JANUARY • 1944

electronics

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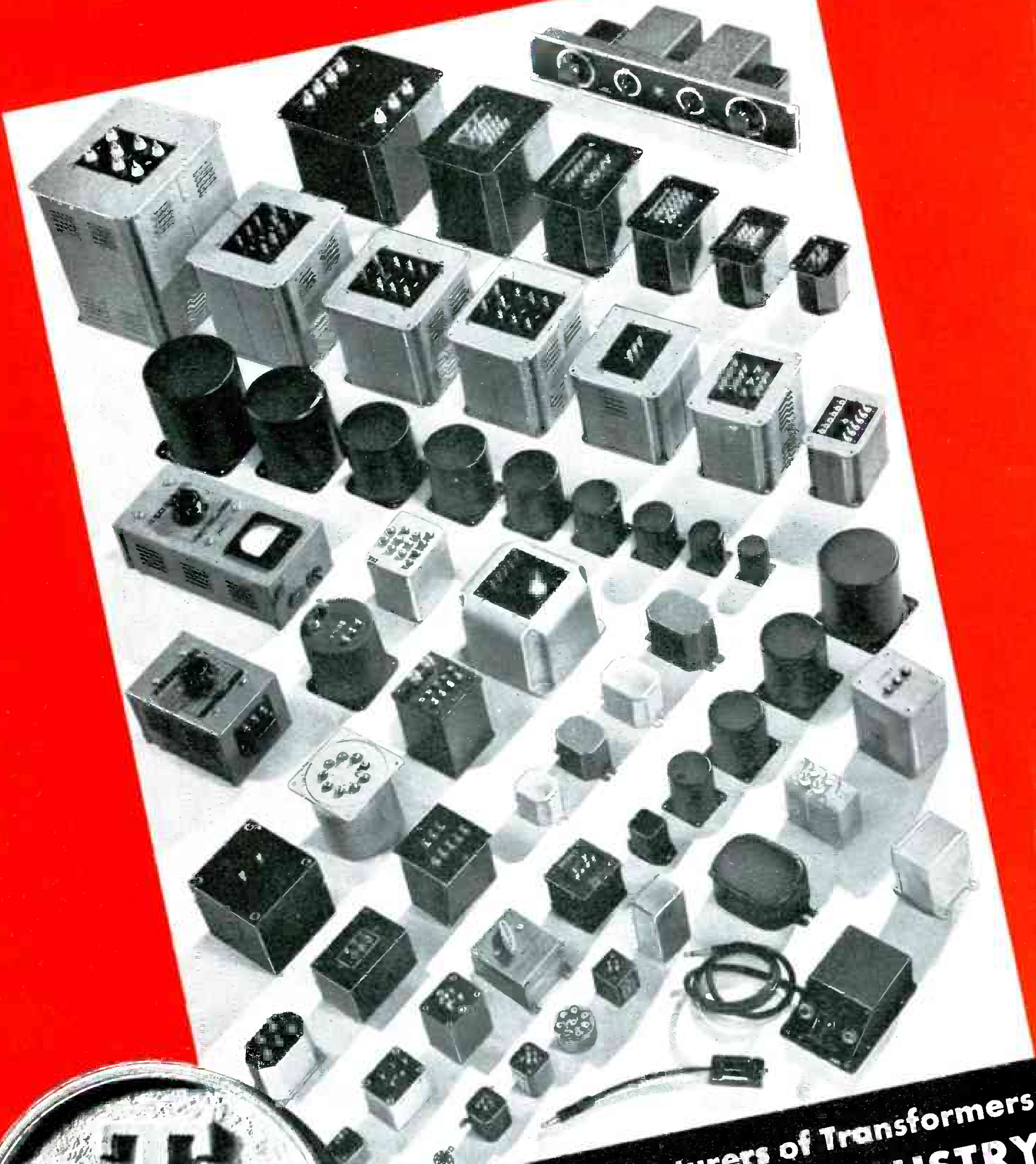

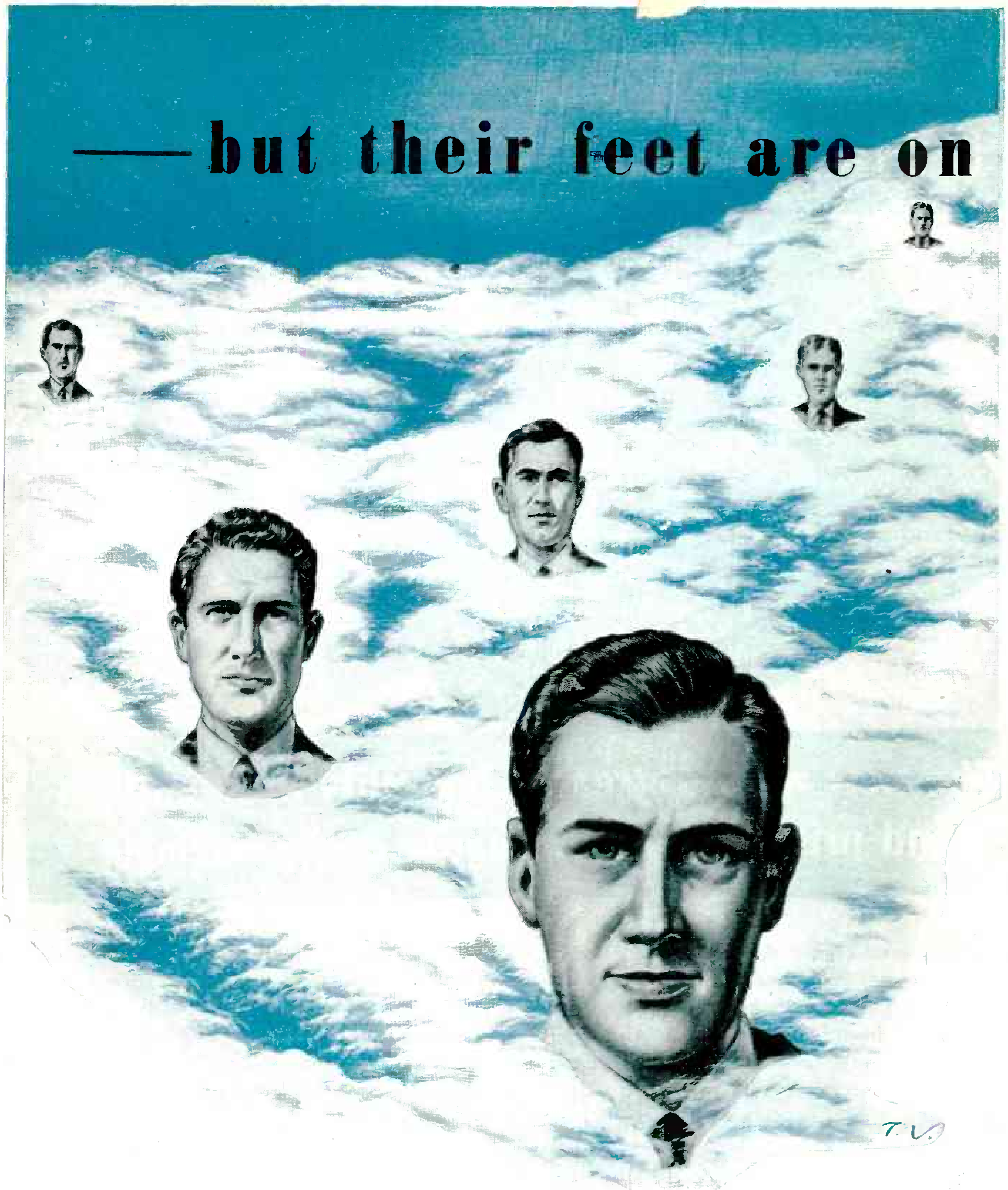
—but their feet are on

electronics

JANUARY • 1944

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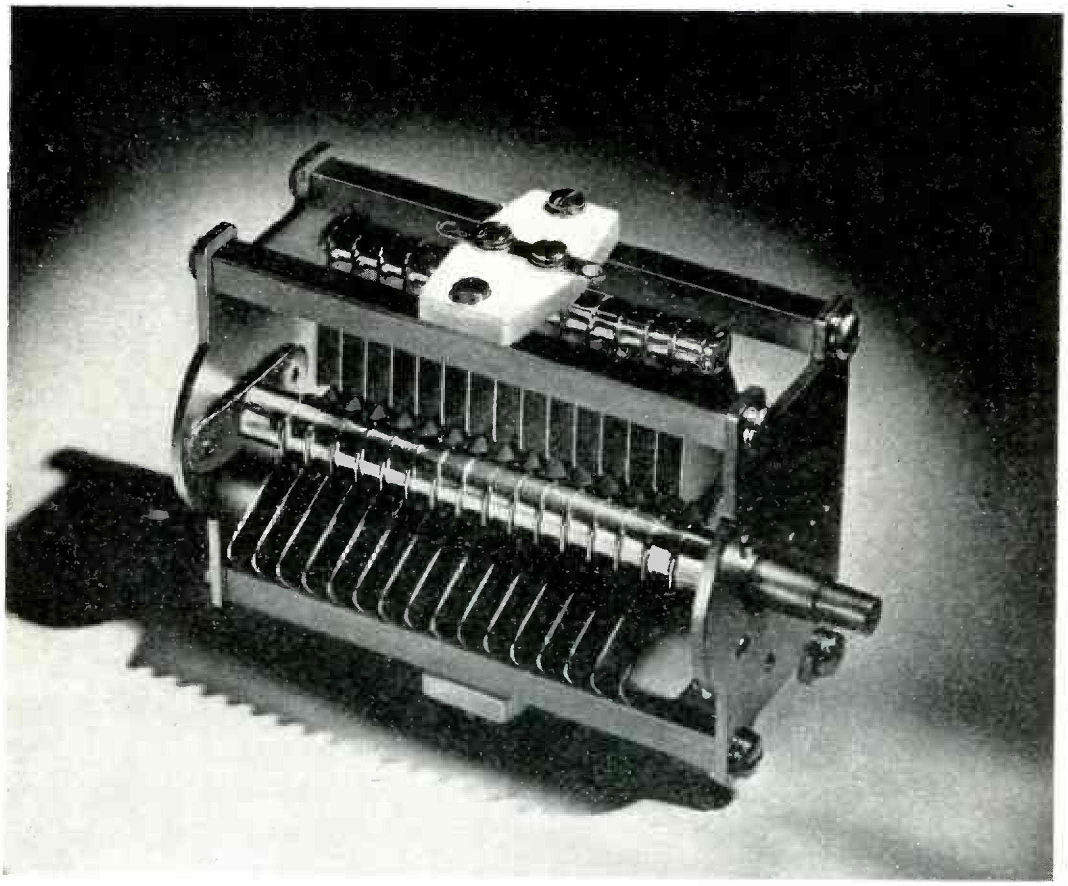

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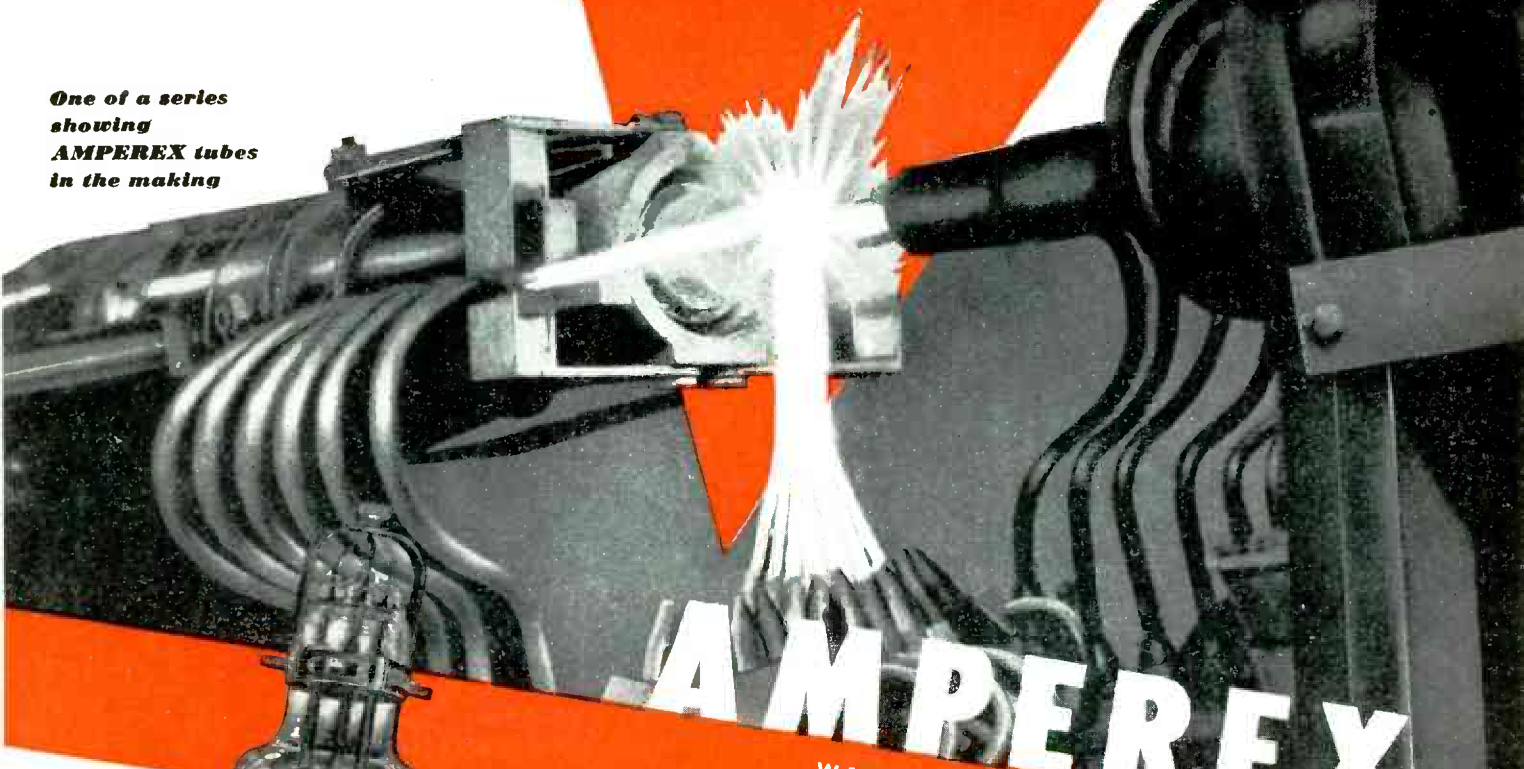

AMPEREX

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TRANSMITTING AND RECTIFYING TUBES

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

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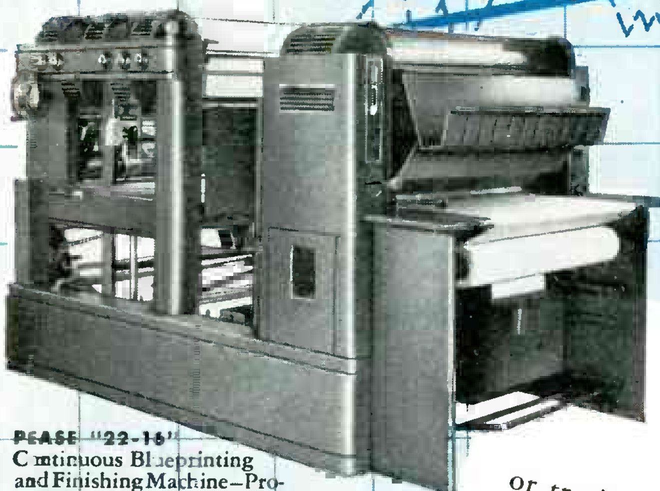

PEASE "22-16"
Continuous Blueprinting and Finishing Machine—Production Speed, 20 feet per minute. (Model "22," not shown, has a Production Speed of 30 feet per minute.)

EXCLUSIVE PEASE FEATURES

- **Sliding "Vacuum-like" Contact** smooths out tracings, prevents errors in printing.
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Pease Continuous Blueprinting Machines are simple in operation and combine printing and finishing in one complete continuous operation. They smooth out "production kinks" with their own actual production speed of 30 feet per minute in the case of Pease "22" (not shown) and 20 feet per minute with Pease "22-16."

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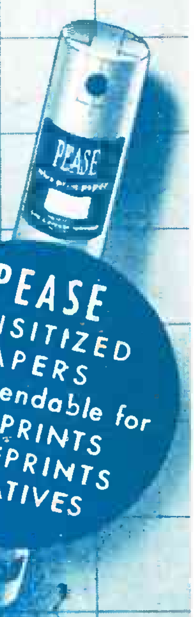

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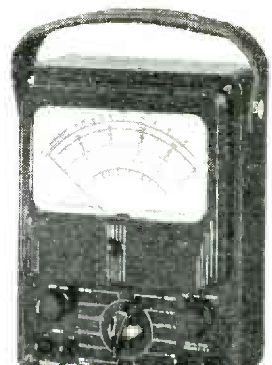
Pease Blueprinting Machines A TYPE AND SIZE FOR EVERY REQUIREMENT INCLUDING DIRECT PROCESS PRINTING AND DEVELOPING MACHINES

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.



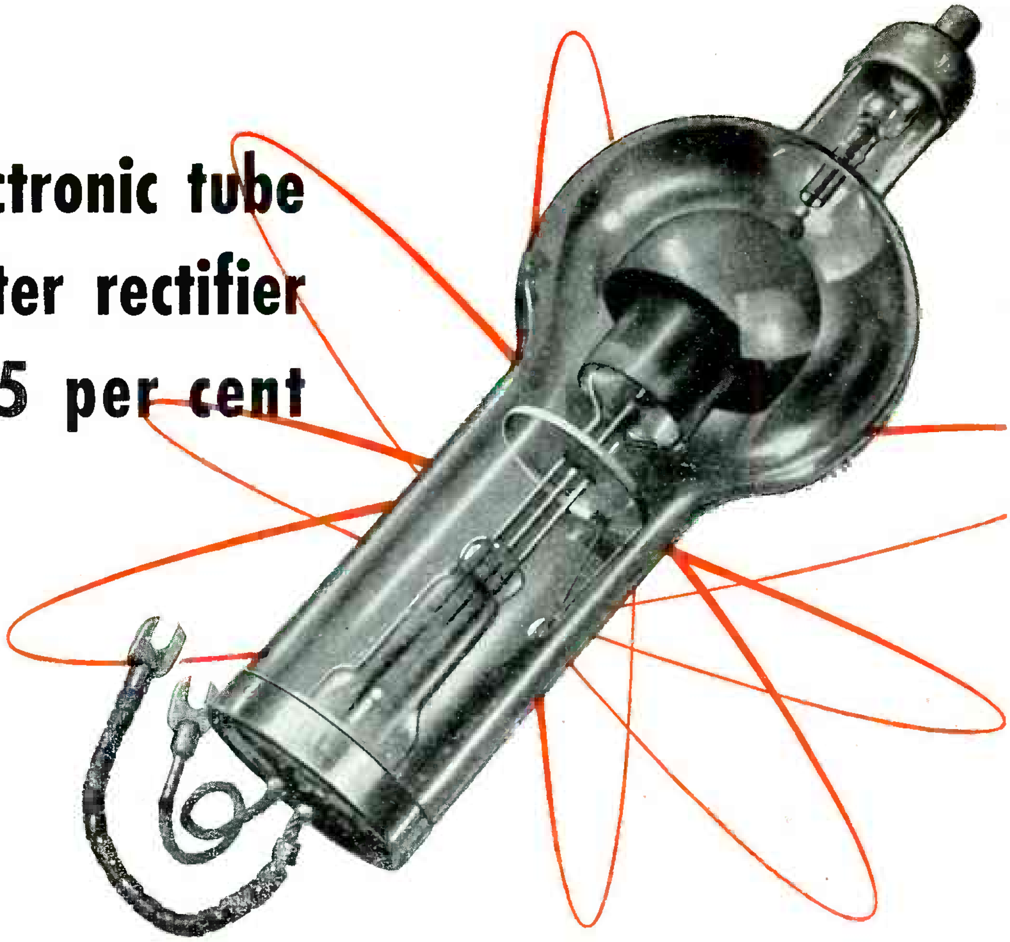
SIMPSON ELECTRIC COMPANY
5200-5218 W. Kinzie St., Chicago 44, Illinois

Simpson

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.*

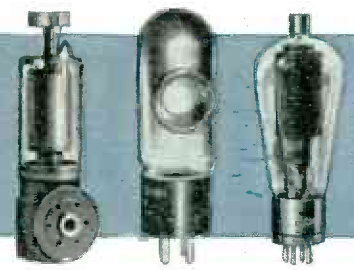
BACK THE ATTACK — BUY WAR BONDS!

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

GENERAL ELECTRIC FM · TELEVISION · AM

160-C2

See G.E. for all three!



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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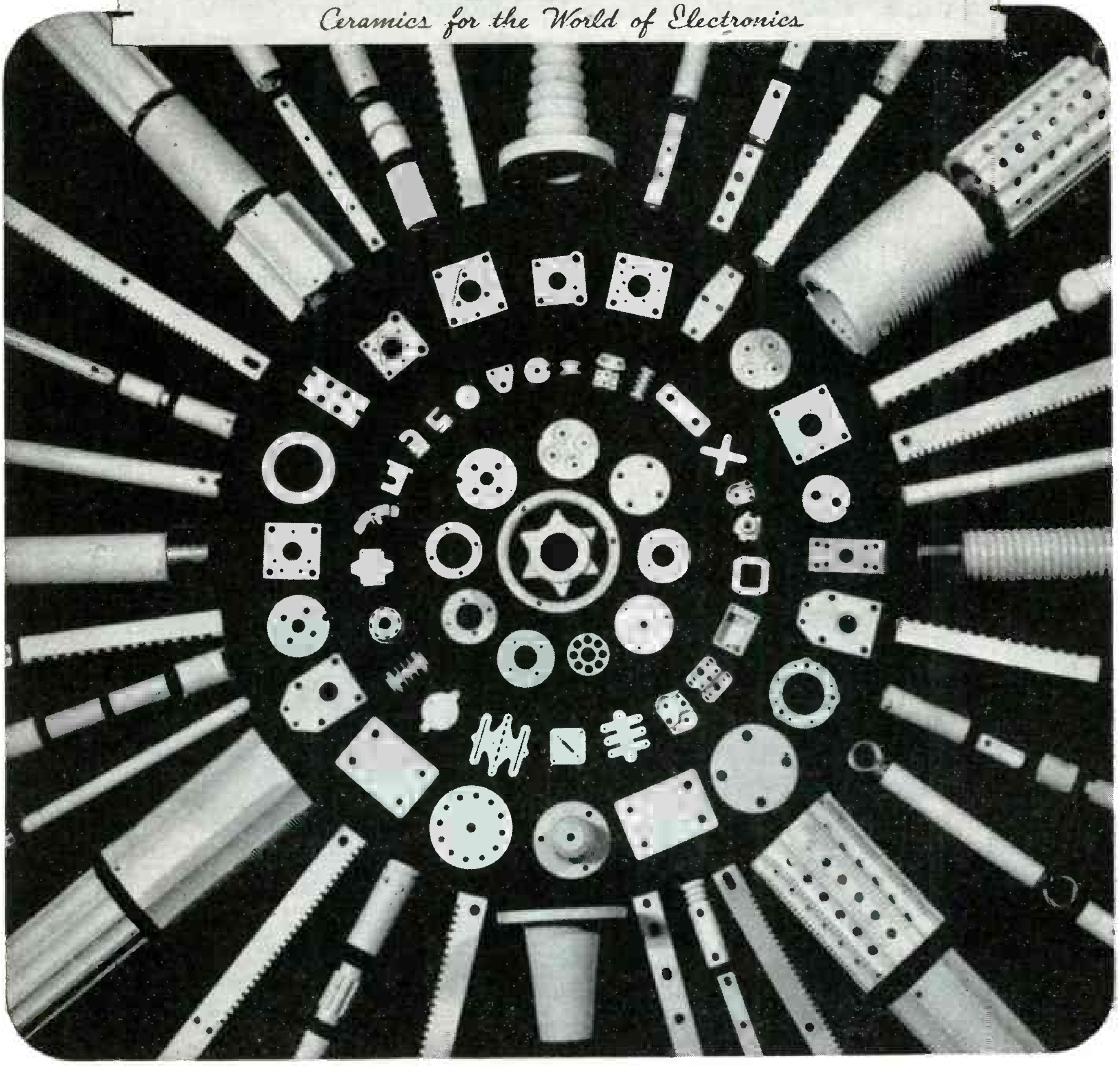
STUPAKOFF

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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ARMY E NAVY "for great achievement"

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Buy War Bonds

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"UNITED" electronic power tubes cannot be spun out on swift, automatic assembly lines. The painstaking manufacturing of these sensitive devices requires the skill of human hands.

Here at the "United" Plant, incredibly accurate hands perform under a system of personal supervision by electronic engineers. One by one, the steps of forming and fitting the stems, leads, plates, grids, wires and rods combine to produce transmitting tubes of such flawless precision that they consistently win top rating for performance. Never before were the hands of craftsmen and the brains of scientists so superbly "United" in advancing the scope and purpose of electronics.

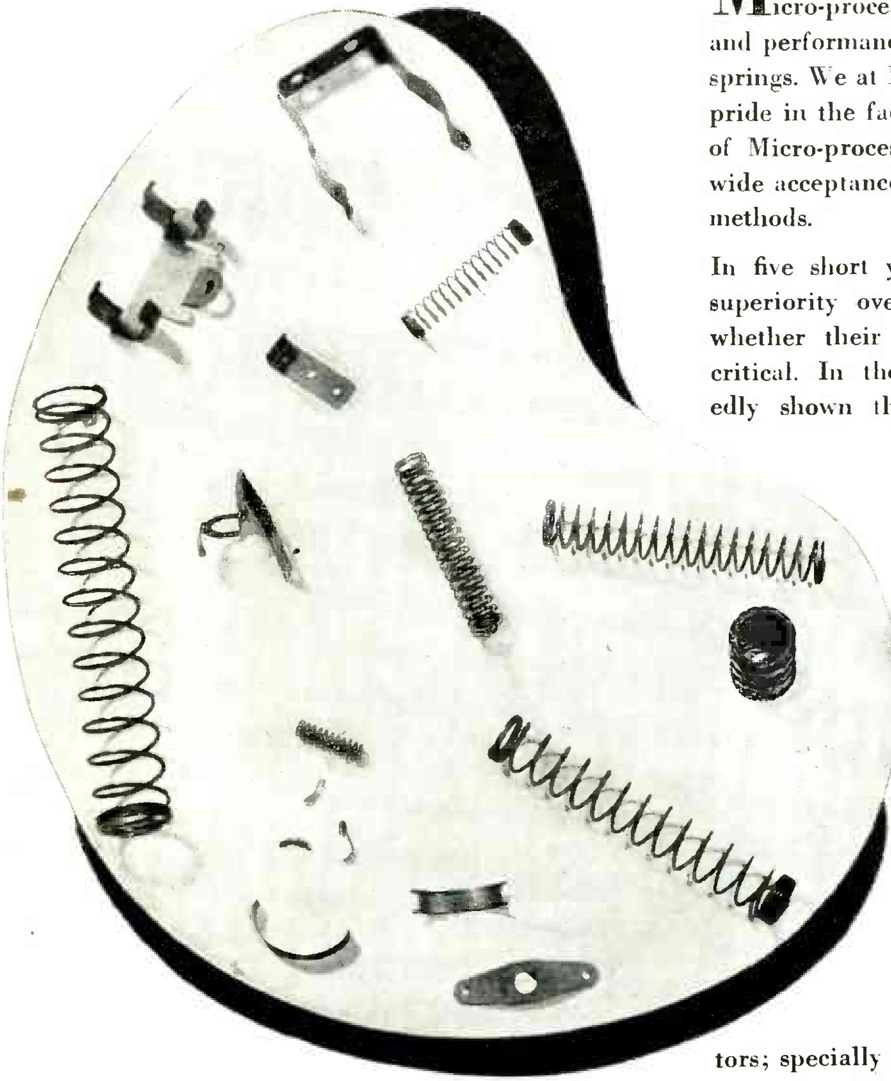
Consistent technical advances in tubes, now required for war, some day will be more readily available to you for radio communication, physiotherapy and industrial electronics. Remember to look for "United" on the tubes.

UNITED ELECTRONICS COMPANY

NEWARK, NEW JERSEY

"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 nationwide 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.

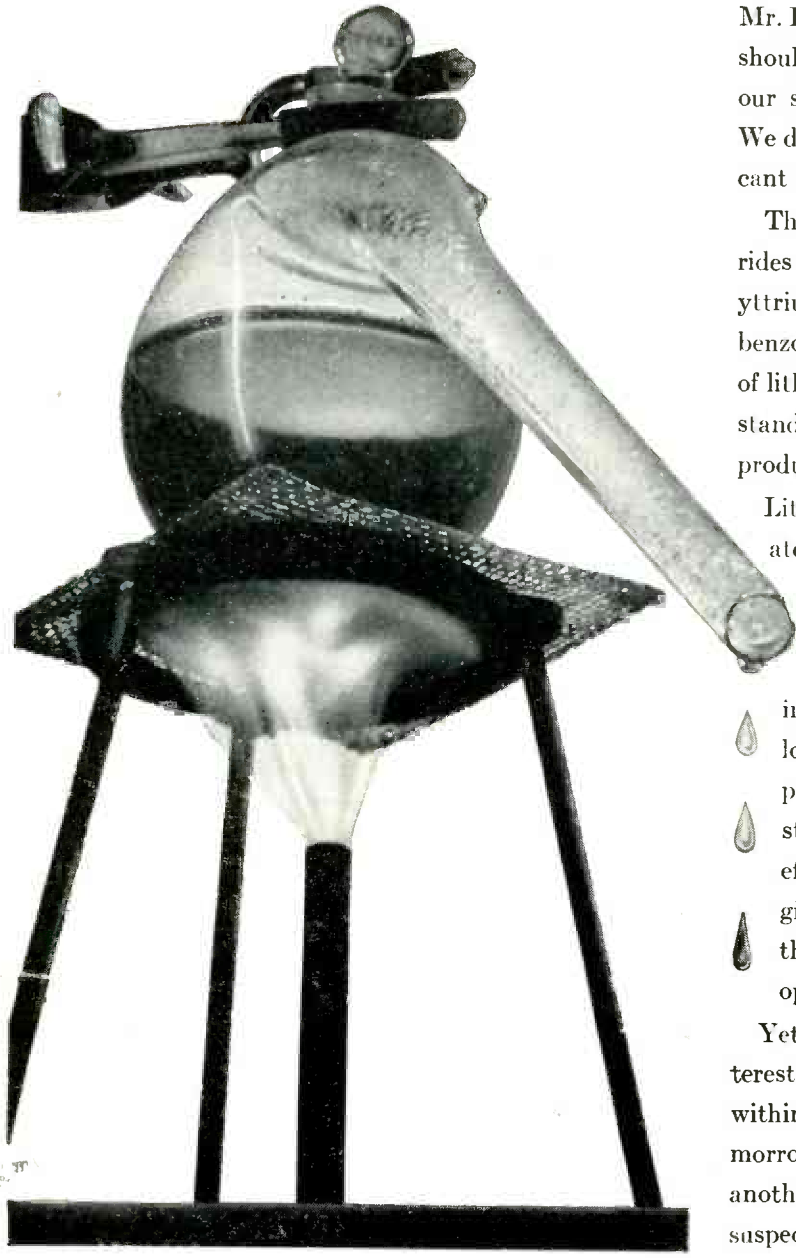
By re-defining the possibilities of spring performance we have opened new avenues for the use of beryllium copper springs — *Micro-processing, more than ever before, is a servant to the nation's industry.*

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

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West Coast Representative: GRIFFIN CHEMICAL CO., San Francisco, California

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.

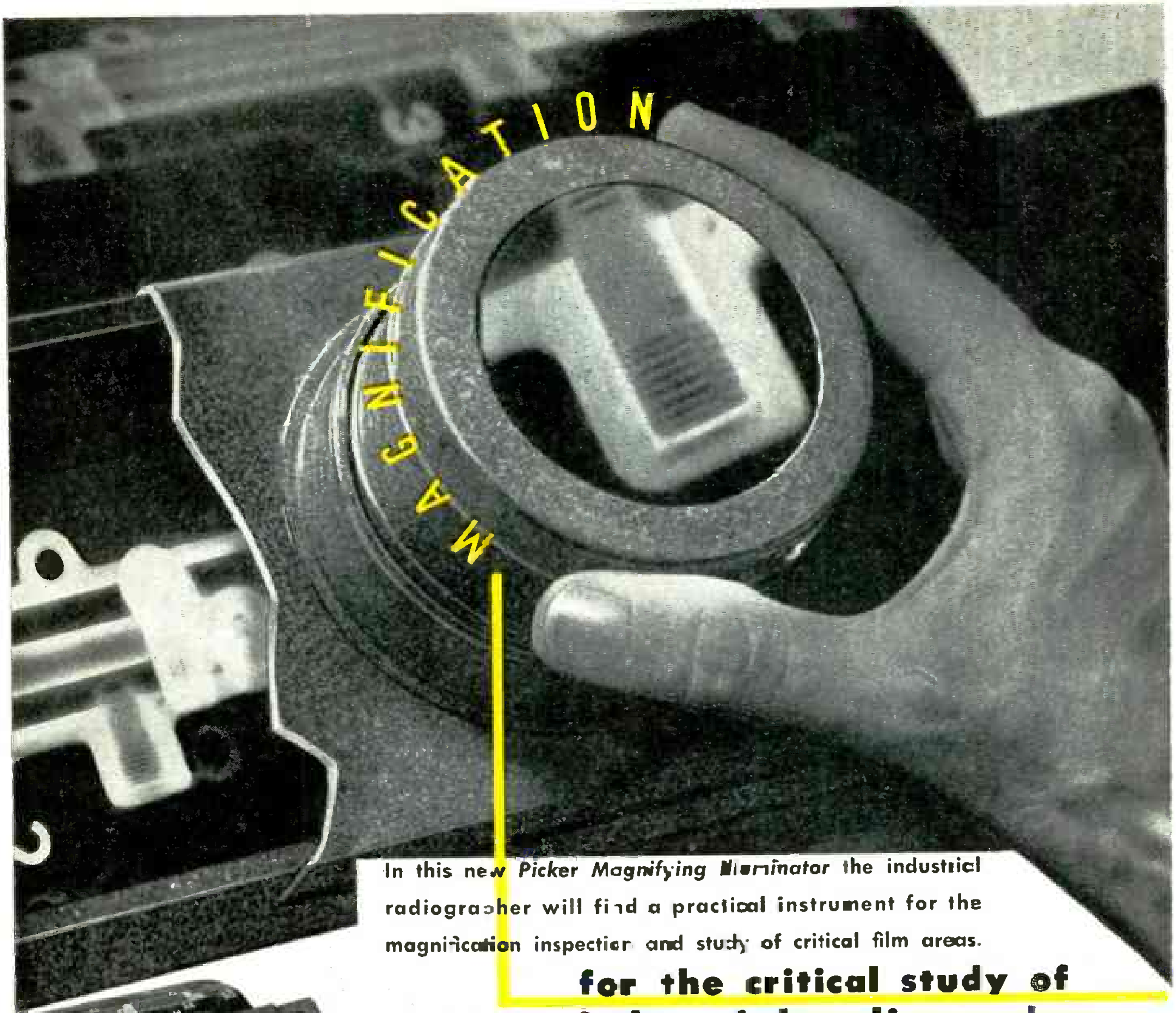
And now, as a further service, DuMont engineers have compiled a manual of pertinent data, together with detailed descriptions of DuMont tubes and associated equipment. This data is in loose-leaf form. The binder permits constant revision to keep pace with the fast-moving cathode-ray technique. Each manual 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.

PICKER MAGNIFYING ILLUMINATOR

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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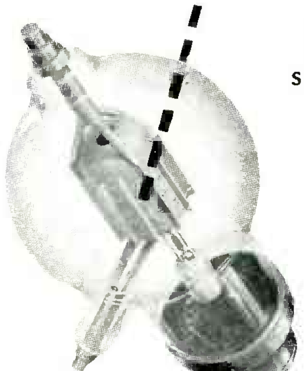
TANTALUM
(ATOMIC WEIGHT: 180.88)
IN MINERAL AND POWDERED FORM

Tantalum is one of the earth's rare and unique metals. Rare because it is mined in only a few spots in the world. Unique because it is the only metal that readily absorbs gases.

This ability of tantalum to soak up and retain gases—even while being subjected to intense heat—makes tantalum priceless in the manufacture of electron tubes.

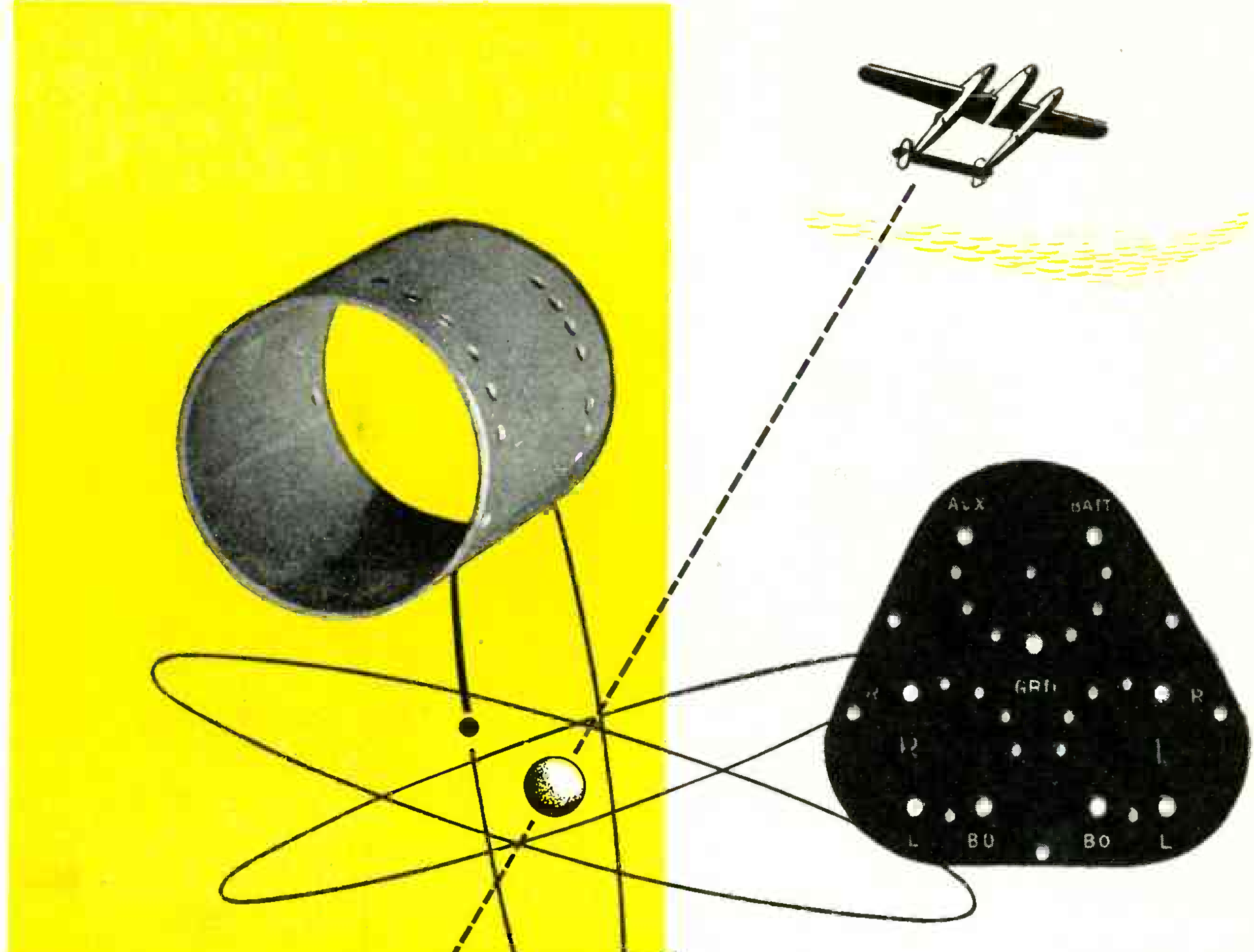
Up until the time Heintz and Kaufman engineers built the first vacuum tubes with tantalum plates and grids, the electronics industry had to rely on chemical "getters" to absorb gases. These chemicals are not stable—the heat from an overloaded plate causes them to release gas suddenly, and the tube goes dead.

One of the reasons you will find so many Gammatrons in use where dependability is essential, is that all Gammatrons have tantalum plates and grids. They can and do take heavy overloads safely—punishment which would cause any other type of tube to cease functioning.



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

Gammatron Tubes



Formica MF—Glass Mat Base—Is a High Frequency Insulating Material That Can Replace Ceramics for Many Uses!

One of the recent developments of accelerated research in the Formica laboratories—Grade MF—has qualities of the greatest usefulness to the electronic designer.

As an insulating material it permits only minimum losses at high frequencies.

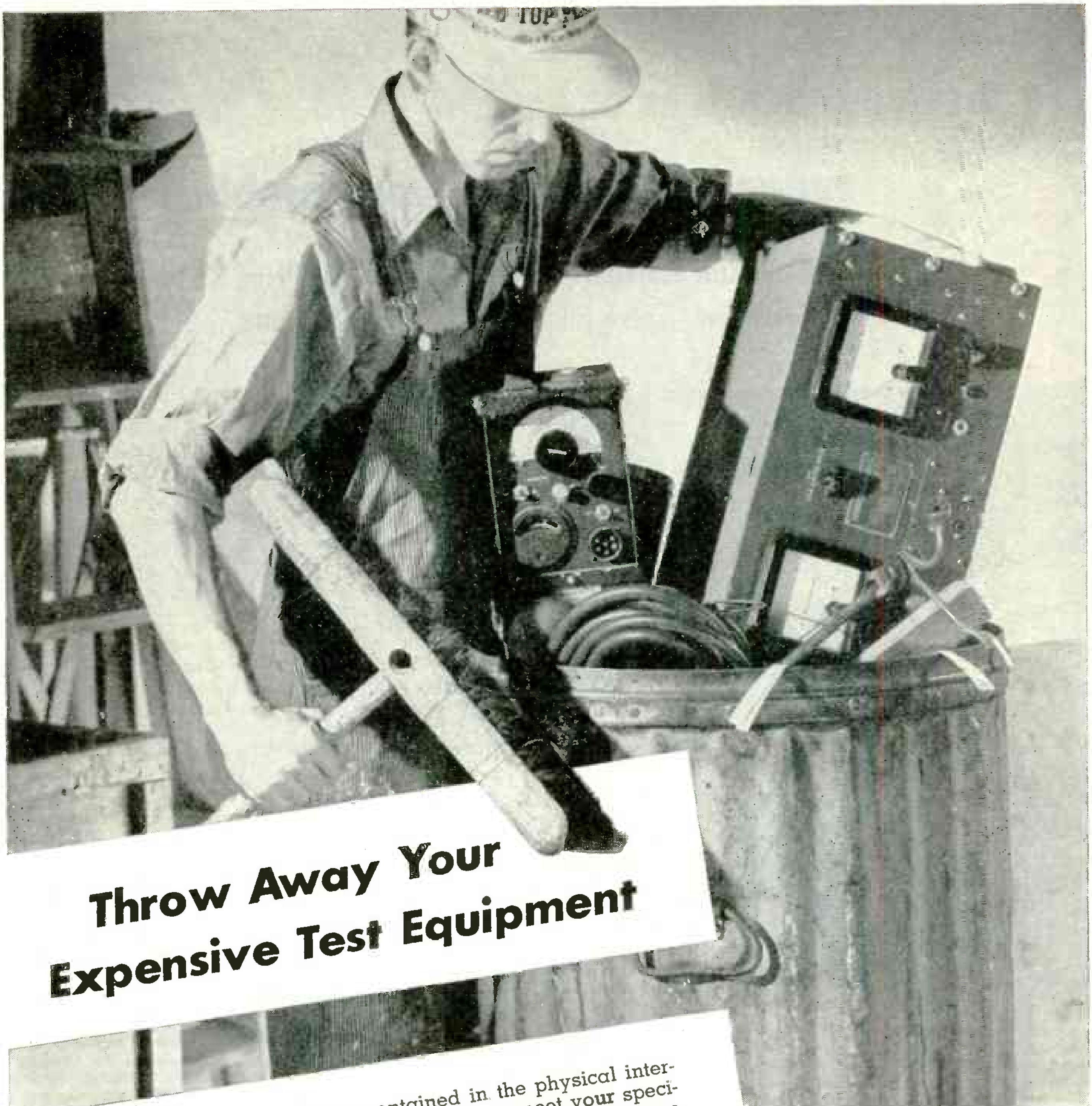
It has mechanical strength to stand extreme conditions of vibration and stress in antenna insulators, coil forms, tube bases.

Its efficiency is little affected by moisture absorption. Cold flow is less than for the best previous grades of laminated plastics. It is readily machined, and therefore handled at low costs in production.

"The Formica Story" is a sound-moving picture showing the qualities of Formica, how it is made, how it is used. It is available for meetings.

THE FORMICA INSULATION COMPANY

4661 SPRING GROVE AVE., CINCINNATI 32, OHIO



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.

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

RAYTHEON

RAYTHEON MANUFACTURING COMPANY
Waltham and Newton, Massachusetts

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

Do these applications of "Vinylite" Plastics 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.

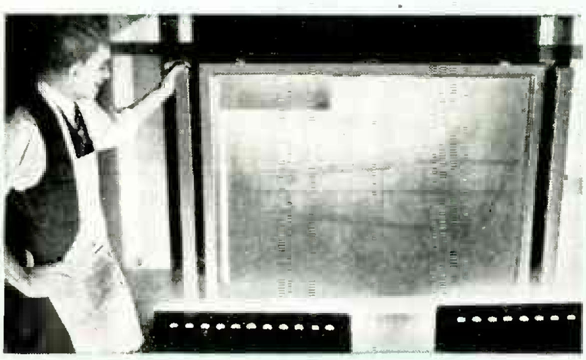
Then, too, VINYLITE Plastics are strong, lightweight, dimensionally stable, non-flammable, resistant to water, oils, and chemicals.

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."

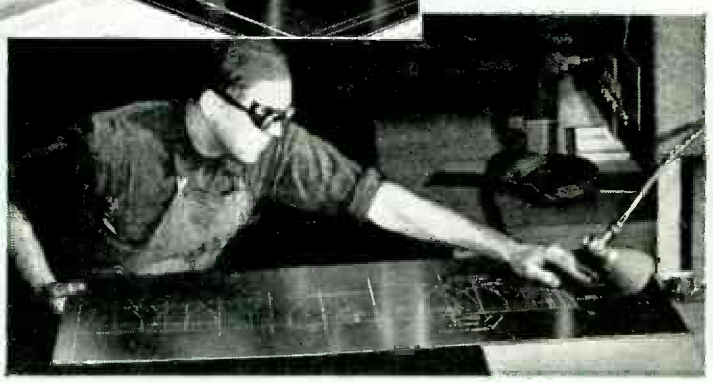
Plastics Division
CARBIDE AND CARBON CHEMICALS CORPORATION
Unit of Union Carbide and Carbon Corporation
UCC
30 EAST 42ND STREET, NEW YORK 17, N. Y.

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.

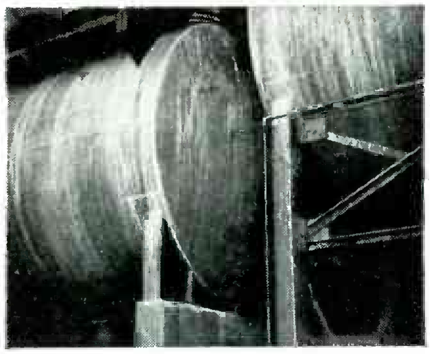


After checking the steel plate against the original drawing, it is cut to shape. The entire process, from drawing to templet is completed in only one hour.

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.

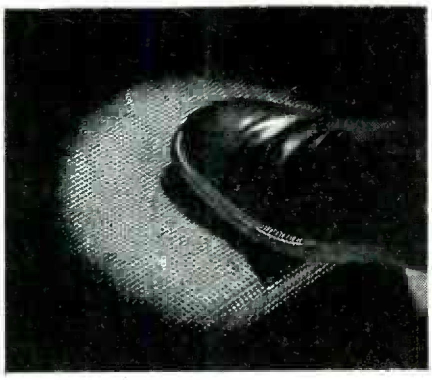
A manufacturer of machine roll coverings experimented with an extruded tube of VINYLITE Elastic Plastic applied over the metal core. But, with vulcanizing impossible, how could this new material be successfully bonded? The answer came in the form of an adhesive made with VINYLITE Resins. And because 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 swaging, 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

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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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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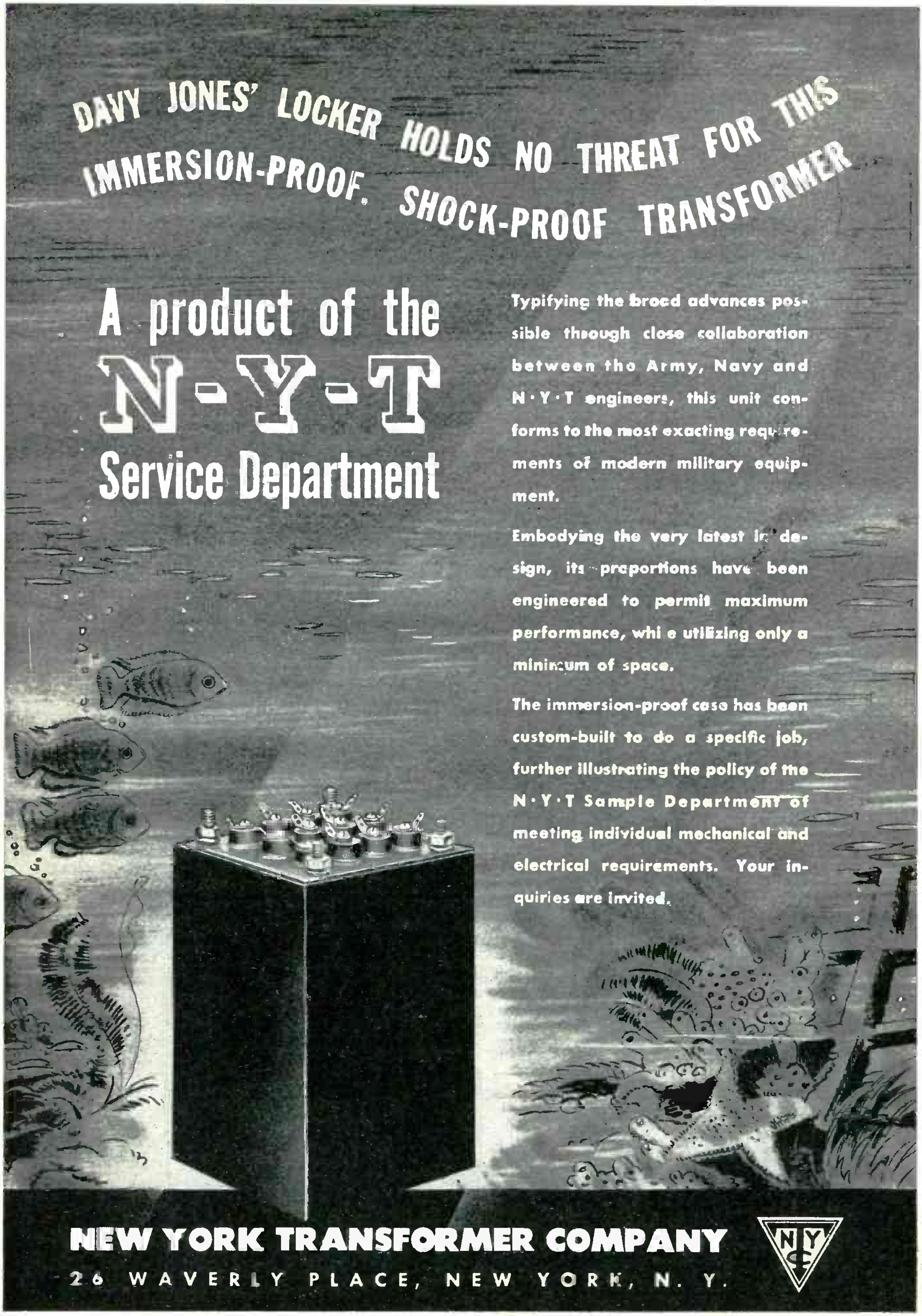

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A product of the
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Service Department
Typifying the broad advances possible through close collaboration between the Army, Navy and N·Y·T engineers, this unit conforms to the most exacting requirements 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.
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DR 24 G

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

DR 872 A

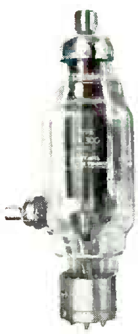
Medium power Rectifier. 10,000 volt inverse peak. Extensively used for power supplies from 1,000 to 5,000 volt output. Current output . . . 2 tubes . . . 2½ amperes.

DR 873

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

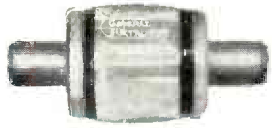
DR 17

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

Specialists in
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FOR ELECTRONIC APPLICATIONS

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 pre-udices, 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.

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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.

CORNING
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Research in Glass

Electronic Glassware

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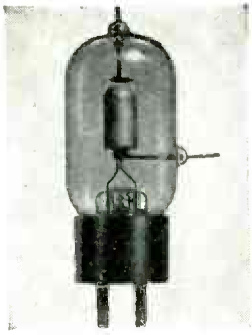
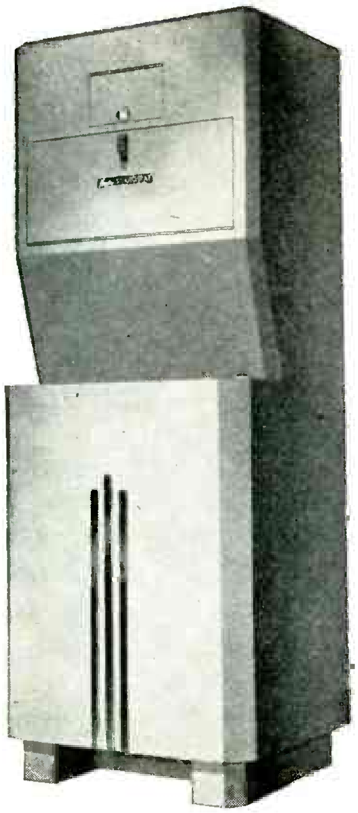
Norelco Searchray
Saves Manufacturing Trouble



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.

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

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KEEP BUYING MORE WAR BONDS

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

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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

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. . . 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.

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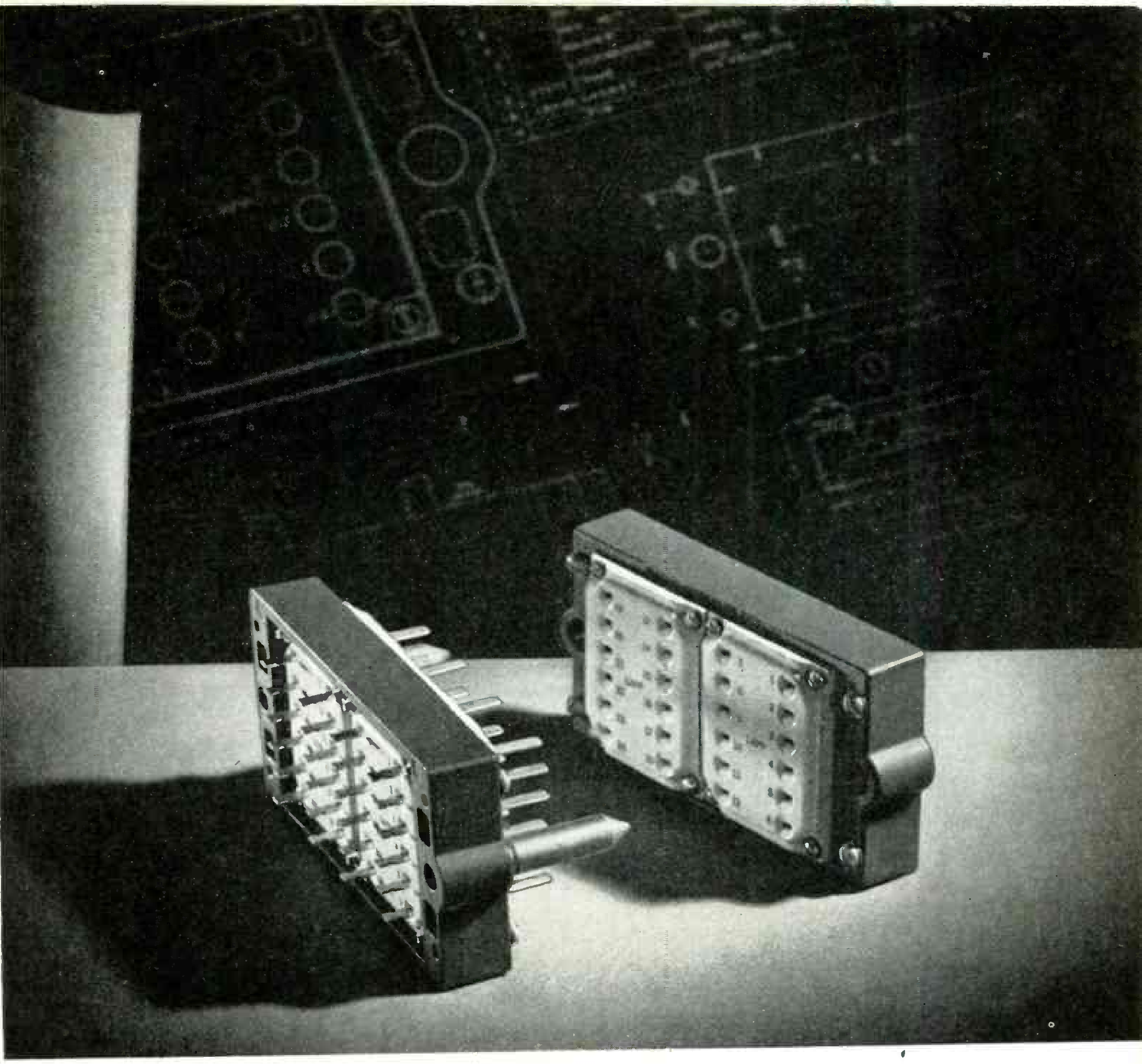
Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters...Aircraft Instruments... Electric Tachometers...Dial Thermometers.

FOR OVER 55 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS



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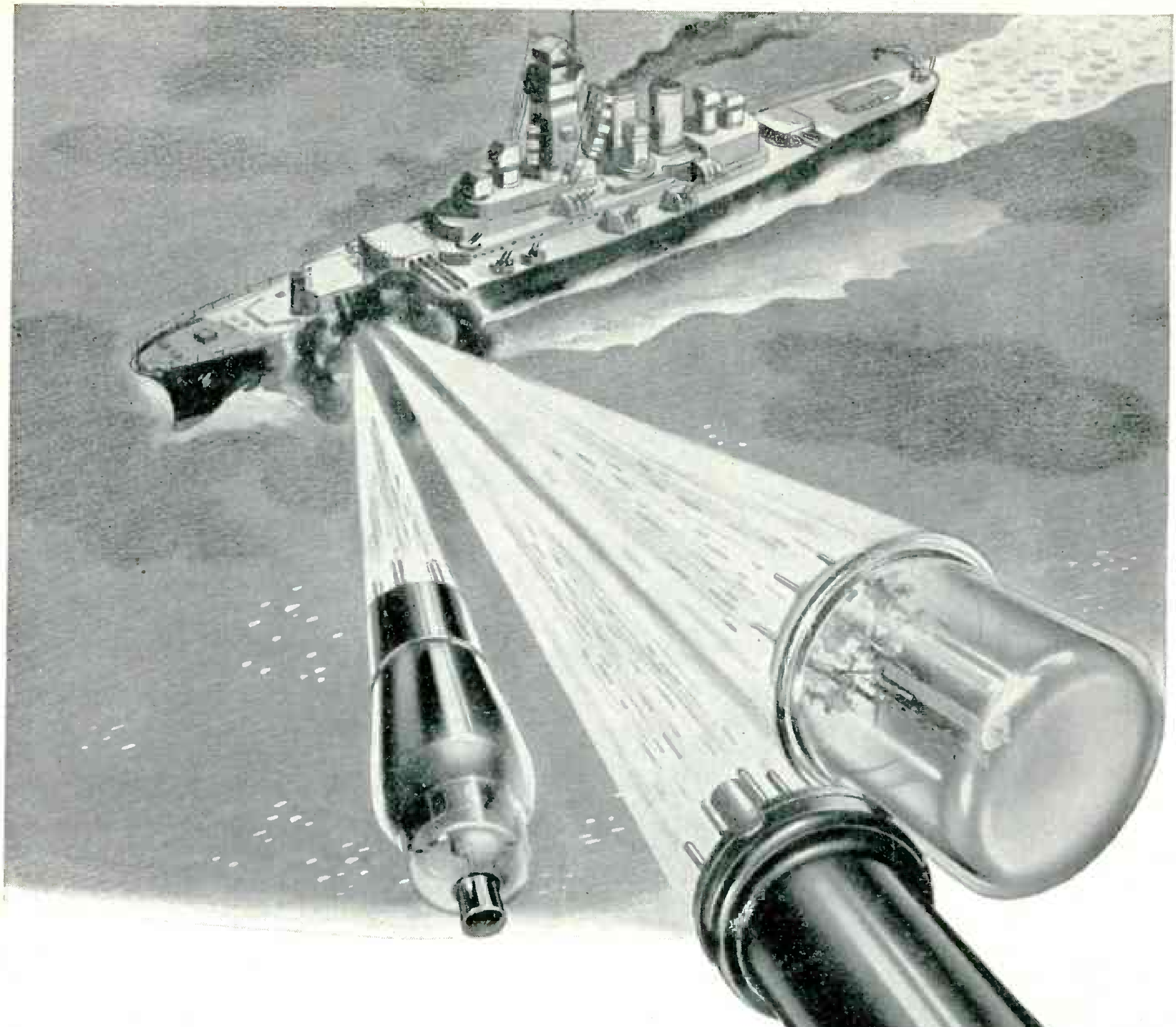
This is a special-purpose electronic part. It is a plug-receptacle assembly for use with rack-panel type of mounting. Twenty-four silver-plated phospher-bronze contacts are provided, each male and female contact full floating between steatite plates. Heavy guide pins and matching holes in the frame assure perfect alignment.

We don't know that your product has any need for such a part as this. We do know, however, that this part is most exactly suited to its special requirement, just as are hundreds upon hundreds of other parts which have been created through Lapp engineering and Lapp production facilities directed to the solution of specific problems.

With a broad basic knowledge of ceramics—their capabilities and their limitations—Lapp has been able to simplify and to improve many types of electronic equipment through engineering and production of sub-assemblies that make most efficient use of porcelain or steatite and associated metal parts.

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

Lapp



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.

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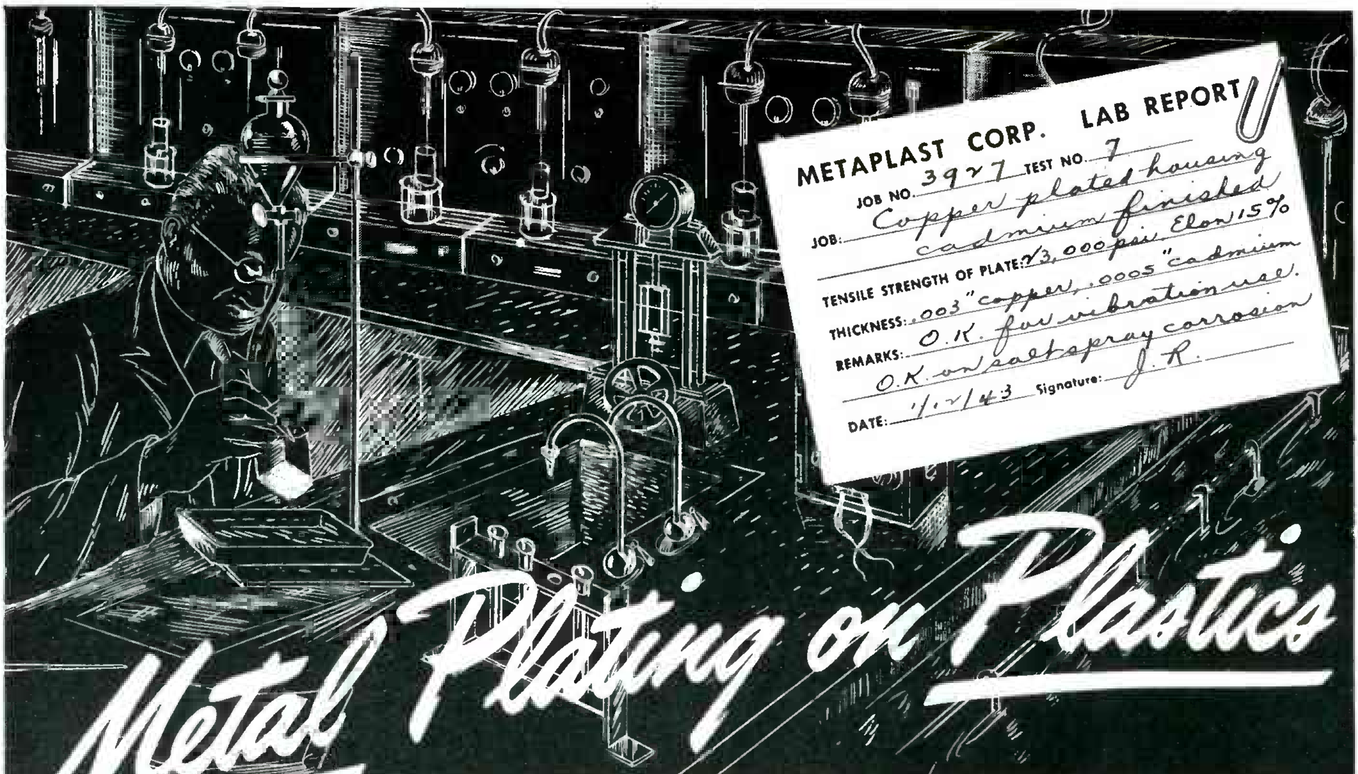

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. . . Thousands of Plastic Housings plated with copper and cadmium for our Bombers.

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.

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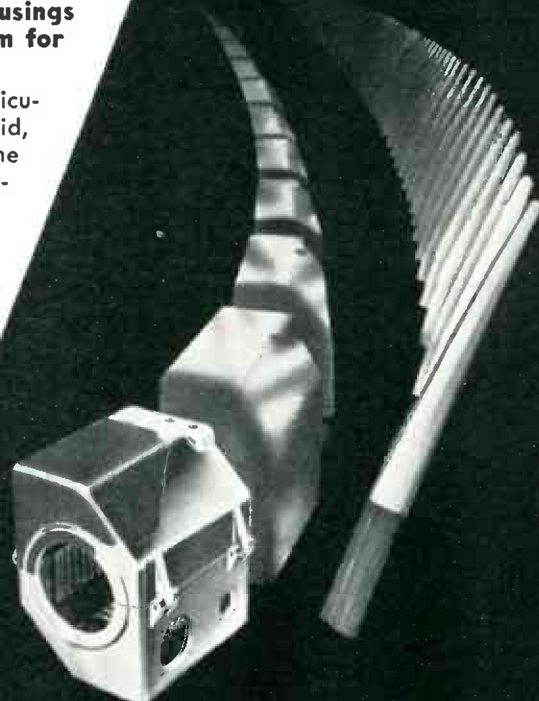

Metaplast

Metal Plating on Plastics

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

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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 pertormance.

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.

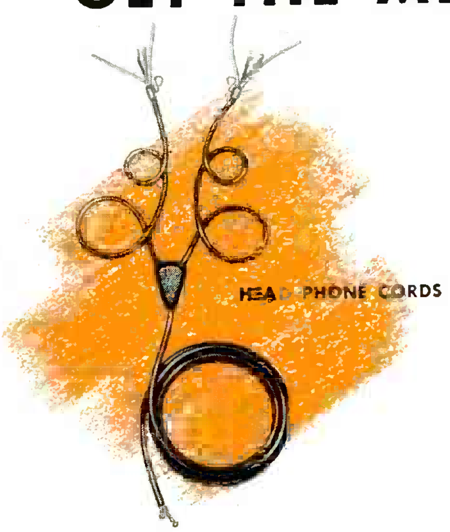
AEROVOX *Capacitors*

INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. • SALES OFFICES IN ALL PRINCIPAL CITIES

Export: 100 VARICK ST., N. Y. C. • Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.

"GET THE MESSAGE THROUGH"



—Another War Service of Belden Electrical Cords

This is an electrical war—planes, tanks, ships, submarines—all are electrical-mechanical devices. Hence, practically all the country's electrical wire capacity has been mobilized.

Belden Corditis-free Electrical Cords have gone to war. They are used on head phone sets for important communications equipment —to "Get the Message Through." This is but one of the hundreds of instances where Belden Cords are insuring long, dependable service on war equipment.

Dependable cords will enable the war equipment you build to deliver 100% service. Investigate Belden Electrical Cords today.

Belden Manufacturing Co., 4625 W. Van Buren St., Chicago, Ill.

Belden WIRE

CORDITIS-FREE ELECTRICAL CORDS

"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

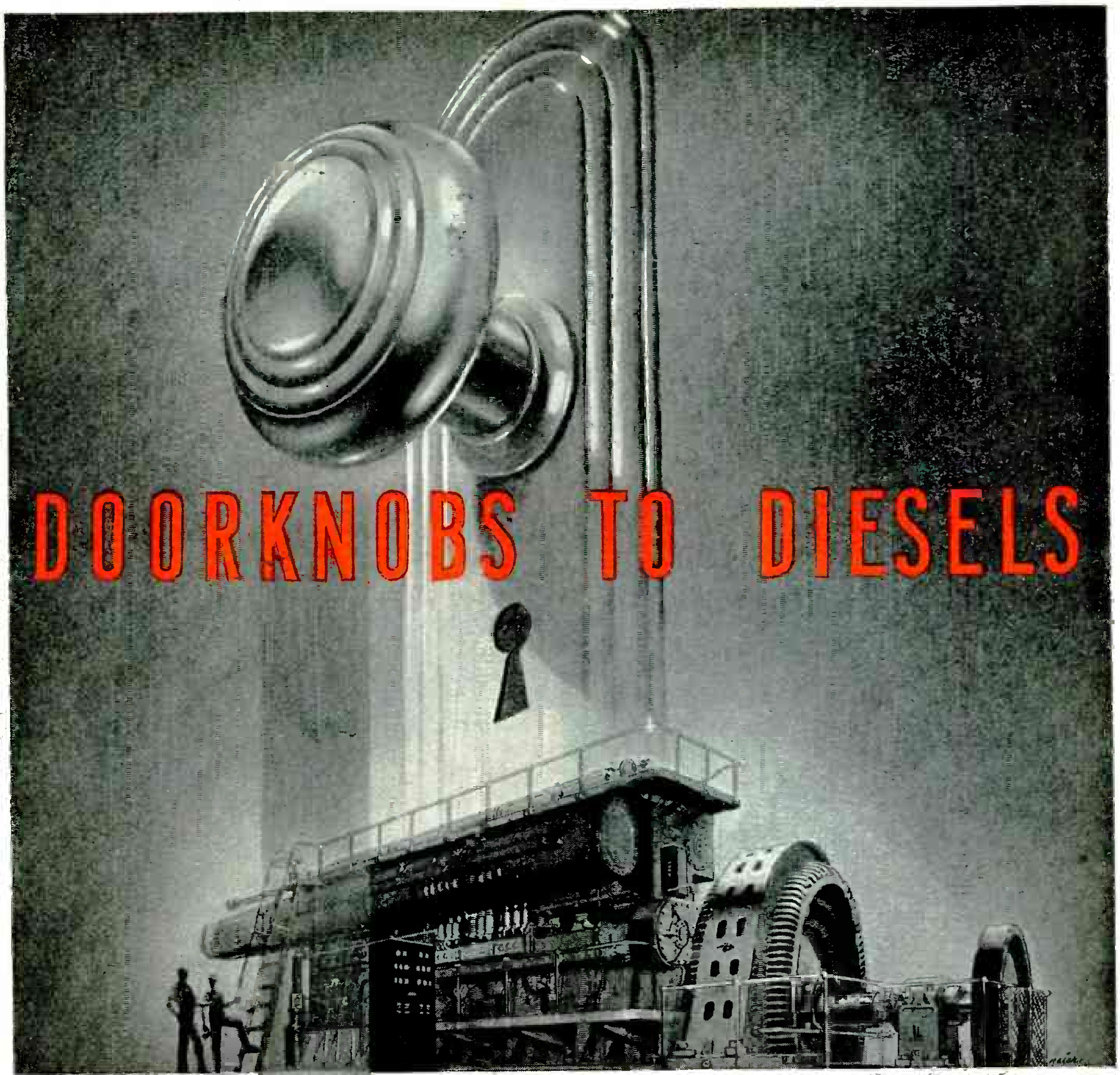
WORLD'S EASIEST, FASTEST, SAFEST METHOD OF PRODUCTION SCREW DRIVING

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



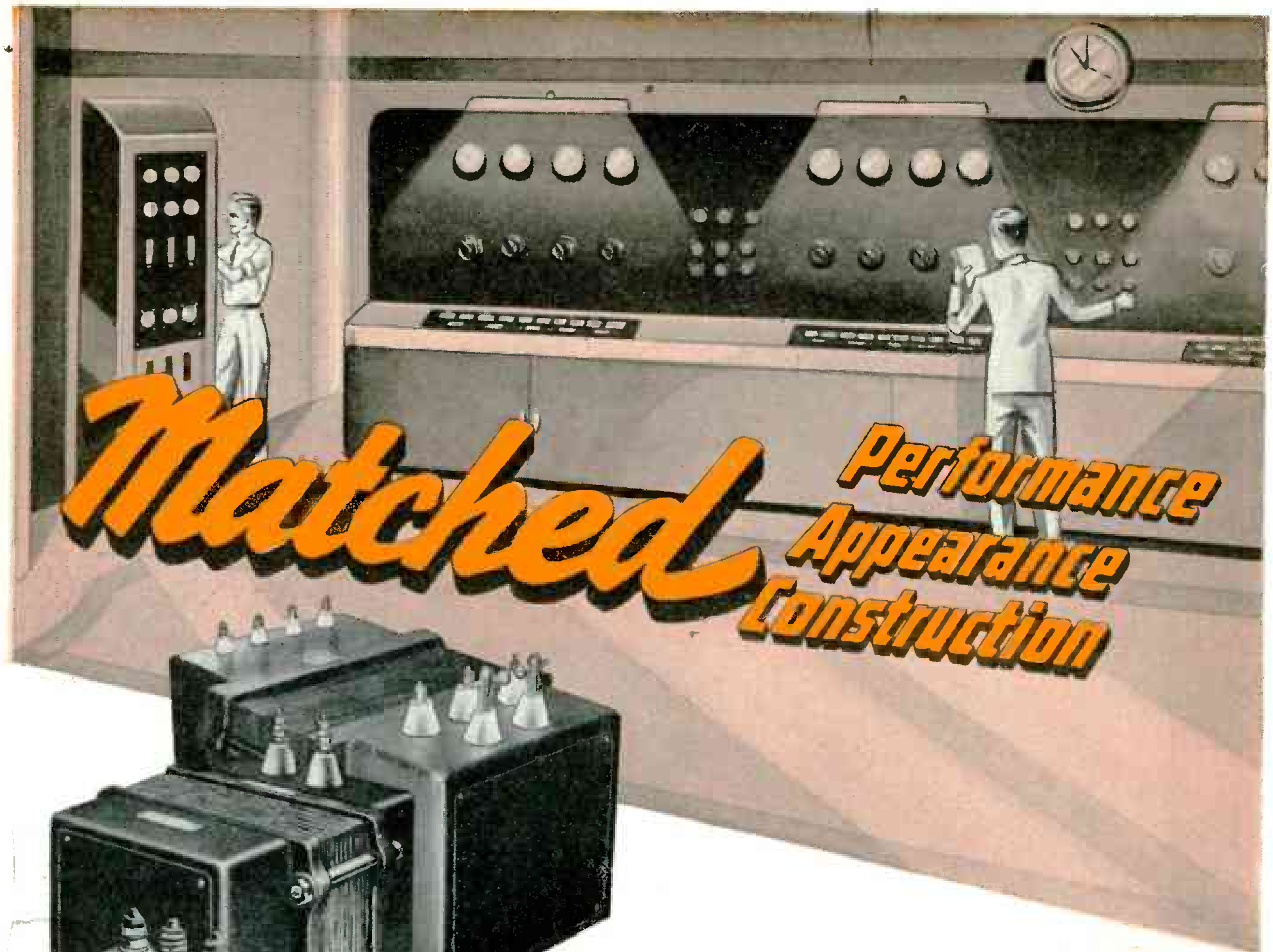
The Western Brass that went into doorknobs and a myriad of peacetime items is flowing into diesel engines and battle equipment of every description. . . The output of our mills at East Alton, Ill., and New Haven, Conn., now many times multiplied, is helping our boys to blast the foes of Freedom—speeding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

Western BRASS PRODUCTS

Western BRASS MILLS

TRADE MARK REG. U. S. PAT. OFF.

Division of WESTERN CARTRIDGE COMPANY, *East Alton, Ill.*



Matched Performance Appearance Construction

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.

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

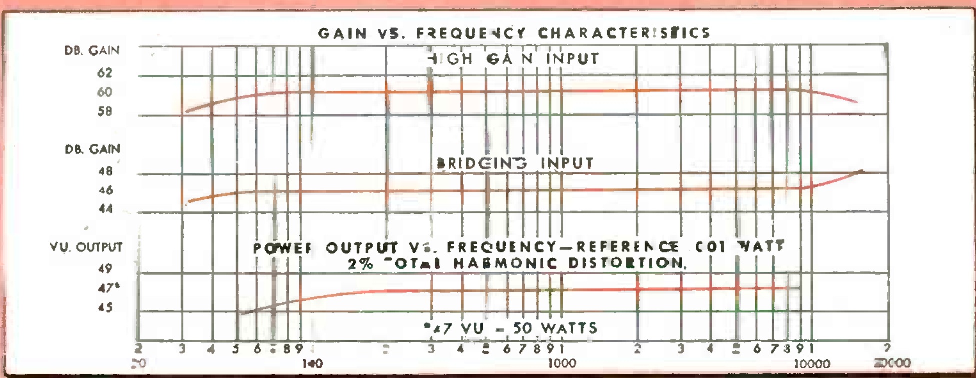
THE MOST ECONOMICAL METHOD OF PRODUCING SMALL METAL PARTS TO CLOSE TOLERANCES WITHOUT WASTE

THE BEAD CHAIN MANUFACTURING COMPANY

MOUNTAIN GROVE AND STATE STS., BRIDGEPORT 5, CONN.

In Production Now!

Input impedance 600 ohms and bridging. Gain 60 db in the former case, 46 in the latter. Output impedance adjustable 1 to 1000 ohms.



THE LANGEVIN TYPE 101-A Amplifier is a good amplifier. Its most outstanding virtue is excellent low-frequency wave form at high output levels, as shown in graph above. In this regard it is unique among commercial amplifiers. Its volume range is also excellent, inherent noise level being 68 db unweighted below full output of plus 47 VU at 2% RMS harmonic distortion. The frequency characteristic leaves nothing to be desired in the reproduction of music. Electrically and mechanically it is as good a product as we know how to build after more than 20 years experience in the sound field. Specification upon request.

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK	SAN FRANCISCO	LOS ANGELES
37 W. 65 St., 23	1050 Howard St., 3	1000 N. Seward St., 31

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

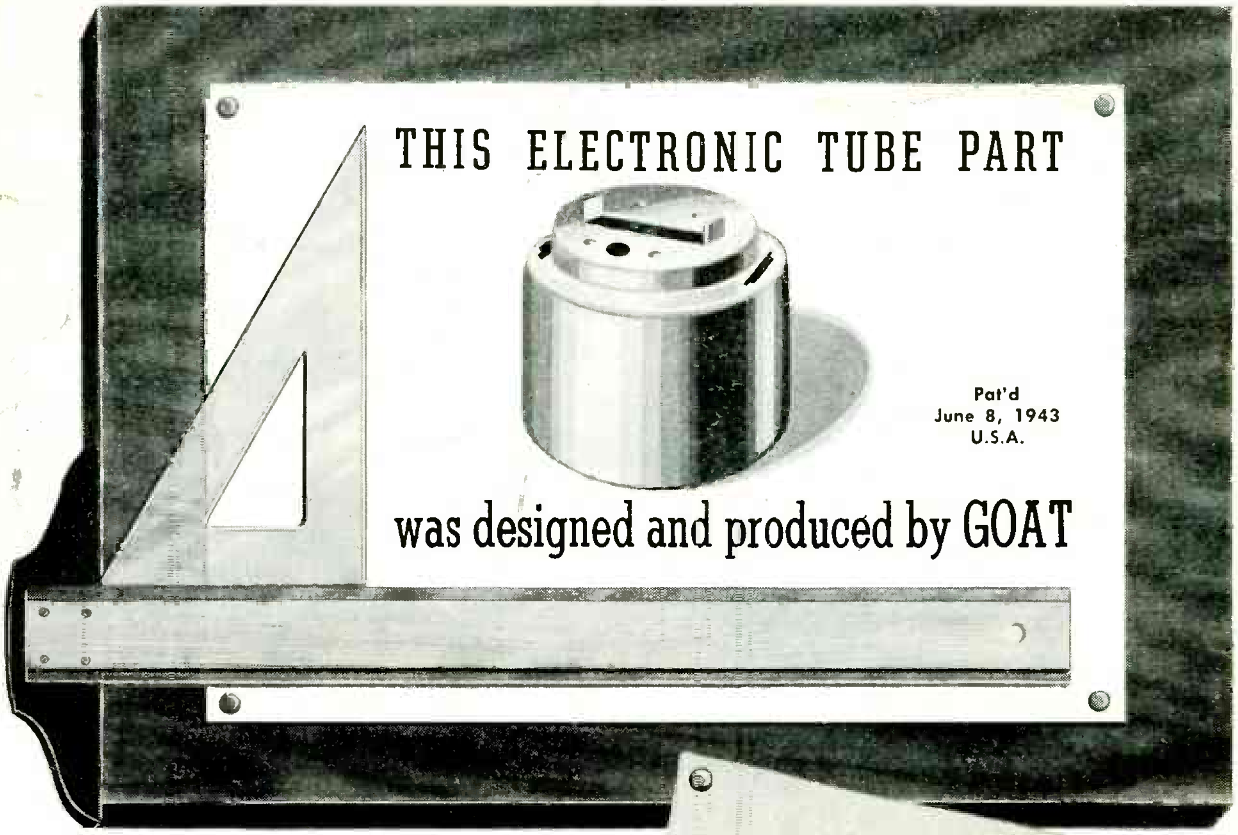
LUMARITH*

A CELANESE* PLASTIC

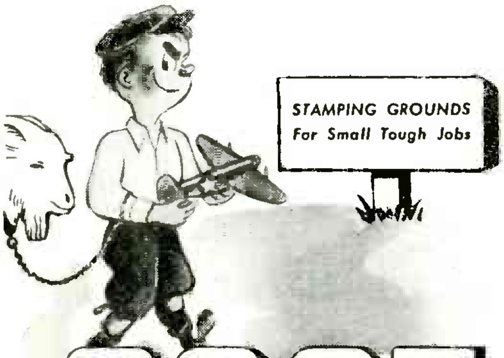
*Reg. U. S. Pat. Off.


SHE WANTS
ACTION
FOR HER MONEY

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*

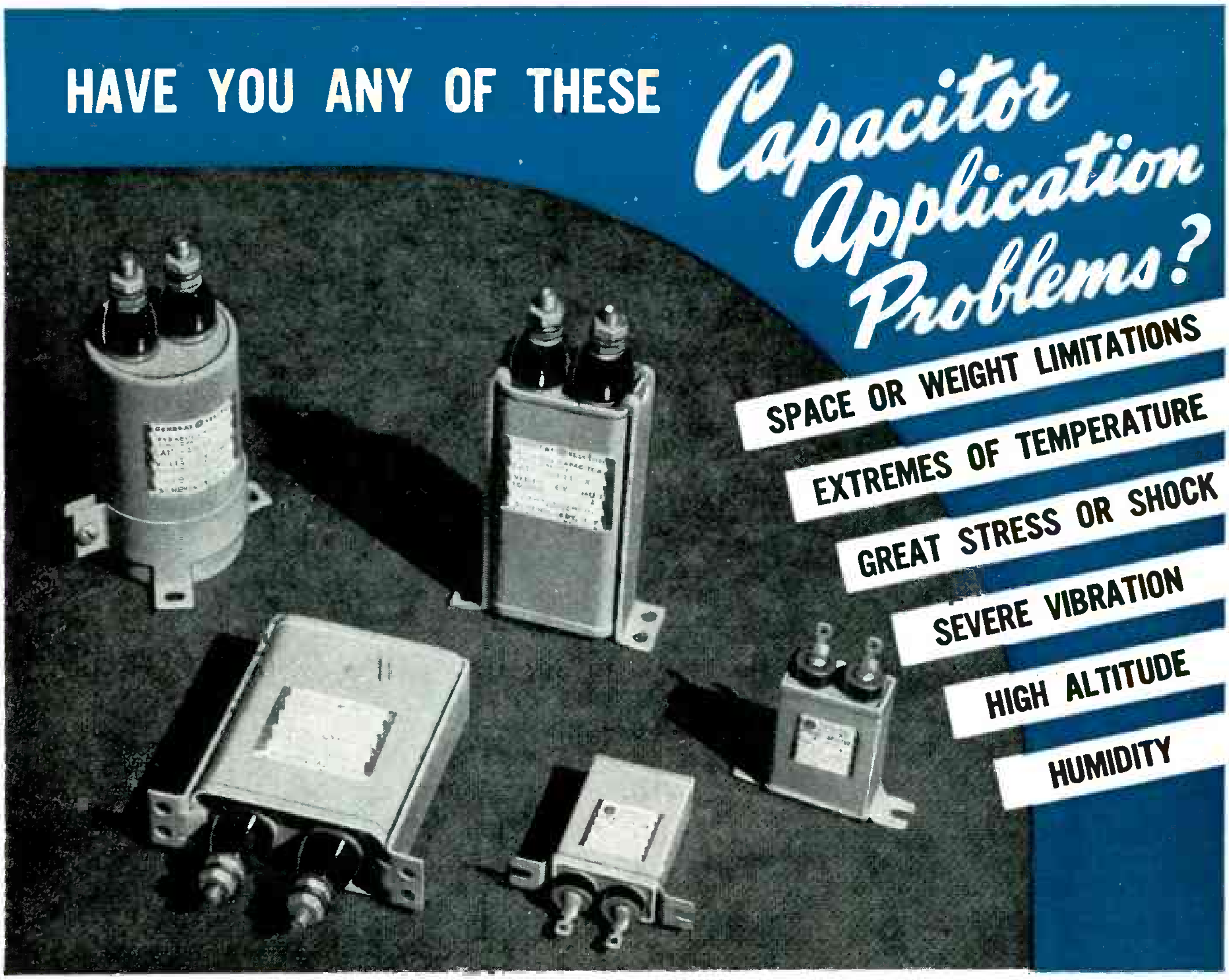
FOR rapid, permanent installations of STA-KON Pressure (Solderless) Wire Terminals, correctly engineered T&B STA-KON Tools are indispensable. • All T&B Tools are quick and easy to operate. • There are different models for whichever type of power you prefer: manual, air, hydraulic or electric. • In fact, 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



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

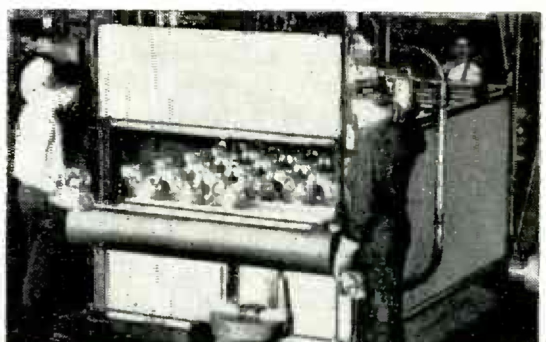
PYRANOL CAPACITORS

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.

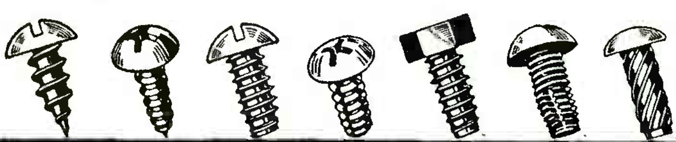


With the *Simplest* Fastening method... P-K Self-tapping Screws... Gehnrich spreads scarce Manpower further!

"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

NEW YORK • CHICAGO • LOS ANGELES • LONDON • HAVANA

Awarded to Our Hicksville Long Island Plant for Outstanding Achievement in War Production

When Station YTG, operated by the guerrilla forces of Gen. Draja Mikhailovich in the Nazi-infested woods and mountains of Yugo-slavia, sought means for sending news and official dispatches to the world, it called Press Wireless.

How contact was made with this heroic little station and how, in spite of frequent interruptions due to enemy attacks, it has been giving the world, thru Press Wireless, news of the gallant struggle the Yugo-slavian patriots are making against the invaders constitutes one of the most interesting radio stories yet to come out of the war.

Press Wireless considers it an honor to perform this service for YTG and regards that station's unsolicited call as recognition of the efficiency of Press Wireless in world-wide radio communications.

Press Wireless is now handling more international radio press traffic and more radio photos than any other communications company in the world.

PRESS WIRELESS, INC., IS DEVELOPING OR MANUFACTURING

- HIGH POWER TRANSMITTERS
- DIVERSITY RECEIVERS
- AIRCRAFT AND AIRFIELD RADIO EQUIPMENT
- RADIO PRINTER SYSTEMS
- MODUPLEX UNITS "TRADEMARK"
- CHANNELING DEVICES
- RADIO PHOTO TERMINALS
- FACSIMILE MACHINES

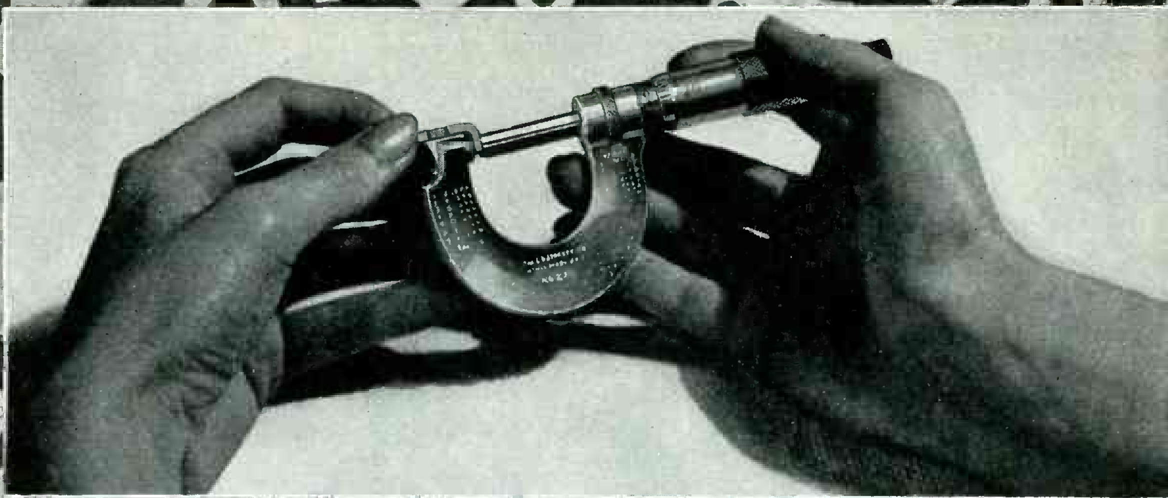
AND OTHER TYPES OF RADIO AND COMMUNICATIONS EQUIPMENT

PRESS WIRELESS, INC.

Executive Offices
435 N. MICHIGAN AVENUE, CHICAGO

Sales Office, Manufacturing Division
1475 BROADWAY, NEW YORK CITY

RIO DE JANEIRO • MONTEVIDEO • BERNE • SANTIAGO DE CHILE



We are just as "fussy" as you!

MANY manufacturers of electrical devices require stamped metal parts of absolute dimensional accuracy. If you are among those who must have close tolerances use Stewart Stampings.

Frequent checks by micrometer, snap gauge and other precision instruments are your assurance that any part manufactured under the Stewart name conforms to specifications. We are just as "fussy" as you.

We carry hundreds of items in stock to meet practically every installation requirement.

Odd shaped pieces stamped and formed from strip or wire on high speed machines.

Our Tool Room is equipped to make dies for your special needs.

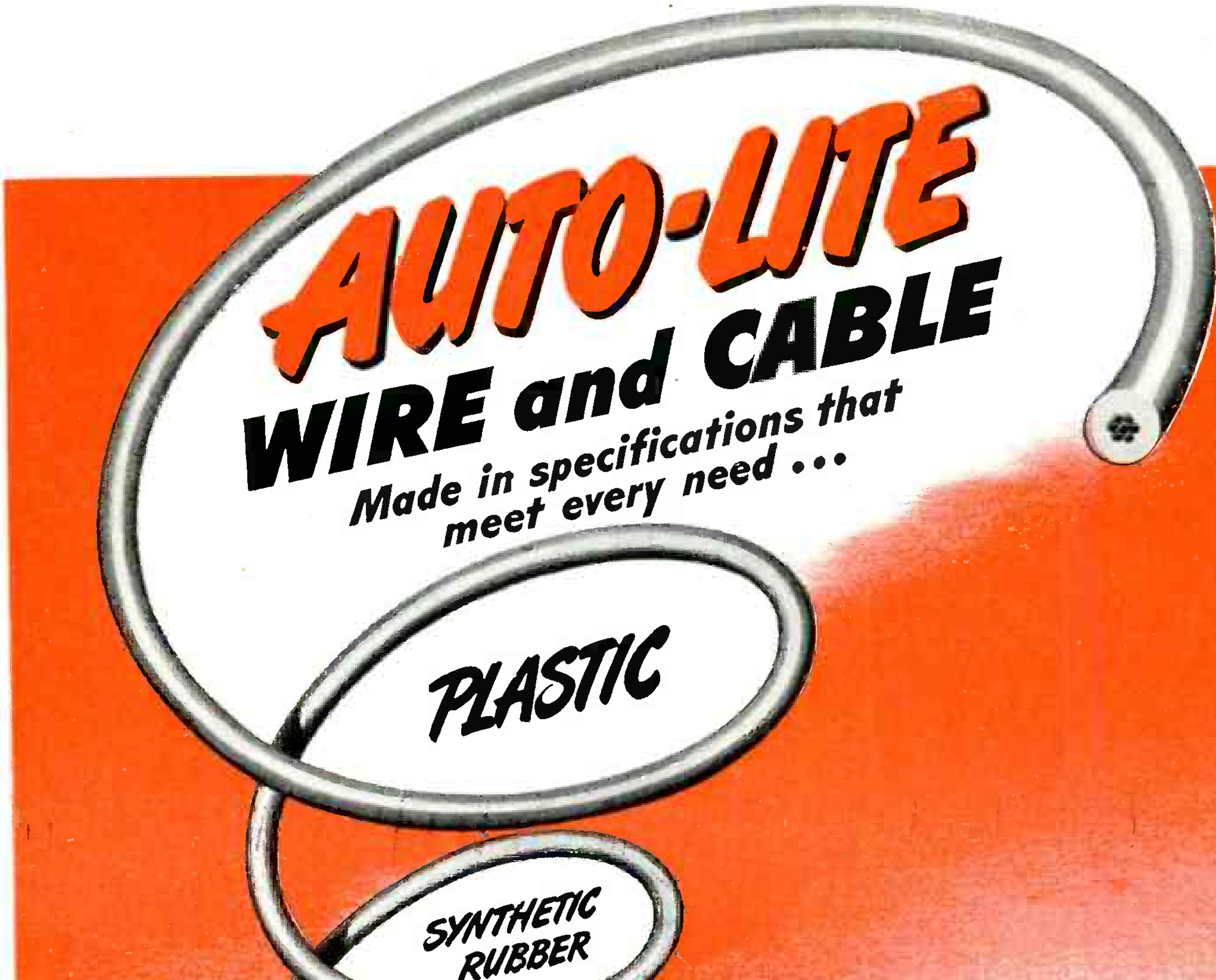
Send for samples and quotations. Let us have your blue prints and specifications.
Quick Response to Inquiries

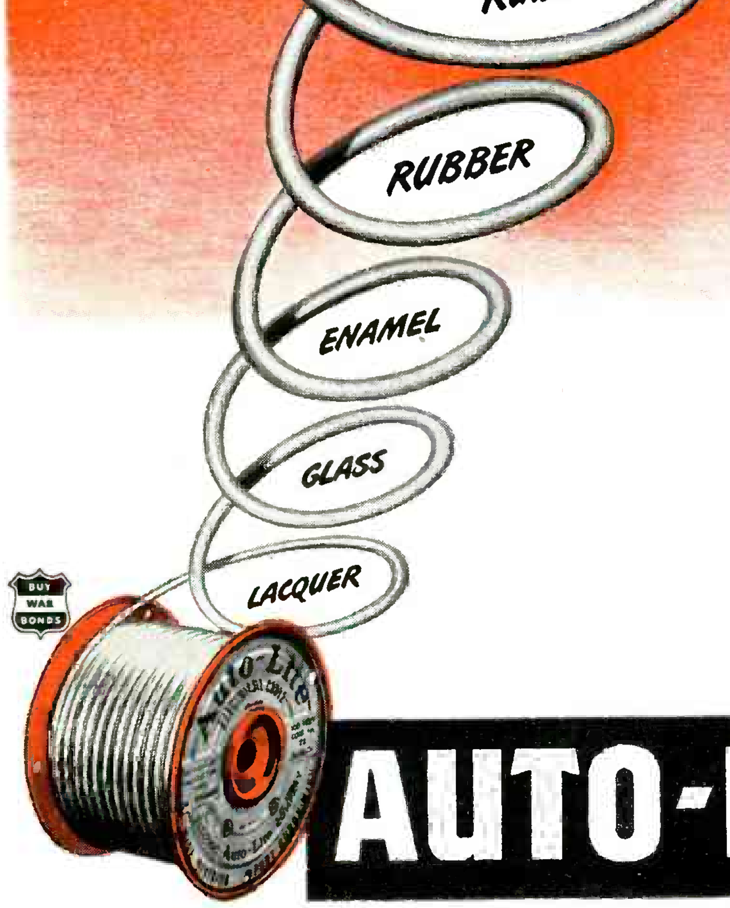
HOT TINNING
NICKEL, CADMIUM, SILVER AND ZINC PLATING
All pieces can be furnished in any desired finish

STEWART STAMPING COMPANY
621 E. 216th Street, New York 67, N. Y.

STEWART

TERMINALS, LUGS, BRACKETS, CLIPS





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

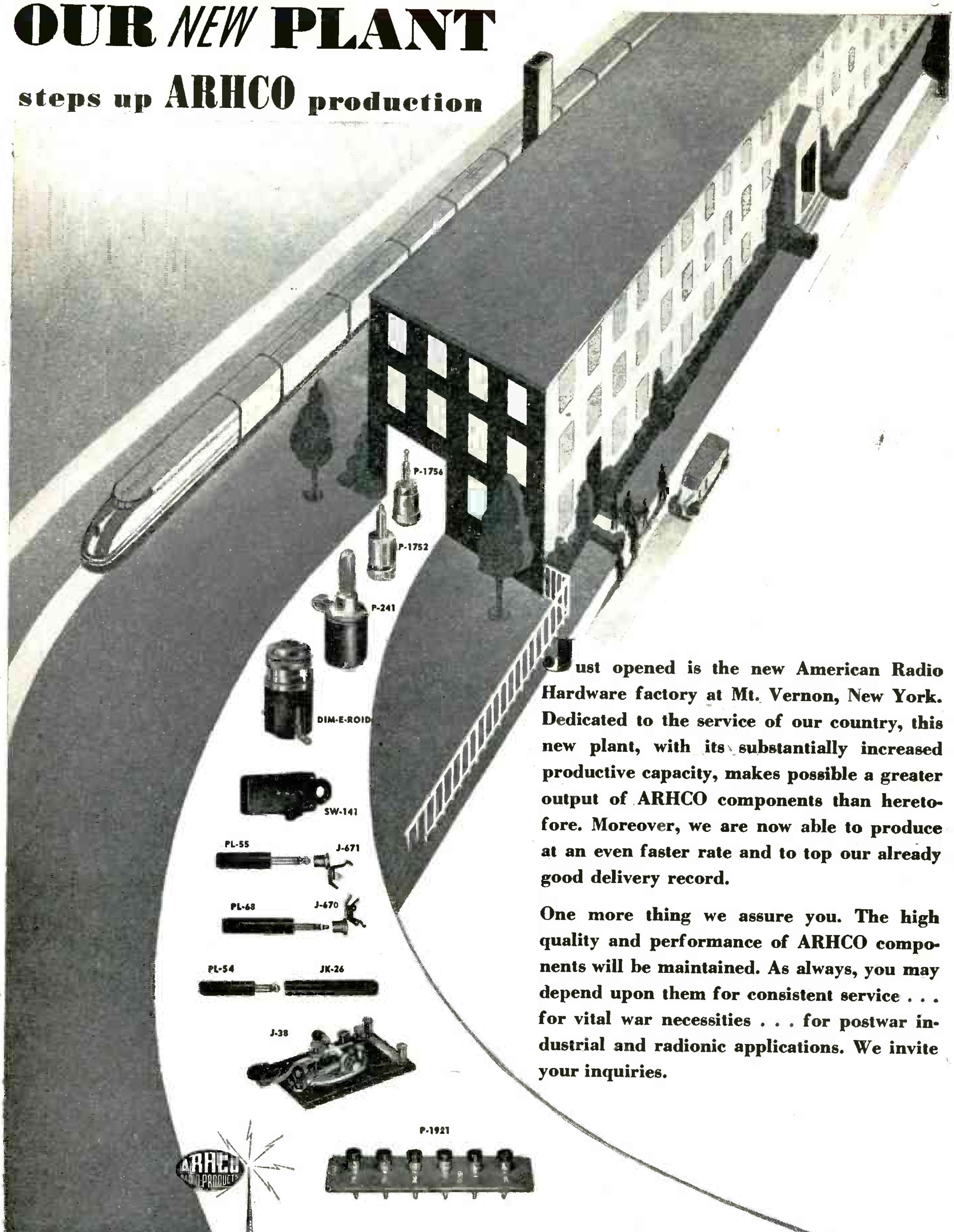
THE ELECTRIC AUTO-LITE COMPANY

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.

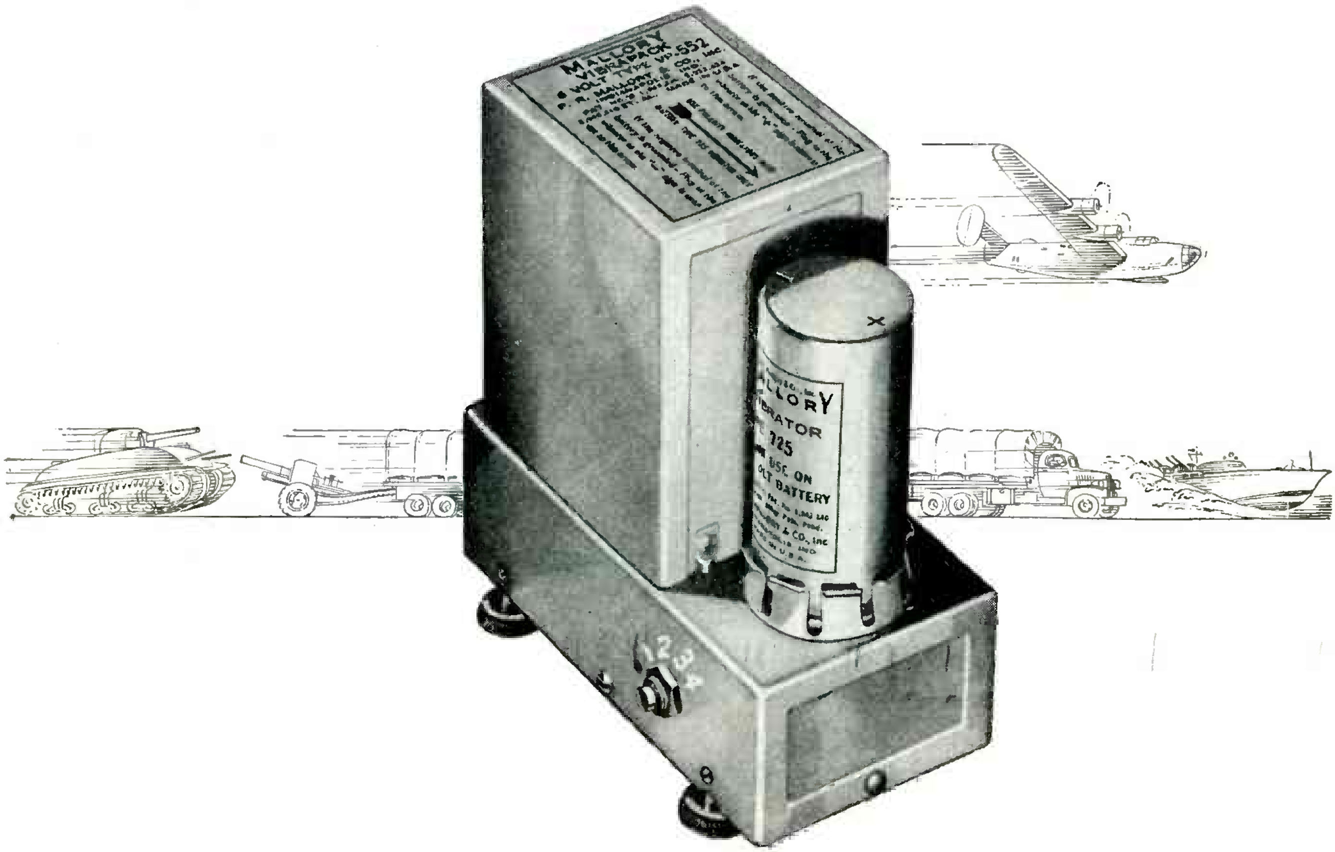
No matter what your power supply problem may be—whether it's primarily one of size . . . weight . . . input . . . output . . . efficiency . . . or whatever—the chances are that *E·L* engineers will be able to provide you with the best solution.

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.

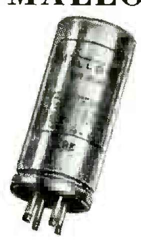
To build vibrator power supplies to master these conditions involved many an engineering headache. But, by new designs and constructions, by better materials and imaginative experiments, Mallory succeeded in building them.

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.

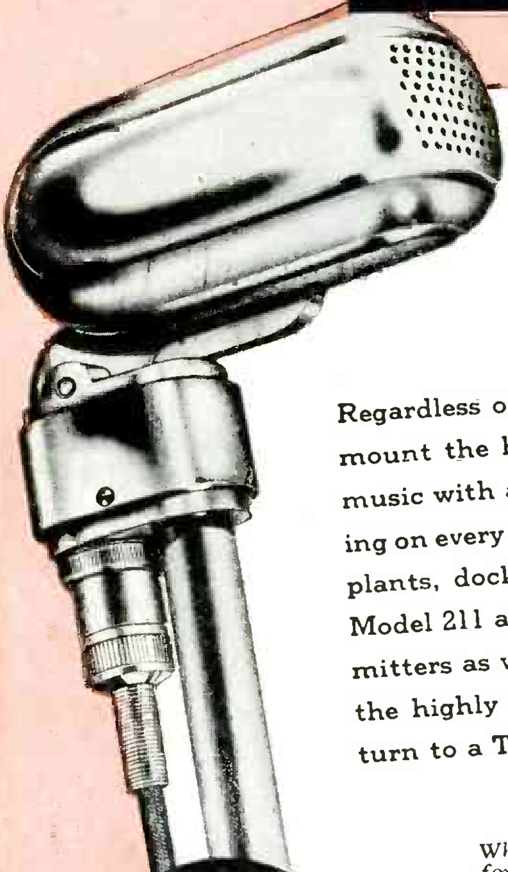
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

It's Your War Too— Buy Bonds and Stamps

P. R. MALLORY & CO. Inc.
MALLORY VIBRATORS AND VIBRATOR POWER SUPPLIES

Dependability Unlimited

TURNER MICROPHONES

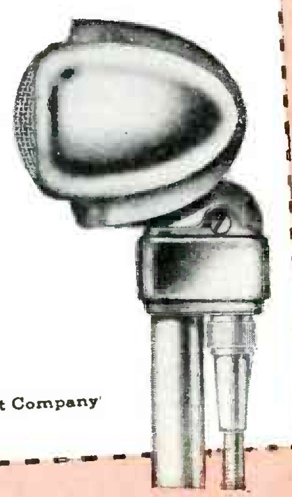


SOUND ENGINEERING

Permits faithful reproduction of all sounds, from the faintest whisper to the loudest train whistle, when you use a Turner Microphone.

Regardless of acoustic or climatic conditions, you can surmount the barriers of distance with clear, crisp speech or music with a Turner. Today, Turner Microphones are serving on every war front — in war plants, air dromes, ordnance plants, docks, army camps, in broadcast studios (for which Model 211 at left is specifically engineered), in police transmitters as well as public address systems of every type. For the highly sensitive transmission, where accuracy is vital, turn to a Turner.

Whatever your need for a Microphone, for indoor or outdoor use, you can be sure of complete satisfaction when you specify Turner. Ruggedly constructed in modern design, Turner Mikes stand up and deliver under toughest usage. (Model 22 D Dynamic and 22X Crystal at right).



TURNER PIONEERS IN THE COMMUNICATIONS FIELD

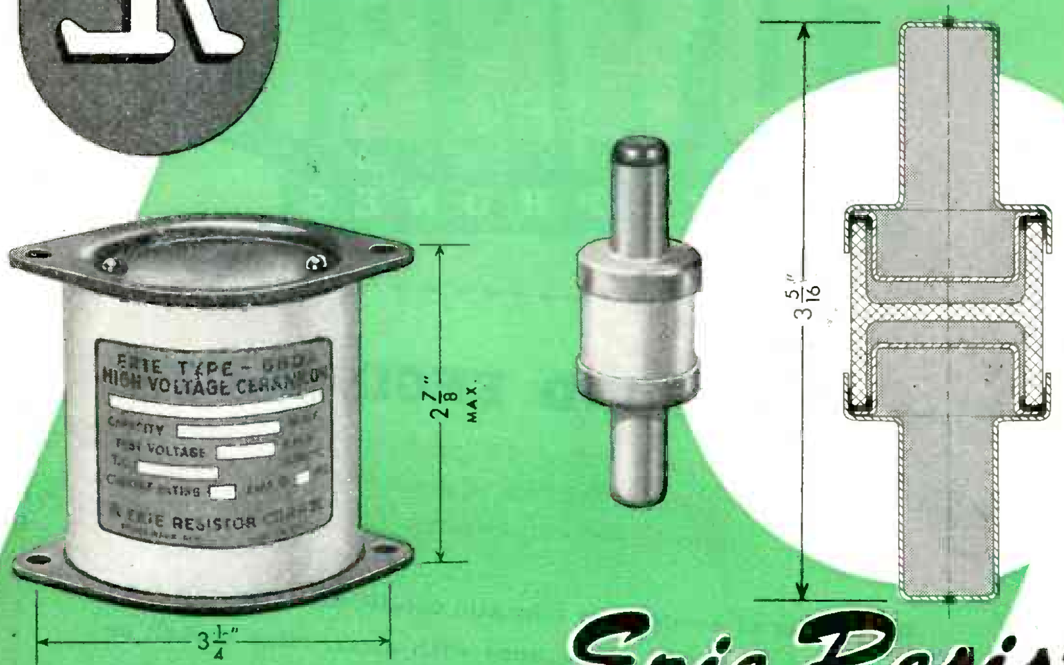
The TURNER Company
CEDAR RAPIDS, IOWA, U.S.A.
Crystals Licensed Under Patents of The Brush Development Company

Free TURNER catalog — **Write today for yours. Gives full details on all available units, and how to care for those you now own.**

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

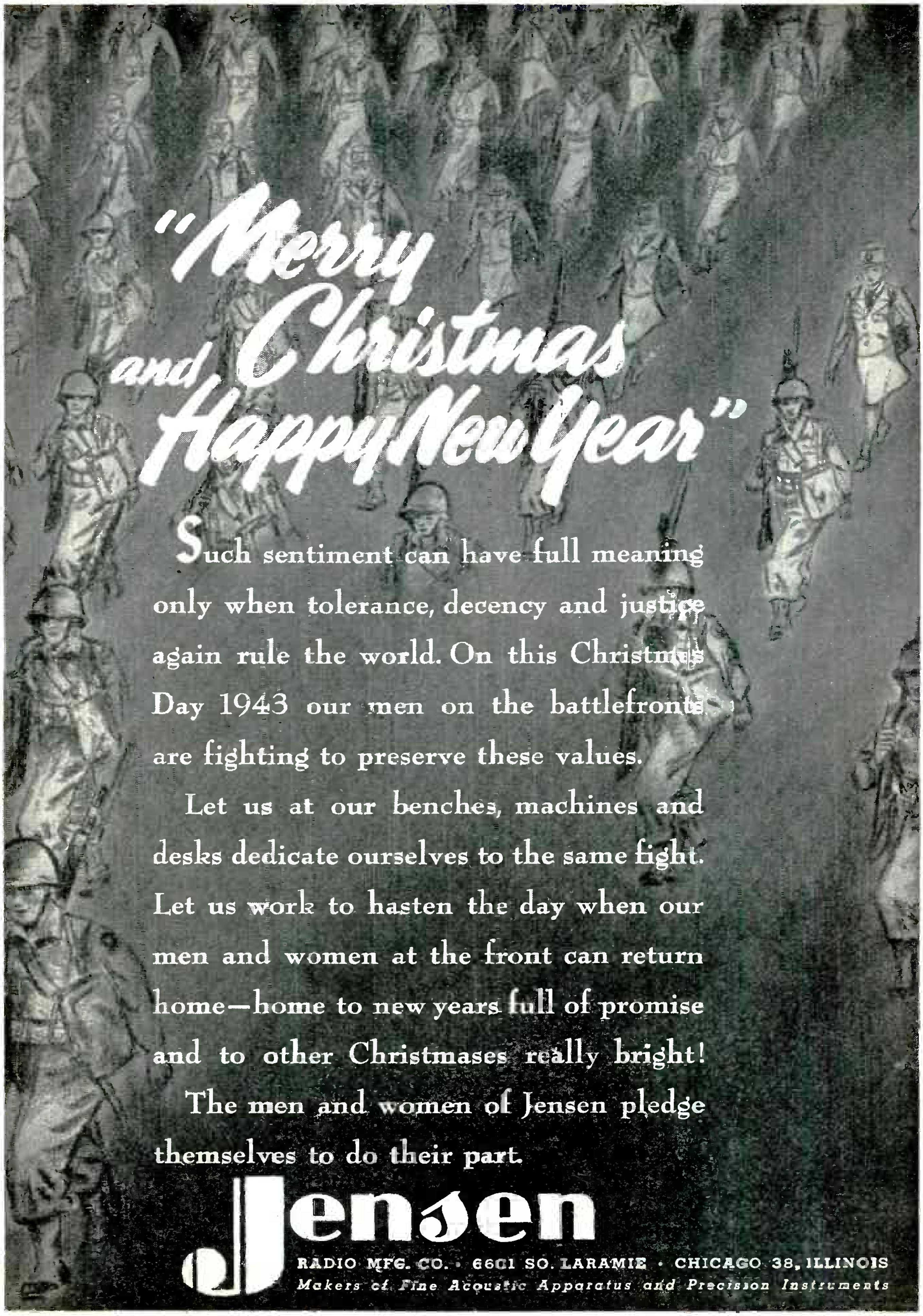
Left: Type 680A Transmitting Ceramicon Maximum capacity 400 MMF in zero temperature coefficient, 2000 MMF in -750 P/M/°C. 10,000 volts D. C. test voltage.

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.

FOR HIGH ACHIEVEMENT IN WAR PRODUCTION

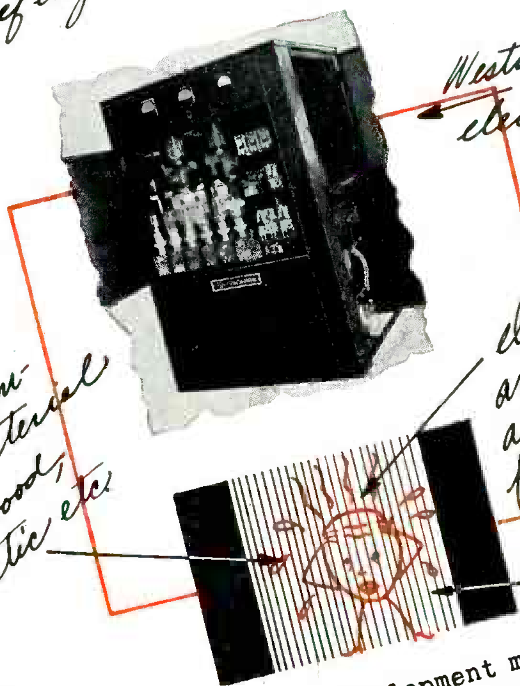
Back The Attack—With War Bonds

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"



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!

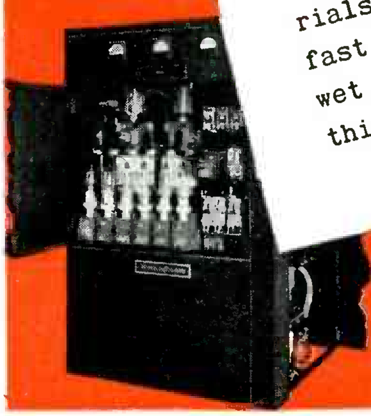
This thermo-electronic heating equipment generates heat uniformly throughout the material—like the "artificial fever" you read about. Best of all, there's no overheating of the outside surface and underheating in the center.

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

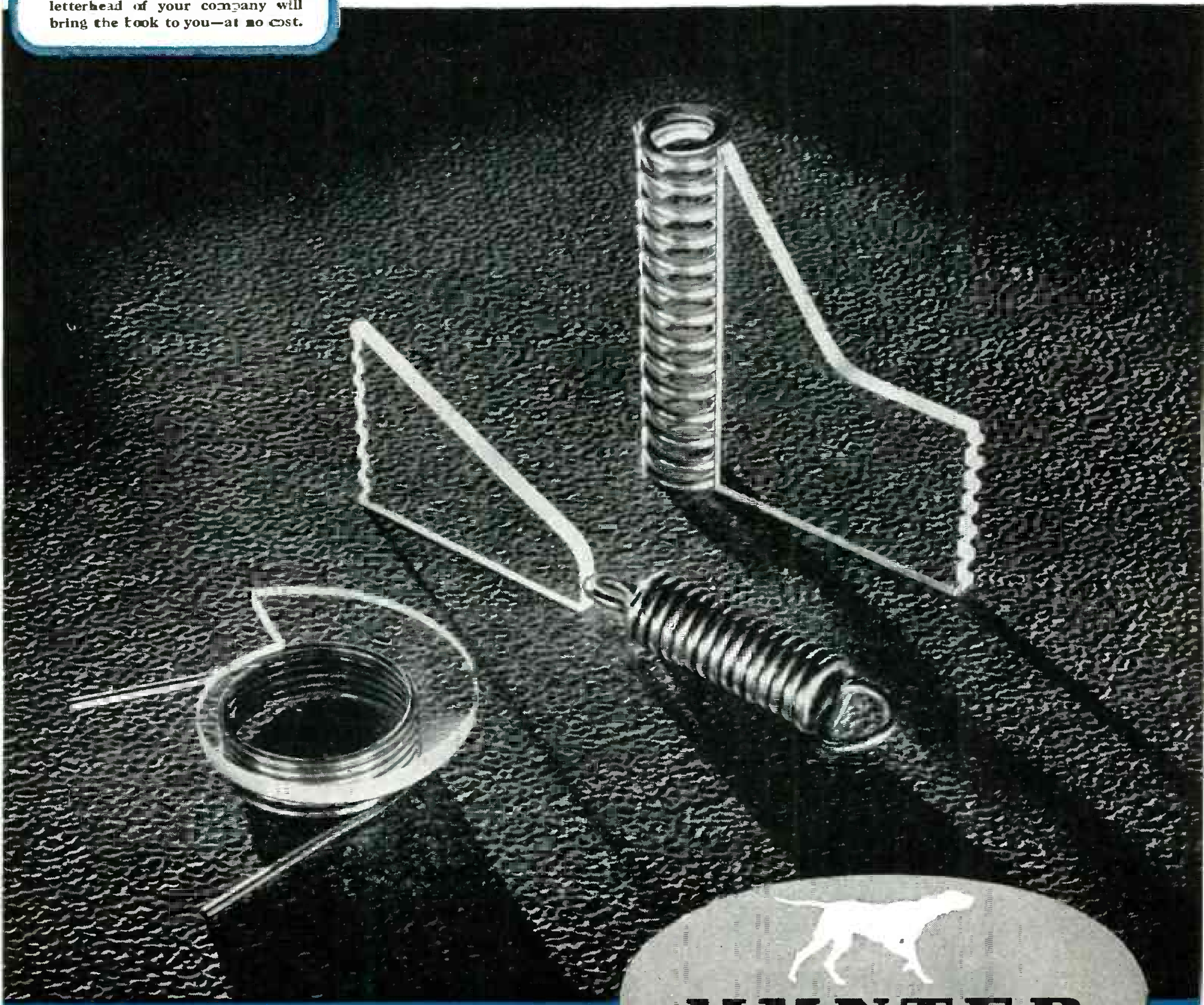
You Can't Build the Future on a Flaw!

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.

PUZZLE...
Where is the Airport?

The pilot knows—because, far below these clouds, the ever dependable radio range constantly sends out safety signals . . . signals which guide him down through the mist, past jagged mountain peaks, on to the haven of the airport.

Radio Receptor, since the very beginning of the U. S. system has worked with governmental authorities in the development of radio ranges and other radio navigational aids.

In peace, we equipped many leading airports and airways. Today, we are making radio ranges and airdrome traffic controls as our special contribution to the war effort.

When peace comes again, *Radio Receptor*, with its rich background of experience in the design, manufacture and installation of radio navigational aids and airport traffic control equipment, will broaden its activities in keeping with the tremendous growth of postwar aviation.

Send for a copy of our non-technical booklet, "Highways of the Air" — DESK E-1

> ***A postwar airport development program to cost approximately $800,000,000 is recommended by William A. M. Burden, special aviation assistant to the Secretary of Commerce. The airport survey, made by the CAA in 1939 and which recommended some 4000 airports, will now be increased to approximately 6000, most of the increase being in small fields. "One thing is certain," Burden said. "And that is, if the program is to be developed on a sound basis, there must be a far higher proportion of local financial participation than there has been in the past."***

Awarded for Meritorious Service on the Production Front

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

★ SINCE 1922 IN RADIO AND ELECTRONICS ★

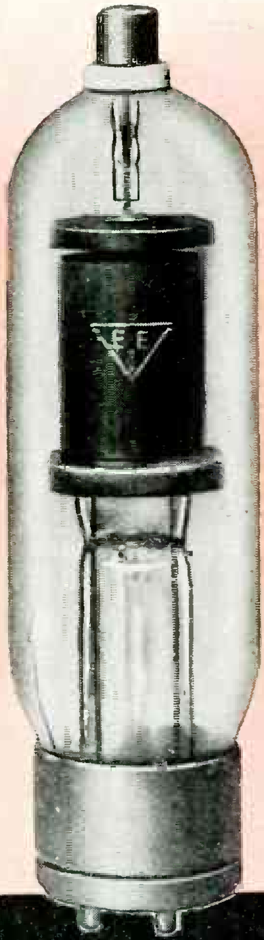
ARMY **NAVY**

E

"... 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.

"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

★ Twisting a piece of wire sounds like a simple matter, but actually, in the making of better springs, it is quite a significant operation. By evaluating the results of a twist test, the Muehlhausen spring technician is able to select stock that will withstand the torsional strains to which springs are subjected in use.

In this test, a specimen of wire, held between two chucks of a specially designed laboratory machine, is twisted clockwise and counter-clockwise a predetermined number of times. Weakness is revealed by premature breakage or the opening of hidden seams. Only wire that can withstand the punishment of the twist test is approved for production.

Scores of such tests are conducted daily at Muehlhausen to make sure that every spring leaving this factory will perform with maximum efficiency and long life.

MUEHLHAUSEN SPRING CORPORATION

Division of Standard Steel Spring Company

760 Michigan Avenue, Logansport, Indiana

TWO NEW FOLDERS — FREE

Die Spring Bulletin illustrates, describes 206 sizes and types of die springs. • Armament Bulletin shows importance of springs for many types of war equipment.

MUEHLHAUSEN

SPRINGS

MS

EVERY TYPE AND SIZE

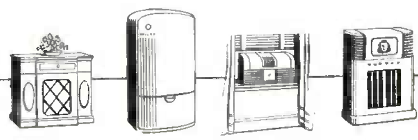
TWO-MAN TORNADO!

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

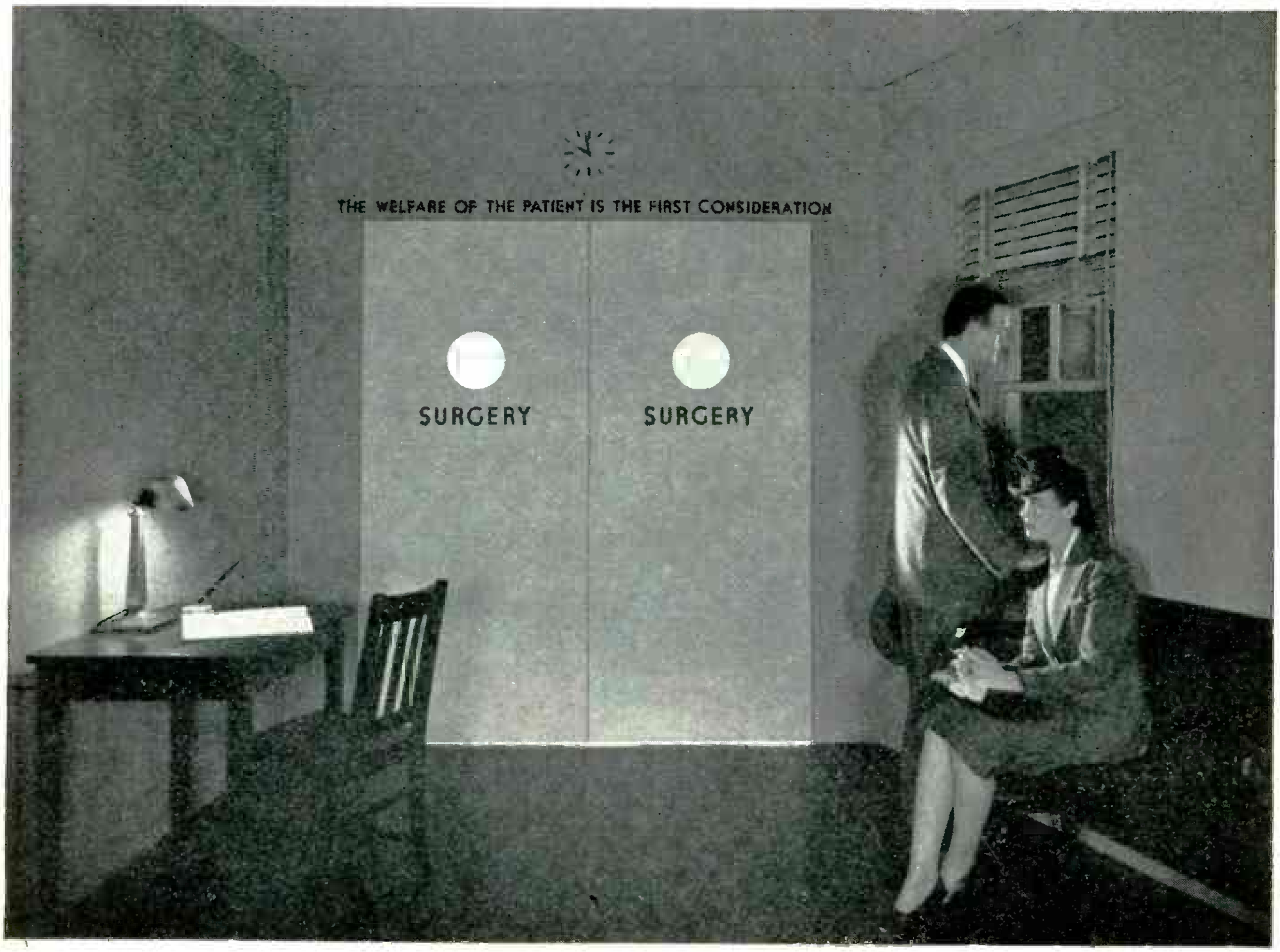
UTAH RADIO PRODUCTS CO., 837 *Orleans St., Chicago, Ill.*

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.

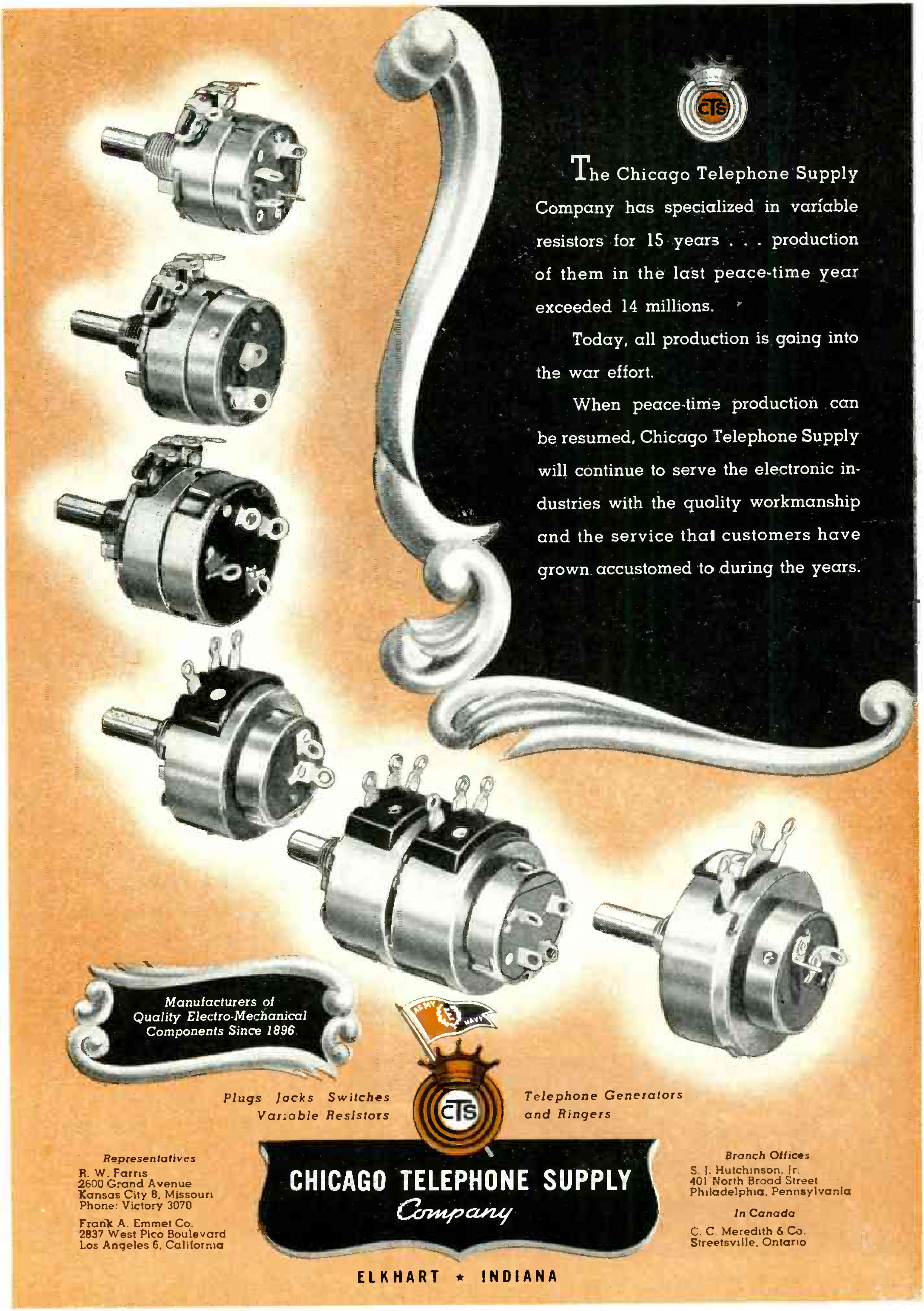
It is measuring, metering, and testing equipment of this kind—equipment that accepts the responsibility of *sustained accuracy**—that is built by Boes. Whether it be for the professions, the sciences, or for production, a Boes-made instrument is worthy of the work that it must do.

* **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
ARMY NAVY
Plugs Jacks Switches Variable Resistors
CTS
Telephone Generators and Ringers
Representatives
R. W. Farris
2600 Grand Avenue
Kansas City 8, Missouri
Phone: Victory 3070
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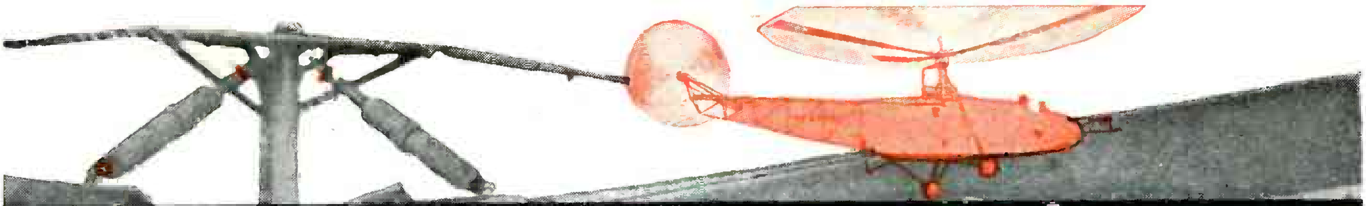


SAFEGUARDING THE HELICOPTER'S HEART

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.

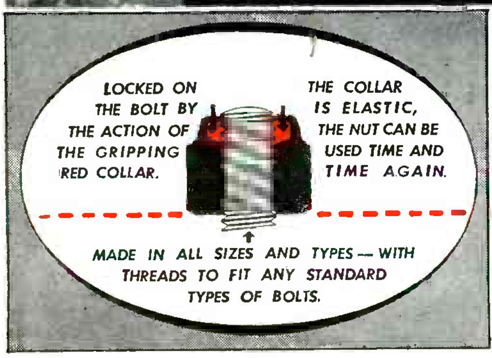
These are the nuts with the red elastic collar—the nuts which have revolutionized aircraft construction.

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.



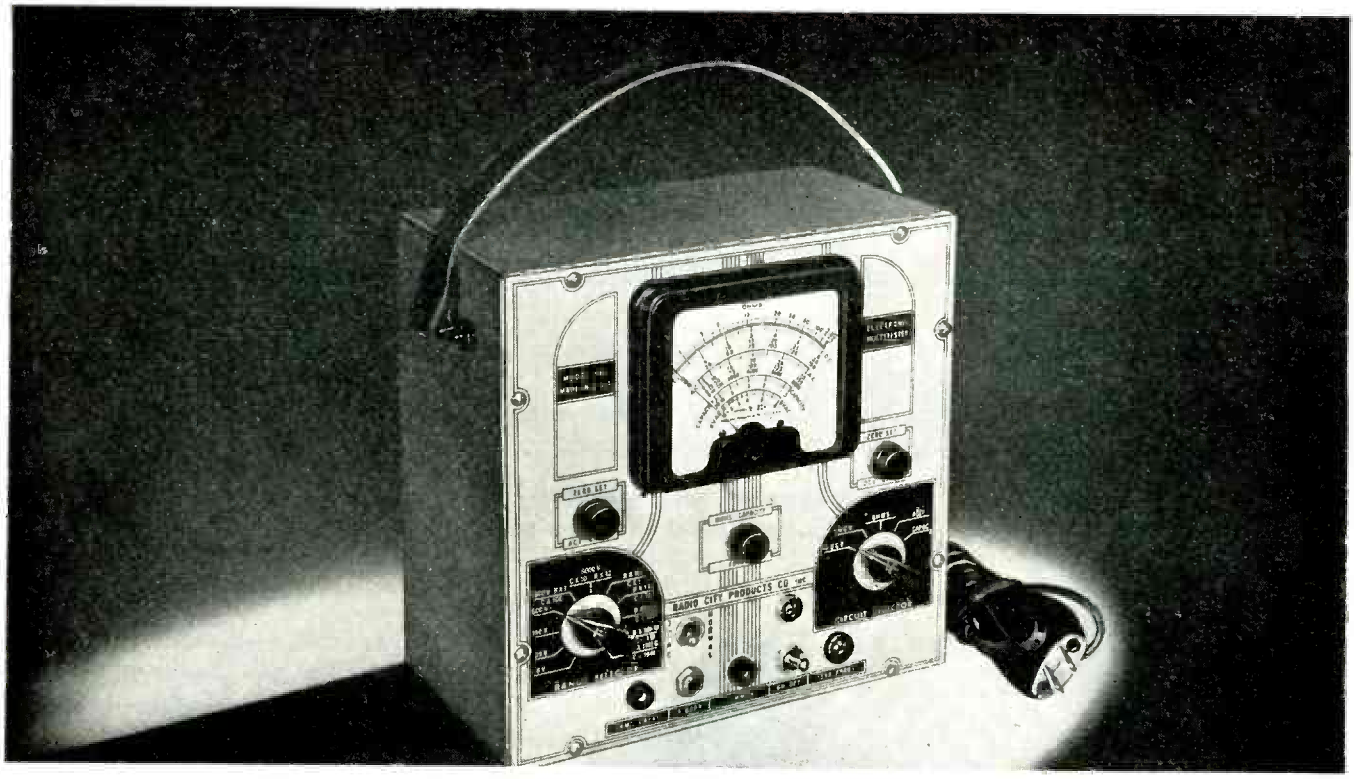
ESNA

TRADE MARK OF

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

ELASTIC STOP NUTS

Lock fast to make things last



electronic multitester

--RCP MODEL 662

Designed to speed production testing and save valuable engineering time in the laboratory, RCP Model 662 Electronic Multitester combines maximum flexibility and sensitivity with general purpose utility. Now being used by the Signal Corps, U.S. Navy Yards, leading research laboratories and government suppliers of precision products, this tester incorporates the latest RCP developments in vacuum tube D.C. Voltmeter, A.C. Voltmeter, Ohmmeter, and Capacitymeter in one instrument.

extra features of model 662

★ 27 Vacuum tube operated ranges.

★ VR105-30 Voltage regulator tube and its associated circuits, insuring freedom from error due to line voltage fluctuations.

★ 13 A.C. and D.C. voltage scales, measuring from a fraction of a volt to 6,000 volts.

★ High voltage test leads; r.f. lead; signal tracing probe; resistance and capacity lead.

★ Wide scale on 4½" D'Arsonval Microammeter with guaranteed accuracy of 2% at full scale. Linear meter movement.

★ Foolproof — maximum protection against meter burn-out. Meter cannot be damaged by checking a live resistor or using too low a range for making a measurement.

★ Has pilot light indicator.

★ Matched pair multiplier Resistors accurate to 1%.

★ Rugged welded steel case, thoroughly shielded. Sloping front.

Crystalline gray finish. Complete with 5 leads; large capacity batteries, easily replaceable, tubes and pilot lamp. Size 9¾" x 9¼" x 7⅜". Weight: 7¾ lbs. net...... **$47.50.**

For complete details of RCP Model 662 Multitester and other RCP Electronic and Electrical Instruments, send for Catalog 126. Our engineers will gladly advise on unusual test problems, either of production or laboratory, on request.

REASONABLE DELIVERIES ARE NOW BEING SCHEDULED

RADIO CITY PRODUCTS COMPANY, INC.

127 WEST 26th STREET — RCP — **NEW YORK CITY**

MANUFACTURERS OF PRECISION ELECTRONIC LIMIT BRIDGES — VACUUM TUBE VOLTMETERS — VOLT-OHM-MILLIAMMETERS — SIGNAL GENERATORS — ANALYZER UNITS — TUBE TESTERS — MULTI-TESTERS — OSCILLOSCOPES — AND SPECIAL INSTRUMENTS BUILT TO SPECIFICATIONS


THE SOUND OF FAMILIAR THINGS . . . .
MADE MORE REAL ON Audiodiscs
a fine recording blank
No more restrictions on the sale of Audiodiscs! Those of you who have waited for these fine recording blanks can once again get them. Now, more Audiodiscs will add enjoyment to the American scene, just as they have brought a chunk of home to soldiers at the front lines.
Built for greater durability, impervious to temperature changes and assuring absolute fidelity of performance, Audiodiscs are "first" with recording and broadcasting studios, for wartime as well as peacetime applications. Audio Devices, Inc., 444 Madison Ave., New York 17, N. Y.
audiodiscs
they speak for themselves

for maximum

BLOWER

performance

115 VOLT 400 CYCLE BLOWER

This L-R #2 Blower, powered with our J31A 1/100 H.P. single phase Capacitor motor measures 4 7/32" overall length, 3¾" overall blower diameter, 1 15/16" overall motor diameter and weighs 19½ ozs. Running at 7200 R.P.M., it circulates 22 cu. ft. per min. continuously. It is designed for use in ambient temperatures up to 80° C. Production facilities enable us to offer prompt deliveries on this equipment, which is outstanding in efficiency and air delivery for its small size and light weight.

NOTE: Type J31A and J49 motors are available for use in other applications. Write for information and performance data.

115 VOLT—60 CYCLE BLOWER

For same application as above but for operation on 60 cycles supplied at 3300 R.P.M. L-R No. 2 Blower, powered with our J49 capacitor motor, circulates 10 cu. ft. per min., continuous duty, with 9 watts input to motor.

J49 Dimensions:
Overall Length..... 2 11/16"
Overall Diameter.... 1¾"
Weight .... 16 ozs.

Manufacturers of *Control Devices*

and Components EAD for Electrical, Electronic and Mechanical Applications

EASTERN AIR DEVICES, INC.

585 DEAN STREET • BROOKLYN 17, N. Y.

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

In the modern industrial plant

articles are counted faster than human eye can function. Electronic devices inspect the interior of solid objects. Electronic equipment controls temperatures, eliminates smoke, operates lights, classifies colors . . . establishes heretofore undreamed of standards of accuracy and increased production.

And that only begins to tell the story. New methods . . . new materials . . . new uses of electricity . . . will be matched by the new and improved standards of design and construction now being perfected by Ferranti Transformer precision and craftsmanship.

In the tempo of things to come, you can rely with confidence upon the things Ferranti is doing today . . . Ferranti Quality and increased facilities will enable you to solve your PRESENT as well as your postwar problems . . . to meet the increased complexities of today's and tomorrow's production.

CONSULT WITH FERRANTI NOW — *wherever Quality and prompt delivery are of paramount importance.*

PLAN WITH Ferranti

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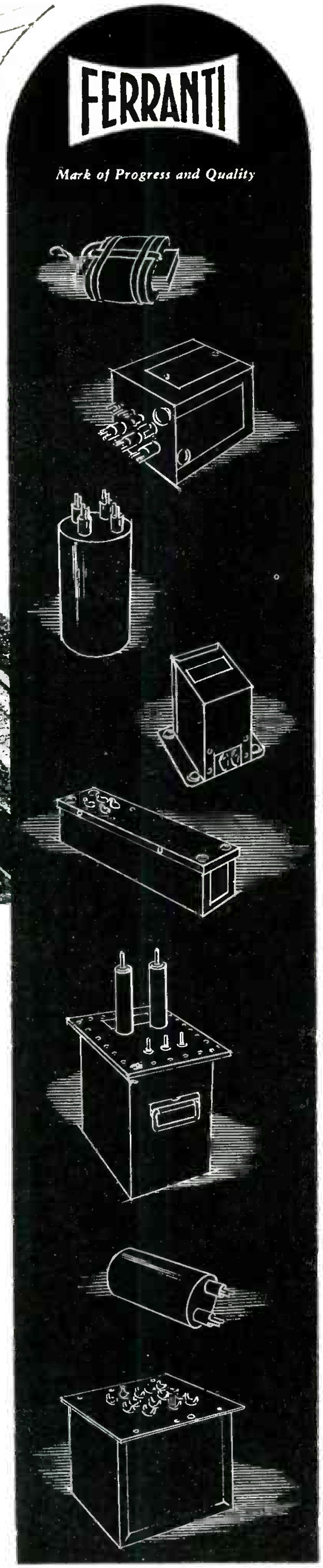


Naturally, we cannot answer all your questions right now. But it is certain that our production of tens of thousands of mechanical tuners and variable condensers to the precision standards required for military use will lead to many new postwar designs.

PHONOGRAPH RECORD CHANGERS – HOME PHONOGRAPH RECORDERS – VARIABLE TUNING CONDENSERS – PUSH-BUTTON TUNING UNITS AND ACTUATORS

ARMY E NAVY

GENERAL INSTRUMENT CORPORATION

829 NEWARK AVENUE, ELIZABETH, N. J.

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.

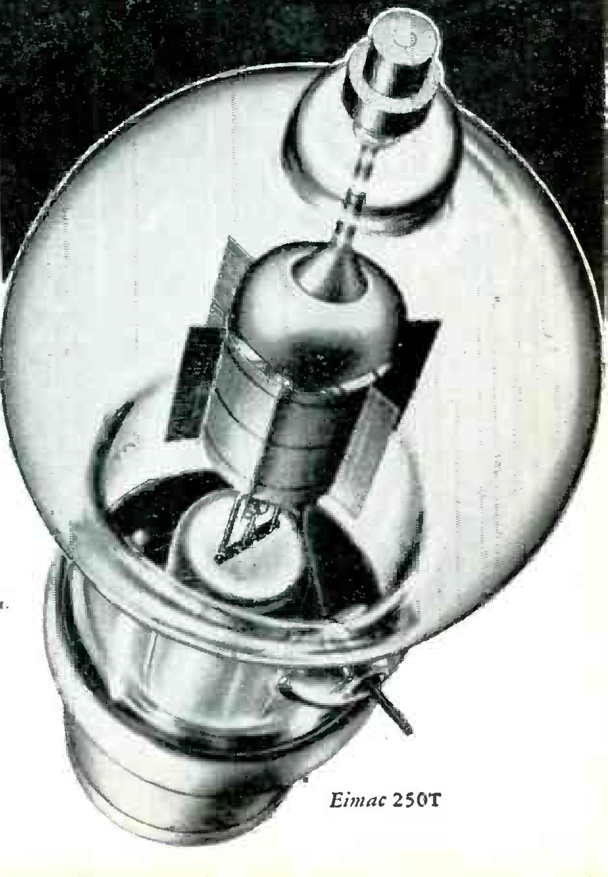
I have not attempted to raise all the important policy questions in terminating contracts, nor do I propose specific solutions for each major problem. Rather it has been my purpose to indicate the complexities of the task which faces us and to urge that intelligent and sound plans be developed now while 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.



Eimac 250T

End of an Enemy

In a split second this enemy plane will be blasted from the skies by a shell from one of our anti-aircraft guns on the ground.

How can a gun hit a plane going 300 miles an hour 20,000 feet up . . . when it takes the shell 15 seconds to get up there and in that time the plane has gone more than a mile? Besides, the shell curves in its flight. Wind blows it. Gravity pulls on it. Even the weather affects its velocity.

The answer is the Gun Director—an *electrical* brain which aims the guns. Swiftly it plots the plane's height and course. Instantly it solves the complex mathematical problem, continuously matching the curved path of the shell to the path of the plane so that the two will meet. It even times the fuse to explode the shell at the exact instant.

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!

Western Electric

The nation's largest producer of electronic and communications equipment for war

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.

From Crystal Set to Walkie-Talkie . . .

The History of MALLORY Components is the History of Radio

For almost a quarter of a century, the history of Mallory electronic components has paralleled the development of radio itself.

From the earliest plugs and jacks, to the latest hermetically-sealed capacitors and vibrators, the list of parts has reflected the progress of the communications industry—literally step by step.

Because of their reputation for outstanding performance in peacetime applications, they were readily adapted to military use.

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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 wide-awake to the portent of frequency modulation, at least in New York. Here it is treated as a sort of ugly step-child 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.

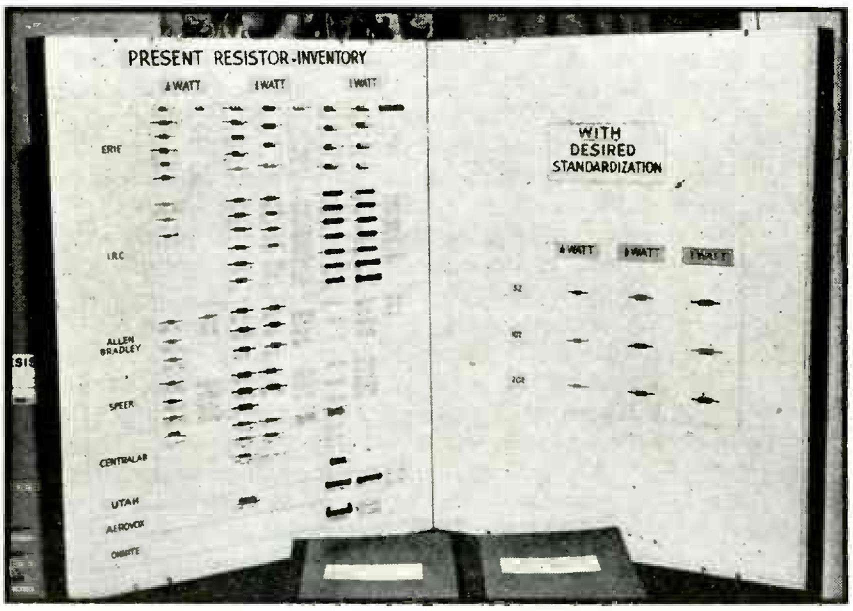
The Objectives of Standards

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, $2\frac{1}{2}$ 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 $2\frac{1}{2}$ 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.



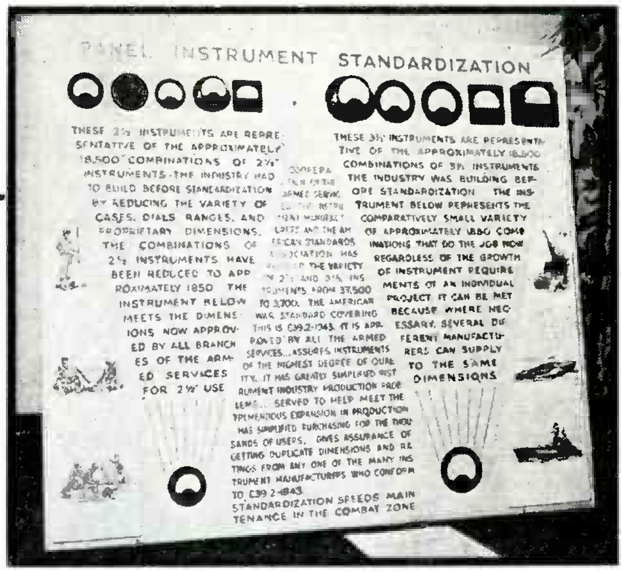
One standardization objective. Left, multiplicity of resistors in a typical prime-contractor's stock. Right, actual requirements

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

* 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

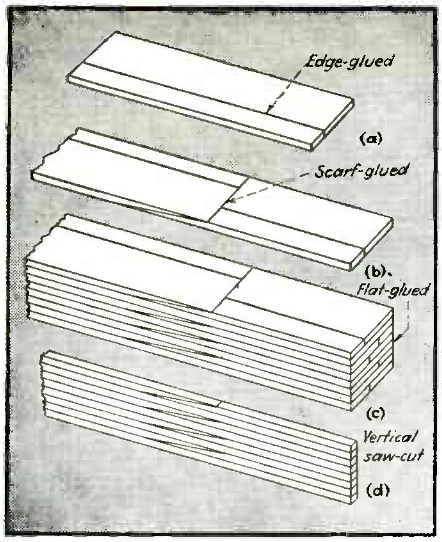
RADIO-FREQUENCY HEATING is being employed to advantage in setting the synthetic-resin glues used in assembling laminated aircraft spars. During the past year the multi-laminar spars used in the Taylorcraft Type L-2 plane have been made by this method and the advantages of using radio-frequency heating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

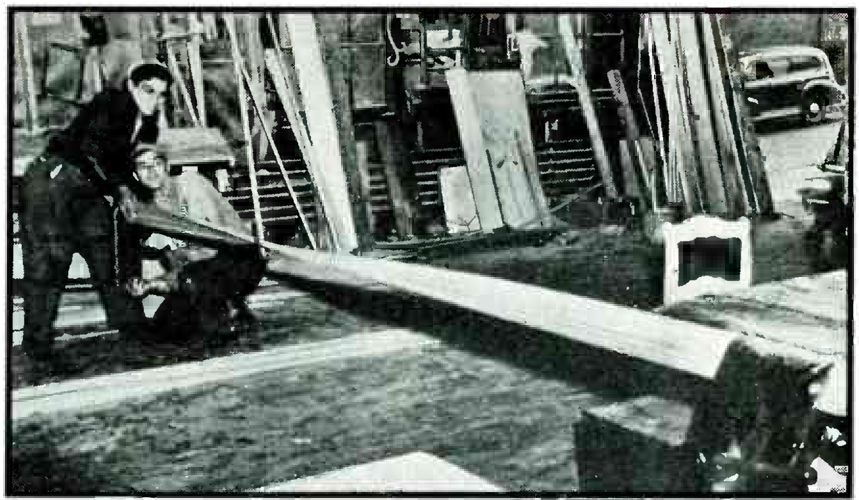
Time for complete setting of the glue has been reduced from eight hours to twenty minutes. Production capability of a single small plant has been upped from 25 spars per day to 200 spars per day. Even more important—the use of r.f. has made it feasible to use smaller pieces of wood, thus overcoming a 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-





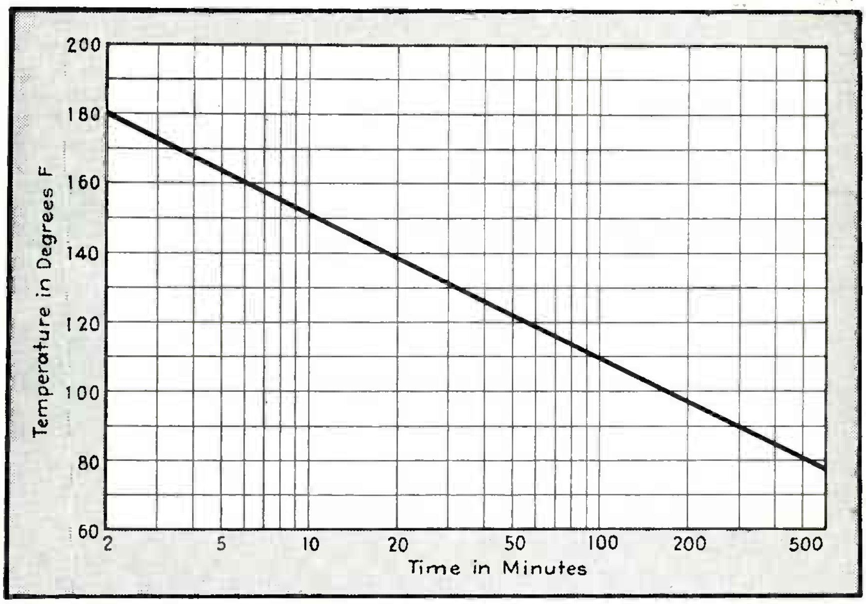


FIG. 2 (above)—Steps in the construction of multi-laminar spar showing (a) narrow boards edge-glued to obtain 6-in. widths, (b) short boards scarf-glued to obtain 16½-ft length, (c) ¾ x 6-in. boards flat-glued to obtain 6 in. x 6 in. x 16½-in. block, (d) block sawed vertically to obtain edge-grain laminated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

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

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

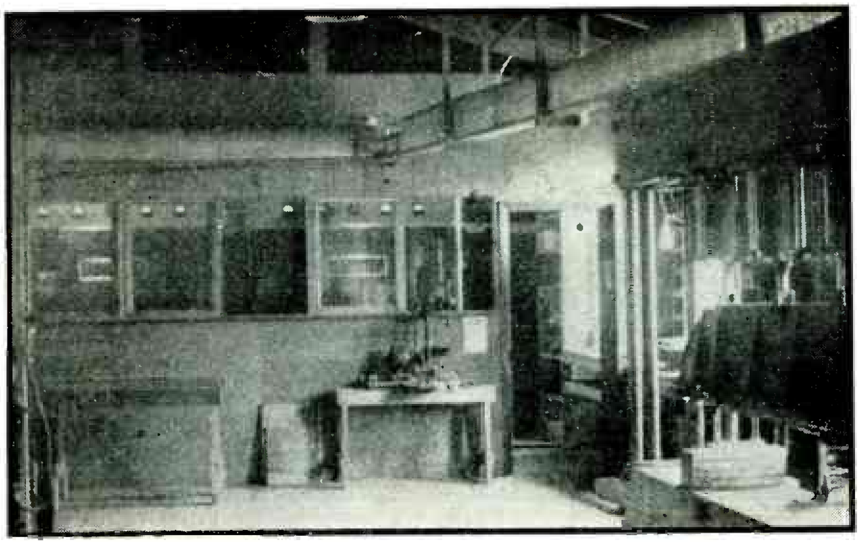


FIG. 5—Radio-frequency equipment installed at Tolerton Lumber Company, Alliance, Ohio, for making laminated spars. The r-f generator is located in the room in the background. Transmission lines consisting of sheet-metal outer conductors and copper tubing inner conductors can be seen running around the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

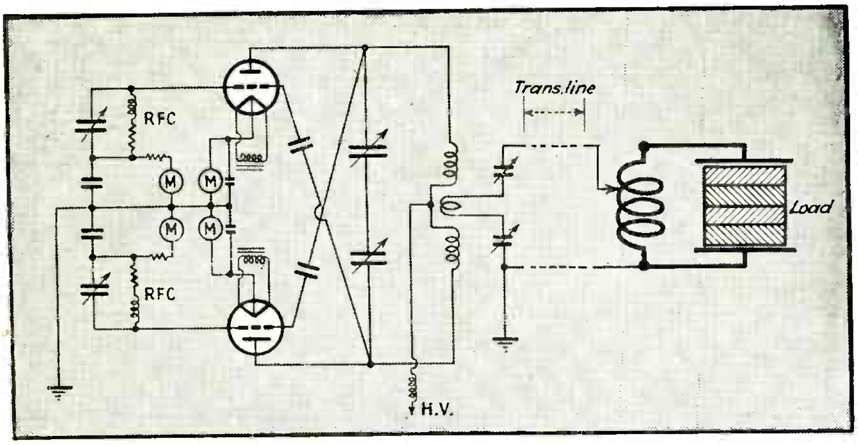


FIG. 6 (above)—Simplified schematic of the r-f generator used in the installation pictured in Fig. 5. The load is tuned by means of inductances in parallel, facilitating the use of transmission lines between generator and load

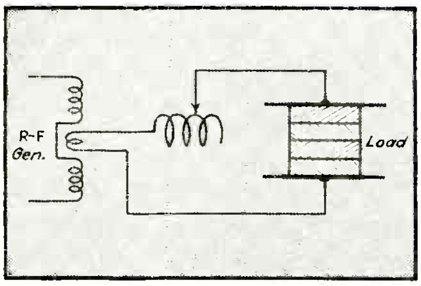


FIG. 7 (right)—An alternative load tuning circuit using series inductance. This arrangement can be used only when the r-f generator is close to the load

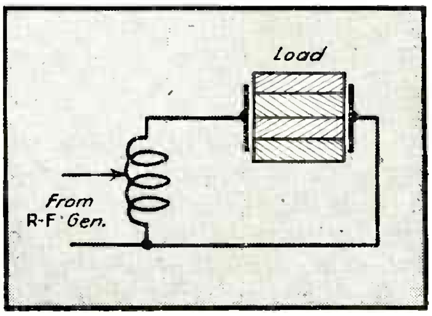


FIG. 8 (below at right)—Arrangement for gluing by concentrating flow of current through the glue lines

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 16½ ft long. This block is then sawn vertically into six strips, each ¾ in. x 6 in. x 16½ ft as shown in Fig. 2d. This laminated plank, which looks as though it had been assembled from a number of ¾-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 ¾-in. thick boards are used), it is in some ways actually stronger than a spar made from a single plank. Such a spar, ¾ in. x 6 in. x 16½ 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,

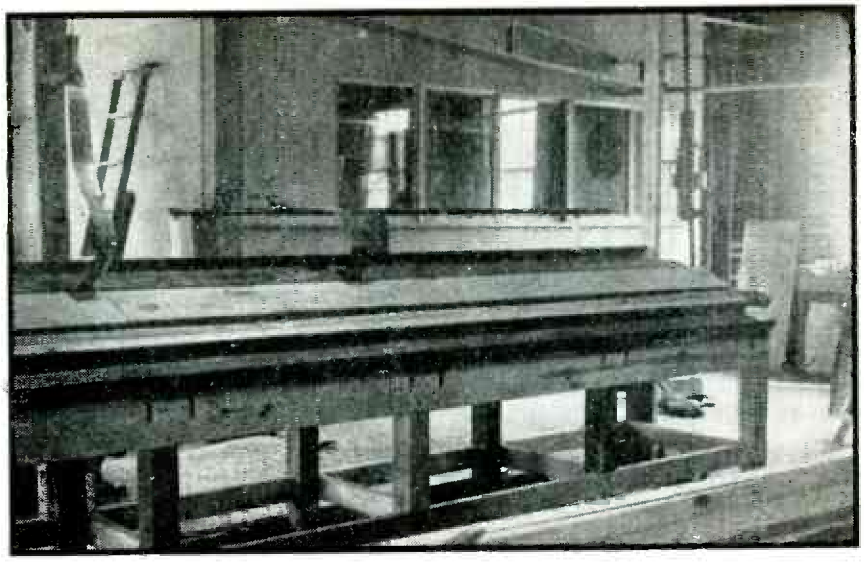


FIG. 9—One end of a special press used for edge-gluing. The fire-hose at the front of the press is utilized to provide fluid pressure along the length of the boards to be edge-glued

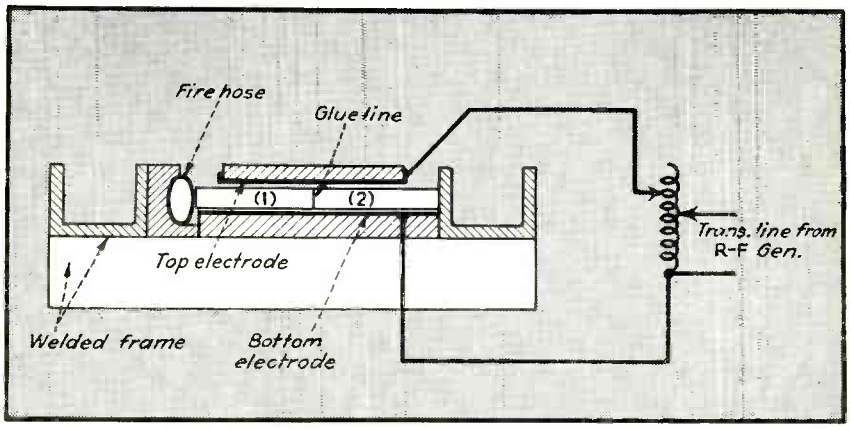


FIG. 10—End view of the edge-gluing press, showing how two boards (1) and (2) are edge-glued by the use of electrodes arranged so that the current flows through the glue line

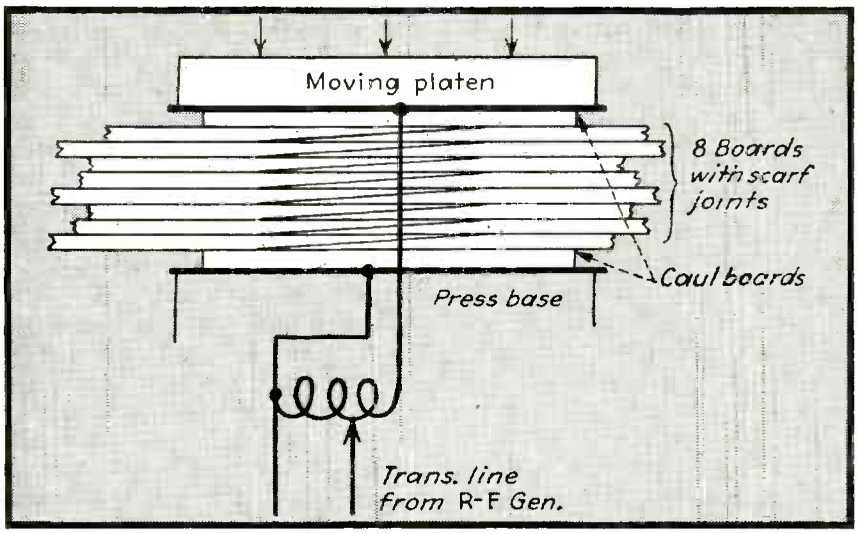


FIG. 11—Arrangement of electrodes for gluing scarf joints in a number of short boards to make up the required 16½-ft lengths

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

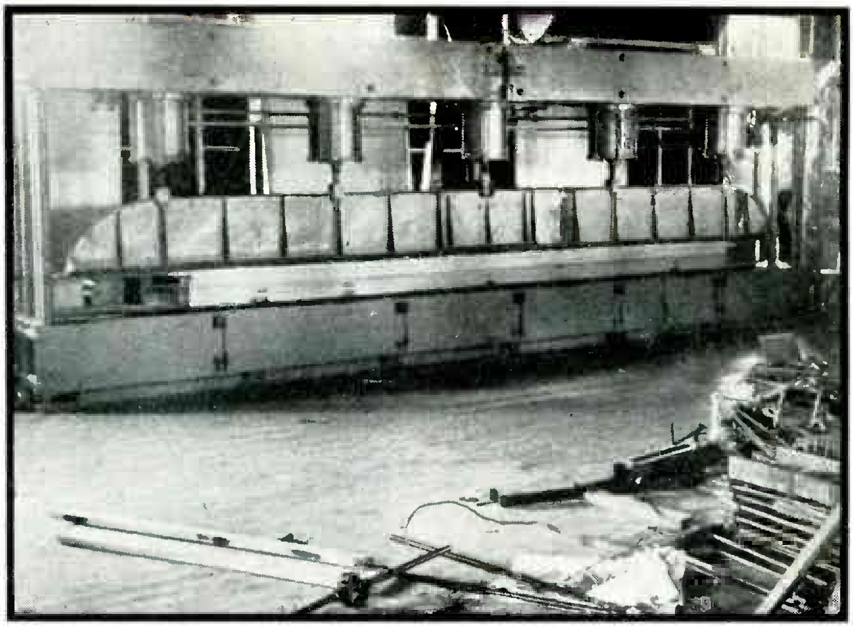


FIG. 13 (right)—Large press used in gluing up the 6 in. x 6 in. x 16½-ft blocks from which multi-laminar spars are sawed

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*)

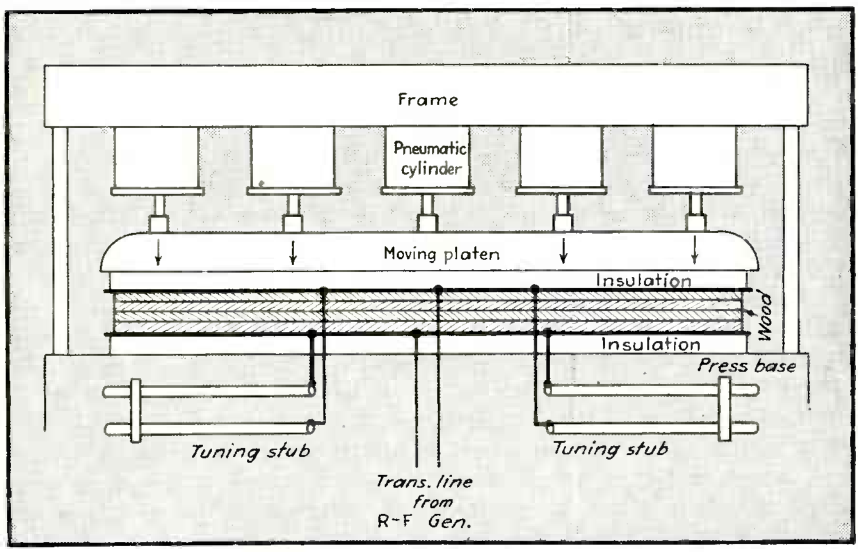


FIG. 14—Arrangement of electrodes and tuning inductances (stubs) on the large press. Two tuning inductances are used in order to reduce voltage variation due to the standing wave along the platen

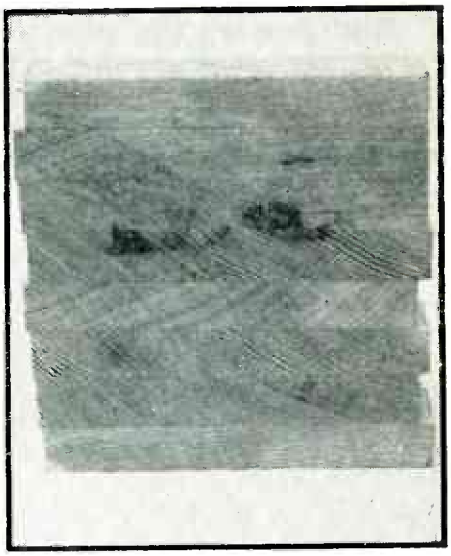


FIG. 15—Piece cut from the end of the 6 in x 6 in. x 16½-ft block from which the multi-laminar spar is cut

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.

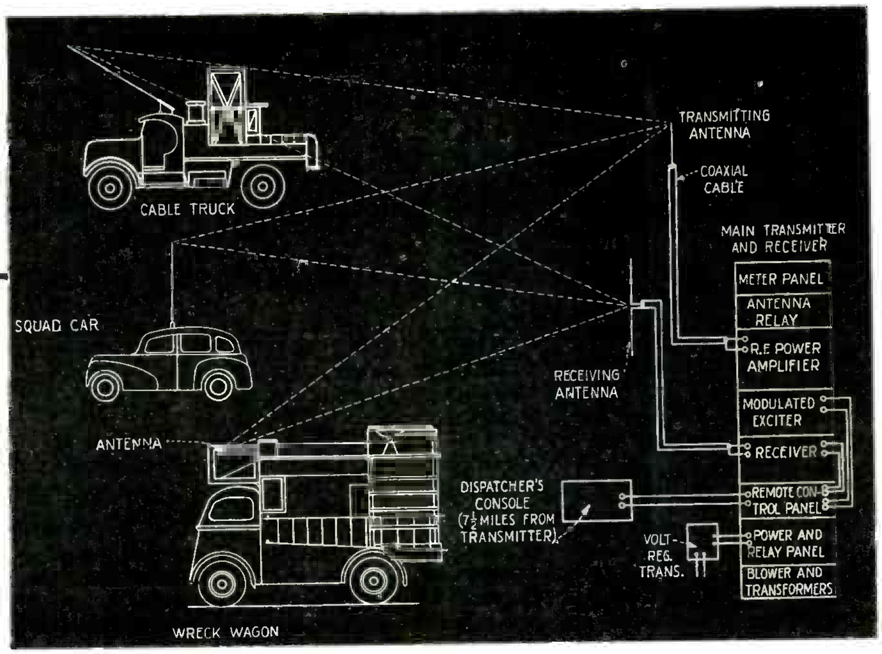
The system fulfills an important need when fires, floods, accidents or other emergencies endanger life and property and normal communication is not readily available. It has even been called upon to obtain medical attention for streetcar passengers suddenly taken ill, and in at least one case a squad 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.

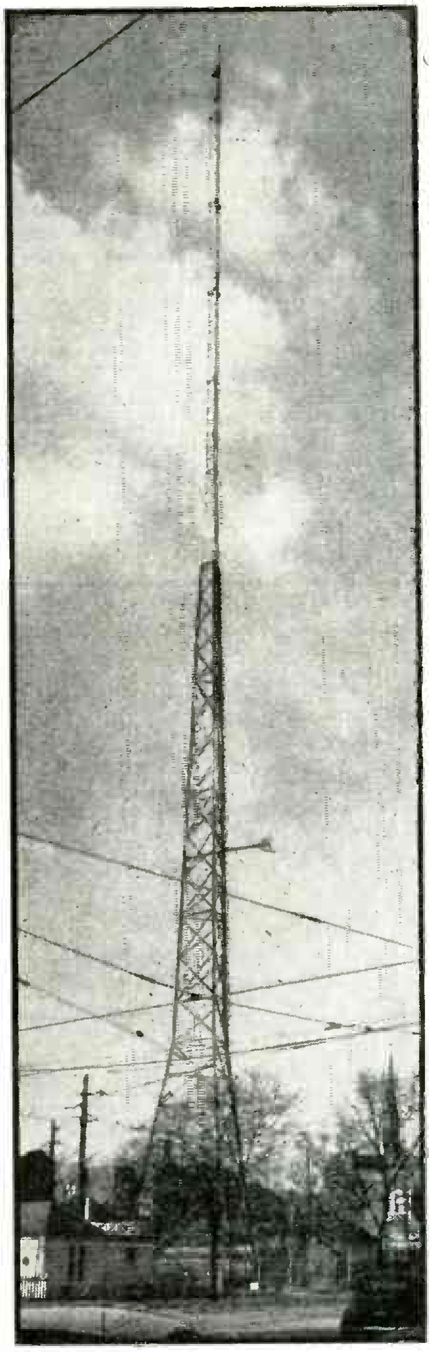
With an area of some one-hundred square miles, Chicago has a population of approximately three and one-half million persons served by several transportation systems, of which the largest is the Chicago Surface Lines. This system provides approximately four million passenger rides per day by means of 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.

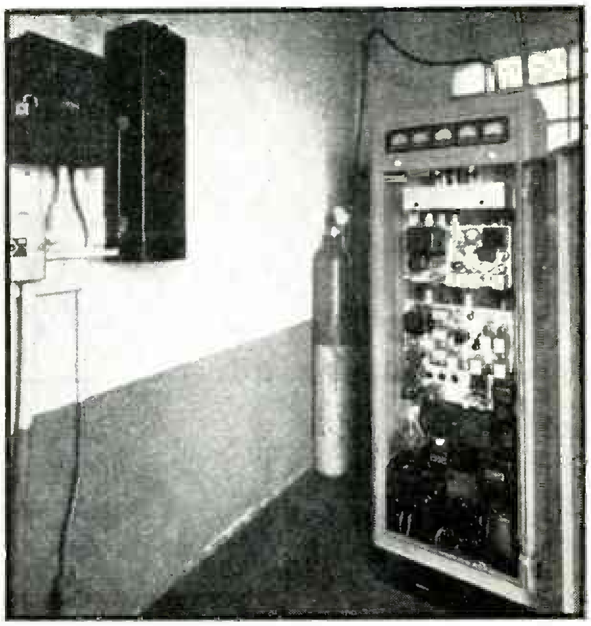
The operation and maintenance of so vast a transportation system requires an elaborate means of communication which in the past has been provided largely by telephone service. Telephone service, however, has been found inadequate for meeting the various emergencies which must necessarily be expected 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

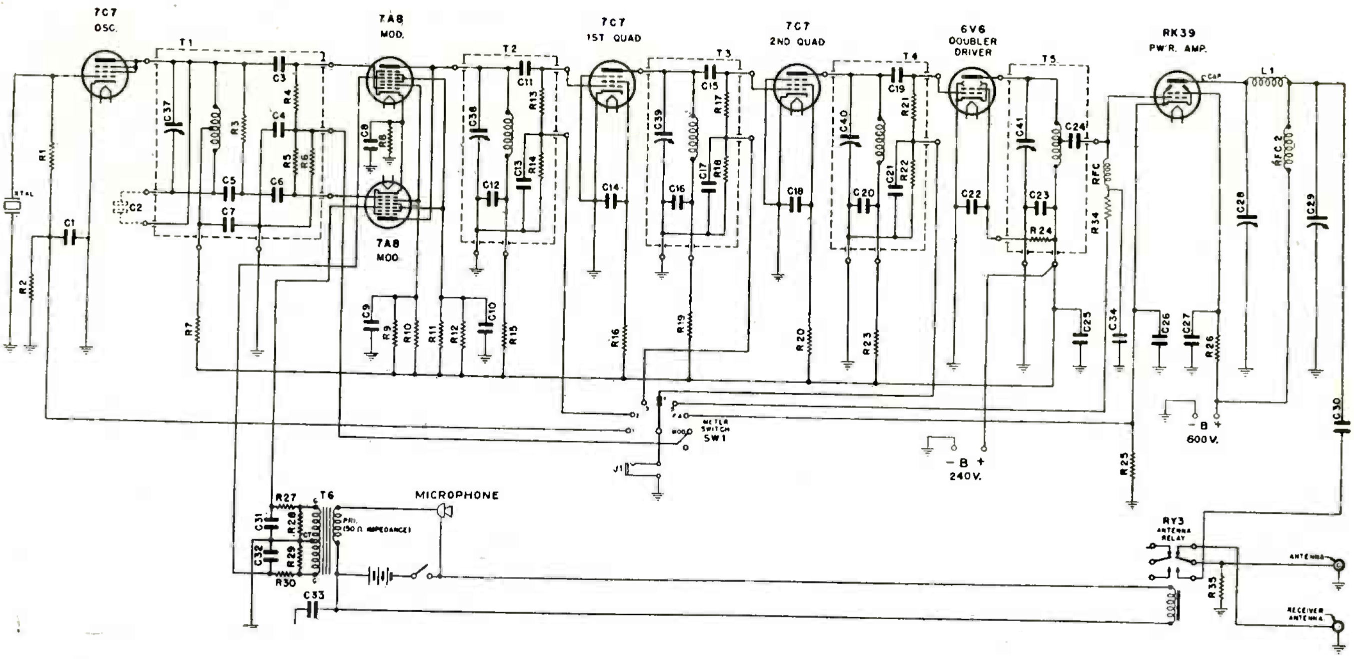


FIG. 2—Simplified schematic wiring diagram of p-m mobile transmitter delivering 30 watts. A similar unit, but with two 807 (or RK39) tubes in parallel in the final r-f stage, and powered from a rectifier-filter system rather than from storage batteries and a generator, is used as the exciter unit for 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	C13—2,000 μμf, 500 v	C25—0.05 μf, 600 v	C37 to C41—trimmers	R12—33,000 ohms	R24—2,200 ohms
C2 —50 μμf, 400 v	C14—2,000 μμf, 500 v	C26—5 to 44 μμf	R1 —470,000 ohms	R13—220,000 ohms	R25—½ ohm
C3 —100 μμf, 400 v	C15—100 μμf, 400 v	C27—50 μμf, 200 v	R2 —1,000 ohms	R14—100 ohms	R26—20,000 ohms
C4 —2,000 μμf, 500 v	C16—2,000 μμf, 500 v	C28—50 μμf, 400 v	R3 —10,000 ohms	R15—1,000 ohms	R27—22,000 ohms
C5 —10 μμf, 400 v	C17—2,000 μμf, 500 v	C29—500 μμf, 400 v	R4 —47,000 ohms	R16—150,000 ohms	R28—220,000 ohms
C6 —100 μμf, 400 v	C18—2,000 μμf, 500 v	C30—0.05 μf, 600 v	R5 —47,000 ohms	R17—220,000 ohms	R29—220,000 ohms
C7 —5,000 μμf, 300 v	C19—100 μμf, 400 v	C31—0.05 μf, 600 v	R6 —100 ohms	R18—100 ohms	R30—22,000 ohms
C8 —20 μf, 25 v	C20—2,000 μμf, 500 v	C32—0.05 μf, 600 v	R7 —4,700 ohms	R19—1,000 ohms	R31—470 ohms
C9 —0.05 μf, 600 v	C21—2,000 μμf, 300 v	C33—5 to 44 μμf	R8 —330 ohms	R20—150,000 ohms	R32—5,000 ohms
C10—0.05 μf, 600 v	C22—5,000 μμf, 300 v	C34—50 μμf, 200 v	R9 —100,000 ohms	R21—220,000 ohms	R33—18 ohms
C11—100 μμf, 400 v	C23—2,000 μμf, 500 v	C35—50 μμf, 200 v	R10—100,000 ohms	R22—100 ohms	R34—22,000 ohms
C12—5,000 μμf, 300 v	C24—50 μμf, 400 v	C36—5 to 44 μμf	R11—33,000 ohms	R23—1,000 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

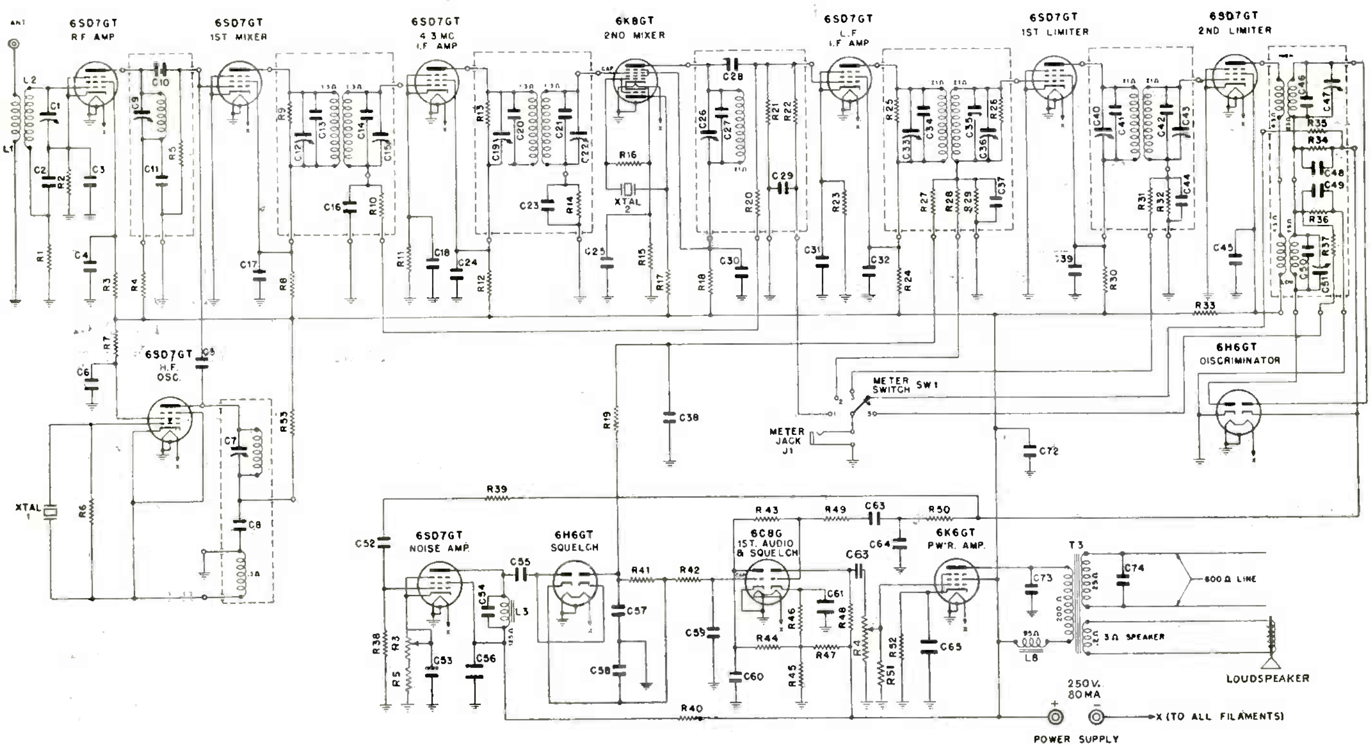
Flexibility of operation has been one of the foremost design characteristics in establishing this radio system. Not only is the equipment of one mobile unit interchangeable with that mounted on any other mobile unit, but with minor modifications which may be easily effected, the same equipment is used 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.

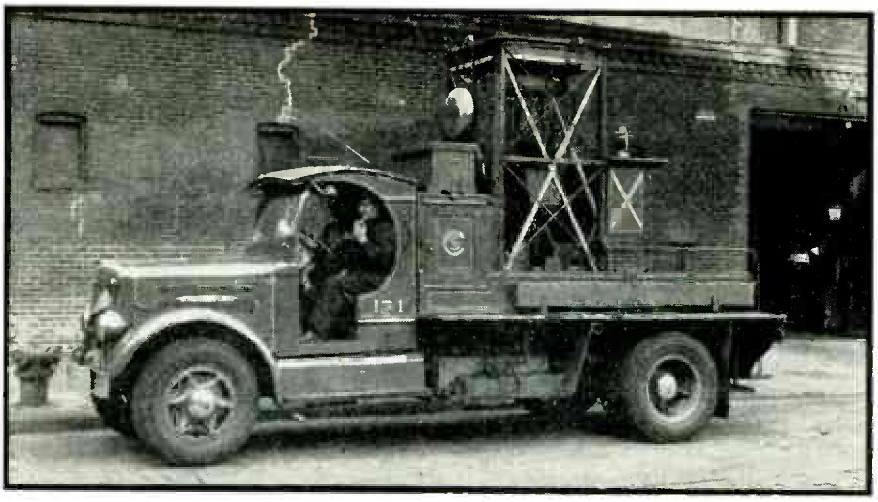
A complete installation for a mobile unit includes the following equipment: (1) antenna; (2) receiver; (3) transmitter; (4) control head; (5) microphone; (6) connecting cable; (7) accessory kit and instruction-service manual.

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.

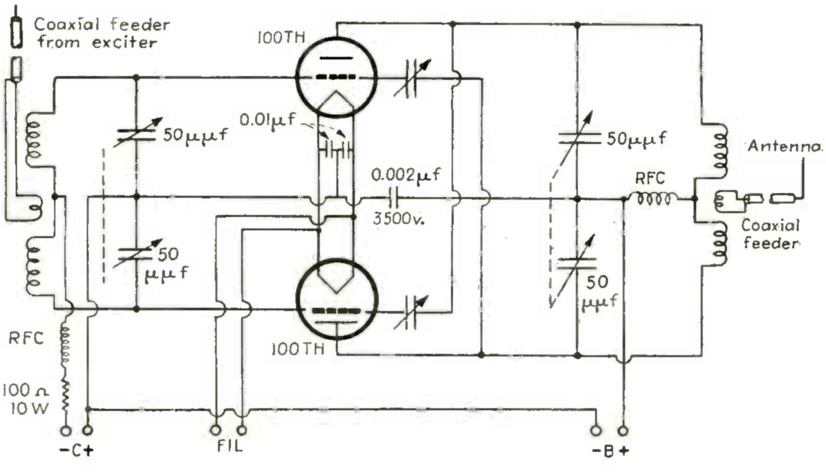
A simplified schematic wiring diagram of the mobile transmitter is shown in Fig. 2. The transmitter employs a 7C7 oscillator connected as a triode, two frequency quadrupling stages each using a 7C7 tube, and a frequency doubler using a 6V6 beam power tube whose power output is fed to the grid circuit 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

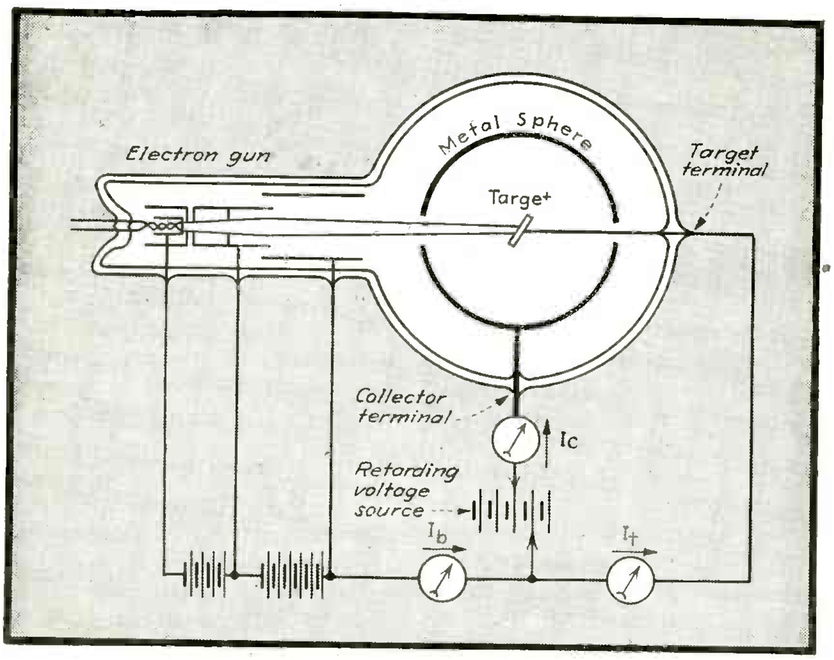
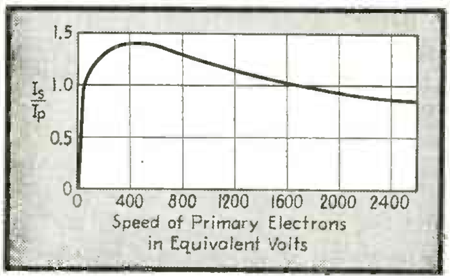


FIG. 1 (above)—Essential features of special cathode-ray tube developed for studying electron bombardment of target surfaces

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



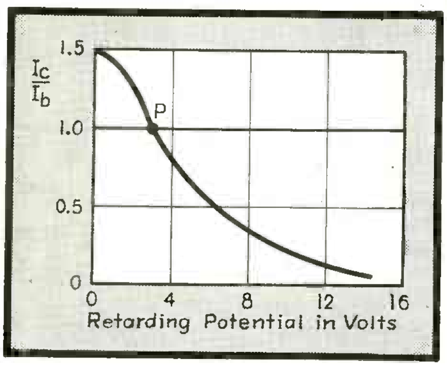


FIG. 3 (left)—Ratio of collector current to beam current as plotted against negative retarding potential (collector negative with respect to target) when using a pure nickel target and a fixed primary electron speed of 500 equivalent volts in the cathode-ray tube of Fig. 1

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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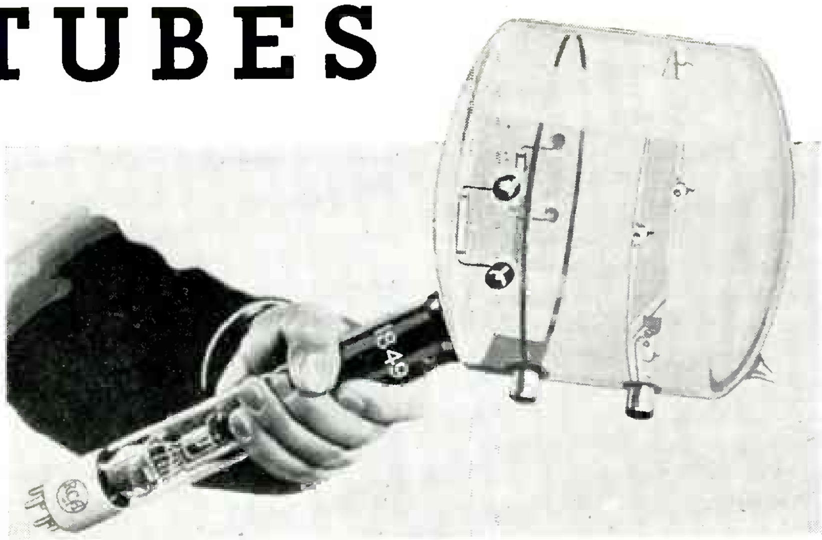
TUBES



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

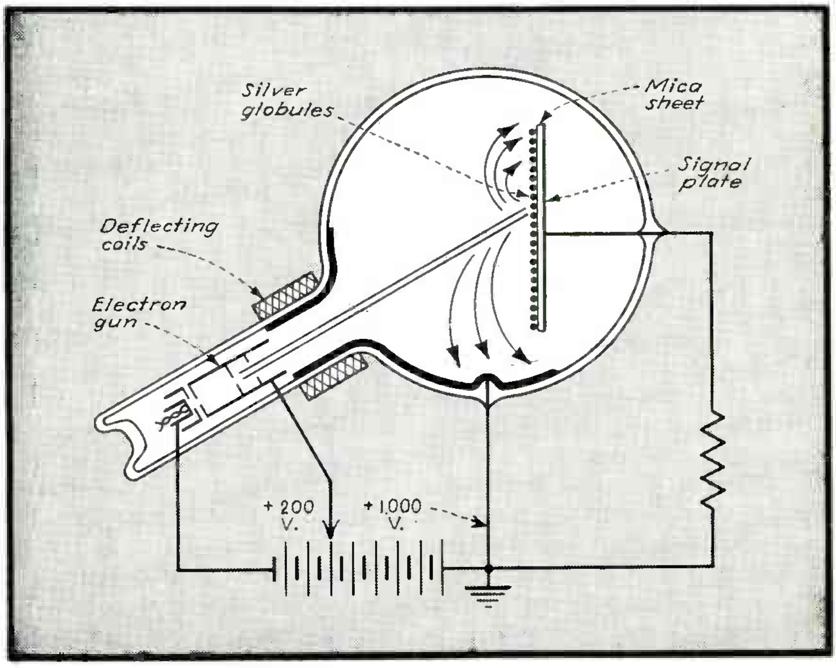


FIG. 4—Essential features of a standard Iconoscope for electronic television cameras

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

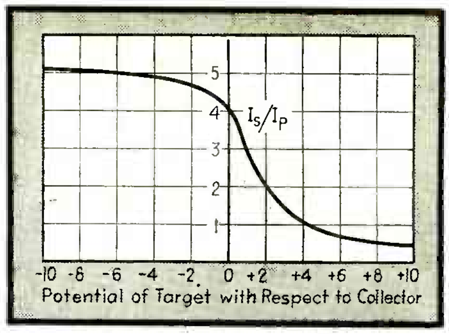


FIG. 5—Secondary emission characteristic of photosensitized silver

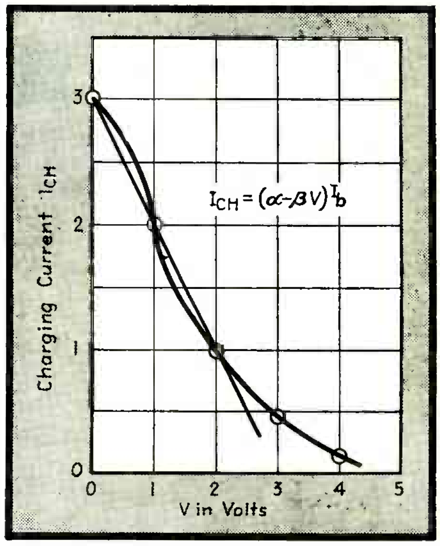


FIG. 6—Charging current characteristic of an Iconoscope mosaic

distribution of secondaries changes little.

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

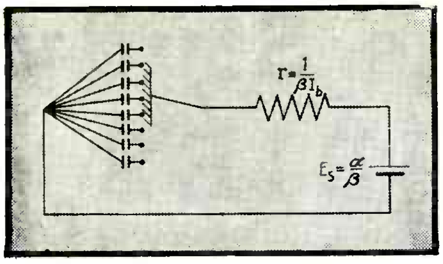


FIG. 7—Equivalent circuit of a dark mosaic undergoing scanning

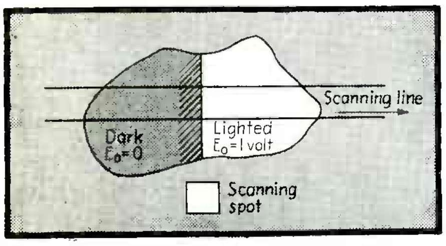


FIG. 8—Scanning from a dark area into a lighted area

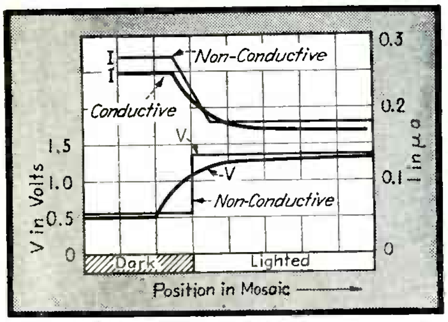


FIG. 9—Transient charging current *I* and mosaic potential *V* during scanning

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

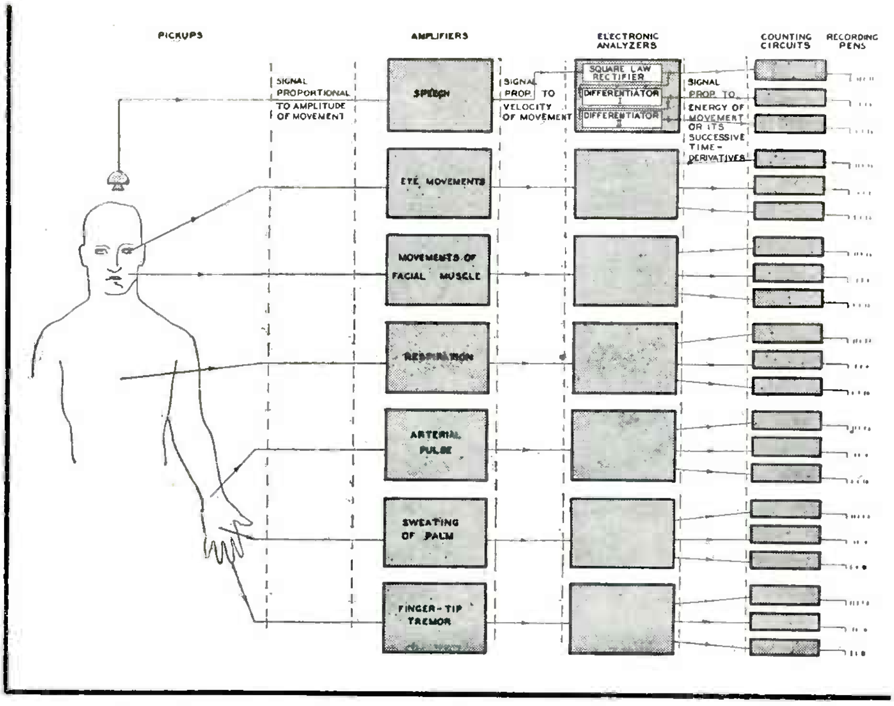


Fig. 1—Block diagram showing seven indicators attached to various parts of the patient, and the successive amplifying, analyzing, counting and recording stages for each indicator

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

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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-

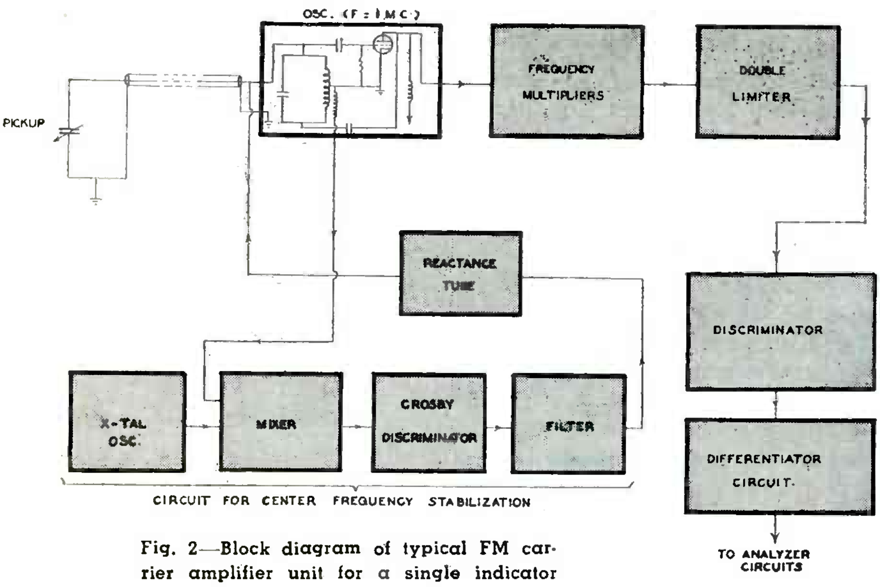


Fig. 2—Block diagram of typical FM carrier amplifier unit for a single indicator

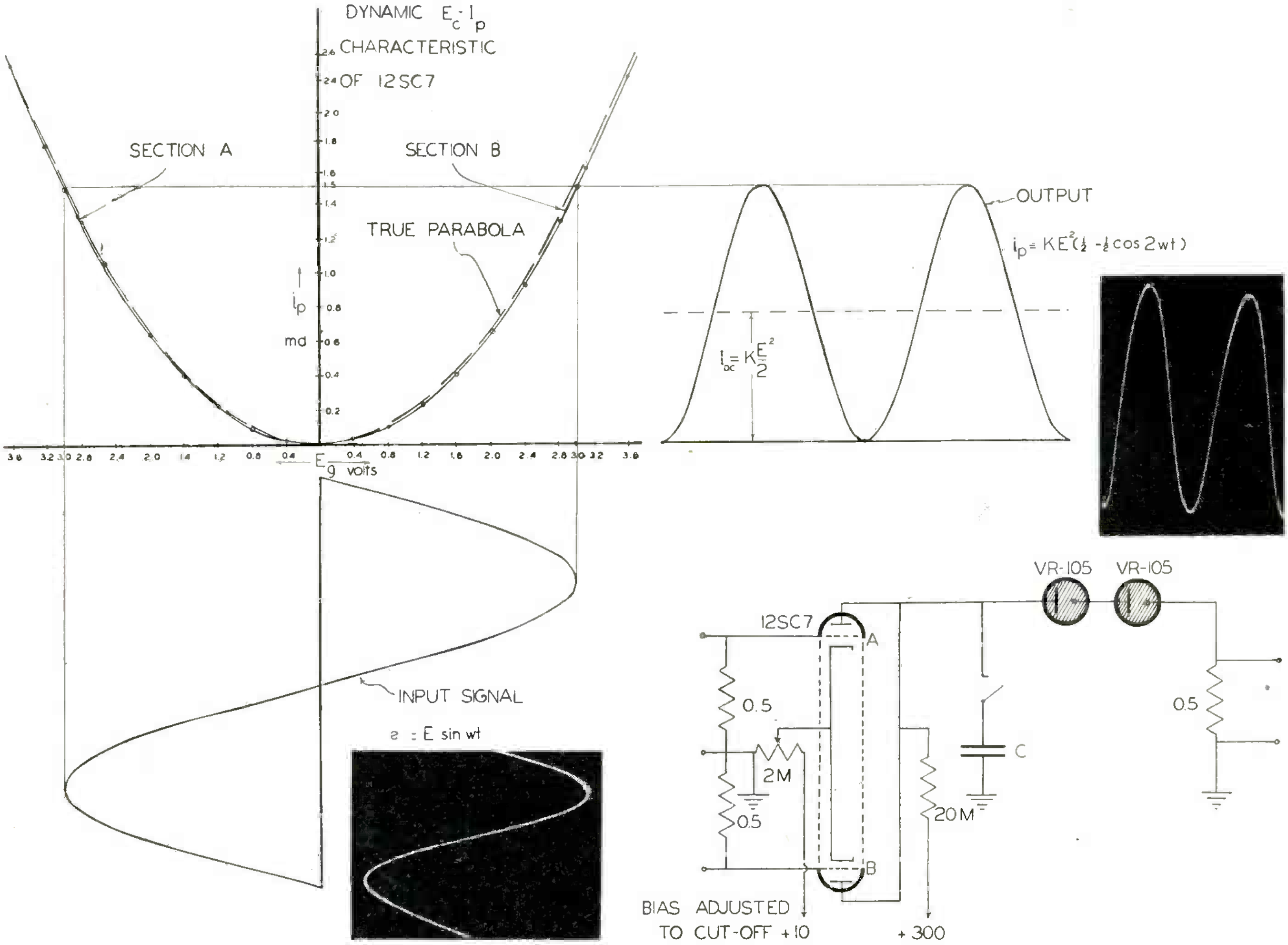


FIG. 3—Square-law rectifier circuit for converting the velocity-time signal into an energy-time signal, and characteristic operating curves. Curves for sections *A* and *B* are plotted back to back in order to show the operation of a stage having push-pull input and parallel output. Projection of the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

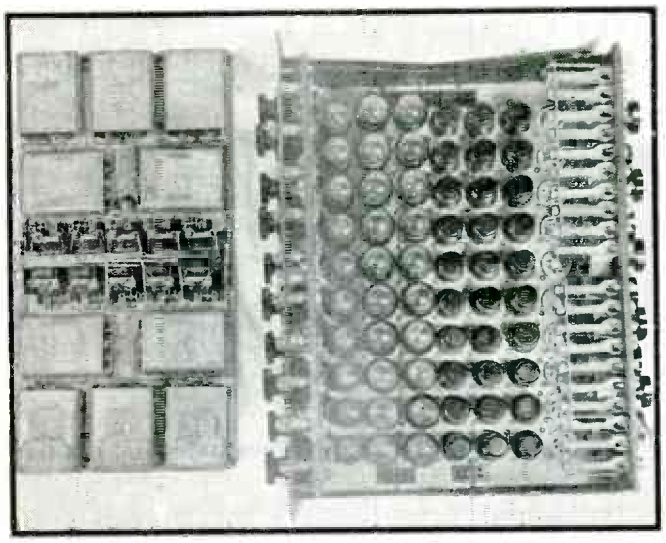
The Technical Problem

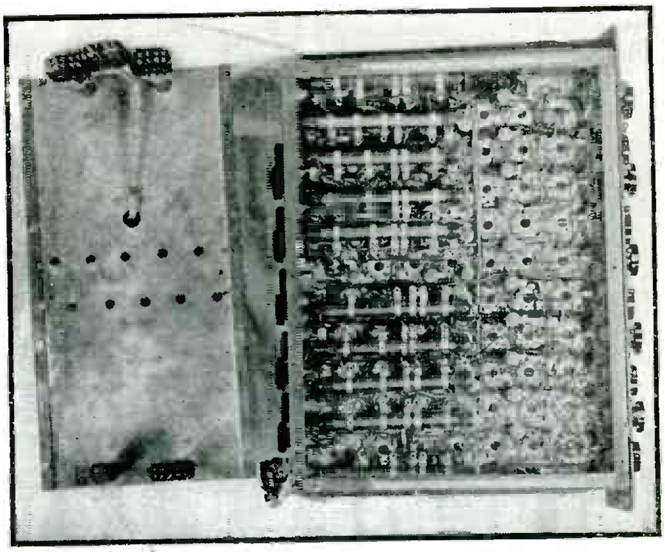
The problems facing the engineer engaged in such work are, on the whole, somewhat different from the average development work in communications. One is soon impressed with the fact that a precise analysis is to be attempted of perhaps the most complex mechanism in existence, of which an almost random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





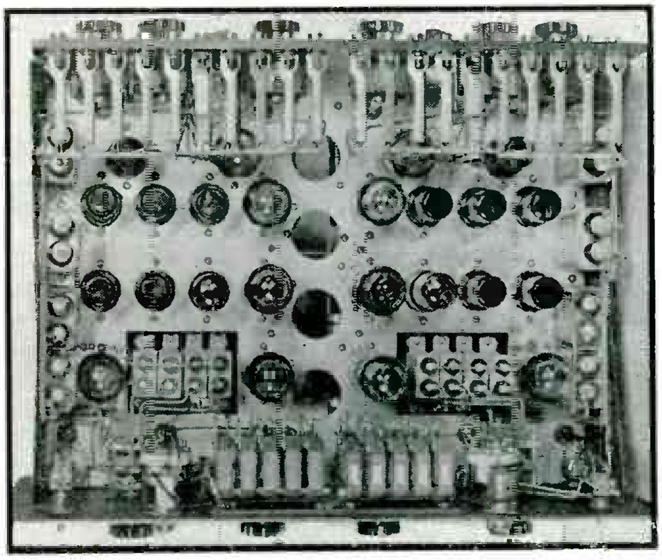
Top and bottom views of the chassis containing ten of the counter circuits of Fig. 5. With 60 tubes on a single chassis (10-35L6, 20-VR-105, 20-12SJ7 and 10-12SC7), a top deck (at left in each view) had to be provided for some of the parts

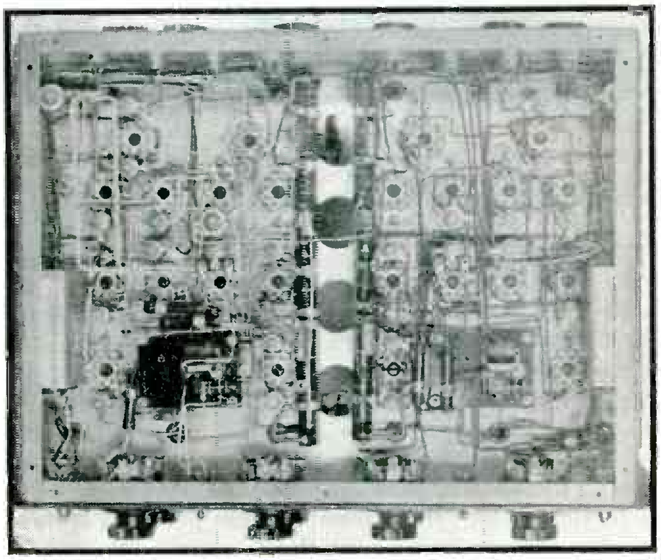
that the degree of control that the nerve centers have on a given organ may be related directly to the average rate at which nerve impulses are dispatched to and received by the organ. There is no way this can be measured at present in a clinically applicable manner. But we may seek some aspect of the 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.

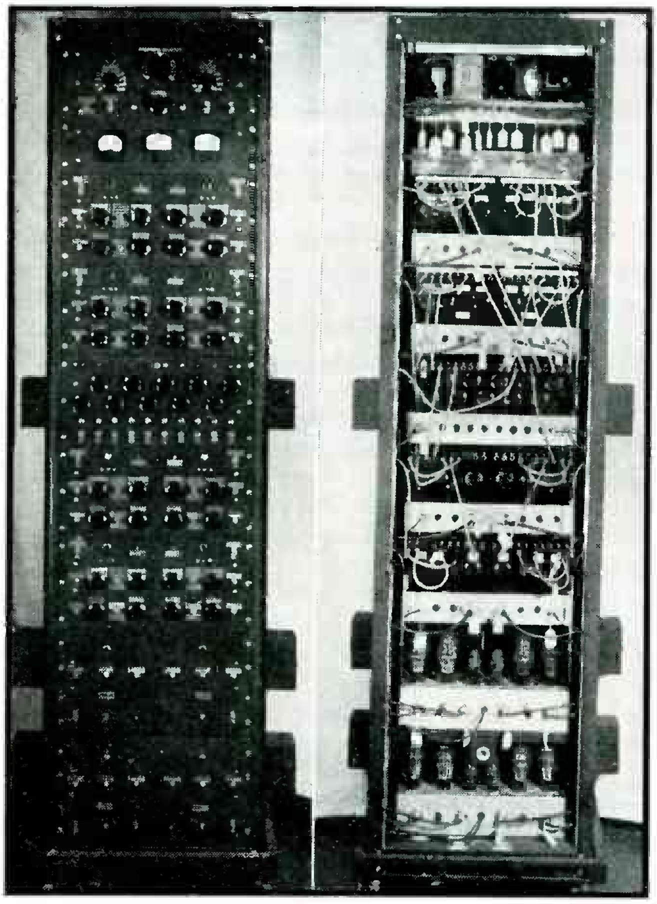
This orientation is, of course, necessarily over-simplified, but accurate measurements are meaningless on the requirements of the apparatus itself.

Use of Carrier System

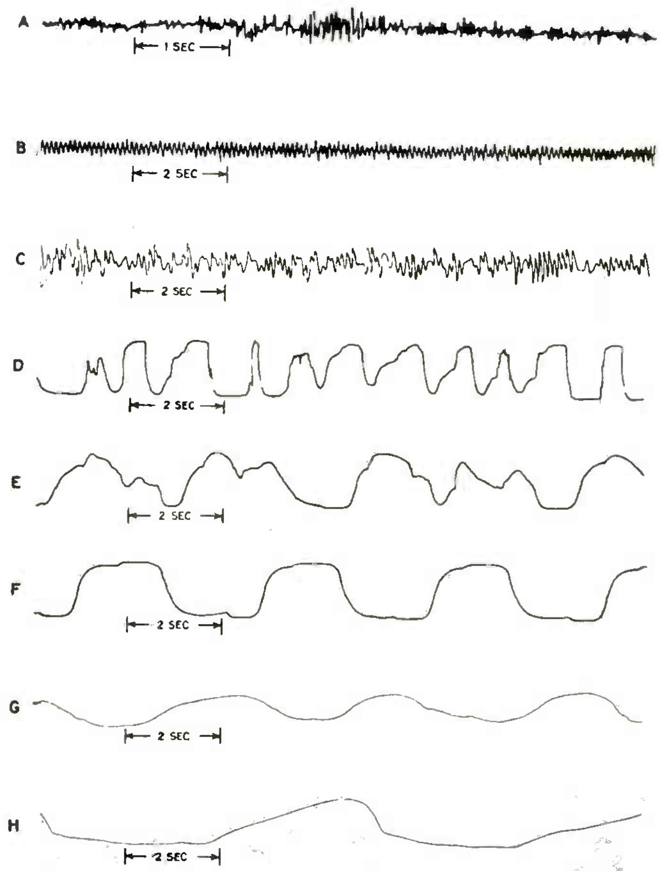
The instrumentation designed for use in this study is subject to many restrictions of both a technical and practical nature. The variations (except in speech) occur at sub-audio frequencies ranging from about 20 cps down to 0.05 cps, with the majority occurring in the neighborhood of 1 cps. Amplifiers 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

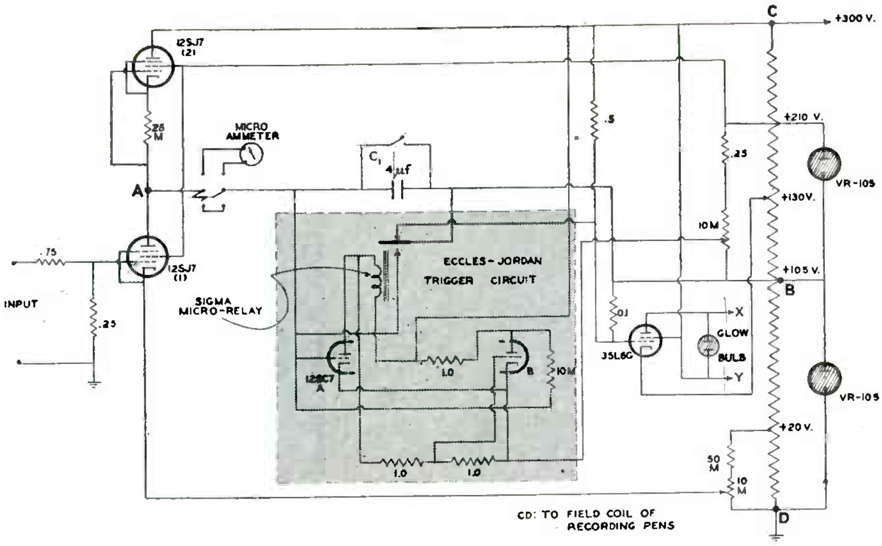
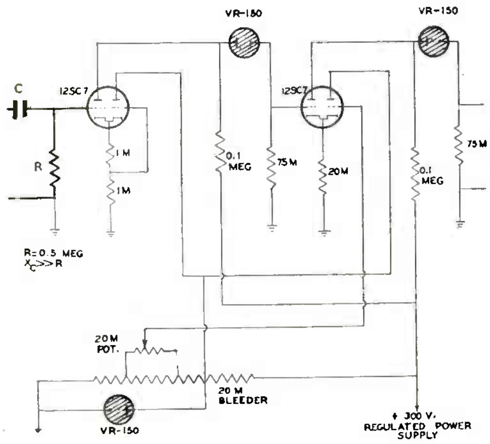


Fig. 4 (below)—Differentiating circuit (*R-C*) and amplifier circuit for very low-frequency signals to compensate for the insertion loss of the *R-C* circuit



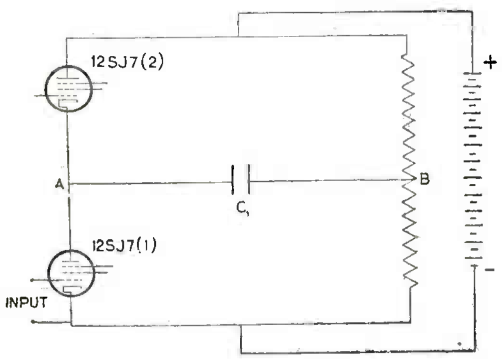


Fig. 6 (above)—Simplified diagram of vacuum-tube bridge in counter circuit of Fig. 5

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*)

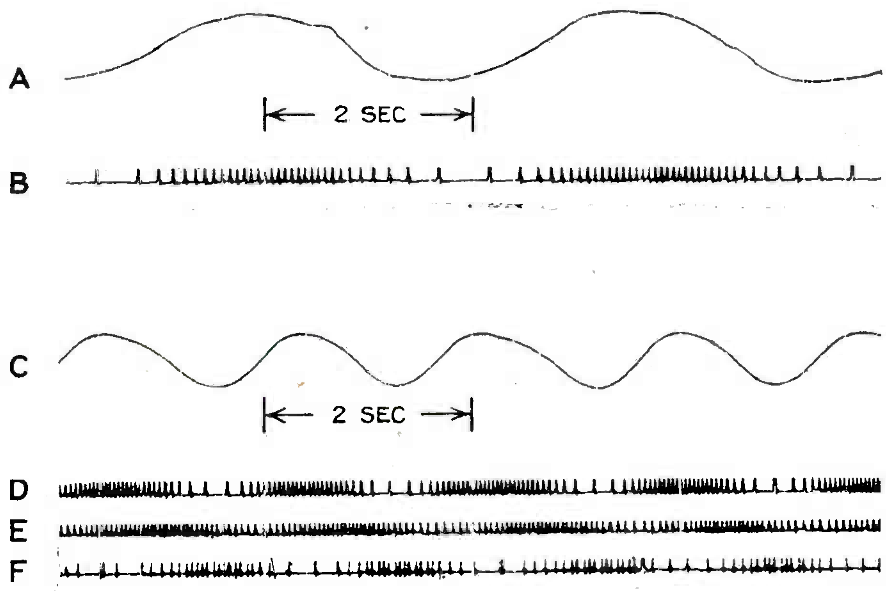
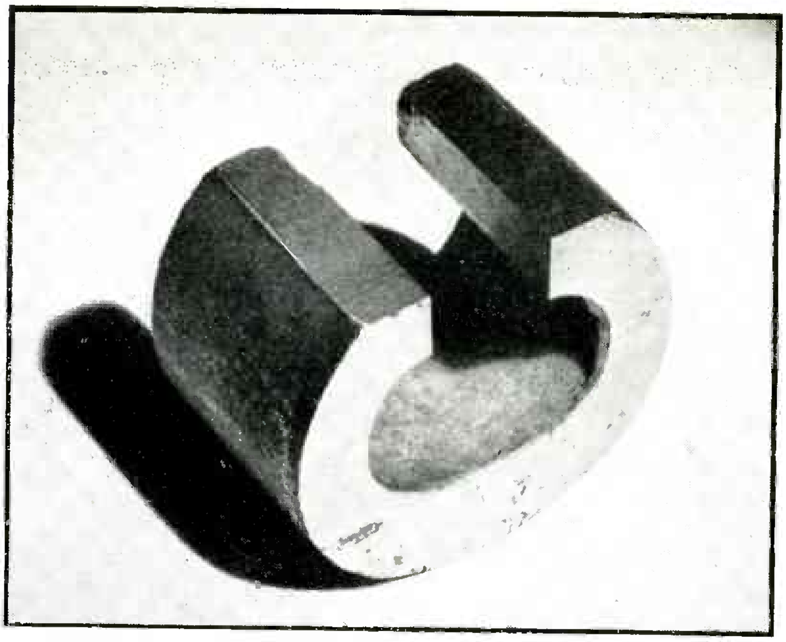


Fig. 7 (at right)—Examples of pulse patterns obtained in time-axis recording. *A* and *B* represent a normal breathing amplitude record with its corresponding time-axis record. *C* is an artificial amplitude signal, and *D, E* and *F* are respectively its time-axis record, the first time derivative and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

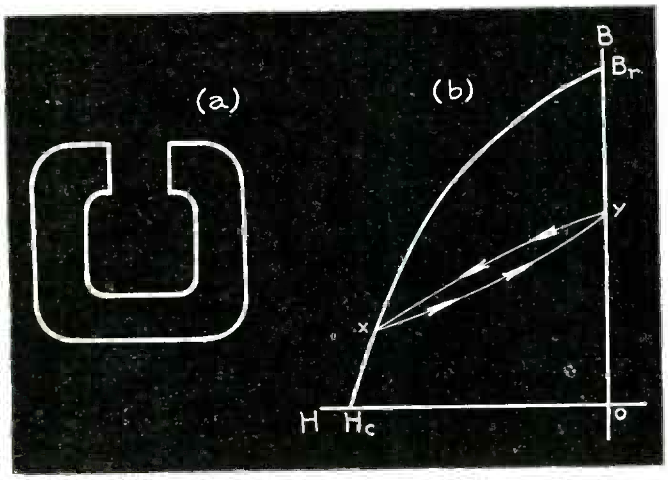


FIG. 1—Basic magnet shape considered in this article, and demagnetization curve showing minor hysteresis loop between x and y

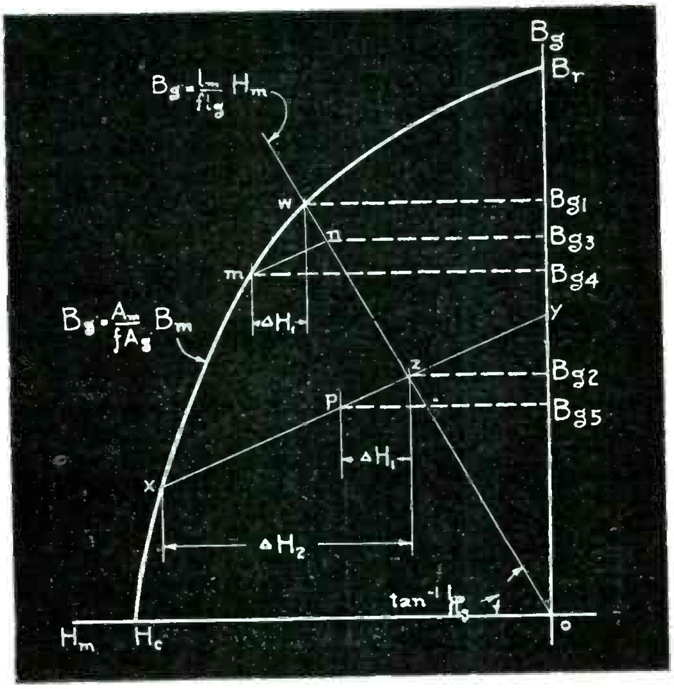


FIG. 2—Plot of Eq. (1) and (2), with minor hysteresis loops represented by straight lines x-y and m-n. This type of graph permits determining stabilizing effect of a demagnetizing field

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.

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

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

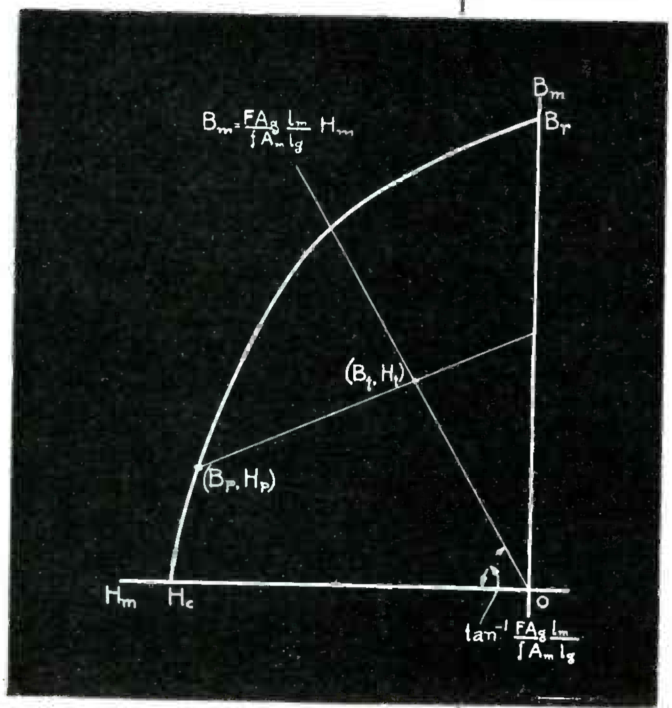


FIG. 3 Graph showing open-circuit condition for same problem as in Fig. 2

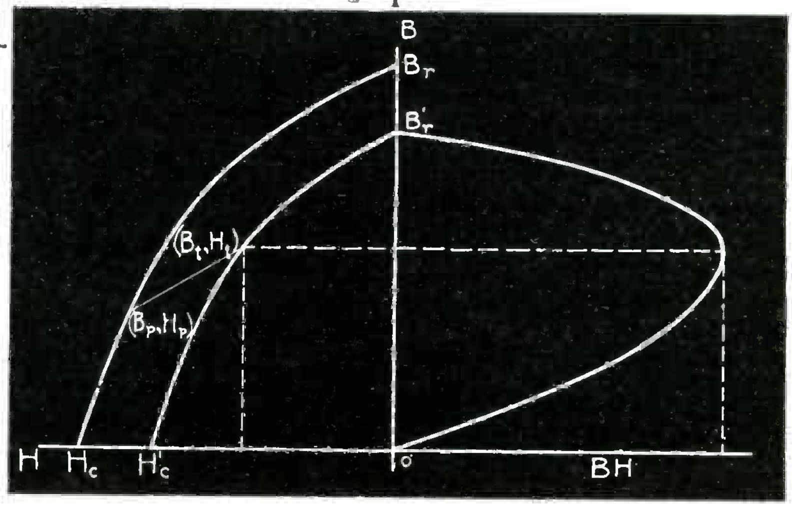


FIG. 4 Final graph, from which the operating point can be determined

* 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:

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

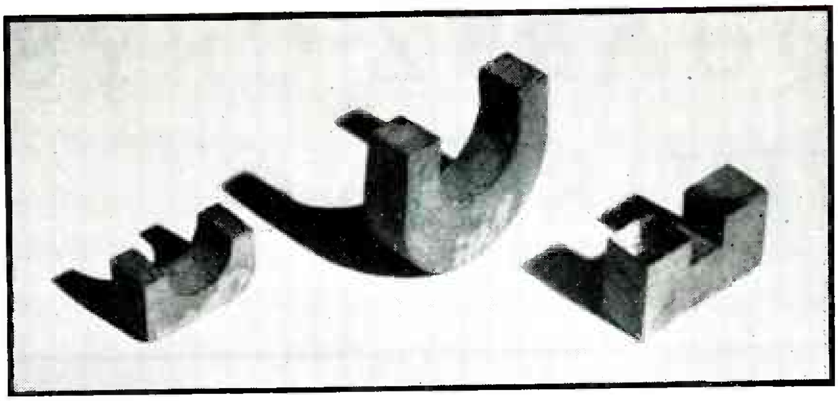
And thus we obtain a value for a, in terms of B_oH_o:

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

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

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

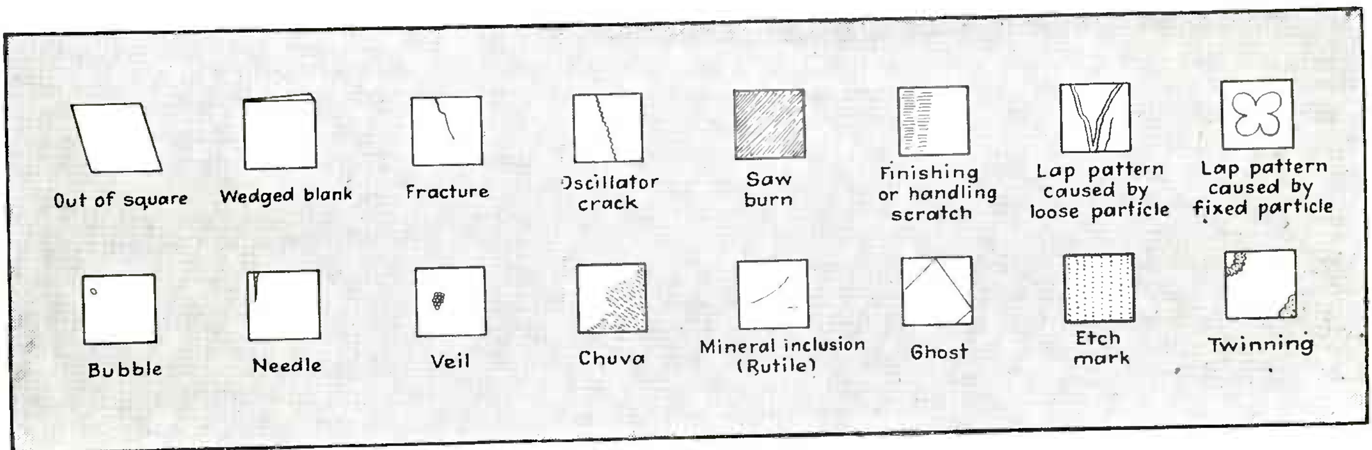


FIG. 3—Examples of imperfections in finished crystals. Finishers must instantly recognize such imperfections

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.

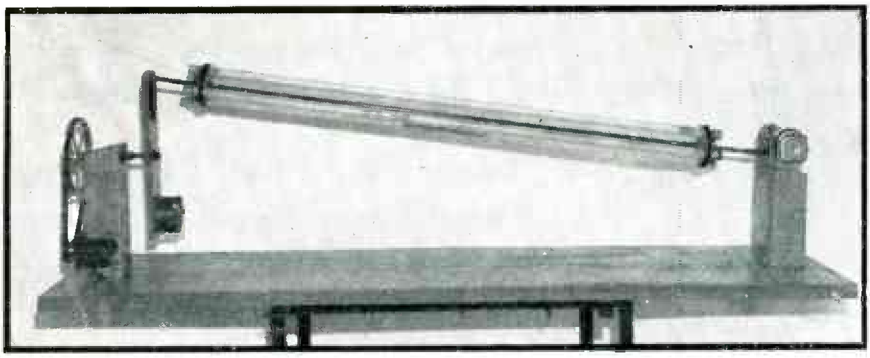


FIG. 5—An automatic "beveling" machine. Crystals and abrasives are placed in glass tubes equipped with baffles. The tubes are rotated and at the same time tilted up and down by means of a motor-driven eccentric

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.

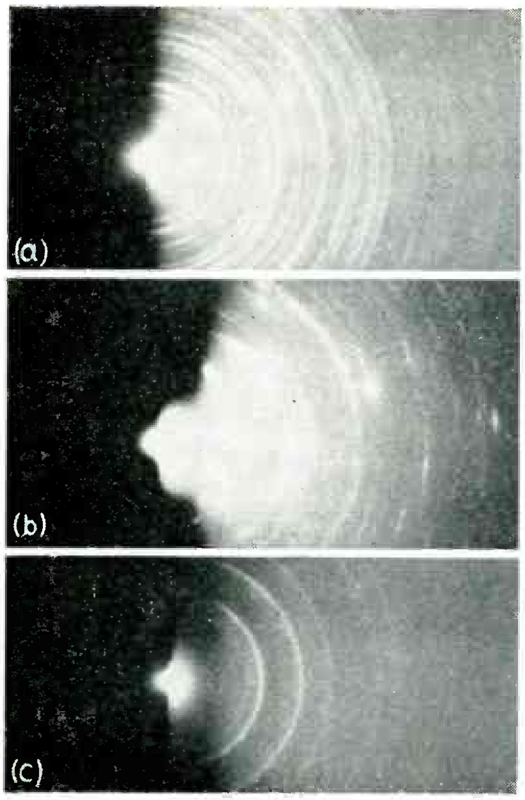
A machine has also been designed for beveling crystals. It is shown in Fig. 5, and is a tubular affair. Crystals are placed in the tubes along with a small amount of abrasive. The tubes rotate slowly, at the same time running on an eccentric so that they are tipped first towards one end and then toward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



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

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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-

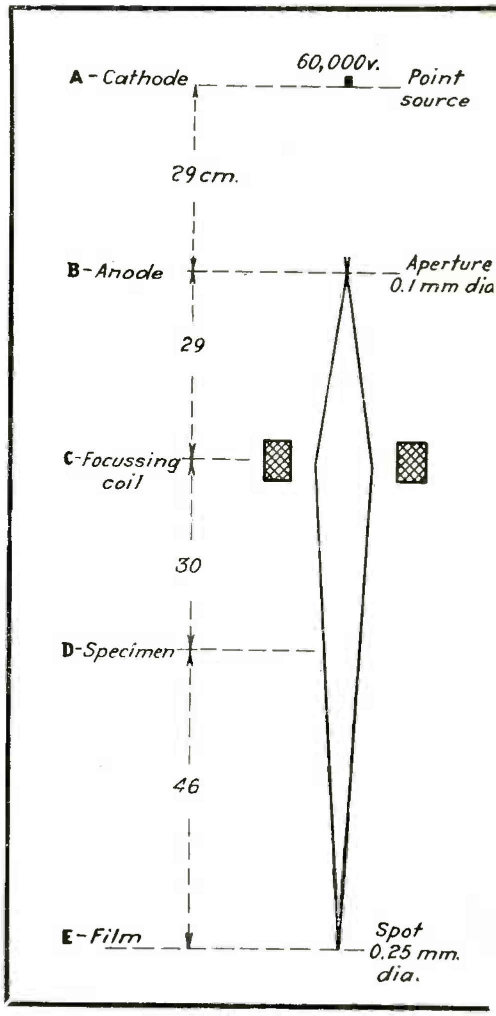

FIG. 1—Optics of electron diffraction camera

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

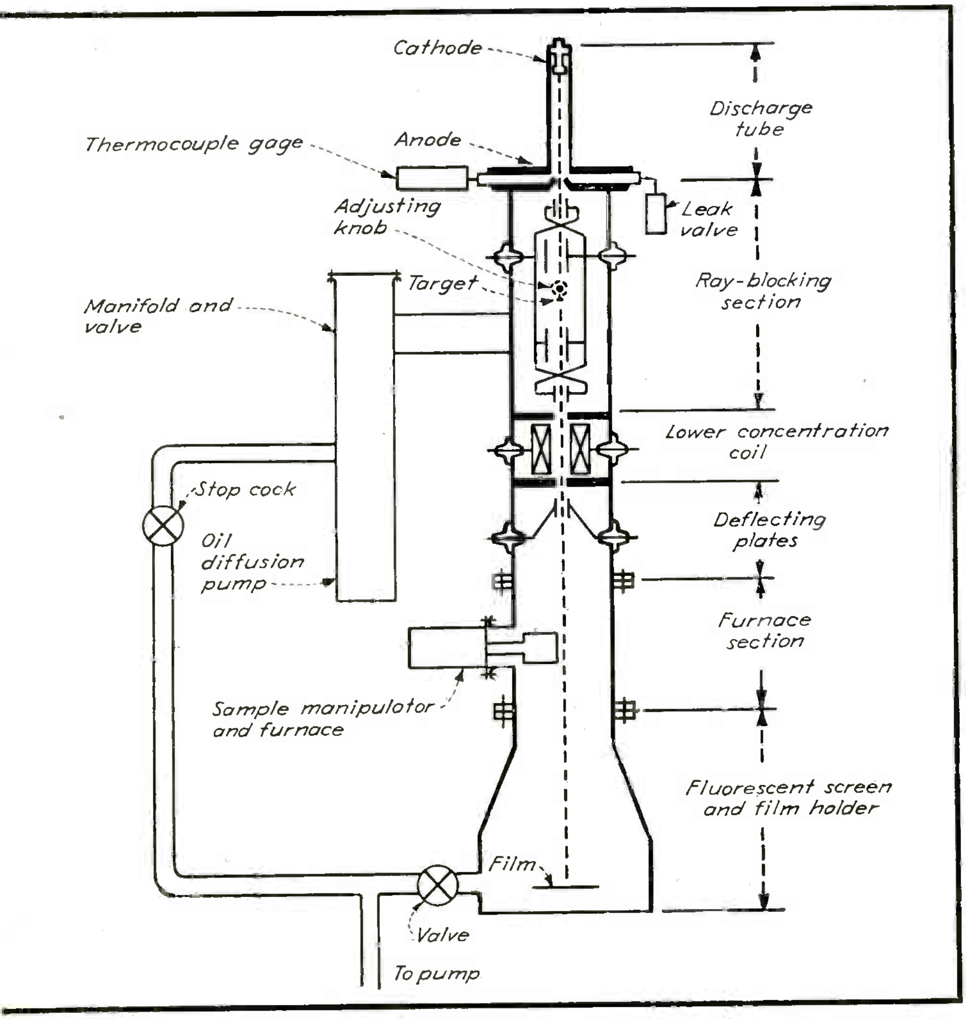

FIG. 2—Schematic diagram of electron diffraction camera

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.

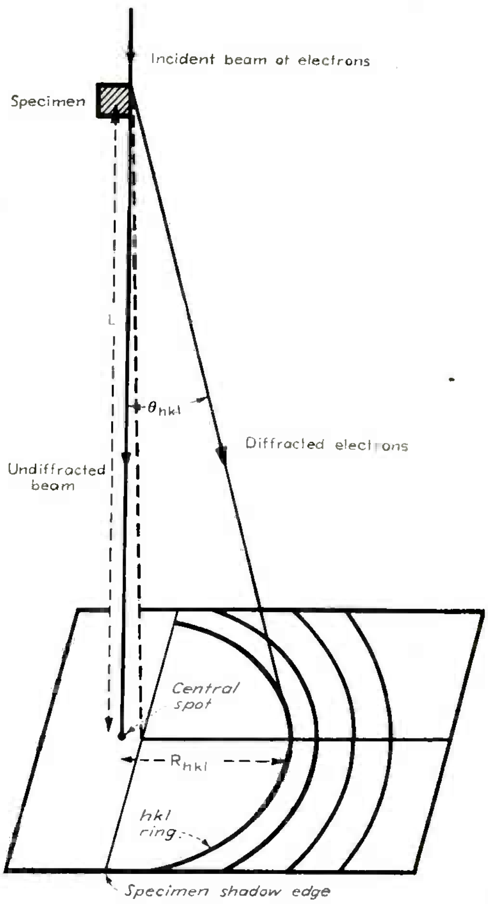

FIG. 3—Schematic diagram of variables involved in reflection patterns

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

Electronic Locator for SALVAGING TROLLEY RAILS

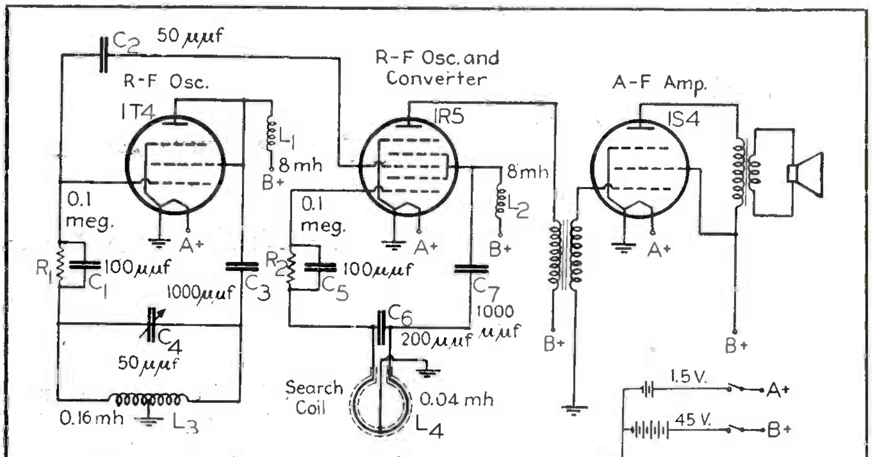

FIG. 1—Complete circuit of locator

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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.

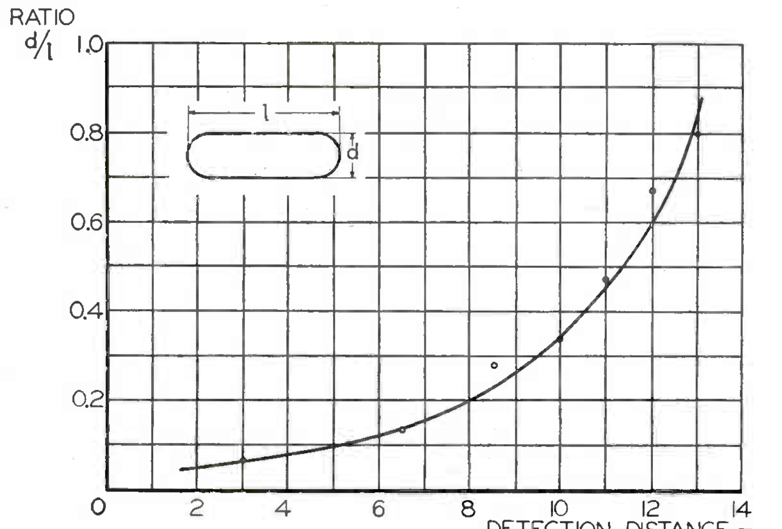


FIG. 2—Effect of search coil shape on distance at which cross-ties can be detected

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.

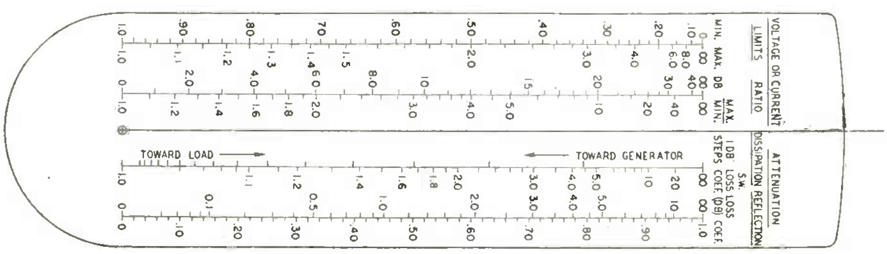
II. Length of line between any two points in wavelengths.

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.

By PHILLIP H. SMITH
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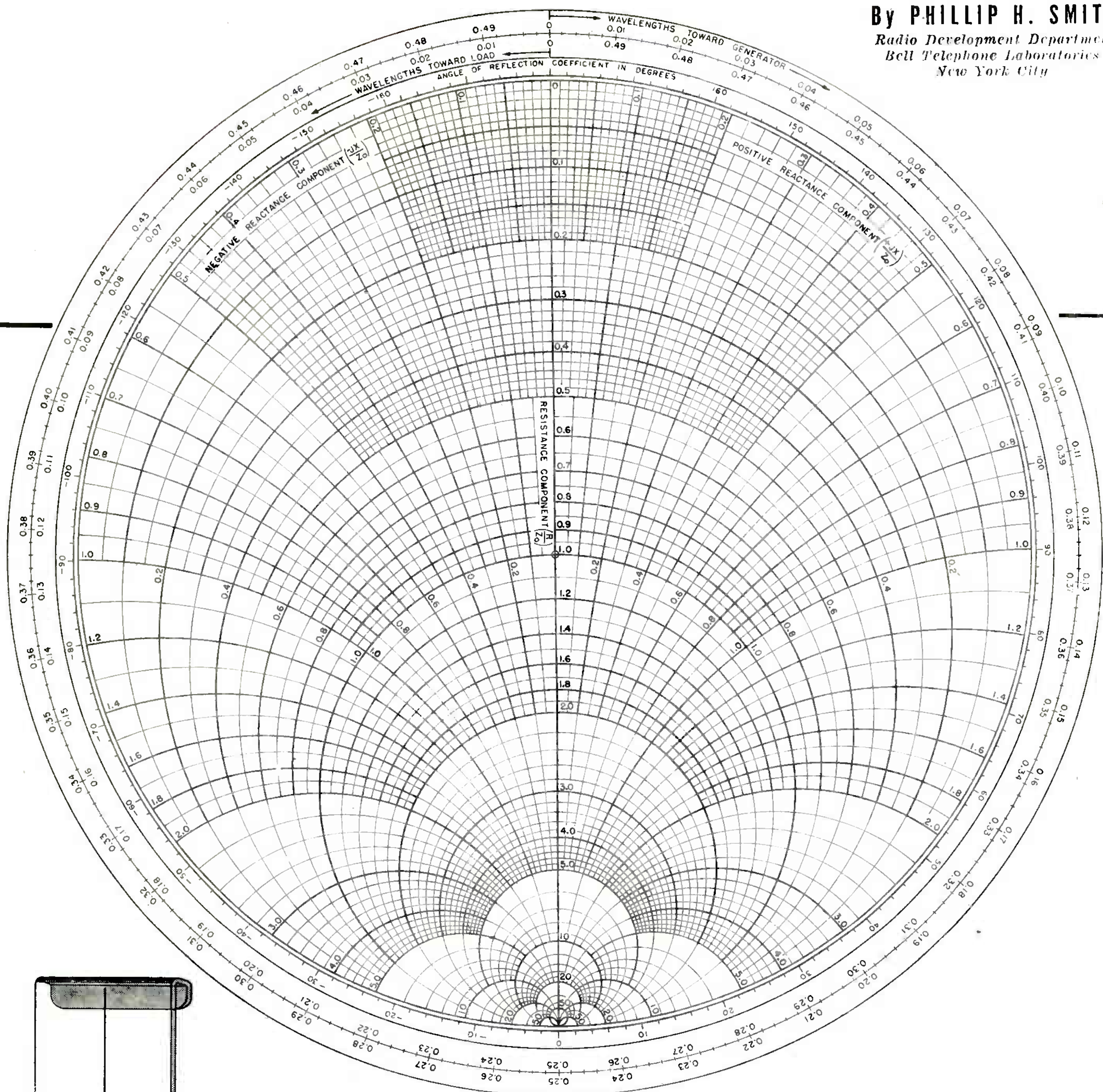
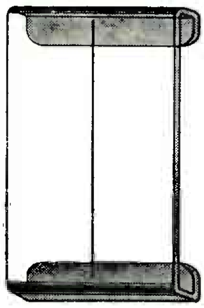




Circular transmission line calculator with separately rotatable "wavelengths" scale around rim. Transparent arm shown at left is pivoted at the center of the calculator. Slider is slipped on arm as crosshair indicating mechanism

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.

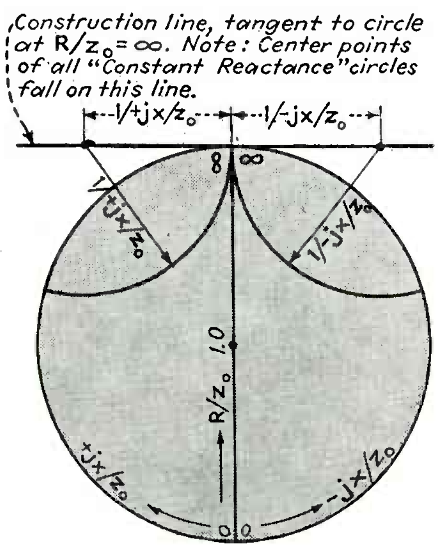
Equivalent Parallel Components of Impedance

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 $\pm$ 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

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

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

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

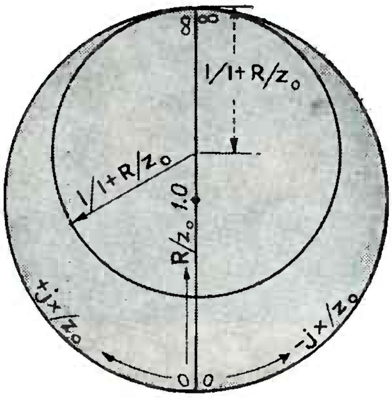
k = magnitude of the voltage reflection coefficient
V_R = reflected voltage
V_I = incident voltage

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.

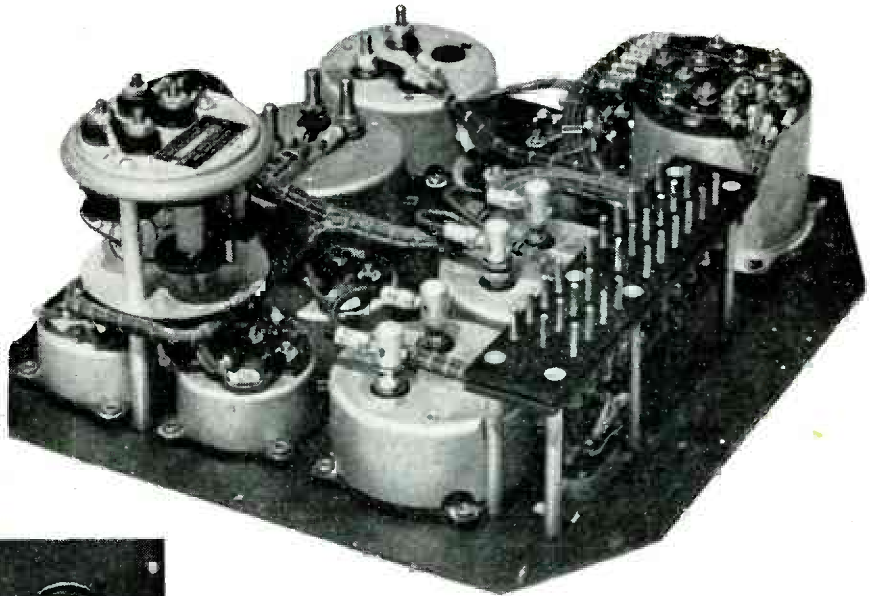
One usually supposes that plugs add weight and thus counteract the benefit derived from facility in overhaul. If sufficient forethought is given to the installation this is not necessarily true. In the case of the aforementioned plug-in instrument panel, enough wire and terminal strips were removed to 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

By A. F. TRUMBULL
Former Supt. of Aircraft Radio Service United Air Lines, Chicago

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



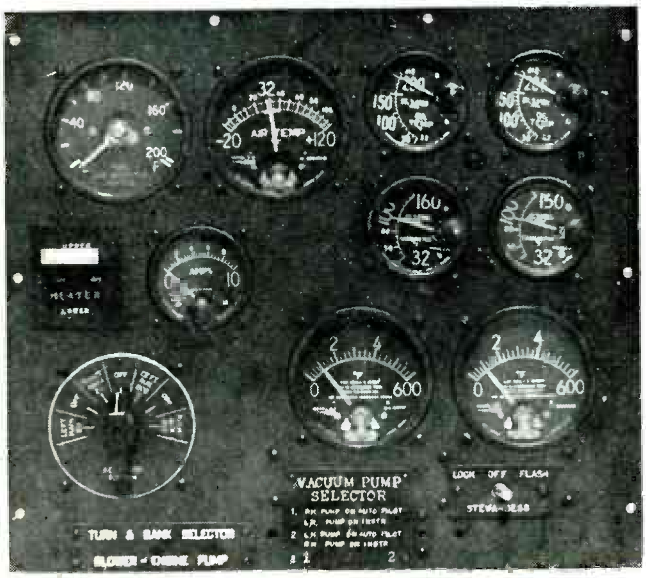


FIG. 1 — Front and rear views of an aircraft instrument panel group equipped with a 30-pin electrical disconnect plug

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.

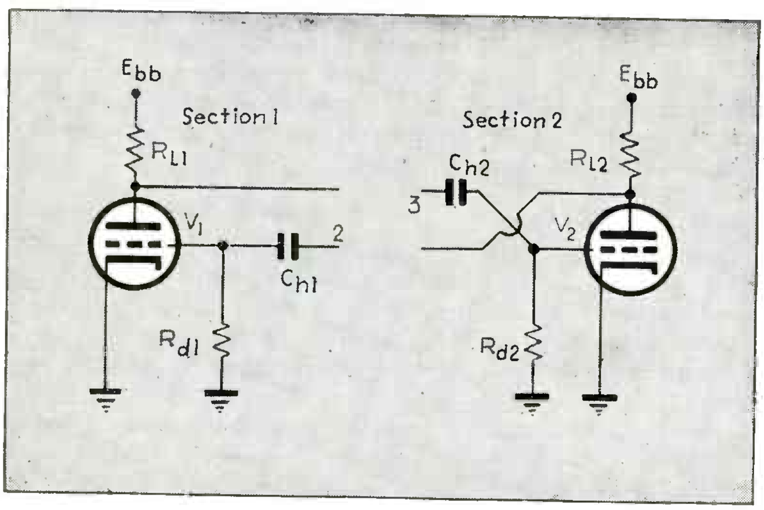
If V_2 is thought of as a switch which closes a circuit and applies a negative step of voltage to terminal 2, it is a simple matter to write the equation that describes the voltage across R_{d1}. When the switch closes, the voltage across R_{d1} will decrease instantaneously from zero to the value of 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.

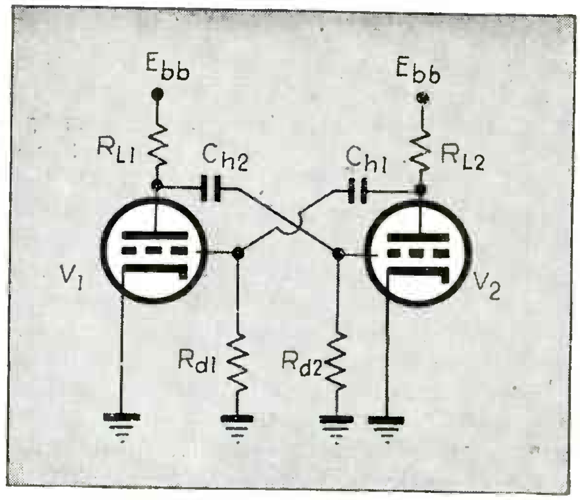
Due to the regenerative action of the circuit, an infinitesimal current through V_1 will be rapidly amplified and will result, according to the above logic, in closing switch V_1, thereby applying a negative step of voltage to terminal 3. When this switch closes, it simultaneously opens switch V_2, i.e., 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.

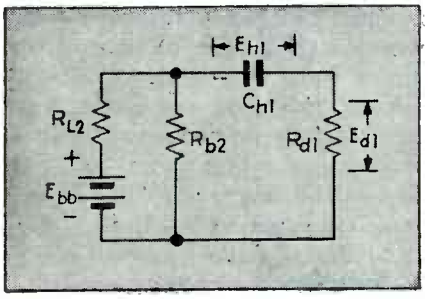
FIG. 1.1—(below at right)—Basic two-triode multivibrator circuit





By EUGENE R. SHENK
RCA Laboratories
New York City

and Design . . . Part I



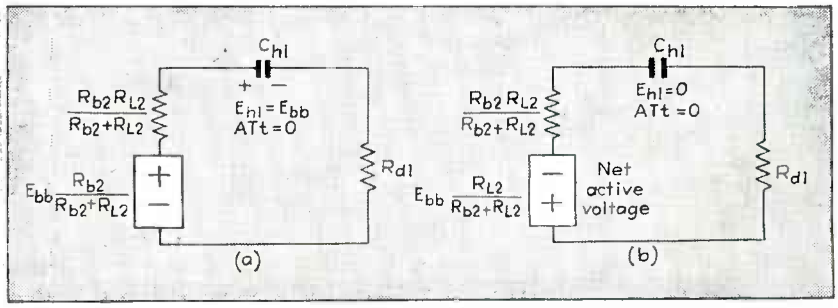


FIG. 1.2—Equivalent discharge circuit of C_{h1} in the multivibrator of Fig. 1.1. V_2 is conducting, and V_1 is nonconducting. $E_{h1}=E_{bb}$ at $t=0$. Time is measured from the instant V_2 becomes conducting. FIG. 1.3 (above at right)—Simplification of Fig. 1.2 by the use of Thevenin's Theorem

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_2 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

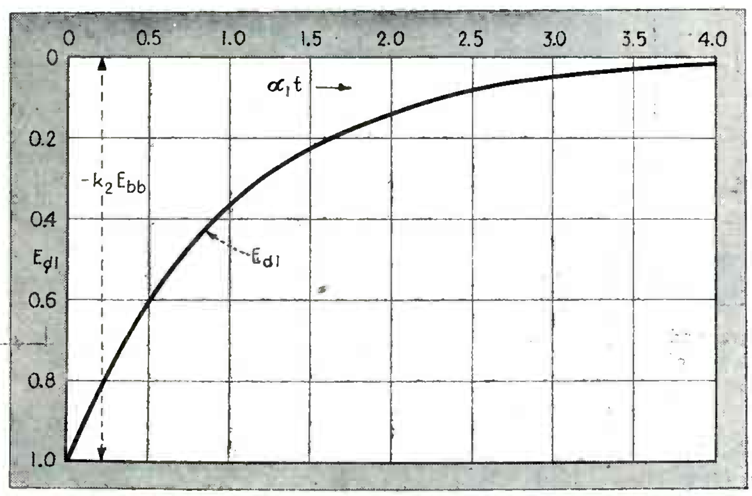
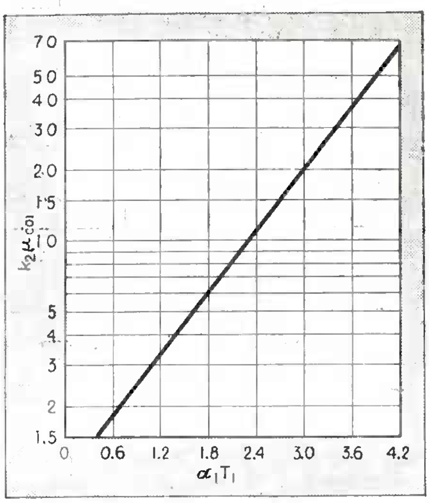


FIG. 1.5—Plot of Eq. (1.5a). By means of this curve, the multivibrator can be designed to operate at a given natural frequency



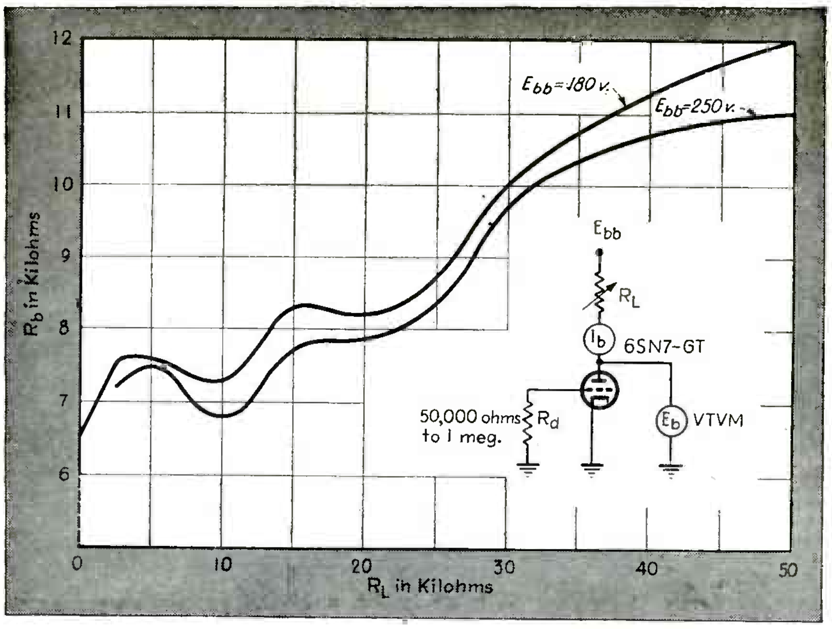


FIG. 1.6—Measured average d-c plate resistance (R_b) of type 6SN7-GT at zero bias as a function of the plate load resistor. R_b is practically independent of R_d for values of R_d in the range of 50,000 ohms to 1 megohm. $R_b = E_b/I_b$

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

$$E_{d1} = -\left[E_{bb}\frac{R_{L2}}{R_{b2}+R_{L2}}\right]\left[\frac{R_{d1}}{R_1}\right]\exp\left[-\frac{t}{C_{h1}R_1}\right] \quad (1.1)$$

$$= -k_2 E_{bb}\exp\left[-\alpha_1 t\right] \quad (1.2)$$

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.

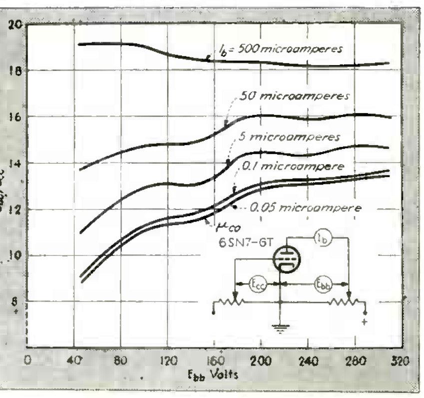
Eq. (1.2) can be written

$$\frac{E_{d1}}{-k_2E_{bb}} = \exp\left[-\alpha_1 t\right]. \quad (1.2)$$

[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_h during its charging time. This charge time constant is considered later.

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



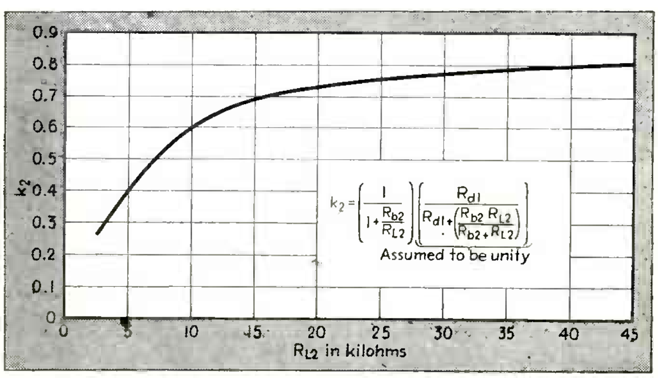
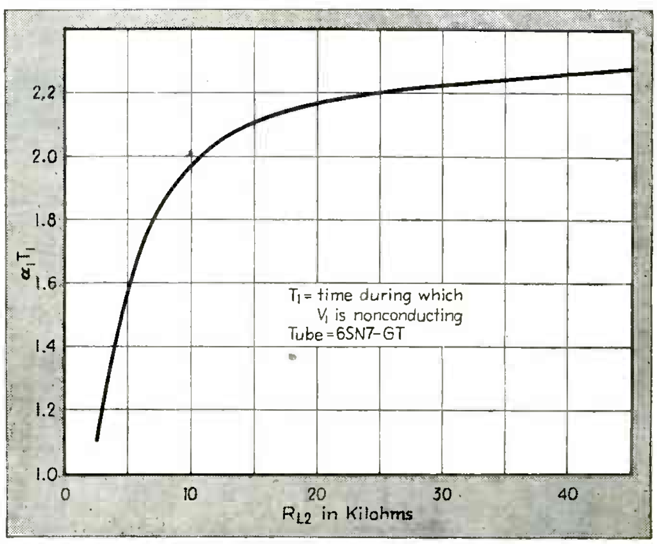
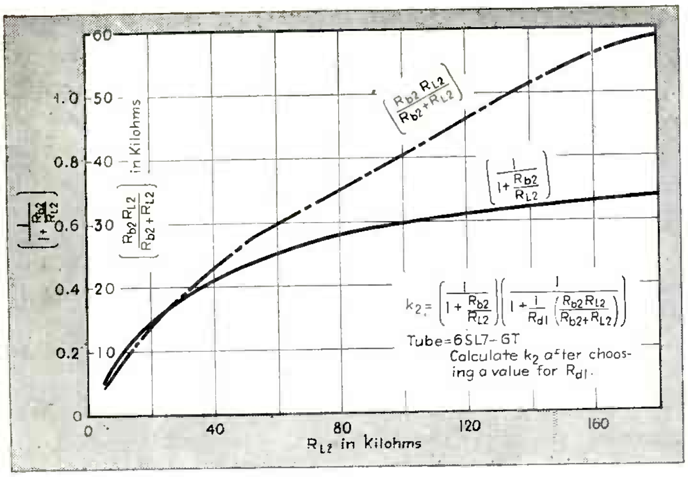


FIG. 1.7—If the second bracket in the expression for k_2 is assumed equal to 1; then, by reading from Fig. 1.6, average values of k_2 can be plotted as a function of R_{L2}. This curve is for type 6SN7-GT in the E_{bb} range of 150 to 250 volts

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





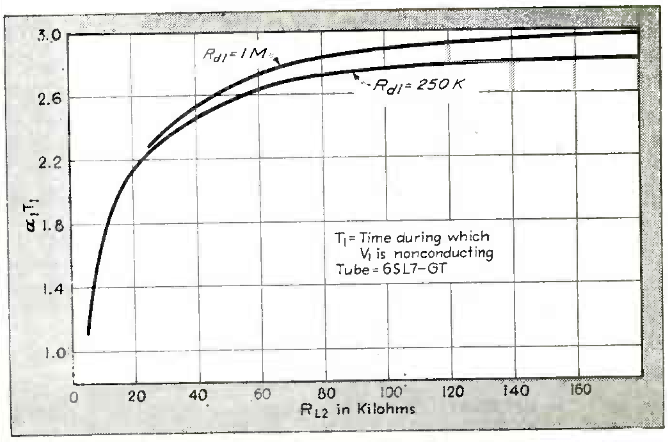


FIG. 1.10—A method of plotting the information necessary to compute the value of k as a function of R_L in cases where the value of the second bracket in the expression for k cannot be considered equal to unity. Measured average values for type 6SL7-GT in the E_{bb} range of 150 to 250 volts. **FIG. 1.12** (above at right)—Similar to Fig. 1.9, but applicable to type 6SL7-GT tubes

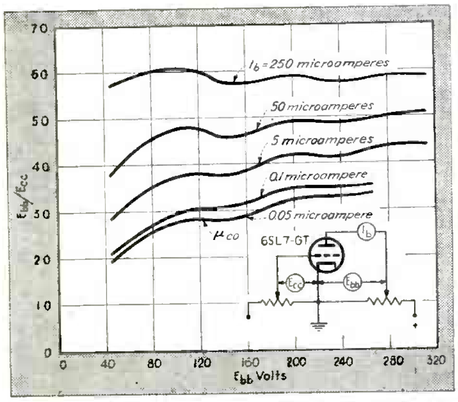


FIG. 1.11—Same as Fig. 1.8, but applicable to type 6SL7-GT tubes. The curve designated μ_{co} is useful in multivibrator design

Substituting the specific values $-E_{co1}$ for E_{d1} and T_1 for t, (1.2) becomes

$$\frac{E_{co1}}{k_2 E_{bb}} = \frac{1}{k_2 \mu_{co1}} = \exp[-\alpha_1 T_1] \quad (1.5)$$

$$\alpha_1 T_1 = -\log_e \left[\frac{1}{k_2 \mu_{co1}}\right] = \log_e [k_2 \mu_{co1}] = 2.30 \log_{10} [k_2 \mu_{co1}]. \quad (1.5a)$$

(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).

$$T_2 = \frac{1}{\alpha_2} \log_e [k_1 \mu_{co2}] \quad (1.6)$$

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

$$C_{h1}\left(R_{L2} + \frac{R_{d1} R_{g1}}{R_{d1} + R_{g1}}\right) \quad (1.8)$$

A steady-state analysis shows that

if $$C_{h1}\left(R_{L2} + \frac{R_{d1} R_{g1}}{R_{d1} + R_{g1}}\right) \lesssim \frac{T_2}{5} \quad (1.9)$$

and if

$$C_{h2}\left(R_{L1} + \frac{R_{d2} R_{g2}}{R_{d2} + R_{g2}}\right) \lesssim \frac{T_1}{5} \quad (1.9)$$

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 $0.91E_{bb}$.

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.)

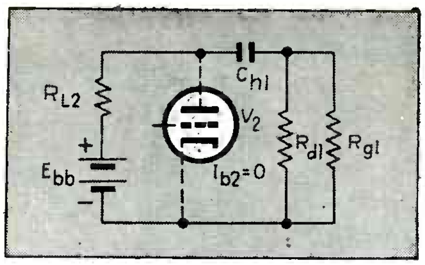


FIG. 1.13—Equivalent charge circuit of C_{h1} in the multivibrator of Fig. 1.1. V_2 is nonconducting, and V_1 is conducting

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,

$$-\Delta E \exp\left[-\frac{t}{CR}\right] + E_s \sin \omega_s t = -E_{co} \quad (2.1)$$

* Two examples of MV design precede Appendix I.

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

[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.

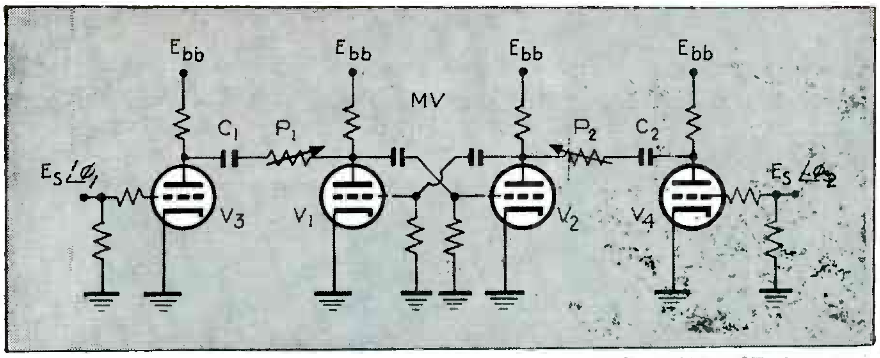


FIG. 2.1—Illustrating one method of applying synchronizing voltage to a multivibrator

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.

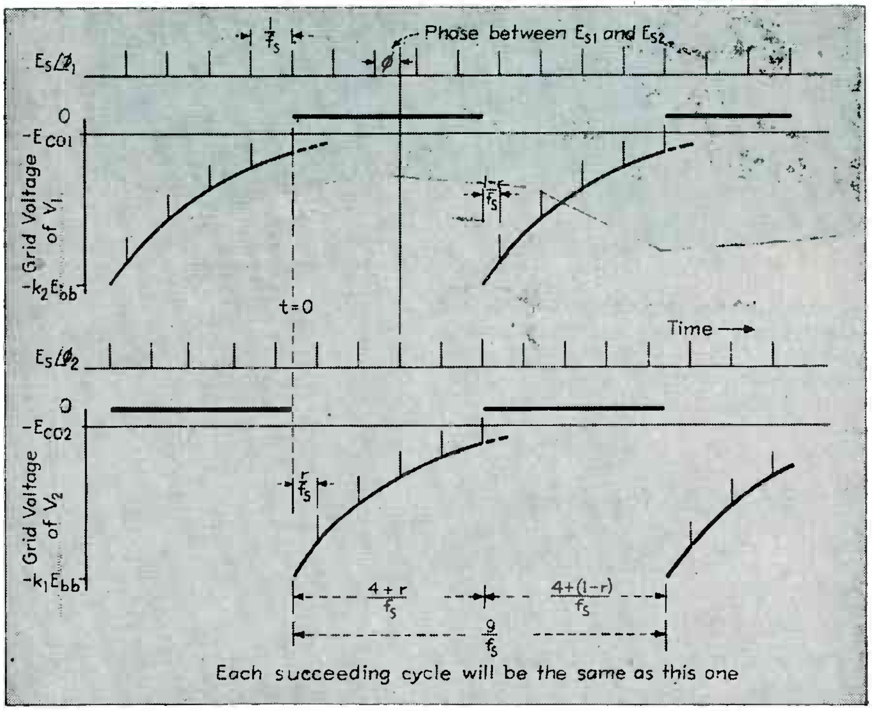


FIG. 2.2—A phase difference between the synchronizing pulses applied to the two tubes of a multivibrator adds a fraction to the order of division of each tube. The two fractions are always complementary

The 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.

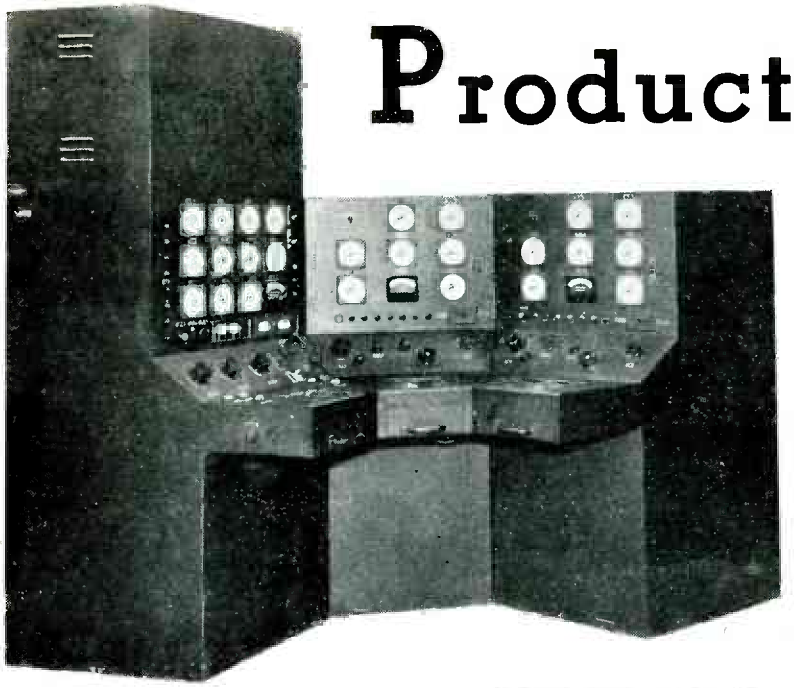
It should be noted that it is not necessary to use push-pull synchronization with every MV that is to divide by an odd number. The only cases for which two phases of synchronizing voltage are required are those for which r has a value other than zero. Consider as an example a MV that is to divide by 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



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

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

By P. M. THOMPSON
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General Electric Co.
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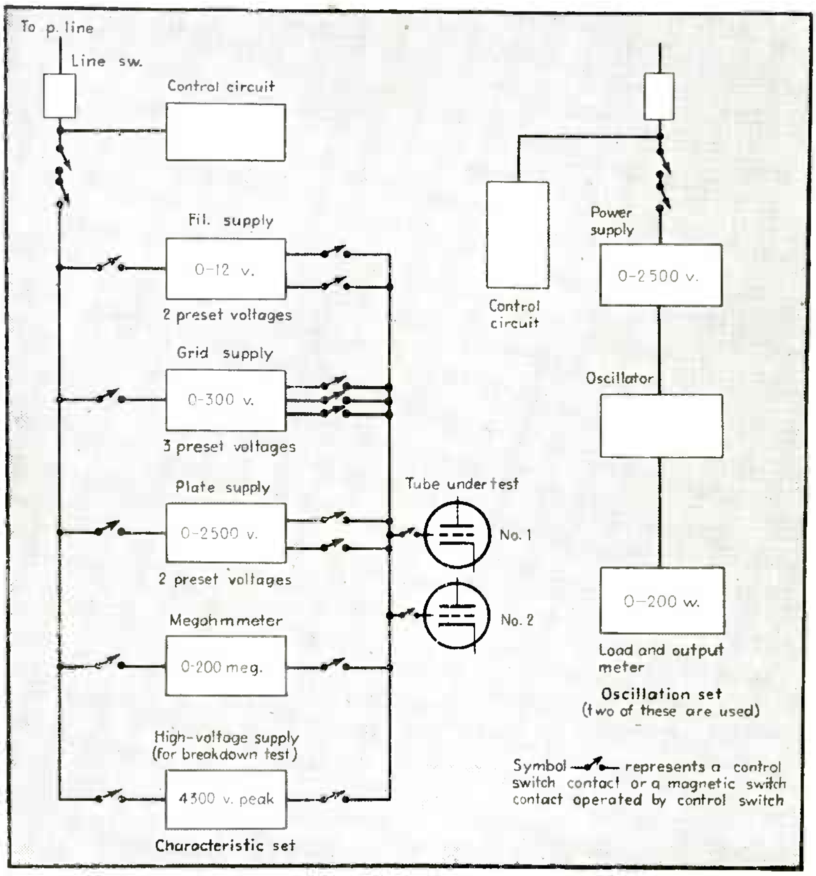


Block diagram of the tester

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-

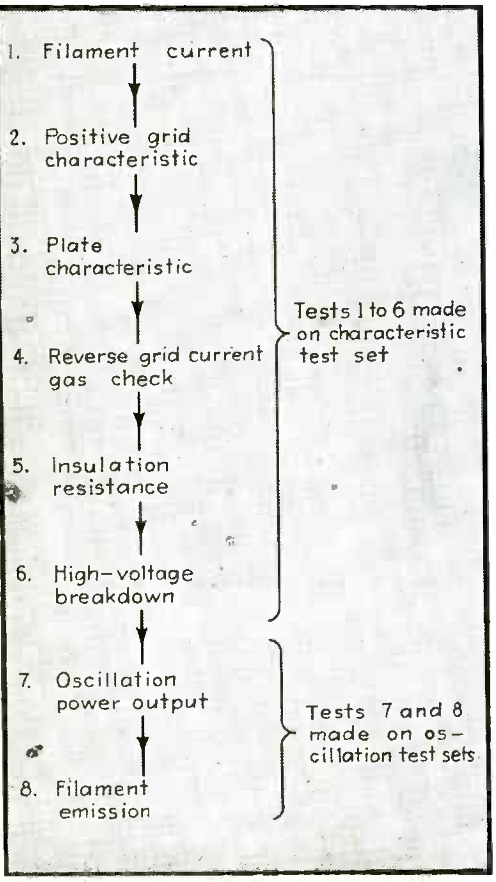
for Transmitting Tubes

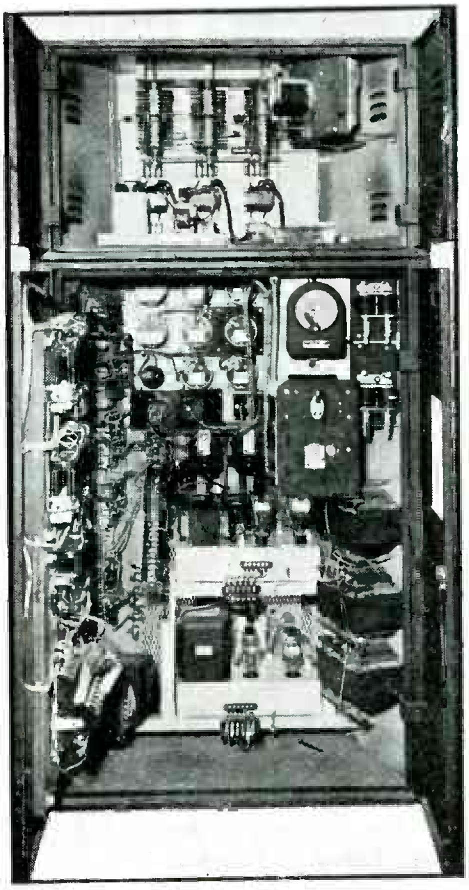
minute runs. This serves as a basis for dividing the tests into two groups. A separate test set was made for each group. Thus, while a tube is on a two-minute run in one set, the operator can take measurements on a tube in the other set, bringing it up to its two-minute run. At this point the operator 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.





Flowsheet showing sequence of tests, and interior view of characteristic test set

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.

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

By DONALD S. BOND*
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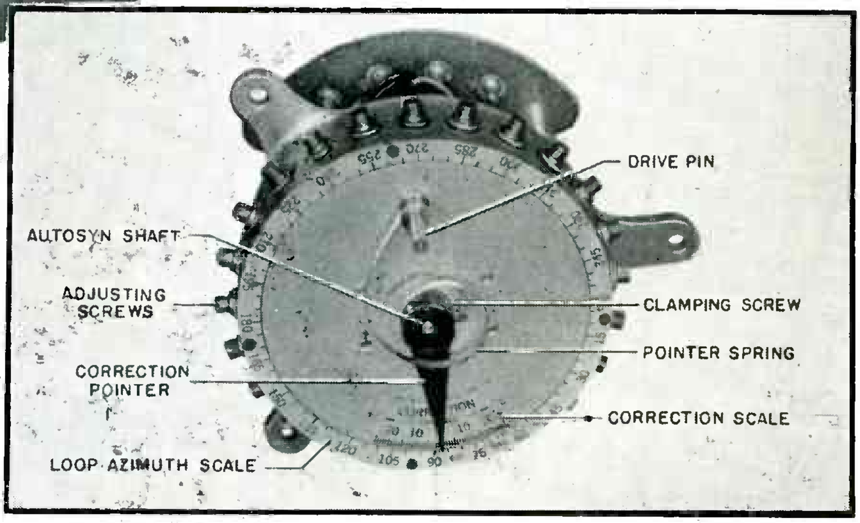
ABOVE: Loop housing and loop base

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.

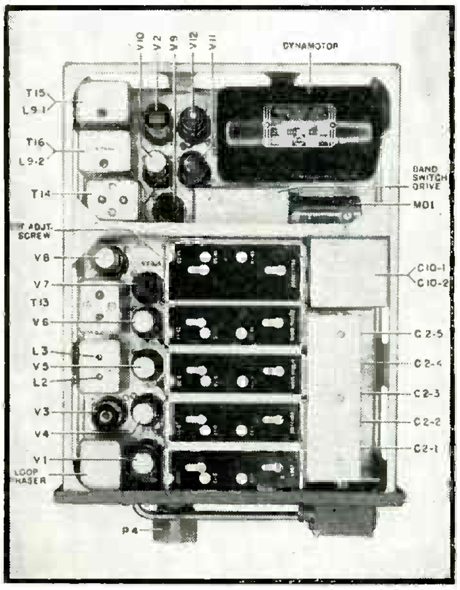
Some points of difference may be noted in comparison with the Mark I equipment. The bearing indicator unit is not mechanically driven from the rotating loop, but instead in the MN-31 it is electrically controlled by means of a self-synchronous repeater system such as Selsyn or Autosyn. Several such indicators 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.

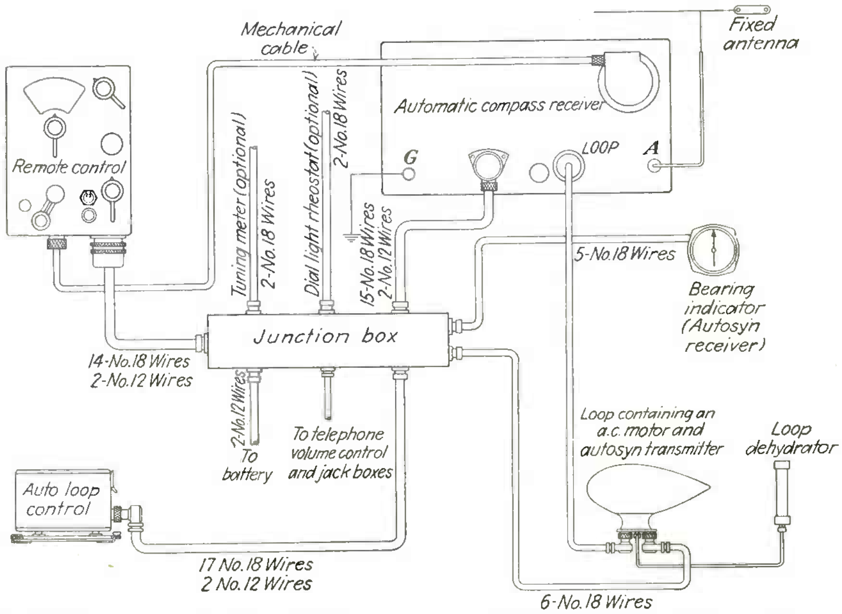
The interconnection diagram of the MN-31 automatic direction finder is shown in Fig. 19, and the various

‡ 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





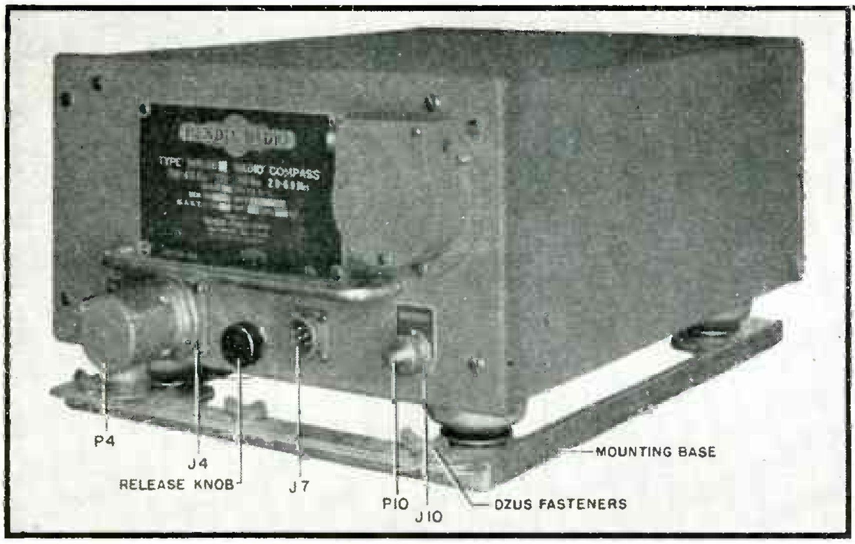


Fig. 19 (Above)—Interconnection diagram of Bendix MN-31 automatic direction finder

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.

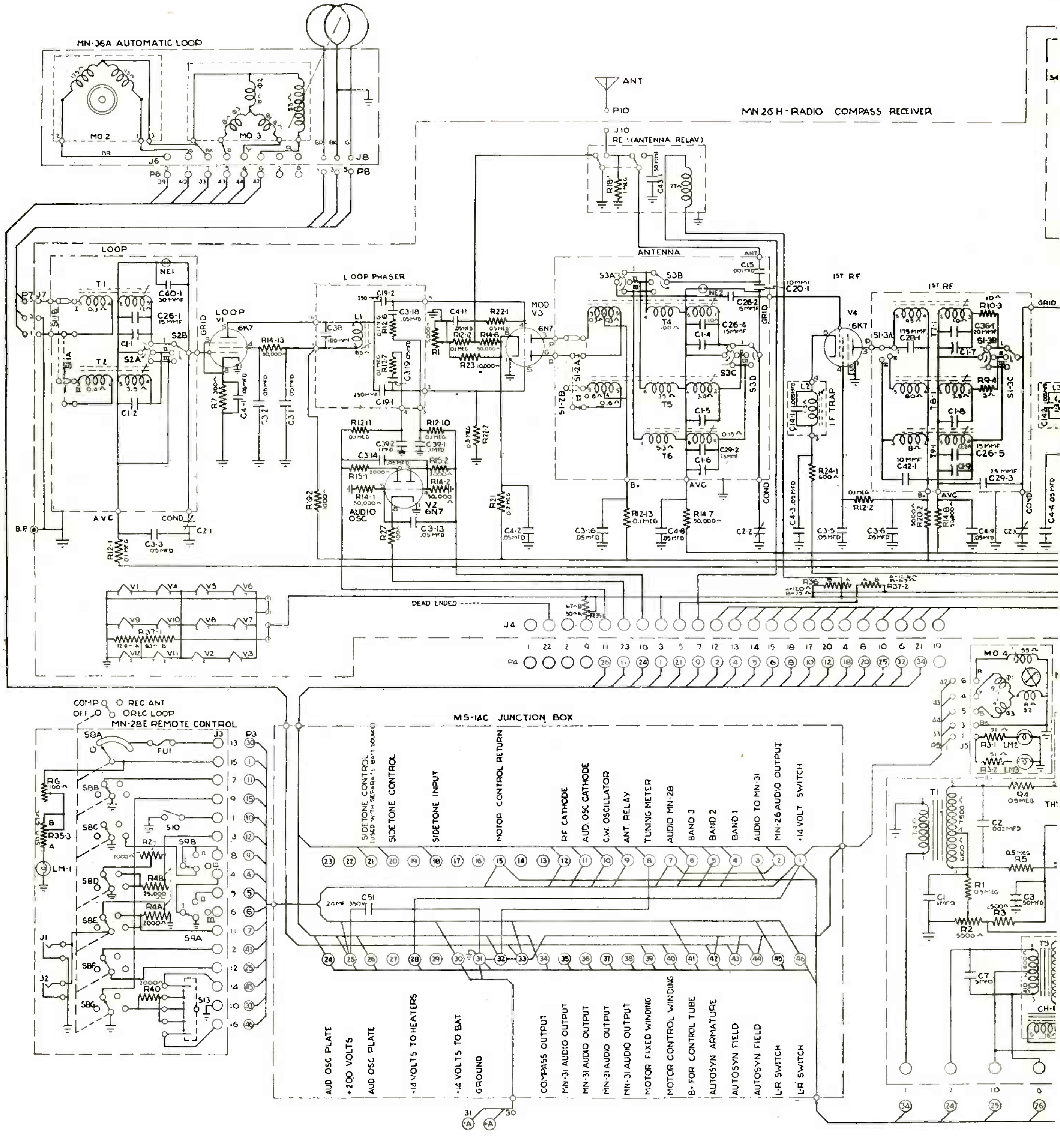
Because of a different type of mo-

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.

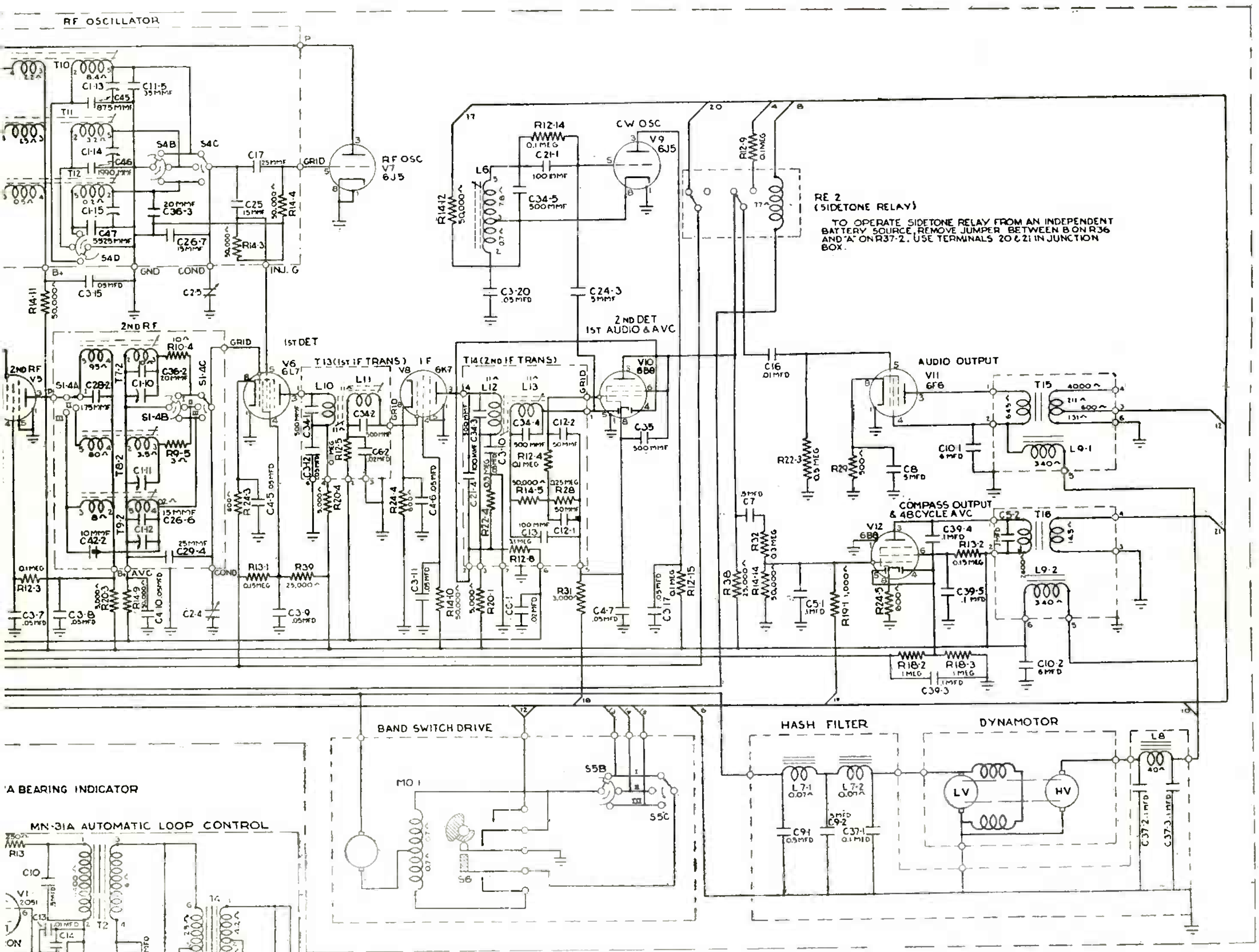
PART III—Bendix Model MN-31 automatic direction finder, in this issue. (Conclusion).



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



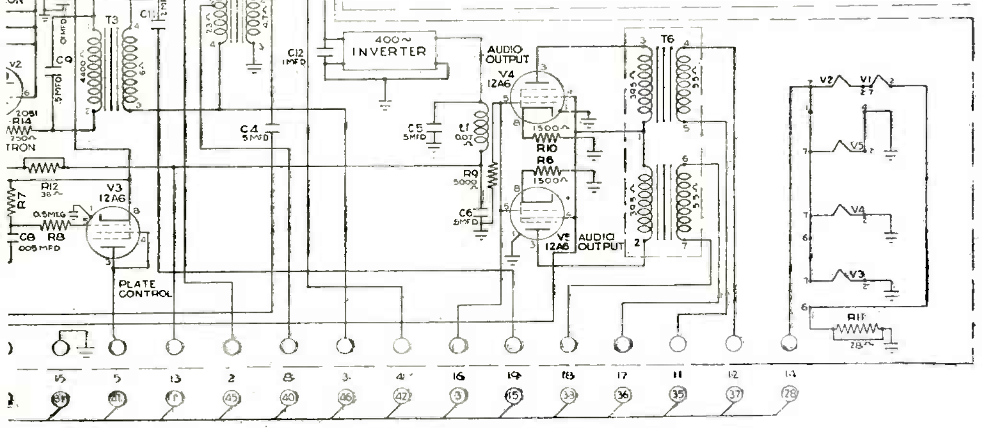


Fig. 20—Complete schematic circuit diagram of Bendix MN-31 automatic direction finder

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

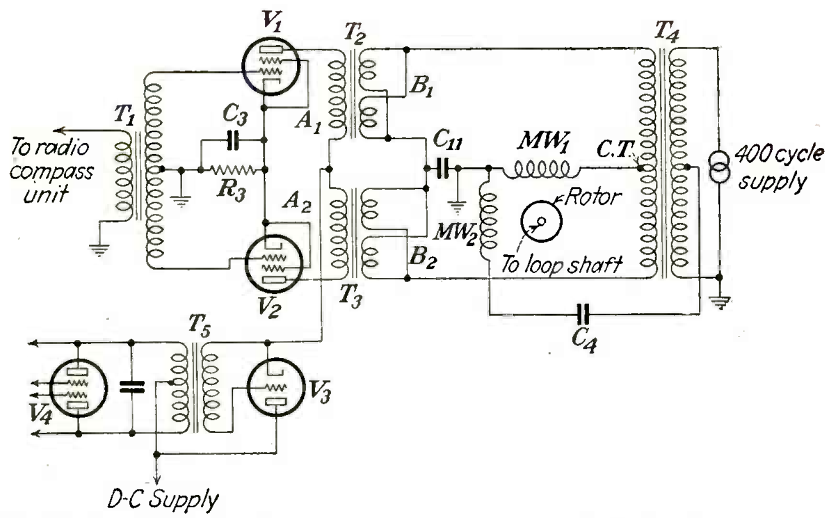


Fig. 21—Simplified schematic diagram of loop control circuit. V_1, V_2—thratron tubes; V_3—plate control tube; V_4—audio osc.; T_1—input tr.; T_2, T_3—saturable reactors; T_4—400-cycle tr.; T_5—audio osc. tr.; MW_1—control winding, loop motor; MW_2—fixed exc. winding, loop motor; C_3, R_3—cathode lag circuit; C_4, C_{11}—motor phasing capacitors

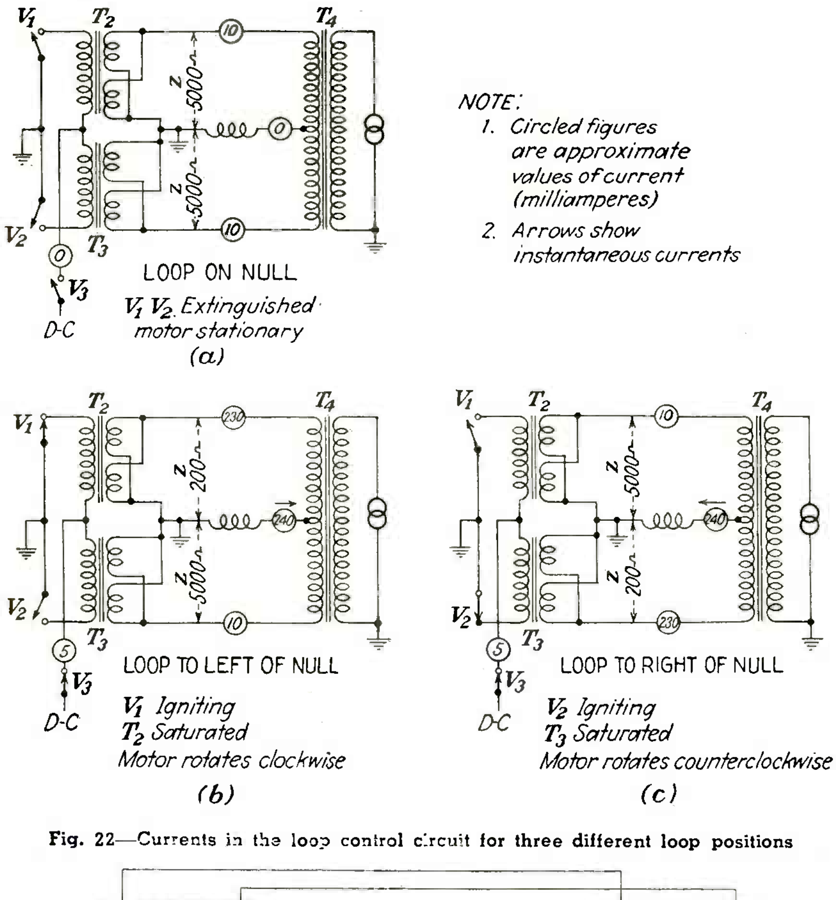


Fig. 22—Currents in the loop control circuit for three different loop positions

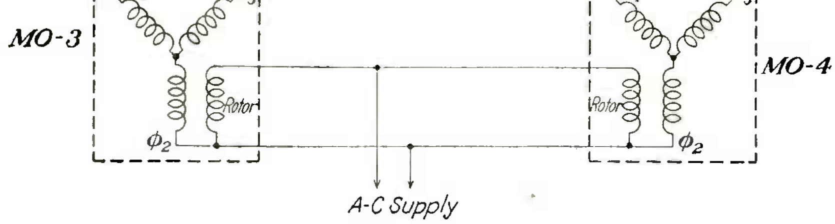


Fig. 23—Simplified circuit of phase windings of Autosyn transmitter of bearing indicator system

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.

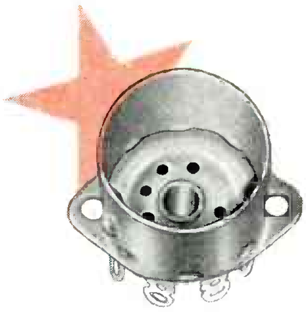
When the loop is at the null position, so that neither V_1 nor V_2 are conducting, reactors T_2 and T_3 present high impedance. As a consequence, there is then no current through MW_1. This is illustrated in Fig. 22(a). But when the loop is off the null position in one direction, so that V_1 is conducting, 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)

CINCH *Miniature* *Shield and Socket Assembly*

ACTUAL SIZE
Patent applied for
Part No. 9834



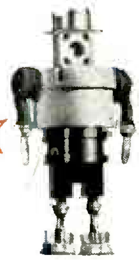
FRONT VIEW: ACTUAL SIZE

BOTTOM VIEW: ACTUAL SIZE

☆ The newest CINCH Miniature Socket development with "integral" or one piece shield and saddle. This is one of the "hottest gadgets" in present day Electronics.

The high base, a product of CINCH ingenuity, virtually acts as a shoe horn . . . as tubes must travel a straight path when inserted or removed thus preventing tube breakage.

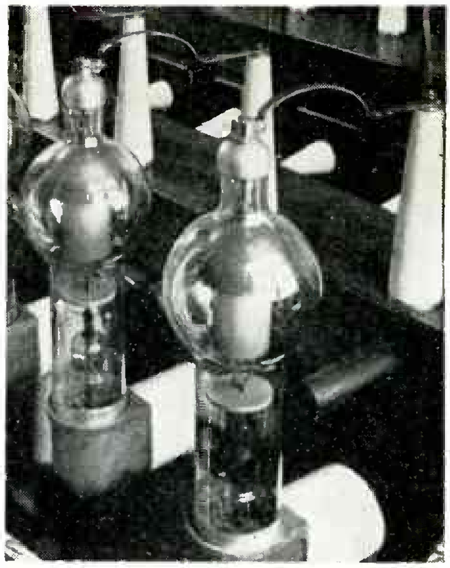
Full floating contacts...a shield base that acts as a support neutralizing vibration shock and distortion. Test reports have definitely proven that pin bending and breakage is reduced. Constructed to simplify assembly and to save labor at inaccessible points. Socket bases supplied both from ceramic and mica filled insulation.



CINCH MANUFACTURING CORPORATION • 2335 WEST VAN BUREN STREET, CHICAGO, ILL.

SUBSIDIARY: UNITED-CARR FASTENER CORPORATION, CAMBRIDGE, MASS.

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.

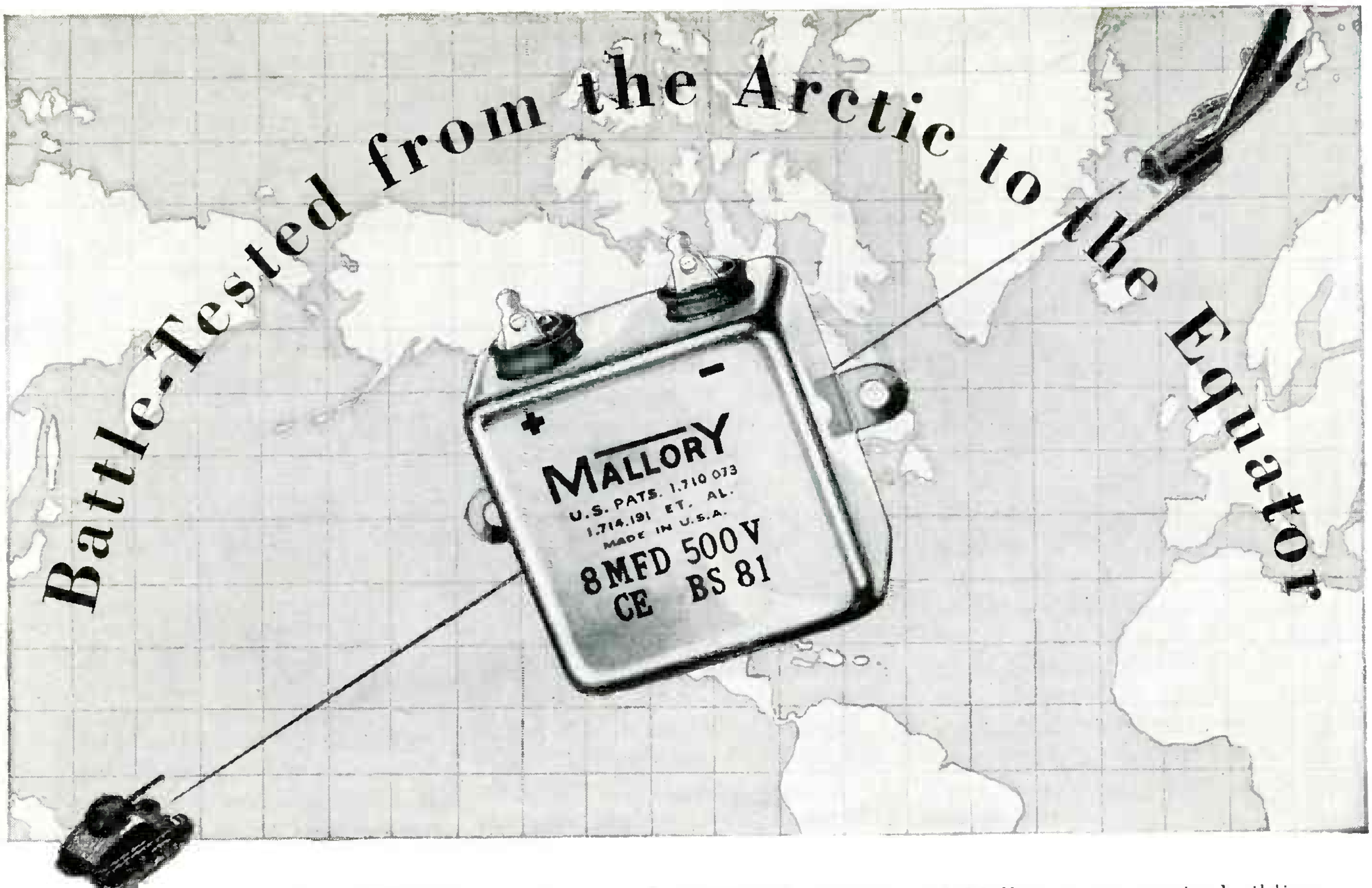
The high power supply contains two 3-phase full wave rectifiers so arranged that their high voltage outputs may be connected either in series or parallel. Each rectifier consists of a bank of six Federal type F-857-B mercury vapor rectifier tubes to convert 60 cycle alternating current into high voltage 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.

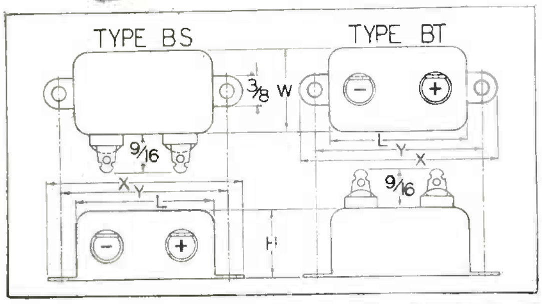
The rectifiers are supplied by a bank of three high-voltage transformers, each of which is equipped with two secondary windings so as to make possible two 3-phase wye connected high voltage secondaries to supply the two 3-phase vacuum tube rectifiers. The transformer secondary windings are equipped with 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.

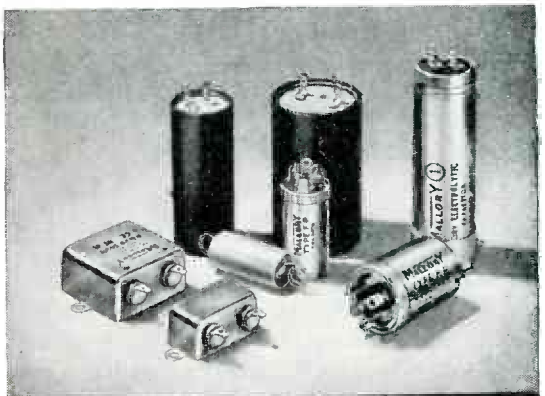
The primaries of the three transformers are so arranged that they may be connected either in wye or delta. This connection allows the total rectifier to operate in either of two ranges, 3,000-15,000 volts d-c output, or 13,500-30,000 volts output. The voltage may be varied steplessly in either of these 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







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.

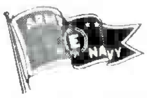
Specifications and complete test data on all Mallory BS and BT Capacitors are listed, with other heavy duty units, in the Mallory catalog. Send for a copy today. Write direct for special assistance when confronted with unusual problems, or see your Mallory distributor.

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

P. R. MALLORY & CO., Inc.

MALLORY

ELECTROLYTIC, FILM AND PAPER CAPACITORS



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.

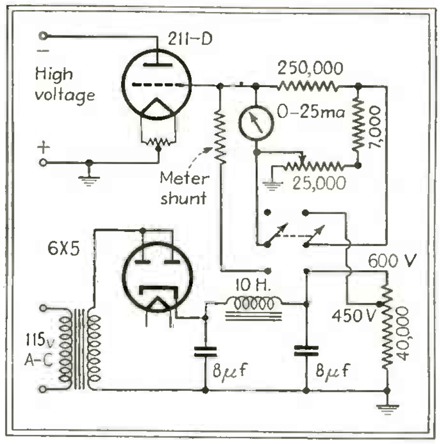
Loaded with enough film to make 36 exposures before reloading, the camera photographs the chest image produced on a fluoroscopic screen in front of the person being examined. X-ray pictures made on the larger film require reloading the camera with film after each exposure and result in higher cost and 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.

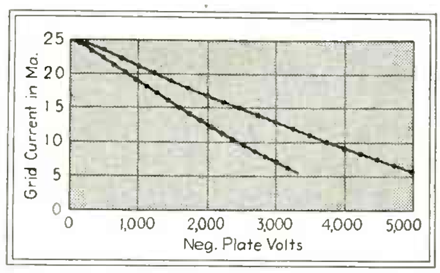
Negative Plate Voltmeter

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

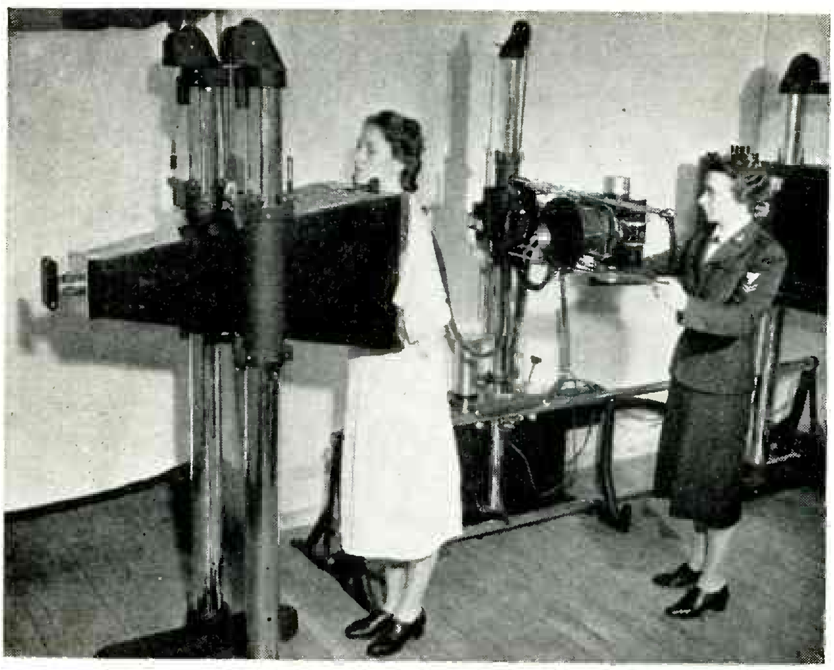
When a tube is used in this manner the amplification factor is about equal to the reciprocal of the normal amplification factor. The transconductance is small and large changes in plate voltage result in small changes of grid current.



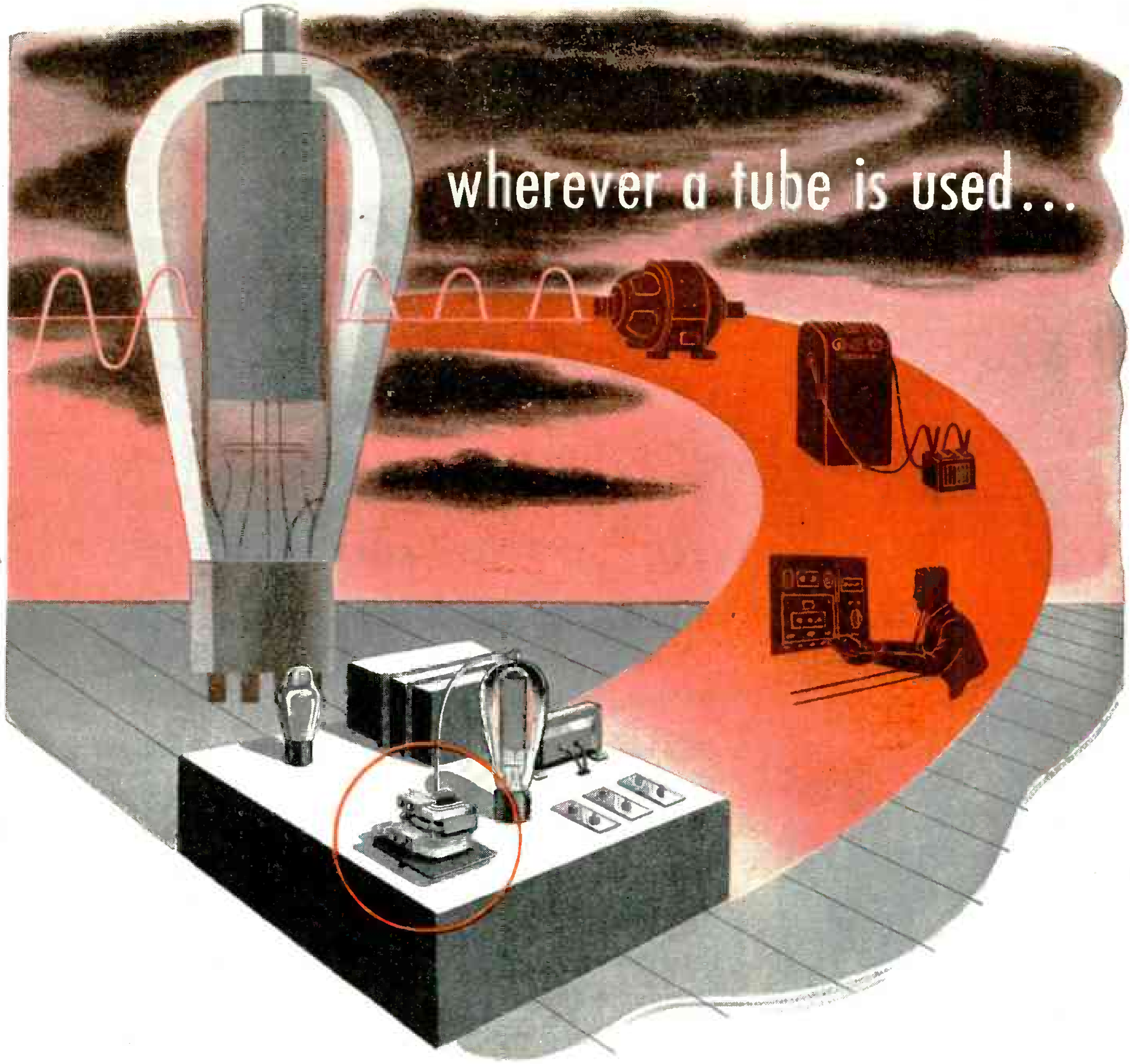
Negative plate voltage plotted against grid current for the 211-D. The curves may be used for calibrating the milliammeter scale in volts

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}.


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

* Terman, F. E., *Proc. IRE*, 16, 447, 1928.

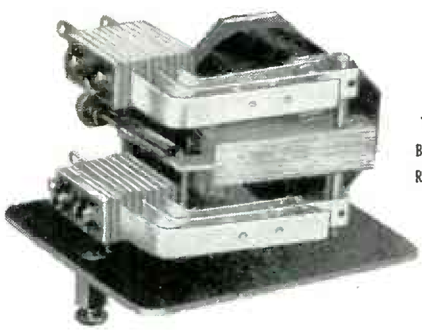


THERE'S A JOB FOR

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.

Centralab CRL

Division of GLOBE-UNION INC., Milwaukee

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.

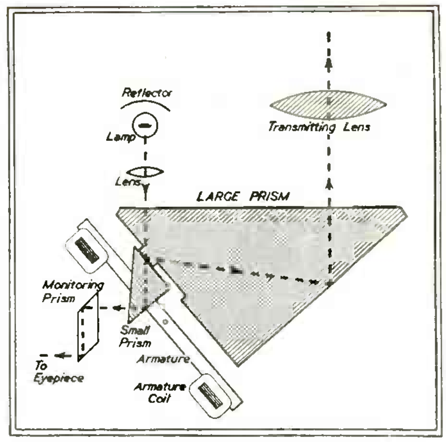
Transmitter

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

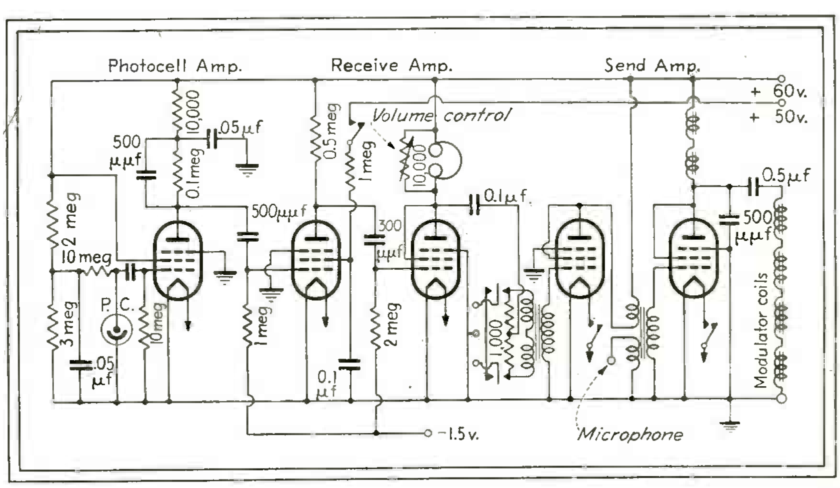
The method of modulating the lightbeam is shown in the illustra-



Arrangement of prisms and lenses in the transmitter for light-beam modulation. A monitoring system for checking the modulation is included

tion. 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 1½ mm, the surrounding glass being blackened.

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

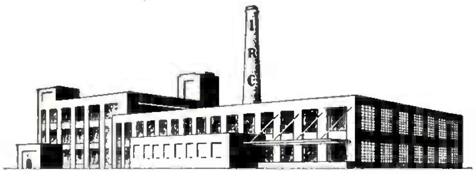


Equipment captured from the German Army contains this circuit of electronic amplifiers for transmitting and receiving voice signals on a beam of light

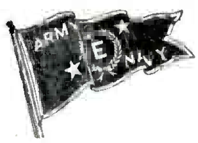
IRC

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

. . . *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.

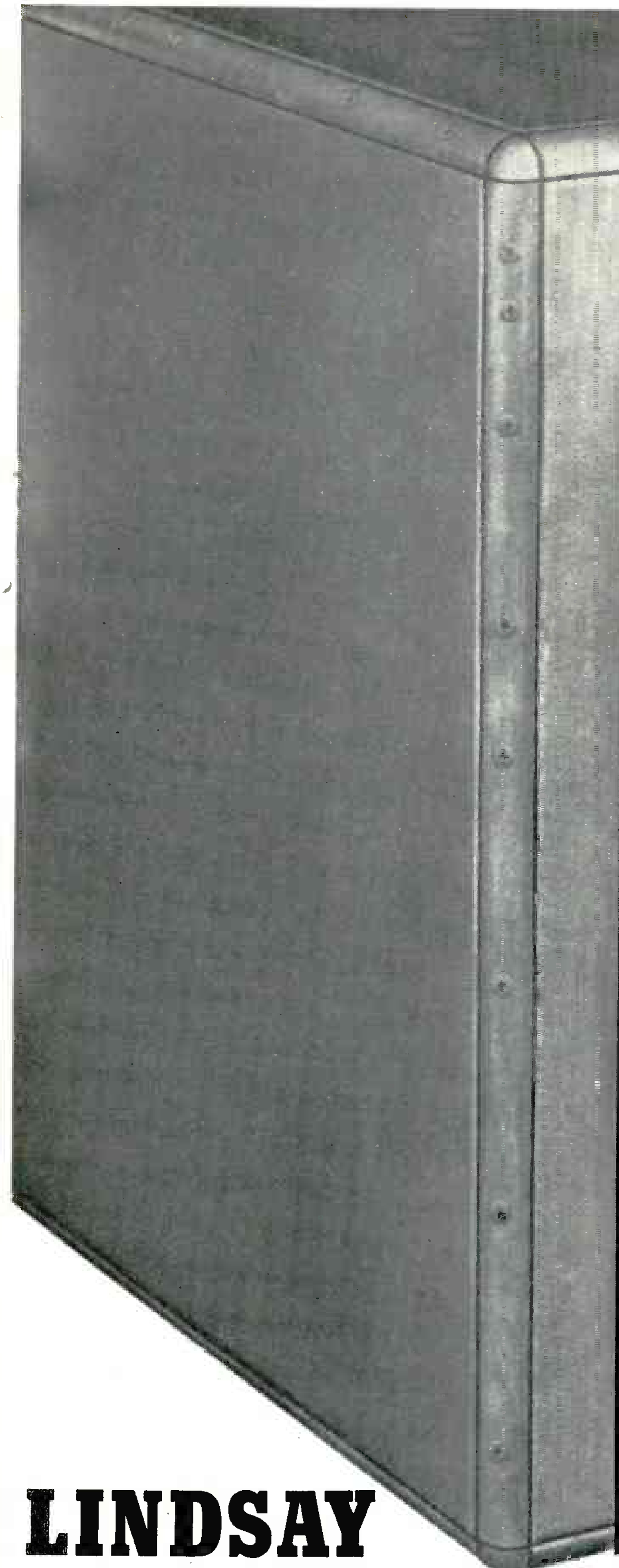
Receiving System

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



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For neatness, strength, light weight, and ease of assembly, investigate this proved, easy method of building cabinets and housings for your electrical, radio, and electronic equipment.

Lindsay Structure assemblies can help you speed up your production of cabinets and housings at once. With Lindsay Structure no tooling up is necessary—no special machinery is required. No riveting, no welding, no waste.

It's easy to order Lindsay Structure units. You merely furnish specifications, and a complete assembly—panel sheets, framing members, fittings, all die-formed, die-cut, die-rolled to exact dimensions—is shipped to you knocked down and ready to put together in your factory or on the spot.

Lindsay Structure engineers will give you immediate service on your pilot jobs. Send your blueprints to Lindsay and Lindsay, 222-D West Adams Street, Chicago 6, Illinois; or 60 East 42nd Street, New York 17, New York.

Lindsay Structure method of assembly. Only simple tools are necessary.

LINDSAY STRUCTURE

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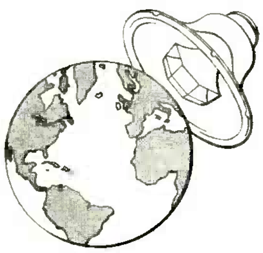
For details, see Sweet's Catalog File

IT S-T-R-E-T-C-H-E-S STEEL



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