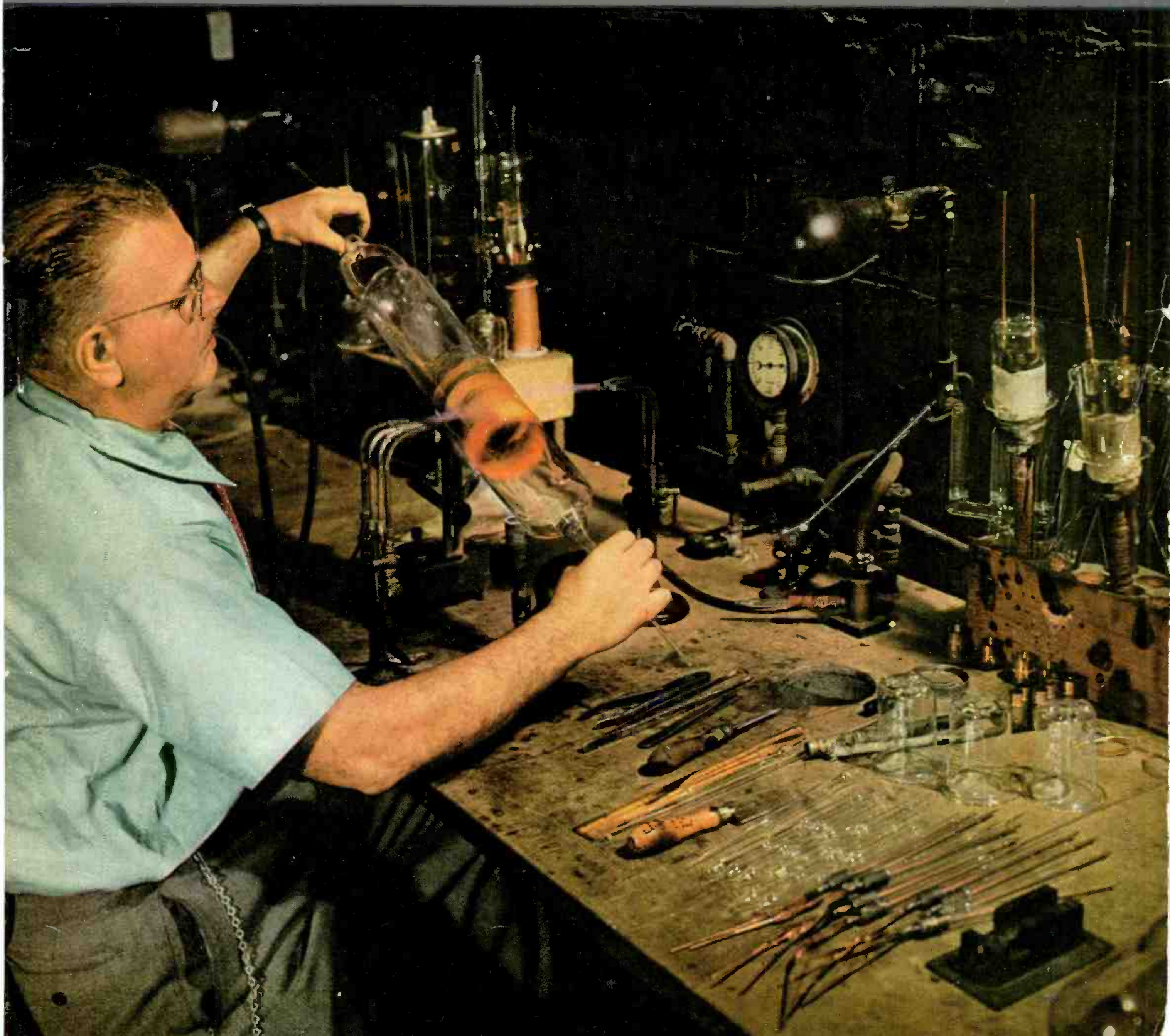
MAY · 1944

electronics



A McGRAW-HILL PUBLICATION

electronics

MAY • 1944

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DEPARTMENTS

CHANGE OF ADDRESS

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Director of Circulation:
Please change my address on Electronics

From ....

....

To ....

....

Signed ....

OLD FAITHFUL GEYSER, Yellowstone National Park. Geologists believe it began erupting before the last glaciation, about a million years ago. Within record, Old Faithful has erupted continuously at about 65-minute intervals, spouting a column of water 95—130 feet high for 4½ minutes.

STILL GOING STRONG

LONG, UNINTERRUPTED service under all operating conditions is the characteristic you want most in a capacitor. Tobe Capacitors serve so well and so long because every step in their manufacture is checked and cross-checked by rigid inspections. Constant improvement through constant research is the promise performed by Tobe engineers. An example is the Tobe CA-255 Capacitor, shown below, now available in a new drawn container of improved construction. Why not call on Tobe for prompt, specialized help on your capacitor problems?

SPECIFICATIONS—CA-255

Mineral Oil Impregnated and Filled. Aluminum Foil. Highest Grade Kraft Tissue.

CAPACITY RATING .... 3 x .1 mfd.
VOLTAGE (working) .... 400 V. D. C.
DIMENSIONS: 1 11/16" wide: 9/16" deep: 2 7/16" long, including channel mounting bracket. Mounting centers 2⅛". Three terminals ½" on centers. Height of terminal ¾". Diameter of mounting holes, .144.
FEATURES: Rugged Channel Mounting Bracket securely soldered to container . . . Increased terminal insulation . . . Rigid terminal lugs afford ample space to handle No. 14 stranded wire . . . Improved streamlined drawn container instead of fabricated can . . . Type, capacity and voltage die-stamped on container. Meets U. S. Army Signal Corps Specifications 71-516-E.

Other values and voltages may be obtained in above mentioned container construction. Send for details of our "OM" and "OD" Capacitors.

TOBE DEUTSCHMANN CORP.
TOBE
CANTON · MASSACHUSETTS

A small part in Victory today...
A BIG PART IN INDUSTRY TOMORROW!


Albanene
REG. U. S. PAT. OFF.
the stabilized
TRACING
PAPER

AAC Quartz CRYSTALS

help keep the communications

Today..and Tomorrow

Illustrated at right is a typical crystal manufactured by Aircraft Accessories Corporation and used in both ground and plane radio installations by America's commercial airlines. Many other types of AAC crystal units are being supplied various branches of the armed service and other government agencies.

Today, practically all AAC facilities are devoted to war production. Tomorrow, advanced AAC electronic developments will be available for the post-war world.

AAC Products

AIRCRAFT

Manufacturers of PRECISION

Burbank, Calif. Kansas

systems of the World's Greatest Airlines Working Efficiently!

REALIZING the extreme importance placed by the airlines upon the proper maintenance of their communications facilities, Aircraft Accessories Corporation has set aside a special division of its crystal laboratories to provide rapid delivery to airlines and associated communications services of a variety of standard crystals. *Deliveries in limited quantities can be made within a few days* after receipt of purchase order with adequate priority.

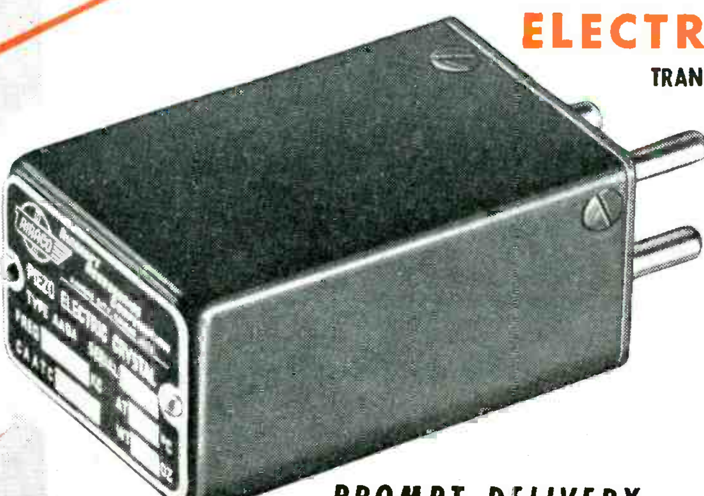
In the manufacture of quartz crystals, AAC development and production engineers employ the experience gained as one of America's largest producers of transmitters and other precision radio equipment. AAC crystal units will meet the most exacting requirements under severe operating conditions. Address all crystal orders and inquiries to Electronics Division, Kansas City, Kansas.

The services of our Engineering Department in designing special equipment are available to you without obligation.

Products of

ELECTRONICS DIVISION

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



Type AA9 Crystal, 2.5 parts/million temperature coefficient, accuracy of carrier frequency .01%. Made in three models—A, G and E, covering total fundamental frequency range of 200 to 10,000 kc. Internal adjustment screw permits small amount of frequency control in the single crystal units, AA9A and AA9G

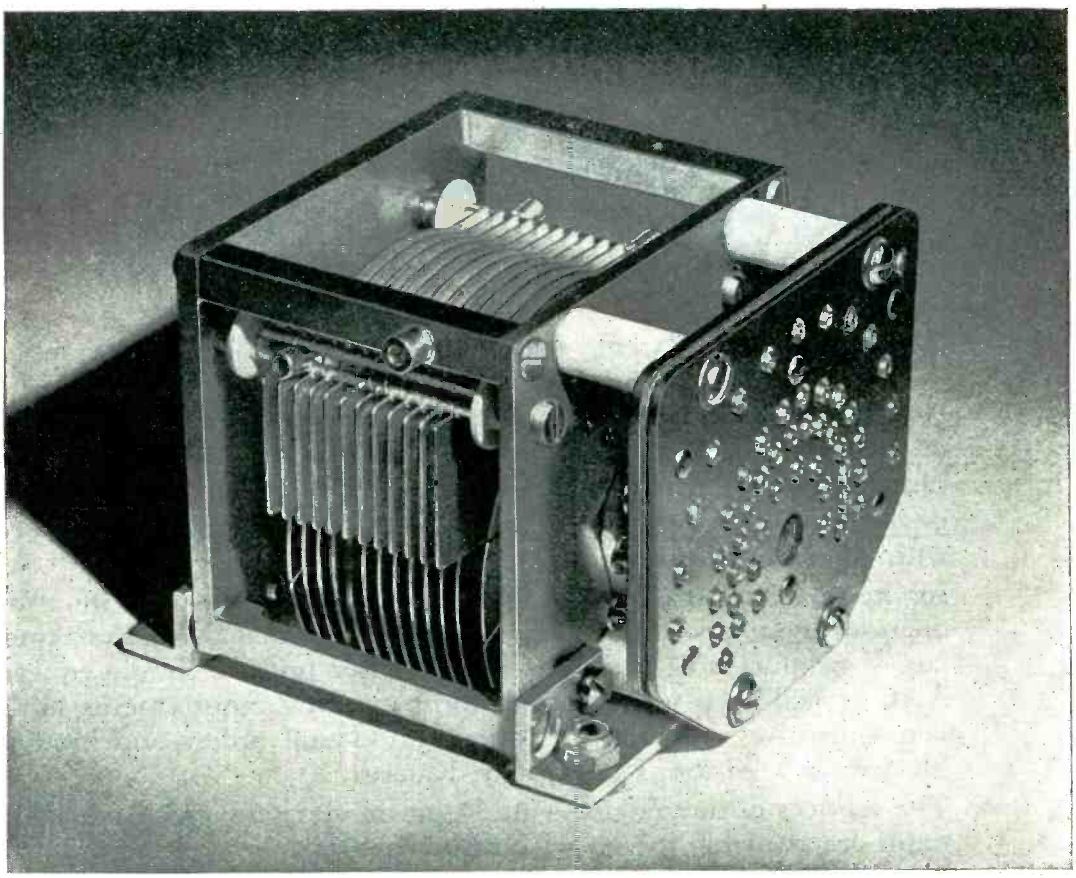
PROMPT DELIVERY

ACCESSORIES CORPORATION

AIRCRAFT EQUIPMENT • HYDRAULICS • ELECTRONICS

City, Kans. | New York, N. Y. | Cable Address: AACPRO

THE "PORCUPINE"



The Porcupine* has 51 trimming adjustments!

NOT long ago a variable condenser had just so many rotor and stator plates and that's all there was to it . . . Today we manufacture hundreds of types complete with all *accessories* to solve many difficult problems.

** So named by the employees who build them.*

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

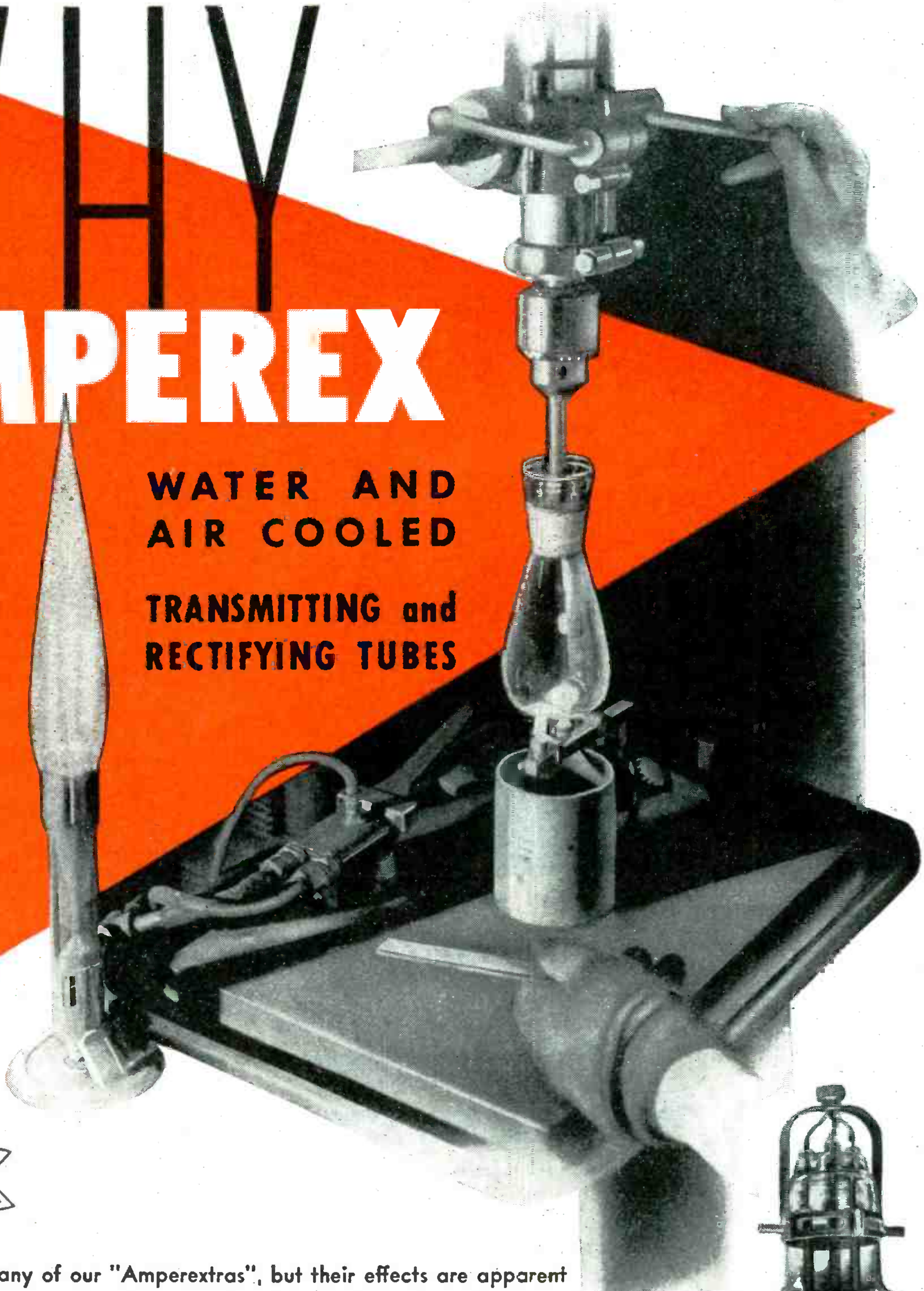
THE SIGN OF QUALITY IN RADIO

HAMMARLUND

WHY AMPEREX

WATER AND AIR COOLED

TRANSMITTING and RECTIFYING TUBES

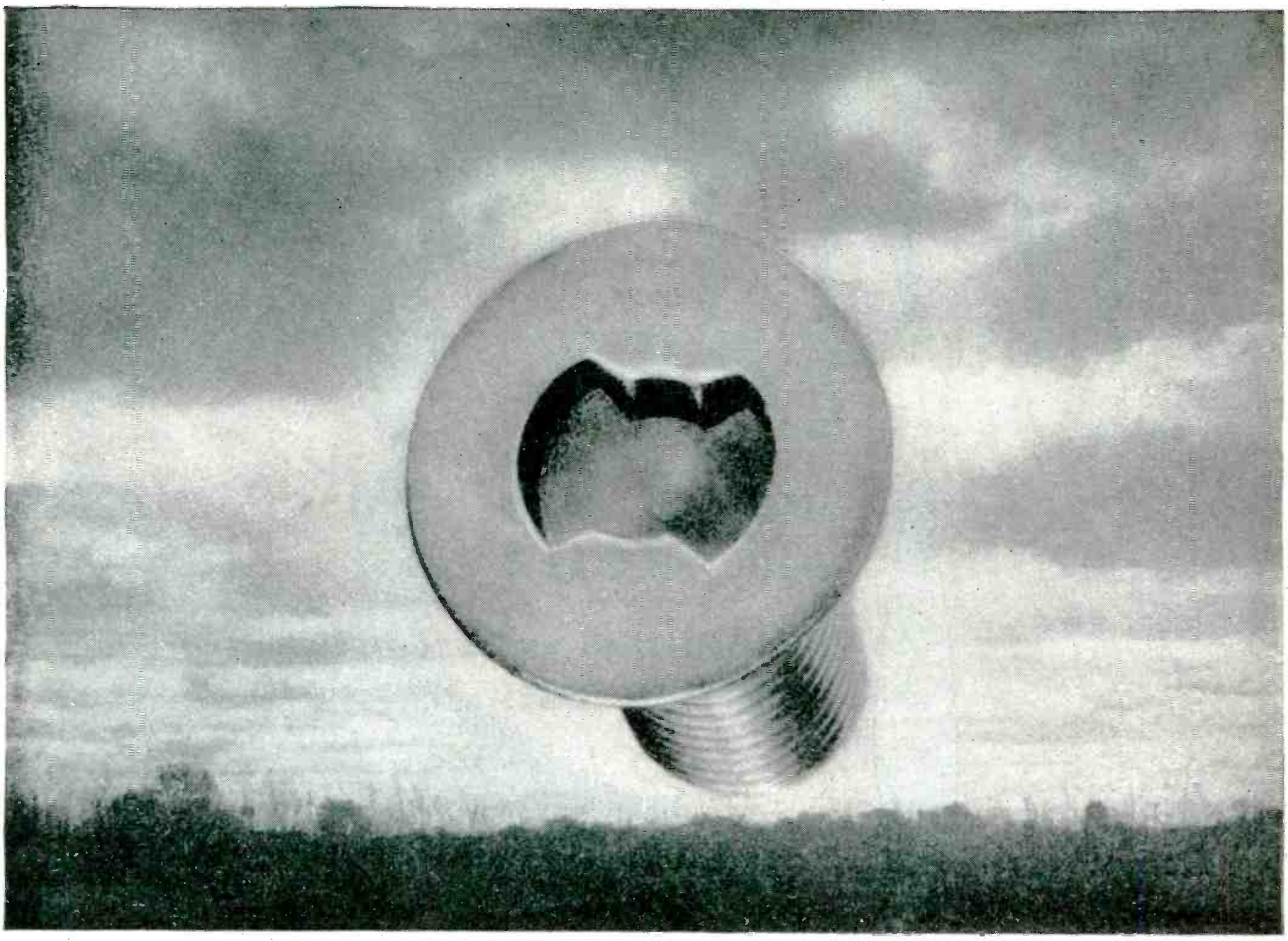


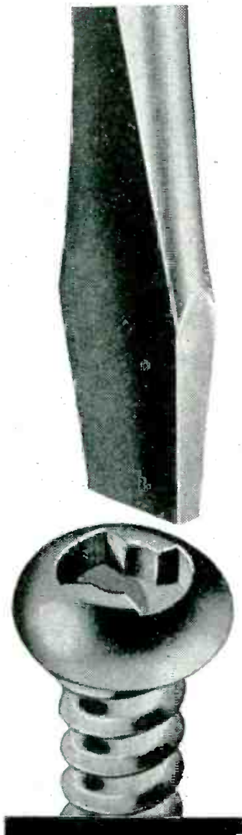
You can't see many of our "Amperextras", but their effects are apparent in the quality, efficiency and longer life of ***Amperex*** tubes. Illustrated is a highly specialized method of glass fabrication. Among our other novel techniques are sealing operation on rotating fires, precise welding, unique way of sealing glass to copper, extremely careful chemical cleaning. These operations are characteristic of the standards of ***Amperex***—the scientific laboratory on an enlarged scale.

Still Your Best Investment . . United States War Bonds

AMPEREX ELECTRONIC PRODUCTS

79 WASHINGTON STREET BROOKLYN 1, N. Y.





New Horizons

in assembly line production have been brought into focus by the advent of CLUTCH HEAD Screws . . . opening the way to new degrees of speed, safety, simplicity, and economy.

What other screw invites operator confidence and speed with a recess bull's-eye target so wide and so easy to hit?

What other screw has a straight-walled recess engineered to reduce end pressure for a safe effortless drive home?

What other screw matches the CLUTCH HEAD Lock-On feature which unites screw and bit as a unit for free one-handed reaching to hard-to-get-at spots?

What other driver approaches the economy of the rugged CLUTCH HEAD Type "A" Bit for long continuous service and simplified 60-second "on-the-spot" reconditioning to original efficiency?

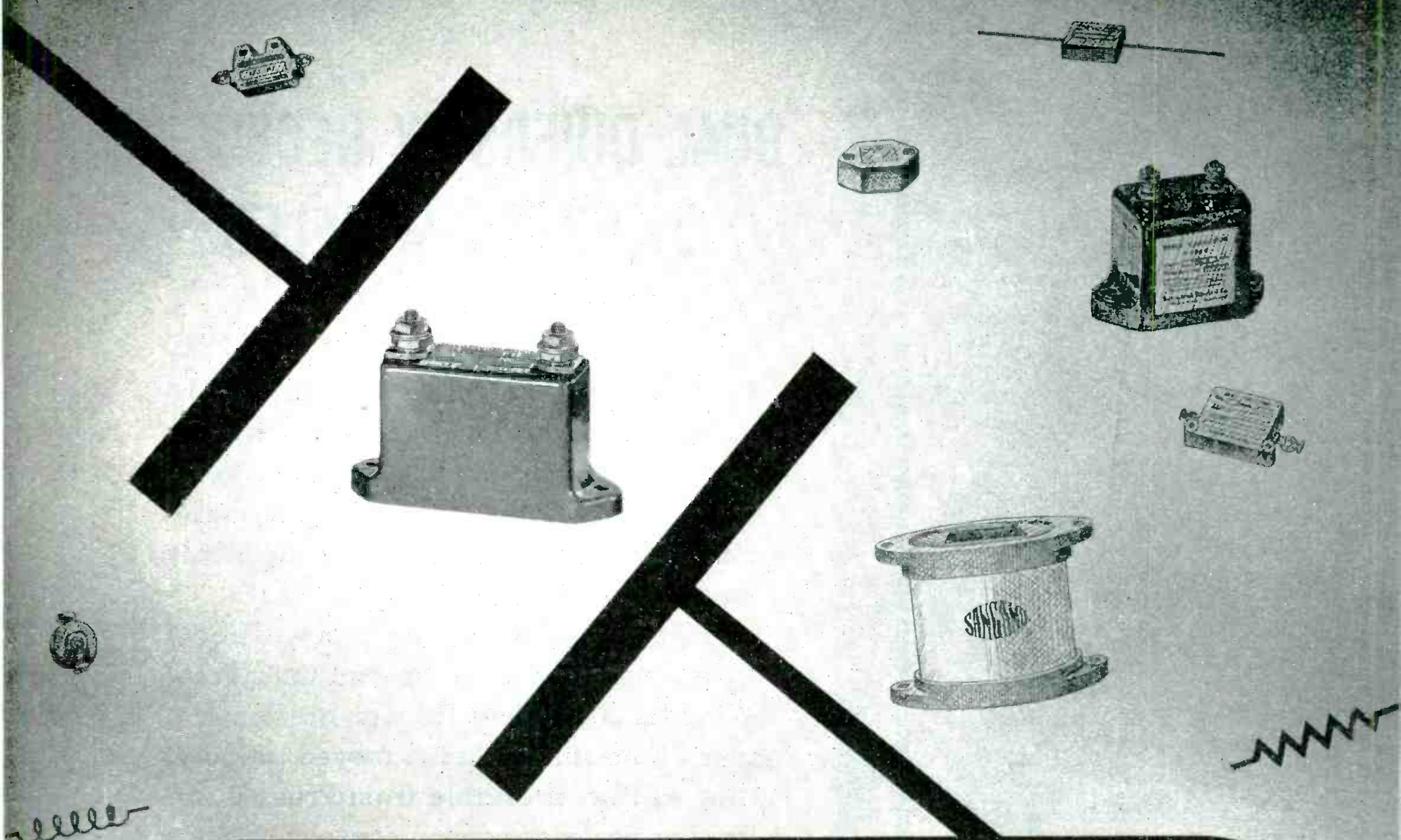
In field service too . . . What other recess has the logical design that makes it operative with the ordinary type screwdriver: even with a piece of flattened steel rod in emergency? And what other than the Type "A" Bit makes it possible to withdraw screws undamaged and saved by the Lock-On for re-use?

That you may personally examine and test these exclusive features, United invites you to send for package assortment of CLUTCH HEAD Screws and sample Type "A" Bit; also fully illustrated Brochure.

CLUTCH HEAD SCREWS

UNITED SCREW AND BOLT CORPORATION

CHICAGO CLEVELAND NEW YORK


SANGAMO

Reserve your place NOW in the coming great new industry ...TELEVISION

USE THE G-E EQUIPMENT RESERVATION PLAN TO ESTABLISH YOUR POST-WAR PRIORITY

TELEVISION has become a fast-moving practical reality. In five major areas — Schenectady-Albany-Troy, New York City, Philadelphia, Chicago and Los Angeles — live talent and film programs are being telecast regularly by established television stations that have been in operation for a number of years.

Advertisers and agencies are now working with many types of programs, and testing commercial techniques and advertising methods that add "visual demonstration" to the present "audio salesmanship" of conventional broadcasting. These experiments are making television history! A successful television relay system already links Schenectady and New York; New York and Philadelphia — forecasting a practical *nation-wide* system of commercial television service.

At Schenectady, in the world's most powerful and best equipped television station, WRGB, General Electric has built the *complete* television system — from transmitter to receiver — antenna to television relay — right down to the air-conditioning and studio equipment . . . ready for your inspection, demonstration and study.

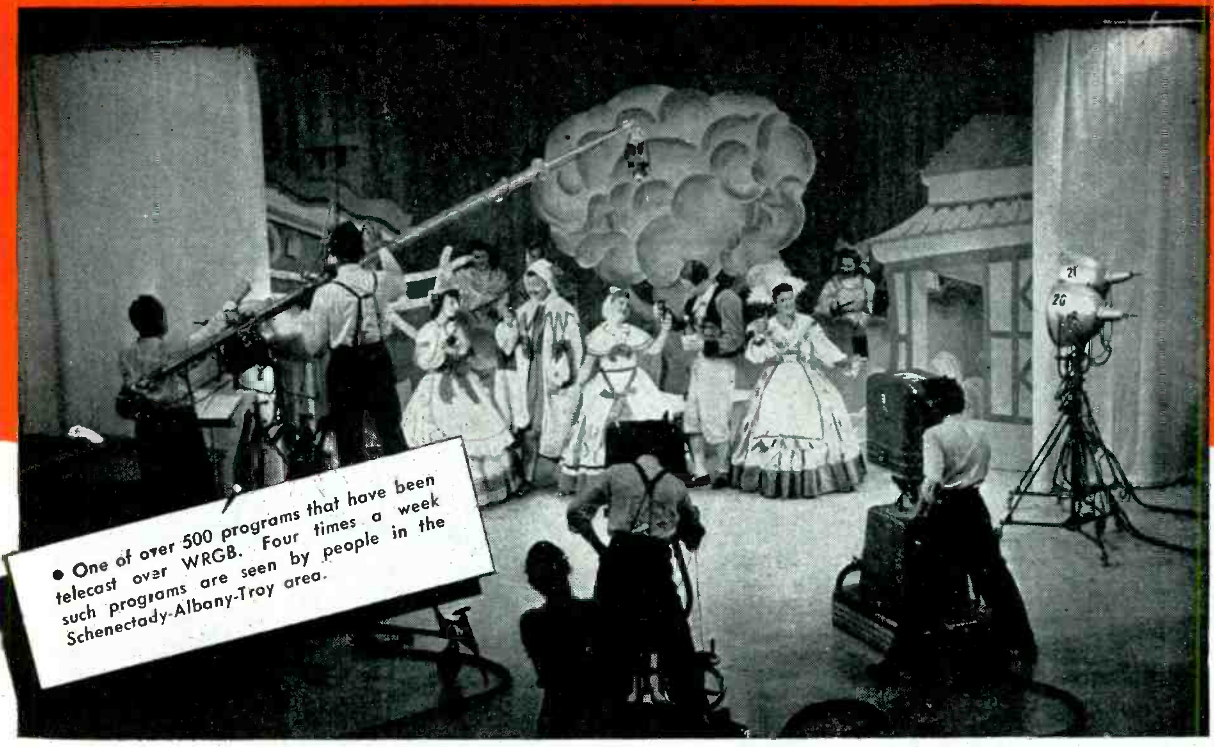
THE G-E TELEVISION EQUIPMENT RESERVATION PLAN

and the brochure, "Television Broadcasting Post-war"

We have mailed these two G-E publications to our list of prospective television broadcasters. The Equipment Reservation Plan will enable you to establish a post-war priority on television equipment. It will enable us to plan definitely for large-scale post-war production — thereby giving you the fastest possible post-war delivery.

If you are interested in entering television broadcasting and have not received these G-E publications, we shall be glad to send them to you. Address *Electronics Department, General Electric, Schenectady, New York.*

General Electric can supply the COMPLETE television broadcast system



COME TO SCHENECTADY... AND SEE THE WORLD'S MOST POWERFUL AND BEST-EQUIPPED TELEVISION STATION

WRGB, General Electric's workshop television station in Schenectady, exists solely as a proving-ground for equipment and programs. Here, G.E. has gained vast experience in the perfection of the *complete* television system. Here, G.E. has established the technical standards for each specific equipment by *actual performance*. Here, G.E. has gathered a huge backlog of programming knowledge from over 500 shows telecast over WRGB.

All of this research, equipment, and "know how," covering over twenty years of television experience, is at the service of prospective television broadcasters.

We do not pretend to be able to solve all the problems of programming. That is a job which the entertainment business and the news business can do — and we are confident they will do it.

We do not pretend to know all about how to make television an effective, economical advertising medium. That is a job which advertisers and advertising agencies can do — and we are confident they will do it.

We do not pretend to know all the answers involved in the business of operating television stations, tying them together as networks, and making them pay. That is a job for those whose business is broadcasting — and we are sure that they can and will do that job.

The success of television will require the closest kind of teamwork between show business, the news business, the advertising business, the business of manufacturing television broadcast equipment and receivers, and the business of retail sales and service of receivers.

General Electric believes that the strongest contribution we can make to this teamwork is television research and engineering, and the manufacture of high-quality television transmitters and receivers to sell at the lowest possible prices.

G.E. also contributes the facilities of station WRGB as a proving-ground to *all* of these separate industries. We are now working with some of the most progressive elements in these businesses. The continuing co-operation of each one in this common effort will advance greatly the coming of national television, and enable it to grow rapidly into the great new industry that will give employment to hundreds of thousands and provide a new world of entertainment to millions.

Electronics Department, General Electric, Schenectady, New York

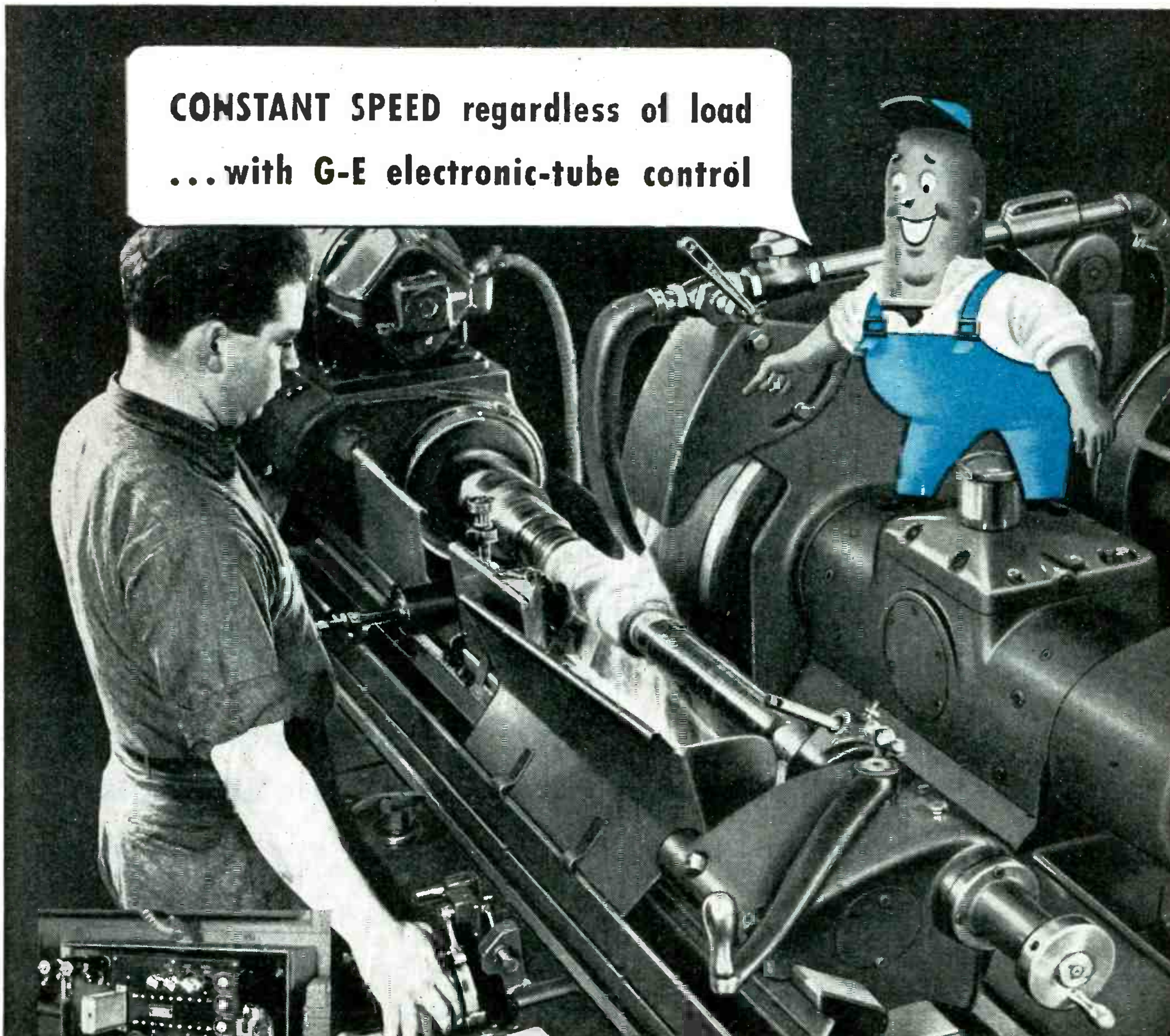
---

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

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

GENERAL ELECTRIC **FM · TELEVISION · AM**

See G.E. for all three!



The G-E thyratron tube is the "heart" of the G-E Thy-mo-trol unit which keeps the grinder going at uniform speed.

WHAT happens when a "hard spot"—or a "soft spot"—is encountered in a grinding machine operation? Nothing to upset the machine's stride when the Thy-mo-trol, the G-E electronic-tube motor control, is used for supplying power to the head-stock. Increased load causes no slowing; reduced load, no over-speeding . . . G-E tubes act as either a spur or a check to the power applied as may be needed to maintain the speed at which the operator has set the machine.

G-E electronic-tube control of motors provides smooth, stepless control of an extremely wide range of speeds. It helps to insure continuous smooth-surface grinding; improve tolerances; reduce rejects — and it provides the *right* speed for each type of grinding operation.

G-E electronic-tube control is similarly applicable to lathes, drill presses, milling machines and other motor-driven machinery subjected to varying loads. The thyratron is but one of a complete line of G-E electronic tubes that are enabling many kinds of industrial machines to do their work better, faster, more economically.

Through its nation-wide distributing system, General Electric is prepared to supply users of electronic devices with replacement tubes.

"HOW ELECTRONIC TUBES WORK"

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

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

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

GENERAL ELECTRIC

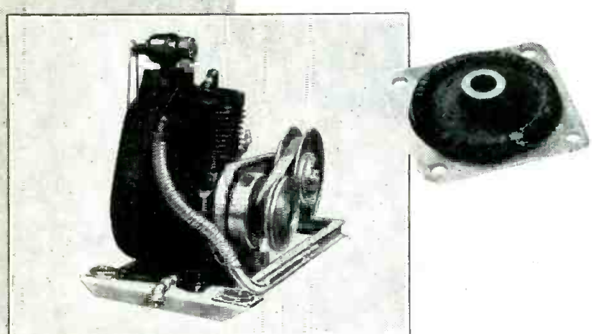
162-C5

PROTECTIVE ENGINEERING . . .

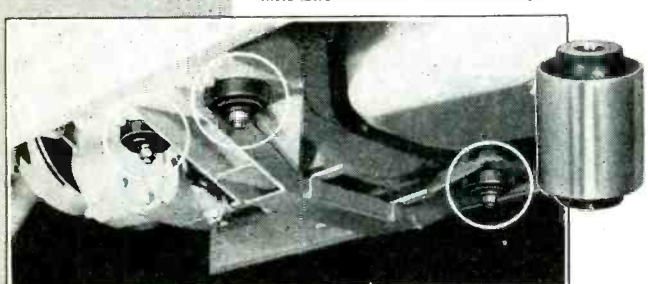
FOR THE ULTIMATE IN VIBRATION CONTROL

Specify

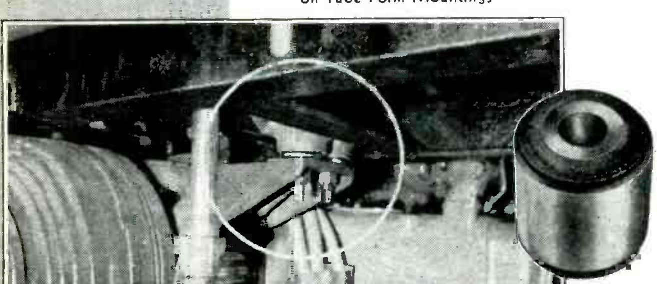
LORD
BONDED RUBBER
Shear Type
MOUNTINGS



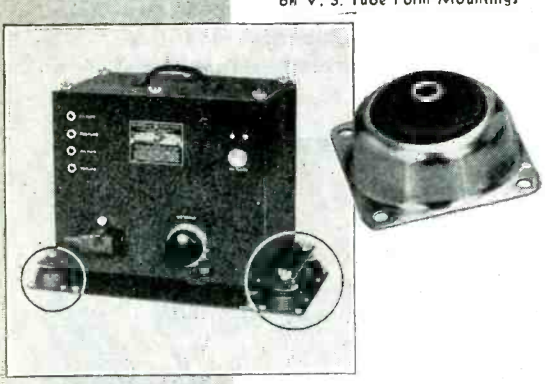
Salsbury Company Moto-Scooter Engine Installation on Plate Form Mountings



Flxible Company Engine Installation on Tube Form Mountings



acf Moto-Railer Engine Installation on V. S. Tube Form Mountings



General Electric Radio Telephone Transmitter Installation on Holder Type Plate Form Mountings

"Protective Engineering" defines in a phrase the precautionary methods used to insure the perfect and continuous operation of modern industrial equipment. The one single factor which causes most breakdowns of equipment is vibration; but vibration can be controlled and its destructive action minimized by using an engineered means of isolation. The modern use of flexible mountings to isolate vibration is a prime example of Protective Engineering.

Lord Shear Type Rubber Mountings are designed to fulfill the requirements of a protective device which will isolate vibration and prevent any destructive action on the assemblies in which they are used. Flexible mountings will prolong equipment life, lower maintenance costs, insure accuracy of operation, reduce weights by eliminating necessity for inertia masses, and cut down noise by breaking up metallic paths for sound travel. These advantages will be gained whether the vibration emanates from the mounted equipment or comes from an outside force.

Necessarily, such a product must be made in many sizes and shapes to isolate any piece of equipment, from light delicate instruments to heavy massive machinery. There are two fundamental designs, illustrated at the left—plate form and tube form, in snubbing and non-snubbing types. The mountings are made with load ratings of a few ounces at 1/16″ deflection up to many thousand pound load ratings with deflections up to ½″ and greater in some cases.

For complete information covering all Lord Mountings, as well as engineering discussion on vibration control, write for Bulletins 103 and 104, or call in a Lord Vibration Engineer for consultation on your vibration problems. There is no obligation.

BACK THE ATTACK WITH WAR BONDS

IT TAKES RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

SALES REPRESENTATIVES
NEW YORK - - 280 MADISON AVE.
CHICAGO - 520 N. MICHIGAN AVE.
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BURBANK, CAL. - 245 E. OLIVE AVE.
CANADIAN REPRESENTATIVES
RAILWAY & POWER ENGINEERING CORP., LTD.
TORONTO, CANADA

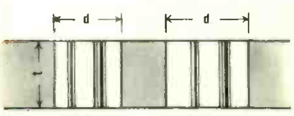
Originators of Shear Type Bonded Rubber Mountings

SUGGESTIONS ON DESIGN FOR THE USE OF SYNTHANE

Synthane technical plastics are easy to machine by usual shop methods. However, the work of the production department can be simplified and costs and spoilage reduced by following these suggestions when designing parts:

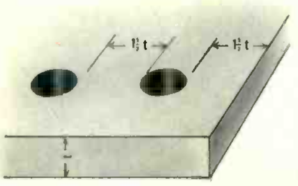
PUNCHED OR SHAVED EDGES—Punching produces a relatively smooth edge in thicknesses up to 1/16 in. For extra smoothness, especially in thicknesses over 1/16 in., shaving should be specified.

PUNCHED vs. DRILLED HOLES—Tolerance can be held closer on drilled holes than on punched holes but rarely is the accuracy of a drilled hole necessary if the hole can be punched.

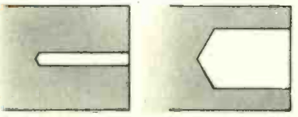


Minimum d = t   Preferred d > t

DIAMETER OF PUNCHED HOLES—The preferred ratio of hole diameter to thickness of material is not less than 1:1. That is, the diameter of a punched hole should not be less than thickness of sheet.

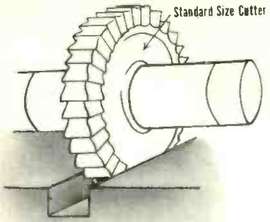


DISTANCE BETWEEN PUNCHED HOLES—PUNCHED HOLES NEAR EDGES—The distance between the circumferences of punched holes or between the circumference of a punched hole and the edge of a piece should not be less than 1-1/2 times the thickness of the piece.



Satisfactory   Objectionable

HOLES PARALLEL TO LAMINATIONS—Avoid large holes parallel to laminations where subsequent pressure, as from a screw, might injure the piece.

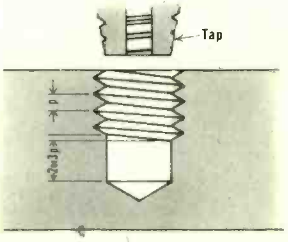


Economical design makes use of standard size tools

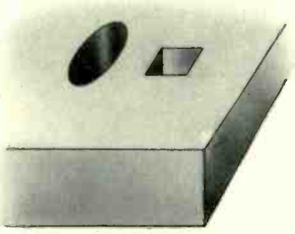
DESIGN FOR MACHINING WITH STANDARD TOOLS—Try to design parts so that machining can be done with standard tools or cutters. Specify standard size holes and slots wherever possible to avoid special tooling.

TOLERANCES—Give careful consideration to tolerances. It is poor economy to specify closer tolerances than are actually needed. As a matter of fact, laminated plastics cannot be held to tolerances such as .000″—.0005″. The minimum tolerance advisable on dimensions under 1/2 in. is a total of .002″. This tolerance is the absolute minimum and all parts should be designed with greater tolerances if possible.

TAPPING TOLERANCES — Tapping should not be specified closer than a Class 2 fit with 65 to 70% of thread. Additional thread depth would add very little strength at the risk of breaking threads.

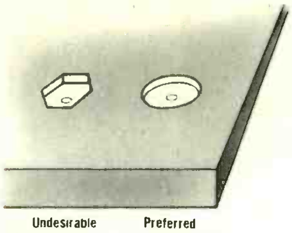


TAPPING IN A BLIND HOLE—When tapping in a blind hole, allow a depth of several threads from the bottom of the hole to first full thread for clearance.



Try to avoid irregular holes unless piece is thin enough to be punched

AVOID IRREGULARLY SHAPED HOLES—Eliminate, wherever possible, irregularly shaped holes unless the thickness of the piece permits punching. Irregularly shaped holes on thicker sections can be made, but special tools are required.



Undesirable   Preferred

IRREGULAR COUNTER BORES AND RECESSES—Eliminate entirely all irregular counter bores and recesses (except round).

MILLED SLOT WITH SQUARE CORNERS — Avoid stopping a milled slot with square corners. Allow the bottom of the slot to emerge to the surface with the natural contour of the cutter. "Climb" milling is recommended.

Correct   Incorrect

MARKING PARTS—Most parts can be marked with a punch, engraved or printed by the Synthographic process. The thinnest of materials can be printed.

FORCED FITS—The close tolerances required for forced fits in metal are not at all necessary in Synthane. Males can be as much as .005″ oversize.

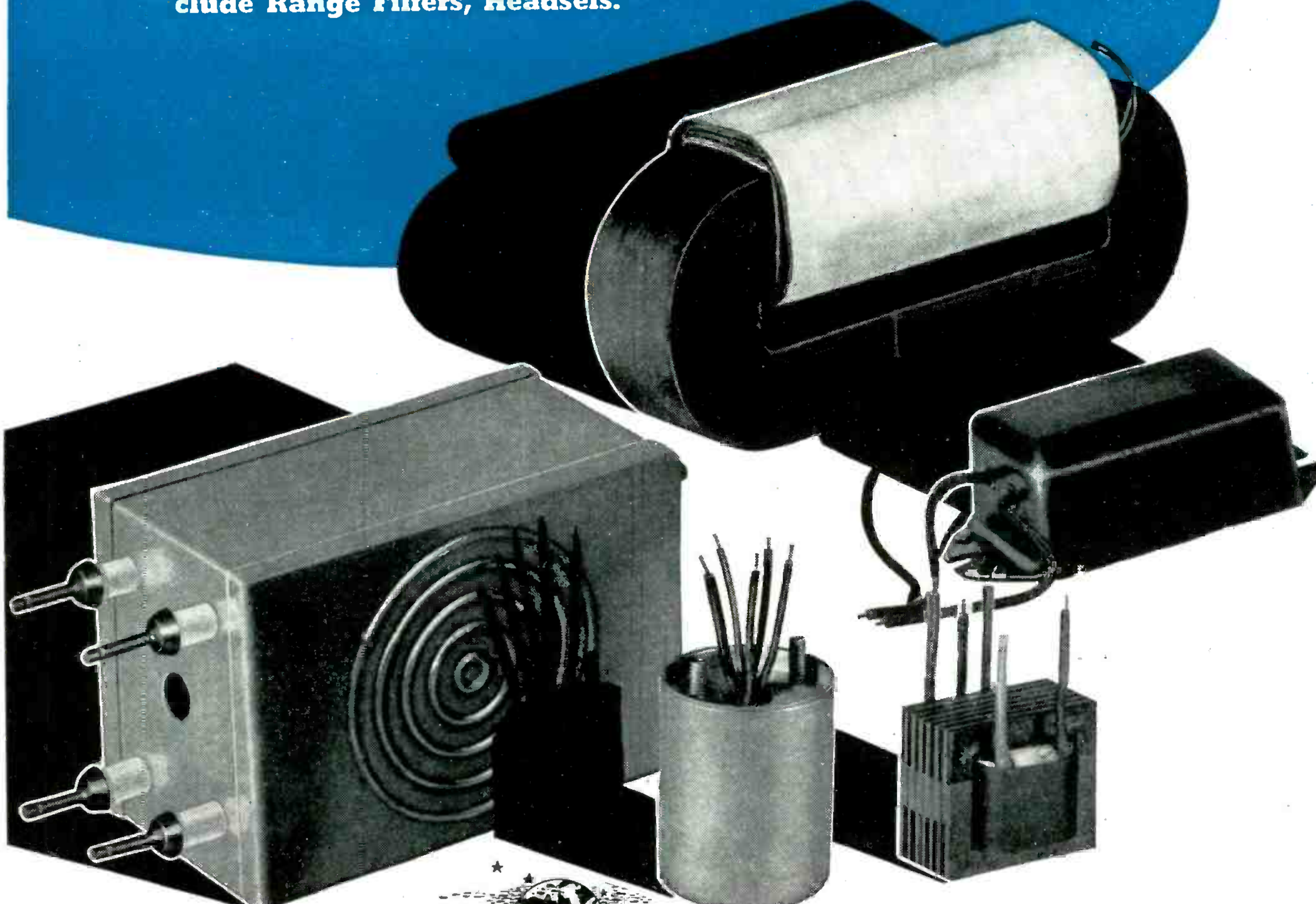
PLAN YOUR PRESENT AND FUTURE PRODUCTS WITH SYNTHANE TECHNICAL PLASTICS

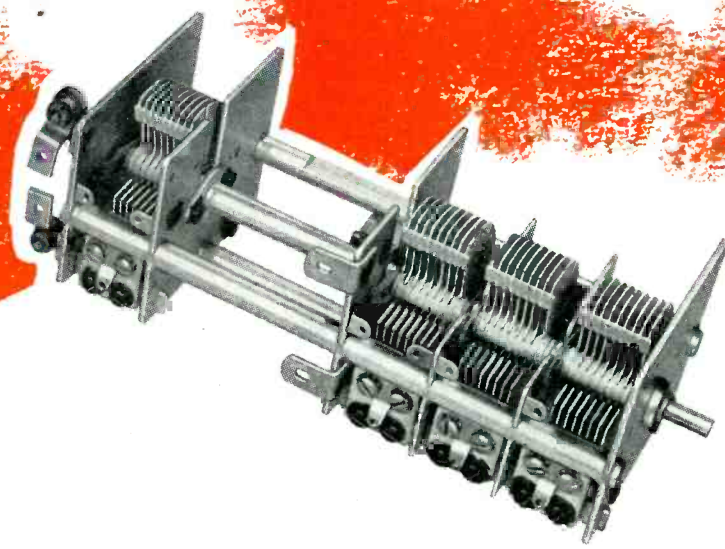
SYNTHANE

SHEETS·RODS·TUBES·FABRICATED PARTS·MOLDED-LAMINATED·MOLDED-MACERATED

SYNTHANE CORPORATION, OAKS, PENNA.

REPRESENTATIVES IN ALL PRINCIPAL CITIES





QUESTION: How important is an air condenser to radio tuning? It is the answer to accurate, distinct radio tuning. This being so, it is significant that today the variable air condensers of Radio Condenser Company are being used by our armed forces on all types of radio communication sets, because this indicates the condenser's performance of accurate tuning. After the war we will return to our manufacture of variable air condensers and push button tuning devices for civilian use. So, in planning your post-war radio manufacture, plan to use Radio Condenser Company products.

RADIO CONDENSER CO.

CAMDEN, N. J.

RADIO CONDENSER CO. LTD., TORONTO, CAN.

The Tool you'll soon *connect with!*

The torch bows out. Today, small wires are terminated or linked together simply by *Indenting* the connector to the wire with the Burndy HYTOOL. Speedy and simple . . . *for no torch, no fuel, no acid are necessary.*

But the *big* feature is that simple Indenting *eliminates faulty connections.* Note the cross-sectional view at the left . . . showing how connector and conductor have been *permanently joined* by indenting with the HYTOOL. *The connection is on to stay!*

It's a better electrical conductor, too; since the Burndy HYDENT connectors used are of one-piece, pure copper construction. *No seams or joints to loosen, or increase resistance!*

Why not have the complete story on this modern connecting method at your fingertips. The Burndy HYDENT Catalog, available on request, gives complete details.

Headquarters for connectors

Burndy

BURNDY ENGINEERING CO., INC.
107 EASTERN BOULEVARD, NEW YORK 54, N. Y.
IN CANADA: Canadian Line Materials, Limited, 13


MULTIPLE-TESTED
X-Ray OK.
JUST ONE OF FEDERAL'S MULTIPLE TUBE TESTS
X-Ray O.K.-your final assurance of a perfect tube from Federal.
Every Federal water cooled tube must pass this pre-shipment test.
It is only one of the "Multiple Tests" Federal makes to bring you the ultimate in vacuum tubes. Every known test of mechanical and electronic perfection is a Federal "must" . . . tubes are tested for high-voltage overload . . . shelf life is given to prevent shipment of tubes with glass strains or slow leaks . . . and a final, all-inclusive, operation test leaves nothing to conjecture.
Federal's "Multiple Testing" adds up to longer tube life . . . uniform electrical characteristics . . . and lower cost of operation. Radio men acknowledge that "Federal always has made BETTER Tubes."
Radio Ranges and Instrument Landing Systems manufactured by Federal mark the principal air routes of the nation and control the landing at many leading airports. Pioneers in the development of Aerial Navigation Equipment, Federal has made spectacular contributions to aviation progress.
Federal Telephone and Radio Corporation
AN IT&T ASSOCIATE
Newark 1, N. J.

These new ration tokens...

what are they made of?

They're made of something that you may never have seen before, but to men in the electrical and other important industries, this remarkable material has been well known for over 70 years.

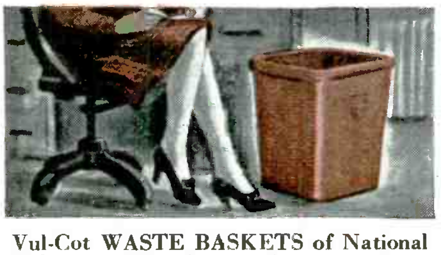
But to tell you simply what it is . . . we take cellulose, treat it chemically to change its structure, then we remove the chemicals by a long puring process. The resultant product—National Vulcanized Fibre.

That's what your tokens that cut down shopping time are made of—that's what thousands of products you see or use every day depend upon. A few are pictured below.

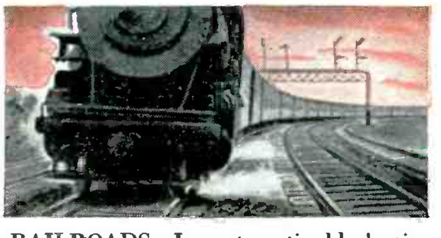
FOOTBALL PLAYERS are protected with head gear and other guards made of National Vulcanized Fibre—it combines toughness with lightness in weight—half the weight of aluminum. One of the strongest materials per unit weight, known.

WELDERS use shields made of National Vulcanized Fibre for it can be molded into just the right shape. Its light-weight, resilient, non-denting, and durable qualities make it practical, economical and long-lasting for this industrial use.

HELMETS that protect workers in mines, shipyards and hazardous industrial jobs are made of National Vulcanized Fibre. It helps prevent injuries—has remarkable property of absorbing impact blows and distributing their forces.



Vul-Cot WASTE BASKETS of National Vulcanized Fibre have wide use in offices, institutions, homes. Carry a 5 year guarantee, made in wide range of attractive colors and shapes; won't splinter or corrode. Look for Indian Head Trade Mark.



RAILROADS—In automatic block signal systems, the only electrical insulating material yet found to possess the required durability and resistance to deformation, is National Vulcanized Fibre. It insures dependable operation of signal systems.

AIRPLANES—In planes, countless parts are fabricated from National Vulcanized Fibre for it combines high dielectric and mechanical strength, shock and wear-resisting properties. A well-known use is the collar in the famous self-locking nut.

TRUNKS and LUGGAGE of quality are made of National Vulcanized Fibre. It provides lightness in weight, great strength and durability. Its tough resiliency gives luggage the ability to withstand hardest use. Look for Indian Head Trade Mark.

Your SHOES—Yes, even there, the chances are you will find National Vulcanized Fibre. It is used in women's shoes as a heel seat reinforcement, because it provides a strong base, a tighter seat and prevents the heels from pulling off.

MANUFACTURERS! DESIGNERS! ENGINEERS!

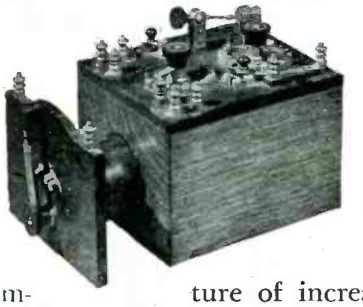
Send for a Free Copy of our eight-page folder which suggests practical and economical uses to which you can put this versatile material possessing such an unusual combination of physical, electrical and mechanical properties. Please write on your company letterhead.

NATIONAL VULCANIZED FIBRE CO.
Wilmington 99, Delaware

WIRELESS COMMUNICATION ON THE WESTERN FRONT

In 1917

FOOTE, PIERSON INSTRUMENTS WERE SERVING THE NATION



Crystal wireless receiver as built for the Signal Corps in 1917

BACK IN WORLD WAR I many military communications were received with the crystal wireless sets Foote, Pierson & Company manufactured for the U. S. Army Signal Corps.

With the manufacture of these SCR 77 crystal sets, Foote, Pierson & Company made an early contribution to the history of military communications. Few then could foresee the eventual importance of radio in modern warfare. Throughout the interval between two wars, our personnel and facilities actively participated in the manufacture of increasingly efficient radio equipment.

The experience of nearly five decades in the manufacture of communications equipment, electronic and mechanical devices, and all of our mass production facilities are fully engaged for the duration. But if your peacetime plans require that all or part of a product be manufactured for you—examine *now* our diverse manufacturing facilities, experience and custom of working to exacting standards.

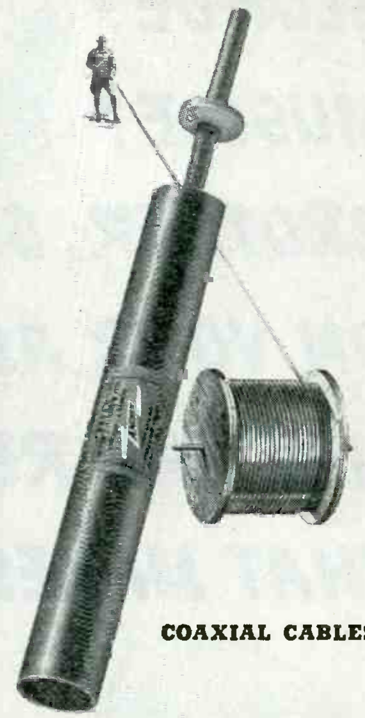
Don't wait for V-day, write to us today!

ARMY ★ E ★ NAVY

FOOTE • PIERSON & CO • INC

MANUFACTURERS OF PRECISION INSTRUMENTS SINCE 1896

75 Hudson Street FP *Newark 4, N. J.*



COAXIAL CABLES

ANDREW Coaxial Cables for the famous HALLICRAFTERS SCR-299

ANDREW Coaxial Cables are standard equipment on the Hallicrafters-built SCR-299: the mobile communications unit that is doing such an outstanding job on the fighting fronts. It is highly significant that ANDREW Coaxial Cables were chosen as a component of this superb communications unit.

The Andrew Company is a pioneer manufacturer of coaxial cables and accessories. The facilities of the Engineering Department are available to users of radio transmission equipment.

DRY AIR PUMP

ANDREW CO.

COAXIAL CABLES. The Andrew Company is now able to supply standard 70 ohm 7/8" soft temper coaxial cable in lengths up to 4,000 feet! The cable is electrically identical to rigid cables of equal size, but has these extra advantages: the cable may be uncoiled and bent by hand, thus greatly simplifying installation; no connectors, junction boxes or expansion fittings need be installed in the field; thus a big saving is made in installation time and labor.

DRY AIR PUMP. This hand-operated pump quickly, efficiently and economically dehydrates the air inside coaxial cables, in addition to having a multitude of other applications. It dries about 170 cubic ft. of free air, reducing humidity from 60% to 10%.

GAS-TIGHT TERMINAL. The new Andrew glass insulated terminal is an outstanding development that provides a 100% air-tight, gas-tight system for gas filled coaxial cables. A special design that minimizes shunt capacity makes this terminal ideally suited to high frequency operation.

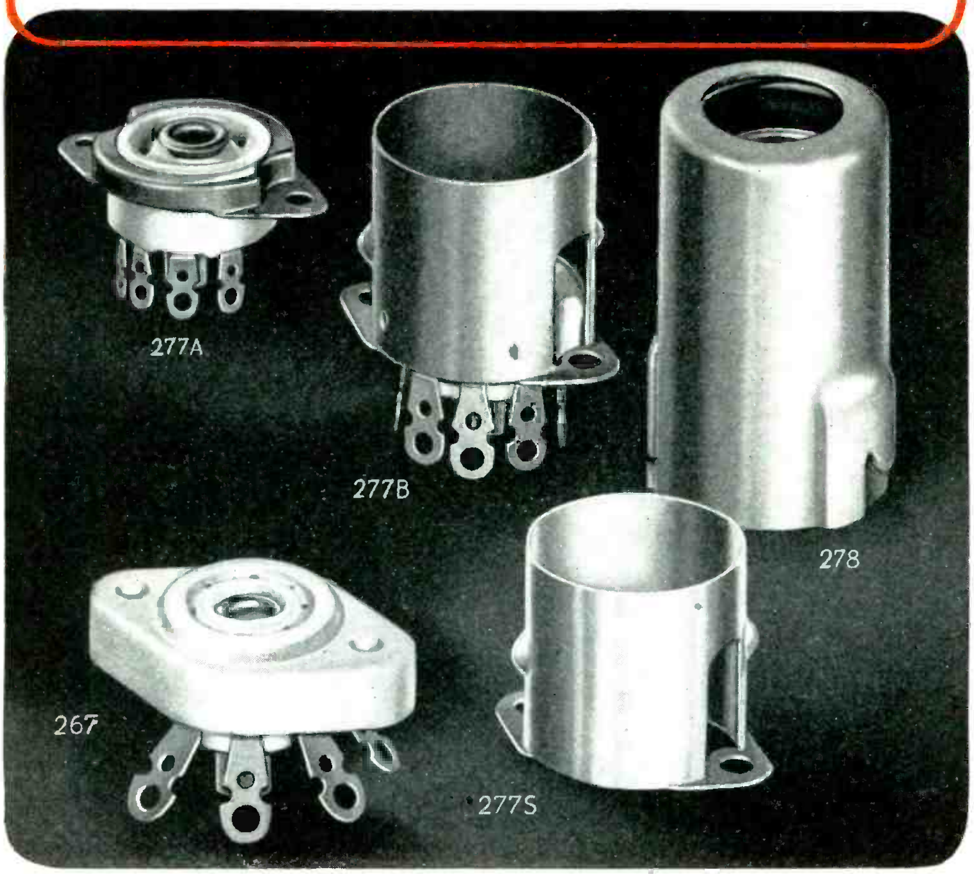
COAXIAL ANTENNA. Suitable for fixed station use and pretuned at the factory to the desired operating frequency, the Andrew type 899 vertical coaxial antenna provides an efficient, easy-to-install, and inexpensive half-wave radiator in the frequency range from 30 to 200 MC. Careful engineering has utilized to the utmost the well known advantages of the coaxial antenna over other types of vertical half-wave antennas.

GAS-TIGHT TERMINAL

CATALOG DESCRIBING COAXIAL CABLES AND ACCESSORIES FREE ON REQUEST.
WRITE FOR INFORMATION ON ANTENNAS AND TUNING AND PHASING EQUIPMENT.

THE ANDREW COMPANY • 363 EAST 75TH STREET • CHICAGO 19, ILLINOIS

JOHNSON MINIATURE SOCKETS



Pre-eminent in the ceramic socket field, it was to be expected that Johnson was asked in 1941 to develop the first miniature ceramic socket (No. 267), or that it was quickly approved and widely adopted a year or more ahead of the field, and today is going into critical equipments by the hundreds of thousands.

The same Johnson skill in engineering both ceramics and metal has gone into the No. 277, and the associated shields and shield base (usable with other sockets as well). These Johnson sockets not only meet standards (developed jointly by us, the W. P. B. Socket Sub-committee, Signal Corps, Navy and private laboratories); in each of them you may count on that EXTRA value that's typical of products bearing the Viking mark. High grade steatite insulation with long creepage and arcing paths and low inter-contact capacity; accurately formed and processed contacts of silver plated beryllium copper or phosphor bronze, freely floating and with just the right tension, feature this series of sockets.

If you have a socket problem, whether it's engineering, design, substitution, or delivery, first try Johnson.

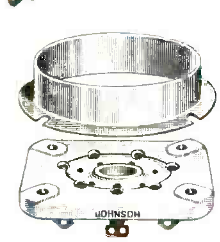
Ask for NEW catalog 968D

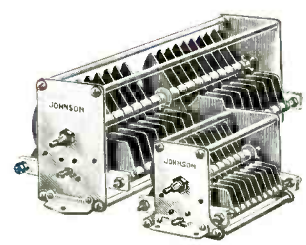
JOHNSON

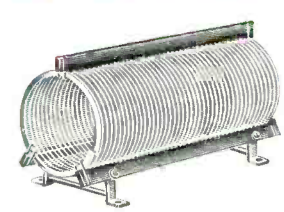
a famous name in Radio

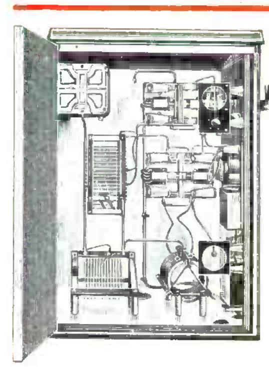
JOHNSON *Made*

PLUGS and JACKS
INSULATORS
SOCKETS
CONDENSERS
INDUCTORS
BROADCAST CABINETS







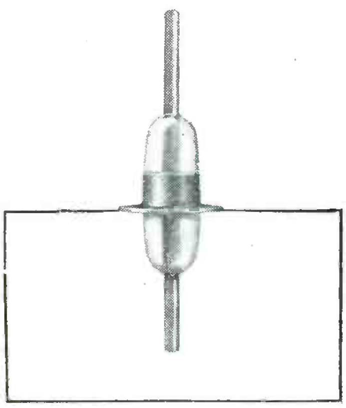


E. F. JOHNSON COMPANY • WASECA • MINNESOTA

A Thousand and One Applications

HERMETICALLY SEAL *with* KOVAR

TRADE MARK 337962, REGISTERED IN U. S. PATENT OFFICE



Single Terminal
Kovar-glass lead-through

Kovar Gauge Glass
or Sight Tube

Leak-proof Kovar-glass
Window Assemblies

ARMY NAVY E "FOR GREAT ACHIEVEMENT"

Use KOVAR for sealing

ELECTRONIC TUBES
TRANSFORMERS
RESISTORS
CAPACITORS
CONDENSERS
VIBRATORS
SWITCHES
RELAYS, ETC.
INSTRUMENTS
GAUGES
METERS
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TRANSMITTERS

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Let's All Back The Attack
Buy EXTRA War Bonds

★

THROUGH the use of Kovar and glass, your product can be sealed hermetically against air, gas, moisture, liquid.

Hermetic seals of Kovar and glass are made in a wide range of styles and sizes, ready for quick, easy assembly to your apparatus. For electrical applications, Kovar seals are made with single or multiple, solid or tubular, electrodes.

The seal between Kovar and glass is a chemical bond in which the oxide of Kovar is dissolved into the glass during a heating process. The result — a hermetic seal — permanently vacuum and pressure tight, effective under the most extreme climatic conditions — tropical to stratosphere.

Kovar IS the answer to permanent vacuum or pressure tight sealing. Let Stupakoff help engineer YOUR hermetic sealing problems with Kovar.

SINCE 1897

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Products for the World of Electronics

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

A*mateur*

B*roadcasting*

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G*overnment*
Army, Navy & Aviation

H*igh Frequency Heating*

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...and so on, throughout the "alphabet" of boundless electronic applications

UNITED 949-A
Efficient h. f. oscillator tube, one of a great many UNITED types now available.

Efficiency from A to Z

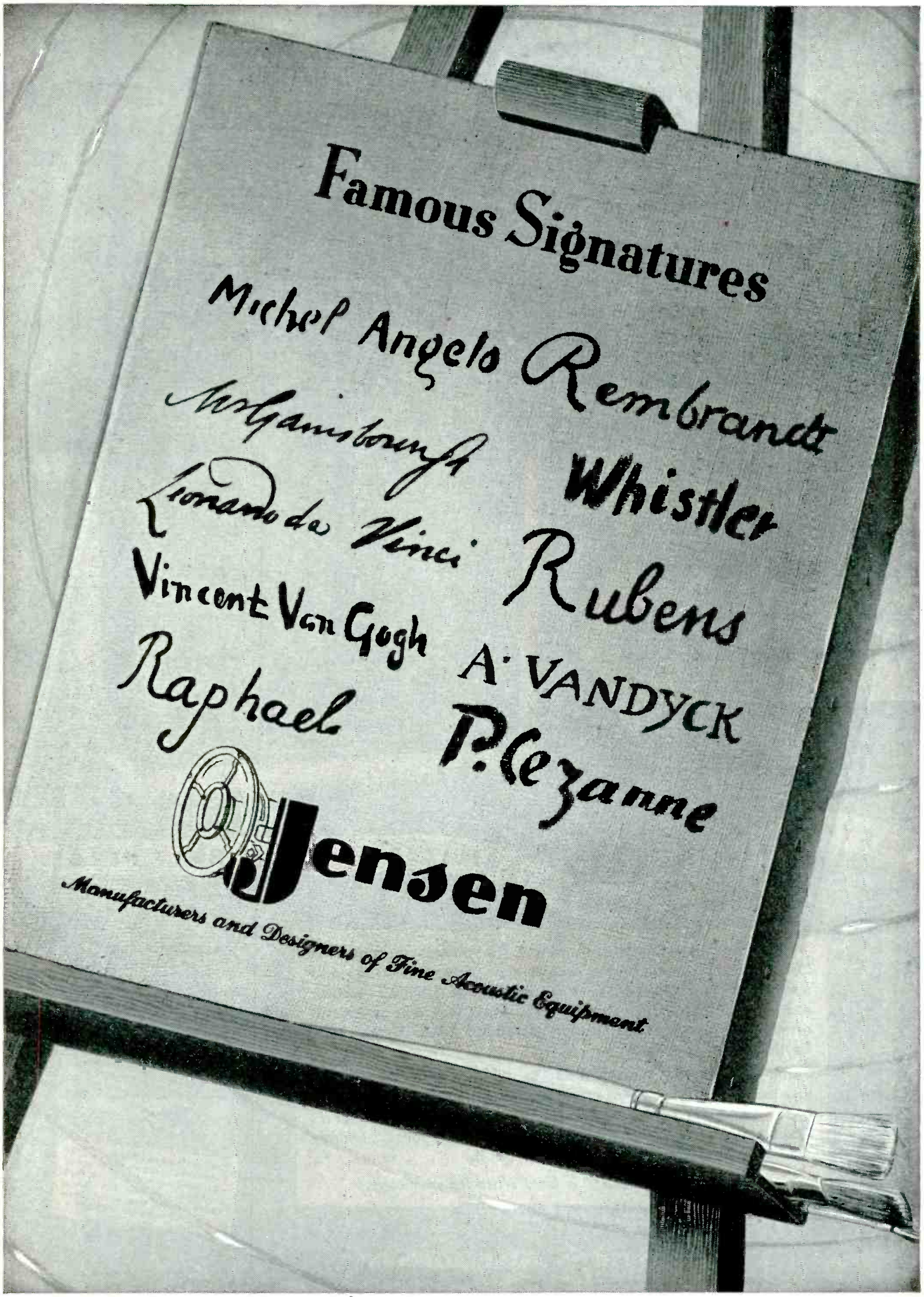
—is assured for long service life when you use UNITED Tubes. Despite the urgent demands upon us for tubes to fill military needs, we have done surprisingly well in keeping other essential requirements supplied.

Write for new catalog giving descriptive data covering an extensive range of tubes for electronic power applications.

UNITED
ELECTRONICS COMPANY

42 Spring Street • Newark 2, N. J.

Transmitting Tubes Exclusively Since 1934


Famous Signatures
Michel Angelo
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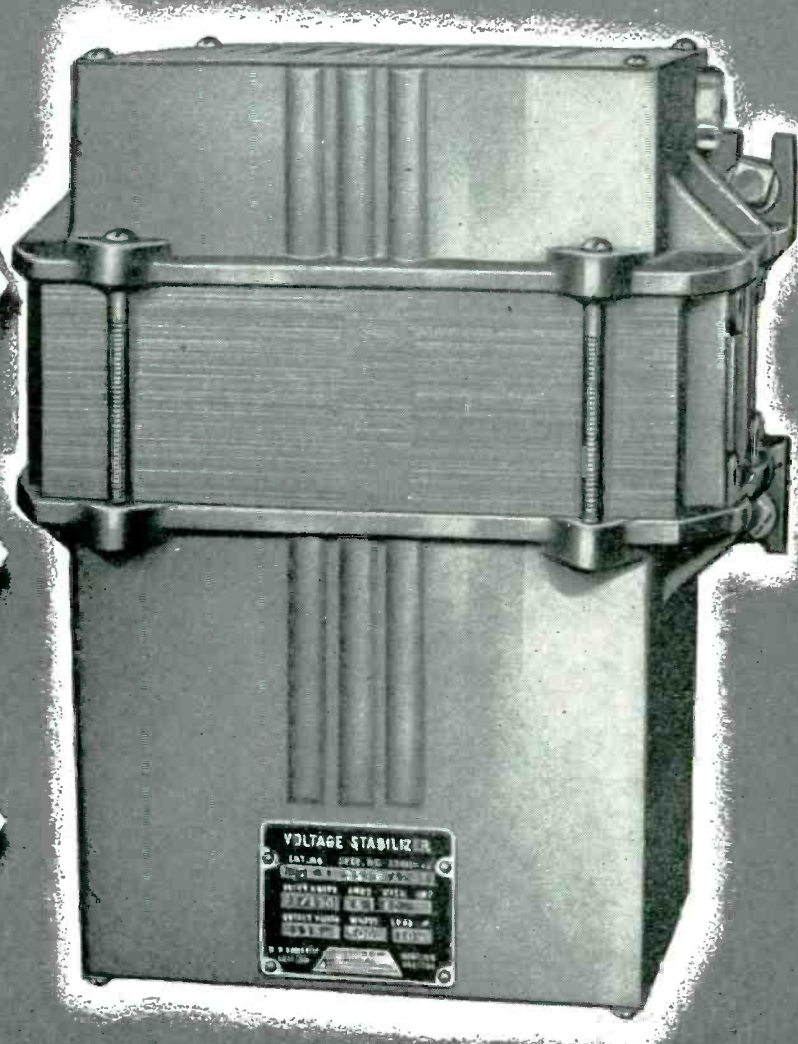
Manufacturers and Designers of Fine Acoustic Equipment

RAYTHEON VOLTAGE STABILIZERS



ENDBELL MODEL

VARYING LINE VOLTAGES STABILIZED TO ± ONE HALF PERCENT

With today's heavy demands for power, line voltages are constantly fluctuating thus impairing the performance of much precision and manufacturing equipment. A Raytheon Voltage Stabilizer incorporated into such equipment will control output voltage to plus or minus ½% over wide fluctucting voltage limits. Here's what Raytheon will do for you.

Stabilize varying AC input voltage to ±½%... Quickly stabilize any load within their ratings... Input voltage is stabilized within 2 cycles, variations cannot be observed on an ordinary volt meter... Stabilizes over wide AC voltage limits, 95 to 135 volts... Entirely automatic operation, connect it and forget it.

New Bulletin DL48-537 is free. Write for your copy.

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

RAYTHEON MANUFACTURING Company

190 WILLOW ST., WALTHAM, MASS.

LURES TO LANDING CRAFT

It's a long jump from fishing lures to landing craft. Such are the versatile uses of metals from Western. Supplied in sheet or strip, drawn or stamped parts, Western metals are now used in vital parts of war equipment that floats—flies—rolls—shoots. Looking ahead to peacetime business, our engineers and metal experts welcome inquiries from designers and engineers working on post-war products. Our mills are located at East Alton, Ill., and New Haven, Conn.

Western BRASS PRODUCTS

Western BRASS MILLS

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

BRASS • BRONZE • PHOSPHOR BRONZE • NICKEL SILVER • COPPER

FASTER WINDING

Fewer Rejects

... WHEN YOU USE FORMEX MAGNET WIRE

TOUGHNESS ... *in terms of abrasion resistance*

Type of wire	Number of scrapes per mil of insulation before failure
Conventional heavy-enameled wire	0.9
Synthetic A	10.0
Synthetic B	9.0
Formex wire	28.0

Abrasion or wear resistance, as determined by the repeated-scrape tester, provides the best single measure of film toughness.

FLEXIBILITY ... *measured by tapered-mandrel test*

Formex wire (bottom) compared with enameled wire (top). The outer surfaces of the films have been elongated by stretching around a tapered mandrel and heating the samples to 150 C. Note the cracks on the enameled wire.

Its tough, flexible insulation enables you to produce tighter coils in less time

● When you're using Formex* magnet wire, you can literally "go the limit" in speed of coil winding and in tension. Its insulation film is so flexible that it can be wound around its own diameter without cracking.

It is so tough that it has thirty times the abrasion resistance of conventional enameled wire; so tough that, even in the ultrafine sizes, the tension limit is determined by the strength of the copper conductor, not by the insulation.

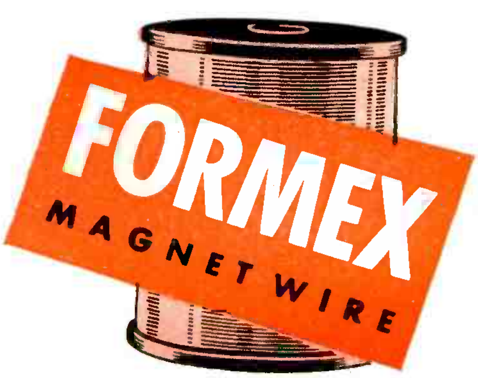
Formex wire is smoother and more flexible than either enameled or fabric-covered wire. It pulls into place readily without forcing or jamming.

Because of this extra strength and flexibility, you can wind coils tighter and faster—and these same qualities will insure more coils passing final inspection.

For more information on Formex magnet wire, get in touch with the nearest G-E apparatus office. *General Electric Company, Schenectady 5, N. Y.*

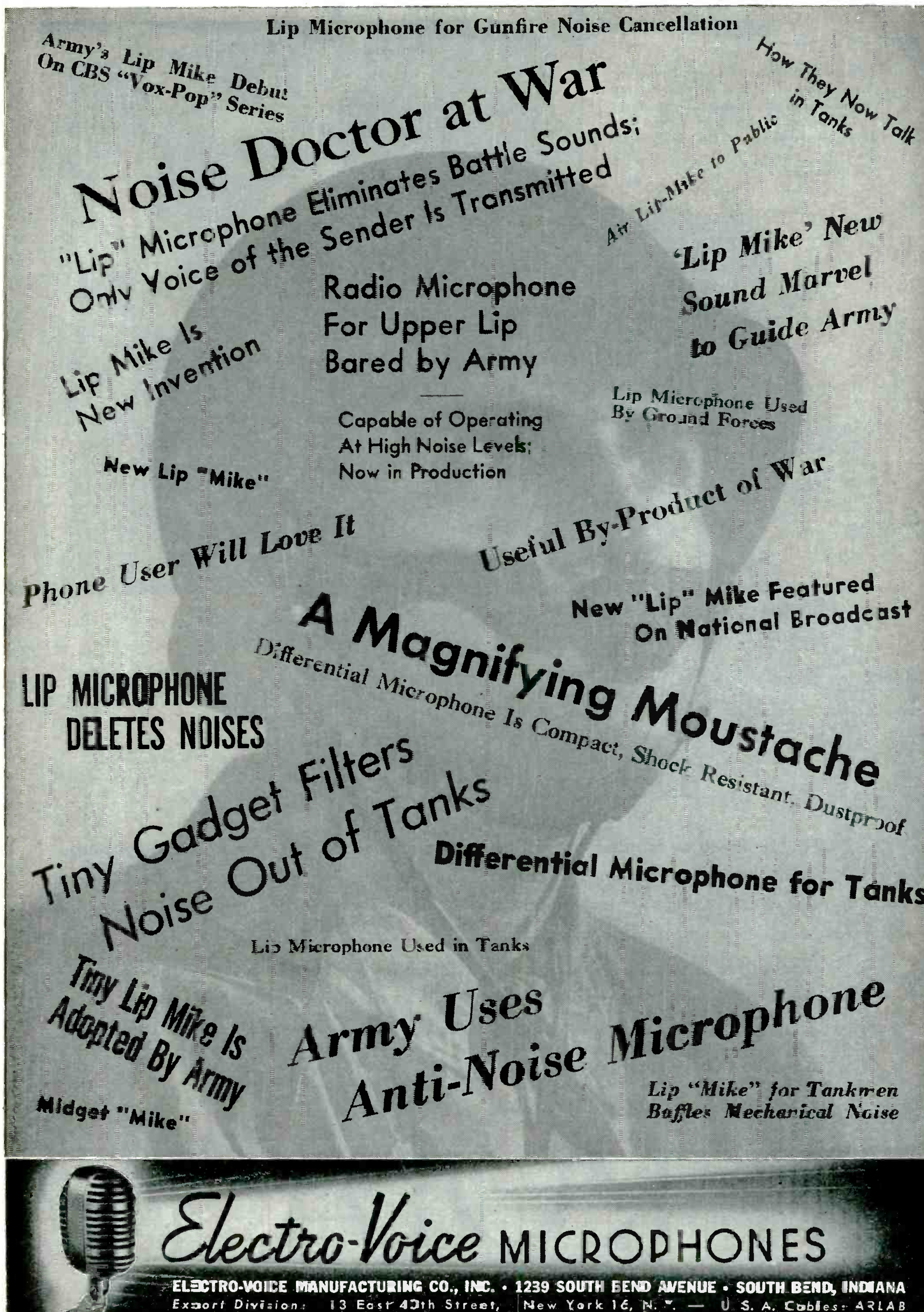
*Reg. U.S. Pat. Off.

BUY WAR BONDS



GENERAL ELECTRIC

503-18-1200



Lip Microphone for Gunfire Noise Cancellation
Army's Lip Mike Debut On CBS "Vox-Pop" Series
How They Now Talk in Tanks
Noise Doctor at War
"Lip" Microphone Eliminates Battle Sounds; Only Voice of the Sender Is Transmitted
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'Lip Mike' New Sound Marvel to Guide Army
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Capable of Operating At High Noise Levels; Now in Production
Lip Mike Is New Invention
Lip Microphone Used By Ground Forces
New Lip "Mike"
Useful By-Product of War
Phone User Will Love It
New "Lip" Mike Featured On National Broadcast
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Differential Microphone Is Compact, Shock Resistant, Dustproof
LIP MICROPHONE DELETES NOISES
Tiny Gadget Filters Noise Out of Tanks
Differential Microphone for Tanks
Lip Microphone Used in Tanks
Tiny Lip Mike Is Adopted By Army
Army Uses Anti-Noise Microphone
Lip "Mike" for Tankmen Baffles Mechanical Noise
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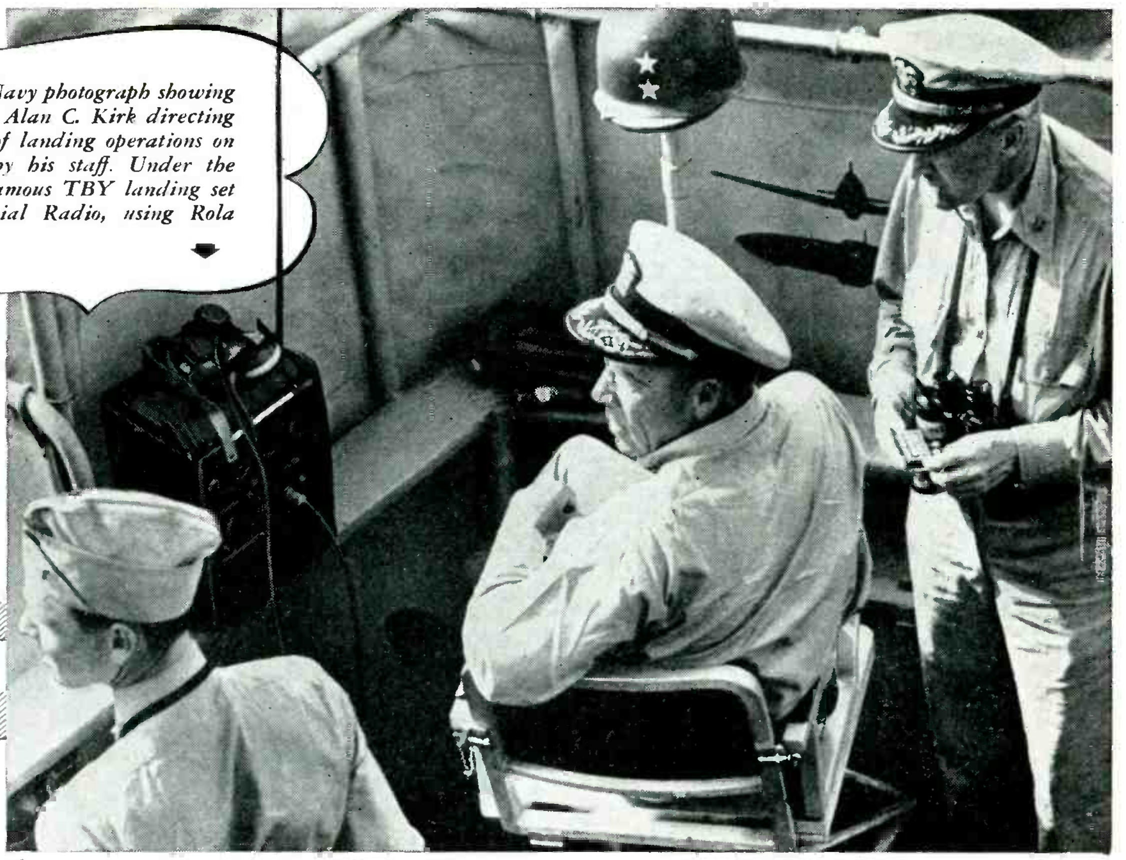
ELECTRO-VOICE MANUFACTURING CO., INC. • 1239 SOUTH BEND AVENUE • SOUTH BEND, INDIANA
Export Division: 13 East 40th Street, New York 16, N. Y. — U. S. A. Cables: ARLAB

Official U. S. Navy photograph showing Rear Admiral Alan C. Kirk directing Naval phases of landing operations on Sicily, aided by his staff. Under the arrow is the famous TBY landing set built by Colonial Radio, using Rola Transformers.



"Design for Invasion"

MONTHS ahead of landing operations the military plans are laid, and often . . . months ahead of that . . . new equipment to serve some new and vital purpose has to be designed and built.

We're now in the invasion phase of the war and with so much staked on the *availability* and *dependability* of Communications, the makers of this equipment have been asked again to increase their output.

The Electronic Industry has done a good job. Now, it must do a *better* one and Rola will contribute to the full extent of its facilities, its knowledge and its ability.

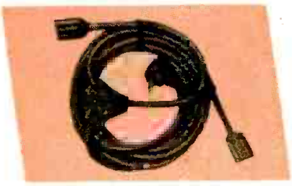
THE ROLA COMPANY, INC., 2530 SUPERIOR AVENUE, CLEVELAND 14, OHIO

ROLA

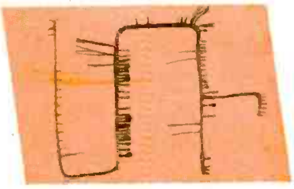
Let's do more ARMY E NAVY *in forty-four!*

MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

A GOOD WAFFLE IRON *PLUS* A GOOD CORD



A Belden Electrical Cord is a complete unit including unbreakable plug, conductor, connector, strain relief.



Belden Wiring Harnesses for all types of electrical machines and equipment produced to exact specifications.

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

For years an identifying mark of a good appliance, Belden electrical cords and plugs are an indication to the prospective customer that the manufacturer was careful in selecting all the parts for his equipment. Free from Corditis, irritating and widely publicized disease that ruins cords and plugs, an imposing percentage of Belden-equipped appliances are still running today—when failure may mean loss of service for the duration.

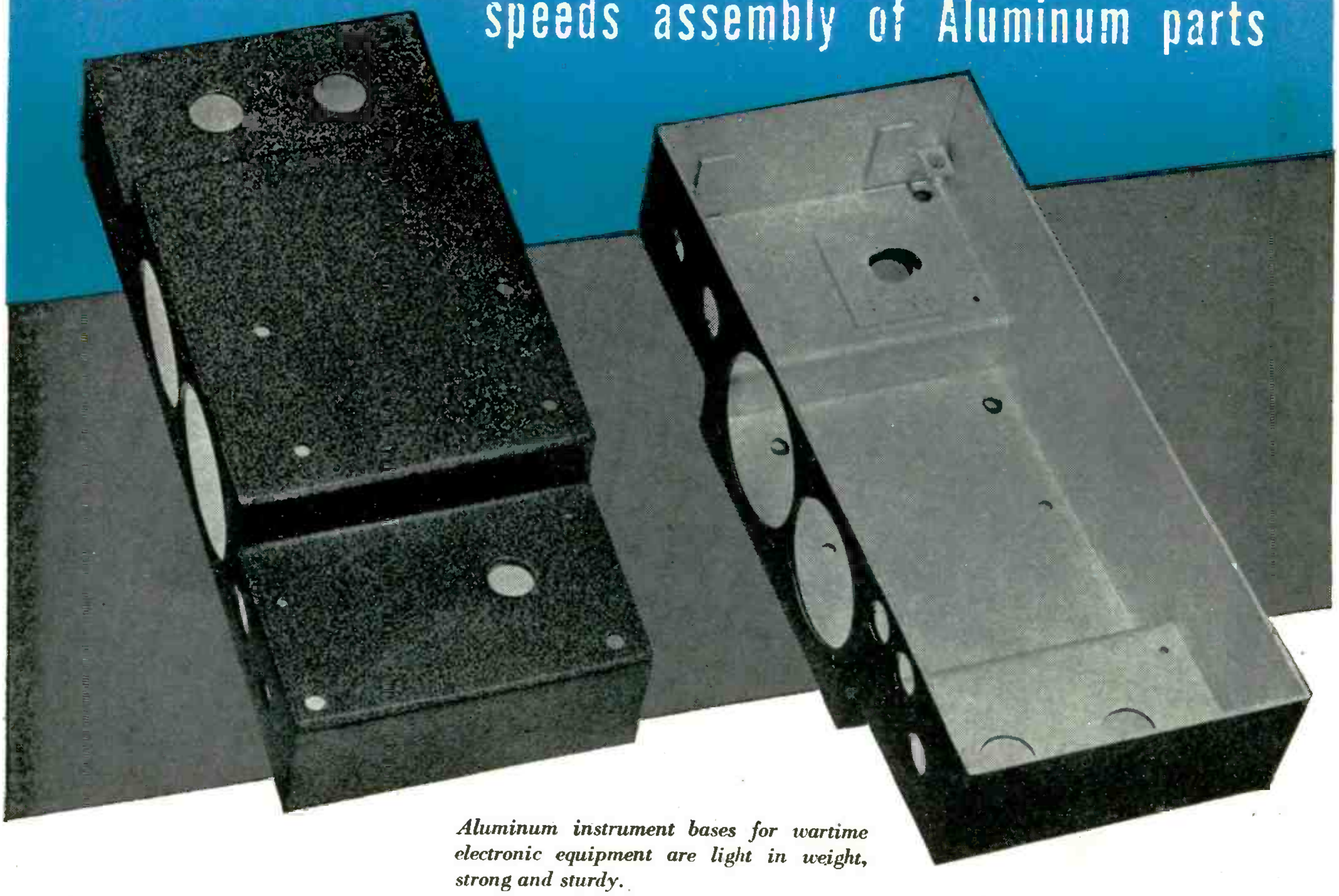
Engineer your new product with a Corditis-free electrical cord—confidence-building sign of a good electrical machine or appliance. Specify Belden.

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

Belden

Corditis-free CORDS

Furnace Brazing
speeds assembly of Aluminum parts



Aluminum instrument bases for wartime electronic equipment are light in weight, strong and sturdy.

Formed from Alcoa Aluminum brazing sheet, the joining of the top to the side walls of this instrument base is completed in a brazing furnace. The job goes fast. Man-hours are low. The part is accurate, neat, rigid and strong. All of the usual advantages of aluminum are retained; light weight, resistance to corrosion, fine appearance.

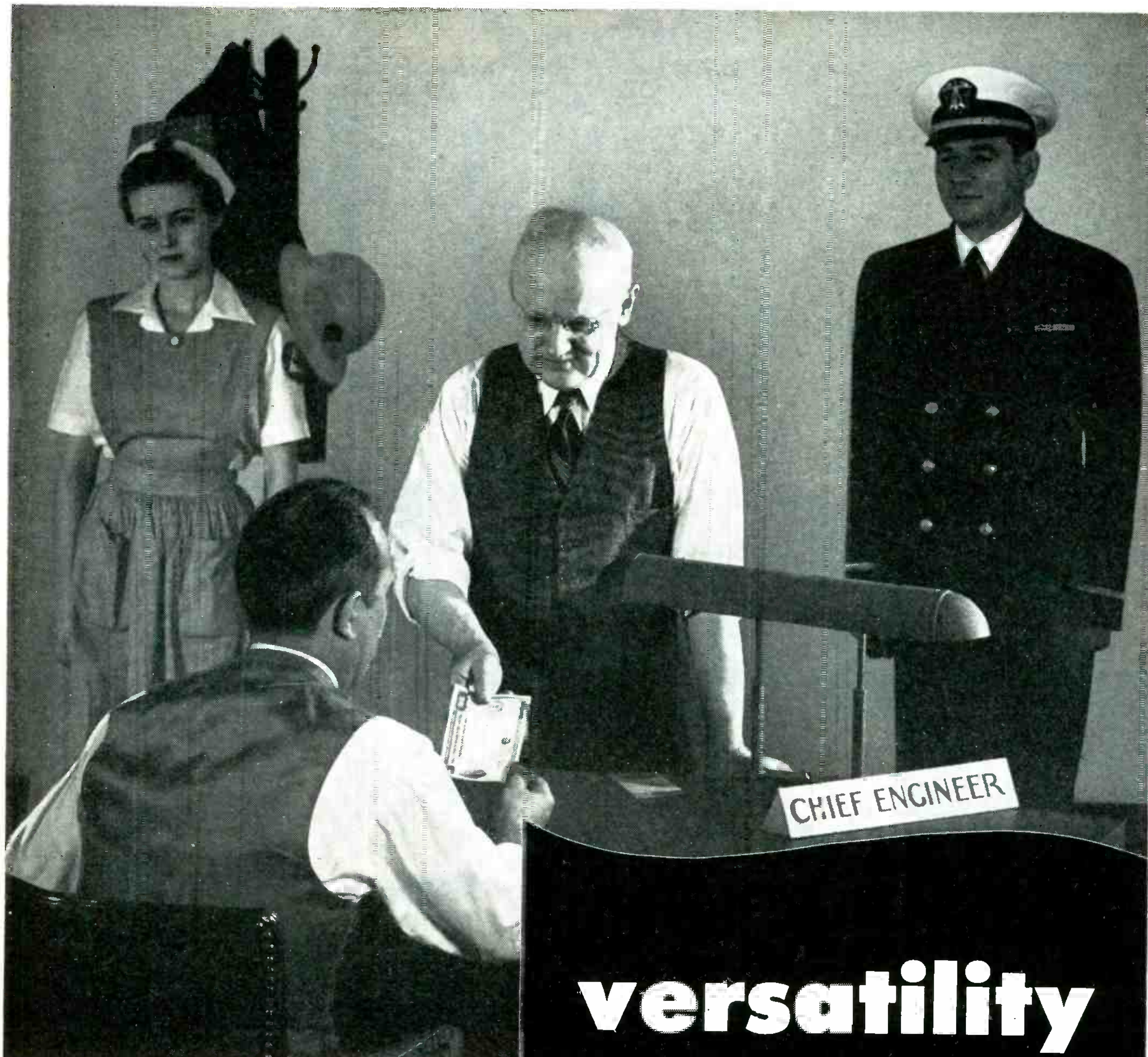
Many a product used by our fighters is getting to them faster because this brazing method of assembling aluminum was adopted. Perhaps you can employ the process to similar advantage, reducing the time and labor required for production, simplifying and improving your products. Alcoa engineers will gladly help you decide.

Too, there may be places where Alcoa Aluminum Alloys will effect additional savings. The light weight of aluminum, its ease of fabrication, make work go faster. Attractive, durable finishes are easy to apply. The use of aluminum may relieve bottlenecks caused by shortages of other materials.

For help on wartime production problems, and data that will assist in including Alcoa Aluminum Alloys in postwar designs, write ALUMINUM COMPANY OF AMERICA, 2136 Gulf Building, Pittsburgh, Pennsylvania.

ALCOA ALUMINUM

ALCOA ALUMINUM REG. T. M.



versatility

Some of the busiest men in the field of electronics today are the engineers and designers. They are spending untold "overtime" hours at the special skills for which they have trained. But they still have time to donate to the blood bank, to be air raid wardens, to participate in scrap drives, to aid the U.S.O. – and they buy war bonds, too. In short, the electronic engineer is going all out to win the war.

Raytheon engineers are meeting and *anticipating* the vast needs of the military. Raytheon is proud to be a leading manufacturer of electronic tubes and equipment that more than meet the severe wartime requirements for high quality and complete dependability.

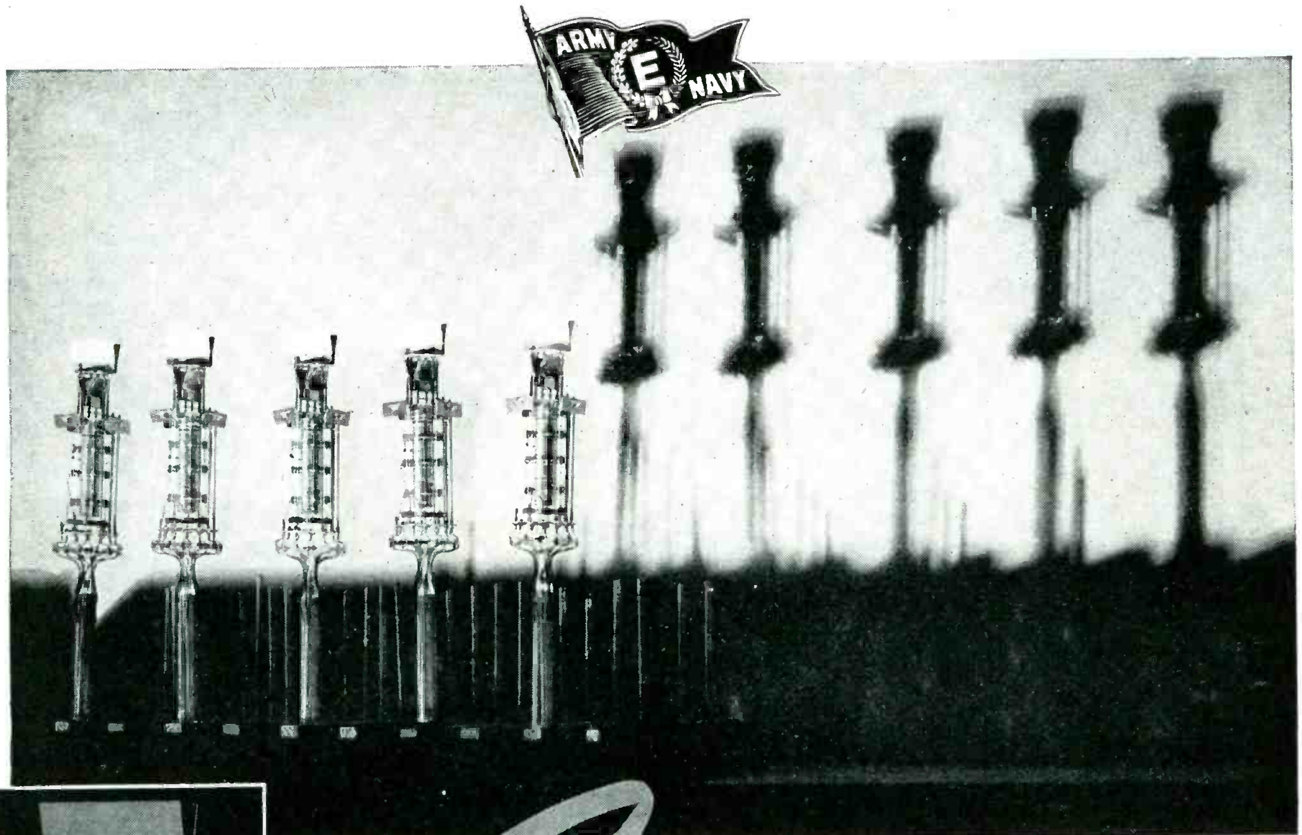
RAYTHEON

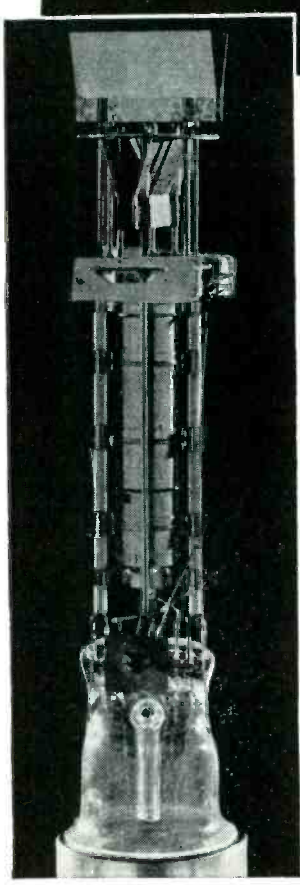
RAYTHEON MANUFACTURING COMPANY

Waltham and Newton, Massachusetts

ARMY-NAVY "E" WITH STAR
Awarded All Four Divisions of Raytheon
for Continued Excellence in Production

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





Guns FOR VICTORY!

Recently the Army-Navy "E" for production excellence was awarded to Allen B. DuMont Laboratories, Inc. In accepting this high honor, Allen B. DuMont said in part:

"Originally the Navy 'E' went to that ship scoring outstanding marksmanship. Today that 'E' again reverts to its original meaning. We of the DuMont organization make *electronic guns.* Each cathode-ray tube contains an electronic gun. We make those guns as accurately as our skill, ingenuity and conscientious inspection can make them. Thus I hope that our 'E' is the direct result of good electronic marksmanship, as reflected by the reports from various battlefronts."

Electronic guns for victory! Such is the DuMont contribution to the war effort, made possible *qualitatively* by years of pioneering experience, and now *quantitatively* as well by a 400% growth in personnel. In four large DuMont plants and in several DuMont laboratories, continuing electronic victories are assured for winning today's war and tomorrow's peace.

The loose-leaf DuMont Cathode-Ray Manual and Catalog is yours for the asking. Write on business stationery for your copy.

DUMONT *Precision Electronics & Television*

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

...meeting the challenge of the Stratosphere!

With the penetration of the 'upper reaches' by air transportation, aircraft design and engineering had to overcome multiple problems. One of the important complexities involved insulation tubing. Violent fluctuations in temperature—actuated by sudden, precipitous altitude differentials—demanded new materials.

To meet the tough requirements of Army, Navy and Air Force specifications, TURBO Extruded Tubing was evolved. This smooth-wall insulation—highly flexible, and with unusual mechanical and dielectrical properties—is unaffected by oxidation or sunlight; and is immune to deterioration under transformer oil immersion. Furthermore, it is resistant to oil, tar, wax, acid and alkali solutions, and is non-absorbent to moisture.

TURBO Extruded Tubing is available in inside diameters ranging from .025 to 1.5 inches, and in endless lengths. Standard colors include black, yellow, red, green, blue, brown and transparent. Samples and data on request.

WILLIAM BRAND & CO.

ELECTRICAL INSULATING MATERIALS • TURBO OIL TUBING AND SATURATED SLEEVING
VARNISHED CAMBRIC • PAPER AND TAPE • MICA AND MICA PRODUCTS

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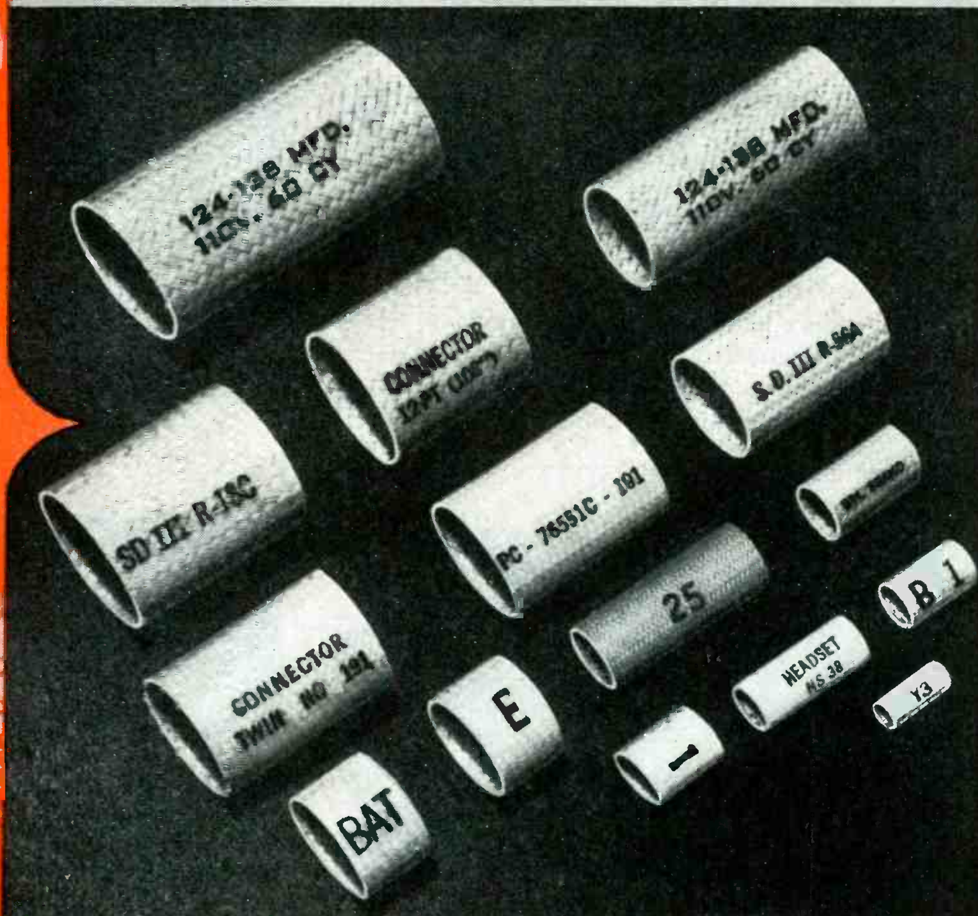
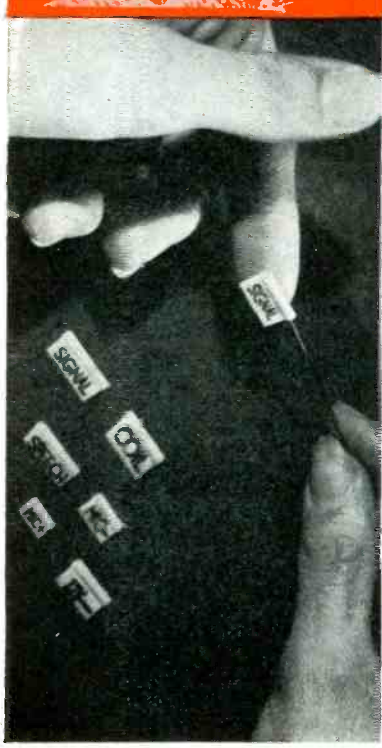
TURBO WIRE IDENTIFICATION MARKERS

Types to meet all equipment and apparatus needs...





AS SIMPLE AND EFFECTIVE AS FINGERPRINTS!

The WILLIAM BRAND organization, headquarters for wire identification markers for leading manufacturers of electronic products, now offers another effective identification component—the Tab-type marker. Comparable in efficiency and economy to the regular TURBO Wire Identification Marker, this new item offers "signal-flag" effectiveness in instantaneously indicating extremely fine circuits.

Snug-fitting and non-projecting, smooth-bore here again facilitates installation even where sharp bends or twists must be circumvented over conductors. Available in any size, length or color, all types meet rigid Army, Navy and Air Force requirements. While a wide range of standard markings are included, special markings can be furnished to specifications.

Write today for samples of TURBO Wire Identification and Tab-type Markers, and the free Specimen Board of the TURBO Line, complete with samples and sizes. A note on your company letterhead will bring them promptly; there is no obligation of course.

WILLIAM BRAND & COMPANY

BLOCK MICA • MICA PLATE AND PRODUCTS • VARNISHED OIL TUBING
SATURATED SLEEVING • VARNISHED CAMBRIC • CLOTHS AND COMPOSITES

276 FOURTH AVE., NEW YORK, N. Y. 325 W. HURON ST., CHICAGO, ILL.

IF IT'S TURBO IT SAFE-GUARDS

". . . So Many Owe So Much To So Few . . ."

IN peace, the Nation's debt to the radio amateur was great. During hurricanes, floods, and other disasters, he sprang forward with emergency communications. His endless hours of patient experimentation—particularly on the high and ultrahigh frequencies—helped open up, as if by magic, whole new segments of the radio spectrum. Traffic enthusiasts surprised the people with unselfish service; DX hounds fostered international good will.

In this "radio" war, the "ham," along with the professional, became the backbone around which the Services and war plants built the myriad, complex communications systems of war, and the secret electronic weapons. He has trained and inspired the new recruits—the tens of thousands of potential "hams."

Hytron, especially, owes much to the radio amateur. When he entered the Services and war plants, he took with him a knowledge of Hytron tubes—particularly v-h-f types—and an admiration for them. Through his enthusiasm, these tubes became vital parts of war equipment. When the time comes to speak out for the return of his precious frequencies, Hytron will not forget him.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

HYTRON RADIO TUBES

BUY ANOTHER WAR BOND

What have you to say?

a Turner *can say it more intelligibly*

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HAN-D
Hang it, hold it, mount it on desk or floor stand — it's truly a handy mike!

Turner
511 Broadcast Model for Studio Performance

Turner
99 Dynamic for Professional Performance

When you need crisp, clear reproduction of any sound, turn to a Turner Microphone. These instruments are scientifically engineered to reproduce faithfully all gradations of volume, amplifying only the vibrations received by the diaphragm, without adding any of the harmonics. From the faintest whisper to the loudest train whistle, a Turner Microphone will reproduce precisely without distortion or blasting.

For indoor or outdoor use, under all climatic and acoustic conditions, you can be sure of intelligible transmissions when you specify and use a Turner. For broadcasting studios, vital war communications in war plants, airdromes, ordnance plants, docks, army camps, police transmitters and other highly sensitive spots where accuracy is of supreme importance, you'll be grateful for a Turner.

Whatever you have to say — whatever sound you want to transmit, be sure of superb performance with a unit that's rugged and dependable — a unit you'll be proud to have seen in your possession. It's time to turn to TURNER.

Crystals licensed under patents of The Brush Development Co.

Turner
U9-S Fills 4 Impedance Requirements

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22X-22D Crystal or Dynamic Units

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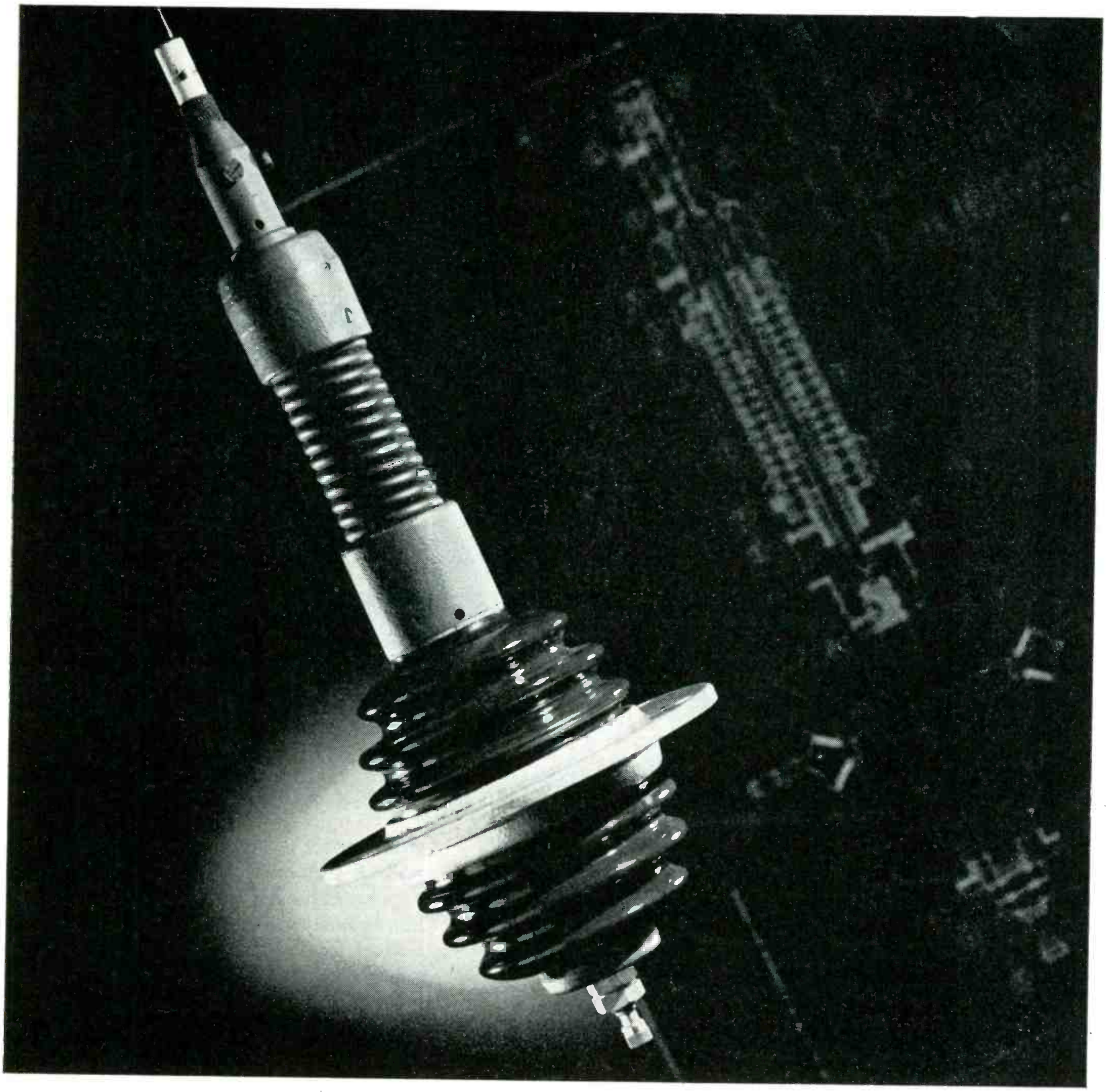
Send for Free Microphone Catalog
The TURNER CO., Cedar Rapids, Iowa

Turner • *Pioneers in the Communications Field*



LAPP-DESIGNED, LAPP-BUILT—TO DO A SPECIFIC JOB

This is an antenna base insulator for use on a communications center transmitter. It is one of several Lapp designs for transmitter and receiver mast bases for military vehicular radio—on jeeps, halftracks, tanks and other rolling equipment.

Whether or not this special-purpose gadget has application to anything you build or propose to build, there's a moral in it for you. In this case, as in hundreds of others, an original and impractical design was modified by Lapp engineers—to provide a part that meets all electrical and mechanical requirements, and that Lapp can build economically and efficiently.

Lapp engineering talent and Lapp production methods are such that we can say, "If it's an assembly that can be made of porcelain or steatite and metal parts, tell us what the requirements are and how you think it might be made; Lapp will tell you how it can best be made—and will make it." Our right to that claim has been proved over and over in military electronic production; it's going to be a competitive advantage to smart post-war electronic producers. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp

● Aerovox silvered-mica capacitors are designed for the most critical applications requiring precise capacitance values and extreme stability. Although otherwise similar in external construction and dimensions to the smaller molded bakelite units, they are encased in molded XM low-loss *red bakelite* for immediate *silvered-mica* identification.

A silver coating is applied to the mica and fired at elevated temperatures. This insures not only a positive bond but permanent stability of the capacitance with respect to time, temperature and humidity. Units are heat-treated and wax-impregnated externally for ultimate protection against moisture penetration.

Ideal for use in circuits where capacitance must remain constant under all operating conditions. These capacitors are specifically designed for use in push-button tuning, oscillator padding circuits, fixed tuned circuits, and as capacitance standards, etc., where accuracy and stability are prime considerations.

● Write for literature . . .

Average positive temperature coefficient of only .003% per degree C.—a remarkably low value.

Excellent retrace characteristics; practically no capacitance drift with time; exceptionally high Q.

Available in three types, 1000 v.D.C. test: Type 1469, .000005 to .0005 mfd.; Type 1479 (illustrated), .0001 to .001 mfd.; Type 1464, .00075 to .0025 mfd., and .001 mfd. in 600 v. D.C. test.

Standard tolerance plus minus 5%. Also available with tolerances of plus/minus 3%, 2% and 1%.

Minimum tolerance for capacitances up to and including 10 mmf. (.00001 mfd.) plus/minus ½ mmf. Minimum tolerance available for all other capacitances, plus/minus 1% or plus/minus 1 mmf., whichever is greater.

• • •

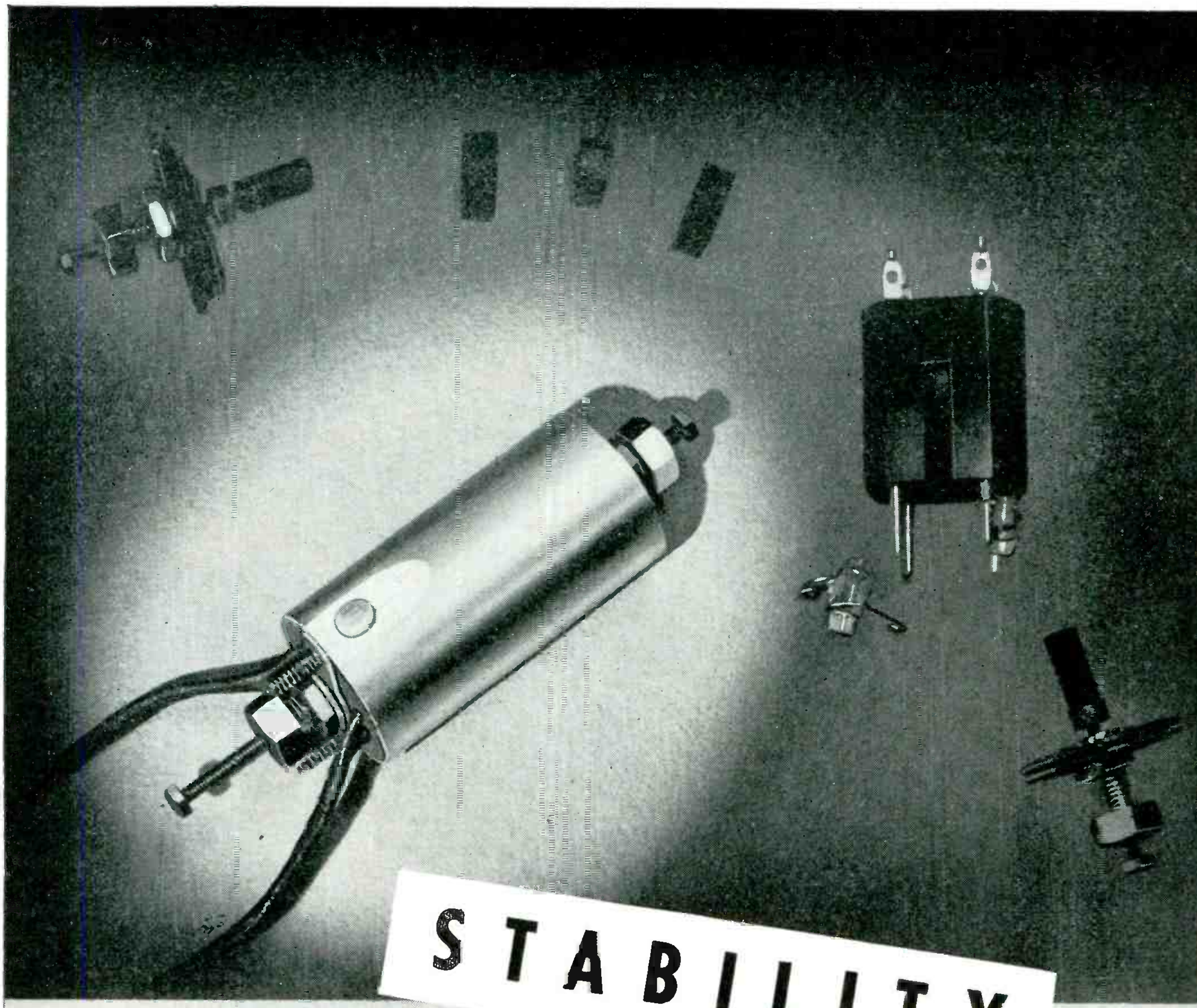
Aerovox is prepared and ready to accept orders for Mica Capacitors which will meet American War Standards.

AEROVOX Capacitors

INDIVIDUALLY TESTED

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

Export: 13 E. 40 ST., NEW YORK 16, N. Y. • Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.



I. F. TRANSFORMERS that drop with paratroopers and ride in tanks must have extreme physical stability, such as the one in the illustration, completely designed and manufactured by *AUTOMATIC*.

Stability is important, too, in a source of supply. Through a depression, a boom, and a war, *AUTOMATIC* has continued to be a stable and reliable source for critical radio parts and assemblies.

KEEP BACKING THE ATTACK!
BUY MORE WAR BONDS

AUTOMATIC WINDING CO., INC.

COMPLETE ELECTRONIC ASSEMBLIES & COMPONENT PARTS

900 PASSAIC AVE. EAST NEWARK, N. J.

38,000 hours of service from a pair of HK-54s

JOHN F. IRELAND, technician in charge of the Barnstable (Mass.) County Police Radio System, deserves much credit for the remarkable life of this pair of HK-54 tubes.

FINAL AMPLIFIER of the main station (WRAQ) at the Barnstable County Jail and House of Correction, showing the pair of Gammatrons still on the job after approximately 38,000 hours of operation.

WRAQ REPORTS GAMMATRONS STILL IN CONSTANT OPERATION AFTER 57 MONTHS

Strong proof of the extraordinary life of Gammatron tubes is contained in the following report from the service files of WRAQ as prepared by Technician John F. Ireland:

"Our main station is on the air 24 hours daily, operating on a frequency of 39,900 kcs. The final amplifier of this transmitter uses a pair of HK-54 tubes with 1100 volts on their plates.

"These HK-54s (Serial Nos. 2270 and 2271) were installed in the transmitter on August 3, 1939. Except for shut-downs of short duration for minor repairs and the checking of other tubes, these 54s have been in continuous use since installation, *and are still on the job after approximately 38,000 hours.*

"To further the life of these tubes the filament voltage, during standby, is dropped from 5.0 volts to slightly under 4.5 volts, a relay shorting the dropping resistor when plate voltage is applied.

"The present modulator tubes, also HK-54s, were installed in the later part of 1939, and from all indications still have a long way to go before being retired. Filament voltage of these has the same treatment as the above."

Every Gammatron is built of the same materials, is exhausted in the same severe manner, and passes the same rigid tests as those in operation at WRAQ.

BUY AN **EXTRA** WAR BOND

HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA

Army-Navy Production Award bestowed for second time on January 15, 1944

Gammatron Tubes

Copper Sulphide

BL METALLIC RECTIFIERS

Selenium

Successfully Operating Below -40°C: Above +60°C!

B-L metallic rectifiers provide efficient, dependable conversion of AC to DC over a wide range of temperature and climatic conditions. Ambient temperatures ranging from below minus 40° C to above plus 60° C are common.

B-L metallic rectifiers are available in a wide variety of sizes and arrangements to fit practically any power requirement or application.

Long experience has made B-L the recognized source of authentic information on metallic rectifiers. No matter what rectifier application you are considering, B-L will be glad to work with you on the engineering details.

Write for Bulletin No. 94

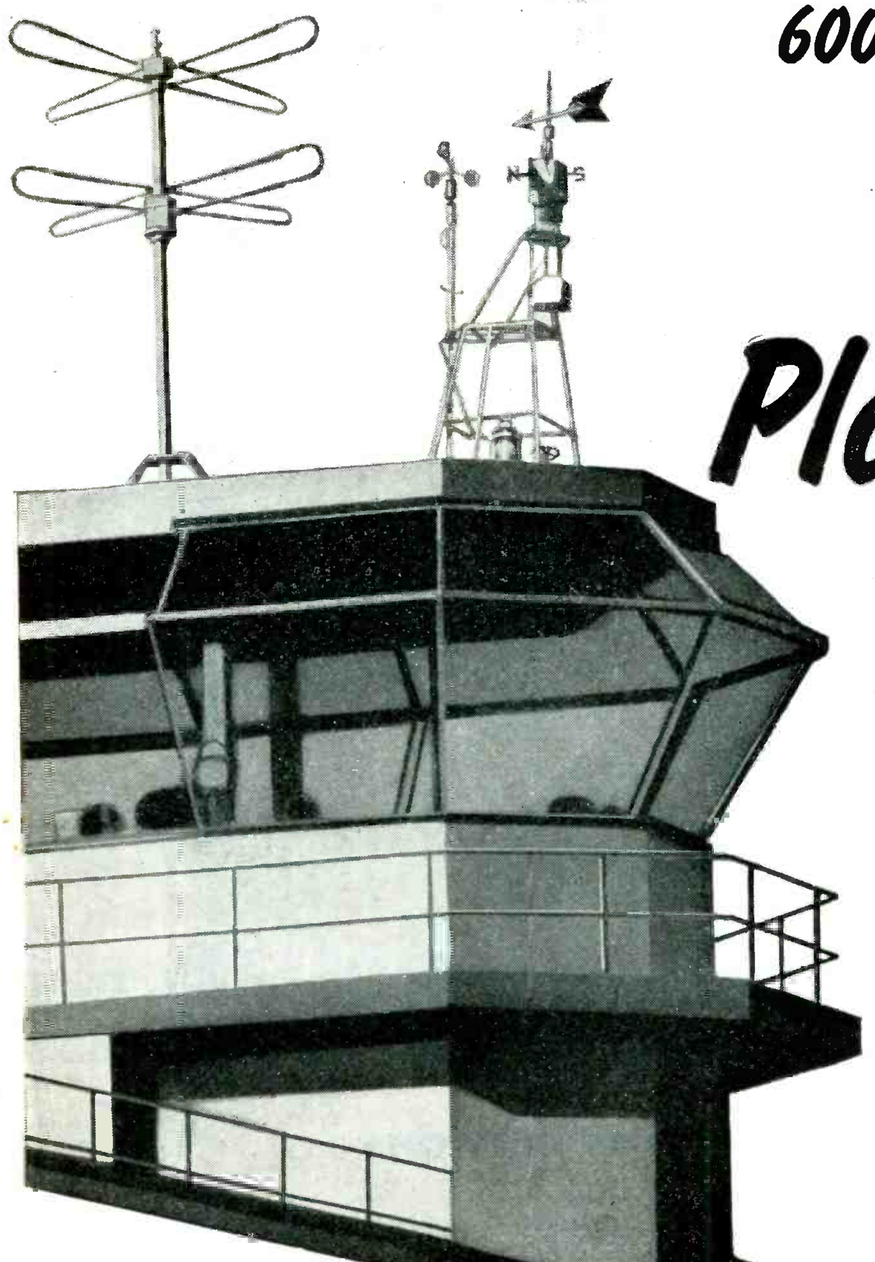
BL

THE BENWOOD LINZE COMPANY • ST. LOUIS 3, MO.

Designers and manufacturers of Copper Sulphide and Selenium Rectifiers, Battery Chargers, and D.C. Power Supplies for practically every requirement.

"We will need 6000 AIRPORTS by 1950"--

CHARLES I. STANTON
Civil Aeronautics Administrator



Radio Receptor horizontally polarized ultra high frequency antenna indicated at top of tower, left.

Plan Now

The planning of *radio facilities for your airport* is as important as the layout of the landing areas themselves.

Specific suggestions for your *airport traffic control radio equipment* and other *airport radio equipment*, based on a vast fund of experience in airport and airway radio installations, large and small, are available without obligation.

Requirements of projected airports and expanded airways may severely tax production capacity. *Act now.*

We invite an opportunity to cooperate with engineers, consultants and local contractors.

ARMY E NAVY

For Meritorious Service on the Production Front

Send for our Airport Radio Questionnaire so that we may be able to aid you now while your airport still is in the project stage. Our non-technical booklet, "Highways of the Air", free on request. Address Desk E5.

RADIO RECEPTOR CO., INC. 251 WEST 19th STREET NEW YORK, 11 N. Y.

Engineers and Manufacturers of Airway and Airport Radio Equipment

SINCE 1922 IN RADIO AND ELECTRONICS

History of Communications Number Four of a Series

SMOKE SIGNAL COMMUNICATIONS

While the puffs of our early American smoke Signals were not as complicated as the Morse Code, this type of communication was a speedy and effective means of communication at that time and could be seen for scores of miles on a clear day. Used for transmitting their battle messages, smoke signals in the days of the early American meant a progressive means of communication.

Restricted by climatic conditions this type of communication was limited in its use. Universal microphones in the part they play in modern electronic voice communication must withstand the climates of the Arctic and the Tropics all in a day's work. Built to accomplish a specific job, Universal Microphones are "getting the message through" on every Allied front.

Model T-45, illustrated at left, is the new Lip Microphone being manufactured by Universal for the U. S. Army Signal Corps. Shortly, these microphones will be available to priority users through local Radio Jobbers.

UNIVERSAL MICROPHONE COMPANY
INGLEWOOD, CALIFORNIA

FOREIGN DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA ·· CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA

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again bring you ***Big News!***

LAST YEAR we announced *Hi-Density Lead* with its advantages of producing Hi-Density line for clear, sharp blueprints . . . its freedom from smudging . . . its easier erasure . . . the extra Hi-Density strength and longer wear . . . and scientifically accurate grading through all 18 degrees from 9H to 6B.

AND NOW . . . as a daily reminder of Eberhard Faber alertness to your needs, this

20 inch SLIDE RULE

Made circular for compactness. Printed on durable cardboard of war-time necessity. Lacquer surfaced for cleanliness. Specially designed with ready reference scales of Cubes and Squares. Table of standard Conversion settings on back. Also Decimal Equivalents . . . Available at a price that invites everyone to *clip the coupon* and get one.

25¢

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Anywhere in U.S.A.

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PENCIL COMPANY
37 Greenpoint Avenue
Brooklyn 22, N.Y.

Here is my 25¢ . . . please mail Slide Rule at once, to

Your Name ________________

Firm Name ________________

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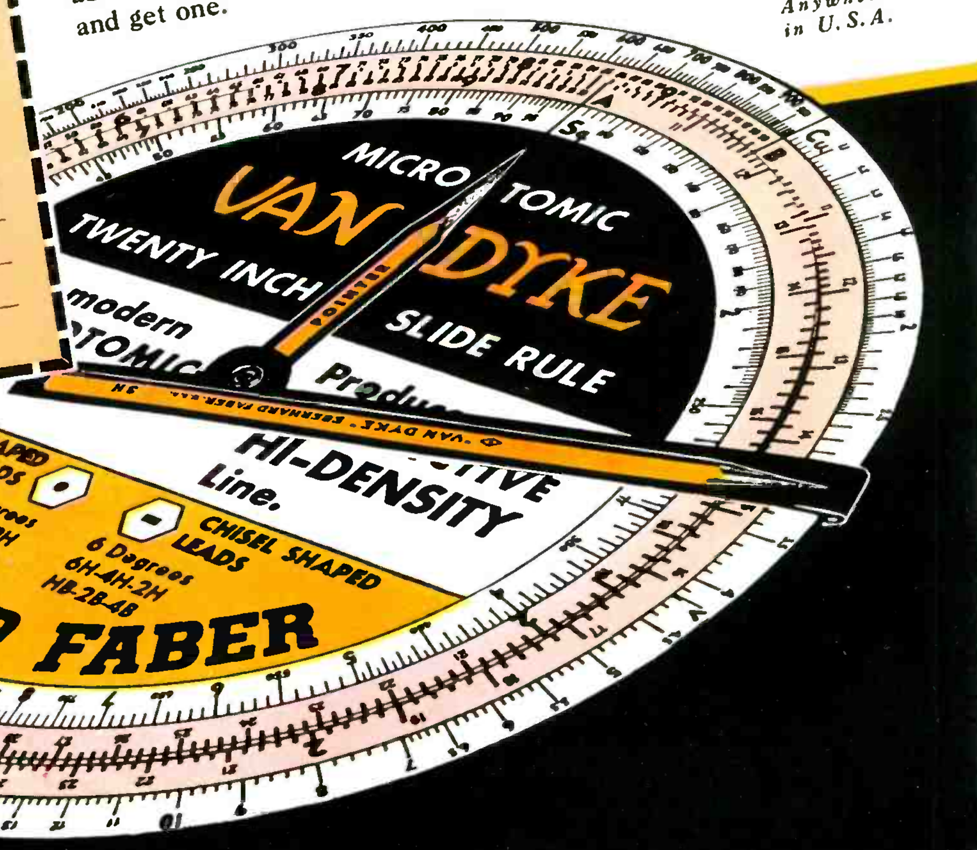


NEW LETTER CONTEST for SERVICEMEN!

ELEVEN 1st PRIZE WINNERS IN 5 MONTHS IN CONTEST #1!

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

SO—HERE WE GO AGAIN!

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

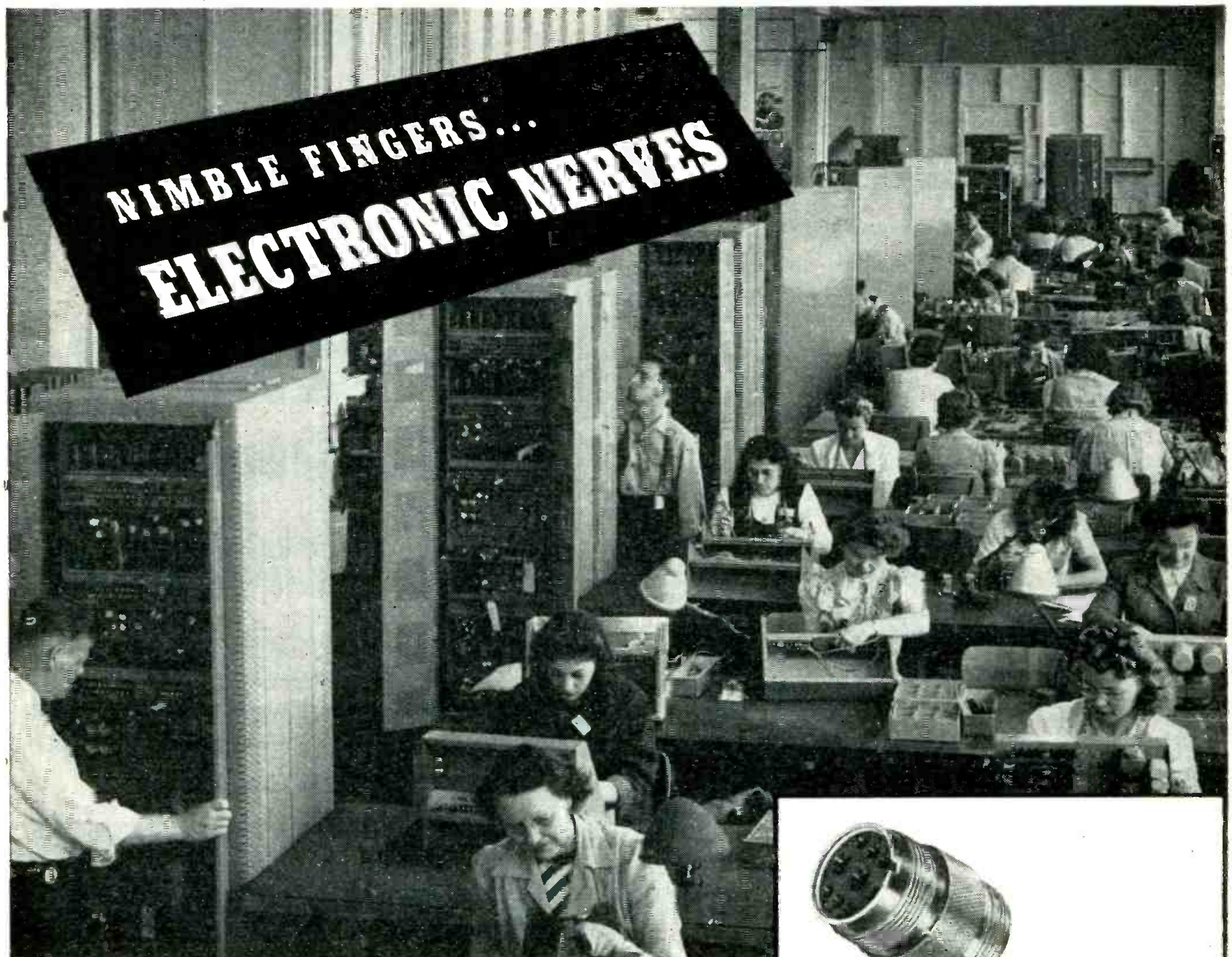
RULES FOR THE CONTEST

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

BUY MORE BONDS!

hallicrafters RADIO

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



Remler components and chassis assembly —marine sound transmitting systems.

NEW RECRUITS trained and supervised by veteran Remler engineers and technicians are helping to supply our armed forces with the electronic nerves of war. This organization manufactures many types of radio, radar and sound transmitting equipment, in addition to plugs and connectors. Improved techniques and expanded facilities frequently permit quotations at lower prices. Manufacturers with tough war jobs are invited to assign part of the task to Remler.

Wire or telephone if we can be of assistance

REMLER COMPANY, LTD. • 2101 Bryant St. • San Francisco, 10, Calif.

REMLER

SINCE 1918

Announcing & Communication Equipment

PLUGS & CONNECTORS

Signal Corps · Navy Specifications

Types:	PL				NAF
50-A	61	74	114	150	
54	62	76	119	159	
55	63	77	120	160	1136-1
56	64	104	124	291-A	
58	65	108	125	354	No.
59	67	109	127		212938-1
60	68	112	149		

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

OTHER DESIGNS TO ORDER

Is Electronic Heat Practical for Your Heating Problem?

ELECTRONIC HEATING of non-metallic substances is sometimes considered expensive — sometimes considered cheap. This is because it has been used in a wide variety of applications, each with its own peculiar characteristics. In any application, the *overall* cost comparisons should be made in relation to the results obtained. These comparisons should include initial outlay for equipment, operating costs, savings in time, improvement in product, and many other considerations.

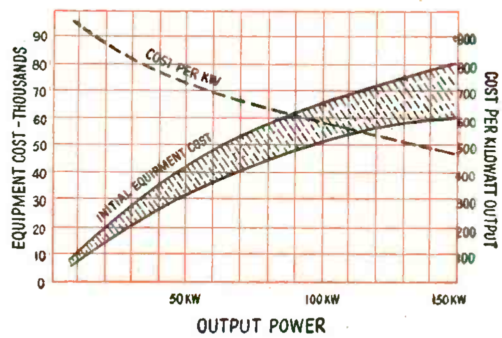
INITIAL COST: Curve A shows the initial cost of electronic heating equipment up to 150-kw output (540,000 BTU per hour, max.). Cost per rated kw-output is lower for high-power than for low-power units. Reasonable expected life of an electronic generator is at least 25,000 hours of operation.

MATERIAL HEATED: In electronic heating of non-metallic substances, high-frequency electricity, generated by electron tubes, is "passed through" the material to be heated. The electrical energy is converted to heat; when the material is homogeneous, it is heated uniformly throughout. Some materials are easier to heat than others. Curve B gives an indication of the efficiency of power-to-heat conversion for various substances. In some applications, electronic heat is used to supplement other methods of heating. For example, preheating a material to produce uniform temperature all the way through often improves results when the material is finally placed in an oven.

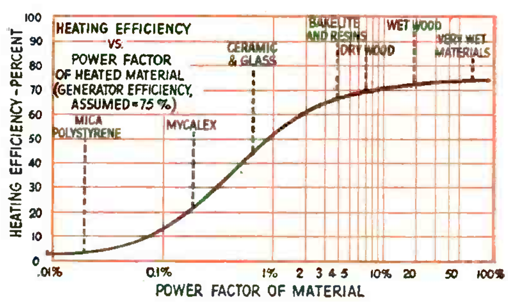
OPERATING COST: Operating cost includes power, and tube replacement. An average figure (based on a 15-kw generator) is 3¢ per kw-hour, or about 1¢ per 1000 BTU *output*. Since electronic heating involves shorter time-cycles than other heating methods, objects heated by electronic means usually lose little heat by radiation or conduction to surrounding objects. Hence, electronic heating usually involves less BTU output from the heat source than other heating methods.

CONCLUSION: Once again, it is pointed out that the improvement in results when electronic heating is used must be considered in comparing the cost to that of other heating methods. For example, plastics molders have been able to increase press output by 50% when electronic preheating was used. Compregwood propeller molding time was reduced 67% by electronic heat.

Send the coupon for further information. Radio Corporation of America, Electronic Apparatus Section (70-45H), Camden, N. J.



• CURVE A—*Initial cost of electronic generators and cost per rated kw based on a number of installations made by different manufacturers.*



• CURVE B—*Assuming a 75% efficiency for the electronic generator, the overall efficiency of an electronic heating installation depends on power factor of the heated material, as shown.*

RCA ELECTRONIC HEAT

BUY WAR BONDS

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION, CAMDEN, N. J.

LEADS THE WAY . . . in Radio . . . Television . . . Tubes . . . Phonographs . . . Records . . . Electronics

RCA, Electronic Apparatus Section, Camden, N. J.

Please send me details on the new RCA 15-B electronic generator.

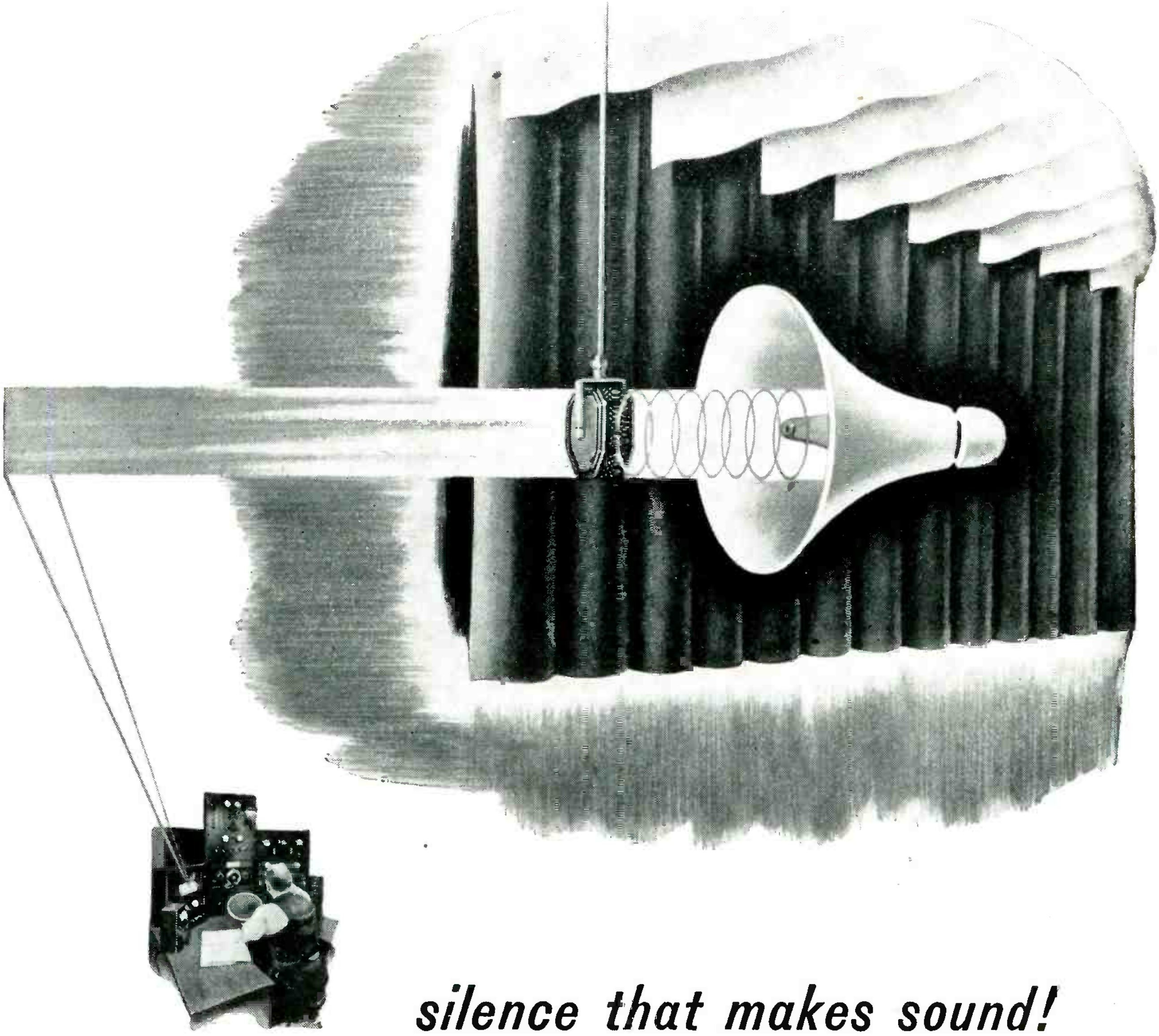
Name...

Company...

Address...

City.........................State.........................

70-45H



silence that makes sound!

In this "dead" room only the sounds which come out of the speakers are recorded. Sounds which would otherwise bounce back from the walls, ceilings or other objects are trapped and lost forever. The absence of reverberation permits scientifically accurate testing in the sound absorbing room of Utah's *complete* testing laboratory.

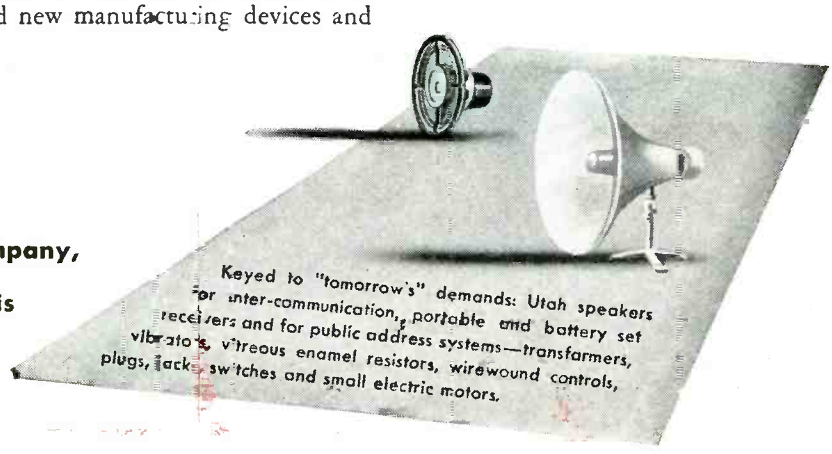
In making practical the many war-created radio and electronic improvements—in adapting them to today's needs and for the commercial requirements ahead, Utah engineers have designed new parts and products, developed new manufacturing devices and methods and have instituted new, more comprehensive testing techniques.

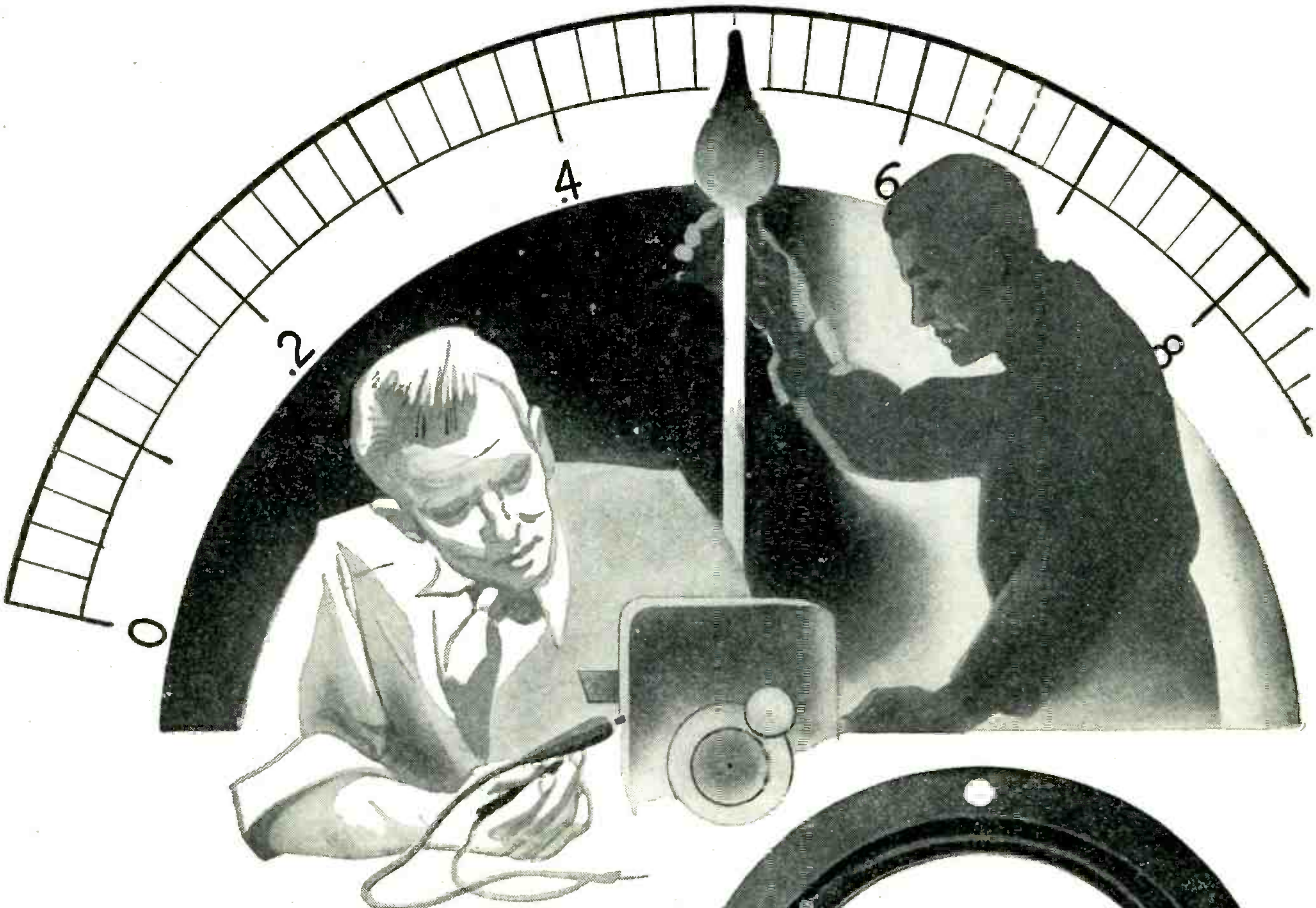
★ ★ ★

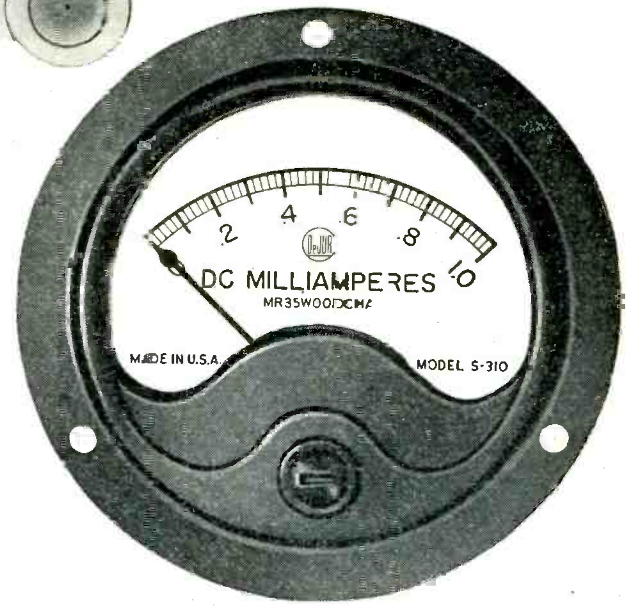
Every Product Made for the Trade, by Utah, Is Thoroughly Tested and Approved

utah Radio Products Company,

8 3 7 Orleans Street, Chicago 10, Illinois







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The use of DeJur precision meters in laboratory test equipment is an endorsement of their accuracy. In many fine laboratories, these meters are subjected to severe day-by-day service. Efficiency remains constant because 25 years of electrical knowledge go into their design and engineering. Application of DeJur components to your needs, in or out of the laboratory, will provide proof of DeJur quality. Our engineers will gladly work with you on any problem of measurement and control . . . for present or peacetime assignments.

Bring the Peace Closer . . . Buy More War Bonds

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DeJur-Amsco Corporation

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

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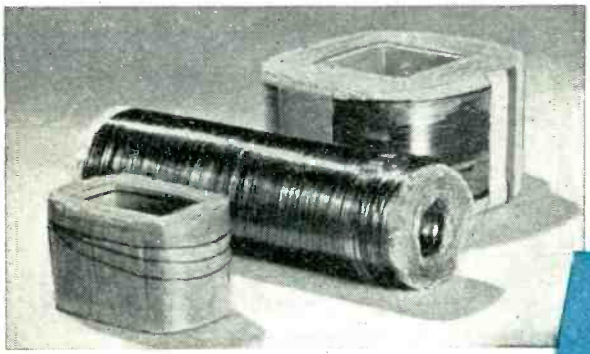
The Black Hand of Corrosion Can Come from the Skies!

Humidity, which settles on and in electrical equipment, is the forerunner of corrosion that disrupts communications and impairs the operation of electrical instruments and services.

That is why it is so important to use an insulation material which is resistant to electro-chemical oxidation when in the presence of current-carrying copper wire and moisture.

Lumarith (cellulose acetate) is big in the news today because it is resistant to the corrosive influence of moisture. In foil, film, molded and other forms, it is the ideal insulator for coils, tubes, bobbins and other electrical parts.

The Celanese Celluloid Corporation's research department has prepared a booklet outlining the properties of Lumarith dielectrics. The information you will need: dielectric strength, resistivity, power factors, etc. is readily available within its pages. Write for your copy. Celanese Celluloid Corporation, *The First Name in Plastics*, 180 Madison Avenue, New York City 16, a division of Celanese Corporation of America, sole producer of Lumarith and Celluloid plastics. *Representatives:* Dayton, Philadelphia, Cleveland, Chicago, St. Louis, Detroit, Los Angeles, Washington, D. C., Leominster, Montreal, Toronto.



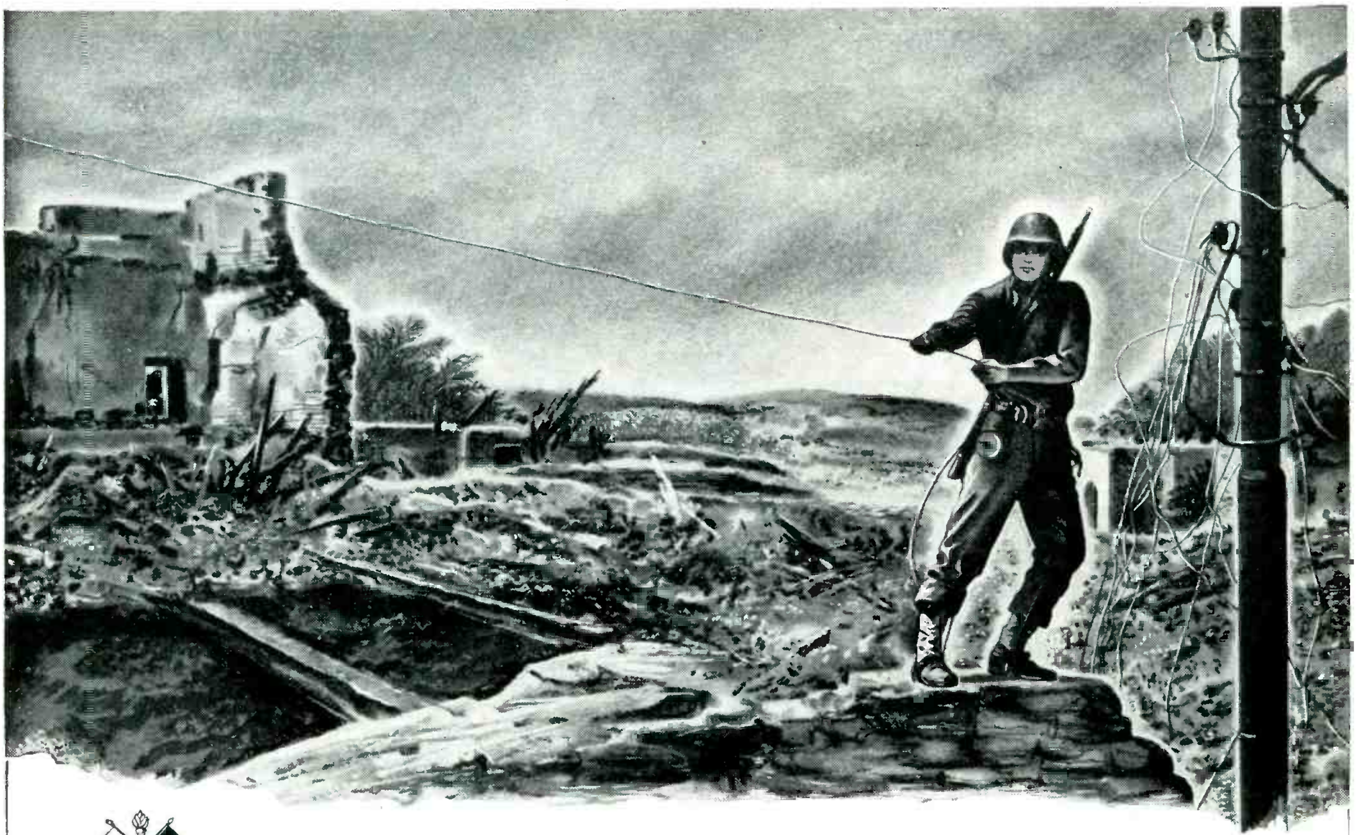
LUMARITH PLASTICS . . IN FILM . . FOIL . . MOLDING MATERIAL AND OTHER FORMS

*Reg. U. S. Pat. Off.

Lumarith*

A CELANESE* PLASTIC

TUNE IN The Celanese* Hour—*"Great Moments in Music"**—Columbia Network, Wednesdays, 10 P. M., E. W. T.



WHERE THE GOING IS TOUGHEST is where the men of the U. S. Signal Corps do business

Behind the front, at the front — yes, and ahead of the front lines, they are laying wire, directing artillery fire, spotting enemy movements and putting their superb technical training into practice with calmness and efficiency in the thick of battle. They don't get as many headlines as they deserve, but they rate and get the thanks of every soldier, from General to buck private.

Many of our own men, now in the service, have been assigned to Signal Corps duty, and are frequently using the very equipment they once helped to build. Their experience in our plant is being put to good use at fighting fronts all around the world. Signal Corps training will in turn make them all the more valuable to us when they return. Thus, important forward strides in communications engineered by the Signal Corps, manufactured by the communications industry, and put to the acid test by superbly trained technicians will be available to serve you in the postwar world.

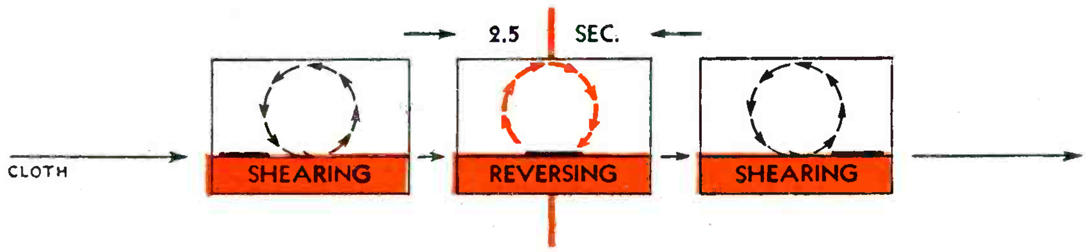
CONNECTICUT TELEPHONE & ELECTRIC DIVISION,

Great American Industries, Inc.

MERIDEN GAI CONNECTICUT

AFTER THE WAR . . . *Advanced*

- TELEPHONIC SYSTEMS
- SIGNALLING EQUIPMENT
- ELECTRONIC DEVICES
- HOSPITAL & SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS
- ELECTRICAL EQUIPMENT
- IGNITION SYSTEMS



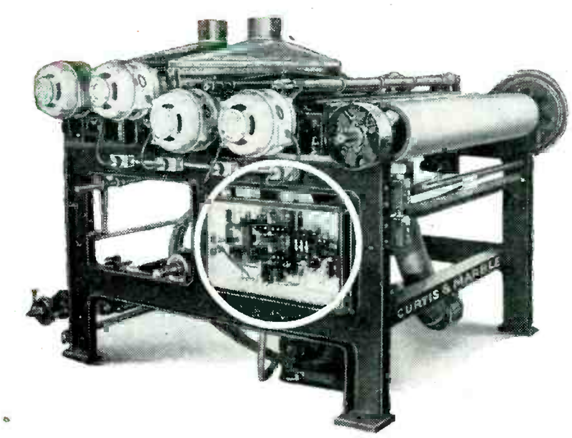
SPLIT-SECOND *Electronic* TIMING...

PROBLEM: The operation of Curtis & Marble Machine Company's Type CMR Automatic Textile Shear demands a split-second timing device for continuous and accurate high-speed action. Its four shear revolvers remove surface or selvage threads from rayon and cotton cloth. When a sensitive detector "feels" a seam, broken needle, or other foreign substance which might damage the shears, the revolvers are instantly reversed *until* the obstruction has passed. This interval — measured in seconds and occurring several times a minute — must be automatically controlled. The operation further requires that a *second* obstruction, appearing *after* the revolvers have been reversed, must serve to maintain them in reverse until it, too, can travel beyond the shears.

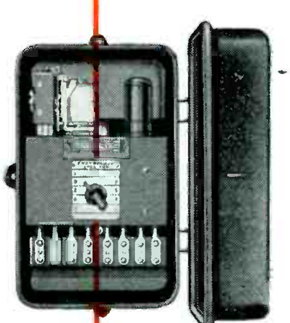
SOLUTION: When Curtis & Marble decided to replace the complex and expensive mechanical device through which this timing operation had been accomplished, all timing methods were thoroughly investigated. Only Photoswitch Timer T15U offered both split-second accuracy and long-life, frictionless operation. Electronic, it eliminated all but one moving part — guaranteed maintenance-free, unlimited-life accuracy. Today, after three years of textile-mill operation, Photoswitch Electronic Timer is an integral part of every Curtis & Marble Automatic Textile Shear.

☆ ☆ ☆

Photoswitch Incorporated also manufactures photoelectric and electronic equipment for level control of liquids and powders, smoke density indication, turbidity control, automatic inspection, machinery safeguards, counting, conveyor control, property protection, and similar industrial applications.



How Photoswitch Electronic Timer Functions on Automatic Textile Shear



On seam detection, shear revolvers are reversed and T15U starts timing interval sufficient to allow obstruction to pass beyond last shear — usually 2.5 seconds. At end of interval, timer relay operates magnetic switch to restore shears to cutting direction of rotation. If second obstruction appears during reversal period, timer immediately recycles to start second interval, thereby maintaining revolvers in reverse until *second* obstacle is safely out of way.

Photoswitch Electronic Timer T15U

Times any interval from 1/20th of a second to two minutes . . . other models to ten minutes. Electronic operation eliminates moving parts, friction, wear — guarantees complete accuracy over an unlimited period. Extensively used on Injection Moulding Machines, Automatic Spraying Equipment, Process Controllers, Embossing Presses, Automatic Machine Tools, etc.

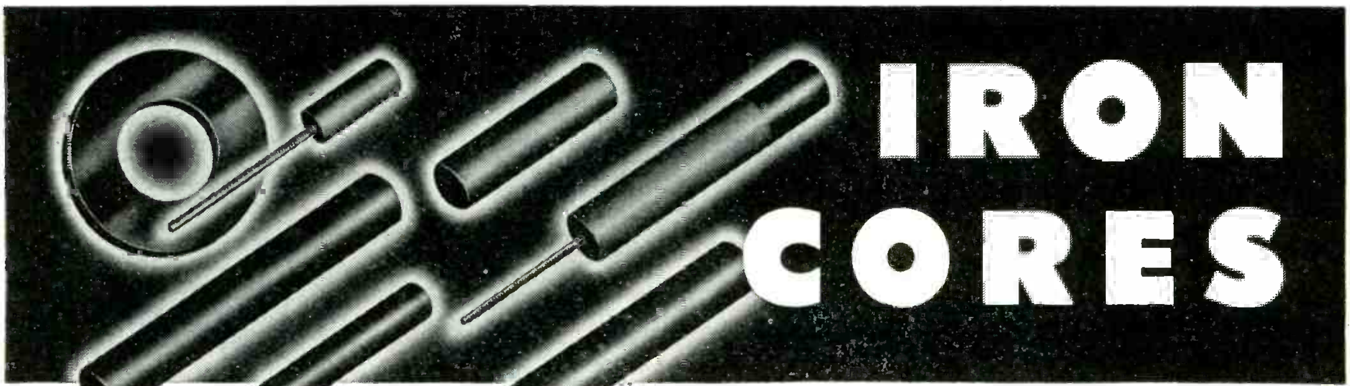
Write for Bulletin 900-A.

Electronic Time Controls

PHOTOSWITCH
INCORPORATED

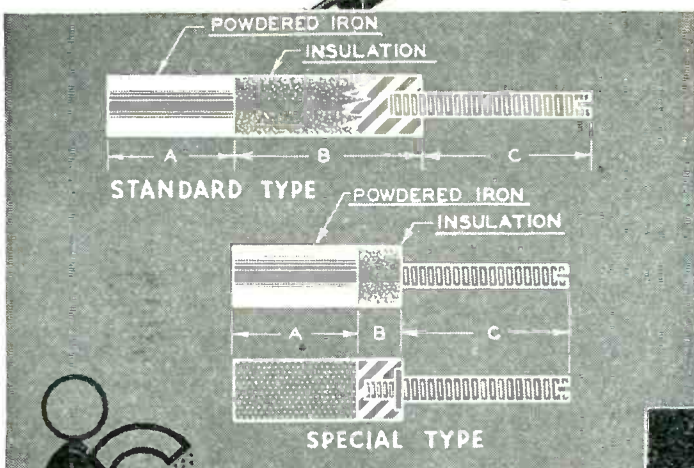
CAMBRIDGE 42, MASSACHUSETTS
District Offices in All Principal Cities
PHOTOELECTRIC AND ELECTRONIC CONTROLS FOR EVERY INDUSTRIAL PURPOSE

IRON CORES



Standard and High-Frequency Types

Long the acknowledged leader in Iron Core manufacture, Stackpole can supply practically any desired type from 100 cycles to 175 megacycles and even higher. Both the Stackpole Standard and High-Frequency types are produced in an almost infinite variety of shapes, sizes, and characteristics to match your needs *exactly.* Also available is a complete line of Stackpole High-Resistivity Cores in either insulated or non-insulated types, and showing a resistance of practical infinity.

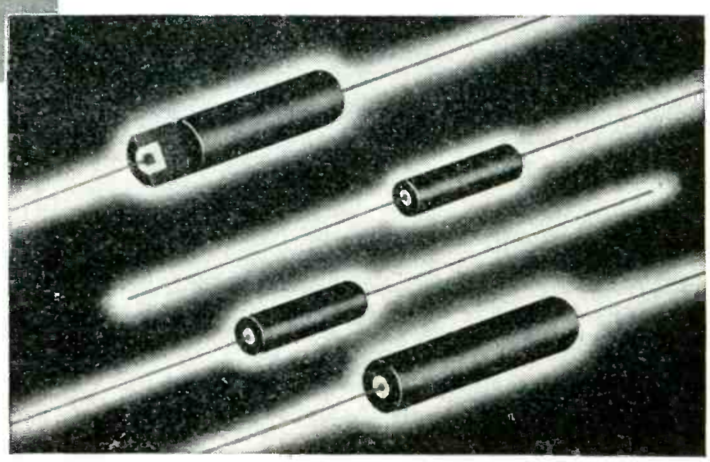


Insulated Types

The screws in these integrally-constructed units are insulated from the iron cores. Thus, the screw is kept out of the coil field and "Q" is greatly increased. The distributed capacity of the coil is reduced and, in applications where the screw is not grounded, there is also a big reduction in hand capacity effect. Ask for Stackpole Engineering Bulletin No. 7.

Iron Cores for CHOKE COILS

These popular Stackpole Cores are designed for use with audio chokes, "hash" chokes, r-f chokes, etc. Not only do they permit reductions in choke coil dimensions, but the iron materially increases the "Q". Insulated leads serve as coil connections and permit convenient point-to-point wiring.



Brushes—Contacts
Sintered Iron Components—Carbon
Regulator Discs—
Battery Carbons—
Fixed and Variable
Resistors—
Switches, etc., etc.

STACKPOLE

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

controlled thread action

It took engineering skill to create the thread action of the Audiodisc coating. During recording the thread "kicks" strongly toward the center. It is free from annoying static. These are only two of the reasons why broadcasting studios continue to put their faith in Audio— and their programs on Audiodiscs.

Audio Devices, Inc., 444 Madison Ave., New York 22, N. Y.

As critical metal restrictions are lifted, Audio will bring to those who want them, more and more aluminum discs.

audiodiscs *they speak for themselves*

All-Purpose Pocket Size Volt-Ohm-Milliammeter

A new modernistic styled, compact unit that provides an answer to all Volt-Ohm-Milliammeter requirements. Incorporates all the testing facilities of larger, more costly equipment. A.C. and D.C. Volts 0–2.5–10–50–250–1000–5000 (D.C. at 10,000 ohms per volt; A.C. 1000 ohms per volt); 0–.1–1–10–100–1000 D.C. Milliamperes, at 100 millivolts; 0–10 D.C. amperes at 100 millivolts; Resistance 0–400 Ohms (10 ohm center scale); 0–40,000 ohms (500 ohms center scale) 0–4 Megohms (50,000 ohm center scale). Self contained batteries. Selector switch control for all ranges.

Completely insulated black molded case and panel, attractive streamlined design. (Leather carrying case also available to hold tester and accessories.)

The Triplett Line—more comprehensive than ever—goes today for war needs but its exacting services in war assure you the final answer for post-war equipment requirements.

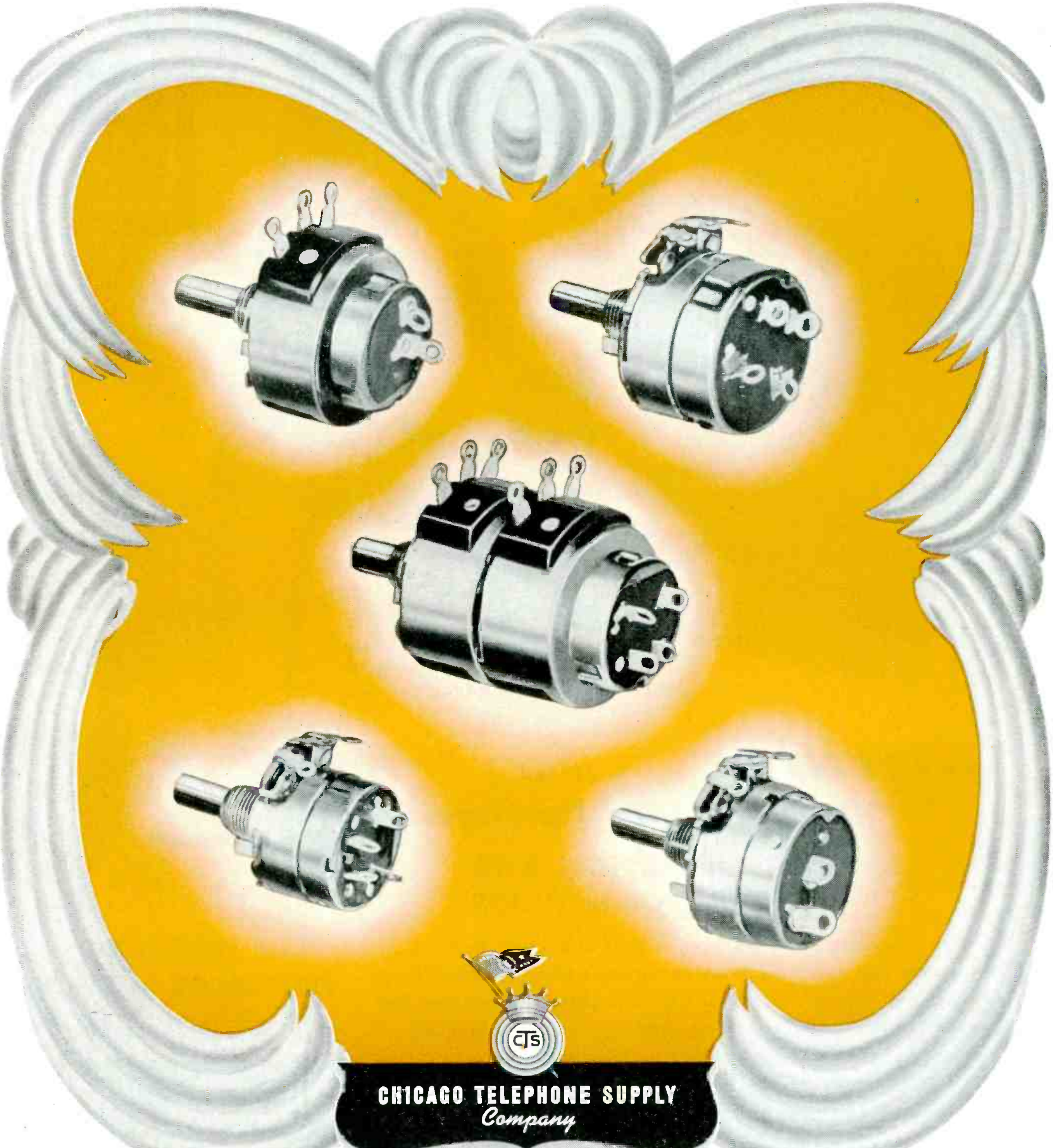
Battery slides into place, Easily inserted or removed.

Twenty position selector switch control for all ranges.

Triplett

ELECTRICAL STANDARDS ARE SET BY TRIPLETT **INSTRUMENT CO.**

BLUFFTON OHIO ★ ★ ★



ELKHART • INDIANA

Since 1928, Chicago Telephone Supply Company has specialized in the production of variable resistors. When the war ends, present and past experience will be utilized to serve the electronic industries with higher-than-ever quality, workmanship and service.

VARIABLE RESISTORS, PLUGS, JACKS, SWITCHES, TELEPHONE GENERATORS, RINGERS

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Manufacturers of Quality Electro-Mechanical Components Since 1896

Calibration of a Lavoie Precision Frequency Meter, using a Crystal Calibrator developed in our laboratories

U H F

Precision . . . plus unprecedented time-saving

IN UHF CALIBRATION AND CRYSTAL-CONTROL METHODS

Our specialization in the development and production of UHF equipment has achieved many remarkable results, among them original methods of calibrating UHF equipment in less than five per cent of the time required by previous methods. Precise and quick techniques for generating and identifying very high harmonic frequencies are used. These principles are equally valuable when applied to crystal-controlled oscillators.

The UHF Precision Frequency Meter shown here is indicative of the scope of our work and is the result of intensive laboratory experimentation which has led us in many directions. In view of this specialized background we believe a discussion of any specific requirements in the UHF field would be of interest to you.

UHF PRECISION FREQUENCY METER

Completely Portable
Battery or AC-Operated
Accuracy 0.1%

Models available from 100 to 2000 megacycles with 2 to 1 frequency coverage on each model. Available only on high priority while our nation is at war.

RECOMMENDED FOR:

- Production testing
- Measurement of oscillator drift
- Independent alignment of transmitters and receivers
- Precise measurements of frequencies

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists in the Development of UHF Equipment

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.*

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

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QUALITY TUBING

For years we at Precision have been specialists in the small seamless tubing field, from ½" O.D. on down to 0.010" O.D. with whatever wall thickness is required, holding to unusual close tolerances. When accuracy and uniformity is the first consideration, we can help you.

We manufacture accurately drawn seamless aluminum, brass, copper and nickel tubing to exact specifications. We also fabricate and form nickel tubing electrode piece parts and various shapes of non-ferrous tubing.

PRECISION *for Accuracy*

Your inquiries for round tubing in all forms are solicited.

PRECISION TUBE CO.

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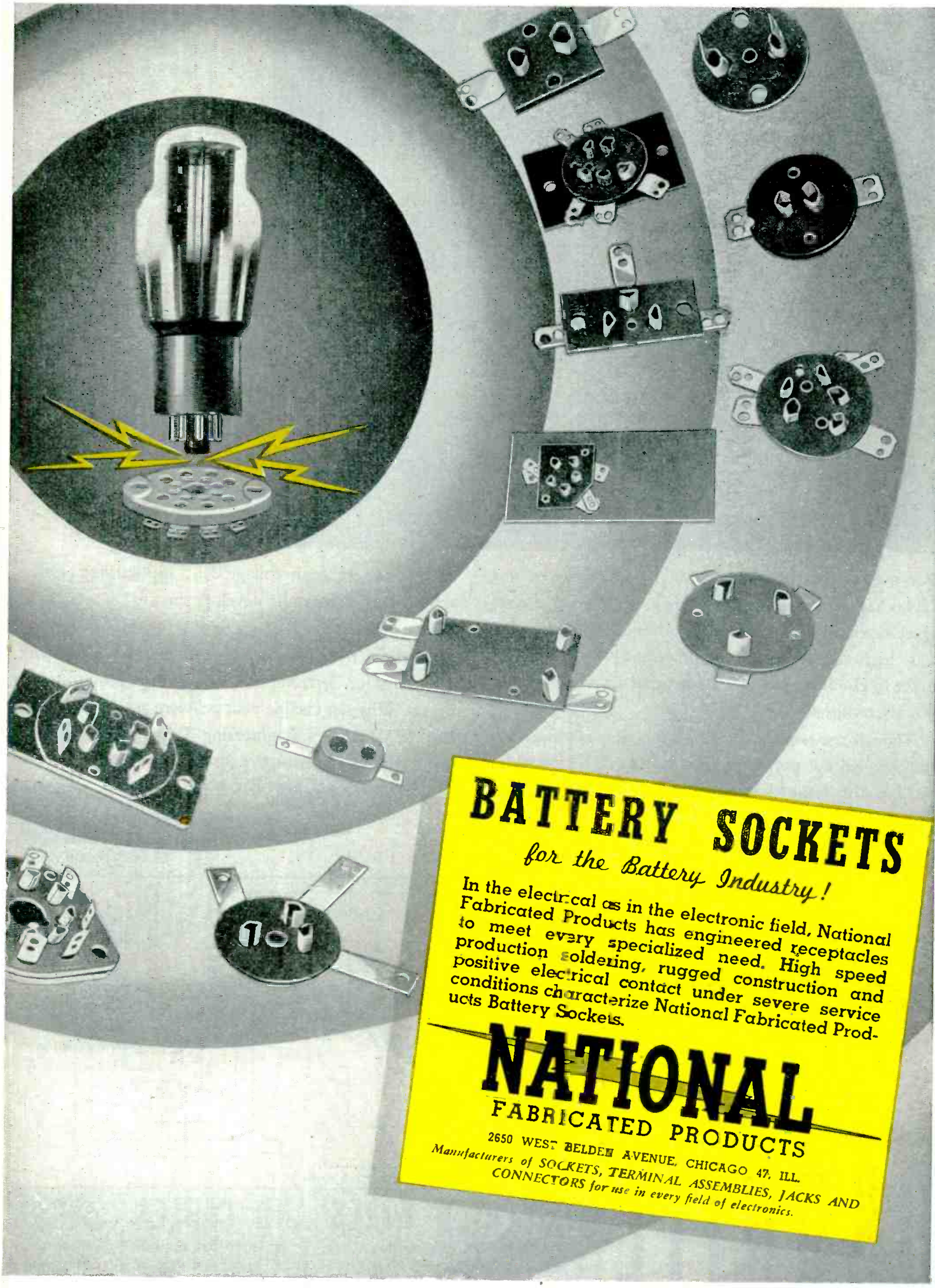
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for the Battery Industry!
In the electrical as in the electronic field, National Fabricated Products has engineered receptacles to meet every specialized need. High speed production soldering, rugged construction and positive electrical contact under severe service conditions characterize National Fabricated Products Battery Sockets.
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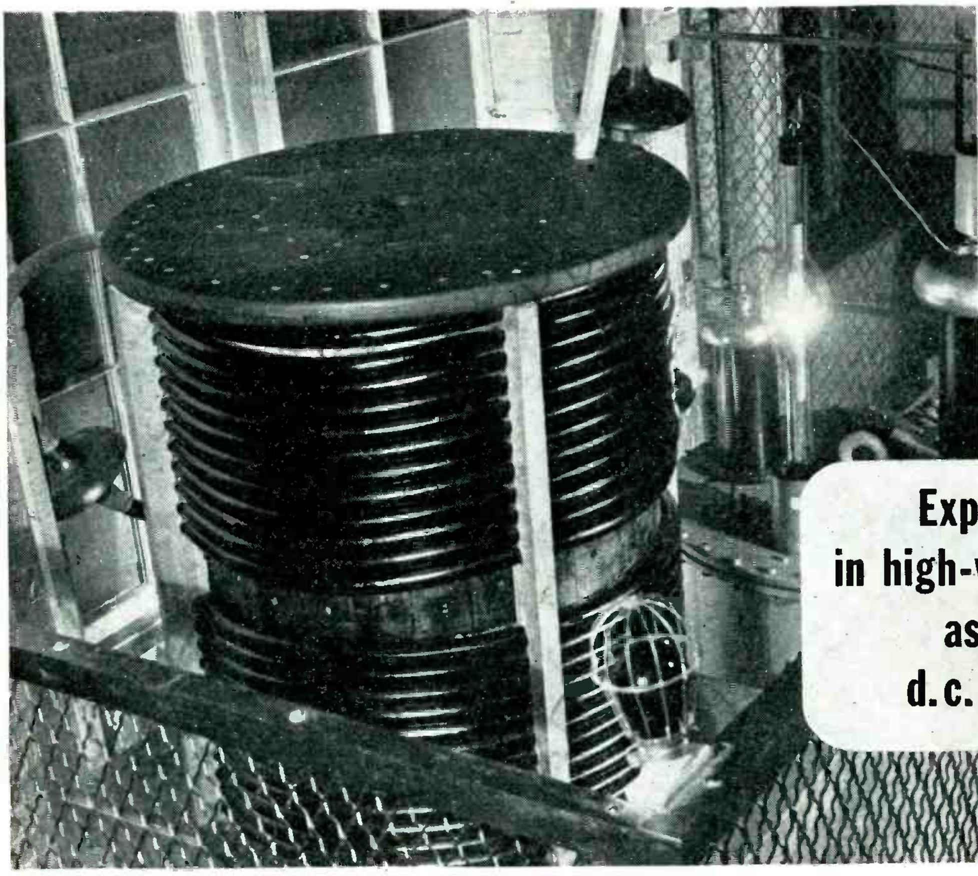
2650 WEST BELDEN AVENUE, CHICAGO 47, ILL.
Manufacturers of SOCKETS, TERMINAL ASSEMBLIES, JACKS AND CONNECTORS for use in every field of electronics.



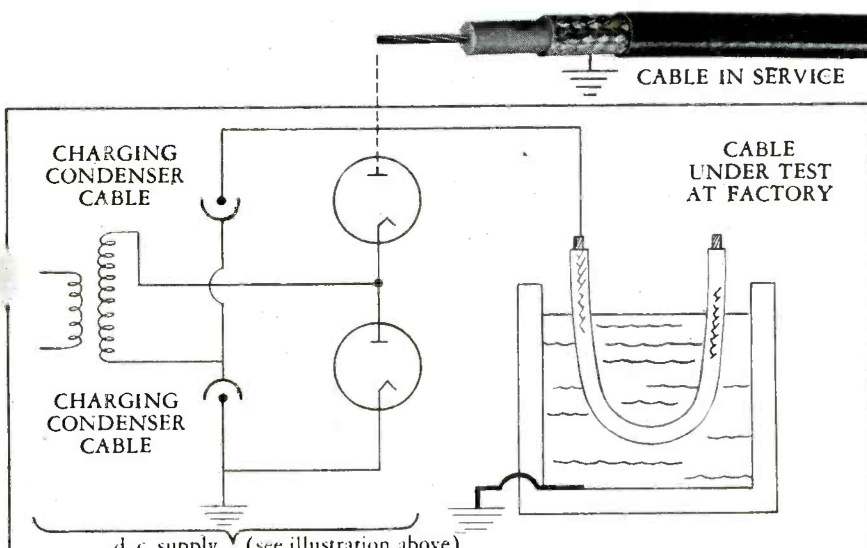
Okonite high voltage cables must pass super-voltage tests made with this d. c. kenotron set.

Experience gained in high-voltage d.c. testing assures reliable d.c. Cable Operation

For over 5 years all Okonite high voltage wires and cables have had to pass our self-imposed factory d. c. tests at voltages of 4 to 5 times those required in standard a. c. high voltage tests. This procedure was adopted in order to eliminate possible defects that a.c. testing could not always locate.

Though not required by purchasers, this extra precaution has led not only to the production of better cables but has also resulted in obtaining cables that are more reliable for the high voltage d. c. applications brought about by new electronic developments.

Our extensive experience with d. c. testing and d. c. applications through x-ray, co-axial and other high voltage cables for electronic uses can perhaps prove of value to you. Why not outline your problem and requirements and let Okonite's Engineering Department cooperate with you in obtaining a solution? Please write to The Okonite Company, Passaic, New Jersey.

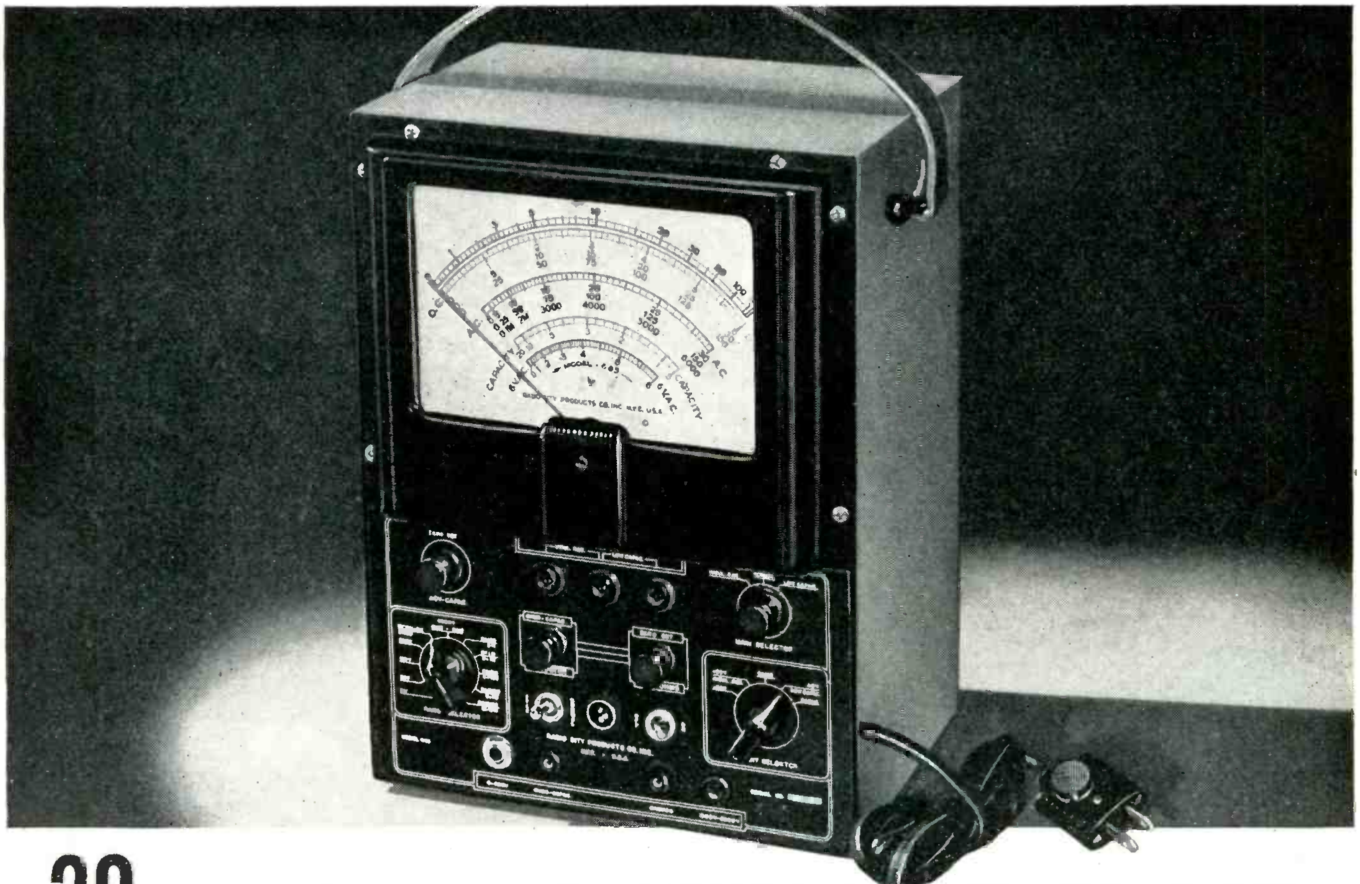


Careful d. c. testing in the factory assures better cable performance in service.

OKONITE

INSULATED WIRES AND CABLES

including Rubber, Varnished Cambric, Paper, Glass and Synthetics for Control, Communication, Power and Lighting in the Electrical and Electronic Fields. 3649



29 PRECISION-MEASURING OPERATIONS IN THIS SINGLE UNIT

RCP INSULATION TESTER Model 665 · $79.50

This multi-purpose model RCP 665, a V.T. Volt Ohmeggor Insulation Tester, is indispensible for accurate testing in shop and laboratory. This is just one unit in the complete line of RCP radio, electrical and electronic testing instruments. All are illustrated and described in Catalog 128 which should be in your files.

As we are in position to schedule reasonably prompt deliveries of most RCP models, we suggest you write for Catalog 128. And if you have any unusual test problem, our engineers will be glad to contribute their specialized experience.

FEATURES OF #665—Insulation testing at 500 volts up to 10,000 megohms. Vacuum tube voltmeter with 13 AC and DC voltage scales measuring from a fraction of a volt to 6,000 volts. Capacitymeter ranges from 2.5 micromicrofarads to 2,000 microfarads. Vacuum tube ohmmeter has seven ranges to 1,000 megohms.

Wide scale on 8″ D'Arsonval Microammeter with accuracy of 2% at full scale Linear meter movement. Maximum protection against burnout. Cannot be damaged by checking a live resistor or by using too low a measurement range.

Direct reading; complete with high voltage test leads, r.f. lead, and signal tracing probe; ready to operate. Rugged metal case provides thorough shielding. Model 665, size: 9¾x12½x6 inches. Weight: 13 lbs. CODE: Utel

QUALITY WITH ECONOMY

The demand of the Armed Forces for quantity as well as quality made it necessary for us to achieve mass production while maintaining difficult standards. You get this extra skill and quantity production economy when you choose RCP.

REASONABLE DELIVERIES ARE NOW BEING SCHEDULED

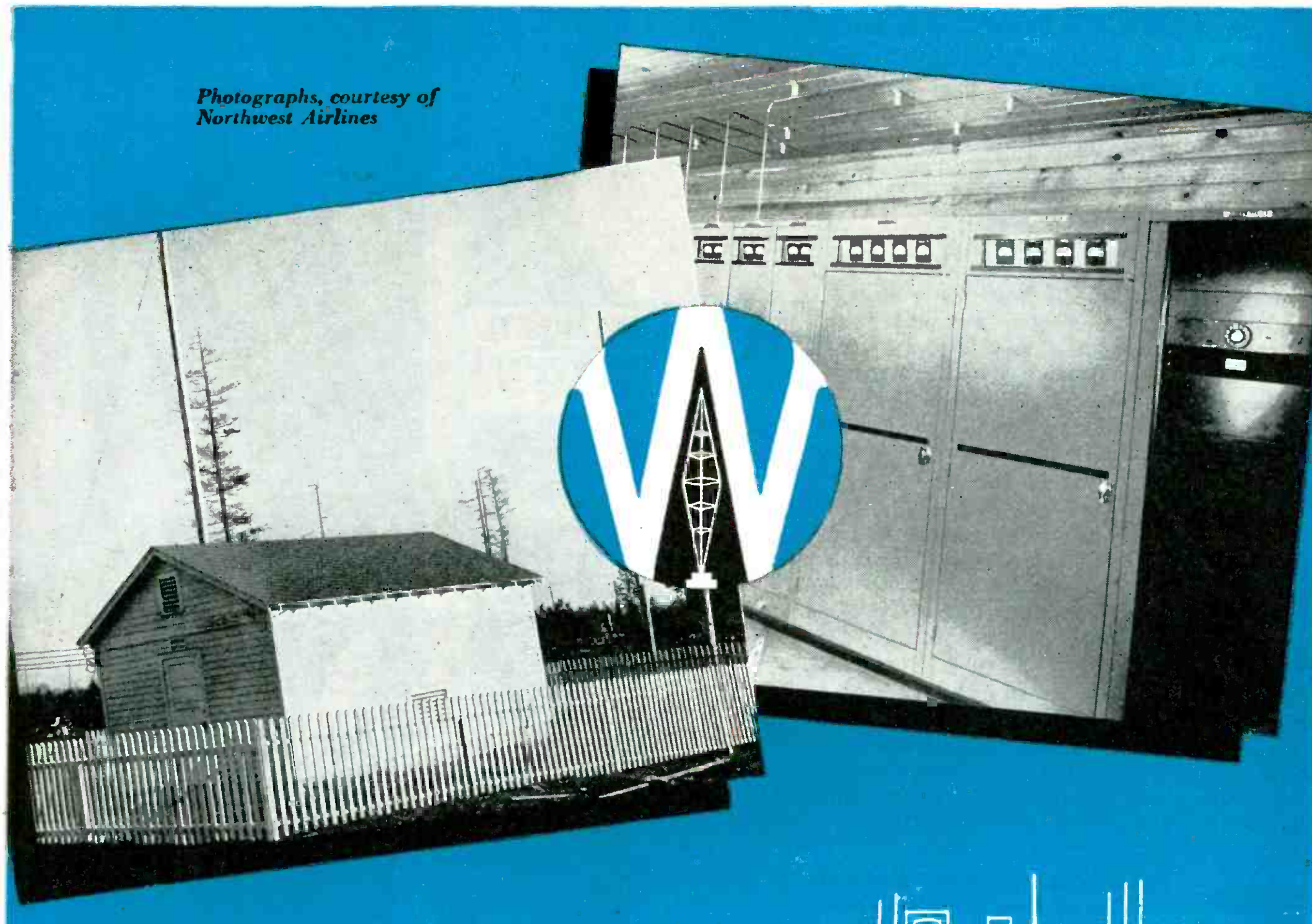
RADIO CITY PRODUCTS COMPANY, INC.

127 WEST 26th STREET — RCP — NEW YORK CITY 1, N. Y.

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

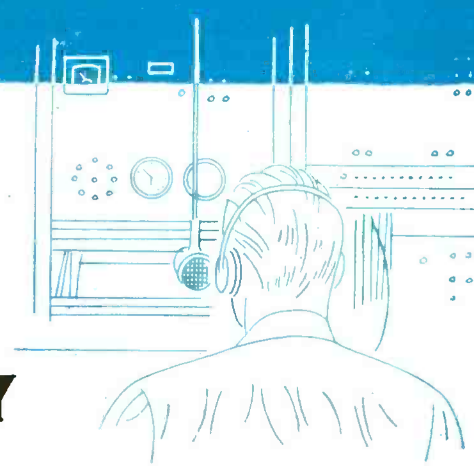
Radio Communications Maintained through Reliable WILCOX EQUIPMENT

by Northwest Airlines



Photographs, courtesy of Northwest Airlines

Throughout the nation, the major commercial airlines are using Wilcox installations to assure dependable radio communications. And throughout the world, Wilcox radio equipment is proving its reliability in military operations.

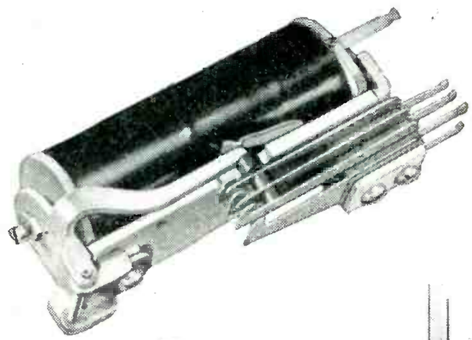


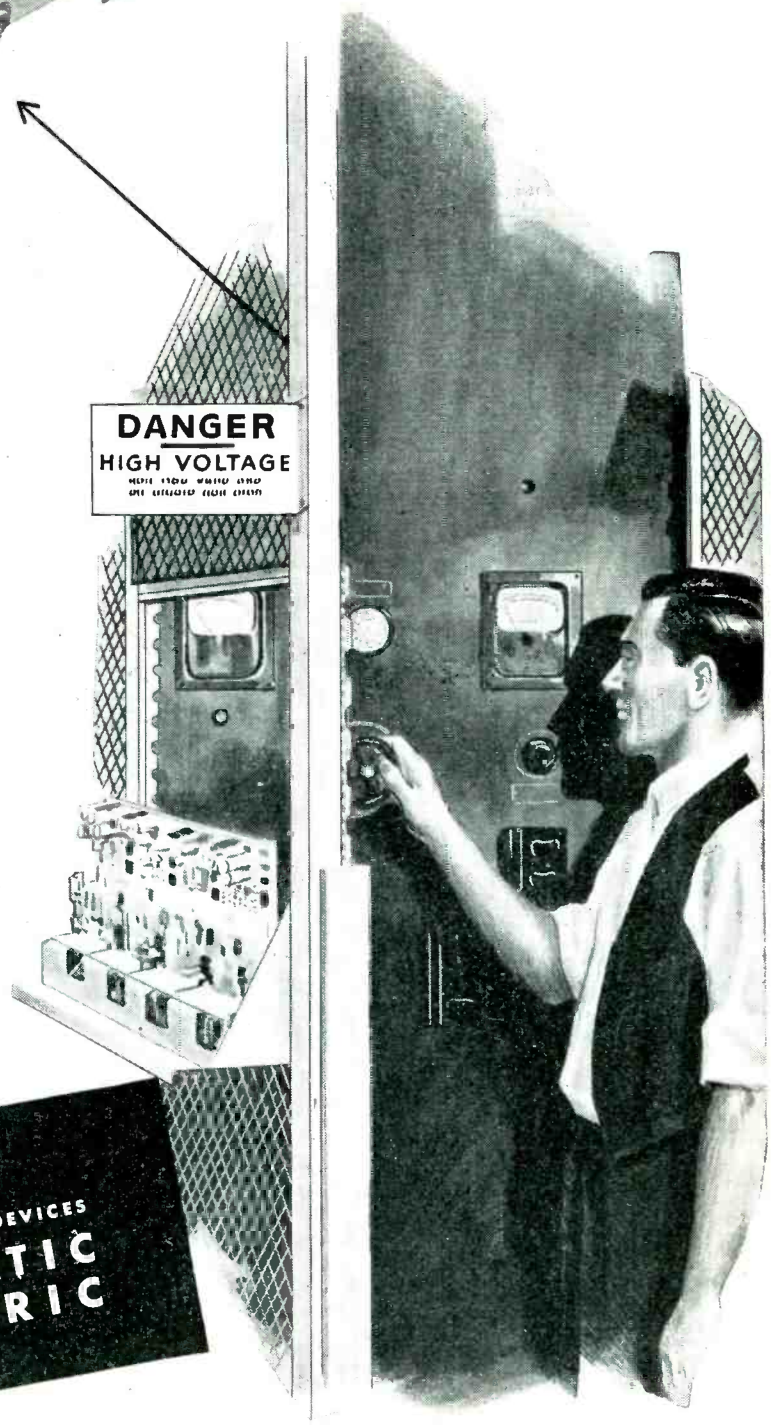
WILCOX ELECTRIC COMPANY

Manufacturers of Radio Equipment

Fourteenth & Chestnut — Kansas City, Missouri

Breakdown Tests Give New slants on Insulation





IN special test rooms like this, Automatic Electric relays undergo insulation breakdown tests under extremely high voltage. From long study of such tests, Automatic Electric engineers have developed effective safeguards against high potentials in actual service.

* * *

When war uses of electrical control equipment focused attention on the need for improved insulation, Automatic Electric engineers were well prepared. For insulation technique is a factor in relay design to which they had already given long study. Today, improved methods to meet wartime needs have not only improved the performance of war equipment, but also will add to dependability of peacetime designs.

Similar studies are constantly being made of spring design, contact materials and pressures, magnetic circuits, finishes and coil designs. The resulting experience is one basic reason why Automatic Electric relays perform so dependably under tough conditions.

You can take advantage of this background by calling in the Automatic Electric field engineer. A specialist in electrical control, he works daily with designers of war products, and will be glad to work with *you* in selecting the apparatus best suited to your needs.

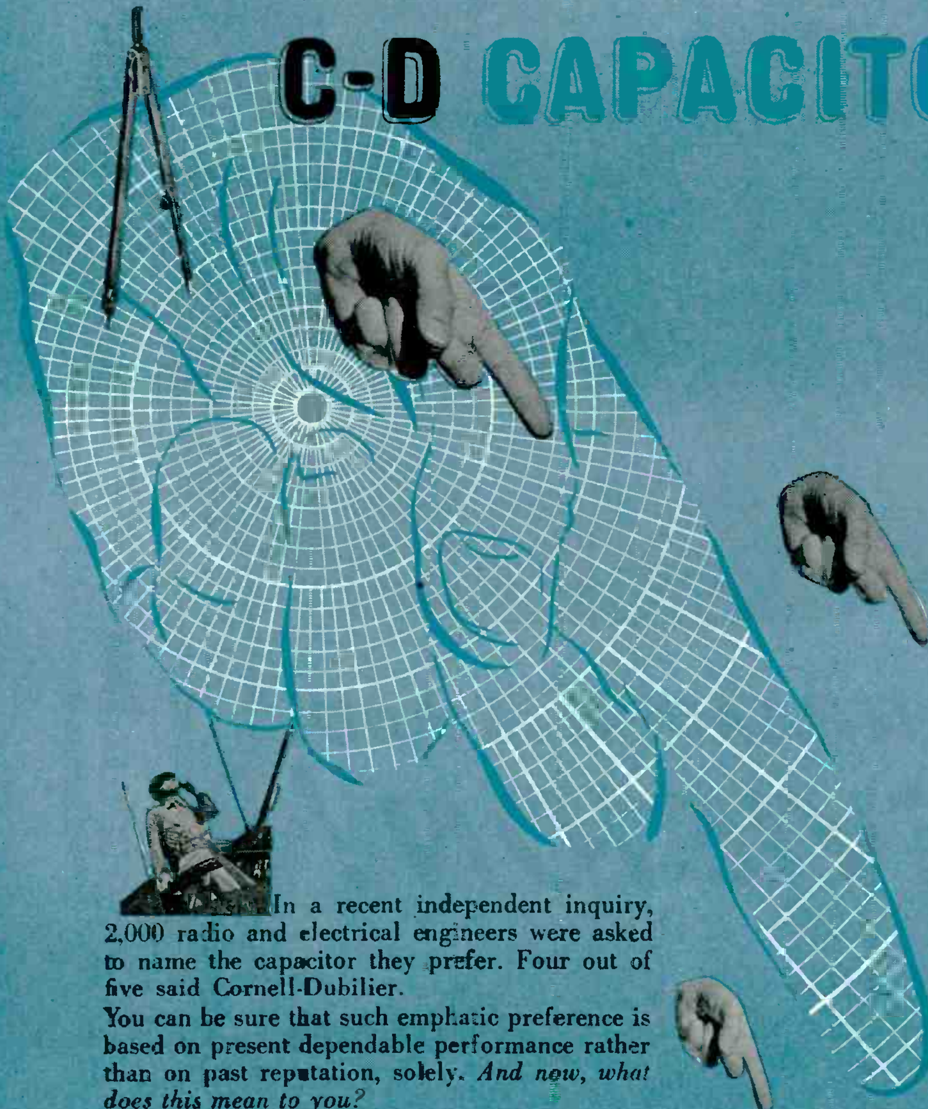
AUTOMATIC ELECTRIC SALES CORPORATION
1033 West Van Buren St., Chicago 7, Illinois
In Canada: Automatic Electric (Canada) Limited, Toronto

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

PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED

why engineers choose

C-D CAPACITORS!



In a recent independent inquiry, 2,000 radio and electrical engineers were asked to name the capacitor they prefer. Four out of five said Cornell-Dubilier.

You can be sure that such emphatic preference is based on present dependable performance rather than on past reputation, solely. *And now, what does this mean to you?*

It means, that no matter how tough your capacitor problem may be . . . no matter how intricate the equipment required to solve it . . . no matter how much research may be required to find the answer: you will get all this and more at C-D. There is scarcely a capacitor type that we haven't already made, and if we haven't, the experience acquired in thirty-four years of manufacture will certainly enable us to design the capacitor you need. Write to Cornell-Dubilier Electric Corporation, So. Plainfield, N. J.

another C-D development

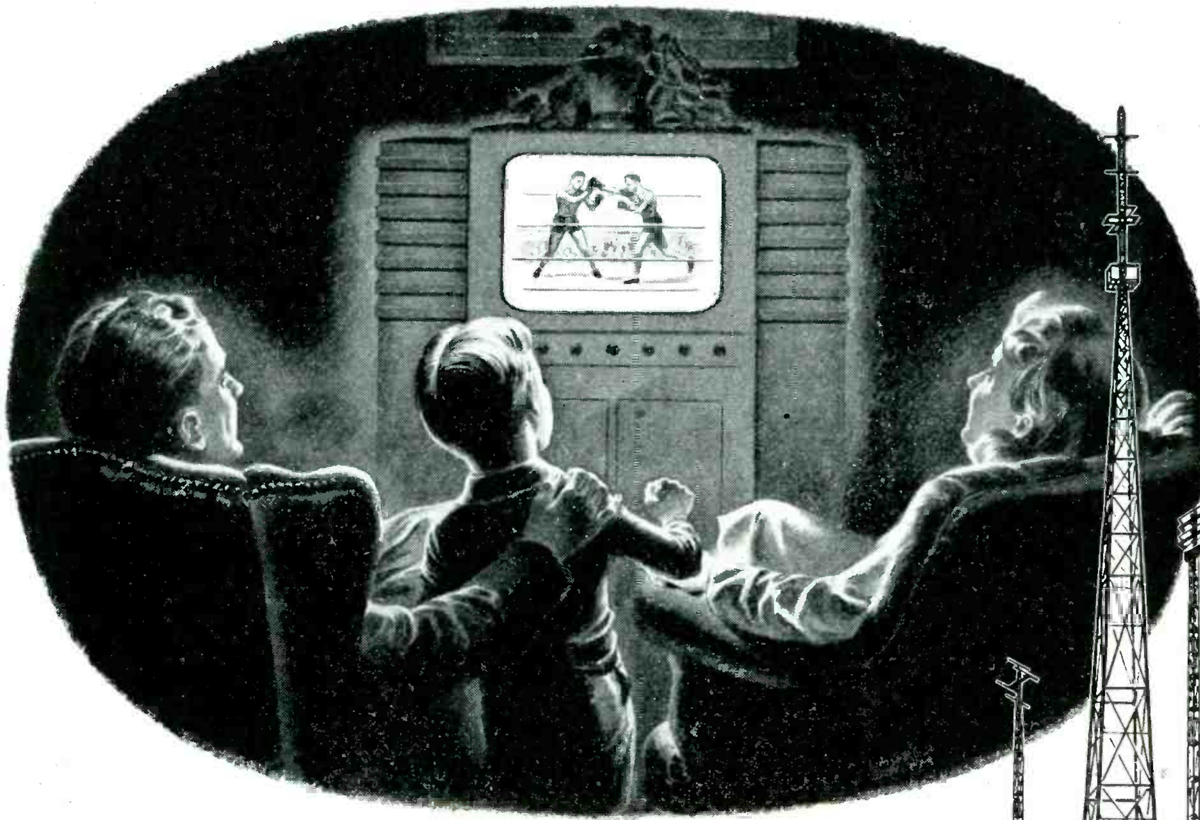
Type YAB is a compact low-capacity, dykanol impregnated and filled bypass capacitor; hermetically sealed.
range at 600 V., .05 mfd. to 1 mfd..
range at 100 V., .05 mfd. to .5 mfd.

Cornell-Dubilier Capacitors

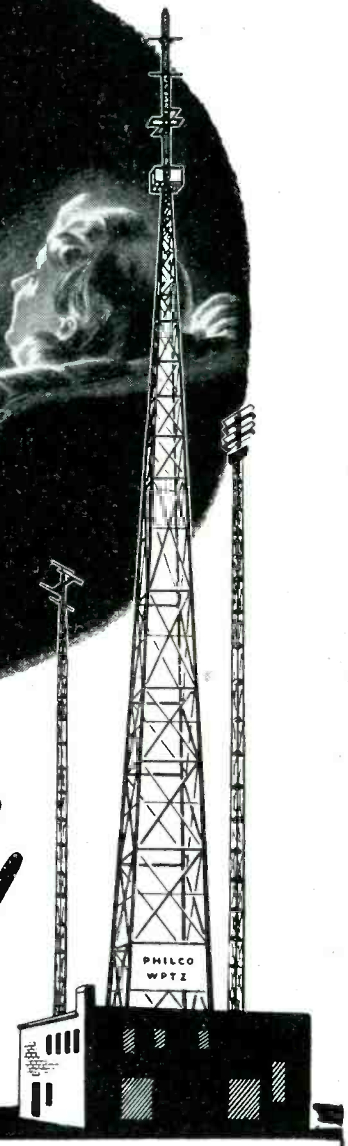
MICA • DYKANOL • PAPER • WET AND DRY ELECTROLYTICS

1910 — 1944

Reg. U. S. Pat. Off.



PHILCO, THE LEADER ... AND TELEVISION!



Much is being said today in the public and trade press about Television, the "billion dollar industry" of the future. Where will Philco, the industry leader, stand when Television is here for you to sell?

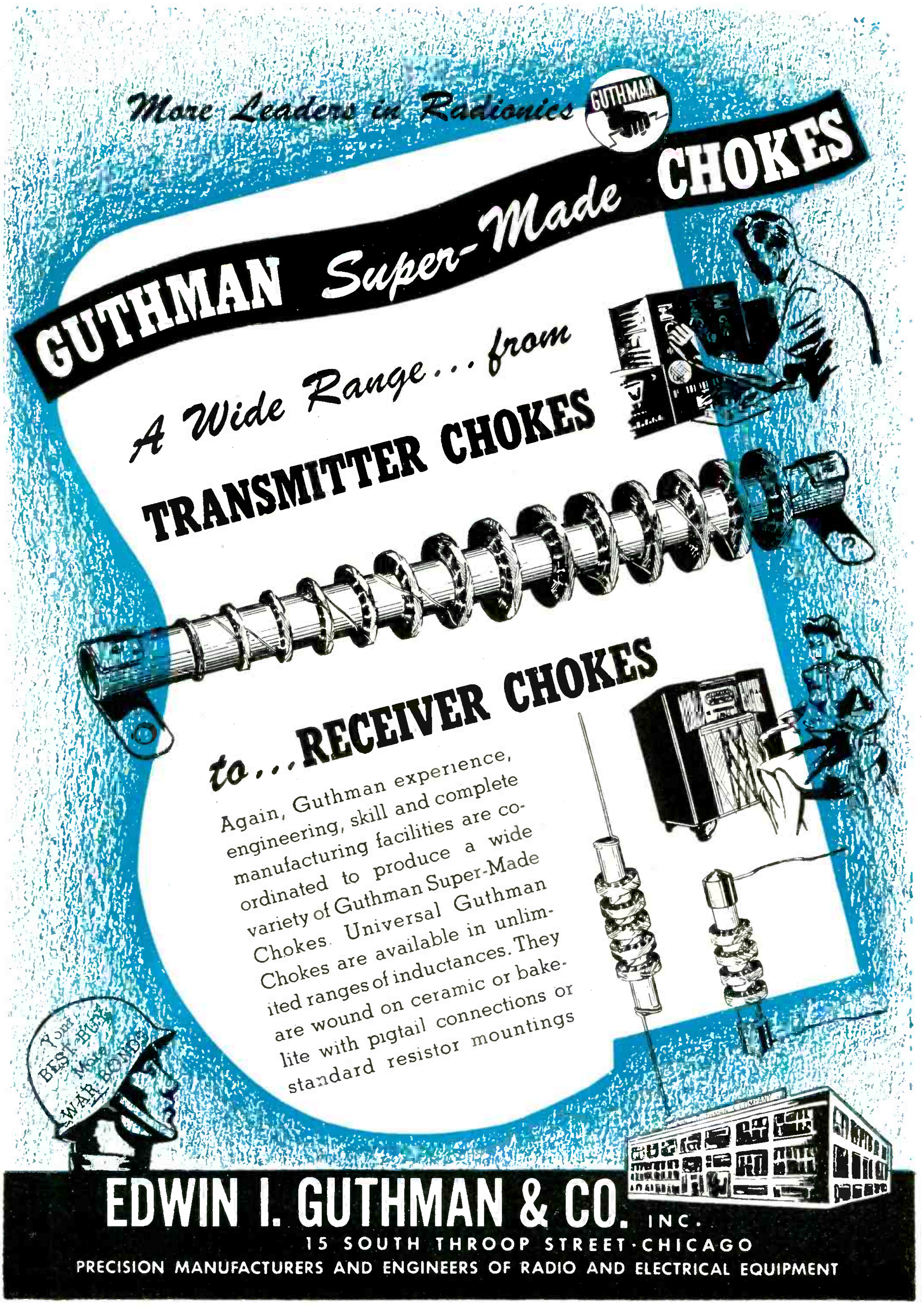
Since 1928, for sixteen years, Philco engineers have devoted millions of dollars to research in the field of television. More than any other research group, they have been responsible for constant improvement in the clarity, sharpness and detail of the television picture. Their pioneer contributions have helped to bring television to maturity, ready for rapid expansion after the war.

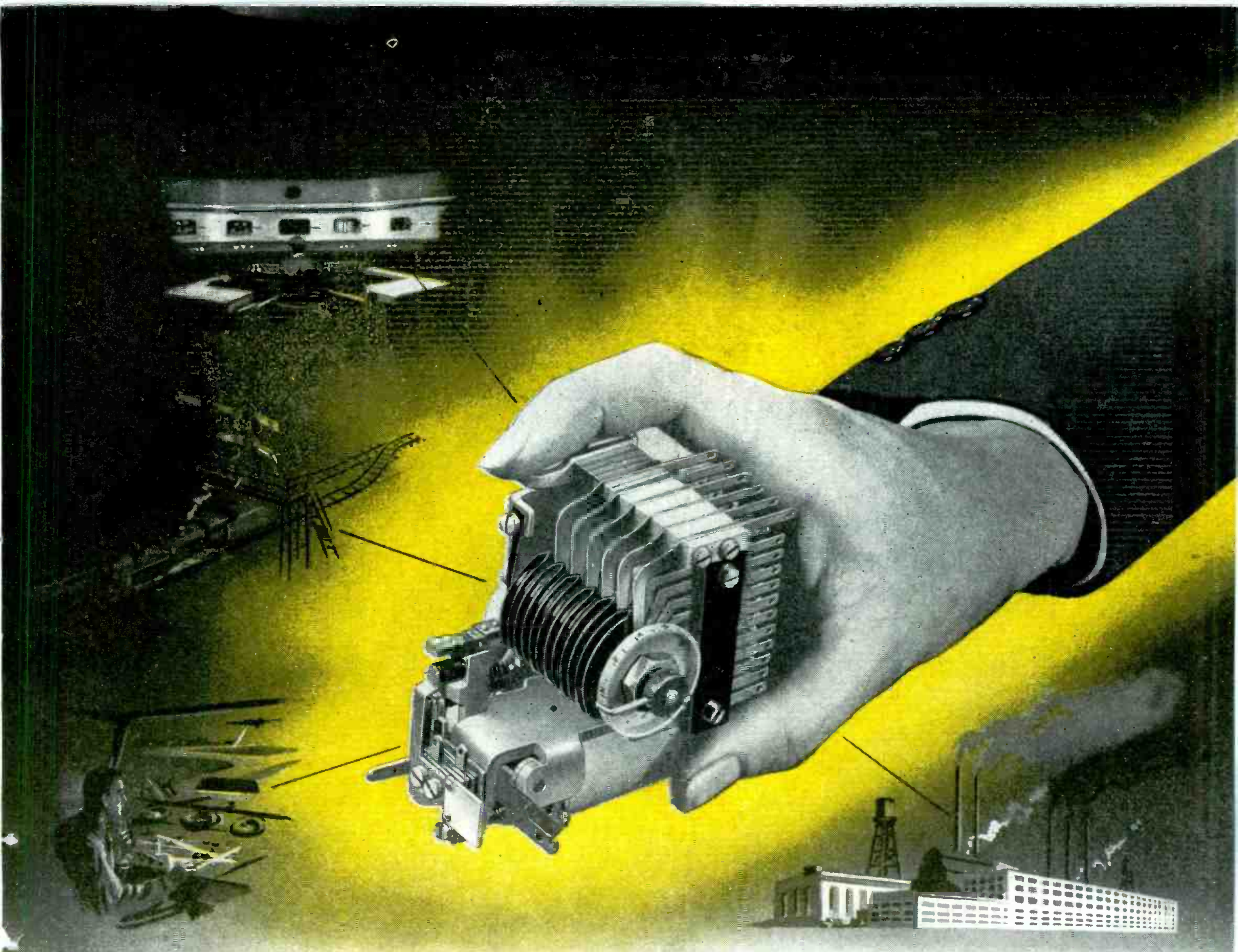
In this and many other directions, Philco has been in the forefront of the developments that make television a bright hope for the future to appliance dealers. And when it is ready to sell in your community, you can depend on Philco to fulfill the obligations of leadership.

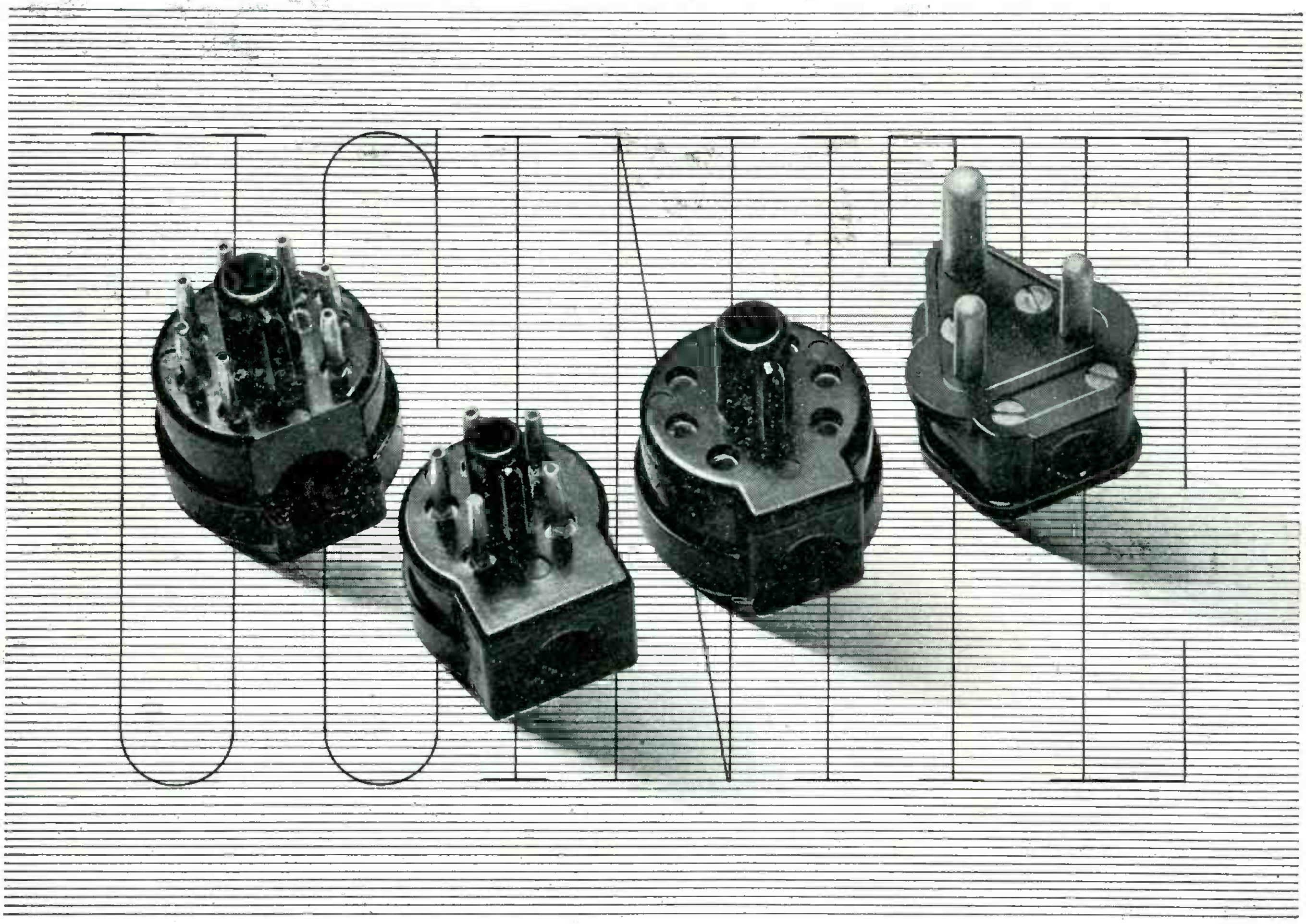
PHILCO TELEVISION STATION WPTZ

Since 1933, Philco has owned and operated its own television station in Philadelphia, sending out studio programs and sports events direct from the scene. It has also rebroadcast programs from New York, establishing the technique upon which future television chains can be built. All this has been a rich laboratory of experience through which Philco engineers will help to make television, some day, a nationwide service.

PHILCO CORPORATION


More Leaders in Radionics
GUTHMAN
GUTHMAN Super-Made CHOKES
A Wide Range... from
TRANSMITTER CHOKES
to... RECEIVER CHOKES
Again, Guthman experience, engineering, skill and complete manufacturing facilities are co-ordinated to produce a wide variety of Guthman Super-Made Chokes. Universal Guthman Chokes are available in unlimited ranges of inductances. They are wound on ceramic or bakelite with pigtail connections or standard resistor mountings
WAR BONDS
EDWIN I. GUTHMAN & CO. INC.
15 SOUTH THROOP STREET · CHICAGO
PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT





A Plug for our Moulded Plugs

Ucinite made three war-vital contributions to the production of these moulded plugs and connectors . . . By modifying the design, critical screw machine parts and labor were replaced by drawn-and-formed sheet brass parts turned out on ordinary punch presses . . . Manufacturing time was speeded . . . Prices were lowered . . . And the customer got a better product.

It is a matter of pride with Ucinite to make our specialized experience count on every order, wherever possible, these days. It is one of our war aims to do every job better, faster and/or at less cost than the first specifications called for.

The UCINITE CO.

Newtonville 60, Mass.

Division of United-Carr Fastener Corp.

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

NO RICH UNCLE PAID FOR OUR EDUCATION

USE A MANUFACTURER'S MANUFACTURER . . . . .

One Contract — One Responsibility — One Cost

Lewyt's business is Contract Manufacturing. We specialize in electric and electronic instruments, chassis and housings; mechanical and electrical assemblies; highest precision machine work; sheet metal fabrications; all types of welding, product finishing, etc.

Our advanced engineering facilities for the design, re-design, or development of your product may interest the man upon whom you place the responsibility of production.

That's the man who should have our 48-page book, "Let Lewyt Do It". Write for it on your business stationery. There is no obligation.

Where we really got our education was in peace-time practice . . . not from a short course in wartime production.

Our shingle has been out for 56 years and we number among our clients many of the biggest names in American Industry.

"C-Day"—conversion to peace-time manufacture—is just 'round the corner. More and more materials are being released for civilian products.

Which "shingle" will you turn to for a professional diagnosis of your conversion program, parts production or new product developments? Some recent graduate of the easy-come-easy-go school, or one of long training in production economies?

Lewyt is *not* a war baby. Lewyt is a "manufacturer's manufacturer" with 56 years of cost-conscious "know-how".

Lewyt returns to peace-time contract manufacturing with long experience in meeting the needs of production engineers who will have only costs and efficiency in mind.

LEWYT CORPORATION, 62 BROADWAY, B'KLYN 11, N. Y.

Lewyt

LET LEWYT DO IT

REMEMBER TO BUY MORE U. S. WAR BONDS

INVASION *and the* FINAL CHALLENGE

The idea that our national security some day would depend upon the successful invasion of continental Europe by our armed forces was inconceivable to the average American but a few short years ago. Yet, today our whole strength is assembled to that very action and for assuring a sound and permanent peace.

America became great without aggression . . . without tyranny. Our greatness has been achieved without destroying others . . . ours is a history of unprecedented industrial progress, of development of our own resources and reliance on our own efforts.

Aggression is foreign to American philosophy. Yet, today we find ourselves faced with the choice of destroying or being destroyed. Today we are confronted by the hard fact that the kind of peace which we all so fervently desire can be achieved only by crushing autocracy and by removing the causes of aggression.

We are now engaged in the accomplishment of the first objective. Since Pearl Harbor a complacent, peace-loving America—the largest of the "soft" and "decadent" democracies—has grown strong and tough. Out of the inherent virility of a free people we have moulded the mightiest force for invasion and attack that the world has ever seen.

We have reached our peak rates of war production. We are producing as much war equipment as all the rest of the world combined.

History will record our industrial mobilization as a phenomenal achievement.

The battle of production has been won!

The full might of our armed forces and those of our allies unleashed against the Axis war machine will bring eventual victory. Two and a half years of intensive preparation, backed by 168 years of growth as a free nation, has given us superiority over twenty years of painstaking preparation by the totalitarian and militaristic countries with their enslaved peoples.

Every American has contributed toward this powerful offensive. Our manufacturers and business leaders have exerted their fullest efforts. Our industries have mobilized their tremendous resources—tapped to the fullest degree their inventive and productive genius. The men and women in the factories, on the farms, and in the mills and mines have played a magnificent part in the tremendous production program. Citizens all are making their contribution to the armed victory that lies ahead

We have demonstrated that a free people under a free enterprise economy can unite in a common purpose.

* * *

When the war is won, we shall be faced by our second objective . . . removing the causes of aggression. This is a social challenge. A challenge to those who would sacrifice our democratic way of life for personal gains or foreign ideologies.

The best insurance for the continuance of our democracy is a successful democracy. That means a dynamic and not a static democracy. All of us who want to preserve the ideals that have made America . . . and that includes all but a handful of extremists . . . must determine to find the policies and programs which will permit us to make the most of the abundance nature has provided for us.

To achieve this end we must recognize the fact that we are but a wheel in the machinery of world economy. A wheel that must drive or be driven. A wheel that must mesh smoothly with the many other wheels or be stripped of its cogs.

We are the only nation on earth free enough and strong enough to shape the mould of its own destiny. We can be hampered by nothing but our own confusion.

* * *

The mind and the heart of all America today brood over the shores of Britain and watch over the narrow waters that wash the beaches of the Continent. And the prayers of all America go with each of those who embark upon that epic passage.

Those of us at home who are producing the fighting tools and who are so earnestly concerned with the problems that will face a postwar America, should see now, even if we may never have seen it before, that all our plans will be worth just exactly what the men and women who make that passage are prepared, competent, and inspired by their leadership to make them worth.

For those men and women are America!

They have gone out from rich homes and poor homes alike, from farms and factories, from schools and churches, from mines and ranches, from offices and studios, to take their places in the battle line. They are a cross-section of the America that is to be.

Whoever may draw the plans for that America, it is those men and women who will make the plans good. Invasion is their first step toward that end. May their work be speedily done, and may our plans be worthy of that work.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

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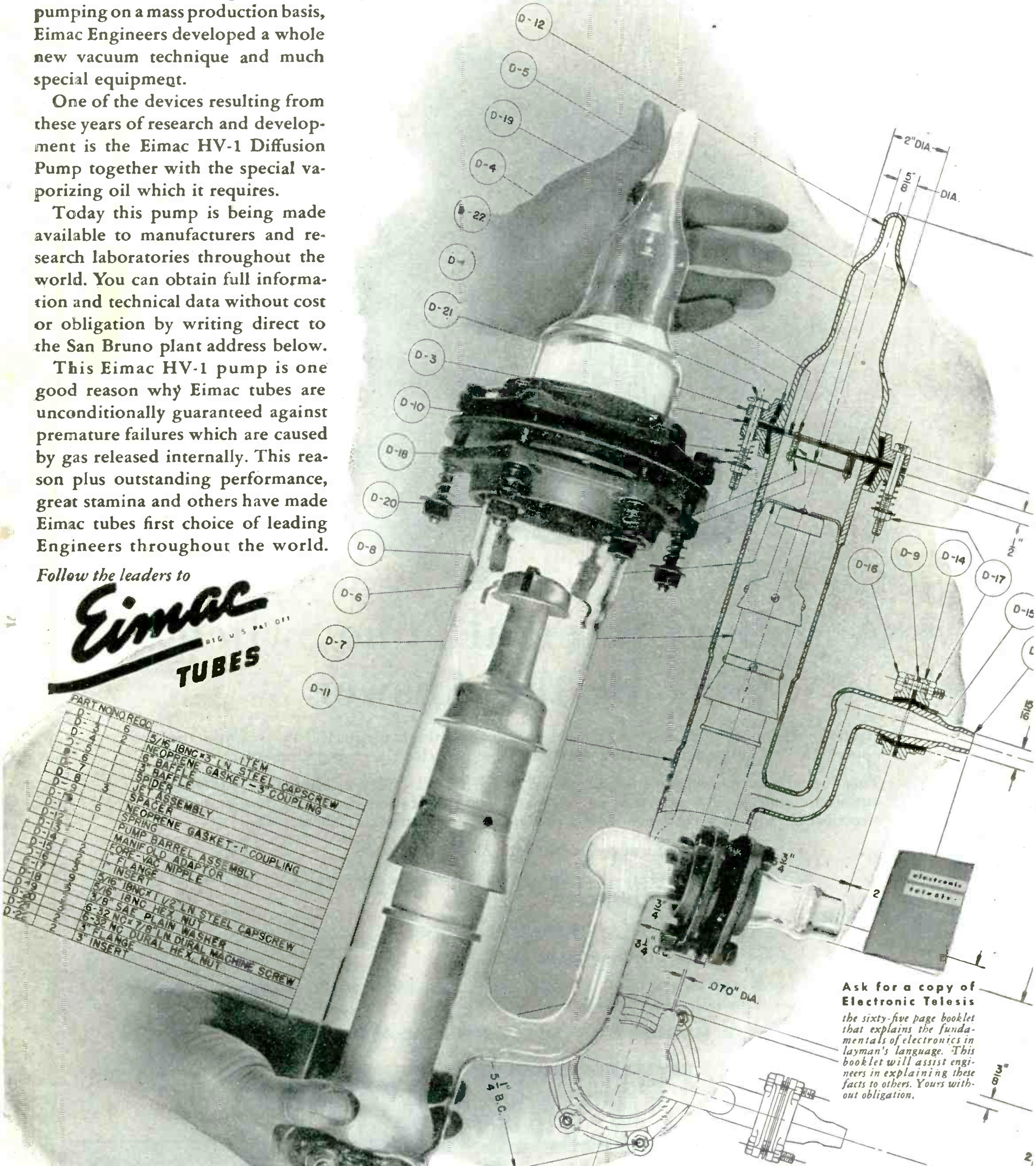

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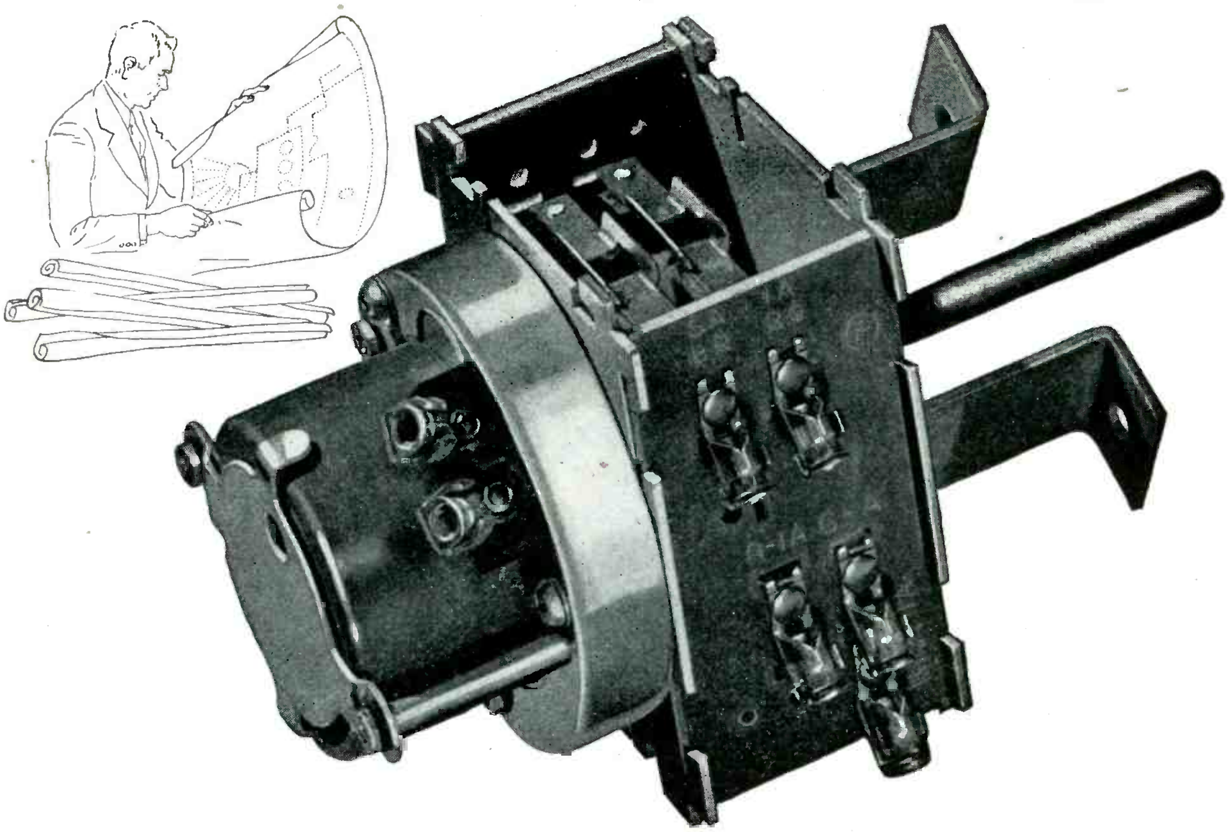

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CROSS TALK

▶ **SYMBOLS** . . . Here we go again!

Mr. Waldemar Kaempffert, Science Editor of the *New York Times*, has written a proposal for the organization of a World Scientific Commission. This was published in the magazine *Tomorrow* and reprinted in New York papers as an advertisement by the International Latex Corporation, March 23, 1944. The gist of the proposal is simply this, "give us international cooperation in science and soon there will be cooperation in other fields, with the result that science will contribute to lasting peace."

The hopes of Mr. Kaempffert, dean of our newspaper science writers, are undoubtedly the hopes of every true citizen of the world—the hope for cooperation with all other citizens so that all peoples of this globe can move forward together in peace. This is most laudable, and, without seeming to be too cynical about the prospect, let us state the difficulty of such cooperation by citing again the problems of getting a very small group of people together on a very small matter.

For a long time, power and communications engineers have been trying to decide upon a common set of symbols to represent the essential components which make up electrical and electronic circuits. Under the powerful stimulus of wartime, considerable pressure has been put behind this attempt at standardization.

On January 22 a large meeting under the aegis of ASA took place, attended by representatives of both the power and the communications interests and also by the armed services who fervently prayed for a quick decision. At this meeting a compromise set of symbols was put forth which seemed to be satisfactory to those present. Letter ballots were duly sent out with the request that they be returned by February 15. But by this date, not all ballots had been turned in and some two weeks later it developed that some of the power people did not feel the compromise symbols were satisfactory.

And so another meeting was held on March 10th. New compromises were set up and at the end of March new letter ballots went out. A month or so from then, say by the middle of May, some indication of the results of the ballotting may become evident. But several months will have been wasted because a few of the power people did not like the compromise symbols advocated at the January 22 meeting. In the meantime the armed services, tired of being stalled, are showing signs of plunging ahead on their own.

Thus the prospect of a world-wide agreement on scientific matters looks a bit difficult—or are we just pessimistic?

▶ **RENEWALS** . . . What with the present shortage of paper and the delays in the mail, it behooves every subscriber to ELECTRONICS who wants to receive all his copies to renew his subscription promptly upon receipt of notice. Otherwise, someone on the present waiting list will begin receiving copies and it will be next to impossible to fill in the lost issues when the tardy renewee gets back on the list.

▶ **RUBBER TEETH** . . . At a recent meeting of the New York Society for Measurement and Control, Dr. Paul G. Weiller, an electronic engineer, brought up an interesting point on the use of tubes in control. Said Dr. Weiller, "You are probably getting all steamed up about the application of electronics to control problems. Yet if you have to connect a load to a motor so that the load will rotate 1/10th as fast as the motor, the sensible thing to do will be to use a set of gears. Any good mechanical engineer can design this arrangement so that the work will turn 100 times per minute if the motor revolves 1000 times per minute.

"Now let us suppose you want to use tubes. You must remember, right off the bat, that electronic devices have 'rubber teeth' and that no matter how carefully you design and engineer your system, you must always provide for the fact that individual tubes of a given type vary in characteristics; that component parts to go with the tubes may vary in electrical characteristics from ½ to 10 percent from the rated normal value; and that sometimes the sum of the variables may all go in one direction.

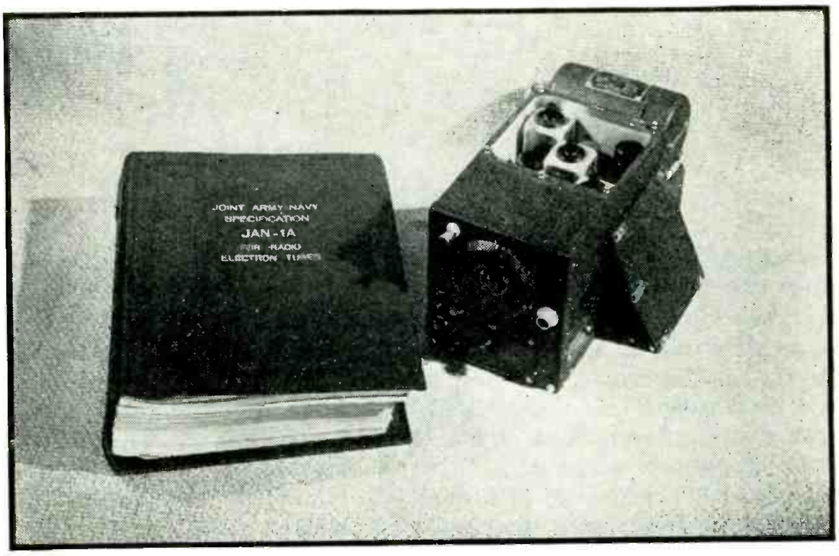
"A simple gear system or any other simple system is always preferable to a complicated system, electronic or not. Gears do not have rubber teeth."

ELECTRONI

Circuit development involves three steps: conception, the working model and the final engineering design, all affected by normal tolerances of parts

By S. B. INGRAM

Electronics Research Engineer
Bell Telephone Laboratories
New York, N. Y.



Electronic units for field use, like this BC454B radio receiver for radio command sets in airplanes, must be designed to take into account the normal tolerance variations in electron tubes. These standard tolerances are set forth in Joint Army-Navy Specification JAN-1A for Radio Electron Tubes

THIS is an electronic war. Many workers in pure science, drafted by government agencies, find themselves suddenly charged with the engineering design of a practical electronic circuit. This article traces the nature of the three general steps required in the development of an electronic circuit: conception, the construction of a working model, and final engineering design.

In general, the circuit designer has a function which he wishes his circuit to perform. He has available an array of components: capacitors, inductors, resistors, transformers, switches, relays and perhaps non-linear elements such as saturable reactors—and finally, electron tubes.

The conception of the circuit is the intellectual exercise of originating, on paper, a device which the originator believes will perform the function required. If the designer is wise, he will give the circuit a thorough mathematical analysis at this stage as an aid to understanding its future operation.

The next step is to build a working model. For the engineer interested in tangible results, the production of the model is merely the application of the scientific method to his particular problem.

In general, unless the circuit is exceedingly simple and conventional, the first model will not work satisfactorily in all respects. Then it must be subjected to a more thorough analysis to determine how it works in its various sections, how its parts interact and how its behavior differs from the theoretical behavior expected on the basis of the original considerations. For this analysis, all the tools of the trade are required—meters, oscilloscopes and other measuring instruments. The analysis will generally explain the discrepancy in performance and will probably also suggest an alternative method of arriving at the desired result.

Both theoretical and experimental methods of analysis must be used and must go hand in hand. In this manner an actual circuit can be evolved which does what it is supposed to do and for reasons which are understood.

Engineering Design

It is too often assumed that when a successful working model has been built the job is done and to put the circuit into production requires only the building of a number of other models just like the first. The fallacy lies in assuming that whole circuits can be exactly duplicated, when the components which they employ involve manufacturing variations and tolerances.

The engineering design of a device consists of making sure that all subsequently produced units will satisfy the performance specification when made out of components which vary over the entire range of their own manufacturing tolerances. Component part manufacturing tolerances are fixed by the limits contained in the acceptance specification of the component in question.

Having conceived the circuit and constructed a working model, the designer should try to make the circuit fail to perform by selecting adverse combinations of components and operating conditions. If he does not do this, his manufacturing department or the users of the equipment will do it for him later to his embarrassment. If adverse combinations of components make it impossible to satisfy the requirements of the perform-

CIRCUIT DESIGN

ance specification, consistency between the specifications of the components and the equipment must be established either by relaxing the requirements of the performance specification or reducing the specified tolerances on the components. Only when such consistency has been established can the engineering design of the circuit be considered complete.

Tube Specifications

Each of the circuit components must have its own specification which describes its nominal characteristics and the permissible manufacturing tolerances. In drafting tube specifications, for example, it is necessary first to determine which of the characteristics are important in circuit operation, then select tolerances consistent with circuit requirements.

If a circuit is being designed around tubes which already exist and whose characteristics are specified, the burden is on the circuit designer to see that his circuit can tolerate variations over the whole range permitted by the tube specifications.

It is interesting to note that the Joint Army-Navy Specification on tubes contains a statement that "equipment using the radio electron tubes covered by this specification shall be designed so that all tubes meeting this specification will perform satisfactorily in the normal service for which the equipment is designed."

This is not by any means a new conception. It is simply the electrical analogue of the concept of various "classes of fit" in mechanical engineering. The American standard on screw threads, for example, specifies tolerances on the dimensions of the threads of nuts and bolts so that for a Class 1, 2 or 3 fit any bolt falling within the tolerances of its specification may be fitted to any nut falling within the tolerances of the corresponding nut specification without the application of undue force or profanity by the mechanic whose job it is to put them together.

It is true that in mechanical engineering a procedure known as selective assembly, in which matched parts must be selected and assembled by a process of cut and try, is well recognized. But the Services have said before and continue to say in broadsides to manufacturers of electronic equipment, in which one can detect a slight note of desperation, that they do not want any electronic equipment which some doughboy is going to be called upon to put together under gunfire by a process of selective assembly. It is the joint responsibility of the designers of electronic circuits and tubes to see that it isn't necessary.

QUESTIONS
to Ask Yourself

Will the circuit work when you put in a spare tube?

Will *all* the models work when you put in *any* of the spare tubes?

You know the tolerance limits of the resistors and capacitors, but do you know the g_m limits of the tubes in the circuit?

Tubes hold a unique position among the components of a circuit because they are generally the only components which are replaceable items. Resistors, transformers and other parts are usually soldered in for the life of the equipment. Their replacement is a repair job to be performed by an expert. On the other hand, replacement of a tube is a more frequent procedure and the equipment must work with any spare tube which is inserted, and any spare tube means any tube which meets the requirements of the specification under which it was accepted.

In many tube specifications there is a tendency to fall back on operation tests, that is, satisfactory performance in a sample unit, as an over-all control of quality. Operation tests have the weakness that they prove only that a given tube will operate in a given unit. They give no assurance that the same tube will operate in another unit with a different combination of components.

Experimental Procedure

The process of establishing consistency between the specification of components and the overall circuit specification can be carried out by a variety of means. In many cases, circuit operation can be sufficiently well subjected to mathematical analysis that the effect of variations in tube characteristics on over-all performance, for instance, can be predicted. In other cases, effects similar to those resulting from variations in characteristics may be produced by substituting tubes known to have characteristics near the extreme specified limits. Variations in characteristics can frequently be simulated by artificial means. For example, a small capacitance may be introduced to represent a variation in the interelectrode capacitance of a tube, or a small direct voltage from a potentiometer may be inserted in series with a grid to investigate the effect of a variation in grid characteristic.

Obviously, considerations as general as those given here will be found subject to many practical limitations when applied in a variety of actual cases. Under pressure of war schedules, it may frequently be impossible to do a one hundred percent job in applying ideal design principles. Nevertheless, any effort spent by the designer in assuring himself that the circuit is capable of accommodating the characteristic variations known to exist in the components is time well spent, since just that many causes of operation or manufacturing trouble will be forestalled.

Police Satellite System

FM signals from 39-Mc mobile transmitters are automatically relayed to a central point by two 118-Mc mountain-top stations when cars are in remote areas. The design of 60-degree corner reflector receiving antennas used to avoid interference is discussed in detail

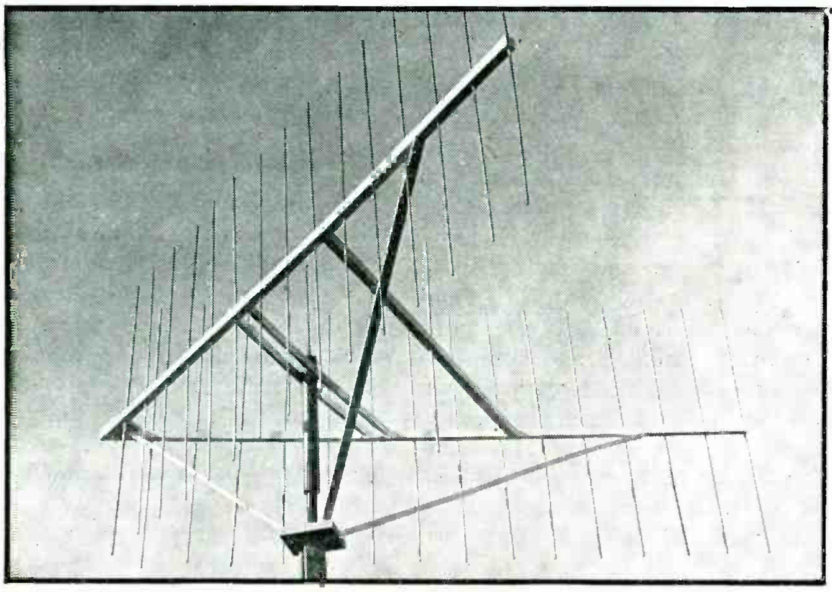
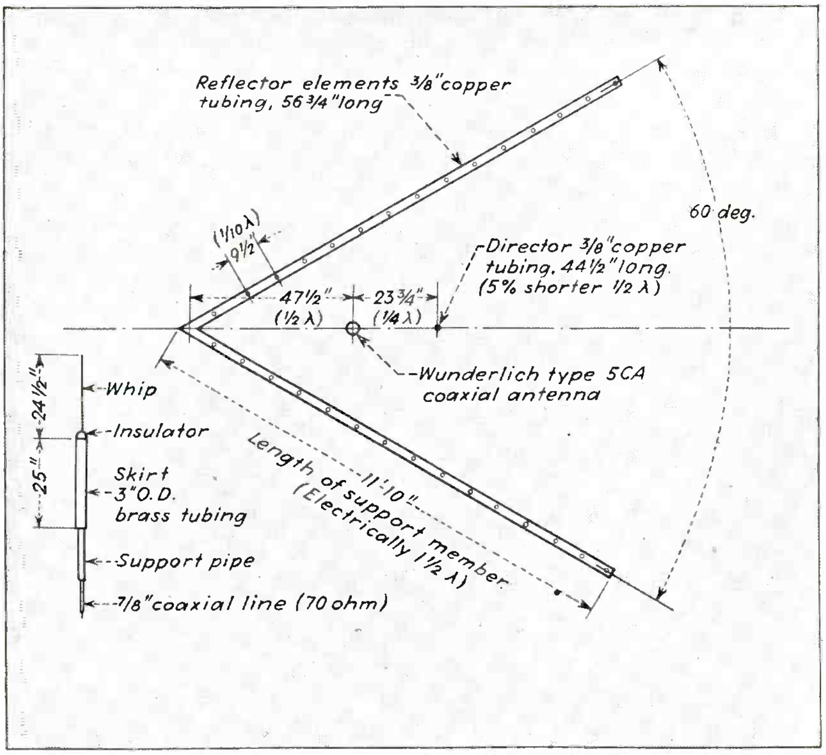


FIG. 1a—One of the two unidirectional 118-Mc arrays used at Sacramento for receiving signals relayed by the Mt. Diablo and Blue Canyon repeater stations. Use of a coaxial antenna permits the entire assembly to be built around a single support-point, facilitating orientation

FIG. 1b—Details of the receiving array pictured in Fig. 1a. The frame is constructed of maple and birch. The two wooden members fastened to the coaxial antenna are lacquered, and other supports are protected by two coats of outside white paint



By E. S. NASCHKE
Supervising Radiotelephone Operator
California Highway Patrol
Sacramento, Calif.

REPEATER STATIONS transmitting on 118,550 kc have recently been installed at Mt. Diablo and Blue Canyon, California, to provide better reception in Sacramento of mobile police units operating on 39,780 kc in remote areas.

Sacramento and the two repeater transmitter sites are nearly in a straight line with respect to each other, lacking only about 15 deg of being so situated. The city lies approximately 65 miles southwest of Blue Canyon and 52 miles northeast of Mt. Diablo.

Both repeater station sites overlook the Sacramento Valley and this created a problem. It was found that transmissions from FM mobile units working in certain areas near the two automatic stations sometimes turned on both repeater transmitters. However, satisfactory limiter action would not always be realized in both control receivers and the transmission from the repeater station so affected would be more noise than intelligible signal.

Since the carrier strength of the 10-watt Mt. Diablo and Blue Canyon FM transmitters is substantially the same, the ultimate signal realized at the loudspeaker connected to the Sacramento receiver was in many cases unintelligible. This fact caused no end of difficulty to the operators on duty at the monitoring point.

This problem led to a search for undirectional receiving antennas

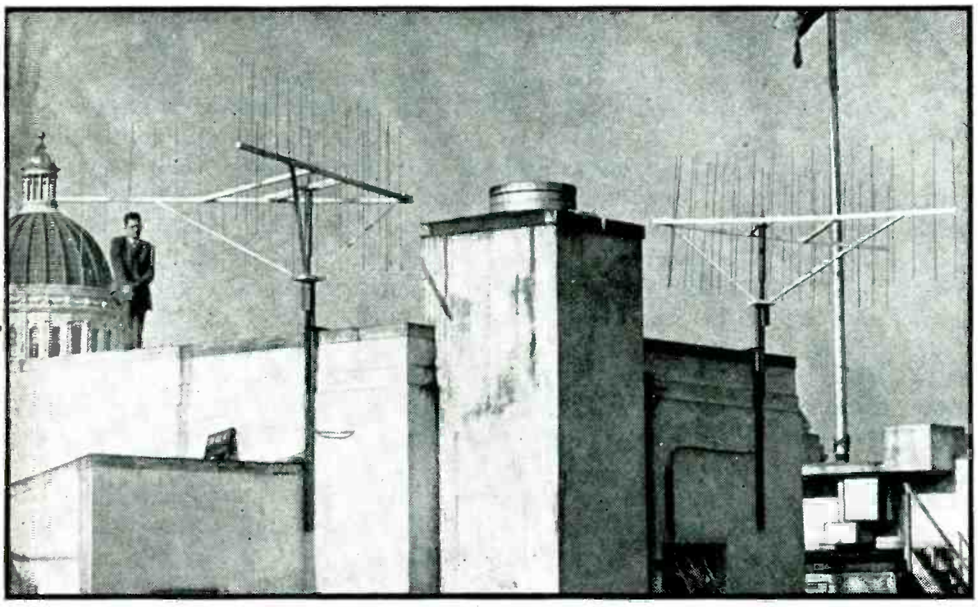


FIG. 2—The two receiving arrays on a Sacramento rooftop. Since the photographs were taken, the array at the left has been moved along the wall to the left to decrease absorption of the signal received from Mt. Diablo by a nearby vertical antenna

for use at Sacramento, one to receive Mt. Diablo and block out Blue Canyon, and the other to receive Blue Canyon and discriminate against Mt. Diablo.

Antenna Array Design

Circumstances made it desirable that each antenna system match the input of available FM receivers; that it require little space for mounting and be unaffected by weather. Before the final design resulted, experiments were conducted with three-element reflector-director arrays and simple parabolic reflectors, with little or no success.

First experiments with a square-corner reflector also left much to be desired. The chief difficulty experienced with experimental models was the lack of sufficiently high front-to-back ratio. While field strength ratios of two-to-one in the case of frequency-modulated signals are usually sufficient to cause the elimination of the weaker signal, reflections from nearby steel objects and buildings prevented realization of the desired results.

Later, attention was drawn to data on square-corner reflectors by Kraus[1] and Terman[2]. Accordingly, a sixty-degree corner reflector antenna was designed, utilizing this data.

First trials with this antenna were disappointing. The same difficulty as before was experienced—too low front-to-back ratio. However, the addition of auxiliary reflector and director elements placed a quarter wave behind and a quarter wave in front of the coaxial element gave surprising results. It was possible to eliminate one of the repeater transmitter signals while receiving the other.

Later tests proved that the auxiliary reflector element was unnecessary and so it was eliminated in the final design. Figure 1a shows how it was possible to build such an antenna system using a single support, and Fig. 1b shows the dimensions of the various elements of the

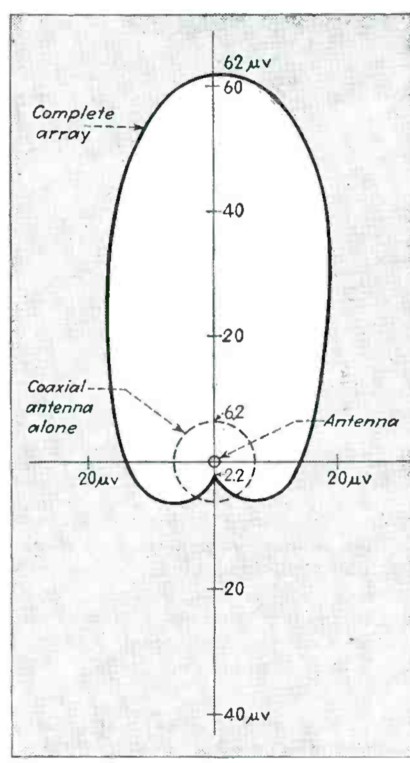


FIG. 3—Field-strength pattern of the 60-deg corner reflector array and, for comparison, the pattern of the coaxial antenna alone

TABLE I
Relative Signal Strengths for Various Positions of Antenna Array With Respect to Distant Transmitter

ANTENNA POSITION	METER READINGS (See text)	
	With Aux. Director (μa)	Without Aux. Director (μa)
Maximum signal	9.5	9
Minimum signal	2.0	6
Midway between minimum and maximum signal positions	6	6

system. Figure 2 shows how the two required antenna systems look on the roof of the receiving station in Sacramento.

Test Results

Table I and Fig. 3 illustrate the effect of rotating either antenna system with respect to the transmitter which it normally receives, together with the effect of removing the auxiliary director element.

The meter readings given were taken in the grid circuit of the first 455-kc i-f amplifier of a Motorola FSR-16B receiver. (See meter-switch position No. 1 in Fig. 3, p. 105, ELECTRONICS, January 1944. The 118-Mc receivers referred to herein are essentially the same. For 118-Mc operation a high-frequency converter unit is added to the front end.)

Initial antenna gain estimates, based on receiver sensitivity curves furnished by the manufacturer, indicated an antenna gain of 15 times, or 23 db. The indicated front-to-back ratio was 52.5 to 1, or approximately 34 db. More precise measurements of the gain of the antenna array and front-to-back ratio have since been made, utilizing a Ferris Microvolter as a standard signal generator. These measurements show a 20 db gain over the dipole antenna. The measured front-to-back ratio is 30 db.

It will be noticed from Fig. 3 that the angle of maximum signal strength is broad, whereas the angle of minimum signal strength is relatively sharp. In adjusting the two receiving arrays at Sacramento best results were obtained by orienting them for minimum signal from the undesired station.

Installation of the two directional receiving arrays has proven well worth while. It not only has reduced the number of unintelligible messages caused by interfering signals but has also improved the signal-to-noise ratio and the tone quality on signals received through the repeater stations. This latter fact is attributed to increased saturation of the limiters in the 118-Mc FM receivers.

System Operation

The audio-frequency output from each of the two 118-Mc receivers used at Sacramento, shown in Fig. 4, is brought into the control room on separate lines and fed into two separate speakers through a control network. A 39,780-kc. FM receiver used to pick up transmissions direct from local cars is also fed into the monitoring position, shown in Fig. 5, and operates a third speaker.

It has been found that by placing the three speakers along the top of the operating desk and separating them from 12 to 18 inches, the operator is able to tell by audible means which speaker is producing the best signal. This being determined, the operator presses the lever switch at his left corresponding to the speaker producing the best signal. This silences the remaining speakers.

A fourth lever-type switch labeled "Mute", when depressed, attenuates the output of all speakers approximately 25 db. This permits the operator to answer the telephone or speak over the interoffice communicating system.

The indicator lamps above the switches provide an additional check. When the switches are in normal monitoring position, all channels open, the green lamps are lit. Red lamps show which switches are off normal settings.

In closing, the author wishes to express his appreciation of the valuable assistance rendered by W. L. Anderson and F. W. Hughes.

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(1)—Kraus, John D., The Corner Reflector Antenna, *Proc. IRE*, 28, p. 513, Nov. 1940.

(2)—Terman, F. E., "Radio Engineers Handbook," First Edition p. 819-821

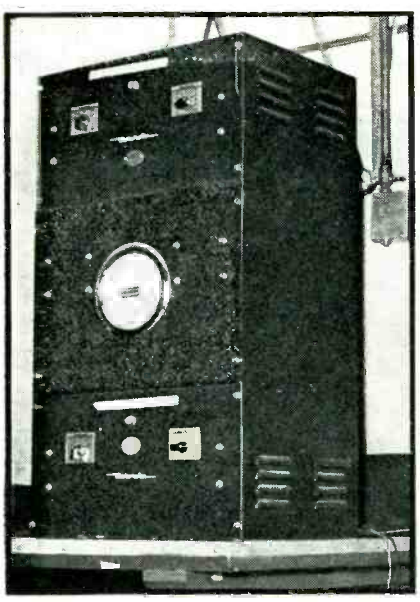
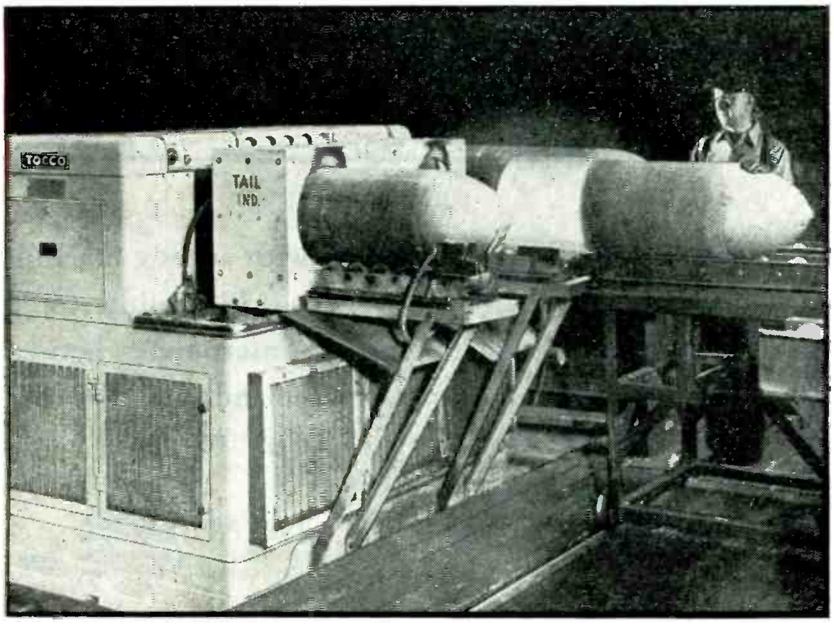


FIG. 4—The two FM receivers are at the top and bottom of this utility rack, with the associated 118-Mc converters mounted behind the center speaker panel. The unit is located in a room on the roof of the Sacramento building, near the antenna arrays

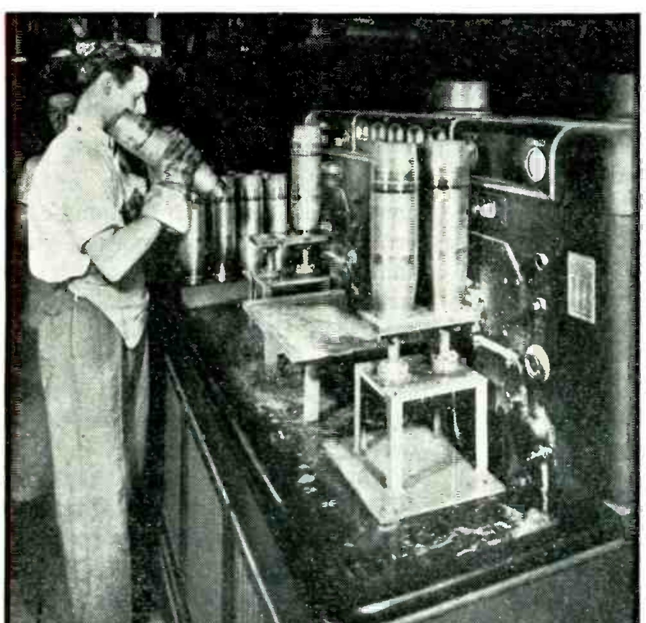
FIG. 5—The receiving station operating position, with separate speakers for the two 118-Mc channels and the 39-Mc channel. The speakers are shown bunched together for photographic purposes and are normally mounted 12 to 18 inches apart back on the wall

INDUCTION HEATING of SHELLS

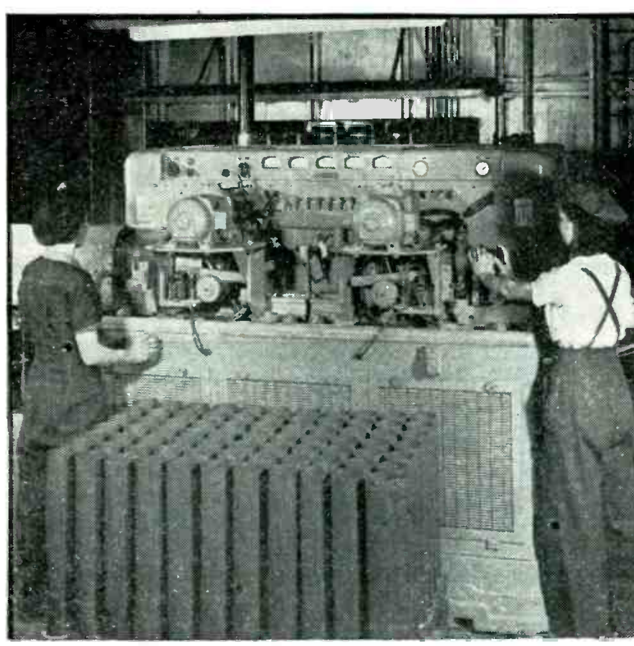


Induction-heating tail ends of 500-lb bombs to 2100 deg F before spinning. One man operates two machines, each with two inductors, and feeds a bomb to the spinner every 49 seconds. Furnace heating would require 5 or 6 minutes

Metal-heating by the induction method has become an important process in armament plants. Some of the many applications that have accelerated war production of bombs, shells, and cartridge cases are shown in the accompanying photographs



An induction-heating unit brazes adaptors on 105-mm chemical shells in one large Detroit plant without heating the sidewalls of the shell. The machine, made by Tocco Division of Ohio Crankshaft Co., has an output of 140 shells per hour



Two jigs support 3-in. steel cartridge cases while they are mouth-annealed at 1300 deg F for four seconds. This induction-heating machine has two stations and an output of 1,000 cases per hour. Hardness before treatment, 98 R.B.; after, 70 R.B.

AUTOMATIC

For Frequency Meters

A 126-tube electronic calibrator combined with adding machines records on paper tape the calibration data at 327 points for an Army SCR-211 two-band frequency meter, interpolates between these points, and automatically prints in the individual calibration book a five-digit dial number for 3252 frequency values

By **DAVID SUNSTEIN** and **JOSEPH TELLIER**

Factory Engineering Division
Philco Corporation, Philadelphia, Pa.

Research Division, Engineering Dept.
Philco Corporation, Philadelphia, Pa.

IN THE MANUFACTURE of highly precise measuring instruments, it is sometimes found necessary, in order to obtain the required accuracy, to hand calibrate each individual instrument. In the particular case at hand, a two-band frequency meter known as the Army SCR-211 is required to maintain an accuracy of the order of 0.01 percent in the field. This frequency meter as manufactured by Philco Corporation consists of an electron-coupled variable-frequency oscillator, which can be checked at certain points of the dial against an internal fixed-frequency crystal oscillator.

Anyone who has had experience in the production of receivers having dials which read directly in frequency can appreciate the practical impossibility of making an oscillator track to a predetermined dial scale within 0.01 percent. For comparison, a good broadcast receiver has an accuracy of about ±10 kc, or about 1 percent. Variations such as inductance, capacitor plate contour and straightness, gear eccentricities, etc., require that the frequency meter be designed with a dial which reads in arbitrary units, and that a calibration booklet be prepared for each meter.

The two bands of the frequency meter cover a fundamental range of 125 to 250 kc and 2 to 4 Mc. The Army specifications call for a listing of calibration points every 0.1 kc on the low band and every 1.0 kc on the high band, or 3,252 calibration points in all. Each of these calibration points is recorded as a five-digit dial number.

Fortunately, it is found that by proper design of the tuning capacitor, the plot of dial reading versus frequency can uniformly be made sufficiently close to a straight line that only every tenth point printed in the calibration book need be hand calibrated, the remainder being interpolated linearly. Thus, hand calibration points are required every 1 kc on the low band, and every 10 kc on the high band, or a total of 327 points must be recorded by hand.

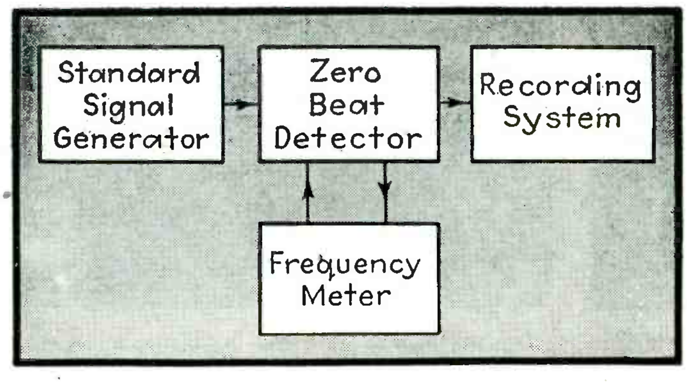


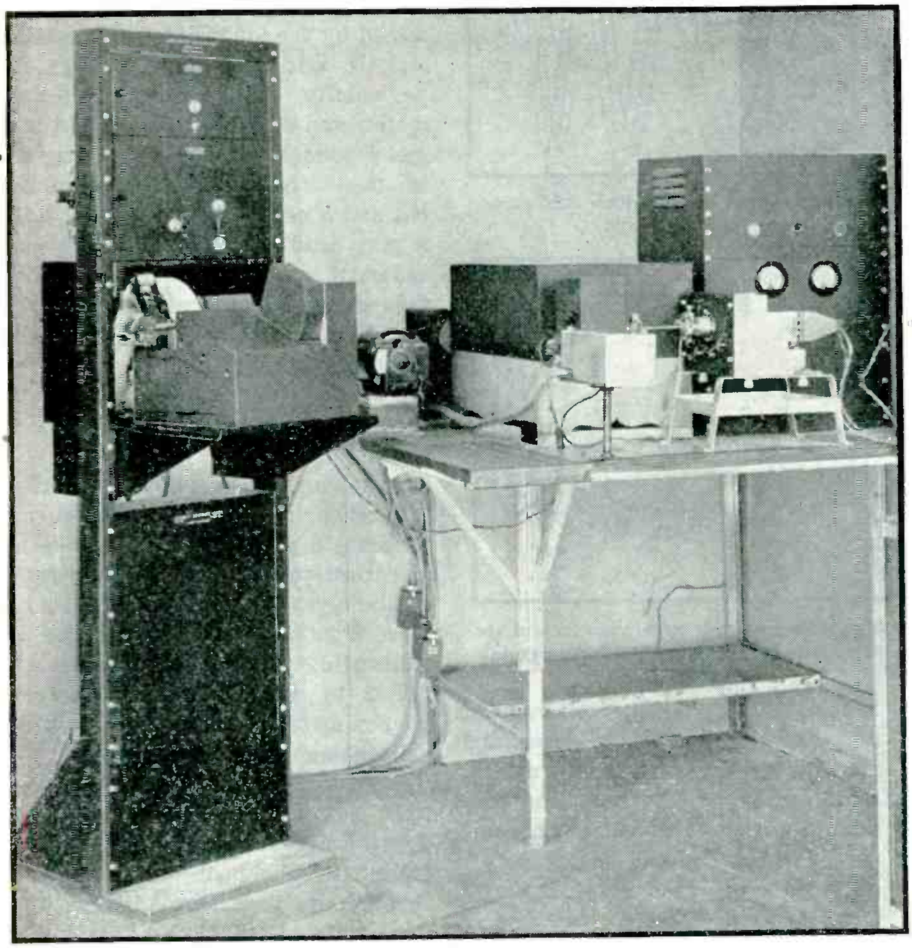
FIG. 1—Block diagram showing the three basic units of the automatic calibrator and their relation to the frequency meter being calibrated

Calibration Time Is Shortened

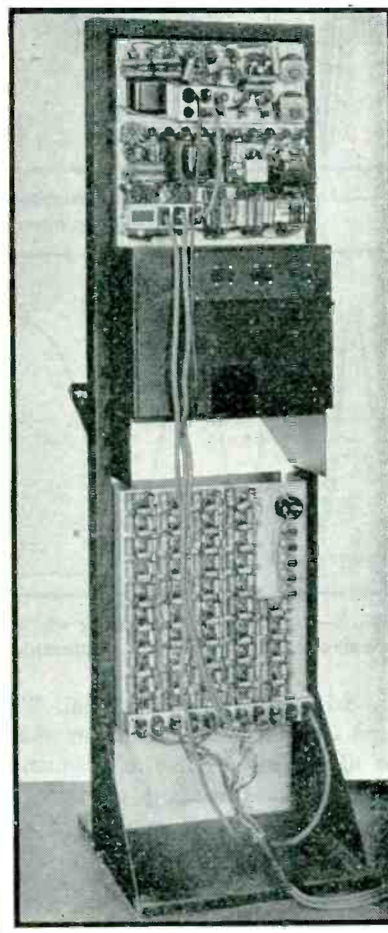
It has been found that on a production basis an average of 2.5 hours was required to hand-calibrate one frequency meter, with another hour to compute the increments between adjacent calibration points so that interpolation could be made, another 1.75 hours to interpolate, and an additional 5 hours to type the calibration booklet. An average of several errors in each original hand calibration, plus additional errors in interpolating and typing, made necessary a very thorough checking of each frequency meter and calibration book, totaling 3.5 hours more.

Thus, to calibrate a frequency meter accurately by hand, including 2.25 hours additional for miscellaneous operations, required a

CALIBRATOR



Overall view of calibrator, showing frequency meter on jig at right center, with dial coupled to zero beat detector. Printing rack is at left. Signal source is not shown



Rear view of printing system, showing number storage bank near bottom

total of 16 man hours. Furthermore, the fact that the frequency meter was under operating conditions during the 2.5 hours manual calibration period necessitated a temperature-controlled room for the calibration process, since ambient temperature changes, if permitted, could put kinks in the calibration curve, thereby rendering the meter inaccurate.

An automatic calibrating machine has been designed and constructed at Philco which, together with semi-automatic interpolating machines capable of typing the book directly, reduces the total calibration time from 16 hours to 6.5 hours. The actual direct time necessary to record the 327 calibration points of each frequency meter has been reduced from 2.5 hours to 16 minutes, and during these 16 minutes, the increments between adjacent calibration points are also automatically tabulated, thereby eliminating the previous hour required for manual computation. The short calibration time also eliminates the need for a temperature-controlled calibrating room. The automatic method has eliminated the human error, thus reducing the required checking time from 3.5 hours to 1.5 hours, which period is primarily devoted to insuring the stability of the frequency meter. Overall, since the equipment is being used on a 24-hour-a-day basis, over 140,000 man hours were saved in 1943.

Automatic Equipment Used

The semi-automatic interpolating machines are similar to the adding machines used by finance companies for scheduling payments, the only difference between the two being the size of type employed. These machines are capable of carrying two totals, one of which may be added to the other and the new total printed, thereby enabling interpolation. Since this device is well known it will not be discussed further here.

The 126-tube automatic calibrating machine has several unusual features. Essentially, it consists of three parts, shown as a block diagram in Fig. 1. The first supplies a source of standard frequencies against which the meter is calibrated. The second provides a means of mechanically continuously driving the dial of the frequency meter and electrically generating a sharp pulse every time the frequency meter is tuned through zero

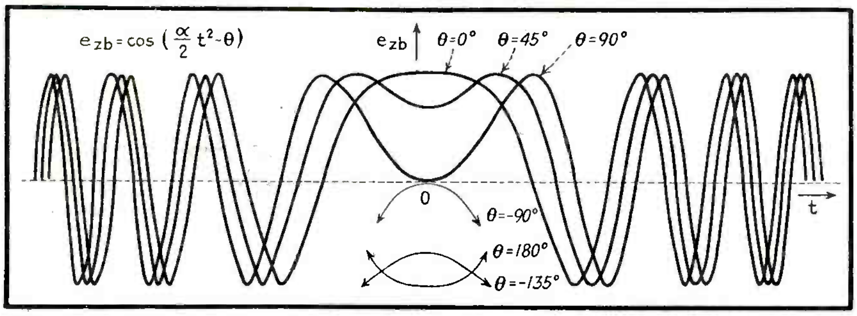


FIG. 2—A few of the infinite number of zero beat wave forms which can occur, depending upon the random value of θ

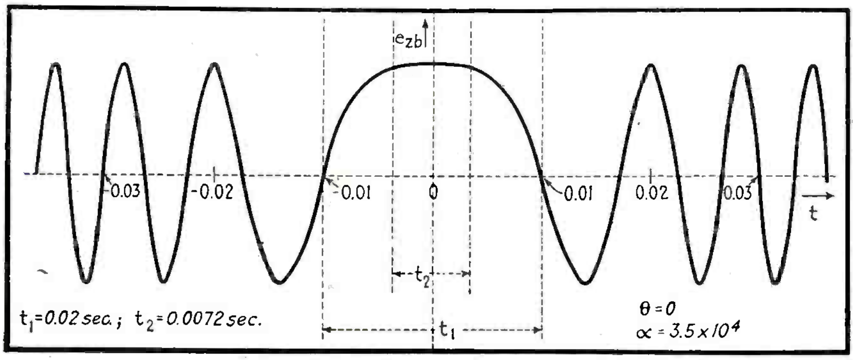


FIG. 3—Zero beat wave form for which θ=0°, and for which a calibrating time of six minutes is assumed. Here t_2 represents the maximum permissible limits for triggering

beat with the standard signal. The third unit records on a paper sheet the dial reading of the frequency meter at that instant of time at which the pulse is generated and also the difference between adjacent dial readings.

Standard Signal Source

As stated previously, calibration points must be taken every 1 kc on the low band and every 10 kc on the high band of the frequency meter. This requires accurate signals at 16-kc intervals for the low band (as will be explained later) and signals 10 kc apart for the high band. The method used for generating these signals employs two multivibrators, each locked in with a crystal oscillator that is continuously monitored against Bureau of Standards radio station WWV. Since this system is conventional, it need not be treated here.

Zero Beat Detecting Problem

Before describing the actual mechanism which was finally designed to detect the instant of zero beat, a short description of the problem involved will be given. That there is a problem at all is a result of the continuous drive applied to the frequency meter. If the drive were stopped at each calibrating frequency, conventional circuits could be used to determine zero beat within a very few cycles. However, as will be seen, the constant rotation of the tuning capacitor of the frequency meter introduces factors which require special consideration.

Let it be assumed that a constant-speed drive is being applied to the tuning capacitor shaft, so that the frequency meter is generating a signal which is changing continuously in frequency. Assume also a single standard signal whose frequency is constant and lies in the range of the frequency meter. And finally, let the outputs of the two signal sources be coupled into a mixer stage whose output circuit is responsive only to signals in the audio range. Then, as is shown in Appendix I, the wave shape of the audio signal developed across the output of the mixer will be as indicated in Fig. 2, where the origin for time ($t = 0$) is taken to be the instant when the frequency meter is exactly at zero beat with the calibrating signal.

It will be noted immediately that more than one form of the zero beat wave shape has been given. There are actually an infinite variety. The exact one taken depends on a quantity indicated as θ, and a constant α. The equation of the zero beat voltage is

$$e_{zb} = E_{zb} \cos\left(\frac{\alpha}{2}t^2 - \theta\right)$$

where the amplitude E_{zb} is determined by the amplitudes of the two signals, α is the rate of change of periodicity, ω_f, of the frequency meter, and θ is a random phase angle dependent on the phase angles of the original beating signals. E_{zb} and α can be held constant, but θ may, and probably will, have a different value each time that the frequency meter passes through zero beat with a calibrating signal. Hence, any of the infinite variety of which six are shown in Fig. 2 can be expected to appear at one time or another.

It remains to be shown that the difference in zero beat wave form presents a problem. Figure 3 is a quantitative picture of one particular wave which might occur. Here θ is taken to be zero, and a calibrating time of six minutes on the 2 to 4-Mc band of the frequency meter is assumed. With this calibrating time, α, the rate of change of periodicity, is $2\pi(4\times10^6 - 2\times10^6)$ divided by 360 seconds. Under these assumptions the time t_1 taken for the beat voltage to go through its first zero value is approximately 0.020 second (Appendix II).

Accuracy Required

To achieve the overall accuracy of calibration mentioned in the introduction, it was desired that the error introduced by the zero beat detector itself should be unreadable on the dial of the frequency meter. Since the latter is graduated into fifty thousand vernier divisions, it was decided that an accuracy of better than plus or minus one part in one hundred thousand (half of one vernier division) would be acceptable. Assuming a linear scale, on the 2 to 4-Mc band of the frequency meter each vernier division represents 40 cycles change in frequency. Therefore it was required that the zero beat indicator trigger when the frequency of the signal under calibration was within 20 cycles of true zero beat. With a calibrating time of 360 seconds the frequency meter changes in frequency 20 cycles in a period of plus or minus 0.0036 second, or a total of 0.0072 second. This is indicated as t_2 on Fig. 3.

The problem of calibrating with sufficient accuracy arises from the fact that the time interval t_2 is relatively short compared with t_1. Over the latter interval the zero beat wave is marked by distinctive characteristics which could be used to trigger the calibrating equipment. But it might be difficult to make such triggering occur always in the shorter interval t_2.

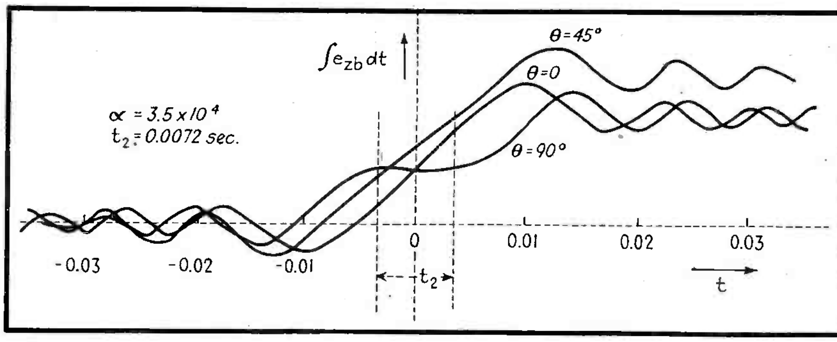


FIG. 4—Integrals of various zero beat wave forms. For $\theta = -90°$, $-135°$, or $180°$, curves identical with those shown for $\theta = 90°$, $45°$ and $0°$ respectively will be obtained, except that the two sets of curves will be of opposite polarity

Integration, A Step Toward Solution

Evidently the best means of utilizing the distinctive nature of the wave form near zero beat is an intergrating network. Such a circuit may be considered most simply as summing algebraically the area under the beat wave curve, adding areas above the zero axis, and subtracting areas below. At times remote from the instant of zero beat, alternate positive and negative areas are relatively small and nearly equal, so that their algebraic sum is small and builds up in amplitude very gradually. However, through the period t_1 Fig. 3) a large positive area is added. The integral or sum hence contains a large positive pulse, building up through the interval t_1. Such a pulse could be used to trigger the indicating equipment.

Referring to Fig. 2, if θ had been 90 deg instead of 0 deg, a very different pulse would have been developed, and in addition it would have begun to build up much earlier in time. It is therefore highly possible that triggering would have occurred outside the period t_2 which has been specified. Further, for other values of θ the pulse might be negative, or there might even be no appreciable pulse at all.

The integrated output voltage obtained for various values of θ is shown in Fig. 4, with the acceptable triggering period t_2 again indicated. These curves are also based on a six-minute calibrating time, and are in the form of Fresnel integrals. Tables of this integral are available.

It is apparent therefore that the major difficulty with the system outlined is the erratic nature of the pulse which would be obtained, with respect to amplitude, shape, and time of occurrence. Fortunately a means of overcoming this difficulty was found. The mathematical basis for the method devised will be stated here, and a proof of this particular case is given in Appendix III.

Principle of Zero Beat Detector

For certain types of functions, of which the integral of the zero beat wave given above is one, the sum of the squares of any two forms of the function which differ only in that they are 90 deg apart is always the same, regardless of the absolute phase of the two forms. Moreover, the resulting function is the square of the envelope of the original function plotted for all possible values of its phase angle.

A simple example of this can be given. If the original function is taken to be $A \sin(\omega t + \theta)$ where θ is any phase angle, then a second form, differing in phase by 90 deg, is $A \sin(\omega t + \theta + 90°)$. But this is the same as $A \cos(\omega t + \theta)$, and the sum of the squares of these two forms is A^2. If a plot of the original function is made for all values of θ, it is seen that the envelope is a straight line of amplitude A, and the square of this envelope is a line of amplitude A^2.

In Fig. 5 is shown the envelope of all the integral curves in Fig. 4, with the dashed line representing the square of this envelope. This dashed line is the pulse which can be derived from the zero beat wave regardless of what value the random angle θ may have. It is only required that a second zero beat wave be produced which differs in the angle θ by 90 deg. This can be done readily, as will be described later. The squaring action produces a sharper pulse than any of the integrals themselves. The acceptable triggering time is again shown as t_2.

This is the basic principle of the zero beat detector. The manner in which it was incorporated will next be described.

Superhet Circuit is Used

For the same fundamental reasons involved in the design of an

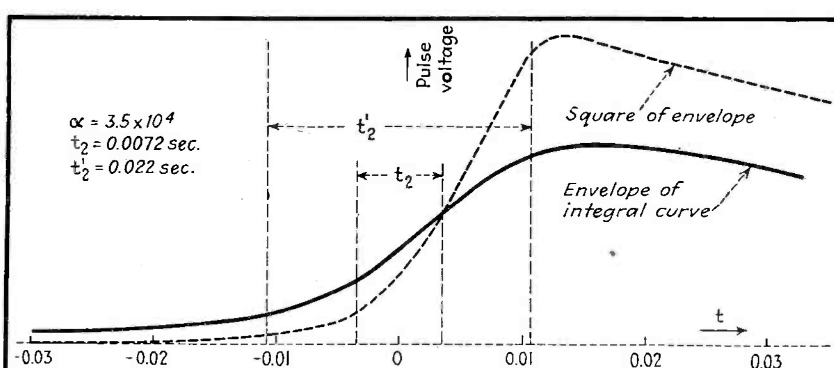


FIG. 5—Pulse form obtained at each zero beat by addition of squared integrals of quadrature zero beat wave forms. This curve is independent of random phase variations between the frequency meter and the standard signal. Note that practically the entire pulse occurs in the interval t'_2.

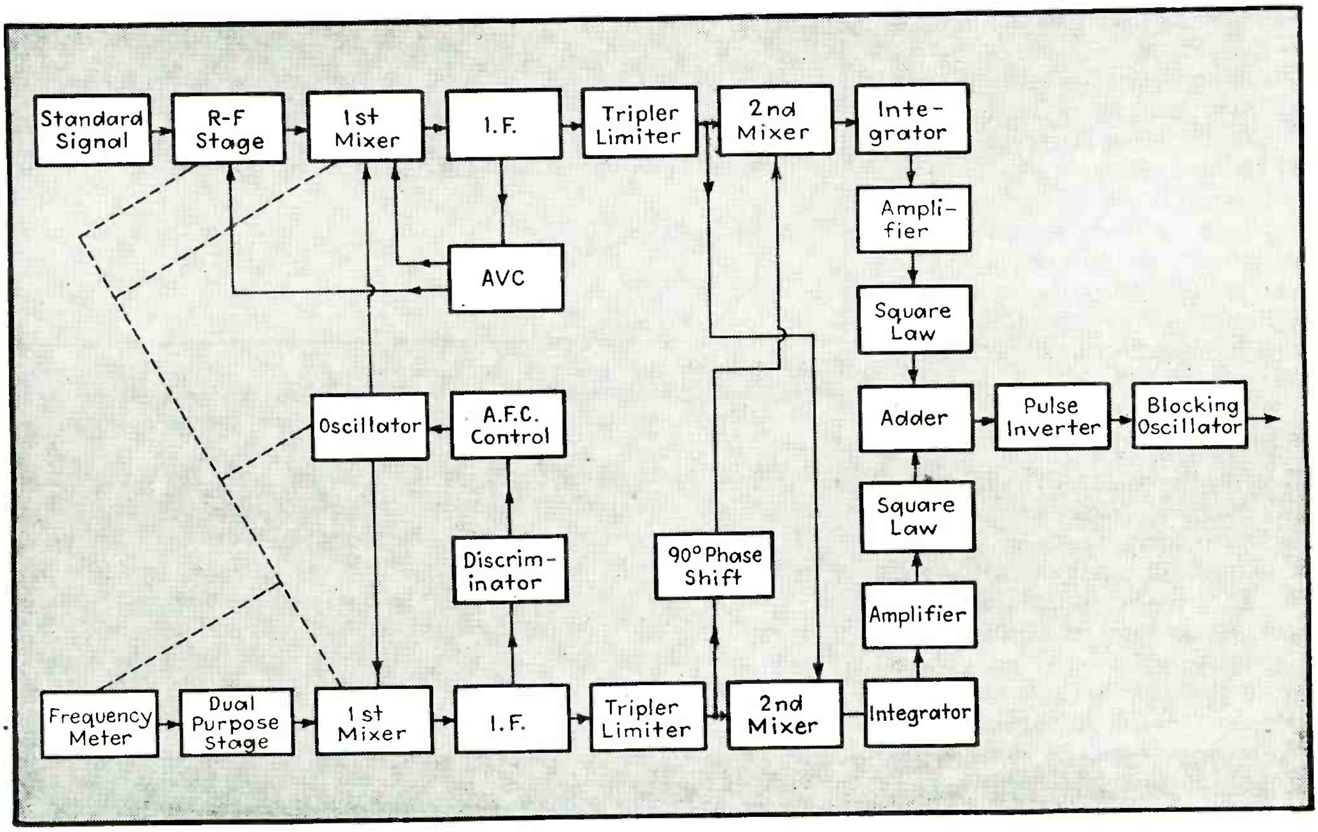


FIG. 6—Block diagram of complete zero beat detector

ordinary radio receiver, it was decided to use the superheterodyne type of circuit for the zero beat detector. There are two channels, one for the standard signal and one for the frequency meter, as shown in the block diagram in Fig. 6. The variable tuned portions of these and the frequency meter are all ganged together, on one motor-driven shaft. This ganging is indicated on the block diagram by the dashed lines, and is pictured in Fig. 7.

Each channel is fed from its own source, converted to an intermediate frequency by a common oscillator, and passed through its own i-f system. Both are then coupled to each of two mixers, the outputs of which are zero beat forms differing from each other in phase by 90 deg. These are each integrated and passed through square law stages, and the sum of the two taken. At this point the required constant-shape pulse has been obtained. The remainder of the detector is made up of circuits for obtaining a large-amplitude pulse suitable for operating the printing mechanism.

These channels will now be examined stage by stage, and those circuits of a unique nature described in some detail.

R-F Section

Channel 1 is fed from a standard signal source, which in this case is a multivibrator held in synchronism with WWV as heretofore mentioned. Since for high band calibration (which will be discussed first) signals are generated every 10 kc from 2 to 4 Mc, it was found desirable to introduce a tuned r-f stage to remove all but a few signals in the vicinity of the one desired. These selected signals are applied to one grid of the first mixer in channel 1.

Channel 2 is fed from the frequency meter through a dual-purpose stage, which for high band operation is effectively a unity gain untuned stage. It will be described in more detail later. The signal is then applied to one grid of the first mixer in Channel 2.

The second grid of each mixer is fed from a common oscillator stage, but from isolated points to prevent channel interaction.

These stages comprise the r-f section of the unit, and as mentioned above are ganged on a common shaft. All except the oscillator are adjusted to tune together and are so geared that their curves of frequency versus shaft rotation are the same as an average frequency meter. The oscillator is adjusted to track 480 kc higher at all points, a frequency which is entirely optional and determined only by design considerations. Because of the type of circuit used to obtain the quadrature signal, however, it is necessary that this frequency, once determined, be maintained exactly. To this end a conventional automatic frequency control circuit is used, operating from channel 2.

First Mixers

The signals developed in the plate circuits of the two first mixers may now be considered. Since the frequencies of the oscillator and the frequency meter are varied together and held to a constant difference of 480 kc, the signal in the plate of the mixer in channel 2 is of course constant at 480 kc. In channel 1 this is not the case because

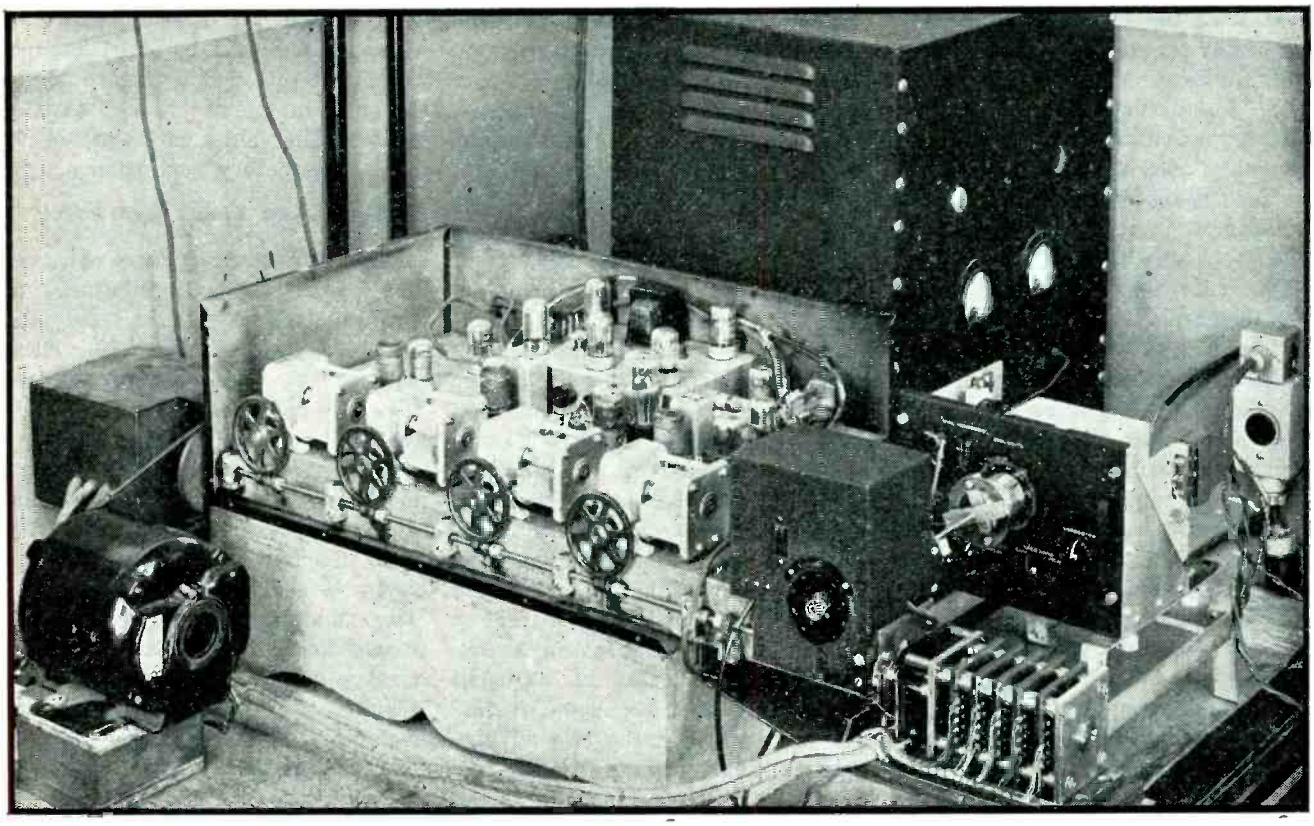


FIG. 7—Overall view of zero beat detector with r-f section open. Note ganging of tuning capacitors to the motor at left, and to revolution counter and frequency meter at right. The i-f channels and pulse-forming stages are in the rack at the rear, together with regulated power supplies for each channel

the signals against which the oscillator is beating are fixed, while the oscillator itself is varying at a uniform rate with the motor drive.

Assume that the oscillator is at 3.48 Mc at some instant. The mixer and r-f stages of channel 1 are then tuned to the particular standard signal which is at 3.0 Mc and the i-f is 480 kc. As the oscillator changes to 3.485 Mc, the beat from the 3.0-Mc signal becomes 485 kc. But at this time the beat from the next standard signal, which is 3.010 Mc, becomes 475 kc, and as the oscillator approaches 3.49 Mc, this beat approaches 480 kc.

Thus, as the oscillator is tuned through each standard signal, the i-f signal in channel 2 sweeps through the frequency 480 kc. If the band width of this i-f channel is held to less than plus or minus 5 kc, there will be only one signal present at any time. This is necessary to prevent spurious beats.

Limiters and Triplers

Proceeding through the two i-f channels, it will be noted that the final i-f stage in each case is a combined tripler and limiter. In order that the calibrating pulse may be of the same amplitude as well as the same shape for each zero beat, it is necessary that the two signals which are actually being combined be of the same amplitude (though not necessarily the same as each other) for each beat.

Limiting is therefore incorporated in the plate circuits of the two final i-f stages, and sufficient gain is provided in the i-f systems so that on the weakest standard signal and the lowest output frequency meter these stages are driven well past their limiting levels. Thus considerable latitude may be permitted in the amplitudes of the harmonics generated by the multivibrator and the output of the frequency meter without impairing in the least the accuracy of the equipment.

An avc system is also employed in the standard signal channel for the same purpose, inasmuch as this channel is particularly subject to wide variations in signal level. With these circuits included in the i-f systems, the amplitude of the signal at each mixer grid is maintained extremely constant.

The use of tripling in the final i-f stages is interesting in that it provides a simple means of tripling the accuracy. Recalling the equation for the zero beat wave, it is seen that the time taken for the beat to go through the distinctive period t_1 is proportional to α. If α be tripled, this time interval is reduced to one third. But α is proportional to the number of cycles of change in frequency per second, and hence if we triple the changing frequency and therefore triple the number of cycles of change per second, the time interval within which a triggering pulse is generated is reduced to one third.

The effect of this is shown in Fig. 5 by expanding the time scale 3 times so that the acceptable triggering interval is represented by t_2'. Channel 2 is tripled of course merely to keep its frequency the same as the center frequency of channel 1. It is obvious that quadrupling or even higher multiplication could be used.

Second Mixers

The output of the final i-f stage of channel 1 is now fed to one grid of each of the two second mixers. The latter are the stages in which the zero beats are actually developed. The actual frequency meter signals and standard signals are not being used directly to produce the zero beat, but since a common oscillator is used, when the i-f signals are identical in frequency it follows that the two r-f signals are also identical.

Note that a slight deviation of oscillator frequency from its proper value, such as might be caused by drag in the afc system, does not impair the accuracy. Such a deviation will of course change both intermediate frequencies by the same amount. Note further that this stepping down from r-f to i-f does not reduce the accuracy in the same way that tripling was seen to increase it; because in this case the reduction in frequency is obtained by subtracting from another frequency, and not by division. The rate of change of frequency, as represented by α, is unchanged.

The output of the tripler stage in channel 2 requires one more operation. It is necessary to obtain not only the third harmonic of the constant frequency, but also a second signal identical except shifted in phase by 90 deg. This is readily obtained by introducing a loosely coupled double-tuned transformer, and taking one signal from the primary and one from the secondary of the latter. With the input at the proper frequency, these signals are in quadrature with each other. It is to maintain input at proper frequency that afc is utilized. The quadrature signals are applied to the second mixers in channels 1 and 2.

The signals found in the plates of the two second mixers are now two identical zero beats between the fixed and varying i-f signals, except that the angle θ is different by 90 deg. (Appendix IV). Each is now ready for integration.

Checking Quadrature at Mixers

Before discussing integrators, a simple means of checking quadrature at this point might well be mentioned. If the outputs of the two second mixers be connected each to one pair of plates of a cathode-ray tube, and two r-f signals of approximately the same frequency applied to the inputs of the system, then an ellipse with axes at right angles should appear on the screen of the tube. The secondary tuning of the quadrature transformer may in fact be adjusted by this method. This should preferably be done with the two r-f signals as nearly of the same frequency as possible since this is the condition which is of interest.

Integrating Circuits

A standard integrating circuit consisting of a large series resistance and low-reactance capacitor is given in Fig. 8, while the actual circuit used is shown in Fig. 9. The difference is occasioned by the fact that it is necessary to incorporate a blocking capacitor between the mixer plate and amplifier grid, and it is also necessary to supply a d-c return for the latter. The actual constants used are determined by two factors. In Fig. 8, the higher the value of R and the lower the reactance of C, the more nearly will the output approach a true integral. However, it is necessary in Fig. 9 that the time constant in the amplifier grid be short enough to permit the grid to return to its normal no-signal bias between pulses. The values given proved to be a satisfactory compromise.

Square-Law Stages and Adder

The two integrals thus obtained are passed through amplifiers to the square-law stages and the adder, shown in Fig. 10. Each square-law stage consists of two type 7B7 pentodes biased to a point where the second harmonic distortion is greatest. They share a common plate resistor, and their grids are driven with opposite polarity from the plate and cathode of a type 7A4 tube serving as phase inverter. The fundamental and third harmonic are balanced out and the voltage across the common plate resistor is predominantly second harmonic, or the square of the input voltage.

Addition of the two squared signals is accomplished by connecting a potentiometer from one pair of plates to the other and taking output from the arm at the center. At this point the signal voltage is the average of the two plate voltages, or one-half their sum. A potentiometer is used so that any unbalance in the square-law characteristics of the pentodes resulting in less output from one pair may be adjusted by moving the arm slightly nearer to that pair. Unbalance between each tube of either pair is first adjusted by means of the variable cathode resistor of the phase inverter.

Here again, cathode-ray tube checks simplify the adjustment of the equipment. R-F signals are

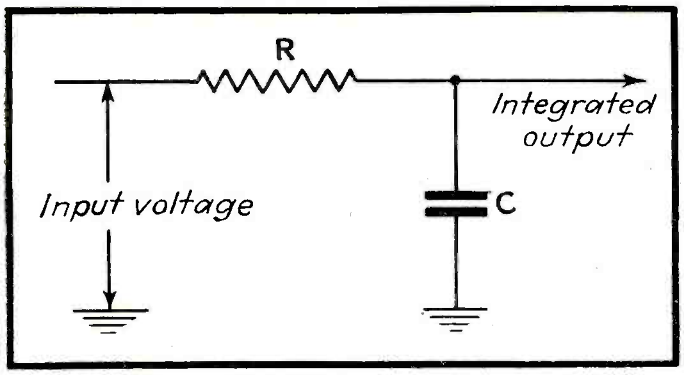


FIG. 8—Conventional integrating network

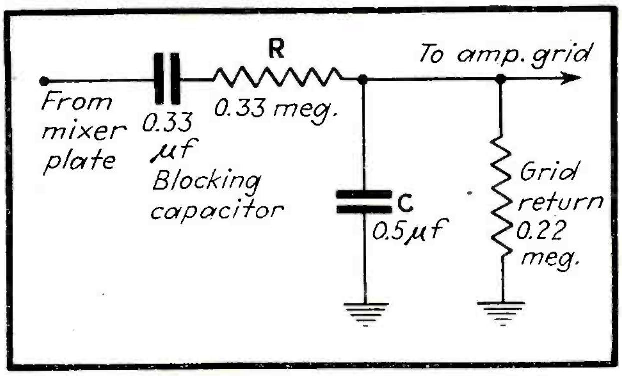


FIG. 9—Schematic of actual integrating circuit used

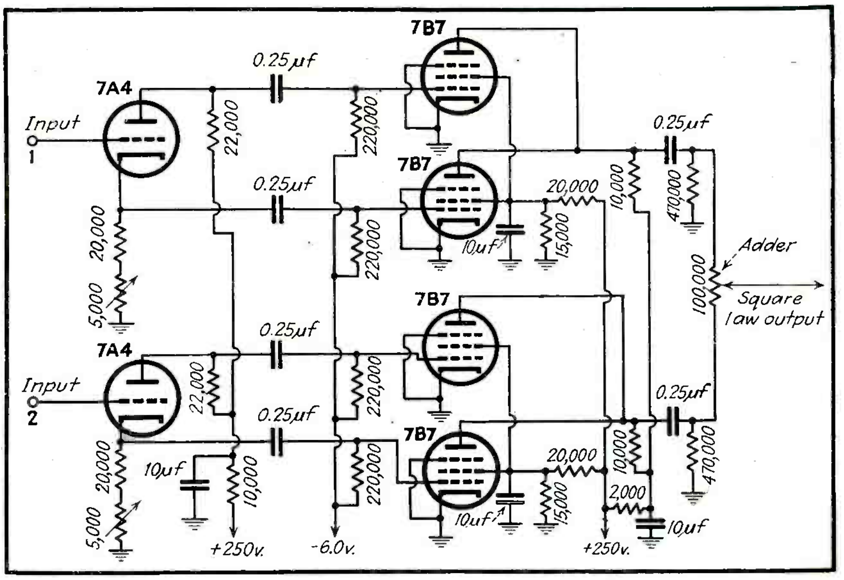


FIG. 10 (above)—Schematic of square-law stages and adder

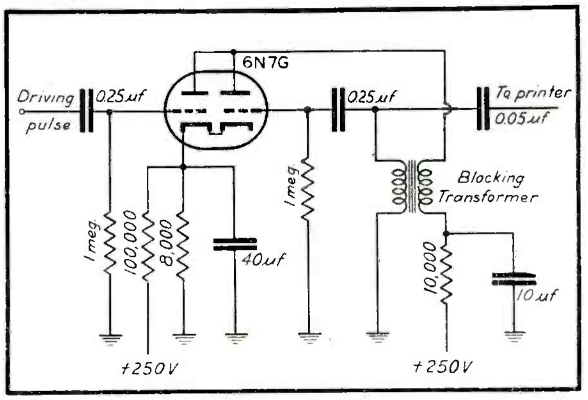


FIG. 11 (right)—Schematic of blocking oscillator which is triggered by pulse from adder and provides final pulse used to actuate printer

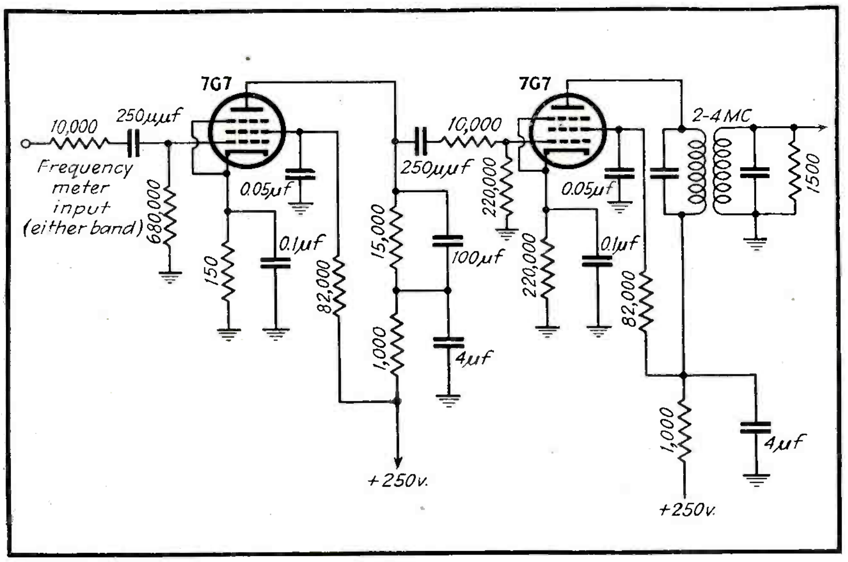


FIG. 12—Schematic of dual-purpose input stage for channel 2. This stage accepts a signal from either band of the frequency meter without switching, and supplies a 2 to 4-Mc signal to channel 2. The latter signal is the fundamental of the high band or the sixteenth harmonic of the low band

applied to the inputs of the equipment, and one phase inverter triode removed. The cathode-ray tube plates are connected to the input of the other phase inverter and to the plates of the corresponding pair of square-law pentodes. Since the audio signal and the square of the latter are thus compared on the cathode-ray tube, there should appear a "hair pin" or U. The resistor in the cathode of the phase inverter is then varied until the tips of the hair pin are of equal amplitude. This indicates equal square-law output from the two pentodes. The operation is then repeated on the other square-law stage.

Since the r-f signals are fixed, the signals at the inputs to the square-law stages are sinusoidal and are the same except for differing in phase by 90 deg. They may be represented by $A \sin (\omega t + \theta)$ and $A \cos (\omega t + \theta)$, and the sum of their squares is A^2, or in other words, a d-c component only. The signal at the arm of the adding potentiometer should thus be a straight line, and of zero amplitude if the oscilloscope does not pass direct current. The vertical plates of the cathode-ray tube are therefore connected to the arm of the potentiometer, and the latter adjusted for a minimum of audio ripple. Some of the latter will be observed, since a certain amount of fourth and higher even harmonics will be present in the output of the square-law tubes.

Blocking Oscillator

At each zero beat there appears at the arm of the adding potentiometer a pulse which is constant in shape and amplitude. It is, however, negative in polarity because of the nature of the square-law stages, and is not of sufficient amplitude to actuate the printing mechanism. To obtain a sufficiently large pulse, the blocking oscillator shown in Fig. 11 is used. The negative pulse is applied to the latter through a polarity inverter, which is merely a resistance-coupled amplifier stage.

It will be noted that positive bias obtained from a voltage divider across the main plate voltage supply is applied to the cathode of the blocking oscillator double triode. The amount of this bias is sufficient to cut off both sections of the 6N7G so that it is normally quiescent. Its free running period (without bias) is long compared to that of the driving pulse, but somewhat less than the time interval between pulses.

When the positive driving pulse appears at its first grid for a short instant, it begins to pass through one cycle of a normal blocking oscillation, and the usual sharp pulse of great amplitude (over one hundred volts) is developed across

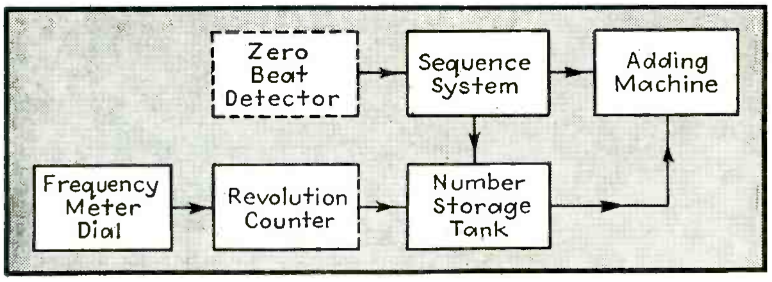


FIG. 13—Block diagram of printing system

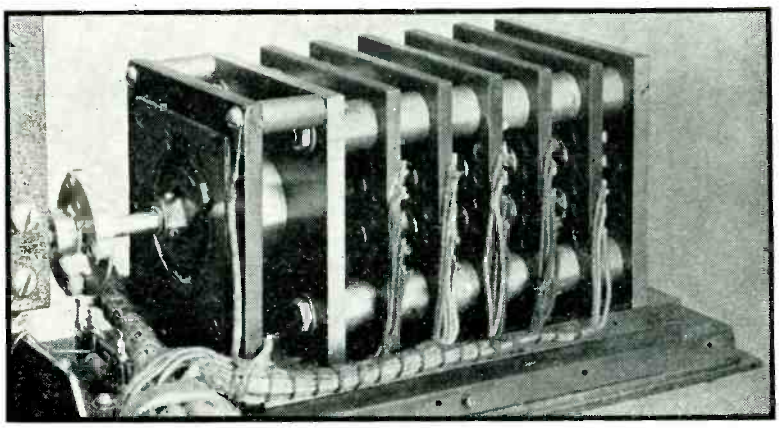


FIG. 14—Open view of revolution counter switch. Note the 5 decks of 10-point switches, and the "disconnect" section at front

the grid winding of the transformer. The second grid immediately blocks and remains cut off for the remainder of the natural period of the oscillator.

The system is thus unresponsive to spurious pulses of any sort during the greater part of the interval between true pulses. By the time the oscillator would normally begin its second cycle the driving pulse has long since disappeared, so that only one output pulse is obtained for each zero beat. This is the final output of the zero beat detector.

Low Band Calibration

Calibration of the low frequency band proved to be more of a problem than had been anticipated. It was originally intended to divide all frequencies by 16 in conformance with the frequency meter itself. Standard signals every 1 kc from 125 to 250 kc, with an i-f value of 30 kc, were to be used. Gradual multiplication through the i-f system was to bring the final frequency again to 1440 kc, so that the balance of the equipment would be the same for both bands.

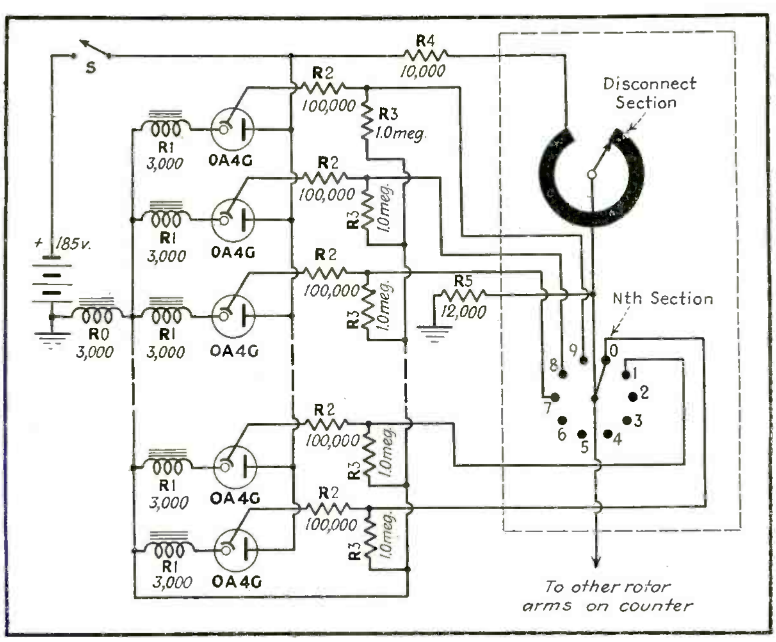


FIG. 15—Schematic of one column of number storage bank. The dashed rectangle at the right encloses a representative section of the revolution-counting switch

Such a system was actually constructed, and was found to be unsatisfactory simply because of the difficulty in eliminating phase modulation from the source of 1-kc signals. In order to synchronize such a source on the 100-kc crystal oscillator, it was necessary to use at least one intermediate multi-vibrator at 10 kc. As a result it was found that while the total number of cycles per second remained correct, the starting time of each cycle was subject to slight variations. This is the equivalent of erratic phase modulation of the 1-kc signals. Because of the enormous multiplication involved (in the worst case, from 1 kc to 250 kc and from 30 kc to 1440 kc) the phase modulation became several cycles of frequency modulation. The zero beat detector is of course very sensitive to frequency modulation, so that spurious beats were obtained in nearly every case.

After considerable investigation a satisfactory means of making the calibration was devised. It will be noted that the sixteenth harmonic of the low band varies from 2 to 4 Mc. By multiplying the signal from the frequency meter by sixteen, therefore, it may be run through the high band calibrator directly. Since calibration points are required every 1 kc of the fundamental, the sixteenth harmonic must pass through zero beat every 16 kc on the calibrator, and a multivibrator producing standard signals every 16 kc from 2 to 4 Mc is required. It will be seen that 126 calibration points will thus be obtained, which is the number required.

To obtain synchronization for the 16-kc multivibrator, an 80-kc multivibrator was locked on the fourth harmonic of the 100-kc standard. The fifth harmonic of the 16-kc multivibrator was then synchronized on the 80-kc signal.

Dual-Purpose R-F Stage

The dual-purpose two-band stage located between the frequency meter and the first mixer of channel 2 is shown in Fig. 12. It was designed to accept signals from either band of the frequency meter without switching, passing the high band directly, and multiplying the low band by 16. The first 7G7 provides considerable gain on the low band, but relative attenuation on the high band because of the capacitor shunting the plate load. The second 7G7 is a straight band-pass amplifier on the high band, and a multiplier to select the sixteenth harmonic of the low band. As a multiplier, the gain of this stage is of course much less than as an amplifier. At the output the signal from either band is of the same order of magnitude, and the overall gain is therefore approximately one.

Recording Problems

The zero beat detector serves to generate a pulse at the instant that the frequency meter is tuned to a calibration frequency. The remaining problem is that of accurately recording the dial reading at this instant. Since the dial is driven through 50,000 vernier divisions in approximately 6 minutes, 139 vernier divisions are passed in a single second. To record accurately the dial reading to the nearest vernier division while the dial is rotating at this speed requires special care. An ordinary revolution printer which momentarily presses a piece of paper against a set of revolving drums carrying the dial reading would cause appreciable blur.

Such a printer could be modified by having the drums stand still while the imprint is being made, after which the revolutions lost by such standstill would have to be made up through a differential or spring storage system. The mechanical complexity of such a recorder, however, is such that frequent maintenance would be required. A Strobotac photograph might be employed as an alternative but fast emulsions would have to be used, either necessitating production delay in development

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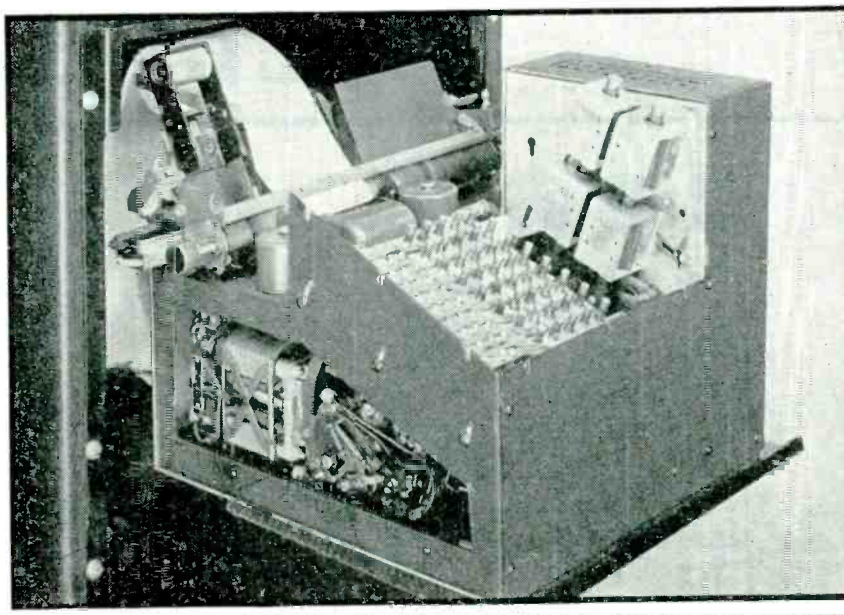
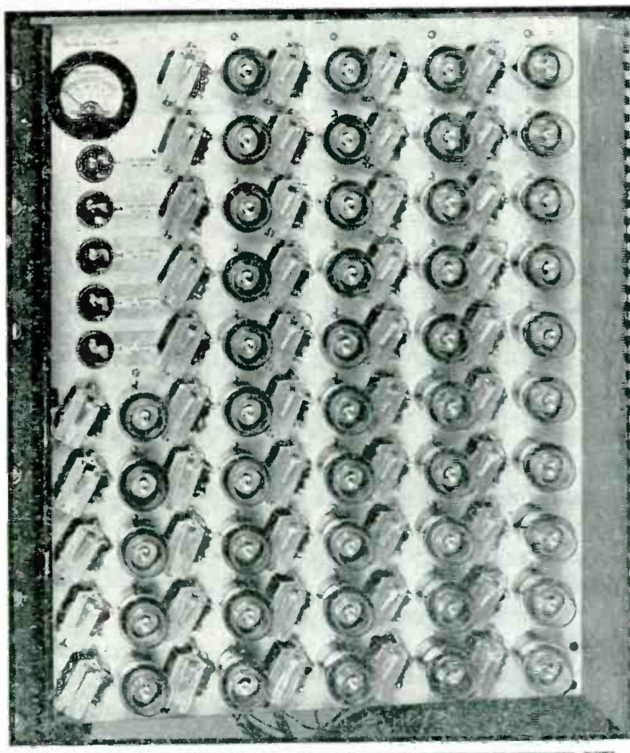
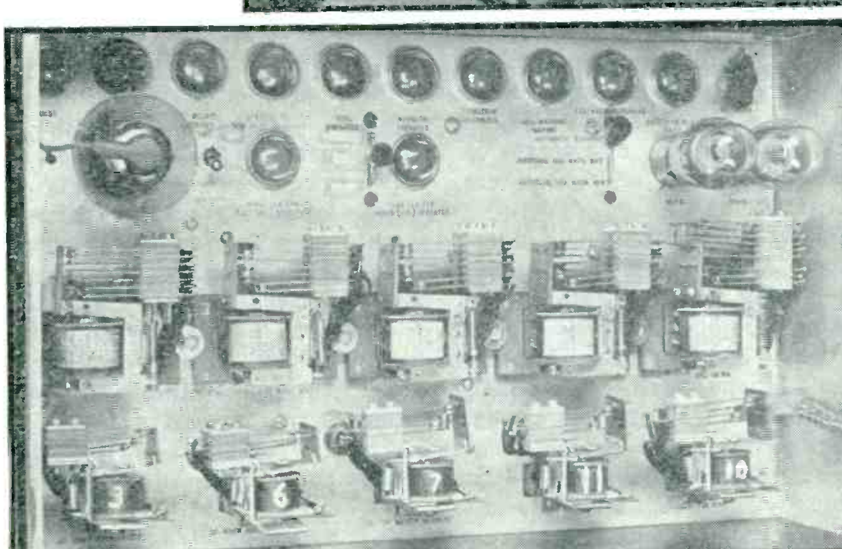


ABOVE
FIG. 16—Open view of adding machine, showing solenoids for actuating keys



RIGHT
FIG. 17—Number storage bank, showing 45 of the OA4G tubes, the associated relays, and monitoring lights and meter at upper left



BELOW
FIG. 18—Sequence system, showing thyratron S at left, relays, and monitoring lights for rapid indication of correct sequence of operations

ELECTRONIC

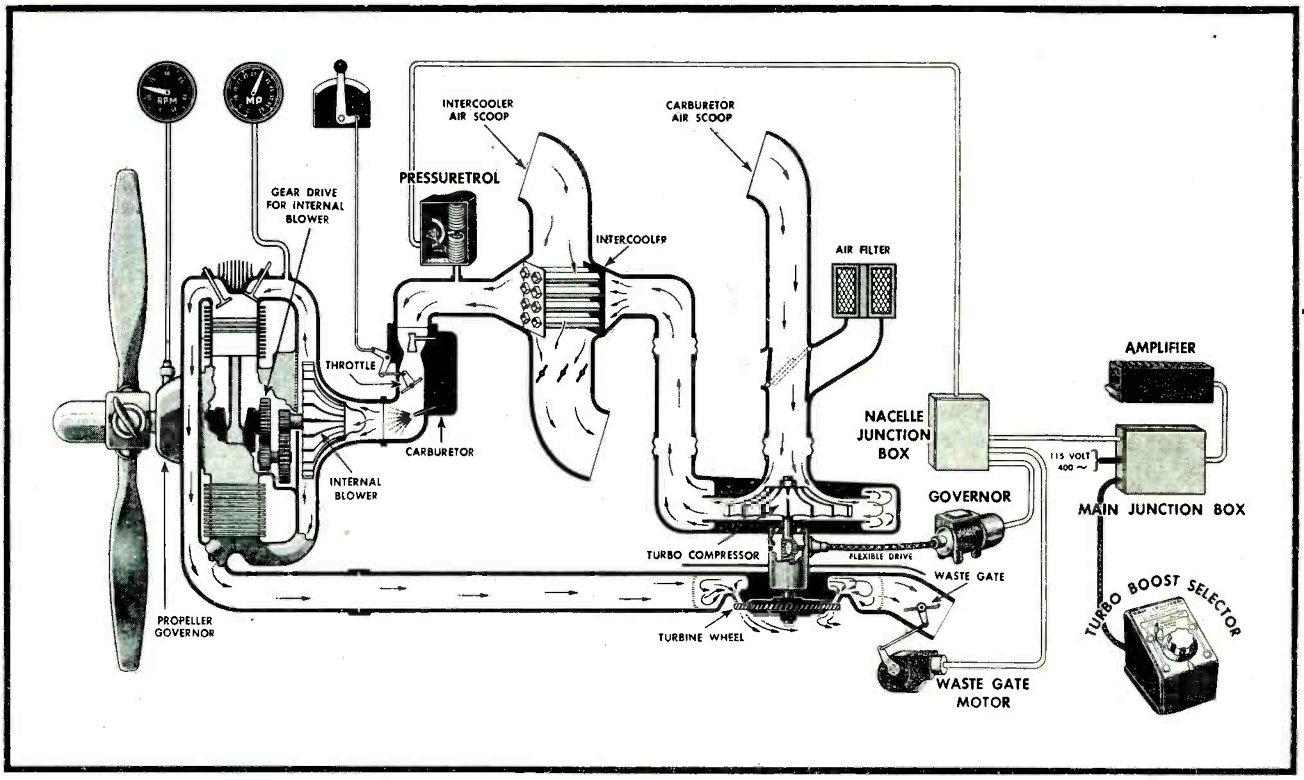


FIG. 1—Schematic diagram of electronic control system and associated mechanical parts of a turbosupercharged engine. The pilot controls the entire system with the single knob on the turbo boost selector box at the lower right

By **WILLIS H. GILLE**
Chief Engineer

and H. T. SPARROW
Chief Electrical Engineer

Aeronautical Division
Minneapolis-Honeywell Regulator Co.
Minneapolis, Minn.

THE PRESSURE at the intake manifold of an aircraft engine is normally kept above atmospheric pressure by a gear-driven internal blower, to obtain greater power from a given engine. At higher altitudes, however, atmospheric pressure decreases and manifold pressure and horsepower decreases correspondingly. This reduction in manifold pressure is offset by the turbosupercharger, a centrifugal air compressor that is driven by a turbine in the exhaust stack of the engine and serves to boost air pressure before it enters the carburetor.

The speed of the turbosupercharger is regulated by opening and closing a waste gate in the exhaust pipe of the engine. When the waste gate is open, exhaust gases escape without passing through the turbine; when closed, the gate forces the gases to impinge against the blades of the turbine wheel and spin the directly-connected compressor. Thus, the horsepower output can be kept constant or changed as desired, independently of altitude, simply by adjusting the waste gate.

Electronic Control Units

The complete electronic turbo regulator developed by Minneapolis-Honeywell Regulator Co. is shown in schematic form in Fig. 1 for one of the turbosupercharged engines of a four-engine bomber. The system contains five major units—a turbo boost selector, a Pressuretrol, a turbo governor, an amplifier and the waste-gate motor. Together these provide automatic regulation of turbosupercharger speed, allowing the pilot to concentrate on flying controls.

The turbo boost selector (at lower right in Fig. 1) is the pilot's only control over the turbo system. Once its four small calibrator potentiometers are adjusted to compensate for small differences in performance of the four engines or their turbos, the pilot can control turbo boost on all four engines simultaneously by adjusting the large central knob which serves the master control potentiometer.

The Pressuretrol unit on the intake manifold is a pressure-sensitive double-bellows device that drives a potentiometer wiper through a sector arm and pinion gear, so that the potentiometer setting is proportional to the pressure of the air being supplied to the carburetor by the turbosupercharger. The Pressuretrol insures that the system will maintain whatever boost pressure the pilot has selected, independently of changes in atmospheric pressure caused by variations in the altitude of the plane.

TURBO REGULATOR for Multi-Engine Airplanes

Speed of turbosupercharger for each engine is automatically regulated through a four-tube electronic circuit to provide a constant engine power condition at any altitude within operating limits, thus allowing the pilot to concentrate on flying the airplane

The turbo governor is a dual safety device driven by the turbosupercharger through a flexible shaft. The governor contains two potentiometers, one acting as an overspeed control to prevent the turbo from exceeding its safe operating speed, and the other acting as an accelerometer that anticipates pressure increases and provides a control voltage in time to prevent overshooting of manifold pressure.

The amplifier responds to the resultant alternating control voltage from the above three units, determines which direction of rotation is needed for the waste-gate motor, and provides the required power for the waste-gate motor.

The waste-gate motor is a two-phase reversible electric motor which positions the waste-gate through a mechanical linkage. As this motor rotates, it operates a balancing potentiometer that delivers an alternating voltage opposed to the resultant of the other potentiometer voltages. When the motor has rotated just far enough to make the two voltages exactly neutralize each other, amplifier power is cut off and the motor stops. The amount of waste-gate movement is thus determined by the magnitude of the original control, and there is no overshooting beyond the desired new position.

A-C Bridge Circuit

The six potentiometers of the electronic control units are connected to three power transformer windings (all on the same core and energized with 400-cps aircraft power) in the manner shown in Fig. 2, to form an a-c bridge circuit. In effect, the alternating voltages across these potentiometers either add to or subtract from one another. For the complete bridge to be balanced, these voltages must cancel, so that no voltage exists between the uppermost wiper and the bottom grounded wiper.

Voltages giving one of the many possible balances are indicated in Fig. 2. Here there are alternating voltages of 3 and 12 volts acting in one direction from ground, offsetting the 15-volt center section acting in the other direction from

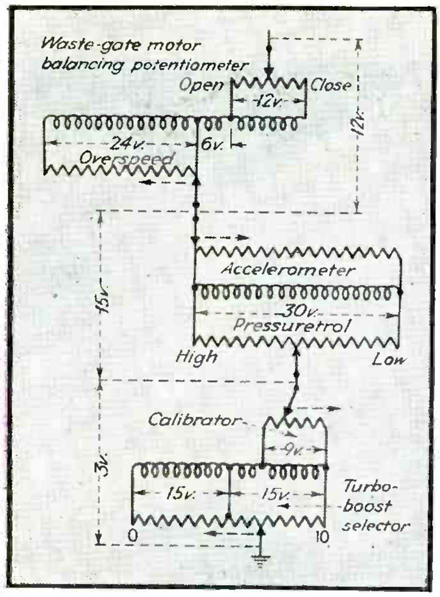


FIG. 2—Complete bridge circuit of the Minneapolis-Honeywell type B control system for turbosuperchargers. All three windings are on a core having a 115-v. 400-cps primary

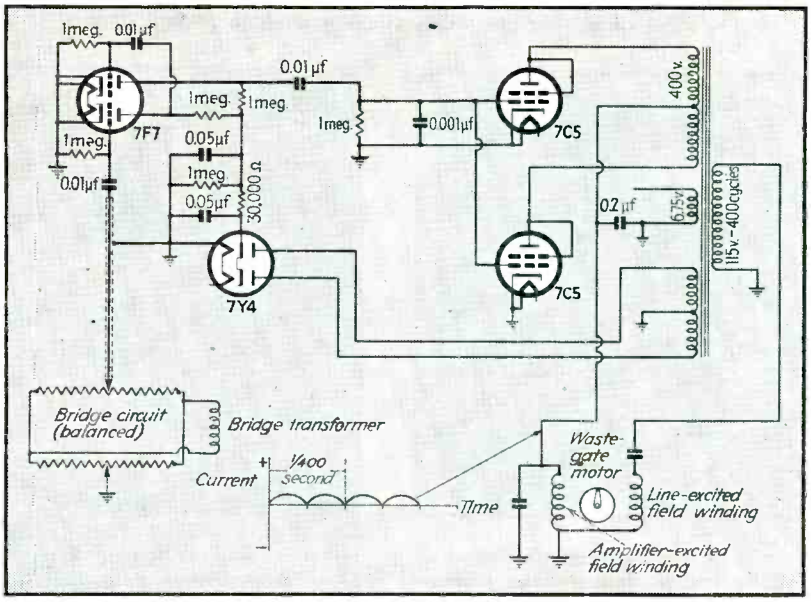
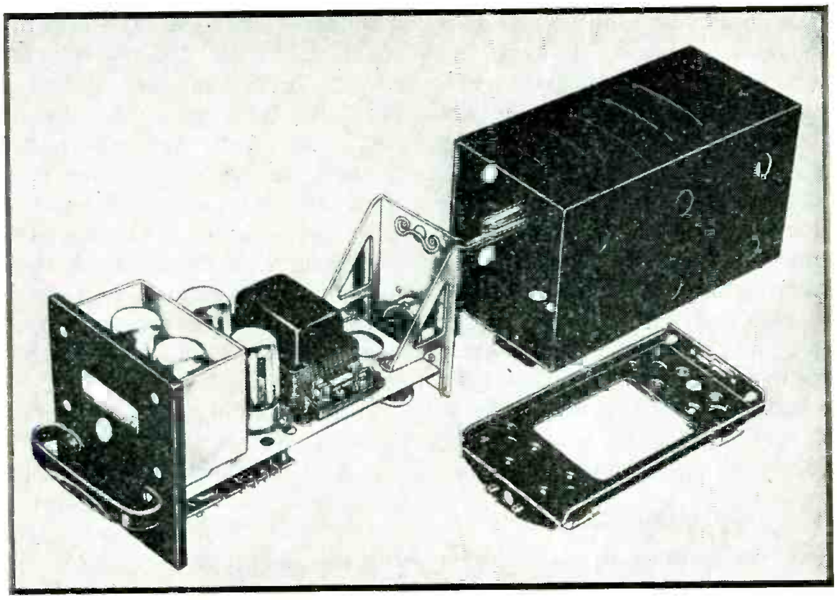


FIG. 3—Circuit diagram of one turbo control amplifier with its bridge circuit (shown in equivalent simplified form here) and its waste-gate motor circuit. Each engine has its own control system like this, with the potentiometer of the turbo boost selector (alongside the pilot) being common to all of the bridge circuits

ground. If the pilot should unbalance this bridge by moving the turbo-boost selector 3 v to the left (for less power), the resultant alternating voltage of 3 v would make the amplifier and waste-gate motor close the waste gate and drive its balancing potentiometer 3 v to the left so as to rebalance the bridge at the new power condition selected by the pilot. Movement of any other potentiometer wiper will likewise initiate waste-gate action and rebalancing.

In actual operation, two or more wipers are caused to move simultaneously. Therefore, it will be well to follow through one simple operation to see how modulating control is obtained.

If, with the bridge balanced, the selector dial is turned to a higher setting, the waste gate moves toward a closed position. As this happens, the turbine starts to speed up and increase the carburetor inlet pressure. Increasing this pressure moves the Pressuretrol wiper to the left, which in turn calls for the waste gate to move toward the open position. A new condition of balance results, with the waste gate slightly closed from its original position and the carburetor inlet pressure (and consequently the manifold pressure) increased from its original value.



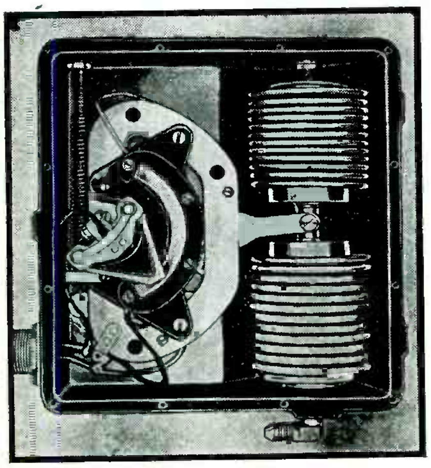
Turbo amplifier removed from its cabinet. The two 7C5 tubes are directly behind the front panel in a chimney-type enclosure, since they handle all current for one phase of the waste-gate motor

Amplifier Circuit

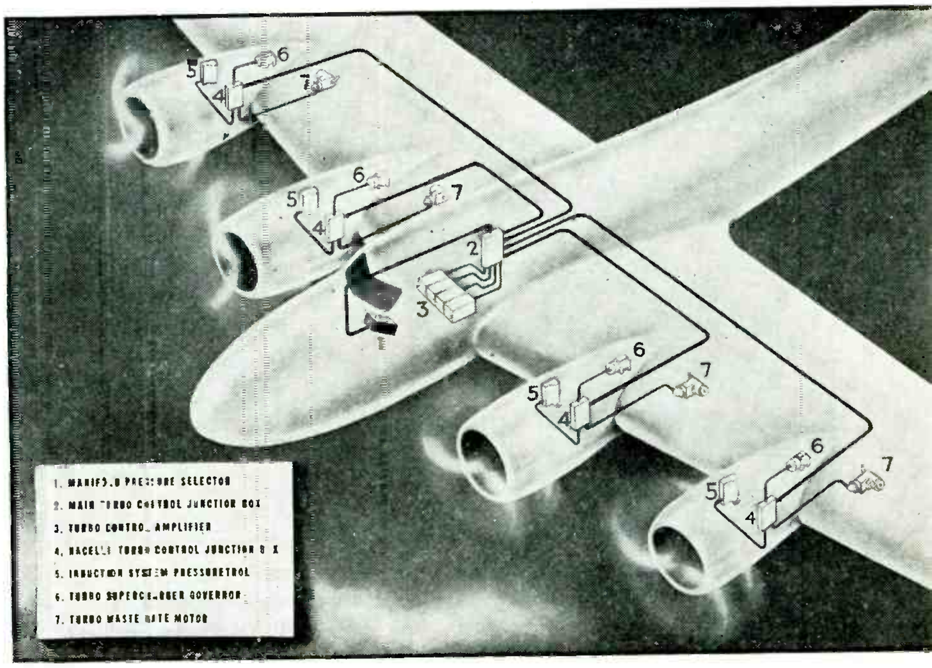
In Fig. 3 is a schematic wiring diagram of the complete turbo control amplifier, along with an equivalent simplified representation of the bridge circuit and the electrical circuit of the waste-gate motor.

The 7Y4 rectifier tube merely serves to convert the 115-v, 400-cps aircraft power to a high direct voltage for the two plates of the 7F7 tube, and hence does not enter into a discussion of the signal and motor circuits. All other tubes and parts operate from alternating voltages.

When the bridge is balanced, no a-c potentials exist in the 7F7 circuits and hence no alternating voltage is fed to the 7C5 tubes. Under this condition, each of these tubes passes only a small current (determined by the self-acquired bias on the control grids) on alternate half-cycles, with this current flowing through the amplifier-excited field winding of the waste-gate motor and acting as a brake on the motor armature. (This balanced-bridge current, the



Interior view of Pressuretrol unit that responds to changes in carburetor pressure



Turbosupercharger control system installed in a B-17 four-engine airplane

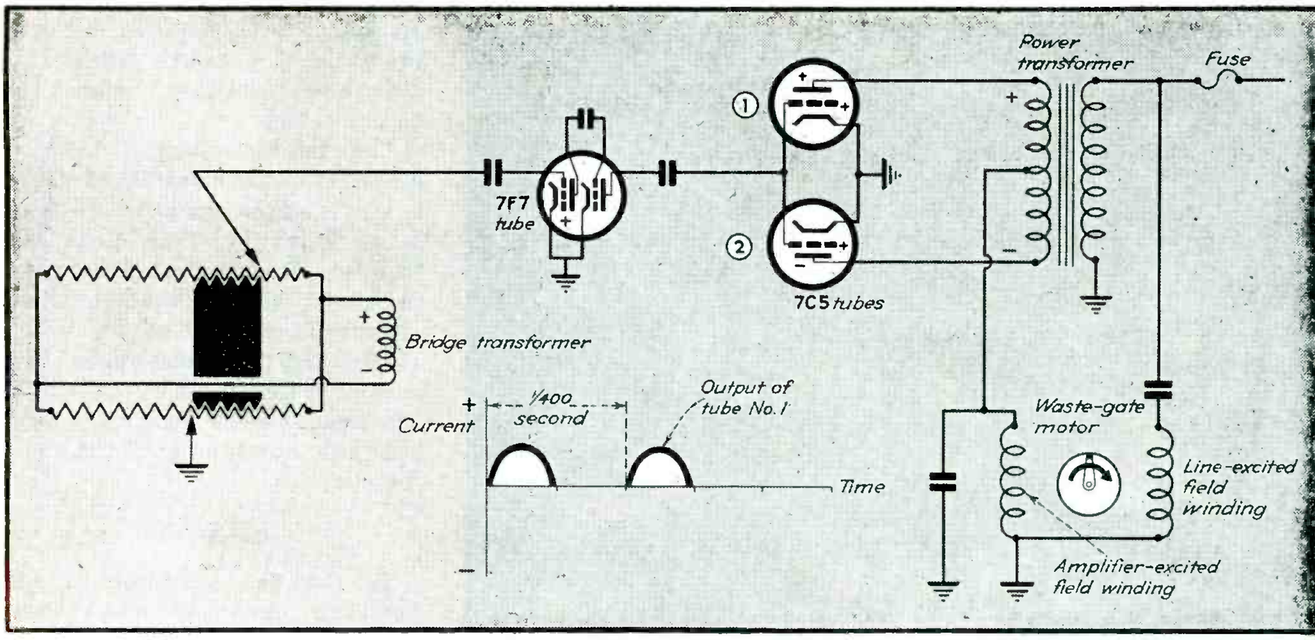


FIG. 4—Simplified version of amplifier circuit in Fig. 3, showing instantaneous polarities for the instant when the upper end of each transformer winding is positive and the bridge is unbalanced as indicated

waveform of which is shown in Fig. 3, causes the resultant motor field to reverse every half-cycle instead of rotating in one direction.)

When the bridge is unbalanced by movement of one of the potentiometer wipers to the right, conditions may be as shown in the simplified signal circuit of Fig. 4. The bridge transformer and power transformer being in phase, corresponding ends of each transformer have the same polarity at each instant. For the instant when the upper ends of the two transformers are positive, polarities are as marked.

The positive voltage pulse (with respect to ground) from the unbalanced bridge acts on the control grids of tubes 1 and 2 after undergoing amplification in the two sections of the 7F7 tube, but only tube 1 conducts since the plate of tube 2 is negative at this instant. Thus, tube 1 supplies current to the amplifier-excited field winding of the waste-gate motor on alternate half-cycles, causing say clockwise rotation.

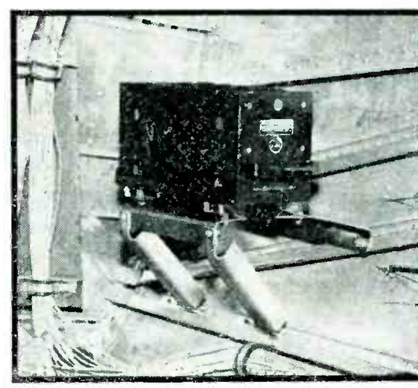
When polarities in both transformers have reversed 1/800 sec later, the grids of tubes 1 and 2 are both negative, and hence no power flows from the amplifier to the motor.

Movement of the upper potentiometer of Fig. 4 to the right thus causes clockwise rotation of the waste-gate motor. A similar analysis will show that movement of the potentiometer to the left will cause counterclockwise rotation of the motor.

Under both conditions of unbalance the 7C5 tubes deliver positive pulses with time intervals between, as indicated by the current curves in Fig. 4. For proper operation of the waste-gate motor, however, it is necessary to have alternating current instead of d-c impulses flowing through the amplifier-excited winding. Therefore, a capacitor of the correct size is connected in parallel with the field winding to form an oscillating circuit. The resulting relationship between current flow through the 7C5 tubes and the amplifier-excited winding is shown in Fig. 5 for each direction of unbalance. Note that the current resulting from operation of one tube is half a cycle out of phase with the current resulting from operation of the other tube—exactly what is required to reverse the direction of the rotating magnetic field of the squirrel-cage induction motor driving the waste gate.

Performance Curves

The curves in Fig. 6 portray typical operating conditions for the electronic turbo regulator during a climb from an altitude of 5000 ft to 32,000 ft.

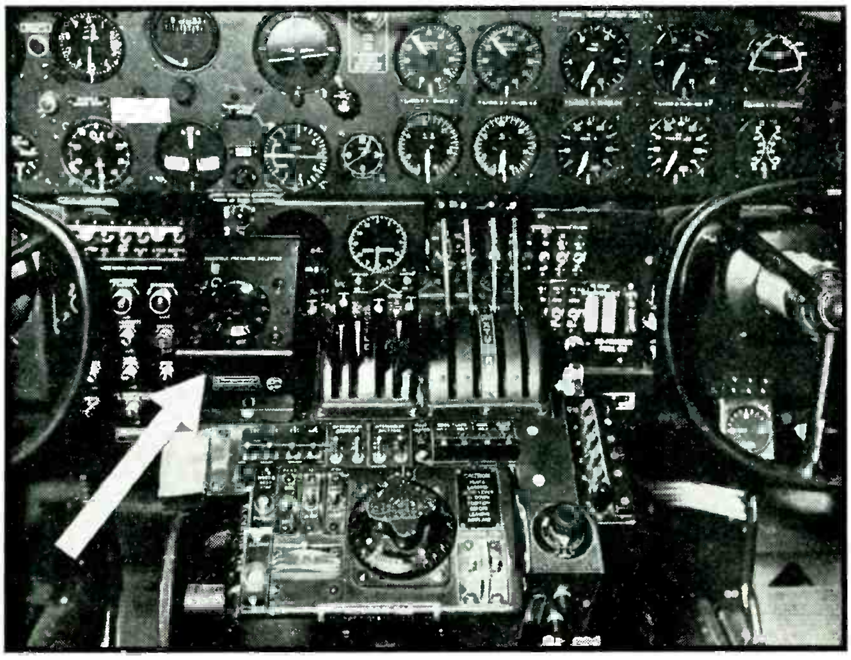


Location of amplifier unit for No. 3 engine in a B-24 airplane

First, the engine rpm is selected (2300 for this illustration) by setting the prop governor control. The engine speed remains constant throughout the climb because of the action of the automatic propeller governors.

The throttle is then moved forward to full-open position, and an intake manifold pressure of 37 in. is selected by means of the turbo-boost selector. The manifold pressure selected for any given flight depends upon speed of flight desired, rate of climb desired, and airplane load.

The pressure boost supplied by the internal engine blower, as represented by the difference between the carburetor inlet pressure and



Location of turbo boost selector at right of pilot on a B-24 airplane

the intake manifold pressure, is a fixed value as long as engine rpm remains constant. Therefore, to maintain a constant manifold pressure, it is necessary for the turbosupercharger to maintain a constant carburetor inlet pressure.

Atmospheric pressure decreases with an increase in altitude, as represented by the atmospheric pressure curve on the chart. It is therefore necessary that the turbine unit increase in speed during a climb. This increase in speed is represented by the turbo rpm line on the chart; it will be noted that the maximum turbine rpm was reached at approximately 30,000 ft. and then the overspeed portion of the turbo governor became effective to prevent further increase in speed.

As altitude increased, the waste gate moved toward a closed position to increase turbo rpm by increasing the pressure differential across the turbine wheel. It is evident that at first a fairly large amount of waste-gate movement was necessary, but as the waste gate approached and passed the half-closed position, very little movement was required because the ratio of pressure differential change to waste-gate change then becomes high.

The resultant effect of this condition on intake manifold pressure is that a slight droop is evidenced at the beginning of the climb, but that less droop occurs during the remainder of the climb until an altitude is reached at which the overspeed control takes effect. The amount of manifold pressure droop has been chosen to give nearly constant horsepower throughout the climb.

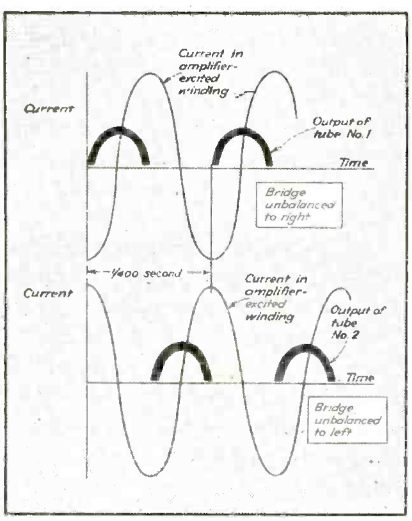


FIG. 5—Curves showing output currents of 7C5 tubes and corresponding currents in amplifier phase of waste-gate motor for both types of bridge unbalance

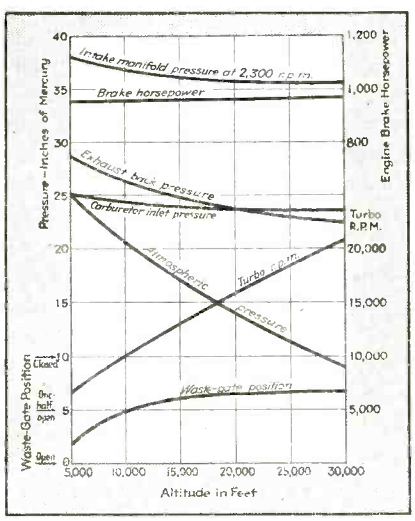


FIG. 6—Curves showing operation of turbo control equipment during a climb from 5000 ft to 30,000 ft

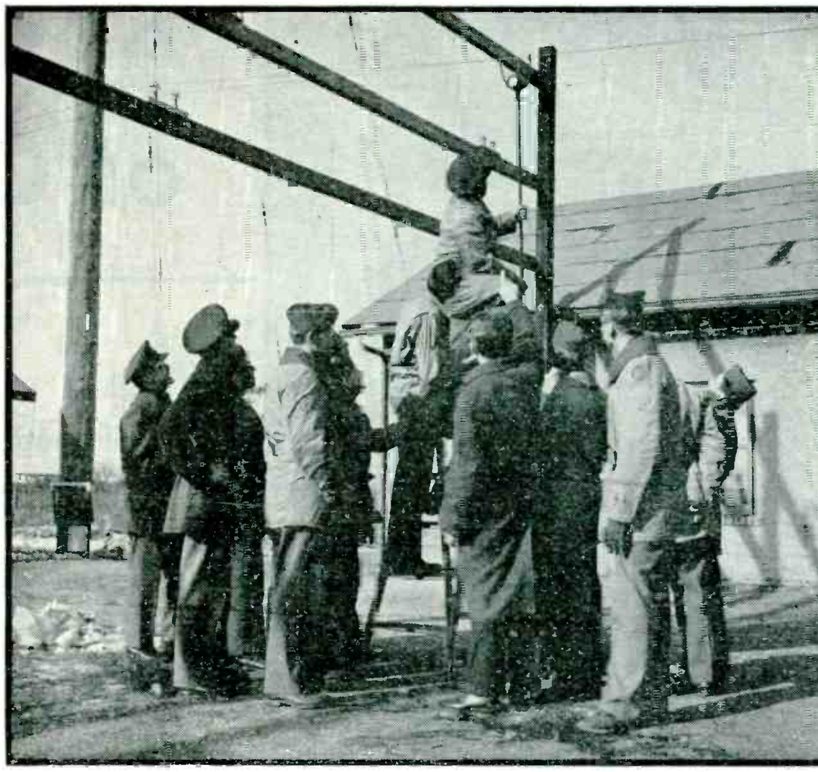
Conclusion

To test the operation of the regulator under extreme conditions, one throttle was fully retarded while cruising at an altitude of 25,000 ft. After the system had restabilized on three motors, this throttle was rammed to full-open position in less than a second—a severe test for any regulator. Photographic records made during the test showed that as the throttle was retarded, the manifold pressure dropped quickly. The propeller governor re-established prop speed after a period of several seconds. The waste gate closed completely and turbo speed dropped.

Things began to happen when the throttle was rammed full open. Manifold pressure increased smoothly. Turbo speed shot up. Original conditions were re-established in approximately ten seconds without exceeding safe turbo speed or manifold pressure and without setting up a hunting or other unstable condition. In fact, the curves for the test even showed fluctuations as the turbo regulator attempted to compensate for an uncertain prop governor. The accelerometer portion of the governor caused the waste gate to open sooner than it would have otherwise, thus limiting to a modest amount the surge above the pressures desired.

The Minneapolis - Honeywell type B control system for turbosuperchargers, just described, is today flying in many of our largest bombers, serving to make the pilot's task simpler and high-altitude flying more dependable.

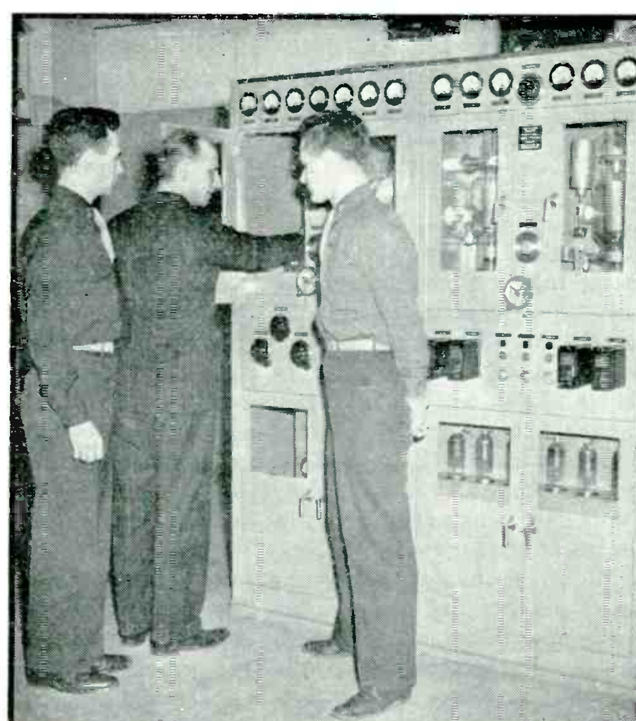
By working on "live" high-power equipment at the Hicksville, Long Island station of Press Wireless, Signal Corps students are learning installation, operation and trouble-shooting in a fraction of the usual time for training



Measuring the standing-wave ratio on a transmission line feeding an antenna

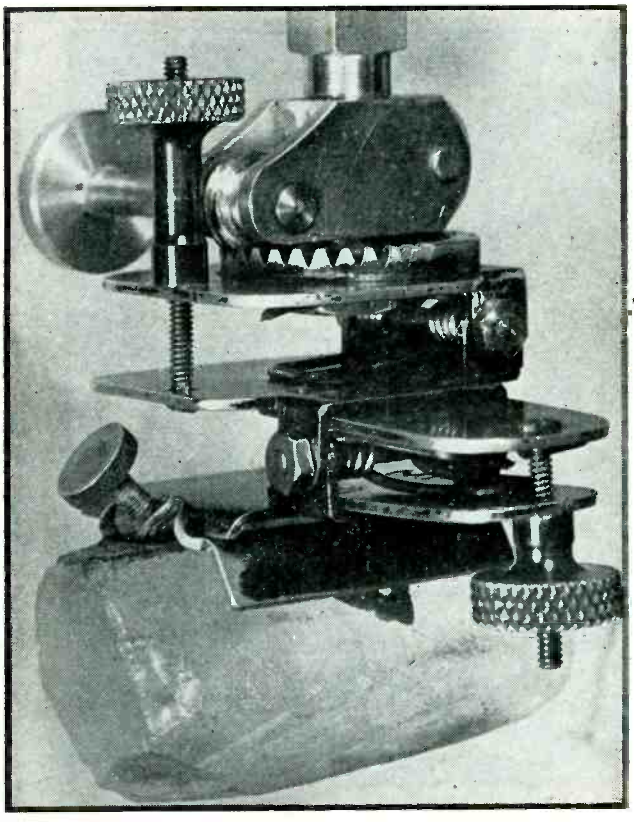
Studying TRANSMITTERS

Working on high-power short-wave transmitters in actual operation



Receiving instruction in adjustment of a 2.5-kw radio transmitter

Rodometric of QUARTZ



Quartz crystal mounted on intermediate swivel fixture in preparation for rodometric examination

A new optical method of determining the positions of the three axes within a fraction of a degree. It involves grinding and etching a small window on the crystal, and observing the characteristic star-and-spots pattern produced at this window by a light beam

ONE OF THE important steps in the production of quartz "crystals" is the determination of the position and polarity of the axes, the "handedness" of the mother crystal, and the presence of twinning. Particularly in the case of crystals that have no well-developed natural faces this usually necessitates a somewhat lengthly procedure, with several steps involving the use of a number of different instruments by several workers, each checking one of the characteristics in turn.

Attempting to improve a shorter method of orientation originally proposed by de Gramont, Professor W. G. Cady of Wesleyan University began in 1939 an investigation which was followed by further development by Mr. H. H. Hubbell. At the suggestion of Professor Cady and with his constant advice the author took up further investigation late in 1940, developing the proposed method of orientation with reference to the spots-and-star pattern described below.

It is now possible for a single worker to determine simultaneously in one observation the following facts concerning a given mother crystal of any size or shape, regardless of the absence of natural faces:

(a) Right or left-handedness.
(b) Position of Z (optical) axis.
(c) Position of X and Y axes.
(b) Polarity of axes.
(e) Presence and kind of twinning at the etched surface.

The accuracy of orientation of the axes depends somewhat on the skill of the worker and the time taken for the observation. Two minutes manipulation by a trained man may fix all axes within a fraction of a degree, and 15 seconds manipulation by an unskilled worker may result in an error up to 2 degrees. Though this so-called rodometric method has been used successfully in commercial practice as a substitute for x-ray orientation methods, more usually it serves to orient the mother crystal for the first cut within about a degree. Any necessary vernier adjustments in the orientation of the mounted crystal on the saw table are made by means of the usual x-ray data obtained from the first cut.

Another aim that has been realized is the simplicity and uniformity of the procedure. It is not necessary for the operator to make any dial settings, take readings or remember numerous conventions regarding the enantiomorphy of quartz or the polarity of axes.

Gives All Data in One Step

The process begins with a preliminary inspection of the crystal between polaroids, and the preparation of a small etched surface ("window") on the mother quartz. The crystal is then mounted on a swivel fixture after a brief optical check. Crystal and fixture are transferred to an instrument called a rodometer, where the complete determination of characteristics is made optically in one step. Then the crystal is re-mounted for the saw-table and is ready for cutting. There is no intermediate cutting, and only one remount is needed.

Disadvantages of the method are: In routine use the final orientation of the crystal is usually not better than ½ to one degree; optically opaque crystals cannot be oriented; the use of hydrofluoric acid for etching may be objectionable; use of the method requires

Examination

CRYSTALS

By **GERALD J. HOLTON**

Department of Physics
Harvard University
Cambridge, Mass.

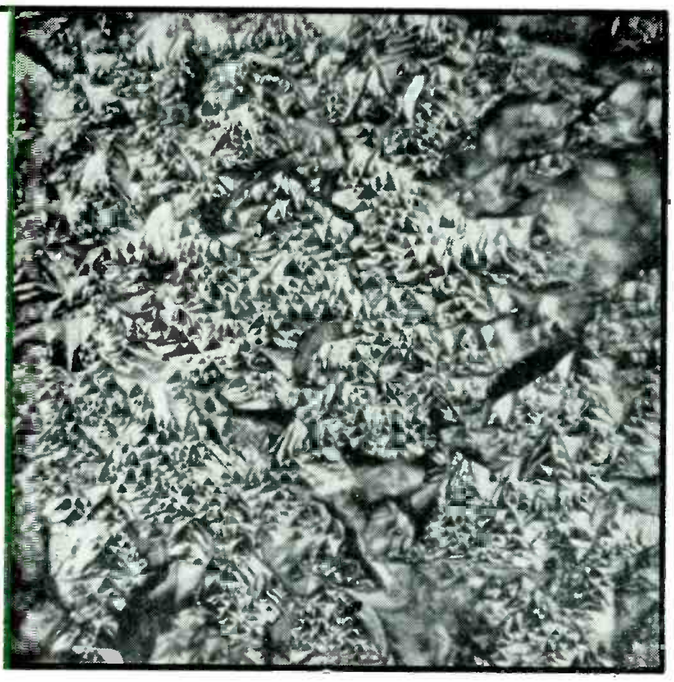


FIG. 1—Appearance of etched ground surface of quartz after three hours of etching, as seen through a microscope. The cracks between the triangular etch pits and pyramids are due to grinding

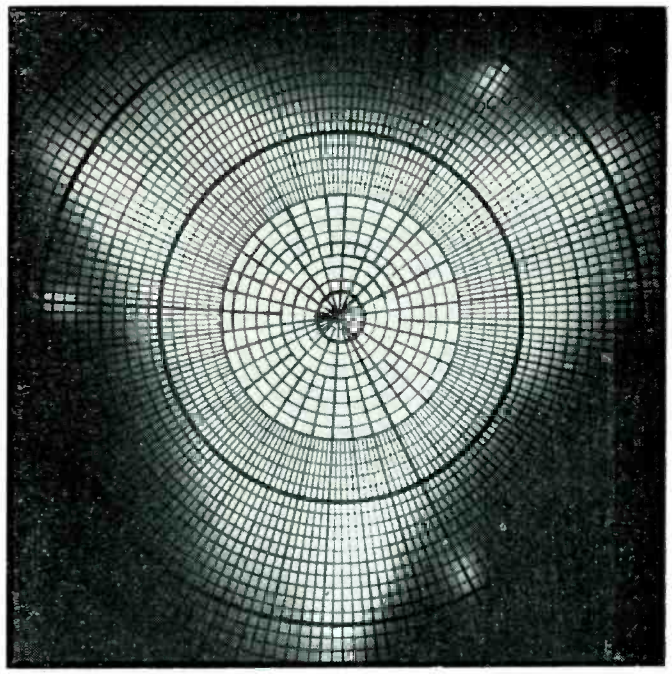


FIG. 2—Refraction pattern for left quartz as seen in a rodometer, on a translucent screen having a superimposed circular net drawing. The three spots are due to refraction from stable etch facets

observance of patent rights; and two mechanical instruments have to be built.

The Refraction Pattern

Rodometry (from *rodere*, to etch) uses microscopically small facets that appear on the surface of crystals upon etching, whose shape and orientation are characteristic of both the crystal on which they appear and the direction of the crystal surface with respect to the axes. Several previous attempts have been made to determine the orientation of a given face or cut, either from the appearance of the etch figures themselves as seen under the microscope, or from the light-pattern obtained by reflection or refraction from the facets.[1] However, the direction of the facets used in most cases changes erratically with such factors as length of etching time, concentration of etching agent, etc. Therefore, such orientation methods are only approximate at best.

Yet, for certain specific reasons[2] there will be some etch facets that are not dependent on these extraneous conditions, and they can produce refraction patterns that may always be related accurately to the orientation of a crystal. These stable facets appear best in the scratches of a ground quartz surface that is approximately parallel to the XY plane, after 2 to 3 hours of etching in hydrofluoric acid. Figure 1 shows the appearance of the etched surface under the microscope.

The trigonal etch pits and pyramids on the surface produce on a translucent screen the star-like triangular refraction pattern in Fig. 2 when a strong narrow collimated beam of light is passed through the crystal along the Z axis. The three "spots" in Fig. 2 are due to refraction from the "stable" etch facets in the scratches of the surface, and these make possible a precise orientation of the etched crystal.

Interpretation of Pattern

The following empirical relationships exist between the light pattern produced by them on a translucent screen and the characteristics of the mother crystal:

(a) The Z axis is parallel to the light beam producing the refraction pattern if the pattern is centrosymmetrical, i.e., if the three spots appear equidistant from each other and from the center as observed on the fixed superimposed "net" on the ground glass screen.

(b) The crystal is right-handed if the spot-pattern appears to be rotated clockwise with respect to the apices or points of the star-pattern; left-handed if rotated counterclockwise.

(c) The Y axes are parallel to

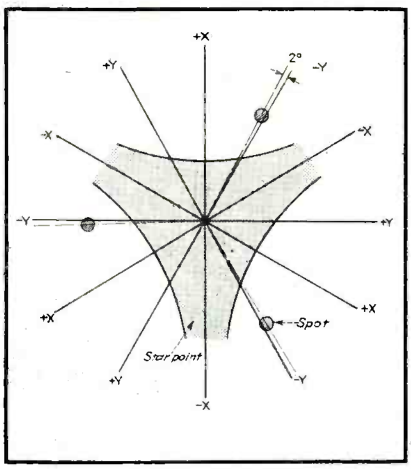


FIG. 3—Relationship between axes and light pattern for left quartz, in which the spot pattern appears to be rotated counterclockwise from the star points

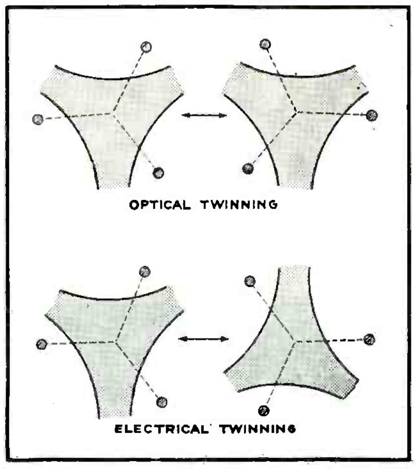


FIG. 4—Effect of the two types of twinning on the refraction pattern as the etched surface is moved in a plane perpendicular to the light beam

lines drawn through the center of the symmetrical pattern toward the spots, but rotated 2 degrees in the XY plane toward the nearer point of the star-pattern (see Fig. 3).

(d) If we assume that the +Z axis points toward the observer, the negative ends of the Y axes are those that point toward the spots; therefore, the ends of the Y axes pointing away from the respective spots are positive. (In this paper the IRE convention[3] for signs and axes is followed throughout.)

(e) The X axes of the crystal are parallel to lines through the center of the pattern and at right angles to the Y axes.

(f) The ends of the X axes pointing toward the points of the star are negative.

(g) The presence of twinning on the surface is detected by moving the etched surface in a plane perpendicular to the light beam; at a twinning boundary the refraction pattern changes abruptly according to the kind of twinning.

(h) Optical (Brazilian) twinning is present if the pattern changes from a typical left-hand to a right-hand pattern, or vice versa; the spots will be found on the opposite sides of the star in the twinned area (see Fig. 4a).

(i) Electrical (Dauphiné) twinning is characterized by a rotation of the whole pattern for 180 deg in the twinned area; the spots remain on the same side of the star (see Fig. 4b). It is to be noted that the position of the star-points may deviate from the average by as much as 20 deg, depending on time of etching, etc. But because the rodometric method relies on the stable position of the spots the determination of orientation will not be affected by the erratic behavior of the star.

Production of the Etch Pattern

The following is a simplified outline of the standard treatment of a mother quartz, from the initial sorting to the point where the orientation can be determined.

(a) Examination of the mother quartz for flaws.

(b) Simultaneous examination for excessive optical twinning and approximate location of optical axis, using polarized light.

(c) Preparation of the "window": After immersion of the crystal in the oil bath, it is cleaned well, and an area of the size of a half dollar is cut or ground on the crystal in a plane that is not much more than 10 deg from the XY plane. The smaller the deviation, the better will be the subsequent refraction pattern. If the crystal is badly damaged on the side opposite the window, a second similar face should be made there.

(d) Grinding of the "window". With carborundum (grade 100) scratches are ground on the window, either on a glass plate or on a rotating horizontal grinding wheel. The grinding should be random and thorough (this step might be replaced by sand-blasting). The grinding "mud" is to be renewed frequently and must be kept free from oil and grease, because it is essential that the window be kept clean throughout the process.

(e) The mother crystals—or at least the windows—are placed in a hard rubber etching vessel containing a mixture of three parts of approximately 50 percent commercial hydrofluoric acid and one part tap water. These proportions and the temperature are not critical, but the acid should be stirred constantly and renewed fairly regularly. After two to three hours the crystals are removed and rinsed. They are now ready for orientation.

Preparation for Orientation

Up to this point it has not been necessary to mount the crystal or to use any jigs, since the window can be made by pressing the quartz against a grinding wheel by hand. From here on, however, the crystal has to be related to a fixed reference system in the orientation procedure. For this purpose the mother crystal can now conceivably be mounted directly and permanently on the swivel fixture used on the saw table; or, as is actually being done, it is mounted on an intermediate swivel fixture from which it can be transferred to the saw table after the one-step orientation procedure. In both cases it facilitates subsequent manipulation if the crystal is mounted with an X axis approximately perpendicular to the mounting surface. In case the intermediate fixture is used the mounting procedure is as follows:

(a) Place the etched window near the eye, and the opposite end of the crystal in a flat-bottomed dish containing a compensating oil bath. (This apparatus is sometimes called a rodoscope.) If light passes from a pin-hole under the dish through the crystal approximately along the Z axis, a refraction patter is seen equivalent to Fig. 1. That figure, however, was obtained on a screen rather than by direct viewing. For the same position of the crystal the two patterns are rotated 180 deg with respect to each other; therefore the directions of the *positive* X axes are approximately in the direction of the star-points as seen in the rodoscope.

(b) Mark the approximate direction of the star-points on the edges of the etched window, and mount the mother crystal with wax on the fixture, with one of the three X axes perpendicular (negative end of axis toward mounting surface, i.e., corresponding mark on window away from fixture). The fixture can be a photographic pan-head with ball and locking handle, fitted with a removable mounting plate for the crystal (Fig. 5).

(c) As seen in Fig. 5, the fixture and the rectangular rod to which it is rigidly attached are transferred with the mounted crystal to the rodometer. There the rod makes a smooth fit and can be clamped in a fixed horizontal socket.

The Rodometric Examination

Several different models of the rodometer[4] have been made; in essence this instrument consists of a strong light source which provides a narrow collimated beam by means of a lens system; the light passes vertically through the horizontal plate-glass bottom of an oil bath into which the lower end of the crystal is immersed. Upon refraction by the etch facets on the window, the light pattern is focussed on a ground glass screen by a lens.

It is the task of the operator to bring the light pattern appearing on the translucent screen into coincidence with the photographically superimposed line drawing (such as is reproduced in Fig. 6). This he does by looking at the screen, either in a darkened room or through a light-shielding hood, while manipulating fixture and mounted crystal until coincidence of drawing and light pattern is achieved, at which point the fixture is locked by a turn of the knob (see Fig. 5. The additional arm is not essential).

If the translucent screen is perpendicular to the undeviated light beam which would strike the center of the superimposed line drawing, the Z axis of the crystal is parallel to the direction of the light beam whenever the light pattern appears symmetrical on the screen. Symmetry is established if the three spots of the light pattern fall into the center of the three rings provided on the drawing. Owing to the erratic behavior of the stars, their positions may deviate somewhat from the drawn figure.

The screen shows a separate drawing for right and for left quartz, because it can then be preset with respect to the fixed rod attached to the fixture, so that locking the fixture after the orientation procedure will, in our example, always result in the X axis of the crystal being accurately parallel to the length of that rod (negative end of axis in direction of free end of rod), regardless of whether it be right or left quartz.

Before removing crystal and fixture from the rodometer, the worker makes a mark on the window to indicate the hand of the crystal. By observation of the light pattern he has already noticed during the first stages of the manipulation whether twinning occurred on the window, and what kind; if desired, a code mark with that information is also put on the mother crystal.

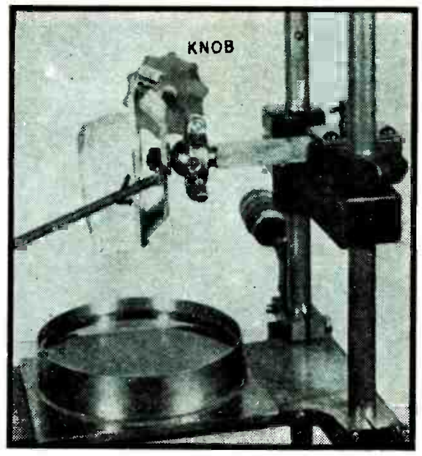


FIG. 5—Upper part of rodometer

The rod with fixture, etc., is now slid out from socket and rodometer, and the oil on the lower portion of the crystal is cleaned off. The orientation of the crystal is now fixed by the following facts:

(a) The right- or left-handedness is marked on the window.

(b) The X, Y and Z axes of the crystal are parallel to the three edges of the rectangular rod, if the rodometer is correctly lined up.

(c) If the positive Z axis is assumed to point upward from the window and a positive X axis points out from the unmounted side of the crystal and parallel to the length of the rod, then a Y axis makes an orthogonal righthanded axial system for right quartz, and a lefthanded axial system for left quartz[3].

Transfer to Saw Table

The orientation of the crystal having been determined, the mother crystal is re-cemented on its free side on a glass plate for final cutting, usually with the positive X axis perpendicularly downward, and the Y and Z axes (in the same plane as the plate) making any desired angle, usually zero degrees, with a ground reference edge of the glass plate.

The procedure for cementing is indicated by the schematic drawing in Fig. 7. The rod is slid into a vertical, tightly fitting socket of the "scaffold" where it can be clamped.

(*Continued on page 252*)

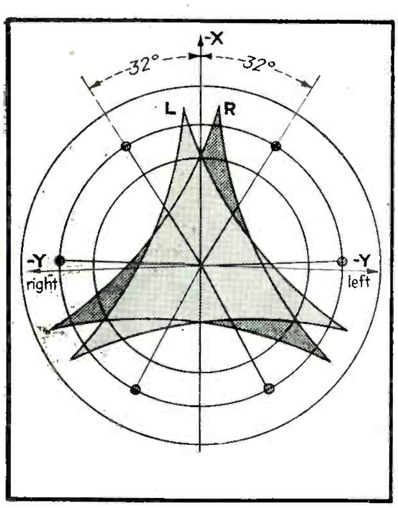


FIG. 6—Superimposed reference drawing for interpreting refraction patterns

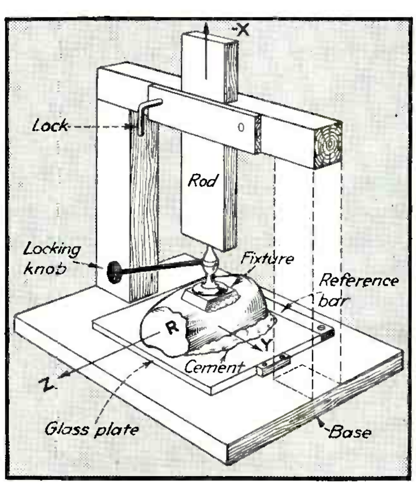


FIG. 7—Final mounting of crystal in scaffold

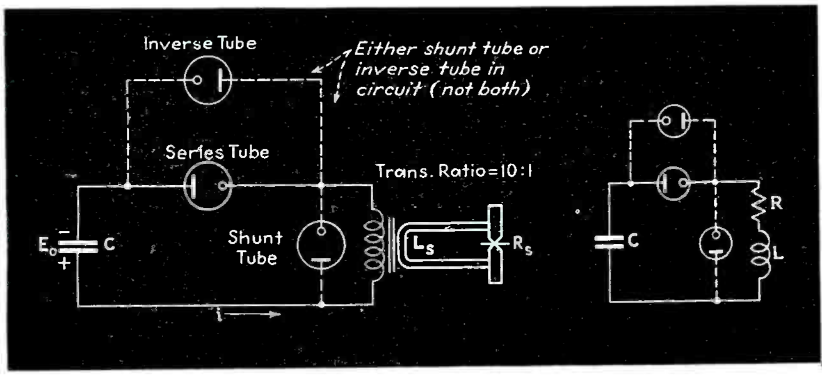


FIG. 1 — Basic capacitor-discharge welding circuit (left), and simplified equivalent circuit (right)

CAPACITOR-DISCHARGE

THE method of welding with electrostatically stored energy employs a capacitor bank, usually of several thousand microfarads, charged to 1500 to 3000 volts. This capacitance is discharged into the primary of the welding transformer, the secondary of which, usually a single turn, connects to the welding electrodes. The frequency at which this transformer operates is the natural frequency of the circuit and varies with the size of the capacitor bank, the inductance of the welding circuit and the turns ratio of the transformer. The wave shape of the welding discharge is a more or less attenuated sine wave which in some systems leads into an exponential discharge curve. In other systems the discharge wave is terminated after duration of one half or one full cycle.

Under no conditions must the transformer be allowed to saturate. A convenient way to check the welding transformer against saturation is to compare the wave shapes of primary and secondary current. If saturation starts, the primary current rises and the secondary power is reduced. The results are: (1) Loss of energy in the transformer; (2) Non-repeatability of weld heat; (3) Possible damage to control elements in the primary circuit.

In the following a method is presented which allows a quick determination of the maximum incremental flux density occurring in the welding transformer under various conditions. In addition, formulas and graphs are developed to show voltages, currents, and duration of the successive phases of the capacitor discharge welding current.

Wave Shape of Welding Current

Welding circuits of the type under consideration generally consist of the capacitor battery, the welding transformer (with electronic tubes as switching elements), and the secondary loop with the welding load. This circuit is shown in Fig. 1. The discharge is initiated by the series tube, and is terminated by the shunt tube, or in some systems by the inverse tube.

The coupled circuits can be simplified to the equivalent circuit shown in Fig. 1 by transposing the secondary inductance and resistance values L_S and R_S into the primary circuit according to the relations

$$R = n^2 R_S \qquad (1)$$

$$L = n^2 L_S \qquad (2)$$

where n is the turns ratio of the welding transformer. It has been shown by direct measurements that the reflected resistance R and inductance L by far outweigh the resistance and inductance of the primary circuit, including leakage inductance and the resistance of the transformer primary.

The attenuation of the welding circuit is expressed by the attenuation angle δ as follows:

$$\sin \delta = \frac{R}{2}\sqrt{\frac{C}{L}} \qquad (3)$$

Using Eq. (1) and (2), the attenuation angle is obtained from the original circuit constants L_S, R_S, C and n, which are known to the transformer designer.

$$\sin \delta = n\frac{R_S}{2}\sqrt{\frac{C}{L_S}} \qquad (4)$$

With increasing turns ratio the attenuation of the welding discharge increases, until when n is

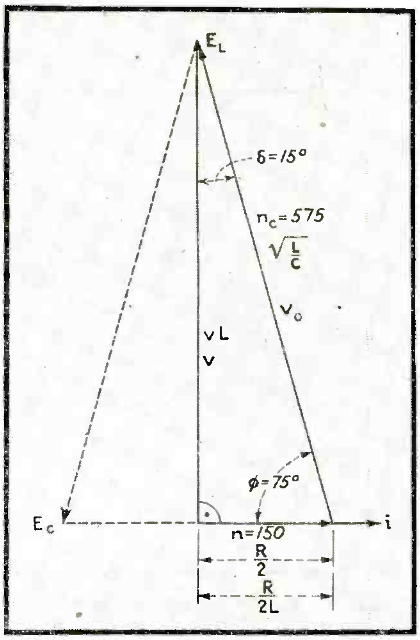


FIG. 2—Attenuation triangle expressing relations in a capacitor-discharge welding circuit, worked out here for the circuit constants given in the example at the end of the article

By H. KLEMPERER Development Laboratory Raytheon Manufacturing Co. Waltham, Mass.

Voltage, current and time relations for the successive phases in capacitor-discharge welding are developed for shunt and inverse tube circuits, and a quick method is given for determining whether undesirable saturation exists in the welding transformer

WELDING SYSTEMS

equal to the critical turns ratio n_c, the circuit is critically damped. The corresponding critical turns ratio is therefore defined as

$$n_c = \frac{2}{R_s}\sqrt{\frac{L_s}{C}} \qquad (5)$$

Having determined the critical turns ratio n_c from the circuit constants, it is possible to draw the attenuation triangle for any turns ratio of the welding transformer. That construction will allow a simple scaling of the constants of the current equation.

The attenuation triangle is a right triangle with the base and hypothenuse drawn in proportion to n and n_c respectively, as in Fig. 2. The top angle is δ, the attenuation angle of the welding circuit, and the complementary base angle is ϕ, the phase angle between voltage and current in the weld circuit.

If the base is scaled in proportion to $R/2L$, which is the inverse oscillation time constant of the welding circuit (dimension sec^{-1}), the altitude will read the natural frequency $v/2\pi$ of the welding circuit.

Thus, reading δ and v from the attenuation triangle, the current equation

$$i = \frac{E_0}{\sqrt{L/C}\cos\delta} e^{-\frac{tR}{2L}} \sin vt \qquad (6)$$

is easily evaluated. The value $\sqrt{L/C}$ can be read from the attenuation triangle, being the hypotenuse if the base is made equal to $R/2$ ohms.

From Eq. (6), the time in seconds, counting from the beginning of the weld, at which the welding current reaches its peak is

$$T_M = \varphi/v \qquad (7)$$

This current maximum has a value in amperes equal to

$$I_M = \frac{E_0}{\sqrt{L/C}} e^{-\varphi \tan\delta} \qquad (8)$$

Systems with Shunt Tube

In welding systems using a shunt tube the welding energy is prevented from oscillating back into

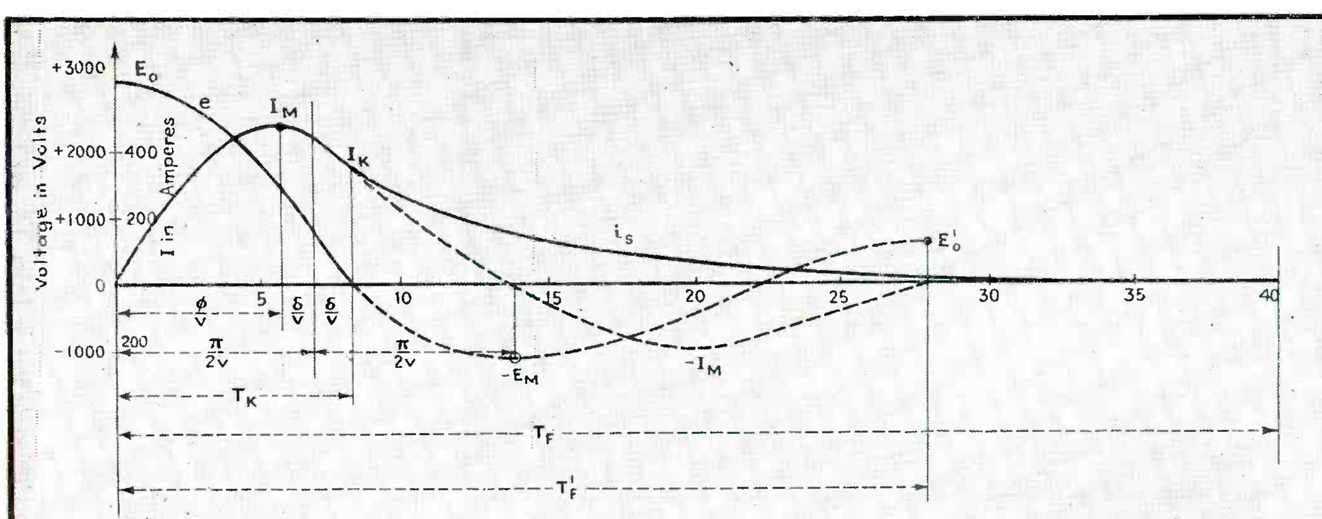


FIG. 3—Welding current and voltage as calculated for the two circuit versions of Fig. 1. Solid lines are for system with shunt tube; dash-dash line for system with inverse tube

the primary circuit. Neglecting tube drops, the current commutates from series tube to shunt tube at the time when the capacitors are fully discharged. This time in seconds is

$$T_K = (\pi - \varphi)/v \qquad (9)$$

The commutating current in amperes at this time has the value

$$I_K = \frac{E_0}{\sqrt{L/C}}\, e^{-(\pi-\varphi)\tan\delta} \qquad (10)$$

After this commutation the welding circuit is changed; the capacitor being disconnected, the current decays exponentially according to

$$i_S = I_K\, e^{-tR/L} \qquad (11)$$

This current, i_S, reaches its end abruptly at the moment when it is too small to support the cathode spot in the shunt tube. This extinction usually takes place somewhere between 5 and 3 amp. Calling the extinction value of the current I_F, the time of extinction in seconds is

$$T_F = T_K + \frac{L}{R}\log_e\frac{I_K}{I_F} \qquad (12)$$

which also designates the duration of the weld.

Considering the welding circuit as a coupled system (Fig. 1), it is evident that a residual current in the secondary keeps on flowing after the primary current thus has ceased to flow. This residual current has an initial amplitude nI_F of several hundred amperes and dies out with the time constant L_S/R_S. Unless suppressed by additional means, discussion of which is outside the scope of this communication, this residual current may cause excessive sparking at the moment when the electrodes are opened.

Systems with Inverse Tube

In the capacitor discharge welding system using an inverse tube instead of the shunt tube, the series tube stays conducting until the current wave has gone to zero. At this time, while the capacitor voltage passes its negative peak, the current commutates from series to inverse tube. Through the inverse tube the former half cycle is repeated with decreased amplitudes and in opposite direction, and at the end of the full period the capacitors carry a residual charge of the original sign.

The inverse voltage peak in volts is

$$-E_M = E_0\, e^{-\pi\tan\delta} \qquad (13)$$

The inverse current in amperes rises to

$$-I_M = \frac{E_0}{\sqrt{L/C}}\, e^{-(\pi+\varphi)\tan\delta} \qquad (14)$$

and the residual capacitor voltage at the end of the welding period is

$$E_F = E_0\, e^{-2\pi\tan\delta} \qquad (15)$$

Finally, the time in seconds of the welding period is

$$T'_F = 2\pi/v \qquad (16)$$

Example

In a typical welding equipment the measured secondary resistance value R_S was 1.14×10^{-4} ohms. This resistance value is much larger than the resistance of the actual weld, which in the case of aluminum is of the order of 10^{-5} to 10^{-6} ohms. The secondary inductance L_S was 9×10^{-7} henry. (The inductance varies mainly with throat depth and height.) The machine was run at $C = 840$ μf and $E_o = 3000$ volts. The turns ratio of the welding transformer was $n = 150$.

From these data and Eq. (5) the critical turns ratio is determined to be $n_C = 575$. The time constant L/R is 7.9×10^{-3} sec.

The attenuation triangle is drawn as shown in Fig. 2. The following data are scaled from the triangle: $\delta = 15°$; $\phi = 75°$; $v = 222$, which corresponds to a natural frequency of 35.4 cps. With these data substituted into the above equations, the following results are obtained: $T_M = 5.9 \times 10^{-3}$ sec; $I_M = 475$ amp; $T_K = 8.2 \times 10^{-3}$ sec; $I_K = 406$ amp.

In the system with the shunt tube, commutation takes place at this moment T_K. An exponentially decaying current i_S flows from here on and comes to an end after a total duration of the weld of approximately $T_F = 40 \times 10^{-3}$ sec.

If the same system is operated with an inverse tube instead of the shunt tube, energy flows back from the secondary circuit through the series tube into the capacitors, which swing negative to $-E_{max} = 1300$ volts. There the inverse tube picks up, the inverse current rises to $-I_{max} = 200$ amp, and the residual positive capacitor voltage at the end of the weld is $E_F = 565$

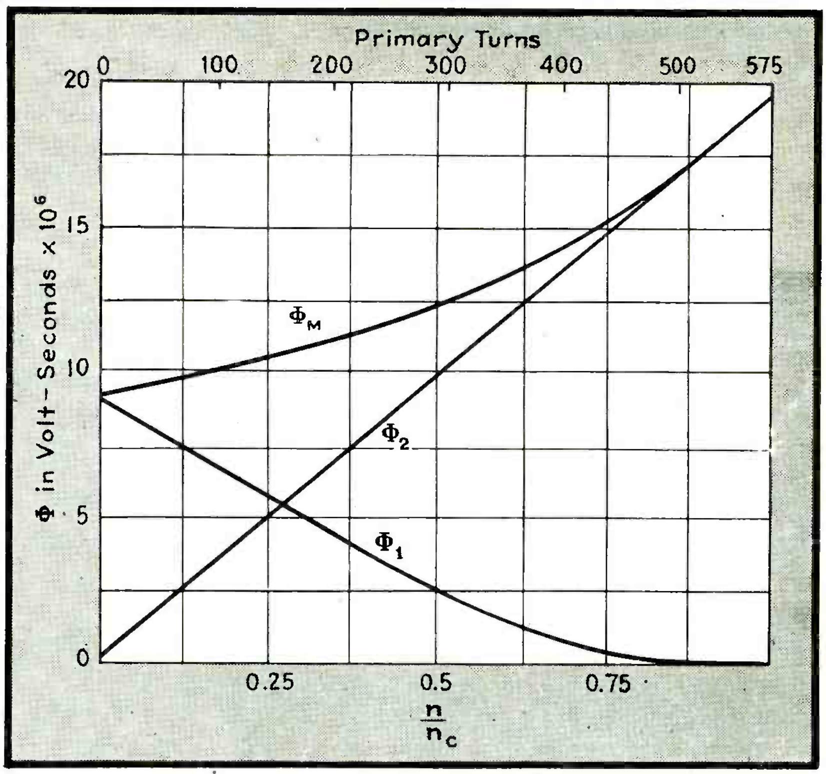


FIG. 4—Maximum flux in the welding transformer of a capacitor-discharge circuit, plotted as a function of the turns ratio. Circuit constants employed are those of the example

volts. The duration of the welding period is $T'_F = 28 \times 10^{-3}$ sec.

Flux Density in Welding Transformer

If the transformer saturates, the above equations do not apply any more because L becomes a function of i. The magnetizing current, which was neglected, grows to a substantial value; primary and secondary current wave shapes do not agree any more. Briefly, the primary current grows in peak value and in tail length, and its energy is largely wasted in the iron. Subsequent welds get weaker and weaker, and a danger point is reached if the tail is so long that the transformer is still energized when the next weld is started.

For these reasons a check of the maximum flux in the welding transformer is desirable. A relation between this maximum flux and the transformer turns ratio can be developed from the fundamental flux equation:

$$\frac{d\phi}{dt}\left[L\,\frac{di}{dt} + R\,i\right]\frac{10^8}{n} \qquad (17)$$

$$\phi_{max} = \frac{10^8}{n}\left[Li + Rit\right]_{E=0}^{E=E_0} \qquad (18)$$

$$\phi_{max} = \frac{10^8}{n}\left[LI_K + R\,C\,E_0\right] \qquad (19)$$

Here I_K is the commutating current of Eq. (10). Since I_K flows at zero voltage, which is the time when the capacitors have transferred their total energy into the welding circuit, these equations hold for circuits using an inverse tube as well as a shunt tube. Substituting Eq. (10) into Eq. (19), we get

$$\phi_M = E_0 \times 10^{-8}[\sqrt{L_S\,C}\;\epsilon^{-(\pi-\varphi)\tan\delta} + n\,R_S\,C] = \phi_1 + \phi_2 \qquad (20)$$

Thus ϕ_M can be readily figured when δ and ϕ are taken from the attenuation triangle (Fig. 2).

The maximum flux in capacitor impulse welding transformers is composed of two terms, ϕ_1 and ϕ_2. Only ϕ_2 is linearly growing with the turns ratio n; ϕ_1 is decreasing in a somewhat exponential manner from an initially high value, and disappears at the approach of critical damping. The sum ϕ_M rises very slowly at low turns ratios and, in fact, does not change too much under practical conditions.

Flux conditions for a transformer in the above calculated welding circuit are plotted in Fig. 4 over the transformer turns ratio. The total flux rises only about 60 percent for a change of turns ratio from 100 to 450 turns.

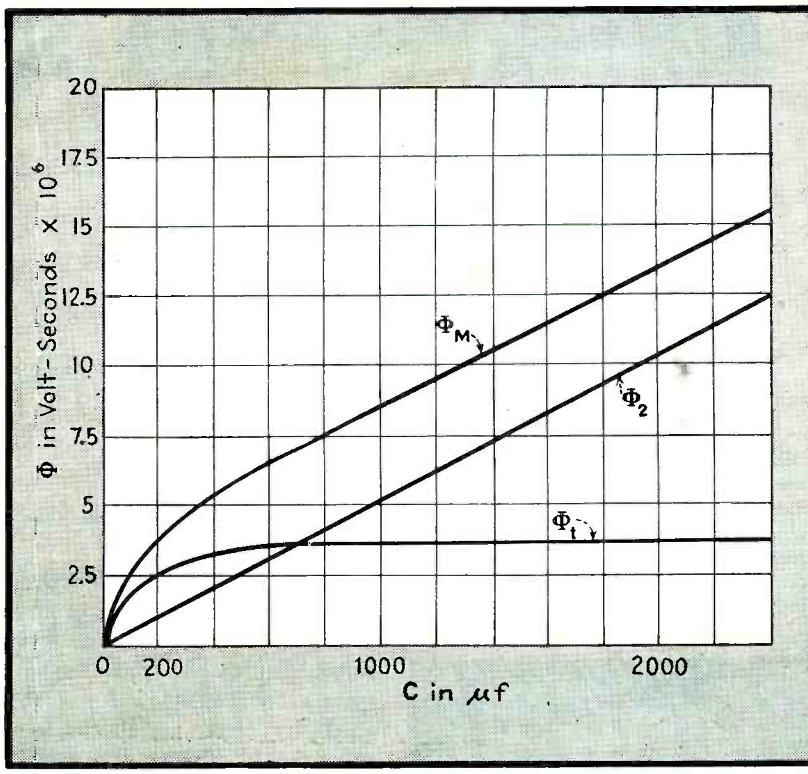
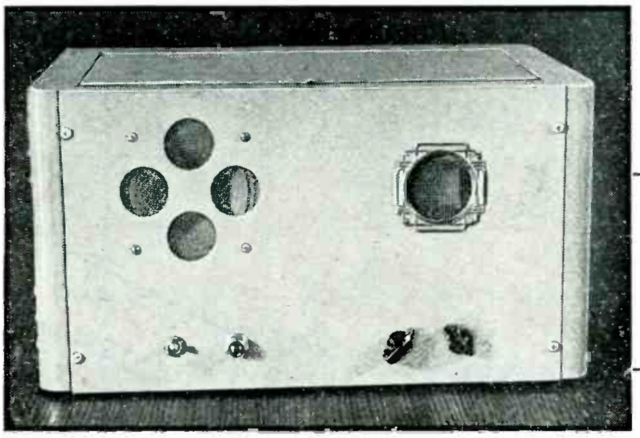


FIG. 5—Curves for maximum flux in the welding transformer as a function of capacitor size, with a constant turns ratio value n of 150. Circuit constants for these curves are those of the example in the article. The two lower curves are for the components that make up the maximum flux at each instant

While the maximum flux rises in proportion to the applied capacitor voltage, it also increases in an almost linear manner, though not in proportion, with the capacitor size. To illustrate this relation the flux conditions in the welding transformer are plotted in Fig. 5 under constant voltage and turns ratio as a function of the capacitor size. Again, as Eq. (20) shows, the two flux components rise in a different manner; one is proportional to the capacitance, and the other, except for very low values, is almost constant. The resulting maximum flux line is fairly straight for practical capacitor sizes. The flux scale of Fig. 5 applies to the above calculated welding circuit and a turns ratio of 150:1.

Some welding systems operate with such a high transformer turns ratio that the capacitor discharge is aperiodically damped. $(n>n_c)$. In these circuits the welding discharge is carried by the series tube alone and, since there is no reversal in the direction of power flow, the series tube may be replaced by a contactor. Disadvantages of this system are long duration of the welding discharge and a high flux in the transformer.

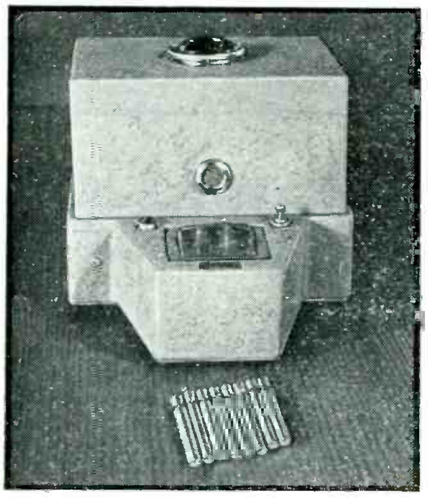
In all welding circuits using capacitor discharge power of substantially unidirectional flow, precautions have to be taken against saturation of the transformer resulting from incomplete demagnetisation after subsequent impulses. To this effect in some systems the primary transformer connections are reversed after each weld. This is done either by means of mechanical contactors or by a double set of discharge tubes. In other systems, electronic flux reset arrangements are used to counteract or reverse the residual transformer flux in the time between the welds. In systems handling small amounts of power only, sometimes an air gap in the welding transformer is provided.



Supersonic

By BOLEY A. ANDREWS
The Vendo Company
Kansas City, Mo.

Completed audio heterodyne amplifier used to pick up inaudible sounds, amplify them and produce a note of proportional loudness in the audible range. Loudspeaker grille is at left on panel, and crystal microphone grille at right



Supersonic instrument for inspecting steel punches. Punches are tapped on the anvil just under the grille protecting the crystal microphone. If the supersonic vibration frequency of a punch is outside the predetermined pass band, the indicator lamp at the top of the instrument is automatically turned on

In the manufacture and distribution of coin-operated beverage vending machines, one of the problems encountered was the loss of revenue when slugs were inserted in these machines. One of the solutions proposed was the measurement of sound frequencies given off by the various coins when set into vibration, as a means of slug detection. This naturally entailed the use of electronics as the means of detecting and selecting these sonic frequencies, and therefore an electronic research and development laboratory was established for the purpose by The Vendo Company about five years ago.

Experiments on specimens of various metals, made into slugs of the same dimensions as genuine coins, indicated that those slug metals having a lower modulus of elasticity than metals in genuine coins would vibrate at a lower frequency. A band pass of about 200 cycles was found to be necessary because variations in thickness of genuine coins due to wear required a little latitude in the detection apparatus.

A few models of slug rejectors using this principle of operation were constructed and tested, but development work on this project was suspended when the efforts of industry turned from peace to war production. All electronic research and development facilities of the company were then utilized to develop instruments for inspection of the thousands of parts which were produced for the various branches of the armed services. Supersonic experiments were conducted on small items such as bullet cores, projectiles, steel punches and small-caliber cartridge cases.

There are three methods of utilizing supersonics for the inspection of materials:

1. Vibrating the article being tested and checking the emitted tone against the tone of a standard specimen; 2. Measuring the duration of sound given off by an article when in free vibration; 3. Passing a supersonic wave through the piece to be tested and measuring the resulting reflection or absorption of the waves.

In the first method, standard specimens are set into vibration and their tones measured to determine the permissible range of tone frequencies. Each piece being tested is then similarly vibrated and its tone measured. Any appreciable difference in tone will then indicate the presence of a flaw. This method is now in use by various industries for testing files, grinding-stones and castings. However, these tests are made by the human ear since these items are of such dimensions that the frequency of vibration is audible.

Measuring Vibration Frequencies

When the frequency of vibration extends above the audible range, which is generally conceded to be above 20,000 cps, an instrument for making these sounds audible is required. This instrument is called an audio heterodyne amplifier. The circuit is shown in Fig. 1, and consists of an amplifier in which is contained a local oscillator that beats with the incoming sound frequency to produce a difference frequency in the audio range. This is similar to the superhetrodyne principle used in communications.

A satisfactory microphone for detection of supersonic frequencies is a type of crystal cell manufactured by The Brush Development Laboratories. This cell is made from rochelle salt crystals cut to resonate at definite frequencies, somewhat as quartz crystals are manufactured. Other types of microphones can also be used, such as a ribbon type in which the ribbon is stretched to resonate at the frequency desired, a condenser type in which the diaphragm is stretched, and a dynamic type in which the cone or diaphragm is made in the

Inspection Methods

Cracks, differences in hardness, changes in dimensions and variations in the composition of many materials can be quickly detected by new techniques utilizing supersonic frequencies. Three different methods, all involving electronic circuits, are described

form of a disc dimensioned to resonate at a certain frequency.

The types of flaws which produce deviations from normal frequency in an article are cracks, a change in hardness, changes in dimensions, and changes in composition. Not all articles can be tested by this method because of such factors as configuration and wide variations in dimensions, hence discretion should be used when trying to adapt this method of inspection to any specific item.

When an article is found which can be tested by measuring its vibration frequency, the procedure is as follows: Several good samples are procured and a frequency test is made. This test consists of vibrating the article by striking it on a hard surface and allowing it to vibrate freely, and picking up and tabulating the sound frequencies. The tabulated frequencies are then analyzed and the band widths established. Some bandwidth latitude is necessary because of small variations in dimensions in the articles.

Next, the production test instrument is constructed. It normally consists of an amplifier having a band-pass filter, a trigger tube and an indicator. The completed instrument will pick out any article which does not have the same vibration characteristics as the standard articles, regardless of whether the sound can be heard, since the tone differentiation is done in the tuned amplifier.

A circuit which has been used for frequency discrimination of sounds above 20,000 cps is shown in Fig. 2. This circuit is capable of good selectivity and will withstand ambient temperatures without changing the frequency response.

The circuit includes a pre-amplifier, a limiter, a broadly tuned fundamental amplifier and a harmonic generator using a triode as a class C amplifier. The triode is biased in such a manner that the tube conducts only when the voltage applied to the grid exceeds a nominal voltage, thus creating distortion of the signal and producing harmonics in the plate load. The plate load circuit is an i-f transformer resonating at about 175 kc. This is followed by a conventional i-f amplifier stage and a diode rectifier which provides a direct voltage for operating a trigger tube. The purpose of the tuned amplifier for the fundamental sound frequency is to allow only those frequencies which are in the prescribed band width to reach an amplitude great enough to operate the harmonic generator; selective harmonic generation is thus attained.

For an example, let us assume

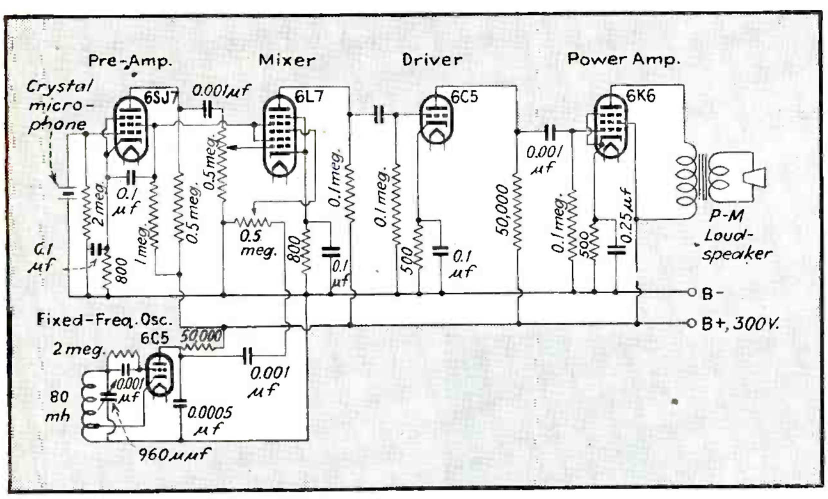
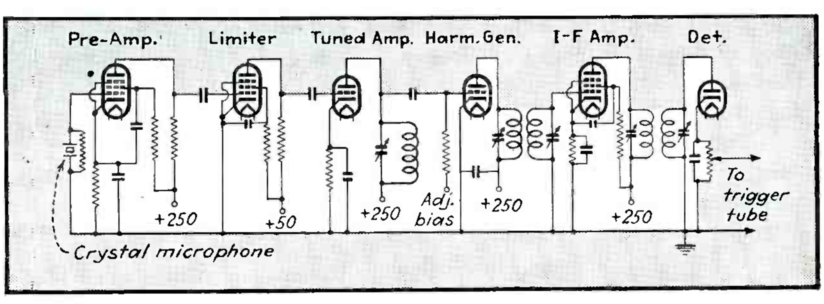


FIG. 1—Circuit of audio heterodyne amplifier used to make supersonic vibrations audible

FIG. 2 (right)—Circuit used to deliver a voltage to a trigger tube when supersonic vibrations picked up by a crystal microphone are outside predetermined supersonic frequency limits



that a band width of 100 cps peaked at 19,500 cps is required. The coil used in the amplifier preceding the harmonic generator would be peaked at 19,500 cps and have a Q of about 8. Since the input voltage to this amplifier is limited, the output to the harmonic generator will be a function of frequency. The bias supply on the harmonic generator is set so that only those frequencies which are about 200 cycles away on each side of the peak voltage will exceed it. Thus, harmonics are generated of these frequencies only since any other frequency will not have sufficient level to overcome this bias. The 9th harmonic of 19,500 cps is 175.5 kc, which is in the tuning range of standard i-f transformers. These transformers may be of the variable coupling type, and so provide a means for obtaining further band-passing.

By using this type of selective circuit it is possible to produce instruments which can be adjusted to any frequency by merely changing the microphone and the tuned coil used in the amplifier stage preceding the harmonic generator. The i-f stage can remain the same, selecting different multiples of the fundamental frequencies so as to be within the tuning range of the 175-kc coils.

Measuring Duration of Sound

The second method of flaw detection by supersonics involves measuring the duration of sound given off by an article when in free vibration. This system is now being used in its elementary form for testing glasses and goblets. It is also used for testing the bondage between two pieces of metals, as in steel-backed bronze bearings. In these applications the testing is all done by the ear, and the article is struck or dropped to produce vibrations.

When an object is set into free vibration, the amplitudes of these vibrations decrease exponentially. This is due to internal friction of the object and is known as the damping property of vibration.

A method of determining the specific damping capacity is by measuring the logarithmic decrement of vibration. This can be obtained by vibrating the object first at its natural frequency, then at

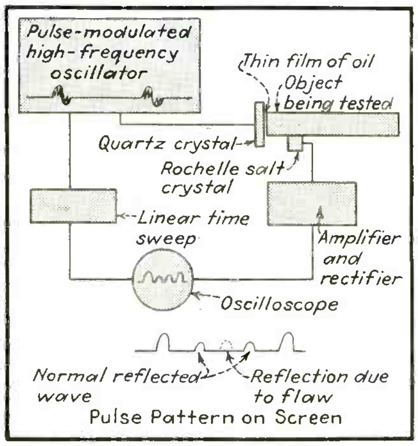


FIG. 3—Flaw detection by observation of reflected supersonic waves

frequencies on each side of the peak frequency, and noting the amplitudes. The analysis is somewhat like the Q measurements taken on coils. The logarithmic decrement e is based upon the resonance curve formula $e = \pi (f_1 - f_2)/f_0$, where f_0 is the frequency at resonance and f_1 and f_2 are frequencies on either side of resonance at which the amplitude of vibration is $1/\sqrt{2}$ times the amplitude of vibration at resonance.

The apparatus required for this type of test includes an audio oscillator, a vibrator, an oscilloscope and a vacuum-tube voltmeter. The standard specimens are first tested and the decrement noted. Any object producing a different value of decrement is rejected.

Measuring Absorption of Supersonic Waves

The third method used in supersonic testing is that in which the supersonic wave is actually passed through the piece to be tested and the resultant reflection or absorption of waves measured. This method is more precise that the two previously mentioned systems, but is more involved and requires a larger amount of apparatus.

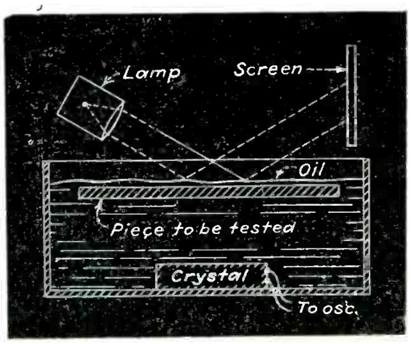


FIG. 4—Flaw detection by immersing specimen in oil and sending a supersonic beam through it. Amount of light reflected from surface of oil is proportional to amount of supersonic energy passed by piece to be tested

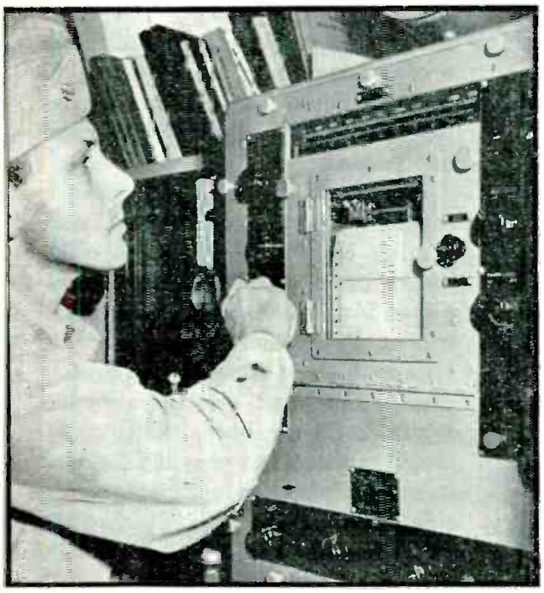
The object being tested is mounted on a suitable support, and a quartz crystal is attached to one end of the test specimen, as shown in Fig. 3. This crystal is connected to a high-frequency oscillator that is pulse-modulated by a low-frequency oscillator. A rochelle salt crystal for picking up the pulses is also attached to the specimen. This crystal is connected through an amplifier and rectifier to a cathode-ray oscilloscope for visual observation of the reflected waves traveling along the test specimen.

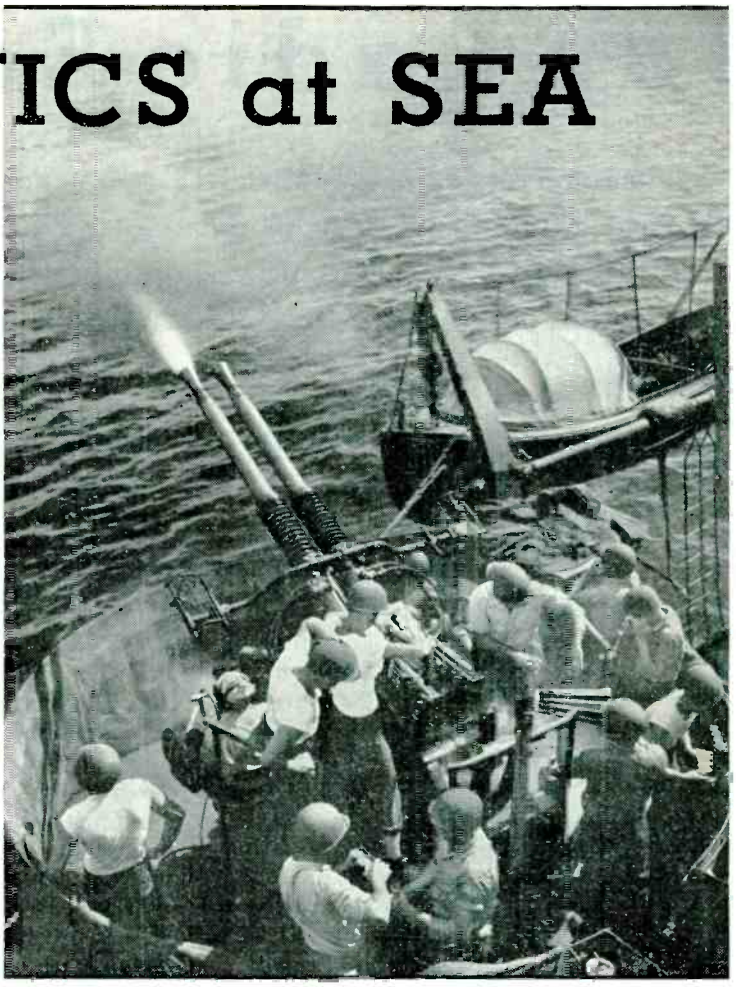
The test is conducted first on several standard specimens, and the reflected waves are noted on the oscilloscope screen. The pattern is a series of reflected pulses which occur at frequent regular intervals when the specimen is flawless. If a flaw exists, there will be in the pattern an extra pulse which is not obtained with a good specimen; this is indicated by the dash-dash curve in the pulse pattern in Fig. 3. If the specimen is a uniform bar, the distance between pulses in the train of reflected waves can be calculated. On specimens of non-uniform structure the reflected waves are compared with those of a standard specimen.

A variation of this method is as follows: A quartz crystal which is connected to a supersonic-frequency oscillator, is submerged in a pool of oil as in Fig. 4. The crystal will send sound waves vertically upward in a beam. At the point where the beam hits the surface of the oil, a light ray is focused and is reflected onto a screen. The piece being tested is immersed in the oil and placed in the sound beam, and the variations in the intensity of the reflected light on the screen are used as an indication of the quality of the specimen being tested. This method was used experimentally by Sokoloff of U.S.S.R. in 1934, and more recently has been used to inspect tires immersed in a tank of water. Any change in the transmissibility of supersonic waves through the tire as it is slowly revolved in the tank will indicate the presence of flaws.

ELECTRONICS at SEA

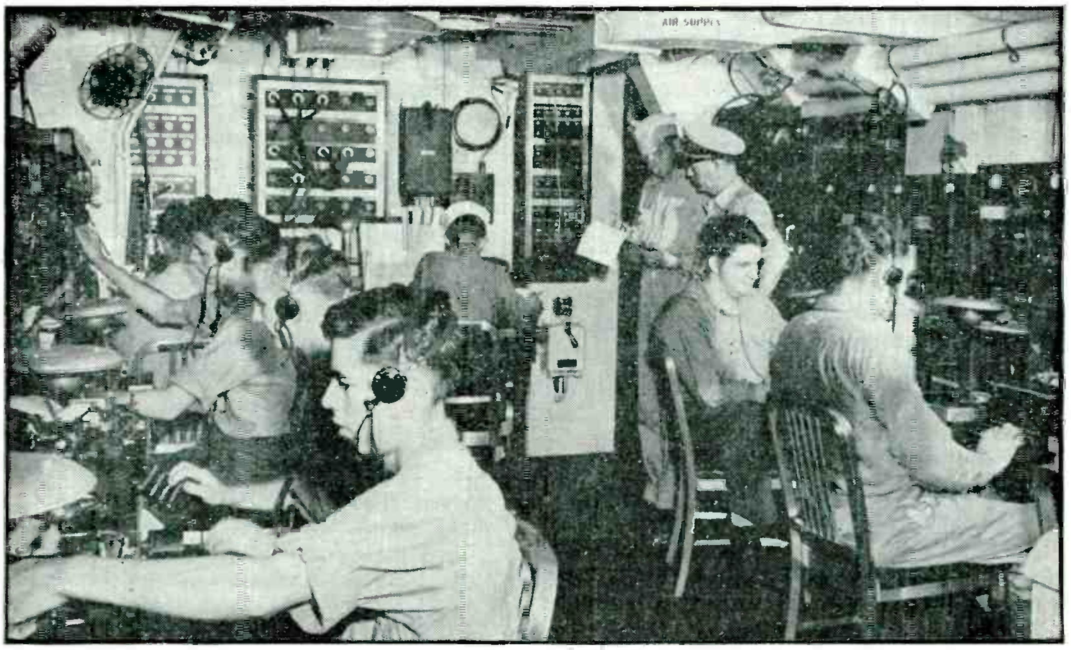
Official U. S. Navy photographs of communications and other equipment in operation aboard a new light cruiser during its shake-down cruise





Range information for anti-aircraft guns is transmitted by inter-ship phone from control stations. The pointer, seated on gun mount at left, adjusts for elevation while the trainer, seated at far right, maintains horizontal position on the target

Left: The navigator takes depth readings from an electronic fathometer



Men in the communications center maintain contact with other ships of the fleet and bases by radio and handle the inter-ship phone system. During the shake-down cruise, the crew learned how to operate equipment under combat conditons

Jap Radio Equipment

A detailed description of the Model 13 command set, a 7 to 11-Mc transmitter-receiver employing cw, mcw and voice modulation and used on scout-bombers and reconnaisance planes. German-Japanese equipment comparisons are also made

By R. A. GORDON *Chief of Aircraft Section, Naval Research Laboratory Anacostia Station, Washington, D. C.*

FROM THE DESIGN, construction and use of component parts employed in captured equipment described here and in previous articles[1, 2] it may be deduced that the pre-war thought and preparation of our two enemies was based on different ideas entirely.

In German equipment we see clear evidence of years of engineering planning with particular emphasis upon mass production, including standardization of parts. Intensive use of non-strategic materials to replace or reduce the use of strategic materials, all assembled to operate under climatic conditions found in North Atlantic atmosphere, indicates that most Nazi equipment was designed for operation under conditions encountered in a temperate zone. Use of medium-power transmitters, short-range direction-finders and other similar gear further indicates that it was to be used primarily in the battle of Britain.

In Japanese equipment we find a different thought uppermost. We find little evidence of careful engineering or planned production. Instead, there was obviously frantic purchasing of all kinds of component parts and materials, mainly from this country, during the period from 1925 to 1940. This would lead one to believe that the Japs purchased outside their own country all possible gear, thus deliberately saving their own metal stores particularly for other war purposes. Possibly the thought was that by the time amateurishly-assembled equipment was used up or lost Nippon would have access to other mineral sources.

The outstanding circuit difference between German and Japanese equipment appears to be the German omission of crystal control, which was probably not considered necessary except in master-control stations due to the short intended range of operation, and the extensive Japanese use of crystal control to keep equipment exactly on frequency, apparently because of the great distances they expected to cover.

Japanese High-Frequency Command Set

The Japanese Model 13 is a command set used in scout bombers and reconnaisance planes. CW, mcw, and voice operation is provided.

The complete equipment consists of the three basic units: transmitter-receiver, a high-voltage dynamotor, and a low-voltage dynamotor (or vibrator-type supply).

The transmitter consists of a crystal-controlled oscillator-doubler combination providing two pretuned channels in the band between 7.6 and 10.6 Mc at a maximum power output of 26 watts cw and 9 watts telephone.

The receiver is a superheterodyne covering a frequency range of 7.6 to 10.8 Mc, having a variable-frequency oscillator and also two crystal-controlled frequencies.

One dynamotor supplies 1000-v d.c. from a 100-v d.c. source. The other dynamotor supplies 250-v from a 12-v d.c. source. All heaters, filaments, and relays operate from the 12 volt d.c. input voltage.

Mechanical Details

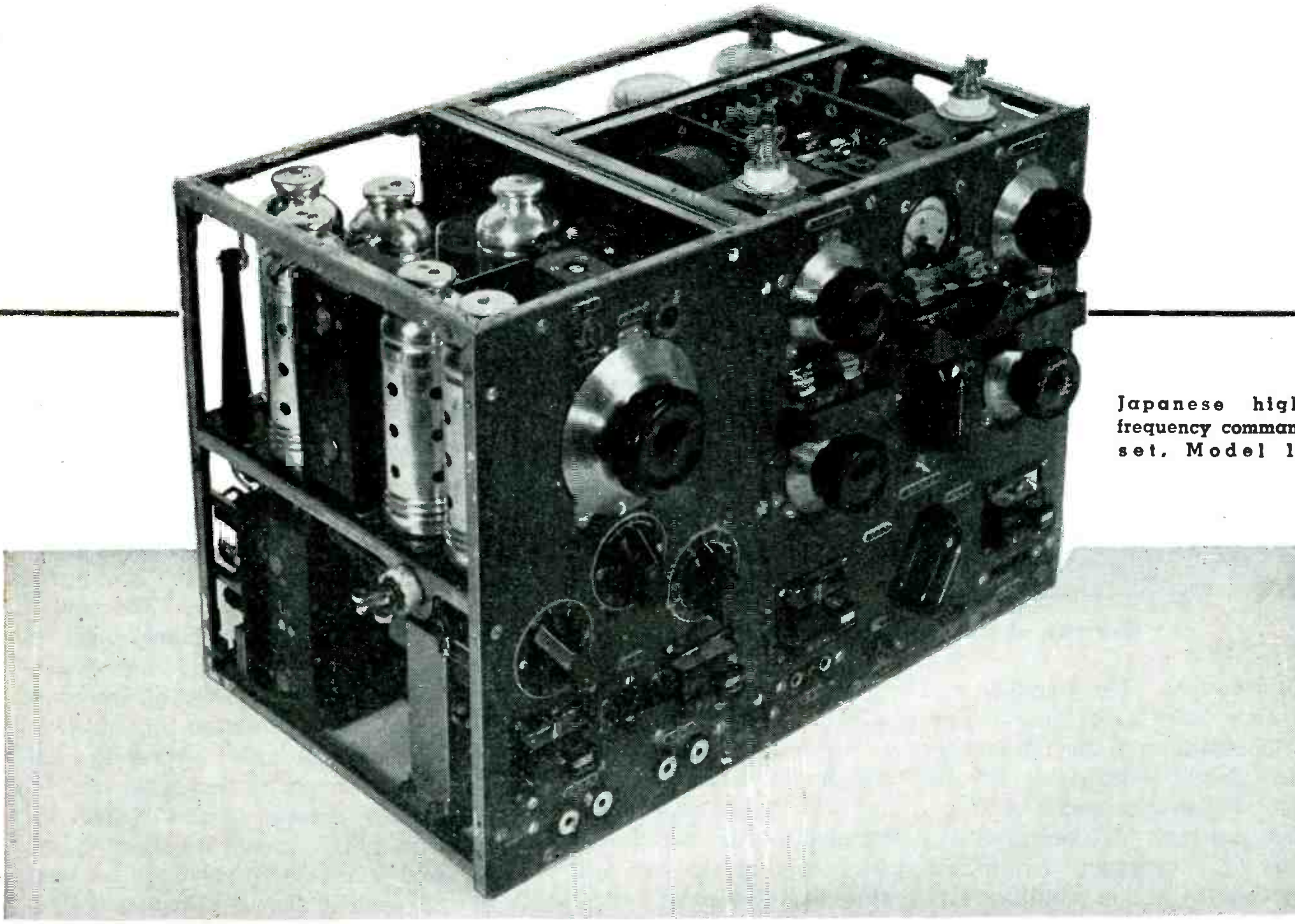
The transmitter-receiver is composed of two separate units. The components are mounted on metal shelves mounted in two small racks made of aluminum and brass angle stock. These racks are clamped together to form the receiver-transmitter unit.

Inter-unit shields and outside covers are made of sheet aluminum. Tuning capacitor plates and other metal parts are made of nickel-plated brass with Bakelite or hard-rubber insulation. Toggle switches appear to be of American manufacture. Band and selector switches are Bakelite or hard-rubber insulated. Outside covers are finished in olive-drab crackle-finish and inside metal parts are finished in olive-drab enamel.

Tube shields are made of thin aluminum, are screwed onto tube sockets, and are equipped with top covers having press-formed handles to facilitate removal.

Dials are of nickeled brass with planetary reduction drives (similar to obsolete American units). Bakelite bar knobs are used on both transmitter and receiver. Receiver output terminals are intended to receive banana-type plugs. The telegraph key socket receives a slit-prong plug, whereas the microphone and telephone changeover switch input plug probably had solid prongs, as spring-pressure contact points are provided in the receptacle.

Power cables are provided with split-contact female plugs on the transmitter-receiver end and solid-prong male plugs on the supply end, split-contact receptacles being used. Tube sockets in the receiver are made of a yellow-brown plastic. The transmitter tube sockets are of



Japanese high-frequency command set, Model 13

white ceramic and are standard American types.

Resistors and other small parts mounted very close to the bottom of the transmitter racks are insulated from the bottom by means of thin sheets of mica glued to the bottom cover.

Fuses are accessible through removable snap-fastened cover plates mounted on the front panel. Other parts are not readily accessible for servicing even after screws and cover plates are removed. Frequency-change switches and selector switches are particularly inaccessible.

A calibration chart for the receiver is mounted in a small celluloid-covered window in a removable access cover on the top of the unit. A circuit diagram is mounted on the underside of the removable cover.

Controls, instruments, indicator lamps, and terminals are well labeled by means of small aluminum tabs inscribed with natural metal characters on a black background.

The following tubes are used:

Jap. Type	Function	Comparable American
UZ6D6	R-F Amp. (Receiver)	6D6
Ut6L7G	Mixer (Receiver)	6L7G
UY76	High-Frequency Oscillator (Receiver)	76
UZ6D6	I-F Amp. (Receiver)	6D6
Ut6B7	Detector — AVC — Audio Amplifier (Receiver)	6B7
UY76	Beat-Frequency Oscillator (Receiver)	76
UZ41	Audio Power Amplifier (Receiver)	41
UY76	Side-Tone A-F Oscillator (Receiver-Transmitter)	76
UZ510	Pentode Crystal Oscillator (Transmitter)	RK20
UZ510(2)	Pentode Power Doubler-Amp. (Transmitter)	RK20

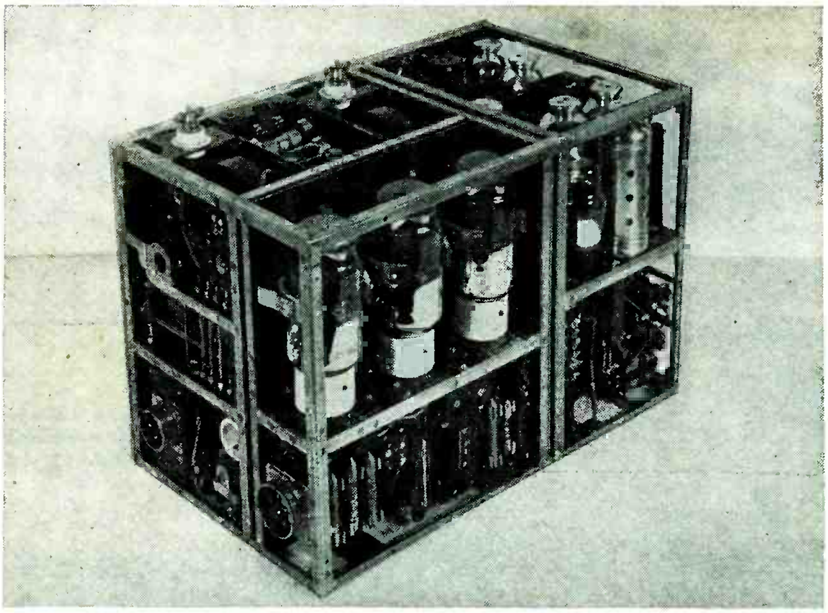
All receiver tubes are of the oxide-coated heater type for operation at 6 v. in series-parallel, whereas transmitter tubes operate at 12 v and are of the thoriated-tungsten filament type.

The Transmitter

The transmitter unit has the following operating controls: Two antenna variometers, two two-gang oscillator and amplifier tuning capacitors, one two-position frequency-change switch, one four-position control switch (*Left* Break-In, *Up* Off, *Right* Stand-By, *Down* Transmitter Oscillator On, With Low Voltage), one send-receive switch, and one switch for shorting the key terminals.

The transmitter consists of a regenerative high-power pentode crystal oscillator, capacitance-coupled to two power pentodes operated in parallel as frequency doublers. For cw operation break-in may be obtained by means of relays cutting the screen-grid supply for both oscillator and amplifier stages, or the oscillator may be switched on by means of the send-receive switch and the amplifier keyed by means of a relay controlling its screen supply only.

For telephone operation the telephone change-over relay is energized by means of a switch on the microphone which also operates the break-in relays. Suppressor-grid modulation is obtained by means of a microphone transformer in the suppressor-grid return lead of the



Rear view of Jap Model 13 transmitter-receiver

amplifier tubes. The amplifier grid and suppressor grid bias voltages are increased and the microphone input circuit completed by the phone change-over relay.

The antenna is energized by means of a two-turn coil inductively coupled to the amplifier tank coil and is tuned by means of the antenna variometers and an external fixed air capacitor in series with the ground-return circuit. A thermocouple r-f ammeter is connected in series with the antenna lead. Neon indicator lamps are capacitively coupled to the oscillator tank tuning circuits to provide indication of oscillation and of the channel in use.

A neon lamp is connected across the microphone transformer to prevent development of high peak voltages. A neon lamp is also used across the high-voltage fuse to indicate burnout.

Channel switching is accomplished by means of a front panel two-position switch which selects the proper crystal and the proper antenna variometer, and also selects the proper two-gang variable capacitor tuning the oscillator and amplifier plate tank circuits, the same coils being used for each channel.

The Receiver

The receiver is provided with the following controls: Main tuning dial controlling the variable-frequency oscillator, r-f amplifier and mixer circuits; a three-position selector switch allowing selection of either of two crystal frequencies or the variable-frequency oscillator; a beat-frequency oscillator vernier tuning capacitor; a switch for shorting the avc and placing the beat-frequency oscillator in operation; a switch opening the cathode circuit of the r-f amplifier and thereby rendering the receiver very insensitive.

The frequency-change switch operates on the oscillator circuit alone and connects either the oscillator coil or either of two crystals. It is necessary to resonate the r-f and mixer circuits by means of the main tuning dial for each crystal frequency.

The receiver consists of a variable-mu pentode r-f amplifier, a pentagrid mixer and a triode tuned-plate oscillator which is used as an untuned (Pierce) oscillator for crystal frequencies. The mixer is followed by one stage of variable-mu pentode i-f amplification operating at 628 kc. A diode second detector and diode automatic volume control are used, followed by a pentode voltage-amplifier stage, a double-diode-pentode tube being used for these stages.

A triode is used as a beat-frequency oscillator, coupled to the i-f amplifier plate. The audio-output stage uses a power pentode. Also located on the receiver chassis is a triode audio-frequency oscillator for use as a cw sidetone oscillator. Gain is controlled by a potentiometer varying cathode bias on the r-f, i-f and mixer tubes. High-impedance output is provided, headphones being coupled by means of a capacitor and choke coil directly to the plate of the pentode a-f output tube.

Sidetone for monitoring is provided on both telephone and cw. For cw an audio oscillator using a triode tube receives its plate voltage from the positive side of the 12-v battery through the keying relay. The output of this audio oscillator is connected through an r-f choke to a neon lamp and through the neon lamp, a resistance, another r-f choke and a capacitor to the input of the final audio stage of the receiver. The output of the microphone transformer is also coupled through a high resistance to the input side of the same neon lamp. The neon tube itself is capacitivly coupled across the antenna circuit, so that when the r-f voltage present in this circuit becomes high enough the lamp ionizes and allows the sidetone to pass through it and be heard in the receiver headphones. The net effect of this arrangement is to provide positive assurance that at all times when the sidetone can be head r-f voltage is present across the antenna circuit.

The Dynamotors

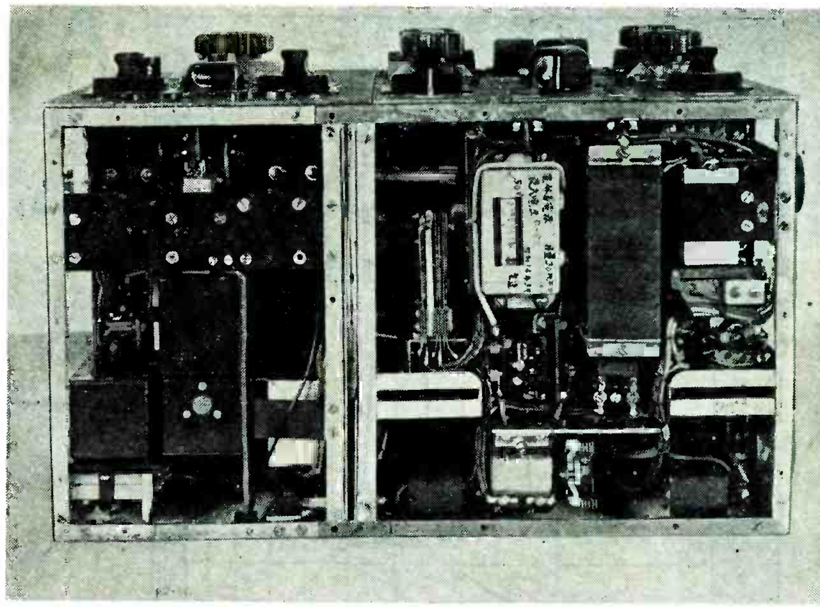
The 250-v dynamotor is rated at 60 ma, drawing 3 amperes. The 1000-v dynamotor is not supplied with a data plate but it is apparently called upon to supply 170 ma at full load, which at 50 percent efficiency would mean a drain of 3.4 amperes. Both units were received in an inoperative condition, and no operating data is available at this time.

The circuit diagram supplied with the equipment shows a vibrator-type supply in use in place of the 250-v dynamotor which was received with the equipment.

The estimated total weight of the complete Model 13 command set equipment ready for operation is 82.5 lb including an allowance of 1.5 lb for headphones and 2 lb for microphone, cable, plugs and control switches necessary for operation.

Four crystals were supplied with

the equipment. The receiver as received was equipped with two crystals designated 8590 kc (C/2) and 7635 kc (1/2). The transmitter was supplied with two crystals designated 8905 kc (1/2) and 8590 kc (1/2). Only the 8590 kc (C/2 was labeled with the Japanese symbol for "receiver." Only the 8905 kc (1/2) crystal could be made to oscillate and its fundamental frequency was found to be 4452.5 kc. Examination of other crystals showed that their fundamental frequencies were one-half those indicated on their plates, making it evident that the designation (1/2) indicates doubler service.



Bottom view of Model 13 aircraft equipment

Test Results

All transmitter measurements were made with a dummy antenna load of 10.35 ohms and 150 $\mu\mu$fd. All receiver measurements were made using a 20,000-ohm output load. These load values yielded maximum output. Receiver sensitivity measurements were made on the basis of microvolts input required to give selected standard output using an r-f input signal, modulated 30 percent at 400 cps.

Receiver Performance

An average receiver sensitivity of 13 microvolts at 10 milliwatts output was obtained. Selectivity is as follows: The overall bandwidth at 6 db down is 19 kc and at 40 db down it is 121 kc, at a frequency of 8905 kc.

The receiver has a poor avc characteristic, the avc serving mainly as a means of preventing blocking at very high levels. With no avc, maximum output is 2.7 watts, obtained at 1000 microvolts; input blocking sets in rapidly after this level is exceeded. With avc on, action starts at about 400 microvolts and the output levels off, 2.7 watts being obtained at 0.1 volt input.

Frequency stabilization was found to be poor. Taking +20 deg C as a zero point, the deviation at −30 deg C was +67 kc, or 0.7 percent. At +50 deg it was −40 kc, or 0.42 percent. The average over the whole range shows a variation of 1.2 kc per degree of temperature change.

Sensitivity was 10 microvolts at +20 deg C and remained fairly uniform until a temperature of −10 deg C was reached. At a few degrees beyond this point the sensivity fell off very rapidly, reaching 300 microvolts for 50 milliwatts at −20 deg C and −30 deg C. The freezing of the electrolyte in the electrolytic capacitors largely accounts for this sudden variation at low temperatures.

The variation of receiver frequency with variation of humidity from 25 percent to 97 percent at a constant temperature of 40 deg C was −27 kc, or 0.28 percent at 9466.7 kc, whereas sensitivity decreased from 13 to 20 microvolts for 50 milliwatt output.

The image-rejection ratio varies from 22 db at 7.6 Mc to 35 db at 8.86 Mc. These values for image rejection compare unfavorably with those for similar equipment of modern design, which are usually 60 db or greater. The i-f rejection ratio indicates an attenuation of 49 db at 7.6 Mc and 57 db at 10.8 Mc. These values compare unfavorably with those of similar equipment of modern design, which are usually 80 db or greater.

The audio system is sharply peaked at 1000 cps, being −17 db at 400 cps and −23 db at 4000 cps. The narrow pass-band results in some improvement in signal-to-noise ratio for cw reception but hurts speech intelligibility.

Transmitter Performance

Transmitter power output remained substantially constant when humidity was varied from 30 percent to 97 percent, whereas the frequency varied 100 cps. On the first high-humidity test a small mica bypass capacitor arced from its high-voltage terminal to a grounded mounting-screw. Considering the 1000-v plate supply across the small spacing allowed, this is probably a not unusual occurrence when operating at high temperature and humidity.

The microphone transformer input voltages (Microphone output) required for various modulation percentages show that with 1 volt at 1500 cps 33 percent modulation was obtained, 2.7 volts being required for 100 percent modulation. With a standard single-button microphone, 35 percent modulation was possible with loud speech input.

Since the audio system consists merely of the microphone input transformer and voltage supply, the fidelity characteristic was plotted on the basis of percent modulation at each audio frequency. The response is substantially flat from 400 to 4000 cps, with rising high-frequency response to cutoff at 8000 cps. This range is adequate to provide satisfactory speech quality.

The audio distortion characteristic of the transmitter was found to be adequate. At 70 percent modulation at 1000 cps, the total harmonic distortion was 7.3 percent. At 400 cps and 50 percent modula-

(Continued on page 339)

Alternatives

By FREDRICK E. HANSON*

Western Electric Co. Kearny, N. J.

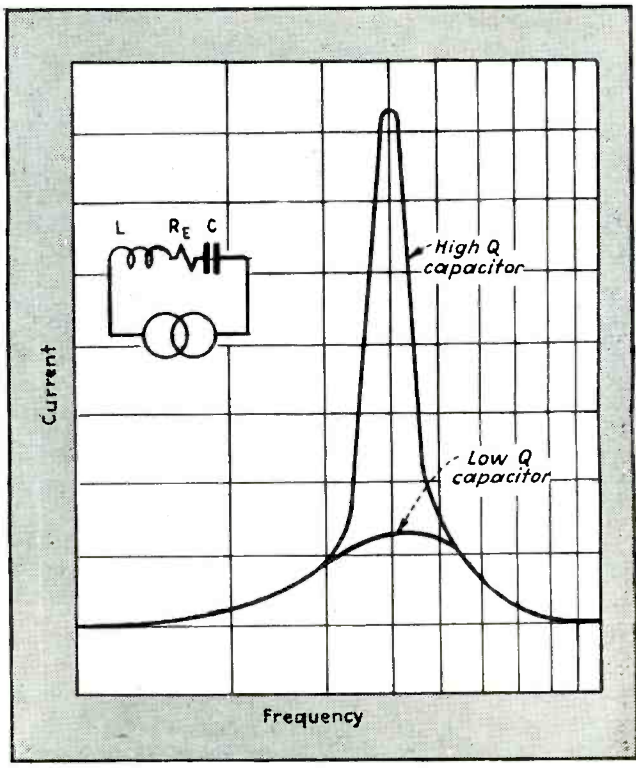


FIG. 2—Curve showing the reduction of current in a resonant circuit due to the additional resistance of a low-Q capacitor

MICA, because of its many intrinsic qualities, including low power factor and stability under a wide range of temperature, is a desirable dielectric for capacitors used in communications equipment and other types of electronic circuits. That the mica capacitor is important is indicated by noting the national production figures for 1943, which reached a rate of about 500,000 capacitors per day.

Although mica capacitors are widely used, and are essential to some circuit applications, it is of interest to note that they have been used extensively in places where other types of capacitors would serve equally well. In view of the demand for mica, it is necessary that we be economical in the consumption of our supply. This suggests a careful review of mica capacitor usage with a view toward applying alternative types of capacitors as far as possible without deleterious effect on the operation of electronic equipment.

Conservation of mica, by using other capacitors where they provide adequate electrical qualities, will assure that the supply of strategic mica will be ample for all the necessary applications. Therefore, let us analyze the qualities of capacitors necessary for some of the more common applications in electronic equipment.

Design Considerations

Fixed capacitors are made of two conducting surfaces separated by an insulating medium, the dielectric. The properties of the capacitor are determined, to a large extent, by the kind of dielectric used. Included in the family of dielectrics are mica, paper, air, glass, ceramics, as well as some recent developments in other dielectric materials.

Electrical losses in capacitors are due to a number of factors, one of which is energy dissipation in the dielectric. These losses may be considered as an equivalent series resistance or effective shunt resistance. The value of this resistance will, of course, determine the power factor of the capacitor. The power factor may be expressed approximately as $R_e\omega C$, where R_e is the effective series resistance in ohms, C the capacitance in farads and ω is $2\pi f$.

The power factor is one consideration in selecting the capacitor required for a given circuit application. Often, in circuit design work we use the expression "Q" to describe capacitor properties. For the higher Q values this is the inverse of the power factor; thus a mica capacitor having a power factor of 0.0005 may be described as having a Q of 2,000.

Another consideration is the stability of capacitance over the operating temperature range. This is particularly important in certain circuit positions of electronic equipment for military use, because of the very wide temperature ranges encountered. Temperatures as low as -55 deg C are commonly encountered in aircraft at high altitudes. Temperatures as high as $+120$ deg C are not unusual in or near dynamotors in aircraft or on ground equipment. The stability in this respect is usually expressed as the temperature coefficient of capacitance. Mica capacitors of the best construction have a temperature coefficient of less than 50 parts per million per deg C over wide operating temperatures.

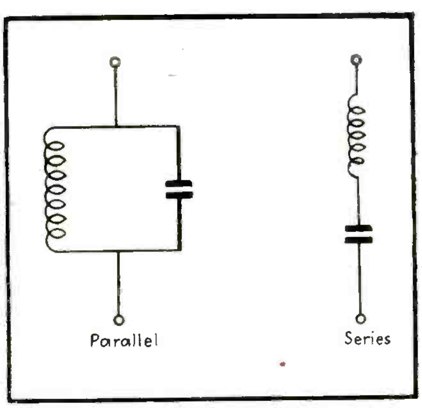
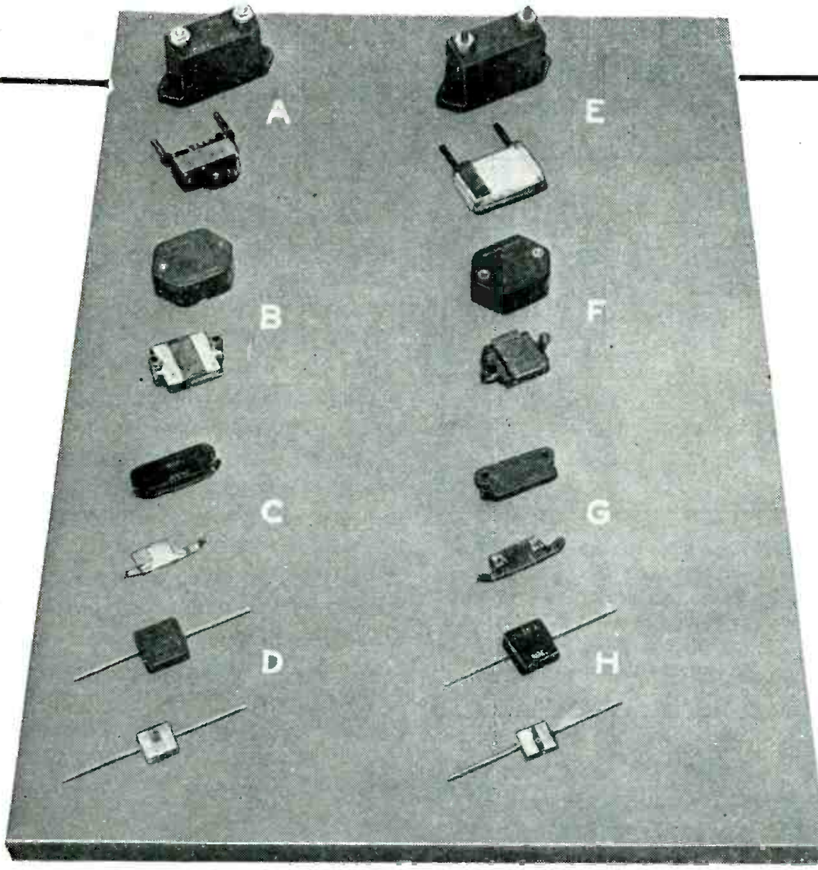


FIG. 1—Fixed-tuned resonant circuits generally require capacitors having high Q

* Member, U. S. Mica Mission, W.P.B., to United Kingdom.

for MICA CAPACITORS

Conservation of high-grade mica, necessary at this time, can be accomplished by use of other dielectric materials in capacitors. The operation of electronic equipment with such alternative capacitors is discussed by analysis of typical circuit applications



Typical mica capacitors and their unit assemblies are shown at *A, B, C* and *D* (left). Alternative types that are mechanically interchangeable are (right): *E*, glass capacitor; *F*, molded Lectrofilm capacitor; *G* and *H*, molded paper capacitor

A companion factor is the "retrace" characteristic, that is, the degree to which the capacitance will return to its initial value at a given temperature after going through the variations which the capacitor experiences in use. In this respect, also, mica capacitors are attractive because they will retrace to within 0.1 percent when carefully constructed.

Last, but by no means least, the capacitor should be capable of withstanding its impressed voltage at any or all operating temperatures without failure during the useful life of the electronic equipment. Mica capacitors of proper design have outstanding performance in life over the entire temperature range mentioned.

Applications for High-Q Capacitors

High-Q capacitors are used in selective circuits designed to resonate at one frequency and discriminate against all others, as in the tuning networks of radio receivers. Such parallel or series resonant circuits are represented in Fig. 1. The tuned circuits illustrated contain a fixed inductance and a fixed capacitance. The resonant frequency is represented as $f_r = \frac{1}{2\pi\sqrt{LC}}$, where L is the inductance in henries and C the capacitance in farads.

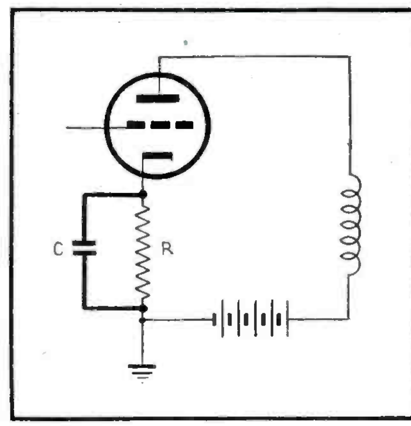


FIG. 3—When used for by-passing, a capacitor may have a low Q without materially affecting the by-pass action

Unfortunately, we do not have inductance without some effective resistance. Likewise the capacitance also has effective resistance, due largely to losses in the dielectric, as previously mentioned.

The current flowing in the circuit illustrated in Fig. 2 is

$$I = \frac{E}{\sqrt{R_e^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

From the equation it may be seen that at the resonant point, when ωL equals $\frac{1}{\omega C}$, the current is large if R_e is small. However, the current is a lower value when the effective resistance is larger. It is evident, therefore, that high-Q capacitors, which have a negligible effective resistance, provide good selectivity while low-Q capacitors produce a broadly tuned circuit. In such selective circuits mica or air capacitors are of great value and are necessary to the best performance of the tuned network. Unless a continuous adjustment of capacitance is required, the mica capacitor is preferred because of its small size.

In most cases the tuned networks are fixed at some particular frequency by factory adjustment and no provision is made for adjustment in service. Here it is obviously desirable that the circuit remain tuned at all temperatures encountered and at all times throughout the normal life of the electronic equipment. The fact that well constructed mica capacitors fulfill these requirements provides a strong argument for their use in tuned circuits.

High-Q capacitors are also required for a number of transmitter applications in order to minimize power dissipation. A primary consideration here is the ability of the capacitor to carry radio-frequency current. These applications require high quality mica capacitors. It is for such usage that we must assure ourselves of an adequate supply of mica.

By-Pass Capacitors

A common use of the fixed capacitor is to provide a by-pass for alternating current. A typical circuit of this type is illustrated in Fig. 3. In this application, the direct current through the vacuum tube flows through the voltage-dropping resistance *R*. Capacitor *C* is used to provide a separate lane of lesser impedance for the a-c signal.

In this application, the effective resistance of the capacitor is so masked by resistance *R*, which it shunts, that it is not an important factor. If we assume *R* to be 1,000 ohms, *C* to be 0.006 μf and the frequency to be 1 megacycle, the impedance varies less than 0.1 percent when an alternative capacitor having a Q of 100 is used to replace a mica capacitor having a Q of 2,000. This impedance change is unimportant since either the resistor or the capacitor may vary by 5 percent or more. In fact, capacitors for by-pass purposes are seldom critical; tolerances of greater than 20 percent are often permissible. By-pass capacitors, therefore, may be of a low-Q design and a mica dielectric is not usually required.

In actual practice, mica capacitors are frequently used in by-pass circuits, and since such capacitors are of larger values they therefore consume a large percentage of good mica.

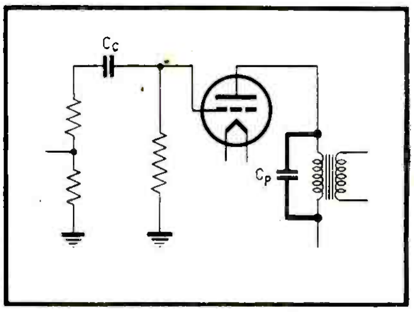


FIG. 4—In audio-frequency amplifiers, both the coupling capacitor C_c and the capacitor C_p across the transformer primary may be low-Q types

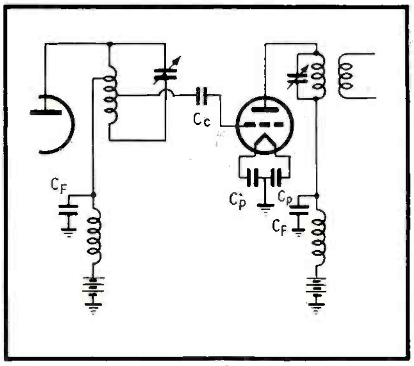


FIG. 5—Capacitors used across low impedance circuits, such as C_p, may have a fairly large dielectric loss without affecting operation of the circuit. Capacitors C_c and C_f are often low-Q types in current production

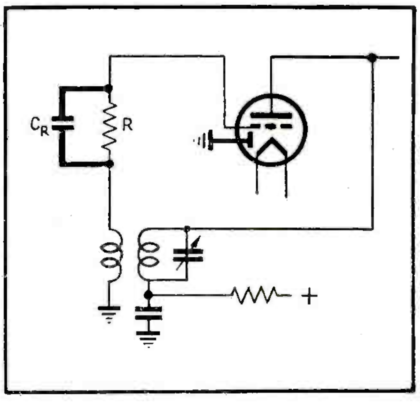


FIG. 6—Detector and oscillator circuits with grid-leak bias arrangements are not materially affected by low-Q capacitors when the leak resistance is small compared to the effective shunt resistance of the capacitor

Other Applications for Low-Q Capacitors

In the resistance-coupled audio amplifier illustrated in Fig. 4 the coupling capacitor C_c need not have a high-Q value. Here, the effective resistance of the capacitor is masked by the resistance of the coupling network.

In the audio amplifier of Fig. 4, capacitor C_p across the audio-transformer primary serves to peak the frequency characteristic. In this circuit the effective resistance of the transformer winding completely masks the capacitor resistance, even when its Q is only 100. It is possible to replace mica capacitors for this application by employing alternative types which use other dielectric materials.

Several capacitors used in the radio-frequency circuit of Fig. 5 may be low-Q types. The coupling capacitor C_c and the filter capacitors C_F have been replaced by paper types in equipments now being manufactured. Similarly the filament bridging capacitors C_p are connected across the resistance of the tube filament and the dielectric loss is a relatively unimportant consideration of the design.

In detector circuits, a commonly used device consists of a capacitor C_R bridged by a grid-leak resistor connected in the grid circuit of the detector tube as illustrated in Fig. 6. The capacitor serves to produce an audio voltage across resistor *R*. Since the resistor functions as a leakage path across the capacitor, the circuit operation is not affected by the Q of the capacitor provided the effective shunt resistance is high compared to *R*.

Alternative Capacitors

The possibilities of using low-Q capacitors in electronic equipment are many. Each such diversion serves to conserve good mica for essential applications. Capacitors which may be used as alternatives to the mica types are obtainable in molded and potted styles which are mechanically interchangeable with their mica prototypes. The photograph at the head of this article illustrates several types of mica capacitors and the alternative ones made with certain other dielectric materials. The substitute capacitors may use oil-treated paper, glass titanates, manufactured bentonite film or other materials. Such ca-

(*Continued on page* 212)

INVESTIGATION OF
Magnetic Tape Recorders

Performance characteristics and curves obtained for a particular application by a parameter-elimination procedure are presented here as being typical of magnetic recorders

By M. C. SELBY

National Bureau of Standards
Washington, D. C.

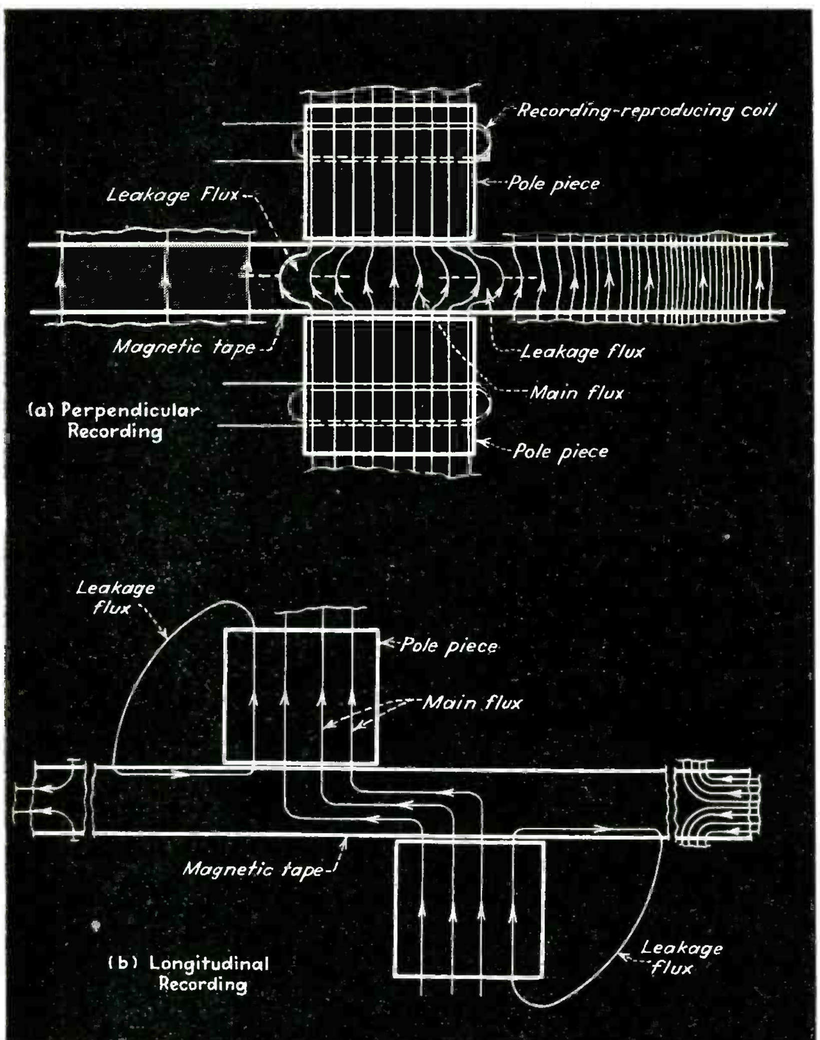


FIG. 1—Positions of pole pieces and approximate flux distribution in magnetic tape for two types of magnetic tape recording

THE PROCESS of recording sound on magnetic tape originated at the end of the last century. Since then considerable progress has been made both in the advancement of the art and in its application.

The major objective in recording sound is usually a uniform response over as wide a frequency range as possible, with the highest output-to-noise ratio. Any variable factor contributing to that end is therefore carefully investigated.

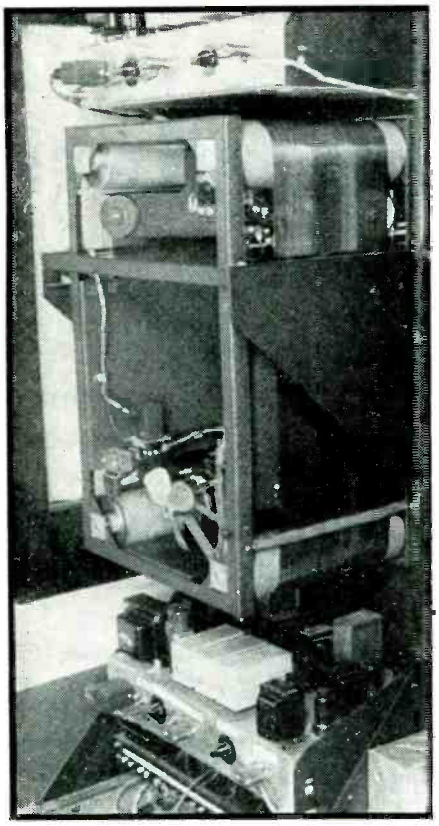
In the particular application covered here, some fundamental factors were fixed. These were the physical dimensions and magnetic properties of the tape and recording-reproducing heads and the tape velocity. The output level and harmonic distortion were to be determined as a function of frequency, input level, pole displacement, polarizing voltage, and obliterating voltage.

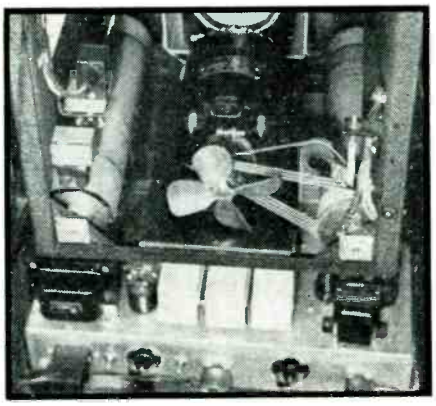
The equipment consisted of a motor-driven, special steel-alloy continuous tape, two recording heads placed on opposite sides of the tape, and two obliterating heads. The object of the obliterating heads is to remove previous records and to restore the magnetic state of the tape for a new record. Either one or both recording heads could be used for reproducing and their relative position with respect to each other could be varied along the tape.

Single-lamination poles approximately $\frac{1}{64}$ inch thick and $\frac{3}{32}$ inch wide were used with each head. The tape dimensions were approximately 0.003 inch in thickness and $\frac{1}{8}$ inch in width. The tape was driven at a fixed speed of approximately 5 feet per second, and the length of the tape was sufficient for a record of about one minute in duration. Two recorders were to be adapted for periodic automatic broadcasts of voice announcements.

Magnetic Recording Methods

The relative position of the two recording heads along the tape determines the method of recording.





Rear view of a magnetic tape recorder and associated chassis, showing air-cooled motor used to drive the endless magnetic tape

Magnetic tape recorder designed in accordance with results of the investigations described in this article. Two identical units are mounted one above the other on the rack for continuous recording

When the poles are directly opposite each other, most of the magnetic flux of the recorded audio frequencies is lined up in a plane perpendicular to the length of the tape; this is called perpendicular recording. When the two heads are displaced so that one of them is ahead of the other along the tape, most of the audio flux is lined up along the tape; this is called longitudinal recording. The two methods are illustrated in Fig. 1.

Major arguments encountered in literature in favor of one or the other method are given in Table I. It seems apparent from the table that even with the tape thickness and tape velocity fixed, the choice of either method depends upon the actual performance of the components given.

Determining Performance Characteristics

In order to explore the level and quality of the output as a function of input into recording heads, frequency, recording-head displacement and polarizing voltage, one would have to obtain a number of curves equal to the product of the numbers of individual parameter-values chosen. If, for example, 10 frequencies were chosen to cover a band of 100 to 6000 cycles for five displacements of the recording heads and for five values of polarizing voltage, it seemed necessary to record and make measurements for a number of points sufficient to plot 250 curves. If, in addition, intermediary values of parameters, effect of obliterating voltage, and the use of single or double reproducing heads were to be explored the task appeared quite formidable, at least from a time-consuming standpoint. After a vain attempt to get satisfactory results by cut and trial, a procedure of wide-range accelerated observations was adopted.

Relative Importance of Parameters

The first step was to determine the relative effectiveness of the parameters. Records were made at three frequencies, at the low, middle, and high end of the spectrum. The voltage input level into the recording head was varied over a wide range in relatively large steps and the output was examined on the screen of a cathode-ray oscilloscope. The order of magnitude of the input required for undistorted output at various frequencies was thus noted.

A few records at individual widely-separated frequencies, each at an input level indicated in the above tests, were made at three relative positions of the recording heads along the tape. It was noticed again by inspection that the high-frequency end was considerably attenuated with increasing distance between the recording heads. One could not regain the output at a wider head separation by increasing the input further. The level of the polarizing voltage was varied while recording widely separated frequences and the output was observed on the oscilloscope. These preliminary tests indicated that the input level was the major factor, recording head displacement second, and polarizing voltage the third in order of importance.

Elimination of Parameters

The second step was to eliminate parameters or reduce their range to

TABLE I.—RELATIVE MERITS OF MAGNETIC RECORDING METHODS

	PERPENDICULAR METHOD	LONGITUDINAL METHOD
ADVANTAGES	Demagnetization (i.e., inherent tendency of small magnets to demagnetize) is constant for all frequencies.	Greater magnetization is usually possible as a result of the drawing process used in manufacturing the tape.
	Decrease in efficiency (i.e., audio output per unit input) can be offset by better design of pole pieces and more suitable recording medium.	Distortion introduced by leakage flux can be reduced by proportioning pole displacement and polarizing voltage, and by reducing signal amplitude.
	Operation at lower speeds, with consequent lower background noise, is possible.	Use of thicker and stronger tape is possible.
DRAWBACKS	Flux spreads beyond the limits of the recorded signal. This introduces distortion increasing with tape thickness.	Leakage flux has a direction opposite to that of the main flux. Part of it tends to introduce distortion.
	Efficiency (as defined above) is lower.	Demagnetization is proportional to frequency.

relatively narrow limits. The first parameter to be closely scrutinized was the least effective of them, namely the polarizing voltage. Observations at widely separated frequencies showed that the effect of this voltage was more noticeable at the low-frequency end and that within the limits of a two-to-one variation in voltage it was not critical. Outside of these limits, the polarizing voltage caused higher distortion. This voltage was therefore fixed at a value approximately half-way between these two limits.

When preliminary tests were made with recording head displacement, it was observed that the background noise level increased with displacement. Continuous-frequency spectrum sweeps were recorded at zero and maximum displacements, with the same input in each case. The input voltage versus frequency had a generally rising characteristic in accordance with first observations. The output was noted at the extreme frequencies and at its maximum. At zero displacement the peak of the output occurred approximately at 2000 cycles, while at a displacement equal to four times the pole thickness the peak shifted approximately to 400 cycles per second. The noise level increased 6 db and the change in its frequency spectrum was in itself unfavorable.

In order to fix the second parameter, namely, the displacement of the recording heads, one had to consider the specific application of the equipment. A high output-to-noise ratio was of prime importance. Fidelity could be overlooked as long as intelligibility was not sacrificed. Hence perpendicular recording was chosen as the superior of the two methods in this particular case.

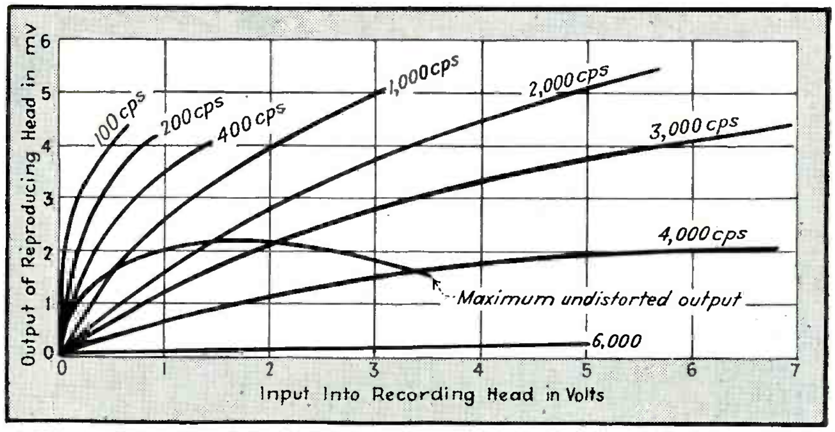


FIG. 2—Input-output curves of a magnetic tape recorder for various frequencies

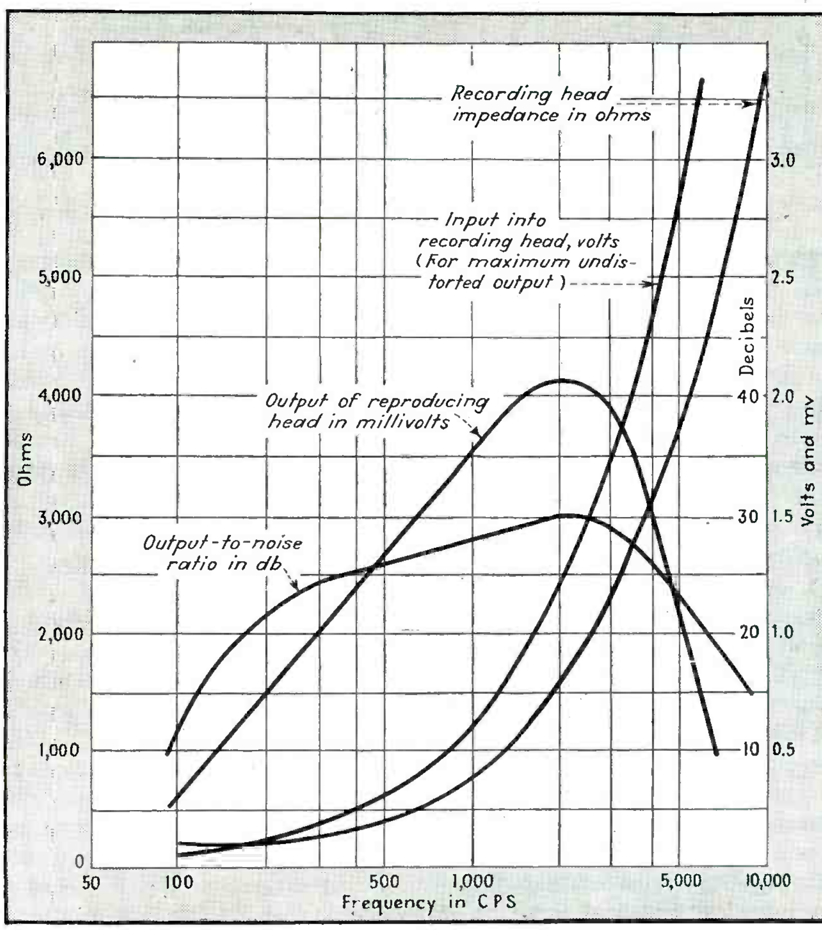


FIG. 3—Performance curves for a magnetic tape recorder

Input and Output Levels

The third step was to fix the optimum input level into the recording head for minimum distortion. This was to determine the final output characteristics and the equalizing networks in input and output circuits. A family of output versus input curves, shown in Fig. 2, was obtained with frequency as a parameter. The points of maximum undistorted output were established by observation and by listening and a final curve of input versus frequency was plotted, as in Fig. 3.

Output was found to decrease greatly with increasing frequency. Input at all frequencies up to 3000 cps had to be kept below a certain maximum for minimum distortion. At higher frequencies, although distortion decreased, the input was limited primarily by the additional output realized per unit input. In this case the little gain in output at inputs above 4 volts hardly justified the higher voltage amplification required with a resultant higher background noise.

Figure 3 shows also the actual output voltage of the reproducing head corresponding to the final input levels, and the ratio of the output at each frequency to the total noise level. Since this ratio is given in decibels, it also represents the relative frequency response of the output. The noise spectrum did not seem to be concentrated in a limited band, so that an attempt to increase the effective ratio by attenuating a particular band was unsuccessful.

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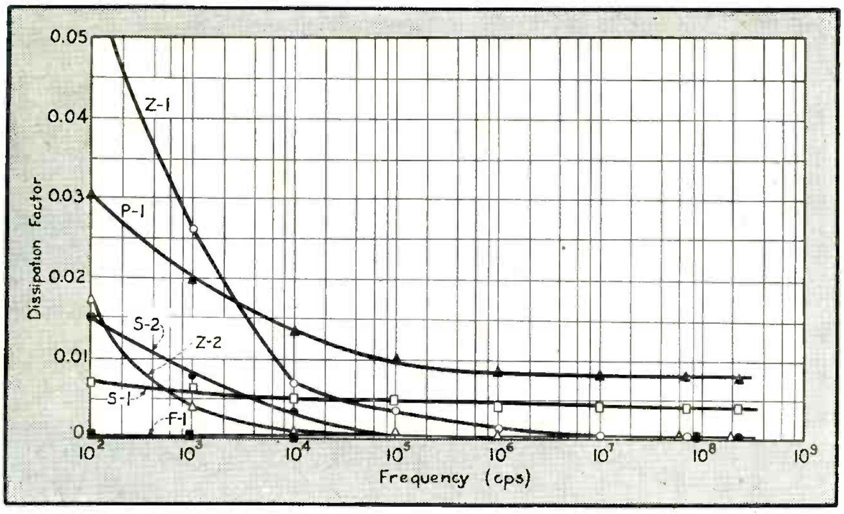
LOW LOSS



By R. RUSSELL, Jr.
and
L. J. BERBERICH

Westinghouse Research Laboratories
East Pittsburgh, Pa.

FIG. 1—Dissipation factor of various bodies versus frequency at 25 deg C

THE EXPANSION in high-frequency applications incident to the development of radio and ultra-high-frequency devices has led to an increasing demand for improved electrical insulation. Added to normally expanded requirements, the heavy demands of the Armed Services have made it necessary that the production of high-frequency insulation be greatly increased. These demands have been met to a considerable extent by expansion of existing production facilities, as typified in the case of ceramic insulation by a much greater output of steatite for radio and other high-frequency uses.

During the early part of the present emergency, substitutes also came into use. For example, steatite has been successfully replaced by more conventional types of porcelain in those components of high-frequency equipment not actually subjected to high-frequency voltages. Moreover, other materials are meeting the requirements, such as glass-mica products, low-loss glasses and special zircon porcelains. Also of interest are ceramic dielectrics for capacitor usage, such as the high dielectric constant (K = 15 to 110) bodies which in most cases consist essentially of titania (TiO_2) in the crystal form of rutile[1], and the still higher dielectric constant (K = 1000 to 10,000) titanate bodies more recently developed[2].

Organic types of insulation are also being used for many high-frequency applications where the properties of a ceramic are not required, but where the particular merits of the organic insulation make its use favorable. Polystyrene, for example, has extremely low-loss properties which can only be approached by ceramics such as fused quartz, ultra-steatite, and special zircon porcelains. Among other organics for high-frequency usage are polyethylene, polyisobutylene, polyvinyl carbazole and various copolymers and mixtures of these with fillers.

In view of the great current need for high-frequency ceramic insulation and the probable future usage in all types of electronic equipment, an investigation was made of various types of ceramic bodies for such applications, considering both the manufacturing problems and the ultimate properties. This included development of a type of ceramic which shall be identified herein as "zircon porcelain".

Requirements of High-Frequency Ceramics

A recent War Standard[3] issued by The American Standards Association in cooperation with industry and the Government Services was devised primarily to classify various grades of steatite. This standard is, however, broad enough in its essential details to include other ceramic materials. The above-mentioned standard and counterpart methods referred to in "Standard Methods of Testing Electrical Porcelain"[4] were conveniently used in all studies of materials herein discussed. The standard specification which was of greatest use deals with the loss factor. The various grades of material, determined after water immersion at a frequency of 1.0 Mc, are as follows:

Grade	Loss Factor
L-1	0.150
L-2	0.070
L-3	0.035
L-4	0.016
L-5	0.008
L-6	0.004

It is pertinent that the ASA Standard[5] for "Steatite Radio Insulators" specifies "Where a definite grade of steatite is not specified, Grade L-3 or better shall be furnished". Thus our interest lies in four grades, although regular high-tension porcelain which has been used successfully in the low-frequency components of high-frequency devices is frequently Grade L-2.

Manufacturing Considerations

Steatite compositions consist essentially of the mineral talc ($3 MgO\ 4 SiO_2\ H_2O$) or one of its related minerals, to which have been added lesser amounts of clay and fluxes. The usual flux is an alkaline alum-

CERAMICS

Zircon porcelains widely used as insulation where ability to withstand heat-shock is important, such as in spark-plugs, have been developed for high-frequency use. Properties of such porcelains and of steatites, ultra-steatites, high-tension porcelain and transparent fused quartz are given. Test methods are described

inum silicate such as feldspar or lepidolite. For the better grades, the alkaline minerals are replaced by alkaline earth fluxes, such as calcium and barium compounds. Other special fluxes have also been used successfully.

Molding may be done using special techniques by any of the conventional ceramic methods, which include pressure forming in steel molds (dry or wet pressing), plastic extrusion, or slip casting. In the dry-press process the molding of steatite has an advantage over many other ceramics in that the mineral talc is comparatively soft, and is also somewhat self-lubricating because of its fibrous and foliated nature. Thus die wear is reduced to a minimum. This inherent softness also makes the material particularly amenable to drilling and tapping in the dried state. In forming by plastic extrusion or by slip casting, steatite is more difficult to handle than most porcelain bodies because of its low clay content and the nature of finely ground talc. Auxiliary plasticizers and bonds and special techniques are thus required.

Steatite is usually fired to a pyrometric cone equivalent of cone 11 to cone 14 (about 1300 to 1400 deg C), thus transforming the raw mixture into a porcelain having the requisite high-frequency characteristics. The fired material is essentially a mass of crystals of magnesium silicate ($MgO\ SiO_2$) in the form of clinoenstatite[6] or one of its polymorphous forms. The magnesium silicates are bonded together with an alkaline or alkaline earth glass in most cases, and cristobalite crystals (SiO_2) may be present as a result of the thermal dissociation of the talc[7] or clay[8] used as raw materials.

The material has a comparatively short firing range[9] for the development of complete vitrification (zero porosity), and this may vary from 10 to 20 deg C for ultra-low loss types to possibly 30 to 40 deg C for ordinary types. By comparison, many porcelains have firing ranges of 50 to 90 deg C. The temperature range for steatite firing is limited between a state of porosity due to underfiring and distortion or vesicular development as a result of overfiring. Thus very close temperature control is necessary in firing.

Zircon porcelains for applications where heat shock and other special properties are important, as for example spark-plug insulators, have been known for many years. Such porcelains did not, however, receive much consideration for high-frequency use until the development work of The Titanium Alloy & Mfg. Co. was first reported in 1942.[10]

Low-loss zircon porcelain compositions contain predominant amounts of the mineral zircon ($ZrO_2\ SiO_2$) to which have been added lesser amounts of clay and fluxes of the alkaline earth and magnesium types, as well as other special fluxes as required.

Such compositions may be processed by any of the methods used for high-tension electrical porcelain. Pressure forming in steel dies is signally successful. Although the dry press method can be used satisfactorily, it has been found expedient to use a wet processing method known as "Prestite" forming, by which uniform density is developed in an evacuated steel die. The wet processing method has a further advantage that excessive die wear, which might be expected from abrasive zircon, is reduced to a practical minimum. Moreover, it is significant that compositions have been developed which have total shrinkages identical with high-tension Prestite porcelain. Thus a great saving in die cost and time has been realized.

TABLE I. MECHANICAL AND PHYSICAL PROPERTIES OF SIX CERAMICS

	Zircon Porcelain (Z-1)	Zircon Porcelain (Z-2)	Steatite (S-1)	Ultra-Steatite (S-2)	High-Tension Porcelain (P-1)	Clear Fused Quartz (F-1)
Specific gravity	3.68	3.76	2.6	2.7	2.4	2.2
Water Absorption, in %	0.00	0.00	0.0 to 0.6	0.0 to 0.2	0.00	0.00
Dye Penetration	None	None	In some cases	In some cases	None	None
Resistance to Heat (Constant Use), in deg. C.	1000	1100	1000	1000	1000	1000
Linear Coeff. of Thermal Expansion (20 to 700 deg. C), per deg. C	4.9×10^{-6}	3.68×10^{-6}	9.1×10^{-6}	8.8×10^{-6}	5.3×10^{-6}	0.5×10^{-6}
Heat Shock	Passed	Passed	Failed	Failed	....	....
Tensile Strength, lb. per sq. in.	12,700	....	8,000	7,500	5,000	....
Compressive Strength, lb. per sq. in.	90,000	....	76,000	70,000	48,000	....
Transverse Strength, lb. per sq. in.	25,000	....	20,000	17,000	11,000	....
Impact Resistance (modified Charpy method) in gm per sq. cm	17,800	....	17,400	....	6,000	....

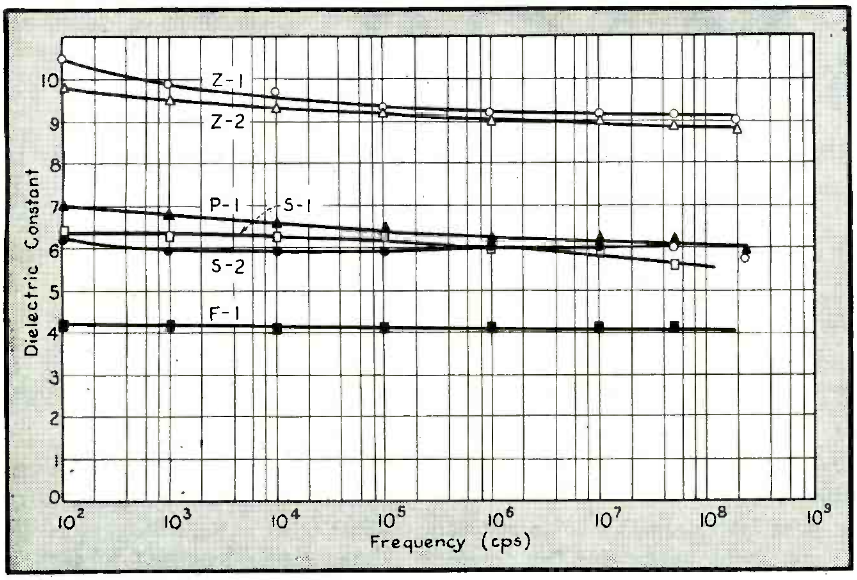


FIG. 2—Dielectric constant of various bodies versus frequency at 25 deg C

Zircon porcelains are also produced successfully by the plastic process, using standard equipment, thus further adding to the flexibility of manufacture, particularly when it must be accomplished with existing industrial facilities. The slip casting method may also be adapted as required, but would seem to have fewer applications.

Depending upon composition, the low-loss zircon porcelains may require temperatures of 1250 to 1450 deg C (cone 9 to cone 16) for vitrification, and bodies have been developed which will fire in the same kilns with high-tension porcelain at about 1300 deg C (cone 11 to 12). It is particularly noteworthy that the compositions have firing ranges of over 50 deg C (2 to 3 cones) in most cases. They are also characterized by extreme density over the entire firing range, which means that the probability of porous ware or firing losses is remote. In the final analysis this would normally insure uniformity of quality.

Mechanical and Physical Properties

The six materials tested and referred to in subsequent discussion are as follows:

S-1—A commercial steatite representing an average grade.

S-2—A commercial low-loss or ultra-steatite.

Z-1—A commercial low-loss zircon porcelain representing an average grade.

Z-2—A low-loss zircon porcelain having somewhat improved properties over Z-1.

P-1—A commercial high-tension electrical porcelain typical of that used for high-voltage, 60-cycle applications.

F-1—Transparent fused quartz.

As regards mechanical and physical properties, it was not possible to make actual tests in all cases due to the impracticability of obtaining complete sets of test specimens. Thus, some data are necessarily presented on the basis of information reported by different manufacturers. In the case of all electrical properties, except dielectric strength, it was possible to obtain specimens and conduct complete tests.

Table I is a compilation of the available mechanical and physical properties. It was found that the zircon porcelains are 37 to 42 percent heavier than steatites. However, even for most aircraft applications the higher specific gravity of the material would not militate against its use, since the total weight of ceramic insulation is but a small part of the weight of the equipment involved.

The zircon porcelains, because of their extremely dense character, have zero absorption and are impervious as tested in high-pressure dye solutions. Of four steatites tested, two were vitreous or dense enough to be classified as impervious, although both showed increases in water absorption after removal of the surface skins. No such skin effects occur with the uniformly dense zircon porcelains.

Low-loss zircon porcelains have excellent thermal properties. Several factors, including thermal conductivity, elasticity, thermal expansion and inherent strength, contribute to the ability of a ceramic to withstand heat shock. Only the latter two factors can be evaluated at present, although an actual heat shock test was conducted to permit study of the materials as affected by all contributing factors.

Type Z-1 successfully passed the ASA standard heat shock test[3] for Class L ceramic radio insulating materials. This test involves twenty cycles of quench from boiling water to ice water (100 deg C to 0 deg C). The specimens thus tested were quenched from successively higher temperatures of 150, 200 and 250 deg C into ice water. The first cracks appeared during the 200-deg C quenching, but these were of less magnitude than the cracks in steatite quenched in the standard manner from 100 deg C. Moreover, the transverse strength of the zircon porcelain specimens was lowered only 30 percent by quenching at 200 deg C. Preliminary tests indicate that zircon porcelains having heat shock properties even better than those for Z-1 are probable.

The coefficient of thermal expansion of steatite is approximately 80 to 140 percent higher than that of various zircon porcelains. The latter are entirely free from crystalline inversion effects and thus have essentially uniform expansions over the entire useful range of temperature. Steatite, on the other hand, may have an irregularity in its expansion due to the presence of cristobalite crystals. This irregularity is due to an inversion from alpha to the beta crystalline form in the range from 200 to 300 deg C, accompanied by a volume change of 2.8 percent which is known to be detrimental to thermal shock properties.

The transverse, tensile and compressive strengths of Z-1 were moderately higher than the reported values for steatite, and a comparative impact test between S-1 and Z-1 indicated a slight superiority for Z-1. Additional development and testing may very well lead to compositions considerably stronger than Z-1, which is the only zircon porcelain thus far tested mechanically.

Electrical Properties

The following electrical properties were determined for the six samples previously enumerated: (1) dissipation factor or tan δ as a function of frequency at 25 deg C, (2) dielectric constant as a function of frequency at 25 deg C, (3) dissipation factor at 100 kc as a function of temperature, (4) dielectric constant at 100 kc as a function of temperature, (5) d-c resistivity as a function of temperature, and (6) dielectric strength at 60 cps. The dissipation factor of all samples was determined at one megacycle, both dry and after water immersion, using two types of electrodes. The two types of electrodes will be discussed in a subsequent section.

The absolute values of the dissipation factor or tan δ are given in all cases. If the loss factor is desired, it is obtained by multiplying the dissipation factor by the dielectric constant. Since for small angles the tangent and the sine are approximately equal, the dissipation factor and power factor may be considered to be identical for values of either up to 0.10.

The measurements from 100 cps to 100 kc were made with a General Radio type 716-AS1 bridge. Those from 1 Mc to 50 Mc were made with a General Radio susceptance variation circuit, type P-513. Those in the neighborhood of 200 Mc were made with a reentrant cavity resonator. The electrodes used in all cases, except as noted, were fired-on silver which insured intimate contact with the samples.

The dissipation factor for the various bodies as influenced by frequency in the range from 100 cps to 200 Mc is given in Fig. 1. Considering this entire frequency range, the high-tension porcelain P-1 has, in general, the highest dissipation factor and fused quartz F-1 the lowest. This is to be expected since the former contains a considerable amount of alkali metals while the latter contains none. The values for the zircon porcelains and the steatites lie in between those for high-tension porcelain and fused quartz, at least in the higher-frequency range. At the lower frequencies Z-1 shows a higher dissipation factor than Z-2. The rise in dissipation factor at low frequencies for both samples may be attributable to the presence of alkaline earth fluxes.

From Fig. 1 it is seen that the Z-1 porcelain approaches the dissipation factor of fused quartz (about 0.0005) at 10 Mc while the Z-2 porcelain approaches the fused quartz value at 100 kc. Fused quartz has such a low dissipation factor that it could not be determined very accurately. Our measurements, however, show that the dissipation factor for fused quartz is definitely less than 0.0005 over the whole frequency range. In Fig. 1 all values for fused quartz are plotted as 0.0005. All points are not shown at the high-frequency end of the plot because four of the curves all approach a 0.0005 dissipation factor and introduction of all points would only result in confusion. Figure 1 also shows that the high-frequency dissipation factors of both zircon porcelains are comparable to that of the ultra-steatite sample S-2.

Figure 2 gives the dielectric constants of the same series of materials as a function of frequency. The zircon porcelains have higher dielectric constants over the whole range of frequency than do the steatites. This is to be expected since the related zirconium dioxide has a dielectric constant of 18. All dielectric constants decrease somewhat with increase in frequency, which is a normal behavior. The higher dielectric constant at the lower frequencies is attributed to the oscillation of ions which contribute less and less to the dielectric constant as the frequency increases, because fewer and fewer of them can follow the field with in-

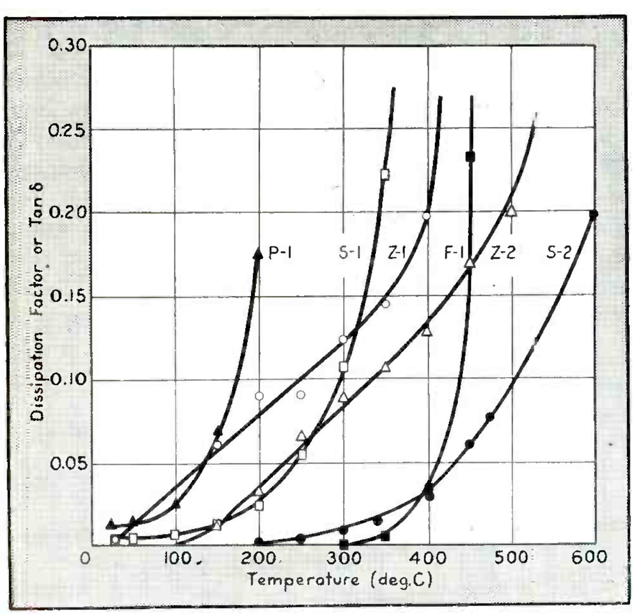


FIG. 3—Dissipation factor at 100 kc of various bodies versus temperature

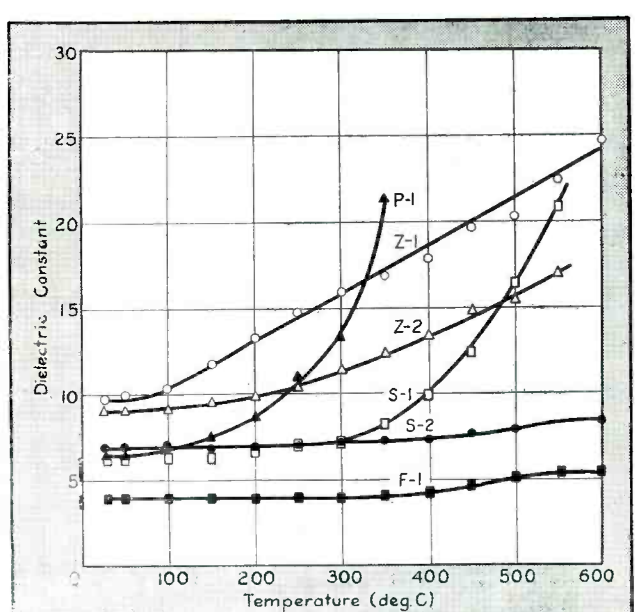


FIG. 4—Dielectric constant at 100 kc of various bodies versus temperature

crease in frequency. The higher dissipation factors observed at the low frequencies and shown in Fig. 1 are also attributed to the same mechanism, for oscillating ions can also contribute to the dissipation factor.

Figure 3 gives the dissipation factors measured at 100 kc as influenced by temperatures up to 600 deg C for the various materials. In the case of these measurements, the electrodes of fired-on silver were backed by solid cylinders of silver. The leads into the oven were also made of silver, insulated by means of fused quartz tubing. The substitution procedure was used in all of these measurements. The first measurement was made with the ungrounded backing electrode in contact with the silver coating on the sample, and the second measurement with the backing electrode raised about one inch from the sample. This procedure eliminated the lead capacitance and capacitance of the ungrounded backing electrode to the oven. Silver was the only conveniently obtainable metal which withstood the high temperatures involved without forming an annoying oxide film on its surface.

Examination of Fig. 3 shows that the high-tension porcelain sample P-1 has a rapid rise in dissipation factor after 100 deg C is reached. The fused quartz sample F-1 and the ultra-steatite sample S-2, on the other hand, do not show a rapid rise until about 400 deg C. The zircon porcelains and the average grade of steatite show rises in dissipation factor in the intermediate temperature region. This indicates that the zircon porcelains in the present state of development are not as satisfactory for use as ultra-steatite where temperatures considerably over 200 deg C are involved. However, development is being continued and the possibility of obtaining a zircon composition with better high temperature behavior is promising.

TABLE II. DIELECTRIC STRENGTH AT 60 CPS

Sample	Thickness (Inches)	Dielectric Strength (Volts per Mil)
Z-1	0.125	280
Z-2	0.125	300
S-1	0.25	230
S-2	0.25	240
P-1	0.25	300
F-1	.....	410

Figure 4 gives the dielectric constant variations with temperature as determined at 100 kc for the various bodies. Here again the high-tension porcelain P-1 shows considerable rise with temperature whereas fused quartz F-1 and the ultra-steatite S-2 show only a small rise with temperature. The zircon porcelains and the average grade steatite are intermediate. The rise in both dielectric constant and dissipation factor with temperature is believed to be caused by the presence of certain ions which can oscillate more and more freely as the structure of the material loosens up as a result of the expansion accompanying the temperature rise. It is known that certain alkali metal ions, particularly sodium, can cause this type of behavior. However, the type of ion present is not the only factor, for the structure of the material also plays an important role.

The influence of temperature on the resistivity of the various bodies is shown in Fig. 5. The high-tension porcelain P-1 has the lowest resistivity over the whole range of temperature as expected. However, zircon porcelains Z-1 and Z-2, as well as the ultra-steatite S-2, have higher resistivities above 500 deg C than fused quartz F-1. This is a somewhat unexpected result and indicates that these materials should find application at high temperatures in those cases where direct voltages are involved. All of the resistivities above approximately 100 megohm-cm were determined with a General Radio type 544-B megohm bridge which applied 500 volts to the samples. The lower values of resistivity were measured with an RCA Junior Voltohmist which applied only a few volts to the samples.

The dielectric strength tests were made at 60 cps according to the ASTM method[4] except that ⅛-inch thick disks were used in some cases. The results for the six materials are given in Table II. The values listed are not strictly comparable because of differences in thickness of test specimens.

Electrical Test Methods

It is evident from the foregoing that in order to completely evaluate dielectric materials it is necessary to determine the electrical properties over wide ranges of frequency and temperature. In order to cover the frequency range from 100 cps to 200 Mc, it was necessary to use three different sets of equipment which have already been identified. No serious difficulty is encountered at frequencies up to 1 Mc. However, at 1 Mc and higher frequencies, extreme care must be exercised. The essential procedures for operating such equipment are described in the ASTM methods.[4]

In order to properly classify a material according to the ASA Standards,[3] it is necessary to measure dissipation factors as low as 0.0003 with reasonable accuracy. Aside from any errors caused by the measuring equipment itself, the following important factors may affect the accuracy to a considerable degree: (1) condition of sample, (2) the type of electrodes applied to the sample, and (3) humidity or moisture conditions.

Condition of Sample

In all dielectric measurements at frequencies much above one megacycle, it is essential to use a sample holder fitted with a micrometer screw. A substitution method is usually used in which the first operation consists of adjusting the circuit to resonance with the sample

TABLE III. EFFECT OF PETROLATUM FILM ON DISSIPATION FACTOR AND DIELECTRIC CONSTANT*

(1) Dielectric Constant of Sample	(2) $\tan\delta_p$	(3) $\tan\delta_x$	(4) $\tan\delta_m$	(5) C_p $\mu\mu f$	(6) C_x $\mu\mu f$	(7) C_m $\mu\mu f$
5	0.0001	0.001	0.00099	3100	28.4	28.1
10	0.0001	0.001	0.00098	3100	56.8	55.9
100	0.0001	0.001	0.00086	3100	568.0	494.0
1000	0.0001	0.001	0.00042	3100	5680.0	2010.0

* Sample thickness of 0.125 in. and petrolatum film thickness of 0.0005 in. are assumed

in place. The sample is then removed, and the second operation consists of turning in the micrometer of the sample holder until resonance is restored. This procedure eliminates to a large extent the effect of inductance and resistance of leads. The sample holder itself is fitted with two heavy metal plates (two inches in diameter in our case) between which the sample is clamped. These plates are as near plane and parallel as it is possible to machine them.

All of the precision adjustments of the sample holder, however, can be nullified when used with a poor sample. It is quite common to receive ceramic samples which are either somewhat warped or wedge-shaped. Obviously, the use of such a sample can bring about large errors, particularly in the dielectric constant. Therefore, all warped or wedge-shaped samples should be lapped until the surfaces are plane and until the two faces are parallel to within one percent of the thickness of the sample.

Sample Electrodes

Since the surfaces of the sample cannot always be made absolutely plane and parallel, it is highly important that the sample be fitted with intimately contacting electrodes. A high-conductivity metal is desirable because the electrodes on the sample may contact the sample holder at only a few points. Lead-foil electrodes applied with a thin film of petrolatum are usually recommended. Such electrodes, however, can lead to errors, particularly when used with the higher dielectric constant materials. In this case the petrolatum films are electrically in series with the sample under test. The measured dissipation factor and dielectric constant are those for the combination of the petrolatum films in series with the sample. That this type of electrode can lead to erroneous results can be shown by a relatively simple analysis.

When the thickness of the petrolatum film is known, its effect on both dissipation factor and dielectric constant can be calculated by means of the following expressions:

$$\tan \delta_m = \frac{C_p \tan \delta_x + C_x \tan \delta_p}{C_p + C_x} \quad (1)$$

$$C_m = \frac{C_p\, C_x}{C_p + C_x} \quad (2)$$

where $\tan \delta_m$ = measured dissipation factor
$\tan \delta_x$ = true dissipation factor of sample
$\tan \delta_p$ = dissipation factor of petrolatum film
C_m = measured capacitance
C_x = true capacitance of sample
C_p = capacitance of petrolatum film.

Equations (1) and (2) express the dissipation factor and capacitance, respectively, for the combination of the sample and petrolatum film when the two are in series. The discrepancy between the true and measured dissipation factor and capacitance increases with the thickness of the petrolatum film and with the dielectric constant of the body under test.

In order to obtain some idea of the magnitude of the errors involved, let us assume that the sum of the thicknesses of the two petrolatum films is 0.0005 in., which approximates actual film thicknesses encountered. Approximate values of the dissipation factor and dielectric constant of petrolatum are assumed to be 0.0001 and 2.2, respectively. It is assumed further that the sample under consideration is ¼ inch thick and 2 inches in diameter and that its true dissipation factor is 0.001. With these assumptions Eq. (1) and (2) can be used to determine the measured values of dissipation factor and capacitance of the sample as a function of the dielectric constant of the body. The results of such calculations are given in Table III.

The difference between the true values of the dissipation factor or

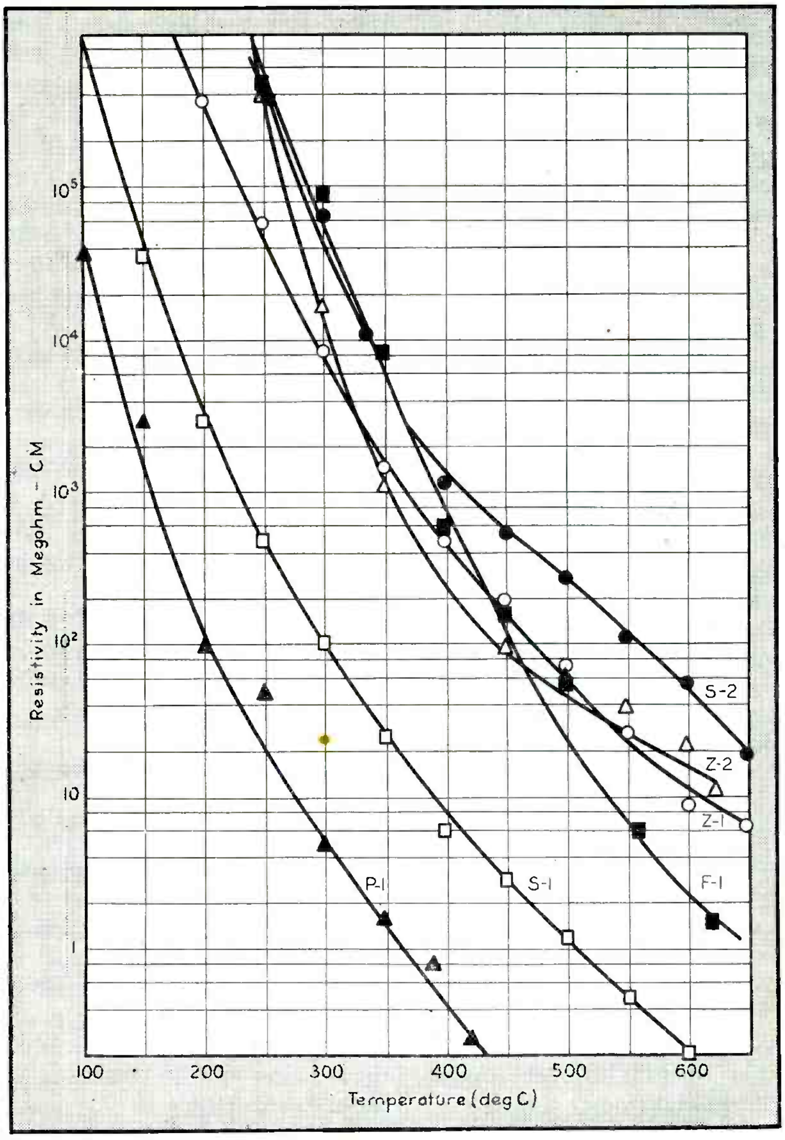


FIG. 5—Resistivity of various bodies versus temperature

TABLE IV. DISSIPATION FACTORS OF CERAMICS — SILVER vs FOIL ELECTRODES

	Lead Foil		Low Temp. Silver Dupont #4132	
Body	Dry	After Water Immersion	Dry	After Water Immersion
Z-1	0.0012	0.0012	0.0011	0.0011
Z-2	0.0006	0.0006	0.0006	0.0006
S-1	0.0035	0.0043	0.0040	0.0050
S-2	0.0006	0.0058	0.0007	0.0026
P-1	0.0088	0.0089	0.0088	0.0088
F-1	0.0003	0.0003	0.0003	0.0003

TABLE V. DIELECTRIC CONSTANTS OF CERAMICS — SILVER vs FOIL ELECTRODES

	Lead Foil		Low Temp. Silver Dupont #4132	
Body	Dry	After Water Immersion	Dry	After Water Immersion
Z-1	9.1	9.1	9.3	9.3
Z-2	8.9	8.9	9.2	9.2
S-1	5.8	5.8	6.0	6.0
S-2	5.8	5.9	5.9	6.0
P-1	5.7	5.8	6.0	6.0
F-1	4.0	4.0	4.1	4.1

$\tan \delta_r$ and the measured values or $\tan \delta_m$ for the samples having dielectric constants varying from 5 to 1000 are obtained by comparing the values in column (3) with those in column (4). For a sample having a dielectric constant of 5 the measured value of the dissipation factor is 99 percent of the true dissipation factor. However, when the dielectric constant of the sample is 1000 the measured value of the dissipation factor is only 42 percent of the true dissipation factor.

Similarly, the differences between the true capacitances and the measured values of capacitance are obtained by comparing columns (6) and (7.) When the dielectric constant of the sample is 5 the measured value is 99 percent of the true capacitance, and when the dielectric constant of the sample is 1000, the measured value is only 36 percent of the true capacitance.

Thus it is seen that large errors are possible when foil electrodes are used on samples having dielectric constants much greater than 10. For most purposes, however, the error for samples having dielectric constants below 10 is not large enough to justify elimination of the use of foil electrodes. For compositions having dielectric constants of about 10, both the measured dissipation factor and the capacitance are approximately 98 percent of the true values.

All of these calculations are based on the assumption that the sample is ⅛ inch thick. Some of the zircon porcelain samples tested, however, were ¼ inch thick and had dielectric constants of about 10. For this combination, the measured dissipation factor and capacitance are about 99 percent of the true values.

Some comparative tests were made at one megacycle and room temperature which to some extent bear out the calculated results of Table III. In this comparison, lead-foil electrodes applied with petrolatum were used on the six bodies in one case, and in the second case, a fired-on silver electrode was substituted for the foil. The results for dissipation factor are given in Table IV and those for dielectric constant in Table V. These tabulations give values for dry samples, as well as for the same samples after immersion in water. The effects of moisture are discussed in the next section and only the values for the dry samples will be considered here.

Examination of Tables IV and V show that the dissipation factor and dielectric constant values are generally lower with foil electrodes than with the intimately contacting silver electrodes. The differences are of the order of magnitude predicted by the foregoing analysis. While foil electrodes do not result in any serious errors for the particular materials selected in this work, they can, however, result in large errors for the high dielectric constant titania and titanate bodies previously mentioned. Foil electrodes also are completely unsuitable for high-temperature measurements because the foil melts at relatively low temperatures, and gas bubbles form in the petrolatum at still lower temperatures. The latter can result in even larger errors than are caused by the presence of the petrolatum film. Thus, it is indicated that fired-on silver electrodes have definite advantages over foil electrodes which have been commonly used.

Effects of Moisture and Humidity

Moisture and exposure to high-humidity atmospheres usually result in an appreciable increase in dissipation factor only when the sample is porous. Any porosity exceeding what corresponds to a water absorption of 0.01 per cent may result in an increase in dissipation factor. Several standardizing groups specify that the electrical properties be determined after a number of days of immersion in water. It does not appear to be generally realized that the only purpose the tests after water immersion serve is to indicate the presence of volume or surface porosity. The dissipation factor of a truly vitreous or non-porous sample does not increase after immersion in water.

There are a number of objections to the test after water immersion as now specified. Chief among these is that it requires several days before results become available. For this reason alone it cannot be used as a production control test. Another important objection to the test is that it does not provide any more information than can be obtained by dye penetration or an absorption test, which provide a simple means for indicating porosity in a short time. Thus, it appears that some consideration should be given to the substitution of a dye penetration or a vacuum absorption test for the time-consuming water immersion test.

Porosity can lead to annoying errors in dissipation factor measurements, especially when porous samples are exposed (even for only a few minutes) to atmospheres having a relative humidity much in excess of 40 percent. It was found that the dissipation factor of a porous sample can be associated fairly well with the relative humidity of the atmosphere in which it is measured. Thus, if reliable dry values are desired on a porous sample, the measurements must be made in a low humidity or preferably a desiccated atmosphere. It should be pointed out, on the other hand, that successful measurements have been made on non-porous samples even when the relative

(Continued on page 338)

Power Factor CORRECTION CHARTS

Charts for determining how much leading reactive power is needed to secure a desired amount of improvement in power factor, with practical data on the use of capacitors and auto transformers for correction purposes and on effects of harmonics

By HARRY HOLUBOW

Thordarson Electric Mfg. Co. Chicago, Ill.

CURRENT taken by a-c electrical equipment such as induction motors, welding equipment, neon signs and lightly loaded power transformers, lags behind the voltage by some angle. The power taken by the equipment is expressed as $P = EI \cos\theta$ watts, where θ is the angle of lag and $\cos\theta$ is the power factor. The power utilized (real power) is less than the product EI (apparent power) by the factor $\cos\theta$, which is always less than one.

Calculations

The expression $EI \cos\theta$ for the power taken by a-c electrical equipment may be represented in vector form as in Fig. 1(a). Inasmuch as voltage E is more or less constant in any given system, the same vector diagram may be used to express power relations, as in Fig. 1(b).

If the real power or the apparent power alone is known, the other may be found from the relation: real power = apparent power × power factor. The reactive power may be found from the relation: reactive power = apparent power × $\sin\theta$.

If from the right-angle triangle in Fig. 1(b) we designate real power as A, reactive power as B, apparent power as C the necessary leading power for correction as Y, the new power factor as $\cos\beta$, and the resultant apparent power as X, as shown in Fig. 1(c), the following relations hold for the calculation of improved power factor:

$$B = \sqrt{C^2 - A} \qquad (1)$$

$$X = \sqrt{A^2 + (B - Y)^2} \qquad (2)$$

$$\cos\beta = \frac{A}{X} = \frac{A}{\sqrt{A^2 + (B - Y)^2}} \qquad (3)$$

The charts in Fig. 2 and Fig. 3 are based on the above equations, and a unit kva of power. They may be used for any load by multiplying the value of leading kva by the value of kva involved.

Use of Charts

Let us assume that we have a load of 5 kva, 45 percent power factor, and it is desired to correct the load to 90 percent power factor. A straight line, in Fig. 2, drawn through 0.45 on the *EXISTING LOAD P.F.* scale from 0.90 on the *DESIRED LOAD P.F.* scale will intersect the *CAPACITANCE IN KVA* scale at approximately 0.675. That means that for each kva we need 0.675 kva of leading reactive power to correct to 90 percent power factor. For 5 kva, 3.375 kva will be needed.

Drawing a straight line through 0.45 and 0.90 on the outside scales in the alignment chart in Fig. 3, we find that the kva ratio is 0.5; that is, instead of having 5 kva before correction, the load is now only 2.5 kva.

There are, in general, two methods of correcting a poor power factor: synchronous machines and static capacitors.

Methods of Power Factor Correction

Several types of synchronous machines are used in correcting load power factor, the most important being the so-called synchronous capacitors and synchronous motor. The synchronous capacitor is a rotating device that carries no mechanical load and draws a leading current. This device requires separate d-c excitation for the fields, and the amount of leading current may be controlled by varying the field excitation. Synchronous capacitors are available in large sizes only and are used to a great extent by the electrical utilities in their distributing sub-stations.

The synchronous motor is similar to the synchronous capacitor in its operation, and usually requires a separate d-c excitation. It differs from a synchronous capacitor in that it is able to carry a mechanical load, but power factor correcting ability is comparatively small as the power factor of a synchronous motor itself is between 80 and 100 percent leading.

The most commonly employed

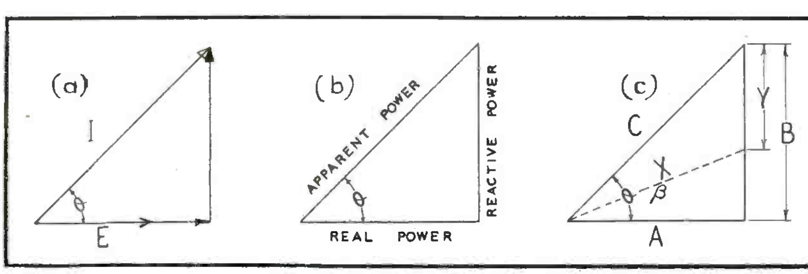


FIG. 1—Vector diagrams representing voltage and power relations upon which the accompanying power factor correction charts are based

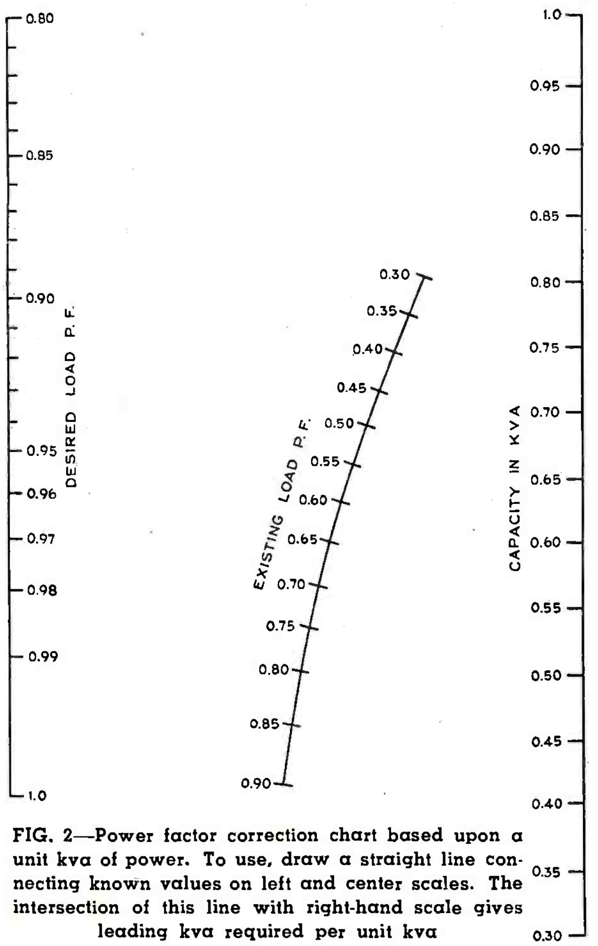


FIG. 2—Power factor correction chart based upon a unit kva of power. To use, draw a straight line connecting known values on left and center scales. The intersection of this line with right-hand scale gives leading kva required per unit kva

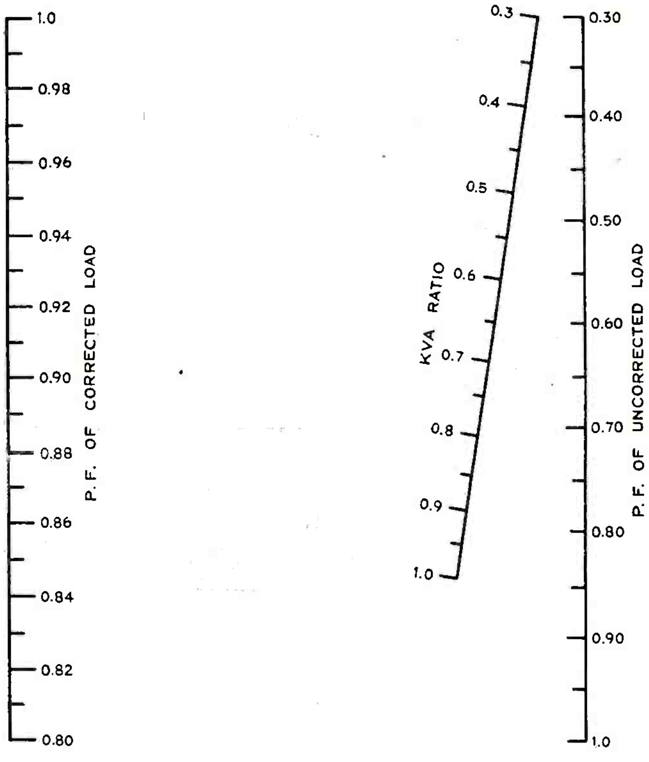


FIG. 3 (above)—Chart giving corrected load kva per unit kva. To use, draw a straight line between known values on the two outside scales. The intersection of this line with the middle scale gives the ratio of the kva of the corrected load to that of the uncorrected load

method of power factor correcting, especially in the case of relatively small amounts of power, is by means of static capacitors. The capacitor takes a 90-deg leading current, hence all of its current is useful for correction. Capacitor losses usually being small, this method is especially economical for the small consumer. Commercial capacitors are available in capacitances ranging from 1 to 40 μf and higher, for voltage ratings of 110, 220, 440, 660 and 2300 volts. Parallel combinations of capacitors can be used to give almost any desired capacitance.

The reactive power of a capacitor may be expressed by the relation: Reactive kva $= E^2C/2.65 \times 10^6$, where C is in microfarads. Where the voltage is low, capacitors have the disadvantage that the capacitance required becomes large. If voltage is 110 volts in the example previously cited, where 3.375 kva is required, the required capacitance as given by this formula is 740 μf. This is rather a large capacitance, and here an auto transformer can be used to advantage. If a 660-volt capacitor is connected across the high-voltage terminals of a 1:6 transformer, the capacitance value as viewed from the primary will appear as the square of the transformer ratio, or 36 times as large. Correction for 3.375 kva will then require only a little over 20 μf.

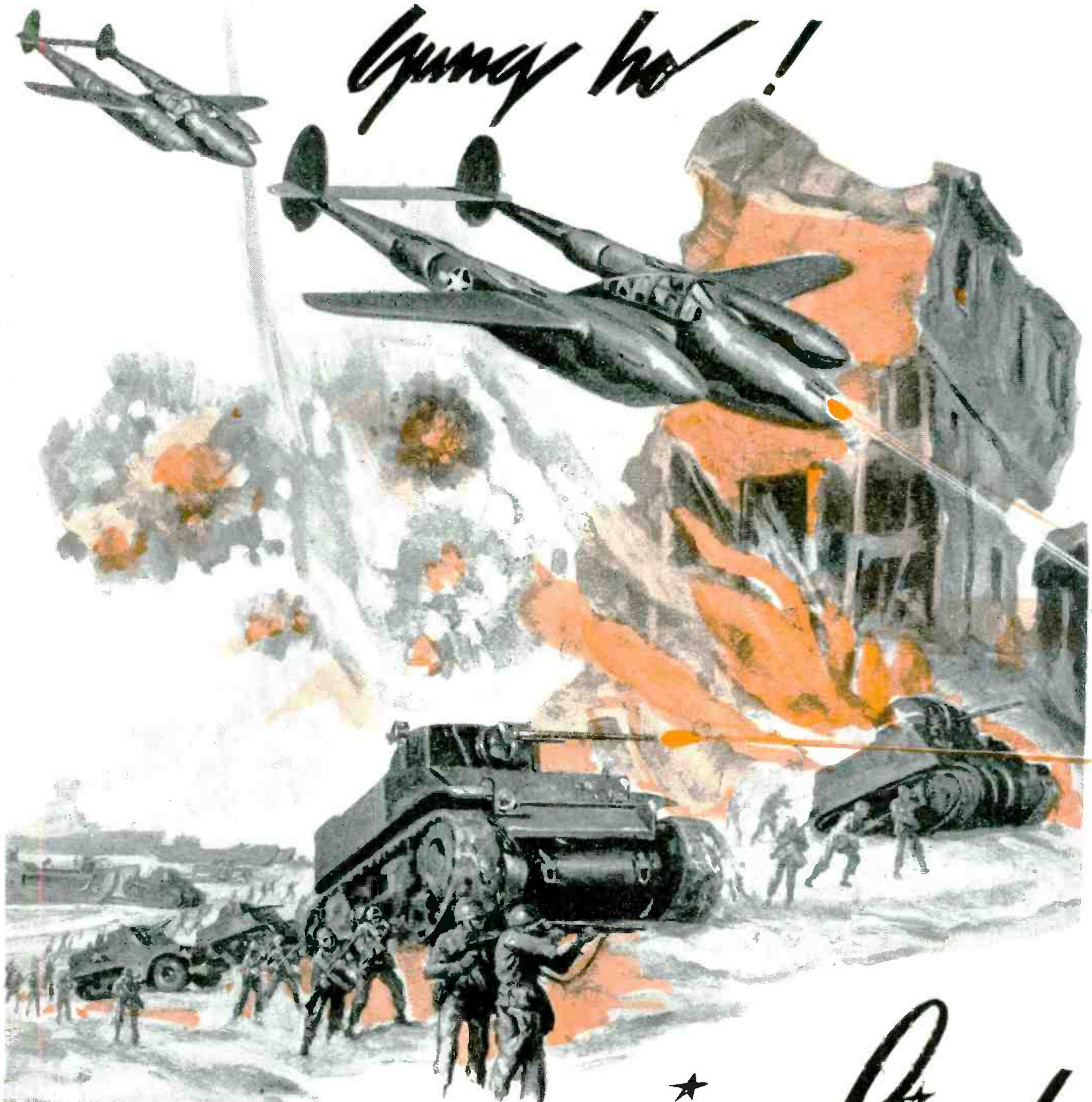
Several transformer manufacturers have available as stock items power factor correctors embodying this principle, in capacities ranging from $\frac{1}{4}$ to $1\frac{1}{2}$ kva. With them, power factor may be corrected right at the device, thus obtaining a saving in copper.

Limitations in Power Factor Correcting

It is not always possible to correct a system to unity power factor. Several types of equipment, such as unloaded transformers, gaseous discharge tubes and welding equipment, take a current that has a high percentage of harmonics. The instantaneous power in an electric circuit is the product of the voltage and current of the same angular velocity (the same frequency), hence the harmonic content of the current does not produce any power and cannot be corrected unless by a leading current of the same frequency.

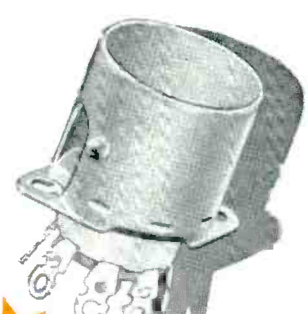
Another source of trouble is the presence of harmonics in the supply voltage when capacitors are used to correct the power factor. It is not uncommon to have the supply voltage contain as high as 15 percent of the third harmonic, and as the impedance of a capacitor to the third harmonic is only 33 percent of that for the fundamental, the third harmonic current taken by the capacitor is nearly 45 percent of the current for the fundamental component. Such conditions would produce at least about 10 percent of uncorrectable r.m.s. current, and the best that could be hoped for is 90 percent power.

Gung ho!



COOPERATION ... is a Cinch

Cooperating with manufacturers of communication equipment and contributing through our parts to the working harmony (Gung Ho) of all branches of the service is CINCH'S part in the biggest job of all time. What's inside a radio is important, especially tube sockets, the heart of the set. CINCH'S years of pioneering and research assure positive contact of each connection between the socket and the tube. Thus communication through such a contact assures the teamwork that brings success for our forces.



Gung Ho from the Universal Picture "Gung Ho"
GUNG (Work)—HO (Harmony)

CINCH MANUFACTURING CORPORATION
2335 West Van Buren St., Chicago, Illinois
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TUBES AT WORK

Electronic Area Calculator

AN ELECTRONIC INSTRUMENT for the measurement of the area of flat sections of material is in use in several industrial plants. So far, it has been applied to determining the size of leather hides in the leather industry and for measuring pattern layouts in the textiles industry. Other possible applications include measurements of the area of ink on printed matter and the surface enclosed by pinpricks of perforated layouts and outlines.

The complete machine is shown in the photograph and consists of two units, one a photoelectric amplifier arrangement for scanning areas of material, and the other an electronic calculator or high-speed counter. The skin or other object to be measured is inserted between rollers that transport it into and through the machine. Extending parallel to the axes of rollers is a long narrow slot. As the skin passes across this slot it comes into the path of a scanning beam of light issuing from an electric lamp.

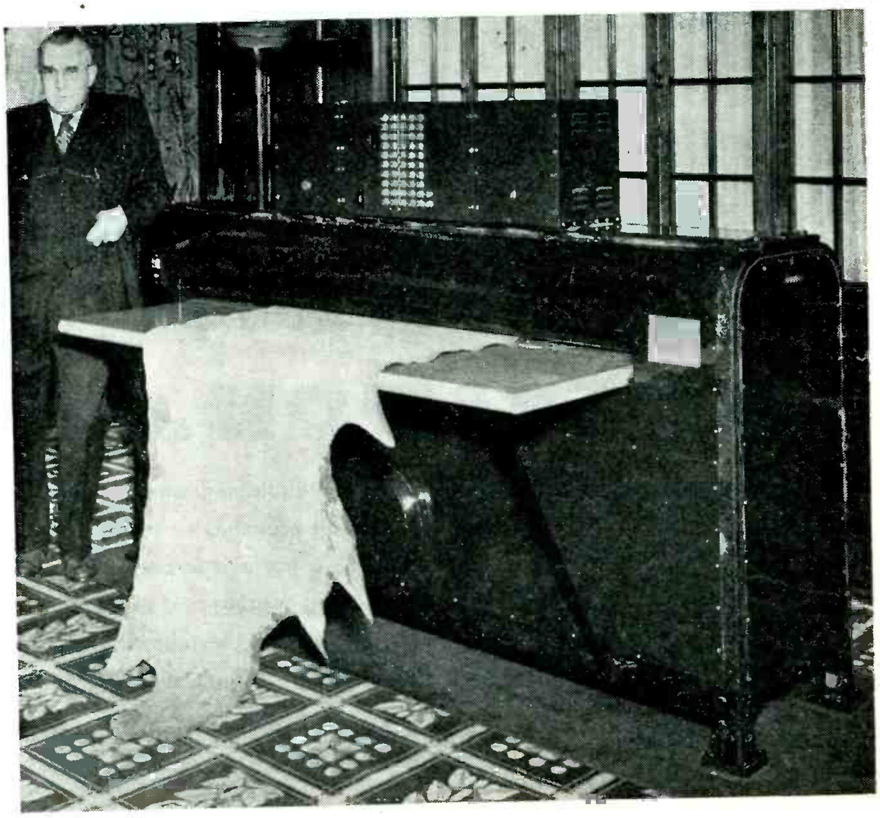
This lightbeam is swept across the width of the skin through the slot. As the beam travels along the slot, it will move part of the distance before it strikes the skin, then cross the skin, and travel the remainder of its stroke out of contact with the leather. These operations are repeated on the return stroke. Since the rate of movement of the beam and the rate of feed of the skin are known, then when the total time interval during which the beam is on the skin is found, the area of the skin can readily be calculated.

Calculations of the area of the skin is accomplished electronically by the instrument mounted in the long rectangular cabinet atop the assembly. This contains vacuum-tube amplifiers and associated power supplies and provides five electronic counter visual columns of ten counts in each column. Each visual count is a numbered lens which is illuminated as each impulse is received from the photoelectrical equipment in the scanning machine.

A reset lever is employed to place all the lights in the columns at zero. The use of two or more counters permits not only individual counts but also permits totalizing the individual counts in the second unit by not making use of the reset. By adding other counters, as many visual columns may be provided as are necessary to the project under consideration. The present rate of individual counting by the machine illustrated is from zero to fourteen thousand counts per second.

Operation of Tubes

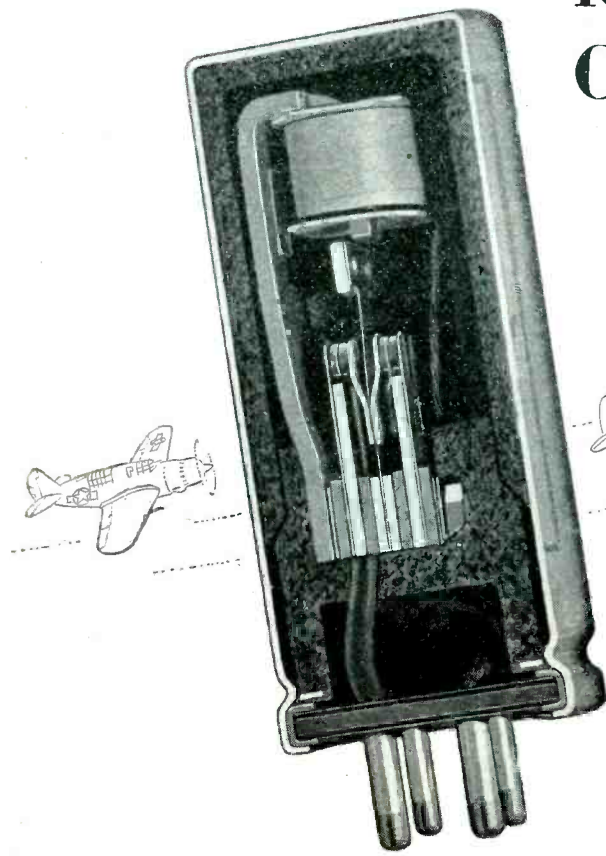
For every indicator light on the panel, there is a corresponding gas-filled electronic tube inside the calculator cabinet. Ten of these tubes are connected in a series arrangement with the last tube connected back to the first, making the circuit a "ring" of ten tubes. The electrical impulses to be counted are fed into the input circuit of this ring. As each impulse arrives, it causes the tube that is conducting to cease and starts the next one in line to conduct. Each indicator lamp on the panel operates only when its corresponding tube is conducting. Thus, if number zero tube is operating, an impulse arrives which causes number zero lamp to go out and number one lamp to come on. The next impulse causes number one to extinguish

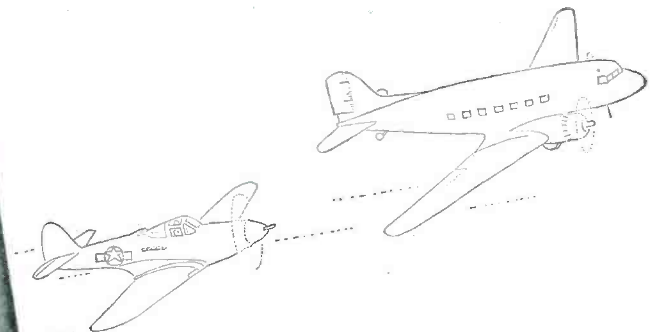


Complete assembly of the Stockton area calculator. The bottom cabinet contains photoelectric equipment that scans thin pieces of hide traveling over a slot. The top cabinet houses an electronic calculator that counts unit areas of the hide

Preferred Flight Companion

for Both Military and Commercial Aircraft





Today's airplanes, military and commercial, fly at amazingly high levels. We think of these altitudes as nothing uncommon, although only yesterday they were considered abnormal. But they were achieved only by overcoming tremendous difficulties—some of them dealing with radio equipment.

Take vibrators, for instance. When a ship flies in the stratosphere, the effectiveness of electrical insulation is so reduced that vibrator efficiency may be seriously impaired, if not completely nullified. It may even be possible for the electrical contacts to sustain an arc. Mallory solved this problem with a special hermetically-sealed vibrator.

The Mallory vibrator is rendered completely airtight at a normal atmospheric pressure of 14.7 pounds per square inch after the hermetic seal has been tested under 20 pounds of pressure. Regardless of altitude or atmospheric conditions, it functions at full efficiency.

If you manufacture receivers or transmitters for aircraft use—or any other battery-powered equipment subject to unusual atmospheric or climatic stresses—complete facts about Mallory hermetically-sealed vibrators will interest you.

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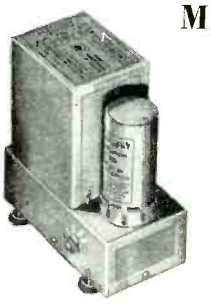

Made by the oldest manufacturer of commercial vibrator power supplies, the Vibrapack offers the most dependable, low cost method of obtaining high voltage direct or alternating current from a low voltage storage battery. Consult us about your application requirements.

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and number two to come on. This goes on until ten impulses have been received, when number zero is again ready to operate.

The first ring of tubes is the unit ring. Another similar ring is used for a count of tens, another for a count of hundreds, and additions may be carried out as far as desired. Every time the unit ring returns to zero, one count is registered on the tens ring. Every ten counts received by the tens ring causes the hundreds ring to count one, in the same manner as the mileage counter of an automobile speedometer.

The operation of the tens ring is only one tenth as fast as the unit ring, and the hundreds ring only one-one hundredth as fast as the unit ring.

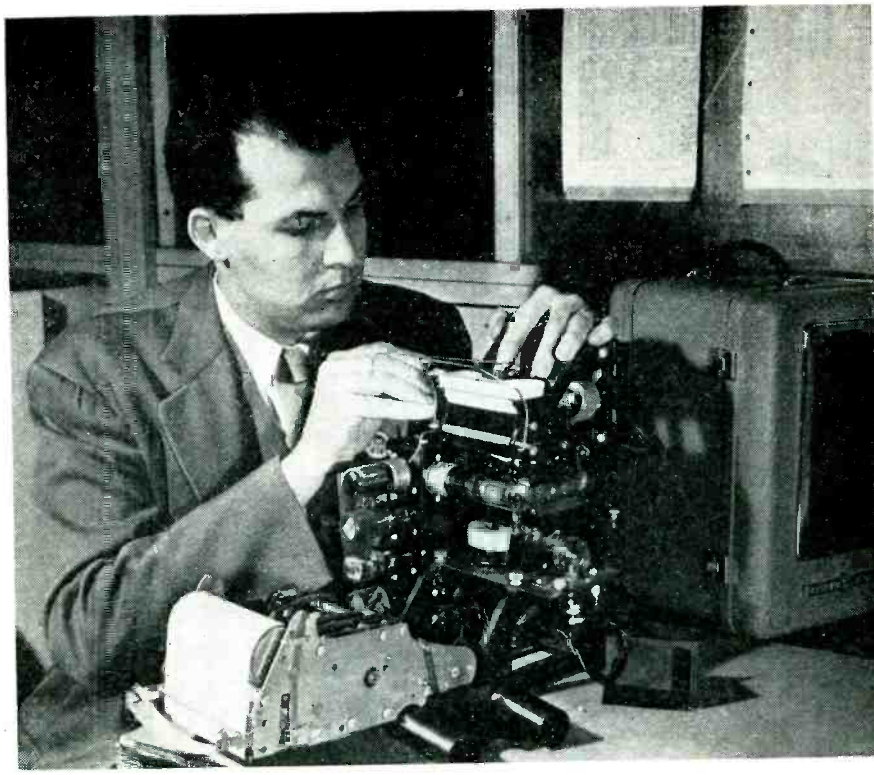
Many uses are possible for such an electronic high speed counter. For example, the speed of missiles could be determined to one-fourteen-thousandth of a second by having the missile pass through two loops spaced a definite distance apart. One loop would start to count pulses from a fixed-frequency generator at a predetermined rate, the second loop would stop the count when the missile passed through.

Several of the machines were built before the war by the Stockton Profile Gauge Corp. of Lowell, Mass. One is now in use for the measurement of hides areas by a large hide and leather company and others are being used in the hide and textile industries for measurement of pattern layouts.

High-Sensitivity Electronic Recorder

ONE-MILLIONTH of a millionth of a watt of electrical power can be recorded full-scale on the instrument shown in the photograph. It operates by the use of phototubes which respond to sensitive impulses relayed through a series of miniature mirrors and lenses.

Applications of the instrument include: recording changes of temperature, pressure, vibration, flow rate in steam boilers and turbines, measuring carbon monoxide concentration in vehicular tunnels and recording vibrations of buildings

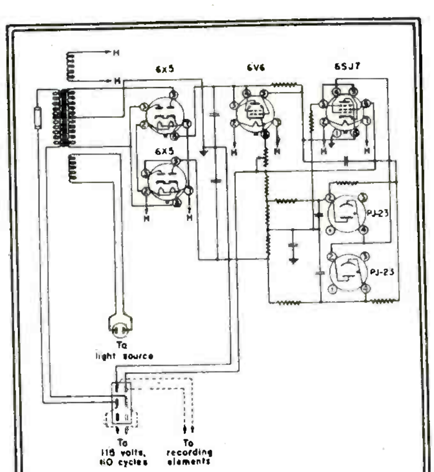


The photoelectric recorder that has a response speed of five cycles per second is tested by D. F. Hang, engineer in the General Engineering Laboratory of General Electric. Miniature mirrors and lenses are used to relay the impulses being recorded

caused by traffic or machine operation. In studying physiological reactions, it has been used to record a person's pulse beat under varying conditions.

The internal parts of the photoelectric recorder are the basic measuring element, the optical follow-up system, the electronic power supply, the recording element, and the chart carriage. These physical components of the recorder are also separate units in the assembly. The basic element is the only measuring device in the recorder and its load is the only one imposed on the input circuit.

The functional relation of the parts of the photoelectric recorder are shown in the mechanical drawing. The shafts of the recording and measuring elements, each carrying a small mirror, are on the same vertical line. The lightbeam is provided by the small incandescent lamp, the light from which is focused by the pair of condensing lenses. This beam is reflected, in turn, by the basic mirror, the spherical mirror, and the recording-element mirror, until it is finally divided between the two phototubes.



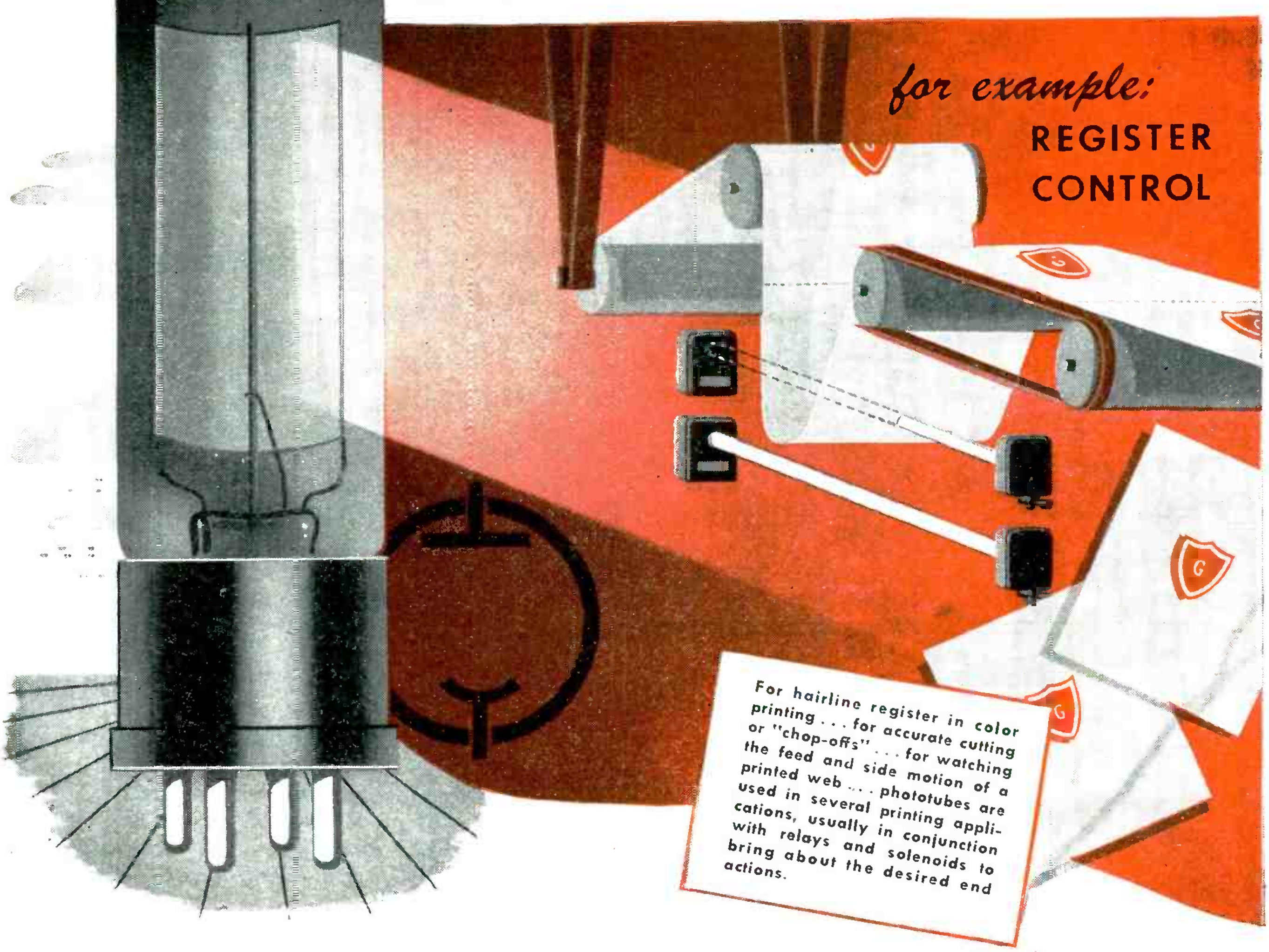
Circuit of the electronic amplifier section of the photoelectric recorder

Operation

When the mirrors of the recording and the basic elements are parallel, the light is equally divided between the two phototubes, and no current flows to the recording-element coil. If the pen is slightly to the right of its correct position, a greater part of the light falls on the nearer phototube. This causes a current to flow from the power supply through the coil in a direction that moves the pen to the left.

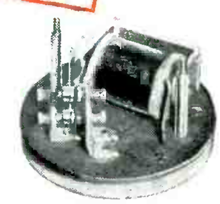
Errors are reduced to negligible amounts, because the function of

wherever a tube is used...

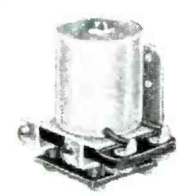


THERE'S A JOB FOR

Relays BY GUARDIAN



SERIES 5 D. C. RELAY. Maximum switch capacity—two normally open, two normally closed, or DPDT contacts. Resistance range .01 up to 15,000 ohms. Send for bulletin 14.



SERIES SC-5 SOLENOID CONTACTOR. Contacts rated at 75 amps. continuous, 300 amps. surge. Contact combination—single pole single or double throw. Coil operates on 18-28 volts D. C. and consumes 7 watts at 24 volts D.C. continuous. Send for bulletin SC-5.

In the electronic circuit there is usually a sensitive relay similar to Guardian Series 5, to control a heavier current in response to the weaker "signal" of the phototube. In some applications, however, the current to be handled may be greater than the contact capacity of the sensitive relay. In this case a power relay or solenoid contactor is controlled by the sensitive relay. Guardian series SC-5 is typical of this type of contactor.

Consult Guardian wherever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications but may be used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

GUARDIAN ELECTRIC

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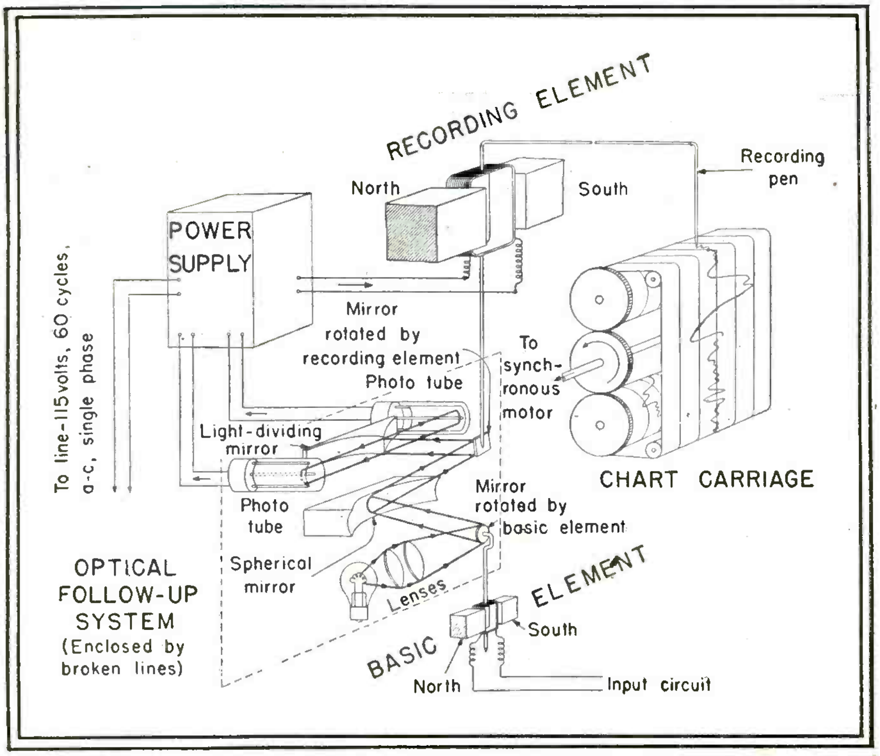


Mechanical arrangement of the mirrors and phototubes used in the recorder. Light reflected from the mirror of the basic measuring element controls the current supplied to the recording element

the optical-balancing system depends upon division of the light rays, and not upon the light intensity. Also, the slightest unbalance causes the power unit to give full output of current. Tube characteristics can change widely without affecting the final result.

The electronic circuit of the General Electric high-speed recorder is also shown. The lower 6X5 rectifier tube on the diagram supplies a constant current through the recording element, and also provides excitation for the phototubes. The two phototubes in the bridge-type circuit control the grid potential of the 6SJ7 tube according to the light division between them. This light balance controls the cathode current of the 6V6 tube which flows through the recording element and which, at balance, is equal and opposite to the steady current from the rectifier.

When the optical system is unbalanced, the current in the 6V6 tube is increased or decreased. The resultant current passes through the recording element and turns this element toward the balance point. The torque available is sufficient to produce a full-scale deflection of the recorder pen in less than 1/10 sec.

A-C Network Calculator

ELECTRICAL CALCULATORS have been in almost continuous demand for solving complicated power system problems ever since this country became involved in the war.

Recently a completely new, enlarged and modern calculator was installed at the Westinghouse plant at East Pittsburgh. Shown in the photograph is one drawer of the unit undergoing a final test for accuracy. The complete unit is the result of experience gained with a board installed in the plant in 1929 and incorporates the best features of eight similar calculators built since that time for central station and industrial customers.

Electronics in Textile Plant

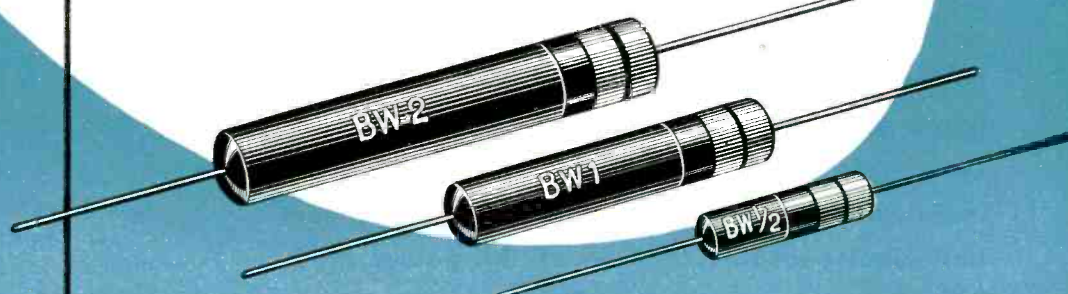
IN ONE SOUTHERN TEXTILE plant, it is essential that the doors between the weave shed and the warp-sizing room be closed as soon as possible after opening to maintain high humidity and temperature conditions within the weave shed. During ordinary operations, trucks are almost continuously carrying beams of yarn between the two rooms and to the cloth inspection room. With manual operation of the doors, the condition of the air was considerably disturbed, but photoelectric relays installed at the approaches to the doors now permit automatic opening and closing and operation of the doors and help maintain essential temperature and humidity conditions in the weave shed.

Another electronic device in the

One of the circuit drawers of a calculator for a-c networks is checked for accuracy by means of a special bridge and an oscilloscope

IRC WILL BE READY

with TYPE BW INSULATED WIRE WOUND RESISTORS



At the first indication of lessened demand by the Armed Services, IRC will be in an excellent position to immediately supply industry's requirements for resistors of *all* types. That IRC units will be available in ample quantities on a favorable price basis is assured because we have developed and are operating on a mass production basis the world's largest resistor plants.

RESISTOR PROBLEMS WELCOME

Feel free at all times to consult with us on your peacetime product design plans involving resistances. You can be certain of unbiased engineering counsel and secure in the knowledge that the subject matter will be held inviolate.

CHECK THESE FEATURES OF TYPE BW WIRE WOUND RESISTORS

1. *Completely insulated wire wound of standard ½, 1 and 2 watt sizes.*

2. *Resistance values: ½ watt—from .24 ohms to 800 ohms; 1 watt—from .5 ohms to 5000 ohms; 2 watt—from 1.0 ohms to 8000 ohms.*

3. *Have wire wound stability and are physically interchangeable with carbon types.*

4. *Available in matched pairs to 1% or 2% for close-tolerance, high-stability applications.*

5. *Element is space wound with copper-nickel or nichrome bare wire securely crimped and molded integrally with leads.*

PREFERRED FOR PERFORMANCE • IRC • FIXED & VARIABLE RESISTORS

INTERNATIONAL RESISTANCE CO.

401 N. Broad St. Philadelphia 8, Pa.

IRC makes more types of resistance units, in more shapes, for more applications than any other manufacturer in the world.

same plant is used in the opening room of the mill, where cotton is removed from the original bale and then partially cleaned and fluffed up into a loose condition by special machinery. At times the cotton being fed into this machine accumulates to such an extent that it overflows from the bin onto the floor, making it necessary for someone to replace it in the feeder hopper.

To shut down the feeding machinery automatically, a mercury switch trips when the cotton in the bin reaches a predetermined level. At this level, however, the continuously rotating cotton in the bin constantly trips the switch. This means repeated starting and stopping of the feeding machinery while the bin is full.

Supplementing the mercury switch with a General-Electric electronic time-delay relay solved the problem. Once the mercury switch has initiated a shut-down period, the relay keeps the cotton-feeding equipment inoperative for a preselected period of time, irrespective of the opening and closing of the mercury switch. After the time period has elapsed, the mercury switch again takes over to start the feeding equipment.

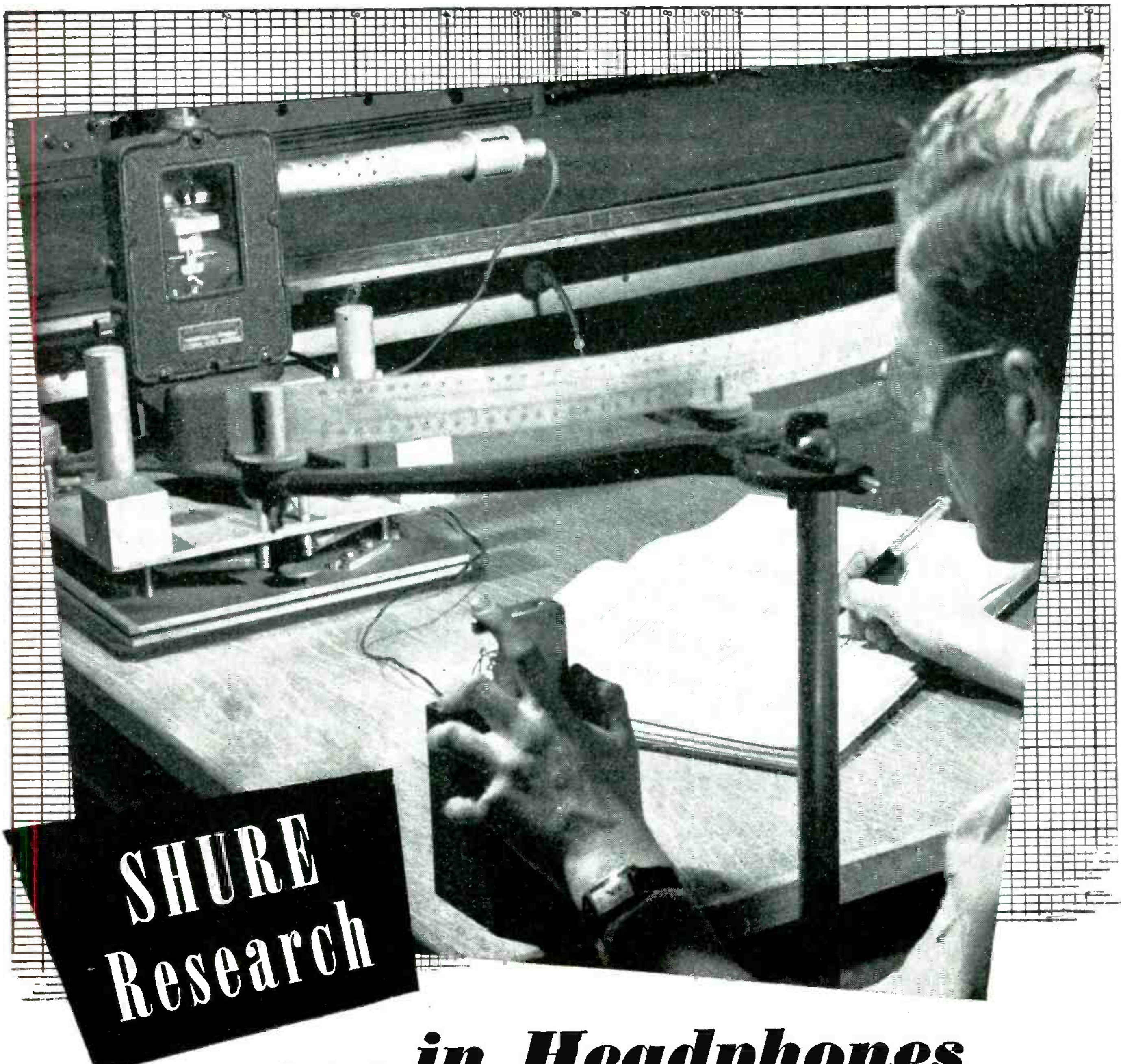
• • •

River Level Recorded by Radio

INCREASES IN THE LEVELS of the Salt and Verde rivers near Phoenix, Arizona, are recorded in a central office in Phoenix by a new radio remote registering system. Gages installed in both streams automatically send radio signals from 25-watt transmitters to the office of the chief hydrographer of the Salt River Valley Water Users' Association.

Previous to installation of the automatic system by Leupold and Stevens Co., the Phoenix office had to depend on telephone calls from observers on the two streams. During flood seasons, when the river level data was most needed, the telephone lines were inoperative due to weather conditions. So far, storms have not upset the radio system.

The transmitting equipment at each station is powered by two 6-volt storage batteries, one of 130, and the other 150 ampere-hour ca-



. . . in Headphones

It is logical that engineers, long trained in designing microphones for transmitting the human voice, should be especially familiar with the techniques of voice reception.

Headphone design, therefore, is a natural province of Shure engineers. The Shure headphone employs a unique moving armature design which combines light weight with sensitivity, simplicity and reliability.

In headphones, as well as microphones, you may continue to look to Shure for leadership.

SHURE BROTHERS, 225 West Huron Street, Chicago

Designers and Manufacturers of Microphones and Acoustic Devices

SHURE MICROPHONES

pacity. Vibrator power packs supply both a telemark coder and transmitter.

Coding Device

The telemark is a combination coding device and time switch. The essential parts of the instrument are several disks which are actuated by a float. The surface of each disk is divided into 10 sectors that contain ridges. In one sector, the ridge is broad—representing zero. The other sectors contain narrow ridges, the number of each representing the digits 1, 2, 3 etc. to 9. When the telemark is signalling, a motor driven contact arm sweeps across these ridges to produce signals which represent the gage height of the river at that moment.

Before the contact arm passes over the gage height disks, it travels over a bar located in the path of its rotation. This bar has the station's call letter cut into its surface. When the arm contacts this surface, the station's identification is transmitted, immediately followed by the gage height.

The time of broadcasts is predetermined and controlled by a time switch. This consists of a weight-driven clock which operates a series of switches that turn the transmitter and telemark on and off every twelve hours below a certain critical gage height, and every hour after that height is reached.

The receiving equipment consists of the receiving antenna, receiver and recorder. Both receiving and transmitting antennas were erected with their axes perpendicular to the direction of transmitting and receiving.

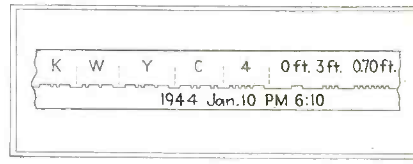
The receiver, a nine tube set, has no adjustments and is fixed-tuned to the transmitter frequency. Connection to the radio recorder is made by means of rubber covered cable and cable plug on back of the receiver.

Recorder

The radio recorder furnishes a continuous graphic record of the flows of the two rivers. It functions automatically when actuated by the receiver and consists of several instruments housed in a cast metal case having a view plate in the top. A Warren telechron clock synchronized to the "on" time of the transmitter turns on the receiver every

hour for a 15-minute period to receive signals, if the transmitters are broadcasting additional readings other than the 12 hour readings.

A roll of tape is mounted on the base and is driven by a small motor from the supply roll to a take-up roll. On this tape is recorded the dots and dashes of an incoming signal from one of the river sta-



Typical recording of the height of a river as sent and received automatically by radio. Two sets of signals are transmitted to insure reception during static intervals

tions. At the beginning of a signal, the tape is started and continues to run for about 1½ minutes, sufficient time to register one set of signals. Succeeding sets of signals start the paper anew.

A capillary pen, attached to a magnetic coil and resting on the moving tape, records each incoming signal. When the transmission is complete, the call letters appear in Morse Code and the gage heights are recorded on the tape.

Another mechanism stamps the year, month, date and exact time of the recorded gage height, one for each signal. Two sets of signals are received from each station. Although one or the other signal may be faulty during electrical interference, a study of both signals will produce one complete signal.

• • •

Electronic Bottle Inspection

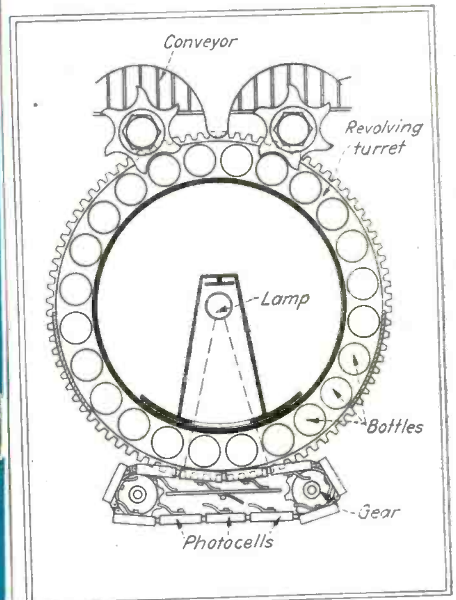
By S. R. Winters

Phototubes have been used for several years for the detection of foreign ingredients in the bottling of soft drinks. Machines for this use in one plant have contained a photocell that traveled in synchronized relationship with a rotating bottle during inspection and was returned to its starting position by means of a cam arrangement. Thus the bottles were inspected one at a time, a process that slowed down the inspection operation.

A modified and faster system that contains a number of photocells mounted on a roller chain has been

designed for the Coca-Cola Co. of Wilmington, Del. by George P. Stout. The mechanical features of the system are shown in the drawing.

The roller chain carrying the photocells is driven by teeth positioned around the outside edge of the revolving turret carrying the bottles. As the turret revolves, the teeth engage the roller chain so that bottles adjacent to the teeth travel in synchronized relationship with individual photocells for the necessary interval during the inspection period. When a bottle be-



Continuous inspection of beverage bottles is obtained by having the bottles travel through a lightbeam in step with moving photocells

comes aligned with a photocell the beam of light from the lamp passes through the whirling contents of the bottle and onto the cell. If the beam is interrupted by a foreign particle in the bottle, this change is registered by the cell. The impulse is amplified by electronic means and caused to reject the objectionable container.

In the first electronic setup it was necessary to wait for the optical system to return to its original position before starting inspection of another bottle. In the modified arrangement the photocell literally meets the bottle on the threshold of operations. The number of photocells on the roller chain, and the manner of their travel, is such as to eliminate the former time lag and thus speed inspection.

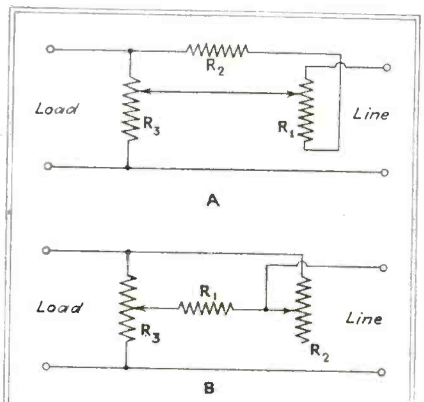
Constant-Impedance Control

By James C. Coe

For reasons of space and maintenance, it is often desirable to reduce the number of variable resistor units used for attenuation to a minimum. By using two variable resistors and one fixed resistor, the insertion loss can be made low with only minor variations of impedance to the source. When this is done, the impedance looking back from the load need not vary through such extremes as with an L pad of the conventional type.

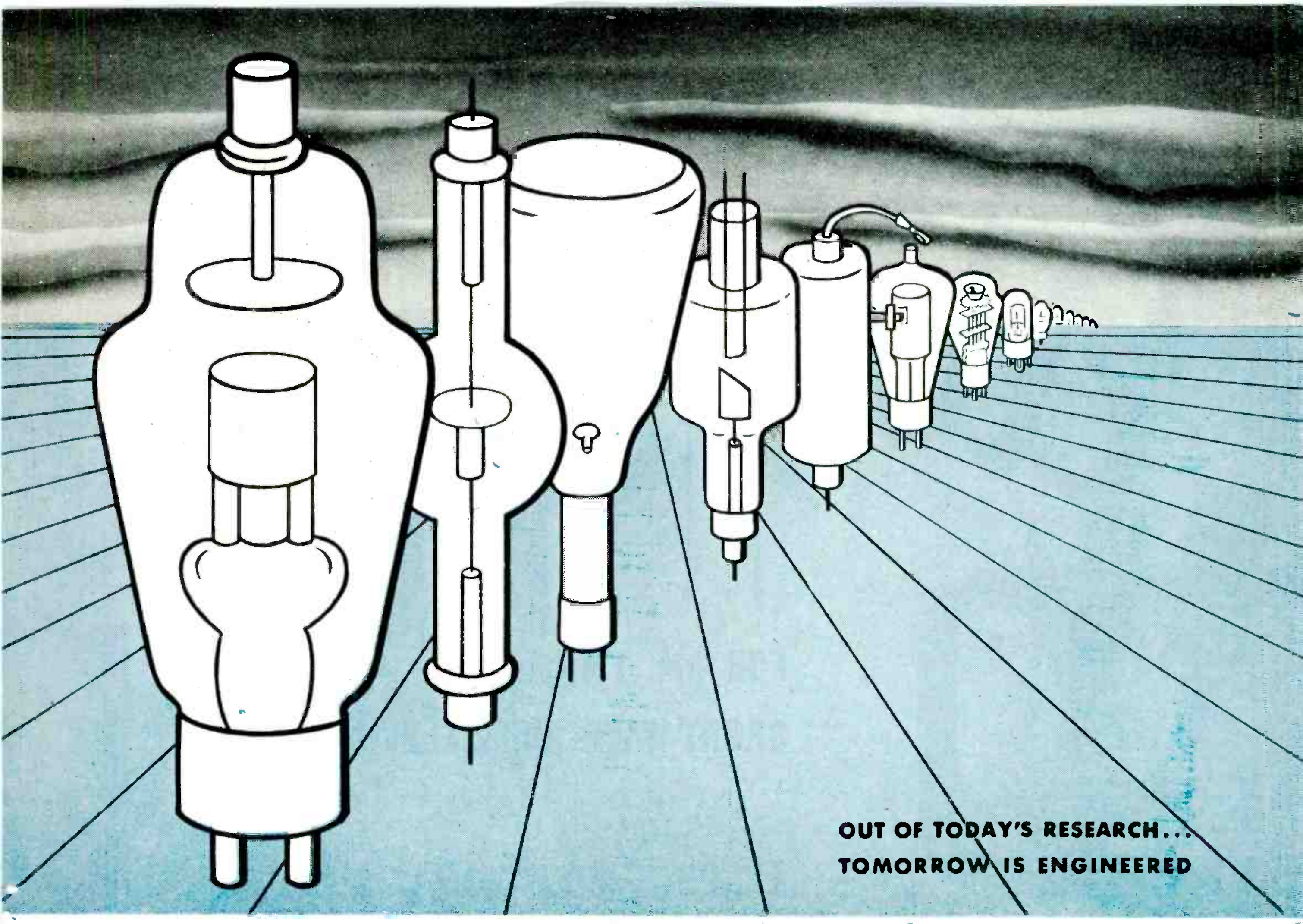
At *A* of the figure, R_3 can be a higher value than the load in order to reduce the insertion loss. The higher it is, the less the insertion loss, but at the mid-point of the control the impedance presented by the resistor and load combination will be higher than at the end points.

For example with R_1 equal to the load impedance, R_2 sixteen times, and R_3 eight times the load impedance, the entire combination of resistors and load presents an impedance of approximately twice the end values when the variable arms to R_1 and R_2 are at the mid-point. As only 26 percent of the available voltage is across the load at this point, it is apparent that a taper results from the use of linear resistors.



Suggested circuits for maintaining practically constant impedance with a minimum of resistance components

With linear resistors the degree of the taper can be changed through a wide range by choice of resistor values. This is an advantage from a manufacturing standpoint, however, since by using tapered resistors an even greater range of tapers is available to the designer. By changing the value of the fixed



THE RIGHT INSULATION FOR HIGH-FREQUENCY APPLICATIONS

THE degree of efficiency and stability of high-frequency circuits depends largely upon use of the correct insulation.

ALSIMAG Steatites are permanent materials. They are hard, rigid, do not distort by loading, nor do they warp or shrink with time.

ALSIMAG Steatite Ceramic Insulators are non-inflammable. As they do not contain carbon, they do not char. Electrically conducting paths are not formed as a result of arc over or other heating.

Corrosive materials do not attack them. They do not absorb moisture.

Mechanical strength is exceptionally high compared with ceramics in general or with organic materials.

ALSIMAG Steatite Ceramic Insulators have exceptionally Low Loss Factor, High Dielectric Strength and High Resistivity.

Many ALSIMAG compositions, each with its particular characteristic, are available to meet all insulating requirements.

AMERICAN LAVA CORPORATION
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ARMY E NAVY

Army-Navy "E"
First Awarded July 27, 1942
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STEATITE CERAMIC INSULATORS

IN **audio** EQUIPMENT

FOR AM, FM, SHORT-WAVE AND TELEVISION

The RCA 44-BX Velocity Microphone and the 77-C Unidirectional Microphone—the finest in quality and the most widely used of all microphones.

The RCA 70-C Transcription Turn-table, most popular everywhere, one or more in every broadcast station—equipped with universal pickup head.

The RCA 64-B Monitoring Loudspeaker, widest frequency response and widest angle of high-frequency response of any standard model speaker.

IN studio speech input equipment RCA has led the field for the past ten years—in recent years by a wide margin.

RCA studio equipment predominates in the studios of all major networks and in a large proportion of the outstanding station installations—large and small.

All of the RCA studio equipment, and all of the RCA broadcast transmitting equipment, sold in the last ten years was designed from scratch by RCA engineers and built exclusively in RCA plants.

RCA experience in broadcast equipment—studio and transmitting—is unequaled.

And note especially—

All of the RCA studio equipment models current at the beginning of the war were designed for the wide response and high standards of FM broadcasting.

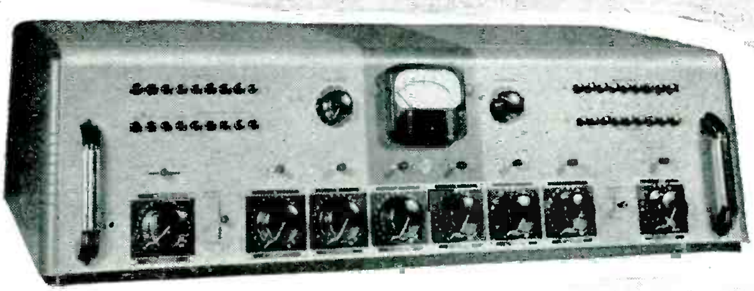
A number of commercially licensed FM stations *on the air today* are 100% RCA-equipped—from microphone to antenna.

RCA

RCA BROADCAST EQUIPMENT

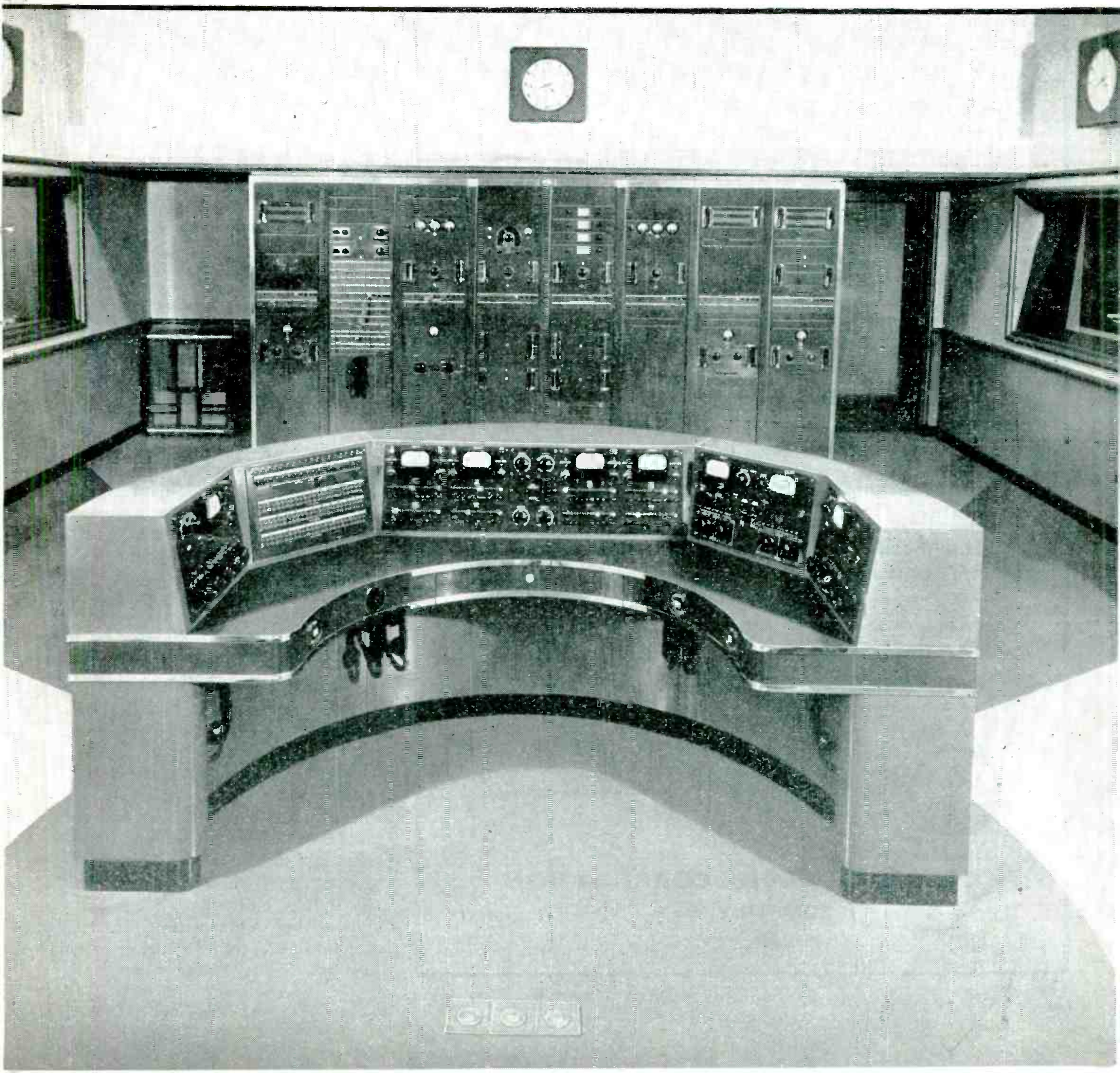
RADIO CORPORATION OF AMERICA

BUY WAR BONDS



● The RCA 76-B2 Consolette, finest, most complete studio equipment of its type. Handles two studios and announce booth. Quality equal to custom-built installations.

(BELOW) Master control room of WFBR, Baltimore. RCA custom-built studio equipments, such as that shown here, are unapproached either in utility, convenience or performance. They are made up to suit the requirements of the individual station exactly—and yet, because they are assembled largely from standard units, they often cost no more than much inferior and decidedly less convenient equipments. All RCA units such as amplifiers, racks and control panel are, of course, also available separately.



resistor R_2, the taper of the combination can be easily altered.

Where infinite attenuation is not required, the circuit shown at *B* can be used. With the same resistance values as above, the greatest variation of impedance is approximately 65 percent more than at the end points of control. With these values 46 percent of the available voltage appears across the load when the contact arms are at the mid-resistance point. While the value of R_3 can be reduced to obtain less impedance variation, R_2 cannot be changed without affecting the maximum attenuation possible.

Of all the combinations of two variable resistors and one fixed resistor, it is believed that these offer most promise.

• • •

Speed Meter for Camera Shutters

By C. J. PENTHER

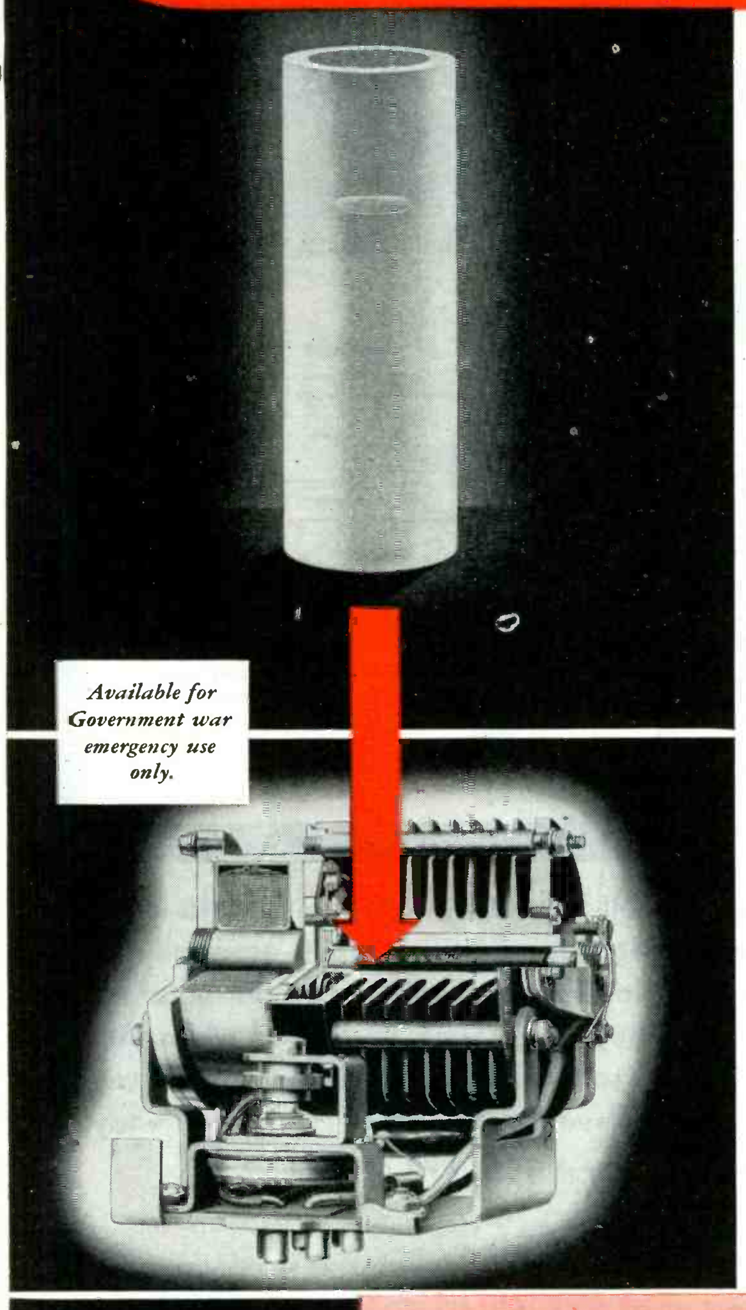
AN ELECTRONIC INSTRUMENT for measuring the effective speed, not the total open time, of a camera shutter is shown in the photograph. The unit forms a simple compact device suitable for counter use in camera stores.

The circuit of the shutter speed meter (called a shutter Speedometer) is given in the diagram. A phototube is connected to produce a current that is proportional to the light intensity reaching it through the camera lens and shutter. The phototube is in series with a capacitor and a direct voltage source so that the total charge accumulated by the capacitor will be directly proportional to the actual exposure, regardless of the variation of intensity during the open period of the shutter.

Operation

The voltage across the capacitor is measured with a vacuum-tube voltmeter having a meter scale which is marked to read shutter speed directly in reciprocal-seconds. Calibration is obtained by marking the scale in terms of the full-scale deflection obtained with constant light intensity. The meter reading then will be the ratio of the voltage built up in the capacitor during measurement, to the standardizing voltage during calibration. These voltages are, re-

THE LITTLE GLASS TUBE THAT HELPS KEEP PLANE VOLTAGES CONSTANT...



IT doesn't look exciting but this little Corning precision tube is flying in our planes to help them out-perform those of our enemy. It is the "heart" of an important piece of apparatus called a carbon pile voltage regulator.

As the name implies, the function of this equipment is to provide even, continuous voltage regulation without lag or fluctuation. This is accomplished by pressure exerted on a stack of carbon discs.

The tube which contains these discs must be smooth, accurate in dimensions and capable of withstanding high temperatures. For it, Eclipse-Pioneer engineers have chosen a precision ground Pyrex tube with an outside diameter of .6245 plus 0 minus .001 inches and an inside diameter of .435 plus or minus .002 inches. Tolerances unheard of five years ago except for optical purposes!

Perhaps Corning's "know how" in glass may some day be of use to you, too. Under the Army-Navy "E" flag at Corning you'll find glasses with high dielectric strength, extreme resistance to thermal or mechanical shock or any combination of these qualities needed to fit your particular requirements. Just to keep you informed we'd like you to have a free study called "There Will Be More Glass Parts In Post-War Electrical Products." Write for your copy to the Electronic Sales Dept. E-5, Bulb and Tubing Division, Corning Glass Works, Corning, New York.

Photo Courtesy Eclipse-Pioneer Division of Bendix Aviation Corporation

CORNING means Research in Glass

Electronic Glassware

T.M.REG. CORNING U.S. PAT. OFF.

T.M.REG. PYREX U.S. PAT. OFF.

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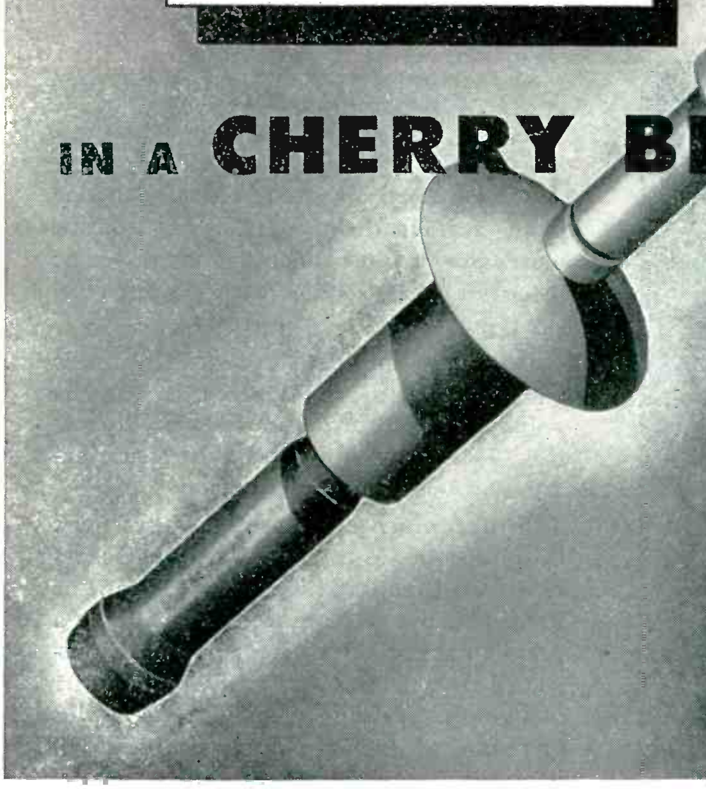
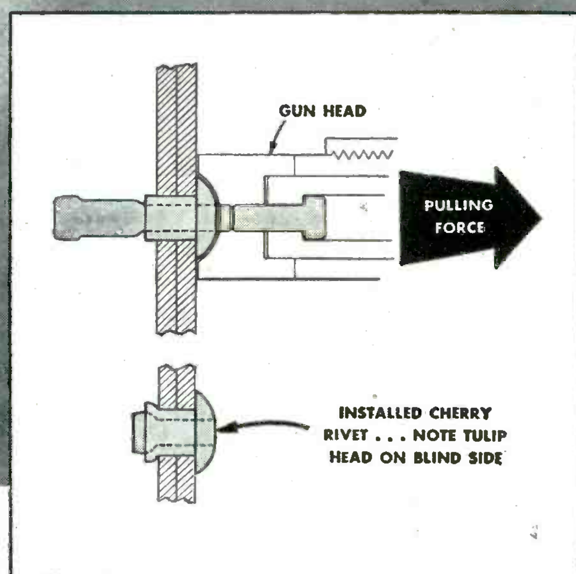
IT'S THE *pull* THAT COUNTS

IN A CHERRY BLIND RIVET



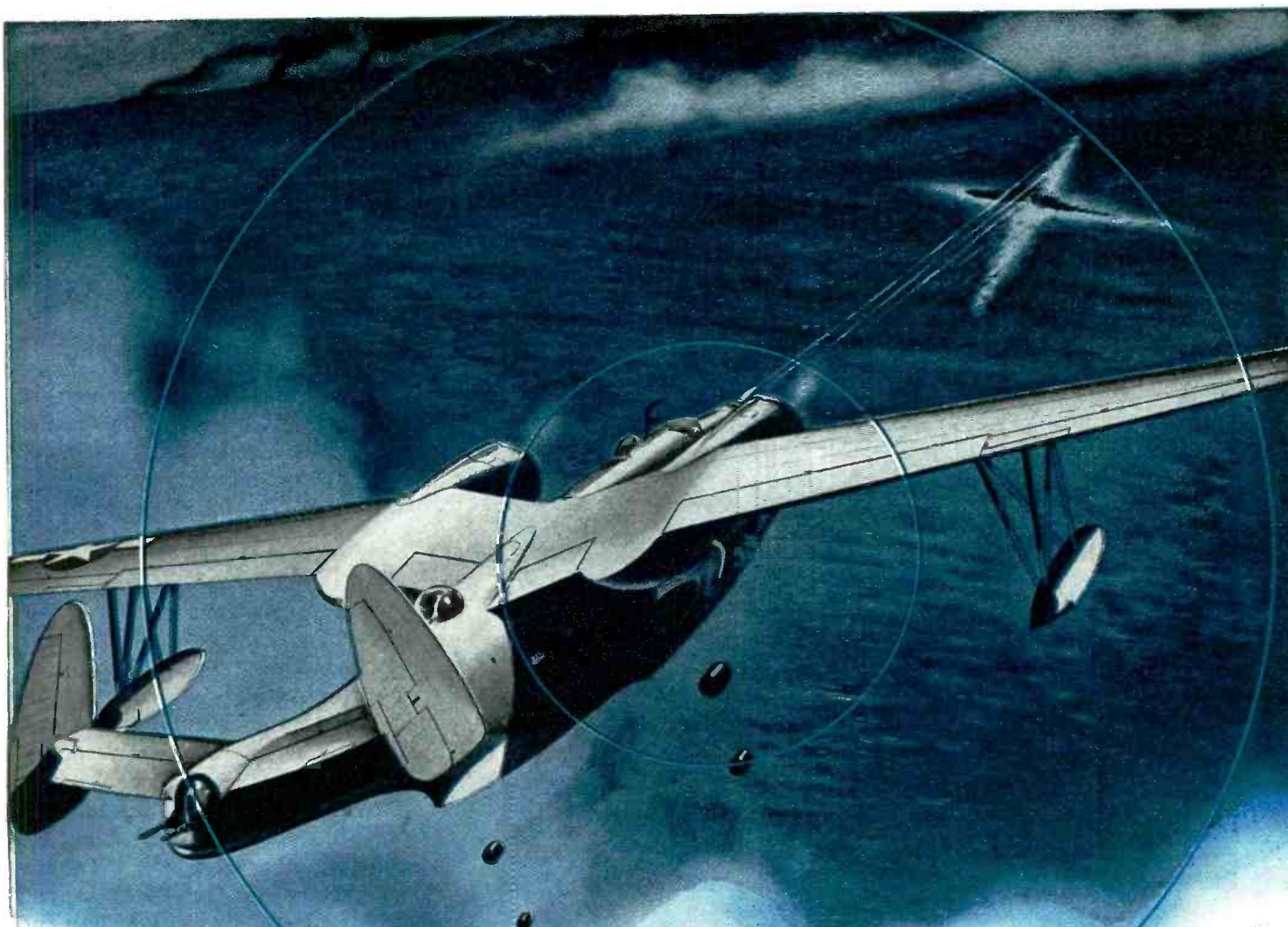


It's pull—not pound—that forms the head of a Cherry Blind Rivet. No hammering, no shock—no bucking bar. Just the steady application of a drawing force for a neat, sturdy, firm, tight joint. Of course Cherrys were designed for those tough jobs where the work has to be done from one side. But they are so easy to use and finish up so well that they are going into many regular riveting jobs—especially on plastics and pliable or brittle materials. They don't bend or spread when used in soft materials. Their heads are well formed and smooth. It's the steady, easy, strong *pull* that does it.

Get this handbook with the complete story of Cherry Blind Rivets. You will find it interesting. Address Department A-120, Cherry Rivet Company, 231 Winston St., Los Angeles 13, Calif.

Cherry Rivets, their manufacture and application are covered by U. S. Patents issued and pending

Cherry Rivet *Company*
LOS ANGELES, CALIFORNIA



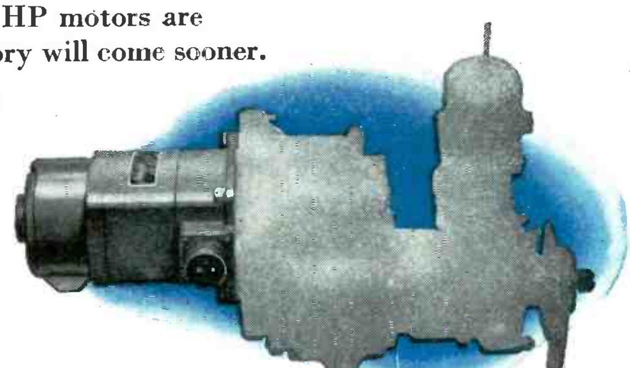
P. B. M. Mariner

TAKING THE "SLAM" OUT OF BOMB BAY DOORS

Bomb bay doors must open quickly and smoothly without jarring . . . *and close without slamming.* Holtzer-Cabot designed a special gear motor to meet these performance requirements which is, today, helping bombardiers blast the enemy.

Many other Holtzer-Cabot special fractional HP motors are providing power for war products so that victory will come sooner.

Our motor development engineers, backed by over 50 years of experience in electric motor design, will discuss your post-war motor problems with you. However, war needs come first and our manufacturing facilities, today, must be strictly limited to building special motors for winning the war as quickly as possible.



SPECIAL MOTORS DESIGNED TO FIT THE APPLICATION

The HOLTZER-CABOT ELECTRIC COMPANY

Designers and Builders of Special Fractional HP Motors and Electrical Apparatus

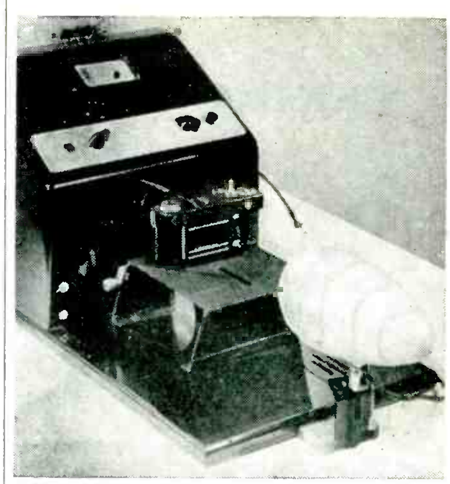
125 Amory Street, Boston 19, Mass.; Chicago, Illinois; New York, N. Y.; Philadelphia, Pa.

spectively, $e = Q/C$ and $E = IR$, from which the effective exposure time is found to be proportional to RCe/E.

The instrument is standardized by adjusting the intensity of the light source for full-scale deflection with the shutter held open. Next the shutter is closed, and C completely discharged through R. The pushbutton is now depressed, disconnecting R, and the shutter operated. The meter then reads the voltage to which C has been charged and directly indicates the shutter speed. Releasing the pushbutton discharges C and restores the meter to zero reading for the next test.

Design

It is desirable to use a meter capable of full-scale deflection between 0.2 v and 4.0 v for the negative charging voltage of 50 v in this circuit, thereby confining the useful operating characteristic of charge vs time to a practical region of linearity, excluding the true exponential portion of the capacitor charging characteristic. The circuit shown in the diagram will cover a range between 1/5000th and 2.0 seconds.



Shutter speed meter used to check timing of a miniature camera. The intensity control, meter-range switch and calibration pushbutton are on the panel. Exposure time is read directly on the meter scale

It is also possible to select ranges by switching different values of resistors instead of capacitors. Although this is advantageous in some cases, the latter case permits one calibration setting for all ranges.

The input current to the volt-

OWI Photo by Palmer in an Allegheny Ludlum plant

To this Flywheel, Many a Bomber

OWES ITS OWN ABILITY TO FLY

HAND BOOK OF SPECIAL STEELS

Newly revised and reprinted—a comprehensive book on the properties, uses, and best methods of handling, treatment, etc. of tool, stainless and other alloy steels. Plenty of tables to facilitate quick reference and selection. 136 pages, pocket-sized, latest data.

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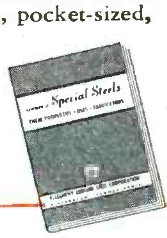


WITHOUT special alloy steels, no modern bomber would fly . . . in fact, there are more of these materials in the big planes than any other single ingredient, a fact not so commonly understood.

Many of these special steels—electrical, corrosion and heat-resisting, valve and nitriding—first passed over the big breakdown mills in Allegheny Ludlum plants. Even more particularly, many of them were developments of our own research, and all of them are raw materials of the greatest portent for the future.

Special steels have eloquently demonstrated their ability to do for a product—perhaps *your* product—what ordinary materials cannot do. Let our Technical Staff help you to fit these tailor-made steels to your needs.

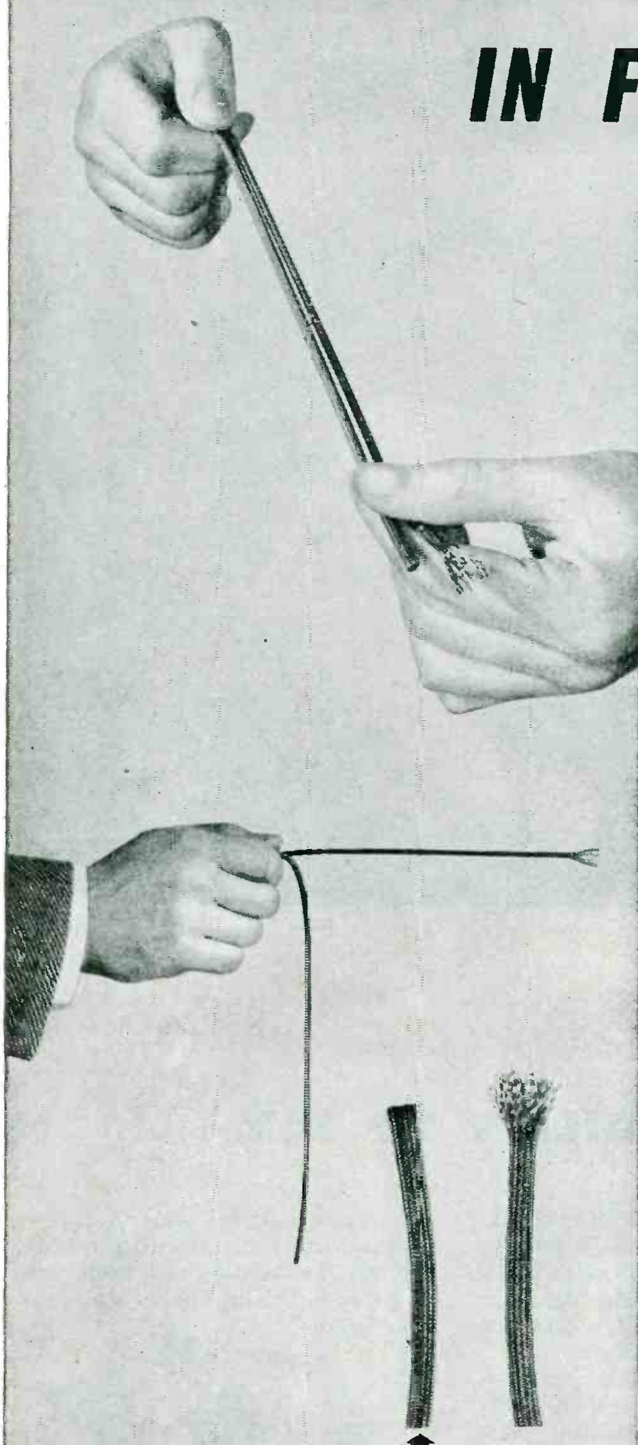
AL STEEL FOR THE NATION'S WELFARE

Allegheny Ludlum
STEEL CORPORATION
BRACKENRIDGE, PENNSYLVANIA

Allegheny Stainless also handled by all Joseph T. Ryerson & Son, Inc. warehouses

W&D A-9334

YOU CAN PROVE TO YOURSELF IN FIVE SECONDS...



THIS—NOT THIS

That new BH Fiberglas "extra Flex" Sleeving is more flexible than saturated sleeving

WE'VE TOLD YOU about the non-fraying quality of the new BH Sleeving. But don't forget the extra flexibility we've built into it. You can prove this to yourself with the five-second test of sleeving flexibility:

Obtain from us a sample of BH Extra Flexible Fiberglas Sleeving equal in size to the saturated sleeving you use now.

Following Figure 1, hold eight-inch lengths of both BH Extra Flexible Fiberglas Sleeving and saturated sleeving between the thumbs and fingers of both hands. Stretch both sleevings to make them straight.

Now release the sleeving ends held in your left hand. Instantly, the new BH Fiberglas Sleeving will fall limp, proving its extra flexibility. The saturated sleeving will remain straight, practically inflexible. The comparison is shown in Figure 2.

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

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

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

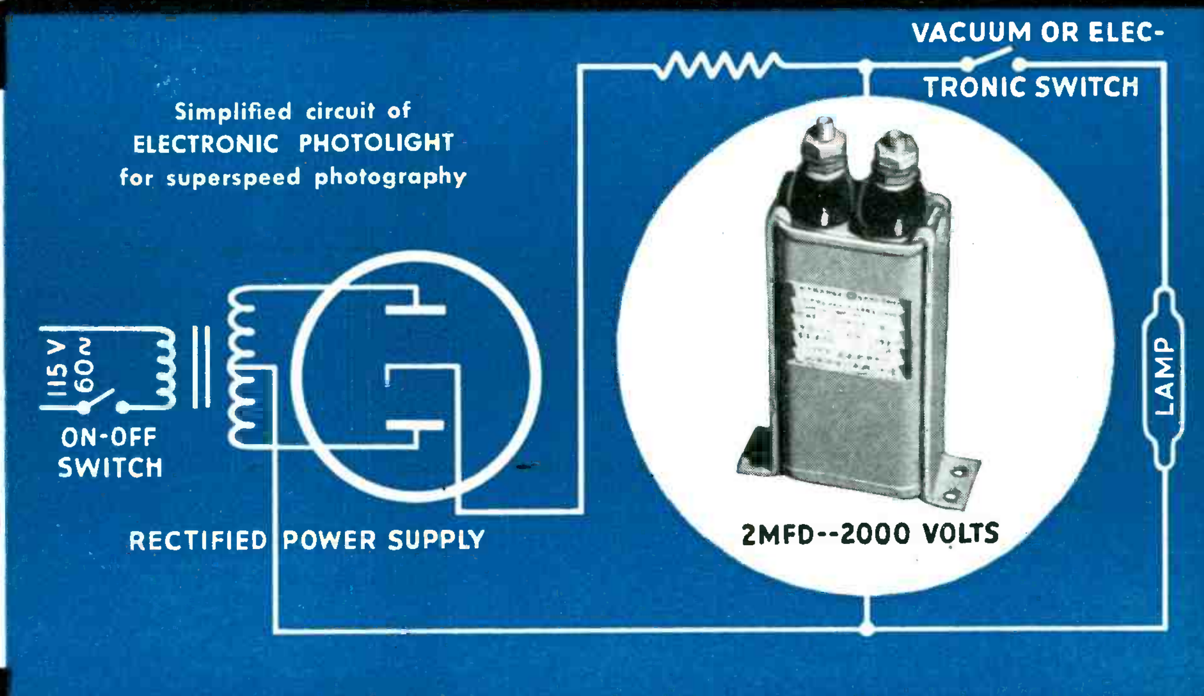
NON-BURNING IMPREGNATED MAGNETO TUBING • NON-BURNING FLEXIBLE VARNISHED TUBING • SATURATED AND NON-SATURATED SLEEVING

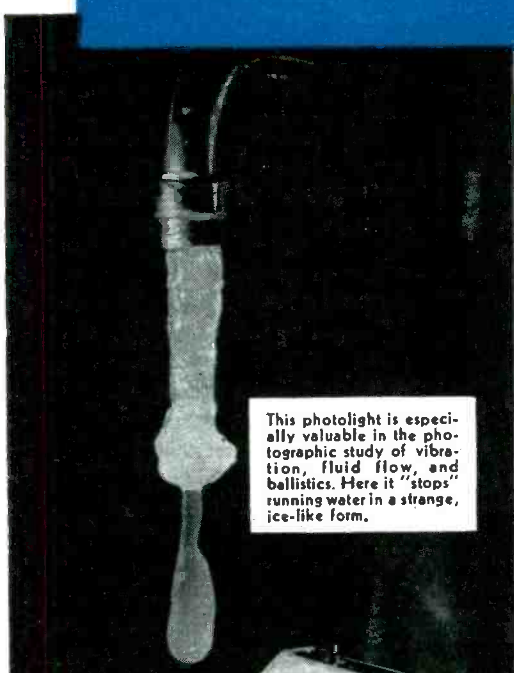
BH PRODUCTS

BENTLEY, HARRIS MANUFACTURING CO.
Conshohocken, Penna.

New Uses of Pyranol Capacitors*

that may suggest short cuts on <u>your</u> circuits





This photolight is especially valuable in the photographic study of vibration, fluid flow, and ballistics. Here it "stops" running water in a strange, ice-like form.

The G-E photolight for very high-speed photography is primarily of interest in research work. It illuminates 20 square feet.

**First in a series of ads that will outline new jobs being done with Pyranol capacitors.*

IN THREE SECONDS this small Pyranol capacitor accumulates enough energy to discharge 4,000,000 watts in four millionths of a second through a mercury lamp, producing a flash one-fifth as bright as the sun's surface.

FEATURES THAT MAKE IT EASY FOR YOU TO DESIGN WITH PYRANOL CAPACITORS

COMPACTNESS—High capacitance per cubic inch, because of the unusual dielectric properties of Pyranol.†

SPACE-SAVING SHAPES—Many of the ratings are available in oval, cylindrical, or rectangular cases to make your design problems easier.

CONVENIENCE—They will work equally well mounted in any position.

DEPENDABILITY—Hermetically sealed for permanence and uniformity of characteristics.

They have long life because of the superior materials used, supervised manufacture, and individual testing. Write for our time-saving catalogs on a-c (GEA-2027) or d-c (GEA-2621) types. They cover our complete line. *General Electric Company, Schenectady, N. Y.*

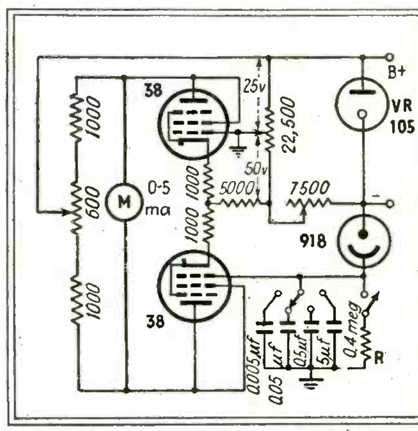
†Pyranol is the G-E trade name for askarel, the synthetic, noninflammable liquid used in treating G-E capacitors.

GENERAL ELECTRIC

407-73-5700

meter circuit is 10^{-12} amp. With the circuit values shown, this will produce in 2.0 seconds approximately a 0.1 percent loss of charge from a 1/1000-second exposure. The meter needle therefore holds its maximum position amply long for a reading. Careful balance, generous feedback, and a voltage regulator tube afford all the stability in respect to line voltage fluctuations that could be desired.

It is interesting to note that the normal 4-percent 120-cps modulation of light intensity obtained



Circuit of electronic components in the shutter speed meter. The phototube is actuated by light from a small spotlight passing through the camera shutter and lens. A conventional power supply is used to provide the *B* voltage

with a tungsten lamp on 60-cps a.c. produced no appreciable error in respect to readings taken with d.c. connected to the lamp.

The Shutter Speedometer introduces to the field of photography a simple, inexpensive instrument for measuring shutter speeds easily and accurately (in daylight) on all types of cameras as fast as the shutter can be operated. It can also be used to set flash bulb synchronizers by arranging the bulb to send its light through the lens and setting the synchronizer to obtain maximum deflection on the timer.

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(6) Long & Blair, *The Photographic Journal* (London), August 1934

(7) U. S. Patent No. 2,274,158 covering the above-described Shutter Speedometer.

"We knew that
AMERICAN PHILLIPS SCREWS
Make Stronger Fastenings Faster...
Now we know, too, that they Cost Less to Use!"

ONLY PHILLIPS SCREWS HAVE THE ENGINEERED, TAPERED RECESS

Anyone can see that American Phillips Screws are the fastest and easiest means of assembly, as well as the most effective protection against spoiled work. And those who scan the cost-sheets can see, too . . . how quickly American Phillips Screws write off their own investment and build a healthy margin over on the credit side.

These savings come both from Phillips engineered design of tapered recess and driver . . . and from American production-control which consistently delivers screws of uniform quality and size, individually inspected for accuracy and serviceability of head, thread, and point. So "buy American," and get these savings for yourself.

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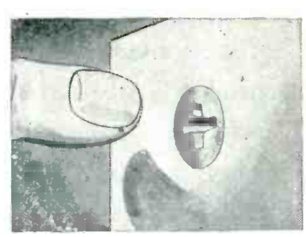
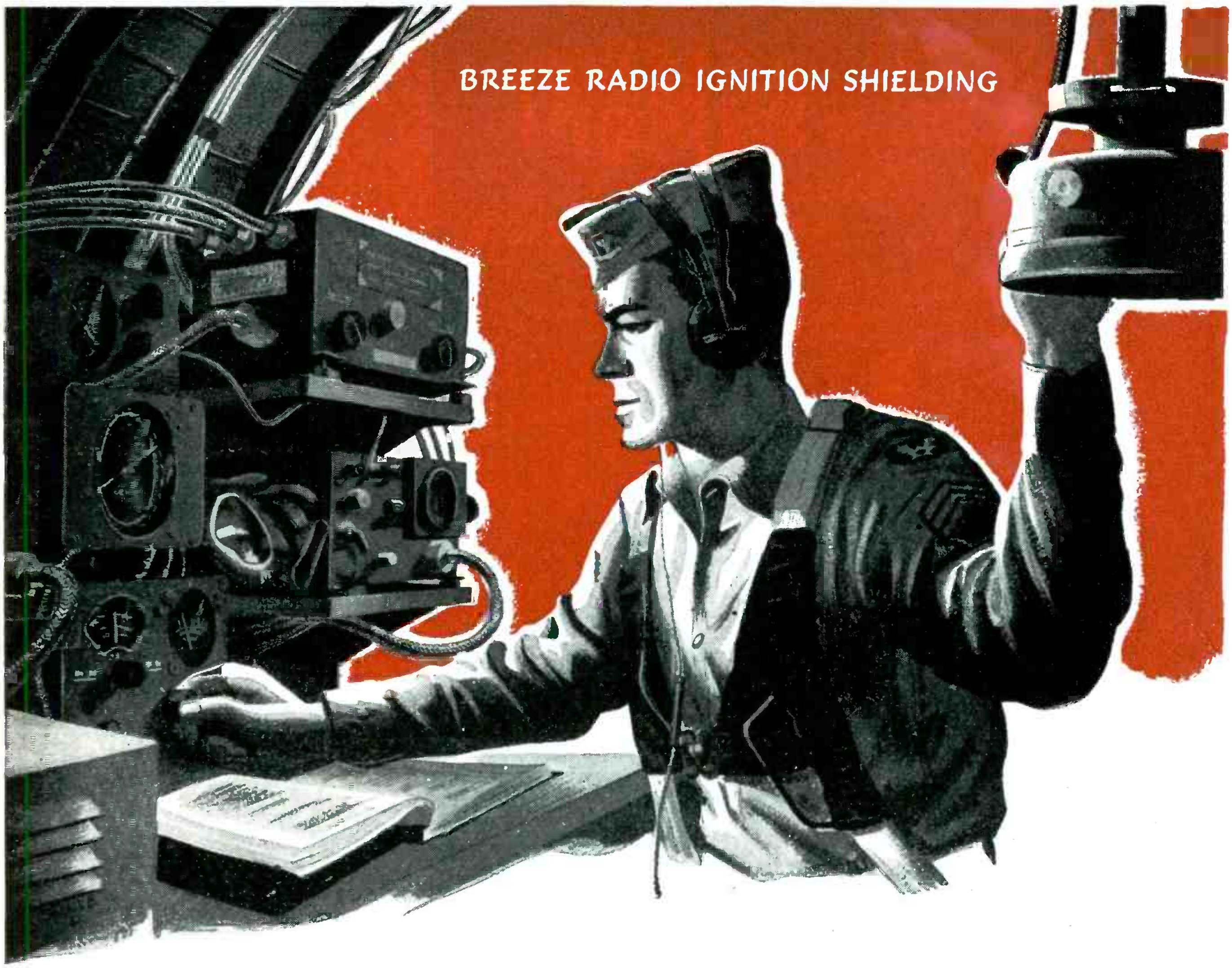
...and here's WHY American Phillips Screws COST LESS on any Screw Driving job

1. **Faster Starting**—One hand holds driver, other holds work. No wobbling, no dropped screws. Phillips screw and driver remain as one self-aligned unit until screw is driven.



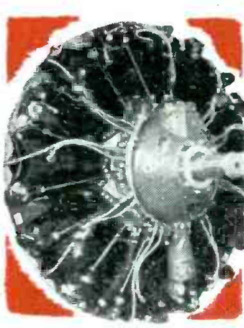
2. **Cleaner Fastenings,** —*every time.* No slanted screws to back out. No gouged work-surfaces, or burred screw-heads. Even unskilled workers get skilled results right from the start.

Put the Screws on the Axis... BUY WAR BONDS!



Friend or Foe?

Over Africa recently a flight of American bombers on their way to a target received radio instructions to change course and attack a different objective. Because of the clarity of reception, an alert operator was able to take a bearing on the signal—only to find that it was coming from the enemy. A call back to base brought out our fighters, who proceeded to the false target and destroyed thirty out of forty-five Messerschmitts which were lying in ambush for the flight of American bombers.



Breeze Radio Ignition Shielding is engineered to designers' special requirements. Look to Breeze for the solution to your shielding problems.

Perfect and undistorted reception and transmission of signals made possible the victory related above. Breeze Radio Ignition Shielding, which effectively guards against the radiation or absorption of radio-frequency interference, maintains a dependable "quiet zone" for static-free communication.

Pioneers in developing Radio Ignition Shielding, Breeze has designed and produced shielding harnesses for hundreds of types of aircraft, marine, and automotive engines. This equipment, now being produced in ever-increasing quantities, supplements the many other items of the well-known Breeze line of accessories for America's fighting units of land, sea, and air.

Breeze BREEZE MARK

CORPORATIONS, INC. NEWARK, N. J.

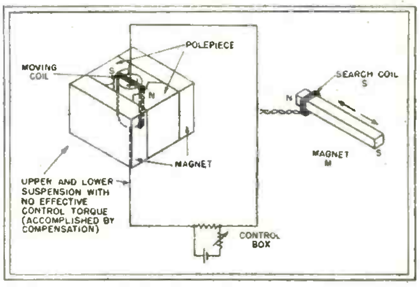
PRODUCTION FOR VICTORY • PRODUCTS FOR PEACE

Fluxmeter Uses Lightbeam

A NEW FLUXMETER, applicable wherever permanent magnets or d-c electromagnets are used, is similar to a lightbeam galvanometer and has a suspension-type element. It uses search coils, which may be made by the user, to provide a ready means of handling a wide variety of magnetic measurements.

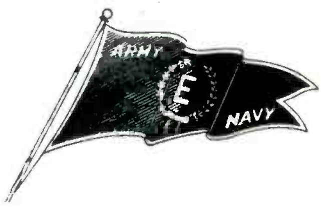
The fluxmeter principle has been recognized for a long time as having definite advantages for certain magnetic measurements. Ideal performance has been difficult to obtain since previous designs have been limited to low sensitivity, pivot friction or fragility, factors that make industrial applications difficult.

The principle of operation of the fluxmeter is illustrated in the diagram. When magnet *M* is moved with respect to search coil *S*, a change of flux linkages occurs and a voltage is induced in the search coil. Current flows in the circuit and the fluxmeter moving coil, suspended in a strong magnetic field, begins to rotate at high speed, just as though it were a d-c motor. The rotation develops counted emf that tends to reduce the current in the circuit to zero. The tendency, therefore, is for the fluxmeter coil to always follow the flux change in the search coil. The suspension exercises no effective control torque, hence there is no tendency for the coil to return to any definite scale position and the reading is maintained until returned to zero.



The circuit of a simple fluxmeter illustrates the principle of operation

Unlike conventional permanent magnet moving-coil instruments, a fluxmeter has no spring to provide countertorque. Hence, an ideal fluxmeter would act like a microvoltmeter of infinite sensitivity. Practically, this means that any small spurious voltages in the circuit will tend to cause a continuous



E-E Electronic Tubes...

public servant number one!

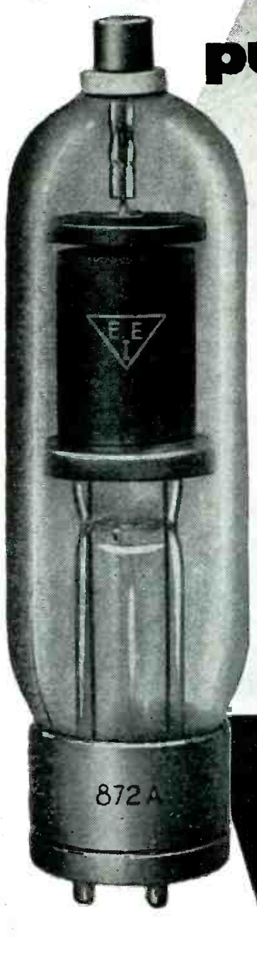


Illustration of
Type 872-A Half Wave
Mercury Vapor Rectifier
Peak Plate Current 5 Amp.
Peak Inverse Voltage 10,000

The unseen electron, at times seemingly devoid of physical entity, is an industrial giant of increasing stature. Fore-sighted industrialists, pouring increasing millions into the science of the free electron, take it sight unseen. To them this disembodied spirit of matter, the intangible free electron, is a genii with a Midas touch. Versatility and efficiency are its very essence. Counting packages, controlling machines and motors, differentiating colors, carrying messages, voices and pictures, separating materials, heating and welding, controlling, guiding, warning, probing and detecting, it is a veritable fountain head of aid and inspiration to the industry of the world . . . .

A MAGIC WAND TO BETTER LIVING.

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motion or "drift" of the fluxmeter coil. The purpose of the control box is to introduce an opposing voltage to compensate for these spurious voltages.

Since the fluxmeter coil always tries to generate a voltage to reduce the current flowing in the circuit to zero, IR drop in the circuit becomes of little consequence and doubling the resistance of the search coil will produce practically no effect on the fluxmeter deflection. It will, however, tend to increase the "drift rate" of the light beam.

The instrument, recently announced by General Electric's Meter Division, is shown in the photograph with its control box.

This G-E fluxmeter uses a lightbeam to show the deflection of a galvanometer coil caused by current induced in a search coil surrounding a magnet

This contains a dry cell, resistors, rheostat and switches and provides a means of introducing the compensating voltage into the meter circuit. The control is also used to return the spotlight index to zero after a measurement has been made.

High flux sensitivities are made possible by interchangeable galvanometers. Any of seven different galvanometers may be used in the instrument to provide sensitivities ranging from 101 lines to 3,275 lines per millimeter.

• • •

Electronic Glueing of Shoe Soles

AN ELECTRONIC PROCESS that attaches soles to shoes by the use of dielectric heating to cure the cement and weld the sole and shoe to-

CONTROL . . .

COMPRISE MANY DIFFERENT TYPES . . .

WITH A WIDE VARIETY OF APPLICATIONS

There are many commercial and industrial fields to which control devices may be applied. These may be electrical, electronic or mechanical, depending upon the specific problem. The exact type of control is determined by our engineers after thorough study of the particular application. The devices may be made sensitive to changes in position, direction, pressure, temperature, time, voltage, current, humidity, light intensity or color. EAD not only builds control equipment to fulfill existing requirements but also builds special-purpose devices for which no previous specifications exist. EAD makes components such as motors, relays, generators, switches, instruments, electrical parts, as well as complete equipment. EAD specializes in working with manufacturers of equipment to develop and supply special components with particular emphasis on light weight and compactness. EAD has the ability and facilities to design and manufacture precision control devices and components.

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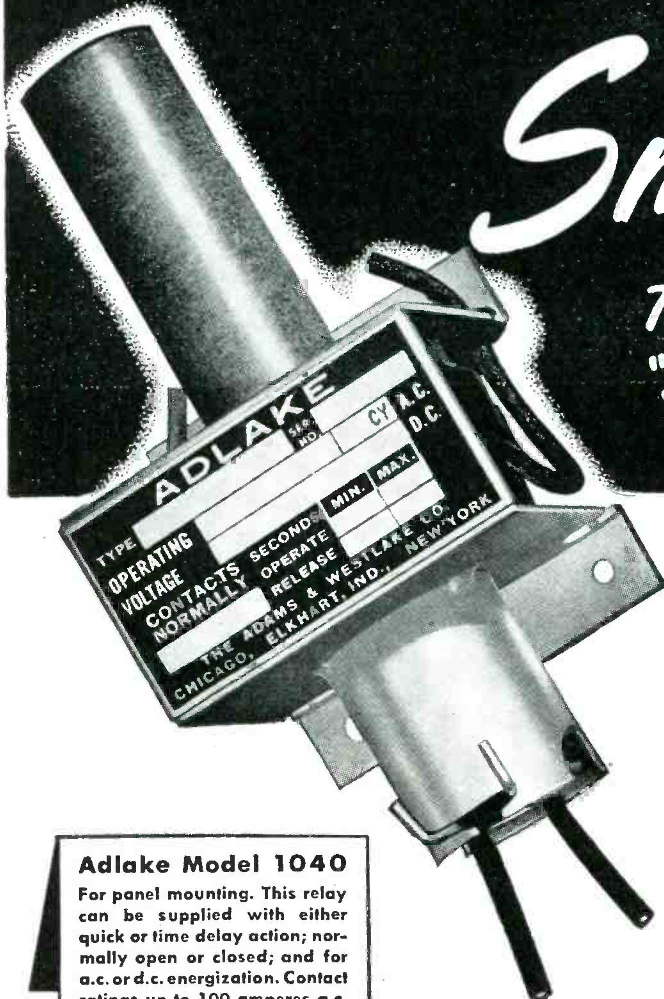
ADLAKE *Plunger-type* MERCURY RELAYS

Snap Action

That Stays "Snappy"!



Adlake Model 1040

For panel mounting. This relay can be supplied with either quick or time delay action; normally open or closed; and for a.c. or d.c. energization. Contact ratings up to 100 amperes a.c. with proportional d.c. ratings.

MERCURY moves *fast.* You know that because you've seen it in action. Due to this inherent characteristic of mercury, Adlake plunger-type *mercury* relays provide the *snap action* so desirable in a relay when contact is made—or broken.

There is positively no tendency toward "molasses in January" operation in these relays. Their action is "snappy" and it *stays "snappy"!*

Hermetically Sealed Contact Mechanism

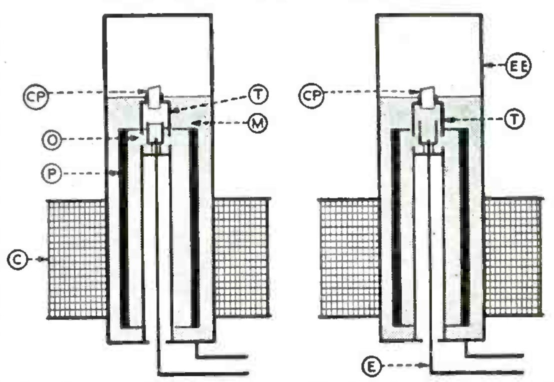
Contact mechanism of Adlake plunger-type mercury relays is hermetically sealed in an *armored* glass or metal cylinder. Dirt, dust, moisture, or oxidation cannot interfere with operation—*in any way or at any time.*

The *liquid* metal mercury contact is positive in action, chatterless, silent, and impervious to burning, pitting, and sticking.

For many kinds of service, no other type of relay provides equal *stamina* and *dependability.* Request complete bulletin.

"Back the Attack—Buy Bonds"

HOW THEY WORK



ENERGIZED—*Coil C pulls plunger P down into mercury. Mercury thus displaced enters thimble T through orifice O. Inert gas in thimble gradually escapes through ceramic plug CP—thus producing time delay.*

ENERGIZED—*Mercury now fills thimble T, is completely leveled off and mercury-to-mercury contact established between electrodes E and EE. Degree of porosity of ceramic plug CP determines length of time delay.*

Adlake TRADE MARK

THE ADAMS & WESTLAKE COMPANY

ESTABLISHED IN 1857 **ELKHART, INDIANA** *NEW YORK · CHICAGO*

MANUFACTURERS OF ADLAKE SPECIALTIES AND EQUIPMENT FOR RAILWAY, AIRWAY, HIGHWAY, AND WATERWAY

A NEW *Erie Ceramicon*

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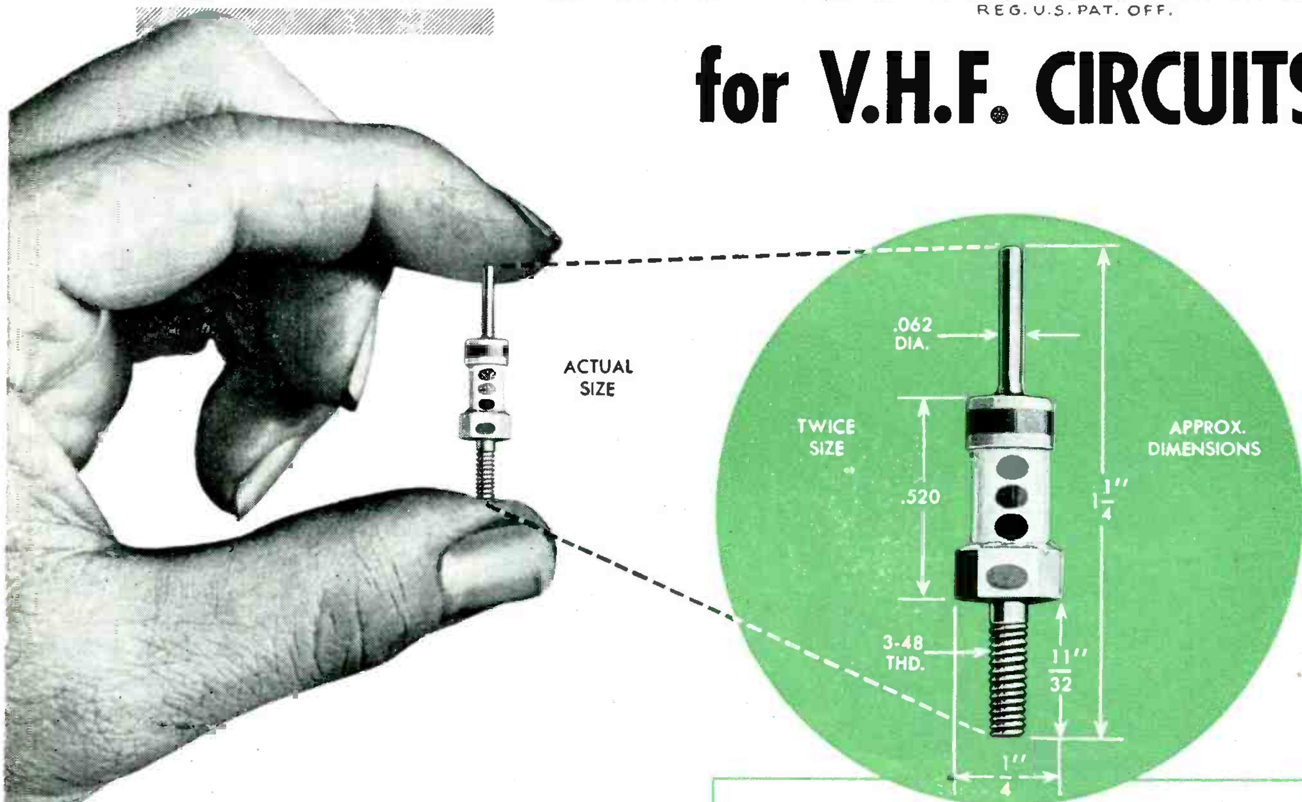
for V.H.F. CIRCUITS



Developed for Important War Application—Ideal for Peacetime F.M. and Television

HIGH Frequency applications have a way of throwing existing component designs into the discard. Short, heavy leads, low series inductance, and other design factors assume greater importance.

Erie Resistor had already had considerable experience in designing tubular and disc ceramic capacitors, and button type silver mica condensers for V.H.F. and U.H.F. equipment. Thus, when engineers from one of the country's foremost research and development laboratories came to Erie Resistor with a new capacitor design problem, the answer was quickly forthcoming, in the form of a basically new style of Erie Ceramicon, pictured above. Approximately 60 days later, finished units were being delivered for the extremely urgent communications equipment for which they were designed.

ERIE STAND-OFF CERAMICON

Maximum Capacity
- 17 MMF.—zero temperature coefficient
- 30 MMF.—330 P/M/°C " "
- 75 MMF.—750 P/M/°C " "

Minimum Capacity, 2 MMF.

Minimum Capacity Tolerance ±0.5 MMF.

Available Temperature Coefficients +100 to —750 P/M/°C.

This compact, stand-off Ceramicon has mechanical advantages that permit it to be rigidly mounted, and support other circuit elements. Electrically, this Erie stand-off Ceramicon has a high resonant frequency, and short electrical path to both silvered plates. The stability and retrace characteristics of Erie temperature compensating Ceramicons are inherent in this new unit.

Is there a place for this new component in your designs for war or peacetime communications equipment? Or if you have any other design problems involving resistors or condensers, our engineers will be glad to discuss them with you.

ARMY NAVY E
FOR HIGH ACHIEVEMENT IN WAR PRODUCTION

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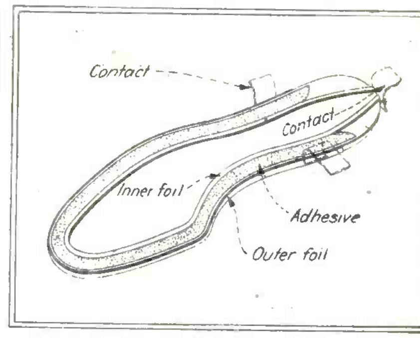
★ ★ ★ *Let's All Back The Attack—Buy EXTRA War Bonds* ★ ★ ★



Two metal foils, mounted along the edges of a layer of adhesive, provide electrodes for the application of r-f energy in glueing shoe soles

gether has been invented by G. Hart, Jr. and E. E. Winkley of Lynn, Mass. Their method has been adopted by the United Shoe Machinery Corp., Flemington, N. J. and is expected to save the relatively long period of drying under pressure now necessary in present shoe cementing operations.

The method consists of attaching to the sole a strip of metal foil running parallel to the inner edge of a band of adhesive and another foil close to the outer margin of the adhesive, preferably upon the periphery of the shoe sole. For strength at points of contact with electrodes of the r-f generator, a folded strip reinforced with cord may be used.

The two foils thus form capacitor elements which, when connected to a sourse of high-frequency r-f power, produce electrostatic heating of the adhesive. This quickly sets the glue and secures the sole to the insole of the shoe.

• • •

Measurement of Filter Chokes

By L. R. Malling

Determination of the inductance of iron-cored reactors carrying direct current presents certain problems which are difficult to overcome with conventional measuring techniques. A method is proposed that not only overcomes the problem of the superimposed direct current but also enables the inductance to be measured with a high alternating current component. The method is particularly applicable to the measurement of iron-cored reactors of the type used in the first section of filters supplying d-c power to electronic devices.

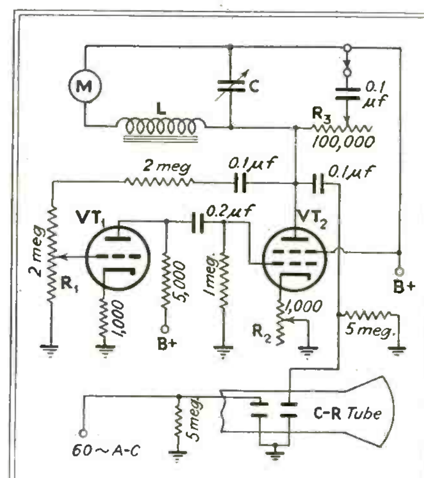
The circuit is shown and con-

sists essentially of a two-tube positive feedback oscillator with a resonant LC circuit in the plate of the second amplifier tube. The reactor to be tested forms part of the LC circuit and the resonant frequency is compared with the 60-cycle power supply frequency. An oscilloscope enables a visual comparison to be easily and accurately made.

Circuit

In the circuit, resistor R_1 controls the amount of feed back applied to the grid of tube VT_1. The bias of the second amplifier tube VT_2 is controlled by resistor R_2 which thus controls the plate current drawn by this tube and the current through the reactor L. Resistor R_3 is a variable control which enables the a-c component across the reactor to be varied. The alternating voltage built up across the reactor is applied to one set of plates of the oscilloscope and a voltage obtained from the 60-cycle power supply is applied to the other set of plates.

For measurement, the resistor R_2 is set so that the meter M reads the required value of direct current in the reactor. Resistor R_1 is then



Novel circuit for determining the inductance of an iron-core reactor while carrying the normal amount of direct current

adjusted so that the positive feedback is just sufficient for oscillations to occur across the combination of inductor L and capacitor C. Accurate adjustment of this feedback control is required to avoid overloading of the second amplifier tube VT_2 with consequent waveform distortion. The variable capacitor C, which might be a decade

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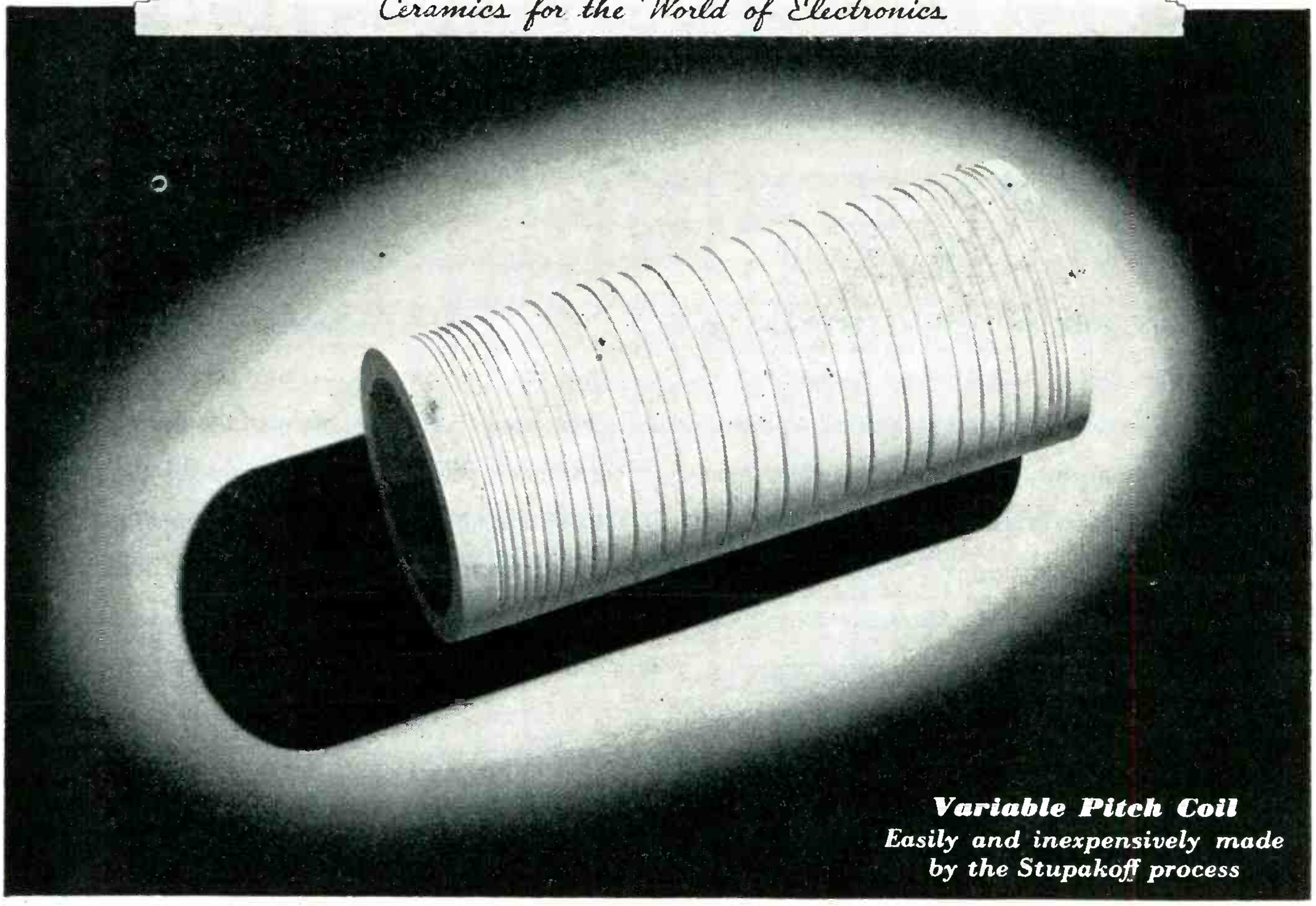

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Controlling factors for wire and cable vary greatly . . . limited space, unusual shape, weight restriction or cost. Insulation is often of paramount importance. Butyrate Tape and Vinylite are two types being used for lighting and low tension circuits in radio production, aircraft construction and other vital war needs.

Our business has been built by supplying wire and wire products that solve problems for designing engineers and manufacturers. Whatever you need, unusual shapes, sizes or special insulation requirements . . . feel free to write us for authoritative recommendations.

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box, is then adjusted until a stationary circular or elliptical pattern is obtained on the oscilloscope. This indicates that there is a constant phase relationship between the two frequencies applied and that the frequencies are identical. The inductance may then be determined from a reactance chart or by calculation from $L = 1/\omega^2C$, where $\omega = 2\pi f$ and f is the power line frequency.

The resistor R_3 is adjusted to give the required magnitude of the a-c component across the inductor. This latter may be measured with a vacuum-tube voltmeter. As R_3 is decreased, the Q of the LC circuit drops with a reduction of the alternating potential across the inductance or cessation of oscillations. The oscillating conditions may be restored by adjustment of R_1.

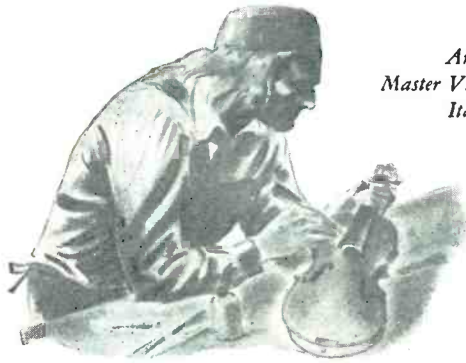
Alternating potentials of the order of a hundred volts are easily obtained across the resonant circuit. The current through the reactor may be increased to any desired value by operating tubes in parallel with VT_2 or by the use of a larger amplifying tube. For ease of reading, the capacitor decade box may be calibrated directly in terms of inductance.

• • •

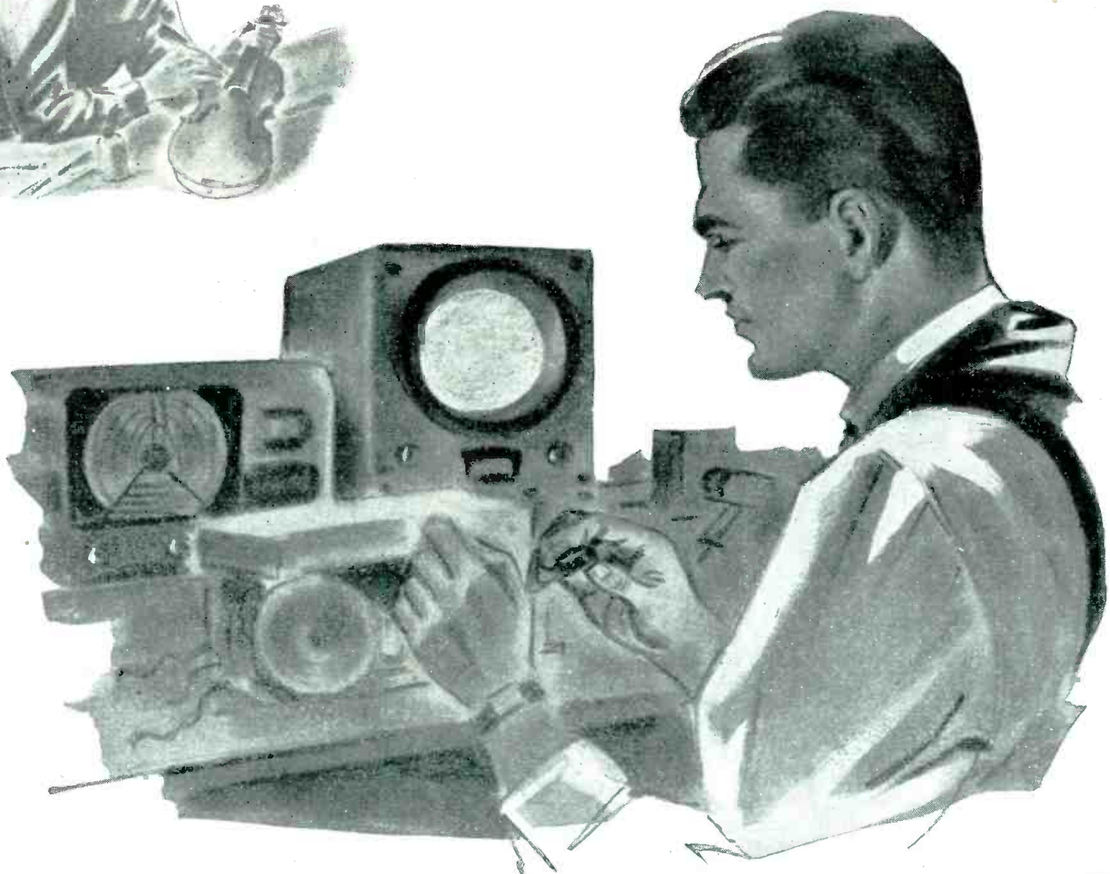
Electronic Mail Sorting

SORTING OF LETTERS in post offices by means of photoelectric equipment was suggested by W. C. White, engineer in charge of the Electronics Laboratory of General Electric Co., in addressing a recent meeting of the Purchasing Agents Association at Schenectady.

"Consider all the routine that takes place in connection with the delivering of a letter by our postal system. It is picked up and brought to the post office in the city from which it is being sent. Here it must be looked at and consigned to a certain large city or district of the country. When it arrives at this destination, it is again looked at to be forwarded to some sub-division or postal sub-station. Here again it must be examined to route it to the particular mail carrier district in which the one to whom it is addressed is located. In all of these cases, much routine work is involved and, when we consider all the millions of letters in transit all

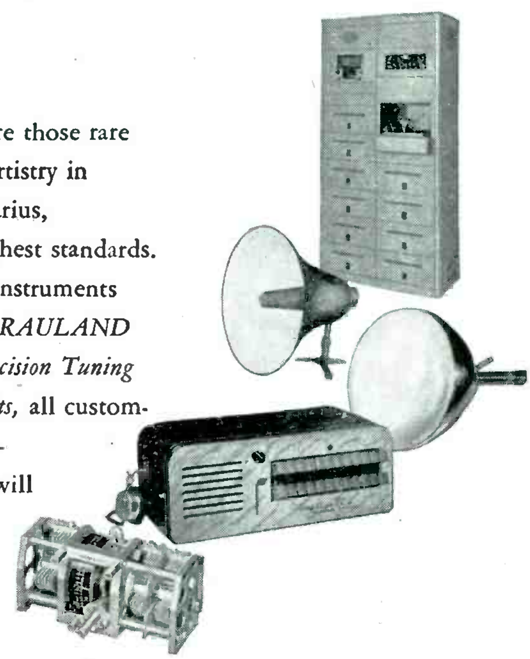


Antonio Stradivari,
Master Violin Maker of Cremona,
Italy; 1644 - 1737



Craftsmanship

In vivid contrast with modern methods of mass production are those rare masterpieces of solitary craftsmen who sought and found perfection of artistry in their handiwork. Immortal through their works are such names as Stradivarius, Rembrandt and others whose ideals of craftsmanship have set our highest standards. Nor has the accelerated and expanded use of modern electronic instruments destroyed those ideals of craftsmanship. In such noted examples of *RAULAND Electroneering* * as *High Powered Cathode Ray Tubes, Frequency Standards, Precision Tuning Condensers, Two-Way Radio, Intercommunicating* and *Sound Control Units,* all custom-engineered for specified tasks, may be seen the hand of master craftsmen—whose products of advanced engineering and precision workmanship will one day be open to unrestricted use for benefit to all mankind.



* *Electroneering*—the *RAULAND* term for engineering vision, design and precision manufacture.

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Electronic AC VOLTMETER *and Accessories*

0.00002 TO 10,000 VOLTS

This enormous range of voltages—five hundred million to one—is accurately covered by our Model 300 Electronic Voltmeter and some of the accessories shown above. Frequency range 10 to 150,000 cycles. Accuracy 2% over most of the range. AC operation. Five decade ranges with logarithmic scale make readings especially easy. Uniform decibel scale also provided. May also be used as a highly stable amplifier, 70 DB gain, flat to 150,000 cycles.

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY, U.S.A.

the time, a tremendous amount of human effort is piled up.

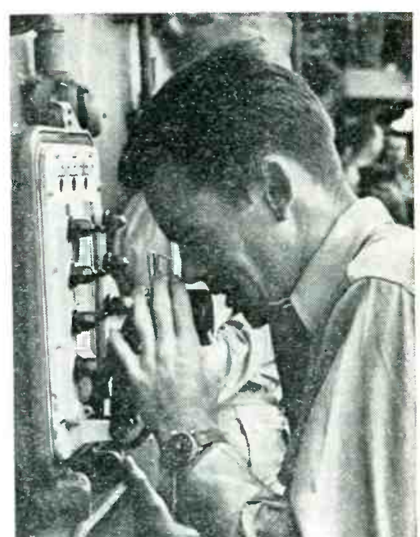
"Now it would be perfectly possible to place along the lower edge of the envelope a sort of black and white checker-board design which would code the address. In other words, a row or rows of black and white squares in certain order would designate the first main subdivision. A second row would identify the postal substation and a third row the city postal carrier district. A form of rubber stamp with movable inserts would be used by the sender or at the first post-office to imprint this design on the letter, utilizing a key sheet to prepare the design from the elements of the address to which the letter is to be sent.

Phototube Scanning

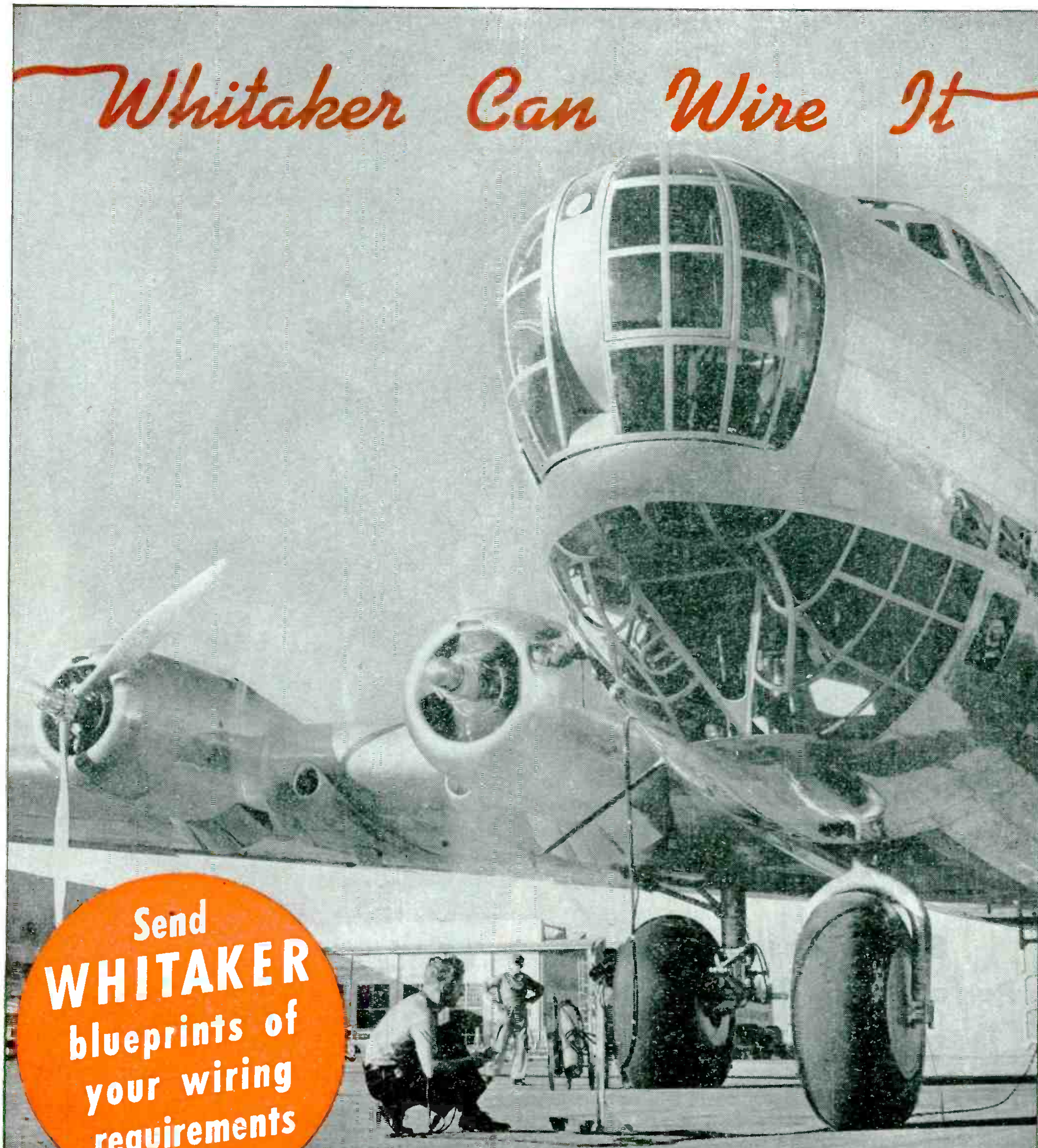
"The great majority of mail which consists of letter envelopes could then be run through a machine that lines up a photoelectric scanner along the bottom edge of the envelope and, as the letter whisked by the electric-eye, it would do the equivalent of reading the address in the coded squares and automatically route the letter to the proper mail bag or container. This would be repeated again for the second row and again for the third row when it arrived in the final

• • •

FIRST-HAND ACCOUNT



After shooting down four Zeros in less than five minutes, Lt. (jg) Eugene R. Hanks tells his shipmates the details over the loudspeaker system of the flattop. Official U. S. Navy photograph



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Are you confronted with a problem of getting wiring assemblies produced quickly . . . accurately . . . satisfactorily . . . in volume — to your specifications? If so — better turn to Whitaker — specialists, backed with a quarter of a century of experience in cables for automotive, electrical, radio, marine and aviation needs . . . Regardless of whether your wiring requirements are immediate, or for the future, it will pay you to get in touch with one of our plants. Supply us with wiring diagrams or blueprints of the assemblies required, and our engineers will give the matter prompt attention.

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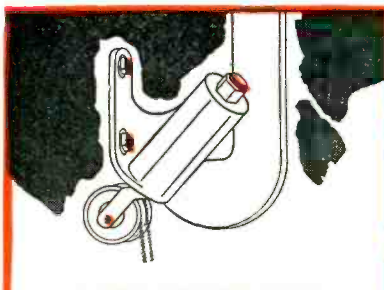
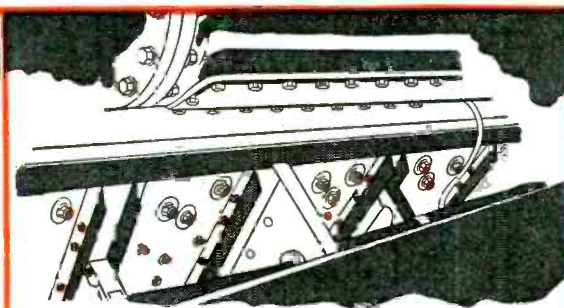
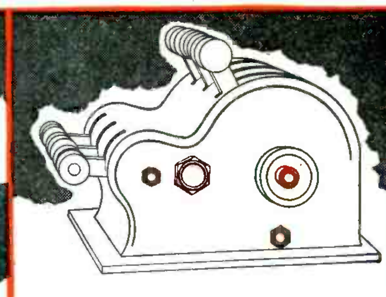


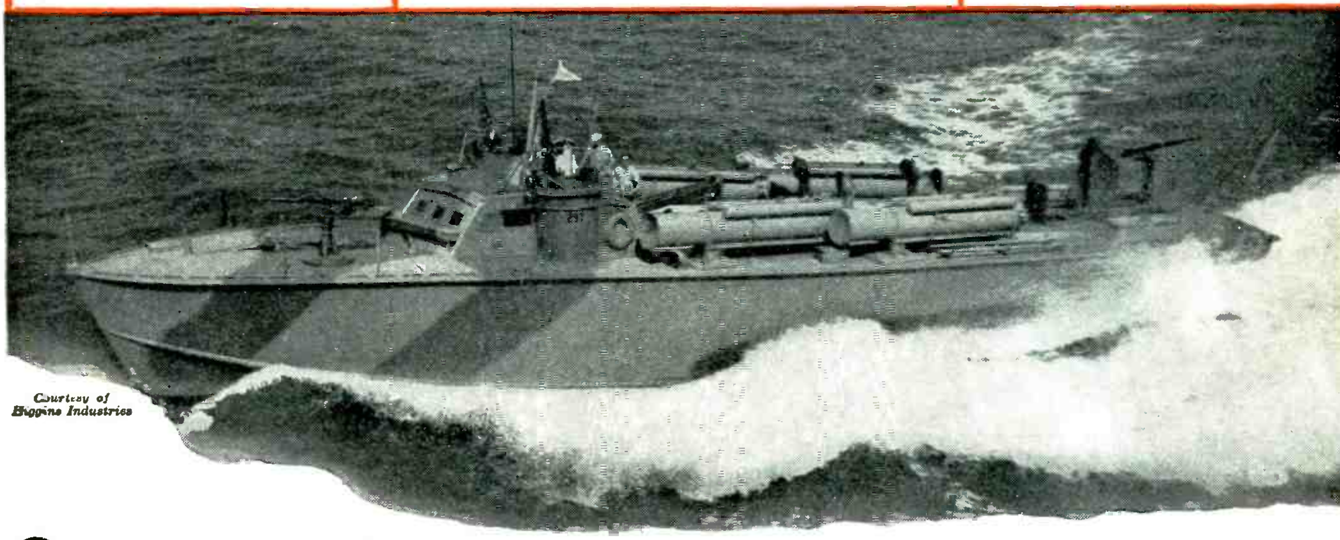
THROTTLE EQUALIZER MECHANISM fastened with Elastic Stop Nuts keeps throttle settings the same, even when the hull is distorted by heavy seas.



ENGINE BEDS. PT boats are a blasting mass of power. Besides, stresses and strains make the hulls weave. So, to hold the engines tight and secure against vibration and other forces, they are fastened down with Elastic Stop Nuts.



ENGINE ROOM SIGNALS and engine controls center in this unit held firm and secure with Elastic Stop Nuts.



Courtesy of Higgins Industries

GRIPPING TIGHT ON THE BATTLING COCKLESHELLS

They're swift. They're light. They're crammed with 4,000 throbbing horsepower that drives them, fighting like demons, through giant seas at breakneck pace.

Naturally they take an awful beating.

Under such shock and vibration only the surest fastenings will hold. That's why throughout Higgins Boats you'll see the famous red collar that marks Elastic Stop Nuts.

These nuts hold fast in the face of the worst vibration. This is accomplished by the elastic collar built in the head of the nut. This collar grips the bolt — presses itself between the bolt threads and holds tight. The nut can't wiggle. It can't turn. It can't shake loose.

These nuts will work wonders in peacetime uses. They'll make products safer, stronger and longer-lasting. They'll keep production equipment working with fewer inspections, take-ups and replacements.

Get the facts from our engineers. They'll gladly tell you about Elastic Stop Nuts and sit down with you to help work out any fastening problem you have.

ELASTIC STOP NUT CORPORATION

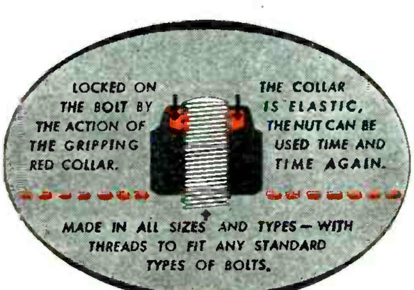
Gentlemen:

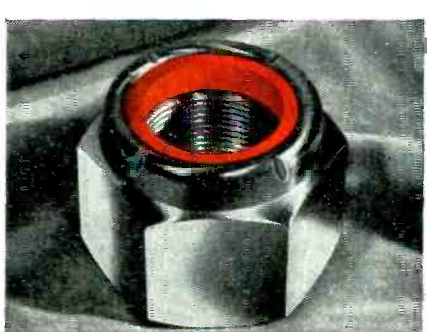
Torpedo boats must be built to stand terrific punishment — not only from heavy seas, but from vibration of engines, machine guns and depth charges. Precious time in maintenance and a greater sense of security are gained by the use of Elastic Stop Nuts at all vital points. Weight is also at a premium in PT's as in aircraft and prohibits the use of more cumbersome and less positive locking methods.

Yours very truly,

Ted Sprague

PROJECT ENGINEER, HIGGINS INDUSTRIES, INC.





ESNA

TRADE MARK OF

ELASTIC STOP NUT CORPORATION OF AMERICA

ELASTIC STOP NUTS

Lock fast to make things last

UNION, NEW JERSEY AND LINCOLN, NEBRASKA

postal sub-district. Thus it would actually have to be looked at only by the carrier who was to make the final delivery at the place of business or residence of the recipient.

One can well imagine the magnitude of routine saving that would result from the universal use of such a method. Of course, one might well raise the question of technological unemployment which would result from the universal use of such devices. However, there is reason to believe that changes of this sort always come more or less gradually and would not present a serious social problem."

• • •

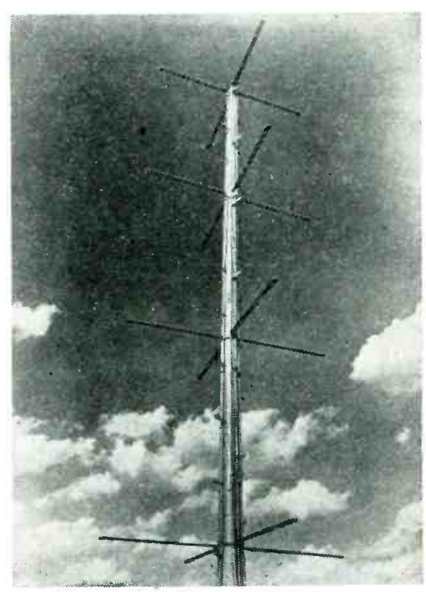
Design of Electronic Megaphone

INITIALLY DEVELOPED for use on board ships where the high surrounding noise level made speech reinforcement necessary, the final design of the RCA electronic megaphone called for use with either a portable battery-powered amplifier or an alternate fixed amplifier.

Since the megaphone must compete in some cases with an unus-

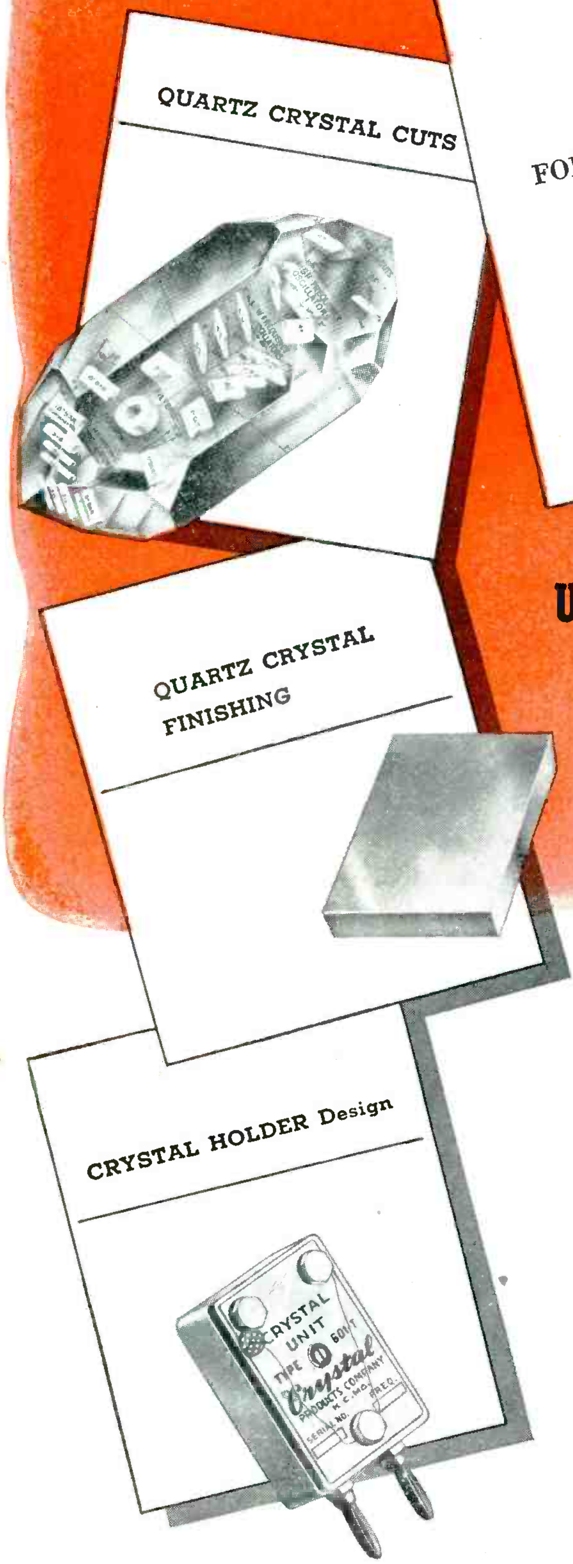
• • •

FM ANTENNA



The four bays of this turnstile antenna at the Zenith FM station WWZR are fed by eight Andrew 1⅝-in. diameter coaxial cables. These lines and the 4⅛-in. feeder from the transmitter are maintained under constant gas pressure. Made by Andrew Co., the cables are connected back to back to provide a balanced 140-ohm line

File This For Reference...



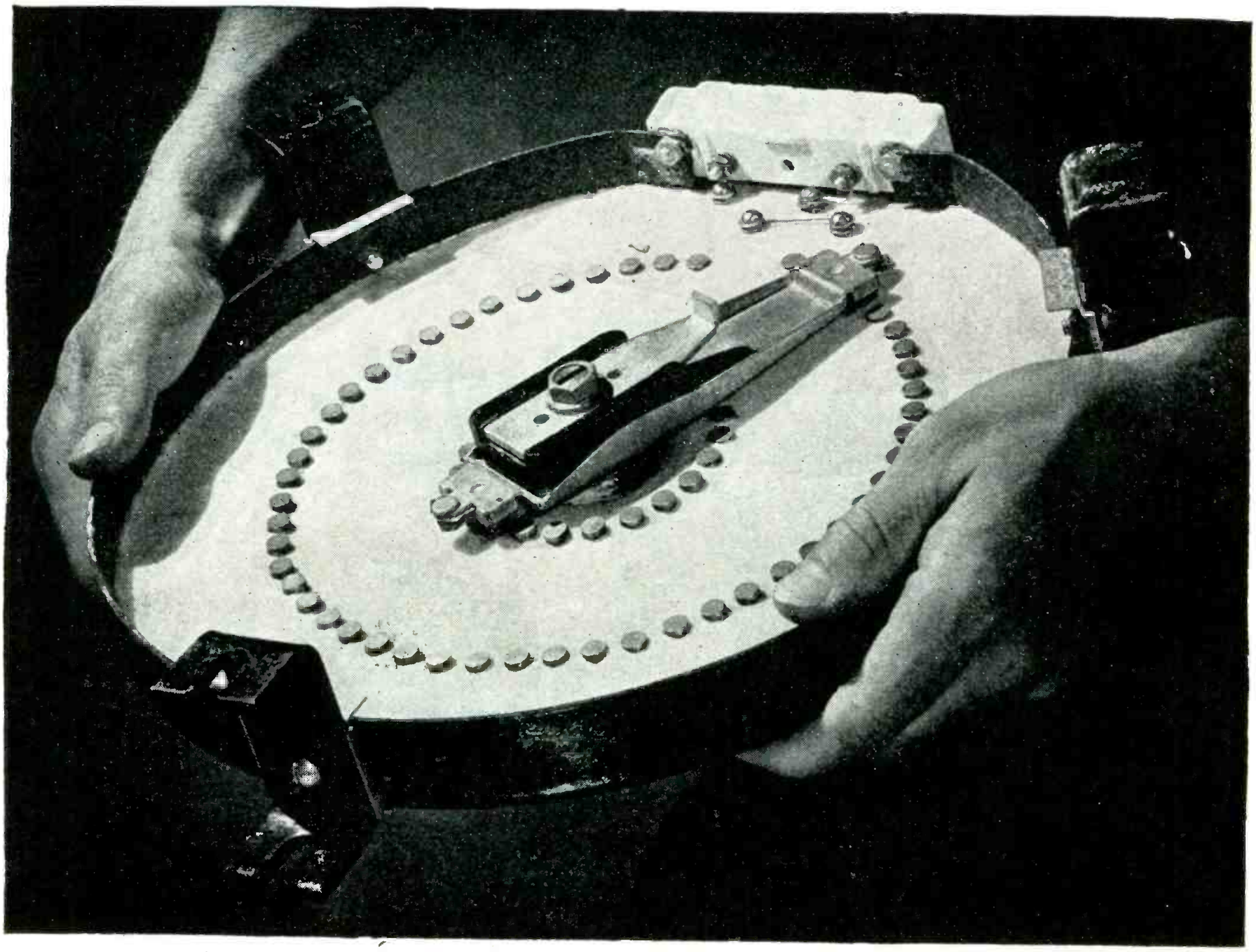
USEFUL INFORMATION ABOUT PRESENT-DAY AND FUTURE APPLICATIONS OF QUARTZ OSCILLATOR PLATES

Here is common-sense, understandable data about the characteristics, production, and adaptation of quartz crystals. Graphically illustrated, these papers are combined in a convenient file for instant accessability. Write for your copy today.

Crystal PRODUCTS COMPANY

1519 McGEE STREET, KANSAS CITY, MO.

Producers of Approved Precision Crystals for Radio Frequency Control

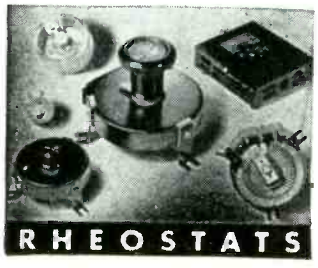


IT'S SUBSTANTIAL

A Rheostat is a piece of equipment where substance and quality spell real economy. A good Rheostat properly installed and used will outlast the machine it controls. It is wise therefore to use the best Rheostat obtainable.

Ward Leonard Pressed Steel Rheostats are built on that premise. They are absolutely smooth in operation due to proper design and fine machining. They dissipate heat from both sides keeping temperatures low. Contacts are round or rectangular solid metal ground for perfect fit. These are but a few of their many advantages.

Ward Leonard Rheostats are made in a wide range of sizes in single and multiple mounting for manual or motor drive. Bulletin 60 gives full particulars. Send for a copy.



Pressed Steel Rheostats are made in 4″ to 18″, Ring types from 1½″ to 4″ incl.

WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control (WL) devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 32 SOUTH ST., MOUNT VERNON, NEW YORK

Special purpose CERAMIC TUBULAR CAPACITORS

In addition to our standard type tubular capacitors Centralab is prepared to furnish SPECIAL PURPOSE Capacitors for radio frequencies (high and ultra-high frequencies) for both transmitter and receiver circuits.

Our extensive laboratory and engineering facilities make possible the production of special types some of which are illustrated here . . . to meet the need of circuits that cannot be serviced through our standard tubular capacitors.

We invite correspondence where special capacitors are indicated.

Send for Bulletin No. 721 for specific details

ARMY E NAVY

Centralab

CRL

Division of GLOBE-UNION INC., Milwaukee

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

ually high noise level, higher output from the unit was provided by shifting to operation with the fixed amplifier. Reasonable flexibility of movement is provided by a forty-foot extension cable between the amplifier and the megaphone.

As shown in the photograph, the microphone of the unit is mounted so that its horizontal axis is 3½ inches above the axis of the loudspeaker. This feature provides the operator with unobstructed vision in the direction his speech is being transmitted and permits full utilization of the megaphone range.

The total weight of the unit is so distributed that the handle is directly beneath the center of gravity. This permits ease of handling and minimizes fatigue when the operator is using the megaphone continuously. If used intermittently, the operator may suspend the unit from a carrying strap which permits it to rest against his chest. This leaves his hands free except when the megaphone is being used.

For applications in which the operator needs only limited movement within a radius of 40 feet, and a commercial source of power is accessible, the megaphone can be driven by the larger fixed amplifier. With the same input level, the fixed amplifier drives the speaker to an output pressure three times as great as that obtained from the portable amplifier. Because of the greater gain, a volume control is

Operation anywhere is provided by this portable electronic megaphone. Mounting of the microphone above the horizontal axis of the loudspeaker permits viewing the place being addressed

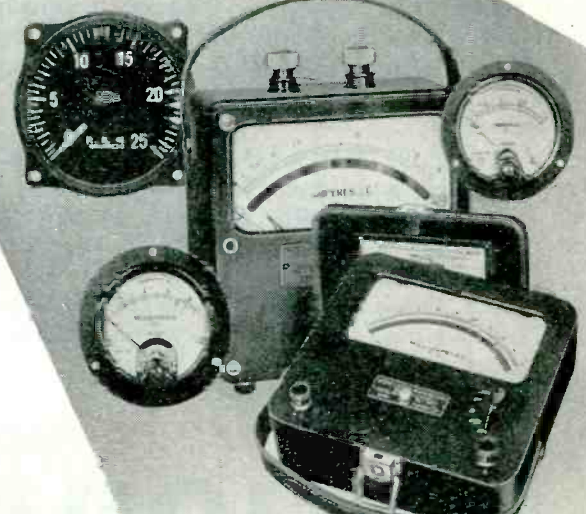
A Third CITATION
FOR THE INSTRUMENT LEADER

. . . FOR MERITORIOUS WAR PRODUCTION

This third citation for meritorious war production . . climaxing a long record of war service . . . is a source of justifiable pride to the men and women of WESTON.

The record began back in the earliest days of our defense period, when a large segment of WESTONS' capacity was assigned to the production of instruments vital to military needs. Thus, when we finally were forced into this world struggle, WESTON was ready for *full-scale war production.*

This new star which adorns our "E" pennant marks the *third* time WESTON has been *first* in this highly specialized field to receive each successive war citation. Weston Electrical Instrument Corporation, Newark 5, New Jersey.



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

WESTON

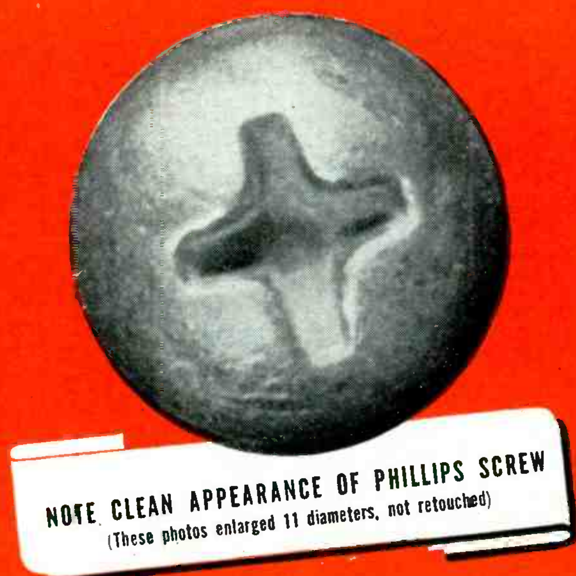
Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters...Aircraft Instruments... Electric Tachometers...Dial Thermometers.

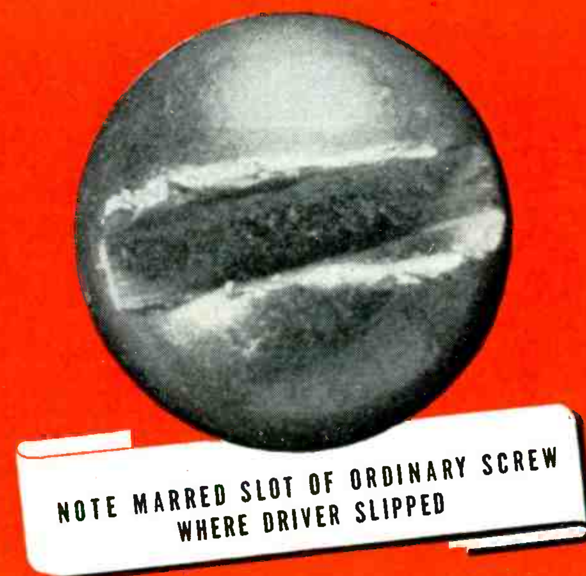
FOR OVER 55 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

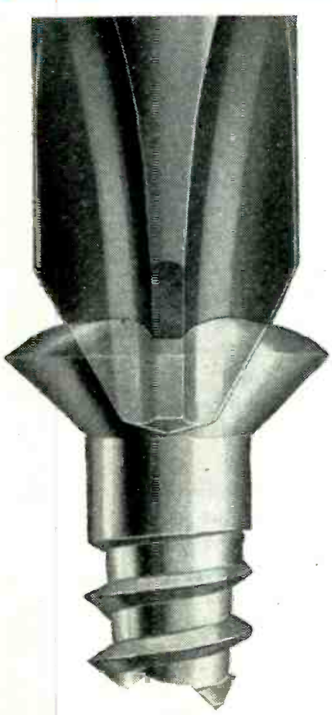
Here's a screw head scientifically engineered for faster starting, faster and easier driving, better appearance. *It's the famous Phillips Screw*—

MADE BY NATIONAL SCREW...

THE TAPERED RECESS HOLDS DRIVER FROM SLIPPING





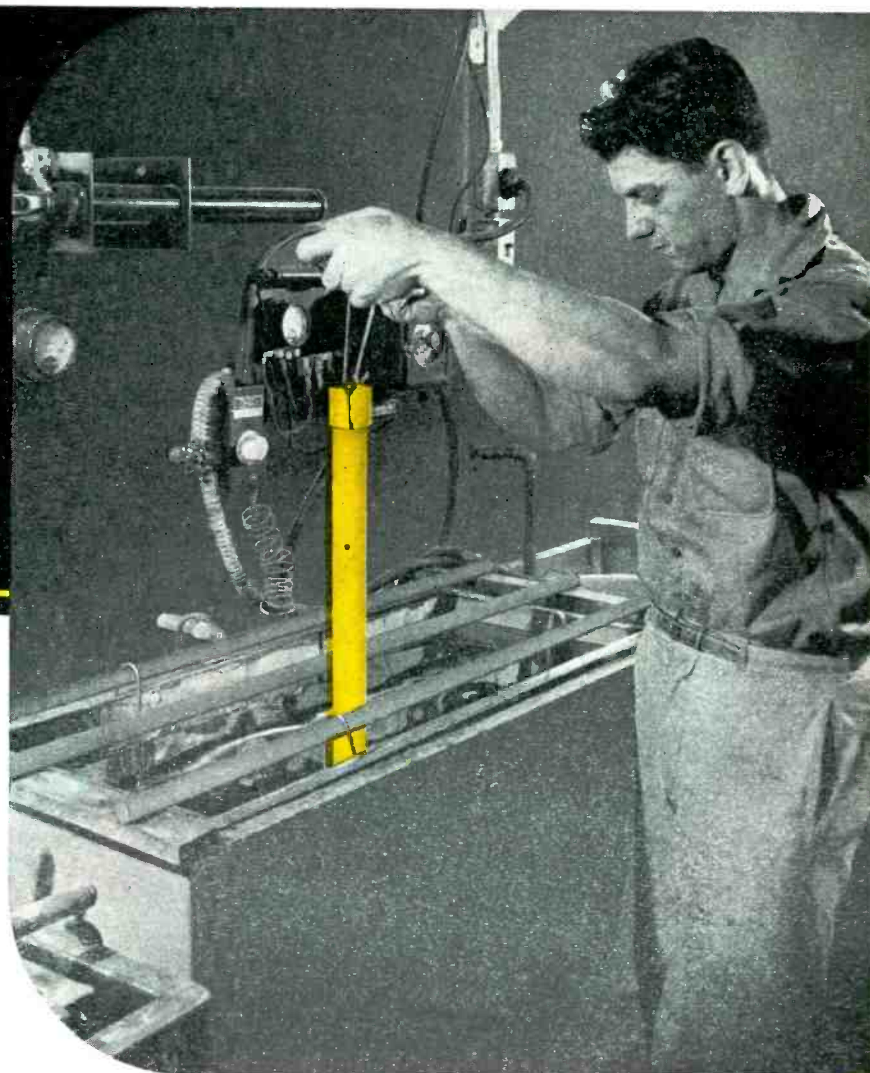


7 *distinct advantages of the Phillips Recessed Screw*

1. Self-centering on the driver
2. Holds driver from slipping
3. Four "wings" give greater driving power
4. Eliminates head breakage
5. Frees operator's hand to hold work
6. Makes better appearance—prevents marring work
7. Simplifies hard-to-get-at jobs

National
HEADED AND THREADED PRODUCTS

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



provided on the front panel to permit adjustment to a comfortable level.

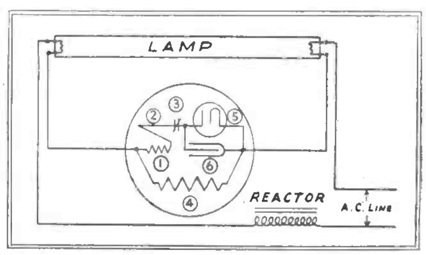
To provide for installations on vessels having only d-c power, an inverter is supplied as an auxiliary unit by RCA Victor Division of RCA, maker of the electronic equipment. Weight of the unit, including reproducer, microphone and cable, is 7½ pounds.

• • •

Fluorescent Starter Eliminates Blink

A STARTER for fluorescent lamps that preheats the cathodes in the usual manner and also permanently interrupts the circuit when the lamp becomes deactivated or reaches the end of its life has been developed by Westinghouse engineers.

The new starter utilizes a simple form of thermal switch in series with the timing switch. When the lamp is in good operating condition, the starter merely provides the time to start the lamp. When the lamp fails, the starter makes a few attempts to put it in operation. The resultant heat brings the thermal switch into play which then permanently opens the lamp circuit. The new device eliminates blinking and reduces current flow through lamp auxiliaries. The starter is fully automatic. When the burned-out lamp is replaced, the starter automatically resumes its normal lamp-lighting function.



Circuit of Westinghouse "no-blink" fluorescent lamp starter. Low-resistance heater (1) carries the starting current, and as the glow switch attempts to start a deactivated lamp, gradually heats the bi-metal (2) and opens lock-out contacts (3) in the glow switch (5) circuit. Open-circuit voltage then exists across resistor (4) which draws a negligible current (power less than 1 watt), but produces sufficient heat to hold lockout contacts (3) open. When the failed lamp is replaced the starter automatically resets to its normal position ready to function again. Capacitor (6) eliminates radio interference

News from NEW ENGLAND

New Home of Electrical Apparatus Company
1200 Soldiers Field Road, Boston 34, Massachusetts

BOSTON ★

HARTFORD ★

OUR new quarters include complete facilities for the sale and demonstration of the products of the manufacturers we represent exclusively in New England. A qualified engineer is in charge of a new, larger, fully equipped Demonstration Laboratory. Here full engineering information can be obtained and our various electrical products can be seen in operation as units or as part of a complete control system.

A new idea is an Assembly Hall where electrical engineering meetings can be held to provide our New England customers with the latest information direct from the engineers and executives of the manufacturers we represent. Through this medium we are keeping pace with New England's tradition for progressiveness and are providing, at a time when most needed, additional facilities to assist our customers. We extend a cordial invitation to you to call upon us whenever we can be of assistance.

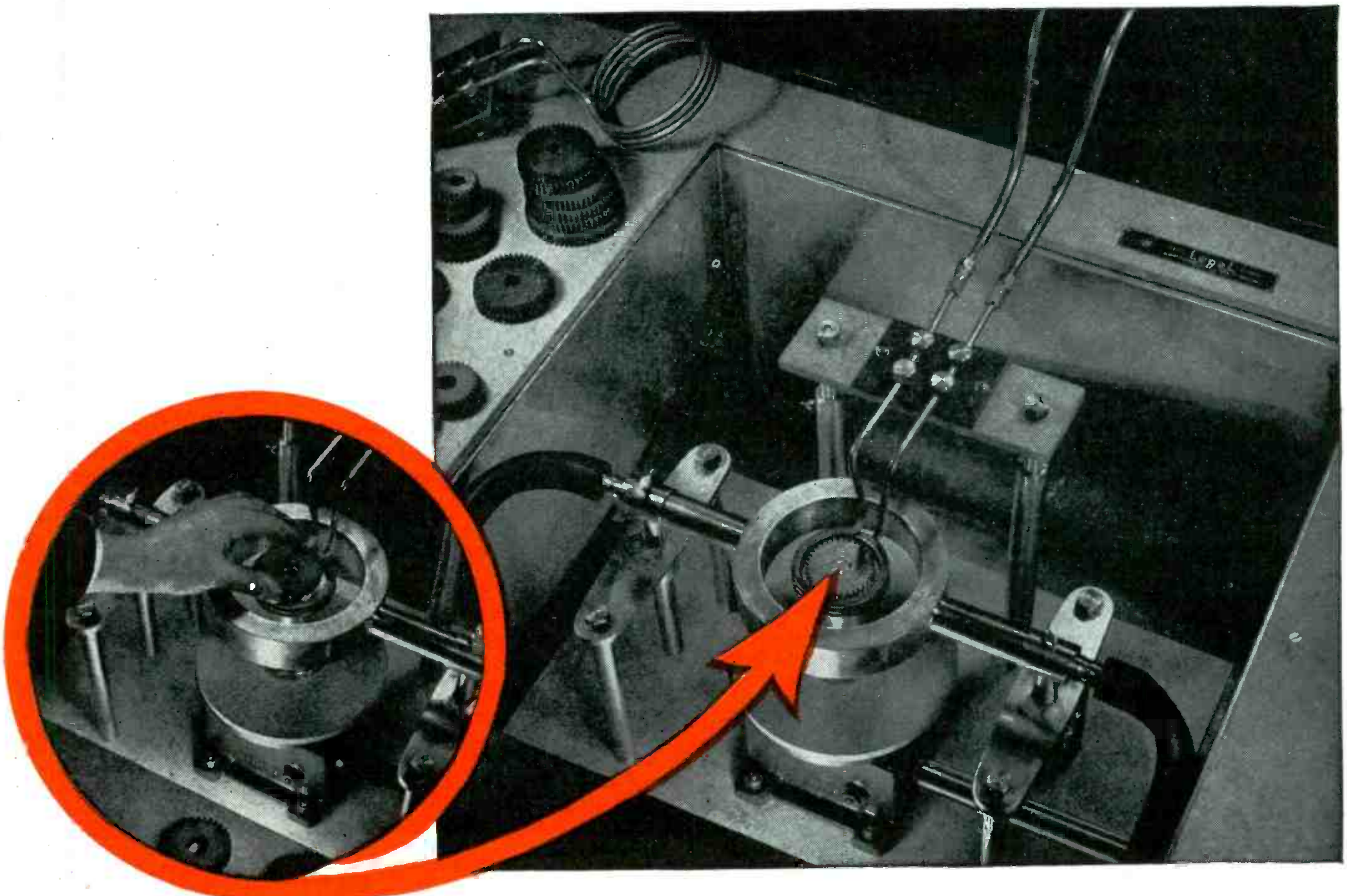
APPLICATION ENGINEERS

WALDO J. KELLEIGH & STAFF — W. S. Gibson – F. E. Reeves – C. B. Walworth
NEW ENGLAND REPRESENTATIVES

RELAYS • RHEOSTATS • FOOT SWITCHES • CAM LEVER SWITCHES • LIMIT SWITCHES • SNAP ACTION SWITCHES • TRANSFER SWITCHES • RESET TIMERS
REMOTE CONTROL SWITCHES • PROCESS CONTROL TIMERS • SOLENOID VALVES • ELECTRONIC DEVICES • TEMPERATURE CONTROLS • PRESSURE CONTROLS
ELECTRONIC CONTROLS • AUTOMATIC PRODUCTION GAUGES

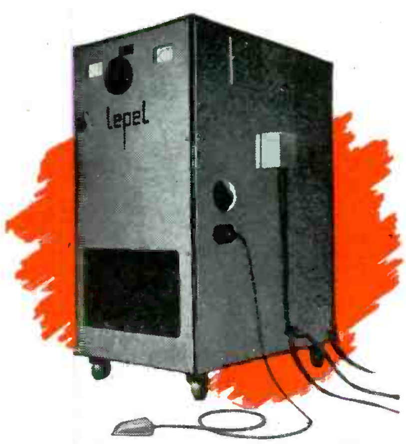
ELECTRICAL APPARATUS COMPANY

1200 SOLDIERS FIELD ROAD, BOSTON 34, MASSACHUSETTS



ANOTHER *Outstanding Improvement*

In Gear Hardening



Lepel High Frequency Induction Heating Units are made in various sizes. The same unit can be used for hardening, brazing, soldering, melting, etc., of both ferrous and non-ferrous metals. Easily converted to peacetime use at no cost. Write for catalog.

THE hardening of gears and pinions, long recognized as an ideal application of high frequency induction heating, is a field in which Lepel has pioneered and developed many noteworthy improvements. It made possible localized hardening, practically eliminating warpage and retaining the toughness and ductility of untreated areas. It produced superior wearing qualities, provided greater uniformity and cut hardening time to a matter of seconds.

Now Lepel offers another outstanding improvement in the hardening of gears and other round-section parts. The new Lepel roto-heating and quenching unit causes the part to revolve at a predetermined speed within the load coil during the automatically-controlled heating and quenching cycles. The result is a degree of uniformity never hitherto achieved by any hardening process — a new high standard of quality for such parts.

The unit, including motor drive, load coils and quench rings, is comparatively inexpensive and can be operated in connection with any standard Lepel Induction Heating Unit.

A Lepel representative will be pleased to call upon you upon request. Or Lepel engineers will harden samples of your parts to your specifications and furnish complete data without obligation.

Lepel

LEPEL HIGH FREQUENCY LABORATORIES, INC.

Pioneers in Induction Heating

39 WEST 60th STREET **NEW YORK 23, N. Y.**

HIGH FREQUENCY INDUCTION HEATING UNITS

Mica Capacitors

(*Continued from page* 132)

pacitors are manufactured as rolled structures, stacked laminations or in special forms.

From evidence at hand, it appears that about half of the mica capacitors now used could be replaced by capacitors made from other materials without compromising quality or performance of electronic equipment. In round figures, this replacement would conserve between ⅓ and ½ of our precious supplies of mica. While it may be argued that other materials are not as efficient or desirable in making capacitors for equal duty and equal size, the materials situation may compel that it be done.

Considerable work has been done with paper dielectrics by the engineers of the Bell Telephone Laboratories and Western Electric to demonstrate that thoroughly reliable capacitors of equivalent size can be made for many of the commonly used types of mica capacitors.

Careful attention has to be paid to the choice of the best grade of paper and the choice of organic impregnants for their suitability at high temperature. Also, careful attention needs to be paid to the matter of attaining moisture-tight casings. It is significant that paper capacitors of such types offer at present a greater promise of saving mica than any of the other alternative materials. By using such alternative capacitors we have eliminated about one-third of the mica types in our equipment, thereby cutting mica needs by about 25 percent.

Some mention should be made here of the engineering studies which are under way on the application of "stained" quality mica for capacitors. This quality of mica is quite readily available but has not been used to any extent in capacitor manufacture. Stained mica, which has good splitting and non-conducting properties, has been used to produce capacitors with a Q-value equal to, or better than, those of alternative types.

Capacitors made of stained mica, paper or other alternative dielectrics can be used without degrading the performance of equipment.

THE ELECTRON ART

Magnetron Oscillator for V-H-F Research

A RELIABLE MICROWAVE oscillator for the range of frequencies from 1700 to 5000 megacycles, corresponding to wavelengths of 17 to 6 centimeters, and useful in laboratory work for instruction and research, is described by J. Tykocinski Tykociner and Louis R. Bloom in Circular No. 48, issued by the Engineering Experiment Station of the University of Illinois. Sufficient details are included in the description to enable teachers and experimenters to build their own microwave oscillators.

In the attempt to construct a suitable magnetron tube, it became clear that it would not be necessary to develop a high-power tube. The conditions in a medium-sized laboratory are hardly applicable for utilizing radiation of intensities beyond those measurable with the usual detectors and bolometers. The task was therefore reduced to the design of a compact tube of about 10 watts input, so constructed that its power could be controlled easily. This simplified the preparation of the tube and made unnecessary the use of facilities usually absent in a college laboratory. For a skilled technician, all that is necessary is a small spotwelder, a vacuum pump system capable of sustaining a pressure of about 10^{-6} mm Hg, and a high-frequency induction furnace, for heating the electrodes during the outgassing process.

Copies of Circular No. 48 may be obtained without charge upon application to the Engineering Experiment Station, Urbana, Ill. until September 15, 1944 or until the supply available for free distribution is exhausted.

Novel Voltage Regulator

THE STANDARD DEGENERATIVE voltage regulator circuit usually becomes difficult to use at voltages above a few kilovolts, particularly in applications where the positive terminal is grounded. A new circuit that avoids this difficulty was described by W. H. Pickering and S. C. Snowden of the California Institute of Technology in a paper contributed to the 258th meeting of the American Physical Society at Pasadena, California in December, 1943, and regarding which an abstract appears in the February issue of *Physical Review* (Prince and Lemon Sts., Lancaster, Pa.)

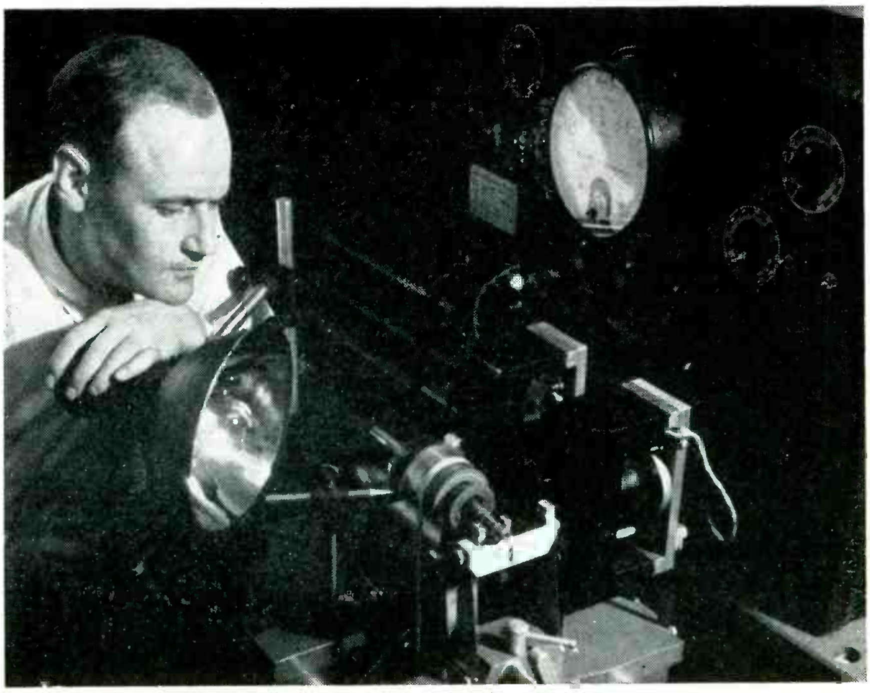
The new circuit uses a radio frequency signal modulated by the variations in output voltage to transmit these variations across the potential difference to a tube in series with the high-potential bus. The voltage limitations are accordingly removed. The sensitivity of the regulator depends as usual upon the total effective amplification of the circuit. Long-time stability depends on the stability of the amplitude or frequency of the radio frequency signal. Either terminal of the output may be at ground potential.

Argument for Electronic Music

By SIDNEY T. FISHER

MUSICAL THEORY, where it touches on the intervals employed in harmony, is in a state of great confusion. The scale universally used for keyboard instruments, the Tempered (diatonic) Scale, inadequately translates musical conceptions, and its weaknesses should be

BALANCING MACHINE

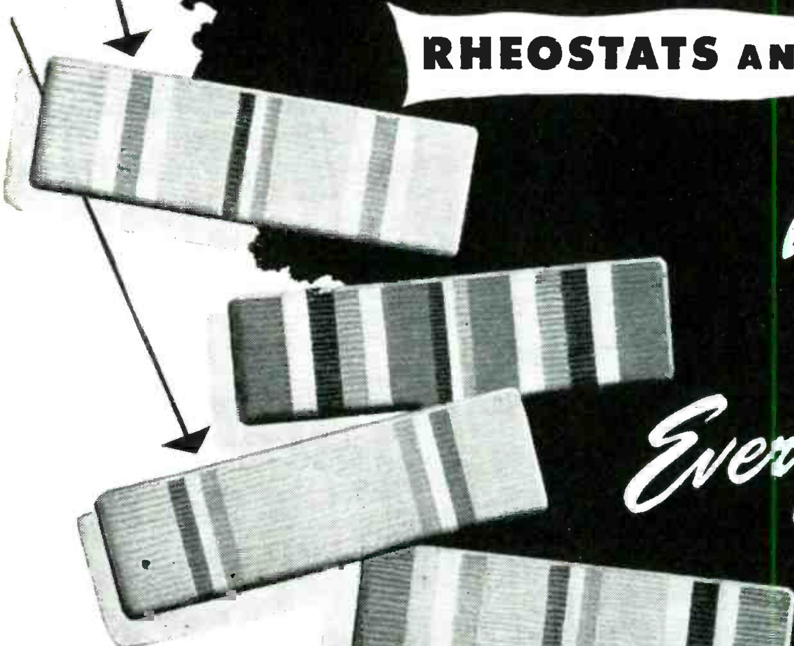


Electronic Dynetric balancing machines show the degree of unbalance of a rotor, while running at normal speed, directly on a meter. The operator sees the spot on the revolving rotor that is out of balance with a stroboscope. The electronic method, developed by Westinghouse research engineers, determines the exact location and amount of corrective mass necessary to eliminate unbalanced vibrations as small as 25-millionths of an inch

OHMITE

RHEOSTATS AND RESISTORS

Veterans of Service on Every Battle Front



In the Fight From The Beginning

Because they have helped pioneer many resistance-control applications . . . and have proved thoroughly dependable . . . Ohmite Rheostats and Resistors have been "in the fight". . . *from the beginning.* Today . . . they serve in countless thousands . . . in all types of critical equipment . . . on every front. They are relied on to function day-after-day under extremes of temperature, humidity and altitude. In resistance-control . . . Ohmite experience makes a difference. Widest range of types and sizes for every need.

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Your Answer Book on Resistance Problems

Write on company letterhead for Industrial Catalog and Engineering Manual No. 40. Gives helpful information on the selection and application of rheostats, resistors, tap switches, chokes and attenuators.

recognized. The Just (diatonic) Scale is in full accord with the spirit of music and the letter of physical laws, and in the light of modern instrumentalities, could now be adopted. Electrical musical keyboard instruments can be designed in a practical form to play the Just Scale in all keys. These are some of the conclusions to be drawn from the facts to be outlined, but it is first necessary to understand scale structure from the musical standpoint.

"Just"-scale musical instruments have been under consideration by investigators for many years and in recent years a number of articles have appeared in musical journals on this subject. Such instruments, due to anomalies in scale structure, have been considered by most authorities as being impossible from a practical standpoint. They have thus become to be regarded by musicians as an ideal to be sought after but impossible of practical attainment. This article has for its object the description of practical instruments whose scale frequencies bear exact harmonic relationships to one another, to the end that maximum harmoniousness may be achieved.

Scale Structure

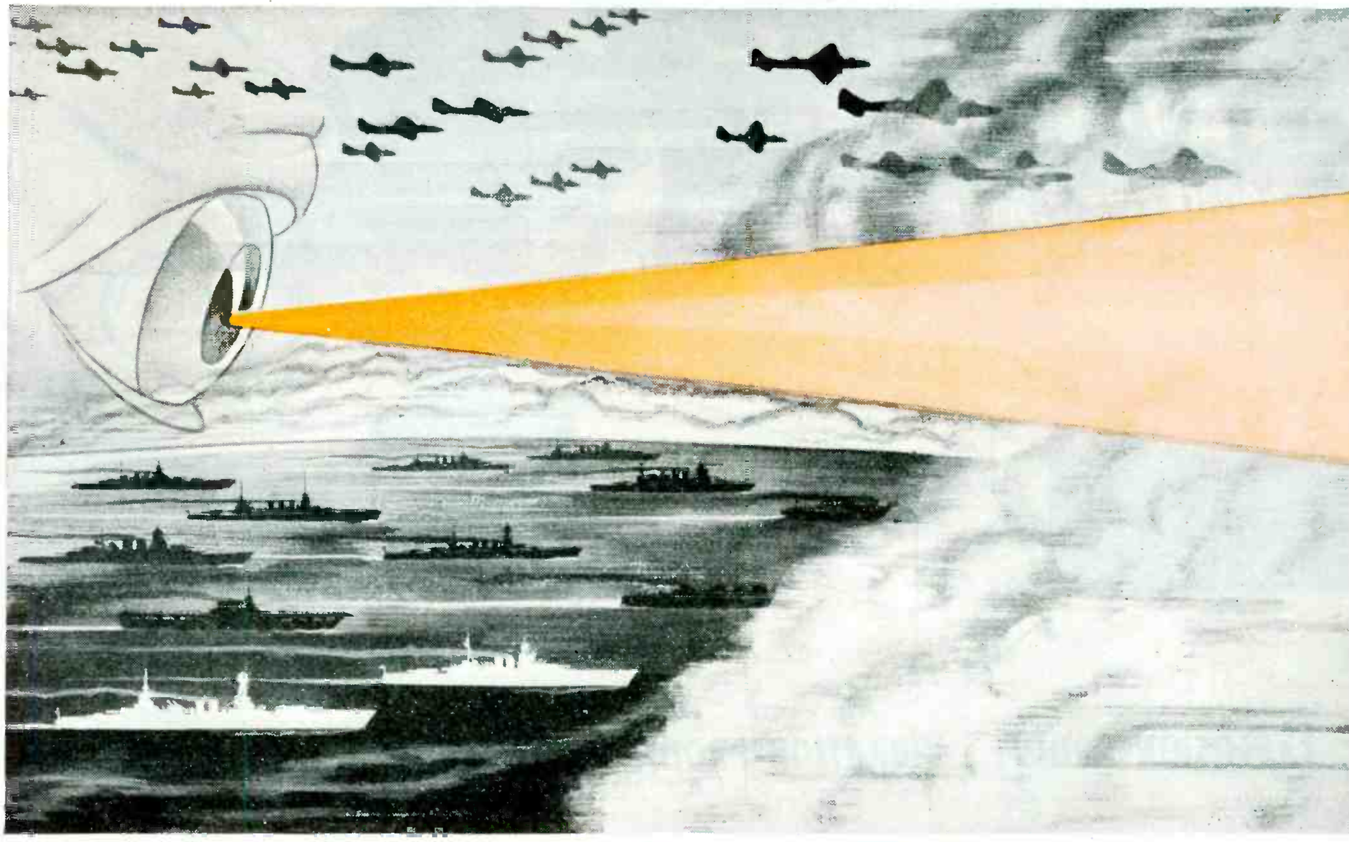
Tones separated by discrete pitch intervals are a universal tradition in modern Western music. An octave of seven notes is usually employed and this is the diatonic scale.[1] In addition, in accordance with an almost universal tradition, five additional intervals are inserted, which break up the five larger intervals of the seven-note scale. Most music—particularly music by the classic masters—is written in the seven-note scale. This scale has its most familiar embodiment in the piano and it is not an exaggeration to say that the keyboard mechanism of the piano has been made the basis of the modern system of music. The scale can be conveniently thought of as it appears on the piano keyboard. If we take the note C as the starting note for an octave, then the seven notes of the diatonic scale are played by the white digitals and the five additional tones which divide the larger intervals of diatonic scale are played by the black digitals.

The scale obtained by playing the

IF YOU NEED

HIGH VOLTAGE RECTIFIERS

FOR SPECIAL WAR APPLICATIONS



CONSULT AMERTRAN!

Recent experience shows that manufacturers can greatly expedite their programs by incorporating AmerTran High Voltage Rectifiers in equipment produced for naval, land and aircraft communications. AmerTran Rectifiers can be completely integrated with your instruments because our engineering staff is thoroughly familiar with present day communications problems . . . and especially well-versed in the application of equipment used in navigating and locating.

Deliveries can be made in reasonable time because we employ a proved, fast production system, including certain recently developed techniques, and have access to stable material sources.

These AmerTran Rectifiers are in every way representative of the quality standards which the American Transformer Company has maintained for forty-three years—a further assurance of acceptance. Responsible manufacturers are invited to forward their specifications.

THE AMERICAN TRANSFORMER COMPANY

178 Emmet Street, Newark 5, N. J.

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

AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

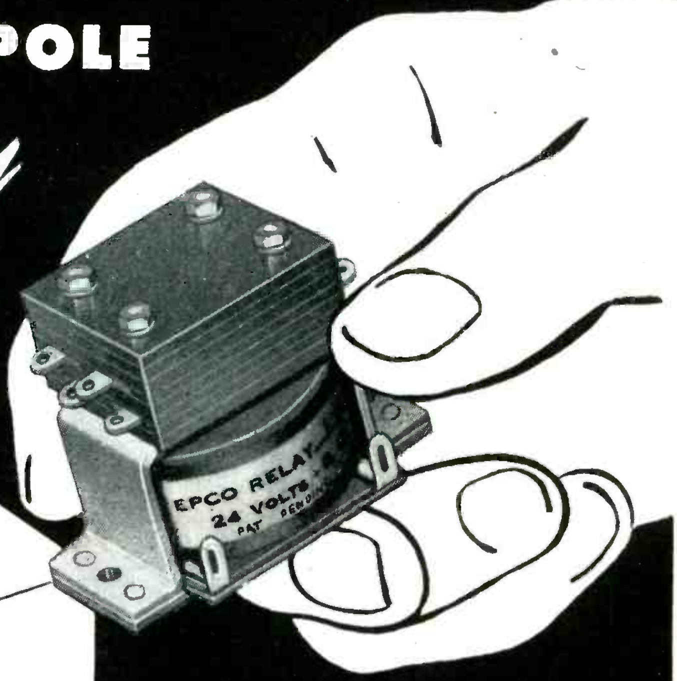
AMER TRAN

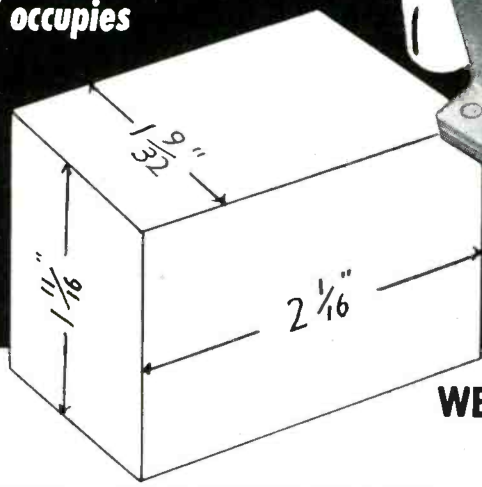
NOW...DOUBLE POLE

Midget Relay

SAVES WEIGHT— SAVES SPACE—

DOUBLE POLE...*Single or Double Throw*
MIDGET RELAY *occupies*
this Tiny space





WEIGHT 4.3 OZ. *(approximately)*

EXPLOSION-PROOF! VIBRATION-PROOF! DUST-PROOF! TAMPER-PROOF!

Rugged...Compact...Light Weight

S43A—DOUBLE POLE, SINGLE THROW

D43A—DOUBLE POLE, DOUBLE THROW

Can be furnished with either solder lugs or boltable connections on coil and contacts.

Check these important features—

Capacity—12 amperes per circuit.

Dimensions—Height 1 11/16"; Width 1 9/32"; Length overall of base 2 1/16"; Mounting holes, center to center, 1 3/4".

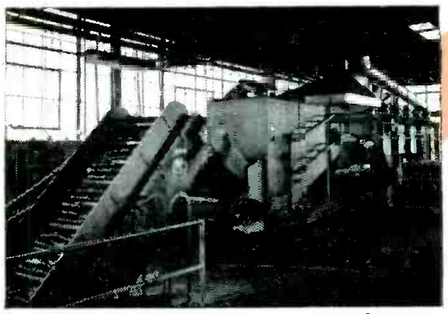
Positive Action—Positive contact pressure insured by overtravel spring.

Tamper Proof—Factory adjusted and sealed; protection against unauthorized re-adjustment.

Specifications—Normal coil rating 24 Volts - 150 m. a. - 3.6 Watts. Contact rating, 12 amps. per circuit. Unit withstands Army tests, including overload, vibration, acceleration, etc.

Electrical PRODUCTS SUPPLY CO.
Affiliated with Electrical Products Corp.
1140 Venice Blvd. Los Angeles 15, Calif.

5 REASONS WHY INDUSTRY LOOKS TO MUEHLHAUSEN FOR LARGE, HOT-COILED SPRINGS!



Controlled atmosphere conveyor type furnace

Specialized facilities enable Muehlhausen to produce springs:

—of any design
—to close tolerances
—in large quantities
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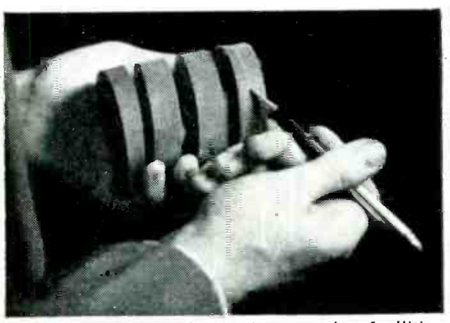

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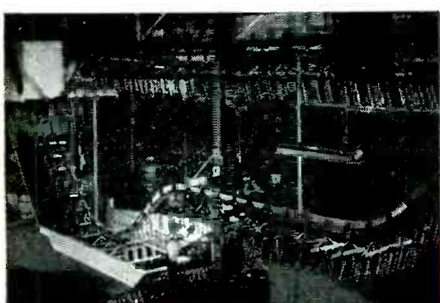

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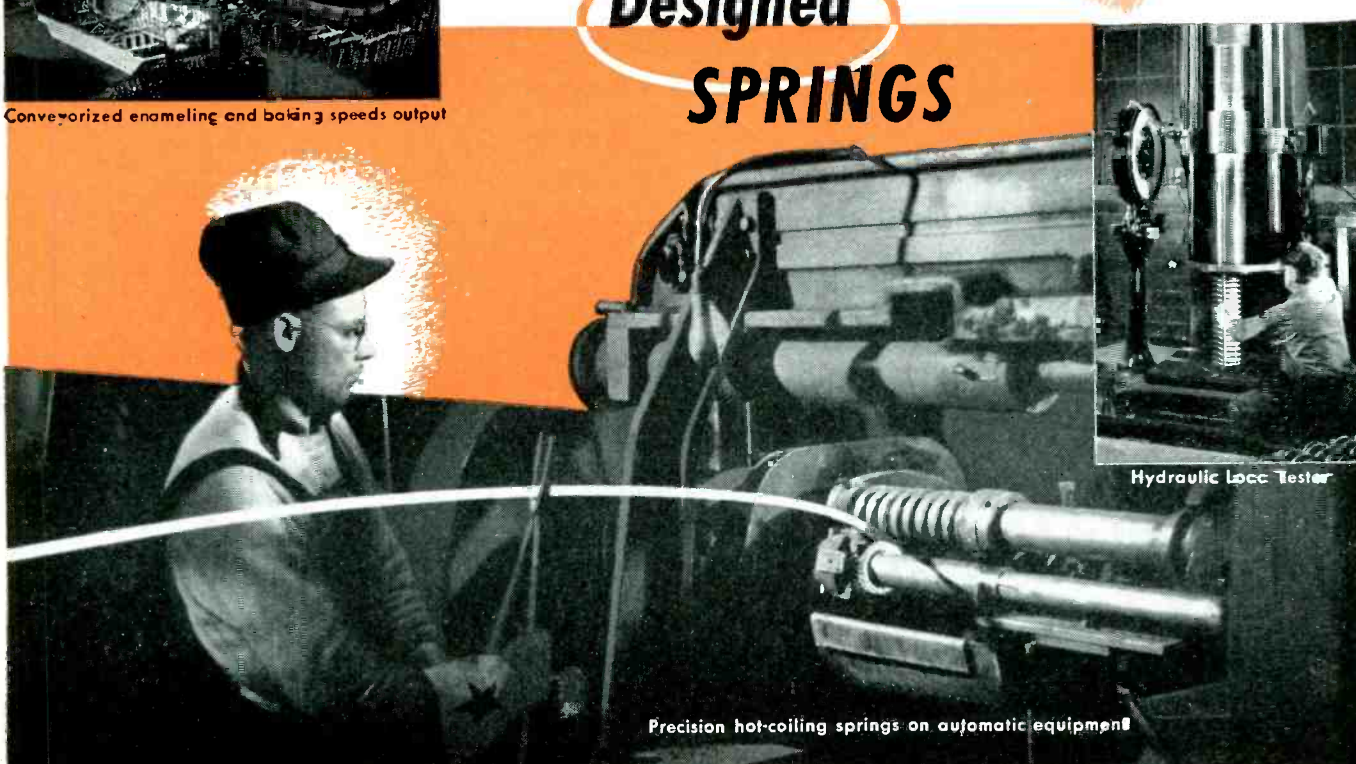

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Precision hot-coiling springs on automatic equipment white notes of the piano in sequence, commencing with C, is called the key of C major, or the natural key. Other keys then are obtained by playing a series of notes, commencing with the key note, which have the same sequence of intervals: tone, tone, semi-tone, tone, tone, tone, semi-tone.

It is advisable to guard at the outset against a common misconception; this is the idea that scales were made first, and music afterwards. Scales are made in the process of creating music. If music consisted only of single-note melodies, the requirements to be met by a scale would allow the widest latitude in choosing the intervals. Modern Western music, however, employs harmony as its most important feature, and it is necessary therefore that certain groups of notes of our scale, sounded simultaneously, should form harmonious chords.

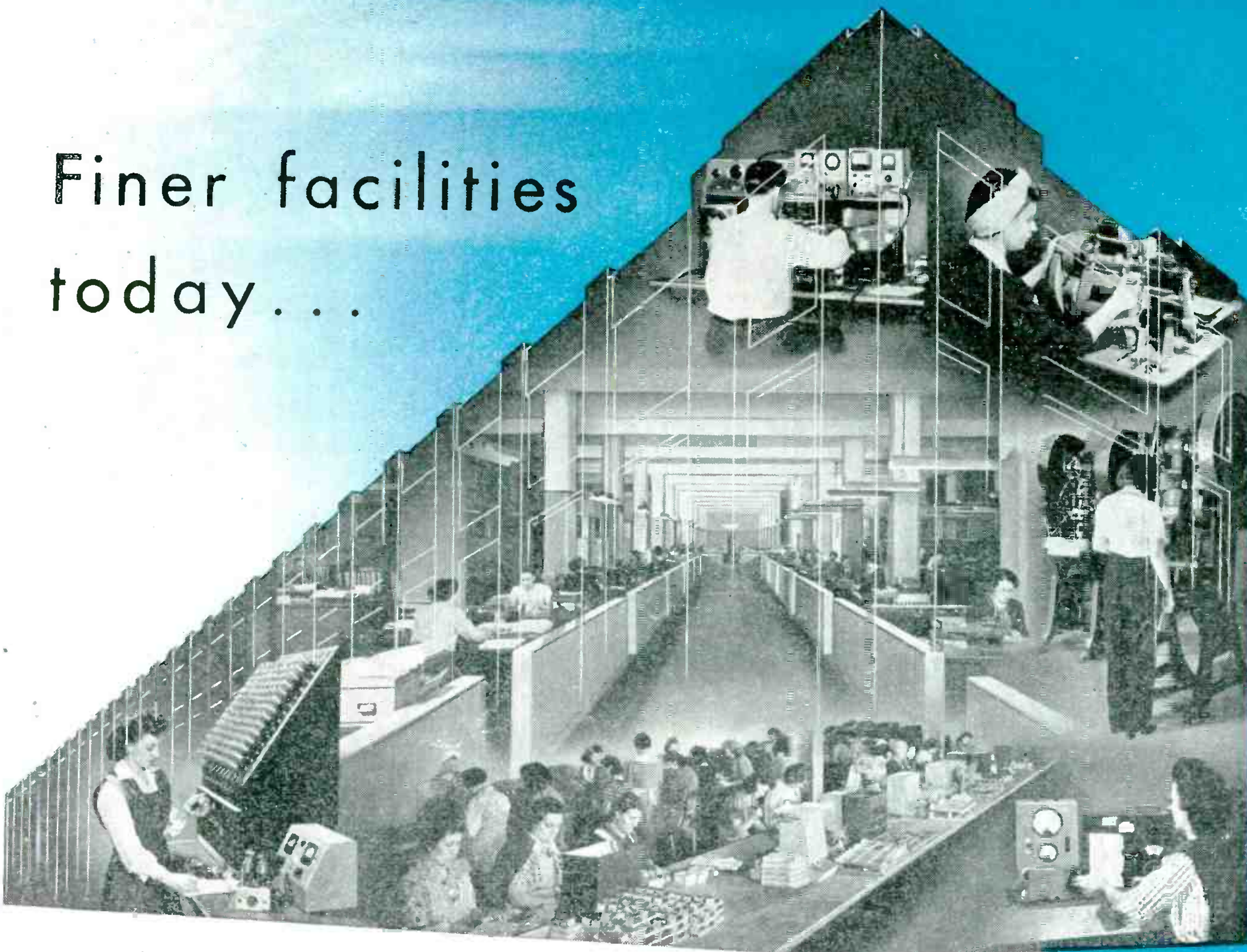
Chords and Harmony

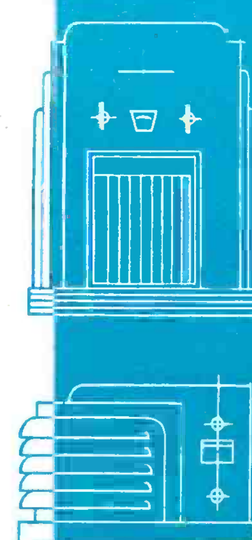
The physical criterion for harmoniousness in a chord is that the ratio of the frequencies of its component tones may be expressed as the ratio of small integers. The smaller the integers the more marked is the consonance. The application of this law to the diatonic scale fixes the intervals *between* the notes as seen in Fig. 1.

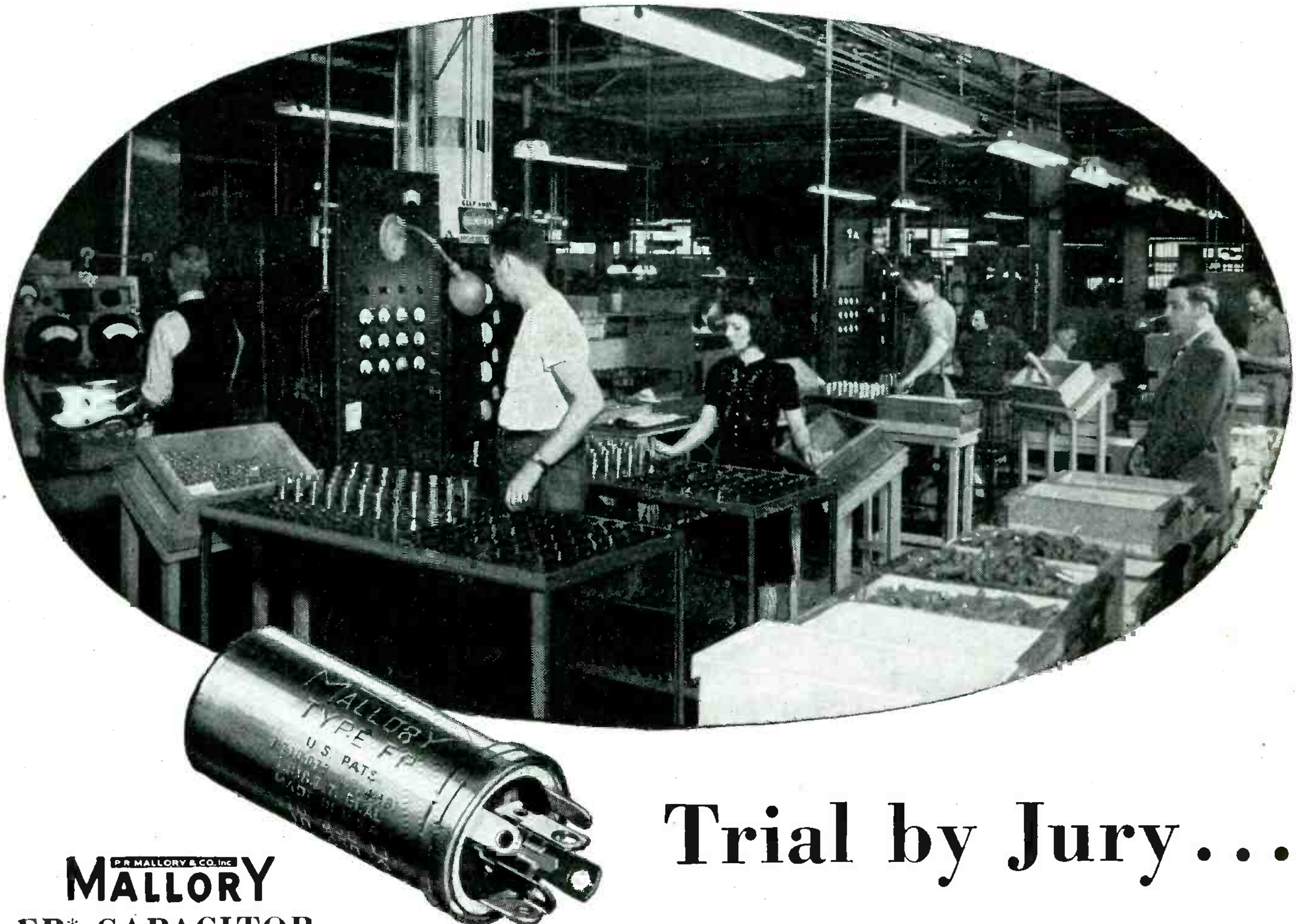
Note:	C	D	E	F	G	A	B	C
Ratio:	1	9/8	5/4	4/3	3/2	5/3	15/8	2
Name:	Unison	Second	Third	Fourth	Fifth	Sixth	Seventh	Octave
Interval		9:8	10:9	16:15	9:8	10:9	9:8	16:15

Fig. 1—The 7-note Just Scale in the key of C (the natural key). This is fundamental in Western culture, and is the idealized form of the scales in actual use

In the first line are the letter names of the notes of the scale, in the key of C, in the second line are the ratios of their frequencies to the leading note, and in the third are the musical names of the intervals obtained by sounding together each of the notes of the scale with the leading note. These intervals form a version of the diatonic scale called the Just Scale. The fourth line shows the frequency ratios between adjacent notes. It will be noted that three sizes of intervals exist, those represented by pitch







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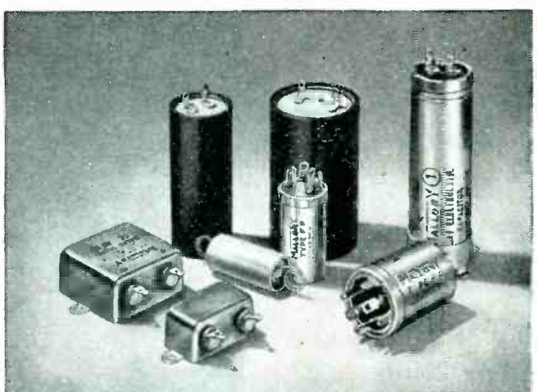

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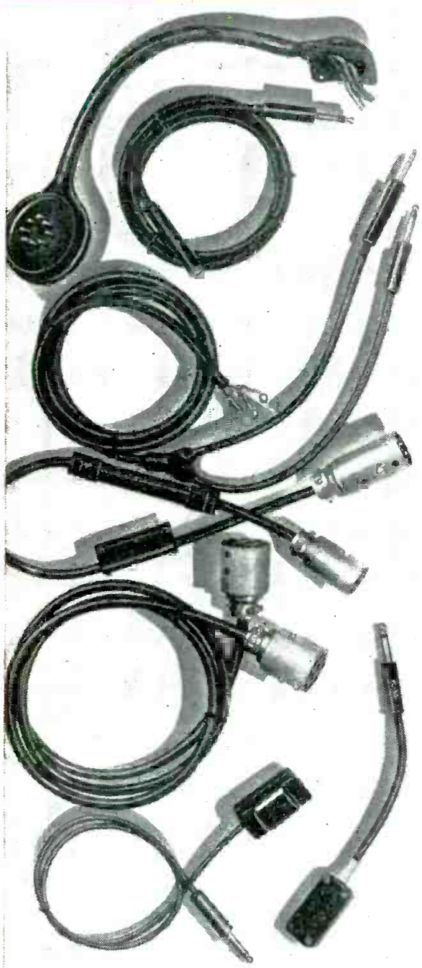

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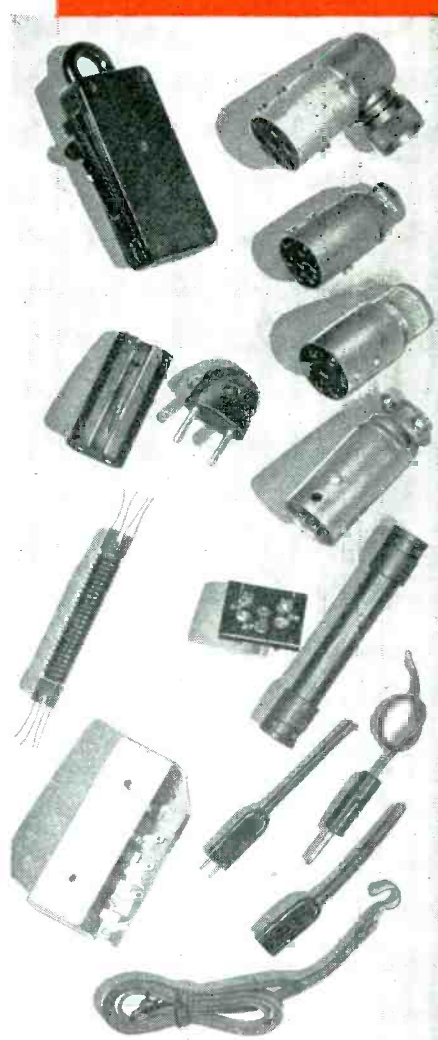

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9306 SANTA MONICA BOULEVARD • BEVERLY HILLS, CALIFORNIA ratios of 9:8, 10:9 and 16:15. The two large intervals, 9:8 and 10:9 are called a tone, and the smallest interval, 16:15, a semi-tone.

Three triads or groups of three notes are considered the foundation of the system of harmony. These chords are the triads having frequency ratios 4:5:6 formed with their lowest note a fifth below the key note, on the key note, and a fifth above the key note. In the octave shown above, these triads are CEG, FAC, and GBD, giving the arrangement of Fig. 2. These three triads define every note in the diatonic scale and fix the ratios at the values listed above.

The Tempered Scale

It is apparent that none of the possible ways of setting up a scale —progressions by fifths (frequency ratio 3:2), by fourths (frequency ratio 4:3), or by thirds (frequency ratio 5:4)—will give the octave note, since all these ratios are prime to one another. The ex-

Note	C	D	E	F	G	A	B	C	D
Ratio	1	9/8	5/4	4/3	3/2	5/3	15/8	2	9/4
	4		5		6				
				4		5		6	
					4		5		6

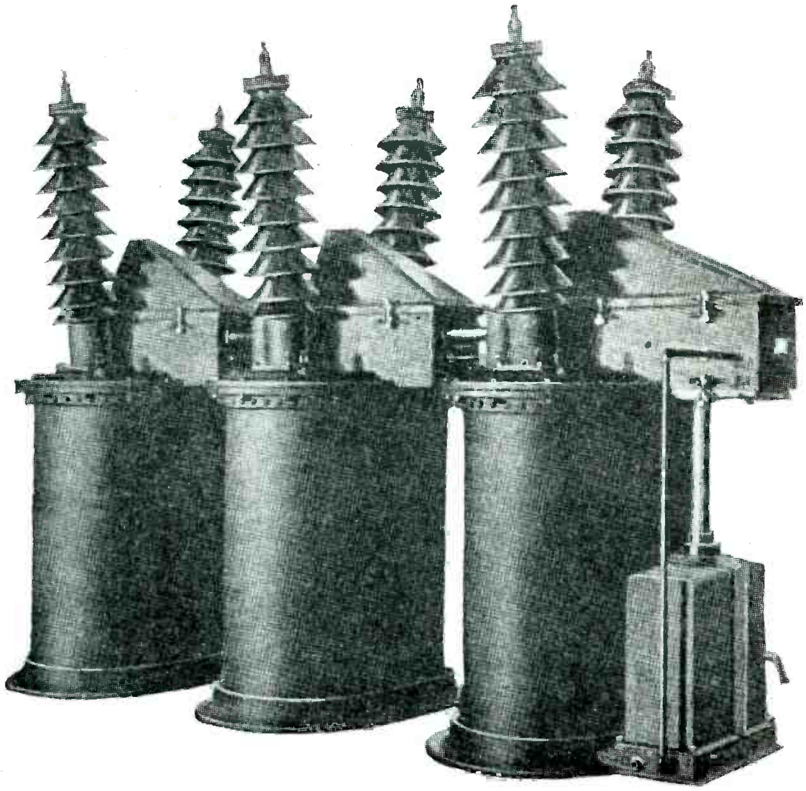
Fig. 2—The three major triads (triad chord = of three notes). These are the chief foundation of harmony as employed in Western music

tremely complicated treatment of diatonic scale structures that exists in musical literature is brought about solely by the fact that the tone sources of traditional instruments cannot be adjusted in frequency to form a new scale for each key change. Figure 3 shows the difficulty graphically.

The Tempered Scale[6] (Scale of Equal Temperament) is universally used today for keyboard instruments and therefore nominally by all musicians. It is based on the simple arrangement that an octave is divided into twelve equal intervals of a semi-tone, each of which, therefore, has a frequency ratio of the 12th root of two. This scale has the great virtue that it permits modulation without limitation. In music, modulation means a change in key, i.e., an overall shift in frequency.

This is shown graphically in Fig. 4. It has the disadvantage that

A Live Wire in 1911—



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Breakdown voltage by Short Time method	Increment of Increase of Test voltage
25 KV or less	1.0 KV
over 25 KV to 50 KV inclusive	2.0 KV
over 50 KV to 100 KV inclusive	5.0 KV
over 100 KV	10.0 KV

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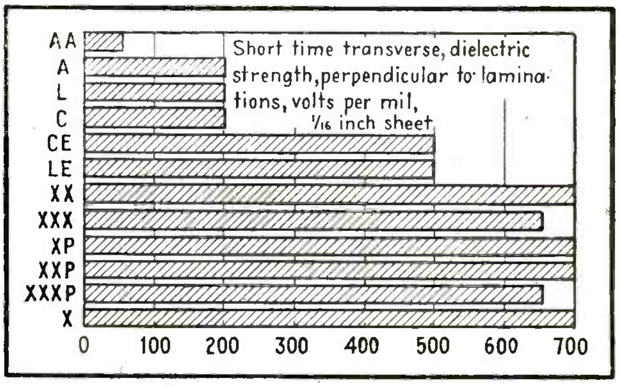

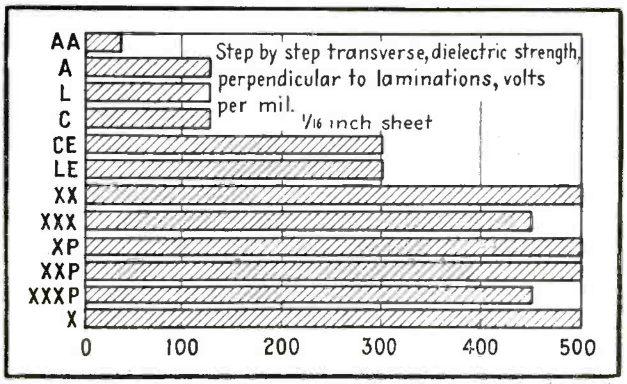

*Excerpts from an article by F. W. Johns, Jr. of the Continental-Diamond Laboratory Staff. A copy of the complete article will be sent on request.

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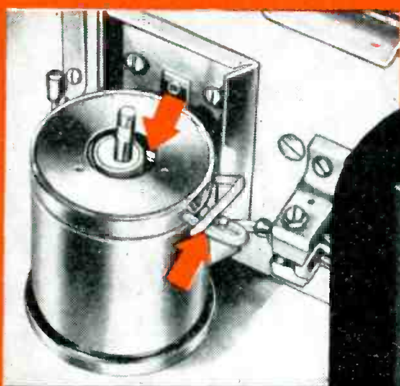

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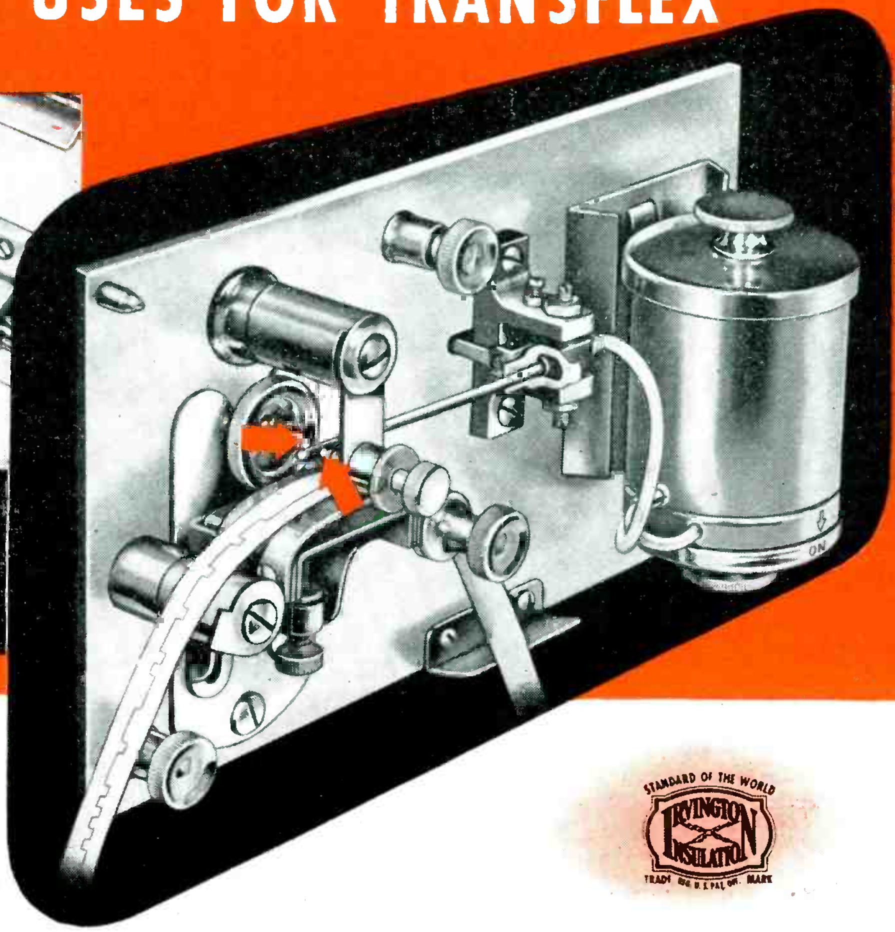

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many of the harmonic intervals are quite inaccurate. Fortunately, the interval of a fifth (nominal frequency ratio 3:2) is very close and this is the most important interval in harmony. However, the intervals of a third and a sixth, which are also of frequent occurrence, are very poor, being about a third of a semi-tone too large. The Tempered Scale, therefore, presents the disadvantages that many subtle effects in music which depend on variations in consonance of different intervals, are largely obscured by the fact that intervals which should sound quite consonant, such as thirds, are somewhat dissonant.

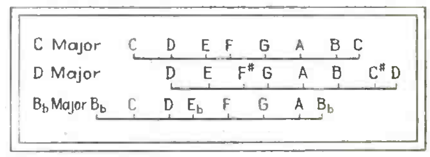

Fig. 3—The effect of changing key in the Just Scale is to shift the frequencies of some of the notes; this is necessary because of the unequal intervals. Logarithms of the ratios are plotted

By virtue of its make-up, the Tempered Scale has the same harmonic intervals in any key. In the Just Scale, when an instrument is tuned in one key, the harmonic structure is changed perceptibly for the other keys, if the instrument is not retuned. In the Tempered Scale a change of key means only a change of pitch. The graphical comparison of the Tempered and Just Scale intervals is shown in Fig. 5.

Helmholtz's Views

The shortcomings of the Tempered Scale have been familiar to musicians and physicists alike since it was first adopted. Helmholtz in 1860 pointed out its serious defects and suggested that in a generation or two the Tempered Scale might have a very marked effect on our acuteness of appreciation for harmony. It appears that his predictions have been fulfilled to a large extent and that the return of a strict perception of harmony is only possible by replacing the Tempered Scale with the Just Scale.

Helmholtz's comments on the differences between the Tempered and the Just Scales are worth quoting because they outline clearly the reasons leading up to the work de-

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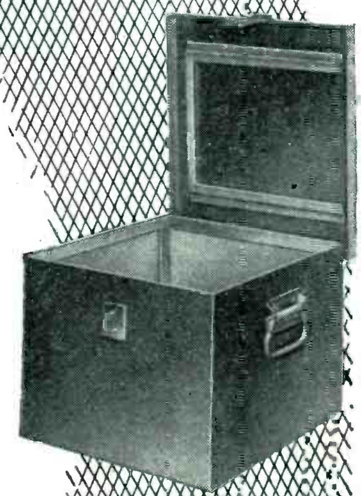

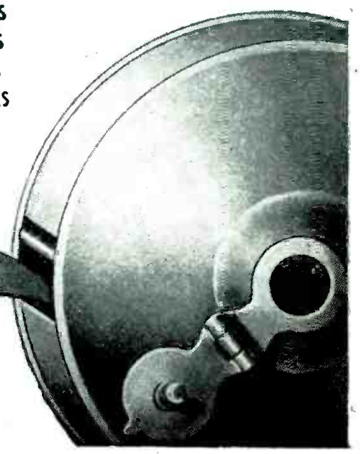

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HELP SHORTEN THE WAR . . . BUY MORE WAR BONDS scribed in this paper. They show that the deficiencies of the Tempered Scale have been fully recognized, as has been the excellence of the (7-note) Just Scale. And yet until the present, no practical solution has been obtained for the application of the Just Scale to keyboard instruments.

The following excerpts are from the 4th English edition of Helmholtz's "Sensations of Tone":

"As regards musical effect, the difference between the just and the equally tempered intonations, is very remarkable. The justly intoned chords, in favourable positions . . . possess a full, and, as it were, saturated harmoniousness; they flow on, with a full stress, calm and smooth, without tremor or beat. Equally tempered chords sound beside them rough, dull, trembling, restless. The difference is so marked that everyone, whether he is musically cultivated or not, observes it at once. . . .

"It must not be imagined that the difference between tempered and just intonation is a mere mathematical subtlety without any practical value. That this difference is really very striking even to unmusical ears is shown immediately by actual experiments with properly tuned instruments. . . ."

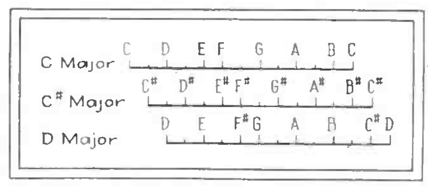


Fig. 4—The effect of changing key in the Tempered Scale is simply to shift the pitch of the music. No readjustment of the scale intervals is involved. Logarithms of the ratios are plotted

It must be realized that the Tempered Scale has been adopted solely because it will permit changing into different keys without any change in the structure of the music. Since the intervals in the Just Scale are unequal, if a modulation from one key to another is to be made, then of necessity the scale must be readjusted so that it can maintain the exact sequence of intervals in the key. With conventional keyboard instruments, this is not possible and the Tempered Scale is the only practical solution.

At various times, proposals for

new keyboards have been made. A complication of the keyboard is not a practical approach to the problem because of the considerable difficulty it adds to the work of the performer. It is, however, the only possible approach to a solution in the case of traditional instruments.

Electronic Instrument Possibilities

With the introduction of electrical methods of producing musical tones we have, for the first time, the facility offered to us of key changes which will be strictly harmonious on an instrument tuned in the Just Scale. This is true only because the frequencies of the tone generators of electrical instruments can be instantaneously and accurately readjusted.

That complications will be introduced into an electrical musical instrument by the use of the Just Scale is demonstrated by Fig. 3. It is seen that a digital on the keyboard must have access to a considerable number of slightly differ-

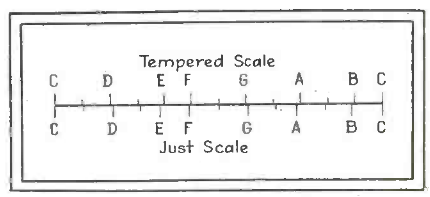
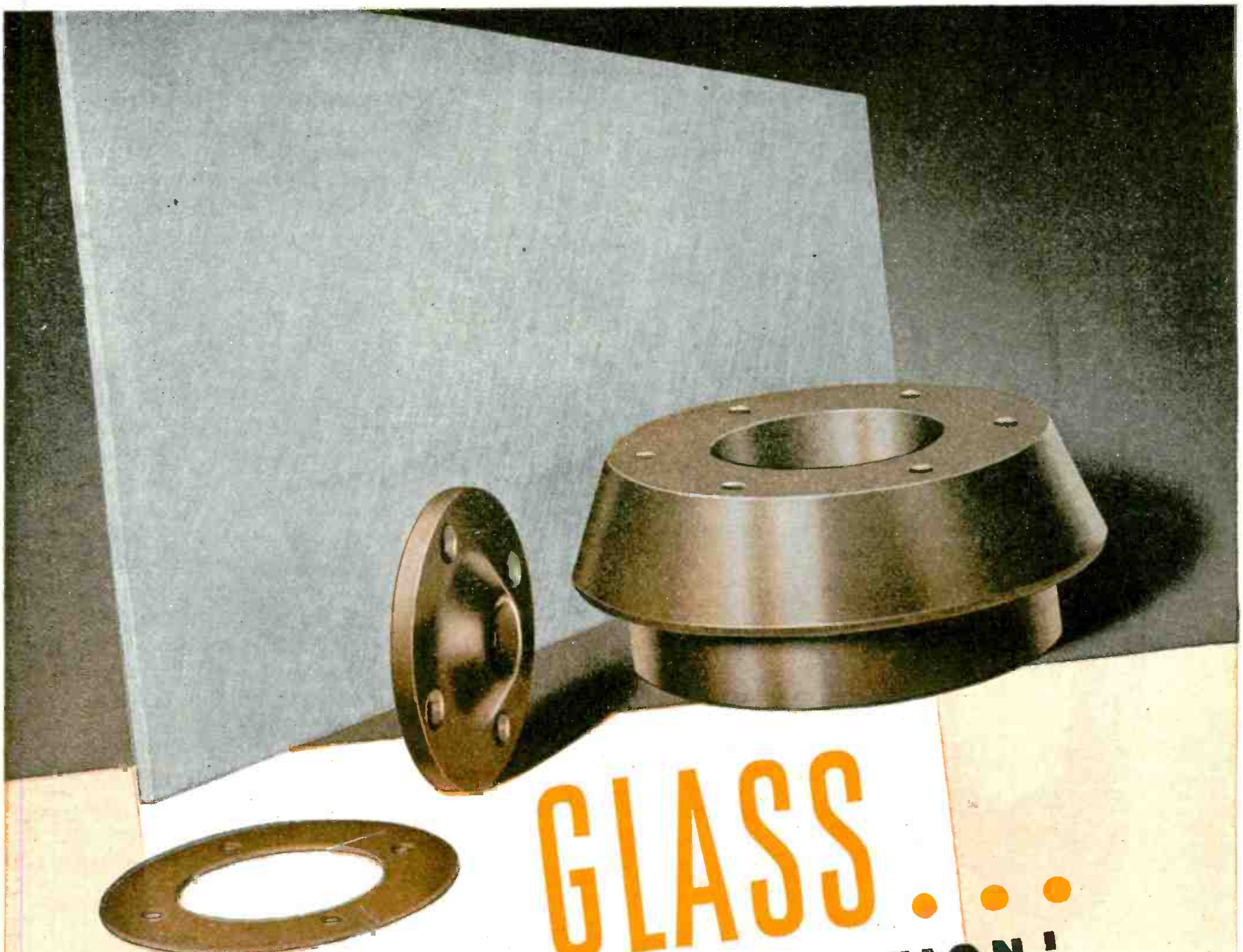


Fig. 5—Comparison of Tempered and Just Scale intervals. Logarithms of the ratios are plotted

ing frequencies if exact harmonic ratios are to be preserved in all keys. In conventional instruments, this is an insurmountable obstacle. It has been judged so by Helmholtz, and all other writers in the field.

Electrical musical instruments are not new in themselves, but the idea of tuning them in the Just Scale and providing means by which this scale can be adjusted correctly for each key signature appears to be original. It is entirely credible that such an invention will make a profound impression on musicians. Development of practical forms of instruments appears to be of importance. One of the most obvious ways to approach the problem is to take a highly-developed existing instrument such as the Hammond (Electric) Organ and redesign it in such a way as to make this proposal workable.

The Hammond Organ[2] consists



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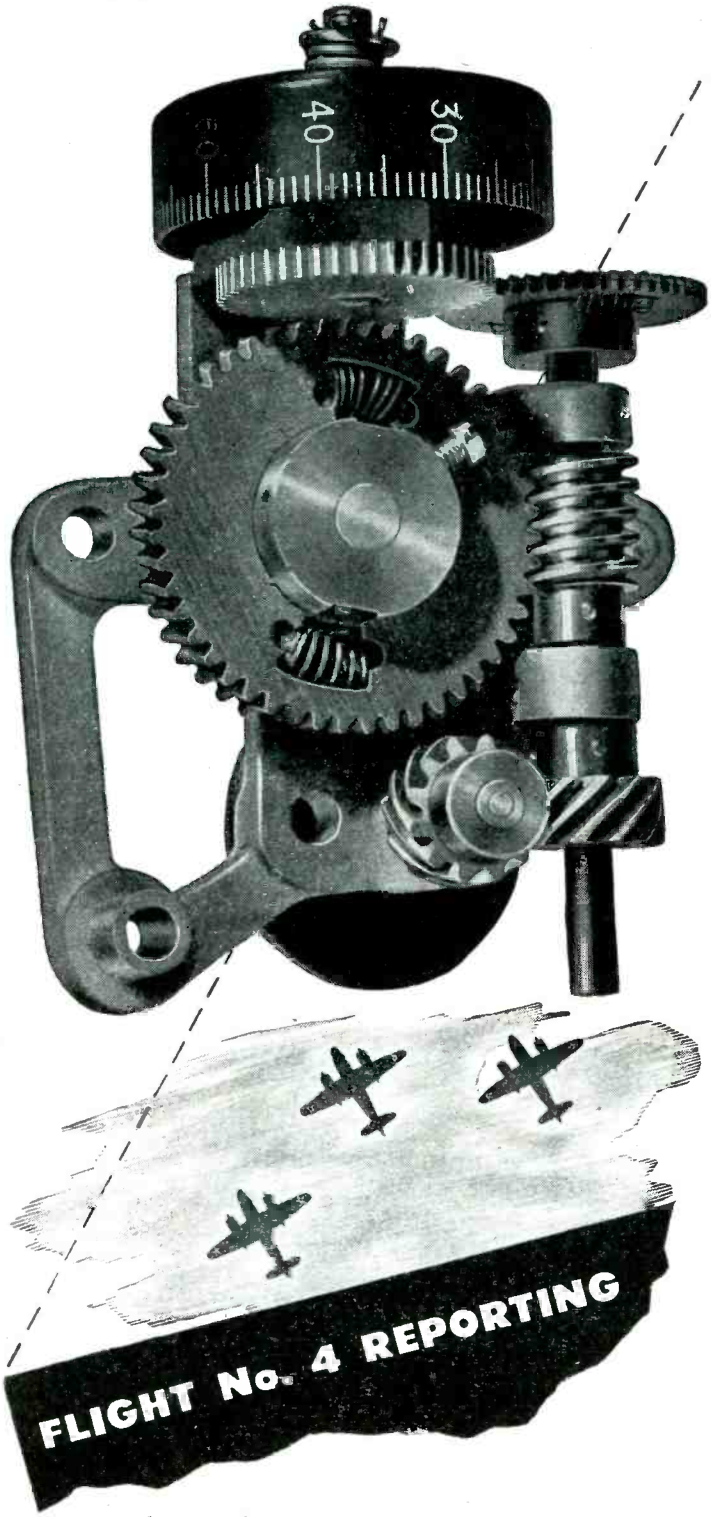

of a number of rotary generators driven from a single synchronous motor. There is one generator for each note of the keyboard plus some extra generators for harmonics that lie beyond the keyboard range. All these generators produce tones which lie almost exactly on the Tempered Scale.

It should be noted that the Hammond instrument in its harmonic make-up differs from conventional pipe organs because all the frequencies used in the synthesis of any musical quality lie in the Tempered Scale; in other words, natural harmonics are entirely suppressed and tempered harmonics are substituted. This avoids the serious clash that occurs in conventional pipe organs between natural harmonics and tempered fundamentals which lie very close together. In no other instrument, to the author's knowledge, are tempered harmonics used, and while the results may not be immediately perceptible to the lay ear, the characteristic harmoniousness of the Hammond Organ, which becomes apparent after some familiarity with it, must be ascribed to this basic improvement.

Hammond Organ Modifications

The application of the Just Scale to the Hammond Organ[3] or to other instruments of this general character, is carried out as follows: The tone wheels and gears are changed so that the frequencies of the generators lie on the Just Scale. The motor is coupled to the main drive shaft through a 15-position gear set, including 15 magnetic clutches. Thus the drive can be at any one of 15 speeds, depending on which clutch is operated, and the speed may be instantaneously changed by operating any other clutch. The clutches are operated from a row of 15 pushbuttons arranged along the base of the instrument and intended to be actuated by the left foot. These pushbuttons are marked with key signatures from C♯ to C♭ and (including the natural key) permit playing in 15 major and 15 minor keys. This appears to be adequate for practically all music now existent.

Operation

When the pushbutton for the key of C is operated—that is, the natural major key—the motor speed

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is such that middle A is 440 cycles per second and all other tones on the keyboard are exactly in the Just Scale. The instrument then can be played in the key of C in the Just Scale. There is no question of the use of tempered or natural harmonics. A number of additional generators must be added in each octave to take care of some harmonics of notes other than the key notes.

If it is wished to changed the instrument so that it can be played in the key of E, then the pushbutton marked "E" is depressed. This will release the "C" clutch and operate the "E" clutch and the speed of the main drive shaft will be changed to 5/4 of its former speed. The instrument will therefore be raised in pitch in the ratio of 5/4 and upon playing on the white notes as before, i.e., in the key of C major, the instrument will sound in the key of E. Since all the harmonics and added generators are changed in the same ratio, the organ is still in the Just Scale and this scale is correctly tuned for the key in which it is being played.

It will be noted that except for accidentals, in major keys the performer need only learn to play on the white notes. The instrument then always plays as though the music were in the natural key and it sounds in the key corresponding to the pushbutton which is operated.

Each pushbutton would be labelled with the key signature. For instance one of the pushbuttons—that for the key of D, say—would be labelled "D—2♯ major". To each of these pushbuttons would be wired a small illuminated indicator with the same label as the pushbutton. These indicators would be mounted in a row between the two manuals so that the organist is always aware of the key to which his instrument is tuned.

A Transposing Instrument

It will be seen that this organ is a transposing instrument and that existing music could not be readily played on it unless it were written in the key of C. All organ music would have to be transcribed to this key, with the key signature in which it is to sound marked separately. Minor keys would have to be transcribed to the naturally cor-

responding minor. The key-signature indication could very well take the form of an added note below the bass staff and, as far as the performer is concerned, would be simply one more note to be played, which he could play with his left foot. To avoid confusion with bass notes, the keynote names could be used.

Such an instrument as this would be learned much more readily than present day conventional keyboard instruments. The student would no longer be obliged to master the complicated and cumbersome scheme of key signatures which music has evolved. The playing position of his hands on the keyboard would never be changed and the black notes would only be necessary for accidentals or for minor keys. The student, therefore, would devote the major part of his energy to the artistic development of his music rather than to the mastering of the mere mechanics of notation.

That such an instrument could not be put into use immediately is fully appreciated; that an instrument of this general character should eventually become widely used is, however, maintained. A sufficient interval of time must elapse to permit the transcription of a large amount of existing music into the natural key before such a scheme could be of much use. The ultimate advantages are beyond argument. Such a transposing instrument is readily evolved from a Hammond Organ or similar device because of the simple nature of the mechanism for speed changing. It will be apparent that the transposing feature can be readily applied also to the instrument to be described next.

Altering the Novachord

Another instrument which is adaptable practically is the Hammond Novachord[1]; this is typical of all instruments which obtain their tones from vacuum-tube oscillators. In the Novachord, twelve oscillators forming the top twelve notes of the keyboard are employed, and all other tones are obtained through a frequency-dividing and harmonic-generating system. The addition of an elaborate control system allows waves of any general character to be produced. The instrument, not being restricted to steady-state

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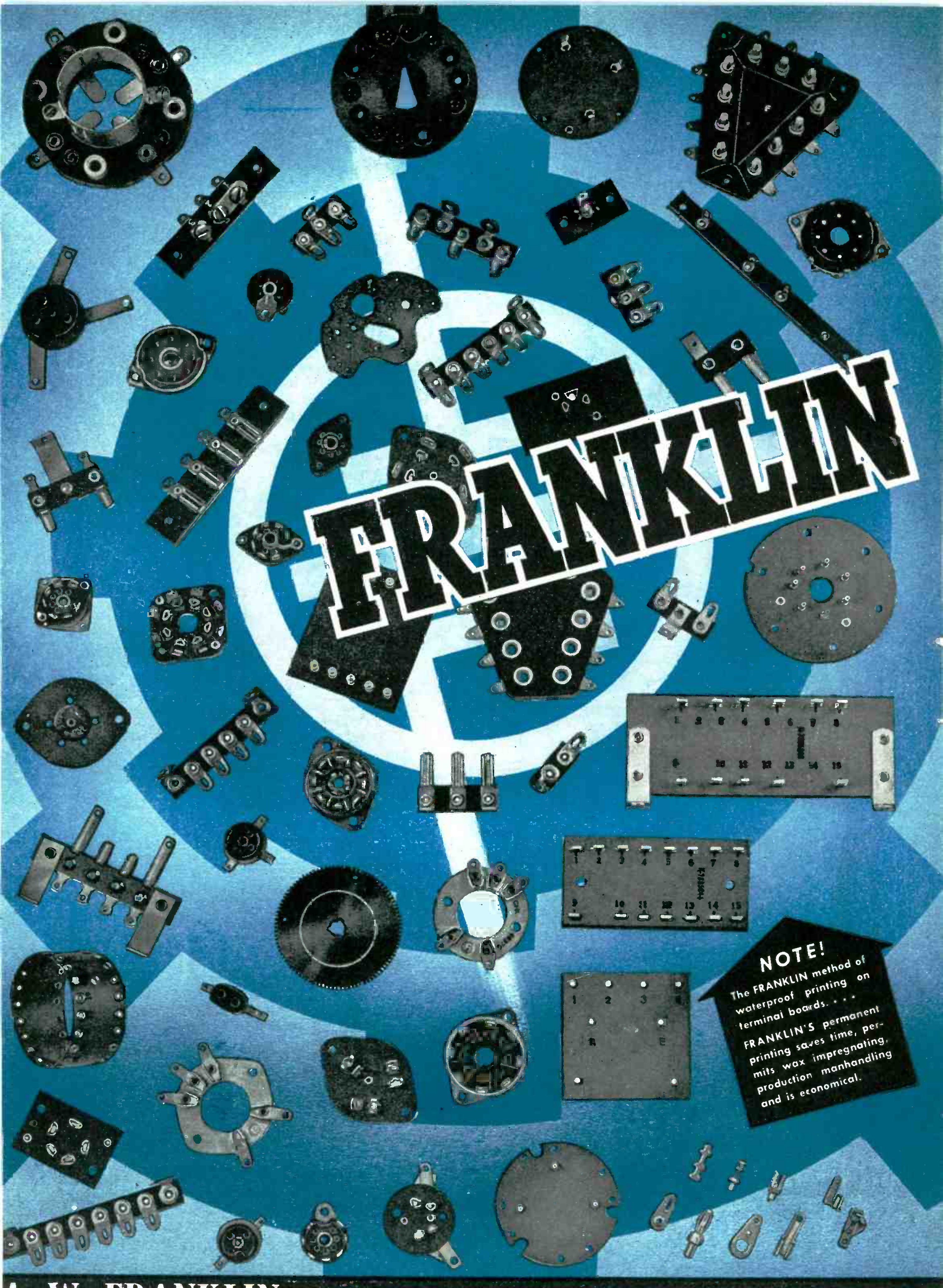

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Sockets • Terminal Strips • Plugs • Switches • Plastics Fabrication • Metal Stampings • Assemblie tones as is the Hammond Organ, will, with reasonable accuracy, imitate most of the conventional instruments. Using this sort of an instrument as a basis, the author would suggest a new instrument tuned in the Just Scale as follows:

A row of pushbuttons will be provided along the base of the instrument intended to be operated by the left foot. These buttons, of which there will probably be 15, will be labelled with 15 key signatures from C# to C_b which, in the major keys, is from seven sharps to seven flats and in the minor keys from four sharps to ten flats. Each of these pushbuttons will operate a 12-contact relay and the circuit is so arranged that only one relay can be operated at a time. Above the manual appear 15 illuminated signals which indicate which relay is operated. To each of the 12 contacts of each relay is wired a small capacitor and these are the tuning capacitors of the 12 oscillators.

When any relay is actuated, therefore, the 12 oscillators are adjusted to frequencies corresponding to the 12 capacitors that are cut into the circuit. Since all other tones on the instrument are derived

• • •

PORTABLE ELECTRON MICROSCOPE

A suitcase-model electron microscope for operation from the regular 110-volt line was demonstrated recently to the Radio Club of America at Columbia University, N. Y. C. Ten times more powerful than the best light microscope, the unit is shown to F. A. Klingenschmitt, right, president of the club, by Igor Bensen, General Electric development engineer from the 12 tones of the top octave, it follows that all the frequencies on the keyboard are governed by each pushbutton.

This instrument can be made a transposing instrument such as the organ already described, if the tuning capacitor is chosen of such a value as to step the whole octave upwards or downwards by a uniform amount as different relays are operated. It can also be arranged to be played exactly as conventional instruments are played by merely adjusting the frequencies of the notes of the octave so that for any desired key the frequencies will occur in the correct sequence. We should find ourselves with an instrument which is played exactly as a piano or an organ is played today, but which will sound in the Just Scale. It will be possible on this instrument to have an additional pushbutton which would tune the instrument in the Tempered Scale if for any reason this were desired, as for example, in order to play chromatic music.

Amplifier Considerations

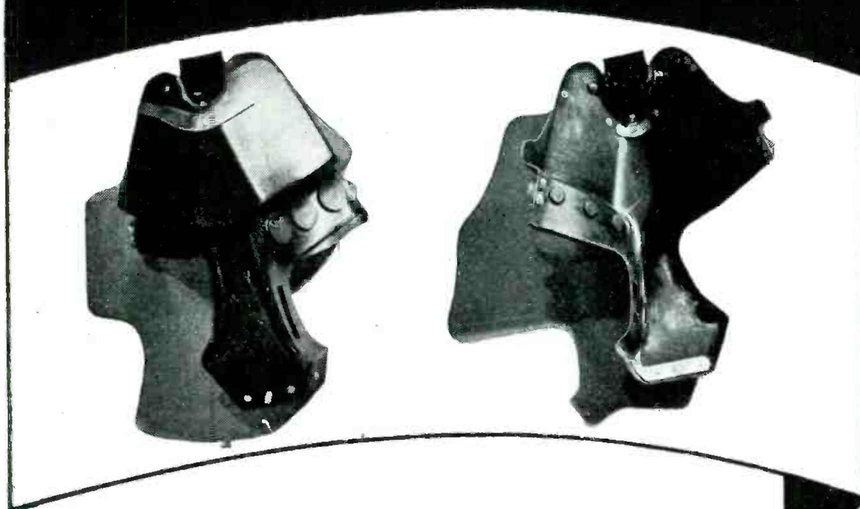
One of the design difficulties in electrical and electronic musical instruments is that the nominal power rating of the amplifier-loudspeaker system, which is based on

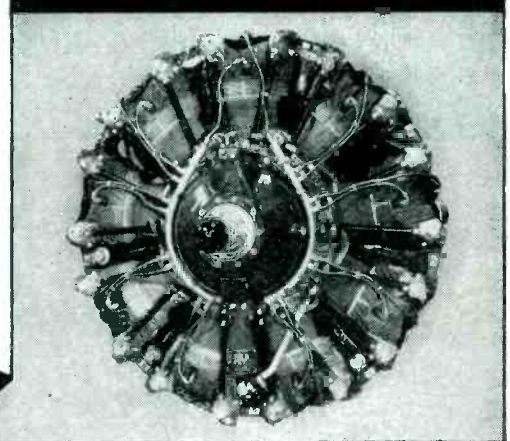
• • •

ENTERTAINMENT FOR WOUNDED

Patients at the St. Albans Naval Hospital on Long Island are entertained 10 hours a day from this Stromberg-Carlson control cabinet, operated by Lucille Ingebretson, pharmacist 2C. It contains FM and AM receivers, an automatic record changer, pre-amplifier and monitor speaker, and supplies 12 booster amplifiers on the system

Laminated Plastic Air Deflectors





Intricacy of design and contour of typical PANELYTE air deflector is shown in photo above. *Right:* Wright Cyclone 9, showing deflectors and push-rod housings in place.

ANOTHER *outstanding application* OF PANELYTE

The PANELYTE deflector baffle was perfected after two years extensive cooperation (engineering and production) with Wright Aeronautical Corporation. Developed as a substitute for (then) critical aluminum, PANELYTE Baffles, approved by Army and Navy Air Corps, were adopted at that time by three large manufacturers of air-cooled engines.

These deflectors, completely immune to corrosion, effect a weight-saving of 20%, withstand wide range of temperature change, and are not subject to vibrational disintegration or fatigue. They have been flown more than 300,000 miles. In the case of the PANELYTE baffle, heat treatment, anodizing and painting, are eliminated. Life expectancy, not yet determined, is several times that of aluminum. Baffles are delivered complete with both rubber and metal, ready to assemble on the engine. Where higher temperatures are encountered asbestos base PANELYTE is used.

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negligible distortion for a sine wave, cannot be approached when complex waves formed from many harmonic components in random phase relation are transmitted. This reduction in power output is due to the possibility at any instant of the amplitudes of all the components adding arithmetically, so that the voltage or current peak is the arithmetical sum of all the components, while the loudness of the power output is only the root-mean-square sum.

In an instrument tuned to the Just Scale, such as either of the two described, it is possible to fix the phase of all the components of a tone so that the peak amplitudes of all the waves could never add up at any instant. Even in an instrument tuned in the Tempered Scale this is worth doing, since the octave components, that is the sub-harmonic, and the second, fourth and eighth harmonics, are exactly correct and a precise phase relation can be maintained.

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(1) Fisher, S. T., "Electrical Production of Musical Tones". *Jour. of the Soc. Mot. Pic. Eng.*, Mar., 1939.
(2) Hammond, L., U. S. Patent No. 1,956,350.
(3) Fisher, S. T., U. S. Patent No. 2,273,768.
(4) Hammond, L., U. S. Patent No. 2,126,682.
(5) Fisher, S. T., U. S. Patent No. 2,293,499.
(6) Fisher, S. T., "An Engineer Looks at Music."—*Jour. Eng. Inst. of Canada*, Oct., 1942.

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Sound Psychology

YOU CAN DO a lot with sound. You can use it as a direct emotional stimulus; you can induce a physiological basis for the generation of emotion. With sound, you can control metabolism; you can increase or decrease muscular energy; you can increase respiration; you can increase or decrease pulse rate; you can control the threshold of sensory perception; you can reduce, delay, allay or increase fatigue. The techniques for accomplishing all these ends exist. It is susceptible of use as a part of an artistic idiom. To the extent permitted by technical limitations, it has been an element in the showman's art since there first were "shows". It still awaits full, conscious exploitation.

The control of sound and its psychological and physiological effects are described by Harold Burris-Meyer of Stevens Institute of Tech-

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WESTERN SALES HEADQUARTERS • SAN FRANCISCO nology in a paper in which the above paragraph appeared and which was delivered at a meeting of the Society of Motion Picture Engineers and published in the Journal of the Society. The paper notes some of the implications of the application of sound to motion pictures.

Included in the paper is a list of five methods of controlling sound in order to get the most from it. The list follows:

(1) Control of the intensity of the sound. The dynamic range must be from several db below theater ambient noise level (in a well-designed theater, this level will stay substantially below 40 db), to at least 120 db, which is a perfectly tolerable intensity with tremendous effectiveness when used with discretion. Such a dynamic range must not be accompanied by harmonic distortion at the peaks. It must be possible to record and reproduce sounds with steep wave fronts as found in explosions or in some compositions of Moussorgsky.

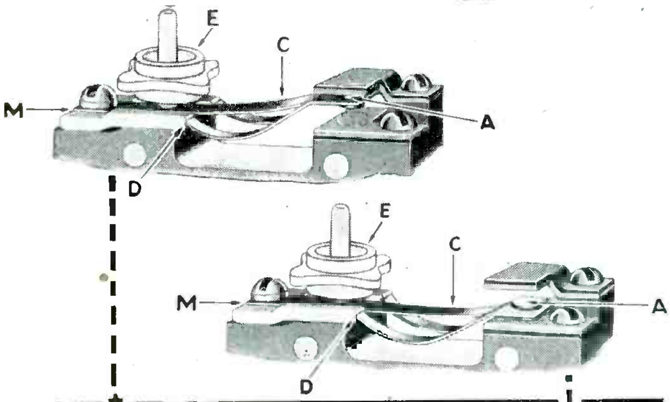
(2) Control of the spectrum, which involves the ability to get any auditory signal, including frequencies above and below audible range, on the track and back off it again, to all members of the audience. It means remaking, electronically reprocessing or synthesizing, any sound to give it any predetermined spectrum. It means a theater in which the sound is so distributed that all the frequencies on the track reach everyone in the house at substantially the appropriate levels. Only with such control of spectrum will the drum in Emperor Jones have maximum effectiveness, or cause the opera-goer to prefer the celluloid to the stage production.

(3) Control of reverberation. This means not only electronically controlled over-all decay time, but control of the shape of the decay curve in at least three separate frequency zones. It means theaters with uniform sound decay patterns, with all variations therefrom carried on the film. Then an organ record may sound like a cathedral organ, echoes may be realistic, and a scene in a tent may sound like a scene in a tent.

(4) Control of the apparent direction of the sound. This means having the sound come from any point in a sphere surrounding the

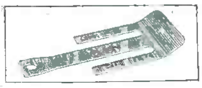
Why MICRO SWITCH

PROVIDES A LONG SNAP-ACTION LIFE

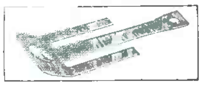


Micro Switch Operating Principle

The operating principle of the Micro Switch as illustrated here is simple and fundamentally correct. The long member of the one-piece spring "C" is supported as a cantilever at "M". The two shorter compression members of the spring rest in specially shaped (patented) V's. When the plunger "E" deforms the long tension member, the cantilever force overcomes the vertical force supplied by the compression members and the free end of the spring "A" snaps the contact from one stop to the other with lightning-fast speed. Snap action in the reverse direction occurs when the deformation of the tension members of the spring by plunger "E" is removed.



This one-piece beryllium copper spring is heat treated to provide the high fatigue resistance necessary to insure a minimum of 5,000,000 trouble-free mechanical operations, at full overtravel.



The rivet type contact is of superfine silver 99.95% pure.

The operating plunger is a highly polished, hard, stainless steel pin molded into an accurate Bakelite head. This head is so shaped that it cannot rotate, hence bears on the switch spring at the same point through millions of operations.

Micro Switch provides lightning-fast, snap-action control of electric circuits with reliable and positive operation accurately repeated over millions of cycles.

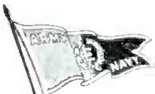
This performance is made possible by use of the unique, field tested, and proven operating principles of the Micro Switch. The snap motion of the Micro Switch contact is in the same direction as that of the operating plunger. There are no reverse bends in the Micro Switch spring, and there is no life-limiting "oil can" action.

The experience of design engineers with millions of Micro Switches in a great variety of applications has shown performance ability and operating characteristics never before found in snap-action switches.

Its small size, its high electrical rating, its ability to operate satisfactorily for millions of operations on minute movement and force differentials, its availability in various types of housings and a wide range of actuators . . . have made Micro Switch the choice of design engineers for precise operation of many types of equipment.

Micro Switch is Underwriters' listed and rated at 1200 V.A., at 125 to 460 volts a.c. Capacity on d.c. loads depends on load characteristics. A wide variety of basic switches and actuators provides characteristics varying from high vibration resistance to sensitivity requiring only 2/1000 ounce inches of operating energy.

Micro Switch Handbook-Catalog No. 60 will give you complete details as to electrical characteristics, construction, applications and dimensions. If you happen to be specializing in aircraft equipment, also send for Handbook-Catalog No. 70.



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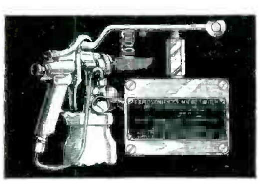
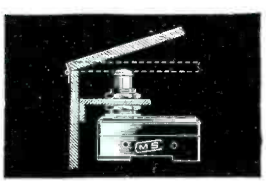
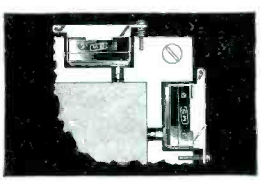


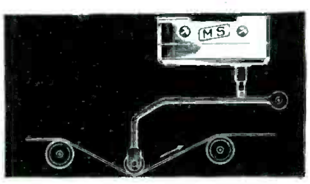
An explosion-proof Micro Switch is used with a spray gun to cut off the ventilating system of the spray booth automatically when the gun is hung up.



Micro Switches with push button actuators are used as safety switches on high tension cabinet doors. A normally open switch breaks circuit as door is opened.



Two Micro Switches with spring type plungers are used to insure correct position of material in jigs and fixtures.



Spring plunger Micro Switches serve as break indicators in textile and paper mills.

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audience — from the projection booth, from below the stage, from over the proscenium, from the side wall, or from no place, or from an apparently moving source, i.e., starting in one location and ending in another. It means freeing the sound from the spatial limits of the screen so that the Angels' Chorus can be heard from above, or the laughter of Lazarus can develop the audience.

(5) Control of the apparent distance from which the sound comes. This suggests that the sound must appear to originate from any point or area in a sphere of any size surrounding the audience. It must be able to move along a straight or curved line from any point in any sphere to any point in any other sphere; for example, a mile behind the projection booth to a point within the ear canal of each member of the audience. The control of apparent distance involves, of course, control of direction and control of spectrum.

• • •

VHF Generators and Titanium at Chicago IRE Meeting

THE LIMITATION of negative-grid triodes as very high frequency generators, particularly due to transit-time effects, interelectrode capacitances and lead inductances, were discussed by John M. Cage of Allis-Chalmers Mfg. Co. at the March Technical meeting of the Chicago Section of IRE. Brief mention was made of the use of positive grid or retarding field and magnetron tubes for taking advantage of transit time effect. The major portion of the discussion was devoted to an outline of the behavior of tubes of the klystron type, in which electron velocities are periodically accelerated and decelerated to provide electron grouping or bunching.

The history of titanium compounds as dielectric materials was presented by G. M. Ehlers, chemical engineer of Globe Union, Inc., who pointed out that a survey of literature in 1927 showed that titanium was not used as a dielectric previous to this date but came under study by 1932. An important feature of titanium compounds is that they are tropic-proof. His talk served as an introduction to a tech-

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As a matter of fact, perhaps we can get together now, but if it happens we can't, remember we have a date in and for the future. When we both can keep it, you can again take advantage of Anaconda service and the benefits derived from the single product control "from mine to consumer" backed by years of continuous metallurgical experience.

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nical talk by Peter Sherwood on measurements of capacitance, leakage, power factor, and temperature coefficients of ceramic dielectric capacitors. This consisted largely of a discussion of the three or four most promising methods of measuring these electrical quantities and a description of the test procedures developed for this purpose by Globe Union.

The meeting was held at Radio City, Milwaukee, where the 215 engineers were the guests of the Milwaukee Journal, which operates the 50-kw f-m station WMFM. The guests visited the station and the new studios at Radio City.

• • •

New Math Tables

FOUR NEW VOLUMES in the series of mathematical tables sponsored by the Bureau of Standards have been made available. They are: Table of reciprocals of the integers from 100,000 through 200,009 (VIII + 204 pages), $4.00; Table of Bessell functions J_0 (z) and J_1 (z) for complex arguments (XXLIV + 406 pages), $5.00; Table of circular and hyperbolic tangents and cotangents for radian arguments (XXVIII + 412 page), $5.00.

The volumes are bound in buckram and are uniform in appearance with those previously issued. Publication of the volumes has been taken over by Columbia University Press, Morningside Heights, New York 27, N. Y. and orders should be sent to this address, not to the Bureau of Standards.

• • •

X-RAY ON CRUISER

The medical officer on a new light cruiser x-rays a member of the crew during the shakedown cruise. Official U. S. Navy photograph

Examination of Quartz Crystals

(*Continued from page* 117)

The glass plate, underneath and accurately perpendicular to the rod, is pressed against a reference bar while the crystal is being cemented on it. As soon as the cement hardens the swivel fixture can be separated from the crystal by softening the wax with a small flame or by activating a built-in electric heater. Fixture and rod are withdrawn, leaving the crystal on the glass plate and ready for the saw table. There, the knowledge of the hand of the crystal, direction of the axes, and the type of cut to be made determines the final setting.

The first cut is taken through the routine x-ray examination which determines any necessary final adjustment of the saw table. Since the deviation of all axes from their correct orientation will, as a rule, be small, this x-ray check does not involve "hunting" for a meter response as may be necessary with cuts initially farther from the correct orientation.

In conclusion, certain precau-

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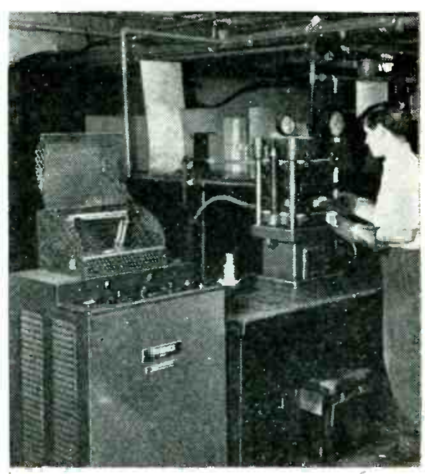
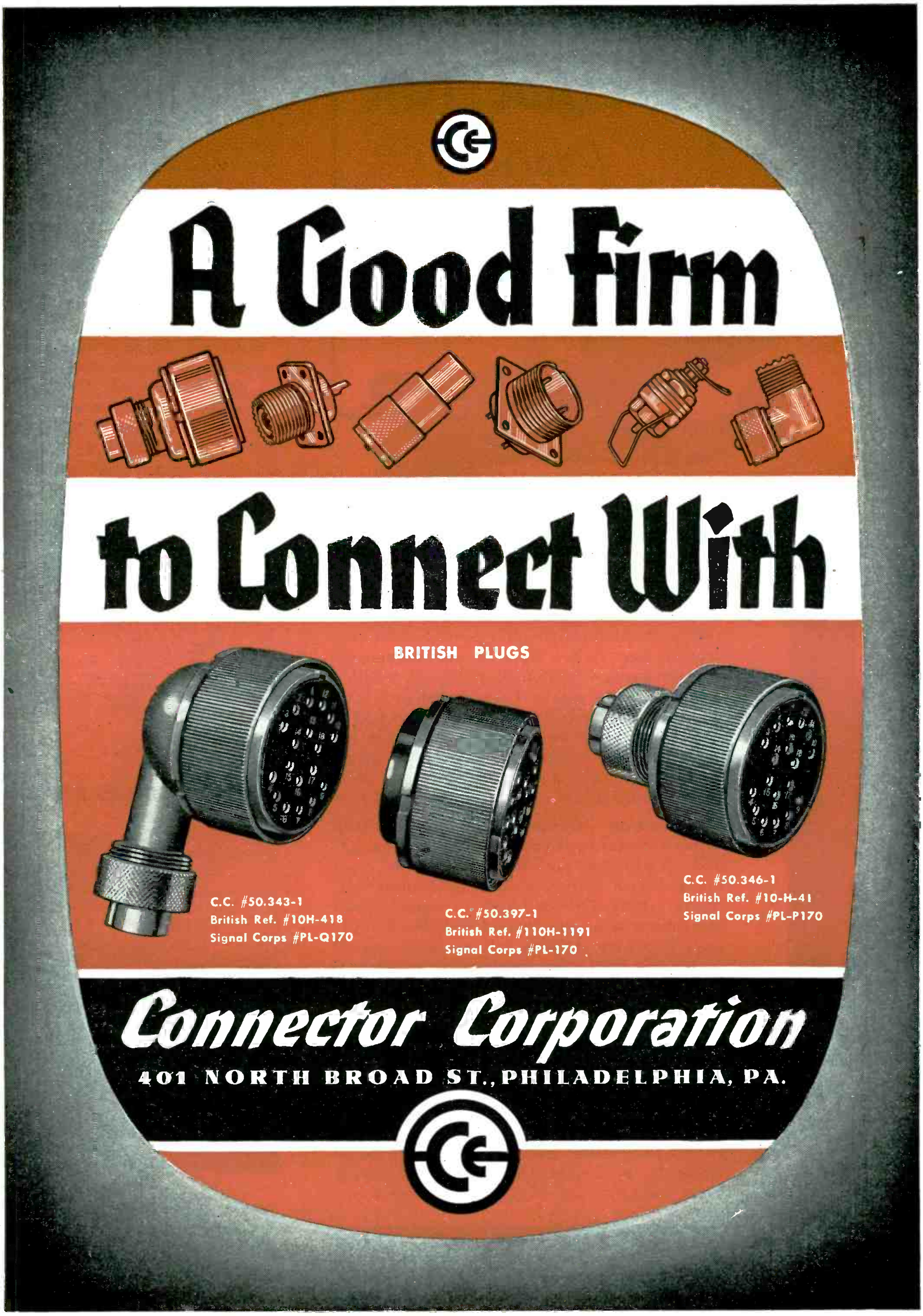
DIELECTRIC HEATING OF PREFORMS



The high-frequency generator at the left is used to heat preforms at the Plastics Industries Technical Institute in Los Angeles. It preheats one pound of compound per minute before molding in the compression press at the right. Made by Airtronics Mfg. Co., a division of Aerocrafts Corp., the unit is of value in research development and practical training of students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tions are recommended for the most efficient use of the rodometric method:

(a) For cementing, a mixture of cherry-rosin and beeswax is suitable. Some harder cement should be built around the mother quartz before the final sawing.

(b) The window should not be touched directly by the hand, and should be kept clean at all times; this applies also to the lenses and the oil bath in the rodometer.

(c) A regular check for alignment of the instruments is advisable.

Figures 4, 5 and 6 were kindly supplied by Professor Cady. Grateful acknowledgement for helpful suggestions also is extended to Professor J. R. Harrison of Tufts College and to Mr. John M. Wolfskill and the research staff at Bliley Electric Co. of Erie, Pa.

REFERENCES

(1) de Gramont, Armand, Recherches sur le Quartz Piezoelectrique, Paris, 1935.

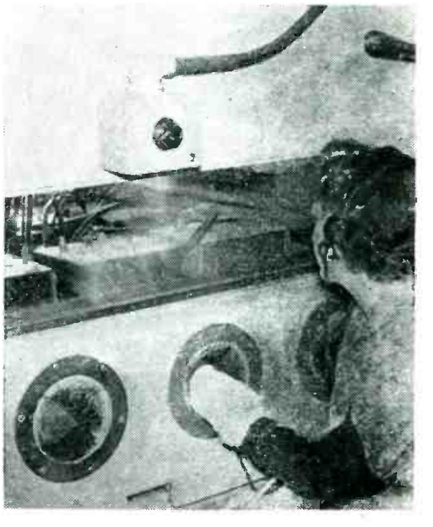
(2) Holton, G. J., Theory and Application of Etchfigures on Quartz, thesis, Wesleyan University, Middletown, Conn.; also in pending patent.

(3) Cady, W. G., and Van Dyke, K. S., Proposed Standard Conventions for Expressing the Elastic and Piezoelectric Properties of Right and Left Quartz, *Proc. IRE*, 30, p. 495, Nov. 1942.

(4) Detailed technical information and listings of supply sources for components are given in the Manual for the Construction and Use of the Rodometer, Scott Laboratory, Wesleyan University, Middletown, Conn.

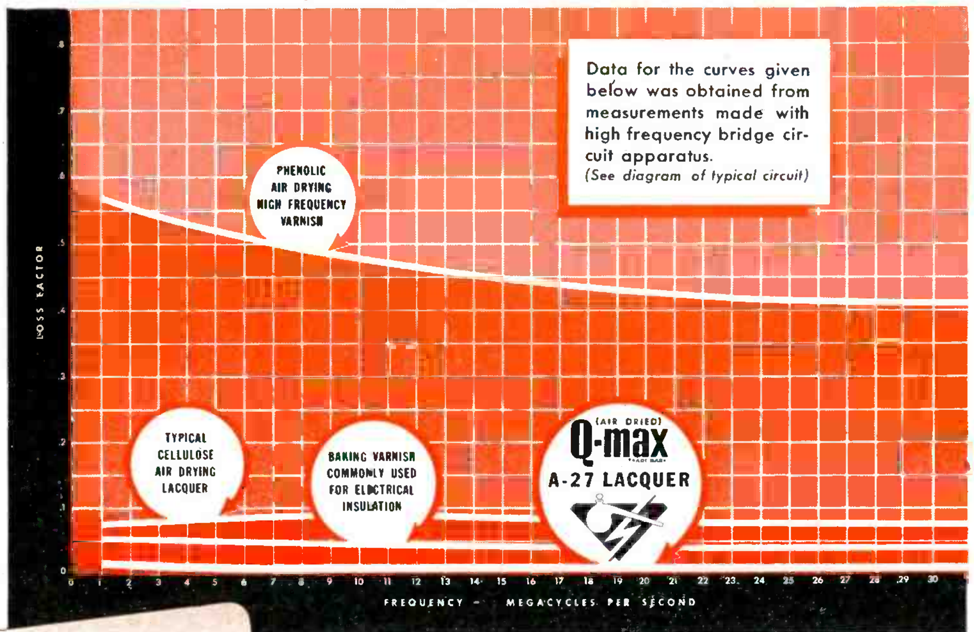
• • •

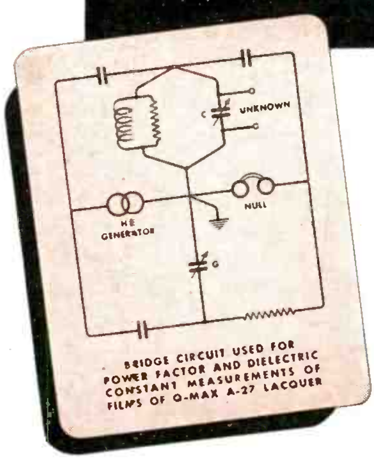
ARCTIC RADIO TEST



Aircraft radio instruments are tested in this cold chamber at 65 deg below zero at the radio division of Bendix Aviation Corp. Flexible coverings over the portholes of the chamber permit the muff-covered hand of the operator to adjust the controls of the equipment

A Loss Factor Comparison





Q-MAX A-27

versus:

TYPICAL INSULATING COATINGS

Unmatched for use in radio frequency applications, Q-Max A-27 has a low loss factor which remains nearly constant as frequencies increase from 1 megacycle. Its film is tough, uniformly heavy and self-leveling; it has a solids content of 45% and its low viscosity permits either brush or dip application. A study of properties and test values of this new, improved insulating lacquer is available and will be sent, on request, to engineers and manufacturers in the radio field. Write for the Q-Max A-27 booklet . . . twenty-four pages of test data, photographs and test curves valuable to those interested in insulation for high frequency circuits.

Q-Max A-27 has innumerable applications in the R.F. field. Among them: R.F. solenoid windings; impregnation for multi-layer or star coils; as a tape saturant; as a stiffening or strengthening medium; surfacer for wood or other porous materials; treatment of R.F. coils.

Shipped direct from our Jersey City factory, in 1-, 5- or 55-gallon containers.

Q-MAX CHEMICALS DIVISION

Communication PRODUCTS COMPANY, INC.

744 BROAD ST., NEWARK 2, N. J. · FACTORY: 346 BERGEN AVE., JERSEY CITY, N. J.

Coaxial Transmission Line and Fittings · Sterling Switches · Auto-Dryaire
Antenna and Radiating Systems · Q-Max A-27 Radio Frequency Lacquer

NEWS OF THE INDUSTRY

Quartz and tubes for civilians; Canadian radar-electronics; Science Talent Search winners; General Ingles tells of equipment in tropics; Chicago War Production Conference; London news letter

Surplus Electronics Components

A CLEARING HOUSE for the interchange of inventories of surplus radio and electronic components between prime contractors, the armed services and the Radio and Radar Division of WPB has been provided by organization of a Component Recovery Section in the Division. The section was established after the program was recommended and approved at various WPB Industry Advisory Committee meetings. The plan is to return surplus components to the productive stream and thus smooth the flow of production of end equipment required in the greatly increased military electronics program this year.

The Component Recovery Section receives idle and excess inventory lists resulting from cancellations, terminations and changes in prime contracts and also surplus inventory lists from the Armed Services and prime contractors. In turn, the Section distributes these lists to Army contracting officers and Procurement Districts, ANEPA (Army-Navy Electronics Production Agency), the Radio Material and Supply Officers of the Navy and to prime contractors requiring critical components.

Possibilities for 1948

IF THE CONDITIONS assumed by "Foreign Trade after the War" (the statistical study and projection recently made by the Bureau of Foreign and Domestic Commerce) are reached, and the total exports of electrical and electronic goods in 1948 amount to $195,000,000, then the following estimated distribution will be a *possibility:*

	Millions of dollars
Generators, converters, arc welding and generator parts and accessories	14.0
Primary batteries	5.3
Secondary batteries	5.0
Transformers	6.3
Power switches, lightning arrestors, etc.	4.0
Power switchboards	2.0
Meters and testing equipment	6.5
Motors and parts	20.0
Motor controls	4.0
Electric locomotives	2.0
Station and warehouse trucks	.4
Portable electric tools	2.0
Electric lamps	2.0
Lighting fixtures	5.0
Electric refrigerators	24.0
Other motor-driven household appliances	7.5
Domestic heating appliances	2.0
Industrial electric furnaces	2.0
X-ray and therapeutic apparatus	3.5
Radio transmitting and receiving apparatus	33.0
Wire-communication apparatus	6.0
Wiring devices	7.5
Other electrical appliances, n. e. s.	31.0
Total	195.0

Quartz Released for Civilians

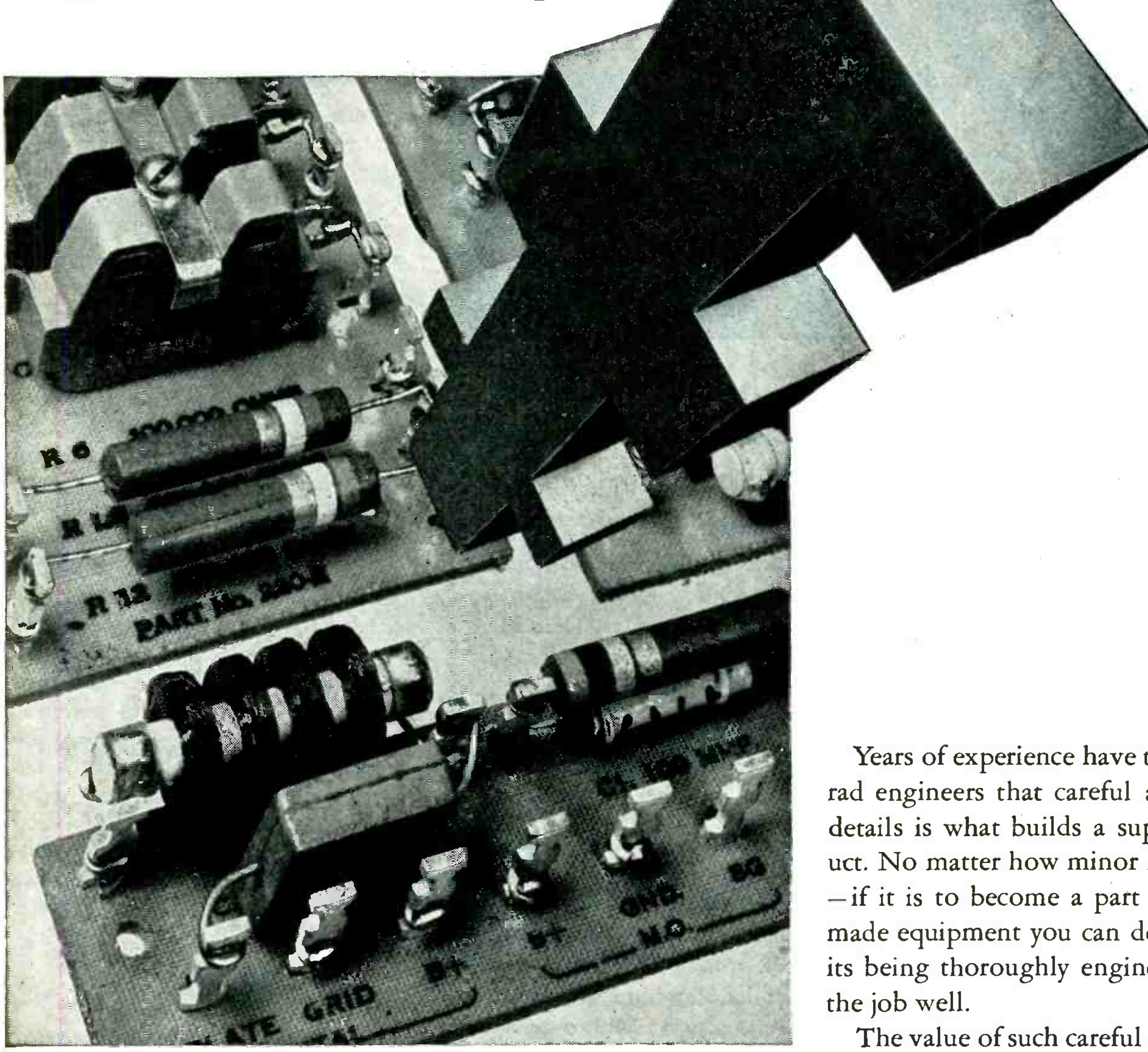
THE PERMITTED USES of quartz crystals have been extended to include purposes other than military by the War Production Board, in amending Order M-146. Previously, crystals were available only for war purposes.

Quartz crystals may now be used for manufacture of radio oscillators and filters for commercial broadcasting stations and communications systems and for Governmental activities directly connected with defense, public health, welfare, or security. This will permit police,

BLIND REPAIR RADIOS FOR ARMY

More than 250 radios have been put in good working order by blind students at the New York Institute for the Education of the Blind. Supplied by the Special Services Division of the Army, the sets are repaired by the students and returned to be sent to hospital ships, camps and recreation centers

It's tiny but it's engineered to the job



The little metal tab above serves to illustrate the extent to which Techrad engineers go in the production and development of superior radio equipment. Instead of considering it as just a soldering lug Techrad engineers approached it as a major project. As a result of this engineering a better method of manufacture was born. In Techrad products you'll find hundreds of these little tabs... forming tap switch contacts, connector panels saving time and confusion in production.

Years of experience have taught Techrad engineers that careful attention to details is what builds a superior product. No matter how minor it may seem—if it is to become a part of Techrad-made equipment you can depend upon its being thoroughly engineered to do the job well.

The value of such careful engineering is clearly evidenced by the performance of Techrad products. You'll appreciate this fact once you adopt them or employ the assistance of Techrad engineers. Such assistance is available to you without cost or obligation. Simply write, giving details of your problem.

Remember Master Engineering takes nothing for granted... not even a soldering lug.

TECHRAD

Technical Radio Company

Over ten years of continuous experience

275 Ninth Street • San Francisco, California

Export Agents: Frazar & Hansen, 301 Clay St., San Francisco, California, U. S. A.

forestry service and similar activities to get equipment they need.

Quartz for the manufacture of optical or electrical parts for use in research or production instruments manufactured to fill orders rated AA-2X or better has also been made available.

18 Million Civilian Tubes

IF MILITARY ORDERS are completed and if facilities and labor are available, manufacturers are permitted to produce "over-runs" above quota of vacuum tubes for civilian use. Because of this, at least 18,000,000 "MR" (maintenance and repair types) tubes are anticipated for civilians this year.

Although such increased production will not meet all present civilian needs for radio tubes, the War Production Board expects it to improve materially the current shortage. Because of the backlog of demand for tubes, longer radio listening hours, and the use of old or repaired radios, the number of tubes needed for replacement by civilians in 1944 has been estimated at more than 41,000,000.

The WPB directive to manufacturers to trade types each manufactures will make possible more equitable distribution. This would provide each company with a balanced stock of tubes from which jobbers will be able to obtain a certain percentage of their 1941 purchases.

RMA Electronics Promotion

EMPHASIS ON the important part that radio and electronic manufacturers have played in the war effort will be placed in a Radio Manufacturers Association campaign planned by the RMA advertising committee.

The opinion was expressed by committee members that the public had not been sufficiently informed of the vital part the radio-electronic companies had played in producing essential equipment for waging the war. Detailed plans for accomplishing this purpose will be developed at future meetings of the committee and by the board of directors.

Canadian Radar and Electronics Industry

FACTS AND FIGURES on the production of communications equipment in Canada were disclosed by the Honorable C. D. Howe, Minister of Munitions and Supply, in a speech on war appropriations made in the Canadian House of Commons. Excerpts from the speech follow.

"The value of our production in communications in 1940 was one million dollars, in 1942, 60 million dollars; and in 1943, 136 million dollars. The radio and communications industry is now operating at a level some eighteen times greater than in 1939. We have orders on our books to the value of 400 million dollars, and we do not expect to reach peak production until the second quarter of 1944.

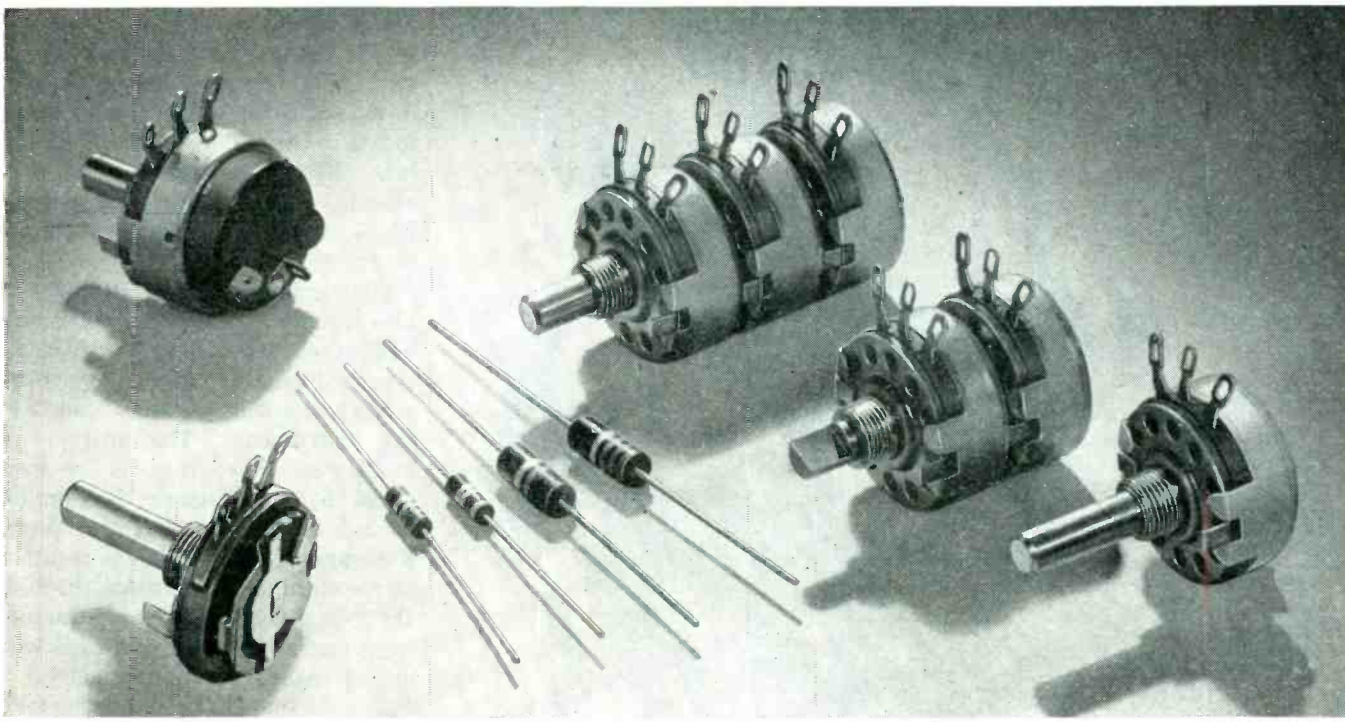
"There are approximately 4500 different items in current production by some fifty prime contractors and several hundred sub-contractors. The items include: Amplifiers, antennas, cable, radio compasses, remote control units, radio direction finders, signalling lamps, 23 types of radio transmitters, power generators, quartz crystals, 25 types of radio receivers, 19 types of transmitting and receiving sets, 6 types of telephones, radio tubes, and switchboards, to mention but a few.

Radar

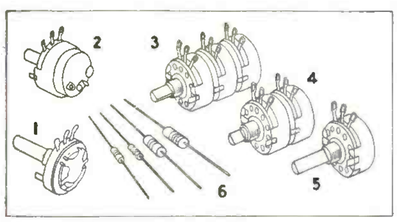
"Some twenty major types of radar equipment have been developed for a variety of applications, ranging from one type of anti-aircraft defence having 60,000 components, and 270 radio tubes, mounted in several large trucks, to small compact airborne units used for submarine detection at sea and target location on land.

"Obviously, this is a type of equipment in which there must be constant and rapid improvement if we are to maintain our superiority over the enemy. This means frequent change in design, which in turn requires great flexibility in production methods.

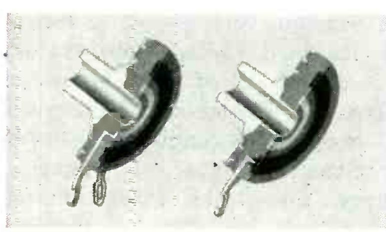
"A major factor in the production of communications equipment has been the contribution of *Research Enterprises Limited*, a Crown company which was set up in the early months of the war. In 1943, the total value of the com-



Reliable Resistors for all extremes of service conditions



1—Type J Bradleyometer with cover removed. 2—Type JS Bradleyometer with built-in switch. 3—4 Bradleyometers assembled in triple and dual construction to fit particular control needs. 5—Type J Bradleyometer. 6—½ And 1 watt Bradleyunits.



Sectional views of Bradleyometers showing how terminals are imbedded in solid molded resistor element.

These adjustable and fixed resistors are solid, molded units which are not affected by heat, cold, moisture, or hard use.

The Bradleyometers are the only composition type adjustable resistors that will consistently stand up under the Army-Navy AN-QQ-S91 salt spray test. Insulation, resistor material, terminals, face plate, and threaded bushing are molded into a single unit. The resistor element has substantial thickness (approximately 1/32 inch) and can be varied during manufacture to provide practically any resistance-rotation curve. Once the unit has been molded, its performance does not change. Bradleyometers are the only continuously adjustable resistors having a two-watt rating with a good safety factor. Enclosures are dust-proof and splash-proof.

Bradleyunits are molded fixed resistors with lead wires imbedded in the homogeneous resistor material. They will sustain an overload of ten times rating for a considerable period of time without failing. No special wax impregnation is necessary to pass the salt water immersion test. Available in insulated and non-insulated types. Write for details.

Allen-Bradley Company, 110 W. Greenfield Ave., Milwaukee 4, Wisconsin

A-B Quality

ALLEN-BRADLEY

FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY

munications equipment produced by the Company was 60 million dollars. The Company also has produced optical equipment and instruments to the value of 10 million dollars. From its optical glass, Research manufactures binoculars, range finders, and a wide variety of other instruments.

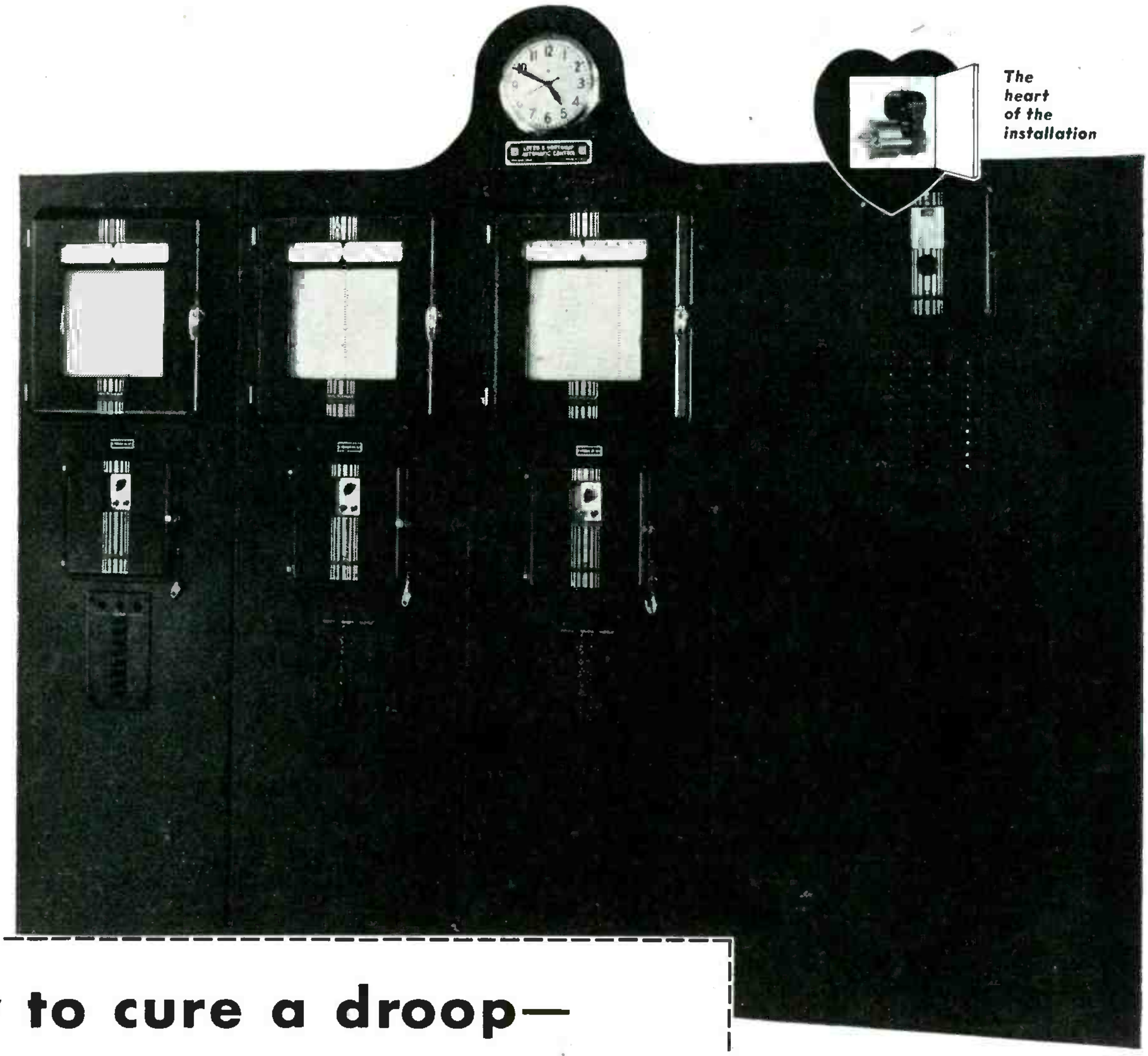
"The communications industry is also producing fire control boxes and other sonic devices of many types, including torpedo components and a wide variety of gun-laying instruments. The entire communications program is co-ordinated by the Signals Production Branch of the Department of Munitions and Supply. This has resulted in the elimination of waste through the simplification of manufacturing practices and the more efficient use of manufacturing capacity."

Scholarships Awarded in Science Talent Search

IN THE THIRD ANNUAL Science Talent Search, the top scholarship awards, four-year $2,400 Westinghouse Science Grand Scholarships, went to Anne Hagopian, 16, of New York City, and Charles Davidson, 18, Fort Bridger, Wyo.

Eight other teen-age scientists received four-year Westinghouse Science Scholarships worth $400 each, three were awarded $200 scholarships, and 25 were granted one-year scholarships of $100 each. The scholarships were presented by Dr. Harlow Shapley, Director of the Harvard College Observatory and chairman of the board of judges of the Science Talent Search.

The Search is conducted each fall by Science Clubs of America, through more than 4,000 affiliated high school clubs. The scholarships are provided by Westinghouse as a contribution to the advancement of science in America. They can be used to attend any degree-granting college or university of the recipient's choice, subject to the approval of the scholarship committee of the Science Clubs of America. Scholarships will be held in trust, for use after the war, for any recipients unable to use them immediately because they enter military service. Acceptance of the Science Talent Search scholarships



How to cure a droop—
with a Telechron motor

Telechron synchronous motors power the automatic droop corrector in this control panel for heat-treating furnaces.

Around the clock, these sturdy little motors keep temperatures in line with loads in the nation's metal industries — saving vital fuel, conserving process materials, speeding production with economy. Even before changes are big enough to show on the charts, Telechron motors step in to help hold furnaces at peak efficiency.

As adaptable as they are dependable and accurate, these motors make hair-trigger control of industrial processes possible in many fields. Motors are available for 12 to 250 volts for all commercial frequencies and from 1 to 1800 rpm. Their industrial applications include:

Timing	**Cycling Operations**	**Measuring**
Controlling	**Signaling**	**Gaging**
Metering	**Fixed Process Controlling**	**Regulation**
Recording		**Communications**
Switching		

For 25 years we have been supplying industry with self-starting synchronous motors for all kinds of timing, recording and control jobs. Our experience is at your service. Just write to the Motor Advisory Service, Dept. C.

Telechron

REG. U. S. PAT. OFF.

WARREN TELECHRON COMPANY, ASHLAND, MASSACHUSETTS

MAKERS OF TELECHRON ELECTRIC CLOCKS AND SYNCHRONOUS MOTORS

does not prevent recipients from accepting other scholarship offers.

Charles Davidson, the top boy finalist, is a country boy, who in addition to his scientific interests embracing such subjects as electronics, hemistry, microscopy, painting and biology, is an athlete. He was captain of the football team at high school, and won a light-heavyweight boxing award.

He has been working for the past six years on his own scientific projects and has built a highly departmentalized home shop to accommodate his interests. One of his projects is the design of an "invisible searchlight", using infrared rays and an electronic pick-up, for military use in scanning enemy battle lines undetected. He plans to become a research scientist.

Sixteen-year-old Anne Hagopian, who is small and dark-haired, is the youngest girl finalist ever selected to receive the Westinghouse Science Grand Scholarship. A student at the Brearley School in New York City, she paints and draws in addition to her scientific interests. She has constructed models of atoms, and an original model to demonstrate principles of geometry. She plans to attend Radcliffe College and become a research physicist.

Underwriters' Labs Fifty Years Old

CELEBRATING ITS fiftieth anniversary, Underwriters' Laboratories, Inc. has come a long way in its ability to serve clients, sponsors, and the public since its inception half a century ago in a small room "over the horses" of Fire Station No. 1, Chicago, where its staff consisted of one engineer, an assistant and a clerk. Laboratory equipment was a bench, a table, a few chairs, and $350 worth of electrical apparatus.

The Laboratories are an outgrowth of the first Chicago World's Fair in 1893 where one of the features was Edison's incandescent lighting. During the construction period, a number of fires were caused by the new lighting system and insurance interests in Boston sent an engineer to Chicago to investigate the hazards of the electric light. That engineer was William Henry Merrill, founder-president

Sensitive, Snap-Action Operation

FOR USE ON SLOWLY-VARYING COIL CURRENTS

EXTREMELY CLOSE DIFFERENTIAL

. . . between pick-up and drop-out for either current or potential operation may be obtained by use of a resistor across the coil of the 79XAX, thus reducing coil current to a value just sufficient to hold the contacts closed. Any further decrease in current or voltage will operate the contacts.

Extreme sensitivity can also be obtained by use of a resistor, and the addition of a special coil to the 79XAX. These maintain the relay in a balanced condition. Any slight unbalance of the bridge or other power source will, through the upper coil, buck or boost the lower coil and cause the contacts to snap-operate.

In addition to all of the advantages of conventional sensitive relays, Struthers-Dunn Type 79XAX is designed so that its armature practically completes its travel *before* the contacts snap-operate to the corresponding position. This, plus the fact that contacts remain closed *with full pressure* up to the instant of transfer, permit this relay to be used in a number of unusual ways. Such applications include overcurrent protection particularly in the range of 1 to 100 milliamperes, or in connection with shunts furnishing potentials in the range of 1 to 100 millivolts; pulsing circuits where the relay must "pump" or "scratch its own back"; sensitive vacuum tube circuits, and various others.

Normal sensitivity is 0.01 watt, although this sensitivity can be heightened by means of various circuit arrangements. Contact arrangement is S.P.D.T., and contact rating 10 amps. 110-V a.c., and 10 amps. 24-V d.c. Balanced construction withstands 10 G vibration and shock. Write for Data Bulletin describing this relay and giving circuit diagrams.

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

ONE OF THE STRUTHERS-DUNN

5,288 RELAY TYPES

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

Following the fire horses at each call to the fairgrounds, Merrill's job was to determine what piece of electrical equipment, if any, had caused the fire and why. This work and the reports written attracted considerable attention in manufacturing and insurance circles.

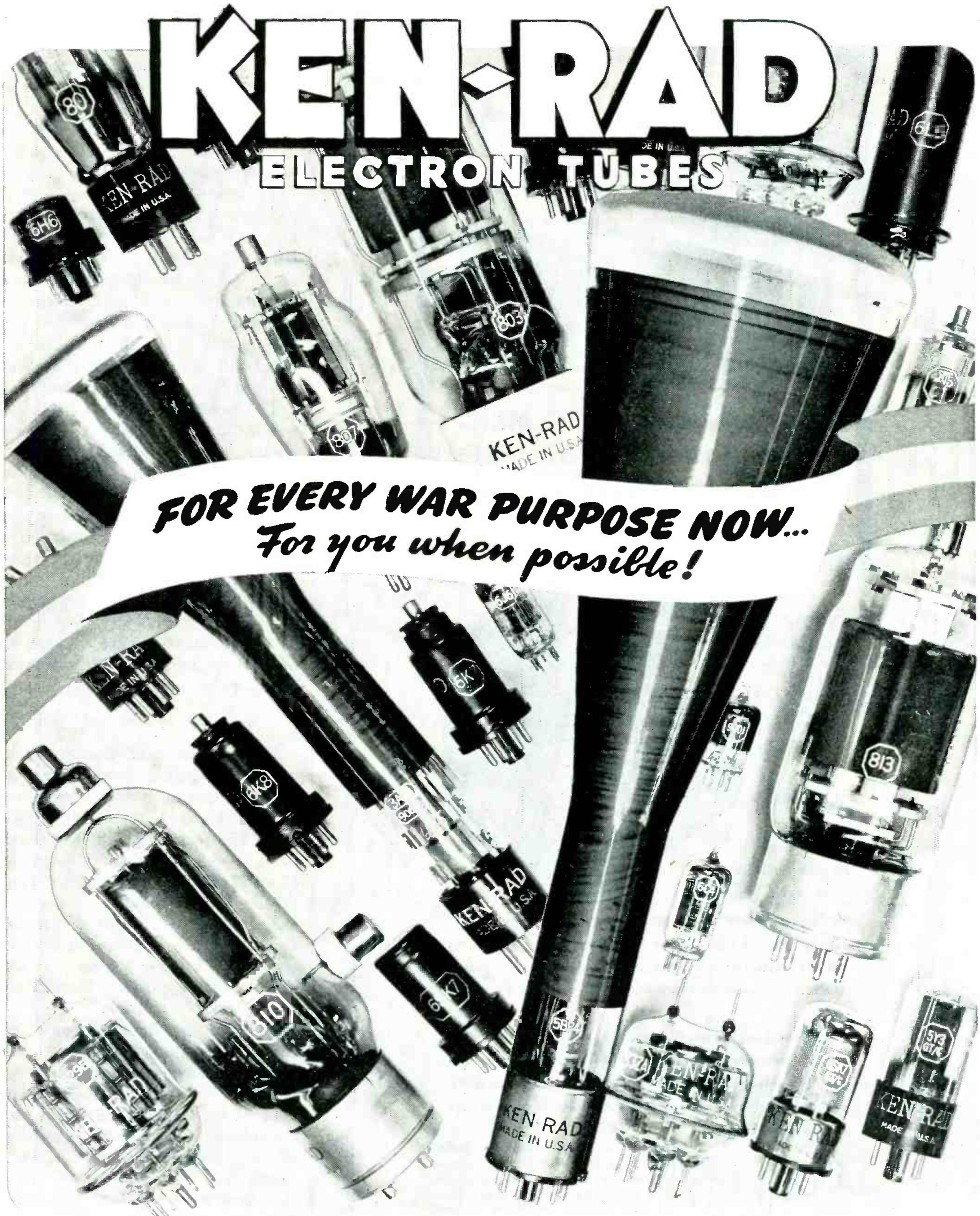
The tale is told how one day Merrill was sitting in a poker game with the boys of Fire Patrol Station No. 1 when the signal for the station sounded on the automatic alarm system. No one seemed to notice it. The game continued. The alarm was repeated, and a moment later the signal sounded the third time. Mr. Merrill turned to the Chief. "Isn't that your call?" he asked. "Yes," replied the Chief, "but we don't answer that. It's on the automatic system and even the horses know it's a false alarm and won't come out of the stalls." This incident is credited with having started the engineers on an investigation of the faults and failures then existing in automatic fire alarm systems.

Today, the Laboratories maintain, at the main testing station in Chicago, seventeen departmental laboratories equipped with much unusual and unique test equipment. Much of the special equipment is designed by the engineers and some is constructed in the Laboratories' shops. Other testing stations are maintained in New York, San Francisco and the vicinity of Chicago.

Three hundred seventy-five thousand products have been approved by Underwriters' Laboratories to date and are listed in its booklets of tested and inspected items. As 50 percent fail the first time they are tested, many more than 375,000 products have been investigated. The 5,000 manufacturers of approved devices, materials, and systems produced in a normal year, in their more than 5,500 factories, half a billion of these safeguarded articles.

General Ingles Reports on Signal Corps in Pacific

NO DELAY IN MILITARY operations has occurred because of lack of communications material and no critical shortage of Signal Corps equipment exists in the Pacific



TRANSMITTING TUBES
CATHODE RAY TUBES
SPECIAL PURPOSE TUBES

KEN-RAD

EXECUTIVE OFFICES
OWENSBORO · KENTUCKY
EXPORTS 15 MOORE STREET NEW YORK

RECEIVING TUBES
INCANDESCENT LAMPS
FLUORESCENT LAMPS

areas, according to Major General Harry C. Ingles, Chief Signal Officer, on return from a tour of inspection of the Pacific theaters of operation.

We expressed the belief that one of the major factors in the current military successes in the Pacific is "the closest possible cooperation" between the Army and the Navy and the harmonious relations between the commissioned and enlisted personnel of both services. Throughout the Pacific Area the Army and Navy use combined signal centers in which it is not unusual to find a Navy channel manned by a soldier and vice versa.

The primary purpose of his trip was to discover at first hand how signal communications are functioning and how adequately signal material is being supplied. Because of the enormous distances in the Pacific and because of intervening water, radio has become the primary means of communication. Wire, he said, is used extensively only after landings have been made and in instances where the density and damp foliage of the jungles makes radio less effective.

Jungle Country

Gen. Ingels said the Solomons and New Guinea areas were the worst jungle he had ever seen, especially because of the big trees, often 250 feet high, which make it hard to get through and have the effect of cutting down on the range of the Walkie-Talkies. These can talk four to five miles, sometimes as much as ten. It depends on how wet it is in the jungle the day they are being used. The weather is the worst drawback.

Some of the Japanese communications equipment—notably the field telephone and switchboard—is good. Illustrating the imitativeness of the Japanese, he said that Americans had captured a number of radio tubes with the RCA trademark, but on examination found that these were not American tubes but Japanese tubes copied so exactly that the trademark was included.

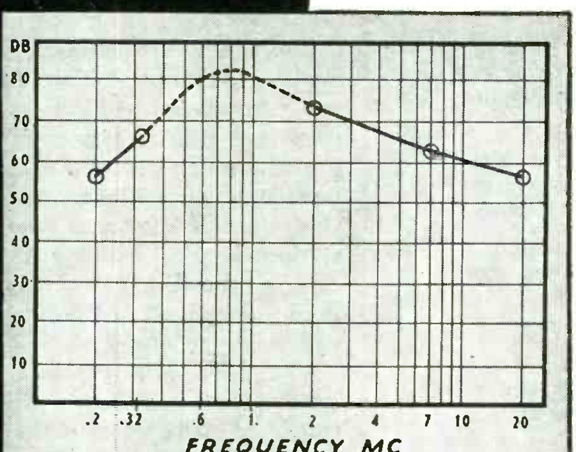
Procurement

Gen. Ingles said that the Signal Corps procures about 96,000 items of communication equipment of various kinds. Procurement has

......RADIO NOISE SUPPRESSION PROBLEMS *Answered*

POWER EQUIPMENT (25 to 400 ampere ratings)—For heavy-duty radio noise suppression service, Sprague offers a standard Filter line to match exacting military specifications (Wright Field 32331). Long service has proved their ability to answer problems of noise suppression on airplane motors, generators, inverters, and similar equipment.

LOW CURRENT APPLICATIONS (25 amperes and less)—Although designed to the same performance specifications as the foregoing heavy-duty line, sizes and weights of these Sprague Type JX Filters have been reduced. High attenuation characteristics assure high-fidelity radio reception under adverse conditions of man-made interference. They are exceptionally compact, mount in any position, have negligible power consumption, and operate efficiently over a broad temperature range.



ATTENTION CURVE
for Sprague Type JX-51 10 ampere filter with unshielded leads. Weight .37 lb., overall size, 2¾" x 2" x 1⅛".

Whatever your radio interference suppression problem "ASK SPRAGUE." A broad background of experience in this field over many years covers almost every type of equipment—military, naval, industrial, or home.

SPRAGUE SPECIALTIES CO., North Adams, Mass.

ARMY E NAVY

SPRAGUE

CAPACITORS · KOOLOHM RESISTORS

come up 70 percent in the last six months and is now quite satisfactory.

There is no critical shortage of equipment in the Pacific area. There are some things of which they have not enough yet, but all three commanders in the Pacific—Admiral Nimitz, Admiral Halsey, and General MacArthur—reported to the General that they had never been delayed or held up in operations because they didn't have communications equipment available.

Communications equipment takes an awful beating in being unloaded, the General said. There are no piers or docks. Equipment comes in on a ship, is taken off in a net, run to shore on a barge, then picked up on a net again in the driving rain and landed on the beach in the rain and often left there for a month or so; very rough treatment for such sensitive electrical equipment.

The jungle weather is hard on dry batteries. The only way they are kept in good condition is to keep them in cold storage. We are now trying to develop special batteries for that particular climate.

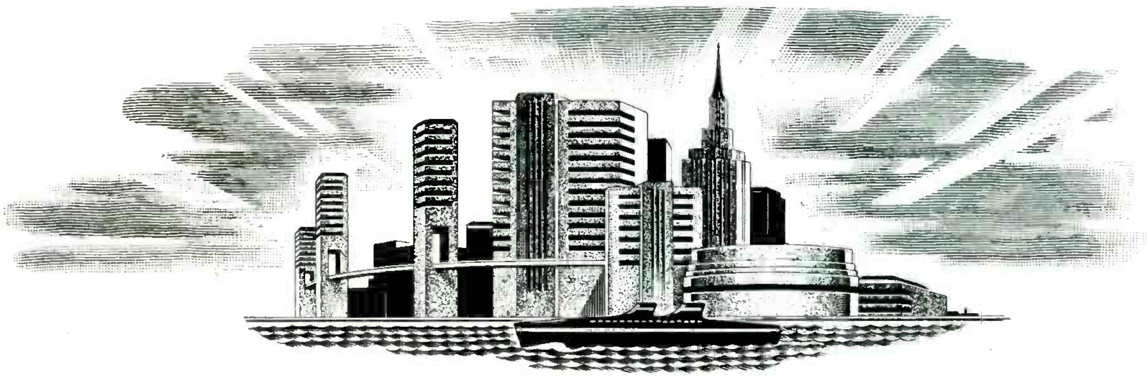
Tropical Treatment

Radio sets are specially treated against moisture and against fungus. In these tropical countries there are special types of fungus growths which will spoil all the contacts in a surprisingly short time. Our chemists know a fungus-resisting chemical which puts off the fungus growth for a long time. Radio equipment is fungus-proofed and water-proofed.

The best water-proofing is the water-proof container. The container is made water-proof by use of a rubber gasket. The antenna comes out through a rubber gasket so that the set will operate in the rain. In the case of heavy station equipment, this is not necessary because it is put under some sort of shelter which has been erected ahead of time. Water-proofing is accomplished by spraying and brushing over all the separate leads and connections with a spray gun or brush.

A FUZE is a mechanical detonator, while a fuse contains a powder train, according to the Army.

TELEVISION 1954 A.D.



Back in 1944, you few men of vision in broadcasting management clearly foresaw that the addition of sight to sound would open up vast new business possibilities.

You took a tip from experimental commercials during the war years which showed the spectacular effectiveness of mass persuasion by television. Shortly after victory, television time *did* leap into great demand . . . just as you thought.

DuMont anticipated, just as you did, that there would be a peacetime scramble to be "first with television." So they completed their designs for telecast equipment that set new highs in signal transmitting efficiency and new lows in maintenance and operating costs.

Then the DuMont Equipment Reservation Plan was formulated so that you prospective television station owners could *have* that equipment in operation at the earliest possible postwar moment. This plan placed DuMont's extensive experience in television station building and management at your command. In addition, this plan gave you "postwar priority" in the equipment you needed.

That, you thought, was one sample of television talk that sounded down to earth . . . it would cut down your trial-and-error losses, and put your telecasting business on a sound and practical footing at the earliest possible moment.

So you dropped a line to DuMont and got on the Television bandwagon—on time . . . back in 1944.

We know it's 1944! So you're invited to learn about the DuMont Plan now. Send for our new booklet "Planning Your Television Station." Do it today!

DUMONT *Precision Electronics and Television*

ALLEN B. DuMONT LABORATORIES, INC., GENERAL OFFICES AND PLANT, 2 MAIN AVENUE, PASSAIC, N. J.
TELEVISION STUDIOS AND STATION W2XWV, 515 MADISON AVENUE, NEW YORK 22, NEW YORK

Television Technique for Spot News

AN INTERESTING DEMONSTRATION of the speed with which news events can be put on film, developed and televised was made in connection with the awarding of an Army-Navy "E" to the Du Mont Laboratories in Passaic, N. J.

Paramount News sent camermen to the theater where the ceremonies were held. One camera was set up close to the stage and the second was placed about half-way up an opposite aisle. Interchanging of lenses was made for closeups and long shots.

The movie was actually edited while it was filmed, rushed to New York for processing, and a few hours later was broadcast to viewers in three states over W2XWV. A transcription of the ceremony was also made and broadcast over WOR that night, two hours after the telecast.

Chicago War Production Conference

EXCEEDING THE HEAVY registration of last year, the second Chicago War Production Conference, held at the Stevens Hotel on March 30, drew a registration of approximately 3,400 engineers, production superintendents, factory managers, and similar personnel engaged in war production activities. Thirty-three panels on various topics of war production were held. Interest in the panels on electronics was second only to that of the panels on management.

Two afternoon panels on electronics were held and the attendance at each panel was between 350 and 400 persons. The first panel was devoted largely to broad general topics connected with the war experiences of radio personnel whereas the second panel had the production and manufacturing problems of the radio industry as its theme.

The first speaker on the electronics panel was Kenneth W. Jarvis, vice-president in charge of engineering, Sheridan Electro Corp., who delivered a talk entitled "Radio, Indispensable To Victory", after being introduced by Paul

Will Wire-Failures Make Your Peace-Product A WHITE ELEPHANT?

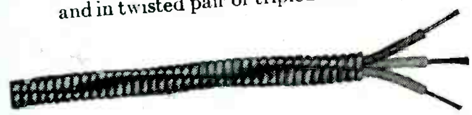
...Not If You Wire-Plan In the Design Stages

Investigate ROCKBESTOS PERMANENTLY INSULATED WIRES, CABLES AND CORDS
For Long-Lived Performance

ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt.

The first lightweight, small diameter, flame-resistant hookup wire, designed in 1937 and widely used since in airborne and ground communication systems, electronic devices, instruments and apparatus. Operating temperatures range from 125° C. to minus 50° C. Also with tinned copper shielding braid and in twisted pair or tripled construction.



ROCKBESTOS THERMOSTAT CONTROL WIRE

Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125", .025" or (for 115 volt service) .031" of felted asbestos insulation and steel armor. A multi-conductor control wire for low voltage intercommunicating, signal and temperature control systems. Its life-time heatproof and fireproof insulation and rugged abrasion-resisting steel armor will give you trouble-proof circuits.

ROCKBESTOS TYPE CA LEAD WIRE

Has high dielectric strength and moisture resistance for use where heat and humidity are encountered. No. 20 to 8 AWG solid or stranded copper, monel or nickel conductors insulated with synthetic tape and various thicknesses of felted asbestos finished in black, white or colors for coding purposes. Also with All-Asbestos insulation only, where high moisture resistance is not required.

ROCKBESTOS MULTI-CONDUCTOR FIREWALL RADIO HOOKUP CABLE

This type of cable is made up of 1000 V. individual Firewall Radio Hookup Wires (as illustrated at top of column) of required size and number of conductors, cabled, and braided or shielded according to customer's specification. For example, this special 14 conductor No. 22 AWG cable was taped, shielded with tinned copper braid, then jacketed with a black, glazed cotton braid with a flameproof finish.

These are but a few of the 122 different wires, cables and cords, designed for severe operating conditions by Rockbestos.

Time was when a product was designed, built, and finally wired with just about anything that could be hooked up and poked or jammed into place.

Today, however, manufacturers *wire-plan* their products in the design stages . . . instead of by trial and error. Experience has proved that advance consideration of such factors as dielectric strength, operating temperatures, diameters, voltage ratings, bend radii of wire ways, resistance to destructive elements, etc. . . . eliminates the possibilities of wire-failure before the products reach the users.

If you are working on, or planning your post-war equipment, investigate Rockbestos *permanently-insulated* wires, cables and cords. There are 122 standard constructions . . . each with built-in *permanent* characteristics to resist heat, flame, cold, moisture, oil, grease or corrosive fumes. And if a standard won't do, then Rockbestos Research will design a "special" to meet your particular operating requirements. All you need do is outline your problems and our engineers will make their recommendations.

For wire-engineering assistance or information on Rockbestos *permanently insulated* wires, write our nearest branch office or:

Rockbestos Products Corporation • 411 Nicoll St., New Haven 4, Conn.

ROCKBESTOS RESEARCH

Solves Difficult Wiring Problems

INVEST IN BONDS • MAKE EVERY PAYDAY A LAY-AWAY DAY

NEW YORK BUFFALO CLEVELAND CHICAGO PITTSBURGH ST. LOUIS LOS ANGELES SAN FRANCISCO SEATTLE PORTLAND, ORE.

Smith of the Galvin Mfg. Corp., panel chairman.

Pointing out that mobility was an essential requirement for modern military radio equipment, Mr. Jarvis outlined five principle wartime applications of radio: (1) defensive military operations, (2) offensive military operations, (3) radio control of various types of missiles (4) builder of morale for civilian and armed personnel, and (5) direction finding of enemy transmitting stations. An important application of radio which is not always fully realized is its application by both sides in the conflict, for the purposes of propaganda. Much of the modern practical military operations are made possible only because of the mobility and portability of reliable radio equipment. The practice of jamming communications practically assures that the side having the most reliable and most highly developed communication equipment will have an important advantage over the adversary.

Handy-Talkie

Albert T. Williams, chief production engineer of Galvin Mfg. Corp., spoke on "Experience in Engineering a Specific Radio; The Handy-Talkie" and demonstrated many of his points by disassembling and exhibiting one of the handy-talkie units. Originally conceived as a portable two-way communication unit about the size of an ordinary telephone handset and employing three tubes in a regenerative circuit, experience soon showed that these requirements did not lend themselves to practical use in the field or to desirable production in the factory.

Light weight, ease and operation, compactness and easy servicing in the field were requirements that had to be established in the design and production of this unit. The final model employs five tubes, and is completely self contained in a thin aluminum die-casting housing complete with batteries, microphone, earphone, and collapsible antenna. The small size of the handy talkie, together with the required reliability of operation, made necessary special design and construction of extremely minute parts.

Colonel C. N. Sawyer, Signal

GENERAL RADIO COMPANY

FOUNDED 1915

Manufacturers of RADIO AND ELECTRICAL LABORATORY APPARATUS

THIRTY STATE STREET
CAMBRIDGE 39, MASSACHUSETTS

CABLE ADDRESS, GENRADCO, BOSTON
BENTLEY'S CODE
TELEPHONE TROWBRIDGE 4400

REPLACEMENT PARTS
NOW AVAILABLE FOR
G-R EQUIPMENT

Gentlemen:

Many instruments returned to our Service Department for repair require only the replacement of some simple and inexpensive part. Users of G-R equipment very often can save themselves valuable time, labor, and repair charges by securing replacement parts and installing them.

We maintain small stocks of the more commonly used parts for just such replacements. Many times you can secure these parts from us more quickly than from any other source.

When urgently needed we will accept telegraphic orders for replacement parts for instruments of our manufacture, in many cases saving a number of days of "out of service" time to users.

Before ordering these parts, be sure they cannot be obtained locally. Restrict your orders to parts for General Radio equipment and please do not order more than is needed for the instrument being repaired. Always specify Type and Serial Number of instrument, part designation by wiring diagram and manufacturers part number, purchase order number and priority certificate. In many cases, we can ship the same day a telegraphic order is received

This service in no way curtails the facilities of our factory Service Department, when it is necessary to return instruments for major repair, or for recalibration. Even under wartime pressure, the Service Department is able to give remarkably quick service. It will be glad to assist you in any manner possible.

Our SERVICE AND MAINTENANCE NOTES should be of considerable help in avoiding and shooting trouble in many G-R instruments. Do you have a copy? We will be glad to send one, gratis, on request.

Sincerely

H. H. Dawes

Service Manager

ARMY E NAVY

Corps, U. S. Army, illustrated his talk, "Army Experiences With Radio Equipment On The War Front" by means of slides and photographs of actual conditions encountered in the Pacific. Complimenting radio engineers and manufacturers for the quantity and quality of radio equipment which they had produced and which enabled the United States to be the best equipped in this respect, Colonel Sawyer indicated that considerably more attention must be paid to the packaging, shipping, water-proofing and fungus-proofing of equipment intended for use in the islands of the Pacific.

Tropical Problems

The Colonel's statement that radio equipment is not subjected to handling with kid gloves during military operations was amply borne out by slides illustrating the arrival and storage of equipment at depots in the South Pacific. It was indicated that repair and maintenance facilities are frequently not available and radio equipment must often be operated by native personnel having no training, experience, or appreciation of the characteristics and behavior of radio equipment.

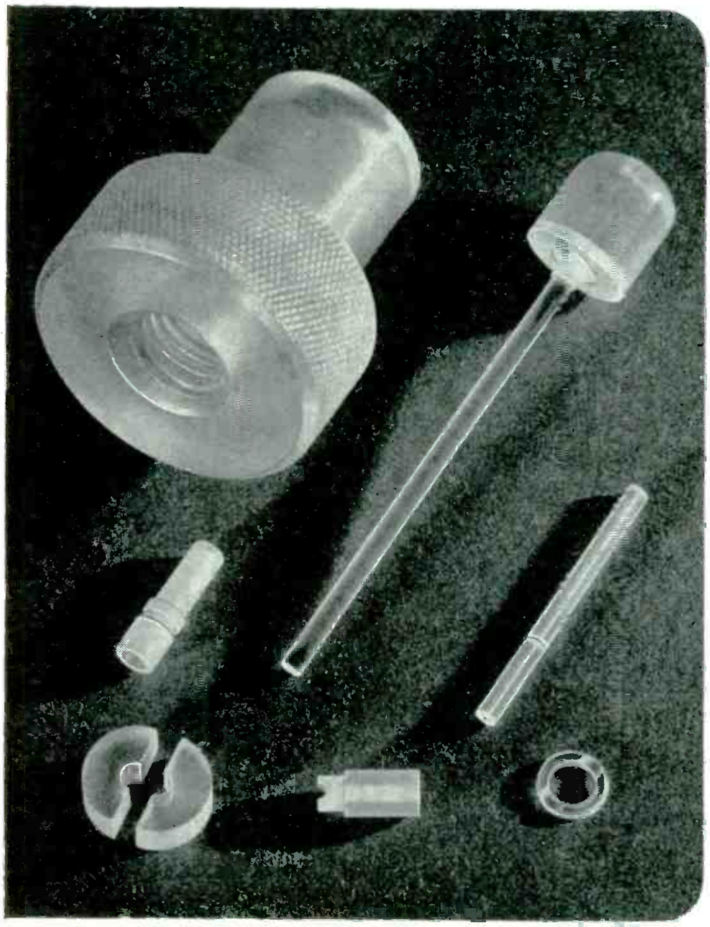
The chief complaints arise because radio equipment becomes immersed in water, because moisture-proofing is entirely inadequate for tropical conditions, and because packing is often too poor to meet the rugged conditions of military operations. Perhaps the most outstanding complaint is due to the rapid growth of fungus on equipment and considerably greater effort on the part of manufacturers must be directed to a satisfactory attack on this problem.

Backed up by recent experience with the Marines in the South Pacific, Lieut. Colonel Robert C. Walton of the Bureau of Ships spoke on Navy experience with radio equipment on the war front. This talk reinforced that by Colonel Sawyer in calling for greater protection of radio equipment against fungus, water, and in providing more thorough and adequate packing.

Production

As chairman of the second panel on electronics, Paul Smith introduced James W. Sharp of Zenith Radio Corp. who spoke on "Mass

HOW TO CEMENT PLAX POLYSTYRENE



PLAX POLYSTYRENE IS SUPPLIED in sheets, rods and tubes. It is also available in the famous Polyflex* Sheet and Polyflex* Fiber, tough and flexible extruded forms with wide insulation application. Machined parts such as those shown above (in actual sizes) are produced by Plax, to your specifications. Plax also supplies a polystyrene cement.

Other Plax wartime production includes various forms of cellulose acetate, cellulose acetate butyrate, ethyl cellulose, methacrylate, and styramic.

Write for bulletin on "Fabricating Polystyrene," containing full details of polystyrene's properties.

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

Three different types of cement can be used with polystyrene.

1. Solvent. Cementing with a solvent is similar in principle to welding. The solvent softens the polystyrene surfaces to be joined. The surfaces are held together under light pressure. The softened surfaces unite. The solvent is absorbed by the body of the plastic and the joint becomes solid and rigid. In this method, surfaces must fit exactly before the solvent is applied. Machined surfaces are usually cemented by this method.

2. Polystyrene solution. A thin layer of dissolved polystyrene is spread over the surfaces to be joined. The pieces are held together under light pressure. The solvent in the solution evaporates or is absorbed, leaving a joining layer of solid polystyrene. This method of cementing does not require perfectly fitting surfaces because the dissolved polystyrene in the cement will fill small surface irregularities. However, close tolerances cannot be maintained because the dissolved layer of plastic will vary with each application of cement. The bond will take from 12 to 36 hours to dry because a large amount of solvent is introduced at the joint. This method of cementing can be speeded by using a thicker solution, which has been warmed to make it fluid. Thus the amount of solvent to be evaporated is reduced.

3. Adhesive. This can be used to join polystyrene to other materials and to metal. The Thiokol, Glyptal, and Reanite Cements are variations of this type. These cements are classed broadly in three categories: drying adhesives, non-drying adhesives, and curing adhesives. The drying adhesives are most commonly used. The non-drying materials are weak in shear but extremely resistant to vibration, while the curing adhesives are temperature resistant. When partially cured, such adhesives give welds having a high degree of vibration and temperature resistance.

When cements employing a polystyrene solvent are used, and most cements do, the unit should not be stressed or assembled until dry. The solvent softens and weakens the polystyrene. If a load is applied, before the solvent evaporates and the plastic becomes rigid, the chance for distortion or cracking is great.

In many instances, heat sealing may be used instead of cementing.

PLAX
FOR PLASTICS
NOT SUBSTITUTES ··· IMPROVEMENTS
133 WALNUT STREET · HARTFORD 5 · CONN.

Production Of Precision Radio Equipment". He outlined the problems encountered in conversion from peace-time to war-time production of radio equipment. The precision of military equipment required completely new design and methods of manufacture.

Many of the problems encountered in building precision equipment are mechanical rather than electrical in nature and result because of the relatively large thermal coefficients of expansion. For example, in a frequency meter, the expansion coefficients were sufficient to prevent satisfactory production without electrical means of frequency compensation.

In general it is the practice at Zenith for the project engineer to be completely familiar with and take full charge of all phases of operation and production of one type of equipment. This makes it possible to put into effect quite rapidly the necessary changes in production even before the necessary records and other paper work can be established.

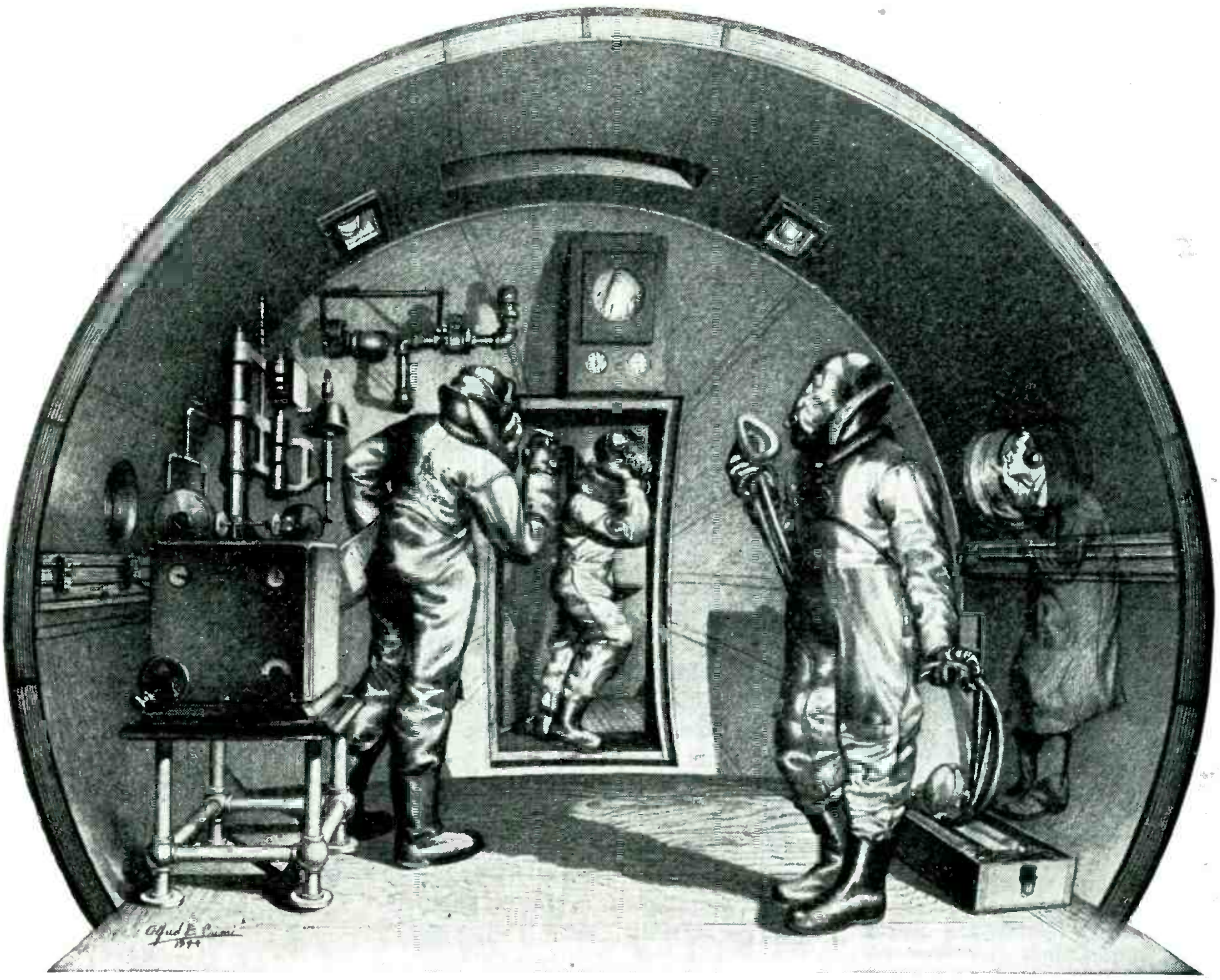
Packing and shipping of radio equipment was discussed by William Stack, also of Zenith. He pointed out that what was standard practice in packaging prior to the war is no longer adequate because of the stringent demand of military requirements. Fungicide sprays have been developed and radio equipment is now frequently sealed in lead-lined containers containing several pounds of silica jel. He estimated that equipment protected in this way could be immersed in salt water for two years or more and still operate when removed from this submersion test.

Handling of change orders was discussed by Samuel Jones of Zenith Radio Corp.

Custom Built Equipment

R. E. Samuelson, chief engineer of the Hallicrafters Company, said that two types of custom built equipment are possible: (1) that in which all design and production is made for the customer as required and without any common units as a basis and (2) custom units built around a standard basic unit of considerable flexibility, in which the customer's demands may be incorporated as variations of design.

The Hallicrafters organization



This will take a man higher even than a P-51.

THIS scientific apparatus looks quite earth-bound.

But, for experimental purposes at least, it can take a man higher than any aircraft ever built.

It is Sperry's new High Altitude Laboratory, constructed through the cooperation and assistance of our Government, and dedicated to the service of our Country in memory of Frederic Blin Vose, a Sperry engineer who lost his life in the performance of his duties in the war effort.

This laboratory helps find the answers to questions like these:

How does man react in the stratosphere when the sub-zero cold bites through his heated flying suit? Will an instrument that works perfectly at 2000 feet, "conk out" at 40,000 feet?

The laboratory can mechanically simulate atmospheric pressures equivalent to those met at altitudes over 45,000 feet. It duplicates temperatures as low as 87 degrees below zero Fahrenheit.

This permits the testing of flight instruments and the reactions of men who use them under atmospheric and temperature conditions virtually identical with those met 8 miles up.

Testing the *combination* of man and instrument in this laboratory will result in better protection for the lives of our military and naval flyers, and makes possible improved instrument design and more efficient operation.

Experienced engineers and a medical staff, trained in the technique of the physiology of high-altitude flying developed by the Mayo Clinic and the Medical Departments of the Armed Forces, direct the Sperry laboratory. This laboratory serves other war manufacturers as well as our Armed Forces.

It is Sperry's hope that the tests and studies of man and his instruments in this laboratory will make possible the development of the perfect man-instrument team that will function in complete harmony in the frigid blue of the stratosphere.

Sperry Gyroscope Company INC.

BROOKLYN, NEW YORK DIVISION OF THE SPERRY CORPORATION

GYROSCOPICS • ELECTRONICS • AUTOMATIC COMPUTATION • SERVO-MECHANISMS had set up their production of amateur radio equipment on the second system, which was found to be well adapted for expansion of war production of military radio equipment. Early experience with the HT-4 transmitter, which was later developed into the SCR-299, was recalled. The simplicity and versatility of the basic design were important factors in permitting the rapid expansion of manufacture on a production line basis as described in the April 1944 issue of ELECTRONICS. In the interest of mass production, no design changes which will delay production are made on the production line. When special equipment or designs are required, it has usually been found possible to make the changes upon completion of a standard unit or, if this is not feasible, to employ special technical help (not a part of the production line) to carry out the modifications at a point removed from the assembly line.

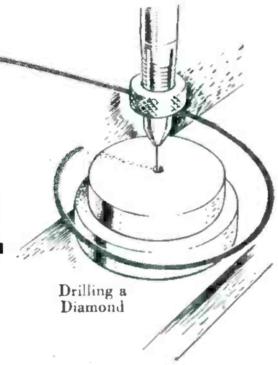
Herbert Hartley, also of Hallicrafters, continued the discussion by outlining some of the requirements of amateurs which had been found desirable for military application. Complete band switching as well as the possibility of changing frequency within any band, compactness of equipment, coupled with good appearance, and high efficiency on "watts per dollar" basis were high on the list of desirable features of radio transmitter equipment.

Excessive Secrecy

Paul Smith, of Galvin Mfg. Corp. gave a talk entitled "How Understanding Military Detective-Measures Aid Production". It was shown that restriction of information is sometimes an evil, tending to thwart production by making it difficult to keep personnel thoroughly informed of changes required and reasons therefore. Yet the demands of the military make such restrictions necessary.

In addition to the restrictions imposed by the Army and Navy, most manufacturers operate under other restrictions imposed by the Federal Bureau of Investigation, The Secret Service, The Office of Scientific Research and Development, The National Defense Research Committee, and The Office of Emergency Management. The re-

Norelco QUALITY CONTROL begins at the beginning!



Drilling a Diamond

An example of how NORELCO quality control begins at the beginning is the fine wire which goes into the central elements of the 4-window X-ray Diffraction Tube illustrated below. The tungsten is of our own manufacture. It is drawn into wire in our own plant . . . through diamond dies of our own drilling.

Quality control that begins at the beginning is common to all NORELCO Electronic Tubes. That is why they can be depended upon for high efficiency, consistent performance and long life.

Although all the tubes we produce are now going to the armed forces, we invite inquiries from prospective users of various types of Transmitter, Amplifier, Rectifier, Cathode Ray and Special Purpose Electronic tubes. A list of tube types we are especially equipped to produce for commercial communications equipment and industrial applications will be sent on request.

In addition to electronic tubes and quartz crystals for military communications on land, sea and in the air, we make for our war industries: Searchray (X-ray) Apparatus for Industrial and Research Applications; X-ray Diffraction Apparatus; Direct Reading Frequency Meters; Electronic Measuring Instruments; High Frequency Heating Equipment; Tungsten and Molybdenum Products; Fine Wire in many metals and various finishes; Diamond Dies.

And For Victory We Say: Buy More War Bonds

Norelco ELECTRONIC PRODUCTS by NORTH AMERICAN PHILIPS COMPANY, INC.

Executive Offices: 100 East 42nd Street, New York 17, New York
Factories in Dobbs Ferry, New York; Mount Vernon, New York (Metalix Division); Lewiston, Maine (Elmet Division)

strictions of these various organizations are seldom correlated and at times may even be conflicting.

An extensive study of the requirements of these various agencies has indicated the possibility of establishing a policy which can be applied in most manufacturing plants. The essence of this analysis is that any single order can be broken down into various degrees of restricted information, and that while certain phases of a particular contract may be highly secret, other components may be in the confidential, restricted, unrestricted or unclassified classification. By recognizing the degree of the restrictions required, by zoning the manufacturing plant in such a way that the more confidential matters are properly protected and surrounded by less restricted activities, and by exercising judicious surveillance in all design and manufacturing phases, a completely satisfactory and workable system may be devised.

London News Letter

By John H. Jupe
London Correspondent

Super-sensitive Voltammeter. Using a taut strip suspension, a new voltammeter has recently been put on the market in Britain with the amazing sensitivity of 100,000 ohms per volt. The lowest current range is 0–10 microamperes. A knife-edge pointer and mirror scale are fitted and the overall accuracy is 0.5 percent. As shown in the illustration, the instrument

New British 0-10 microammeter for 100,000 ohm per volt voltmeter

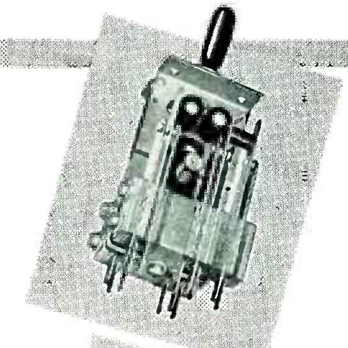
New

GENERAL CONTROL COMPANY MASTER CAM LEVER SWITCHES

General Control Company, the original cam lever switch specialists, now have the newest, most complete line of Cam Lever Switches ever offered. All models have such (patents pending) features as static shielding, roller cam action with no-sliding friction, single bolt contact assembly — all are of metal construction for strength and rigidity; contact build-ups are assembled under pressure; spacers are varnish-impregnated Bakelite; improved contact wiping action reduces pitting and sticking; new spring lifters are riveted in, and are 5/16″ in diameter to prevent sticking to adjoining sections, and to guarantee smooth, positive action — all are built to Government specifications.

New

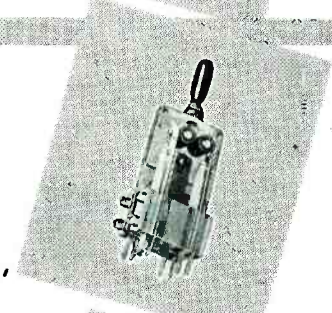
MODEL MCL-CS



The new Model MCL-CS is of similar design to our familiar Model MCL-FS, except that coil springs are used instead of flat springs to assure floating action and equal pressure on both sides of the cam, regardless of the number or arrangement of contacts on each side of the switch. It can be supplied with either light or stiff action on the control knob to suit your requirements. This model is rated at 10 amperes, 125 volts A. C. and is outstanding for long life and dependability.

New

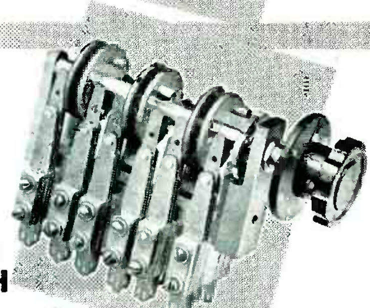
MODEL MCL "MIDGET"



The new Model MCL "Midget", for aircraft and other light duty applications, is now under development. This will be the lightest switch ever designed for this field, yet will have all the features of the larger Model MC-FS. The frame is made of strong, light metal. The "Midget" can be mounted in a *single* hole in the control panel. It is rated at 5 amperes. We will be pleased to furnish advance details to design engineers.

New

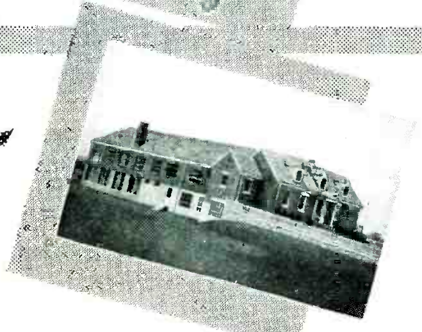
ROTARY CAM LEVER SWITCH



The new Rotary Cam Lever Switch is designed for one to six index positions. Any combination of contact arrangements can be used in each of these six positions. It is adaptable to actuate practically any number of circuits in sequence (or repeat) with the convenience of a single control knob. A single hole only is required for mounting, and contacts in any section can be removed from frame by removing a single bolt. The Rotary is rated at 10 amperes, 125 volts A. C.

New

MODERN PLANT



Our new, modern plant makes available many times the previous floor space for expansion of present products and development of new products. New facilities include a completely equipped laboratory, and an engineering staff for development work. In addition to Cam Lever Switches, General Control Company manufactures 32 types of manually-operated foot switches, electro-mechanical and electronic control devices, and production gauging equipment.

GENERAL CONTROL COMPANY

1200 SOLDIERS FIELD ROAD, BOSTON 34, MASS.

follows the usual design of sub-standards in general appearance. All range changes are made by means of a single switch.

The value of such an instrument in the radio laboratory is immense and I believe that it will prove very useful in the television field as external resistors can be supplied to extend the voltage range. It is made by the London firm of H. Tinsley and Co. and the price in Great Britain is approximately equivalent to $60.

Electronic Prospecting Lamp. The use of electronics in prospecting for minerals has taken a new turn with the introduction of a small portable ultraviolet ray lamp by G. E. Co. of Britain. It solves the difficulties of examining certain rock specimens when the wanted ore is practically the same color as the surrounding material. An example is scheelite (calcium tungstate) which is used, among other things, for cathode-ray tube screens. Under ultraviolet illumination, the true ore glows with a brilliant bluish-white light and can be easily detected.

The new lamp uses a cold cathode mercury vapor tube, bent to a U-shape and fitted with a convenient handle. Alternating current at the required voltage is obtained from a low voltage direct current source by the use of a vibrator and transformer.

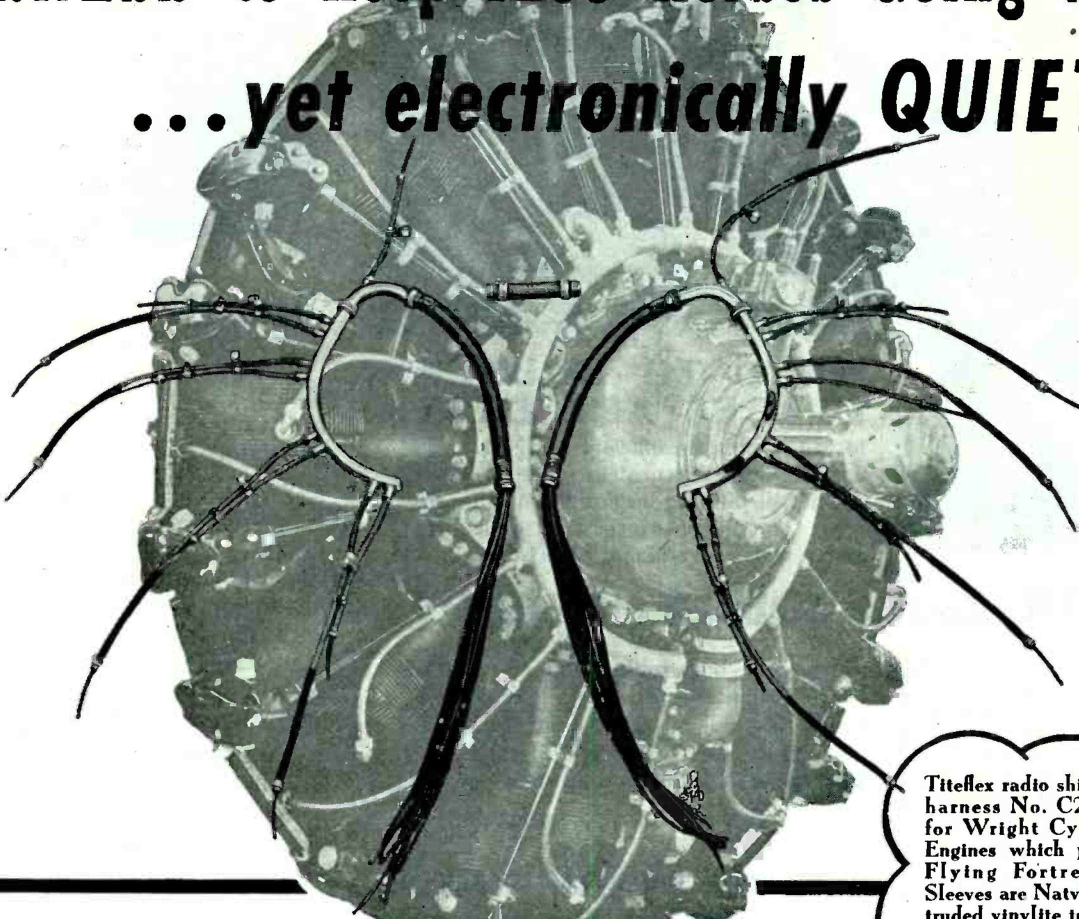
Electro-Chemical Etching. It is common in engineering work to mark metal objects but the existing methods have a variety of drawbacks. Acid etching and engraving are slow and expensive, while some modern alloys are too hard for either engraving or stamping. The last mentioned method is certainly rapid but it sometimes tends to deform an article or to raise nasty burrs.

A new method overcomes these difficulties and can be applied to practically any metal, including stainless steel, high-speed steel, Stellite copper, iron, nickel, brass, white metals, resistant alloys etc., and is quite cheap and quick to operate.

A main feature is that ordinary wax stencils, such as any typist can prepare; are used as "masters". A few sheets of blotting paper are placed on the lower

HARNESS to Keep 1200 Horses Going Strong

...*yet electronically* QUIETED!



Titeflex radio shielded harness No. C26980 for Wright Cyclone Engines which power Flying Fortresses. Sleeves are Natvar extruded vinylite tubing, and identification markers are Natvar.

Titeflex harnesses physically protect high tension ignition systems from magneto to plugs and, at the same time, shield vital lines of communication from the principal source of interference—the ignition system itself.

A tremendous job, when you stop to consider that these Titeflex harnesses perform in a wind stream of over 300 mph—with or without rain and ice, but always subject to vibration. And at temperatures ranging from 50°F. below zero up to 300°F. at the spark plug end!

We are proud of the fact that Natvar extruded vinylite tubings and identification markers are contributing to this performance.

What about *your* requirements? Write, wire, or phone us for deliveries either from nearby wholesaler's stock, or from our own.

Natvar

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished cellulose acetate
- Varnished Fiberglas cloth
- Varnished papers
- Varnished tubings and sleeving
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded Vinylite tubing
- Extruded Vinylite identification markers

Write for bulletins

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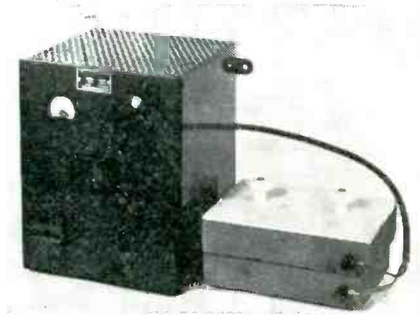


British electro-chemical etching apparatus for marking metal equipment and tools

block shown in the illustration and are damped with a special etching solution. The stencil is then laid on the pad with the article to be marked on top. Finally, the upper electrode is placed in position and, after current has been flowing for about 5–50 seconds, an engraving approximately 0.0005 inch deep is produced. Awkardly shaped articles may be dealt with by fitting a damped pad and stencil to a curved metal surface and rolling the pad over the job.

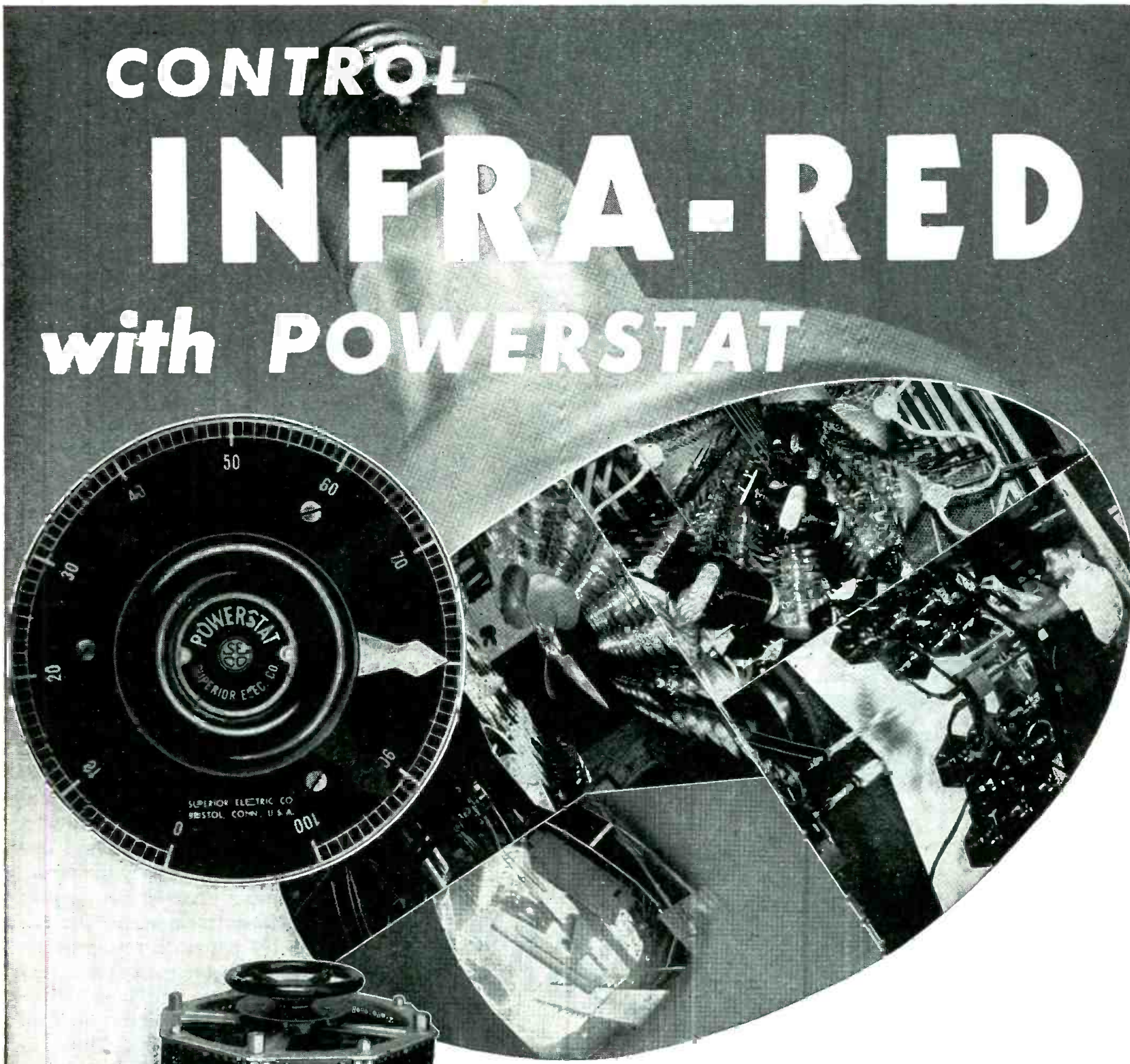
Many types of work lend themselves to etching on simple machines designed for the purpose and, as a stencil is normally good for about 15 etchings and up to 50 small articles may be treated at once, the method can be easily dovetailed into modern production schedules.

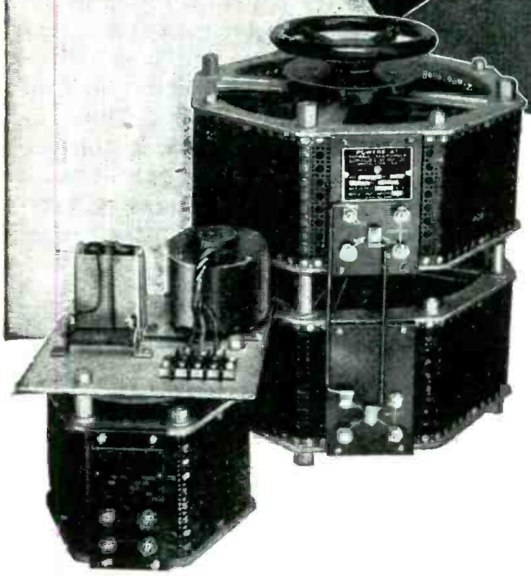
The approximate price of the complete equipment is $100, exclusive of packing, and it is sold by Griffin and Tatlock Ltd. of London.

Automatic Machine Finds Bent Tube Pins. It is surprising how mechanical vibrations are being increasingly used in engineering production as a means of analyzing and sorting. A recent development which has come to my notice concerns the testing of radio tube pins for straightness and burrs on the end. It was found that defective pins jammed in the base-fitting machines and caused a 10–15 minute shutdown each time. Hand inspection was too slow and expensive and eventually the London firm of Fraser and Chalmers developed a machine to do the job automatically.

The method is quite simple. A table vibrated by an electromagnetic vibrator is fitted with glass decks which slope very slightly in a direction at right angles to that

CONTROL INFRA-RED with POWERSTAT





By simply turning a knob on the manually operated POWERSTAT Variable Voltage Transformer or by pushing the control button of the MOTOR-DRIVEN POWERSTAT the proper voltage is applied to infrared lamps to meet your heating requirements. The exact energy needed to process materials of varying thickness, color, or moisture content is conveniently and accurately obtained with POWERSTAT variable voltage control.

POWERSTAT control eliminates complicated mechanical and electrical arrangements . . . meaning more speed, greater economy, and reduced space requirements.

Produced in sizes up to 75 KVA for single or polyphase operation on 115, 230, or 440 volt circuits a POWERSTAT can control any baking, drying, dehydrating or pre-heating process.

Send for Bulletins 149LE and 163LE

SUPERIOR ELECTRIC CO. 204 LAUREL ST. BRISTOL, CONN.

SUPERIOR *Electric Company*

of the oscillation. The pins to be inspected are fed on to the decks at a point where the motion would tend to make them travel forward. Straight pins then move in a lateral direction, as gravity tends to make them roll sideways, while the motion of the table tends to move them forwards. Faulty pins, however, do not roll but more or less move forward in a straight line.

This difference in modes of movement is used to separate the good and bad pins. Deviation of more than 0.006 inch from straightness or a lip of more than 0.003 inch will cause rejection.

F-M in a Nutshell. "F-M makes a fair signal perfect, a poor signal good and a useless signal inaudible." *K. I. Jones of Cossors Ltd.*

Thermal Tuning. I came across an interesting British patent recently in which the resonant frequency of a circuit is varied in an ingenious manner. It makes use of the fact that the strict formula for a parallel resonant circuit includes a resistance term, which is generally ignored as its effect is small. Under certain circumstances, however, it must be taken into account and it is then possible to vary the resonant frequency merely by varying the resistance included in the circuit. In the patent, a resistor composed of compounds having a very high temperature coefficient of resistance is made to form part of the oscillatory circuit. Then, by placing a small electric heater adjacent to the resistor, the resonant frequency can be changed by varying the current through the heater.

ANEPA Investigation

LIQUIDATION OF the Army-Navy Electronics Production Agency, after an investigation conducted by the staff of the Committee on Civil Service, House of Representatives, has been agreed upon by members of the committee, according to Rep. Robert Ramspeck, chairman of the Committee. It was charged that the agency was duplicating the work of Army and Navy expeditors and, to a large extent, overlapping the functions of WPB.

Chicago Radio Engineers Discuss Postwar Electronics

J. E. BROWN, assistant vice-president of Zenith Radio Corp., Hugh Knowles, vice-president of Jensen Radio Mfg. Co., and Beverly Dudley, Western Editor of ELECTRONICS, led a round table discussion on the postwar outlook for the electronic industry at a meeting of the Radio Engineers Club of Chicago in March.

In an informal discussion, the future of postwar television and frequency modulation was discussed, particularly with regard to emphasis on the probable development of high fidelity broadcasting. The majority opinion seems to be that while there were possibilities of producing high fidelity equipment, the public was not yet educated to take full advantage of the present technical possibilities.

Mr. Dudley pointed out that induction heating devices, electronic welding, electronic motor control, and certain phases of industrial electronic control appeared, at the present time, to offer the greatest possibilities for packaged electronic items in the postwar market. There is a great desire on the part of manufacturers to sell packaged electronic items but development has not yet reached the point where it is possible to eliminate a rather considerable degree of engineering in most electronic applications to industry.

It was pointed out that in the postwar field, it appears likely that the electronic engineer will be added to the staff of manufacturing companies and will work in cooperation with the mechanical engineers in the design and production of new equipment. Such a procedure would make it possible for electronic control systems to be incorporated as an integral part of the unit rather than as being added as an accessory unit which is now often the case.

As a result of the vast interest in communications and industrial electronics, it appears likely that colleges may offer courses in industrial electronics in which the industrial applications are systematized and treated in a manner similar to that of radio communication.

Many startling and revolution-

ary applications of the principles of electronics are possible but not all of these have sufficient economic advantage to warrant their adoption. It was pointed out that the adoption of electronic devices after the war would depend, in large measure, upon their economic advantage or their ability to accomplish things which cannot be done at all or which cannot be done well by other systems.

Television at ASME Meeting

APPLICATION OF motion pictures to war needs was the dominant theme of the 55th semi-annual technical conference of the Society of Motion Picture Engineers held in the Hotel Pennsylvania, New York, in April.

A symposium on television highlighted the opening session. High-speed photography, 16-mm film developments, and 16-mm standardization were a few of the other topics covered.

Radio Business News

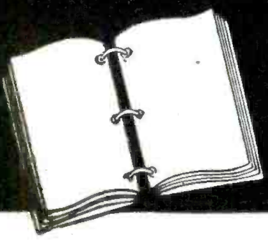
HYTRON CORPORATION has acquired a feeder plant at Beverly, Mass. for production of electronic tube mounts.

WEBSTER PRODUCTS, making dynamotors, voltage regulators and inverters, has increased floor space by nearly 20 percent.

A SUSPENSION ORDER has been issued by WPB prohibiting a Boston firm from receiving electronic equipment for three months and restraining sales except on orders carrying a AA-1 priority rating. The action arose from complaints that the company scheduled orders for 7,650 radio tubes, certifying that it was entitled to purchase them under the provisions of order L-265. WPB claimed that the certifications were false in that the tubes ordered were not required to replace tubes delivered to customers out of inventory.

PHIL-AMERICAN INC., peacetime maker of Philharmonic radios, will move the entire plant to 528 East 72nd St., New York, N. Y., a six-fold increase in space. The company now manufactures military radio, test equipment and naval ordnance.

Designing Molded Plastics Parts: G-E MYCALEX



From the engineering files of One Plastics Avenue

G-E mycalex is an inorganic compound composed of ground mica and a special glass, having unique heat and electrical properties, and ranking above all other insulators for certain applications because of a combination of features possessed by no otber material. Because it is singularly different from other molding compounds, special consideration must be given in designing parts to be made from G-E mycalex. This material is particularly valuable for use in ignition, radio and electronics equipment.

Desired Design Characteristics of G-E mycalex Parts

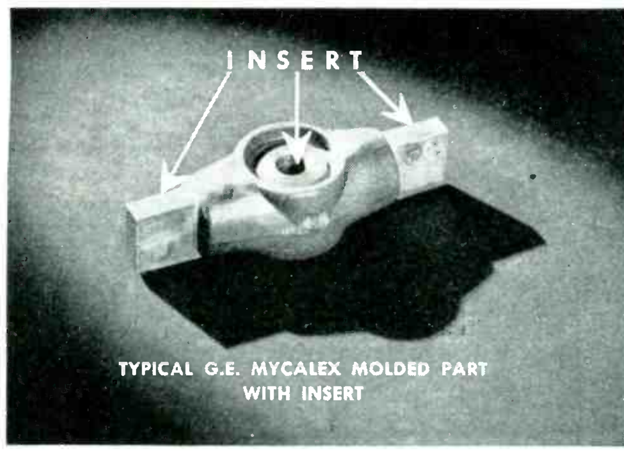
1. Well rounded corners and fillets.
2. Three to five degree taper on mold walls is desirable.
3. Minimum wall thickness of parts $\frac{1}{16}$ inch.
4. Minimum hole diameter $\frac{1}{16}$ inch.

Advantages of G-E mycalex

1. Ready anchorage of metallic inserts in material during molding.
2. Molding of holes in part.
3. Close tolerances in molding.
4. Ability to produce intricate shapes.
5. Reduction or elimination of finishing and machining operations.

Properties

1. High dielectric strength.
2. Low power factor.
3. Prolonged resistance to electric arcs.
4. Chemical stability; negligible deterioration with age.
5. Dimensional stability; freedom from warpage, shrinkage, etc.
6. Imperviousness to water, oil, and gas.
7. Resistance to sudden temperature changes.
8. Low coefficient of thermal expansion.
9. Exceptional heat resistance.
10. Insulating properties compare favorably with porcelain.



TYPICAL G.E. MYCALEX MOLDED PART WITH INSERT

Types of G-E mycalex

#2801—General purpose grade for all molded parts. Used where mechanical strength is of primary importance.

#2800—Lower loss factor, lighter weight and smoother finish. Unaffected by changing atmospheric conditions; has superior stability of power factor after prolonged immersion in water.

GENERAL ELECTRIC is the nation's largest molder of plastics. The combined experience and plastics "know-how" of its chemists, designers, product engineers, toolmakers and molders is available to all interested. Write for G-E mycalex booklet, Section N-250, General Electric Co., Plastics Divisions, Pittsfield, Mass.

Hear the General Electric radio programs: "The G-E All-Girl Orchestra" Sunday 10 p.m. EWT, NBC. "The World Today" news, every weekday 6:45 p.m. EWT, CBS.

BUY WAR BONDS

PD-250

GENERAL ELECTRIC

ELECTRICAL APPARATUS CO. is now located at 1200 Soldiers Field Road, Boston, Mass., where a completely equipped demonstration laboratory is in charge of a qualified engineer.

ELECTRIC SERVICE MANUFACTURING CO. is the new name of Electric Service Supplies Co. of Philadelphia, Pa.

STROMBERG-CARLSON CO., owner of and operator of WHAM and WHFM, has applied to FCC for a license to operate a commercial television station.

EITEL-MCCULLOUGH, INC. has reduced operating time to two eight-hour shifts and personnel two-thirds, affecting over one thousand workers, pending new government contracts.

INTERNATIONAL RESISTANCE CO. AND CONNECTOR CORP. have opened their own offices at 165 Broadway, New York 6, N. Y.

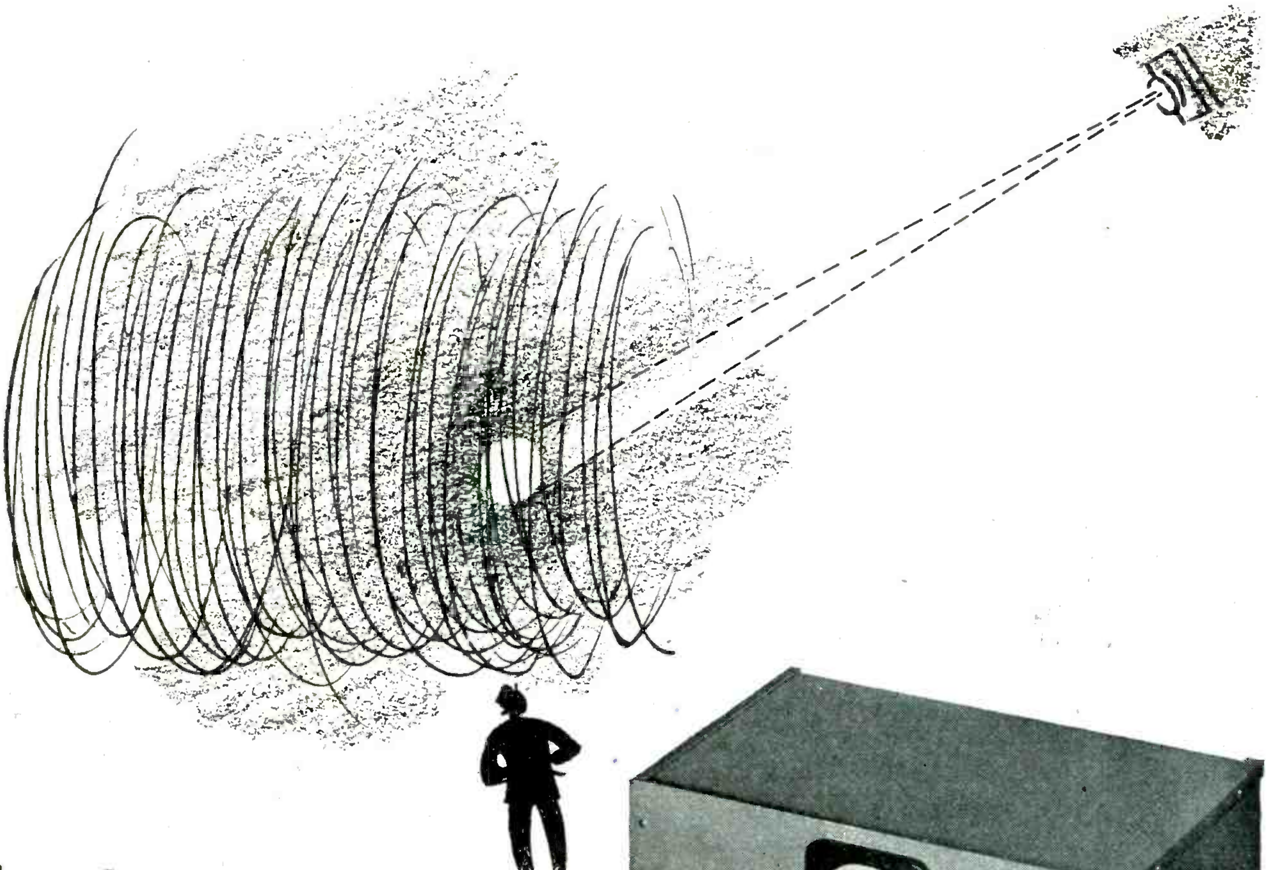
HOFFMAN RADIO CORPORATION, successor to Mission Bell and Mitchell-Hughes radio concerns, has initiated a poster campaign in California, Oregon, Washington, and Arizona.

GRAYBAR ELECTRIC CO. reports that all former officers and directors of the company were reelected at the annual meeting of the board of directors.

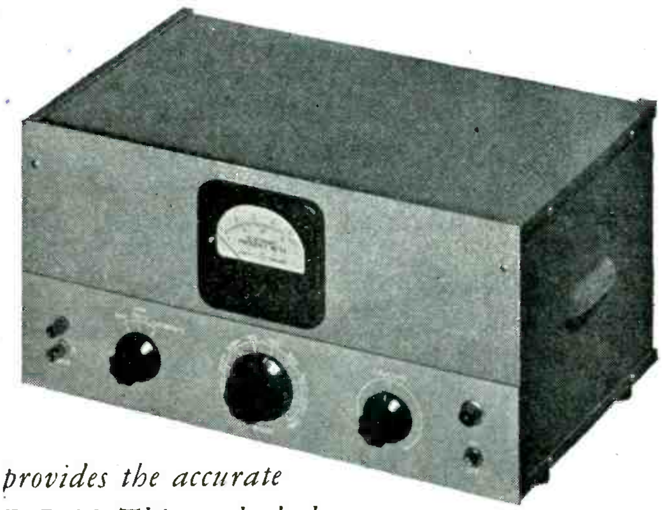
JOHN MECK INDUSTRIES has been issued RCA and Hazeltine licenses to manufacture radio receivers.

SOLAR MANUFACTURING CORP. reports a net profit of $368,000 in 1943 after providing for Federal taxes. This compares with a net profit of $147,000, after tax provisions, for 1942.

UTAH RADIO PRODUCTS CO. has announced that W. A. Ellmore, vice-president in charge of engineering, has assumed the additional duties of heading the sales department. Chester L. Walker, former chief engineer, has become sales manager in charge of manufacturing and equipment division. Marion S. Danisch, chief engineer of Ucoa Radio Sociedad Anonima, South American affiliate of the company, has be-



Could you measure 3,000,000 R.P.M.?



So far as we know, there is no man-made machine capable of turning at 3,000,000 R.P.M. But, if there were the *-hp-* 500A Frequency Meter could theoretically measure it. As a matter of fact, several of these frequency meters are in service today measuring R.P.M. on high speed war equipment. The high order of speeds being measured is a tribute to the accuracy and dependability of *-hp-* instruments.

Here's How -hp- 500A Measures Terrific Speeds: *A mirror surface spotted on one end of the rotator's shaft reflects a beam of light through a photo electric cell. The pulses thus created are measured as an electrical frequency. The number of pulses per second multiplied by 60 provides the accurate R. P. M. This method places no load whatsoever on the machine being tested.*

hp Instruments have found their way into many unusual applications such as this. The solution to your special problem may be found here. Just drop a note giving us the details, and our engineers will be glad to cooperate, without cost or obligation, of course. Ask for *-hp-* catalog No. 17A which gives much valuable information about electronic tests and measurements as well as complete data on *-hp-* instruments. Write today.

HEWLETT-PACKARD COMPANY

P. O. Box 847A, Station A Palo Alto, California

847

come chief engineer and Gordon S. Carbonneay, production engineer for many years, has assumed new duties as engineer in charge of the quality control division.

WATERBURY COMPANIES, INC. is the new name of Waterbury Button Co. of Waterbury, Conn., maker of radar parts, airplane L.S.T., fuses, and lenses.

SYLVANIA ELECTRIC PRODUCTS plant at Brookville, Pa. will be expanded to utilize sealing and exhaust equipment in a new section. A West Coast headquarters office has also been opened by the company at 111 Sutter St., San Francisco, Cal.

CUTLER-HAMMER, INC. has established a sales office in Columbus, Ohio in the Chamber of Commerce Bldg., 30 East Broad St. Russell D. Yoder is engineer in charge.

PHILCO RADIO AND TELEVISION CORP. has bought a factory from General Aircraft, Ltd. as a potential production plant for post-war television.

Personnel

Dixie B. McKey has resigned as general communications engineer of the Graybar Electric Co. to become technical supervisor of radio for the Oklahoma Publishing Co., owner of WKY, KLZ and KVOR.

Edward M. Deloraine, general director of the laboratories division of Federal Tel. & Radio Corp. has been elected a director of International Tel. & Tel. Corp.

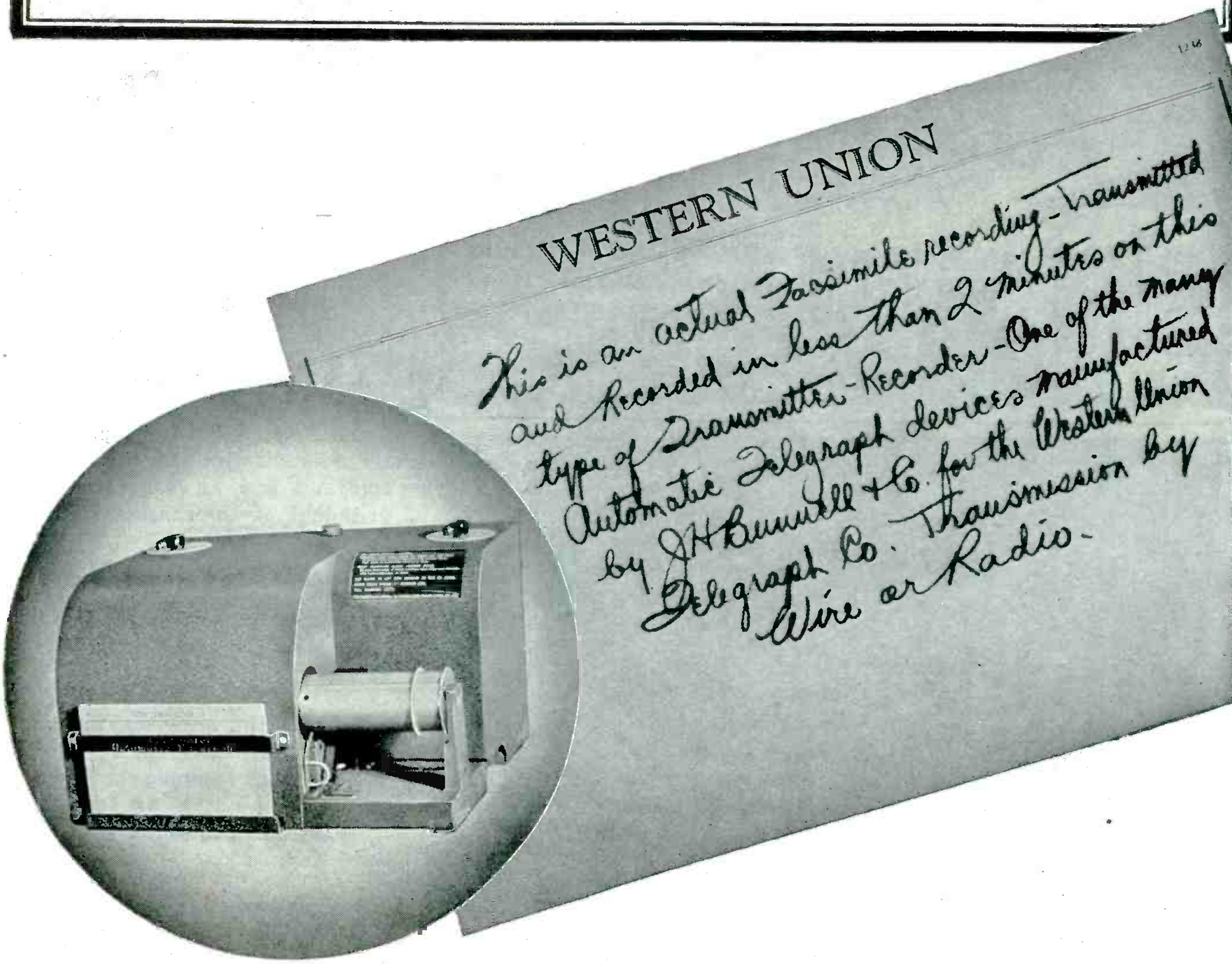
Ludwig Arnson, who sent the first CQD from an American ship in 1903, has received the Marconi Medal of Achievement reflecting forty years of undivided service to the cause of radio communications development.

Frank R. Benedict has been appointed manager of product performance analysis at the Westinghouse East Pittsburgh plant.

Charles S. Powell, engineer with Graybar Electric Co., has become vice-president and director of the company.

Facsimile

Tells its own story!



J. H. BUNNELL & Co.

DESIGNING ENGINEERS AND MANUFACTURERS OF
ELECTRONIC INDUSTRIAL & COMMUNICATIONS EQUIPMENT

GENERAL OFFICES: 215 Fulton St., New York City · FACTORIES at Brooklyn, N.Y.

Mrs. Martha Kinzie has been elected assistant secretary of the Radio Technical Planning Board

and will be responsible for processing of papers in connection with the work of the board.

J. S. Jammer has been appointed general commercial director of Federal Tel. & Radio Corp. He is an assistant vice-president of the company and an assistant vice-president of International Standard Elec. Corp.

H. W. Whitmore has been appointed chief engineer of Kold-Hold Mfg. Co. of Lansing, Mich., succeeding R. H. Swart.

Will Baltin, program manager of DuMont television station W2XWV, has resigned that post to accept new duties as secretary-treasurer of Television Broadcasters' Ass'n, Inc.

Scott W. Smith, physicist with The Kelley-Koett Mfg. Co., has been appointed a member of an advisory committee conducting research in the field of fluoroscopy for the National Academy of Sciences and the National Research Council.

Arthur J. Wilson, former chief of the production control branch of the WPB radio and radar division, has been appointed director of the production scheduling

division, replacing Robert M. Hatfield who resigned to accept a commission in the Navy.

David Nierenberg, president of Electronics Heating & Brazing Co. of New York, died recently at his home.

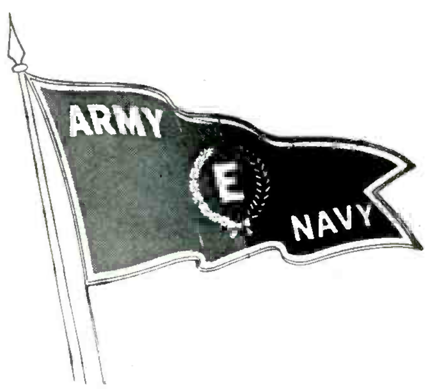
A. F. **Rucks** has been elected president and general manager of C. J. Tagliabue Mfg. Co.

Glenn Bannerman has been reappointed president and general manager of the Canadian Association of Broadcasters.

William A. Lewis, director of the school of electrical engineering at Cornell University, has been appointed consulting electrical engineer to the Armour Research Foundation.

Lewis E. Scott, former superintendent of the resident school of American Television and more recently industrial engineer with Consolidated Aircraft and Douglas Aircraft, has joined the staff of Hoffman Radio Corp. of Los Angeles, Cal., as method engineer.

Ben Kievit, supervisor of Customer Services of Sylvania Electric Products, Inc. in Emporium, Pa., has been moved to the New York office as field engineer for the metropolitan and New England areas.



THE GRAY MANUFACTURING CO., Hartford, Conn.
E. F. JOHNSON COMPANY, Waseca, Minn.

PERMANENT MAGNETS MAY DO IT BETTER

Fighting Words Flash through!

RUMBLING over the treacherous roads in Italy and lunging ashore on Jap island-fortresses, this "rolling radio station" of the U. S. Signal Corps has won high praise for its splendid performance in the battle of communications.

Built by the Hallicrafters Co., and designated "SCR-299", it also illustrates a number of the constantly growing uses for which *permanent magnets* are employed today. In the 299's loud speakers, headsets, microphones, telephones, instruments and magnetos, permanent magnets are extremely vital parts.

In many other types of electrical and electronic equipment for land, sea and air warfare, permanent magnets perform equally important functions. And because of our 34 years of specialization in this field, our organization has played a leading role in designing and manufacturing permanent magnets for numerous applications.

This unusual experience should prove valuable to you in solving your engineering problems . . . and our engineers will be pleased to consult with you. Write us, on your letterhead, for the address of our office nearest you and a copy of our "Permanent Magnet Manual".

★

Help Win the War in 44-
Buy War Bonds!

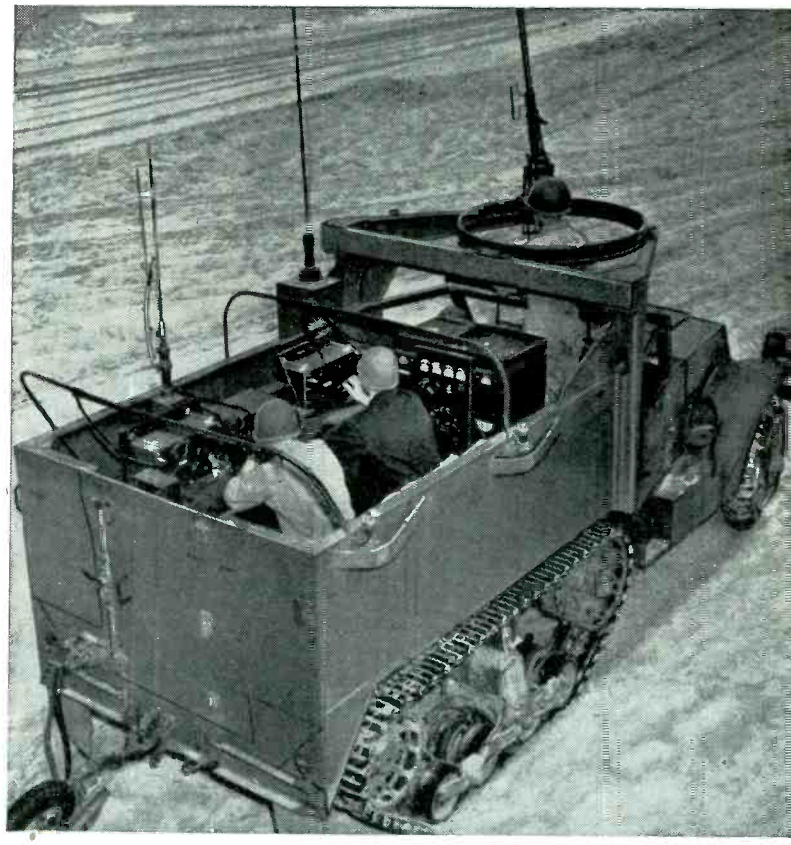
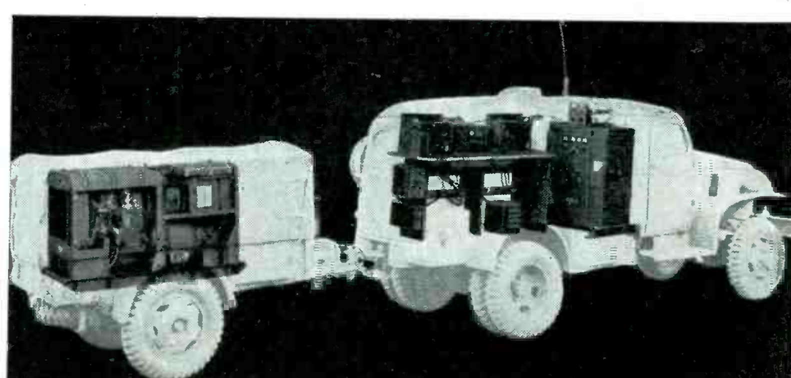


PHOTO COURTESY U. S. ARMY SIGNAL CORPS



The "SCR-299" is mounted in various types of vehicles and is also used, dismounted, as a fixed radio station.

The
INDIANA STEEL PRODUCTS
Company

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

★ **Specialists in Permanent Magnets Since 1910** ★

Magnetic Tape Recorders

(*Continued from page* 135)

Figure 3 also shows the impedance of the recording heads as a function of frequency. The input into the recording head generally follows the shape of the impedance curve. The effect of input levels on distortion at the low-frequency end seemed too critical to follow a generally rising input characteristic; but higher undistorted output can be realized at the higher frequencies with increased input.

Conclusions

Reproducing with two heads increased distortion without any material contribution to the output level. Obliterating voltage had no effect on performance when varied between relatively wide limits, but it was usually necessary to obliterate two times to remove all traces of previous records.

The parameters in order of their effectiveness were thus found to be recording input level, displacement of recording heads, polarizing voltage, and obliterating voltage. The largest single contributing factor to distortion was the recording input voltage at the lower half of the frequency spectrum, the input level getting more critical as the frequency was lowered.

Considerable time was saved by the adopted parameter-elimination procedure, exploring individual parameters in the reverse order of their relative weight. One may expect considerable departure from these results in efficiency and noise level with different magnetic materials, head construction and tape velocities; however, agreement of output response with deductions and curves found in literature shows that the characteristics arrived at above are typical of magnetic recorders in general.

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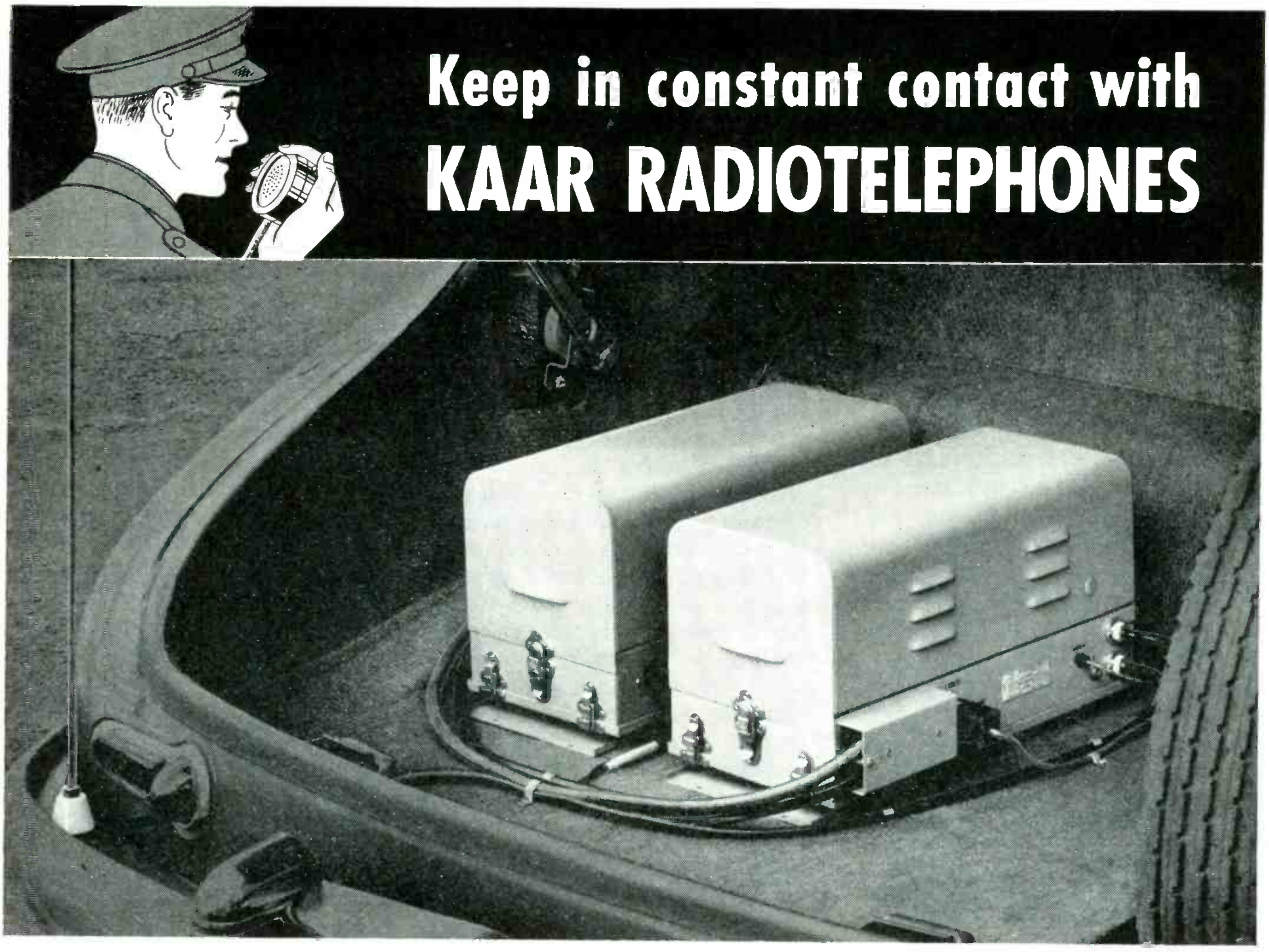


KAAR PTS-22X TRANSMITTER

22 WATTS—30-40 MC

The Kaar PTS-22X transmitter provides reliable and efficient high-frequency communication from military, civil and commercial mobile units. It has a rated output of 22 watts.

The standby current is zero, as instant heating tubes are used, lowering the demands on the battery of the vehicle. Transmission is completely controlled by a "push-to-talk" button on the microphone. This button lights the tubes, starts the dynamotor power supply, silences the receiver, and switches the antenna to the transmitter—all in a fraction of a second!

KAAR PRS-9X RECEIVER

10 TUBES—30-40 MC

A remote control box, mounted on the dash of the vehicle, controls the receiver located in the trunk compartment. The box contains a combined *on—off* switch and volume control, a red jewel light to indicate when the receiver is on, and an *off* switch for the no-signal squelch circuit.

The no-signal squelch circuit automatically silences the receiver except when calls are actually being received. In addition, an automatic noise silencer circuit makes difficult reception understandable by reducing electrical and ignition interference.

For swift checking and servicing, both the transmitter and receiver may be removed from the vehicle by releasing four luggage-type catches. The dust covers are likewise removed by releasing two catches.

For transmission in the 1600-2900 KC range inquire about Kaar PTL-22X transmitter and 11X receiver. Other ranges available on special order.

KAAR ENGINEERING CO.

KAAR

ENGINEERING CO.

PALO ALTO, CALIFORNIA

***Export Agents:* FRAZAR & HANSEN**

301 CLAY ST., SAN FRANCISCO 11, CALIF., U. S. A.

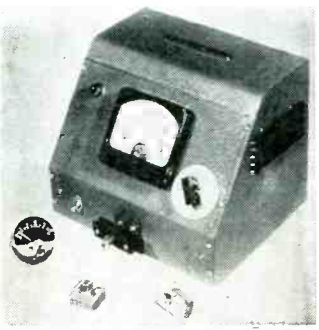
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs

Flux Meter

AN ELECTRONIC PERMEABILITY comparator for permanent magnet testing has been developed as an aid in production of radio and radar instruments and may be used for checking and comparing the magnetic flux of any shape or type of permanent magnet.

Designed primarily for checking the saturation of special Alnico



meter magnets, this new device can be used for comparing various types of magnet steel. Different sizes and shapes of search coils may be used and may be made small enough to insert in the air gap of assembled meters.

The fluxmeter has no moving parts besides the indicating meter, and it employs a special vacuum-tube circuit operating from a.c. circuits.

J. Thomas Rhamstine, 300 Beaubien St., Detroit 26, Mich.

Covers for Magnets

TWO DIFFERENT TYPES of covers are available to prevent contact of steel tools or other ferro-magnetic pieces with magnets. These covers are designed for greater economy, efficiency and saving in time.

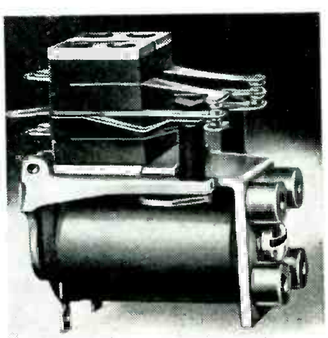
The first of these covers gives full protection up to temperatures of about 350 deg. F. The cover is formed by molding around the magnet, by hand, a dry flexible plastic material saturated with a special solvent. Soaking in this solvent gives it flexibility which enables the operator to cover all parts no matter what shape or size or curvature of contours. When the magnet is suitably covered (in about two to four minutes) it is then placed in an infrared or drying oven for a few hours. The tacky covering becomes dry and firmly bonded to the magnet, forming a hard protective surface of sufficient thickness to prevent loss of energy content of the magnet.

The second of these covers withstands temperatures above 700 deg F. It is made with a fabric which is soaked with a special inorganic solution to make it pliable enough to be molded readily around the magnet. When the cover is smoothed into shape it is given a second coating of this solution, with a brush. The cover is then baked in an infrared ray oven.

Cinaudagraph Corp., Stamford, Conn.

Telephone-Type Relay

ILLUSTRATED IS MODEL TKL, the latest addition to the manufacturer's line of telephone-type relays, developed for high frequency use. The relay utilizes Mycalex insulation but can be supplied with approved bakelite insulation for



standard switching service. The coil of the relay is sealed with cellulose acetate for resistance to humidity. The relay meets all standard salt spray specifications and will withstand shock and vibration to 10 G. The contacts are normally made with palladium for maximum sensitivity, but they are also available, on request, in silver or special alloy. Double pile-ups or contacts are available from a single "A" (SPSTNO), "B" (SPSTNC) or "C" (SPDT) arrangement to a maximum of four "C" combinations. The unit, less contact pile-ups, weighs 1½ ounces and measures 1 7/16 x 13/16 x 1 1/16 inches. Tapped studs (brazed to the frame) facilitate easy mounting and prevent short circuiting of the coil.

Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.

Control Instruments

THESE INSTRUMENTS, designated as "Chronotrols," are designed to enforce any desired heating or cooling program. They provide completely automatic temperature regulation regardless of the changes in temperature desired for a given process or application. The temperature cycle desired is cut out on a disc, and its rotation by a synchronous motor moves the temperature setting-lever of the control instrument. High-speed response of the control unit to changes in temperature is achieved by the lack of mechanical linkage between the measuring and the control sections. The frequency of oscillating current flowing between pick-up coils (mounted on the temperature control setting index) is changed when a control flag (mounted on the pointer or pen arm) is moved between the coils by a temperature rise, or is moved from between the coils by a temperature drop. This frequency change in the control circuit governs the output current of a vacuum tube, acting to open relay contacts which, in turn, operate fuel valves or switches.

Twenty-five models are available. Ten of these are for proportioning control, and the others are for use in two-position on-off, and three-position on-intermediate-off control for high and low temperature applications. Thermometer

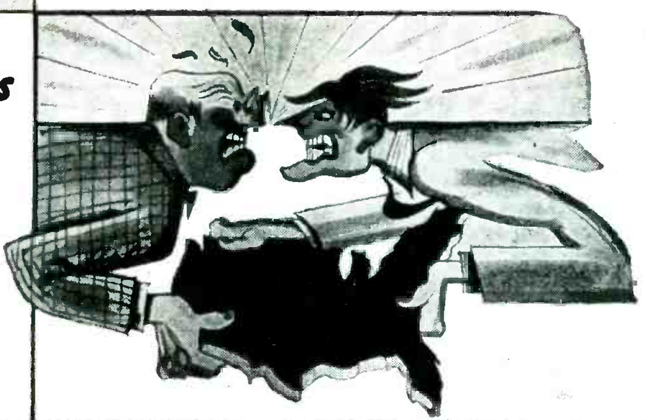
Three attitudes that hamper the War Effort

IGNORING NATIONAL DESTINY

Many men are solving the problems of war as they would ordinary business difficulties. Having solved them, they ignore the most important phase. Their attitude toward the war's meaning and its effect on national destiny is apathetic and disinterested.

USING VITAL ISSUES TO PERSONAL ADVANTAGE

To further their own selfish aims, many men seize upon vital issues to confuse and confound the average citizen. When the times call for statesmanship, America is treated to a sorry spectacle of demagoguery, greed, blocs, distortion, shrewd manipulation of emotions.



PULLING IN DIFFERENT DIRECTIONS

While commands in various war theatres are being consolidated and strengthened, here at home there are men who have forgotten the unity after Pearl Harbor. Each is off on his own particular project, seldom remembering that thousands of other men will die before the conflict is over.

THERE IS NO PLACE IN THE COUNTRY FOR SUCH MEN

We of ECA are working not only to produce the materials of war but, like all good citizens, to help attain the objectives of the war. We know that we must be vigilant . . . especially so now. Men of evil intent have come out of hiding. In smoke-filled rooms attractive bargains are being arranged — with the "little people" included out. Energy which should be devoted to the support of the Commander-in-Chief, and those under him, is being used to stir up distrust and dissension. What appears to be overlooked is that the ultimate aim of victory is a decent world . . . where men of good will live and work together with a full understanding of each other's needs and hopes and aspirations. We have already learned, the hard way, what isolationism and selfishness and disunity can mean. Must history again repeat itself?

eca

REPRINTS OF THIS ADVERTISEMENT AVAILABLE

ELECTRONIC CORP. OF AMERICA

45 WEST 18th STREET • NEW YORK 11, N.Y. WATKINS 9-1870

SHAPPE-WILKES INC.

models are available in recording as well as indicating types.

Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.

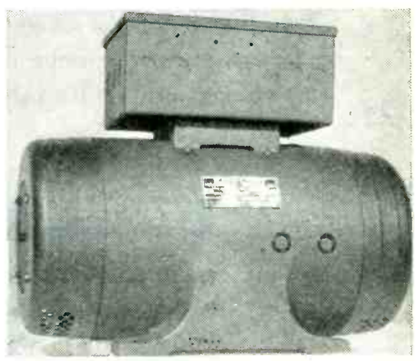
Midget Amperite Regulator

A COMPACT AUTOMATIC regulator, designated as T-6 Tube, is useful where space is at a premium. It is obtainable in voltage ranges of 1 to 10 volts, and current carrying capacities of 0.15 to 1.0 amp. The voltage across the regulator will increase approximately 250 percent with a 10 percent change in current. This regulation is obtained by the use of an iron filament hermetically sealed in a hydrogen atmosphere. A standard two-contact auto base is used.

Amperite Company, 561 Broadway, New York 12, N. Y.

High Frequency Motor Generator

A NEW LINE OF HIGH frequency motor generators includes a unit (illustrated) which weighs 110 lbs and measures approximately $16\frac{3}{8}$ x $8\frac{3}{4}$ x $13\frac{1}{4}$ inches. Frequencies which the unit provides, are either 400 or 800 cps. The motor winding may be tapped to deliver 60 or 120 cps at either 1800 or 3600 rpm. Voltages

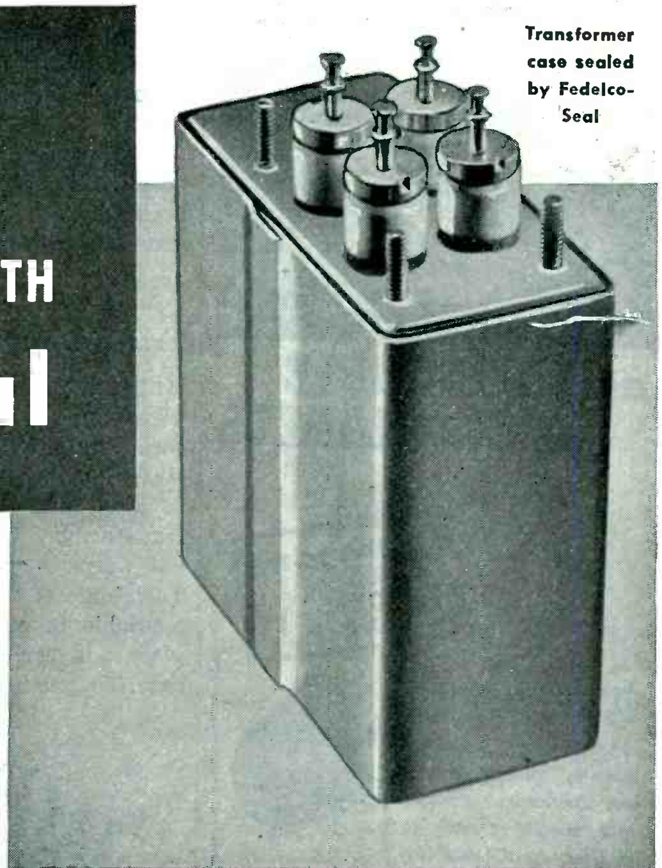


available are from 60 on the tapped winding to 250 on the 800 cps winding. Capacities up to 1000 watts may be furnished. The motor can be wound for d-c voltages rated at 110 or 220 volts, or it can be furnished for three-phase use at slightly lower capacities. Voltage regulation is rated approximately 6 percent at 120 cps, and 24 percent at 720 cps. Frequency regulation is 1.6 percent at 1000 volt-amps.

Another unit has a capacity of

GIVE YOUR PRODUCT PERMANENT IDEAL WORKING CONDITIONS WITH

Fedelco-Seal



Transformer case sealed by Fedelco-Seal

FEDELCO-SEAL makes good products *better* products. By incorporating the element in which a device operates at peak efficiency as an integral part of the unit, Fedelco-Seal insures a permanently ideal sphere of operation.

Illustrated here is a transformer sealed in an air-tight case by the Fedelco-Seal method. It is an example of the way Fedelco-Seal can bring to the products of all industry an entirely new conception of performance.

Abrasive dust, corrosive fumes or explosive gases have no effect on devices when sealed by Fedelco-Seal. Ordinary air, containing moisture, can be sealed out and any pre-determined operating condition—dry air or gases, such as oxygen, helium or nitrogen, under any reasonably desired pressure—can be permanently sealed in.

Let Federal Electric engineers show you how your product may be enhanced in value by surrounding its operating parts with working conditions most ideally suited to it. Fedelco-Seal may be the something new for which you have been looking.

Send us details of your problem and a sample of your product. Our engineers will be glad to show you what Fedelco-Seal can do for you. Call or write today.

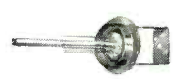
HOW PRE-DETERMINED OPERATING CONDITIONS ARE SEALED INTO A DEVICE BY FEDELCO-SEAL

EXAMPLE: CLARE TYPE "K" RELAY

1

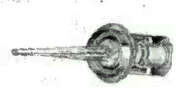
Steel base is stamped. It is shown here ready for mounting of relay assembly.

2



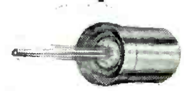
Glass button with fused-in lead wires is sealed to a metal ring. This ring is then brazed to a metal skirt and finally to the steel base.

3



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

4



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

5

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

6

Octal base is placed over header skirt and wires are soldered to base pins. The relay within the housing is now ready for use under any pre-determined conditions without regard to atmosphere, pressure, or temperature.

FEDERAL ELECTRIC COMPANY, INC.

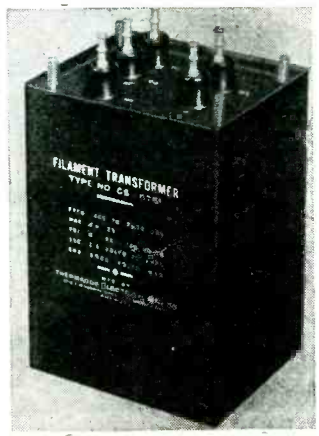
8700 SOUTH STATE STREET, CHICAGO 19, ILLINOIS

250 volt-amps at 400 cps, single phase at 2000 rpm. This unit is also supplied for three phase (belt-driven).

The manufacturer, Kato Engineering Co., (Mankato, Minn.), will build these high frequency motor generators to specification.

Transformers

ILLUSTRATED IS Type No. CS-8751 transformer which is enclosed in a case designed to eliminate any strain on the solder seal. The case is steel, and is rustproof. These transformers have passed the Signal Corps 5-cycle immersion test. Terminals of the transformers are available in molded bakelite or of glass and are solder-sealed to the case. The mounting bolts are welded



gas tight. The transformers are potted with a rubber seal compound. The manufacturer states this new type case will eliminate the mechanical cause of transformer failure due to shock from temperature or humidity changes, and vibration.

Thermador Electrical Mfg. Co., 5119 S. Riverside Drive, Los Angeles, Cal.

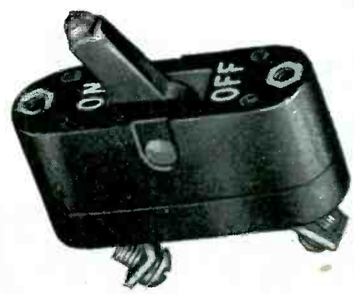
—◊—

ULTRAVIOLET LIGHT has been used in skin grafting to determine when blood circulation has been established in a piece of skin being transferred. Sodium fluorescein is injected into a vein and causes the skin to become yellow-green under ultraviolet light if the blood is circulating properly.

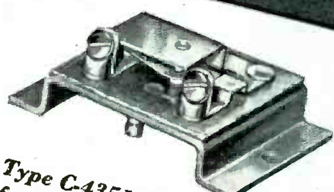
For the EXTRA Element of Safety

Type PM (NAF-1131) Circuit Breaker

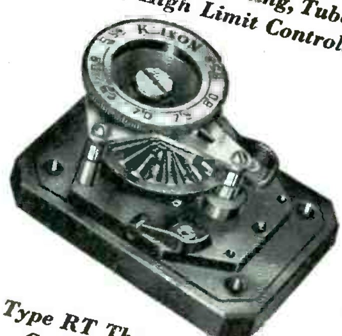
Type B-3120 Thermostat and Heater. Crystal Dew Point Control



Type C-6363 Switch Circuit Breaker



Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.



Type RT Thermostat. Adjustable Crystal Temp. Oven Control

Type ER Series. Ambient Compensated Time Delayed Relays

Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens

... Use KLIXON Disc-Operated Controls

No matter what the control problem . . . motor and transformer overheat protection, electrical circuit overload protection, thermal time delays or temperature control for radio equipment . . . you get an extra element of safety when you use Klixon snap-acting controls. The reason lies in the actuating element . . . the scientifically calibrated Spencer thermostatic disc. This disc does away with complicated relays, toggles, magnets and other fussy parts. It "snaps" to a solid make or a quick, clean break. And because it has no complicated moving parts, it keeps on providing protection for years on end.

Klixon Snap-Acting Controls are small, compact, light in weight and are unaffected by altitude, motion, shock or vibration. They are available in many standard types to meet most control requirements. Write for complete information.

KLIXON

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

SPENCER THERMOSTAT COMPANY, ATTLEBORO, MASS.

Relay Set

ALTHOUGH THIS RELAY SET (designated as SS-5) has been developed primarily for use with the manufacturer's "Red-Top" thermo-regulator, it may also be used in conjunction with galvanometers, contact-equipped meters, gages, or other relay-operating instruments that require low-gram contact pressure. The relay set consists of a sensitive iron-core-magnet type relay which can be operated on 110 volts, 2 amps, and a solenoid type mercury plunger relay (the tube of

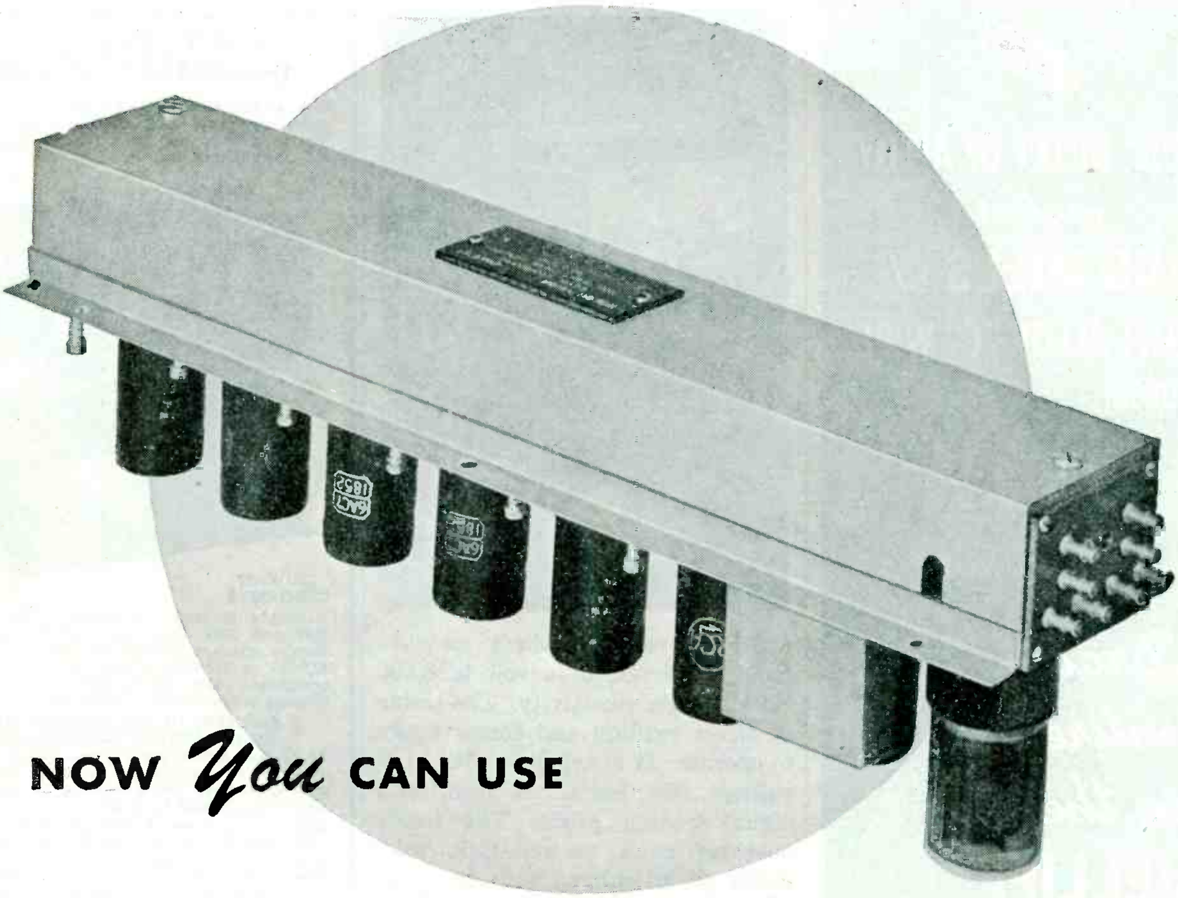
which will handle a load up to 30 amps at 110 volts a.c., or 20 amps at 220 volts.) These two relays are mounted side by side on a hinge-covered housing which measures $5\frac{3}{4} \times 5\frac{1}{4} \times 3\frac{1}{2}$ inches. A convenient terminal block is furnished below the two relays with marked terminals for line connection. A 4-foot armored cable, equipped with a plug, is attached to the side of the housing and is all ready for connection to the instrument.

The list price of the unit is $20.00 f.o.b Philadelphia.

H-B Instrument Co., 2504 N. Broad Street, Philadelphia 32, Pa.

Volt Ohmeger Insulation Tester

INSULATION TESTING at 500 volts up to 10,000 megohms is provided with Model 665 electronic multitester, which also serves as a capacity meter and which will measure from 2.5 micro microfarads up to 2,000 microfarads. The unit uses a VR 105-30 voltage regulator tube to insure freedom from error due to line voltage fluctuations. There are thirteen a-c and d-c voltage scales



NOW *You* CAN USE

THE HARVEY "AMPLI-STRIP"

This I-F and AUDIO amplifying unit has proved itself on many applications of vital importance. It is now available with electrical characteristics to suit your requirements.

The *Harvey Ampli-Strip* is representative of Harvey design and production facilities that have been painstakingly built up over years of specialization in radio and electronics engineering exclusively. The electronics knowledge, precision manufacturing and testing resources responsible for equipment such as this may prove of great practical value to you now or in the critical re-conversion period ahead.

Your inquiries will be given prompt and careful attention.

HARVEY OF CAMBRIDGE

HARVEY RADIO LABORATORIES, INC.

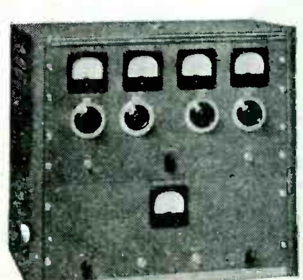
439 CONCORD AVENUE · CAMBRIDGE, MASS.

HARVEY

106 PA REGULATED POWER SUPPLY

for Laboratory D. C. Source — Range 200 to 300 Volts

Write for new bulletin



HARVEY 100-T TRANSMITTER

Compact • Dependable
Easy to Operate

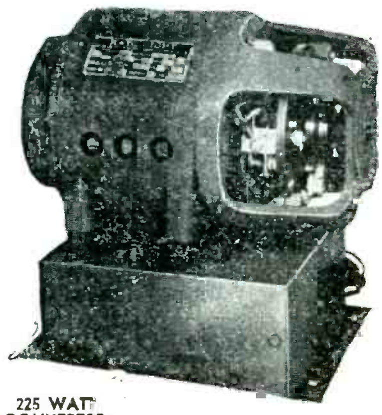
A 100 WATT TRANSMITTER—TELEPHONE AND TELEGRAPH

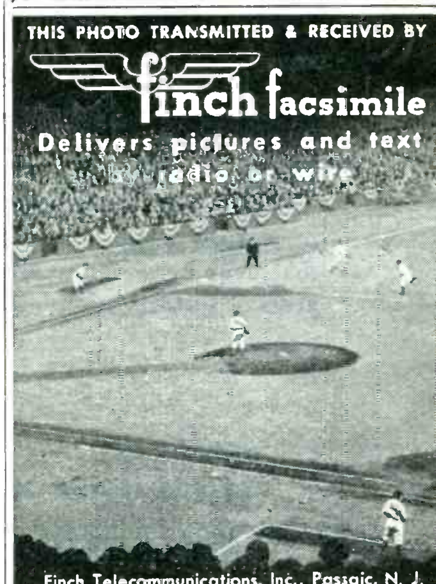
(with 29 ranges) which measure from a fraction of a volt to 6,000 volts at high sensitivity. The tester is direct reading and comes ready to operate. It is supplied with high voltage test leads, r-f lead, and signal tracing probe. The tester operates as a vacuum-tube voltmeter on all ranges with an input resistance rated 16 megohm maximum. The V-T ohmmeter has 7 ranges to 1,000 megohms. The scale of the instrument is an 8 inch D'Arsonval microammeter with an accuracy of 2 percent. The movement is linear. The meter cannot be damaged by checking a live resistor or by using too low a range for making a measurement.

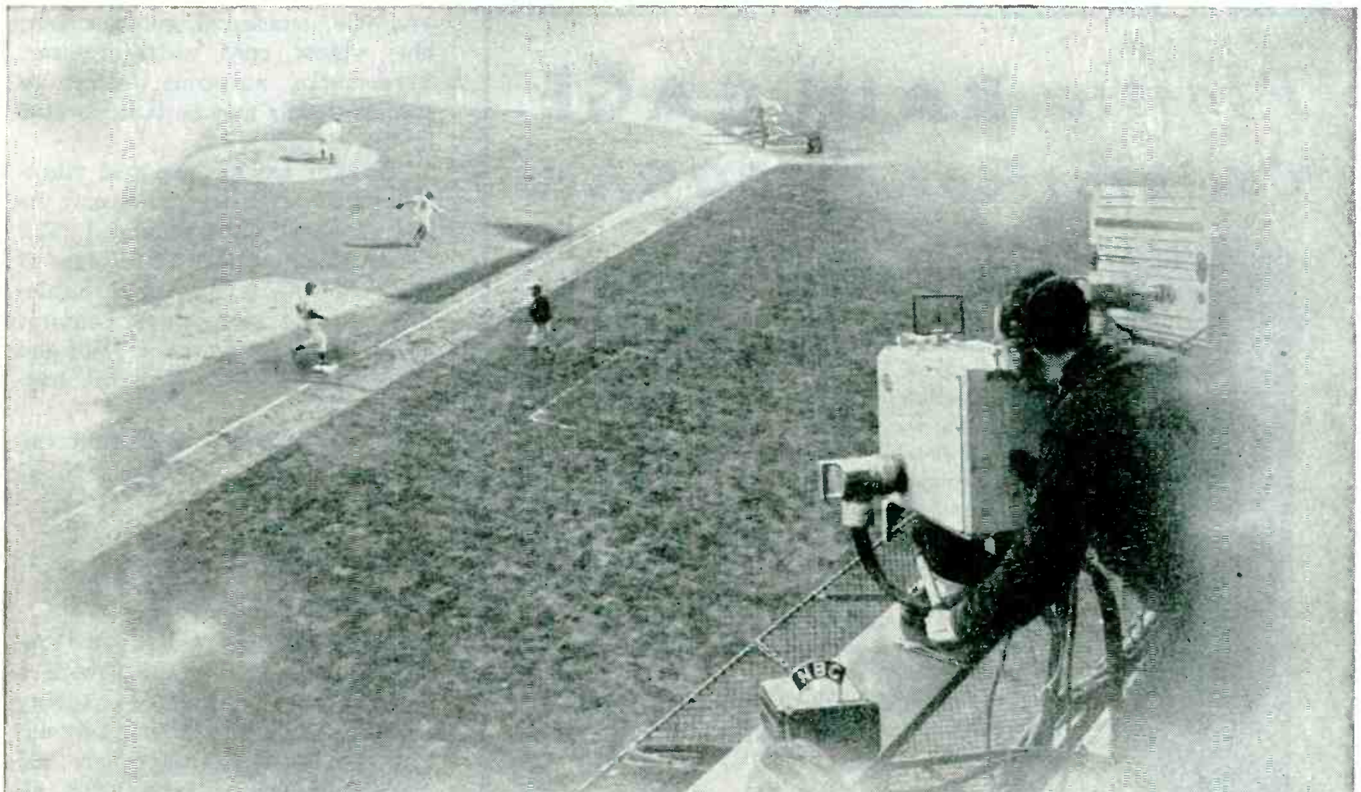
Catalog No. 128 describing this instrument is available from the manufacturer, Radio City Products Co., Inc., 127 West 26th St., New York 1, N. Y.

Pilot Light Assembly

"COMPACTO" PILOT LIGHT assembly is designed to adapt a large jewel holder to a panel where mounting space behind the panel is limited; and to provide a large surface light on a low voltage panel. The assembly is made of brass, or aluminum, with a socket house made of Navy specification Bakelite, which is sealed with Bakelite varnish. A screw-in type jewel holder facilitates bulb replacement. Seven finishes are available. The lenses are available as smooth (clear color) or diamond-faced, and sand-blasted all over or on the back. Lens colors







NEW VISIONS for Tomorrow's World

● IT DOESN'T MATTER NOW whether clouds hide the sun, or whether evening shadows fall on the baseball diamond. If the fans in the grandstand see the game so can the modern television camera.

That was not always so; the pre-war television "eye" needed as much sunshine as it could get to illuminate the scene. The same was true of football—final quarters were occasionally "washed out" on the television screen.

But thanks to research, conducted at the RCA Laboratories, a new super-sensitive television camera, rivaling the human eye in its ability to see under conditions of poor light is in prospect for the post-war world. Then, by television you will see every last-minute play of the ball game as clearly as if you were in the stands. Entertainment, sports, news events will pass before your eyes with every detail, every shadow faithfully reproduced.

Today, RCA's research facilities are devoted to providing the fighting forces of the United Nations with the best radio and electronic equipment available. Tomorrow, these same skills will continue to serve America in developing and creating new and finer peacetime products.

RADIO CORPORATION OF AMERICA

RCA LABORATORIES • PRINCETON • NEW JERSEY

RCA leads the way in radio—television—electronics

RCA

TUNE IN! . . . RCA's great new show, 7:30-8:00 P.M. EWT, over the Blue Network, every Saturday ★ BUY WAR BONDS EVERY PAY DAY ★

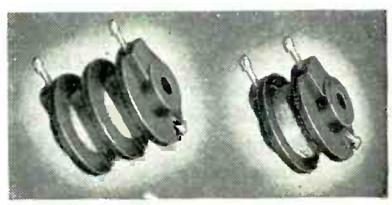
available include red, green, amber, blue, yellow, opal, white or clear. Trademarks, numerals, letters or special signals may be incorporated in the assembly.

The unit has silver-plated vibration-proof terminals, and may be had grounded or ungrounded. The socket accommodates all voltages of the following lamps: T-3¼ miniature bayonet base, single contact; TS-53 miniature bayonet base; and Mazda No. 51 G-3 miniature bayonet base.

The Dial Light Co. of America, 90 West Street, New York, N. Y.

Bobbin-Type Koolohm Resistors

THESE BOBBIN-TYPE KOOLOHM resistors have been treated with a current and temperature ageing process to assure stability. Standard resistance tolerances are ±5 percent for full wattage rating, although closer tolerance (as low as ±½ percent) can be provided at lower wattage ratings. The maximum power rating is 2.5 watts, and maximum resistance is 250,000 ohms in a section ⅝ inches wide and having a diameter of 1⅜ inches. The



maximum recommended operating temperature (ambient plus rise) is 150 deg C.

These bobbin-type resistors are wound with the flexible ceramic-insulated Koolohm resistance wire on molded high-temperature plastic forms, fitted with lug terminals molded integrally into the forms. Units are varnish-impregnated to provide additional protection against tropical humidity conditions. The resistors may be used as meter multipliers, as resistance standards in control instruments, as resistance elements of RC oscillators, as power resistors of medium wattage ratings in values to ½ megohm, and where a high degree of stability is required.

Sprague Specialties Co., Resistor Div., North Adams, Mass.

Oster
REG. U. S. PAT. OFF.

FRACTIONAL H.P. ELECTRIC MOTORS

TYPE C-2B-1A (illustrated) — developed especially for aircraft use. Well adaptable to blower applications, under most adverse conditions. Designed for continuous duty. Ball-bearing-equipped — built in an aluminum die-cast housing. 1/100 H.P. 6, 12, 24 or 115 volts A.C.

1/100 H. P.
(Enlarged Illustration)

PROVED PERFORMANCE

Oster Type 2-CB motors stand up under the most adverse conditions in blower applications . . .

Designed to save space and weight and to give you dependable service

You can depend on Oster motors to live up to the world-wide reputation of pre-war Oster appliances, and to deliver results that add to the prestige of your product for war and peacetime uses. Careful engineering and precision workmanship assure you of dependable, trouble-free performance... the all-around satisfaction that justifies your good judgment in choosing a dependable source for motors.

Illustrated is a type C-2B-1A, 1/100 H.P. model in current production; other models up to ¼ H.P. Let us help you fit this or other Oster motors to your requirements.

M-15

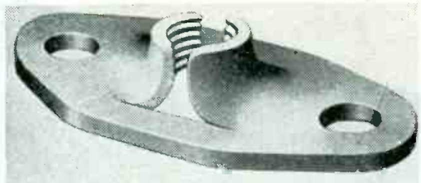
John Oster Mfg. Co. of Illinois
Department L-15
Genoa, Illinois

15 Years
Experience in building fractional horsepower Motors

— is your assurance that you are dealing with a seasoned, dependable source — with a reputation for quality, and a background of electrical engineering research and design.

Speed Nut

A NEW "HI-STRESS" speed nut (No. A6103H-1032) conforms to AAF specification No. 25531, and is light in weight. It is a one-piece integral unit with low installation torque and is designed for speedier insertion of screws and bolts. It is interchangeable with nut plate AN362, for high temperature applications. Another feature of this new product is that it retains its self-locking torque after many removals.



Tinnerman Products Inc., 2106 Fulton Road, Cleveland 13, Ohio.

Dielectric Test Set

MODEL 1031-G DIELECTRIC test set provides a convenient d-c source for voltage breakdown tests up to 4000 volts. It utilizes a half-wave circuit that delivers up to 18 ma. A resistive guard circuit is provided so that momentary shorts on the output do not damage the instrument. The high voltage output is delivered at safety connectors to which may be readily connected 24-inch flexible cables which are insulated and terminated in high voltage test prods. The ground terminal of the instrument is provided with a heavy duty clip. A neon glow lamp indicates charge and discharge of capacitive test specimens, as well as breakdown of the insulation under test. An output indicating meter shows the voltage being applied to the specimen and a primary Variac provides continuous control of the output voltage. No extended warm-up period is required and the test voltage is available as soon as the instrument is turned on. The unit is self-contained and comes in a ventilated steel cabinet which measures 8 x 10 x 8 inches. Also supplied with the instrument is a flexible cord and attachment plug for connection to a 110 volt, 60 cps circuit.

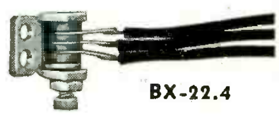
Technical Apparatus Co., Boston, Mass.

Copper Oxide Rectifiers

"COPROX" DESIGNATES a group of copper oxide rectifiers. They utilize gold contacts on the copper oxide pellets and have adaptable mountings. Pre-soldered lead wires (or other arrangements) are used to prevent overheating during the assembly of the equipment using these rectifiers. Units available include: BX-100 which is a center tap, full wave rectifier completely enclosed in Bakelite. It operates in special circuits rated up to 8 Mc. Type

BX-22.3

BX-100



BX-22.4

BX-22.3 is a double bridge rectifier with a good temperature and temperature-current characteristics. BX-22.2 is a full-wave rectifier. Type BX-22.4 is a double half-wave rectifier. BX-22.5 is single half-wave rectifier. The manufacturer states that conservative ratings for these rectifiers show low forward resistance and high leakage resistance.

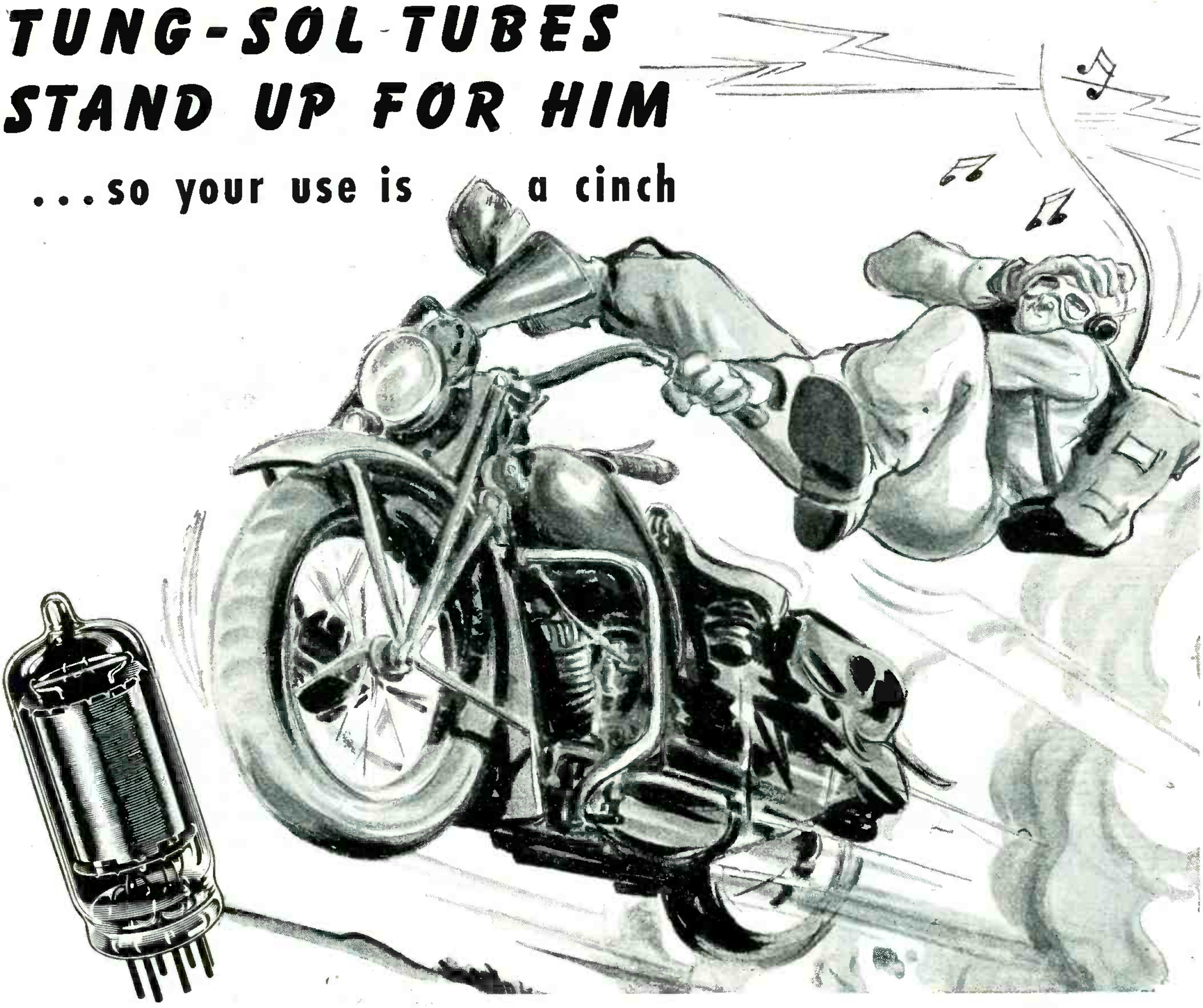
Bradley Laboratories, Inc., 82 Meadow St., New Haven 10, Conn.

Resistors

THESE RESISTORS are designated as "Meg-O-Max" and are made with a minimum of critical materials. They are for use in high discharge circuits, and may be used at high voltages and high ambient temperatures. The resistors are made of a series of pressed and sintered ring-shaped segments electrically joined which make the units non-inductive. The units are encased in a hermetically sealed glass envelope which is provided with ferrule terminals.

TUNG-SOL TUBES STAND UP FOR HIM

...so your use is a cinch



The enviable record of TUNG-SOL Electronic Tubes in military equipment shows the ability of these tubes to withstand abuse far beyond ordinary civilian requirements. This sturdiness is the result of many construction features developed by TUNG-SOL engineers in their never ending cycle of designing and testing.

A typical TUNG-SOL feature is the method of anchoring the filament tension spring. It practically eliminates the possibility of spring failure, one of the causes of damage to the filament. It is the sum of these features that enables TUNG-SOL Electronic Tubes to remain efficient longer under adverse conditions.

After the war, manufacturers of electronic products will find at TUNG-SOL a wealth of engineering and production skill to help them make new or better electronic devices. Those engaged in war work are invited to bring their problems to TUNG-SOL now.

ANCHORING THE FILAMENT TENSION SPRING (GREATLY ENLARGED)

The common practice was to spot-weld the end of the spring to the top of an anchor post. The weld always causes crystallization of the spring at the point where flexibility was needed. The TUNG-SOL design locates the weld back from the fulcrum point so that the crystallization is at a point where it cannot impair the spring.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

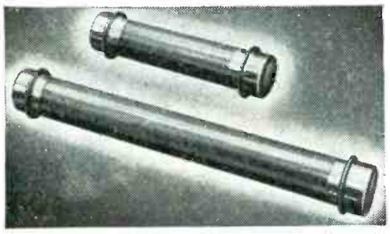
ARMY E NAVY

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS

The resistors are available in two lengths: Type 1 measures 5$\frac{9}{32}$ inches long and has a range of from 3600 ohms to 100 megohms; Type 2 measures 9$\frac{25}{32}$ inches long and has a range of from 6800 ohms to 100 megohms.

The resistors may also be used as

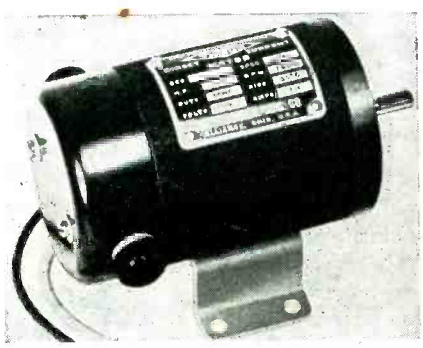


high voltage bleeders and as coarse meter multipliers for voltage indicators, or in such applications as high-voltage networks, measuring equipment, rectifier systems, high-voltage dividers, and as broad accuracy meter multipliers.

Sprague Specialties Co., Resistor Div., North Adams, Mass.

D-C Motor for Aircraft

A NEWLY DESIGNED aircraft-type d-c series motor is primarily for use in airborne equipment. It operates (continuous duty) on 13 volts d.c., 7.4 amps, and delivers full 1/12 hp at 7,500 rpm. The motor measures 4$\frac{5}{16}$ inches in length and 2$\frac{3}{4}$ inches in diameter. It is of ball-bearing construction and weighs 3$\frac{1}{2}$ lbs. The diameter shaft extension measures

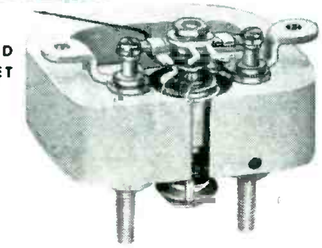


$\frac{1}{4}$ inch. The motor has low temperature rise and is suitable for operation under high ambient temperatures.

The basic design of the motor described above can readily be modified to other applications with either shunt or series windings for a desired voltage, current, and hp output.

Alliance Mfg. Co., Lake Park Blvd., Alliance, Ohio.

G-M *Can Supply* METERS



SOLID MAGNET

if ... THESE SPECIFICATIONS MEET YOUR D-C METER REQUIREMENTS ...

G-M's production facilities can now serve a few additional volume users of meters ... and assure deliveries in keeping with today's wartime needs • Over 100,000 meters have been supplied for one aircraft application alone ... if the specfications below meet your requirements ... and if your problem is quick delivery ... write, wire or phone today.

1. General—Designed to conform to "American War Standards C39.2-1944" for Electrical Indicating Instruments.
2. Size—2½", Round, Flush Mounting, Panel Type.
3. Case—Standard case is of moulded bakelite. Available also in metal (brass) case.
4. Solid alloy-steel magnet (not laminated).
5. Range, D-C—Available from 0-200 micro-amperes to 0-10 amperes, or 0-3.0 volt to 0-200 volts, D-C.

Avail yourself of both our engineering and production facilities for quick attention and experienced service.

G-M

G-M LABORATORIES INC.
4313 NORTH KNOX AVENUE, CHICAGO 41, ILLINOIS

Buy WAR BONDS & STAMPS

Pilot Light

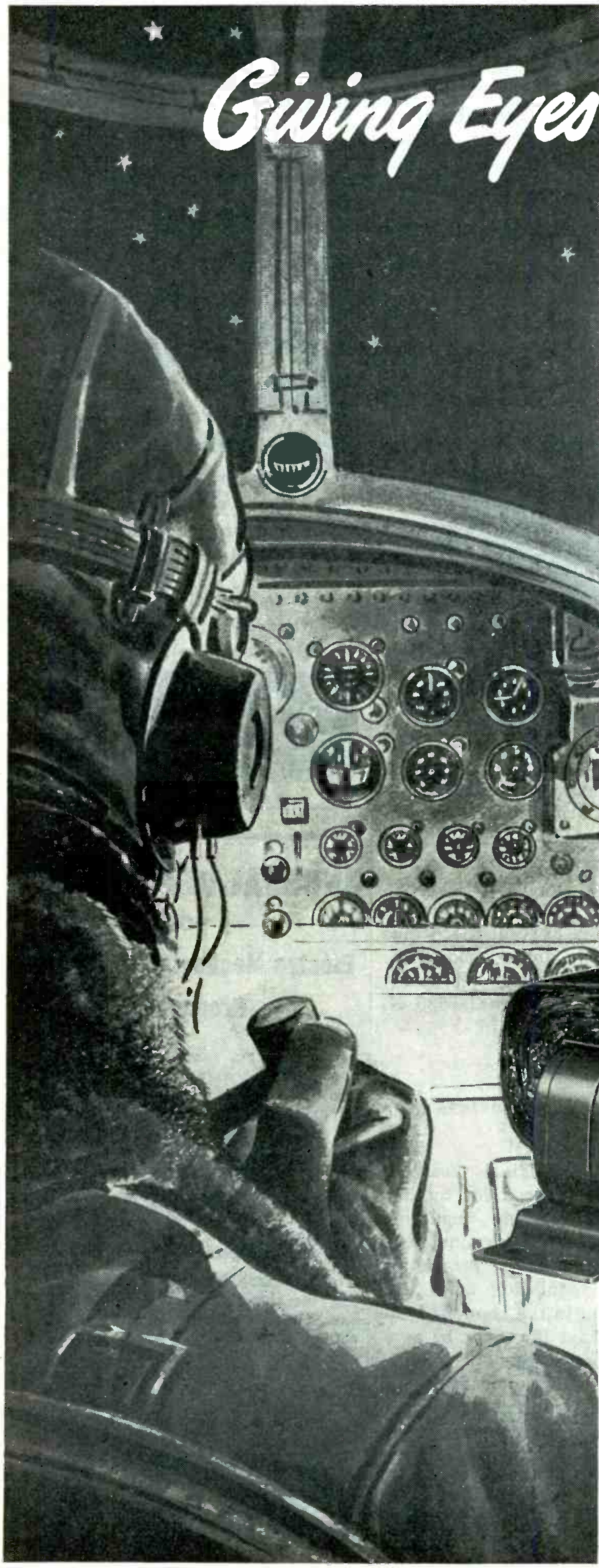
Pilot lights, designated as S11, are available for either panel or switchplate mounting and are for use with the manufacturer's standard S11 lamp bulb, rated at 10 watts and available in all colors. The bulb is recessed into the unit

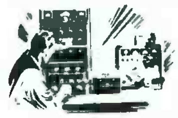
from the front of the panel so that the tip of the lens, which is exposed, assumes the appearance of a lens. This recessing provides exterior ventilation to the lamp bulb and protection against breakage. H. R. Kirkland Co., Morristown, N. J.

Hermetic-Sealing Alloy

Kovar is a patented alloy, consisting of iron, nickel and cobalt, developed by Westinghouse Electric & Mfg. Co. It is marketed by the Stupakoff Ceramic & Mfg. Co., Latrobe, Penna., and is available in forms of rod, wire, tube, sheet, or in special shapes.

Kovar-glass seals have been previously used in the manufacture of electronic tubes to make a vacuum pressure tight seal with glass, and are now available for other applications such as in transformers, resistors, capacitors, switches, relays, heating elements, instruments, compressors, etc. The seal consists of an electrode and a flange with an intervening thermal-shock-resistant sealing glass. The vacuum and pressure tightness of the seal is made by a heating process which results in a chemical bond between the glass, the electrode and the flange. The glass seals are designed to withstand varying degrees of pressure, temperature and humidity. For manufacturers who are not equipped with glass working equipment and cannot use Kovar in unfinished form, Stupakoff can supply Kovar sealed terminals and assemblies which are ready for soldering, welding or brazing.





Vacuum-Tube Volt Meter

THESE VACUUM-TUBE volt meters are for use in radio and audio frequency production and laboratory measurements. Features include sensitivity, stability, and a built-in standard cell for calibration checks. The voltage ranges are rated 0.5, 5, 20 and 200 a.c. Frequency ranges are from 2 cps to 150 Mc. Resonant frequency is 350 Mc. The instrument is accurate to 2 percent of the full scale on voltage, and 2 percent to 150 Mc on frequency. There is an automatic zero adjustment on all

ranges, with readings varying from 1 percent with 10 percent line voltage fluctuation. The model illustrated (No. 201) has a built-in probe, and a rated input capacity of 10 $\mu\mu$f. It is priced at $125. Model 200 has the same characteristics as Model 201 except that it has a separate probe and sells for $135. Its rated input capacity is 5 $\mu\mu$f.

Televiso Products, Inc., 6533 N. Olmstead, Chicago 31, Ill.

Pre-Insulated Solderless Terminals

PRE-INSULATED terminals designed to eliminate the need for buying, stocking and applying insulating sleeving to crimped terminals are available on a mass production scale. The insulation is permanently bonded to the copper of the terminal so that it cannot be accidentally removed. One operation is required to use these terminals, and that is to crimp the terminal on the wire with available precision installation dies. The pre-insulation takes the exact contour of the crimp without distortion, cracking or drying out in use. Identification of terminals and matching dies is achieved

THE NEW SCIENCE OF SMOOTHNESS

Not many years ago engineers took vibration for granted. They designed their metal parts carefully and machined them accurately. They lubricated them properly. Beyond that, what could they do?

Then a discovery was made. It was a simple discovery but one that has changed the whole course of machine design. A United States Rubber Company scientist found that rubber could be engineered just as you engineer steel. Its physical properties could be measured exactly. It could be engineered into the machine at blueprint stage just like any other part.

And when rubber was placed at exactly the right spots, vibration was cut to the vanishing point and engine and manpower efficiency was increased.

That discovery was the beginning of a new conception of machine design. During the war years it has moved ahead at lightning speed.

Today electronics depends on it. Engines could not be operated efficiently without it. Ships, airplanes, industrial machines, trains, streetcars have reached new levels of development because of the rubber springs we call rubber mountings.

Serving Through Science

From the first discovery till today, our engineers in the field and in the laboratory have studied the problem of vibration damping. In cooperation with the Army and the Navy and with industrial design engineers, they have worked on countless vibration problems of nearly every kind.

When you are designing equipment for war production and for post-war production—remember that vibration is a waster. Smoothness spells efficiency, economy and speed. Rubber mountings can give you smoothness.

United States Rubber Company engineers, trained to the job, are serving through science to conquer vibration, to speed our fighting forces. They are planning with industry for smoother, speedier production—today and tomorrow.

UNITED STATES RUBBER COMPANY

1230 Sixth Avenue, Rockefeller Center, New York 20, N. Y. • In Canada: Dominion Rubber Co., Ltd.

Listen to the Philharmonic-Symphony program over the CBS network Sunday afternoon, 3:00 to 4:30 E.W.T. Carl Van Doren and a guest star present an interlude of historical significance.

by the use of markings which are available in two sizes: red is used for terminals and dies for wire sizes 22 to 18, and blue is for wire sizes 16 to 14.

Bulletin 29 describes these terminals available from Aircraft-Marine Products Inc., 1521 North 4th St., Harrisburgh, Pa.

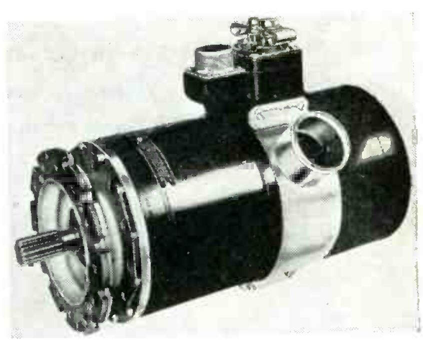
Coating

INSL-X COATING provides a tough, hard coating impervious to moisture, acids or alkalis. It will not chip or crack and may be used with a minimum of labor on stator field-coils on electric motors. It is unnecessary to tape the coils after winding. All that is necessary is to secure the corners tightly since the coating tends to contract when drying and in this way provides a sealing coat that holds the wire as in a vise, and prevents vibration or shifting. The manufacturer recommends Insl-x No. 33 for pre-shaped coils and No. 11-6 (a more flexible material) for coils where shaping is done after insulation.

Insl-X Co., 857 Meeker Ave., Brooklyn, N. Y.

AC-DC Power Supply Systems

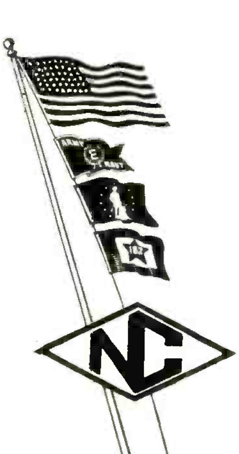
TYPE 1097 engine driven ac-dc generator provides 200 amps at 28.5 volts d.c. and 10.4 amps at 115 volts a.c. at speeds from 4400 to 8000 rpm. The system consists of an engine driven generator and a carbon pile voltage regulator. Both



a-c and d-c outputs are available simultaneously over the entire rated speed range. The generator is designed to mount on the main engine generator of aircraft.

Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

The NC-100XA has gone to war. Under the pressure of the emergency following Pearl Harbor, many stock receivers of the NC-100 series went into action, and served brilliantly. Since then growing experience has led to a long series of minor changes and improvements, culminating in the superb receiver shown in the photograph above. We cannot show what is inside the cabinet until after the war, but a glance at the front panel will make any amateur recognize an old friend. It is stripped for action and in battle dress, but it is still the old reliable NC-100XA. And like its amateur prototype, this new Navy model is winning an impressive reputation for brilliant performance and absolute reliability.



NATIONAL COMPANY, INC., MALDEN, MASS.

Insulation Tester

MODEL C-2 "MEGOHMER" utilizes a new spillproof, lightweight storage battery as a power supply for the 500 volts d-c test potential used in making insulation resistance measurements. A special vibrator transformer circuit is built into the instrument to step up the low voltage to a steady test potential. A wet cell battery instead of dry cells is used so that the battery can be readily replenished by recharging, and for this purpose, a special charging circuit is also built into the instrument to make it feasible to charge the battery either from a.c. or d.c. The tester reads directly in megohms or ohms, has a wide coverage and is easy to read and operate. There is a guard circuit to prevent errors through surface leakage. Bulletin No. 445 illustrates and describes more thoroughly this unit available from Herman H. Sticht Co., Inc., 27 Park Place, New York, N. Y.

Regulated Power Supply

MODEL 44 of this series of regulated power supplies was described in April ELECTRONICS. Model 42-A is now also available. It delivers 1.0 to 1.5 volts, d.c., at 500 milliamps. This unit is suitable as a filament supply in production-testing of equipment using battery-type tubes. The hum content is rated at less than 2 millivolts.

A third model (no model number has been announced) soon to be available is designed to deliver 45 volts at 40 milliamps. This regulated supply will have approximately the same size and weight as a standard "B" battery.

Radio-Television Institute Inc., 480 Lexington Ave., New York 17, N. Y.

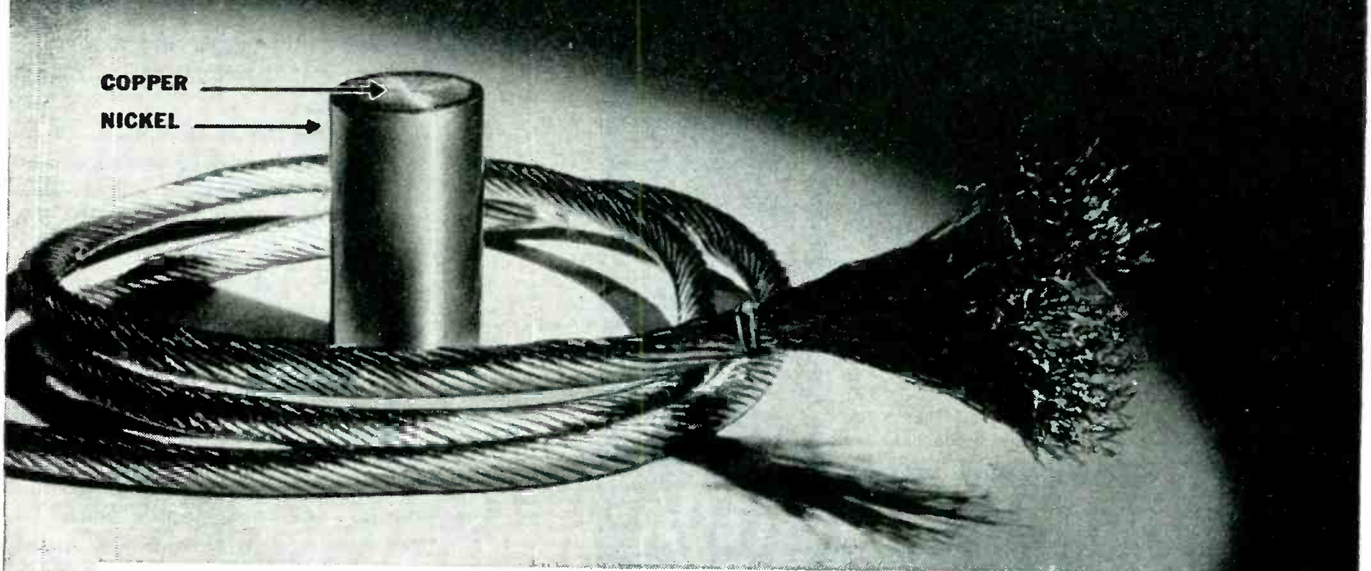
Insulating Replacement of Fibre and Rubber

SPUN ACETATE GROMMETS are available for use in aircraft, hydraulic controls, small motors, and other applications where small grommets are used. The grommets are made of acetate film which is spirally wound and laminated for strength. They have high insulating properties and are very tough. They

They wanted

A METAL THAT DIDN'T EXIST

...but an ingenious combination met all requirements



A new metal was needed for wire . . . with a combination of properties not found in nature.

It had to have high heat and electric conductivity *plus* strength and resistance to oxidation at high temperatures.

Copper had the required conductivity but it couldn't stand the heat.

Nickel had the high-temperature strength and corrosion resistance but its conductivity was too low.

The answer was an ingenious combination, "Kulgrid", devised by Callite Tungsten Corp., Union City, N. J. It consists of a copper core, over which is firmly bonded a sleeve of strong, corrosion-resistant Nickel.

The result is a conductor with 70% of copper's conductivity . . . 100% of Nickel's resistance to oxidation and corrosion. It can stand up under high temperatures, fatigue, embrittling conditions, and stresses four times greater than copper without breaking.

One of the INCO Nickel Alloys may be the answer to *your* metal problem. Tough, strong and corrosion-resistant as a family . . . and with individual *specialized* properties . . . they are available in practically any shapes and sizes that may be wanted down to

wire, 1/3 the thickness of human hair
tubing, finer than a mosquito's stinger
strip, 1/3 the thickness of this paper

"Tremendous Trifles," a booklet which discusses the INCO Nickel Alloys in detail will be sent to you on request.

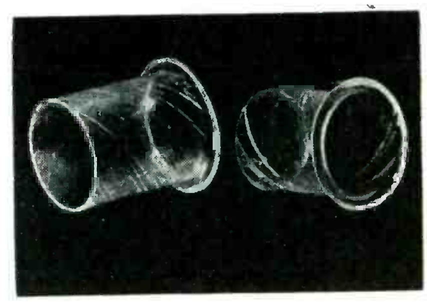
THE CYLINDER *is a section of bi-metal rod . . . copper core and nickel jacket. It is cold-drawn by Callite Tungsten Corp., to the .006" fineness of the flexible stranded wire illustrated.*

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK 5, N. Y.

FIRST STEP IN MAKING "KULGRID" *bi-metal wire is insertion of copper rod into Pure Nickel tube. The two-in-one wire has 70% of the conductivity of copper . . . is strong and corrosion-resistant, even at high temperatures.*

INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL
"KR" MONEL • INCONEL • NICKEL • "Z" NICKEL
Sheet...Strip...Rod...Tubing...Wire...Castings



are light in weight, and are resistant to oil, moisture and climatic conditions.

Available, to specification, in all wall lengths and diameters and suitable wall thicknesses from Precision Paper Tube Co., 2035 W. Charleston St., Chicago 47, Ill.

Metal Coatings for Steatite Insulator Surfaces

THESE METAL COATINGS are composed of a layer of silver and an electro-copper plate. To give a strong and permanent bond between the steatite and the metal, the silver is fixed at a high temperature to the surface of the steatite, and the electro copper plate is put on top of the silver to increase the thickness of the metallic plate. This combination provides a means for solder-sealing parts (over limited temperature ranges) to ceramic. The metallic surface also provides a convenient method of adding shields to reduce corona effect in high frequency circuits used at high altitudes.

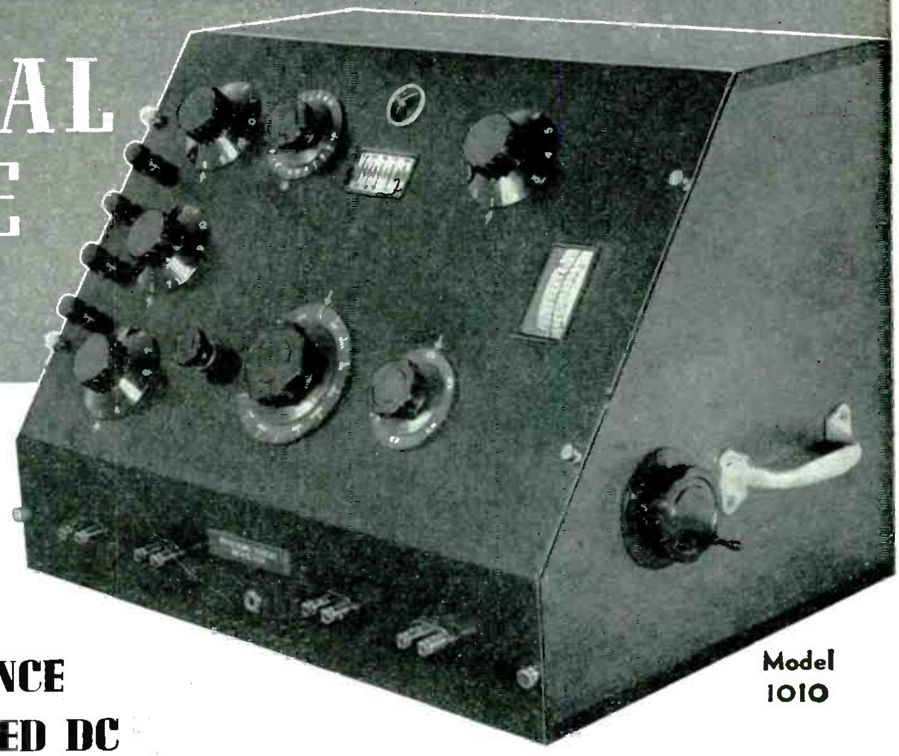
General Ceramics & Steatite Corp., Keasbey, N. J.

Conductive Coatings

A NEW CERAMIC TYPE composition produces electrically conductive coatings that may be applied to a variety of non-conductors such as glass, plastics, porcelain, soapstone, wood, cloth and paper. The coating is applied to non-conducting base materials by either spraying, dipping or brushing. It is then either air dried or baked. The ceramic contains silver powder and produces a surface of low electrical resistance and high conductivity. Aging, or exposure to sulfides has slight effect upon the conductivity of the coating.

A number of coating materials have been formulated. The differ-

A NEW UNIVERSAL BRIDGE



Model 1010

★ **WIDE RANGE**

★ **½% ACCURACY**

★ **6 BRIDGES IN ONE**

★ **MEASURES INDUCTANCE WITH SUPERIMPOSED DC**

One of several instruments designed to meet the requirements of our military development program — now made available for general sale.

The Universal Bridge permits measurement of:

- **RESISTANCE** — Range: 10^{-4} to 10^{10} ohms.
  Accuracy: 1 ohm to 1 megohm, within ½%,
  below 1 ohm and from 1 megohm to 100 megohms within 1%
  above 100 megohms the error increases to 5%.

- **CAPACITANCE** — Range: 10^{-6} to 100 microfarads.
  Accuracy: 100 μμf to 1 μf within ½%,
  other ranges, within 2%.

- **INDUCTANCE** — *With no D. C. flowing*
  Range: 10^{-6} to 100 henrys
  Accuracy: 100 μh to 1h, within 1%,
  other ranges, within 2%.

  With superimposed D. C.
  Range: .1 to 100 henrys
  Accuracy: Within 2%

FEATURES — Inductance of iron cored chokes and transformers can be measured with up to 500 m. a. of D. C. flowing.

Facilities for measurement of frequency, Q and power factor are included in the Bridge.

The bridge contains a 1 megohm resistance decade in steps of one ohm — this is brought out to terminals so that it can be used externally.

Complete and self-contained unit . . . in addition, provision has been made to plug in external facilities such as outside standards, oscillators, null indicators, etc., to extend the usefulness of the bridge.

Your inquiry will receive prompt attention, as will inquiries concerning the application of our engineering facilities to the solution of your industrial control, inspection or instrumentation problems.

INDUSTRIAL PHYSICS — INSTRUMENT DEVELOPMENT

WR WHITE Research

899 BOYLSTON STREET, BOSTON 15, MASS.

ences depend upon the requirements, the base material to be coated and the desired degree of adherence and film toughness. Briefly, they include a conductive-coated cloth and a flexible conductive film. Of these, Nos. 4132, 4489, 4503 and 4530 are in commercial production. There is also a thermoplastic conductive cement which is available by special arrangement.

Working samples of all these materials for evaluation purposes can be obtained from Ceramic Products Div., Electrochemicals Dept., E. I. du Pont de Nemours & Co., Wilmington 98, Del.

Coiled Cords

ELECTRICAL EQUIPMENT manufacturers may be interested in a retractable electrical cord which can be stretched to approximately seven times its original length. It is available in a variety of lengths from a

newly formed company known as Cordage, Inc., an affiliate of Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago, Ill. The name of this coiled cord is Kellogg Koiled Kord."

Literature

Parts for Radio and Aircraft Instruments. D-c and r-f (2½ inch) voltmeters and ammeters are described and illustrated in a new type of parts publications. Nos. GEG-3750 through GEG-3754 cover instruments for radio and other communications equipment and Nos. GEG-3755 through GEG-3758 cover instruments for aircraft. To facilitate identification, the parts are illustrated in such manner as to show their proper relation to each other in an assembled instrument. General Electric Co., Schenectady, N. Y.

Directory of Commercial Laboratories. This directory consists of 42 pages and is a guide to the leading independent, testing, research and inspection laboratories of America. It gives the scope of activities of these laboratories and the advantages to be derived from utilizing their services in the solution of scientific, engineering, testing and inspection problems. It was prepared by American Council of Commercial Laboratories and copies may be obtained from the Executive Secretary, A. J. Nydick, 63 Wall St., New York 5, N. Y.

D-C Motors. Direct-current motors ranging in sizes from 1/6 to 300 hp are illustrated and described in a 12-page bulletin, Form 3421. Century Electric Co., 1806 Pine St., St. Louis 3, Mo.

Fasteners. Volume 1, No. 1, of a publication called "Fasteners" is a new publication of American Institute of Bolt, Nut, and Rivet Manufacturers (1550 Hanna Bldg., Cleveland 15, Ohio) which functions as a clearing house for technical problems in connection with the application and use of headed and threaded products. Some of the articles contained in this first issue include "The Rolled Screw Thread Process" by G. S. Case, The Lamson and Sessions Co.; "Cold Driving of Large Rivets" by W. E. Fowler, Jr., Riveting Apparatus, Inc.; "How Tight Should a Bolt Be?" by J. O. Almen, Research Labs. Div., General Motors Co.

Soldering Torches. Cat. 152 Schmidt soldering torch is an internally gas fired soldering torch for making electrical connections and is described in bulletin 13A-152 along with three other torch units available from National Electric Coil Co., Columbus, Ohio and Bluefield, W. Va.

Thermostatic Bi-Metal. Bulletin No. 155 gives technical data on Calliflex Bi-Metal, of various types available in either strip or coils or in special shapes. This is a material for use as the responsive element in automatic temperature control. Callite Tungsten Corp., 540 39th St., Union City, N. J.

Plastics Catalogs. Three manufacturers have published data on plastics, and they are as follows:

1. "Facts About Plastics", a 24-page booklet designed primarily for non-technical personnel interested in obtaining a general knowledge of plastics and their applications (and limitations) for present and post-war uses. Properties related to "Insurok" and other plastics are discussed. Two main groupings of plastics, "Thermosetting" and "Thermoplastic", are described and illustrated. The Richardson Co., Dept. 100, Melrose Park, Ill.

2. "Hopp Plastics Today and Tomorrow" briefly describes sheet fabrication, printing, lamination, die making, injection and extrusion molding done by this company of such plastics as Lumarith, Vinylite and Ethyl Cellulose. Detailed characteristics (physical, thermal, electrical and chemical) are given. The Hopp Press Inc., 460 West 34th St., New York 1, N. Y.

3. "Facts About Plastic Tubing" is a new illustrated catalog on this manufacturer's fibronized extruded plastic tubing. It contains a number of product data sheets describing the characteristics and applications of numerous products including Irv-O-Lite types XTE-30, XTE-130 and Ivi-Flex extruded tubing, Transflex transparent tubing, and Hyflex tubing, as well as the manufacturer's plastic marker insulators. Irvington Varnish & Insulator Co., Irvington, N. J.

Frequency Measurements. The purpose of this particular article "H.F Frequency Measurements" (Part 1), as contained in the April issue of *The Aerovox Research Worker* is to review, from an academic standpoint, the several methods of frequency measurement especially applicable to the region between 30 Mc and 30,000 Mc, to explain how the utility of existing lower-frequency standard-signal equipment may be extended to permit extremely high frequency measurements, and to describe several special systems and devices which are specifically for use in the region 30–30,000 Mc. Issues of the *Research Worker* are published by the Engineering Department of Aerovox Corp., New Bedford, Mass.

Coil Winding Tapes. "Kappa" cellulose, acetate rayon coil winding tapes are featured in an 8-page booklet which gives electrical and physical test data, specifications, packaging, prices and samples. Wm. E. Wright & Sons Co., West Warren, Mass.

Solderless Wiring Devices. Catalog SD-1 is a nicely edited and illustrated catalog (printed on coated stock) on AMP products such as solderless insulation support terminals, standard and flag type terminals, connectors, lighting contacts, cable lugs, wiring plugs, standard and quick disconnect bonding jumpers, splicing terminals and grid clips. Hand tools, and installation presses are described and illustrated, and complete working instructions for setting up crimping dies are included. Data, specification and dimensional charts, and Army, Navy and commercial wire sizes are given for each item listed. A section is also devoted to wire reference data. This reference manual is a 72-page sectionalized catalog. Aircraft-Marine Products, Inc., 1591B North 4th St., Harrisburgh, Pa.

Tube Substitution Directory. A comprehensive tube substitution directory, contains 16 pages of more than 2,000 suggested tube substitutes for civilian radio receivers. Commercial Engineering Section Radio Corp. of America, Harrison, N. J.

Centrifugal Blower Units. Many different blower units which may be used to cool tubes are described in engineering data sheets. Also available is literature describing the motors used to power the blower units. The blower units mentioned include Model J50 and Model J51 centrifugal types; J52 variable frequency centrifugal; J53 28 volt, d-c unit; Models J54, J55, J56 midget centrifugal J57, 115 volt, 60 cps; J58, 115 volt, 400 cps; and J59 a 28 volt, d-c unit. Literature is also available on Model L-R, No. 2, blower rated 115 volts, 400 cps; as well as Model J49 rated 115 volts, 60 cps. Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.

Airport Traffic Control. A booklet called "Highways of the Air" is a non-technical piece of literature with diagrams and illustrations. It tells about radio's contribution to the safety of human life in air transport, and it outlines the function of the manufacturer's equipment (radio ranges and markers). The booklet tells what a "beam" is, how it is generated, and how it is sent to the pilot for his guidance. Also discussed are the air traffic control systems of LaGuardia Airport, the National Airport, and other air terminals. Radio Receptor Co. Inc., 251 West 19th St., New York 11, N. Y.

Aluminum Notebook. Twelve economic advantages of aluminum are profusely illustrated and described in a booklet called "Aluminum Imagineering Notebook." The twelve advantages mentioned include: light weight; high resistance to corrosion; high electrical conductivity; high conductivity for heat; high reflectivity for light and radiant heat; workability; non-toxicity; strength in alloys; non-sparking; non-magnetic; appearance and high scrap and reuse value. Aluminum Company of America, Pittsburgh, Pa.

Hard Rubber Products. A 4-page folder designated as Catalog Section 9405 gives fairly complete data on the use of hard rubber parts which may be used in radio, electrical and X-ray equipment. Sections are devoted to the qualities, types of products, and suggestions for machining these hard rubber products. Standard grades (B. F. Goodrich, Defiance, Albonite) and special grades are described. Also listed are the important properties of these three standard grades. The folder also contains the approximate weights of sheet, rod or tubing. The B. F. Goodrich Co., Akron, Ohio.

Postwar Jobs In Electronics. Students, teachers, counselors and others may be interested in a six-page folder on "Occupations in Electronics", one of a new series of leaflets describing opportunities in fields which may be expected to expand when the war ends. Each leaflet covers the nature of the work, abilities and training required, methods of entrance and advancement, geographical distribution of employment, postwar prospects, and other advantages and disadvantages. The booklet is by John E. Crawford of The Radio Corporation of America and Forrest H. Kirkpatrick of Bethany College. It is distributed by Occupational Index, Inc., New York University, Washington Square, New York 3, N. Y. for a remittance of 25 cents.

Mercurial Thermostats. Bulletin No. 344 contains specifications (and illustrations) for temperature controls used for checking electrical characteristics of completed test equipment. Bender Scientific Glass, Inc., 2529 North Carlisle St., Philadelphia 32, Pa.

Check-Chart. The chart illustrates Decal nameplates and describes application methods, types and uses, as well as special features (such as retention and shut-off fluorescent, non-specular, mar-proof and elasticized nameplates). It shows how to select and specify the right name plate for 16 different types of surfaces. A check-list is given of 25 wartime uses for name plates now used on different types of combat equipment. Copies of "Decal Check-Chart" may be had from The Meyercord Co., Dept. RT, 5323 W. Lake St., Chicago 44, Ill.

Development and Uses of Dry Batteries. This 48-page booklet is titled "The Inside Story of Dry Batteries: A Guide for Students" and is intended to give the reader the background of dry batteries from the time of Alessandro Volta's discovery of the electrochemical principle, in 1798, to the units of today. The booklet is used by government training centers, as well as other educational institutions, and since issues are limited only one copy can be sent to each applicant. National Carbon Co., 30 East 42nd St., New York 17, N. Y.

Low-Loss Ceramics

(*Continued from page* 142)

humidity was in excess of 50 percent.

Acknowledgment. The authors wish to acknowledge the development work of The Titanium Alloy & Mfg. Co. in the field of high-frequency ceramic insulation and the very helpful advice and cooperation of their research staff, particularly Dr. E. Wainer. Appreciation is also expressed to the following engineers at the Westinghouse Research Laboratories for the preparation of the samples and the conduct of many of the tests: Messrs. R. S. Weisz, W. C. Mohr, A. M. Stiles, E. W. Lindsay, M. N. Ross, and C. N. Works. The many contributions of the engineering staff at the Westinghouse Porcelain Division are also gratefully acknowledged, as are the encouragement and helpful cooperation of Mr. D. G. Little and others of the Westinghouse Radio Division.

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(4) American Society for Testing Materials. (a) "Standard Methods of Testing Electrical Porcelain," A. S. T. M. Designation: D116-39; (b) "Tentative Methods of Test for Power Factor and Dielectric Constant of Electrical Insulating Materials," A. S. T. M. Designation: D150-41T.

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(10) Wainer, E., and Salomon, A. N., Electrical Report No. 7, The Titanium Alloy Mfg. Co., Industrial Chemical Division, Electrical Research Laboratory, July 6, 1942.

AUTOMATIC MACHINES *produce in one day 3,500 glass jewels, substituted for the sapphire jewels formerly obtained from Switzerland.*

Jap Radio Equipment

(Continued from page 129)

tion 7.0 percent total harmonic distortion was observed. These values are considered to be satisfactory for the service intended.

General Observations

One of the features in the design and operation of the Japanese equipment is that of employing quartz crystals to control the receiver beat-frequency. The transmitter employs two crystal spot frequencies and the receiver also employs two crystal spot frequencies, the frequency of the receiver crystals differing from that of the transmitter crystals by the frequency of the receiver i-f amplifier. The crystals are mounted in a Bakelite housing which slides into clip contacts, and when seated in place, this holder actuates a switch which reverts the master oscillator from self-oscillator condition to that of crystal control at the frequency of the respective crystals. The same system is used for the beat oscillator in the receiver.

Another feature that is interesting is the use of small neon lamps connected across the high-potential side of the transmitter tuned circuits, used as tuning indicators in place of meters. This, of course, means a saving in cost and a considerable saving in space on the front panel. It does not, however, give the operator any indication as to the condition of the tubes in any of the tuned circuits, but it does indicate that all circuits are working satisfactorily provided the voltage breakdown and the neon lamps are adjusted for the proper working voltage for each amplifier stage.

The output tuning of the transmitter is accomplished by means of Bakelite variometers wound with enameled-copper wire. These appear to have been made in Germany and appear satisfactory for limited power and limited-frequency range equipment.

There is no indication of the use of remote control. Tuning and changing frequency of the equipment must be accomplished from the front panel, the only remote operations being the starting and stopping of the dynamotors and the keying of the transmitter.

It is noticed that the output- indicating meter was shunted with a removable shunt, which would indicate the Japanese have one standard type output meter.

Several familiar ceramic tube sockets are used, along with old American selector switches, control knobs, variable rheostats, etc. In general, one gets the impression when inspecting this equipment that the Japanese, possibly during the period 1928–1930, bought out several bankrupt broadcast receiver manufacturers' stocks and used this stock as the component parts for aircraft communication equipment. Practically all the operating relays are direct copies of standard domestic relays.

The Japanese are using rubber for power cables. These cables are all of American manufacture and all are dated 1940.

It is noticed in the Japanese equipment that practically all fixed resistors are of German make.

The Japanese make no use of plastics or die castings, the equipment being frame-constructed with all component parts mounted by means of screws and nuts and secured in various places to support members of the frame. German

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PRECISION GAGE

Dimensions of less than two-millionths of an inch are measured by this gage made by Sheffield Corp. It will reveal the degree of expansion of a piece of metal when warmed by a human hand equipment is practically the opposite in construction, as the Germans make extensive use of die-castings, moldings and stampings, and there is very little machine work done in the construction of German equipment other than the mounting of the component parts.

There is no indication on any of the Japanese equipment of use of shock-mountings, the old style "Bongee" cord suspension being used.

The transmitter power input requirements are considered excessive for the power output available, especially for voice operation, even when considering that the efficiency of the output tubes is lower than if the tubes were operating at their proper rates.

The operation of the transmitter and the receiver for voice operation is considered unsatisfactory, and it is thought that the units must have been designed primarily for cw operation.

The total power input, estimated on the basis of 50 percent dynamotor efficiency, is 381 watts for cw and 311 watts for voice-operation, yielding outputs of 26.6 and 9.2 watts respectively. This represents an estimated overall efficiency of 7 percent cw, 3 percent voice. These values are considered comparatively low for this type equipment. The average American equipment of the same power output would approximate an overall efficiency of from 7 to 12 percent.

In conclusion, it can be stated that the Japanese equipment compares unfavorably with present American naval aircraft communication equipment covering the same frequency range and approximately the same size and weight.

REFERENCES

(1) Gordon, R. A., Captured Axis Equipment, p. 94, ELECTRONICS, March 1944.
(2) Gordon, R. A., German UHF Command Set, p. 132, ELECTRONICS, April 1944.

POWER COMPANIES have found that defective distribution transformer tanks can be fitted with Hipersil cores and new windings and, because of the difference in thickness between hot-rolled silicon steel and Hipersil, provide a 7½-kva transformer in a 5-kva tank.

Automatic Calibrator

(Continued from page 107)

by established photographic concerns, or requiring that the radio firm manufacturing the frequency meter go into the photographic business.

Recording System Used

To overcome these objections, it was decided to use an adding machine as the printer by providing a means of setting up the dial reading of the calibration point on the keyboard.

The complete recording system is shown in the block diagram in Fig. 13. The frequency meter dial is mechanically coupled through a gear drive of suitable ratio to an electrical revolution counter. This counter (see Fig. 14) consists of 5 decks of 10-point selector switches, each deck being geared to its adjacent deck by a 10:1 intermittent stepdown so that every time the "tenths" rotor rotates between 9 and 0, a gear link advances the "units" rotor by one stator segment. Every time the "units" rotor passes between 9 and 0 another gear link advances the "tens" rotor by one segment, etc.

The stator contacts selected by the rotors at any given instant, therefore correspond to the numerical dial reading at that instant. If, at the particular instant at which a reading is to be taken, the "tenths" rotor happens to be between contacts, then the next point to be contacted will be recorded.

For this reason and because of the practical impossibility of adjusting the "tenths" rotor so that it will break contact with the "9" point exactly simultaneously with the breaking of the rotor contact in the units section, a "disconnect" section is added. The rotor of this section is directly coupled mechanically to the "tenths" rotor, and the stator segment is so arranged that the rotor and stator are in contact throughout approximately 330 deg of rotation. The remaining 30 deg is a little greater than the angle throughout which the "tenths" rotor is not in contact with either the "9" stator contact or the "0". Electrically this "disconnect" section is in series with the voltage supplied to the remaining rotor sections, so that the switch is rendered electrically inoperative during the mechanical throw-over period.

Each stator contact of the revolution counter is connected to the starter anode of a cold-cathode gas discharge tube (OA4G) as in Fig. 15, which shows the schematic of one column of the number storage bank. The circuit is so arranged that when switch S is open, all voltages are removed from the tubes, leaving them de-ionized.

When the reading on the counter is to be recorded, switch S (which is actually a thyratron ionized by the pulse from the zero beat detector) is closed, supplying 185 volts to the anodes of all the tubes. Resistors $R4$ and $R5$ supply approximately 100 volts to the starter anode of the first tube to be selected by the rotor of the counter switch.

Under these conditions, the tube selected will ionize and reduce its anode-cathode potential to 70 volts. Since $R1 = R0$, 57.5 volts will appear across $R0$ and will act as a positive bias on the cathodes and starter anodes of the remain-

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MASK MICROPHONE

Fliers of the Royal Canadian Air Force wear this combination oxygen mask and microphone for high-altitude flying. Concerned about "washouts" due to faulty speech, RCAF asked Bell Telephone Labs to instruct personnel in clear enunciation ing tubes. Further rotation of the counter switch rotor will then supply an effective starter anode-to-cathode voltage of only 42.5 volts to any subsequent tubes selected, and this value is insufficient to ionize any of them.

After S is closed, the first tube to be contacted by the counter switch becomes ionized and will remain ionized until switch S is opened. (This "opening" will actually be a deionization of the thyratron being employed for S, after storage of the number is no longer required).

Thus the number storage bank constitutes an electrical means of storing the dial reading of the frequency meter at any calibration point for any desired length of time. This reading is transferred from the storage bank to the keyboard of an adding machine by having the plate current of each ionized OA4G tube operate a relay (coil represented by $R1$ in Fig. 15) which in turn operates a corresponding solenoid that presses the proper number key of the adding machine. A view of the adding machine and solenoids with cover off is shown in Fig. 16, and the entire number storage bank with the front door open is shown in Fig. 17.

Sequence of Printing Operations

After the dial reading of the calibration point is set up on the adding machine, it is required that the reading be printed and that the difference between adjacent readings also be tabulated. This necessitates the following sequence of operations:

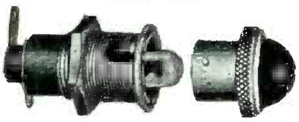
(a) Press the "non-print" button.

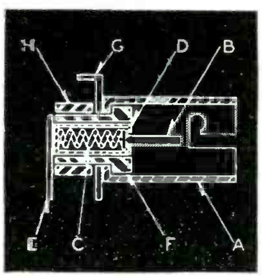
(b) Press the "+" button if the frequency meter dial is revolving to increasing numbers.

(c) After the machine starts running, release all pressure.

(d) When the machine comes to rest, press the total button.

(e) After the machine starts running, release the pressure. (During the ensuing cycle of the machine, the difference between the present calibration point and the





previous one will be printed.)

(f) When the machine comes to rest, again press the "number keys, as still determined by the number storage bank.

(g) Press the "–" button.

(h) When the machine starts running, open switch S of Fig. 15 by deionizing the thyratron used as S, thereby deionizing the cold-cathode tubes of the number storage bank so as to prepare it for a new calibration point; also remove pressure from all keys. (During this cycle of the adding machine, the dial reading of the calibration point will be printed.)

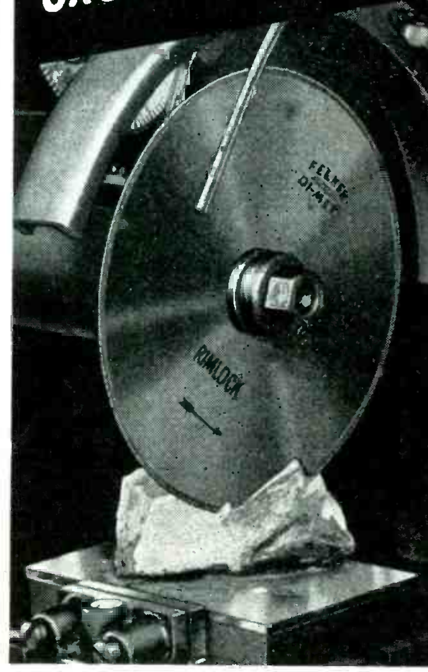
If the dial of the frequency meter is being driven from high numbers to low (on one band it is driven in one direction, and in the opposite direction on the other), then operations (b) and (g) above are reversed.

All of the above operations are performed by means of conventional relay switching practice, with each operation initiated by the closing or opening of a contact placed on the adding machine in such a manner that the contact is closed while the machine is cycling and the contact is opened when the machine comes to rest. The entire sequence system is shown with cover open in Fig. 18.

Contact-Failure Detector

A safety device is incorporated in the sequencing system to insure against incorrect calibrations in case of failure of any one of the contacts of the revolution counter. (Such failure might be expected to be rather frequent since the fastest revolving rotor of this switch makes over 100 contacts per second. In actual use 24 hours a day, the particular design employed in the revolution counter gives a contact failure about once every two months, or after about 500 million contactings.)

This safety device operates upon the time interval between the instant that the pulse is received from the zero beat detector and the instant that the one OA4G tube in each column of the number stor-



age bank becomes ionized. If this interval is less than approximately 0.01 second, then the calibration point is printed in the normal manner; but if, through a contact failure of the revolution counter, the interval exceeds 0.01 second, then no calibration point is printed. This is arranged by a suitable relay system consisting of one relay coil of a fast-operating relay inserted at $R0$ of Fig. 15 for each column of the number storage bank, and a slower-operating relay connected from the plates of the OA4G to ground.

If the slow-operating relay closes after the five fast relays have operated (the difference in operating time between the two types of relays is 0.01 second) then the contacts of the revolution counter are apparently in proper working order and the circuit is arranged to permit the normal printing sequences previously described to be executed. If, however, the revolution counter skips a contact point at the instant that a dial reading is to be recorded, the OA4G which should have been ionized does not become ionized and hence the slow-acting relay will be operated before the fast-acting one. Through suitable additional relay circuits, this causes the sequence

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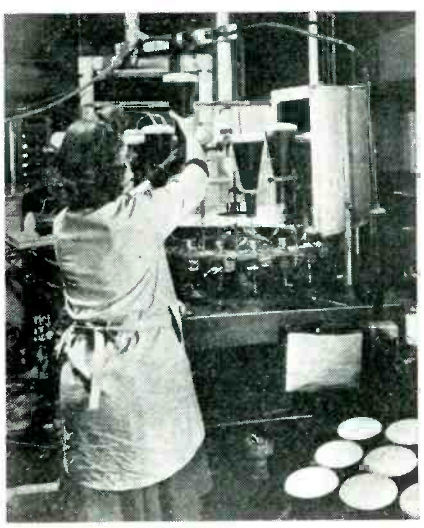
CATHODE-RAY TUBE FACTORY



After the sealing-in operation, cathode-ray tubes are baked, bombarded, evacuated and sealed on this machine. A complete tube leaves the machine every two minutes at the North American Philips plant system to omit the calibration reading entirely and to leave two blank spaces on the recording tape.

Use of Calibration Tape

In this manner, then, the dial readings at the calibration points are recorded. The actual frequency corresponding to any given dial reading is determined from the known frequency at the start of the calibration tape and the number of readings intervening. In practice, after the calibration tape has been completed by the machine, it is placed upon a ruled table which has marking lines corresponding to certain reference frequencies. In this manner, key frequencies (such as those which start each page of the finished calibration booklet) can be marked off.

The ruled calibration tape is then used to set up manually the interpolating machines, which supply ten interpolated calibration points for each one appearing on the tape and which simultaneously print the pages of the completed calibration book.

Credit is acknowledged to Mr. D. B. Smith and Mr. E. S. Brotzman who directed the development of the zero beat detector and the recording system respectively, and to each of the following for their in-

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SONDE BALLOON

U. S. Navy aerographers mates release a weather balloon with radio sonde equipment that will transmit signals indicating temperature, humidity, and air pressure at various altitudes. Official U. S. Navy photograph valuable contributions: W. Frear, F. Reed, W. Newbold, H. H. Harris, M. Ames, H. Brough, M. Riccardi, E. O. Thompson, I. Stephan, W. Mattison, A. F. Nickel, D. Karcher, C. Woll, W. Miller, A. Miller, H. Seher, W. Bareiss and F. Kotulka.

Appendix I

e_f = instantaneous voltage output of frequency meter

E_f = peak value of e_f

e_s = instantaneous voltage output of standard signal

E_s = peak value of e_s

e_{zb} = instantaneous value of zero beat voltage

E_{zb} = peak value of e_{zb}

θ_f = instantaneous value of the argument of the sine function representing e_f

ω_f = instantaneous periodicity of e_f

$= \dfrac{d\theta_f}{dt}$

ω_s = periodicity of standard signal

α = rate of change of $\omega_f = \dfrac{d\omega_f}{dt}$ (assumed to be constant)

ϕ_f = phase angle of frequency meter signal (value of θ_f at instant of zero beat)

ϕ_s = phase angle of standard signal

$\theta = \phi_s - \phi_f$

t = time measured from the instant of zero beat

$$e_f = E_f \sin \theta_f = E_f \sin \left(\int \omega_f \, dt\right)$$

$$\omega_f = \omega_s + \alpha t$$

$$\int \omega_f dt = \omega_s t + \frac{\alpha t^2}{2} + \phi_f$$

$$\therefore e_f = E_f \sin \left(\omega_s t + \frac{\alpha}{2} t^2 + \phi_f\right)$$

$$e_s = E_s \sin (\omega_s t + \phi_s)$$

The product of these two signals, as obtained in a mixer, neglecting all but audio-frequency terms, is

$$e_{zb} = E_{zb} \cos \left(\frac{\alpha}{2} t^2 - \theta\right)$$

Appendix II

If $\theta = 0$, then

$$e_{zb} = E_{zb} \cos \frac{\alpha}{2} t^2$$

for a calibrating time of 6 minutes,

$$\alpha = \frac{2\pi (4 \times 10^6 - 2 \times 10^6)}{360} = 3.5 \times 10^4.$$

Let T = value of t for which e_{zb} goes through its first zero values. Then

$$\frac{\alpha}{2} T^2 = \frac{\pi}{2};\ T = \pm 0.01 \text{ sec. and } t_1 = 0.02 \text{ sec}$$

Appendix III

Given the function $f_1(x) = \int \cos (x^2 + \theta)\, dx$ (1)

A second form of the function differing in phase by 90 deg is

$$f_2(x) = \int \cos \left(x^2 + \theta + \frac{\pi}{2}\right) dx = \int \sin (x^2 + \theta)\, dx \qquad (2)$$

It is desired to show that

$$[f_1(x)]^2 + [f_2(x)]^2 = f_3(x)$$

where $f_3(x)$ is independent of θ and its amplitude is equal to the square of the envelope of $f_1(x)$ plotted for all values of θ.

Expanding Eq. (1)

$$\begin{aligned} f_1(x) &= \int \cos x^2 \cos\theta dx - \int \sin x^2 \sin\theta dx \\ &= \cos\theta \int \cos x^2 dx - \sin\theta \int \sin x^2 dx \\ &= C\cos\theta - S\sin\theta \qquad (3) \end{aligned}$$

where $C = \int \cos x^2 dx$, and $S = \int \sin x^2 dx$

Similarly

$$f_2(x) = C\sin\theta + S\cos\theta \qquad (4)$$

$$[f_1(x)]^2 + [f_2(x)]^2 = C^2 + S^2 = f_3(x) \qquad (5)$$

and $f_3(x)$ is obviously independent of θ.

Let Eq. (4) represent the general function. To determine the amplitude of the envelope at any point, x, the function must be maximized with respect to θ, holding x constant:

$$\frac{d}{d\theta}\left[C\sin\theta + S\cos\theta\right] = C\cos\theta - S\sin\theta = 0$$

$$\tan\theta = C/S \quad (6) \qquad \sin\theta = \frac{C}{\sqrt{S^2 + C^2}} \quad (7)$$

$$\cos\theta = \frac{S}{\sqrt{S^2 + C^2}} \quad (8)$$

Substituting (7) and (8) in (4)

$$\tan\theta = C/S \qquad (6)$$

$$\sin\theta = C/\sqrt{S^2 + C^2} \qquad (7)$$

$$\cos\theta = S/\sqrt{S^2 + C^2} \qquad (8)$$

Substituting Eq. (7) and (8) in Eq. (4) gives

$$\text{Envelope} = C\frac{C}{\sqrt{S^2 + C^2}} + S\frac{S}{\sqrt{S^2 + C^2}} = \sqrt{S^2 + C^2} \qquad (9)$$

The square of Eq. (9) is equal to Eq. (5), which was to be proved.

Appendix IV

In Appendix I, let the constant frequency signal change in phase by 90 deg. Then

$$e_s = E_s \sin(\omega_s t + \phi_s + 90°).$$

Thus

$$e_{sb} = E_{sb}\cos\left(\frac{\alpha}{2}t^2 - \theta - 90°\right) = E_{sb}\cos\left(\frac{\alpha}{2}t^2 - \theta'\right), \text{ which}$$

is the same zero beat wave except that $\theta' = \theta + 90$ deg.

PAY FOR RADAR RATINGS in the British Royal Navy has been increased, ranging from 2s. a day for instructors to 3d. a day for new ratings. Special badges are not issued to the officers and ratings in the radar branch.

NEW BOOKS

Electron-Optics

By PAUL HATSCHEK *(translated from German by Arthur Palme), American Photographic Publishing Co., Boston 15, Mass., 1944, 161 pages, price $3.00.*

A PLAIN-LANGUAGE presentation, without mathematics, of the fundamentals of electron lenses produced by electric and magnetic fields for use in electron tubes. The book was written in 1935 and 1936, and was intended for those having no previous knowledge of this field, then in its infancy. The translator has added one chapter surveying the progress made in electron optics since that time, with emphasis on the electron microscope.

The book could well serve as an elementary textbook covering one phase of electronics, building a broad groundwork necessary for understanding new developments. Teachers of electronic subjects may glean useful ideas for improving their lectures from the many analogies and simple step-by-step explanations of how electron beams are bent in television tubes, amplifiers, multipliers and other electron tubes.—J.M.

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The Mathematics of Physics and Chemistry

By HENRY MARGENAU, *Associate Professor of Physics, and* GEORGE MOSELEY MURPHY, *Assistant Professor of Chemistry, both of Yale University. D. Van Nostrand Company, New York, 1943, 581–xii pages. Price $6.50.*

A COMPACT COLLECTION of many of the important advanced mathematical techniques used in modern theoretical physics and chemistry will be found in this book. Engineers interested in wave radiation and propagation, the modes of oscillation of cavity resonators, heat flow, noise, linear electric networks, or the approximate solution of certain algebraic, transcendental, or ordinary differential equations can well find in it a ready review of pertinent abstract relations.

In the main the level is that suitable for engineering graduates, although certain parts assume a more advanced background in mathematics or in quantum physics and chemistry.

A highly condensed treatment makes the volume more appropriate as a reference or expanded handbook than as an introduction to the topics treated. These are: the mathematics of thermodynamics; ordinary differential equations; orthogonal polynomials; vector analysis; vector and curvilinear coordinates; calculus of variations; partial differential equations of classical physics; proper values and proper functions; mechanics of molecules; matrices and matrix algebra; quantum mechanics; statistical mechanics; approximate solutions; linear integral equations; and group theory.

The frequency of misprints is a little high, the usual mark of a first printing. For the most part the corrections are evident. An unfortunate error occurs in the expansion of the generating function of the Tschebyscheff Polynomials on page 128. Here $n!$ should be deleted. Also in the definition of these polynomials in equation (2-54), page 74, the second (n-3) should be (n-4). Disconcerting to the mathematically minded is the omission of restrictive conditions on various relations, and the apparent absence of limit processes in setting up differential equations. For an example of the latter see pages 147 and 148. Also the incomplete statement of a few problems might disturb a reader not familiar with these problems. Problem a of page 39 illustrates the point.

The influence of German literature crops out at various points, such as: in deviations from the American partial-derivative notation on pages 3, 82, and 83; the designation of the equation of a series LR circuit with constant applied voltage as "Helmholtz's equation" on pages 39 and 42; the assignment of Gauss's name to the "normal" distribution curve discovered by DeMoivre in 1753; and the preference for "eigen" over the short English equivalent "proper". This last preference is fairly common in quantum literature, however.

As far as time variations are concerned the treatment covers the steady state nearly exclusively. Lack of interest in transients is shown by remarks on page 55 where it is stated that the complementary function is of little interest in physical

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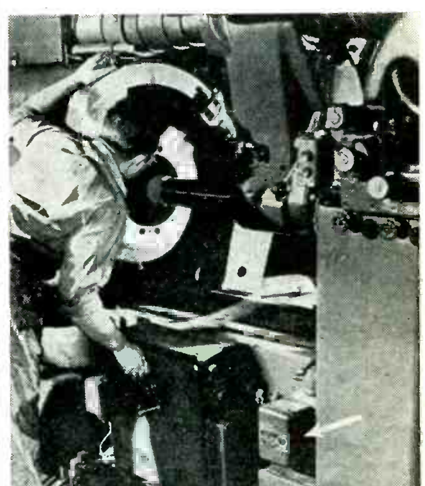
ELECTRONIC TIME DELAY



Grinding concentric bores in motor stators is controlled by an electronic time-delay relay, shown by the arrow, that stops the operation. The General Electric timer is preset for the amount to be ground and the size of the grinding wheel applications because it decays exponentially with time and will be damped out eventually.

Refreshing touches appear in the handling of some of the conventional topics. An example is the footnote on the many mathematical uses of the word "homogeneous". The reader will appreciate the examples and the problems with answers scattered through the text. Quantum physics and even recent nuclear questions are treated in an up-to-date manner. The same cannot be said of several of the mathematical topics. A moderate number of references to other literature, especially books, is included.

Briefly then, Margenau and Murphy have collected in one book a wide expanse of mathematical methods whose treatment in consequence is somewhat sketchy.—J.L.B.

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Physical Foundations of Radiology

By OTTO GLASSER, *Professor of Biophysics, Cleveland Clinic Foundation,* EDITH H. QUIMBY, *Associate Professor of Radiology, College of Physicians and Surgeons, Columbia University,* L. S. TAYLOR, *Chief of X-Ray Section, National Bureau of Standards, and* J. L. WEATHERWAX, *Philadelphia General Hospital and Graduate School of Medicine, Univ. of Pa., published by Paul B. Hoeber, Inc. (Medical Book Dept. of Harper & Bros.), New York 16, 1944, 426 pages, price $5.00.*

A POOLING of teaching experiences to provide an elementary and non-mathematical textbook suitable for two groups: physicians preparing to enter the field of radiology, and physicians already in this specialized field but desirous of review or further information. It answers the demand by students of radiology for serious instruction in radiation physics, and includes considerable information on nuclear physics to provide a background for keeping up with current developments. Throughout the book, the fundamental aspects of radiologic physics have been stressed, and the chapters on x-ray diagnosis and on biologic effects of radiation are deliberately written to be stimulating rather than complete.

The nineteen chapters, each concluded with a bibliography, cover history, concepts of matter and radiations, high-voltage generators, roentgen ray tubes, production and nature of x-rays, diagnostic procedures, measurement of x-ray dosage and quality, radioactivity, measurement of gamma rays, neutrons and artificial radioactivity, biologic reaction, therapy records, and roentgen ray and radium protection. An appendix contains 16 pages of roentgen ray depth dose tables.

The book is highly recommended, for the quality of its illustrations and the excellent editorial welding together of chapters by four different authors as well as for the clarity and technical merits of the text matter. With the rapidly increasing importance of electronics in medicine, especially in the utilization of recently discovered artificially radioactive materials, it becomes practically compulsory reading for workers in radiologic physics and all related fields.—J.M.

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A.S.T.M. Standards on Electrical Insulating Material

By A.S.T.M. COMMITTEE D-9, *American Society for Testing Materials, 260 S. Broad St., Philadelphia 2, Pa. 1944 (issued annually), 502 pages, paper cover, price $2.75.*

NEW MATERIAL in this year's edition gives requirements for phenolic molding compounds, laminated thermosetting materials, vulcanized fiber sheets, rods and tubes, natural block mica and mica films suitable for use in fixed mica capacitors, orange shellac and other lacs, pin-type lime glass insulators, and tensile properties of plastics. Eight standards cover insulating varnishes, paints, lacquers and their products, three cover mineral oils and five are related to ceramic products such as glass, porcelain and steatite. Two tables of contents, one in numeric sequence and the other grouped by general subjects, together with a 17-page subject index speed locating of desired data.—J.M.

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Illustrated Technical Dictionary

Edited by MAXIM NEWMARK, *The Philosophical Library, New York, 352 pages, price $5.00.*

A COLLECTION of officially approved standard definitions obtained from engineering, trade and industrial organizations and government agencies, with emphasis on terms dealing with standards and measurements, practical applications of mathematics, chemistry and physics, aeronautics, electricity, radio, synthetics, plastics, automotive mechanics, and shipbuilding. Broad coverage has also been given to fields of current importance in the war effort, to subjects listed in pre-induction outlines and to subjects encountered in technical and vocational schools.

Features of the book include strictly alphabetical listing of compound terms (not as "microscope, electron"), a comprehensive system of cross references, excellent use of approximately 90 illustrations to clarify difficult terms, and good representation of new terms like Dzus fastener, alclad, lucite, radar, etc.

The term radar is defined thusly: *Abbreviation for "Radio Detecting And Ranging" apparatus. It is based on the principle that ultra high-frequency radio waves radiating through space are reflected from the surface of objects within the field of radiation. The direction* *of such an object in space can be determined by a directional antenna array, and its distance can be determined by the time required for the reflected waves (the "echo") to travel back to their point of origin. Also called "radio locator".*

A five-part Appendix contains American standard abbreviations, units of weight and measure, temperature interconversion tables, a table of chemical elements, and geometrical shop data.

Though primarily intended for engineering, technical and trade libraries, the book should also prove valuable to general libraries and to teachers and students of engineering, scientific and vocational subjects.—J.M.

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The Radio Amateur's Handbook

By STAFF OF AMERICAN RADIO RELAY LEAGUE, *480 pages of text and 184 pages of advertising and index. Price, $1.00. Twenty-first edition, 1944. American Radio Relay League, West Hartford, Conn.*

SINCE AMATEUR radio stations are silent for the "the duration" The Radio Amateur's Handbook has temporarily lost its primary function—that of providing the fundamentals of radio and practical constructional data to radio amateurs. But the Handbook has found an equally important war-time function in the training of radio personnel for war activities and in presenting practical data on high frequency techniques in which radio amateurs have always been specialists.

The twenty-first edition does not differ at all from its predecessor in intent, general scope, or method of treatment; the theoretical and constructional portions remain separated. Only in relatively minor matters is the text changed to bring it more nearly in line with current needs. A chapter on carrier current communication has been added and the chapter on war emergency radio service has been expanded and rewritten.

The value of the Handbook may best be judged when it is realized that the present editions brings to more than 1,120,000 the number of copies which have been printed. —B.D.

Bibliography and Abstracts on Electrical Contacts

By A.S.T.M. COMMITTEE B-4 *(chairman—Erle I. Shobert, II, Stackpole Carbon Co.), American Society for Testing Materials, 260 S. Broad St., Philadelphia 2, Pa., 1944, 137 pages, price $5.00.*

A COMPILATION of 837 references to the literature appearing between 1835 and 1943 on the subject of electrical contacts, arranged in chronological order, with practically all references since 1910 being accompanied by abstracts taken from *Science Abstracts, Chemical Abstracts* and other sources or specially prepared by members of the committee. A subject index divides the bibliography into the following groups of references on separate problems and details involved in the subject of electrical contacts: General; Contact Materials; Circuit Breaker Design and Testing; Relays; Stationary Contacts; Sliding Contacts; Misc. Contact Applications; Contact Resistance and Temperature; Electric Arc as Applied to Contacts; Electric Arc in General; Spark Discharge; Glow Discharge; Low Voltage Arc; Contact Wear; Circuit and Circuit Parameters as Applied to Contact Operation. In addition, an author index is provided for those wishing to follow the work of a particular individual. A three-page key to abbreviations of publications is in itself a valuable reference to anyone having need to decipher abbreviations of foreign publications.—J.M.

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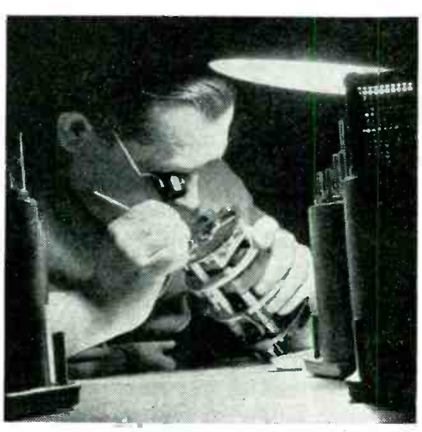
NAVY WIDE-SCALE METER



This worker is making final adjustments on a 150-kw polyphase circular scale instrument. The scale covers a 250 deg arc as required on U. S. Navy switchboard installations

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronic industry or comment on articles which ELECTRONICS has published.

Voltage Doublers

On page 354 of the March 1944 issue of Electronics and in your "Backtalk" Department appear two diagrams of a series line feed or half-wave doubler with a common cathode condenser.

We believe it is in order to call your attention to the fact that this is a patented circuit and is covered by U. S. Patent No. 2,172,692, assigned to P. R. Mallory & Co., Inc. This circuit is described in detail on page 59 of our MYE Technical Manual.

R. M. Ellis
P. R. Mallory & Co., Inc.

Recording

Re: Mr. Donald F. Pennie, p. 357, March 1944:

(1) *Why* does "compression in one axis of the sound track dimension require compression in the other"? (Your guess is as good as mine).

(2) (From the Inability-to-see-forest-because-of-trees Department).

Re: the electronic recording system in general:

(a) As the so-called "aperture" in this case is obviously nothing but the actual cathode-ray spot itself, the whole question boils down to the possibility of obtaining a small enough ratio of spot size to total available screen area to insure a record of practical playing time. As television experience has arrived at 441 lines as a practicable amount of resolution obtainable with modern cathode-ray tubes, we will use this figure in the discussion.

(1) 441 × 441 equals 194,481, or

the number of individual elements.

(2) For a scanning aperture of ½ wavelength and an upper frequency limit of 9000 cps (motion picture practice) we arrive at a figure of 18,000 scanning elements per second.

(3) 194,481/18,000 equals about 11 seconds, the playing time of the record.

Assuming that a short recording like this might have a limited usefulness for some purposes, I suggest that surplus inventive energy be devoted to the slight problem of tracking and avoidance of cross-talk between lines.

(b) Mr. Pennie's suggestion of a mechanical system obviously removes the "electronic" from the proposal, and takes most of the fun away. I suggest as a further refinement that the scanning source be made fixed, and the record move past it. A drum might be covered with tinfoil, for instance, and slow, stable motion imparted to it with a hand crank.

JOHN R. COONEY
Waldoboro, Maine

More on Recording

THE FOLLOWING NOTE on recording is probably not original, but the writer has seen no mention of it in the literature and it is perhaps worthy of particular attention in these days of conservation.

The maximum playing time of a disc record is realized when the recorded surface extends from the outside of the record to half way toward the center and no further. To carry the recording beyond this point represents a loss of fidelity or a waste of possible recording time.

In the final analysis the factors which limit the amount of time that can be recorded on a record are the material of the record and the required fidelity of the recording. These two factors together determine the minimum allowable velocity of the groove with respect to the stylus. Consideration of this leads directly to the conclusion stated in the paragraph above.

The playing time, T, of a disc record, may be written:

$$T = (R - r)\frac{n}{\omega}$$

(*Continued on page* 360)

where: R is the outer radius of the recorded surface
r is the inner radius of the recorded surface
n is the number of grooves per unit radius
ω is the angular velocity (rpm if T is minutes.)

The minimum track velocity occurs at the inner radius, r. Suppose, then, that the required fidelity and the recording material determine v, the minimum allowable track velocity. Then:

$$v = 2r$$

$$\text{or } \omega = \frac{v}{2\pi r}$$

Substituting this value for ω in the first equation, differentiating with respect to r and equating to zero, gives,

$$R = 2r$$

The outer radius, R, is determined by the diameter of the record, hence turntable speed should be chosen according to the formula:

$$\omega = \frac{v}{\pi R}$$

There are several outstanding advantages in adhering to the foregoing relationships, not the least of which is the greatly increased wearing time of a record recorded only half way in. The outstanding disadvantage is, of course, the necessity of changing the turntable

(*Continued on page* 366)

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ELECTRONIC CHARTS

Used principally in the Westinghouse electronics laboratory and experimental factory, charts by Willard Lund teach assemblies to untrained as well as experienced operators. A simple chart that showed tubulating a small glass exhaust tube to the main bulb reduced rejections by about 25 percent

POSITIONS VACANT

SALES ENGINEER WANTED, Chicago territory, for established manufacturer of metal fasteners widely used by industry on war and peacetime products. Prefer resident Chicago area, age 30-35 with engineering training. Give full details, education, experience, draft status, age, salary expected and recent photograph. Require statement of availability if engaged in war work or essential activity. P-615, Electronics, 330 W. 42nd St., New York 18, N. Y.

DESIGN ENGINEER wanted to direct the Design as the Idea man of Special Test Sets for checking and testing important units of Electronic Equipment Essential to the War Effort and in High Priority groups. Graduate Electrical Engineer with Electronic experience wanted. Yearly salary. Location near Atlantic Coast. Write outlining Education, experience and basis of availability. P-658, Electronics, 330 W. 42nd St., New York 18, N. Y.

GRADUATE ELECTRICAL ENGINEERS or men with equivalent industrial experience, for the development and design of pocket size radio and audio frequency equipment. We are especially interested in qualified engineers looking to the post war period who, at present, are not being used in their highest skill or capacity. The company is well established in the electronic field, located in the suburbs of a large metropolitan city in New England. P-659, Electronics, 330 W. 42nd St., New York 18, N. Y.

SOUND ENGINEER—to estimate and make layouts on industrial and marine sound and intercommunicating systems. Must be experienced. Post war opportunity. P-660, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRICAL ENGINEER to do experimental work in developing radio tube making equipment. Position offered is that of equipment design engineer on advanced developmental project. Applicants having previous training in radio tube or lamp manufacturing equipment preferred. However, applicants having qualified technical background and ability will be considered. Write RCA Victor Division, Lancaster, Pa.

(Additional Position Vacant ads on pages 362-365)

EMPLOYMENT AGENCY

ENGINEERS — Mechanical—Industrial—Electrical—Chemical—Civil—Architectural, etc. Our specialized service to Technical and Scientific men only, for over 50 years, continuously at the same address, enables us to offer a fine selection of positions for high grade Manufacturing Executives, Production Managers, Metallurgists and Technical men of all types. The Engineering Agency, Inc., 53 W. Jackson Blvd., Chicago 4, Ill.

POSITION WANTED

CONSULTING ENGINEER (electrical & mechanical) complete laboratory facilities. 15 years practical experience electronics & relay controlled systems, instruments, motion picture sound recording installations, broadcasting equipment. Authority on ground systems. Art Davis, 1508 W. Verdugo, Burbank, Calif.

REPRESENTATIVE WANTED

MANUFACTURER of wire wound, vitreous enameled resistors interested in securing representatives for various territories. RW-668, Electronics, 330 W. 42nd St., New York 18, N. Y.

FOR SALE

FOR SALE: 2 high frequency generators, 2 k.w. output, 3 phase, up to 50 megacycles, suitable for experimental work only. FS-667, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

WANTED

WANTED—RCA type 931 or 931A tubes from individual or company. Can supply AA-1 priority. Reply W-661, Electronics, 68 Post St., San Francisco 4, Cal.

(Additional Wanted ad on page 362)

I DO NOT Know all about corporation law, finance and everything else—But

I am a good Production and Sales Manager

with many years experience in the appliance field. Am thinking of making a change; am now successfully managing an Electronics business. Present earnings $15000—but most interested in Post-War opportunity and have some good ideas.

PW-666, Electronics
520 North Michigan Ave., Chicago 11, Ill.

WANTED

SALES ENGINEER

Excellent wartime and post war opportunity for the right man, covering Chicago territory for a manufacturer whose products are well known and widely used, especially in the electronic field. Applicant must have engineering training or at least five years of practical experience in engineering or manufacturing. Prefer man between 30 and 35 years of age. Write stating details of education, age, previous connections, experience and salary. If already engaged in war work, require a statement of availability. Address

SW-652 Electronics
330 West 42nd St., New York 18, N. Y.

NEW LINES
WANTED

Manufacturers' agent with technical personnel located in Chicago, contacting electrical manufacturers and automotive manufacturers, wish to add new lines. Raw materials preferred. Established over forty years. Cover Illinois, Indiana, Ohio, Michigan, Wisconsin, Minnesota and Iowa. Interested in development postwar era.

RA 657, Electronics
520 North Michigan Ave., Chicago 11, Ill.

Attention Manufacturers

**Do your planting and weeding early
Be ready to harvest when Victory comes.**

Plan your distribution now, be ready for your post war production output.

Of course you must continue on war production work day and night to speed that final day. Therefore, post war business is the furthest from your mind now. But to plan then, in a short space of time, would be an expensive problem.

As a manufacturers representative for over 15 years in the New England and New York territory, constantly calling and talking to various distributors of radio and appliance lines, I find these progressive distributors are anxious to plan now as to "Whose" lines they will carry. Together, we are planning. Why not You be the "Whose" line the distributor will sell.

With my past record of volume business and established clientele, I could help you in establishing your product with the cream of the crop in this territory.

Your inquiry will be held strictly confidential.

RA-649 Electronics
330 W. 42nd St., New York 18, N. Y.

Established manufacturers representative and associates contacting midwest industries desire one more industrial and one radio parts line.

RA-653, Electronics
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Your Invitation

When in Boston (Beantown) let us know — We will be glad to acquaint you with the places to go, and see, including our new 4 story display storage and office building at 885 Boylston Street.

ANOTHER SOURCE OF SUPPLY

Send your name to us and get on our mailing list. We distribute standard brand lines, and have available choice items in electrical and radio specialties. Let us know your wants.

Write—Phone—Wire

THE LOUIS M. HERMAN CO.
885 Boylston St., Boston 16, Mass.
KEnmore 3720-3721-5154

FREELAND & OLSCHNER PRODUCTS, INC.

**REBUILDERS OF
RADIO TRANSMITTING TUBES**

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**BEST QUALITY, USED
ELECTRON TUBE MACHINERY**

Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

AMERICAN ELECTRICAL SALES CO., INC.
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WANTED — SURPLUS

Radio Parts of every description—Radio Hardware of all types—Screws, Nuts, Solder Lugs, Rubber Grommets, Hookup Wire, Etc.
We particularly seek government cancellation or rejected material

LOUIS GANCHER CO.
50 West Broadway, New York 7, N. Y.
"In Radio Since 1921"

AMERICAN MANUFACTURERS *of* ELECTRICAL *and* ELECTRONIC INSTRUMENTS

which they desire to introduce to the British Market are invited to send particulars of their products to —

THE ELECTRICAL APPARATUS CO., LTD.
ST. ALBANS, ENGLAND

ADDITIONAL EMPLOYMENT ADS ON PAGES 276, 324 & 353

Electrical, Radio Engineers Technicians, Laboratory Assistants

wanted for important war work

Interesting development work and test equipment design for mass production of electro-acoustical devices. Experience in electronics, acoustics or audio desirable.

Good opportunity to get familiar with latest in audio and acoustical laboratory equipment and to do interesting research work.

Excellent working conditions and postwar opportunities with long established manufacturer.

Call or write to:

Chief Engineer

DICTOGRAPH CORPORATION

95-25 149 Street, Jamaica, New York

Near LIRR station.
(18 minutes from Pennsylvania Station.)

WANTED

ELECTRONIC ENGINEERS

A well established company of excellent reputation located in the east, offers permanent position to a few engineers who have educational training and background in Electronic engineering or Physics. Unusual opportunities offered men who possess originality and initiative in connection with research and developments relating to television, radio, sound reproduction and other applications. Write full particulars relative to education and experience.

P. 635, Electronics, 330 West 42nd St., New York 18, N. Y.

Per[illegible] Employment

ELECTR[illegible]C DEVELOPMENT [illegible]IGINEERS

Well-established Eastern Massachusetts concern desires graduate electronic engineers with flair for research and eye to future. Permanent position concerned at present with important development work for government with increased opportunities after the war. Unusual openings for men with capacity and initiative. Must be U. S. Citizens.

P-670, Electronics
330 W. 42nd St., New York 18, N. Y.

WANTED

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By leading television and electronics organization in Manhattan a number of first class engineers specialized in Electronics, Physics, Physico-chemistry, and High-vacuum Technique, for research and development mainly on most important post-war products. Give full details of experience and salary. Replies held in strictest confidence.

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ENGINEERS DRAFTSMEN

Openings for Mechanical or Electrical Engineers with college degree or equivalent, preferably with engineering experience in the manufacturing field. Work is on government projects and involves analyzing manufacturing data and drawings, making tool and machine analysis and making manufacturing layouts, developing of assembly methods which involves a specific knowledge of metal working machines, machine tools, jigs, fixtures, punches and dies and testing equipment.

Also several vacancies for Draftsmen who have had experience either in designing or detailing machinery and mechanisms.

War Manpower regulations will be observed.

Write to:

Employment Manager

WESTERN ELECTRIC CO.

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Baltimore—24, Maryland

RADIO ENGINEERS

WANTED

For laboratory design and development work we are interested in radio engineers with a college degree in communication engineering or physics or with the equivalent in radio design experience. We wish to add to our staff competent engineers for work on war products now and later to participate in our post-war development program.

Write, giving full details as to education, age, experience, family and draft status and salary desired.

If you are now engaged in essential industry at your highest skill please do not apply. We will welcome correspondence from honorably discharged service men who can qualify as radio engineers. Applicants living outside the Chicago area must obtain a "Statement of Availability" from their nearest U. S. Employment Service office.

MAJESTIC RADIO & TELEVISION CORPORATION

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WANTED

PRODUCT DESIGNERS AND DETAILERS

Work on small electro-mechanical devices. Excellent postwar prospects. Must comply with W.M.C.

Address reply to:

LEAR AVIA, INC.

Piqua, Ohio **Att: R. J. Biggs**

WANTED

Electronic Engineer

Electronic Engineer for Development Department of large industrial instrument company. Post War Position. Thorough design knowledge of tube circuits, oscillators, filters, modulators required. Experienced with servo mechanisms desirable. Location New England. Write detailed experience, draft status, availability.

P-669, Electronics
520 North Michigan Ave., Chicago 11, Ill.

SURPLUS PARTS WANTED

RADIO AND ELECTRONIC PARTS

All Field

Tubes, Phonograph Motors, Pickups, Condensers, Resistors, etc.—Any Quantity—Samples Appreciated

What do you need?

EDWARD BLOCK

53 Bancroft St., Springfield 7, Mass.

company that makes strictly for its own use, to be played only on its own turntables, the disadvantage is small. To the amateur who does his own mechanical work and records for pleasure, it is practically no disadvantage; the writer has found that, taking into consideration the high frequency response of his cutting head, about eight minutes can be put onto a cheap ten-inch disc without serious loss.

SUTHERLAND MACKLEM
Research Enterprises Ltd.
Leaside, Ontario

Inductance Bridge

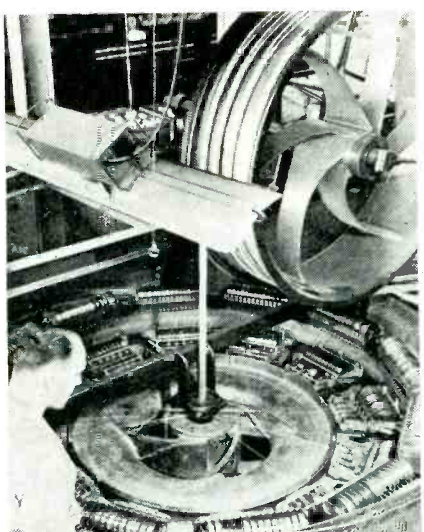
SEVERAL QUESTIONS have arisen in connection with Mr. Mittleman's article in February ELECTRONICS ("Inductance Bridge for Communication Circuits.") The following comments, contributed by Mr. Mittleman should be useful to readers who have been interested in this article.

The maximum inductance which it is practical to measure on this bridge is about 250 microhenries as the instrument has been described.

The 25,000 ohm resistor in the cathode circuit of the 6C5 tube is intended to establish the initial op-

• • •

WIRE WEAVER



This basket-weaving machine braids wire sheathing on a cable for naval use. The machine weaves 360 wires at one time and was shown in U. S. Steel's annual report for 1943

ADVERTISERS IN THIS ISSUE

erating condition of the vacuum-tube voltmeter. In the absence of a signal, the cathode resistor is adjusted until the plate current of the 6C5 reads 1 milliampere, normal plate current as indicated in the schematic diagram.

The abbreviations S.L.F. and S.L.C. have been used for about two decades to mean "straight line frequency" and "straight line capacitance" when applied to condensers. An S.L.F. condenser is one in which capacitance varies in such a way that the frequency of a tuned circuit is proportional to the angle of rotation of the rotary plate. On the other hand, an S.L.C. condenser is one in which the capacitance is directly proportional to the angle of rotation of the rotary plate.

Condenser C_o should be shown as a variable condenser. This is the zero adjustment shown as the small condenser in the center of the panel just above the binding post. The condenser C_c shown in the schematic wiring diagram as 300 $\mu\mu$f S.L.C. is in reality an adjustable condenser which is fixed in capacitance once it is adjusted. The other two condensers shown associated with switch Sw_2 should be variable as shown.

B. DUDLEY
Western Editor, ELECTRONICS
Chicago

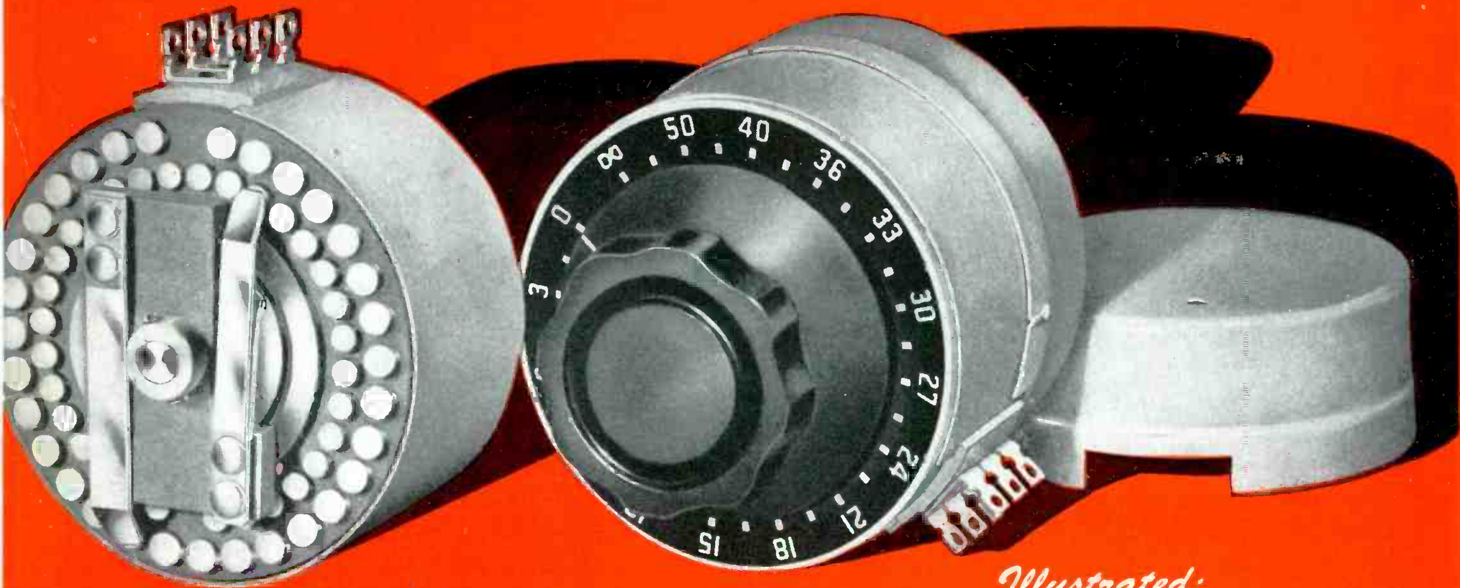
• • •

FIREMAN'S WALKIE-TALKIE

Used to direct firemen from the street at a recent fire in New York City, this walkie-talkie is tested by assistant fire chief John J. McCarthy. The fireman at the right is contacting fire headquarters with a two-way radio-telephone in the car

DAVEN PRESENTS AN IMPROVED

LINE OF FAMOUS ATTENUATORS • • •



Illustrated:
TYPE 330-G WITH DETENT

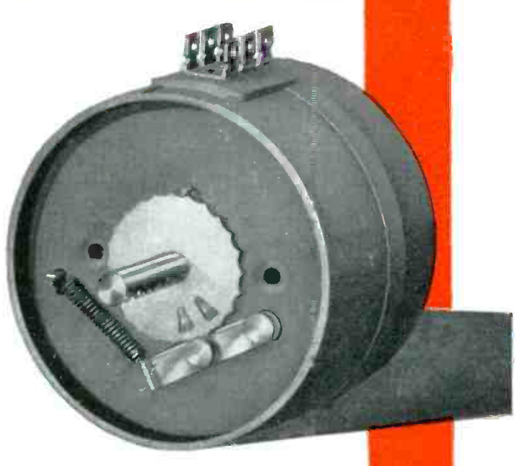
NEW DETENT GEAR *(Indexing Device)* Preferred by leading laboratories and accepted by United States Signal Corps, Navy and other governmental agencies. The new DAVEN Detent Gear provides more positive action, greater degree of accuracy, more uniformity in operation, longer life and a stronger stop mechanism.

NEW MATERIALS The contacts and switches of these attenuators are made of tarnish-proof silver alloy, giving uniform and definite electrical contact. Cleaning and lubricating of the contact points are now completely eliminated.

NEW TYPE STEEL COVER More rugged than heretofore, this DAVEN designed cover affords improved magnetic shielding. The body of the cover forms an integral part of the attenuator assembly, protecting the resistors. A snap-on cap gives ready access to switch blades and contacts.

This improved line of attenuators is the result of DAVEN'S persistent search for better methods. These attenuators are noise-free in operation . . . supply positive values for each setting of the dial . . . and will meet the most rigid specifications. In broadcasting, television, sound studios, commercial communications and electrical laboratories, where quality of performance knows no compromise — depend on DAVEN attenuators.

BACK THE ATTACK...KEEP BUYING MORE WAR BONDS



Front View of Detent Mechanism. Attenuators without detents available in standard and special DAVEN models.

THE **DAVEN** COMPANY
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

HOW TO SELECT PHOTOTUBES

PHOTOTUBES have found such a wide variety of applications that many types have been developed to meet special needs. The complete RCA line includes both gas-filled and high-vacuum phototubes, with various spectral responses and a variety of sizes and shapes. And for applications requiring extreme sensitivity, RCA supplies multiplier phototubes.

A phototube acts as a light-actuated electric valve. (It does *not* convert light energy to electrical energy, but acts only as a control device.) The current passed is in proportion to incident light. Some phototubes are "high-vacuum" types; some are filled with an inert gas (such as argon) to increase current-carrying capacity.

A multiplier phototube contains additional electrodes (dynodes) which emit secondary electrons and thus greatly increase sensitivity and output current as compared to 2-electrode phototubes.

Color Sensitivity: The cathode coating material and the envelope glass determine color sensitivity. RCA phototubes fall into five "color groups":

Use	Tube Types	Maximum Color Sensitivity
With incandescent lamps	High vacuum: 925, Gas-filled: 868, 920, 924, 927*, 928	Red and infra-red
With incandescent lamps—and for infra-red application	High vacuum: 917, 919, 922*. Gas-filled: 918, 921*, 923, 930*	Similar to above, but sensitivity extended further into infra-red
With light source for colorimetry application	High-vacuum: 926	Blue light. Approximates the human eye
With daylight, carbon-arc, or mercury-vapor light source	High-vacuum: 929*, 934. Multipliers: 931-A*, 1P21	Blue light. Very sensitive to incandescent light at a color temperature above 2700° K.
For ultra-violet measurement	High-vacuum: 935, 1P28	Same as above, but special glass envelope permits high ultra-violet sensitivity

*An RCA Preferred Type Tube

Color response curves are available on all RCA phototubes.

Vacuum- or Gas- or Multiplier-Type? Several important factors to be considered in selecting the general type of phototube for a service are given in the following table. Specific values should be considered in selecting the actual tube type.

Characteristic	High-Vacuum type	Gas-filled type	Multiplier type
Sensitivity	Low	Medium	Very high
Current Output	Low	Medium	Very high
Amplification factor	1	Up to 10	Up to 1,000,000
Relative signal-to-noise ratio (including amplifier stage)	Low	Intermediate	High
Anode Volts	Up to 500	Not over 90	Up to 1250
Distortion (audio)	Negligible	Appreciable in some cases	Negligible
Frequency Range	Limited largely by circuit	Limited by tube performance	Limited largely by circuit

Gas-filled phototubes are, at present, extensively used for sound-on-film reproduction and for relay work. Vacuum-types are widely used where high sensitivity is needed; for precision measurement where stability of calibration is essential; and for high-speed work.

Sensitivity: The sensitivity of a phototube may vary according to whether the light change is abrupt or continuous. *Static sensitivity* is the ratio of anode direct current to constant light flux. *Dynamic sensitivity* is the ratio of the variation of anode current to the variation of light input. The sensitivity of gas-filled phototubes drops off as light-source frequency increases.

Optical Systems: The use of phototubes usually involves some sort of optical system. The fundamentals of optics must be carefully considered in the successful application of phototubes.

Mechanical Features: As illustrated at left, several types of tubes are available. Size, vibration, directional requirements, etc., all may influence the choice of one of the many RCA phototubes.

Phototube Life: Phototubes are inherently sturdy, long-lived tubes and when operated under recommended conditions, give extended reliable service.

Application Hints: Here are a few general suggestions on applying phototubes:

1. In relay and measurement circuits where tubes must respond to very small amounts of light, avoid leakage currents outside tube. Keep tube terminals and sockets clean. Erratic leakage currents will affect results.
2. In amplifiers where low leakage is important, select top cap types such 917, 919, or 935.
3. Shield phototube and leads to amplifier or relay tubes when amplifier gain or phototube load resistance is high.
4. Where high-frequency response is important keep phototube leads short to minimize capacitance shunting of output.
5. For constant calibration of high-precision vacuum phototube devices, keep anode voltage at or below 20 volts. Keep incident light spread over wide cathode area.
6. Design or circuit constants should be based on tests with the equipment operating over the expected range of line-voltage variation.
7. RCA voltage-regulator tubes can improve phototube circuit performance.
8. Anode characteristic curves on phototubes can be used to predict performance under given operating conditions.

What Phototube Do You Need?

Due to space limitations, the suggestions presented here are brief and in a condensed, summary form. If you have a specific application problem or wish to discuss your phototube requirements with us, write to RCA, Commercial Engineering Section, 713 S. Fifth Street, Harrison, N. J. For further published information on RCA Phototubes and how to use them, send the coupon at left.

Send for this valuable data

Free to electronics engineers: "RCA Phototube Booklet," complete with 11 typical circuit diagrams, curves, tables, and clearly written text. Address:

FREE!

RCA, 713 South Fifth Street, Harrison, N. J.

Please send free phototube data to:

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RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION • CAMDEN, N. J.

The Magic Brain of all electronic equipment is a Tube and the fountain-head of modern Tube development is RCA.