulses of synchronizing voltage being applied to the MV.

In the circuit of Fig. 2.1 both positive and negative synchronizing pulses are applied to the MV. Consider the portion of the MV cycle when V_1 is "on" and V_2 is "off". V_3 is supplying positive and negative pulses of $E_s\angle\phi_1$ to the grid of V_2. At the same time V_4 supplies both positive and negative pulses of $E_s\angle\phi_2$ to the grid of V_1. The negative pulses if $E_s\angle\phi_2$ will be amplified and inverted in V_1 and coupled into the grid circuit of V_2. Therefore, two voltages are acting to synchronize V_2—the positive pulses of $E_s\angle\phi_1$ and the amplified, inverted negative pulse of $E_s\angle\phi_2$. Under these conditions, $E_s\angle\phi_2$ is almost certain to take control of V_2. Similarly, $E_s\angle\phi_1$ will control V_1.

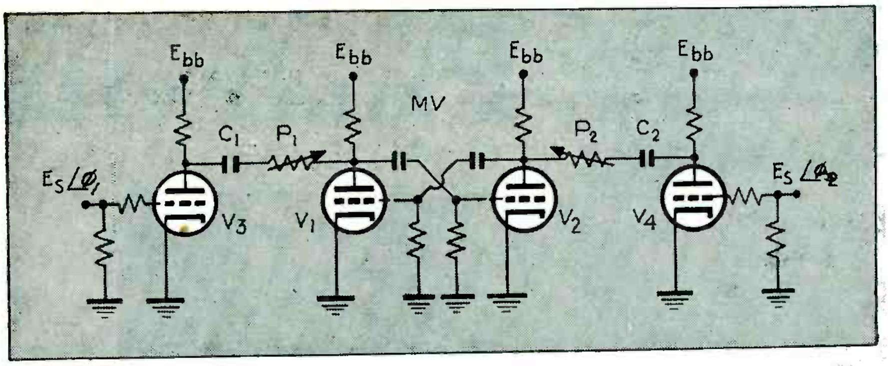


FIG. 2.1—Illustrating one method of applying synchronizing voltage to a multivibrator

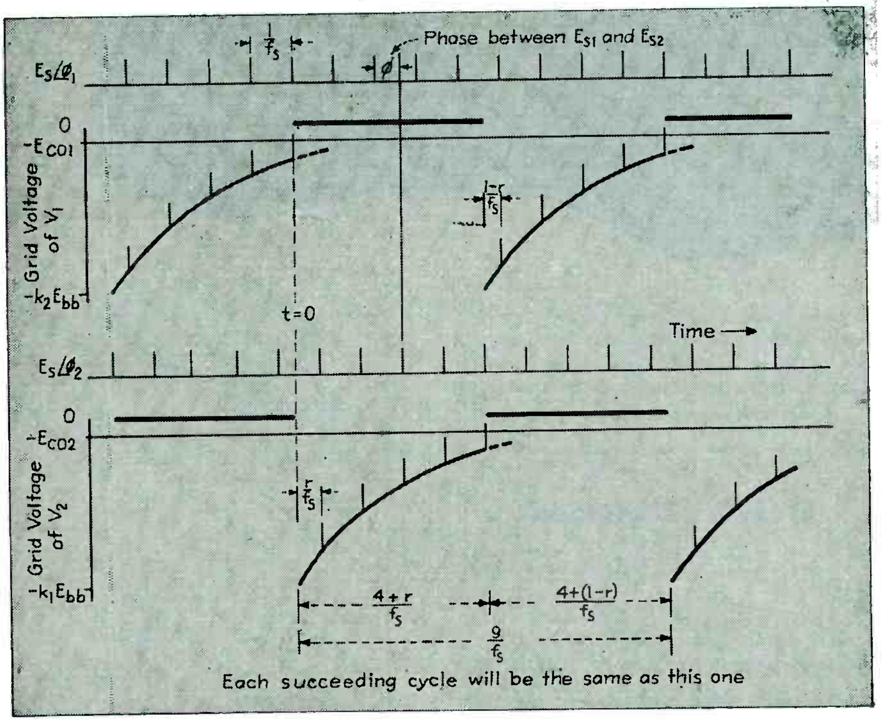


FIG. 2.2—A phase difference between the synchronizing pulses applied to the two tubes of a multivibrator adds a fraction to the order of division of each tube. The two fractions are always complementary

The Order of Division

Suppose one section of a MV is to divide the synchronizing frequency by a fraction, r, or an integral number plus a fraction. Then the order of division of the other section of the MV must include a fraction $(1-r)$. If both sections of the MV are to be synchronized in such a case, the synchronizing voltage must be supplied to the two tubes in different phases. The phase difference between the two voltages must be ϕ where

$$\phi = 360r \text{ deg.} \qquad (2.2)$$

This is illustrated in Fig. 2.2. At time equal to zero a synchronizing pulse causes V_1 to conduct. Therefore, the grid voltage of V_2 decreases to $-k_1E_{bb}$. Due to the phase difference between the two synchronizing voltages, the first pulse occurs at the grid of V_2 at time equal r/f_s. The additional nonconducting time of V_2 must be an integral number of periods of the synchronizing wave. On Fig. 2.2 four periods are included. The fifth pulse trips V_2.

The first pulse at the grid of V_1 occurs $(1-r)/f_s$ seconds after V_1 becomes non-conducting. As a result, the "off" time of V_1 includes, in addition to an integral number, a fractions $(1-r)$ of the period of the synchronizing voltage. Thus, the period of the MV includes one period of the synchronizing wave which is contributed partly by V_1 and partly by V_2.

If synchronizing voltage is supplied to both tubes in the same phase, r is zero and each tube divides by an integer only.

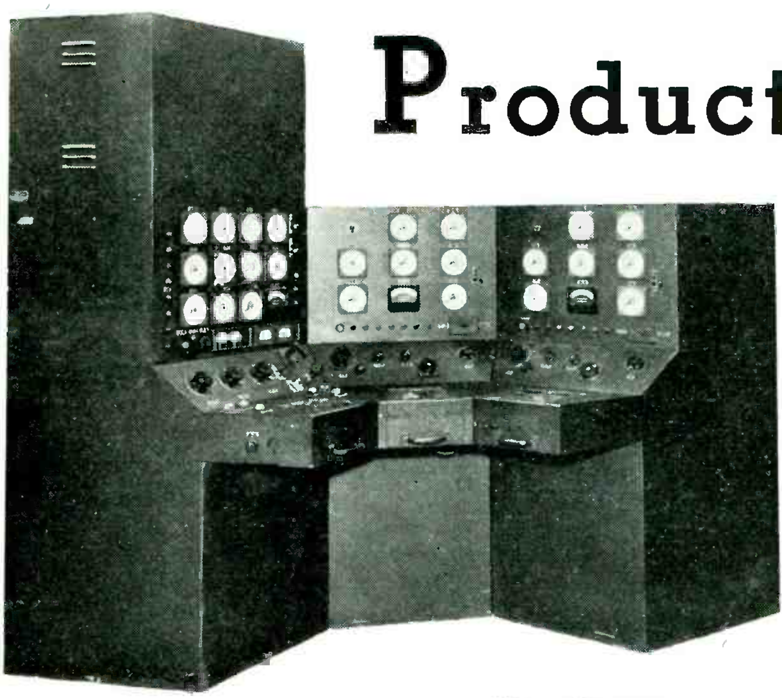
It should be noted that it is not necessary to use push-pull synchronization with every MV that is to divide by an odd number. The only cases for which two phases of synchronizing voltage are required are those for which r has a value other than zero. Consider as an example a MV that is to divide by seven. If a 50/50 output waveshape is needed, then each tube must divide by $7/2 = 3.5$. In this case $r = 0.50$, so push-pull synchronization *is required*. However, if it were not necessary to provide a 50/50 output waveshape, then one tube could divide by four and the other by three. Now $r = 0$ and the synchronizing voltage *must* be supplied to both tubes in the same phase. Different orders of division can be obtained in the two tubes either by using a different value of time constant with each tube or by supplying a different amplitude of synchronizing voltage to each tube. Both of these methods are entirely feasible. How either can be done and still maintain optimum synchronizing conditions is considered later in this paper.[3]

Suppose a MV is to divide by an even number, say 6, and a 2 to 3 output waveshape is wanted. Then one

[3] If sinusoidal synchronizing voltage is used, the statements in this and the succeeding paragraph are modified.

(*Continued on page 332*)

Production Tester

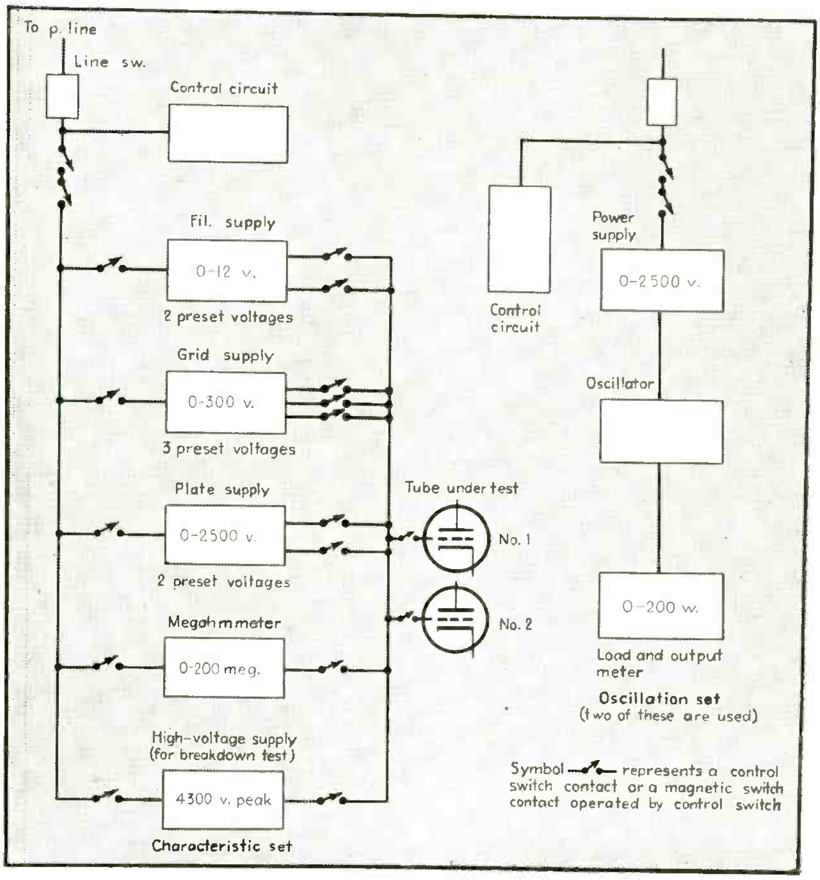


Complete transmitting-tube tester. The tall characteristic test unit at the left handles two tubes at once while each of the two smaller oscillation test sets at the right handles one tube at a time

Semi-automatic equipment permits one operator, handling two 50-watt tubes at a time, to make all necessary checks. Duplicate sockets eliminate waiting during two-minute warm-up periods. Sequencing interlocks avoid the possibility of skipped tests

By P. M. THOMPSON

Testing Department
General Electric Co.
Schenectady, N. Y.



Block diagram of the tester

TRANSMITTING TUBES must be tested thoroughly, accurately and often according to the specifications of both the manufacturer and the ultimate user. Tests applied to transmitting tubes are varied, but in the 50-watt family the following are usually made:

The filament current is measured at rated voltage. A positive grid-current check is made with the plate current saturating the filament emission. The plate characteristic is determined. The tube is subjected to a two-minute run at more than rated plate dissipation. At the end of this run the reverse grid current is measured, giving evidence of any gas that might be in the tube. The leakage resistance is measured between various tube elements and high voltage is applied to see if the tube breaks down. The tube is operated in a power oscillator circuit and its useful output is measured. The filament emission is determined by measuring the filament voltage drop necessary to reduce the output by a certain amount.

Obviously, with such an array of tests required for every tube (and sometimes additional tests made on about every 100th tube) efficient testing methods are absolutely essential to maintenance of a satisfactory production rate. For this reason semi-automatic testing sets have been devised and these have been in operation for several months.

Certain measurements follow two-

for Transmitting Tubes

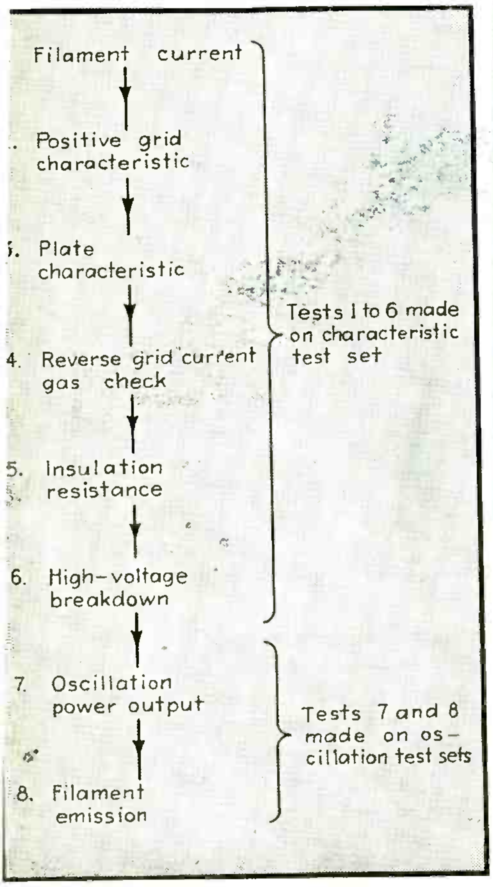
minute runs. This serves as a basis for dividing the tests into two groups. A separate test set was made for each group. Thus, while a tube is on a two-minute run in one set, the operator can take measurements on a tube in the other set, bringing it up to its two-minute run. At this point the operator returns to the first tube. This dovetails the tests into each other and avoids wasting the operator's time during the two-minute runs.

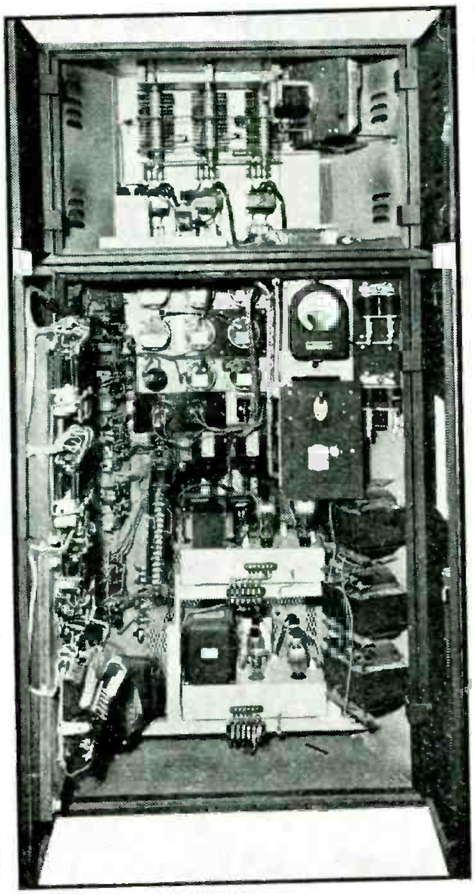
Specifically, the oscillation output test and the emission check are made on an oscillation test set, while the remaining tests are made on a characteristic test set. (It was found that the characteristic test set could easily be built to handle two tubes simultaneously. On the other hand, the space requirements of an oscillator made it desirable to build two oscillation test sets, each handling one tube at a time.) The operator works back and forth between characteristic test set and oscillation test sets, handling two tubes at a time. A separate set of meters is provided for each of the two tubes under test.

Test Set Design Details

The oscillation test sets each contain a Hartley-type oscillator with a lamp load. The output of the oscillator is measured by means of a phototube reading of the load-lamp brilliancy. The phototube is calibrated by switching the lamp into a 60-cycle circuit and varying the applied voltage until its output is comparable to that obtained when lighting the lamp with radio-frequency power. By reading a wattmeter in the 60-cycle circuit, the power dissipated by the lamp to produce the measured brilliance, hence the oscillator output at that point, is known. Switching the lamp into the 60-cycle line is accomplished by means of a relay controlled by a snap switch.

Since a direct-current filament supply is desirable on the characteristic test set, a three-phase copper-oxide rectifier is used. A high-voltage rectifier supplies the normal plate voltage, and a low-voltage rectifier is used to supply grid voltage and low plate voltage for the emission test. High voltage for the breakdown test is obtained from a three-phase 3000-volt transformer. The insulation-resistance test is made with a conventional resistance meter circuit operating from a rectifier on one phase of the 3000-volt transformer.





Flowsheet showing sequence of tests, and interior view of characteristic test set

The various voltages are selected and applied to the tubes by means of contactors which are controlled by a selector switch of the multiple-stage type. Each separate test has a position on the control switch, and in each position the proper contacts on the selector switch close to pick up the contactors that will apply the desired voltages. Where two voltages are needed from the same supply for different tests, separate controls are used for each voltage. For instance, two filament voltages are necessary, so two filament-dropping resistances are used and each is pre-set to the voltage it is to deliver. When one or the other of these resistances is put into the circuit by the selector switch, the pre-set voltage appears at the tube, saving the operator the time necessary to go from one voltage to the next by hand adjustment. The same system is used on the plate-voltage supply, the grid-voltage supply, etc. The operator inserts tubes with the switch in the "off" position and takes successive tests by turning the switch from one position to the next, taking all of the tests in one complete revolution.

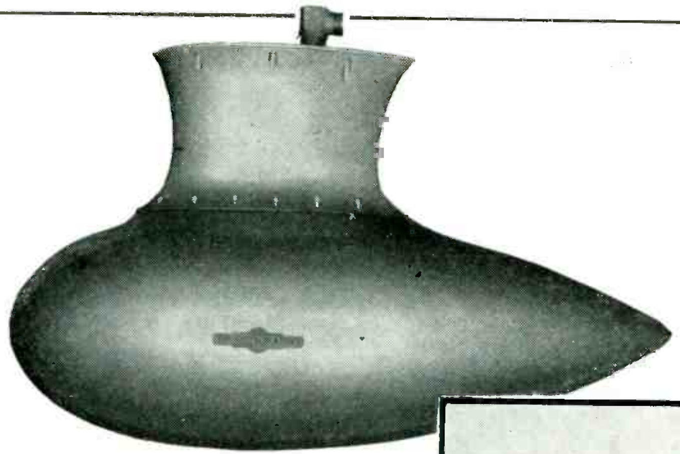
Sequence and Safety Precautions

As a precaution against carelessness that might result in skipping a position, and to insure the proper

(Continued on page 326)

VISUAL DIRECTION

Description and circuit of the Bendix Model MN-31 automatic direction finder for aircraft, which automatically provides a direct indication of the bearing of the radio station tuned in by the pilot. A self-synchronous repeater system is used for the bearing indicator

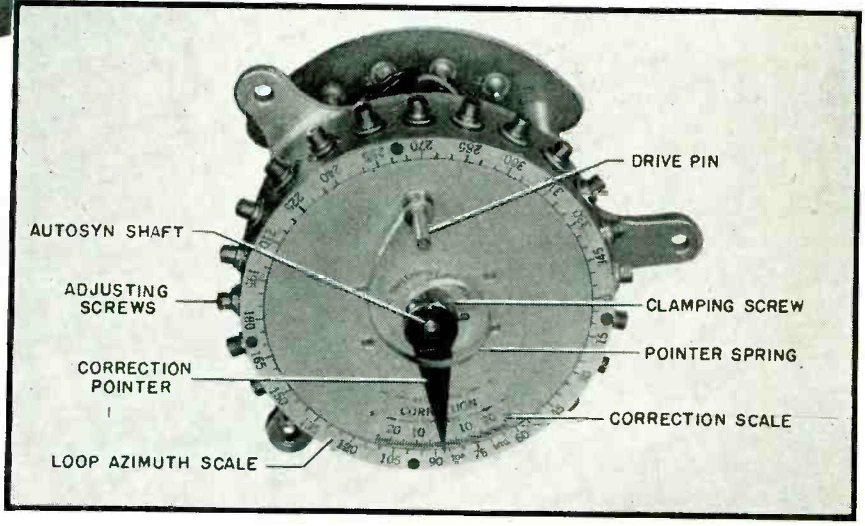


ABOVE: Loop housing and loop base

By DONALD S. BOND*

Radio Corporation of America, Camden, N. J.

BELOW: Mechanical compensator positioned between the motor-driven loop and the Autosyn transmitter



MANY OF THE principles of visual systems described in the two earlier articles of this series are employed in the MN-31 aircraft automatic direction finder built by Bendix Aviation Corporation.‡ This unit is designed for applications in which the following types of operation are required: (1) Reception (nondirectional) of either modulated or unmodulated signals; (2) Automatic direction finding (with nondirectional sense antenna); (3) Loop reception and aural null direction finding with either modulated or unmodulated signals.

The system is of the self-orienting loop type like the RCA-Sperry Mark I system, and provides automatically a direct indication of the bearing of the radio station which has been tuned in. Various models are available, differing principally in the frequency coverage. Typical is the equipment for covering the aircraft beacon, the marine beacon and communication, and the broadcast bands in three ranges: (1) 200–410 kc, (2) 410–850 kc, and (3) 850–1750 kc. Other models cover frequencies down to 150 kc and may substitute communication reception in the range 2200–4250 kc or 2900–6000 kc for direction finder operation on band 3.

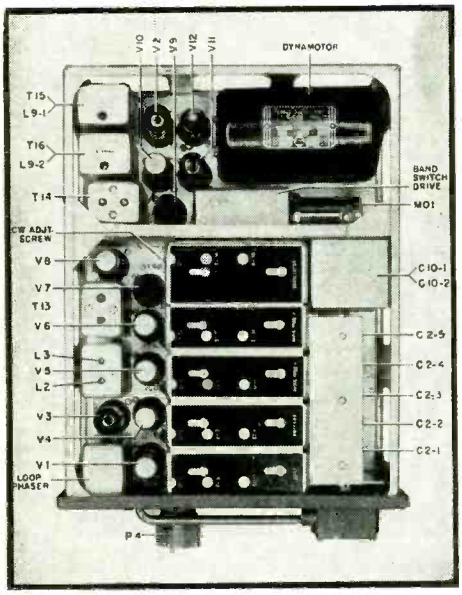
Some points of difference may be noted in comparison with the Mark I equipment. The bearing indicator unit is not mechanically driven from the rotating loop, but instead in the MN-31 it is electrically controlled by means of a self-synchronous repeater system such as Selsyn or Autosyn. Several such indicators may be connected to the transmitter unit located in the loop assembly. The motor control circuits are located on a separate chassis rather than being part of the receiver. The control unit is separate from the bearing indicator. This latter arrangement is often of advantage when installation space in the cockpit of an airplane is at a premium. There is no provision in the MN-31 equipment for substitution of a sense loop for the nondirectional antenna under precipitation static conditions when automatic operation is required.

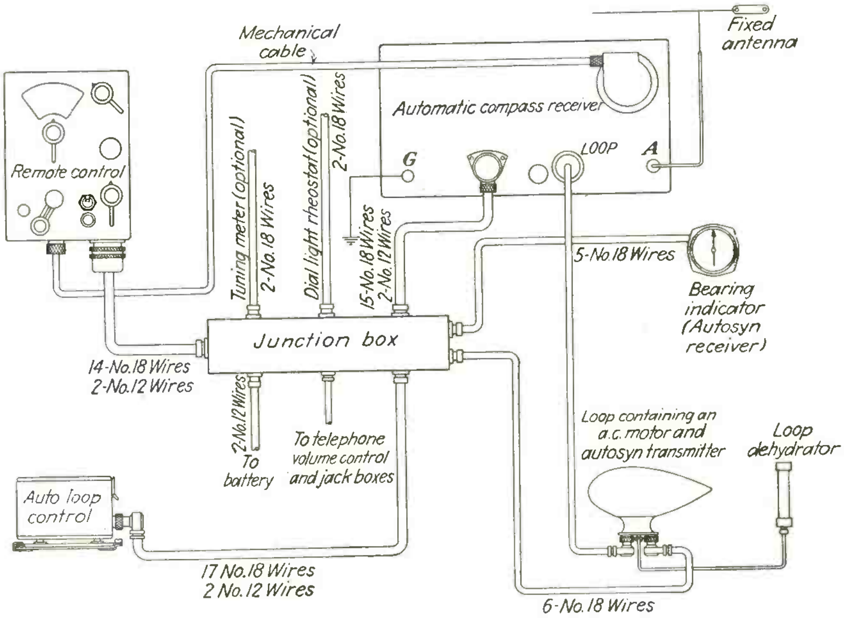
The interconnection diagram of the MN-31 automatic direction finder is shown in Fig. 19, and the various

‡ Webb, W. I., and Essex, G. O., The Automatic Radio Compass, *Aeronautical Engineering Review*, 1, November, 1942.

* *This series of three articles is condensed from Chapter VI of the book "Radio Direction Finders", by D. S. Bond, to be published by McGraw-Hill Book Co., Inc.*

FINDERS . . . Part III





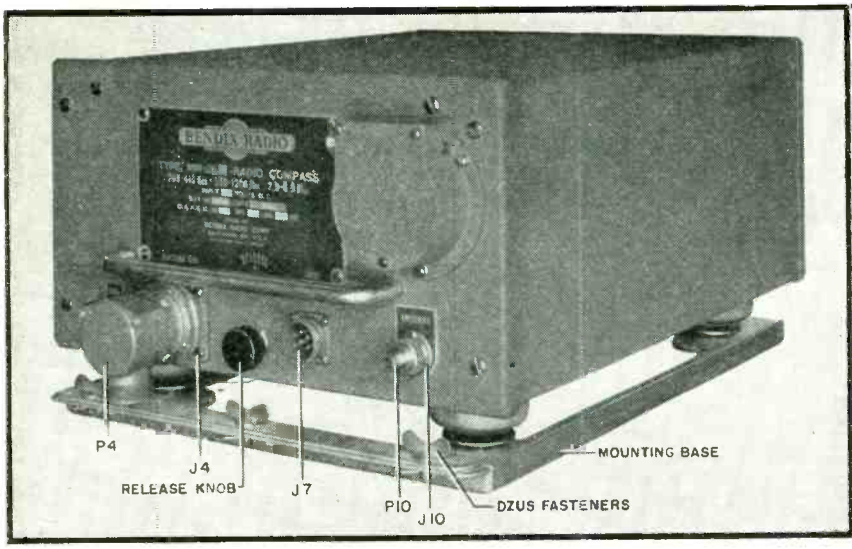


Fig. 19 (Above)—Interconnection diagram of Bendix MN-31 automatic direction finder

Photos at left: Exterior and chassis views of Bendix type MN-26 automatic radio compass receiver for the MN-31 system

major units in the system are illustrated throughout this article. The circuit is given in Fig. 20, for equipment serving as a direction finder on two bands (200–410 kc and 550–1200 kc) and as an airline communication receiver on the third band (2900–6000 kc). Automatic direction finder operation with the MN-31 equipment is best explained by taking up in order the receiver circuits, the loop control circuit and the bearing indicator system.

Receiver Circuits

Some of the points of difference between the Bendix MN-31 direction finder and the Mark I equipment may be seen by a study of Fig. 20. Operation of the circuit will be considered for the lowest band. The signal picked up by the shielded loop of the MN-36A unit (upper left on diagram) is fed through a transmission cable to the loop circuit transformer T_1 in the radio compass receiver unit. This transformer in turn couples to loop amplifier V_1. This tube has the same sort of reactive plate load as in the apparatus previously considered. There is a resultant 90-deg. phase shift of the signal between the grid of V_1 and the grids of the following balanced modulator stage. This latter consists of a double triode V_3 and performs the function of a balanced modulator. The modulating frequency in this case is 48 cps.

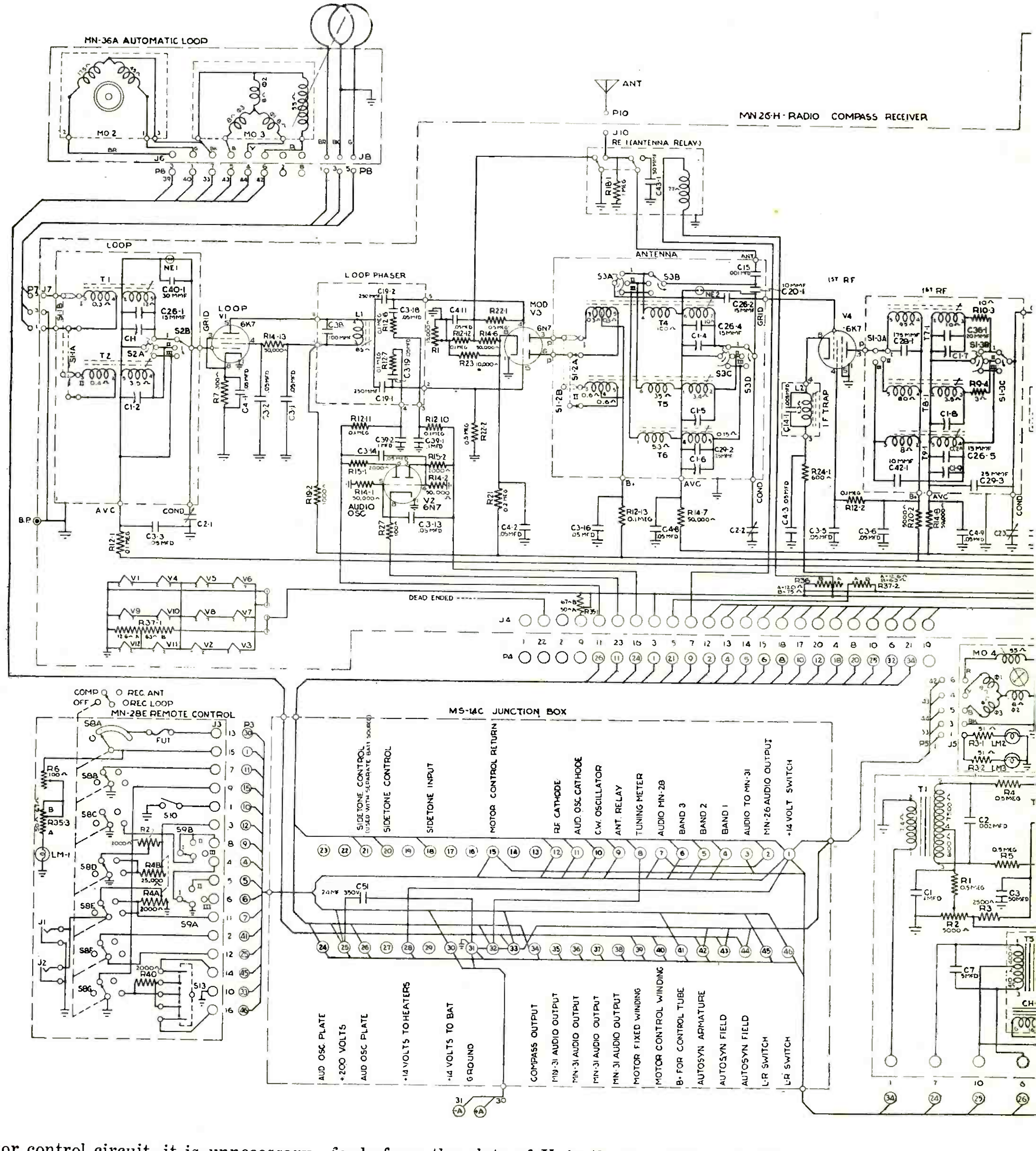
Because of a different type of mo-

THIS SERIES OF THREE ARTICLES INCLUDES:

PART I—Principles of automatic and right-left types of visual direction finders. Nov. 1943 ELECTRONICS.

PART II—RCA-Sperry Mark I automatic direction finder. Dec. 1943 ELECTRONICS.

PART III—Bendix Model MN-31 automatic direction finder, in this issue. (Conclusion).



tor control circuit, it is unnecessary to furnish power for the loop driving motor from this a-c source. Accordingly, the 48-cycle oscillator consists of V_2 coupled to a tuned circuit consisting of transformer T_5 and capacitor C_7 in the MN-31A automatic loop control unit.

The carrier-suppressed double sideband output of the loop channel feeds from the plate of V_3 in the receiver in push-pull fashion to the corresponding primary of antenna transformer T_4. The nondirectional antenna is coupled to the other primary of T_4, since under conditions of operation as an automatic direction finder the antenna relay RE_1 is in the normal position shown. It will be noted that protective neon tubes NE_1 and NE_2 are connected across the grid circuits of loop and antenna transformers respectively to prevent damage when a nearby transmitter is operated at or near the receiver frequency.

The r-f amplifier system in the MN-31 contains two tubes, V_4 and V_5. The total number of tuned circuits is the same as in the Mark I, but the

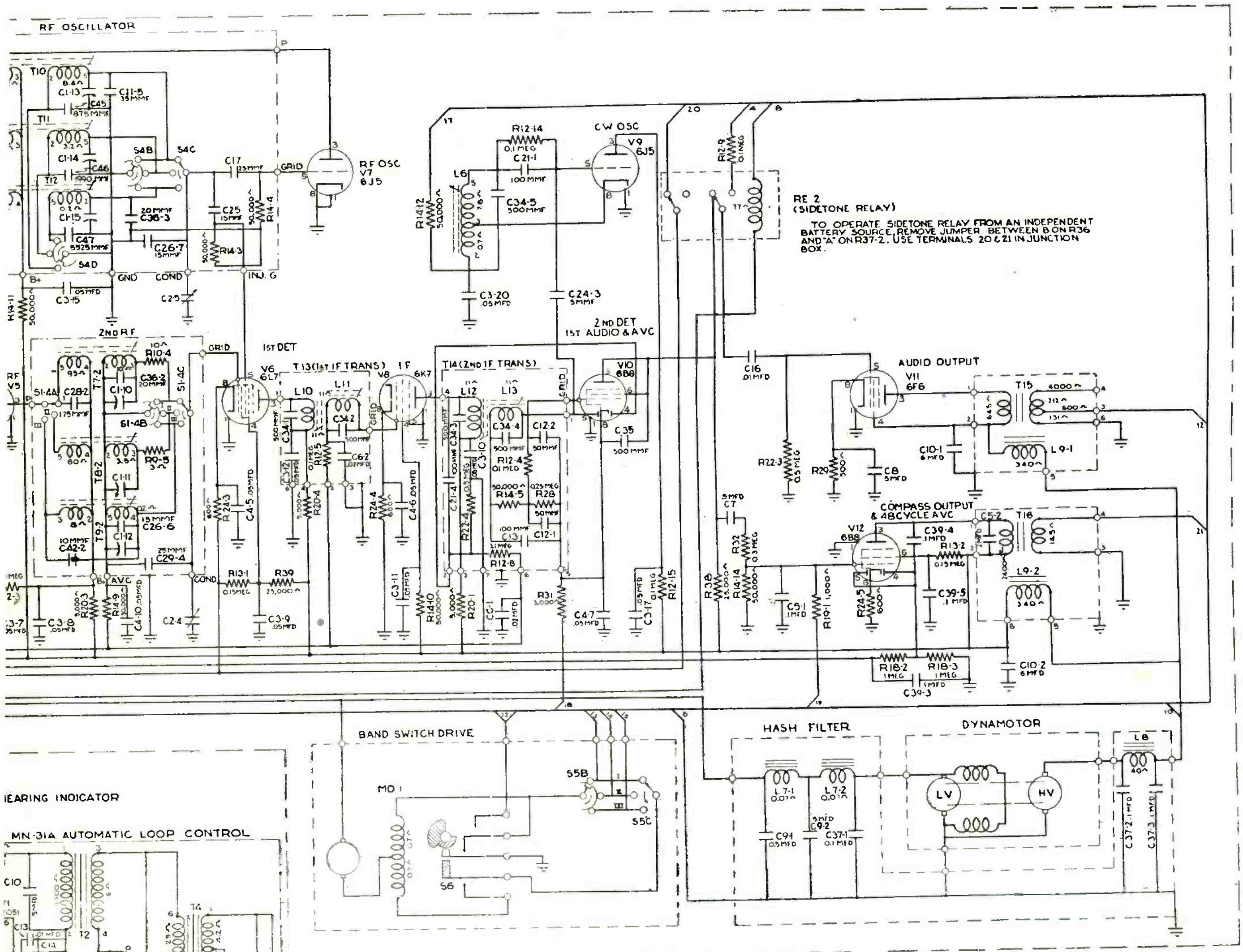
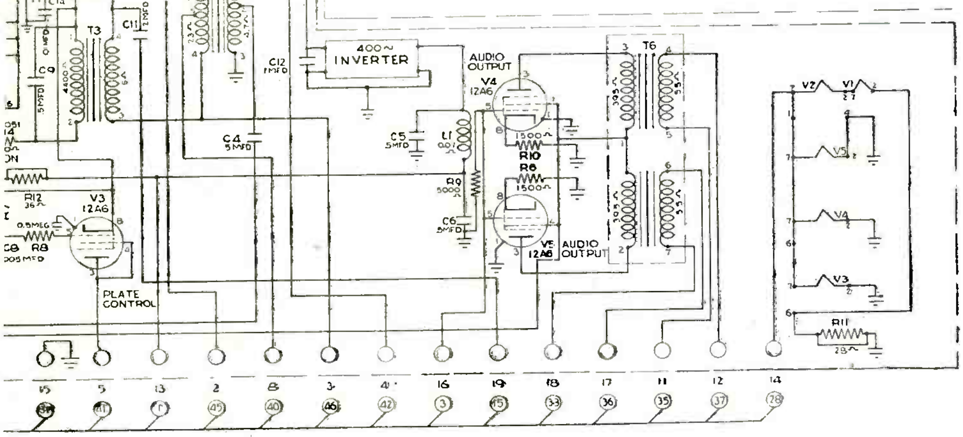



Fig. 20—Complete schematic circuit diagram of Bendix MN-31 automatic direction finder

latter uses a so-called link coupled circuit instead of the additional r-f amplifier tube. The converter or first detector, V_6, is driven from a separate oscillator tube, V_7. The advantage of the separation of tube functions in this stage is more evident on the high-frequency communication band. The intermediate frequency is 112.5 kc. Two wave traps tuned to this frequency are interposed in the cathodes of the r-f amplifier tubes to reduce the spurious response at the intermediate frequency.

The i-f amplifier has tube V_8 and two double-tuned transformers, T_{13} and T_{14}, feeding into V_{10}. This latter serves as detector, automatic volume control, and first a-f stage. A separate c-w oscillator, V_9, working 1 kc above the intermediate frequency, is provided for communication reception with unmodulated waves. The tube may be turned on by means of a control on the operator's unit.

The audio output stage consists ordinarily of V_{11} feeding into one or more phone channels. In case dual output is desired with no interaction of one channel upon the other, a supplementary pair of output tubes may be used. These are included in the automatic loop control unit and are designated as V_4 and V_5. A dynamotor serves to furnish the B supply.

As in the Mark I system, loop overload control is secured by rectification of the control signal by the diode of V_{12} and connection of this output

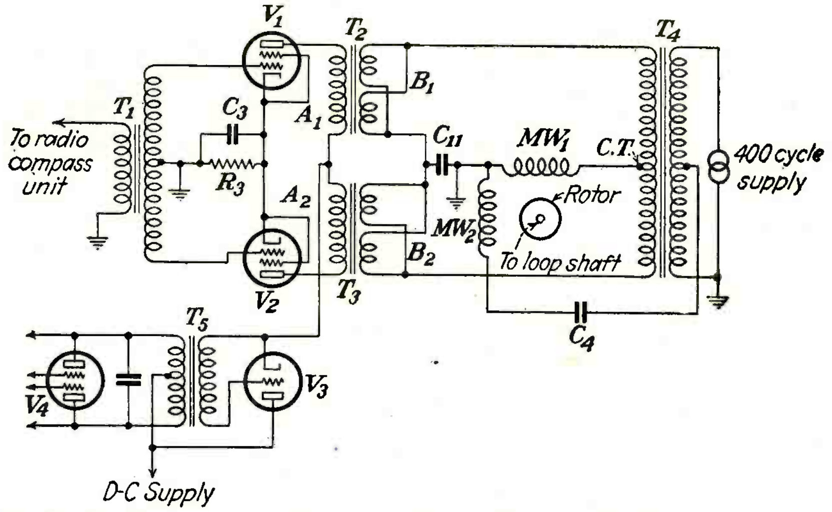


Fig. 21—Simplified schematic diagram of loop control circuit. V_1, V_2—thratron tubes; V_3—plate control tube; V_4—audio osc.; T_1—input tr.; T_2, T_3—saturable reactors; T_4—400-cycle tr.; T_5—audio osc. tr.; MW_1—control winding, loop motor; MW_2—fixed exc. winding, loop motor; C_3, R_3—cathode lag circuit; C_4, C_{11}—motor phasing capacitors

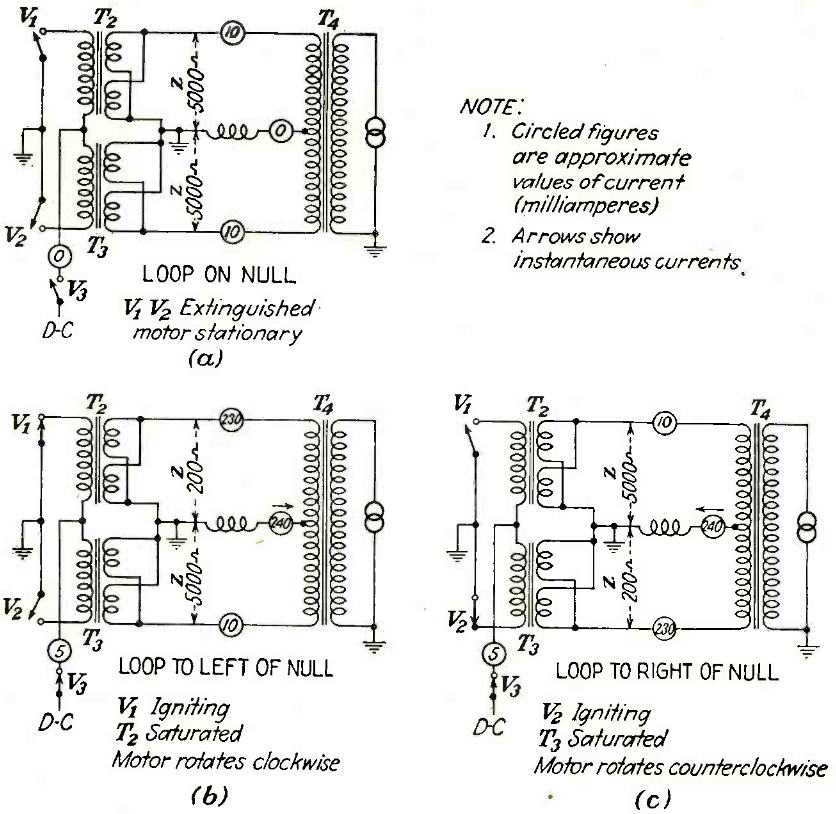


Fig. 22—Currents in the loop control circuit for three different loop positions

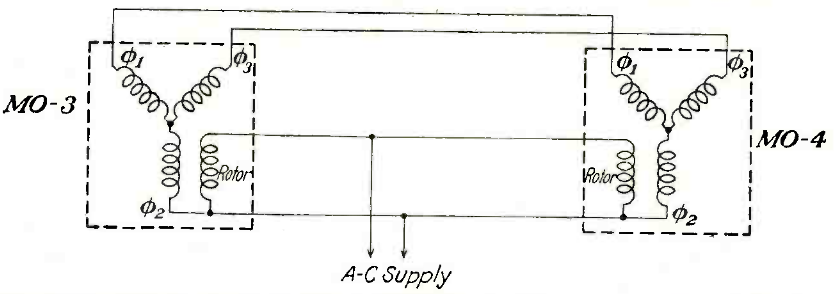


Fig. 23—Simplified circuit of phase windings of Autosyn transmitter of bearing indicator system

back to the grid return of amplifier V_1 in the loop channel.

Loop Control Circuit

Audio-frequency signal from the plate of V_{10} is fed to the compass output tube, V_{12}. Transformer T_{16} is connected in the plate circuit of this tube and is tuned to the modulating frequency of 48 cycles. It thereby rejects the main portion of speech modulating frequencies and furnishes a 48-cycle signal of reversing phase and variable amplitude to the input of the automatic loop control unit. This voltage is applied through push-pull transformer T_1 to the grids of thyratron tubes V_1 and V_2 in the same manner as in the Mark I design. The operation of the motor control circuit is rather different, however. The simplified schematic diagram of Fig. 21 will illustrate the operation.

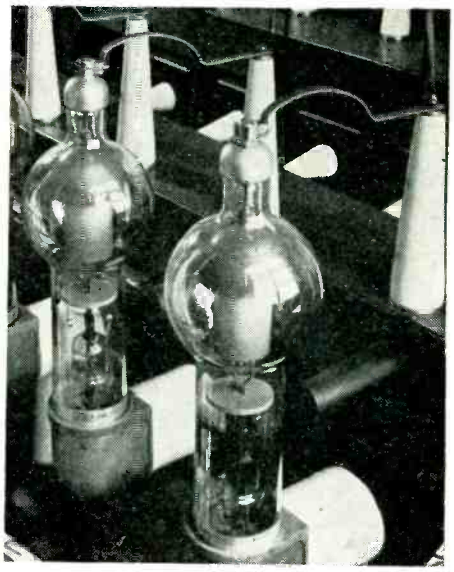
T_2 and T_3 are saturable reactors connected in the plate circuits of the two thyratrons. The d-c windings carry the plate current whose magnitude determines the impedance measured across the a-c windings, B_1 and B_2. Loop motor control winding MW_1 becomes effectively connected to either terminal of 400-cps transformer T_4, dependent upon the impedance presented by B_1 or B_2.

When the loop is at the null position, so that neither V_1 nor V_2 are conducting, reactors T_2 and T_3 present high impedance. As a consequence, there is then no current through MW_1. This is illustrated in Fig. 22(a). But when the loop is off the null position in one direction, so that V_1 is conducting, current flows from the appropriate half of the secondary of T_4 through B_1 and phasing capacitor C_{11} to motor winding MW_1. This is case (b) of Fig. 22. On the other hand, when the phase of the 48-cycle voltage is reversed with respect to the plate supply on V_1 and V_2, it is V_2 whose impedance becomes low, and a current from the 400-cycle supply of opposite phase flows through MW_1. This is shown as case (c).

The plates of V_1 and V_2 are excited in the same phase from a 48-cycle supply derived from transformer T_5 in the loop control unit. Plate control tube V_3 is fed from this

(*Continued on page 202*)

TUBES AT WORK



Cooling of high power rectifier tubes is provided by an air blast through the pipe behind each tube. This maintains the proper temperature for condensation of the mercury vapor in the tube

Versatile High Power for Industrial Research

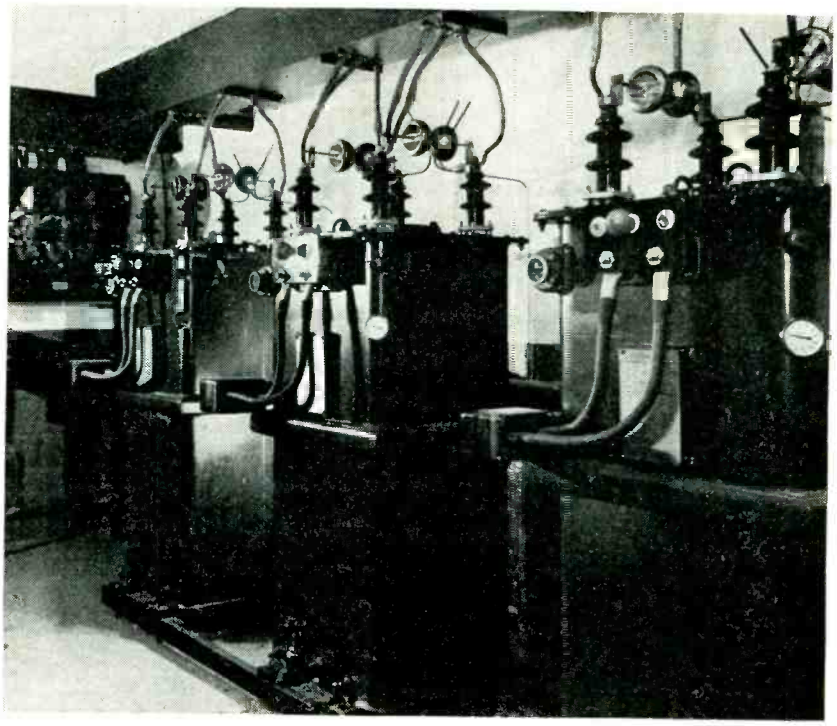
ONE OF THE LARGEST power supplies of its type now in operation in this country is shown in the photographs. It can provide a power output of 400 kw of direct current and allows the voltage output to be varied from 3,000 to 30,000 volts. This gives a flexible range useful for laboratory research and development purposes and the unit is so used in the field of electronic heating at the industrial electronics laboratory of the Federal Telephone and Radio Corp.

The high power supply contains two 3-phase full wave rectifiers so arranged that their high voltage outputs may be connected either in series or parallel. Each rectifier consists of a bank of six Federal type F-857-B mercury vapor rectifier tubes to convert 60 cycle alternating current into high voltage direct current for generating high frequency power. Each tube is provided with an individual air stream directed at its base to insure proper temperature for the condensation of mercury vapor within the tube.

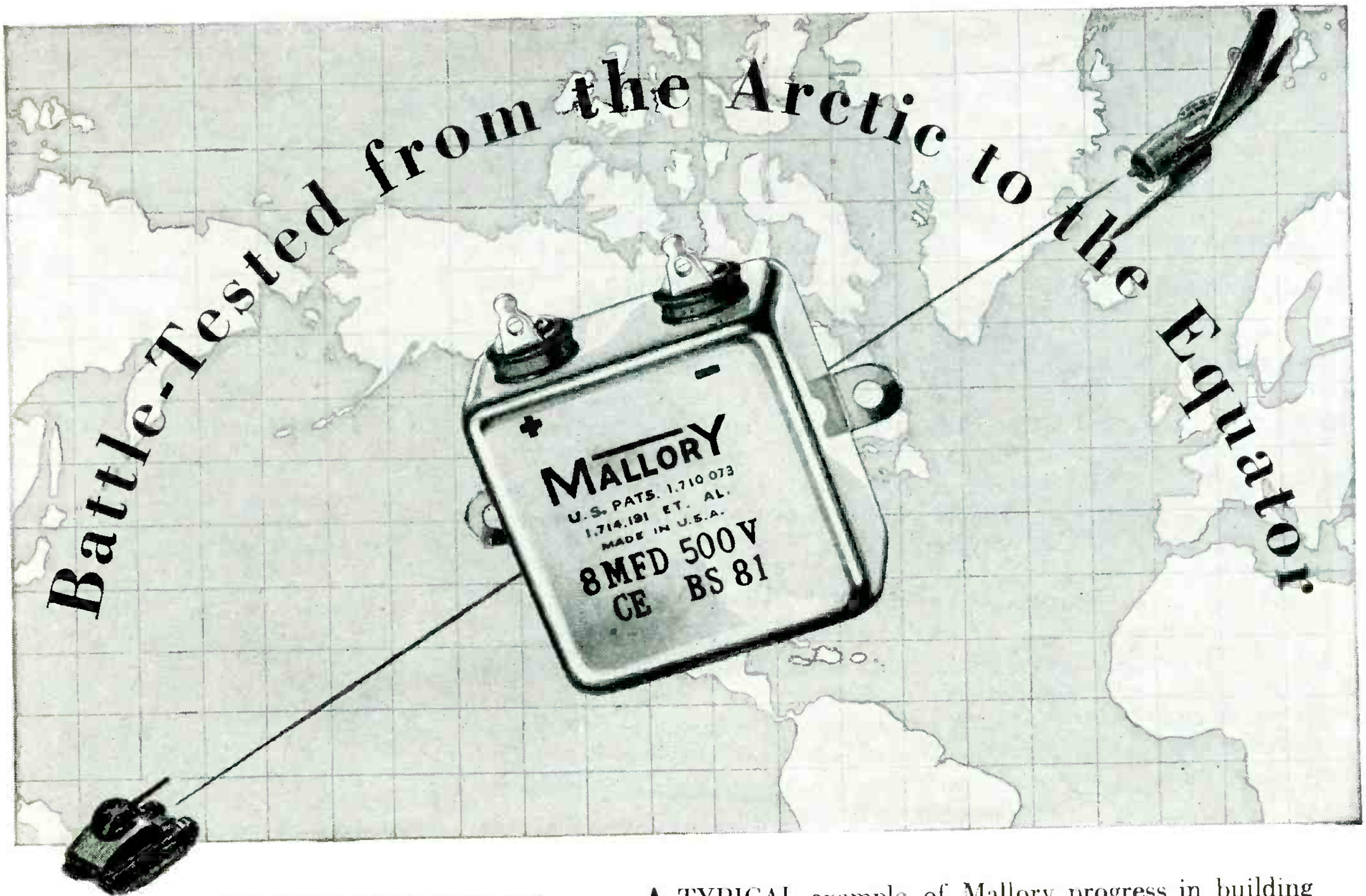
The rectifiers are supplied by a bank of three high-voltage transformers, each of which is equipped with two secondary windings so as to make possible two 3-phase wye connected high voltage secondaries to supply the two 3-phase vacuum tube rectifiers. The transformer secondary windings are equipped with safety gaps across each individual secondary winding, as well as from each secondary winding to ground. All high voltage connections between the transformer bank and the rectifiers are individually shielded from each other.

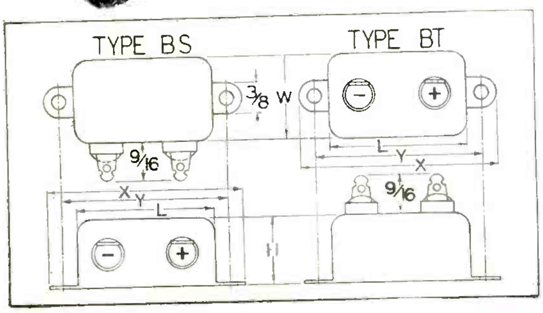
The primaries of the three transformers are so arranged that they may be connected either in wye or delta. This connection allows the total rectifier to operate in either of two ranges, 3,000-15,000 volts d-c output, or 13,500-30,000 volts output. The voltage may be varied steplessly in either of these ranges by means of a 30 percent buck-and-boost induction voltage regulator.

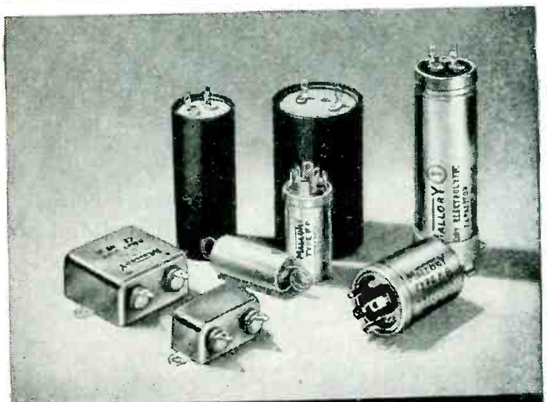
The switch gear associated with the high power voltage power supply includes a heavy duty contactor in the primary of the transformer bank, as well as a high-speed circuit breaker capable of disconnecting the entire power supply in less than two cycles. All control circuits for the rectifier and power supply are contained on one panel. These control circuits run between two complete



A power vault contains the high voltage transformers that supply the rectifiers. Each transformer has two secondary windings, protected by safety gaps, that permit two 3-phase wye connections. High voltage leads between the transformer bank and the rectifiers are individually shielded







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MALLORY

ELECTROLYTIC, FILM AND PAPER CAPACITORS

A TYPICAL example of Mallory progress in building components is this BS 81 "Bathtub" Capacitor. Rated at 8 mfd. 500 volts, with a 700 volt surge, it is hermetically sealed in a steel case measuring only 2"x1¾"x1". Its −40° C impedance at 120 cycles runs as low as 220 ohms. The Capacitor itself has been thoroughly tested in war service from the arctic to the tropics.

In addition to withstanding great extremes of temperature, the double sealing and extra mechanical strength of this Capacitor protect it against vibration, humidity, atmospheric pressure and corrosive fumes. It is available in ratings from 10 mfd. 25 volts to 8 mfd. 500 volts, and is normally supplied with two side terminals—and with the working unit insulated from the case.

Specifications and complete test data on all Mallory BS and BT Capacitors are listed, with other heavy duty units, in the Mallory catalog. Send for a copy today. Write direct for special assistance when confronted with unusual problems, or see your Mallory distributor.

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

Keep Faith with the Men Who Fight — Buy War Bonds sets of terminal boards, one of which is at the rectifier control panel and the other is located in the power vault. By this means it is possible to readily change or adapt the control circuits to any sequence of operations or to any special safety or functional requirement.

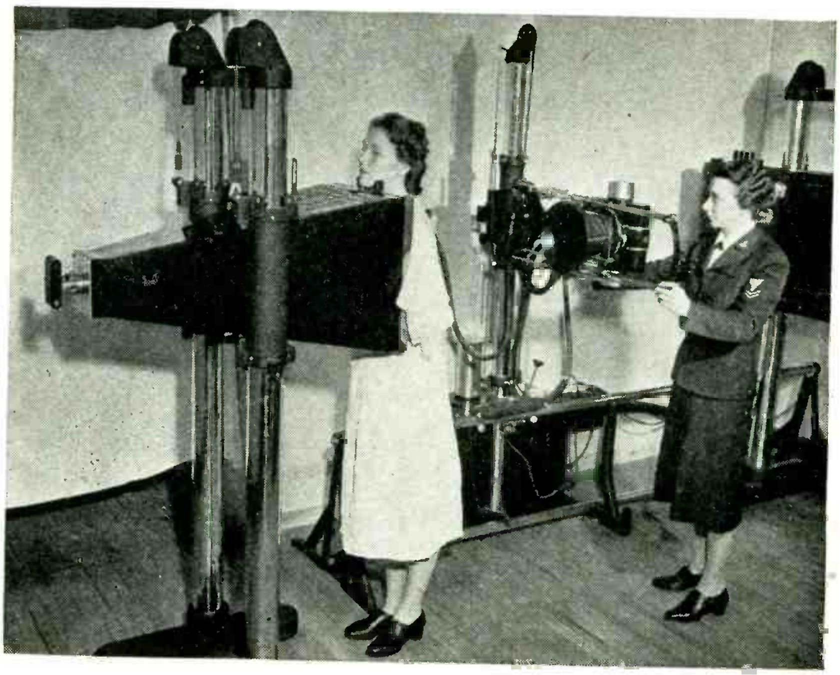
Candid Camera X-Rays

A CANDID CAMERA x-ray machine for mass production technique has been developed for the Navy. Chest images are photographed in 3/20 sec. on 35-mm film, a radical departure from the usual method of producing x-ray pictures on standard 14 by 17-inch film. Costs are reduced to about seven-eighths of a cent per exposure, compared with nearly $1 for the larger film.

Loaded with enough film to make 36 exposures before reloading, the camera photographs the chest image produced on a fluoroscopic screen in front of the person being examined. X-ray pictures made on the larger film require reloading the camera with film after each exposure and result in higher cost and slower production.

With the miniature film, the 36 exposures are developed at one time and the resulting pictures are examined in an electric viewing device. Technicians then determine whether or not "suspect" cases should be called back for re-examination.

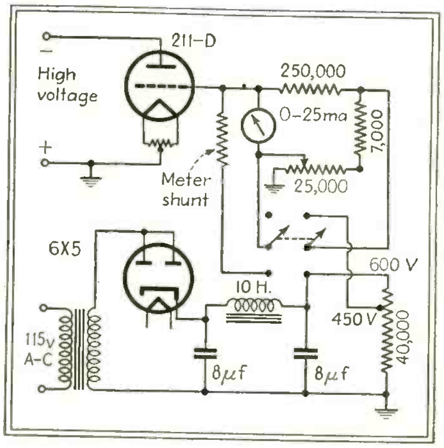
One of the candid camera units is used at the Naval Training School for Women Reserves at Hunter College, N. Y. and has examined nearly 20,000 WAVES for tuberculosis and other chest conditions since last February. The machine is capable of examining 2,000 persons a day and employs the fastest technique yet developed for mass x-ray surveys, according to C. V. Aggers, manager of the Westinghouse x-ray division. At Hunter, four in 1,000 WAVES are found to have tuberculosis and are returned home for treatment.



At extreme left is the miniature camera used for photo fluorography at Hunter College in examining WAVES. An exposure of 3/20 sec is made on 35-mm film. Pharmacist's Mate 3C Lillian Helton has her chest snapped by the x-ray camera, while Pharmacist's Mate 2C Louise Werner focuses the rays

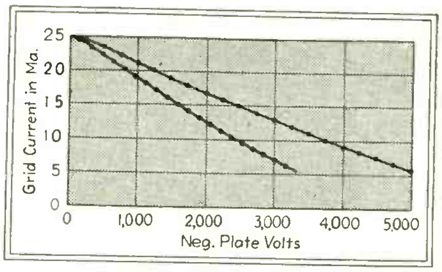
Negative Plate Voltmeter

A HIGH-RESISTANCE VOLTMETER capable of measuring negative voltages as high as 5,000 volts is shown in the diagram. The voltage to be measured is applied to the plate of a 211-D tube, and the grid of the tube forms the output circuit. Since the plate is negative, no current flow takes place in this circuit. The grid is maintained at a positive potential by the power supply and current flow in this circuit is measured on the milliammeter. Such an instrument may be called an "inverted voltmeter" as described by Terman,* and its use in Geiger counter work for measuring high negative potentials is reported by M. Kupferberg in the August, 1943 issue of the *Review of Scientific Instruments*.



Circuit of electronic voltmeter that employs a negative plate and positive grid for measurement of high negative potentials

When a tube is used in this manner the amplification factor is about equal to the reciprocal of the normal amplification factor. The transconductance is small and large changes in plate voltage result in small changes of grid current.

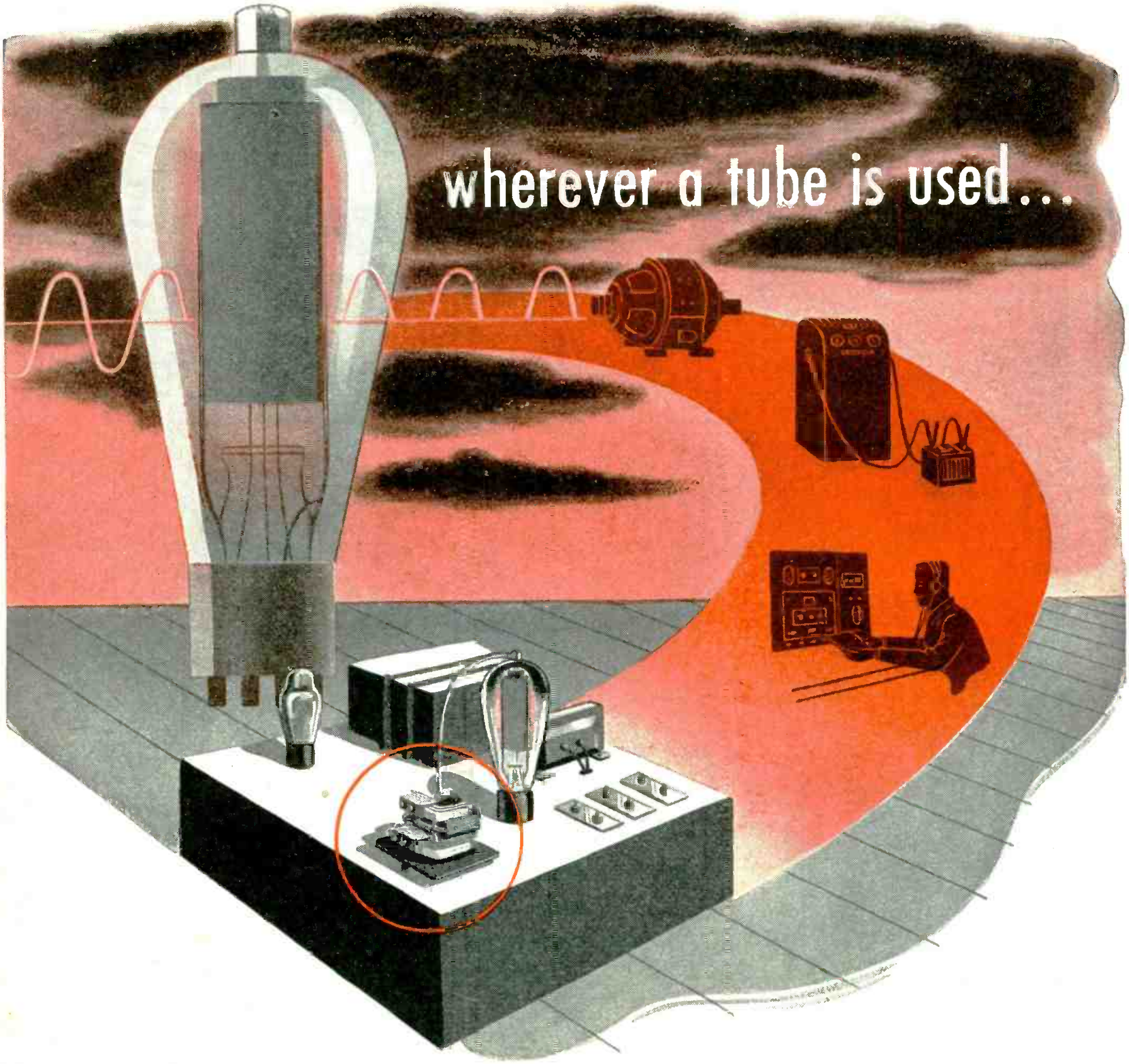


Negative plate voltage plotted against grid current for the 211-D. The curves may be used for calibrating the milliammeter scale in volts

The grid current-plate voltage curve for the 211-D is shown, and is practically linear from 500 to 5,000 volts. For the 0-3,000 volt range the current may be read from a 0–25 ma milliammeter, or a direct-reading voltage scale may be used on the meter. A shunt is provided across the meter to increase its range to 50 ma when reading 5,000 volts. Zero adjustment is accomplished by the variable resistor in the grid circuit.

At 5,000 volts the current drain from the circuit under test was found to be 10^{-6} ampere and from this the total input resistance from plate to ground was found to be 5×10^9.

* Terman, F. E., *Proc. IRE*, 16, 447, 1928.

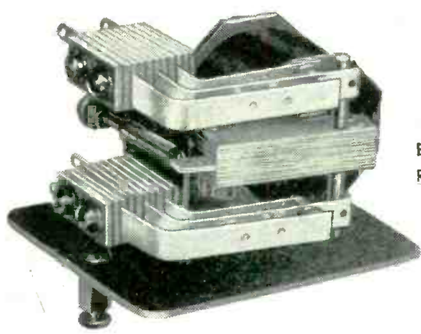


THERE'S A JOB FOR

Relays BY GUARDIAN

★ Wherever the rectifier type of tube is used, generally there's a job for a relay . . . a RELAY by GUARDIAN . . . in secondary and/or primary circuits where double pole, double throw "on and off" switching is desirable.

Typical of such a relay is the Guardian Type B-100. This double pole, double throw relay is equipped with silver contact points having a capacity up to 1500 watts, 60 cycle non-inductive A C.; and in A.C. primary circuits of any inductive power supply delivering up to and including 1 Kw. Standard coils operate on 50-60 cycle A.C., 110 volts, consuming approximately 8½ VA. Coils available for other voltages. Write for Bulletin OF-112 showing standard relay types.



TYPE B-100 RELAY

Electronic rectification, long used to convert A.C. to D.C. power, is now coming into use to operate variable speed D.C. motors . . . battery chargers, etc. In such applications, the type B-100 relay shown above is often used.

GUARDIAN ELECTRIC

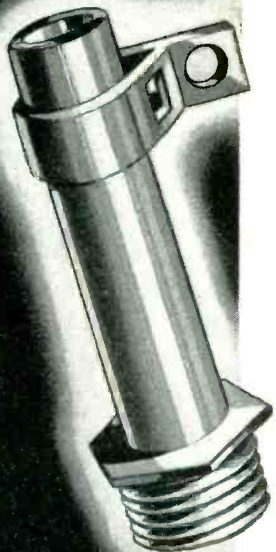
1625-P W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

Centralab offers

Type 817-001 55MMF ± 10%
Neg. Temp. Coefficient
—.00052 MMF/MMF °C
Test voltage is 2000 V.D.C.
working voltage 1000 V.D.C.

Type 817-002
Mechanically as above
Capacitance 15 MMF ± 20%
Sketch is TWICE actual size.



Type 814-078 300 MMF ± 10%
Neg. Temp. Coefficient
—.00075 MMF/MMF °C
Test voltage is 1400 V.D.C.
working voltage 500 V.D.C.
Sketch is TWICE actual size.

Two Types of
BUSHING MOUNTED CAPACITORS
for special applications

Both types are used in high frequency circuits where a capacity ground to the chassis and a "lead through" is desired.

The ceramic capacitor tube is plated internally and externally with silver and then with copper. The tube is snug fit in the brass bushing and the external capacitor plate is soldered to the bushing.

In types 817-001 and 817-002 the tinned copper wire is also snug fit inside the capacitor tube and is soldered to the internal plate.

We are equipped to produce other sizes and capacities where quantity need justifies the tooling of special parts.

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PRODUCERS OF VARIABLE RESISTORS ... SELECTOR SWITCHES — CERAMIC CAPACITORS, FIXED AND VARIABLE ... STEATITE INSULATORS

Centradite

a new Centralab Ceramic Material

Centradite is particularly recommended for coil forms where thermal expansion must be low to prevent undue change in inductance. At 20-600°C thermal coefficient of expansion is 3.1×10^{-6} as compared to 8.3×10^{-6} at 20-800 °C for Steatite.

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

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

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

★ LOW THERMAL EXPANSION

★ HIGH RESISTANCE TO HEAT SHOCK

★ LOW POROSITY

★ LOW LOSS FACTOR

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

Centralab

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PRODUCERS OF VARIABLE RESISTORS . . . SELECTOR SWITCHES — CERAMIC CAPACITORS, FIXED AND VARIABLE . . . STEATITE INSULATORS

Crane Stability Gage

LARGE BOOM CRANES that lift heavy sub-assemblies for warships have booms that extend over 100 feet and exert considerable leverage against their mounts. The crane operator, perched in a cab sixty feet high, is constantly conscious of the danger of the crane overturning and must carefully adjust his controls.

H. P. Kuehni, of G-E general engineering laboratory, points to the safety limit marking on the dial of the crane stability gage he developed

To eliminate this danger, a crane stability gage, shown in the photograph, has been developed by General Electric. The gage provides the operator with a continuous indication of the margin of safety and is arranged to stop the crane automatically if the boom is extended too far or is too heavily loaded.

Nazi Light-Beam Telephone

THE FIRST REPORTED practical use of communication by means of a lightbeam has been disclosed to have been made by the German Army in Libya. Equipment of this type was captured in the Battle of Alamein and has been examined in the laboratories of the British Royal Corps of Signals in the Middle East. The equipment is described by Capt. D. Gifford Hull in the October, 1943 issue of *Electronic Engineering* (43-44 Shoe Lane, London, E.C. 4, England). A condensation of the article follows.

The German apparatus contains a transmitter-receiver head which resembles an oversize pair of binoculars. This is mounted on a tripod and contains the lamp, the modulation device, color filters, transmitting and receiving lenses, the photocell and its amplifier. Two audio amplifiers, one for transmitting and one for receiving, are mounted in a separate box with the necessary batteries.

The effective range of the apparatus depends largely on atmospheric conditions, but five miles is about the average. This range is considerably decreased in rain, and increased when the atmosphere is very clear. The apparatus was not tested in fog, but it is assumed that although the infrared ray will to a large extent penetrate fog, the range is considerably reduced.

Greater distances are possible if the lamp filament is keyed by a pushbutton provided. This provides facility for Morse transmission, but reception must be visual.

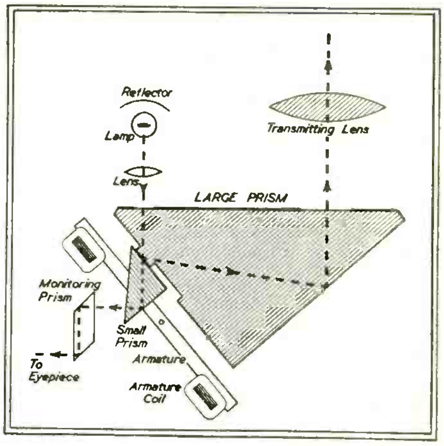
Transmitter

The transmitter lamp has a coiled filament, and consumes 4 watts from a 4.8-volt supply. The lamp has a prefocused filament and a detachable holder. The lamp house contains a mirror which focuses the light on the modulator unit.

After modulation, the light beam passes through a filter, which may be white, red, infrared, or diffused, depending on the setting of the filter selector knob. The modulated and filtered lightbeam passes through an 80-mm lens, which focuses it to a virtually parallel beam.

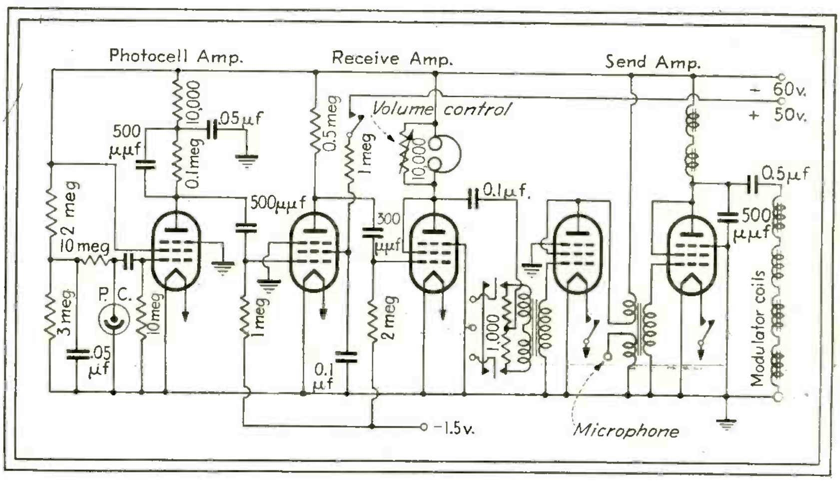
Action of Modulator

The method of modulating the lightbeam is shown in the illustration. Light from the lamp-house strikes the hypotenuse side of a right-angle prism. The light beam is reversed in direction by two internal reflections of the prism. The other angles of the prisms are not quite 45 deg, so that at the point of first reflection the mean angle of incidence is approximately the critical angle for glass and air media. Under these conditions, partial reflection and partial refraction take place. The area at which this first reflection takes place is a small rectangle measuring 3 by $1\frac{1}{2}$ mm, the surrounding glass being blackened.



Arrangement of prisms and lenses in the transmitter for light-beam modulation. A monitoring system for checking the modulation is included

An armature, consisting of a flat metal strip pivoted at its center, is mounted so that its ends are located closely between the pole pieces of the armature coils. These are so phased that one pushes and the other pulls. A small right-angle prism is carried on the armature, near its center, and is so positioned that one of its sides rests in contact with the

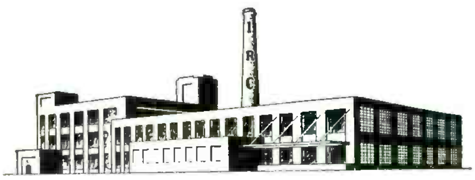


Equipment captured from the German Army contains this circuit of electronic amplifiers for transmitting and receiving voice signals on a beam of light

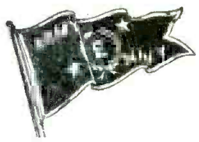
IRC

PROMISES

MILLIONS MORE IN '44



NEW PLANT—To meet increased demands for IRC resistors it became apparent early last year that a new IRC Plant was the only solution. From the blueprint stage, in January of '43, the project became a functioning reality by Fall. Now both great plants are turning out huge quantities of resistance devices for war needs.



NEW STAR—Twenty-four hours a day . . . seven days per week, right through the calendar! That's been the pace at IRC ever since war was in the rumor stage. During the months of actual combat, while we couldn't work longer hours, we've worked successively harder to reach the seemingly unattainable quotas established for us by those charged with supplying our Fighting Forces. That we've done a creditable job is attested by the fact that our Army-Navy E pennant now flies a second white star "for great and continuing contribution to the cause of freedom."

ACKNOWLEDGEMENT—Despite the many problems of wartime construction and procurement, IRC's new plant was equipped and "in production" with minimum difficulty. To commemorate the spirit of cooperation which made this achievement possible and to give credit where credit is due, we've prepared a booklet entitled "Reporting on Plancor No. 1666." A copy will be gladly sent to interested executives.

INTERNATIONAL RESISTANCE COMPANY

403 N. Broad Street • Philadelphia 8, Pa.

small rectangle of the main prism. As the armature moves in accordance with the voice currents, so the pressure of the small, moving prism against the large prism changes in accordance with the voice currents.

Pressure Variation

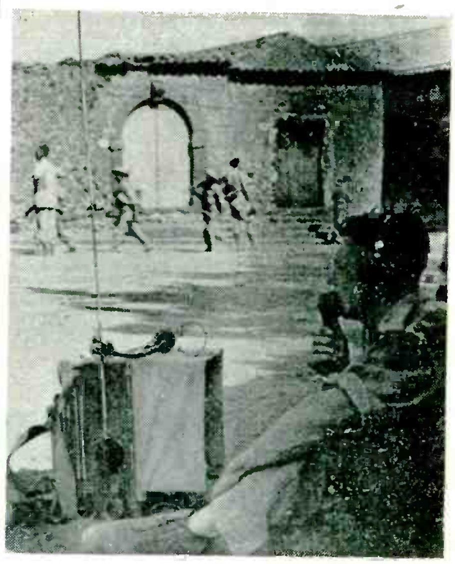
Since the small prism is mounted close to the axis of rotation of the armature, its travel is small, but its pressure is great. Thus, it is the pressure of the small prism on the large one that alters, not so much the air gap between the two.

If these two glass surfaces were truly optically flat and in perfect contact there would be no change of medium at this point and no internal reflection would take place. Hence, no light would pass through the main prism. But as soon as the contact between the prisms becomes imperfect, a change of light media will occur and internal reflection will result. In practice, the contact is never perfect; in fact, for all pressures of the prism, most of the light is reflected. But the varying pressure brings about a varying degree of contact, which, in its turn, varies the amount of light reflected through the main prism. This, coupled with the fact that the angle of incidence is nearly the critical angle, makes the modulator a relatively efficient device.

A device is incorporated to control

• • •

BRITISH WALKIE-TALKIE



A British signalman contacts other units with his wireless transmitter-receiver while passing through the Sicilian town of Belpasso, near Catania

SHURE Research

. . . Throat Microphones

Sounds transmitted through the throat present different problems in microphone design than sounds transmitted through the mouth. For better design, correlation had to be established between throat vibrations and sounds transmitted by the mouth. To do this, special throat microphones having constant acceleration characteristics were developed for use in conjunction with laboratory standard microphones and frequency analyzers. Experiments covered the frequency range of speech sounds and tests included a variety of callers to study the effect of the thickness of throat tissues. Shure Research has produced a throat microphone that has been declared definitely superior. It is the kind of research that assures you the superior microphones of tomorrow.

SHURE BROTHERS, 225 W. Huron Street, Chicago

Designers and Manufacturers of Microphones and Acoustic Devices

ARMY E NAVY

SHURE
MICROPHONES

the quiescent, no-signal pressure of contact. The operator adjusts this to give maximum sensitivity and minimum distortion. It controls, to some extent, the direction of modulation. It is paradoxical to say that overall upward modulation takes place, if one is considering the amount of light that enters the prism; but with respect to the quiescent light level leaving the prism (i.e., taking into account the amount lost at the first reflection for zero signal) it appears that upward and downward modulation does occur.

No attempt has been made to measure the depth of modulation, but if the instrument is operated on white light, and an observer stands in the beam, a very marked flicker is noted when the operator speaks.

The sending amplifier normally uses but one triode-connected tube. This is fed by the microphone, and the anode is parallel fed, the anode load being the armature coils of the modulator.

Receiving System

The modulated, filtered light (white, red or infrared), is picked up on the 80-mm lens of the receiver and focused on to the photocell, located at the back of the head. The photocell changes in electric potential are amplified by the one-stage photocell amplifier, located within the head. The audio output is fed by a cable to the main receiving amplifier.

The vacuum tubes are standard German Army high-gain, directly heated pentodes, R.V.2P.800 and resemble the British catkin type. They are mounted upside down in a tubular holder, being supported at both ends. The photocell amplifier is conventional; the cell receives a positive voltage by means of a high-resistance potentiometer from the d-c line. The anode circuit has a resistance-capacitance network that attenuates at about 4,000 cps, the purpose being presumably to minimize photocell hiss.

This amplifier uses two tubes in cascade, resistance-capacitance coupled, and the last valve is triode-connected to secure a low impedance for the phones. The output is also taken to the telephone bridge input circuit.

The send-receive switch normally switches on the appropriate amplifier, and thus duplex operating is not

possible. For the purpose of working into a telephone line, the switch is turned to "Telephone," and this places the bridge circuit in the sender amplifier input and in the receiver amplifier output. The bridge is balanced, to prevent acoustic feedback over the entire system. The bridge input circuit attenuates the microphone current, so in this condition the switch puts another tube in the sender amplifier circuit to compensate for the loss.

The audio-frequency response of both amplifiers falls off commencing just below mean voice frequency so that attenuation at 300 cps and below is very high. This feature is very useful in that it minimizes low-frequency flutter due to hot air currents rising from the ground in the optical path.

Photocell

The photocell is small in size, resembling a button about one inch in diameter. It is of the "Thalofide" type, and changes its resistance in accordance with variations of light intensity. The cell is very sensitive to red and infrared light, and a built-in red filter is incorporated. The output of the cell is in the order of one na per lumen. The polarizing voltage is taken from the d-c line via a high-resistance potentiometer, and about 30 volts is applied to the cell. The output of the cell is applied to the amplifier through a 100-$\mu\mu$f capacitor which, together with the 10-megohm grid resistor, affords considerable attenuation at low frequencies.

Monitoring System

A telescope is used to align the station to the distant terminal, and also as a monitoring device to check the action of the modulation. The hypotenuse side of the smaller prism has a clear space on it, which is placed close to another prism, which carries the light into the eye-piece of the telescope, being suitably focused by a small lens. The light that is lost at the first reflection of the main prism is passed on to the smaller moving prism. This light is in turn passed on to the eye-piece. The contact surface of the moving prism has a small grid mesh etched on it (not for the purpose of affecting the contact surface) and it is the image of this grid which appears in the eye-piece. The image of this grid

SCOVILL COLD-FORGING "KNOW HOW" CAN HELP YOU

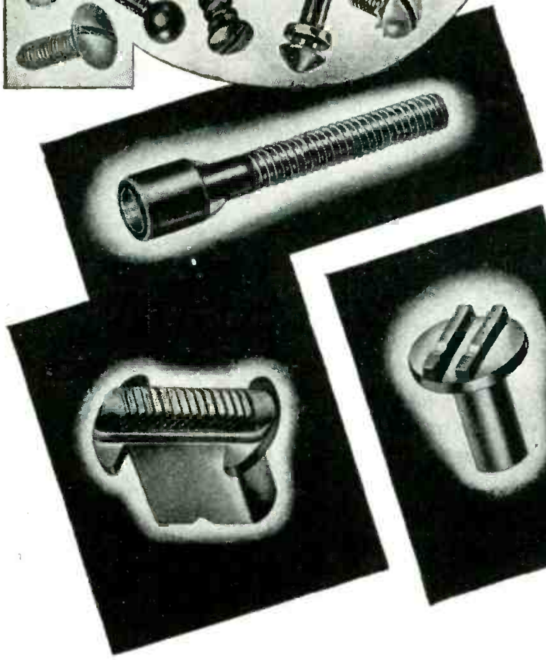
with your war and post-war screw products needs

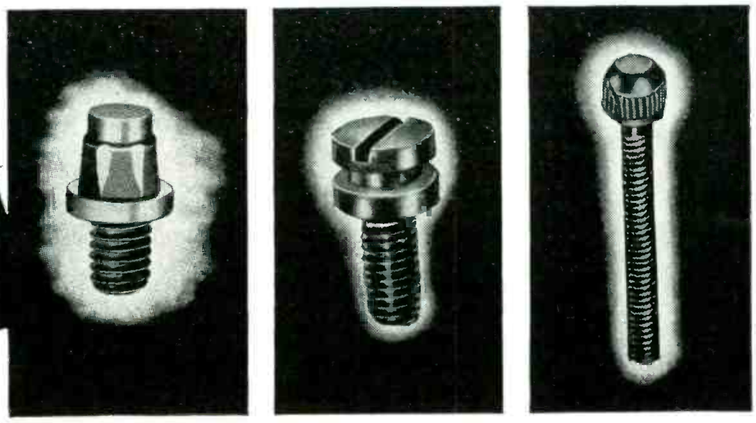
Here are a few of the many practical proofs that Scovill has the cold-forging "know how" to solve your special and standard screw products problems for minimum money—materials—motions.

Some are newly designed war jobs—others civilian—still others are prewar products now important in war work. *All* are the result of years of demonstrated Scovill ability to find the *best* way to make screw products *right*.

Today this "know how" is largely engaged in war work. But it is neither new nor adaptable only to war products. Behind the added ingenuity born of wartime pressure and shortages, are years of unusual peacetime skill.

This war is far from over—but the practical problems of your postwar production are drawing closer. NOW is the time to discuss with our nearest office when and how our cold-forging skill can serve you.





Please Note: *Kindly pass this on to others in your plant. We are still handling new work to the limits that current war commitments permit, stating the situation promptly and frankly.*

SCOVILL MANUFACTURING COMPANY

WATERVILLE SCREW PRODUCTS DIVISION

WATERVILLE 48, CONN. TEL. WATERBURY 3-3151

NEW YORK, Chrysler Building • DETROIT, 6432 Cass Avenue • CHICAGO, 1229 W. Washington Boulevard • PHILADELPHIA, 18 W. Chelten Avenue Building
PITTSBURGH, 2882 W. Liberty Ave. • SYRACUSE, Syracuse-Kemper Insurance Bldg. • LOS ANGELES, 2627 S. Soto St. • SAN FRANCISCO, 434 Brannan St.

IN FM BROADCASTING

RCA has been and will continue to be an active leader in FM development.

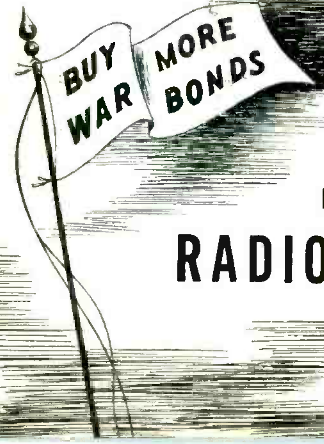
A considerable number of FM Transmitters designed, built and installed by RCA are in service...including five 10 KW's, one of which is shown at the right.

RCA engineers have had more experience in building (and operating) radio transmitters than any other group.

And the truth is that FM Transmitters do not differ very greatly from other transmitter installations, particularly Television.

RCA has always pioneered in development of high-frequency antennas ...and is now building many different models for the armed services.

RCA will continue to offer top-rank transmitting equipment for every broadcast need... in AM, in FM, in Short Wave, and in Television.



RCA

RCA BROADCAST EQUIPMENT

RADIO CORPORATION OF AMERICA

becomes brighter and duller with modulation. In practice, it is noted that only on peak modulation does the grid image appreciably change in intensity. This monitoring system is entirely visual, and gives no indication as to the quality of the transmission. It is complementary to the true modulation, being, as it were, "inside out."

Power Line Fault Locator

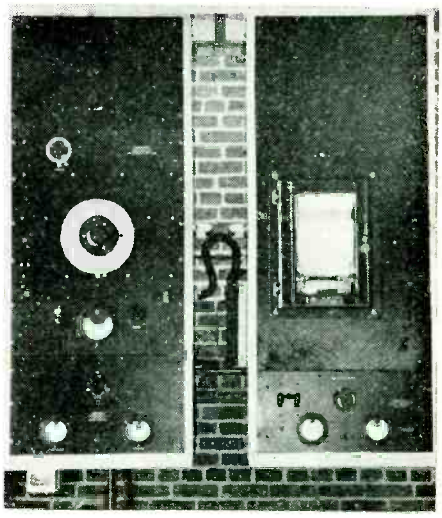
By W. H. Blankmeyer
The Montana Power Co.
Butte, Montana

An Electronic fault locator, for use on long-distance overhead transmission lines, traces and locates open circuits or short circuits in a few minutes, an operation that might take many hours by ordinary methods. The accuracy is normally well within two percent.

The instrument was designed by J. E. Allen and G. J. Gross and depends upon two factors for operation, the reflection of a signal from an impedance irregularity in the line and the phase shift of the signal along the line between the test point and the irregularity.

The signal or testing power is a-c which is variable in frequency from 100 to 100,000 cps. The signal current is applied to the line and is recorded as the frequency is steadily changed in one direction. The recorded current will have a series of peaks separated by a constant frequency difference. It is this frequency difference by which the distance to the fault or impedance irregularity is calculated.

The current peaks are the result of the reflected wave returning to the source at various phase angles as the frequency is varied. At some frequencies the reflected wave will be out of phase and at other frequencies in phase with the signal source. This causes a corresponding variation of impedance and similar changes in



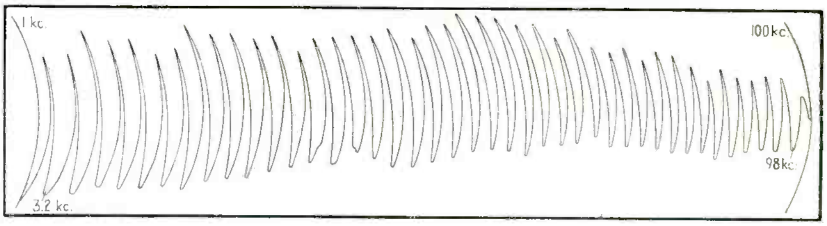
Electronic transmission line fault locator for determining the distance of shorts or opens from the power plant

the current fed to the line. Regardless of the nature of the line fault, the current peaks are spaced equally over the frequency range. The nature of the fault determines the frequency at which the first current peak occurs. After that the spacing is the same for all faults at a given distance from the test point.

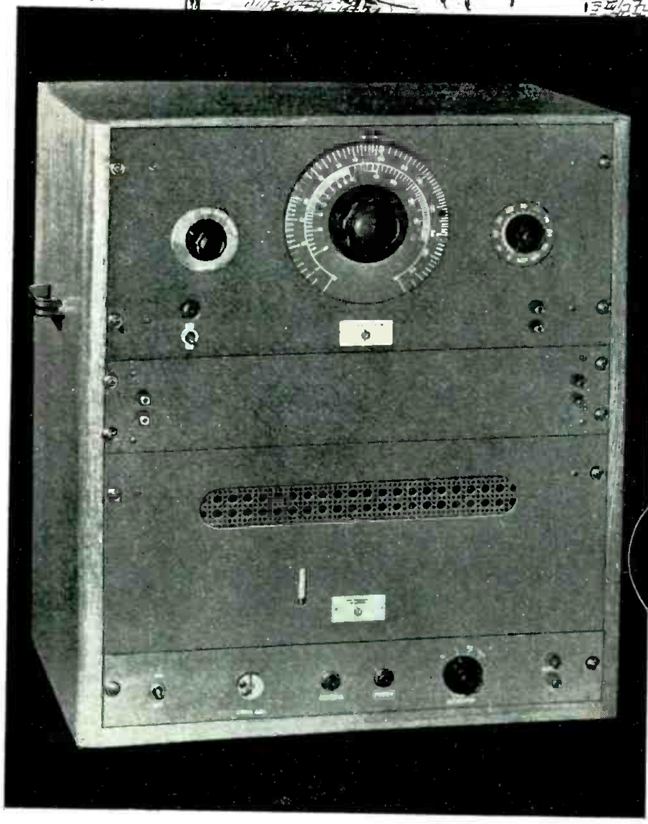
Interpreting Graph

The graph shown is a current-versus-frequency recording made on a faulty line. The first current peak occurred at 3.2 kc. There are 40 current peaks (maximum current downward) between 3.2 kc and 98 kc. The spacing between peaks is then 98,000 – 3200/40 = 2370 cycles. The distance to the fault is determined by the relationship $L = V/F$, where L equals distance in miles to the fault, V equals velocity of propagation in miles per second, and F equals frequency difference between successive current nodes in cps.

In power system work, distances on transmission lines are expressed in tower numbers instead of in miles. Consequently for better use of the locator the tower numbers for each line are previously plotted against



A graph of current plotted against frequency, made on a faulty line. The current peaks are the result of the reflected wave returning to the source at various phase angles as the frequency applied to the line is varied from 100 to 100,000 cycles



how -*hp*- instruments can be combined to solve a wide range of problems...

Two or more standard -*hp*- instruments combined in single cabinet make an ideal set-up for individual stations on the production bench or for a small laboratory. Illustrated is the -*hp*- Model 100AR Low Frequency Standard and the 202DR Audio Oscillator. A quick review of the capabilities of these two instruments will show the value of such a combination.

For example: The model 100A provides standard frequencies of 1-kc, 10-kc and 100-kc. The out-put of each of these frequencies is available through separate terminals so that standards can be utilized at several stations on a production bench simultaneously. Model 202D Audio Oscillator provides extremely wide range of frequencies—2 cps to 70 kc—on a direct reading scale. The dial operates with planetary drive at 5 to 1 reduction for accurate adjustment over 270°. This instrument posesses all the outstanding features of all -*hp*- resistance tuned oscillators — no zero setting is required.

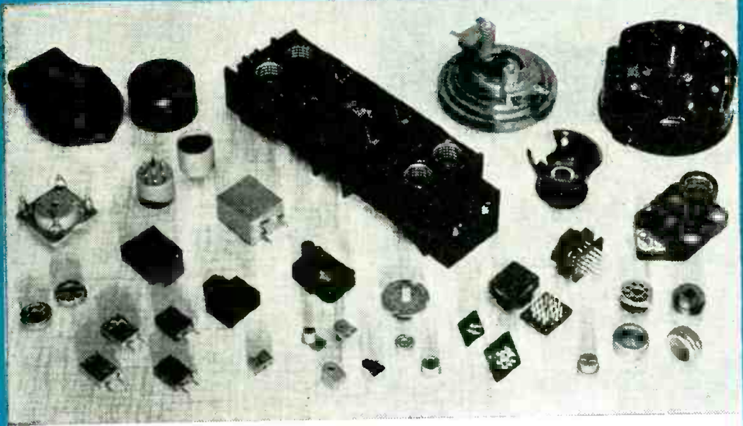
With this combination of instruments you can calibrate audio equipment, make accurate interpolations and standardize such measurements to a high degree. You can make distortion measurements on audio amplifiers, make accurate bridge measurements and work in the supersonics. The power out-put is sufficient to drive signal generators and other equipment.

Get full information about -*hp*- instruments today. There are many combinations other than the one described here that you can use to great advantage. Remember, -*hp*- instruments give you great economy with no sacrifice of accuracy and flexibility. Write today giving details of your problem so that we can be of greatest help to you. There's no obligation whatsoever.

HEWLETT-PACKARD COMPANY

P. O. BOX 335P, STATION A, PALO ALTO, CALIFORNIA

750



Why we put the first sentence IN BOLD TYPE

Durez plastic materials are of the phenolic group, which is thermosetting.

Our laboratory men explain it is that fact which makes it the most widely used type of rigid plastic material in the electrical industry. That's an important statement for the man who's searching for improved materials or who's at the blueprint stage with plastic parts for post-war products. That's why we put the first sentence in bold type.

Because Durez is a thermosetting plastic, it has inherent dimensional stability even in the presence of high temperatures. With Durez compounds heat resistance at 300° F. is common, while special Durez series are produced for heat up to 500° F.

Although phenolic resins share this heat-resisting characteristic with other compounds of the thermosetting group, they have a definite advantage in exhibiting greater durability. Laboratory data and years of performance records show that Durez compounds result in tight-fitting connections which *stay tight*. Dimensional stability against high heats and cold flow usually makes a strong case for Durez.

Durez offers the electrical engineer marked versatility when it comes to electrical properties. It is almost a "tailored-to-measure" proposition because a wide range of fillers can be used. Arc resistance, low loss factors, high dielectric strength or any other electrical property can be readily extended for a particular application.

The oil resistance of Durez phenolic plastics is another asset for the engineer-designer. Among thermosetting plastics, phenolics are better suited to oil surroundings than any material yet developed. Our own data, which we should like to send you, shows that Durez has a particularly high rating on this score.

We have referred you to the four characteristics which are responsible for the electrical industry's successful use of the Durez materials during the last twenty years. Of course, other essential properties have played their part in adding to the preference for Durez.

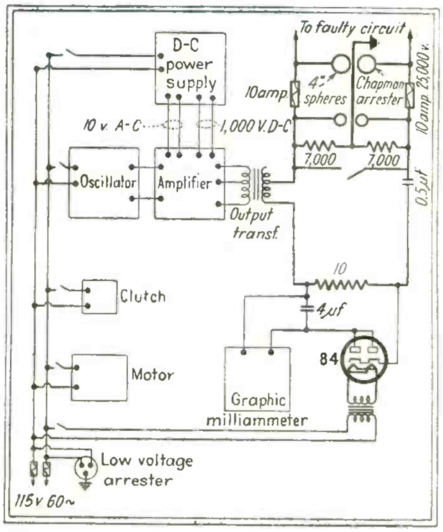
We hope you are far enough ahead in your thinking on after-the-war production to want to know more about what your molder can do with Durez compounds. Talk it over with him, or write us direct. We'll start the ball rolling. Working with you and your molder, we perhaps can bring the blueprints a few steps closer to actuality. Durez Plastics & Chemicals, Inc., 81 Walck Road, N. Tonawanda, New York.

EFFECT OF CERTAIN FILLERS ON THE PROPERTIES OF TYPICAL DUREZ MATERIALS FOR ELECTRICAL APPLICATIONS

	ORGANIC FILLER	MINERAL FILLER	COMBINATION FILLER
Specific Gravity	1.31-1.36	1.76-1.96	1.44-1.52
Tensile Strength Lbs per Square Inch	6000-8000	4000-6500	5000-6500
Compressive Strength PSI	25000-30000	19000-28000	25000-26000
Flexural Strength PSI	9500-11000	7500-10500	8500-10500
Impact Strength — (ASTM) Izod	0.24-3.0	0.24-0.8	0.24-0.8
Water Absorption (%) 24-hour immersion (ASTM)	0.5-1.6	0.1-0.7	0.6-1.0
Dielectric Strength (Volts per Mil)	300-550	250-630	300-550
Dielectric Constant (RT) 10^6 cycles	5.0-6.0	4.8-5.0	4.5-6.0
Power Factor (RT) 10^6 cycles	.03-0.1	.003-.06	.03-0.1

DUREZ PHENOLIC MOLDING COMPOUNDS AND RESINS

PLASTICS THAT FIT THE JOB



Circuit arrangement of the units forming the line-fault locator. Care was taken to protect the operator and the equipment from surges resulting from lightning or induction from parallel lines

frequency so that less time is consumed in calculations. This aids in speeding the repair crew on their way to the break.

The case of trouble as recorded by the locator in the graph proved to be a broken conductor lying on the ground between tower 391 and 392. The break was caused by snow piling on the conductor.

Speed of Propagation

The propagation constant is calculated by applying artificial faults to the line at known distances from the test points. It was found that the propagation constant is not the same on all lines. The figure varies between 181,000 and 183,000 miles per second.

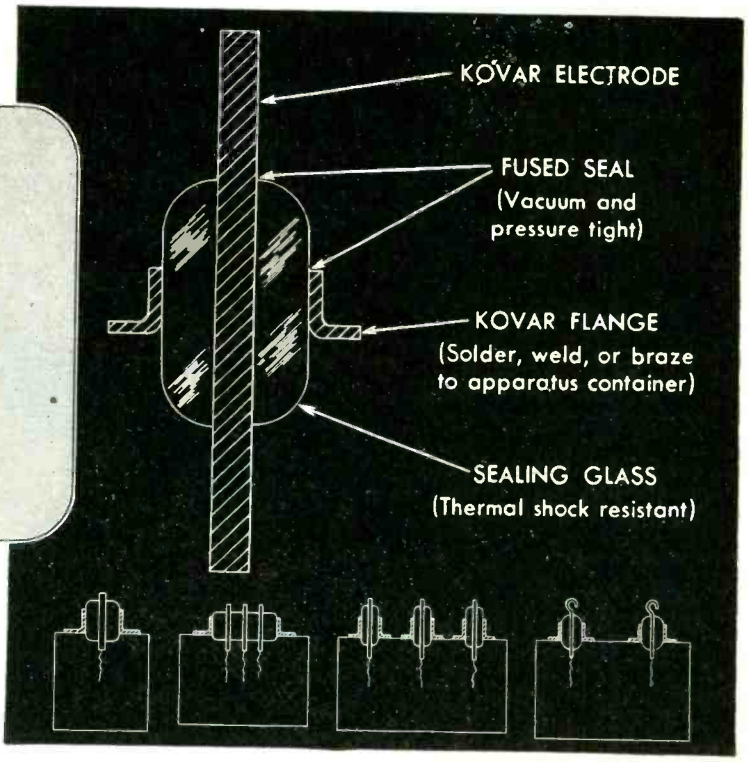
The diagram shows the main components used in the fault locator.

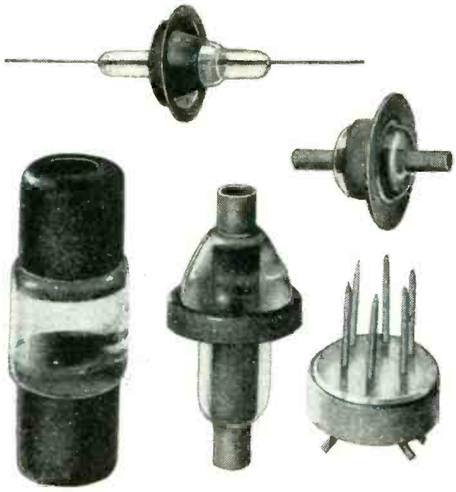
It consists essentially of a beat frequency oscillator, amplifier and power supply, graphic milliammeter with rectifier, output transformer, protective apparatus and connecting cables.

The oscillator is the beat frequency type having a frequency range of 100 to 100,000 cps and has an output of about 4 watts. The amplifier uses two 50-watt tubes in push-pull.

The recording milliammeter has a range of 0-5 ma. An 84 tube is used to rectify the signal voltage for the d-c instrument. The recording mechanism of the milliammeter is mechanically coupled to the frequency control on the oscillator. In this way the current is automatically plotted against the frequency.

WE'VE BEEN DOING IT FOR YEARS





SEALING GLASS TO METAL WITH KOVAR

TRADE MARK 337962, REGISTERED IN U. S. PATENT OFFICE

KOVAR, an iron-nickel-cobalt alloy, was primarily developed to meet the need for metal-to-glass seals in electronic tubes. Kovar matches the expansion of hard or thermal shock resistant type glass—is readily formed by machining or deep drawing—resists mercury attack.

The seal between Kovar and glass is a chemical bond in which the oxide of Kovar is dissolved into the glass during a heating process. The result—a permanently vacuum and pressure tight seal effective under the most extreme climatic conditions—tropical to stratosphere.

Stupakoff supplies Kovar sheet, rod, wire, tubing; and for those not equipped for glass-working, Stupakoff makes Kovar sealed terminals and other assemblies designed for soldering, welding or brazing to metal containers to form vacuum or pressure tight seals.

Kovar IS the answer to permanent vacuum or pressure tight sealing. Let us help engineer YOUR sealing problems.

Use KOVAR for sealing

- ELECTRONIC TUBES
- TRANSFORMERS
- RESISTORS
- CAPACITORS
- CONDENSERS
- VIBRATORS
- SWITCHES
- RELAYS, ETC.

"for great achievement"

Buy War Bonds

SINCE 1897

STUPAKOFF

Products for the World of Electronics

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Electronic Pistol Shoots Ultraviolet Rays

An air-cooled ultraviolet lamp, made in the form of a pistol, is being used to irradiate local "targets" on skin surfaces or within cavities of the body. The new "pistol-lamp" is capable of producing a first-degree erythema in contact with the average untanned skin in two seconds. Substantially more ultraviolet can be obtained through application under minute and accurate control.

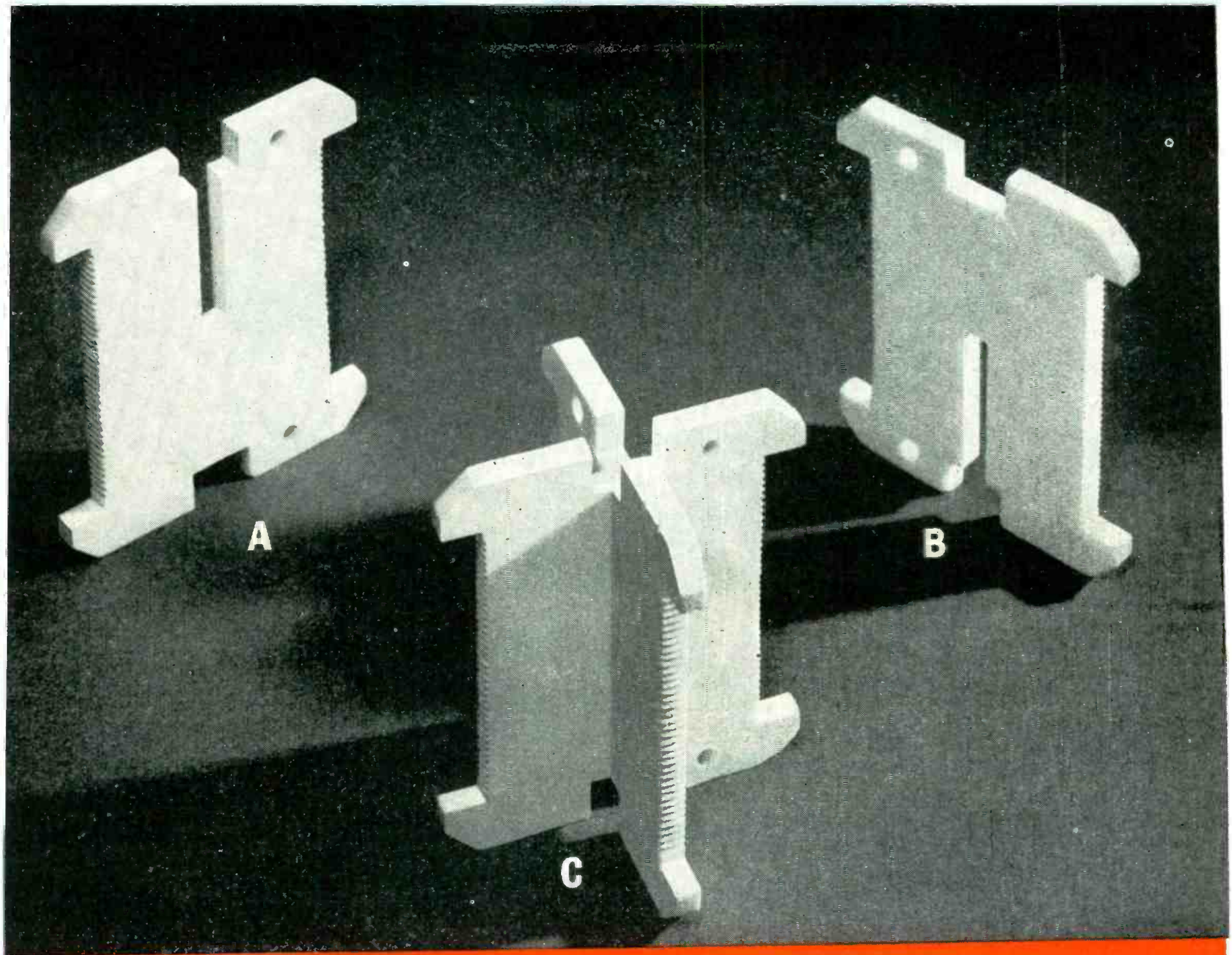
The ultraviolet intensity for the spectral region 3130 A to 1850 A on contact with the front window or muzzle is 70,000 microwatts per square centimeter. The burner is a transparent, fused quartz, self-lighting tubular C-shaped vessel equipped with activated electrodes of the thermionic type. Input is 160 watts, with metal lead-ins for the electric current sealed directly to the quartz.

Small areas and cavities of the body can be given ultraviolet treatment with a new Aero-Kromayer lamp made in the shape of a pistol. Lt. (JG) Dorothy Lovedahl of St. Albans Naval Hospital, L. I., treats a sailor's infected ear

It uses the principle of aerodynamics instead of a water-cooled system. The casing is of torpedo design, 3 inches in diameter and 10½ inches long, and is provided with a pistol grip for easy manipulation.

Known technically as an Aero-Kromayer lamp in recognition of Prof. Ernst Kromayer, its originator, the unit is a product of Hanovia Chemical and Mfg. Co., Newark.

Slow-healing wounds ofter respond favorably when ultraviolet is applied, and the new lamp is also useful for treating abscesses, indolent ulcers, psoriasis and other diseases.



A + B = C

AND SAVED THE CUSTOMER LOTS OF MONEY

"Of course we can make it," we told a customer after studying his latest blueprint of a coil form, "but we can save you a lot of money and give you more satisfactory service if you follow the suggestions of our Engineering staff. The boys recommend making the piece in two parts. They can be pressed quickly at a high production rate and assembled into a coil form of practically the same design as you brought us." Above are illustrated the parts which we finally shipped to the customer. Simple as A, B, C, isn't it?

But it demonstrates that it is well worthwhile to consider the services of American Lava when designing Steatite Ceramic Insulators. Perhaps we can make recommendations that will be of real benefit to you.

Army-Navy "E"
First Awarded July 27, 1942
Second Award: "Star" February 13, 1943
Third Award: "Star" September 25, 1943

ARMY E NAVY

ALSIMAG

TRADE MARK REGISTERED U. S. PATENT OFFICE

STEATITE CERAMIC ELECTRICAL INSULATION FOR ELECTRONIC USES

AMERICAN LAVA CORPORATION

CHATTANOOGA 5 TENNESSEE

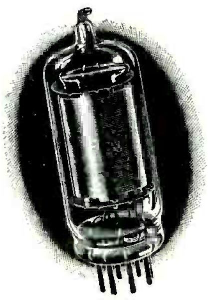
A SOLDIER'S FIRST CONCERN IS FOR HIS EQUIPMENT

...and TUNG-SOL's first concern is to build sturdiness into Electronic Tubes to withstand the rigors of war service.

TUNG-SOL "Vibration-Tested" tubes are giving a good account of themselves in radio sets and other electronic devices in fighting equipment of all kinds. The work done in TUNG-SOL laboratories long before the war is the reason. Many of the causes for early tube failure were found and these weaknesses corrected by improvements in design and construction.

The wide experience gained in developing and producing Tung-Sol "Vibration-Tested" Electronic Tubes for war will be available when the war is won. Manufacturers of electronic devices and controls, who are now planning new products, will find TUNG-SOL research engineers ready and able to assist in designing circuits and selecting the correct "Vibration-Tested" tubes.

TUNG-SOL
vibration-tested
ELECTRONIC TUBES



Every TUNG-SOL tube of new design and tubes picked at regular intervals from the production line, are subjected to severe vibration while current, introduced through the various circuits, is carefully measured. Tubes that pass this exacting test are truly "Vibration-Tested."

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Sales Offices: ATLANTA, CHICAGO, DALLAS, DENVER, DETROIT, LOS ANGELES, NEW YORK

ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS

Frequency-Comparison Circuit for C-R Tubes

VOLTAGES OF TWO different frequencies can be combined for comparison to give a circular trace with re-entrant loops on the screen of the cathode-ray tube, of one of the types shown in Fig. 1.

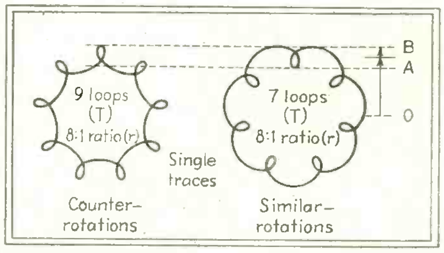


Fig. 1—Stationary trace produced where the higher frequency is a multiple of the lower frequency

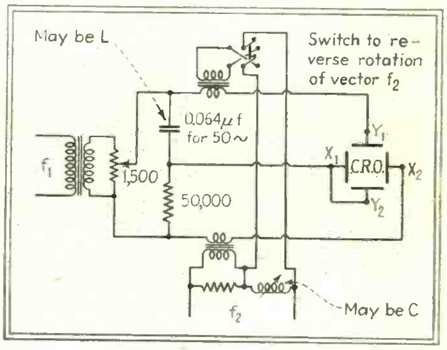


Fig. 2—Circuit used to produce traces of the types shown in Fig. 1 and 3

The circuit of Fig. 2 adds a short, rapidly rotating voltage vector to a longer, more slowly rotating one, their senses of rotation being either opposite or the same. With opposite rotation, the loops are extroverted; with the same directions, they are introverted. A stationary pattern will result as long as the higher frequency is a multiple either of the lower frequency or of an integral fraction of the lower frequency, the pattern in the latter case being "multiplex" and of the type shown in Fig. 3.

If there is no integral relationship between the frequencies the pattern will rotate on the screen, and the frequency ratio is shown to be given by

$$r = T + m/m - pT/mn_1$$

where T is the number of re-entrant loops; p is the speed of the pattern in rps, in the direction of the slower vector and n_1 is the frequency of this vector in cycles per second and m is the multiplicity of the pattern.

The negative sign corresponds to

What was missing at the first automobile show?

● The Twentieth Century opened with a blaze of glory at the first automobile show in New York. The world's finest electric and steam cars were on display, and there were even a few gasoline carriages.

But there wasn't a single steering wheel on the lot!

Here was the outstanding invention of its time, yet it lacked the most important single thing on any automobile today. All those cars were imitations of carriages—with handles for steering, and whip sockets for no reason whatever!

The evolution of design just doesn't happen overnight. That's why we believe you'll be interested to know this is the fiftieth anniversary of Stromberg-Carlson — makers of radio, telephones and sound equipment.

Today, Stromberg-Carlson brings its 50 years of experience to bear on the design and manufacture of communications equipment for war. Tomorrow, this experience will again be applied to making good the statement, *"There's nothing finer than a Stromberg-Carlson!"*

Stromberg-Carlson is prepared to help you now with your postwar planning in the design and production of electronics equipment. This service entails no obligation. Call on us!

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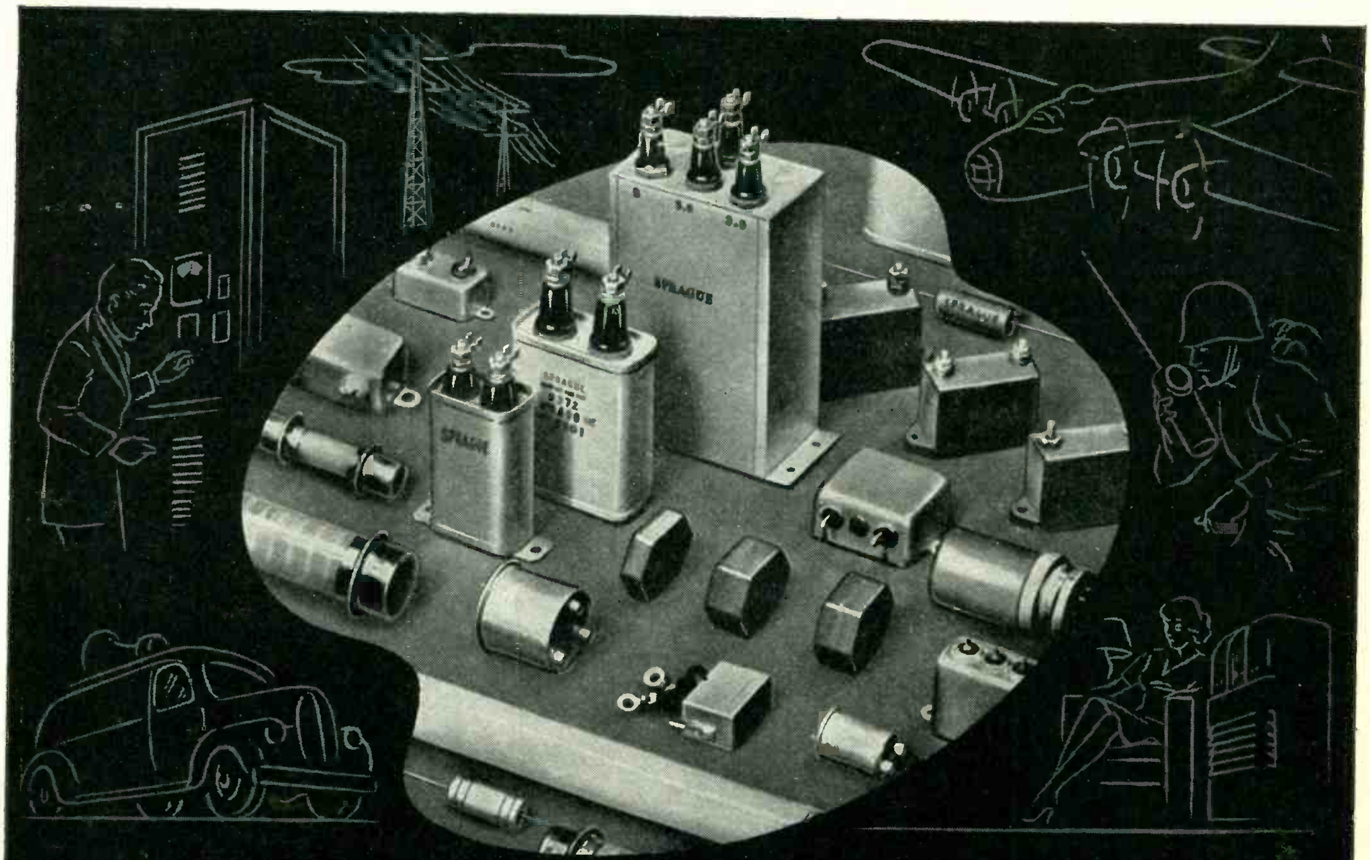


Radiotone

Gives You All 3

RADIO

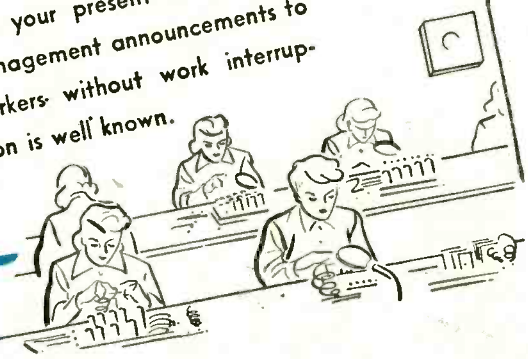
Radiotone assures the finest radio reception and reproduces the original program with true fidelity. Music in industry has proved its ability to increase plant morale and production efficiency.

RECORDING

Radiotone records voice, orchestra or radio programs ready for instant reproduction. Permanently records management messages and directors meetings.

PUBLIC ADDRESS

Radiotone can be equipped with any number of loud speakers or used in conjunction with your present P.A. system. Value of management announcements to workers without work interruption is well known.



DEALERS CAN PARTICIPATE *NOW!*

In the distribution of Radiotone to essential industries, including schools and other institutions . . . as well as the complete line of Radiotone accessories including recording discs and needles. Write for catalog and complete details.

Radiotone

Division of
THE ROBINSON HOUCHIN OPTICAL CO.
Columbus, Ohio

Hollywood, 7356 Melrose Ave. ★ SHOWROOM AND SALES OFFICE, 1011 Chestnut St., Philadelphia

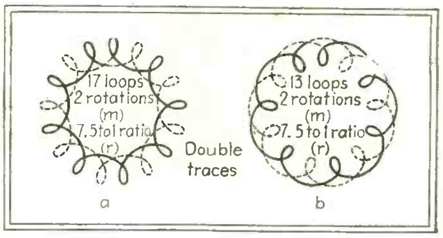


Fig. 3—Stationary trace produced where the higher frequency is a multiple of an integral fraction of the lower frequency. The rotations are opposite at *a* and in the same direction at *b*. The dotted portion is shown for clarity; the lines are actually continuous

extroverted loops and opposed rotations; the positive sign to introverted loops and similar rotations. Thus counter rotations give more loops than similar rotations, and half the difference gives the multiplicity of the pattern; that is, the number of rotations of the slower vector before the beam trace closes on itself to give a complete pattern.

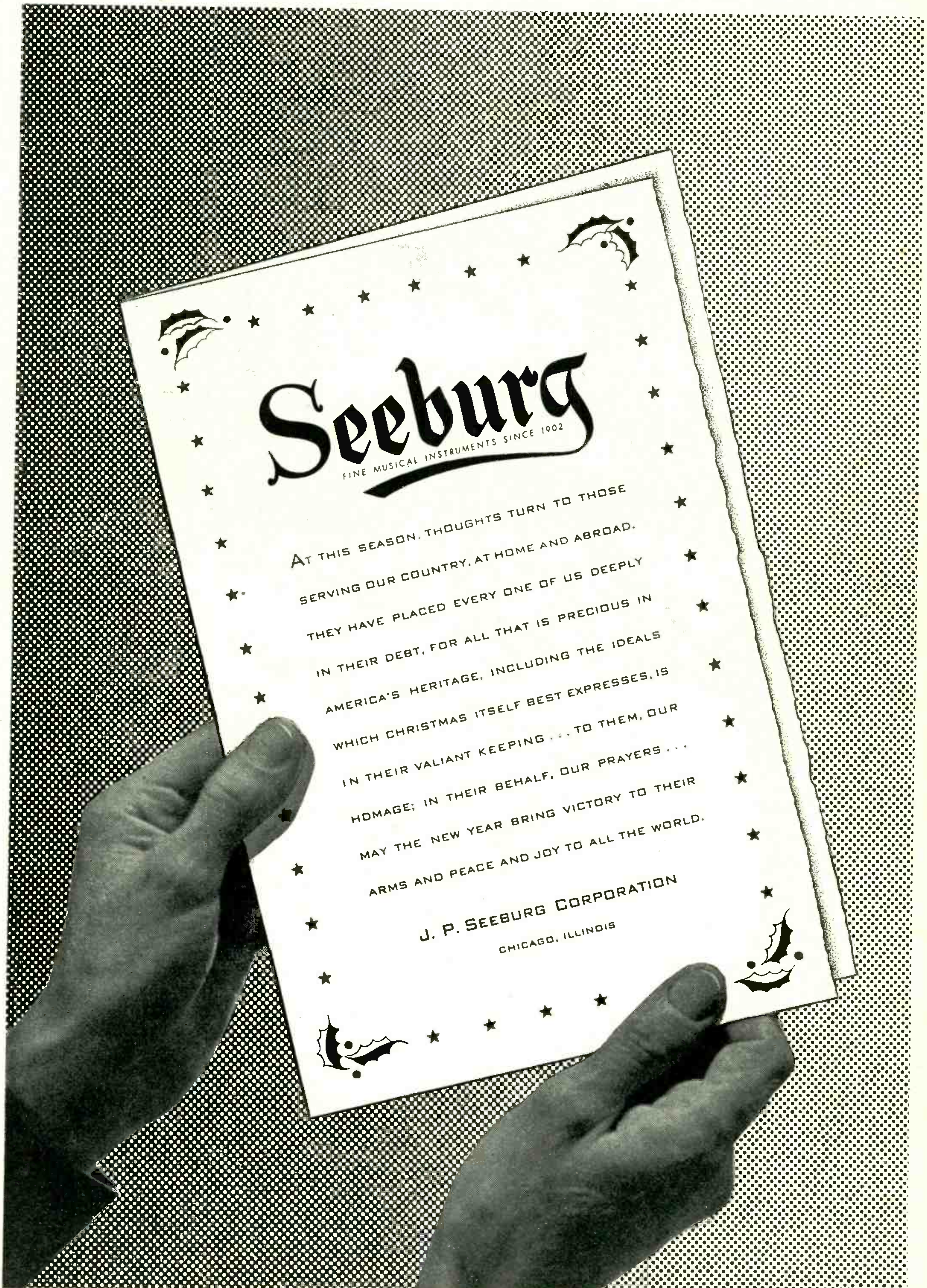
The formula $p = 0$ gives the frequency ratio for a stationary pattern, and $m = 1$ gives single patterns as in Fig. 1. Also, p has to be given its correct sign, and thus the direction of rotation of the lower frequency must be known. This vector is ordinarily derived from a phase-splitting circuit; the direction of rotation, where not deducible from the circuit connections, can be deduced from the type of distortion caused when an auxiliary capacitor (or inductance) is added to the phase-splitting circuit. Details and proofs of this test, and the facts and formula stated above, are given in the complete paper by G. H. Rawcliffe in Part III, Dec. 1942 of the *Journal of the Institution of Electrical Engineers* (British).

• • •

Moving Coil Oscillograph

FOR RECORDING PERIODIC and aperiodic changes which are too rapid for a regular strip chart recorder and too slow to be satisfactorily observed on a cathode-ray tube, a moving coil oscillograph may be used. Many medical applications of recording oscillographs require either d-c response characteristics or at least linear response characteristics at a fraction of a cycle per second. For this purpose transformer coupling is not practical and the moving coil must be directly connected to the plates of the driving tube.

In an early model of a direct re-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AT THIS SEASON, THOUGHTS TURN TO THOSE
SERVING OUR COUNTRY, AT HOME AND ABROAD.
THEY HAVE PLACED EVERY ONE OF US DEEPLY
IN THEIR DEBT, FOR ALL THAT IS PRECIOUS IN
AMERICA'S HERITAGE, INCLUDING THE IDEALS
WHICH CHRISTMAS ITSELF BEST EXPRESSES, IS
IN THEIR VALIANT KEEPING . . . TO THEM, OUR
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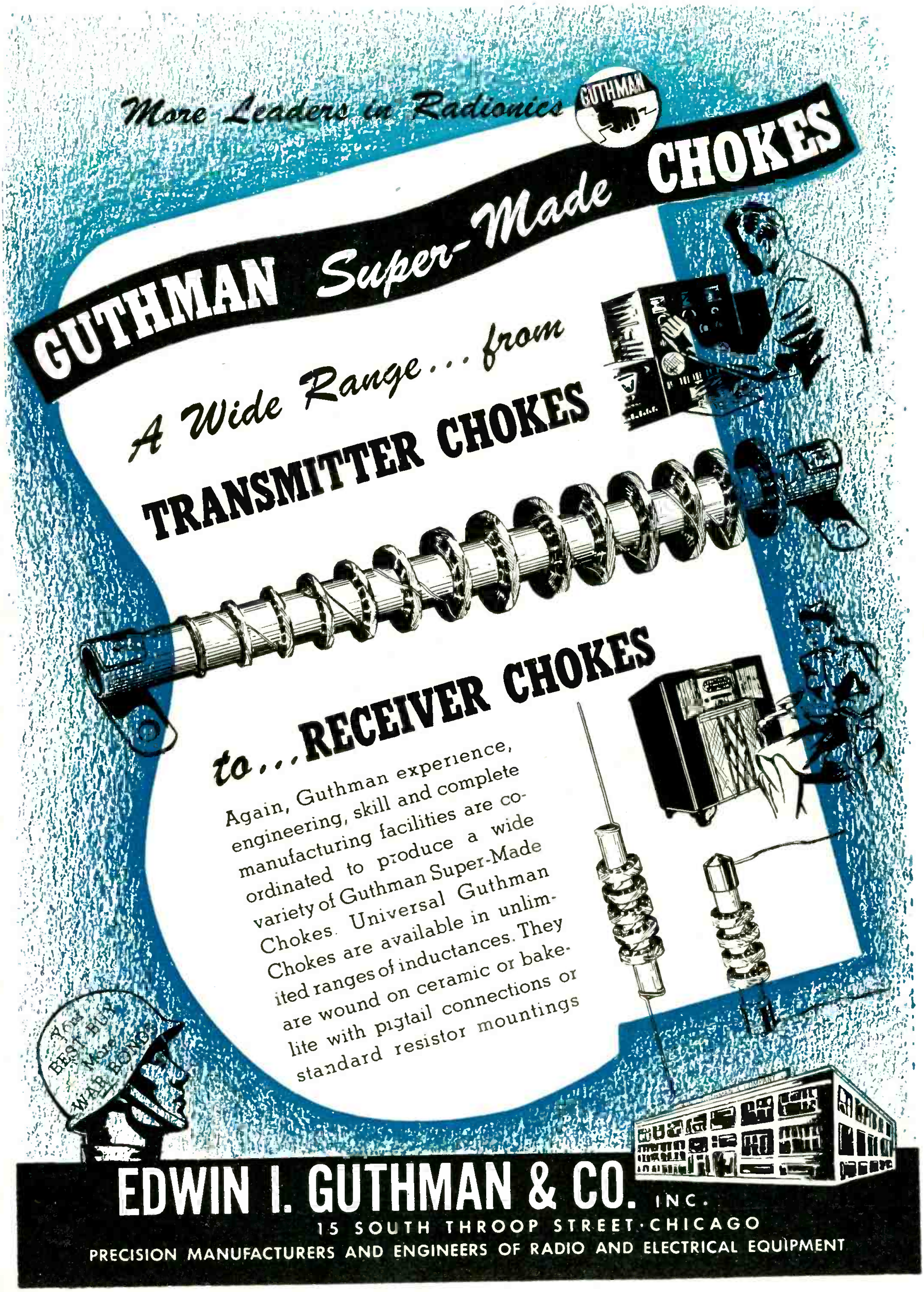
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Again, Guthman experience, engineering, skill and complete manufacturing facilities are co-ordinated to produce a wide variety of Guthman Super-Made Chokes. Universal Guthman Chokes are available in unlimited ranges of inductances. They are wound on ceramic or bakelite with pigtail connections or standard resistor mountings
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PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT

cording oscillograph, described in ELECTRONICS for October 1939, the moving coil impedance was approximately 500 ohms and the unit was energized by means of a shunt resistive network. This circuit resulted in considerable power loss, caused by the mismatched impedance and the shunting effect of the plate resistors.

A high-impedance moving coil arrangement has been developed by Rahm Instruments, Inc. to increase the sensitivity of the oscillograph. As shown in Fig. 1, the center-tapped coil forms the total plate load of the tubes and matches the plate-to-plate impedance.

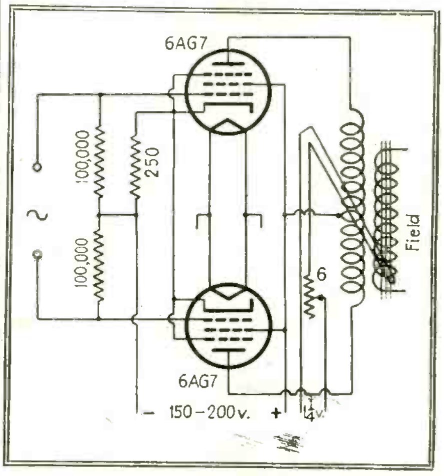

Fig. 1—Circuit of the pushpull stage used to drive the moving coil and actuate the stylus of the recording oscillograph

The magnetic field for the moving coil is produced by an electromagnet having a field coil of approximately 400 ohms resistance requiring 100 to 200 ma of exciting current. The field coil resistance may be made higher

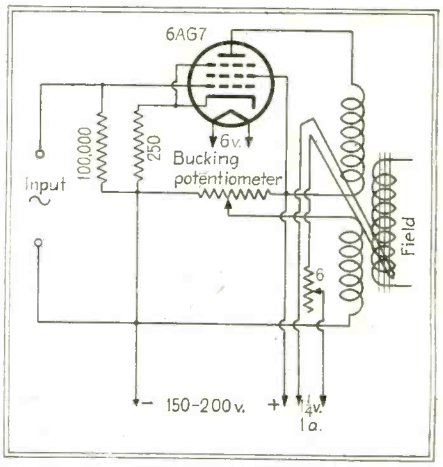

Fig. 2—The moving coil may be driven by a single-ended stage if the magnetizing effect of the plate current flow is balanced out by a bucking circuit

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Copper Sulphide **Selenium**

THE KEY to many a puzzling new industrial development is frequently the right application of Power Conversion. At the heart of many of today's electrical marvels is a Metallic Rectifier Stack. Equipment designs once believed impossible or impractical are now in common daily operation—rendering efficient, dependable service.

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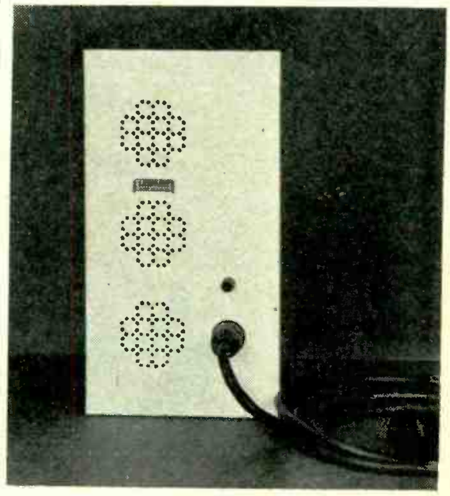
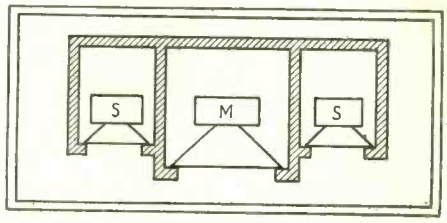


One of the triple-speaker units for the Lenkurt loudspeaking telephone system, made by Frank I. DuFrane Co., Inc. This panel is for a hospital room

sound wave of increased air pressure is impressed on the microphone from one speaker there will be an equal and opposite sound wave from the other speaker. If a perfect balance could be obtained there would be no net movement of the cone of the microphone diaphragm because of the cancellation. In practice a perfect balance cannot be obtained but a considerable amount of acoustical cancellation is accomplished.

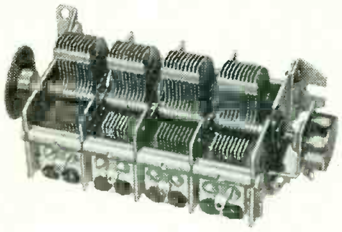


Mounting the speakers and microphones in separate padded compartments prevents backside radiation

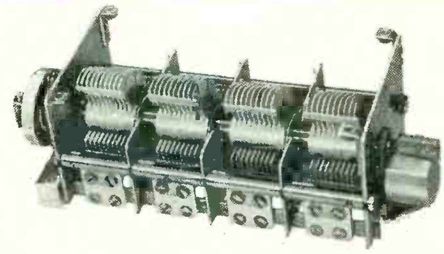
The speakers and microphone are mounted in a cabinet as shown in the drawing, and each unit is separated from the others by a partition. The remaining space in each enclosure is partly filled with sound absorbent material so that the backside radiation of sound from the speakers is largely absorbed. The microphone enclosure provides a reduction of sound pickup from the speakers through the back of the cabinet.

To limit the range over which the acoustical balance must operate, the amplifier is adjusted so that the frequencies below 400 cycles and above 4000 cycles are attenuated. This does not seriously impair speech intelligibility.

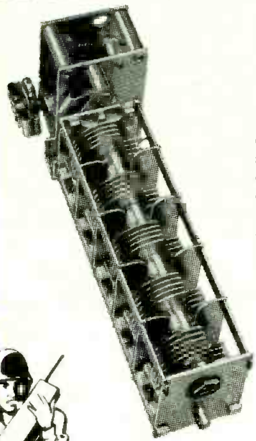
...THAT VITAL MESSAGES OF OUR FIGHTING FORCES WILL BE RECEIVED -*Distinctly!*



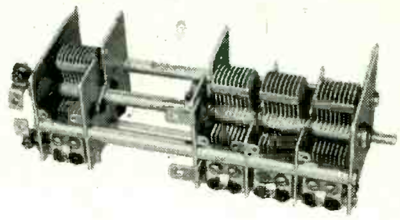
America's planes, once they're pointed toward the enemy, must receive every radio communication message *distinctly!* Accurate radio tuning is assured with Radio Condenser Company's variable air condensers.



Ships making their way in strange waters — they, also, use Radio Condenser Company's variable air condensers, so that there is accurate tuning to receive each message.



Even small radio communication sets, strapped to our soldiers as a vital part of their equipment, use these variable air condensers. Distinct tuning is the reward.



Of no less importance are the radio communication sets in our big powerful tanks. They, too, play an important part, and even when the going is rough-and-tumble, these air condensers provide accurate radio tuning.

The variable air condensers of Radio Condenser Company are today being used by our armed forces . . . not only on radio apparatus in tanks, but on planes and all types of radio communication sets.

This means, currently, that we are engaged 100% in war work. But, after the war, we will again be in a position to provide manufacturers of radio sets with a new, modern line of air condensers and push button tuning devices. So, in planning your post-war radio manufacture, plan to use Radio Condenser Company products.

RADIO CONDENSER CO.

CAMDEN, N. J.

RADIO CONDENSER CO. LTD., TORONTO, CAN.

or lower to suit specific applications. A permanent magnet assembly may also be used.

The moving coil may also be operated from a single-ended stage as shown in Fig. 2. In this case a potentiometer is employed so that the plate current of the tube through one half of the coil may be effectively cancelled by current flow through the other half.

The pen arm of the recorder is equipped with a nichrome stylus which is heated by passing a current of about 0.8 amp through it. This melts the fusible surface of the recording paper and eliminates the use of ink or other fluid. This type of pen has no measurable friction and the system can be properly damped electrically without mechanical adjustments. Any desired density of line can be obtained by varying a rheostat to control the temperature of the stylus. The length of the pen arm depends upon the frequency response and the sensitivity of the unit.

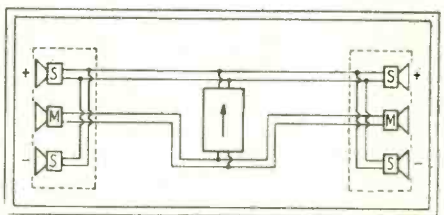
• • •

Loudspeaking Telephone

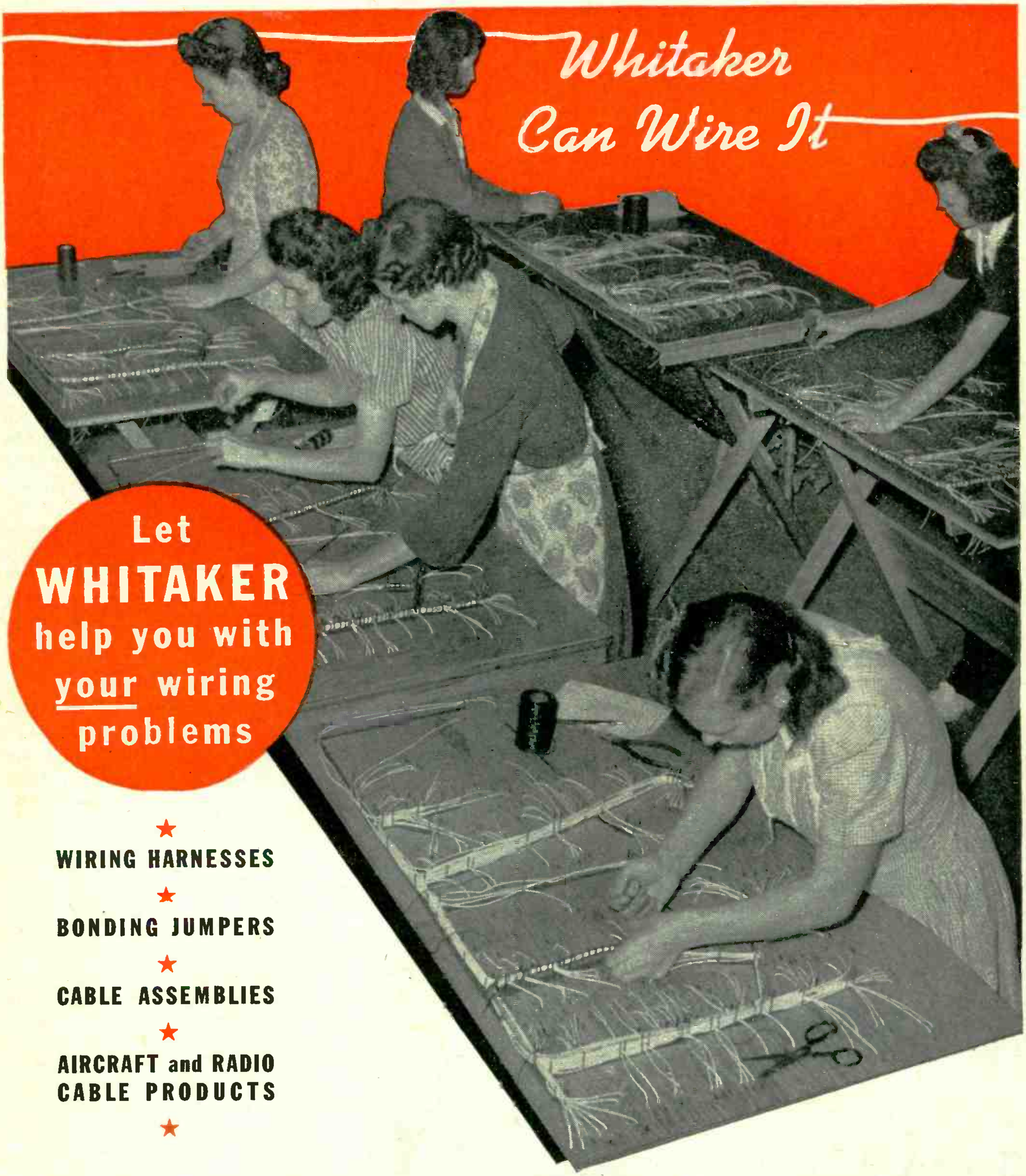
TWO-WAY LOUDSPEAKER telephone service between two or more locations, so that persons conversing may speak and listen at a distance from the apparatus without operating the usual "talk-listen" switch, is provided by the circuit shown in the diagram. This is obtained by using an acoustically balanced combination of speakers at each station to overcome acoustic feedback and resultant howling.

Each station in the system is arranged with three loudspeakers. One of these is employed as a microphone, while the other two speakers have their voice coils connected in parallel and out of phase with each other.

The third speaker is used as a microphone and is placed midway between the two loudspeakers. When a



Circuit of acoustically balanced telephone system. Speakers S have their voice coils connected out of phase so that the cones move in opposite directions. Sound waves from the cones cancel one another and little energy remains to feed back through the system



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● Jacks-of-all-trades have their place . . . but *not* in General Electronics Industries. Everyone in this organization, from top-flight research engineers to service men and their assistants, is an electronics specialist.

We have no miracle gadgets nor mysterious cure-alls for sale. Our business is the proper application of electronics to solve individual production problems. This begins with diagnosis, *follows through* with research, perhaps special design, and includes expert service before and after completion of the job.

To assist you in your post-war production planning, one of the largest organizations specializing in Electronics offers the skill, experience and unsurpassed facilities that have successfully met the most exacting tests of war.

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Music for Morale

To HELP COMBAT wartime fatigue, a sound system is used to supply music to workers in the plant of the Barbour Welting Co. at Montello, Mass. Records are played for fifteen minutes every hour from 10 a.m. to 12 and from 12:45 to 4:45 p.m. News broadcasts are received on a tuner unit and go out over the system during lunch and recreation periods.

Electrical transcriptions are accommodated on a slow-speed turntable which is also used to record musical accomplishments of talented workers

All the programs originate in the studio shown in the photographs, which contains a control panel that permits selecting any or all departments in four factory buildings. Popular numbers are most often used and many employees bring in their favorite records for the enjoyment of their fellow workers. Microphones are also available for addressing selected departments and to broadcast safety cautions.

Control panel and record changers for supplying music to workers in four factories of a Massachusetts plant

R-F Heating

(Continued from page 101)

spars. A corner of this press can be seen at the right in Fig. 5 and a full view in Fig. 13. The moving platen is 8 in. wide and 20 ft long. Pressure is applied by pneumatic cylinders which, since the photo was taken, have been increased from five to nine in number so that pressures of the order of 200 lb per sq in. can be obtained over the surface of a spar 6 in. wide and 16½ ft long.

The electrode arrangement for this big press is shown in Fig. 14. The most notable feature is the provision of two tuning inductances. These are stubs made of 1½-in. copper pipe mounted on standoffs at the back of the press. This arrangement, which was suggested by Bierwirth,[3] is used to reduce the voltage variation along the press which would normally occur due to the fact that at 8.5 Mc the 16½-ft length of the spar is an appreciable part of a wavelength. By spacing the two inductances at one-third intervals, as shown, the voltage along the spar is held within 10 percent.

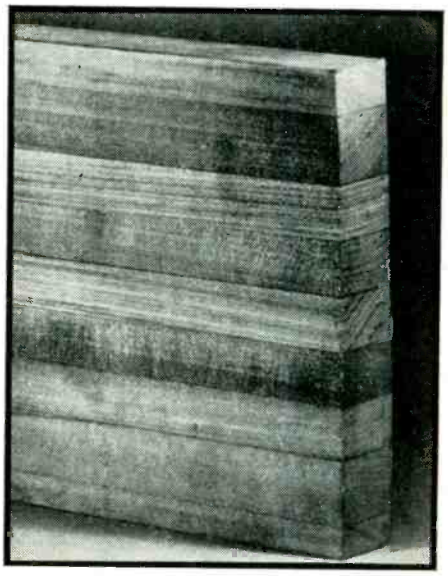

FIG. 16—End of a multi-laminar spar made by the radio frequency method

Due to the fact that the power factor and dielectric constant of the wood change during the cycle, it is necessary to make minor adjustments of the stub shorting bars if precise tuning (and maximum heating effect) is desired.[4] Fairly good results, however, can be obtained by tuning the stubs so that resonance occurs at about the middle of the cycle. This

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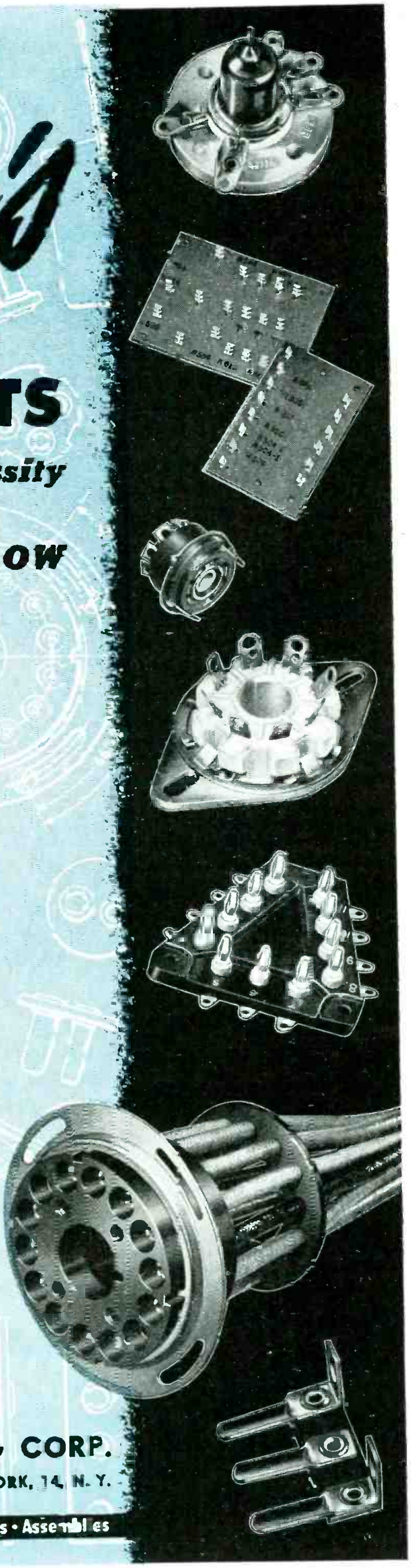
Sockets, Plugs, Switches, Contacts, Terminal Boards and Assemblies to perform electronic applications unheard of prior to Pearl Harbor Day was the crying need two short years ago.

Franklin engineers, like all American Industry, tackled the job with one purpose in mind . . . to quickly supply the armed services with newly designed electrical fittings to perform required electronic applications while withstanding most severe manhandling.

By discarding every precedent and starting from scratch Franklin engineers developed new Sockets, Plugs, Switches, Contacts, Terminal Boards and Assemblies which found high favor with manufacturers of electronic units and with the armed services.

Franklin's New Line developed for today's war equipment will find many applications for tomorrow's peacetime electronic equipment.



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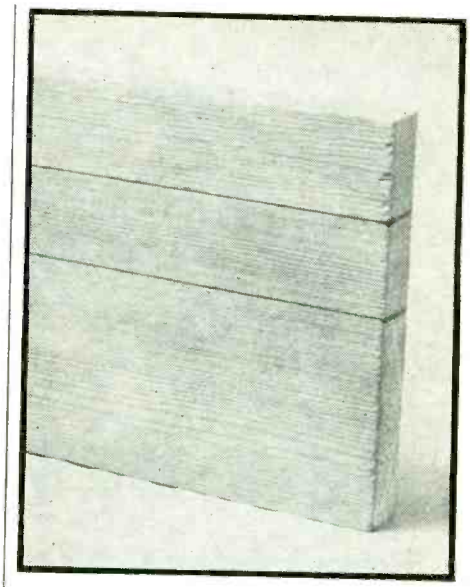


FIG. 17—Edge-glued joints in ¾-in. thick board made by the method shown in Fig. 10

obviates the need of retuning during the operation.

A piece cut from the end of a 6 x 6-in. block made in the big press is shown in Fig. 15. Such a block is sliced vertically to obtain a multi-laminar plank from which the final spar is cut and shaped. An end of one of these planks is shown in Fig. 16, and edge-glued joints are shown in Fig. 17.

Strength of Multi-Laminar Spar

The spars made by this process have been very satisfactory in every respect and have rated highly in every test to which they have been subjected.

The L-2 plane weighs 1300 lb, fully loaded. In static tests, Taylorcraft engineers have placed 5000 lb on a single wing panel constructed with multi-laminar spars. This is equivalent to 10,000 lb over the plane's total wing surface. The spars "took it" without the slightest trace of damage.

Incidentally, the all-metal (fabric-covered) wings of earlier Taylorcraft commercial trainers—from which the L-2 was developed—were considerably heavier than the wood wings and took loads up to only about 3800 lb.

REFERENCES

(1) Taylor, John P., Heating Wood With Radio-Frequency Power, *Trans. ASME*, April 1943.

(2) Taylor, John P., Radio-Frequency Heating Speeds Plastic Molding Operations, ELECTRONICS, Sept. 1943.

(3) Bierwirth, R. A. and Hoyler, Cyril N., Radio-Frequency Heating Applied to Wood Gluing, *Proc. IRE*, Oct. 1943.

(4) Brown, George H., Heat-Conduction Problems in Presses Used for Gluing of Wood, *Proc. IRE*, Oct. 1943.

Aluminum just naturally belongs in the Electronics picture

Electronics at work frequently involves aluminum in some form or other; in the device itself or the apparatus working with it. Designers and manufacturers will find in the following tabulation the properties which make versatile aluminum so highly desirable for such equipment.

LIGHTNESS with HIGH STRENGTH — The light weight of aluminum is its most striking quality; lightness with high strength. It weighs only one-third as much as the heavy metals.

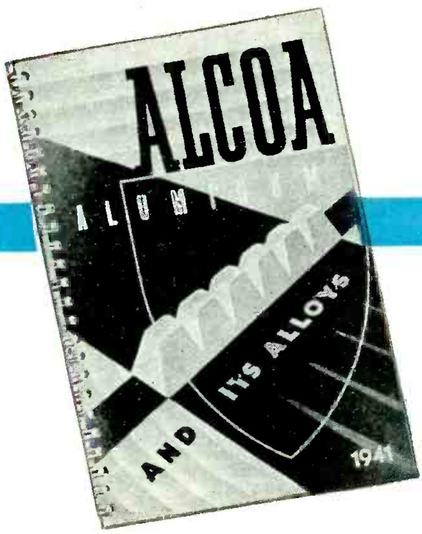
RESISTANCE TO CORROSION — Aluminum is able to resist the corrosive action of the atmosphere and a great variety of chemical compounds.

HIGH THERMAL and ELECTRICAL CONDUCTIVITY — Heat is distributed rapidly throughout its mass, usually permitting higher ratings. And aluminum is also an excellent conductor of electricity.

NONMAGNETIC NONSPARKING — Being nonmagnetic and nonsparking, aluminum is especially desirable for many electronic and associated devices.

EASY TO FABRICATE — Alcoa Aluminum Alloys are available in every commercial form, and are easily fabricated by all common methods. They can be economically finished in a wide range of durable, attractive surface finishes.

The booklet, "Alcoa Aluminum and Its Alloys," presents in concise form much fundamental information of value to designers and manufacturers. If you are wondering about including aluminum in your military or postwar products, you should have a copy. Mail the coupon today.



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Equipment Distribution

(*Continued from page 107*)

in many ways. For example: Independent electronic consultants are established throughout the country. These men can be employed to solve specific problems. Electronic specialists can be employed by the jobber on a full time basis. Independent, engineering-minded, factory representatives can supply both sales and engineering talents needed for distribution on a part-time basis. Specialty organizations acting as factory branch service stations can be created in specific territories.

In this group good technical sales and service literature is of extreme importance, as direct control of the application and installation of complex equipment is out of the hands of the manufacturer.

Component Parts

Group 3—At present almost all replacement radio components are distributed through jobbers. So are most of the component parts for industrial electronic applications.

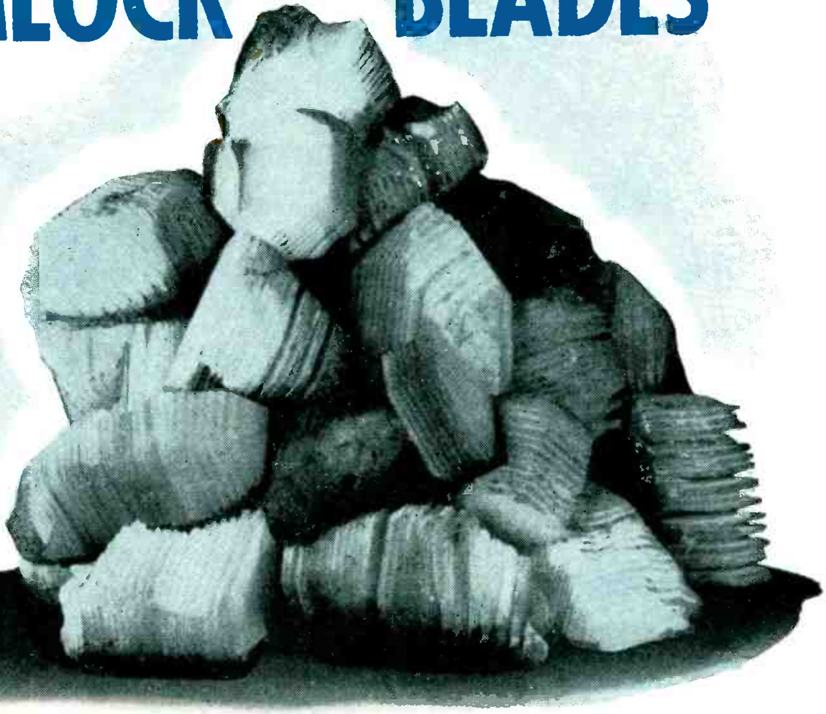
As the field of industrial electronics broadens, it may develop its own unique methods of distributing component parts and, possibly, break away entirely from the radio receiver replacement field.

The specializing jobber of industrial electronic components, if there is to be one, would probably be a large distributing house, because large dollar volume and very complete stocks must be maintained at all distribution points to properly serve industry. This will be an essential, as industry in general will not completely accept electronic devices until it is certain that it can purchase replacement parts locally in case of breakdowns.

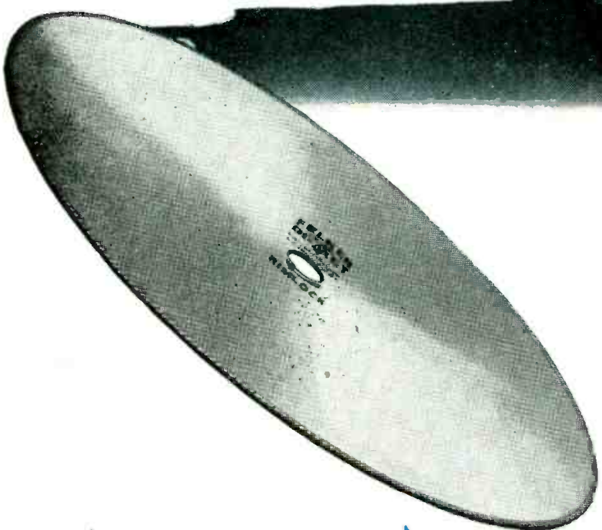
Component parts manufacturers will have to supply industrial electronic component parts jobbers with proper tools with which to serve industry. These should include a well-balanced and complete line, catalogs with technical data, and consistent promotional support.

In all three product groups technical knowledge will play an extremely important part in the distribution scheme. Industrial electronics will, in fact, call for a new and higher order of sales engineering talent.

MORE *Quality* QUARTZ PRODUCTION by maintaining the free cutting action of DI-MET RIMLOCK BLADES



DI-MET Rimlock quartz cutting wheels are characteristically fast, smooth, free-cutting blades ...but—the *proper operation* of Rimlocks not only gives better over-all results in blade life, etc., *but greatly improves wafer quality as well by reducing checking and wedging.* The Rimlock that lasts the longest produces the best wafers...and that's why the free cutting qualities of Rimlock blades should be maintained.



The method is easy—merely follow the simple suggestions outlined below. They have been especially worked out to insure you *more* and *better* quartz production...

1. *Operate Rimlocks at the proper speed!* Surface speed should range from 4000 to 4500 s.f.m., which is an r.p.m. of approximately 2000 for an 8" diameter wheel.

2. *Keep feed pressure light!* A load of 7 lbs. is generally ample. Maintain a light firm pressure. Too much pressure dulls the blade, results in "dishing," which causes wedging and increases checking.

3. *Use abundant coolant, accurately directed.* Flood both sides of blade generously and be sure coolant actually reaches the line of cut . . . do not compromise. Maintain quality coolant.

4. *Use ample motor power!* Variation of blade r.p.m. during cutting lowers blade efficiency, dulls cutting edges and destroys accuracy. A ¾ h.p. motor is recommended for general quartz cutting operations.

Results of following these 4 rules are well worth the effort. Wear is reduced to a minimum . . . re-sharpening (which shortens blade life) is less frequent . . . accuracy is maintained. *And most important of all, the longer life of your Rimlocks produces more high quality wafers!*

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FELKER MANUFACTURING CO.
1116 BORDER AVENUE, TORRANCE, CALIF.

MANUFACTURERS OF DIAMOND ABRASIVE WHEELS

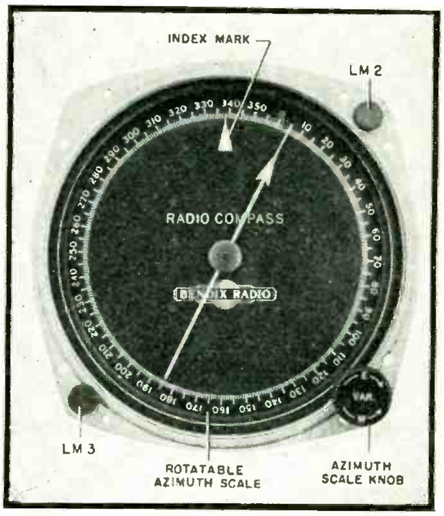
Direction Finders

(*Continued from page 148*)

supply, and its load is placed in the cathode circuit. On negative half-cycles of the grid voltage V_3 is cut off, but on positive half-cycles voltage is applied to the plates of V_1 and V_2 through reactors T_2 and T_3.

At all times the second winding MW_2 of the two-phase motor is excited continuously from a voltage obtained from the primary of T_4 serving as a step-down auto-transformer. Phasing capacitors C_{11} and C_4 are in the circuits of MW_1 and MW_2 respectively. The proper conditions are thereby established for reversal of rotation in accordance with the phase of the 48-cycle grid signal.

It is well to note at this point that such a circuit allows power to be supplied from a source of quite different frequency (400 cycles) from the modulating frequency (48 cycles) used in the loop circuit. As a result, the phase relationships of the two systems are entirely independent. Advantage is taken in such a circuit of the use of saturable reactors so that much lower power-handling capacity of thyratrons V_1 and V_2 is necessitated. Each reactor is so wound that the split a-c windings which make up B_1 or B_2 induce very little alternating voltage in plate windings A_1 and A_2. In small size units, where the required torque is also small, it becomes feasible to keep motor winding MW_2 continuously excited. The ystem of Mark I avoids this difficulty when the loop has reached the null position.



Bearing indicator of MN-31 system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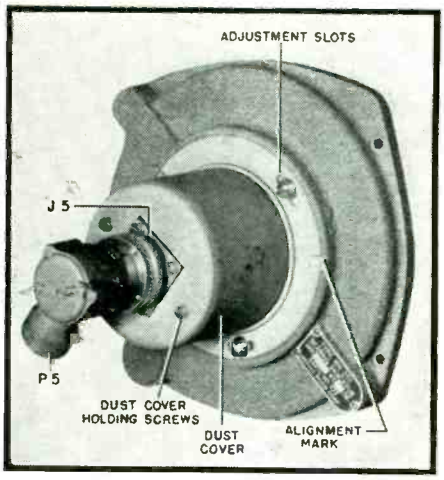
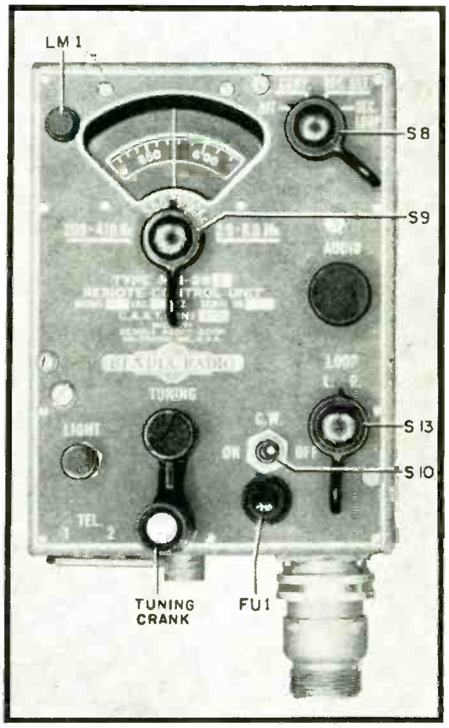


Rear view of bearing indicator

In the *MN*-31 direction finder, anti-hunt operation is secured by two means. In the first place, the loop motor is designed to have extremely small moment of inertia. This becomes more practical because of the fact that it is not required to drive a tachometer type of flexible shaft connected to the bearing indicator unit. In the second place, the automatic loop control unit serves to give anti-hunt action by virtue of a circuit which is frequently referred to as an anticipator. In the common cathode lead of thyratrons V_1 and V_2 a resistor-capacitor combination, R_3 and C_3, is included. When either thyratron passes plate current, the voltage across R_3 biases off both tubes by an



Remote control unit of Bendix MN-31 automatic direction finder system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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
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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
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appropriate amount. Then when the 48-cycle signal diminishes as the null point is being approached, a condition is reached at which the conducting tube is cut off. This will occur before the control signal reaches zero, and as a result the motor will coast (but with rapid damping) to the null point. The exact adjustment of R_8 is not important because of the fact that if the loop stops short of the correct position, the d-c bias appearing across C_3 will fall to zero in a very short interval. Then if there is a control signal from T_1 still present on the grids, the motor will start up again and go to the proper rest point.

Bearing Indicator System

Indication of loop position is given by means of a self-synchronous transmission system. Mechanically connected to the loop is Autosyn transmitter MO_3 (upper left in Fig. 20). At the indicator itself is a similar unit, receiver MO_4. The rotor windings of these two units are connected in parallel across the 400-cycle supply. The phase windings, denoted by ϕ_1, ϕ_2 and ϕ_3 in Fig. 20 or the simplified circuit of Fig. 23, are interconnected. Then if the two rotors do not occupy the same relative angular position, currents will be set up in the phase windings in a manner to develop a restoring torque and to bring the indicator unit, MO_4, to the correct position. The angular ac-

• • •

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British wireless operator and his equipment on a motor torpedo boat. These little boats help protect convoys in the English Channel from German E-boats and Galietboats

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curacy of such a data transmission system is of the order of ±1 deg. since most of the fixed residual errors of a given installation may be corrected by means of a mechanical compensator. Power supply for the indicator unit and for the motor control circuits is derived from a rotating machine, a 400-cycle inverter.

Mechanically interposed between the loop with its motor drive and the self-synchronous transmitter, MO_3, is a mechanical compensator. It shows the point of connection of the Autosyn shaft and the correction means. This latter consists of a series of adjusting screws spaced at 15-deg. intervals around the periphery. These may be set to insert at each of these points as much as ±25 deg. of angular displacement between the loop and the Autosyn unit. The correction scale indicates directly this compensation. This may be contrasted with the method used in the Mark I direction finder, where a cam is cut to give he required correction. In the MN-31 unit the compensator adjustment screws act to displace radially a flexible tape, against which a cam follower presses. Thus quadrantal or other types of error of a given installation may be compensated.

Acknowledgment is made to Bendix Aviation Corporation, Sperry Gyroscope Company, and Radio Corporation of America for permission to use certain of the material and illustrations which appear here.

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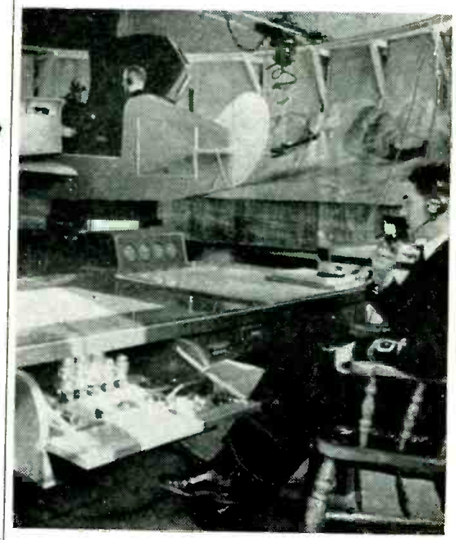
BRITISH LINK TRAINER



A Link trainer in action at a Royal Naval Air Station. The desk contains an electronic amplifier that the instructor uses to communicate with students during blind flying training

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Perhaps we can talk about a coil problem . . . how thoroughly we're organized to help you on such a problem only military censorship forbids telling now. Or it may be that you manufacture your own coils and will be interested in discussing magnet wire—any shape—any insulation that your operations require.

As a matter of fact, perhaps we can get together now, but if it happens we can't, remember we have a date in and for the future. When we both can keep it, you can again take advantage of Anaconda service and the benefits derived from the single product control "from mine to consumer" backed by years of continuous metallurgical experience.

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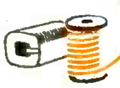
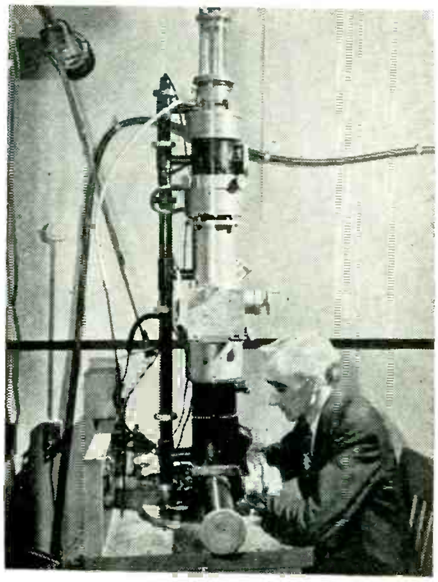


magnet wire and coils

ANACONDA WIRE & CABLE COMPANY

THE ELECTRON ART



Dr. Prebus focuses his electron micro-diffraction camera. The electron microscope camera is the cylindrical black tube at the base of the instrument, while near his head is the diffraction camera. The source of the electron beam, a tungsten filament, is at the top of the assembly

Electron Micro-Diffraction Camera

By Olof J. Olson

The first electron micro-diffraction camera on this continent is now in operation at the Radiation Laboratory of Ohio State University. It was designed and built by youthful Dr. Albert F. Prebus, Canadian-born electron optics scientist.

The new instrument is a marked refinement of the electron diffraction camera and an extension of the range of vision of the electron microscope. In the new instrument, a fine beam of electrons is adjusted to strike a selected microscopic area or a single structure in the specimen. By switching on and controlling the strength of a magnetic electron lens immediately below the specimen, it is possible to observe and photograph the magnified image of the selected microscopic area or a single structure in the specimen. With the area or specimen in the identical position, the diffraction pattern may be observed or photographed by merely switching off the magnetic lens.

The electron diffraction camera is a few years older than the electron microscope. In the electron diffraction camera, the beam of electrons is directed against the surface of a specimen. The electrons which have collided with the atoms in the specimen are deflected from their original direction of travel and are permitted to strike a fluorescent screen. There they form a pattern in direct ratio to the number of electrons that strike the area. This pattern, when photographed, usually consists of a regular array of spots and rings of light and shadows as shown in Fig. 1.

However, the electron diffraction camera was developed without the use of magnetic electron lenses and

Fig. 1 (left)—Diffraction pattern of crystalline colloidal particles of kaolin produced by the electron micro-diffraction camera Fig. 2 (right)—Colloidal particles of kaolin magnified 30,000 times by the electron microscope camera

the patterns photographed with it provide information which is only a statistical average for all of the structures in an entire specimen. Since no specific area or specimen in the area can be selected, magnified and studied (as in the new instrument by using the magnetic electron lens), erroneous conclusions often crop up regarding a given substance due to the presence of contamination or an unanticipated structural form.

The two photographs with this ar-

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A portion of the Army display of captured enemy equipment shown at the Fall meeting of IRE in the lobby adjoining the auditorium of the Hotel Sagamore, Rochester

OHMITE RHEOSTATS

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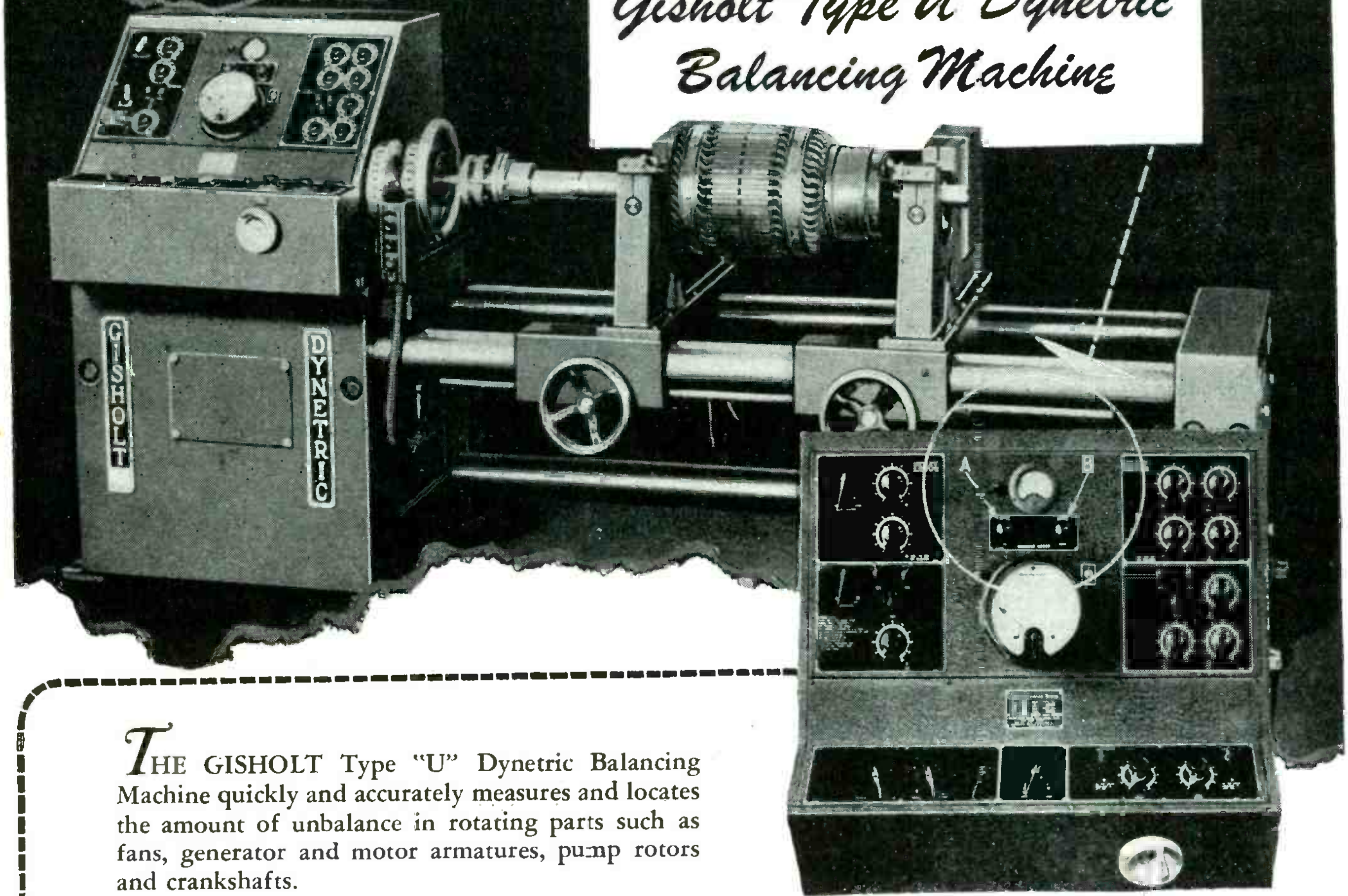

THE GISHOLT Type "U" Dynetric Balancing Machine quickly and accurately measures and locates the amount of unbalance in rotating parts such as fans, generator and motor armatures, pump rotors and crankshafts.

Vibrations as small as .000025″ caused by an unbalanced part generate a voltage in the electrical system directly proportional to the amplitude of the vibrations. This voltage is greatly amplified to obtain distinct, reliable readings.

Two Ohmite Rheostat-Potentiometers are employed in the amplifier to give an accurate adjustment of the current generated. They make possible quick, easy adjustment of the electrical system to show the exact location of the unbalance and the amount of correction necessary. An Ohmite Model "J" (Knob "A") is used for fine adjustments. Ohmite Model "L" (Knob "B") for coarse adjustments.

This is another example of the contribution of Ohmite Rheostats to precision accuracy in a wide variety of applications. Their time-proved design and construction insure permanently smooth, close control. There are ten wattage sizes from 25 to 1000 watts, in straight or tapered winding, in single or tandem units. Ohmite Engineers are glad to assist you on any problem.

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ticle were taken by the new instrument. They are of kaolin clay, used extensively in the manufacture of fine porcelain.

Figure 2 shows colloidal particles, taken with the electron microscope camera, magnified 30,000 times. The white line represents the magnification of a particle that actually measures 125,000 of an inch. Figure 1 shows the diffraction pattern of the same crystalline colloidal particles, as captured by the electron micro-diffraction camera.

The new instrument is the third electron microscope that Dr. Prebus has designed and built at Ohio State since his arrival three years ago. He now is building an instrument that is intended to be a further refinement of the instrument described in this article.

Electron Microscopy Bibliography

PAPERS that have appeared in scientific periodicals on the subject of electron microscopy have been compiled in the form of a bibliography by Claire Marton of Stanford University and Samuel Sass of the University of Michigan, and published in the October, 1943 issue of the *Journal of Applied Physics*, 175 Fifth Ave., New York 10. An attempt has been made in the compilation to present the field as completely and impartially as possible.

The material is arranged in eight categories: books, emission microscopy, transmission type microscope, optics of the transmission type electron miscroscope, image defects, electron speeds above 100 kv, different related instruments, and applications of the transmission type microscope. The arrangement is chronological and within each year alphabetical by author and title. The bibliography covers the developments of the art in the past ten years and extends to May, 1943.

Polycylindrical Endovibrators

A MULTIPLE RESONANT LINE that consists of a cylinder with two end plates and contains a number of coaxial cylinders mounted inside, is described by M. S. Neyman in *Izvestia Elektroprom. Slab Toka,* No. 2, 1940 and abstracted in the August 1943 issue of *Wireless Engineer.*

The internal cylinders are mounted alternately to one or the other end plate so that their free ends do not quite reach the other end plate. The arrangement is equivalent to a number of coaxial lines connected in series, each of which is formed by the outer surface of a cylinder and the inner surface of the next larger cylinder. The mechanical and electrical advantages of the system over an ordinary resonant line are pointed out, and methods are suggested for designing a system with a given diameter of the outside cylinder so as to obtain the lowest decrement for the greatest stabilizing effect.

New Television System

INVENTION OF an electronic television system that transmits the equivalent of an entire image at all times, with scanning being employed only at the receiver, was announced recently in New York City by Dr. Palmer H. Craig, head of the Department of Electrical Engineering at the University of Florida, Gainesville, Fla.

The required band width for video in the Craig system is 60 kc or less, according to the announcement, which means that the system could utilize carrier frequencies near the present broadcast band, with corresponding large coverage and network operation.

Dr. Craig already has to his credit a number of inventions in the fields of applied physics and electrical engineering, and his published works include two feature articles in ELECTRONICS on the Kathetron, an external-grid control tube on which he was granted five patents.

Although the proposed new system of television has not been constructed yet in its entirety, Dr. Craig stated that parts of the system had been built and tested individually with satisfactory results.

The description of the Craig system as set forth here was prepared by Dr. Craig's assistants to set forth basic principles only, and is not intended to be a complete analysis of each component part.

Basic Concept of System

In the sending equipment, light incident upon an elementary area of a photosensitive screen in one end of a camera tube causes electrons to be emitted in number proportional to the intensity of the light. These electrons ionize gas in the tube directly behind this elementary area. The positive ions formed are in turn caused to travel in a narrow beam, at a definite velocity determined by their mobility through a series of equally spaced electro-magnetic pickup loops.

If this beam of ions is intermittent it will cause induced voltage of definite value in these loops, determined by their geometry and the

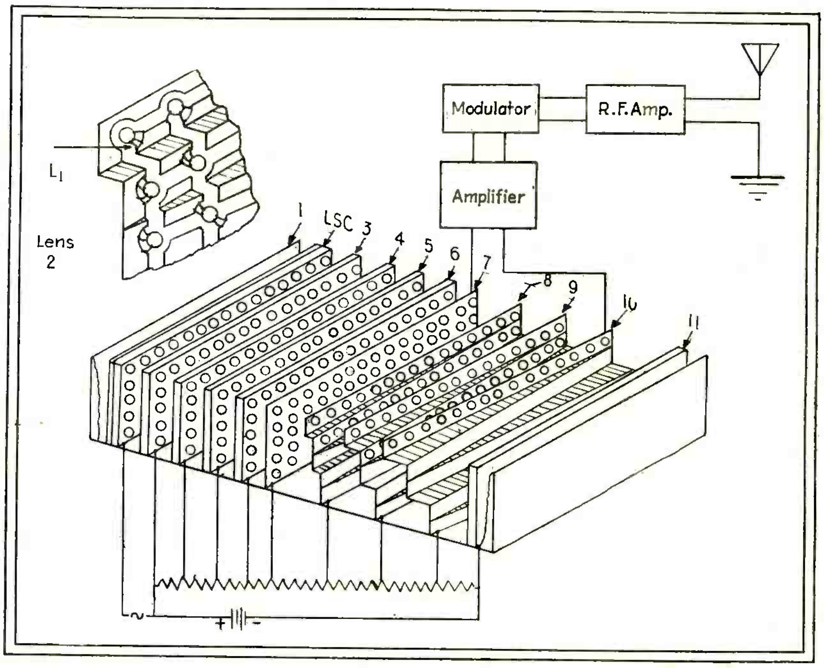

Fig. 1—Construction details of cathode ray pickup tube used in television camera of Craig system

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ELECTRONICS

velocity and intensity of the ion beam. The frequency of this induced voltage will be determined by the velocity of the ions and distance of separation of the pickup loops.

A second elementary area of the photosensitive screen has its corresponding ion stream, which in turn passes through its own set of loops. If the distance of separation of this set of loops is different than in the first case, then the velocity of the ions remaining the same, the frequency produced in the loops will be different than in the previous case. Thus each elementary area of the photosensitive screen will have its corresponding voltage of definite frequency induced in the loop system. If these loops are all connected in series there will result a complex voltage wave containing all the frequencies and amplitudes corresponding to all the elementary areas of the photosensitive screen, and therefore characteristic of the incident light.

The purpose of the receiving set is to remove from this complex wave one frequency at a time which will determine the position of the elementary area and the intensity of the original light on this area, and reconstruct an image corresponding

• • •

ELECTRONIC MEGAPHONE

A portable amplifier and self-contained batteries permit this electronic megaphone to be used anywhere for sound reinforcement. A product of Operadio Mfg. Co., the unit has the same specifications outlined on page 125 of November ELECTRONICS

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Relays for the Electronic Age of Tomorrow are Battle Proven Veterans of Today

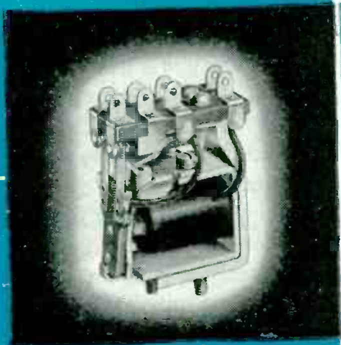
BO

MODEL BO DP DC COIL DATA				
COIL NUMBER	NOMINAL VOLTS	AMPERES	RESISTANCE	WATTS
24	2.1	1.21	1.7	2.5
28	5.0	.500	10.0	2.5
29	6.0	.422	14.2	2.5
30	7.8	.319	24.5	2.5
32	13.2	.190	70.0	2.5
34	20.0	.125	160.	2.5
35	24.0	.106	230.	2.5
36	32.0	.078	415.	2.5
40	77.0	.032	2380.	2.5
42	112.	.022	5000.	2.5

Also readily available for AC.

BO is a compactly designed 2 pole DC 2½ watt relay; equipped with a semi-balanced armature; withstands vibration to 12 G; operates at temperatures of + 70° C. or – 50° C.; resists corrosion; weighs 4 ounces; measures 1⅞ by 1⅜ by 1-17/32 inches; standard is double pole double throw and rated 15 amperes at 24 volts DC or 110 volts AC.

BJ



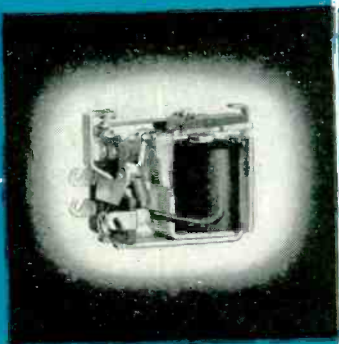
MODEL BJ DP DC COIL DATA				
COIL NUMBER	NOMINAL VOLTS	AMPERES	RESISTANCE	WATTS
18	0.36	5.590	0.06	2
20	0.57	3.520	0.16	2
22	0.89	2.240	0.40	2
24	1.41	1.414	1.00	2
26	2.25	0.089	2.53	2
30	5.65	0.354	16.	2
33	11.6	0.173	67.	2
36	22.5	0.089	255.	2
38	35.4	0.056	625.	2
40	56.6	0.035	1600.	2

Also readily available for AC.

BJ is a small and compactly designed 2 watt relay; equipped with a semi-balanced armature; withstands vibration to 12 G; operates at temperatures of + 70° C. or – 50° C.; weighs 2¼ ounces, measures 2-5/16 by 1-9/16 by 25/32 inches; can be supplied in various contact arrangements, standard is double pole double throw and rated 5 amperes at 24 volts DC or 110 volts AC.

Shown are 4 of the outstanding Relays in Allied's complete line. Operating characteristics shown are nominal and can be varied to meet special requirements. Coils are cellulose acetate sealed against humidity and salt spray. Bakelite parts are wax impregnated.

AR



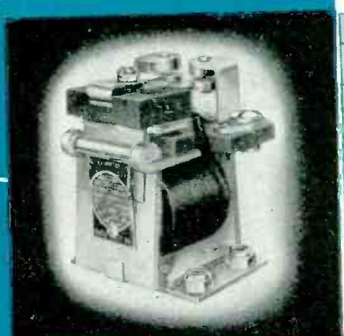
MODEL AR SP DC COIL DATA				
COIL NUMBER	NOMINAL VOLTS	AMPERES	RESISTANCE	WATTS
20	.329	3.043	.108	1
22	.526	1.900	.277	1
24	.844	1.185	.712	1
28	2.158	.461	4.70	1
32	5.568	.180	31.0	1
35	11.31	.088	128.	1
38	22.98	.035	528.	1
40	36.81	.027	1355.	1
42	59.03	.017	3485.	1
44	94.68	.011	8965.	1

Also readily available for AC.

AR & AS are featherweight 1 watt relays; weigh only 50 grams, measure 1-3/16 by 1⅝ by 15/16 inches; contacts handle 5 amperes at 24 volts DC or 110 volts AC single pole double throw.

Model AS is insulated from frame . . . otherwise identical to model AR.

AN



MODEL AN SPDB DC COIL DATA				
COIL NUMBER	NOMINAL VOLTS	AMPERES	RESISTANCE	WATTS
24	3.07	1.140	2.70	3.5
27	6.16	.568	10.8	3.5
30	12.3	.284	43.4	3.5
31	15.6	.225	69.1	3.5
32	19.6	.178	110.	3.5
33	24.8	.141	175.	3.5
34	31.1	.112	277.	3.5
36	49.5	.071	700.	3.5
39	99.2	.035	2810.	3.5
40	125.	.028	4460.	3.5

AN & ANS are power relays with 3½ watt coils; equipped with semi-balanced armatures; withstand vibration to 12 G; operate at temperatures of + 70° C. or – 50° C.; weigh 9 ounces; measure 2½ by 2¼ by 1-31/32 inches; standard is single pole single throw normally open double break and rated 50 amperes at 24 volts DC.

Model ANS has special alloy contacts to handle 75 amperes DC . . . otherwise identical to model AN.

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to the light image impressed on the sending photoelectric surface. These single frequencies are removed one at a time by a beat oscillator and crystal filter. The amplitude of the wave determines the intensity of the light given out from the elementary area of the reconstructed image, and the frequency of the wave determines the position of each elementary area.

Operation of Transmitter

The transmitter analyzes the entire picture area substantially instantaneously and transmits a complex wave on each analyzing operation, the wave being made up of component waves having different frequencies determined by the elementary image areas which are illuminated at any given instant. The transmitter does not scan the image in the usual way, but each elementary area of the image to be transmitted acts simultaneously with the other elementary areas to establish separate component waves of a frequency dependent upon the position of the corresponding elementary area in the image area, the amplitude of each component wave being dependent upon the degree of illumination of the corresponding elementary area. The analyzing operation is repeated periodically at a rate of sixteen times per second or higher, that is, a rate sufficient to secure the illusion of continuous change in the reproduced

• • •

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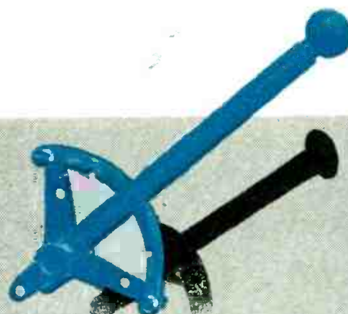

125 military planes awaiting aluminum supercharger control handles. Lewyt designed one of steel for greater strength, lower cost and **much quicker production**

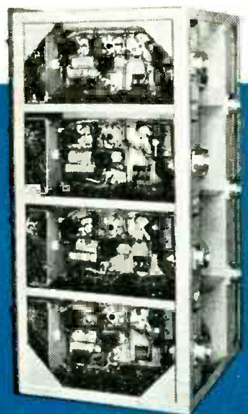

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image at the receiving station.

At the receiver, the transmitted image is reproduced by building up the elementary areas with scanning apparatus which traverses each point of the image area in the usual manner, but there is no necessary relation between the rate of scanning of the receiver and the rate of transmission of the composite wave from the transmitting station. A receiver is needed that can be tuned to selectively receive any component of the complex wave within the entire range of frequencies transmitted. The tuning of the receiver is varied simultaneously with the scanning operation to select the wave component being transmitted by an elementary area of the transmitter image corresponding in position to the elementary area of the received image which is being scanned at the particular instant. The scanning cycle of the receiver is made sufficiently high to secure the illusion of continuous change in the reproduced image.

Part of the transmitting tube is shown in perspective in Fig. 1. It is provided with an insulating envelope, 1, in one end of which is located a light-sensitive cathode *LSC* on which an optical image is formed of the object or subject to be transmitted, the image being formed by a suitable lens system represented at 2. Electrons are emitted from the surface of cathode *LSC* in accordance with the degree of illumination of any

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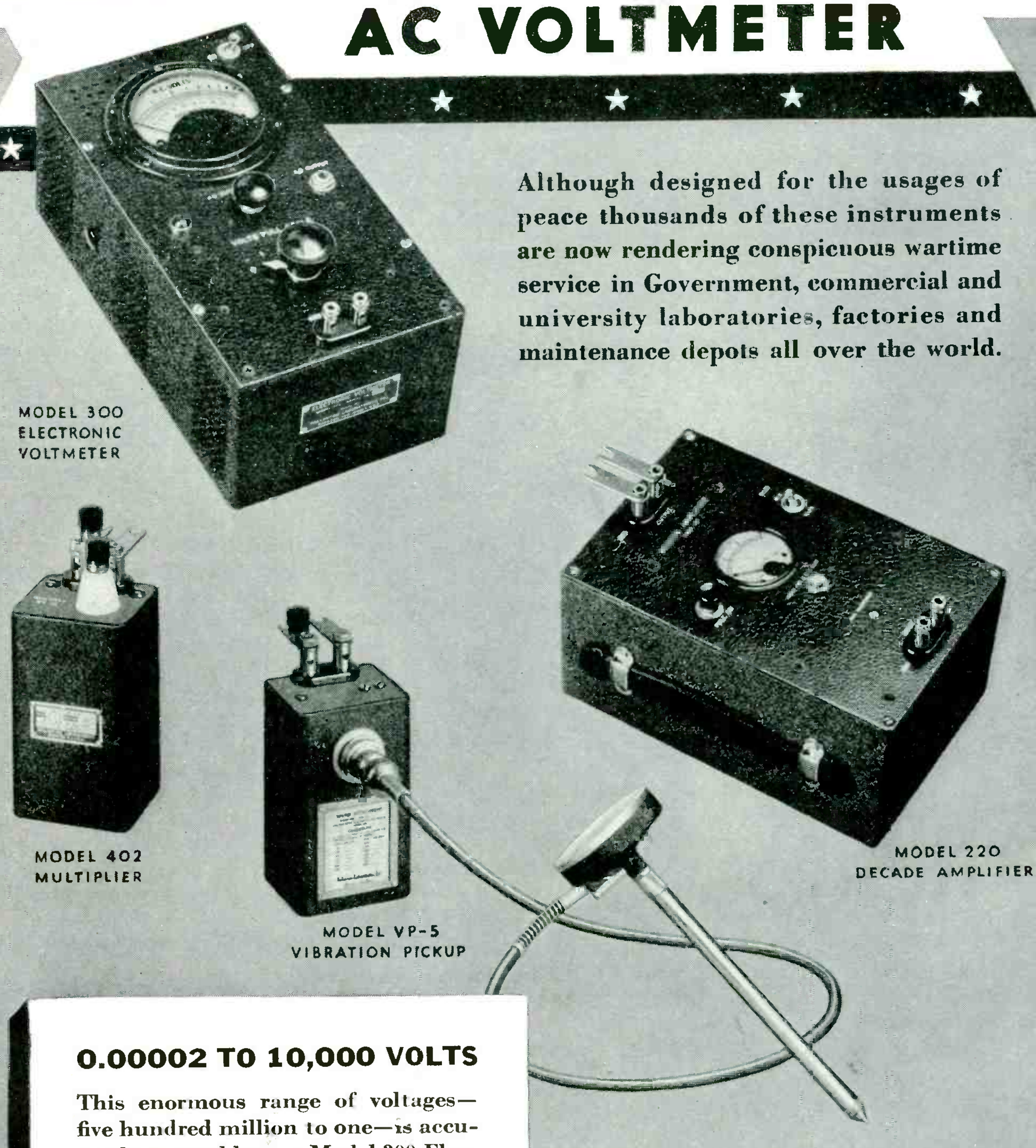

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particular point or area of the cathode. The cathode *LSC* is faced with a metal plate of some thickness, drilled with closely spaced holes of the size of the elementary scanning area to be used. These holes will act as a part of the electronic focusing assembly.

A control grid 3 is arranged parallel to cathode *LSC*. This grid is formed of a metallic plate of some thickness having holes formed therein corresponding to the various elementary areas of the image area on cathode *LSC*. The potential difference applied between *LSC* and grid 3 will give the electrons emitted by *LSC* sufficient energy to obtain maximum ionization of the gas in the region just beyond grid 3. Grid 3 must be properly placed with respect to *LSC* so that the corresponding holes in *LSC* and grid 3 cause proper focusing of the electrons.

A series of grids (4, 5, 6) of some thickness have holes located to correspond with the holes in grid 3 and the elementary areas of *LSC*. These grids are so placed as to give a potential gradient that will maintain the gas ions at a definite determined velocity of drift, and keep them focused in a straight-line stream corresponding to each elementary area.

A number of perforated plates (8, 9, 10) are arranged in nonparallel relation between the collector plate

• • •

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2 and the grid 6. These plates carry pickup loops described later. The potential gradient between grid 6 and the plate will, on the average, be the same as between grids 4, 5, 6. This will be accomplished by arranging the necessary potentials to plates 8, 9, 10. The tube is filled with a suitable ionizable gas or a small quantity of mercury vapor.

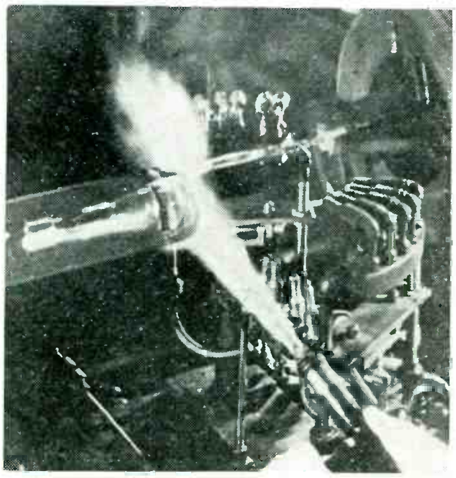
Holes in grids 3, 4, 5 and 6 correspond to the number and arrangement of the elementary areas in the effective image area of cathode *LSC*. In actual practice, these perforations would be of relatively small size by comparison with the effective image area and would be more numerous than in the arrangement shown in Fig. 1. In actual practice, the grids might be provided with perforations consisting of two hundred horizontal rows each containing two hundred perforations, which would correspond to 40,000 elementary areas in the effective image area.

Perforated plates 8, 9 and 10 are formed of suitable insulating material such as glass, mica, or the like, and each plate is perforated with the same number and arrangement of perforations as grids 3, 4, etc. They are of step-like construction, so that the distances of separation vary from hole to hole vertically and horizontally, but lengthwise along the tube the holes would be equally spaced from plate to plate.

The transmitting tube also contains a series of pickup loops on

• • •

X-RAY TUBE IN LATHE



Sealing the anode mount into a 220-kv industrial x-ray tube. An inert gas is flushed through the tube during this operation to prevent oxidation of electrodes plates 8, 9 and 10, shown in detail at L_1 in Fig. 1. This design can be obtained by stamping out the permalloy portion by means of a die, utilizing a film of permalloy about 0.001 inch thick. This permalloy design is then insulated with an extremely thin film of enamel or similar insulating material. The equivalent of turns of wire around portions of the permalloy pickup loops is obtained by electroplating a metallic deposit on both sides of the permalloy configuration.

This electro-plated equivalent of turns of wire can be put on by etching both sides of the permalloy configuration with a conductor such as graphite, which has been covered in all parts not desired to be electroplated by means of a very thin film of insulating material. Exposed portions are then electroplated on both sides, making sure that the edges are electrically continuous to form the electrical equivalent of turns of wire.

Thus, we have what is equivalent to a magnetic core, through apertures of which the ions pass. This core is wound with turns of wire for pickup purposes, so that if a "burst" of electrons or ions passes through one of the apertures, it will induce in the permalloy a magnetic flux and this flux will induce an electrical emf in the coil wound around the permalloy core. The loops of every third aperture are connected in series and are in turn connected automatically to the amplifier.

Grid 3 is controlled in potential with respect to cathode *LSC* so as to cause the grid potential to become alternately positive and then negative with respect to the cathode. This may be accomplished by any suitable sharply peaked control circuit represented by the a-c source between *LSC* and grid 3.

The purpose of changing the potential of grid 3 from negative to positive at periodic intervals is to produce "bursts" or clouds of electrons passing from cathode *LSC* through the apertures in grid 3 at spaced time intervals. Successive groups of electron "bursts" are produced at a rate of the order of sixteen per second or higher. The electron streams passing through grid 3 ionize the gas in the space between grids 3 and 4 and cause streams of ionized gas molecules to pass through grid 4, through plates 8, etc., and to collector plate 11.

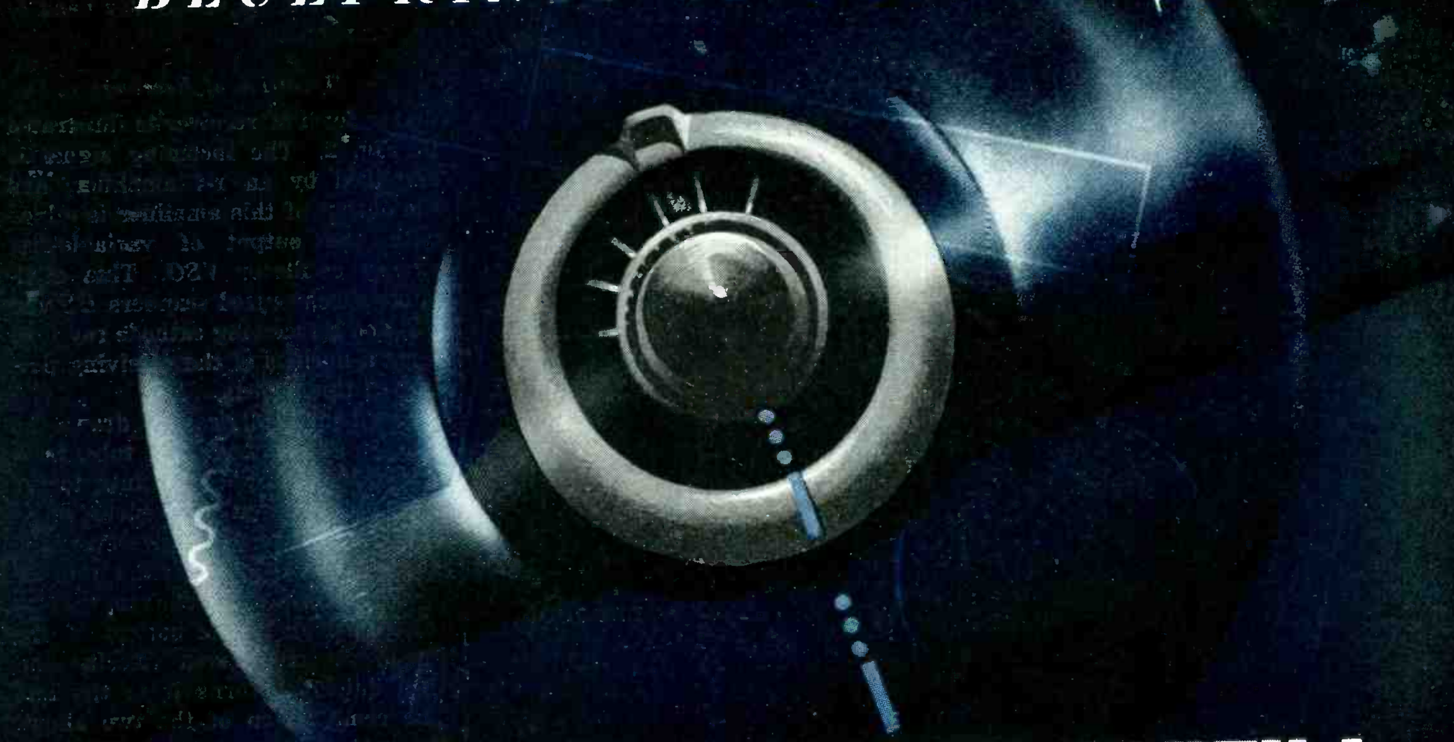
Operation is as follows: During the time intervals when grid 3 is negative with respect to cathode *LSC*, no electrons pass through the grid 3 and the tube is inoperative. During the very short "peaked" intervals when grid 3 becomes positive with respect to the cathode, electron streams pass through the apertures in grid 3, and the quantity of electrons in each stream is dependent upon the degree of illumination of the image areas on the cathode directly in line with the respective apertures in grid 3.

The positive potential on grid 3 accelerates the electrons towards the grid, and the momentum acquired by the electrons carries them through the apertures of the grid and into the space between grids 3 and 4 where they strike the gas atoms and ionize the gas by bombardment. The electrons slow down in this region and reverse their direction of travel, tending to return to grid 3 where their charges are neutralized. The positive ions proceed towards grids 4, etc., and pass through the apertures of these grids and travel towards collector plate 11. Each group of positive ions passing through an aperture in one of the pickup plates causes a variation in the magnetic condition of the core strip around the aperture, and thereby results in the generation of a voltage pulse in the pickup conductor carried by the core strip.

Accordingly, any given burst or group of ions which passes from grids 4, etc., through the four pickup plates 8, etc., to collector plate 11 will produce four voltage pulses in the input circuit of the modulator, and these voltage pulses will be spaced apart by time intervals dependent upon the distance of separation between the pickup plates and upon the speed of travel of the ion burst.

With a fixed speed of travel of the ions, each ion stream passing through the aligned apertures in these plates will generate a voltage wave in the input circuit of the modulator having a frequency depending upon the distance between corresponding holes in the pickup plates. Thus, a burst of ions passing through the aperture at the left end of the plates 8, 9 and 10 will produce a wave having a frequency located at one limit of the frequency band of the transmitter, while a burst of ions passing through the aperture at the right end of plates 8, 9 and 10 will produce a wave having a frequency located at the

BLUEPRINTS OF SAFETY



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other limit of the frequency band of the transmitter.

Operation of Receiver

One form of receiver is illustrated in Fig. 2. The incoming signal is amplified by an r-f amplifier, and the output of this amplifier is mixed with the output of variable-frequency oscillator *VSO*. This oscillator, synchronized scanners *HS* and *VS*, and a receiving cathode ray tube form a nucleus of the receiving portion of this system.

The horizontal scanner draws the spot on the cathode ray tube from the left-hand side of the tube to the right-hand side at some given velocity and then very quickly returns it to the left-hand side. The vertical scanner draws the spot from the top of the image to the bottom of the image at some given velocity and then quickly returns it to the top. The combination of the two allows the spot to trace out say 200 horizontal lines, each having say 200 picture elements.

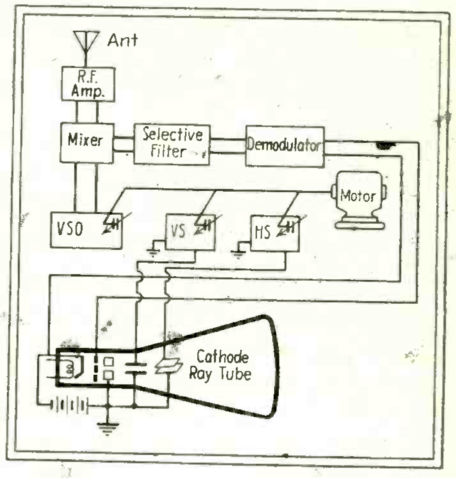
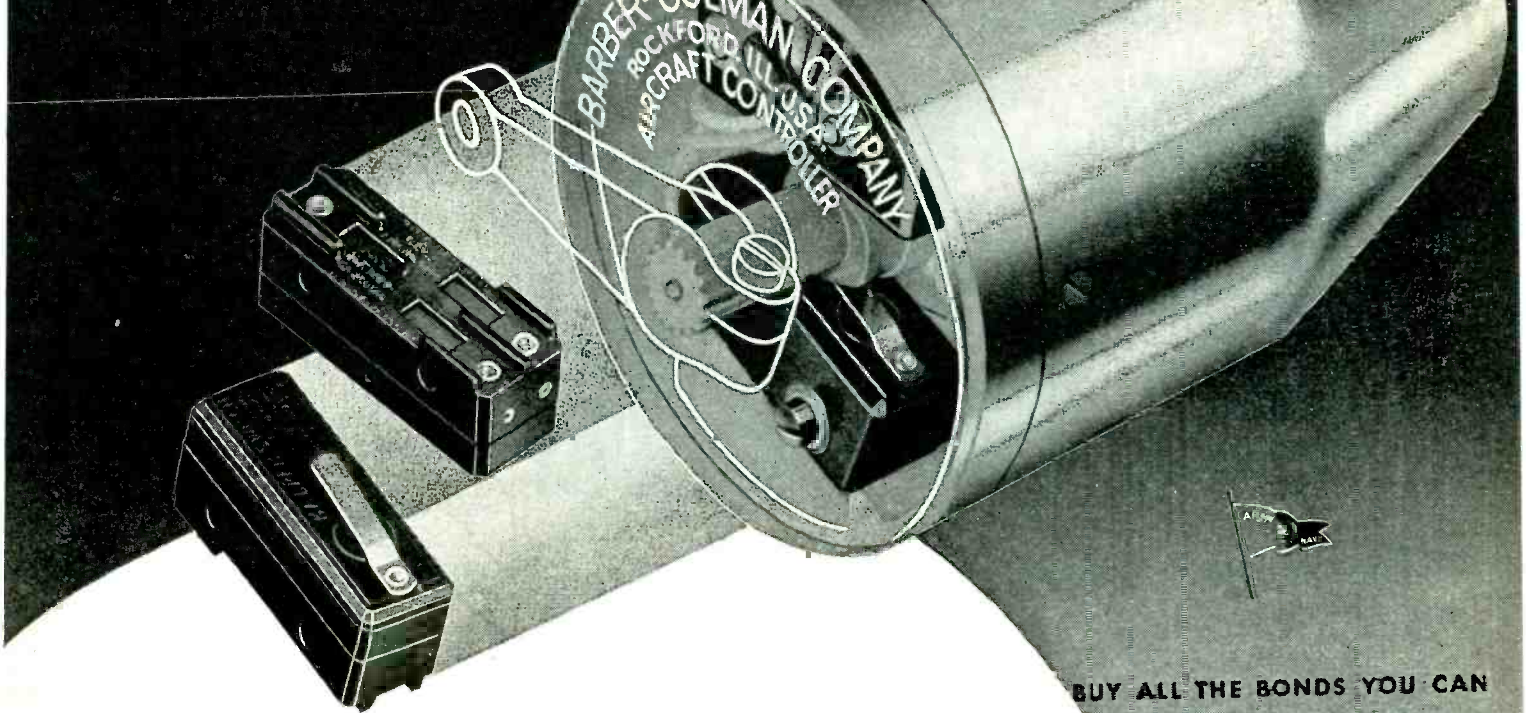


Fig. 2—Block diagram of picture receiver used in Craig television system

The operation of *HS* and *VS* are synchronized with the variable frequency of *VSO*. This could be accomplished electrically or by means of an electric motor drive. With the motor drive we could mount a small variable capacitor to control the sweep frequency of *HS* and another to control the sweep frequency of *VS*, both on the same shaft. On this same shaft there could be mounted another variable capacitor which would control the variation in frequency of *VSO*.

The frequency of *VSO* is varied so it will beat with the various fre-

Not Only a Part, But a Part of Important Parts . . .



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Made Only By Micro Switch Corporation . . . Freeport, Illinois quencies in the incoming signal in such a manner as to produce at all times a fixed frequency to which the selective filter *SF* is tuned. This is, of course, providing that the component of frequency was present in the incoming signal which, when beat with the frequency at that instant of *VSO*, will produce the frequency to which *SF* is tuned. If the difference between any component of the incoming frequency and the frequency of *VSO* at that instant is not equal to the frequency to which *SF* is tuned it will indicate that that particular frequency component of the incoming signal was not present.

Since *VSO* is synchronized at all times with *HS* and *VS*, whether or not the grid of the cathode ray tube allows electrons to pass at some given position of the spot due to *HS* and *VS* will depend upon whether that particular frequency component was present in the incoming signal. If present, the grid will allow electrons to pass at that instant, and if not, no electrons will pass in the cathode ray tube, so that we will get a luminous spot on the fluorescent screen of the cathode ray tube.

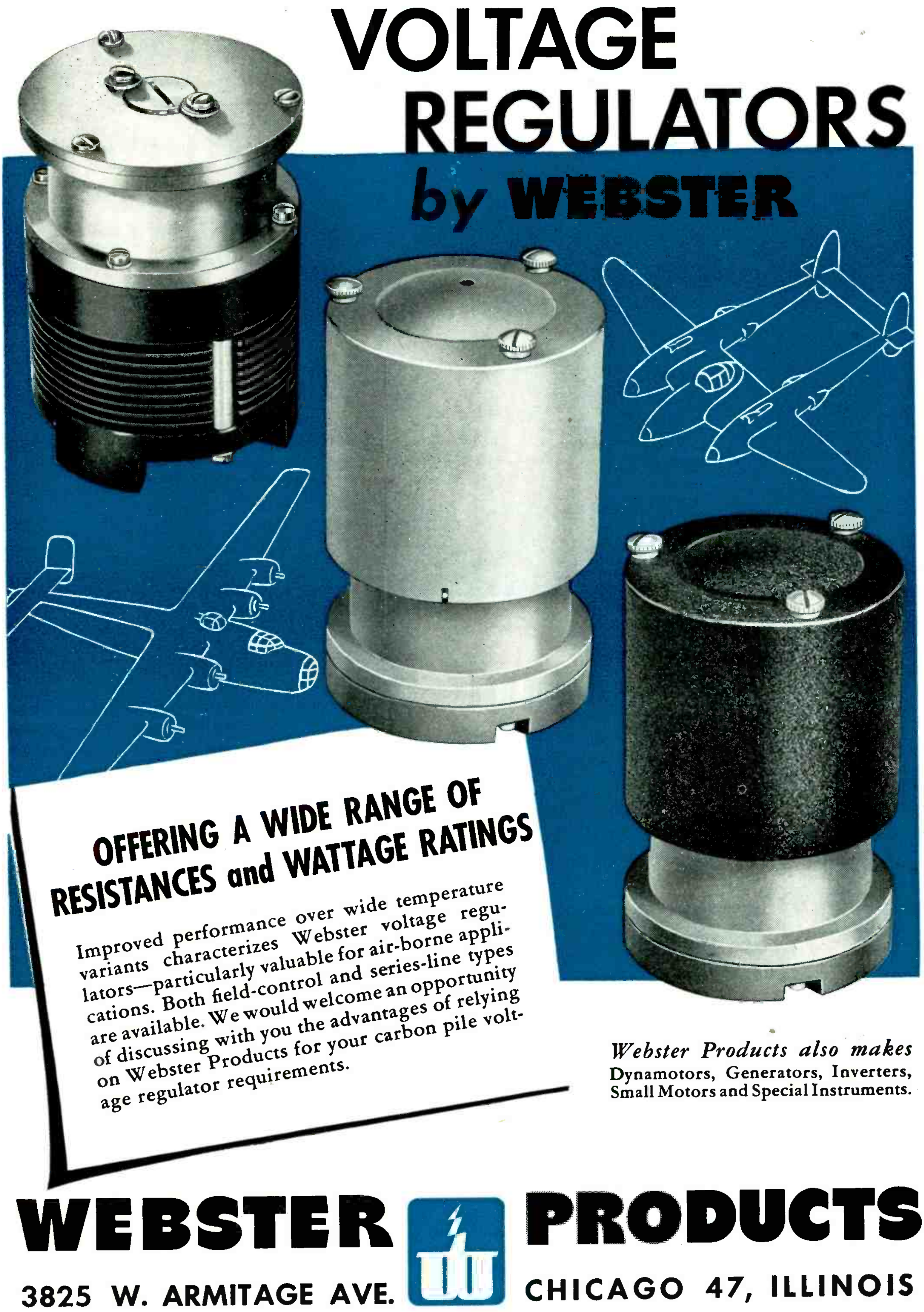
SF will be an extremely selective filter, such as a temperature-controlled crystal filter. It is contemplated that in this system each frequency associated with some given spot will differ from its neighboring spots or elements by approximately one quarter of a cycle. Let us assume for the purpose of calculations that there are 40,000 individual picture elementary areas. If there is a one-cycle differentiation between each adjacent element, there will be a total of 40,000 cycles band width. This is 40 kc or roughly four times the bandwidth now employed in commercial radio broadcasting.

Mathematical Considerations

It can be shown mathematically that the induced voltage in a pickup loop is dependent upon the square of the approach velocity of electrons in the beam.

To arrive at numerical results, it is necessary to consider the area of the photosensitive cathode which determines the size of the charge e, the approach velocity V and the size of the loop. The larger the charge e, the greater will be the induced voltage E.

Assume a cathode 3 feet by 2 feet. If there are to be 240,000 picture ele-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ments, there will be 600 in each row and 400 down each column. That is, there will be 200 perforations per foot in the pickup grids, or 12 x 2.54/200 equals 0.1524 cm/perforation or loop.

In general, the equation for the current from one picture element may be expressed as $I = SE_pA_p/N$ microamperes, where S is the luminous sensitivity in microamperes per lumen, E_p is the illumination in foot-candles falling on the picture element, A, is the area on the camera plate in square feet, and N is the total number of picture elements. Now if 30 complete pictures are to be transmitted each second, taking into consideration the spacing between pulses, the current will flow for approximately 1/50 sec. Therefore the charge e which will flow from each picture element during one pulse is $e = (SE_pA_p/N)\,dt = SE_pA_p/N50$ microcoulombs.

The illuminous sensitivity is generally in the order of 50 microamperes per lumen, and the plate illumination about 1 foot-candle (cf. Fink's "Principles of Television Engineering"). Using these figures the actual charge emitted from one picture element during one pulse is $e = (50)\ (1)\ (6)/(240{,}000)\ (50) \times 10^{-6}$ coulombs $= 2.5 \times 10^{-10}$ coulombs.

This will be the electronic charge emitted from the photosensitive cathode. It will produce about 25 times as many positive ions through gaseous amplification, which is described in Dow's "Fundamentals of Engineering Electronics." Therefore the charge which will approach the aperture of the pickup loop will be of the order of 6.25×10^{-9} abcoulombs. Obviously it will not be a point charge as considered previously, but assuming a spherical distribution of charge, the effects will be essentially the same as if the charge were concentrated at a point at the center of the charge.

Before calculating the actual voltage induced in the loops, we must consider the permeability of the magnetic part of the loop, and, most important, the approach velocity of the charge.

The maximum permeability of permalloy is given as 100,000 in "Standard Handbook for Electrical Engineers," Seventh Edition.

The mobility of argon ions in the range of pressures and fields com-

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monly used is about 30 cm/sec/volt/cm. Assuming an average potential gradient of 50 volts/cm, the velocity of approach will be about 1500 cm/sec.

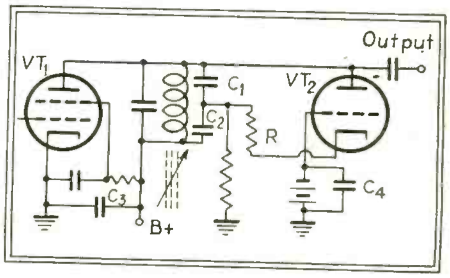
We are now in position to use these values to calculate the maximum voltage induced in the loop. Considering each loop as being wound with ten equivalent turns, and substituting this and the other numerical results in the voltage formula, we calculate the maximum induced voltage to be 67.5 microvolts. This is well above the random noise level.

• • •

Constant Regeneration

UNIFORM REGENERATION over a wide band of frequencies may be obtained by use of the circuit shown in the diagram. This is accomplished by using one vacuum tube as an amplifier and another tube in a separate feedback circuit, instead of combining both functions in one tube in the conventional manner. The circuit appears in a patent abstract in *Wireless World* (British) for July, 1943.

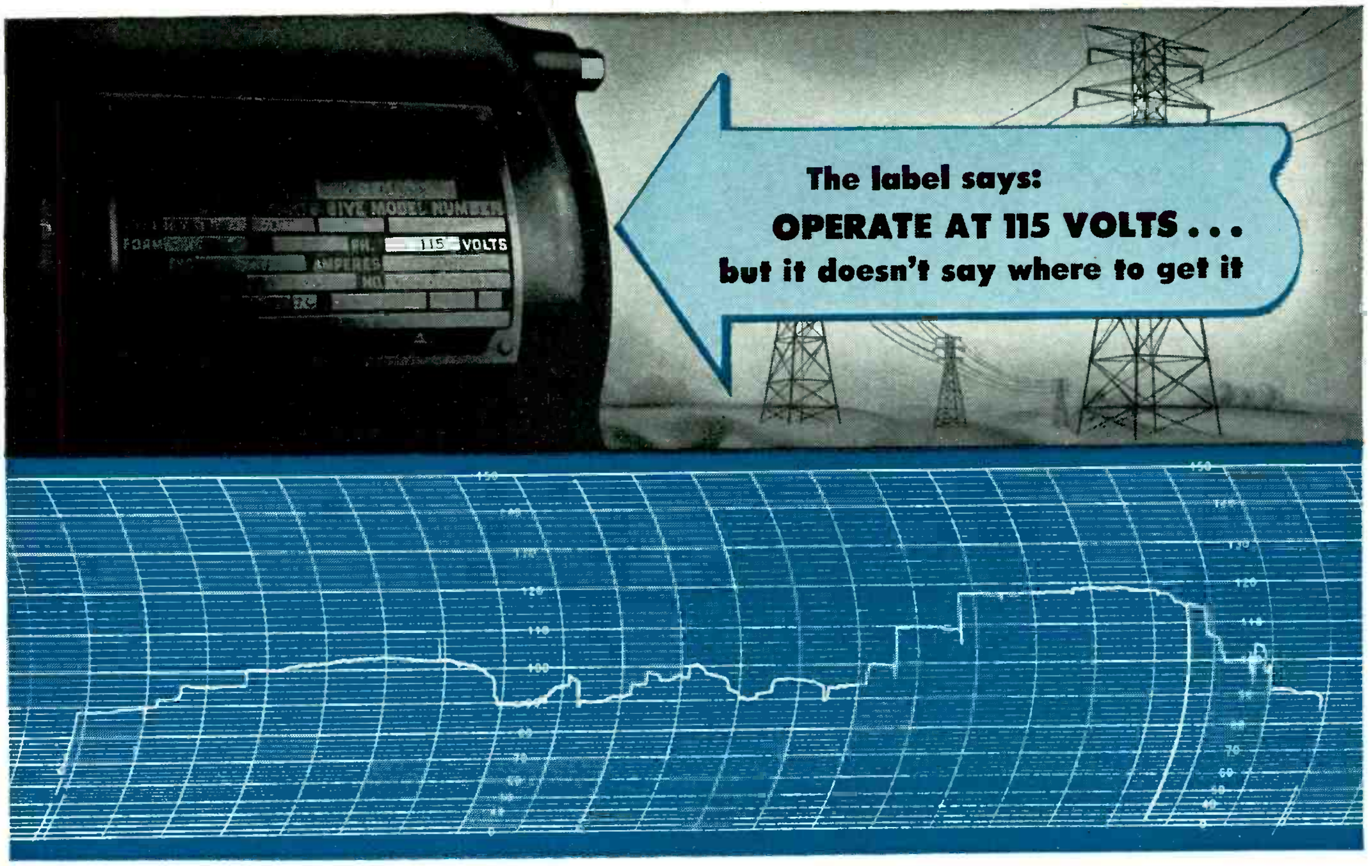
The plate circuit of VT_1 contains a tuned circuit which is shunted by two capacitors C_1 and C_2 in series. The cathode of VT_2 is connected through a resistance R to a point between the two capacitors, while the r-f circuit to the grid is completed through resistor R and capacitors C_2, C_3, and C_4.



This circuit employs one tube for amplification and another for regeneration to obtain uniform regenerative operation over a wide band of frequencies

Feedback in the plate circuit is provided by capacitor C_1. Capacitors C_1 and C_2 thus couple the resonant circuit of VT_1 to the grid of VT_2 as well as provide feedback for VT_2 to regenerate the signal energy.

Constant gain over a wide band of frequencies is maintained by tuning the resonant circuit with a powdered iron core to preserve a constant ratio of inductance to resistance over the frequency range.



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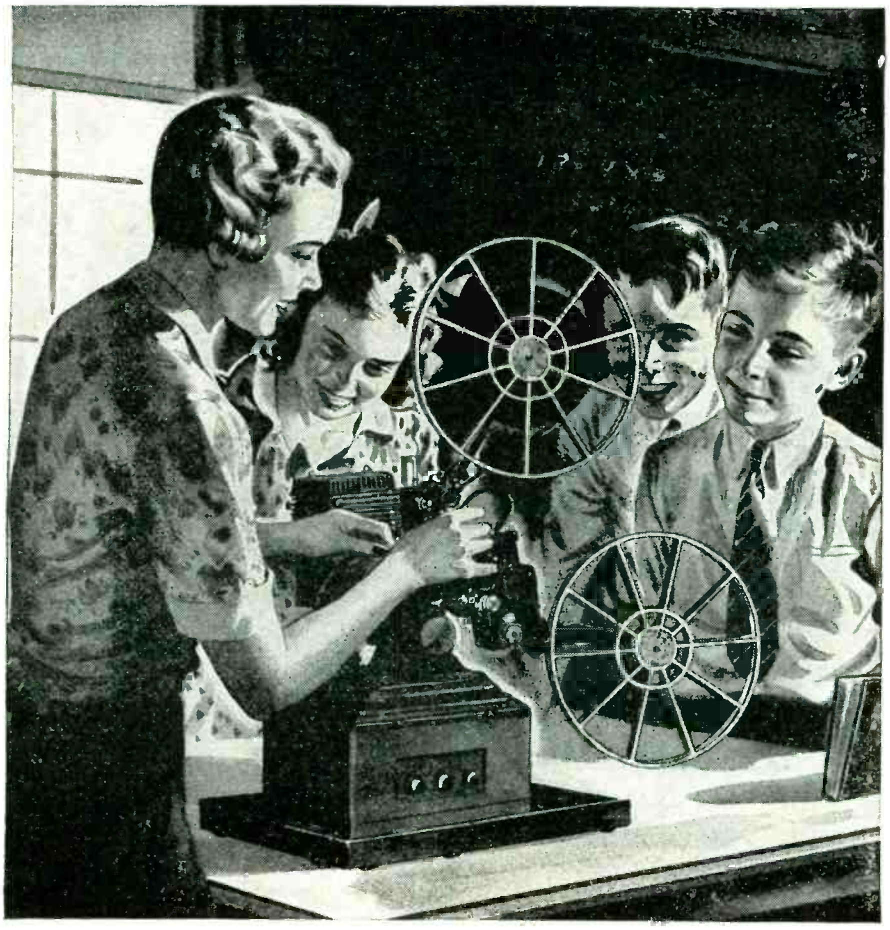

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Radio Plugs

(*Continued from page* 135)

trol panel in a future four-engine transport. It requires a screw ejector applying over 300 pounds pull to separate the two halves, because of the resultant of the total friction of all contacts. Other methods of ejection for large multi-contact plugs involve the rack-and-pinion principle or self-ejection lock rings.

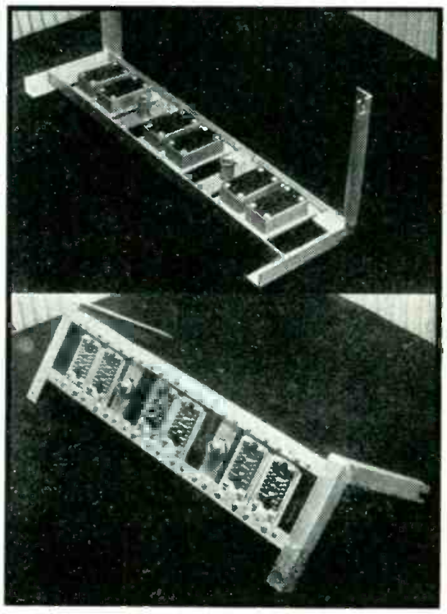
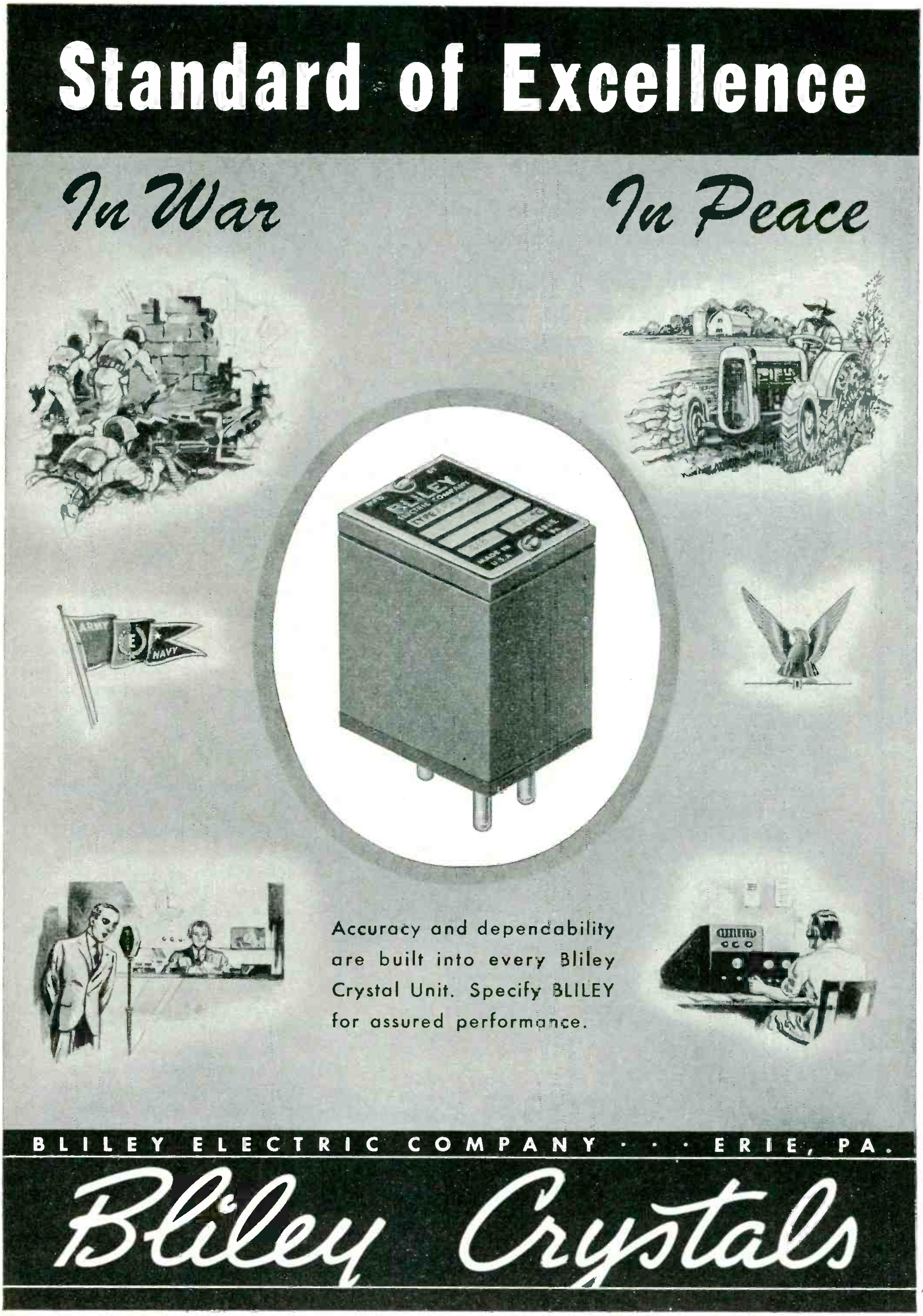


FIG. 2—Pin and socket views of an aircraft plug unit having a total of 180 contacts

Since disconnect plugs are so important, it naturally follows that in themselves they must not represent a potential source of trouble which would nullify their advantages. There is little, if any, resemblance between the electrical plugs used in airplanes and those we find in the home. The airplane plug must be light, compact, durable, liquid and vibration-proof and 100 percent positive in contact. The lives of all aboard an aircraft may depend upon the reliability of the electrical disconnect plugs, hence design engineering, precise machining and careful inspection are essential in the manufacture of plugs for aircraft use.

TO PROVIDE a solder seat between porcelain and a metal transformer, the surface of the porcelain is painted with a gold-platinum liquid and fired at a required temperature. The paint provides a metallic base to which solder will adhere.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P-M System

(*Continued from page* 106)

ious switching remote control circuits which are incorporated in the mobile unit. However, it does indicate that the antenna is normally connected to the receiving circuit and that operation of the transmitter is effected by closing the push-button in the microphone circuit. This switching arrangement also turns on the dynamotor for providing plate supply although this is not shown in the diagram.

Except for the final amplifier, which uses a single tube operating at 100 ma at 600 volts, all of the amplifier and modulator tubes in the transmitter operate with a plate supply of 240 volts. A dropping resistor in the plate circuit of the oscillator tube reduces the plate supply of the oscillator to 200 volts. A jack and meter switch is provided for measuring the voltages applied to the grids of the various tubes.

Except possibly for the first r-f amplifier and modulator, the transmitter design is straight-forward. All essential features may be ascertained from the schematic wiring diagram and list of circuit components.

Receivers for Mobile Units

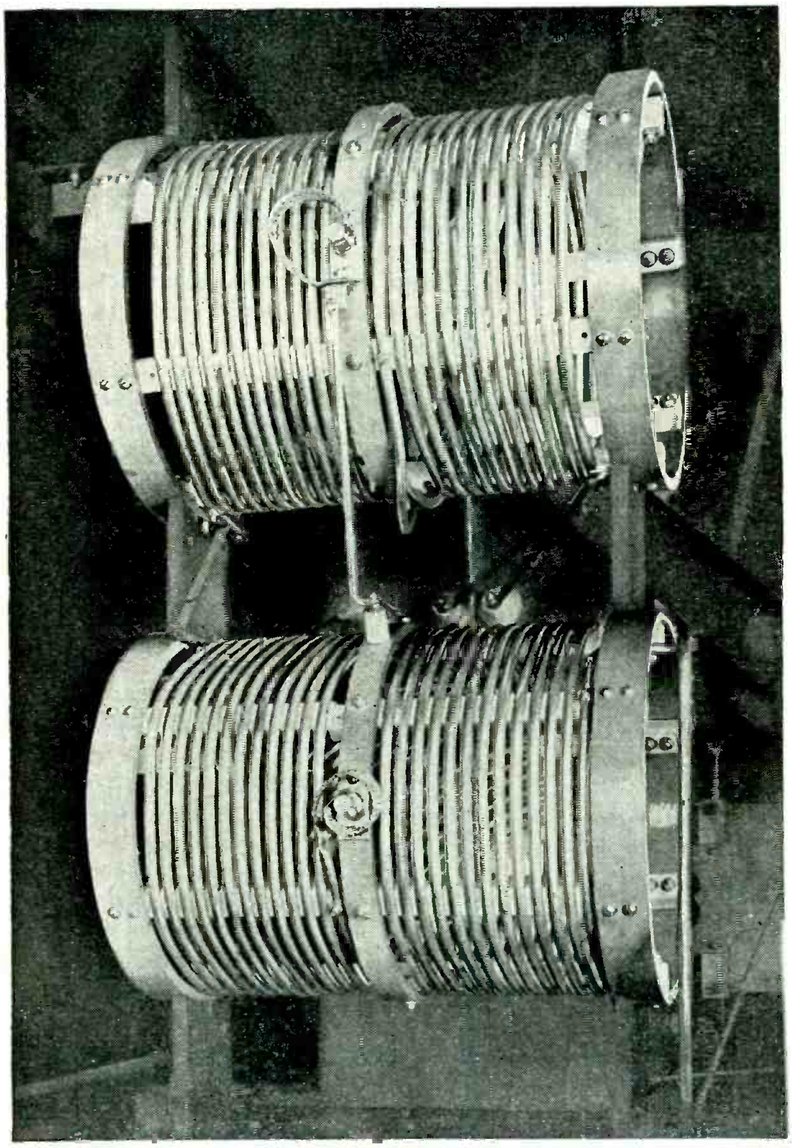
The receiver is designed to receive phase-modulated signals in the band from 30 to 40 Mc. It is adjusted at the factory for operation at the specified frequency, which in this case is 39.86 Mc. The frequency of operation is determined by means of quartz crystals in both oscillators of the double superheterodyne circuit. Complete modulation is achieved when the frequency deviation is 15 kc.

A schematic wiring diagram of the receiver is shown in Fig. 3. Volume and squelch circuits are operated from a control panel on the dashboard rather than from the receiver itself. When intended for operation in an automobile, the receiver is operated from a 6-volt storage battery and a power unit which supplies 80 ma at 250 volts.

The receiver circuit is a double superheterodyne with one stage of amplification at the carrier frequency, crystal-controlled i-f oscil-

How Good

are Bunnell Transmitters?



Well, we don't make the biggest transmitters. And we don't make the most.

But every one we build is especially designed for its special purpose. And every detail of every part of every transmitter must be meticulously correct.

Call it idealism. Or perfectionalism. It's good business for us. And better performance for you!

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HIGH POWER RADIO FREQUENCY GENERATORS ★ TRANSMITTERS
RECEIVERS ★ AUTOMATIC TELEGRAPH EQUIPMENT

Dispatcher's console at main office

lators, two limiter stages, a three-tube squelch system which makes the receiver virtually inoperative except when a carrier is received, and a two-stage audio amplifying system. A double-winding transformer, whose secondary may be used to feed a dynamic loudspeaker or a 600-ohm telephone line, is provided. Except for a few controls mounted on the dashboard within easy reach of the operator, all controls and circuits are contained in a steel cabinet housing the receiver.

Grid and plate circuits of the r-f amplifier are tuned to the assigned carrier frequency. The first crystal-controlled oscillator beats with the incoming signal to produce the first intermediate frequency of 4.3 Mc. One 6SD7GT mixer tube produces this intermediate frequency, which is amplified by another 6SD7GT as first i-f amplifier. The second i-f mixer uses a crystal whose resonant frequency is the sum of the two intermediate frequencies, or 4,775 kc.

The oscillator for the first i-f mixer is a multiple of the crystal frequency. The fifth harmonic of the crystal is mixed with the incoming signals to produce a frequency of 4.3 Mc. A 6K8GT operates as a combined second oscillator for the second intermediate frequency. A second crystal operating in the triode section of the 6K8GT produces a frequency which establishes the second intermediate frequency at 455 kc. This is amplified by another 6SD7 i-f ampliefier. The output of the second i-f amplifier is then fed to two limiter tubes and thence to a 6H6 double-diode discriminator circuit.

The discriminator used in this re-

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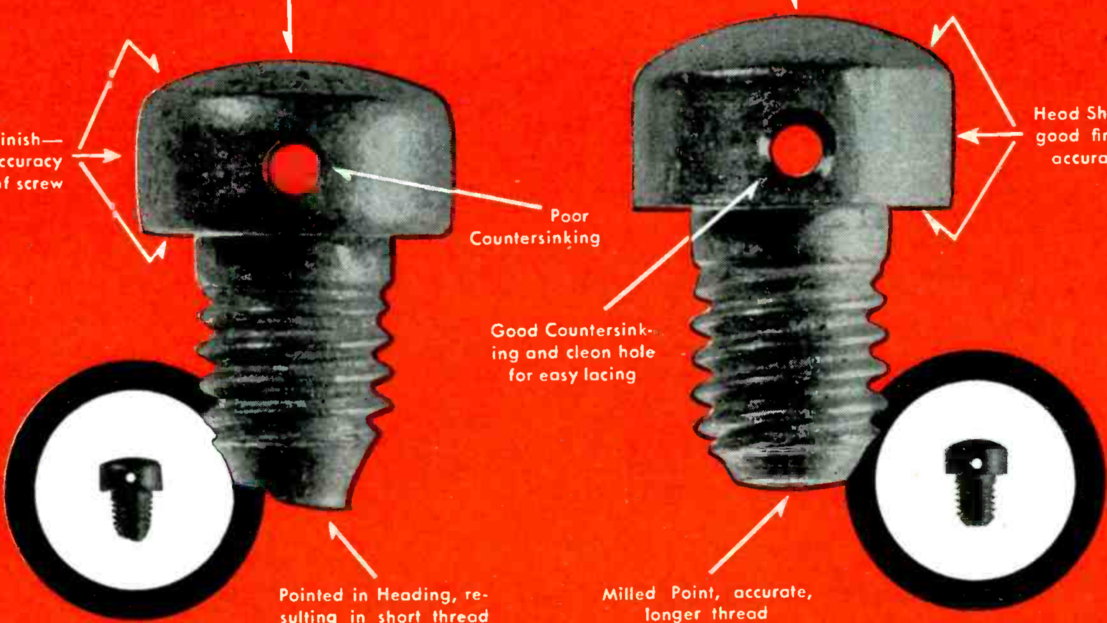
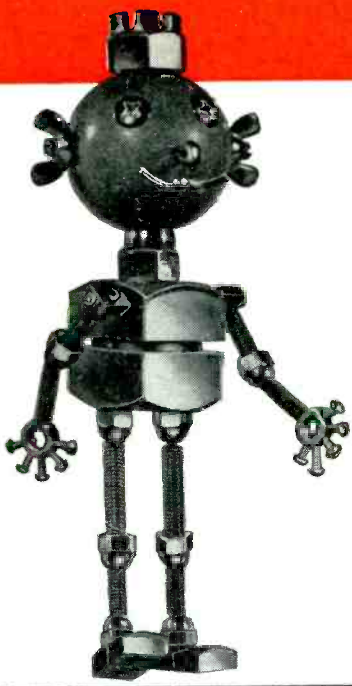
AND IT'S THE MICROSCOPIC DIFFERENCES THAT COUNT IN AIRCRAFT WORK





A customer making aircraft complained about some screws and sent us a batch of them. One look and we saw that they were not ours. The contrast between the other screws and National's was striking.

In order to make the difference clear we show above photographs of one of the screws made by ordinary production methods, and one of ours, together with actual magnifications of these same photographs.

The specifications called for AN screws with close tolerances, made of 4037 steel and heat treated. That's why methods commonly practiced for making competitive screws wouldn't do for this job.

National methods are stepped up to aircraft requirements.

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ceiver is of the "back-to-back" type. It consists of two resonant circuits each feeding an individual diode. The diode loads are so connected that the individual voltages developed in each are added to obtain the net output. One of the resonant circuits is tuned approximately 27 kc above the intermediate frequency of 450 kc and the other an equal amount below this intermediate frequency. When the center carrier frequency is applied the output is zero, but becomes positive or negative as the carrier is increased or decreased from the center frequency.

Receiver Squelch System

Ordinarily the output of the discriminator would be fed directly into the audio frequency amplifier. However, in this case a squelch circuit is interposed between the discriminator and the audio amplifier to make the loudspeaker inoperative except when signals are received. The squelch circuit is composed of the 6SD7GT noise amplifier, the 6H6GT squelch circuit diodes and the left-hand section of a 6C8G double triode. In the absence of this squelch circuit system, output from the discriminator is fed to the right-hand section of the 6C8G double triode which acts as an audio amplifier, and is then further amplified by the 6K6GT power output tube.

With the squelch system in operation, the circuit behavior is approximately as follows: The signal from the output of the discriminator is fed through the input of the noise amplifier. The voltage impressed on the grid of the noise amplifier is then amplified by an amount determined by the setting of the squelch resistor *R*3. The amplified voltage is then passed on to the double-diode rectifier.

In the absence of a carrier, random fluctuation voltages are amplified by the noise amplifier and are passed on to the squelch double diode. It will be noted that the diode is connected in such a way that capacitors *C*57 and *C*58 are charged with such polarity as to decrease the negative bias of the left-hand triode of the 6C8G tube. This permits plate current to flow in the left-hand section, and effectively short-circuits the output of the first audio amplifier so that no signal of

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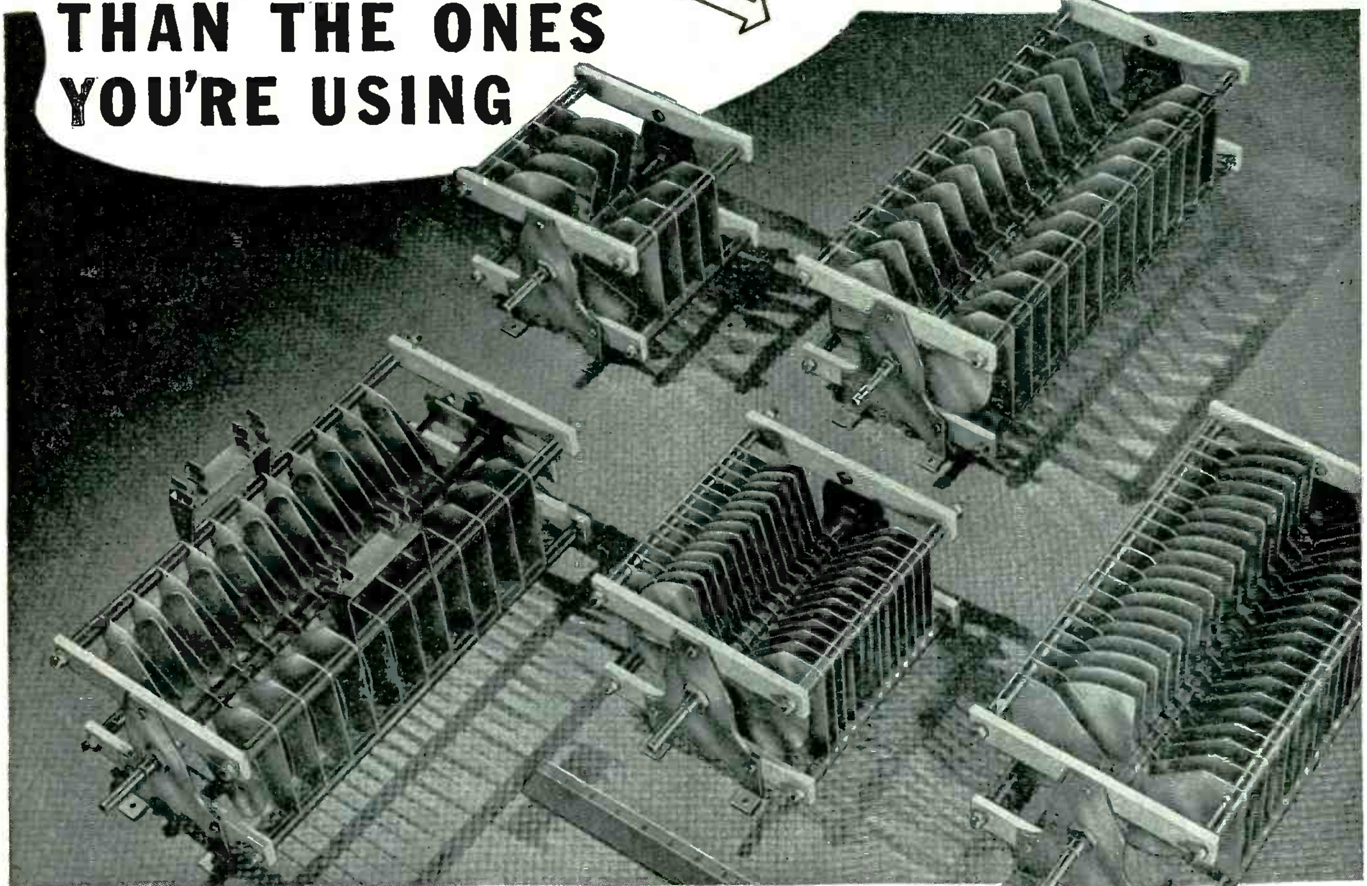

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A radical improvement in any product generally calls for a radically new design—and that's the B & W Type CX Variable Condenser to a "T".

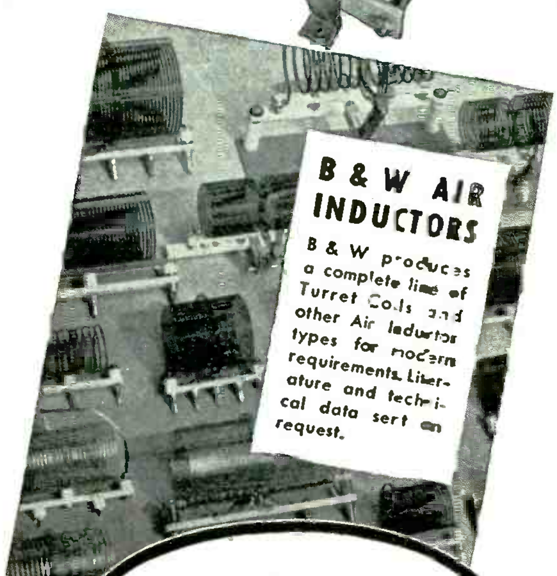
It has perfect electrical design symmetry plus built-in neutralization.

It is more durable mechanically.

The design lends itself admirably to the built-in mounting of standard B & W coils in such a way that lead lengths and resulting lead inductance are reduced to an absolute minimum.

By any test, by any comparison you care to name, it will prove itself superior to conventional types.

True, the shape and physical dimensions of the B & W Type CX Condenser are such that minor design modifications of existing equipment are necessary to incorporate them—but the results are well worth the effort. As for new equipment, CX Condensers are remarkably convenient and effective—facts which B & W engineers welcome the opportunity to prove. Write for folder.



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appreciable magnitude is passed on to the amplifier in the absence of a carrier.

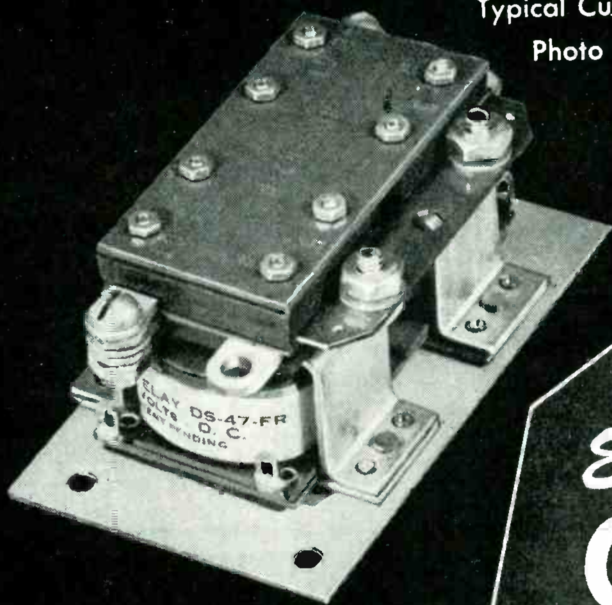
When a carrier signal is received, the noise amplifier is biased to its cutoff value, cannot operate the squelch diode, and accordingly the left-hand triode section of the 6C8G is biased to cutoff and permits signal to pass through the first audio amplifier and on to the power amplifier.

It will thus be seen that the purpose of this squelch circuit is to reduce the output of the loudspeaker by about 20 db except when the signal is received. This squelch circuit has considerable operating advantage since there is no noticeable output from the loudspeaker to distract the driver of the mobile unit except when signals are received from the transmitter. If such a circuit were not employed, a certain amount of extraneous noise and background signal would be continually present from the loudspeaker.

Transmitter and receiver units mounted behind driver's seat in squad car. Cable connectors permit quick removal of units

The transmitter and receiver are connected together and to the power supply and antenna by means of plug and jack cable connectors. In addition, the dashboard contains a control head panel having controls for the squelch circuit and volume output, terminals for the hand mi-

Typical Custom-built application.
Photo actual size (Total capacity 50 amperes)



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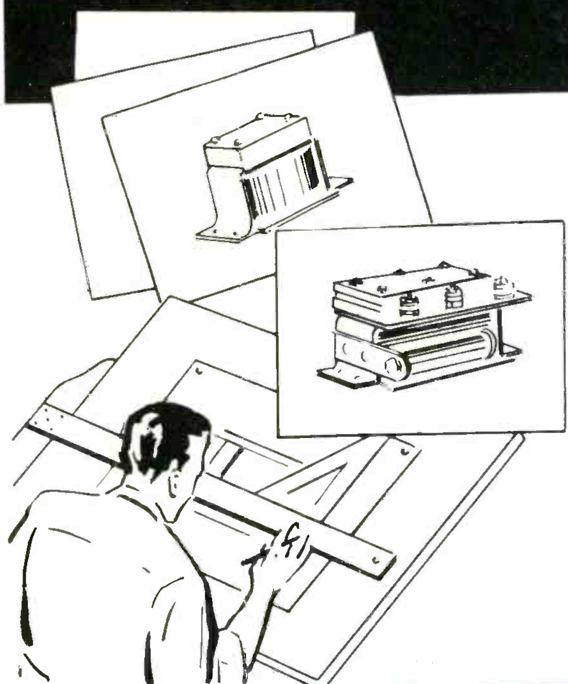

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Positive Action — Overtravel spring insures positive contact pressure and instant "break" release.

Tamper Proof — Factory adjusted and sealed; protection against unauthorized re-adjustments.

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crophone, and operating pilot lights. All units are conveniently and rapidly connected or disconnected by means of suitable cables.

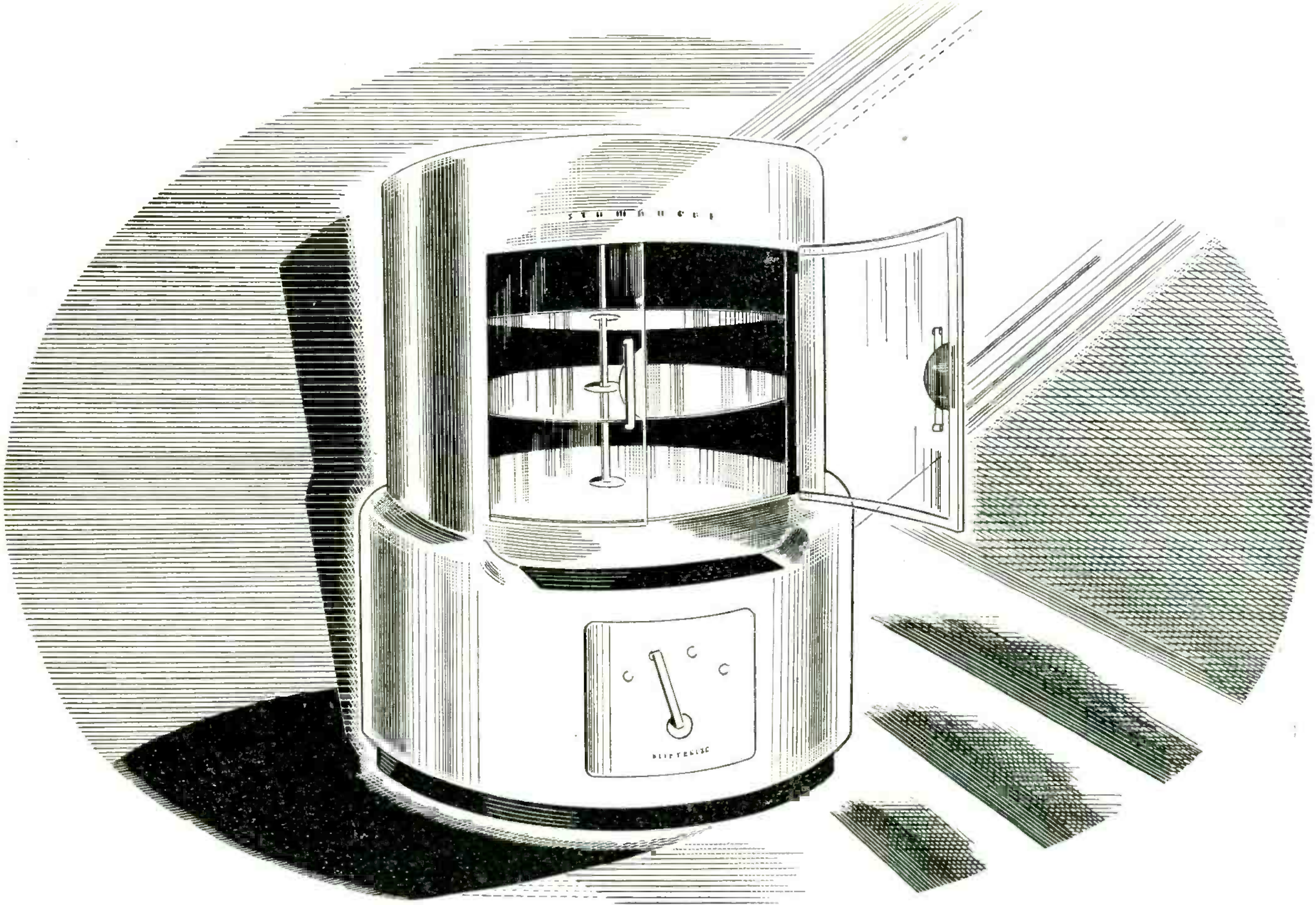
The transmitter and receiver are usually mounted behind the driver's seat in the Chevrolet squad cars where they are out of the way. In the cable trucks and wrecking wagons the radio equipment is contained in wooden trunks above and to the rear of the driver's cab. The only controls which the operator may be required to use are conveniently mounted on the dashboard in the case of squad cars, or on the ceiling of the cabs in the case of wrecking wagons and cable trucks.

Equipment at Main Station

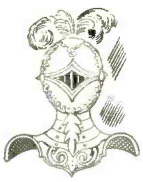
The principal transmitting and receiving equipment is located approximately seven miles west of the loop, where a tall three-cornered steel tower is used. At the base of the antenna is a small tile brick building providing power supply for the transmitter and receiver, photoelectric control for the automatic lighting of the tower, the necessary transmitting and receiving equipment, remote control panels, and cabinets of spare parts and test equipment.

The transmitting antenna is a 17-ft half-wave vertical coaxial mounted on the top of a three-cornered steel tower 250 feet high, making a total height of 267 feet. This is considerably higher than any of the surrounding structures and provides effective communication not only throughout all sections of Chicago itself but in surburban districts as far as the Wisconsin and Indiana state lines. Because of its height and the presence of the Chicago Municipal Airport a few miles to the south, it is required that the tower be illuminated at night. A Photronic barrier-layer cell mounted approximately one-quarter of the way up the tower and feeding sensitive relays in a Weston photoelectric control automatically turns the lights on as required.

Power is fed to the antenna by a $\frac{7}{8}$-inch coaxial cable continuously filled with nitrogen by means of a two-stage valve and a tank of gas in the transmitter-receiver room. A pair of telephone lines connects the transmitter and receiver to the dispatcher's control console approximately 7.5 miles distant.



THE PART YOU CAN'T SEE . . .



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Today's fighters are protected as a knight in armour never was . . . part of that protection is due to research in rubber . . . part of it is due to precision production.

Both of these things will pay dividends in your post-war products. Johnson is making rubber parts to a thousandth of an inch tolerance . . . parts that depend on specially developed formulas to stay resilient at 75 degrees below zero . . . and stay firm at hundreds of degrees above . . . all this at high pressures . . .

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There will come a day, though, when we all have to think about transferring the boys' names from the honor roll to the pay roll, and getting back to our regular job of supplying a peacetime market. To meet that great day with a minimum of time waste is important to the boys coming back . . . and important to you.

Lay your plans now. Let us help you. Johnson engineers and designers can help you solve problems in your post war products . . . and come up with the right answers in the right kind of rubber in the specific part you need . . . and this precision in rubber perfected in wartime will serve you well in peacetime.

We will be ready to supply you when the time comes . . . but the time to think about it and plan ahead is now . . . not then.

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At the 86-foot level a vertical dipole is installed on the side of the tower to serve in case of defects either in the vertical coaxial cable on the top of the tower or the coaxial line connected to the top antenna. A shielded capaline cable extends from the dipole to the inside of the transmitter room where it may be connected to the 50-watt exciter unit in the transmitter-receiver cabinet. Power for the transmitter is obtained from a single-phase, three-wire 220-110 volt, 60-cycle line. A voltage-regulating transformer is used to supply the a-c power to the transmitter-receiver combination.

A block diagram of the main transmitter, also shown in Fig. 1 indicates some of the interconnections and remote control features which cannot well be shown in the schematic wiring diagram. The equipment itself, mounted in a steel cabinet, is shown in one of the photographs.

The transmitter is composed of a driving unit and 250-watt push-pull power amplifier feeding the coaxial cable which is connected to the radiating dipole. The exciter unit is similar to the 30-watt transmitter employed in the mobile units except that two 807 tubes in parallel are used to produce a power output of 50 watts instead of the 30 watts produced in the mobile units. Power output from the 50-watt exciter is fed to the grid circuit of two 100TH triodes in the push-pull neutralized circuit of Fig. 4. Power supply for the exciter unit as well as the main amplifier is obtained from a rectifier-filter system operating from the 60-cycle line.

The transmitter is so arranged that in case of failure of the final amplifier, the 50-watt output of the driver stage may be coupled directly to the antenna. A spare oscillator or driver is kept in the station at all times for emergency replacement. Except that these two exciters are operated from a rectifier-filter system rather than from a dynamotor and have increased output through the use of a second tube in parallel, they are identical with the transmitters used in the mobile unit. Therefore, it is practical to interchange the transmitter of a mobile unit for that in the main station by changing power supply.

The main transmitter is operated

by remote control from the dispatcher's office at 231 So. LaSalle Street in Chicago's loop. The filaments are operated at 80 percent of their rated voltage when no communication is taking place. When the dispatcher at the downtown office wishes to transmit a message, a remote control mechanism brings the filaments up to normal voltage in a negligibly short time. Through this procedure, the transmitter is always available for instant operation (since no appreciable time is lost in bringing the filaments from 80 percent to 100 percent or normal voltage) and at the same time tube life is conserved.

Except for the use of a more effective receiving antenna with its associated coaxial cable, and operation from the power supply system, the main receiver is identical with those used in the mobile unit.

Performance of System

During the year and a half of continuous operation, the system has given satisfactory performance. The range of satisfactory communication is considerably beyond the requirements of the city limits. The use of phase modulation with squelch circuits on all receivers to reduce output of the loudspeaker except when the carrier is received is largely responsible for the success of the system. A trip in one of the touring cars to various parts of the city demonstrated the speed with which the squad cars, wrecking wagons, or cable trucks may be dispatched as emergency conditions warrant. In spite of many tall steel buildings in and immediately surrounding Chicago's loop, no difficulty was experienced due to inadequate signal strength. Furthermore, it has shown that there are no dead spots in any of Chicago's 190 square miles.

The operation and maintenance of this radio equipment is under the direction of S. D. Forsythe, electrical engineer of the Chicago Surface Lines. All radio equipment was designed, built, and installed by the Galvin Manufacturing Company of Chicago.

The assistance of Mr. Paul Murray, Chicago Surface Lines, and Mr. Norman E. Wunderlich, Galvin Manufacturing Company, in the preparation of this article is gratefully acknowledged.

NEWS OF THE INDUSTRY

Parts standards conference; candid photos of IRE Rochester meeting; new calls for FM stations; program for winter IRE meeting; war standard for fixed resistors; London News Letter

War Committee On Radio Holds Parts Standards Conference

THE AMERICAN STANDARDS Association's *War Committee On Radio*, of which S. K. Wolf of the War Production Board is chairman, held a two-day conference for discussion of electronic equipment component parts standards at the Lord Baltimore hotel in Baltimore, Md., November 17 and 18. In attendance were just under a hundred executives and engineers of the ASA, the WPB, the Army and Navy and prime contractors. On the first day Bendix Radio, host to the group, staged a tour of one of its nearby plants to show some of the practical results of applied standardization in the manufacture of communications gear.

WPB officials lead the second-day panel discussions. Opening the meeting, Mr. Wolf said that standards had been developed for ten components representing perhaps 50 percent of all the parts currently needed and that work on 20 others was well advanced. He pointed out that a 30 to 35 percent increase in the production of equipment was needed in 1944 and that, in view of the manpower shortage and the present full utilization of plant facilities, standardization was just about the only way to obtain it. Standards, Mr. Wolf continued, would not, however, be "shoved down industry's throat."

Elmer Crane, introducing subsequent WPB speakers, inferred that prime contractors were expected to "police" the situation in the interests of the war effort in future dealings with component suppliers. He attributed resistance to standards on the part of certain component manufacturers, said to be in the minority, to premature preoccupation with post-war competitive questions.

D. J. Connor, obviously aware of the fact that prime contractors representing users of component parts rather than manufacturers of such components constituted his audience, commented that the desirability of standards appeared to be evident to all but that present methods of insuring universal acceptance of them needed considerable stiffening. Using resistors as an example of what could be accomplished, he told how 63 types in four categories had been reduced to 27.

Discussing tubes, F. C. Bash said that despite the availability of some 1,500 types the Army and Navy now confined at least 75 percent of its new equipment specifications to 150 types, using the remainder only where absolutely necessary and for replacement in older gear. He said that standardization with respect to Nonex or so-called "hard" glass and other physical details had permitted a 50 percent increase in the production of certain water-cooled transmitting tubes without increase in labor or factory facilities.

H. P. Rockwell, discussing panel instruments, said that in peacetime one-third of all the meters purchased were catalog items while the remainder for the most part embodied minor changes involving special design and only occasionally

Delegates to the *War Committee On Radio* meeting held recently in Baltimore for discussion of component parts standards. Bendix Radio, host to a group which included representatives of the WPB, the ASA, prime contractors and the Army and Navy, staged a tour of one of its nearby plants during the two-day session

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This Rockbestos All-Asbestos Insulated Lead Wire will not dry out and crack under heat and vibration, won't rot, swell or flow as a result of contact with oil or grease, and has ample moisture resistance for most applications.

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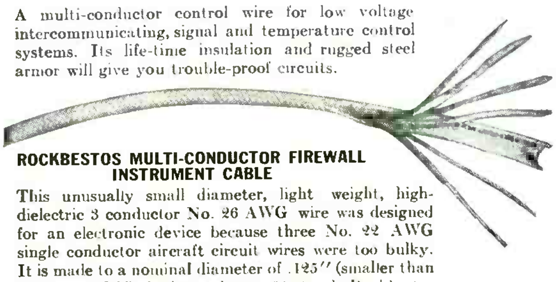

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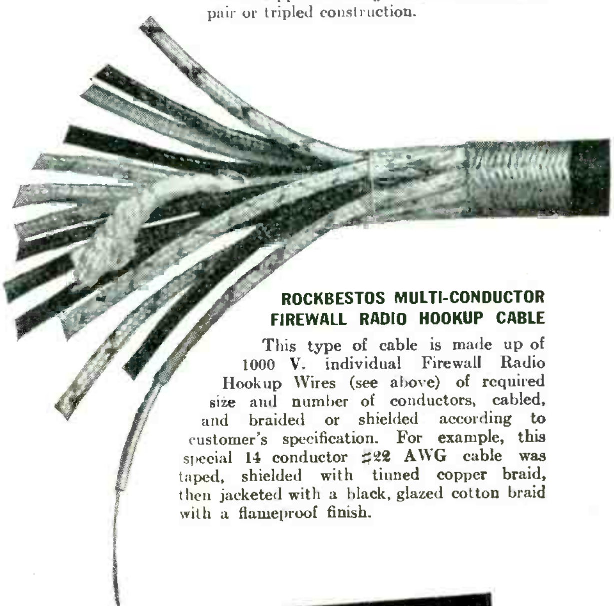

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This type of cable is made up of 1000 V. individual Firewall Radio Hookup Wires (see above) of required size and number of conductors, cabled, and braided or shielded according to customer's specification. For example, this special 14 conductor #22 AWG cable was taped, shielded with tinned copper braid, then jacketed with a black, glazed cotton braid with a flameproof finish.

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justified. He said that even today, with manufacturers limiting and combining types and production expanded at least three times from the pre-war peak, few individual orders were for more than 5,000 meters and most of them were for mere hundreds. He suggested that further reduction in the number of required instrument types could readily be obtained through standardization and development of a "preferred" list, pointed to the excellent type-limitation job which has been done by the Army and Navy in connection with non-radio aircraft instruments such as those used in connection with altimeters and tachometers.

Harry Sparks, also discussing instruments, said that possibly 30,000,000 meters may be needed this year, told how, back in 1934, reduction in the number of watt-hour meters made for public utilities from 80 of a certain type to 2 cut production costs and saved 50 per cent of the labor required in the field when taking readings, cited the fact that standardization on fewer non-radio instruments for aircraft has cut the production backlog so that not one plane is now held on the ground for lack of such instruments.

Frank McIntosh told how standards helped even in the maintenance of civilian radios, pointing out that speaker, mica-capacitor and resistor stocks now appeared adequate to take care of the 52,000,000 receivers in use and that reduction of the types of other components through standardization would soon remove bottlenecks. He said that the war effort, the public and the industry would be served by reduction of replacement electrolytic capacitor types from several hundred to nine, reduction of a similarly large number of paper capacitor types to nine, reduction of volume-controls from 2,700 types to eleven and transformer types, including audio chokes, from 375 to twelve.

Men commenting from the floor during the panel discussion were too numerous to list here but the following names, with affiliations, will serve to indicate the variety of interests which were vocal at the meeting: William Hilliard, H. L. Spencer and L. J. Hruska of Bendix, H. R. Menefee and J. M. Caller of Sperry, D. F. Schmit of RCA, H. D. Sarkis of Crosley, F. E. Hansen of WE, W. A. Bischoff of Bell, Col. L. J. Harris, Maj. R. Framme, Capt. B. Spano and Lt. R. Geiger (USN).

Guests at a dinner at the conclusion of the panel discussion included: (Army) Maj. Gen. P. B. Colton, Maj. Gen. L. D. Clay, Brig. Gen. J. F. Gardner, Col. G. C. Irwin; (Navy) Vice Adm. S. H. Robinson, Rear Adm. Earle W. Mills, Rear Adm. C. R. Jones, Capt. J. B. Dow, Comm. D. R. Hull, Lt. Comm. R. L. DeGroff. Also at the head table were R. C. Ellis of WPB and P. G. Agnew of ASA.

IRE—ROCHESTER—1943

Candid-camera shots, taken here and there around the convention hall at the Sagamore, by the editors of ELECTRONICS


W. R. G. Baker
General Electric


George Lewis
Int'l Tel. & Tel.


Virgil Graham
Sylvania


D. B. Foster
Majestic


I. E. Mouromtseff
Westinghouse


D. J. Phelps
General Inst.


R. H. Manson
Stromberg-Carlson


R. S. Burnap
RCA


Roger Wise
Sylvania


L. Podalsky
Sprague


Sam Norris
Amperex


Monte Cohen
Sickles


George Floyd
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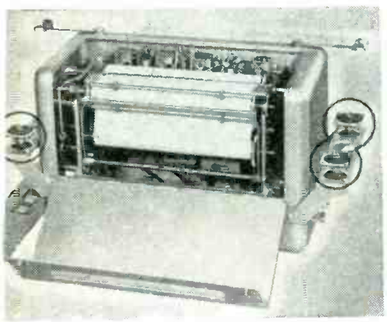

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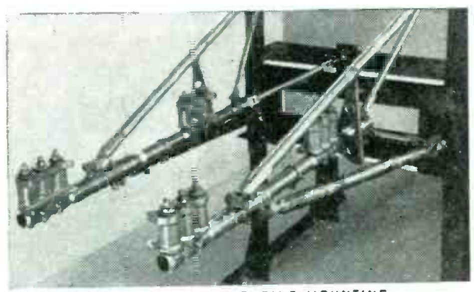

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INCREASE PERSONNEL EFFICIENCY by eliminating nerve wearing noise and vibration, translated through solid conduction.

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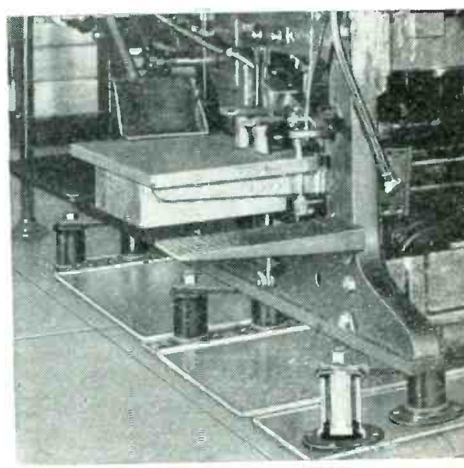
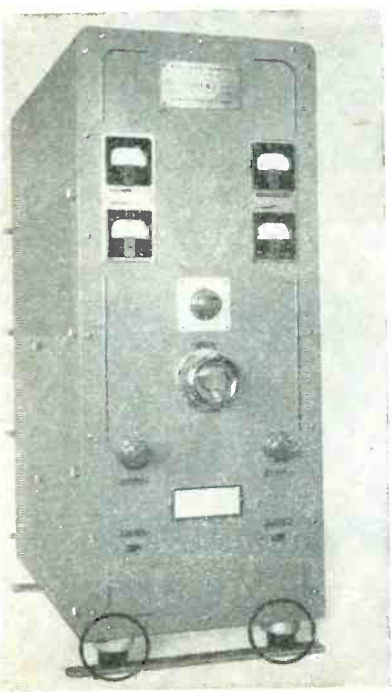


HEAVY PRINTING PRESS



MARINE RADIO TRANSMITTER

IT TAKES RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
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S. S. Sondles
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Globar

W. F. Diehl
Air. & Mar. Inst.

Arthur Lynch
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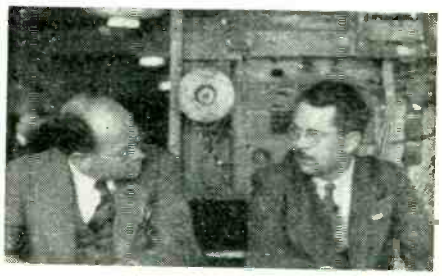
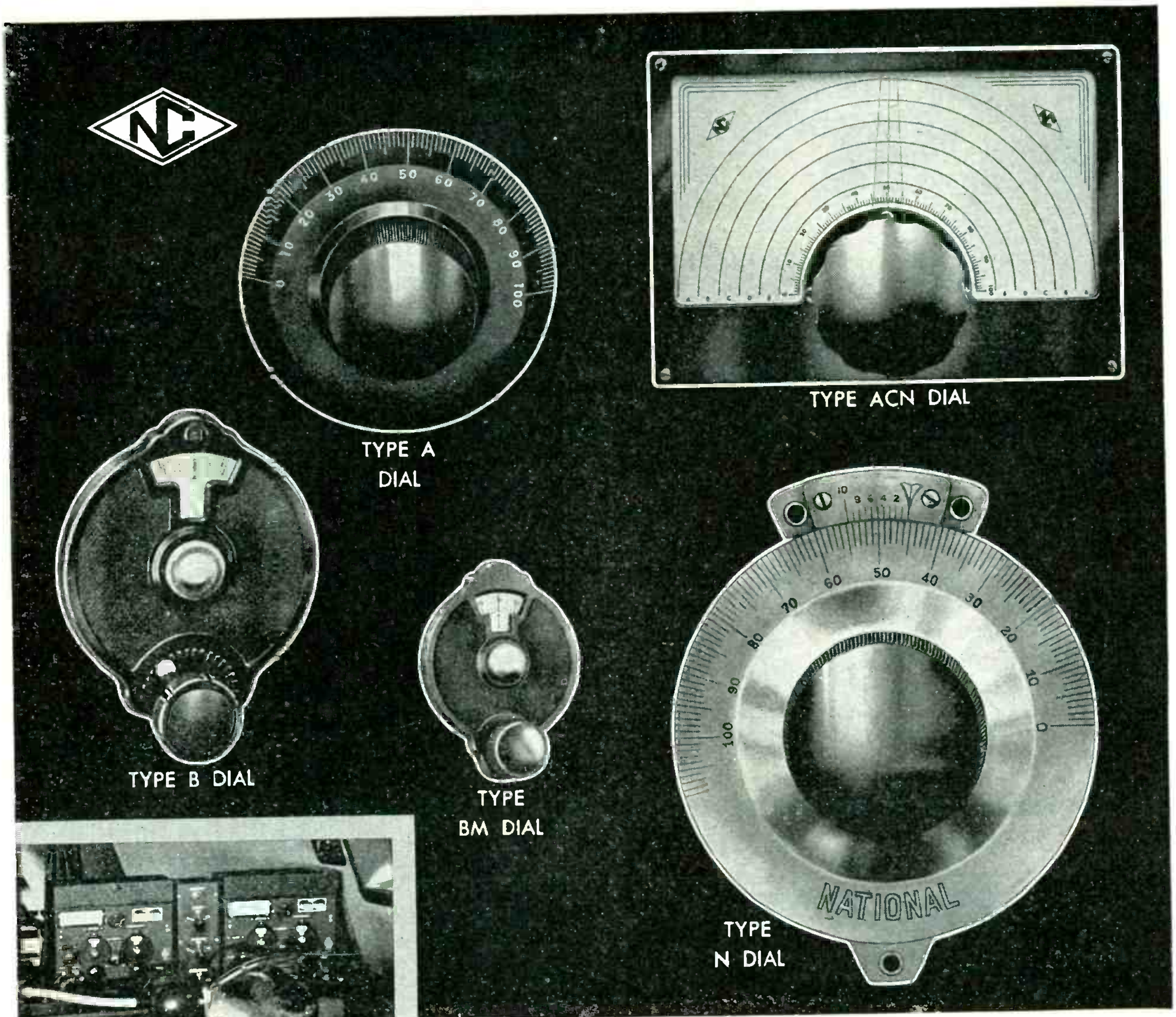


Harry Ehle, IRC — J. Morelock, Weston



The photograph immediately above shows an installation inside a Pan-American Clipper. National Dials have been a favorite with Pan-American Airways for many years.

TYPE N DIAL—Four-inch diameter with engine divided scale and flush vernier. 5 to 1 ratio.

TYPE ACN DIAL—Designed for direct calibration. Dial bezel size 5″ x 7¼″.

TYPE B DIAL—Compact, variable-ratio drive inclosed in bakelite case. Illuminator available.

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ACCURACY
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In War as in Peace, National Dials provide the smooth effortless control that makes the operator master of his equipment. Enormous increases in our productive capacity are meeting war-time demands, and National Dials are available with reasonably prompt delivery to users having the necessary priority.

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Electronic Enterprises

Salvage Manual

A COMBINATION MANAGEMENT manual and technical guide for salvage operations has been published by the Technical Service Section, Industrial Salvage Branch, Salvage Division of WPB.

The book was prepared and edited by an editorial board of industrial salvage engineers and business paper editors, and covers every possible phase of practical industrial salvage operations. The material is presented in 26 chapters which include chapters on organizing and planning a salvage department, administrative factors, methods of handling metal scrap, and case histories of exemplary practice.

The 245-page volume is entitled "Salvage Manual for Industry" and is available at 50 cents per copy from the Superintendent of Documents, Government Printing Office, Washington, D. C.

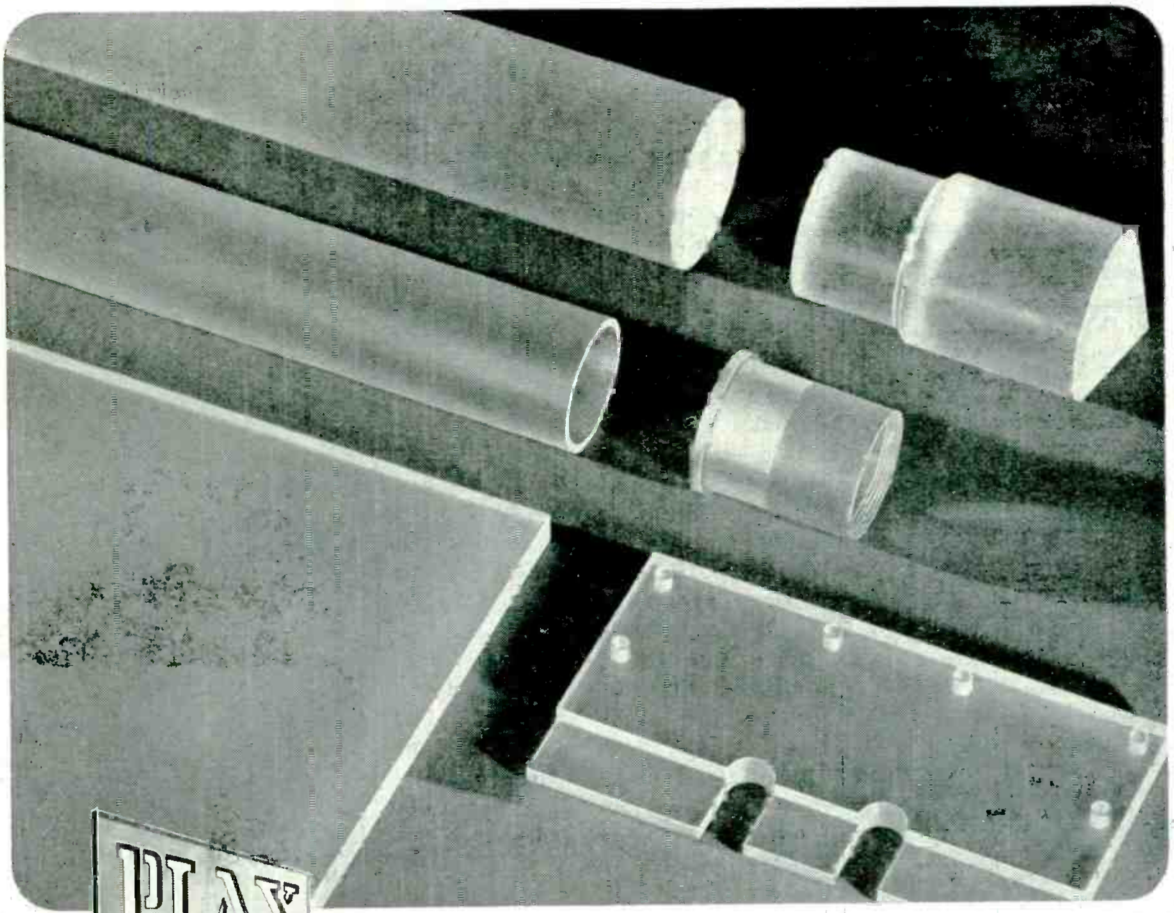
PLAX POLYSTYRENE *Sheet, Rod, and Tube Application Hints*

"Polystyrene has been found to be best suited to the process due to its chemical inactivity, dimensional stability, and moldability. The low water absorption . . .

—Electronic Industries, Oct. 1943, p. 75

"Polystyrene was selected for this application because it has good acid resistance and can be machined readily to close tolerances . . ."

—Product Engineering, Oct. 1943, p. 623



PLAX FOR PLASTICS

NOT SUBSTITUTES···IMPROVEMENTS

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Plax's bulletin on machining polystyrene (available to you on request) is helping many manufacturers use available production facilities to turn electronics' most versatile insulating material into a wide variety of high-frequency components.

Write the Plax Corporation, 133 Walnut St., Hartford 5, Conn., for sheets giving complete data on polystyrene's unique physical, chemical, electrical, and thermal characteristics . . . and for data on other interesting plastics now fabricated by Plax.

Navy View on Standards

THE INCREASED electronic production required by the needs of the armed forces in 1944 makes it imperative that the subject of component parts standards be given serious consideration by engineers at this time. (See feature article on this subject in this issue of ELECTRONICS.) Since the matter of simplicity of design in U. S. Navy radio equipment is becoming increasingly important the following views of the Navy Department, Bureau of Ships, originally distributed only to the Design Branch of the Radio Division, may well serve as a guide to design engineers.

The Bureau views with concern the trend toward increasingly complex radio and allied electronics equipment. This tendency is objectionable because of the large variety of slightly different components to be manufactured for initial production, the difficulties confronting servicing personnel in maintaining equipment, and the astronomically large variety of components that must be carried in stocks throughout the world.

It is fully realized that in part the equipment complications arise in improvements intended to afford the Fleet equipment with improved operating characteristics. It is also, realized that electronics designers have been schooled for years, in particular, to strive for perfect performance from each circuit. Frequently this urge to reach perfection has resulted in assemblages of circuits that not only meet the overall performance characteristics desired but also have a large margin of unusable capacity.

The Bureau desires that design supervisors be instructed to carefully examine each proposed design with a view to the ultimate production of the simplest possible functionally satisfactory equipment.

A few examples of the questions that should be considered during such an examination are:

(a) Considering the overall performance desired, is this special component (transformer, capacitor, etc.,) actually necessary or will the component now in production be really satisfactory though slightly less efficient?

(b) Considering the overall performance desired, and all of the resistors (or capacitors) used, of approximately the same size, as a block, would it be undesirable or imprac-

ticable to use the same resistor value at all circuit points? Could that value be a standard one?

(c) Considering the overall performance desired, is it necessary to use so many different tube types? Or would it be desirable from a broad viewpoint to use fewer types perhaps even at the expense of an added stage?

(d) Have the layouts and wire plans become complicated because of a desire for ultimate performance (particularly gain) from each stage, so that excessive overall performance has been obtained at the expense of ease of maintenance?

(e) On the other hand, are there components included that are marginal in design; that is: Do the transformers, capacitors, etc., have a sufficient factor of safety against excessive current or voltage to insure trouble-free operation? Are tubes being worked beyond their ratings?

While it is fully appreciated that the problem posed is not easy, it is believed that in the forward rush of the war the virtues of simplicity are in danger of neglect. The Bureau has no desire at all to impair performance to secure pure simplicity, but is not at all convinced that all present complexities are necessary.

The earnest cooperation of all design agencies will be appreciated. It is now thought that the result of such action will be better equipment for the ultimate purpose which is victory.

Signal Corps in Italy

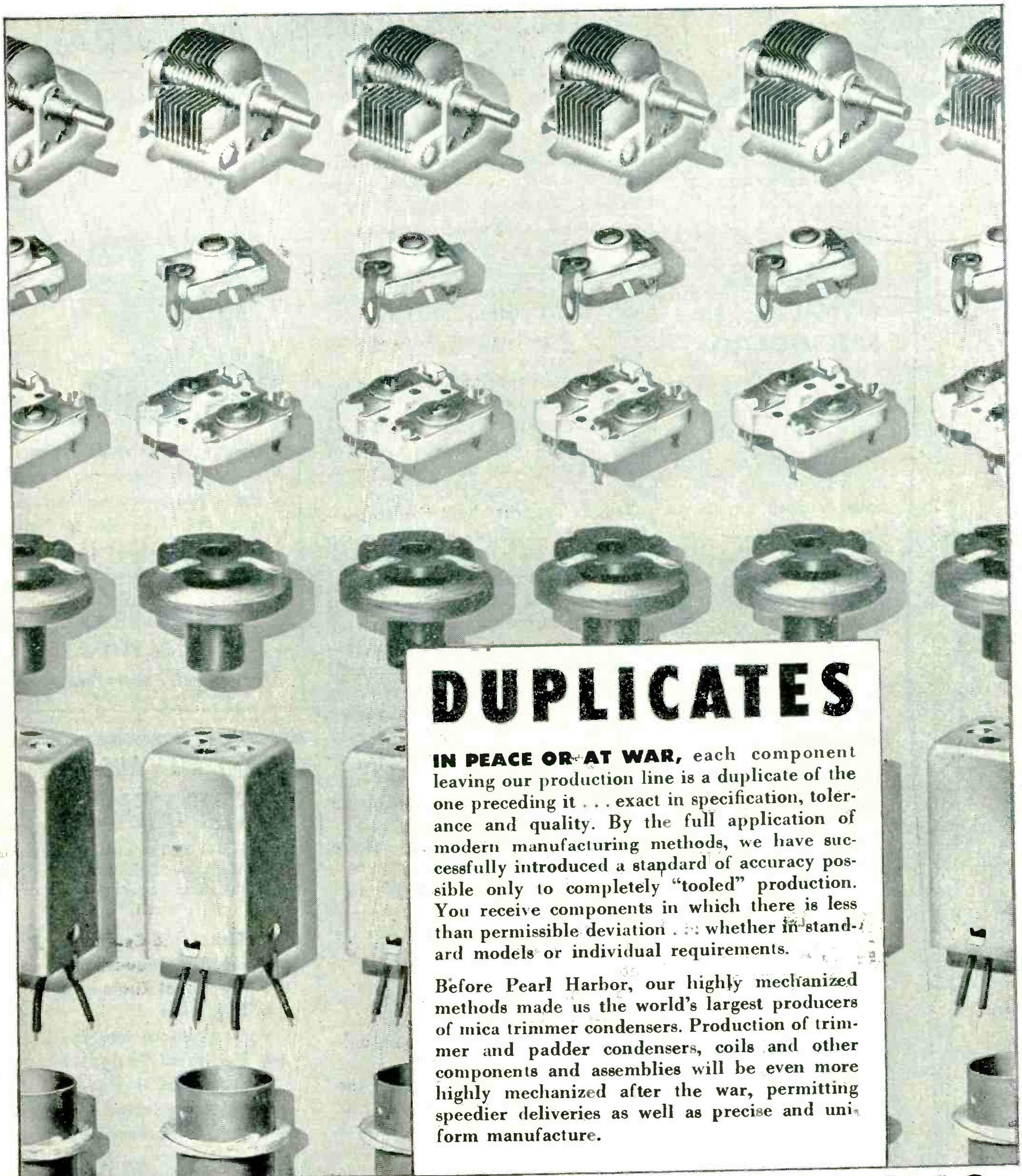
THE FOLLOWING ARTICLE was received in the Office of the Chief Signal Officer from a War Observer attached to the American Fifth Army now battling in Italy. The portions enclosed in parentheses have been added by the Office of the Chief Signal Officer to explain more fully the writer's references.

With the Fifth Army in Italy—Communications, like rations, are one thing the artillery, engineers and doughboys depend on at all times, particularly in a landing operation.

And communications those troops had when they invaded the Salerno Sector on "D" Day, September 9, 1943, when virtually every type of troops in the Fifth Army hit the sand.

This wasn't all happenstance. It came about through careful planning by the Signal Corps.

Communications with ships in the harbor—command ships, rather than



DUPLICATES

IN PEACE OR AT WAR, each component leaving our production line is a duplicate of the one preceding it . . . exact in specification, tolerance and quality. By the full application of modern manufacturing methods, we have successfully introduced a standard of accuracy possible only to completely "tooled" production. You receive components in which there is less than permissible deviation . . . whether in standard models or individual requirements.

Before Pearl Harbor, our highly mechanized methods made us the world's largest producers of mica trimmer condensers. Production of trimmer and padder condensers, coils and other components and assemblies will be even more highly mechanized after the war, permitting speedier deliveries as well as precise and uniform manufacture.

AUTOMATIC WINDING CO., INC.

COMPLETE ELECTRONIC ASSEMBLIES AND COMPONENT PARTS

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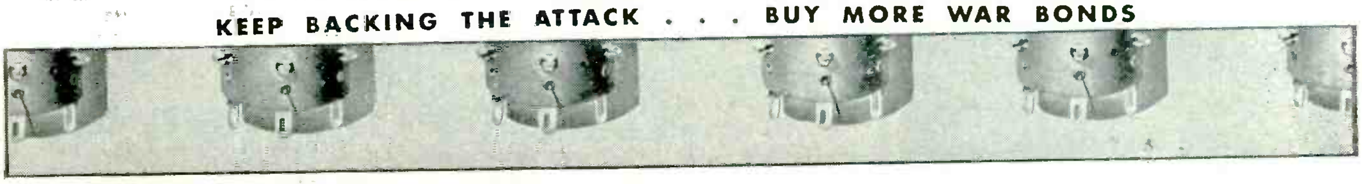
KEEP BACKING THE ATTACK . . . BUY MORE WAR BONDS



the conventional well-grounded Army command posts—were established at almost the precise moment the first troops set foot ashore, and although maintenance of these lines was rugged at times, there were few instances where the troops ashore were out of instant contact either with their sister platoons, companies, battalion or regimental headquarters or the higher echelons of command.

The work of the Signal Corps was inspiring, and in order to furnish the high command with the necessary verbal picture these men frequently got out ahead of the combat troops.

In Italy, one Signal company actually got ahead of the Infantry, with the result that the information they phoned back to the crews of heavy guns of the destroyers, cruisers, and other craft in the harbor offshore, brought about the destruction of German Mark VI tanks which threatened the whole landing party.

Though virtually every type of equipment the Signal companies had at their disposal that day, and for days to come, was in use, there was little opportunity to determine which piece of equipment was the most valuable. Like the artilleryman or engineer, it all depended on whom you talked with, each had his favorite. The consensus was, however, that the "handie-talkie," that small compact radio set that gives the platoon an opportunity to communicate with its company commander or battalion leader instantly, won universal approval. It provided much needed communication with isolated groups and parties sent forward to reconnoiter.

(The handie-talkie is a five-tube transceiver, built with the precision of a wrist watch. Complete with battery, it weighs five pounds. When not in use the set is slung over the soldier's left shoulder by a strap, and the telescopic antenna collapses into the case. Extending the antenna turns on the set automatically. The only other adjustment that is necessary is to push the "press to talk" button under the operator's fingertips, changing the circuit of the set from a receiver to a transmitter.)

Regimental communications officers were generally high in their praise of the 600 series, which gained considerable use during this invasion.

(The 600 series of Signal Corps radios consists of three different

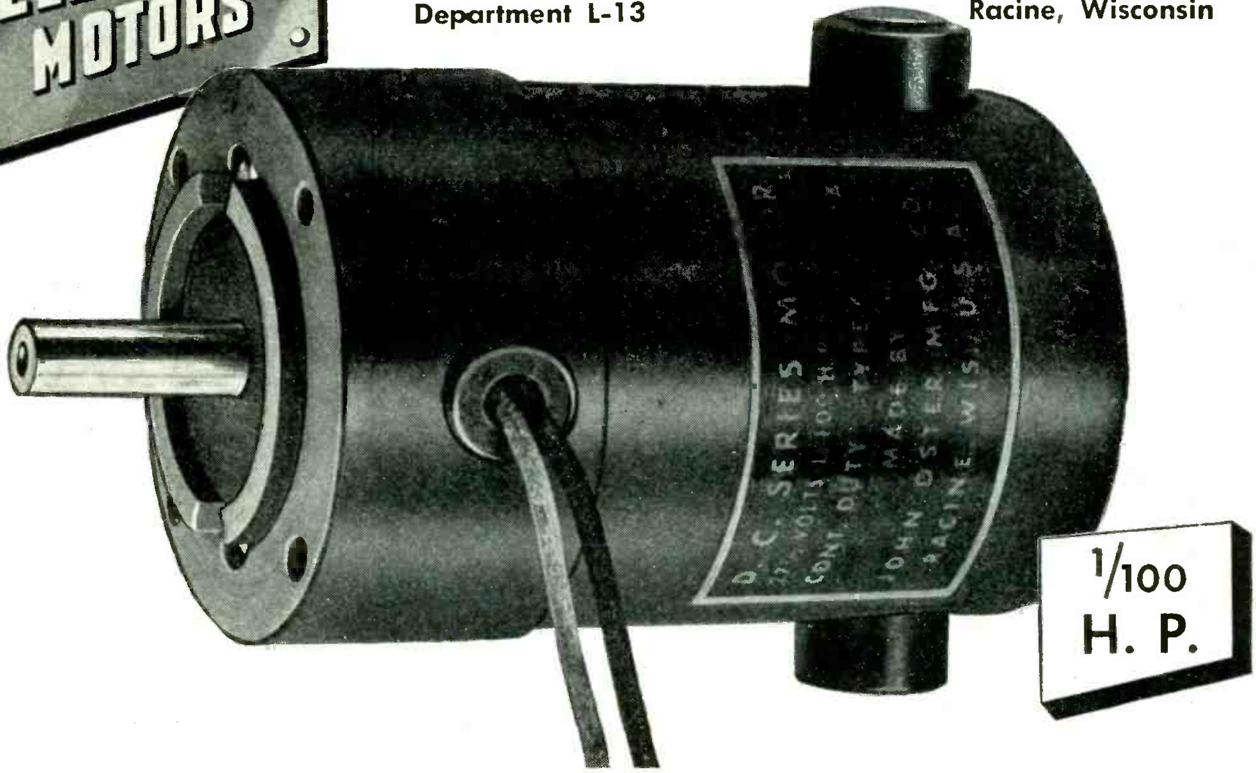
Dependable Power for Blower Applications

... Oster Type C-2B Motor (1/100 H. P.) stands up in severe ambient temperatures

This specialized motor, developed for vitally important war-time applications, operates satisfactorily in a 90° ambient, for continuous duty. It is quality-built by the Oster organization, which for 15 years has been building fractional horsepower motors for use exclusively as original equipment on Oster motor-driven appliances. Ball-bearing equipped; built in an aluminum die-cast housing; 6, 12, 24, or 115 volts DC, 115 volts AC . . . You can depend on Oster motors to live up to the world-wide reputation of pre-war Oster appliances, and to deliver results that add to your own reputation for selecting sources wisely. Let us help you fit this or other Oster motors to your requirements. M-13

John Oster Mfg. Co.

Department L-13 Racine, Wisconsin



types: the SCR 608, SCR 609, and SCR 610. All are operated with frequency modulation for voice communications and are used by combat troops to set up wireless nets during battle. The SCR 608 is a mobile artillery and field artillery set which is powered from the storage battery of the vehicle in which it is installed, and is extremely rugged in construction. It consists of two receivers and one transmitter mounted on a single base. Intercabling complications are by-passed by a series of plugs on the set matching sockets on the base. The set has a number of channels which can be changed instantaneously by push-button tuning.

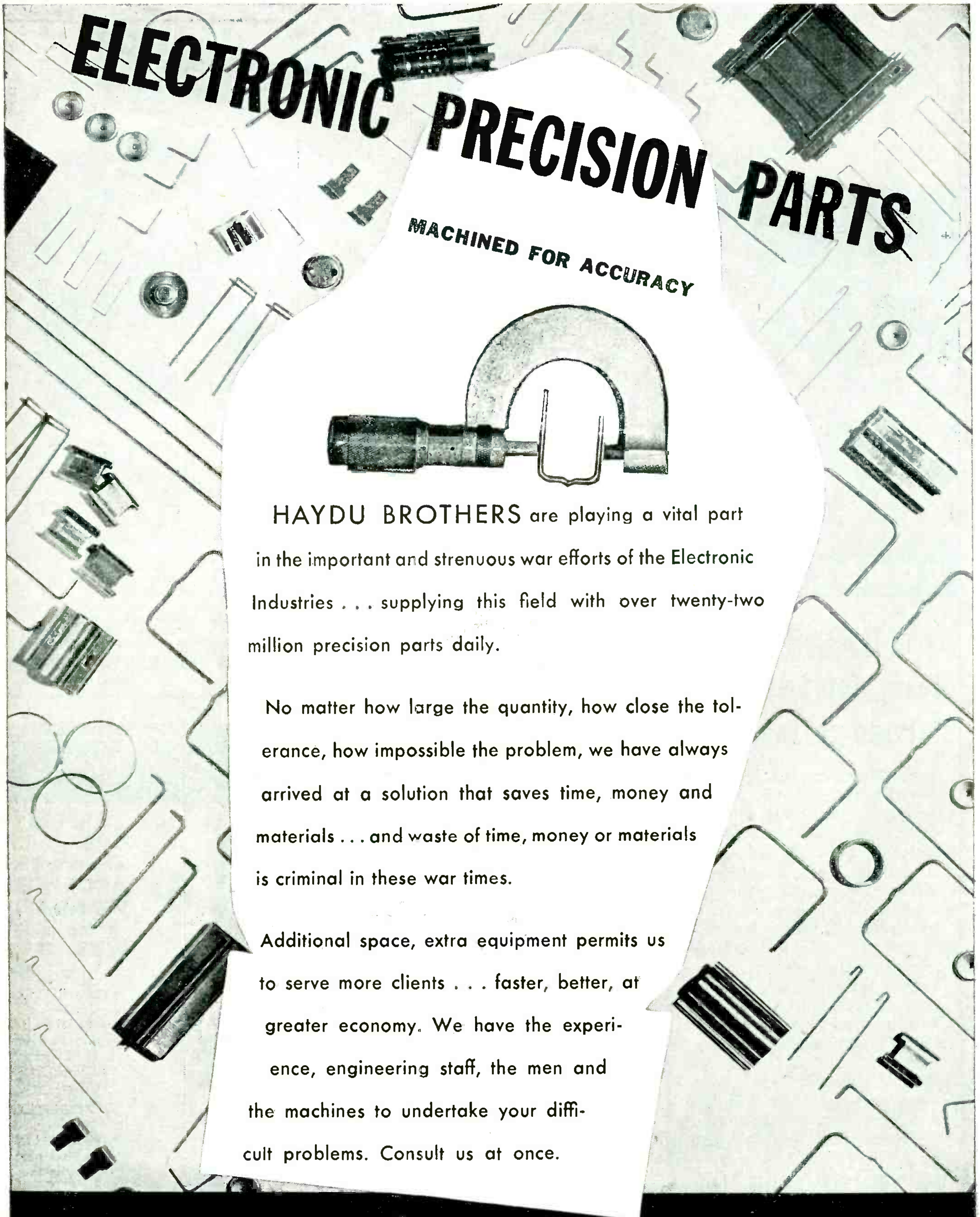
The SCR 609 is a two-piece battery-operated set, each part of which looks like a portable typewriter case when carried. It has a telescopic antenna, which can be fitted into the top case when not in use. It is operated when set down, and has a choice of several channels, selected by flipping a switch. The SCR 610 is similar to the SCR 609 with added components allowing it to be operated while in motion in a vehicle. It gets its power from the storage battery of the vehicle in which it is mounted.

During the early operations most of the equipment had to be brought ashore in "ducks" which frequently shipped water in the high seas. On the assault phase of the operation, some 200 tons of signal equipment was brought ashore by the Fifth Army and its respective units.

WPB Cancels Restrictions on Discs and Styli

RESTRICTIONS on the transfer of blank recording discs and cutting styli (recording needles) have been removed today by the War Production Board through an amendment to Limitation Order L-265, and individuals can now purchase these parts for home recording without priority ratings.

The discs and styli are used chiefly in connection with radio broadcasting and sound recording, and to a lesser extent by individual consumers for home recording purposes. Commercial users of such discs and styli purchase them normally as operating supplies, the Radio and Radar Division of WPB said.



Civilian Tube Distribution

A PLAN FOR MORE balanced distribution of receiving tubes for civilian use was proposed at the first meeting of the electronics industry advisory committee of distributors and representatives of the WPB.

Under the plan, each of the tube manufacturers would offer for sale to the other manufacturers a certain minimum percentage of each type of tube he manufactures, so that all manufacturers would have a supply of all types of tubes. The manufacturers then would offer to their electronics distributors a supply of tubes based on a percentage of the amount of tubes by type which the distributors purchased in 1941.

The plan, proposed by Frank H. McIntosh, chief of the Domestic and Foreign Radio Branch of the Radio and Radar Division of WPB, presiding officer of the meeting, was approved by the distributors' committee although no formal decision was reached. The proposal provides that manufacturers would set aside a suitable quantity of their production for export purposes.

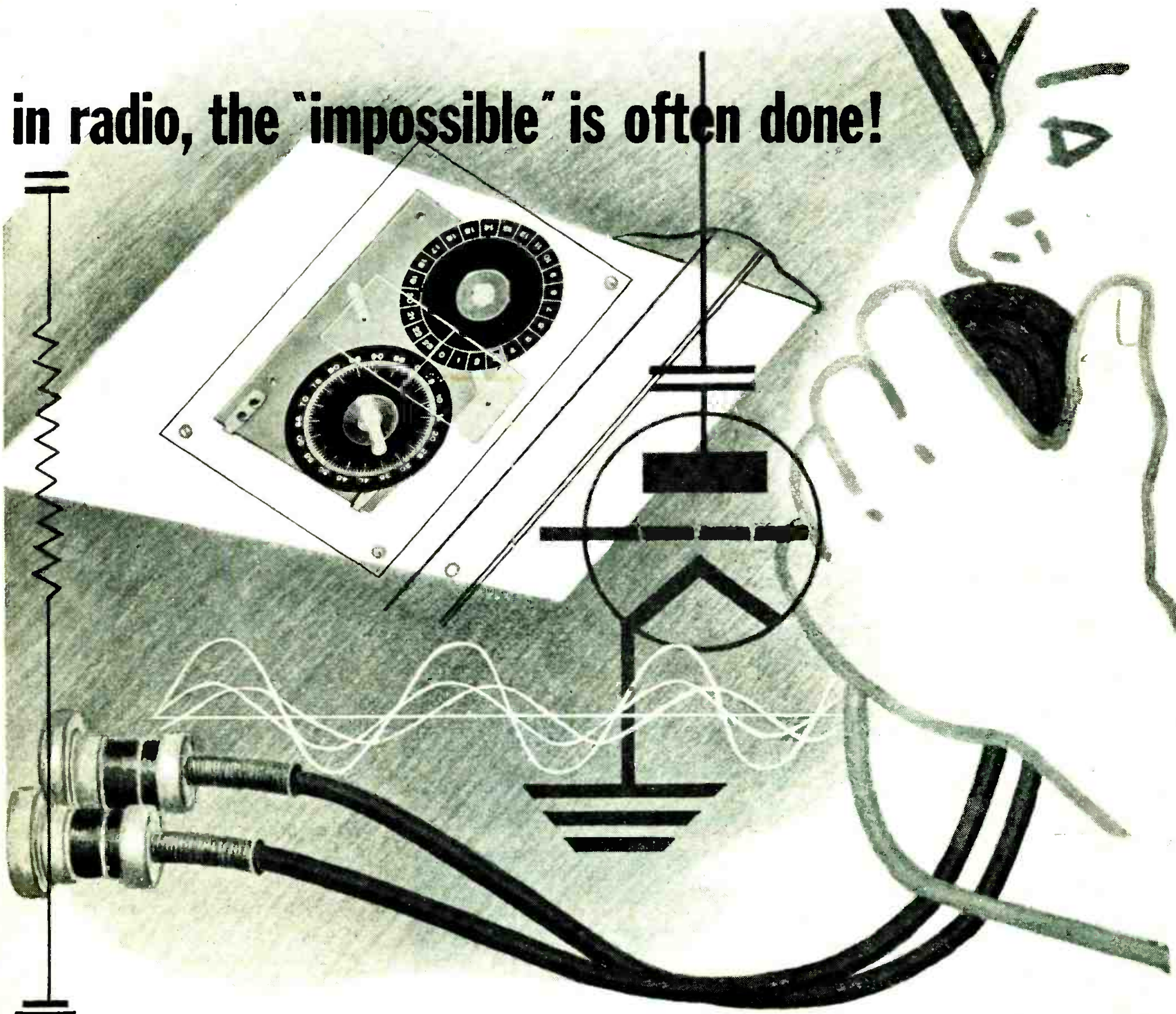
Post-War Electronic Conveyor Belt for Communications

IN A RECENT SPEECH before the National Lawyers Guild in Washington, FCC chairman James L. Fly stressed the importance of preparing now for an effective international communications system. The problem is one which he feels must claim a prominent place in the peace conference and one which requires utmost international cooperation.

What the world needs, according to Commissioner Fly, is a communications system comparable to that now serving nations within the British Empire. To accomplish this, he advocates a consolidation of American international carriers into a single system to be able to deal with monopolies owned and backed by other governments. South American facilities should be freed from Axis controls. "Our consistent aim should be the unfettered flow of communications." To accomplish this, the FCC chairman outlined certain basic principles that must be accepted by all nations at the peace conference.

He attached special importance to the principle of instantaneous radio

in radio, the "impossible" is often done!



The whole history of progress in radio is punctuated by the accomplishment of a series of seemingly impossible tasks. Had the industry stopped every time it was faced with these difficult problems the so-called era of electronics would be non-existent today. Fortunately within the radio industry there are a few courageous individuals and firms who never are willing to accept the dictum that "it cannot be done."

Techrad is an organization of experienced radio engineers who belong to the pioneering group. Their approach to every problem in radio engineering is to keep focused upon the ideal objective and to leave no stone unturned to achieve the right result even though it may seem impossible at the start. Years of successful experience "doing the impossible" has taught Techrad engineers the knack of producing radio components and complete transmitters of surprisingly superior quality.

When you adopt Techrad equipment you can be sure that every detail, even to the smallest, most unimportant component is soundly engineered and produced. That's because Techrad engineers are firmly convinced that anything worth building is worth building well.

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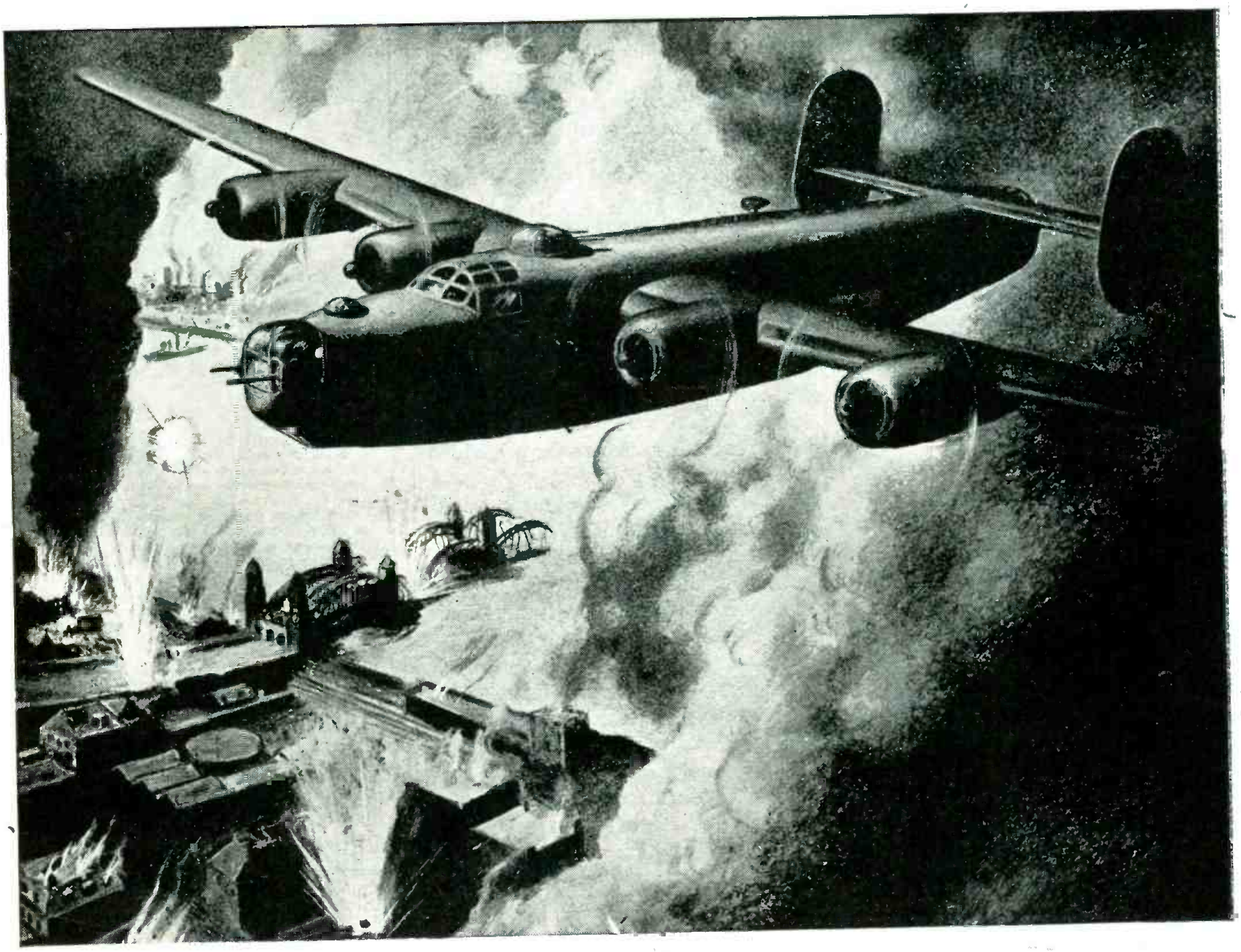
communications between all important areas of the globe, with perhaps an "electronic conveyor belt" in the equatorial zone to conserve frequencies. This would consist of main transmitting stations located in Puerto Rico, West Africa, Egypt, India, China, Guam, Havana and Mexico. All important world points would key into this belt for instantaneous transmission, and full international use could be made of frequencies which are now useful only for short-range communications during particular hours of the day or seasons of the year. For example, a message from New York to Sydney would be put on the belt at Puerto Rico, automatically relayed via Mexico, Hawaii and Guam, where it moves off the belt and down to Sydney. Relatively few frequencies would do the work of many. Technical developments of more immediate benefit are those which permit as many as 12 radiotelegraph circuits to operate in a channel which heretofore would accommodate only one circuit. Fly also pointed to the possibilities of single sideband transmission, which cuts channel requirements in half.

Other principles advocated by the FCC chairman in working out a worthwhile international communications system are uniform rates for all messages throughout the world, low enough to encourage communications; uniform and low press rates; free exchange of information which would lead eventually to international radio broadcast and to international television.

War Standard for Fixed Resistors

A NEW WAR STANDARD for fixed composition "carbon" resistors of less than 5-watt rating has been announced by the American Standards Association. The new standard has been developed at the request of the War Production Board with the cooperation of the War and Navy Departments and the radio industry. This specification will be used by the armed forces in the design of new equipment and as far as practicable, for replacement parts also.

The standard is designed to control the preparation of new manufacturing facilities for resistors, which are now being expanded because of a severe shortage of these parts. De-



For the next 20 seconds, the pilot's name is Elmer!

APPROXIMATELY 20 nervous seconds elapse between the time a bomber goes into its final run and the time it pulls out and heads for home.

During these vital 20 seconds, which determine whether the mission succeeds or fails, the pilot of this bomber is a machine—the Sperry Gyropilot.* He's "Elmer" to the U. S. bomber crews—"George" to the fliers of the R.A.F.

Why is the plane turned over to Elmer? Because Elmer provides the precision control necessary to maneuver the airplane correctly during the bombing run.

Elmer holds the ship steadier—truer—than any man can do. His errorless control is one of the big reasons for the accuracy of American precision bombing.

Elmer not only does this but, going to and from the target, he can hold the big ships in level flight and on their course with no hand on the controls.

Naturally, a device like this is not created overnight. Sperry developed the first automatic pilot before the last war. It was designed to increase safety in flight. Pioneering and development work continued. In 1933, Wiley Post flew around the world alone with the aid of a Sperry Gyropilot.

Post's epochal flight furnished spectacular proof that Elmer was practical. Sperry Gyropilots were soon standard equipment on transport planes the world over. When World War II came, still further improvements had been made to give Elmer the precision needed for bombing missions.

Improvements are still being made. When the war is over, Elmer, along with many other Sperry devices developed for peace and adapted to war, will return to the work for which he was originally designed.

With more than 30 years of development behind him, Elmer, the Sperry Gyropilot, will be well-equipped to serve tomorrow's world-wide airlines.

American bombers are now being equipped with the new Sperry Gyrotronic Pilot, a precision, electronic version of the Gyropilot.**

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SPERRY
GYROSCOPE COMPANY, INC.
Brooklyn, New York
Division of the Sperry Corporation

signers of radio equipment are expected to utilize this standard as extensively as possible in order that maximum production may be had with a minimum waste of time and material to facilitate servicing of equipment in the field.

The specifications for the new war standard, Fixed Composition Resistors (C75.7-1943) cover fixed composition resistors suitable for use in all non-specialized applications in communications and electronic equipment. Performance requirements, test methods, standard dimensions, standard resistance values and ratings for these resistors are contained in the standard.

There are fixed composition resistors now in use that are not covered by the new standard and do not permit complete substitution by the proposed resistors. Because of this it is not intended that their manufacture be immediately discontinued. Neither is the standard intended to apply to special fixed resistors having rigid requirements and a tolerance of less than five percent.

The standard may be had without charge, for procurement purposes only, from any government agency concerned. It may be obtained for 60 cents from the American Standards Association, 29 West 39th St., New York 18, N. Y.

Television Receivers Surveyed

THE PRESENT OPERATING status of television receivers now in the hands of the public is indicated by the results of a survey conducted by NBC and disclosed by John T. Williams, of the television department of NBC, at a luncheon of the American Marketing Association.

The first question asked in the questionnaire was, "What make of television receiver do you own?" Reports on 1434 receivers, with 22 returns reporting more than one receiver, indicated the following breakdown in percentage: RCA 60.7, DuMont 10.4, G-E 10.2, Andrea 5.9, Westinghouse 1.4, other makes and unknown 11.4.

The second question read, "What size screen does your receiver have?" The same 1434 receivers indicate screens of the following size: over 12 inches 3.9 percent, 12-inch 50.2, 9-inch 20.5, 5-inch 22.5, unknown 2.9 percent.

The operating condition of all tele-

vision receivers was the subject of the third question. The returns showed that 66.7 percent of the receivers were excellent or good, 14.1 percent fair, 4.8 percent poor, and 11.2 percent not operating. This shows that in spite of long usage and inability to get repairs or service, more than 80 percent of the receivers are still in fair or better operating condition. Comments from those people that have inoperative receivers indicated that there is a high degree of interest in television among those set owners with the greatest reason for complaint.

The fourth question concerned the size of the audience before each receiver. Of 1113 home returns, 92.1 percent of the total of that category, an average audience of 8 people be- ore each home receiver was reported. In round figures, this is composed of an average of 3 men, 3 women, and 2 children.

In 155 public places, 78.3 percent of all those public places returning their questionnaires, an average audience of 46 individuals view the programs. This group is composed of approximately 31 men, 11 women, and 4 children.

In judging the results of the questionnaire, it must be remembered that today's audience is limited to television receivers manufactured mainly during 1941 and prior to that date. There are approximately 5000 receivers in the New York City area. Some 800 receivers are in the Philadelphia area, and approximately 400 in the Albany-Troy-Schenectady area.

Educational Color Movie Available

A 16-MM COLOR FILM entitled "Crystals Go to War" is available without charge for showing before engineering groups and societies. The film shows factory manufacturing and testing processes used by Reeves Sound Labs., 62 West 47th St., N. Y.

Produced under the supervision of the U. S. Army Signal Corps, the film was shown publicly for the first time to engineers attending the Rochester Fall meeting of the IRE. Complete time of showing is forty minutes. Information regarding the availability of the film may be obtained from Fred H. Pinkerton of the company.

New Calls for FM Stations

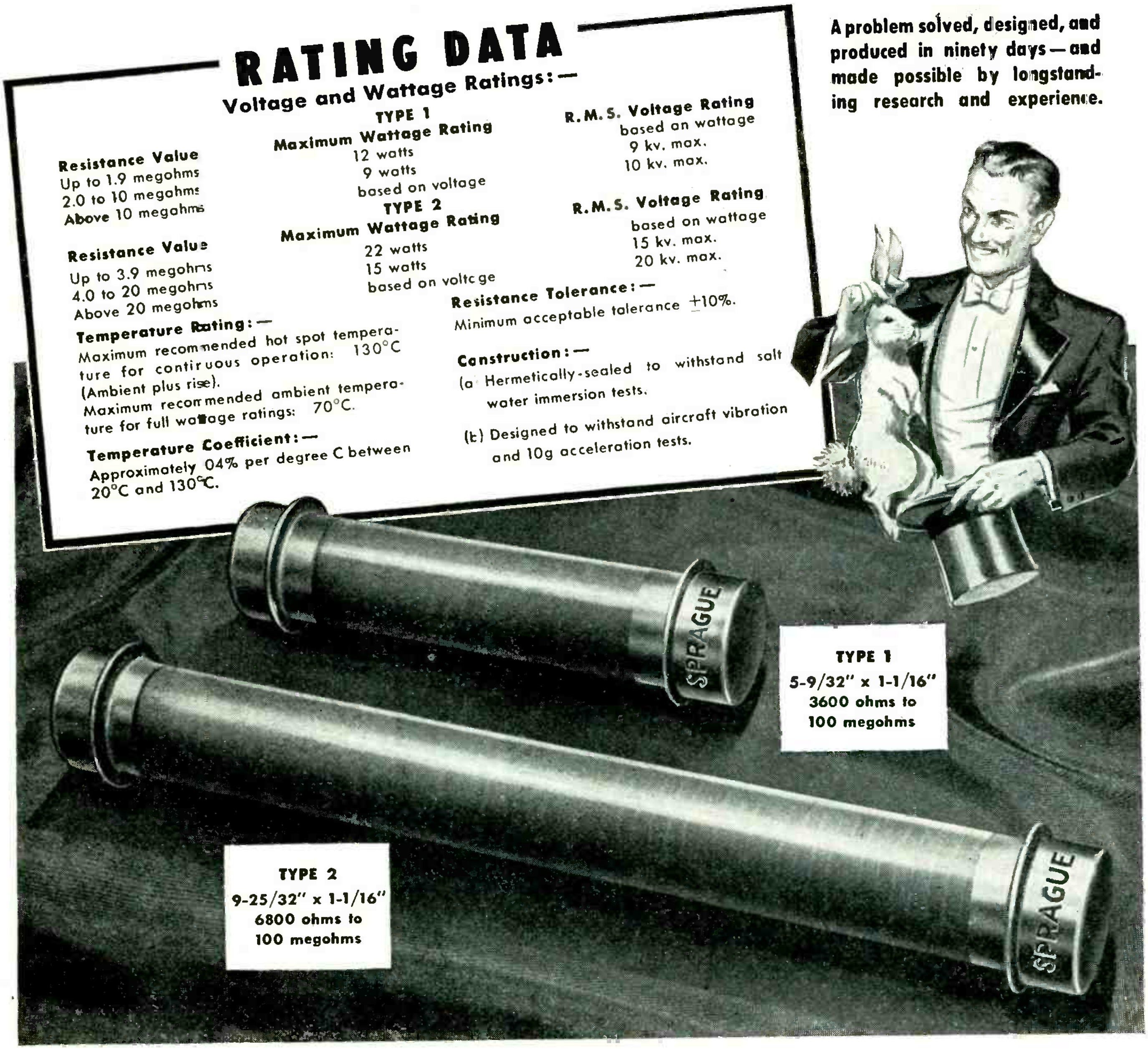
THE NEW CALL LETTERS of the commercial FM broadcast stations, designed to eliminate the combination numeral-letter arrangement previously used, are listed below. The old calls are also given for identification. There are still a number of experimental and educational stations operating under their old calls and these have not been listed.

WBRL	W45BR	Baton Rouge, La.
WNBF-FM	W49BN	Binghamton, N. Y.
WGTR	W43B	Boston, Mass.
WBZ-FM	W67B	Boston, Mass.
WWZR	W51C	Chicago, Ill.
WGNB	W59C	Chicago, Ill.
WBBM-FM	W67C	Chicago, Ill.
WDLM	W75C	Chicago, Ill.
WMIT	W41MM	Clingman's Peak, N. C.
WELD	W45CM	Columbus, Ohio
WENA	W45D	Detroit, Mich.
WLOU	W49D	Detroit, Mich.
WMLL	W45V	Evansville, Ind.
WOWO-FM	W49FW	Fort Wayne, Ind.
WTIC-FM	W53H	Hartford, Conn.
WDRC-FM	W65H	Hartford, Conn.
KOZY	K49C	Kansas City, Mo.
KHJ-FM	K45LA	Los Angeles, Calif.
WMFM	W55M	Milwaukee, Wisc.
WMTW	W39B	Mt. Washington, N. H.
WSM-FM	W47NV	Nashville, Tenn.
WNYC-FM	W39NY	New York, N. Y.
WGYN	W47NY	New York, N. Y.
WQXQ	W59NY	New York, N. Y.
WHNF	W63NY	New York, N. Y.
WABC-FM	W67NY	New York, N. Y.
WOR-FM	W71NY	New York, N. Y.
WABF	W75NY	New York, N. Y.
WIP-FM	W49PH	Philadelphia, Pa.
WFIL-FM	W53PH	Philadelphia, Pa.
KYW-FM	W57PH	Philadelphia, Pa.
WCAU-FM	W69PH	Philadelphia, Pa.
WPEN-FM	W73PH	Philadelphia, Pa.
WTNT	W47P	Pittsburg, Pa.
KDKA-FM	W75P	Pittsburg, Pa.
WHEF	W47R	Ro[illegible] N. Y.
WHFM	W51R	[illegible]chester, N. Y.
W[illegible]CA	W47A	Schenectady, N. Y.
WGFM	W85A	Schenectady, N. Y.
WSBF	W71SB[illegible]	South Bend, Ind.

Winter IRE Meeting

THE WINTER TECHNICAL meeting of the Institute of Radio Engineers will be held on Friday and Saturday, January 28th and 29th, at the Hotel Commodore, N. Y. Engineers who plan to attend will be interested to know that the American Institute of Electrical Engineers is holding technical meetings the early part of the same week. Communications papers will be presented on Thursday, January 27th, and may be heard by early-comers to the IRE meeting. Major General Colton will speak on "Enemy Communication Equipment" at a joint AIEE-IRE session on Thursday evening. Both of these meetings will be held at the Engineering Societies Building, 29 West 39th St., N. Y.

The Institute has been requested to cooperate in conserving the nation's transportation facilities and is confining the mailing of Winter Technical Meeting notices to members residing east of the Mississippi.



A problem solved, designed, and produced in ninety days—and made possible by longstanding research and experience.

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HIGH-RESISTANCE, HIGH-VOLTAGE RESISTORS

Less than 3 months from the presentation to Sprague Koolohm Resistor engineers of the problem of designing high-resistance value units capable of dissipating power at voltages up to 20 kv. and at high ambient temperatures, the first Sprague Meg-O-Max Resistors were on the job! Moreover, they used practically no critical materials, were of smaller physical size, and presented a degree of resistance stability and mechanical ruggedness not available in other units, exclusive of costly wire-wound meter multiplier types!

Entirely unique in construction, Meg-O-Max Resistors are formed of a series of molded segments. These are joined non-inductively, and the assembly is then encased in a hermetically-sealed, rugged glass envelope provided with ferrule terminals to withstand aircraft vibration tests, salt water immersion tests, and tests for mechanical shock produced by rapid acceleration.

In addition to use as a high-voltage bleeder and as a broad accuracy meter multiplier for a voltage indicator, Meg-O-Max Resistors find many applications in measuring instruments, rectifier systems, high-voltage dividers, and as broad accuracy meter multipliers. Specify Meg-O-Max for High-Resistance—High-Voltage requirements.

Data sheets gladly sent upon request. Samples sent only on firm's request, giving details of application.

SPRAGUE SPECIALTIES COMPANY
Resistor Division • North Adams, Mass.

A NEW DEVELOPMENT BY THE MAKERS OF KOOLOHM INSULATED WIRE-WOUND RESISTORS

TRADEMARK REGISTERED

The complete program follows:

FRIDAY, JANUARY 28

9:00 A.M. to 12:20 A.M.

Registration

Address of Welcome—B. E. Shackelford, Chairman, 1944 Winter Technical Meeting, L. P. Wheeler, Presiding

Ceremony of "passing the Gavel" from retiring President Wheeler to incoming President Turner

Annual Meeting of the Institute, H. M. Turner presiding

Amendment of Institute's Charter

Dr. Wheeler resumes Chairmanship for the Session of Technical Papers.

12:30 P.M.

President's Luncheon—Professor Turner

2:30 P.M.

Symposium — Haraden Pratt presiding, "Work of the Radio Technical Planning Board", W. R. G. Baker, Chairman of Radio Technical Planning Board; Several Panel Chairmen.

4:30 P.M.

Mr. Pratt resumes Chairmanship for the Session of Technical Papers

7:00 P.M.

I. R. E. Banquet (Informal), Lewis, Master of Ceremonies.

Awards, presented by Prof. Turner

1943 Medal of Honor—to Haraden Pratt

1943 Morris Liebmann Memorial Prize—to W. L. Barrow

1943 Fellowship Awards—to S. L. Bailey, C. R. Burrows, M. G. Crosby, C. B. Feldman, Keith Henney, D. O. North, K. A. Norton, S. W. Seeley, D. B. Sinclair, Leo Young, Harry Diamond

Annual Address of retiring president, L. P. Wheeler

Prominent Speaker on timely subject (to be announced)

SATURDAY, JANUARY 29

10:00 A.M.

Symposium—H. M. Turner Presiding

"Engineering Work of the Federal Communications Commission" by E. J. Jett, chief engineer, FCC

Timely Broadcast Matters" by G. P. Adair, Assistant chief engineer, FCC

Police, Aviation and Maritime Services" by W. N. Krebs, Chief of the Safety and Special Services Division, FCC

"International Point-to-Point and Allocation Problems" by P. F. Siling, chief of the International Division, FCC Engineering Department

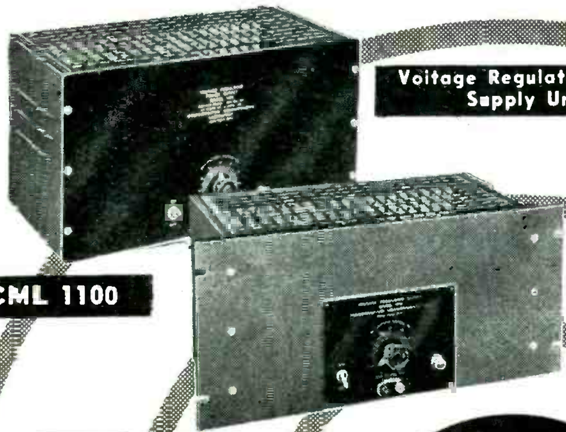
12:30 P.M.

Students' Luncheon

2:30

Technical Session — Lloyd Espenschied Presiding

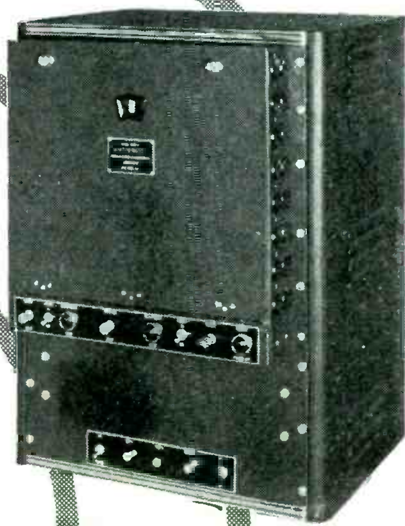
It is also expected to have prominent American, British, Russian and Chinese authorities outline radio engineering in their respective countries



Voltage Regulated Power Supply Units

CML 1100

CML 1110

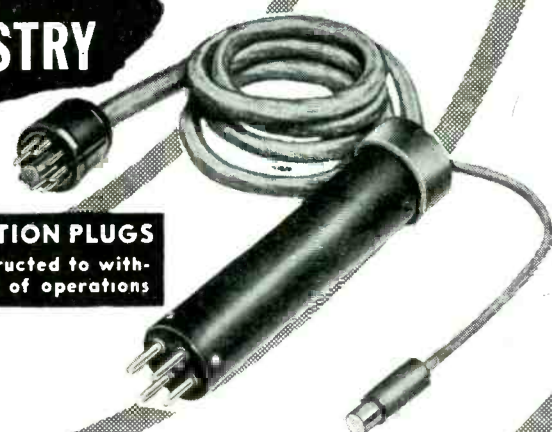


ROTOBRIDGE

Automatic tester checks for proper wiring, correct resistance, reactance, capacity and inductance values

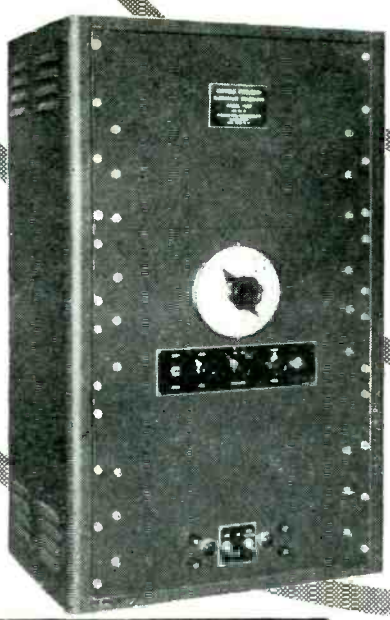
CML

SERVES THE ELECTRONIC INDUSTRY



CML PRODUCTION PLUGS

Especially constructed to withstand thousands of operations



MODEL 1420 GENERATOR

Developed to furnish test power over a wide frequency range

Each CML development shown on this page is keyed to the most rigorous wartime specifications for accuracy. All are contributing importantly to precision and efficiency in scores of laboratory and industrial applications. From the Production Plug to the new Model 1420 Generator, CML offers equipment of accredited performance.

WRITE FOR DESCRIPTIVE BULLETINS

COMMUNICATION MEASUREMENTS LABORATORY

120 GREENWICH STREET, NEW YORK 6, N. Y.

WPB Relaxes Restrictions

THE PRIORITY RATING of persons engaged in the radio broadcasting business for obtaining radio maintenance, repair and operating supplies was raised from AA-2 to AA-1 and permission to use the "MRO" symbol has been continued by the War Production Board through issuance of amended Order P-133.

Commercial sound recording, which had a rating of AA-5 under the previous order, was assigned an AA-2 preference rating. Broadcasting tube inventory restrictions are clarified in the amended order by requiring return to the manufacturer of all used power tubes of 250 watts or more.

Special provision has been made for radio and other electrical repairmen to purchase $150 worth of copper wire or one-eighth the amount used in 1941, whichever is greater. Industrial maintenance and repair men may buy up to one ton of copper wire and one ton of copper and brass products and may be authorized to use an AA-2 preference rating.

Industrial Incentive Films Available

NINE 16-MM SOUND FILMS, showing action shots from many scenes of our global war, are now available through a national distribution system to war plants who wish to show their employees what the material their own hands have turned out is doing to the enemy. Most of these films are "restricted" and cannot be viewed in commercial theaters.

Included in the subjects are action pictures of the Navy's newest and deadliest anti-submarine weapon—the Destroyer Escort, landing of the Marines on Guadalcanal, "The Life and Death of the Hornet"; and several reels of captured German films.

The films are described and procedure for obtaining them outlined in a folder obtainable from the Chief of the Industrial Incentive Division, Navy Department, 2118 Massachusetts Avenue, Washington, D. C. A nominal fee of $1 for three reels or less in any one shipment is charged to cover costs. Plants not having projection facilities may contract with a local film distributor for an experienced operator and 16 mm projector.

CASED MODEL

RAYTHEON

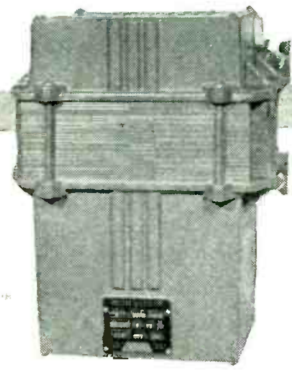
Voltage Stabilizers

Accurately Control Fluctuating Voltage to ± ½%

Raytheon Voltage Stabilizers are available for incorporation in your product or equipment for almost any type of service. There are three designs—cased, uncased and endbell models—to meet your installation requirements. All Raytheon Stabilizers deliver controlled output voltage to ± ½% over their full rating. Write, outlining your needs—Raytheon Engineers will make recommendations.

Raytheon Voltage Stabilizers Give You These Outstanding Advantages . . .

- Hold constant varying A. C. input voltage to ± ½%.
- Stabilize at any load within their ratings.
- Quick action . . . stabilizes within 2 cycles . . . variations cannot be observed on an ordinary volt meter.



Endbell Model

- Wide A. C. input voltage limits . . . 95 to 135 volts.
- Entirely automatic . . . no moving parts . . . requires no maintenance . . . connect it and forget it.

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

RAYTHEON MANUFACTURING Company 190 WILLOW ST. WALTHAM, MASS.

London News Letter

By JOHN H. JUPE
London Correspondent

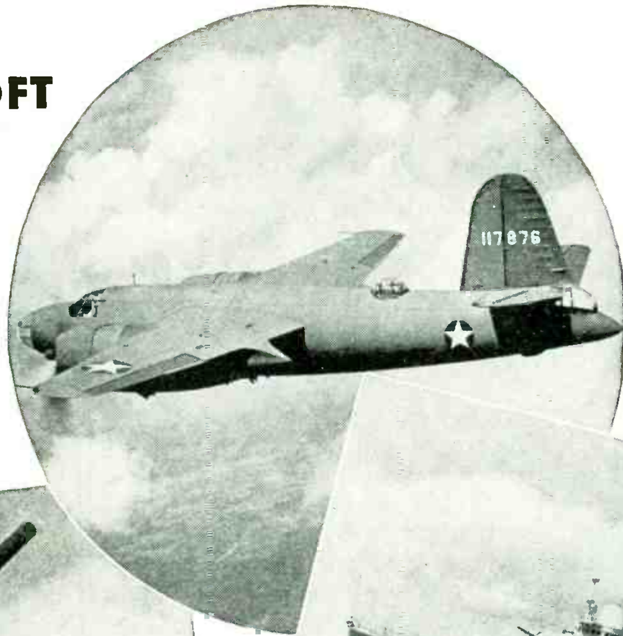
Nazi Light-Beam Telephone. As far back as 1935 we knew that the Germans were working on a light-beam field telephone set for use in the field. From papers captured in Libya, after the war started, we learned that it had become part of their regular equipment, but it was not until the Battle of Alamein that the Allies captured any of the actual equipment. Examination has now been carried out and has recently been described in *Electronic Engineering* by Captain D. Gifford Hull of the British Army.

The intensity of the light beam is modulated by microphone currents passed through a single-stage amplifier. The apparatus depends for its success mainly on a pair of Carl Zeiss prisms so arranged that the speech currents vary the contact pressure between them, causing a change of reflection and refraction. An ordinary metal-filament lamp is used as the light source and white, red and infrared filters are used, producing a beam 6 yards wide at a mile from the transmitter and 30 yards wide at the maximum range of 5 miles.

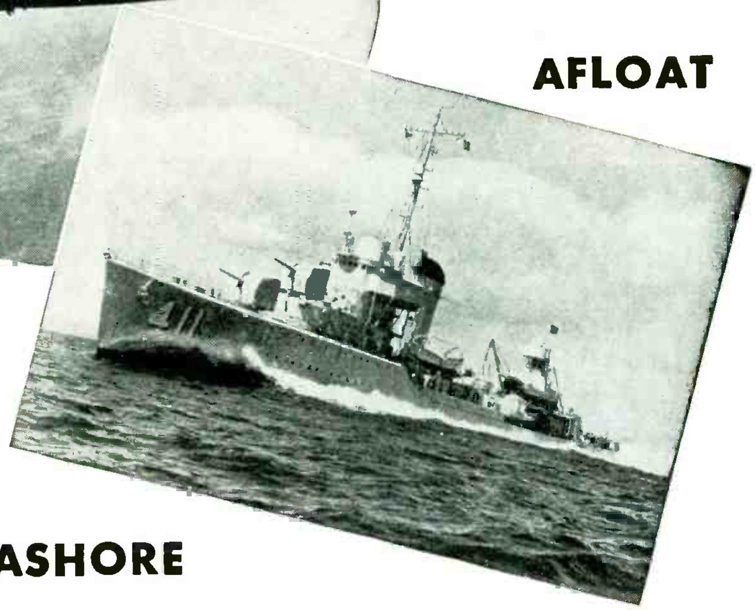
For reception, five high-gain pentodes are used in conjunction with a thalofide-type photocell. To reduce the effect of heat ripple in the desert both transmitting and receiving amplifiers are designed to have a cut-off below 300 cps. Morse keying can be used, and the apparatus can be linked to telephone lines if necessary. The total weight of the equipment is 54 lb.

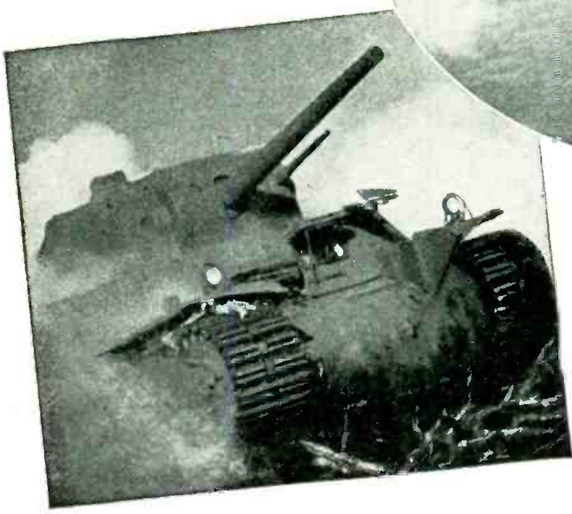
Whether the British Army has anything comparable I cannot find out but in 1933 the Marconi Company in England demonstrated an experimental light-beam telephone using a gas discharge tube and modulating the beam at its source. The tube was dumbbell-shaped and contained both neon and sodium. Operation with the former was obtained by applying potential and with the latter by passing current through a few turns of nichrome wire coiled outside the envelope and so vapourizing the sodium. Two valves were used in the transmitter, together with an audio-frequency oscillator for keying tone. Reception was by means of a caesium cell coupled to

ALOFT



AFLOAT

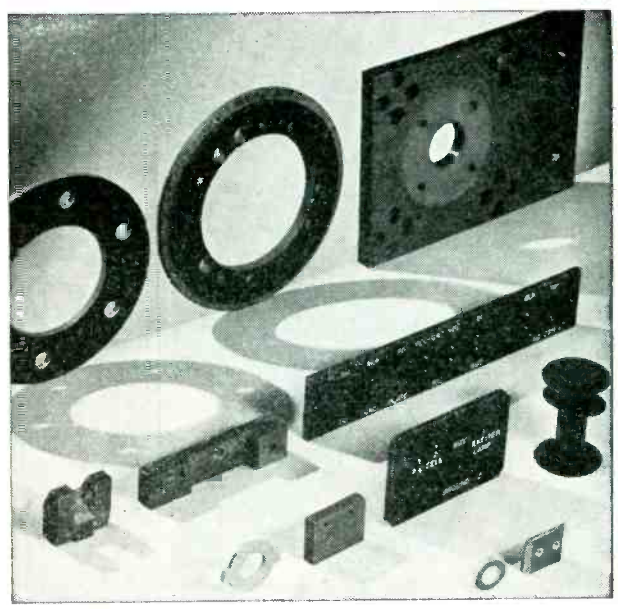




ASHORE

A CONTINENTAL DIAMOND *product*

is in there slugging!



C-D makes hundreds of electrical and mechanical parts which are vital to the successful operation of radios, guns, controls, communication systems, and all electrically energized units in our fighting equipment afloat, ashore and aloft.

Many of these applications posed new problems and conditions for NON-metallics. The research and experience which resulted has provided our laboratory with a wealth of "know how" which is at your disposal to help solve your "What Material?" problems.

C-D products include **THE PLASTICS... DILECTO—a laminated phenolic: CELORON—a molded phenolic: DILECTENE—a pure resin plastic especially suited to U-H-F insulation . . . THE NON-METALLICS, DIAMOND Vulcanized Fibre: VULCOID—resin impregnated vulcanized fibre: and MICABOND—built-up mica insulation.** Folder GF describes all these products and gives standard sizes and specifications.

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

CD-43

Continental-Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK • DELAWARE four amplifier stages. The overall range on telephony was 2-3 miles, at night, but this could be increased by changing to telegraphy. Daylight reduced the range to about 75 percent of the above.

Radio Altimeter. British Patent No. 552260 describes an interesting principle in this field, based on measuring the distance of a reflecting body by noting the time taken for a reflected radio wave to return to its point of origin. One way of measuring the time is to vary the frequency of the outgoing wave in a cyclic manner and to measure the heterodyne frequency set up by the outgoing and incoming waves, with the aerial tuned to the mean frequency of the repeated cycle. This obviously produces a drop in efficiency at the limits of the frequency travel.

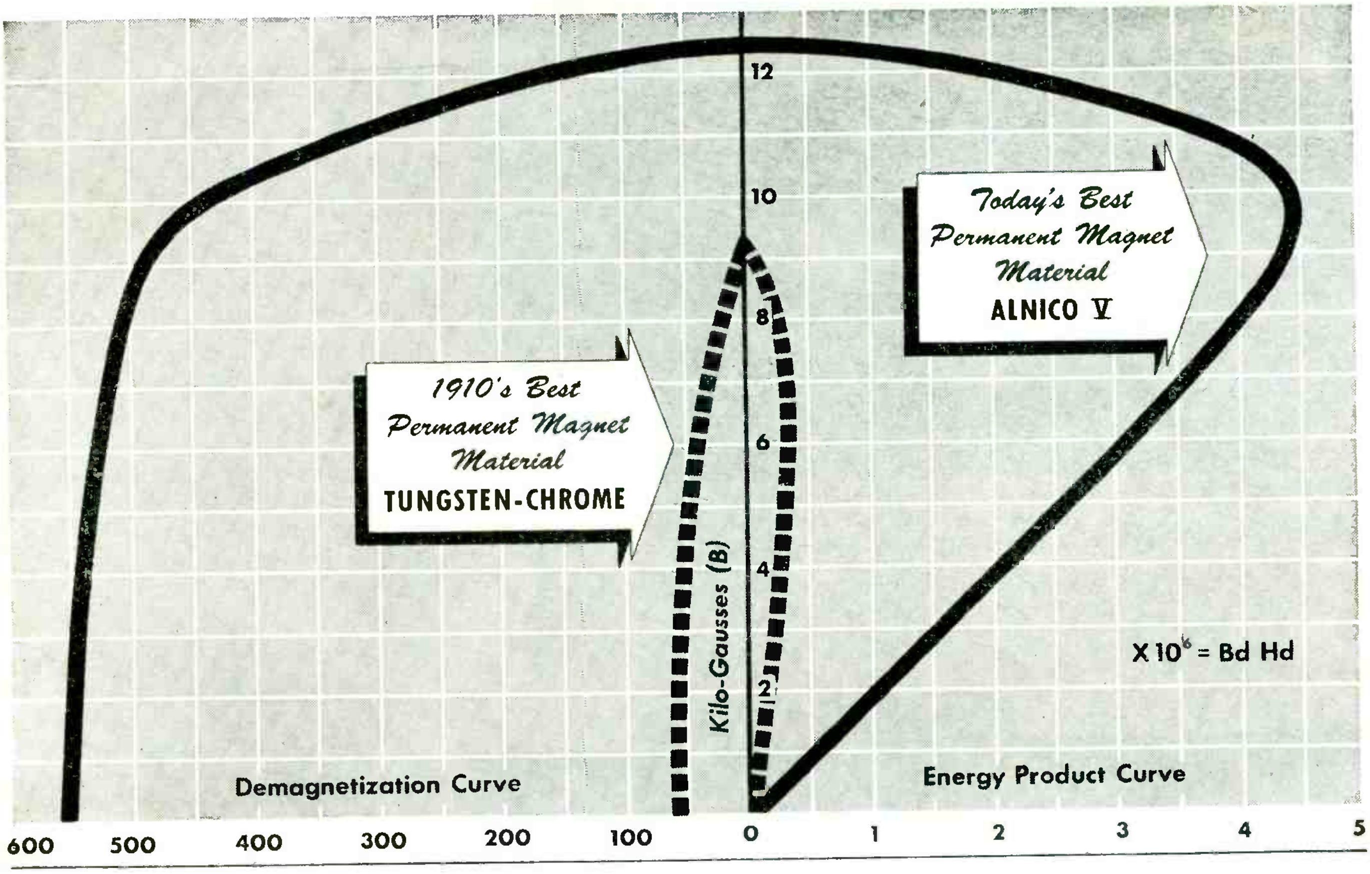
In the patent mentioned the aerial tuning is ganged with the circuits of the carrier oscillator so that the varying transmitted wave is always radiated at high efficiency. As the difference between the two end frequencies is small, reckoned as a percentage of the carrier, the amount of detuning experienced by the returning wave is negligible.

Electronic Stimulator for Physiological Research. Apparatus for this purpose should fulfill several requirements and in *Electronic Engineering* for October, Thorp and Robinson describe an instrument which goes a long way toward the ideal characteristics.

A relaxation oscillator charges a capacitor linearly by means of a high-impedance pentode, where the anode current is almost independent of the anode voltage. Discharge is triggered with a gas-filled triode and the resultant waveform has a very steep front with almost linear decay. Other characteristics are: (1) the pulse space ratio is high; (2) approximate load matching is possible; (3) frequency is variable between $\frac{1}{10}$ cps to 3250 cps and extensions either way are possible; 4 single pulses can be obtained, (5) hunting is completely absent and the waveshape can be observed on a small cathode-ray tube.

If the Nazis Only Read ELECTRONICS. "The electron microscope is a German invention which, it is hoped, will never become available to the enemy." *Deutsch Bergwerkszeitung*

PERMANENT MAGNETS MAY DO IT BETTER



Increased Energy Has Made Possible Many New Uses for Permanent Magnets!

Today's permanent magnets of Alnico V have a stored energy ten times that of 1910's tungsten-chrome magnets!

This energy increase, the economies in bulk and weight resulting from it, plus significent advances in design and fabrication, have made it possible to use permanent magnets in countless *new* products.

Specializing in this *one* industry for 33 years, our organization has assumed a leading role in permanent magnet developments. We've constantly originated new shapes, new applications, and new techniques in metallurgical control and precision manufacture. This experience should prove invaluable to you in the solving of your engineering problems.

Our engineers will be pleased to consult with you. Write us, on your letterhead, for the address of our office nearest you—and a copy of our 30-page "Permanent Magnet Manual".

Back the Attack with War Bonds!

The INDIANA STEEL PRODUCTS *Company*

★ SPECIALISTS IN PERMANENT MAGNETS SINCE 1910 ★

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

Radio Business News

RADIOS, toasters, and vacuum cleaners head the list of appliances turned in to Commonwealth Edison in a swap drive in Chicago.

COMMERCIAL ENGINEERING LABS. of Detroit, Mich. has become Commercial Research Labs., Inc.

SYLVANIA ELECTRIC PRODUCTS, INC. is converting a former furniture factory at Williamsport, Pa. to production of electronic equipment. This makes the 18th plant for the company.

FERRANTI ELECTRIC, INC. has opened a new factory in Brooklyn, N. Y. Offices continue to be located in new, larger quarters in the RCA Building, New York City.

MEC-RAD DIVISION of Black Industries, 1400 East 222nd St., Cleveland, Ohio, has been formed to manufacture the mechanical components for electronic devices. Major products will be transmission lines and radiation components. The parent company operates Black Boring & Machine Co.

DETROLA CORP. has merged with International Machine Tool Corp. to form International Detrola Corp.

ASTATIC CORP. of Youngstown, Ohio, has arranged to purchase a three-story building in Conneaut, Ohio.

WESTERN ELECTRIC CO. discloses that 50 percent of its total sales of war materials to the government since the U. S. entry into the war has been produced by subcontractors. This exceeds by 10 percent the rate which the WPB requested prime contractors to establish in an effort to step up the output of munitions and provide business for smaller manufacturers whose prewar production has been shut off through the diversion of strategic materials into war production. The company currently does business with more than 6.500 subcontractors and suppliers.

GENERAL RADIO CO. has opened a new office at 920 S. Michigan Ave.

WBCA, Schenectady, first FM station to become a full-fledged affiliate of a network, will carry Mutual programs.

RADIO & TECH. PUB. CO. has been sold to Farrar & Rinehart by Alfred A. Ghirardi.

125,000 copies of "Radiotron Designer's Handbook," published by Amalgamated Wireless Valve Co., Ltd., have been sold in Australia, the United Kingdom and the U. S. A.

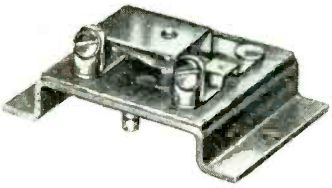
Personnel

Major William Minnis Perkins, former assistant manager of the RCA equipment tube section at Camden, died of acute luekemia in Walter Reed Hospital, Washington, D. C. He held a reserve commission, was called into active service in April, 1942, and was assigned to duty in Washington in the Office of the Chief Signal Officer of the War Department. At the time of his death he was Chief of the Equipment Branch of the Requirements Division.

William A. Lewis, director of Cornell University's school of electrical engineering, has been named consulting electrical engineer to the Armour Research Foundation at Illinois Tech and also a research professor in the electrical engineering department.

Ralph A. Hackbush, vice-president-elect of IRE and vice-president in charge of radio at Research Enterprises Ltd. of Canada, has rejoined Stromberg-Carlson of Canada as vice-president and managing director.

Ralph A. Hackbush



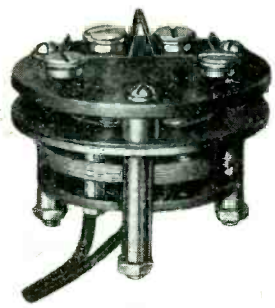
Type C-4351 Series
Used for Tube Warming, Tube Cooling, and High-Low Limit Controls

Type B-3120
Crystal Dew Point Control

Type C-2851 Series
Used as Roughing Controls on Outer Crystal Ovens and High-Low Limit Controls

Type RT
Adjustable Crystal Temp. Oven Control

Type C-6363
Switch Circuit Breaker



Type ER Series
Ambient Compensated Time Delay Relays

AWAKE AT THE SWITCH

24 HOURS A DAY

Type PM
(NAF-1131)
Circuit Breaker

KLIXON SNAP-ACTING CONTROLS

When it comes to controls for motor and transformer overheat protection, electrical circuit overload protection, or temperature controls for radio equipment, you want them to operate surely and accurately—every time.

Klixon Controls meet all operating requirements. Actuated by the foolproof snap-acting Spencer Disc, they always make a quick clean break or positive make. Because they have no fussy, complicated parts, Klixon controls are unaffected by shock, vibration, motion or high altitude regardless of the mounting position. They are space and weight savers, too.

Klixon Controls are available in many standard types to meet your control requirements. See what they can do for you. Our engineering department will help you solve your problems. Write:

KLIXON

SPENCER THERMOSTAT COMPANY, ATTLEBORO, MASS.

Crystal Finishing

(*Continued from page* 125)

turned over by baffles placed within the tubes. This machine simultaneously puts a uniform bevel on as many as 500 crystals. The bevels are superior to those made by hand finishing.

One particular advantage of the two machines described is the fact that coarse abrasive can be used in place of the optical powder used in hand finishing. The supply of these optical powders has become quite critical in recent months. Considerable supervision is, however, still required and, of course, there is still the problem of frequency-checks.

Etching Procedure

The acid-dip process of finishing quartz crystals has been used by several manufacturers for a number of years. When this process is used, semi-finished crystals are given to the finisher, who removes the final 15 kc or so by dipping the crystal into an acid bath for a certain period of time. Instead of removing quartz from the surface by grinding, the finisher removes quartz by the dissolving action of hydrofluoric acid.

This process is both exacting and precise, but due to the extreme danger of hydrofluoric acid and the extensive equipment necessary, has not been generally adopted. Recently, however, it has been found that certain harmless fluorides can be used in place of hydrofluoric acid. This has led to much experimentation with the etching of crystals to frequency.

The latest development is mass etching. By the previous etching procedure, crystals were etched one at a time. By the new procedure, crystals are first classified and etched in a regular department, in groups of 50 to 100, and are then given to individual finishers. The finisher's job is then largely one of mounting the crystal. A mass-etching setup is shown in Fig. 6.

Etching is a satisfactory method of finishing but crystals must be quite free from scratches or defects or oil, as they will otherwise etch unevenly. It has been found that etched crystals are much cleaner than those

For mobile two-way communication specify KAAR RADIOTELEPHONES

KAAR PTL-10X TRANSMITTER

10 WATTS • 1600-2900 KC*

The PTL-10X is a highly efficient medium-frequency mobile transmitter. It provides communication from a moving vehicle over distances ranging from 50 to 75 miles when used with AUTO-LOAD self-loading antenna.

The "Push-to-Talk" button on the microphone completely controls the transmitter, lighting the instant heating tubes, starting the power supply, automatically silencing the receiver, and switching the antenna to the transmitter. The standby current is zero.

Models for special applications are available, including the PTL-22X medium frequency transmitter with 22 watts output, and the PTS-22X, a 22 watt transmitter for operation in the 30-40 MC band.

◀ KAAR AUTO-LOAD ANTENNA

This antenna, with matching coil in the base, is designed for use with the PTL-10X (or with similar medium frequency transmitting equipment) and matches the 72 ohm transmission line from the transmitter and receiver without auxiliary tuning equipment. It provides an efficient method of obtaining maximum signal strength at medium frequencies with a short antenna. It can be quickly installed on the rear bumper or on the side of any vehicle.

**Special ranges to 7000 KC available on special order*

KAAR 11X RECEIVER

6 TUBES • 1600-2900 KC*

The popular 11X receiver is a crystal controlled superheterodyne for mounting in an automobile or other vehicle. It contains a no-signal squelch circuit, and is designed for commercial, civil, and military applications.

This receiver offers remarkable accessibility. The top is removed by simply pushing aside two snap catches, or the entire receiver can be whisked out of the vehicle by releasing only four catches.

KAAR

ENGINEERING CO.

PALO ALTO, CALIFORNIA

Manufacturers of high grade mobile and central station RADIOTELEPHONE EQUIPMENT • POWER PACKS • CRYSTALS • VARIABLE CONDENSERS MICROPHONES • AUTO-LOAD ANTENNAS

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

ground on abrasive and age much less.

Some manufacturers are using a combination of machine finishing and etching to advantage, sometimes doubling production in a short time. Others stick to more conventional methods and do fine work. However, no matter what method is used, supervising a finishing department is no easy task. Many other little factors not mentioned here influence production. These include dust in the air, humidity and temperature of the room. The finishing department supervisor rarely gets rid of one headache before another is on its way. But production must go on and many of the difficulties disappear as rapidly as they come, without anyone placing a finger on the exact cause. Perhaps, after the war, more research can be done in locating and eliminating these difficulties.

BATTLE NOISES, reproduced over address systems, are used for testing ensitive instruments in Army Signal Corps laboratories

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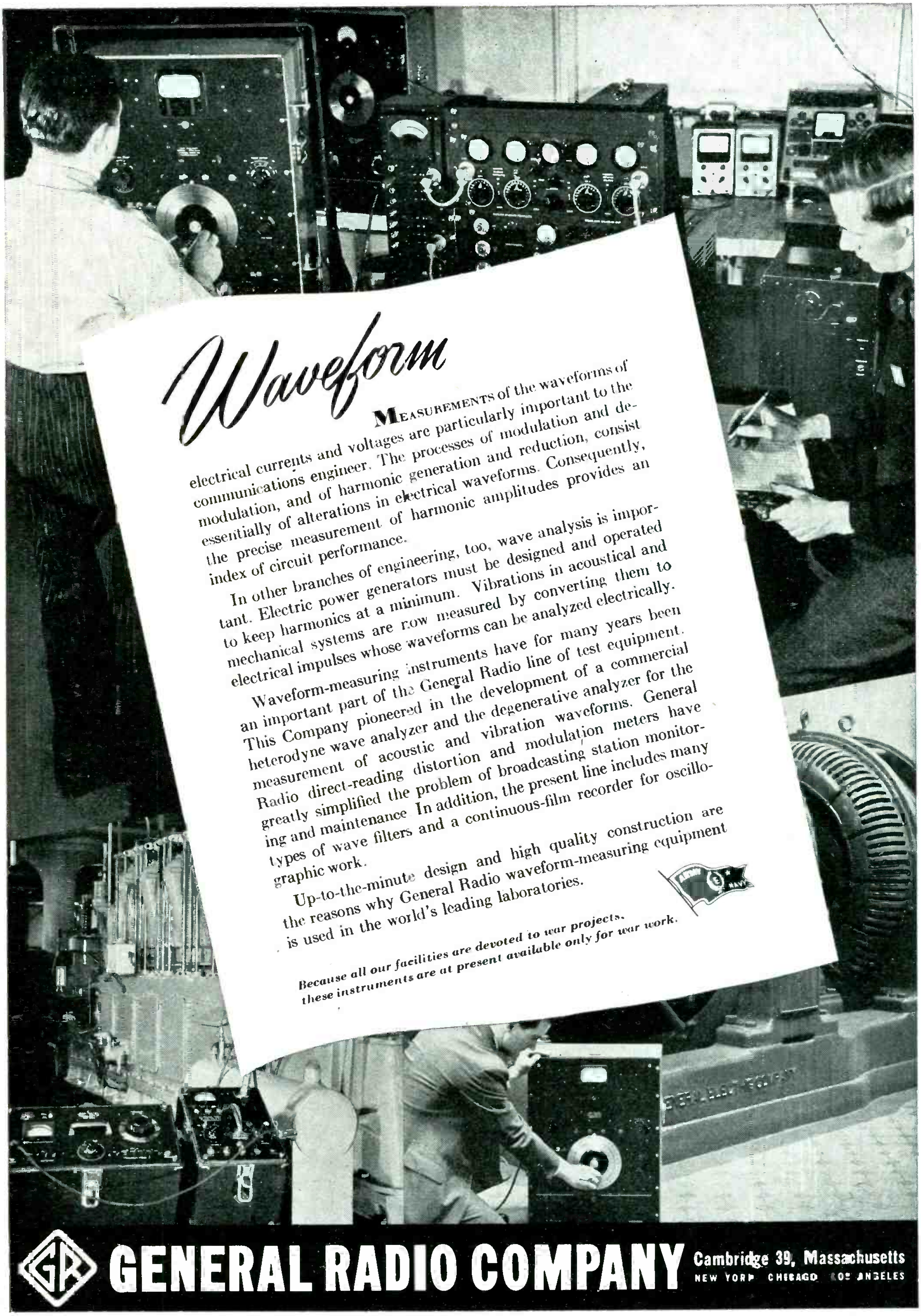
BRAZILIAN QUARTZ MINE

Native workers mining quartz for crystals in the Sete Lagoas district of Brazil. A substantial tonnage of the mother crystals is transported by Naval Transport planes returning to the United States from outbound trips.—Official U. S. Naval photograph


Waveform
MEASUREMENTS of the waveforms of electrical currents and voltages are particularly important to the communications engineer. The processes of modulation and demodulation, and of harmonic generation and reduction, consist essentially of alterations in electrical waveforms. Consequently, the precise measurement of harmonic amplitudes provides an index of circuit performance.
In other branches of engineering, too, wave analysis is important. Electric power generators must be designed and operated to keep harmonics at a minimum. Vibrations in acoustical and mechanical systems are now measured by converting them to electrical impulses whose waveforms can be analyzed electrically.
Waveform-measuring instruments have for many years been an important part of the General Radio line of test equipment. This Company pioneered in the development of a commercial heterodyne wave analyzer and the degenerative analyzer for the measurement of acoustic and vibration waveforms. General Radio direct-reading distortion and modulation meters have greatly simplified the problem of broadcasting station monitoring and maintenance. In addition, the present line includes many types of wave filters and a continuous-film recorder for oscillographic work.
Up-to-the-minute design and high quality construction are the reasons why General Radio waveform-measuring equipment is used in the world's leading laboratories.
ARMY E NAVY
Because all our facilities are devoted to war projects, these instruments are at present available only for war work.
GR
GENERAL RADIO COMPANY
Cambridge 39, Massachusetts
NEW YORK CHICAGO LOS ANGELES

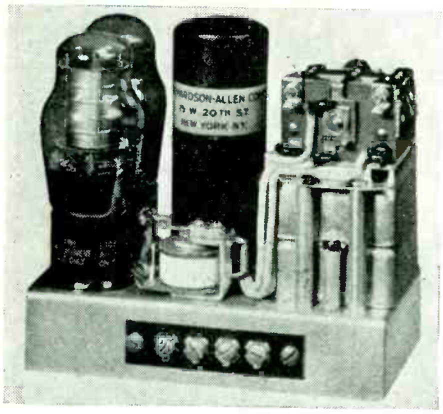
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs. Each month descriptions of these new items will be found here

Electronic Time-Delay Switches

TYPE RA-1335-S electronic switches, capable of operating from power-supply sources having any specified frequency between 25 and 2,000 cps, provide fixed time delays over a wide range. Units contain a selenium rectifier, two oil-impregnated paper-dielectric capacitors, two vitreous-enamel wire-wound power resistors, two insulated $\frac{1}{2}$-watt carbon resistors, two aircraft-type relays and two standard cold-cathode type gaseous tubes (OA4G and VR150-30). All components are moisture-proofed for tropical use. All wiring is glass-insulated, ANJ-C-48 No. 18 stranded.

A typical unit meeting AN requirements operates within 5 percent of the rated 20-sec time delay when



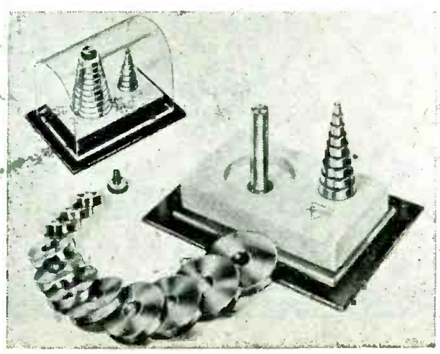
energized by power supplies turning out between 100 and 135 volts at frequencies between 350 and 450 cps, at temperatures ranging between 40 and 65 deg C with up to 95 percent relative humidity. Maximum temperature rise on continuous duty from a 25 deg C ambient is 25 deg C. The unit withstands 10-g shock-impact or vibration-acceleration tests and will meet 200-hour salt-spray test requirements. Mounting is permissible in any position.

The 400N unit described in the paragraph above is available with 110 or 220 volt single-phase spst 10 amp double-make-double-break contacts. A standard connection plug or terminal board is furnished, at the option of the purchaser. The unit measures 5 inches high, $5\frac{3}{8}$ inches long and $3\frac{1}{4}$ inches wide. Flange mounting on $5\frac{1}{2}$ by $3\frac{1}{2}$ inch centers is provided. Power required to operate is 10 watts. Weight is $3\frac{1}{4}$ lbs.

Richardson-Allen Corp., 15 West 20th St., New York 11, New York.

Master Setting and Checking Rolls

SAV-WAY INDUSTRIES announce a set of master setting and checking rolls for the checking of micrometers and other precision inspection and gaging instruments. The set was developed by the manufacturer in connection with its production of precision aircraft, automotive and ordnance parts. This set consists of twenty individual rolls ranging from 0.100 to 2.000 inches in diameter. The rolls are hardened, ground, and lapped to gage makers' X tolerance. They are deep frozen before finish



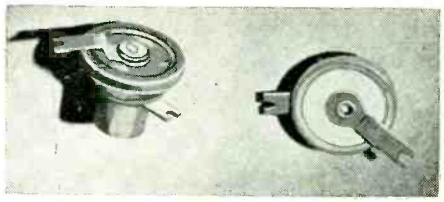
grinding to eliminate internal strains and provide accelerated ageing.

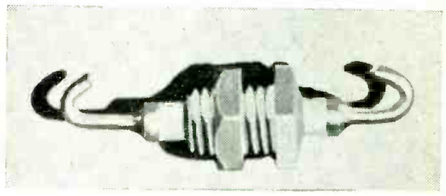
The rolls provide a convenient means of making twenty quick, accurate checks throughout the entire range of an instrument at one time. In addition to checking, these rolls are useful in setting up jobs where dial indicators and amplifiers are to be used. The set is housed in a transparent plastic case which provides necessary protection, gives a clear view of the contents, and insures that all rolls are in place when the set is returned to the tool crib.

An illustrated instruction booklet entitled "The Use and Maintenance of Micrometers" may be had by addressing Sav-Way Industries, Box 117, Harper Station, Detroit 13, Mich.

Capacitors

TYPES 830 AND 831 are special-purpose oil-impregnated silver mica capacitors that are particularly useful in high-frequency applications.

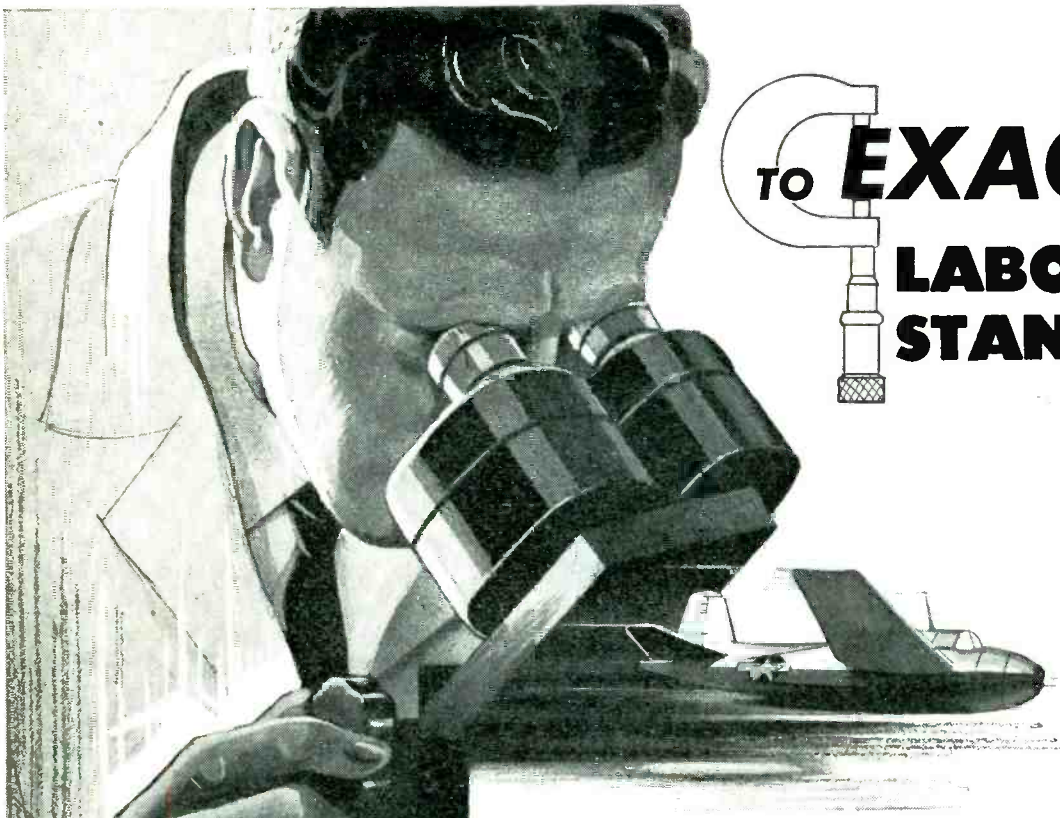




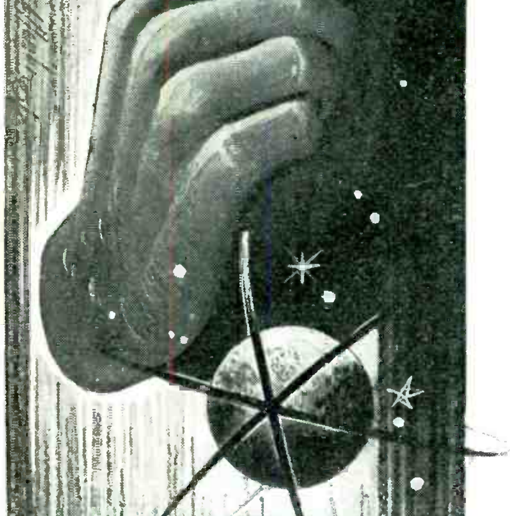
Capacitances now manufactured range from 65 $\mu\mu$f to a maximum of 500 $\mu\mu$f. Both types are made of mica discs individually silvered. The assembly is vacuum impregnated with transil oil. The outside metal ring or cup connects to one plate of the capacitor, and the center terminal connects to the other plate by means of a coin silver rivet. Other metal parts are silver-plated brass.

Type 830 has a metal cup holding the mica capacitor and is assembled to a threaded brass mounting stud with a terminal in the center. Stud, terminal and shell are electrically connected.

Type 831 is of "lead through" construction. There is a center terminal on each side, with the terminals connected to each other and to one plate



TO EXACTING LABORATORY STANDARDS..



Over the long period of years separating the past from the present, ECA has been called upon to tackle the development and production of innumerable types of specialized radio and electronic equipment. Consequently, our facilities are geared to exacting laboratory standards. We can handle the most delicate assignments with understanding care and painstaking skill.

Typical of the apparatus produced by ECA is this Rectifier Power Unit for general laboratory operation. Operating from a 105-125 volt, 50-60 cycle line, it delivers a maximum of 150 ma at 300 volts DC and has an open circuit voltage of 450 volts DC and 45 watts power output from 6.3 volts AC centertapped terminals. The hum voltage is 0.1% at 150 ma for all voltages above 150 volts. Continuous panel control of the DC output voltage is provided through a variable autotransformer.

Did you read the list marked "Killed in Action" in your paper today? A pint of your blood might have saved the life of an American boy. Visit your local Red Cross Blood Bank . . . Do it now.

eca

ELECTRONIC CORP. OF AMERICA

45 WEST 18th STREET • NEW YORK 11, N. Y. • WATKINS 9-1870

of the capacitor by means of a coin-silver rivet. The other capacitor plate contacts the outside metal shell or ring.

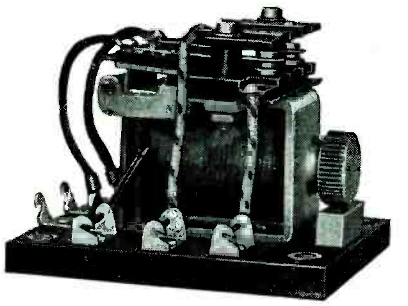
General specifications of types 830 and 831 are: voltage 1300 volts, d-c test; 500 volts d-c working. After 100 hours exposure to relative humidity of 100 percent at 40 deg. C, power factor is less than 0.1 percent and leakage at 1000 volts d. c. not less than 5000 megohms. All units are color coded in μf.

Bushing-mounted capacitors are identified as type 817 and are used in high-frequency circuits where a capacitance ground to the chassis and a "lead through" is desired. The ceramic capacitor tube is plated internally and externally with silver and then with copper. The tube is a snug fit in the brass bushing and the external capacitor plate is soldered to the bushing. The tinned copper wire is also a snug fit inside the capacitor tube and is soldered to the internal plate. The entire unit is wax impregnated after assembly. Dimensions, capacitance, temperature coefficient and voltage breakdown are all closely related and changing any one of these details will change the others. The unit in current production is part 817-001. Capacitance is 55 $\mu\mu$f plus or minus 10 percent. Temperature coefficient is -0.00052 $\mu\mu$f/$\mu\mu$f/deg. C, test voltage is 2000 volts d. c., working voltage is 1000 volts d.c. Other capacitances and sizes can be manufactured if the quantity needed justifies the tooling of special parts.

Centralab, 900 East Keefe Ave., Milwaukee, Wis.

Adjustable Overload Relay

SERIES 445-G33393 relay is used as an overload protection in circuits with varying current demands. The outstanding characteristic of this relay is that it can be adjusted to close at any value from 0.200 to 0.750 amp by means of an adjustable core which varies the reluctance of the magnetic circuit. The contacts are rated 5 amp at 115 volts, 60 cps, and are available in combination up to three pole DT. The coil current is adjustable from 0.200 to 0.750 amp. It can be wound to operate on current or voltage ranges where the minimum wattage is over 0.32 watt and the maximum wattage is under 4.5 watts. Resistance is rated 8 ohms. Temperature rise is 52 deg C at 0.750 amp. The vibration resistance is 8 times gravity, energized or de-energized. (Tested at 45 cps at 0.080 inch excursion.) Insulation to ground (tested) is 900-volts a.c. The unit



measures 1 3/16 x 2 3/8 x 2 7/8 inches, and weighs 9 ounces. The mounting holes are center to center, 2 3/8 x 1 7/8 inches.

Guardian Electric, 1621 West Walnut St., Chicago, Ill.

Radio-Frequency Capacitometer

A NEW RADIO-FREQUENCY capacitometer, designed for precision measurements of small capacitance and inductance, is available from the Specialty Division of the Electronics Department, General Electric Co., Schenectady, N. Y.

Application of the meter is in industrial, college, and other laboratories. The instrument weighs 55 lb

and is a completely self-contained portable unit housed in a steel case. Indicating instruments, controls and fuse are conveniently mounted on the instrument panel. The front panel and base can be withdrawn from the cabinet as a unit for standard rack mounting.

The capacitometer measures directly at radio instead of audio frequency, with measurements being performed with the aid of an oscilloscope instead of ear phones. The scale on the unit can be read from zero to 1000 $\mu\mu$f when measuring capacitance, with inductance measured in the range of zero to 1000 microhenries.

Low-Resistance Test Sets

TWO NEW LOW-RESISTANCE test sets, Type 654 (Army range) and Type 653 (Navy range) include regular features of previous models but are portable and facilitate greater freedom, ease, and speed of operation because the test unit (containing the meter, batteries, switches, control, etc.) is supported in front of the operator by means of adjustable shoulder straps. Applications of the unit include testing of aircraft bonding, railroad bonds, radio equipment, contact resistance of relays, circuit breakers and switches. Type 654 is rated at 0.005 and 0.5 ohm full scale, and Type 653 is rated 0.003 and 0.3 ohm full scale.

Shallcross Mfg. Co., Collingdale, Pa.

Oscillograph

TYPE S-8 OSCILLOGRAPH is a general-purpose instrument designed for high-speed recording. It can be supplied with 12, 18, or 24 galvanometers for independent recording channels. Recording is made on a moving chart of sensitized paper. The external record receiver can be removed from the oscillograph at any time for development of the records it contains. By means of a quick-change transmission, 16 record speeds covering a range of 120 to 1 can be instantaneously selected. The standard record speed range is from 1/3 to 40 inches per second. Speeds higher or lower than this are also available.

Type OA-2 bifilar-type galvanometers which cover a wide range of characteristics from a natural frequency of 200 cps to 10,000 cps, and sensitivities to 50 mm/ma at 1 meter are available for use with the instrument. Also available are type OD coil-type galvanometers with natural frequencies as low as 50 cps, and sensitivities as high as 1000 mm/ma at 1 meter. Accurately calibrated attenuators (from 0 to 100

A QUIET CORNER ON THE "SECOND FRONT"

A corner of the department devoted to inspection of plugs and connectors. Signal Corps inspectors in constant attendance.

SKILLED REMLER ENGINEERS and technicians, plus complete tool and die, plastic molding and screw machine facilities permit complete follow through on prime or sub-contracts for the manufacture of components and complete communication equipment. Each step, from specified or original designs to finished job is rigidly supervised. Present contracts and schedules enable Remler to consider additional electronic assignments. Extensive facilities and improved techniques frequently permit quotations at lower prices.

Wire or telephone if we can be of assistance

REMLER COMPANY, LTD. • 2101 Bryant St. • San Francisco, 10, California

New Remler
NAVY PLUGS

Illustrated: two new Navy Plugs. Listed below: Army Signal Corps Plugs and Connectors... new Navy Plugs.

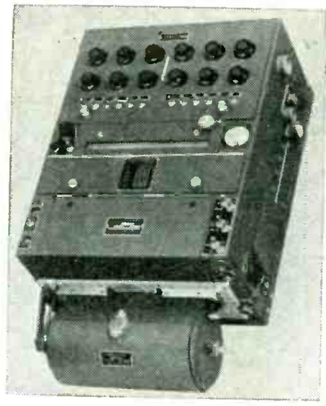
Types:	PL				NAF
50-A	61	74	114	150	
54	62	76	119	159	
55	63	77	120	160	1136-1
56	64	104	124	354	
58	65	108	125		No.
59	67	109	127		212938-1
60	68	112	149		

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

OTHER DESIGNS TO ORDER

REMLER
SINCE 1918
Announcing & Communication Equipment

percent in 10 percent steps) are provided for each galvanometer channel. Fuses are provided in the circuits to guard against accidental injuries to the galvanometer elements from excessive current. Connection to the galvanometers can be made by means of individual receptacles which are useful for general-purpose laboratory work, or by means of a multi-terminal receptacle which is useful in field applications where it is desirable to connect the oscillograph to auxiliary equipment by means of a single cable. The oscillograph has a footage dial on the control panel.



Bulletins and more complete details are available from the manufacturer, Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colorado.

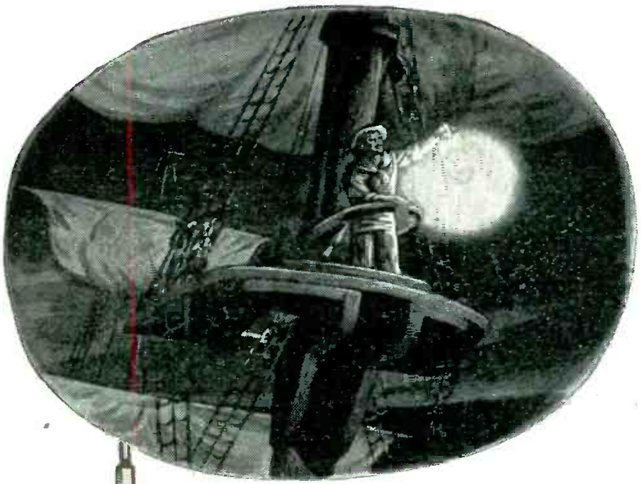
Ceramic-Insulated Coaxial Cable

A CERAMIC-INSULATED coaxial cable is available in long lengths up to 3000 feet or more, in ⅞ inch diameter. Its special advantage is that it is pliable in comparison to rigid cables, due to use of soft-temper copper.

Victor J. Andrew Co., 363 East 75th St., Chicago 19, Ill.

Signalling Timer

THE NEW SERIES S signalling timer is designed to command visual and audible attention the instant a time interval is completed. It provides for the automatic closing or opening of a circuit at the end of elapsed time, and operates additional buzzers, bells or lights at remote locations. The instrument comes in a metal case which may be attached to any wall or panel or standard switch box. It measures 5 x 5 x 3½ inches.



2 FLASHES TO A WAITING WORLD 1805 . . . 1944

A crude lantern flashed the news of Nelson's victory at Trafalgar to watchers on the English coast. Thus, the second night after the battle the news began its slow spread around the world.

TODAY, while the smoke and flames of a bombed city rise high in the sky, news of a raid goes around the world by radio before the planes return to their home bases.

SENTINEL has played a prominent part in developing the miracle of radio—is playing a *vital part* today, in creating and producing wartime equipment which is helping to carry out the strategy and guide the action of our armed forces.

The Sentinel radios of tomorrow will emerge conditioned by this wartime experience . . . radio and electronic Products that promise volume sales for Sentinel dealers.

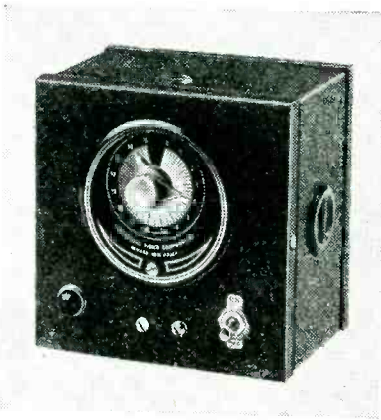
Sentinel

RADIO

Quality Since 1920

SENTINEL RADIO CORPORATION
2020 RIDGE AVENUE, EVANSTON, ILL.

The timer operates on alternating current, 115 to 230 volts; 25, 50 and 60 cps, 1000 watts. The voltage and frequency may be specified. The



motor is a slow-speed, self-starting synchronous type. The contacts are pure silver. The following types of Series S timers are available:

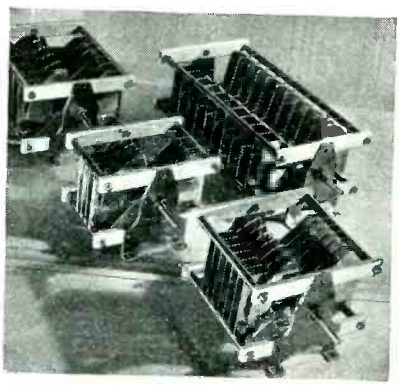
*Model	Dial Calibration
S—1M	1 second
S—3M	5 seconds
S—5M	15 seconds
S—10M	15 seconds
S—15M	15 seconds
S—30M	1 minute
S—1H	1 minute
S—3H	5 minutes

* The model number also designates the rated maximum time interval. M representing minutes and H representing hours. Prices range around $20.00.

Industrial Timer Corp., 117 Edison Place, Newark, N. J.

High-Power Variable Capacitors

FOR ELECTRONIC HEATING applications there are available heavy-duty variable air capacitors which feature electrical design symmetry, built-in neutralization and mechanical durability. These capacitors are designated as B & W Type CX Variable,



and are available in almost any required capacitance for electronic heating use up to 5 kw, 12,500 volts. The units are constructed so that

Your VOLTAGE PROBLEM *please*

TO obtain the exacting performance of today's industrial processes and electrical equipment — use POWERSTAT precision voltage control.

SECO'S standard line of distortionless variable transformers enables you to set voltage quickly and exactly to any specified value independent of load, power-factor, and frequency.

SECO'S line of manually or motor driven POWERSTATS for remote push-button or automatic operation is applicable to your control problem.

INFRA-RED OPERATIONS

RADIO TRANSMITTERS

ELECTRO-PLATING

ILLUMINATION

DEGASSING

VACUUM TUBE MANUFACTURING

LABORATORY TESTING

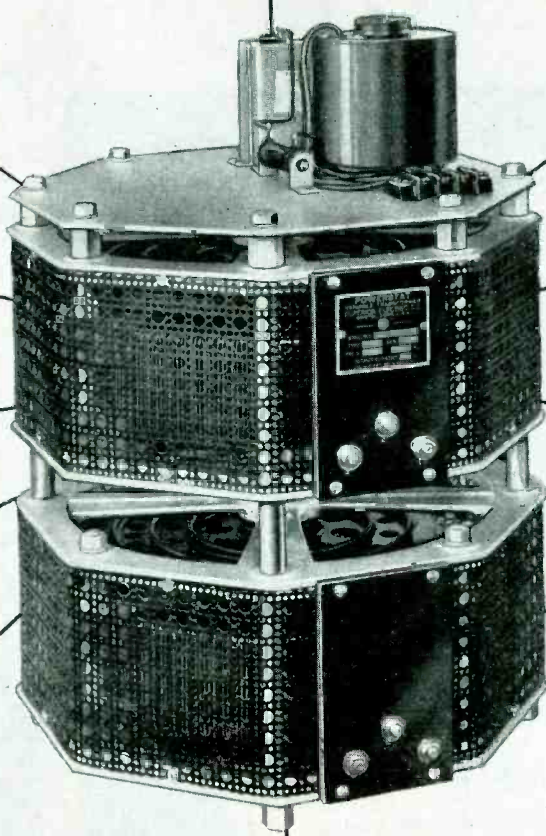
ELECTRONIC DEVICES

ELECTRIC FURNACES

DIELECTRIC TESTING

MACHINE CONTROL

X-RAY APPARATUS



Standard types are available for single or polyphase operation on 115, 230 or 440 volt circuits in capacities up to 75 KVA.

Send for Bulletins 149 LE and 163 LE

SUPERIOR ELECTRIC COMPANY

200 LAUREL STREET • BRISTOL, CONNECTICUT

they lend themselves to the built-in mounting of standard inductors in such a way that lead lengths and resulting lead inductance are reduced to a minimum.

An "Engineering Data Sheet" is available from the manufacturer, Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.

400-Cycle Vibrating Reed Frequency Meter

THE BASIC CHARACTERISTICS of these new 400-cycle vibrating reed frequency meters are similar to those described in May ELECTRONICS, page 230, for the 60-cycle meters. Two models are available in the 400-cycle type and these are Model 33-F and Model 33-FX.

J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.

Electronic Temperature Indicator

AN ELECTRONIC TEMPERATURE indicator (Model 25A) is available to industries which do not require an expensive recording pyrometer. A switch on the front panel gives instantaneous selection of three temperature ranges. The standard limits of the instrument are from −100 deg. to ±1000 deg. C. (−212 to +1832 deg. F) with a normal accuracy of ±2 percent. Five pairs of terminals for five thermocouples are provided, any one of which can be switched into the circuit so that the temperature at five different points can be read.

Connecting wires between thermocouple and instrument carry only fractional voltages from the thermocouple and therefore no special provisions are necessary for insulation. Varying lengths of thermocouple leads will not affect the calibration. The instrument can be operated with approximately 100 feet of connecting wire between thermocouple and in-

***1421 CAST ROD**

FORM AVAILABLE

Cast Rod — Maximum length—10″

PHYSICAL PROPERTIES

COLOR—	pale yellow to water white
MACHINABILITY—	good, similar to brass
SPECIFIC GRAVITY—	1.04–1.06
IMPACT (Dynstat)—	.07–.08 ft. lbs.
FLEXURAL STRENGTH— (Dynstat)	7500–10,000 lbs./sq. in.
WATER ABSORPTION—	less than 0.1% in 24 hrs.
DIELECTRIC CONSTANT—	2.4 to 2.5
POWER FACTOR—	.0006–.0009

SOLVENT RESISTANCE—Generally insoluble in most solvents but swells in aromatic hydrocarbons.

The General Electric Plastics Divisions have developed a new material with unusual characteristics. This new plastic has the ability to withstand very high temperatures without melting. It has high dielectric strength, low power factor, and low dielectric constant. This material has been successfully used for applications in the radio industry where other plastic materials have proved unsatisfactory. For further information write section N-248, One Plastics Avenue, Pittsfield, Mass.

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

PD-248

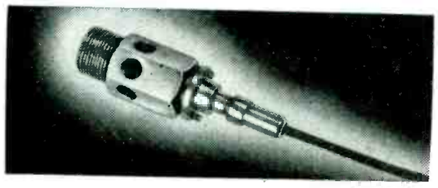
BUY WAR BONDS

dicator. The instrument is easy to operate, requires no supervision, is adapted for permanent use, is not affected by ordinary plant building vibrations, and is designed so that it cannot be damaged by overload or wrong application. It comes in a standard radio relay rack, panel built into a metal cabinet, and weighs 24 lb.

Industrial Electronics Div., North American Philips Co., Inc., 419 4th Ave., New York, N. Y.

Improved Pickup

ELECTRO PRODUCTS Laboratories (549 W. Randolph St., Chicago, Ill.) is now producing a new and improved pickup (designated as No. 3000B). It has a bayonet type socket which provides quick, reliable contact between connection cable and pickup. Adapter adjustments are made simpler by the use of two set-screws which replace the older type hex-



agonal nut. This construction permits easy installation and removal from the engine with an ordinary socket wrench. The pickup coil operates at constant polarity and has impregnation that withstands continuous operating temperatures of 350 deg. It provides quick replacement of either diaphragm or coil for economical operation and long life. The pickup may be used for studies of detonation conditions in internal combustion engines, and for compression conditions in pumps and other devices where there are variations in pressure. It also may be used to actuate a cathode-ray oscillograph or the manufacturer's knock-intensity indicator for rating of engine fuels.

Direct-Current Timing Motor

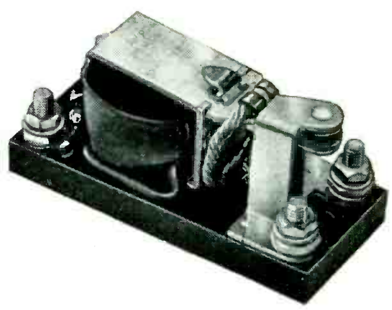
HAYDON MFG. CO., INC., of Forestville, Conn., announced their "Haydon D-C Timing Motor" for timing applications on direct current.

This is a normally running 6-volt motor with resistance wire calibrated at the factory for 12 volts, 24 volts, and other voltage applications. It is available with all the various output shaft speeds which the company now has in its a-c line of timing motors (these speeds are secured through sealed-in lubricated gear trains). Speeds available are from 100 rpm down to one rpm.

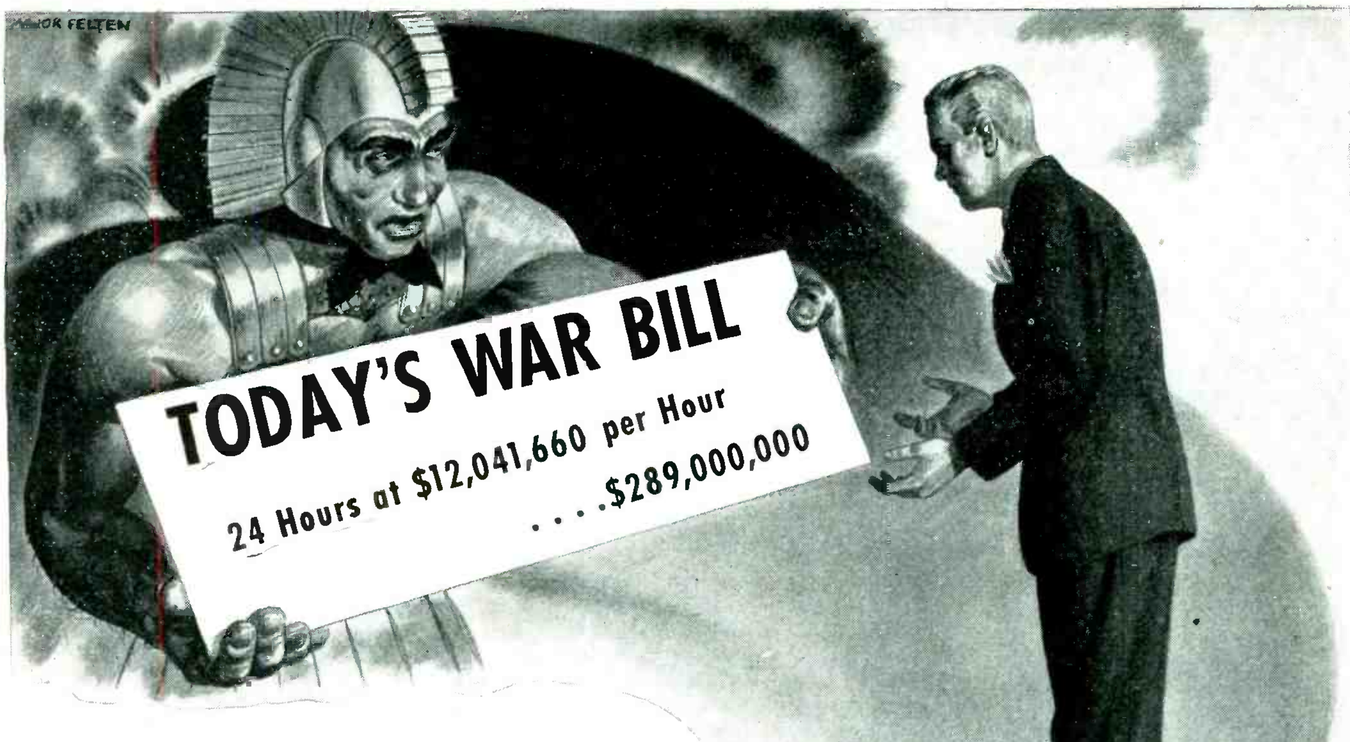
Consistent speed is obtained by the governor effect of an electrical eddy current drag built into the motor. There is no arcing at high-altitude operation and brush life is long. The motor can be purchased with special lubricant for operation at extremely low temperatures. Other features include new design, reversible travel, weight of approximately 6 ounces, and operation on a current input of approximately 100 ma., no load. The motor, including gear reduction, measures $2\frac{7}{16}$ x $2\frac{1}{8}$ x $1\frac{3}{8}$ inches.

Shockproof Relay

DESIGNED FOR airplane use where precaution must be taken against unintentional operation of contacts, Type 17AXX relay meets specified requirements for this type of unit. The manufacturer states actual tests show that it will withstand acceleration tests of better than 90 gravitational units—or from eight to ten



times the G-rating of ordinary relays. The relay is rugged, small in size, and light in weight. Units

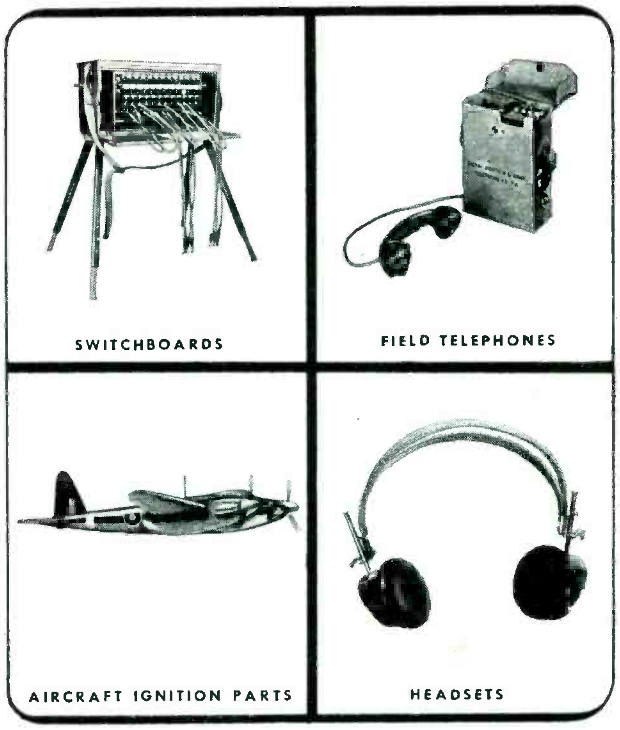


OFFICIAL government figures disclose that our war cost had reached 289 million dollars a day by mid-year, 1943, and the cost has been over 7 billion dollars a month ever since.

As manufacturers of communications and aircraft material on which human lives often depend, we know of one heartening reason for this tremendous cost: Uncle Sam will not compromise with quality at the expense of our fighting men. They are getting the finest, most dependable equipment any army ever had. And that saves lives.

Is it any wonder we are being asked to dig down and buy War Bonds until it hurts? And isn't it well worth it, knowing that our sacrifice is maintaining quality as well as quantity of weapons? Our people here at Connecticut Telephone and Electric Division think so . . . they are 100% pledged to regular payroll deductions for War Bonds, on an average of 15% of their incomes.

OUR CONTRIBUTION TO THE WAR EFFORT



GREAT AMERICAN INDUSTRIES INC.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

MERIDEN, CONNECTICUT

ARMY E NAVY

Engineering, Development, Precision Electrical Manufacturing of this type are supplied with series coils for any direct current, or with shunt coils for use on 12 or 24 volts d.c.

Struthers-Dunn, Inc., 1321 Arch St., Philadelphia, Pa.

Alternate for Micro-Crystalline Wax

TO MEET THE SHORTAGE of micro-crystalline wax, Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y., announces the development of Witco Hamp Wax, a new group of waxes available (without allocation) for military and essential civilian products. The wax is essentially a hard amorphous petroleum wax which possesses high resistance to moisture vapor transmission. It is available in several grades, with melting points ranging from 155 deg. F to 168 deg. F and penetration of 35 to 50 at 77. The product is amber in color and is available in several grades from the manufacturer's plant in Chicago.

Samples for trial purposes are available by writing Wishnick-Tumpeer, Inc., 295 Madison Avenue, New York 17, N. Y.

Indicator Lamp; Safety Door Interlock Switch

A SMALL MOLDED PLASTIC indicator lamp has been announced by the Specialty Division, Electronics Department, General Electric Co., Schenectady, N. Y. A special feature is a lock-on color cap which cannot be shaken loose and will not "freeze" to the base. As many as five circuits can be identified on one panel by the use of five different color caps. The lamp is supplied ready for mounting. The base is mounted directly to the back of the instrument panel and the color cap is screwed into the base through the panel. A coil spring applies constant pressure to the base of the lamp bulb to maintain a good electrical contact. The lamp takes 6- to 8-volt bulbs.

Applications include radio transmitters, and any other equipment or control device where a glow lamp is needed to show that the device or circuit is on or off.

Also available is a safety door interlock switch, designed as an emer-

gency device to interrupt control circuits where access doors are opened when the power is on. It has a carrying capacity of 10 amp, 110 or 220 volts a.c. or d.c., and an emergency opening capacity of a-c 7½ amp, 110 or 220 volts; d-c on low inductive circuits, 5 amp, 125 volts; 2½ amp, 250 volts. Application covers a wide range where doors, windows or covers must be interlocked for the protection of the equipment and safety of the personnel, such as doors on radio transmitters, x-ray and therapeutic machines, burglar alarms, and signal controls for fire doors.

Literature

Measuring Instruments. A new catalog on aircraft and industrial testing instruments is divided into five sections covering aircraft gyro test instruments, aircraft vibration test instruments, aircraft industrial production testers, industrial vibration measuring instruments, and electromechanical laboratory and production test equipment. Each section contains pictures and descriptions of the main functions and applications of Televiso's basic instruments, which are constructed so as to permit electrical and mechanical modifications to fit the particular application desired by the purchaser. Copies are available from Televiso Products, Inc., at 6533 North Olmsted Ave., Chicago.

Visual Aid Vacuum Tube Chart. This chart shows all parts of a typical radio tube individually and in relation to the final construction, for instruction purposes. It also contains element classifications and symbols for all types of tubes, sketches of base pin arrangements and numbering systems. This chart, measuring 30 x 45 inches, is printed on heavy paper and equipped with wooden dowels to facilitate hanging on laboratory or classroom walls. Copies are available from National Union distributors at $1.00 but are furnished free to Signal Corps or other recognized institutions conducting fully accredited radio courses.

THE MODEL 610-B

MEG-O-METER

A NEW-BATTERY OPERATED

INSULATION TESTER!!

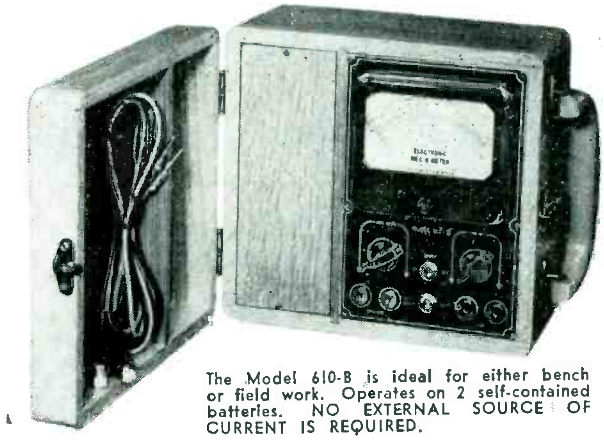
INSTANTLY INDICATES THE EXACT LEAKAGE OF ALL INSULATION FROM ZERO UP TO—

200 MEGOHMS

AT A TEST POTENTIAL OF

500 VOLTS D.C.

SUPPLIED BY A BUILT-IN BATTERY AND VIBRATOR POWER SUPPLY



The Model 610-B is ideal for either bench or field work. Operates on 2 self-contained batteries. NO EXTERNAL SOURCE OF CURRENT IS REQUIRED.

FEATURES:

* **NO HAND CRANKING**—The 500 Volt Test Potential is made instantly available by throwing the front panel toggle switch.

* **3 RESISTANCE RANGES**—In addition to the 0 to 200 Megohm Range which is used for Insulation Testing 2 additional lower resistance ranges are provided. The 2 lower resistance ranges are 0 to 20,000 Ohms and 0 to 2 Megohms.

* **METER MOVEMENT**—A 4½" 0 to 200 Microampere sensitive meter guarantees extremely accurate readings on all ranges.

* **DIRECT READING**—All calibrations printed in large, easy-to-read type enabling exact determination of leakages from 0 to 200 Megohms. In addition, the Megohm scale is also subdivided into BAD (0 to 1 Megohm) DOUBTFUL (1 to 3 Megohms) GOOD (3 to 200 Megohms) sections. The BAD Section which indicates the danger point is printed in red.

Model 610-B comes housed in a beautiful, hand-rubbed Oak cabinet complete with cover, self-contained batteries, test leads and instructions. Size 9½" x 8½" x 6". Shipping weight, 16 pounds. **Price $62.50**

Important: **We also make the Model 610-E Meg-O-Meter which operates on 110 Volt 60 Cycle A.C. current. The Model 610-E is especially recommended for production testing where product must meet specified insulation requirements. Model 610-E provides exactly same services as the Model 610-B except that it operates on 110 Volt A.C. current instead of batteries. Price of Model 610-E complete is $52.50**

THE NEW MODEL 590

VOLTAGE TESTER

Reads Like A Thermometer!!

Automatically Indicates—

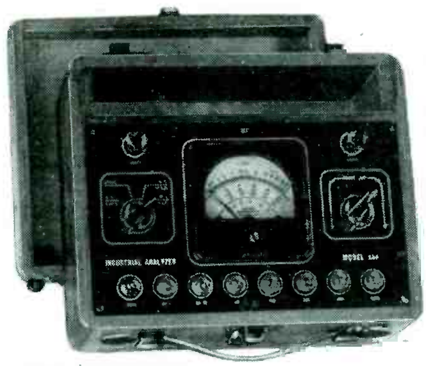
- Whether the voltage is 110, 220, 440 or 660 Volts.
- If the current is A.C. or D. C.
- If the appliance, motor, etc., connected in the line is "open".
- Which leg is "grounded".
- If the frequency is 25 or 60 cycles.
- If the fuse is "blown".
- When one side of an appliance or motor connected to the line under test is "grounded".
- Excessive leakage between a motor and a line.
- When a three phase motor is running erratically due to a "blown" fuse.

No meter, No switching, No tip jacks. To use: simply connect the needle pointed test prods across any line and this truly versatile instrument will instantly indicate the Voltage, frequency, type of Current, etc. Rugged, dependable and efficient, this amazing electric tester measures only 1¾" x 5" x 1⅝" and weighs only 5 ounces. Unlike most electrical testing instruments which necessarily require a great amount of care, the Model 590 is designed for "bang around" maintenance work, and yet due to the unique design it compares favorably in sensitivity with expensive metered instruments in that it draws less than 1 Milliampere of current.

MODEL 590 comes housed in a beautiful hand-rubbed, wooden cabinet. Panel is of etched steel. Shipping weight 2 pounds. Complete with instructions. Only $5.85

THE MODEL 560

INDUSTRIAL ANALYZER



MEASURES:

A.C. AND D.C. VOLTAGES UP TO . . . . . 1500 VOLTS
RESISTANCE UP TO . . . 2500 OHMS
A.C. CURRENT UP TO . . 30 AMPERES

FEATURES:

* COMPLETELY PORTABLE—NO EXTERNAL SOURCE OF CURRENT REQUIRED
* SAME VOLTAGE SCALE USED FOR BOTH A.C. AND D.C.
* ALL CALIBRATIONS PRINTED DIRECTLY ON METER. NO COMPUTATION OR CHARTS.

SPECIFICATIONS:

5 A.C. AND D.C. VOLTAGE RANGES: 0 to 60/150/300/600/1500 Volts
2 RESISTANCE RANGES: 0 to 250 Ohms 0 to 2500 Ohms
A.C. CURRENT: UP TO 30 AMPERES

MODEL 560 INDUSTRIAL ANALYZER comes housed in a beautiful, hand-rubbed wooden cabinet complete with cover, self-contained battery, test leads and instructions. Size 8½" x 7" x 4¼". Shipping weight 7 pounds. . . . . .Only $28.50

SUPERIOR INSTRUMENTS CO.

227-A FULTON ST. NEW YORK 7, N. Y.

Resistance Welding. Circuit fundamentals and operation of the numerous types of G-E electronic controls available to meet the exacting requirements of individual resistance welding processes and jobs are covered in an attractive 46-page booklet designated GET-1170. Simplified circuit diagrams are used liberally. For the most part it consists of reprints of six articles previously published in ELECTRONICS by General Electric engineers. These articles are: electronic welding control; seam and pulsation welding controls; special welding controls; timers for welding control; energy storage welding controls; servicing resistance welding controls. Available free from General Electric Co., Schenectady, N. Y.

Applications of Mycalex. An eleven-page publication describing the nature, properties, advantages and applications of compression-molded Mycalex can be obtained from the G.E. Electronics Department at Schenectady. Mycalex is a stone-like product made from mineral ingredients to meet exacting high-frequency insulation requirements. It is used extensively as an insulator in various types of electrical apparatus, particularly in radio, industrial control and heating equipment.

Beryllium Copper. Although this "wonder alloy" is a vital factor in spring design, little has been published on it. However, Instrument Specialties Co., Inc., Little Falls, New Jersey, has issued an interesting bibliography of beryllium copper with explanatory comments on each reference. The development of the electronic micrometer helped make possible the production of precision, low-drift beryllium copper springs.

Army Contracts. An "Army Purchase Information Bulletin" has been published by the War Department to assist business men in negotiating contracts with the Army. This pamphlet contains lists of supplies and equipment generally purchased. It answers such vital questions as: Who does the buying? Where is he located? What does he purchase? How are negotiations opened? Copies may be obtained from Small War Plants Branch, Purchases Division, Army Service Forces, Washington, D. C.

LAST MONTH HE WAS SANTA IN THE TOY STORE

THIS MONTH HE TOOK HIS

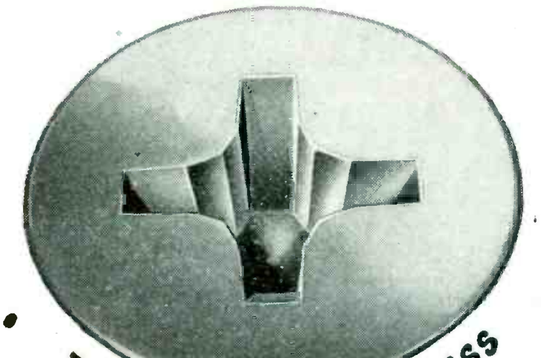
GRANDSON'S PLACE

AND HE'S DRIVING SCREWS LIKE A 21-YEAR OLD.

FOR THE PLANT WHERE HE WORKS USES THE RECESSED HEAD SCREW

THAT MAKES DRIVING DUCK SOUP...

IT'S **PHILLIPS** ➡➡➡➡



THE ENGINEERED RECESS

Anyone can drive Phillips Screws! Today, screw driving is one production job anyone can tackle without any special talent or training. The job that once called for strong arms and skilled hands now is a cinch for the operator who never tackled a screw driving job before!

It's the Phillips Recessed Head Screw that does the trick! With Phillips Screws, the greenest operator quickly becomes as skillful as a veteran. No fumbling . . . no wobbly starts . . . no slant-driven screws or dangerous screw driver skids. Workers turn out flawless jobs every time — and faster than ever before. Time studies prove that Phillips Recessed Head Screws step up screw driving speed as much as 50 per cent!

Imagine what this means to you in terms of man-and-training-hours saved . . . of increased production . . . finer workmanship. Then match these important advantages against slotted head screws — or any other type you may be using.

PHILLIPS *Recessed Head* SCREWS

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

TO MAKE WARTIME QUOTAS AND PEACETIME PROFITS

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

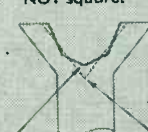
Faster Driving: Spiral and power driving are made practical. Driver won't slip from recess to spoil material or injure worker. (Average time saving is 50%.)

Easier Driving: Turning power is fully utilized. Workers maintain speed without tiring.

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

IDENTIFY IT!

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



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

23 SOURCES

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
General Screw Mfg. Co., Chicago, Ill.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
Milford Rivet and Machine Co., Milford, Conn.
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

Permanent Magnets

(*Continued from page* 121)

We know, from our earlier discussion of stabilized magnets, that as the demagnetizing influence on a magnet is decreased, its operating point moves back toward the B ordinate along a minor hysteresis loop. And this is exactly what happens in this case. As the demagnetizing influence upon the magnet is decreased from the open-circuit condition to the working gap condition, the operating point moves up the minor hysteresis loop from the point (B_p, H_p) to the point (B_t, H_t) which is the intersection of this loop with the straight line of Eq. (10).

Final Operating Point

The point (B_t, H_t) is the final operating point of the magnet. As the machine is put into operation and additional magnetizing and demagnetizing influences, due to the current in its coils, are brought to bear upon the magnet, the operating point will oscillate back and forth along the minor hysteresis loop about the point (B_t, H_t). (The reader will understand that the influences referred to in the previous sentence are not steady and constant in magnitude but are instead influences which vary in magnitude with a frequency equal to the speed of the machine or some integral fraction or multiple of that speed.) The final flux density in the working air gap of the machine may be readily computed from the magnet operating point (B_t, H_t) and the fundamental design equations for magnets.

Flux Density in Air Gap

Now, let us set up the analytical processes. The first question is: After the magnet is saturated and removed from the magnetizer, how far down the demagnetization curve does its operating point travel? This question is answered by an empirical equation giving the value of the quantity B/H for an open-circuited magnet as a function of the quantity l/D*

$$B/H = (1.89 - a)\,(l/D + a)^{1.82} \qquad (11)$$

* Eq. (11) is not accurate for very small values of l/D. There exists a more compli-

Extra hands

More than just sheet steel specialists, ours is an organization where top emphasis is placed upon the men and women responsible for designing and building our products. Working as a team, over a long stretch of years, we've welded together a fine group of exacting, conscientious artisans, supplemented by skilled replacements and additions due to the war.

We build cabinets, chassis, panels and racks for diversified electronic equipment . . . quickly, precisely, economically. The hundreds of different dies available will reduce the cost of the dies needed on your job and may, in many instances, eliminate die-cost entirely. Because of these unique facilities, we manufacture to required specifications at the lowest possible cost. Moreover, we'll go over your plans with you . . . make recommendations if they can be helpful . . . suggest means of expediting deliveries. Briefly, ***ours is an extra pair of hands*** . . . offered willingly as part of a firmly-established policy of unselfish service to our clients.

The services of a Karp engineer are available for a discussion of your problems.

ANY QUANTITIES — ANY METAL — ANY SIZE — ANY FINISH

ARTISANS IN SHEET METAL

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CABINETS
CHASSIS
RACKS
PANELS

KEEP BACKING THE ATTACK . . . BUY MORE WAR BONDS

cated equation which is accurate even at small values of the argument, but because of the greater simplicity of Eq. (11) and because it is accurate at practical values of l/D, it is to be preferred. Eq. (11) is for straight magnets. It may be used with fair accuracy for four pole rotors but a connection factor is necessary if it is to be used in connection with horseshoe magnets.

where l = mean length of magnet along path of magnetization.

D = effective diameter of magnet = $2\sqrt{Area\ of\ Magnet/\pi}$

a = alloy constant as defined by Eq. (9)

From the above equation, together with a demagnetization curve for the alloy we are using, we can determine the point (B_p, H_p) of Fig. 3.

We now have everything we need to determine the point (B_t, H_t) if we but have the slope of the minor hysteresis loop connecting the two points. Minor hysteresis loops sometimes accompany demagnetization curves of standard alloys but, in general, technical publicity on permanent magnets disregards them entirely, and the information is often difficult to obtain.

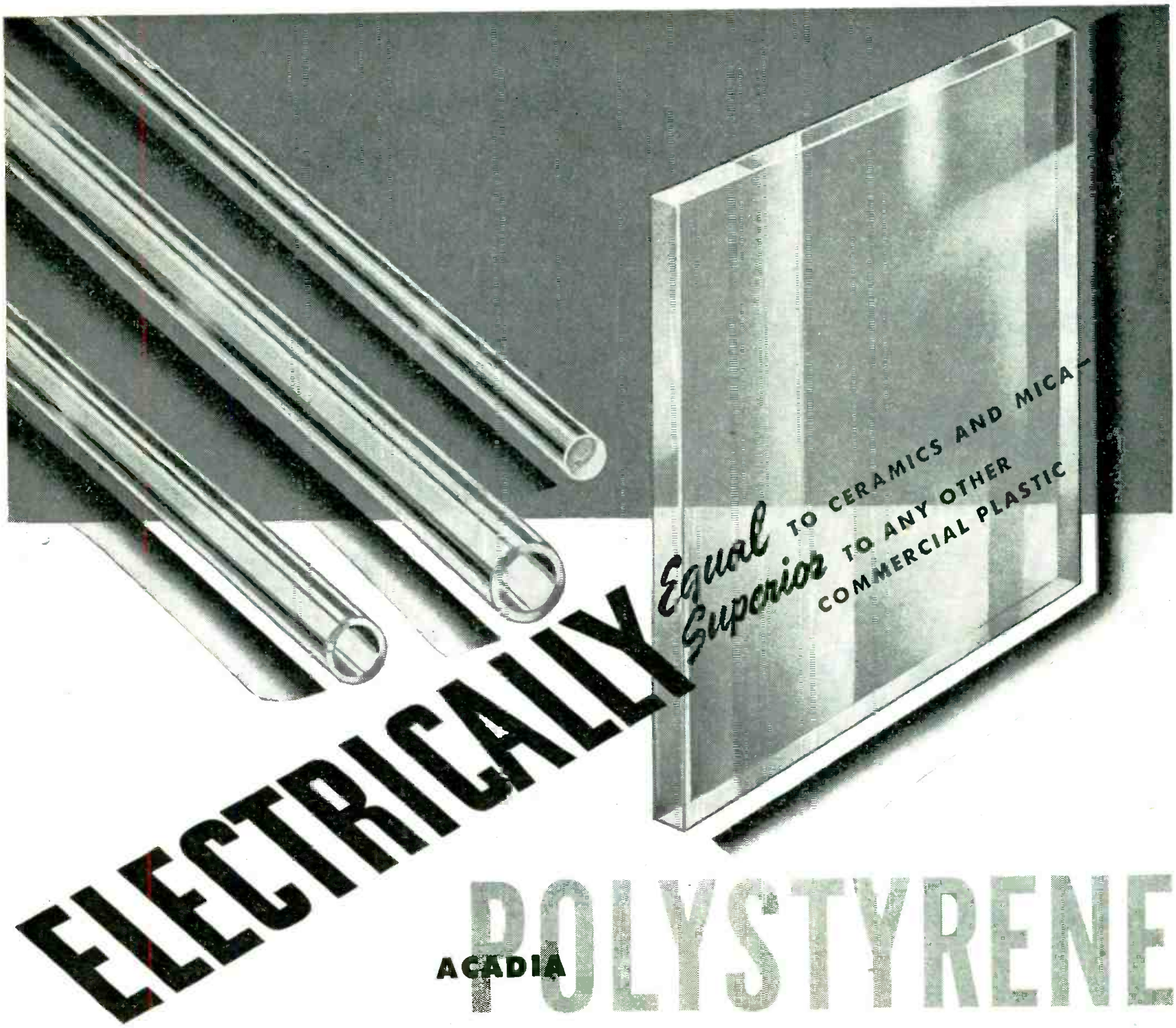
The author discovered several years back, however, that, although the slopes of the minor hysteresis loops connected with any one demagnetization curve vary as a function of the point on the curve at which they originate, all of them are very closely approximated by the slope of the demagnetization curve itself at the point B_r. This means, then, that we may obtain very easily the slope of a minor hysteresis loop for any demagnetization curve in terms of the B_r, H_c and a for that particular curve. Referring to Eq. (3) and differentiating B with respect to H, we get:

$$\frac{dB}{dH} = \frac{-B_r H_c (1-a)}{(H_c - aH)^2} \qquad (12)$$

Setting $H = 0$ in the above equation, we get the slope of the demagnetization curve at B_r and consequently the slope of the minor hysteresis loops connected with that particular demagnetization curve:

$$\left.\frac{dB}{dH}\right|_{H=0} = m = -\frac{B_r}{H_c}(1-a) \qquad (13)$$

It is to be noted that the slope m in the above equation is negative even though in the ordinary convention a minor hysteresis loop has a positive slope. This, of course, is due to the fact that for convenience we have reversed the convention and are



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Send for complete data giving physical properties of Acadia Polystyrene, plus a table of specifications on its electrical properties.

Acadia Styraloy

Flexible at −100°F and has many of the electrical properties of Polystyrene. Ideal for numerous electrical applications. Write for information on forms now available, and data on physical and electrical properties.

● Acadia Polystyrene is an outstanding plastic for the electrical field, offering an unusual combination of highly desirable electrical properties. Dielectric strength and power factor offer a favorable comparison with the electrical strength of ceramics and mica, and a considerable advantage over other commercial plastics.

Consider also these values: zero water absorption; relative freedom from adverse effects by acids, alkalies, alcohol, stack gases, weather, etc; an excellent dielectric constant value, and high tensile strength of 3500 to 5000 lbs. per sq. in. Add to these Acadia's wide experience in the plastics field, and you have the reasons why Acadia Polystyrene merits your investigation.

Complete details are available on request—for quick reference some of Polystyrene's outstanding values are given here:

Dielectric Constant	2.5 to 2.6 at frequencies 10^6
Power Factor, 60 cycles	.0001 to .0003
10^3 cycles	.0001 to .0003
10^6 cycles	.0001 to .0008
Dielectric Strength, Volts/Mil 1/8" thickness	
Short time	500 to 700
Step by step	450 to 600
Volume Resistivity, ohms-cms	10^{17} to 10^{19}
Heat Resistance	150°F to 175°F
Softening Point	190°F to 250°F
Specific Gravity	1.05

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ACADIA *Synthetic* **PRODUCTS**

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Processors of Synthetic Rubber and Plastics • Sheets • Extrusions • Molded Parts treating H_c and H in general as positive rather than negative values.

It is now possible to write the straight-line equation for the minor hysteresis loop connecting the points (B_p, H_p) and (B_t, H_t) of Fig. 3:

$$B = B_p - m\,(H_p - H) \qquad (14)$$

where m is as defined in Eq. (13).

The final operating point, (B_t, H_t) of the magnet may be determined by the simultaneous solution of Eq. (10) and (14). Performing this operation, we get

$$B_t = \frac{B_p - mH_p}{1 - \dfrac{mfA_m\,l_g}{FA_g\,l_m}} \qquad H_t = \frac{B_p - mH_p}{\dfrac{FA_g\,l_m}{fA_m\,l_g} - m} \qquad (15)$$

From the above and either one of the two fundamental design equations, namely $F\,B_g A_g = B_m A_m$ and $f\,B_g\,l_g = H_m l_m$, we obtain the gap flux density:

$$B_g = \frac{B_p - mH_p}{\dfrac{FA_g}{A_m} - \dfrac{mfl_g}{l_m}} \qquad (16)$$

Thus the problem—given the magneto and the magnet, determine the flux density in the working air gap—is solved. This problem was deliberately chosen first because the steps of its solution and the actual workings of the physical entities involved have a chronological parallelism which enhances the understanding of both.

Finding Size of Magnet

Although presented first, the preceding problem for obvious reasons is by no means so important as the problem—given the magneto and the required gap flux density, determine the size of the magnet. At first glance it may seem silly to make a special problem out of a case involving three general factors when the only change is between the dependency and independency of the factors. But further thought will reveal that when the size of the magnet is the required factor, it is really two factors, the length and the area of the magnet, that are required. As a consequence, to obtain a unique solution to the problem, we must impose one more condition.

The first problem may be broken down to its essentials in the following way—given l_m, A_m, l_g, A_g, F, f, B_r, H_c, and a, determine B_g. With these specifications there is no control over the point (B_t, H_t) and it lands wherever it happens to land. Now, since it is necessary to add a

They wanted wire, tube and sheet in

Split-Hair Sizes

...and found the strong, corrosion-resistant metals they sought among the INCO Nickel Alloys

Are you looking for metals in ultra-fine sizes for essential applications today...or for your new products after the war?

Do you want...in addition to the split-hair size ...metals with strength, toughness and high resistance to corrosion?

Then take a look at these examples of how INCO Nickel Alloys can be produced in practically any form or size you may want for applications that need a rustless corrosion-resisting material with high mechanical properties...

THE WIRE shown in the magnified photo above knotted around two strands of human hair is 0.0009" thick. A pound would stretch 80 miles. It is a regular commercial product of the Driver-Harris Co.

THE TUBING, smallest ever drawn, is compared with a mosquito's stinger. Outside diameter of this nickel tube is 0.0019"; inside diameter, 0.0004". Superior Tube Company produces commercial tubing in INCO Nickel Alloys as small as 0.010", outside diameter.

THE STRIP is .00075" thick . . . one-third the thickness of this page. It would take more than 1300 strips to equal an inch. This nickel strip is made by Somers Brass Company for regular commercial use.

In addition to their group properties of high strength, toughness and corrosion resistance, individual INCO Nickel Alloys have *specialized* properties for applications requiring high-temperature strength, special hardness, resilience, etc.

"Tremendous Trifles" a booklet which discusses the properties, sizes and forms of 8 INCO Nickel Alloys will be sent to you on request. Please give Company, Name and Title. Address:

THE INTERNATIONAL NICKEL COMPANY INC.
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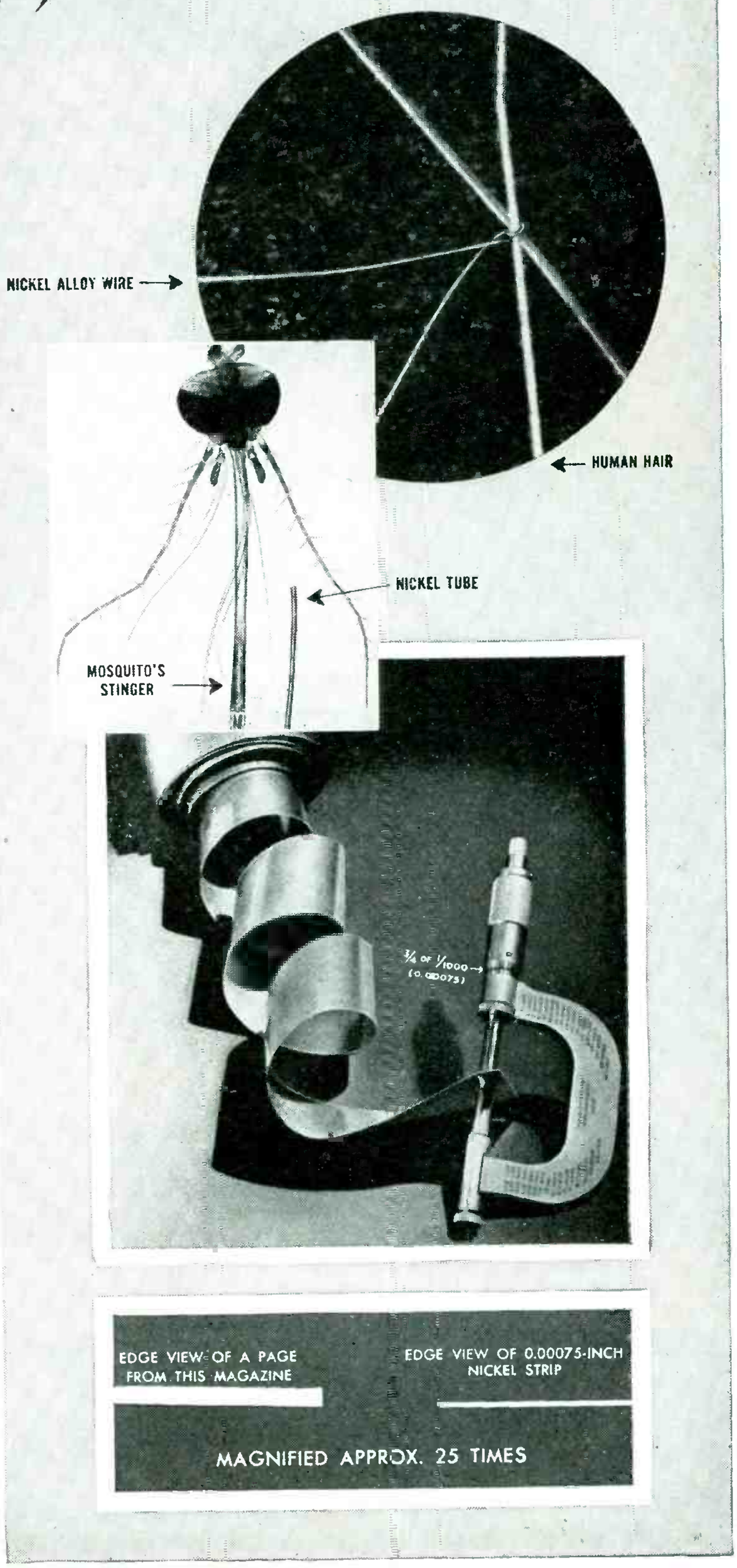
Sheet... Strip... Rod... Tubing... Wire... Castings



further condition to the already established requirements of our second problem, what more natural requirement could we choose than that of working the magnet material at its best possible efficiency under the circumstances—or, in other words, at the highest possible value of the product $B_t H_t$? The essentials of the second problem now become—given l_g, A_g, F, f, B_r, H_c, and a, and the requirement that the magnet be the smallest possible and still fulfill all other conditions, determine l_m and A_m.

Obviously, we are in full position to solve this problem as soon as we have converted the efficiency requirement to a specific equation which we may solve in conjunction with our others. This may be done fairly simply.

Referring to Fig. 4, we see that the final magnet operating point (B_t, Ht) must lie on some minor demagnetization curve such as B'_r H'_c. This would be the demagnetization curve obtained if initially the magnet material were not saturated. Obviously, an infinite number of such curves lie between the demagnetization curve itself and the origin, and (B_t, H_t) must lie on one of them. The curve $B'_r H'_c$ has accompanying it an energy product curve, and it is our job to make sure that the point (B_t, H_t) coincides with the point of maximum energy product of $B'_r H'_c$. Since $B'_r H'_c$ is a proportionately reduced curve, we may write:

$$B'_r/B_r = H'_c/H_c \quad \text{or} \quad B'_r/H'_c = B_r/H_c$$

We know from Eq. (7) that if (B_t, H_t) be located at the maximum energy product point, then

$$B_t/B'_r = H_t/H'_c \quad \text{or} \quad B'_r/H'_c = B_t/H_t$$

Consequently,

$$B_t/H_t = B_r/H_c \qquad (17)$$

This, then, is the one additional necessary condition to the solution of the second problem, and we find ourselves armed with six equations (Eq. 3, 11, 16, 17 and two in 15) to determine four incidental unknowns (B_p, H_p, B_t and H_t) plus the two desired unknowns (l_m and A_m).

SEVEN SIMULTANEOUS dimensional inspections on machine gun bullets at the rate of 93 bullets per minute is reported by one ordnance plant for a phototube machine made by Electric Eye Equipment Co., Danville, Ill.

B.I.W. COAXIAL CABLES

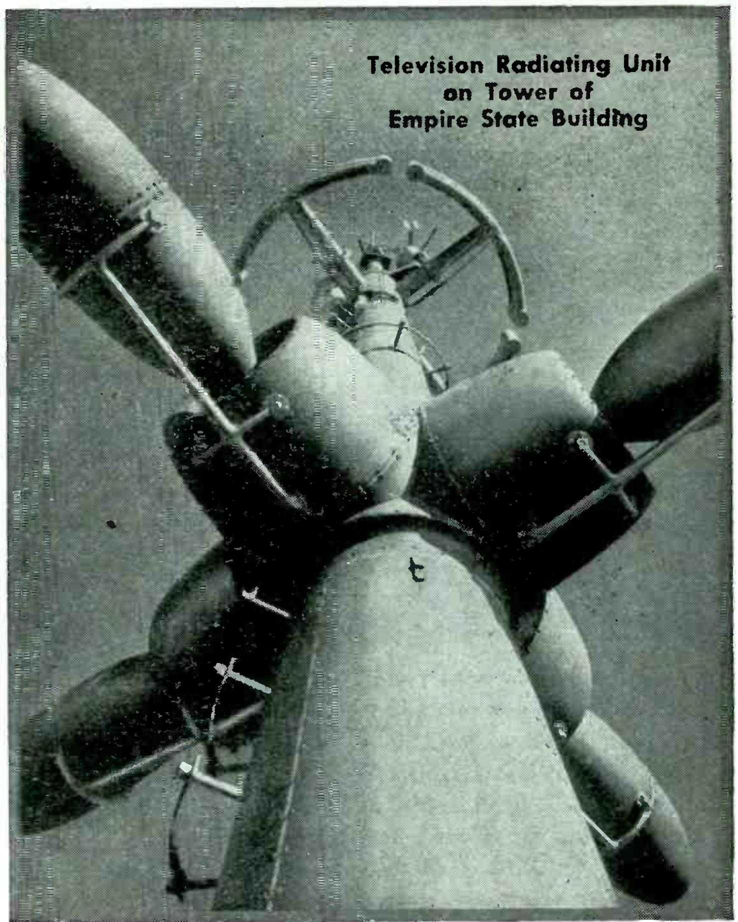
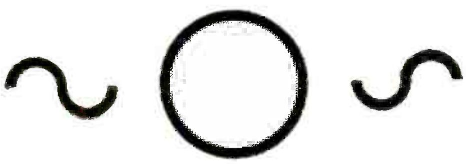


Photo by courtesy of National Broadcasting Co.

• B. I. W. Coaxial Cable is used in connection with important television stations. Some of the first television camera cables made are the product of B. I. W.

Coaxial cables and B. I. W. special purpose multiple conductor cables are today playing important parts in winning the war. They will be available to broadcasting stations and manufacturers in the electronic industry when the war is won.

B. I. W. Standard Cables, featured in the description and table on this page, may be modified as to size of conductor and type of over-all covering. However, see how closely the detailed specifications of the Standard Cables may meet your prospective requirements.



TYPE CO-X-1A-CC — Small flexible cable insulated with poly-styrene cup-shaped beads, covered with black cotton braid with white tracer, coated with lacquer.

TYPE CO-X-2A-WP—Flexible cable insulated with poly-styrene cup-shaped beads, covered with double cotton braid saturated and finished with moisture-proof compound.

TYPE CO-X-2B-RS — Weatherproof and high heat resisting cable insulated with non-melting steatite cup-shaped beads, covered with synthetic rubber sheath.

TYPE CO-X-2R-RS— Extra flexible weatherproof cable insulated with low-loss rubber compound covered with synthetic rubber sheath.

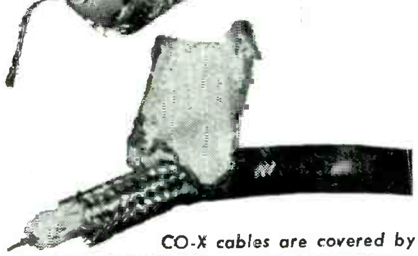
TYPE CO-X-2R-RS ARMORED — Same cable as above covered with synthetic rubber sheath and basket weave steel armor braid.

TYPE CO-X-2S-VS — General purpose cable insulated with low-loss synthetic insulating dielectric covered with waterproof synthetic sheath.

Write us regarding your probable post-war requirements.

Multiple Conductor Cables — *We make a practice of combining CO-X cables into multi-conductor cables with the proper number of control and lighting circuits required for high frequency apparatus.*

Type CO-X-4A-WP — *Very low-loss cable insulated with special cup-shaped beads of styramic compound, with black lacquered cotton braid covering.*



Type CO-X-2C-WP — *Small extra flexible low-cost cable with fabricated low-loss insulation, covered with water-proof synthetic tape and cotton braid smoothly finished with flexible flame-proof lacquer.*

CO-X cables are covered by patents or patent applications.

Electrical Characteristics of BIW Standard Coaxial Cables

Type No.	Size of Conductor	Diameter Cable	Capacity MMf/Ft.	Characteristic Impedance Ohms
CO-X-1A-CC	22	1/4"	12.5	115
CO-X-2A-WP	22	3/8"	9	115
CO-X-2B-RS	22	1/2"	10	158
CO-X-4A-WP	22	1"	6	200
CO-X-2C-WP	26	1/4"	12.5	108
CO-X-2R-RS	18	7/16"	25	70
CO-X-2S-VS	18	13/32"	21	70

BOSTON INSULATED WIRE AND CABLE CO.

61 BAY STREET BOSTON, MASS.

Transmission Line Calculator

(*Continued from page* 133)

of the rate at which the impedance locus spirals in or out.

The starting point for this nonlinear scale must be capable of being set at any impedance point on the coordinates. Also, the scale must be capable of measuring attenuation in either direction from the starting point depending upon whether conditions are to be observed in a direction from an initial starting point "toward the load" or "toward the generator". To accomplish this the scale is laid out without markings, in 1-db steps. Thus, to take into account an attenuation of say 3 db it is necessary to count off three 1-db intervals in the proper direction along the attenuation scale from whatever starting point may have existed, before reading the answer on the impedance coordinates. The proper direction to go in correcting the impedance for attenuation of the line is indicated upon the attenuation scale itself.

Standing Wave Loss Coefficient

The scale along the radial arm labeled "S.W. Loss Coef." shows the additional copper or dielectric loss due to the presence of standing waves in the vicinity of the standing wave measurement. This added loss coefficient, which multiplies the calculated loss in decibels for a matched line, does not affect the line impedance. This added dissipation within the line is caused by the fact that the line conducts more average current and is required to withstand more average voltage for a given transmitted power when standing waves are present than would normally be the case if the line were properly matched.

Since copper losses at any point are proportional to the square of the current and dielectric losses or leakage losses are proportional to the square of the voltage, the percentage increment in losses applies equally to either type of loss. This loss coefficient refers more accurately to the increase in losses over a half wavelength of transmission line in the immediate vicinity of the standing wave measurement. In cases where the copper and dielectric or leakage losses are approximately equal it holds closely for any fractional part of a half wavelength. In this special case, when moving along the line, the change in copper loss due to the standing current wave is approximately compensated by an equal and opposite change in dielectric or leakage due to the reversed slope of the voltage wave, resulting in a substantially uniform increase in loss for any fractional part of a half wavelength. If, due to attenuation, the standing wave ratio and consequently the standing wave loss coefficient change in moving along the line, for example several wavelengths, then the increased loss for the entire line section traversed lies between the coefficient limits indicated at each end.

Reflection Loss (or Gain)

The "reflection loss" may be derived from the reflection coefficient (k), which as described is the ratio of reflected to incident voltage. The reflection loss in decibels is

$$db = \log_{10} 10 \frac{P_{absorbed}}{P_{incident}} \qquad (3)$$

The absorbed power is proportional to the square of the incident voltage (V_I^2) minus the square of the reflected voltage (V_R)^2 and the incident power is proportional to the square of the incident voltage (V_I^2). Therefore

$$db = 10 \log_{10} \frac{V_I^2 - V_R^2}{V_I^2} \qquad (4)$$

$$= 10 \log_{10} 1 - (V_R/V_I)^2 \qquad (5)$$

$$= 10 \log_{10} (1 - k^2) \qquad (6)$$

If the attenuation of the line is negligible, the "reflection loss" does not represent an actual loss of power, for if an impedance match is made at the sending end of the transmission line with the generator, a "reflection gain" takes place which neutralizes the "loss" at the load end. When the attenuation is not negligible, the reflection loss at the input (which actually represents an equivalent reflection gain when the input impedance to the line is matched to the generator impedance) will be less than the reflection loss at the load. This difference between the reflection loss, which can be read on the radial arm of the calculator, at the two ends of the line represents an additional dissipation loss within the line itself

"It's this solid molded resistor element that makes the difference"

ACTUAL DIAMETER 1-1/16 INCH

Type JS Bradleyometer with a built-in switch.

Bradleyometers may be used singly or assembled for dual

— or triple construction to fit any control need.

The resistor element in Allen-Bradley Type J Bradleyometers has substantial thickness (approximately 1/32-inch thick), and in this respect differs from the film, paint, or spray type variable resistors. The Allen-Bradley variable resistor is molded as a single unit with the insulation, terminals, face plate, and threaded bushing. This simple construction does away with rivets, welded or soldered connections, and unreliable conducting paints. The Allen-Bradley type of variable resistor will prove reliable under all extremes of service conditions.

During manufacture, the resistor element may be varied throughout the length of the element to provide practically any resistance-rotation curve. Once the unit has been molded, its performance is not affected by heat, cold, moisture, or hard use. It not only is remarkably quiet when first manufactured but gets even better with age.

Bradleyometers are the only continuously adjustable composition resistors having a two-watt rating with a good safety factor. The Allen-Bradley Bradleyometer is the only commercial type variable resistor that will consistently stand up under the Army-Navy AN-QQ-S91 salt spray test. Write for specifications.

Allen-Bradley Company, 110 W. Greenfield Ave.
Milwaukee 4, Wisconsin

FIXED RESISTORS

½ WATT

Bradleyunits are molded, fixed resistors with lead wires embedded in homogeneous resistor material. They will sustain an overload of ten times rating for a considerable period of time without failing. No special wax impregnation is necessary to pass the salt water immersion test. Available in standard RMA values from 10 ohms to 10 megohms in both the insulated and non-insulated types.

1 WATT

ELEMENT ACTUAL SIZE

ALLEN-BRADLEY
FIXED & VARIABLE RADIO RESISTORS
QUALITY

which is caused by the increased average current and voltage.

Standing Wave Ratio

The standing wave ratio (*SWR*) is expressed as a number greater than 1.0. The position of the standing wave along the line is significant and it is important to remember in using the calculator that it is always at a current maximum point that the impedance is a minimum and "real", i.e., the current maximum point always falls along the R/Z_o axis (when Z_o is real) at a point between 0 and 1.0.

Likewise, it is important to remember that the current minimum point always falls along the R/Z_o axis at a point between 1.0 and ∞. The voltage standing wave is always positioned just a quarter wavelength along the line either side of the position of the current standing wave, so that a voltage minimum point on the wave will always coincide in position with a current maximum point and likewise a voltage maximum point will always coincide in position with a current minimum point.

Thus, the relative position between impedance and current distribution (standing waves) is most conveniently referred to these pure resistances or real impedance positions along the R/Z_o axis, and standing wave measurements are made with respect to these points along the line.

A given standing wave ratio uniquely defines the locus of impedances encountered along a uniform transmission line when the latter has negligible attenuation. To determine this locus the slider along the radial arm is set to coincide with the known standing wave ratio. The impedance locus then appears at the intersection of the cross-hair index when the arm is swung around through one complete revolution. The passage of this intersection point once around the calculator is equivalent to moving one-half wavelength along the transmission line, and it is thus seen that the impedance circle locus closes upon itself and then repeats for any two points a half wavelength apart and greater. The impedance locus passes through the resistance axis twice in one revolution of the arm about the coordinates, at which two positions the impedance is maximum and minimum respectively and, as described, the current and voltage,

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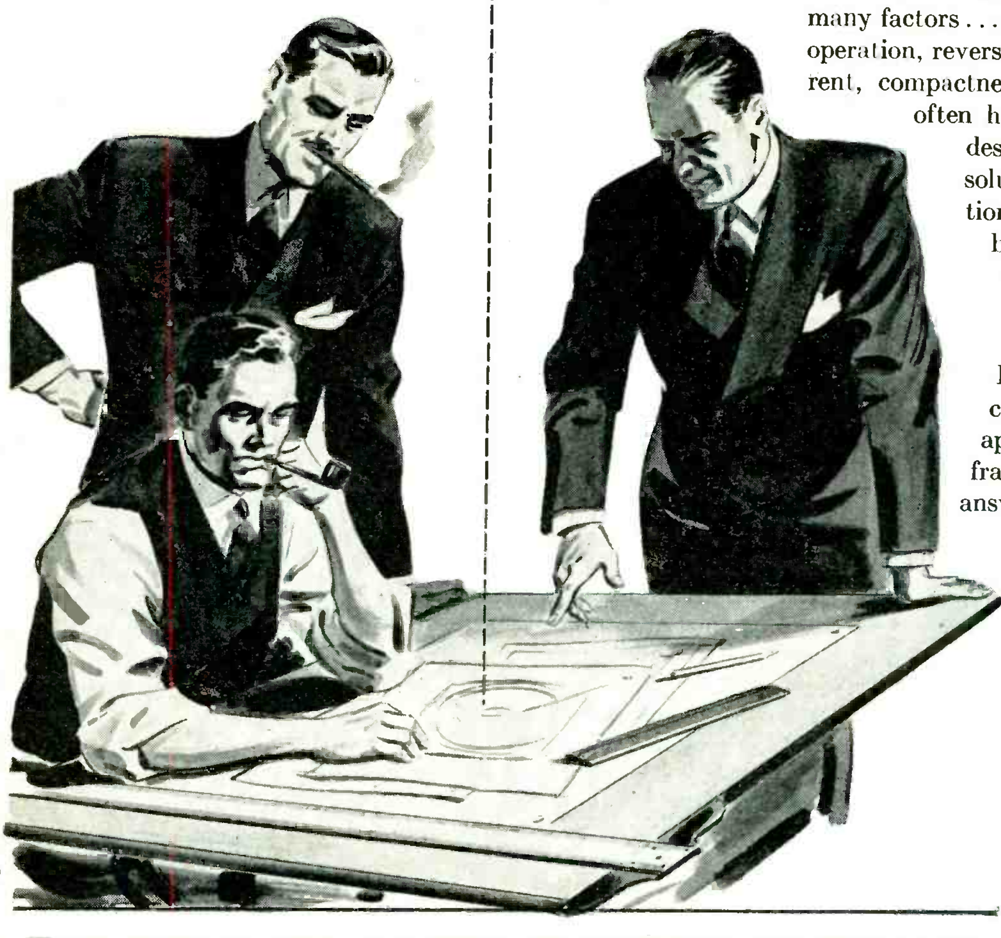

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likewise, go through maximum and minimum values.

The measurement of standing waves is often accomplished through the use of sliding capacitive or inductive probes (depending upon whether voltage or current waves respectively are to be observed). The output power taken from the probe is at a low level compared to that flowing in the main line so as not to disturb the line characteristics.

Standing Wave Ratio Expressed in Db

The probe output is amplified through a double detection receiver. The receiver includes an attenuator in its i-f amplifier circuits which is calibrated in decibels. The rectified output of the receiver is indicated on a reference level meter. It is convenient to adjust the meter output to an arbitrary reference mark and observe the change in attenuation required when going from a maximum to a minimum point along the standing wave. The standing wave amplitude ratio may then be expressed in decibels. Thus, a 6-db standing wave will have a ratio of maximum to minimum amplitude of 2 to 1. Used in this sense the term has no significance insofar as loss or power ratio is concerned. A scale is provided to permit expressing the standing wave ratio in decibels.

Relative Voltage or Current at Maximum and Minimum Points

If a transmission line is conducting a given amount of power it will do so most efficiently when standing waves are eliminated. However, there are cases when it will be acceptable or even desirable to permit standing waves to exist. In this case the line must be designed to withstand the increase in current and in voltage at the antinodes. This increase at the antinodes in both current and voltage (and decrease at the nodes) is plotted along the radial arm and refers to the increase or decrease at these points over what it would be if the line were properly terminated and were conducting the same amount of power to the load.

The voltage magnitude (E) at any point along the line in terms of the *equivalent parallel resistance* (R_{par}) component and the power (P) is

$$E = \sqrt{R_{par} \times P} \qquad (7)$$

whereas the current magnitude (I) at any point in terms of the *series resistance* (R_{ser}) component and the power (P) is

$$I = \sqrt{\frac{P}{R_{ser}}} \qquad (8)$$

In either case, the reactive component is not involved.

At the maximum and minimum impedance points the series and parallel components become the same. At these points the maximum and minimum current and voltage are conveniently evaluated from the standing wave ratio, characteristic impedance, and power as follows:

$$I_{min} = \sqrt{\frac{P}{SWR \times Z_o}} \qquad (9)$$

$$I_{max} = \sqrt{\frac{SWR \times P}{Z_o}} \qquad (10)$$

$$E_{min} = \sqrt{\frac{P \times Z_o}{SWR}} \qquad (11)$$

$$E_{max} = \sqrt{P \times Z_o \times SWR} \qquad (12)$$

where Z_o = characteristic impedance in ohms.
P = power in watts.
SWR = voltage or current standing wave ratio expressed as a number greater than unity.

Example for Use of the Calculator

A coaxial r-f transmission line having a characteristic impedance of $50 + j0$ ohms is terminated in an unknown impedance which causes a standing wave near the load such that $E_{max}/E_{min} = 2.0$. A voltage maximum point on the standing wave exists 0.175 wavelength from the load. The line is 2.84 wavelengths long and has 1.0 db attenuation.

A. To find the load impedance:

(1) Set the slider on the radial arm to the position on the E_{max}/E_{min} scale opposite 2.0.

(2) Rotate the radial arm until its index line coincides with the R/Z_o axis between 1.0 and ∞ (where the voltage is maximum), and rotate the length scale around the rim until its 0 point is aligned with the index line on the radial arm.

(3) Rotate the radial arm 0.175 wavelength counterclockwise "towards load" (from the voltage maximum point) as measured along the length scale at the rim and read the series components of the load impedance as $R/Z_o = 0.60$ and $+jX/Z_o = 0.36$. Since Z_o is $50 + j0$

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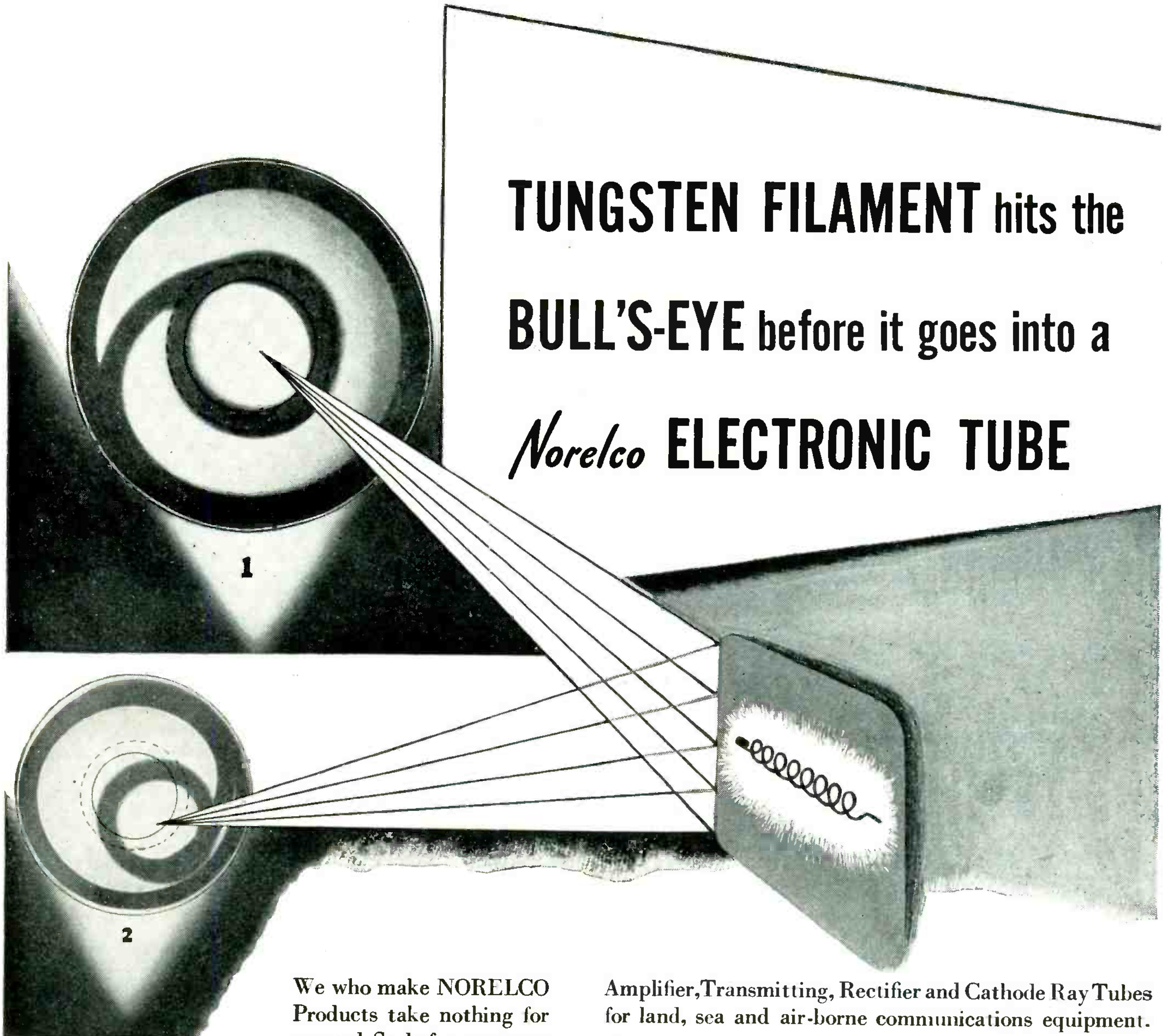

We who make NORELCO Products take nothing for granted. So, before tungsten filament coils are anchored to assemblies in tubes, they go into the limelight of a slide film projector. The projection beam is focused squarely through the dead center of the coil, and is projected against a screen on which a circle is painted.

A perfectly wound coil [*No. 1 above*] will cast its image on the screen coincident with the painted circle. An imperfectly wound coil [*No. 2 above*] *may* give adequate performance when assembled into certain types of electronic tubes—but since we who make NORELCO electronic products like to prevent possibility of failures before they get a start, we reject coils that do not meet our high standards of coil winding.

This is only one of the 61 inspections to which the various parts and assemblies of one type of NORELCO electronic tube is subjected before the final inspections in test operation.

Today, all our resources and experience are devoted to making the electronic tools and devices that will hasten Victory. Tomorrow, they will be free to serve industry in creating a new world.

For our Armed Forces we make Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes for land, sea and air-borne communications equipment.

For our war industries we make Searchray (X-ray) apparatus for industrial and research applications; X-ray Diffraction Apparatus; Electronic Temperature Indicators; Direct Reading Frequency Meters; High Frequency Heating Equipment; Tungsten and Molybdenum in powder, rod, wire and sheet form; Tungsten Alloys; Fine Wire of practically all drawable metals and alloys: bare, plated and enameled; Diamond Dies.

And for Victory we say: Buy More War Bonds.

★ ★ ★

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Factories in Dobbs Ferry, N. Y.; Mount Vernon, New York (Philips Metalix Corporation); Lewiston, Maine (Elmet Division) ohms this corresponds to $Z_L = 50(0.60 + j0.36) = 30.0 + j18.0$ ohms.

B. To find the input impedance:

(1) As in A(1) and A(2) above

(2) Rotate the radial arm 2.84 − 2.50* = 0.34 wavelength clockwise "toward generator" as measured along the length scale and read the series input impedance components (before correcting for attenuation) as $R/Z_o = 0.64$ and $+jX/Z_o = 0.44$.

Since Z_o is $50 + j0$ ohms, this corresponds to $Z_s = 50\ (0.64 + j0.44) = 32.0 + j22.0$ ohms.

(3) Correct for attenuation by moving the slider index only along the arm "toward generator" 1 decibel unit. The input impedance components are then read as $R/Z_o = 0.72$ and $+ jX/Z_o = 0.37$, which corresponds to $Z_s = 50(0.72 + j0.37) = 36.0 + j18.5$ ohms.

C. To find the total dissipation in the line:

(1) The attenuation as stated in the problem is 1 db, which is the nominal loss without standing waves. The increased attenuation due to standing waves (as observed at intersection of slider index with "S.W. Loss Coef." scale) is 1.25 times at the load end and 1.14 times at the generator end. The slider is set respectively as for B(2) and B(3) above. The dissipation loss for the whole line can be shown to be increased due to standing waves by the *difference* read on the reflection loss scale at the two ends of the line. This is seen to be 0.51−0.31 = 0.20 db. Thus, in this case the total dissipation loss within the line is 1.20 db.

D. To find the increase in voltage or current at the maximum point due to standing waves:

(1) With the slider index set as at B(2) and B(3) respectively, the increase over the uniformly distributed voltage (no standing waves)

* Subtract the largest whole number of half wavelengths to obtain equivalent length less than one-half wavelength.

due to the mismatch of impedance at the load is seen from the "Limits" scale to be 1.41 times at the load end and 1.31 times at the sending end of the line. At the nulls it is reduced to 0.707 and 0.761 times respectively. The actual magnitude of the voltage depends upon the power.

Construction Data

The data for construction of the main impedance coordinates of the calculator is shown in the figure.

It will be seen that all of the circles of constant resistance are centered on the resistance (R/Z_o) axis between the limits where $R/Z_o = 1.0$ and ∞ and that these circles are all tangent to the edge of the coordinate system at the point when $R/Z_o = \infty$.

The circles of constant reactance are all centered along a straight line perpendicular to the R/Z_o axis at the point where $R/Z_o = \infty$.

The scales along the radial arm of the calculator are conveniently plotted as a function of the magnitude of the voltage reflection coefficient k (a linear scale running between 0 at the center and 1.0 at the rim). The formulas utilized are:

Minimum Voltage or Current (N):

$$k = 1 - \frac{2}{1 + (1/N^2)} \tag{13}$$

Maximum Voltage or Current (X):

$$k = 1 - \frac{2}{1 + X^2} \tag{14}$$

Standing Wave Ratio (db):

$$k = 1 - \frac{2}{1 + \log^{-1} \text{db}/20} \tag{15}$$

Standing Wave Ratio, greater than unity (SWR):

$$k = 1 - \frac{2}{1 + SWR} \tag{16}$$

Attenuation (db):

$$k = 1 - \frac{2 \tanh (0.11512 \text{ db})}{\tanh (0.11512 \text{ db}) + 1} \tag{17}$$

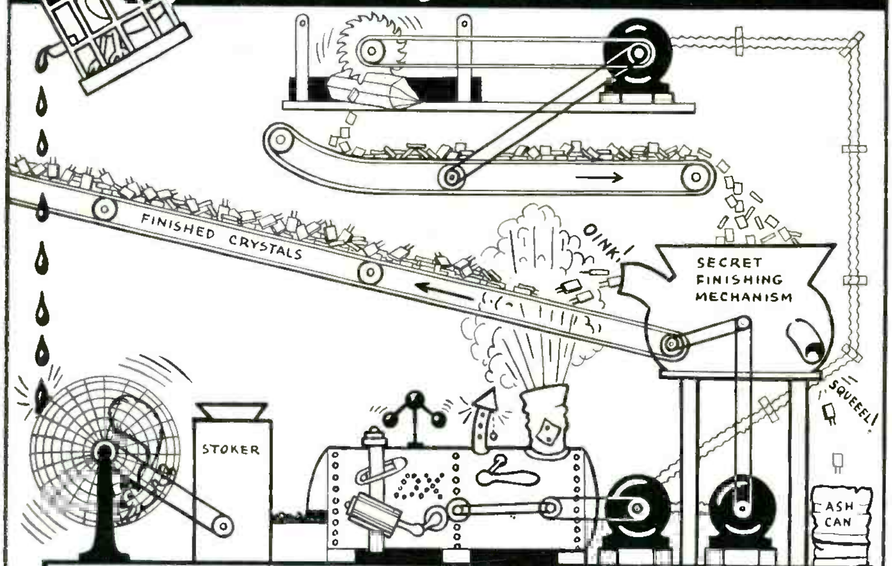
Standing Wave Loss Coefficient (C):

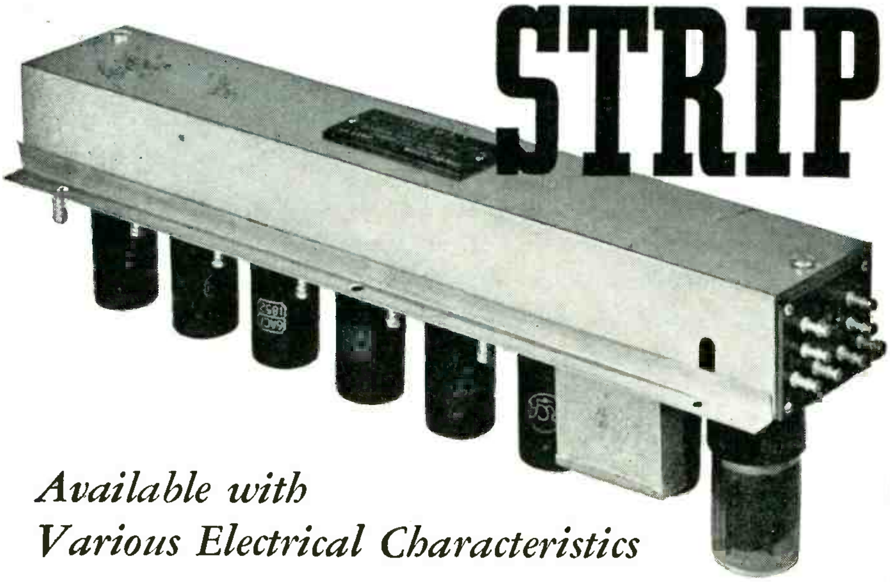
$$k = 1 - \frac{2}{1 + C + \sqrt{C^2 - 1}} \tag{18}$$

Reflection Loss in db:

$$k = \sqrt{\frac{\left(\log^{-1} \frac{\text{db}}{10}\right) - 1}{\log^{-1} \frac{\text{db}}{10}}} \tag{19}$$

Arrangements have been made with the Emeloid Co. of Arlington, N. J. for manufacturing and marketing the radio transmission line calculator in durable plastic.





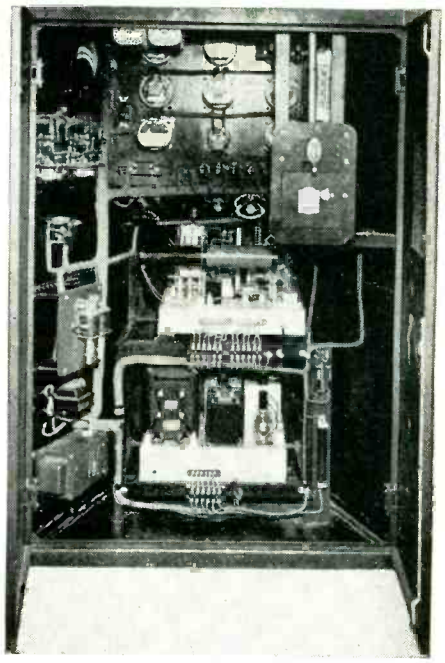
Production Tester

(*Continued from page* 143)

sequence of tests, the overall circuit is interlocked so that the control switch has to be turned first to the "off" position and then rotated in the correct direction from "off" before any test voltages may be obtained.

Overload protection is provided in both the oscillation and characteristic test sets by means of quick-acting magnetic overload relays. With a shorted tube in the socket, the relay picks up quickly enough to prevent damage to the meters.

Safety to the operator is provided by means of an interlock on the "gate" covering the tubes under test.



Interior view of oscillation test set for checking transmitting tube performance during production

The interlock system removes voltage from the control circuit, thus dropping out the contactors and removing all voltage from the tube sockets. Two line contactors ahead of all the power supplies are used. It is extremely unlikely that both contactors will ever stick closed.

Red and green signal lights are provided on the front panel to indicate the position of the contactors, so that even in the remote case of failure of the contactors, the operator is warned of the failure. All of the controls are within easy reach of the operator and the meters are easily read.

Television Tubes

(*Continued from page* 111)

differential equation which when solved by conventional methods gives

$$\frac{dV}{dt} + \frac{r + R_1}{r R_1 C} V = \frac{E_0 r + E_s R_1}{R_1 r C}$$

$$V = E_s \frac{R_1}{r + R_1} + E_0 \frac{r}{r + R_1} \left(1 - e^{\frac{-r + R_1}{r R_1 C} t}\right) \quad (5)$$

At $t = \infty$ a new steady state is reached, expressed by

$$V = E_s \frac{R_1}{r + R_1} + E_0 \frac{r}{r + R_1} \quad (6)$$

Scanning Currents and Potentials

The transient charging current while scanning the boundary is given by

$$I_0 = I_{CH} = (\alpha - \beta V)\, I_b = (E_S - V)/r$$
$$= I_0 \frac{1}{r + R_1} \left[E_S - E_0 \left(1 - e^{\frac{-r + R_1}{r R_1 C} t}\right)\right] \quad (7)$$

For values of constants encountered in practice, a plot of the charging current I is given in Fig. 9. A spot which instantaneously equalized all the charges under it has been assumed. That such a condition actually occurs, there is little doubt. However, authorities disagree as to the values of electron densities at which the surface under bombardment begins to be thoroughly conductive.

If there is no surface conductivity under the electron spot, the nonconductive charging current curve in Fig. 9 applies. It may be seen that it is of small importance whether there is, or is not, conductivity under the spot. Except for a small difference in the duration of the transient, the two discharge processes differ very little one from another. The magnitudes of current changes are between 8 and 9 hundredths of a microampere.

The potentials V left over on the mosaic by the scanning spot are also almost equal in the two cases, as is shown by the lower curves of Fig. 9. A thing to note, however, is that it is hard to expect a potential change on the globules from before to after scanning, greater than 6 tenths of a volt. For a most efficiently activated mosaic this value may rise to one volt.

Mosaic Capacitance

So far in this study of charging action of the electron bombardment some broad simplifying assumptions were used. This action was studied under the assumption that the mosaic plate is infinite in area, but has constants per unit area of the actual mosaic. As a result expressions were obtained for the video-frequency currents, time constants, potentials of the mosaic before and after scanning, etc. An infinite area, however, means an infinite capacitance capable of absorbing any charge without a change in voltage. Actually, the iconoscope mosaic has large but finite capacitance, which may be considered infinite only for the upper region of the video frequencies.

At low video frequencies the mosaic capacitance plays a very important part, as is substantiated by the experimental evidence shown in Fig. 10. When scanning a mosaic in the dark, the iconoscope output current is not zero. In fact, its peak-to-peak value is of the order of 5×10^{-8} ampere. In the reproduced picture this spurious or dark spot current would produce a great distortion, if it were not compensated for and balanced out.

Now, if a light pattern of horizontal bars is thrown on the mosaic, a square wave of current is generated by the bombardment. The square wave is superimposed on the dark-spot signal. The oscillograms show the wave shape of one field of television signal with its darkspot signal (vertical dark spot). Besides the vertical dark spot there is a horizontal dark spot in the signal, but in these oscillograms, the line frequency and all higher frequencies were filtered out.

Spurious Output Signals

The spurious signal of the Iconoscope is a result of scanning of the mosaic by the bombarding beam. Essentially, the Iconoscope is an a-c device, since its output current flows to its signal plate which is a terminal of a 0.013-μf capacitor. The secondary emission current at a steady-state condition therefore has to average out to a value equal to the beam current, while the bombarding electrons are knocking out five times their number from the mosaic. The excess electrons return to other parts of the mosaic and charge it in their turn. They charge it in a nonuniform manner, contributing to the vertical and horizontal spurious signals.

In general, with the mosaic in darkness at the start of the scan of a frame (or a field, rather) more electrons flow to the collector or second anode than are supplied by the beam to the mosaic. The current flows down from the signal plate, charging it negatively. Somewhere in the middle of the scan the flow of electrons to the mosaic becomes equal to the flow to the collector, and the current to the signal plate becomes zero. Then it reverses direction and charges the

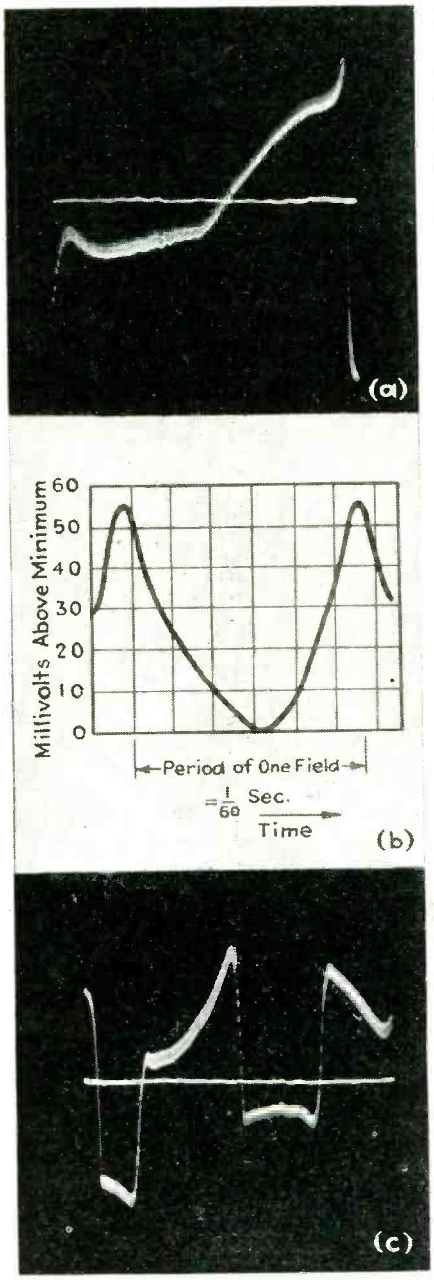
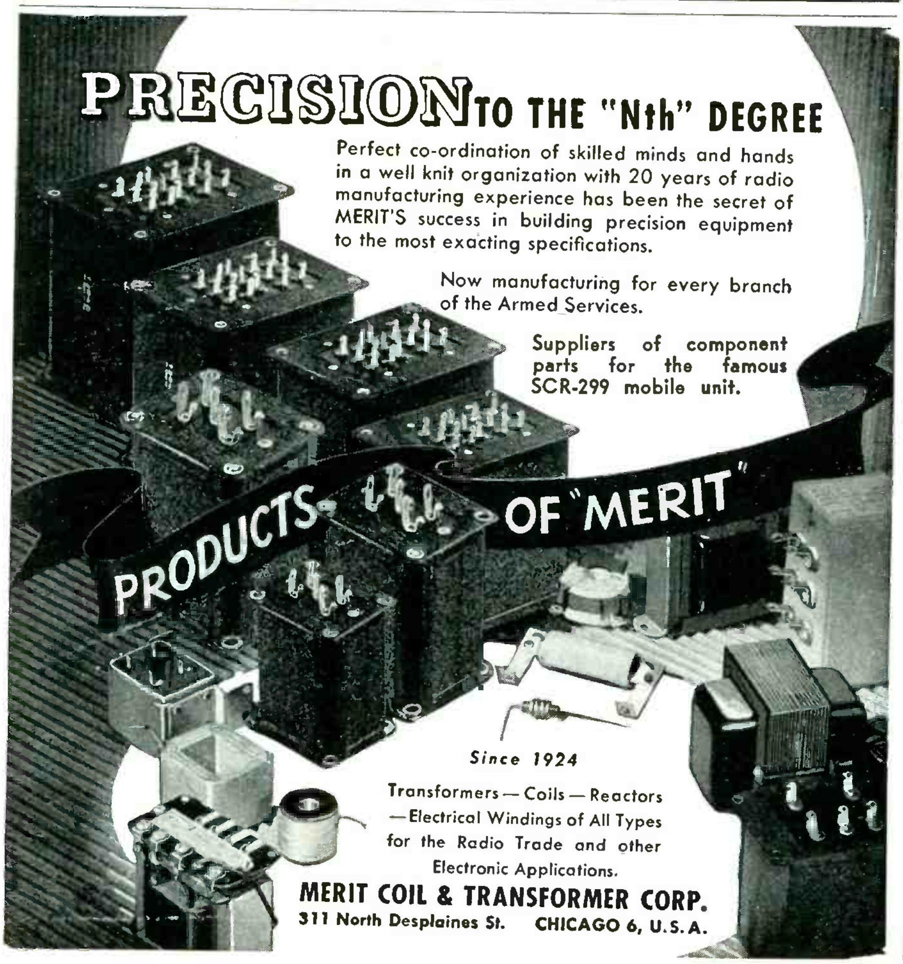


FIG. 10—Oscillograms and curve showing effect of mosaic capacitance. (a)—Signal plate current with mosaic in darkness; (b)—signal plate potential with mosaic in darkness; (c)—signal plate current with mosaic illuminated by 120-cycle square wave pattern



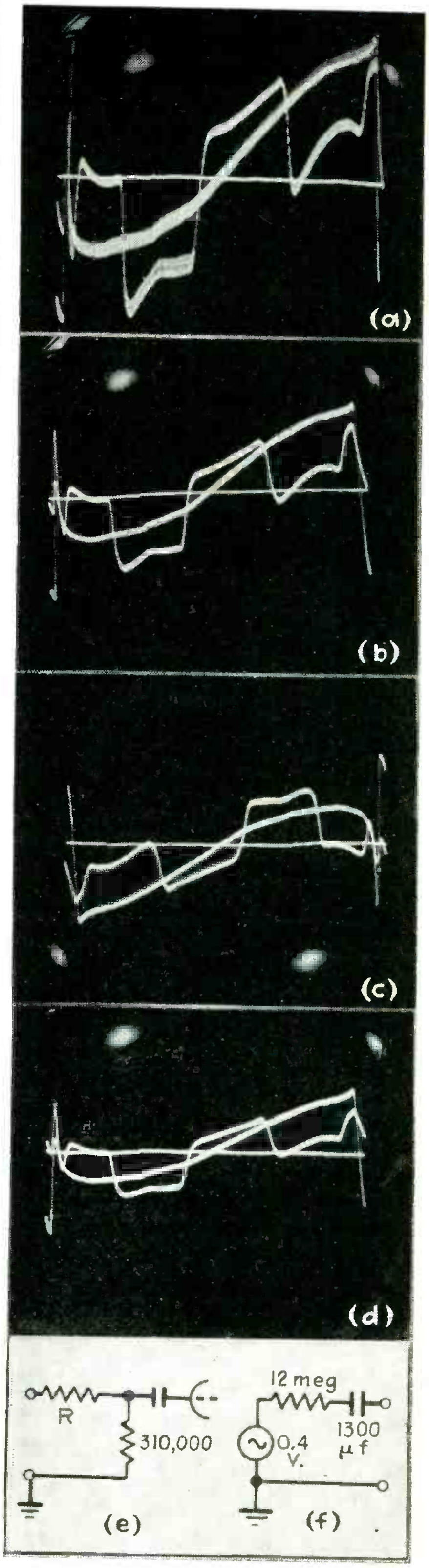


FIG. 11—Internal impedance measurements on an Iconoscope having a beam current of 0.1 ua and a 180-cycle square-wave output signal. Impedance values R in Iconoscope circuit (c) for the four oscillograms are as follows: (a)—0 ohms; (b)—6 megohms; (c)—12 megohms; (d)—18 megohms. The equiva'ent circuit at 180 cycles with no backlighting is shown at (f)

signal plate in a positive direction, while the flow of electrons to the mosaic is larger than to the collector.

Equivalent Generated EMF

Since the Iconoscope is a generator of electrical signals, one may inquire whether it can be represented as a source of an emf generated in some sort of a passive network. Since its output occurs as a current between an output terminal and ground one may inquire as to the value of equivalent emf generated and the magnitude and sense of its equivalent impedance, reactance and resistance. These have been investigated by the old reliable experimental method used in determining the emf and the internal resistance of a battery. The device is loaded with resistances of various values and the output current is read by a suitable meter. A set of simple simultaneous algebraic equations results which when solved yields the desired values.

Effect of Bar Pattern

Assume that a pattern of alternating black and white bars is thrown onto a mosaic of a normally operating Iconoscope. The resultant signal is then composed of a 180-cycle square wave plus a spurious signal. The voltage output across a normal coupling resistance is observed, then resistors of different values are inserted in series with the normal coupling resistor. The resultant oscillograms are shown in Fig. 11. Apparently more than the capacitance of a single picture element is active in the Iconoscope at low frequencies—about one-tenth of the mosaic area in fact, while the emf generated by the Iconoscope is 0.3 to 0.5 v.

Conclusions

As we have just shown, the fact that the Iconoscope is utilizing electron bombardment and secondary emission does not mean that it is in a class of devices which are foreign to communications engineers. It is a generator of electrical signals, having an internal impedance and a definite electromotive force. Its characteristics are readily measured and used in the design of television systems; while certain of its actions do not make it an ideal generator of a video signal, it has made possible modern high-definition television.*

* For a list of references on the subject the reader is referred to the extensive bibliography in "Television," by Zworykin and Morton, John Wiley & Sons, New York, 1940.

Multivibrator

(Continued from page 141)

tube must divide by 2.4 and the other by 3.6. Now $r = 0.4$ and the phase difference between the two synchronizing voltages must be $360 \times 0.4 = 144$ deg.

When the synchronizing voltage is supplied to the two tubes in the same phase, it acts to make them both conducting at the same time. Assume V_1 is conducting. When V_2 begins to conduct, it must operate to stop the plate current of V_1. Therefore, V_1 is acted upon by two independent voltages of opposite polarity. For reliable synchronization, V_2 must easily overcome the action of the synchronizing voltage and stop the flow of plate current through V_1. This can be insured by using a value of $k_2E_{bb} >> E_{s1}$, where E_{s1} is the value of the synchronizing voltage as referred to the grid of V_1. This condition is ordinarily satisfied without giving it any special consideration, particularly for values of N equal to or greater than three.

Example I

A symmetrical MV is to operate at a natural frequency of 1000 cps[4]. The tube is a type 6SN7-GT. E_{bb} is 180 volts. Design the MV.

Solution:

(a) Since the MV is symmetrical, $T_1 = T_2 = T_{MV}/2$, i.e., each tube contributes half the total period.

(b) Choose $R_{L1} = R_{L2} = 20{,}000$ ohms.

(c) To satisfy (1.9)

$$C_{h1\,max} = \frac{T_2}{5\left[R_{L2} + \dfrac{R_{d1}\,R_{g1}}{R_{d1} + R_{g1}}\right]}$$

$$= \frac{1}{2 \times 10^3 \times 5\,[20 \times 10^3 + 1.5 \times 10^3]} = 0.00465\ \mu f$$

(d) From Fig. 1.9 read $\alpha_1 T_1 = \alpha_2 T_2 = 2.16$.

$$\alpha_1 T_1 = \frac{T_1}{C_{h1}\left[R_{d1} + \dfrac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}}\right]} = 2.16$$

(e) If C_{h1} is chosen as 0.0005 μf,

$$R_{d1} + \frac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}} = \frac{T_1}{2.16\,C_{h1}}$$

$$= \frac{1}{2 \times 10^3 \times 2.16 \times 5 \times 10^{-10}} = 4.63 \times 10^5 \text{ ohms.}$$

(f) The value of R_{b2} for R_{L2} = 20,000 ohms is read from Fig. 1.6 as 8.4×10^3 ohms. Therefore,

$$R_{d1} = 463 \times 10^3 - 6 \times 10^3 = 457{,}000 \text{ ohms.}$$

Figure 1.14 is a schematic diagram of the MV. If it is desired to adjust the frequency accurately to 1000 cps, a 250,000 ohm resistor in series with a 500,000 ohm rheostat can be used for R_{d1} and R_{d2}. This will permit adjusting the MV for symmetrical wave shape and correct frequency for different tubes.

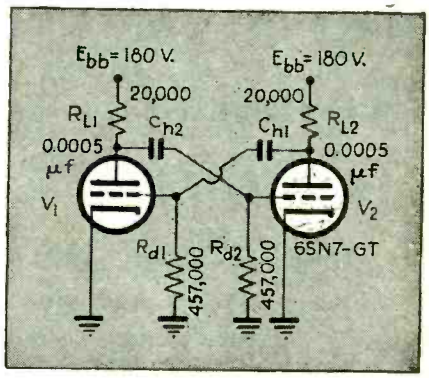


FIG. 1.14—Multivibrator designed in Example I

A MV was built using resistors and capacitors having values within 1 percent of those shown on Fig. 1.14. The natural frequency of the circuit for nine different tubes—three each of two different standard brands and one inferior brand—and three values of plate supply voltage is tabulated in Table I. The design, which was based upon 1000 cps at $E_{bb} = 180$ volts, is in error by a maximum of 5.8 percent for the first seven tubes. The maximum error between tubes (No. 1 and No. 6) is 6 percent. While the center frequency obtained with tubes No. 8 and No. 9 differs appreciably from the average of the first seven tubes, the percentage change in frequency with change in E_{bb} is about the same for all tubes.

If the total change of MV period as E_{bb} is decreased (from 180 volts) to 150 volts and increased to 210 volts is attributed to variation of μ_{co} (reference to Fig. 1.6 shows this to be reasonable; since, for R_L = 20,000 ohms, R_b does not change sufficiently to affect k), the result of reading Figs. 1.7 and 1.8 and substituting into Eq. (1.52) of Appendix

[4] By a symmetrical MV is meant one in which all the components of one section are identical to the corresponding components of the other section.

TABLE I

Tube	Brand	Natural Frequency For E_{bb} of		
		150v.	180v.	210v.
1	Standard 1	1022	998	985
2	"	1061	1034	1016
3	"	1070	1044	1020
4	Standard 2	1041	1017	997
5	"	1064	1034	1020
6	"	1085	1058	1038
7	Inferior	1085	1050	1031
8	"	1186	1151	1133
9	"	1211	1180	1163

Measured natural frequency for various tubes and plate supply voltages used with the multi-vibrator of Fig. 1.14.

I is (for a decrease of E_{bb} from 180 volts to 150 volts)

$$\frac{dT_1}{T_1} = -\frac{0.72\,(12.4 - 11.6)}{0.72 \times 12.4}\left[\frac{1}{\log.\,(0.72 \times 12.4)}\right] = -0.0295 = -2.95\%$$

The minus sign enters because the change in μ_{co} is in a negative direction. (Although the variations involved are too large to be considered differential changes, the accuracy obtained from the equation is still quite good.) Hence, the period at $E_{bb} = 150$ volts will be 97 percent of that at 180 volts or the frequency should be 1031 cps, an increase of 31 cps. A similar calculation shows that at 210 volts the frequency should be 980 cps.

Example II

A MV is to have a natural frequency of 50 cps. The tube is a type 6A6. E_{bb} is 200 volts. The value of E_{cc} required for plate current cutoff is -10 volts. Design the MV to supply a 20/80 output waveshape.

Solution:

(a) $T_1 = 1/50 \times 2/10 = 0.004$ sec.

(b) $T_2 = 1/50 \times 8/10 = 0.016$ sec.

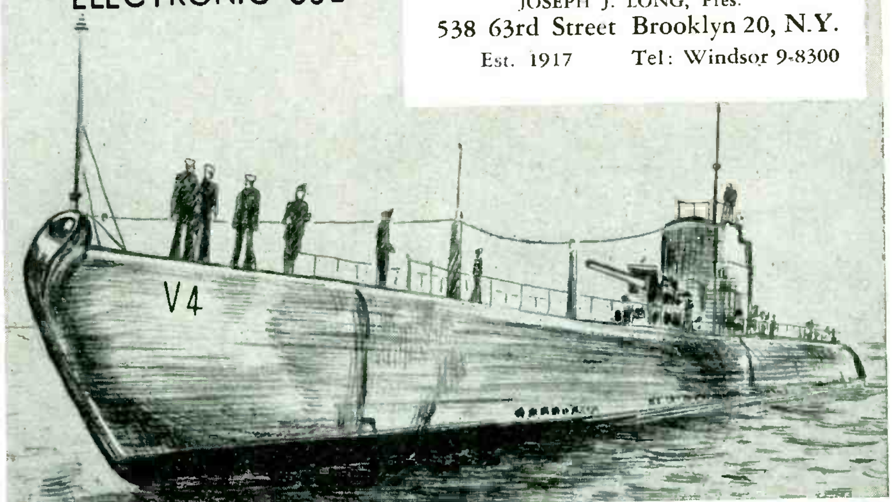
(c) Let $R_{L1} = R_{L2} = 50{,}000$ ohms. Then from the I_b vs. E_b family of curves, $R_b = 25{,}000$ ohms.

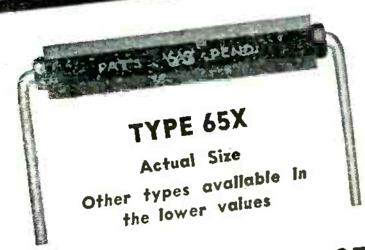
(d) If $R_{d1} >> \frac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}}$, then $k_2 = 1/[1 + (R_{b2}/R_{L2})] = 0.67$.

(e) $k_2\mu_{co1} = 0.67 \times 200/10 = 13.4$.

(f) Reading from Fig. 1.5, for $k_2\mu_{co1} = 13.4$, $\alpha_1 T_1 = 2.60$.

Since $k_1\mu_{co2} = k_2\mu_{co1}$, $\alpha_2 T_2 = \alpha_1 T_1 =$





2.60. Then $\alpha_1 = 2.60/T_1 = 650$. Similarly, $\alpha_2 = 162$.

(g) Substituting in (1.9) to find maximum values of C_{h1} and C_{h2} gives

$$C_{h1max} = \frac{0.016}{5} \times \frac{1}{(50 \times 10^3 + 1.5 \times 10^3)} = 0.062\ \mu f.$$

$$C_{h2max} = C_{h1max} \times \frac{0.004}{0.016} = 0.0154\ \mu f.$$

If $C_{h1} = 0.002\ \mu f$,

$$R_{d1} = \frac{1}{C_{h1}\alpha_1} - \frac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}} = \frac{1}{2 \times 10^{-9} \times 6.5 \times 10^2} - \frac{25 \times 50 \times 10^6}{75 \times 10^3} = 752{,}000 \text{ ohms}$$

and, choosing $C_{h2} = 0.008\ \mu f$, R_{d2} is also equal to 752,000 ohms.

Figure 1.15 is a schematic diagram of the MV. In order that the wave shape might be adjusted to 20/80, it would be well to use a 500,000-ohm rheostat and a 500,000-ohm resistor in series as R_{d1} and R_{d2}.

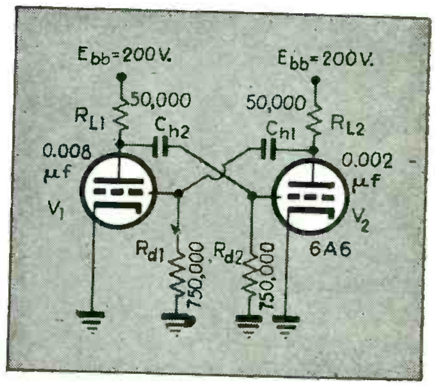


FIG. 1.15—Multivibrator designed in Example II

Selecting components to an accuracy of 1 percent, this circuit was built and the natural frequency resulting with four different tubes of a standard brand was 48.9, 50.1, 50.3 and 52 cps respectively. Figure 1.16 is a plot of natural frequency as a function of E_{bb} for two of these tubes. All values for the other two tubes fell between these curves. This figure shows that changes in E_{bb} affect the frequency in a similar manner as changes in C_h. Therefore, the effect of a given change in E_{bb} can be stated in terms of an equivalent change in C_h. From Fig. 1.16, as E_{bb} increases from 180 to 360 volts—a 100 percent increase—the natural frequency (No. 1 tube) decreases from 52.8 to 48.8 cps, an increase of 8.2 percent in the period of the MV. In this case, a 100 percent increase in E_{bb} is equivalent, in its effect upon the natural period, to an 8.2 percent increase in the capacity of both C_{h1} and C_{h2}. De-

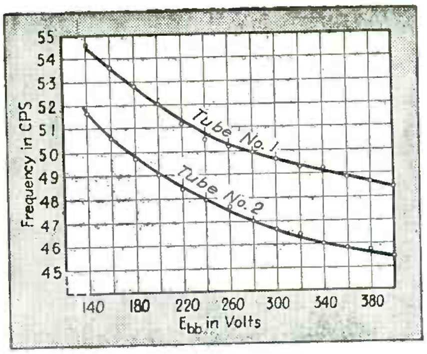


FIG. 1.16—Plots of natural frequency vs. E_{bb} for two type 6A6 tubes in the multivibrator circuit of Fig. 1.15

creases of 10 percent in E_{bb} from 200 volts and 400 volts are equivalent to decreases of 1.5 percent and 0.8 percent in the values of *both* time constants. In general, rate of change of frequency vs E_{bb} decreases as E_{bb} increases.

With 50,000 ohm plate load resistors, as shown in Fig. 1.15, the natural frequency decreased smoothly by 4.4 and 4.3 cps for tubes No. 1 and No. 2 respectively in the E_{bb} range from 180 to 400 volts. When these 50,000 ohm resistors were decreased to 10,000 ohms and the condensers increased in capacity to bring the frequency back to approximately 50 cps, the frequency varied 7.8 and 6.2 cps for the same tubes in the same E_{bb} range. This confirms the desirability of using values of R_L that are large in comparison with R_b in order to blot out the effect upon k of variations in R_b. The resulting large value of k is also desirable, as found in Appendix I, because it helps to minimize the effect upon T_{mv} of variations in μ_{co} and in k. To sum up—experiment shows that in a group of four type 6A6 tubes the variations of natural frequency from tube to tube as well as those variations resulting from changes in E_{bb} with a given tube, are approximately half as great for $R_L = 50{,}000$ ohms as they are for $R_L = 10{,}000$ ohms.

With some types of tubes, k varies appreciably (from tube to tube or with changes in E_{bb}) and in the opposite direction from the changes in μ_{co}. As a result, the percentage variations in the product $k\mu_{co}$ are likely to be less than those of either k or μ_{co}. If, in these cases, R_L is made small in order to allow R_b greater control over k, the normal value of the product $k\mu_{co}$ will be decreased proportionately. In Appendix I it is shown that the effect upon T_{mv} of a given percentage change in $k\mu_{co}$ increases as $k\mu_{co}$ decreases. Hence, if small values of k are employed to use changes in k to compensate changes in μ_{co}, the compensating effect must be rather pronounced if a net improvement is to be obtained over the minimizing action of the larger k. Experiment indicates that, for given circuit conditions, the degree of compensation is subject to considerable variation with replacement of the tubes. Generally, the larger values of R_L (and, therefore, of k) are preferable.

Appendix I

It is desired to find the rate of change of T_1 with change of $k_2\mu_{co1}$ in Eq. (1.5a).

$$T_1 = \frac{1}{\alpha_1} \log_e \left[k_2\ \mu_{co1} \right] \qquad (1.5a)$$

The derivative of T_1 with respect to $k_2\mu_{co1}$ is

$$\frac{d\ T_1}{d\ (k_2\ \mu_{co1})} = \frac{1}{\alpha_1\ k_2\ \mu_{co1}}$$

Substituting for α_1 from Eq. (1.5a),

$$\frac{dT_1}{d\ (k_2\ \mu_{co1})} = \frac{T_1}{k_2\ \mu_{co1} \log_e [k_2\ \mu_{co1}]}$$

$$\frac{dT_1}{T_1} = \left[\frac{d\,(k_2\ \mu_{co1})}{k_2\ \mu_{co1}}\right]\left[\frac{1}{\log_e [k_2\ \mu_{co1}]}\right] \qquad (1.52)$$

From Eq. (1.52) it is seen that a given percentage variation of $k_2\mu_{co1}$ will produce less percentage change in T_1 for larger original values of $k_2\mu_{co1}$. This indicates the desirability of using a large k as a means of minimizing variations of the natural period with replacement of tubes, i.e., with changing values of μ_{co} and R_b.

Failure to satisfy (1.9) is equivalent to decreasing the value of k. This is due to the fact that C_h does not charge fully to E_{bb}. As a result, the net active voltage in the circuit of Fig. 1.3b is decreased.

Since the change in the period of the MV is proportional to the change in the logarithm of k, (1.9) can be considerably undersatisfied without introducing excessive error into Eq. (1.5a). When (1.9) is not fully satisfied, k becomes a function of C_h, R_d and the value of μ_{co} obtaining at the plate voltage at which the tube begins to pass current. Evaluation of μ_{co} as E_{bb}/E_{co} is no longer valid, since the plate voltage is less than E_{bb} by an amount equal to the charge current multiplied by R_L. (See Fig. 1.13). The magnitude of E_{co} is, therefore, a function of this charge current.

The voltage to which C_h discharges depends upon E_{co}. The value of the charging current at any instant is a function of the voltage across C_h when it begins to charge. This circle of inter-dependencies renders the solution of the circuit extremely difficult. Any equations obtained would be cumbersome and hard to interpret for practical design purposes. If (1.9) is satisfied, the current flowing in the circuit of Fig. 1.13 is essentially zero when the tube begins to pass current. Consequently, the above circle of dependencies is broken and the solution of the circuit is greatly simplified.

If k_2 becomes a function of C_{h1}, the interval T_1 is no longer *linearly* proportional to C_{h1}. The departure from linearity is usually very small. Although T_1 is never linearly proportional to R_{d1}, for most practical purposes it will be, if R_{d1} is considerably greater than $R_{b2}R_{L2}/(R_{b2} + R_{L2})$.

Symbols Used In This Paper

The numerals 1 or 2 appended to a subscript indicate the section of the circuit in which the component or voltage is located. See Fig. 1.0.

C_h = Plate to grid coupling capacitor.
E_{bb} = Plate supply voltage.
E_{cc} = Grid supply voltage.
E_{co} = *Magnitude* of d-c grid voltage required for plate current cutoff.
E_s = Peak amplitude of the synchronizing voltage. Except where it is specifically stated to the contrary, E_s is considered positive.
f_s = Frequency of the synchronizing voltage.

$$k_1 = \left[\frac{1}{1 + \frac{R_{b1}}{R_{L1}}}\right]\left[\frac{R_{d2}}{R_{d2} + \frac{R_{b1} R_{L1}}{R_{b1} + R_{L1}}}\right]$$

$$k_2 = \left[\frac{1}{1 + \frac{R_{b2}}{R_{L2}}}\right]\left[\frac{R_{d1}}{R_{d1} + \frac{R_{b2} R_{L2}}{R_{b2} + R_{L2}}}\right]$$

MV = Multivibrator.
N = Order of division of *one synchronized section* of multivibrator. See Fig. 1.0.
N_1 = T_1/T_s = Order of division of V_1 and its associated components.
r = Fractional part of N.
r_1 = Fractional part of N_1.

$$R_1 = \left[R_{d1} + \frac{R_{b2} R_{L2}}{R_{b2} + R_{L2}}\right]$$

$$R_2 = \left[R_{d2} + \frac{R_{b1} R_{L1}}{R_{b1} + R_{L1}}\right]$$

R_b = d-c plate resistance of the tube.
R_d = Grid resistor.
R_g = Grid-cathode resistance of the tube.
R_L = Plate resistor.
t = time.
T_1 = Non-conducting time of V_1.
T_2 = Non-conducting time of V_2.
T_{MV} = $T_1 + T_2$ = Period of the multivibrator.
T_s = Period of the synchronizing voltage.

$$\alpha_1 = \frac{1}{C_{h1}\left(R_{d1} + \frac{R_{b2} R_{L2}}{R_{b2} + R_{L2}}\right)}.$$

$$\alpha_2 = \frac{1}{C_{h2}\left(R_{d2} + \frac{R_{b1} R_{L1}}{R_{b1} + R_{L1}}\right)}.$$

μ_{co} = E_{bb}/E_{co}. Usually $\frac{1}{2}$ to $\frac{3}{4}$ of the rated amplification factor of the tube.

Head Injuries

(*Continued from page* 117)

activity has been measured by means of the potentials developed on the skin immediately adjacent to the contracting muscles. This requires small electrodes attached to the skin at the proper points. However, the level is quite low (5–50 microvolts) and the noise and hum pickup are excessive without prohibitive shielding precautions. For this reason the activities of the eye and face muscles are picked up by means of the effect of impedance changes, between the electrodes, which are known to accompany the activity. The latter is made to produce phase shifts in a 2-Mc signal fed into the skin electrodes.

The electrodes are very small white-gold cups filled with electrode jelly, attached with a small piece of adhesive tape, and connected with fine litz wire. Once on, they are practically unnoticable to the patient. Furthermore, the level and frequency of the initial signal are such that hum and noise problems are completely eliminated. (One of the problems of this research is to verify the correlation between actual movements and the accompanying impedance changes. At present, the evidence in favor of it seems very good.[2])

Sweat Pickup

The amount of sweat secretion is measured in a similar manner. A small platinum mesh is placed on the palm of the hand as one plate of a capacitor, of which the skin is the dielectric and the interior of the hand is the other electrode. During secretion a column of conducting fluid connects across this capacitor. The pickup thus acts like a "leaky" capacitor in which the amount of leakage is taken as a measure of the sweat activity. The leakage is measured by means of phase shift in an r-f circuit. Again, assumptions are made, based on fairly good evidence, concerning the amount of fluid secreted and the work done by the secretory organs. These likewise require verification.

Mechanical-Movement Pickups

In the cases of respiration, finger-tip tremor and heart action, the pickups are all small variable capacitors which are made to modulate the frequency of an oscillator in accordance with the instantaneous displacements. The respiratory movements are picked up by means of a pneumatic tube around the patient's chest, connected to a tambour which in turn drives the variable capacitor. For the finger-tip tremor, the fingers rest on a spring-mounted variable plate directly over a fixed shielded plate, forming a unit akin to the condenser microphone. The movements of the arterial pulse are communicated to a smaller identical unit by means of a small lucite rod resting lightly on the wrist over the radial artery, giving a signal on the basis of which heart activity is derived.

FM Amplifier System

Figure 2 is a block diagram representing the type of amplifying system used by nearly all of the channels. The pickup is represented as a variable capacitator connected by means of a coaxial cable across the tank circuit of a "soft" tuned oscillator (one whose frequency can easily be varied) which is frequency modulated in the standard fashion. In those pickups where the signal is represented by a phase shift, the latter is converted into equivalent frequency deviations and the balance of the circuit is identical.

The oscillator output (of the order of 1 Mc) is fed into a series of conventional frequency multiplier stages having a total multiplication varying from about 40 to 250 depending upon the particular indicator. (Multiplication is used to secure greater frequency deviation and thus a greater output from the discriminator circuit.) The output of the multipliers is fed through a standard FM cascaded limiter to remove spurious amplitude variations, then put through a conventional FM discriminator. The output of the latter is an amplified amplitude-time function of the indicator movements. The differentiator circuit following the discriminator converts this signal into a velocity-time function in which the output voltage is proportional to the instantaneous velocity.

The circuit for center-frequency stabilization operates by beating some of the oscillator signal with the output of a stable crystal oscillator in the mixer stage, the output of which is fed into a Crosby discriminator[3] adjusted to deliver zero voltage when the oscillator is at the carrier frequency. For drift above and below the carrier frequency it delivers positive and negative voltages proportional to drift, actuating a reactance tube that changes the oscillator tank circuit tuning to compensate for the drift.

The Crosby stabilization scheme for FM modulators is especially valuable for some of these channels, since it eliminates the slow changes occasioned by the patient shifting in the chair. (Acoustic and mechanical disturbances picked up extraneously are easily eliminated by suitable filters following demodulation. The latter are not indicated.)

A definite advantage accrues in using FM carrier amplification. The noise level in most hospitals, where this type of apparatus would be exclusively used, is usually excessive. The apparatus is necessarily placed in another room from the patient and the input cables are apt to be long. Since in some cases the input signals are as low as −85 db, noise and hum pickup is commonly experienced. Furthermore, considerable noise energy exists in the sub-audio range. Consequently, the use of FM results in a definite advantage as regards signal-to-noise ratio over a d-c amplifier, and the shielding requirements are much less stringent.

Converting Amplitude Signal to Energy Signal

To obtain a signal proportional to the instantaneous kinetic energy, it is necessary merely to square the velocity signal. This is accomplished in a conventional manner by utilizing the curved portion of the characteristic of a triode. The latter is biased to cut off, and the operating potentials are adjusted to give an output voltage which is proportional to the square of the input and is hence proportional to the instantaneous kinetic energy of the input signal.

The double-triode type 12SC7 tube in the circuit of Fig. 3 was found to be highly satisfactory for this purpose. The proper combination of plate resistance, plate voltage and bias, plus a careful selection of the tube itself, give a dynamic characteristic which is very closely parabolic over an input voltage range of more than three volts. As a result of the push-pull input and parallel output circuit the odd harmonics are cancelled, leaving only a few percent of the fourth harmonic as distortion.

Adjusting for Square-Law Operation

It was found that tubes which had been aged by several hundred hours of operation could be most easily adjusted for square-law operation. Final adjustment of the circuit is made by an oscilloscopic comparison of the input and output signals of a sine-wave voltage pattern.

If the input signal is given by $e = E \sin \omega t$, then $i_p = Ke^2 = KE^2 \sin^2 \omega t$, or

$$i_p = K\left(\frac{E^2}{2} - \frac{E^2}{2}\cos 2\omega t\right) \quad (1)$$

Thus, the a-c component of the output signal is cosinusoidal at twice the frequency of the input. A more accurate adjustment initially is obtained by plotting the $E_c - I_p$ dynamic characteristic. The d-c component of the output represents the average energy. Capacitor C may be switched into the circuit of Fig. 3 to filter out the a-c component and provide a voltage proportional to the average energy alone. This is useful in cases where the instantaneous variations are too rapid to be recorded successfully in the manner described below.

Differentiating Circuit

For purposes of analysis, two successive time derivatives of the energy-time function are developed by means of the differentiating circuit shown in Fig. 4. If the reactance of C is large compared to R for all fre-

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ALTITUDE CHAMBER

RCA Victor engineers made this transparent altitude chamber for aircraft radio equipment tests from the Plexiglas nose cone of a bomber. It permits measurements and observation by many engineers from all directions quencies contained in the signal being differentiated, then the voltage developed across R is proportional to the rate of change of the input signal.

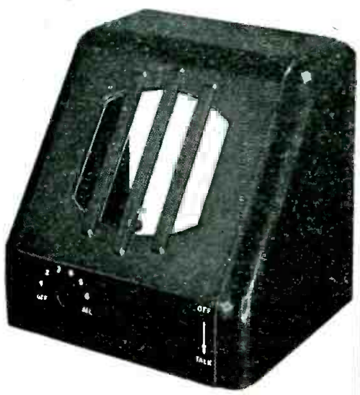
The rest of the circuit is a d-c amplifier to overcome the insertion loss introduced by the CR network. The gain of the amplifier is adjusted to equal the attenuation of the highest-frequency signal, for which the phase shift is nearly 90 deg. When X_c is equal to about $100R$, as in the actual circuit, this attenuation is 20 db. The amplifier employs a double-section triode for each stage, in such a way that zero drift is practically eliminated. Two stages are used to avoid objectionable phase reversal. The use of conductive tube coupling, also described by Miller, leaves a positive potential of some 40 volts, which must be ballanced out in the subsequent counting circuit. A high degree of regulation is required for the voltage supply.

The second derivative may be obtained by cascading two such differentiating circuits. However, the number of such circuits which may be used in cascade without excessive distortion was found to be limited to two at these frequencies. This is due to the fact that noise and hum frequencies are so far above the signal frequencies that they are transmitted through the differentiating circuits

• • •

ITALIAN SWITCHBOARD

View of a ten-line Italian telephone switchboard for field use. Switches rather than cords are used for making connection. Except for broken transmitter horn, this captured equipment appears to be in operating condition. It would seem that the microphone and its support might easily be damaged by accidental closing of the cover of this unit



without any attenuation. Consequently, after passing through two of these circuits the signal-to-hum and the signal-to-noise ratios are reduced by a factor in the neighborhood of 10,000.

In view of the excessive interference fields encountered, no further amplification could be tolerated. The design of suitable filters to overcome this situation is impractical. There is also the consideration of increasing amplitude and phase distortion with each successive stage. Phase shift is particularly objectionable in differentiating circuits.

Since it is considered to be likely that a greater number of successive derivatives would be of value in the analysis of the fine structure of the various energy-time records, the development of other methods of obtaining derivative signals was considered, in which the attenuation would not be so great. A method for obtaining successive derivatives from the quantized time-axis records of the energy signals is described later.

Counting Circuit Provides Quantized Time-Axis Record

The output of the square-law stage and associated differentiators are individually connected to the input of a counting circuit like that in Fig. 5. The purpose of the counting circuit is to convert an amplitude-variable signal into a frequency-variable one. The circuit generates short pulses at a rate directly proportional to the amplitude of the input signal. The counting circuit is an adaptation of the voltage integrator circuit developed by Stevens of Harvard University.[4]

The operation of the counting circuit may be seen in the simplified diagram of Fig. 6. It consists of a bridge circuit which has pentode tubes 12SJ7(1) and 12SJ7(2) as two of the arms. Assume that, with zero input voltage to tube 12SJ7(1), the bias voltages of these tubes are so adjusted that the potential of point A is equal to the potential of point B. An input voltage will upset the balance of the bridge by changing the plate circuit resistance of 12SJ7(1), causing a change in the potential at point A and establishing a difference of potential across C_1. If the input voltage increases negatively, a positive potential will appear from A to B, charging capacitor C_1 through the plate circuit of, 12SJ7(2). Since

12SJ7(2) is operated as a constant-current tube, the charging current will also be constant. If I_c is the charging current, then $I_c = dQ/dt$, which is a constant, and $Q = kt + K$.

The voltage across capacitor C_1 at at any instant is $E = Q/C_1 = kt/C_1 + K/C_1$. The voltage across the capacitor thus increases linearly with time, and the rate at which it increases is proportional to the signal voltage at the input of 12SJ7(1), provided it is not too large.

If a means is provided of suddenly discharging the capacitor when the voltage across it has reached a predetermined critical value, then the rate at which it is so discharged is directly proportional to the amplitude of the input signal over its range of operation. An Eccles-Jordon trigger circuit[5] is connected across the capacitor as shown in Fig. 5 and is so adjusted as to trip when the positive voltage between A and B has reached a value determined by the setting of the bias potentiometer. This value may be about 1 or 2 volts.

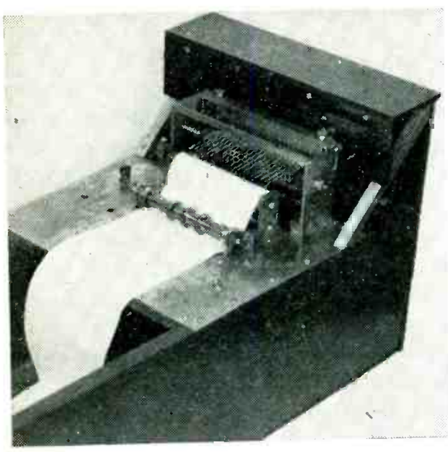


Fig. 8—Pen-writing unit containing 20-pen Esterline-Angus operation recording unit and tape puller

A fast-acting micro-relay in the plate circuit of the first section of the 12SC7 trigger tube short-circuits the capacitor, discharging it almost instantaneously. The discharging pulse causes the trigger circuit to reverse itself into its original position, and the capacitor begins to charge over again. At the break of the upper contact of the relay a 35L6G tube is momentarily brought into operation, causing an intensive short pulse of current to flow in its plate circuit. The current flows only during the action time of the relay, since it is biased to cutoff at all other times. These pulses are fed into the field coils of an electromagnetic lever which causes an ink-writing pen to make a lateral mark on a strip of moving paper. Examples of the type of record may be seen in Fig. 7. A bank of 20 such pens was obtained from an Esterline-Angus operation recorder and was adapted as shown in Fig. 8 for use with a 6-in wide paper tape.

Advantages of Time-Axis Recording

Time-axis recording is especially suitable for very low-frequency signals. If the counting circuit is linear and sufficiently rapid, we may obtain in one-eighth inch of width on the paper a record which would require at least one inch for a standard amplitude record without loss of resolution. A transcription from this type of record to a standard amplitude record could easily be made, if desired. This could be done by erecting an ordinate from the mid point of the interval between two successive pulse marks to a height inversely proportional to the interval. Such transcriptions, however, are not contemplated for the purposes of this work.

Twenty time-axis records are made simultaneously on the inexpensive 6-inch wide paper tape. Seven are energy-time functions of the various psychophysiological indicators and thirteen are various first and second time derivatives. Both economical and clinical considerations demand that all records be made simultaneously. A further advantage of being able to observe possible pattern effects is derived from observing all the functions in juxtaposition. Even with a sacrifice in dynamic range, twenty standard amplitude records would require a paper strip several feet in width. The operation of such a recorder would be prohibitively expensive on a clinical basis.

Perhaps the greatest advantage of time-axis records is the fact that the integral of the energy-time function over any interval is obtained by merely counting the number of pulses over the interval. Referring to Fig. 9, an energy-time function $E = F(t)$ is represented, together with its time-axis record, which is shown as a series of pulse marks along the time axis. From the operation of the pulse-generating circuit, it is clear that the instantaneous pulse frequency is inversely proportional to the instantaneous amplitude of E.

Thus, $E = An$, where n = the instantaneous pulse frequency and A is the proportionality constant. If we represent the instantaneous pulse interval by Δt, then we can put n equal to $1/\Delta t$, so that $E = A/\Delta t$ or $A = E\Delta t$. We see that this constant represents the area of the shaded rectangle, and that this area must be the same, regardless of the particular interval for which it is measured, since as Δt decreases E must increase in proportion, and vice-versa.

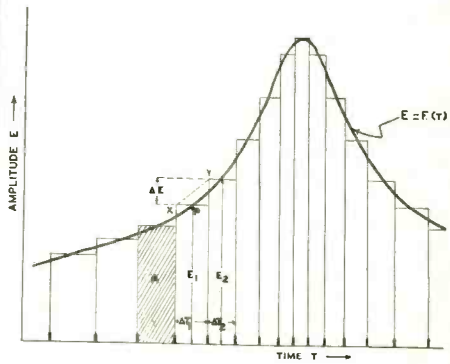


Fig. 9—Illustration of relationship between an amplitude record (heavy curve) and a time-axis record (short black pulse lines along time axis)

Thus, when the circuit is calibrated and the value of A determined, the area under the curve is obtained by the simple process of counting the pulse marks. Each pulse represents an equal increment of area, and may be likened in this case to a "quantum" of the energy signal. In view of the fact that more than half a mile of paper tape is used for each patient in the initial study, this method of obtaining the integral of the signals while at the same time preserving their individual character is of extreme value.

Electronic Method of Obtaining Many Derivatives

It is also evident from Fig. 9 that the derivative of the function at any point P may be likewise obtained from the time-axis record directly. From the figure it is seen that

$$\left(\frac{dE}{dt}\right)_P = \frac{\Delta E}{\Delta t_1} = \frac{A\,(1/\Delta t_1 - 1/\Delta t_2)}{\Delta t_1} = E\left(\frac{1}{\Delta t_1} - \frac{1}{\Delta t_2}\right) \quad (2)$$

(Since $E = A/\Delta t_1$). Actually this quantity is the slope of the line XY).

The expression on the right in Eq. (2) affords a means of obtaining the derivatives of the time-energy function electronically. A relatively sim-

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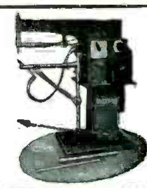

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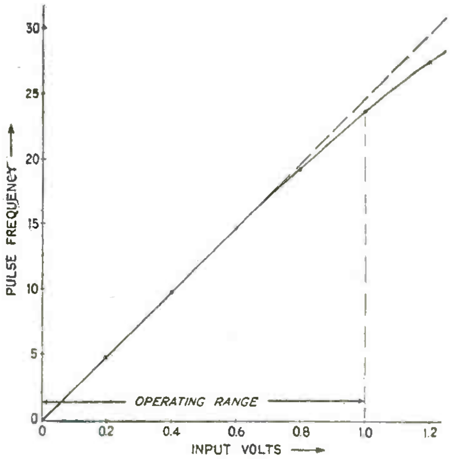
ple circuit, controlled by the successive pulses, can be made to generate a voltage proportional to the derivative. For example, a capacitor which is charged to a fixed voltage initially can be made to discharge through a constant-current tube for a period of time equal to Δt_1. The voltage remaining at the end of the interval is proportional to $1/\Delta t_1$. The second pulse is then made to initiate a similar discharge from a second capacitor throughout the period Δt_2. If the first capacitor can be made to hold the charge remaining at the end of the second pulse until the end of the third pulse, and both capacitors are connected in subtractive series, the overall voltage is proportional to $(1/\Delta t_1 - 1/\Delta t_2)$. The latter is passed through a modulator tube whose gain is controlled by the original signal E, so that its output is proportional to $E(1/\Delta t_1 - 1/\Delta t_2)$.

This procedure may be repeated many times without introducing serious distortion and furthermore, it is not subject to the attenuation and interference difficulties of the circuit of Fig. 4. An instrument embodying this principle is at present being designed in conjunction with means for automatically totaling and averaging the plurality of time-axis records.

Auxiliary equipment necessary for the calibration and monitoring of the various channels had to be constructed especially for this apparatus. A mechanical sine wave generator ranging from 10 cps down to 0.05 cps provides a signal generator for testing purposes. Frequency control is obtained by means of continuously variable ratio drive. A low-frequency oscilloscope having a long-persistence screen was constructed for visual monitoring and used with a Du Mont model 215 linear time base generator. Many other smaller pieces of equipment were designed and constructed for the use of this study. These include scaling circuits, erating disagreeable sounds, as well as electro-mechanical devices for the purpose of applying stress to the patient.



Calibration curve of a typical counting circuit (solid line), indicating a useful operating range up to approximately 1 volt

Analysis of the Records

Since the fundamental orientation of the problem is to seek characteristic differences between normal and abnormal records of the energy-time functions which represent the activity of certain psycho-physiological indicators, it is apparent that an accurate waveform analysis of these functions is a prime requisite. Practical considerations for clinical application require the pertinent analyses to be performed automatically and instantaneously—in other words, electronically. The difficulty involved in obtaining by electronic means Fourier transforms of signals at these frequencies need hardly be described. It is partially for this reason that the successive derivatives are recorded. The higher order derivatives tend to magnify small differences in the fine structure of the waveform that would otherwise be masked, and it may well be that the

(Continued on page 352)

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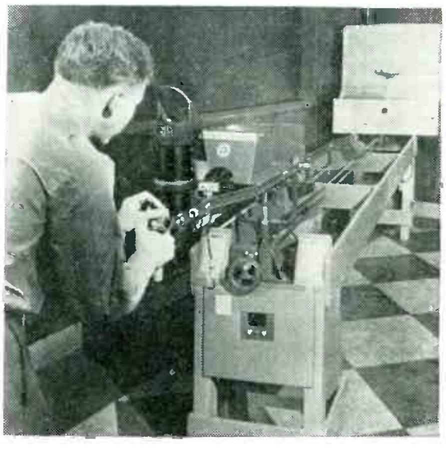

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desired answer may be obtained from an array of derivatives.

There still exists the possibility that a Fourier analysis may be applied to this problem. The type of input functions which are recorded together with their time derivatives are at best quasi-periodic, with no two subsequent cycles superimposable. However, on the basis of the fact that there exists a fundamental similarity in the activity of a given indicator organ at all successive times, we may attempt to obtain the harmonic amplitudes of each succeeding cycle of activity considered by itself and then to apply statistical procedures to obtain a representative or average cycle in terms of which the activity may be represented as a completely periodic function. This seems to be the only basis upon which such an analysis would have meaning, and it seems equally logical that a Fourier analysis of the equivalent periodic function will be a powerful method of rooting out the characteristic differences.

The recorded data give us an evaluation of the function and its successive derivatives at any point. We may use these values as the basis of analytically computing the amplitudes of successive harmonics, thus

$$\overline{V}_n = A_n + jB_n = \frac{2j}{\pi}\int_0^T F(t)\epsilon^{-jn\omega t}\,dt$$

where $\overline{V}_n$ represents the harmonic vector amplitudes and T is the time interval equal to a single period.

The function $F(t)$ may be developed in a Maclaurin's series:

$$F(t) = C_0 + C_1t + C_2t^2 + \ldots + C_nt^n$$

where the C's are given by

$$C_n = \frac{1}{n!}\frac{d^n[F(0)]}{dt^n}$$

and whose values are obtained numerically from the records at the beginning of the cycle. Substituting in the above integral, we get

$$\overline{V}_n = \frac{2j}{\pi}\int_0^T (C_0 + C_1t + C_2t^2 + \ldots)\epsilon^{-jn\omega t}\,dt$$

If the function can be represented by the power series in the interval of convergence of its corresponding Fourier development, by the use of a reasonably small number of significant coefficients, then the V_n's can be obtained through this relationship. When the integrations are performed, the successive amplitudes are obtained as convergent series involving the numerically known derivative coefficients. The whole operation could conceivably be performed electronically without undue difficulty according to methods already developed.

Conclusion

In view of the magnitude of the task described above, the apparatus has assumed somewhat gargantuan proportions. When and if a satisfactory diagnostic method has been evolved, the process of simplification will begin. Owing to the difficulty of anticipating the crucial factors and the pressure under which this research is being done, the massive approach to the problem was judged most likely to yield significant results in the shortest time. The final justification of the effort involved must await the compilation of case records at present being taken. In the meantime it is hoped that this description will serve as a stimulus for the application of newer and more powerful electronic methods in the problems of medical research.[6]

ACKNOWLEDGEMENTS

The authors are indebted to Mr. Harry Sands and Mr. Harold Fagin, research psychophysiologists on the Head Injury Project for many helpful discussions and guiding criticisms throughout the development of this apparatus.

The authors also wish to acknowledge the valuable advice and suggestions of Professors John B. Russell of Columbia University and Thomas A. Jenkins of New York University. In addition, acknowledgment is given to the valuable work of the following members of the technical staff: Jan Seidner, at present with Sylvania Electric Products Corp.; Kenneth F. Channon, Jr., John B. Marsey, Alan Smolen, Russell Young, Jay McElwain, Edward S. Wozniak and Seymour Farkas, all at present of the U. S. Army Signal Corps; Marcel Thienpont of the U. S. Navy; Harry Sonnemann, Harry Robin and Edward Koury, at present students at R.C.A. Institute. The actual construction and much of the testing and development of the apparatus was done by the above in their spare time while in training at R.C.A. Institute, and the completion of the apparatus in such a short time is in large part due to their efforts. Finally, the authors express gratitude to Mr. Frank Rieber of the Rieber Research Labs., New York City for his gift of the low-frequency generator.

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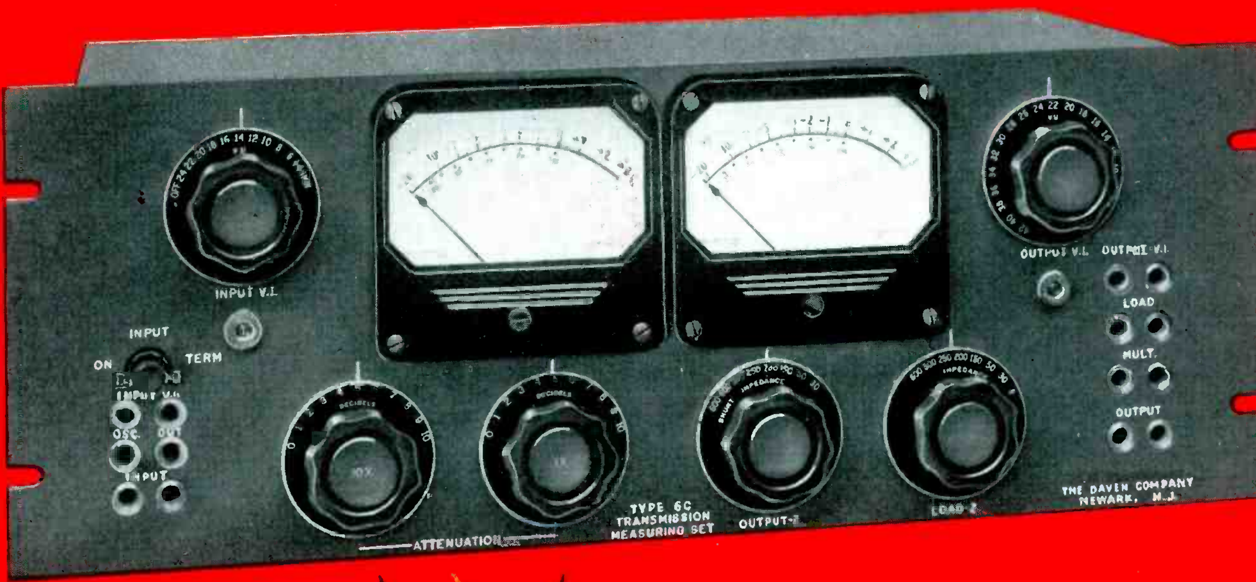
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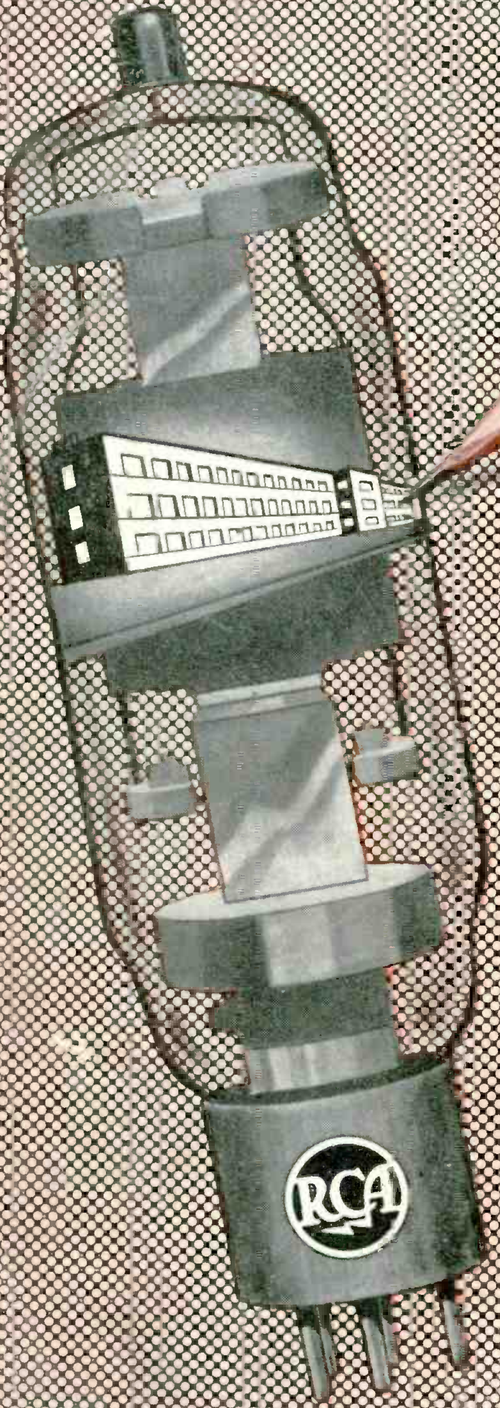

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