APRIL · 1945

electronics

A McGRAW-HILL PUBLICATION

electronics

APRIL • 1945

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DEPARTMENTS

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CD-604, CD-605 TRANSFORMER-CORD SETS

UTC production facilities for these Signal Corps headset adapters permit acceptance of additional quantity orders for quick delivery. Also available in hermetic construction.

ALL PLANTS

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

United Transformer Corp.

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...one of many Westinghouse contributions to progress in electronic and communications equipment design

Micarta "444" is one of many Westinghouse products developed especially to meet engineers' demands for their new designs.

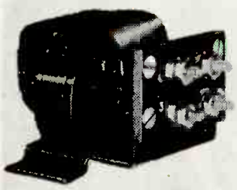
Here is a quick check list of some important Westinghouse developments . . . what they are, where to use them, what they will do. Like Micarta, each possesses characteristics giving designers greater freedom and flexibility.

Your nearest Westinghouse office can give you complete data on any of these exceptional communications products. Ask for the book number shown in parentheses on each item.

A QUICK CHECK LIST OF SOME WESTINGHOUSE COMMUNICATIONS PRODUCTS

MATERIALS

Hipersil Cores . . .



Ready - to - assemble Hipersil cores have ⅓ greater flux-carrying capacity and eliminate time-wasting stacking of tissue-thin laminations by hand. (B-3223-A)

Tuffernell Insulating Materials . . .

Developed during 50 years of field experience, Westinghouse "Tuffernell" insulating materials supply the *right* grade needed for numberless communications jobs. (B-3322-A)

Solder-Seal Prestite . . .

New high-strength Zircon Prestite offers remarkable versatility for communications products . . . it has low loss, high resistance to thermal and mechanical shock and can be supplied with standard Solder-Seal for true hermetic joining to metals. (B-3244)

PARTS AND ASSEMBLIES

Inerteen Capacitors . . .

Light weight, small volume and high reliability are features of Inerteen Capacitors for d-c service at 400 to 250,000 volts. Inerteen—the liquid dielectric is noninflammable . . . non-explosive. (B-3300)

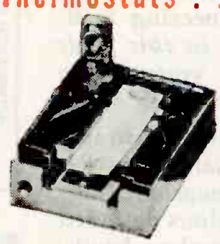
Electronic Tubes . . .

Uniform, trouble-free, long-life service is built into every electronic tube in the Westinghouse line . . . Pliotrons, Kenotrons, Phototubes, Thyratrons and Ignitrons. (SP-204)

Instruments . . .

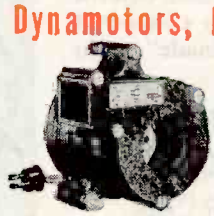
Westinghouse instruments range from miniature panel size to 4-foot boiler room indicators for all types of mountings. (B-3283)

Thermostats . . . Heaters . . .



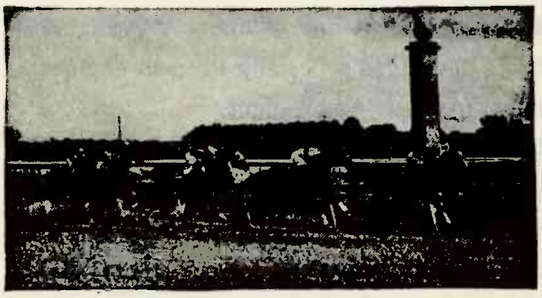
If it takes electric heat, Westinghouse can help solve the control problem with a well-stocked line of thermostats that will handle any job up to 650° F. The tiny thermostat illustrated is for final temperature control in a crystal oven. (B-3344)

Dynamotors, Motors and Blowers . . .

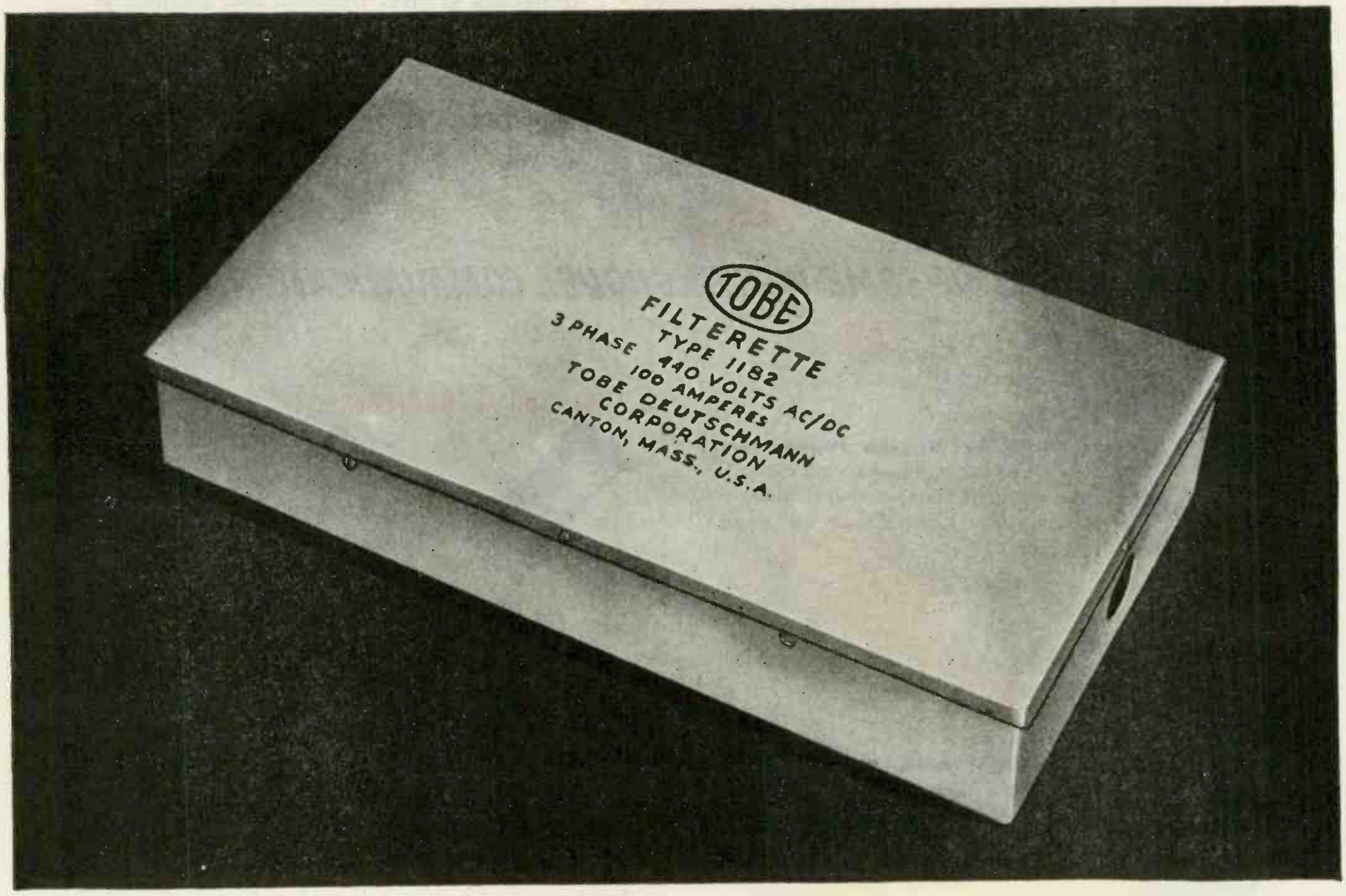


Smooth, functional design gives these rotating components high flexibility for radio equipment. Light weight and compactness are the keynotes in the design of these long-lived devices. Available for a wide range of frequencies and voltages. (B-3242)

EQUIPMENT FOR THE COMMUNICATIONS INDUSTRY



AWAY AHEAD!



Tobe Leads the Noise Elimination Field

Few problems are as vexing as the elimination of unwanted radio interference set up by the operation of nearby electric motors. And few sources of engineering advice on this subject are as experienced as the Tobe Engineering Staff. *Tobe is the acknowledged leader in this field;* our organization has devoted 17 years to the intricate problems of noise elimination.

The large #1182 Navy-Type Filter illustrated above is an example of our specialization. Examine the curve and container dimensions. This is only one of a large number of filters designed to meet special needs. Send for complete details. Let us help you solve any problem connected with blotting out unwanted "man-made" radio static. Your inquiries are welcome.

TOBE DEUTSCHMANN CORP., CANTON, MASS.

GRAND CENTRAL TERMINAL BUILDING
NEW YORK 17, N. Y.

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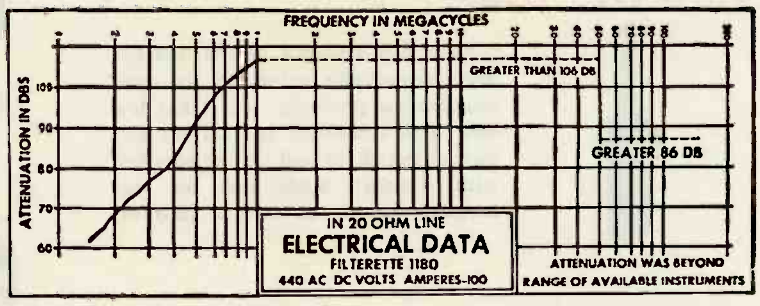
GLENDALE 4, CAL.

230 NORTH MICHIGAN AVE.
CHICAGO 1, ILL.

2-159 GENERAL MOTORS BLDG.
DETROIT 2, MICH.



SUPPRESS MAN-MADE RADIO STATIC
TOBE
FILTERIZED

TYPE 1182—ATTENUATION RANGE
150 KC to 150 MC

CONTAINER DIMENSIONS

Length . 22 1/8" Height . . 4 1/8"
Width . . 11 7/8"

This unit contains three #1180 Filterettes, each bearing Navy-Type No. CTD 53177.

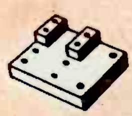
HOW THE "BIG THREE" MYCALEX PRODUCTS

Answer Military Needs for Advanced Electronic Insulation... and Afford New and Wide Horizons for Post-war Product Improvement

1 MYCALEX 400

A general purpose insulation, especially fitted for high frequency applications; combines low loss factor with machinability to close tolerances, impermeability to water and oil; not subject to distortion below 700° F. Free of carbonization. Approved by Army and Navy as Grade L-4 insulation. Fabricated to your specifications.

2 MYCALEX K



A series of improved capacitor dielectrics, with dielectric constant *selectable* from 8 to 15. Available in the form of large sheets (14"x18"), or long rods ¼" to 1" in diameter. Low power factor and high dielectric strength. Ideal for use in equipment with variable capacity. MYCALEX K-10 approved by Army and Navy as Grade H1C5H4 Class H material (JAN I-12). Fabricated to your specifications.

3 MOLDED MYCALEX

A low-loss, high temperature injection molded insulation which can be formed into intricate or irregular shapes, with or without metal electrodes or metal inserts molded in. Adaptable to high production rates and can be sold at moderate prices.

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

We have plant facilities to fabricate MYCALEX parts to your order. Send for detailed characteristics and specifications of any or all three grades of MYCALEX.

MYCALEX CORPORATION OF AMERICA

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Clifton, N. J.

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"OWNERS OF 'MYCALEX' PATENTS"


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Behind bombing missions and dog fights
at every one of our invasion points
you'll find Super-Pro receivers
on twenty-four hour duty with the AACS
under almost impossible
operating conditions.
BAND WIDTH
LIMITER
OFF ON
MAIN TUNING
MANUAL
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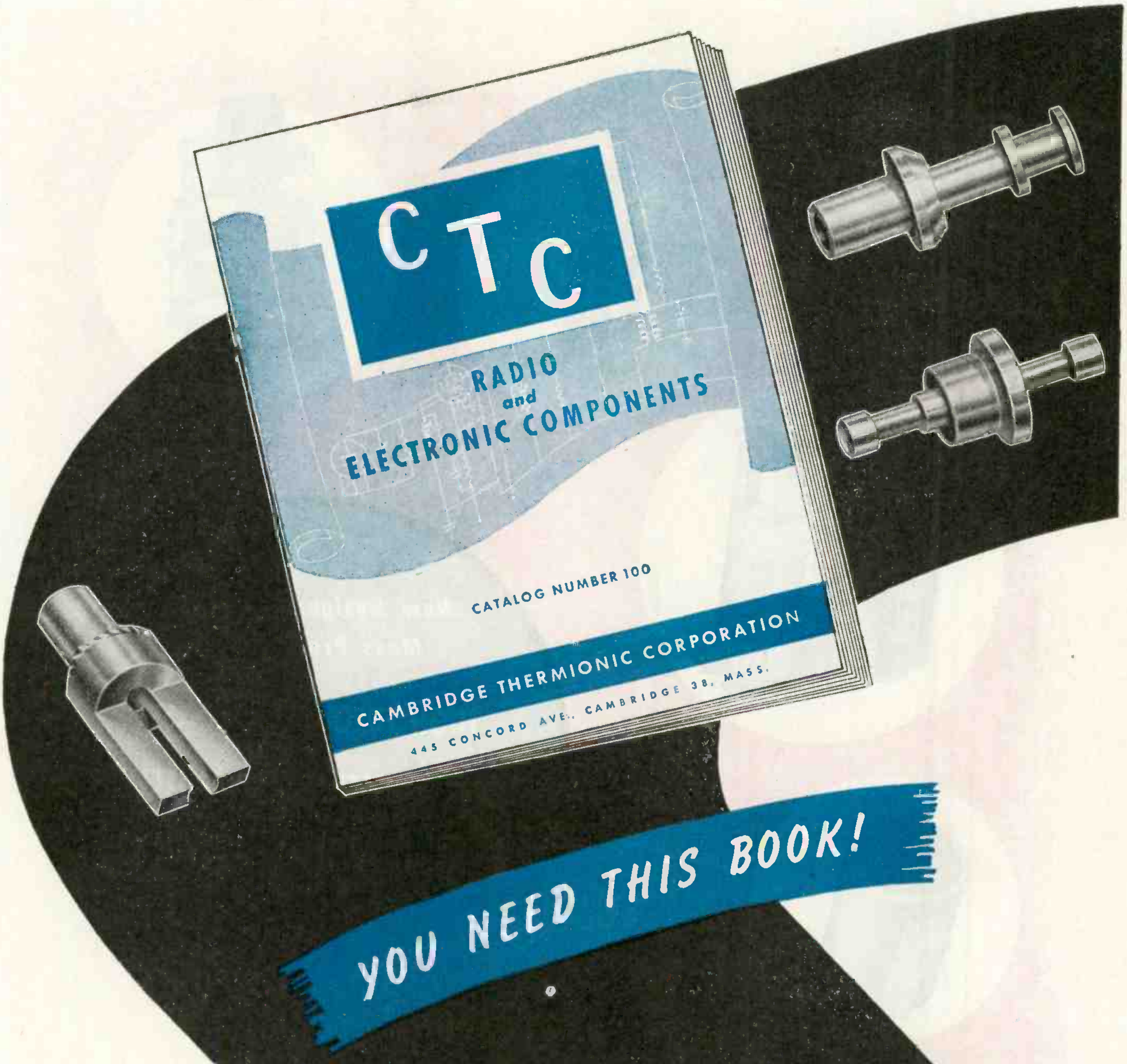
THE SIGN OF QUALITY
ESTABLISHED 1910
THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., N.Y.C.
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT



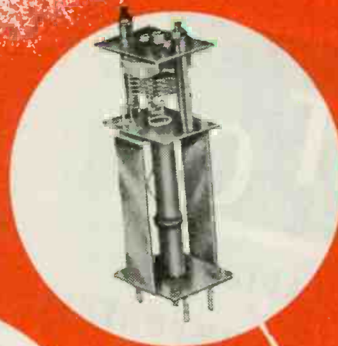
It contains complete information on recent C. T. C. radio and electronic components designed to speed production and improve the performance of precision equipment.

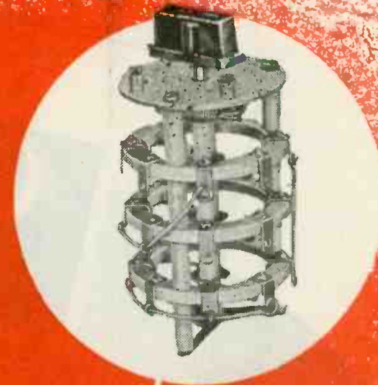
You'll discover how the new line of C. T. C. Terminal Lugs and Swaging Tools saves time and money through faster, cleaner assembly. It contains specifications for C.T.C. Crystals and facts about a thumb-size I-F Ultra-High Frequency Transformer.

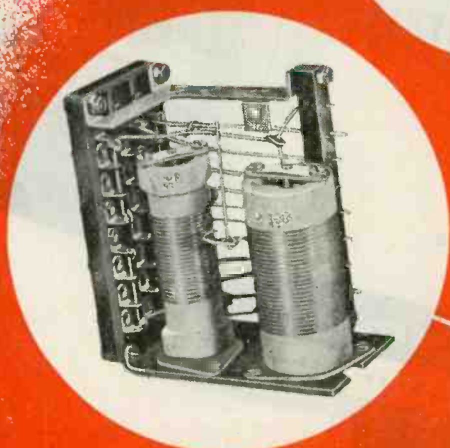
You need this book for your files. Write for your copy today.

CTC

CAMBRIDGE THERMIONIC CORPORATION
439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

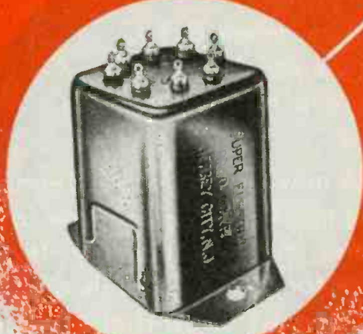






New Designs Simplify Mass Production!

HIGH FREQUENCY COILS, TRANSFORMERS AND SWITCHES FOR ELECTRONIC APPLICATIONS



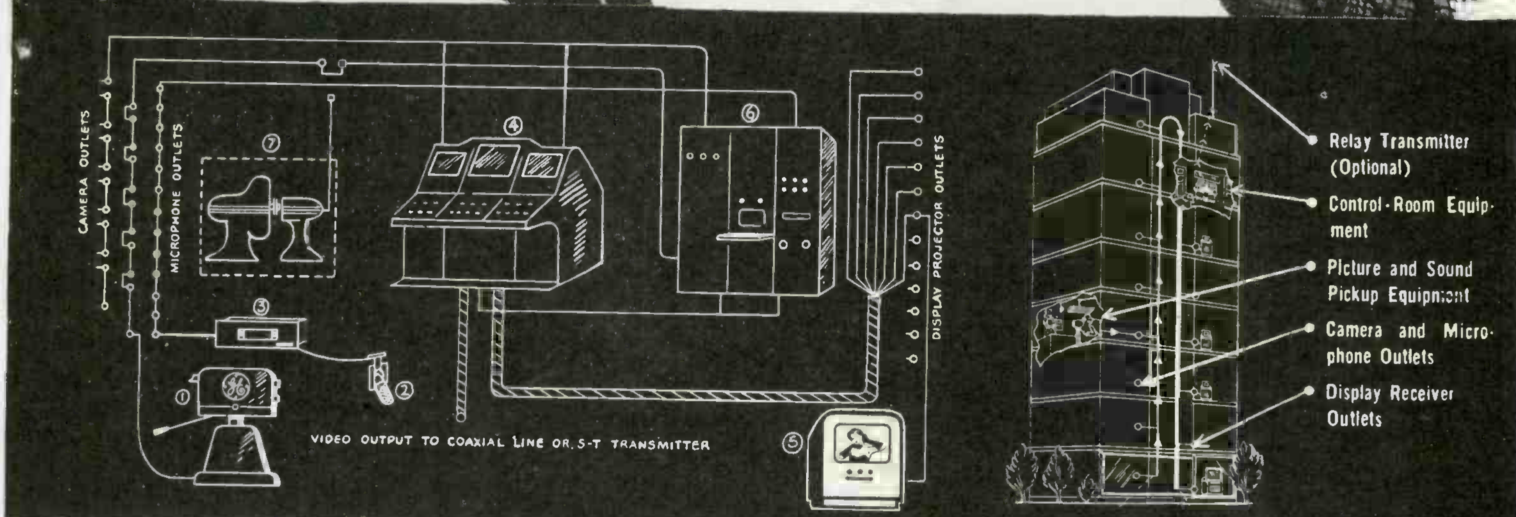
Originality of design coupled with precision workmanship sets apart the SE units shown here. They are, however, but a small sampling of the extensive range of SE-engineered vital parts we are producing to our customers' own specifications. Our complete facilities, including laboratory, design, development and manufacturing, are available to interested makers of electronic equipment.

INQUIRIES ARE INVITED

SUPER ELECTRIC PRODUCTS CORP.

1057 Summit Avenue **Jersey City, N. J.**

Also Makers of Transformers for: Power • Audio Frequency • Luminous Tube



A typical G-E Intra-Tel system. With the Intra-Tel system, portable television cameras and sound microphones can be operated from any place in store or plant. Pictures and sound picked up by cameras (1) and microphone with microphone amplifier (2) and (3) are fed by cable to the control and monitoring console (4). Outlets at the console make it possible to feed picture and sound signals by cable to any number of display receivers (5). Amplifiers and pulse generator (6) maintain signal levels and synchronize scanning, respectively. Film projector (7) is used for motion pictures.

Plan to visit General Electric's great television proving ground — WRGB at Schenectady. Every Wednesday and Friday are "open house" days. Write for the folder, "How to get to Schenectady," or see your local G-E broadcast equipment representative.

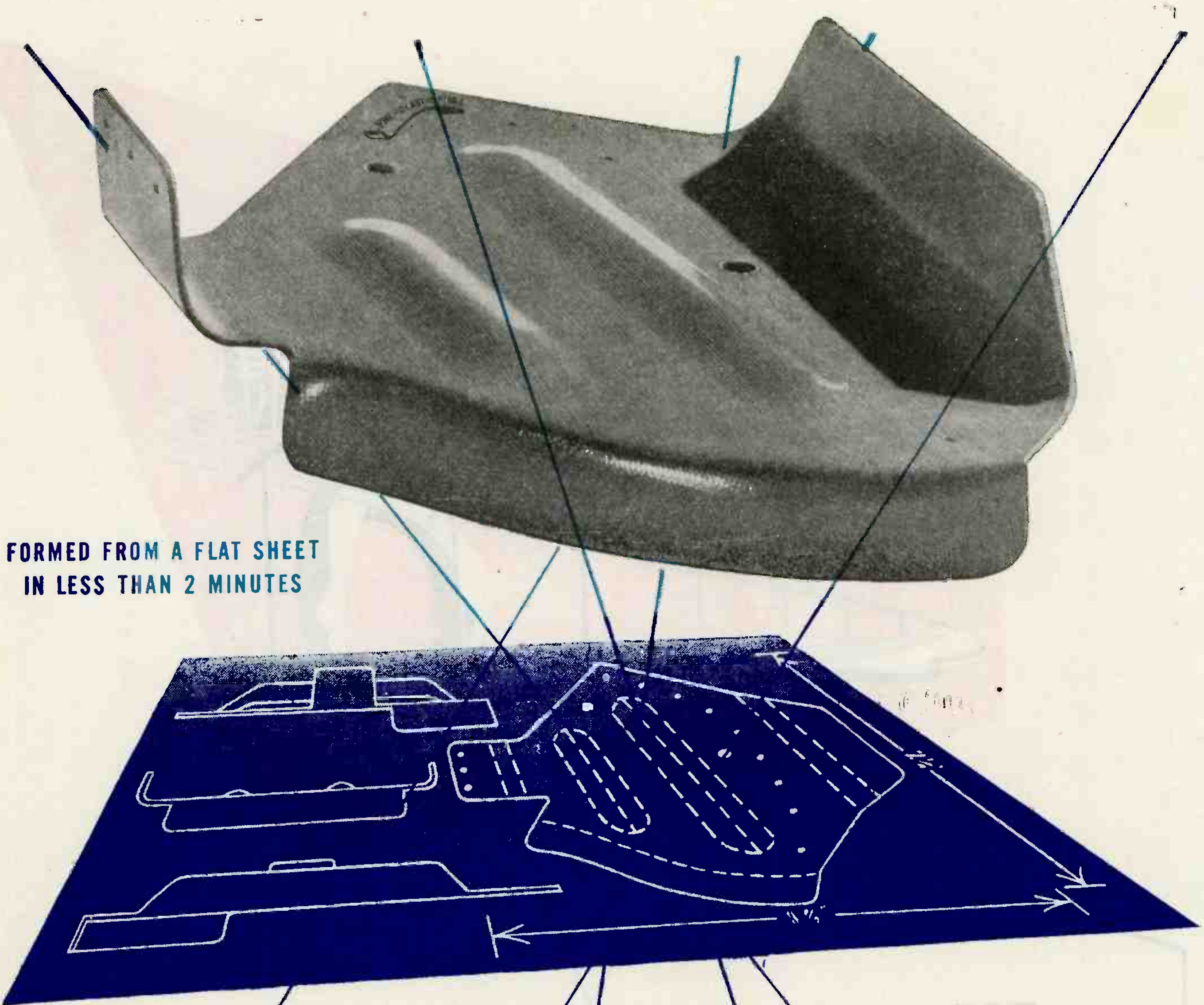
Establish a delivery priority now on your future television equipment. General Electric offers you the "G-E Television Equipment-Reservation Plan." Write for your copy. It explains how you can assure yourself early delivery of your television equipment.

Hear the G-E radio programs: "The World Today" news, Monday through Friday, 6:45 p.m., EWT, CBS. "The G-E All-Girl Orchestra," Sunday 10 p.m., EWT, NBC. "The G-E House Party," Monday through Friday, 4 p.m., EWT, CBS.

ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

FM • TELEVISION • AM

See G.E. for all three!



TAYLOR PHENOLASTIC FIBRE

THE METHOD by which ordinary sheets of fully-cured Phenol Fibre are re-heated and formed into various shapes is a new development to which users of Laminated Plastics are turning with ever-increasing interest. Now, Taylor engineers, working in the new Taylor Research Laboratory, have developed a *special* fibre which forms *better* and *easier* than standard grades of Phenol Fibre. This new development is called Taylor *Phenolastic Fibre*—a Phenol Fibre with special, elastic qualities. This new product has many advantages. Unlike metal, Phenolastic Fibre is not reduced in section at the maximum point of draw. Shapes involving compound curves and comparatively deep draws are easily made with no sacrifice in the strength of the material. Send us the facts about your product and our engineers will gladly tell you whether it can be made easier or better or more economically with Taylor Phenolastic Fibre.

TAYLOR FIBRE COMPANY

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

NORRISTOWN, PENNSYLVANIA • OFFICES IN PRINCIPAL CITIES • PACIFIC COAST HEADQUARTERS: 544 S. SAN PEDRO ST., LOS ANGELES

DOES YOUR EQUIPMENT WORK AS WELL *IN FLIGHT AS IT DID IN THE LABORATORY?*

Modern electronic equipment is carefully and skillfully built to assist our airmen in locating and neutralizing enemy installations, and to guide them safely back to their home bases. Laboratory tests are made to assure high efficiency and uniformity in these devices.

However, it has been demonstrated that vibration and shock as experienced in high powered military aircraft can reduce the efficiency of radio equipment as much as 50%, even though total failure may not always occur.

Electronic equipment may even pass laboratory vibration tests only to fail under the continuous beating of long flight missions. Moreover, combat damage to aircraft may induce vibration conditions undreamed of by the radio engineer.

The one type of vibration and shock mounting which will cushion and protect airborne equipment under all conditions has proven to be the Robinson Vibrashock*. It has the reserve capacity to meet emergency conditions, and staying power to outlast the airplane itself.

Newly designed units should be protected by Robinson mounts and their use as replacement mountings on current equipment may almost entirely eliminate servicing problems.

The Robinson Organization is ready to assist and advise on vibration mounting problems.

* Trade Mark

ROBINSON
AVIATION, INC.
730 Fifth Avenue, New York, 19, N. Y.
First National Building, Hollywood 28, Calif.

VIBRATION CONTROL ENGINEERS

NOW FLYING AT THE SANTAY MASTHEAD

★ The coveted Army-Navy Production Award was presented to the Santay Corporation on March 24, 1945! It represents official recognition for the fine record established by Santay in producing war equipment. The entire Santay organization is justifiably proud of this award . . our country's expression of approval for a job well done. All of our facilities have been working 24 hours a day for many months, for VICTORY! Santay's war production has concentrated upon our regular type of products . . injection molding, metal stamping and electro-mechanical assemblies. The skill and precision craftsmanship for which Santay workers are widely known are indicated in this award. These same fine qualities can be depended upon in *post* war production in equal or surpassing measure to that employed in our production *before* and *during* the war.

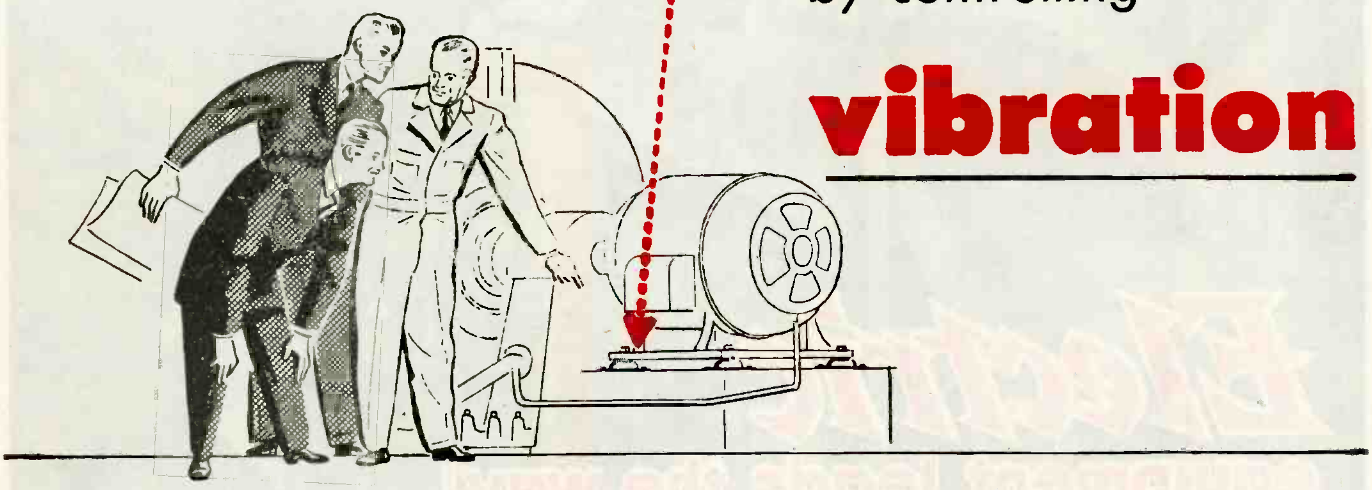
INJECTION MOLDING • METAL STAMPING • ELECTRO-MECHANICAL ASSEMBLIES

SANTAY CORPORATION 353 NORTH CRAWFORD AVE., CHICAGO 24, ILLINOIS

FORMERLY SINKO TOOL & MANUFACTURING CO.

REPRESENTATIVES: POTTER & DUGAN, INC., 29 WILKESON STREET, BUFFALO 2, NEW YORK • PAUL SEILER, 7779 CORTLAND AVENUE, DETROIT 4, MICHIGAN • QUEISSER BROS., 108 E. NINTH STREET, INDIANAPOLIS 2, INDIANA

Protection starts here by controlling **vibration**



YOU remember the old story about the lost nail—and the shoe, the horse, the rider, the general, the battle, and the war that went haywire in consequence. The story doesn't begin soon enough — the nail was lost because of vibration.

In your plant or your product, it may be a screw . . . a bolt instead of a nail; a motor instead of a horse; but it's still vibration that starts the trouble. And you can sink two-foot bolts into the concrete base, but still you haven't kept the motor from shaking itself to pieces, or diminished the nerve wracking noise that's keeping morale and production down.

For more than twenty years Lord's business has been the isolation and control of vibration. Lord has lifted the methods of attack on the destructive forces of vibration to a highly developed science. When Lord engineers make a study of your plant or your product, there's no guesswork about their recommendations.

Lord Shear Type Mountings and other Bonded Rubber Products embody many exclusive techniques and patented features which cannot be copied.

Every genuine Lord Product has the name "LORD" molded into the rubber section, as a means of ready identification, and as a guarantee to the user that he is receiving Lord quality.

If you have a vibration problem, or a mechanical design problem involving the use of functional rubber, it may best be solved by means of rubber-bonded-to-metal. Call in a Lord Vibration Engineer, or write for literature on the subject. There is no obligation.

LORD
SHEAR TYPE
Bonded Rubber
MOUNTINGS

IT TAKES BONDED RUBBER *In Shear* TO ABSORB VIBRATION.

LORD MANUFACTURING COMPANY
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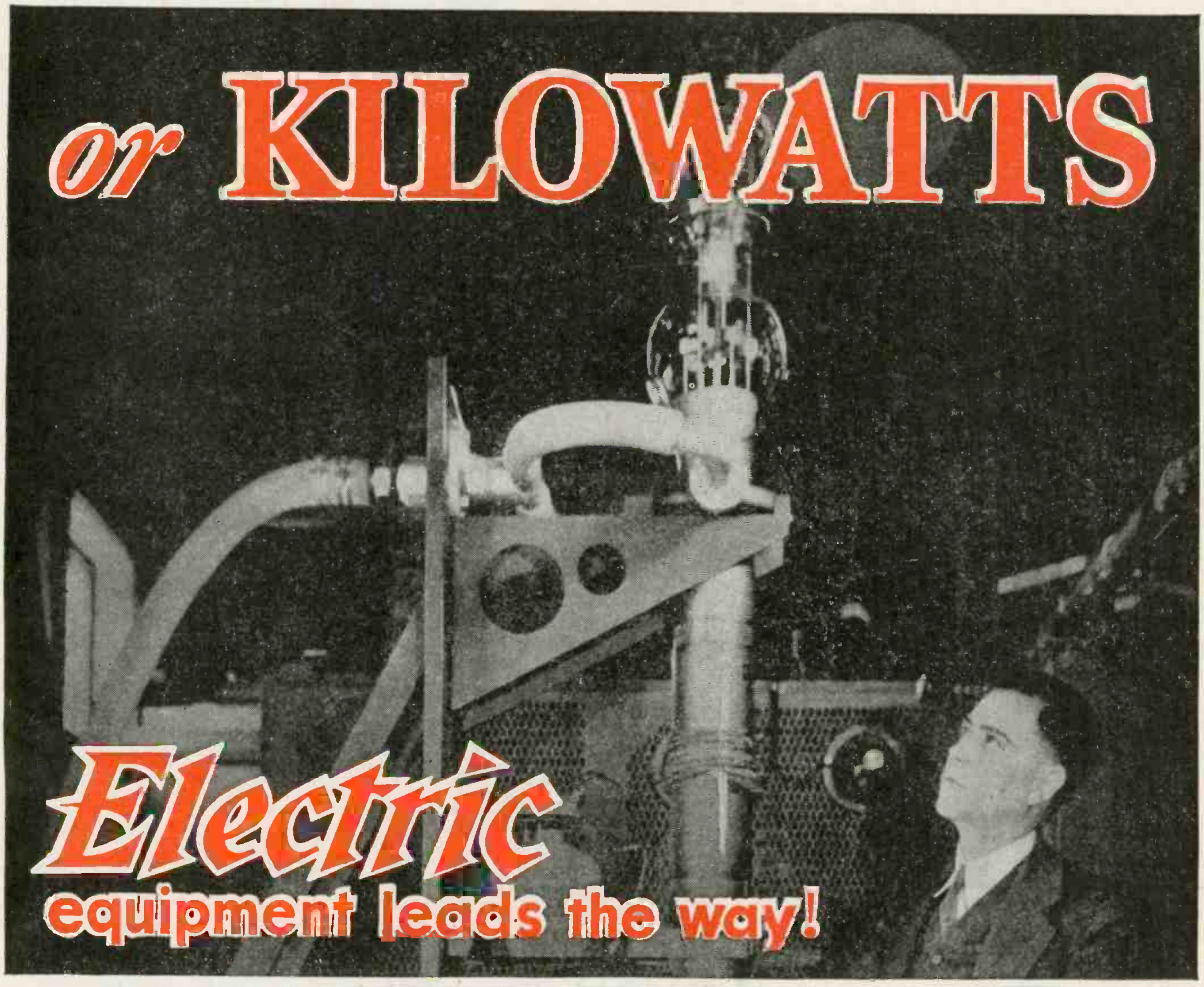
BUY MORE WAR BONDS

Originators of Shear Type Bonded Rubber Mountings



or KILOWATTS

Electric equipment leads the way!

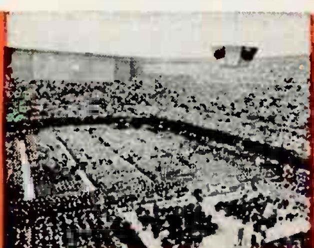
types of tubes have been introduced by Western Electric and Bell Telephone Laboratories for war services. These new tubes — and the techniques used in developing and manufacturing them — will find many important uses in communications at the war's end.

In all forms of electrical communications, count on Western Electric for continuing leadership.

Western Electric

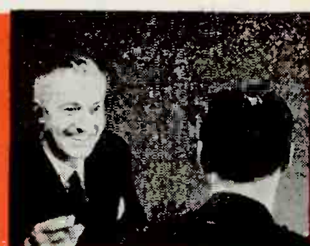
Distributed by Graybar Electric Company

Buy all the War Bonds you can . . . and keep all you buy!



SOUND SYSTEMS

TELEVISION



HEARING AIDS

ACOUSTIC INSTRUMENTS

knowledge in all of these fields

MILLIWATTS

Why Western Electric equipment leads the way!

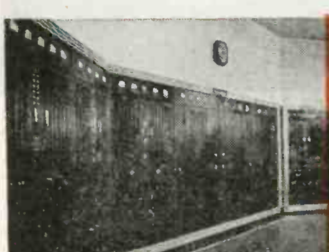
1. Western Electric products are designed by Bell Telephone Laboratories—world's largest organization devoted exclusively to research and development in all phases of electrical communication.

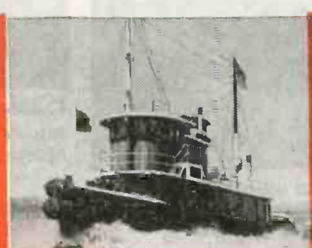
2. Since 1869, Western Electric has been the leading maker of communications apparatus. Today this company is the nation's largest producer of electronic and communications equipment.

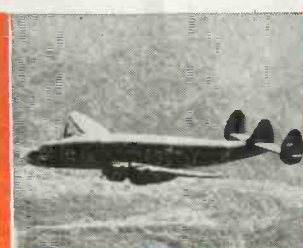
3. The outstanding quality of Western Electric equipment is being proved daily on land, at sea, in the air, under every extreme of climate. No other company has supplied so much equipment of so many different kinds for military communications.

From tiny tubes to eight foot water cooled giants—from vest pocket aids for the hard of hearing to super-powered radio transmitters—Western Electric has led the way in electrical communications equipment for many years.

Western Electric vacuum tubes for over 30 years have been noted for their uniformity and long life. Scores of new and radically different


BROADCASTING


MARINE RADIO

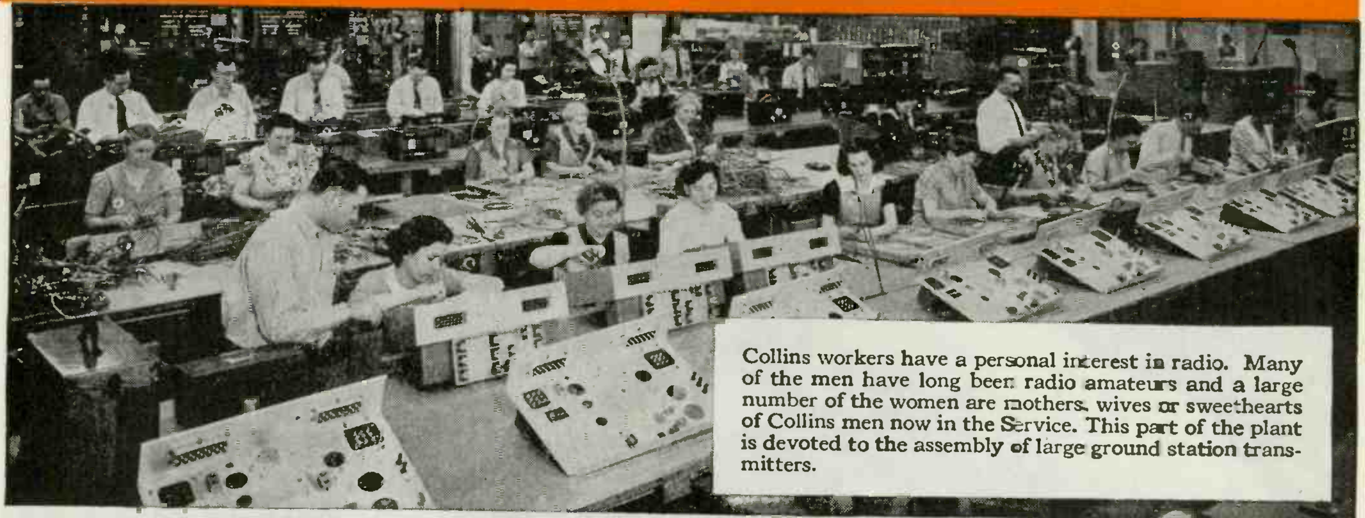

AVIATION RADIO


MOBILE RADIO

Western Electric has specialized

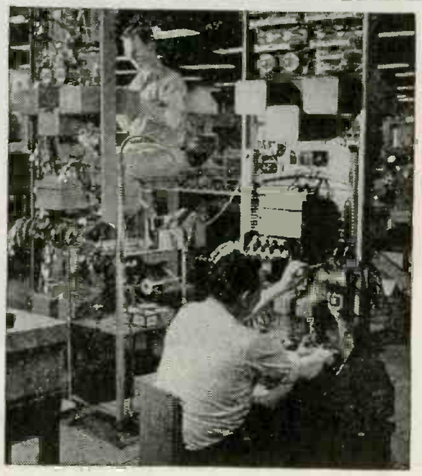
People who make Collins Radio

A few of the more than 3000 specialists who design and produce high quality radio communication equipment in the Collins plant.

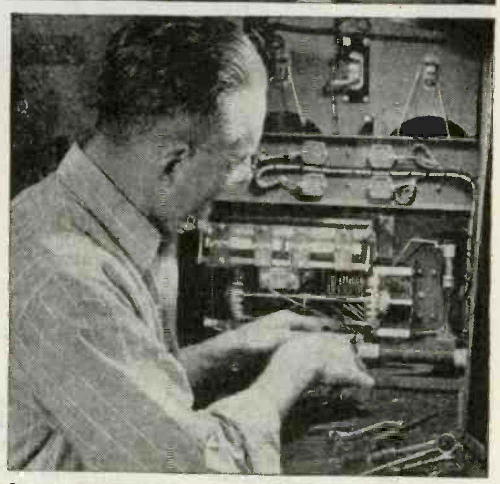


Collins workers have a personal interest in radio. Many of the men have long been radio amateurs and a large number of the women are mothers, wives or sweethearts of Collins men now in the Service. This part of the plant is devoted to the assembly of large ground station transmitters.

The technicians who wire the critical r.f. circuits in the exciter unit understand why each wire must be located and terminated with great care, exactly as engineered.

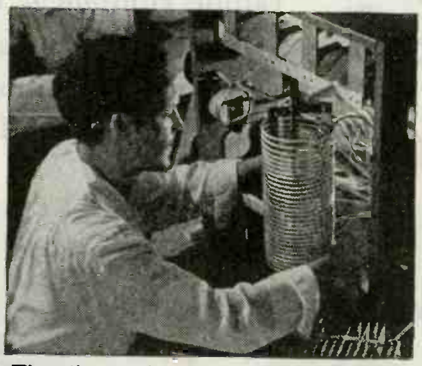


These men know what it means to the field service man to have cables neatly positioned so that component terminals are accessible and item numbers in full view.



Collins is a radio man's radio organization. Men of high technical integrity have come here from all parts of the country because Collins standards are their own ideals of excellence.

Skilled mechanics assemble and synchronize the heavy duty Autotunes used on the output network of the 3000 watt Collins 231D ground station transmitter.



First line craftsmen assemble the Collins pi output network, which matches into a wide variety of single wire and vertical antennas.

Collins final-test men check every transmitter function critically, from the operator's point of view.

ARMY E NAVY

IN RADIO COMMUNICATIONS, IT'S . . . COLLINS

Collins Radio Company, Cedar Rapids, Iowa; 11 W. 42nd St., New York 18, N.Y.

"WS" AND "WSB" FILAMENT TRANSFORMERS

ELIMINATE EXPOSED SECONDARY LEADS!

Simplify your rectifier circuit by installing AmerTran "WS" or "WSB" filament transformers. These ingenious two-in-one units incorporate the tube socket in the transformer body and in the "WSB", the center tap is brought out through the ceramic base. Thus, they eliminate filament wiring and save copper, promote safety, reduce maintenance and cut costs.

Because of their inherent ruggedness, these transformers are being used in ratings formerly restricted to oil-immersed apparatus. Both AmerTran "WS" and "WSB" transformers are moisture-proofed and insulated well above the average. Their test voltage is two and a half times their rated d.c. operating voltage.

Primary taps are arranged to permit close control of secondary voltage. Other features include completely enclosed windings, compound filled and full electrostatic shields. Send for Bulletin No. 14-5.

AMERICAN TRANSFORMER COMPANY, 178 Emmet St., Newark 5, N. J.

AMERTRAN PRODUCTS

MODULATION TRANSFORMERS — AUDIO FREQUENCY TRANSFORMERS
HERMETICALLY SEALED TRANSFORMERS
TRANSTAT A.C. VOLTAGE REGULATORS
HIGH VOLTAGE RECTIFIERS — WAVE FILTERS
OTHER ELECTRONIC AND INDUSTRIAL TRANSFORMERS

AMERTRAN

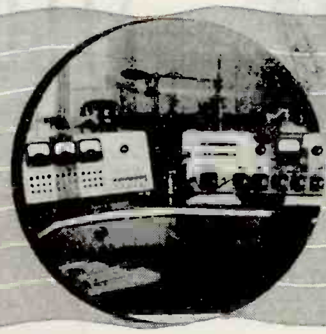
MANUFACTURING SINCE 1901 AT NEWARK, N. J.

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

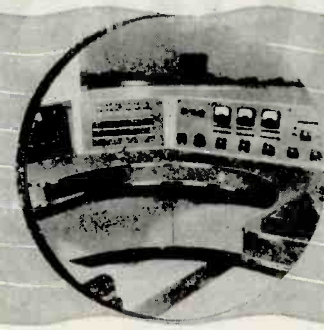
In Equipment for

Before the war, RCA engineers had designed a complete line of equipment for FM broadcast stations. A considerable number of RCA-built, FM broadcast transmitters were installed and are on the air today. In the important (because it is chiefly used in New York, Chicago and other metropolitan centers) 10KW category, for instance, five RCA 10KW, FM transmitters have been installed. More than of any other make. An additional quantity of these transmitters was built but was diverted for war purposes.

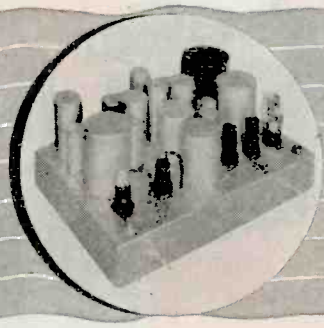
1. HIGH FIDELITY MICROPHONES—The RCA 44-BX Microphone is the standard of the industry. After the war, RCA will have even better microphones, insuring maximum FM response characteristics.



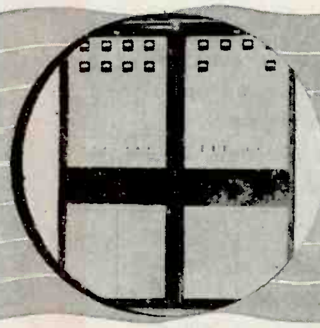
2. STUDIO CONSOLETTES — The RCA 76-B2 Consolette is well-suited for small and medium-sized FM stations and the individual studio booths of larger stations. Complete facilities for two studios, booth announcements, turntables, remotes, etc.



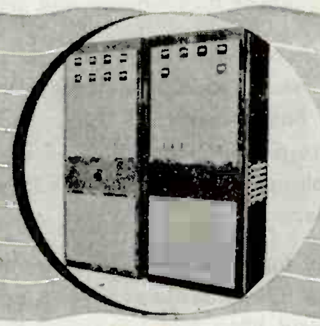
3. STUDIO CONSOLES—RCA, custom-built studio consoles are ideal for the high-quality requirements of FM. Shown here is the control console of FM Station WBRL, Baton Rouge, La.



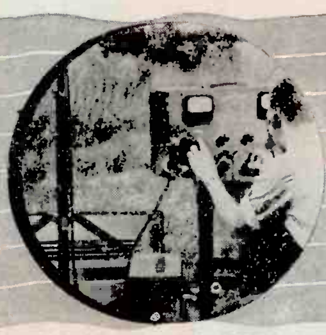
7. HIGH-QUALITY AMPLIFIERS—The several types of standard, RCA studio amplifiers are well-suited for FM use. All amplifiers have a flat frequency response, which may be compensated, when desired, for particular installations.



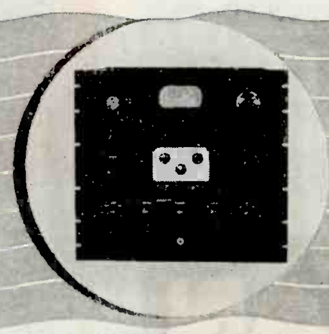
8. 1 KW FM TRANSMITTER—This is the RCA FM-1-B Transmitter, built before the war, a number of which were installed and are in operation. After the war, RCA will offer a complete new line of FM transmitters of all powers.



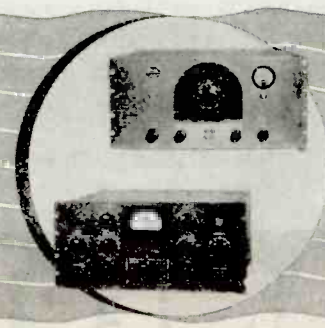
9. 3 KW FM TRANSMITTER—This is the RCA FM-3-B Transmitter, built and sold before the war. The same exciter is used in all RCA FM Transmitters from 1 KW to 50 KW.



13. FM FIELD-INTENSITY METER—The RCA 301-B Field Intensity Meter, which has a frequency range of 20 to 125 megacycles—and a built-in discriminator circuit—is the only commercially produced unit suitable for FM use.

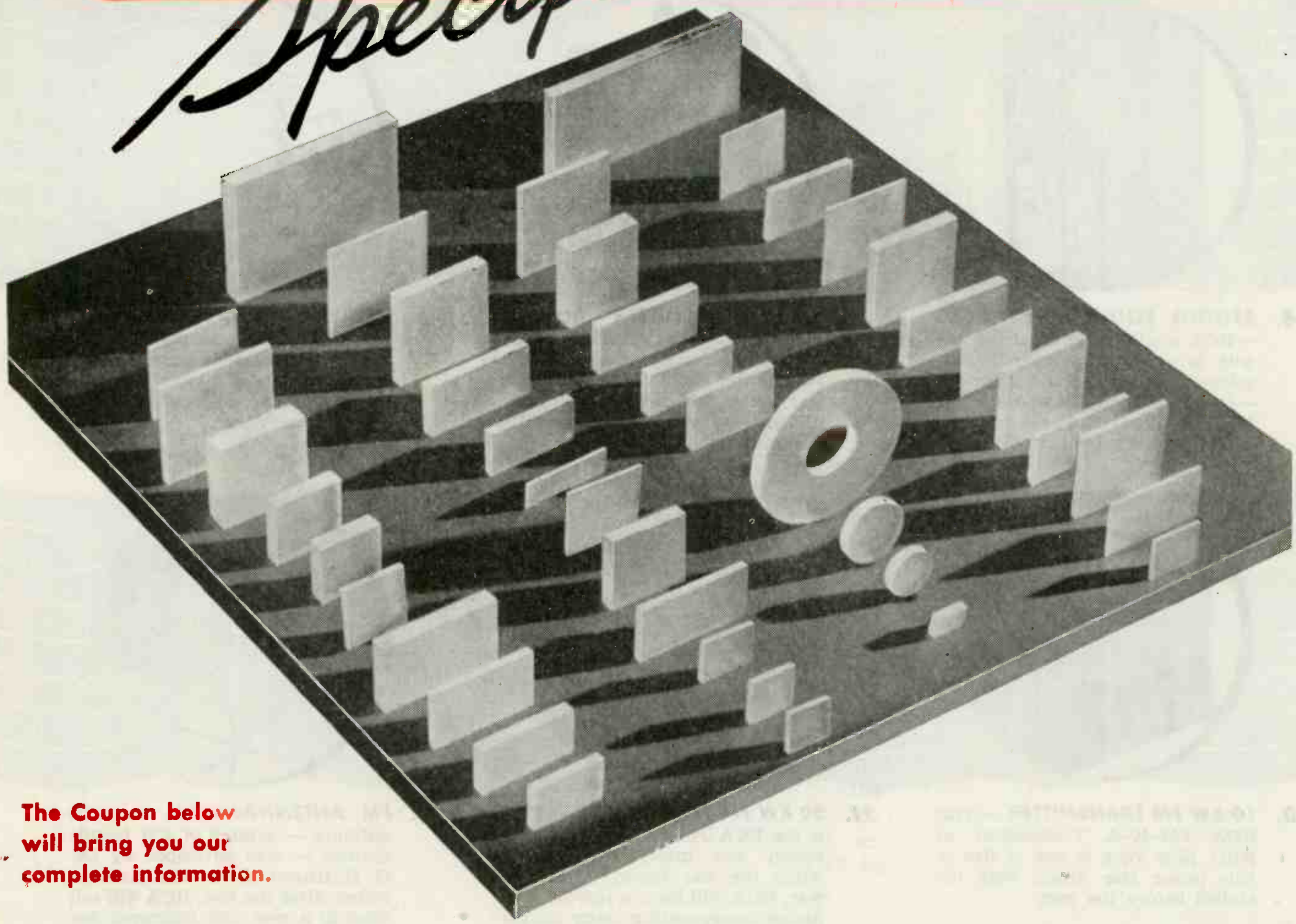


14. FM MONITORS — RCA FM frequency monitors and FM modulation monitors are the finest built for this specific purpose—are fully approved by the FCC for FM station use.



15. MEASURING EQUIPMENT — For making "proof-of-performance" measurements of AM noise level, FM noise level, frequency response and distortion, the RCA 68-B Oscillator and 69-C Distortion Meter are recommended.

CRYSTAL BLANKS to Your *Specifications*



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Our crystal blanks are cut to specifications from selected Brazilian quartz and guaranteed free from all impurities, mechanical and electrical imperfections. Dimensions, temperature coefficients and frequencies are guaranteed within your specifications. Supplied in either "rough-sawed", "semi-finished" or "electrically-finished" blanks as desired. Remember Crystal Products when you need crystals.

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How

● *The automatic stacking machines shown have enabled Sangamo to play an important part in meeting the heavy and exacting requirements of wartime America. Well-trained operators, adequate facilities, and competent supervision have contributed in some measure in helping the United States to become the world's leader in Electronic developments.*

THESE OPERATORS who assemble Sangamo mica capacitors are fully aware of the dependability required in their performance. They know that full quality must be built into these units to meet the high standard set at Sangamo. Skilled operators, utilizing the most modern mechanical equipment, contribute to the excellence of the finished product, be it the smallest or the largest capacitor.

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EXCELLENCE IS BUILT INTO....

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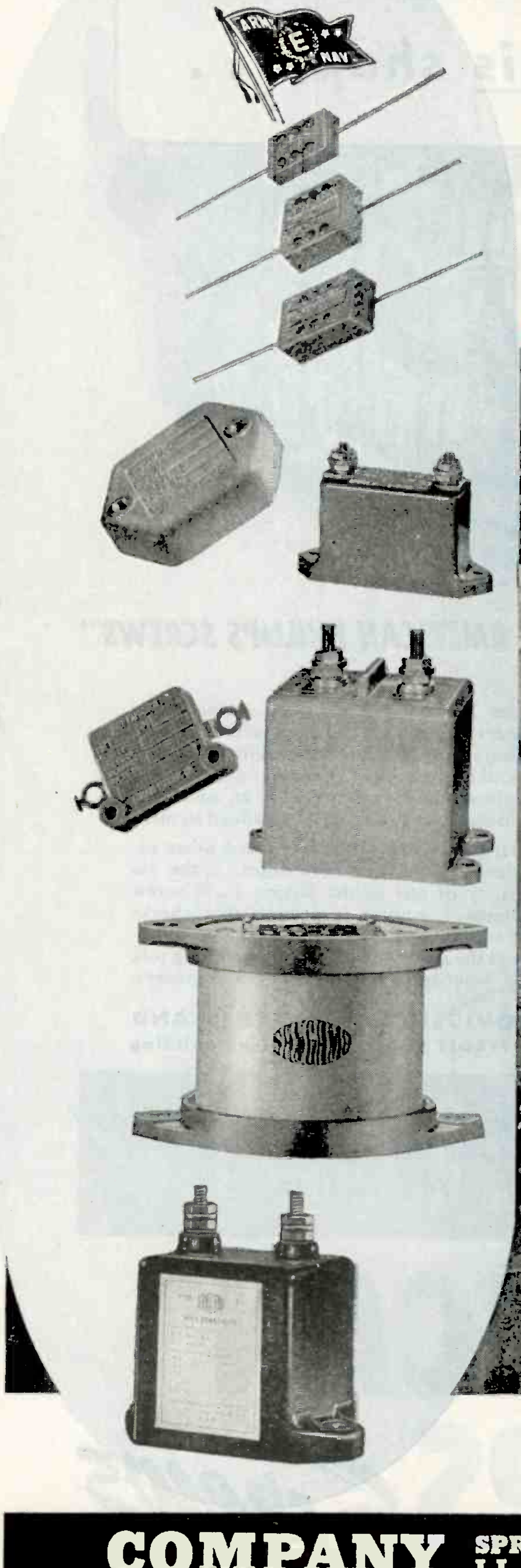

MICA CAPACITORS

•

Capacitor Assembly

•

A MICA CAPACITOR consists of a number of alternate layers of mica film and a conducting metal plate. As the capacity of the unit varies directly with the area of the active surface of the plate and inversely with the thickness of the dielectric, these factors must be accurately controlled in order to produce a satisfactory capacitor.

The assembling or stacking of these units may be done by hand with the use of mechanical stacking fixtures, or automatically, by utilizing special assembly machines. Since 1929, automatic machines, designed and developed by Sangamo, have been used for stacking many types of Sangamo capacitors. This method of stacking has insured accurate positioning of the foil, which is essential for long life and trouble-free operation of any capacitor unit. The automatic assembly machines are designed so that the length of each foil is very accurately controlled; as the mica previously has been gauged to within very close limits and inspected for all defects or flaws, a uniform capacitor results. Since many of the large capacitors consist of series sections and comprise in all many hundreds, and in some cases thousands, of pieces of mica, automatic stacking insures consistent quality and facilitates increased production. A large battery of these assembling machines enables Sangamo to produce many thousands of capacitors of all values each day and each is built with that precision and care required to insure dependable operation in all types of electronic equipment.

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"Nothing ever put so much NEW LIFE in this shop . . .

. . . as these Quick and Easy-Driving AMERICAN PHILLIPS SCREWS"

Yes, it always boosts the morale of workers when they're freed from the slow, exhausting, dangerous work of hand-driving slotted screws . . . and switched onto the fast, effortless, safe method of power-driving American Phillips Screws.

Output jumps to new highs. Accidents and rejects hit bottom. *Total time-savings climb as high as 50%.* For American Phillips Screws banish the fear of mistakes, instil new self-confidence, build pride in good work. In fact, good work is the *only kind* that *can* be done, with American Phillips Screws. The recessed head stays straight on the 4-winged driver 'till the screw is turned up tight and flush. And this surety of operation means fairer return on fixed overhead . . . an advantage no shop, large or small, can afford to miss.

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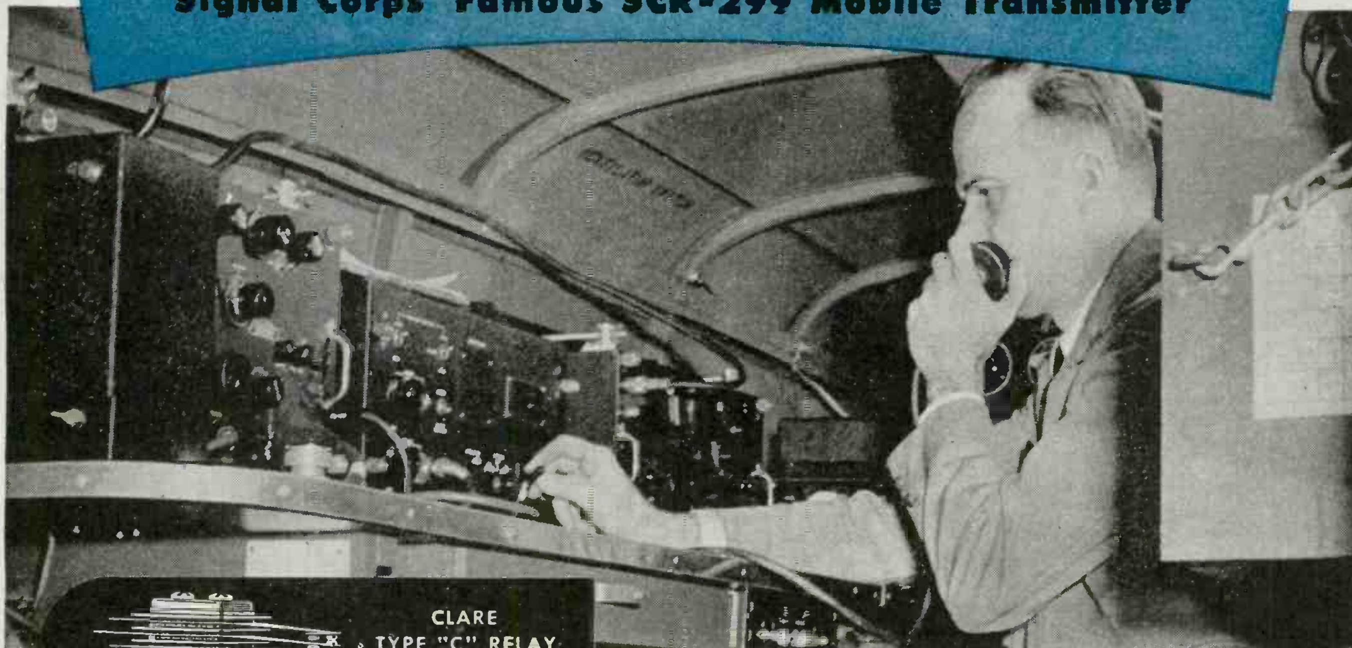
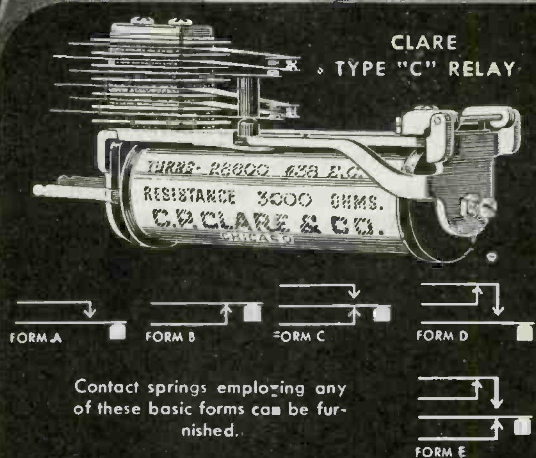
345 Hudson Street, New York 14, N. Y.

CLARE "Custom-Built" RELAYS

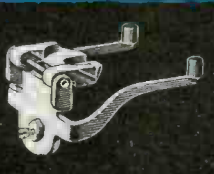
Are Send-Receive Relays in the Signal Corps' Famous SCR-299 Mobile Transmitter



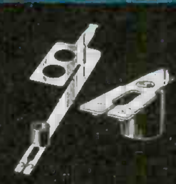
CLARE TYPE "C" RELAY



Contact springs employing any of these basic forms can be furnished.



Double arm armature assembly of stainless steel shaft, operating in a marine brass yoke. Heelpiece, core and armature assembly are of magnetic metal.



Spring bushing insulators are made of Bakelite rod under patented process. Resist vibration and withstand heavy duty service.

High voltage spring pile-up insulators of special heat-treated Bakelite. Has minimum cold flow properties, low moisture absorption content and permits punching without cracks or checks.

Contacts are welded to nickel silver springs by special process. May be of precious metals or alloys in 12 different standard or special types and sizes.

In the forefront of land operations in every war theatre has been the Signal Corps' famous SCR-299 mobile intercommunication unit, whose transmitter is built by The Hallicrafters Company of Chicago, Illinois.

Clare Type "C" d.c. Relay is used as a part of the speech amplifier of the SCR-299. Its function is that of the control relay for the circuit which changes over the equipment from "send" to "receive" or from "receive" to "send." Under certain conditions the relay is controlled by an impulse sent over as much as a mile of telephone wire from a remote observation or command post.

This Clare Relay has stood up remarkably well in the field and has contributed greatly to the outstanding performance of the SCR-299. In choosing a Clare "Custom-Built" Relay for this important function, The Hallicrafters Company left nothing to chance. Clare performance was well known. Clare's ability to "custom-build" just the relay to serve as these important nerve centers simplified design and assured the quick, positive action, the rugged dependability, the resistance to vibration that a mobile radio transmitter must have.

Illustrated here are a few of the Clare "custom-building" features that have revolutionized designing and made it possible for Clare Relays to reduce overall relay cost, simplify installation and assure more dependable performance in hundreds of applications, such as sequence control of machine tools, radio, radar or other electronic controls, electric eye controls, counting equipment and alarm systems.

Clare engineers are ready at all times to "custom-build" a relay to your exact requirements. Send for the Clare catalog and data book. Address: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

CLARE RELAYS

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


The TINYMITE
SMALLEST PAPER CAPACITOR - - -
yet 100% MOISTUREPROOF
TYPE P5N
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FEATURES
1. Bakelite Resinoid Ends. Lead wire cannot pull out, even under hot conditions.
2. Non-Inductive.
3. Excellent Temperature Coefficient.
4. Very high leakage Resistance.
5. Fine Power-Factor.
6. Range from 20 MMFD to .25 MFD. From 150 volts to 600 volts.
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Model S-37.

Model S-36.

hallicrafters

equipment covers the spectrum

● Hallicrafters equipment covers the radio spectrum. From low to ultra high frequencies there is a Hallicrafters receiver ready to meet your special requirements. Although certain equipment operating in the ultra high frequencies cannot be described at present for security reasons, the characteristics of Hallicrafters standard line of receivers may be disclosed. This line includes:

Model S-37. FM-AM receiver for very high frequency work. Operates from 130 to 210 Mc. Highest frequency range of any general coverage commercial type receiver.

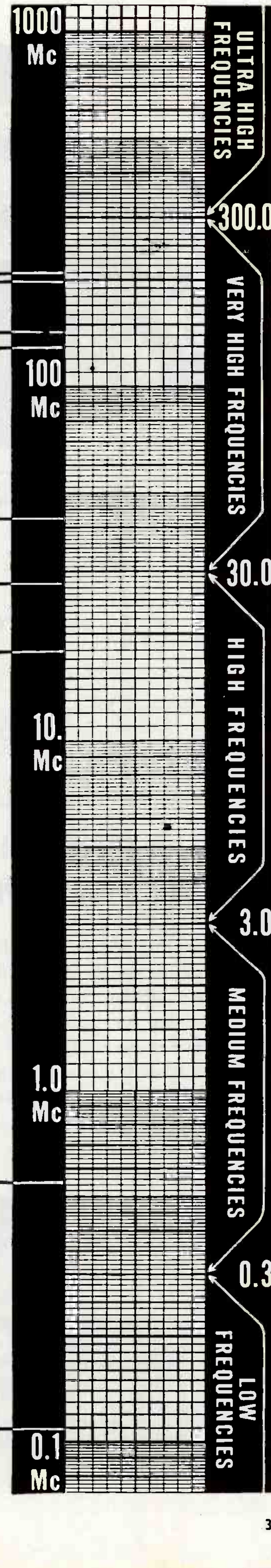
Model S-36. FM-AM-CW receiver. Operates from 27.8 to 143 Mc. Covers old and proposed new FM bands. Only commercially built receiver covering this range.

Model SX-28A. Operates from 550 kc to 42 Mc continuous in six bands. Combines superb broadcast reception with the highest performance as a versatile communications receiver.

Model S-22R. Completes Hallicrafters coverage in the lower end of the spectrum. Operates from 110 kc to 18 Mc in four bands. A.c./d.c. operation.

Model SX-28A.

Model S-22R.



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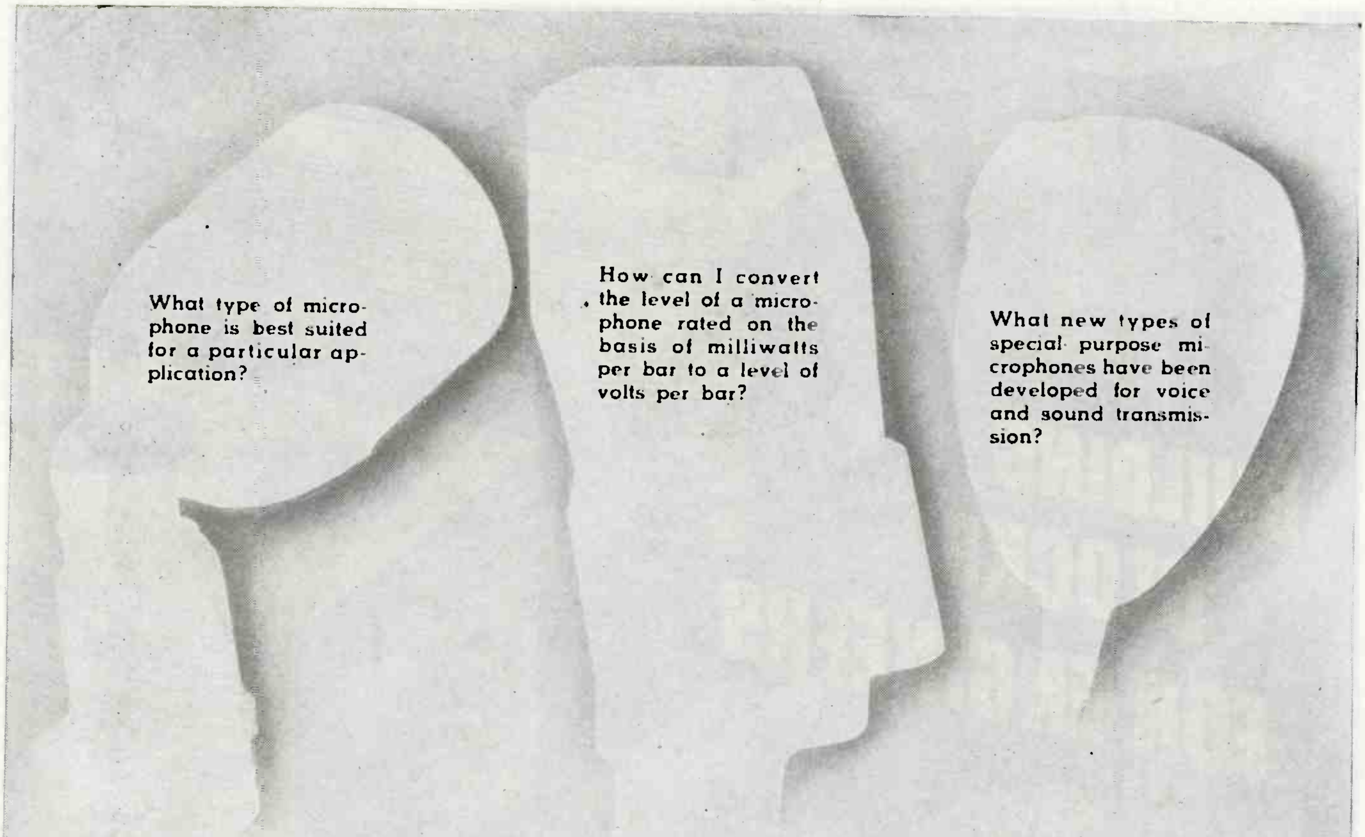

These and many other answers may be found in the NEW and COMPLETE Electro-Voice CATALOG

More than an exposition of microphone types, the new Electro-Voice Catalog provides a source of valuable information which should be at the fingertips of every sound man. It contains a simplified Reference Level Conversion Chart which marks the first attempt in the history of the industry to standardize microphone ratings. Several pages are devoted to showing basic operating principles of microphones . . . offering a guide to the proper selection of types for specific applications. And, of course, every microphone in the Electro-Voice line is completely described, from applications to specifications.

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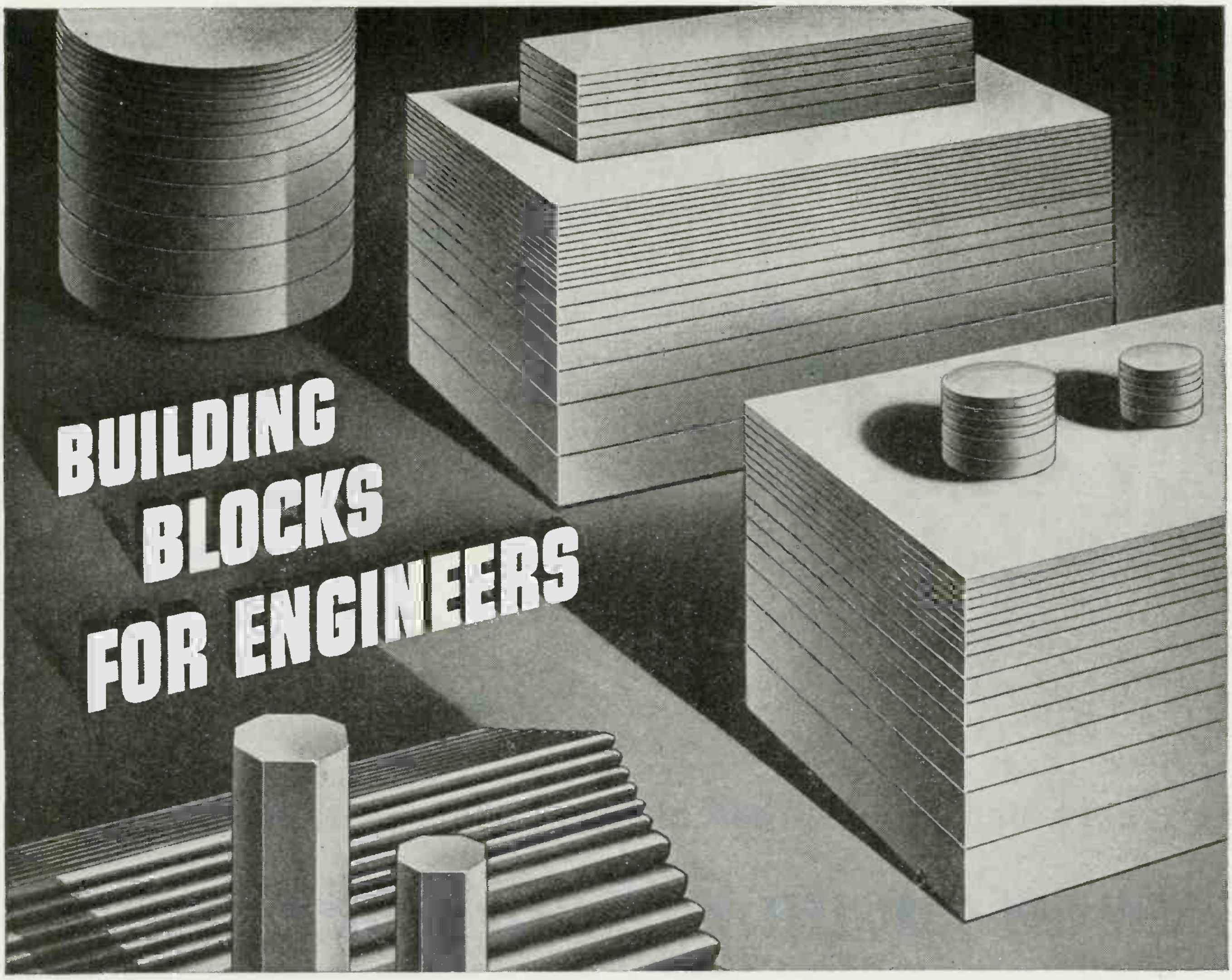
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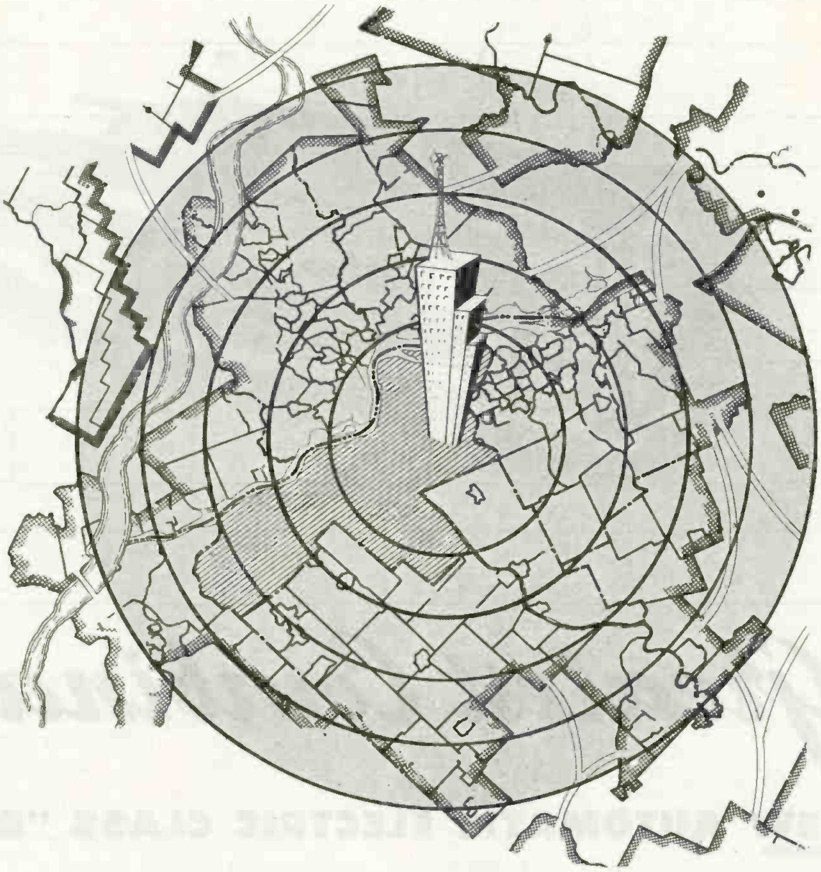
BLOCKS
FOR ENGINEERS



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Television promises unprecedented profit and prestige to men of vision and energy. Television will be tomorrow's highroad to local and national leadership.

If you plan to toss your hat in the Television ring, arrange *now* to assure both early postwar delivery of your telecasting equipment and the proper training of your Television station's operating personnel. Both equipment and staff training are provided for in DuMont's Equipment Reservation Plan.

DuMont-engineered telecasting equipment has rugged dependability and practical flexibility; will be designed for economical operation and is realistically priced. These facts have been spectacularly demonstrated by more than 4 years' continuous operation in 3 of the nation's 9 Television stations.

Furthermore, a pattern for profitable station design, management and programming has been set at DuMont's pioneer station, WABD New York . . . a pattern and backlog of Television "know-how" which is available to prospective station owners. Call, write or telegraph today.

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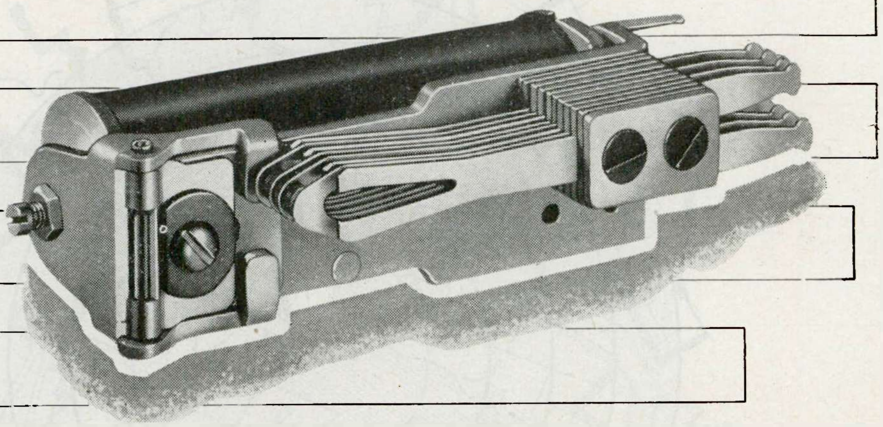
CONTACT PRESSURE

DEPENDABILITY

DURABILITY

COMPACTNESS

VERSATILITY



— in Greatest Combination

THE NEW AUTOMATIC ELECTRIC CLASS "B" RELAY

● When you need a relay that's sensitive enough to operate on minute current, yet has the high contact pressure needed for perfect closure, you'll find the Automatic Electric Class "B" Relay worth investigating.

If you need a relay that will switch many circuits, yet is compact enough for multiple mounting in small space, you'll find Class "B" the perfect solution.

Or perhaps you are interested in extra durability, for long service under tough conditions. Then you'll need the in-built quality for which Class "B" has become famous.

No other relay—even in the Automatic Electric line—can give you a greater combination of all these essential qualities. Get the full story on Class "B"—one of the forty basic types described in the Automatic Electric catalog. Ask for your copy of Catalog 4071.

CHECK THESE FEATURES of the New Class "B" Relay

Independent Twin Contacts—for dependable contact closure.

Efficient Magnetic Circuit—for sensitivity and high contact pressure.

Unique Armature Bearing—for long wear under severe service conditions.

Compact Design—for important savings in space and weight.

Versatility—Available for coil voltages to 300 volts d-c and 230 volts a-c, and with capacities up to 28 springs; also with magnetic shielding cover, when specified.

No other relay can give you a greater combination of all these essential qualities.

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PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED

LOOKING FOR A VERSATILE MATERIAL?

● The end bells illustrated above were manufactured by the Sampsel Time Control Company. Used as casings for covering the end connections of high speed electric machines, these small but vital items are no simple job to produce. The machine tolerances are quite close and the parts must have a high degree of stability. In fact the boring of a seat for a ball bearing is held to .0003" tolerance while one shoulder diameter is turned to .0008" tolerance.

As a result of an ingenious mold design, these end bells are molded in a single operation. Notice how the inserts are molded-in making for ease of assembly and fabrication.

The tremendous progress which America's custom molders have made during the past three years in developing new molding methods and processes is exemplified by the efficient production of just such items as these end bells.

The material selected for these end bells was a general-purpose Durez phenolic molding compound. Besides possessing excellent moldability, this Durez compound possesses such versatile properties as oil and grease resistance, dielectric strength, self-insulation, excellent wearability and heat resistance.

The unusual versatility of Durez phenolics has made their usage practically universal throughout industry. Add to this the quarter century's experience which Durez technicians have acquired through active participation in the successful development of many plastic products and you can readily appreciate the benefits of working with our organization. The services of the Durez staff are available at all times to you and your custom molder. Durez Plastics & Chemicals, Inc., 324 Walck Road, North Tonawanda, N. Y.

DUREZ

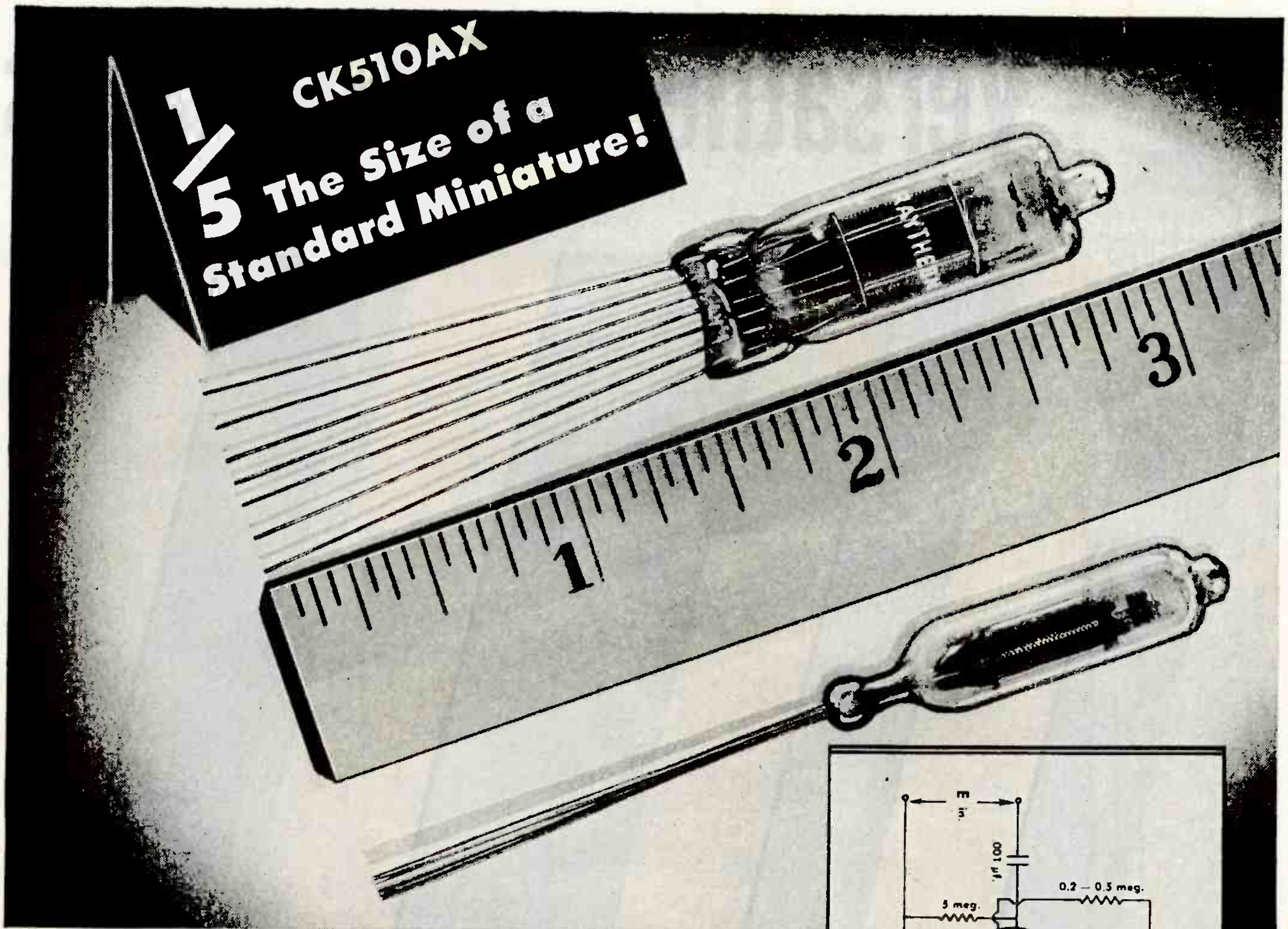
PHENOLIC RESINS

MOLDING COMPOUNDS

INDUSTRIAL RESINS

OIL SOLUBLE RESINS

PLASTICS THAT FIT THE JOB



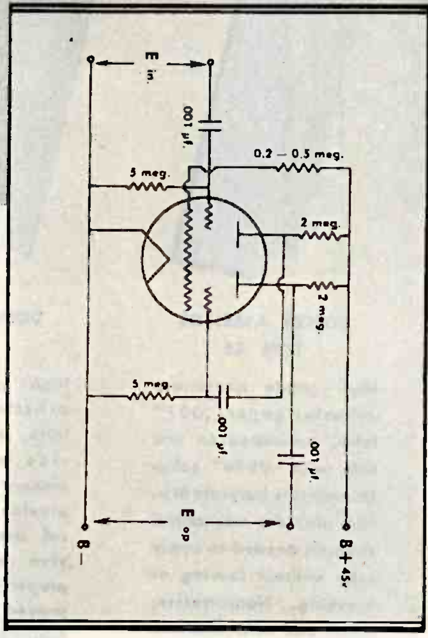
RAYTHEON CK510AX . . . A DUAL SPACE CHARGE TETRODE AUDIO AMPLIFIER TUBE

Raytheon engineers recently developed a tube radically different in design and performance—yet so *small* that many users were amazed by its capabilities. It is the CK510AX, which is essentially a very low-drain filament type dual tetrode intended for cascade operation as a high-gain audio-amplifier.

A unique feature is a space charge grid around the filament—which produces two virtual cathodes, one for each section. Thus from a single filament two individual tetrodes are obtained, between which there is a minimum of interaction.

This tiny tube occupies only one-fifth the physical volume of a standard miniature type, yet voltage gains of approximately 250 may be obtained in the simple circuit illustrated here. The CK510AX is further proof of Raytheon's ability to develop new and better tubes . . . tubes that will be in ever-increasing demand in the new era of electronics to come.

PLEASE DIRECT INQUIRIES TO OUR COMMERCIAL ENGINEERING DEPARTMENT, NEWTON, MASS.



Specifications of CK510AX

Physical:

Bulb	T2X3 Flat Glass
Maximum Length	1.25 inches
Maximum Width	.385 inches
Maximum Thickness	.285 inches
Minimum Lead Length	1.25 inches

Electrical:

Filament Voltage	0.625 volts
Filament Current	50 ma
Maximum Plate Voltage	45 volts
Control Grid Voltage*	0
Space Charge Grid Current	75 to 150 ma
Approximate Voltage Gain	250

*Grids Returned to Negative Filament through 5 megohms.

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Versatile DOPLEX tapes

TRADE-MARK

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CLEVELAND PLANT

DOPLEX ASBESTOS TYPE AB

High-grade nonferrous asbestos paper, .007" thick, laminated on one side with .0016" cellulose acetate butyrate film. Film provides mechanical strength needed to apply tape without tearing or breaking. Noncorrosive, alkali and acid resistant. *Meets Class B insulation requirements* at lower cost. For use where higher temperatures are encountered.

DOPLEX ASBESTOS TYPE CL

High-grade nonferrous asbestos paper, .007" thick, laminated on one side with minimum amount of cotton cloth to provide extra mechanical strength and abrasion resistance. These properties are further improved by a flame-inhibiting coating on cloth side. Noncorrosive and nonferrous; minimum organic content. *Another less expensive Class B insulation.*

DOPLEX ROPE PAPER TYPE PJT

High-quality thin rope paper laminated on one side with a special flame resistant cellulose film.

For use as a separator or barrier in cables. Prevents sulphur in rubber compounds from attacking and penetrating untinned copper conductors. Conserves space, only .0035" thick.

DOPLEX ACETATE TYPE AA

This 4-ply tape, only .004" thick, provides equivalent dielectric to .007" of varnished cambric at normal temperature and humidity, with even more marked improvement after 7 days in humid atmosphere at 250° F. Retains dielectric and physical properties after dipping and baking in varnish. Recommended for all uses requiring thin, high dielectric insulation.

Made by the makers of "LEXEL" tape and "DOBAR" laminated paper insulation

JOHNSON *for* HIGH POWER COMPONENTS

To meet the need for a light-weight, high-capacity, high-voltage tank condenser for transmitter applications, Johnson engineers developed a new type of condenser. The unit illustrated has a capacity of 1200 mmf. at a peak voltage of 40,000 volts at 2 megacycles. Nearly any combination of capacity and voltage ratings may be had. The capacity may be varied in the field by removing plates or altering spacing.

The plates are made of fabricated sheet steel, heavily copper plated and enamelled. Rounded edges increase the breakdown voltages. Vertical tie rods of copper tubing furnish good conductivity between plates. Plates are secured to the upright supports with aluminum castings.

A protective gap is incorporated in the condenser to protect the plates from damage in case of excessive voltages or surges. The mounting base is welded channel iron, which forms a strong support. A very convenient mounting for the tank inductance is formed by the two cross beams at the top of the condenser.

This condenser will find wide application in high power equipment because of its compact and efficient construction.

Ask for Catalog No. 968D

Other JOHNSON Products for High Power . . . . .
INDUCTORS, variable & fixed • TRANSMISSION LINE EQUIPMENT • SOCKETS • SWITCHES • COUPLINGS • CHOKES • ANTENNA PHASING UNITS • GAS-FILLED CONDENSERS • CONTACTORS INSULATORS

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E. F. JOHNSON COMPANY • WASECA • MINNESOTA

In their design considerations leading Tube Manufacturers are now specifying MYKROY because it provides the ideal combination of essential insulation characteristics . . . *low-loss — dimensional stability — high strength and heat resistance.*

Through advanced engineering ideas utilizing improved materials and better techniques, modern radio tubes achieve a high degree of efficiency. Complete vacuums within the tubes provide the perfect low-loss inter-electrode insulation; externally, however, insulation of lower dielectric properties is often used, considerably reducing tube efficiency.

The external leaks that occur at plate, grid, filament, tube base and socket terminals due to poor insulation, seriously reduce power output. To reduce these external power losses to a negligible minimum, you can now obtain tube accessories and parts made of MYKROY . . . *the perfected mica ceramic insulation.*

Write for full information today. Ask for your copy of the MYKROY Bulletin #104 — containing the scientific facts about this vastly improved Radio Tube Insulator.

MECHANICAL PROPERTIES*

MODULUS OF RUPTURE..................18000-21000psi
HARDNESS
Mohs Scale 3-4 BHN. BHN 500 K9 Load. 63-74
IMPACT STRENGTH........ASTM Charpy .34-.41 ft. lbs.
COMPRESSION STRENGTH........................42000 psi
SPECIFIC GRAVITY..2.75-3.8
THERMAL EXPANSION.........000006 per Degree Fahr.
APPEARANCE.................Brownish Grey to Light Tan

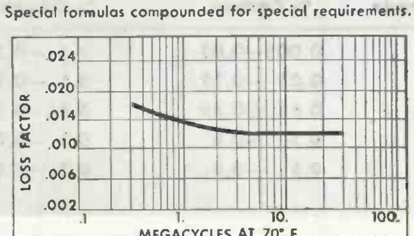
ELECTRICAL PROPERTIES*

DIELECTRIC CONSTANT......................................6.5-7
DIELECTRIC STRENGTH (1/8")..........630 Volts per Mil
POWER FACTOR............001-.002 (Meets AWS L-4)

***THESE VALUES COVER THE VARIOUS GRADES OF MYKROY**

GRADE 8. Best for low loss requirements.
GRADE 38. Best for low loss combined with high mechanical strength..
GRADE 51. Best for molding applications.

Special formulas compounded for special requirements.



Based on Power Factor Measurements made by Boonton Radio Corp. on standard Mykroy stock.

MADE EXCLUSIVELY BY

ELECTRONIC MECHANICS INC.

70 CLIFTON BLVD., CLIFTON, N. J.

CHICAGO 47; 1917 N. Springfield Ave., Tel. Albany 4310
EXPORT OFFICE: 89 Broad Street, New York 4, New York

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

"The following is electrically transcribed..."

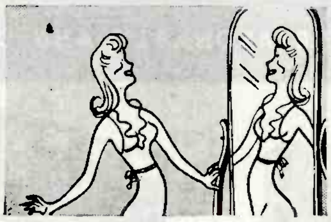
on PRESTO discs!

To any modern youngster or her Mommy, the Super Suds jingle is as familiar as the works of Mother Goose. In two years, this merry snatch of song has proved itself a commercial with "super-do"—lilting its way into the musical memory of America, and, incidentally, selling a whacking big heap of suds.

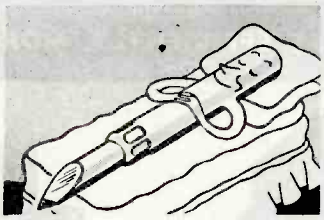
Super Suds "spots" are cut on PRESTO discs. *Most important transcriptions are.* For recording engineers know that PRESTO discs give finer results with less margin for error—*actually perform better than most of the recording equipment on which they are used.* That's why you'll find, in most large broadcasting stations, recording studios and research laboratories, the standard recording disc is a PRESTO.

WHY BROADCASTING STUDIOS USE MORE PRESTO DISCS THAN ANY OTHER BRAND

Less Surface Noise



No Distortion



Easier on Cutting Needle

No Fussy Needle Adjustments

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS

PRESTO

RECORDING CORPORATION

242 West 55th Street, New York 19, N. Y.

Walter P. Downs Ltd., in Canada

To assist the equipment designer Federal offers comprehensive data on high frequency cables.

This technical information sheet provides the design-engineer with pertinent electrical and physical characteristics...including impedance, capacitance, attenuation, diameter, materials, and weight . . . for Federal's wide variety of high-frequency cables.

Single and double braid, armored, dual conductor and dual coaxial, air-spaced, low capacitance lines, and antenna lead-in wire . . . there's a right type for your job, backed by the built-in superiority that's a tradition with Federal.

Special developments in flexible low-loss cables by Federal have resulted in superior cables for all types of transmission. For a better job, see Federal first.

Write for your cable information sheet today.

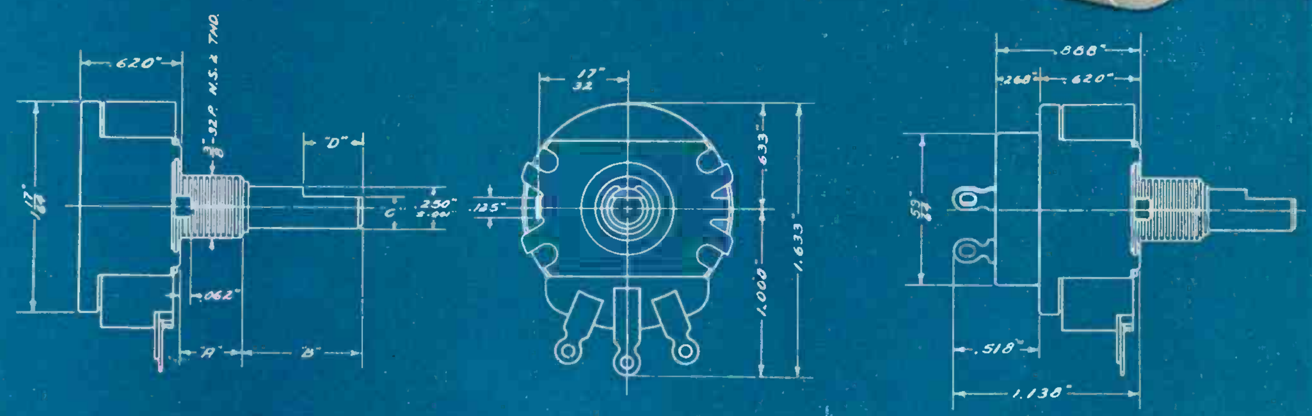
Federal Telephone and Radio Corporation

An IT&T Associate

Newark 1, N. J.

Precision Engineered
VARIABLE RESISTORS

Space Requirements for 252 Series and GC-252 Series



252 SERIES

GC-252 SERIES

● Good engineering reduces the element of chance to an absolute minimum. At CTS, every rule of good engineering no matter how slight its application, is strictly adhered to.

Typical of this are the contacts in all CTS variable resistors. Every contact has multiple—and independent—wiping surfaces whose precision workmanship practically eliminates the chance of faulty contact.

Such engineering craftsmanship has made CTS variable resistors known all over the world for *dependability.*

When your production plans call for new developments in variable resistors, consult these leading specialists — the CTS engineers.

Manufacturers of Quality Electro-Mechanical Components Since 1896

VARIABLE RESISTORS
PLUGS AND JACKS
SWITCHES, RINGERS
TELEPHONE GENERATORS

CTS

CHICAGO TELEPHONE SUPPLY
Company

ELKHART • INDIANA

REPRESENTATIVES

R. W. Farris Co.
406 West Thirty-fourth Street
Kansas City 2, Missouri
Phone: Logan 7495

*Frank A. Emmet Co.
2837 West Pico Boulevard
Los Angeles 6, California
Phone: Rochester 9111

BRANCH OFFICES

S. J. Hutchinson, Jr.
401 North Broad Street
Philadelphia 8, Pennsylvania
Phone: Walnut 5369

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C. C. Meredith & Co.
Streetsville, Ontario

IN ENGLAND

Chicago Telephone Supply Co.
St. John's Woods
103 Grove End Gardens
London, N. W. 8, England

IN SOUTH AMERICA

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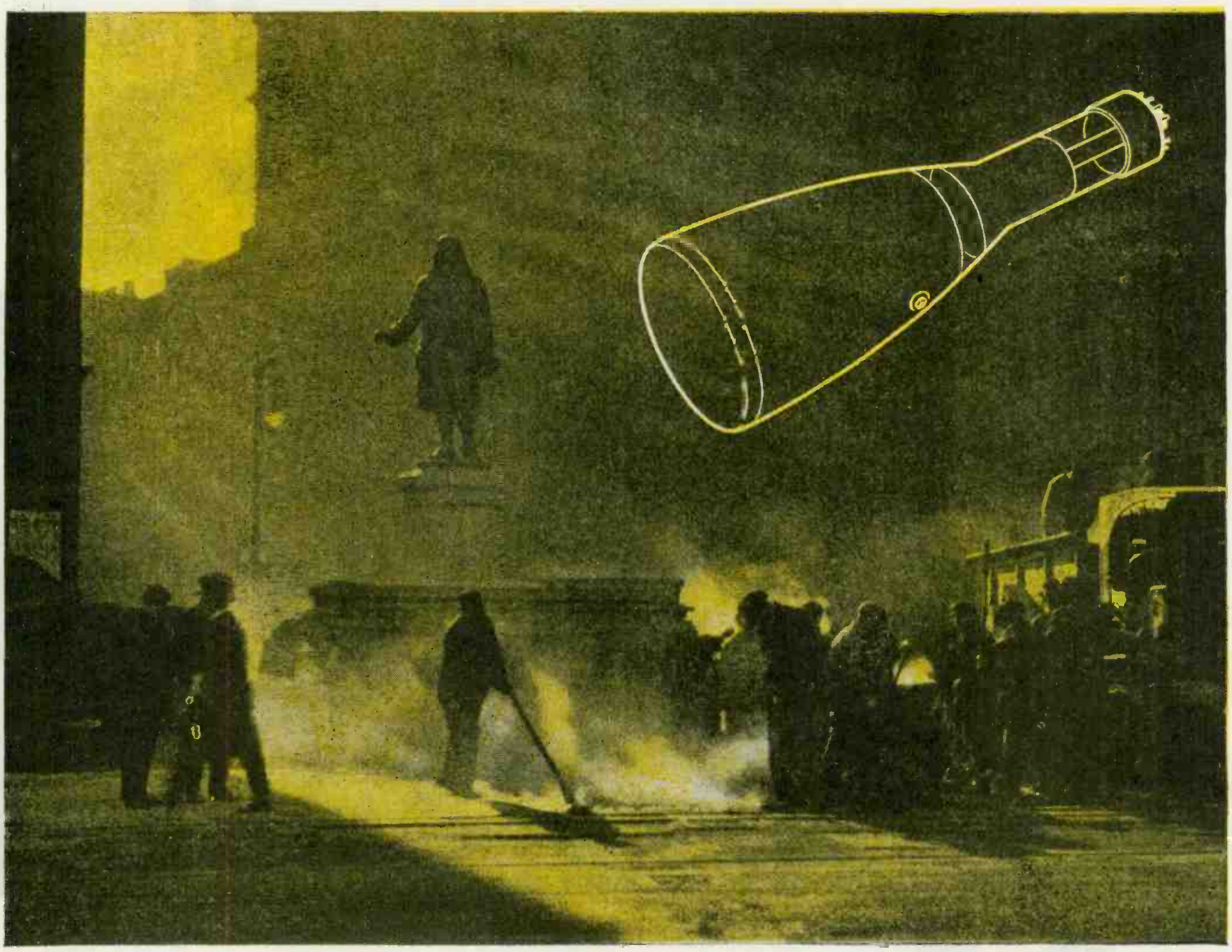
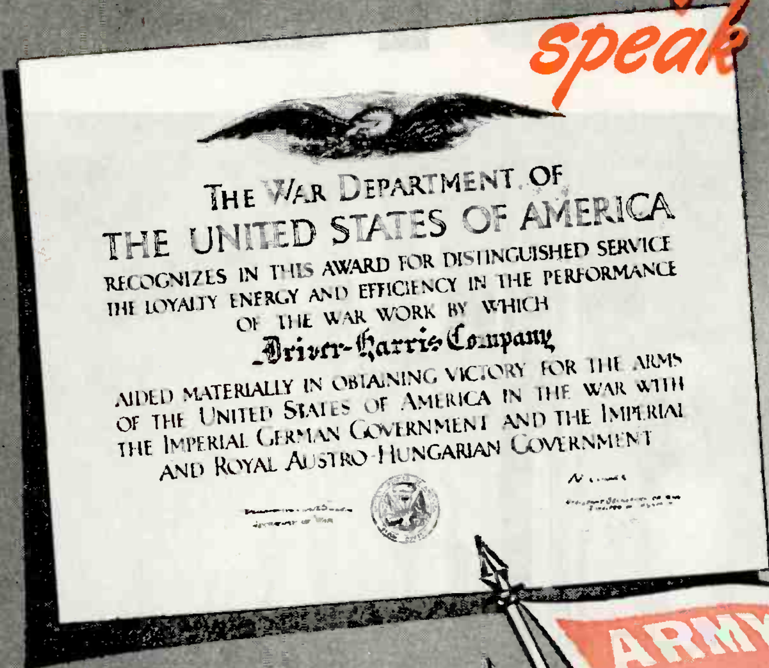
Cordoba 1472
Buenos Aires, Argentina
South America

Masculino 2624
Montevideo, Uruguay
South America

Avda. Conselheiro Rodrigues
Alves 1067
Villa Mariana
Sao Paulo, Brazil
South America



Some Things speak for themselves


THE WAR DEPARTMENT OF
THE UNITED STATES OF AMERICA
RECOGNIZES IN THIS AWARD FOR DISTINGUISHED SERVICE
THE LOYALTY ENERGY AND EFFICIENCY IN THE PERFORMANCE
OF THE WAR WORK BY WHICH
Driver-Harris Company
AIDED MATERIALLY IN OBTAINING VICTORY FOR THE ARMS
OF THE UNITED STATES OF AMERICA IN THE WAR WITH
THE IMPERIAL GERMAN GOVERNMENT AND THE IMPERIAL
AND ROYAL AUSTRO-HUNGARIAN GOVERNMENT

1918

The parade of citations and stars awarded to Driver-Harris for contributions to the war effort in the highly specialized field of alloys, began as far back as 1918.

This equivalent of the Army-Navy "E" was awarded to our craftsmen 27 years ago in recognition for their "loyalty, energy and efficiency."

1945

4th CITATION

First exclusive manufacturer of electrical and heat-resistant alloys to receive the Army-Navy "E" Award for the 4th time. There is no greater reward for the steadfast devotion of Driver-Harris employees to their country in time of war.

Famous for *Nichrome *made only by*

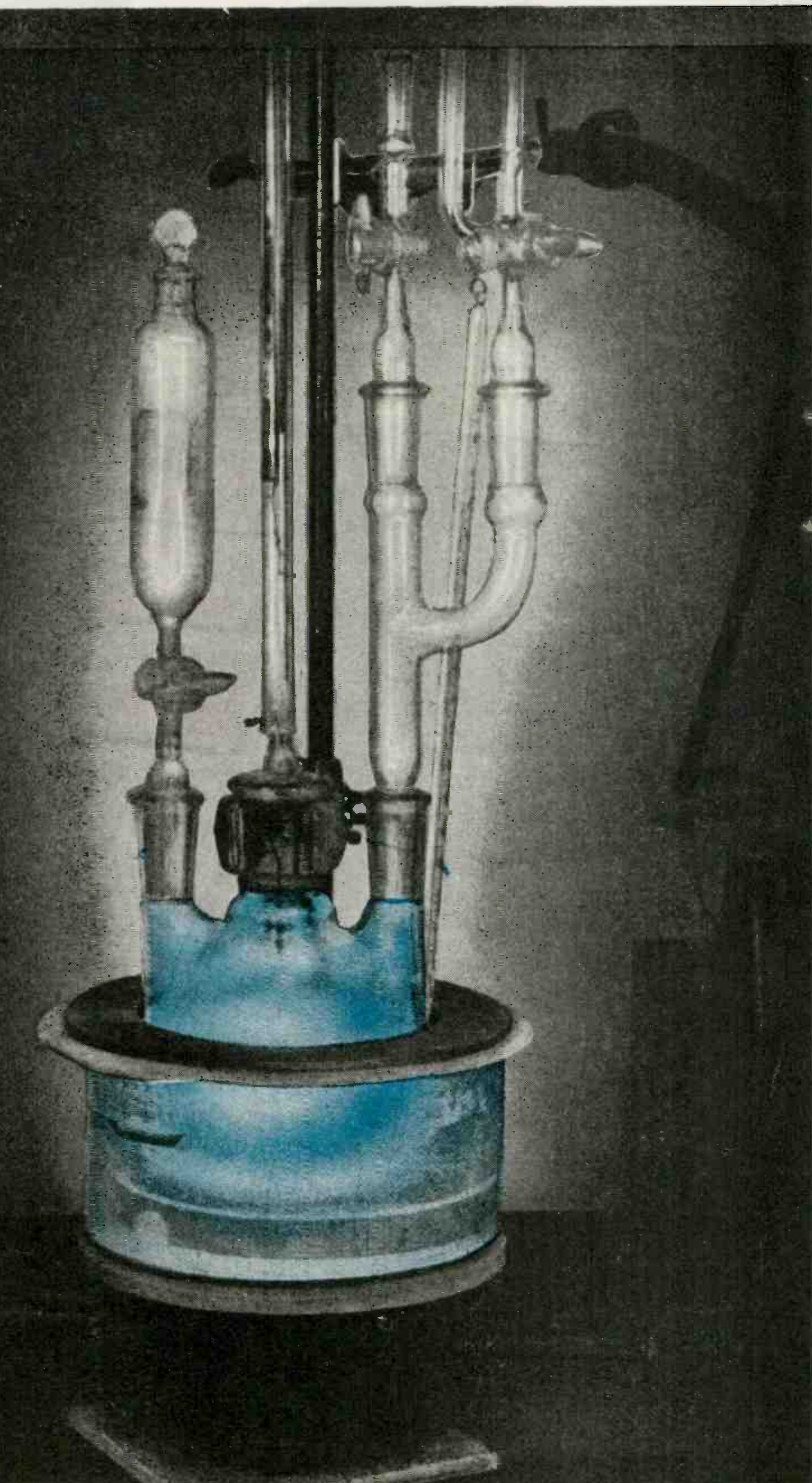
Driver-Harris COMPANY

HARRISON, N. J.

Branches: Chicago • Detroit • Cleveland
Los Angeles • San Francisco • Seattle

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

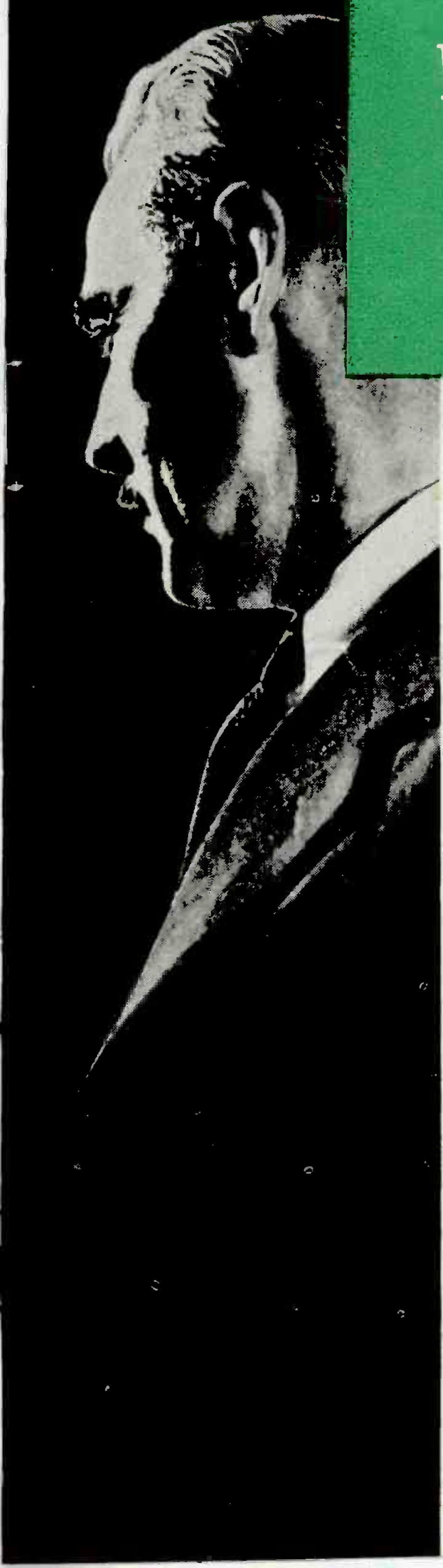
TO RESIST



Electronic bombardment of high voltage cable oil under vacuum at 10,000 volts, a test as unique as it is purposeful, is but one indication of the searching investigations here undertaken.

VOLTAGE . . .

Here, wire and cable Research tests every component beyond the severest demands of service-in-the-field.



Looking far beyond today's needs, General Cable Research is prepared for the days when there will be commercial application of voltages beyond those of yesterday and today. Research endeavor is exploring in many directions, examining many products, evaluating the stability of many materials under the severest conceivable conditions. When the demand can be met, General Cable high voltage wires and cables will be available.

GENERAL CABLE CORPORATION

Manufacturers of Bare and Insulated Wires and Cables for Every Electrical Purpose


Connect
WITH DICO
CO-AXIAL CONNECTORS TO "AN" SPECIFICATIONS
Performance-proved in specialized high-frequency applications — where only the finest is acceptable — DICO co-axial connectors are now available for additional service to the electronic industry. A catalog will be furnished at your request; please give type designations of the connectors you require.
ENGINEERING • DESIGNING
CASTING • WELDING
MACHINING • SILVER SOLDERING
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DICO
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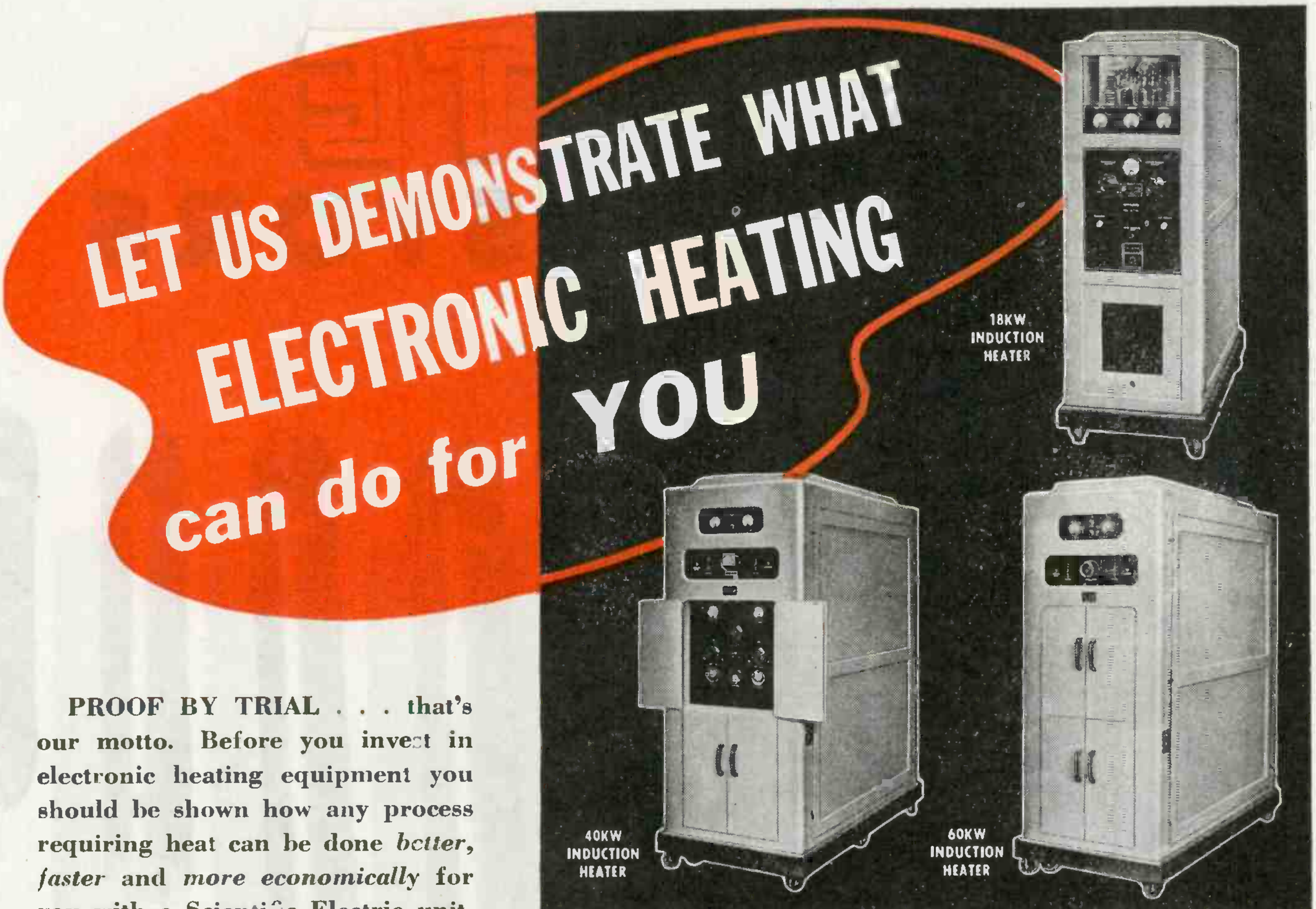


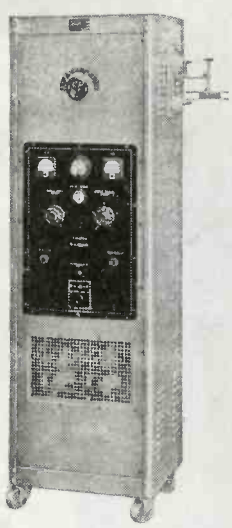
PROOF BY TRIAL . . . that's our motto. Before you invest in electronic heating equipment you should be shown how any process requiring heat can be done *better*, *faster* and *more economically* for you with a Scientific Electric unit.

Our engineers will gladly—*without obligation*—make a study of the heating process under consideration. They will then make recommendations supported by practical demonstrations on the S.E. heater best suited for the job.

This procedure will enable you to figure accurately the economies that will result; also permit you to estimate the time required to pay for the equipment out of resultant savings.

You can submit your heating problems to us with the assurance that absolute secrecy will be observed, if so desired. Investigate the advantages of applying electronic heating in your manufacturing operations NOW. Consult with us at your earliest opportunity.

Write for free copy of
The ABC of Electronic Heating



3 KW DIELECTRIC HEATER
Dielectric Heating Units priced from **$1500.**
(3 KW complete)

5 KW INDUCTION HEATER
Induction Heating Units priced from **$1285.**
(for 5 KW complete with 1 work coil)

Manufacturers of
Vacuum Tube and Spark Gap Converters Since 1921

Scientific Electric

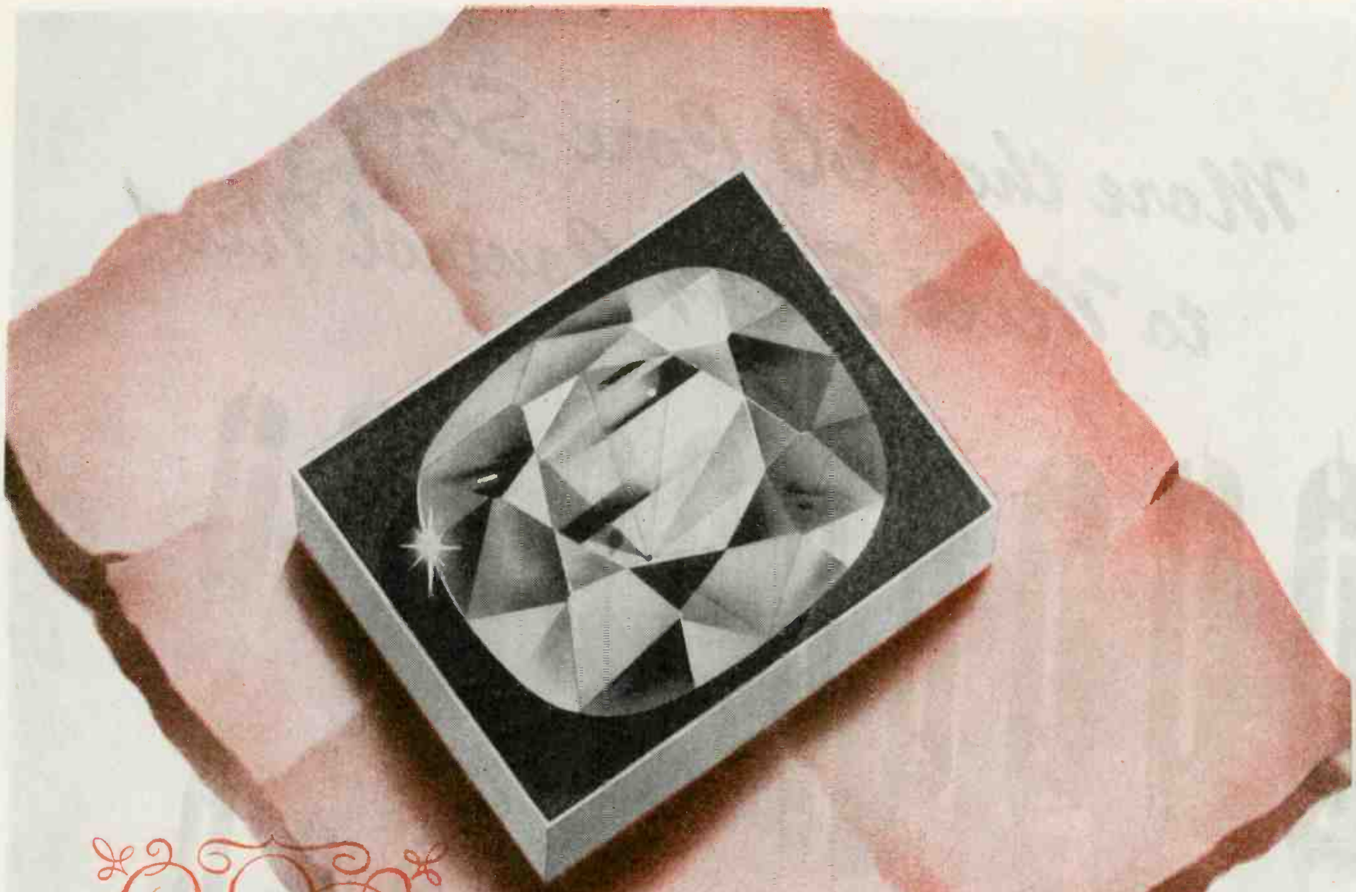
DIVISION OF "S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE ST. GARFIELD, N. J.

Scientific Electric Electronic Heaters are made in the following range of power; 3—5—7½—8—10—12½—15—18—25—40—60—80—100—250 KW.—and range of frequency up to 300 Megacycles depending on power required.


OHMITE
RESISTORS


More than 60 Core Sizes to Meet Every Control Need
Large resistors. Small resistors. Stock units. Made-to-order units. You get the exact size and type you need at Ohmite, to solve your particular problem. More than 60 different core sizes . . . as large as 2½″ diameter by 20″ long . . . as small as 5/16″ diameter by 1″ long. Where required, special sizes can be produced. Terminals, mountings, enclosures are available for all types of applications.
Ohmite quality is time-proved. These rugged resistors serve in all types of critical equipment for war, industry, research and communications. They give trouble-free resistance control under extremes of temperature, humidity, shock, vibration, altitude. Experienced Ohmite engineers are at your service always.
Write on company letterhead for Industrial Catalog and Engineering Manual No. 40.
OHMITE MANUFACTURING CO.
4816 Flournoy St., Chicago 44, U.S.A.
OHMITE
Be Right with OHMITE
RHEOSTATS • RESISTORS • TAP SWITCHES



Quality Counts

THE Koh-i-nor is one of the world's most magnificent diamonds. Weighing 106-1/16 carats, it is famous for its brilliance and luster. Of course, a diamond is considered supreme as a jewel because it is the hardest, most imperishable and most brilliant of all gems. The Koh-i-nor's reputation places it in a separate class apart from other diamonds due to its flawless quality — a true example of the fact that, with any product, *Quality Counts.*

THE WARD PRODUCTS CORPORATION, realizing this fact, has long been the leader in the manufacture of one-piece and sectional antennas for automobile and home radios. **WARD** products are quality products, the workmanship of craftsmen using modern equipment under ideal conditions. Many important design changes pioneered by **WARD,** have become accepted standards in the industry . . . For quality antennas for all applications, look to **WARD.**

BUY WAR BONDS

THE WARD PRODUCTS CORPORATION
1523 EAST 45th STREET, CLEVELAND 3, OHIO

WARD Antennas

● Aerovox popularized this type. Originally a *special* item made only to order and at custom-built prices, it was Aerovox that selected and standardized the sizes, voltages and capacitances so that standard Aerovox stack-mounting units could be regularly produced, listed and properly priced. The rest is history.

Especially intended for various transmitting and electronic applications, these heavy-duty micas have found wide usage in military and peaceful applications alike. Such units are especially popular in heavy-duty transmitting applications such as grid, plate blocking, coupling, tank and by-pass functions. Also in carrier-current applications.

***Special* yesterday, *standard* today, Aerovox stack-mounting mica capacitors have contributed greatly to available quality equipment and outstanding performance.**

● Literature on request . . .

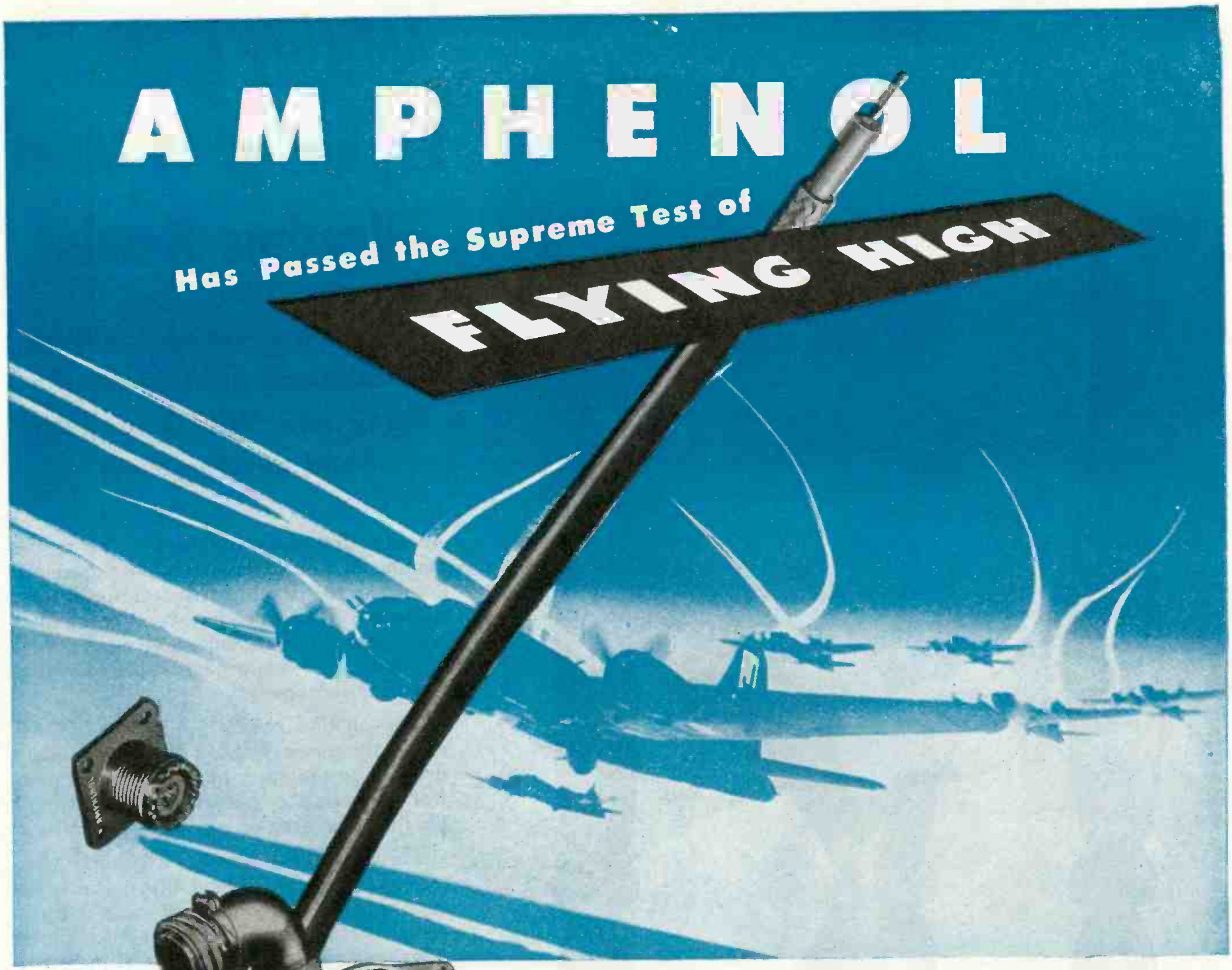
Check list . . .

- ✔ **Low-loss glazed ceramic case for long creepage path between terminals.**
- ✔ **Corona losses eliminated on inside and outside alike.**
- ✔ **Cast-aluminum terminal ends for low contact resistance between stacked units.**
- ✔ **Close-tolerance mica units equalize loading of series-connected sections**
- ✔ **Mica sections rigidly clamped in low-loss non-magnetic clamps and heat-treated for maximum capacitance-temperature stability.**
- ✔ **Mechanical design permits units to be stacked and thereby connected in series, parallel and series-parallel. Dummy units are available to support and insulate active units.**
- ✔ **Units may be bolted together through holes in aluminum caps.**
- ✔ **Standard listings; normally available without delay; at the right prices.**

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.

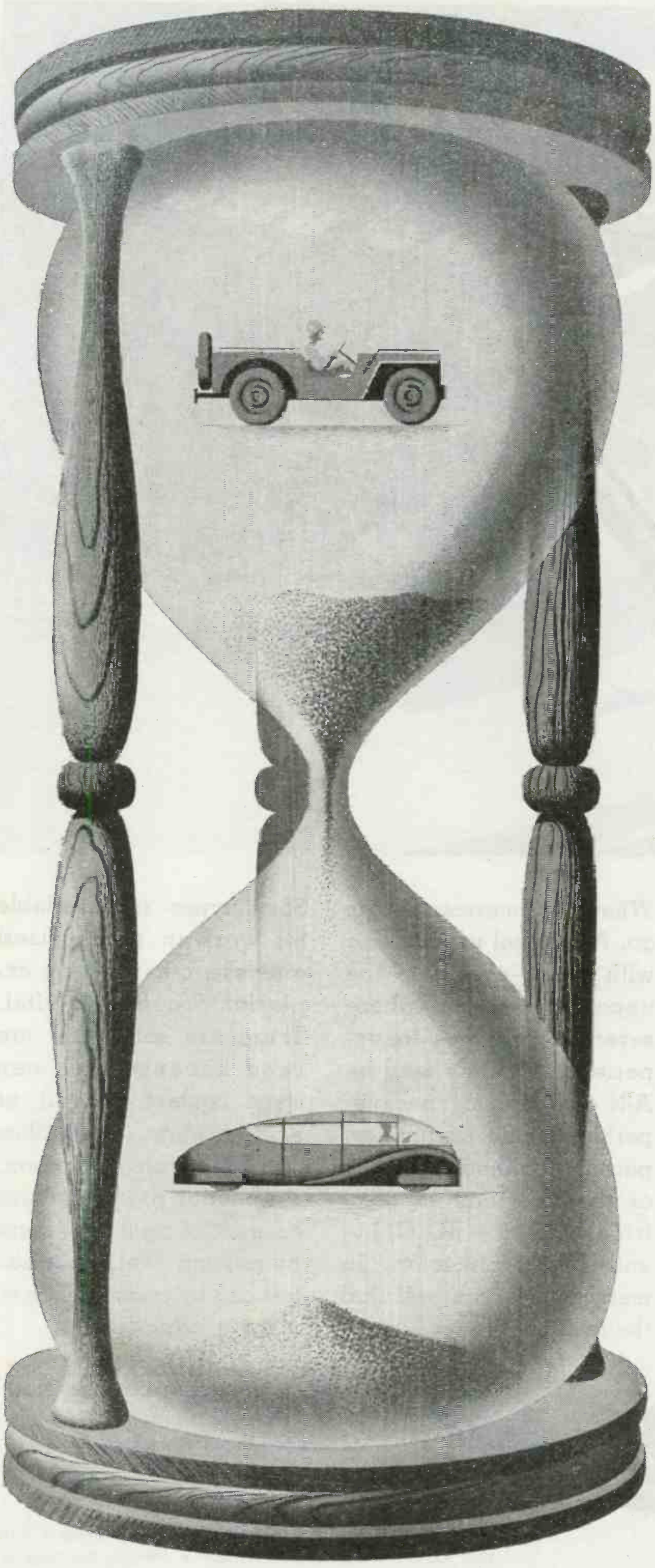


Wherever American planes go, Amphenol products go with them—even into the upper stratosphere where severest conditions are experienced. They may be A-N or British connectors, perhaps cable assemblies, perhaps synthetic conduit, or the aristocrat of electrical wiring—RG Cable and U.H.F. connectors. In many planes you will find them all.

Some types are available for work in pressurized quarters, others where explosion-proofing is vital. There are some that are used because they can stand contact with oil, or acid or water. Regardless of where you find them, Amphenol products have earned the right to be there by passing every required test and by performance on many a firing line.

AMERICAN PHENOLIC CORPORATION
Chicago 50, Illinois
In Canada—Amphenol, Limited—Toronto

Connectors (A-N, British, U.H.F.) Cable Assemblies • Conduit, U.H.F. Cable • Radio Parts • Plastics for Industry



WILCO facilities Expanded to Meet Wartime Needs!

But Postwar Industry will be the ultimate gainer from the many new WILCO products and developments

As the Hourglass indicates . . . at the coming of peace, the skill and experience gained in the development and application of new WILCO products and techniques will mean much to automotive, electrical appliance and many other types of manufacturing customers.

Though now chiefly applied to the war effort, these new WILCO developments are destined to play as vital a role in the postwar industrial "comeback" as they are now playing in scores of wartime applications.

Thermostatic Bimetals, Electrical Contacts, and Precious Metal Bimetallic Products are such important factors in the precision performance of ships, planes, tanks, guns, and various instruments of the Army and Navy that the H. A. Wilson Company has found it necessary to enlarge its facilities and develop these important new products and techniques.

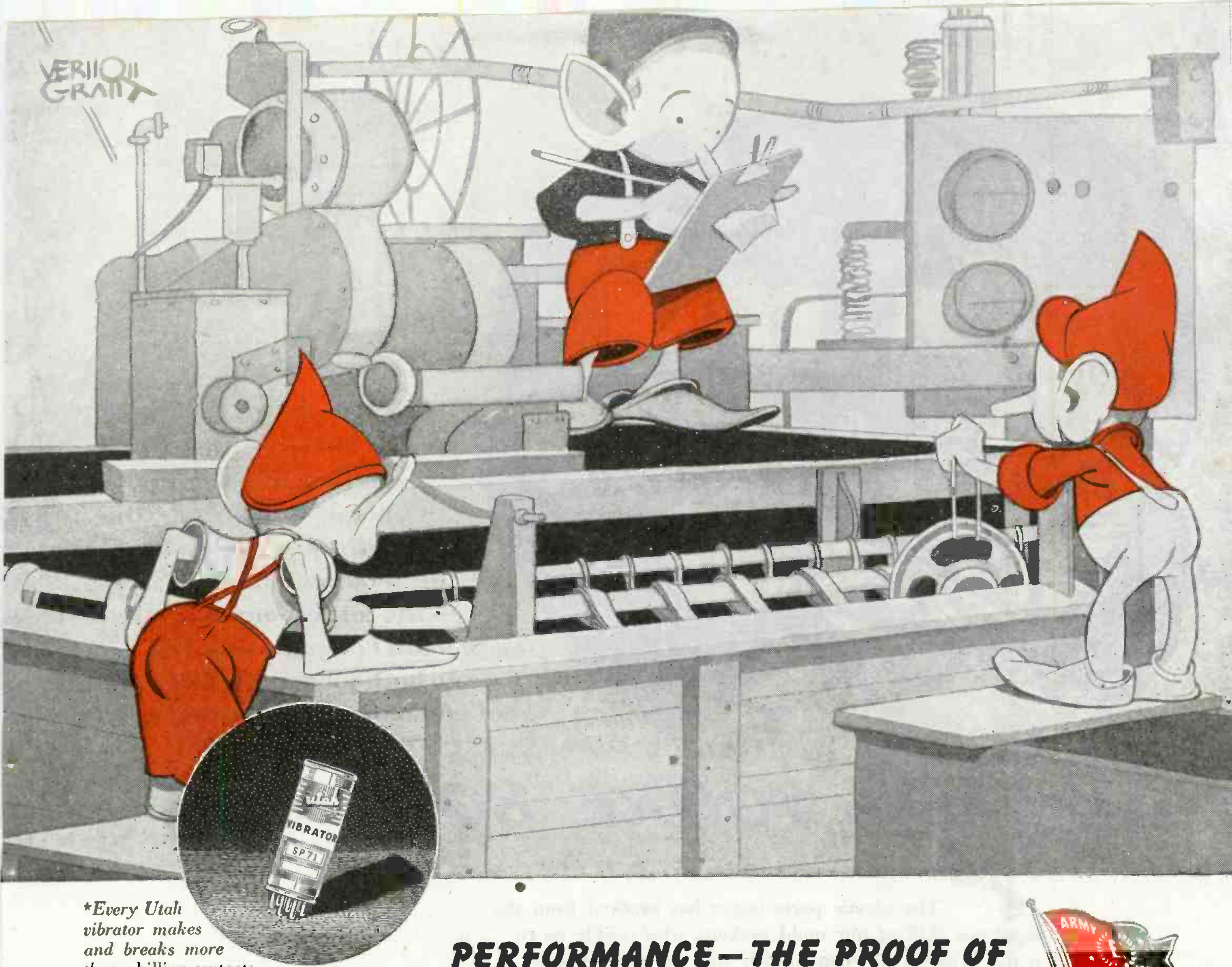
In the postwar period no company will be better equipped to meet individual requirements for Thermostatic Bimetals and Electrical Contacts on any desired scale than the H. A. Wilson Company, pioneers in this field.

WILCO PRODUCTS ARE: *Contacts*—Silver, Platinum, Tungsten, Alloys, Sintered Powder Metal. *Thermostatic Bimetal*—High and Low Temperature with new high temperature deflection rates. *Precious Metal Collector Rings* for rotating controls. *Silver Clad Steel*—for bearings, shims, reflectors, *Jacketed Wire*—Silver on Steel, Copper, Invar, or other combinations requested. *Silver Clad Steel. Rolled Gold Plate.* Special Materials.

THE H. A. WILSON COMPANY
105 Chestnut Street, Newark 5, New Jersey

WILCO

Thermometals—Electrical Contacts
Precious Metal Bimetallic Products



**Every Utah vibrator makes and breaks more than a billion contacts during its lifetime.*

PERFORMANCE—THE PROOF OF UTAH QUALITY

You take for granted the plating process in the manufacture of Utah's radio parts and electronic devices. Just as you would take for granted the Utah loud speakers in manufacturers' sets.

But Utalins* don't. They work on this phase of production as carefully as if they were plating with gold. They know that plating is one of the more important steps in the production of these products of precise manufacture . . . of proven performance. Products that stand up under every condition known to man.

Utalins* begin with nothing but raw materials. As each step follows in the process of manufacture . . . tool making, welding, punch press, electroplating, and all the other steps . . . it's checked, re-checked, tested, supervised. Finally the finished products, shipped from Utah's self-contained factory, prove the Utah method correct. For they speak by performance.

utah
RADIO PRODUCTS COMPANY
CHICAGO, ILLINOIS

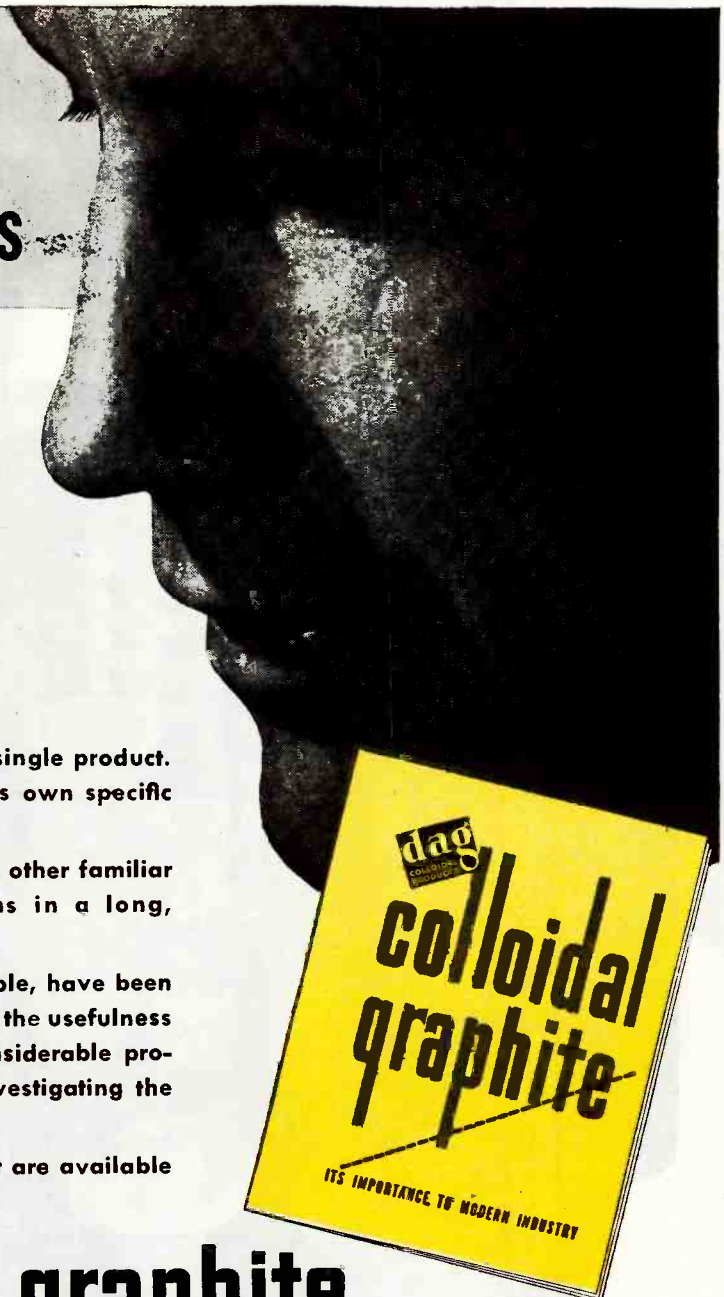
UTAH RADIO PRODUCTS COMPANY
820 Orleans Street, Chicago 10, Illinois

Utah Electronics (Canada) Ltd., 300 Chambly Rd., Longueuil, Montreal (23) P.Q. • Ucoa Radio, S. A., Misiones 48, Buenos Aires

**Utah's helpers.*

Solutions to

SOME OF YOUR PROBLEMS



Dag dispersions of colloidal graphite crown with success many a search for solutions to difficult lubrication problems like these:

- **Minimizing Diamond-Die Wear and Wire Breakage.**
- **Providing Lubrication and Conductivity Simultaneously.**
- **Producing a Non-Reflective Ray-Focusing Anode.**
- **Obtaining a Shielding Material Which Can Be Applied Like Paint to Any Surface, Whether Rigid or Flexible.**

Don't think of **dag** colloidal graphite as a single product. Actually it is many products in one, each with its own specific advantages and applications.

Oildag*, Aquadag, Glydag, and some of the other familiar Acheson products are only a few dispersions in a long, versatile list.

Many **dag** suspensions, hitherto not available, have been developed during the war, thus greatly broadening the usefulness of colloidal graphite. You may save yourself considerable production and maintenance grief by thoroughly investigating the family of **dag** dispersions.

A complete product list and general booklet are available on request without obligation.

dag colloidal graphite

REG. U.S. PAT. OFF.

ACHESON COLLOIDS CORPORATION, Port Huron, Michigan

** Oildag, Aquadag and Glydag are registered trade marks of Acheson Colloids Corporation.*

TO GET THESE — **MAIL THIS**

These new bulletins on *specific* applications for **dag** colloidal graphite are yours for the asking

- **421** — **dag** colloidal graphite for ASSEMBLING AND RUNNING-IN ENGINES AND MACHINERY
- **422** — **dag** colloidal graphite as a PARTING COMPOUND
- **423** — **dag** colloidal graphite as a HIGH TEMPERATURE LUBRICANT
- **431** — **dag** colloidal graphite for IMPREGNATION AND SURFACE COATINGS
- **432** — **dag** colloidal graphite in the FIELD OF ELECTRONICS

—just fill in and clip the convenient coupon opposite

ACHESON COLLOIDS CORPORATION
PORT HURON, MICHIGAN DEPT. 5-D

Please send me, without obligation, your general booklet on **dag** colloidal graphite, and also free copies of the specific bulletins checked below:

No. 421 ☐ NAME ____________
No. 422 ☐ POSITION ____________
No. 423 ☐ FIRM ____________
No. 431 ☐ ADDRESS ____________
No. 432 ☐ CITY ________ ZONE No. ______ STATE ______

OUR PRESENT OIL SUPPLIER IS ____________

(Lubricants containing **dag** colloidal graphite are available from major oil companies.)

It must be made of
Steatite
WHETHER in the field of communication (high and ultra-high frequency) or in the various industrial electronic fields, there is no substitute for Centralab Steatite.
There are no other materials that can be made in as many varied forms and shapes as Steatite. Our engineering and laboratory facilities are at your disposal.
Producers of VARIABLE RESISTORS —SELECTOR SWITCHES—CERAMIC CAPACITORS, FIXED AND VARIABLE — STEATITE INSULATORS — AND BUTTON-TYPE SILVER MICA CAPACITORS.
NAVY
Centralab
CRL
Division of GLOBE-UNION INC., Milwaukee

WHEN MAGNET WIRE *Must take the RAP!*

FORMEX * helps keep down rejects—lowers cost of completed windings.

Few operations put magnet wire to a tougher test than bench assembly of armatures and stators. And rough treatment is intensified by today's push for high production despite high labor turnover.

Because of its exceptionally tough and flexible insulating film, FORMEX magnet wire can take a lot more such abuse than conventional enameled wire. When coils are being wound, bonded, baked, formed, or handled, this extra toughness (and extra resistance to heat-shock and solvents) helps to reduce rejects without requiring "babying" techniques.

As the world's largest user of magnet wire, General Electric makes the same sort of comparisons of installed costs as you might make. These comparisons show that, even in those few cases where the cost of Formex may be slightly higher than the cost of conventional magnet wire which it replaced, the higher first cost is definitely offset by lower costs of manufacturing the completed coil or installed winding. In addition, the choice of Formex for *new designs* permits more compact windings, which, in turn, save space, copper, and frame materials.

Why not, right now, ask your G-E representative for complete information and samples of Formex wire. *General Electric Company, Schenectady 5, N. Y.*

Round wire sizes: No. 8 Awg to .001 in.
Rectangular wire: Full range of sizes

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

FORMEX MAGNET WIRE

*Trade-mark Reg. U.S. Pat. Off.

GENERAL ELECTRIC

503-22-1200

Out of the War Came *BETTER* Insulation!

STRIKING progress in many lines during the all out war effort will have great value in the future and will pay back a part of the terrible cost of war.

Formica FF and MF grades developed during this time have introduced glass base laminated sheets to electrical engineers and have provided insulation of a new high quality in the laminated form.

Some of these grades are excellent high frequency insulators—comparable with ceramics—yet they maintain the easy machinability and workability of laminated parts. They can be punched, drilled, milled. Some of them have exceptional heat resistance for use in motor slot wedges and similar applications.

They will produce better electrical devices at lower costs in the years to come, and contribute in a small way to making a better world.

Engineering data on request.

THE FORMICA INSULATION COMPANY
4661 Spring Grove Avenue
Cincinnati 32, Ohio

FORMICA

Attention
EQUIPMENT MANUFACTURERS

HEINTZ and KAUFMAN
takes the lead in solving a problem which has plagued the equipment designer

Heintz and Kaufman is establishing a standardization policy which will be heartily welcomed by all who design and service electronic equipment.

From now on, whenever you engineer your equipment around Gammatron tubes you can be sure that *identical* replacement tubes will be readily available throughout the life of that equipment!

Thus while Heintz and Kaufman will continue to develop new and improved Gammatrons, these advancements will never embarrass the equipment manufacturer since they will not result in the discontinuance of any Gammatron type.

We are starting this program off by standardizing the specifications for 22 Gammatron types, the outstanding products of our 17 years of tube research and development.

The electrical and physical uniformity and quality of these 22 types will be maintained at the level of Joint Army and Navy specifications. We feel that these specifications are sufficiently high to serve as a sound basis for our standardization policy.

With the establishment of this progressive policy, Heintz and Kaufman Ltd. is taking the lead to end the problem you have always faced of redesigning equipment in production because of variations in type characteristics, and to prevent the premature obsolescence of equipment from the same cause.

Here are the 22 types of Gammatrons which we pledge will be available during the years ahead, always conforming to the same high specifications:

14 TRIODES: HK-24, 24G, 54, 254, 354C and E, 454L and H, 654, 854L and H, 1054L, 1554, 3054.

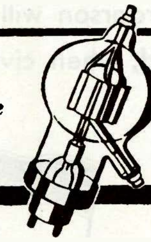
1 PENTODE: HK-257B.

4 HIGH VACUUM RECTIFIERS: HK-253, 953B, D, and E.

3 IONIZATION GAUGES: VG-2, VG-24G, VG-54.

Our advertisement next month will contain additional data on the above types, and will also include a list of Gammatrons available primarily for replacement use.

Have you written for the specification sheet on the HK-1054 Gammatron?



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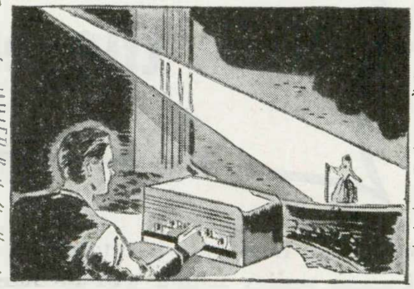

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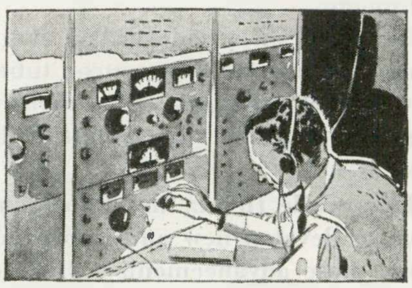


COMMUNICATIONS

EXPERIMENTAL

INDUSTRIAL

THYRATRON WL-678
Grid Controlled Mercury Vapor Rectifier

General Characteristics	55° C Max. Thg	50° C Max. Thg
Filament Voltage	5.0 Volts	5.0 Volts
Filament Current	7.5 Amperes	7.5 Amperes
Filament Heating Time (Minimum)	1 Minute	1 Minute
Typical Control Bias at Rated Voltage	—50 Volts	—75 Volts
Maximum Ratings		
Anode Voltage, Peak Forward	10000	15000
Anode Voltage, Peak Inverse	10000	15000
Anode Current, Average	1.6 Amperes	1.6 Amperes
Anode Current, Peak	6 Amperes	6 Amperes
Temperature Range, Condensed Mercury	25 to 55° C	25 to 50° C

THIS NEW 15,000 VOLT THYRATRON

provides split-cycle control of high power for R. F. heating units, and radio transmitters

The WL-678 combines the high voltage characteristics of a Kenotron, the efficiency of a Phanotron, and the controlability of a Thyratron. This latest feat of Westinghouse engineering offers the electronic equipment designer the following outstanding advantages:

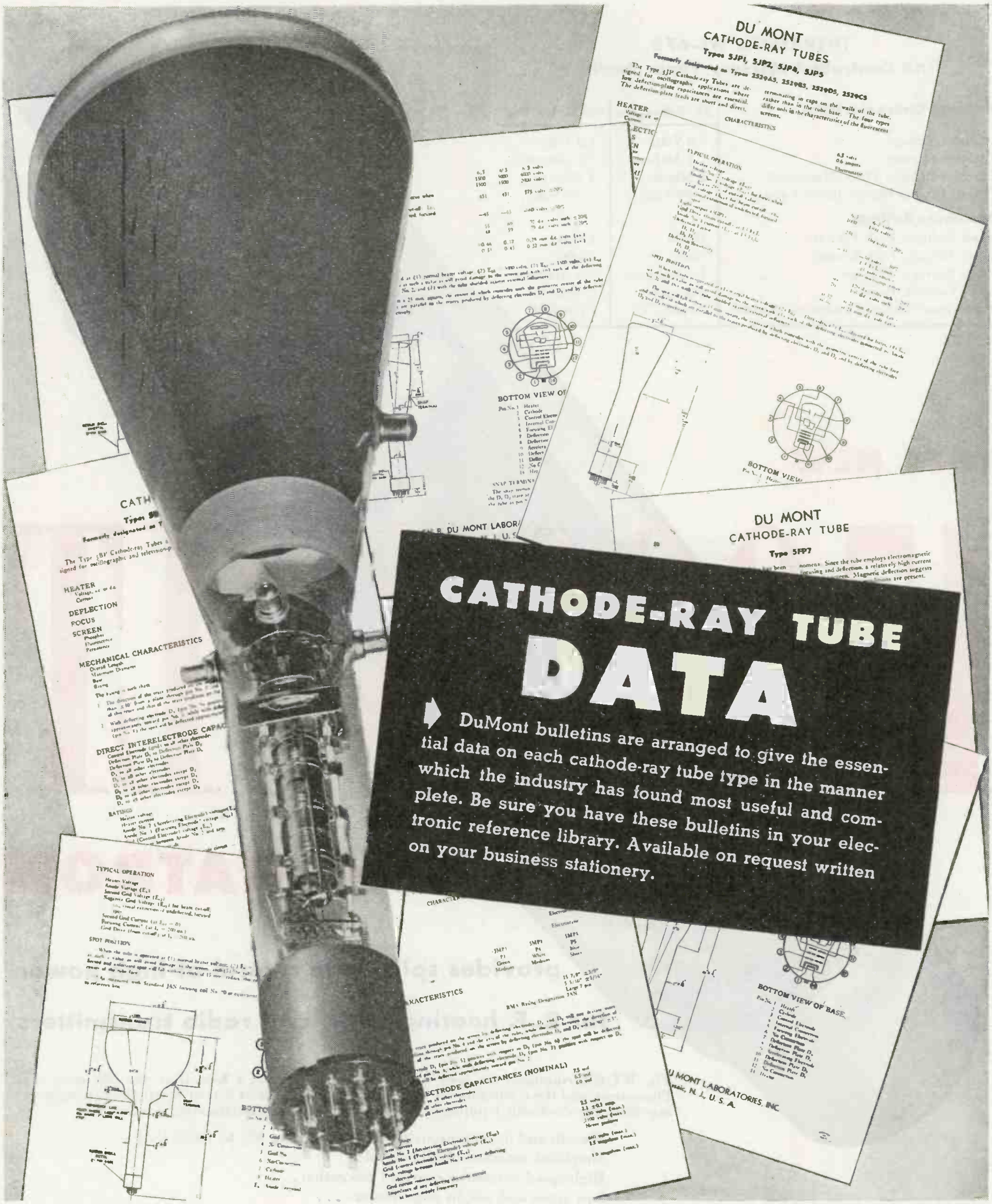
- Smooth and instantaneous power control from 0% to 100% load . . .
- Simplified automatic load control . . .
- High speed automatic overload protection . . .
- Low space and weight requirements . . .
- Low control power requirements . . .

For more detailed information—write to your nearest Westinghouse office or to Westinghouse Electric and Manufacturing Company, Lamp Division, Bloomfield, N. J. Westinghouse Electronic Tube distributors are located in principal cities.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

Quality Controlled Electronic Tubes



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DUMONT *Precision Electronics & Television*

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

Problems are our Dish— TRY YOUR KNOW-HOW ON THIS ONE!

HOW MANY PAGES DID THIS WORM EAT . . . AND WHY?

Ten books are arranged in orderly fashion on a shelf. Each book has 100 pages, making 1,000 pages in all. A worm starting on the first page of the first book eats through the last page of the last book. How many pages has he eaten?

The answer to this one will be given in next month's advertisement or in reply to your written query. But don't give up, it's simple to solve as is our ability to solve your design, fabricating, production and assembly problems.

FRANKLIN KNOW-HOW and WHAT-WITH CAN SOLVE YOUR PROBLEM of design, fabrication, production and assembly of small metal and laminated parts.

At Franklin you will find engineers with the Know-How of design and the What-With in equipment and facilities for coordinated efficient production . . . tool and die makers who click the first time . . . facilities for compression molding of bakelite parts . . . equipment for making plastic parts including laminations . . . machinery for fabricating small metal parts . . . hot tinning . . . plating . . . parkerizing . . . vacuum impregnating . . . tropicalization . . . all the facilities to do a job from the raw material to the finished part and complete assembly.

Franklin coordinated engineering, design, fabrication and production assures economical use of materials, low competitive costs and quick certain deliveries . . . let Franklin solve your production problems.

LAST MONTH'S PROBLEM AND ITS SOLUTION

Problem — D is a missionary interviewing 3 natives of a country where everyone has either black or white feet. The white footed ones can tell only the truth and the black footed natives can tell only lies. All three natives are wearing boots; Who is the Liar?

D to A—"What is the color of your feet"?
A—Mumbles incoherently.
D to B—"What did A say"?
B—"A says he has white feet".
C—"B lies, A says he has black feet".

Solution — "A" can only answer that he has white feet for if he has black feet he must lie and say white and if he has white feet he must tell the truth and say white. Therefore B told the truth and C is the liar—simple isn't it.

ELECTRONIC COMPONENTS **A.W. FRANKLIN** MANUFACTURING CORP.
175 VARICK ST., NEW YORK 14, N.Y.

SOCKETS • TERMINAL STRIPS • PLUGS • SWITCHES • PLASTIC FABRICATION • METAL STAMPINGS • ASSEMBLIES

Again it's HYTRON—Easy on the Battery!

HY1269 HY31Z HY65 HY69 HY1231Z

In mobile operation, the battery is the kingpin. Two-way police radio takes it out of the battery twenty-four hours a day. Conservation of battery power during stand-by periods is mandatory.

Instant-heating Hytron tubes with thoriated tungsten filaments came to the rescue of police radio. Only when on duty, does police radio equipment draw power when Hytron tubes are used. Filament and plate power go on together.

And that's not all. The Hytron HY31Z, HY65, HY69, HY1231Z, and HY1269 are rugged. HY65 performance in two-way motorcycle police radio has proved this. Including 12-volt filament tubes for marine applications, Hytron's instant-heating line is versatile. Concentration is on the R. F. beam tetrode — work horse of transmitting tubes — but also included is the HY31Z twin triode for Class B. One type can power a whole transmitter — R. F. and A. F. — thus simplifying the spares problem (e.g., Kaar Engineering transmitters built around the HY69).

Wartime uses are bringing additions to the Hytron instant-heating line. Watch for future announcements.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON

RADIO AND ELECTRONICS CORP.

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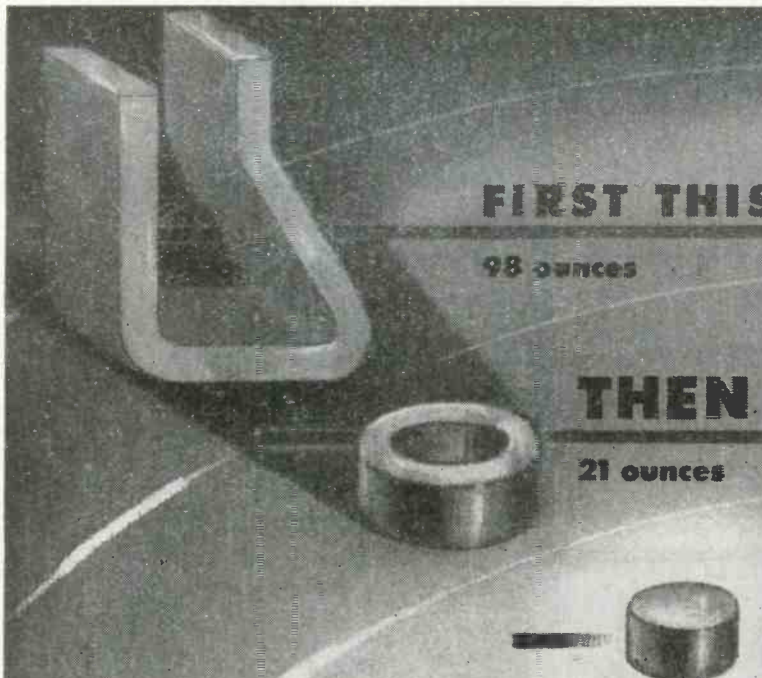


FIRST THIS–in 1930*

98 ounces

THEN THIS–in 1940*

21 ounces

NOW–in 1945*

4.64 ounces

ALNICO 5

by Jensen

FIFTEEN YEARS AGO, when JENSEN introduced the first Permanent Magnet Loud Speaker in the United States, the magnet itself weighed 98 ounces (6.1 pounds)—a bulky, costly structure . . . but, still an outstanding *first* by JENSEN. ¶ By 1940, through advanced design and without decreasing the magnetic strength, JENSEN had reduced the weight of the magnet for an equivalent speaker to 21 ounces! ¶ Now, with ALNICO 5 the most powerful magnet material ever developed, JENSEN is able to obtain the same magnetic strength as in the original 1930 design with a magnet weighing only 4.64 ounces, giving compactness and light weight *with* highest efficiency.

Jensen

SPEAKERS WITH ALNICO 5

* *All of equal performance ability*

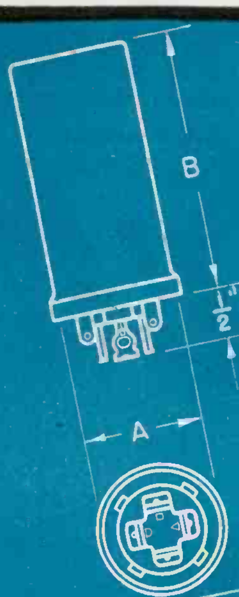
Specialists in Design and Manufacture of Acoustic Equipment

JENSEN RADIO MANUFACTURING COMPANY, 6601 SOUTH LARAMIE AVENUE, CHICAGO 38, ILLINOIS

MEMO TO *Purchasing Dept.*

For postwar, recommend we standardize on Solar's hermetically-sealed, patented special twist-prong base Type DY electrolytic. They're properly protected against moisture.

E.M.



ENGINEERING · SPECIFY *Solar* · DEPARTMENT

PART NO.	SOLAR PART NO.	CAP'Y MFD.	WKG. VOLTS	DIMENSIONS "A"	DIMENSIONS "B"
51 B50-1	DY-61	20+20	150	1"	2"
51 B50-2	DY-92	20+20	450	1"	3-3/8"
51 B50-3	DY-94	10+10	450	1"	2-1/2"
51 B50-4	DY-132	15+10+20	350-350-25	1"	2-1/2"
51 B50-5	DY-141	10+10+20	450-450-25	1"	3"

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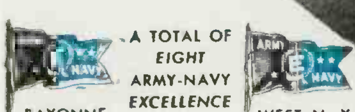
Prominent engineers consistently show their preference for Solar Capacitors. Solar pledges continued production of superior quality capacitors to merit that preference. Solar Manufacturing Corporation, 285 Madison Avenue, New York 17, N. Y.



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AMERICA WANTS PROSPERITY

A BOOK to be published early in April by the McGraw-Hill Book Company carries the provocative title "Prosperity: We Can Have It If We Want It." Its authors, Messrs. Shields and Woodward, state in vigorously challenging terms their conviction that the United States will emerge from war with human, material and technological resources adequate to provide a nation-wide standard of living unprecedented in world history. They present, too, their formulation of the several policies and procedures which must be followed by government, business, and labor if we are to realize our potential for a high and sustained prosperity unmarred by prolonged periods of severe unemployment and business stagnation such as have haunted our economic past.

The specific proposals set forth will elicit both enthusiastic acclaim and acrid dissent, for the book deals in far from gentle fashion with many of the currently fashionable panaceas for assuring prosperity by magic formula. It examines, and discards as effective guarantors of prosperity, whatever their individual merits upon other grounds, programs for public works, slum clearance, subsidizing of small business, foreign loans, social insurance, deficit government spending, redistribution of income, the numerous formulae for monetary management, repeal of the anti-trust laws, or any of the loosely-phrased admonitions that government should do nothing and allow everything to take its course untrammeled by controls of any kind.

On the positive side, the book urges clear recognition of the fact that prosperity, under a system of business enterprise, depends primarily upon the existence of competitive incentives that spur capital investment to provide better tools and equipment, that improve organization and technology to insure continuously increasing productivity per man-hour of work, and that enlarge markets by producing what the consumer wants at lower prices to the end that real incomes may be increased.

In short, prosperity depends upon profitable and expanding business and employment opportunity, so it becomes the part of enlightened government, business, agriculture and labor policy to promote those measures which will forward rather than retard the major aim of expanding production.

However great the room for dissent upon the adequacy, or the phrasing, of the specific recommendations it makes, the approach of this book has one virtue of solid merit. It attacks positively the problem of what steps should be taken to achieve and hold prosperity rather than merely devising a poultice to be applied when and if we run into a decline.

Virtually all responsible spokesmen for government, and for business, labor, and agricultural groups, are agreed upon the goal of prosperity. Moreover, they agree that, insofar as possible, it should be achieved through the effort of private enterprise, with government intervention utilized only as a last resort. But despite this unanimity, almost all public discussion of the problem has concentrated upon the nature, the extent, and the timing of such government expenditures as may be found necessary to combat deflation. Since upon this question there is far from general agreement, our procedure has created an exaggerated sense of divergence in a field in which, so far as fundamentals go, we all are in accord to quite an unusual degree.

☆ ☆ ☆

No confusion should be caused by the fact that the generally current phrase for prosperity is "full employment." The latter phrase merely states the goal in terms of human values, which are good terms in which to state any goal. What matters is that we generally are agreed as to what we mean when we say that we want prosperity or full employment. Not only do we know what we mean, but within very rough limits we can give dimension to our concepts. There are a few whose appraisals are somewhat lower, but most competent estimators set the goals for about 1950 at an average annual employment in civilian jobs of between 55 and 57 million persons, with a gross national product of between \$185 and \$200 billion measured at 1943 price levels. This contrasts with the 1944 level of non-military employed of 51½ million, and a gross output for the end of 1944 of over \$200 billion. It assumes a reduction of the average work-week to 40 hours.

It will take some such levels as these to provide employment for those who seek work, with only sufficient "frictional" unemployment (those temporarily listed as unemployed because of the normal turnover between jobs) to afford reasonable labor-market flexibility to both workers and employers. The non-military employment figures are generally consistent with the officially stated postwar goal of jobs for 60 million workers, since the latter figure is generally understood to be an estimate of the *labor force,* which includes members of the armed services and an allowance for frictional unemployment.

There are a number of reasons why the estimates cannot be figured more closely, and why no one can be very confident even of the validity of the stated limits. The chief points of doubt in the employment estimates relate to how many withdrawals there are likely to be on the part of women, oldsters, and youngsters, who now are in the labor force to a number more than 6 millions beyond normal expectancy; how many men will be retained in the armed forces; and whether the postwar frictional unemployment should be calculated as approximating the current 1 million or the 3 million so-listed in the prosperous year of 1929. Additional uncertainties cloud the estimates of gross national product. Notable among them is the fact that no one is sure of the war's effect upon man-hour productivity trends, in view of the fact that half of our current output has consisted of products that had no substantial counterpart in our peacetime price or production series.

☆ ☆ ☆

Nevertheless, despite such qualifications, it is fair to say that we do have a general conception of the magnitude of our postwar goals. Although they are well within our production potentials as demonstrated in this war, they are formidably beyond any previous record of peacetime achievement. Only the most sanguine optimism could lead one to expect that they will be achieved without concerted will, planning, and cooperative effort. Only blind recklessness could engender confidence that once attained they will automatically be held, let alone expanded in normally healthful growth.

If we were to follow past patterns, our war-built boom would, after a period of uncertain length, collapse into disastrous depression. The very magnitude of our recent growth would contribute to the depth and duration of the subsequent trough. Yet a fall even to the level of our previous peacetime-peak-year 1939, has been estimated by The Federal Reserve Board to imply unemployment for between 15 and 20 million persons. If human values have importance, that is something that must not be allowed to occur. If business values have importance, we must not tolerate again such losses as occurred from 1930 to 1933, when sales over the four year period were $128 billion less than would have been provided if the 1929 level had held, and corporate profits declined from more than $7 billions in 1929 to an average annual loss of $1 billion over the next four years. A repetition of these things cannot be tolerated—*if foresight and cooperative effort can prevent them.*

☆ ☆ ☆

In January of this year Senator Murray introduced in the Senate a bill entitled "The Full Employment Act of 1945." It instructs the President to submit to Congress plans for eliminating both unemployment and inflation, including recommendations for correcting structural defects in the economic system. It provides for a Joint Congressional Committee to consider the proposals of the President, to take testimony from experts and the general public on these proposals or any others it may wish to consider, and after weighing all the facts to submit its findings to Congress. It provides for an advance budgeting of the constituent parts of a full-employment economy, and commits the Federal Government to provide, in advance, for sufficient expenditures (through private contractor channels) to make up for the gap between estimated private expenditures and the amount necessary to assure full employment.

By no stretch of the imagination can The Full Employment Bill, in its present form, be regarded as acceptable to business. Yet it may well present a test of whether or not American business can deal with problems in this area in a statesmanlike fashion. Such statesmanship will consist in demonstrating first, that the Bill is not acceptable because of deficiencies which preclude the possibility of its accomplishing the avowed purposes; and second, that business is able and anxious to offer constructive suggestions for remedying these deficiencies.

It is easy to point to weaknesses in the Bill. To mention only a few of major importance: The proposal to make advance Federal expenditures to compensate for estimated deficiencies in prospective private expenditures is completely impracticable. No one in the country can predict future trends with sufficient accuracy for this purpose; no one can tell what the constituent parts of a really high, *stable* peacetime budget should be, for in our boom-or-bust economy we have no stable pattern to project; no one can tell, within reasonable limits, how much the government should spend *in advance* to assure full employment. The Bill pronounces labor's right to work without defining commensurate responsibilities which it should exercise. It does not define the areas of proposed government expenditure in such a way as to allay business fears of government competition or the general public suspicion of leaf raking. Above all, the Murray Bill is defective in that, despite a somewhat vague pronouncement in favor of forwarding private business activity, it recommends a single specific designed to supplement such activity rather than stimulate it.

The very definition of certain of these faults suggests their remedies. But the positive task of stating how the Bill should be amended in order that it may have effective usefulness is far from simple. Yet it is enormously to the advantage of American business to undertake it. Fortunately, there is a representative group sponsored by industry, The Committee for Economic Development, which has for some time been working intensively upon the problem, and which is excellently equipped to offer sound and progressive advice. It should be used for this purpose.

American business cannot afford to take a negative attitude toward legislation in this field. Some legislation undoubtedly will pass, for the problem is one in which there is a grave government responsibility. But equally there is a comparably important responsibility upon all citizen groups. None of them has more to gain or lose from the rise or fall of prosperity than American business.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

THIS IS THE 34TH OF A SERIES

"WE USE EIMAC TUBES EXCLUSIVELY IN ALL OUR LARGER GROUND STATIONS"

Says Robert F. Six

PRESIDENT, CONTINENTAL AIR LINES

CONTINENTAL AIR LINES, INC.
MUNICIPAL AIR TERMINAL
Denver 7, Colorado

January 9, 1945

Chief Engineer
Eitel-McCullough, Inc.
870 San Mateo Avenue
San Bruno, California

Dear Sir:

An airline must have a communication system which is absolutely dependable. For that reason, we scrutinize with great care the records we keep on the performance of the various components used in our transmitting and receiving equipment.

Included among these records are those on Eimac transmitting tubes—used exclusively in all of the larger ground stations operated by Continental Air Lines. I am pleased to tell you that these records show that your transmitting tubes are averaging well over 20,000 hours of service in our stations.

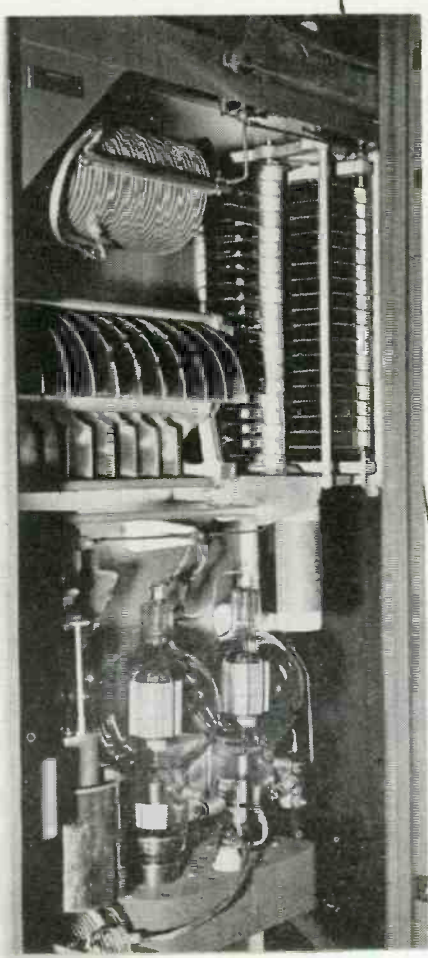
Sincerely yours,

Robert F. Six
Robert F. Six
President

RFS/lad

ROBERT F. SIX
President
Continental Air Lines

Below... a pair of Eimac 450-T tubes in the panel of Continental ground station transmitter built by Wilcox.



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Get your copy of Electronic Telesis... the sixty-four page booklet which gives the fundamentals of electronics. This little booklet will help electronic engineers explain the subject to laymen. It's yours for the asking... no cost or obligation. Available in English and Spanish languages.

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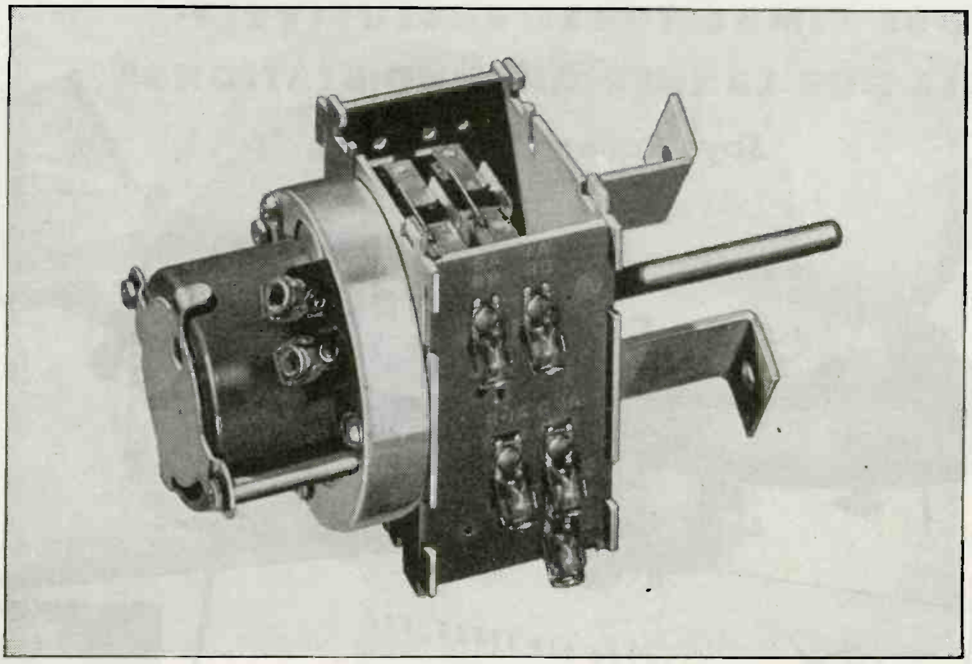
Brains of Your Postwar Product—a Mallory Interval Time Switch



HERE'S a precision part—developed by Mallory for controlling automatic home laundry equipment, washing machines and dryers—that seems almost human.

Controlled by a Mallory Interval Time Switch, a piece of electrical or electronic equipment performs a pre-determined sequence of operations automatically. Simply set a dial, and the machine's "thinking" is done for it by the Mallory switch.

Construction of the time switch is typical of the *precision workmanship* for which Mallory is noted. The small sturdy motor is sealed in oil—requires no lubrication. Precision springs assure smooth mechanical operation, and contacts of a special Mallory alloy have uniformly low electrical resistance. The entire switch is ruggedly built for dependability and long life.

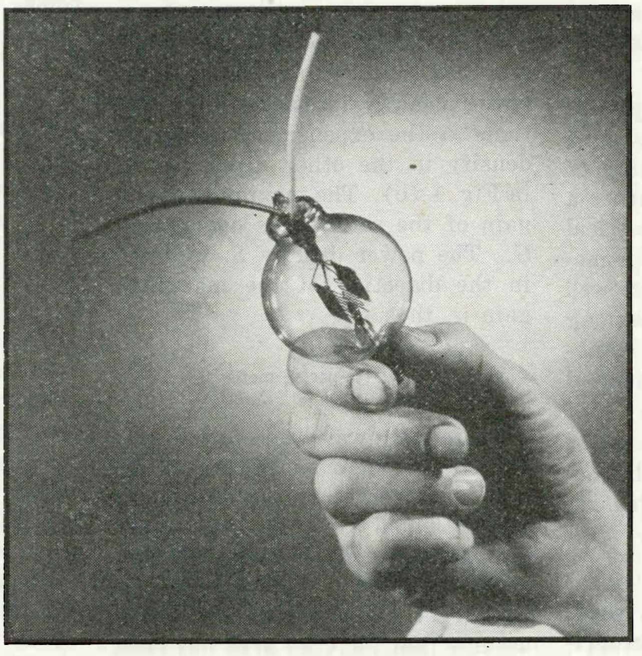
Manufacturers of industrial, electrical and electronic equipment . . . seeking greater operating efficiency and output . . . will find many uses for the Mallory Interval Time Switch, as have makers of household appliances. The postwar trend to automatic operation is evident.

Now is the time to discover how *you* can incorporate the "brains" of this switch in your postwar products—for the greater efficiency that assures greater sales appeal. Consult Mallory while your designs are being planned.

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

CROSS TALK

▶ **BIRTHDAY** . . . This is ELECTRONICS' fifteenth anniversary issue. In April 1930, when the first issue was published, this country along with all others was in the midst of a great economic depression. Engineers' brains, however, were not sterile; and some of the devices which are so useful today came from seeds planted in the early 1930's.



On the masthead of the first issue of ELECTRONICS, April 1930, appeared the name of the pioneer, Dr. Lee deForest. This photo of one of his early audions (used in color on the cover) commemorates not only our birthday but the whole art that has come from his early invention

Fifteen years ago, electronics was very simple, technically. Pentode tubes were creating quite a stir, the die-hards of the industry stating that triodes were ok with them and why clutter up the business with more complex structures. Radio set manufacturing companies were advertising the "perfect" tone quality of their products; tube manufacturers were using electronic heating but no one else gave it much of a thought.

Ten years ago the FCC was about to reallocate the broadcast spectrum and, as always, was under terrific pressure to add a thousand or two stations to those already spraying the ether with palaver. WBEN in Buffalo celebrated the first anniversary of its seven-meter broadcasting station W8XH. Engineers were aware of the advantages of the high frequency carrier, but, as usual, station managers felt that something new like short-wave operation was a complicating idea and might upset the standard-band setup.

In April, just five years ago, engineers were debating heatedly whether f-m had any advantages over a-m. Today the technical advantages are well recognized, and although there are a few who refuse to be converted, their objections are usually on specious and not technical grounds. The only question is whether f-m is to stay where it is in the spectrum or go upstairs into the 80-100 megacycle region where the air may—or may not—be cleaner. Five years ago there was talk of the greatly expanded communication services that would come with the microwaves—but even the best dreamer could not have imagined all the microwave applications that have come from the accelerated research due to war.

Just five years ago, engineers were still hunting for jobs. In spite of all manner of shots in the arm, the country was still sick economically. Europe and Asia were at war; but Americans had not yet felt the cold breath of strife. Today, jobs are hunting for engineers. The whole world is at war; money is cheap—but to get a cigarette you've got to stand in line or monkey with the black market.

Fifteen years ago, ELECTRONICS pioneered a new and strange word. For a number of years the circulation remained at about 6000; then our subscribers increased in number and have continued to do so ever since. Today the circulation is about 24,000. Within a short two or three years, additional hundreds of thousands of men have learned what electronics can do. It must be the sincere hope of all of us that most of these hardened and experienced electronic technicians will find their place in the post-war sun.

The Radar

The basic relationship which governs the design of a radar system is an equation which relates the radiated power and receiver sensitivity to the distance and size of the detected object. This equation is here derived from fundamental considerations

CONSIDERATIONS OF SECURITY at present forbid disclosure of the performance of particular radar equipment. No such prohibition applies to the fundamental principles which govern radar operation.

The basic factors concerned are the formation and propagation of radio beams, and the reflection of radio waves when they encounter a sudden change in the electrical properties of the transmission medium. These fundamentals are well known. They are, in fact, among the earliest fundamentals established in the radio art, enunciated by Hertz in 1887.

It is the purpose of this paper to examine the factors which govern the perception of reflected radio waves.

Power Considerations

The equation which links these factors may be termed appropriately the *radar equation*, since its formulation is applicable to the radar system. The simplest and most fundamental form is the *free-space radar equation*, which governs the radar signal when it is propagated between a radar and a reflecting object or target in otherwise empty space. The free-space radar equation relates the power radiated from the radar (transmitter output and antenna gain) to the power delivered to the terminals of the receiver, taking account of the attenuation in space and the reflecting properties of the target. It is derived as follows:

Consider a transmitter which delivers a peak power of P_t watts to the radiator. If the radiator were an isotropic source, this power would be radiated equally in all directions, filling a sphere of constantly increasing radius as in Fig. 1(a). The density of the power, at a distance r meters, would be equal to the power radiated divided by the area $4\pi r^2$ of the sphere.

In practice, the radiator is directional, a fact which increases the power density in particular directions at the expense of the power density in the other directions as in Fig. 1 (b). The maximum power gain of the radiator is denoted by G_o. The power density S_t radiated in the direction of the maximum gain is, then

$$S_t = \frac{G_o P_t}{4\pi r^2} \text{ watts per sq meter} \tag{1}$$

When the wave encounters the target, at range r, the target absorbs and reradiates an amount of power equal to the impinging power density S_t times the scattering cross-section or *echo area* of the target, σ square meters. We may assume that the echo area has been determined empirically. The target is, then, a source of radio waves, of power σS_t watts. It is evident that the power re-radiated is not uniform in all directions, but the value σ is taken as that effective in the direction toward the radar.

The wave, in traveling the distance r back to the radar, spreads through a sphere of radius r, as in Fig. 1(c). Hence it displays, at the radar, a power density of

$$S_r = \frac{\sigma S_t}{4\pi r^2} \text{ watts per sq meter} \tag{2}$$

Substituting Eq. (1), this is

$$S_r = \frac{G_o P_t \sigma}{(4\pi)^2 r^4} \text{ watts per sq meter} \tag{3}$$

This power density is gathered by the effective absorption cross-section of the receiving antenna, A_o sq meters, and generates a power at the receiver input of

$$P_r = A_o S_r \text{ watts} \tag{4}$$

Substituting Eq. (3), this becomes

$$P_r = \frac{A_o G_o P_t \sigma}{(4\pi)^2 r^4} \text{ watts} \tag{5}$$

Equation (5) is most informative if it is recast to express the range of the target in terms of the other quantities,

$$r = \sqrt[4]{\frac{P_t A_o G_o \sigma}{P_r (4\pi)^2}} \text{ meters} \tag{6}$$

This is the general form of the free-space radar equation.

The form of the equation of most practical interest is that expressing the maximum range at which detection of a given target is possible. For a given transmitter power P_t, antenna system $A_o G_o$, and target echo area σ, the range is limited by the minimum received power P_{min} which will generate a barely discernible response in the radar indicator. The maximum range is then given by

$$r_{max} = \sqrt[4]{\frac{P_t A_o G_o \sigma}{P_{min} (4\pi)^2}} \text{ meters} \tag{7}$$

A surprisingly large amount of information is given by this equation. It states that the maximum range of a radar depends on the fourth root of: (1) the transmitter power, (2) the antenna gain and absorption area $G_o A_o$, (3) the target echo area α, and (4) the inverse $1/P_{min}$ of the minimum discernible received power.

Equation (7) also reveals that equal effects on the maximum range may be achieved by increasing the transmitter power P_t, or the power sensitivity $1/P_{min}$ of the receiver. It indicates the apparent facts that the range is greater when the an-

EQUATION

tenna gain is high and when the target has a large effective area.

The fourth-root modifies these relationships in a very important way. It indicates that a given increase in maximum range is obtained only at great expense in additional transmitter power and antenna gain and that the range possible when viewing large targets is only slightly greater than that possible with small targets. Doubling the value of transmitted power, for example, increases the maximum range, by $\sqrt[4]{2} = 1.19$ times. Doubling the value of A_o, G_o or σ (or halving the value of P_{min}) has the same small effect, i.e., a 19-percent increase in maximum range. In engineering terms, a 12-db increase in transmitted power or receiver sensitivity is required to double the maximum range.

The radar equation expressed in Eq. (7) gives no clue as to the dependence of radar performance on the operating wavelength or frequency. This information is implicit in the quantities A_o, G_o and σ. The radiator gain G_o and absorption across section A_o are readily computed, to a fair approximation, from the operating wavelength and the area of the reflector surface.

Influence of Operating Wavelength

The gain is defined as the ratio of the solid angle subtended by a point-source radiator to the solid angle subtended by the beam. The angle subtended by the beam depends evidently on the form of the radiator. One of the commonest forms is the circular reflector, whose diameter is D meters and whose area across the face is $A = \pi D^2/4$ sq meters. The beam produced is of circular cross-section and occupies a minimum angular width, between half-power points, of

$$b = \frac{\lambda}{D} = \frac{\lambda}{2\sqrt{A/\pi}} \text{ radians} \qquad (8)$$

where λ is the operating wave length in meters. The maximum gain of such a beam radiator, relative to an isotropic radiator, is

$$G = \frac{8\pi A}{3\lambda^2} \qquad (9)$$

The radiator proper is customarily a dipole mounted at right angles to the direction of maximum gain. The dipole has an inherent power gain, in that direction, of 3/2 over an isotropic radiator. Hence the total maximum gain G_o of the radiator is

$$G_o = \frac{3}{2} \times \frac{8\pi A}{3\lambda^2} = \frac{4\pi A}{\lambda^2} \qquad (10)$$

The absorption cross section A_o is related to the maximum receiver antenna gain G_r by the following:

$$A_o = \frac{G_r\lambda^2}{4\pi} \text{ sq meters} \qquad (11)$$

When the radar uses a single reflecting system and dipole (or dipoles) for transmitting and receiving, $G_r = G_o$, and

$$A_o = \frac{G_o\lambda^2}{4\pi} \text{ sq meters} \qquad (12)$$

Substituting Eq. (10) for G_o

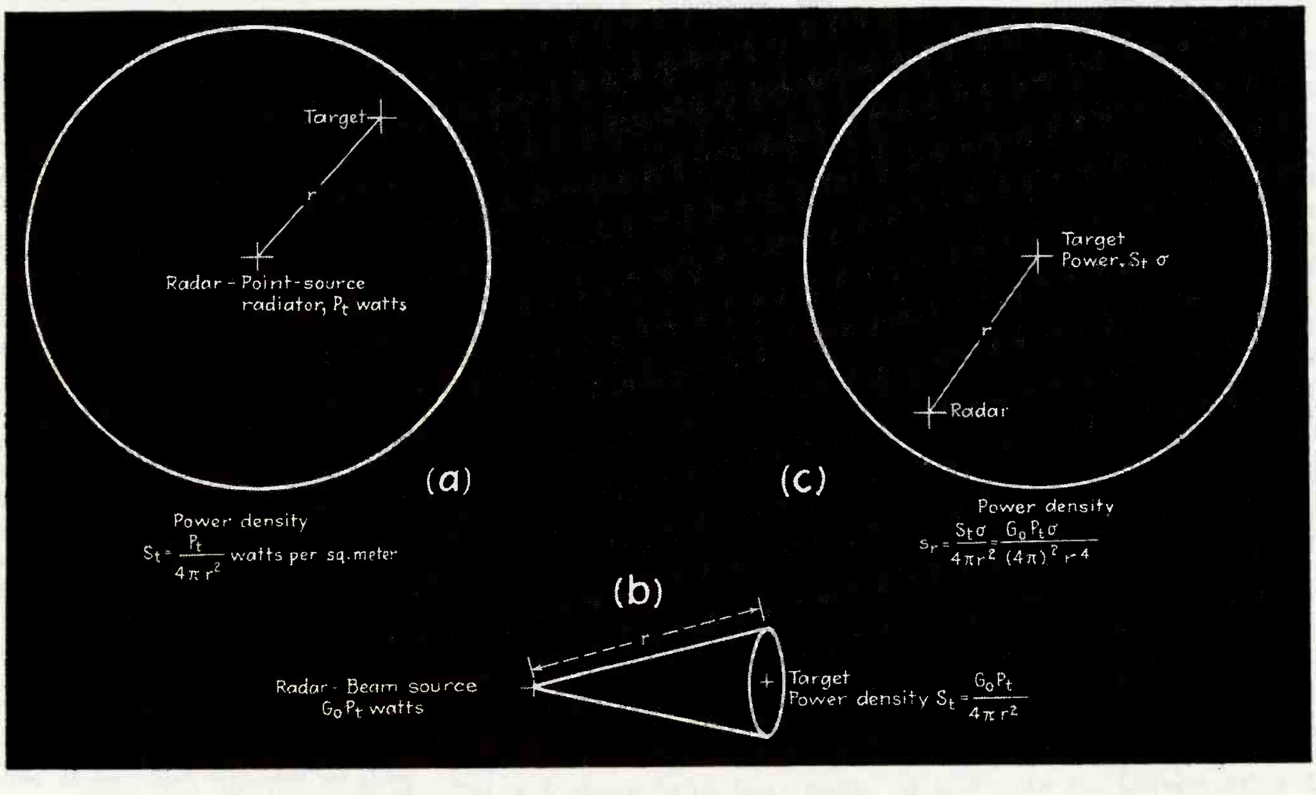


FIG. 1—Geometric relations underlying the radar equation

$$A_e = A \text{ sq meters} \tag{13}$$

which is simply the area of the reflector.

The dependence of the echo area σ on the operating wavelength cannot be generally stated except for targets of simple shape. Accordingly the quantity σ is retained without further analysis, with the understanding that its contribution to the radar equation does in fact vary with the operating frequency, but in a manner which is so dependent upon the particular target and its aspect that no general conclusions can be drawn.

Returning now to the radar equation for maximum range, Eq. (7), and substituting Eq. (10) and (13) for G_o and A_e, we obtain

$$r_{max} = \sqrt[4]{\frac{P_t A^2 \sigma}{P_{min} \lambda^2 4\pi}} \text{ meters} \tag{14}$$

This equation indicates that the maximum range increases inversely as the square root of the wavelength, or directly as the square root of the frequency, provided that we can choose the area A of the reflector without regard to frequency. Thus if we can select a convenient value of A and let it remain fixed, the maximum range will increase slowly, all other factors remaining unchanged, as the frequency is increased.

One important aspect of radar design is the beam width, λ/D. As the wave length is decreased (frequency increased) with a given area of reflector, the beam becomes narrower. A practical limit is reached, with a fixed value of A, when the beam becomes so narrow that it is impractical to scan a large region of space in a reasonable time. Hence it is of interest to consider the effect of frequency on maximum radar range, when the beam width is fixed. To show this, Eq. (14) is re-written, substituting Eq. (8), as

$$r_{max} = \sqrt[4]{\frac{P_t \pi \sigma \lambda^2}{P_{min} 64b^4}} \text{ meters} \tag{15}$$

Thus, when the beam width is fixed, the maximum range *increases* with the square root of the operating wavelength. It is necessary, of course, to use large reflectors to produce a suitably narrow beam at low frequencies, but when this is done, the range achieved is greater than in comparable high-frequency radars of the same beam width.

Influence of Receiver Characteristics

The quantity P_{min}, which represents the power sensitivity of the receiver, must be examined in detail to relate the maximum radar range to receiver characteristics. P_{min} is the minimum reflected signal power to which the receiver will give a discernible response against noise. The quantity depends, therefore, on: (1) the amount of noise present, and (2) the amount of signal necessary to give an indication just distinguishable against the noise.

The first factor, the noise present, arises from many sources, the most important of which is circuit (thermal) noise generated in the receiver. The second factor, the minimum signal required to produce a response against the noise, is fundamentally a psychological quantity, since the act of discerning the signal involves the eye and mind of the observer. Before the least discernible signal can be specified in a particular instance, it is necessary to know the type of indicator employed, and similar factors involved in transferring the signal voltage into an indication.

The minimum discernible received power P_{min} is taken as equal to the thermal noise generated in the receiver output, thus

$$P_{min} = nkT\Delta f \text{ watts} \tag{16}$$

where n is the receiver noise figure, k is Boltzmann's constant, 1.38 x 10^{-23} watts per degree per cycle, T is the absolute temperature in degrees Kelvin (degrees centigrade plus 273 deg), and Δf is the effective bandwidth of the receiving system in cps.

The quantity $kT\Delta f$ is the available external noise power,[1] that is, one-quarter of the noise power ($4kT\Delta f$) generated by the random motion of charges in space and developed in the radiation resistance of the antenna. The equivalent temperature of space is not definitely known, so the limit of receiver sensitivity is not, as yet, a definitely known quantity. For purposes of standardization T may be taken as 290 deg K (room temperature) and $kT\Delta f$ equals 4 x 10^{-21} watts per cycle of effective bandwidth.

The fact that the thermal noise power present in radio reception increases in direct proportion to the effective bandwidth has important consequences. To show this, we substitute $nkT\Delta f$ for P_{min} in Eq. (14),

$$r_{max} = \sqrt[4]{\frac{P_t A^2 \sigma}{nkT\Delta f\, 4\pi \lambda^2}} \text{ meters} \tag{17}$$

This equation states that the maximum range decreases as the bandwidth is increased. The bandwidth required varies inversely as the pulse width. In particular, for optimum peak signal-to-noise ratio, the bandwidth should be approximately $1/d$ Mc where d is the pulse length in microseconds.[2] Substituting $\Delta f = 1/d$ in Eq. (17) we obtain

$$r_{max} = \sqrt[4]{\frac{P_t\, d\, A^2 \sigma}{nkT\, 4\pi \lambda^2}} \text{ meters} \tag{18}$$

Hence the fourth root of the energy of the pulse $P_t d$ (the peak power times the pulse length) determines the range of the system, rather than the peak power alone.

The above analysis is made plausible by the following reasoning: The range of a radar may be increased by increasing the peak power of the pulse, provided the pulse length is not proportionately decreased in the process. If the pulse length is decreased in proportion, the necessary bandwidth and the thermal noise power increase, in proportion, so no benefit is derived from the increase in peak power. In other words, high peak power is not used for its own sake. It is used, rather, to obtain sufficient average power for a given maximum range, when the pulse specifications have been set by other considerations.

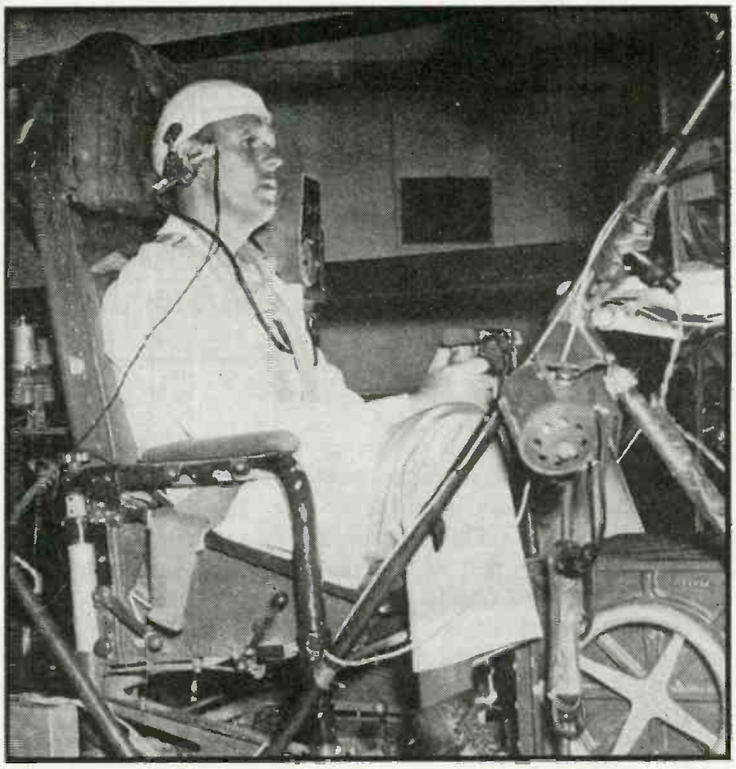
The application of the radar equation depends on specific numerical values of the constants. Unfortunately none of the pertinent factors, such as operating frequencies, pulse lengths and peak power, antenna dimensions, receiver noise figures, or target echo areas, may be disclosed for the present.—D.G.F.

REFERENCES

(1) Friis, H. T., Noise Figures of Radio Receivers. *Proc. IRE*, 32, p. 419, July 1944.

(2) Hansen, W. W., Band-Width Requirements for Pulse-Type Transmissions. *QST*, 29, No. 2, p. 11, Feb. 1945.

HUMAN Centrifuge



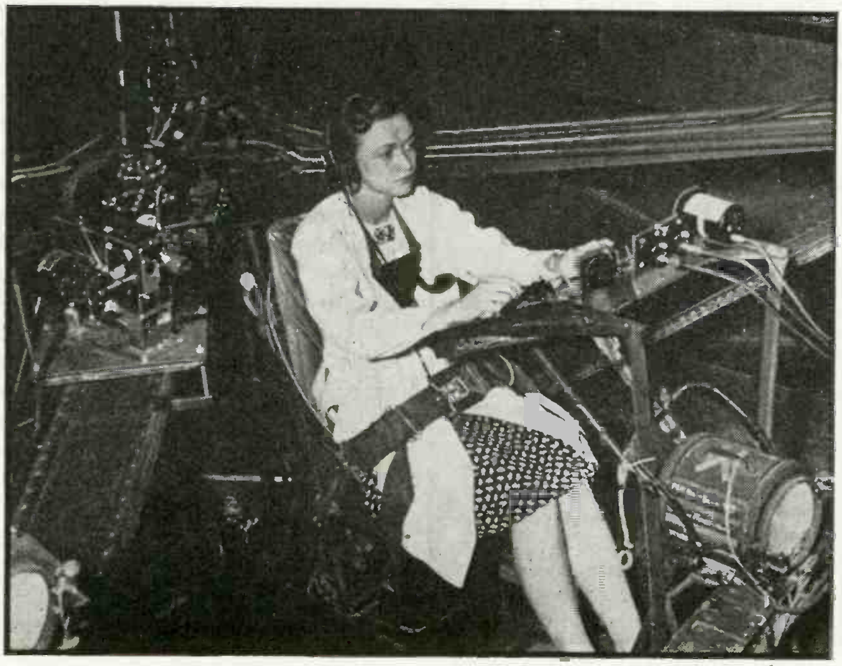
Intensity and duration of gravity increase at the termination of a dive are simulated in the aero-medical laboratory at Wright Field. Effects on pilot are studied by numerous means involving electronics

SEATED in an aircraft pilot's position, a volunteer, above, is whirled in a human centrifuge at speeds calculated to reproduce the effect of pulling out of a dive at various values of g.

The seat is trunnion-mounted at the end of a revolving arm and assumes a horizontal position sideways under the influence of centrifugal force. Thus the pilot's physical attitude with respect to his motion becomes analogous to the actual pullout. The equipment is located in the aero-medical laboratory of the AAF materiel command, Wright Field, Dayton, O.

Attached to the subject's ear is a photoelectric plethysmograph which monitors the fullness of his blood vessels. The twisted pair coming over his shoulder leads to the light source in front while the heavier cord is the shielded line from the phototube. The cap is plastic and bears electrodes for brain-wave pickup.

Actual measurements are performed in an adjoining room over lines which extend from the pilot position by way of the axis of the centrifuge and can be seen leading up the central column in the lower illustration. The observation desk is at the axis and revolves with the subject. Telephone communication is maintained with him from this point and motion pictures are taken by the motor-driven camera at the left. Floodlights for this purpose are in the foreground.



Control of the program of rotation of the centrifuge is photoelectric and determined by a curve drawn on a paper strip. Scanning of the strip establishes the time taken for the unit to get up to speed, the number of g exerted, and the duration of the test. It is thus possible to repeat exactly the same set of conditions.

Some of the findings from these tests show that a tense pilot, or one who yells during the pullout, blacks out less easily than a relaxed pilot. Subjects who have had repeated rides in the centrifuge black out at a lower g rating than novices because the excitement in prospect raises blood pressure. As the ride becomes familiar, the effect disappears. Taping of the body and prone or crouching positions also make it possible to undergo faster pullouts.

PRACTICAL ELECTRONIC

Men who manage plants considering the inclusion of tubes in post-war products will be interested in this text telling what tubes can and can not do. Producers of packaged controls will also find it informative and some suggestions should prove helpful to engineers previously concerned with communications equipment design

THE QUESTION, "Shall we go in for electronic control?" currently concerns many manufacturers in many fields. This article is dedicated to those men in management who have to decide. It also may serve as a reminder, to engineers who have devoted their efforts mostly to radio, of the vast difference between communications devices and those adapted to industrial control work.

It is obviously advisable for manufacturers contemplating new products to consider the application of electronic controls to their particular line. The incorporation of such controls into any piece of equipment may have important economic consequences for the maker. It may improve performance and create a new demand for an existing product. On the other hand, it may cause serious losses if it is not acceptable to the user.

The Place of Electronics

Let us put this newest of arts in the proper perspective with reference to other, older means of getting things done.

Industrial electronic devices are intermediate links which take power at their input terminals in one form and deliver it to the output terminals in another form. The electronic device itself can amplify, rectify, switch, time and perform other such functions but it almost invariably remains just a part of some non-electronic processing equipment. The input may be the power line or it may be a weak signal from a sensing element such as a thermocouple, pressure gage, or what have you. At the output end there is in almost all cases either a relay or a motor which actually performs the desired work. This fact precludes many of the ambitious dreams of new electronic marvels. If those responsible for final decisions on new products will keep it in mind, many disappointments will be avoided.

To make this abundantly clear, let us consider a web printing machine. Web printing machines are designed to print and cut labels in large quantities for toothpaste and similar mass-production packages. Phototube devices are often employed to make sure the machine cuts the labels at the proper place. The phototube has immensely increased the accuracy of such machines but would have been of little value had not machines been redesigned to print and cut labels faster and faster. In this case the usefulness of the phototube was contingent upon the ability of engineers to make the mechanical parts of the machine operate successfully at higher and higher speeds.

The case is typical. It is not enough to design a properly functioning electronic link for a product. It is also necessary to improve the overall performance of the device in order to achieve maximum utilization of the capabilities of the electronic link. Unless this overall improvement is possible, electronics is probably out of place.

Some of the Pitfalls

Pitfalls await the novice electronic control designer. In fact, he is liable to make his first mistake right in the choice of the function of the electronic link.

There are other pitfalls in the design details. To turn out an electronic controller or an electronic instrument is an engineering job of the first order. It takes time and money and sometimes the patience of Job, and when it is all done field tests must be undertaken. These tests may show that devices which perform in a perfectly satisfactory manner during the most grueling laboratory tests will still fail in some respects in the field. They must often be radically changed before they can be put on the market with full confidence and with the assurance that the advantages they give a device over competitive products are not more than offset by faults and operational difficulties.

No doubt the employment of an electronic link adds to the sales appeal of a product. This is due to the blaze of publicity which electronics has received and because of the great assistance it has been to the war effort. Unfortunately electronics has been over-publicized.

Any appreciable number of electronic fakes, involuntary or deliberate, would discredit industrial electronics for a long time. To market an electronic device which is no better and does no more than its mechanical or electrical competitor of olden days would also result in

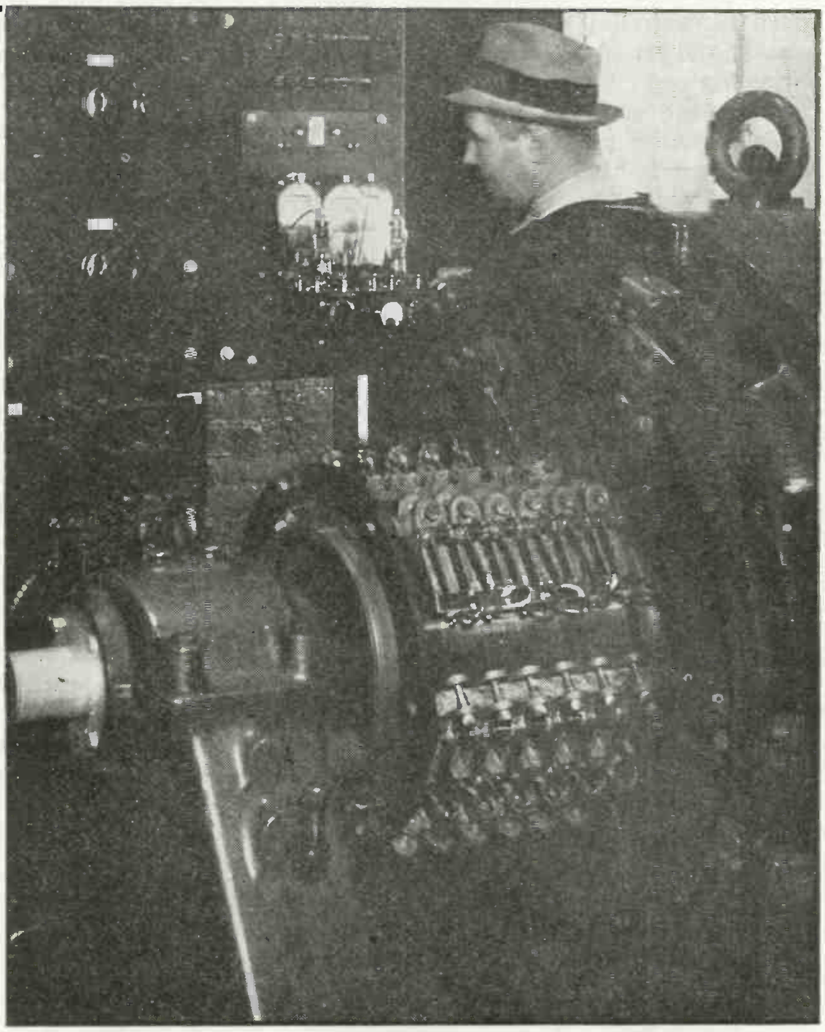
ABOUT THE AUTHOR

DR. WEILLER, a widely-known consultant specializing in electronic equipment design, has had many years of experience both in the laboratory and in the field

THAT a man whose commercial destiny is so inextricably bound up with the future of electronics should be at once optimistic about the use of tubes in industry and perturbed about possible misapplications will be understandable to many readers, as it is to the Editors

INDUSTRIAL CONTROLS

By PAUL G. WEILLER
New York, N. Y.



(Westinghouse)

discredit to industry even if the use of vacuum tubes in the device gives it enhanced sales appeal. Therefore, before releasing a new device embodying electronic control, be doubly sure that it has some new features which competitive devices do not have. Be sure that it is better than your previous number. At best the device will do things that have never been done before; at the very least, the advantage will be in greater convenience of operation, installation or maintenance.

If you are hesitant in the final evaluation of results, call in a competent outsider for an opinion. Then compare your opinion and his and you will learn a great deal. One is, as a rule, a poor judge of any product one has lived with a long time.

Technical Advantages

So much for sales appeal, positive and negative. Are there any great technical advantages in the use of electronics? Decidedly, yes.

Among the advantages of electronic control the almost infinite speed of response is probably the most important one. The response of the vacuum tube is instantaneous for all practical purposes. Electronic circuits, however, do have time constants though the time delay is generally negligible.

Welding timers constituted the first large-scale and exceedingly successful industrial application of electronic circuits. The task of the welding timer consists of delivering to the welder primary powers running into hundreds of kilowatts but only for a short time. Welding is commonly done at one cycle, that is, one-sixtieth of a second, and sometimes with a time period as short as a quarter-cycle. The electric energy must be perfectly synchronized so that the start is made at the beginning of some half-cycle, or at least at a definite electrical angle with respect to it. Electronic timing is indicated because it is extremely difficult to devise mechanical or electro-mechanical timers to handle the large current with sufficient accuracy and without rapid deterioration of the contacting device.

Applications requiring the high speed of electronic devices are legion. In military photography from planes, for instance, it is imperative to open the camera shutter a few microseconds after a dropped flash-bomb explodes. This can be most successfully accomplished by an electronic device. Devices for measuring the speed of projectiles were made before the advent of the electron tube but the new electronic devices are so vastly superior that they displace the old types.

The second important advantage of electronic control is its sensitivity. A multitube amplifier is not necessarily more sensitive than a fine mirror galvanometer but a galvanometer can move a pointer or a light-band up the scale and nothing more. If the power for a furnace is to be started or stopped, as directed by the galvanometer deflection, a coupling unit must be added which translates the position of the galvanometer pointer into a function of some current-making and breaking device.

The modern link between a galvanometer pointer and a contactor on the wall or an electric motor is an electronic device. Where the sensitive galvanometer pointer in itself can accomplish no work, a motor or relay can be operated by the output of an electronic circuit which is controlled by the galvanometer and yet adds no load to the galvanometer.

The third advantage of electronic control is its suitability for remote control. There are, for example, serious obstacles in the way of using conventional thermometers and pyrometers with their sensing and indicating elements separated by great distances. The usual bulb thermometer is connected to the indicator and controller by a capillary of minute diameter. If the indicator is 200 feet from the bulb the capillary is cumbersome and not too reliable. Electronic links can be operated over almost any desired distance with conventional wiring.

There is at least one other major point of superiority. This is the flexibility of control design. The variety of tubes and other circuit elements available is almost as great as the number of combinations in a chess game. Therefore the electronic control can be given almost any characteristics. It can be fast, or time delays may be readily incorporated. It can be rugged and sensitive at the same time. It can be comparatively inexpensive or a luxury device selling for thousands of dollars.

Typical Industrial Applications

Though the number of packaged industrial items containing electronic controls is not yet large, many successful special applications have been made. Some of the more important uses are worth specific mention.

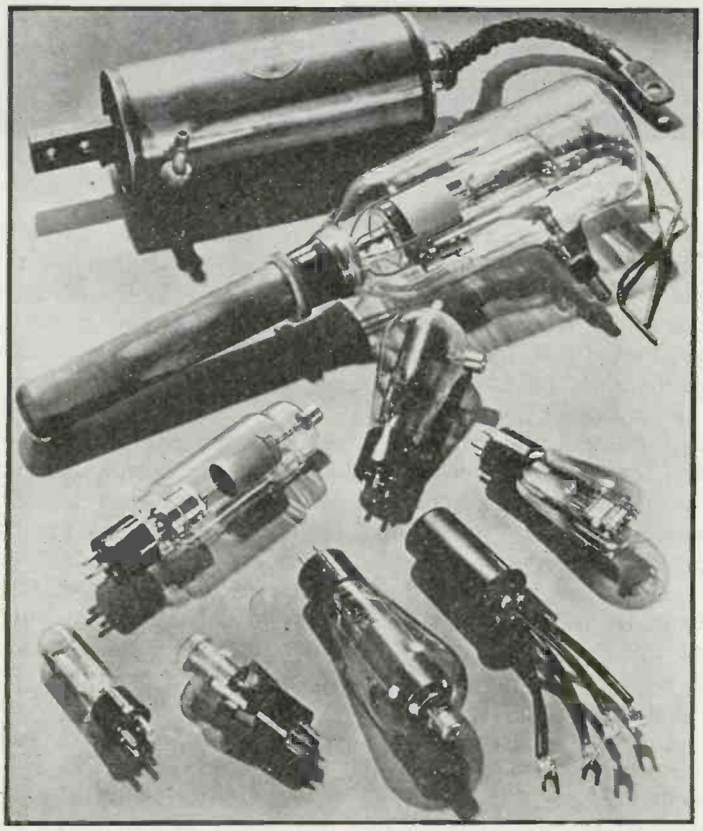
Electronic control of d-c motors was a major industrial application of electronics. In response to electronic, electrical, or mechanical monitoring devices, tubes here regulate or change the speed of the motor in the required manner.

Electronic links have been extremely useful in stopping or starting some or all operations on high-speed machines where mechanical methods become awkward or impossible. If, for example, you wish to use some very delicate sensing device to start, stop or control heavy equipment, an electronic link will probably do the job better than anything else. An electronic device may, for instance, be designed to follow up the movement of an instrument pointer. The motorized follow-up equipment may perform almost any control function, near the instrument or miles away from it. Though the pressure of the pointer on the follow-up mechanism can not be more than a fraction of a milligram, reliable operation can be had by electronic methods. There are cases where no contact whatever between pointer and follow-up fingers is allowable. There the capacitance relay or inductive relay fills the bill.

In many devices the follow-up or control system must be actuated by the light-beam of a mirror galvanometer, by a drawn line or by the transparent or opaque portions of a template. Here a phototube relay does the job. One interesting application is the automatic cutting torch, which reproduces the pattern of a template.

When the number of instruments on an aircraft used in test flights became so large that visual observation was a nightmare, automatic recording methods were devised. The oldest consisted of photographing the instruments with one or more motion picture cameras. All instruments had to be located within the proper range of the camera and the record was available only some time after the plane had landed. Now each instrument is connected with a transducer which modulates the frequency of an f-m radio transmitter. The signals are received on the ground, demodulated and recorded on a paper strip or sound film. Results are available while the plane is in flight. The pilot can be warned by radio in case of approaching failures. If the plane crashes, the record remains intact and may give reliable information on the events preceding the crash.

Electronic devices for the inspection of metals for uniformity, soundness and size are in use in many places. Devices of this type may discover cracks, slag inclusions, voids, changes in chemical composition, faulty heat treatment, under or over size. The devices are nondestructive and very fast. Old style tests sometimes destroy or



General Electric Co.

TYPICAL INDUSTRIAL TUBES—They are generally used in combination with smaller varieties such as those employed in radio receivers mar the test pieces and are much slower.

Several of the newest automatic pilots for airplanes are now electronic devices, operated through follow-up systems by one vertical and one horizontal gyro. Automatic landing systems land a plane smoothly in the densest of fogs without any assistance by the pilot. Only electronic control devices can accomplish this task.

There are a large number of electronic timing devices. Some of them deliver power impulses of accurately timed duration, while others serve to measure time intervals. The various stroboscopes and also the newest of flash devices for photographic use may also be classified as electronic timers. Short-duration timing lends itself admirable to electronic methods. For long intervals other types of timers are often more suitable.

The rectifiers furnishing the current for the electrolytic cells of our new aluminum and magnesium plants and for some railroads are electronic devices. There are also electronic train controls, electronic level indicators and controls and numberless other devices, all in successful practical use.

In addition, there are many electronic instruments devoted entirely to laboratory or diagnostic work. Industrial electronics has indeed come of age technically and economically. Even before the war sales of industrial electronic devices ran into the millions.

TYPICAL ELECTRONIC CONTROL SYSTEM

I: A detecting or measuring device or sensing element converts physical changes into electrical impulses

PHYSICAL CHANGES	*DETECTING OR MEASURING DEVICES*
Speed, rate of flow, thickness, temperature, pressure, position, color, opacity, reflectivity, tension, slack, strain, voltage, current, resistance, etc.	*Phototubes, thermocouples, capacitance electrodes, conductivity electrodes, thermometers, thermostatic strips or bellows, strain gages, microphones, vibration pickups, resistance elements, etc.*

II: A vacuum-tube amplifier builds up the strength of the initial impulses and sometimes also selects the correct impulses needed for achieving the desired control

III: An actuating device, responding to the amplified electrical impulses either directly or through relays or contactors, performs the action required to regulate or control the industrial machine in the desired manner.

EXAMPLES OF ACTUATING DEVICES

Electromagnets or solenoids that open or close valves, kick objects off conveyor belts, shift gates in chutes, cut off the flow of materials, etc.
Electric motors that open doors, move elevators, conveyors or cars, operate machinery, change settings of heavy valves or control handles, regulate dampers, etc.

Reliability is Essential

We may seem to fall into the same old error of overboasting electronics. In order to correct any such impression, let it be said that many electronic devices sold to industry have ended in the factory morgue or curio cabinet after a six-week trial. Reason: the devices were difficult to use, or required too much supervision and maintenance.

The unreliability inherent even in some frequently-advocated designs is generally due to two factors. The first is the availability of a large number of possible circuits, many of which have not been thoroughly tried. There is a powerful incentive for the designer to be over-ingenious. Very few really complicated circuits are sufficiently reliable for industrial use.

A 10-percent variation in the output of a radio receiver over a period of time will be barely noticeable. Infrequent clicks will be ascribed to static. But we can permit neither static nor 10-percent variations in industrial devices. Such misoperation might cause spoiled products or even loss of life.

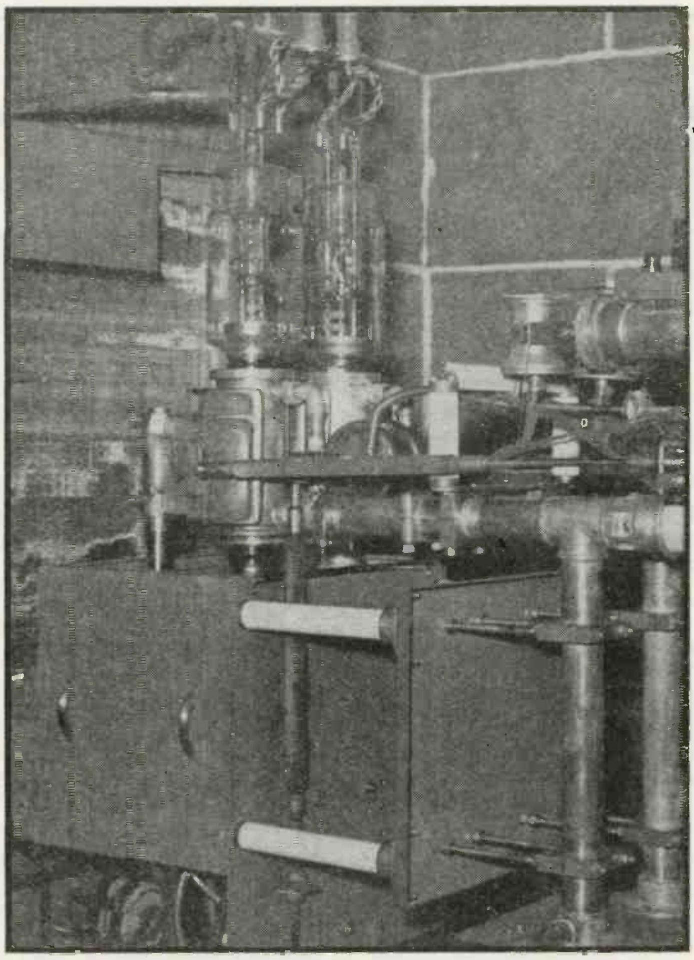
The second factor is the marginal erraticism of many sensitive electronic circuits, caused by a variety of characteristics of circuits and tubes which are not too well understood. For example, vacuum tubes in industrial circuits are often used on portions of their characteristic curves which are not published because they are of no importance in communications, for which the tubes were originally designed. These details may vary from tube to tube and cause difficulties. As an additional example, industrial control circuits more often than not operate on transients and transients have not been as thoroughly investigated as the usual steady-state oscillatory phenomena by the average engineer.

All this emphatically does not lead to the conclusion that electronic devices are less reliable than their mechanical and electrical brethren. It means only that electronic devices require more time, ingenuity and meticulous care for the final tests before releasing a product for use.

When all faults inherent in the circuit are eliminated we still have to investigate the effects of stray magnetic and electrostatic fields, surges on power lines, radio-frequency impulses derived from arcs and sparks, and the effects of dirt and humidity. All or any of these are commonly present in industrial plants.

Electronic industrial devices are often competing with mechanical controls consisting of a considerable number of punchings or screw-machine parts. Even after final machining most of these parts cost only a few cents. Electronic components are much more expensive. Therefore, there are severe limits to the number of parts which can be used if the price is to be kept reasonable.

Industrial electronics is as replete with opportunities as it is beset with traps for the unwary. We know that the harder the road, the greater the prize at its end; but let me say to manufacturers and communication engineers: Industrial electronic devices are not radio transmitters or receivers. There is a vast difference.



The 50-kw final amplifier at WMFM, using a pair of WL-899A tubes. Filament circuits are at the top, grid circuits at the bottom. Neutralizing capacitors are built around the tubes. The tuning capacitor and part of the tank circuit can be seen

A 50-KW

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PRESENT INDICATIONS are that many of the f-m stations planned for post-war operation will be of the high-power type required to serve large areas. A detailed description of 50-kw WMFM will therefore be of interest, since this station employs one of the few high-power transmitters on the air at the present time.

Of particular interest to many broadcast station engineers will be the phase-shift modulator incorporating circuits developed by Major Edwin H. Armstrong to correct deficiencies in earlier types.

Phase-Shift Modulator

The phase-shift modulator utilizes high-gain tubes introduced just prior to the outbreak of the war. The majority are still in use after more than 15,000 hours of service, corresponding to a daily 13-hour schedule of operation.

Following are some of the improved modulator's characteristics:

FREQUENCY. 50 to 15,000 cycles within 1 db plus or minus, including 100 microsecond pre-emphasis.

DISTORTION, measured at 100 percent modulation on a GR-732A distortion and noise meter:

50 cycles	1.5%
100	1.2
400	1.0
1,000	0.8
5,000	0.7
7,500	1.0

NOISE LEVEL, below 100 percent modulation. Average weekly measurement around 70 db, depending on choice of tubes.

OUTPUT POWER AT CARRIER FREQUENCY. 15 watts to a balanced coaxial line.

AUDIO FREQUENCY INPUT. Zero level, 500 ohms at 6 mw.

CARRIER FREQUENCY STABILITY. Average of 300 cycles.

The output frequency of the modulator is dependent upon a single temperature-controlled oscillator. Frequency stability is not difficult to maintain over long periods, as is shown in Fig. 1. This graph represents two month's operation and was arrived at by taking the maximum deviation for each day's operation from the log sheets and plotting against time. The average value of deviation is much less than the maximum values shown. The maximum deviation permitted by present standards is plus or minus 2,000 cps from center frequency.

The modulator, shown in block diagram form in Fig. 2, and schematically in Fig. 3, is composed of five major units. The first unit is the audio section. This consists of three 6C5's, used as a resistance-coupled amplifier and a phase inverter, the output of which feeds a pair of 6P5GT's in push pull. Inserted in the grid circuit of the first 6C5 is a resistance-capacitance pre-emphasis network whose time constant corresponds to 100 microseconds as prescribed by present engineering standards. The push-pull stage is coupled to the screen

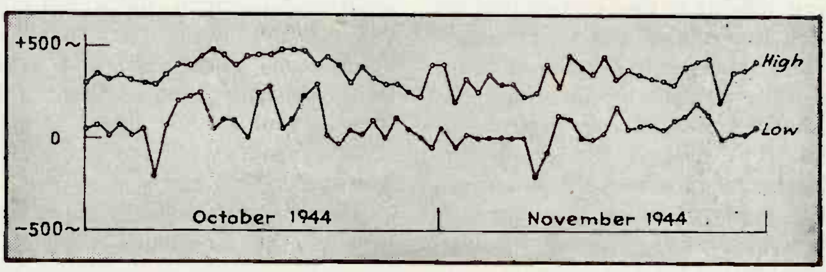
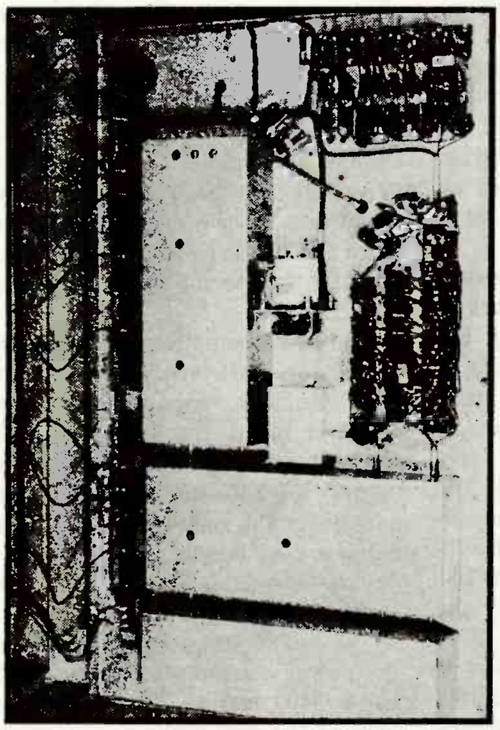
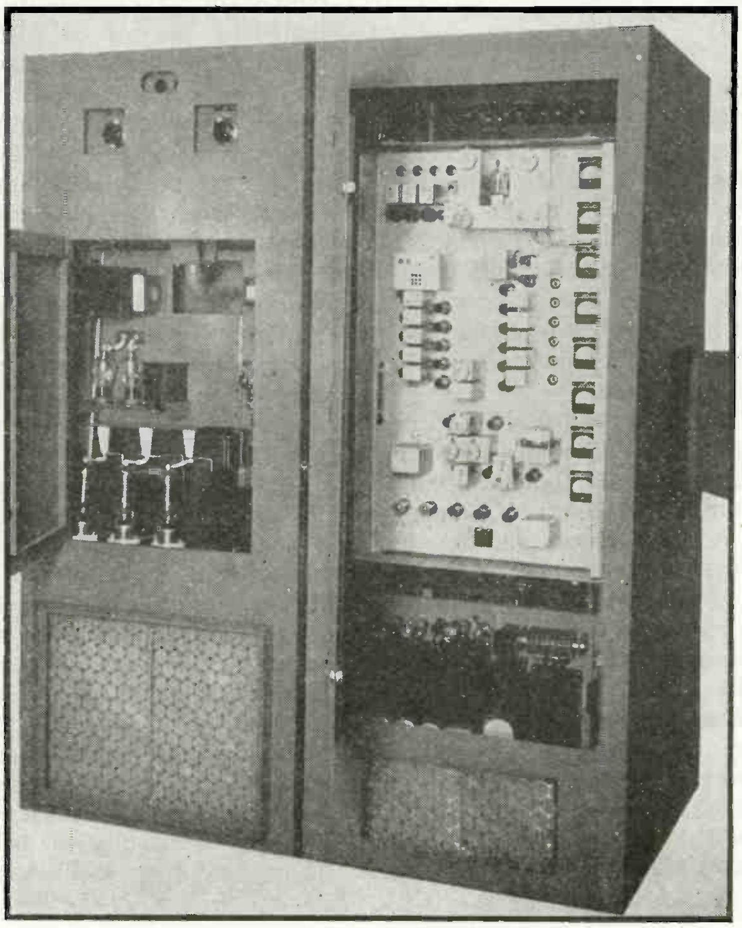


FIG. 1—Graph showing maximum frequency deviations of the modulator unit over a period of two months

F-M TRANSMITTER

The phase-shift modulator, designed to insure center carrier-frequency stability and to avoid other deficiencies of earlier types, is described in detail. Construction of the 250-watt and 3-kw amplifiers and the high-power final stage is covered





ABOVE—The modulator unit swings open on hinges, facilitating maintenance

RIGHT—The unit at the right in this photo is the 250-watt driver and the phase-shift modulator, built by Radio Engineering Laboratories and seen from the back. Rectifiers are in the bottom of the cabinet. At the left is the 3-kw r-f amplifier

grids of the balanced modulator, in the second unit. In the grid circuit of the modulator is another network, sometimes called the corrector, which produces the inverse audio-frequency effect necessary with a phase modulation system.

Section two includes oscillator, buffer and phase-shift modulator. These circuits all operate on 190 kilocycles and the tubes used are 6SJ7's. A crystal-controlled oscillator supplies the primary source of frequency and its output is fed into a buffer amplifier. The output of this buffer divides itself into two parts, one supplying excitation to the control grids of the balanced amplitude modulator and the other part bypassing the modulator completely. The output of the modulator is such that the unmodulated carrier is suppressed and the side band modulation is shifted in phase 90 degrees.

Inserted in the plate circuit of the modulator is a phase-splitting network which divides the side bands into two branches equal in amplitude but 180 degrees displaced with respect to each other. The unmodulated carrier, bypassed around the balanced modulator, effects a junction at the output of these two branches, thereby combining the carrier and sidebands. A comparatively small frequency excursion from 190 kc is realized by this method of modulation and a very large frequency multiplication is necessary to produce a final deviation of 75 kc on each side of the center-carrier frequency.

The third and fourth sections consist of two cascade frequency-multiplier chains identical up to their converters but opposite in phase. It is here that one of the main criticisms of the first Armstrong modulator was corrected. The former depended on two crystal-controlled oscillators for carrier-frequency stability. The newer type minimizes drift by a very ingenious method to be described.

The function of the two multiplier chains and their converters is two-fold; one automatically cancels out any frequency drift in the 190-kc crystal and the other represents a multiplication of the primary frequency and its modulated frequency-shift. Each chain is made up of five tubes and each of the multiplier stages acts as a tripler. Thus each chain supplies a 15,390-kc signal to its converter. This represents a multiplication of 81 times.

Modulator Details

By introducing into one converter a current from a crystal oscillator operating on, say, 1000 kc, a beat of 14,390 kc is obtained. This corresponds to the difference between 15,390 and 1000 kc. The heterodyne beat of 14,390 kc is injected into the converter of the second multiplier chain, whose input is 15,390 kc and identical to that of the other chain.

Combining 14,390 kc and 15,390 kc produces a difference beat of 1000 kilocycles again, but with all the frequency modulation components on it, and cancels out any drift in the 190-kc crystal. As an example of this, suppose the 190-kc crystal drifted up in frequency enough to operate its output chain on 15,400 kc instead of 15,390 kc, then the 1000-kc crystal would produce a beat of 14,400 kc. Since both multiplier channels would be 15,400 kc, the injection of the frequency of 14,400 kc would still give a frequency difference of 1000 kilocycles.

It can thus be seen that the output frequency of the modulator unit is independent of the 190-kc crystal. To demonstrate this action it is only necessary to replace the crystal with a signal generator and manually vary the frequency. Whether the crystal frequency drifts higher or lower is unimportant, provided it does not drift beyond the pass-band of the multiplier chain. This possibility is eliminated by the use of a low-drift crystal. Therefore, only the change that occurs in the second crystal's frequency results in a change of the center carrier frequency. Deviation of this frequency is minimized by using a low-drift crystal and a temperature-controlled oven.

The modulator has an extremely low residual hiss and hum level at its output. Noise generated in the early stages tends to balance out in the mixing process, much the same as 190-kc oscillator drift cancels out.

The fifth and last section of the modulator consists of a chain of additional multipliers. Since the frequency shift is insufficient at 15,390 kc (less than 2000 cycles) the heterodyne or beat-back to 1000 kc serves the additional function of allowing the shift to be multiplied another 48 times. The difference frequency of 1000 kc is fed to the final chain of multipliers and is always the carrier frequency divided by 48. Multiplication is accomplished by four doublers and one tripler, the output of the latter being approximately 15 watts on the carrier frequency. This would bring the carrier to 48 megacycles, and capable of a frequency swing of 75 kc plus or minus.

Shifting the second crystal frequency to a value lower than 1000 kc would bring the carrier somewhat lower in the f-m band, but would not change the overall multiplication constant. Therefore, it is not necessary to make a change in the 190-kc oscillator frequency and its multiplier chain to accomplish a change of carrier frequency. As an example, to change 45.5 to 46.7 Mc, it is only necessary to change the frequency of the second oscillator from 947.91 kc to 972.91 kc and to re-align the second multiplier channel.

The power supplies for the entire modulator unit are located below the modulator compartment. There are four in all, the 550-volt supply for the power doubler and tripler stages, the 250-volt regulated plate supply for the remainder of the circuits, a d-c filament supply using a dry-disk rectifier stack, and a bias supply. The primary source of power is 220 volts single-phase and the power consumption is approximately 400 watts. The power controls of the modulator are interconnected with the circuits of the succeeding stage.

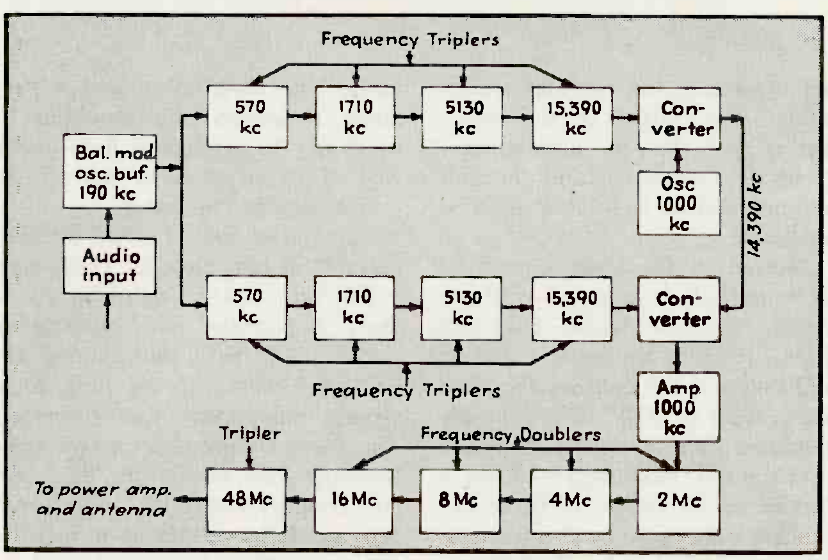


FIG. 2—Block diagram of the phase-shift modulator system. A complete schematic is shown in Fig. 3

250-Watt and 3000-Watt Amplifiers

The 250-watt r-f amplifier of the WMFM transmitter consists of two HK-257 pentode tubes in a push-pull circuit. This amplifier and its rectifier are located in the same cabinet as the modulator described and occupy the major portion of the space. An excess of grid excitation for this stage is taken from the power tripler through a balanced coaxial line. The 1750-volt rectifier is located directly below the amplifier and supplies the necessary plate power.

In conjunction with the two HK-257 tubes an overload relay is used which trips out on excess current. After several seconds a time-delay relay automatically closes, re-applying the plate voltage to the tubes. This automatic motor-driven recycling relay can be adjusted for any time delay desired up to thirty

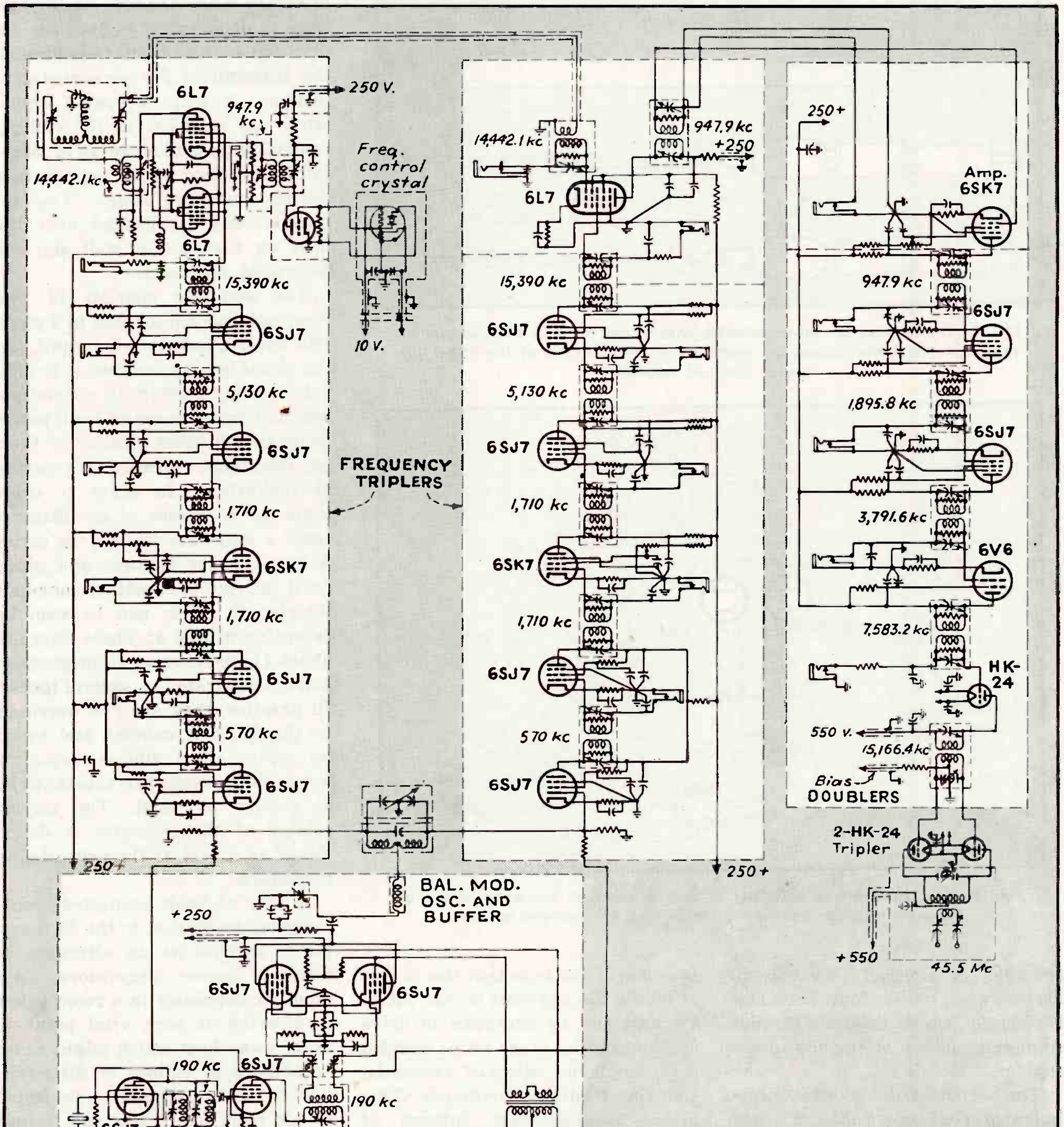


FIG. 3—Schematic of the WMFM phase-shift modulator shown in block-diagram form in Fig. 2

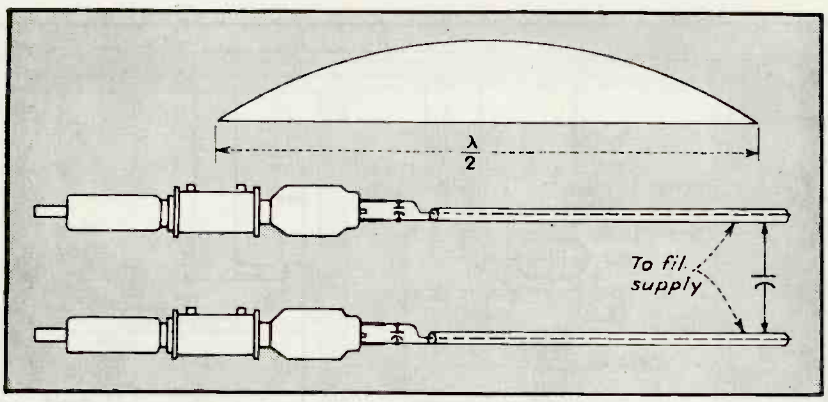


FIG. 4—The addition of half-wavelength lines in the WL-899A filament circuits overcame difficulties caused by reactance in these circuits of the 50-kw f-m station final r-f amplifier

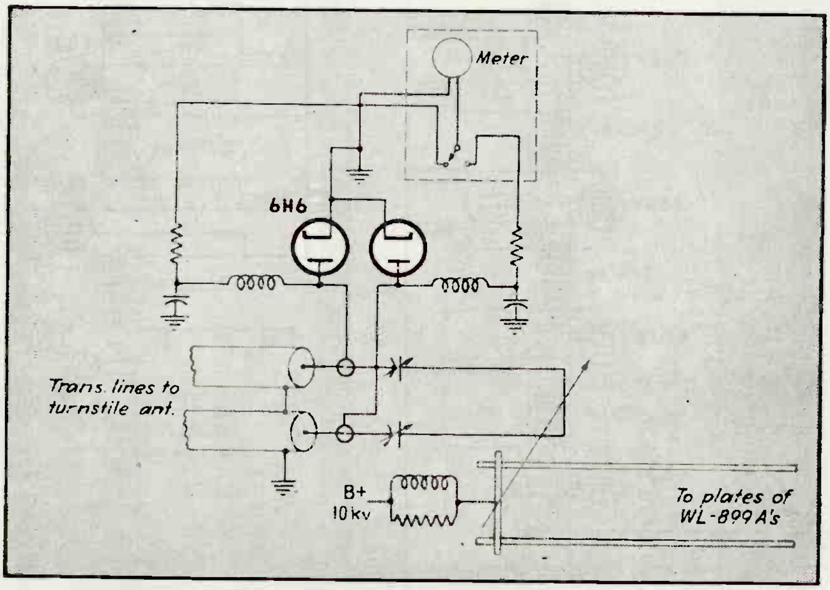


FIG. 5—This vacuum-tube voltmeter is used in place of thermo-ammeters at the input to the transmission lines feeding the antenna system

seconds. A centrally located air blower, mounted on four Lord rubber shocks, expels dead air through spun-glass filters at the top of the cabinet.

The output of the 250-watt stage is transferred by a balanced ⅞-inch coaxial line to the grid circuit of the three-kw amplifier located in a cabinet adjacent to the combined modulator amplifier. This unit is self-contained, including a three-phase half-wave plate rectifier (872's) and the full-wave grid-bias rectifier (866's). Two Eimac 1500T tubes are connected as a class-C neutralized amplifier and the output of this stage is adjustable from 1 to 3 kw by means of a step-type regulator which controls the plate voltage.

A plate input of three-kw d-c power will deliver sufficient grid drive to the final power amplifier. It is worthy of note that the output of either the 250-watt or the three-kw unit can be arranged to drive any succeeding stage or be coupled to a single or balanced transmission line feeding an antenna. This makes possible easy cutback of power to the antenna in case of emergency. The two lines carrying the power to the final amplifier grids are each approximately 30 feet long. They were carefully adjusted to minimize standing waves and this work results in unusually low required driving power and long tube life.

50-kw Amplifier

The final r-f amplifier is located in a separate room, completely shielded including the floor and door. Copper-wire screen is used over the only window and a mesh size was chosen which would not interfere with visibility of the meters. A double door is used for access and is double-interlocked with the transmitter for personnel protection. A motor-operated ventilator was installed in the ceiling, controlled by a thermostat to maintain a constant room temperature during operating hours. Two intake louvers are located near the floor on the outside wall and are controlled manually.

The amplifier consists of two Westinghouse 899A tubes in a push-pull neutralized class-C circuit. At the ultrahigh frequencies it is difficult to bring directly to ground potential the filaments of high-power water-cooled tubes because of their physical size, thereby preventing neutralization. In order to overcome the reactance of the filament leads a long line is used in series with each tube filament and tuned until the line is effectively one-half wavelength. This can be seen by referring to Fig. 4. These lines are about 11 feet long at 45 megacycles and are separated by several inches. In practice, they are run overhead to the filament cabinet and tuned by means of a sliding capacitor until the filaments are substantially at ground potential. The correct setting of the capacitor is determined as a part of the neutralizing procedure.

A pair of Scott-connected transformers are located in the final amplifier cabinet as an alternate to filament power generators. Air from a compressor in a room below is directed at each vital point to carry away heat which might cause breakdown or failure of dielectric. About thirty points are protected by air from ½-inch jets and include filament seals, grid capacitors, grid seals, grid tank-coil and antenna coupling capacitors. The remainder of the air jets are directed over the glass envelopes of the tubes. The plate tank coil is a part of the water cooling system. More than ample room is allowed around the entire unit for servicing.

The output of the amplifier is coupled to two 3⅛-inch coaxial transmission lines and at the input of these lines is a remote-reading vacuum-tube voltmeter. This remote-reading meter was installed in place of two thermo-ammeters. An extension line from each diode was run to the control desk, where the remote meter is placed for easy observation. The meter is arranged for convenient switching to each diode and log notations are regularly made. A schematic diagram of the meter is shown in Fig. 5.

Other equipment associated directly with the 50-kw amplifier includes the high-voltage rectifier unit, the control desk, cooling apparatus, and power-supply machines. The high-voltage rectifier unit consists of six Westinghouse 869B tubes connected as a three-phase full-wave rectifier delivering 15,000 d-c volts at 7.5 amperes to the power amplifier tubes. The power transformer, filter choke, and a motor-operated regulator are mounted just outside the building in a vault. The regulator is in the primary circuit of the high-voltage transformer and its control circuits terminate at the control desk. In the event of a power failure or an outage, the regulator automatically returns to a minimum voltage position for circuit and tube protection. This function is included in another re-cycling mechanism which, in effect, removes the plate voltage. The circuit is locked out after six automatic three-second recycling operations have taken place. After the difficulty has been rectified the locked-out mechanism can be released by operating a pushbutton at the desk.

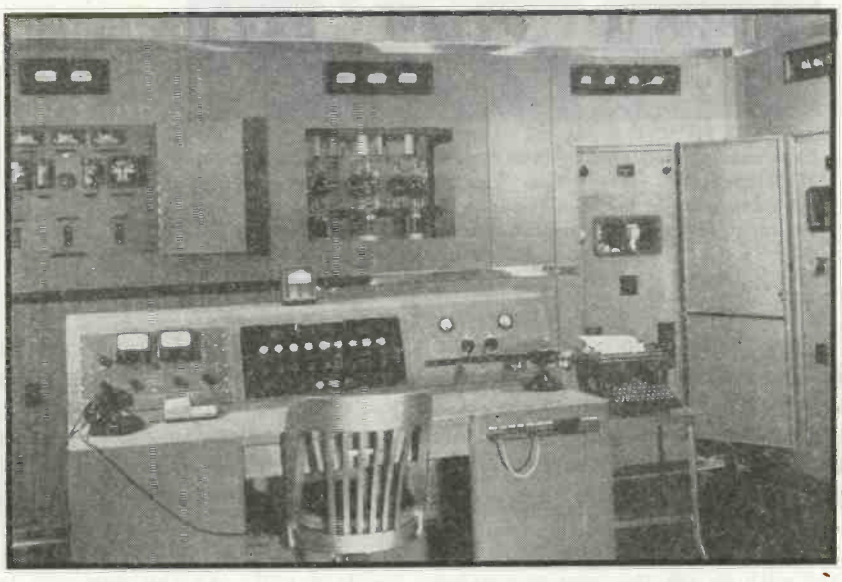
Single pushbutton automatic starting for the entire transmitter can be obtained at the power console. Independent control can also be had with each unit properly interlocked for mutual protection of equipment and personnel. Two tower-monitoring lights were built into the desk for the two-flasher beacons. Another feature of the desk is a Teletalk unit which proves indispensable for communicating with the tower top, tuning house or basement workshop.

Cooling, Shielding and Grounding

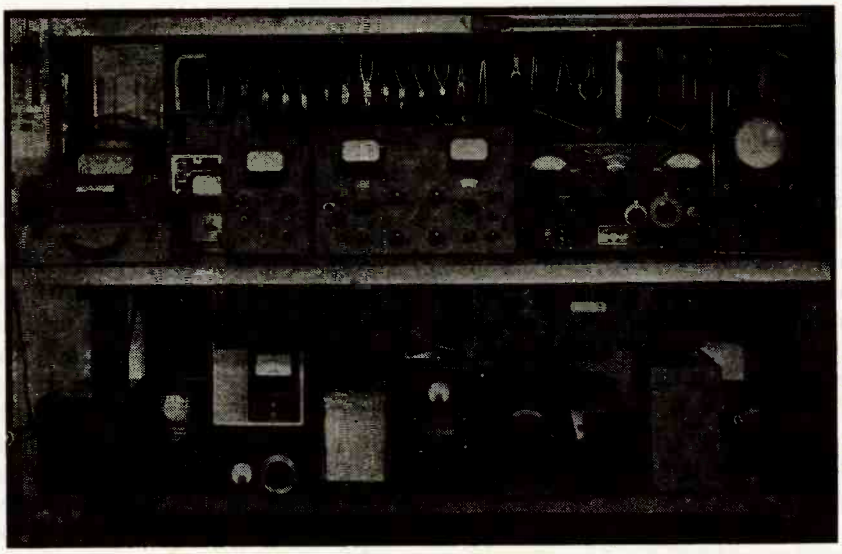
Directly below the power-amplifier room is the cooling room. Located here is the evaporative cooler, motor-generator set, water pumps, the air compressor, etc. Adjacent to the cooling room is a tube storage space, where the larger spare tubes are racked for easy access.

A quite different conception of good grounding between units is necessary compared to standard broadcast-band practice. Because of the inductance of ordinary wires at the f-m frequencies it is best to install five to six-inch copper straps. Several recent installations have been made with the units mounted on copper sheet (five to six-thousandths inch stock) fastened to the floor with a mastic and covered with linoleum, rubber or asphalt-tile. Surprisingly, little trouble is experienced if the proper precautions are taken and, particularly, if the power amplifier is well shielded.

Installations planned to include low-level audio amplifiers and microphones may find it necessary to place them in a separately shielded room or at least some distance from the power stages. Receivers and test equipment also can be included in this setup. Care should be taken in the installation of low-level audio lines to see that they are sufficiently far away from low-frequency power lines to eliminate the possibility of ground currents within the shielding. Since the service an f-m transmitter renders is high quality in nature, it is well to have the speech-input room situated and treated to minimize extraneous noises, thereby allowing better monitoring conditions.



The WMFM control room. Units, from left to right, include the 250-watt r-f amplifier and modulator, the 3-kw amplifier, the 15,000-volt, 7.5-ampere rectifier and the low-voltage control equipment. The master-control console is in the foreground



The f-m station's workshop, showing some of the test equipment used for maintenance

Electronic

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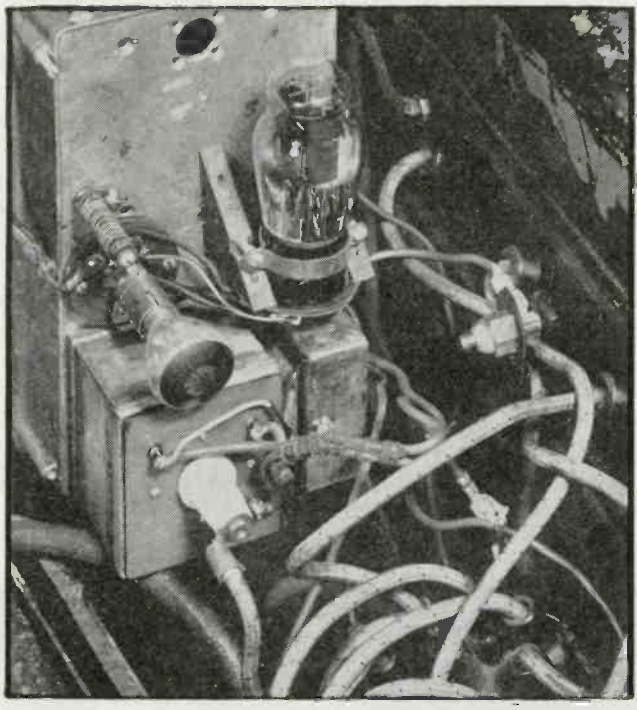

Experimental electronic ignition system which has operated for 5500 miles in a 1941 Buick. The circuit is an outgrowth of work described in the text. The tube is a type 80 and the 42-cp 6-v lamp is used as a coil ballast-resistor. Spark plugs are 14-mm Lodge RC5/2 aircraft type

AMID the many improvements and innovations with which the automotive industry normally lays siege to the public fancy each year, one factor has steadfastly retained its original form through more than two decades. This element, the spark ignition system, is associated with by far the largest portion of internal combustion engines produced in this country.

The Conventional Circuit

Briefly, as shown in Fig. 1, the traditional arrangement includes a transformer of the open-core type —the ignition coil—having its primary winding connected across the storage battery of the main electrical system in series with a cam-actuated breaker whose contacts are shunted by a capacitor (having a value of 0.2-0.4 μf) to prevent arcing. The breaker cam, located in the distributor, is driven by the engine at one-half the crank-shaft speed and with an angular position causing the breaker arm to be actuated whenever a spark is required.

Immediately upon opening of the breaker points, the flow of current through this portion of the circuit is interrupted and transferred to the breaker capacitor, whose potential executes the familiar series of damped oscillations shown in Fig. 2. The first oscillation usually reaches an amplitude of 200-350 volts and a corresponding voltage is developed across the primary of the ignition coil. As the primary inductance is generally 5 to 10 millihenrys, the frequency of this oscillation is normally in the region of 2000 cps.

The secondary winding, having about 60 times as many turns as the primary, is wound about the primary and develops a voltage of 10 to 15 kv, which is then distributed to the plug to be fired by a rotating contact in the distributor head.

As seen in Fig. 2, the peak voltage available for firing the plug is not developed at the instant the breaker contacts open, but ¼ cycle later. At an engine speed of 3000 rpm, corresponding to a road speed of 60 mph, this lag amounts to 2.25 crankshaft degrees. Because the time lag between opening of the interrupted contacts and the peak voltage remains constant, this results in an effective retarding of the spark timing as the engine is operated at high speeds, and requires compensation which is introduced into the automatic speed-advance part of the mechanical structure of the distributor.

The magnitude of the influence exerted by such mistiming is best judged with relation to the proportional deviation from the most favorable spark advance-speed characteristic. Figure 3 illustrates the relation between engine speed and the number of degrees of spark advance required to develop maximum brake torque (curve A). In addition to this ideal curve, Fig. 3 also shows the performance actually obtained in a representative production engine (curve B).

Lack of agreement between these two curves appreciably exceeds any lag introduced by the delay in attaining peak firing voltage, thereby demonstrating that this factor has only negligible influence on engine performance. The displacement lag between the ideal and actual spark advance curve is deliberately introduced to prevent detonation.

Shortcomings

There are three further difficulties peculiar to the system of Fig. 1 which have elicited several solutions. First, there is extreme sensitivity in the secondary circuit to loading such as may be produced by dirt on the exterior of the spark plug insulator, combustion deposits on the interior end of the insulator, or pure volume leakage through the insulator due to the loss in insulating properties accompanying high operating temperatures.

How serious this problem is can readily be understood from the fact that with a 15,000-v peak secondary voltage, a 10-megohm load may absorb nearly all the energy stored in the magnetic field of the coil at

Ignition Systems

Application of the electron art to automotive and aircraft ignition systems promises solutions to the problems of cross-firing, maintaining spark intensity at high speeds, and reducing sensitivity to secondary loading from deposits on the spark plugs

the moment of interruption as shown in the shaded first ¼ cycle of oscillation of Fig. 2.

Total power taken from the coil during the build-up of the voltage pulse to its peak value is proportional to the square of the shaded area in Fig. 2 and is conveniently expressed by $W = (1/R)\int_{t_0}^{t_1} E^2\,dt$, where t_0 is the moment of break and t_1 is the time at which the peak excursion occurs.

Systems insensitive to secondary loading have been developed in which the peak voltage comes at the moment of contact actuation. Here t_0 equals t_1, the value of the definite integral becomes zero, and circuit losses are without influence on the peak voltage available. In the conventional engine, only the first voltage peak need be considered because if the gap is not fired at this time, it never will be. If level of first voltage peak is kept up, the fact that succeeding waves may die away more rapidly is unimportant.

A further difficulty of the conventional ignition system lies in the possibility of cross-firing. All the cables to the spark plugs are bunched together and led through a common conduit. Since these are very high-impedance circuits, the coupling between adjacent cables often develops enough voltage to fire the plug in a cylinder which is at a part of the work cycle where it must not be fired. This is prevented in systems where the lines to the plugs are kept at low impedance.

Lastly, there is the problem of maintaining spark intensity at high interruption speeds. The peak voltage obtainable is proportional to the break current, and this decreases as the interrupter speed increases since less and less time is allowed for the current in the primary to build up. This, together with the necessity of holding the low-speed break current to 2 or 3 amperes to obtain reasonably good interrupter contact-point life, is a definite limitation on the high-speed performance of engines.

Functional Modifications

A constant break current is secured simply in the arrangement of Fig. 4, in which the standard ignition circuit is modified by the insertion of a hydrogen-filled ballast in the primary excitation line.[1] At high speeds of interruption, current through the coil tends to decrease, which permits the ballast resistor to cool and decrease its resistance by an amount very nearly compensating for the shorter build-up period. The converse occurs at low speeds and prevents the break current from exceeding the safe limit of 3 amperes.

To minimize the effects of secondary loading, the standard circuit has been further modified to the arrangement of Fig. 5, in which the breaker circuit includes the ballast resistor, a charging reactor L, and the battery.[2] At break, the voltage across capacitor C begins to rise, but no current flows through the primary of the sparking transformer until the breakdown voltage of the gas-filled two-electrode tube V is exceeded, after which capacitor C discharges through the primary to produce a pulse with an extremely steep wave front in the secondary.

Because of the short time of rise of the pulse, its peak value is practically independent of the loading on the secondary circuit and this circuit will perform satisfactorily with a shunting resistance as low as 100,000 ohms connected to the

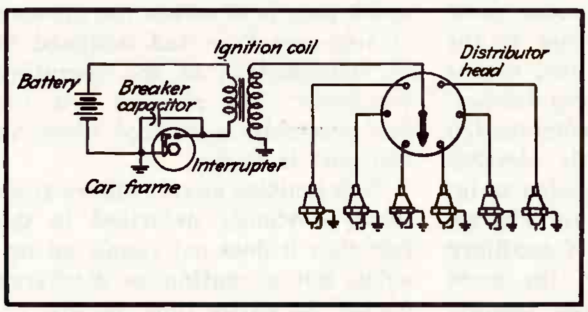

FIG. 1—Time-honored automotive ignition system involves this simple circuit which is particularly susceptible to faulty operation caused by loading of the secondary through deposits of dirt or carbon

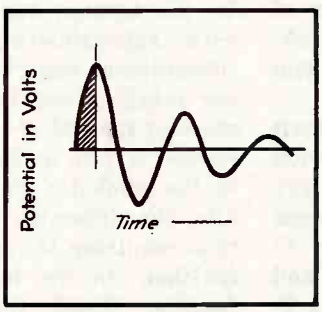

FIG. 2—Highly-damped sinusoid like this arises across breaker points of conventional system when they open. The first peak is in the neighborhood of 300 v and the frequency around 2000 cps

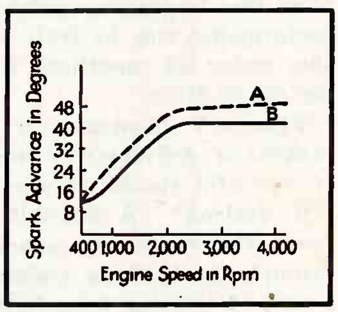

FIG. 3—Engine-speed versus spark-advance curves show (A) the maximum brake torque theoretically available and (B) the actual performance attained by a typical production engine

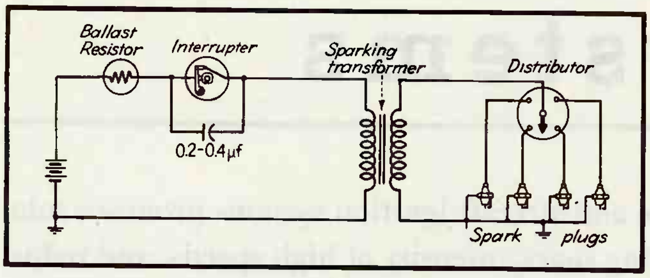

FIG. 4—Addition of a ballast resistor in the primary excitation line gives a constant break-current which permits better high-speed operation

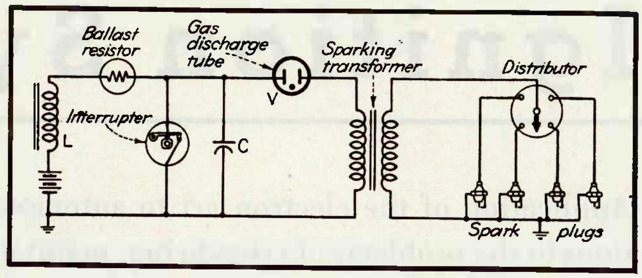

FIG. 5—Further addition of a charging inductor and gas-filled discharge tube in primary circuit gives freedom from effects of secondary loading

secondary, whereas the ordinary ignition system will have ceased to operate with a megohm resistor in this position.

Figure 6 illustrates still another ignition system[3] relatively insensitive to secondary loading, and includes a charging inductor L connected to the battery in series with a first interrupter I_1. When I_1 opens, voltage builds up across C_1 and charges C_2 through the hot-cathode gas-filled tube V. Now, when the spark is desired, interrupter I_2 closes and develops the requisite voltage in the secondary of the sparking transformer.

Interrupter I_1 may be actuated at any time previous to the time the spark is required, and only I_2 need be critically timed. Although C_2 may be charged to several hundred volts when the contacts in I_2 close, these contacts nevertheless have a long life, as the current is zero when they close, and has fallen again to zero by the time the contacts are opened.

High-Voltage Sources

The circuits thus far described all operate directly from the 6-volt battery in the main electrical system of the vehicle. When freed from this limitation, reliability of performance may be truly remarkable under all conditions for long periods of time.

Figure 7 illustrates a circuit capable of delivering a succession of powerful sparks at almost any rate desired.[4] A 300-volt source feeds the reservoir capacitor C_1 through the limiting resistor, and a pair of igniting transformers T_1 and T_2 are arranged in conjunction with C_3 and the interrupter I so that C_3 is alternately charged through T_1 and discharged through T_2. As C_3 charges through T_1, a voltage is developed in the secondary which is applied to the igniting band around the tube V_1, causing this tube to fire and charge the capacitor C_3 to line potential through the primary of the sparking transformer.

Since C_3 is now charged, it is ready at once for the next operation, which is initiated when the interrupter I discharges C_3 through the transformer T_2, thus firing the tube V_2 whose igniting band is connected to the secondary of T_2. This discharges C_3, and prepares it for the succeeding operation of V_1.

Cross-Firing Cure

None of the foregoing arrangements have attempted to overcome the problem of cross-firing which, it will be remembered, was due to the high impedance of the circuits being run in the common conduit. The arrangement of Fig. 8 overcomes this[5], and is peculiarly suited as well to meeting the ignition problems presented in the fuel injection engine where a continuous discharge is preferable over a momentary igniting spark.

The spark-fired fuel injection engine is not to be confused with the spontaneously firing Diesel engine. In the former, compression pressures approximating those in the conventional vaporized fuel engine are retained and the gas temperature at the end of the compression stroke is not sufficiently elevated by the adiabatic compression to ignite the incoming liquid charge, thus requiring the use of auxiliary ignition. In the latter, the more familiar Diesel, the gas temperature at the end of the compression stroke has attained such a value that the incoming charge is ignited thereby without auxiliary means.

Unless a continuously active igniting means is located in the path of the incoming fuel, the turbulent flow currents in the cylinder above the rapidly moving piston may sweep the flame front away from the incoming fuel and cause incomplete or irregular combustion. The tube is connected with the transformer T_1 in a Hartley oscillator circuit working at 25 to 50 kc and delivering power into a low-impedance secondary with one end grounded and the other connected to the rotating arm of a distributor assembly. As the arm passes over the conducting segments set in the insulating housing of the distributor head one after another of the spark plug step-transformers is connected to the low-impedance output from the oscillator.

Only one of these transformers T_2 is shown in Fig. 8, the others being similarly connected. One transformer is associated with each plug and is located immediately adjacent to the plug, so that distribution takes place at a low-impedance level, and the high-impedance portion of the sparking circuit is free of cross coupling to other spark plugs, thus eliminating the possibility of cross-firing.

The step-up transformer at the spark plug is of either the air-core or iron-core type and designed to be self-resonant at the operating frequency. The smallest size for this assembly is secured when an iron core is used.

This ignition circuit differs from those previously described in the fact that it does not supply an impulse, but a continuous discharge during the entire time the distributor wiper arm is in engagement with the stationary contact. As earlier remarked, this is of particular advantage in fuel injection engines, though in certain designs of engines introducing a gaseous fuel mixture into the combustion chamber it may also be used to advantage.

High-Altitude Problems

The weaknesses of distribution at the high-voltage level, while apparent in automotive vehicles, become especially serious in the design and operation of aircraft at attitudes of 30,000 feet and higher. At such heights, pressure of the atmosphere has dropped from its sea level value of 76 cm Hg to 23 cm Hg and the insulating capacity of the atmosphere is correspondingly reduced from the sea-level value for the disruptive gradient—31 kv per cm.

Conservative design, under these circumstances, requires that the conductive properties of air be borne uppermost in mind, with lesser reliance on it as an insulating medium. One answer has been the introduction of pressurized harnesses within which the conductors of the high-tension distribution system are located, thereby retaining sea-level operating conditions.

It is very difficult to insure a completely leak-free harness under the extreme temperature cycling and vibration conditions encountered in the vicinity of the aircraft engine, and in a later modification, use has been made of the presence of the supercharger which reproduces sea-level operating conditions for the engine itself to extend this benefit to the ignition system.

Now, clearly, the inclusion of additional apparatus for a pressurized harness adds materially to the weight of the complete engine. It may well be that an arrangement performing the distribution operation at low-voltage level, with reduction of the harness weight, may offer a net advantage even though it requires some auxiliary apparatus.

A system devised in 1938 with this in mind is shown in Fig. 9 and employs an auxiliary converter unit to raise the supply potential from the system voltage of 24 v to 300 v, which is then fed across the two series-connected capacitors C_1 and C_2 whose center tap is grounded[6]. Capacitor C_0 is merely a reservoir to eliminate surges from the output windings of the converter. The two gas tubes V_1 and V_2 are connected in series with the lines across capacitors C_1 and C_2 and the various contacts of the cam-operated distributor to the primaries of the sparking transformers T_1, etc, one of which is associated with each plug.

Gas tubes V_1 and V_2 are of the type requiring a positive grid potential to establish conduction and having an inductor L_1 connected between anode and grid, and a second inductor L_2 shunted by a capacitor C_3 connected between grid and cathode. Since capacitor C_3 is an integrating device, there can be no voltage developed across it until current has flown for an appreciable time, and firing of the associated tube is delayed by this effect for a purpose later to be evident.

With the interrupter cam in the position shown, the anode of V_2 is connected to the primary of T_1, thus connecting capacitor C_2 across the primary of T_1 in series with the discharge tube. No appreciable current flows at the instant of contact closure, since the tube V_2, not being ionized, is as yet an open circuit. The current through L_1 begins slowly to build up, charging the ca-

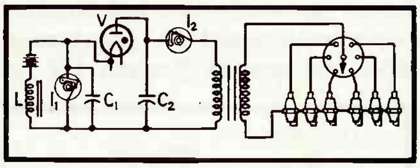

FIG. 6—Insensitivity to secondary loading and long contact life are features of this circuit involving a second interrupter. Critical timing is only required for the second breaker

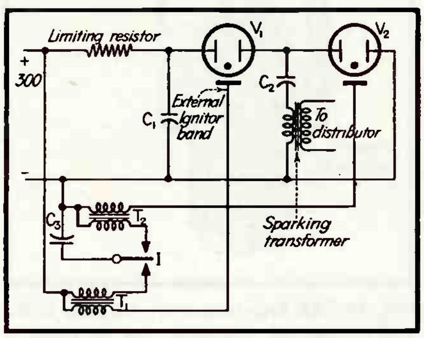

FIG. 7—Availability of a high-voltage source makes possible the application of a circuit which provides powerful sparks at a rate of speed higher than can be attained in a make-and-break arrangement

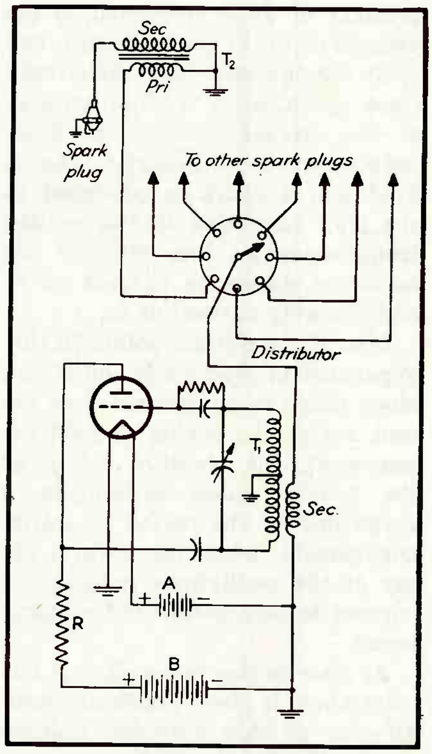

FIG. 8—Triode in circuit as shown attacks problem of cross-firing between high-impedance spark-plug leads. This circuit is particularly useful in fuel-injection-type engines using a continuous discharge

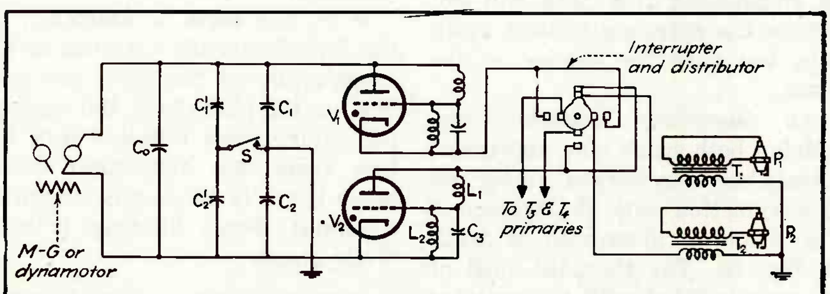

FIG. 9—Aircraft ignition systems encounter problem of high-altitude loss in insulating properties of the atmosphere. This circuit gets away from arc-over, leakage, and cross-firing by using special spark plugs and two gas-filled triodes

pacitor C_3, which after a time reaches the firing potential of tube V_3, establishing the arc and permitting the passage of the main discharge current.

The purpose of this delay is to prevent passage of the heavy main discharge before the contacts have become firmly engaged. During this period, capacitor C_2 is discharged and C_1 becomes charged, both currents adding to increase the energy in the spark produced at the plug P_1. The circuit is thereby cocked for the next cycle of operation. This is initiated when, upon the continuing rotation of the cam, the primary of T_2 is connected to the cathode of V_1, V_3 having been previously disconnected from the circuit. Once again, after a slow build-up of the current through the delay inductance, the discharge tube is fired and a spark is produced in the plug connected to the excited transformer T_2, this time by the combined discharge current of C_1 and charging current of C_2.

Life of the contact points in this apparatus is practically unlimited, since there is no current flow except during the period of solid engagement, the blocking action of the control tubes preventing a surge during the period of initial engagement, while the natural decay of the oscillations reduces the current to zero before the contacts break.

As distribution takes place at 300 volts, there is also no difficulty with arc-over at high altitudes, leakage on the distribution lines, or cross-firing. When, for starting purposes, more energy is needed in the spark, this is secured by closing the switch S, to effectively parallel C_1 and C'_1 and C_2 and C'_2. It should be emphasized that this will not change the sparking voltage available, but only the energy in the spark.

An ingenious assembly embodying both spark plug and transformer has been worked out for use in conjunction with the system of Fig. 9 and is illustrated in detail in Fig. 10. The threaded shell of the plug is fitted with an insulated central electrode projecting into the interior of a molded assembly in which the step-up transformer is embedded.

Shown in vertical section in Fig. 10, the transformer comprises an 800-turn secondary wound directly on a laminated or pressed iron core, with the 25-turn primary wound over the secondary. One end of the secondary is connected to the core, which is conductive and fitted to engage the projecting end of the center electrode. The other end of the secondary, together with one end of the primary winding, is connected to the shield slipped over and secured to the shell.

Power is fed to the primary from the incoming line through a contact at the top of the molded transformer assembly, the lead terminal being maintained in engagement with this contact through the ac-

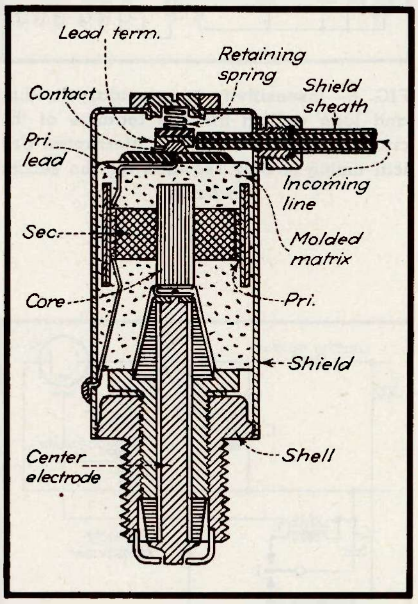

FIG. 10—All high-frequency currents in the spark-produced transient are confined to the spark plug itself in this design which serves with the circuit shown in Fig. 9

tion of the retaining spring. This keeps the whole interior assembly pressed tightly against the center electrode.

With this form of assembly, all the high-frequency currents in the spark-produced transient are confined to the plug itself, the remaining interference reflected into the line from the distributor being much lower in value and located in a circuit where filtering is relatively simple.

Multi-Electrode-Tubes and High-Tension Systems

Turning now to high-tension distribution systems incorporating multiple-electrode tubes, we en-

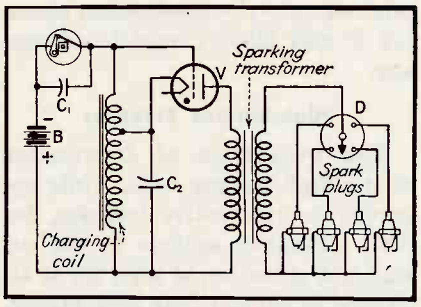

FIG. 11—Breakdown of gas-filled tube in this arrangement generates a high-voltage pulse in the secondary

counter the arrangement of Fig. 11, operating directly from the 6-volt storage battery, and having a tapped charging coil connected to the battery in series with the standard breaker or interrupter[7].

When the breaker is opened, a damped sinusoid appears across the charging coil, charging C_2, connected across the primary of the sparking transformer in series with the anode-cathode path of the gas-filled hot-cathode discharge tube V. Capacitor C_1 is connected across only a portion of the charging coil, and the control grid of the tube is connected to the opposite end of the coil so that as the anode is driven positive, the control grid is driven negative.

By using a discharge tube requiring positive grid voltages for firing when the anode voltage is below 100 volts, and negative grid voltage for firing when the anode voltage is greater than this, it is possible to proportion the turns so that the tube characteristic and the voltage characteristic of the charging coil intersect at any chosen point, say 200 anode volts. There is then no current flow in the sparking transformer until this voltage is reached, whereupon the tube V breaks down to generate a high-voltage pulse in the secondary of the sparking transformer which is then impressed on the selected plug by the distributor.

Another circuit with which some work was done in 1939 is that shown in Fig. 12, wherein an interrupter I_1 connected to a charging transformer and the battery, operates in conjunction with a rectifier to charge a reservoir capacitor C through a limiting resistor.[8] Again the reservoir capacitor is connected to the primary of the

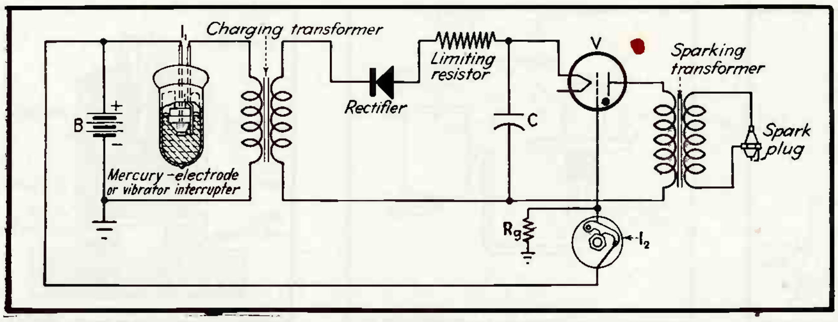

FIG. 12—High-speed acceleration is improved by this circuit which combines power-supply interrupter with timed breaker and gas-filled triode

sparking transformer by the anode-cathode path of a gas discharge tube V whose grid is, in this case, normally connected to ground and the negative terminal of the battery through the resistor R_g.

A second interrupter I_2 is connected between the positive terminal of the battery and the control grid, and upon closure, causes the tube V to fire and generate a spark in the plug connected to the secondary circuit. This circuit operates with very little breaker-point current and is relatively immune to trouble from poor insulation in the secondary circuit. Though the development used a mercury-electrode interrupter for I_1, a synchronous vibrator supply has been used with the circuit rearranged to permit operation of the gas-discharge-tube filament at chassis potential, and at high speeds the system has developed sparking potentials in excess of those provided by the best coils at the more favorable low speeds. The most noticeable performance improvement was a gain in acceleration possible with engine speeds over 3250 rpm (65 mph) and this was retained despite wide variations from the recommended values for the plug-gap spacing.

The circuits of Fig. 13 and 14 are designed to overcome restrictions on design freedom imposed by the hot-cathode type of discharge tube, both employing the 631-P1 for control purposes. The 631-P1 is a cold-cathode gas-filled discharge device having two control elements interposed between the anode and cathode.

Its particular adaptability for this type of work is due to the extremely high peak currents which it is able to pass and to its availability for instant operation resulting from lack of heater requirements. The tube itself is most familiar in connection with stroboscopic apparatus where it has found wide application as a highly satisfactory light source.

Figure 13 shows a system designed for an engine having a single ignition coil and a single distributor.[9] A 300-volt source is connected across the reservoir capacitor C_0 and bridged by the series-connected capacitors C_1 and C_2.

The junction point of the two impulse-generating capacitors C_1 and C_2 connects through the primary of the ignition coil to the interconnected cathode and anode of a pair of 631-P1 tubes connected in series across the supply line. Interrupters I_1 and I_2, actuated by the cam in the distributor housing, successively place a positive bias on one of the grids in the two gas tubes, causing a primary discharge through T first in one direction and then the other.

The 1-meg resistor across C_1 insures that C_2 will be charged to the full line potential when the apparatus is turned on after a period of inactivity, in which case the operation is as follows: as the cam rotates clockwise, contacts I_1 first separate, after which contacts I_2 close, placing a positive bias on the control element of V_2. This triggers off the discharge of capacitor C_2 through the primary, to which there is added the charge current of capacitor C_1 being readied for action on the next cycle. Upon the continuing rotation of the breaker cam, the contacts at I_2 are opened and those of I_1 close, firing V_1 and restoring the impulse capacitors to their original state ready to continue the operation.

Figure 14 is a similar ignition system designed for operation with two ignition coils working through two distributor heads[10]. The two 631-P1 tubes are symmetrically connected in the two supply lines leading to either end of the series-connected ignition-coil primaries. The center tap from the two primaries goes to the tap between the two capacitors C_1 and C_2. As interrupter I_1 closes, the positive potential on

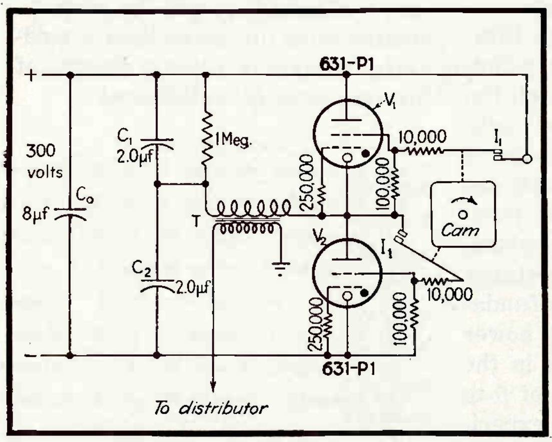

FIG. 13—Cold-cathode tubes serve this system in conjunction with a single ignition coil and one distributor. A high-voltage source is required

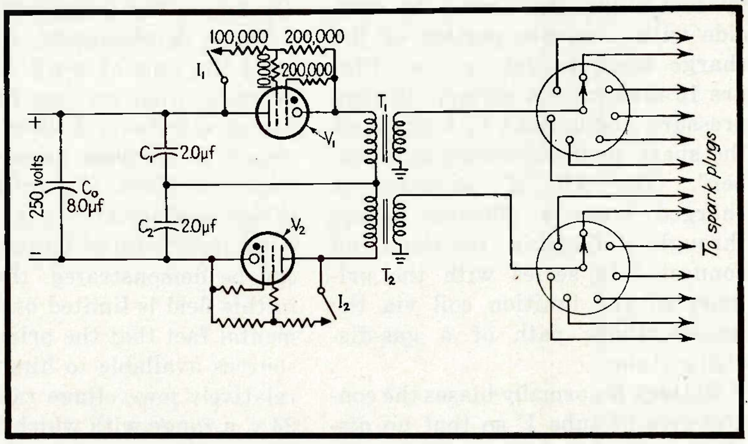

FIG. 14—This circuit uses cold-cathode tubes with two coils and two distributors. Ability of these tubes to carry high surge currents makes them ideal for this service

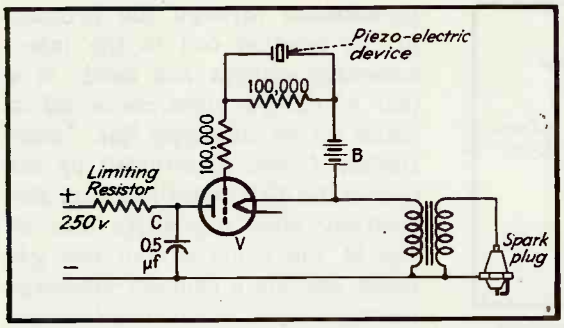

FIG. 15—Ignition can be directly related to the pressure-time curve by a system utilizing a crystal as shown

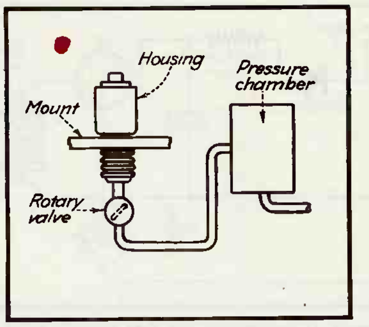

FIG. 16—Diagram of hydraulic actuator system shows how rotary valve admits pulsations from pressure chamber

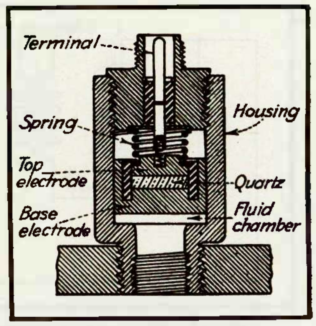

FIG. 17—Detail of the piezoelectric housing from Fig. 16. Crystal pressure arises from deflection of base electrode

the control element fires V_1, connecting ignition coil T_1 across C_1 to discharge and charge C_2. On the next cycle of operation V_2 similarly fires, discharging C_2 and recharging C_1. The 631-P1 is especially suited for this type of service as contrasted with the hot-cathode types because of its very great surge-current-carrying capacity.

Unless surge currents of 2 to 5 amperes can be reliably supplied, neither these nor any of the previous circuits will deliver satisfactory performance. The high cathode powers required in the hot-cathode type of discharge tube to secure these peak anode currents, together with the heating time required, have up to now limited the development in this direction.

Unconventional Timers

With tubes controlling the discharge circuit, it is no longer necessary to use relatively massive breaker points for controlling the moment of spark initiation. In the case of fuel-injection engines in particular, benefits can be derived by controlling the timing to coincide with a certain portion of the charge pressure-time curve. Figure 15 illustrates a system utilizing pressure fluctuations to trigger off the spark in the combustion chamber[11]. The 0.5 μf capacitor is charged from a 250-volt source through a limiting resistor, and connected in series with the primary of the ignition coil via the anode-cathode path of a gas-discharge tube.

Battery B normally biases the control-grid of tube V so that no discharge can take place, and is connected to this grid in series with a pressure-responsive piezoelectric device. Connected to the proper portion of the fluid feed system, this piezoelectric actuator generates a positive voltage which, when it reaches the proper value, permits firing of the tube and passage of the spark across the terminals of whichever spark plug is connected through the distributor to the ignition-coil secondary at the moment.

The general scheme of the hydraulic actuator system is portrayed in Fig. 16, showing a pressure reservoir connected through a rotary valve to the hydraulically driven piezoelectric actuator. The rotary valve is synchronized with the engine crankshaft in the same manner as the camshaft, and each time the valve port sweeps into register with the line connections, a pressure pulse is applied to the piezoelectric element. Figure 17 illustrates the internal details of the quartz pulse-generator used in this arrangement. As the pressure wave drives the base electrode in the direction of the top electrode, pressure on the quartz plate rises, developing the trigger voltage.

These developments, which illustrate the type of work done to improve ignition systems through the use of electronic devices and techniques in the past decade, make it clearly evident that although superior performance over the presently incorporated ignition systems can be demonstrated, the designer in this field is limited by the fundamental fact that the primary power sources available to him are in the relatively low-voltage range of 6 to 24 v, a range with which the experienced electronics designer associates heater operation, not anode excitation.

All the systems described embody some means to work the space discharge portion of the associated electronic device at a voltage in excess of 100 volts, and most use gas discharge tubes to decrease the power lost within the tube. That an increase in voltage level is an indispensible expedient. is evident upon a moment's reflection, for no conventional gas discharge devices have pick-up potentials as low as 6 volts, which is even lower than the arc-voltage required after establishment of the discharge.

Costwise, an electronic ignition system is still at a disadvantage, for it requires a step-up device and some synchronized contacting device in addition to the tube and auxiliary components, and the make-and-break system does not have to reckon with the cost of these latter elements. In the aircraft field, with problems peculiar to itself, and the trend toward higher primary a-c or d-c power-supply voltages, the supply-voltage limitation is steadily becoming less effective. When sufficiently superior performance can be demonstrated with not more than a moderate increase in price, a growth of interest is to be anticipated.

References

(1) Bychinsky, Wilfred A., U. S. Patent 2,222,498.
(2) Bychinsky, Wilfred A., U. S. Patent 2,222,498.
(3) Randolph, Donald W., U. S. Patent 2,003,466.
(4) Knight, Henry de Boyne, U. S. Patent 2,175,900.
(5) Cotter, William F., U. S. Patent 1,968,930.
(6) Hooven, Frederick J., U. S. Patent 2,180,358.
(7) Randolph, Donald W., U. S. Patent 2,027,617.
(8) Randolph, Donald W., U. S. Patent 2,203,579.
(9) Peters, Melville F. and Blackburn, George F., U. S. Patent 2,260,331.
(10) Peters, Melville F. and Blackburn, George F., U. S. Patent 2,278,483.
(11) Knight, Henry de Boyne, U. S. Patent 2,248,574.

TEST SET for Quartz Crystals

Details and development steps in the creation of a master "go—no-go" gage which determines, against applicable specifications, the electrical suitability of a wide variety of quartz crystal types

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PRIOR TO World War II, the quartz crystal industry of this country consisted of perhaps four or five major manufacturers and two dozen or so smaller producers. The advent of Lend-Lease and the subsequent entry of our country into the war immediately created a terrific demand for radio and electronic equipment and components of all kinds.

Crystals quickly became one of the most critical items. The wartime program called for many thousands per month as a starter, whereas a pre-war order for 500 or 1,000 crystals was a large one, indeed. Consequently, it was necessary that existing crystal manufacturers reorganize their plants and processes to a mass-production basis. Among the many developments which have materially contributed to mass crystal production is the crystal test set.

Such a test set was not in general use by the industry prior to, and for some time after the outbreak of war. Rather, it was customary practice for the radio equipment manufacturer to supply to the crystal manufacturer a representative item of the equipment in which the crystal was to be used. The equipment thus supplied to him became the crystal manufacturer's production standard, to which he established a working relationship on his production test oscillators.

Early Test Sets

Pre-war problems in crystal manufacture were multiplied to the extreme when military orders were placed. Everything necessary for crystal production was scarce: technical knowledge and methods, trained personnel, materials, space, and equipment. Test sets for crystal manufacture were generally unknown and the practice of using the actual radio equipment as a production standard was followed for a time. Use of the radio itself, however, was awkward and generally unsatisfactory from a technical standpoint. At the same time, the armed forces were crying for every available means of communications. As a final discouragement, military security definitely restricted display of new equipment.

Accordingly, crystal test sets were soon developed which represented fairly well the actual requirements of the radio sets, and were simple to operate. These test sets, however, had little advantage over the actual equipment except for the important one of releasing equipment urgently needed for military use.

Maintenance of the crystal test

Front and rear views of quartz crystal test set show simplicity of design. All controls are available on the panel which also carries the correlation data chart for establishing the tests for various crystal units sets was a problem. As with the actual radio equipment when used in crystal production, the useful production life of the test set was short. Tubes aged or burnt out, and batteries lost their voltages. Consequently, the Galvin crystal engineering group began thinking of an ideal crystal test set. This unit would be stable, thus requiring a minimum of calibration maintenance. It would be so designed that the requirements for many types of crystals, not just one, could be accurately and quickly established on it, and duplicated at any time. A table of adjustments would be provided to facilitate the setting up of any established correlation. The set would be entirely a-c operated.

Relation of Test Set to Equipment

The fundamental requirement of a crystal test set with relation to the equipment in which the crystal is to be used is, of course, quite simple: the test set shall cause the crystal to operate just as it does in the radio equipment. To obtain this performance, the test oscillator must be so designed that its input characteristics are the same as presented to the crystal by the crystal oscillator in the radio equipment. Thus, frequency and activity (r-f voltage) requirements for the crystal are duplicated to a high degree of accuracy by the test set.

The maximum frequency tolerance and minimum activity requirements of the crystal are generally determined by the radio engineer after a working model of the radio set has been designed and built. The frequency tolerance depends upon a number of factors: transmitting frequency, receiver bandwidth response, and others. The minimum activity value is that below which the crystal will not produce satisfactory operation of the equipment, all other variables being at their minimum values. In some equipment, the crystal has been required to produce proper set operation even when other components are somewhat below their minimum values.

To the activity value which is established as a minimum, a safety factor is usually added. The activity value itself is usually expressed or evaluated in terms of one of the following: rectified grid current of the oscillator tube, d-c bias voltage produced on the grid of the following tube, r-f signal voltage at the grid of either the oscillator or following tube, r-f voltage at the grid of a mixer tube, d-c bias voltage on modulator or a-f output tubes, etc. The minimum requirements are given to the crystal engineer so that he can proceed to establish an accurate crystal test set against average radio equipment.

The crystal test set is usually correlated to an average radio in the following manner: with the test set input adjusted to duplicate that of the equipment, frequency measurements are made on a number of crystals over the operating range as a check that a given crystal, operating in the test set, does reproduce very accurately its frequency when operating in the radio equipment. A number of crystals having activity values above, below and at the minimum are then used to determine the average test-set grid meter reading which corresponds to the minimum crystal activity in the radio equipment.

Thus correlated, the test set and associated radio equipment then become standards and, as such, are reserved from further use until such time as it may be desired to confirm primary correlation. Other test sets are calibrated against the one established as primary standard. Of the secondary standards, one is reserved from use—against which the working standards may be checked from time to time. The crystal manufacturer receives other calibrated reference-standard test sets which have been established against one of the working secondary standards.

Design of the New Test Set

Inasmuch as each crystal oscillator is different in each of a number of types of Signal Corps equipment manufactured by Galvin, a like number of early primary standard test sets was established, duplicated and maintained. Consequently, when the concept of an ideal crystal test set arose, the variety of oscillator characteristics to be encompassed was indeed impressive. As examples of variables encountered: only one of all radio sets involved used crystal oscillators each presenting the same shunt capacitance to the crystal. Several different types of tubes were used. Circuit variety was extensive, as were plate, grid, screen and cathode-bias voltages and component values.

Obviously, the new test set must be confined to only those variables absolutely necessary to its function as a multi-crystal correlation standard. Therefore, grid and plate capacitors must be variable, and of sufficient capacitance range to meet minimum and maximum values found in actual equipment. Likewise, the grid-bias resistor must be variable so that the rectified grid current could be regulated to a desired meter value. It might be de-

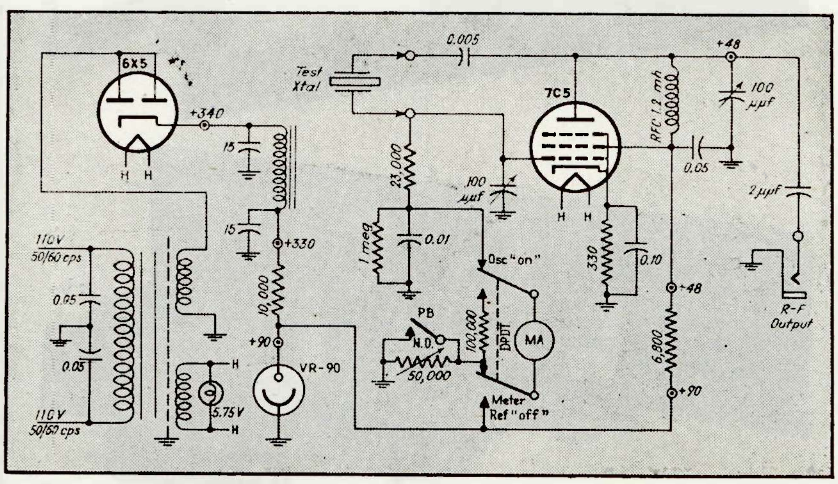


FIG. 1—Circuit diagram of Model CES-1 standard crystal test set. Note reduced heater voltage to insure long tube life

sirable to incorporate variable d-c plate-voltage control, but this feature would be omitted from preliminary plans.

The oscillator circuit would be the Pierce type, since nearly all the radio equipment concerned used one or another variation of the basic Pierce circuit. The entire test set would be a-c operated, with d-c voltage regulation. The oscillator tube would be operated far below its nominal d-c plate and screen voltages; likewise, the heater would be operated at sub-normal voltage. Because of these reductions in operating points, tube aging and burn-out would be minimized.

Preliminary sketches of the circuit (see Fig. 1) and physical layout of the new test set were made. Then a model was built and given preliminary tests whose results well justified completion of the development.

After construction, performance tests, and correlation, three Model CES-1 Standard Crystal Test Sets were shipped to the Long Branch Signal Laboratories for their tests. A short time later, tentative approval and an engineering report of the findings were issued. Following this, the Laboratories, through the cooperation of Lt. Col. W. F. Atwell and Maj. E. F. Mitchell, sent two of their engineers to Galvin to confirm the prime correlations which had previously been established. Full approval and acceptance of the CES-1 Crystal Test Set as a standard by the Signal Corps was announced soon afterwards.

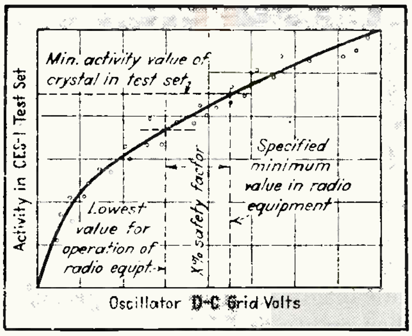
Performance of Sets

After the first production group of CES-1 test sets had been in service for a few weeks, it became evident that the activity-correlation stability of some units was not as consistent as that of others. A thorough investigation of several of the unstable units disclosed two sources of trouble: erratic grid-bias and meter-reference resistors and unstable VR-90-30 voltage-regulator tubes.

Although the VR-90 tubes, as well as the entire test set, had been aged 60 to 100 hours prior to being placed into service, it was found that many of the tubes did not hold their specified regulating characteristics. This situation was remedied by aging of the regulator tubes in a special rack Unstable units were discarded and the acceptable ones were placed into service in the test sets. This program was applied to all CES-1 test sets, as well as to considerable engineering laboratory equipment which used the VR-90 voltage regulator.

After extensive tests, the resistors which had given trouble were replaced in all test sets by a semi-precision type.

The stability of both the voltage-regulator and the resistors involved in the meter-reference circuit was important to the extreme since a given resistor value was to be set up at any time to an accuracy of ±5 microamperes, in terms of direct current on the activity meter. Circuit variations ordinarily considered as very small therefore became quite important. A switching circuit was added to the test set so that the operation of the VR-90 tube can be checked at any time against a B+ reference value, established and recorded on the correlation chart when the tube is put into service. The meter-reference value, established by a variable resistor in the oscillator grid circuit and the constant B voltage, simultaneously establishes the proper activity correlation for the particular crystal involved.



Typical activity correlation curve relates CES-1 test set indication to average radio equipment requirement. These curves are the means by which determinations of specification values are made for crystals

After these improvements were made, the stability of the test set had improved so that nearly a year ago, crystal suppliers were changed over to a schedule calling for routine checking of their test standards at 2-month intervals by the crystal engineering division at Galvin, the prime contractor. Of course, if and when a component failure should occur, the test set is to be returned for complete servicing and re-standardization. This has not yet occurred, however.

Setting up a calibrated CES-1 test set for a given correlation is a simple matter. The necessary data are included in the chart mounted on the front panel on the instrument. The procedure consists of setting up two dial values and one meter-reference value for each correlation. This operation requires less than one minute.

Future Developments

In order to advance the simplicity of standardizing crystal test sets further, it is contemplated that artificial minimum-activity crystals may be available at some time in the future. Such units will be made to a desired characteristic which will correspond to an actual minimum-activity crystal in the radio equipment concerned. With such artificial crystals, the crystal manufacturer or the Signal Corps inspector may, at any time, standardize his crystal test set without returning it to his prime contractor, or to the Signal Corps, whichever action applies. This particular development by the Signal Corps Laboratories has not yet been completed, although one form of it is in practical use.

While the crystal test-set problem seems well in hand, there remains much to be done. For one thing it is expected that some day the crystal engineer and the radio engineer will work hand in hand on the design of any new equipment in which crystals are to be used. Difficult crystal manufacturing problems might be avoided if this sort of cooperation were to be practiced. More efficient crystal circuits generally are possible when the specialized knowledge of the crystal engineer is used. The crystal specialist, on the other hand, has the obligation of hastening the day when the performance to be expected of a crystal will be defined, in practice, as a function of the crystal itself, rather than in such arbitrary terms as those discussed in this article.

DIELECTRIC

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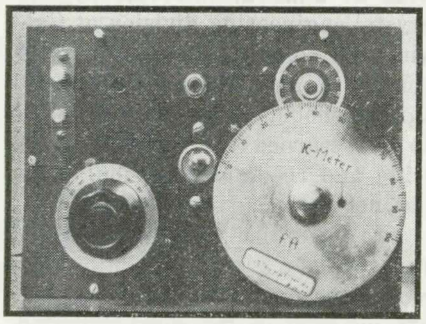

This photograph shows the dials of the meter capacitors, terminals for connection to the test cell, and the 6E5 which serves as oscillator and resonance indicator

In the past thirty years dielectric measurements have become important in the study of molecular structure[1, 2, 3] and in laboratory procedure.[4] Most apparatus used to make these measurements has been designed for high precision, and is costly and complicated.

The purpose of this paper is to discuss dielectric-constant measurements, and to describe a simple instrument which is accurate to one percent and suitable for many laboratory and industrial measurements.

The Dielectric Constant

The dielectric constant k is generally defined[5] as the ratio of the permittivity of the substance being investigated to that of empty space ($k = \epsilon/\epsilon_0$); k, however, is more often thought of as the ratio between the capacitance of a capacitor immersed in a dielectric and its capacitance in empty space. In fact, most methods for measuring k depend on this latter concept. The dielectric constant of dry air (1.00059 at 0°C) is generally taken as unity since most measurements of k are not made to better than 0.1 percent.

Dielectric constants measured at low frequencies cover the range from 1 to nearly 100. This is a remarkably wide range compared to a related property, the optical refractive index, which only covers the range 1.000 for vacuum to 2.950 for chrome-spinel. Dielectric constants of some common materials are shown in Table I.

Since water has such a high dielectric constant, a small amount of it can be detected in liquids such as benzene, and powders such as flour and tobacco, by dielectric measurement. Commercial moisture meters based on measurement of k have been made.[6] Molecular dipole-moment measurements depending on k measurements will be discussed later.

* Elgin National Watch Co. Industrial Fellowship

Methods of Measuring k

Any method used for measuring capacitance can be applied to measuring k. It is only necessary to make the measuring cell a capacitor of such form that the space between the plates can be filled with the substance to be measured. The ratio of the capacitance when filled, to that when empty, is k.

In most k measurements the substitution method is used. The test cell, of capacitance C_T, is placed in parallel with a calibrated variable capacitor of capacitance C_M, in a circuit arranged to indicate balance when the sum of C_T and C_M is a constant C_0. The capacitance of the test cell, when filled with a liquid of dielectric constant k_1, is k_1C_T. At balance

$$k_1C_T + C_{M1} = C_T + C_{M0} = C_0 \quad (1)$$

Table I. Dielectric Constants

Substance	k	Substance	k
Benzene	2.3	Glass	5.0–10.0
Quartz	4.5	Diamond	16.5
Castor oil	4.7	Acetone	21.3
Mica	5.7–6.5	Water	81.0

Table II. Dielectric Constants and Temperature Coefficients of Standard Liquids

Substance	k at 20°C	$\delta k/\delta t$ per °C
Benzene	2.283±0.002	−0.0019
m-Xylene	2.374±0.002	−0.0019
Ethyl ether	4.335±0.005	−0.019
Aniline	7.21 ±0.05	−0.025
Acetone	21.3 ±0.1	−0.096
o-Nitrotoluene	27.4 ±0.1	−0.15
Nitrobenzene	35.7 ±0.3	−0.18

$$k_1 = 1 + \frac{C_{M0} - C_{M1}}{C_T} \quad (2)$$

where C_{M0} is the capacitance of the calibrated capacitor when the test cell is empty, and C_{M1} is the calibrated-capacitor capacitance when the test cell is filled with a substance of dielectric constant k_1.

It is difficult to ascertain the true value to use for C_T since the medium only partially fills the space surrounding the test cell electrodes, and also because there are stray capacitances in the circuit connecting C_T and C_M. Consequently, Eq. (2) is seldom used, and a calibration against a standard liquid of dielectric constant k_2 is made, with provision to always fill the cell the same way for each determination. By this method it is possible to eliminate C_T from the calculations as follows:

$$k_1C_T + C_{M1} = C_T + C_{M0} = C_0 \quad (1)$$
$$k_2C_T + C_{M2} = C_T + C_{M0} = C_0 \quad (3)$$

Rearranging, and dividing,

$$\frac{(k_1 - 1)C_T}{(k_2 - 1)C_T} = \frac{C_{M0} - C_{M1}}{C_{M0} - C_{M2}} \quad (4)$$

Eliminating C_{M0},

$$k_1 = 1 + (k_2 - 1)\frac{\Delta C_{M1}}{\Delta C_{M2}} \quad (5)$$

where ΔC_{M1} and ΔC_{M2} are the changes in the calibrated capacitor from the condition that the test cell was empty to the condition that it is either full of the unknown dielectric material or the standard dielectric material respectively.

Table II shows a list of standard liquids appearing in The International Critical Tables.[7]

For measurements at audio frequencies, capacitance bridges are customarily used to measure C_M. At radio frequencies up to 100 megacycles the heterodyne beat method shown in Fig. 1 is used. The latter is capable of great precision, and most research workers in dielectric constants have made use of it for the past twenty years.[8, 9, 10]

Another principle applied to measuring k at radio frequencies is

CONSTANT Meter

Simple method for measuring dielectric constant by utilizing the plate current characteristic of a crystal oscillator as it is tuned through its oscillating range. The meter can be made automatic for industrial applications or it can be used to measure capacitance

the resonance method, which makes use of a constant-frequency reference oscillator loosely coupled to a tuned circuit. The tuned circuit contains an inductor, a standard capacitor, and the measuring cell, plus a means of determining resonance such as a thermogalvanometer or a vacuum-tube voltmeter as illustrated in Fig. 2. This is just another method of ascertaining when C_T plus C_M equals C_0.

Another resonance method used in the frequency ranges above 100 megacycles is to vary the oscillator's frequency and observe maximum oscillator reaction from a cavity resonator immersed in the dielectric.[11] The dielectric constant is proportional to the square of the resonating frequency. The dielectric constants of most substances show anomalous behavior in the hundred-megacycle region; this is because the relaxation time of molecules is on the order of 10^{-8} second, and with an excitation frequency of 10^8 cps they are not able to follow the rapid changes in the applied electric field.

The K-Meter

The k-meter developed in this laboratory is simple and inexpensive. Only one tube, an electronic ray tube of the magic-eye type, is used. The costs of parts, including power supply, is about twenty-five dollars.

The critical capacitance effect utilized in this k-meter is the well-known snapping-in of a crystal oscillator as the tuning capacitor is changed from too high a value toward the range in which the crystal oscillates. This effect was first used by Henriquez of Holland in connection with dielectric-constant measurements.[12]

Figure 3 shows a graph of the plate current of a triode crystal oscillator plotted against tuning capacitance. Curve A is obtained with decreasing values of capacitance; curve B with increasing values. It will be noted that the circuit stops oscillating with a larger value of capacitance than the starting value. This electrical-backlash represents a constant increment of capacitance for a particular oscillator, and is useful in checking the linearity of the measuring capacitors. In the region x-y the curve is steepest. This critical portion of the curve is used to locate the balance for each capacitance determination.

K-Meter Construction

Upon conception of the idea to use the 6E5 as both oscillator and indicator, there were some misgivings as to the tube's ability to handle both jobs well. The first model built on a breadboard worked remarkably well, however, and the 6E5 proved to be an excellent crystal oscillator for the purpose. The curves shown in Fig. 3 were taken on the circuit now in use.

The circuit of the k-meter is shown in Fig. 4. The total change in capacitance of the measuring capacitor C_M is about 7 $\mu\mu$f for 180-deg rotation. It is linear between 15 and 90 on the dial, which is graduated into 100 divisions in 180 deg. C_1 is a capacitor to bring the total circuit capacitance into the oscillating range. The dials of these capacitors read increasing numbers with decreasing capacitance; thus, when C_T increases, the C_M dial is increased proportionally to maintain balance.

It is interesting to note that not only is the direct plate current indicated by the 6E5, but also the amplitude of the radio-frequency oscillations. This dual indication makes the critical point easy to read.

The oscillator unit is assembled with the precautions taken with a frequency meter. All r-f wiring is rigid and well spaced. The parts are tied or clamped in place to prevent changes in stray capacitance. The unit is built on the panel, making removal from the cabinet easy.

X-cut and AT-cut crystals have been tried. The X-cut crystal has a better snap-in than the AT-cut type. A ten centigrade-degree change in temperature causes a 0.03 percent change in frequency for an X-cut crystal at seven megacycles. Since the precision of the dials and measuring capacitors is about 0.5 percent, this drift of the X-cut is allowable, and desirable because of the better indicator action which it gives.

The frequency used is not critical. Up to about ten megacycles the dielectric constants of most materials are the same as those measured by direct-current methods. Seven-megacycle crystals were used because they were available, and because operation at their frequency gave good accuracy using small measuring cells.

If the instrument is warmed up

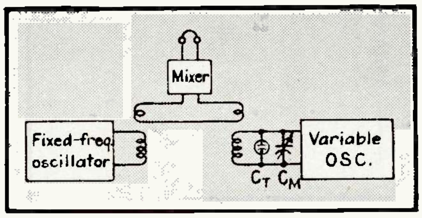

FIG. 1—Block diagram of the heterodyne method of measuring dielectrics

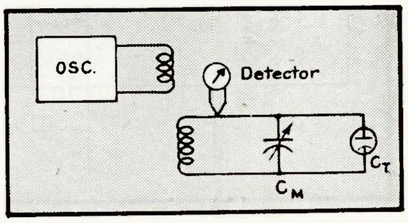

FIG. 2—Resonance method for dielectric constant measurements

for half-an-hour it will have done ninety percent of its drifting. After two hours warm-up, the circuit can run for days with a zero drift less than that which can be read on the dial of C_M.

Automatic Operation

No voltage regulation is necessary. Line voltages of 100 to 135 volts gave no shift in the zero setting of C_M. When the line voltage was reduced to 75 volts the pattern on the 6E5 was too dim to be clearly seen and the zero of C_M shifted 0.5 dial division, corresponding to a 0.2 percent error in the dielectric constant of benzene.

The instrument has been made to operate automatically by connecting a spdt relay in the plate circuit of the 6E5. The relay operates a reversible four-rpm motor connected to the vernier drive of the dial on C_M. The motor decreases C_M until balance is reached, at which point the relay operates, whereupon the motor reverses until the relay again operates. In this manner the k-meter can be made to record continuous changes in dielectric constant due to temperature variations. A suitable recording system can be attached to the motor shaft.

The Test Cell

Whether the substance to be measured is a gas, liquid or solid, it must be made the dielectric of a capacitor. Dielectric-constant measurements on gases are performed with elaborate equipment[4] and are outside the capabilities of this k-meter. Cells for liquids are of greatest interest to the practical physical chemist since much chemistry depends on the properties of liquids and solutions.

Most cells described in the literature are of glass coated with metal walls. Several cells of excellent design are described in the literature.[10, 13] Glass cells are adapted to precision measurements, but are difficult to make since not only is a good glassblower required, but also one able to do a careful job of silvering or platinizing the electrodes.

A simple demountable cell that is easily cleaned is shown in Fig. 5. This cell uses semi-micro quantities of sample; only two milliliters of sample are required to fill it. It is stainless steel and can be turned on a lathe in several hours. A punch mark is made on one side of the outer steel test-tube electrode so that the center part can always be plugged in with the same orientation. A sapphire centering pin set in the bottom of the central electrode increases the overall reproducibility of measurements from one percent error without the pin to 0.3 percent error with the pin. This increase in accuracy is valuable when making molecular dipole-moment measurements or tests for impurities.

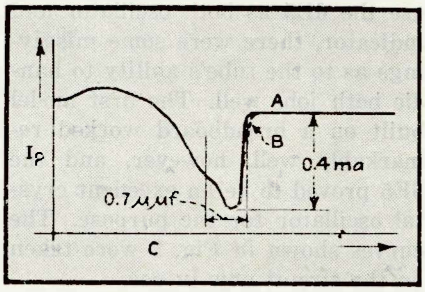

FIG. 3—Plate current of a crystal oscillator changes as the tuning capacitor is tuned through resonance. Data for this curve was taken from an oscillator using the triode section of a 6E5 tube, and an X-cut 7-Mc crystal

Using two milliliters of sample in the cell brings the liquid level above the recessed shoulder so that volumetric errors cannot cause large errors in k. A plus or minus five percent error in measuring a sample causes a ± 0.7 percent error in k for $2<k<3$. Using this cell, one dial division of C_M corresponds to $\Delta k = .010 \pm .003$. Due to the type of measuring capacitor used, actual dielectric-constant values can only be relied on to plus or minus one in the third significant figure.

A similar cell made to fit in a test tube rather than to be self-contained was described by Hazen.[14] A dip-cell has been used with the k-meter. It was made of flat nickel plates. A cell made of concentric cylinders is preferable, however, to one of flat plates, because the parallel-plate capacitor suffers from larger edge effects. For solids in powder form such as flour and cut tobacco, special cells must be devised for the particular problem[4].

Chemical Applications

In the chemical laboratory k measurements are useful in the identification of compounds, the control of distillations and reactions, the determination of purity, and the measurement of molecular dipole moments.

Isomers of organic liquids can often be identified by their dielectric constants. If it is known that only two isomers exist in a sample, the concentrations of each can be determined if their k's are known. For example, ortho-xylene has a k at twenty degrees centigrade of 2.58 and meta-xylene under the same conditions has a k of 2.37. Using the test cell described above there is a twenty dial-division increment on C_M from ortho- to meta-xylene, making it possible to measure 2.5 percent ortho- in meta-xylene by reading C_M to one-half a dial division.

Dielectric constant measurements have been used to follow the course of distillation in a three-component system. The variation of k is shown in Fig. 6. Such distillations may be

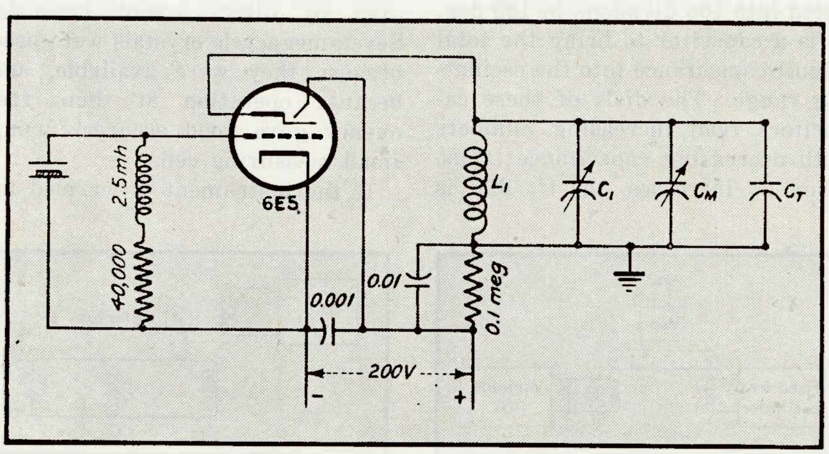

FIG. 4—This type of dielectric-constant meter uses few parts. The 6E5 tube serves both as oscillator and balance indicator. The power supply can have no direct-current path to ground

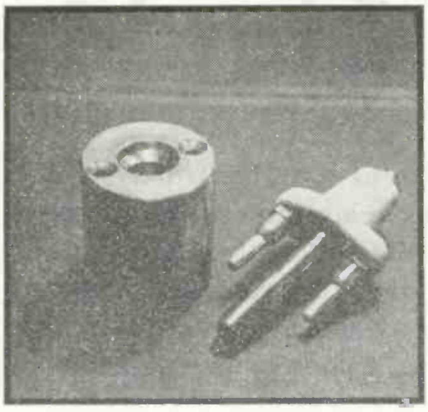

FIG. 5—The liquid or powder whose dielectric constant is to be measured is made the dielectric of this concentric capacitor used as the test cell

automatically controlled by having distillation receivers cut in at a fixed value of k.

Two samples of wheat flour of known moisture content were obtained. One-gram samples were weighed to an accuracy of 0.1 percent, and k measurements made. Sample A contained 9.3 percent moisture by weight; sample B, 12.9 percent. Sample B had a dielectric constant 0.67 greater than sample A, a difference of almost 70 dial divisions for a moisture difference of 3.6 percent. However, for reproducible results a special cell is needed.[4]

Capacitance Measurements

Many small capacitance effects can be detected and measured by the k-meter. Some of these are academic and primarily used for demonstration purposes, while others have more useful applications.

The radius in centimeters of an isolated metal sphere is equal to 0.900 times its capacitance in micromicrofarads. A sphere can be isolated for purposes of demonstration by supporting it 10 or 20 cm above the instrument on a stiff wire. The wire connects the sphere to the high side of the capacitance measuring terminals. This principle has been used both to measure the diameter of 2.0-cm spheres to the nearest 0.02 cm and to check the linearity of the measuring capacitors by using spheres as small increments of capacitance.

A very convincing demonstration of the capacitance effects of insulation and wire diameters can be made by using equal lengths of insulated wires of varying diameters as capacitors. A one-cm length of spaghetti-type insulation slipped over a three-cm length of number eighteen bus wire gave a 0.8 dial-division change in C_M. These demonstrations using the k-meter would be valuable in a course in electrical measurements, and are made more simply than with a precision capacitance bridge.

Temperature and Pressure Measurements

The k-meter has been used to follow automatically the temperature indications of a standard mercury-in-glass thermometer. A wire was wrapped around the bulb to make capacitive contact with the mercury, and a piece of metal foil was wrapped around the stem. The k-meter with motor drive was connected to these electrodes. With the particular thermometer used, a one-centigrade degree temperature change gave a two-dial-division change on C_M. By sealing a lead into the mercury bulb and using a thinner glass wall this could be magnified.

The meter has also been used to follow minute variations in level of a mercury-in-glass manometer. One electrode was inserted in the mercury; the other was a tight-fitting metal cylinder mounted at the meniscus. With standard eight-mm glass tubing of one-mm wall thickness C_M gave 96 divisions per centimeter of mercury pressure change. This corresponds to 0.5 cm of mercury motion inside the sleeve electrode. The sensitivity of these mercury-in-glass devices used with the k-meter is partly due to the high dielectric constant of glass.

Molecular Dipole-Moment Measurements

The dipole moment of a substance is a measure of its molecular symmetry, or lack of it.[3, 15] It represents the part of a dielectric's polarization due to orientation in the electric field, and is large for unsymmetrical molecules such as nitrobenzene. Molecular dipole-moment measurements have been valuable in determining the actual structure of molecules.

Molecular dipole-moment is generally measured by correlating dielectric constants, densities, and refractive indices for a series of dilute solutions of the dipole substance in a non-polar substance such as benzene. More exotic methods, such as Estermann's molecular-ray method[10], have been applied to the measurement of the dipole moment, but k-measurements form the basis of most of the research in this field. Hence the k-meter is directly applicable to molecular dipole-moment measurements.

Few schools include experiments on dielectric constants in their undergraduate physical - chemistry curricula. This is due in part to the lack of a simple instrument of student-grade. The k-meter described herein is sensitive enough to measure the dipole moment of substances such as nitrobenzene whose dipole moment is of the order of 10^{-18} esu, and would prove valuable in teaching.

REFERENCES

(1) Nernst, *Z. Phys. Chem.*, 1894.

(2) Ratz. *Z. Phys. Chem.*, 1894.

(3) LeFevre, "Dipole Moments," Chemical Publishing Co., 1938.

(4) Reilly and Rae, "Physico Chemical Methods," Vol. II, p. 501–531, D. VanNostrand, 1940.

(5) Frank, "Introduction to Electricity and Optics," p. 206, McGraw-Hill, 1940.

(6) Ebert and Waldschmidt, *Z. Phys. Chem.*, 1931.

(7) "International Critical Tables," Vol. VI, p. 73-107, McGraw-Hill, 1929.

(8) Zahn, *Phys. Rev.* **24**, 400, 1924.

(9) Williams, *J. A. C. S.*, **52**, 1900, 1931.

(10) Esterman, *Z. Phys. Chem.*, 1928.

(11) Wyman, *Phys. Rev.*, 35, 623, 1930.

(12) Henriquez, *R. T. C. D. P. B.*, **54**, 327, 1935.

(13) Henriquez, *Physica.*, 2, 434, 1935.

(14) Hazen, *R. S. I.*, **14**, 141, 1943.

(15) A Symposium on Dipole Moments, *Trans. Faraday Soc.*, 30, 1934.

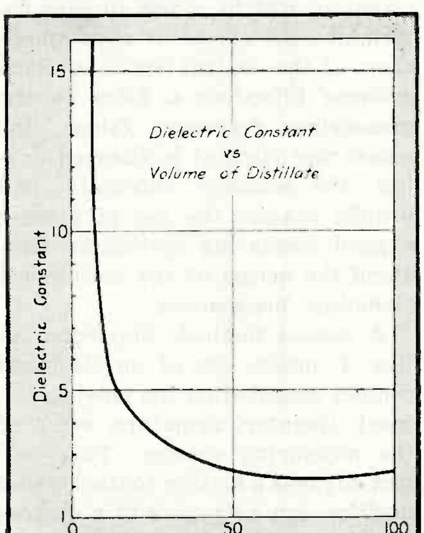

FIG. 6—One industrial application of the dielectric-constant meter is to determine the condition of the charge in a still pot. This curve is for the separation of acetone, toluol, and benzene

Automatic Liquid

In an industrial electronic liquid level control system, capacitance changes produced in an immersion or manometric capacitor cause the plate current of an oscillator to change and operate a relay. A pyrometric control system utilizing inductance changes produced by a meter flag moving between split coils is also described

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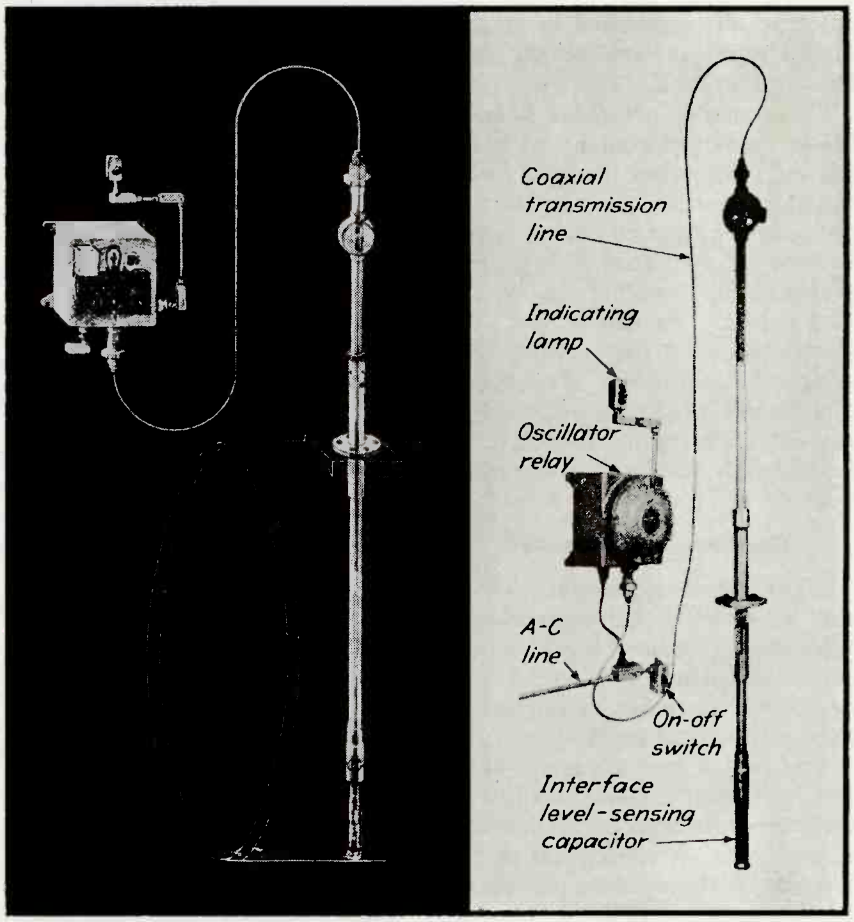
It is axiomatic that before a variable in an industrial process can be controlled automatically, the change in the variable must first be measured. The measuring instruments used for this purpose are generally either direct indicating or null balance types, and incorporate the usual pointer and calibrated scale for indicating the measured quantity. The measurement must then be converted to a control action, by adding a contact system to the pointer or by other means. An all-electronic system has obvious advantages over such electro-mechanical arrangements, but a brief analysis of contact-making systems will be helpful in evaluating possible industrial applications for the all-electronic measuring and control system to be described in detail in this article.



Typical industrial application of oscillator relay system, as installed in a fuel tank to sense the interface level between water at the bottom of the tank and gasoline above the water, and photographic illustration showing component parts of this installation. The oscillator relay here controls a pump that removes the water from the bottom of the tank when it rises above a predetermined level

Types of Contact Systems

Direct electrical contacting control systems as applied to sensitive measuring apparatus have until recently taken two differing general design forms. One method involves incorporation of a motor-driven mechanical detent mechanism in which the position of the indicating pointer is sensed by a mechanical clamping system, which in turn determines the closed or open conditions of the control contacts. Such systems introduce a delay in the measuring response (since the measuring element is clamped during the sensing interval) and usually require the use of a more rugged measuring system to withstand the action of the mechanical clamping mechanism.

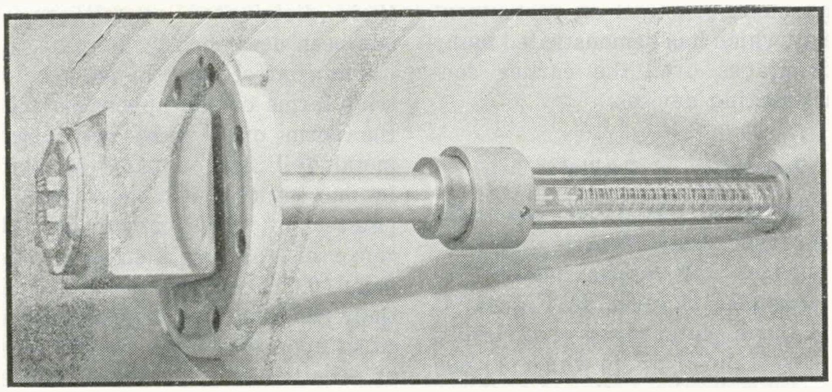
A second method, illustrated in Fig. 1, makes use of an electrical contact mounted on the moving element (pointer, armature, etc.) of the measuring system. This contact engages a mating contact whose position can be preset to a desired position on the scale of the instrument. These contacts in turn are used to close a circuit to a pilot relay which controls the final desired corrective function in the control system.

Drawbacks of Mechanical Systems

Both the mechanical and electrical contact making methods entail drawbacks from the standpoint of design as well as function. The first introduces undesirable delays in the system and requires an enhanced ruggedness in the design of the measuring apparatus. The second method sometimes involves instrument redesign since carrying

From a paper delivered at the National Electronics Conference, Chicago, 1944.

Level Controls



Immersion capacitor designed for use with oscillator relay to sense liquid levels in a high-pressure system. Note the heavy construction and the film-destroying corrugations on the protecting tube

of a contact upon the measuring element usually introduces disturbances to the torque-weight ratio of the instrument. The small forces available in sensitive measuring instruments introduce problems of contact failure due to film formation or contact adherence, and errors in measurement due to electrostatic fields present in the neighborhood of the contact surfaces. These measuring errors can be analyzed further with reference to Fig. 1.

A source of electrical energy in series with a pilot relay and the contact system supplies energy for the relay when an upscale motion of the pointer closes the contact system. By means of its contacts, the relay in turn controls auxiliary apparatus in the control circuit. Two major force disturbances are present in the mechanism, as follows:

(1) The source creates an electrostatic field, and introduces an attractive force between the two separated contact faces when in close proximity. Such force creates a false displacement of the indicating pointer and, therefore, causes a measurement error.

(2) With the contact faces in partial contact but separated by some types of surface films, a large attractive force may be present which acts to delay parting of the contacts as the energy in the measuring system falls, again introducing a measurement error.

Although the above-mentioned forces introduce opposite effects upon the instrument, a resultant force invariably exists to cause measuring error. The extent of these forces may be seen from the following: Let the contact faces represent the boundary conductors of an electrical capacitance having an air dielectric. The energy stored per cubic centimeter of dielectric is $KF^2/8\pi$ ergs where F is the electric field intensity and K is the dielectric constant (approximately 1 for air). If the contact areas are assumed equal and close together, the surface density of charge σ is the same on both surfaces and, by Coulomb's theorem, the intensity between the surfaces at all points is $4\ \pi\ \sigma/K$ dynes.

Now let the surfaces be parted by a small distance, $\delta\ y$, and let P represent the force of attraction, in dynes, between the surfaces. Neglecting the fringe effects, the work done in separating the contacts by this distance is $P\delta y$ ergs. If the area of the contact surfaces be represented by A sq cm, the increase in energy stored due to the increase in dielectric volume will correspond to the work done, or $A\delta yKF^2/8\pi$ ergs, from which $P = AKF^2/8\pi$ dynes. Since $F = V/d$, the force of attraction in dynes may be written in terms of V and d as $P = AKV^2/8\pi d^2$ dynes. If D is the pivot-to-contact distance on the pointer, the disturbing torque T is then equal to PD.

Since the potential V may be several volts the forces acting upon the measuring pointer of a sensitive instrument due to the fields created may become a considerable fraction of the useful measuring torque of the instrument. The usual design torque values in dynes per cm per degree rotation for representative moving-coil instruments with jewel pivots and spiral springs range from 0.09 to 0.3, and the disturbing force can be a considerable fraction of this total available force.

A similar analysis may be made of the second disturbing effect. In this case, it will be noted that the dielectric medium is a film of thickness $d = \delta\ y$. Depending upon atmosphere, contact materials can form upon their faces a semi-conducting film of high dielectric constant, having a possible thickness of the order of a fraction of a millimeter. Inasmuch as the forces present are also a function of the dielectric constant of the film, such forces may reach figures many

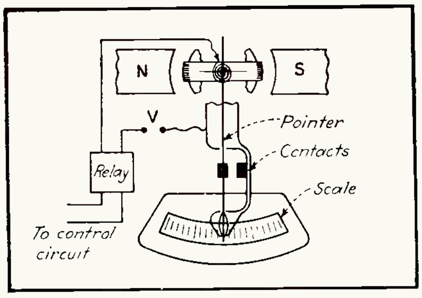


FIG. 1—Basic arrangement of a moving-coil contacting instrument, wherein the meter pointer carries a contact

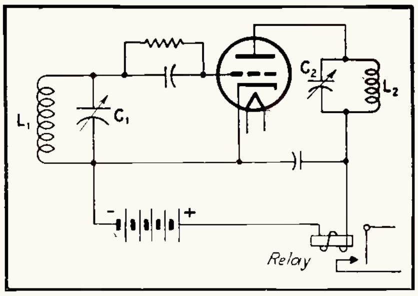


FIG. 2—Tuned grid, tuned plate oscillator circuit used in all types of oscillator relay systems

times in excess of those obtained for the dielectric constants of true insulators. In order to reduce the effect of these forces, many designers have attempted expedients such as reducing the areas of the contacts, reducing the potential V (and therefore requiring an increase in sensitivity of pilot relays), and changing the relative areas of the contact faces with respect to each other or the relative shapes of the contacts. However, these expedients do not eliminate the force disturbances, but only reduce their effect with a resultant required compromise between allowable disturbance error and desired sensitivity.

These problems in the design of sensitive contact-making instruments have resulted in compromises which usually have limited the application of such apparatus.

The advent of the electronic oscillator mechanism as a relay device has made possible a new approach to such design problems, and made practical an instrument relay which has demonstrated many advantages over the earlier contact-making devices.

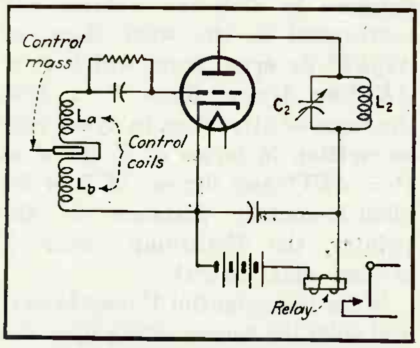
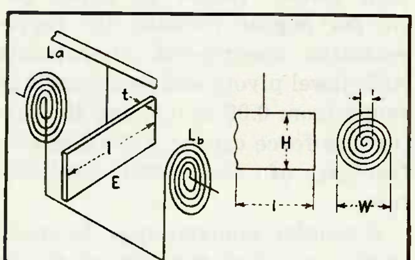


FIG. 3—Oscillator relay circuit in which movement of a non-ferrous metal flag into or out of a pair of coils affects oscillator operation sufficiently to actuate a relay



Flag ind = L_F

$$= 4\pi A\left[\left(1+\frac{r^2}{8a^2}\right)\log_\epsilon \frac{8a}{r} + \frac{r^2}{24a^2} - 175\right]$$

Flag r-f res = $R_F = R_{d\text{-}c}\left[1+\frac{A^2}{12}-\frac{A^4}{180}\right]$

Where $A = \dfrac{2\pi F \mu t H}{10^3\, lS}$

$a = \dfrac{W-ID}{2}$

$r = \dfrac{t}{2}$

F = *frequency, cps*
S = *specific res, ohms per cu cm*
μ = *permeability (10 for aluminum)*
l, H, *and* t = *flag dimensions, cm*

FIG. 4—Two views of the control mass and coils used in the oscillator relay system, with basic equations for inductance and r-f resistance of the moving flag attached to the meter pointer

Description of Oscillator Relay

The basic circuit of the oscillator type relay, functioning at a frequency of approximately 15 megacycles, is given in Fig. 2. It is a tuned plate, tuned grid circuit, due to Kuhn-Huth, in which parallel resonant circuits $L_1 C_1$ and $L_2 C_2$ are placed respectively in the plate and grid circuits. Sustained oscillations are produced through the interelectrode grid-plate capacitance of the tube when the plate and grid tanks are both resonant at approximately the same frequency. Under these conditions, the steady plate current is at some low value based upon the strength of oscillations, and the negative value of bias applied to the grid due to the presence of the grid leak and capacitor.

If one of the resonant circuits is detuned, the strength of oscillations is considerably decreased or halted entirely, with the consequent disappearance of grid bias and rise in plate current. By properly choosing circuit components, applied voltages and tube characteristics, it is possible to produce large changes in plate current with small departures from resonance.

Since either the grid or the plate tank may be deresonated or reresonated by a change of inductance or capacitance in the proper direction, a variety of control methods by change of either inductance or capacitance is available, with consequent control of plate current. By introducing an electromagnetic contact-making relay into the plate circuit, the plate current change may be made to perform a useful function.

Application of Oscillator Relay

The circuit of Fig. 3 permits the inductance L_1 to be rapidly altered by the motion of a metallic control mass attached to the pointer of a sensitive measuring instrument. The modification involves replacing the grid coil of Fig. 2 with the split inductances L_a and L_b. Capacitor C_1 has been eliminated since the inductances are resonated by their distributed capacitance, as has been described by Lorentz.

The control mass in most industrial forms of the apparatus takes the form of a light non-ferrous metal foil flag, usually of aluminum, rigidly attached to the pointer of the instrument. Because of the small sizes of such flags (0.002 × 0.375 × 0.750 inch), their weights have little disturbing effect upon the torque-weight ratios of sensitive measuring equipment. The inductances L_a and L_b are positioned at either side of the axis of motion of the flag in such a manner that the metal flag may pass between these inductances without touching them. The introduction of the metal flag between these inductances reduces their inductance and increases their effective resistance.

The Control Inductance

To obtain large changes in plate current ΔI_p with small changes in pointer position, $\Delta I_p/\Delta\delta y$, it is desirable that the inductance change with flag motion be as large as possible. One method of attaining such a condition is to concentrate the inductance in as small a geometrical volume as possible, consistent with the design of an effective inductance and allowable space considerations. A good form for such inductances is the plane spiral, sometimes termed a pancake coil.

Effect of Flag on Inductance

A rapid decrease in the total inductance and an increase in the effective resistances of the inductances will occur when the metal flag passes between the two coils. The reduction of the effective inductance and increase of resistance depend upon the frequency and the electrical constants of the flag material. The decrease in inductance is due to the fact that the introduction of a non-ferrous metal body into the alternating field of the inductance causes an induced alternating current flow within the metal body. These currents set up a field opposing the inductor

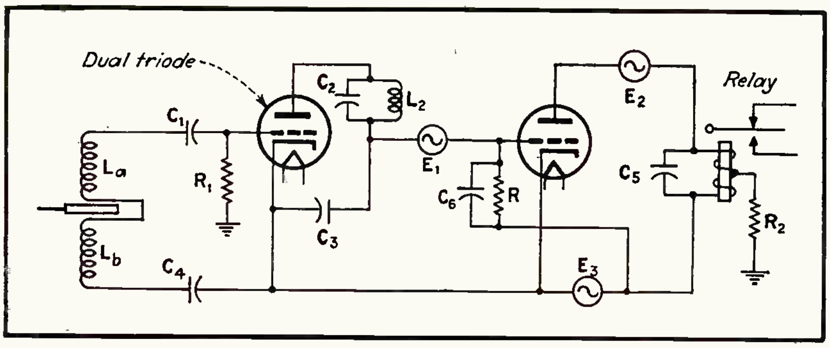


FIG. 5—Oscillator relay circuit arranged for operation from a power transformer energized by the a-c power line and having three separate secondary windings providing a-c voltages E_1, E_2, and E_3

field, with a consequent change in effective coil inductance and a resultant decrease in inductance.

If L_a and L_b are control inductances, the total inductance $L_t = L_a + L_b + 2M$, where M = mutual inductance. Consider the flag as a short-circuited single-turn secondary of a transformer operating at a frequency of 15 megacycles. If I is the current in the coils at a frequency $\omega/2\pi$, and the induced emf in the flag is $E_F = \omega M_0 I$, the induced flag current is $I_F = E_F/Z_F = \omega M_0 I/Z_F$. Since I_F lags E_F by the phase angle θ, the reactive component of flag current I_F is $I_F \sin\theta$ and is 180° behind I. The voltage induced in the coils due to $I_F \sin\theta$ is $E_{L(R)} = (\omega M_0)\ I \sin\theta = \omega L_F\ (\omega M_0/|Z_F|)^2$, and the total reactive voltage in the coils is $[\omega L_t - \omega L_F (\omega M_0/|Z_F|)^2]I$. The inductance change with flag entry is $\Delta L_t = -L_F(\omega M_0/|Z_F|)^2$, with L_F being as defined in Fig. 4.

The energy involved in the circulation of the induced eddy currents must be drawn from the inductor field and, therefore, an apparent increase in the effective resistance of the inductor is obtained. The induced current I_F lags E_F by the angle θ, and $\tan\theta = \omega L_F/R_F$. The active component of I_F is in phase with E_F, and so $I_F \cos\theta = (\omega M_0)\ IR_F/|Z_F|^2$. The voltage induced in the coils by $I_F \cos\theta$ is $I_F\ (\cos\theta)\ (\omega M_0)I$ and $E_L(A) = IR_F\ (\omega M_0/|Z_F|)^2$. Since $E_{L(A)}$ lags I by 180°, it can be considered resistive voltage drop and $I(\omega M_0/|Z_F|^2$ represents ΔR_L, the increase in the high-frequency resistance of the coils.

Both the decrease in inductance and increase in effective resistance introduce control effects upon the oscillator in the direction required for obtaining large changes in the plate current, because the inductance change de-resonates the system and the increase in resistance reduces resonant energy.

Possible Disturbing Forces

The flow of high-frequency alternating current through inductances L_a and L_b gives rise to both an electromagnetic and electrostatic field in their vicinity. Since both these fields are a function of the current and potential in these inductances it is conceivable that some disturbing forces might be present to act upon the control flag and the instrument pointer to which it is attached. The introduction of a conductive non-ferrous metal flag into the magnetic field of the total inductance L_t involves a repulsion phenomena due to eddy current induction in the metal flag, while induced electrostatic charges on the flag due to the electrostatic field may introduce some attractive force. However, the energy levels are exceedingly minute and such disturbing effects are negligible. However, minute as these forces may be, it may be of some interest to mention the reason for their presence.

Electromagnetic Repulsion Effect

If a non-ferrous metal ring or disc is present in an alternating magnetic field and is in such position with respect to the field that the lines of force pass through the disc, an alternating potential will be set up in the disc which is 90 degrees in phase displacement from the magnetic flux. This potential in turn causes a current flow in the material which sets up a reactive field which exerts a force tending to move the material in the magnetic field. Such a force is proportional in magnitude and direction to the product of the corresponding instantaneous values of current and flux. The force for any period is equal to the average of the instantaneous forces during the period. If the disc has no self-inductance, the current would be in quadrature with the inducing flux and the average forces during alternate quarter periods would be equal but in opposite directions; thus the average force during the whole period would be zero and, therefore, the disc would have no tendency to move in the field.

However, in actuality even a flat metal sheet has some inductance, and the induced current would therefore lag behind the induced voltage. The current phase, therefore, would be more than 90 deg behind the magnetic phase, and a summation of instantaneous forces during a half period would reveal a larger average force than the instantaneous force summation, having a finite negative value in the alternate period. The result is a small repulsive component between the two fields.

Thus, if the flag is threaded by flux $MI_0 \sin\omega t$ due to current $I_0 \sin\omega t$ in the coils, the induced emf in the flag is $E_F = M\omega I_0 \sin(\omega t -$

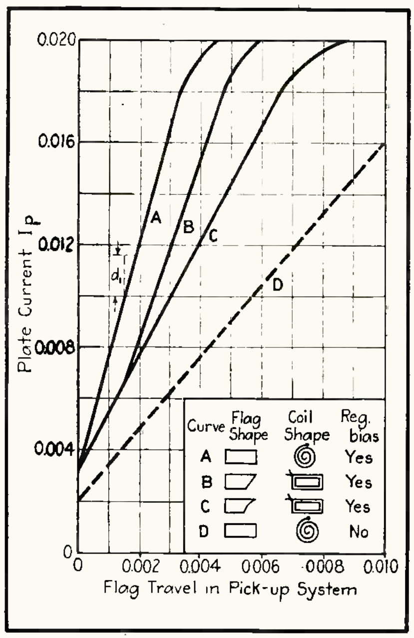


FIG. 6—Effect of flag travel, flag shape and use of regeneration on plate current of an oscillator relay system

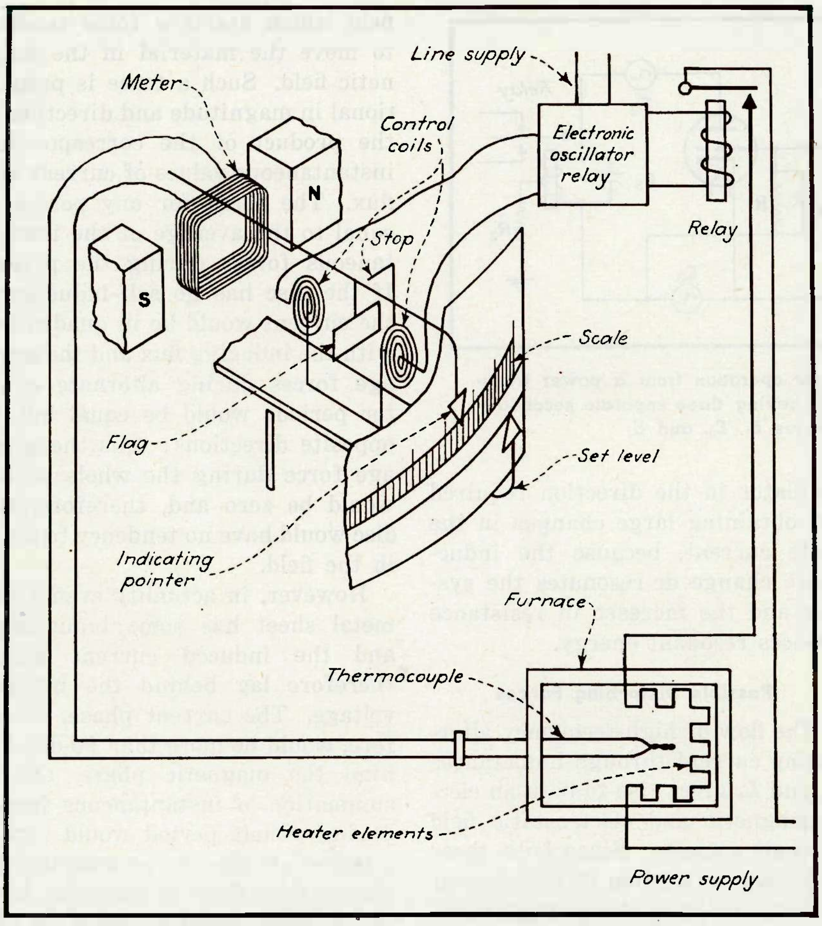


FIG. 7—Schematic diagram showing arrangement of basic elements of an oscillator relay system, with connections to a pyromatic control system shown as a typical application

$\pi/2$). Now E_F lags I_0 by 90 deg and, if flag inductance L_F is neglected, the flag current I_F and flag emf E_F will be in phase, and $I_F \propto M\omega I_0 \sin(\omega t - \pi/2)$. The force between the two currents will then be proportional to the product $I_0 I_F$. Therefore, the force $\propto M\omega I_0^2 \sin \omega t \sin(\omega t - \pi/2)$. It will be seen that the mean of quantity $\sin \omega t \,(\sin \omega t - \pi/2)$ is zero where harmonic components differ in phase by 90 deg. Therefore, if $L_F = 0$ the mean force $= 0$. However, L_F, although small, can never reach zero, and I_F lags behind I_0 by more than 90 deg. Under these conditions, force $\propto M\omega I_0^2 \sin \omega t \sin(\omega t - \pi/2 - \theta)$ and $\propto$

$$[M\omega I_0^2 \sin^2 \omega t \cos(\pi/2 + \theta)] - \left[\frac{M\omega I_0^2}{2} \sin 2\,\omega t \sin(\pi/2 + \theta)\right]$$

The mean value of the last term is zero, while the mean value of the first term $= \frac{1}{2} M\omega I_F \cos(\pi/2 + \theta)$. Since the computed value of $\cos(\pi/2 + \theta)$ is negative when θ is small, the force upon flag is repulsive, the flag experiencing a repulsive impulse once for each cycle.

Because the energy present in the inductance is minute, the repulsive forces are negligible. The small disturbing force possibly remaining acts perpendicular to the plane of the flag and is hence ineffectual.

Because it is not possible to have the existence of an electro-magnetic field without the presence of an electrostatic field, the introduction of a metal flag into the field of the inductors may cause the formation of induced electrostatic charges on the flag surfaces. Such charges, if different in sign from charges present upon the plane faces of the inductances, may introduce slight attractive forces. By insuring that the metal flag surface is at the same potential level as the inductance surface by an appropriate leakage resistor network and proper grounding, the slight effect of such induced electrostatic charges is eliminated.

Force measurements on delicately balanced instruments, involving both the repulsion forces present due to the high-frequency electromagnetic fields and the slight forces due to electrostatic charges, have been measured in a number of cases. The results obtained indicate that such apparatus may be used in conjunction with measuring equipment whose torques are in the order of 0.03 dyne per cm per degree without introducing detrimental disturbing forces.

Industrial Version of Circuit

For industrial use the oscillator relay circuit has been rearranged as shown in Fig. 5, for operation directly from an a-c power line. The split inductance L_a-L_b and the plate tank circuit L_2-C_2 are the same as in Fig. 3, but energy for the plate circuit of the oscillator is now supplied by a secondary winding of a transformer serving as source E_1.

When the oscillator has been resonated, oscillation will occur due to the coupling inherent in the in-

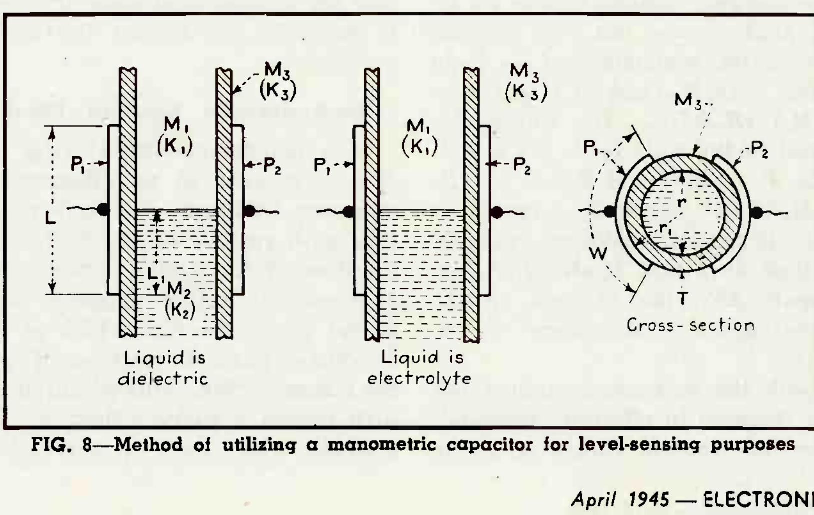


FIG. 8—Method of utilizing a manometric capacitor for level-sensing purposes

TABLE 1. DIELECTRIC CONSTANTS OF MATERIALS

MATERIAL	DIELECTRIC CONSTANT K	MATERIAL	DIELECTRIC CONSTANT K
ASPHALT	2.68	AIR	1.000590
EBONITE	2.72	ACETIC ACID	9.7
GLASS, FLINT	9.90	ALCOHOL AMYL	17.4
MARBLE, CARRARA	8.3	ALCOHOL ETHYL	44.3
MICA	5.66	CARBON BISULPHIDE	2.626
PARAFFIN	2.10	GLYCERINE	56.2
PORCELAIN, HARD	5.73	CASTOR OIL	4.67
QUARTZ	4.69	OLIVE OIL	3.11
SHELLAC	3.10	PHENOL	9.68
SULPHUR, AMORPHOUS	3.98	WATER	81.07

ter-electrode capacitance between grid and plate during every positive swing of the a-c supply of the plate circuit. Capacitor C_3 bypasses r-f energy around load and source E_1. The steady plate current condition due to the grid bias produced by grid resistor R_1 flows through oscillator plate coupling resistor R. Since the steady plate current component in the oscillator plate circuit can never reach zero, no matter what the intensity of oscillation, a compensating bias is supplied at E_3 to offset the normal drop across load resistor R due to oscillator minimum plate current at resonance.

The effective bias attained on the grid of the amplifier stage is, therefore, the algebraic sum of E_3 and E_R. During the time that the plate potentials are in the positive portions of the applied a-c cycle, the effective bias on the grid of the amplifier section is approximately zero, with a consequent high average plate current in the second stage. This plate current maintains the relay in a preset contact position. Capacitor C_5 across the relay furnishes energy to the relay during the negative portion of the a-c cycle, and thus prevents chatter.

From the standpoint of design simplicity, the introduction of the direct-coupled amplifier stage results in greatly increased overall sensitivity with the obvious advantage of attaining reasonably large plate current levels for the operation of a high-wattage relay mechanism. For convenience, a dual triode is used for the oscillator and amplifier.

The bias return for the oscillator grid circuit is taken through bias resistor R_2 from a tap on the relay. The effect of the introduction of such regeneration is to cause large changes in bias on the oscillator due to plate current changes through the relay, and since the direction of bias change is that required to augment the trend of amplifier plate current change, small changes in flag position initiate large changes in plate current.

The effect of flag travel on plate current is shown in Fig. 6 for a rectangular-shaped flag used with regenerative bias (curve A) and with fixed bias (curve D) obtained by connecting the bias resistor to the cathode. Within limits, the contour of these curves may be modified by properly shaping the flag areas and by changing the geometry of the control inductances L_a and L_b; curves B and C are examples.

By making use of a steep characteristic such as curve A, with a relay having a small operating current differential, and properly positioning such a relay characteristic on curve A, such as at d_1, an extremely small flag motion will change the contact condition. In fact, oscillator relay mechanisms of this type are possible in which changes of flag position of the order of 0.0001 inch cause a change in plate current from cut-off to maximum.

Relay Operation

The relay characteristic (operating differential) is customarily chosen to permit operation to take place at approximately the midpoint of the plate current characteristic. This insures long-term functioning despite changes in tube life. Ageing of the tube and reduction in emission lowers the maximum plate current and causes a small upward creepage of minimum plate current. Furthermore, choosing midpoint operation permits relay operation on a relatively linear portion of the plate current characteristic. This type of operation is of greater significance where the oscillator mechanism is to be used for a positioning function.

The change in plate current may be positive or negative with flag motion, depending upon the positioning of plate tank capacitor C_2 in Fig. 5. By resonating the oscillator with the flag all the way out of the coils, a high plate current is obtained in the amplifier plate circuit. Upon entry of flag into the coils, the oscillator is de-resonated and plate current through the relay drops.

In some cases, a reversal of this operation is desirable. This may be

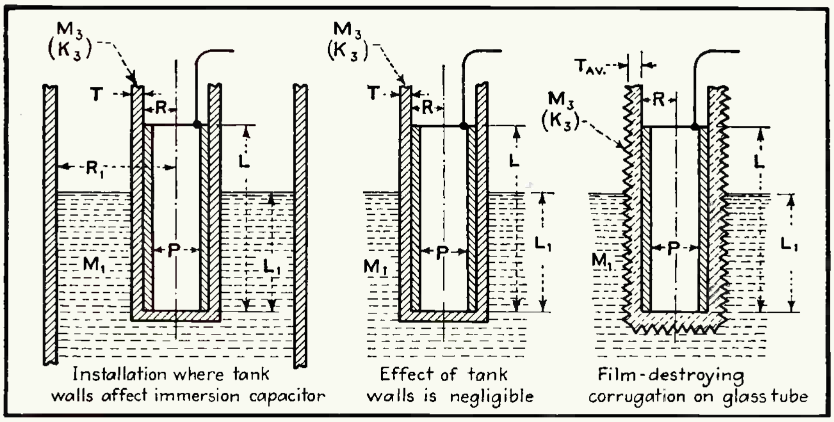


FIG. 9—Use of immersion capacitor for level-sensing applications

obtained by adjusting capacitor C_2 so the oscillator is de-resonated and plate current in the amplifier stage is positioned on the lower edge of the resonance curve skirt (proper side) with the flag removed from coils L_a-L_b. Upon flag entry into the coils, the oscillator is resonated by the inductance change and plate current through the relay rises.

Thus, in the former case relay current falls with flag motion into the coils, while in the latter case relay current rises with flag motion into the coils.

Fail-Safe and Stability Features

The former method is the one commonly preferred where the apparatus is supplied for automatic control function, since a failure of line supply leaves the contact system of the relay in open condition and thus leaves the controlled apparatus in de-energized condition. The stability of circuits of this type is unusually good since they are to a great extent self-damping from the standpoint of spurious oscillations, and are also to a certain extent self-compensating for line voltage changes.

As an example, consider an increase in line voltage to the transformer supplying the voltages E_1, E_2, and E_3. Normally, one would expect the increase in line voltage to increase the plate currents in the tube plate circuits. However, an increase in plate current in the first stage increases the negative bias of the amplifier stage, with a resultant counteracting effect upon the tendency to an increase in plate current in the second stage. The self-compensation in these circuits is usually in the order of 10 percent in plate current change for the usual line voltage extremes met with in practice. With some sacrifice in sensitivity, the compensation effect may be improved to approximately 6 percent. Where extremely good regulation is required (in the order of 2 percent), a simple regulating system may be added to the circuit.

Industrial Version

A partly exploded view of an industrial oscillator relay instrument is shown in Fig. 7. The pointer carries the control flag, and the control

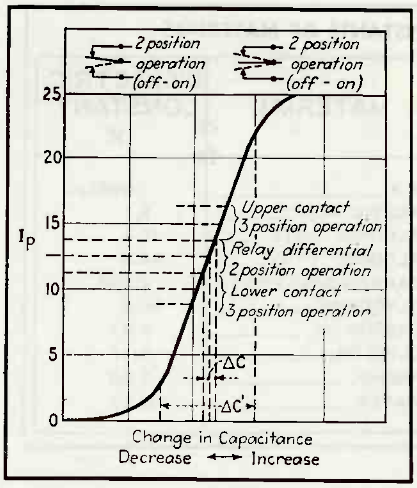


FIG. 10—Typical tuning curve for oscillator relay

coils are mounted on a lever which may be manually set to any desired scale position. A level-indicating pointer shows the coil position at which contacting is to occur. A pointer stop mounted on the setting lever prevents the pointer from moving too far beyond the setting level, as this would allow the flag to pass completely through the field of the control coils and destroy normal functions of the control mechanism. Flexible leads bring energy to the control coils from the oscillator system.

The apparatus of Fig. 7 is shown adapted to a pyrometric control system in which the electrical measuring instrument is a millivoltmeter energized from a thermocouple heated in the furnace. The heater elements of the furnace are energized through the relay contacts.

Although one of the major industrial uses of the oscillator relay mechanism just described is as an instrument relay in applications ranging from automatic control pyrometers to galvanometer torque amplifiers, there is another major class of applications. In this class, the mechanism senses a condition change in a process directly, rather than through the intermediary means of a measuring instrument. An example of such is its use as a materials level sensing mechanism.

Materials Level Sensing

In many industries the sensing of materials level in storage tanks is an important problem. These tanks may be a portion of a reserve storage system such as is common in petroleum fields, or may be a portion of a complete processing plant in which the levels vary constantly as the product is added or subtracted from the process. The types of materials encountered in modern industry range from hydrous and anhydrous mixtures and compounds to highly corrosive fluids such as acids and alkalis.

The most frequent and simplest mechanism met with in these problems is a float which is introduced into the storage container, and whose position is a function of the materials level. Since the float position must in turn be translated to a useful result exterior to the storage container, a translating mechanism is included which in some cases takes the form of a mechanical transmitter (shaft and stuffing box, or diaphragm seal) or a pneumatic or hydraulic transmission system (flapper valve or pilot relay). These intermediary mechanisms in turn control the position of a remotely situated valve or an indicating or recording mechanism, as dictated by the problem requirement.

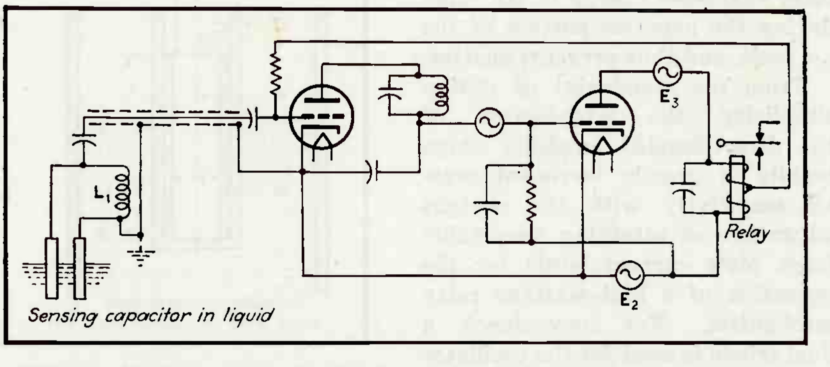


FIG. 11—Oscillator relay circuit adapted for liquid-level sensing operation

Unfortunately, the wide range of materials conditions to which these float-type devices are applied, complicated with such factors as chemical attack, mechanical erosion and friction, high temperature and high pressure conditions, have made these mechanisms prone to a variety of service failures, unless they are constructed with such care and attention to detail in view of the conditions to which they are exposed, as to make their cost and upkeep disproportionately high.

Materials usually stored in a liquid or solid state may have electrical conducting, semi-conducting or electrical insulating properties. That is, they may be termed electrolytes, dielectrics, or partials. These materials, therefore, may be used to vary the capacitance of an electrical capacitor by allowing them to become a portion of the capacitor structure.

Capacitance Considerations

The capacitance of a simple air dielectric capacitor having two parallel metal plates is directly proportional to the dielectric constant. Thus, $C_0 = AK/4\pi D$ esu, where K is the dielectric constant (approx. 1 for air), A is the area of a plate in sq cm and D is the distance between inner surfaces in cm. (1 esu = 1.11 $\mu\mu$f.)

If we replace the air dielectric by a new dielectric medium having a higher value of K, the capacitance will be increased. Obviously, such a capacitance method is only acceptable where the new medium is a true dielectric. If the new material is a good conductor (electrolyte) no charge could be present in the capacitor. However, we may insulate the plates with a dielectric film, whereupon if fringe effects are neglected the capacitance in esu is given by $C_1 = AK_1/4\pi(D_1 + D_2)$, where K_1 = dielectric constant of films (values for some common liquids are given in Table I), and $D_1 = D_2$ = thickness of films in cm (uniform).

If the new electrolyte medium is allowed to rise between the capacitor plates to some distance L, the capacitance increase becomes approximately a measure of the height of the medium between the plates.

The level-sensing capacitors usually take either of two design forms. One form consists of a pair of partial cylindrical metal segments clamped geometrically around the circumference of a manometer column of glass or plastic tubing, where liquid level is taken by manometric means.

The second form consists of a capacitor element within a non-metallic protecting tube, mechanically designed for immersion in storage containers under high pressure and/or temperature.

The manometric capacitor, various forms of which are illustrated in Fig. 8, functions under two conditions: (1) The medium in the manometer is a dielectric; (2) The medium is an electrolyte.

If the liquid is a dielectric, the empty capacitance in esu is

$$C_0 = \frac{WL\left(1 + \frac{[2r_1 - (r_1 + r_1\pi/6)]^2}{3\,(r_1 + r_1\pi/6)^2}\right)}{4\pi\left[2\,\frac{(r_1 + r_1/6) - (r + r\pi/6)}{K_3}\right] + \left[\frac{r + r\pi/6}{K_1}\right]}$$

where L = length of plates, cm
W = width of plates, cm ($2\pi R_1/3$ at manometer surface)
K_1 = dielectric constant of M_1 (medium in empty column, usually air)
K_2 = dielectric constant of M_2 (liquid medium)
K_3 = dielectric constant of M_3 (about 6 for glass)
r = inner radius of manometer column, cm
r_1 = outer radius of manometer column, cm

With the column filled (plates topped), K_1 increases to K_2 and C_0 becomes C_1.

If the liquid is an electrolyte (conductor) the empty capacitance will be the same as above, while with the column filled the capacitance in esu will be $C_1 = WLK_3/4\pi[2(r_1 - r)]$. Upon recession, many electrolytes with high surface tension may leave a conducting film on the interior surface of the column and this may disturb the capacitance measurement. The use of a nonionic agent on the interior surface of the column prevents wetting and film formation.

In all the above cases we may consider the capacitance to vary between C_0 and C_1, and neglecting edge fringing field effect, the capacitance variation between the limits C_0 and C_1 will be a function of L_1, the height of the liquid between the plates.

In the level-sensing capacitors of Fig. 9, the conditions of functioning are again two-fold; i.e., the media may be either dielectric or electrolyte.

The Immersion Capacitor

In both immersion units, the capacitance change again takes place between the limits C_0 and C_1, while the capacitance is again a function of L_1, the height of the liquid in the area of the sensing plate.

When immersion capacitors are used with electrolytes, recession of liquid sometimes leaves a conducting film on the surface of the protecting tube. Such a film can disturb the capacitance measurement. By corrugating the outer surface of this tube as shown at the right in Fig. 9, such films are broken up as the liquid recedes. The change in capacitance is still a function of the height of liquid in the area of the sensing plate.

Capacitance-Measuring Relay

The oscillator relay mechanism is ideally suited for sensing the change in capacitance of the level-sensing capacitors in a liquid or

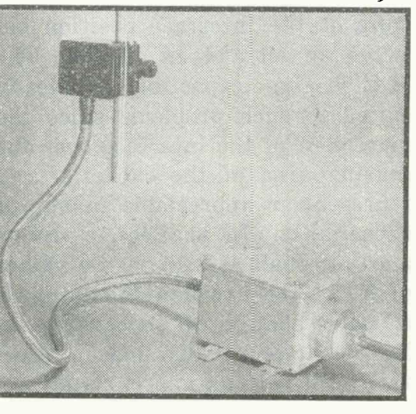


Fig. 12—Industrial manometric capacitor clamped on manometer tube (upper left) and junction box for connecting flexible to semi-flexible coaxial transmission line

materials level control system. The oscillator relay may be either deresonated or reresonated by the change in capacitance produced by a change in level. The overall sensitivity to capacitance change is the ratio of the plate current change to the capacitance change.

In Fig. 10 is illustrated a typical tuning curve of an oscillator relay, in which ΔC represents the critical capacitance change of a level-sensing capacitor with media of low dielectric constant. By proper design of the sensing capacitors, the ratio $\Delta I_p/\Delta C$ may be made a constant for liquids of widely varying dielectric and conductive properties. Conversely, $\Delta C/\Delta L_1$ becomes a constant for media of widely varying properties.

Liquid Interface Sensing

An interesting application of capacitive level-sensing systems is the sensing of the position of the interface boundary between two liquid media of differing density and differing dielectric and conductive properties. There are four conditions of interest to be considered:

- Denser liquid (bottom) is an electrolyte; Lighter liquid (top) is a dielectric
- Denser liquid (bottom) is a dielectric; Lighter liquid (top) is an electrolyte
- Denser liquid (bottom) is a high-K dielectric; Lighter liquid (top) is a low-K dielectric
- Denser liquid (bottom) is a low-K dielectric; Lighter liquid (top) is a high-K dielectric

Typical of such problems is sensing the interface between gasoline and water in underground reservoirs or the interface position between an oil and an alcohol. The level-sensing capacitor is ideally suited to such problems since the movement of the interface over the sensing area of the capacitor can represent an appreciable change of capacitance. In practice, a difference as small as 1.15 in the values of K for the two liquids can cause a usable change ΔC in capacitance for a change of 0.010 inch in interface level with an appropriately designed sensing unit.

When one of the liquids is an electrolyte, much greater dependable sensitivities may be attained. The proper portion of the tuning curve must be chosen, for an electrolyte at the top will give a negative change in capacitance with interface rise in an immersion capacitor, while an electrolyte at the bottom gives a positive change in capacitance with interface rise.

Oscillator Circuit for Liquid-Level Operation

The oscillator relay circuit is adapted for level-sensing applications by making the level-sensing capacitor serve as the grid resonating capacitance, as shown in Fig. 11. Circuit operation is the same as before, except that the capacitance change ΔC resonates or deresonates the oscillator.

In many applications of the apparatus it is undesirable to mount the oscillator relay mechanism in close proximity to the liquid level sensing device, and it becomes necessary to provide some convenient means whereby the energy from the oscillator may be led to the sensing capacitor system without excessive loss. The use of a coaxial transmission line is ideally suited for the purpose, inasmuch as it presents fixed conditions of linear capacitance, inductance and impedance while providing satisfactory mechanical strength. A metal-clad transmission line constructed of heavy tubing, with low-loss, high-strength bead insulation and fairly large gauge internal conductors, has been very satisfactory.

Remote Control Operation

In these liquid level sensing devices the level-sensing capacitor assembly includes a terminating inductance L_1 and coupling capacitance C_1 placed at one end of the transmission line, while the other end of the transmission connects to the oscillator apparatus. Transmission lines up to 200 feet in length are entirely feasible and such lengths pretty well fulfill all usual industrial requirements.

Because of the very low radio-frequency energies present in a level-sensing capacitor serving as a portion of the grid resonant section of the oscillator, fracture of the protecting tube does not expose inflammable or explosive vapors to possibilities of ignition by sparking.

Accuracy is High

The narrow field of influence of these sensing devices make possible sharply defined sensing levels. However, there are some cases where large changes in line supply cause small shifts in the sensing level due to small changes in relay operating level. Voltage-regulating systems, previously mentioned, minimize such effects.

Where multi-contacting operation is required, as in some throttling applications, compound relays having diverse operating levels can be used by properly positioning their operating levels on the resonance curve, as shown in Fig. 10.

Industrial Version

In Fig. 12 is shown one form of industrial manometric capacitor clamped around a manometer leg. The sensing plates are within a sealed housing, and are insulated from the effects of moisture and dirt on the outer surface of the manometer. The transmission line is partly flexible to allow a reasonable range of clamping position. The junction box allows changeover from flexible to semi-rigid transmission line going to the remotely located oscillator relay.

Oscillator relay mechanisms are readily applied to more complex systems and to a wide variety of level-sensing applications. Such oscillator devices are the heart of a host of apparatus designs such as position-translating mechanisms, proportional devices, telemeters, torque amplifiers, and many others.

Bibliography

(1) Esnault-Pelterie. On the Coefficient of Self Inductance, *Comptes Rendus*, Tome 205, No. 18, 1937.

(2) Levy, S., Electro Magnetic Shielding Effect of an Infinite Plane Conducting Sheet Between Coaxial Coils, *Proc. I. R. E.*, 24.

(3) Kirkpatrick, C. B., Magnetic Induction Field of Air Core Coils, *Wireless Engineer*, Aug. 1943.

(4) Burch, C. R., "Theory of Eddy Current Induction," Ernest Benn Ltd., London, Eng.

(5) Pender, H., and Warren, S., "Electric Circuits and Fields," McGraw-Hill Book Co., New York City.

(6) Morecroft, J. H., "Principles of Radio Communication," John Wiley & Sons, New York City.

(7) Hund, A., "Phenomena in High Frequency Systems," McGraw-Hill Book Co., New York City.

(8) Eccles, W., "Wireless Telegraphy & Telephony," Benn Bros. Ltd., London.

(9) Nottage, W., "The Calculation and Measurement of Inductance and Capacity," Iliffe & Sons Ltd., London.

(10) Thompson, E., Novel Phenomena of Alternating Currents, *Transactions A. I. E. E.* 4.

(11) Moullin, E., "Theory & Practice Radio Frequency Measurements," Charles Griffin & Co. Ltd., London, Eng.

(12) Gray, A., Absolute Measurements In Electricity and Magnetism, Sir Isaac Pitman & Sons Ltd., London, Eng.

(13) Page, L., "Principles of Electricity," Van Nostrand Co., New York City.

(14) Scott, K. L., "Variation of Coil Inductance Due to Eddy Current Effect," Technical Monograph, Bell Telephone System.

(15) McLean, D., "Measurement of Wetting of Dielectrics," Technical Monograph, Bell Telephone System.

(16) Schelkunoff, S., Equivalence Theorems In Electro Magnetics, *Bell System Technical Journal*, XV, Jan. 1936.

Receiver With 2 Mc I-F

Complete circuit of five-tube receiver for high-quality local reception. Use of high i-f value gives coverage of 100 to 1750 kc in a single range by tuning only the local oscillator. Applications in f-m and communication receivers are also covered

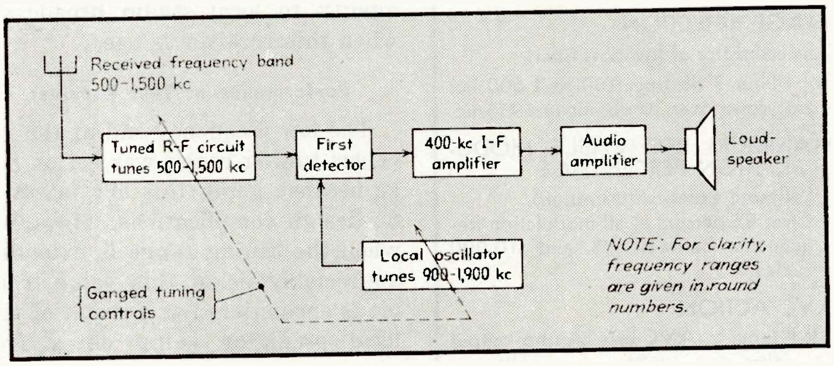


FIG. 1—Block diagram of conventional broadcast receiver, which requires ganged controls for tuning the r-f input circuit and the local oscillator

By **HARVEY KEES**

Electronics Research, Inc. Evansville, Indiana

EARLY DESIGNERS of superheterodyne receivers used comparatively low-frequency i-f amplifiers, apparently to obtain satisfactory gain and selectivity. However, new design techniques and modern tubes make it possible to obtain satisfactory gain and selectivity even where relatively high intermediate frequencies are used, and thereby take advantage of other useful features.

A Conventional Receiver

In Fig. 1 is a block diagram of a superheterodyne broadcast band receiver of the simplest conventional design. The salient features of this set are (1) the 400-kc i-f amplifier, (2) the necessity of tuning the r-f circuit between the antenna and first detector over a three-to-one (500 to 1500 kc) frequency range and ganging the tuning control for this circuit with that for the oscillator which covers a greater than two-to-one (900 to 1900 kc) range, and (3) the relatively poor suppression of image responses from signals in the range of 1300 to 2700 kc. The main purpose of the t-r-f circuit ahead of the first detector is the elimination of such images.

Use of High I-F Value

A block diagram of a simple five-tube broadcast and longwave receiver using a high-frequency i-f amplifier is shown in Fig. 2. The use of the 2000-kc i-f amplifier makes it necessary to tune only the local oscillator in this receiver, and that over a range considerably less than two-to-one (2100 to 3500 kc) for a receiving range of fifteen-to-one. Signals which cause image responses in this receiver lie in the range of 4100 to 5500 kc, and are easily eliminated by the low-pass filter between the antenna and first detector. No variable tuning control is required for the low-pass filter.

As might be expected, the receiver of Fig. 2 has some limitations. Since all signals in its tuning range appear on the control grid of the first detector tube, spurious responses result from beats between, and harmonics of, strong signals. This means that weak signals cannot always be received in the presence of strong signals—which amounts to saying that the maximum length of receiving antenna that may be used is limited by that value which will cause the strongest signal in the tuning range of the set to overload the first detector.

Circuit of Experimental Receiver

A simple five-tube receiver of the type outlined in Fig. 2 was constructed and tested. A block diagram of this working version is

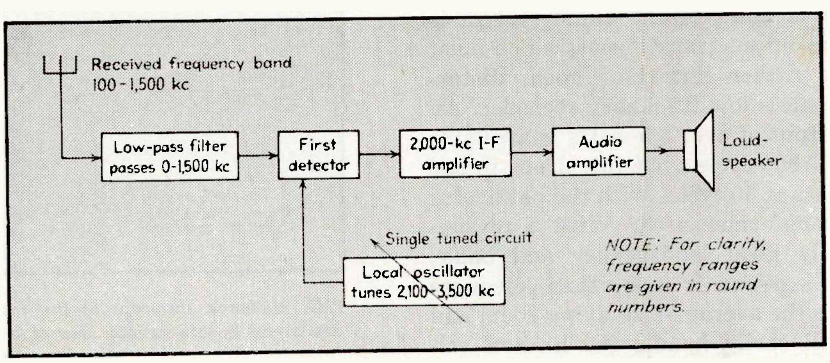


FIG. 2—Block diagram showing essential features of a broadcast and long-wave receiver having a 2-megacycle i-f amplifier

shown in Fig. 3, and the schematic diagram appears in Fig. 4. This receiver was designed primarily to give high-fidelity reception of local broadcast stations in the metropolitan area of Boston, Massachusetts, and has a number of interesting features.

A type 6SA7 tube is used as first detector and local oscillator. The 6SA7 was chosen after experimental trials of a number of converter tubes and found to be the best for this type of set, as far as ability to handle a wide range of signal strengths without spurious responses is concerned. A three-section low-pass filter is used between the antenna and 6SA7 control grid, giving an image rejection of well over 30 db.

The i-f amplifier has a center frequency of 2000 kc and is down 3 db at about 10 kc off resonance. This bandwidth is about the minimum necessary for reasonably high-fidelity reception. Only one i-f amplifier stage is used, employing a 6SG7 pentode. The i-f transformers are modified standard 1500-kc iron-core units, the coil inductances being reduced and mutual coupling increased.

A type 6SN7 double-triode tube serves as diode detector and first audio amplifier; one section has its plate and grid tied together to act as a diode. The 6SN7 affords a means of obtaining a diode and triode with separate cathode connections in one envelope.

The audio system uses the 6SN7 triode section to drive the 6V6 final amplifier stage. The cathode of the 6SN7 is grounded through the secondary winding of the output transformer, providing enough inverse feedback to reduce the gain of the system by a factor of three. The weak point of the audio system is the output transformer, which must be rather large for good, distortionless low-frequency response. An output of over 3.5 watts is available at 1000 cycles, but this drops to one watt at 50 cycles with the particular transformer used. With a reasonably good loudspeaker and baffle, this power is more than adequate for the average-size living room and will easily handle the limited volume range transmitted by most broadcast stations. The frequency response of the audio system is flat within 3 db from 25 to 20,000 cycles.

TABLE I. PERFORMANCE OF RECEIVER USING 2-Mc I-F AMPLIFIER

AUDIO-FREQUENCY RESPONSE

Overall: Flat within 3 db, 25 to 7,500 cycles.

Audio System Only: Flat within 3 db, 25 to 20,000 cycles.

SELECTIVITY

Down 6 db at 15 kc off resonance
Down 20 db at 20 kc off resonance
Down 40 db at 40 kc off resonance

IMAGE REJECTION

(Characteristics of low-pass filter)

Flat within 3 db from 100 to 1,600 kc, and down over 30 db above 1975 kc.

MAXIMUM RECEIVABLE MODULATION PERCENTAGE

(Without excessive distortion).

Over 85 percent at all modulation frequencies between 25 and 10,000 cycles.

AVC ACTION

R-F input volts	AVC bias volts	Audio output volts
2.0	10.5	1.00
1.0	8.5	0.85
0.1	5.5	0.55
0.01	3.5	0.30
0.005	2.4	0.28

Another interesting feature of the receiver is the balance between avc action and audio gain. The gain of the audio system is so low that the power output capabilities of the 6V6 stage cannot be exceeded. That is, the r-f stages of the receiver overload before the audio system distorts.

Listening tests at a location in a residential section of Boston indicate that the set is fully capable of serving the purpose for which it was designed, that of a high-quality local receiver. In fact, the receiver is almost too good as far as tone is concerned; network and recorded programs are easily recognized as being inferior in tonal quality to local studio broadcasts when this receiver is used.

Performance of Test Receiver

The low-frequency end of the receiver tuning range was set at 100 kc because going this low involved no design complications. However, when the tuning range is extended appreciably below this value trouble is encountered as a result of the local oscillator being on a frequency near that of the i-f amplifier. The wide single-band tuning range of 100 to 1750 kc involves no great tuning problems, even without a vernier dial.

The usefulness of the receiver is limited by the strongest signal in the received band. That is, there appears to be a critical maximum amount of signal voltage that may be applied to the control grid of the 6SA7 first detector, and when this value is exceeded a heterodyning squeal appears in the background on all signals. This squeal disappears completely when the input signal is reduced below the critical

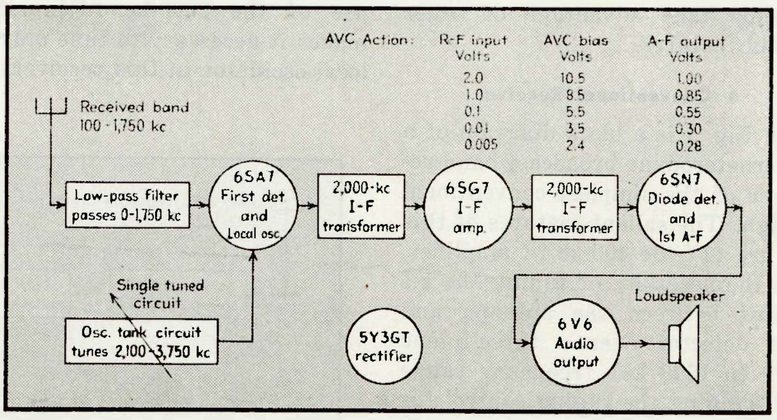


FIG. 3—Block diagram of the test receiver for which constructional details are given in this article. Use of a 2000-kc i-f value permits high-quality local reception with only five tubes

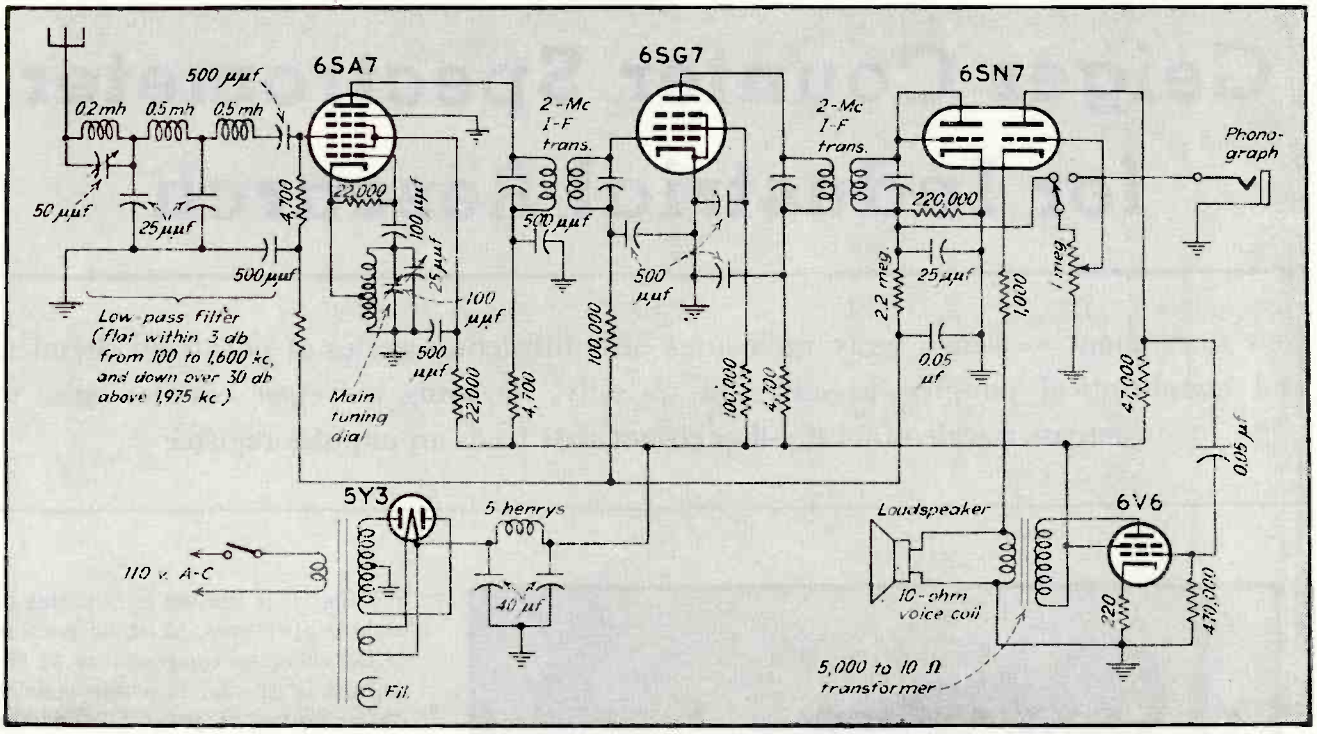


FIG. 4—Schematic circuit diagram of test receiver using 2000-kc intermediate frequency amplifier, with values of all component parts

value. Thus, the range of signal strengths that may be received is somewhat limited, and the length of antenna that may be used with the set is not sufficient to permit reception of weak, distant signals in a location where there are strong local signals. It was definitely determined experimentally that increasing the i-f gain of the set after the first detector or increasing the gain of the audio system would make possible reception of a wider range of signal strengths. However, since high-fidelity reception of weak signals in the broadcast band is not generally possible (due to the 10-kc spacing between adjacent channels) it does not appear desirable to provide for such reception in this particular receiver.

Other Applications of High-Value I-F Amplifiers

A high-frequency i-f amplifier is almost an essential requirement in an f-m receiver, and it is a simple matter to convert a dual-bandwidth f-m receiver, such as the Hallicrafters S-27, to a dual-purpose receiver which covers the f-m band and a band extending from about 100 kc to the i-f amplifier frequency (5 Mc with the S-27).

Where a higher intermediate frequency, such as 20 Mc, is used the possibilities become quite interesting. It is not difficult to build a stable 20-Mc i-f amplifier having a bandwidth well under 100 kc. If a second converter is used, as shown in Fig. 5, almost any desired selectivity is available, along with a novel bandspread feature.

The receiver of Fig. 5 covers 100-15,000 kc in one range. A bandspread dial, tuning the second local oscillator 100-kc above and below its center frequency, provides an accurately calibrated bandspread action over exactly 200 kc at any point in the 100-15,000 kc range of the receiver. For f-m reception a limiter stage and discriminator are substituted for the second converter and narrow i-f circuits, the low-pass filter ahead of the first detector is replaced by a band-pass filter covering the f-m band, and the oscillator tank circuit is switched to operate over a suitable range. The essential features of this receiver have already been tried experimentally breadboard fashion.

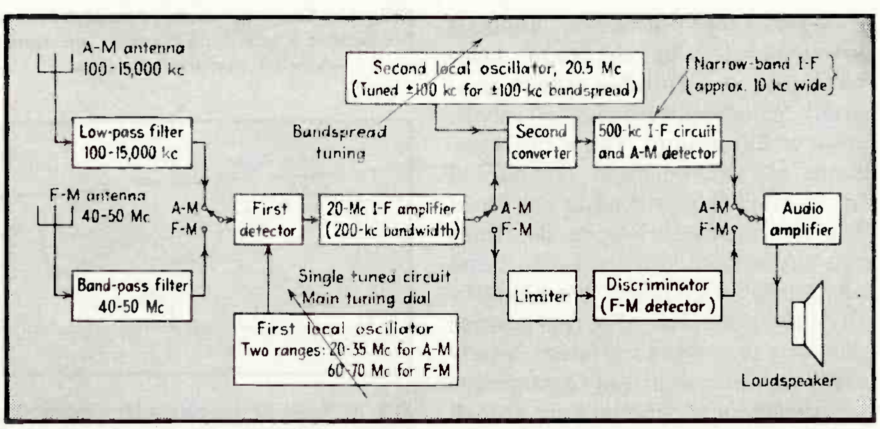
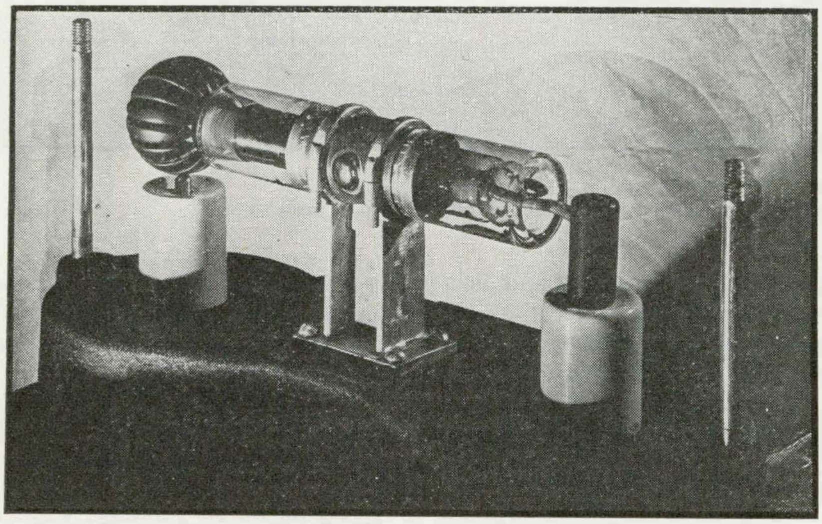


FIG. 5—Block diagram of proposed combination a-m/f-m communication receiver employing a 20-Mc i-f value. Both local oscillators are tuned, but the second is used only for bandspread purposes

Geiger Counter Spectrometer for Industrial Research

New instrument measures x-ray intensities and diffraction angles of powdered chemical and metallurgical samples directly and speedily, by using a Geiger counter tube to actuate a scale-of-64 flip-flop circuit that feeds an impulse register



X-ray tube used in the Geiger-counter focusing spectrometer (housing has been removed)

X-RAY DIFFRACTION has many applications in the chemical and metallurgical industries, but its techniques have been confined until recently to the laboratory and to highly trained personnel. Conventional procedure entails photographic exposure, processing, and density comparisons of the finished film strips.

The Geiger counter spectrometer described below measures x-ray intensities and diffraction angles directly, without intermediate photographic steps. It is simple enough for unskilled operators performing routine industrial processes, yet also meets the precise requirements of laboratory research. The instrument was developed at the Naval Research Laboratory, where it has been in regular use for the past two years.

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X-Ray Powder Diffraction

X-rays for diffraction analysis are generated by electronic bombardment of a suitable target, generally molybdenum, copper, cobalt, iron, or chromium. The x-ray spectrum of molybdenum[1] bombarded by 35-kilovolt electrons is shown in Fig. 1; characteristic x-ray lines are superposed on the background of "white" radiation. To simplify the interpretation of x-ray powder patterns the target radiation is partially monochromatized through the use of filters which strongly absorb the $K\beta$ radiation and pass the $K\alpha$.

In Fig. 2(a), assume the beam is monochromatic of wavelength λ, and that it is limited by a series of pinhole apertures. A small portion of the chemical compound to be examined is ground to a fine powder and mounted at point C. Let the dotted line indicate the orientation of a particular set of crystal planes in a single powder particle, the planes being normal to the plane of the figure. If the spacing of this set of planes is d, the x-ray beam is reflected only when

$$n\lambda = 2d \sin\theta \qquad (1)$$

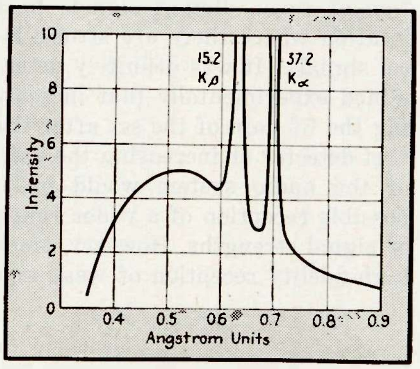

FIG. 1—X-ray spectrum of molybdenum bombarded with 35-kilovolt electrons, showing characteristic lines

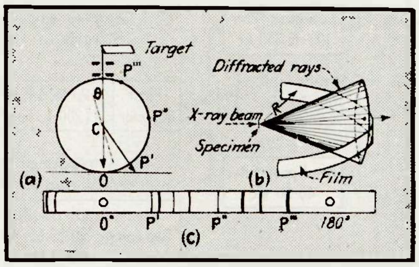

FIG. 2—Basic arrangement for analysis by powder diffraction (a), use of cylindrical film to intercept a cone of diffracted radiation (b), and example of pattern obtained on film (c)

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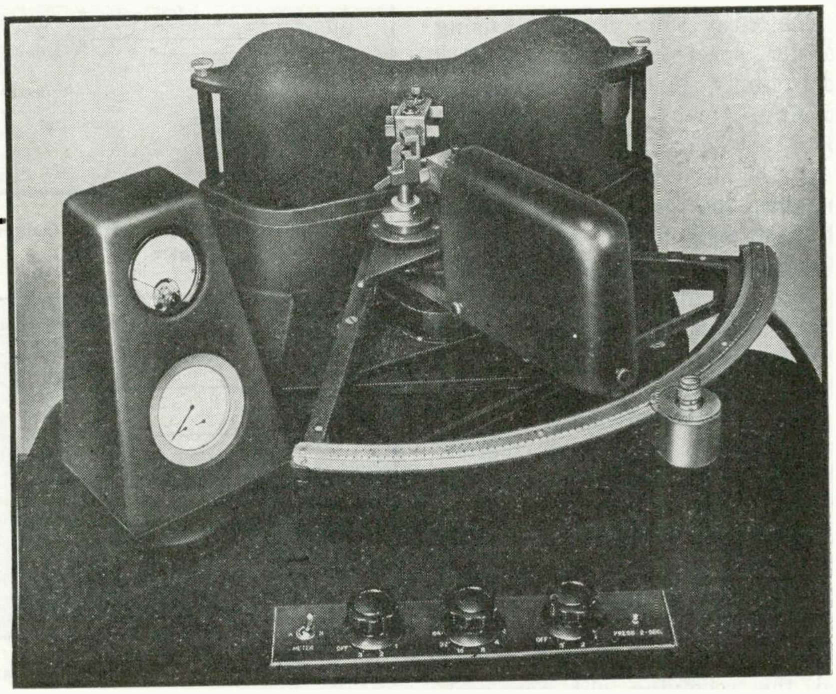
Here n is the order of diffraction, and θ is the glancing angle.

The myriad of small crystal fragments that make up the powder specimen are oriented in all directions. The particle whose orientation is represented in Fig. 2 (a) is only one of a large number of particles aligned to reflect at the angle θ from the same set of lattice planes. These sets of planes, however, make all possible angles with the plane of the figure. The rays diffracted from the entire specimen are therefore the generators of a cone of semi-apex angle 2θ about the primary beam as an axis, as indicated in Fig. 2(b).[2]

Corresponding to each set of interplanar spacings (the so-called d values) there is a diffracted cone of different Bragg angle θ. If a photographic film is mounted perpendicular to the incident beam direction, as shown in Fig. 2(b), the diffraction cones from the various d spacings intercept the film in concentric circles. The more common arrangement for photographic registration is to surround a rod-shaped powder sample with a cylindrical film strip. The intersections of diffracted beams with the film are then curved traces which approach circular arcs at zero and 180 degrees, and straight lines in the 90-degree direction, as in Fig. 2(c). The obvious method of identifying compounds is to place the pattern of an unknown side by side with standard patterns so that the zero positions match. If the unknown shows a set of lines coincident with the lines of a standard and in roughly the same intensity relationship, the unknown must contain the standard material.



Focusing spectrometer engineered by North American Philips Co. The counting meter scale at the lower left indicates radiation intensities directly as the Geiger tube is rotated from one end to the other of the graduated quadrant that shows diffraction angles. The x-ray tube is in the dumbbell-shaped housing at the rear

One of the earliest Geiger counter spectrometers simply used a counter to scan the arc normally covered by film in a cylindrical power camera.[3] The counter was mounted on an arm pivoted at the specimen axis. This method of scanning, however, is poor in comparison with focusing arrangements.

Focusing Powder Spectrometers

The focusing powder spectrometer engineered by North American Philips Company is capable of precision angular measurements and resolution beyond that attainable by means of photographic cameras. In addition, the instrument may be adapted to measurement of pinhole transmission patterns, fiber orientation, and low-angle scattering. The essential features are a zero to ninety-degree scale, with a dial micrometer to indicate hundredths of a degree, and a specimen holder geared to rotate at half the speed of the Geiger counter scanning arm. The angular positioning mechanism is free

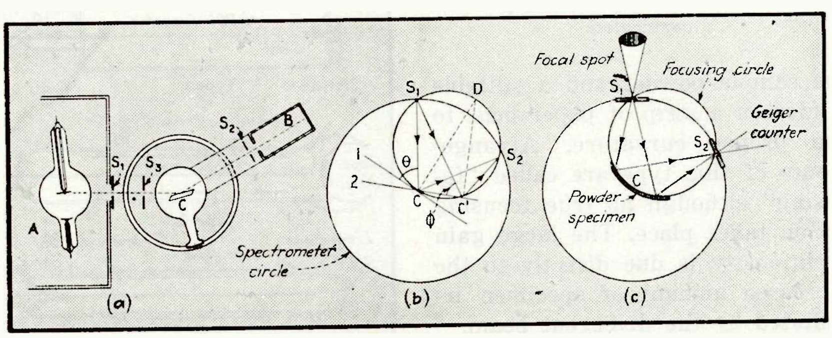


FIG. 3—Bragg ionization spectrometer for single crystal analysis (a), focusing crystal arrangement of Bragg spectrometer (b), and focusing spectrometer arrangement for powder diffraction (c)

of backlash; this permits resetting angles directly to 0.01 degree.

The x-ray tube of the focusing powder spectrometer is mounted horizontally inside its protective housing. A cone of x-rays from the focal spot converges on the first of a pair of slits, directly in front of the exit aperture in the housing. This slit acts as the source of a diverging pencil of radiation. The second slit controls the degree of divergence and thereby the area of specimen irradiated. Rays reflected from the specimen are brought to a focus on a receiving slit before the window of the Geiger counter. The three slits mentioned thus far are bilateral and calibrated in thousandths of an inch. A fixed slit of wide dimensions is included ahead of the counter slit to reduce the amount of stray radiation entering the counter. The source slit and the receiving slit are each spaced ten centimeters from the spectrometer axis.

Focusing spectrometers date back to the early days of the development of x-ray diffraction techniques. The original Bragg ionization spectrometer[4], shown in Fig. 3(a), was designed for use with a single crystal. The incident x-radiation was collimated by a system of slits, and after reflection was measured by the scanning ionization chamber. A subsequent development employed a divergent beam and provided for rocking the crystal about the spectrometer axis, as in Fig. 3(b). By maintaining equal distances from the rotation axis C to the entrant slit S_1 and to the receiving slit S_2 of the ionization chamber, a focusing action was derived. At each position of S_2 on the spectrometer circle, a different wavelength is received. While this arrangement yields a true focusing, it contributes no increase in intensity to the reflected radiation.

The use of powder samples with the focusing crystal spectrometer was described by W. H. Bragg in 1921[5]. If the specimen face conforms to the arc of a circle which passes through the slits S_1 and S_2, as in Fig. 3(c), then all rays from S_1 to the specimen to S_2 make equal Bragg angles. The specimen can be prepared by spreading a mixture of

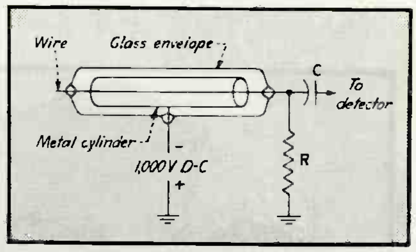


FIG. 4—Fundamental circuit of Geiger counter

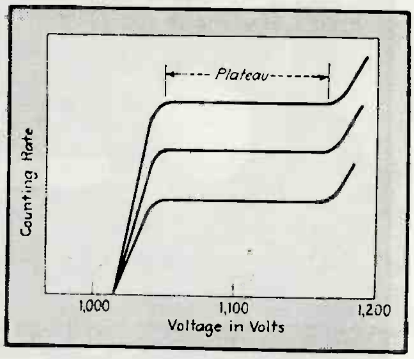


FIG. 5—Geiger counter plateau curves

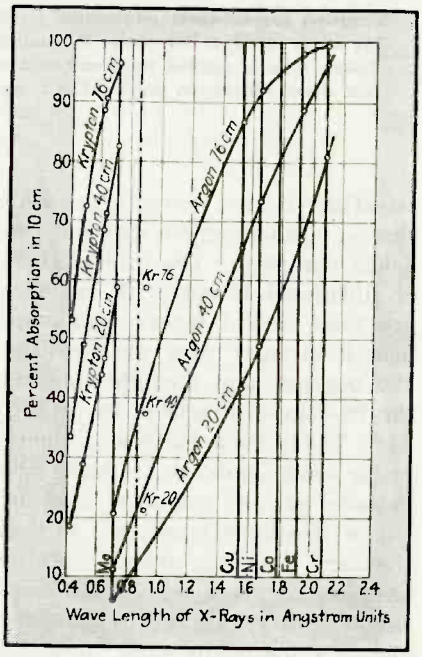


FIG. 6—Absorption of x-radiation by argon and by krypton at various wavelengths and pressures, for a path length of ten centimeters

the sample powder and a suitable binder on a strip of paper bent to the proper curvature. Arrangements of this type are called "focusing" although no true focusing action takes place. The large gain in intensity is due directly to the increased amount of specimen irradiated by the divergent beam.

The focusing circle of Fig. 3(c) is only hypothetical and applies to one particular Bragg angle. Points S_1 and C are fixed in practice and S_2 moves with the spectrometer arm. As the Bragg angle increases, the curvature of the hypothetical focusing circle increases. To preserve the focusing condition exactly at all angles would require that the specimen curvature be adjusted to match the circle at each setting of S_2. A working compromise is arrived at by using a plane specimen and limiting the divergence of the primary beam sufficiently to avoid introducing excessive errors in the measured diffraction angles.

Most specimens can be prepared by mixing the powdered material with collodion or other binder and spreading a thin layer of the mixture onto a glass slide. Other methods involve packing the powder into a shallow form, with the aid of a spatula, or sprinkling the powder into a form faced with a thin flat film that is highly transparent to x-rays.

Geiger Counters for X-Rays

Relatively few laboratories have published powder diffraction data obtained with the Bragg type ionization chamber spectrometer. The reason lies in the difficulty associated with ionization chamber measurements of the very weak currents involved. Brentano and his co-workers[6] have investigated focusing spectrometer arrangements using film in preference to an ionization chamber, but these methods require that limited portions of the film be exposed step by step in order to register all of the powder pattern in focus.

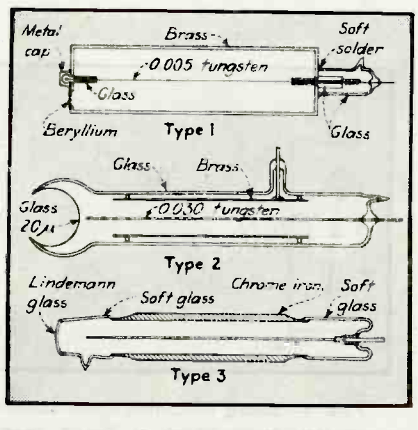


FIG. 7—Three types of Geiger counter tubes suitable for detecting soft x-rays

The excellent results obtainable with the present instrument are due to the efficiency of the Geiger counter technique employed. The counter tube is prepared with close to 100-percent efficiency for the characteristic x-ray wavelength used in the powder crystal analysis; in other words, one count is produced for almost every x-ray quantum entering the tube. This is to be compared with values of four to fifteen counts per hundred quanta attributed to the x-ray counters previously used.[8, 9] Furthermore, in photographic measurement, the number of quanta required to produce a diffraction line on film is roughly 10^4 to 10^5, for minimum detectable blackening; a Geiger counter measurement of the same x-ray energy would have an accuracy of better than one-tenth of a percent. Comparisons with secondary electron multiplier tubes based on the work of Eisenstein and Gingrich indicate a factor of 25 to 50 in favor of the Geiger counter described below.

The high sensitivity of the Geiger counter lies in its ability to detect individual quanta of radiation. The formation of a single ion pair anywhere within the active volume of a counter tube releases a flow of current large enough to operate a relay directly.

In its simplest form a Geiger counter consists of a coaxial wire and cylinder arrangement as shown in Fig. 4. The electrodes are usually enclosed in a glass envelope containing a suitable gas mixture at a small fraction of atmospheric pressure. The passage of ionizing radiation triggers a momentary discharge and develops a voltage pulse at capacitor C. Following the discharge, the counter recovers quickly to its original condition and is ready to detect the next ionization.

The characteristic curve of a Geiger counter, in Fig. 5, indicates the number of discharges or counts per second as a function of applied voltage. Up to a minimum voltage, the threshold, no counts are detected. Above this threshold, the counting rate increases only slightly over a range of a hundred or more volts. This region is called the plateau. The upper limit to the plateau is set by the inception of self-sustained discharges. The various curves of Fig. 5 correspond to different intensities of radiation.

Counter Tubes

A counter tube detects x-rays by virtue of the charged secondaries released within its active volume, and x-rays of the wavelengths employed in diffraction work are absorbed almost entirely by photoelectric effect. When the counter is triggered by photoelectrons released from the cathode wall its efficiency cannot be very high, since only a relatively small fraction of these electrons escape from the wall into the accelerating field of the tube. On the other hand, if photoelectric absorption of the x-rays takes place in the gaseous contents of the tube, every x-ray quantum produces a count.

In most published work on Geiger counters for x-ray diffraction the tubes were designed to receive the x-ray beam on the cathode wall, with negligible gaseous absorption. These tubes yielded quantum counting efficiencies of the order of four to fifteen percent, with the higher values obtained through use of a cathode surface whose critical absorption limit fell at slightly longer wavelength than the radiation being measured.

The counter tube employed in the present spectrometer is designed for almost complete absorption of the x-ray beam in the gaseous volume. This is accomplished by filling the counter tube with a high pressure of a gas whose absorption coefficient is large for the x-ray wavelength employed.

The percentage of the x-radiation absorbed by argon and by krypton in a ten-centimeter counter tube is shown in Fig. 6. Argon, at pressures close to atmospheric, absorbs more than 85 percent of the $K\alpha$ radiations of Cu, Co, Fe, and Cr. Krypton strongly absorbs the K_α rays of Mo.

The counter tubes are designed to permit passage of the x-rays through a gas path ten centimeters in length without striking the electrodes. Three tube constructions are sketched in Fig. 7. In type 1, the x-rays are admitted through a beryllium window sealed off to one side of the tube axis. The anode is a fine tungsten wire mounted under spring tension and insulated by glass sleeves at the ends. Type 2 comprises a brass cylinder and stiff tungsten rod anode enclosed in a Pyrex glass envelope. A bubble window, 20 microns thick, readily transmits the x-rays.[10] Type 3 differs from type 2 in that the fragile

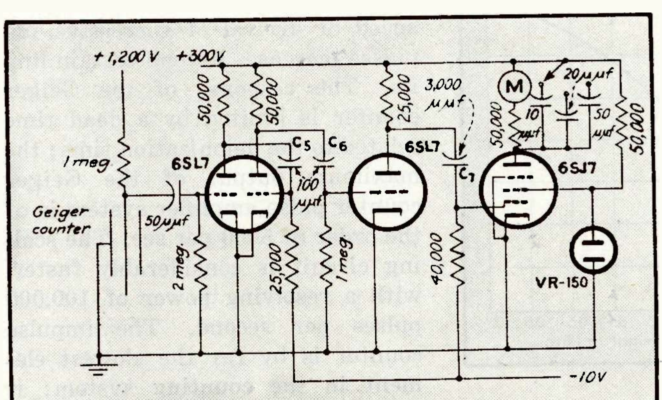


FIG. 8—Pulse producer and pulse averaging circuit of counting rate meter used in Geiger counter focusing spectrometer

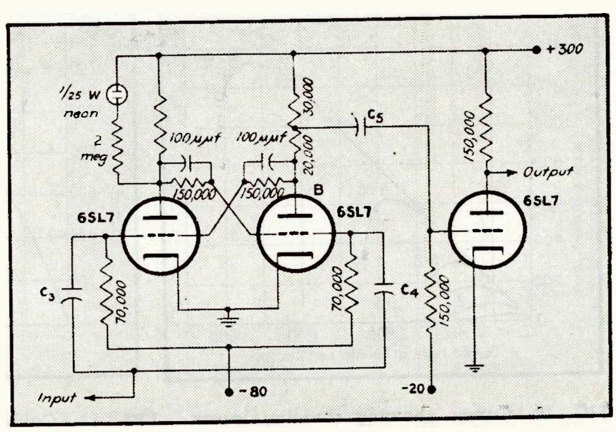


FIG. 9—Basic scale-of-two trigger circuit and rectifier output stage employed in the scale-of-64 counting arrangement

bubble window is replaced by a thicker Lindemann glass window, and the cathode cylinder of chrome-iron is sealed directly to soft glass ends.

The addition of a small amount of organic vapor, such as ethyl alcohol, to the rare gas filling, makes these tubes self quenching. The discharges are extinguished internally by a space charge mechanism and a large external series resistance is not essential to the counting action. Using a value of 2 megohms for R in Fig. 4, maximum counting rates of the order of 5000 per second are obtainable with conventional detecting circuits.

Circuits

Two types of intensity measurement are employed—a counting-rate meter for rapid scanning, and a scale-of-64 vacuum-tube counting circuit with timed counting intervals of 15, 30 or 60 seconds.

The counting rate meter, composed of a uniform pulse producer and a pulse averaging circuit, is shown in Fig. 8. The averaging is accomplished in a resistance-capacitance tank provided with a selection of capacitors to make up time constants of 5, 10 and 20 seconds. Uniform pulses are derived from a succession of pulse shaping, amplifying, and limiting stages. The Geiger counter anode is coupled through a small capacitor to a two-stage preamplifier mounted in the same housing as the counter tube. The pulses developed on the counter wire appear as negative pulses, sharpened and amplified, in the output of the preamplifier. A third stage of amplification and differentiation suffices to equalize all pulses at counting rates up to 3000 per second. These uniform pulses are applied to the grid of the averaging stage.

The resistance-capacitance averaging tank is placed in the anode circuit of a pentode. In this arrangement, the amplitude of each pulse delivered to the capacitor is independent of the voltage across it. The parallel resistor draws leakage current in proportion to the capacitor voltage; a microammeter in series with the resistor serves to measure the current. A choice of capacitors permits adjusting the charging time or speed of response of the indicator. Circuit constants and supply voltages are selected to yield approximately one microampere per pulse per second.

Flip-Flop Counting Action

The basic unit of the scale-of-64 counting circuit is shown in Fig. 9. It consists of two tubes, A and B, in a triode flip-flop circuit coupled to a rectifier stage. The flip-flop unit is essentially a resistance-coupled two-stage amplifier with regenerative feed-back. It can be shown readily that this combination has only two states of stable equilibrium. If the circuit is not in one of its equilibrium states any very small disturbance is amplified regeneratively so that one tube draws more plate current and the other is driven towards cut-off. When one tube reaches cut-off, the amplification process ceases and since the tubes are directly coupled they remain in this configuration. The reverse action can be initiated, however, by applying a sufficiently large signal to the grids. The action then proceeds in the same manner, as the other tube is driven to cut-off. The two states of equilibrium are (1) tube A conducting, B non-conducting and (2) A non-conducting, B conducting.

When input pulses are fed to the grids of tubes A and B, the flip-flop action described above causes the plate potentials to rise and fall on successive pulses. To obtain a division of the input pulses by two, one plate is coupled to a stage capable of responding to only one polarity of pulse. The complete scaling circuit therefore consists of a succession of flip-flop units separated by rectifiers, in the form of triode amplifiers, biased to cut-off. Each flip-flop stage can respond to pulses of either polarity, but each rectifier passes only positive pulses, which appear as negative pulses in its output.

The output pulses from the preamplifier are sufficiently strong and sharpened to activate the scaling circuit. The output of any section of the scaling circuit may be coupled to the grid of a thyratron which operates an impulse register. Scale ratios of 2, 4, 8, 16, 32 and 64 are selected in this way.

The timer circuit operates a relay which shunts the pulse output of the first scale stage to ground between timing intervals.

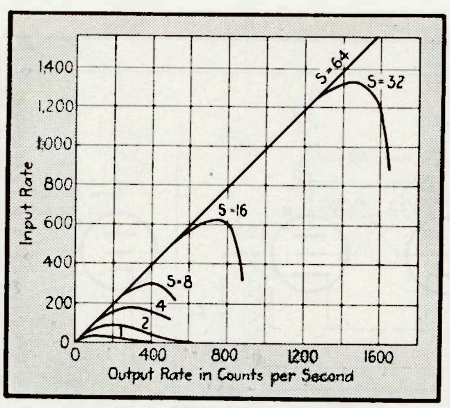


FIG. 10—Curves showing counting losses as a function of the scaling ratio

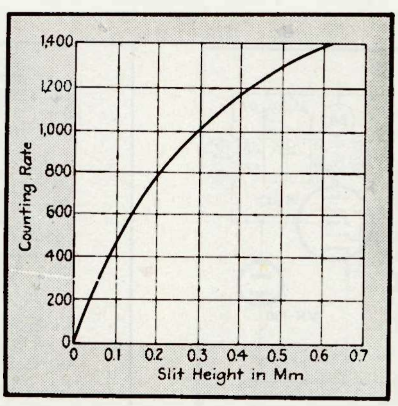


FIG. 11—Calibration curve of complete counting system for focusing spectrometer

Counting Losses

The Geiger counters and counting systems described above do not continue to record accurately as the speed of arrival of successive impulses increases beyond certain limits. The response of the Geiger counter is limited by a dead time related to the deionization time; the maximum output of the Geiger counter pulse amplifier system is of the order of 5000 per sec. The scaling circuit is considerably faster, with a resolving power of 100,000 pulses per second. The impulse counter is by far the slowest element in the counting system; it cannot record two counts when the pulses are separated by less than about 0.01 second.

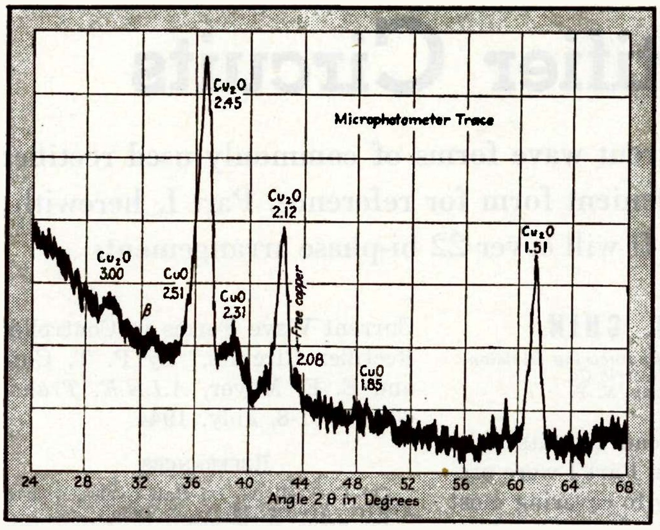


FIG. 12—Microphotometer trace of photographic pattern obtained with conventional powder diffraction camera, for copper oxide pigment. Smaller peaks are difficult to distinguish

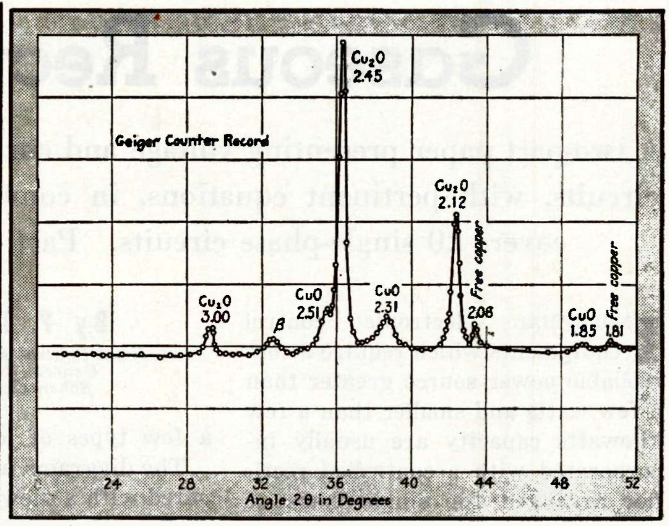


FIG. 13—Plot of focusing spectrometer data for the sample of Fig. 12, showing clearer delineation of peaks. Sample contains both cuprous and cupric oxide and some free copper

By making the scaling ratio sufficiently large it is possible to eliminate the counting circuit completely as a source of counting losses. The limitations then reside entirely in the Geiger counter and its amplifier system. The dependence of output counting rate on the scale ratio is illustrated in Fig. 10.

The distribution in time of the x-ray quanta arriving at the Geiger counter is random, or in other words, the time of arrival of any quantum is not influenced by the arrival of any preceding quantum. The probability of arrival of two successive quanta separated by a small interval is proportional to the length of that interval but even at low counting rates some quanta follow each other too closely to be resolved. To determine the curve of counting rate versus incident x-ray intensity, the intensity may be varied in a known manner and the corresponding counting rates observed. The spectrometer is equipped with a calibrated wedge type slit height control on the Geiger counter entrance slit. With the spectrometer arm set at zero degrees, the intensity entering the counter is proportional to this slit height. A typical calibration curve is shown in Fig. 11.

Performance

The performance of the Geiger counter x-ray powder spectrometer may be compared with photographic powder camera technique by referring to Fig. 12 and 13. A copper oxide pigment, containing both cuprous and cupric oxides and some free copper, was the powder specimen. The Geiger counter pattern shows superior sensitivity, greater resolution and a much lower background level at the smaller Bragg angles, yet only one-tenth the time of the photographic exposure was required to obtain the spectrometer data. Equivalent resolution could be achieved photographically with finer beam collimation, but only at the expense of increasing the exposure by another factor of five to ten. The spectrometer measurements consumed little more time than is usually spent in setting up for the photographic exposure and in processing the film.

In most chemical identifications by the powder pattern method, only the positions and relative intensities of the strongest lines need be determined. This information is obtainable by rapid scanning, with rate meter observation. For quantitative analyses, the line positions are generally known, and counts are needed at only a few points to get the peak, background, and half-maximum intensities.

Applications

Paint pigments are quickly analyzed for relative amounts of different crystal forms. An analysis of titanium dioxide white pigment for rutile and anatase modifications can be completed in less than ten minutes, with an accuracy of ± one percent.

With boiler scale, it is a means of identifying many silicate and phosphate scales and aids in determining the nature of chemical reactions between scale products.

In studies of engine wear and lubrication it identifies deposits on filters, valves, bearings, etc.

For ceramics and refractories, it rapidly checks uniformity of raw material supplies and fixed products.

In powder metallurgy, it indicates the degree of alloying of metal powder mixtures at different sintering temperatures.

It gives a measure of phase constitution of alloys, as for example, relative amounts of martensite and retained austenite in heat-treated steels. The chemical composition of the alpha phase of brass can be determined to ± one percent from a simple measurement of diffraction angle.

References

(1) Ulrey, C. T., *Phys. Rev.* 11, p. 401, 1918.
(2) Barrett, C. S., "Structure of Metals," McGraw-Hill Book Co., New York, 1943.
(3) LeGalley, D. P., *R.S.I.* 6, p. 279, 1935.
(4) Bragg, W. H., and Bragg, W. L., *Proc. Roy. Soc.* A 88, p. 428, 1913.
(5) Bragg, W. H., *Proc. Phys. Soc.* 33, p. 222, 1921.
(6) Brentano, J. C. M., *Proc. Phys. Soc.*, 37, p. 184, 1925; 47, p. 932, 1935; 49, p. 61, 1937.
(7) Locher, G. L., *Phys. Rev.* 50, p. 1099, 1936.
(8) Sullivan, H. M., *R.S.I.* 11, p. 356, 1940.
(9) Eisenstein, A., and Gingrich, N. S., *R.S.I.* 12, p. 582, 1941.
(10) Shaw, C. H., *Phys. Rev.* 57, p. 877 (1940); Beeman, W. W. and Friedman, H., *Phys. Rev.* 56, p. 392 (1939).
(11) Lifschutz, H., *R.S.I.* 10, p. 21, 1939.
(12) Davey, W. P., *General Electric Review* 25, p. 565, 1922.

Gaseous Rectifier Circuits

A two-part paper presenting voltage and current wave forms of commonly used rectifier circuits, with pertinent equations, in convenient form for reference. Part I, herewith, covers 20 single-phase circuits. Part II will cover 22 bi-phase arrangements

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INDUSTRIAL electronic control equipments which require a controllable power source greater than a few watts and smaller than a few kilowatts capacity are usually incorporated with a controlled rectifier arranged for single-phase or bi-phase connections. Little information can be found on the behavior of these rectifier circuits. The present standard textbooks on rectifiers are more or less centered on the polyphase uncontrolled rectifiers operated under the so-called normal mode of operation. Although a considerable number of papers in technical periodicals have covered single-phase and bi-phase rectifier circuits, most of them deal with *uncontrolled* rectifiers. Furthermore, the treatment in most of these papers is limited to one or a few types of load circuits only.

The diagrams in Part I were prepared with a view to covering most of the commonly used single-phase rectifier circuits, while those in Part II do the same for bi-phase rectifier circuits. In each diagram, the voltage and the current wave forms at different parts of a rectifier circuit are sketched and the analytical solution of the instantaneous, average, and rms currents is listed whenever the analytical solution is not too complicated.

Construction of voltage and current wave forms is presented in an AIEE paper entitled "A Graphical Analysis of the Voltage and the Current Wave Forms in Controlled Rectifier Circuits," by P. T. Chin and E. E. Moyer, *A.I.E.E. Trans.*, 63, p. 501-8, July, 1944.

REFERENCES

(1) Cockrell, W. D., Half Cycles, *General Electric Review*, 38, No. 8, 1935.

(2) Stout, M. B., Behavior of Half Wave Rectifiers, ELECTRONICS, Sept. 1939.

(3) Cobine, J. D., "Gaseous Conductors", McGraw-Hill Book Co., New York, 1939.

(4) Pender, "Electrical Engineering Handbook—Vol. 5, Communication," John Wiley & Sons, Inc., New York, 1936.

(5) M.I.T. Electrical Engineering Staff, "Applied Electronics", 1943.

(6) Wallis, C. M., Half-Wave Gas Rectifier Circuits, ELECTRONICS, Oct. 1938, p. 12.

(7) Millman, J., and Seely, S., "ELECTRONICS", McGraw-Hill Book Co., New York, 1941, p. 422.

(8) Ware, L. A., Operation of a Thyratron as a Rectifier, *Proc. I.R.E.*, Nov. 1942, p. 500.

(9) Shade, O. H., Analysis of Rectifier Operation, *Proc. I.R.E.*, July 1943, p. 354.

(10) Wallis, C. M., Full Wave Rectifier Analysis, ELECTRONICS, Mar. 1940, p. 19-22.

(11) Vedder, E. H., and Puchlowski, K. P., Theory of Rectifier—D-C Motor Drive, *A.I.E.E. Technical Paper*, May 1943.

(12) Flake, J. M., Operation of Vapor Tube Rectifier Circuits with Opposing Direct Voltages, ELECTRONICS, June 1943, p. 100.

TABLE I. REFERENCES FOR RECTIFIER CIRCUITS

LOAD	Part 1: SINGLE-PHASE, SINGLE-WAY		Part II: BI-PHASE		
	Phanotron	Thyratron	Two phanotrons	Two thyratrons	Phanotron thyratron
R	Fig. 1 p. 368 of (1) p. 32 of (2) p. 473 of (3)	Fig. 8 p. 474 of (3) p. 422 of (7)	Fig. 21 p. 486 of (3)	Fig. 26, 41*	Fig. 34
L	Fig. 2 p. 368 of (1) p. 481 of (3)	Fig. 9 p. 482 of (3)			
C	Fig. 3 p. 368 of (1) p. 476 of (3)				
R,L in series**	Fig. 4 p. 16–02 of (4) p. 283 of (5)	Fig. 10, 11 p. 484 of (3) p. 500 of (8)	Fig. 22, 23 p. 487 of (3) p. 354 of (9)	Fig. 27, 28, 42* (11)	Fig. 35, 36, 37
R,C in parallel	Fig. 5, 6 p. 369 of (1) p. 479 of (3) p. 275 of (5)				
E_B,R in series		Fig. 13 p. 476 of (3)		Fig 29 p. 100 of (12)	Fig. 38
E_B, L in series		Fig. 14 p. 485 of (3)			
E_B,L,R in series	Fig. 7 p. 12 of (6)	Fig. 15, 16	Fig. 24, 25 p. 19 of (10) p. 354 of (9)	Fig. 30, 31, 32, 33	Fig. 39, 40
R, L in parallel	Fig. 20 p. 369 of (1)				
R,L in series C in parallel	Fig. 19 p. 369 of (1)				

*Inverse Parallel Circuit.
**Phanotron & Thyratron = Fig. 17, 18 = p. 16 = 05 of (4).

TABLE II. NOMENCLATURE

Small letters stand for instantaneous values

Capital letters with subscript stand for average effective values

Subscripts:

- s—Transformer sec.
- t—Tube
- L—Inductance
- R—Resistance
- C—Capacitance
- d—Rectifier output
- B—Battery or cemf
- av—Average
- rms—Root mean square

- e —Instant. voltage
- e_s —Transformer secondary voltage
- e_t —Tube voltage (e_{t1} for 1st tube, etc.)
- e_{pf} —Peak forward volt.
- e_{ii} —Initial inverse volt.
- e_{pi} —Peak inverse volt.
- e_L —Inductance voltage
- e_R —Resistance voltage
- e_C —Capacitance voltage
- e_d —Rect. output volt.

- E —Specific voltage
- (E) av.—Average voltage
- (E)rms—RMS voltage
- E_B—Battery voltage or counter emf
- E_s —Peak value of transformer sec. volt.
- i —Instant. current
- i_d —rect. output current
- i_{pd} —Rectifier output peak current
- i_t —Tube current
- i_{tp} —Tube peak current
- i_L —Current through L
- i_R —Current through R
- i_C —Current through C
- I—Specific currents
- (I) av—Average cur.
- (I) rms—Root mean square current
- θ_f —Firing angle
- θ_e —Extinction angle
- θ_C —Conduction angle $= \theta_e - \theta_f$
- ϕ —P-F angle
- ω —Angular speed in radians per sec ($= 2\pi f$)

SINGLE PHASE UNCONTROLLED RECTIFIER

NO. OF TUBES: 1 PHANOTRON

NATURE OF LOAD: R

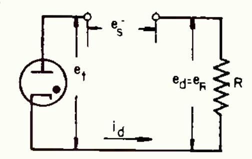
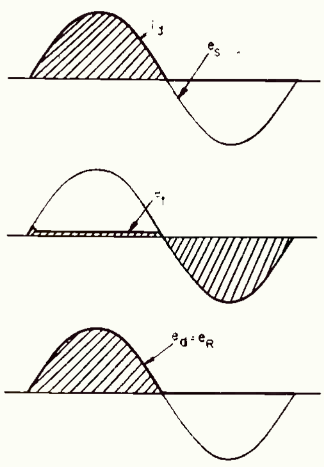


FIG. 1



$i_d = \frac{E_S}{R}\sin\omega t \quad \pi \geq \omega t \geq 0$

$i_{pd} = \frac{E_S}{R}$

$(I_d)_{av} = \frac{E_S}{\pi R}$

$(I_d)_{rms} = \frac{E_S}{2R}$

$e_t = 0 \quad \pi \geq \omega t \geq 0$

$= E_S \sin\omega t \quad \pi \leq \omega t \leq 0$

$e_{pi} = E_S$

$e_d = E_S \sin\omega t \quad \pi \geq \omega t \geq 0$

$= 0 \quad 2\pi \geq \omega t \geq \pi$

$(E_d)_{av} = \frac{E}{\pi}$

$(E_d)_{rms} = \frac{E}{2}$

SINGLE PHASE UNCONTROLLED RECTIFIER

NO. OF TUBES: 1 PHANOTRON

NATURE OF LOAD: L

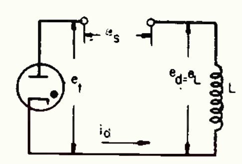
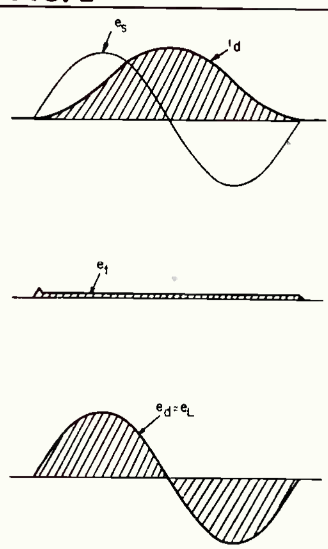


FIG. 2



$i_d = \frac{E_C}{L\omega}(1 - \cos\omega t)$

$I_{pd} = \frac{2E_S}{L\omega}$

$(I_d)_{av} = \frac{E_S}{L\omega}$

$(I_d)_{rms} = \frac{\sqrt{1.5}\,E_S}{L\omega}$

$e_t = 0$

$e_{pi} = 0$

$e_d = e_L = E_S \sin\omega t$

$(E_d)_{av} = 0 \quad (E_L)_{av} = 0$

$(E_d)_{rms} = \frac{E_S}{\sqrt{2}}$

SINGLE PHASE UNCONTROLLED RECTIFIER

NO. OF TUBES: 1 PHANOTRON

NATURE OF LOAD: C

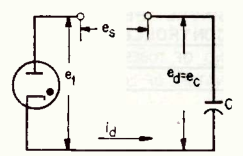
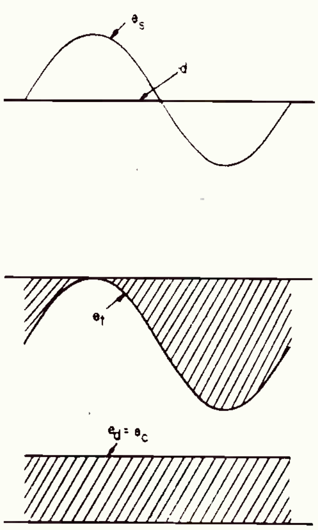


FIG. 3



$i_d = 0$

$e_t = E_S(1 - \sin\omega t)$

$e_{pi} = 2E_S$

$e_d = e_c = E_S$

SINGLE PHASE UNCONTROLLED RECTIFIER

NO. OF TUBES: 1 PHANOTRON

NATURE OF LOAD: L,R IN SERIES

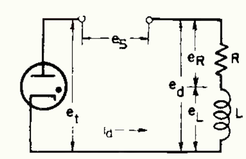
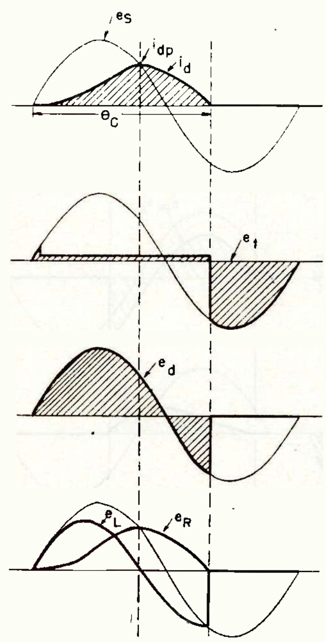


FIG. 4



$i_d = \frac{E}{Z}\left[\sin(\omega t - \phi) + \sin\phi\, e^{-\frac{R}{L}t}\right]$

$e_t = 0 \quad \alpha > \omega t > 0$

$= E_S \sin\omega t \quad 2\pi > \omega t > \alpha$

$e_{pi} \geq E_S$

$e_d = e_R + e_L$

$= E_S \sin\omega t \quad \alpha > \omega t > 0$

$= 0 \quad 2\pi > \omega t > \theta_e$

$(E_d)_{av} = \frac{E}{2}(1 - \cos\theta_e)$

$(E_d)_{rms} = \frac{E}{2}\sqrt{\frac{\theta_e}{2\pi}}$

SINGLE PHASE UNCONTROLLED RECTIFIER

NO. OF TUBES. 1 PHANOTRON

NATURE OF LOAD: R C IN PARALLEL

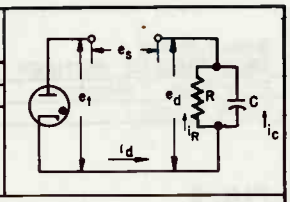
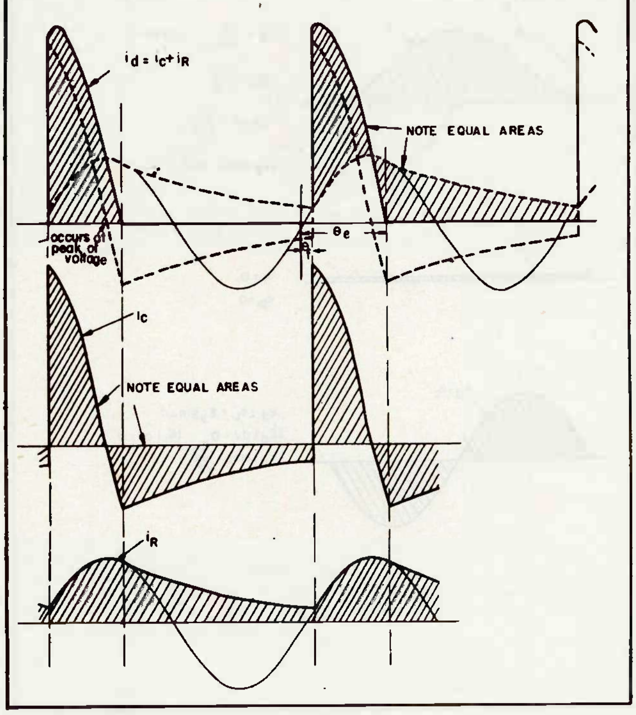


FIG. 5



SINGLE PHASE UNCONTROLLED RECTIFIER

NO. OF TUBES: 1 PHANOTRON

NATURE OF LOAD: R, C IN PARALLEL

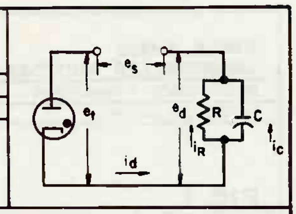
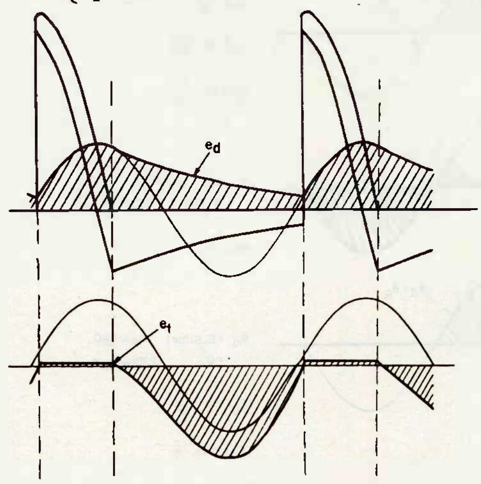


FIG. 6

$$i_R \begin{cases} = \frac{E_s}{R}\sin\omega t & \theta_f \le \omega t \le \theta_e \\ = \frac{E_s}{Z}\epsilon^{\frac{\phi-\omega t}{\tan\phi}} & \theta_e \le \omega t \le 2\pi+\theta_f \end{cases}$$



$$i_C \begin{cases} = E_s\omega C\cos\omega t & \theta_f \le \omega t \le \theta_e \\ = -\frac{E_s}{Z}\epsilon^{\frac{\phi-\omega t}{\tan\phi}} & \theta_e \le \omega t \le 2\pi+\theta_f \end{cases}$$

$$i_d \begin{cases} = \frac{E_s}{Z}\sin(\omega t+\phi) & \theta_f \le \omega t \le \theta_e \\ = 0 & \theta_e < \omega t \le 2\pi+\theta_e \end{cases}$$

SINGLE PHASE UNCONTROLLED RECTIFIER

NO. OF TUBES: 1 PHANOTRON

NATURE OF LOAD: R, L, E_B IN SERIES

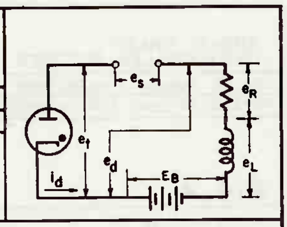
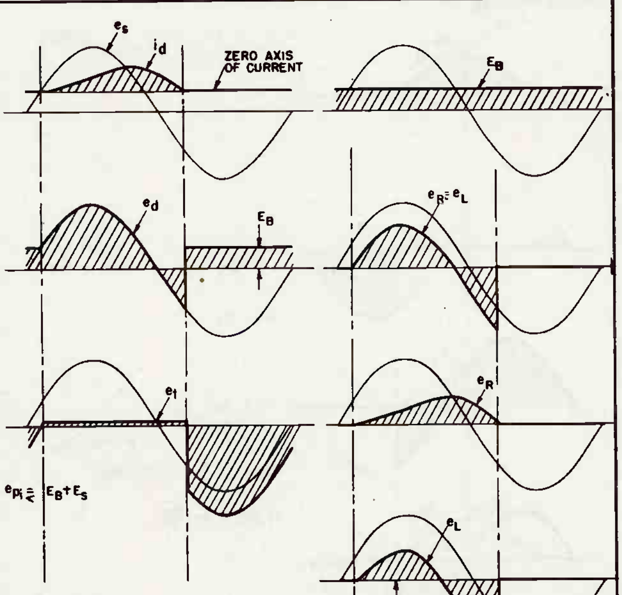


FIG. 7



$$i_d = \frac{E_s}{Z}\sin(\omega t+\theta_f-\phi) - \left[\frac{E_s}{Z}\sin(\theta_f-\phi)\right]\epsilon^{-\omega t\cot\phi} - \frac{E_B}{R}\left(1-\epsilon^{-\omega t\cot\phi}\right),\ \text{WHERE } \theta_f = \sin^{-1}\frac{E_B}{E_s}$$

SINGLE PHASE CONTROLLED RECTIFIER

NO OF TUBES 1 THYRATRON

NATURE OF LOAD. R

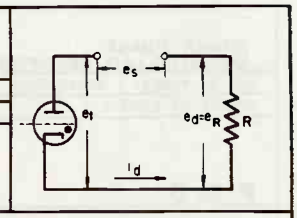
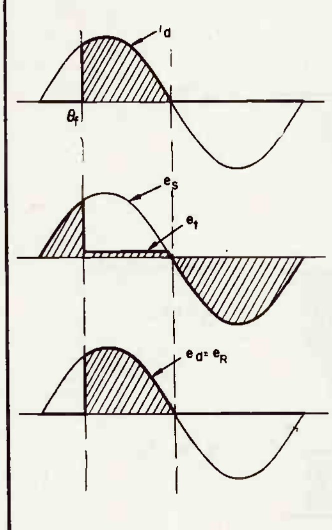


FIG. 8



$i_d = \frac{E_s}{R}\sin\omega t$

$(180^\circ \ge \omega t \ge \theta_f)$

$= 0$ $(\omega t > 180^\circ)$

$(I_d)_{av} = (1+\cos\theta_f)\frac{E_s}{2\pi R}$

$(I_d)_{rms} = \frac{1}{2}\left[\frac{1}{\pi}(\pi-\theta_f)+\frac{\sin 2\theta_f}{2}\right]^{\frac{1}{2}}\frac{E_s}{R}$

$e_f = E_s\sin\omega t$

$(\theta_f \ge \omega t \ge 180^\circ)$

$= 0$

$(180^\circ \ge \omega t \ge \theta_f)$

$e_{pi} = E_s$

$e_d = e_R = i_d R$

$(E_R)_{av} = (I_d)_{av} R$

$(E_R)_{rms} = (I_d)_{rms} R$

SINGLE PHASE CONTROLLED RECTIFIER

NO OF TUBES: 1 THYRATRON

NATURE OF LOAD: L

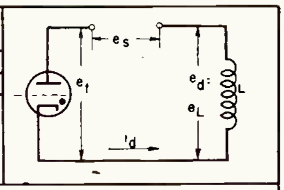
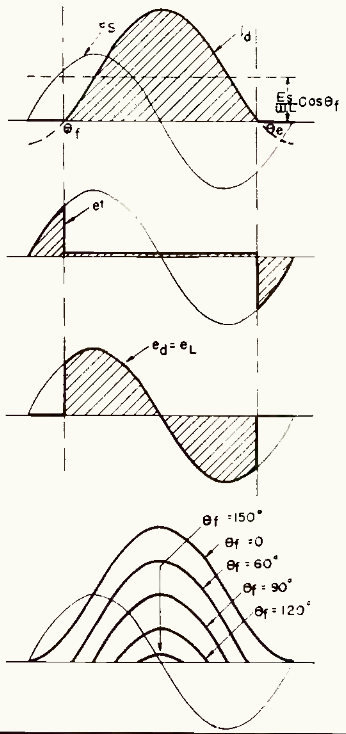


FIG. 9



$$i_d = \frac{E_s}{\omega L}(\cos\theta_f - \cos\omega t) \quad (\theta_e \geq \omega t \geq \theta_f)$$

$$= 0 \quad (\theta_f \geq \omega t \geq \theta_e)$$

$$\theta_e = 360° - \theta_f$$

$$i_{pd} = \frac{E_s}{\omega L}(1 + \cos\theta_f)$$

$$(I_d)_{av} = \frac{E_s}{2\pi\omega L}\left[(\cos\theta_f)(2\pi - 2\theta_f) + 2\sin\theta_f\right]$$

$$(I_d)_{rms} = \frac{E_s}{\omega L}\left\{\frac{1}{2\pi}\left[\left(\frac{1}{2} + \cos^2\theta_f\right)(2\pi - 2\theta_f) + \frac{3}{2}\sin 2\theta_f\right]\right\}^{\frac{1}{2}}$$

$$e_L = e_d = E_s \sin\omega t \quad (\theta_e \geq \omega t \geq \theta_f)$$

$$= 0 \quad (\theta_f \geq \omega t \geq \theta_e)$$

$$(E_L)_{av} = 0$$

$$(E_L)_{rms} = E_s\left[\frac{1}{2\pi}\left[(\pi - \theta_f) + \frac{\sin 2\theta_f}{2}\right]\right]^{\frac{1}{2}}$$

CURRENT WAVE FORMS FOR DIFFERENT FIRING ANGLES

SINGLE PHASE CONTROLLED RECTIFIER

NO OF TUBES: 1 THYRATRON

NATURE OF LOAD: R, L IN SERIES

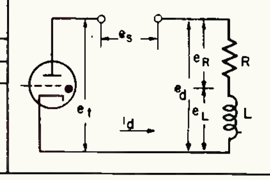
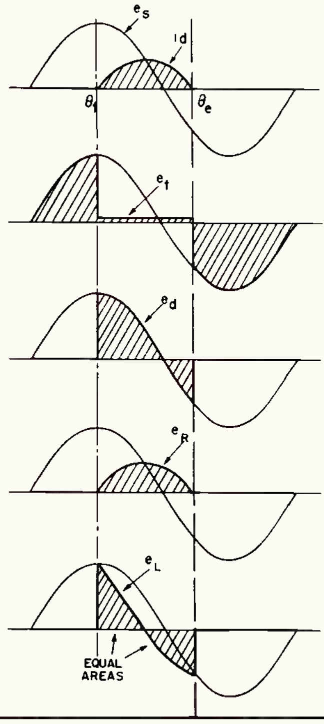


FIG. 10



SINGLE PHASE CONTROLLED RECTIFIER

NO. OF TUBES: 1 THYRATRON

NATURE OF LOAD: R, L IN SERIES

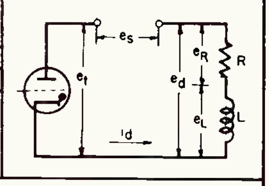
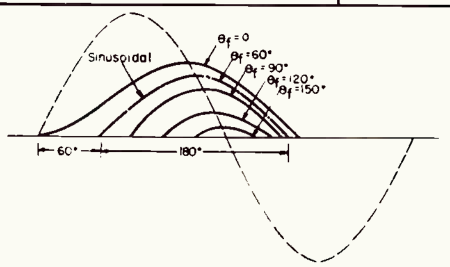
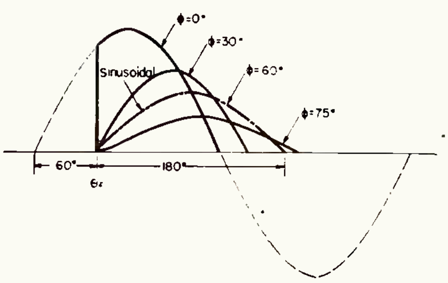


FIG. 11



CURRENT WAVE FORMS AT DIFFERENT FIRING ANGLES WITH A LOAD HAVING A P.F. OF 0.5 ($\cos\phi = 0.5$)



CURRENT WAVE FORMS FOR LOAD OF DIFFERENT POWER FACTOR ANGLE FIRED AT 60°

$$i = \frac{E_s}{\sqrt{R^2 + (\omega L)^2}}\left[\sin(\omega t + \theta_f - \phi) - \epsilon^{-\omega t \cot\phi}\sin(\theta_f - \phi)\right]$$

SINGLE PHASE CONTROLLED RECTIFIER

NO OF TUBES: 1 THYRATRON

NATURE OF LOAD: R, C IN PARALLEL

R_1 USED TO LIMIT PEAK CURRENT

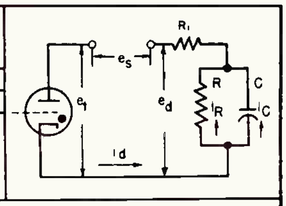
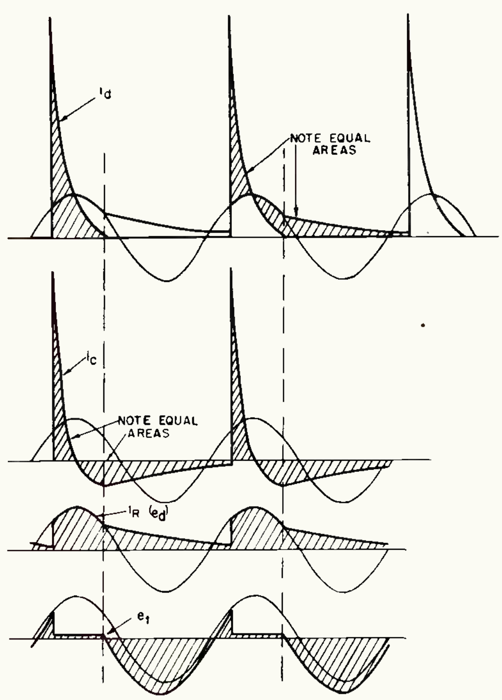


FIG. 12



SINGLE PHASE CONTROLLED RECTIFIER

NO. OF TUBES: 1-THYRATRON

NATURE OF LOAD: R, E_B IN SERIES

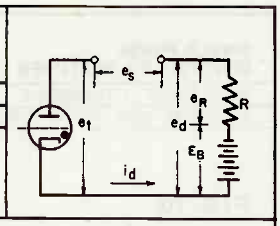
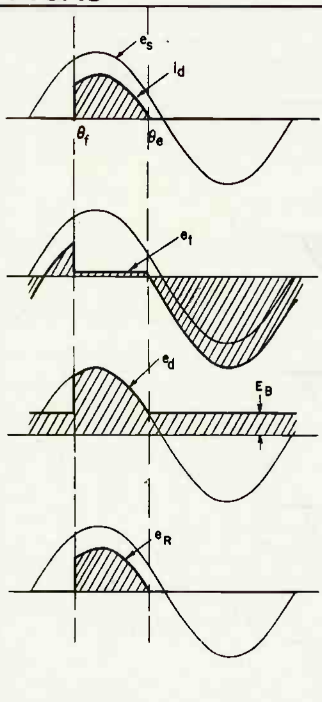


FIG. 13



$$(I_d)_{av} = \left[E_s \cos\theta_f + (\theta_f - \tfrac{\pi}{2})\right]\frac{E_B}{\pi R}$$

$$(I_d)_{av} = \left[\frac{E_s \cos\theta_f + E_B(\theta_f - \frac{\pi}{2})}{\pi R}\right]$$

$$e_{pi} = E_s + E_B$$

$$(E_d)_{av} = (E_R)_{av} + E_B$$

$$(E_R)_{av} = (I_d)_{av} R$$

SINGLE PHASE CONTROLLED RECTIFIER

NO. OF TUBES: 1 THYRATRON

NATURE OF LOAD: L, E_B IN SERIES

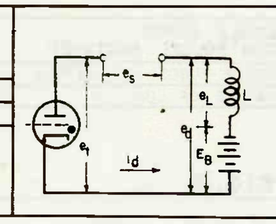
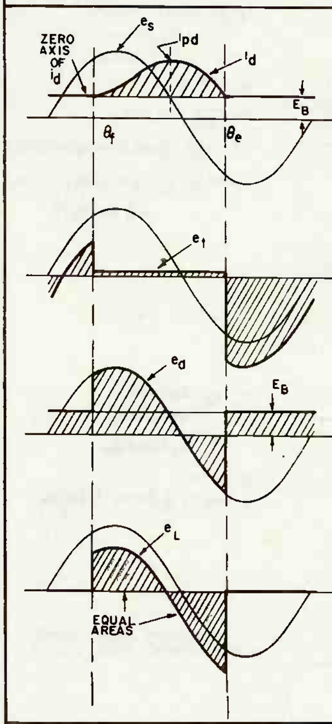


FIG. 14



$$i_d = \frac{E_s}{\omega L}(\cos\theta_f - \cos\omega t) - \frac{E_B}{\omega L}(\omega t - \theta_f)$$

$$e_{pi} \leq e_s + E_B$$

SINGLE PHASE CONTROLLED RECTIFIER

NO. OF TUBES: 1 THYRATRON

NATURE OF LOAD: R, L, E_B IN SERIES

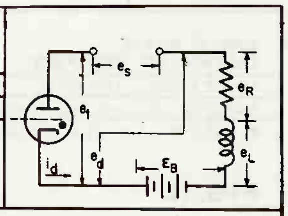
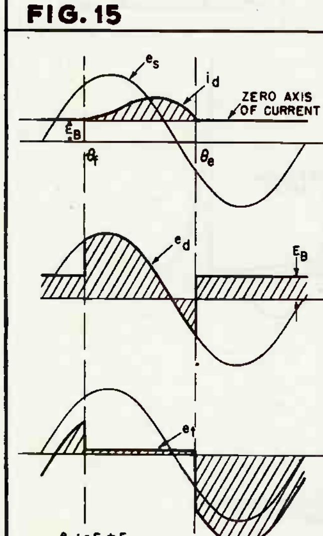
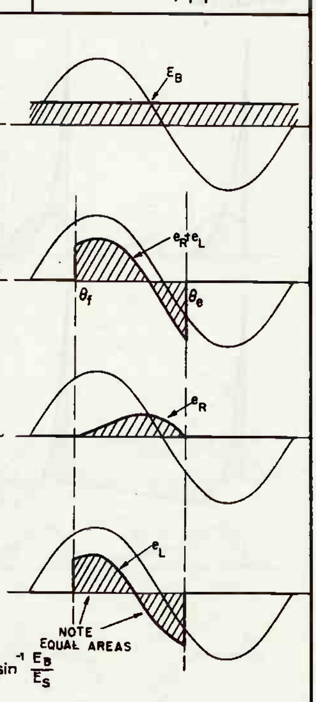


FIG. 15





$$e_{pi} = E_B + E_s$$

$$i_d = \frac{E_s}{Z}\sin(\omega t + \theta_f - \phi) - \left[\frac{E_s}{Z}\sin(\theta_f - \phi)\right]\epsilon^{-\omega t \cot\phi} - \frac{E_B}{R}\left(1 - \epsilon^{-\omega t \cot\phi}\right),\ \text{WHERE } \theta_f \leq \sin^{-1}\frac{E_B}{E_s}$$

SINGLE PHASE CONTROLLED RECTIFIER

NO. OF TUBES: 1 THYRATRON

NATURE OF LOAD: R, L, E_B IN SERIES

INVERSION

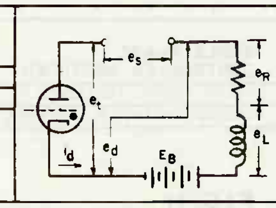
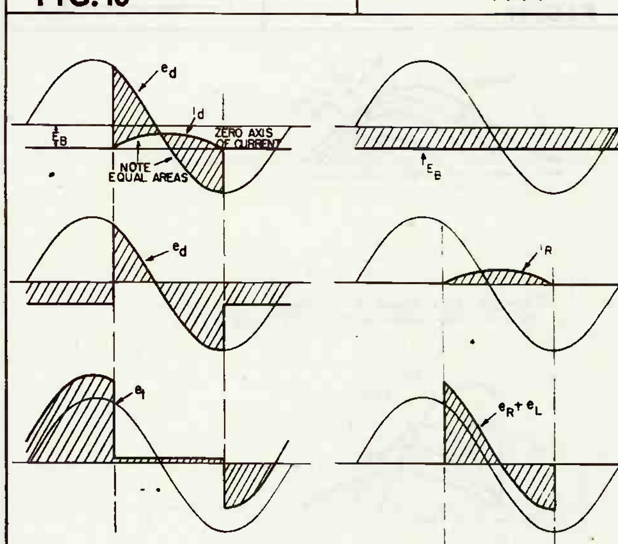
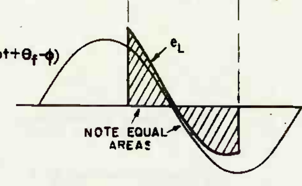


FIG. 16





$$i_d = \frac{E_B}{R}\left(1 - \epsilon^{-\omega t \cot\phi}\right) + \frac{E_s}{Z}\sin(\omega t + \theta_f - \phi) + \left[\frac{E_s}{Z}\sin(\theta_f - \phi)\right]\epsilon^{-\omega t \cot\phi}$$

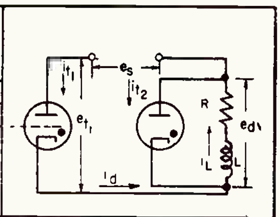
SINGLE PHASE CONTROLLED RECTIFIER

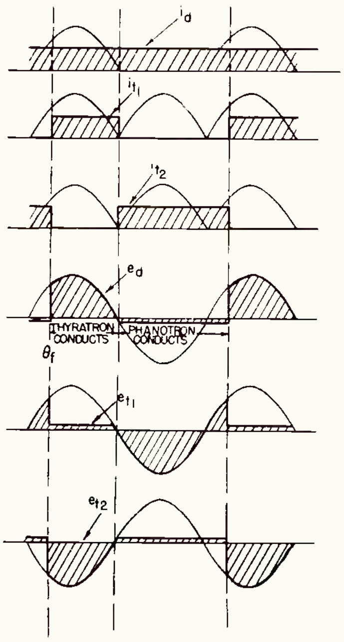
NO. OF TUBES: I PHANOTRON, I THYRATRON

NATURE OF LOAD: R,L IN SERIES (HIGHLY INDUCTIVE)

"ZERO" ANODE CIRCUIT
NEUTRAL ANODE CIRCUIT
"FREE WHEELING" CIRCUIT

FIG. 17





$$(I_d)_{av} = \frac{(1+\cos\theta_f)}{2\pi}\,\frac{E_s}{R}$$

$$(I_{t_1})_{av} = \left(\frac{\pi-\theta_f}{2\pi}\right)(I_d)_{av}$$

$$(I_{t_2})_{av} = \left(\frac{\pi+\theta_f}{2\pi}\right)(I_d)_{av}$$

$$(E_d)_{av} = \left(\frac{1+\cos\theta_f}{2\pi}\right)E_s$$

$$(E_d)_{rms} = \left[\frac{1}{2\pi}\,\frac{(\pi-\theta_f)}{2} + \frac{\sin\theta_f}{4}\right]^{\frac{1}{2}} E_s$$

$$e_{pi1} = E_s$$

$$e_{pi2} = E_s$$

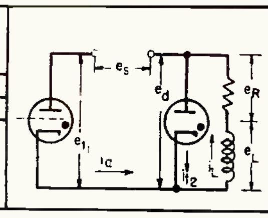
SINGLE PHASE CONTROLLED RECTIFIER

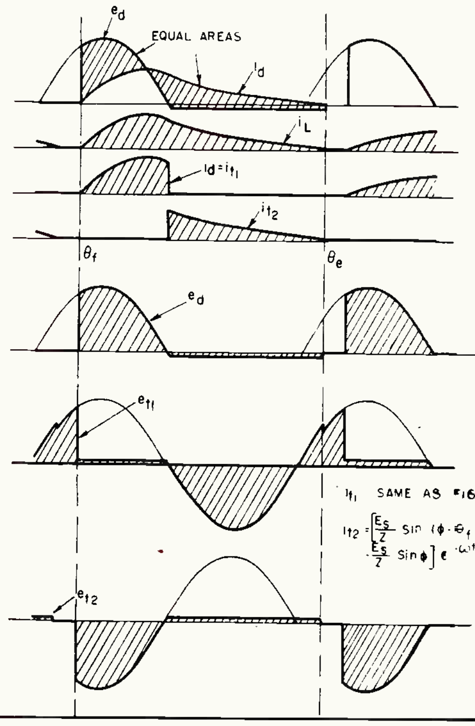
NO OF TUBES: I PHANOTRON, I THYRATRON

NATURE OF LOAD: R,L IN SERIES

DISCONTINUOUS CURRENT

FIG. 18





i_{t_1} SAME AS FIG 11

$$i_{t_2} = \left[\frac{E_s}{Z}\sin(\phi-\theta_f)\,\epsilon^{-(\pi-\theta_f)\cot\phi} - \frac{E_s}{Z}\sin\phi\right]\epsilon^{-\omega t\cot\phi}$$

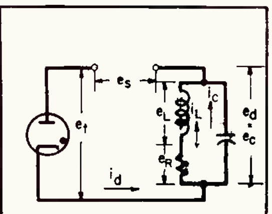
SINGLE PHASE UNCONTROLLED RECTIFIER

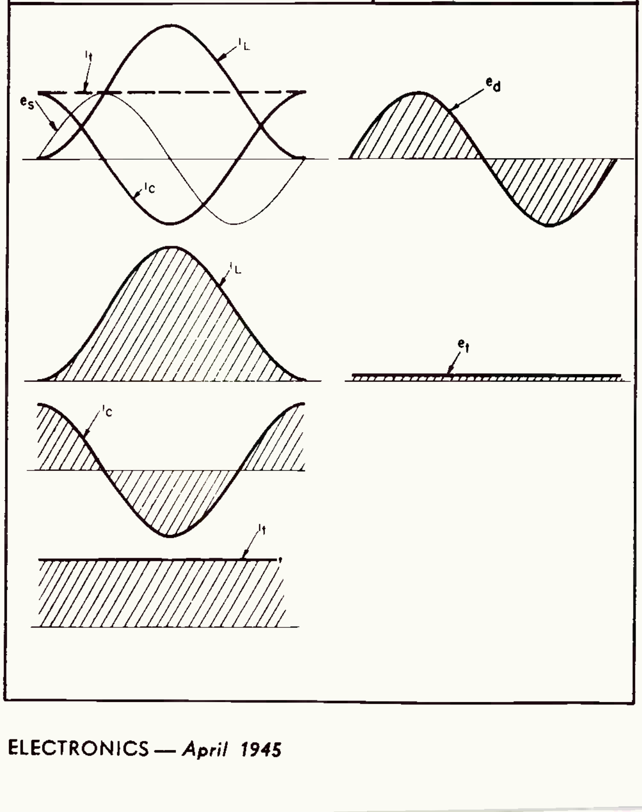
NO OF TUBES. I PHANOTRON

NATURE OF LOAD: R+L IN PARALLEL WITH C

$R = 0.\ \omega^2 LC = 1$

FIG. 19





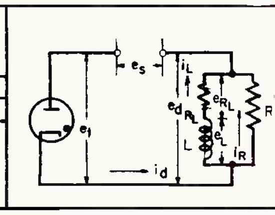
SINGLE PHASE UNCONTROLLED RECTIFIER

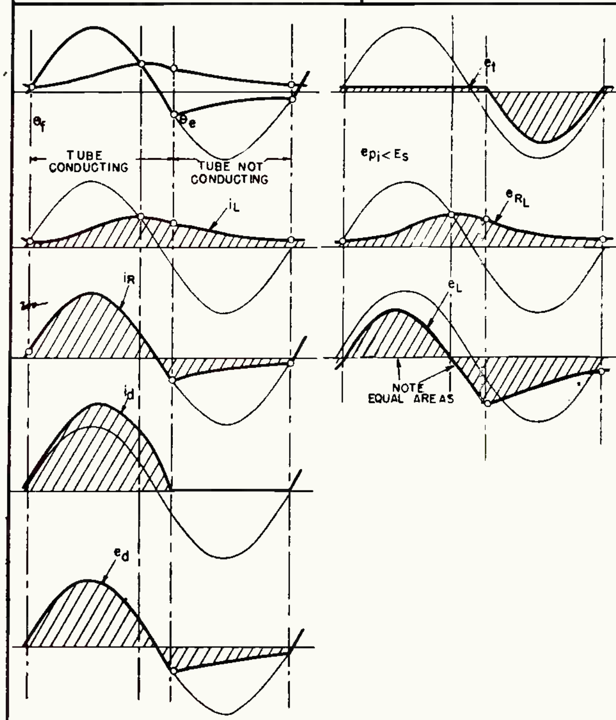
NO. OF TUBES: I PHANOTRON

NATURE OF LOAD: R,L IN PARALLEL

$R = R_L$

FIG. 20

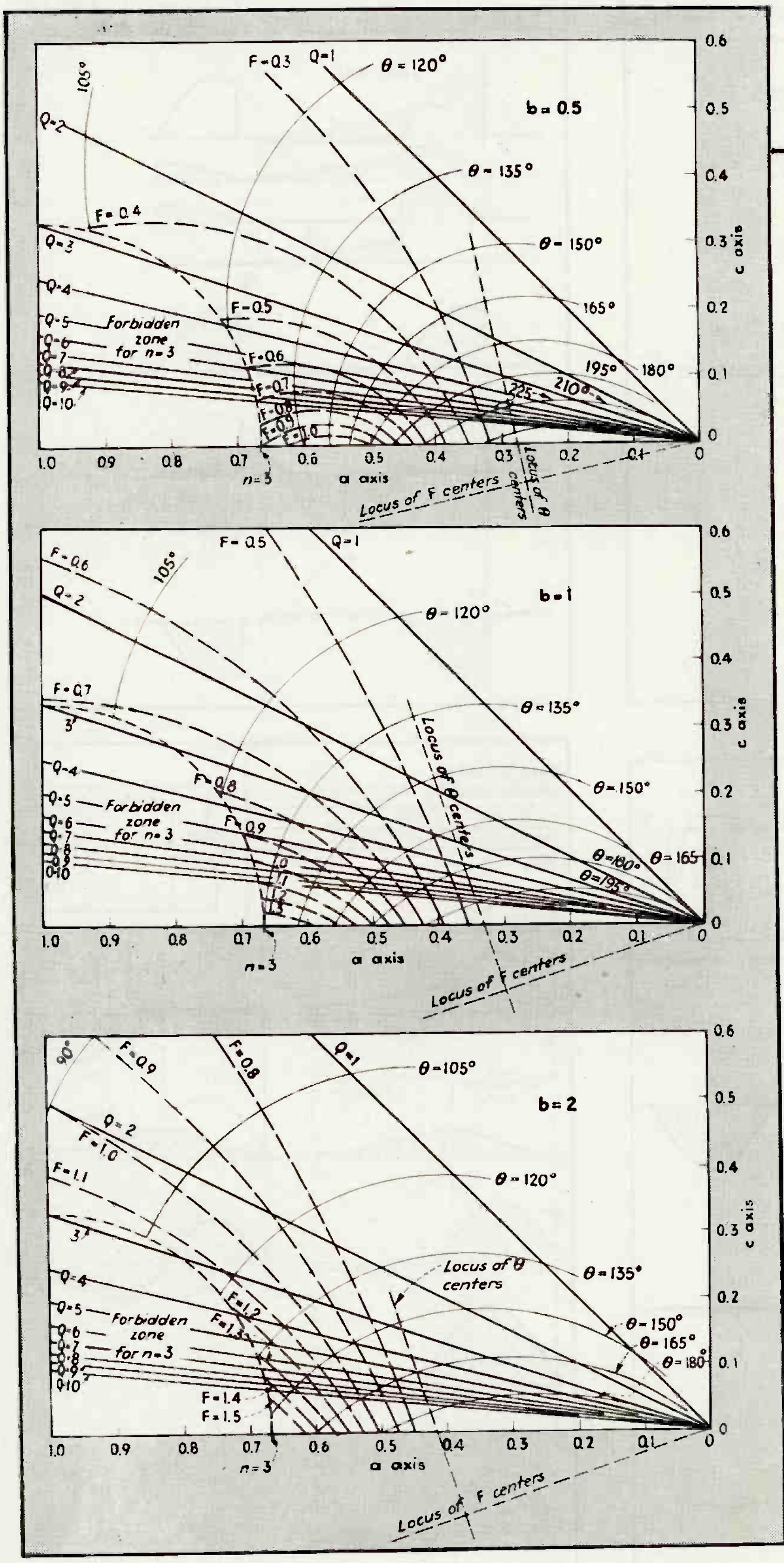




DESIGN of L-C

By ROBERT W. WOODS

Academic Dean, Union College
Lincoln, Nebraska



Charts for use in design of leading phase-shift networks

PROPER OPERATION of many electronic circuits depends upon the relative phase relation of voltages in associated circuits. To obtain the required phase relation some form of phase-shift net-work is used. If the current drain is small, simple R-C networks are adequate; but where the current is large, special equipment is required, such as a three phase source with isolating transformers for the selective mixing of the phases.

The familiar T-section L-C high-pass filter can be used for such requirements, but the calculations are laborious. The following analysis simplifies this design problem, without the inaccuracy of assuming an infinite Q for the coil to be used in the filter.

Filter Circuit Equations

We will assume a sinusoidal input voltage which originates in a source of negligible internal impedance compared to the input impedance of the loaded phase-shift network, and also assume that the network load is a linear element without reactance. If $C_1 = C_2 = C$ in Fig. 1, application of a-c theory gives the complex expression

$$\frac{e_R}{e_{in}} = \frac{b\left\{[ab(a-1)+c(bc-1)] + j[a(2a-1)+c(b+2c)]\right\}}{[(2a-1)+bc]^2+[b(a-1)-2c]^2} \qquad (1)$$

where $a = \omega^2 LC$
$b = \omega CR$
$c = \omega C_r$

From Eq. (1) we obtain an expression for the angle θ by which e_R leads e_{in}.

$$\tan\theta = \frac{a(2a-1)+c(b+2c)}{ab(a-1)+c(bc-1)} \qquad (2)$$

Likewise we obtain the attenuation

Phase-Shift Networks

Graphs facilitate design of filter-type phase-shift networks used in circuits handling large power. Required voltage and current ratings for components are determined analytically. Technique is applied to phase-lead filters using finite-Q coils

factor F which is the absolute value of the ratio given in Eq. (1).

$$F = \left|\frac{e_R}{e_{in}}\right| = \frac{b\sqrt{a^2+c^2}}{\sqrt{[(2a-1)+bc]^2+[b(a-1)-2c]^2}} \quad (3)$$

The quantities θ and F are thus functions of three independent variables a, b, and c, and can be plotted in three-dimensional space as contour surfaces. If we confine our attention to planes parallel to the a-c plane in this a-b-c space, the intersections of both the θ and F contour surfaces with these constant-b planes give a family of circles which is very easy to plot. Furthermore, it can be shown that the F circles form an orthogonal family with the θ circles. Rearranging Eq. (2) gives Eq. (4) from which circles for a discrete set of values of θ can be plotted in each constant-b plane.

$$\left[a-\frac{1-b\tan\theta}{2(2-b\tan\theta)}\right]^2+\left[c+\frac{b+\tan\theta}{2(2-b\tan\theta)}\right]^2 = \left[\frac{\sqrt{(1+\tan^2\theta)(1+b^2)}}{2(2-b\tan\theta)}\right]^2 \quad (4)$$

Similarly, rearranging Eq. (3) gives Eq. (5) for the F circles.

$$\left[a-\frac{2+b^2}{4+b^2(F^2-1)/F^2}\right]^2+\left[c+\frac{b}{4+b^2(F^2-1)/F^2}\right]^2 = \left[\frac{b\sqrt{b^2+1}}{F[4+b^2(F^2-1)/F^2]}\right]^2 \quad (5)$$

Equations (4) and (5) are each in the form $(a-\alpha)^2+(c-\gamma)^2 = r^2$, the equation of a circle with center (α, γ) and radius r. The locus of the centers (α, γ) of the F circles is a straight line in each b plane whose equation is $b\alpha + (b^2+2)\gamma = 0$ where α and γ are obtained from Eq. (5).

The locus of the centers of the θ circles is also a straight line $(b^2+2)\alpha' - b\gamma' = (1+b^2)/2$ where the parameters α' and γ' are coordinates of the centers of circles obtained from Eq. (4).

By analytic geometry it is shown that these two straight lines are mutually perpendicular at the point

$$(a, c) = \left(\frac{b^2+2}{2(b^2+4)}, \frac{-b}{2(b^2+4)}\right)$$

These geometrical relations are the property that makes it easy to plot the contour circles of θ and F on the various constant-b planes. Such planes are given for values of b equal 0.5, 1.0, and 2.0.

On these same constant-b planes other useful lines can be drawn by taking various ratios of a, b and c. Thus $a/c = Q = L/r$ is the equation of a family of straight lines through the origin.

Design Safety Factor

By applying a-c theory to the network, safety factors are calculated and given by the following relations.

$$\frac{e_{c1}}{e_{in}} = \frac{[(a-1)(2a-1-b^2)+2c(b+c)] - j[b(a^2+c^2)+c(b^2+1)]}{[(2a-1)+bc]^2+[b(a-1)-2c]^2} \quad (6)$$

$$\frac{e_{c2}}{e_{in}} = \frac{[a(2a-1)+c(b+2c)] - j[ab(a-1)+c(bc-1)]}{[(2a-1)+bc]^2+[b(a-1)-2c]^2} \quad (7)$$

$$I_L = \omega C e_{in} \times \sqrt{\frac{[c(b^2+2)+ab]^2+[(2a-1)-bc+b^2(a-1)]^2}{[(2a-1)+bc]^2+[b(a-1)-2c]^2}} \quad (8)$$

These safety factors should allow for extreme conditions as well as for normal operating conditions. It turns out that greatest voltage strain appears across C_1 if the load comes open, or analytically if b becomes infinite. Under this condition Eq. (6) simplifies to

$$|e_{c1}/e_{in}| = n = 1/\sqrt{(a-1)^2+c^2} \quad (9)$$

Rearrangement of Eq. (9) gives an equation for a circle which bounds a forbidden zone of operation. This boundary is given by $(a-1)^2+c^2 = (1/n)^2$. One such forbidden zone boundary for $n = 3$ has been plotted on the b planes.

Illustrative Design

As an example of the application of this analysis, suppose that we wish to shift the phase of the filament voltage of a 250TH tube by 120 degrees. The value of the elements in the phase shifter will be more reasonable if the shifting is

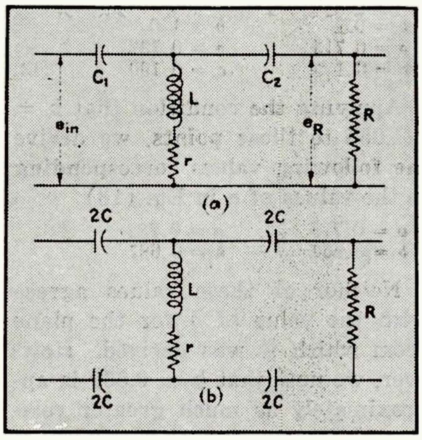


FIG. 1—Either an unbalanced (a) or a balanced (b) high-pass filter can be used to introduce a leading phase shift

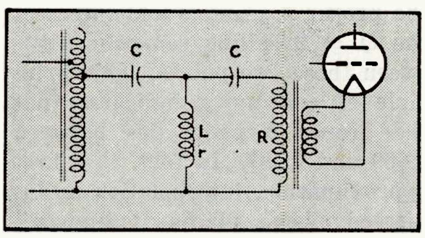


FIG. 2—Application of phase shifting to filament supply

accomplished in the primary circuit of the filament transformer as illustrated in Fig. 2.

As a starting point in the design, the coils available for the phase shifter were considered. One had the parameters $L = 0.173\ h$; $r = 17$ ohms at 60 cps, hence

$$Q = (377 \times 0.173)/17 = 3.84 = a/c \quad (10)$$

With the filament transformer to be used—a 12-volt secondary—67.5 volts at 1.1 amp was required across the primary to supply the 7.5 volts for the filament, and therefore the apparent load would be $R = 67.5/1.1 = 61.36$ ohms, whence

$$r/R = 17/61.36 = 0.277 = c/b$$
$$\text{or } c = 0.277b \quad (11)$$
$$\omega L/R = a/b = 1.065$$
$$\text{or } a = 1.065b \quad (12)$$

Only two of the three expressions in Eq. (10), (11) and (12) are independent, the third being derivable from the other two. Consequently we now have three independent conditions to harmonize, namely $\theta = 120°$; $Q = 3.84$: and either $a = 1.065\ b$ or $c = 0.277b$.

We are to find the value of b that will provide the solution of our problem. Referring to the planes where $b = 0.5$ and $b = 1.0$, we find that the $\theta = 120$ degrees circle crosses the $Q = 3.84$ line at

$$\begin{array}{ll} b = 0.5 & b = 1.0 \\ a = 0.713 & a = 0.732 \\ c = 0.185 & c = 0.190 \end{array} \quad (13)$$

Applying the condition that $b = a/1.065$ to these points, we derive the following values corresponding to the values of a in Eq. (13).

$$\begin{array}{ll} a = 0.713 & a = 0.732 \\ b = 0.669 & b = 0.687 \end{array}$$

Neither of these values agrees with the value of b for the plane from which it was derived. However, we note that $b = 0.669$ is approximately as much greater relatively than $b = 0.5$, as $b = 0.687$ is less than $b = 1.0$. Since the 120-degree circles are intersections of a continuous surface with successive b planes, the 120-degree circle in the proper b plane would intersect the $Q = 3.84$ line somewhere between these two points. This principle of continuity indicates that the proper b plane lies between 0.669 and 0.687. In fact, to a first approximation, interpolation as indicated above places it approximately midway between these values, giving $a = 0.7225$ and $c = 0.1875$. From these values and Eq. (11) and (12) we find that $b = 0.6778$.

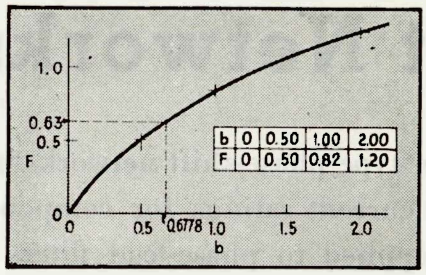


FIG. 3—Graphical interpolation is used to determine the attenuation factor F from the value of b obtained from the charts

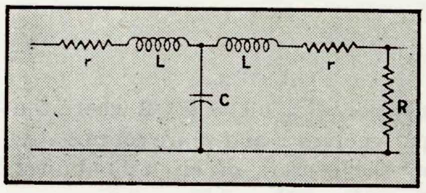


FIG. 4—Low-pass filter is used to introduce a phase lag

An alternative algebraic method for solving for the correct value of b is to substitute the values $\tan\theta = \tan 120° = -1.7321$, $a = 1.065b$, and $c = 0.277b$ in Eq. (2) and solve the resulting quadratic equation for b. One of the two answers is negative and manifestly spurious, but the other is $b = 0.6801$, from which we obtain $a = 1.065b = 0.7245$, and $c = 0.277b = 0.1883$.

The graphically determined values agree within 0.5 percent with the algebraically determined values. This algebraic method is probably as easy to perform as the graphical one. Both are presented, however, because of the vivid way in which the graphical method shows the interrelations of the various quantities.

R	0	61.36	∞
$\dfrac{e_{c1}}{e_{in}}$	0.575	1.138	2.98
$\dfrac{e_{c2}}{e_{in}}$	1.270	1.040	0
I_L	2.005	1.755	3.15

Table I—Evaluation of safety factors for use in determining the voltage rating of the capacitors and current and power ratings of inductor used in the phase shifter of Fig. 2

To determine the value of F to be used, we can interpolate by plotting F at $(a, c) = (0.7225, 0.1875)$—using the values of a and c obtained graphically—and the values of b for which the charts are plotted. This interpolation is carried out graphically in Fig. 3. For the previously determined value of b we find that $F = 0.63$.

Choice of Components

The required value of e_B is 67.5 volts, therefore $e_{in} = e_B/F = 107$ volts. Also $C = b/\omega R = 0.6778/377 \times 61.36 = 29.35 \times 10^{-6}$ farads. The safety factors are also evaluated for use in specifying the components, and are given in Table I.

The maximum voltage required of the capacitors will be $2.98 \times 107\ \sqrt{2} = 452$ volts. The current-handling ability of the coil must be 1.755 amp, and its power dissipation must be $I_L^2 r = 52.2$ watts.

The unit was built from these specifications and is serving its purpose very well. The assumption that the load contain no reactive component was not rigorously true; the internal impedance of the generator was not completely negligible, but the phase shift which was obtained was near enough to the required value to accomplish the purpose for which the shifter was designed.

Extension to Phase-Lag Circuit

A very similar treatment is possible for the phase-lag circuit shown in Fig. 4. In this case

$$\tan\theta = \frac{a(2-a) + c\,(b+c)}{(a-1)\,(b+2c)}$$

$$F = \frac{b}{\sqrt{[(a-1)(b+2c)]^2 + [a\,(2-a) + c(b+c)]^2}}$$

As before, we assign parametric values of θ and F in these equations, but the resulting curves in the constant b planes are not circles and therefore are difficult to plot. However, once constructed, their application is the same as for the phase-lead circuit. Likewise the algebraic method of solution described in discussing the phase-lead circuit is equally applicable to the phase-lag circuit. The equation in b resulting from the substitutions is linear and correspondingly easier to solve in the latter case.

HYPERBOLIC CHART

Conversion of hyperbolic tangent and cotangent of complex propagation constant $\gamma = \alpha + j\beta$ to rectangular coordinates simplifies transmission-line impedance calculations

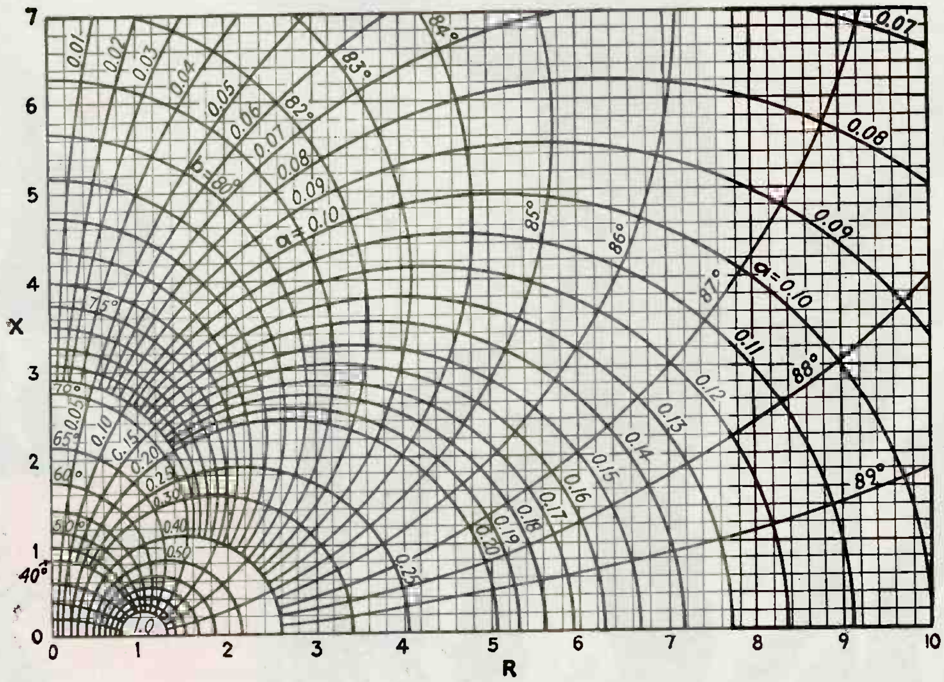


Chart for obtaining transmission-line impedance $R+jX$ from hyperbolic function of propagation constant

By PERRY H. WARE

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Cambridge, Mass.

IN DEALING with transmission-line problems, both communications and power engineers have occasion to use hyperbolic functions. The most commonly encountered are the tangent and cotangent, which relate the short-circuit and open-circuit impedance to the characteristic impedance and propagation function in the familiar expressions

$$Z_{sc} = Z_0 \tanh \gamma L$$
$$Z_{oc} = Z_0 \coth \gamma L$$

Since γL is a complex quantity, calculation of its hyperbolic functions involves considerable time and effort. The accompanying chart affords a simple means of evaluating the tanh and coth of $\gamma = \alpha + j\beta$.

The group of circles marked in degrees represents the imaginary part, β, while the other group corresponds to the real part, α. In order to use the chart, the following procedure should be followed:

Add or subtract multiples of 180 degrees to the imaginary part, β, of the complex angle until the remainder is positive and less than 180 degrees.

Determine the value of b from Table I.

Determine the rectangular coordinates at the point of intersection of the proper b circle with the a circle corresponding to α. For the rectangular coordinates so determined, R is always positive; the sign of X is determined from the last column of Table I.

Value of β in degrees	Function	Value of b in degrees	Sign of X
0 to 90	tanh	β	+
	coth	$90 - \beta$	−
90 to 180	tanh	$180 - \beta$	−
	coth	$\beta - 90$	+

Table 1—Relation of sign of X and value of b to magnitude of β

The following examples illustrate the use of the chart and Table I. In each example $a = 0.13$ and $b = 86$ degrees.

$$Z_{sc}/Z_0 = \tanh(0.13 + j266°) = \tanh(0.13 + j86°) = 6.0 + j3.2$$
$$Z_{sc}/Z_0 = \tanh(0.13 + j274°) = \tanh(0.13 + j94°) = 6.0 - j3.2$$
$$Z_{oc}/Z_0 = \coth(0.13 + j184°) = \coth(0.13 + j4°) = 6.0 - j3.2$$
$$Z_{oc}/Z_0 = \coth(0.13 + j356°) = \coth(0.13 + j176°) = 6.0 + j3.2$$

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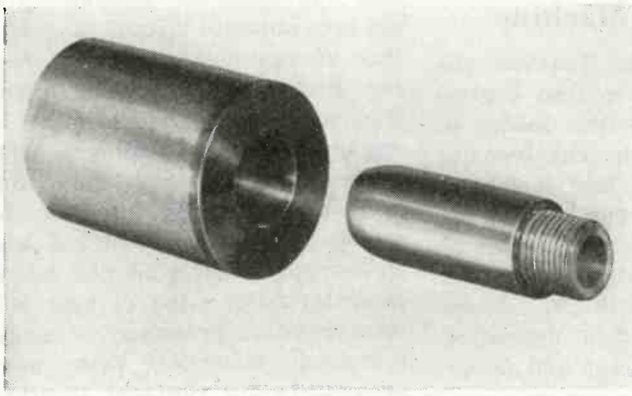
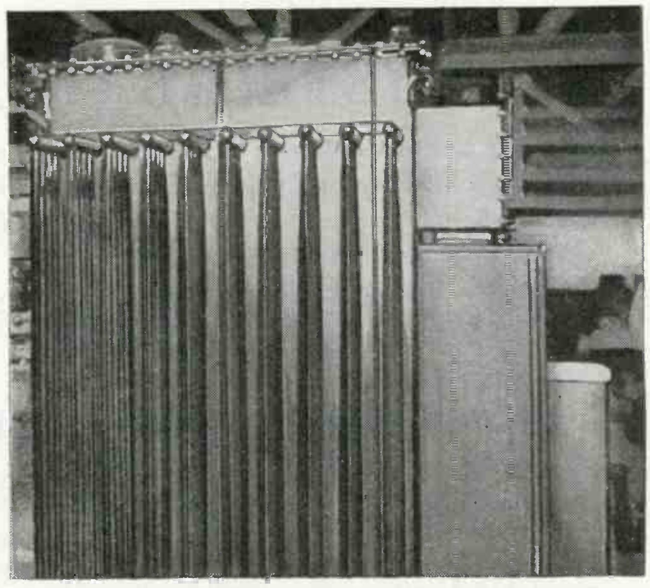
Carry 3,000 Amperes at 15,000 Volts





THOUSANDS of Mallory Contacts are giving dependable performance and long life in oil and air circuit breakers for heavy power applications. The heavy-duty contacts illustrated are required to interrupt and carry 3,000 amperes at 15,000 volts, in a giant oil circuit breaker. To meet these requirements calls for contacts that are plenty rugged!

A "plug-and-socket" type of contact assembly is used. To carry the heavy current, contact surfaces of Elkonite* 3W3, a Mallory refractory metal composition, have been specified on the recommendation of experienced Mallory contact engineers. The plug is made of copper with a complete cover of Elkonite on the contacting surface.

The socket is also made of copper, with an insert of Elkonite at the contact point. In the actual installation, the socket is cut into several segments, each mounted on a spring.

Mallory engineering "know-how" for solving contact problems covers the range from these large circuit breaker applications to the most minute silver or tungsten contacts for small relays, electronic and automotive controls.

Consult Mallory while your electronic or electrical product designs are being blueprinted. It pays to come to Mallory—Contact Headquarters—for experienced engineering help, the widest selection of contact and contact backing materials, and the most complete manufacturing facilities in the industry.

Write today for your copy of the Mallory contact catalog. The New Mallory Contact Data Book will be sent gratis to engineers when requested on company letterhead. Available to students, libraries and schools at $2.50 per copy, postage paid.

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

TYPICAL PHYSICAL PROPERTIES OF ELKONITE 3W3

Density: gm.–cc.	13.6
lbs.–cu.in.	.49
Conductivity, % I.A.C.S.	30-35
Hardness, Rockwell B	85-92
Tensile Strength, psi	80,000
Cross Breaking Strength, psi	130,000

Other grades of Elkonite are available with properties adapted to practically all heavy-duty contact applications.

*Reg. U.S. Pat. Off. for electric contacting elements.

INDUSTRIAL CONTROL

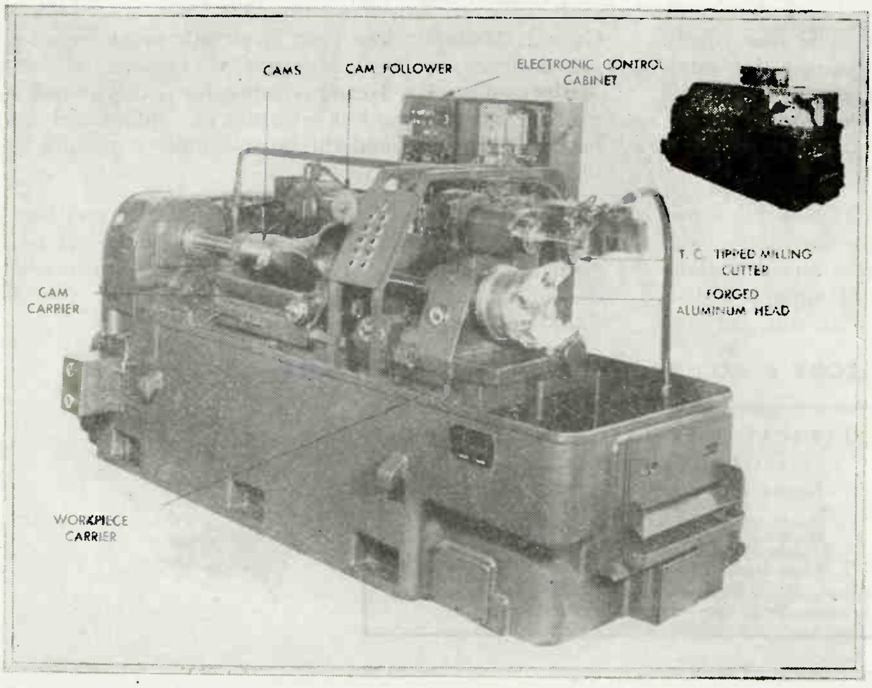
Built-in Electronic Control on Milling Machine

By combining the best features of electronic and hydraulic control, Sundstrand Machine Tool Company has designed and built a special machine for milling the circular, partial and dome fins on a forged aluminum airplane cylinder head. The one machine handles in two operations the milling of the same number of fins which formerly required four machines and four separate operations.

Actually, the milling of the circular and partial fins is done in one operation. The milling of the dome fins requires a change in the cams, the cutter and the work-holding fixture.

The path followed by the cutter is very irregular and constantly changes in shape and depth for each successive fin. However, the automatic electronic feed control keeps the fragile cutter loaded to full capacity. If the cut becomes light, the rate of feed increases, and if the cut becomes heavy, the rate of feed decreases. The rate of feed varies automatically within a range of 6 in. to 60 in. per minute, with the actual rate depending upon the depth of cut and horsepower consumed.

The machine has a complete automatic cycle after loading and an operator could run more than one machine if desired. There is no waste motion or cutting of air under the irregular cutting since adjustments are positive and the cutter can be set to rapid approach to within ¼ in. of each fin.



A combination of electronic and hydraulic controls on this one Sundstrand cylinder-head fin miller permits cutting the same number of fins as formerly required four machines. During the milling operation, the work is totally enclosed as shown in the insert

Unusual Methods of Applying Electronic Heat

By E. D. Tillson
Commonwealth Edison Company
Chicago

Some time ago it was announced to industrial customers of Commonwealth Edison Company that induction and dielectric heating units had been obtained through the courtesy of equipment manufacturers for running heat trials. Plant managers were invited to bring in any product within reason for test.

The result was surprising. Hog medicine, armatures, chicken feathers, popcorn, golf clubs, peanuts, and surgical sutures are only seven examples from a list of over 200 heterogeneous processed or semi-processed materials that were brought in for electronic heating tests. Some of the methods that were developed for applying electronic heat to various articles in production are described in the following case histories.

Figure 1(a) shows how an irregularly shaped metal strap was heated locally at points where it was later to be folded into a final assembly. The temperature required was 700 deg. F. The job was accurately done in 16 seconds.

The next illustration, Fig. 1(b), shows a powdered metal ring in which diamond particles are embedded. The problem was to sinter the metal to form a grinding wheel. The required temperature, 1400 deg F, was attained in 10 seconds. Unfortunately, the customer involved in this experiment did not have the proper mold material for so high a temperature and it disintegrated. However, he was satisfied that the application is a sound one, and is now making up molds from albarene.

Collapsible metal tubes such as shown in Fig. 1(c) are filled with tooth paste, ointment, etc., and are then sealed by folding and crimping at the bottom. A certain percentage of these folds later open up and the ointment comes out the wrong end. This was stopped by coating the inner metal surface with a plastic bonding film, folding, and heating to 250 deg F by a


Effective April 1st.
All shipments of I R C Type BT and BW resistors will be
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PREFERRED FOR PERFORMANCE
IRC
FIXED & VARIABLE RESISTORS
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401 NORTH BROAD STREET, PHILADELPHIA 8, PA.
IRC makes more types of resistance units, in more shapes, for more applications, than any other manufacturer in the world.

single-turn coil and loose coupling. The time required was only one second.

Output

The production for that particular customer was 17,000 tubes per day. No doubt the job can be done faster, but the unfolded portion of the tube, made of very thin lead, is hard to handle.

Some attempts have been made to heat the crimping dies by gas heat or other means, but there is a tendency for the lead to stick to the heated die so that the fold opens up as the dies are retracted. With induction heat, no physical contact is needed and this is avoided.

Collapsible tubes are painted and printed by the "roll-on" process. For drying the paint, the tubes were placed on a series of steel rods. The tubes are open at the bottom and the paint on the outside of the tube is dried by heat dissipated from the steel rod on the inside. Using electronic heating, the drying time is two minutes with the rod heated to 400 deg F. Convection oven heating, the alternative process, required 20 minutes for the base coat and 20 minutes for the overprint.

Thorium oxide is a chemically pure precipitate, white in color. It is used for gas mantles, high-temperature tubes, beakers, etc. The laboratory was called upon to fuse this oxide at 5,000 deg F. Several methods were tried and one, illustrated in Fig. 1(d), was finally developed which appears thoroughly practical. This involves the use of a special coil of six turns, 3 inches in inside diameter, embedded in a six-inch hard glass container together with a carbon crucible two inches in diameter and three inches high containing the oxide to be fused.

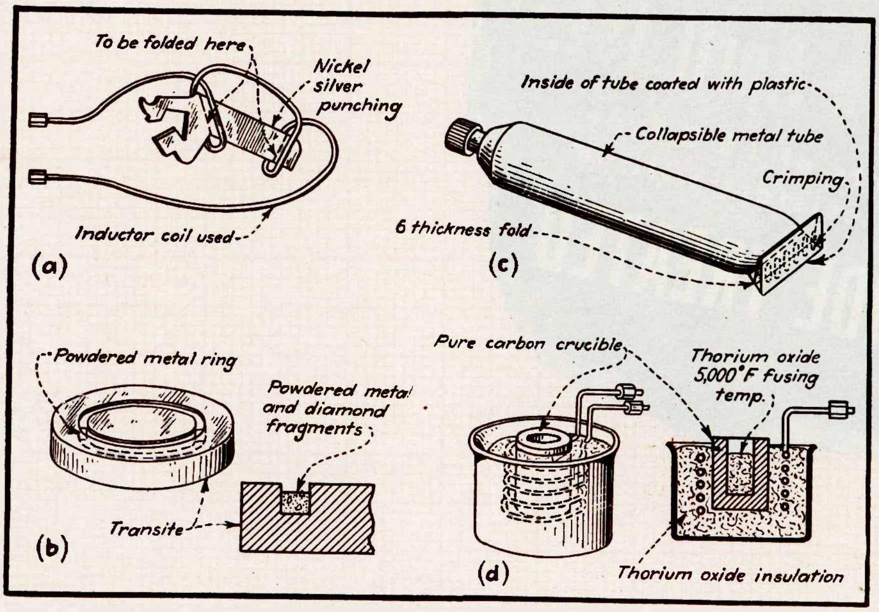


Fig. 1—Shape of coil used to heat two spots on a metal strap for later bending. (a) Powdered metal and embedded diamond chips for a grinding wheel are shown at (b). At (c) is a collapsible metal tube ready for sealing by induction heating. An arrangement for fusing thorium oxide in a carbon crucible is shown at (d)

The space between the outside of the crucible and the walls of the outer container are also filled with thorium oxide packed around the coils as a heat insulator. Its insulating value when used in this manner is very high. A 2-ounce load of thorium within the crucible is fused in 14 minutes. The only known alternative is electric arc fusing of very small quantities, which is a relatively tedious and uncertain method and is also believed to be wasteful of thorium.

Centrifugal Casting

Illustrated in Fig. 2(a) is a mold for centrifugal casting of steel parts. Many plant engineers are acquainted with ordinary centrifugal casting, but this operation has some new features. It employs a heavy sheet-metal cylinder enclosing a sand mold. A polystyrene pattern is used instead of wood. The styrene is melted out by induction heating applied to the metal cylinder and steel is injected into the cavity by centrifugal force.

Accurate castings requiring no subsequent machining are produced in very high carbon steels, stainless steel, or almost any metal desired. A slow rate of heat is required at the start to prevent excessive moisture and alcohol in the sand mix from exploding the mold. On these particular samples, the ideal seemed to be four one-minute cycles separated by one-minute intervals. The method formerly used required from 1¼ to 1½ hours to melt out the styrene. Considerable experiment has been done on sand cores and sprue plugs. Both operations appear quite feasible and desirable.

Impregnation

In drying a small armature, preheating with induction heating was done before dipping it into insulating varnish. Afterwards it was baked by induction heating at 240 deg F. A six-turn coil was used. One minute was required for preheat, and for baking, two minutes with power on, which brought the piece to curing temperature after which baking occurred from residual heat. This is in contrast

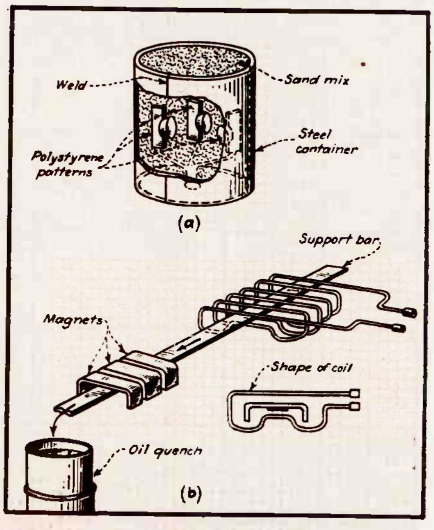
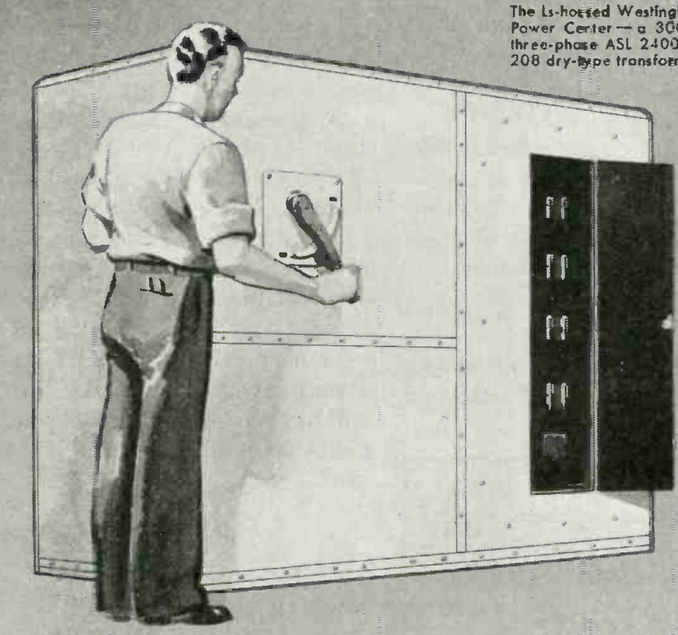


Fig. 2—A mold for centrifugal casting of steel parts is shown at (a) and a method of heat-treating and quenching magnets at (b)



The Ls-housed Westinghouse Power Center—a 300 kva three-phase ASL 2400-120/208 dry-type transformer.

Compact and light in weight, this Westinghouse Power Center Unit means new speed and efficiency in power installation. This easily-handled "package power" can be located at the actual load center to simplify wiring problems and effect savings of up to 75% in secondary cable requirements.

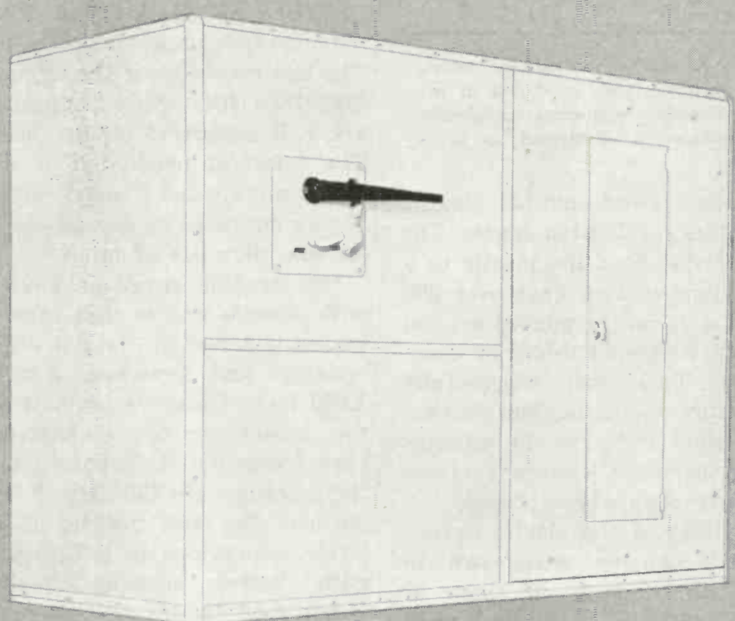
Lindsay Structure, modern method of light metal construction, contributes to the unusual lightness and compactness of the power center unit. Utilizing the principle of uniform tensioning to provide a unique high strength-weight ratio, Ls makes additional supports unnecessary even in housings for heavy machinery. And Ls units leave the equipment they house readily accessible with the removal of the nearest panel.

Parts for Lindsay Structure, available in steel or non-magnetic aluminum, are pre-formed to your individual requirements. A new war service also makes it possible to furnish completely or partially assembled units—ready for the installation of your machinery or equipment—anywhere in the United States.

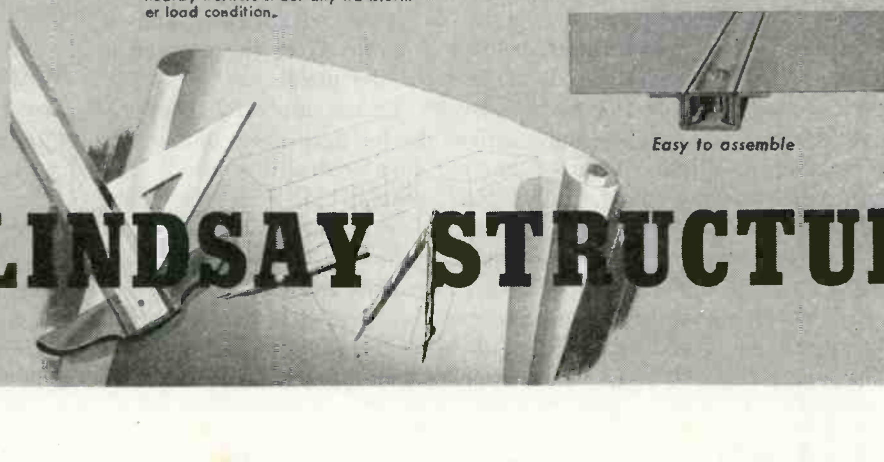
Check the possibilities of Lindsay Structure as a cabinet or housing for *your* product. **Write to Lindsay and Lindsay, 222-D W. Adams St., Chicago 6, Ill.; or 60 E. 42nd St., New York 17, N.Y.; or to Lindsay Structure (Canada) Ltd., Dominion Square Building, Montreal.**

Lindsay Structure Houses Westinghouse Power Center Unit

This sturdy, attractive, pre-formed structure available in steel or non-magnetic aluminum



An unusually safe type of installation, the Westinghouse Power Center Unit requires no vault—yet safeguards nearby workers under any transformer load condition.



Easy to assemble

LINDSAY STRUCTURE

U. S. Patents 2317629, 2263510, 2263511
U.S. and Foreign Patents and Patents Pending

In every case, heating before impregnation increases the depth of penetration and heating after impregnation prevents case-hardening, brought about by premature surface hardening. A great many of these jobs can best be done by high-frequency heating.

The magnets in Fig. 2(b) required heating to 1700 deg F and oil quenching. This was accomplished in 13½ seconds, as contrasted with 16 minutes in a convection oven.

In the manufacture of golf clubs, a bond was needed between the steel head, weighing between 8½ and 10 ounces, and the steel shaft of the golf club. The tapered hole in the head had been previously coated with polyvinyl acetate. The head was heated to 350 deg in one second and a very severe torsional test was applied. This method is now in regular use. The bond has been pronounced unbreakable, and there is no discoloration of the chrome plating.

Steel banding strap such as used on packing cases must be blued, both the flat and edge surfaces. The temperature required is 650 deg F. A flat coil of 18 turns was used and the strap blued at the rate of one foot per second. The customer now uses a lead bath 30 feet long and 100 tons of lead. Induction heat for this purpose entails an electrical demand of approximately 80 kilowatts for a daily production of 264,000 feet of strap.

Dielectric Heating

All sizes and types of abrasive wheels have been submitted for cure or polymerization of the binding resin. On one particular type, some difficulty was experienced due to swelling, but otherwise an acceptable curing job was done. It is believed that if the wheel were retained between two perforated transite plates and a perforated transite ring was used for the periphery, the moisture would escape without causing swelling. Apparently the pressure is not great. In fact, it is possible to keep the grinding face accurate merely by wrapping a few turns of mucilage tape around the wheel before treating. There has been no opportunity to retest this particular wheel, but others have been successfully cured without distortion. The temperature depends upon the resin used. It may be anywhere from 150 to 350 deg F. Aluminum oxide is frequently employed as the abrasive. This wheel was heated dielectrically in ten minutes. The alternative method requires 36 hours.

Casting Teeth

A mold for casting teeth is shown in Fig. 3(a). Instead of sand, we have here a vinyl chloride plastic, a soft sticky yellowish mass. The problem is to heat the plastic to a flowing temperature (not over 290 deg F) so it can be poured around the teeth without bubbles or overheating. This was successfully done in three minutes. The alternative method required 30 minutes and, furthermore, certain portions are nearly always overheated.

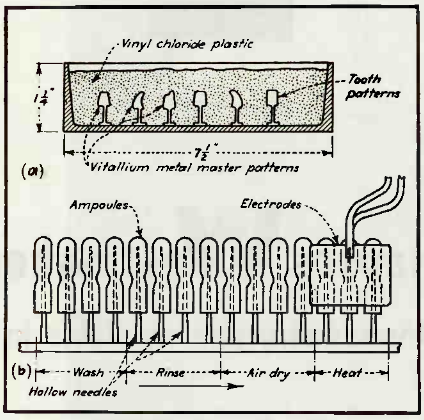


Fig. 3—A resilient mold for manufacturing false teeth is shown at (a). A conveyor-belt operation for sterilizing ampoules is illustrated at (b).

The virtue of the plastic is that the teeth can be withdrawn in spite of the "non-draw" shape of the tooth and in a single flask mold without parting lines. The plastic is merely forced back by the pattern as it is withdrawn, and it closes in again after the pattern is free from the mold.

Brake lining material was required to be preheated before insertion in a hydraulic press. The lining consists of asbestos fiber, phenolic resin, filler and brass filings. Because of the filings there were breakdowns of single and double thicknesses of the material. This was overcome as more layers were added. By treating four layers at once with dielectric heating, the temperature was raised to 500 deg F in one minute.

A non-skid neoprene shoe sole must be polymerized under a press of 100 pounds per square inch. A plate facing must be used which does not cause the neoprene to stick to it. The sample was polymerized in two minutes at 200 deg F. Incidentally, all these curing jobs that have been carried out with steel or aluminum alloy molds in the past will have to be cured in non-metallic molds if dielectric heating is to be used.

Drying Ampoules

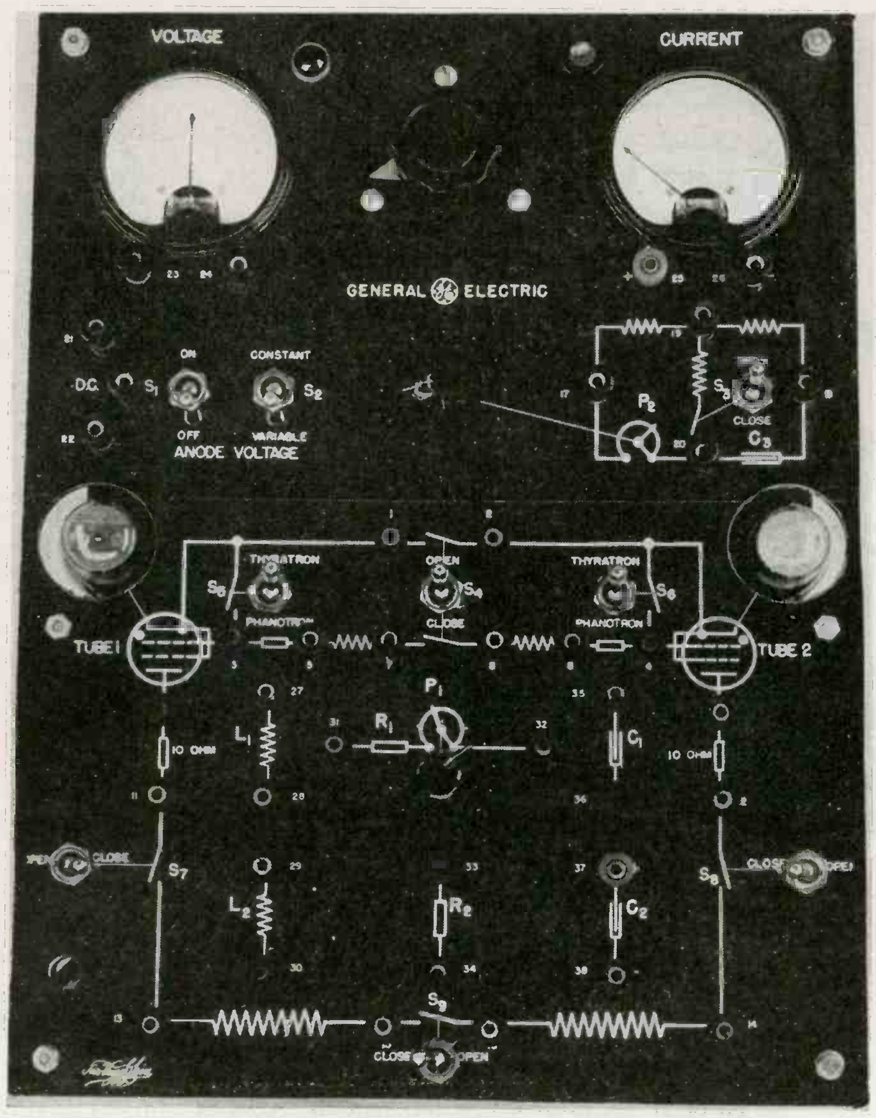
Ampoules are filled with sulfa drugs, penicillin, etc., and shipped to the Army and Navy. After sterilization, the moisture must be removed. In the dielectric-heating process worked out for this operation, the ampoules are mounted on hollow needles through which distilled water and air are successively sprayed. All of this occurs on a conveyor belt as shown in Fig. 3(b). The last operation is the drying by high frequency while the ampoules are still supported on the needles. The speed of production is about 60 per minute and it could evidently be accomplished by a machine having six kilowatts of input.

One trouble surgeons have had with sheep's gut is that after the wound is sewed up the gut absorbs moisture and stretches. A roll of 1,000 feet of gut was submitted to the laboratory to be heated by high frequency. It is known that a temperature of 300 deg F case-hardens the gut, making it relatively impervious to moisture and with better slipping qualities. Ovens used for the process require an eight-hour bake. The job was done by high frequency in six minutes.

Wave-Form Demonstrator for Controlled Rectifier Circuits

By P. T. Chin and E. E. Moyer

Electronic control equipment is more and more frequently using controlled rectifiers of the gaseous-discharge type. The one-way valve action of the rectifying element produces nonsinusoidal and often



Front panel of wave-form demonstrator, developed for use as a teaching aid in industrial electronics classes

discontinuous wave forms in the rectifier circuits. The formation of these wave forms is not too evident to those who are familiar only with circuits under ordinary sinusoidal driving forces.

The equipment described can be used, with the assistance of one or more cathode-ray oscilloscopes, to demonstrate:

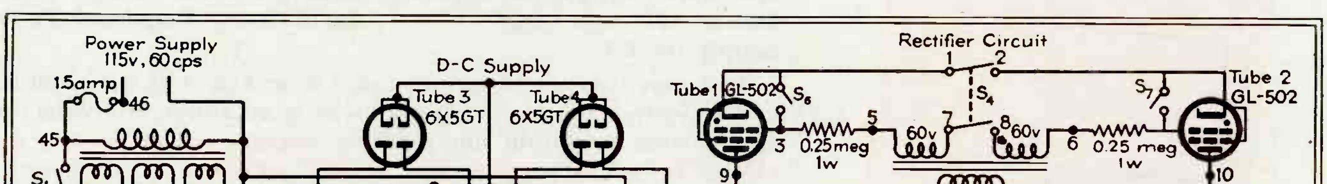
1. Methods of grid control of thyratrons:

(a) D-C bias only
(b) A-C bias of fixed amplitude and variable phase angle
(c) A-C bias of fixed amplitude and fixed phase angle plus d-c bias of variable magnitude

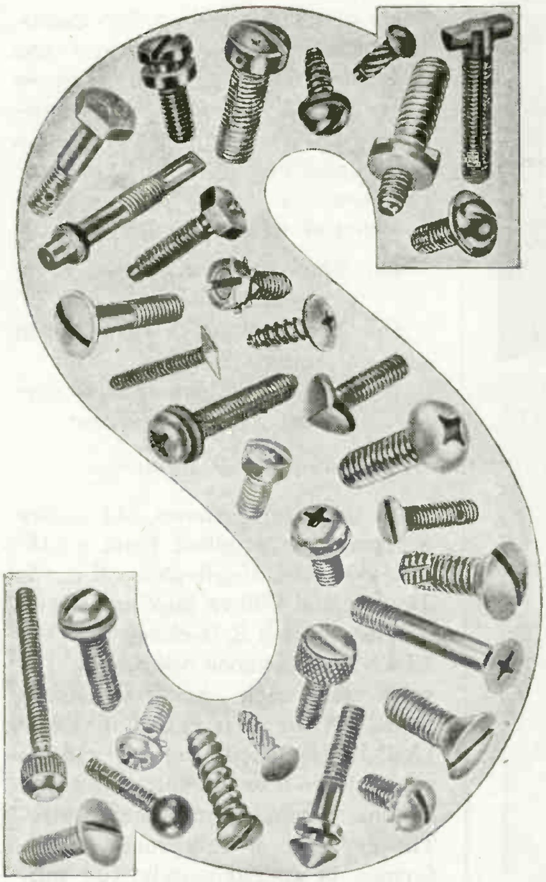
2. The behavior of single-phase (one phanotron or one thyratron) and bi-phase (two phanotrons, one phanotron and one thyratron, or two thyratrons) half-wave rectifier circuits supplying a load consisting of *R*, *L*, *C*, counter electromotive force, or any combination of these, and showing:

(a) The voltage wave form across the load
(b) The voltage wave form across the tube
(c) The wave forms of tube current and load current
(d) The inverter action of a controlled rectifier supplying an inductive load

3. Using high-vacuum diodes in-



Circuit of wave-form demonstrator for controlled rectifier circuits. All terminals numbered from 1 through 38 go to jacks on the front panel, for use with patch cords in setting up various circuit combinations for connecting these terminals to the two meters



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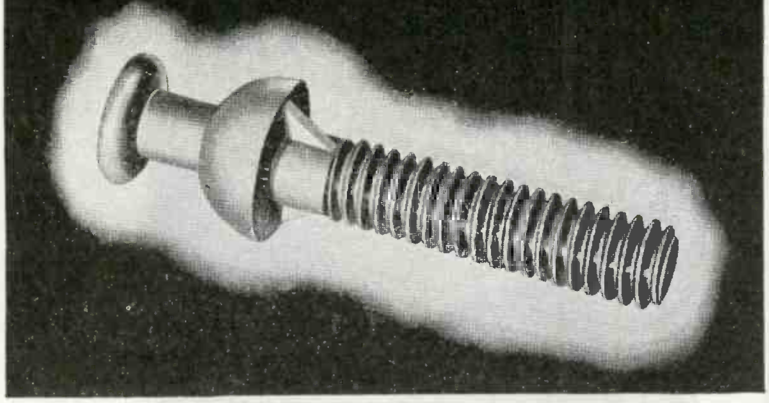

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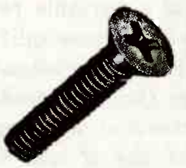

1 Phillips Recessed Head Screws—The modern, effective, time-saving fastening device proven in tens of thousands of assembly lines. Other standard head styles are also available.

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Forethought, when your product is still in the design stage, can mean timely delivery of fastenings for that "long planned" fast assembly job. Your early and precise choice of fastenings—standard or special—may be vital to the fast and exacting assembly job required for an advantageous start on postwar production.

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stead of phanotrons or thyratrons, the behavior of single-phase (one rectifying element) and bi-phase (two rectifying elements) half-wave rectifier circuits supplying a load consisting of *R, L, C,* counter electromotive force, or any combination of these, and showing:

(a) The voltage wave form across the load
(b) The voltage wave form across the tube
(c) The wave forms of tube current and load current

Description of Equipment

As the circuit shows, the entire equipment is supplied from a 115-volt, 60-cycle, single-phase line. It draws about 100-va maximum load.

When switch S_2 is closed to CONSTANT, the anode voltage is 115 volts on each anode-to-neutral phase. When S_2 is closed to VARIABLE, the anode voltage can be varied from 0 to 115 volts by means of the variable autotransformer. The capacity of this anode transformer is approximately 100 milliamperes d-c output from the bi-phase half-wave rectifier circuit.

Phase-shifting Network

A midtapped transformer winding, a capacitor, and a variable resistor are arranged in a phase-splitting bridge circuit. The output voltage of the bridge (between midpoint of the transformer winding and the junction of the *R* and *C* bridge arms) can be varied in its phase relation to the supply voltage (anode voltage of the thyratrons) by varying the resistance arm of the bridge. This output voltage supplies the primary winding of a grid transformer whose two secondaries supply the grid circuits of the thyratrons.

This d-c source is derived from two bi-phase rectifiers connected together so that their output voltages oppose each other. The primary windings of the two anode transformers are connected to the slider of the variable autotransformer in such a manner that as the slider is rotated the voltage of one transformer is reduced while that of the other is increased; thus the d-c output from the two rectifiers is caused to be variable from +100 volts to −100 volts (approximately). The capacity of this d-c

source is approximately 75 ma.

This d-c source is intended to be used as the d-c bias for grid control or as a counter electromotive force in a load circuit.

Switching Arrangement

The different types of rectifier circuits can be set up conveniently and quickly from a minimum number of circuit parts. The function of each switch is explained in the following:

S_1—The opening of this switch removes power from all devices except the tube filaments, which can be de-energized only by disconnecting the a-c supply lead. The pilot light is ON when S_1 is closed; S_1 should be opened when circuit connections are being made.

S_2—As explained already.

S_3—When this switch is opened, the grid transformer, T_2 is de-energized. This is necessary when d-c bias only is used to grid control the thyratrons.

S_4, S_5—Opening these two switches segregates the anode, the cathode, and the grid circuits of the two thyratrons. This is necessary for the inverse-parallel, the voltage-doubler, and the zero-anode circuits.

S_6, S_7—When these switches are closed, the bias on the grids of the thyratrons is made zero because the grids are connected to the respective cathodes. The thyratrons thus lose their grid control characteristics and act as phanotrons. When S_6 and S_7 are opened, grid control is possible.

S_8, S_9—These switches are connected in the anode circuits of thyratrons. Therefore if one tube is required, the switch in the anode circuit of the unused tube can be opened to isolate that tube. This switch also provides an opening in the anode circuit so that the d-c milliammeter can be inserted in the circuit to read average values of tube current.

Circuit Details

Two instruments are provided on the panel. One is a 150-0-150-volt, zero center, permanent magnet type (d'Arsonval) d-c voltmeter (800 ohms/volt). This volt-

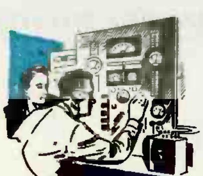
Planned convenience speeds production on these efficient assembly benches.

COLLABORATION:

N-Y-T service to the electronic manufacturer begins at the design stage. The experience of N-Y-T design engineers extends into every field in which transformers are used. These men are at your service.

ENGINEERING:

N-Y-T engineers will meet your requirements at minimum unit cost. They also know how to design transformer components so as to simplify your production assembly and reduce dimensional requirements.

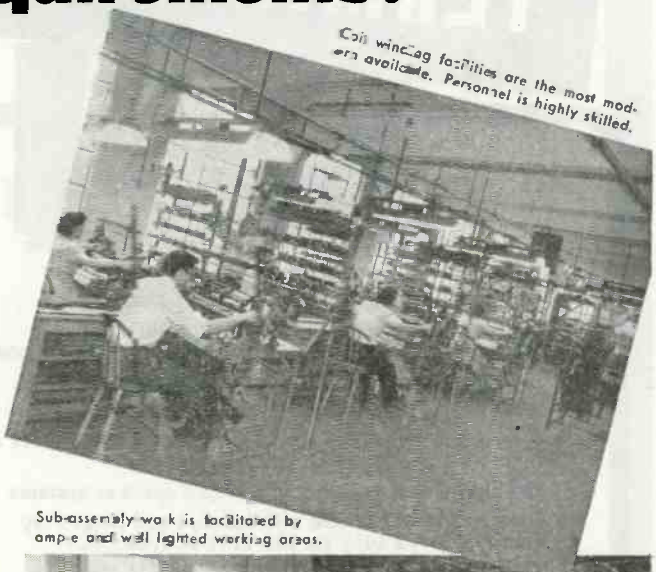


MANUFACTURING:

Highest quality is paramount. Not only electrical characteristics but all materials used in assembly are held to the most exacting requirements. Rigid inspection is imposed at every stage of production.

THE NAME FOR PRECISION

...ready to meet present and post-war transformer requirements!



Coil winding facilities are the most modern available. Personnel is highly skilled.

Sub-assembly work is facilitated by ample and well lighted working areas.

Complete in every phase of transformer manufacture, the Alpha Division of N-Y-T embraces one of the most modern equipped plants in the East, including complete laboratories, engineering and manufacturing facilities.

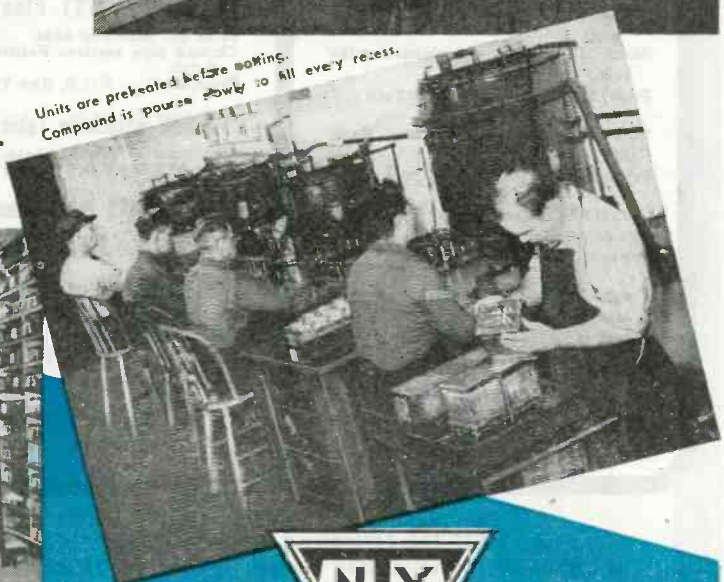
This new plant is now at peak production and is rapidly assuming the roll of 'transformer department' to many of the leading manufacturers of electronic equipment.

NEW YORK TRANSFORMER COMPANY

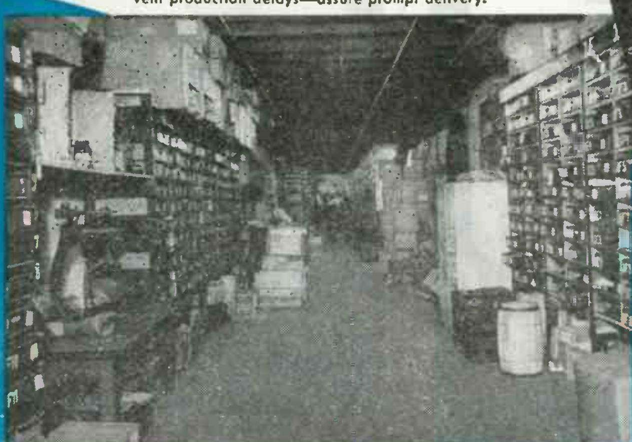
GENERAL OFFICES

26 WAVERLY PLACE, NEW YORK 3, N. Y.

Units are preheated before potting. Compound is poured slowly to fill every recess.



Ample inventories systematically stocked prevent production delays—assure prompt delivery.



TRANSFORMERS, CHOKES AND FILTERS

meter is intended for indication of the average voltage across the load or a circuit component. The zero-center feature is useful when demonstrating the transition from rectification to inversion to show that the output voltage of the thyratron circuit reverses although the current through the tubes continues in the same direction. The other meter is a 0-200 ma, permanent magnet type (d'Arsonval movement) d-c milliammeter. (This is a 10-ma movement.) This instrument is intended for indication of the average current through the load, through a tube, or through a circuit component.

Safety Resistors

Resistors R_3 and R_4 are connected in series with the anodes of tubes to limit the surge current incident to short-circuits, arc-back, or capacitor-input filters. At the same time these resistors provide sufficient *IR* drop so that the anode-current wave can be viewed on a c-r oscilloscope.

To study high-vacuum tube rectifiers, the two thyratrons can be replaced by two 6X5GT double diodes, which have the same socket connections for heater, anode, and

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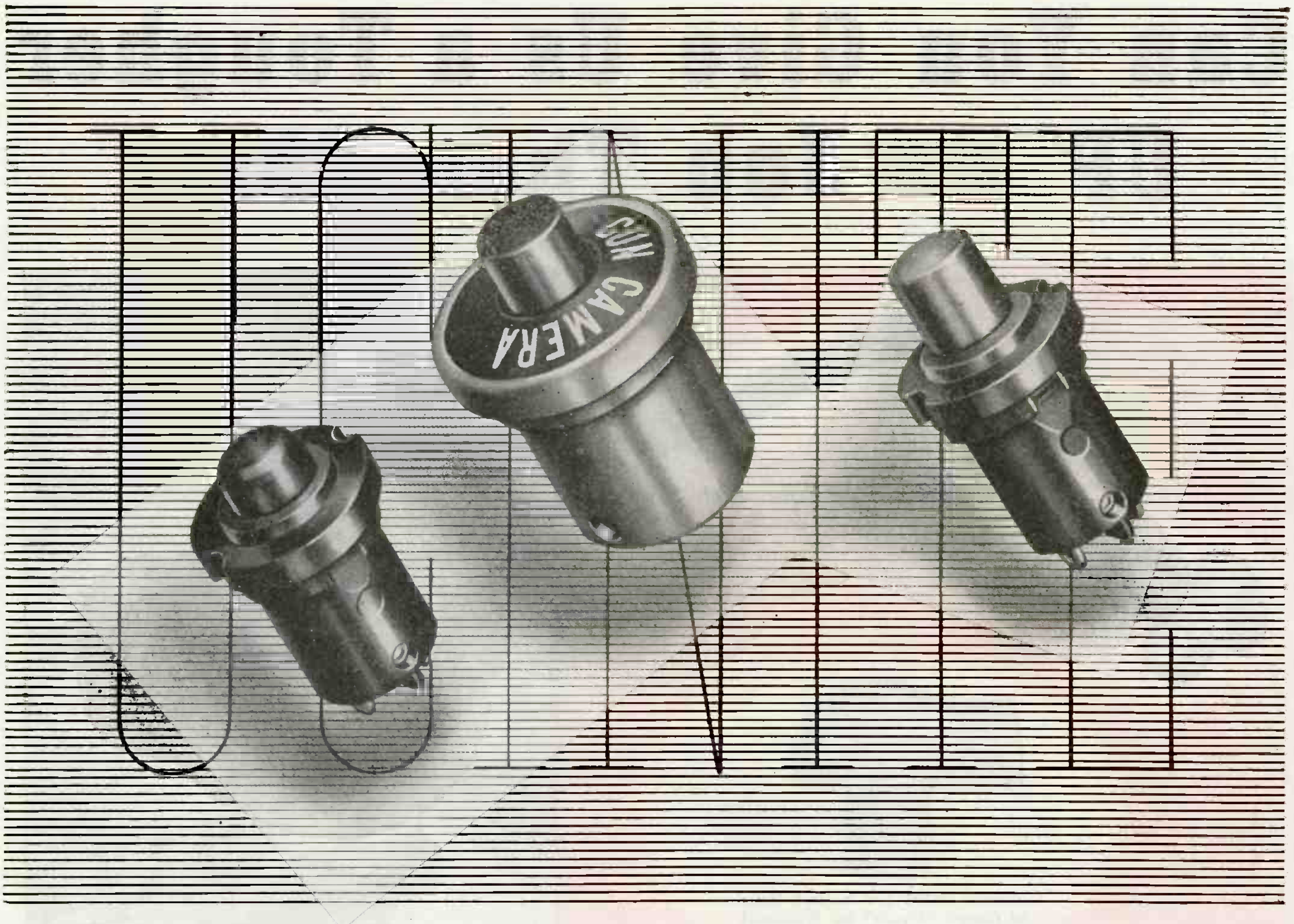
FACSIMILE ON MOVING TRAIN

The conductor of a Rock Island freight train removes a facsimile message sent to him by radio from a wayside station. A complete message form is turned out in three minutes



Push-Button De Luxe

This Ucinite push-button switch is used in planes for turret control. It fires machine guns, and operates gun cameras and intercommunication microphones. On the Republic "Thunderbolt" it is used to squirt water into the carburetor for emergency spurts of speed.

An exclusive Ucinite design, this push-button switch represents a departure in switch operation. Its wide acceptance is due to its special usefulness in close quarters and its ability to operate under extreme variations of air pressure and temperature.

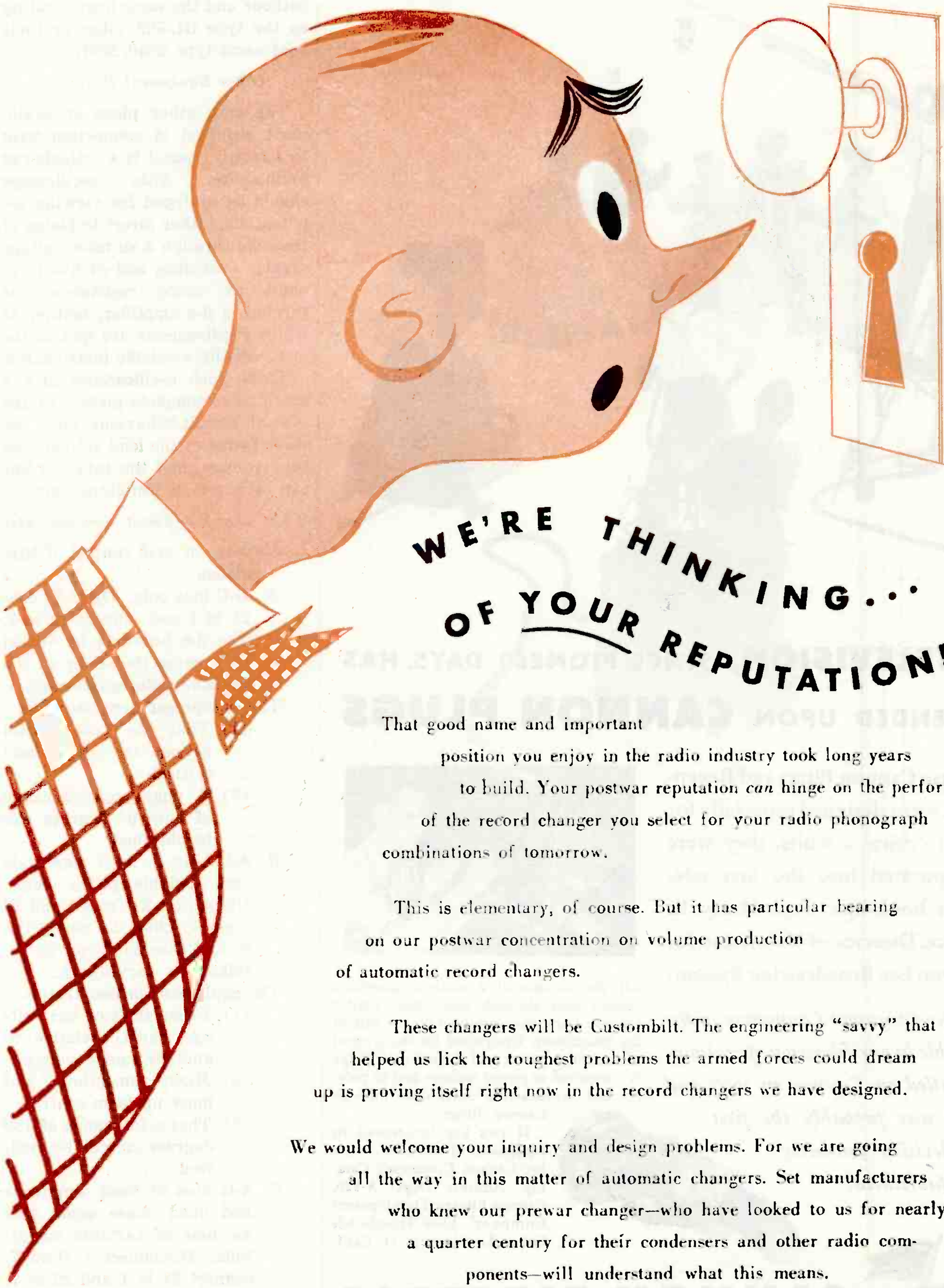
Here is one war-developed gadget with a real postwar future.

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.



WE'RE THINKING... OF YOUR REPUTATION!

That good name and important position you enjoy in the radio industry took long years to build. Your postwar reputation *can* hinge on the performance of the record changer you select for your radio phonograph combinations of tomorrow.

This is elementary, of course. But it has particular bearing on our postwar concentration on volume production of automatic record changers.

These changers will be Custombilt. The engineering "savvy" that helped us lick the toughest problems the armed forces could dream up is proving itself right now in the record changers we have designed.

We would welcome your inquiry and design problems. For we are going all the way in this matter of automatic changers. Set manufacturers who knew our prewar changer—who have looked to us for nearly a quarter century for their condensers and other radio components—will understand what this means.

GENERAL INSTRUMENT CORPORATION

The first in our Industry to be so honored — ARMY E NAVY

829 NEWARK AVENUE • ELIZABETH 3, N. J.

cathode and the same heater rating as the type GL-502 tubes or their equivalent type 2050/2051.

Other Equipment Required

The only other piece of equipment required in connection with this rectifier panel is a cathode-ray oscilloscope. This oscilloscope should be equipped for viewing d-c potentials, either direct to plates of the tube through a suitable voltage divider (variable, and of five megohms or more resistance) or through a d-c amplifier, neither of which requirements are met in the more readily available instruments.

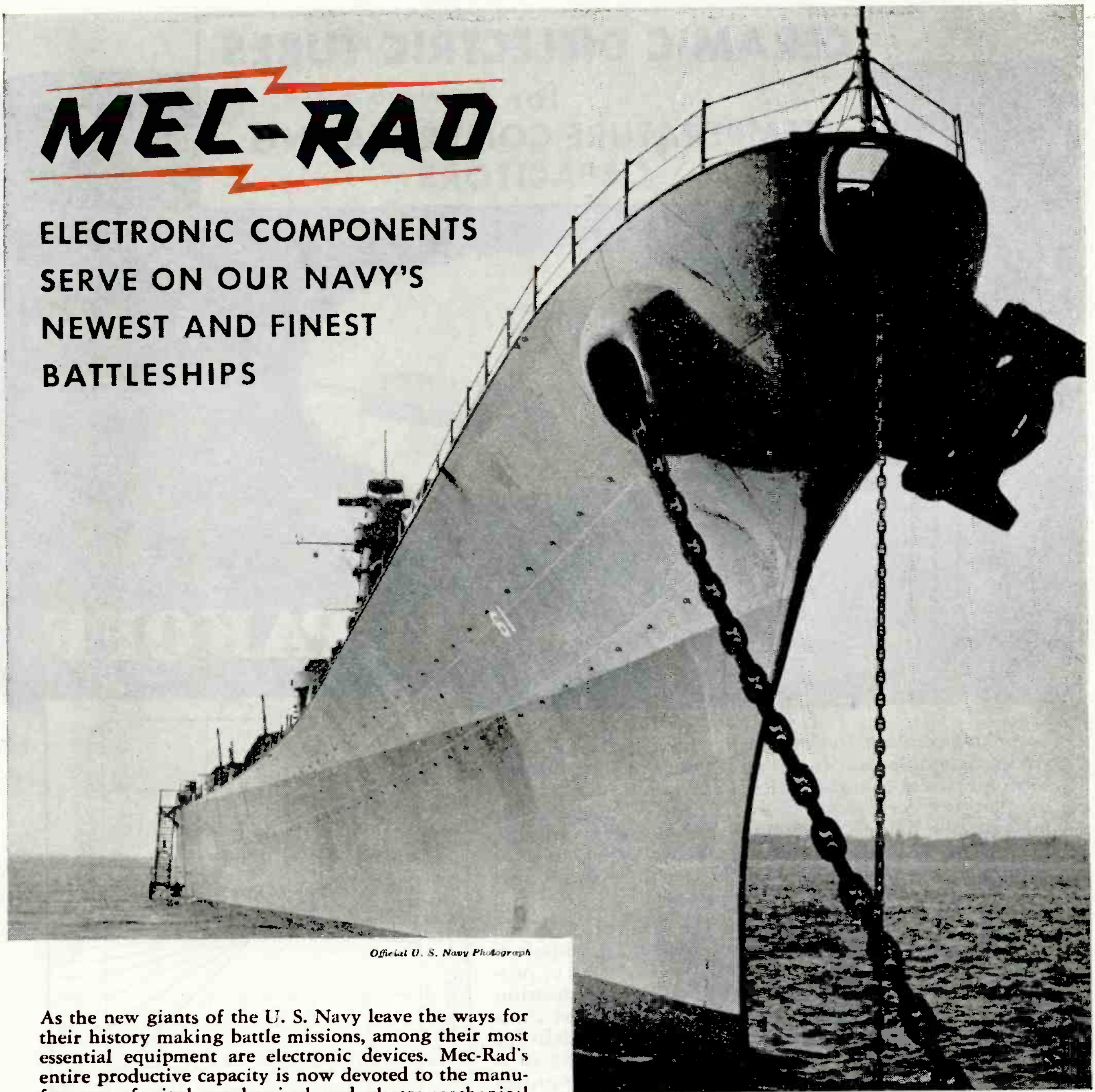
Three such oscilloscopes give a much more complete picture of the over-all circuit behaviour, since the wave forms of the load voltage, the tube voltage, and the tube current can be observed simultaneously.

What the Equipment Demonstrates

1. Methods of grid control of thyratrons
   A. D-C bias only. Open S_3, connect 21 to 1 and connect 22 to 7. The d-c bias can be varied by turning the slider on the variable autotransformer.
   The equipment demonstrates:
   (1) That the grid control action is rough and critical
   (2) A phase control range of only 90 degrees can be obtained
   B. A-C bias of fixed amplitude and variable phase angle. Disconnect 21 from 1 and 22 from 7, close S_3, connect 1 to 7. Phase shift can be obtained by varying R_2.
   The equipment demonstrates:
   (1) Phase shift of one voltage (grid) relative to another anode voltage
   (2) Much smoother and more uniform control
   (3) That a full range of 180 degrees cannot be realized
   C. A-C bias of fixed amplitude and fixed phase angle plus d-c bias of variable magnitude. Disconnect 1 from 7, connect 21 to 1 and 22 to 7, close S_3.
   The equipment demonstrates:
   (1) That approximately 180 degrees of phase control is possible
   (2) The effect of different

MEC-RAD

ELECTRONIC COMPONENTS SERVE ON OUR NAVY'S NEWEST AND FINEST BATTLESHIPS



Official U. S. Navy Photograph

Bow-on view of the U.S.S. IOWA, archetype of the Navy's newest class of battleships.

As the new giants of the U. S. Navy leave the ways for their history making battle missions, among their most essential equipment are electronic devices. Mec-Rad's entire productive capacity is now devoted to the manufacture of vital mechanical and electro-mechanical components for these electronic units.

Our work includes "fancy brass plumbing" of all types involving soft and hard soldering, close tolerances, precision machining, careful assembly and finishes ranging from lacquer to silver and rhodium plating.

After the war our specialized facilities will be available to the electronic industry for peacetime needs. You can use our engineering "know-how" based on years of experience in this field, for planning your post-war products today.

MEC-RAD

DIVISION-BLACK INDUSTRIES

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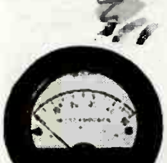
WHAM!
"HE WAN'STA KNOW WHY THEY CALL THIS THA' PACIFIC THEAYTER"
SWISH
ZING



fixed phase-angles of the a-c component of grid voltage on the control characteristic

(3) That this method of control is apt to be critical near the almost-phased full-off position

2. The behavior of single-phase and bi-phase half-wave rectifier circuits with different types of load

The equipment demonstrates:

(a) The voltage across the load
(b) The voltage across the tube
(c) The current through the load
(d) The current through the tube

Under conditions of:

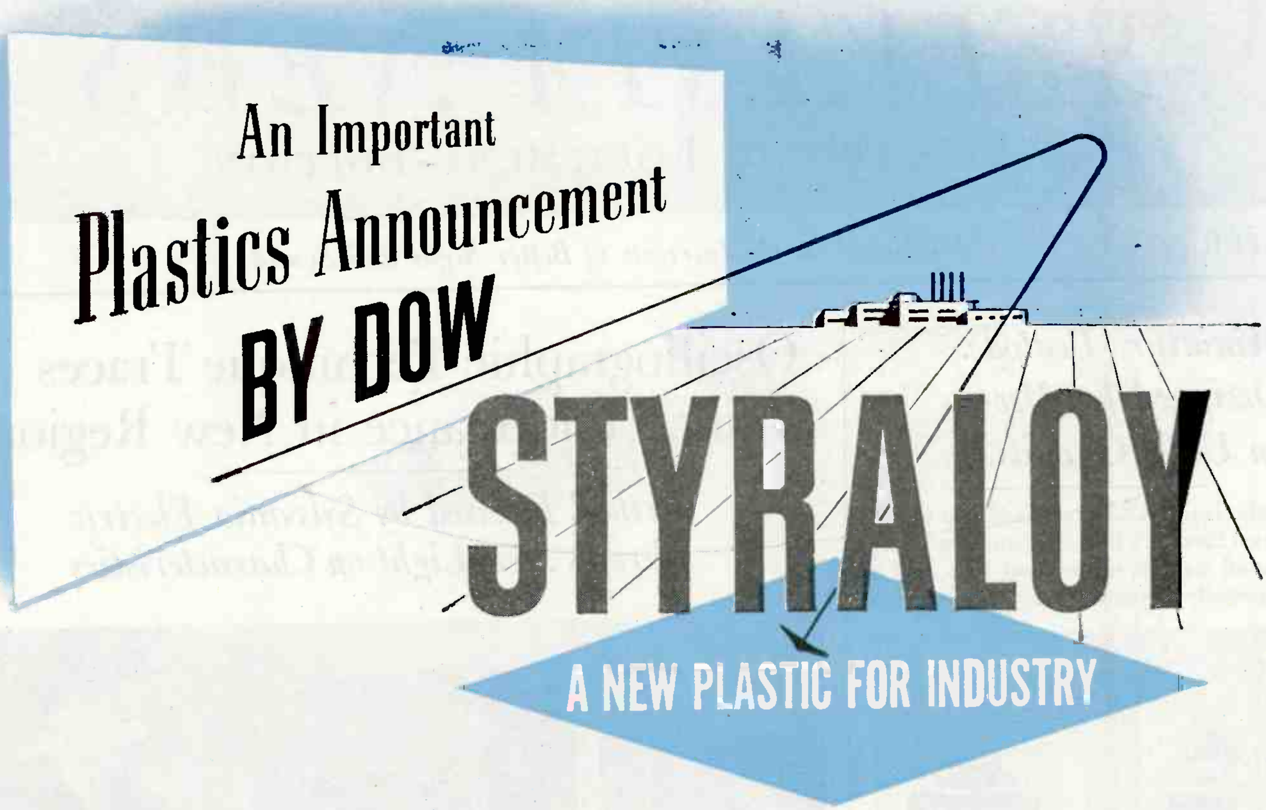
(a) Different phase control angles (if the tube is a thyratron)
(b) Different values of circuit constants (e.g., different ratios of L/R in an inductive circuit, or different ratios of counter electromotive force to anode voltage)

Of particular interest is the sudden change in the grid control characteristic at the point of transition from continuous to discontinuous load current when the load is

• • •

SURRENDER AMPLIFIER

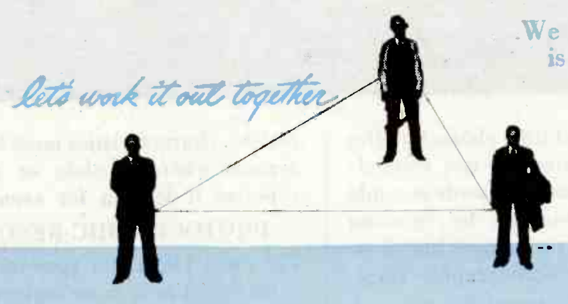
Cornered Japs in Burma are invited to give up by members of Psychological Warfare Division of SEAC using this electronic megaphone. If first call is ignored, Japs get shelled. Then music is played and followed by second call. If this is not effective, all-out shelling is



Highly significant among countless new materials developed for war requirements is Styraloy—trade name for a remarkable group of plastics belonging in a category between rubber-like materials and rigid thermoplastics.

"Working it out together" with the Armed Forces, Dow developed the first of this impressive new line—Styraloy 22—to provide a one-piece cable sheathing with a low power loss at high frequencies and possessing great durability and flexibility. These unique qualities—combined with others presented below in capsule form—point to its use in a broad range of products. As a result, unlike many war-born materials, Styraloy anticipates a peacetime career of great importance.

Now that Styraloy is available for commercial purposes, molders and manufacturers or designers will find Dow equally willing to cooperate with them in developing to the fullest extent the numerous applications indicated by the impressive list of Styraloy's properties. "Let's work it out together."



We at Dow know from experience that success in plastics is not a one-man nor even a one-industry job. It calls for the combined skill and cooperation of manufacturer or designer plus fabricator plus raw materials producer. Working together, this team saves time and money and puts plastics to work successfully. Call us—we'll do our part.

PRESENT AND POTENTIAL USES: One-piece cable sheathing; handles for tools, household appliances, etc.; gaskets; bushings; coil forms; floor mats; scuff plates; many applications still to be ascertained.

PROPERTIES AND ADVANTAGES: High dielectric strength, low power loss over all frequencies. Power factor only .005 at 100-300 megacycles. Flexible and shock resistant from −90° F. to 212° F. Specific gravity less than 1 (floats in water). Water absorption only .2 to .5%. Resists heat, ozone, and most chemicals. Highly resistant to abrasion. Resists permanent indentation. Ideally suited to extrusion of complex cross sections and readily fabricated by other molding techniques. Easily machined.

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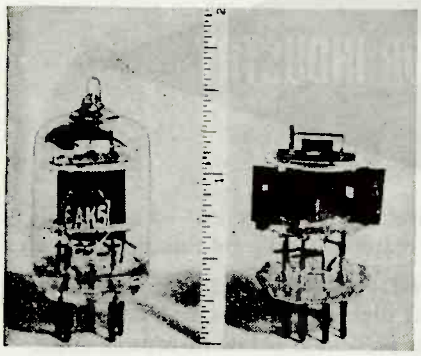
SYLVANIA NEWS

ELECTRONIC EQUIPMENT EDITION

APRIL — *Published in the Interests of Better Sight and Sound* — 1945

Miniature Pentode Designed for Use In UHF Circuits

Tube Type 6AK5, a new addition to Sylvania Electric's line, is a miniature sharp cut-off pentode in the short bulb, and is especially suitable for use in ultra high



frequency equipment. Small size and high efficiency make it useful in portable equipment.

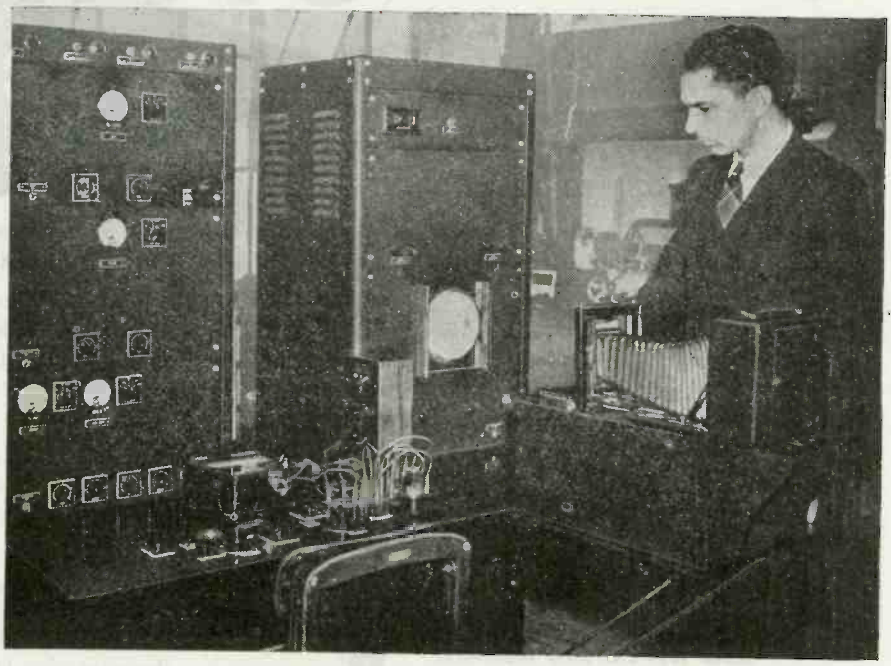
Full technical information may be obtained from Sylvania Electric.

SYLVESTER SURVEY

"Would you say your postwar radio choice would be the large console type or the smaller, table-top model?"

Oscillographic Technique Traces Tube Performance in New Regions

Method Devised by Sylvania Electric Throws New Light on Characteristics



The measurement of tube characteristics in regions where previous test methods were inapplicable has been made possible through the development, by Sylvania Electric, of a new procedure, based on photographing an oscillographic trace.

EARLIER METHODS

Formerly, tube characteristics were taken by a point-by-point method. This was extremely slow, and had the still greater disadvantage that it could be used only in those parts of the characteristics where the tube would not be damaged by continuous operation. In many recent applications, characteristics must be known in regions where a plate or grid would vaporize if left on for even a second.

PHOTOGRAPHIC RECORDING

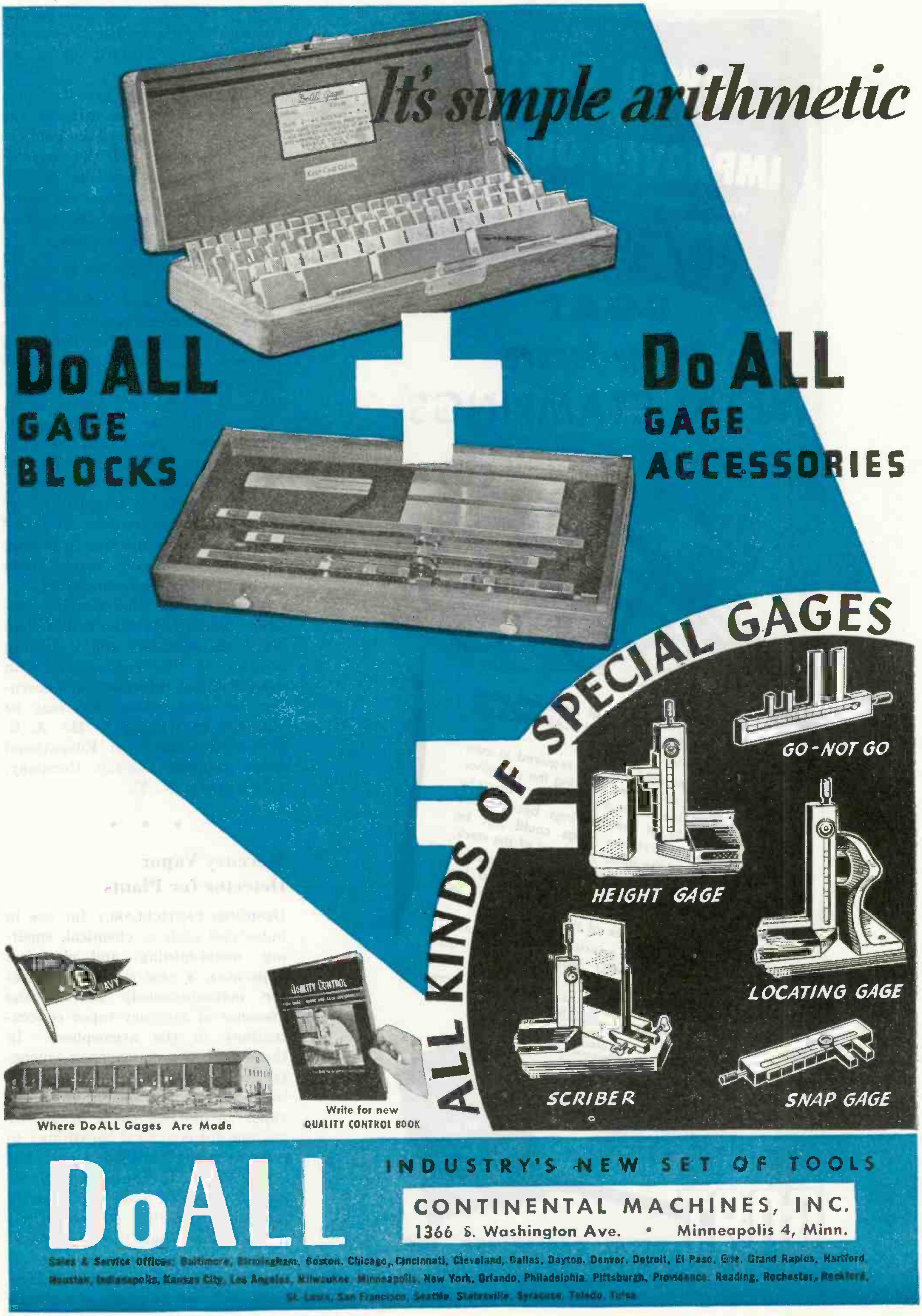
The new technique permits taking of characteristics in these regions. The oscillographic trace of the characteristics is shown on a special Sylvania 7-inch cathode ray tube, and may be photographed.

Improved tubes and circuits are expected to result from the use of the new method, equipment for which was built in Sylvania Electric's Commercial Engineering Laboratory.

SYLVANIA ELECTRIC

SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa.

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


It's simple arithmetic
DoALL
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ALL KINDS OF SPECIAL GAGES
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St. Louis, San Francisco, Seattle, Statesville, Syracuse, Toledo, Tulsa

highly inductive, and the partial remedy for this condition when the inductance is shunted by a resistance.

Also of interest is the effect of a counter electromotive force on the grid control characteristic, particularly in the case of the inverse-parallel circuit when the hold-off period of the incoming thyratron widens from the usual 180 degrees and approaches 360 degrees.

Rectifier Data Sheets

The current and voltage wave forms at different parts of the circuit are tabulated for the more common single-phase and bi-phase half-wave rectifier circuit combinations in a two-part presentation, "Gaseous Rectifier Circuits" starting in the April, 1945 issue of ELECTRONICS. These examples will serve as a pattern for the instructor who wishes to complete all of the circuit combinations. It is interesting and instructive to predict these various wave forms, then verify them on the equipment.

Copies of the photographic diagram (using industrial rather than electronic symbols) and a drilling templet of this instrument with more detailed information concerning the construction, etc., may be obtained by writing to Mr. A. C. Stevens in charge of Educational Sales, General Electric Company, Schenectady, N. Y.

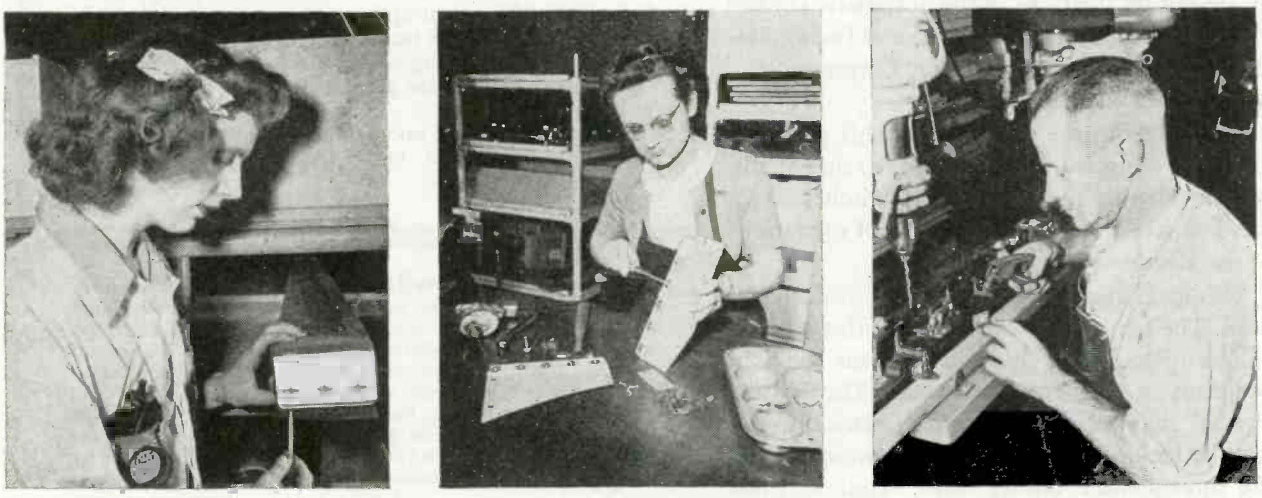
• • •

Mercury Vapor Detector for Plants

DESIGNED PARTICULARLY for use in industries such as chemical, smelting, metal-mining, and electrical apparatus, a new electronic detector instantaneously detects the presence of mercury-vapor concentrations in the atmosphere. In these fields, mercury-vapor concentrations must be kept below the toxic limit (1.2 parts mercury vapor in 100,000 parts of air by volume, for continual breathing) to safeguard the health of employees.

Announced by the Special Products Division of G-E, the detector measures directly concentrations as high as one part in three million parts of air by volume and as low as one part in two hundred million parts, with an accuracy of approxi-

Photos courtesy of Boeing Aircraft Company



SPEED NUTS HELP THESE BOEING WORKERS BOOST B-29 PRODUCTION

TINNERMAN PRODUCTS, INC.

2106 Fulton Road, Cleveland 13, Ohio

In Canada: Wallace Barnes Co., Ltd., Hamilton, Ontario *In England:* Simmonds Aerocessories, Ltd., London

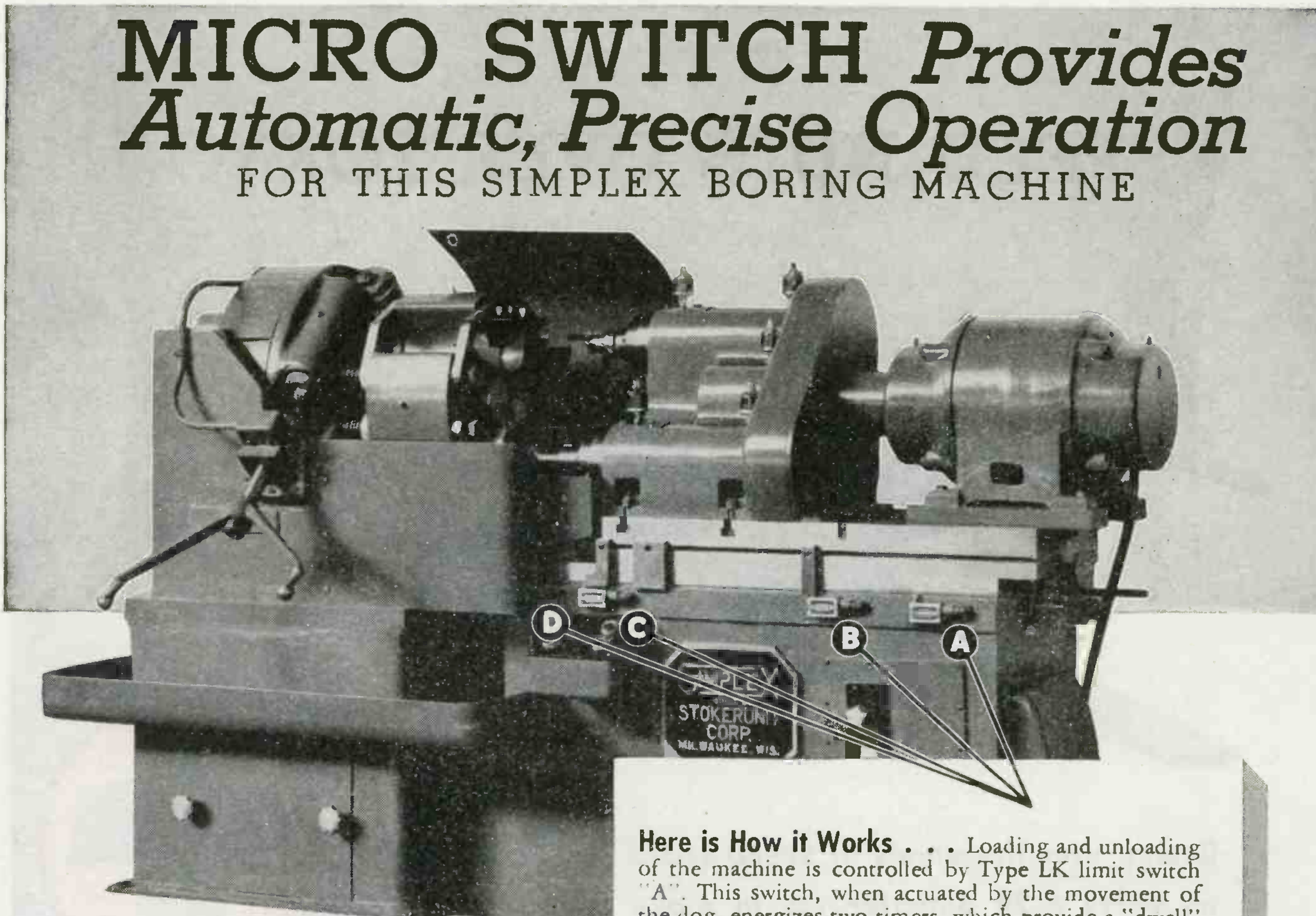
Speed Nuts

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

FASTEST THING IN FASTENINGS

MICRO SWITCH *Provides Automatic, Precise Operation*

FOR THIS SIMPLEX BORING MACHINE



Here is How it Works . . . Loading and unloading of the machine is controlled by Type LK limit switch "A". This switch, when actuated by the movement of the dog, energizes two timers, which provide a "dwell" and also a time cycle on a solenoid which furnishes a return to the table.

Steel clad switch "B" controls the limit of the return table travel after the boring cycle is completed.

As the head travels up to the work, the dog trips steel clad switch "C" which opens to de-energize a solenoid allowing a coarse feed travel. At the completion of the coarse feed travel, a dog contacts steel clad switch "D" which closes to energize another solenoid giving a fine feed travel.

Five other switches, not visible, control operations of the spindle motor and the coolant pump and regulate the speed of operation.

Ruggedness and dependability of the sensitive "Micro Switch" snap-action switches is amply illustrated by their use in the automatic control of the Simplex Precision Boring and Facing Machine made by the Stoker Unit Corporation of Milwaukee, Wisconsin.

Every step in the operation of this precision machine, designed for boring and facing shells, is controlled by the use of nine switches so located as to regulate the sequence of operations of the automatic cycle.

This machine consists of a fixture and spindle head. The fixture rotates about a horizontal axis and is hydraulically indexed to four different positions in each complete cycle. The "Micro Switch" snap-action switches automatically control the feeding cycle on the table which carries the three-spindle boring head. Four of these switches are visible in this illustration.

Do You Need a Switch To . . . control temperatures, help to package products, bottle fluids, record airplane flights, make change, dispense drinks, heat water, control electronic tubes, or steer ships? "Micro Switch" snap-action switches successfully control many such operations . . . and thousands more. "Micro Switch" engineers, experienced in the application of millions of these precise, snap-action switches to products for both war and peace, will be glad to show you how they can add long life and reliability to your product at lower cost. Write for the "Micro Switch" Handbook-Catalog today.

LET'S ALL BACK THE ATTACK — BUY EXTRA WAR BONDS

MICRO SWITCH TRADE MARK

A DIVISION OF FIRST INDUSTRIAL CORPORATION

Freeport, Illinois, U. S. A., Sales Offices in Principal Cities

The basic switch is a thumbsize featherlight, plastic enclosed, precision snap-action switch. Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate reproducibility **of performance is maintained over millions of operations. Basic switches of different characteristics are combined with various actuators and metal housings to meet a wide range of requirements.**

mately 5 percent. When set at its highest point of sensitivity, it is also capable of measuring with reasonable accuracy concentrations as low as one part in a billion. It will also detect mercury if it is carried by a gaseous medium whose spectral absorption band does not overlie the 2537 Angstrom wavelength.

The detector draws air from the atmosphere at the rate of one-quarter to one-half a cubic foot per minute through a cylindrical absorption chamber which contains an ultraviolet lamp and a photo-

Instantaneous detection of mercury vapor in the air of industrial plants is made with this G-E instrument. It measures concentrations as small as one part in 200,000,000

tube. Normally, the lighted ultraviolet lamp permits normal current to flow through the phototube, but the presence of mercury-vapor in the air drawn into the absorption chamber intercepts and scatters the ultraviolet light, thus reducing the phototube current. This unbalances a bridge circuit so that the drop in phototube current is electronically translated into an upscale reading on the indicating microammeter of the detector.

• • •

Dielectric Heating in Woodworking Industry

To raise the temperature at the center of a six-inch block of wood to 280 degrees F takes nine hours when conventional heating methods are used. The same result can be achieved in four minutes by the application of electronic dielectric heating.

An increase in the production rate of glued wood aircraft spars

NO MERE AUTOMATONS are the girls who tend machines in Remler factories. They know how to make minor adjustments to keep equipment in top running condition; they learn the operation of several machines and switch from one to the other to lessen fatigue. • The machines are "beauties" too. In many instances they have been designed by Remler engineers to perform multiple tasks which save time and speed up deliveries. • For complete sound transmitting systems; radio, plugs, connectors and special electronic devices manufactured to order, consult—

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			

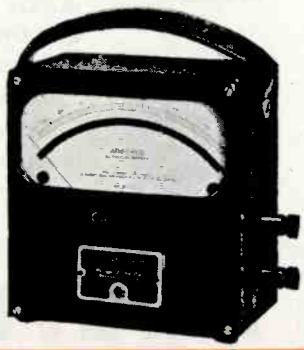
OTHER DESIGNS TO ORDER

ROLLER-SMITH 4.5" PANEL INSTRUMENTS...

for Quick and Accurate Readings

Where panel conditions permit their installation these 4.5" semi-flush Bakelite case instruments provide maximum readability. Scale length of d-c instruments is $3\frac{7}{8}$ inches and for a-c instruments is $3\frac{21}{32}$ inches. All instruments except rectifier types are accurate within 1% of full scale value at any point on the scale. Rectifier types, approximately 5%.

Incorporating the long life and dependability developed during 40 years of fine instrument manufacture, R-S 4.5" panel instruments have a diversified field of application which includes: Radio Transmitters; Control Panels; Battery Testers and Chargers; Electronic Tube Testers and Analyzers; Automotive Analyzers: Instrument Test Units; Sound Movie Equipment; Motion Picture Control Panels: Arc Welding Equipment; Experimental and Amateur Radio; General Electrical Laboratory Testing; General Communications, etc.



Any practical range can be supplied on short notice in d-c and a-c (Repulsion iron-vane and Rectifier type) models, with single or multi-range scales. Correspondence is invited.

OTHER R-S INSTRUMENTS: *Panel, switchboard and portable instruments of practically every standard size, shape, capacity, type and style are included in the R-S line of electrical instruments. Shown here are (upper) 3.5" Miniature Panel Ammeter conforming to American War Standard C39. 2-1944 and (lower) "Steel-Six" Portable Ammeter.*

and don't forget . . . BUY WAR BONDS

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Canadian Plant: ROLLER-SMITH MARSLAND, LTD., Kitchener, Ontario

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS • AIRCRAFT INSTRUMENTS • SWITCHGEAR • AIR AND OIL CIRCUIT BREAKERS • ROTARY SWITCHES • RELAYS • PRECISION BALANCES from 25 to 400 spars per day has been made without any increase in the number of presses. By facilitating edge-gluing and scarf-jointing of narrow strips and short sections, and the lamination of boards, electronic heating has permitted manufacture of spars that are stronger and less costly than those cut from a single piece of wood. At the same time, lumber waste has been practically eliminated.

In the manufacture of molded compregwood propeller blades, using RCA equipment to generate electronic power for preheating precarved layups of resin-impregnated wood, the temperature throughout the preform could be raised to 260 deg F in eight minutes, at which time transfer to steam heated dies was effected. Formerly, two and one-half hours were required to secure a complete closure of the dies; now, with electronic preheating of the preform, they close in three or four minutes. The total time during which the press is tied up has been reduced from seven hours to three hours.

Besides facilitating improvements in quality and strength and savings in production time and costs, C. N. Batsel, of RCA recently pointed out at a meeting of the Southern Woodworkers Association in Atlanta, Ga., electronic power heating and moisture-proof glues make possible for the first time the highspeed production of pieces involving thick sections, formerly impracticable because of the excessive heat transfer time required with conventional hot-gluing methods.

• • •

Production Testing of Swivel Joints

USE OF AN UNBALANCED bridge circuit for testing communications systems in Martin electric turrets has resulted in a saving of 600 percent of the time originally used for this testing work.

Developed by an engineering quartette, George Andrews, Leo Douville, Harold Horner and Herman Roemer, all of Glenn L. Martin Company, the tester is used for testing swivel plugs and permits acceptance only of components which meet manufacturing specifications. The wiring problem, due to

BAKELITE

TRADE-MARK

LOW-LOSS—DESPITE HEAT AND HUMIDITY

BM-16981 is a new phenolic, mica-filled molding material with extraordinary low-loss characteristics under hot, humid conditions. BM-16981, indeed, retains its superior insulation qualities after long periods of immersion—greatly surpassing in this important respect all other mica-filled phenolics tested by the Bakelite Laboratories.

With its extreme resistance to water absorption, its excellent dielectric properties, and good molding qualities, BM-16981 brings you the opportunity to improve the performance of molded parts in applications subjected to heat and high humidity.

Specify BAKELITE molding material BM-16981 for completely new measures of service where atmospheric conditions are generally unfavorable for electrical insulation. Department 7 will be glad to send you detailed information upon request.

TRADE MARK

BAKELITE CORPORATION

Unit of

Union Carbide and Carbon Corporation

UCC

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

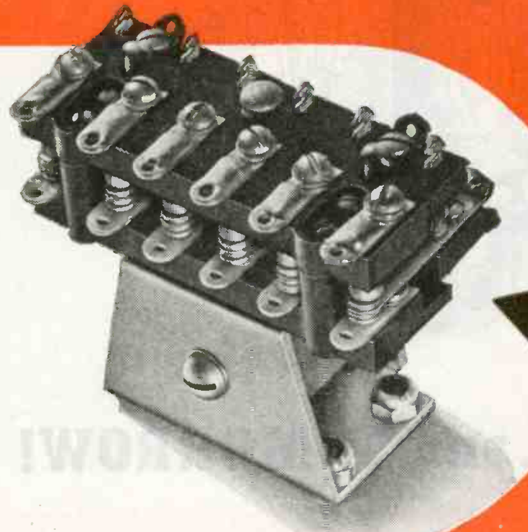
Molding Plastics

ELECTROSTATIC VOLTMETER

FERRANTI ELECTRIC, INC. 30 ROCKEFELLER PLAZA NEW YORK, N. Y.

Ferranti Electric, Ltd., Toronto, Canada • Ferranti, Ltd., Hollinwood, England

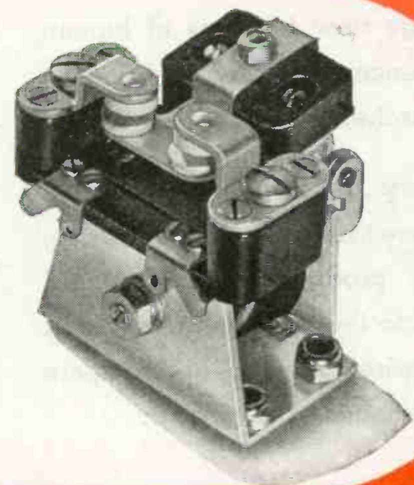
Here is *advanced* Relay Engineering!



TYPE BN

The Allied 6-pole, double-throw BN type embodies many new improvements for heavy duty 6-pole switching . . . permits individuol adjustment of contacts. Molded Bakelite is used throughout the relay. Contacts are rated at 10 Amperes. As in all Allied relays, the BN is designed for compoctness and minimum weight. May be furnished normolly open or normally closed or double-throw. Available in AC or DC. Weighs 11 oz. Write for complete operating characteristics, etc.

Height: 2 9/16" Length: 3" Width: 1 23/32"



TYPE CN

The CN relay is the result of advanced engineering technique and succeeds Allied's successful AN type . . . a power reloy expressly designed for breaking heavy current. Contoct roting is 50 Amperes at 24 Volts DC with silver contacts; with alloy contocts the contact roting is 75 Amperes at 24 Volts DC. *(The latter arrangement with the alloy contacts is known as the CNS type.)* The contact arrangement is single pole, single throw, double break, normally open or normally closed. The new design incorporates molded Bakelite insulation, greater electrical clearance and over-all improved mechanical structure. Available in AC or DC. Complete data on request.

Height: 2½" Length: 2¼" Width: 2"

The two relays described above are typical examples of the many new types of relays Allied is constantly designing for its customers' widely diversified requirements.

Allied's engineering staff continually works to improve relay designs and to develop new magnetic control devices for present anc future manufacturers whose products require electrical control. The highly practical accumulated knowledge of these men is at your command. Send us your control problems!

ALLIED CONTROL COMPANY, INC.

2 EAST END AVENUE (at 79th Street) NEW YORK 21, N. Y.

FACTORIES: NEW YORK CITY • PLANTSVILLE, CONN.

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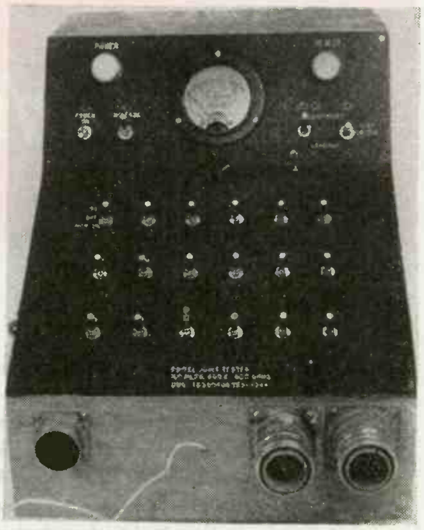
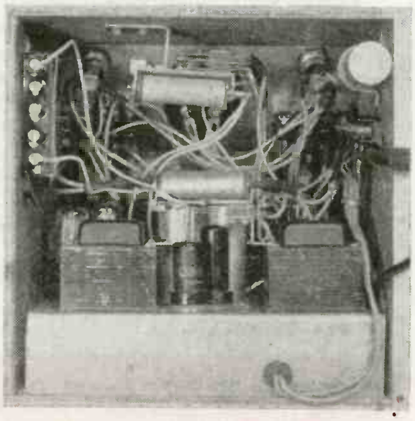


Panel view of the swivel joint tester used on communications equipment for Martin electric turrets. It measures leakage between contacts and resistance of contacts

leakage in the tester, was a complicated one.

The instrument makes both an insulation test at 100 megohms and a continuity test at 0.02 ohms. In the insulation test, an unbalance is set up when the leakage between contacts is less than 100 megohms. Detected by the electronic equipment, this causes a relay to operate,



Lights on the front panel of the plug tester are controlled by the relays shown in this rear view of the instrument

automatically lighting an indicator signal. This light has to be released before tests can continue on other circuits.

Continuity of the contacts is checked by passing approximately three amperes through each circuit and measuring the voltage drop as indicated on a meter. An open circuit unbalances the bridge and causes the red light to glow. An acceptable circuit is indicated on a calibrated meter.

Greater acceptance and increased production of ZIRMET (FOOTE DUCTILE ZIRCONIUM) for gettering (purity 99.9% +) permits . . .

50% PRICE REDUCTION

Now costs only 2¢ to 3¢ per tube

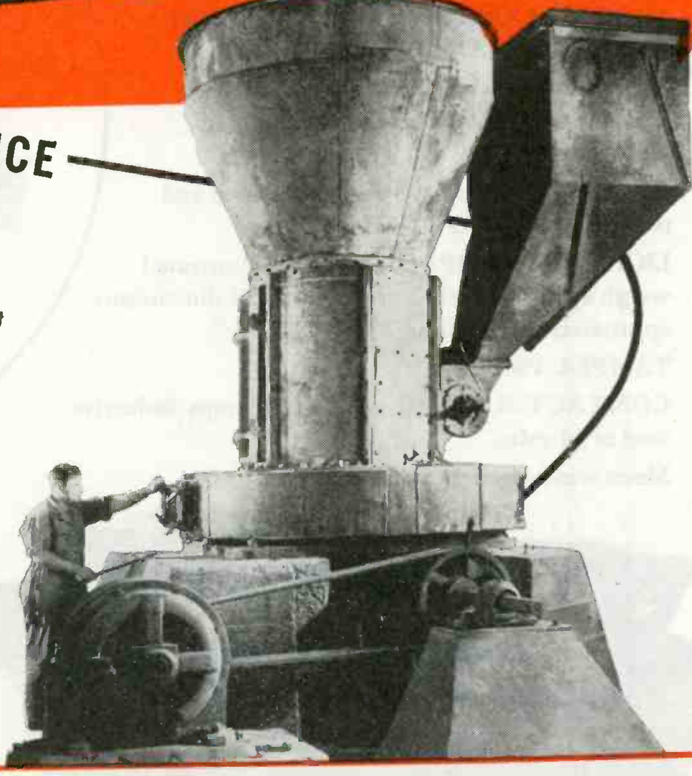
Need approximately but one-eighth square inch of .003" or .005" sheet for a continuous getter in usual sizes of tubes.

- Ductile Zirconium can be used in all types of tubes, including mercury vapor rectifiers.
- Readily spot welded to tantalum, molybdenum, nickel, etc.
- Corrosion resistant.
- Ease-of-use effects savings in production costs.
- Non volatile (produces clear tubes)
- Best temperature: 400°C. or over.

ZIRMET (FOOTE DUCTILE ZIRCONIUM) IS NOW AVAILABLE IN PRODUCTION QUANTITIES OF SHEET, WIRE OR ROD

Write immediately for details and quotation.

WHERE SIZE IS A SCIENCE—



This is one of many types of mills used by Foote for producing from ores and minerals the grindings and granulations consumed by industry. The all-important control of particle size through grinding, and the processes related to grinding such as tabling, calcining, drying and magnetic separation are reduced to a science at Foote's three plants.

Foote
MINERAL COMPANY
A Step Ahead in Industrial Ores and Chemicals

PHILADELPHIA • ASBESTOS • EXTON, PENNSYLVANIA
Home Office: 1617 SUMMER STREET, PHILADELPHIA 3, PA.
West Coast Repr.: Griffin Chemical Co., San Francisco, Calif. • English Repr.: Ernst B. Westmen, Ltd., London, Eng.

GREATER SAFETY

EXTRA

Aviation

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LOS ANGELES, CALIFORNIA

Hermetically Sealed Relay

high capacity . . weight approx. 5 oz.

At last . . a high capacity Relay engineered for high altitude performance . . . HERMETICALLY SEALED against MOISTURE, HUMIDITY, EXPLOSIVE VAPORS, DUST, PRESSURE CHANGE, and CORROSION.

Regardless of how high aircraft ceilings are bumped . . . this is a relay that can take the ride.

Laboratory models have been completed and tested . . . CEILING UNLIMITED.

LIGHT and COMPACT — models illustrated weigh approximately 5 ounces; overall dimensions approximately: Height, 2″; width, 1⅜″.

TAMPER PROOF.

CONTACT RATING — 20 to 25 amps inductive load at 30 volts.

Meets winterization requirements.

Unit has withstood Army test, including overload; vibration 55 cycles per second with .06′ excursion; acceleration of 10 gravity units; salt spray tests of 240 hours duration.

★ ★ ★

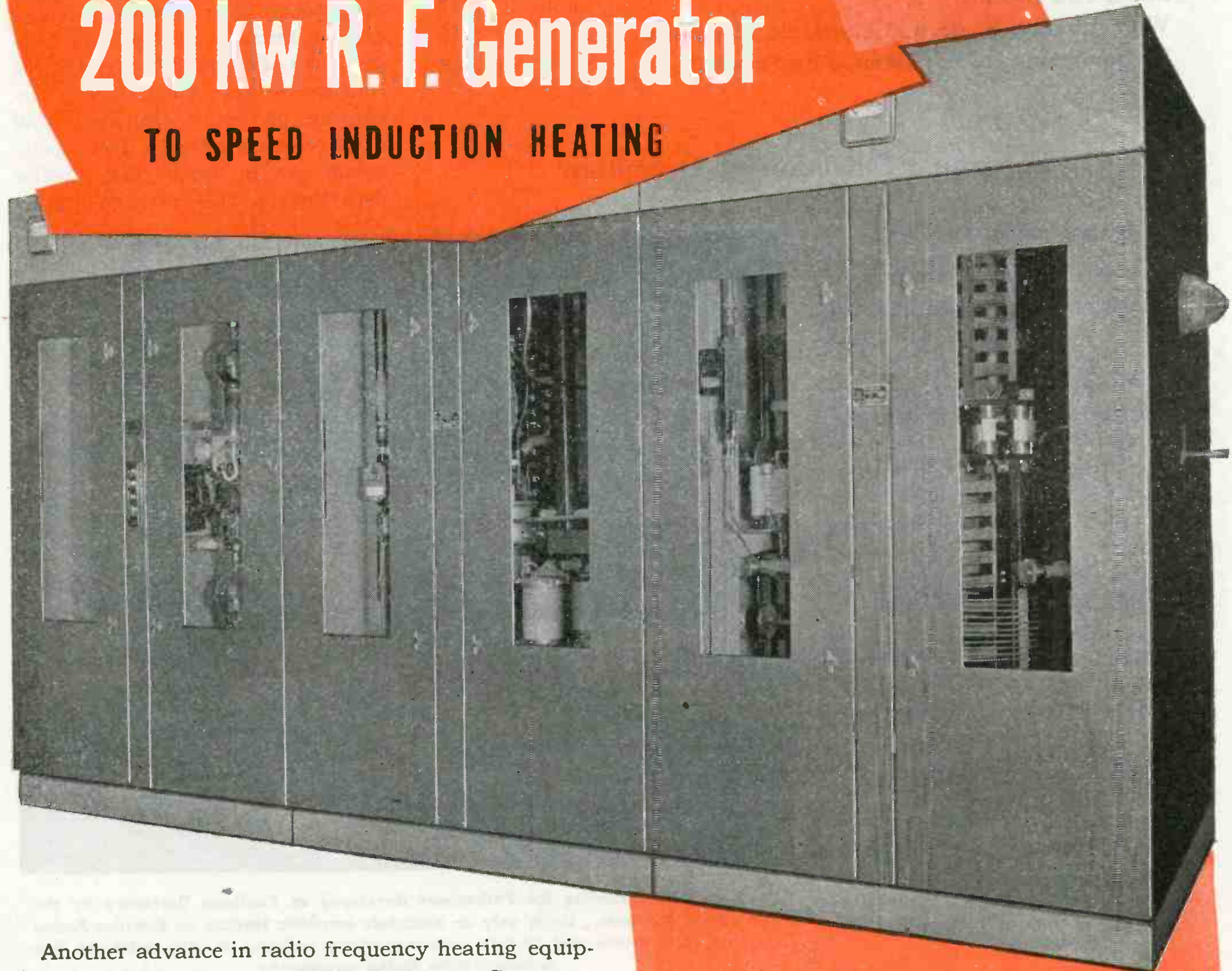
This is the Relay of the future . . . also worth your consideration in many commercial installations.

Electrical
PRODUCTS SUPPLY CO.
Affiliated with Electrical Products Corp.
1140 Venice Blvd. Los Angeles 15, Calif.

Here's a

200 kw R. F. Generator

TO SPEED INDUCTION HEATING



Another advance in radio frequency heating equipment is this Westinghouse Radio Frequency Generator for induction heating.

This 200kw generator is a complete power source, built with all the performance characteristics of Westinghouse industrial equipment. Timing, for example, is automatic according to a predetermined load cycle and power consumption is determined by the work being done.

Consecutive heats can be repeated automatically without interruption or duplicated at any future time with accuracy. Once the generator is adjusted to a process, operation requires only pushing buttons and setting dials to calibration data.

The 200kw generator is one of a complete Westinghouse line including 2, 5, 10, 20, 50 and 100kw sizes. For more information, ask for Descriptive Bulletin 85-800, or give your nearest Westinghouse representative your specific problem. Westinghouse Electric & Manufacturing Co., P. O. Box 868, Pittsburgh 30, Pa.

J-08108

This 200kw, 450kc r.f. generator may be installed adjacent to the work, or at a remote point. Dead-front construction safeguards operators. From left to right, cubicles contain rectifier and control panel, radio frequency oscillator and tank circuit.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Electronics at Work

TUBES AT WORK

Electronic Detection of Deception

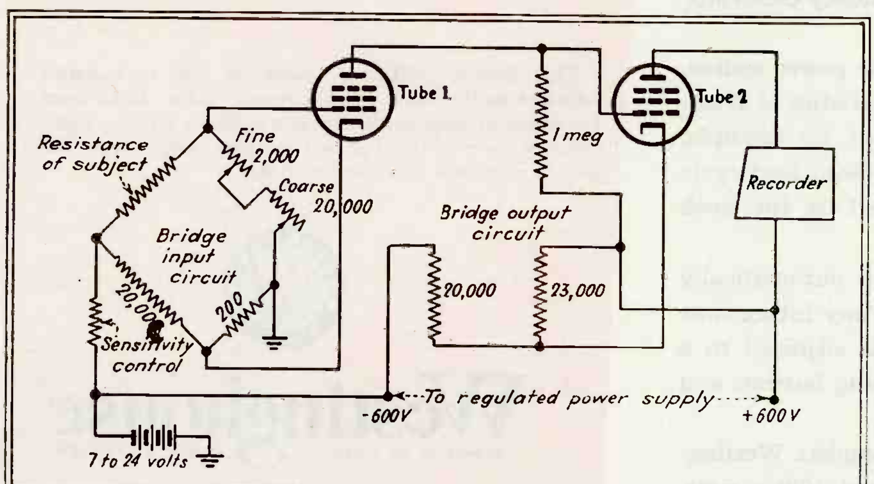
By DR. JOSEPH F. KUBIS
Associate Professor of Psychology
Fordham Univ., New York City

THE APPLICATION of electronic and electrical techniques to the broad field of human emotions, and especially to the detection of deception in normal and abnormal subjects, involves fundamental reactions whose utilization for lie-detection purposes can be traced back to the days of ancient Greece. According to history, the doctor of a certain king felt the pulse of a subject during questioning, to detect changes in blood pressure associated with emotions accompanying deliberate lies.

Around 1900, word lists developed by Jung were in vogue for lie detection, with the subject speaking the first word that came into his mind after hearing a word on the carefully prepared list. Differing reaction times for words pertaining to the crime in question, as compared to neutral words, often pointed to lies in previous testimony.

In Russia, one scientist picked up finger tremors during questioning, with favorable results. Next came observation of respiration during cross-examination, continuous observation of blood pressure, and the continuous and simultaneous recording of both respiration and blood pressure with the Keeler polygraph now in use by many police departments. This instrument gives

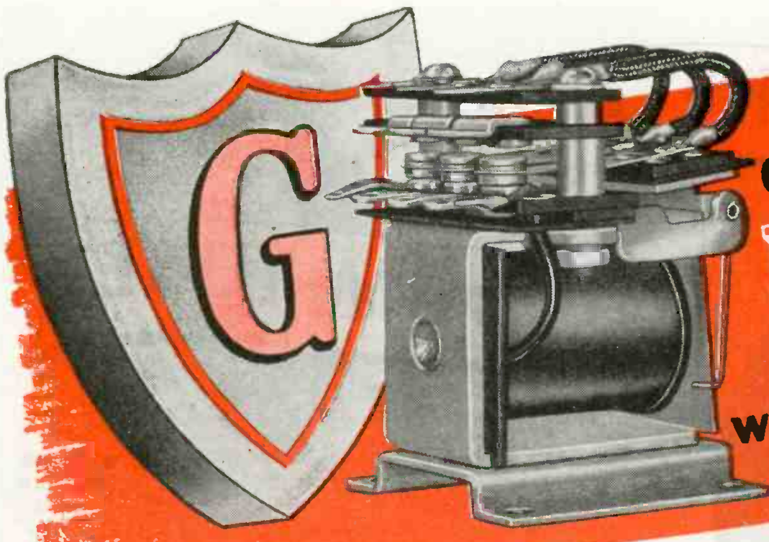
Dr. Kubis demonstrating the Pathometer developed at Fordham University by the late Father Summers. Using only an electronic amplifier feeding an Esterline-Angus recorder, it measures and records each momentary variation in skin resistance due to perspiration during questioning



Basic Pathometer circuit, illustrating the electronic principles involved in amplifying changes in skin resistance. The actual circuit now being used employs more conventional balanced stages for d-c amplification, along with feedback for greater stability accompanying increased sensitivity. The sensitivity level is changed by varying the amount of resistance in series with the subject or by changing the d-c voltage source

from 75 to 85 percent accuracy, but interpretation of the record pattern requires considerable skill. Oftentimes the variations traced on the paper by the recorder are so slight that they are interpreted with difficulty.

All lie detectors are based on the fundamental principle that the telling of a lie creates a situation of conflict and attendant emotional disturbance within the individual. Though internal, this disturbance may be expressed in many ways, such as blushing, paling, perspiring, shaking, fidgeting and the like. The clever or habitual liar can with a little practice easily conceal such observable reactions, but he cannot repress or control certain involuntary reactions, such as minor vari-



GUARDIAN Series 345 RELAY

a "Basic Design" with many variations

meets special applications

saves time . . . saves tooling . . . speeds delivery!

If your application requires a specially designed relay Guardian engineers can be of great help to you. But, as a result of their wide experience in designing "specials" they have evolved a standard design so flexible that it is now specified in numerous applications that would ordinarily require a specially designed unit. Perhaps you can use it in your "special" application . . . with a saving in money and delivery time. This unusually flexible relay is the SERIES 345. Its chief features are the large coil winding area, numerous contact combinations, the non-binding pin type armature hinge pin, its resistance to shock and vibration, and an ability to operate in extremes of temperature. It is now being used in aircraft, radio, and other exacting applications to insure dependable performance.

STANDARD SERIES 345—The ample coil winding area of the SERIES 345 gives you a wide range of windings for various voltages and currents. Coil winding area is approximately .75 cubic inches. Average power required is 3.56 watts with three pole, double throw contacts of 12½ amp. capacity. Coils are available for either A.C. or D.C. operation.

The maximum switch capacity of the Standard Series 345 is three pole, double throw. Contacts are rated at 12½ amperes at 110 volts, 60 cycles, non-inductive A.C. Moving contacts are attached to but insulated from the armature by a bakelite plate. Terminals are solder lugs. Weight is 6½ ounces.

VARIATIONS OF THE SERIES 345 RELAY

TIME DELAY

WINDING—Multi-wound coils are available for operation on two or more circuits. Or coil may be wound to operate on the discharge of a 3 mfd. condenser.

CONTACTS—Normal switch capacity is three pole, double throw; maximum switch capacity may be up to six pole double throw with 12½ amp. contacts, or any variation of contact combinations within this range, including the operation of contacts in sequence. The flexibility of the contact springs may be increased through the use of coil spring rivets.

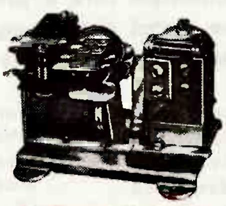
TIME DELAY—On D.C. coils a time delay of 0.25 seconds on release or 0.06 second on attract may be achieved through the use of copper slugs which require these time intervals for saturation or de-energizing depending on whether they are used on the heel or head of the coil.

DUST COVER—For applications where this relay may be subject to injury or in atmosphere where dust may be present in sufficient quantity to impede operation, the SERIES 345 may be equipped with a metal dustproof cover.

SCREW TERMINALS—Screw type terminals are optional for applications where terminals must be disconnected occasionally or where solder lug terminals are not otherwise practical.

DUST COVER

INTERLOCKING: Here the series 340 a-c relay is coupled with the d-c coil of a series 405 short telephone type relay in an overload application. Under normal conditions the series 340 contacts are mechanically held in a closed position. Normal current flows through the series 405 coil and then through the series 340 contacts to the circuit for which overload protection is desired. Excessive current, however, energizes the series 405 coil, releasing the locking arrangement and breaking the series 340 contacts. Push button control resets to normal but is ineffective if current is still excessive.



INTERLOCKING UNIT

SERIES 345 RELAY DATA

Normal Volts	Minimum Volts	Normal M.A.	Minimum M.A.	Coil Resist.	Normal Wattage
6	4.8	600	480	10	3.56
12	9.8	300	245	40	3.56
24	18	148	111	162	3.56
32	25.6	112	89	287	3 56
115	92	31	25	3720	3.56

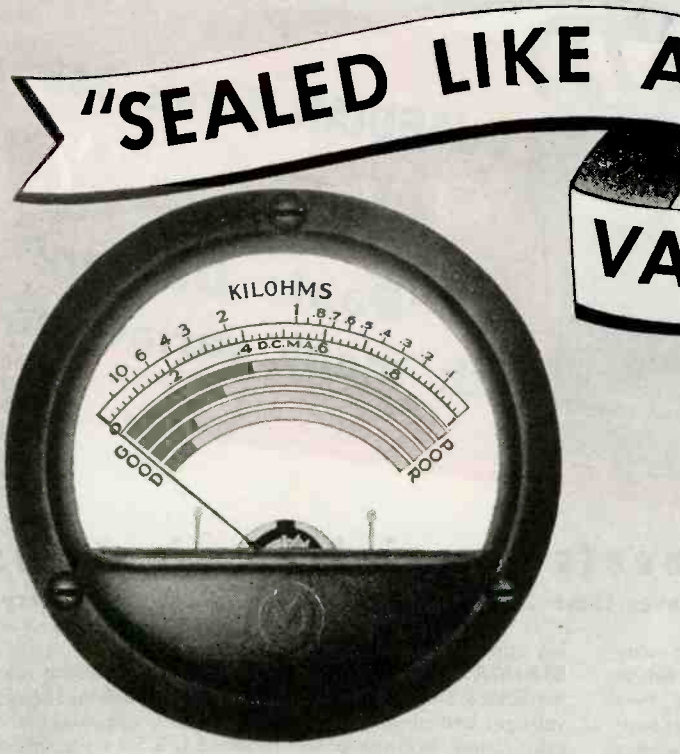
Minimum operating wattage........................2.3

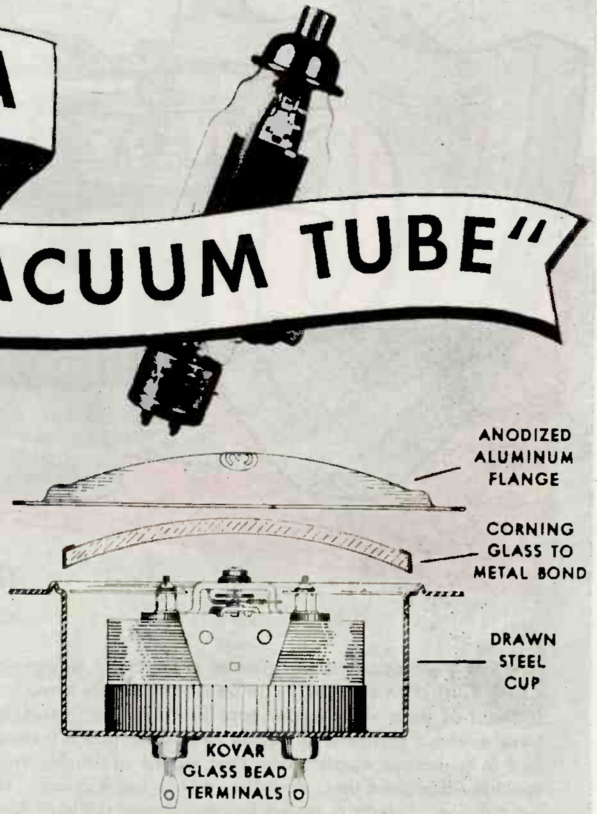
If you will write us about your relay problems our engineers will be glad to make recommendations which may save you time and money. Should you desire a quotation, please mention quantity.

GUARDIAN ELECTRIC

1625-D W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY





At last . . . a truly satisfactory answer to the urgent need for a tropicalized electrical indicating instrument

Glass-to-Metal Hermetically Sealed 2½" and 3½" Instruments by Marion

Utilizing an entirely different design and construction approach, Marion engineers have completely licked one of the toughest problems ever assigned to our industry. By building the mechanism into a protective cup-like frame, and then sealing the glass cover to the metal rim, unequivocable hermetic sealing has been achieved with a minimum number of seals.

- There are no rubber gaskets, no cement seals.
- Can be immersed in boiling brine solution for weeks without deterioration of seals.
- Windows are of double thickness ***tempered*** glass processed for solder sealing, and are highly resistant to shock.
- Instruments are completely dehydrated and are filled with dry air at sea level pressure.
- A newly designed crowned crystal permits greater scale length, reduces shadows, and makes for better visibility.
- Magnetic shielding permits interchangeability on any type of panel without affecting calibration; can be supplied silver plated for extra R.F. shielding.
- Silver clad beryllium copper hair springs reduce zero shift at all temperatures.
- Standard Kovar glass bead type terminals with solder lugs.
- Special phosphate finish on cases meets two-hundred-hour salt spray test.
- Window sealing process developed and perfected in cooperation with engineers of the Corning Glass Co.
- Instruments manufactured in accordance with AWS Spec. C-39.2 1944 ***plus*** hermetic sealing.

TYPE HM 2 DIRECTLY INTERCHANGEABLE WITH AWS TYPE MR 24 AND 25
TYPE HM 3 DIRECTLY INTERCHANGEABLE WITH AWS TYPE MR 34 AND 35

Available in all DC ranges. Write for additional details

MARION ELECTRICAL INSTRUMENT COMPANY

MANCHESTER, NEW HAMPSHIRE

Warnings against unstable voltages are unnecessary on equipment protected with built-in CONSTANT VOLTAGE

Unstable voltage on commercial power lines is so prevalent that many manufacturers of electrical and electronic equipment have found it necessary to warn their customers of its existence and its possible effects on the operation and efficiency of the equipment.

There is an easy and inexpensive solution to this important problem—specify a SOLA CONSTANT VOLTAGE TRANSFORMER as a component part of your equipment. There are several types of SOLA CONSTANT VOLTAGE TRANSFORMERS specially designed for this purpose—small, compact units in capacities ranging from 10VA to several KVA. Other capacities and designs can be custom built to your specifications.

Once installed in your equipment they require no pampering or supervision. They are fully automatic, instantly correcting voltage fluctuations as great as ±15%. They are self-protecting against short circuit.

No sales manager will overlook the added salability of a product that features this guarantee of performance, low maintenance cost and satisfaction to the user.

SOLA engineers with wide experience in the application of the SOLA CONSTANT VOLTAGE principle are available for consultation on details of design specifications.

SOLA Constant Voltage Transformers

To Design Engineers:
Complete, new hand-book of Constant Voltage Transformers available on request.
Ask for Bulletin DCV-102

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

ations in breathing, increased reactivity of his heart and almost imperceptible changes in the electrical character of his body.

One of these involuntary body reactions, known since 1790, is the change in the apparent electrical resistance of the skin of the subject during emotional stress. This was utilized by the late Dr. W. G. Summers, a Jesuit scientist and psychologist and founder of the Department of Psychology at Fordham University, in the development of his ink-recording psychogalvanometer, called the Pathometer. When this instrument is used to pick up and record the variations in resistance between two points on the skin during questioning, a single recording provides easily interpreted indications having better than 98 percent accuracy in the diagnosis of guilt and innocence. The suspect feels nothing and hence has no opportunity to control the involuntary electrical changes occurring at the surface of his skin. No diagnosis of guilt or innocence made with this equipment has yet been contradicted by later evidence, and already over 300 criminal situations have been diagnosed with the aid of the Pathometer. Although applied chiefly to criminal cases largely in cooperation with police authorities, it has been more recently used by the armed forces and also in connection with the diagnosis of mental disorders.

These simple metal electrodes, held in the palms by straps, are the only connection to the subject during a deception test with the Fordham Pathometer

The Fordham technique involves attaching a german silver electrode in the palm of each hand with a simple strap or bandage, applying a direct voltage of from $1\frac{1}{2}$ to $22\frac{1}{2}$ volts

CONCENTRICITY...

For Uniform Transmission Characteristics in High Frequency Lines

In coaxial cables, more than in any other types, accurate relationship between the component parts is essential.

Concentricity and uniformity of conductors and dielectric join in Anaconda Coaxials to effectively fulfill the objectives of electrical designers.

Each type is specifically designed to serve best in the intended application. All electrical characteristics are held within close limits to uniform standards assuring accurate surge impedances.

In addition to manufacturing standard types of coaxial cables, Anaconda offers research and engineering facilities to meet needs for specialized types.

45306

ANACONDA COAXIAL CABLES
Anaconda coaxial cables are made in a variety of types to Army-Navy specifications.

ANACONDA WIRE & CABLE COMPANY

General Offices: 25 Broadway, New York City 4

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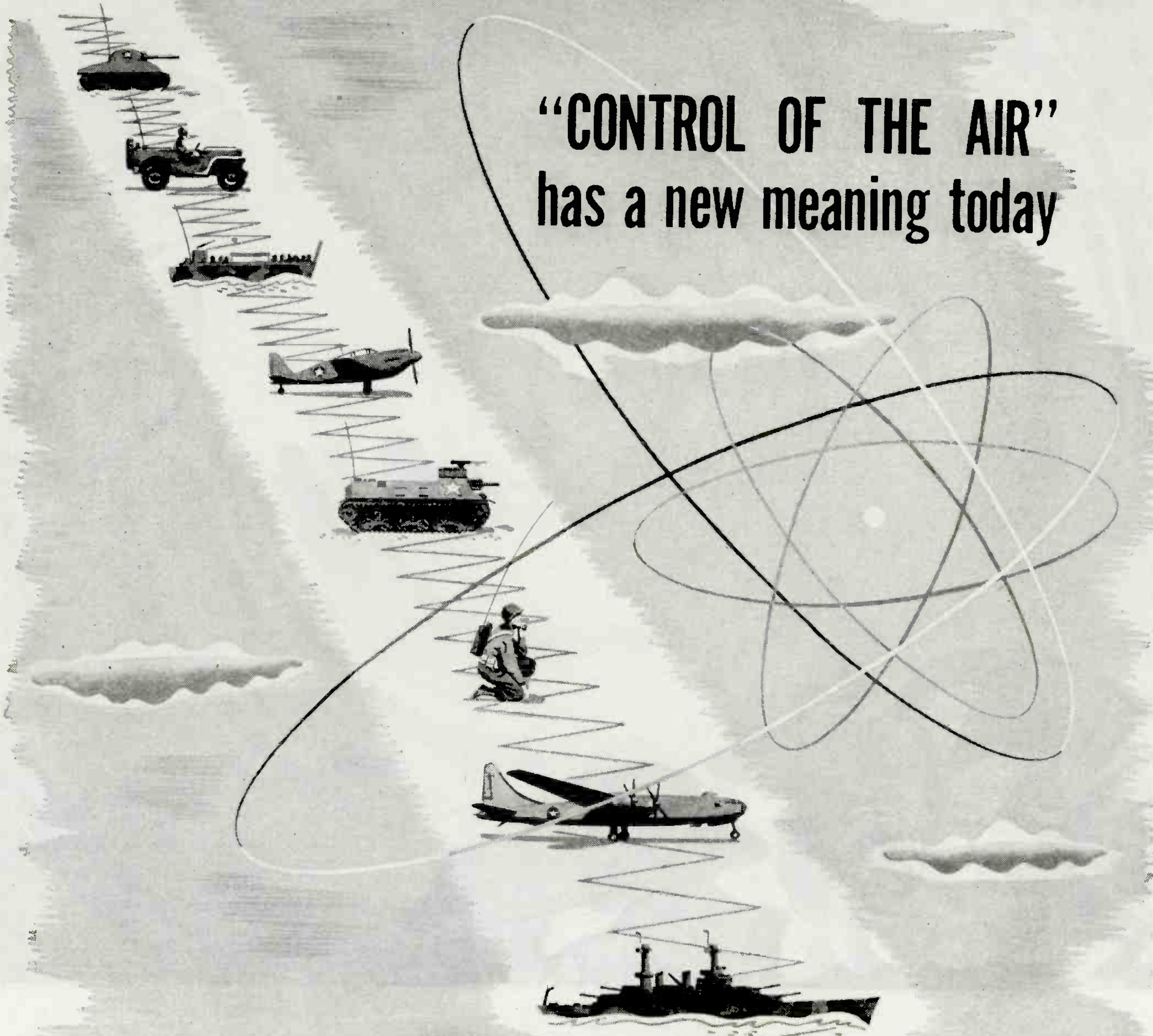
"CONTROL OF THE AIR" has a new meaning today

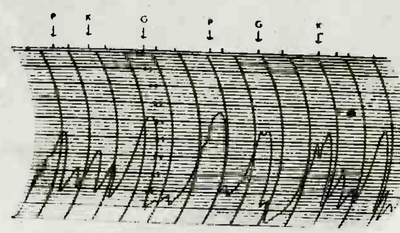


Yes, we're talking about a different kind of air control than that established by Allied fighters and bombers. For the air today is full of high-frequency impulses, launched by varied types of radio and electronic equipment and performing varied functions of communication, detection, ranging and safeguarding. From compact mobile radio sets to highly intricate radar equipment, Delco Radio products are helping to bring new "air supremacy" to America's armed forces. Delco Radio Division, General Motors Corporation, Kokomo, Indiana.

KEEP BUYING WAR BONDS

Delco Radio
DIVISION OF
GENERAL MOTORS

(depending upon the electrical resistance of the subject, which can range from 6,000 to 120,000 ohms for various individuals and different times of the day), and using a two-stage d-c amplifier and Esterline-Angus ink-recording milliammeter to produce a trace of current versus time. The current is proportional to the resistance between the pick-up electrodes; both current and resistance vary as much as



Sample record of a guilty person, showing consistently large reactions to questions pertaining to guilt (G), to actual possession of stolen object (P) and to knowledge of person who stole object (K)

10 percent for large emotional reactions, and from 3 to 5 percent for responses to questions evoking embarrassment or touching on crime but not involving personal guilt or knowledge.

The use of only one index eliminates the problem of analyzing conflicting indications encountered with other techniques. Thus, a blood pressure curve may indicate truthfulness while the respiration curve will indicate a lie.

Nature of Examination

The person examined is comfortably seated in a large arm chair facing away from the operator, so that the latter is uninfluenced by the facial expressions of the suspect. After preliminary balancing of the person into the electrical circuit, the operator proceeds with the questioning. This is done in a low monotone, special care being taken to eliminate any stress or inflection upon critical words or phrases.

The questions are prepared beforehand. They are specific to the case under investigation and are worded to obtain either a yes or no answer. A summary of the case and history of the persons involved is studied a few days before the examination as a guide for preparing the questions.

Several different sets of questions are prepared, two or three

No matter how tiny the coil

LUMARITH* C.A.

Keeps the Black Hand of Corrosion at bay

MANY TYPES of insulation, in the presence of moisture and current, create free acids highly corrosive to current-carrying copper wire. In such instances this electrolytic action is a *built-in* hazard.

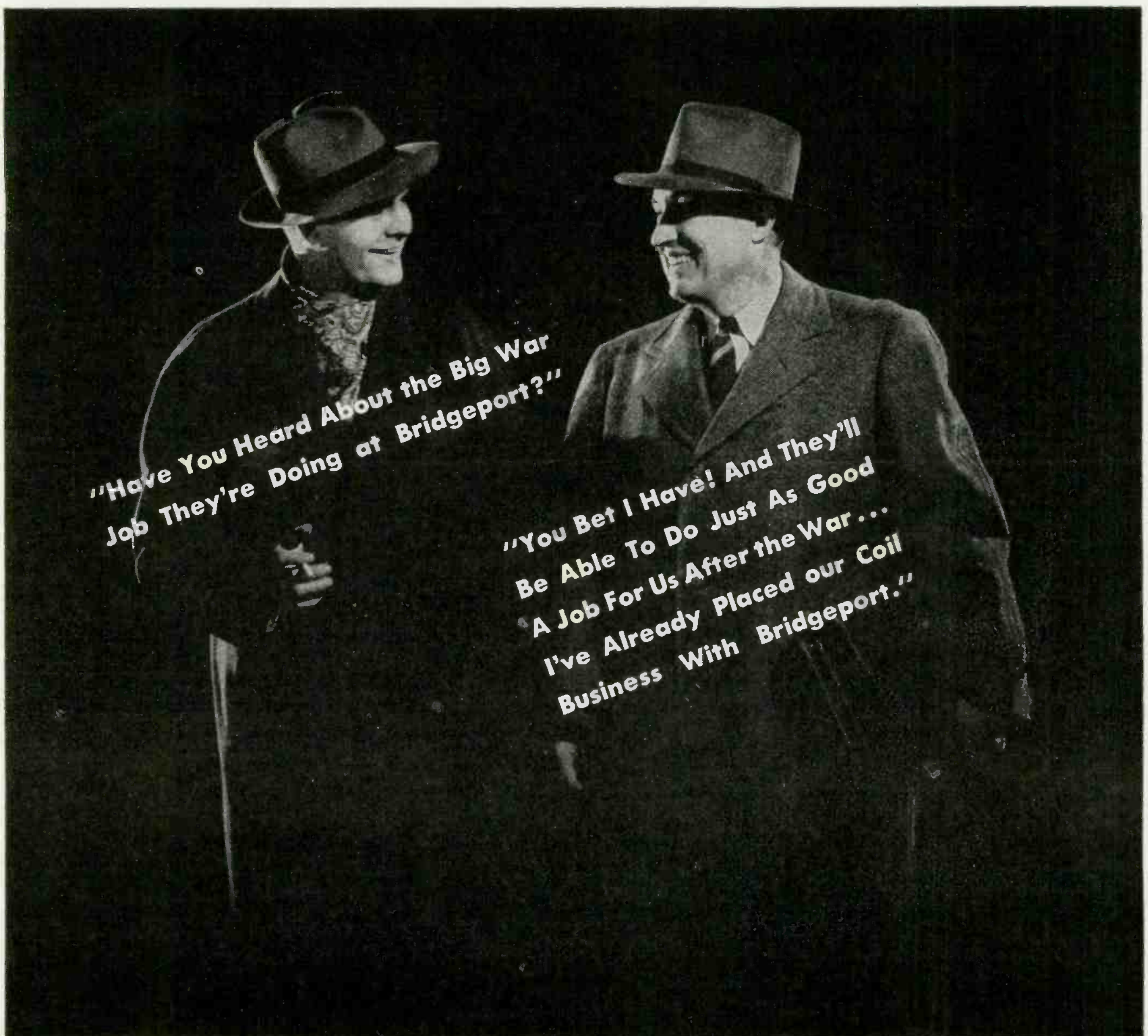
Lumarith C.A. (cellulose acetate base) is chemically inert in electrical applications. It does not give rise to corrosion even on fine copper wire.

Many fabricators use tubing of spiral wound Lumarith C.A. film to make exceptionally strong cores. They are offered by various manufacturers in round, square and oval shapes. Other Lumarith C.A. films are available in plain or in special mat finish (A78) for easier winding. Slippage is reduced, visibility increased.

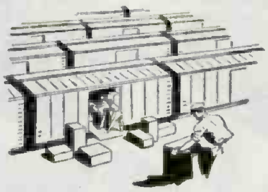
Lumarith C.A. is also supplied in thin foil for coil linings, coverings and interlayer insulation, and in molding materials for coil spools, bobbins, housings, bases and plugs. Send for the Lumarith Electrical Booklet. Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N.Y.

A Celanese Plastic*

*Reg. U. S. Pat. Off.



YES, BRIDGEPORT WILL DO A BIG POSTWAR JOB



Right now, Bridgeport is turning out search coils and variometers in the huge quantities necessary to meet the needs of the armed forces, and with the quality required by exacting military specifications. That same capacity and skill will be brought to bear on your postwar orders.

Bridgeport's central location, right near the population center of America, gives you the added advantage of fast, trunk line delivery service to any point. Write to us TODAY to insure early postwar delivery of R.F. Coils and Chokes, I.F. Transformers and Transmitting Coils and Chokes.

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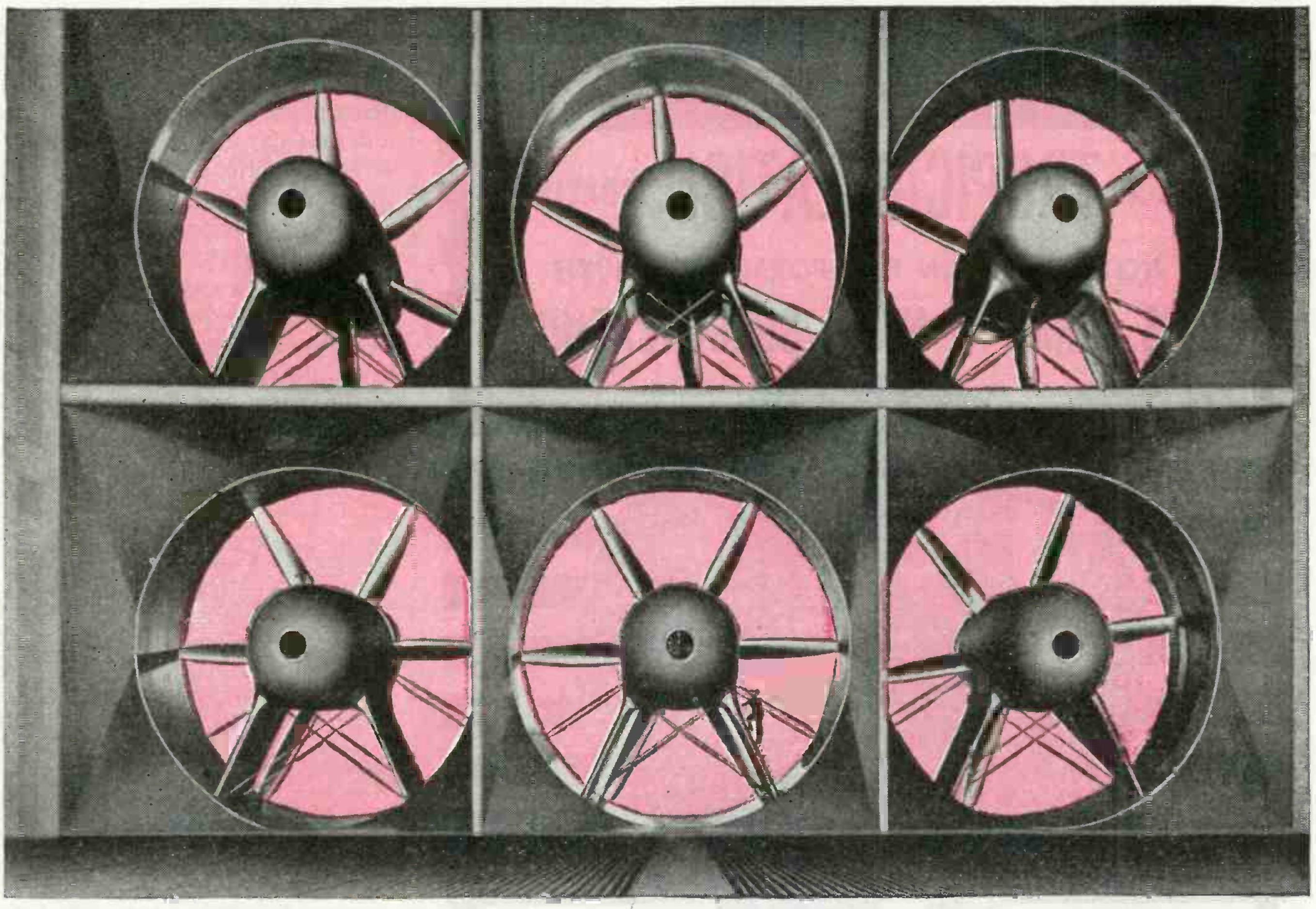


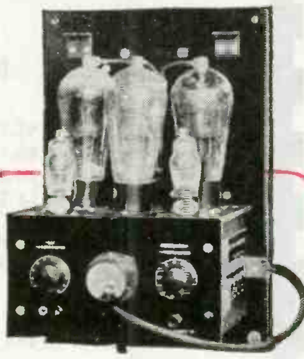
how to tame 36,000 horsepower

Above you see the six giant propellers for one of Uncle Sam's mighty new wind-tunnels — where NACA research engineers are working out the designs for still faster and higher-flying planes.

Driving these 40-foot propellers are six 6000 hp motors, each weighing 57 tons. And in spite of the size of the motors, the complicated system of exciters, generators, spinning shafts and whirling propellers—the speed of each motor must be held to extreme accuracy.

By making a complete study of the system, Westinghouse engineers were able to determine the proper regulator system to do the job. It turned out to be the small, compact electronic regulator shown at the right. By responding to minute changes in speed, it automatically makes the necessary adjustments—compensating for any fluctuations in power supply or changes in load. Thus, through the delicate sensitivity of electronic tubes, it is possible to tame 36,000 hp.

Accurate speed and voltage regulation is just one of the many practical applications of electronics perfected to meet wartime demands. You may want to know more about this or other electronic developments for your industry. Your nearest Westinghouse office is ready to provide full information . . . or write to Westinghouse Electric & Mfg. Co., P.O. Box 868, Pittsburgh 30, Pa. J-91071



THE ELECTRONIC REGULATOR

Through the sensitivity of electronic tubes, this device accurately regulates the speed by controlling the voltage on the "running" generator, despite fluctuations in power supply or changes in load. It has wide applications in continuous process industries, wherever accurate control of machine speed is essential to uniformity of product.

Westinghouse
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

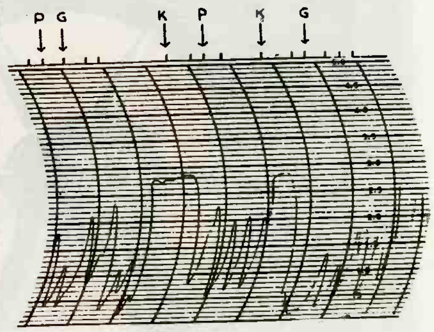
Electronics at Work

TUNE IN JOHN CHARLES THOMAS, SUNDAY—2:30 EWT, NBC.
HEAR TED MALONE, MON. TUES. WED. EVENINGS, BLUE NETWORK.

ELECTRONIC EQUIPMENT FOR INDUSTRY AND HOME · ELECTRONIC TUBES · RADIO AND TELEVISION being given on each of two days comprising the test period. The goal is to gain corroborative evidence as to guilt or innocent on two different days, possibly under different emotional conditions, on which the operator is justified in rendering judgment.

The accuracy of any lie detector depends to a great extent upon the nature of the questions used and the sequence in which they are given. In general, questions related to the crime and involving knowledge, guilt or possession are repeated frequently in various forms during the questioning period. They are interspersed with two or more so-called neutral questions like "Did you ever carry a revolver?" or "Were you ever arrested?", selected to cause emotional embarrassment larger than a normal reaction. By making the neutral questions apply to crime, though not necessarily to the guilt of the subject, the investigators secure an emotional standard that gives adequate comparative criteria.

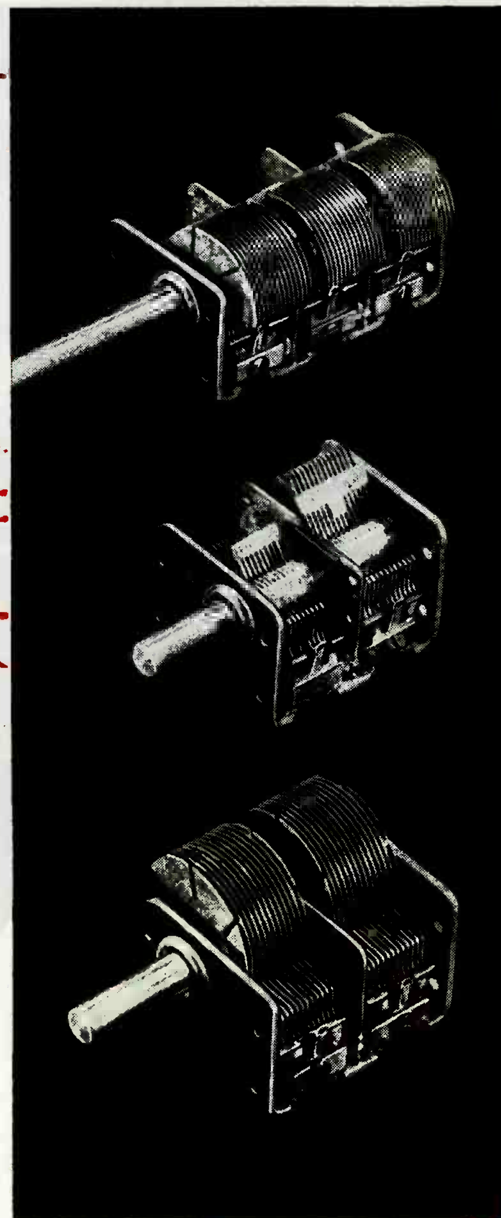
One or two questions alone cannot indicate truth or deception; many questions must be given to note the trend in the reaction. For example, in the case of a murder suspect, a very strong reaction may be given even by an innocent person the first time that the question "Did you kill him?" is asked. Each succeeding time this question is asked, however, the reaction will



ACCOMPLICE

Sample record of an accomplice to a crime, showing a large reaction to question K. "Do you know who took the money?", but not to P. "Do you have the money?" or G. "Did you take the money?" The latter two give galvanic reactions of about the same magnitude as the matter-of-fact standard questions interspersed among the critical questions

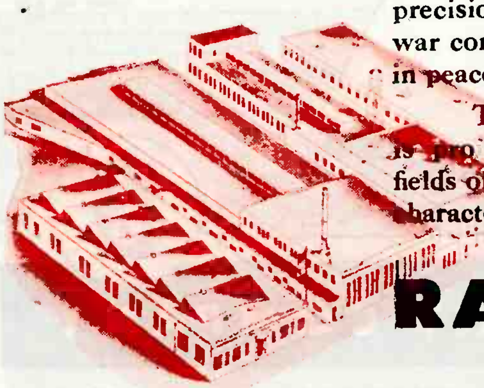
WHY R/C CAPACITORS?



FROM start to finish R/C products are researched, engineered, designed and produced by men who "*know how*"—men whose sole business is the making of better variable capacitors, *and has been for over 23 years.*

Accurate, modern methods of production make possible a precision component, produced to meet the exacting demands of war communications as well as the specifications of manufacturers in peace.

This broad background of experience is one of which R/C is proud. . . It assures leaders in the Radio and Electronics fields of components which, in every respect, match the quality characteristics they demand.



RADIO CONDENSER CO.

CAMDEN, N. J.

RADIO CONDENSER CO., LTD., TORONTO, CANADA

Now!

At the Willow Run Bomber Plant of the Ford Motor Company, the Brush Surface Analyzer determines the smoothness of oleo strut pistons.

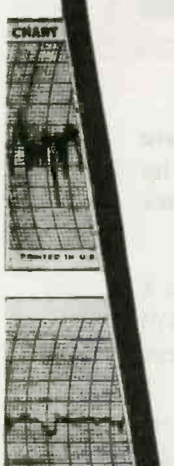
NO PRIORITIES are necessary to purchase a Brush Surface Analyzer . . . Approximately two week delivery on unrated orders . . .

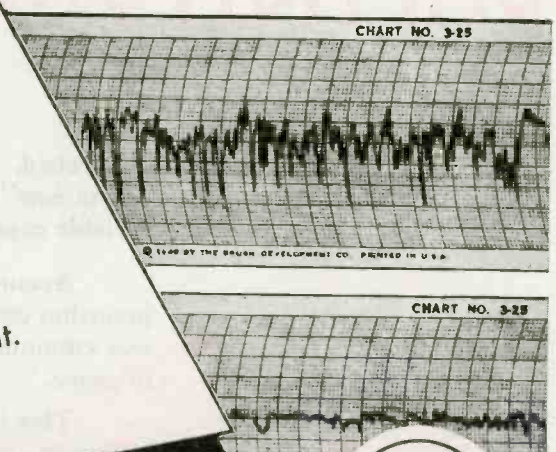
THE BRUSH SURFACE ANALYZER

measures and records the irregularities as shallow as a millionth of an inch on steel . . glass . . plastics . . plated and painted surfaces.

Ask for a demonstration at your plant.

An Illustrated brochure, SURFACE FINISH—.000001", sent on request.





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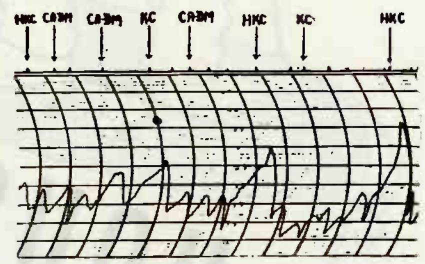
be less and will finally be normal as the initial startle and fear response drops to the level of the emotional standard response. However, if the subject is guilty even though denying the crime, the Pathometer trace will show almost uniformly high response each time that the pertinent question is asked.

The lie detector can only prove whether or not a man believes what he says. Thus, if a mental case who believes he is Napoleon is subjected to the test, the lie detector will invariably indicate truthfulness each time the question is asked "Are you Napoleon?". On the other hand, it



Gradually diminishing response (reading from right to left) to the question "Did you help kill Mrs. C?" shows the subject's denials of crime to be truthful. Pathometer evidence here resulted in a confession and the electric chair for the murderer, and proved the innocence of a suspect who was deliberately incriminated by the murderer in his confession

is practically impossible to fake a belief and fool the lie detector. This is important in insurance compensation cases, where people have succeeded in feigning injuries or even paralysis before the best doctors, yet cannot fool the lie detector.

The lie detector should not be used in approximately 10 percent of the cases, involving mentally unstable subjects, those in which drugs have been used, and cases where fatigue has not been eliminated.

Legal Decisions

There are at least three cases already in which the results of the Fordham Pathometer have been admitted in evidence. In 1938, for the first time in the history of lie detection, evidence based upon a deception test was introduced in court and accepted as legal evidence over the objection of the district attorney (People vs. Kenny (167) Misc. 51, 3 N.Y.S. (2d) County Ct. 1938). Deception test results were

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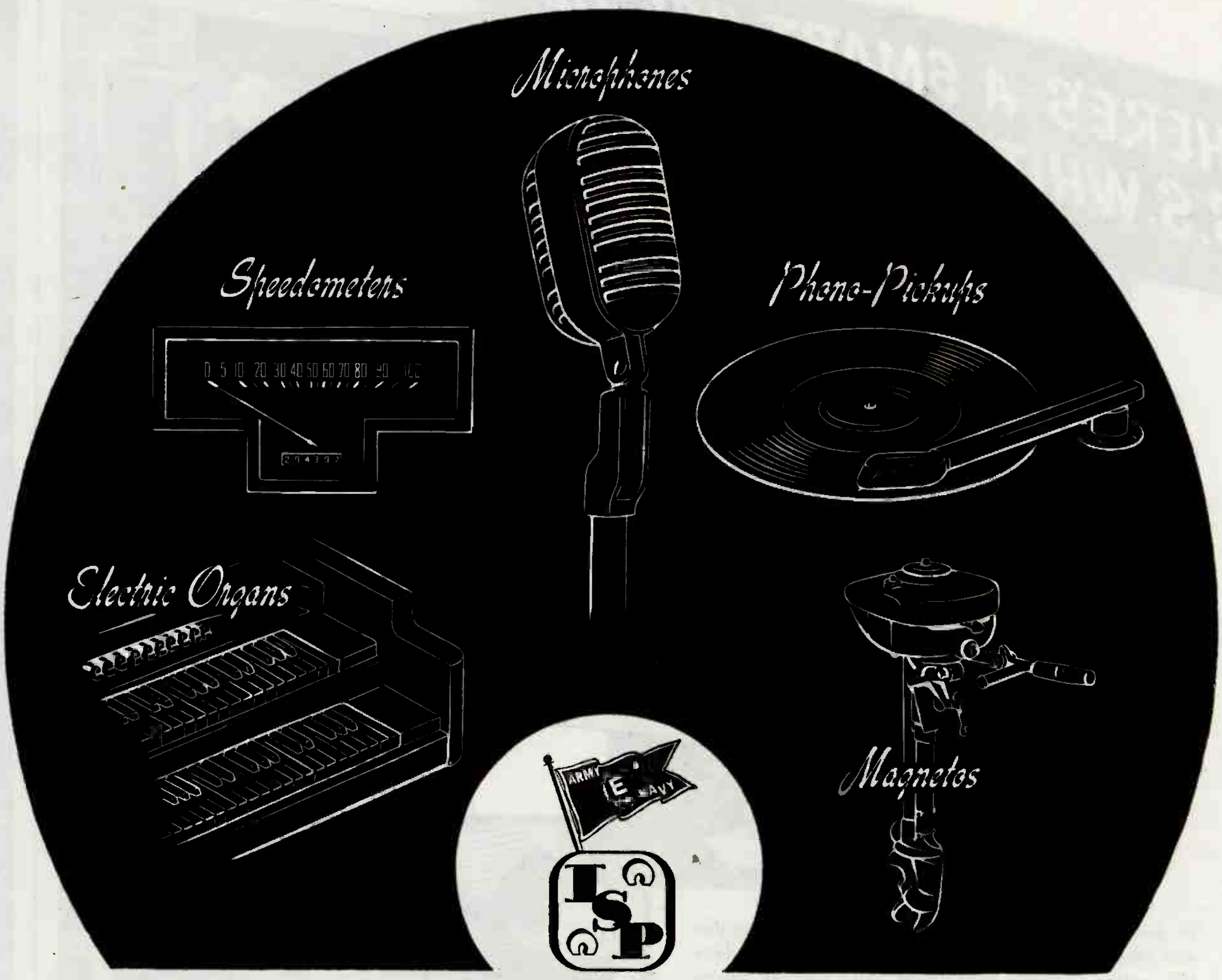

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The ability to create an electric current through the agency of a permanent magnet suggests to the engineer or product designer a wide range of useful applications.

Permanent magnets are able to transform mechanical into electrical energy in two ways—

1. *By producing a magnetic field through which an electrical conductor is moved mechanically—as in the case of generators, magnetos and velocity or dynamic microphones.*

2. *By acting as a polarizing agent, where reluctance to the magnetic circuit is varied by mechanical means; for example—the phonograph pick-up and inductor type magnetos and generators.*

This characteristic of the permanent magnet permits its use for the generation of electricity for actual power uses, or to produce devices for the control, detection and measurement of many materials.

Backed by 34 years of experience as the largest exclusive manufacturers of permanent magnets, our engineers will gladly consult with you on problems where the use of permanent magnets may do the job better. Write for free copy of technical booklet: *"Permanent Magnets Have Four Major Jobs"*.

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also accepted as evidence before a referee in a compensation court, again over the objection of the defense attorney (Industrial Board of State of New York, case No. 37514096). In New York City, a magistrate's court similarly accepted such evidence. In all these instances the subjects were tested by means of the Pathometer.

BIBLIOGRAPHY

(1) Summers, W. G., Science Can Get the Confession, *Fordham Law Review*, Nov. 1939, p. 335–354.

(2) Kubis, J. F., Medicine and Lie-Detection, *The Linacre Quarterly*, XI, No. 2, p. 28–30, Apr. 1943.

(3) Hoch, P., Kubis, J. F., and Rouke, F. L., Psychogalvanometric Investigations in Psychoses and other Abnormal Mental States, *Psychosomatic Medicine*, VI, No. 3, p. 237–243, July 1944.

• • •

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A SERIOUS FIRE HAZARD to life and property exists when gasoline is transferred from one container to another in the vicinity of an operating radar set. High-frequency current is induced into the containers and sparks jumping between them can cause an explosion and fire. The filling of gasoline heaters in radar sets and the filling of power plant and vehicle fuel tanks near radar sets are the chief sources of this hazard. It is recommended that a radar set be shut down when it is necessary to pour gasoline from one container to another in the vicinity of the set.

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By EDWARD C. WARRICK

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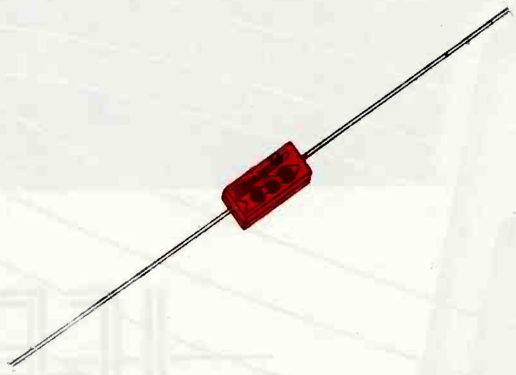

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Temperature Coefficient	Plus or minus 100 parts/million**
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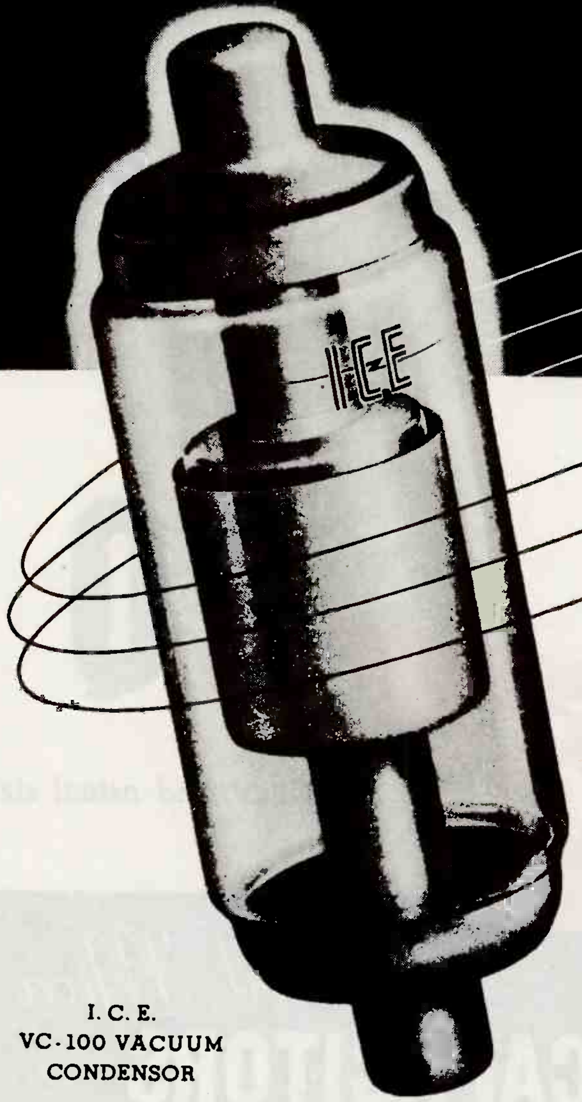

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L. W. LORD, President   M. H. PHILLIPS, Vice President and Treasurer   A. O. BLADES, Plant Manager entirely or performed for a very short time when delivered to our fighting men. Many of these failures were due to moisture and water getting inside the cases onto the working parts during shipment, in field warehouses or in actual field service. The engineers of the Signal Corps and manufacturers were called upon to develop ways and means of combating this problem. One of the problems, moisture proofing, can be solved by waterproofing the housing of the unit in addition to the moistureproof treatment of some of the component parts.

To accomplish this all shafts, openings, windows, etc., must be sealed; all rivets and spot welded seams must be waterproofed; covers and their mountings must be properly designed. Not only must everything on or through the case be watertight, but ways and means had to be found to dissipate the heat generated inside the case.

Metal Cabinets

It had been standard practice to form a box out of sheet metal, fastening the sides or ends by riveting or spot welding. The removable side or end was held in place by screws. Louvers were often placed in the sides and back for ventilation.

To replace a case of this construction and still save as many tools as possible, a step bracket (see Fig. 1) around the entire open end of the

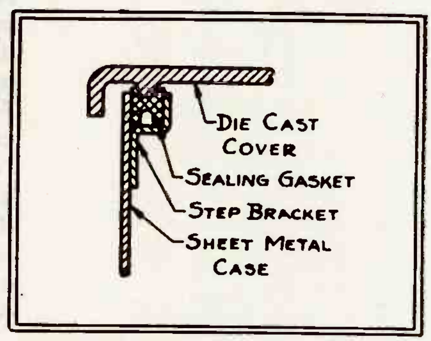

Fig. 1—Detail of end of a metal cabinet showing use of a step bracket

case to carry a gasket can be added. The removable cover is made from a die casting having a locating flange to fit around the outside of the case and a V-ridge to fit into the gasket material. External clamping latches are used in place of screws. The latches are spot

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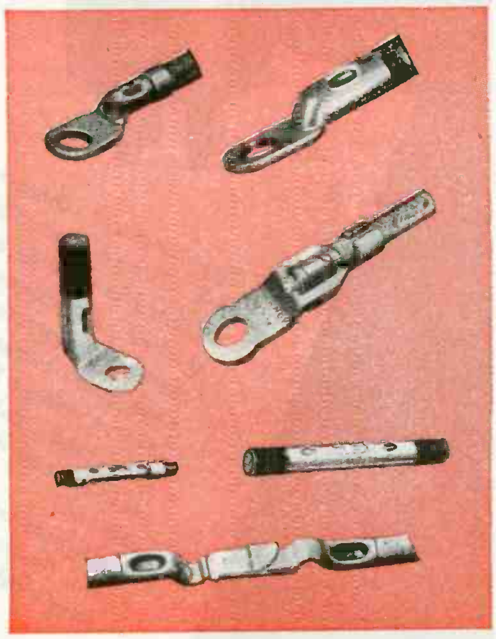

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welded to the exterior of the sheet-metal case and latch over the die-cast cover. The louvers are omitted, and to help dissipate the generated heat, the entire inside of the case is painted black. All seams are brazed or welded their entire length and the tenons of tapped studs to be used for mountings are first dipped in a hard-setting sealing compound and then riveted to the case.

Glands in Holes

All shafts subject to movement are waterproofed by use of packing glands. The design of the gland is determined by the space available and the type of panel through which the shaft extends. If the panel is a die-cast or sand-cast piece where a counterbore can be utilized, then the construction con-

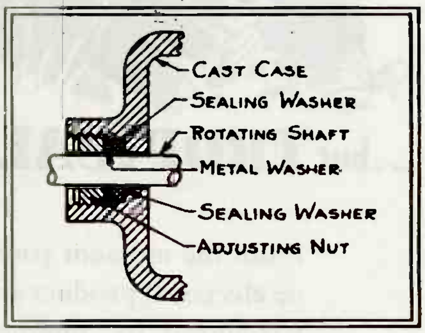
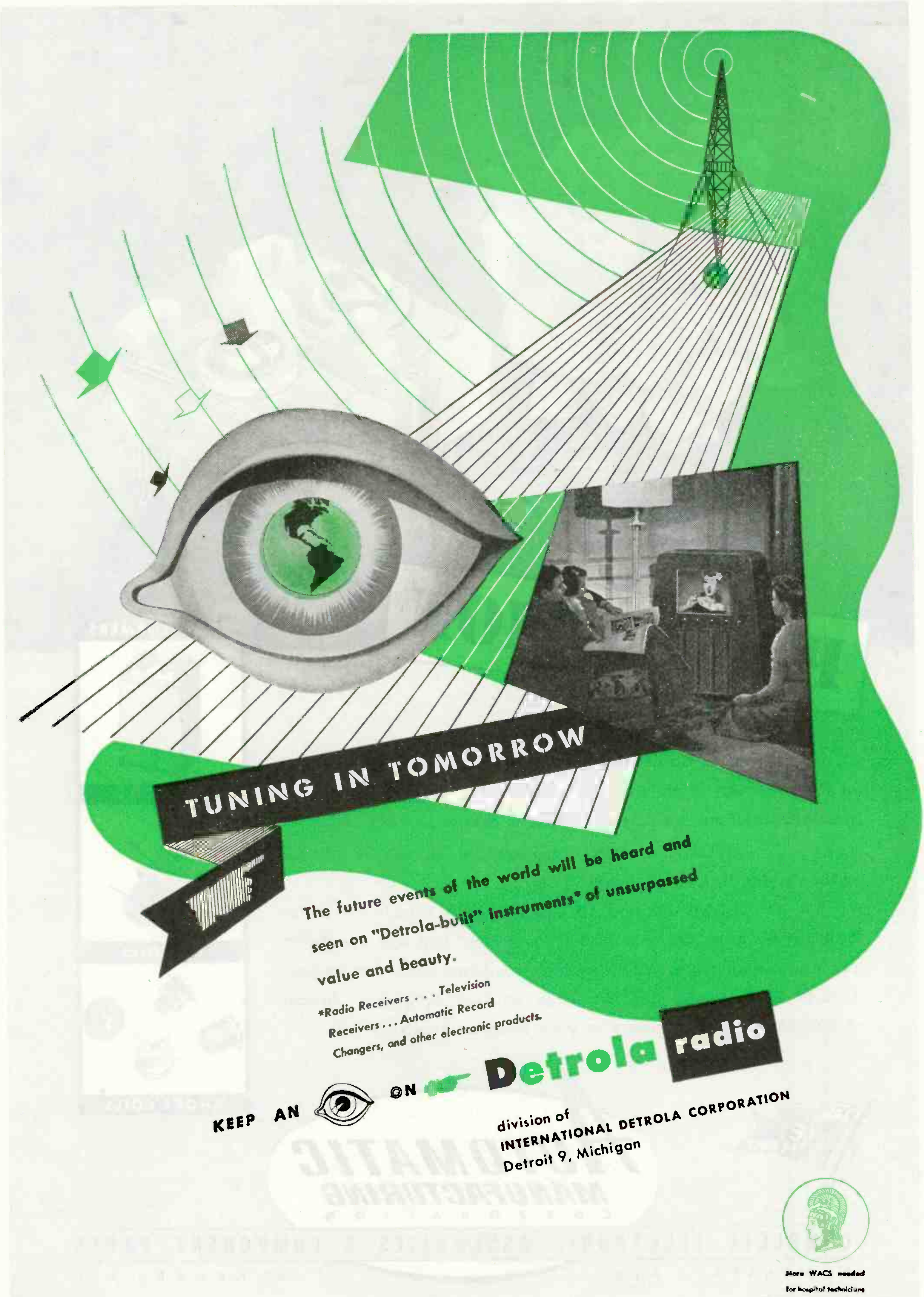


Fig. 2—Method of sealing a shaft hole in a cast panel

sists of a circular rubber washer backed up with a metal washer. This type of construction is shown in Fig. 2. A packing nut is used to hold the rubber and metal washers in place. As the packing nut is tightened, it forces the rubber against the bottom of the counterbored hole. Since the diameter of the counterbore is just slightly larger than the outside diameter of the rubber washer, it also causes the rubber to seal around the shaft. A suitable lubricant is used on the shaft to prevent the rubber from gripping the metal.

For sheet-metal panels, a different type of gland is used. As shown in Fig. 3, this type of construction consists of a metal bushing having a rubber diaphragm vulcanized to it. The rubber diaphragm is held in place by screws through the panel and diaphragm into a back-up metal disc. These screws are dipped into a sealing compound before being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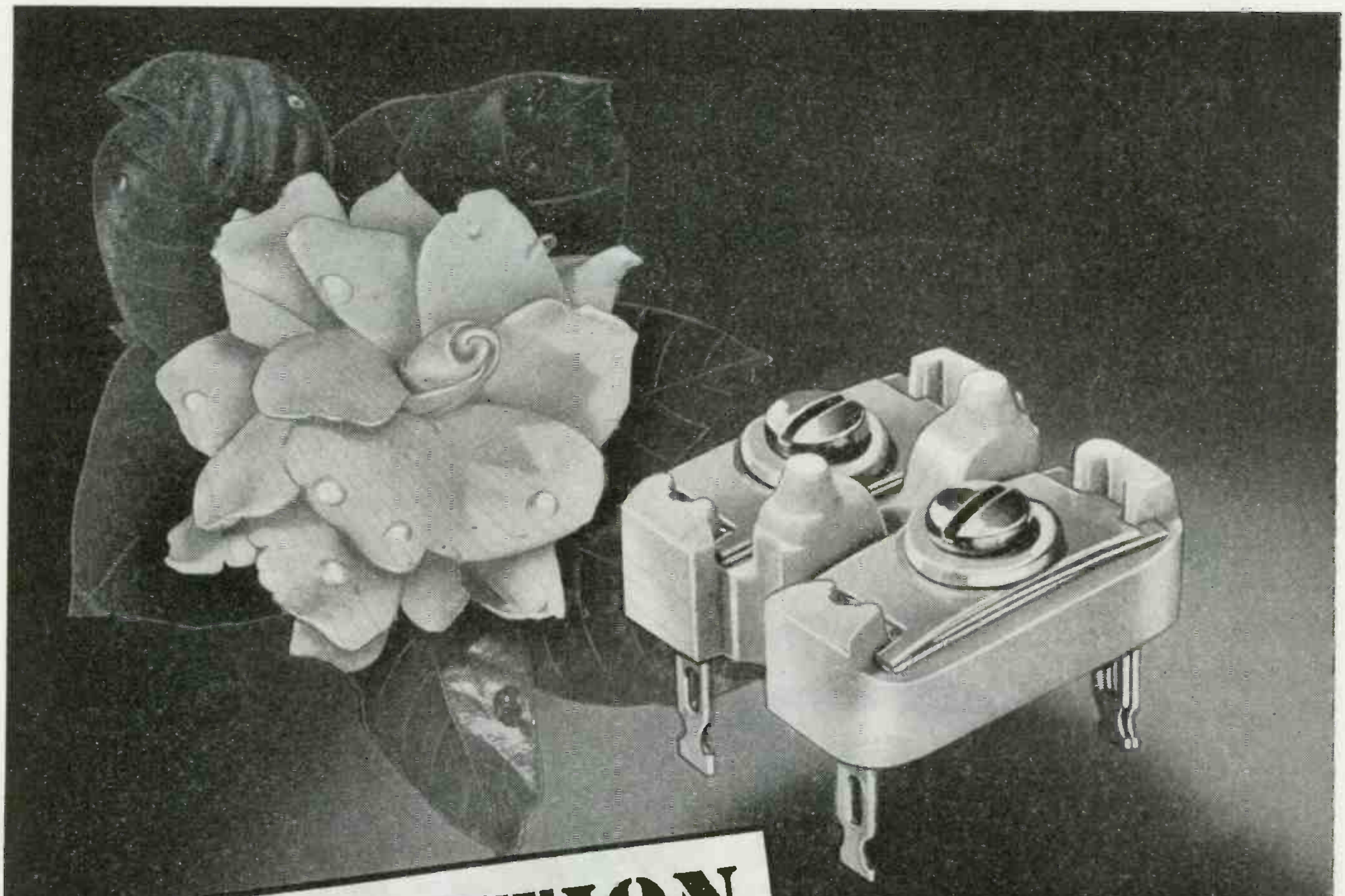

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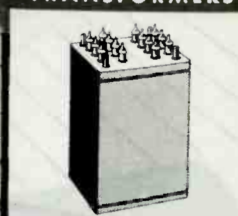

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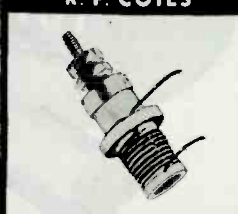

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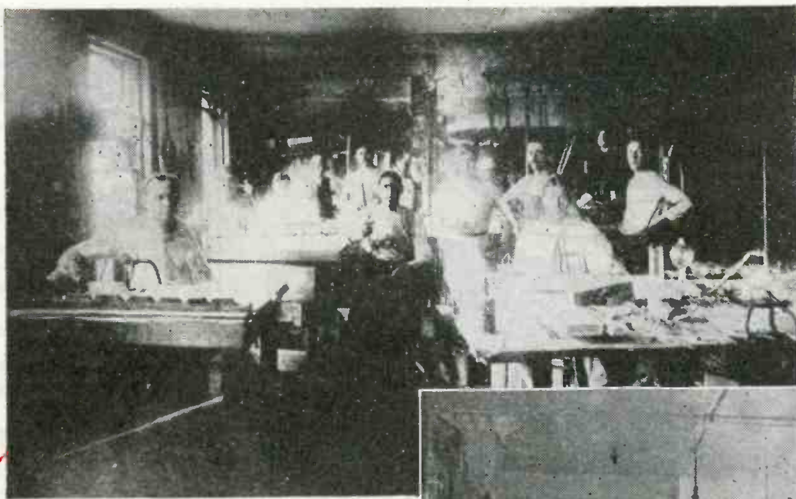

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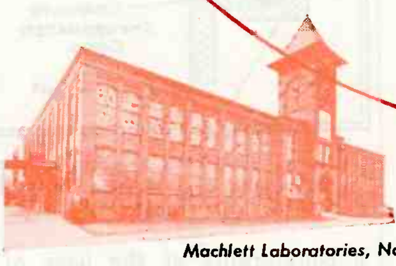

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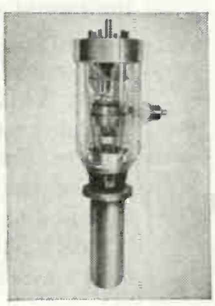

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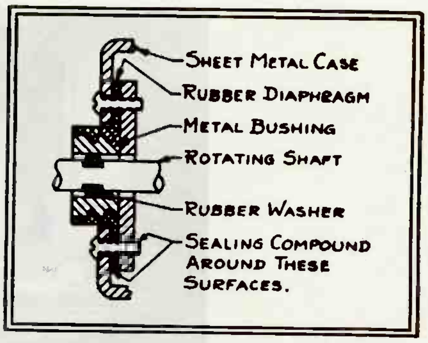

Fig. 3—Gland construction for sealing a sheet-metal panel

assembled. Sealing compound is also placed between the diaphragm and the panel. The rotating shaft for this type of installation has an undercut which carries a rubber sealing washer which is circular in cross section. The diameter of the bushing, being slightly less than that of the rubber washer when installed on the shaft, causes the rubber to be squeezed between the shaft and the bushing, creating the seal. As in the preceding type of gland, lubricant is used between the rubber and the bushing.

The third type of packing gland used requires considerably more space than the two explained above. This method has been used for years on propeller shafts and water pumps and is illustrated in Fig. 4. It consists of a packing nut having

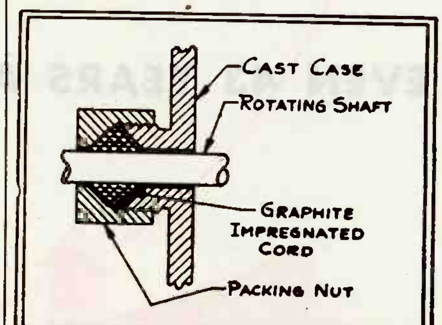

Fig. 4—Shaft hole can also be sealed with impregnated cord and a packing nut

a countersink at the base of the threads and a packing gland having a similar countersink. A graphite impregnated cord, which is wound around the shaft, is forced into the small space created by the countersinks. This seals around the shaft as well as around the inside diameter of the gland. The impregnation of the cord serves as a lubricant and as a water seal.

Pushbuttons and toggle switches used on some pieces of equipment

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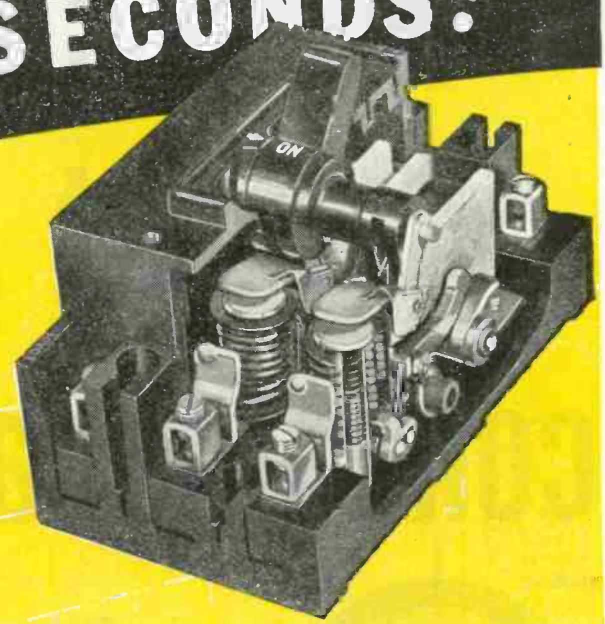

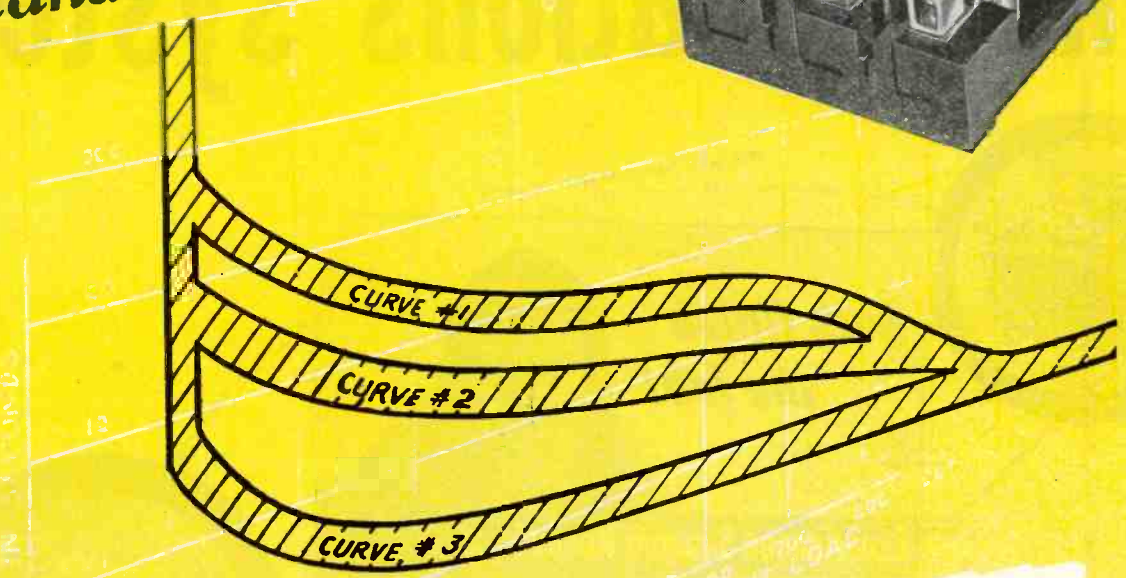

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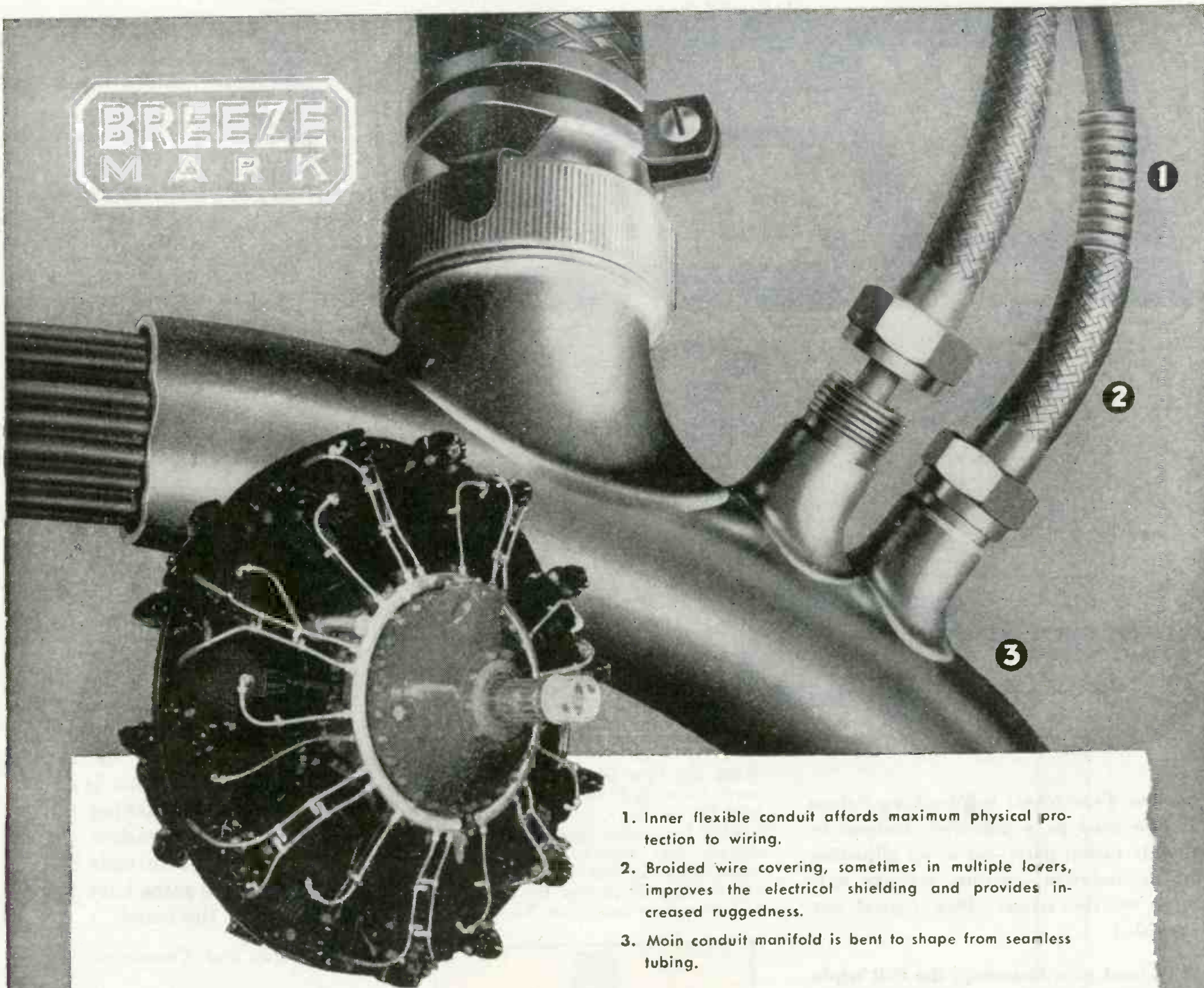

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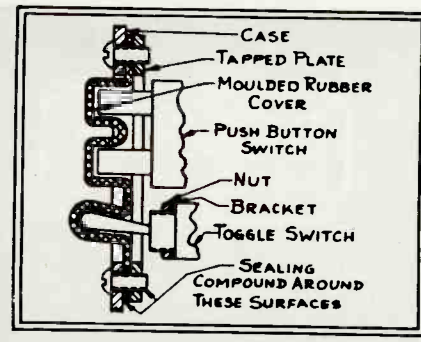

Fig. 5—A molded rubber cover seals pushbuttons and toggle-switch handles

are covered with a molded rubber cover as shown in Fig. 5. This cover is fastened to the panel with screws and a back up plate. Sealing compound is placed between the panel and the cover and also on the screw threads. The rubber cover has molded extrusions which fit over the buttons or switch handle, making them readily accessible.

In cases where it is necessary to run tie rods through the panel, the tie rods are sealed by using a rubber gasket backed up by a cup washer. This construction is shown in Fig. 6. As the fastening nut is tightened, the cup washer forces the rubber into the threads of the tie rod and at the same time forces it tight against the panel.

Cables and Connectors

Cable connectors for electrical leads proved to be somewhat of a problem. However, the manufacturers of these connectors produced a unit having inserts molded into a Bakelite base which in turn is sealed in a metal shell by means of a sealing compound. The connector is mounted to the panel with a gasket between the two pieces. The screws used for mounting are screwed into blind tapped holes or dipped into sealing compound and fastened into screw plates.

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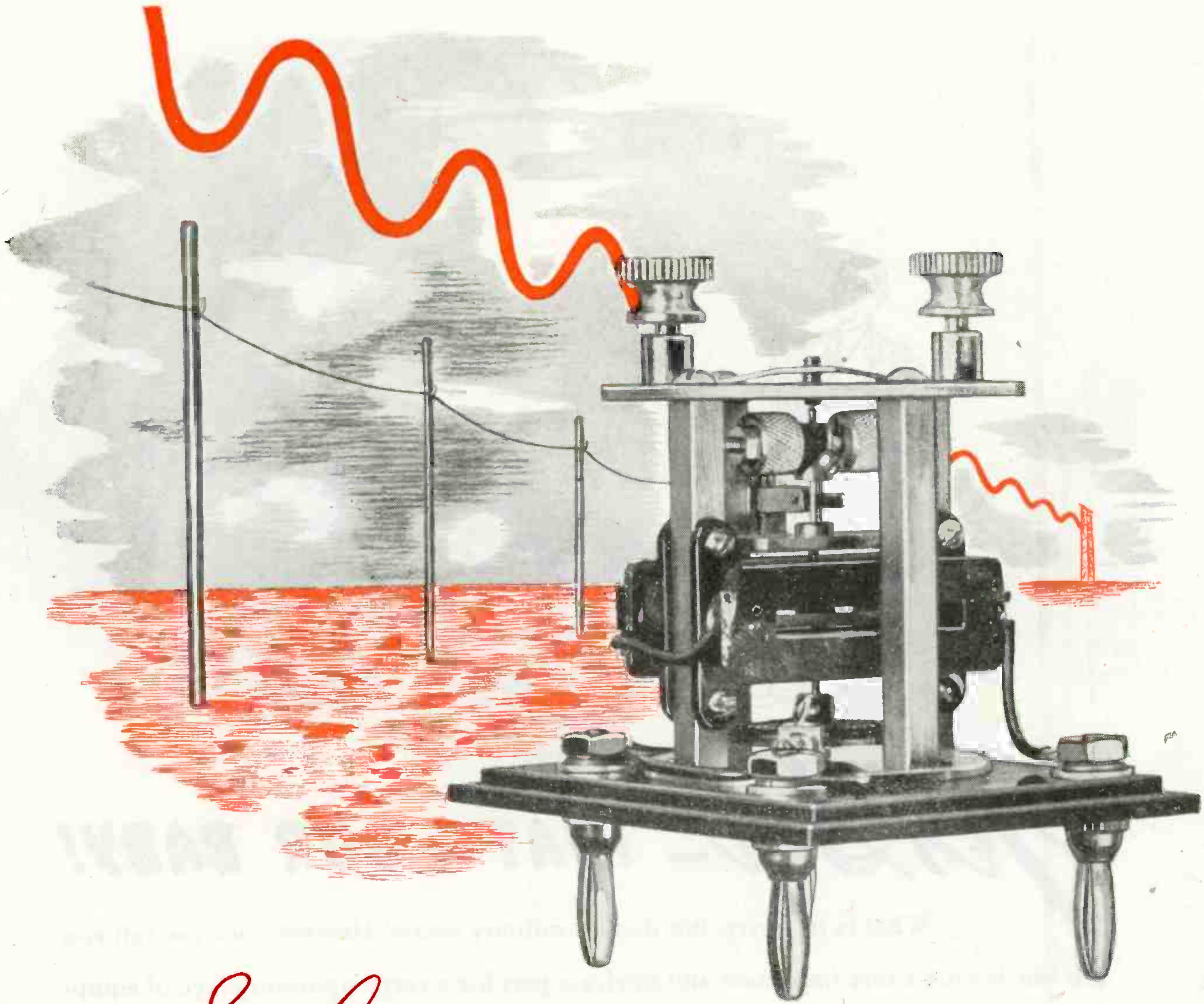

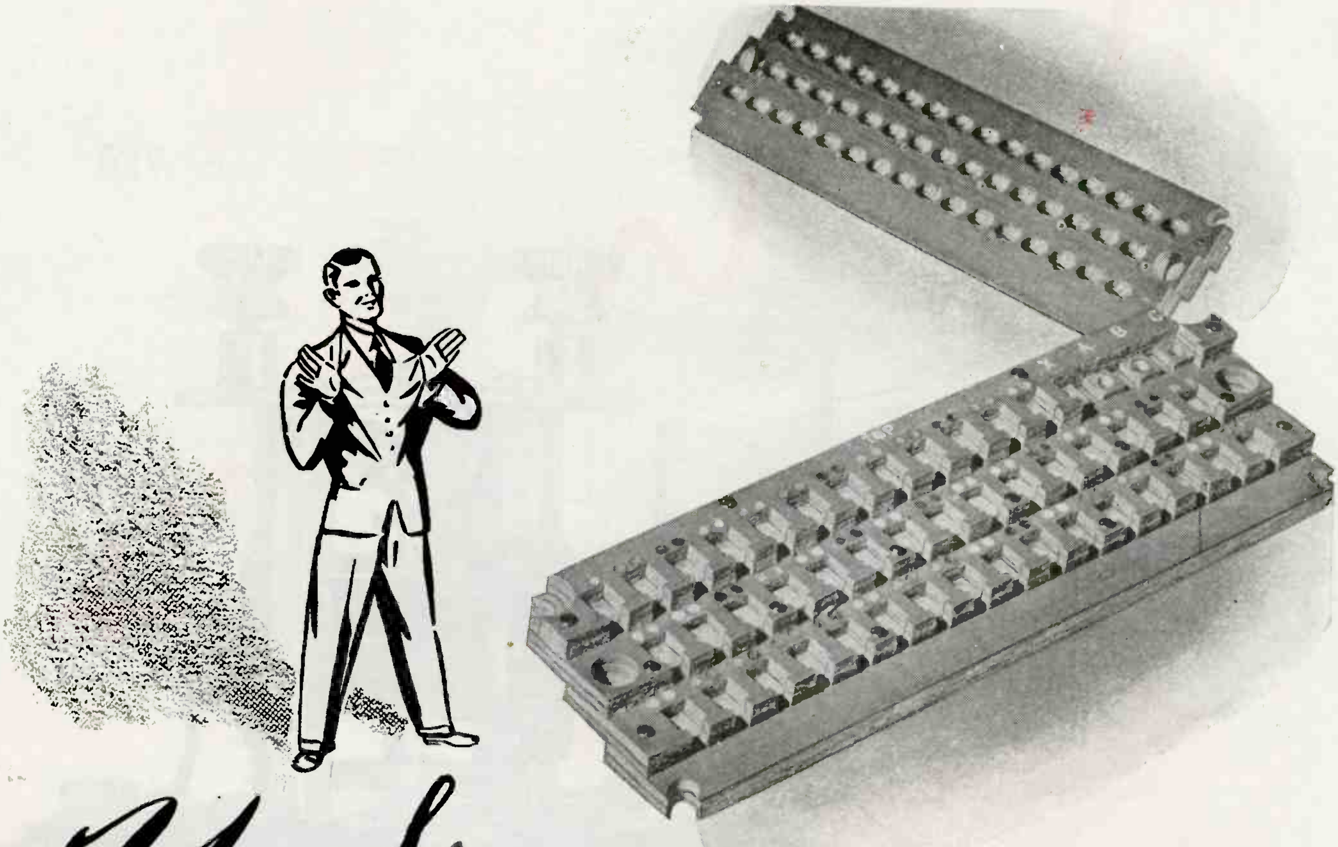

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problem: more power in a hurry...

CORNELL-DUBILIER HAD THE ANSWER

American Industry had to speed up for war production. That meant more electric power—much more. But there was no time to build new generating equipment, nor could we release copper and other critical materials.

CORNELL-DUBILIER ENGINEERS HAD A SOLUTION . . . C-D Power-Factor Capacitors. They're easy to install quickly, they save man-hours and critical materials.

Like all C-D Capacitors, power factor units *are precision products.* To make sure of their perfection, highly trained men, long skilled in testing capacitors check and recheck repeatedly throughout production.

Devotion to detail is a habit with C-D craftsmen. Their precision methods have made C-D's famed for dependability since 1910. *Look to C-D for capacitors of better-than-specified quality, performance and life.* Cornell-Dubilier Electric Corporation, South Plainfield, N. J. Other Plants: New Bedford, Brookline, Worcester, Mass. and Providence, R. I.

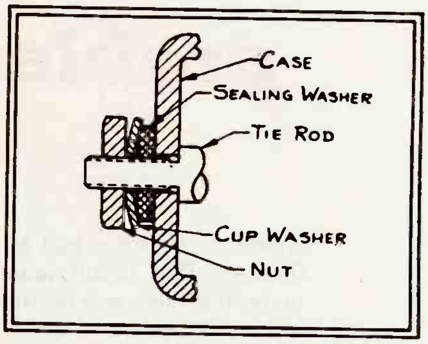


Fig. 6—Simple seal for tie rods

answer being a liquid tar drawn into one end of the cable by a vacuum applied at the opposite end. Cables sealed in this manner are tested under three feet of water for a period of twenty-four hours. Careful examination at the end of this time disclosed that water had not traveled from one end of the cable to the other. In assembling the cable to the unit, the end of the cable into which the melted tar had been drawn is left in the open while the opposite end is sealed into the case. By assembling in this manner, water is excluded from the entire length of the cable.

Phone Jacks

The final and most troublesome part of waterproofing was phone jacks used for plugging in a microphone, ear phone, speaker or transmitting key. These jacks must be easily accessible and at the same time must be waterproof. Spring-actuated hinged covers, having a rubber gasket, were tried but due to production tolerances were not too successful. A rubber balloon arrangement shown in Fig. 7 fastened and sealed to the inside of the case around the jack body, having a hole for wires to pass through, proved satisfactory. The wires are first coated with a rubber cement,

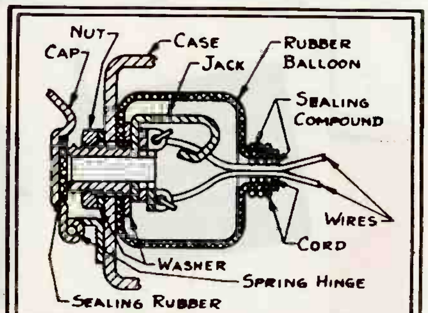
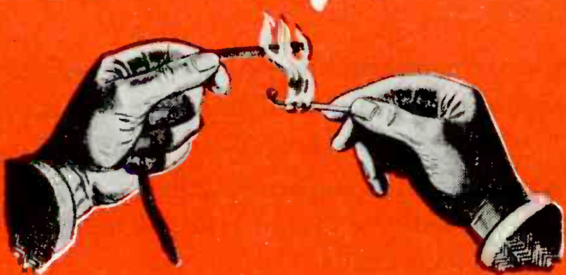


Fig. 7—A rubber balloon behind the panel and an auxiliary rubber cover seals a phone jack

BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

CAN'T BE SCORCHED!

MAKE THIS FLAME TEST



Hold a match under a piece of BH *Extra Flexible* Fiberglas Sleeving. The flame does not burn, char or otherwise affect it. And temperatures much higher than usually encountered electrically are just as readily resisted by the inorganic Fiberglas!

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2 WAYS BETTER

NON-FRAYING • NON-STIFFENING

FEW electrical insulations can double in brass as heat insulations. Yet so effectively heat resistant is BH *Extra Flexible* Fiberglas Sleeving that actual service records show it refuses to burn even in direct contact with heat units. The reason—both yarns *and* impregnation are non-inflammable!

A special gum base and dye applied by an exclusive BH process is responsible for many more features. It permanently *prevents fraying, stiffening and abrasive wear.* The sleeving is unusually flexible and takes the roughest handling without fraying. It does not harden and crack with age—lasts indefinitely without deterioration. It is also non-crystallizing at low temperatures.

Fiberglas is non-absorbent and unaffected by moisture, oil or grease—qualities ideally suited to appliance manufacture for instance. And it has high dielectric and tensile strength.

"Punishment" tests prove that BH *Extra Flexible* Fiberglas Sleeving is the most logical insulation for a host of tough jobs. Why not see for yourself? It's available in all standard colors and all sizes from No. 20 to 5/8", inclusive. Write for samples today and compare!

BH SPECIAL TREATED FIBERGLAS SLEEVING UNAFFECTED BY HEAT UP TO 1200°F!

This is a high quality sleeving that will not fray when cut and withstands heat up to 1200°F. Yet no saturant is used in the exclusive BH process! Flexible as string, too. Made in natural color only—all standard sizes. Try it!

BH PRODUCTS

ALSO SLOW-BURNING IMPREGNATED MAGNETO TUBING • SLOW-BURNING FLEXIBLE VARNISHED TUBING • SATURATED AND NON-SATURATED SLEEVING

BENTLEY, HARRIS MANUFACTURING CO.

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then passed through the hole in the balloon. The flange on the balloon is then tied tightly around the wires with a piece of cord and more rubber cement applied. This method is now being used in production. Other arrangements which may prove superior are now in the experimental stages.

We believe there will be many applications of waterproofing to various pieces of special equipment after the war. The time spent in research and development and the production line experience gained during the war will permit us to produce products which will give dependable performance under all conditions.

• • •

Transmission of Color Pictures by Facsimile

COLORED PHOTOGRAPHS can be sent and received at any distance in the form of three-color separation films ready for the customary photographic processing in assembling a colored print, according to a patent covering transmission of color by facsimile granted recently to Finch Telecommunications, Inc.

The system is based on standard facsimile equipment and practice of the Finch system, with certain changes in transmitter and receiver. In transmitting copy or black and white photographs and drawings, transmitting and receiving drums are the same size and diameter and are synchronized to operate at equal speeds. On the ordinary black and white Finch facsimile transmitter, the scanning head assembly includes an exciting lamp, lens system, and photocell, which are given a reciprocating motion through the operation of a driving cam at the bottom of the main driving shaft. During each cycle of operation, the scanning head is swung from left to right through an angle of 42 deg and is returned to complete its cycle in one second. The drive is by a 1/15-hp synchronous motor that operates at 1800 rpm and drives the scanning mechanism by means of speed-reducing gears with a step-down of 30:1, which turns the main drive shaft at a speed of 60 rpm.

Full Color Transmitted

While the patent anticipated transmitting the primary color sep-


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LONELIEST RADIO STATIONS
In a bleak and desolate Long Island marsh stands a small windowless house — alone and mysterious. But the three antenna masts surrounding it offer a clue to its function.
This is United Air Lines' radio communications station, remotely-controlled from a hangar at La Guardia Field. The pilot's contact with the ground, it transmits such vital information as weather conditions, wind direction, and air traffic instructions.
Here dependability is a *must* . . . and this Federal transmitter — the FTR-5 — is on the job every minute of the day, every day of the year. The only direct human attention it receives is a routine inspection visit . . . about once a month.
The need was for efficient, unfailing service . . .
. . . *which Federal equipment delivers.*
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COILFORMS OF NYLON

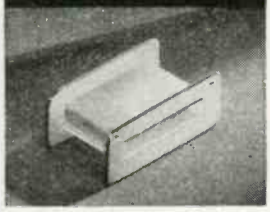
Used in U. S. Navy Sound-Powered Telephone Units

FOUND TOUGHER—LESS EXPENSIVE—MORE HEAT-RESISTANT

THE OLD WAY

PAPER COILFORMS made of three layers of 0.004 inch gummed kraft paper, with vulcanized fiber flanges, anchored by fillet of phenolic cement.

THE NEW WAY



NYLON COILFORMS injection molded of Du Pont FM-1 nylon molding powder by Boonton Molding Co. Boonton, N. J., for Control Instrument Co., Bklyn., N.Y.

FOR PLASTICS, CONSULT DU PONT

ADVANTAGES—For maximum sensitivity and output in Navy sound-powered telephone units, many turns of wire must be placed as close to an armature as possible. Though the wall of the nylon core is only 0.012 inch thick, it maintains, under test, dimensional and dielectric stability at temperatures ranging from −60° F. to +400° F. According to the manufacturer, operations have been reduced from six to three, thus contributing to cutting the cost of the finished coilform by 50% with the use of nylon. With the old materials only about 10% yield was obtained; with nylon the average yield is better than 95%. With a two-cavity die, injection-molded nylon has increased coilform production per man 800 to 1000%.

AVAILABILITY—The current supply of Du Pont nylon is available only for war applications and experimental work. For information write E. I. du Pont de Nemours & Company (Inc.), Plastics Department, Arlington, New Jersey.

aration prints of a colored picture to a remote point, transmissions to date have been from a full color print to three color separation positives, assembled into colored prints by the usual photographic methods after reception.

For color transmission, the equipment receives minor changes in transmitter and receiver. A color disk is interposed between the scanning eye and the picture on the drum of the transmitter. This color filter contains triangular gelatine sections of the three primary colors so that each in turn is filtered out and transmitted to be recorded by exposure of the film on the receiver drum.

Separations Made by Receiver

The transmitting cylinder on the color transmitter revolves at 300 rpm while the color disk revolves but once in the same time. Thus, the first color selected for transmission is filtered out and sent. The receiver, located in a dark room, has on its drum unexposed films of the same measurement as the full color picture on the sending drum. The receiving drum revolves at only 100 rpm and has three times the circumference of the transmitting drum, so that it takes all three films to record the three principle colors.

During the time the transmitter

• • •

CHINESE RADIO INDUSTRY

Army receiving equipment is tested in a plant of the Central Radio Works near Kweilin that has, at least until recently, produced all the radio apparatus used by the Chinese Army and broadcast stations operated by the government


Belden CONNECT-A-CORD
PRE-WAR
POSTWAR

M-R

#868 EX A New Star in Mitchell-Rand's Galaxy of SEALING and POTTING COMPOUNDS

Now in world-wide service, successfully withstanding the rigors of climatic extremes . . . from minus 40° F. to plus 180° F.

After two years in test #868 EX was made available to meet the most damaging conditions known for potting compounds. Its qualities soon became apparent and today #868 EX is doing 'Yeoman Service' protecting war equipment by resistance to cracking from low temperatures and flow from elevated temperatures while retaining the necessary electrical and waterproof characteristics.

868 EX is especially suited for sealing transformers, lightning arrestors, communication equipment and other products which require potting for positive protection against moisture despite extreme temperatures, plus or minus.

#868 EX has a high content of mineral filler.

. . . after being subjected to 180° F. for 8 hours showed very good resistance to cold flow.

. . . submitted to temperatures of minus 40-50° F. for several hours, did not fracture readily or show excessive brittleness. At 0° F. to 20° F. 868 EX showed remarkable flexibility.

. . . has good adhesion, toughness, resistance to fracture, waterproof and dielectric qualities.

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Softening Point (ring and ball)		245° F.
Specific Gravity (60° F.)		2.02-2.03
Penetration of Basic Compound	32/200/60	26
	77/100/5	40
	115/50/5	55
Flash Point		475° F.
Fire Point		565° F.
Suggested Pouring Temperature		400° F.-425° F.

Upon written request a One Gallon Sample of #868 EX will be sent, gladly, for laboratory tests

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Fiberglas Saturated Sleeving and Varnished Tubing
Asbestos Sleeving and Tape
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth and Tubing
Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevings
Impregnated Varnish Tubing
Insulating Varnishes of all types
Extruded Plastic Tubing

has sent a complete line from top to bottom of a picture, the receiving drum revolves only one-third of a revolution, covering a single line on one color film. In this way, the scanner selects and transmits impulses for the different colors, the receiving electric eye opening and closing to expose the films in the proper places for each of the primary colors.

Identifying Separations

In sending a picture, it is necessary to transmit an identification mark indicating the order in which the colors are being scanned. The color filter may be started with any of the three colors and will automatically rotate through the series. Without identification of this order of scanning the colors, the person on the receiving end might, with certain pictures, meet difficulty in knowing which color a film represents.

The films formed at the receiver are positives. In assembling them into a picture, the process is the same as in making the usual full-color print of a photograph. Received positives are on thin translucent or transparent gelatine. After the film is developed, it is bleached in the conventional manner and the separations are dyed to their proper color with an aniline dye or by toning them with metallic salt solutions which combine with the silver retained in the print. Finally, the monochrome colored prints are superimposed to form an integral final picture, laminated on paper or board back as in the case of any colored photographic print.

Use of the system commercially as a post-war project suggests that photographs now regularly transmitted over long distances may be increasingly sent in color. The principle deterrent, however, would appear to be limited use of color reproduction either by letter-press printing or photo-offset in magazines and other periodicals. The method also suggests itself as a rapid and low-cost method of ordinary color separation by an engraver who might set up transmitter and receiver in the same room and separate either prints or color negatives into three separation negatives from which to make plates for letter-press printing of color.

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THE ELECTRON ART

Transmission Line Parameters for Wave-Guide Behavior

WAVE GUIDES are analyzed on the basis of transmission-line theory and the results applied to conditions of guides used as resonators, and to terminal and input impedance in two companion papers in *Journal of Applied Physics* for July 1944. In the first paper, David Middleton and Ronald King develop equations for hollow wave guides of arbitrary cross section. In the second paper, Middleton presents some applications of this analysis to particular wave guide configurations.

The special value of the expressions for stream and potential distributions as derived in the first paper is that they are of the same hyperbolic form as transmission-line equations, and hence can readily be interpreted in terms of the already familiar transmission factors of line and terminal parameters, standing wave ratio, and efficiency of power transmission.

However in drawing such parallels, the three-dimensional field configuration of the guide with its different modes and possible variety of boundaries must not be omitted. That is, although the stream and

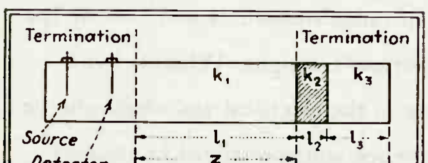

Fig. 1—Wave guide configuration for which terminal impedance as a function of added length l_3 beyond the dielectric (shaded section) was determined. The operating conditions were: wavelength, 10 cm; wavelength in guide, 16.8 cm; radius of guide, 3.65 cm; conductivity of brass, 1.43 × 10^7 mhos/m

potential functions of the field along the guide axis are shown to be expressable in the same form as transmission-line voltage and current, thereby providing a tool for solving transmission problems, the variation of the field perpendicular to the axis must be considered in practical applications. For example, two guides can present the same terminal impedance and yet not be matched unless the guide shape and wave mode are comparable.

By obtaining expressions for wave-guide behavior which are the

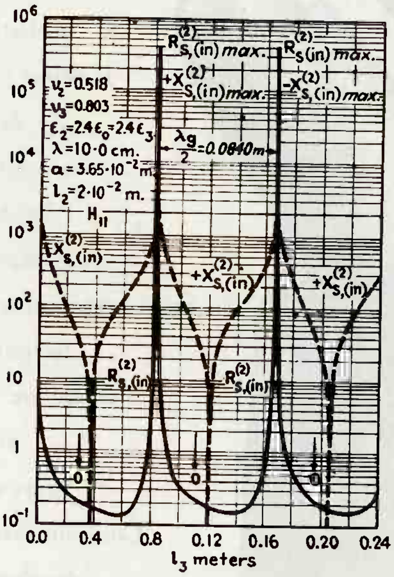

Fig. 2—Terminal impedance of guide of Fig. 1 for which the attenuation in guide is 2.11 × 10^{-3} nepers/m; in the dielectric is 2.93 × 10^{-3} nepers/m; phase shift in guide is 37.5 rad/m; in dielectric is 83.4 rad/m

counterparts of transmission-line propagation parameters, the analytic treatment enables wave-guide problems to be stated in terms of such quantities as characteristic impedance, propagation constant and phase shift. These constants are evaluated from physical parameters of the guide and dielectric material, and the transmission portion of the design carried out along familiar lines. This is, as the authors point out, a convenience of viewpoint and not an exact analogy, because the wave-guide equations so derived do not contain as a limiting case the transmission-line equations.

One illustration of this approach given in the second paper is that of the terminal impedance of a cylindrical brass pipe excited in the H_{11} mode and containing a dielectric as shown in Fig. 1. The terminal resistance and impedance are shown in Fig. 2.

Two Methods of Measuring U-H-F Fields

MEASURING ULTRA-HIGH-frequency electric fields by the induced dipole and dielectric thermometer methods is described in the June, 1944 *Philosophical Magazine* (Taylor & Francis, Ltd., Red Lion Court, Fleet Street, E.C.4, London), by K. R. Makinson and H. D. Fraser.

The fields to be measured were of 136 Mc and 510 Mc. At the lower frequency, both the dielectric thermometer and induced dipole methods gave corresponding results. At the higher frequency, the dielectric thermometer appeared useful only for comparative field strength measurements; the induced dipole was found to be more accurate.

The induced dipole method depends on the measurement of the couple exerted by the field on a small metallic strip lying at an angle of 45 degrees to the electric vector. The instrument was calibrated at 1.2 Mc and the calibration was independent of frequency up to higher than 500 Mc.

Construction of the induced dipole instrument is shown in the drawing. The copper vane dipole had the dimensions 2 cm × 6.5 mm × 0.1 mm. The only limitation on the upper frequency which this instrument can measure correctly is that the dimensions of the dipole be far less than the wavelength. The glass containing tube was coated with lacquer to prevent deposition of moisture which would tend to screen the dipole from the electric field.

For conductive strip and electromagnetic field, the couple is zero when the strip lies parallel to or perpendicular to the field and is at maximum when it lies at an angle

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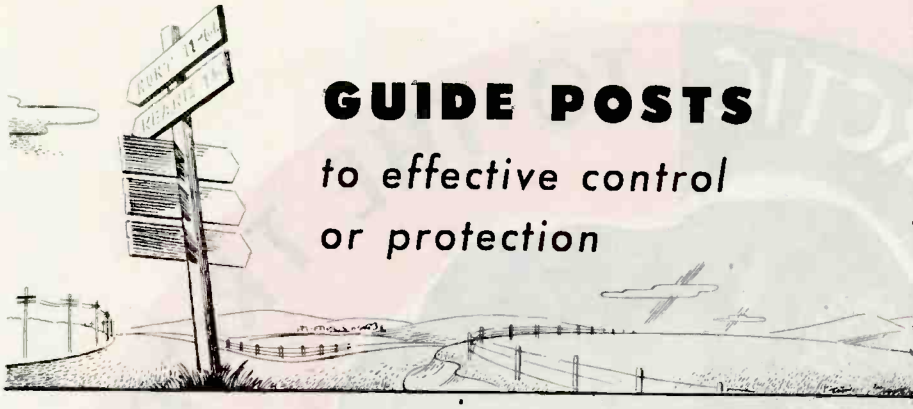
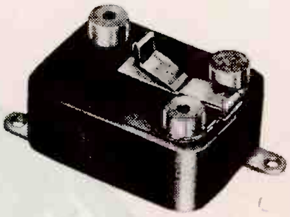
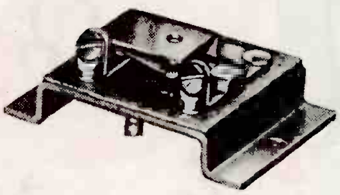


GUIDE POSTS

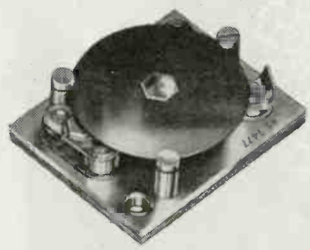
to effective control or protection



Type C-7220 Precision Snap Switch 12 amps. 30 Volts D. C. 125 Volts A. C.



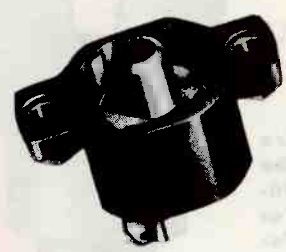
Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.



Type B-3120 Thermostat and Heater, Crystal Dew Point Control

Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.

Type RT Thermostat. Adjustable Temperature Control.



Type PM (NAF-1131) Circuit Breaker

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In hundreds of applications . . . from motor and transformer overheat protection, electrical circuit overload protection, thermal time delays to temperature control for radio equipment . . . Klixon snap-acting Controls are operating accurately and dependably year in and year out.

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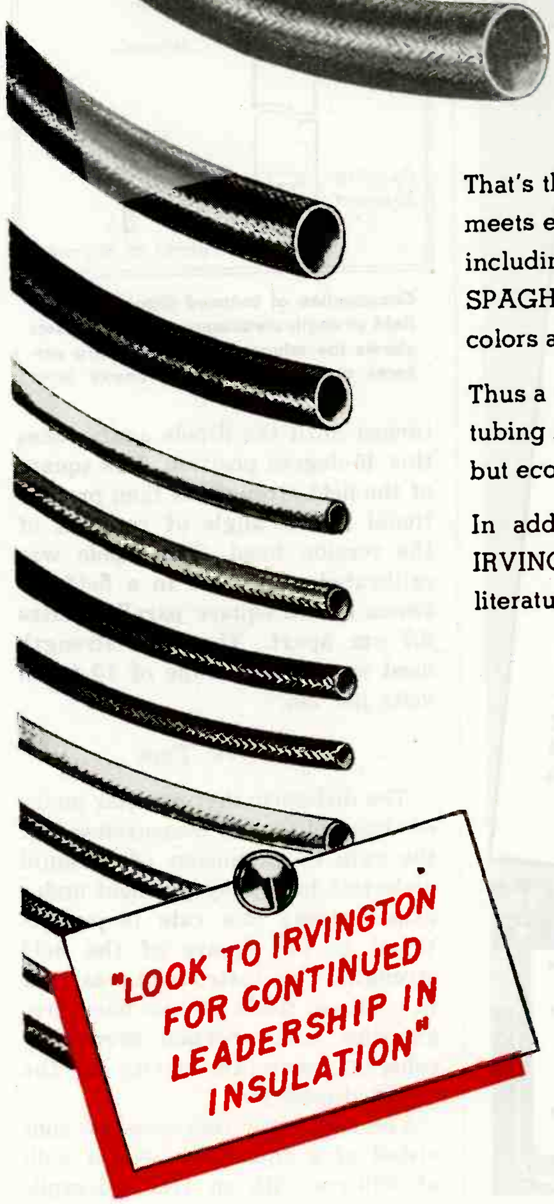

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Thus a recommendation from IRVINGTON can be unbiased . . . you get the tubing *best* suited to your needs, not only from the standpoint of efficiency, but economy as well.

In addition, you get that extra increment of electrical surety which IRVINGTON'S 'know how' and 'manufacturing control' provides. For literature, or engineering assistance, write to Dept. 106.

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- Extruded Plastic Tubings
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- Varnished Fabrics and Papers
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- Cardolite Resins

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IRVINGTON
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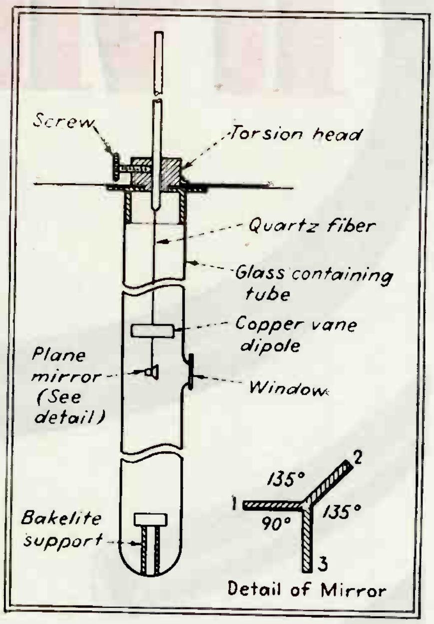
of 45 degrees. On the basis of this, the dipole was placed first at 0 degrees, then at 90 degrees to the field. That the correct position had been found was indicated by switching the field on and off and noting that there was no deflection of the dipole. With the field off, the dipole strip was then set midway between these two positions, therefore being at 45 degrees to the field. With the field on, the torsion head is



Construction of induced dipole for u-h-f field strength measurements. The insert shows the minor details: reflecting surfaces are represented by heavy lines

turned until the dipole again takes this 45-degree position. The square of the field strength is then proportional to the angle of rotation of the torsion head. The dipole was calibrated at 1.2 Mc in a field between 20 cm square parallel plates 6.7 cm apart. The field strength used was in the range of 10 to 30 volts per cm.

Dielectric Type

The dielectric thermometer method depends on the measurement of the rate of expansion of a liquid dielectric heated by the field under examination; this rate is proportional to the square of the field strength. This instrument was used to compare fields at two fixed frequencies using normal propyl alcohol of uncertain purity as the liquid dielectric.

The dielectric thermometer consisted of a thin glass walled bulb of 0.73 cm with an attached capil-

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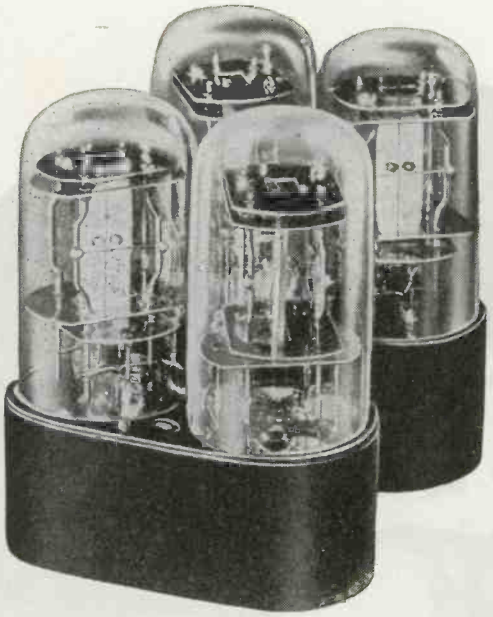
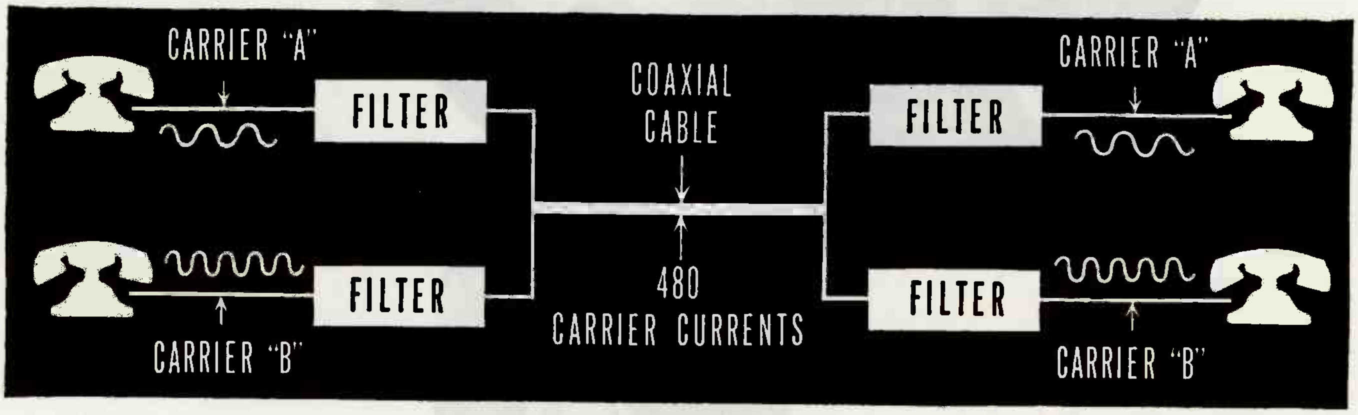
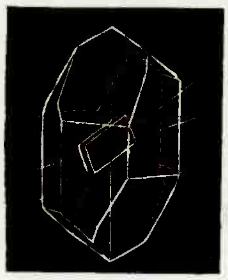


Crystal gateways for your voice





Four hundred and eighty telephone conversations over a coaxial cable was one of the last peacetime achievements of communication research in Bell Telephone Laboratories. In this multi-channel telephone system, each conversation is transported by its own high-frequency carrier current. At each end of the line are crystal gateways; each opens in response to its own particular "carrier" with the message it transports. In telephone terminology, these gateways are filters.

The ultra-selective characteristic of these filters is made possible by piezo-electric quartz plates, cut in a special manner from the mother crystal, and mounted in vacuum. Each set of plates is precisely adjusted so that the filter responds only to the frequency of its assigned channel, rejecting all others. In the coaxial terminal equipment, such crystal gates sort out messages for delivery to their four hundred and eighty individual destinations.

In recent years, Bell Telephone Laboratories research has provided the Armed Forces with many types of electrical equipment in which frequency is controlled by quartz crystals. Notable is the tank radio set which enables a tank crew to communicate over any one of 80 different transmission frequency channels by simply plugging in the appropriate crystal. The future holds rich possibilities for the use of quartz crystals in Bell System telephone service.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for our Armed Forces at war and for continued improvements and economies in telephone service.

lary tube. The bulb was screened from draughts by a thin paper cylinder. The rate of expansion of the dielectric was found to be constant for the first minute.

Sensitivities of various liquids were examined. *N*-propyl alcohol of unknown purity was found to be the most sensitive. Calculations from the dielectric constant of alcohol verified the observations made with this dielectric thermometer within the accuracy of the known constants. The dielectric thermometer was calibrated against the induced dipole.

Because of the greater portability of the dielectric thermometer, it was decided that the best procedure would be to calibrate this thermometer against the more sensitive induced dipole and to use the thermometer for field measurements.

• • •

Photoelectric Fourier Analysis

FOURIER SYNTHESIS and analysis by a new photoelectric method is described in the October 1944 *Philosophical Magazine* (Taylor & Francis, Ltd., Red Lion Court, Fleet Street, E.C.4, London) by R. Furth and R. W. Pringle.

The system makes use of a disk of photographic film on which the pattern shown in Fig. 1 is repro-

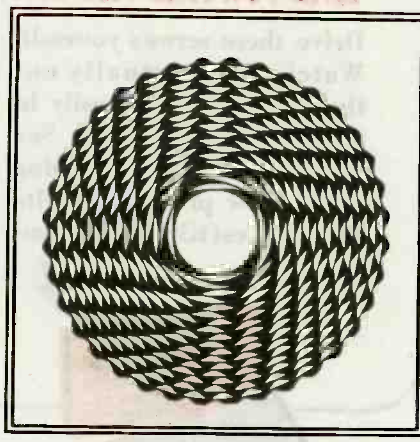


FIG. 1—Optical disk contains sine and cosine terms of the fundamental and harmonics

duced. On the disk, pairs of circles contain the various harmonics. The inner ring contains the sine term of the fundamental, the second ring contains the corresponding cosine term. In this way succeeding rings contain sine and cosine terms for harmonics up to the ninth. The disk

Cathode Ray Tubes For War and Post-War

AMONG the many types of tubes produced by North American Philips for war purposes is the 5-inch cathode ray tube illustrated here. The problem with this type tube was to produce it in volume with evenly coated screens having no pinholes or other defects.

The ability to produce, in volume, NORELCO cathode ray tubes that meet rigid specifications, is the result of experience gained by an organization with a background of over half a century of research and development in the electrical field.

Although NORELCO tubes now go to our armed forces, a list of tube types we are especially equipped to produce will be sent on request.

North American Philips will have post-war facilities available for the development and production of tubes for projection television; also amplifier, transmitting, rectifier and special purpose tubes.

Write today for interesting booklet on "How and Why Cathode Ray Tubes Work" and the brochure describing the background of North American Philips in the science of electronics.

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OTHER PRODUCTS: Quartz Oscillator Plates; Searchray (Industrial X-ray) Apparatus, X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Tungsten and Molybdenum Products; Fine Wire; Diamond Dies.

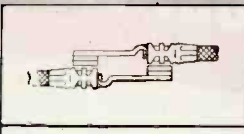
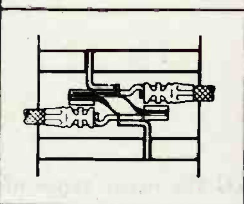
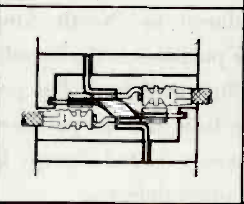
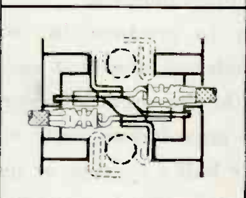
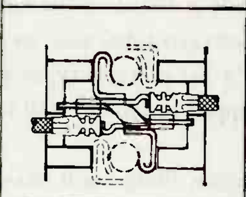
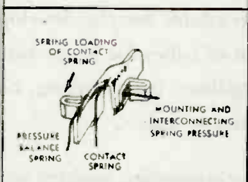
Norelco Electronic Products by **NORTH AMERICAN PHILIPS COMPANY, INC.**

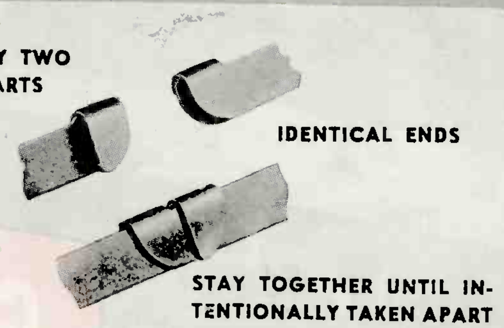
Dept. C-4, 100 East 42nd Street, New York 17, N. Y.
Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Div.); Lewiston, Me. (Elmet Div.)

A SPRING NOT IN THE HANDBOOKS

Typical of the engineering which has produced AMP SIMPLIFIED WIRING is the development of the conducting member of the AMP connector block. After careful study of the job to be done, the goal was set and the problem analyzed in logical functional design stages.

The result is a device — simple, economical and completely satisfactory — which does the job desired. The conductor member supplies connect ends for the disconnect terminals and, by a series of ingenious spring actions incorporated in its design, is itself held firmly in place in the block and is a means of sound electrical connection between adjacent members.

	Terminals are in position for shortest possible overall length.
	Conductor design starts, taking minimum lateral space and providing support tabs.
	Contact surfaces extended, block reshaped to hold members securely and help insulate unit.
	To connect adjacent members tabs are shaped as spring members; metal plugs may be inserted.
	Bend in mounting tab creates spring pressure against mounting screw and on terminal slot.
	Completed conductor member.



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2. Modify or adapt design of present members of components to incorporate identical end as integral part of metal stamping — to which splicing terminal may be attached or detached at will.
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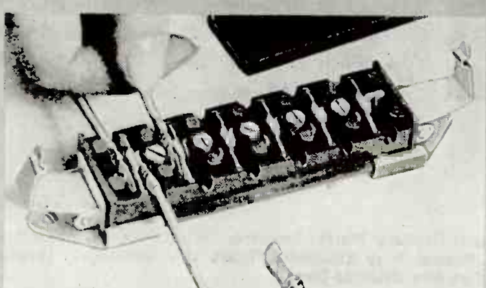

AMP connector block assembled. Connections insulated and locked when cover is in place.

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BUS BAR

is rotated between a light source and a photoelectric cell at a speed of 300 rpm. Associated with each ring is an optical wedge. The output of the photoelectric cell is fed through amplifiers to an oscilloscope.

In operation, the optical wedges are adjusted to give the amplitude on the oscilloscope screen of the particular harmonic sine or cosine terms of the function being synthesized. This adjustment is done individually for each one of the rings with all the others blanked out.

A continuous-control potentiometer driven from the same shaft as

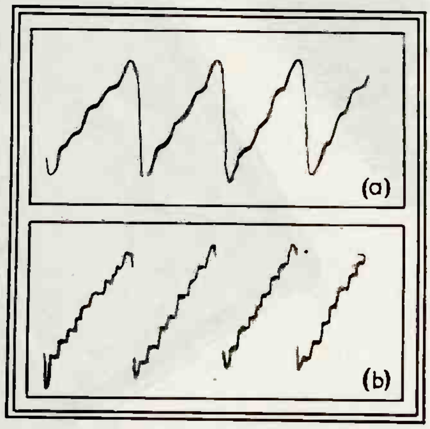

FIG. 2—Synthesis of a saw-tooth wave using (a) the first four terms in the Fourier series and (b) using the first eight terms

the optical disk provides the time-base for the oscilloscope. Fig. 2 shows a sawtooth wave synthesized by this method.

This photoelectric method can also be used for analysis of the Fourier terms in a given periodic function. The terms of such a function are given by the formula

$$a_n = (2/T)\int_0^T \cos(2\pi n/T)tf(t)dt \qquad (1a)$$

$$b_n = (2/T)\int_0^T \sin(2\pi n/T)tf(t)dt \qquad (1b)$$

These integrals can be evaluated

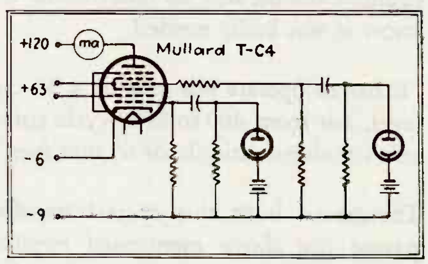

FIG. 3—The use of a mixer tube to combine two light impulses from the phototube Fourier analyzer accomplishes electrically the required mathematical integration of a product


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Engineering Department Report
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SOLUTION:
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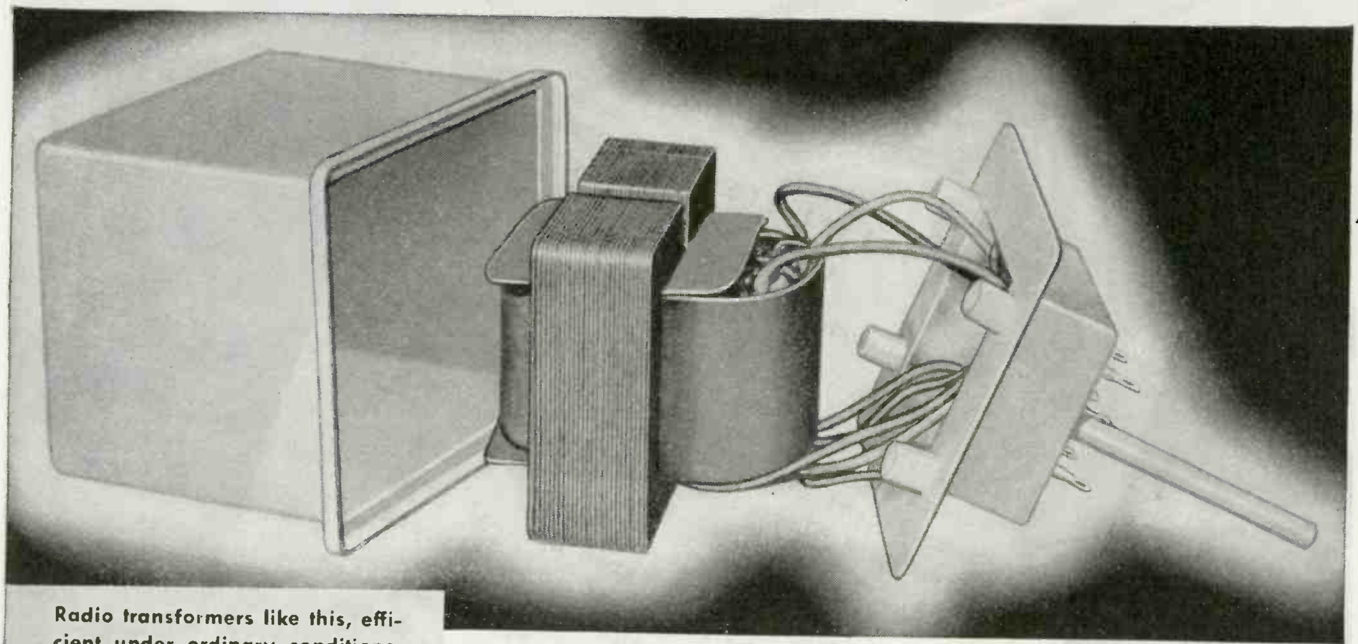
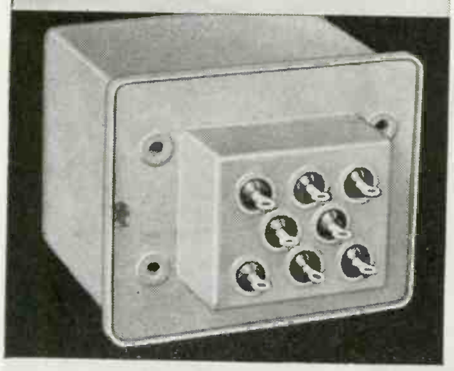
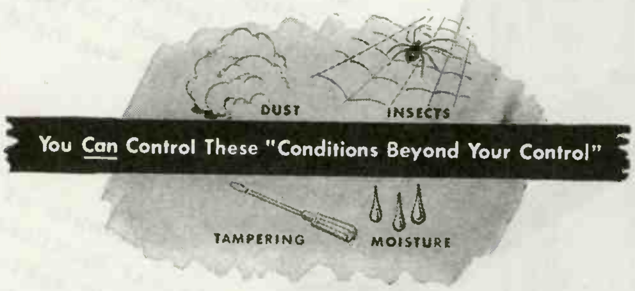
How Fedelco-Sealing solved *this* environment* problem



Radio transformers like this, efficient under ordinary conditions, had been going bad in airplanes. The trouble was traced to moisture, condensation being accelerated by changes in altitude and temperature. Fedelco-Sealing solved the problem. A metal case was designed to fit the original mounting—one requirement; leads were brought through sealed terminals in the base, and the cover was sealed on. Then the case was exhausted, refilled with dry air, and sealed permanently, ending moisture troubles.



* ENVIRONMENT may cause trouble . . .



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by the circuit of Fig. 3. The plate current of the circuit is

$$i = i0 + Ag_1 + Bg_2 + Cg_1g_2 \qquad (2)$$

If the two grid voltages are made functions of time this last term of Eq. (2) becomes of the form

$$C(1/T)\int_0^T g_1(t)g_2(t)dt \qquad (3)$$

where $g_1(t)$ is made to represent the term to be analyzed by plotting it in polar coordinates on a supplementary disk mounted in the transparent center of the disk of Fig. 1, and $g_2(t)$ is obtained from the harmonic sine-cosine disk by blanking out all but the desired ring.

The technique consists of obtaining a current reading for i of Eq. (2) with both the harmonic and the function optical systems active. The function (g_1) system is darkened and a current corresponding to

$$i_2 = i_0 + Bg_2 \qquad (4)$$

is obtained. By darkening the harmonic (g_2) system, a current corresponding to

$$i_1 = i_0 + Ag_1 \qquad (5)$$

is obtained. With both the optical systems dark i_0 is obtained. From Eq. (2), (4) and (5) and the value of i_0 the solution for Cg_1g_2 is

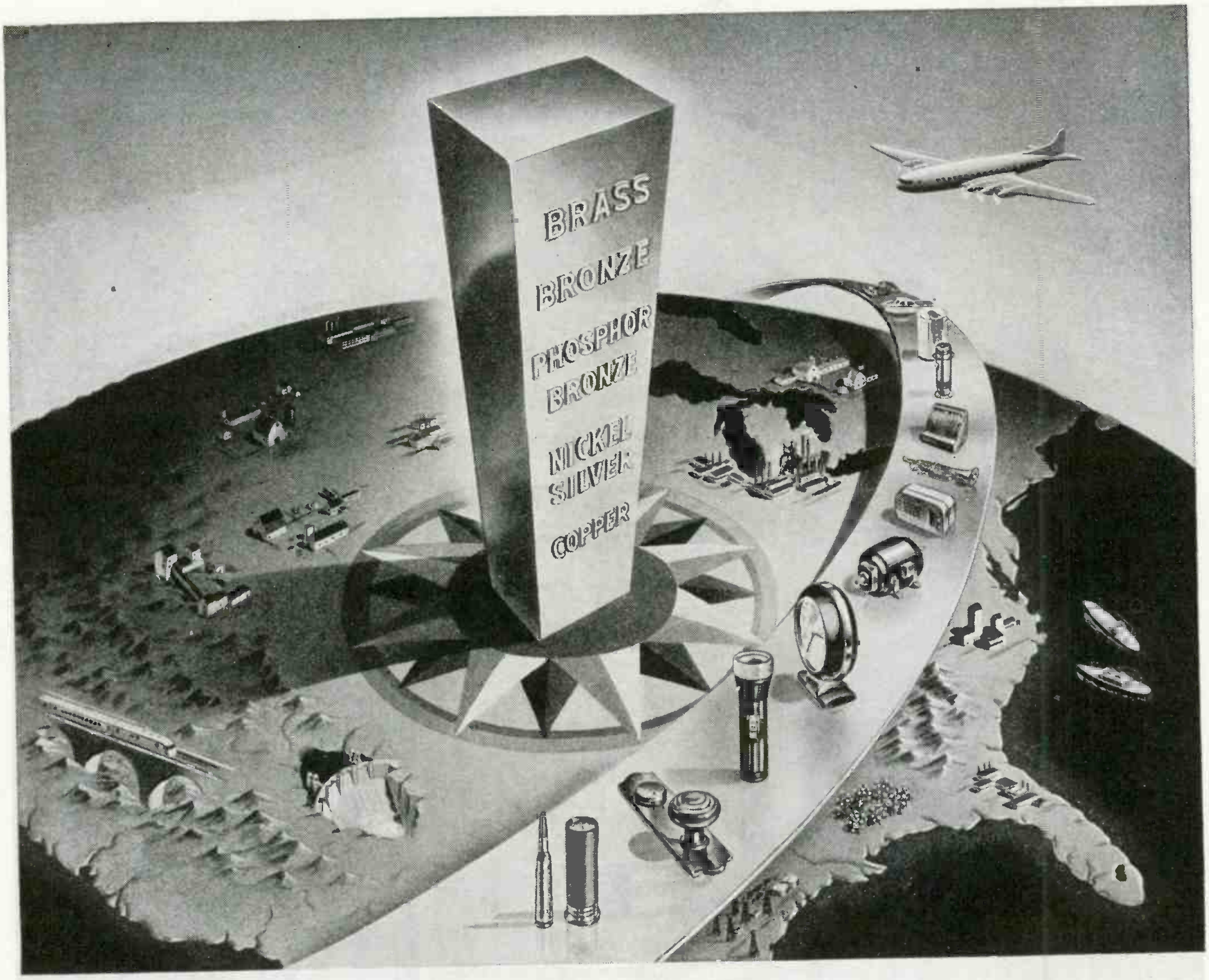
$$Cg_1g_2 = i - i_1 - i_2 + i_0 \qquad (6)$$

which is the value of the definite integral of Eq. (3). An analysis of a square wave carried out in this method is given in the table.

n	a_n (exp)	a_n (theor)	b_n (exp)	b_n (theor)
1	0	0	42	42
2	0	0	1	0
3	0	0	13	14
4	0	0	0	0
5	1	0	7	8.4
6	−1	0	2	0
7	2	0	6	6

This table gives a comparison of the experimental and theoretical harmonic coefficients of a square wave and shows the utility of the method

The equipment described for this synthesis and analysis was an experimental laboratory model. The authors believe that, with proper care in construction of the optical system and the use of specially designed circuits, the accuracy of the method could be greatly improved. The ease of operation and versatility of the method both for demonstration and as an analytical



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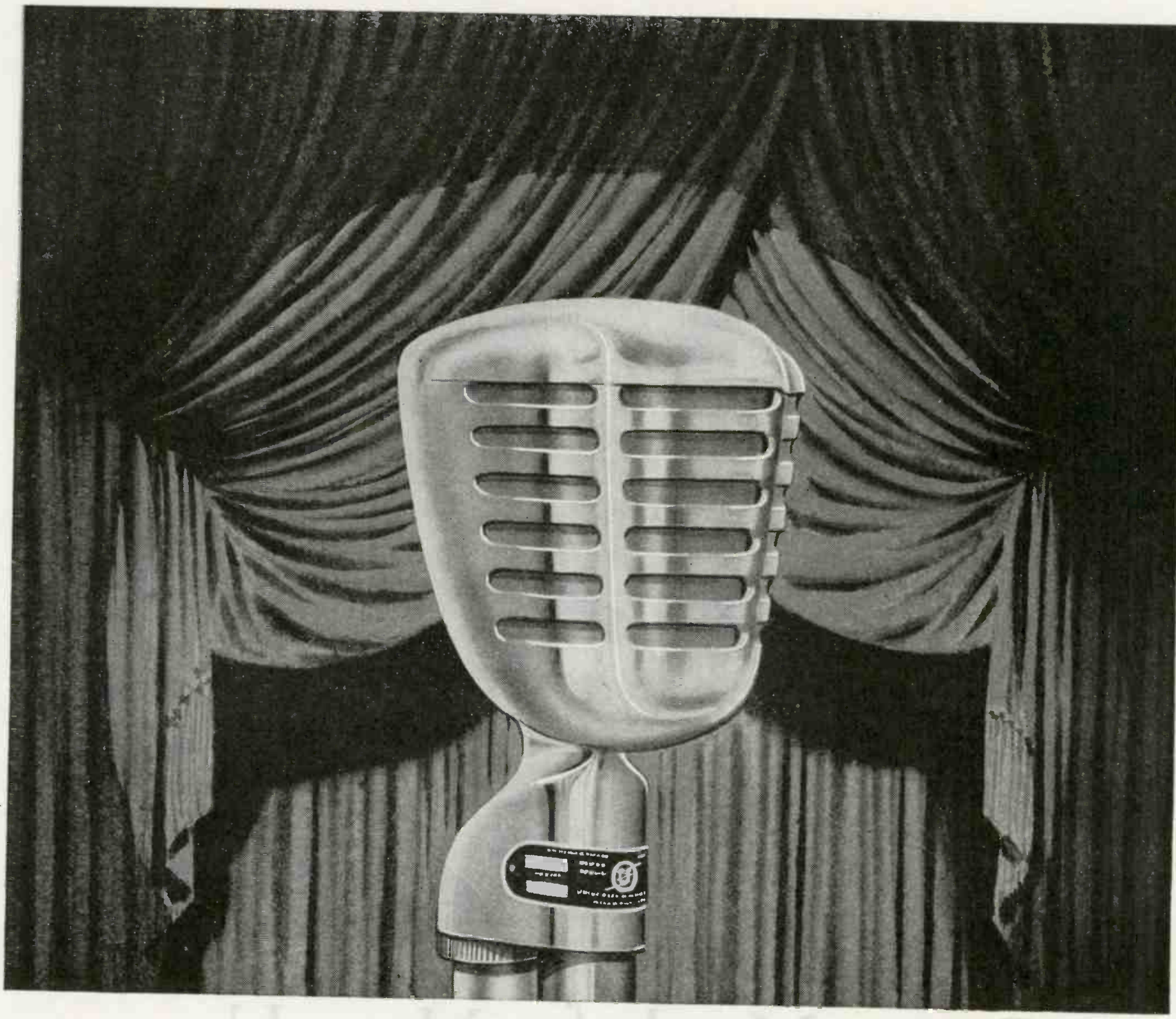

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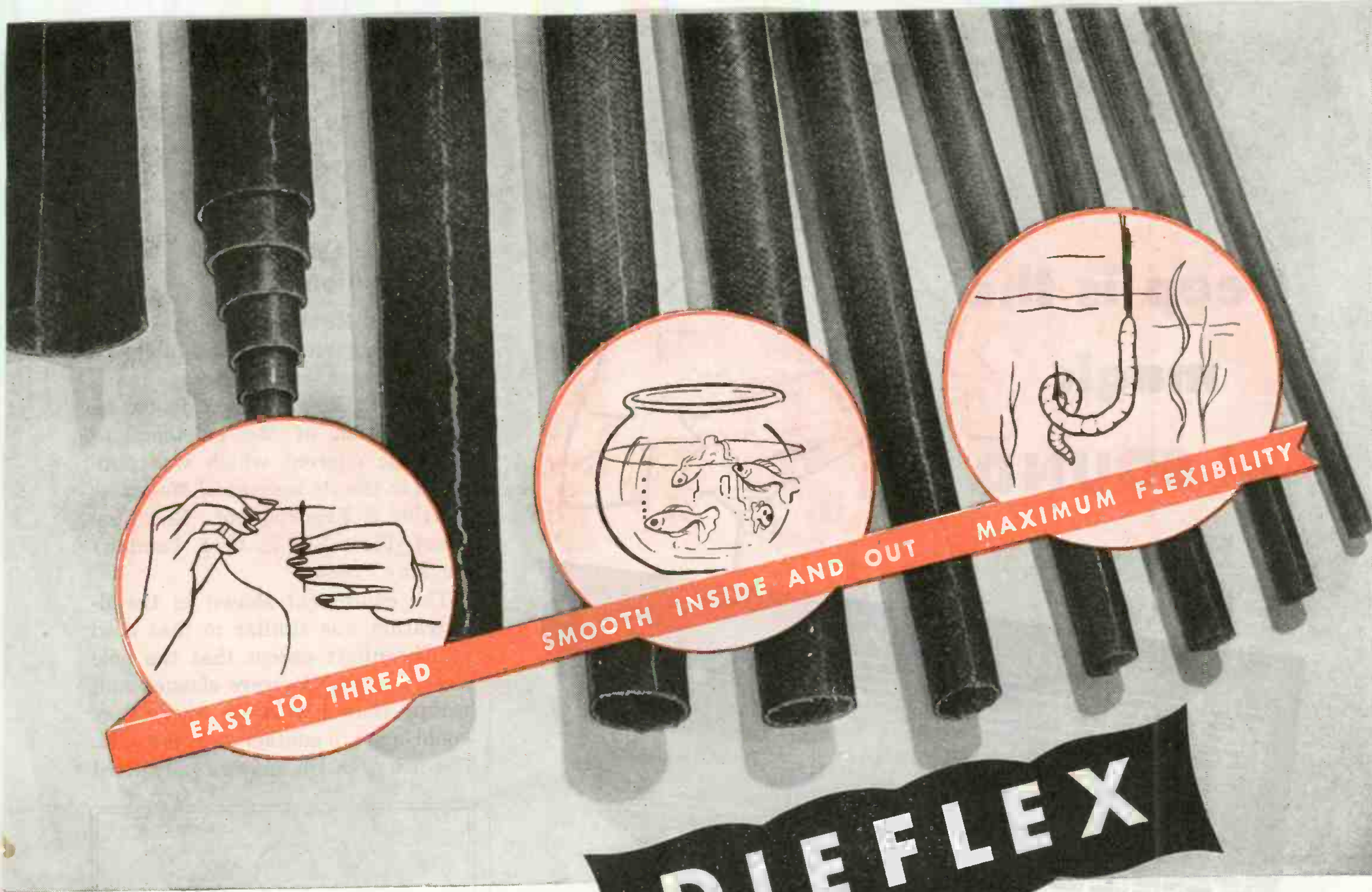

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Dieflex Products are a decided aid in manufacturing—the smooth inside treated bore is easy to thread—prevents snagging—facilitates telescoping. The roundness and non-flattening qualities—extreme flexibility and non-fraying qualities, give maximum workability and protection. The Fiberglas grades give permanence. Its complete varnish impregnation gives excellent protection against moisture, oils, and chemicals and provides maximum electrical insulating qualities.

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tool are amply illustrated by results obtained from the experimental setup.

• • •

Magnetic Current Investigation

TO VERIFY EHRENHAFT'S CLAIMS of having experimentally established the existence of a pure magnetic current, D. M. Millest conducted an investigation of the existence of magnetic current which was published in the *Philosophical Magazine* (Taylor & Francis, Ltd., Red Lion Court, Fleet St., E. C. 4, London) for May, 1944.

The equipment shown in the illustration was similar to that used by Ehrenhaft except that the pole pieces, P_1 and P_2 were cleaned and heavily coated with tin where they would come in contact with the acid. The use of a tin coating permitted

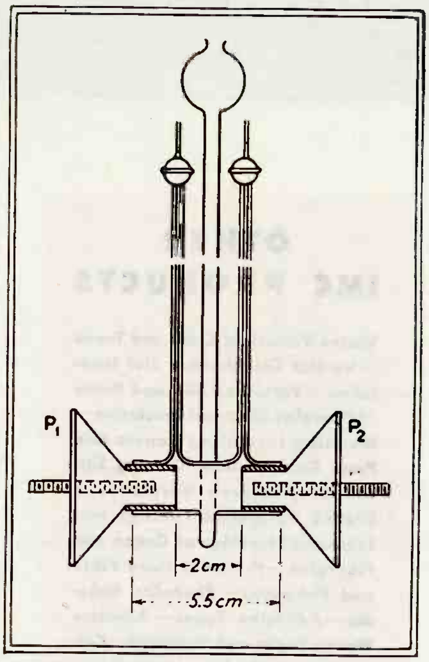
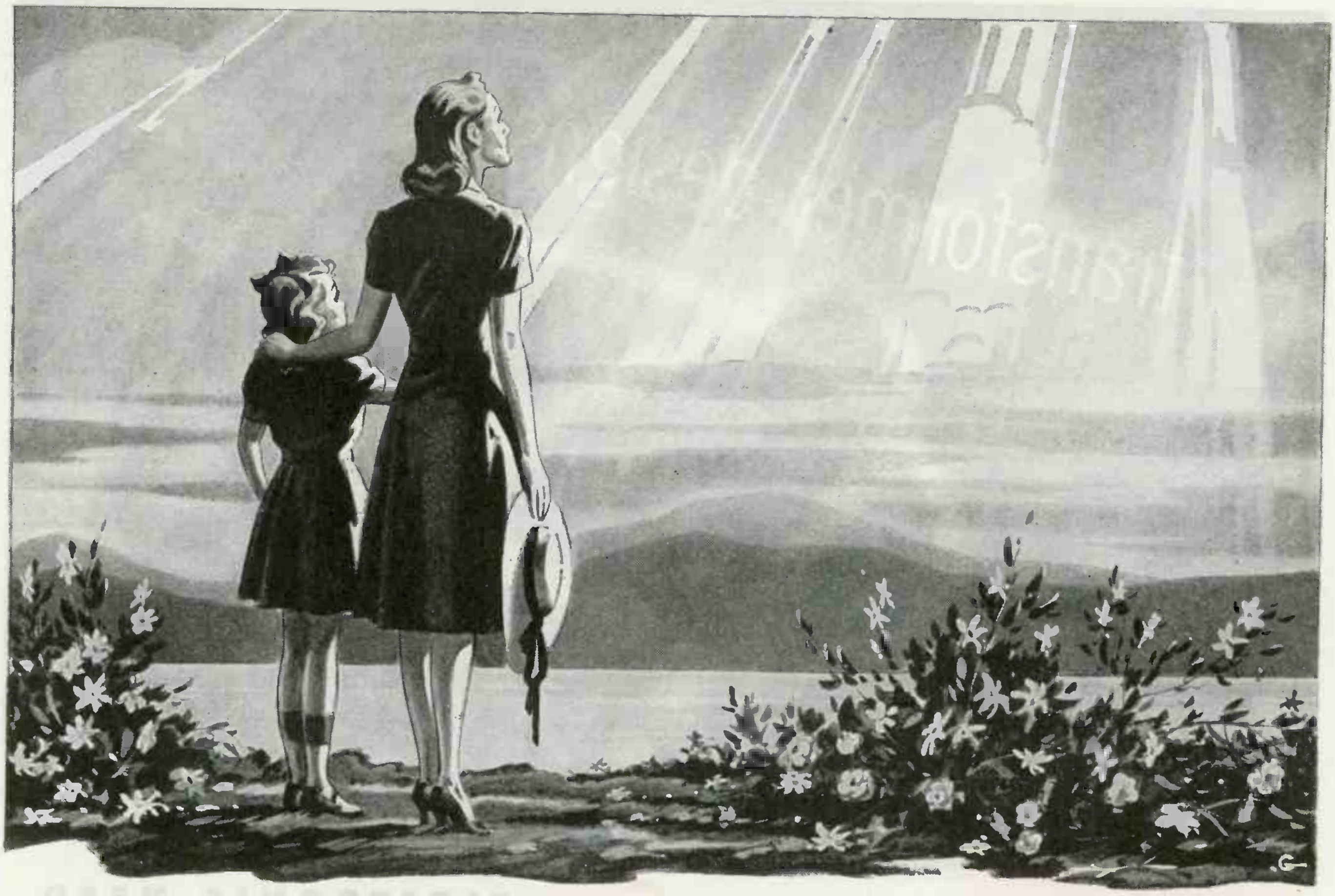


FIG. 1—Voltameter with tin-plated electro-magnetic pole pieces from which gas was expected to be liberated if there is a magnetic current

the conduction of electric current through the magnet and electrolyte which might take place as a consequence of the looked for disassociation. The use of paraffin by Kendall to protect the pole pieces from electrolytic action might have interfered with this passage of electric current.

The experimental technique consisted of passing current through the electromagnet for periods of approximately 8 hours. A field of



IT'S SPRING...

and the Plants are Booming!

NO, *THAT'S NOT A TYPOGRAPHICAL ERROR.* We're not speaking of the agricultural variety of plants. We mean WAR plants—like this one at Eastern—and we mean *booming!*

When the Japs dive-bombed us into war, all America prayed for a quick ending. Yet here is still another Spring—a fourth peace-shattered Spring—and the enemy is still fighting back.

It's a tough war and we at Eastern Amplifier know it! Eastern is all-out for Victory, doing its utmost to help end the conflict before another Spring comes. Eastern-built equipment is helping America's war machines to navigate with certainty—to bomb with accuracy. But we're not stopping there! Eastern engineers are available for consultation on any electronic problem. They are serving *NOW!*

With the advent of peace, we shall turn our skill to the creation of better electronic products for a better America. Meanwhile, on request, let us send you the next of a series of articles on important phases of electronics, prepared by our engineering staff. Ask for Brochure 4-F.

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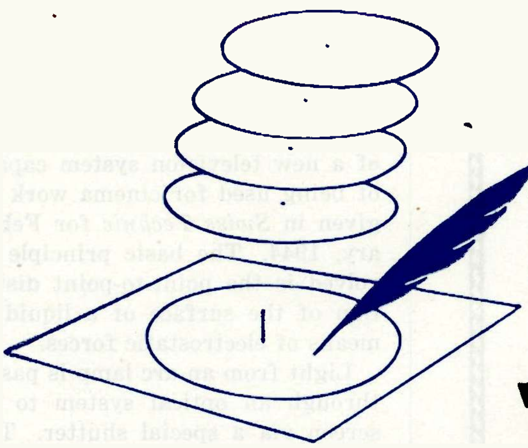
Announces the acquisition of

WEBSTER PRODUCTS

The former Webster Products organization and facilities will be retained intact and will operate as the Electronics Division of Webster-Chicago Corporation. This division is now manufacturing dynamotors and voltage regulators for the war program.

For peacetime production, the Electronics Division will resume manufacture of Webster Record Changers as well as several new, but related products, already designed and ready for postwar production. Watch for later important technical and merchandising information over this new signature.



Again Postwar, You Will Find Webster Record Changers in High Quality Combinations

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ELECTRONICS DIVISION

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approximately 3,000 gauss at the center of the region between the poles was maintained. Liquid in the voltameter was battery acid diluted with an equal volume of distilled water and boiled before use. Current was reversed between successive runs so that during one run the left-hand pole was a south pole and in the succeeding run the right-hand pole was a south pole.

Although gas was liberated, it was in such small quantities and its liberation so erratic from run to run that it was concluded from these observations there is still considerable doubt as to the existence of a magnetrolytic effect, but that the experiments do not completely exclude possibilities. Because of bubbles of gas which appeared in the horizontal arm of the voltameter, it was believed that air dissolved during the filling of the voltameter was liberated from the bulk of the acid, and not exclusively at the magnetic poles. However, the negative results of Kendall seem to be amply verified by these experiments, and in the absence of any indications from theoretical considerations as to the most favorable experimental arrangements, all that can be concluded from these results is that it will be necessary to conduct additional experiments similar to those of Ehrenhaft before the existence of magnetic current is definitely established or disproved.

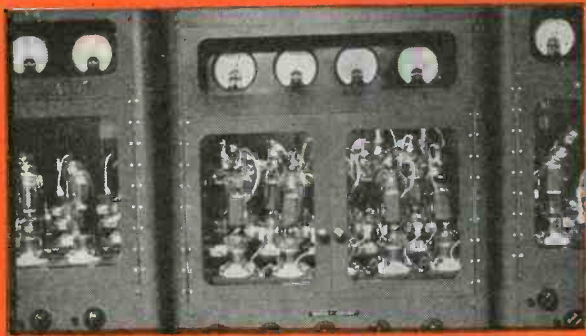
• • •

London Letter

By John H. Jupe
London Correspondent

Large Screen Television. Details of a new television system capable of being used for cinema work are given in *Swiss Technic* for February, 1944. The basic principle involved is the point-to-point distortion of the surface of a liquid by means of electrostatic forces.

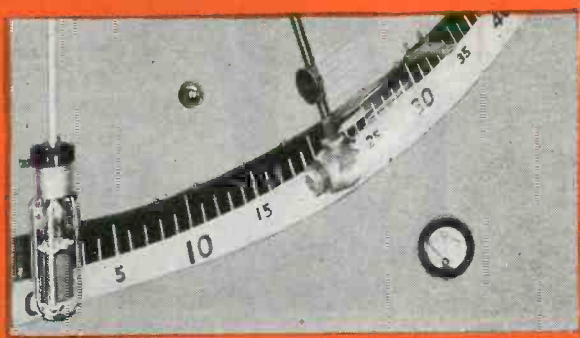
Light from an arc lamp is passed through an optical system to the screen via a special shutter. This shutter consists of a trough containing a heavy mineral oil such as apiezonol in a layer about 0.1 mm thick, being spread evenly over the surface of the plate (which revolves) by a squeegee. Included in the optical system are two grilles arranged so that the light rays passing between the lower grille are exactly blocked by the upper



*QST-1—Life testing is an important Quality Standard test at United. It is a strictly observed procedure whereby life expectancy is controlled in "run-of-production" tubes.

QST-2—A unique test is applied to every United tube to assure noise-free operation.

Who sets the *Quality Standard* FOR TRANSMITTING TUBES



QST-3—United tubes designed for very rough service have extra, built-in shock resistance proved by the severe Bump Test each tube must pass.

*Quality Standard Test.

Brilliant United craftsmanship is steadfastly verified and maintained by skillful and vigilant testing—truly representative of daily production. For this reason every United tube must pass through a series of critical examinations that do not permit any defects, no matter how minute they may be, to escape unnoticed.

By maintaining Quality Standard Tests of the highest order United engineers and technicians have achieved recognition for leadership. To engineers everywhere, the name United is the *trusted* standard by which other transmitting tubes are judged and measured.

For every electronic application including radio communication, physiotherapy, industrial control and electronic heating, standardize with tubes that are *the* Quality Standard. "Tube up" with United.

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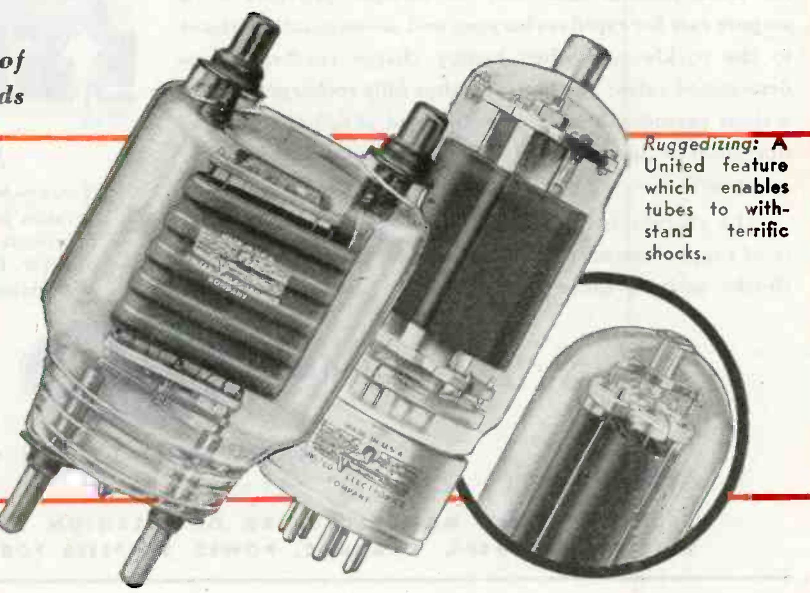
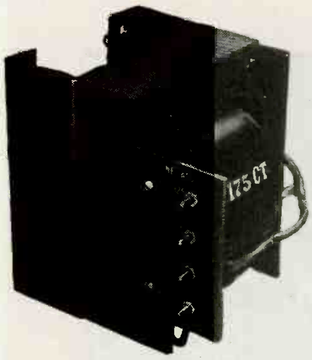
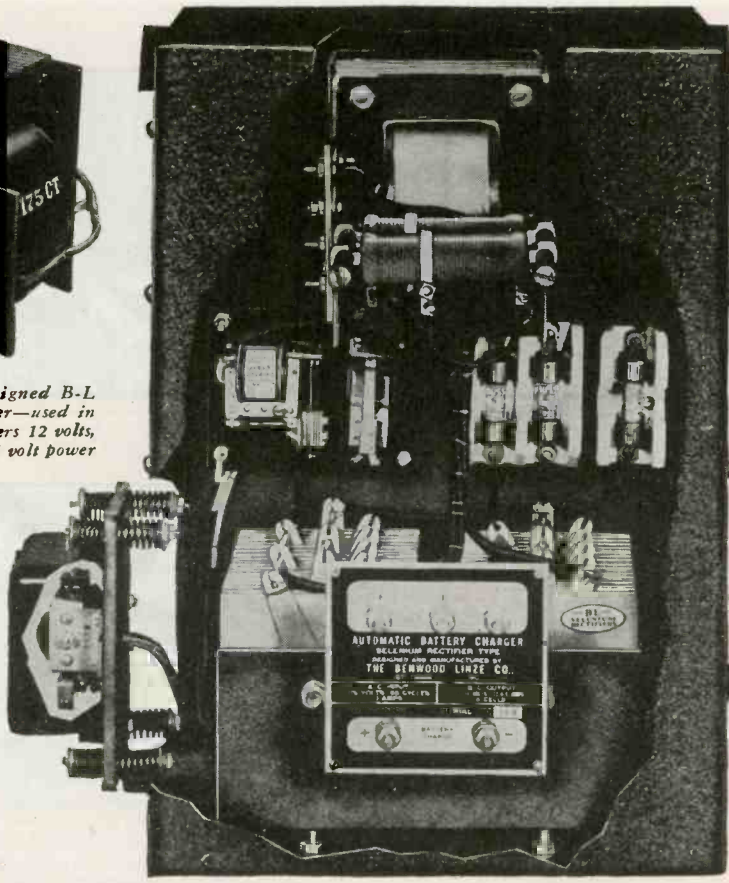


Ruggedizing: A United feature which enables tubes to withstand terrific shocks.



Above—Specially designed B-L heavy duty transformer—used in battery charger. Delivers 12 volts, stepped down from 115 volt power supply.



At left—Another example of B-L Battery Charger designed to meet specific needs.

Above—Specially designed B-L Selenium Rectifier converts AC to DC in the Battery Charger.

This B-L Battery Charger was designed to meet special need in Airport Fire Truck

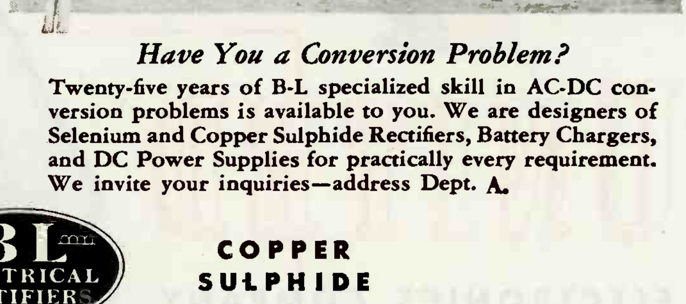
It maintains a 12 volt, 6 cell heavy-duty storage battery, which is a component part of the fire truck shown at the right, and furnishes power for mechanical operation of the booms directing the mass carbon dioxide discharge.

Since the nozzles must be directed to the proper position in extinguishing a fire, reliability of the mechanical drive, including the battery, is very important.

The battery is kept fully charged at all times by means of a trickle charge supplied by this B-L Charger. When the truck returns after use, the charger provides a 12 ampere rate for rapid recharging and automatically reduces to the trickle rate when battery charge reaches a predetermined value. The battery is thus fully recharged within a short period of time and maintained at full charge. The operation of this charger is fully automatic and it requires no attention.

The charger is mounted in the body of the truck and is of rugged construction, capable of withstanding severe shocks such as those encountered in operating mobile equipment over rough terrain. It is provided with a B-L selenium rectifier comprising two stacks, a heavy-duty B-L transformer, relays for automatic charge rate control and adjustable pre-set resistors. The entire equipment is housed in a heavy gauge steel cabinet.

Cardox Airport Fire Truck—*(capacity, 3 tons of liquid CO_2 supplemented by 500 gallons of foam)—extinguishing in 20 seconds simulated crash fire, involving 400 gallons of gasoline and 150 gallons of oil.*



Have You a Conversion Problem?

Twenty-five years of B-L specialized skill in AC-DC conversion problems is available to you. We are designers of Selenium and Copper Sulphide Rectifiers, Battery Chargers, and DC Power Supplies for practically every requirement. We invite your inquiries—address Dept. A.

SELENIUM — B L ELECTRICAL RECTIFIERS — **COPPER SULPHIDE**

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DESIGNERS AND MANUFACTURERS OF SELENIUM AND COPPER SULPHIDE RECTIFIERS, BATTERY CHARGERS, AND D. C. POWER SUPPLIES FOR PRACTICALLY EVERY REQUIREMENT.

grille when the oil film is undistorted.

A cathode-ray beam from the electron gun charges the surface of the liquid electrostatically, the beam being subjected to scanning motion by deflector coils and given an intensity modulation by another coil so that there is deformation of the normal molecular alignment of the oil in proportion to the strength of the incoming signal, and a pencil of light is able to pass over and around the upper grille on to the screen.

The deformation of the film is purely local and persists only for a short time, the charges being dissipated by arranging that the oil is slightly conducting.

Owing to the considerable concentration of light in the optical system and the focussing of the electron beam, a fair amount of heat is produced and both the grilles and oil trough are water cooled, the latter by a cooling plate.

No performance data has yet been released concerning this apparatus but it seems to be promising, since the designers have taken the trouble to produce rather bulky apparatus (of high mechanical precision), much of which must be operated in a high vacuum.

Undersea Amplifier. Details have just been released of experiments carried out in 1943 by the British Post Office on a submerged thermionic repeater for a submarine cable used for carrier-current telephony circuits.

Three stages are used in the amplifier, each stage having two spare tubes which can be brought into the circuit by impulse switching from a shore station. Commercial tubes are used and life tests showed that they would have a probable life of 20,000 hours ± 25 percent. Power for the amplifier is fed from the shore, via the cable and a ground plate, 0.63 amp. at 230 direct volts being the supply.

The weight of the equipment is about 2,000 lb, but much of this is due to the fact that the cases have to withstand continuous sea immersion.

The first repeater built, and claimed to be the first ever included in a working cable system, was laid in the sea between England and Ireland in June 1943, and by its use the number of carrier

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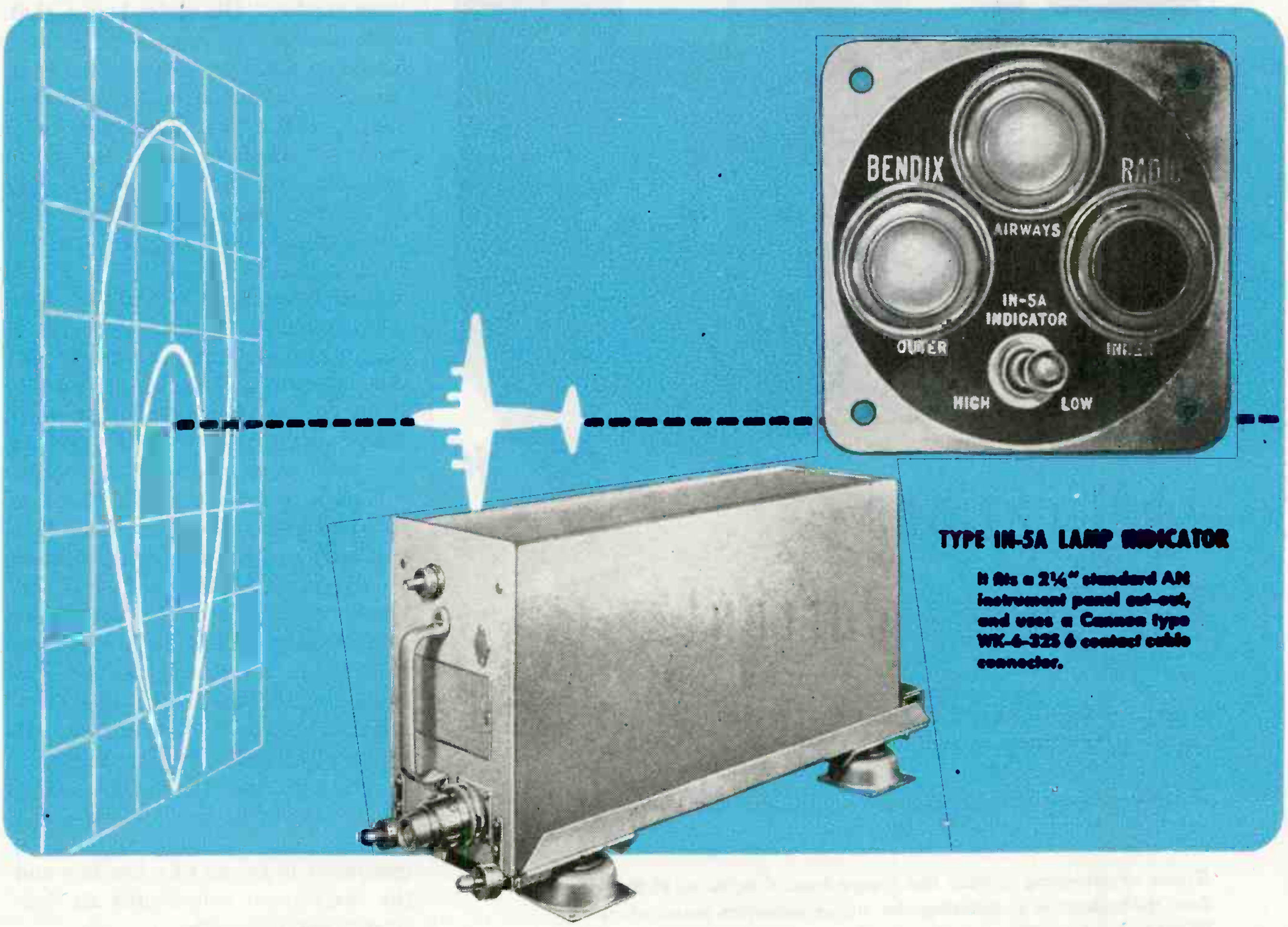
A NEW 75 MEGACYCLE MARKER RECEIVER

Improved Indication at Low Battery Voltage—A new minimum in unwanted lamp operation—½ A.T.R. Size Case—Reduced Weight



Does your marker receiver give good indications when battery voltage drops to eleven (or twenty-two) volts? Does unwanted lamp operation confuse the pilot during instrument approaches? These difficulties have been eliminated in the design of the new Bendix Radio MN-53 marker receiver; and, in addition, valuable weight and mounting space have been saved.

This receiver is available in a number of different types. This same unit may be used with either twelve or twenty-four volt systems. A centralized radio power supply may be used, or an individual dynamotor may be plugged right into the unit. In addition there is a model that is both mechanically and electrically interchangeable with existing airline marker equipment.

Another feature of this new marker receiver is variable coupling of the intermediate frequency transformers. IF adjustment is thus greatly simplified and the desired band pass characteristic can be easily obtained.

For further information on this latest product of Creative Engineering, write direct to the Sales Department, Bendix Radio.

Bendix RADIO DIVISION

BENDIX AVIATION CORPORATION, BALTIMORE 4, MARYLAND

STANDARD FOR THE AVIATION INDUSTRY

circuits in the cable was increased from 24 to 48. Unfortunately, however, a filter capacitor broke down after 5 months service and the repeater had to be raised, but the replacement equipment is still working satisfactorily.

"Compandor" Gripes IEE Speaker. A speaker at an I.E.E. meeting has drawn attention to the fact that there is no such instrument as a "compandor." His claim being, that with part of the apparatus, in say, England and the other part in America, we cannot speak of it as a single item. The suggestion was that we should adopt the term "companding" to indicate the use of volume compressors at the sending end and of expanders at the receiving end.

A new Electronic Voltmeter. The research laboratories of the G.E. Co. in England have recently developed a new electron-optical instrument for measuring peak voltages in the range 2-20 kv, a.c. or d.c. with an accuracy of 3 percent.

It is based on a triode theorem in which the angle of the beam in a focussed electron system is defined by the ratio of two voltages; the anode voltage and the modulator grid voltage. When both terms in this ratio are multiplied by the same factor, the beam angle remains constant, the modulator bias voltage being directly proportional to the voltage to be measured, when the latter is applied to the anode. Thus, a high voltage is measured in terms of a low one and the instrument constitutes an electronic potentiometer.

This principle can be applied to high-voltage tubes so that they act as their own voltmeters and the range can be extended as desired.

The tube developed has a capacitance of 9 cm and in certain cases can be used in circuits of 1 Mc or higher, because even at the lowest anode voltage, the transit time is only 1/100 cycle and the instrument is free from the inevitable lag of a spark-gap voltmeter.

The instrument measures peak voltages only and gives no information concerning wave form. It should, however, prove very helpful in measuring rapidly fluctuating voltages of widely differing wave forms and where the values obtained with a spark gap voltmeter are known to be unreliable.

CO-OPERATION IS IN THE CARDS

Here is Help in Your Electronic Problems

Each of the representatives listed above is a key man in the Sickles Field Engineering and Co-ordinating Service . . . ready at all times to aid you in any matter related to radio and electronic parts and components. Chances are they've got on-the-spot information you require, for they're all men with long experience in their field. But if your problem is out of the ordinary they'll quickly take it to headquarters, where Sickles' highly skilled production organization and technical staff will work out the right answer.

Jot down the address nearest to you for prompt, efficient co-operation whenever you need it.

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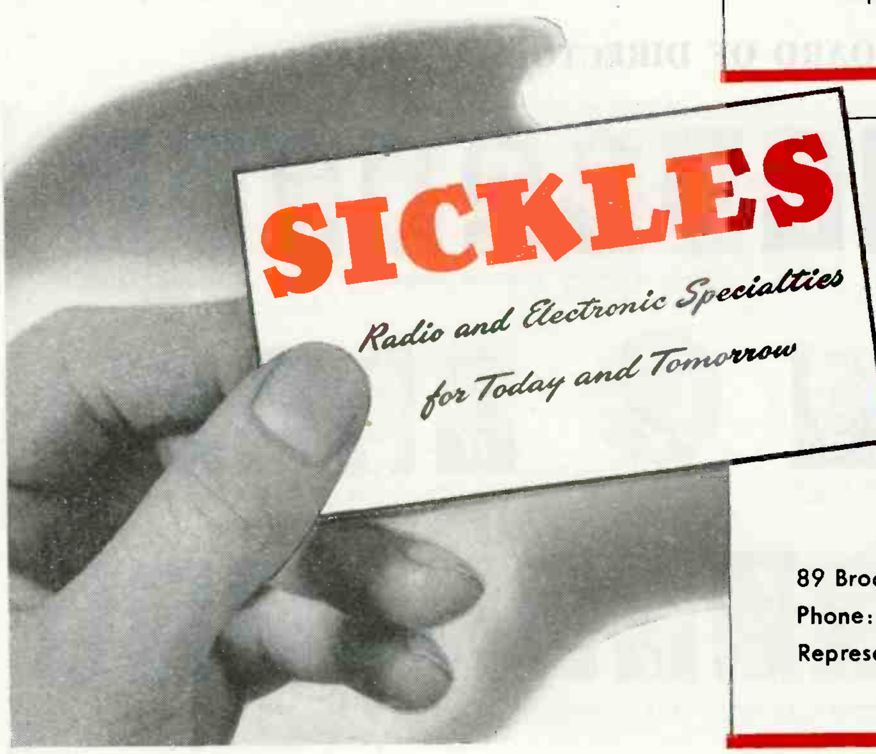

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NEWS OF THE INDUSTRY

Association officers; television for industry; network finances; FCC report; train radio, science committees; meetings; news of Washington, companies, and people

Railway Radio Demonstrated at Baltimore Chapter IRE

RELIABLE RAILROAD communication can be expected for a distance of five miles with a 5-watt a-m transmitter and suitable receiver, according to J. W. Hammond of Bendix Radio Division, Bendix Aviation Corp., who presented a paper on the subject during a recent meeting of the Baltimore Section of IRE.

Reviewing field experiences encountered on railroads throughout the country, he described tests of end-to-end communication made through all imaginable types of terrain and in all weather conditions. As he pointed out, differing services such as end-to-end, yard-to-train, terminal-to-train and train-to-train require different circuits but in the interest of a unified system the objective has been to do all tasks with the same equipment.

Limitations of range at vhf did not prove as severe as had been expected, although the road requirements that the antenna be both low and narrow *did* limit radiation efficiency. This problem was solved by a capacitance-loaded, vertical, end-fed rod. The discussion was concluded by an actual demonstration of communication from the meeting hall to a mobile truck.

Permission was obtained by the Baltimore Section during the winter meeting in New York to supplement its income with paid advertising and use the proceeds to implement a new program of activity.

Preliminary plans being formulated in the Section propose the eventual establishment of a technical reference library; a complete experimental laboratory outfitted with suitable test equipment, power supplies, and other requirements; a Section radio station devoted to experimental research and development; annual Section awards in recognition of outstanding accomplishments of members in that area; unlimited freedom in choice of speakers and subjects; an employment and placement service; technical refresher courses and examination assistance; an expanded social calendar; and more elaborate publication activities.

Nationalized Measurements and Control

A NEW NATIONAL ASSOCIATION, to be called the Instrument Society of America, is being planned by members of the Society for Measurement and Control in Chicago. The objective is to consolidate related organizations in Washington, Pittsburgh, New York, and Boston into a national organization whose membership would be open to individual members not now affiliated with existing local groups.

Wireless Operators' 20th Anniversary

SEVERAL AWARDS for achievements within the electronics field were presented during the twentieth annual dinner-cruise of the VWOA (Veteran Wireless Operators Association), held in New York recently.

Opened by messages of salute from General Dwight D. Eisenhower and Admiral Ernest J. King, the meeting included as guests many of those prominent in the field besides the individuals in the

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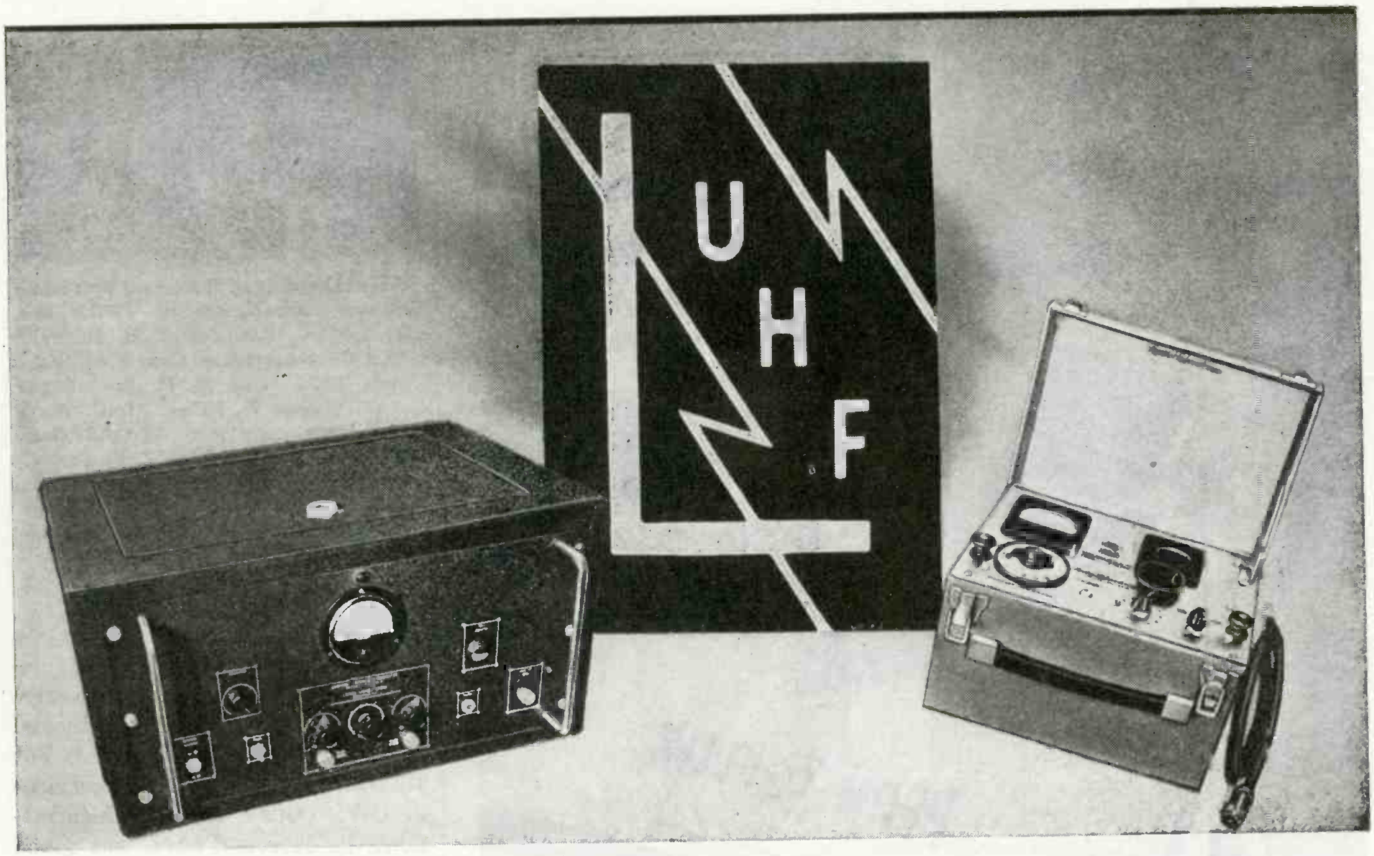
UHF

Assembled during the recent 20th-anniversary dinner-cruise of VWOA are E. K. Jett, FCC; Col. T. H. Mitchell, RCA Communications; Capt. E. M. Webster, USCG; Gen. H. M. McClelland, AAF; George W. Bailey, NDRC; W. J. McGonigle, president VWOA; Gen. Frank E. Stoner; Adm. J. F. Farley, USCG; F. C. de Wolf, Dept. of State; Gen. H. C. Ingles; Capt. A. H. Adams, USN; and A. J. Costigan, Radiomarine Corp. of America

accompanying illustration.

To the Television Broadcasters Association in significance of pioneering research and progressive development, the Marconi Memorial Service Award was presented. For his transmitter-installation services to OWI (Office of War Information) R. Morris Pierce was given the Marconi Medal of Service.

The Marconi Medal of Achievement went to Dr. Allen B. DuMont for the pioneering of his organization in the field of communications. To Orrin E. Dunlap Jr., Radio Corp. of America, went the Marconi Memorial Medal of History for his writing of the book "Radio's One Hundred Men of Science".

Other Marconi Memorial Medals went to T. R. McElroy, McElroy Mfg. Corp.; E. A. Nicholas, Farnsworth Television & Radio Corp.; Ludwig Arnson, Radio Receptor Co.; Gen. H. H. Arnold, U. S. Army Air Corps. Additional awards were made to outstanding heroes of the Armed Forces and the Maritime Service.

Industrial Television

A SINGLE OPERATOR in a control room may be able to control a full battery of lathes, punch presses, or other machines through television, in the opinion of L. M. Clement, vice-president in charge of research and engineering at The Crosley Corp., who addressed a midwestern club recently.

In the system he visualizes, floormen would be dispatched to load and unload machines at the direction of the dispatcher in the television control room. Other useful abilities in the television cam-

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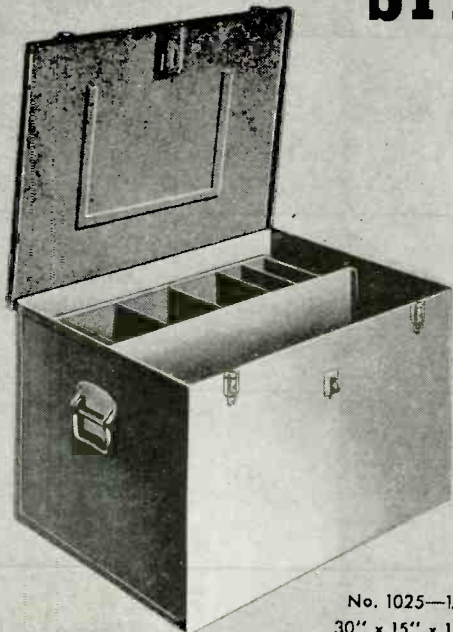
...for every needed use!



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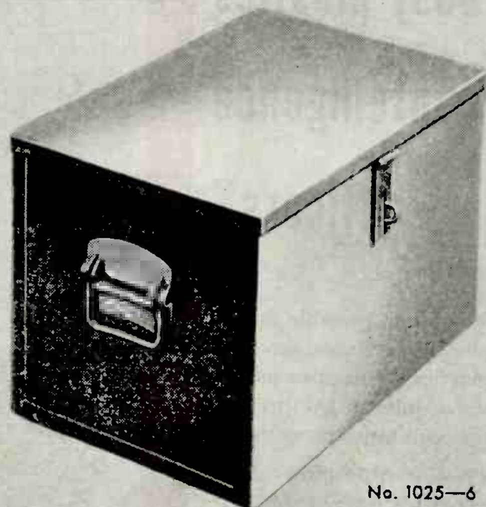
30" x 15" x 12"
(Partitions not included)



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24 STOCK SIZES

As per specification 42 B 9 (Int) for shipboard use, Electrical and Mechanical. Navy grey finish. Immediate Delivery.

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Number	Length	Width	Height	Number	Length	Width	Height
1025- 1	12	6	6	1025-13	18	18	12
1025- 2	12	9	6	1025-15	24	15	12
1025- 3	12	12	6	1025-16	24	15	15
1025- 4	12	9	9	1025-17	24	18	12
1025- 5	18	9	6	1025-18	24	18	15
1025- 6	18	9	9	1025-19	24	18	18
1025- 7	18	12	9	1025-20	24	12	9
1025- 8	18	6	6	1025-23	30	15	9
1025- 9	18	15	9	1025-14	30	15	12
1025-10	18	12	6	1025-22	36	12	9
1025-11	18	15	12	1025-21	42	9	9
1025-12	18	12	12	1025-24	42	12	9

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349 Broadway, New York 13, New York • Factory: Brooklyn, New York

COLE STEEL OFFICE EQUIPMENT

will again be available after the war

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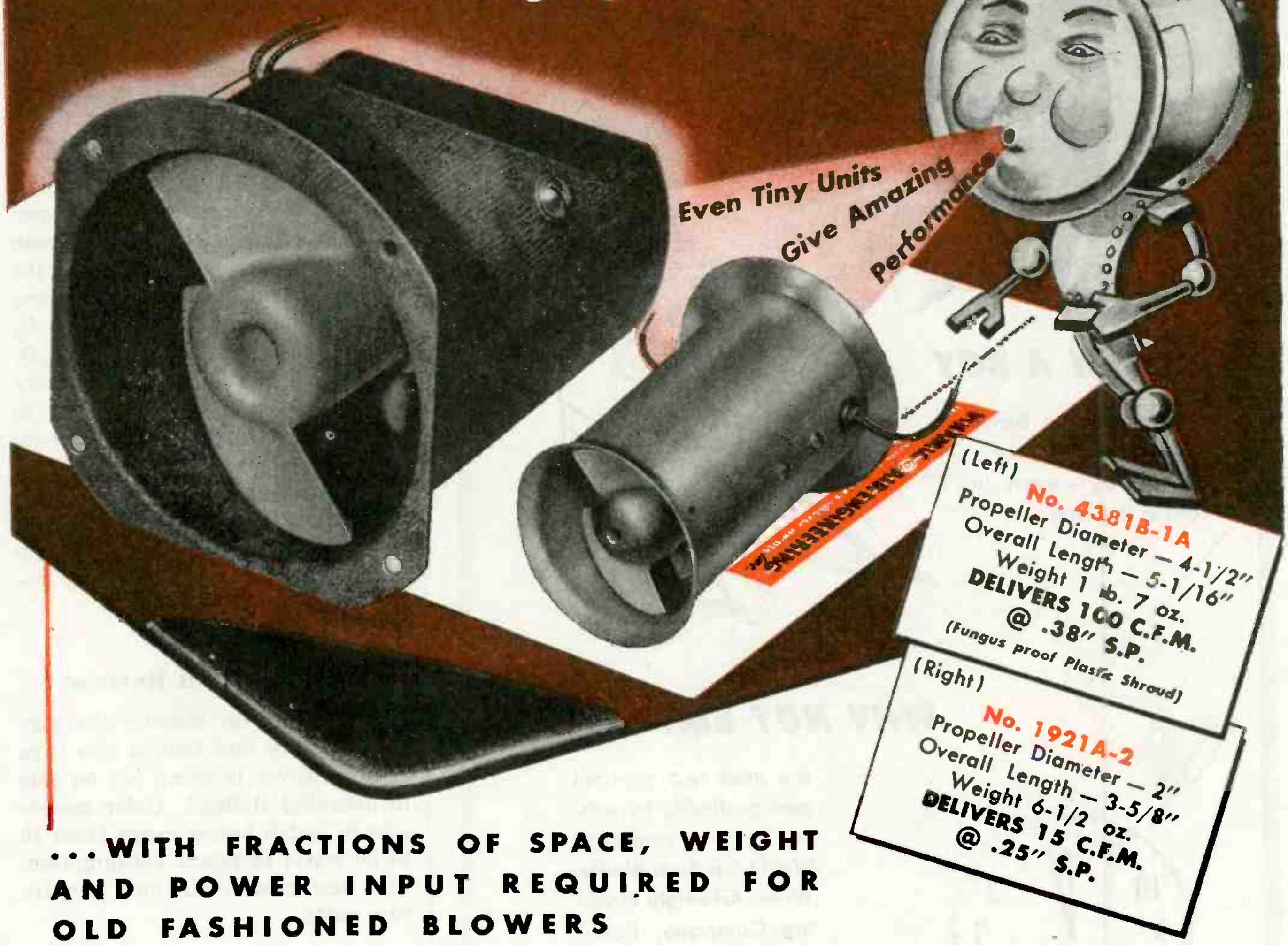
DELIVER MORE AIR

at high pressures



...WITH FRACTIONS OF SPACE, WEIGHT AND POWER INPUT REQUIRED FOR OLD FASHIONED BLOWERS

No longer is heavy, bulky blower equipment required for efficient air delivery against high pressures. Dynamic Air Axial Flow Blowers, representing over 12 years of development, now bring you the advantages of *direct* air flow with amazing savings. Much smaller, lighter and more economical in both first cost and operation, they bring great new possibilities for air engineering against static pressures as high as 9" W.G.

The two small models shown above indicate the new high performance standards you can expect from axial flow — and in all fields, from electronics to heavy industry. They are made in 60 to 400 cycles AC and 24 to 115 volts universal DC-AC.

Other equally efficient models are available up to 42" diameter. All are designed to rigid air delivery and weight specifications. Adaptations can be made to the most precise requirements of weight and space limitations.

Consult us about your blower problem.

DYNAMIC AIR ENGINEERING Inc.
LOS ANGELES, U. S. A.

era as applied to industry might involve placing it in a furnace, in a cold room, under water, or in many other places where no human operator could go.

Going from industrial to broadcast television, he quoted the following figures which suggest that the possible maximum viewing audience is of the order of 40,000 to 50,000 people. The equipment is distributed as follows:

	Stations	Receivers
New York	3	5000
Philadelphia	1	1200
Schenectady	1	450
Chicago	2	300
Los Angeles	2	250

On the subject of viewing, Mr. Clement said experience has shown that the proper distance is between 4 and 8 times the height of the picture. Thus, for a 7-in. picture, the viewing distance is 2½ to 5 ft, for an 18-in. picture, 6 to 12 ft, and for a normal motion picture screen of 15 ft in height, 60 to 120 ft. Thus, he said, the 7-in. picture produced by a table-type television set should be satisfactory for a small family group, while an 18-in. picture is about as large as is required for an ordinary living room.

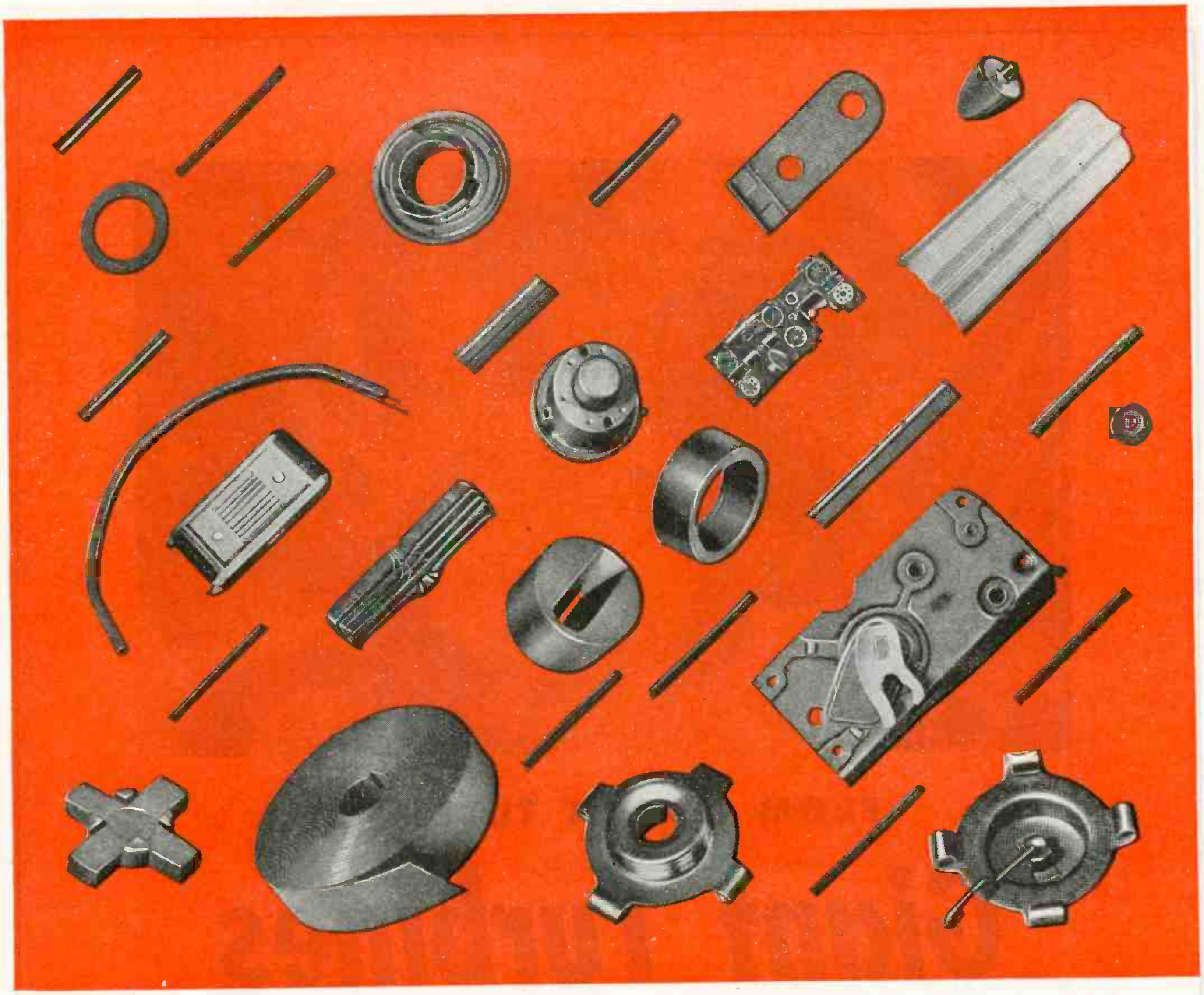
Load Building in Reverse

BECAUSE OF THE SERIOUS shortage of electricity and fuel, a new type radio receiver is being put on sale in liberated Holland. Older models now in Dutch homes range from 10 to 20 watts in power consumption. The new model will only require two watts.

Finalists in Science

FORTY SCIENCE-TALENTED high school seniors have been chosen as finalists in the fourth annual Science Talent Search which culminates in the awarding of $11,000 in Westinghouse scholarships.

Of the forty, sixteen showed definite and wide interest in electronic subjects. One has built eleven radio receivers, another, an electronic rectifier for electrolyzing metallic sodium, and a third, his own oscillograph for measuring speed of bullets. Other activities include light-beam sound transmission, a 5-octave electronic organ, brain-wave study, investigation of shock treatment as used in depres-



Not everybody

FEW manufacturers possess the versatile production facilities of The Standard Products Company.

Standard is prepared to develop and plan for industry, parts of molded rubber, steel stampings, plastics, in almost any shape or form.

The services of The Standard Products Company Research Laboratory and Engineering Departments are at your disposal.

Let us have the necessary data and our engineers will submit designs and proposal.

The Standard Products Company is the world's largest manufacturer of glass run window channel and contour weather strip. Production and replacement channel for passenger cars, truck cabs, busses, motor boats, airplane cabins and streamlined trains is now available for delivery.

Your inquiries are solicited.

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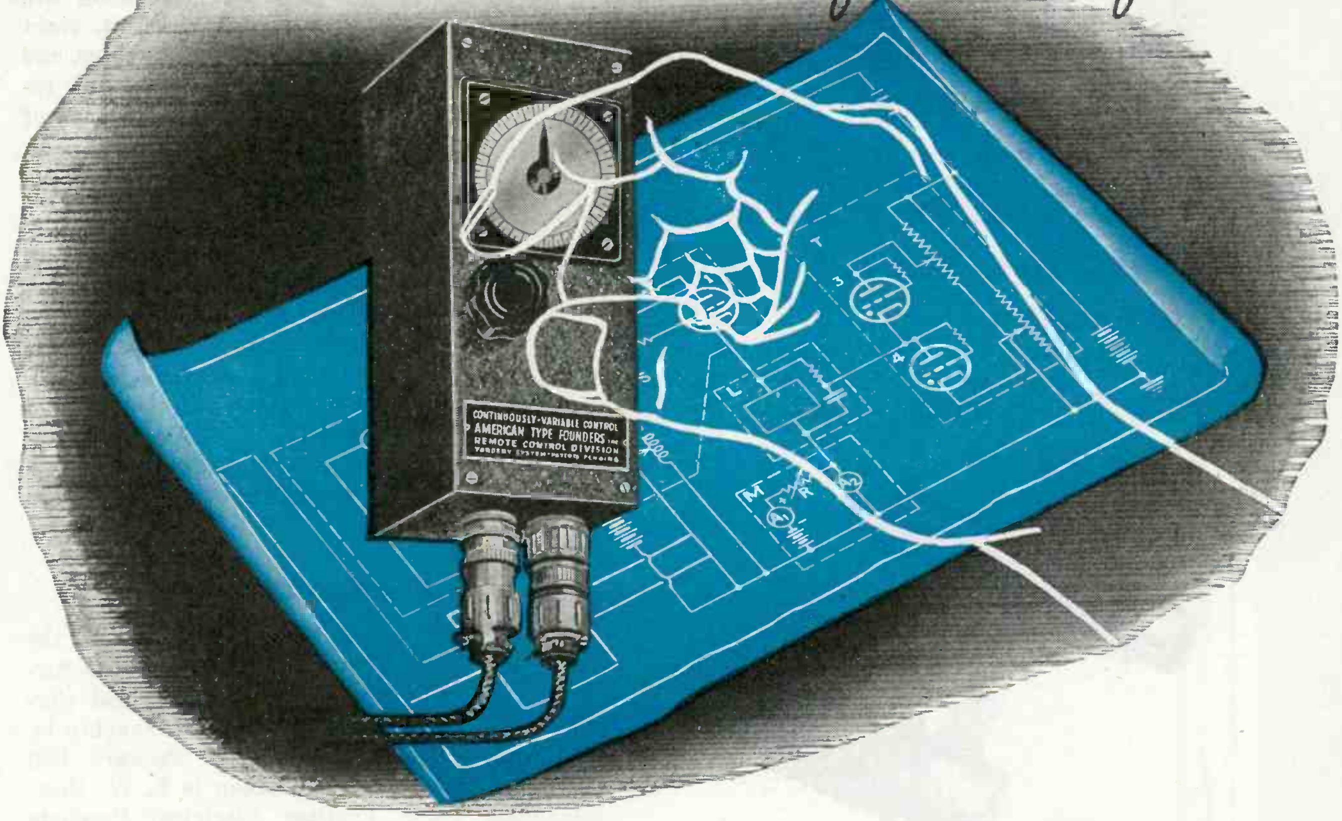

Control Remotely...ELECTRICALLY

ATF precision remote controls are handling some of the war's most exacting remote control jobs. And they are finding wide application in planning for the exacting industrial jobs of tomorrow . . . for the accurate adjustment or setting of communications equipment, machine tools, valves, fuel supplies, power controls, and other machinery, from remote or obscured points.

If your post-war planning involves a problem of precise positioning, the solution may rest with one of these proved ATF electrical control units. Their hair-line precision, extreme simplicity, and their ability to withstand temperature extremes and mechanical abuse will give your product a decided edge in post-war selling.

Complete literature available. The services of ATF engineers are freely offered to assist in applying these units to your products.

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sive psychology, development of vector modulation, and construction of carrier current equipment.

As a result of interviews and examinations, two of the group will be given \$2400 scholarships, eight will be given \$400 scholarships, and others will get shares of the remaining \$3,000 at the discretion of the judges.

Radios Nazi Germany

THE LAST STRONGHOLD of Axis resistance in Europe has been besieged from ten different countries and territories by powerful 50,000-watt shortwave transmitters, according to RCA Victor Division of the Radio Corp. of America, suppliers of 23 such transmitters and a larger number of smaller powered units.

West Coast Elections

THE LOS ANGELES COUNCIL of the West Coast Electronic Manufacturers Association recently held elections resulting in chairmanship by Howard Thomas of Packard Bell Co. Vice-Chairman is L. W. Howard, Peerless Electrical Products Co., while James L. Fouch, Jr., Universal Microphone Co., becomes treasurer.

Prosperous Networks.

AS REVEALED IN a recent release by FCC, major network time sales reached an all-time high of \$126,-330,491 for 1944. These preliminary figures indicate that total major network time sales have more than

WASHINGTON MEETING

Members and guests at a Washington IRE section meeting examine a display board showing construction of the GE lighthouse tube, subject of the evening's discussion. They are: J. W. Greer, Navy Dept.; F. W. Albertson, vice-chairman of the section; T. B. Jacocks, GE; E. F. Peterson, GE, who presented the paper; H. A. Burroughs, chairman of the section; and H. H. Lyon, chief engineer, WOL, Washington

HOLD THAT TIGER!

A few curt words whispered into the mouthpiece of a "handy-talkie" directs a deadly hail of mortar shells upon a stalking Tiger tank. Insurance against failure in crucial moments is the precision wire that serves as the arteries of American communication equipment at the fighting fronts.

SPENCER Precision WIRE

FINE STEEL AND ALLOY WIRE

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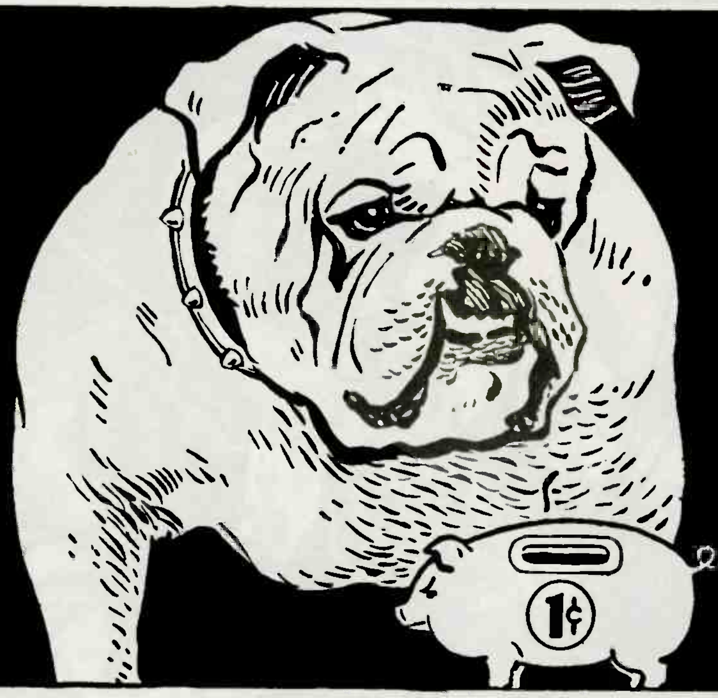

YOU'LL HAVE TO WATCH YOUR PENNIES...

IN THE PEACETIME COMPETITION

With the coming of peace and a return to the American way of producing goods at a profit in highly competitive consumer markets you'll *have* to be certain that every step from initial blueprint and tool design, through the machining, stamping and assembly line, up to packaging and delivery is planned and executed with utmost efficiency and with the minimum of cost.

In the production of war munitions Oiljak has maintained an enviable record of production of intricate parts and on time deliveries, in accordance with strict Government inspection—and has actually reduced the estimated and approved cost, thus saving the Government considerable sums, by skillful planning and supervision of the work. These same skills in metal manufacturing, improving designs and reducing costs are available to manufacturers as they convert to peacetime merchandise. It may transmit your penny savings into dollar profits to confer with us on any metal manufacturing problem.

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THE OILJAK MANUFACTURING Co., INC.

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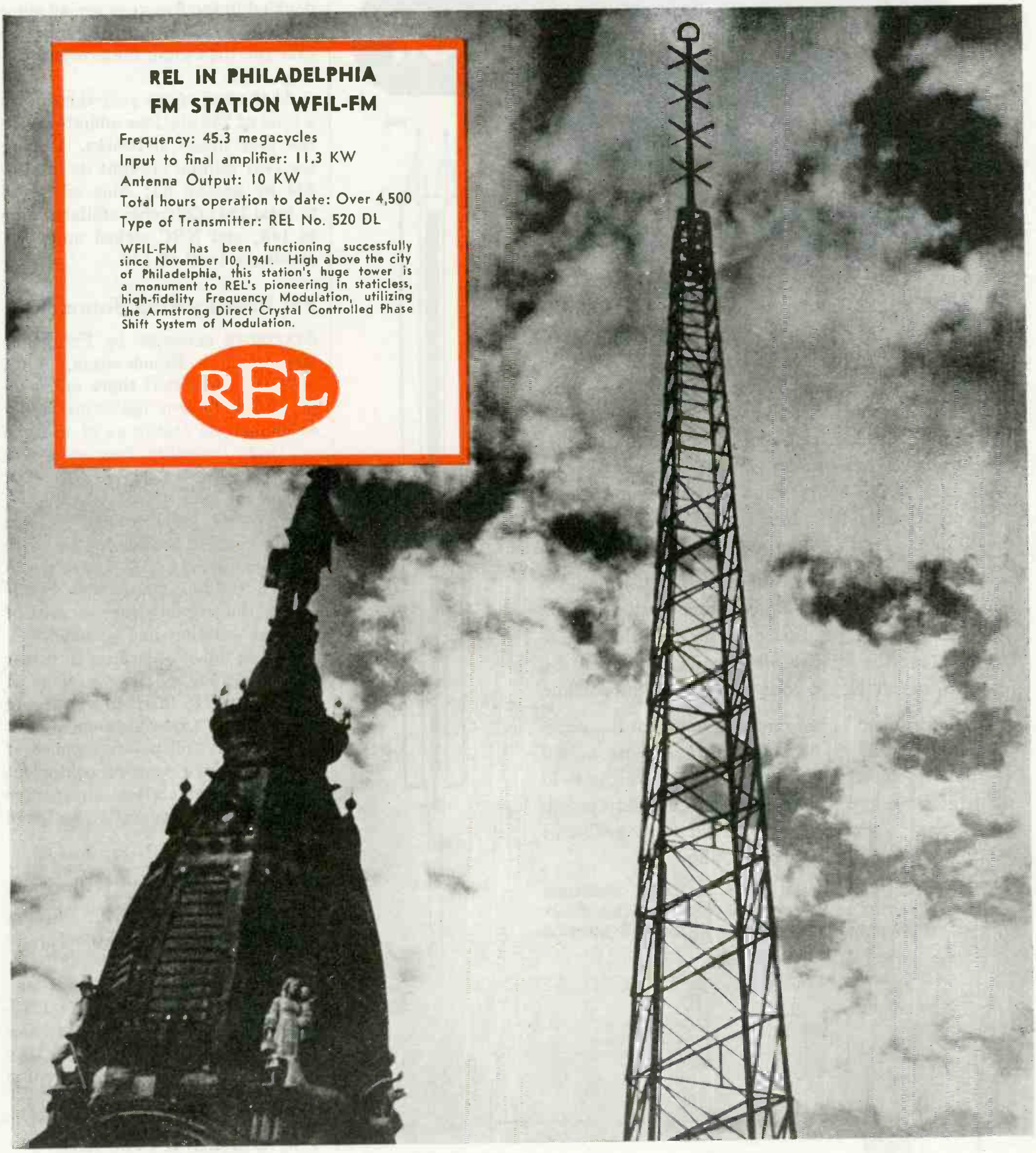
THE JOB COMPLETE FROM BLUEPRINT TO FINISHED PRODUCT



Sales Representatives

MICHIGAN	MIDWEST	PACIFIC COAST
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PIONEER MANUFACTURERS OF FM TRANSMITTERS EMPLOYING ARMSTRONG PHASE-SHIFT MODULATION

RADIO ENGINEERING LABS., INC.

Long Island City, N.Y.

doubled in the five-year period since 1939. They are up 21.2 percent over the 1943 total, the previous all-time high.

At the end of the year there were a total of 730 stations affiliated with the four major networks. During the year Mutual brought its total to 244 by adding 33; Blue added 20 to total 194; Columbia affiliated nine to 143; and NBC picked up seven, making a total of 149.

FM Broadcasting Summary

STATISTICS RELEASED by Frequency Modulation Broadcasters, Inc. (FMBI) show that there are a total of 46 stations operating under a commercial status as of the end of 1944, including four new stations which were added to the list during the year.

Currently, applications for f-m construction permits on file with FCC are quoted at 353 and approximately 100,000,000 persons reside within the primary service area of stations existing and planned.

Broken down according to power there are four existing stations at 1 kw, ten at 3, thirteen at 10, and eleven at 50. Other stations are not operating at full power because of wartime restrictions of equipment and labor. Per station, an average monthly cost of operation is listed at $3,014.

Resistance Welder Officers

DURING A RECENT MEETING, the Resistance Welder Manufacturers' Association elected Charles Eisler of Eisler Engineering Co. to succeed Floyd E. Taylor, Swift Electric Welder Co., as president. Co-vice-presidents are David Sciaky of Sciaky Bros. and H. V. Beronius of Welding Machines Mfg. Co.

The Allocation Proposals

THE SEARCH FOR SPACE in the radio spectrum is like a dog race, in the opinion of James L. Fly, former FCC chairman. Speaking before the Television Press Club in New York recently on the allocation proposals, he advocated that the demand for space be kept out in front of the engineers on the assumption that they might, like the greyhounds, lose interest in the race if they caught the rabbit.

Commenting on the factors which

went into the Commission's decisions, he said that there had been a tendency to evaluate more highly those services having to do with safety, particularly safety of life, as contrasted with factors having to do with convenience or luxury. There was also a higher rating given to those democratic services that benefited the greatest number of people.

Speaking about the future, he advised the would-be prognosticator to look at the living room and try to imagine different units of furniture to represent a-m radio, f-m radio, television, and facsimile. He thought the conclusion was inescapable that there would eventually be a single service.

Radio Club Officers

AT A RECENT MEETING of its directors, the Radio Club of America announced the reelection for 1945 of F. A. Klingenschmitt, president; O. J. Morelock, vice-president; Joseph Stantley, treasurer; M. B. Sleeper, corresponding secretary. Mr. Morelock is also serving as chairman of the Papers Committee.

Resistance Welding Training Course

DIFFERENCES BETWEEN welding processes and the application of electronic control to resistance welding are the subjects covered in a new seven-part training course released to industry. The material was put together originally for Westinghouse workers but made available to others at reproduction costs.

Subjects covered by the course are as follows:

Part One—Basic Definitions of Welding Technology; Forge Welding; Gas Welding; Thermit Welding; Electric Arc Welding; Resistance Welding.

Part Two—Types of Resistance Welding Work; Spot; Projection; Seam; Butt; Flash; Duty Cycle.

Part Three—The Ignitron and the Thyratron: Fundamentals of Electronic Tubes; Ignitron; Thyratron.

Part Four—How the Flow of Resistance Welding Current is Started and Stopped.

Part Five—How the Amount of Resistance Welding Current is

from arctic to tropics

THIS BOND REMAINS PERMANENT

From the arctic to the tropics—at all altitudes—this permanent hermetic seal of steel and steatite is now successfully protecting all types of communication equipment.

For SEALEX combinations—a new method of joining steatite and metal *permanently* in various combinations—produces a bond which not only withstands great extremes of temperature, but gives proved protection against vibration, humidity, and Salt Spray Corrosion, as well.

SEALEX Bushings will contain air at 50 pounds per square inch after a thermal change test of 25 cycles from —65° C to +125° C. They are available in single terminal and multiple terminal designs for high and low voltage requirements.

For long-life, dependable, trouble-free service, specify SEALEX Combinations. Specifications and complete data on all SEALEX Bushings available for quick delivery are listed in the SEALEX catalog.

Send for a copy today. Write us for any special assistance you may require, when confronted with hermetic sealing problems.

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General Ceramics AND STEATITE CORP.
KEASBEY NEW JERSEY

1393

ELCO meets the challenge of the Jungle with FUNGUSIZED* PRECISION *wire-wound* RESISTORS!

ELCO engineers not only met the new requirements of the U. S. Signal Corps, but exceeded them by several hundred percent. Further evidence of the way ELCO tackles a job.

ELCO *FUNGUSIZED RESISTORS are so treated to combat the destruction powers of parasitic organisms. They are made to stand up in stifling jungle heat and humidity.

IF YOUR RESISTOR SPECIFICATIONS CALL FOR ANTI-FUNGUS TREATMENT—*CALL ELCO*

PROMPT DELIVERIES as usual!

SPECIFICATIONS:

"A-1"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—½% standard accuracy—non inductive pie wound—½ watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A-R"—Same as A-1, with leads reversed.

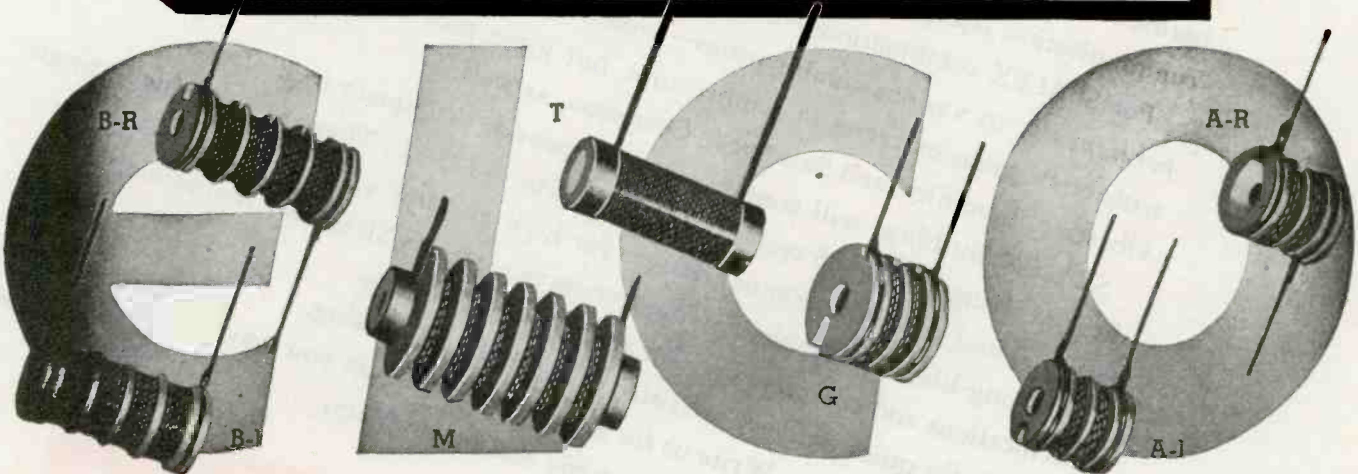
"B-1"—15/16 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—½% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—⅛ x .015 strap terminals—35 to 35,000 ohms—2 watts. 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

"M"—1-13/32 long x ¼" dia.—Mountable with 6-32 screw—⅛ x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy. Baked varnish finish.

"G"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. ½% standard accuracy—non inductive pie wound .8 watts. 30° temperature rise in free air. 100° C. maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.



Get to know **ELCO**

RESISTORS COMPANY

114 West 18th Street, New York, N. Y.

Telephone · Watkins 9-4774-5

Assembling the filament stem of a 50 kilowatt vacuum tube at the Federal Telephone and Radio Corporation plant at Clifton, New Jersey. Ten fire, seven jet Litton burners.

What you may expect from LITTON

JET MIX BURNERS. Litton engineered Jet Mix Burners, proved by 13 years of practical industrial performance, have stepped up production in a number of urgent war industry operations—spectacularly so in vital vacuum tube output.

Compact in size, Litton burners are designed to achieve almost complete carburetion thus eliminating the intense light so injurious to eyes, while permitting low volume operation with complete absence of pop outs – explosions due to rapid change of fire size. Other features of Litton burners include low cost, use of oxygen-gas or oxygen-hydrogen at low and non-critical pressures, uniform size of high temperature flame. They articulate at both head and base, are quickly replaceable, and maintain oxidizing conditions permitting work close to burner tips. Models available are: single jet, two to twelve fire assemblies; large size, seven jet, six or ten fire assemblies; Annealing Burner for bench mounting or with handle. Also hand torches with single or seven jet burners. Complete catalog listings may be had on request.

Litton

ENGINEERING LABORATORIES

REDWOOD CITY, CALIFORNIA, U. S. A.

Controlled: Phase-Shift Heat Control.

Part Six—Electronic Timing Controls in Resistance Welding: Basic Principles of Electronic Timing; Synchronous-Precision Weld Timer; Nonsynchronous Timer; Sequence-Weld Timer.

Part Seven — Energy - Storage Control; Capacitor-Discharge Type; Magnetic Type.

Material costs for a class of 20 are $50, including the lesson and quiz booklets, supplementary literature, slide films and records, and instructor's manual. Slide films are for operation on 35-mm equipment.

FCC Activity Report

ACCORDING TO COMPILATIONS included in the tenth annual report of the Federal Communications Commission covering the period up to June 30, 1944, the number of standard broadcast stations has jumped from 912 to 924 by the addition of sixteen new licensees and the dropping of four. 320 emergency radio stations were authorized, running the total in this class from 3558 to 3863 including deletions.

Under the heading of miscellaneous radio services, the following figures are shown:

Class of Station	Total Stations 1942	1943	1944
Geological	302	325	358
Provisional	22	36	87
Motion Picture	15	10	8
Mobile Press	3	3	3
Relay Press	7	5	5
Total	349	379	461

Geological stations are used by oil companies and other organizations for the determination of the character of underground strata of the earth. Low-power portable and mobile geological stations are used for communication by personnel of field parties prospecting for oil and for transmitting signals and impulses to the seismic recording instruments from geophones at the various pickups at distances up to fifteen miles from the centrally located recording truck.

Provisional stations are restricted in use for communications relating to safety or practical necessity relative to projects of benefit to the public. Licenses are issued on a temporary basis only and for a limited period of time not to exceed one year, subject to renewal if the need continues. The increase

ONE WAY TO GET YOUR VOICE HEARD

There are just two drawbacks to this method: (1) the range is limited; (2) it's not done after a certain age.

To get your voice heard *when* you want it and *where* you want it, Harvey-Wells manufactures *completely dependable* communications equipment.

For peacetime communications in the marine industry — in aviation — in public safety services — Harvey-Wells will continue to transmit the human voice efficiently and reliably.

Know the company that wants your business! Our CASE BOOK tells the story of Harvey-Wells and its place in Electronics. Send for it today. Your name on your letterhead is sufficient.

ARMY E NAVY

Harvey-WELLS
ELECTRONICS

SETTING THE PACE FOR PROGRESS IN COMMUNICATIONS

HARVEY-WELLS ELECTRONICS, INC. SOUTHBRIDGE, MASSACHUSETTS shown is attributed largely to use by guards at war material production plants.

Relay press stations are used for short distance communication on very high frequencies from the scene of important news events to the nearest point where wire line facilities are available, while mobile press stations operate on high frequencies and provide radiotelegraph communication between maritime mobile stations and land stations.

Motion picture stations are used for communication with parties on location in isolated areas where no other communication facilities are available.

Other U. S. figures include:

Service	Total Stations June 30, 1944
AVIATION	
Aeronautical	365
Aeronautical Fixed	105
Aero. & Aero. Fixed	0
Aircraft	2631
Airport Control	28
Flying School	12
Flight Test	27
Marker Beacon	3
Instrument Landing	0
	3171
SHIP	6301
EMERGENCY	
Municipal Police	1906
State Police	452
Zone Police	88
Interzone Police	31
Forestry	925
Special Emergency	451
Marine Fire	10
	3863

Not Much Propaganda

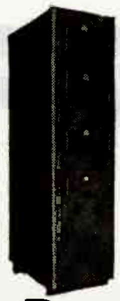
A SURVEY RECENTLY run off for Sylvania Electric Products Inc. shows that less than 2 percent of the American public can be reached regularly by axis propaganda, even if all short-wave receivers were capable of receiving enemy programs.

Set owners in different parts of the country and in different income groups were interviewed so that radio listening habits could be determined as a guide to design of postwar receivers.

It was discovered that about 52 out of every 100 sets in use may be tuned to short waves although 37 percent of them are never used for that purpose.

Electronic Train Control

FOR THE EXPEDITING of freight traffic and as a factor in safety, railroad radio has proved of value, in the opinion of E. A. Dahl, speaking



Techrad's Production and Engineering . . . a combination that clicks!

• Techrad's engineering takes nothing for granted and each product represents an advanced technique in production accuracy. • Techrad engineers insist on the perfect component—if they can't find it they build it. To them, there is no substitute for quality! • Techrad is your assurance of trouble-free service under the most adverse conditions. Every detail is planned for easy operation. • Over a decade of continuous experience behind each Techrad product: transmitters, direction finders, receivers, marine equipment, interpolating counter dials, Techrad dial lock, Techrad knob.
• All Techrad services and products are guaranteed.
• When you consult our engineers on your problems you will receive prompt and thoughtful attention. Write now for complete information.

technical radio company

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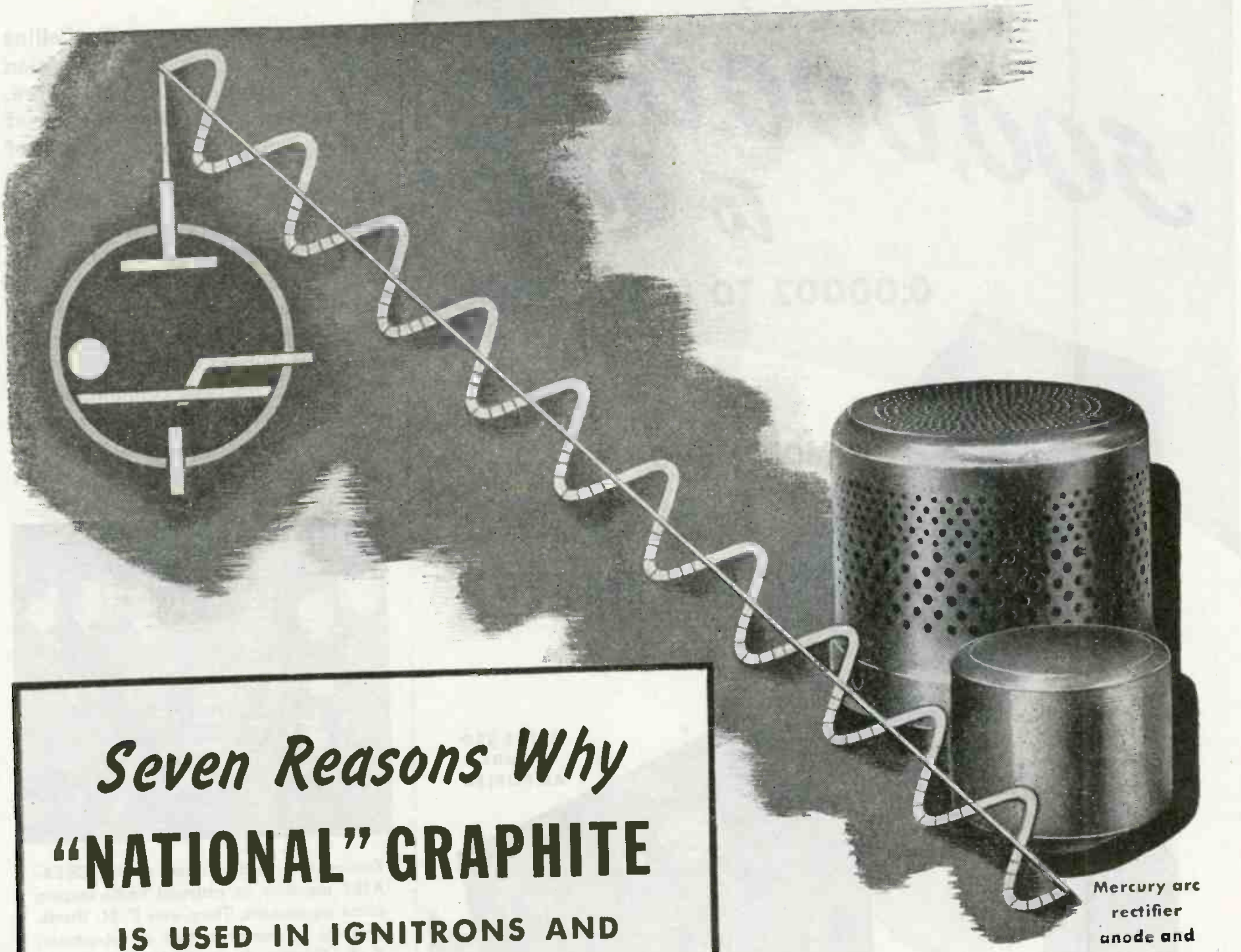
Over a decade of continuous experience



Mercury arc rectifier anode and shield

Seven Reasons Why "NATIONAL" GRAPHITE

IS USED IN IGNITRONS AND OTHER ELECTRONIC TUBES

In ignitron rectifiers . . . and in many types of industrial and radio tubes . . . "National" electronic graphite is used for anodes and other tube components because of:

1. Purity higher than any other anode material.
2. Greater energy dissipation, permitting higher tube ratings.
3. Higher permissible operating temperatures than with other anode materials, allowing wider range of applications.
4. Low expansion characteristics and absence of distortion and warping.
5. Close dimensions.
6. Ease of machining, providing more latitude of design and construction.
7. Light in weight.

In addition, the reduction of heat lessens the tendency of other tube parts to warp, while the structural strength of "National" electronic graphite gives added assurance against breakage from vibration and shock.

Representatives of National Carbon Company will gladly consult with you in the design and on the advantages of "National" electronic graphite for components of any type of tube. Inquire at our nearest Division Office.

The registered trade-mark "National" distinguishes products of National Carbon Company, Inc.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

General Offices: 30 East 42nd Street, New York 17, N. Y.

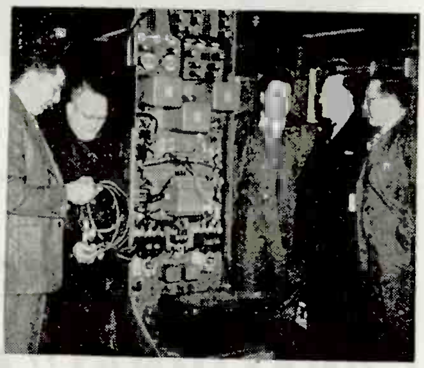
Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

KEEP YOUR EYE ON THE INFANTRY . . . THE DOUGHBOY DOES IT!

at a recent meeting of the Collins Radio Technical Association (CRTA) in Cedar Rapids, Iowa. The session was a joint meeting of CRTA and the Iowa Section of AIEE.

The talk by Mr. Dahl was preceded by a history of train-control systems presented by A. E. Ganzert, electrical engineer for the Rock Island Railroad.

According to Mr. Dahl, radio will supplement telephone, telegraph, and teletype communication but will not supersede these techniques. The experiments which he has finished running for Rock Island include carrier current on 175 kc and radio on frequencies ranging from 40 to 2700 Mc. He pointed out that extremely high frequencies are especially convenient for direct communications since antenna lengths vary inversely with frequency and physical space is at a premium.



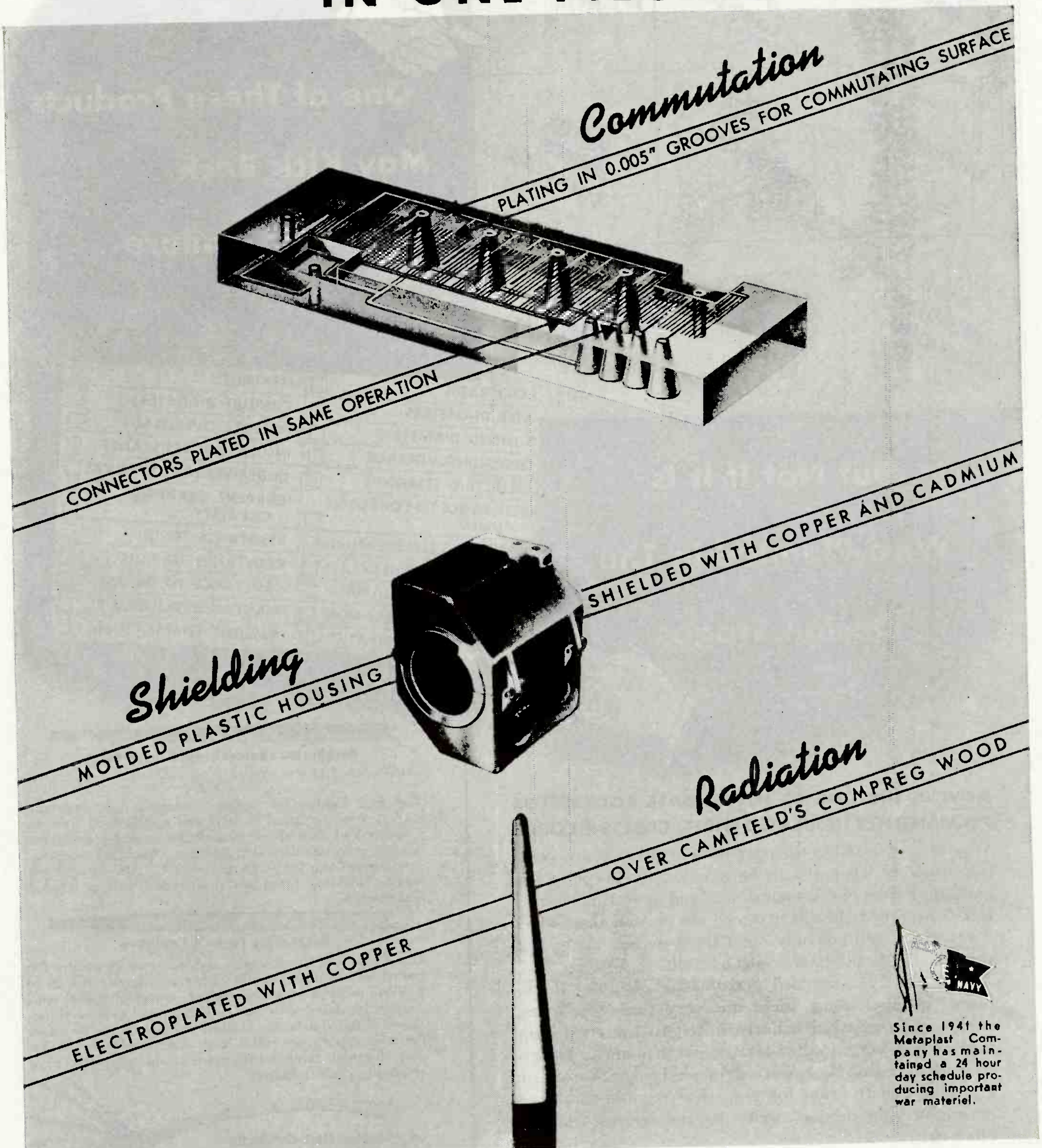
Engineers in attendance at the CRTA-AIEE meeting on railroad radio inspect some equipment. They are: F. M. Davis, director of research and development; T. A. Hunter, director of oscillator development; and L. M. Craft, operations manager—all of Collins Radio Co.: A. E. Ganzert, electrical engineer; and E. A. Dahl, electronic engineer—Rock Island Railroad.

Gun Location by Sound Ranging

New equipment has been announced by the Signal Corps for use in sound ranging and location of enemy guns. The new equipment is less than half the size and weight of that used by the Army at the beginning of the war and photographic recording is being replaced by a dry recorder which eliminates the need for photographic chemicals.

In the system, a microphone

Metaplate CONDUCTOR AND NON-CONDUCTOR IN ONE PIECE



Metaplast COMPANY

205 West 19th Street
New York 11, N. Y.

Metaplast Process Patented and Licensed

METAL PLATING ON PLASTICS

Here a British Army operator uses radio to effect liaison between the listening post and the recording center where sensitized paper records the gunfire-impulses picked up by the sound-ranging microphone array

array is spread through the area behind the front lines with wire connections to a central station. Microphones pick up signals from enemy gunfire or our own shell bursts and the differences in time of arrival provide data for geometric calculations on the position of the detonation.

Private British Television

IT IS REPORTED that television, discontinued in Great Britain at the start of the war, is being tried out again on a closed-circuit basis. Owners of receivers are not yet permitted to see what the new developments are.

Science After the War

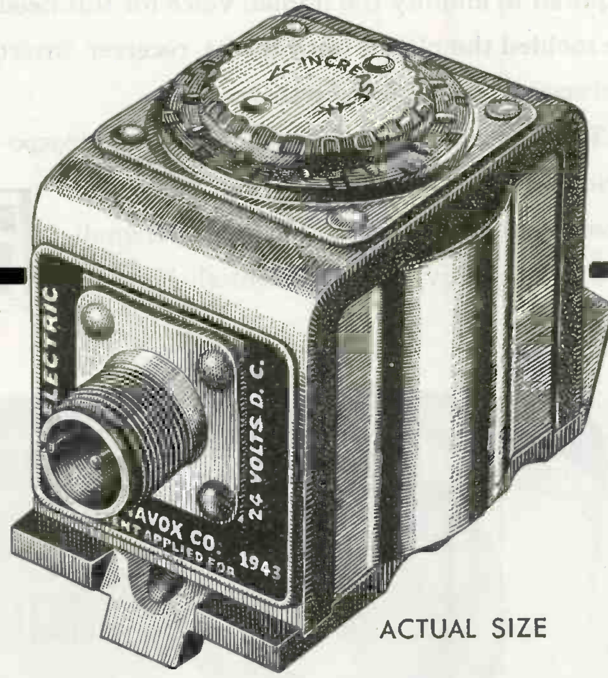
FOUR ADVISORY COMMITTEES have been set up under OSRD (Office of Scientific Research and Development) to search out answers for four questions recently asked by President Roosevelt in a letter to Dr. Vannevar Bush, director of the Office.

Question 1 was "What can be done, consistent with military security, and with the prior approval of the military authorities, to make known to the world as soon as possible the contributions which have been made during our war effort to scientific knowledge?"

The committee to deal with this question is chairmanned by Dr. Irvin Stewart, executive secretary of OSRD. Its members include: Dr. Karl T. Compton, MIT; Dr. J. B. Conant, Harvard; Dr. M. A. Tuve, Carnegie Institution; Dr. J. P. Baxter, OSRD & Williams College; and C. L. Wilson, OSRD.

The second question relates to

MAGNAVOX IS ALSO HEADQUARTERS FOR SOLENOIDS



ACTUAL SIZE

THIS is the youngest of the Magnavox family, but like the other members is on top of the heap.

Did you know: That every solenoid used by any branch of the armed forces—firing all automatic weapons from .30 calibre machine guns to 105 m. m. cannon—was developed by Magnavox?

● That Magnavox has been providing every type of solenoid—fifty different models?

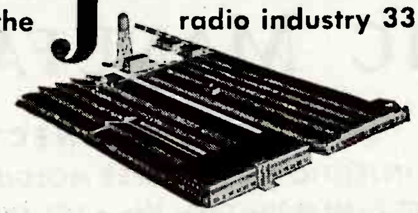
● That the production of solenoids by Magnavox during the war has been greater than that of all other manufacturers combined?

● At present we can only consider inquiries for quantity production, but that situation will change. If you have any solenoid problems, we suggest that you consult our technical department. Their skills are at your service, plus the outstanding facilities of our completely modern six-acre plant.

The Magnavox Company, Special Devices Division, Fort Wayne 4, Indiana.

Magnavox

has served the radio industry 33 years



SPEAKERS • CAPACITORS • SOLENOIDS • ELECTRONIC EQUIPMENT

Plastic Throat Parts for a BIG VOICE!

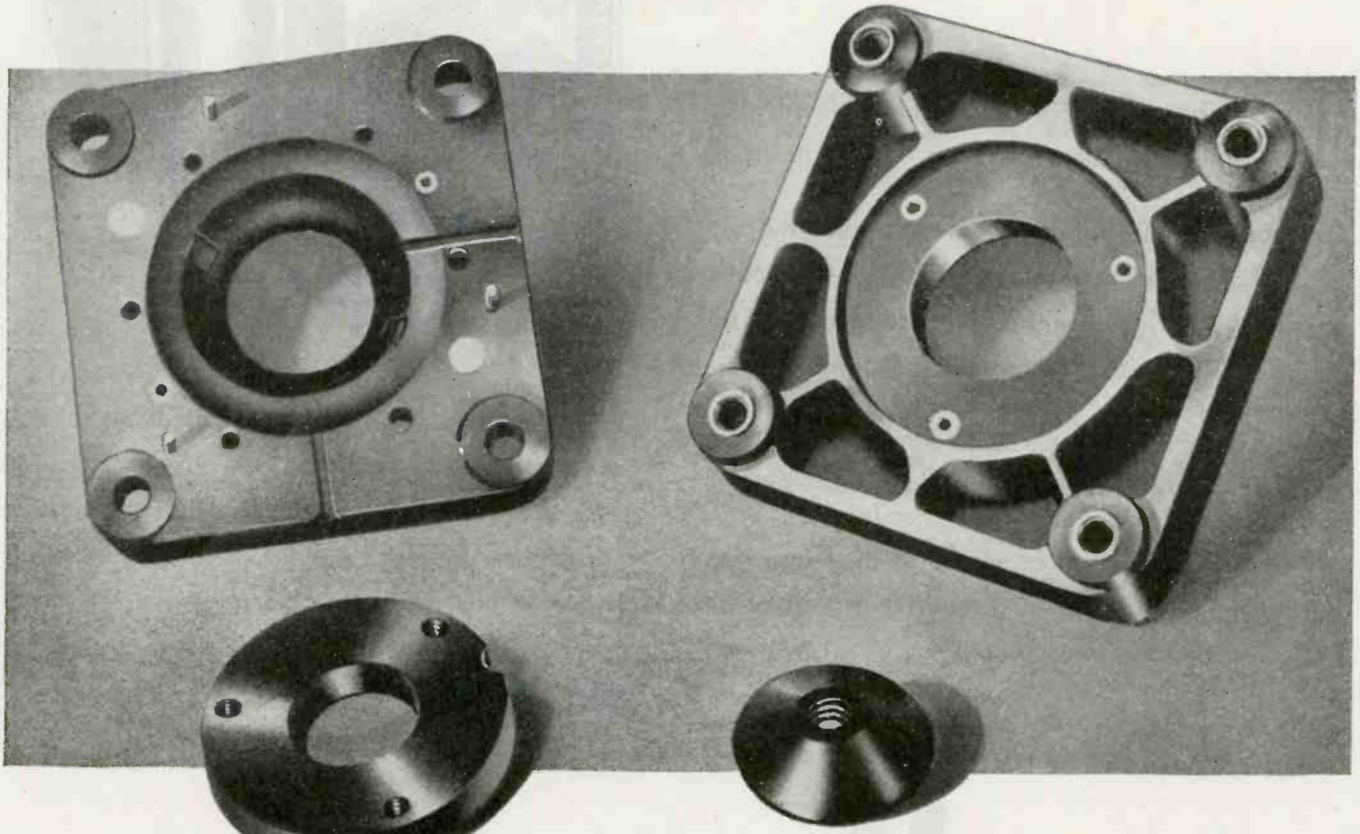
A voice strong enough to carry across miles of sea and land . . . and to be heard above the sounds of battle . . . urgent, time-saving words of command and direction. This was the voice needed by the Navy to co-ordinate operations between landing craft, ships and shore. For the special equipment required to amplify the human voice for this need we molded the plastic horn throat, receiver, insert and spacer parts shown on this page.

The job called for precise molding and incorporation of inserts. Tolerances had to be held close to avoid affecting sound and tone qualities. Quick delivery was essential. How we met these requirements is indicated by this quotation from a letter sent to us by Western Electric Company, makers of the amplifying system:

"Your company was called upon to furnish all of the required plastic parts. We feel that without your help the program could not have been a success, and we would like to express our appreciation of your fine work and excellent cooperation."

We have collected information on our plastics engineering, molding and assembly services in a most convenient form. If you are interested in obtaining product improvement thru plastics, write for free Folder File E 4.

PM
REG. U.S. PAT. OFF.



★ *Advantages of these plastic molded parts include resistance to shock, vibration and corrosion. Exceptionally close tolerances are held.*

PLASTIC MANUFACTURERS

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MOLD MAKING • INJECTION & TRANSFER MOLDING • COMPLETE ASSEMBLY

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Scene from Warner Bros. Picture
"RHAPSODY IN BLUE"

Fairchild Portable Recorder

Quality Transcription

... that keeps the original music and speech *alive!*

Your station announcer . . . not quality variation . . . should tell your listening audience whether your broadcast is a 'live' or 'recorded' program.

'Live' and 'recorded' quality should be practically indistinguishable!

Fairchild-built recording channels put the fundamental tone and all overtones up to 8,000 cycles on the record at full strength. The bass takes on the character of the individual instruments instead of the all-too-prevalent overall 'boom, boom' which leaves the listener wondering whether the recorded sound is string bass, brass horns, bassoon or drums.

At the other end of the sound spectrum, and throughout all intermediate ranges, Fairchild recorded sound comes back over good playback systems with absolute *naturalness*. No doubt remains in the listener's mind that he's hearing the 'live' qualities of the orchestra, band, or the even-more-difficult-to-record individual performances of the piano or pipe organ.

Fairchild Portable Recorder descriptive and priority data are available. Address *New York Office:* 475 - 10th Avenue, New York 18; *Plant:* 86-06 Van Wyck Boulevard, Jamaica 1, N. Y.

SOUND EQUIPMENT

FCI

Fairchild CAMERA AND INSTRUMENT CORPORATION organizing a program for continuing the war of science against disease and will be investigated by a committee of medical people.

Question three is concerned with steps which should be taken by the government to aid research activities by public and private organizations. The chairman of the committee looking into this is Dr. Isaah Bowman, president, Johns Hopkins University, and the secretary, Prof. W. Rupert Maclaurin, MIT.

Other members include: Dr. I. I. Rabi, Columbia University; Dr. J. T. Tate, University of Minnesota; Charles E. MacQuigg, Ohio State University; Dr. Walter C. Coffey, University of Minnesota; Rev. J. Hugh O'Donnell, University of Notre Dame; Dr. Clarence A. Dykstra, University of California; and Dr. Oliver E. Buckley, Bell Telephone Laboratories.

Under category four, an effective program will be formed for discovering and developing scientific talent in American youth. Chairman of the committee looking into this problem is Dr. Henry Allen Moe, of the John Simon Guggenheim Memorial Foundation.

Other members are Dr. J. B. Conant, Dr. R. E. Doherty, Carnegie Institute of Technology; Dr. Henry A. Barton, American Institute of Physics; Dr. Watson Davis, Science Service; Henry Chauncey, Harvard; and T. R. McConnell, University of Minnesota.

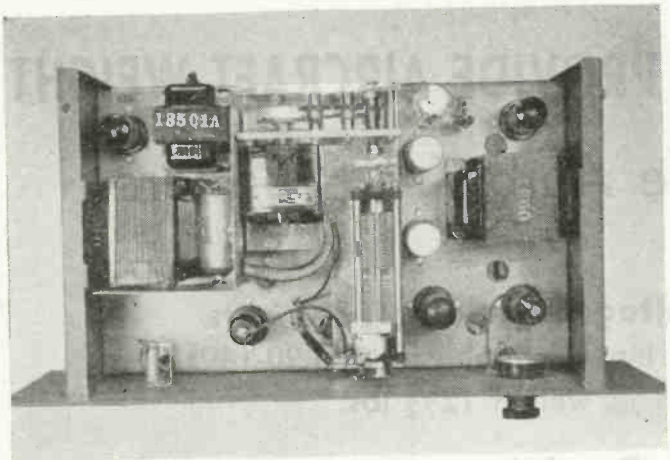
Security Board

Meanwhile, to serve the hiatus between the expiration of the present OSRD and the establishment by Congress of a new independent agency to develop war weapons, Secretary of War Stimson, Secretary of the Navy Forrestal, and Dr. Frank B. Jewett, president of the National Academy of Sciences, announced the establishment of a Research Board for National Security.

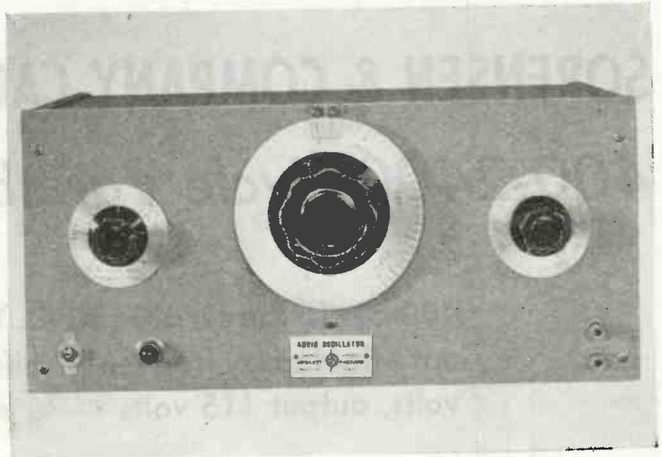
Membership in the executive committee will include: Karl T. Compton, MIT, as chairman; Brig. Gen. W. A. Borden, War Department Special Staff, and Rear Admiral J. A. Furer, Navy Department.

Among the civilian board members are: Dr. Oliver E. Buckley,

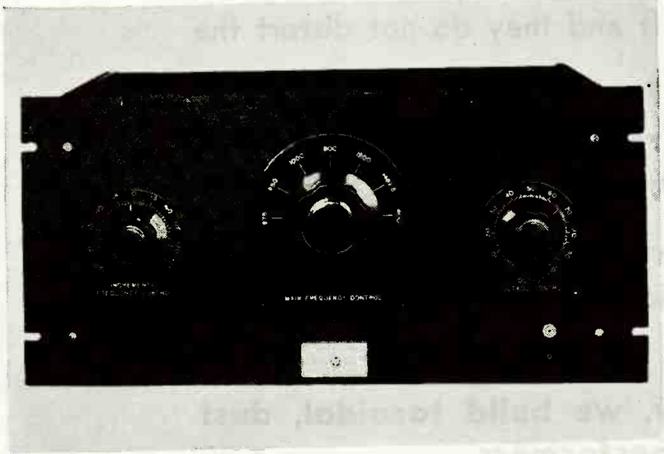
3 EXAMPLES OF *-hp-* ENGINEERING TO SOLVE SPECIAL PROBLEMS



This instrument automatically varies the output frequency from 1000 cps to 3000 cps and back to 1000 cps once each second. It's another example of a special oscillator on which information has not been restricted during the war.



This special unit was developed to supply a readily adjusted frequency between 24 and 26 kc, and is now in use testing secret devices for the war effort. To give an accurate incremental variation of the frequency, a separate control was provided.



To facilitate rapid production tests for a prominent western radio manufacturer, this special oscillator was designed and constructed. Seven fixed audio frequencies are instantly obtained by means of a single control knob. Small incremental variations of frequency are controlled by another knob.

The Hewlett-Packard organization has had wide experience in the development of special equipment for laboratory and production work where specific and exacting problems are encountered. The answer quite often requires only an adaptation of a standard *-hp-* instrument, but in some cases new instruments are developed for the particular problem. Today all of the standard *-hp-* instruments are confined to war work. However, *-hp-* engineering facilities are at your service to assist in solving your individual problem. A letter will bring further information without obligation.

HEWLETT-PACKARD COMPANY

BOX 1014A · STATION A PALO ALTO, CALIFORNIA

1014

Canadian Office: 560 King Street West, Toronto 2, Canada

Hard to Get?

SORENSEN & COMPANY CAN PROVIDE AIRCRAFT WEIGHT

400-2400 Cycle Variable Auto Transformers

400 cycle Electronic A. C. Voltage Regulators, 500 watts, not affected by frequency shift. Input voltage variation 90-140 volts, output 115 volts ± 3/4 of 1%, weight 12 1/2 lbs.

60 cycle Electronic Voltage Regulators, 1200 to 1750 watts, input 50 to 70 cycles, 90-140 volts; output 115 volts constant to 3/4 of 1%, weight 60 lbs.

These A. C. Voltage Regulators are not to be confused with the resonant type regulators on the market as they are not affected by wave form, or frequency shift and they do not distort the output wave.

Audio Components, Power Transformers and Chokes—all frequencies. Frosterite construction or hermetically sealed.

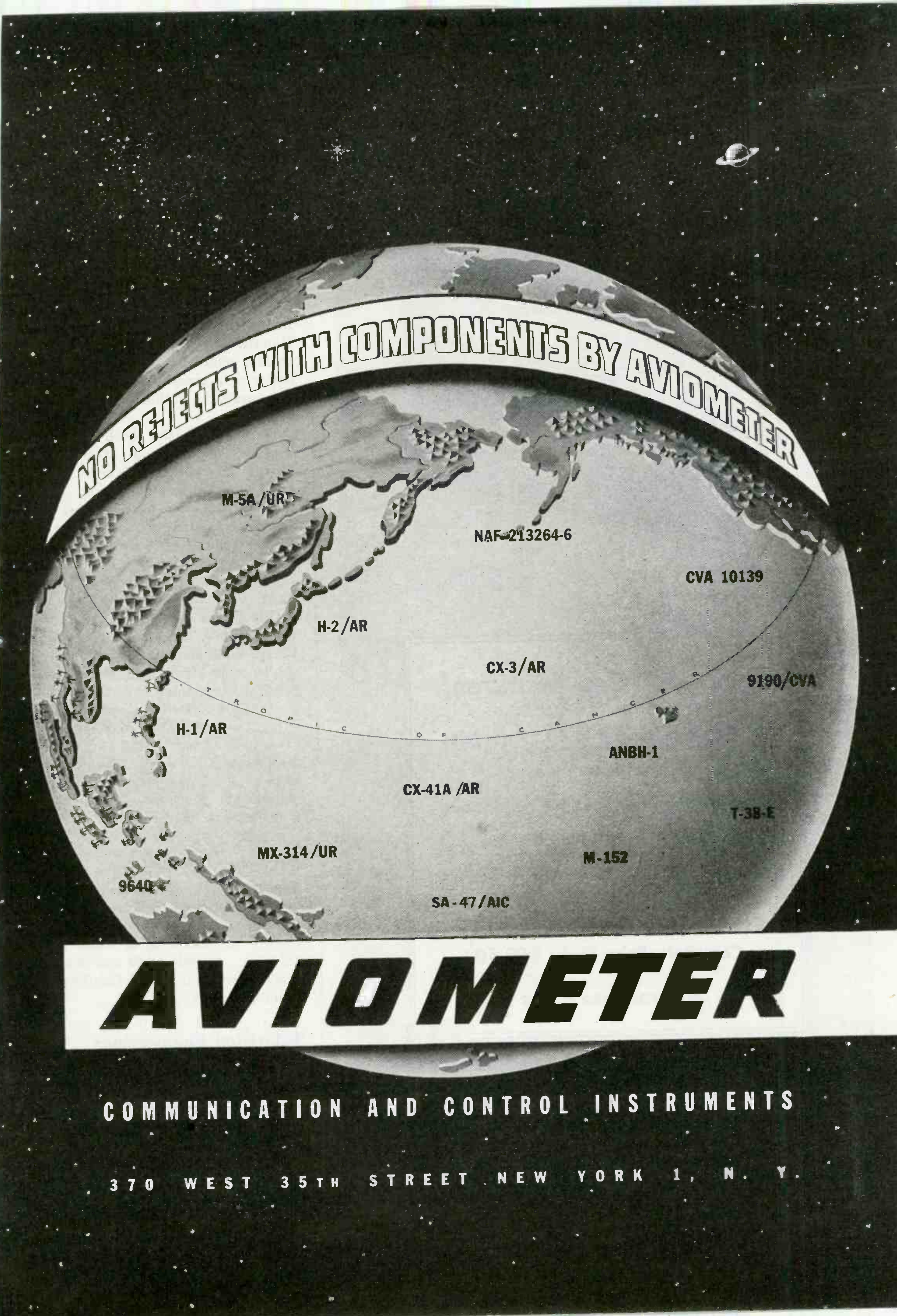
Constant Intensity Light Sources, capable of modulation—for use in printing of photographic film, microscope photometry and spectral analysis.

Where Hi "Q" is necessary, we build toroidal, dust core coils for choke and transformers.

A normal delivery schedule can be provided on any of these items. Your inquiry invited.

SORENSEN & COMPANY

AIRBORNE ELECTRONICS » » STAMFORD, CONN.


NO REJECTS WITH COMPONENTS BY AVIOMETER
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H-2/AR
CX-3/AR
9190/CVA
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Bell Telephone Laboratories; Prof. Lee A. DuBridge, University of Rochester; Zay Jeffries, General Electric Co.; Prof. C. C. Lauritsen, California Institute of Technology; Prof. E. O. Lawrence, University of California; and I. I. Rabi, Columbia University. Among military members is included Maj. Gen. Harry C. Ingles, chief signal officer.

RMA Trade Directory

RECENTLY PUBLISHED by Radio Manufacturers Association is a booklet combining the membership list with a trade directory including product listings of normal production.

Contents of the book include lists of officers and executives, boards of directors, and past presidents of the Association. Detailed information on personnel is shown for standing committees, special committees, divisional executive committees, sections of divisions, and the engineering department.

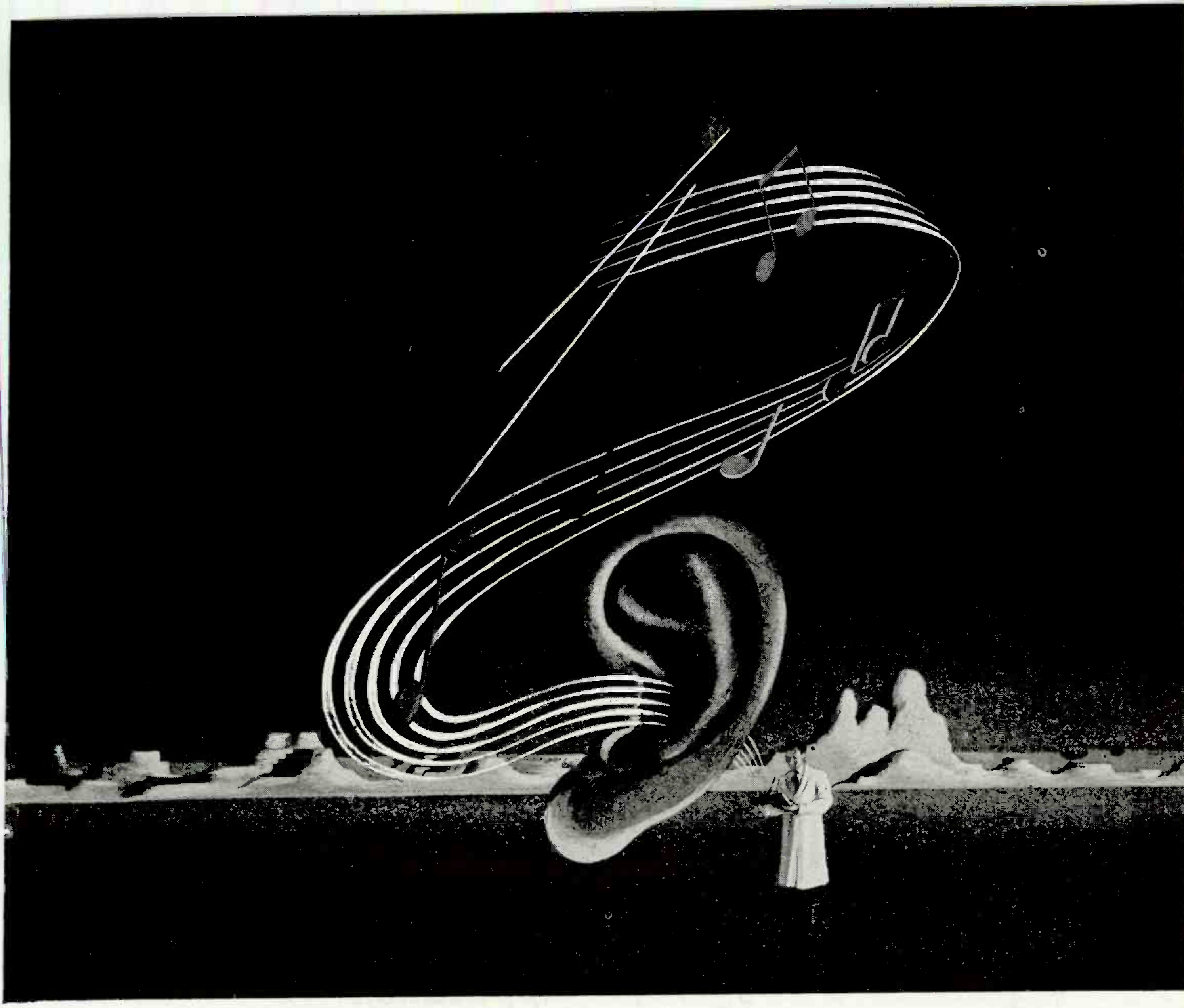
Other data includes a roster of the Radio Technical Planning Board, WPB and OPA industry advisory committees. In the membership section, member companies are listed by personnel, products, and trade names and cross-indexed according to their membership in the set, tube, transmitter, parts, amplifier, and sound equipment divisions. Associate members are likewise listed.

Servicing Legislation

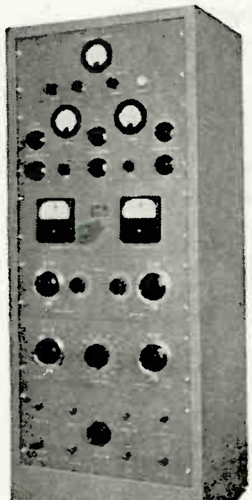
ACCORDING TO INFORMATION received by RMA, a bill has been introduced in the Oregon State Legislature to require the licensing of radio repairmen. A similar bill was previously introduced in the California governing body.

Television Engineering Committee

TELEVISION BROADCASTERS Association forms an engineering committee chairmanned by F. J. Bingley, Philco Radio & Television Corp. Others members of the committee are: W. J. Purcell, General Electric Co., Schenectady; Dr. Thomas T. Goldsmith Jr., Allen B. DuMont Laboratories Inc.; David B. Smith,



WHEN STEEL SINGS OFF KEY

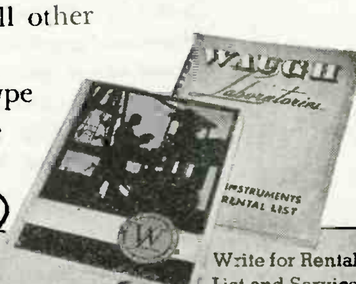


Above: WAUGH INDUFLUX, TYPE F

At Waugh we have developed magnetic testing equipment which measures the voice of steel.

It has been applied to many special purposes: non-destructive production line testing of shell cases and armor plate; correlation of magnetic readings with hardness and change in grain structure; sorting steel of various grades. It has spotted trouble where all other instruments have failed.

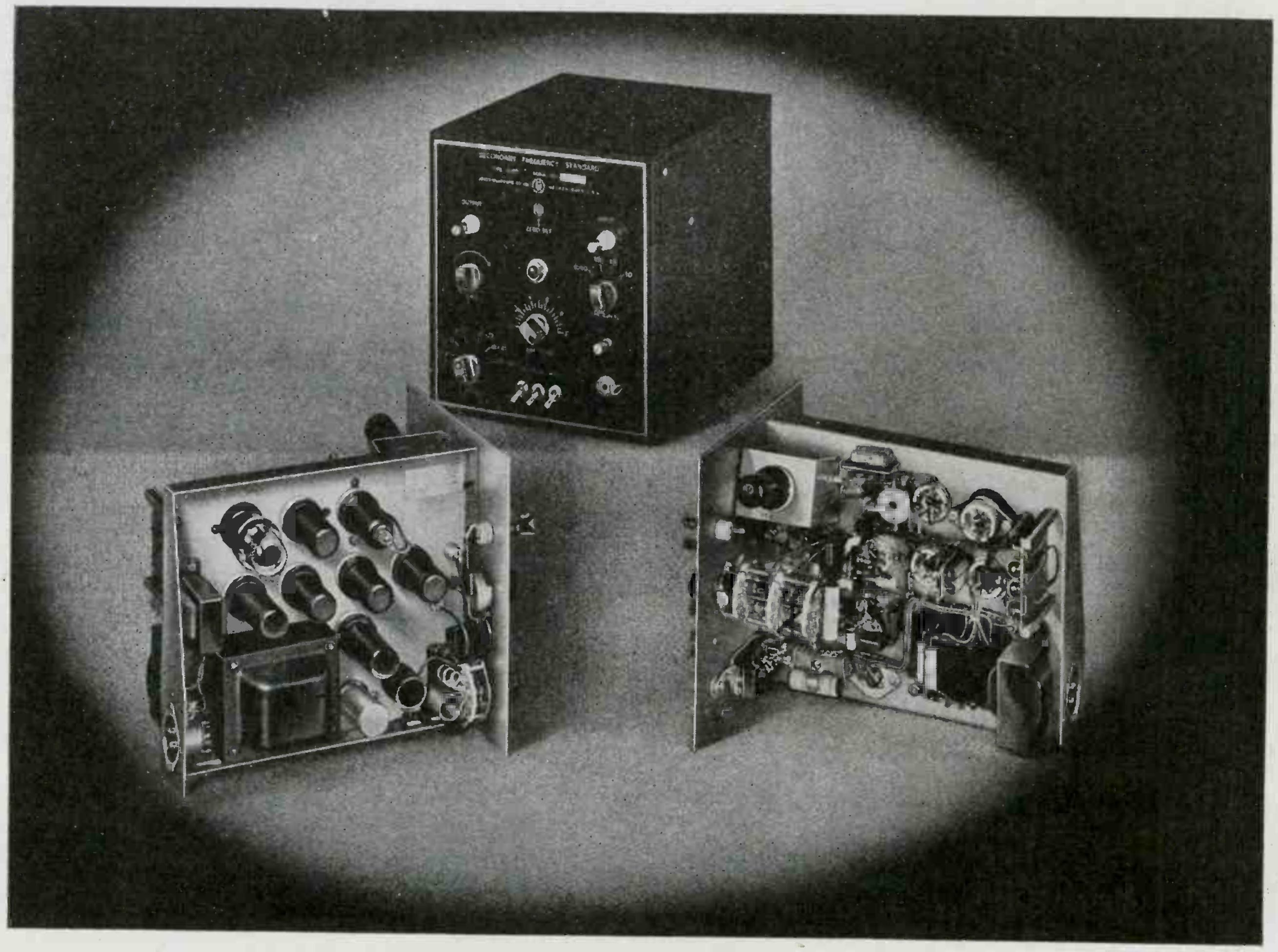
This instrument is the Waugh Induflux, Type F. If steel presents unsolved problems, write for details.



Write for Rental List and Service Manual on business letterhead.

WAUGH Laboratories

Pacific Coast Branch: 180 East California St., Pasadena 5, California ◆ **420 LEXINGTON AVE., NEW YORK 17, N. Y.**



"Designed for Application"

THE 90505 SECONDARY FREQUENCY STANDARD

A Precision Frequency Standard for both Laboratory and production uses. Designed around the GE G-18 and G-18A crystal, having a frequency temperature coefficient of less than 1 cycle/Mc/C°. The crystal is sealed in Helium in a standard metal tube envelope. Adjustable output provided at intervals of 10, 25, 100, and 1000 KC with magnitude useful to 50 MC. Harmonic amplifier with tuned plate circuit and panel range switch. 800 cycle modulator, with panel control switch. Panel plate supply control switch. In addition to Oscillators, Multi-vibrators, Modulators, and Amplifiers, a built-in Detector with 'phone jack and gain control on the panel is incorporated. Easily adjusted to WWV. Self-contained AC power supply with VR 150-30 voltage regulator. Used in quantity by Signal Corps. Navy, FCC, British and all large government prime contractors such as GE, RCA, Western Electric, Sperry, Westinghouse, etc. Cabinet size 9" x 9⅝" x 10½", weight 20 lbs. Compact, dependable, stable, trouble-free. Price complete with GE crystal and tubes $135 net, f.o.b., Malden for 115 V. 60 cycle model. Available for the duration, of course, only with proper priority.

JAMES MILLEN MFG. CO., INC.

MAIN OFFICE AND FACTORY

MALDEN, MASSACHUSETTS, U. S. A.

Philco Radio & Television Corp.; O. B. Hanson, NBC; Robert Shelby, NBC (alternate); E. A. Hayes, Hughes Productions, Los Angeles; George Lewis, Federal Telephone and Radio Corp.; Harry Lubcke, Don Lee Broadcasting System, Hollywood; and H. L. Blatterman, Earle C. Anthony, Inc., Los Angeles.

Morale Radio

DEVELOPMENT is complete on a new Signal Corps radio receiver to be used for morale and recreational purposes by troops overseas. Known as R-100/URR, the unit provides reception for medium and short-wave broadcasts and operates from self-contained batteries or from a-c or d-c power sources.

MEETINGS TO COME

APRIL 4; INSTITUTE OF RADIO ENGINEERS, New York Section; Wartime Developments in Electronics, by Dr. W. L. Everitt, national president; Engineering Societies Building, 33 W. 39th St., New York, N. Y.; J. T. Cimorelli, secretary, Radio Corp. of America, Harrison, N. J.

APRIL 11; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, New York Section, Electron Ballistics in High-Frequency Fields; Mines Building, Columbia University, New York, N. Y.; Prof. C. W. van der Merwe, symposium chairman, Dept. of Physics, Washington Square College, New York University, New York, N. Y.

APRIL 12-14. ELECTROCHEMICAL SOCIETY, 87th General Meeting, Hotel Claridge, Atlantic City, N. J. Colin G. Fink, secretary, Columbia University, New York 27, N. Y. Subject to postponement or cancellation.

APRIL 12-14. OPTICAL SOCIETY OF AMERICA, Cleveland, Ohio. Arthur C. Hardy, secretary, Massachusetts Institute of Technology, Cambridge 39, Mass. . . . Cancelled.

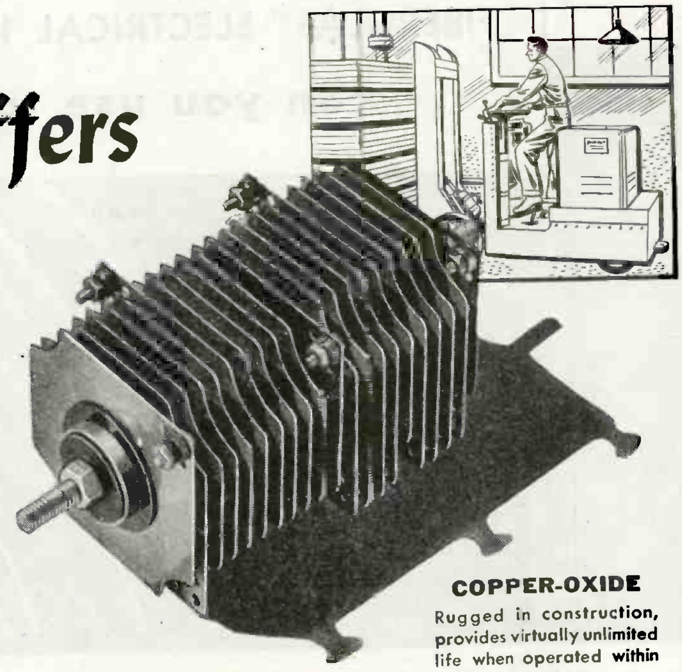
APRIL 16-20. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, Spring Meeting, Palmer House, Chicago, Ill. . . . Cancelled.

APRIL 20-21; ASSOCIATED POLICE COMMUNICATION OFFICERS, New York Chapter; Annual Meeting, Schenectady, N. Y.; Francis A.

(*Continued on page* 330)

RECTIFIERS FOR EVERY D-C APPLICATION

Only G-E Offers All 3



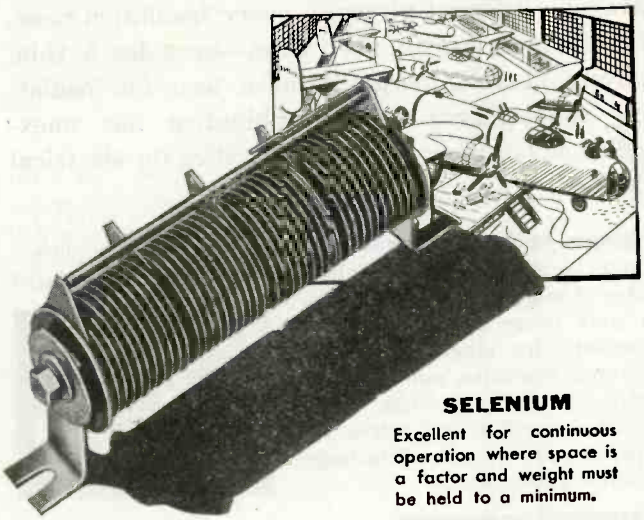
COPPER-OXIDE
Rugged in construction, provides virtually unlimited life when operated within rated capacities.

Wherever low-voltage power is needed whether for instruments, relays, solenoids, motors, battery charging, plating, or any other d-c application, G.E. can supply the exact size and type rectifier to do the job.

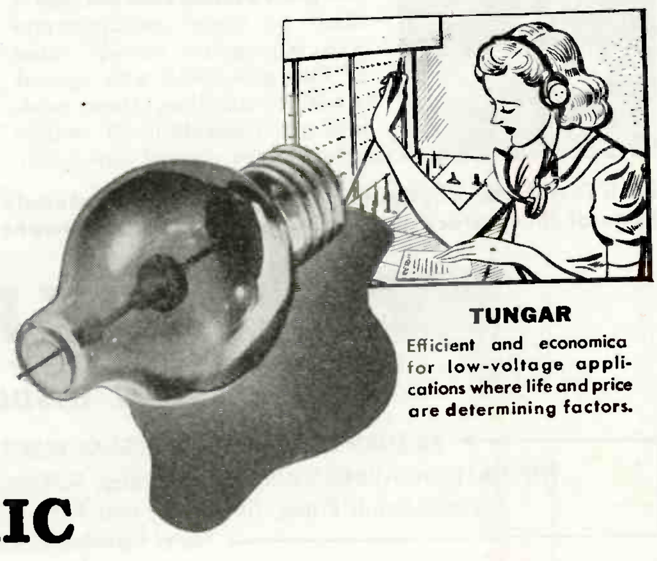
G.E. and only G.E. designs and builds the three types of low-voltage rectifiers most commonly used; copper-oxide, selenium and Tungar. Each rectifier differs in characteristics, basic materials and construction.

The conditions under which a rectifier is to operate and the results that are to be obtained determine which type will do the most economical, most efficient and most satisfactory job.

G-E engineers will gladly analyze your rectifier needs and offer their recommendations. Whether they recommend copper-oxide, selenium or Tungar you can be sure their selection is impartial for G.E. offers all three. For more information write to Section A457-119, Appliance and Merchandise Dept., General Electric Company, Bridgeport, Conn.



SELENIUM
Excellent for continuous operation where space is a factor and weight must be held to a minimum.



TUNGAR
Efficient and economica for low-voltage applications where life and price are determining factors.

BUY WAR BONDS AND KEEP THEM

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. "The G-E House Party" Monday through Friday 4:00 P.M. EWT, CBS.

GENERAL ELECTRIC

CONTROLS FOR WORLD MARKETS

Ward Leonard Controls have an enviable record of performance in war equipment. On the sea, under the sea, on the ground, and in the air — subjected to widely varying climatic conditions in all parts of the world!

Obviously manufacturers who are planning world-wide postwar markets can be certain that the Ward Leonard controls they incorporate in their products will give continuous trouble-free service.

Write for our catalogs describing the types of controls you need.

RELAYS—light, intermediate and heavy duty.

RESISTORS—withstand heat, moisture, vibration and other adverse conditions.

RHEOSTATS—wide range of sizes, types and current ratings from ring types to industrial assemblies.

WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

ARMY E NAVY

Electric control WL devices since 1892.

WARD LEONARD ELECTRIC COMPANY · 32 SOUTH ST. · MOUNT VERNON, N. Y.

(*Continued from page* 326)

Burns, secretary, 240 Centre St., New York 13, N. Y.

APRIL 25-26. AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, North Eastern District Meeting, Buffalo, N. Y. . . . Cancelled.

APRIL 26-27. INSTITUTE OF THE AERONAUTICAL SCIENCES, National Light Aircraft Meeting, Detroit, Mich. . . . Cancelled.

APRIL-MAY; NATIONAL ASSOCIATION OF BROADCASTERS, Annual Conference. . . . Cancelled.

MAY 2; INSTITUTE OF RADIO ENGINEERS, New York Section; Allocations, by E. K. Jett, FCC Commissioner; Engineering Societies Building, 33 W. 39th St., New York, N. Y.; J. T. Cimorelli, secretary, Radio Corp. of America, Harrison, N. J.

MAY ——; SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, 1945 Spring Meeting, Buffalo, N. Y. W. M. Murray, president, P.O. Box 168 Central Square Station, Cambridge 39, Mass. Subject to postponement or cancellation.

MAY 11-12; ACOUSTICAL SOCIETY OF AMERICA, New York, N. Y.; Wallace Waterfall, secretary, 350 Fifth Ave., New York 1, N. Y. Subject to postponement or cancellation.

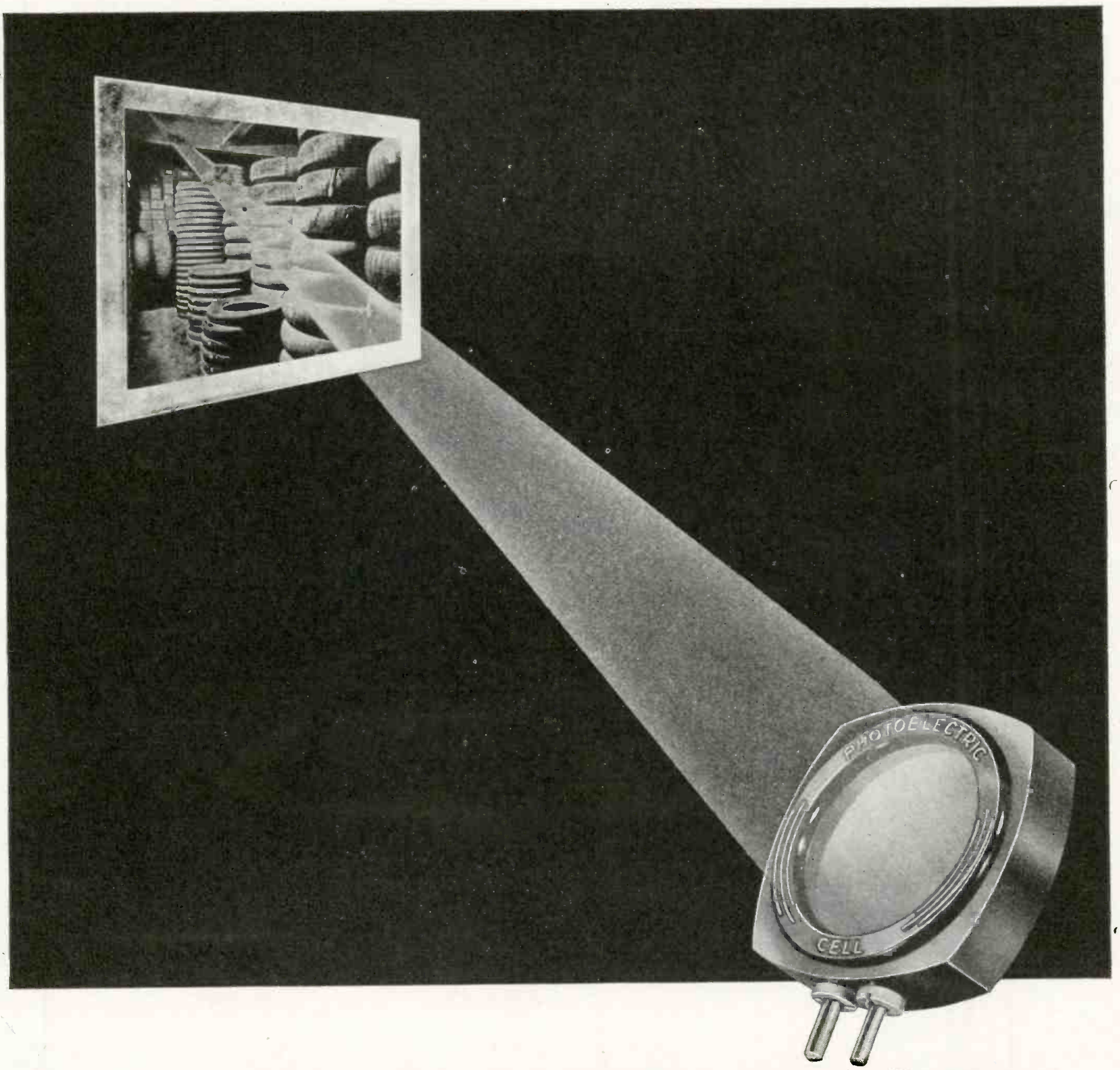
MAY 14-18; SOCIETY OF MOTION PICTURE ENGINEERS, 57th Semi-Annual Technical Conference; Hollywood-Roosevelt Hotel, Hollywood, Calif.; W. C. Kunzmann, convention vice president, P.O. Box 6087, Cleveland 1, Ohio. Subject to postponement or cancellation.

MAY 28; AMERICAN SOCIETY FOR MEASUREMENT & CONTROL, Meeting on Process Control; Roosevelt Hotel, Pittsburgh, Pa.; L. M. Susany, secretary, Carnegie Institute of Technology, 4400 Forbes St., Pittsburgh 13, Pa.

JUNE 25-29; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, Summer Technical Meeting; Detroit, Mich.; H. H. Henline, secretary, 33 West 39 St., New York 18, N. Y. . . . Cancelled.

WASHINGTON NEWS

RESISTORS. During 1944, the fixed- and variable-resistor industry shipped 600,496,000 units valued at $48,000,682, as compared to 1943



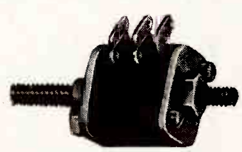
How to make a beam of light scream "FIRE!"

Fire protection by means of Luxtron* photocells employs a steady source of light. When blocked by smoke or deflected by smoke particles, it decreases or increases the flow of current from the cell and activates the entire protection system. . . . By using Luxtron photocells, light can be converted to electric energy, sufficient to operate meters and meter relays without costly bulky amplifiers, and with assurance of long life under strenuous conditions.

Photocells today are doing everything from calmly watching batches of textiles for perfect color match . . . to sitting undismayed on roaring machinery, stopping it when trouble is in sight. To learn if photocells can help you, write Bradley Laboratories.

*T. M. REG. U. S. PAT. OFF.

Another Bradley Development



This is one of a unique group of "Coprox" (copper oxide) rectifiers developed and manufactured by Bradley with the same understanding of electrical circuits that goes into Luxtron photocells. Write for illustrated "Coprox" bulletin.

PHOTOCELLS—MASTERS OF LIGHT — BRADLEY — MASTER OF PHOTOCELLS

BRADLEY LABORATORIES, INC., 82 MEADOW STREET, NEW HAVEN 10, CONNECTICUT


U. S. NAVY
Certificate of Achievement
Radar-Radio Industries of Chicago Inc.
FOR ITS UNTIRING EFFORTS IN ORGANIZING THE ELECTRONICS INDUSTRY TO SPEED THE PRODUCTION OF VITAL WAR MATERIAL FOR THE UNITED STATES NAVY........
SECRETARY OF THE NAVY
1944

shipments of 398,361,000 units worth $35,066,000, according to WPB. Average cost per resistor ranged from 10.3¢ in August, 1943, to 7.1¢ in January, 1945, a reduction of 31 percent.

According to information given the Industry Advisory Committee at a recent meeting, new designs of electronic equipment are expected to bring about a greater demand for precision wire-wound resistors. Because resistor manufacturers are not allowed to order raw materials except to fill recorded orders, the existing situation where their backlog has dropped may cause an increase in the length of delivery time.

RADIO FREQUENCY CABLES. Approved by the War and Navy Department for use of procurement services of the Army and Navy is JAN-C-17 covering coaxial and twin conductor cables for radio frequency. Types included are flexible and semi-flexible, coaxial, twin conductor, and dual-coaxial shielded cable for radio frequencies and employing solid and semi-solid dielectrics of low-loss polymeric resin, thermosetting compounds, or vulcanized synthetic rubber.

Designated by Army Number 71-4920 and Navy Number 16C8, the specification lists applicable specifications, types, material and workmanship, general and detail requirements, methods of sampling, inspection and test, and packing and marking for shipment. Detail requirements are covered by over forty individual cable specifications.

ELECTRON TUBE NEEDS. Requirements for 1945 being about 25 percent higher than the 12,000,000 radio tubes a month needed in 1944, WPB has created a radio-tube task committee to advise on methods for increasing production. Consisting of members from both AFL and CIO organizations, it will discuss difficulties present in the various tube plants.

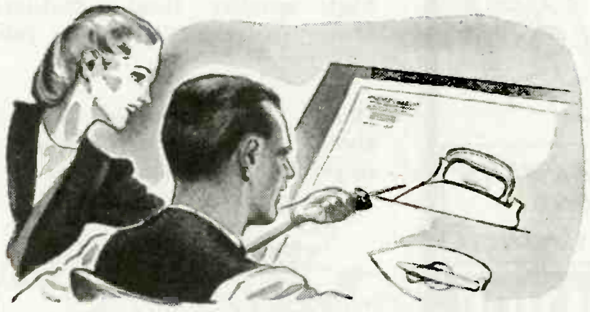
The committee suggested that much of the production difficulties come from labor turnover brought about by low wage rates. At the same time the receiving-tube-scheduling advisory Committee feels that completion of certain facilities will make it possible for in-

EASY ON MEN!

Hand driving screws into garnish molding is slow, hard work. But as long as he used slotted screws, this world-famous manufacturer of automobile bodies didn't dare risk power driving. Driver skids came too high – and too often!

EASY ON THE POCKETBOOK!

A change to Phillips Recessed Head Screws ruled out driver skids . . . permitted use of power methods. Also eliminated one operation involving countersunk washers. All of which added up to substantial cost-savings!



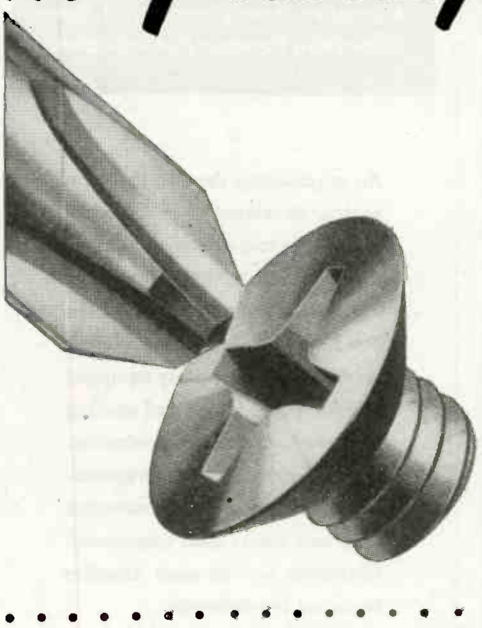
EASY ON ENGINEERING!

Easy on assemblymen . . . easy on the pocketbook . . . Phillips Screws are kind to design staffs, too. With Phillips, engineers can build product strength and rigidity up to specifications slotted screws just can't approach!

EASY ON THE EYES!

Besides being strength-builders, Phillips Screws are also great little sales-builders. They help dress up any product . . . do away with unsightly burrs that snag clothing and make an otherwise sweet piece of merchandise look sour!

It's Phillips ... the engineered recess!



In the Phillips Recess, mechanical principles are so correctly applied that every angle, plane, and dimension contributes fully to screw-driving efficiency.

... It's the exact pitch of the angles that eliminates driver skids.

... It's the engineered design of the 16 planes that makes it easy to apply full turning power – without reaming.

... It's the "just-right" depth of recess that enables Phillips Screw Heads to take heaviest driving pressures.

With such precise engineering, is it any wonder that Phillips Screws speed driving as much as 50% – cut costs correspondingly?

To give workers a chance to do their best, give them faster, easier-driving Phillips Recessed Head Screws. Plan Phillips Screws into your product now.

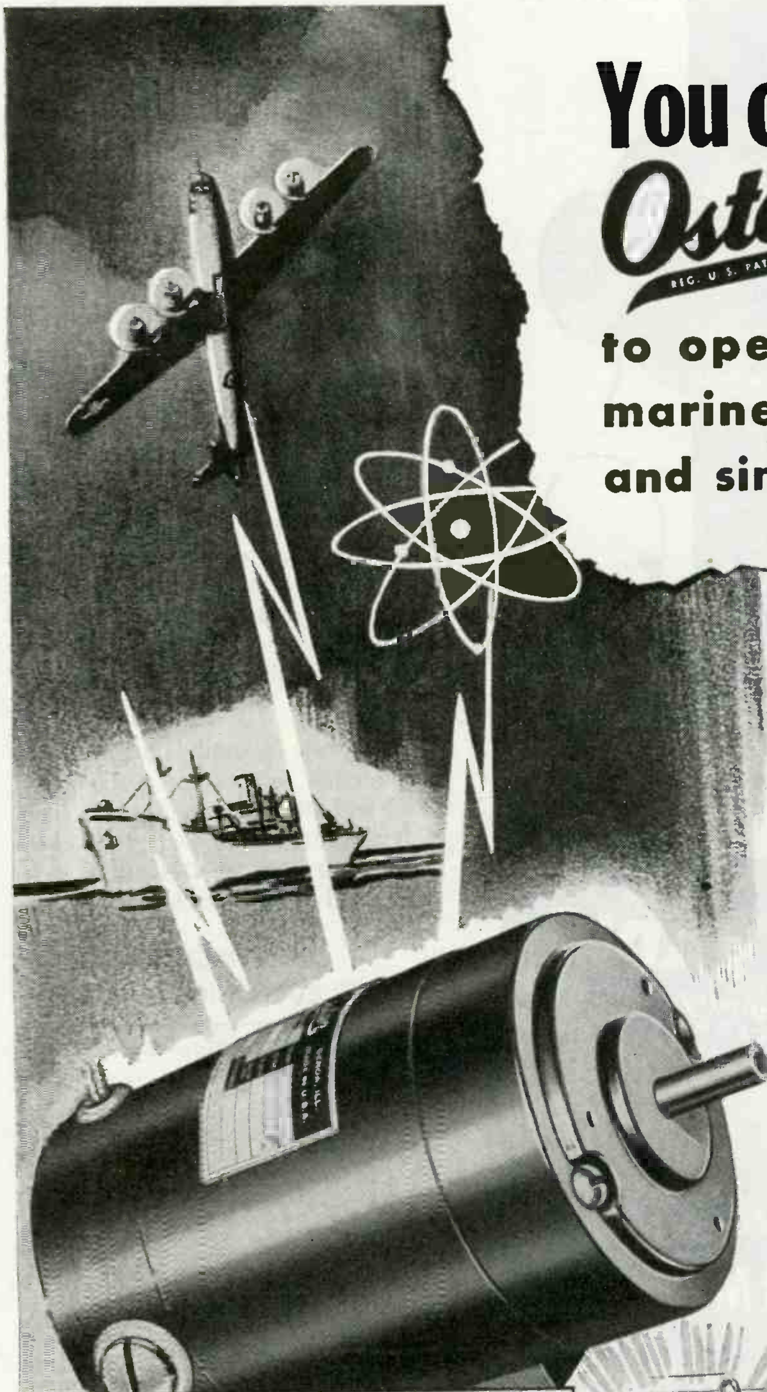
PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

Made in all sizes, types and head styles

25 SOURCES

American Screw Co., Providence, R. I.
Atlantic Screw Works, Hartford, Conn.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
General Screw Mfg. Co., Chicago, Ill.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
Manufacturers Screw Products, Chicago, Ill.
Milford Rivet and Machine Co., Milford, Conn.
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
The Steel Company of Canada Ltd., Hamilton, Canada
Wolverine Bolt Co., Detroit, Mich.



You can rely on this Oster Blower Motor

REG. U. S. PAT. OFF.

to operate dependably in marine, aircraft, electronic, and similar applications . . .

In planning your post-war product, it is well to remember the design and operating advantages of this Oster blower motor. Although it has been especially designed for use in the marine, aircraft, and electronic fields, it may have qualities that fit your particular product. Check these features:

Housing: Die cast, zinc field housing and aluminum end brackets. Totally enclosed.

Finish: Black baked enamel.

Weight: 5 lbs.

Bearings: Single shielded ball bearings lubricated with a grease suitable for any specific application. Bearing housings fitted with steel inserts.

Windings and Insulation: Field coils and armature wound with a select grade of insulated copper wire and impregnated with a high quality heat and moisture resisting insulating varnish.

Mounting: Available with either base mounting or machined pads.

Brushes: Metal graphite or electro. graphite brushes of ample size to assure unusually long brush life. Phosphor bronze or beryllium copper brush springs.

Temperature Rise: 55°C. maximum frame temperature rise at rated output.

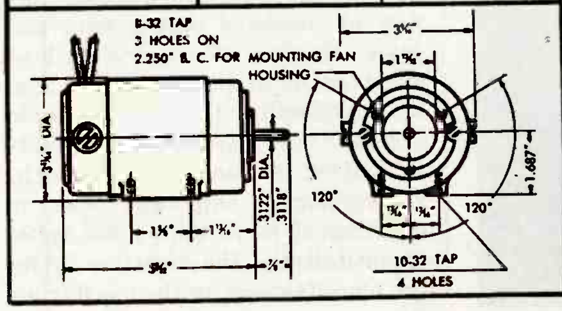
Modification: Motors can be furnished with special shaft extensions, mounting arrangements, finishes, leads, etc.

Let us help you fit this and other Oster Motors to your requirements.

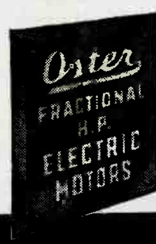
Buy WAR BONDS

PERFORMANCE WITH #3 L-R TURBO TYPE BLOWER

Type	F-9A-3	F-9-4S
Voltage	115 A.C. 60 CYC.	27 D.C.
Amps. Input	2.7	7
R.P.M.	6000	6000
Rotation	Clockwise Drive End	Clockwise Drive End
Starting Torque in % of F. L. Torque	200	300 — 400



You can recommend Oster Motors with full assurance that they will live up to the world-wide reputation of pre-war Oster appliances, Oster-powered.



M-24

John Oster Manufacturing Co.

DEPARTMENT L-24 • RACINE, WISCONSIN

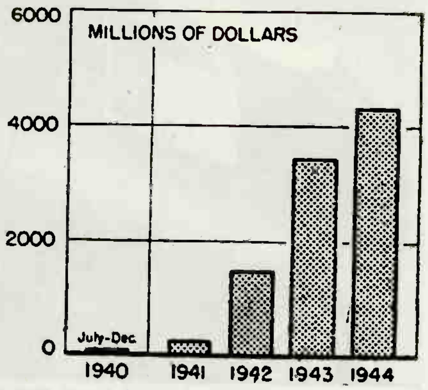
creased military requirements to be filled.

Shipments of forty critical types of receiving tubes are being frozen at the factories to allow specific authorization and direction by WPB. Forty-one other types were declared obsolete for the duration.

RECEIVER DESIGNATIONS. Several stipulations have recently been issued by FTC (Federal Trade Commission) under which radio companies have agreed to cease and desist from representing that any radio receiving set contains a designated number of tubes when any of the tubes do not perform recognized and customary functions in the detection, amplification, and reception of radio signals. Other stipulations have been issued relative to the cessation of price manipulation.

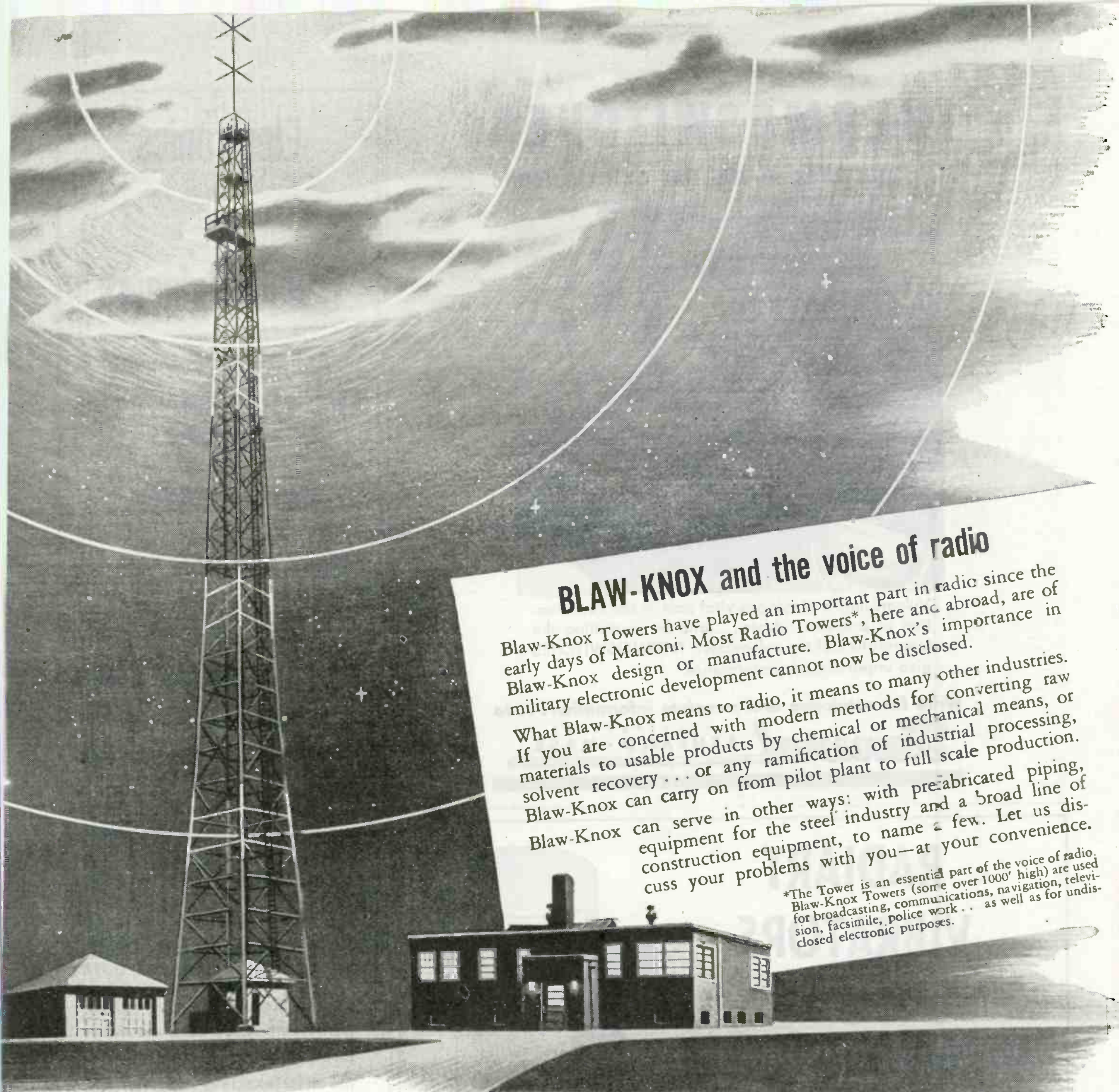
MUNITIONS PRODUCTION. Actual production figures for communication and electronic equipment from January to November, plus scheduled figures from December show the trend charted in the accompany-

COMMUNICATION AND ELECTRONIC EQUIPMENT



ing illustration. Total for 1944 equals $4,293 million. Schedule for January 1945 is $397 million.

LEAD-SHEATH WIRE. Limitations have been imposed by WPB on the amount of lead that may be used as a protective sheath in the manufacture of insulated copper wire and cable. Because of the present lead shortage, no producer may use lead as a protection for wire or cable unless it is for fire alarm and traffic control, telephone and telegraph, railway signal, shipboard cable, or a rating of more than 2,000 volts. Quantitatively, the directive limits the manufacturer to the use during



BLAW-KNOX and the voice of radio

Blaw-Knox Towers have played an important part in radio since the early days of Marconi. Most Radio Towers*, here and abroad, are of Blaw-Knox design or manufacture. Blaw-Knox's importance in military electronic development cannot now be disclosed.

What Blaw-Knox means to radio, it means to many other industries. If you are concerned with modern methods for converting raw materials to usable products by chemical or mechanical means, or solvent recovery . . . or any ramification of industrial processing, Blaw-Knox can carry on from pilot plant to full scale production.

Blaw-Knox can serve in other ways: with prefabricated piping, equipment for the steel industry and a broad line of construction equipment, to name a few. Let us discuss your problems with you—at your convenience.

*The Tower is an essential part of the voice of radio. Blaw-Knox Towers (some over 1000' high) are used for broadcasting, communications, navigation, television, facsimile, police work . . as well as for undisclosed electronic purposes.

BLAW-KNOX COMPANY

A PACEMAKER FOR AMERICAN INITIATIVE AND INGENUITY

2077 FARMERS BANK BLDG., PITTSBURGH, PA.

LEWIS FOUNDRY & MACHINE DIVISION, Rolls and Rolling Mill Machinery

POWER PIPING DIVISION, Prefabricated Piping Systems

COLUMBUS DIVISION, Ordnance Matériel

SPECIAL ORDNANCE DIVISION, Bofors Anti-Aircraft Gun Mounts and Mechanisms

BLAW-KNOX DIVISION, Chemical & Process Plants & Equipment, Construction Equipment, Steel Plant Equipment, Radio & Transmission Towers . . . General Industrial Products

PITTSBURGH ROLLS DIVISION, Rolls for Steel and Non-Ferrous Rolling Mills

UNION STEEL CASTINGS DIVISION, Steel and Alloy Castings

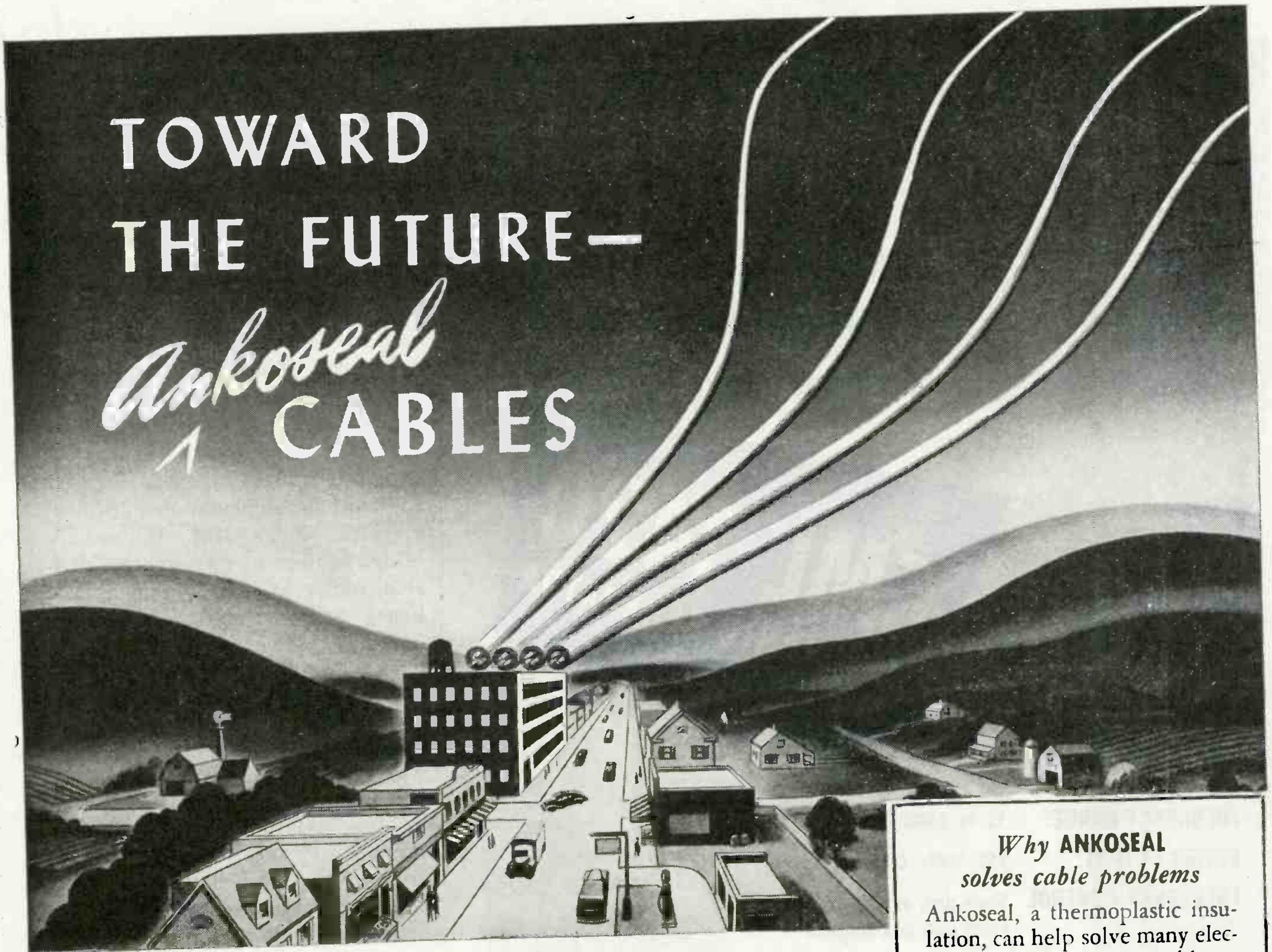
NATIONAL ALLOY STEEL DIVISION, Heat and Corrosion-Resistant Alloy Castings

MARTINS FERRY DIVISION, Bofors Anti-Aircraft Gun Mounts

BLAW-KNOX SPRINKLER DIVISION, Automatic Sprinklers and Deluge Systems

A FEW VICTORY PRODUCTS

ANTI-AIRCRAFT GUN MOUNTS · GUN SLIDES · LANDING BARGES · SYNTHETIC RUBBER PLANTS · PIPING FOR NAVAL VESSELS · POWDER PLANTS · ROCKETS · 16" PROJECTILES · CAST ARMOR FOR TANKS & NAVAL CONSTRUCTION · CHEMICAL PLANTS



Why ANKOSEAL *solves cable problems*

Ankoseal, a thermoplastic insulation, can help solve many electrical engineering problems, now and in the future. *Polyvinyl* Ankoseal possesses notable flame-retarding and oil resisting characteristics; is highly resistant to acids, alkalies, sunlight, moisture, and most solvents. Polyethylene Ankoseal is outstanding for its low dielectric loss in high-frequency transmission. Both have many uses, particularly in the radio and audio fields. Ankoseal cables are the result of extensive laboratory research at Ansonia—the same laboratories apply engineering technique in the solution of cable problems of all types.

COMMUNICATION-WITHOUT-WIRES—the keynote of the nation's ability to wage modern war—has brought in its train a great paradox: A need for *more and different cables*. And the same needs will extend into the post-war world.

In the solution of the current problems that this need has raised, we at Ansonia, in all modesty, have played no small part. Ankoseal polyvinyl and polyethylene cables have been designed to meet the particular needs of our Army and Navy — needs which, of course, must remain secret, but which involve using *engineering techniques* in the solution of the problems they present.

To other government agencies requiring "fussy" cable jobs, Ansonia offers the "Yankee ingenuity" which has enabled this organization to meet these requirements — accurately and on time. And to business men now and in the post-war world, Ansonia, through its Ankoseal thermoplastic cables, offers the same ability to meet similar problems to their satisfaction.

THE ANSONIA ELECTRICAL COMPANY

Specializing in "Ankoseal" a Thermoplastic Insulation

ANSONIA • CONNECTICUT

A Wholly-Owned Subsidiary of

NOMA ELECTRIC CORPORATION

GENERAL OFFICES • NEW YORK, N. Y.

—In peacetime makers of the famous Noma Lights—the greatest name in decorative lighting. Now, manufacturers of fixed mica dielectric capacitors and other radio, radar and electronic equipment.

March of only 9 percent of the amount of lead used during the calendar year 1944 in manufacturing these products. After April 1 he may use during any calendar quarter 25 percent of the lead used in 1944.

SIGNAL CORPS REORGANIZATION. Five new divisions have been established under the Engineering and Technical Service of the Signal Corps. They are: communication equipment development division under Col. Herbert G. Messer; electronic equipment development division, under Lt. Col. Carl S. Kleinau; development management division, under Maj. Willard A. Muir; equipment coordination division, under Lt. Col. Joseph A. Mahoney and maintenance division, under Maj. George M. Cooper.

FREQUENCY-STANDARD EXTENSION. An extension of service by the National Bureau of Standards results in transmission from station WWV of a 15 Mc signal at night as well as in the daytime. Otherwise unchanged, the services include standard radio frequencies, standard time intervals accurately synchronized with basic time signals, standard audio frequencies, and standard musical pitch—440 cps. Frequencies used are: 2.5, 5, 10 and 15 Mc which are now all continuous night and day except the first which is scheduled from 7 pm to 9 am EWT or 2300 to 1300 GMT.

BUSINESS NEWS

AMERICAN TELEPHONE AND TELEGRAPH CO. has announced its ability and eagerness to supply program transmission channels to meet the present and future requirements of f-m broadcasters.

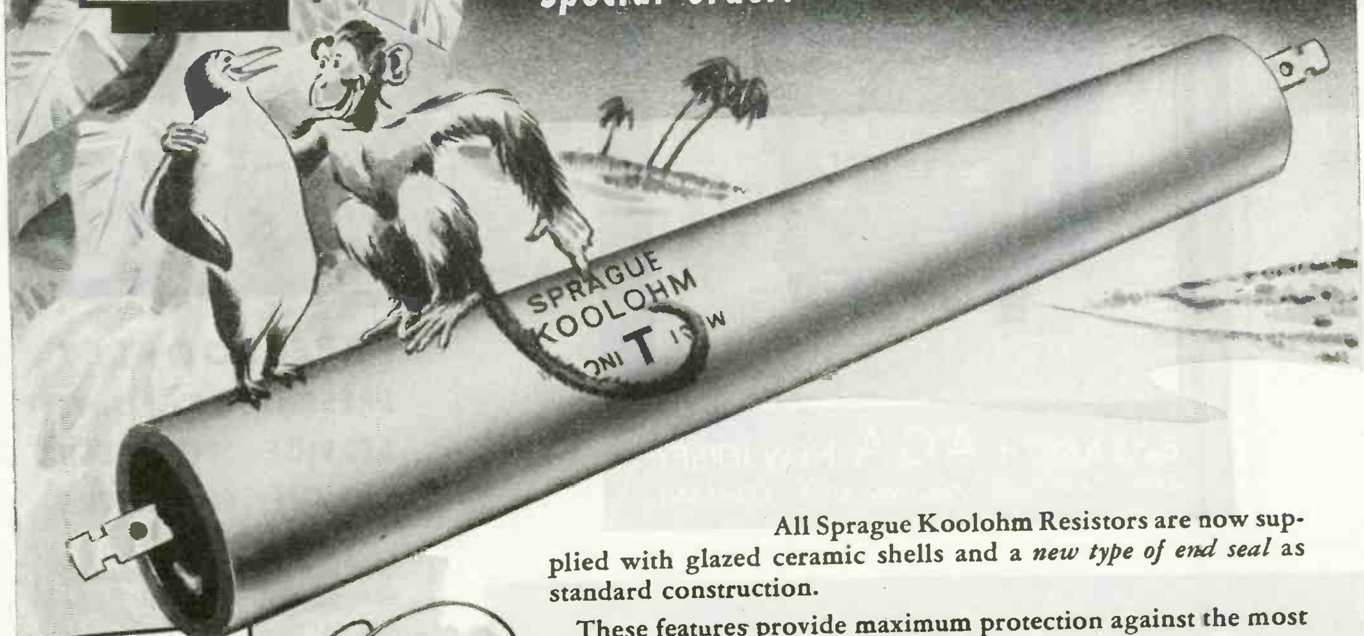
RESISTANCE WELDER MANUFACTURERS ASSOCIATION launches a program of cooperative education activity on the subject of resistance welding. Objective will be to encourage advances in design, welding technique, and fabricating procedure.

FISHER PIERCE CO. is a new concern established at 62 Ceylon St., Boston 21, Mass., to produce timers and related electronic equipment.

ASSOCIATED ELECTRONICS CORP., consulting engineers, have moved

T IS FOR "TROPICALIZED"

. . . . which means that STANDARD Sprague Koolohms now have the same EXTRA HUMIDITY PROTECTION formerly obtainable only on special order.



All Sprague Koolohm Resistors are now supplied with glazed ceramic shells and a *new type of end seal* as standard construction.

These features provide maximum protection against the most severe tropical humidity and corrosive conditions. Extensive tests in the laboratories of the armed forces and prime contractors have proven the ability of the "KT" construction to "take it" under the most brutal air thermal shock, humidity, and corrosive conditions.

Type "KT" Koolohms correspond to characteristic "J" of resistor specification JAN-R-26.

All previous catalog designations remain the same except for the addition of the letter "T" to the old type numbers to designate the new standard construction.

Thus "T" is for "Tropicalized"—and all Sprague Koolohms have it. One type of Koolohm, the *standard* type, does the job—under any climatic condition, anywhere in the world.

SPRAGUE ELECTRIC CO., Resistor Division, North Adams, Mass.
(Formerly Sprague Specialties Co.)

ARMY E NAVY

SPRAGUE
KOOLOHM RESISTORS

TRADEMARK REG. U. S. PAT. OFF.

AGASTAT

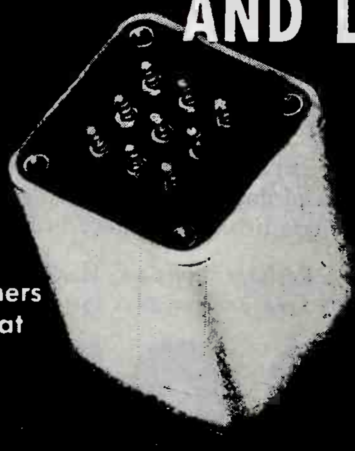
ELECTRO-PNEUMATIC RELAY

COMPACT:
4 IN HIGH
2½ IN DEEP
2½ IN WIDE
WEIGHT:
1½ POUNDS

ELIZABETH A·G·A NEW JERSEY
AMERICAN GAS ACCUMULATOR COMPANY

Quality

AND LOTS OF IT



★ Transformers for Combat

In Active Service Over the Entire Globe

DINION COIL COMPANY

CALEDONIA, N. Y.

NEW GUIDE TO PRECISION-MADE PLASTICS

By Sillcocks-Miller

FREE BOOKLET PRESENTS 4-POINT SERVICE TO HELP DESIGN ENGINEERS

How the facilities and experience of Sillcocks-Miller specialists can help you solve your problems in precision-fabricated plastics is told in a new illustrated booklet now available.

Designers and manufacturers in need of plastic parts and products made to extremely close tolerances will find the Sillcocks-Miller Company a most dependable source for design and development service and for highest quality production.

Whether you are now using plastics or want to learn why it will pay you to convert to plastics, you should have a copy of this helpful booklet. Write for it today — without obligation.

SILLCOCKS-MILLER CO.
Office & Factory
10 W. PARKER AVE., MAPLEWOOD, N. J.
Mailing Address, SOUTH ORANGE, N. J.

It Costs You Less to Pay a Little More for Sillcocks-Miller Quality

to new and larger quarters at 132 Nassau St., New York 7, N. Y. A new department is added for the compilation and editing of technical manuals.

MAJESTIC RECORDS INC. is a newly formed major subsidiary of the Majestic Radio and Television Corp., Chicago, Ill. Executive offices and recording studios of the new company will be at 29 West 57th St., Manhattan, while the production plant and general offices will be in Newark, N. J. President of the new record corporation is

James J. Walker, former mayor of New York City, shown in the illustration with Eugene A. Tracey, president of Majestic Radio and Eli Oberstein, executive vice-president of the New York operation.

ESPEY MFG. CO. announces that its plant is ready for conversion to television production in 72 hours from the time parts are available.

BELMONT RADIO CORP., Chicago, Ill., and Raytheon Mfg. Co., Newton, Mass., are negotiating a merger.

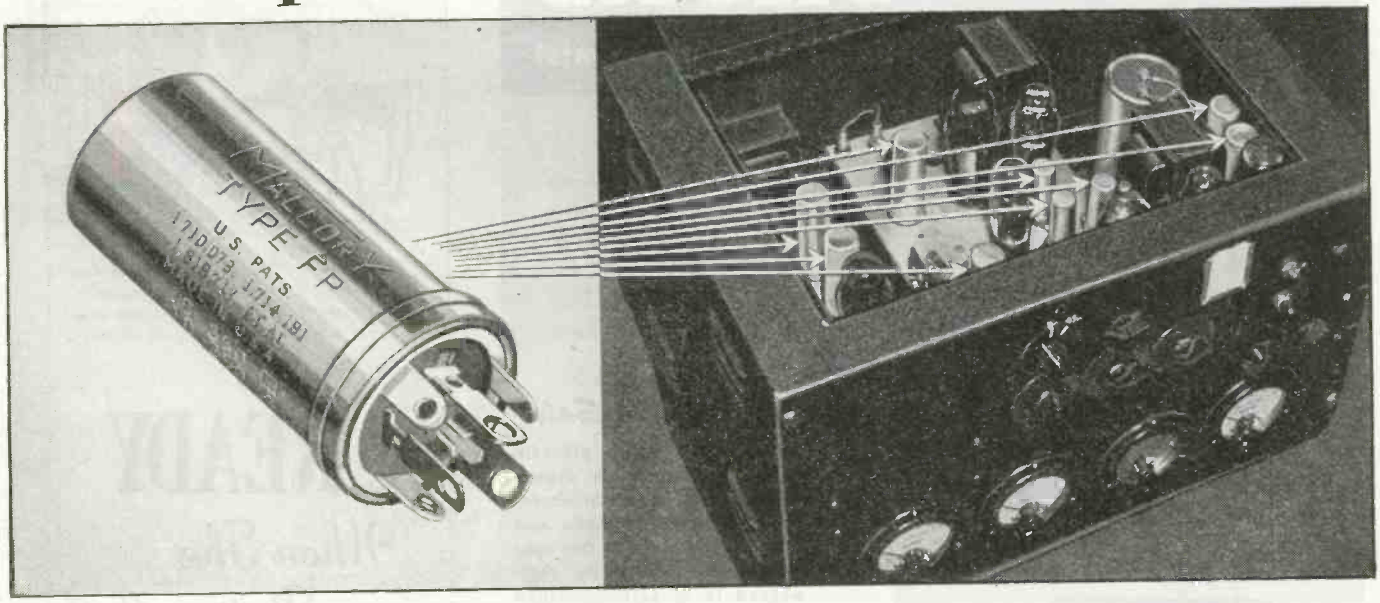
HYTRON CORP., Salem, Mass. proposes to double its working capital in anticipation of a greatly expanded postwar radio tube market.

WEBSTER-CHICAGO CORP., Chicago, Ill., has purchased Webster Products, also of Chicago. Facilities and personnel will be retained intact and will operate as the electronics division of the parent company.

WESTINGHOUSE ELECTRIC & MFG. Co. changes the name of its radio division to industrial electronics division, while its former radio receiver division becomes the home radio division.

BENDIX RADIO DIVISION of Bendix Aviation Corp. uses a specially

"Tops" for Top Mounting . . .



MALLORY "FP" CAPACITORS

WHEREVER you need dry electrolytics, Mallory "FP" Capacitors are your best choice. Top chassis mounting for ease and speed of assembly is merely one advantage. Check the list of "FP" features below against your own design and manufacturing problems.

Mallory research and engineering, coupled with precision manufacturing, have built exceptionally long life into "FP" Capacitors. They save chassis space, too, since they are the smallest capacitors available for any given electrical rating.

Mallory "FP's" have been specified for the best electronic equipment . . . radio and television receivers and transmitters, the newest electron microscope, and test and laboratory apparatus of the highest quality.

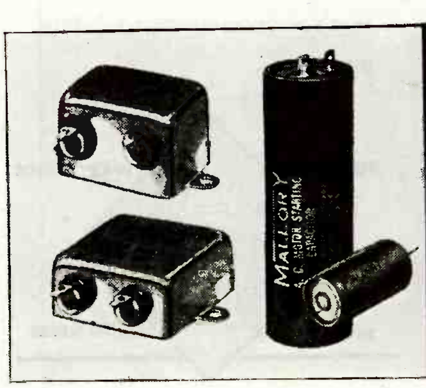
Mallory "FP" Capacitors are manufactured *uniformly* to precision standards. They are ideal when you want to maintain high precision in volume production.

Check this list of "FP" advantages, and send for the Mallory catalog—containing specifications on "FP's" and many other precision electronic parts. Get your free copy of the catalog from your nearest Mallory Distributor, or write us today.

Check List of "FP" Features

- Top chassis mounting for ease in assembly and servicing.
- "Twisted ear" mounting eliminates other hardware.
- Internal cartridge design provides minimum coupling.
- Identical type mounting for all rated capacities.
- Ratings from 3000 mfd. at 10 volts to 80 mfd. at 450 volts.
- Avoids engineering problems on special capacitors.

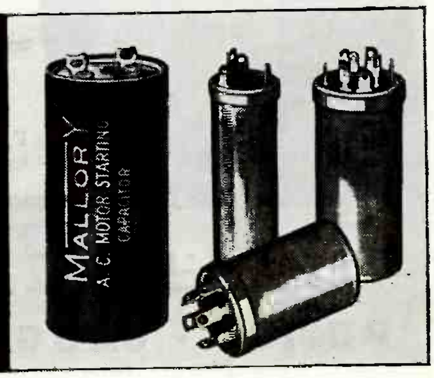
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA



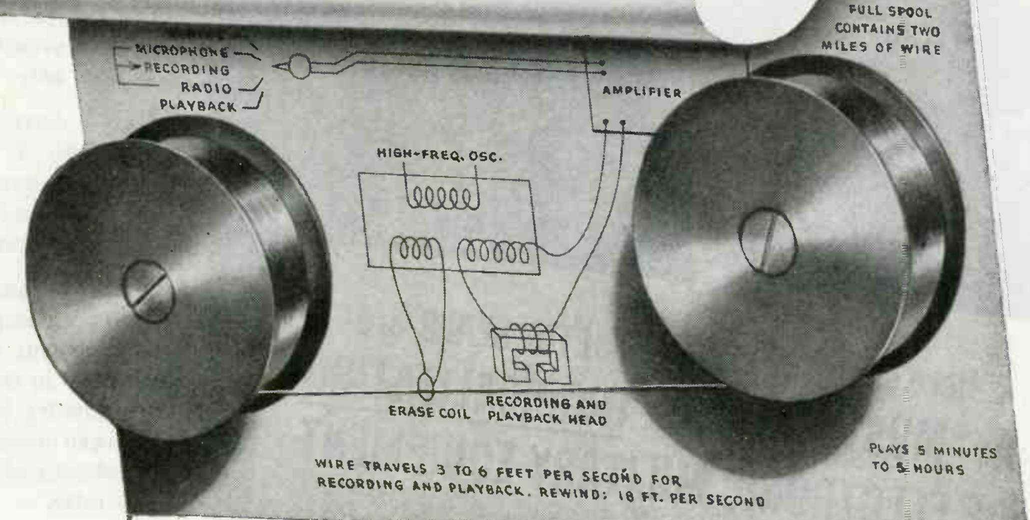
P. R. MALLORY & CO. Inc.

MALLORY

Electrolytic, Film and Paper CAPACITORS



NOW—WIRE SPEAKS!



A thin, swift wire shimmers across the poles of a magnet. Magically, it is sound-impressed with music snatched from the air — the voices of children — the words of a business conference.

In an instant — it is playing back every note, tone and inflection. Clear. True. Faithful. Prompt as an echo — lasting as the metal of the wire itself.

What is it? Lear Wire Recording. Modern recording — brought to practical usefulness in Lear laboratories.

No longer the scratch and hiss of needle-on-record. No longer the mess and fuss of shaving dictating-machine cylinders. No longer reliance on fallible memory or scribbled notes for the precise statements at meetings or conventions, or the actual words of individual conversations.

Instead — office machines will record instructions, take dictation, listen in on important meetings. And at home your radio will catch and hold hours of entertainment from favorite programs.

You can record, reproduce or erase at will — you can re-use any reel any time.

Interesting? The possibilities are endless. Of course you'll want to know more! So send the coupon — or write Lear, Incorporated — for the fascinating booklet that explains and explores Lear Wire Recording — and its meaning to you.

LEAR RADIO

RADIO DIVISION: GRAND RAPIDS 2, MICHIGAN
Home Radio Sales: 230 E. Ohio St., Chicago 11, Illinois

Lear INCORPORATED

See what Lear dealers are going to have to offer. Fine radios plus the Lear Wire Recorder — the newest contribution to complete home entertainment.

This advertisement sets the stage. It tells the millions of people waiting for new radios that a new thrill will come with Lear Home Radios. They'll be anticipating the Lear Wire Recorder.

If you would like to be able to offer these radios to your customers, write for information on the Lear Franchise.

Want more information on Wire Recording?

LEAR, Incorporated
Home Radio Sales Division, 230 East Ohio Street, Chicago 11, Illinois.

Gentlemen:
Please send me your free booklet on Wire Recording offered in Lear national magazine advertising.

Firm Name ____________________

Individual ____________________

Address ____________________

equipped Lockheed Lodestar for daily tests of performance and airworthiness of its products. Time required for test has been cut by more than 50 percent.

HALLICRAFTERS CO., Chicago, Ill., removes its foreign division to new quarters at 1791 Howard St. as a step in greatly enlarged export activities after the war.

HARCO STEEL CONSTRUCTION CO., Elizabeth 4, N. J., has available motion picture films demonstrating the high speed erection of radio and other structural masts and towers.

AEROVOX CORP., New Bedford, Mass., changes hands and a new management takes over. No other company in the capacitor or electrical industry is involved, stock having been purchased for the private investment of W. Myron Owen and associates.

COLUMBIA MACHINE WORKS, Brooklyn, N. Y., principally active in Naval electronics, is acquired by Maguire Industries—former Auto-Ordnance Corp., New York, N. Y.

NEW YORK UNIVERSITY announces new evening graduate courses in powder metallurgy in the graduate division of its College of Engineering.

BROWN INSTRUMENT CO., Philadelphia, Pa., adds to the curriculum of its school of instrumentation free courses in electronic strip chart and humidity control instruments.

COLLINS RADIO CO., Cedar Rapids, Iowa, has acquired its own test airplane and is planning the construction of suitable hangar and laboratory facilities for research and development on airborne communication and navigation equipment.

ARMOUR RESEARCH FOUNDATION adds five new names to the roster of wire-recorder licensees. New participants include E. H. Scott Radio Laboratories, Chicago, Ill.; J. P. Seeburg Corp., Chicago, Ill.; Lewyt Corp., Brooklyn, N. Y.; Radiotechnic Laboratory, Evanston, Ill.; and Boosey & Hawkes Ltd., London, England.

POLYTECHNIC INSTITUTE of Brooklyn has organized a separate division for polymer chemistry under the direction of Dr. Herman F.

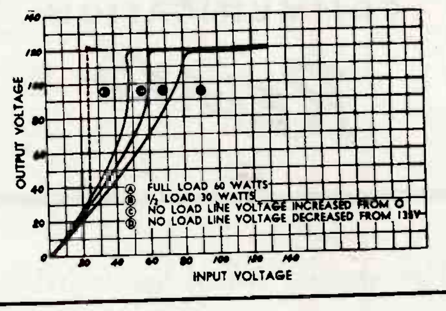
RAYTHEON VOLTAGE STABILIZERS
Provide Stabilized Voltage ±½% WITHIN 2 CYCLES

All precision as well as other types of electrical equipment requires steady, uniform voltage for accurate operation. Raytheon Voltage Stabilizers meet this need by providing accurately controlled voltage to ±½% of 1%.

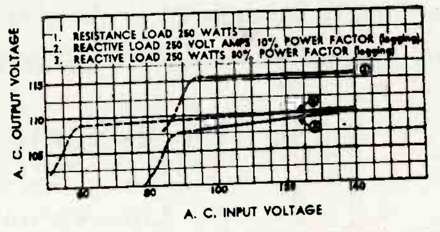
Entirely automatic in operation, the Raytheon Voltage Stabilizer requires no maintenance, no adjustments. Simply incorporate it into new products or equipment already in use and it will take care of itself providing uniformly stabilized voltage.

Raytheon Voltage Stabilizers provide these advantages: Stabilize voltage at any load within their ratings . . . Hold constant varying AC input voltage to ±½ of 1% — within 2 cycles . . . Control wide AC input variation — 95 to 130 volts. Write for Bulletin DL48-537. It gives the complete story.

INPUT VS. OUTPUT VOLTAGE
(Type VR 2)



OUTPUT VS. INPUT VOLTAGE
(Type VR 4)



Tune in the Raytheon radio program: "MEET YOUR NAVY," every Saturday night on the Blue Network. Consult your local newspaper for time and station

RAYTHEON
MANUFACTURING COMPANY
Electrical Equipment Division
190 WILLOW STREET, WALTHAM, MASS.

The coveted Army-Navy "E," for Excellence in the manufacture of war equipment and tubes, flies over all four Raytheon Plants where over 16,000 men and women are producing for VICTORY.

Devoted to research and manufacture of complete electronic equipment; receiving, transmitting and hearing aid tubes; transformers; and voltage stabilizers.

Marks. The division's research program involves modern techniques including x-rays and radio-active isotopes.

WINCHARGER CORP., Sioux City, Iowa, has acquired the Benjamin patent No. 1,841,593 for automatic phonograph record changers.

WESTINGHOUSE ELECTRIC & MFG. Co. has conducted a round-robin meeting presenting electronics to company engineers in plants at Baltimore, Bloomfield, and East Pittsburgh.

UNIVERSITY OF CALIFORNIA is sponsoring a no-fee electronic training course for members of the International Brotherhood of Electrical Workers. Headed by James L. Brown of General Electric Co. as instructor, the course is held at Los Angeles, Calif. Another class operated by the Union is designed to prepare members for FCC license examinations.

RCA VICTOR CO. OF CANADA, LTD. supplied ten radio transmitters to the Chungking government for use by the AVG Flying Tigers. This equipment is credited with having carried the burden of American airforce ground communications on that Asiatic battlefront from 1941 until now.

YORK RESEARCH CORP., New York, N. Y., forms a new electronics laboratory at 63 Park Row, New York. Facilities are headed by J. Knox Tillotson.

PERSONNEL

RALPH A. HACKBUSCH, vice president, Stromberg-Carlson Co., To-

ronto, is elected vice president of the newly organized Canadian Radio Technical Planning Board.

E. F. PHILIBSEN has been appointed chief engineer and production manager of Sorensen & Company, Stamford, Conn., manufacturer of airborne and other types of electronic equipment. He was at one time a member of Montgomery Ward's engineering staff, has recently re-

Rubber Insulation for weapons

Engineering rubber mountings for military purposes continues to be a full-time job for United States Rubber Company specialists in that field.

In the race to develop new and more accurate weapons, eliminating disturbing vibration becomes increasingly complex. Electronic instruments in planes, tanks and surface craft, as an example, must be insulated far more perfectly than ever before.

U. S. Rubber scientists, working closely with military experts and manufacturers of war materiel, are helping to win this fight against vibration and shock. Such effort—rightfully given priority until victory is assured—means that service to manufacturers of non-military goods has had to be sharply curtailed.

But the knowledge being gained in the adaptability of rubber compounds and the precision-engineering of rubber mountings is invaluable.

We are eager to cooperate with you on problems of vibration-insulation. But if we must postpone the date, we are sure you will understand.

SERVING THROUGH SCIENCE
WITH ENGINEERED RUBBER MOUNTINGS

Listen to "Science Looks Forward"—new series of talks by the great scientists of America—on the Philharmonic-Symphony program. CBS network, Sunday afternoons, 3:00 to 4:30 E.W.T.

UNITED STATES RUBBER COMPANY

1230 SIXTH AVENUE • ROCKEFELLER CENTER • NEW YORK 20, N.Y. • *In Canada:* DOMINION RUBBER CO., LTD.

One OF THE PRODUCTS *Jelliff* MAKES *is fine* RESISTANCE WIRE

Carefully-controlled annealing is part of the manufacture of all Jelliff resistance wire

not plain steel, copper, or magnet wire—but special resistance wire as fine as .0008 in. dia., drawn by special Jelliff methods to insure uniformity and top quality

ALLOYS FOR EVERY PURPOSE

ALLOY "A"—Nickel-chromium; non-magnetic; spec. resistance 650 ohms/CMF.

ALLOY "C"—High resistance to oxidation and corrosion; for electronics and industrial equipment.

ALLOY "D"—Nominally 30% nickel, 15% chromium, balance iron. Specific resistance 600 ohms/CMF.

ALLOY "45"—Copper-nickel for winding precision resistors. Constant resistance over wide range of temperatures.

KANTHAL—Unavailable for duration; we will be pleased to supply data for your post-war requirements.

OTHER *Jelliff* PRODUCTS

WIRE MESH CLOTH: Woven in a wide variety of styles, sizes, metals and alloys.

DIPPING BASKETS: Sturdy, heavy-duty construction to meet all dipping-basket requirements. Engineering service on proper selection of metals and alloys.

FABRICATED PARTS: Strainers, filters and other parts fabricated from wire mesh. Complete operations from drawing and weaving to fabricating and assembly done in a Jelliff plant.

Write for our "Wire Data Book"

The C. O. Jelliff Mfg. Corp.

123 Pequot Road • Southport, Conn.

WIRE PRODUCTS Jelliff SINCE - 1880

BLOWERS for Electronic Equipment

Easy-to-install . . . compact . . . quiet-running . . . economical . . . these are the features which make Pilot Blowers ideal for the important job of air circulation and ventilation in Radio Equipment. Available in standard models to move from 15 to 100 C.F.M. Write for Bulletin 507.

FASCO

SHADED POLE F. H. P. MOTORS

Tell us what your requirements are and we will send you "fact sheets" giving complete specifications on these dependable, efficient, low-cost Motors. For continuous or intermittent duty with H.P. ratings ranging from 1/15 to 1/500 H.P. and from 1550 to 3400 R.P.M. Plain round or with base or resilient mounting . . . open or enclosed cases.

F. A. SMITH MFG. CO., INC.
801 DAVIS ST., ROCHESTER 2, N.Y.

SHADED POLE MOTORS **Pilot** CENTRIFUGAL BLOWERS

High-Voltage CONTROLS

★ The ingenious Clarostat Series 60 Hi-Voltage Coupler provides either 3,000 or 10,000 volts breakdown insulation between the control proper and its shaft and mounting.

This coupler is available with Clarostat Midget Controls Series 37 (composition-element) and Series 43 (wire-wound). Also with the large Series 58 wire-wound controls. Likewise with Clarostat multiple controls.

Especially desirable for controls used in high-voltage circuits such as television equipment, cathode-ray oscillographs, and many electronic applications.

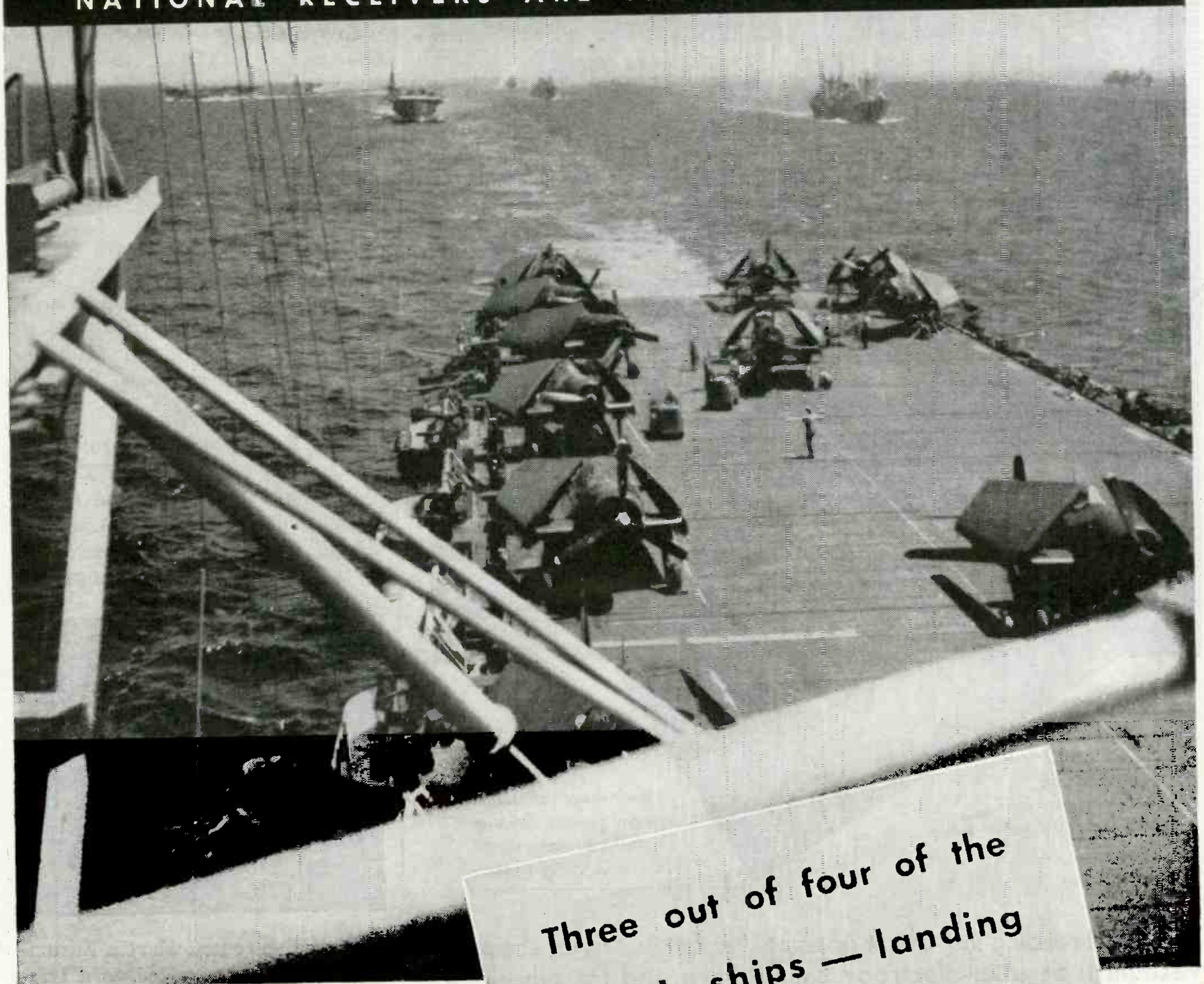
Neat. Unit mounts as readily as usual control. And SAFE where high voltages are involved.

★Write for DATA . . .

CLAROSTAT *Controls and Resistors*

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N.Y.

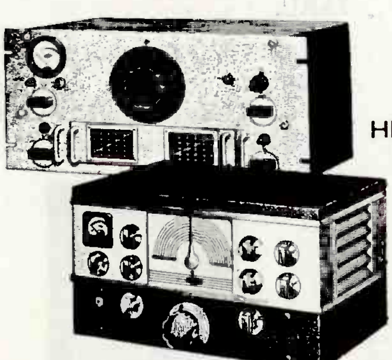
NATIONAL RECEIVERS ARE THE EARS OF THE FLEET



OFFICIAL U. S. NAVY PHOTOGRAPH

Three out of four of the Navy's ships — landing craft or larger — are equipped with receivers designed by National.

The photograph above was taken from the deck of the USS Tulagi, participating in the August, 1944, invasion of France. Modern amphibious operations require superb radio communications.



HRO

NC-200

NATIONAL COMPANY

MALDEN MASS, U. S. A.

NATIONAL RECEIVERS ARE IN SERVICE THROUGHOUT THE WORLD

turned from the Aleutians, where he worked for the Alaskan Communication Service on a Civil Service basis.

H. A. WINNE, vice president, becomes manager of engineering of the apparatus department of General Electric Co., Schenectady, N. Y.

WILSON A. CHARBONNEAUX leaves Burlington Instrument Co., where he was chief engineer and general manager, to take the post of manager and chief engineer at Automatic Control Engineers, Burlington, Iowa.

DR. E. F. W. ALEXANDERSON, consulting engineer, General Electric Co., is presented with the Cedergren Gold Medal of the American Society of Swedish Engineers, New York, N. Y. The award, made by

the Swedish consul, Martin Kastengren, was characterized as a tribute not only to a scientist but to a creator of good will and closer contacts between two democratic nations.

GEORGE W. BAILEY is elected executive secretary of IRE. Presently chief of the scientific personnel office of OSRD, he will continue in that activity for the duration. He is also president of ARRL and of IARU.

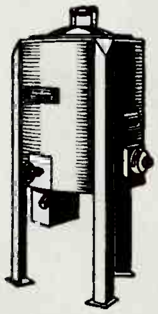
BENNETT S. ELLEFSON becomes assistant to the vice president in charge of engineering at Sylvania Electric Products, Inc., Bayside,

WHAT IS THE STA-WARM METHOD?

1. It is co-operative engineering service to determine the correct heating, melting, conveying or dispensing equipment needed to handle the kind of compound you specify in the volume and manner your job requires.

2. It is a high standard of design for the heating tank, kettle or pot which the engineering survey shows is needed. It includes efficient design that assures the essential element of low heat concentration to avoid possibility of carbonizing or burning the compound regardless of the size or shape of the heater or material to be employed.

3. It is the dependable, uniform construction of the heater which must pass rigid laboratory tests before approval and shipment.

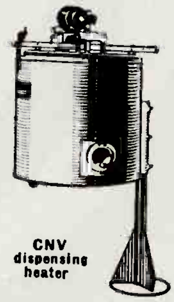


WV melting tank

This is the Sta-Warm method.

By this method you are assured of heating equipment that is tailored to fit your job, rather than tailoring your job to the equipment. What more basically sound method could you ask for in choosing compound or soft metal heating and melting equipment?

When you think of heated compounds, think of Sta-Warm equipment for heating them. Inquire today for bulletin 038W

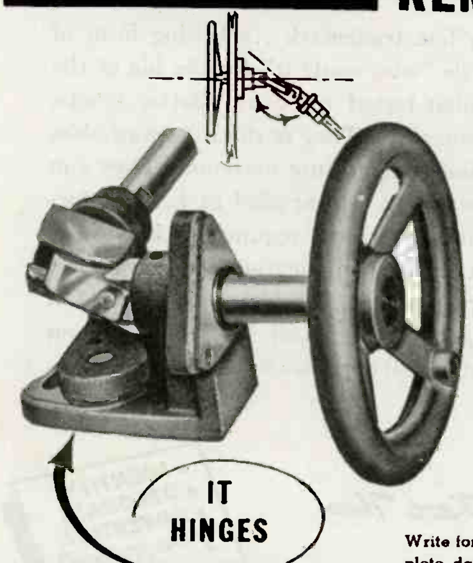


CNV dispensing heater

STA-WARM ELECTRIC CO.
1000 N. CHESTNUT ST. • RAVENNA, OHIO

Piezo
TRADE MARK

HINGED UNIVERSAL LINK JOINT—Type H
for the simplification of
REMOTE CONTROLS



The type "H" hinged Universal Link Joint with solid shafting has three distinct advantages for remote controls. (1) Simplicity of installation (the Universal Link Joint hinges from 0 to 90°). (2) A minimum of backlash. (3) Output shaft turns in exact angular rotation with the input shaft.

This method is particularly recommended for panel operation of dial and rheostat controls, switches, variable condensers, variable transformers, coils, remote operating rods and other mechanical adjustments.

Write for Bulletin 45B for complete data and specifications.

PIEZOELECTRIC CORPORATION
110 EAST 42nd ST., NEW YORK 17, N. Y.

VICTORY* *will mold Plastics for you...*

***after* VICTORY**

We'll be ready to do a better molding job for you . . . when we've finished supplying the needs of many prime contractors to the Armed Forces.

Molding plastics for War still demands most of our time and equipment . . . it's VICTORY'S* bit toward complete Victory . . . but it's also paving the way for *better-molded* products for you in the days of Peace.

Wartime lessons in precision molding have sharpened the wits of our engineering staff. Solving tough problems has broadened our knowledge of handling a great variety of thermo-plastics. Our workers are better craftsmen because they have learned the importance of *extreme* accuracy.

Whatever plastic product you're planning to use, consult with our engineers at once. On certain contracts we may be able to begin molding *right now.*

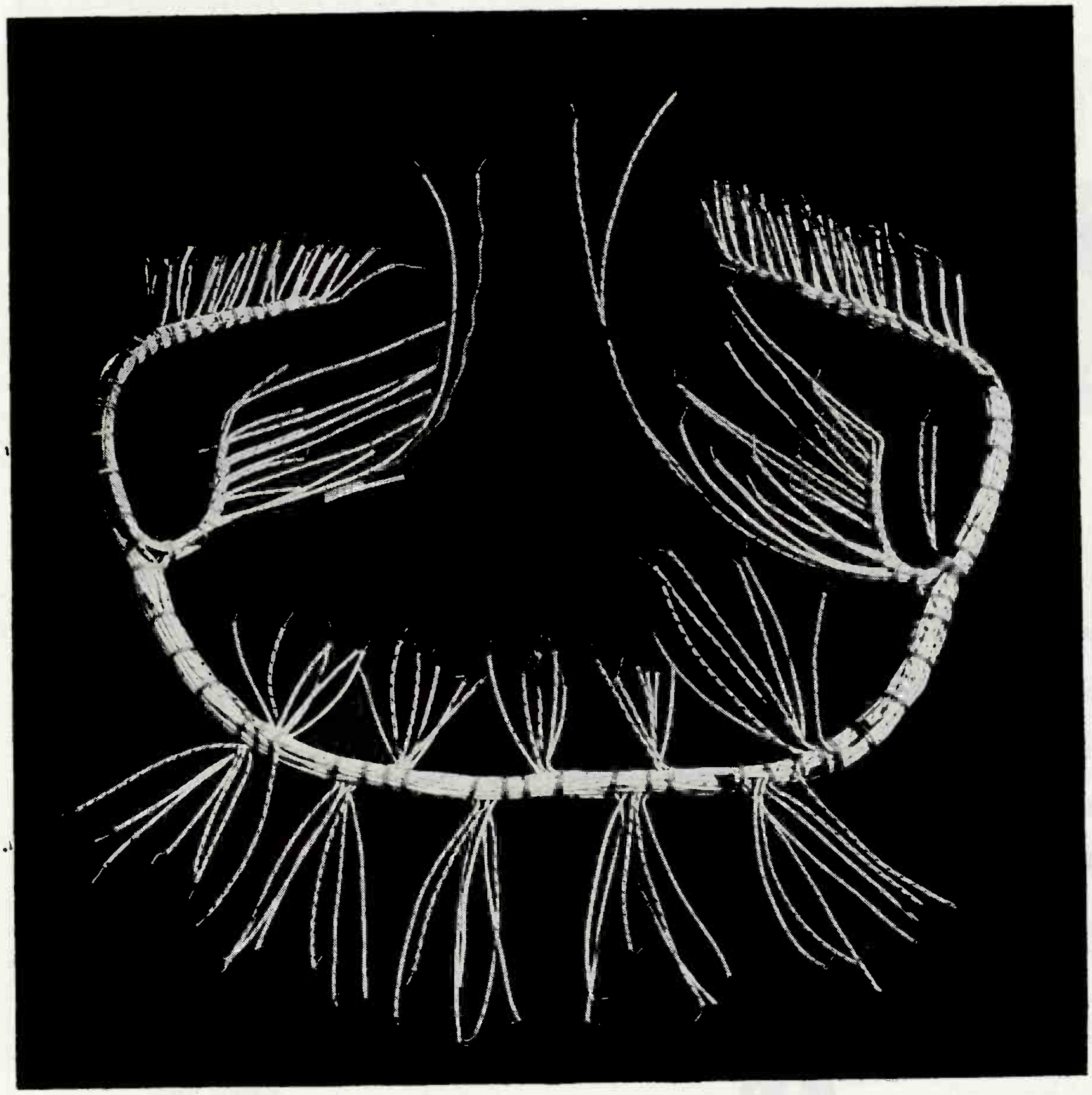
Member: Society of the Plastics Industry

Automatic Injection Molding
Small and large parts
UP TO 17-OZ. SHOTS
Lumarith, Tenite, Fibestos, Plastacele, Crystallite, Lucite, Ethyl Cellulose, Polystrene, Lustron, Styron, Cellulose Acetate and others . . . all molded to your exacting specifications.

***VICTORY MANUFACTURING COMPANY**
1724 W. Arcade Place, Chicago 12, Ill.
ESTABLISHED 1930

A HEAVY WIRING HARNESS

by a Wire Manufacturer



helps solve your manpower problem

Use Lenz Laced Wiring Harnesses, constructed of approved types of color coded insulation to speed up your assembly operations, and release *manpower* for other work on the assembly line.

The Lenz organization, manufacturers of radio and instrument hookup, has the experienced personnel that can produce these harnesses with meticulous care and regard for precision, to meet your exact specifications.

Quotations will be gladly furnished on receipt of sketch and specifications.

LENZ

IN BUSINESS SINCE 1904

LENZ ELECTRIC MANUFACTURING CO.

1751 North Western Avenue • Chicago 47, Illinois

L. I. He has been connected with the company since 1937.

VIRGIL M. GRAHAM of the RMA Engineering Department is alternate representative of the association on the governing council of ASA.

L. C. F. HORLE, manager of the RMA Data Bureau, has been designated to represent the association on the governing council of ASA.

HOWARD J. BECK is made chief engineer in the broadcasting division of Farnsworth Television & Radio

Corp., including radio station WGL. Mr. Beck was formerly chief inspector at the company's Fort Wayne, Ind., plant.

RAY C. ELLIS, formerly director of the WPB radio and radar division has been lent by General Motors Corp. to Johns Hopkins applied physics laboratory, Silver Spring, Md.

AWARDS

Workers of the following concerns in the electronic field have been awarded Army-Navy E burgees for excellence in production:

Andrea Radio Corp.
Long Island City, N. Y.

Bendix Aviation Corp.,
Pacific Div.
North Hollywood, Calif.

Freed Radio Corp.
New York, N. Y.

Harvey-Wells Electronics Inc.
Southbridge, Mass.

Muter Co.
Chicago, Ill.

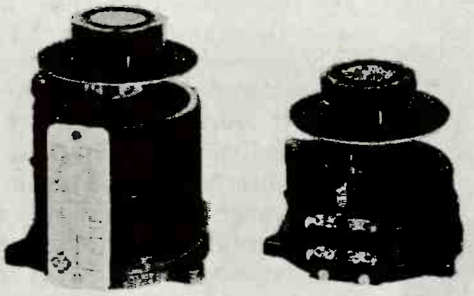
Pacific Sound Equipment Co.
Hollywood, Calif.

Regal Electronics Corp.
New York, N. Y.

Sperry Gyroscope Co.
Brooklyn, N. Y.

United States Instrument Corp.
East Orange, N. J.

A NEW VARIAC FOR 400 TO 2600 CYCLES



200-CU
60 ~

NEW 60-AU
400-2600 ~

SAME POWER RATING

DESIGNED for an increasing number of applications requiring the control of power at frequencies higher than 60 cycles, this new VARIAC meets the need for a unit for frequencies between 400 and 2600 cycles. It is a companion to the widely used Type 200-C having substantially the same power rating . . . 860 va; with a load current of 5 amperes, rated, and a maximum current of 7.5 amperes near zero and line voltages.

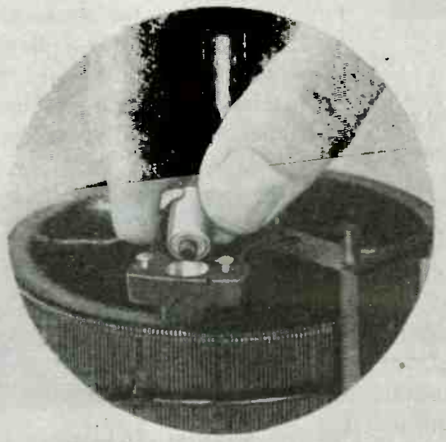
A number of new mechanical features are incorporated in the Type 60-A VARIAC. Included are:

- New unit brush construction requiring no tools for brush replacement and designed to prevent contact between brush holder and winding when the brush wears away.
- Positive rotor contact with NO pigtail
- Combination screw and solder terminals
- Fully insulated hollow steel shaft
- Improved bearings, suitable for motor drive.

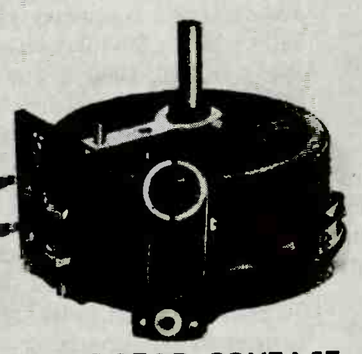
As seen in the photograph, the Type 60-A VARIAC is considerably smaller than its 60-cycle counterpart. The Type 60-AU is priced at $13.00 and the 60-AM at $15.00.

Because all VARIAC production is scheduled months in advance on high priority war orders for 60-cycle models, these new VARIACS are now available only in sample quantities.

- **WRITE FOR BULLETIN 920**

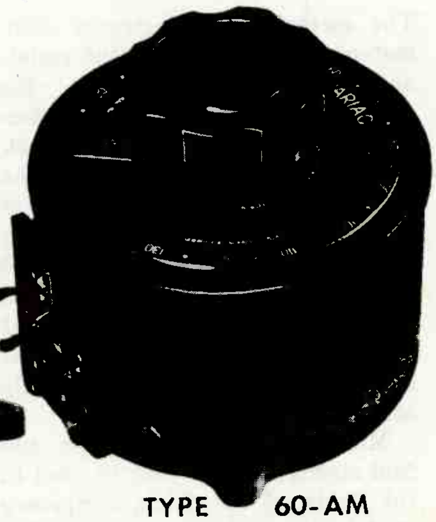


UNIT BRUSH — REPLACED IN A FEW SECONDS



POSITIVE ROTOR CONTACT WITH NO PIGTAILS

TYPE 60-AU



TYPE 60-AM

VARIAC

MADE ONLY BY

GENERAL RADIO COMPANY

Cambridge 39, Mass.
NEW YORK
CHICAGO
LOS ANGELES

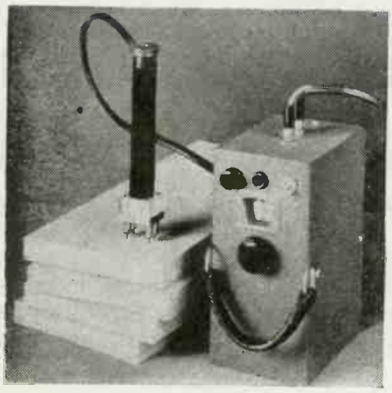
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Measuring Devices

DATA IS NOW available on several types of measuring instruments manufactured by Measurements Corporation of Boonton, N. J.

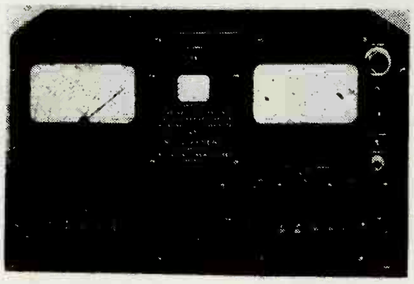
The first instrument is Model 5M moisture detector which is equipped with a Model 4E electrode, and which measures the moisture content of wood and wooden products from 8 to 24 percent of dry weight.



5M4E moisture detector

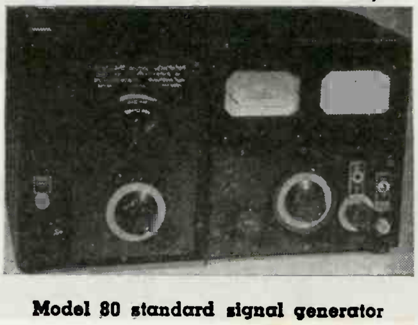
The meter is an electronic ohmmeter which operates on the resistance principle. To measure the moisture content, the four-pin electrode is hammered into the object. An indicator lamp flashes when the dial is turned to moisture content of wood. Power for operation is supplied by self-contained A and B batteries. An adjustment knob is used to compensate for change of battery voltage. Selection of wet stock from dry stock is quickly accomplished.

Model 58 u-h-f radio noise and field strength meter may be used in the fields of television, frequency modulation, diathermy interference, ignition noise measurements, facsimile on any u-h-f carrier within the range of the instrument in amplitude modulation or facsimile. Specifications of the meter are: 15 to 150 Mc in five bands (dial is directly calibrated in megacycles); 1 to 100,000 microvolts measured across a 70-ohm line; 1 to 100 microvolts on a semi-logarithmic output scale; balanced resistance attenuator with ratios of 10, 100, and 1000 ahead of all tubes; accurate gain standardization from internal shot-noise diode; a special calibration dial which eliminates need for charts; a tuned r-f amplifier eliminates image response (all circuits are accurately tracked); provision for direct operation of a 5-milliamp recorder; push-button switching throughout for rapid operation; and a built-in regulated dual power supply for operation from either 115-v ac or 6-v dc.



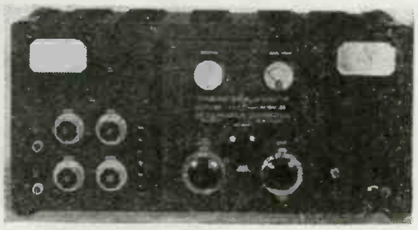
Model 58 uhf meter

Three standard signal generators include Model 65-B Laboratory Standard, Model 80 and Model 84 u-h-f instrument. Model 65-B utilizes a transmission line output system for eliminating lead resonance errors. Frequency range of this instrument is rated 75 kc to 30 Mc in 6 push-botton selected ranges. Output voltage is continuously variable from 0.1 microvolt to 2.2 volts. Output impedance is 5 ohms at 0.2 volts, rising to 15 ohms at 2.2 volts.



Model 80 standard signal generator

Tenative specifications of Model 80 standard signal generator are: Carrier frequency range 2 to 400 Mc; individually calibrated dial with 6 overlapping bands; an automatic range indicator which eliminates errors in the selection of correct frequency scale; output is continuously variable from 0.0 to 100,000 microvolts; Output impedance is fixed at 50 ohms; amplitude modulation is provided from 400 or 1,000 cycles or for external audio modulation; a video modulation jack is provided for connecting an external pulse generator directly to the oscillator plate circuit. Pulses of 1 microsecond can be obtained at higher carrier frequencies.



Model 84 uhf generator

Tentative specifications of Model 84 u-h-f standard signal generator are: Carrier frequency range, 300-1000 Mc. Modulation—for am, choice of 400, 1000 or 2500 cycle internal and external up to 30 kc. Percent modulation is directly indicated up to 30 percent; pulse repetition rate is continuously variable, from 50 to 100,000 cps in three ranges; pulse width is continuously variable and calibrated from 1 to 50 microseconds; pulse delay (with respect to synchronizing output) is continuously variable and calibrated from 0 to 50 microseconds.

Portable Electric Megaphone

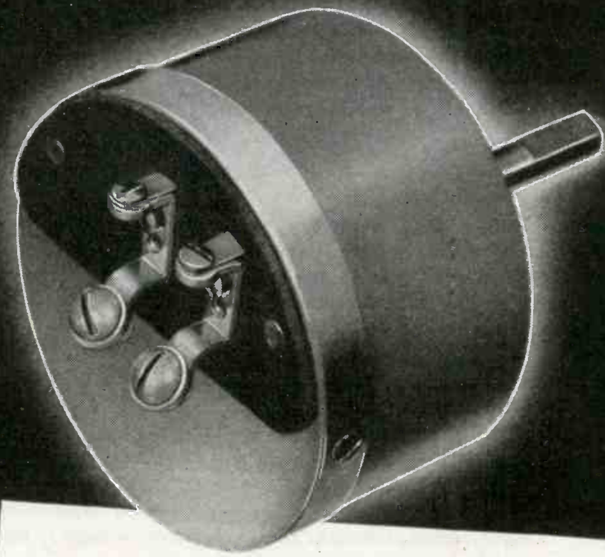
APPROVED BY THE Merchant Marine Inspection and U. S. Coast Guard, Model 100 Type M megaphone makes communications over a great distance possible by the use of electronic amplification. The megaphone consists of two units: a com-

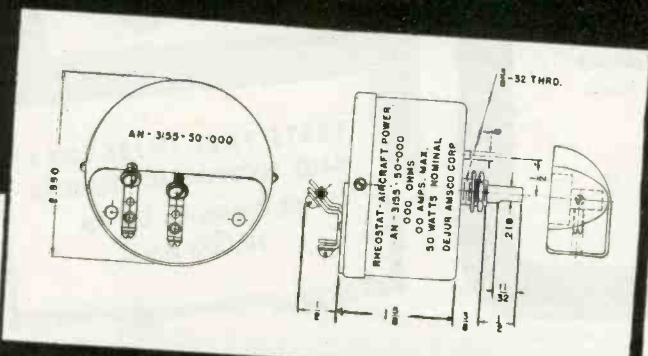
Still Another DeJUR Achievement

Completely Enclosed
ARMY-NAVY
Rheostat-Potentiometer

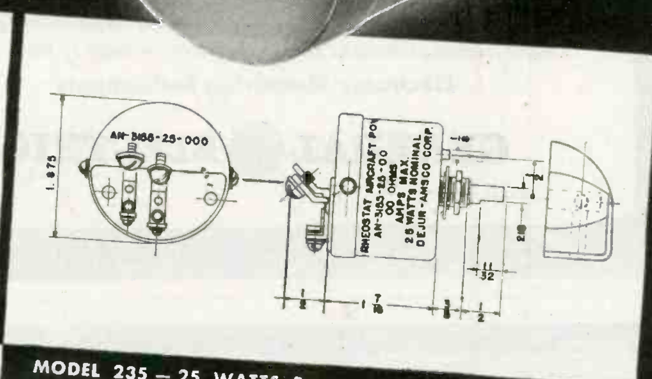
DESIGNED TO CONFORM TO SPECIFICATIONS

JAN. R-22





MODEL 231—50 WATTS, Ranges from ¼ to 10,000 OHMS



MODEL 235 — 25 WATTS, Ranges from 2 to 5000 OHMS

These two new DeJur rheostat-potentiometers are completely enclosed in permanently sealed, corrosion-proof metal cases. Terminals are brought through a sealed terminal board. Thus, no dust can penetrate, no varying degrees of heat, cold or humidity can affect their high operating efficiency. Rigid requirements, including the salt spray corrosion test, are met.

Supporting these advantages is the excellence of DeJur precision construction. You can subject these instruments to great shock or vibration . . . take them up miles into the air . . . and their close tolerances remain unaffected. Write for additional details, or consult with a DeJur engineer. Special features built to order—length of shaft (round, slotted or flatted) can be provided to individual specifications.

ARMY E NAVY

BUY
AND
HOLD
MORE
WAR
BONDS

DeJUR-AMSCO CORPORATION

GENERAL OFFICE: NORTHERN BLVD. AT 45th STREET, LONG ISLAND CITY 1, N. Y.
IN CANADA · · · ATLAS RADIO CORP. LTD., 560 KING ST. WEST · TORONTO, CANADA

TYPICAL USES OF ROGERS-BORDS

BM-9725* disk for molding

3G443 back for binder

BAYRU cut for midsole

KAYGREY jewel box pieces

ROYALGREY insulator for transformer

3G316 as waste basket

XM-15000E cap for canteen

HE'S USING BM-9725* -ANOTHER ROGERS-BORD

PROBABLY every time you use the telephone you use another ROGERS-BORD, for most telephone handsets use this material — identified as BAKELITE molding plastic BM-9725 — for the mouthpiece or for strengthening the main molded structure.

ROGERS makes numerous other multi-purpose BORDS by the ROGERS PROCESS of wet-laminating cellulose fibers in various formulations. Molding BORDS are handled on conventional molding presses. All others can be formed, drawn, shaped and punched with a single stroke of a punch press — ready for use without curing, or they may be subsequently treated or painted.

The resultant products will support a man's weight and are naturally economical. The Fabricating Division of ROGERS is equipped to handle all punch press, drawing and stamping work, including die making. ROGERS does no plastic molding.

You probably already use a ROGERS-BORD every time you lift a telephone. You may profit by making your next call one for more data on ROGERS-BORDS. *Write for the ROGERS-BORD SAMPLE BOX, containing numerous fabricated parts and samples of materials.*

ROGERS CORPORATION
Formerly
The Rogers Paper Manufacturing Co.
107 Mill St. Manchester, Conn.

***"BAKELITE" BM-9725**

This ROGERS PROCESS blend of phenolic resin and cellulose fibers, made exclusively for the BAKELITE Corporation, comes in sheet, blanked or diced forms. It is a medium high impact thermosetting plastic . . . another ROGERS-BORD.

ROGERS

MANUFACTURERS AND FABRICATORS OF SPECIAL FIBROUS AND PLASTIC MATERIALS

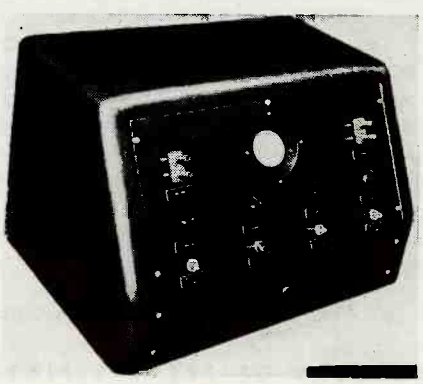
bination microphone and loudspeaker equipped with a pistol grip, squeeze-to-talk, switch and a strap permitting the unit to be suspended from the neck or shoulder of the user; and a battery-powered amplifier which is also equipped with a carrying strap. Both units are connected by a 6-ft. heavy-duty electric cord. The amplifier weighs 8 lb and 2 oz and measures $7\frac{1}{2}$ x $7\frac{1}{2}$ x $4\frac{3}{4}$ in. The megaphone weighs 6 lb and 12 oz and measures $13\frac{1}{2}$ x $10\frac{1}{2}$ in. Units are splashproof and shockproof.

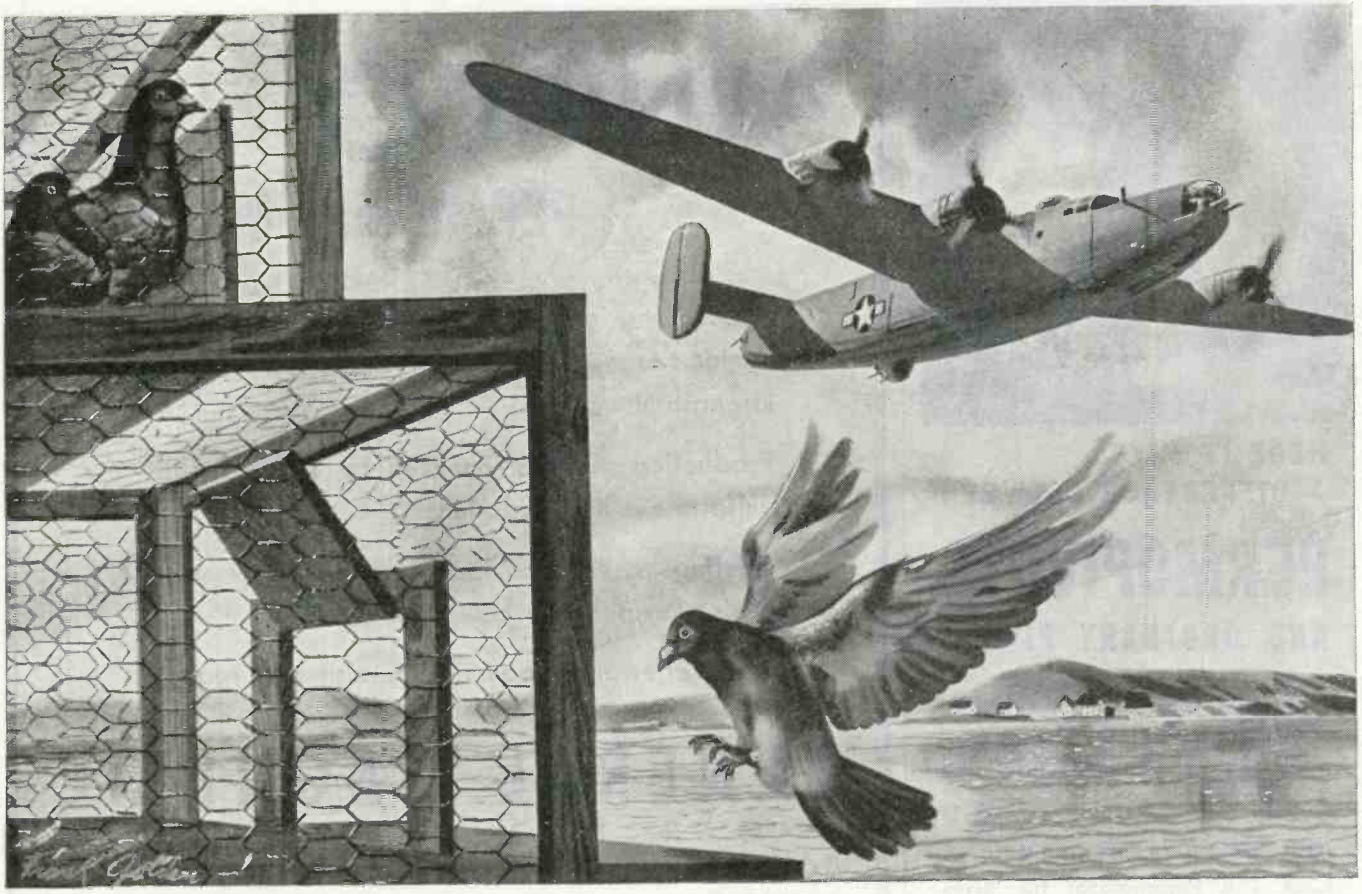
Hose-McCann Products Co., 177 Pacific St., Brooklyn 2, N. Y.

Sherron Electronic Instruments

SOME TYPES OF equipment manufactured by Sherron Electronics Company (1201 Flushing Ave., Brooklyn 6, N. Y.) may be described as follows:

Model SE1 is a cathode ray null detector designed for all a-c bridge measurements and for use in production applications. The unit is both a high impedance detector and an undistorted, filtered and shielded





What gives a plane its *homing instinct?*

IN THESE days when airplanes span continents and oceans non-stop, navigational and communications devices are of critical importance.

For these are the instruments which give an airplane its *homing instinct* . . . its sense of direction which spells safety and schedule maintenance.

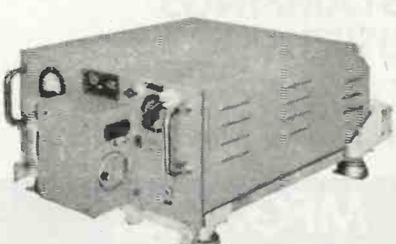
We at the Wheeler Insulated Wire Company take pride in the part which Bendix Aviation Corporation has played in supplying man-made homing instincts to thousands of modern airplanes.

For Wheeler insulated wire goes into both the Bendix aircraft radio compass . . . and the Bendix long-range radio telephone equipment.

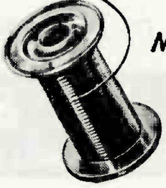
Windings for precision-made equipments such as these are part of Wheeler's everyday job. We've been making high quality coils and transformers for 35 years . . . not for a very large list of customers, but for a very fine one.

When wartime demands permit, we hope to introduce our products to many new customers. If you are going to manufacture anything which could use the products we make—Wheeler is a good name to remember.

Bendix Type MN-26 Radio Compass



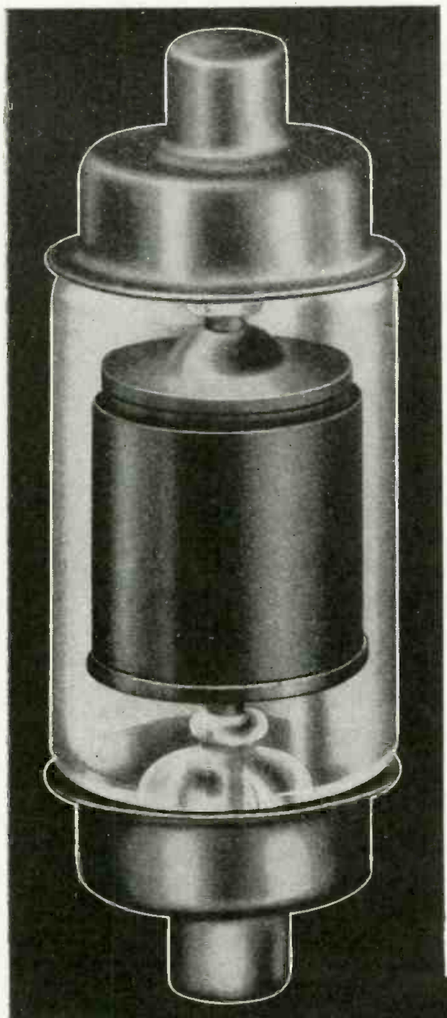
Bendix Type RTA-1B Communication Unit



The Wheeler Insulated Wire Co., Inc.

BRIDGEPORT 4, CONN.

Manufacturers of Magnet Wire... Litz Wire... Coil Windings Transformers... Ballasts for Fluorescent Lighting



FOR YOUR NEWLY DESIGNED Transmitting and Electronic Heating Equipment Use

Jennings RADIO

VACUUM ELECTRONIC COMPONENTS

6 to 250 mmfds.

HIGH VACUUM CAPACITORS

20 to 60 amps. • 20KV to 32KV

ADVANTAGES:

1. Relatively small physical size.
2. Electrical characteristics independent of atmospheric pressure and humidity.
3. No dielectric losses.
4. No ceramic or internal insulator.
5. Ferrule type mounting.
6. Zero power factor at most frequencies.
7. Low distributed capacity.
8. High current carrying capacity at high voltage.
9. Unlimited life expectancy.
10. Universal adaptability.
11. Rugged mechanical construction.
12. Comparatively light weight.
13. No cold emmission.

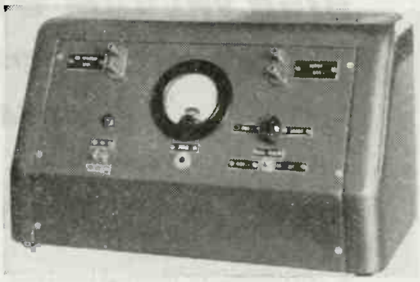
JENNINGS RADIO MANUFACTURING COMPANY

1098 EAST WILLIAM STREET, SAN JOSE 12, CALIFORNIA

Photograph shows final tests of Jennings High Vacuum Capacitors

source of 1000 cps. Comparison of frequencies is obtained by the use of Lissajous figures. Gain is 80 db at an input voltage of 100 microvolts. Bridge detector impedance is 1 megohm. The instrument is self protected against overload or damage. Automatic gain control eliminates the necessity of resetting while adjusting the bridge balance.

As an auxiliary to a-c bridge measurements a standard null detector is available. This unit gives

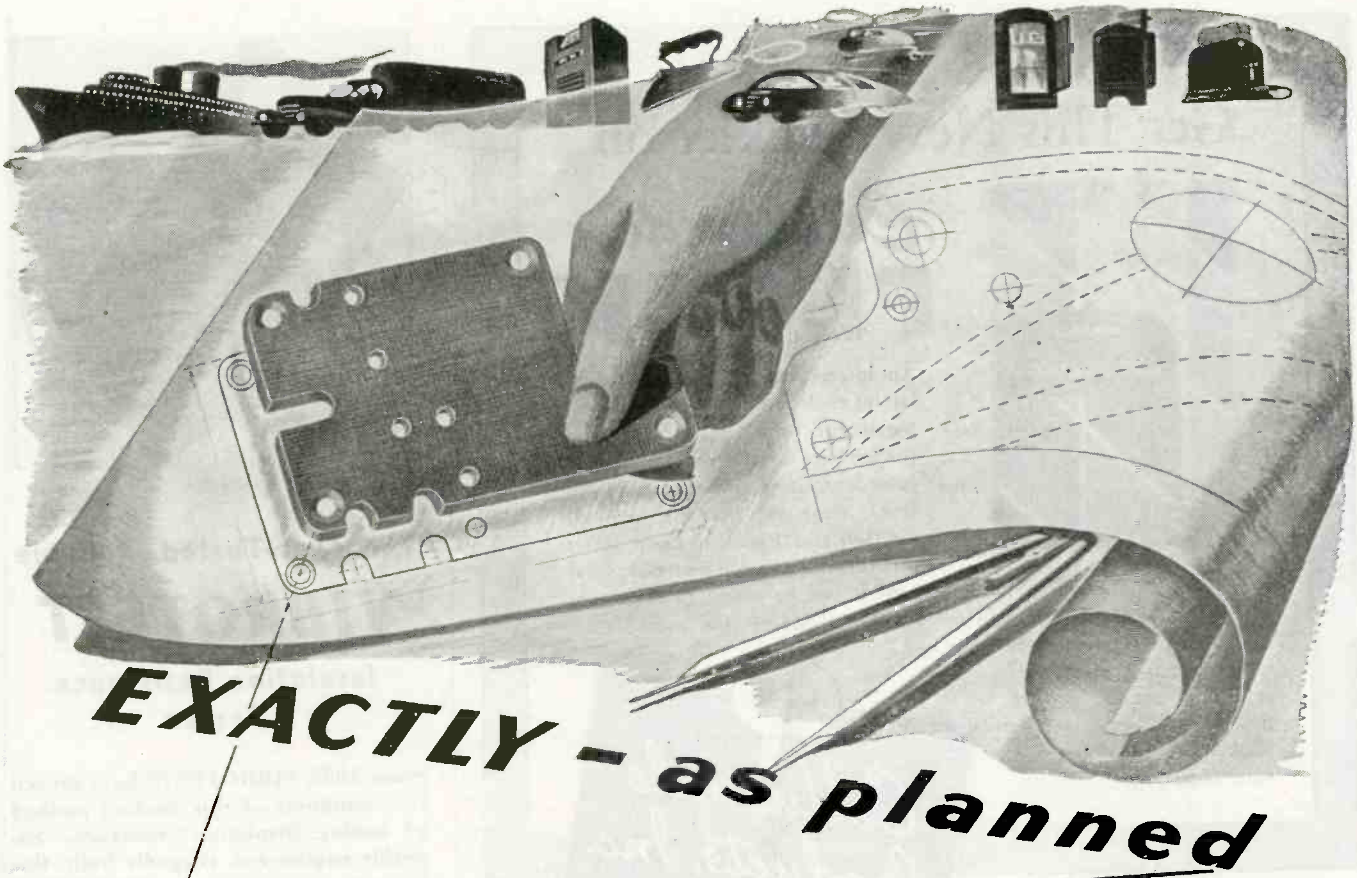


an appreciable deflection with an input of 0.01 volt. An input of 32 volts will not cause the meter to swing off scale. These detectors are equipped with a 1000-cycle source of sufficient level to operate any standard bridge, and a filter circuit to insure that only the desired frequency is activating the indicating meter. Arrangements are provided to disconnect both the internal tone source and filter circuit.

Model SE-10 precision tolerance bridge is accurate to 0.1 percent.

The unit has an electronic visual gauge which can be used as an inspection tool to safeguard against faulty components; or it may be used as an automatic filter to grade components for their individual tolerance. The unit checks a-c resistance and impedance, capacitance and inductance. Tests are made automatically. Instead of meter readings, rejects are indicated visually and audibly.

Model SE-20 is a production test set which will automatically test 720 vacuum tubes per hour. The unit has complete adjustable con-



EXACTLY — as planned

This DILECTO Gr. "L" part was punched from sheet, drilled and counterbored. It is an electrical insulating part for an Army Tank. It must stand up under severe mechanical abuse.

KD-45

CONTINENTAL-DIAMOND can supply you with fabricated plastic, vulcanized fibre, or mica parts EXACTLY to your blueprints . . . whether your requirements be a few pieces or a million pieces. C-D NON-metallics are especially adaptable to close tolerance fabricating; where close tolerances are needed.

Before designing NON-metallic parts to close tolerances, consult our design engineers. Their experience in helping design thousands of fabricated parts will save you money and time, by helping you avoid specifications which are beyond the possibilities of NON-metallics.

Booklet FP—"The design and fabrication of plastics and vulcanized fibre," should be on the desk of every one of your design engineers and draftsmen. We'll be glad to send you as many as you need.

C-D PRODUCTS

The Plastics

DILECTO—A Laminated Phenolic.
CELORON—A Molded Phenolic.
DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.
HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

The NON-Metallics

DIAMOND Vulcanized FIBRE
VULCOID—Resin Impregnated Vulcanized Fibre.
MICABOND—Built-Up Mica Electrical Insulation.

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Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

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Bulletin GF gives Comprehensive Data on all C-D Products. Individual Catalogs are also Available.

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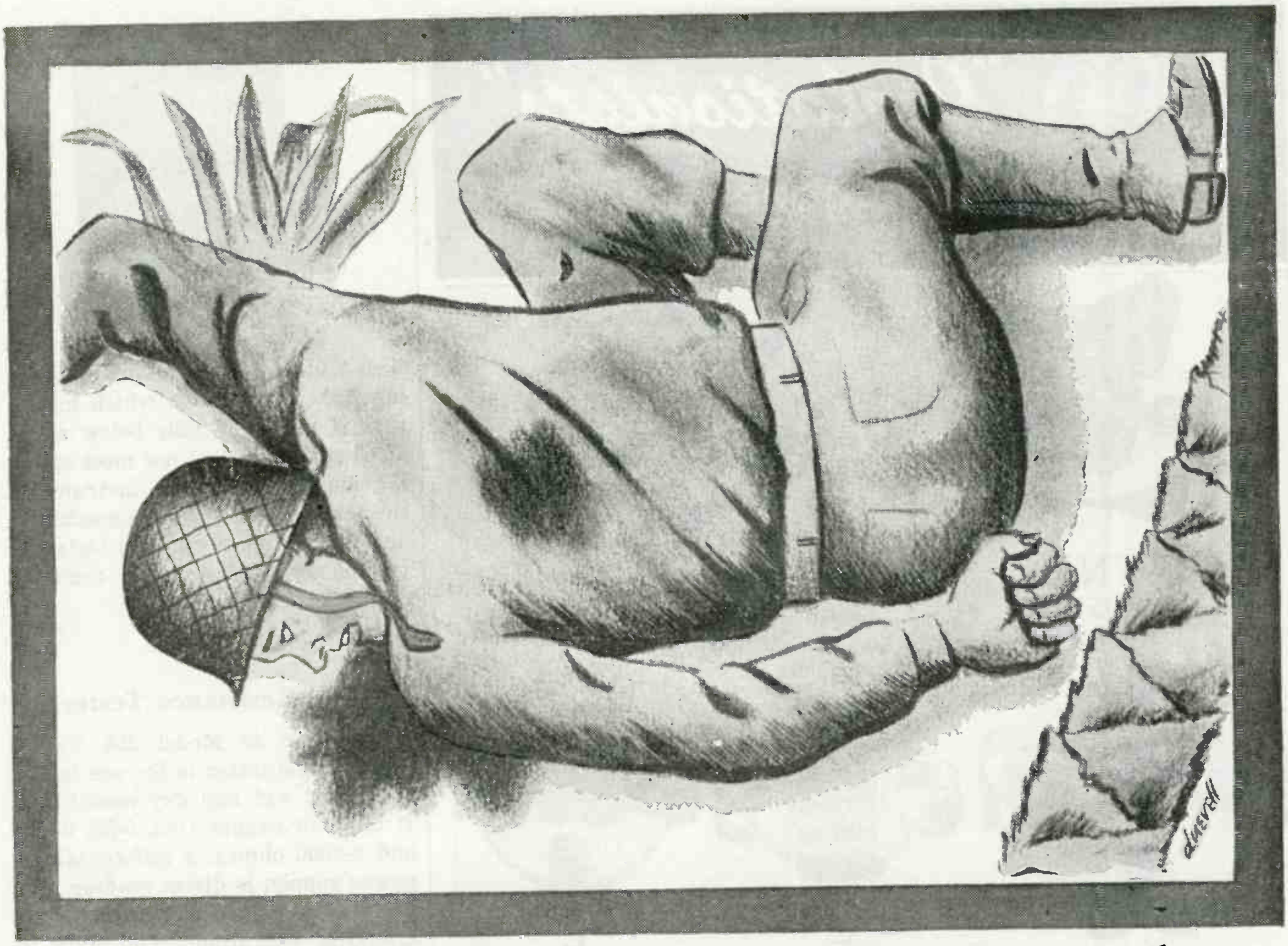
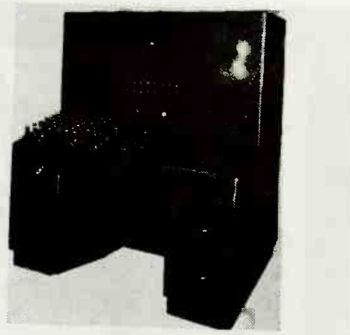




trols and uses a "go-no-go" indicating light test system which means that if any tube falls below a desired range, or does not meet specification as set on the instrument, the test set will stop automatically, and will not continue with tests until the rejected tube is removed from the test socket.

Ground Resistance Tester

DESIGNATED AS Model 255 Vibroground, this tester is for use in extremes of wet and dry conditions. It has four ranges (0-3, 0-30, 0-300 and 0-3000 ohms), a self-contained power supply, is direct reading and requires no calculations and no cranking operation. The unit is

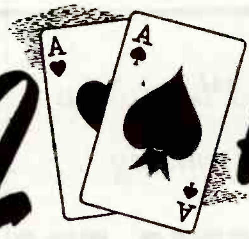
Model 255 VIBROGROUND

lightweight and portable, and comes in a one-piece welded metal case which is water-tight and which excludes strays from all sources. A triple range Vibroground, Model 251, for average ground conditions is also available.

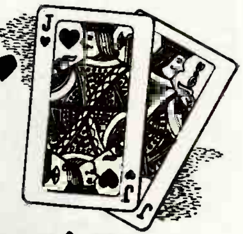
Associated Research Inc., 231 S. Green St., Chicago 7, Ill.

Resistors

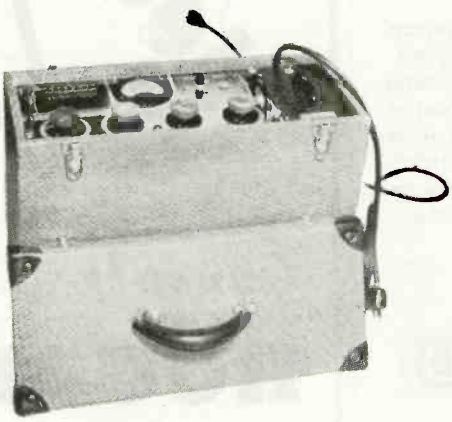
PRE-WAR CONSTRUCTION of shafts in this manufacturer's resistors (designated as Radiohm of the split knurl midget types) is again being



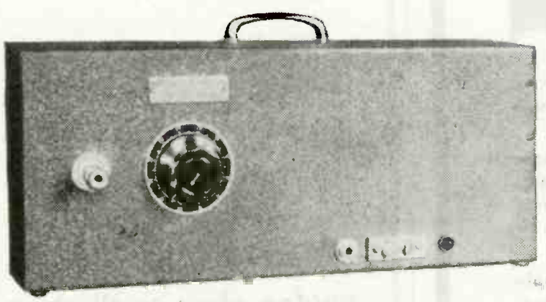
2 ACES... that are JACKS "of all trades!"



A FAMOUS PAIR



- THE GATES 3 CHANNEL PORTABLE REMOTE AMPLIFIER FOR ALTERNATING CURRENT OR BATTERIES.
- THE GATES REMOTE CONDITIONER FOR SINGLE MICROPHONE REMOTE PICK UPS. A.C. OPERATED.



Gates

Remote Pick-Up Amplifiers

This famous pair . . . truly "a Jack of all trades" . . . for they have been "Aces" in doing an outstanding job of remote broadcasting from Maine to Pango Pango—from Macy's windows to Montana's mountains—from Sandlot ball games to World Series—from Presidents to Prime Ministers. For more than a decade Gates Remote Amplifiers have served broadcasters for every need and purpose. From year to year they have been modernized, but in efficient performance they still remain the same in name, type number and service.

Here's what one broadcaster writes about his Gates DYNAMOTE: "—My Gates Dynamote is so much superior to my studio speech system quality, that I have discarded my studio equipment until new equipment can be obtained."

Another wrote: "—I am using my Gates Dynamote as standard for overall frequency response for the entire transmitting plant."

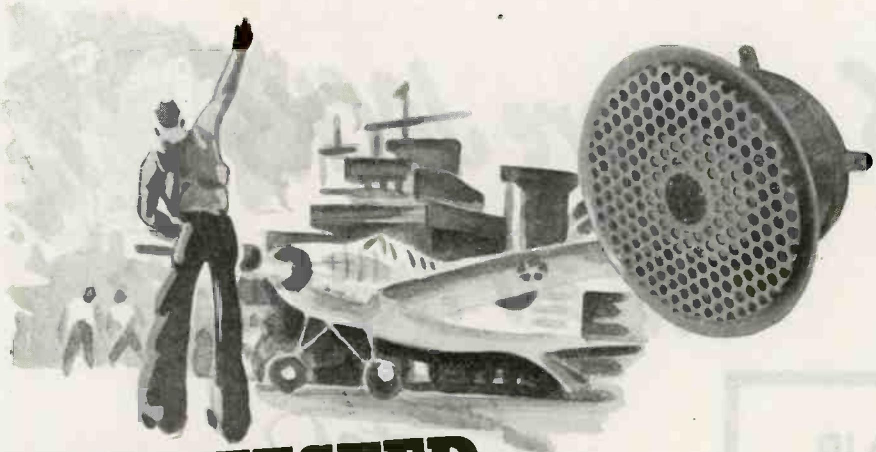
This, plus the fact that Gates Remote Conditioners are used in nearly every U. S. broadcast station for single mike pick-ups, is proof that this famous pair have been engineered for efficiency and economy. This is why Gates Remote Amplifiers are now in use in every theatre of war, bringing to America's loud speakers the war events from the place where history's biggest news is taking place!

Wartime restrictions do not allow the sale of new broadcasting equipment without priority, therefore, this equipment is presented merely to acquaint you with Gates' current developments.

Ask About Our Priority Plan for Prompt Delivery When Gates Equipment Is Again Available

Gates RADIO COMPANY, Quincy, Illinois, U. S. A.

MANUFACTURERS OF RADIO BROADCAST TRANSMITTERS, SPEECH EQUIPMENT, ANTENNA TUNING AND PHASER UNITS, AMPLIFIERS, REMOTE EQUIPMENT, BROADCAST STATION AND TRANSMITTER ACCESSORIES.



WAR-TESTED

During the critical stress of battle, men and equipment prove themselves. Materiel that has performed dependably under highly abnormal War conditions has stamina to spare in normal peacetime operation. Atlas Sound Loud Speakers have come through their War tests with flying colors. War-tested Atlas Sound manufacturing facilities and personnel will soon again be ready to go to work for you on new designs or minor conversions. Contact them for details.

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Complete Catalogue on Request

ATLAS SOUND CORPORATION

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TWO BOOKS EVERY ENGINEER NEEDS

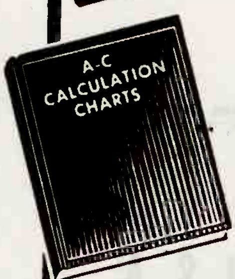
THE CATHODE-RAY TUBE AT WORK by John F. Rider

The cathode-ray tube is the most universally used device for research, engineering and maintenance in the radio and electrical fields.

In using this device to its fullest capabilities, it is necessary to understand its theory and functioning. This book presents a complete explanation of the various types and what role each element within the device plays. Different types of cathode-ray oscillographs are discussed.

More than half the book is devoted to the practical applications illustrated with unretouched photographs of actual oscillographs.

338 PAGES . . . 450 ILLUSTRATIONS . . . $4.00



A-C CALCULATION CHARTS

This book is a tremendous time saver for engineers and others who work on electrical communication and electrical power problems. Faster than a slide rule. It covers all alternating current calculations in series circuits, parallel circuits, series-parallel and mesh circuits, at frequencies from 10 cycles to 1000 megacycles. 146 Charts—7" x 11"—Two colors—$7.50.

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Whether your peacetime products are to include electronic equipment, electrical appliances, stoves or what have you, the Rogan Organization will gladly provide cost-free advice on all phases of plastic production.

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Your Specifications Today!

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Compression Molders and Branders of Plastics

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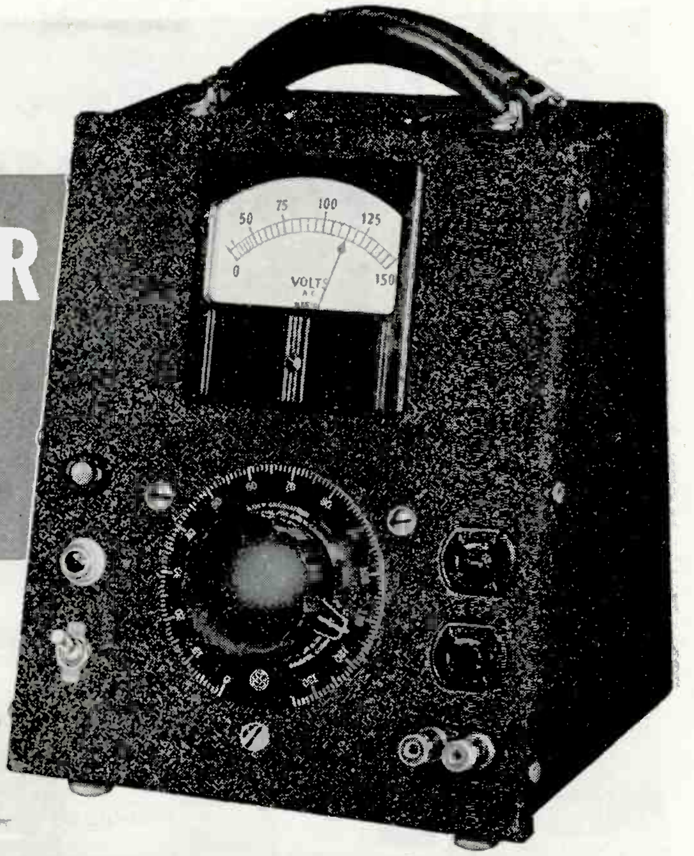
TO SET YOUR

VOLTAGE

use a POWERSTAT



VOLTBOX

..for..

RESEARCH

PRODUCT-TESTING

HEAT RISE

LIFE CYCLE

QUALITY-CONTROL

etc.

IN presenting this new and unique instrument, SECO offers a portable source of variable a-c voltage for the laboratory, assembly line, or maintenance shop. There is no bother or delay in collecting and setting-up separate instruments. Included in the light-weight and compact VOLTBOX are all the essentials and more. Besides a POWERSTAT variable transformer to obtain the required voltage and a 1% voltmeter to accurately set the output — other features incorporated are an "on-off" switch, dial light, output receptacles, binding posts, and an input cord and plug.

By connecting the VOLTBOX shown above to a convenient 115 volt outlet, an output variable from 0-135 volts is available. Its current rating is 7.5 amperes. Other types are manufactured for 230 volt operation.

We invite your inquiries.

Send for Bulletins 149 LE and 163 LE

SUPERIOR ELECTRIC COMPANY

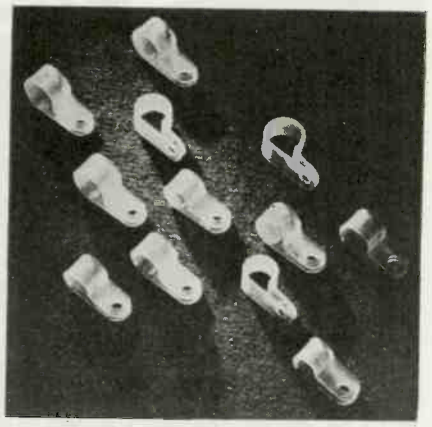
403 LAUREL STREET, BRISTOL, CONNECTICUT

utilized. Extruded brass rods (3 in. long) are used instead of threaded steel. The brass rod can be cut to the desired length, and the fins can be slotted to the exact depth of the original control without removal of the tip. Radiohms affected by this pre-war construction process are CRL part numbers NK-136 to NK-144 inclusive, and NK-172 to NK-174 inclusive.

Centralab Div., Globe Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

Cable and Wire Clips

PLASTIC CABLE clips (illustrated) are now on a production basis and are available in a variety of sizes for use as fasteners for wires and cables. A feature of these clips is the rolled edges of their design and the abrasion-free nature of the plastic surface which prevents in-



sulated materials from wearing off. Clips are non-corrosive, non-conductive, light in weight, strong and resistant to acids, alkalies and oils. They are fabricated with LT Ethocel, a thermoplastic developed by Dow to provide toughness, shock resistance at low temperatures, and low dimensional change over a wide range of atmospheric conditions.

Commercial Plastics Co., fabricates these clips. Write Dow Chemical Co., Midland, Mich.

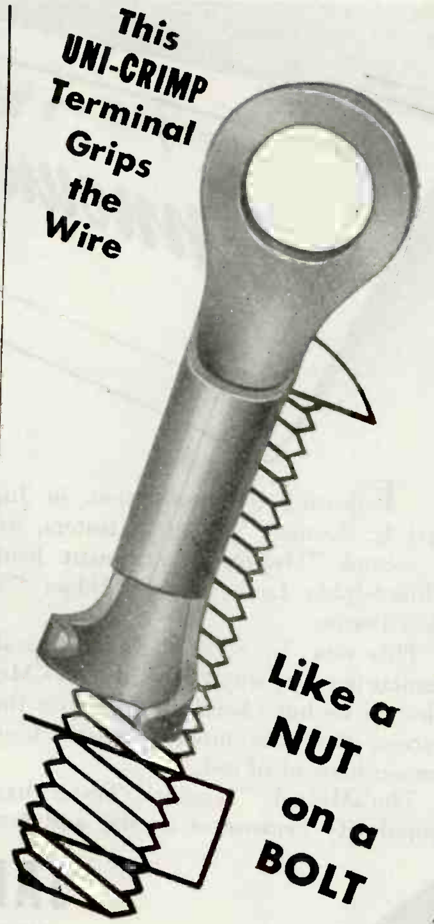
Small Dynamotors

A SERIES OF SMALL dynamotors are designated as Multi-Output Micro-Magmotors which will be available in quantities after the war. These motors have a permanent magnet field and furnish outputs totaling up to 100 w. This wattage can be divided over two or even three dif-

Die cut metal stampings in limited quantities can be produced to your special requirements at 15% to 20% of the cost of permanent type tools. No matter how small your quantity requirements or how intricate your work, we can show you a definite saving. During our twenty-three years of specialized experience in this service, there has been no other method of producing metal stampings in small lots that can equal the process originated by Dayton Rogers.

Our new, illustrated booklet #176-17 will give you full particulars.

DAYTON ROGERS MFG. CO. 2835 12th Avenue So. Minneapolis, Minnesota



Easy to Install

— With hand crimping pliers or indenting tools. You can even use ordinary side-cutting pliers!

You can't see it in the above illustration, but the entire inside of the UNI-CRIMP barrel is ***serrated,*** somewhat like the threads inside a nut. When this terminal is crimped onto the wire, it's there to stay!

This UNI-CRIMP Terminal will stand a lot of vibration and hard service. Extensive tests, in the laboratory and in service, have proven that. And, because of its pure electrolytic copper, it makes a connection of the highest conductivity.

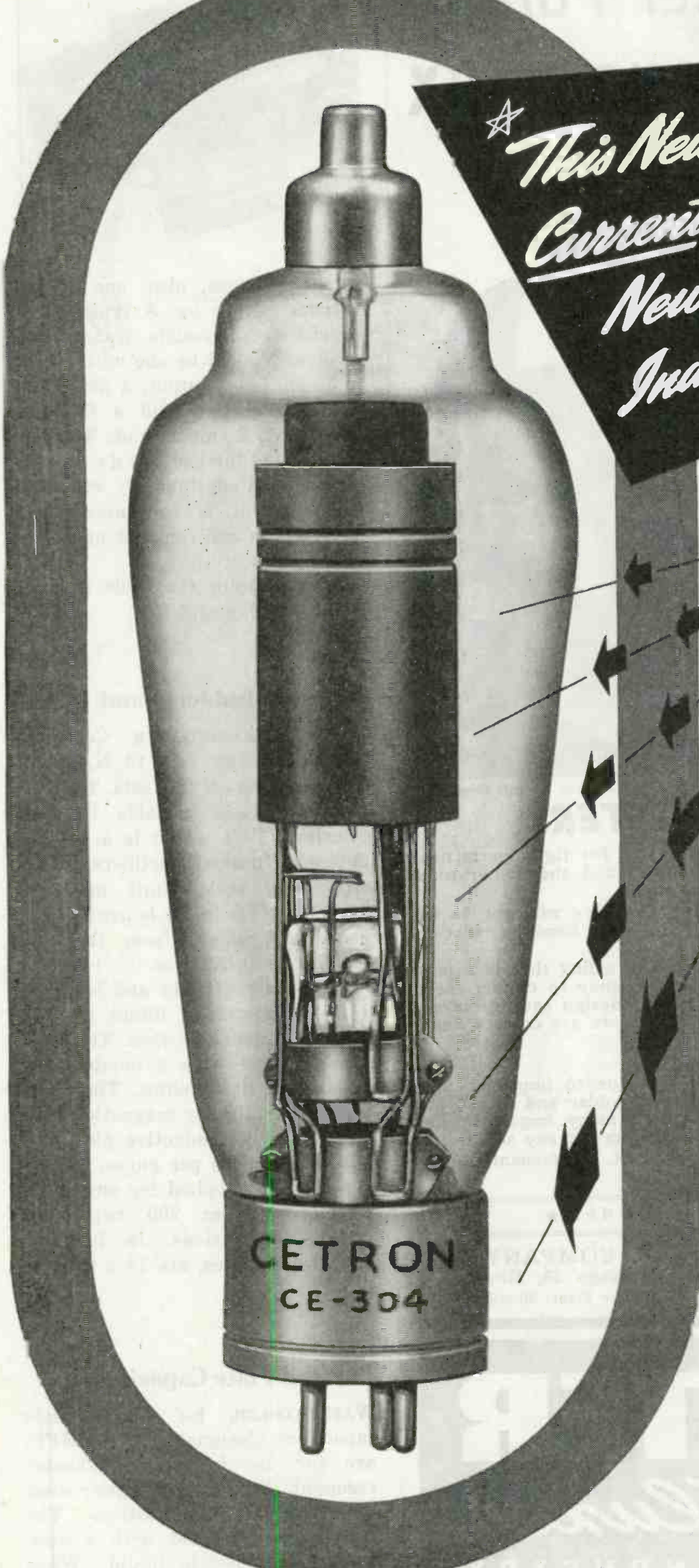
You'll like the way the UNI-CRIMP installs, and the way it performs. Write today for Bulletin UC-2, giving specifications.

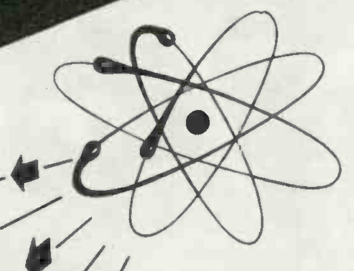
H. B. SHERMAN MFG. CO.
BATTLE CREEK, MICHIGAN

Sherman

Solderless and Solder Type Terminals and Lugs . . . Wire and Cable Connectors . . . Splicing Sleeves . . . Fuse Clips

✩ This New Cetron High Current Thyratron brings New Efficiency to Industrial Operations





CETRON

CE-304

In the Cetron CE-304 tube shown here, Continental Electric Company engineers have reached a new high in concentrating super-efficiency in the smallest possible space.

CE-304 is a mercury vapor filled tube with a peak current rating of 125 amperes and an average current rating of 12.5 amperes DC. This high current thyratron-type tube is designed to be particularly useful in welding control and motor control applications.

CE-304 uses industrial type 4-pin base; is sturdily constructed. Patented filament design gives exceptionally high output with minimum of cathode power.

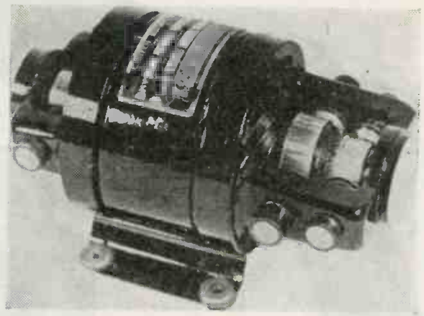
CE-304 is built to give long life in all sorts of industrial and other applications where dependability is an important consideration.

Write for Bulletin No. 119

CONTINENTAL ELECTRIC CO.

GENEVA, ILL.

Chicago: 903 Merchandise Mart . . .
New York: 265 W. 14th St.



ferent voltages, also, one of the outputs can be ac. A typical unit (perhaps for mobile transmitter-receiver) would be one with a 350-v, 50-milliamp output, a 250-v, 25-milliamp output, and a 6.3-v ac (100 cps), 2-amp output. The 6.3-volt a-c and the 250-volt d-c outputs can be used continuously while the 250-v output is for intermittent duty. Units are compact and light in weight.

Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.

Variable Inductor and Filters

UNITED TRANSFORMER Co., 150 Varick St., New York 13, N. Y., announces two new products. The first of these is a variable inductor (Series V1-C) which is a tunable device for peaked amplifiers, filters, etc. This sealed unit measures $1\frac{1}{4} \times 1\frac{7}{16} \times 1\frac{7}{16}$ in. It is available in inductance values from 10 millihenries to 10 henries.

High pass (HP-1) and low pass (LP-1) interstage filters are the other products available. The units are designed with a nominal impedance of 10,000 ohms. The filters utilize a dual alloy magnetic shield which reduces inductive pickup to 150 millihenries per gauss. Either type can be supplied for any cutoff frequency from 200 to 10,000 cycles. Dimensions, in hermetically-sealed cases, are $1\frac{1}{2} \times 2\frac{1}{2} \times 2\frac{1}{2}$ in.

Parallel-Plate Capacitors

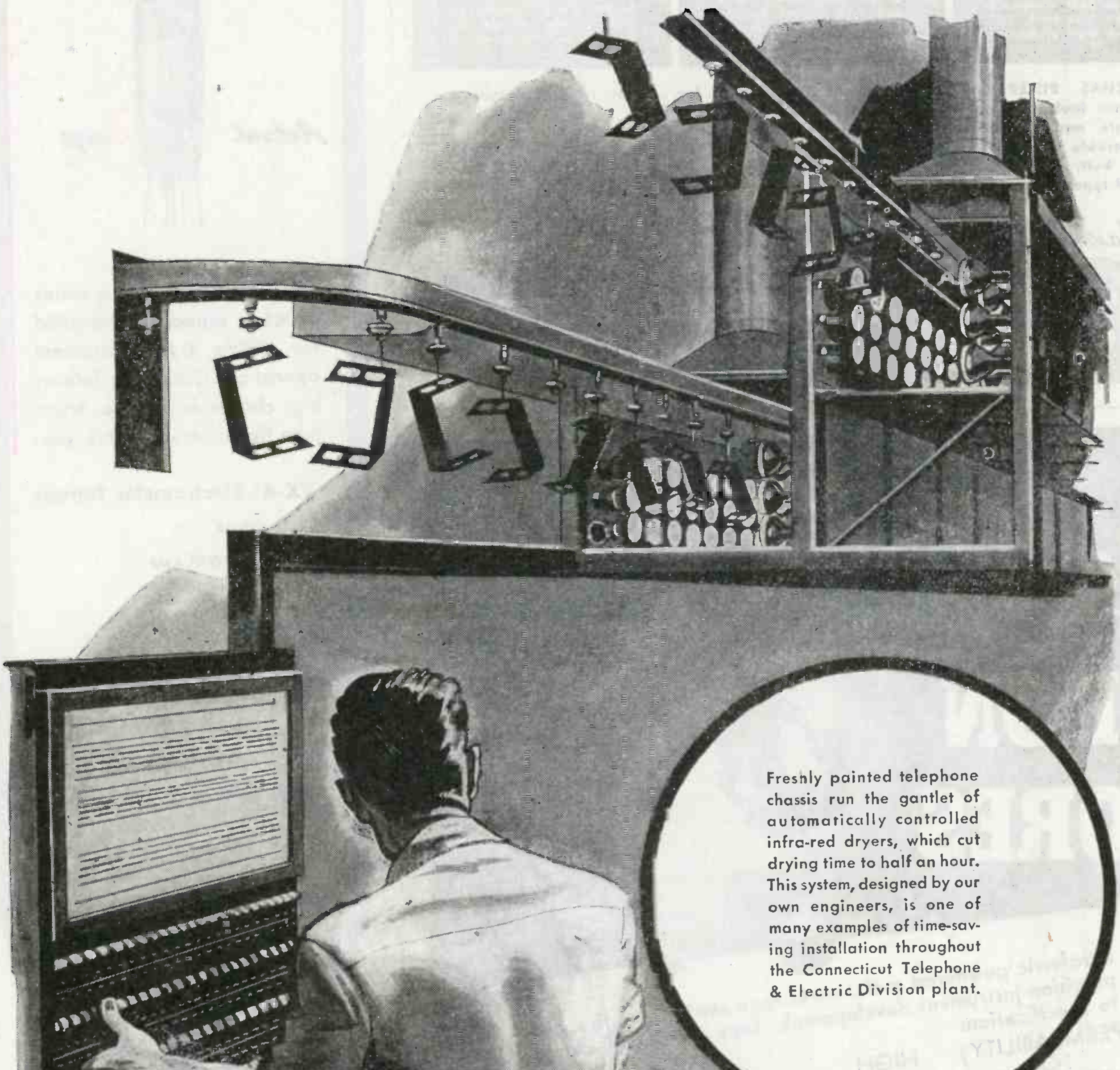
WATER-COOLED, h-f parallel-plate capacitors, designated Class HFP, are for use in electronic-heater resonant circuits and other electronic-oscillator applications. The capacitors are filled with a new, synthetic dielectric liquid. When connected in parallel with an in-

"DO NOT SQUANDER TIME"

... Benjamin Franklin

At Connecticut Telephone and Electric Division, production is unhurried, as it must be to maintain accuracy and quality in precision electrical and electronic manufacturing. We substitute *time-saving* methods for *hustle and bustle.* This has enabled us to keep abreast of the ever-increasing need for military communicating equipment of uniform dependability.

After the war, you will very likely use electrical equipment, electronic devices, or communicating systems made at Connecticut Telephone and Electric Division . . . Or you may be one of the many manufacturers who will use our engineering and manufacturing facilities in connection with your own products . . . In either case, our time-saving methods will be your gain, measured by the important standards of uniform high precision, and speed of filling your orders.



Freshly painted telephone chassis run the gantlet of automatically controlled infra-red dryers, which cut drying time to half an hour. This system, designed by our own engineers, is one of many examples of time-saving installation throughout the Connecticut Telephone & Electric Division plant.

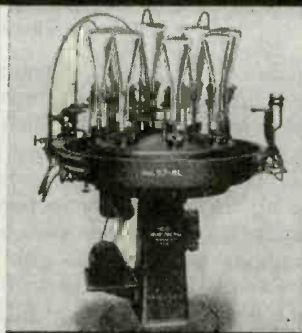
CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES, INC. • MERIDEN, CONNECTICUT

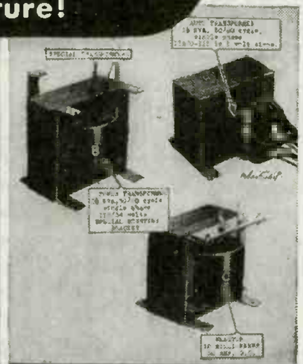
EISLER EQUIPMENT

..complete and diversified for every phase of electronic* manufacture!

(A) No. 600-KC3P, 50 KVA Press Type Spot Welder, 3 Spots, Air Operated, 18" Throat—a high production unit.



(B) No. 57-8L New Eisler 8 head type Tipless Sealing Machine. Adaptable for all types and sizes of bulbs.



(C) EISLER Special Transformers and Reactors — high or low voltage; air cooled, oil immersed or uncased.

The CHAS. EISLER line of specialized electronic tools, machines and devices is complete and diversified. Included are innumerable types of welders — spot, seam, butt, rocker, arm, pneumatic and special types. Also included are hundreds of devices for vacuum tube manufacture — glass tube cutters, slicers, stem and sealing machines as well as an all-inclusive line of transformers for every industrial and general need.

* EISLER serves 99% of American vacuum tube producers today. Write for completely illustrated catalog now—you incur no obligation.

Chas. Eisler

Eisler ENGINEERING COMPANY
751 SO. 13th STREET NEWARK 3, NEW JERSEY

PyroFerric

IRON CORES

Pyroferric powdered metal cores have kept apace the vital precision instrument development. They are manufactured to specification:

PERMEABILITY } HIGH
"Q" }
RESISTANCE } as desired FREQUENCY { HIGH
LOW { MEDIUM
{ LOW

Consult Pyroferric on your Powder Metallurgy requirements

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

• What a host of potentialities in electronic development is contained in this new VX-41 electrometer tube.

Actual  *size*

The VX-41 is one of a series of tubes especially designed for stable D.C. instrument operation. Check the following characteristics to know how this tube can serve you.

VX-41 Electrometer Tetrode

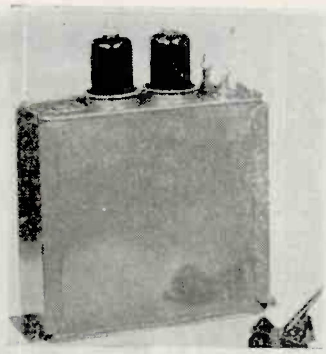
I_f	IOMA
I_g	5×10^{-15} AMP
I_P	MAX. 250 μa.
μ_{g2}	1.0
E_{g2}	—3V
Gm	(as electrometer) 20 μmhos
E_f	1.25 V
R_g	1×10^{16} ohms
R_P	50000 ohms
μ_{g1}	8.0
E_{g2}, E_p	4.5 V

We solicit inquiries on special D.C. instrument tube requirements.

MFD. BY

THE VICTOREEN INSTRUMENT CO.

5806 HOUGH AVENUE
CLEVELAND 3, OHIO

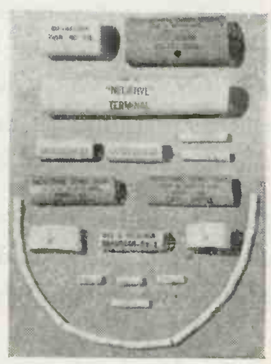


ductance coil, the capacitors constitute the resonant circuit which determines the frequency of the oscillator. In such applications, the capacitors are operated at relatively high voltages, and may be required to carry heavy currents continuously at frequencies of 50 kc to several megacycles. Features of the units are: low losses at high frequencies; uniformly high dilectric strength; high current rating per unit volume; and convenient mounting and connection facilities. Capacitors are available in standard ratings ranging from 2000 v, 0.025 microfarad to 9000 v, 0.0056 microfarad. Bulletin GEA-4365 illustrates and describes the capacitors in detail.

General Electric Co., Schenectady, N. Y.

Wire Markers

TURBO WIRE MARKERS are available in all colors, as well as in clear, transparent polyvinyl extruded tubes, made by a production process which permits any desired location of the imprinting, circumferentially or longitudinally, in any diameter or length. Markers are easily installed. They are designed to replace metal and paper tags. Inflammability and crimping are eliminated. The markers are extruded from polyvinyl chloride resin, are



SCOVILL charted a new "course" for radio compass terminals and made them faster and better for less

Scovill Electrōnents may give you the same competitive advantages*

Electric terminals for radio compasses were needed faster than screw machines could turn them out of rod stock. Asked to suggest a speedier method, Scovill recommended stamping them out of sheet metal. Given the job, Scovill produced many more terminals per day at a much lower cost . . . and paid an extra dividend in the form of better electrical properties. That was because the sheet brass used had a higher copper content and higher conductivity than the brass rod necessary in the former method.

With the same kind of ingenuity applied to your small electronic components or complete assemblies, the chances are that Scovill can save you time and money. Investigate the designing service, manufacturing ability in all metals, and wide range of metal-working facilities that have won for Scovill the title of "Masters of Metal". Fill in coupon below and mail today.

*Electrōnents = Electronic Components

Scovill
MANUFACTURING COMPANY
WATERBURY, CONN.

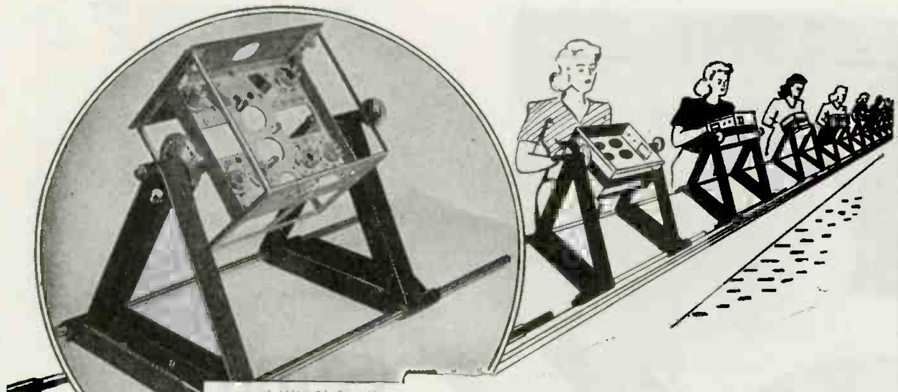
Please send me a free copy of "Masters of Metal" booklet describing your facilities. I am interested in the ELECTRŌNENT* applications checked.

☐ Batteries ☐ Dials ☐ Panels
☐ Record Changers ☐ Escutcheons ☐ Sockets
☐ Clips ☐ Jacks ☐ Stampings (misc.)
☐ Condensers ☐ Lugs ☐ Tubes

Other applications..

SCOVILL MANUFACTURING COMPANY
Electronic Division
22 Mill Street, Waterbury 91, Connecticut

Name..
Company..
Address..



This New Jig Speeds Radio Assembly

1) Holds chassis in any position to step up soldering and all other assembly operations. 2 models (friction or positive indexing 360° around axis).
2) Adjustable to any size within base limits of the jig. Comes in 5 standard sizes (4", 6", 9", 12" or 15" swing), or will make jigs to your specifications.
3) Sturdy, rigid constraction.
4) Can be loaded and unloaded in two seconds.
5) Prices start at $11.50.

Information about our Dummy Tubes, Pin Straighteners, Precision Gages, Test and Adapter Plugs and other Tools is yours upon request.

ROBERT L. STEDMAN MACHINE WORKS

SPECIALISTS IN MASS PRODUCTION TOOLS

OYSTER BAY, LONG ISLAND NEW YORK

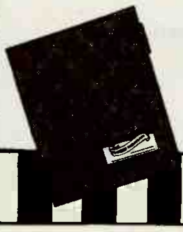
NOW!

AS THIN AS .005"

IN COILED-STRIP FORM

THIS NEW DEVELOPMENT is now available for production applications from Burgess rolling mill facilities. It can be supplied in widths from 3/4" to 5" and from .010" to as thin as .005".

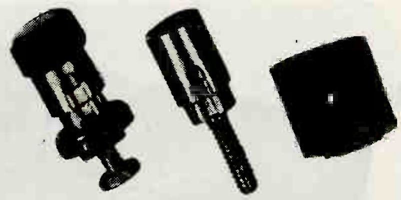
COMPLETE INFORMATION — technical specifications, cost figures, sample strip, and the answer to your problem — is available free in new folio.



Sample on request. Write Dept. M-7

BURGESS BATTERY COMPANY

FREEPORT, ILLINOIS



THERE IS NO SUBSTITUTE FOR EBY SPRING BINDING POSTS

From the product designer through to final assembly and use in the field, the Eby Spring Binding Post line offers top service based on dependability.

The spring binding post offers unique advantages that can't be duplicated:

1. No screw cap to tighten or come loose with vibration.
2. Constant, even pressure on the wire at all times in all positions.
3. Easy one-hand feeding of wire into the post.
4. Corrosion - resistant, long-life springs.
5. Complete range of sizes, stem lengths, and accessories for every application.

Replace with Eby Spring Binding Posts — Write today.

HUGH H. EBY INCORPORATED

18 W. CHELTEN AVE.

PHILADELPHIA, PA.

TOP
FREQUENCY STANDARD
(60 cycle) for use with external power supply

CENTER
CHRONOGRAPH
Records time intervals with resolution to .001 second

BOTTOM
FREQUENCY STANDARD
(120 cycles) with self-contained power supply

These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.

These tuning fork assemblies are available only in single or multi-frequency instruments of our own manufacture which are designed to test, measure or control other precision equipment by mechanical, electrical accoustical or optical means.

The dependability of these frequency standards is being demonstrated for myriad purposes in all climates and under all working conditions.

If you have need for low frequency standards of exceptional accuracy, your inquiries are invited.

American Time Products, Inc.

580 Fifth Ave. **New York, N. Y.**

Dist. of Western Electric & Watch Master Watch-rate Recorders moisture absorbent and have good insulating properties. They can be used to identify circuits and leads of electrically energized equipment and controls.

William Brand & Co., 276 Fourth Ave., New York 10, N. Y.

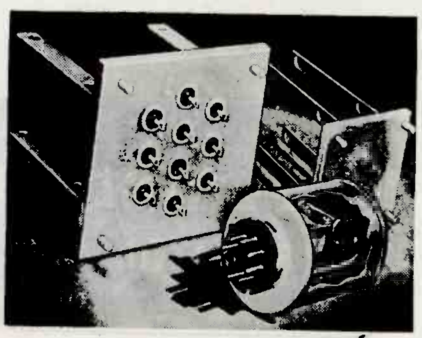
H-F Vacuum Tube, Power Tube

EXHIBITED AT THE Winter Technical Meeting of the IRE was a high-frequency vacuum tube for use in short-wave equipment being built for government services by Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J. The tube was developed especially for high-power, high-frequency broadcasting. It has an output of 200 kw, requires a steady flow of 2,400 gallons of water per hour, and weighs 350 lbs.

Another Federal exhibit was a new, compact power tube, the first of a series being developed especially for general industrial use in h-f heating equipment. The tube is designed to withstand the shocks and vibrations which may be encountered in manufacturing plant operations. It is supplied with 6-in. flexible copper leads which are permanently secured to the tube terminals to eliminate glass damage in attaching and adjusting terminal clamps. It has a power input of 3,500 watts.

Sealed Headers, Mountings

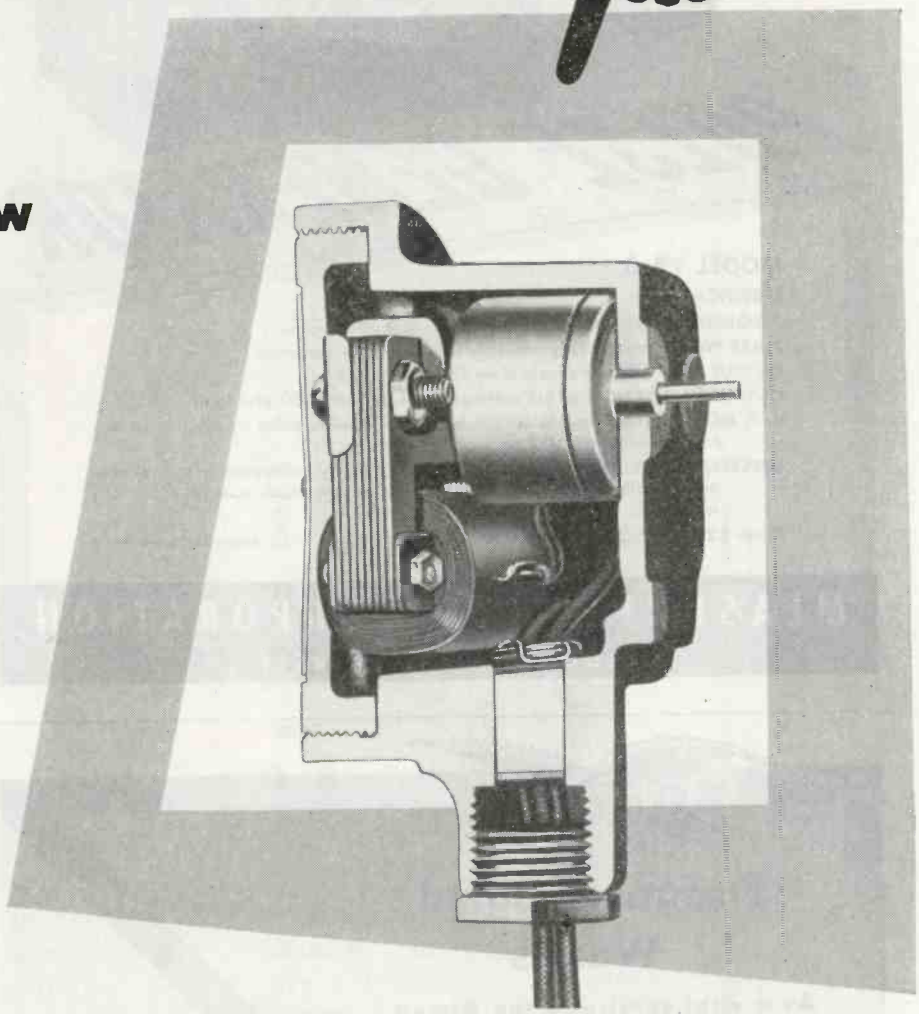
ALL TYPES OF sealed headers and sealed mountings for electrical components are available in any desired number of hermetically-sealed connections. Terminals are of a glass-bead type. Units are shock-proof and heat-resistant and provide a chemically-bonded seal between the shell and glass, as well as between the glass and Kovar



EXPLOSION-PROOF!

AN IMPROVED NEW TELECHRON MOTOR

SMALL—COMPACT—ACCURATE. Here's a new EXPLOSION-PROOF synchronous timing motor that operates with safety under the most hazardous conditions!



THIS new Telechron EXPLOSION-PROOF motor is already performing smoothly and safely in war plants under conditions highly conducive to explosion . . . in the production of chemicals, synthetic rubber, high octane gasoline and ammunition. In exhaustive tests, with *internal* and *external* firing, it has never failed.

It has been developed by Telechron primarily for timing of automatic switching and controls in industrial processes where atmospheres contain ethyl vapor, gasoline, petroleum, naphtha, alcohols, acetone, or natural gas. Its safety factors offer profitable protection to paint, varnish, and lacquer plants, or to any industry or mining operation where there is danger of explosion.

The new Telechron EXPLOSION-PROOF motor is approved by the Underwriters' Laboratories under their label service for use in Class 1, Groups C and D hazardous locations. Various shaft speeds, voltages, frequencies, and designs for many industrial applications.

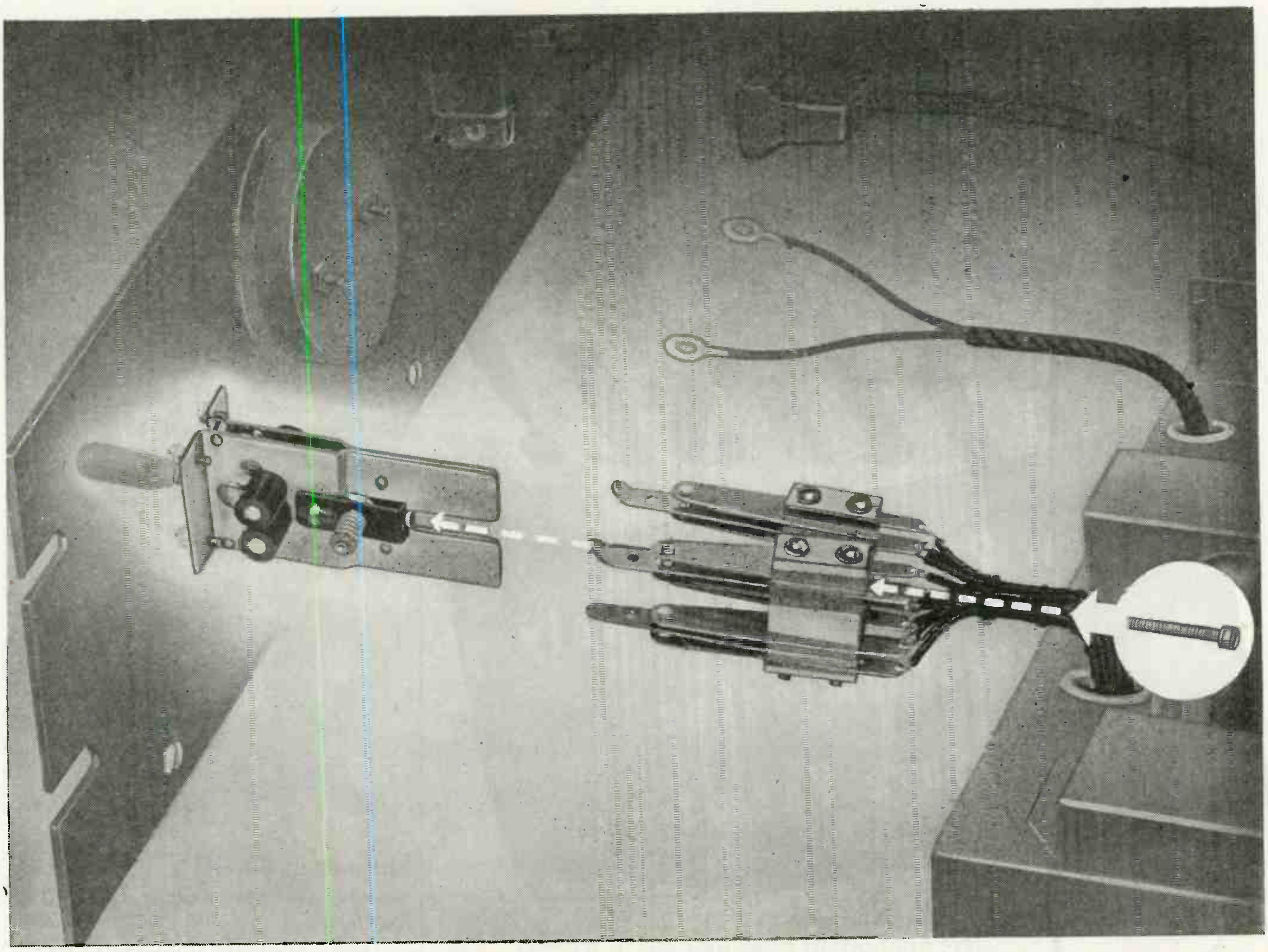
• *For more information concerning the new EXPLOSION-PROOF Telechron motor, and how you can use it for greater safety in your plant installations . . . or details on our many other synchronous self-starting motors for instrumentation . . . write to Motor Advisory Service, Dept. C. Our 25 years' experience is at your service.*

Telechron

REG. U. S. PAT. OFF.

WARREN TELECHRON COMPANY, ASHLAND, MASS.

MAKERS OF TELECHRON ELECTRIC CLOCKS AND SYNCHRONOUS ELECTRIC MOTORS



Single Bolt Assembly ON MODEL MCL LEVER SWITCHES

SPEEDS CHASSIS-TO-PANEL ASSEMBLY ON ELECTRONIC & COMMUNICATIONS EQUIPMENT

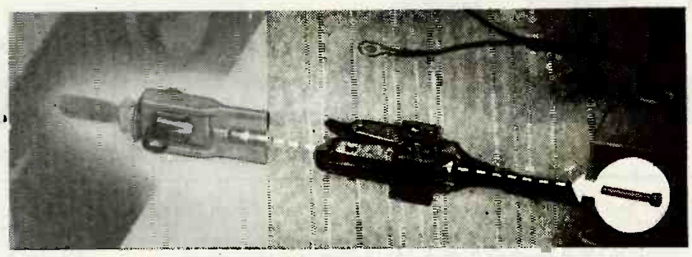
This *exclusive** General Control Company feature means savings in time and labor during original assembly and at any time that maintenance, rewiring, etc. is required. Consider the convenience of this feature when build-ups must be assembled to a frame that is buried among other units on the back of the control panel. During assembly of equipment, the Model MCL can be wired where it is most convenient—the control lever can be mounted anywhere on the panel where it is most convenient for the operator—there is no need to compromise.

The "Midget" Model MCM also has the single bolt assembly feature. This unusual lever switch *weights only 3½ ounces with 12 contact springs.*

All General Control Company lever switches have unlimited contact possibilities; all parts are non-corrosive; all have easy, positive roller action, regardless of number or arrangement of contacts on each side of switch.

* PATENT No. 2,351,236

The "Midget" MODEL MCM *has it too!!*



GENERAL CONTROL COMPANY

1202 Soldiers Field Road BOSTON 34, MASS.

corrosion-resisting electrodes. The glass is annealed for strain elimination and as a protection against thermal or mechanical shock. High and low voltage-terminal types are available for inclusion in a header assembly. Headers can be fabricated to suit individual specifications. Illustrated are headers for can-type units.

Electronic Testing Laboratories, Inc., 44 Summer Ave., Newark 4, N. J.

Reference Recorder

A NEW REFERENCE recorder, Model AV-2, records on cellophane tape up to eight hours continuously and without supervision. Compared to

the manufacturer's Model AV it is smaller and has an improved indexing control.

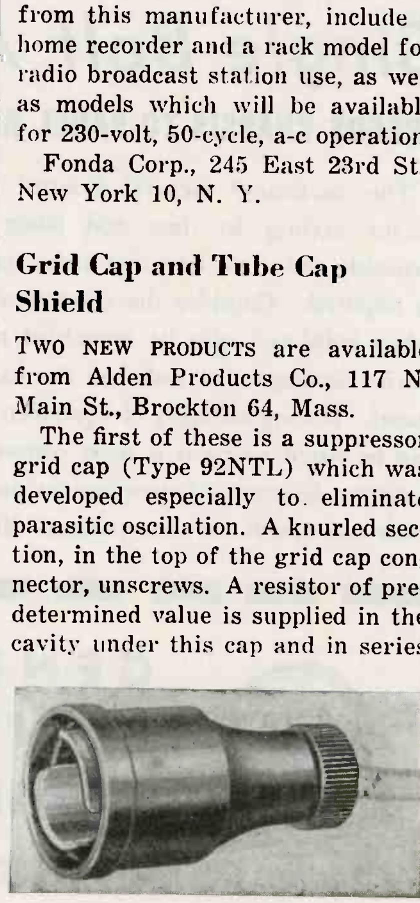
Other products available postwar from this manufacturer, include a home recorder and a rack model for radio broadcast station use, as well as models which will be available for 230-volt, 50-cycle, a-c operation.

Fonda Corp., 245 East 23rd St., New York 10, N. Y.

Grid Cap and Tube Cap Shield

TWO NEW PRODUCTS are available from Alden Products Co., 117 N. Main St., Brockton 64, Mass.

The first of these is a suppressor grid cap (Type 92NTL) which was developed especially to eliminate parasitic oscillation. A knurled section, in the top of the grid cap connector, unscrews. A resistor of predetermined value is supplied in the cavity under this cap and in series



25 YEARS *Specialization in* RELAYS

New Feature . . . eliminates "bounce" and "chatter"

Microphone Hummer

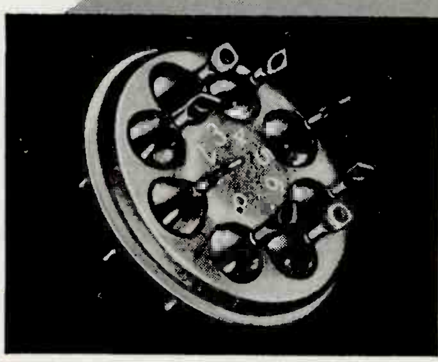
Twenty-five years' experience in solving all types of Relay Problems . . . Complete facilities for Designing, Engineering, Manufacturing . . . Specialists in producing Relays of exceptional power and sensitivity for Aircraft, Intercommunications-Systems, Electronic Devices. Exclusive Kurman features provide greater dependability, longer life, more precise performance . . .

Send data for quotations. Write for new descriptive Bulletins.

KURMAN ELECTRIC CO.

35-18 37th STREET • LONG ISLAND CITY 1, N. Y.

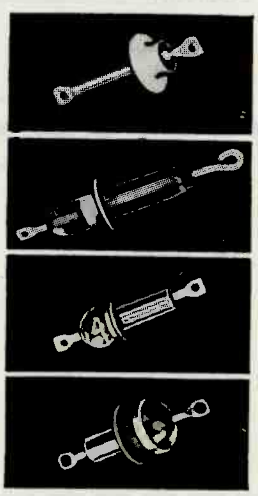
E-I HERMETICALLY-SEALED MULTIPLE HEADERS



- ★ VACUUM TIGHT SEAL
- ★ KOVAR METAL ELECTRODES
- ★ PYREX GLASS BEAD
- ★ MANY STANDARD TYPES
- ★ ANY TYPE TO SPECIFICATIONS
- ★ SOLDER OR WELD EASILY

A complete and diversified line of E-I 4, 5, 6, 7 and 8 electrode hermetically sealed Multiple Headers are now available as standard stock items. All are supplied at mass production prices—no special tool or die costs involved. Individual sealed terminals are also included in a wide variety of standardized types. All special shapes or forms can be supplied to exact specifications at slightly higher cost.

All include Pyrex glass bead—immune to thermal or electrical shock. Pyrex annealed to eliminate strain. Kovar electrode and shell solders and welds easily and forms absolute vacuum tight chemical bond with glass—lead becomes integral part of housing. Multiple Headers can be fabricated in any form to specification—write today.



EI INC

ELECTRICAL INDUSTRIES • INC.

42 SUMMER AVENUE, NEWARK 4, N. J.

YOU

SHOULD KNOW

. . . the advantages of buying from a Complete Manufacturer, such as SNYDER.

Prompt Delivery
Better Price
Production Control
Maintenance of high Standards

When permissible SNYDER will be first.

ANTENNAE by

SNYDER

MANUFACTURING CO. • PHILADELPHIA

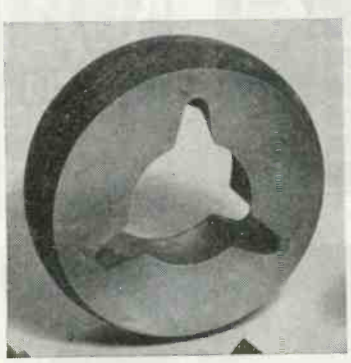
COMPLETE MANUFACTURERS FROM START TO FINISH

• With red points as scarce as they are, this mistake is understandable but, when a design engineer says he wants a field of 3500 *GAUSS*, the chances are good that he has something else in mind—possibly a permanent magnet.

And if it *is* a permanent magnet, it's an odds-on bet that he'll be tough about such details as size, shape, weight, allowances for grinding and other factors he considers essential.

Neatest way out of any such situation is to humor him—"Yes" him—tell him to stay right where he is while you get in touch with Cinaudagraph, where they speak his language.

4-CC-2



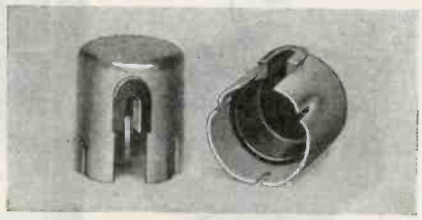
Typical of the many varieties of Permanent Magnets designed and made by Cinaudagraph.

CINAUDAGRAPH CORPORATION

2 Selleck Street Stamford, Connecticut

with the attached lead. The cap also clamps to the lead wire providing strain relief. This particular cap is made for $\frac{9}{16}$-in. diameter tube top cap, but others are available with top or side lead for most similar applications where a series resistor is required in the lead of the connector.

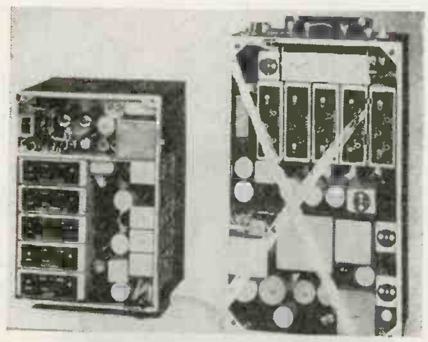
The second product is the TCIM patented tube cap shield which is

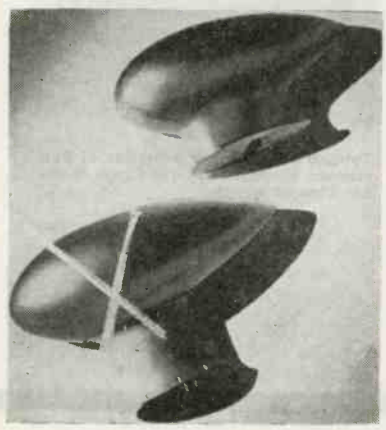


now available to industry. It provides, in addition to electrostatic shielding, a molded insulating lining which prevents the tube top cap from grounding to the shell. It also provides a smooth rolled edge for the lead wire entrance to eliminate chafing caused by vibration.

Aircraft Radio Direction Finder

THESE NEW RADIO direction finders for aircraft have a receiver that is lighter and smaller than the older models. The new compass is a 4-band instrument (instead of three bands used in the older model SCR-269) which operates on regular air-





"CLIENT WILL BUY A BUSINESS"

If some of your War activities cannot be continued profitably in Peacetime, then perhaps a client of ours* can help you.

Our client wishes to buy a going business or a complete department of a permanent organization.

This is to help them in the rapid expansion of a growing concern whose success is due to Electrical and Electronic Engineering talent, backed by proven merchandising ability.

Anything that can be made and sold to any branch of Electrical Communications will interest them; this includes Radio, Telephone, Telegraph, Television, Radar, Wire Photo, Sound on Film, Wire or Disc. An accessory widely used in these fields would be ideal.

Also, any items that would carry their technical ability into Industrial markets or into Air, Ground or Marine Transportation would be attractive.

They are particularly interested in products with protected positions either by virtue of patents, special "know-how" or limited markets; however, they would be glad to consider situations relating to mass markets.

They prefer products whose quality demands Engineering and Manufacturing skill thereby justifying above average sales prices and careful selling attention.

If you will be forced to stop work on any of your projects after V-day, either because they are out of line with your Peacetime activities or because they have insufficient sales volume to be of interest, then our client would like to meet you.

They would like to study your situation with reference to their ability to take over one of your projects, either now or later, and continue it on a mutually profitable basis.

All answers will be held confidential. Please reply to:

Cory Snow, Inc.

•MERCHANDISING•ADVERTISING•

739 BOYLSTON ST. BOSTON 16, MASS.

**We are authorized to furnish the name of our client if requested on your business letterhead.*

craft supply of 28-volt dc. Alternating-current voltages for the indicators and the loop drive motor are produced by a small vibrator. Reception continues if the a-c voltages fail since the loop can be turned manually. The fourth band is the 100-200 kc band which has been added to take radio navigational aid from the many European and Asiatic stations.

Fairchild Camera & Instrument Corp., 475 Tenth Ave., New York 18, N. Y.

One and One-Half Inch Panel Instruments

TWO MANUFACTURERS announce panel instruments of the one and one-half-inch type.

General Electric instruments utilize the internal-pivot design and are available in two forms to meet the various requirements for war equipment. A waterproof design is for use where the equipment may be accidentally submerged in water, exposed to rain, or used in extremely humid atmosphere. The conventional moisture-resisting design is for use in aircraft or other service where the instrument will be protected from the elements.

Roller-Smith instruments are designed to withstand extreme conditions of temperature, humidity, vibration and shock in aircraft service. The manufacturer states immersion tests show the units will withstand hydrostatic pressures up to 14.7 psi without case leakage. Accuracy is rated at 2 percent. They are available in all practical ranges above 50 millovolts as d-c voltmeters, and in all practical ranges above 500 microamps as d-c ammeters. Lower ranges can be supplied for other applications.

BUS-BAR
Formed in 2 PLANES to .001" ACCURACY

WITH
DI-ACRO BENDER No. 2

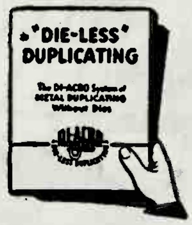
ONE-HALF ACTUAL SIZE

A heavy Copper Bus-Bar for panel board and terminal assemblies is illustrated, accurately duplicated in two planes with angles formed both flat and edgewise, across the material horizontally and vertically.

DI-ACRO Bender No. 2 has a forming radius up to 6" and capacity of ½" cold rolled solid steel bar or equivalent.

Many electrical and other parts can be duplicated without dies, saving Man Hours and Critical Materials and helping to meet rush delivery schedules. DI-ACRO Precision Machines — Shears, Brakes, Benders — form angle, channel, rod, tube, wire, moulding, strip stock; bi-metals, dielectrics, sensitized materials, fiber slot insulation, frequency reeds, etc.

Send for Catalog "DIE-LESS DUPLICATING" showing all models of DI-ARCO Benders, Shears and Brakes, and many examples of parts formed by "DIE-LESS DUPLICATING"



DI-ACRO PRECISION MACHINES DIE-LESS DUPLICATING

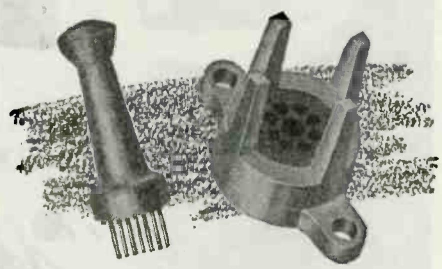
Pronounced "DIE-ACK-RO"

O'NEIL-IRWIN MFG. CO. 321 Eighth Ave. So., Minneapolis 15, Minn.

SPEED UP

MINIATURE TUBE SET ASSEMBLY . . . CUT TUBE FAILURES WITH THE

★STAR DOUBLE-CHECK SYSTEM

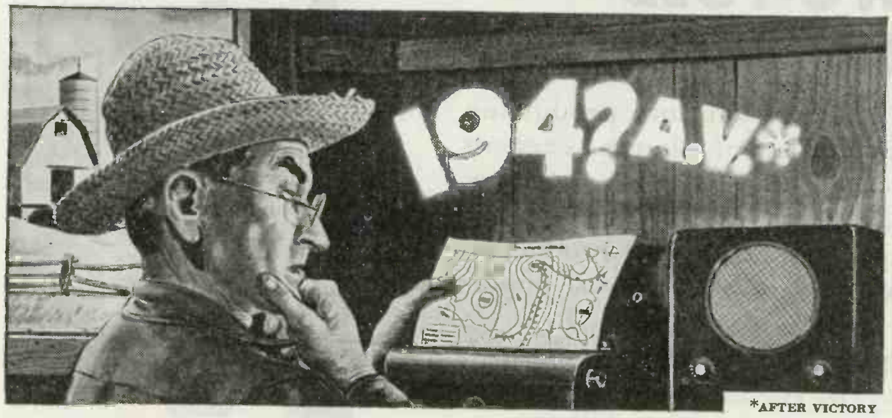


Assure high set production by equipping your Assembly Departments with STAR MINIATURE SOCKET WIRING PLUGS* to align socket contacts during wiring, and STAR MINIATURE TUBE PIN STRAIGHTENERS* to provide an easy, perfect fit when tube is inserted. A simple "double-check" that insures smoother assembly flow and fewer tube failures.

* Fills a requirement for your Assembly Department and meets the specifications of WPB Sub-Committee on Miniature Tubes.

For Complete information and prices—write
RADIO ACCESSORY DIVISION

STAR EXPANSION PRODUCTS CO.
147 Cedar Street, New York 6, N. Y.



*AFTER VICTORY

"'pears we're in for a spell of rain"

Farms in outlying districts will be able to get detailed and long-range weather maps postwar by virtue of the new radio facsimile.

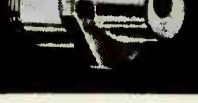
But such devices, dependent on precision parts, will only be made available to the public on a large scale with precision manufacture *on a mass-production, low-cost basis.*

Precision techniques that keep costs down and volume production up has been the basis of the Ericsson operation for the last 30 years—with the precision of war only increasing our knowledge. If you have a postwar precision problem, you might find it interesting to discuss with us.

(*Below*) Some of the many thousands of our precision parts that help "Keep 'em flying and fighting."

ERICSSON ESTABLISHED 1911

Let's All Back The Attack — Buy EXTRA War Bonds



ERICSSON
SCREW MACHINE PRODUCTS CO., INC
25 LAFAYETTE STREET, BROOKLYN 1, N. Y.

FOR
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SILVER

WIRE - SHEET - TUBING
SILVER BRAZING ALLOYS & FLUXES

PLATINUM

WIRE - RIBBON - FOIL
SEAMLESS TUBING

YOUR INQUIRIES ARE INVITED FOR ALL APPLICATIONS OF PRECIOUS METALS TO ELECTRONIC PRODUCTS.

PRECIOUS METALS — AW — SINCE 1875

THE AMERICAN PLATINUM WORKS
N. J. R. R. AVE. AT OLIVER ST.
NEWARK 5, N. J.

Electronic Timers

ELECTRONIC TIMERS, designated as Series 5000, measure $3\frac{7}{8}$ x $3\frac{3}{4}$ x $3\frac{3}{4}$ in. and are intended for built-in applications where no individual housing is necessary. The four standard types available include Models 5010, 5020, 5030 and 5040. Model 5020 requires a warm-up period of 3 sec before the unit is ready to operate. The other three models require 30 sec. The units are rated for loads up to 2 amp at 115-v ac. Mounting is achieved by an insulating strip located on the rear of the timers.

Fisher-Pierce Co., 62 Ceylon St., Boston 21, Mass.

Thyratron Tube

RCA-3D22 IS A SENSITIVE, four-electrode thyratron for use in relay and grid-controlled rectifier applications, particularly those involving motor-control service. It is conservatively rated to handle an average output current of 0.75 amp in continuous operation. The tube utilizes a sturdy and compact single-ended construction which eliminates bulb terminals with their attendant flexible leads. Because of its xenon-gas filling, the tube has a control characteristic which is essentially independent of ambient temperature throughout the range from −75 to +90 deg. C. It also has small preconduction or gas-leakage currents, low control grid to anode capacitance, and low control-grid current.

RCA Victor Div., Radio Corp. of America, Harrison, N. J.

Thermostatic Delay Relay

PORCELAIN HEATERS are utilized in this new thermostatic metal-type delay relay which has higher ratings than the unit described in August 1943 ELECTRONICS. Delays from 1 to 120 seconds can be obtained. Contact ratings are 10-amp,

Electrical Papers

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★ **ONAN ELECTRIC GENERATING PLANTS** supply reliable, economical electric service for electronics applications as well as for scores of general uses.

Driven by Onan-built, 4-cycle gasoline engines, these power units are of single-unit, compact design and sturdy construction. Suitable for mobile, stationary or emergency service.

Model shown is from W2C series, 2 and 3-KW, 60-cycle, 115 volt; powered by water-cooled, 2-cylinder engine.

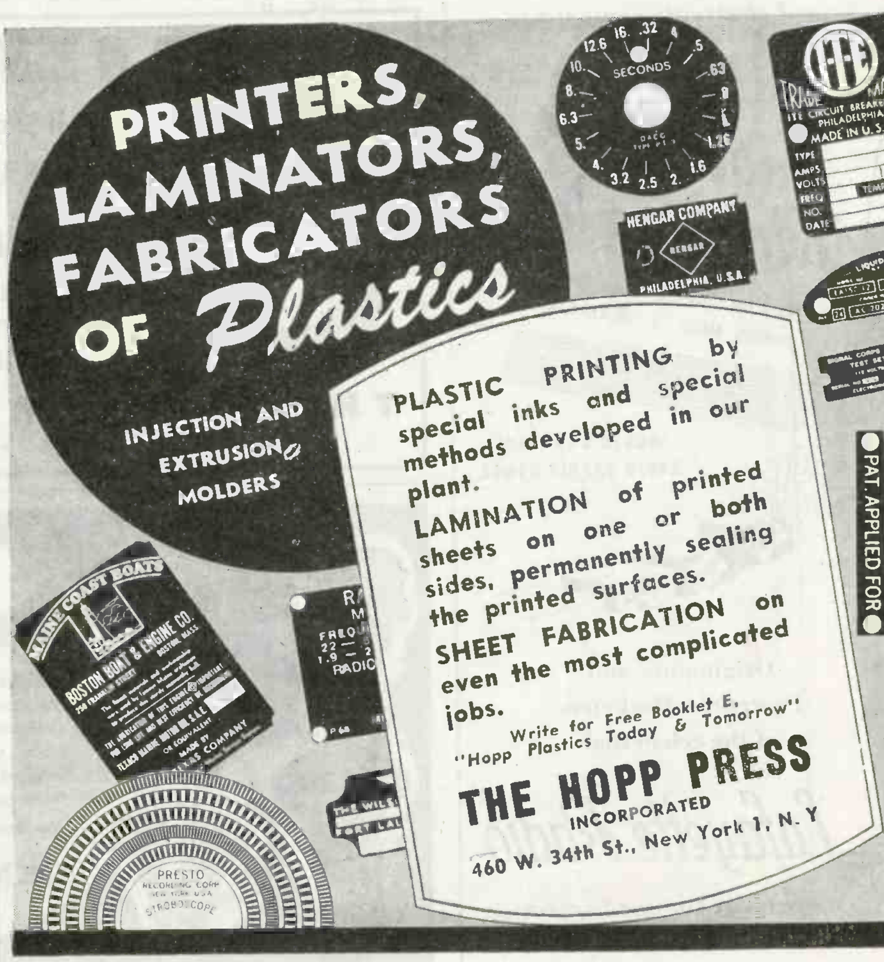
ELECTRIC PLANTS **Onan** POWER AND LIGHT FOR EVERY NEED

"Models range from 350 to 35,000 watts. A.C. types from 115 to 660 volts; 50, 60, 180 cycles, single or three-phase; 400, 500, and 800 cycle, single phase; also special frequencies.

D.C. types range from 6 to 4000 volts.

Dual voltage types available. Write for engineering assistance or detailed literature".

D. W. ONAN & SONS — 3262 Royalston Ave. Minneapolis 5, Minn.



115-volt, ac. The relay is compensated for ambient temperature changes from 40 to 110 deg F and is available as a SPST normally open, or SPST normally closed device. Hermetic sealing provides protection against altitude, moisture or other climatic changes. The unit is explosion proof, and its octal radio base permits easy replacements.

Amperite Co., 561 Broadway, New York 12, N. Y.

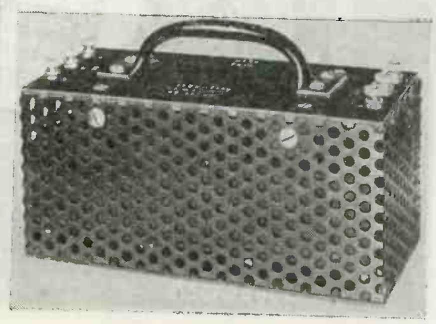
Vacuum-Tube Voltmeter

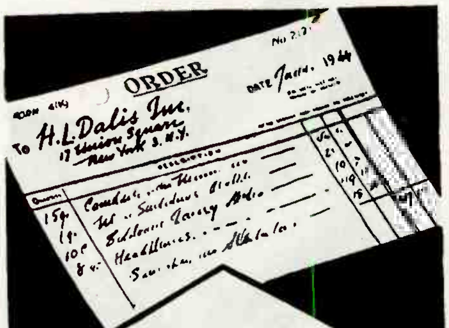
SPECIFICATIONS OF a vacuum-tube voltmeter, designated as Model VM-27, which may be used in the laboratory, or for engineering design or production testing, are as follows. The voltage range is from 0.1 to 100 volts ac or dc, and the frequency range is 20 cycles to over 100 Mc. The unit has five ranges:—1, 3, 10, 30 and 100-volts, full scale. The peak response is calibrated to read the rms value of a sine wave, or 0.707 of the peak of a complex wave. Accuracy is rated better than 2 percent on all ranges. The unit is factory adjusted, and operates from 105 to 125 volts, 60 cycles. It consumes 30 watts of power.

Alfred W. Barber Laboratories, 34-04 Francis Lewis Blvd., Flushing, N. Y.

Isolating Transformer

THE PRODUCT illustrated is an isolating transformer (designated as Catalog No. 7242) for use in the laboratory, and for testing and portable applications. The unit is wound for three-phase but may be employed on single-phase circuits. It is a compact component, rated 250 va, 115 volts, 1:1 ratio. Frequency range is 60 to 400 cycles. Units are rugged and drip-proof,





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And to help you order just what you need, we have the big Dalis catalog which is yours for the asking. Write on your business letterhead for your copy.

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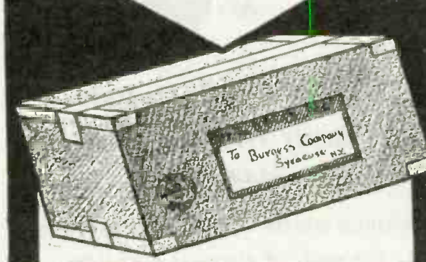

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MOLDED TERMINAL STRIPS

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Available in lengths from 1 to 20 terminals.
2 Types: NAS 17 and NAS 18. Prompt deliveries.

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36 YEARS OF PLASTIC MOLDING EXPERIENCE

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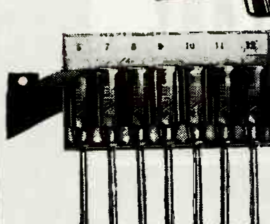

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NUT DRIVERS

Xcelites are just the nut drivers for your "close Quarters" electrical work! Hollow shaft (insulated, if desired) fits easily over long bolts. Finely-machined socket grips two nuts at once! Genuine Xcelite handle is fire and shock resistant. Available on satisfactory priorities, delivery necessarily delayed by wartime conditions. Ask your dealer or write Dept. C now!

A Handy Set in Holder

Saves time, too! Seven Xcelite nut drivers, each with different colored handle to flash you the size at a glance . . . complete in sturdy metal holder. Nut sizes 3/16"-3/8". Enjoy these short-cuts by ordering now!

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Orchard Park New York
Back the Attack *Buy More War Bonds*

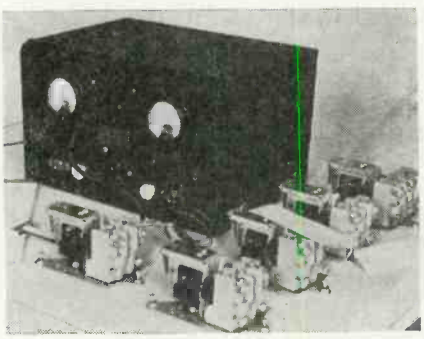
XCELITE QUALITY TOOLS PREFERRED BY THE EXPERTS

measure 8½ x 5½ x 4 in., and weigh 16½ lb.

New York Transformer Co., 26 Waverly Place, New York 3, N. Y.

High Voltage Tester

MODEL NL5-H5 unit (illustrated) is a lightweight, compact high voltage supply for testing corona effects, leakage and breakdown of all types of dielectrics and assemblies. The unit can be supplied with an auxiliary capacitor network for momentary high current breakdown tests. Normal current range is 0 to 2½ milliamp. The auxiliary capacitor network is designated as Model NL5-H5-IU and is furnished

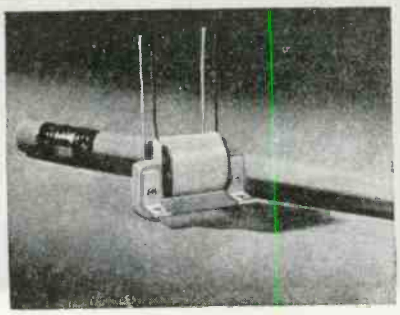


in a separate steel box with a large standoff insulator for high voltage terminals. Ranges of the tester are from 0 to 5 kv, 0 to 10 kv and 10-0-10 kv (10 kv each side of ground or 20 kv between output terminals). The increment of voltage from zero to maximum rating is indicated by a calibrated voltmeter. A milliammeter indicates commencement of leakage and also gives quantitative indication. A safety feature is the use of a micro-switch to operate the high voltage relay when the cover is lifted. Voltage is controlled by a variable transformer. Accessories include three 6-ft test leads with banana jacks and alligator clips. The unit can be used for either laboratory or production testing.

Northern Laboratories Ltd., 3-01 27th Ave., Long Island City 2, N. Y.

Midget Transformer

THESE TRANSFORMERS measure 31/32 x 37/64 x 7/16 in. and are small enough to be incorporated directly into the cases of earphones or hand-held microphones. They utilize a new design and new materials, and are



designed to operate with a uniform frequency response within ±2 db from 100 to 8000 cycles. Units can be made with windings to provide impedances as high as 200,000 ohms, and when used as a choke coil, with inductive reactance as high as 1 megohm. Units may be potted, shielded or hermetically sealed.

Permoflux Corp., 4900 W. Grand Ave., Chicago 39, Ill.

Wire-wound Resistors

AN ADDITION TO this manufacturer's line of components are Type GRW wire-wound resistors which meet Army-Navy specification JAN-R-26. Seven standard sizes are available (GRW-10 to GRW-16 which correspond to Army-Navy types RW-10F to RW-16F). Resistance values covered by these seven types are from 0.1 ohm to 46,000 ohms, with power ratings from 15 to 140 volts. The units are completely sealed and have pyrex-glass enclosure tubes which are specially heat-treated to achieve optimum stress distribution and to provide increased resistance to thermal shock and mechanical damage. Connections are welded rather than soldered.

International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

H-F Paper-Dielectric Capacitors

A NEW LINE of high-frequency paper-dielectric capacitors (available in ratings of 5000 to 20,000-volt dc, 0.01 microfarad) are available primarily for grid and plate-clocking service in electronic oscillator circuits of h-f induction-heating equipment. They can also be used to advantage in other h-f oscillator circuits. By the use of three

paper-dielectric capacitors instead of four mica capacitors, costs may be reduced plus lower losses and lower voltage drop across the capacitor. The capacitors are hermetically sealed in rectangular metallic cases, and are supplied with removable footed-type brackets, which provide for four-point mounting in any position. The 20,000-volt rating is available in two designs—one in a plain case, and the other with cooling fins to permit a higher current-carrying capacity.

Bulletin GEA-4388 tells about these capacitors and is available from General Electric Co., Schenectady, N. Y.

Ceramic Insulation

MYCALEX K SERIES is a new ceramic for use as a dielectric in capacitors. It can be supplied with dielectric constant values ranging from 8 to 15, at 1 Mc. Mycalex K-10 has been approved by Army-Navy (Jan. 1-12)

as Class H material. K Series is available in thicknesses of $\frac{1}{8}$ to 1 in., in 14 x 18-in. sheets; in thicknesses down to $\frac{1}{32}$ in. in smaller sheets; and from 14 to 18 in. rods, measuring $\frac{1}{4}$ to 1 in. in diameter. The material can be readily molded and machined.

Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.

Loudspeaker

RANGING IN SIZES from 2 to 15 in. is a complete new line of loudspeakers which will handle capacities from 1 to 20 w and which are designed to give an acoustical output in 2-db steps. A magnet alloy is used to provide magnetic efficiency and to save weight. The speakers are dust proof. Metal parts are rust-proof finished. Permoflux Corp., 4900 W. Grand Ave., Chicago 39, Ill.

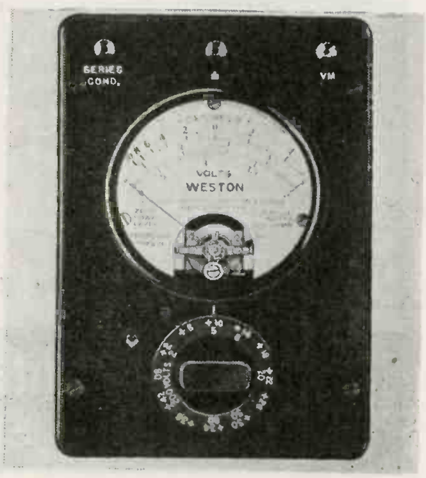
Lightweight Blower

A NEW LIGHTWEIGHT blower for heat dispersion is Model No. 2½ which has been added to this manufacturer's line. The unit weighs 3½ oz and delivers 50 gfm at 8000 rpm. It is not affected by climatic or temperature changes, and is available with shaft bores of either 0.1895 in. or ¼ in.

L. R. Manufacturing Co., Torrington, Conn.

Portable Test Meter

MODEL 695, Type 11, a compact, portable instrument, which is essentially a rectifier-type voltmeter, provides readings in decibels (from −4 to +35 in all ranges), as well as in volts (from 2 to 200, in 7 a-c ranges). The meter can be used for power-level measurements in all types of sound equipment and in radio receivers. Constant impedance is 20,000 ohms. When connected across any sound line, the ranges can be shifted continuously without varying the line impedance. A self-contained condenser provides blocking for any d-c component. The instrument is cali-



brated for 500-ohm lines with zero level of 6 milliwatts or 1.732 volts. With each instrument a chart is provided which gives interpolation values on lines other than 500 ohms. Test leads are supplied. Dimensions are approximately 5½ x 3¾ x 3⅛ in.

Weston Electrical Instrument Corp., 617 Frelinghuysen Ave., Newark 5, N. J.

Literature

FM Program Transmission. This is the title of a 12-page brochure released by American Tel & Tel (195 Broadway, New York, N. Y.) in answer to the question of whether the Bell System can provide program transmission channels which will meet the present and future needs of fm broadcasters. The booklet points out that the Bell System already is furnishing studio-transmitter links to the majority of fm stations now in operation. These links transmit a frequency band of 15,000 cycles as specified by FCC. The booklet also states that present broad band carrier telephone facilities can readily be adapted for 15,000-cycle program circuits by adding special terminal equipment. Another statement points out the fact that whether wire or radio links are used to transmit fm programs, the Bell System will use them, citing as evidence of this the A.T. & T.'s projected microwave radio-relay system between New York and Boston. This trial installation was under development before the war, and is intended to test broad-band transmission by radio of various types of communications, including long distance telephone messages and television, as well as broadcast programs. Directed radio beams will operate simultaneously in both directions and be relayed at stations situated about 30 miles apart.

Test Instruments. Such instruments as Model 785 industrial circuit tester, Models 665, 663 and 697 volt-ohm-milliammeters, Model 689 ohmmeter, Model 796 insulation tester, Model 564 volt-ohmmeter, Model 772 analyzer, Model 633 a-c

clamp-ammeter, Models 461 and 539 current transformers are described and illustrated in Circular R-24-C, an 8-page booklet entitled "Multi-Range, Multi-Purpose Test Instruments" which are for use in industry, laboratories and schools. Weston Electrical Instrument Corp., Newark 5, N. J.

Technical Monographs. These monographs are a series of booklets available from the Technical Service Dept., of Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago 38, Ill., and are available at 25 cents each. Monograph No. 1 on loudspeaker-response measurements was announced in November 1944 ELECTRONICS. Monograph No. 2 is titled "Impedance Matching and Power Distribution in Loud Speaker Systems." Monograph No. 3 is titled "Frequency Range and Power Considerations in Music Reproduction." No. 4 is called "The Effective Reproduction of Speech."

General Catalog. Nineteen types of measuring instruments are described and illustrated in Catalog No. 45 which also gives a brief summary of the background of Ferris Instrument Co., Boonton, N. J.

Control Instruments. General information as well as circuits and ratings are contained in Bulletin No. 149 which tells about Powerstat variable transformers which are used to obtain continuously variable output voltages from a-c power lines. Bulletin No. 116 describes other types of Powerstats. Superior Electric Co., Bristol, Conn.

Electrical Connecting Devices. A new 32-page catalog, No. 14, illustrates and describes a complete line of multi-contact plugs and sockets, terminal strips, fuse mounts, barrier strips, etc., available from Howard B. Jones Co., 2460 W. George St., Chicago 18, Ill.

Resistor Guide. Technical engineering data giving types, descriptions and specifications on eighteen different resistors is contained in a 4-page folder available from Madison Electrical Products Corp., Madison, N. J.

Electrical Contacts. Standard forms and sizes and typical as-

semblies are contained in a 4-page folder, designated as Catalog C-11, which tells about solder-backed contacts manufactured by Gibson Electric Co., 8350 Frankstown Ave., Pittsburgh 21, Pa.

"Know-How" Booklet. "Lear Know-How" is the title of a new booklet which gives a complete story of this manufacturer's equipment in its present and potential uses. Lear, Inc., Piqua, Ohio.

Component Circular. A 2-color, 4-page circular describes relays, switches, condensers, coils and other products made by Comar Electric Co., 2701 Belmont Ave., Chicago 18, Ill.

Components Catalog. Catalog No. 100 contains complete information on many of the radio and electronic components available from Cambridge Thermionic Co., 445 Concord Ave., Cambridge 38, Mass. Products described include terminal lugs, x-ray oriented crystals, u-h-f i-f transformers and pressure and hand-swaging tools.

Wire Catalog. Firewall aircraft wire for aircraft control, power, instrument and lighting circuits is described in a 24-page catalog (Bulletin No. 53-A). Rockbestos Products Corp., New Haven 4, Conn.

Radio Parts and Hardware. Some 500 items consisting of chemicals and hardware for use in radio are described in a 20-page catalog. Walter L. Schott Co., 9306 Santa Monica Blvd., Beverly Hills, Calif.

Coupling Transformer, Plugs and Jacks. Bulletin No. 31 contains data on a rhombic antenna coupling transformer, and on coaxial plugs and jacks. Andrew Co., 363 East 75th St., Chicago 19, Ill.

Background Brochure. The title of this brochure is "Case Book" which portrays the personnel and factory operations involved in the manufacture of Harvey-Wells communications equipment. Illustrations and brief descriptions of various types of instruments available are also given. Harvey-Wells, Inc., Southbridge, Mass.

NEW BOOKS

Vibrator Analysis

By N. O. MYKLESTAD, *Research Associate, Guggenheim Aeronautical Laboratory, California Institute of Technology, McGraw-Hill Book Co., Inc., New York*, 300 *pages, price* $3.50.

RARELY DOES the dean of an engineering science take time out from his research to publish a text expressly written for the uninitiated. However, Mykelstad has presented the fundamentals and analytical methods for studying vibration with especial care to define terms so that the beginner will not be misled or confused.

Undamped and damped vibrations, free and forced vibrations, and vibrations of several degrees of freedom both translational and rotational are discussed. The final chapter culminates in an analysis of flutter of propeller blades. Each section contains problems with answers as well as illustrative examples and solutions.

To the electrical engineer the mathematics of these mechanical vibrations will readily be recognized as that of transient circuit analysis, except for the different symbols and their physical significance.—F.R.

• • •

British Standard Glossary of Terms Used in Telecommunication

B.S. 204: 1943, *published by British Standards Institution*, 28 *Victoria St., London, S.W.*1, 107 *pages, price* 3/6. *Also available from American Standards Association*, 70 *East Forty-fifth St., New York* 17, *N. Y.* (*price* $1.25).

THIS SECOND REVISION (first published in 1924; first revision in 1930) of one of the few authoritative glossaries of electronic terms in print defines with British terminology the technical terms used in speech testing and acoustics; in transmission practice; in vacuum-tube design and use; in cathode-ray tube applications; for electrical characteristics of transmission circuits and equipment; in telegraphy, telephony, radiocommunication, television, and radio direction-finding; and for fire alarms.

According to H. M. Turner, past-president of IRE, who reviewed the standard in *Industrial Standardiz-*

ation, essentially the same subject matter is covered as in the standard on corresponding American terms. He notes a few departures, however, particularly in the inclusion in the British standard of such unfamiliar terms as psophometric voltage, logatom, chronopher, omniaerial ,and singing suppressor. The terms Klystron and rhumbatron are defined in this publication for the first time.

• • •

Dictionary of Engineering and Machine Shop Terms

By A. H. Sandy, *Instructor and Lecturer, Borough Polytechnic, London. American edition published by Chemical Publishing Co., Brooklyn, N. Y., 1944, 153 pages, $2.75.*

Compiled in this handy volume are the definitions of many important terms used in machine shops, industries and engineering literature, as gathered by the author during many years of experience both in industry and as a lecturer. Its clear and simple language will make this dictionary useful not only for engineers and students of engineering, but also for foremen and specialized workmen of the various shops and industries. Electronic engineers concerned with production problems will find here in convenient form the definitions of many unfamiliar terms.

• • •

What are Cosmic Rays?

By Pierre Auger, *Ecole Superieure Normale, Paris. University of Chicago Press, Chicago 37, Ill., 1945, 150 pages, $2.*

The author has written primarily for an educated scientifically-inclined public who want to be familiar with current developments in science without having to acquire a knowledge of physics and mathematics. The subject is not one in which the average layman can find interest, however, for three reasons: first, cosmic rays have not yet been put to practical use; second, no effect on humanity has yet been discovered; and third, they are still a scientific curiosity of unknown origin and value, at least as far as the book discloses. On the other hand, however, the fact that scientists have during the past 40 odd years gone to the ends of the earth, miles above the earth, into deep mines in the earth, and

far down in the oceans to check the intensity and variations in cosmic rays, deserves the attention at least of thinking men.

The translator, Maurice M. Shapiro, points out that this is the only volume in English that gives a broad and up-to-date discussion of all the major cosmic-ray phenomena. Arthur H. Compton, winner of the Nobel Prize in physics in 1927, recommends it with the statement that "For the audience for which it is intended, the book is distinctly the best that has yet appeared."

The story of the discovery of cosmic rays is told first and various detecting devices described and illustrated. These devices provided means of indicating ionization of gases, which is produced by cosmic rays. The studies are then traced through "the heroic epoch" during which "investigators plunged with fervor into an exploration of the new terrain", gradually making order out of chaos. The studies here included the well known stratosphere balloon flights, such as that by Piccard, the Belgian professor of physics. One result of this study is that "today the variations of latitude of cosmic-ray ionization are well known, and they provide a conclusive argument in favor of the corpuscular and electrically charged nature of the primary cosmic radiation." Also the extra-terrestrial origin of the cosmic particles has been proved. However, question No. 1, "what is the origin of the rays?" remains unanswered. The fifth and final chapter summarizes existing data.

The author has made an effort to give the book a popular flavor by means of chapter subjects and sub-headings such as: The physicist is defied, enter Jules Verne, a cosmic rainstorm, cosmic block-busters, a phantom particle, and epitaph of a mesotron. If these headings lead the reader to expect as easy and pleasant reading as Paul de Kruif's articles on medical research and progress, he is sure to be disappointed. It will take more persistent effort to stay with it, and concentration to learn from it.—M.G.V.

• • •

NOTE: The price of "Theory and Application of Electron Tubes", Second Edition, by H. J. Reich, is $5.00 as stated in the Dec. 1944 issue of ELECTRONICS, and not $4.50 as erroneously given in the Jan. 1945 issue.

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published

Who Invented the Electron Microscope?

Dear Sirs:

MR. L. A. AUSTRIAN, in his letter on page 380 of your December 1944 issue, has evidently mistaken the Ultra Microscope, invented in 1902 by H. Siedentopf and R. Zsigmondy[1], for the Electron Microscope which was invented nearly thirty years later and was then industrially developed in Germany and in this country.

The Ultra Microscope makes use of visible light, illuminating submicroscopic particles transversely to the direction of vision and thus forming an image consisting merely of irregular points, without any definition.

The other reference of Mr. Austrian with respect to the Electron Microscope contains inter-German polemical material all of a later date than the priorities of the U. S. Patents of Dr. Rüdenberg cited by me, which are of May 30, 1931. Hence I referred[2] to this scientist as the true inventor of the Electron Microscope. In his basic patents this modern instrument is described for the first time with all the fundamental and necessary details. Usually we call the originator of such patents the inventor of the new device.

HARRY STOCKMAN
Cruft Laboratory, Harvard University Cambridge, Mass.

(1) *Ann. d. Phys.*, 10, p. 1, 1903.
(2) ELECTRONICS, p. 362, Mar., 1944.

• • •

Cold-Water Cure

Dear Mr. Henney:

UNPREPARED LISTENERS confronted with high and low fidelity reproduction and asked to choose between them will invariably choose the low fidelity. The reasons are many but are mainly those mentioned in your editorial on the subject.

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for low fidelity reproduction was a real problem to me in manufacturing and trying to sell (at fancy prices) high fidelity reproducers. The answer to it was very simple.

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But after he had submitted to this torture he was asked to listen to a well-balanced high fidelity reproduction of the same record. This he found extremely pleasing until suddenly in the middle of it we turned the tone control full on, cutting out everything above about 3500 cycles in the manner of the best commercial consoles. His disgust at this effect was as great as his horror of the distortion in the other direction.

By this roundabout process we at least sold our reproducers, and to the best of my knowledge all our customers have remained sold on them. Perhaps the method was not a fair test of listener preference but it was the only simple and quick way of removing the long "wash-tub" conditioning to which commercially available radios had subjected him.

SUTHERLAND MACKLEM
Inspection Board of United Kingdom and Canada
Ottawa, Ont., Canada

• • •

On the House

Dear Mr. Henney:

WOULD IT BE POSSIBLE to insert a correction notice into an early issue of ELECTRONICS in regard to the following typographical error in my article, Relays in Industrial Tube Circuits, Jan. 1945.

On the 4th and 3rd lines from the bottom in the left column of page 137 it reads:

$$G_m' = G_m r_p\ (r_p + R_l)$$

This should read:

$$G_m' = G_m\ r_p/(r_p + R_l)$$

Of course, this error would not fool an expert, but I feel, that its correction would be in line with the high standard of ELECTRONICS.

ULRICH R. FURST
Chicago, Ill.

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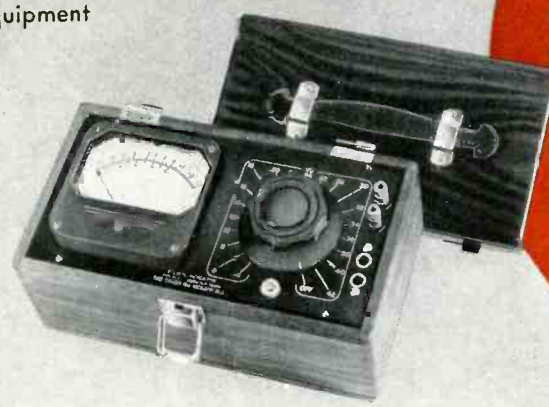

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TYPE 910
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