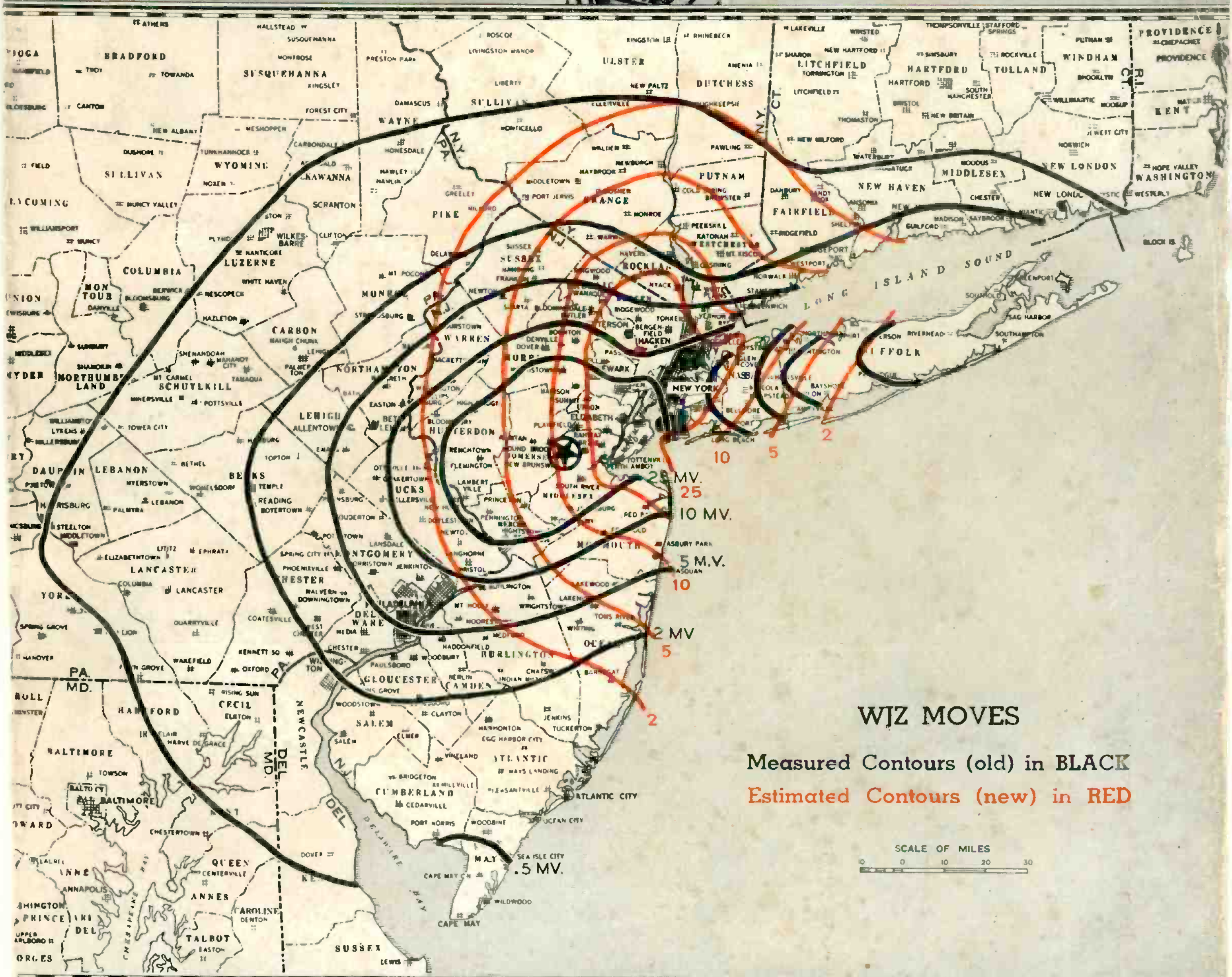
electronics



OCTOBER - 1943

electronics

OCTOBER • 1943

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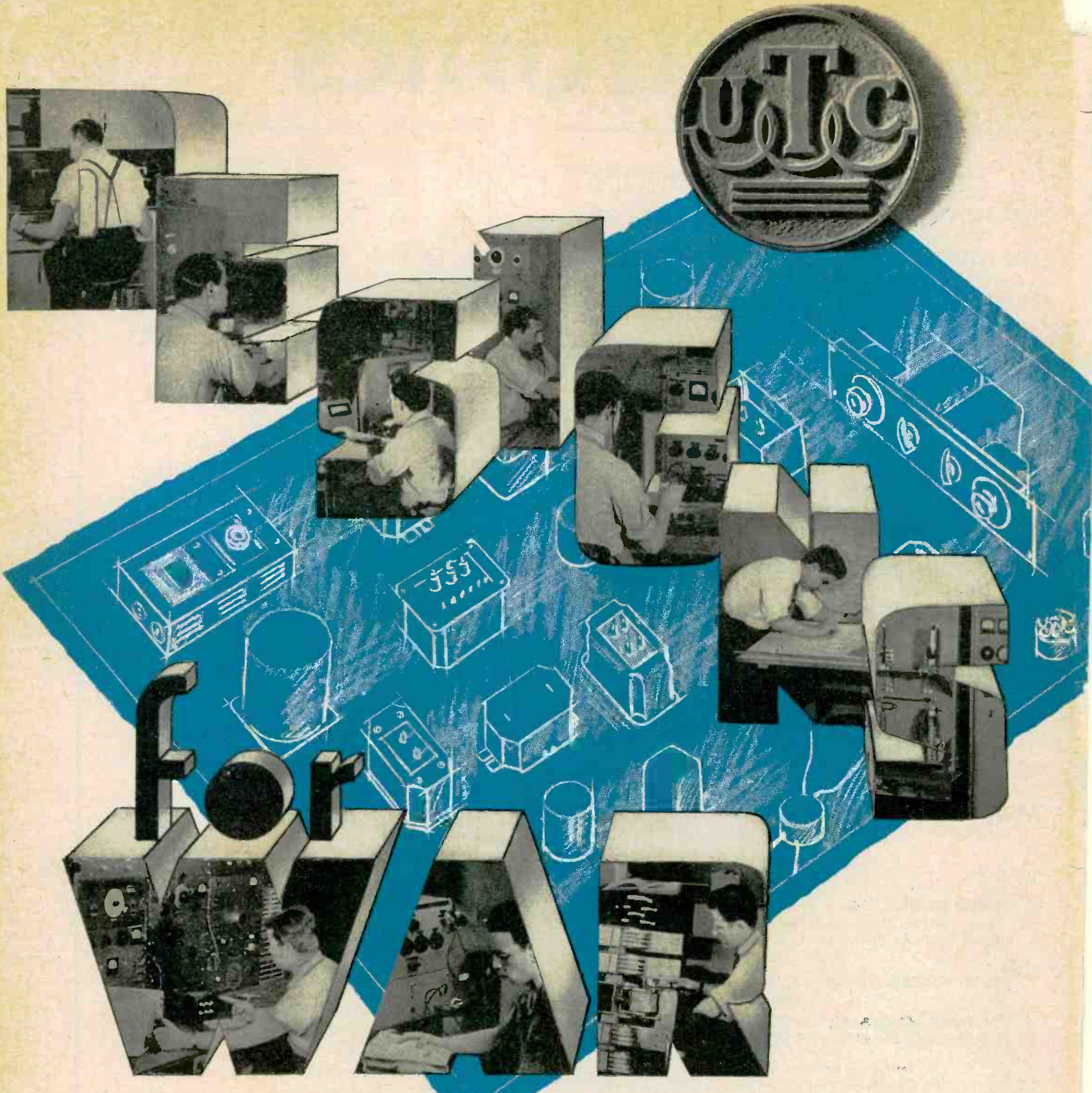

The bulk of UTC production today is on special units designed to specific customers' requirements. Over 5,000 new war designs were developed this past year. These designs ran from open type units to hermetically sealed items capable of many cycles of high and low temperature and extreme submersion tests. They included units from 1/3 ounce in weight to 10,000 lbs. in weight and from infinitesimal voltages to 250,000 volts. It is impossible to describe all these thousands of special designs as they become available. Our staff of application engineers will be more than pleased to discuss your problem as related to special components.

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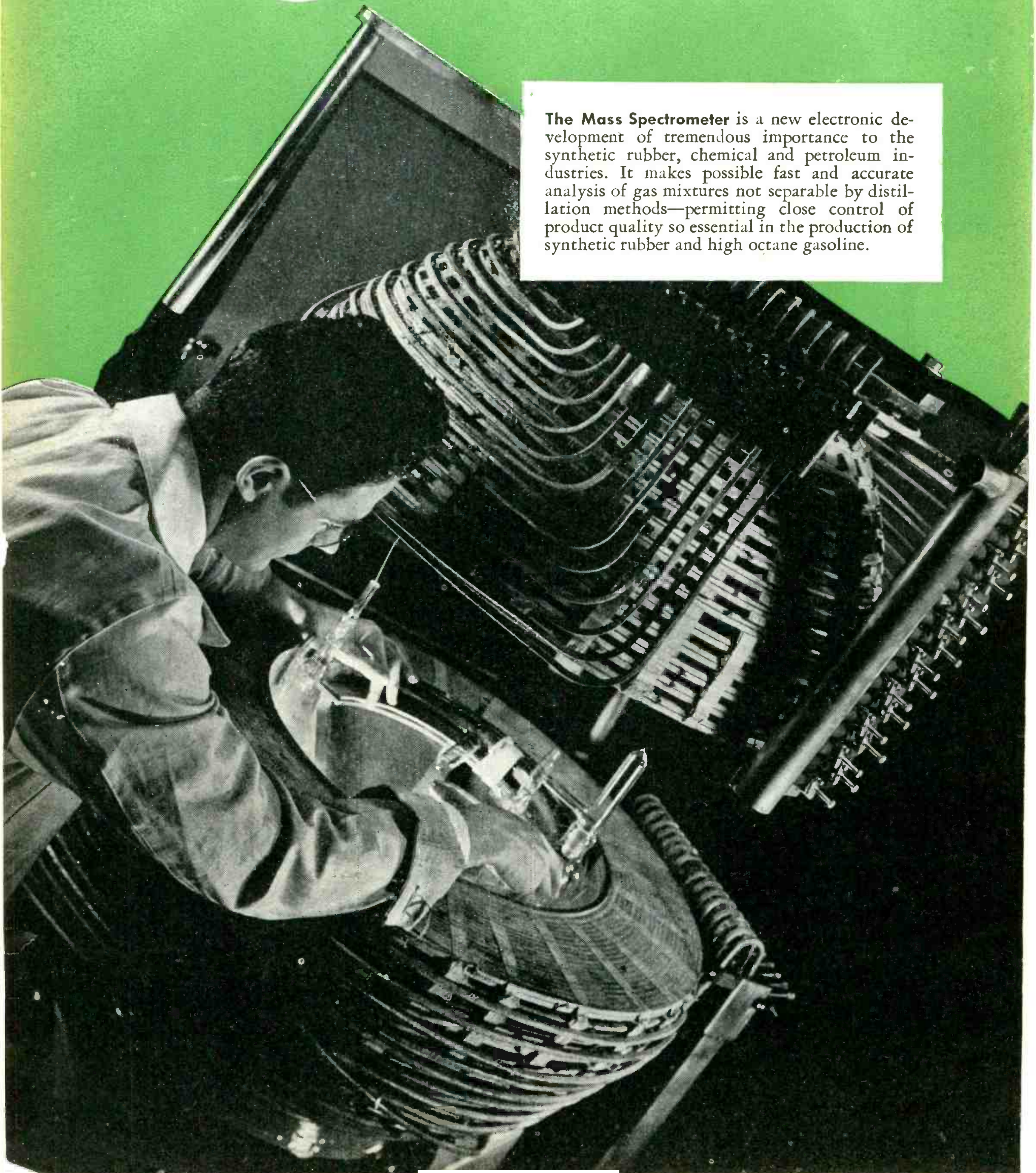
Electronics

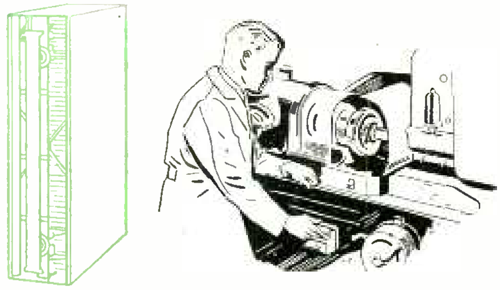


The Mass Spectrometer is a new electronic development of tremendous importance to the synthetic rubber, chemical and petroleum industries. It makes possible fast and accurate analysis of gas mixtures not separable by distillation methods—permitting close control of product quality so essential in the production of synthetic rubber and high octane gasoline.

. . at Work

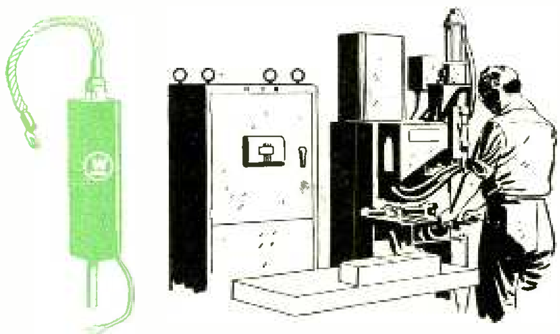
Electronic science is serving America's wartime industry in countless ways. New and better techniques are being constantly developed. Established production processes are being speeded up and improved. Here are a few of the ways Westinghouse scientists and engineers are putting electronics to work.

Bacteria and Mold are Destroyed by ultra-violet radiation produced by the Westinghouse Sterilamp, an electronic tube. Sterilamps are widely used to sanitize the air in rooms or working areas where pharmaceuticals, medical supplies or foods are prepared, processed or stored.



Where Precision Work is carried on, PRECIPITRON* electric air cleaners remove tiny abrasive and corrosive particles that might damage highly finished surfaces. Electronic tubes rectify current, which charges every dust-bearing particle. These particles are drawn to, and precipitated on, charged collector plates.

"Bonding" Plywood is an important new application of high-frequency heating. Operations which formerly took hours are now performed in minutes. Vacuum tube oscillators, similar to radio broadcasting tubes, are used to produce uniform heating throughout the piece—without injury to finish or structural qualities.



Storing Electrical Energy for resistance welding operations permits current to be drawn slowly from the a-c line—and applied in exactly equal amounts to produce strong, uniform welds. As the operator presses the switch, an exactly uniform amount of current is delivered for each weld by Ignitron tubes.

*Trade mark registered

J-91033

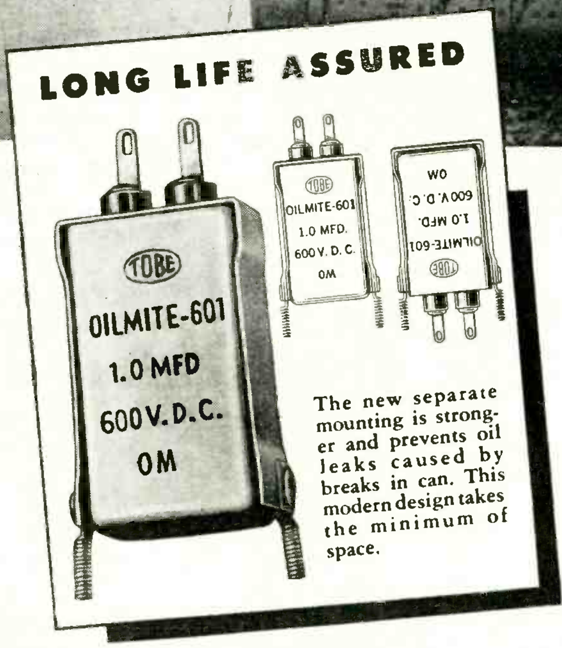
For further information on Westinghouse Electronic devices, write for Booklet B-3264. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

WESTINGHOUSE W

Westinghouse ELECTRONICS

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

U. S. S. Constitution—"Old Ironsides"



YOU WANT capacitors that can stand up and take it. The well-nigh flawless record of Tobe Capacitors as to "returns" proves they have that outstanding requirement of durability.

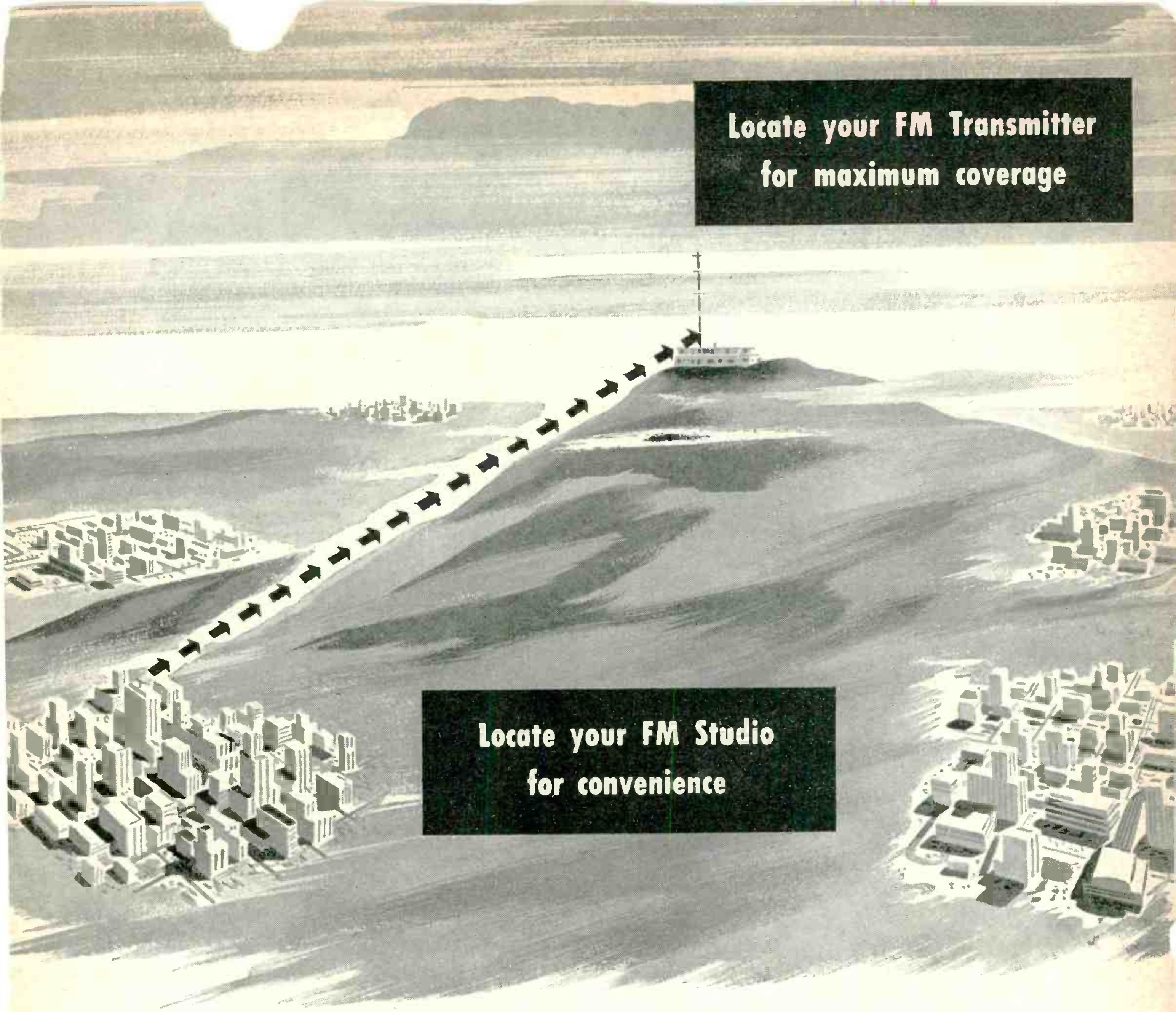
This quality is built into each and every Tobe Capacitor by advanced engineering practices and production methods. And their rating is always an "understatement".

Shown here is the Tobe Oilmite Capacitor. Filled and impregnated with mineral oil it is used as a filter condenser in war equipment. The new hold-down bracket permits inverted or upright terminals, with wiring either underneath or on top of chassis.

TYPE	OM
RATINGS	.05 to 2.0 mfd. 600 V.D.C. .05 mfd. to 1.0 mfd. 1,000 V.D.C.
STANDARD CAPACITY TOLERANCE.	= 10%
TEST VOLTAGE	Twice D.C. rating
GROUND TEST	2,500 Volts, D.C.
SHUNT RESISTANCE	.05 to 0.1 mfd. 20,000 megohms. .25 to 0.5 mfd. 12,000 megohms. 1.0 to 2.0 mfd. 12,000 megohms.
POWER FACTOR	At 1.000 cycles—.002 to .005
CONTAINER SIZE	Width 5/8", length 1-5/16", height 2¼"
MOUNTING HOLE CENTERS	1½"

TOBE DEUTSCHMANN CORP.
TOBE
CANTON · MASSACHUSETTS

A SMALL PART IN VICTORY TODAY—A BIG PART IN INDUSTRY TOMORROW



Bridge the gap without wires with a G-E *ST relay*

PROGRAMS from W41MM, the Gordon Gray studio at Winston-Salem, N. C., are today being relayed, *without wires*, to its 3-kw transmitter high on Clingman's Peak 110 *miles away*. A G-E Station-to-Transmitter unit makes this wireless relaying possible. In similar use at FM stations in Chicago and Schenectady, and at international short-wave stations in Boston and New York, the S-T relay has proved its economy, reliability, and unequaled transmitting fidelity in months of flawless day-in, day-out service.

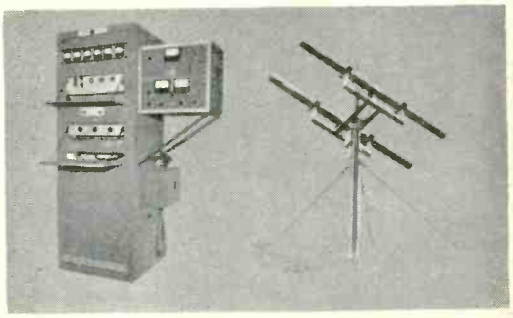
General Electric S-T equipment permits complete FM program fidelity from 30 to 15,000 cycles . . . the total range of the human ear. This apparatus takes the place of technically inadequate or prohibitively expensive wire-line construction . . . for *no* connecting wires are needed! General Electric alone has pioneered and developed this wireless type of equipment . . . and G. E. is the only manufacturer who can supply it.

A complete General Electric S-T relay-equipment installation includes:

1. A 25-watt FM transmitter.
2. A rack-mounted station monitor.
3. A double-conversion, crystal-controlled superheterodyne FM receiver.
4. Special directional antennas that provide a 100-fold power gain between studio and transmitter.

It's not too soon now to start locating the site for your post-war FM transmitter. G. E. has the experienced engineering personnel to help you find the best location, the S-T relay transmitter and receiver to reach it, and the studio and antenna equipment to operate it . . . plus broadcast and programming experience to help you select and train your future FM engineering and studio staffs. We welcome your inquiries. *Electronics Department, General Electric, Schenectady, New York.*

Tune in "THE WORLD TODAY" *and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to "The Hour of Charm" at 10 P. M. E.W.T. over NBC.*

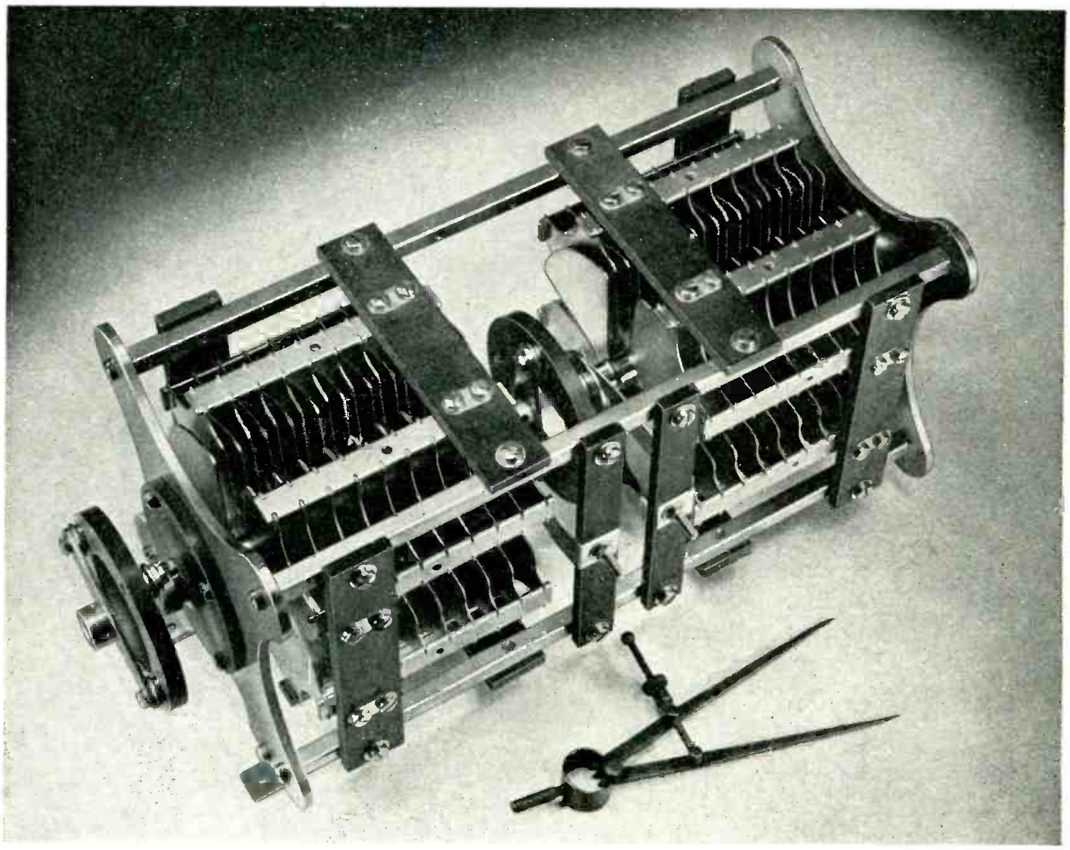


GENERAL ELECTRIC FM · TELEVISION · AM

160-88

STUDIO EQUIPMENT • TRANSMITTERS • ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

LEADERSHIP



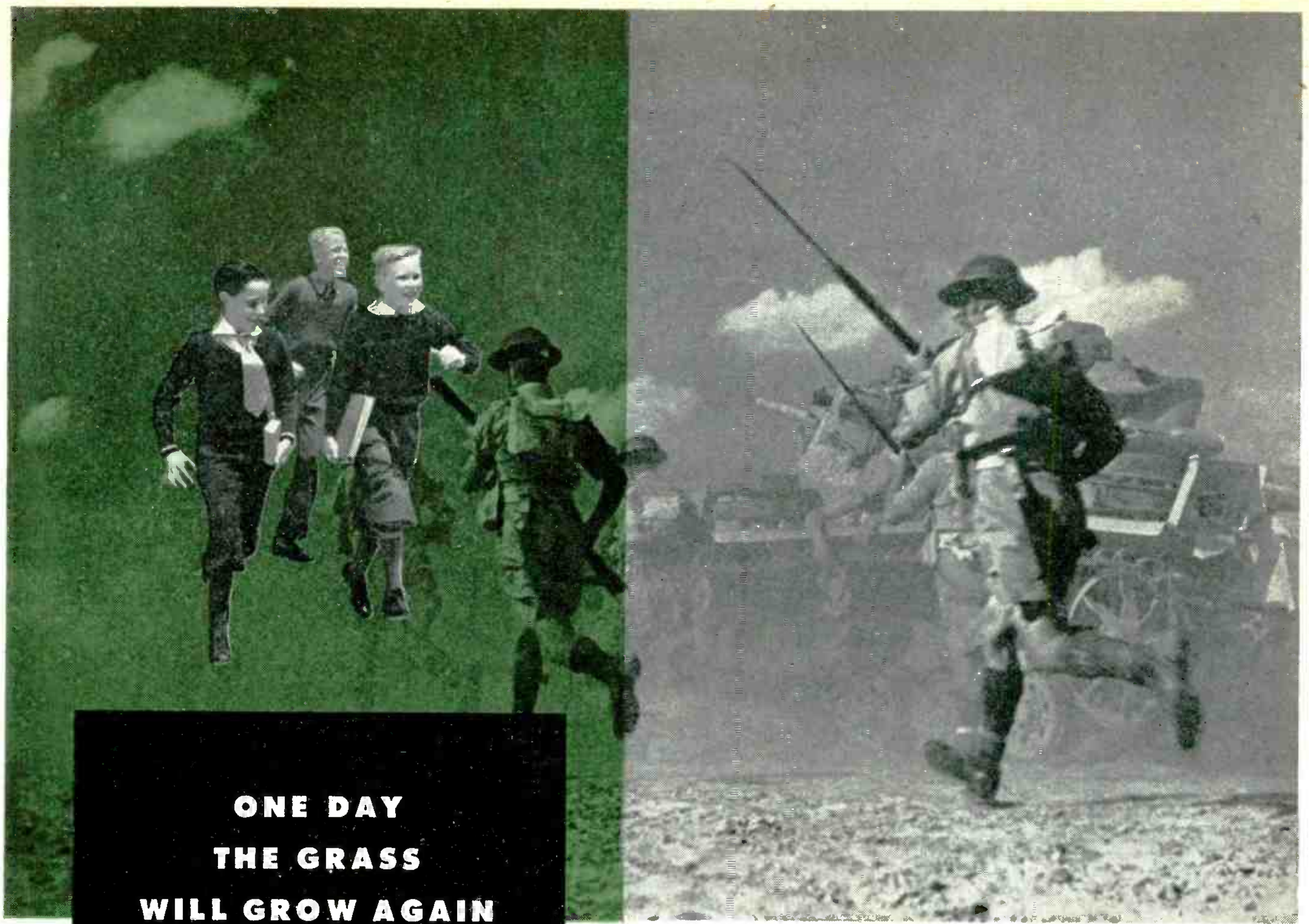
RADICALLY new ideas in the design of Hammarlund condensers will point the way to many improvements in the communications field.

If you are planning a product embodying new technique, Hammarlund is best equipped to lend full engineering cooperation.

THE SIGN OF QUALITY IN RADIO

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

HAMMARLUND



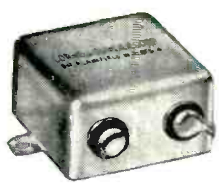
ONE DAY
THE GRASS
WILL GROW AGAIN

20th Century-Fox Film "Desert Victory"

One day the sound of running feet will be those of children at play, not the feet of men charging into battle over the battle-scarred earth. Then the grass will once more be green.

Because our job calls for constant action, we have never let the grass grow under our feet. For 33 years we have been building capacitors, and out of these years of specialization has come a product famous for extra long life and extra dependability.

Low Capacity By-Pass Capacitors
Type DY



Type DY Dykanol By-Pass Capacitors are non-inductively wound, and fill the need for dependable Capacitors of fractional capacities that will operate efficiently in r.f. and a.f. by-pass, audio frequency coupling and A.C. circuits under all humidity conditions and at temperatures up to 80°C. Hermetically sealed, they have been especially designed to fill the requirements of aircraft, submarine and marine applications for maximum capacity and voltage in minimum space. For further details write for Catalog No. 160T.

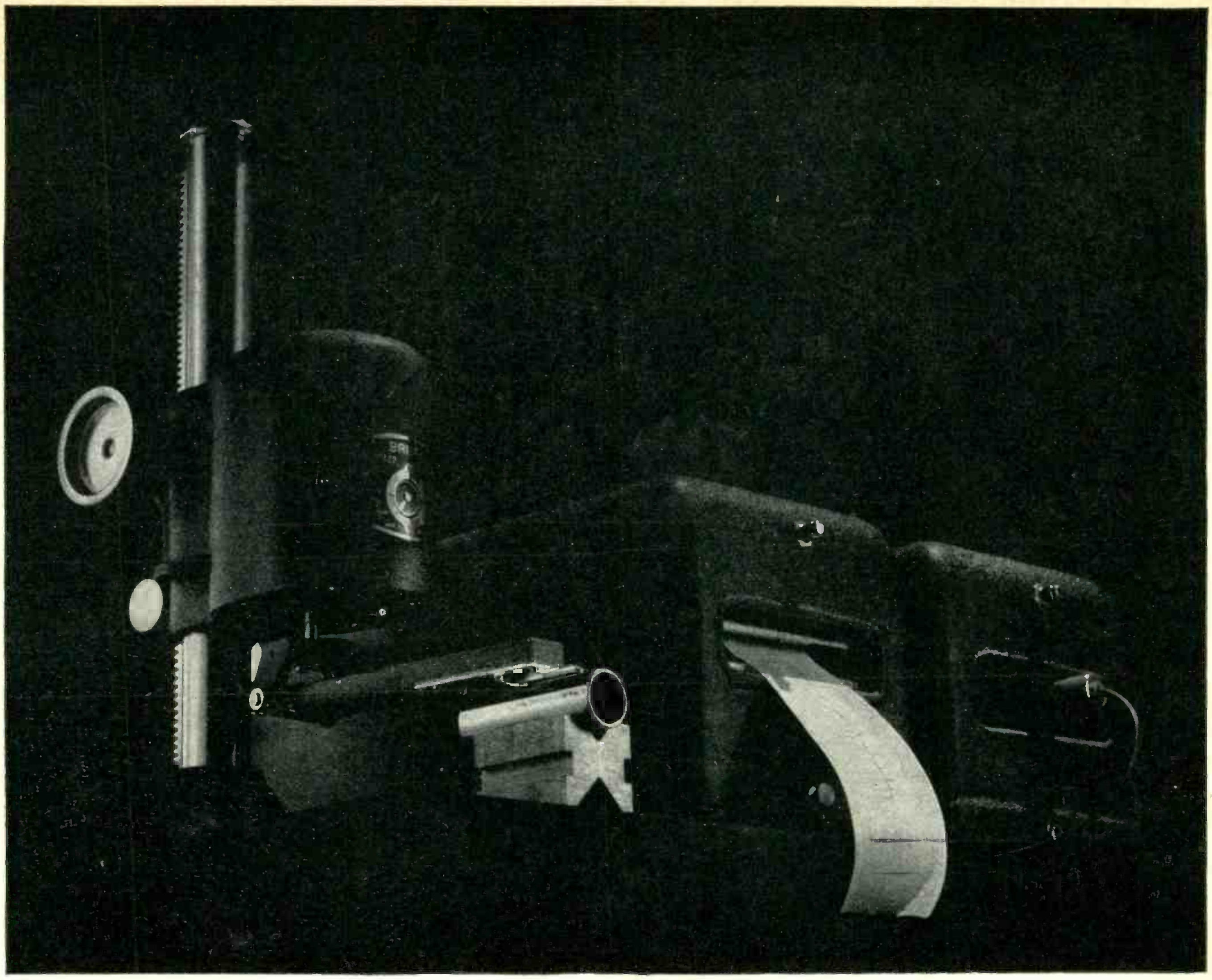
Today CD capacitors are known as the world's finest. That is why there are more CD's in use than any other make . . . for wartime as well as civilian applications.

Cornell-Dubilier

MORE IN USE TODAY
THAN ANY OTHER MAKE.

capacitors

MICA • DYKANOL • PAPER • WET AND DRY ELECTROLYTICS



TWISTERS, BENDERS, and BIMORPHS

for War . . and the Peace to come

The keynote to Victory is Teamwork. The Allies have it in battle and production. Twisters, Benders, and Bimorphs form a team as a part of The Brush Surface Analyzer that measures the smoothness of finished surfaces. This tiny team can do the work of an army of men.

Today Brush Crystals are doing wartime service, but in the peace to come these same crystals (Twisters, Benders, and Bimorphs) will serve people everywhere in untold ways.

Thus, The Brush Development Company works today, for the better things tomorrow.

SEE US
IN ROOM 843
AT THE NATIONAL
METAL SHOW

THE BRUSH DEVELOPMENT COMPANY

3311 Perkins Avenue — Cleveland, Ohio

BRUSH
CRYSTAL
PRODUCTS

THE McELROY CODE

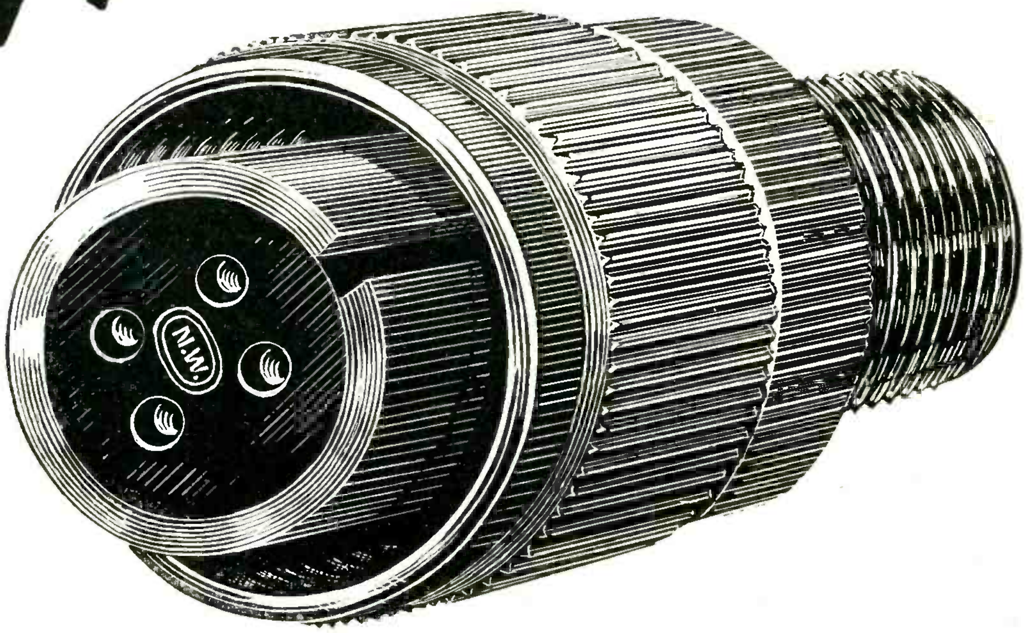
This is the McElroy Code. This is the key to our thinking. This is the force which generates McElroy initiative. This is the power of creative engineers in concerted action. This is why McElroy is the world's largest manufacturer of automatic radio telegraph apparatus.

McElroy MANUFACTURING CORP.
82 BROOKLINE AVE., BOSTON, MASS.

WORLD'S LARGEST MANUFACTURER OF AUTOMATIC RADIO TELEGRAPH APPARATUS

At home as well as on the battlefront, blood plasma helps save lives... donate a pint of blood to the Red Cross today.

We Specialize in A N Plugs



. . . from the Engineering and Designing to the Machining and Assembling

Because we are plug specialists, you have fewer delivery worries when the plugs you buy contain the N-W stamp. For that symbol means that you are getting a plug from a manufacturer who makes (with the exception of one tiny part) the entire plug.

Being the only completely self-contained plant in the country, when we make a promise we are in a better-than-usual position to keep it because we do the engineering, designing, toolmaking, die-casting, insulator-molding, machining and assembling. And if desired, we are equipped to give each aluminum die-cast part the diachromatic finish. Our production capacity amounts to many thousands of AN Connector and Signal Corps Plugs per day. And our manufacturing technique has been developed to a degree where product perfection is virtually assured.

Ours is not purely a wartime effort. We are building for the peace, too. That's why we have a large engineering staff working constantly on the further improvement and development of electrical connectors.

We urge you to visit our factory and examine our facilities with an eye to their being utilized for the purpose of increasing your production and thus stepping up the flow of completed equipment to our armed forces.

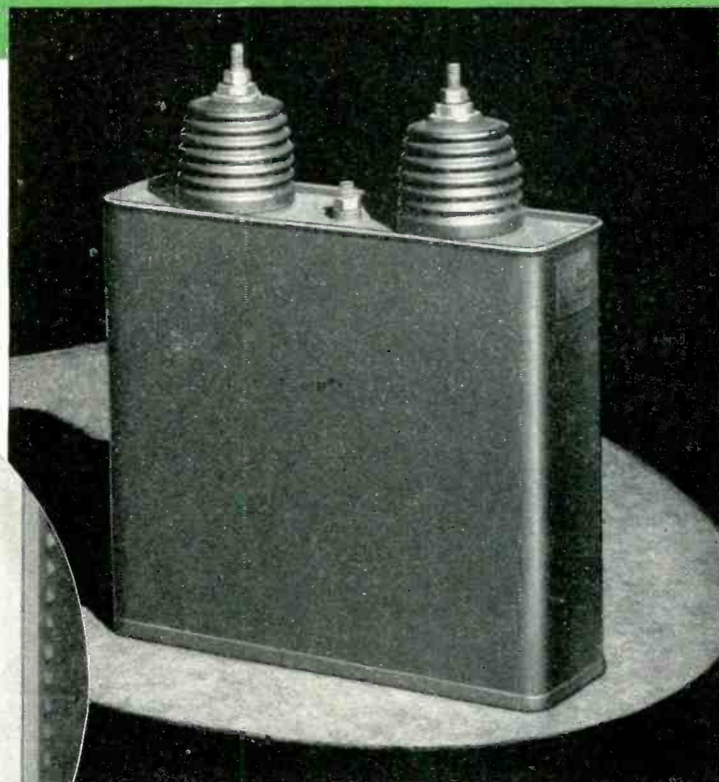
Write, wire or telephone . . .

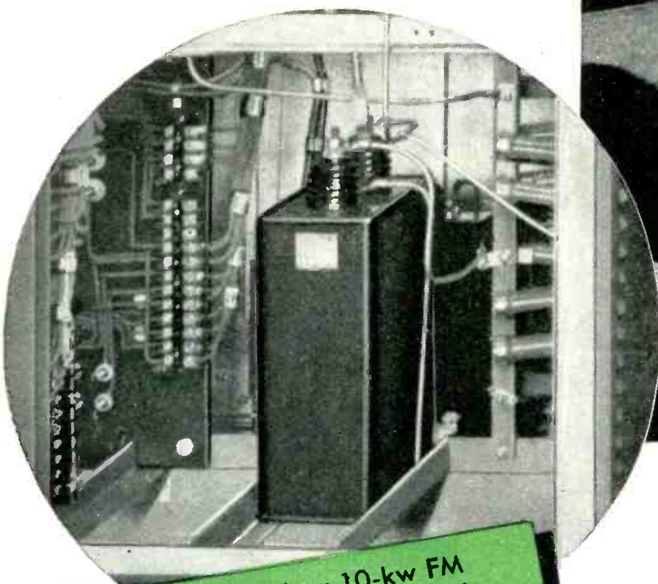
NORTHAM WARREN CORPORATION
War Works Division
STAMFORD, CONNECTICUT

Quick Delivery

PYRANOL CAPACITORS

for High-voltage D-c Service





Used as a filter in a 10-kw FM transmitter. This is one of many applications.

30 *Standard Ratings* (5–75 kv) *to choose from*

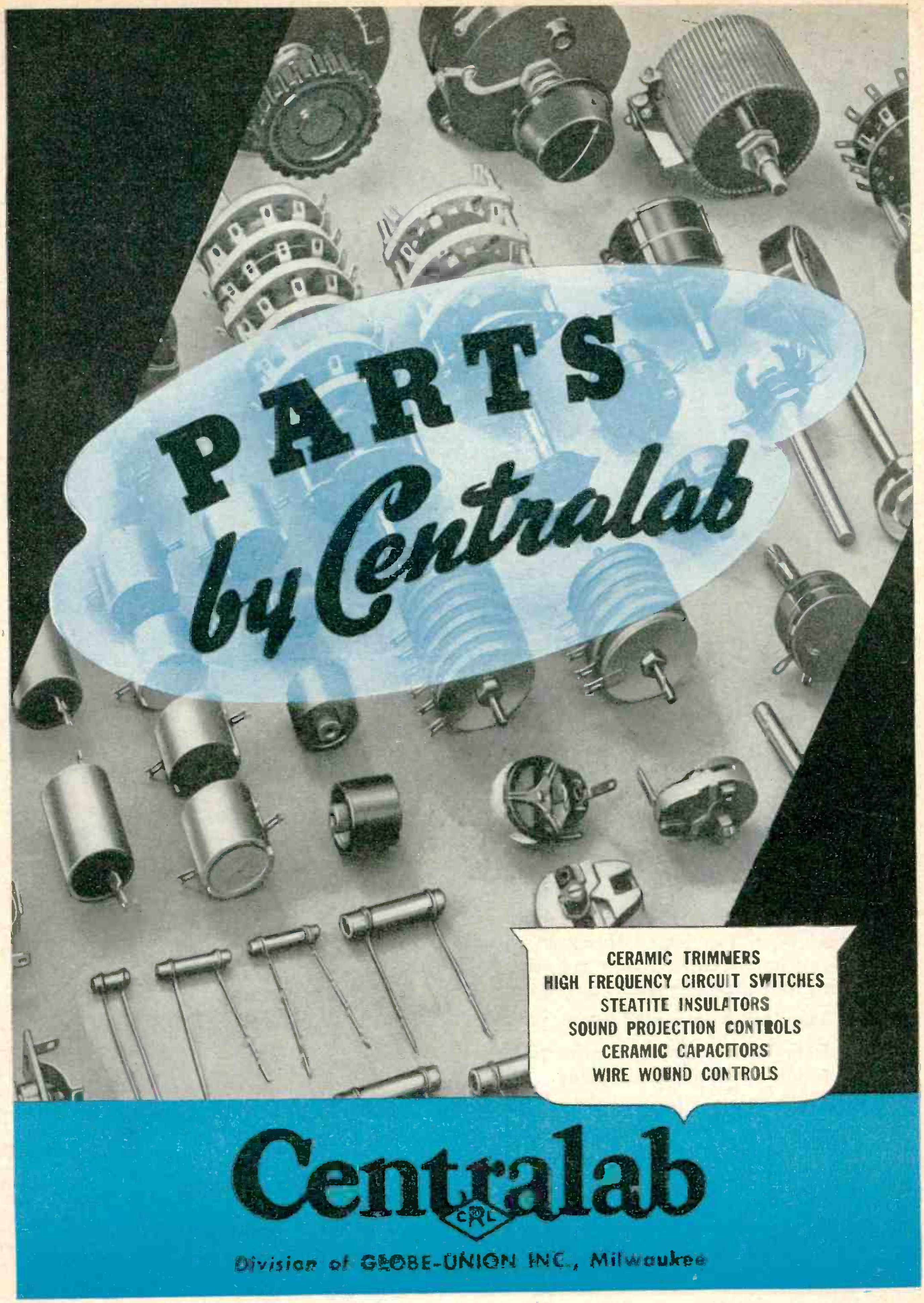
FILTER problems take a beating when you install Pyranol* capacitors for high-voltage d-c service. Here are other useful facts to remember about Pyranol capacitors:

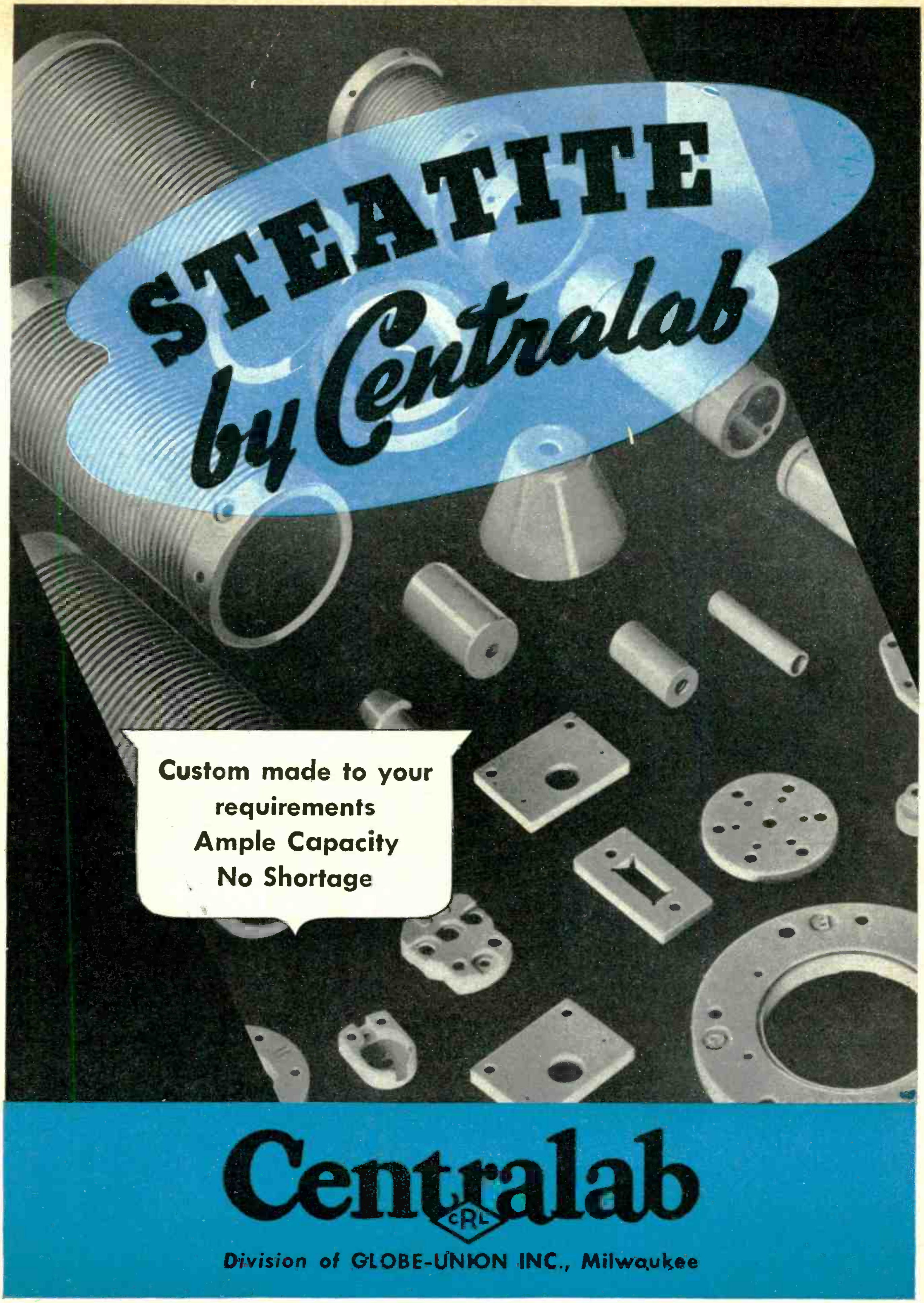
- They can be mounted in any position.
- Reliable performance is ensured by superior materials and individual testing.
- Substantially increased manufacturing facilities now enable us to make prompt deliveries.

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

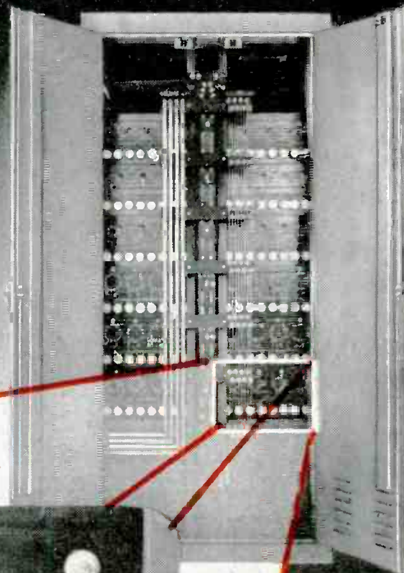
BE SURE TO GET your copies of these time-saving catalogs on our complete line of Pyranol capacitors for built-in applications. Ask for GEA-2621A (d-c types) and/or GEA-2027B (a-c types). General Electric Co., Schenectady, N. Y.

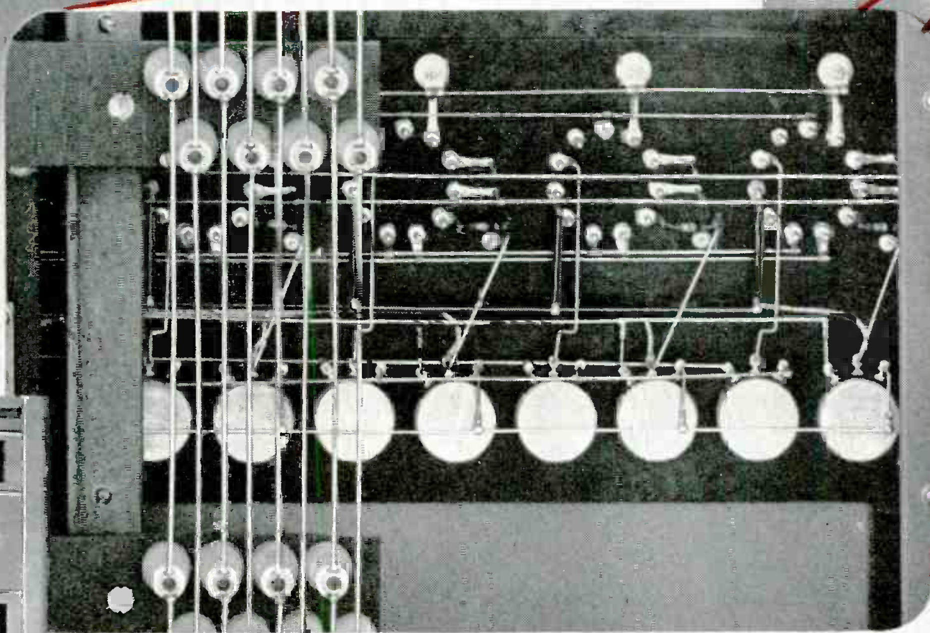
GENERAL ELECTRIC


PARTS
by Centralab
CERAMIC TRIMMERS
HIGH FREQUENCY CIRCUIT SWITCHES
STEATITE INSULATORS
SOUND PROJECTION CONTROLS
CERAMIC CAPACITORS
WIRE WOUND CONTROLS
Centralab
CRL
Division of GLOBE-UNION INC., Milwaukee


STEATITE
by Centralab
Custom made to your requirements
Ample Capacity
No Shortage
Centralab
CRL
Division of GLOBE-UNION INC., Milwaukee

The Inside Story OF PERFECT WORKMANSHIP





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

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

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

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

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

TEMCO

RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.

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A *mateur*

B *roadcasting*

C *ommercial*

D *iathermy*

E *lectric Welding*

F *ilm-Sound*

G *overnment*
Army, Navy & Aviation

H *igh Frequency Heating*

I *ndustrial Electronics*

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

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

Efficiency from A to Z

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

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

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ELECTRONICS COMPANY

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Transmitting Tubes Exclusively Since 1934


FOR RADIONIC and ELECTRICAL APPLICATIONS
Micamold
MICAMOLD is a name that stands for sure-fire dependability. Our products have been carefully designed to cover almost every application in which a capacitor is used. Should you be working on a project where a special design or rating is needed, our engineers will gladly cooperate.
Oil Filled Paper Capacitors
Made in many container types with impregnants to meet all specifications.
Molded Paper Capacitors
Perfectly sealed small units. Some types are ideal as mica capacitor alternates.
Molded Mica Capacitors
A most complete line of standard and special case types. Reasonable deliveries of large quantity schedules.
Electrolytic Capacitors
Available in various classes for radio and electrical equipment.
Molded Wire Wound Resistors
The finest small resistors in the lower resistance values.
Help give a wounded soldier a fighting chance... donate a pint of blood to the Red Cross today.
MICAMOLD RADIO CORPORATION
1087 FLUSHING AVENUE
BROOKLYN 6, N. Y.

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"AS *Exact* AS THE STARS"

WALTHAM SCREW PRODUCTS

MEET EVERY CLOSE-TOLERANCE DEMAND *Through*

Our 53 Years of Precision Experience!

Today, wherever delicate instruments or precise weapons of warfare are in use, you will find WALTHAM SCREWS and allied products working for VICTORY.

Produced in range from the "almost infinitesimal" to the larger utility sizes, these *quality* screws are playing a vital part in the manufacture of planes, tanks, ships, guns—and the instruments which guide them.

But our fifty-three years of precision experience have done more than produce a superior screw.

Utilizing that wonder-tool of modern industry—the Automatic Screw Machine, with all of its adaptations—we have gained notable achievements in a number of new fields. Behind these successes have been the craftsmanship, accumulated skills and Yankee *ingenuity* which have characterized this company's steady growth and progress for three generations.

Recent additions to plant and equipment enable us to place our complete facilities at your service in creating custom-built screw machine products. Submit sample or blueprint for quotations.

WRITE FOR THIS *Interesting* BOOKLET!

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77 RUMFORD AVE., WALTHAM, MASS.

Screw Machine PRODUCTS


Standard of Excellence
In War
In Peace
Accuracy and dependability are built into every Bliley Crystal Unit. Specify BLILEY for assured performance.
BLILEY ELECTRIC COMPANY · · · ERIE, PA.
Bliley Crystals

(Photograph Actual Size)

Improved Features

Sealed Chamber—Makes Relay Explosion Proof and Dust Proof; serves as effective arc quench.

Excess Capacity—Rated at 25 amperes; operates satisfactorily at 50 amperes; tested without failure at 120 amperes high inductive load.

Light and Compact—Standard model above (S47D) weight only 4.7 ounces; overall dimensions as follows: Height, 1 9/16"; Width, 1 21/64"; Length (less base), 1 7/16"; Overall of base, 2 1/16"; Mounting holes, center to center, 1 3/4".

Positive Action—Overtravel spring insures positive contact pressure and instant "break" release.

Tamper Proof—Factory adjusted and sealed; protection against unauthorized re-adjustments.

Reversible Contacts—If worn from excessive use contacts may be reversed in the field, thus providing new surfaces without disturbing adjustment.

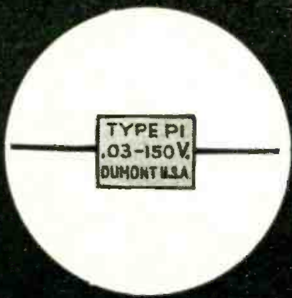
Electrical
PRODUCTS SUPPLY CO.
Affiliated with Electrical Products Corp.
1140 Venice Blvd. Los Angeles 15, Calif.

Specifications:

Normal Coil Rating. 24 volt - 150 m. a. - 3.6 watts.

Contact Rating. 25 amps. inductive load at 30 volts.

Unit has withstood Army tests, including overload; vibration 55 cycles per second with .06" excursion; acceleration of 10 gravity units; salt spray tests of 240 hours duration.



HAVE YOU A SPACE PROBLEM ?

★ *DUMONT offers the Smallest Paper Capacitor* for your space problem . . . Regardless of its wee size, it gives the most satisfactory results for the big job as well.

IT IS NON-INDUCTIVE SUITABLE FOR 95° Humidity operation.

Leads are sealed in Bakelite Resinold.

TYPES P1 and P2	TYPES P1N and P2N
Suitable for 95° Humidity	Suitable for 100° Humidity

DUMONT
ELECTRIC CO.

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CAPACITORS FOR EVERY REQUIREMENT
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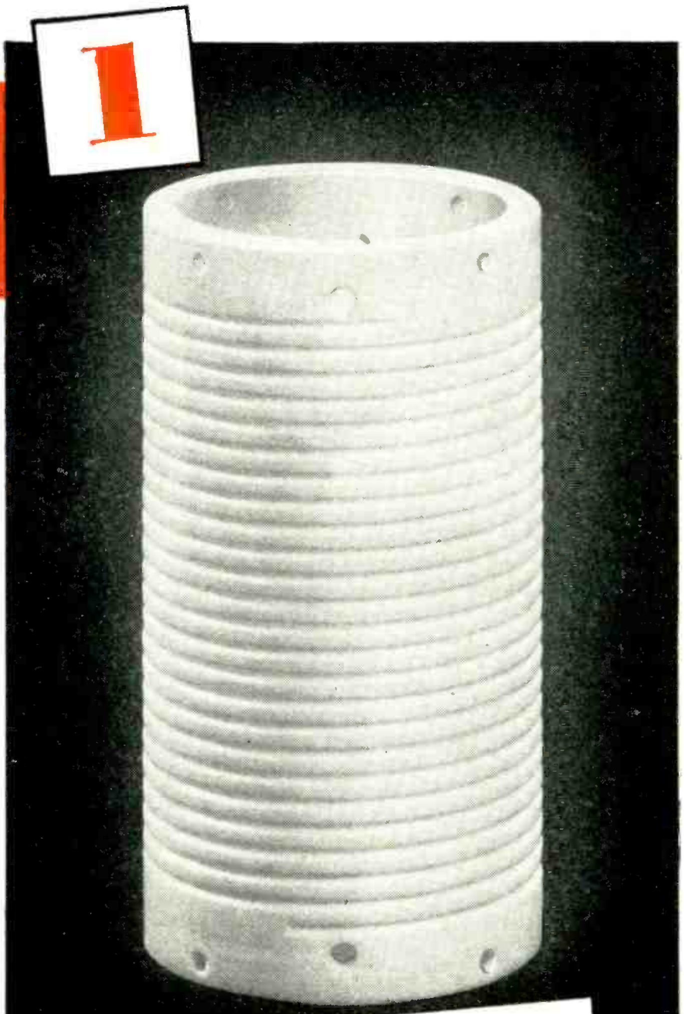
NEW PLASTIC
INSULATING
GROMMETS
#3/P-231
ALL HOLES ARE CONCENTRIC
#3/P-232
ALL CORNERS CHAMFERED
#3/P-234
ALL THREADS CLEAN & LUBRICATED
#3/P-233
ALL PARTS MATTE FINISH
Of special interest to production engineers seeking to cut down assembly time operations, Creative's new line of 100% phenolic plastic insulating grommets offers many important advantages. These new grommets, available in four standardized sizes, have been developed especially for use by Radio, Electronic Generator, Dynamotor, Aircraft and other manufacturers. Holes are concentric, with all corners chamfered, avoiding wire chafing. All threads are clean and lubricated. To promote easy gripping and reduction of assembly time all parts are matte finished.
Electrically, Creative grommets are ideal. For example, dielectric strength averages about 260 to 430 v.p.m.; dielectric constant 5.5 to 7.4; power factor at 10⁶ cycles .02 to .05. Water absorption is unusually low at only .5% in 24 hour test.
Creative grommets, available from stock, are sold at prices which reflect mass production efficiency
SEND FOR SAMPLE CARD
AND PRICE LIST NOW
INSULATING GROMMETS BY CREATIVE
Creative Plastics Corp.
978 KENT AVENUE
BROOKLYN 5, NEW YORK

NOW 3 TYPES OF TO FIT



Comparative Analysis of 3 Corning Coil Form Methods

	MULTIFORM COIL FORMS	BLOWN COIL FORMS	PRECISION GROUND COIL FORMS
O. D. Diameters	9/16" to 12"	1" to 3"	¼" to 1½"
Lengths	0.70" to 10½"	2½" to 9"	½" to 6"
Wall Thickness	3/32" to ⅞"	⅛" to ⅜"	3/64" to 3/16"
Maximum Threads per inch	32	12	24
Tolerance	± 2% but not less than ± 0.010" on all dimensions	± 0.015" on root diameter of thread	± 0.002" on root diameter of thread
Holes	Mold formed	Punched or ground	Punched or ground
Metallizing	Yes	Yes	Yes
Types of Glass	No. 790 Only	No. 707 or No. 774	No. 707 or No. 774

Comparative Properties of Corning Coil Form Glasses

	#790	#707	#774
Maximum Operating Temperature (°C)	800	425	500
Linear Expansion (0-300°C) per °C x 10^{-7}	8.5	31	32
Water Absorption—24 hrs.(%)	<.01	None	None
Volume Resistivity log R at 20° C	13.0	17.0	14.7
S.I.C.—20° C—1 MC	4.0	3.95	4.65
P.F.—20° C—1 MC	0.18	0.06	0.42
L.F.—20° C—1 MC	0.72	0.24	1.95

MULTIFORM COIL FORMS

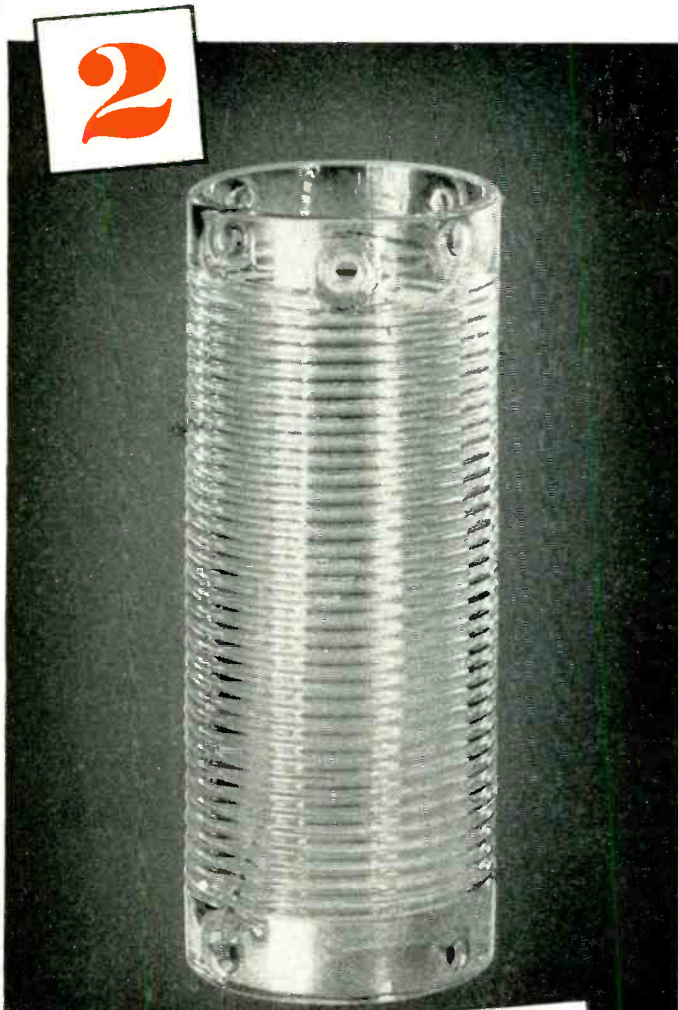
This exclusive Corning Glass Works' method offers coil forms with all-round superior electrical characteristics . . . yet moderately priced in any quantity. Low coefficient of expansion. Most adaptable to complicated shapes or where multiple holes are required. Good thread contours. Can be metallized for applying mounting assemblies or terminal clips. Made from No. 790 glass only.

Pyrex Insulators

BRAND

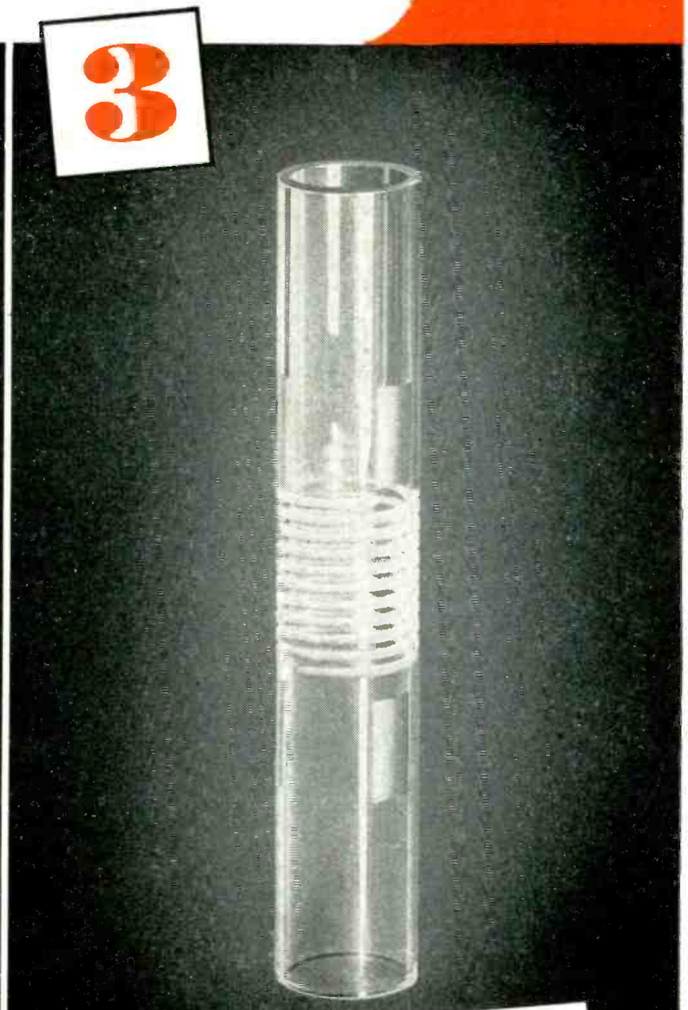
"PYREX" is a registered trade-mark and indicates manufacture by Corning Glass Works

CORNING COIL FORMS EVERY NEED!



BLOWN COIL FORMS

In minimum quantities of 12,000 to 15,000 units for No. 774 glass, this Corning method provides coil forms at rock-bottom prices. Forms are unusually strong mechanically and are transparent for easy inspection of internal assemblies. Can be metallized for applying mounting assemblies or terminal clips. Can also be made from No. 707 glass in limited quantities by hand molding, for the duration.



PRECISION GROUND COIL FORMS

This method, while slightly more expensive, produces most accurate thread contours. Adaptable to any quantity. Has advantage of transparency. Mountings or terminal clips can be applied by metallizing. Made from either No. 707 or No. 774 glasses.

MAIL COUPON TODAY

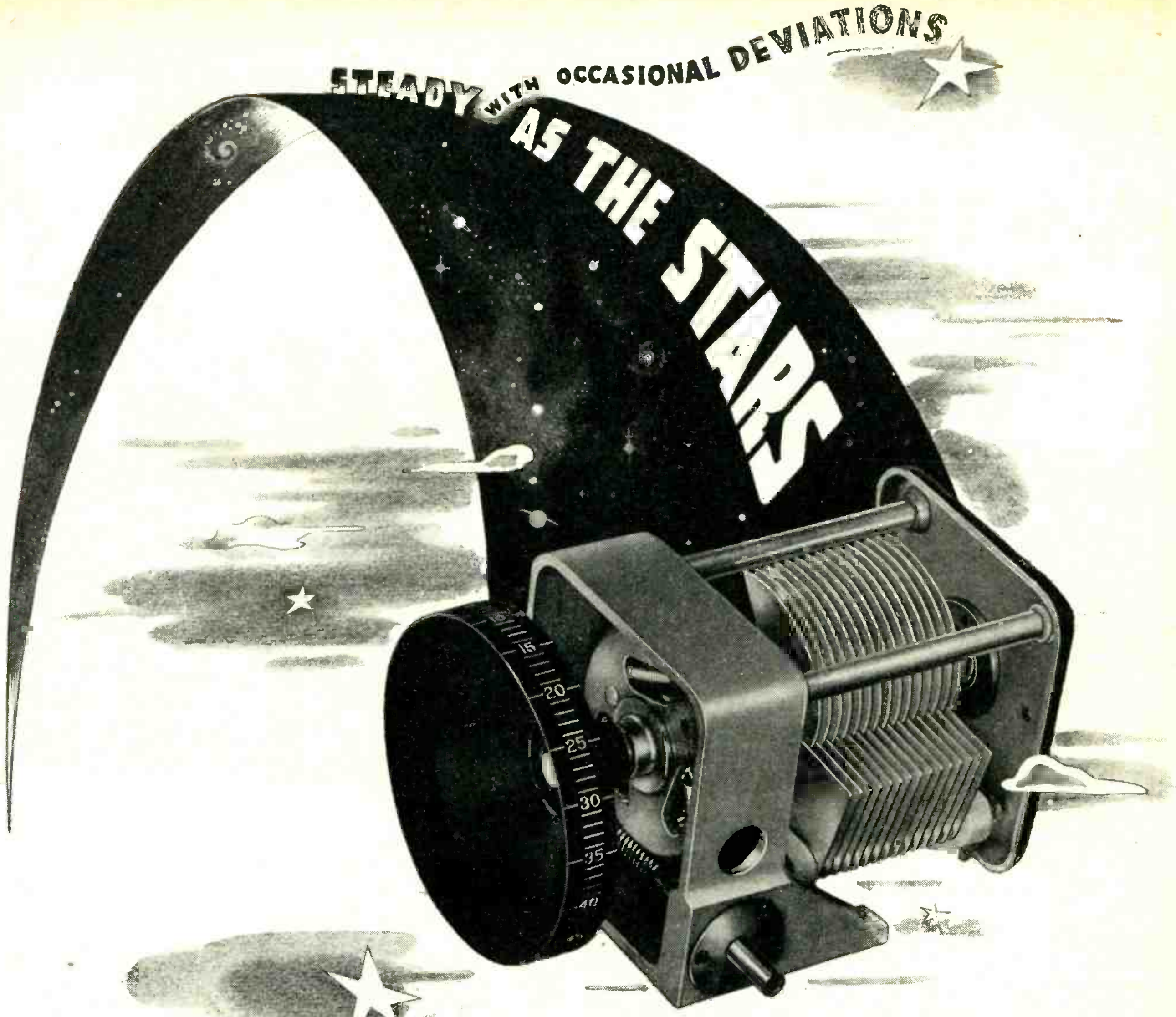
Corning Glass Works
Insulation Division, Dept. E10-2
Corning, N. Y.
Please send me the full story on Corning's 3 Coil form methods.

Name..

Company..

Street...

City...


STEADY WITH OCCASIONAL DEVIATIONS
AS THE STARS

We* will work with you on any problem involving the use of...

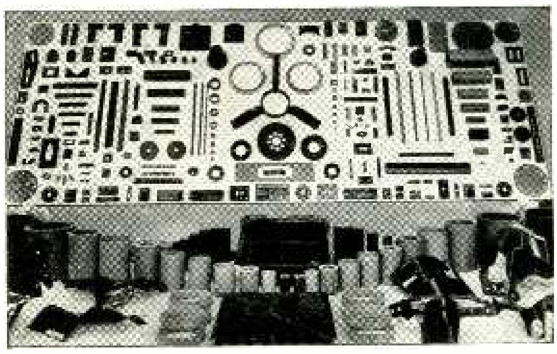
STRUCTURAL LAMINATED RESINOUS **plastics**

FRANKLY, up to now the Panelyte Division of the St. Regis Paper Company has been too busy "growing up" with important users of our laminated plastics to take time to talk about our successes. Instead of broadcasting each advance, we have quietly continued working in close cooperation with customers—producing a variety of grades of structural laminated resinous plastics for specific applications—assisting in the more efficient design of parts—and molding and fabricating them by mass production methods.

Through this simple—but sensible pre-Pearl Harbor method of operation—PANELYTE became America's largest producer of thermo-setting molded laminated plastic parts, serving the automotive, chemical, electrical and refrigerator industries. Our "down to earth" slant on plastics and our way of working enabled us to step up production to meet vastly increased War demands.

Because we produce a wide range of laminated plastics in sheets, rods and tubes (paper, fabric, wood veneers, glass fabric and asbestos base types), molded forms, and fabricated parts, and because we have *"waited to see" the performance record of each application,* we know what PANELYTE Plastics can—and cannot do . . . and our engineers base their recommendations accordingly.

Our mass production facilities and technical information may prove most valuable to you if you are looking for an improved—or perhaps less expensive—structural, mechanical or electrical part. Our engineers will work with you on any problem involving the use of thermo-setting laminated plastics.



Illustrated are some of the 2000 parts we are manufacturing for the aviation industry. PANELYTE, mechanical and electrical parts are used, also, by the Navy, Signal Corps and Direct Service Procurement.

* PANELYTE DIVISION, ST. REGIS PAPER COMPANY . . . AMERICA'S LARGEST PRE-PEARL HARBOR PRODUCER OF THERMO-SETTING MOLDED LAMINATED PLASTICS

PANELYTE *the structural plastic*

PANELYTE DIVISION
ST. REGIS PAPER COMPANY
230 PARK AVENUE
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MASS PRODUCTION OF SHEETS, RODS, TUBES, MOLDED FORMS, FABRICATED PARTS

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Today, when there can be no "second bests", more and more engineers are relying upon Audiodiscs for their unquestioned superiority on every score.

They know that whether it's a speech by a national leader, the preservation of vital war statistics, or a swing band recording for our boys overseas—absolute fidelity is matter-of-fact acceptance with an Audiodisc recording blank.

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From the sheets of glass, smoother than any aluminum base, of absolutely correct gauge and strength, to the finest lacquer coating applied by an exclusive Audio process, Audiodiscs assure a longer-lasting blank—perfect playback performance every time!

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audiodiscs

they speak for themselves

**No. 2 in a series depicting milestones in the history of Farnsworth Television.*

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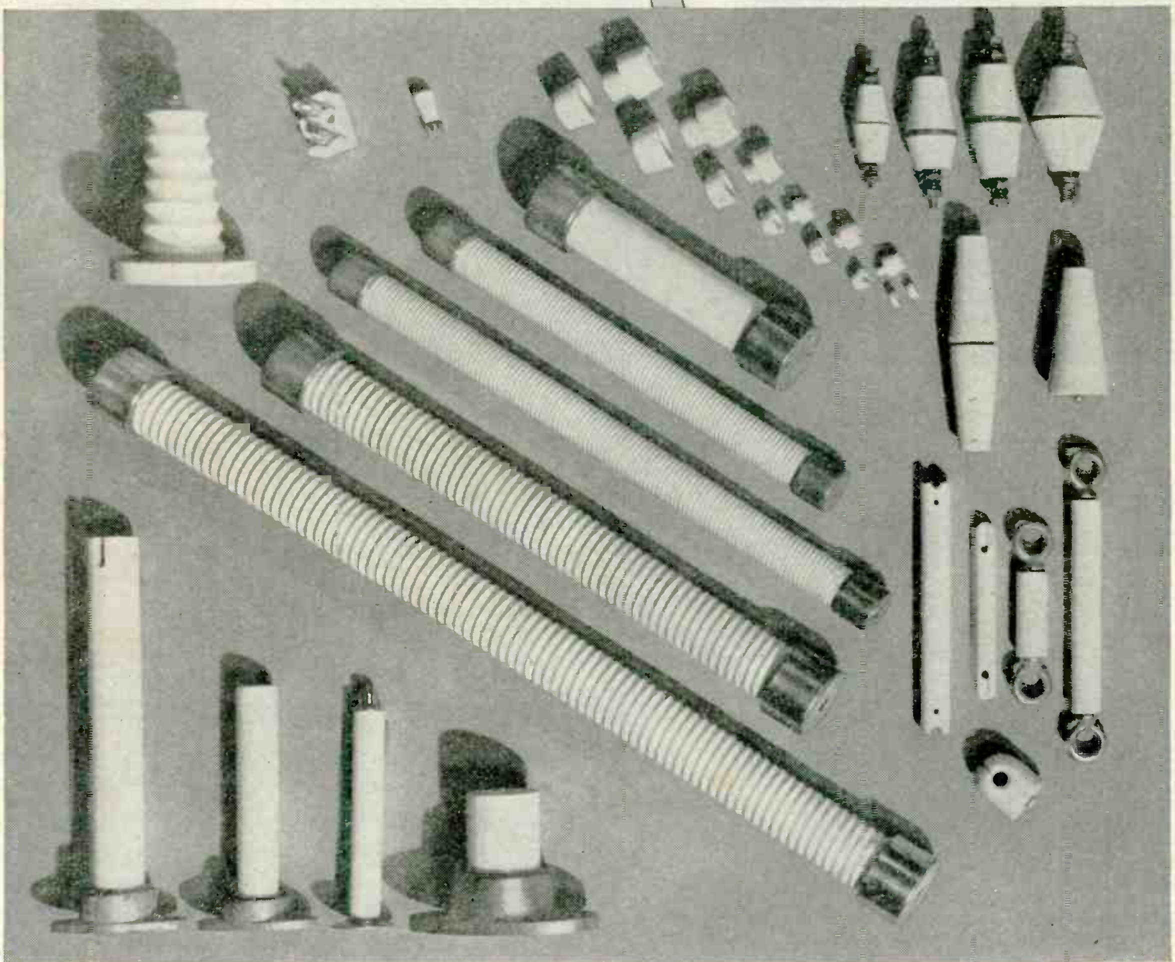
FOUNDED IN 1897

Ceramics for the World of Electronics



Low Loss Steatite Insulators and Assemblies

In addition to thousands of styles and shapes of low loss Steatite Insulators, we also manufacture many with METAL FITTINGS ATTACHED, ready for use. These include standoff, lead in, strain and other standard lines of Steatite Insulators.

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"for great achievement"

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AMERTRAN HERMETICALLY SEALED TRANSFORMERS

. . . Impervious to all climatic conditions!

BECAUSE they must go with our Armed Forces everywhere, AmerTran Hermetically Sealed Transformers are built to remain water-tight, air-tight and fungus proof through Tropic Heat and Arctic Cold.

They are extremely flexible in size and terminal arrangement and are ideally suited for fine wire applications. As Transformers, as Reactors, as Wave Filters, they are used in communications, navigating, locating and controlling apparatus. Minimum weight and dimensions for their purposes make them ideal for airborne applications. Enclosing cases and terminal boards are die-made, insuring close tolerances and uniformity. AmerTran quality of design, materials and construction make these Transformers suitable for today's exacting requirements and tomorrow's better living.

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

AMERICAN TRANSFORMER COMPANY
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AMERTRAN
MANUFACTURING SINCE 1901 AT NEWARK, N. J.

More Bendix-designed UHF radio communication equipment and automatic radio compasses than all other makes combined . . .

NOW USED OVER EUROPE BY U. S. ARMY AIR FORCES

American war birds are darting at Fortress Europa . . . and in their wake hover mighty fleets for airborne invasion. Our fighters, bombers and transports will darken Axis skies.

In the job of guiding them to secret destinations, and directing and coordinating their swift, complex manœuvres, Bendix Radio* Equipment will fill a vital role.

For in the European theatre, the U. S. Army Air Forces use more Bendix-designed U H F Communication Equipment and Automatic Radio Compasses *than all other makes combined.* The reason: Designing and producing such equipment for aircraft has been the highly specialized business of Bendix Radio from its very inception . . . long before the war.

Just as Bendix Radio has set the pace in Aircraft Electronic Equipment for wartime application, so it will lead in developing new electronic marvels for peacetime flight, thus helping make *The Vehicles of Victory . . . the Transports of Tomorrow.*

* TRADE MARK OF BENDIX AVIATION CORPORATION

THE INVISIBLE CREW
PRECISION EQUIPMENT BY
Bendix Aviation Corporation

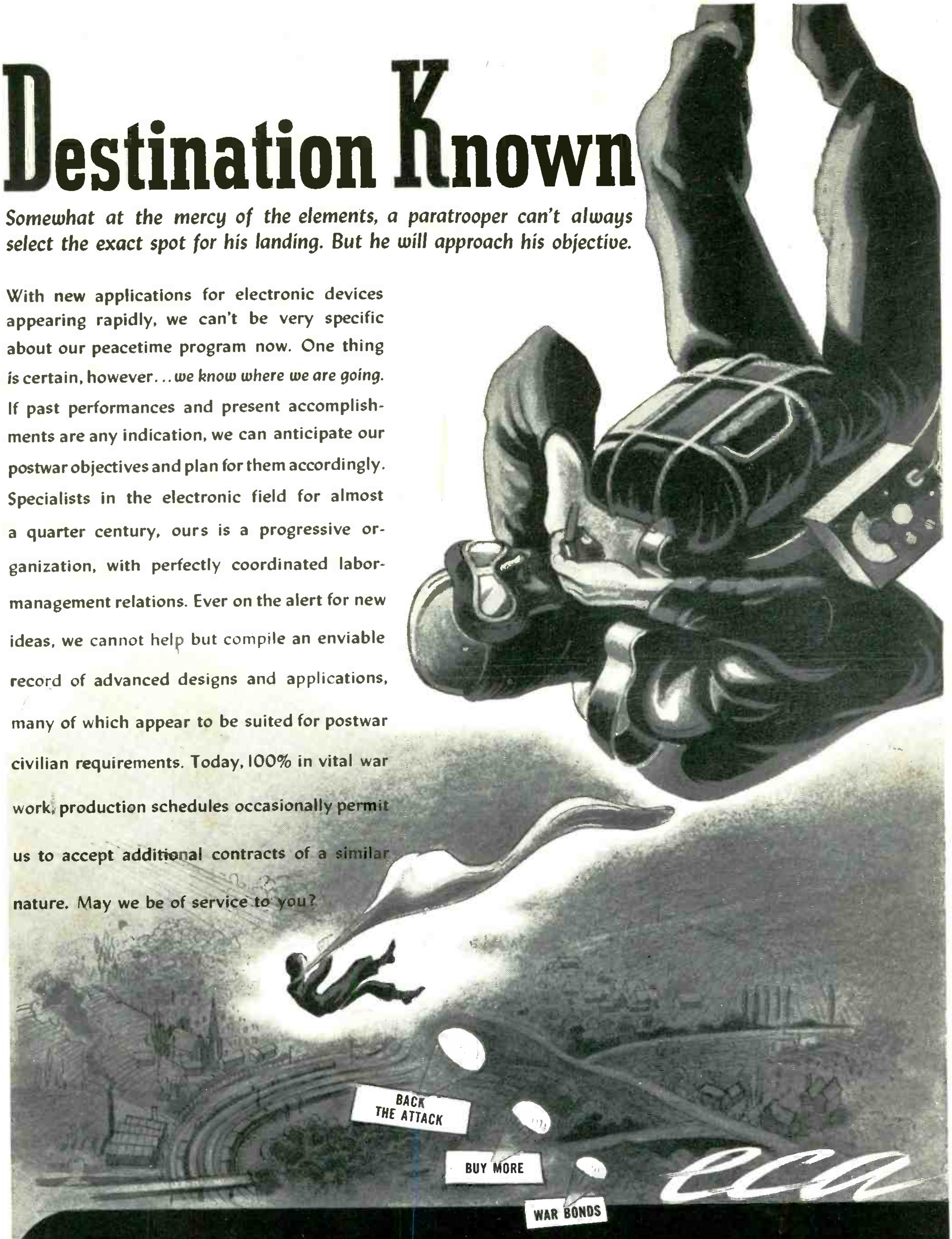
BENDIX RADIO

BENDIX RADIO DIVISION OF THE BENDIX AVIATION CORPORATION

Destination Known

Somewhat at the mercy of the elements, a paratrooper can't always select the exact spot for his landing. But he will approach his objective.

With new applications for electronic devices appearing rapidly, we can't be very specific about our peacetime program now. One thing is certain, however... *we know where we are going.* If past performances and present accomplishments are any indication, we can anticipate our postwar objectives and plan for them accordingly. Specialists in the electronic field for almost a quarter century, ours is a progressive organization, with perfectly coordinated labor-management relations. Ever on the alert for new ideas, we cannot help but compile an enviable record of advanced designs and applications, many of which appear to be suited for postwar civilian requirements. Today, 100% in vital war work, production schedules occasionally permit us to accept additional contracts of a similar nature. May we be of service to you?



ELECTRONIC CORP. OF AMERICA

45 WEST 18th STREET • NEW YORK 11, N.Y. • WATKINS 9-1870

don't worry about details . . .

. . . unless you demand the best of components for the finished product. War-time man-hours must be spent with the greatest care to assure maximum results in terms of all-around performance and serv-iceability. Therefore, only the best of tubes should be incorporated into electronic designs. The quality and dependability of Raytheon Tubes is a time-tested fact, proven in both military and civilian experience.

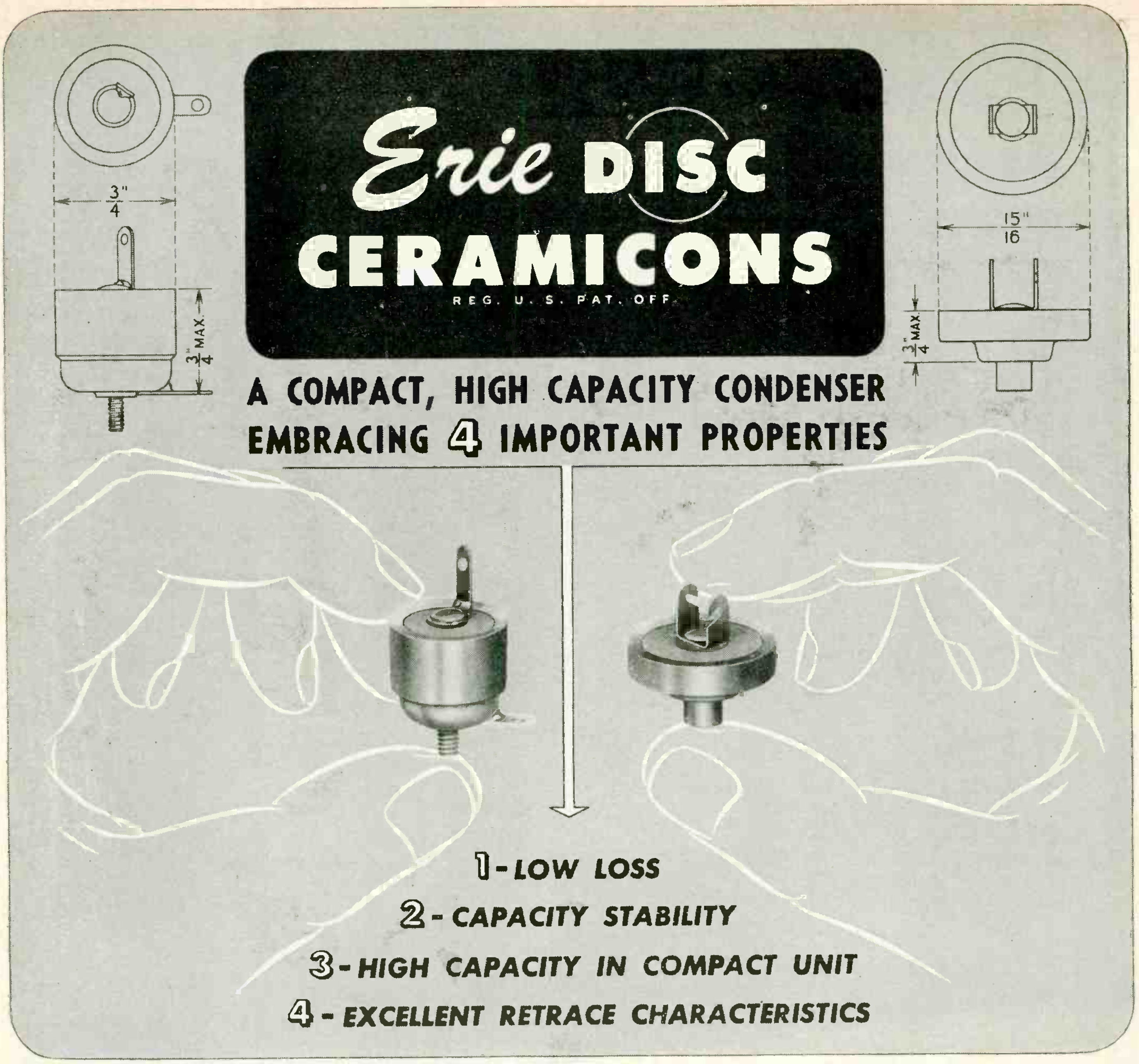
Just how well Raytheon has succeeded in designing, developing and producing special tubes is apparent in Raytheon's unique produc-tion record. When these engineering skills and production facilities are again available for gen-eral domestic use, the Raytheon trademark will continue to play a leading part in the new era of electronics.

RAYTHEON

RAYTHEON MANUFACTURING COMPANY
Waltham and Newton, Massachusetts

FOUR "E" AWARDS FOR EXCELLENCE
Each Division of Raytheon has been Awarded the Army and Navy "E"

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



DEVELOPED by Erie Resistor to meet the demand for compact, high capacity ceramic condensers for high frequency work, these disc-type units provide all of the inherent properties of ceramic dielectrics. This design represents a distinct advance from conventional construction, yet embodies the basic principles of the tubular type Ceramicons, produced in large quantities by Erie Resistor for more than 7 years.

Erie Disc Ceramicons are made in two sizes: Type 160, ¾" diameter and rated at 500 volts D.C., and Type 170, 15/16" diameter which is available in 500, 1000, and 1500 volts D.C. ratings. The height of each style varies from ¼" to ¾", depending on the capacity and temperature coefficient desired.

Maximum capacity in N750 temperature coefficient:

Type 160— 500 volts D.C.	4000 MMF
Type 170—1500 volts D.C.	1500 MMF
Type 170—1000 volts D.C.	4000 MMF
Type 170— 500 volts D.C.	7500 MMF

Each type is available in several different terminal designs, and mounting stud is tapped or threaded as shown in illustration. Erie Disc Ceramicons have many applications in radio transmitters, receivers, and other electronic equipment. For complete information send for data sheet.

BACK THE ATTACK—BUY WAR BONDS

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

That day the KAIMILOA made electronics history

It was in April, 1925, that we received this message from Mr. M. R. Kellum, skipper of the four-masted schooner *Kaimiloa,* who was gathering scientific data in the South Seas:

"BUILD NEW TRANSMITTER . . . USE YOUR OWN JUDGMENT . . . MEET YOU HONOLULU THREE WEEKS."

Hampered by tropical static, the 1 KW Navy Standard Spark Set aboard the yacht was not getting through. It was imperative that Mr. Kellum keep in touch with his business interests on the mainland, so he placed the problem in the capable hands of one of the co-founders of Heintz and Kaufman, Ltd.

The solution was the first short-wave transmitter ever installed aboard a ship. Short-wave was then in the experimental stage, and there was great confusion as to how transmitters should be designed. Among other things, the tuned-grid, tuned-plate circuit was said to be worthless on short-waves.

But in the allotted three weeks we were installing the *Kaimiloa's* new transmitter in Honolulu, and it had a tuned-grid, tuned-plate circuit that oscillated down to 10 meters! From then on KFUH put through consistently good signals to the States, and many hams still recall the thrill of working Operator Fred Roebuck in the South Pacific.

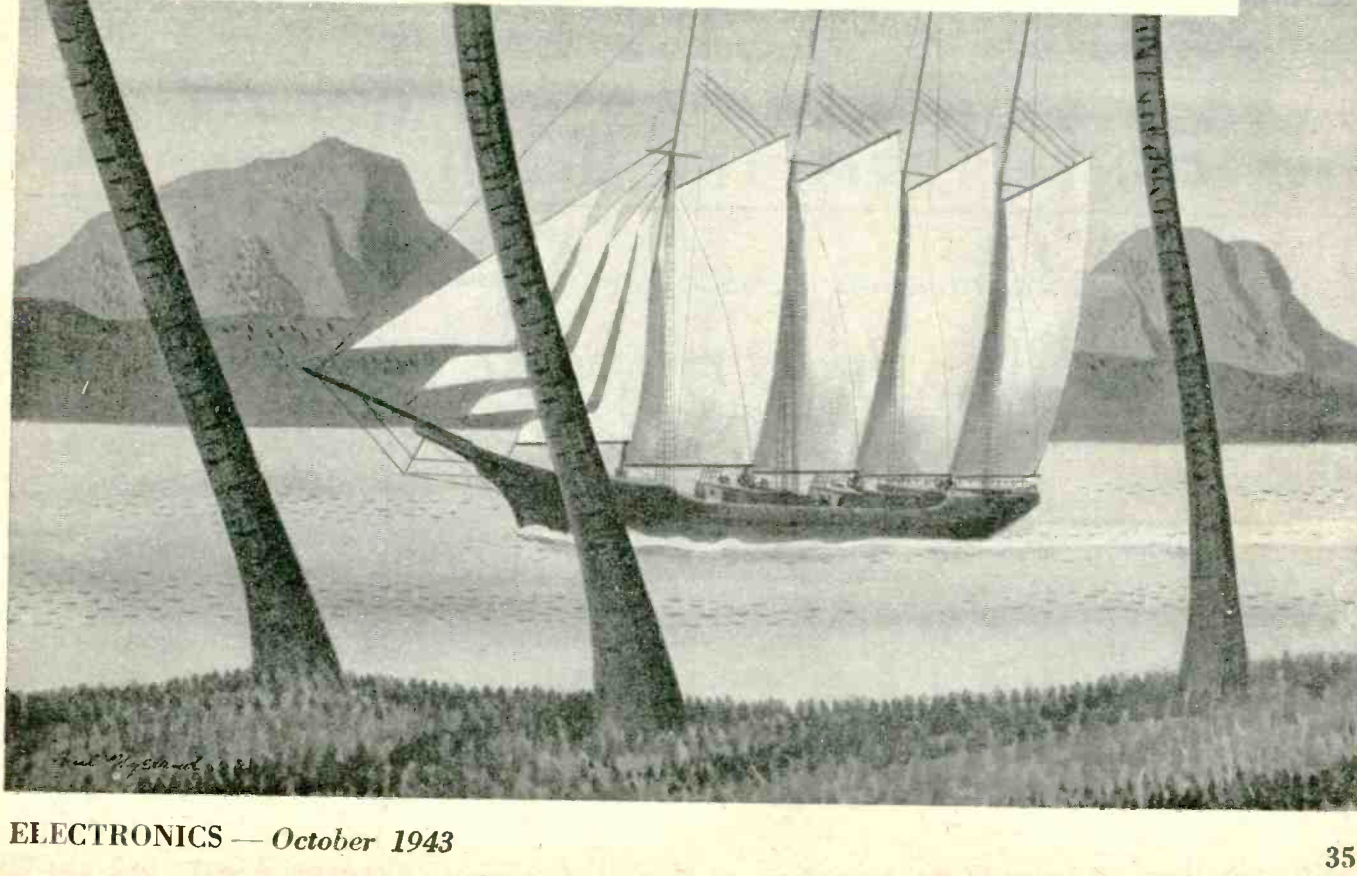
The swift and brilliant solution of problems in radio communication, traditional with Heintz and Kaufman engineers, is exemplified by the constantly expanding line of Gammatron tubes which handle the most difficult electronic assignments with unsurpassed efficiency.

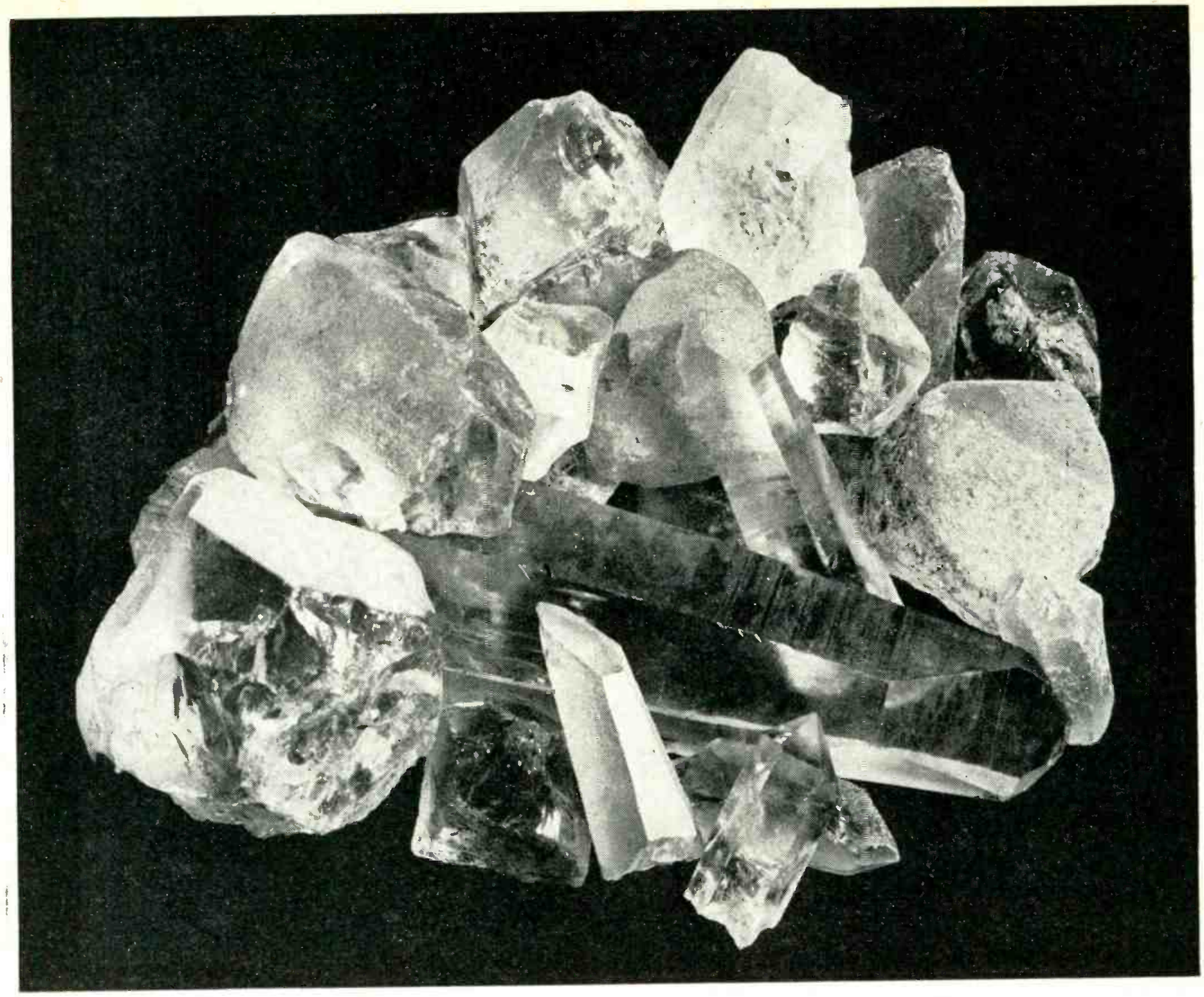
HEINTZ AND KAUFMAN, LTD.

SOUTH SAN FRANCISCO, CALIFORNIA, U. S. A.

Gammatron Tubes

HK-854 . . . This Gammatron triode, capable of handling high voltages, gives remarkable performance at high and very high frequencies. Maximum plate dissipation, 450 watts.





CROSS SECTION OF MOTHER QUARTZ AS IT COMES FROM THE HEART OF BRAZIL

Three requirements are necessary for producing the perfect

OSCILLATING QUARTZ CRYSTAL

1—Knowledge	The August E. Miller Laboratories have a background of more than a quarter century in Quartz Research.
2—Organization . . .	The August E. Miller Laboratories is staffed by experts in every department—no problem is too difficult for them to attempt to solve.
3—Equipment	The August E. Miller Laboratories are equipped with the most modern instruments and machines known for the production of the Oscillating Quartz Crystal.

AUGUST E. MILLER LABORATORIES, 9226 Hudson Blvd., North Bergen, N. J.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IN "Winning the Battle of Communications!"
The latest development in military communications equipment deserves the best in speech reproducers . . . it is natural, therefore, that Jensen speech reproducers were specified for the famous SCR-299, the high powered mobile communications unit as built by Hallicrafters. Jensen speech reproducers are serving with equal distinction in all branches of the armed forces.
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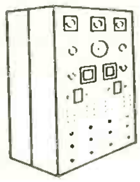
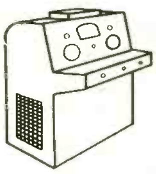
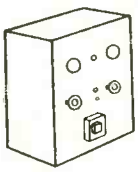
PRODUCTION TEST EQUIPMENT

Guardian of your Future!







Today's productions tests are helping to save soldiers' lives, to hasten Victory. But these tests are performing a vital service for you, too. They're telling the world that your equipment is capable of doing its designated job . . . despite wartime's trying conditions. And that's worthwhile insurance for any manufacturer's postwar future.

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ELECTRONIC DIVISION

SHERRON METALLIC CORPORATION

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SYNCHRONOUS MOTOR USERS...

Have you heard about the new G-E electronic synchronous-motor exciter? Can be used in place of rotating exciters to save space, materials. Takes standard a-c power and electronically gives you steady, easily controlled d-c. Quiet. Dependable. Low-current control circuit for easy automatic control if desired. Small, single control, like radio volume control, adjusts voltage. Ties in with standard synchronous-motor controls. Uses long-life G-E phanotron rectifier tubes. Any G-E office can quote. Ask about CR7501-B.

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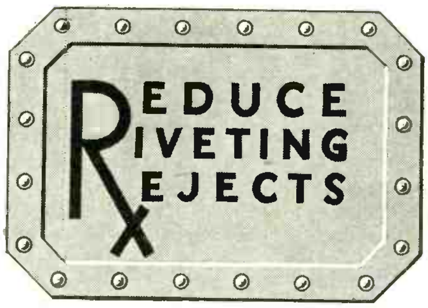
New G-E Thy-mo-trol drive gives you full, stepless speed control on a single dial. Operates from a-c power. No gears, clutches, or belts needed to vary speed. Smooth, shockless acceleration at maximum permissible rate. No current peaks on line. Dynamic braking for quick stops. Holds speed within plus or minus 2% from no load to full load at any speed up to basic. Full torque at low speeds! It pulls and pulls and pulls. Compact. Easy to install. Motor is only major moving part. Ask about CR7507. Bulletin GED-972A. Standard ratings up to 10 hp. Special forms and ratings if you need them.



If exact timing would improve your riveting results, install G-E electronic timers. They take the guesswork out of timing. One Detroit manufacturer found they cut rejects for new operators—improved results for old operators. They use simple circuit, yet provide exact timing. Several ratings available, covering time ranges from 1/20 second to two minutes. Good for millions of operations. Low cost. Sturdy. Knob on front for easy adjustment. Many other applications, too.

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Too much noise fatigues workers, cuts down production. Have you too much noise in your factory? Find out with a G-E sound-level meter. Accurately tells you *how much* noise and where it's coming from. No guesswork. This high-precision instrument gives quantitative measure of sound as it affects the human ear. Small, portable, battery-operated. Easy to use; requires no special training. Full instructions given. Many companies have purchased sound-level meter for multitude of purposes. See Bulletin GEA-3151.

PHOTOELECTRIC RELAYS IN STOCK!

Limited quantity of high-speed relays (CR7505N100). More than 450 operations a minute. Operates on light-intensity change of ½ foot-candle. Time delay up to ½ second for holding relay closed after light impulse, which may be as short as .001 second. Excellent for simple register-control jobs. Automatic seal-in circuit if desired. Relay contacts handle up to 10 amp at 230 volts. Operates on 115 or 230 volts, a-c; 50/60 cycles. Power consumption, 30 watts. Many special features.

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General Electric, Sec. H 676-101
Schenectady, N. Y.

In addition to "Practical Electronic Ways," Bulletin GEA-3891, please send me the bulletins checked.

- ☐ GEA-4091—Vibration motors and meters
- ☐ GED-972A—Thy-mo-trol drive (electronic motor control)
- ☐ GEA-1755E—Photoelectric relays
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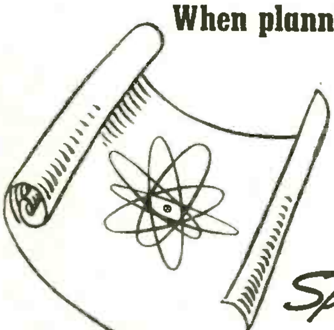
When planning new machines, processes, buildings—

LOOK TO ELECTRONICS

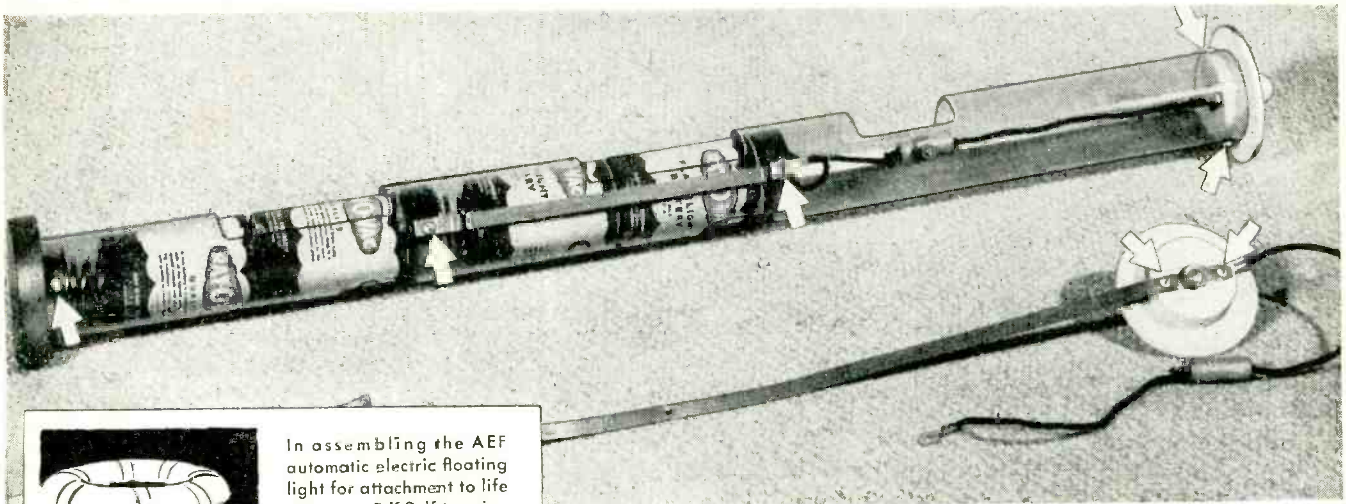


Electronic production aids, like these on this page, offer real opportunities for improvements and economies. Come to General Electric for electronic answers to your problems. ***General Electric, Electronic Control Section, Schenectady, N. Y.***

Speed Production Electronically

GENERAL ELECTRIC

Question every fastening!



In assembling the AEF automatic electric floating light for attachment to life preserves, P-K Self-tapping Screws are used to: Fasten a lug terminal, a brass circuit carrier strip, and the transparent plastic battery container to the Tenite top plate, and to the solid lead base. Also to attach brass strip and the plastic container to fibre circuit spacers.

PARKER-KALON

Quality-Controlled

SELF-TAPPING SCREWS

Assembly Work-hour Savings planned on the drafting board

- with P-K Self-tapping Screws

Able designers planned ahead for production speed and low assembly costs when they specified Parker-Kalon Self-tapping Screws for the AEF Floating Water Light. For ten different fastenings of plastic to plastic and metal to plastic, P-K Self-tapping screws topped every other fastening method for speed, security, and savings.

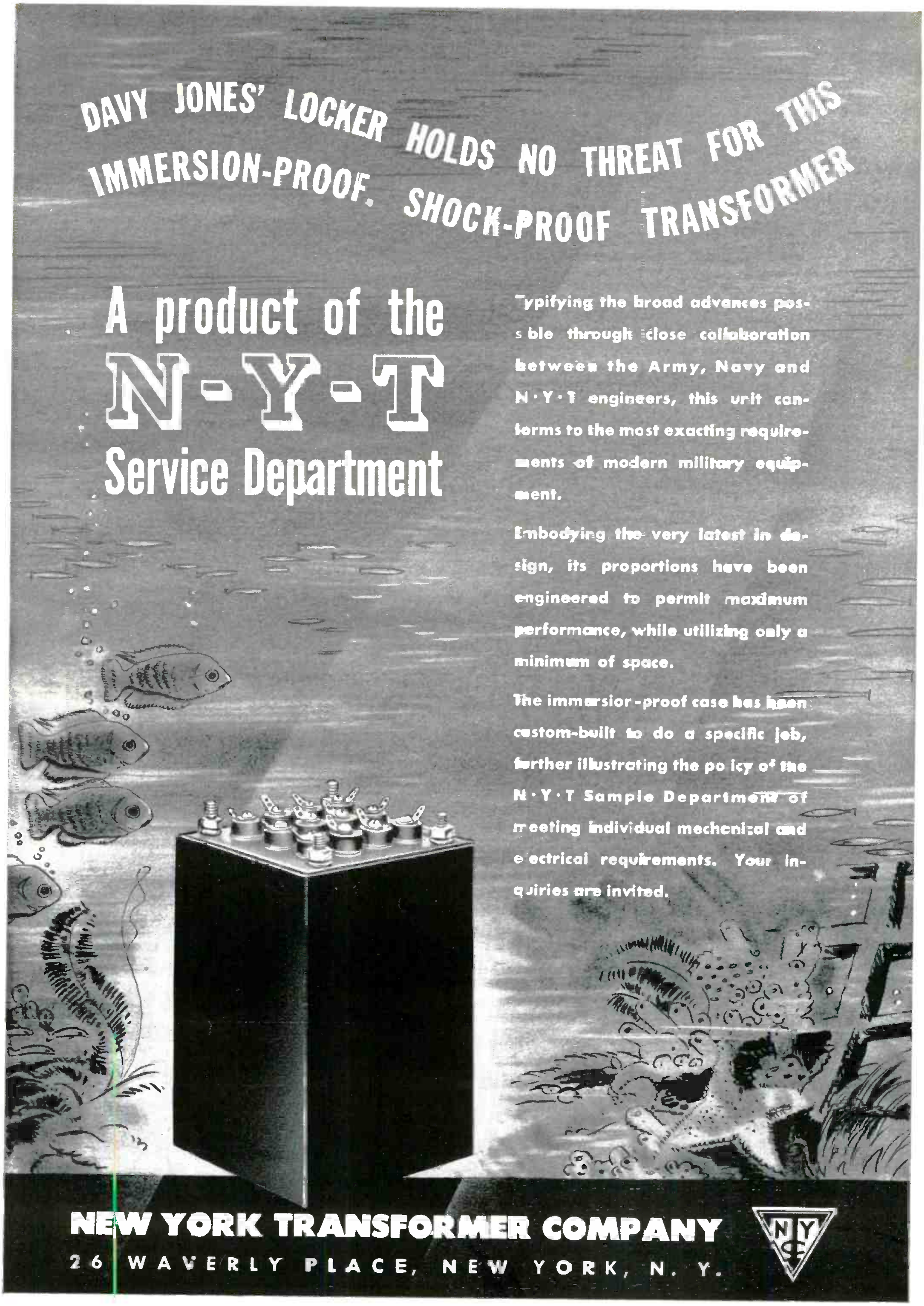
This ingenious life-saving aid made by A. E. F. Water Light Corporation, New York, is an important war product in record demand by the Army, Navy, and Maritime Commission. No time can be spared in its production for minute-wasting assembly methods. P-K Self-tapping Screws make the assemblies the simplest, quickest way, in one operation. They form their own strong threads in the material as they are turned into drilled or molded holes. Costly tapping and tap maintenance, or complicating inserts, are avoided . . . training of new workers takes less time.

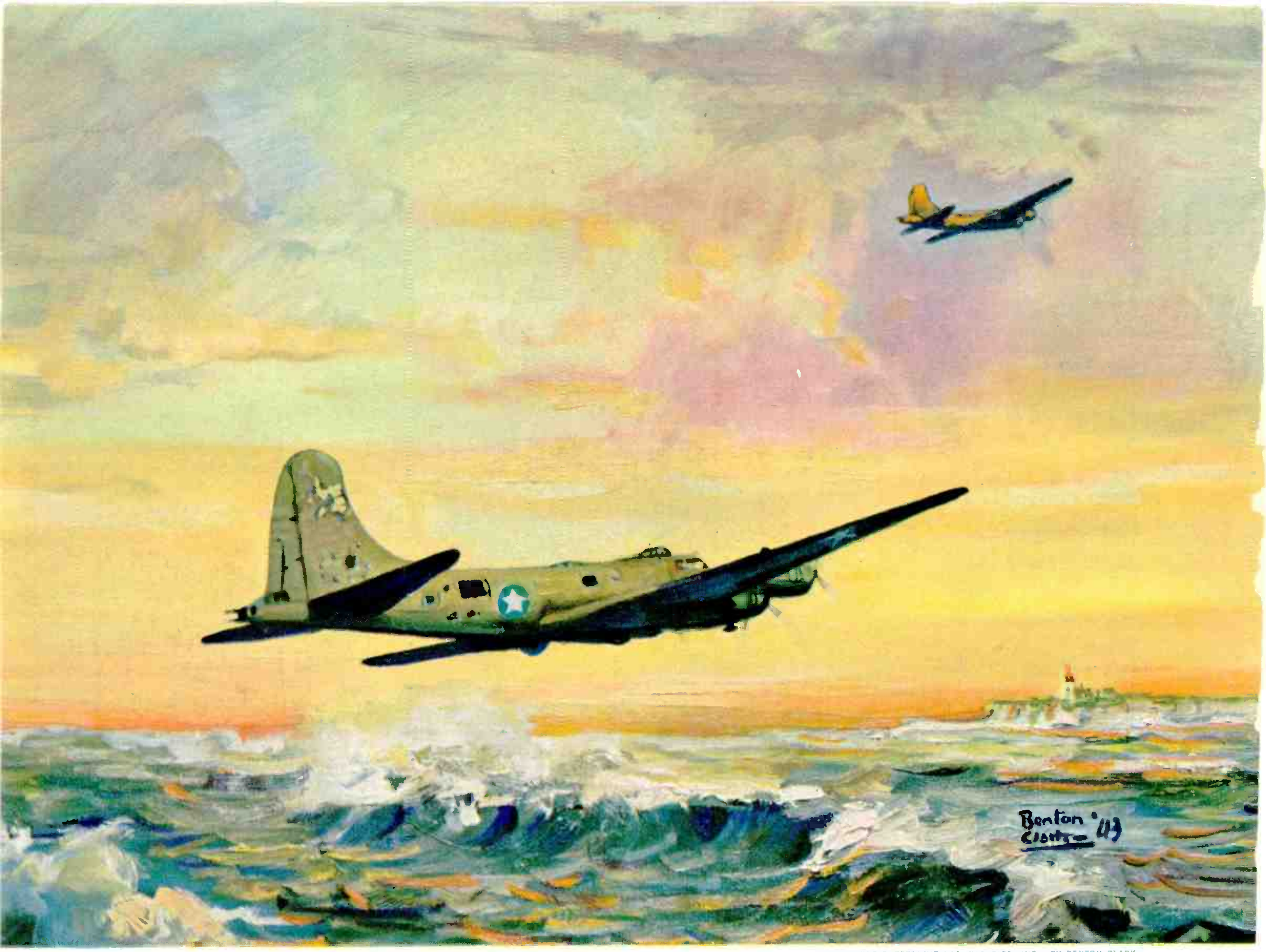
Uncover the Work-hour Waste in Your Assemblies

Every war production plant needs all the work-hours P-K Self-tapping Screws can save. *Question every fastening job* on your drafting board or production line *now* – make sure you can't use Self-tapping Screws before you put up with slower, complicated methods.

Ask for a P-K Assembly Engineer to call and help you uncover all opportunities to gain work-hours, improve products with Self-tapping Screws. Or, mail assembly details for recommendations. Parker-Kalon Corporation, 192-194 Varick Street, New York 14, N. Y.

SELF TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY


DAVY JONES' LOCKER HOLDS NO THREAT FOR THIS
IMMERSION-PROOF, SHOCK-PROOF TRANSFORMER
A product of the
N-Y-T
Service Department
Typifying the broad advances possible through close collaboration between the Army, Navy and N·Y·T engineers, this unit conforms to the most exacting requirements of modern military equipment.
Embodying the very latest in design, its proportions have been engineered to permit maximum performance, while utilizing only a minimum of space.
The immersion-proof case has been custom-built to do a specific job, further illustrating the policy of the N·Y·T Sample Department of meeting individual mechanical and electrical requirements. Your inquiries are invited.
NEW YORK TRANSFORMER COMPANY
26 WAVERLY PLACE, NEW YORK, N. Y.



PAINTED FOR ELECTRONIC LABORATORIES, INC., BY BENTON CLARK

The 'Game Goose' gets home . . . again

● **The old girl's done it again. She's laid her eggs where they'll count most—and in spite of hell and high flack, she'll soon be smoothing her ruffled feathers at home.** —The capacity of America's fighting men and machines to absorb punishment, as well as dish it out—to come back again, and again, and again—is no accident.

Electronic Laboratories is proud of the *E·L* equipment that is helping the 'Game Goose,' and every American fighting plane, get home again.

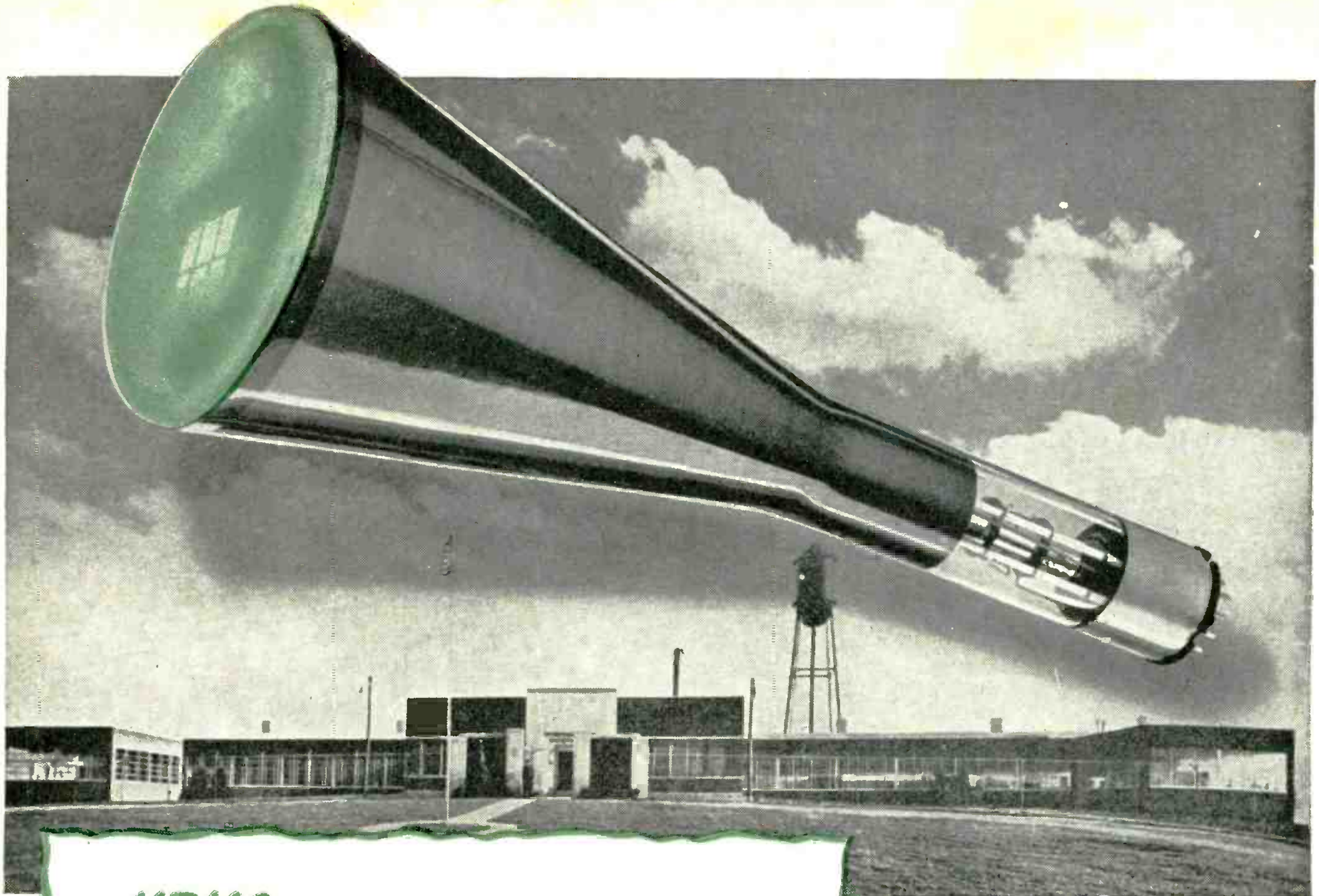
On every front where the United Nations are in combat, *E·L* Vibrator Power Supplies are proving themselves as rugged and reliable as the company they keep. At high altitudes, in steaming jungles or blazing deserts, they perform their appointed task with the greater efficiency and freedom from wear, characteristic of *E·L* Vibrator Power Supplies.

Wherever electric current must be changed in voltage, frequency or type, *E·L* Vibrator Power Supplies and Converters offer many definite advantages, for peace, as well as for war.

★ **For Operations of Radio Transmitter-Receiver**—E·L Model S-1200 Vibrator Power Supply. Input Voltages: 12, 24, 32, and 110 Volts DC, and 110 Volts AC—50-60 Cycles; Output: 600 Volts DC at 150-250 MA., 300 Volts DC at 75-150 MA.; 6-8 or 10 Volts DC at 1 A.; 110 Volts AC (50-60 cycles) at 75 Watts. Maximum Output Power: 280 Watts; Maximum Dimensions: 26 1/16" x 14 31/32" x 13 37/64"; Weight: 160 lbs.

Electronic
LABORATORIES, INC.
INDIANAPOLIS

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



MEMO **for Post-War Reference:**

NATIONAL UNION IS ONE OF THE LARGEST PRODUCERS OF CATHODE-RAY TUBES

In our cathode-ray tube production record, now climbing upward week by week, we see the working out of plans made long ago. Here are the dreams of our engineers come true. Here is the model factory they planned and equipped especially for cathode-ray tube manufacture—one of the Industry's largest. Here are the mass production machines they designed—built by this company's own equipment division. Here are the hundreds of skilled workers to whom they taught this special art of tube making that calls for the utmost precision and accuracy. Here are their laboratories with research continuing at an even greater pace, as though their work had just begun. And here are the results of all this thought and effort—National Union Cathode-Ray Tubes *by the carload.* Today, enroute to those who need them most—our fighting forces! Tomorrow, destined to bring to millions of homes a marvelously improved kind of television with larger images, with greater sharpness, reality, at mass-market prices—and to thousands of factories many new precision testing and measuring devices.

For engineers and production men, National Union is planning a comprehensive electronics industrial service—available as soon as war commitments permit.

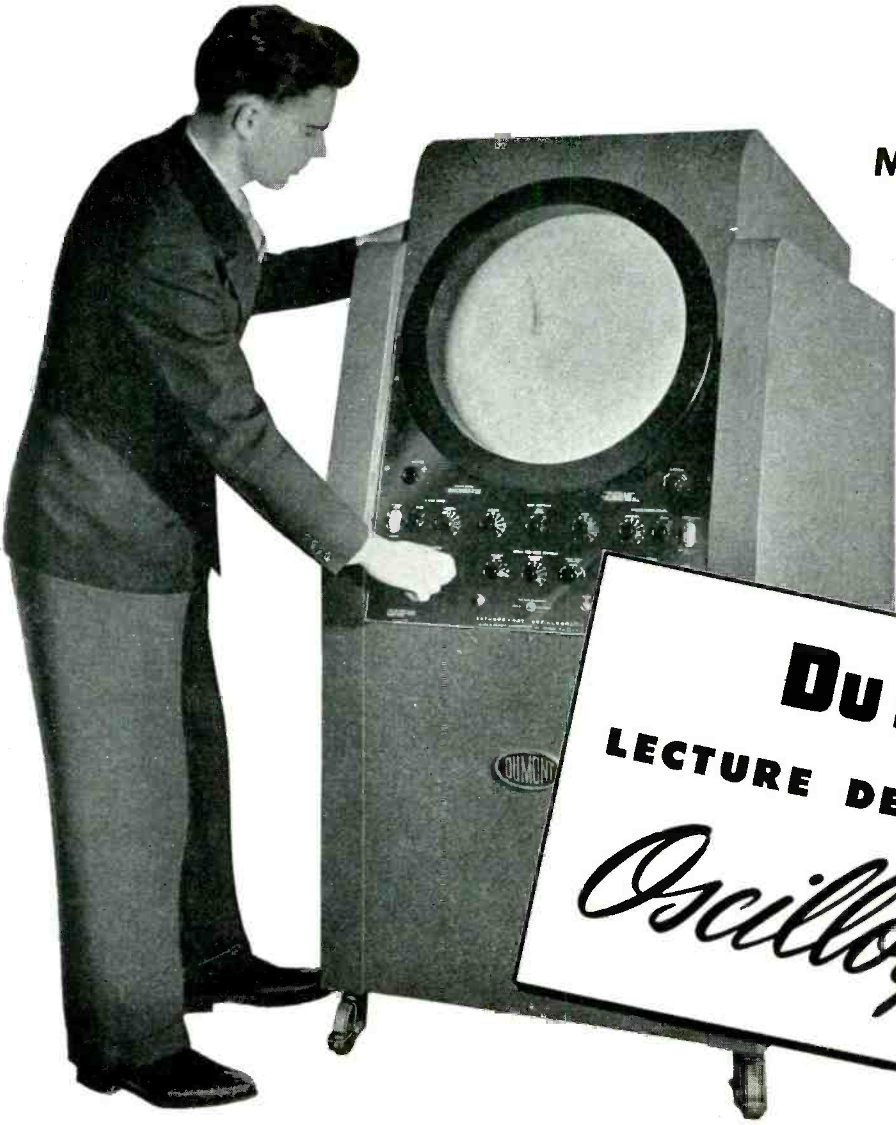
NATIONAL UNION RADIO CORPORATION NEWARK, N. J. LANSDALE, PENNA.

NATIONAL UNION

RADIO AND ELECTRONIC TUBES

MOUNTAINS OUT OF MOLEHILLS—

electronically speaking . . .



DuMONT

LECTURE DEMONSTRATION

Oscillograph

DuMONT TYPE 233 OSCILLOGRAPH

DuMont Type 20AP1 intensifier-type 20" dia. cathode-ray tube. Medium-persistence green screen. 6000 v. total accelerating potential.

X- and Y-axes arranged for either conductive or capacitive coupling through stepped attenuator. Z-axis and synchronizing circuit capacitively coupled.

X- and Y-axes amplifier frequency response 2 to 75,000 c.p.s. Z-axis, 10 to 750,000 c.p.s.

Linear time-base generator: frequency of sweeps, single or continuous. Frequency range, 8 to 30,000 sawtooth c.p.s. Synchronized with either positive or negative polarity of power line frequency, external signal or Y-axis signal.

Instantaneous type of positioning circuits.

Elimination of trapezoidal distortion of image and non-symmetric deflection.

Dimensions: 60" high x 28" wide x 36" deep. Weight: Approximately 325 lbs.

Self-contained power supply. 115 v. 50-60 c.p.s A.C. Approximately 350 watts.

DuMont Type 233 cathode-ray oscillograph is a giant-screen instrument of moderate cost. Suitable for lecture demonstration. Or for laboratory studies in which detailed analysis of fine-structure wave forms is required. This instrument is already playing a vital role in the war effort.

The 20-inch DuMont cathode-ray tube provides a brilliant trace observed with ease at distances normally encountered in lecture halls and even large auditoriums.

Other essential features are the identical amplifiers for signal deflection along both horizontal and vertical axes; the Z-axis amplifier for intensity modulation of the cathode-ray; a linear time-base generator; and the associated power and control circuits. Sturdy metal cabinet mounted on locking casters. Sloping control panel directly below screen. Completely self-contained. Plugs into usual A.C. outlet.

Write on your business letterhead, for bulletin describing this instrument, or for manual and catalog on entire DuMont line. Type 233 is available for early delivery, on proper priority.

DUMONT

ALLEN B. DU MONT LABORATORIES, Inc.
Passaic • New Jersey
Cable Address: Wespexlin, New York

CASH PRIZE CONTEST!

FOR RADIO MEN IN THE SERVICE!

"Write a Letter"

As you know, the Hallicrafters make SCR-299 Communications trucks. We are proud of our handiwork and proud of the job you men have been doing with them on every battle front.

RULES FOR THE CONTEST

We want letters telling of actual experiences with SCR-299 units. We will give $100.00 for the best such letter received during each of the five months of November, December, January, February and March! **Closing dates: midnight of last day of each month!**

We will send $1.00 for every serious letter received so even if you should not win a big prize your time will not be in vain.

Your letter will be our property, of course, and we have the right to reproduce it in a Hallicrafters advertisement.

Good luck and write as many letters as you wish. V-Mail letters will do.

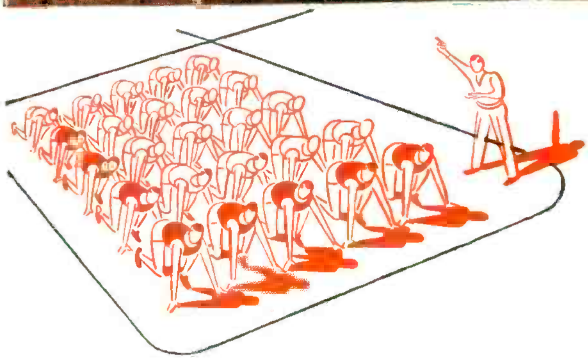
W. J. Halligan

BUY MORE BONDS!

the hallicrafters co.

2611 INDIANA AVENUE, CHICAGO, U.S.A.

MAKERS OF THE FAMOUS SCR-299 COMMUNICATIONS TRUCK



Although it weighs more than 600 sprinters its nervous system responds like an athlete's to the starting gun. Its radio hears commands, its control system instantly executes them.

Formica laminated plastic sheets, tubes and rods in various grades are used for punched parts, insulating spools, veri-chromed control panels, insulating spacers, breaker arms, bushings, radio socket bases, terminal strips, rheostat cores and other di-electric parts.

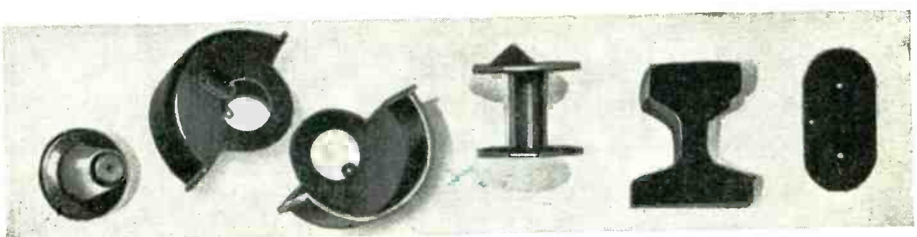
Its properties* suggest peacetime uses in every process and product that depends upon a healthy mechanical nervous system.

***PROPERTIES**

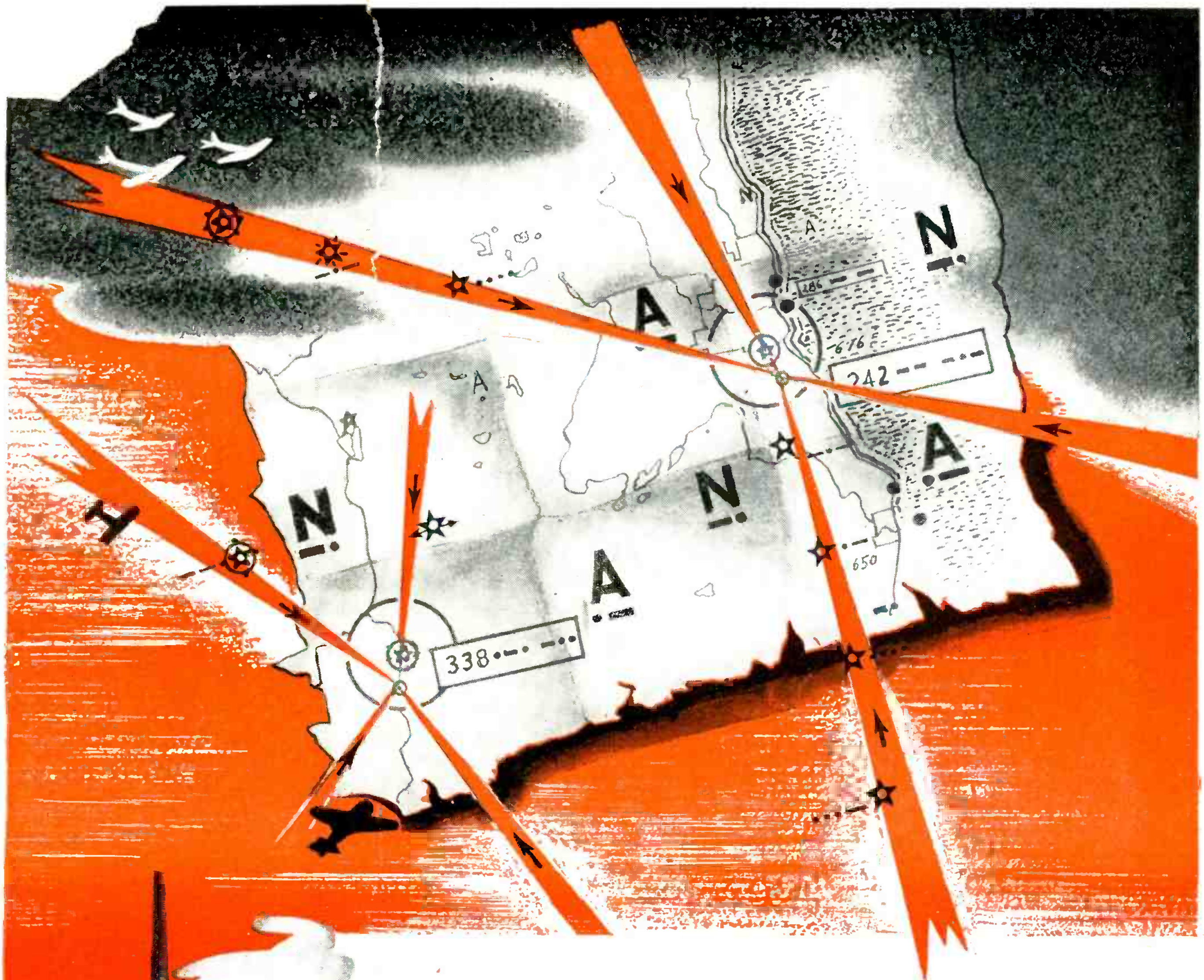
HIGH DI-ELECTRIC STRENGTH
LOW POWER FACTOR
DIMENSIONAL STABILITY
EASY MACHINABILITY
LACK OF COLD FLOW
RESISTANCE TO ABSORPTION

ARMY E NAVY

FORMICA



THE FORMICA INSULATION COMPANY, 4661 SPRING GROVE AVE., CINCINNATI, OHIO



"Highways of the Air"...

Each year, millions of miles are flown in safety over highways of the air . . . with the aid of RADIO RECEPTOR equipment . . .

RADIO RANGE BEACONS • LOCALIZERS
MARKERS: FAN, "Z" AND SPOT • AIRPORT TRAFFIC CONTROLS
AIRPORT COMMUNICATIONS EQUIPMENT

RADIO RECEPTOR engineers, cooperating with government agencies, have made important contributions to flight safety and efficiency. Many of these improved ground-to-air navigation devices are now in general use. Our present military assignments will further advance the scope and dependability of RADIO RECEPTOR equipment in peacetime travel and transport.

We will send, on request, a copy of our revised brochure, "HIGHWAYS OF THE AIR", *now in preparation. Please write on your business stationery to our Executive Offices.*

251 WEST 19TH STREET, NEW YORK 11, NEW YORK

KEEP BUYING WAR BONDS AND STAMPS

RADIO RECEPTOR CO., INC.

Awarded for Meritorious Service on the Production Front

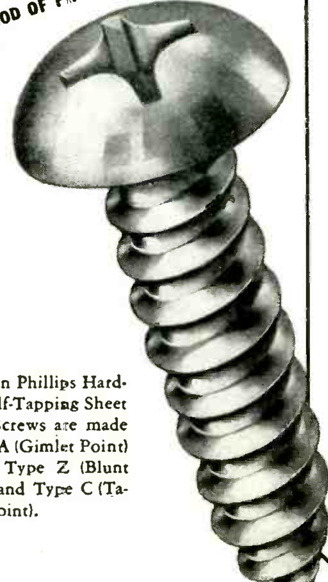
SINCE 1922 IN RADIO AND ELECTRONICS

"The Boss is 20 Years Younger
since we cut our assembly time in half with AMERICAN PHILLIPS SCREWS!"

Production comes out of the doldrums with a rush, when assemblies are changed over to American Phillips Screws. For then you're free of delays from slow, uncertain driving . . . crooked screws that have to be backed out and re-driven . . . spoiled work and broken screwheads . . . and lost-time accidents from slashed hands. The modern method of American Phillips Screw Driving enables new workers to do A-1 work right from the start . . . with the 4-winged driver and recessed screw-head that align themselves to *drive automatically straight,* and set up flush-tight with the work surface . . . without physical strain or mental hazards. So production executives who change to American Phillips Screws not only pat themselves on the back . . . they get an *extra* pat on the back from all their assembly workers, too.

And what's more, they get 3 exclusive American advantages with every order: *American Value,* guaranteed by self-checking count, and individual inspection that makes sure every screw is A-1. *American Engineering,* that brings you all important improvements first, and helps with any special problems. *American Service,* that gives reasonably prompt delivery even in wartimes, because the American line is complete. You, yourself, can get rid of a lot of headaches . . . and hike production as much as 50% . . . by changing *now* to double-quick American Phillips Screws.

WORLD'S EASIEST, FASTEST, MOST ACCURATE METHOD OF PRODUCTION SCREW DRIVING

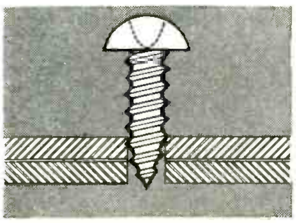


American Phillips Hardened Self-Tapping Sheet Metal Screws are made in Type A (Gimlet Point) shown, Type Z (Blunt Point), and Type C (Tapered Point).

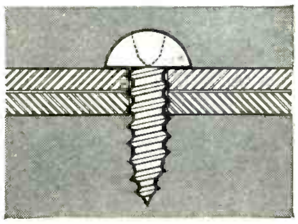
AMERICAN SCREW COMPANY

PROVIDENCE, RHODE ISLAND

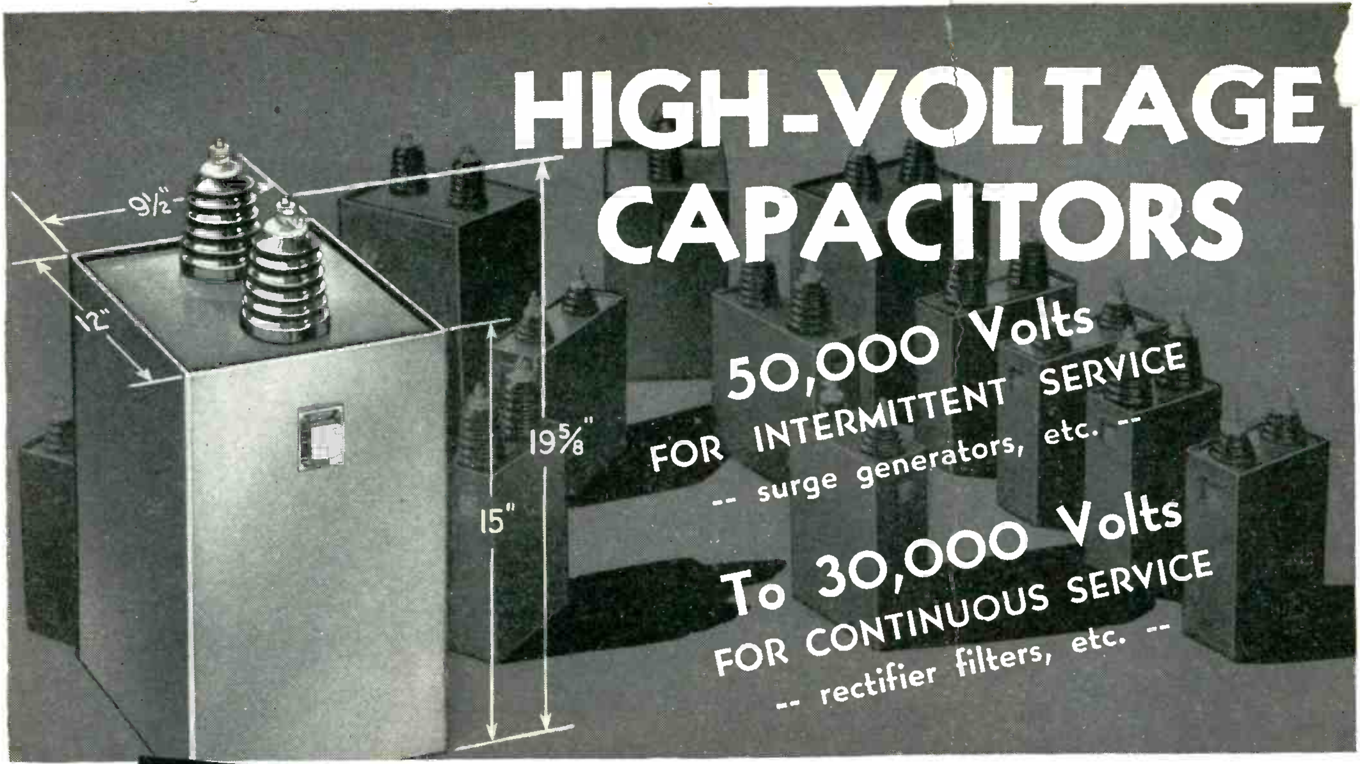
Chicago: 589 E. Illinois Street *Detroit:* 5-267 General Motors Building



American Phillips Driver and Screw form a single, straight-line driving unit . . . and stay that way until screw is completely driven in.



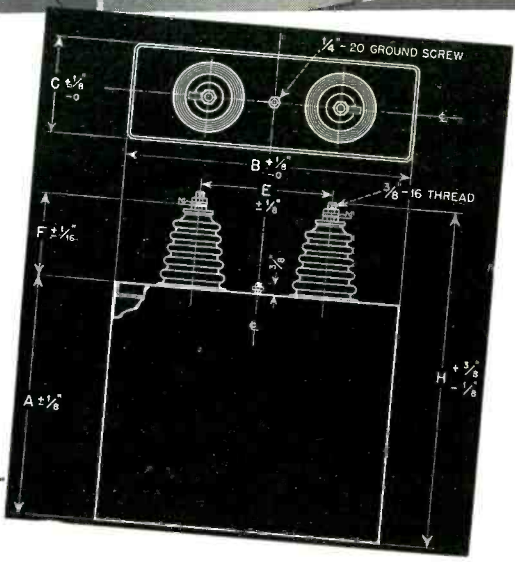
American Phillips Hardened Self-Tapping Sheet Metal Screw sets up tight and straight in drilled or clean-punched holes.



HIGH-VOLTAGE CAPACITORS

50,000 Volts
FOR INTERMITTENT SERVICE
-- surge generators, etc. --

To 30,000 Volts
FOR CONTINUOUS SERVICE
-- rectifier filters, etc. --



AEROVOX Series '20

TYPE 6020—6000 v. D.C. Work 2.0 mfd. to 10.0 mfd.
TYPE 7520—7500 v. D.C. Work 0.5 mfd. to 6.0 mfd.
TYPE 10020—10,000 v. D.C. Work 1.0 mfd. to 5.0 mfd.
TYPE 12520—12,500 v. D.C. Work 0.5 mfd. to 5.0 mfd.
TYPE 15020—15,000 v. D.C. Work 0.25 mfd. to 3.0 mfd.
TYPE 20020—20,000 v. D.C. Work 0.25 mfd. to 4.0 mfd.
TYPE 25020—25,000 v. D.C. Work 0.2 mfd. to 1.0 mfd.
TYPE 37520—37,500 v. D.C. Work 0.1 mfd. to 1.0 mfd.
TYPE 50020—50,000 v. D.C. Work 0.1 mfd. to 0.5 mfd. also 25,000 v. Output (12,500 - 12,500 v.) for Voltage-Doubler Circuits 0.25-0.25 mfd. to 0.5-0.5 mfd.

● To meet certain radio and electronic requirements, Aerovox engineers have developed the Hyvol Series —20 oil-filled capacitors covering voltage ratings from 6000 to 50,000 v. D.C.W. Already many of these capacitors are in military service.

Giant, Aerovox designed and built, winding machines handle up to several dozen "papers". Likewise a battery of giant tanks permits long pumping cycles for thorough vacuum treatment, followed by oil impregnation and filling, of the sections. The multi-laminated kraft tissue and hi-purity aluminum foil sections are uniformly and accurately wound under critically controlled tension to avoid mechanical strain.

The sections are *connected directly across the full working voltage*. In the higher capacity units, a plurality of sections are *connected in parallel*. These capacitors are not to be confused with the series-connected sections heretofore frequently resorted to in attaining high working voltages. Sections are hermetically-sealed in sturdy welded-steel containers. Rust-proof lacquer finish. Cork-gasketed pressure-sealed glazed porcelain high-tension pillar terminals.

● Regardless whether it be giant high-voltage capacitors or a low-voltage by-pass electrolytic, send that problem to us for engineering collaboration, recommendations, quotations. Catalog on request.

AEROVOX Capacitors

INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. • SALES OFFICES IN ALL PRINCIPAL CITIES
Export: 100 VARICK ST., N. Y. C. • Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.

RCA 935—A NEW PHOTOTUBE

FOR PRECISE MEASUREMENT OF

ULTRAVIOLET RADIATION

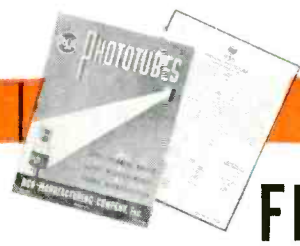
2000 A°
ULTRA VIOLET
VIOLET
BLUE
GREEN
YELLOW
ORANGE
6300 A°
RED
INFRA-RED

IF YOU deal with ultraviolet radiation and have a measurement or detection problem, RCA 935 may be of help to you. This new tube was designed by RCA engineers to give high sensitivity in the ultraviolet range—down to 2,000 Angstroms—yet to eliminate the effects of infra-red radiation. Applications already include use in the detection of certain hazardous gases, in the continuous analysis of certain solutions, and for the measurement of ultraviolet radiation *per se*. There's an RCA phototube for nearly *every* application.

The RCA 935 has an overall length of 4¼ inches (max.); max. diameter, 1-5/16 inches; skirted miniature cap; T-9 bulb; intermediate shell octal 5-pin base. Maximum ratings are as follows: anode supply voltage, 250 (d-c or peak a-c); anode current, 20 microamperes; ambient temperature, 50°C; luminous sensitivity at color temperature of 2870°K, 30 microamperes per lumen. Mounts in any position. Range: 2000A° to 6300A°. *RCA Victor Division, Radio Corporation of America, Camden, New Jersey.*

Here are the 935's most important features:

- **High ultraviolet sensitivity — 0.02 microamperes per microwatt (at 2537 A°)**
- **No response to infra-red**
- **High vacuum—for high stability**
- **High leakage resistance — 500,000 megohms**
- **Special envelope glass — providing excellent U-V passage**



The Magic Brain of All Electronic Equipment Is a Tube — and the Fountain-Head of Modern Tube Development Is RCA.

TUNE IN "WHAT'S NEW?"

RCA's great new show Saturday nights, 7 to 8, E. W. T., Blue Network.

RCA ELECTRON TUBES

FREE!

RCA, 459 S. 5th Street, Harrison, N. J.
Please send me the RCA publications checked below:
........RCA Phototubes—containing 16 pages of helpful information on phototube operation for relays, measurement, and sound reproduction.
........RCA 935—a technical data sheet on this new RCA ultraviolet-sensitive phototube.

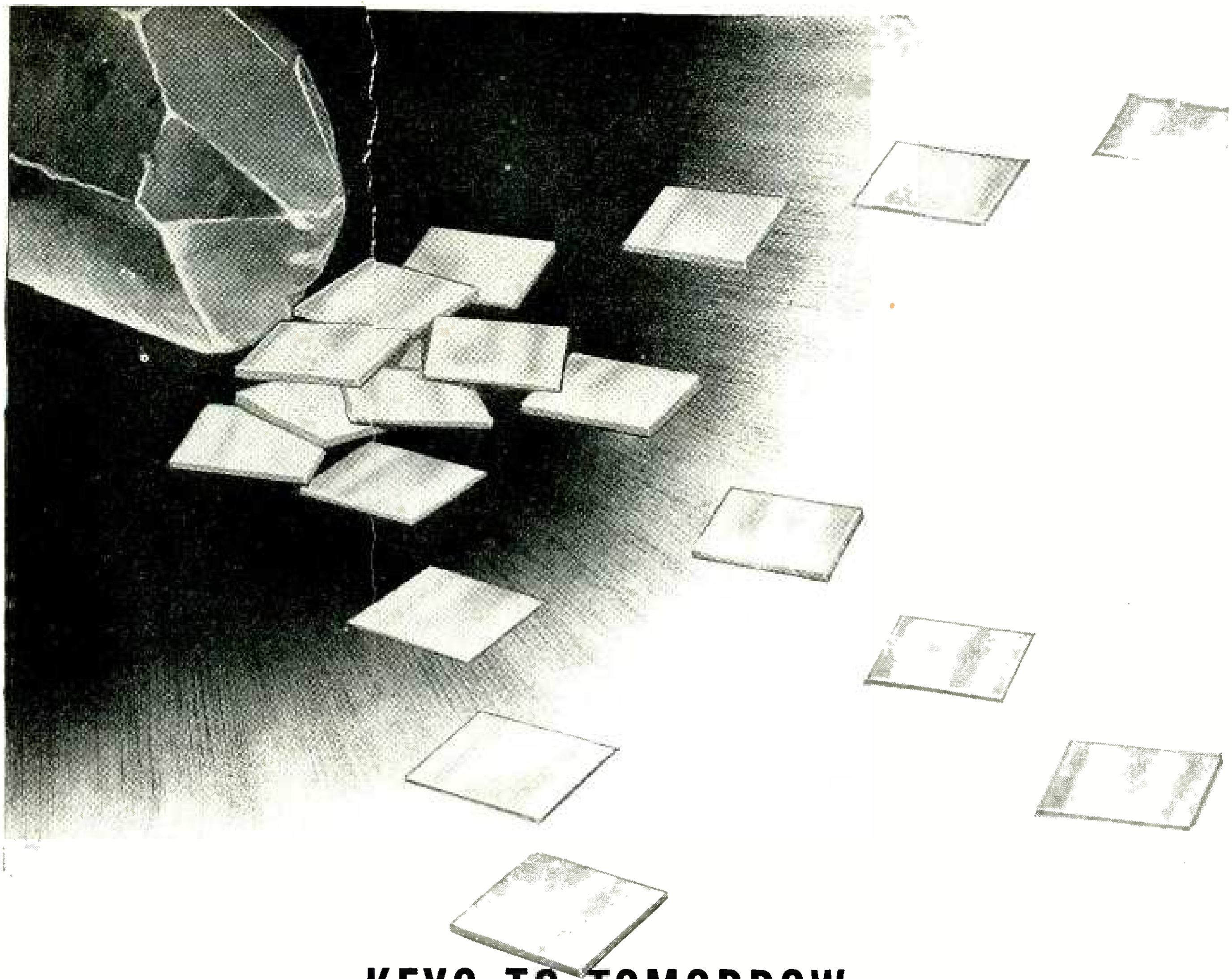
NAME..

(COMPANY)..

STREET..

CITY..STATE ....


JAMES KNIGHTS
Crystals
MARKED FOR DEPENDABILITY!
THE JAMES KNIGHTS CO.
FREQ. 100 KC
TYPE H3M
SANDWICH, ILLINOIS
JK
CRYSTALS
DO YOU NEED THESE TYPES!
★ 100 KC. coated bars—3 PPM or less per 0° Centigrade. (Other frequencies: 50 KC. to 200 KC.)
★ 1000 KC. precision metal tube mounted crystals
★ Bertrand plates
★ 20-23 Atomic plane standards
Precision production now available on the above special quartz products. Tell us your requirements on these or other crystal types which we may be able to supply.
PRECISION CUTTERS OF QUARTZ for COMMUNICATIONS & OPTICAL USES
Any Type, Cut or Frequency
The JAMES KNIGHTS Company
SANDWICH, ILLINOIS
PHONE 65



KEYS TO TOMORROW

Locked within this crystal are keys to countless unexplored avenues of scientific and industrial knowledge. But it takes a consummate skill to release them. Such a skill is reflected in the scientific precision and craftsmanship which characterize oscillator plates and filter crystals by Philips. They have been proved worthy in their current service to Allied arms at war. They will be worthy of the task of helping open the doors upon a better tomorrow.

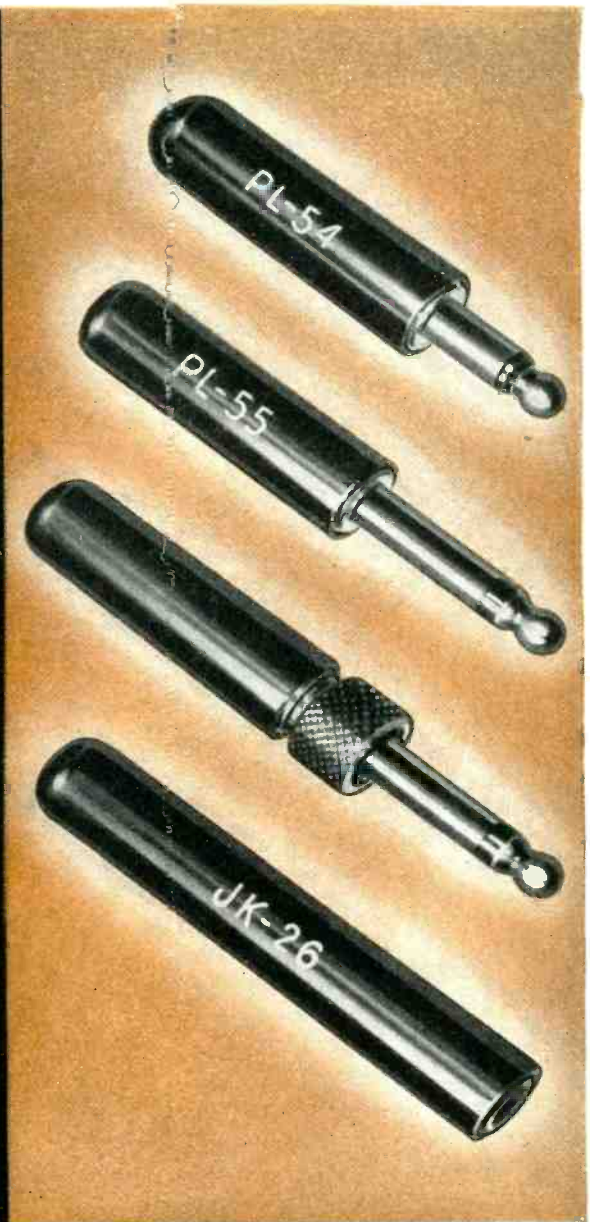
For our Armed Forces we make Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes for land, sea and air-borne communications equipment. *For our war industries* we make Searchray (X-ray) apparatus for industrial and research applications; X-Ray Diffraction Apparatus; Electronic Temperature Indicators; Direct Reading Frequency Meters; Tungsten and Molybdenum in powder, rod, wire and sheet form; Tungsten Alloys; Fine wire of practically all drawable metals and alloys: bare, plated and enameled; Diamond Dies. *For Victory we say: Buy More War Bonds.*

Norelco ELECTRONIC PRODUCTS by NORTH AMERICAN PHILIPS COMPANY, INC.

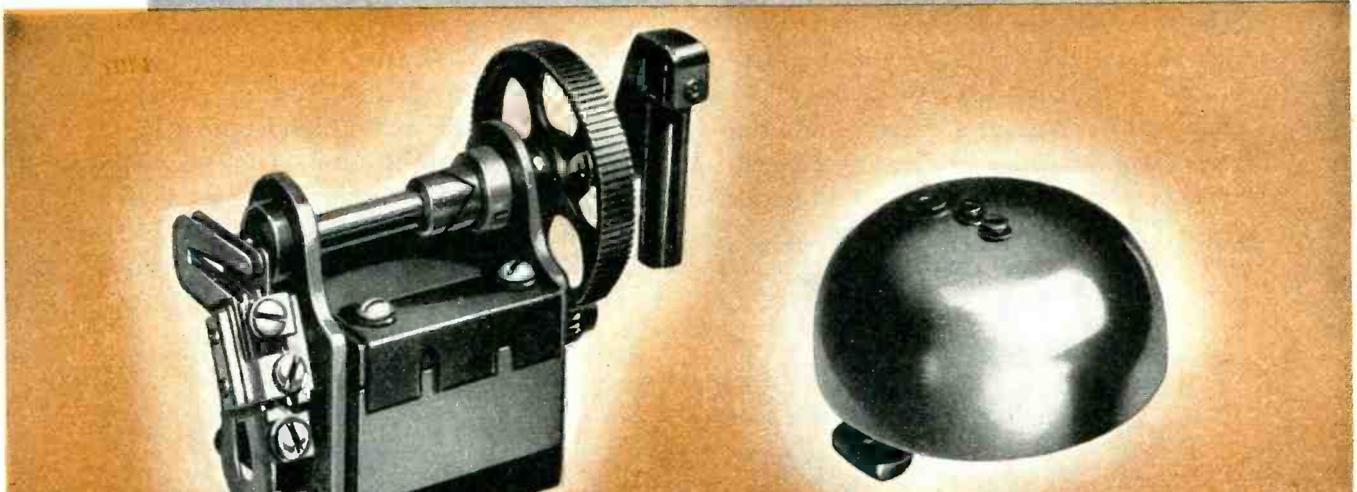
Main factory and offices in Dobbs Ferry, N. Y.; other factories at Lewiston, Maine (Elmet Division); Mount Vernon, N. Y. (Philips Metalix Corp.)
Industrial Electronics Division, 419 Fourth Avenue, New York 16, N. Y.

Quality and dependability have been the watchwords at Chicago Telephone Supply Company — for more than 46 years. No step in the process of manufacturing high quality electro-mechanical components is overlooked or slighted. Each step, from the original designs to the finished product is carefully supervised to insure the greatest operating efficiency and complete dependability for the life of the product.

Manufacturers of electronic equipment are invited to make inquiries. Our engineering skill, great production facilities and dependable delivery service are at your disposal. Send us specifications of your special requirements.



Manufacturers of Quality Electro



Telephone generator and ringer are shown less than actual size.

KEYS TO TOMORROW

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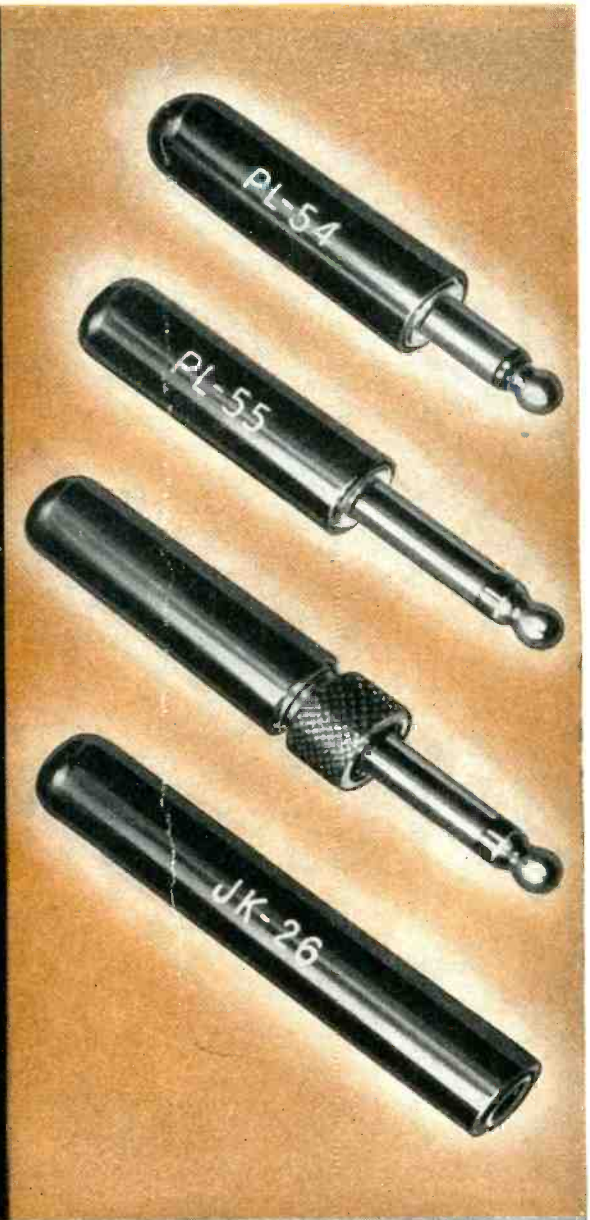
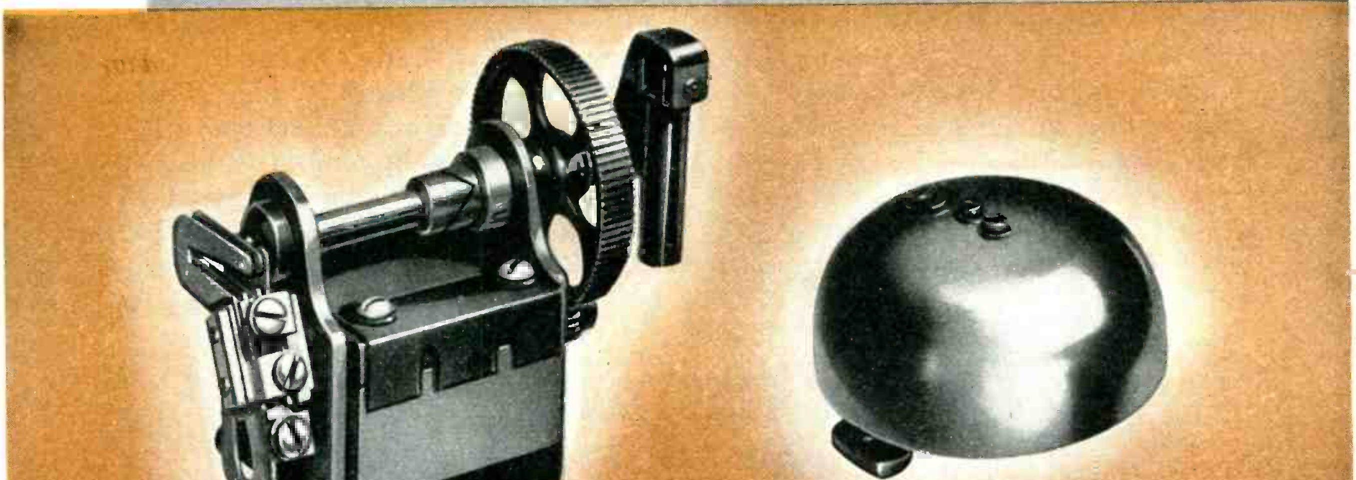
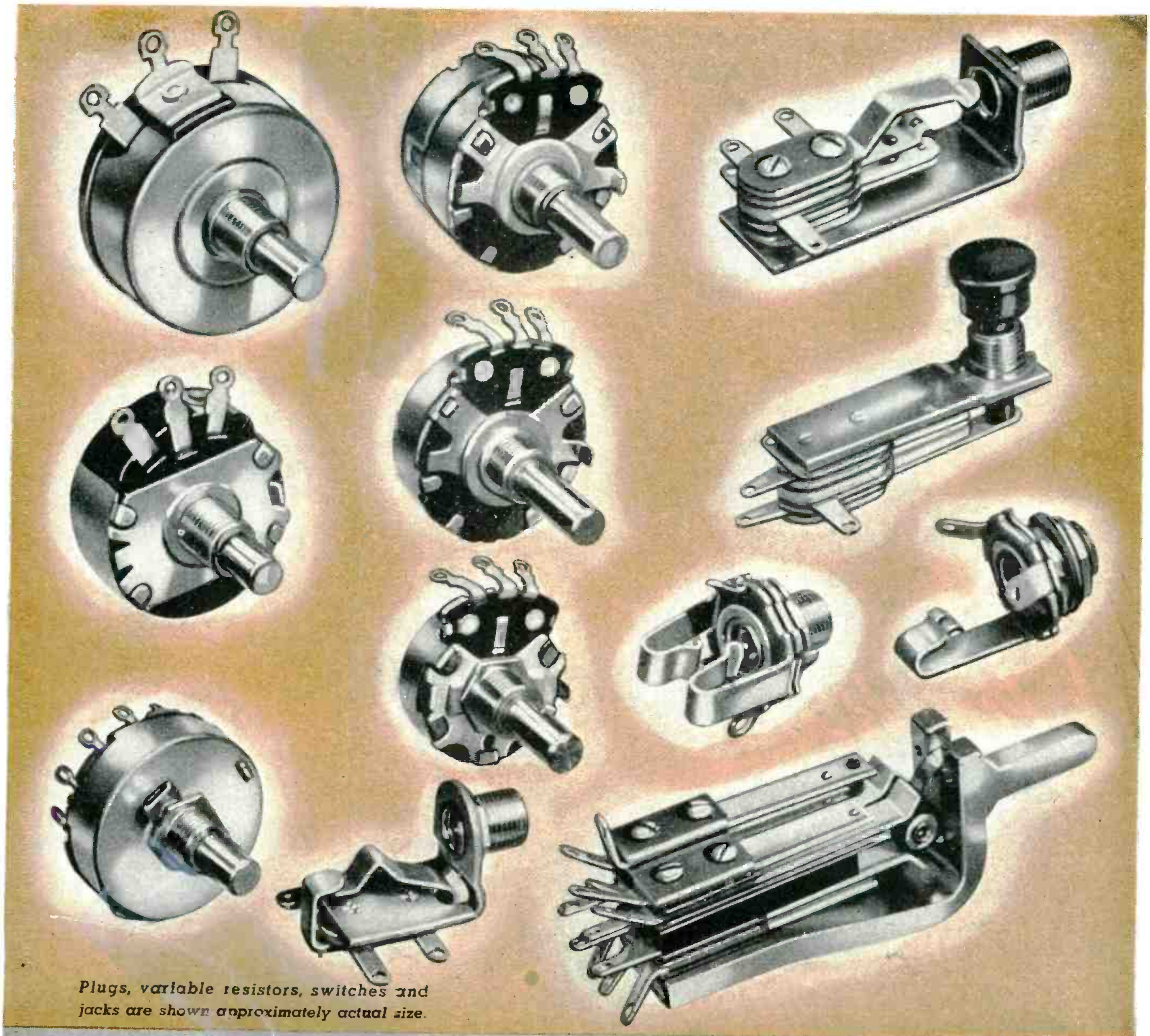


Manufacturers of Quality Electro



Telephone generator and ringer are shown less than actual size.



Mechanical Components Since 1896


CRYSTALS
Quickly
Your temperature coefficient and absolute frequency specifications for crystals will be met quickly, in small or large quantities, by our Special Crystal Division. Such service—with speed and without red tape—is of definite assistance to those industries engaged in special war work.
Just reach out and
PHONE PLYMOUTH (Indiana) 33
US
RUSH
JOHN MECK INDUSTRIES
PLYMOUTH, INDIANA
EXCELLENCE
IN MUSIC AND VOICE
RECREATING INSTRUMENTS

...as a Weathercock to the breeze!

The demands of war in an industrial as well as a military sense, are ever changing. We must be sensitive to these changes — always ready to meet them, regardless of the cost in disappointment, upset schedules, temporary confusion, more work where it seemed that the most possible was already being done. We constantly endeavor to make this the keynote of our operations, realizing its necessity in hastening ultimate victory!

• RIBBON • STRIP •
ROD
SPECIAL ALLOYS
WIRE

WILBUR B. DRIVER CO.
NEWARK — NEW JERSEY

VIBRATION TESTED

Long before the war, TUNG-SOL established the practice of "Vibration-Testing" all radio tubes of new design and tubes picked out at regular intervals from the production line. Making tubes that meet government standards was nothing new.

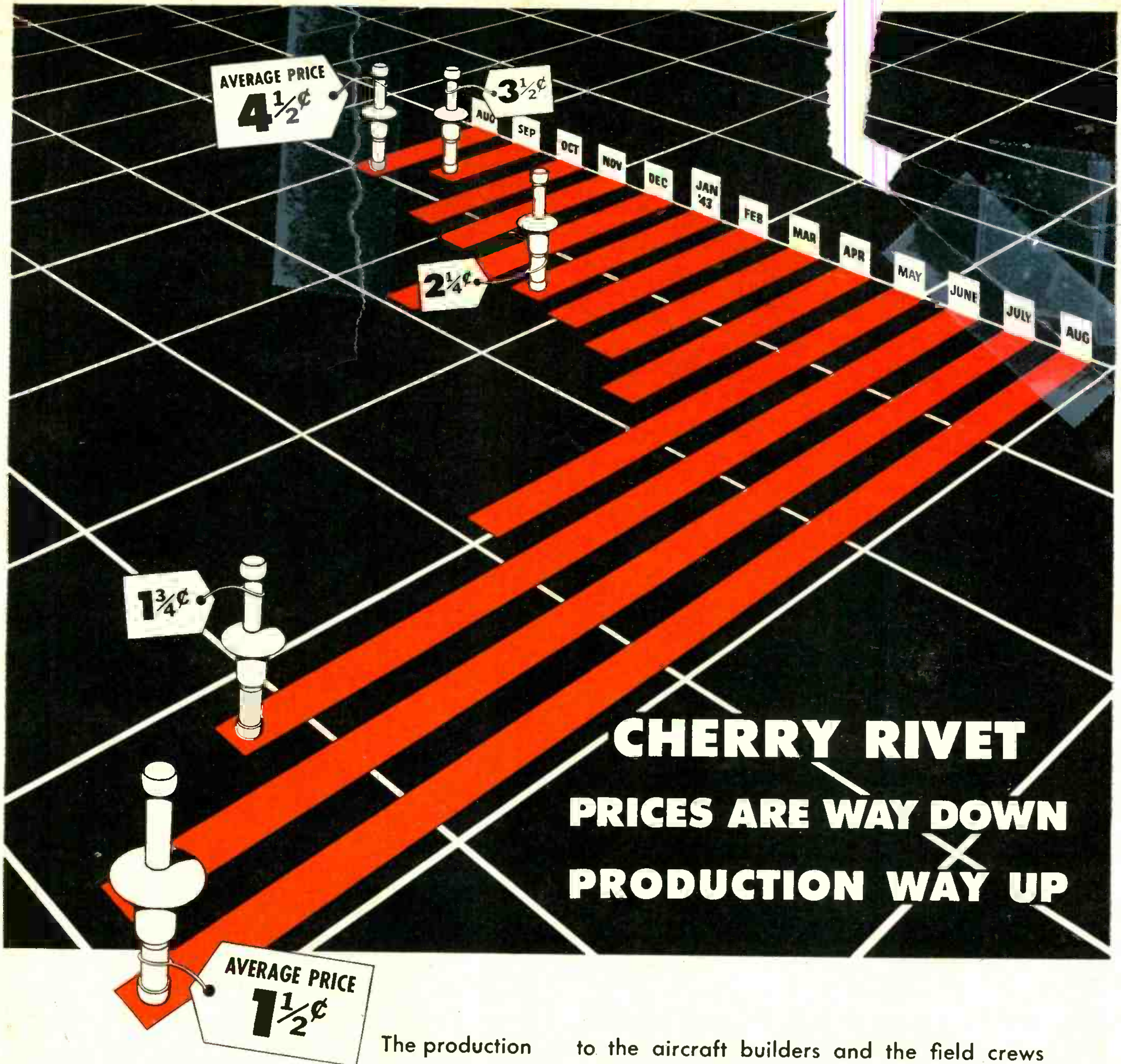
Today the TUNG-SOL Radio Tubes in communication equipment of jeeps and planes and tanks and in portable sending and receiving sets are subjected to far more severe conditions than will ever be encountered in civilian uses. TUNG-SOL Tubes are giving praiseworthy performances . . . a direct result of "Vibration-Testing."

Manufacturers of electronic devices and of electronically controlled equipment will find TUNG-SOL a most satisfactory source of dependable tubes for every application. TUNG-SOL research engineers will be glad to assist you now in making your post-war products more efficient through Electronics.

Current is introduced through the various circuits of the tube while it is being rapidly vibrated. Uniformity of the current flow is indicated by sensitive meters and is positive proof of proper design and construction. Tubes that pass this most exacting test are truly classed as "VIBRATION-TESTED."

TUNG-SOL
vibration-tested
RADIO TUBES

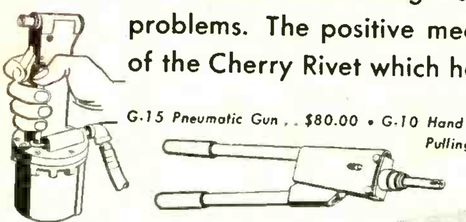
TUNG-SOL LAMP WORKS INC., NEWARK, N. J., *Sales Offices:* ATLANTA, CHICAGO, DALLAS, DENVER, DETROIT, LOS ANGELES, NEW YORK
ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTERS



The production of Cherry Blind Rivets in August was five times greater than in August a year ago. In that time, the average price has dropped to ⅓ of its original level.

This means that you can now use Cherry Rivets to solve more design and production problems. The positive mechanical action of the Cherry Rivet which has proved itself to the aircraft builders and the field crews of our armed forces can now save time and money in an even wider range of uses.

Orders have increased faster than production, resulting in a large undelivered backlog. In spite of this, scheduling now permits partial delivery on new high priority orders within 30 days. Immediate delivery on emergency orders. Immediate delivery on tools.

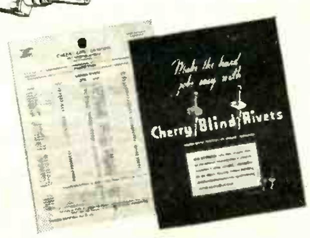


G-15 Pneumatic Gun . . $80.00 • G-10 Hand Operated Gun . . $16.60
Pulling heads extra as needed.

CHERRY RIVETS, THEIR MANUFACTURE AND APPLICATION ARE COVERED BY U. S. PATENTS ISSUED AND PENDING.

GET COMPLETE STORY

Handbook A-43 tells how to use Cherry Rivets in blind or hard-to-get-at structures. New price list also available. Address Department A-120 Cherry Rivet Company, 231 Winston Street, Los Angeles 13, California.



Cherry Rivet Company

LOS ANGELES, CALIFORNIA

PROTECTED

against excess anode Temperature

through the use of graphite anodes . . . pioneered for the industry by our engineers.*

Experienced heads, which among other things pioneered the graphite anode and the carburizing of thoriated filaments, have joined in this young and virile company to develop and manufacture the finest in vacuum products for electronic applications . . . with no prejudices, no preconceptions, no antiquated equipment or methods to hinder their creative and productive abilities.

This tube, type DR300, is a typical example of these skills. It is a rugged tube for rugged service with a plate dissipation of 300 watts. Severe service tests in high frequency furnaces have consistently proved this tube superior.

Inquiries are invited.

ESPECIALLY ADAPTED FOR HIGH FREQUENCY BOMBARDERS

*We refer persons interested in this pioneering work to an article by D. E. Replogle which appeared in the December 1933 issue of Electronics, pages 338, 339.

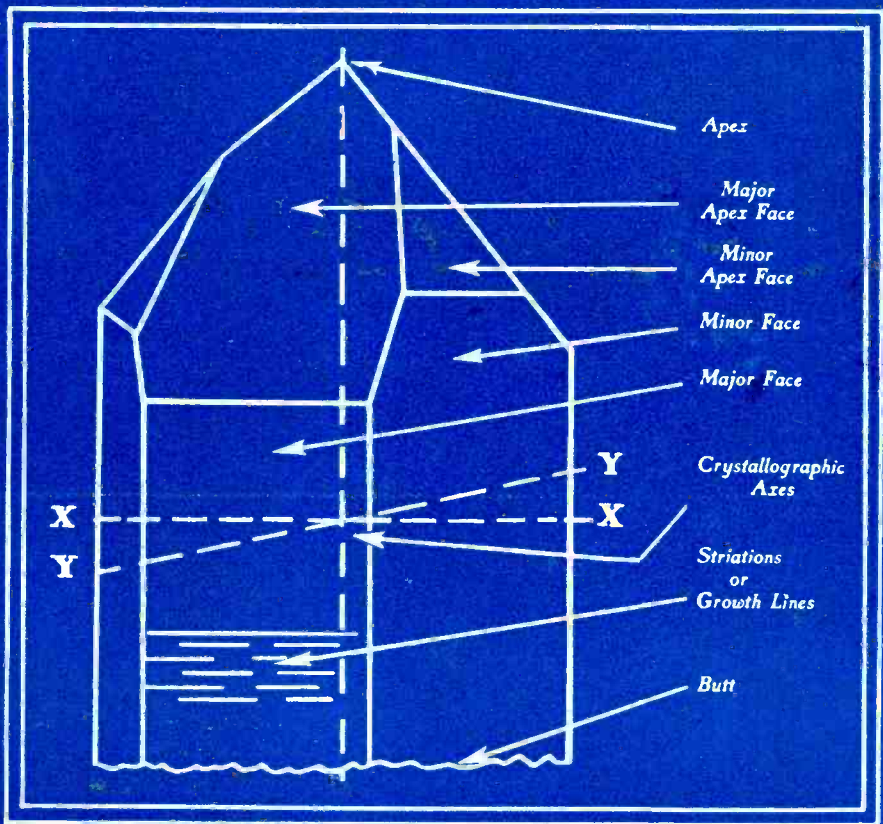
GENERAL ELECTRONICS INC.

101 HAZEL STREET, PATERSON, N. J.

SPECIALISTS IN ENGINEERING AND MANUFACTURING VACUUM PRODUCTS FOR ELECTRONIC APPLICATIONS

THE INSPECTION OF QUARTZ...

DIAGRAMMED BY CRYSTAL PRODUCTS



Quartz with the better piezo-electric properties are imported. The mineral is usually classified according to size with pieces ranging from 100 to 300 grams.

A shipment of quartz nearly always represents a cross section of the quartz supply . . . some crystals will have good faces and apexes, others only few faces and no apexes, and still others no faces or apexes at all. It is therefore necessary that they be expertly sorted, usually into three groups, each one to be treated in a different method before cutting.

Next, in order, comes the study of impurities in the different kinds of crystals. The impurities can be seen with the naked eye, by having a beam of light pass through the crystal. This shows up such impurities as fractures or cracks, foreign particles included within the crystal, bubbles, needles, veils, color and ghosts or phantoms. The latter are cases where the crystal contains internal colored bands or planes parallel to the faces of the crystal. These really represent stages of growth of the crystal and it appears to the eye as if one crystal has grown within another. Crystals with excessive amounts of impurities are, of course, rejected.

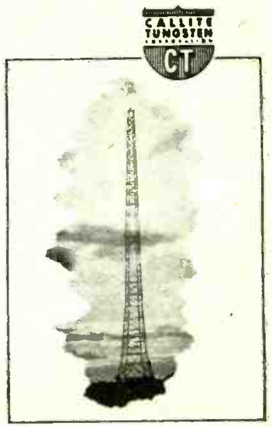
Crystal PRODUCTS COMPANY
1519 McGEE STREET, KANSAS CITY, MO.

Producers of Approved Precision Crystals for Radio Frequency Control

"Hot News" from far places is flashed instantly through the medium of high-powered radio transmitters the very heart of which is the vacuum tube. Dependability, stamina and outstanding performance capabilities are attributes which such tubes must possess. One outstanding example of vacuum tube construction is the EIMAC 304T Tube. This unusual tube is built on a revolutionary design which mounts four triode units in a single glass envelope.

Contributing to the stamina of such vacuum tubes, now in wide service, are grid and plate leads made from Callite Tungsten Rods and Callite Thoriated Filament—evidence of Callite dependability. Other Callite products, backed by Callite metallurgical and engineering knowledge, plus precision production, are functioning in many of today's most vital electronic and electrical devices.

Consult Callite Tungsten Corporation, 544 Thirty-ninth Street, Union City, N. J. Branches: Chicago, Cleveland. Cable: "Callites."

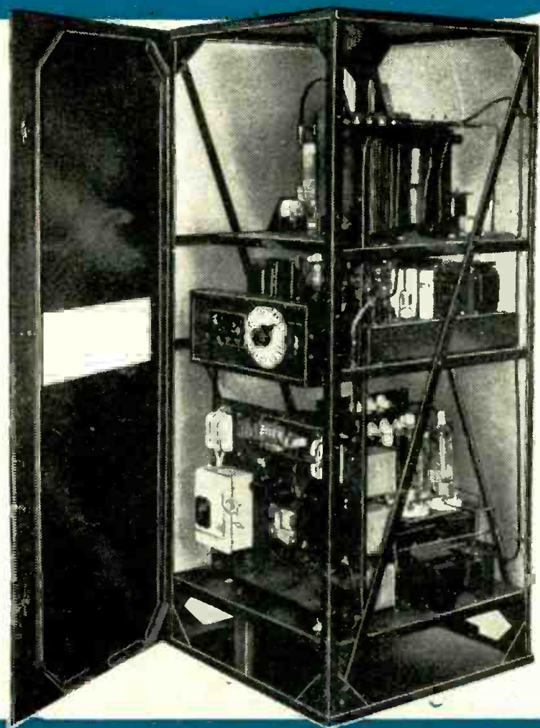


Callite Tungsten Corporation SPECIALISTS IN

ELECTRICAL CONTACTS of refractory and precious metals, bi-metals, lead-in wires, filaments and grids—formed parts and raw materials for all electronic applications.

2 Important Units for FASTER ELECTRONIC CIRCUIT TESTING

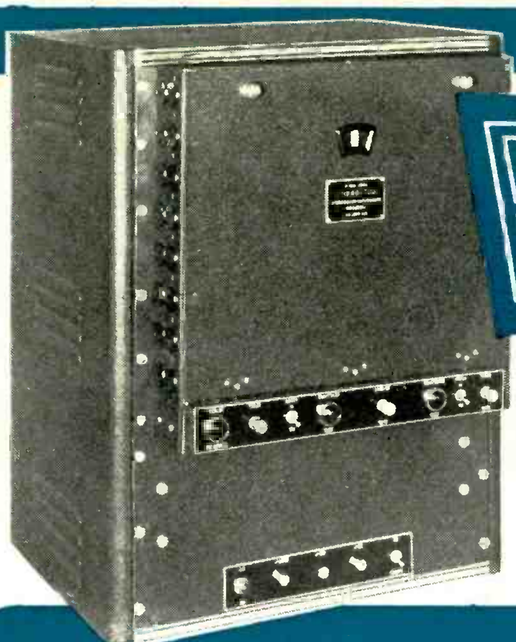
1 CML 1400 - new ELECTRONIC GENERATOR



FREQUENCY RANGE — 300 to 3500 cycles
POWER OUTPUT — 1400 Watts — Regulation 2%

An unusually versatile source of test power. CML 1400 is proving especially valuable for complete system tests on the production line through a wide range of power frequencies. Also important for testing aircraft radio *right in the plane,* without using aircraft power. Simple operation; foolproof controls.

BULLETIN SENT ON REQUEST.



ROTOBRIDGE 2

Pat. applied for

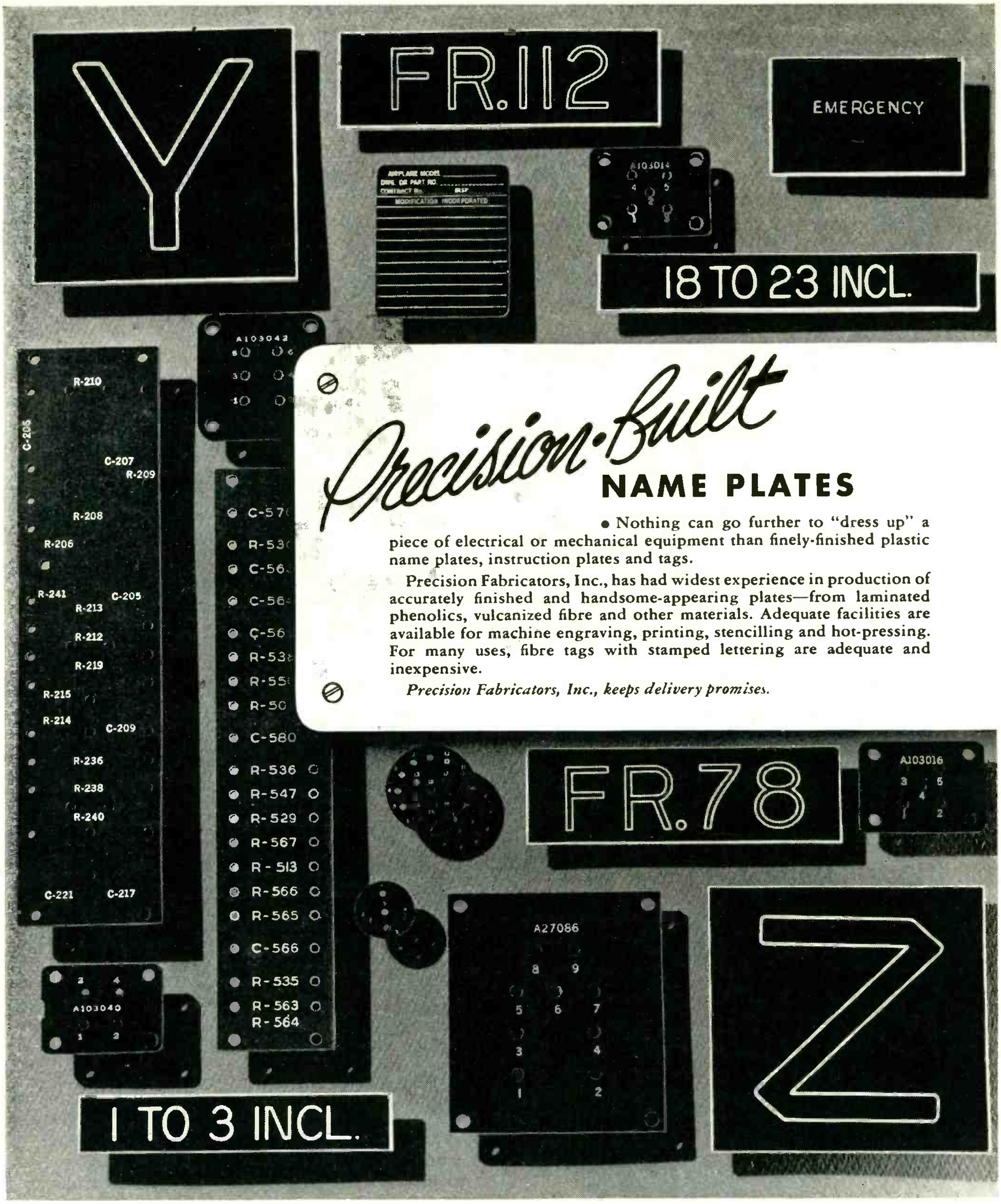
HIGH SPEED AUTOMATIC CABLE CIRCUIT TESTER

Rotobridge tests a circuit a second — with Wheatstone bridge accuracy! Automatically checks cables for continuity, opens, shorts, etc. Will check circuit resistance values down to .001 ohms. Also adaptable for resistance and reactance tests on all types of electronic equipment.

BULLETIN SENT ON REQUEST.

COMMUNICATION MEASUREMENTS LABORATORY

116-118 GREENWICH STREET • NEW YORK



Precision-Built

NAME PLATES

• Nothing can go further to "dress up" a piece of electrical or mechanical equipment than finely-finished plastic name plates, instruction plates and tags.

Precision Fabricators, Inc., has had widest experience in production of accurately finished and handsome-appearing plates—from laminated phenolics, vulcanized fibre and other materials. Adequate facilities are available for machine engraving, printing, stencilling and hot-pressing. For many uses, fibre tags with stamped lettering are adequate and inexpensive.

Precision Fabricators, Inc., keeps delivery promises.

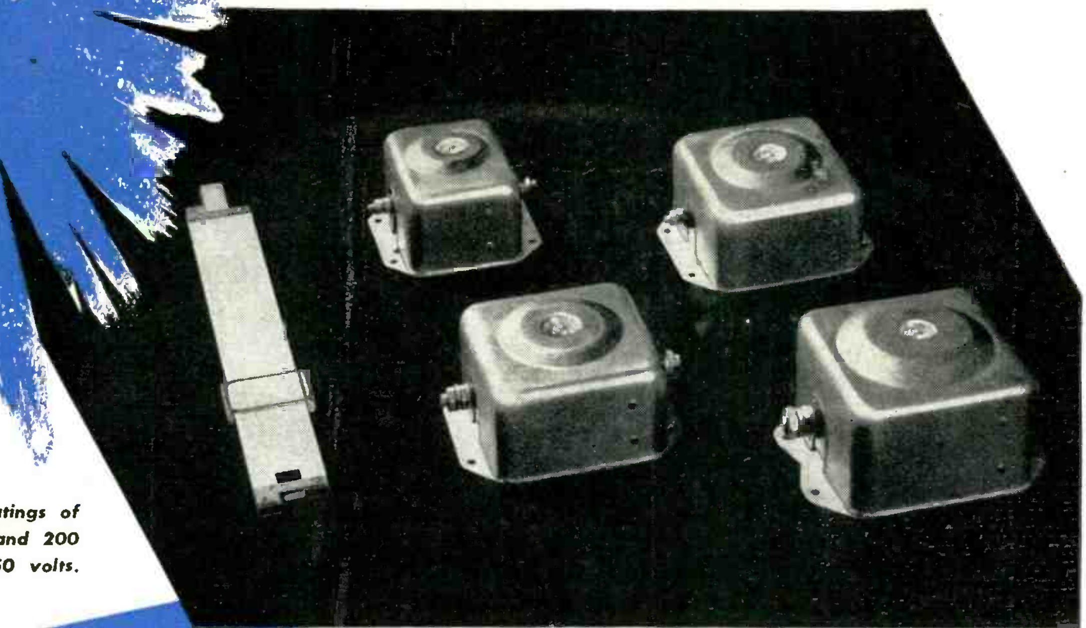
PRECISION *Fabricators* INC.

ROCHESTER, N.Y. NEW YORK: 369 LEXINGTON AVE. • DETROIT: 14319 STRATHMOOR AVE. • PHILADELPHIA: 6710 HOLLIS ST.

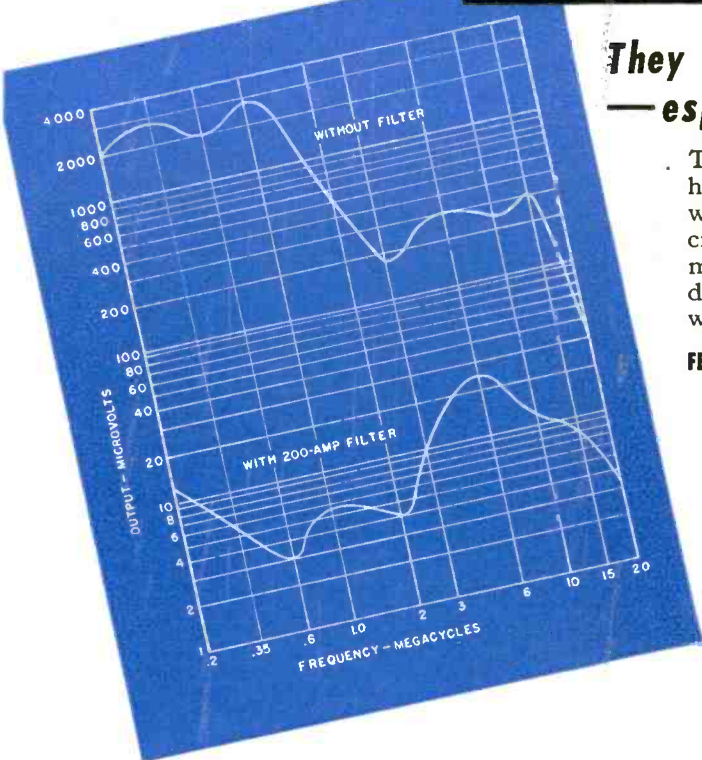
SPECIFICATION FABRICATORS OF MYCALEX ★ PHENOL FIBRE ★

VULCANIZED FIBRE ★ RUBBER ★ ASBESTOS AND OTHER MATERIALS

NEW G-E RADIO-NOISE FILTERS for Aircraft



Available in ratings of 25, 50, 100, and 200 amp, d-c, at 50 volts.



Radio-noise voltage measured on aircraft generator with and without G-E 200-amp filter

They provide excellent noise suppression —especially from 200 to 20,000 kc

These filters help immeasurably in providing the high-fidelity radio reception so important in aerial warfare. They attenuate radio-noise voltage on aircraft electric systems (on circuits with such equipment as generators, amplidynes, inverters, and dynamotors). They are particularly helpful in systems where open wiring is used to save weight.

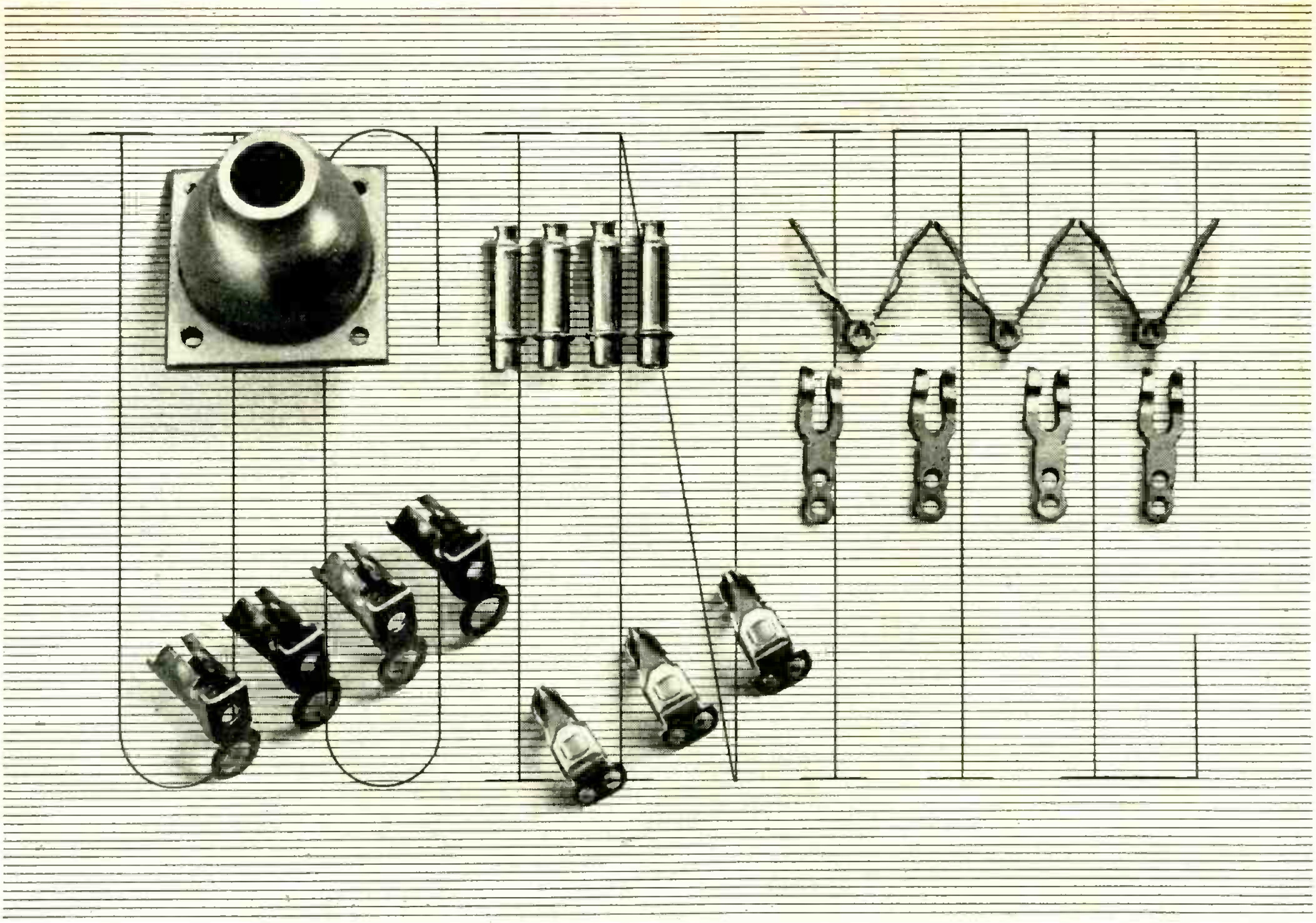
FEATURES

- **High attenuation characteristic results in excellent noise reduction**
- **Compact and lightweight (For 100-amp rating, shown in left foreground above, approx 2 1/5 lb, measuring approx 5 by 4 by 2 1/2 inches)**
- **Can be mounted readily in any position**
- **Operate efficiently over a wide temperature range (−50 C to 50 C)**
- **Comply with U.S. Army Air Forces specifications, including the stringent requirements as to vibration and acceleration**

FOR FURTHER DATA on these filters ask your G-E representative for Bulletin GEA-4098, or write to General Electric Company, Schenectady, New York.

GENERAL ELECTRIC

407-58-5700



"Drawn and formed"

Our specialty, at Ucinite, is making small intricate metal parts that we can draw and form on non-critical machines. We like to do these hard jobs that save strategic materials and cut down costs and production time. And we have the men and the machines to handle them efficiently.

Ucinite offers you all the advantages of dealing with a complete and self-contained unit. We do our own fabricating, plating, heat-treating and assembling. Why not refer your special problems to us?

The UCINITE CO.

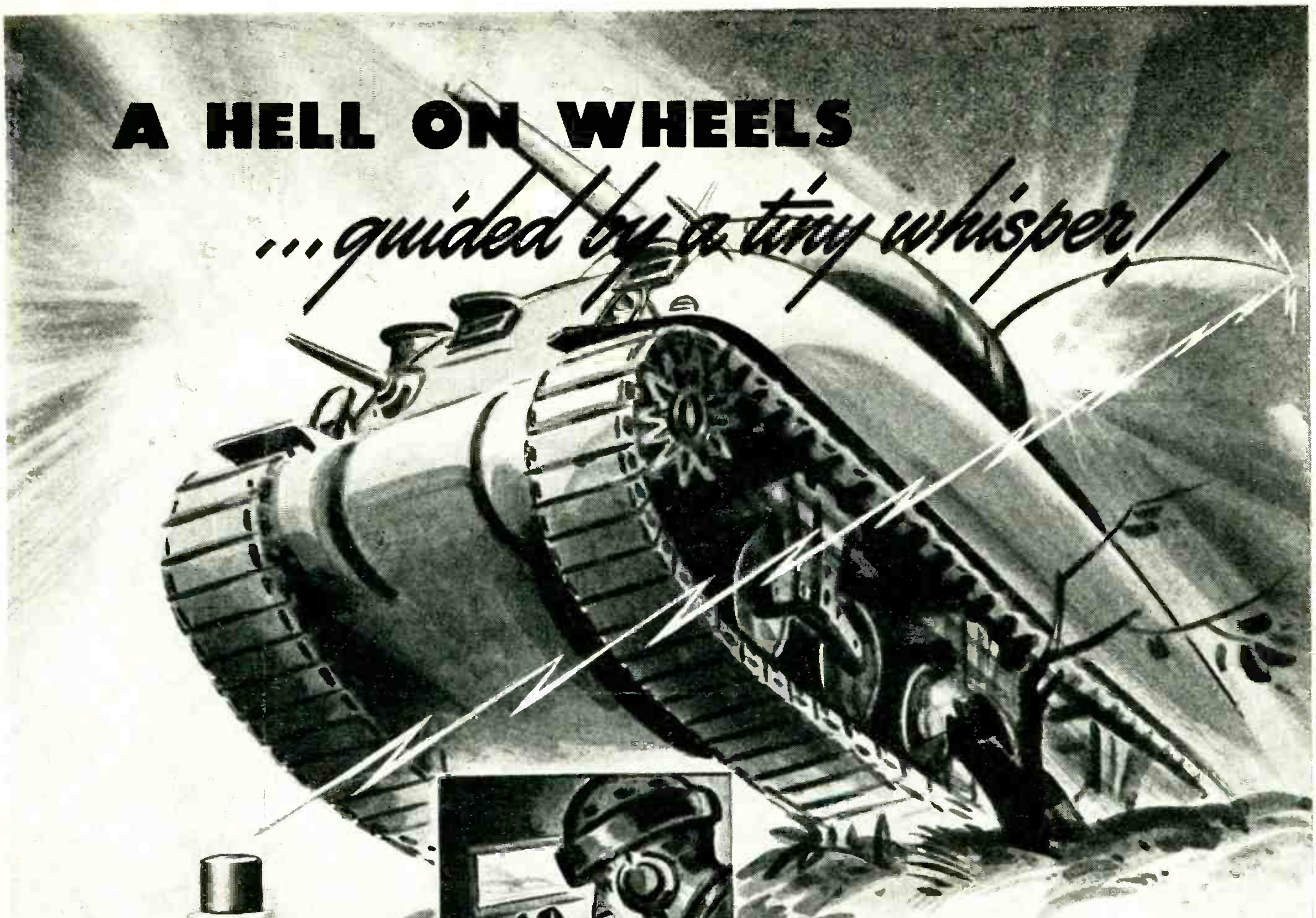
Newtonville 60, Mass.

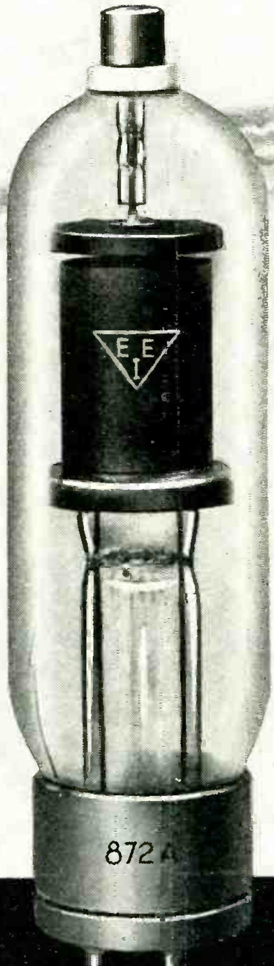
Division of United-Carr Fastener Corp.

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

A HELL ON WHEELS

...guided by a tiny whisper!





Ever been in a tank?
One of those mighty juggernauts look impregnable on an assembly line, fairly comfortable when not in motion, even cool as you listen to a discourse on its superiority.

But raise the temperature to 120 or 130 degrees, have the engine roaring two or three hours, and drive it over rough terrain at top speed. Top all this with an adversary with a steel gray eye at the sights of an 88mm. job, and the picture has atmosphere . . .

A lurching, belching inferno of aches, agony and strain. You've plastered the enemy right and left—you're tense, then numb, with the excitement of the kill. Sweat half blinds you as it pours down into your eyes; concussion and ricochetting have all but deafened you. Suddenly you and your crew are alone . . . lost . . . cornered . . .

For all your life to come—the office or shop, the vacations, home life, the joys and heartaches—you'll be thankful for that tiny voice of radio that gives you the way out.

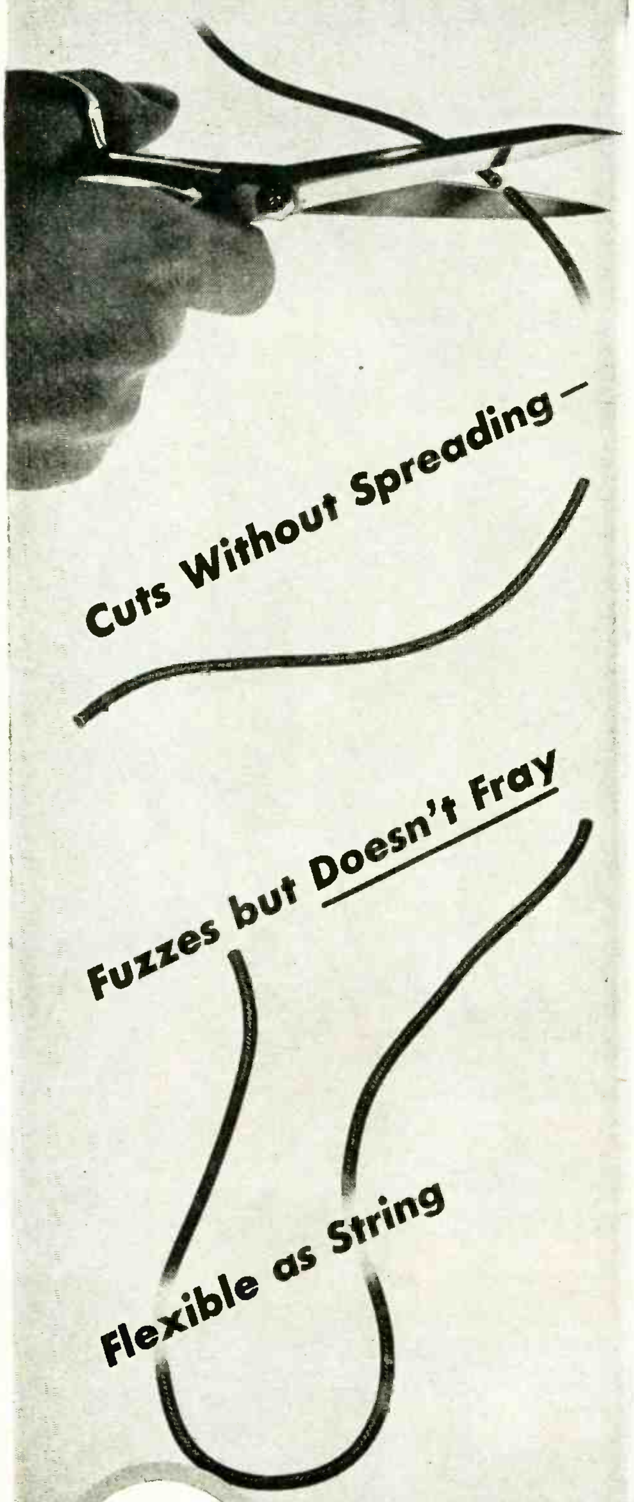
E-E electronic tubes are prominent in communications and Signal Corps applications, as well as all other military phases where power and transmitter types are used. Factual information and specifications are available in the new E-E Data Book; write for your copy today.

ELECTRONIC ENTERPRISES, INC.

ELECTRONIC ENTERPRISES

65-67 SEVENTH AVENUE NEWARK, NEW JERSEY

NEW BH FIBERGLAS SLEEVING



You've waited a long time for a sleeving that was *both* flexible and non-fraying. Now it's here—BH Extra Flexible Fiberglas Sleeving.

As an example of the hundreds of uses for this new product, let's look at a typical brush shunt job. Sleeving for this application should be flexible. When cut to length, the ends should not fray or spread. Formerly, brush manufacturers stiffened the ends of the sleeving to prevent fraying and also to facilitate threading onto the pigtail. BH Extra Flexible Fiberglas cuts cleanly without spreading, eliminates the extra dipping operation. Furthermore, in service the ends do not fray. Constant vibration produces only the slightest fuzz. Yet even these are but a few advantages of this new sleeving.

**NON-FRAYING • FLEXIBLE • HEAT-RESISTANT
NON-INFLAMMABLE • WATER-RESISTANT
NON-CRYSTALLIZING at LOW TEMPERATURES**

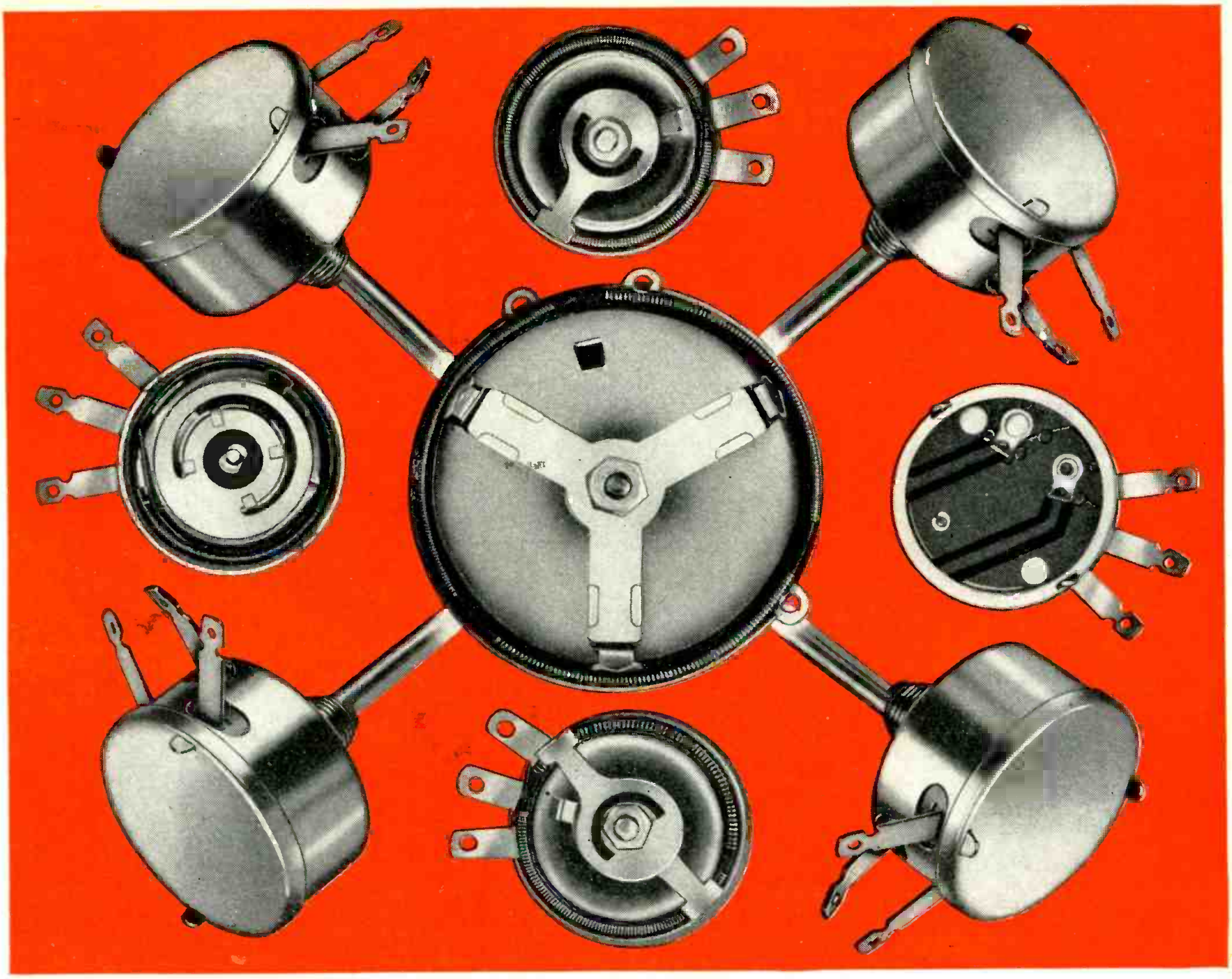
The new BH Extra Flexible Fiberglas Sleeving is woven from the choicest continuous-filament Fiberglas yarns. It possesses high dielectric strength, is water-resistant and, like all BH Sleeving and Tubing—is non-inflammable.

All sizes, from No. 20 to 5/8″, inclusive, are available. Write for samples of this radically new and different sleeving today—in the sizes you desire. Seeing is believing! Bentley, Harris Manufacturing Co., Dept. E, Conshohocken, Pa.

BH PRODUCTS

NON-BURNING IMPREGNATED MAGNETO TUBING • NON-BURNING FLEXIBLE VARNISHED TUBING • SATURATED AND NON-SATURATED SLEEVING

BENTLEY, HARRIS MANUFACTURING CO.
Conshohocken, Penna.



THESE VETERANS ARE SERVING

...*WHERE RESISTANCE IS IMPORTANT!*

IN MANY a war product—on land, at sea and in the air—Utah engineering and precision manufacturing safeguard the successful performance of many types of equipment. Indispensable to wartime service, Utah Wirewound Controls are passing the tough test of combat with flying colors.

Available in rheostats, potentiometers and attenuators, Utah Wirewound Controls are supplied in five sizes—3, 4, 9, 15 and 25 watts—with total resistances from 0.5 ohm to 25,000 ohms.

In all types of applications, under all kinds of operating conditions, Utah construction and design have proved their worth. In Utah Controls, high quality resistance wire is evenly wound on a substantial core, clamped tightly to the control housing. The result is a rugged and dependable variable resistor.

Typical of the Utah line is Utah Potentiometer Type 4-P. This rugged control dissipates 4 watts over the entire resistance element. Resistance elements are clamped in place in a cadmium-plated, all-metal frame, resulting in maximum heat dissipation for its size.

Find out if Utah controls can solve your electrical control problems. It costs nothing to get the facts—and may save you a great deal of time and money. Write today for full engineering data on Utah Wirewound Controls.

UTAH RADIO PRODUCTS COMPANY, 837 Orleans St., Chicago, Ill. Canadian Office: 560 King St. W., Toronto. In Argentine: UCOA Radio Products Co., S.R.L. Buenos Aires.

PARTS FOR RADIO, ELECTRICAL AND ELECTRONIC DEVICES, INCLUDING SPEAKERS, TRANSFORMERS, VIBRATORS, VITREOUS ENAMELED RESISTORS, WIREWOUND CONTROLS, PLUGS, JACKS, SWITCHES, ELECTRIC MOTORS

utah

CABLE ADDRESS: UTARADIO, CHICAGO


OUR INSPECTION DEPARTMENT IS MORE CRITICAL THAN YOURS
PLASTICS
by the ARNOLD BRILHART COMPANY
means every piece according to specifications... NO REJECTS!
We specialize in helping both the large and small company solve their difficult problems in plastics.
ACCURATE MACHINING ~ INTRICATE MOLDING
SPECIAL DESIGN ~ QUALITY PRODUCTION.
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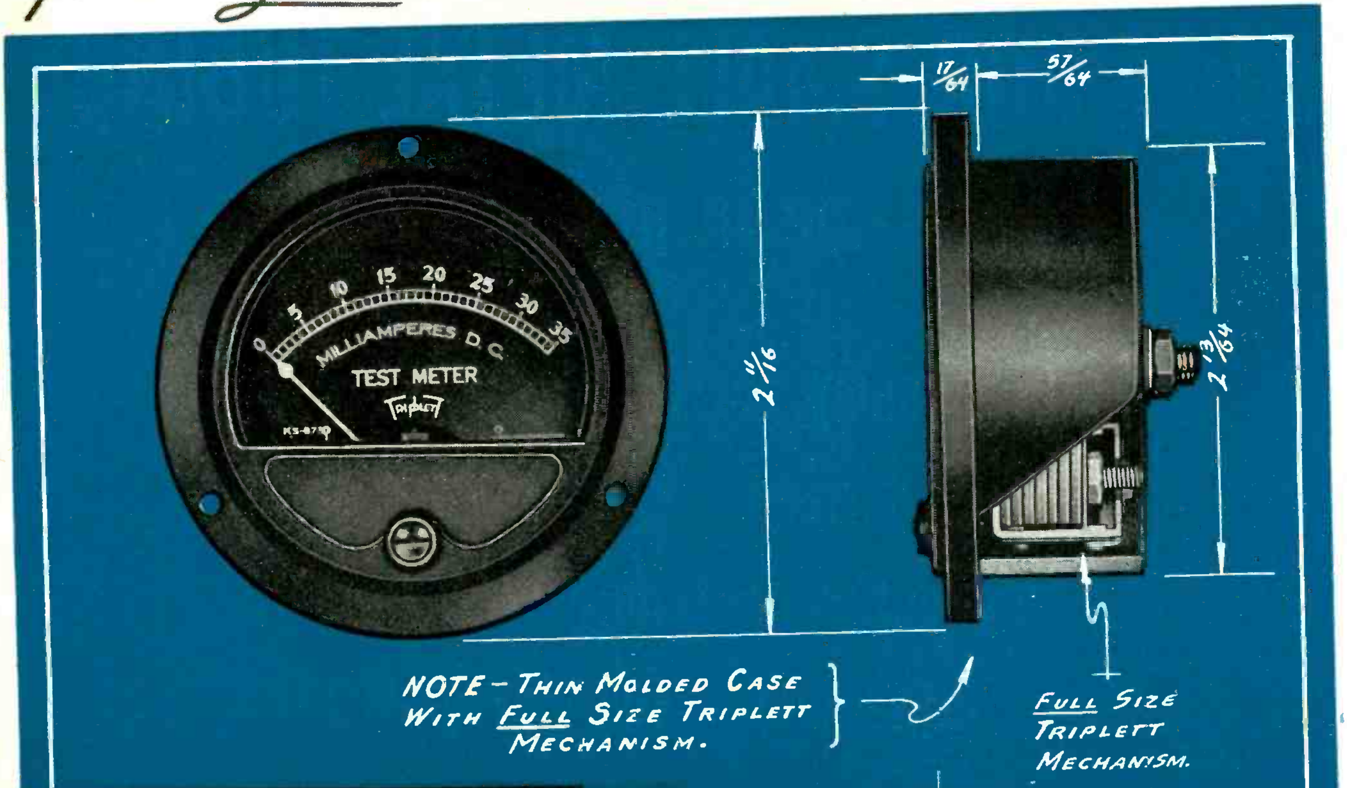
TRIPLETT
Thin-Line INSTRUMENTS



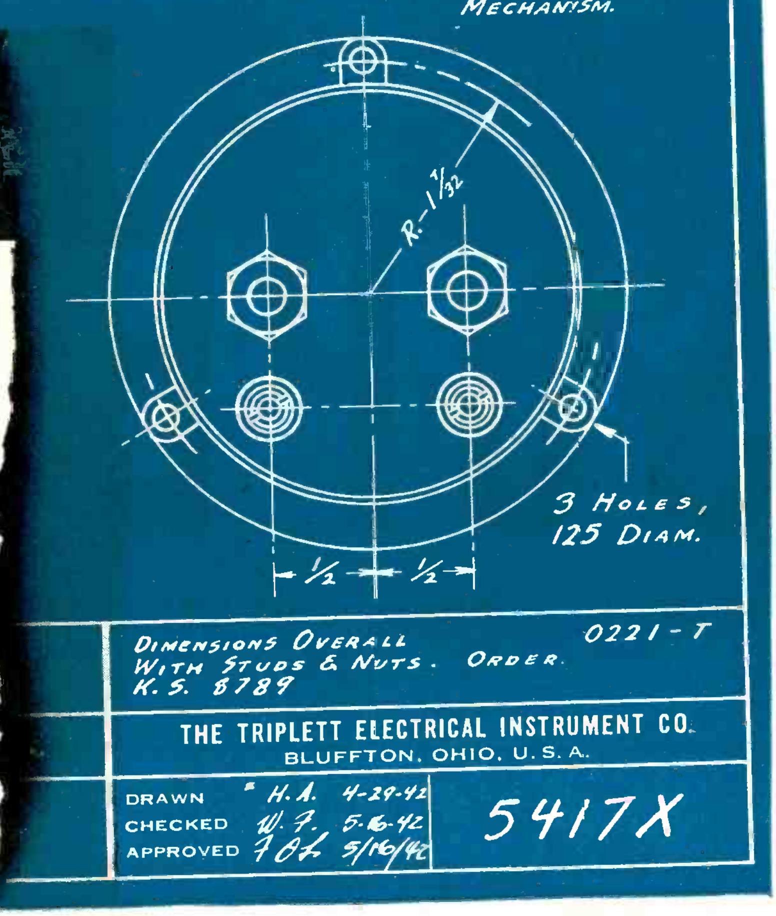
TRIPLETT *Thin-Line*

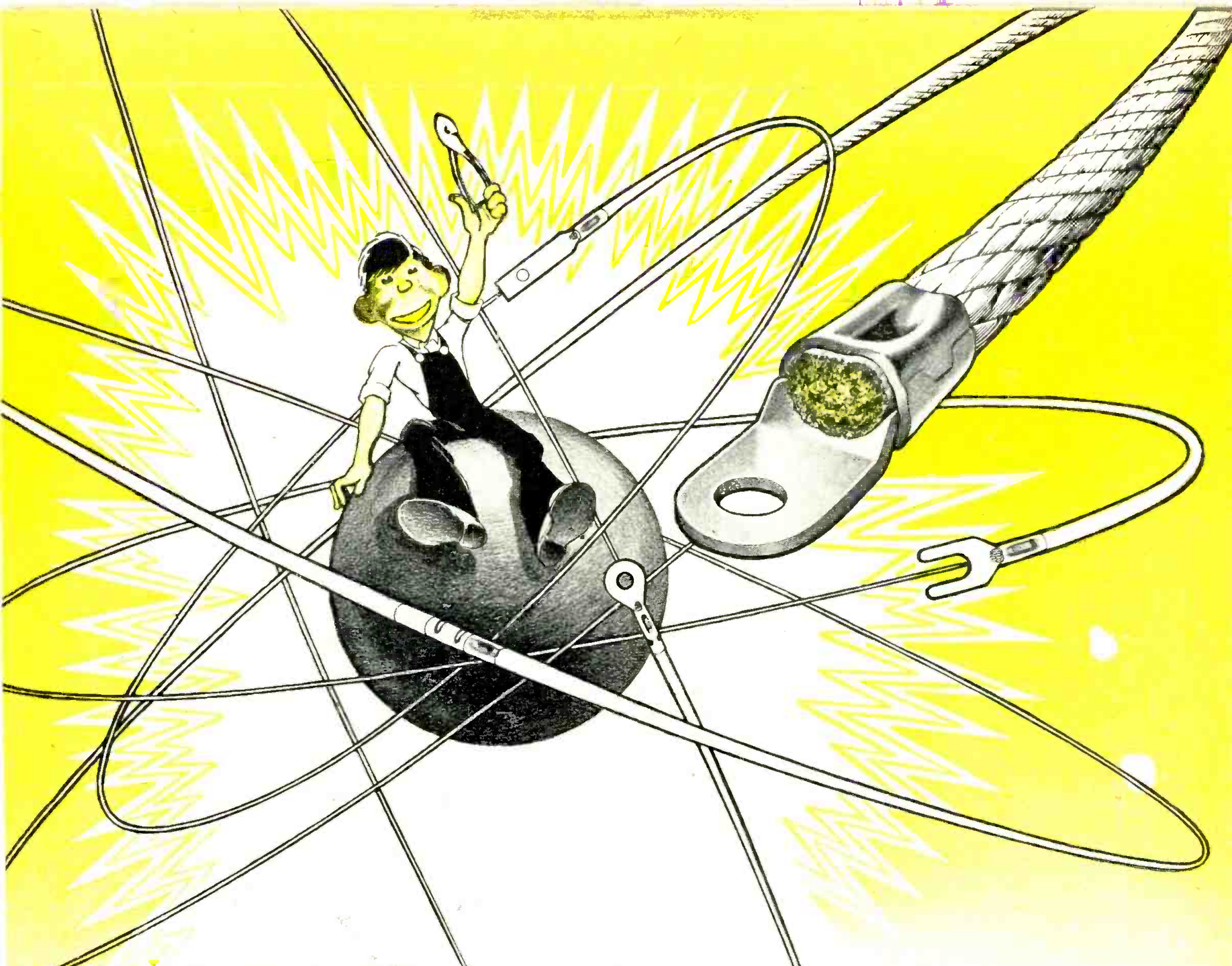
INSTRUMENT "SPECS"

- Minimum case depth.
- Full standard size rigid mechanism . . . no projecting base.
- Wider shroud strengthens face: focuses attention on scale.
- Simplified zero adjustment.
- Sapphire or equivalent jewels. All component parts finely made and of superior quality.
- Balanced Bridge Support.
- Metal Bridges at both ends.
- Separate Scale Mounting.
- Doubly Supported Core.

Also available in metal case

NOTE: When space is at a premium and for all installations where space is efficiently used, Triplett Thin-Line Instruments set a new standard of precision performance in "condensed" space. For full details write for Triplett Thin-Line Bulletin to The Triplett Electrical Instrument Co., Bluffton, Ohio.





IT IS essential that all metal-to-metal electronic connections shall be permanent, and resist vibration and corrosion. • T&B Pressure (Solderless) STA-KON* Wire Terminals are meeting the exacting requirements of well-known manufacturers of electronic equipment. • They are made in a wide variety of wire capacities, in scores of designs, with and without insulation grip. • Approved. • Patented. • STA-KONS* of all sizes are quickly, permanently and easily installed, even by green hands, with correctly engineered T&B Pressure Tools. • These tools are designed to operate manually or with whatever type of power you prefer—air, hydraulic, electric. • Under the T&B Plan, STA-KONS*, like all other T&B Products, are sold only through T&B Distributors who reduce the manufacturer's selling costs, thereby reducing the cost of all electrical equipment to the user.

WRITE US FOR FULLY ILLUSTRATED STA-KON* BULLETIN 500

*STA-KON Registered U. S. Pat. Office.

THE THOMAS & BETTS CO.

INCORPORATED

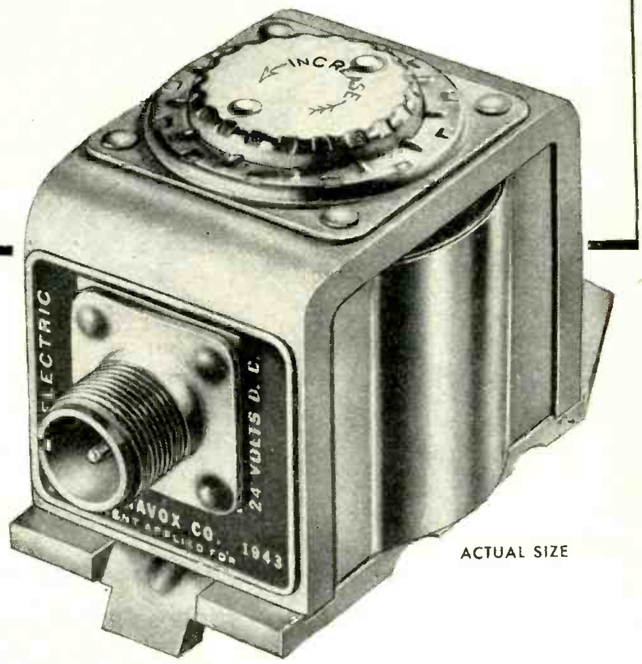
MANUFACTURERS OF ELECTRICAL FITTINGS SINCE 1899

ELIZABETH 1, NEW JERSEY

In Canada: Thomas & Betts Ltd. Montreal

GUNS ON EVERY FRONT NOW ARE FIRED BY THIS MAGNAVOX CONTROL

Electric Gunfiring Solenoid, designed and manufactured by Magnavox, now standard with United Nations Armed Forces.



ACTUAL SIZE

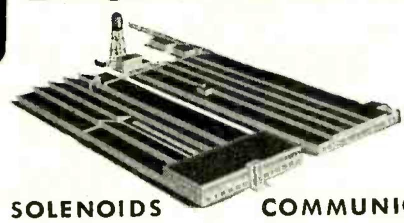
COMPARED WITH former gunfiring controls, this Magnavox Solenoid increased firing efficiency 180%, decreased battery drain 50% and cut weight 18%. Cost was cut to a fraction by Magnavox design and mass production methods. These precision devices are now made one hundred times as fast as formerly. Thirty-six models, for various types and sizes of guns, now roll off the Magnavox production lines by the hundreds of thousands.

This is just one example of problems taken in stride by Magnavox engineers, creating and manufacturing military equipment ranging from solenoids to the most intricate types of complete radio communication systems.

Magnavox brings to the war effort the skill and "know how" developed by 32 years of designing, engineering and manufacturing for the radio industry, plus the splendid facilities of the completely modern new six acre plant, finest machine tool equipment and the production economies of efficient management. The Magnavox Company, Fort Wayne 4, Ind.

Magnavox skill and craftsmanship won the Navy "E" in 1941, among the first awarded... now with 3 White Star Renewal Citations.

FOR 32 YEARS **Magnavox** HAS SERVED THE RADIO INDUSTRY



LOUD SPEAKERS • CAPACITORS • SOLENOIDS COMMUNICATION & ELECTRONIC EQUIPMENT

...OR 2500 MCM CABLE....

ALL SIZES BETWEEN....

Burndy HYLINE Connectors

(INDENT TYPE)

provide connections *stronger* mechanically...
***more efficient* electrically...at far lower cost!**

"Can we change to HYLINE connectors without interrupting pressing manufacturing schedules"...is the question often asked by manufacturers to-day!

The answer is...you can adopt HYLINE indent type connectors any minute of any day...and save time, and money, right from the start!

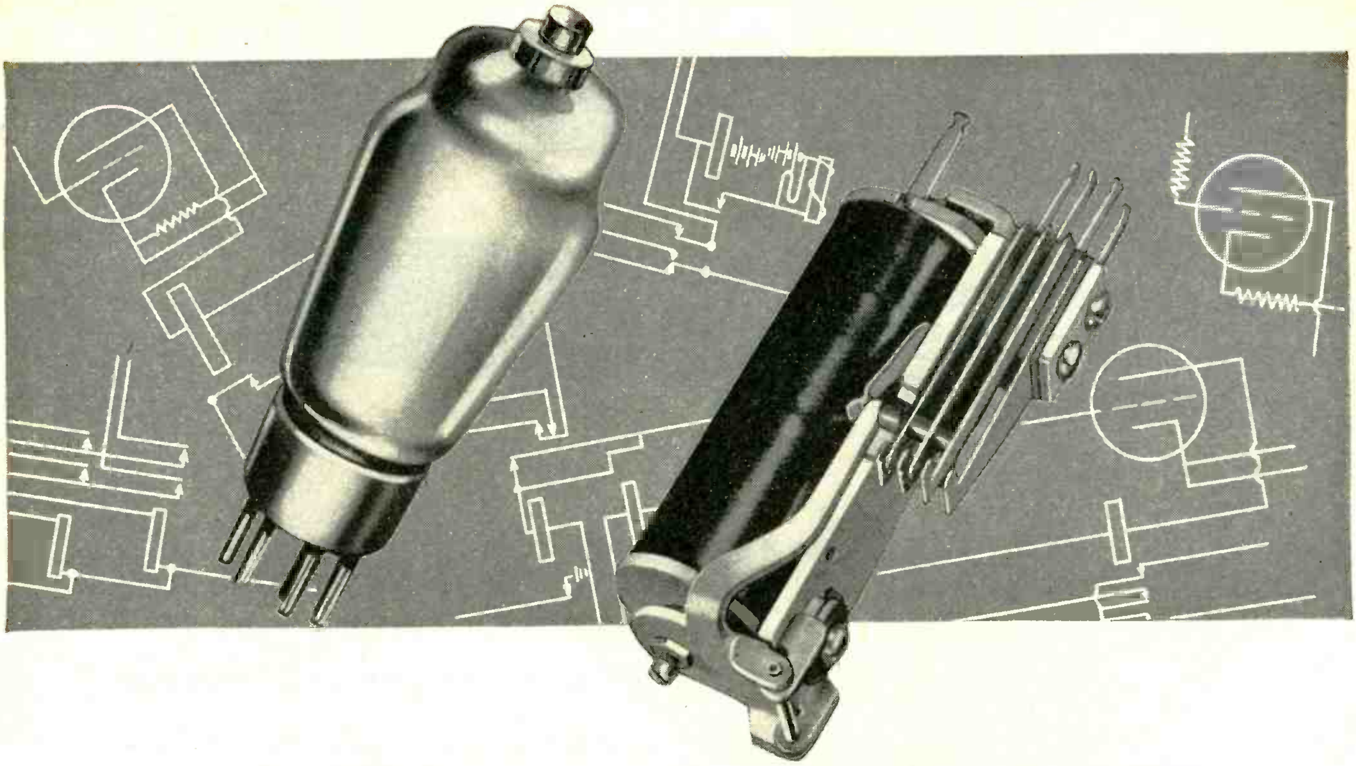
You simply discard troublesome, and questionable, soldering procedure. In its place you substitute the simple Burndy *indent* method of connecting, which requires no training or special skill (see illustrations at left). You'll cut the time required for connecting, *at least in half!*

Most important, however, you'll get connections that are *uniformly* high in mechanical strength and electrical efficiency. For HYLINE connectors are formed *from pure copper,* in *one piece*...and when indented to the wire the Burndy way provide a low resistance connection that's on to stay. Thus you improve circuit efficiency, while eliminating maintenance due to poor connections.

Why not get *all* these advantages, right now. The cooperation of Burndy engineers is freely offered; or, we shall be glad to send a copy of the new HYLINE connector catalog on request.

ELECTRICAL CONNECTORS

BURNDY ENGINEERING COMPANY, INC., 107 EASTERN BOULEVARD, NEW YORK 54, N. Y.



THE TEAM THAT IS MAKING MIRACLES COME TRUE

All along the fighting fronts where the tools of war are being used—and in industrial plants where they are being made—electronic science is working miracles to hasten the day of victory.

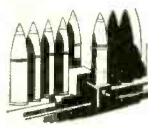
Team-mates in this new world of magic are the electronic tube, in its infinite variety of types and applications, and the Automatic Electric relays, stepping switches and other control devices that are so often needed to make electronic developments take practical and useful form.

Electrical control has been Automatic Electric's sole business for over fifty years. That is why electronic designers in scores of industries are finding it both helpful and profitable to work with Automatic Electric field engineers in determining the right control apparatus for each job. Together, they speed new electronic developments through the laboratory and into the production line.

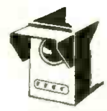
If you have a control problem—whether electronic or just electrical—it will pay you to take these two steps: First, be sure you have the Automatic Electric catalog of control devices. Then, if you would like competent help in selecting the exact combination to meet your need, call in our field engineer. He will be glad to place his experience at your disposal.

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

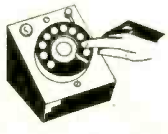
Automatic Electric control devices are working with electronic tubes in these typical applications:



Quality control—automatic inspection and sorting operations

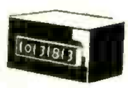


Detecting and indicating—checking operations and revealing unstandard conditions



Automatic or directed selection of mechanical or electrical operations

Selection and switching of signaling and communication channels



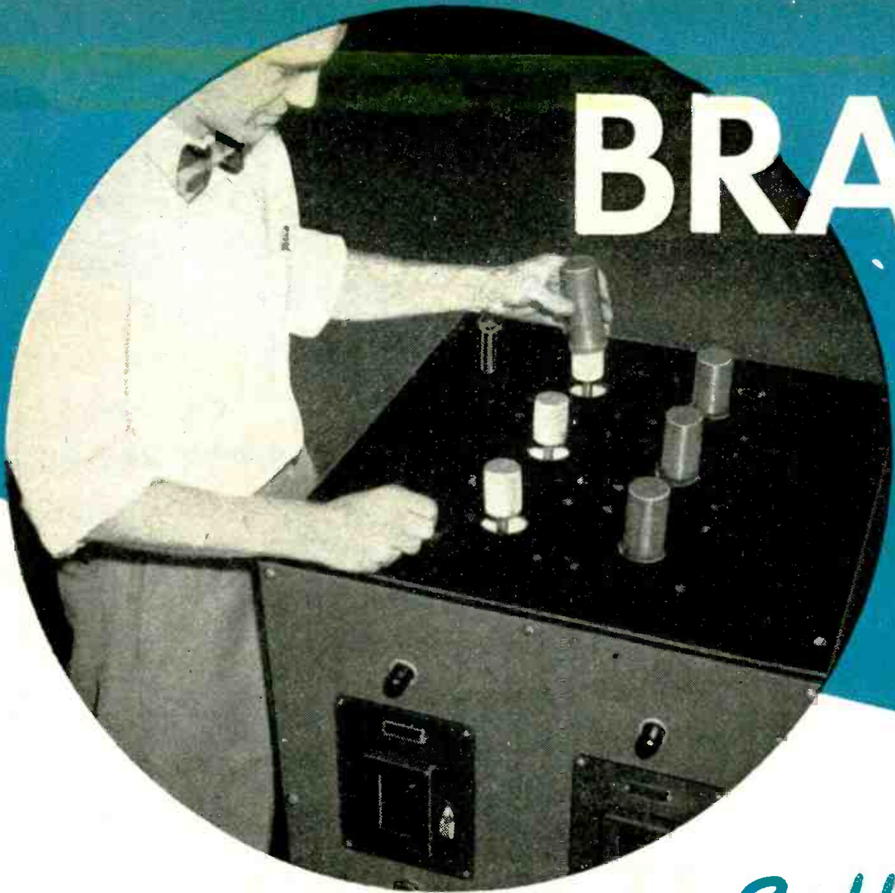
Counting and totalizing of mechanical or electrical operations

Time, temperature and sequence control of industrial processes.

The Automatic Electric catalog of control apparatus is the most complete reference book on the subject ever published. Write for your copy.

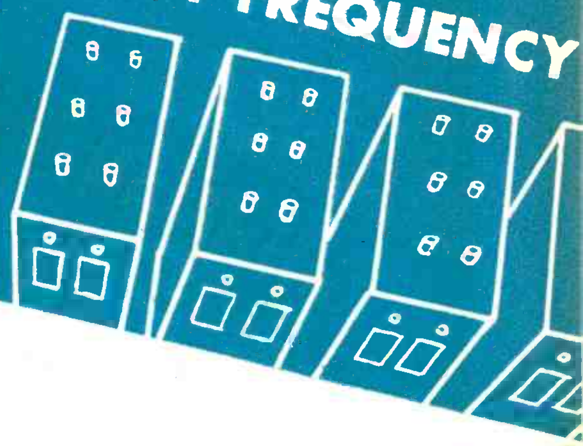
Relays
AND OTHER CONTROL DEVICES
by AUTOMATIC ELECTRIC

MUSCLES FOR THE MIRACLES OF ELECTRONICS



BRAZING

WITH AJAX HIGH FREQUENCY



is Self-Contained and Automatic

HERE'S WHAT'S BEING DONE WITH AJAX BRAZING

- Adapters for Chemical Shells
- Bursters tubes
- Bourdon tubes for gauges
- Tubing from strip
- Fuse Seat Liners
- Stencil to Base Plate
- Lids to Tin Cans
- Tungsten Carbide Tips to Tool Shanks

●

Inquiries from manufacturers desiring to incorporate electronic heating in their post-war products are partcularly welcome.

This new brazing unit works in conjunction with a small high frequency converter. When three pieces are brazed it switches over to the other line of three. Timing is exact. Quality, quantity, and cost are predetermined.

A battery of four units, for instance, can braze 24 fuse seat liners per minute. Other jobs can be brazed with the same equipment, modified at little expense. Larger units with tube converters or generators are also available.

AJAX-NORTHRUP EXPERIENCE. Our experience in high frequency heating and melting dates back to the pioneer applications in this country 25 years ago. During the intervening period, hundreds of unusual applications have been perfected.

This accumulation of experience — including recent applications to vital industries is at the disposal of those companies who desire to speed up their war efforts or plan now for conversion to peace time production.

AJ 54

AJAX

AJAX HIGH FREQUENCY FURNACES

NORTHRUP AJAX ELECTROTHERMIC CORPORATION, AJAX PARK, TRENTON, N.J.

ASSOCIATE COMPANIES: THE AJAX METAL CO. *Non-Ferrous Ingot Metal for foundry use.*
AJAX ELECTRIC FURNACE CORPORATION. *Ajax-Wyatt Induction Furnaces for melting.*
AJAX ELECTRIC CO., INC. *Ajax-Hultgren Salt Bath Furnace and Resistance Type Electric Furnaces.*

Another Leader in Radionics
GUTHMAN MOLDED PAPER CONDENSERS
for Big Jobs in Small Quarters
Thousands of these important little Guthman condensers perform their necessary duties under most exacting conditions in radio equipment. They are manufactured to meet the rigid specifications of the signal corps.
Due to the compactness of these units, they are being widely used for small battery equipment, and are best adapted for use in circuits where the D. C. does not exceed 120 volts.
Guthman Molded Paper Condensers, molded in type CMP 20 case for low voltage use, are available up to .01 mmfd. capacity. In the manufacturing of these condensers the finest Kraft Paper and Aluminum Foil are used.
Each condenser is given a transformer oil impregnation, which insures uniformity of quality. These Guthman condensers are then molded in a high grade bakelite case, normalized and heat treated, and then vacuum impregnated at high temperature.
EDWIN I. GUTHMAN & CO. INC.
15 SOUTH THROOP STREET · CHICAGO
PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT

HAVE YOU CHECKED THESE FACTS ABOUT HIPERSIL*

...the new electrical steel?

Here are illustrated six of the more important advantages of Hipersil . . . the new electrical steel that frees designers from the limitations of ordinary silicon steel. Of course, these advantages vary with the application.

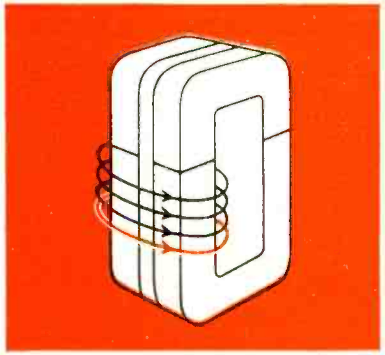
Today, for example, two features of Hipersil, more than any others, are solving many high-frequency problems. These are:

1. Hipersil makes available laminations as thin as .003 . . . thinner than ordinary paper. This is required for the best ultra-high-frequency performance.
2. Hipersil cores are wound from continuous strips . . . bonded together . . . and then cut into *only* two pieces. This feature alone eliminates all of the painstaking work and long time required to stack "tissue-thin" laminations.

GET ALL THE FACTS ABOUT HIPERSIL . . . Write for B-3223, a data book crammed with application and performance facts about Hipersil. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N.

J-70418

**Registered trade-mark, Westinghouse Electric & Manufacturing Company for HIgh PERmeability SILicon Steel.*



1/3 More Flux-Carrying Capacity

. . . provided by this grain-oriented magnetic steel produced by a new Westinghouse-developed rolling and heat-treating technique.

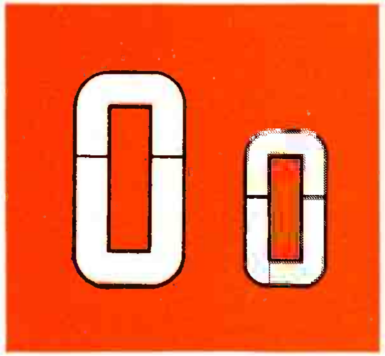
Reduces Weight 30% to 50%

By increasing flux-carrying capacity 1/3, Hipersil reduces weight of unit as much as 30% to 50%.

It is ideal for aircraft application.

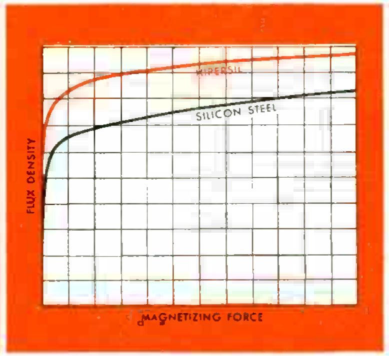
Simplifies Transformer Assembly

Hipersil cores are wound from one strip . . . then split into two pieces. Easy assembly. No laminations—just 2 or 4 pieces to handle.



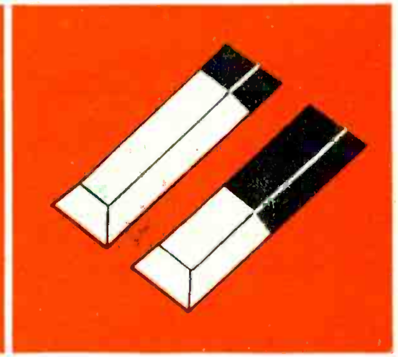
Smaller Size Core Cross Sections

...and coils possible with Hipersil are ideal for airplane, tank, submarine, walkie-talkie applications and where space is at a premium.



Wide Range of Linear Response

Knee of saturation curve for Hipersil is higher than for ordinary silicon steel. Approximately 1/3 greater straight-line response for winding and core cross section.



Saves Critical Materials

It is possible to save 10% of copper in radio transformers . . . 50% of nickel used in alloys for transformer laminations.

Westinghouse HIPERSIL

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

ONE OF A SERIES OF ADVERTISEMENTS SHOWING DeJUR PRECISION PRODUCTS IN ACTION ON THE HOME FRONT

Because of the secrecy encircling war production, little can be told of a meter's importance to almost every phase of the work. Suffice it to say that over a wide range of industrial electronic applications . . . heat treating, counting, refining, sound detection, color selection, and many others about which not a word has been spoken or written . . . electrical measuring instruments are universally used.

It is of interest to know . . . for present and future reference . . . that DeJur precision meters are built into the equipment employed by many war plants. Wherever used, these meters enjoy confidence from the standpoint of sensitivity, durability and dependability. Peace will usher in even more new uses for meters. To insure absolute satisfaction, specify DeJur.

Send your blood out to fight . . . donate a pint to the Red Cross today

Awarded the Army-Navy "E" for High Achievement

DeJUR-AMSCO CORPORATION

SHELTON, CONNECTICUT

NEW YORK PLANT: 99 Hudson Street, New York City • **CANADIAN SALES OFFICE:** 560 King Street West, Toronto

How to Trap Gremlins in Springs

ALL OVER BUT THE SHOOTIN'

Is Hitler washed up? We don't know. But we do know that thousands of planes, ships, tanks and bombs are pointed his way, helped by springs. And that the design of many of these springs can be facilitated by reading "Science in Springs". Your copy is now ready for you and will be mailed immediately on receiving your name on your business letter...

IN a cluster of draftees, in a barrel of apples, in a clip of shells, in a batch of springs . . . in *every* quantity made by nature or man ... there are variations from any chosen standard. What those variations are and why they occur it is often important to know. When springs run into millions, *statistical control* must be exercised to bring the largest possible portion within the desired specifications. Statistical control of springs uncovers the gremlins of quality and production, detects underlying causes for variations, controls or eliminates them, anticipates changes in quality. In the example below, a sample lot of springs was tested for load and length and readings noted. From the results a frequency curve of variations and a "skyscraper" chart were prepared. The height and location of the "Skyscrapers" show how many, and how much springs vary from given specifications. Statistical control is everyday work at Hunter, a matter-of-fact part of insuring the ONE right spring for your job.

Varied and interesting ...

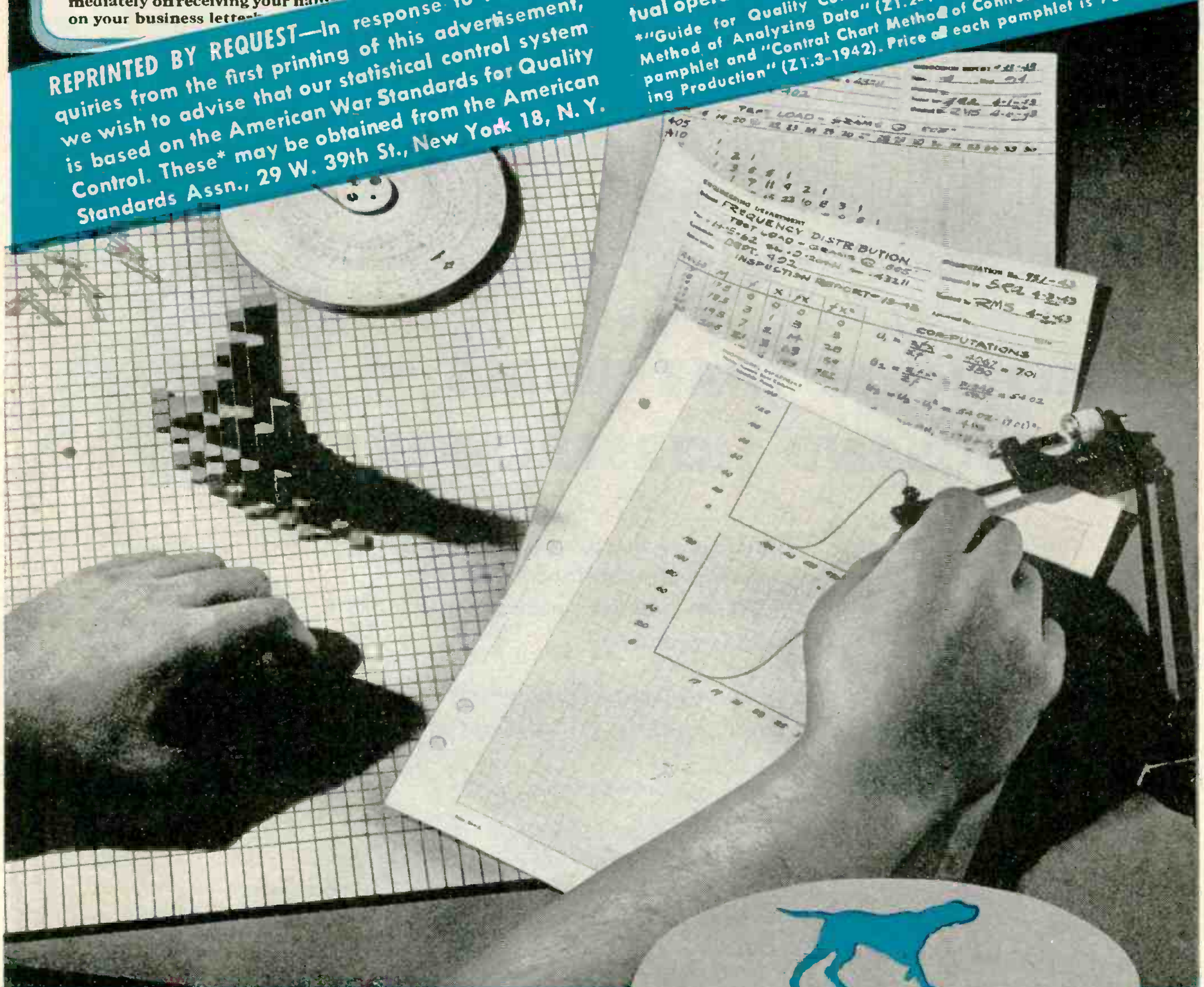
AT YOUR COMMAND

Write, wire ...

REPRINTED BY REQUEST—In response to many inquiries from the first printing of this advertisement, we wish to advise that our statistical control system is based on the American War Standards for Quality Control. These* may be obtained from the American Standards Assn., 29 W. 39th St., New York 18, N. Y.

Any authorized person who happens to be in our vicinity is welcome to drop in and see our system in actual operation. Hunter Pressed Steel Co., Lansdale, Pa.

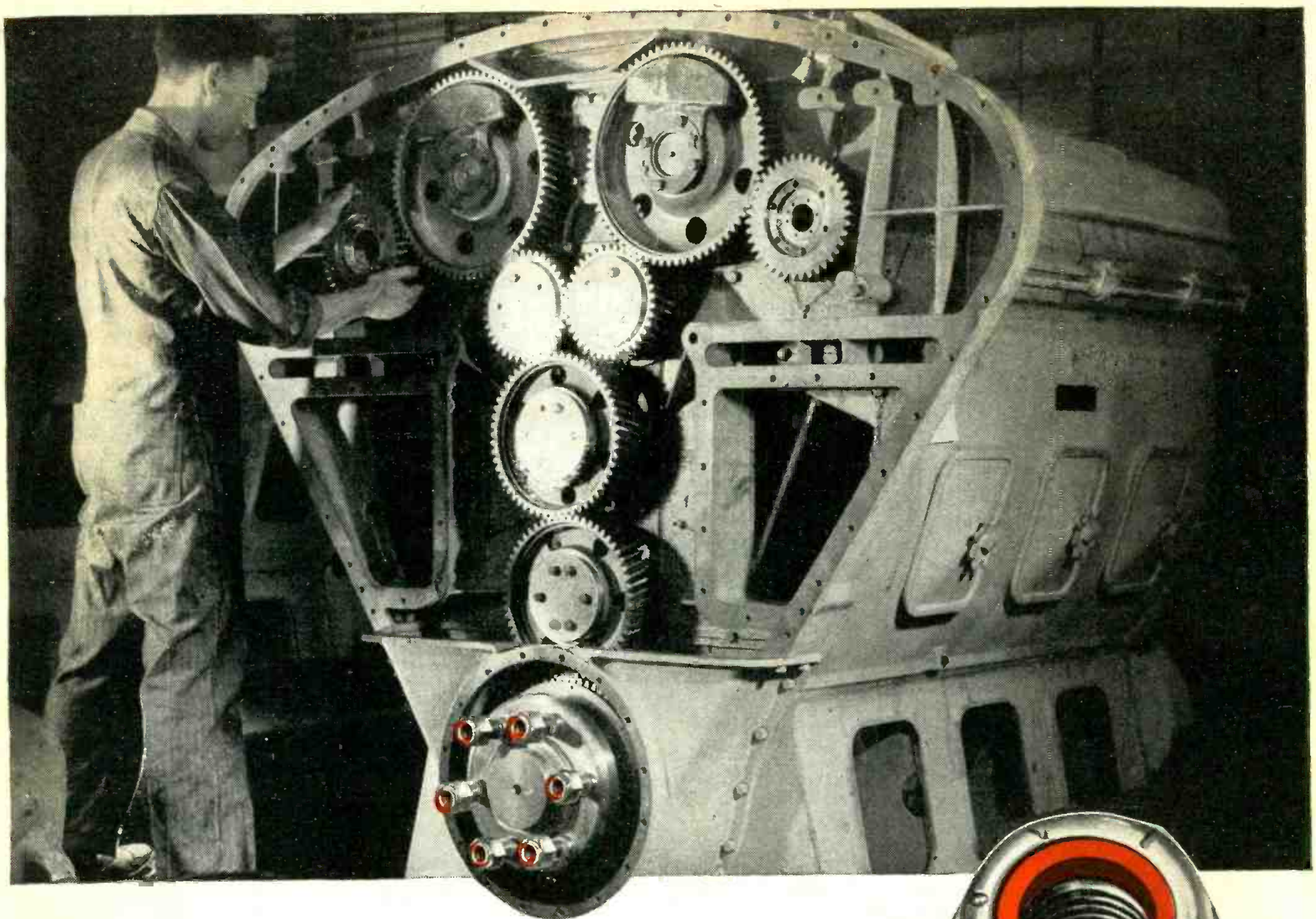
*"Guide for Quality Control" (Z1.1-1941) and "Control Chart Method of Analyzing Data" (Z1.2-1941) printed together in one pamphlet and "Control Chart Method of Controlling Quality During Production" (Z1.3-1942). Price of each pamphlet is 75 cents.

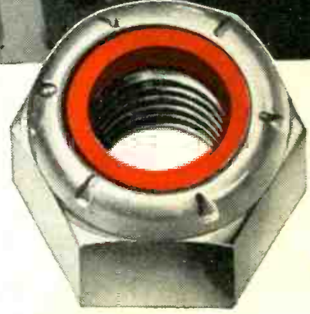


HUNTER

Science in Springs

HUNTER PRESSED STEEL COMPANY, LANSDALE, PENNA.





SIX NUTS THAT BRIDLE A THOUSAND HORSEPOWER

THIS is the business end of a powerful Diesel engine.

Well over a thousand horsepower spins through that coupling — through those six studs.

To connect that coupling, old-style lock fastenings wouldn't do. They couldn't both lock and be tightened to spread the load evenly. So studs failed.

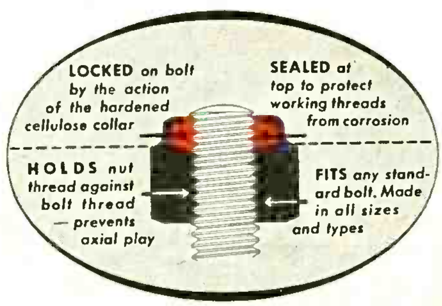
The solution shows in the photo — Elastic Stop Nuts.

With these fastenings, uniform pressure was obtained as well as complete security against nuts working loose.

In the peacetime production to come, equally puzzling problems will plague manufacturers.

And we are prepared to help. Our engineers who today are solving war production problems will be ready to share their wide experience with you.

Whenever you have a fastening job let us know. Our men will work with you on it and recommend the correct Elastic Stop Nut to produce a better product or to facilitate its manufacture.



ELASTIC STOP NUTS

Lock fast to make things last

ELASTIC STOP NUT CORPORATION OF AMERICA, UNION, NEW JERSEY

ESNA TRADE MARK

Free Enterprise

WE MUST ACT TO PRESERVE IT!

LIKE a leaf floating downstream, we are being carried along toward a new and uncharted economy. What this new economy will be like will depend, to no small extent, upon what industry does or fails to do during the coming months. Time is short; in fact, we may suddenly find ourselves standing on the threshold of a peace economy with our war boots still on our feet.

While bending every effort to win the war, we cannot afford to be caught unprepared for the peace. As Prime Minister Churchill said at Harvard, we are "bound, so far as life and strength allow and without prejudice to our dominating military task, to look ahead to those days which will surely come, when we shall have finally beaten down Satan under our feet and find ourselves with other great Allies at once the masters and the servants of the future." Unless we do look ahead, there is danger that we may become neither the masters nor the servants, but merely the victims, of the future.

The war has quickened our ailing economy and opened our eyes again to the possibilities of peace-time plenty. But it has also brought great dislocations of labor and capital; it has led to abnormal patterns in prices and income distribution; and it has created inflationary pressures with enormous potential powers to injure or to help us in the transition from war to peace.

The pattern of life in postwar America will be just what we make it. All of us will have a hand in shaping that pattern, but business men will have a special responsibility in the reconstruction. As employers of labor and capital and as enterprisers assuming the risks of new ventures, they will have to plan and carry out the conversion from war work to full peace-time production. Because of their key role, business men have a special opportunity to discover, and to help others to understand, the conditions which are necessary if they are to do their job satisfactorily.

This is a narrow view of postwar problems but it is a central view, because no one condition is more vital to the health of the world than a high level of production and employment in the United States. We cannot hope to lead the world out of economic chaos if we fail to put our own house in order. If we fail to adjust our domestic economy, we may destroy Adolf Hitler; but we will not destroy the germ that breeds "Hitlers." If we do not maintain the production necessary for supporting a large volume of imports and exports, then the plans for international monetary stabilization, for good relations with our neighbors, for rehabilitation of stricken countries, and for strengthening the democratic bulwarks against dictatorship are all likely to come to grief. We must demonstrate our capacity for world leadership, or be content to follow the leadership of others.

The prospects for achieving a sound and vigorous economy in the United States are not so good as to warrant complacency on the part of men genuinely interested in free enterprise and the political freedoms incident to it. We have yet to find means to utilize our vast and abundant resources for the good of all. We have yet to learn how to keep men from the terrible experience of unemployment and the fear of want which makes them willing to sacrifice freedom and opportunity for almost any promise of security. We have yet to reconcile the conflicting interests of labor, agriculture, and business so that they can work together effectively. We have yet to learn how to check the fever of inflation and cure the palsy of depression.

When we were attacked at Pearl Harbor, we realized our physical peril immediately and united in a tremendous common effort against the enemy. The onset of economic perils is less obvious. No bombs will signal the deterioration of the private enterprise system, the extension of regimentation, the further control of business by government, and the concentration of political power in less and less responsible hands. If these things should befall us, they will come insidiously while we are preoccupied with self interests and oriented by popular misconceptions. If the freedoms of the individual shrivel as the state grows in power, it will be because the individual is too indifferent or complacent to concern himself seriously with economic problems. If our people are misled by false prophets and demagogues, it will be because business men did not understand economics, because scholars were too ignorant of practical affairs, and because we failed to produce economic statesmen of sufficient stature for the task in hand.

Thinking is hard work. Thinking about things outside our personal experience, about economic processes that are broader and in some fundamental respects different from buying and selling or running a business – is strenuous mental labor. Thinking straight about problems that are beyond our personal and immediate status and our pocketbooks, thinking about problems that involve nation-wide production, nation-wide employment and nation-wide buying power – in other words the operation of our entire economic system – involves real self-discipline. Yet there is no other way to safeguard our freedoms. We cannot rely on trial and error; tinkering takes too long; social experiments which turn out wrong can be undone only at great cost – if at all. If we proceed blindly, we shall flounder into an economic and political morass from which we cannot escape.

We floundered badly all through the Thirties, until the war lifted us temporarily to higher ground. When the war boom is over, we shall be back floundering worse than ever unless we find a solid road along which to proceed.

America has grown rich and strong under a system of political and economic freedom. Opportunity and the necessity of self-reliance have brought forth great accomplishments. The hope of profit and the spur of competition have urged men on to find new and better products, new and better methods, and to risk their savings in pioneer investment. Never has a country achieved so high a standard of living and afforded so large an opportunity for the individual man and woman. It is not surprising that some distinguished business leaders, looking back over their own experience, tell us that everything will be all right if only there is "less government in business."

I wish the solution were as simple as that. However this is only part of the answer. It is becoming increasingly clear that industrial capitalism as we know it contains within itself certain fundamental weaknesses which can lead to its destruction if they are not counteracted. No democracy can survive when twenty to thirty per cent of its workers cannot get jobs. That happened here in the Thirties. For years on end, despite fumbling efforts at recovery one out of every five workers was denied a chance to earn a living in private business. We shall never again have such mass unemployment as occurred in the bottom of the Depression, because the government will take it upon itself to create jobs if business cannot offer them. Whenever that happens, however, the area of private enterprise will be reduced and that of government will be expanded – and the concentration of political power will be increased. This is the challenge we business men face today, and ours is the first opportunity at finding the solution.

The crux of our economic problem is unemployment. Unless there are jobs for ninety to ninety-five per cent of those who are able and willing to work, there will be widespread fear and lack of opportunity, which will drive labor unions, agricultural groups, and business interests to take self-protective measures. Such measures are certain to restrict production, stifle progress, and imperil our democratic way of life. Not all our problems will automatically be solved if we learn how to avoid mass unemployment, but they will at least then have a good chance of solution.

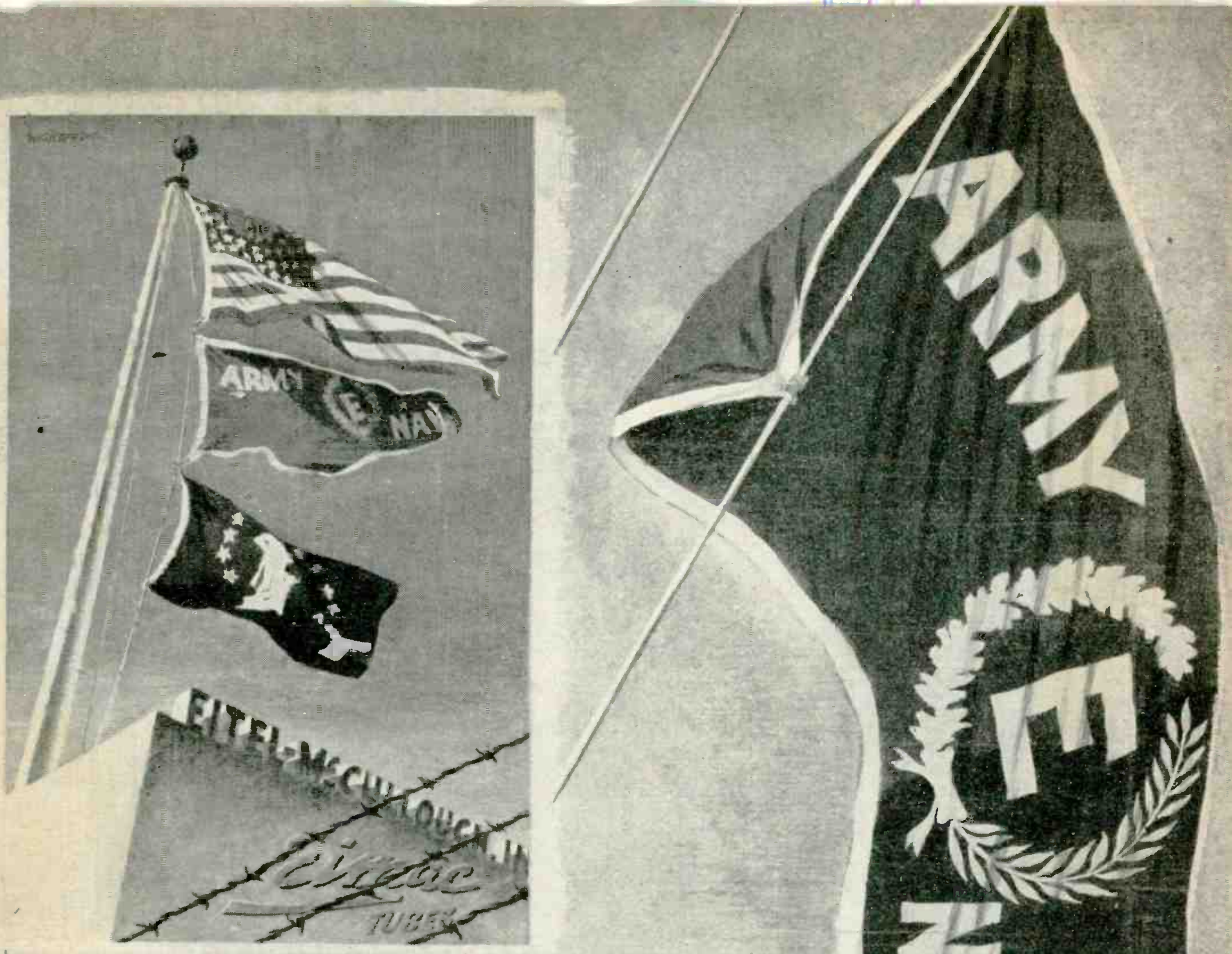
And so American businessmen face a great responsibility! We will have to find the answer to a great many momentous questions. We will have to delve into problems that cannot be solved by precedent.

Looking backward to these times, future historians are likely to say that here we Americans stood at the crossroads and, consciously or not, made our choice between a system of private enterprise and personal freedom and a system of collectivism and regimentation.

It is particularly appropriate, therefore, as the problems of our time take shape and as events rearrange their order and importance, to appraise the steps we are taking and point the way we are going. It is my plan to present such analyses from time to time to the one-and-a-half million readers of McGraw-Hill publications.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.



Eimac gets another "E"

Mass production of a device that has always been hand made in a laboratory is an achievement in itself. But when the whole nation gives pause to *recognize outstanding excellence in this mass production* the achievement becomes all the more striking.

Such honors have been bestowed upon the Eimac organizations not once but twice. First to the San Bruno, California, plant (September 1942) and second, less than a year later, to a plant in Salt Lake City, Utah, that is little more than one year old.

Where does the credit go? . . . to the men and women at the Salt Lake City plant now for their recent triumph . . . and to the men and women of both plants always for their collective cooperation and hard work.

Follow the leaders to Eimac REG. U.S. PAT. OFF. TUBES

EITEL-McCULLOUGH, INC, SAN BRUNO, CALIF.

Plants Located at: San Bruno, Calif., Salt Lake City, Utah

Export Agents: FRAZAR & HANSEN, 301 Clay Street, San Francisco, California, U. S. A.

WASHINGTON FEEDBACK

Government officials whose particular business it is to chart the immediate and long-distance trend of production in the electronics industry are now frankly assuming greater and greater output. The plateau on which it was feared the industry might hang on a dead center has turned out to be a mirage. No plateau is in sight. To the contrary, Ray C. Ellis, Director of the Radio and (Censored) Division of WPB, pointedly declares that schedules must be stepped up between now and the end of December to put the industry on a four billion dollar annual production basis, with a 30 to 40 percent increase in 1944 in the military requirements that the industry must meet.

The actual output of military electronic equipment for July 1943 was $234,000,000. In order to reach the four billion dollar annual figure, the monthly dollar volume of production must jump to approximately $333,000,000 per month or nearly $100,000,000 per month increase over the July total. Much of the increase will be for large, expensive equipment as well as replacement parts.

With this outlook, there is apparently increased determination on the part of Government not to permit the production problems of the industry to interfere with the full realization of the projected program. Mr. Ellis expresses it this way: "Output must be maintained and increased despite difficulties in the field of critical components, experienced labor and other problems facing us."

Several steps in the direction of easing the path of the manufacturer have been taken in addition to the very prominent placement accorded to the industry in the new "Critical List" of the War Manpower Commission. Major General William H. Harrison, new chief of the Signal Corps Procurement and Distribution Service, has held conferences with prime contractors in the sections where the manufacturers' plants are located, resulting in better understanding and increased cooperation between the Signal Corps and the manufacturers. In fact, much credit for the recent rise in production of military communications equipment is given to General Harrison, who took over his present post July 1, 1943.

Another step is the selection of the vacuum tube industry by WPB's Office of Labor Production for a test survey of manpower problems. Whatever procedure is arrived at in this industry probably will be extended to the rest of the electronics field. A certified schedule from each plant of the work being done, the expected expansion, statistics on labor turnover, absenteeism and the number of hours that the employees are on the job will be requested.

CMP Complaints—The WPB order amending the CMP Class "B" products list to place the manufacture of special military communications equipment in the Class "A" designation beginning January 1, 1944 is being reviewed by WPB with the intention of making changes if it seems advisable. One of the complaints of the industry was that the new Class "A" listing would necessitate a more complicated clerical setup and additional help at a time when this is almost an impossibility.

Instrument Ratings—Members of the Industrial Instrument Industry Advisory Committee, meeting with WPB Radio officials recently, declared that reduction in priority ratings for key components would be detrimental to the industrial instrument industry. The contention was advanced by members of the committee that while the industry uses a small percentage of the overall production of key components, industrial instruments are vital to the functioning of war plants and therefore should have higher ratings. Stressed also was the wide variety of products covered in its scope, including thermostats, control valves and gauge glasses.

Radio Resistors—Prospective expansion of radio resistor facilities will provide sufficient capacity to meet requirements of the armed services during the remainder of 1943 and the first half of 1944, according to WPB. The Radio Division continues to recommend that manufacturers accept orders only to the extent of their ability to produce. Under priorities Regulation 1, manufacturers may refuse orders which they cannot deliver because of commitments on equal or higher rated orders. If this practice is followed, purchasers will be forced to sources which are in a position to make the delivery.

FCC Relaxes Rules—Acting on the report of FCC's Committee on Critical Radio Materials, the Commission has relaxed the April 27, 1942 "freeze order" covering new broadcast construction or improved facilities to allow licensing of new local stations of 100–250 watts power, where prescribed conditions can be met. The report of the committee, comprised of Commissioners T. A. M. Craven and C. J. Durr, was the result of a year's study to determine whether additional stations could be licensed or powers increased without hindering the war effort. The committee found that there are 84 applications filed now with FCC for new stations involving power of 250 watts or less and 13 applications for increase in power from 100 to 250 watts. No encouragement is given to applicants seeking increased power or other improved facilities outside the local bracket because of production bottlenecks in the higher-wattage equipment and tubes. Furthermore, tube replacements for FM transmitters are unusually tight because of heavy military requirements for copper anode tubes.

Based also on findings of the Craven-Durr committee, the Commission has announced that under certain conditions it would authorize "judicious" use of idle equipment to increase the power of relay broadcast stations—when existing power is insufficient, to improve the service and even to construct new relay broadcast stations for definite purposes. Applicants must show that all required materials may be obtained without priority assistance for either construction or maintenance.—G.T.M.

Fast Service On Vital Maintenance Parts

War production machinery is speeded and controlled by thousands of electronic parts; all requiring maintenance and repair. Lack of a needed repair part can jam production schedules of vital materials. Quick service is essential.

Here is where the Mallory distributor gives really important help. Like as not, he can supply from stock that desperately needed small order of electronic parts with a high rating. Certainly he can expedite speedy delivery.

Supplying essential maintenance electronic parts in a hurry is just one of the contributions the Mallory distributor makes to war effort. He can be of real service in supplying application suggestions and initial parts for pre-production models for war devices ... in helping construct special test apparatus ... in developing supply sources ... in furnishing data and prices. He will provide you with a copy of the Mallory catalog, indispensable for users of electronic parts!

Call in the Mallory distributor—we are doing our best to keep his Mallory parts stock adequate for speedy service on small orders . . . with high ratings.

Quick, complete information and prices for your purchasing department.

Application data for your engineering and design departments.

Service from stock.

A copy of the Mallory catalog for ready reference.

ARMY E NAVY

P. R. MALLORY & CO., Inc. — **INDIANAPOLIS, INDIANA** • *Cable Address*—PELMALLO

P.R. MALLORY & CO. Inc.
MALLORY
APPROVED PRECISION PRODUCTS

CROSS TALK

► **BD** . . . On October 1, ELECTRONICS takes another big step forward. On that date, Mr. Dudley, for 7 years a member of its editorial staff and for the past 2½ years its managing editor, takes up residence in Chicago as ELECTRONICS' Western Editor. The territory in which Mr. Dudley will represent his paper ediotrially is a vast proving ground for electronic principles, and it rates a full-time editor of his publishing experience and professional standing. Mr. Dudley will be located at the McGraw-Hill office at 520 North Michigan Boulevard, telephone Whitehall 7900; and he will be available for consultation about prospective editorial manuscripts, about technical problems in the fields of electronic control and communication or on any other matter in which an engineer-editor can be helpful.

► **FM vs AM** . . . A point that continually crops up in arguments pro and con on this hot subject is that of the respective service ranges of FM on a line-of-sight basis and AM on a God-knows-what basis. It is argued that since FM is on the high frequencies, it is good only to the horizon and this horizon is not very far away from the transmitting antenna.

The useful range of a broadcast station on any frequency is the distance over which it can be heard clearly. This is the only range that can be sold an advertiser. On the standard broadcast band this is the day-time distance over which the station can be heard above ambient noise. This distance is not very great. At night, however, the same station can be heard, and can create interference, over much greater distances. This is not good service although plenty of people in the country have to listen to it. It is a fact that the night-time service of many local stations is worse than the day-time listening because of interference created by stations at much greater distance.

FM, on the other hand, can be heard no further at night than in day and, as yet, there is no interference whatever. The difference in range between a medium-power FM job on 45 Mc and a high-power AM job on 1000 kc is not very great. A high-power FM transmitter near Boston is regularly and clearly heard in Long Island day or night when nothing whatever can be heard from standard AM broadcast stations in the same region.

By the way—FM listeners in New York City are getting a tremendous kick out of the NBC Symphony at 5 o'clock on Sundays. Here is broadcasting at its best. The joy of hearing these programs via NBC's FM transmitter is matched in intensity only by the disappointment that CBS still has not seen fit to put the New York Philharmonic-Symphony orchestra on its New York FM station.

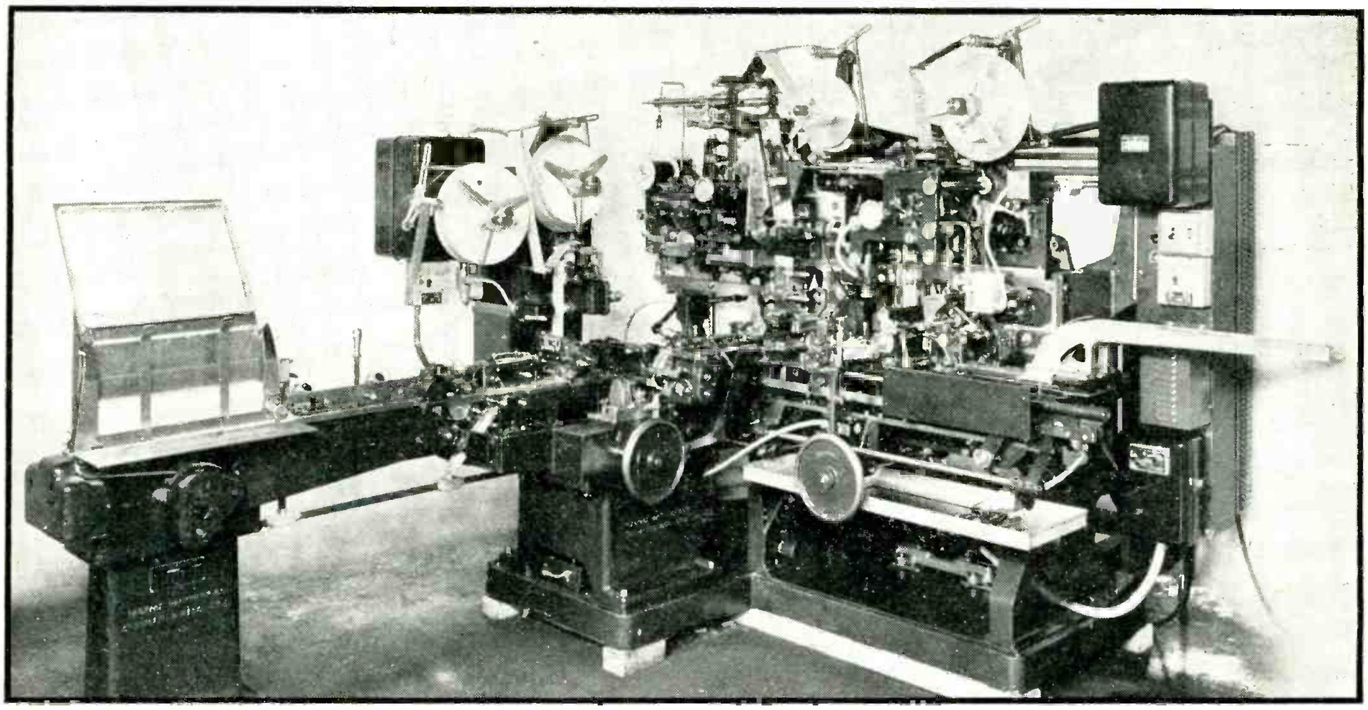
► **RESEARCH** . . . On the subject of research, we quote from an item on this page in November 1935. According to Dr. C. E. K. Mees of Eastman Kodak, research is a gamble. It cannot be conducted according to the rules of efficiency engineering. He states that "research must be lavish of ideas, money and time. The best advice that I can give is don't quit easily, don't trust anybody's judgment but your own; especially don't take any advice from any commercial person or financial expert, and, finally, if you really don't know what to do, match for it." Furthermore Dr. Mees said, "The best person to decide what research work shall be done is the man who is doing the research. The next best is the head of the department.

"After that you leave the field of best persons and meet increasingly worse groups. The first of these is the research director, who is probably wrong more than half the time. Then comes a committee, which is wrong most of the time. Finally there is the committee of company vice presidents, which is wrong all the time."

► **BAZOOKA** . . . Job for the War Department: the new rocket gun which punctures tanks like nobody's business is familiarly called the bazooka. So is a gadget which matches a coaxial line to a doublet antenna. Imagine the opportunity for disaster on the field of battle when somebody puts in a hurry call for a tank buster and gets a coaxial line matcher!

Phototube Control of PACKAGING MACHINES

Unit designs have largely supplanted over-all designs formerly used as labels on wrappers, bags and other merchandise containers. Electronic controls insure proper register of cuts between successive designs when continuous printed webs are used



Package Machinery Company unit used by American Chicle for the automatic handling of Dentyne chewing-gum. Strips of the product are cut into individual sticks at the left, wrapped in printed paper at the center, wrapped in foil and printed paper in groups of six at the right

THERE HAS BEEN a noticeable trend, in packaging and bag-making, toward more extensive use of a printed "unit" design on the wrapper or bag. Unit design tends to supplant the so-called "over-all" design commonly used in the past.

When a unit design is used, it is much less expensive to print on a continuous web of paper than on individual pre-cut sheets. Also, the handling difficulties associated with certain stocks, such as cellophane, make web printing almost essential.

When a printed web is run into a processing machine, such as a bag-tuber or a packaging device, the printed design must be kept in register with the cutter. The slightest error in the relation between the feed-roll travel per machine resolution and the spacing of the printing on the web will result in cutting through the printed design. Even though the error is only 0.1 percent initially, after a few hundred sheets have been run cuts will often occur in the middle of the printed sheet rather than at the end.

A packaging or bag-tubing machine equipped for handling a printed web must incorporate some provision for varying the timing of the draw roll (the roll that draws the paper into the machine) and the rolls that cut off the web. There must also be some means for insuring that the register of the printed matter is synchronized with the operation of the cutting knife. This can be done efficiently by using a phototube to scan the printing and to compare its relative position with that of the cutter.

Register Mark Problems

Since the whole system depends on the phototube response to light impinging upon the printing on the web, the selection and spacing of printed register marks and the method by which the phototube views

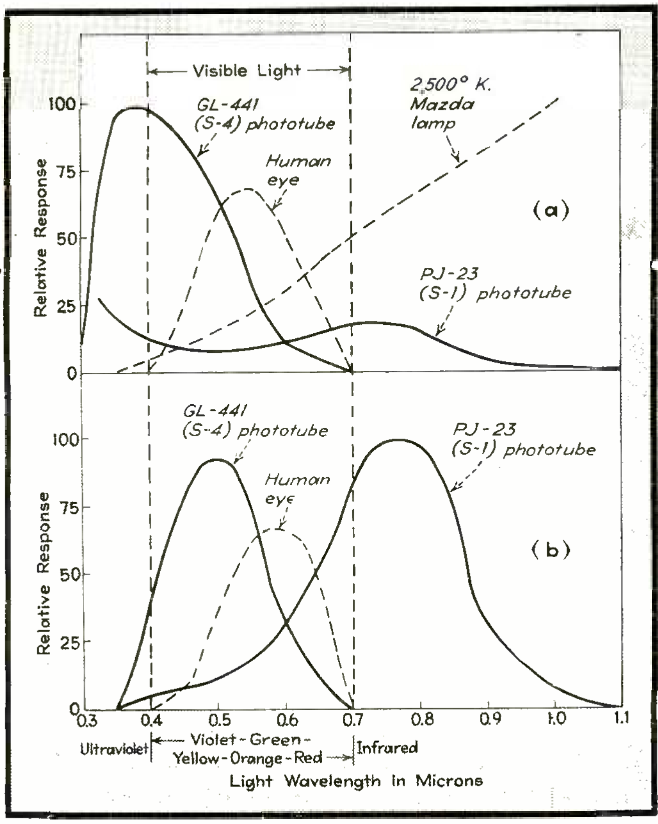


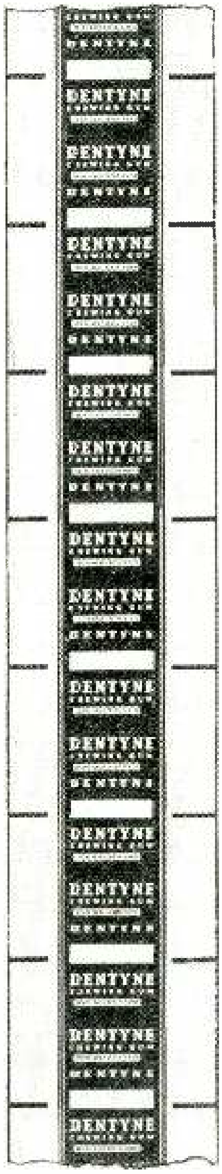
FIG. 1—Response characteristics of two typical phototubes, (a) showing sensitivity to different colors and (b) showing relative response to these colors when they are illuminated by an incandescent lamp

By W. D. COCKRELL

Engineer
Electronics Section
Industrial Control Division
General Electric Co.
Schenectady, N. Y.

these marks are all very important.

To obtain the required amount of light-change at the phototube, we are concerned with the total amount of light striking the phototube and also with the percent change of that light. Obviously, a large percentage change is desirable since it minimizes the effects of small changes in light source intensity due to lamp aging, dirty lenses, or to a change in color or transparency of the material being registered. Figure 1a shows the absolute sensitivity of two common types of phototubes to lights of different colors, while Figure 1b shows the relative response to the colors when illuminated by an incandescent lamp, the light generally employed for this work.



Unit merchandise designs, printed in web form, showing register marks at margins. Reflected light is used for control

The total amount of light striking the phototube depends on the intensity of the light beam, transparency or reflection of the packaging material, the inks used, and the size of aperture before the phototube. To obtain the greatest accuracy, the aperture before the phototube must be narrow in the direction of web motion. Thus, the large effective light change between a highly polished metallic foil surface and a dark ink, or between a directly transmitted beam (such as used with cellophane or with a slit cut in the paper) will result in greater accuracy than would be expected with the same equipment operating on the contrast between a dark line and brown kraft paper.

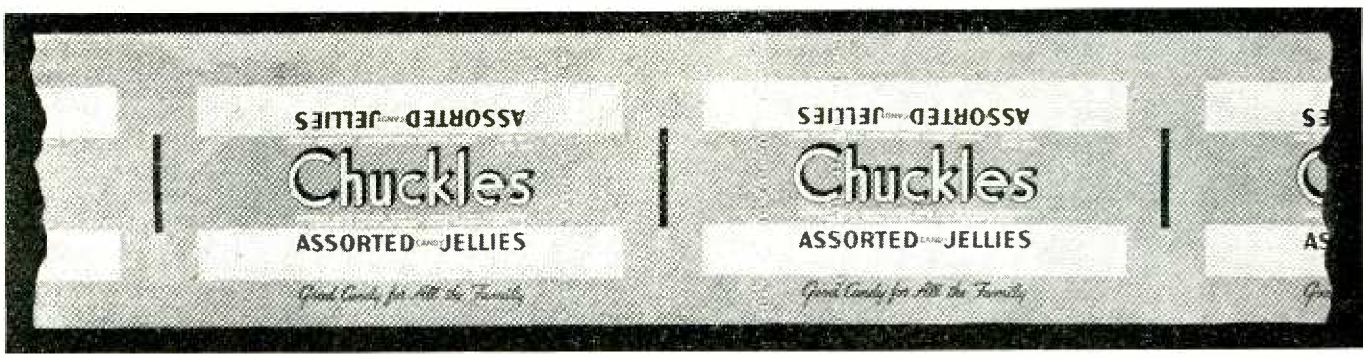
Light Reflection Technique

To register from a printed line on opaque paper, it is necessary to operate by light reflected to the phototube from the surface of the paper. For this purpose, we may use a scanning head and light source such as that shown in Fig. 2, or a more elaborate head which includes an amplifier tube. Typical scanning head optical systems are shown in Fig. 3.

When registering on cellophane, either reflected or transmitted light may be used, depending on which

Unit designs on cellophane. Transmitted light is used for control, the register marks appearing between individual labels

▼



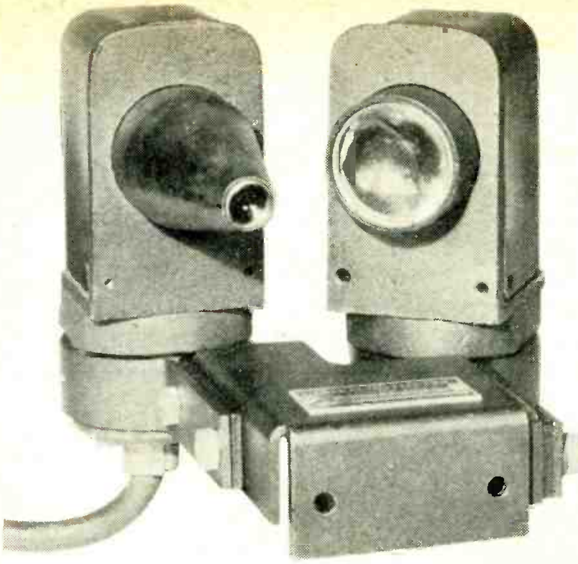


FIG. 2—Typical scanning-head, used where light transmitted from the source is reflected from register marks into the phototube

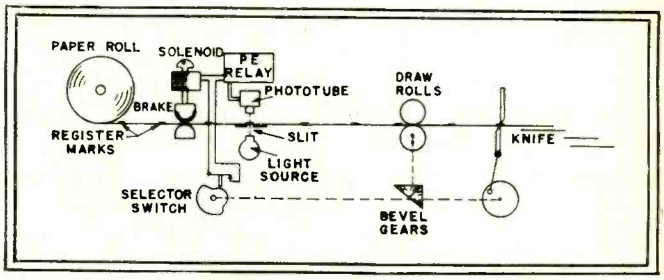


FIG. 5—Schematic of typical intermittent-fed packaging machine. Transmitted light rather than reflected light is used in this instance for control

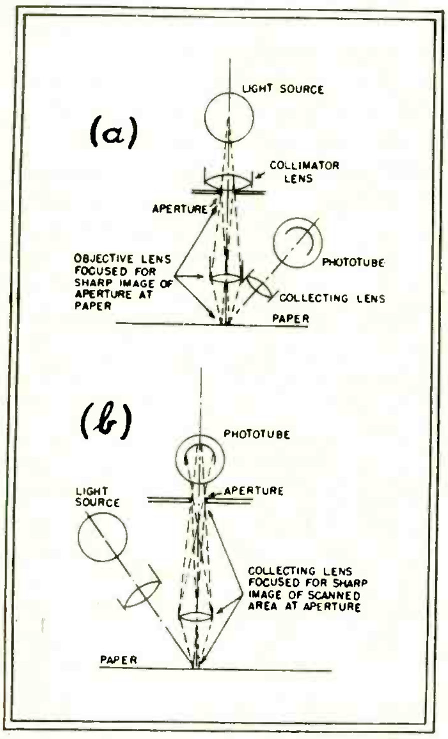


FIG. 3—Elemental lens systems for scanning a paper surface (a) where a sharply defined spot is desired and (b) where viewing of a definite area is desired

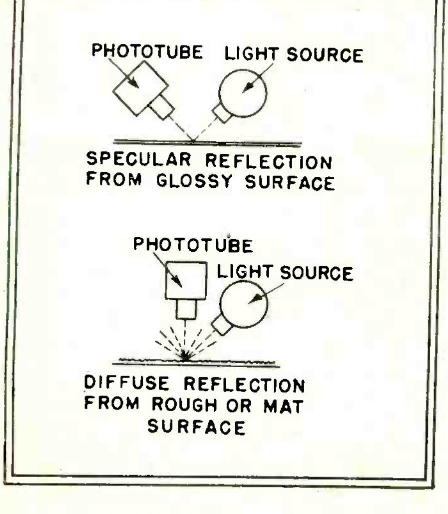


FIG. 4—Arrangement of light source and phototube for specular reflection and for diffuse reflection, the method chosen being dependent upon the character of paper and register marks as explained in text

will produce the greater light change. It is difficult to lay down hard and fast rules as to when each should be used. Light reflected from the surface of a material is of two kinds, "specular" (or mirror) reflection and "diffuse" reflection from a somewhat rough surface, wherein the light is scattered equally in all directions, as shown in Fig. 4.

Specular reflection from a mirror or prism can redirect most of the light beam into the phototube, whereas diffuse reflection, such as from a sheet of white paper, may permit only a small percent of the light to reach the phototube. When specular reflection is used, the phototube must be located quite accurately, otherwise the sharply directional reflected beam may miss it completely. A diffused reflected beam will be effective over a much wider area. Shiny surfaces such as polished foil and waxed or lacquered paper have a high degree of specular reflection. Since most of the light is reflected from the surface of the lacquer and does not penetrate to the paper surface, it is sometimes not practical to register by specular reflection from a printed line which is covered by a coat of lacquer or wax. The smaller the angle between beam and paper (the more nearly parallel the beam is to the paper surface), the greater is the amount of specular reflection.

Color differences are invariably seen by diffuse reflection. If there is considerable specular reflection present, it minimizes the percent change of light due to color contrast. Hence, there may be conditions where a white mark printed as a matte pigment surface may reflect less light to the phototube than the spectral reflection from a highly polished black background. Such a problem is solved by moving the light source or phototube so that the specular ray misses the phototube and only the diffuse white light is received.

Light Transmission Data

When working with cellophane and using light transmitted through rather than reflected from the material, much depends on the type of ink used for the printed register marks. A pigment ink will simply block off the light so that for a given thickness of ink the change in response is fairly independent of color. However, when a dye is used, the lack of an opaque ingredient will generally permit more light to pass and require a more serious consideration of the color used.

A practical register mark is usually made about twice as wide as the accuracy desired. For instance, for an accuracy of plus or minus 1/64 inch, or a total tolerance of $\frac{1}{32}$ inch, a mark $\frac{1}{16}$-inch wide is suggested. The edges of the mark must be well printed and sharply defined. The length of the mark perpendicular to the motion depends largely upon the amount of side motion expected in the web. Normally, the phototube or scanning head views a section about $\frac{1}{4}$-inch wide, so the total width of the mark must be sufficient to prevent the mark from shifting from the scanned point. For most applications, a mark $\frac{1}{2}$ inch long is suitable.

The position of register marks

must be continuously compared with the packaging or wrapping machine cycle. The method of comparison used varies with each type of machine and drive. It may employ a simple shutter which permits the phototube to look at the marks only at definite times. Quite often cam-driven contacts are in use in place of a shutter to "arm" the phototube equipment at certain critical intervals. Where greatest speed and accuracy are desired, a disk having slits accurately spaced and viewed by a second phototube is frequently used.

Packaging Machine Action

Correction must be applied after a misregister has been detected. The method of doing this depends on the design of the machine and the ingenuity of the machine designer. On intermittent-fed machines, the stroke may be lengthened or shortened slightly. If the feed rolls are small, it may be possible to use a compensating roll such as is customary in the printing press industry. However, for the majority of applications it has been found most desirable to use a differential gear between the draw rolls and the cutter. Which part of the machine should be driven directly and which through the differential is determined principally by the comparative power required for the two elements and the effect of the shock on the gearing at the time the cut is made.

Standard Phototube Relays

For slow-operating machines, particularly those having an intermittently-fed sheet, and where the demands of accuracy are not too great, the use of standard or general purpose phototube relays, without modification, is often practical.

Where the cycle of the machine is determined by the time required for the packaging operation rather than by the time required to properly feed the paper, the feed may be moved forward until the register spot intercepts the light beam, at which time the phototube relay will cause the paper drive to be stopped or a brake to be applied to the web as shown in Fig. 5. Then, after the cut has been made, an interlocking arrangement will permit the sheet to be again brought forward and the process repeated.

Greater accuracy may be obtained with a given phototube relay by using a form of variable-speed drive, wherein the major part of the sheet motion is at comparatively high speed but is slowed down near the end of travel. In addition to the time required for the operation of the phototube relay, sufficient time must be added for the mechanical operation of the corrective device used.

A somewhat different type of intermittent-speed machine moves the web each time slightly more (or slightly less) than required. The cumulative error then adds up in a few impressions to the point where the register mark operates the phototube relay and produces a one-way correction which brings the mark back to the beginning point. This saves considerable wear on the correcting mechanism, as it does not have to operate for every impression.

A step towards higher-speed operation is to apply the same principles

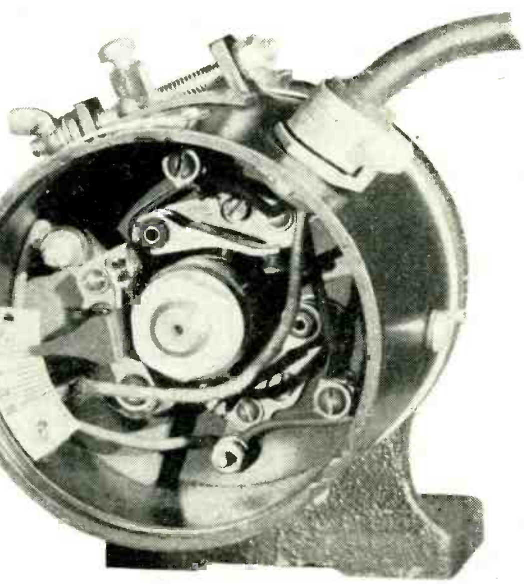


FIG. 6—Rotary selector switch used in connection with phototube register control

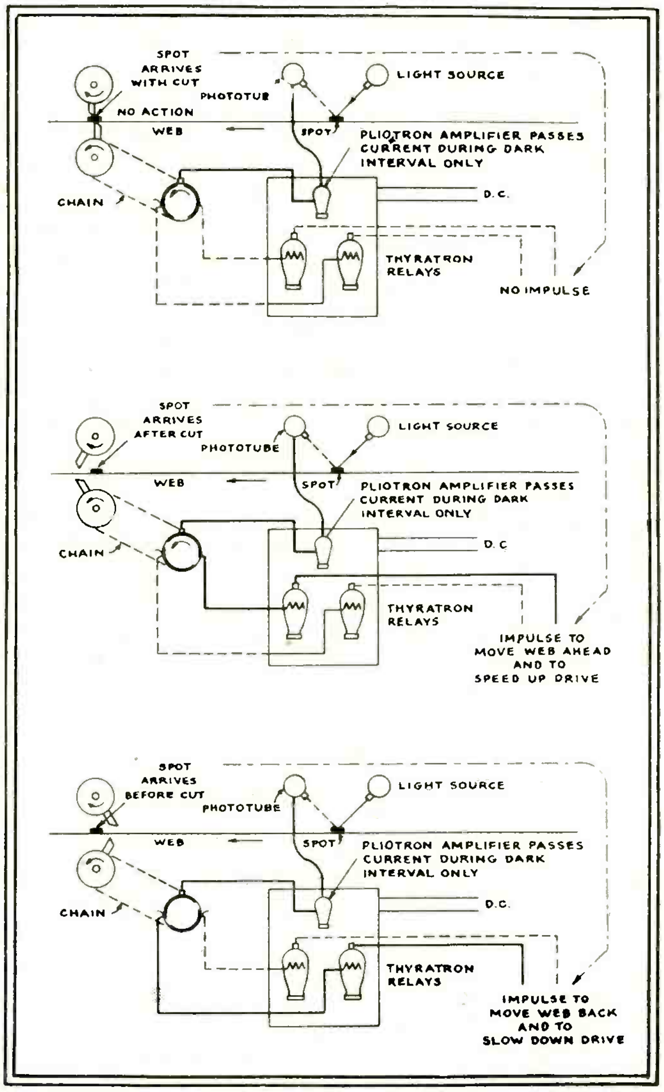
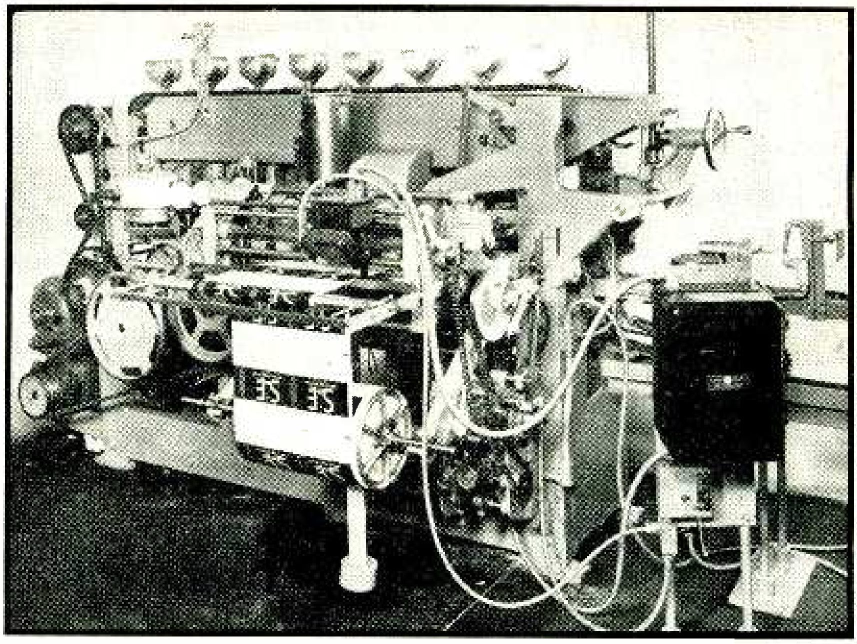


FIG. 7—Schematic diagram of two-way control system which corrects for either fast or slow paper web movement

to continuously-fed stock, always feeding the stock slightly faster or slower than required until the accumulated error in the position of the register mark, checked against machine-driven contacts, indicates that a correction is needed. Contacts which indicate the position of the cutter or other processing elements are usually cam-driven. They are referred to as rotary selector switches.



Another typical packaging machine. The printed wrapper web, with register marks, is seen near the center. The electronic register control panel is visible at the right

One and Two-Way Corrections

The one-way type of register control is capable of producing a correction in only one direction. Its operation is based on the principle of overfeeding or underfeeding, as described above.

Since controls made expressly for such work usually employ an advanced type of scanning head (wherein the amplifier tube is enclosed with the phototube) and provisions are made for a selector switch they operate with a higher degree of accuracy and respond to a smaller color contrast than standard relays.

Capacity coupling is used between phototube and amplifier. Such a system will respond readily to the rapid changes in light that occur when a register mark passes, but may be made relatively insensitive to slow changes such as those caused by aging of the light source or by changes in the background color of the paper used.

The extremely small operating signal obtained from a slight color contrast as seen through a very narrow aperture requires that the amplifier tube be placed as close as possible to the phototube so that the signal will not be lost through excessive capacity or inductance in the connecting leads. Although local conditions will have a great influence upon the speed of operation and the accuracy permissible, apparatus of this type is not generally recommended for paper speeds of greater than 50 feet per minute or an accuracy of greater than plus or minus $\frac{1}{32}$-inch.

The next logical step after one-way register control, is to add a second contact to a rotary selector switch (such as the one shown in Fig. 6) and an additional control circuit, so that the correction may be made in both directions. When using this method, the draw-rolls are set to pull the paper as near to the correct length as possible. Then, any tendency for the paper to go ahead of or lag behind the correct register point is detected by the phototube. The operation of the selector switch indicates the proper direction of correction. An adjustable time-delay circuit is provided so that the correction can be preset to give the best results. A schematic diagram of such an arrangement is shown in Fig. 7.

As long as the correction is made in one direction only, the register mark creeps a fixed distance from the correct position, causing the control to operate and bring it back. However, with two-way register control, we are faced with the problem of the error or tolerance of register in each direction from normal which may be permitted before the apparatus is actuated.

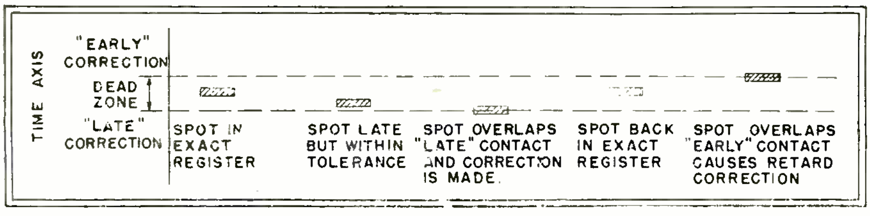


FIG. 8—Diagram showing the action of a two-way control system and the "dead zone" required to avoid hunting

Required Register-Mark Tolerances

The tolerance over which the register mark may move without causing control operation is called the "dead zone", and is shown in Fig. 8. This dead zone must be at least equal to the width of the register mark plus the increment of correction to be made, otherwise each time a correction is made it will throw the register mark to the opposite side of the dead zone and a reverse correction will be made. This will cause undersirable hunting. If the construction of the machine is such that the complete correction cannot be made before the next spot arrives, it will be necessary to increase the size of the dead zone to allow for the follow-up action so that hunting will not start.

It is absolutely necessary that register marks be equally spaced along the web well within the tolerance of register; otherwise, alternate marks might touch opposite sides of the dead zone and start a hunting cycle of their own. It is necessary also that the tension of the paper feed be such that slip of the draw roll will not permit radical changes in the length of cut for which the control cannot compensate.

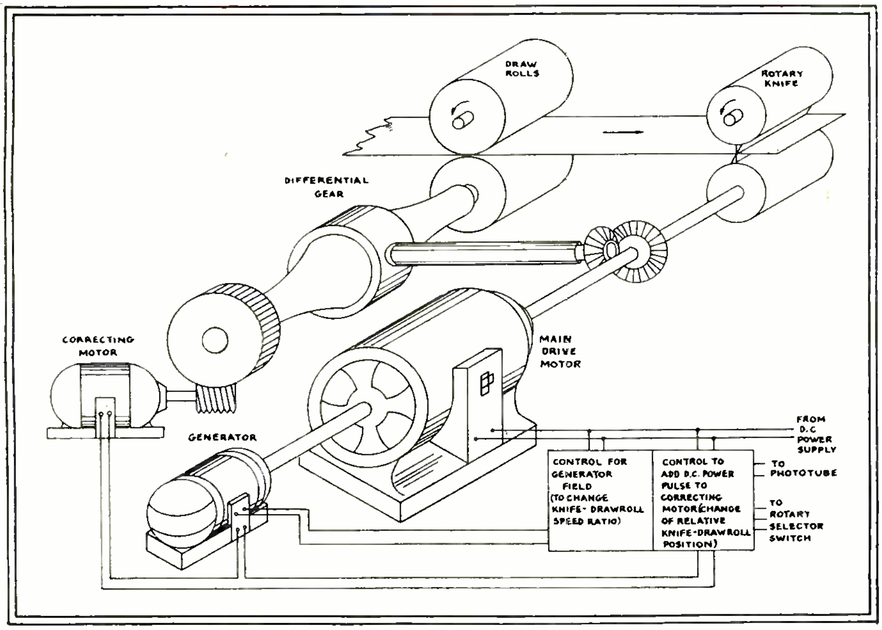


FIG. 9—System incorporating both speed and space correction for extreme accuracy in maintaining register at a high-speed rotary knife of a packaging machine

Since it is impossible for the scanning head to view the register mark at the ideal point, i.e., that at which the cut takes place, we must compromise and view the spot at some position as close as possible to this point. If it is necessary to place the scanning head more than a few register-mark lengths away from the cut, any error (due to shrinkage, etc.,) occurring between register marks will accumulate. This usually is not a serious problem provided the scanning head can be kept within four or five bag lengths from the cut-off point.

As mentioned previously, at higher paper speeds, the differential type of correction is almost universally used. The correction made by this type of equipment should consist of a correction of space or phase angle between the draw roll and the cutter. It is almost impossible to attempt to change just the relative speed of draw roll and cutter without setting up a disastrous hunting cycle.

When using two-way register control, the accuracy and speed permissible depend upon local conditions. It is generally not desirable to operate such equipment at greater web speed than 200 feet per minute. An accuracy of plus or minus 1/64 inch can be obtained where means are provided to keep a constant tension on the feed roll. Signal lights operated from the forward and reverse contacts will give a good indication of whether or not the tension is correct.

Control Employing Speed Change

Another possible refinement is control of the relative speeds of the draw roll and cutter, in addition to their space relations. This may be accomplished mechanically by controlling the tension on the feed roll as each space correction is made. Great care must be taken, however, that the speed change is not sufficiently great to overbalance the space change, otherwise hunting will take place. One form of combined speed and space change is obtained with a single correcting motor, by the use of a contactor and rheostat panel in conjunction with a two-way register control panel. Such a system is illustrated in Fig. 9.

The draw rolls are set to pull the paper through the machine at a speed approximately 1 percent fast. The correcting motor is then geared to a differential as shown in Fig. 10, so that when running at full speed, the differential will cause the draw roll to turn 1 percent slow. Thus, with the correcting motor stopped, we have a speed 1 percent fast and, at full speed, 1 percent slow. Therefore, when the correcting motor is running at approximately 50 percent speed, the draw rolls will be pulling the paper at approximately the correct speed. Also, since the correcting motor is bucking the main motor, its load is extremely light and it is very responsive to changes in armature voltage. By means of an auxiliary control panel, we may then momentarily retard or advance the speed of the correcting motor to obtain a space change and may increase or decrease its average speed to obtain a corresponding effective speed relation change.

In order that the correcting motor may at all times turn at some convenient percentage of the speed of the main motor even though the machine may run fast or slow, the correcting motor is driven by a generator that is geared to the main motor drive. The correcting-motor field is constant and produces maximum torque, but the generator field is fed from a potentiometer rheostat on the control panel. This rheostat is then rotated with each corrective pulse. From the power line, a small direct voltage is fed to the motor armature in a direction which produces the required momentary space-change operation. This system has the added advantage that the average speed of the web is always kept nearly correct. The increment of space correction may thereby be reduced to a much smaller value than that used in the two-way space register control alone.

Equipment using this type of register control has been known to operate at 400 or 500 feet per minute with an accuracy of register of plus or minus 1/64-inch. It must be

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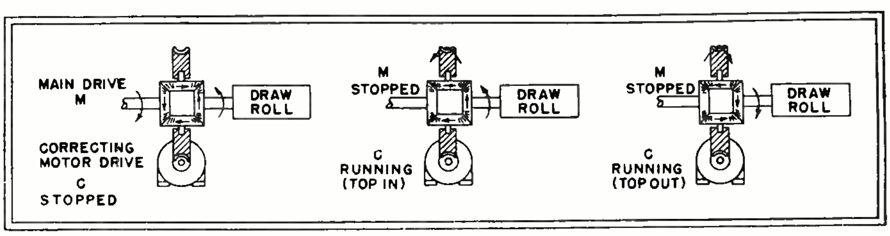
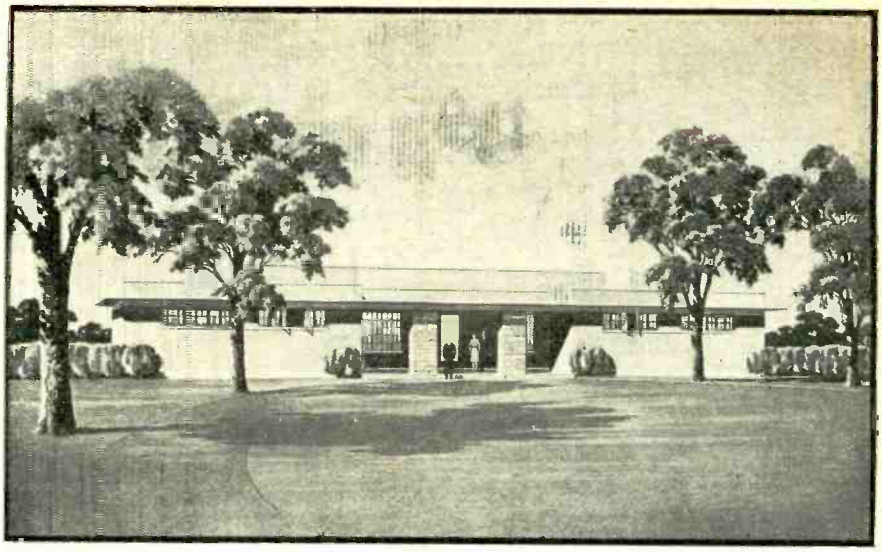
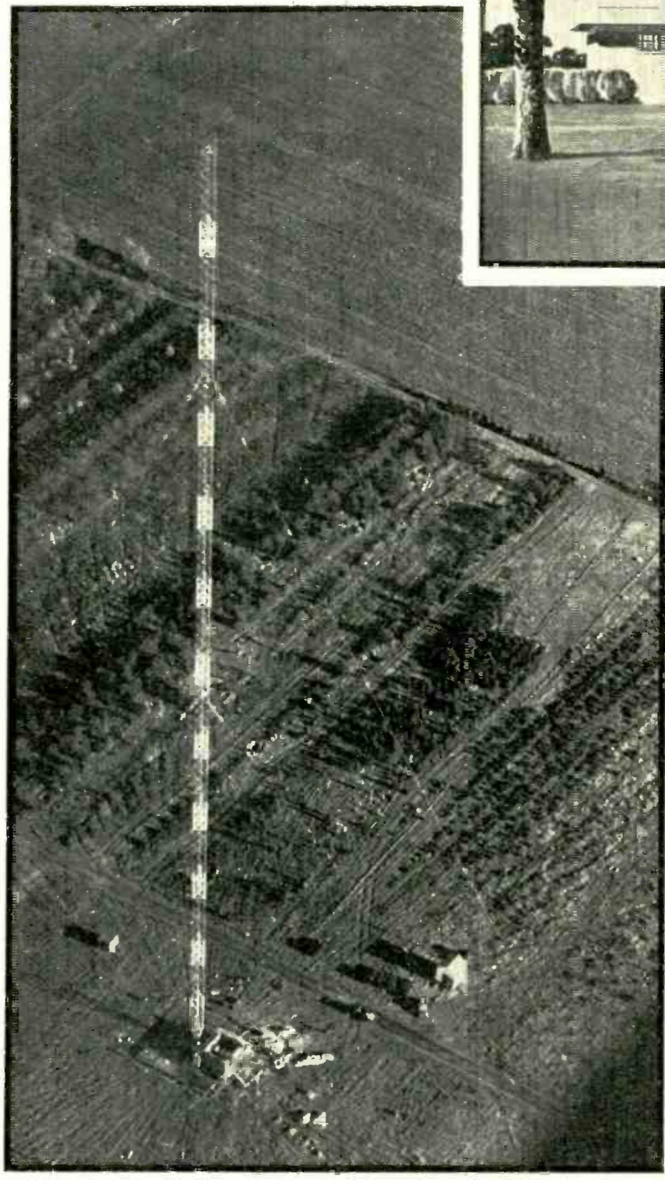


FIG. 10—Action of bevel differential drive, showing how both the main motor and the correcting motor drive the draw roll and how changing the direction of the correcting motor rotation will add or subtract from the effect of the main motor

Architect's wash drawing of the new WJZ transmitter building now being erected at Lodi, N. J., about 9 miles from Manhattan



Aerial view of the WJZ tower at Bound Brook, showing the extent of the ground system that will have to be excavated to salvage precious copper for the new site



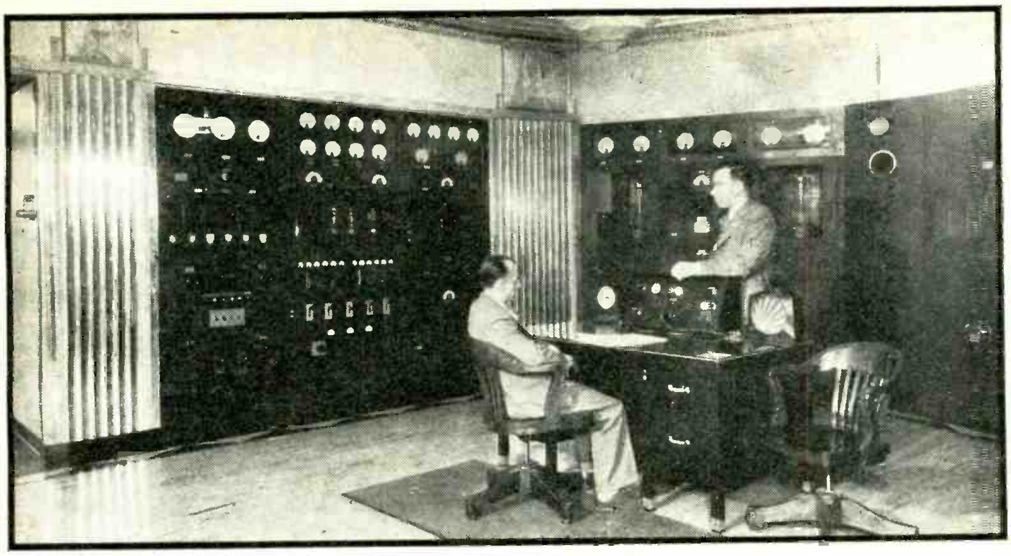
Moving a 50-kw Transmitter...

How WJZ, New York City's oldest broadcast station, is moving its entire transmitter and 640-foot tower to a new site on the North Jersey salt marshes without going off the air, in order to make room at the old Bound Brook site for four new OWI transmitters

THE important role played by short-wave broadcasting in the present war has indirectly resulted in the moving of all transmitting facilities of WJZ, key Blue Network station and second-oldest broadcast station in the country, from the international short-wave broadcasting center at Bound Brook, N. J. to a new site at Lodi, N. J.

The reason for the move dates back to the time when the Office of War Information took over all short-wave broadcasting facilities in this country for defense purposes. The United States then had only a handful of transmitters powerful enough to enter the international competition of short-wave radio to South America, Europe and the Pacific. Our twelve stations had to compete with some thirty German stations, a half dozen Italian stations, and many others.

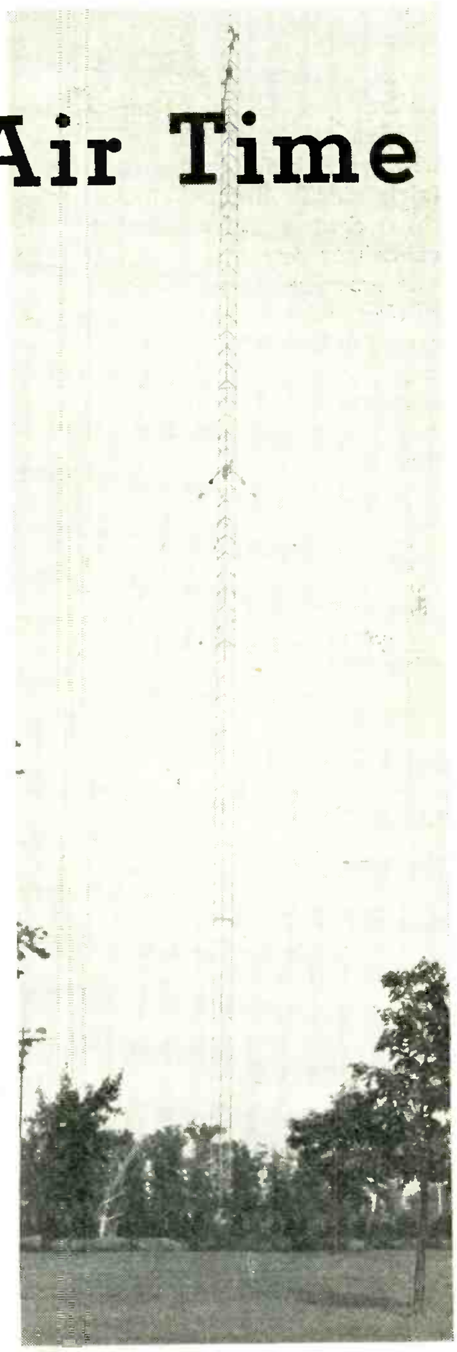
In September 1942 the construction of twenty-two more short-wave transmitters was authorized, all to be 50 kilowatts or higher in power. Locations then had to be found for the new transmitters, and buildings obtained or erected at the sites. It was highly desirable to place these new stations near or at locations of existing transmitters because of availability of power, communication facilities, trained operating personnel, antenna facilities, ample land, etc. For this reason, the decision was made to install four of the new 50-kw transmitters at Bound Brook, alongside NBC's other short-wave stations WRCA and WNBI.



This 50-kw WJZ transmitter at Bound Brook will be moved to a new site without interrupting 24-hour-a-day broadcast service and with an absolute minimum of new construction, by utilizing auxiliary equipment at both old and new sites on a carefully planned schedule

Beginning of dismantling operations on the 640-foot guyed steel tower at Bound Brook will start like this, with steel-workers at the top rigging a pole for lowering the structural members piece by piece. Steel for a new tower cannot be obtained, so this tower will be moved to the new site

..Without Loss of Air Time



This decision brought forth the first problem, that of deciding whether to erect a new building at Bound Brook for the four transmitters, or whether it would be better to use the present WJZ transmitter building and move WJZ facilities elsewhere.

Investigation showed it would be considerably cheaper and more satisfactory to move WJZ and its 640-foot tower. This would give OWI all the space it needs for the added short-wave stations. Therefore, in September 1942 the Blue Network was asked to move its station, with OWI bearing the cost of dismantling and part of the cost of moving the tower and transmitter.

Choosing a New Location

With the Office of War Information backing WJZ in its application for the necessary FCC construction permit and the WPB application for essential materials required, the problem of selecting the new site came up.

Except for a two-year period (the Aeolian Hall days), WJZ had always been a New Jersey station, and the Blue Network wished to retain this association. In New Jersey are the meadows, consisting of large areas of salt marshes flushed with tidewater twice a day. These marshes provide an almost perfect ground for transmitters, with a low and level transmission path to surrounding communities and the New York district.

Large though the marshes are, extending far below and above New York City proper, the desirability of getting a signal into Manhattan as nearly as possible at right angles (so waves would travel a near-minimum distance over highly-absorptive Manhattan skyscrapers in getting to Long Island communities) precluded going too far north or south of Manhattan on the marshes. This restricted the search to an area roughly between Newark Airport and the towns of Paramus and New Milford. In this area were located ten broadcast stations already serving New York City, not to mention a large number of police, aircraft and other communications transmitters.

One of the difficulties in locating a site was the fact that WJZ's frequency is lower than that of any other broadcast station on the marshes. This meant that its tower would be higher than those of the other stations and would re-radiate their signals, appreciably altering the directional patterns if too close to other stations.

It was desirable to find a site near

(*Continued on page* 184)

An A-C Operated Vacuum

Voltmeter suitable for wide range of voltage and frequency uses diode rectifier and a-c operated triode amplifier. Voltmeter is relatively unaffected by line voltage changes, requires no voltage regulator, and can be constructed for twenty-five dollars

ORDINARILY the amplifier incorporated in a vacuum-tube voltmeter operates from a direct-current source of plate supply. This is convenient because almost any reasonable amplification can be obtained with good stability by the use of fairly simple circuits. Furthermore the methods of determining the gain of such an amplifier are likely to be well described in any standard text on electronics. However, such an arrangement requires a rectifier-filter circuit and perhaps a voltage stabilizer, so that the complete voltmeter may become rather bulky and expensive. Since a dependable meter deflection is, after all, the desired end result, it seems logical that a useful vacuum-tube voltmeter might be devised in which the plates of the tubes are operated from an alternating voltage directly, thereby eliminating the rectifier and filter completely.

To be most useful, a vacuum-tube voltmeter should give a correct indication over a wide range of frequencies, preferably from the low end of the audio frequency band to very high radio frequencies. A vacuum tube circuit having a 60 cycle alternating plate voltage could not be expected to provide indications of voltage which are independent of the frequency of the input signal voltage. It is possible, however, to rectify the incoming voltage, whose d-c output may then be amplified by means of suitable circuits operated from an a-c source of power. A circuit of this general type can be used for measurements over a very wide frequency range.

The basic circuit of an a-c operated amplifier is shown in Fig. 1. Because of the rectifying action of the tube unidirectional pulses of current will pass through the load resistor, R_l, in the direction shown by the arrow. As the d-c value of the grid voltage, E_c, is varied, the tube can be considered to conduct current for longer or shorter periods of the half cycle for which the plate is positive, thereby causing both the average value and the root-mean-square value of the load current to vary. Such a circuit is an "amplifier" in the sense that small voltage changes at the input may cause relatively large changes in the voltage across R_l, although the form of the output voltage may not be at all similar to that of the input voltage. A current indicator placed in series with the load resistor, R_l, would register the changes in output caused by the changes in grid voltage, and if this were properly calibrated, the meter could be used to determine the value of the applied grid voltage. Such a circuit constitutes the basic element for a simple a-c operated vacuum tube voltmeter. The instrument to be described is merely an improved version of the circuit of Fig. 1.

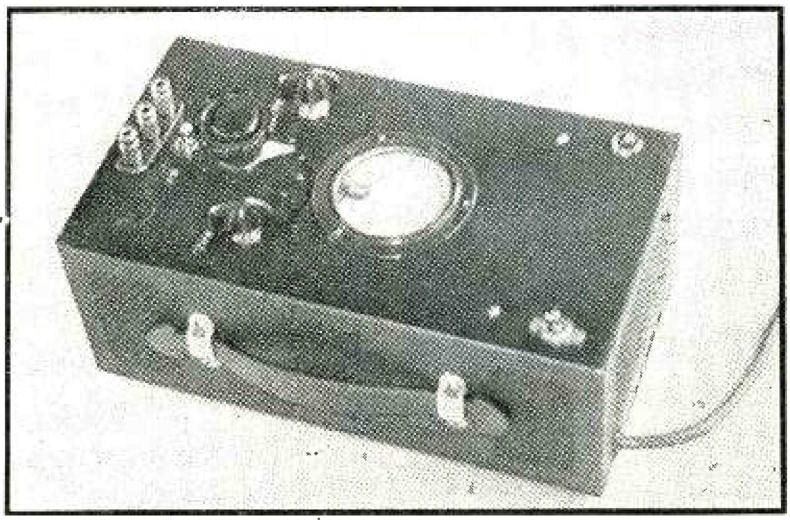
THE careful reader will discern that there is more to Mr. Thurston's article than the description of a highly useful and inexpensive voltmeter. The use of tubes with an a-c source of plate supply has wide application in many industrial devices, particularly if a tube so used is reasonably free from line voltage variations which, laboratory investigation has shown, is the case.

THE analysis of the operation of a triode with a-c plate supply, together with the graphical analysis of the behavior of a-c operated pentodes, as given in "Power Output of A-C Operated Amplifiers" by W. A. Schwarzmann in the August issue, should help stimulate interest in the further development of a-c operated electronic industrial and measuring devices.

Most vacuum tubes are constructed so that the grid potential must be negative to effect plate current cutoff. As a result, the plate current meter of Fig. 1 will indicate some positive value of plate current when the grid is at zero potential. In order to have a meter reading of zero with zero grid input voltage, some kind of balancing scheme is necessary. The circuit of Fig. 2 provides for this balance by allowing the diode, T_2, to supply a bucking current which should be equal in magnitude to that flowing in the plate circuit of the triode at zero grid voltage. By use of the tapped transformer, it is possible to have the plates of T_1 and T_2 positive during the same half cycle, which makes it possible to have

Tube VOLTMETER

By
JAMES NORTON THURSTON
*Department of Electrical Engineering
Massachusetts Institute of Technology
Cambridge, Mass.*



Photograph of the completed voltmeter, ready for operation

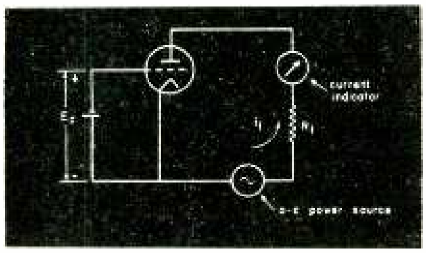


FIG. 1—Fundamental electrical circuit of the a-c operated amplifier

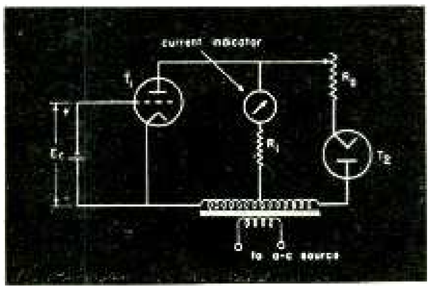


FIG. 2—A-C operated amplifier with balancing circuit to produce zero current through the meter for zero grid voltage of the triode

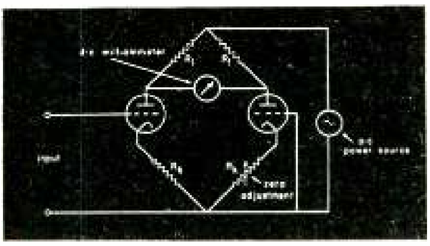


FIG. 3—Simplified schematic wiring diagram of the a-c amplifier which forms part of the vacuum tube voltmeter

the current through the indicating meter balanced to zero at all instants when zero grid voltage is applied. This instantaneous balance is not required if a d-c meter is used as an indicator, but it proved advantageous in the laboratory because it reduced the heating value of the current that passed through the meter and appeared to give a more stable reading.

The basic circuit of Fig. 2 is a thoroughly practical one for vacuum-tube voltmeter service. However, a consideration of the desirable characteristics of a vacuum-tube voltmeter for continued use in the laboratory or shop necessitated the development of circuits more suitable for this type of service than the basic circuit of Fig. 2.

Practical Considerations in Vacuum-Tube Voltmeter Design

The governing principle upon which all vacuum-tube voltmeter design should be based is that the readings must be dependable and reproducible under any ordinary operating conditions. Line voltage variations, which are always present to a greater or lesser extent, must be overcome. In the case of the a-c operated instrument, these were best overcome by the use of balanced circuits since the application of negative feedback was either very difficult or not sufficiently effective. Practical considerations ruled out the use of a regulated power supply for the voltmeter.

The characteristics of vacuum tubes used in any circuit tend to change with time and use. In addition commercial tubes vary among themselves so that the circuits in which these tubes are used may not be dependable for measurement work unless some method is devised for taking account of these changes and

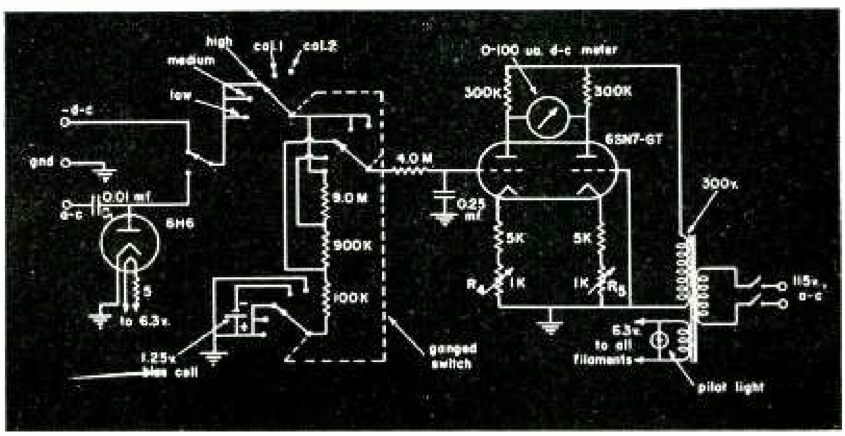


FIG. 4—Schematic diagram of complete a-c operated vacuum tube voltmeter

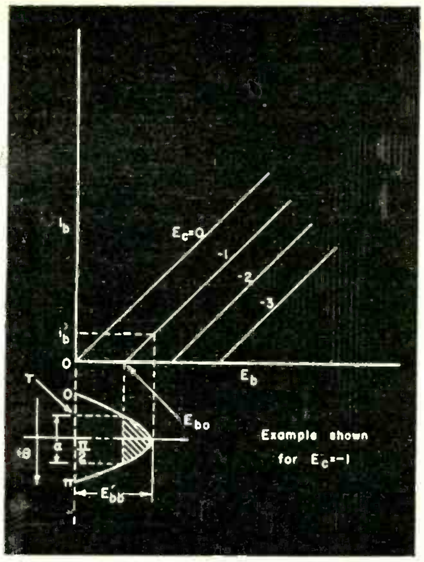


FIG. 5—Idealized triode characteristics and illustration of method of calculating output of a-c operated triode

variations. A special check-calibration method was devised to keep the instrument calibration independent of tube changes.

The indicating meter in the case of vacuum-tube voltmeters operated from d-c sources is ordinarily a d-c milliammeter or microammeter. In the case of the a-c operated vacuum-tube voltmeter, however, some question arose as to what type of meter would be most satisfactory. Laboratory work soon proved that here, also, the d-c milliammeter or microammeter was most satisfactory since such a meter would read average values of plate current. Laboratory work also showed that plate current pulses in the a-c operated amplifier could be made to give an average (d-c) reading of zero, but that the root-mean-square values of the initial and bucking current would be greater than zero. For these reasons, a d-c meter was chosen as an indicator.

In the course of the search for a satisfactory a-c operated amplifier, many interesting circuits were studied but none were as suitable for vacuum-tube voltmeter service as the arrangement shown in Fig. 3, which is a simplified circuit of the amplifier finally used in the a-c operated voltmeter.

The use of two identical tubes in a symmetrical or balanced circuit tends to eliminate changes in calibration due to line voltage variation. In actual operation the two tubes are hardly ever exactly identical and consequently a zero setting is desirable for adjusting the balance of the plate currents. Once adjusted for proper operation, however, balance is obtained over a wide range of voltage changes. The net result is to produce an indication which varies by about ± 2 percent for a line-voltage change of about ± 10 percent.

Since a double triode is used in the a-c operated amplifier, there is a tendency for cathode emission and other tube characteristics to change in the same direction in the two sections of the triode. This helps to maintain a balanced circuit. Furthermore, the use of a double triode in a single envelope saves considerable space inside the instrument.

The arrangement of Fig. 3 has the advantage of providing a meter deflection that is very nearly directly proportional to the d-c value of the voltage applied at the input terminals.

The Complete Vacuum-Tube Voltmeter

The schematic wiring diagram of the complete a-c operated vacuum-tube voltmeter is shown in Fig. 4 and a photograph of the completed unit is shown on page 103. Essentially the instrument consists of a diode rectifier, a voltage multiplier or range switching device, and the double triode balanced a-c operated symmetrical amplifier.

A 6H6 diode is used as the input tube when an alternating voltage is to be measured. One section of this tube serves as the rectifier of the a-c input, while the other section is unused. The physical dimensions of the 6H6 are rather small, which makes this tube useful in voltmeter applications since space is at a premium in an instrument of this type. A small resistor is used in series with the heater of the 6H6 to lower its filament voltage. This tends to reduce the potential which is developed at the grid of the left-hand triode section of the 6SN7-GT as a result of the initial electron velocities emitted from the cathode of the diode.

A selector switch is provided so that either direct or alternating voltages may be measured. The d-c position of this switch simply removes the diode from the circuit and substitutes the direct voltage which is to be measured for the rectified output of the diode. Whichever of these voltages is to be used is impressed across the voltage divider to which the range switch is connected. For a given meter range, this switch simply selects a portion of the voltage available and applies it to a resistance-capacitance filter, after which it is impressed upon the grid of the a-c operated amplifier.

The diode circuit and the polarity marking of the d-c input terminals are arranged so that the signal grid of the 6SN7-GT is always at zero or at a negative potential. This eliminates practically all grid current of the double triode and makes it pos-

(*Continued on page* 224)

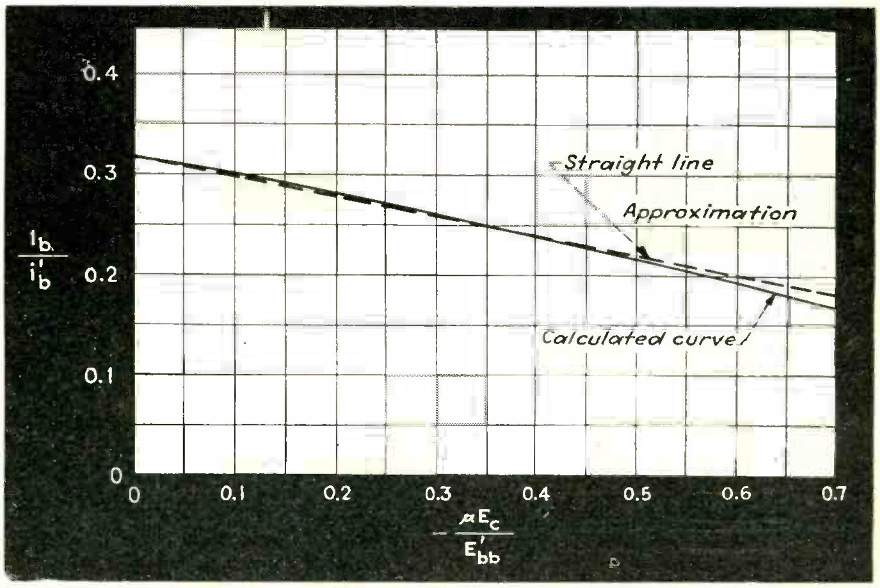
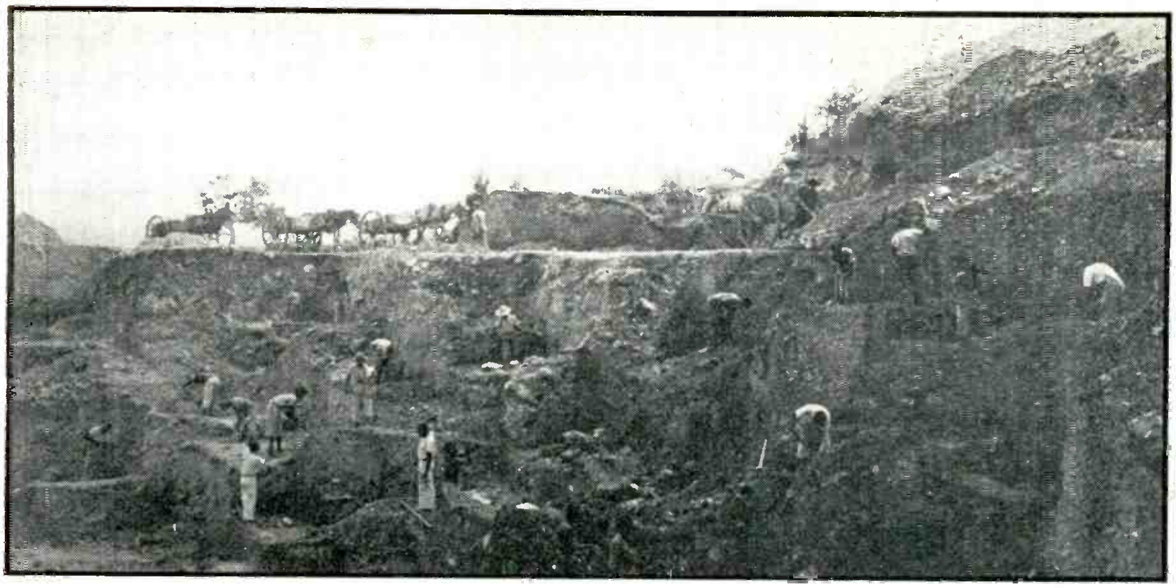


FIG. 6—Curves used in calculating direct plate current of a-c operated triodes



MINING QUARTZ IN BRAZIL

Quartz Crystals in Production

RAW QUARTZ

Six of the major processing steps used at the August E. Miller Laboratories of North Bergen, N. J., to convert mother quartz of ancient Brazilian riverbeds into vital crystal units for military transmitters and electronic equipment are here portrayed

LOCATING THE OPTICAL AXIS

WHEN OUR WORLD was in the making, one of the outstanding unions was that of a silicon atom with two atoms of oxygen, forming a molecule now unromantically called SiO_2. Colonies of these molecules assembled, governed by rigid rules. These developed into the beautiful lattice-like structure of the quartz crystals from which come the postage-stamp size slabs that today permit simultaneous operation of thousands of radio transmitters and other electronic equipment all over the world.

Mining quartz in Brazil is essentially a pick-and-shovel procedure, with native workers probing old veins or the gravel beds of prehistoric rivers by the tedious process of shovelling earth upward from one shelf to the next, then hauling it away in horse-drawn two-wheel carts.

Raw quartz as originally formed by nature is a beautiful hexagonal crystal with slightly tapered sides and many facets at one end. It must usually be broken away from the larger mass of rock out

X-RAY ORIENTATION

of which it has grown, hence one end will be a rough fracture. Most of the quartz coming from Brazil today, however, has rolled around for centuries in gravel beds of rivers, so that original surfaces are largely worn away by erosion.

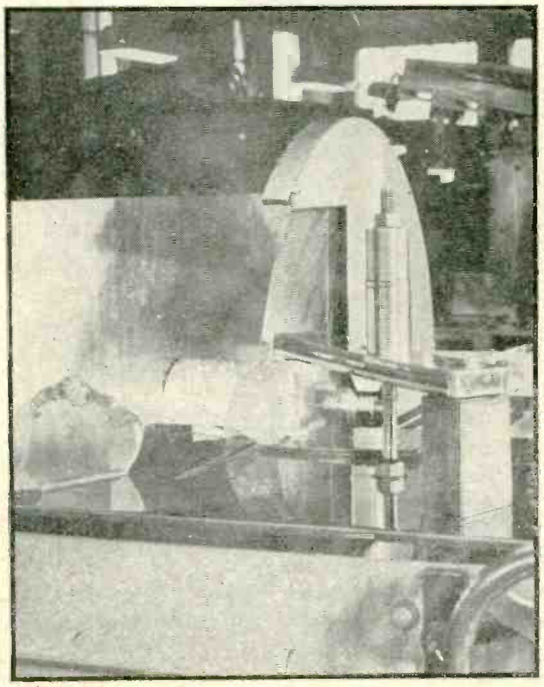
Locating the optical axis, the first step in the preparation of a piece of quartz for cutting into radio crystal units, is done with polarized light in an instrument called a conoscope. The position is marked with crayon as a guide for the next cut. This orientation can be performed accurately even though all surfaces are worn.

X-ray orientation serves to locate other crystallographic axes, used as guides in making the final saw cuts at the correct angles to insure that the crystal frequency will remain essentially constant over a given temperature range.

Sawing into Z sections or large blocks is done on a machine like a circular saw, using a precision saw blade having diamond teeth imbedded in its circumference. The mother crystal is clamped to the saw table, using wood blocks and wedges to position it at the previously determined correct angle. From the Z sections are sliced the wafers or blanks that go next to the grinding room.

GRINDING BLANKS

SAWING Z SECTIONS



Production (continued)

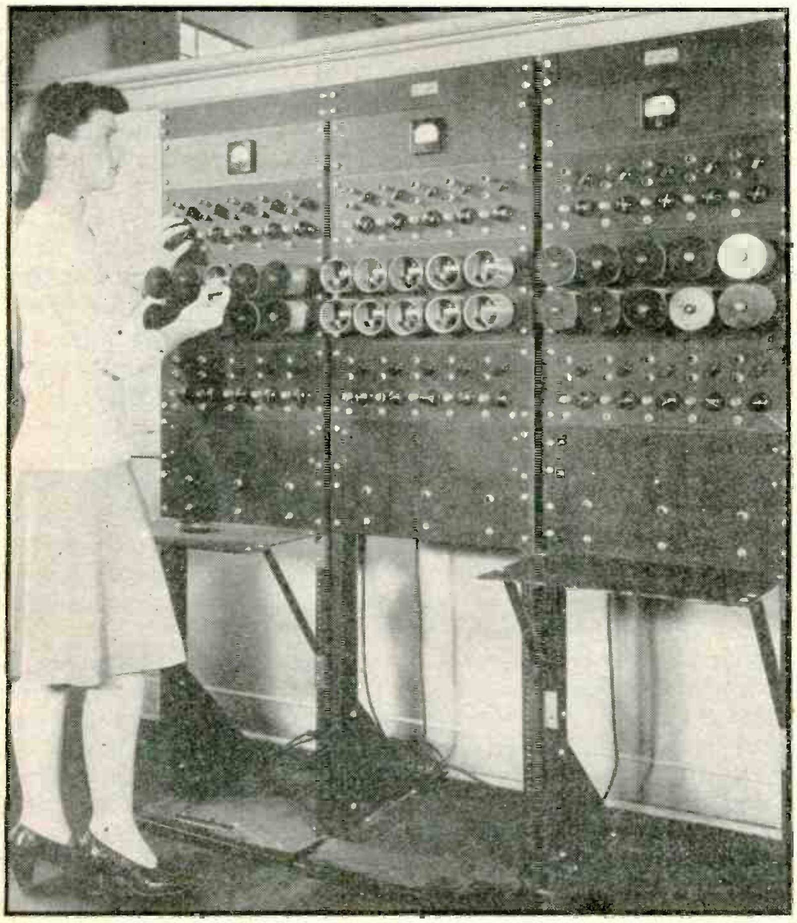
Grinding blanks follows an inspection for defects. Several dozen blanks can often be mounted in a single holder and ground simultaneously, insuring flat and parallel surfaces. Frequent checks of thickness with a micrometer are essential, for the thickness is now brought to within 1/10,000 inch of its final value.

Final grinding and testing generally requires the more delicate touch of a woman's hand, for now dimensions are forgotten and the crystal is brought to its final desired frequency by alternate lapping and measurement of its frequency. This measurement is performed by inserting the carefully washed crystal slab in a holder, plugging the holder into a crystal oscillator circuit, and noting whether or not the oscillator has reached the desired frequency.

Performance tests extending over the entire range from 70 deg. below zero to 120 deg. above zero Fahrenheit are made in tiny individual ovens on racks, permit simultaneous tests of many crystals.

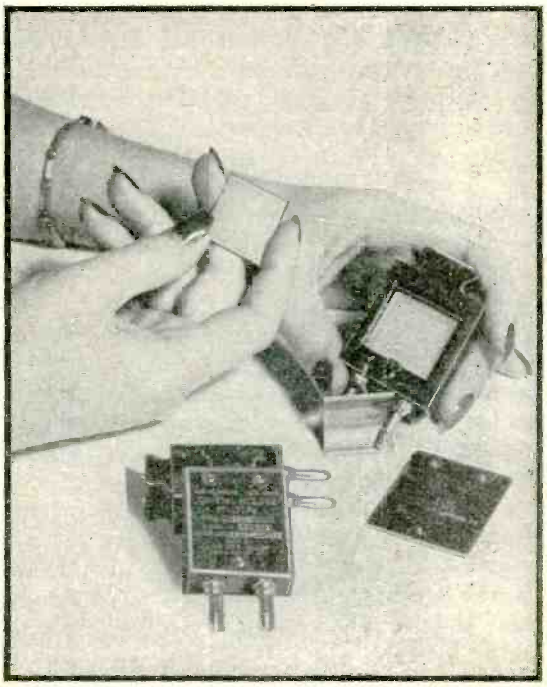
Finished crystal units are mounted in carefully designed holders that generally have plug-in terminals to which the electrodes on each side of the crystal slab are connected.

FINAL GRINDING & TESTING



← PERFORMANCE TESTS

FINISHED CRYSTAL UNITS

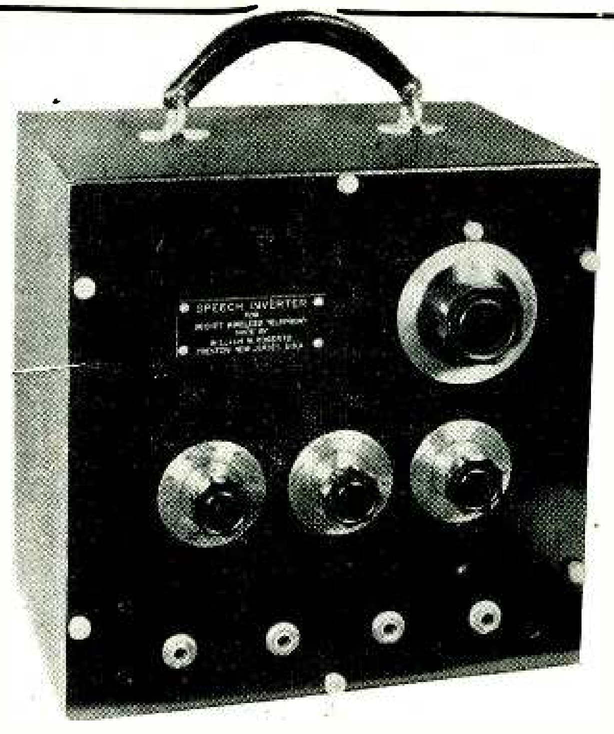


SPEECH

Complete data on a frequency-inverter circuit that scientifically scrambles a human voice for purposes of secrecy in transmission. The same circuit may be used for unscrambling speech at the receiver. Five band-splitting methods that combine with inversion to insure even greater privacy are also taken up

By **WILLIAM W. ROBERTS**

Sperry Gyroscope Co. Brooklyn, N. Y.



Front view of speech inverter for which complete circuit is given in Fig. 2. Upper dial controls inverting frequency. Two input jacks permit use with two receivers to hear both sides of a scrambled radio-phone conversation

IT HAS LONG been recognized that there are times when it is desirable to transmit the human voice over a telephone line or radio telephone circuit in such a form as to be absolutely unintelligible to unauthorized listeners.

Several different methods which have been employed to attain privacy for the spoken word on communication channels will be described. (The war has greatly stimulated progress in this phase of communications and many new systems have recently been developed. The details of these cannot, however, be disclosed at this time due to the dictates of military secrecy.)

In communication over ordinary telephone circuits, the instantaneous amplitudes and frequencies of the electric waves transmitted correspond to the instantaneous amplitudes and frequencies of the various sound-pressure waves making up articulate speech. These speech waves are intelligible only when the fundamental frequency components and their associated harmonics or overtones are transmitted so that the correct relative amplitudes and phase relationships are not too greatly changed. Therefore, any operation which alters these conditions materially will make it impossible to detect the transmitted waves as intelligible speech until the approximate correct relationships have been restored.

In straining ordinary speech through the medium of scrambling, the frequencies of each of the components of speech currents are changed in such a manner that, although the changed speech currents will occupy the same frequency range as that of the original speech, the essential relationship for intelligibility will have been destroyed.

Frequency Inversion

One of the simplest ways of scrambling the human voice is by means of frequency inversion. In this method, a device known as the speech inverter virtually turns a person's voice upsidedown, much as the lens of a camera inverts the image of an object in the field of vision. Everyday English becomes as unintelligible as a strange foreign language, with seemingly no apparent relation to the original speech. Yet this same incoherent jargon may be restored to normal by a similar process of inversion.

In creating inverted speech, normal voice frequencies are caused to modulate in a well known manner a constant audio frequency (inverting frequency) to produce frequencies which are combinations of the speech frequencies and the inverting frequency. These frequencies will include an upper and lower side-band which are, respectively, the inverting frequency plus the voice frequencies and the inverting frequency minus the voice frequencies. If the inverting frequency is just above the highest essential voice frequency, it will be obvious that the lower side-band will be an inverted picture of the original input voice frequencies, so that the low frequencies become highs, and the high frequencies become lows.

Using an inverting frequency of 3000 cycles, as is the case in most apparatus developed before the war, an input frequency of 200 cycles will become 3000 minus 200, or 2800 cycles in the difference frequency band. A 2500-cycle input would become 500 cycles, and all other input frequencies will correspondingly be

SCRAMBLING Methods

inverted. The upper side-band is representative of the original input frequencies raised up in the spectrum by the value of the inverting frequency. In actual practice of secret telephony, this upper side-band is attenuated by filters and only the inverse frequency band is used for transmission.

It is rather difficult to describe the discordant nature of inverted speech, but anyone who has listened to the confused mumble-jumble of a phonograph disk reversed will get a fair idea of the type of meaningless sounds produced. The low frequencies of speech are transformed into high-pitched squeaks, while the highs and over-tones present in the voice produce a succession of low gutteral noises.

On listening to certain words spoken through the inverter, it is possible in some instances to pronounce them. For example, the words "telephone company" when translated by an inverter sound something like "playafiend crinkanope".

The inversion of music results in a jangling of tones which are particularly amusing. This process will mutilate the most beautiful symphony so that it is completely lacking in structure and composition. Increasing-pitch notes of music become decreasing-pitch notes in the inverse frequency band and vice versa.

Inverted speech has long been employed on the trans-oceanic telephone circuits to provide a limited amount of privacy against eavesdropping by short-wave radio listeners. For a higher degree of secrecy on some of the more important telephone links carrying diplomatic calls and such, a form of garbling more commonly known as band-splitting has been employed.

Speech Inverter Circuit Theory

Figure 1 illustrates a fundamental circuit for one type of speech inverter. The same circuit is applicable for both scrambling and unscrambling. It is essentially a Hartley balanced modulator or demodulator in which a pair of triodes are connected to produce certain frequencies and to suppress certain other frequencies.

The term f_v is representative of voice currents, as from an ordinary telephone set, and represents a band extending from 200 to 3000 cycles, which is considered adequate for good communication, measured in terms of satisfaction given to telephone subscribers. The term f_c indicates a sustained high-frequency carrier or inverting frequency. The impedances Z_v, Z_c and Z_L indicate the voice frequency source, inverting frequency source and the output line impedance, respectively.

Since the inverted speech will occupy the same frequency range as

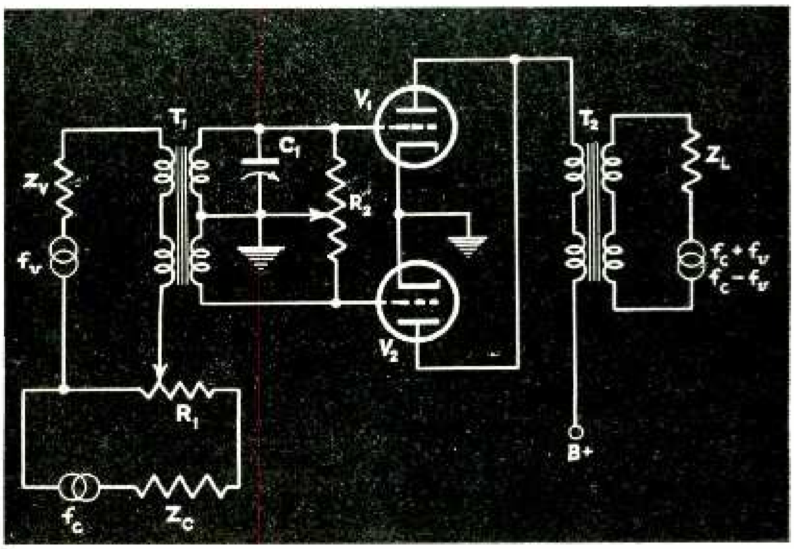
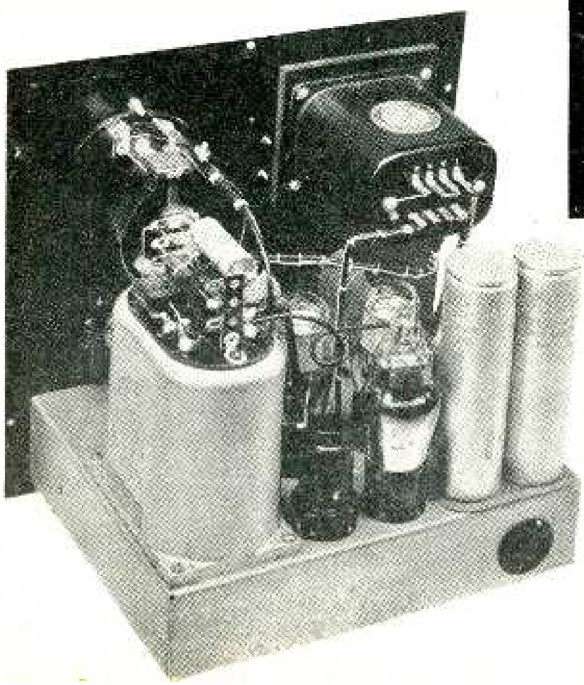


FIG. 1—Fundamental circuit of balanced modulator for speech inversion



Rear view of speech inverter. Operating voltages are obtained from a separate power pack. Intelligible audio signals fed into this unit come out scrambled, while scrambled signals fed into the unit come out unscrambled

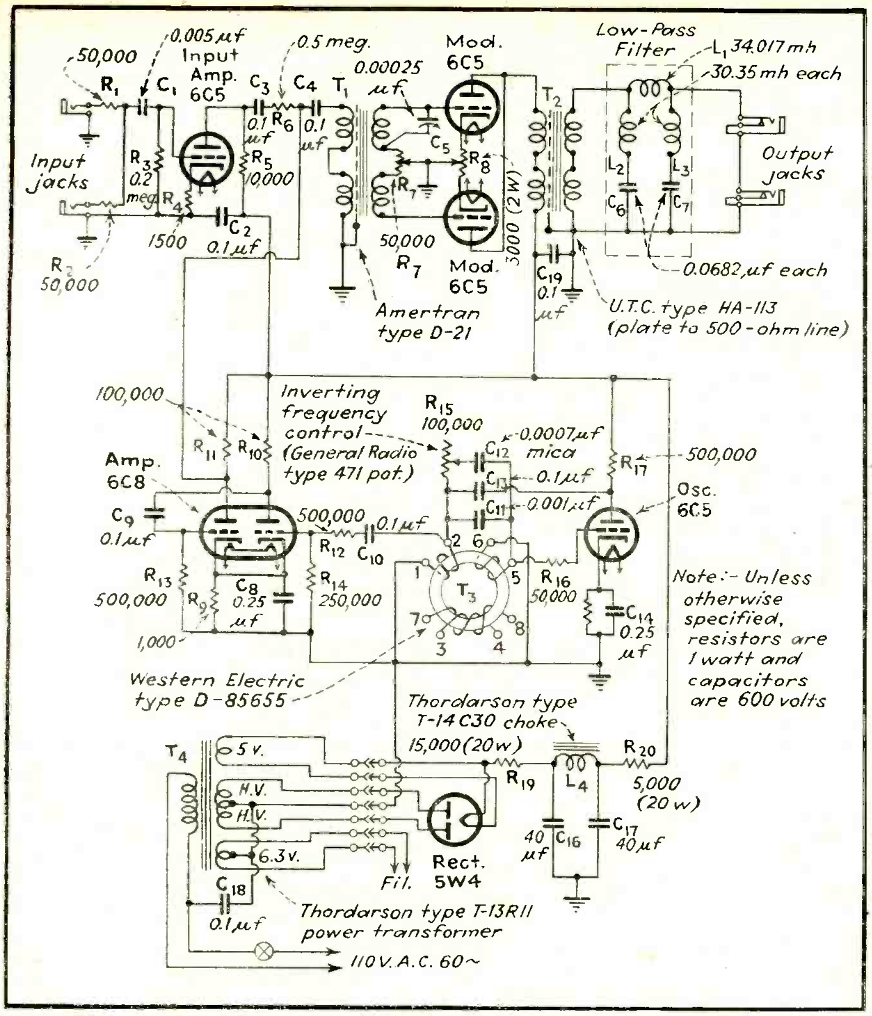


FIG. 2—Complete practical circuit for the speech inverter shown in the photographs. The inverting frequency generated by the 6C5 oscillator is controlled by R_{15}, and is about 3000 cycles with the control at its mid-position

the original speech, but in reverse order, it is essential for complete privacy that these original voice currents f_v do not appear across the output line impedance Z_L. Since the inverting frequency is near but higher than the highest essential voice frequency, it is essential that it, also, does not appear across the output impedance Z_L.

These results are secured to a high degree with the type of balanced modulator shown, producing certain frequencies which are combinations of the voice frequencies f_v and the carrier frequency f_c, but suppressing the unmodified frequencies which are the impressed waves uncombined with each other.

The frequencies produced are the upper and lower side-bands, f_c+f_v and f_c-f_v, which are respectively the inverting frequency plus the voice frequencies and the inverting frequency minus the voice frequencies. It will be seen that the upper side-band f_c+f_v is the original voice frequency band raised up in the spectrum by the value of f_c. The lower side-band f_c-f_v is an inverted version of the original voice frequencies, occupying the same position in the spectrum but in reverse order. High notes then become low notes, and lows become highs.

While the process of modulation is merely a side show in scrambling, an analysis of the interaction of currents to produce sum and difference frequencies will be interesting.

The current in the output of a three-electrode vacuum tube is assumed to be capable of representation by a power series having as an independent variable the voltage impressed upon the input circuit. That is, I_1, the output current from one such tube due to an input voltage v_1, may be completely represented by $I_1 = av_1 + bv_1^2 + cv_1^3 + \dots$ in which a, b, c, etc., are constants depending on the tube characteristics. If another tube having essentially the same constants, a, b, c, etc., be used, the output I_2 from this tube, due to a similar impressed wave, will be substantially $I_2 = av_1 + bv_1^2 + cv_1^3 + \dots$

It is found in practice that all terms in this series after the second power term bv_1^2 may be neglected for most purposes. It is also obvious that the first term, which simply represents the amplifying property of the tube without any frequency modification, plays no part in the modulation process. The property represented by the square term bv_1^2, however, is commonly made use of for effecting the modulation of one input wave by another.

Since one object of using a balanced modulator is to suppress unmodified frequencies, the two tubes are connected with respect to the unmodified waves so that the unmodified wave from one tube is neutralized by that of the other tube, as shown in Fig. 1. The unmodified frequencies are fed into the grids of V_1 and V_2 in push-pull. The plates form a parallel output circuit by means of the substantially zero reactance connection. With this arrangement the input wave v_1 impressed on one tube is reversed in sign relative to that impressed on the other, so that the two waves have a phase difference of 180 deg. and the output currents are added. This produces the result desired, as indicated in the following equation in which the relatively unimportant higher power terms are neglected.

$$I_1 = av_1 + bv_1^2$$
$$I_2 = -av_1 + bv_1^2$$
$$I_1 + I_2 = 2bv_1^2$$

The completeness of this action is dependent, however, upon the tubes being identical as to the properties represented by the constants a and b in the equation, and it is also dependent upon the current I_1 being completely added to the current I_2. The addition of the two output currents represents in part really the cancellation of the undesired component represented by the first power term av_1; therefore, if the current I_1 from the first tube is exactly equal to I_2 but if the adding function does not completely involve both I_1 and I_2, there will be a residue of the component av_1 appearing across output transformer T_2.

Across the secondary of T_1 is a variable resistance R_2, with the adjustable contact going to the common ground or cathode connection. A variable capacitor C_1 is connected in shunt with one half of the secondary winding. The purpose of this is to compensate for any inequalities in the two halves of the secondary winding and to secure a symmetrical balance of the two sides of the circuit with respect to ground.

The two tubes V_1 and V_2 should be carefully selected to have as far as possible identical characteristics. This is important, as has already been pointed out in connection with the above equations.

Potentiometer R_1 is for adjustment of the amplitude of the inverting frequency f_o, which must be large in comparison with the f_n input voltage.

In actual practice there would be included a suitable wave filter connected to impedance Z_L for selecting the inverted side-band.

Complete Speech Inverter Circuit

Figure 2 shows a complete schematic of the speech inverter shown in the photographs. The unit is complete with power supply and a low-pass *m*-derived filter. Two high-impedance input circuits are provided so the unit can be used in conjunction with two short-wave receivers for unscrambling trans-oceanic telephone conversations. Two receivers are necessary if one wishes to hear both sides of a conversation.

The output impedance is 500 ohms looking directly out of the low-pass filter. The two output jacks permit using two pairs of 250-ohm impedance headphones connected in series.

The 6C5 input amplifier is really a mixer stage to couple the outputs of two radio receivers to the modulator input transformer T_1. This transformer plays an important role in the circuit and should be carefully chosen. The Amertran Type D-21 was found to be satisfactory. It can be seen mounted near the top of the panel in the rear-view photograph.

In brief, to supply the grids of the two modulators with voltage at different frequencies that are exactly 180 deg. out of phase and of equal amplitude is an ideal condition but is difficult to attain in practice. A perfect balance obtained for one frequency will not be a perfect balance at another frequency.

The transformer used for T_1 must have low distributed capacitance and low capacitance between windings, and the center tap on the secondary cannot be taken from within a winding. Two leads must be brought out from separate sections of coils to provide magnetic and inductive balance.

Since we cannot have an ideal transformer, the controls R_7 and C_5 are provided to compensate for any inequalities present. The function of R_8 is to provide for balancing the plate currents of the two 6C5 modulators. All these controls are used to balance out of the output circuit the incoming speech waves and the inverting frequency from the 6C5 oscillator. They can be seen as the three small knobs across the bottom in the front-view photograph. Preliminary balancing can be aided by careful selection of the two 6C5 modulators and by interchanging them during the process of balancing. The half of the secondary across which capacitor C_5 must be shunted can only be determined by experiment.

Transformer T_2 is a standard plate-to-line transformer, and any good make will serve the purpose.

The low-pass filter is of the *m*-derived type to provide for suppression of the upper side-band produced by modulation. The filter is calculated with the following characteristics: $f_c = 2810$; $f_\infty = 3620$; $R_o = 477$; $m = 0.63$.

The construction of the filter should be undertaken with the following points in mind. It is essential that the a-c resistances of the various coils be kept as low as possible if sharp discrimination between the unwanted frequencies and the pass frequencies is to be obtained. Honeycomb coils may be used for the inductances since the values in this case are not very high. Choose coils of greater inductance than the values given, and remove turns while checking with an inductance bridge, until the desired value is obtained.

The capacitors can be a paper dielectric type because of the relatively low frequencies involved. The odd values given for C_6 and C_7 can be stacked up from a number of standard capacitors in parallel to provide the correct capacitance.

The inductances should be treated with wax or other moisture-resisting material. The individual inductances should be shielded from each other or spaced by their own diameter and placed alternately at right angles.

The 6C8 amplifier is perfectly straightforward and is for amplification of the inverting frequency

(*Continued on page 270*)

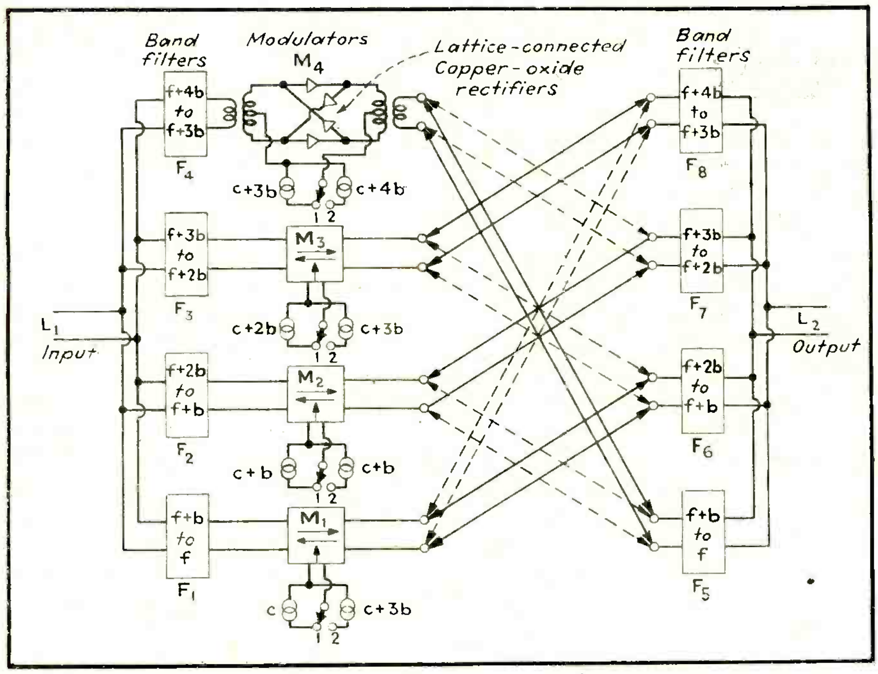
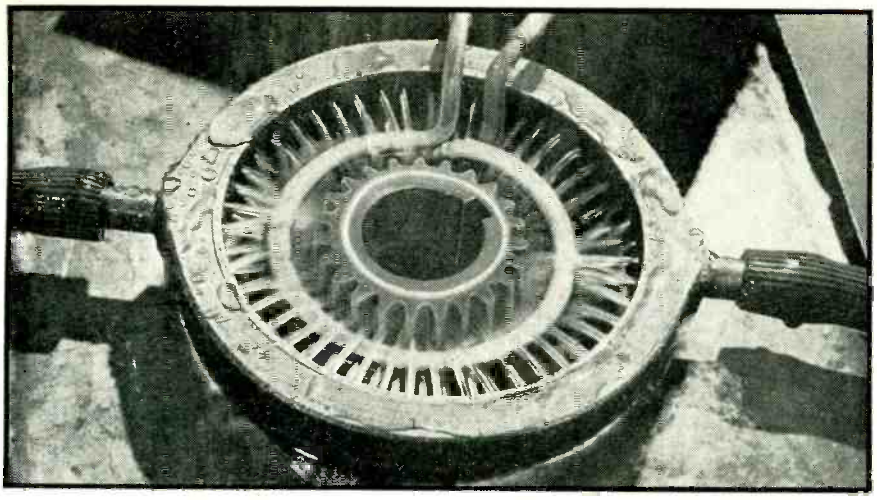
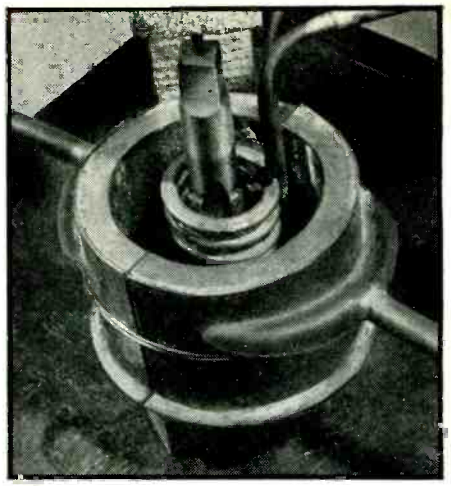


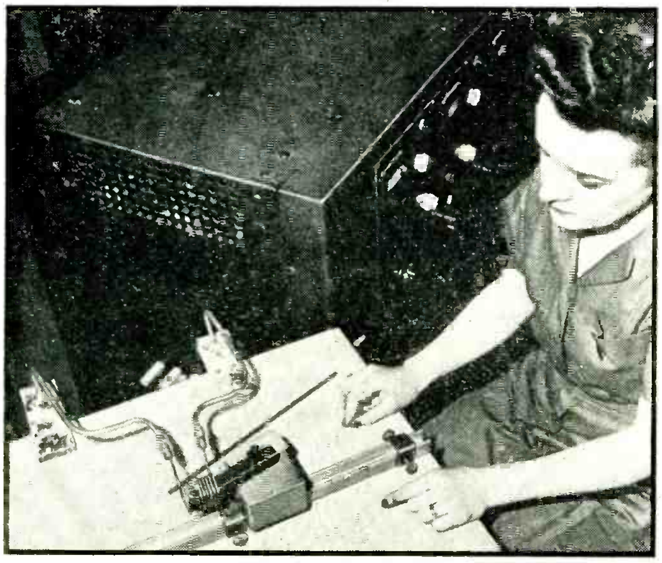
FIG. 3—Basic band-splitting arrangement for increased privacy in radiophone communication. The band filters divide essential voice frequencies into four equal bands of width b, with f being the lowest essential voice frequency. Two oscillator frequencies are available for each copper-oxide modulator to provide speech inversion. The output of each modulator may be fed to either of two filters, one passing the upper and the other the lower sideband, thus providing many possible arrangements



Quick quenching after heating, with a minimum of handling, is achieved by surrounding a work coil with a water-spray quenching ring. The turns of the coil are flattened to permit passage of water between them to get more turns in the available space



Arrangement for hardening a tap by heating only the cutting surfaces, then quenching immediately with a water spray ring



Brazing a cemented carbide tip on a steel shank with Carboloy-General Electric induction heating equipment using a 500-kc vacuum tube oscillator with a water-cooled work coil. The sliding jig positions the tool correctly inside the coil

WORK COILS for High-Frequency Heating

THE LOAD INDUCTOR or work coil of a high-frequency heating unit generally consists of a few turns of copper tubing shaped to fit around or inside the object to be heated. Water is usually forced through the tubing for cooling purposes since the coils carry heavy r-f currents and would otherwise become quite hot in continuous use. The tubing is often flattened in order to secure the desired number of turns within the dimensions of smaller objects.

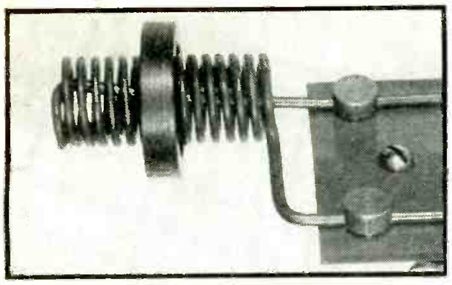
Each new shape of object to be heated generally requires a special coil. Plant engineers are discovering, however, that their own skilled mechanics are capable of making these coils after a bit of practice in handling copper tubing. When coils are made up right in the plant as needed, instead of being ordered from the manufacturer of the heating unit, days or even weeks of time can be saved.

The design of a work coil is to a great extent a combination of experimentation and experience with previous coils. The examples shown in this article, made by engineers at Lepel High Frequency Laboratories of New York City except for the brazing coils credited to Carboloy-GE, will serve as guides in winding coils for similar applications.

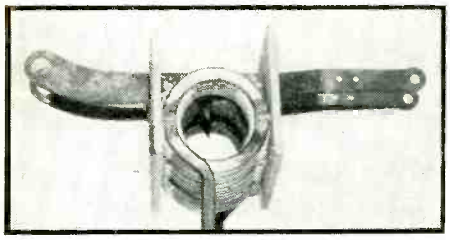
The size of tubing to be used is governed chiefly by the mechanical strength required. Small-diameter tubing is more easily formed, and is generally satisfactory when the coil will not have to support the article being heated. The coil shape need conform closely to that of the object being heated only when it is essential to utilize the full heating potentialities of the power source, as for heating large objects or for securing a desired temperature in the shortest possible time.

Applications

The general run of industrial work which can be handled with electromagnetic high-frequency heating equipment comes under three headings: Hardening and annealing; brazing and soldering; melting.



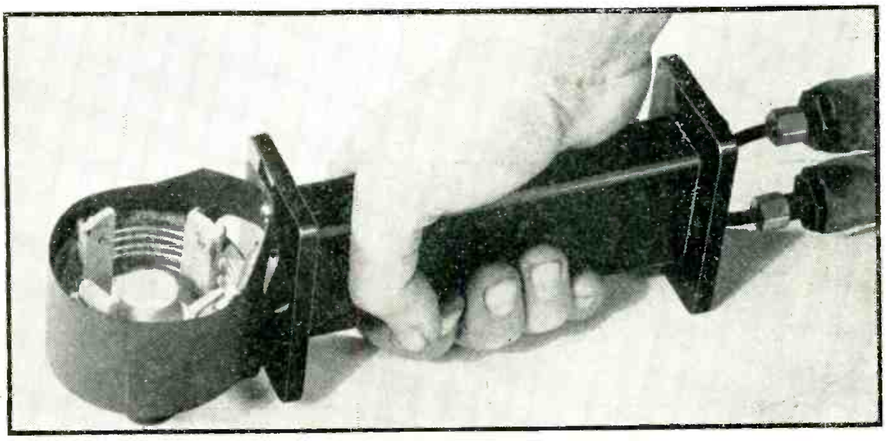
Work coil used for localized heating of the inside of a steel ring



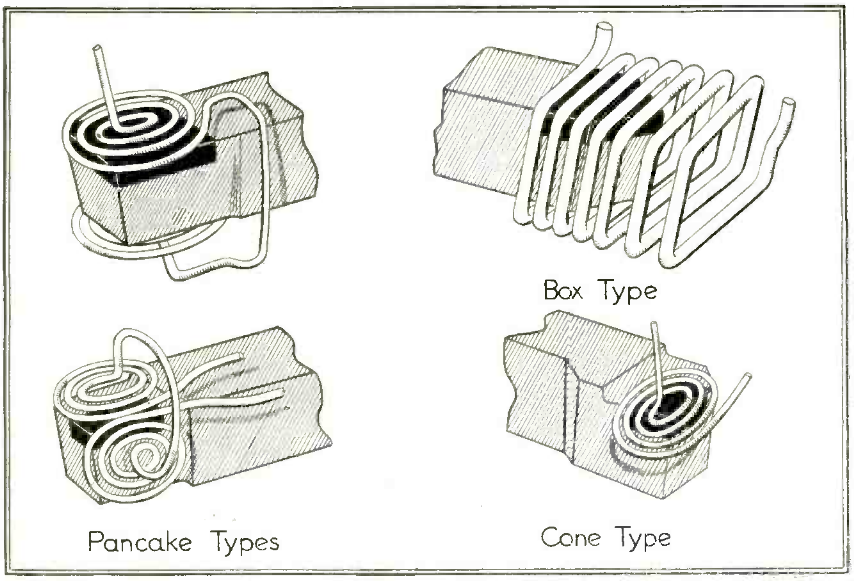
Arrangement for localized heating and hardening of the wearing points of trip levers. The heat is limited to the sections which project inside the work coil

With the work coil, quenching barrel and stock box conveniently positioned in front of the operator, localized hardening is achieved efficiently with no excess heat to create discomfort. The spark gap type heating unit being used here is made by Lepel High Frequency Laboratories, New York City

Past experience generally governs the winding of work coils which transfer r-f energy from high-frequency equipment to the object being heated. The examples given here will serve as practical guides



A plastic handle and flexible connecting leads (conductive tubing) make this work coil as convenient as a soldering iron, particularly for soldering or brazing operations on a moving conveyor. The coil is held around each object in turn until the solder or brazing alloy melts

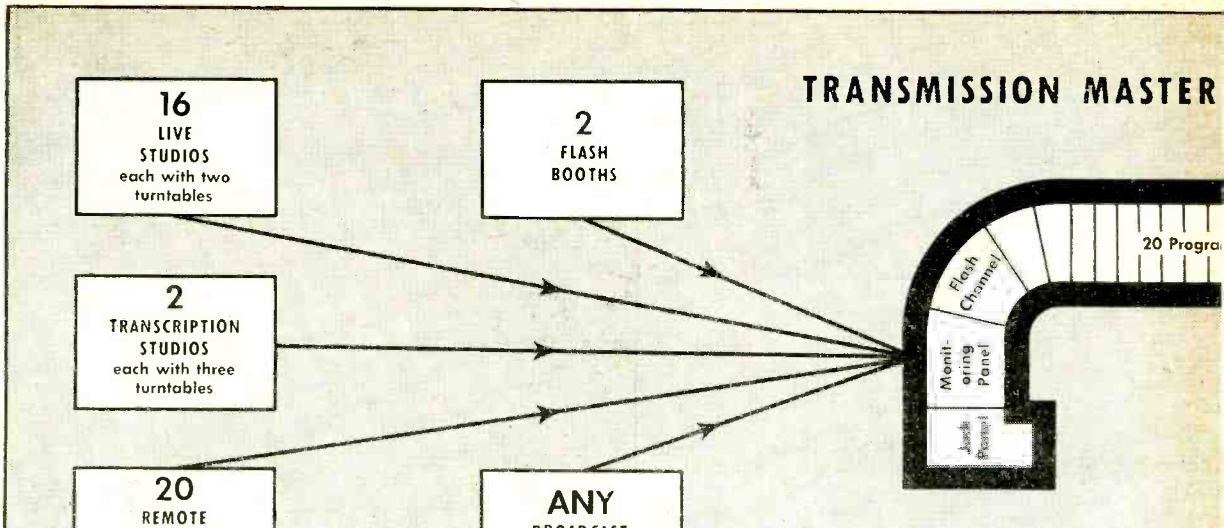


Typical Carboloy-GE work coil arrangements used in induction brazing of carbide cutting tools. When many tools are to be brazed and the heating unit has suffic capacity, several coils can be used in series to braze two or more tools at a time. The small-diameter copper tubing is easily bent to the required shape

Heating for the purpose of hardening or annealing can be produced uniformly throughout an object without too much attention to coil shape or dimensions. The frequency is likewise not critical, and can be as low as 10,000 cycles in some cases.

Surface heating is generally obtained with higher frequencies, so as to utilize more pronounced skin effects. To heat an outside surface, the coil is placed around the object. The inside surface of a hollow or ring-shaped object is heated simply by placing the work coil inside the object. Localized heating can be obtained by shaping the work coil to

(*Continued on page* 299)



Over-all picture of the program and transmission facilities handled through the master control desk. Up to 20 of the inputs

U. S. Short-Wave Broadcast

New Office of War Information radio headquarters equipment in New York City can handle 20 different programs simultaneously, dispatching them to as many as 40 short-wave transmitters. All programs are automatically recorded, some for re-broadcast

WHEN the Office of War Information decided last year to lease every short-wave broadcast transmitter in the United States and feed all except a few West Coast stations with programs passing through a single OWI master control center located in New York City, a multitude of extremely complex switching and control problems was thereby created.

The main goals in designing the technical equipment for this control center were completely flexible provisions for handling up to 20 different programs simultaneously from local or outside points, switching these programs in every conceivable manner to up to 40 different transmitters within a few seconds during station-break intervals, recording every program continuously for reference, recording some programs for later rebroadcast, and monitoring of all programs by censors. The final solution that attains all these goals and many more besides, involved the design and construction of a single master control desk having more program transmission facilities than perhaps any other control desk in the world.

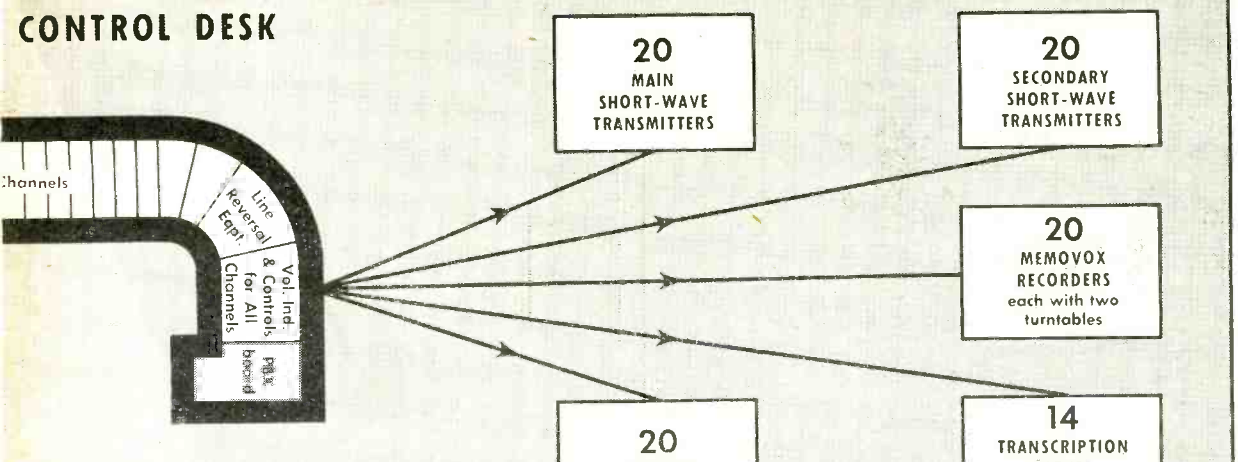
The completed master control desk will have 20 complete and individual channels, capable of handling 20 different programs simultaneously. Programs can originate in 16 new OWI broadcasting studios in the same building as the master control, in two special rooms for transcription broadcasts, in two "flash booths" for special announcements broken into programs, in other radio broadcasting studios in New York City and vicinity, or at any of 20 main short-wave transmitters served by this master control center. A total of 40 different program lines will be brought to the input terminals of the master control desk.

Each of the 20 channels on the control desk is assigned to a particular main transmitter. Up to 20 additional transmitters, called secondary transmitters, can also be served with any of the programs being fed to the main transmitters, but secondary transmitters cannot be fed directly by a control desk channel.

All equipment in program lines going to the 20 main transmitters

Temporary master patch board being used for switching all OWI short-wave programs pending completion of the master control desk, after which this board will be used only in emergencies. As many as a dozen different programs are passing through this board simultaneously under temporary operating conditions, necessitating carefully prepared switching charts for each quarter hour

CONTROL DESK



shown at the left of the desk can be handled at one time, and the desk can feed any or all of the outputs shown.

CONTROL CENTER

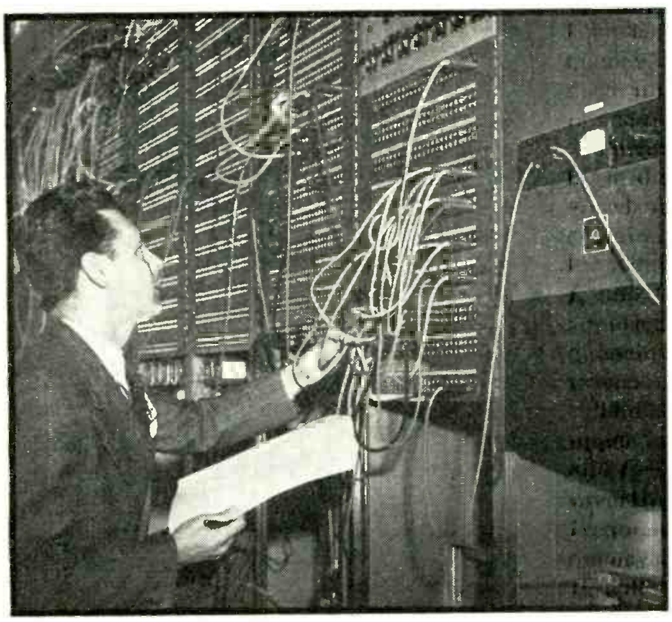
can be reversed from the control desk by means of controls on the line reversal equipment panel, to permit feeding programs over these lines in the opposite direction when desired (from a main transmitter into the control desk).

Transmission Master Control Desk

Each channel on the master control desk contains a total of 47 relays. These switch the channel input to any one of the available program sources, switch the channel output to any number of paralleled transmitter lines up to 20 that are taking the program of the channel, and provide other necessary switching functions. These relays are the recently developed Western Electric type U, capable of handling up to 13 pairs of contacts in a variety of arrangements.

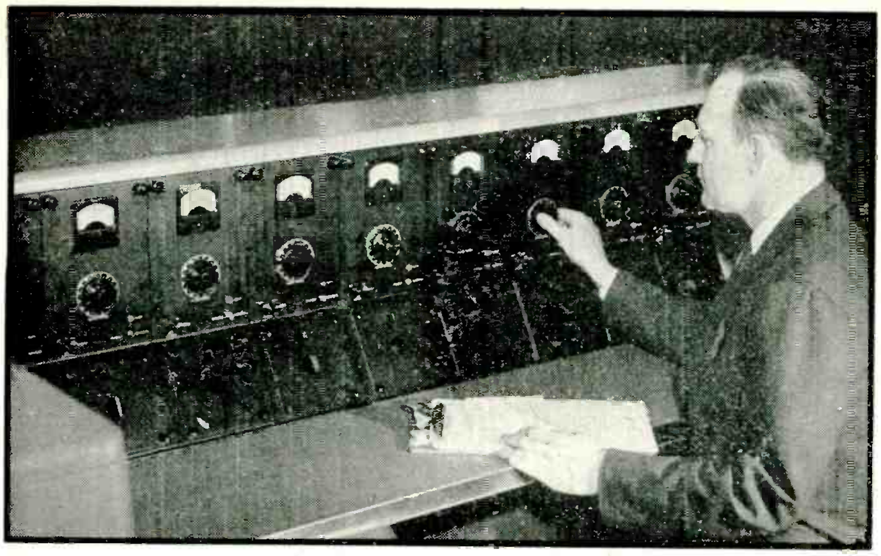
All relays and controls can be preset, so that all 20 channels can be switched simultaneously to an entirely new set-up of program sources and transmitter arrangements within a few seconds on the quarter hour, half hour or hour. There are 61 indicating lights per channel on the master control board to show pre-set and on-air connections.

Additional switching is accomplished with 25 type 479 Western Electric 3-position keys per channel

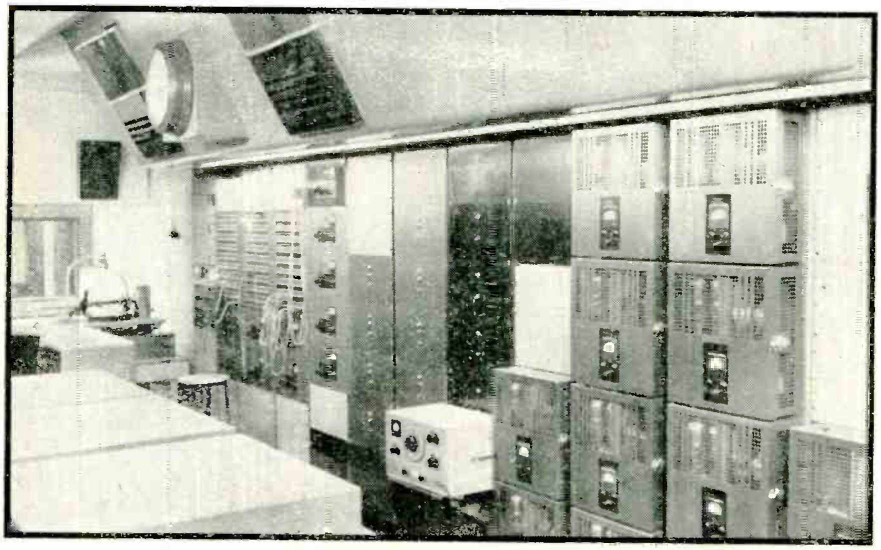


EQUIPMENT SUMMARY

- 10,000 W.E.Co. type 218-A jacks
- 1000 W.E.Co. type U relays
- 350 W.E.Co. standard relays
- 80 RCA type 85X isolation amplifiers
- 60 RCA type 83D line amplifiers
- 56 RCA type 12236 cue amplifiers
- 46 W.E.Co. type 104-B preamplifiers
- 44 RCA type 70-C transcription turntables
- 40 Memovox recording amplifiers
- 24 W.E.Co. type 118 amplifiers
- 20 W.E.Co. type 105 program amplifiers
- 16 modified W.E.Co. 23-C studio amplifiers
- 14 W.E.Co. type 1087 power amplifiers
- 14 RCA type 73A recording lathes
- 4 W.E.Co. type 1126 compressing amplifiers



Recording control desk, at which the recording supervisor can take as many as 14 different programs from transmission master control and dispatch them to transcription recording lathes



Amplifier bank and jack panels serving the transcription recording lathes

View of recording room, showing recording lathes used to produce high-fidelity transcriptions of programs for future rebroadcasting. Each lathe is rubber-mounted on a 700-lb block of concrete

and with an 8-pole, 25-point rotary switch that makes a selection of a program from one of 20 possible sources, feeds interlocked battery voltage to the studios to operate their relays, feeds interlocked battery voltage to section interlocking relays. and feeds automatic program cues to the studio to which the channel has been pre-set. Each channel has a volume control for use when necessary in changing the input level from a program line, and each channel has a volume indicating meter that can be set to any of three lines for level checking, but these facilities are primarily for checking purposes, not for riding gain.

Also on the master control desk is a separate flash channel, so arranged that it can connect any or all transmitters instantly to one of the two flash studios next to the master control room without disturbing channel settings at the master control desk. Normal conditions are completely restored after the flash announcement. It should be pointed out, however, that any announcement of this nature must first be cleared through Washington censorship, and hence does not correspond to the flash news announcements of broadcast stations.

A monitor panel on master control serves three RCA type 64B loudspeakers mounted on the wall facing the control operators. Rotary switches connect two of the loudspeakers to any of 80 different program circuit positions in the building. The third loudspeaker is connected to a Strowger dial system that provides a choice of 100 different program circuits, 20 from studios in the building, 20 from receiving lines, 40 from program channels going out to the prime and secondary transmitters, and up to 20 additional audition, receiving and other circuits.

At one side on the master control desk is a complete PBX telephone switchboard for the control operators, permitting quick communication with any point at which trouble may develop in the vast OWI broadcasting system. This is handled by the transmission operator, who also checks levels of incoming program channels, checks reversing equipment regularly, and keeps up the log containing data on master control setups to the various program sources and transmitters at each minute of the 24-hour operating day. Two operators handle ten channels each at

One of the two turntable drawers in each Memovox unit. Switching between turntables is automatic. Each turntable can emboss a one-hour program on one side of its flexible plastic disc, hence the units can run unattended for two hours at a time

Memovox recorder units, one of which is provided for each program channel on the master control desk, to obtain a reference recording of every program put on the air by OWI. The recorders start up automatically whenever a channel is energized

the control desk, and an additional man serves as control room supervisor.

Master Control Room Equipment

Along the walls of the master control room are 18 racks, containing approximately 8,000 jacks for patch cord connections, 60 RCA type 83D line amplifiers, 80 RCA type 85X isolation amplifiers, four Western Electric type 1126 compressing amplifiers to reduce level peaks that are particularly predominant in certain foreign-language broadcasts, four Western Electric type 118 monitoring amplifiers, and two recording volume indicators with associated amplifying and rectifying equipment for spot monitoring of levels to check the work of studio operators and to place any desired circuit under observation.

One of the transcription recording rooms. It can handle three transcribed programs simultaneously with only a single operator. Electromagnetic brakes hold each transcription stationary with the pickup in the selected position, with the turntable rotating continuously and the record slipping, so the operator can start all three programs at the same time by releasing the brakes

One cabinet contains the Strowger assembly for the entire system, including 36 100-position 2-motion relays with associated control relays for the 36 Strowger dial stations placed at strategic points throughout the building. At each dial station, the program at any of 100 different points in the building may be selected and fed to a monitoring loudspeaker.

Each of the censors that check the programs continually in the building has an indicating light on the master control desk corresponding to the channel he is checking. When this light comes on, the control operator knows that the censor considers a program objectionable, and takes it off the air until the censor's light goes out to indicate that the program is clear again.

All in all, the operators at the master control desk have a total of over 1500 indicating lamps and 20 meters to watch while listening to three loudspeakers that may be blaring forth in three different languages simultaneously.

Studio Facilities

Each of the 16 new OWI studios in the building has its own control room, containing a Western Electric type 23C program amplifier modified for master control interlocked switching and with the number of channels increased from five up to seven to permit studio-to-studio cross-feed and give two turntable channels. The modified amplifier therefore has five low-level channels and two-high-level channels, and permits a choice of three cross-feed channels when programs from more than one studio are to be mixed together on a single program. The control room amplifiers have complete test channels, permitting cue testing of other channels while one channel of the amplifier is on the air.

(*Continued on page* 301)

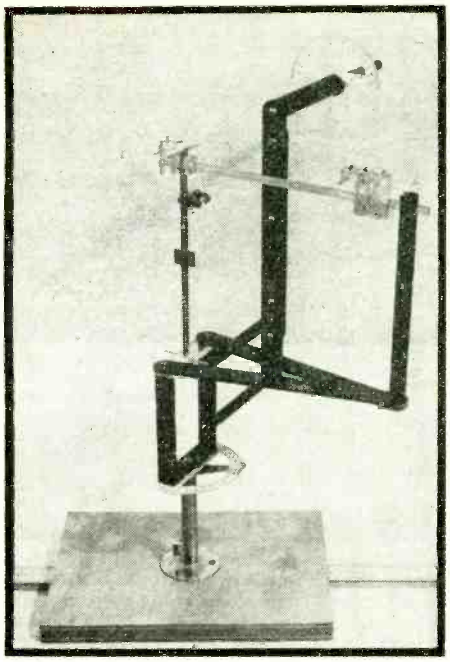


FIG. 10—Bakelite frame for receiving antenna with receiving dipole and reflectors mounted. Protractors indicate angles of orientation of antennas

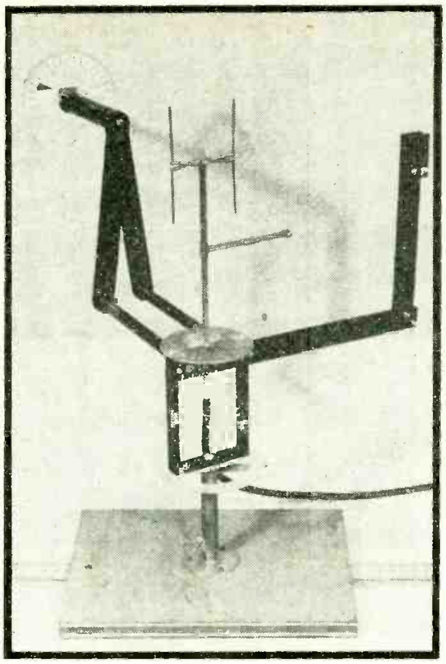


FIG. 11—Frame for transmitting antenna with two-element collinear double end-fire array in position. Note sliding stub between antenna and base plate

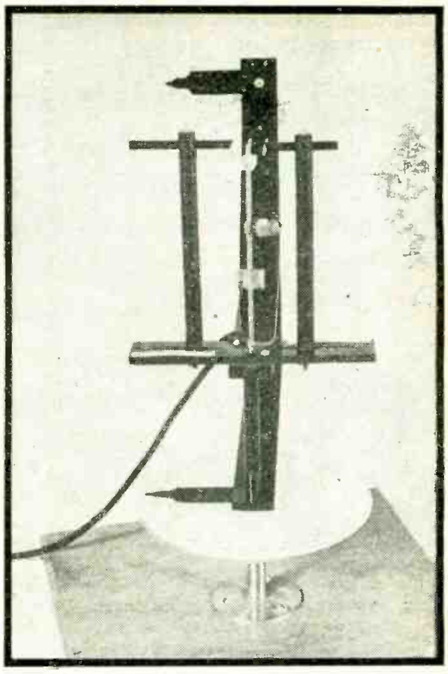


FIG. 12—Receiving antenna with movable director and reflector. The antenna may be mounted horizontally, as shown in this photo, or vertically

PART 2

MICROWAVE PLUMBING

Microwave antennas, easily constructed and used in the laboratory, simplify studies of radiation and propagation. Effects produced at longer waves can be ascertained by treating microwave antennas as models

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THE operating mechanism of an antenna and its distant field furnish two more or less distinct topics for study. In order to investigate the distant field patterns of antennas, one should be in the radiation zone (several wavelengths away) with the receiving unit. A wavelength of 10 cm is therefore used to permit the measurements to be taken in laboratory and lecture rooms of normal size. Pipes and other large metal objects along the walls of the rooms give very little interference at this wavelength.

On the other hand, investigation of the current distribution along an antenna and associated feeders is more feasible at the longer wavelength of say one meter. It may well be worthwhile to duplicate the same antenna system for the two applications.

Receiving Antenna Frame

The universal holding frames of Figs. 10 and 11 are designed for use at a wavelength of 10 cm. Two support posts and scales are mounted on each frame. Vertical and horizontal field patterns may be taken by inserting one or the other of the two posts in the base. The transmitting and receiving assemblies are arranged to slide along a common track to give accurate alignment and separation.

The receiving frame (Fig. 10) contains a section of parallel line at the bottom of which the microammeter leads are attached. The crystal holder and shorting capacitor may be moved along the line to match the load. The top is threaded to take the desired fixed or adjustable antenna rods. In the illustration a polystyrene block has been fitted

Editor's note: Part 1 of this article, dealing with transmission lines and wave guides, appeared in the Sept. 1943 issue of ELECTRONICS.

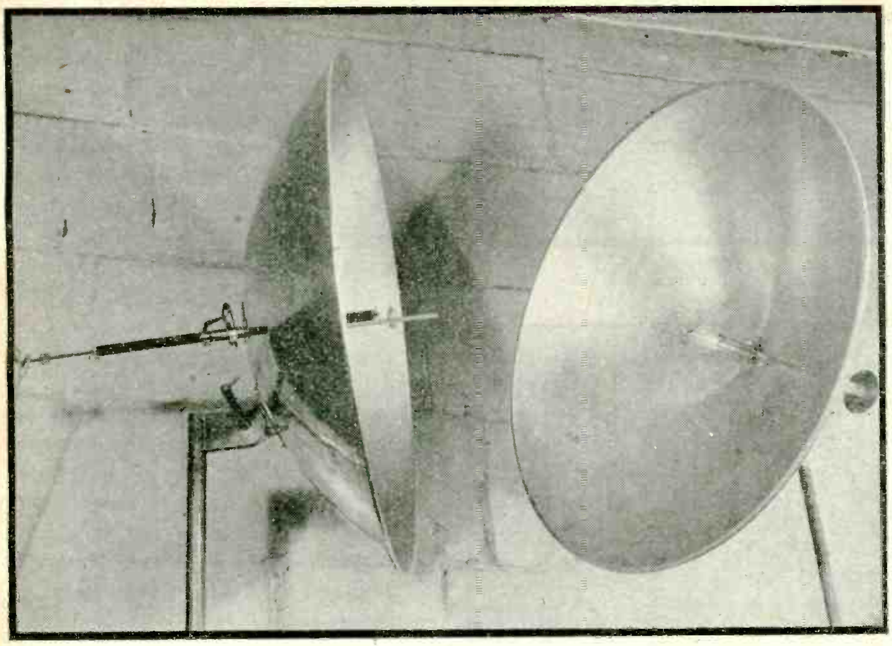


FIG. 13—Paraboloidal reflectors of spun aluminum. Receiving unit, at left, has crystal and capacitor at extreme left. Coaxial line mounting disk is shown at extreme right of transmitting unit. Both antennas use reflector elements to eliminate forward radiation directly from the antenna, so all radiation will be from reflectors

over the line to support a frame for parasitic antennas. Rods of adjustable length may be inserted in the polystyrene holders which, in turn, can slide along the supporting rod. The photograph of Fig. 10 shows a quarter-wave dipole and single director in place; a few reflector frames, one with its reflector element, are pushed back to minimize their effect.

Transmitting Antenna Frames

The transmitting frame in Fig. 11 is of similar construction. A coaxial feeder is attached to the circular base plate of the parallel section. This brass disk acts as a detuning device to prevent unbalanced currents from flowing on the outside of the feeder. Further mention of this effect will be made later. A sliding adjustable stub is provided for matching, and the top of the line is again threaded to take the antenna rods.

Aside from simple antennas which may be mounted with or without parasites as in the receiving frame, a number of special arrays have been constructed. The one shown is a two-element collinear (full-wave) double end-fire (lazy H) array. Rearranging the curved rods to eliminate the cross-over gives the same type broadside array. Multi-element collinear, single end-fire, and other arrays, as well as loops and parabolic reflectors may be mounted in the frame. The lengths of the driven units are critical in these arrays and must be calculated in advance for good performance.[1]

An alternative design for the mounting frame is shown in Fig. 12. The single director and reflector may be moved more readily and are equipped with scales to locate their positions at each setting. The usual crystal and capacitor are mounted on the supporting line of the central (receiving) antenna.

Parabolic Reflectors

Paraboloidal reflectors such as were used in microwave transmission across the English Channel some ten years ago have also been used with success at the 10-cm wavelength. The spun aluminum units in Fig. 13

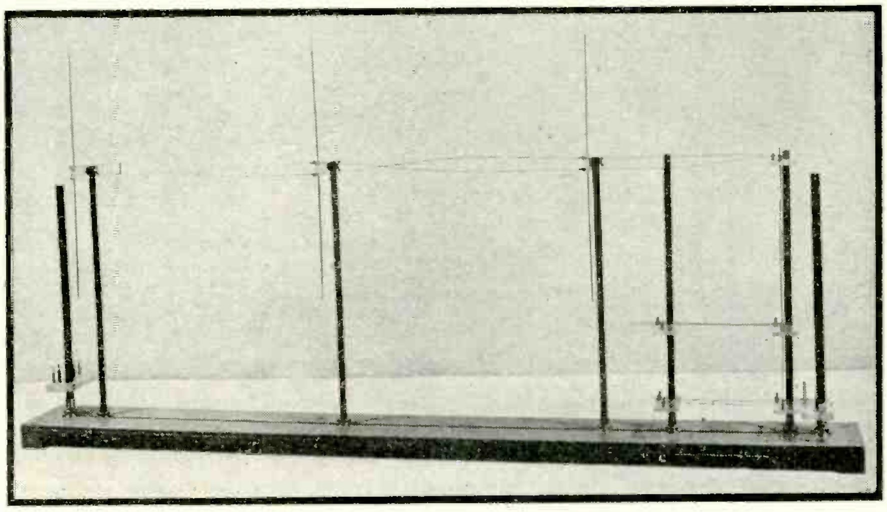
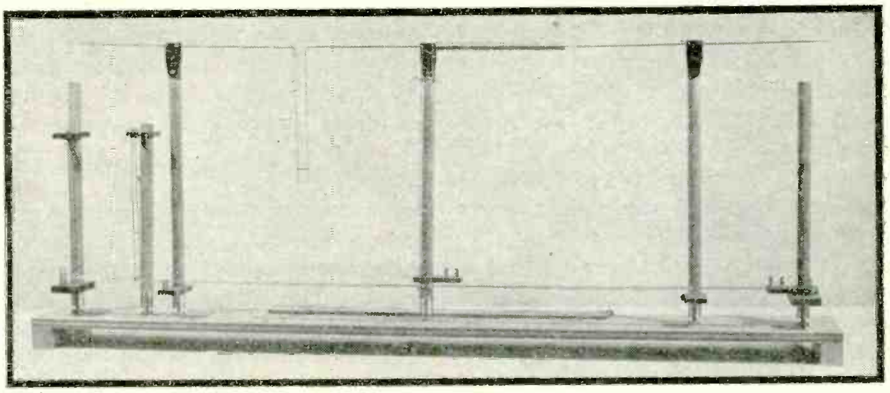


FIG. 14—Three-element broadside antenna array. Antenna length can be adjusted by telescoping brass tube sections of which antennas are made. Proper phase relations are obtained by transposed feeder

FIG. 15—Three-element collinear antenna array, showing two types of phase-reversing devices



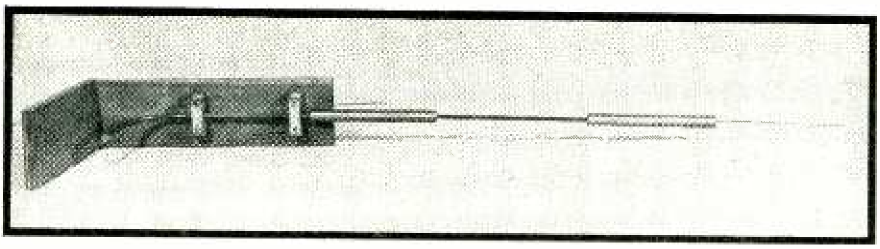


FIG. 16—Three-element collinear antenna with coaxial feed

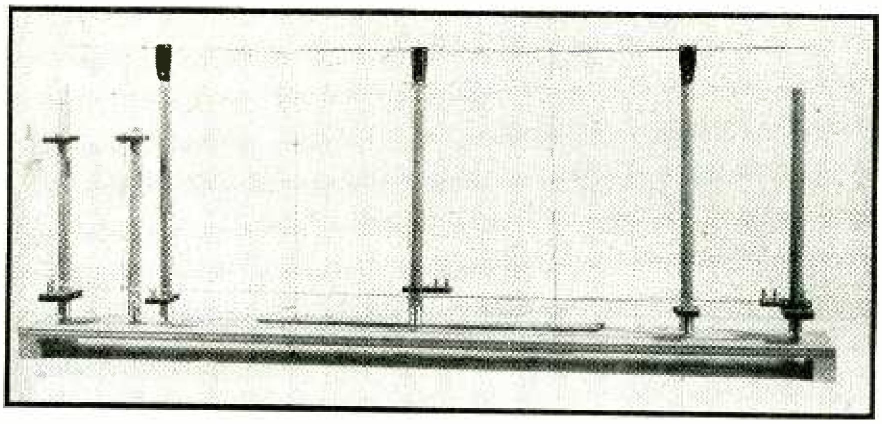


FIG. 17—Coupled antenna constructed from same elements used to build up antenna of Fig. 15. The half-wave section resonates as a whole

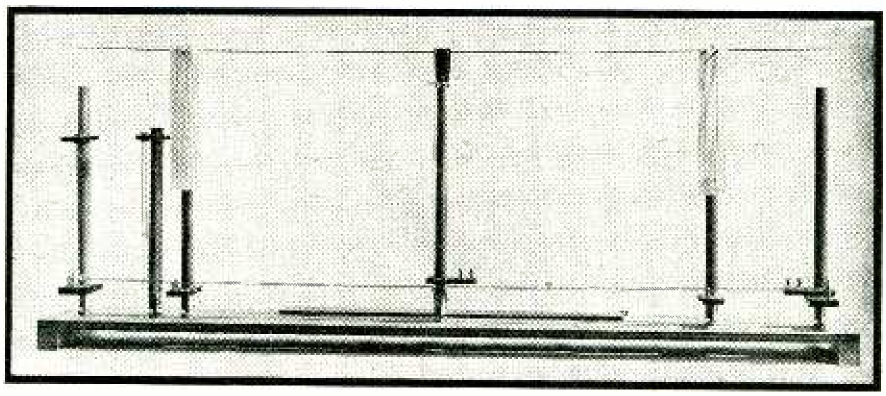


FIG. 18—Coupled antenna, with open quarter-wave stub at left and closed stub at right for detuning

are mounted on heavy tripods whose center column may be rotated to permit directivity measurements.

The antenna support shown consists of a dielectric rod pierced by a parallel line. The cross-section is shaped like two slightly overlapping circles, with the feeder rods at the points of intersection. A spacing of 1 mm in polystyrene gives a characteristic resistance of some 80 ohms for the feeder line, which has ⅛-inch conductors. This low value of characteristic resistance provides a matched load for the coaxial cable from the generator.

The closely spaced parallel line is perfectly suited for coupling to a center fed antenna and gives a symmetrical pattern, which the alternative coaxial mounting on the antenna in Fig. 9 does not. The whole assembly can slide back and forth through a hole at the vertex of the paraboloid.

In the receiving unit (left in Fig. 13) the antenna assembly may be rotated on its axis as well. A single reflector is used in front of each antenna to eliminate direct radiation; crystal and capacitor are visible at the extreme left, and the coaxial line mounting disk is at the right.

Arrays for 1-m Wavelength

The longer wavelength arrays present a somewhat different appearance. The mountings are arranged to permit tilting of the upper insulating support as well as rotation and sliding back and forth of the posts. The feeder line is equipped with double stubs for accurate matching of the load to the generator, which is essential for adequate power transfer. A three-element broadside array with transposed feeder to give proper phase relations is illustrated in Fig. 14; the antennas are adjustable in length.

A three-element collinear array in Fig. 15 is connected unsymmetrically to show two phase-reversing devices. In practice only one type would be used. The left side uses a quarter-wave closed stub, the right-hand one a coaxial sleeve. Note the movable matching stub at the top of the center feeder for properly terminating the line. In this case the line is so short that only one matching device is required, but both units are kept in the circuit to show their use in long lines where they are needed.

A coaxial version is shown in Fig. 16. With the open ends of the reversing sleeves facing down, the unit is a two-element collinear array; mounting the bottom sleeve with open end up gives a center fed antenna with a detuning section for the outer surface of the feeder.

Coupling and Tuning Problems

The ramifications of coupling devices of this sort are demonstrated in Fig. 17 and Fig. 18. The half-wave section at the left in Fig. 17 can resonate as a whole and does. This "antenna mode" dominates, and the effect is thus the same as that of the single rod connected at the right. In general, transmission line theory is inadequate where the section is of correct length to resonate as a whole with the antennas to which it is connected. On the other hand, correct adjustment of the open quarter-wave stub at the left of Fig. 18 gives the same effect as a shorting bar across the top. Here the line mode is the only possible one since a quarter wavelength is too short for self-resonance. Likewise, the quarter-wave closed end stub detunes the part of the system to the right of the stub, acting in the same fashion as a very high resistance.

The tuning of these antenna circuits is delicate since the stubs must present essentially a pure resistance and be inserted exactly at a point of current maximum without them. A small bulb as a tuning indicator has the disadvantage of being a large load in itself, therefore altering the tuning of the element to which it is applied. In general, a probe antenna with crystal and microammeter is to be preferred both for tuning the system and to demonstrate current distributions. A more detailed discussion of the principles of coupled antennas of this type has been published elsewhere.[2]

All but one of the antennas discussed were of the symmetrical center-driven type which lends itself to parallel line feeding. Coupling to such a load with a coaxial line which is itself not symmetrical may cause considerable difficulties. In order to prevent the outside surface of the line from carrying unbalanced currents, detuning sleeves must be used

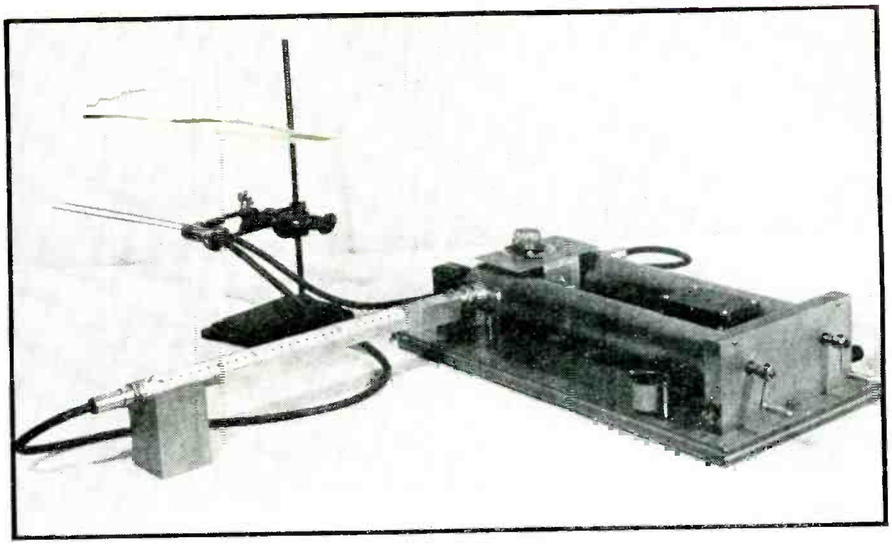


FIG. 20—Microwave oscillator employing single acorn tube and double coaxial tuning elements

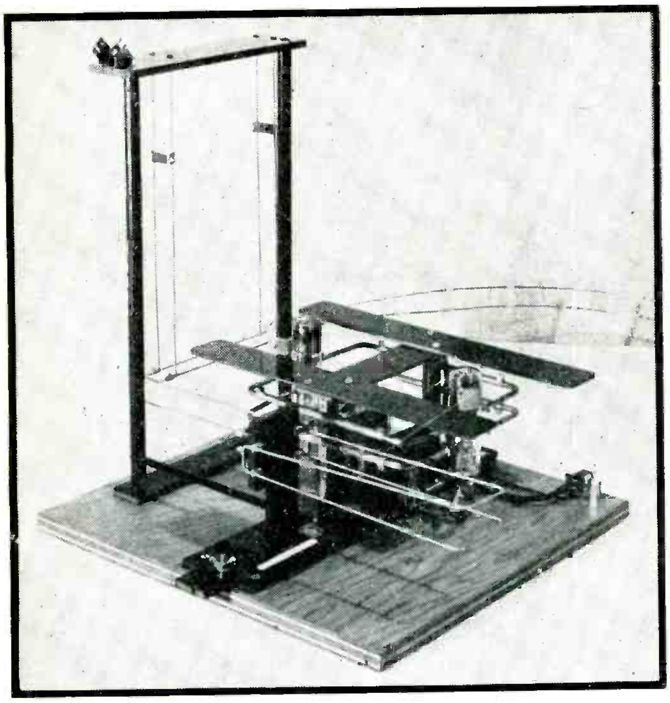


FIG. 19—Two-tube parallel-line oscillator for microwaves

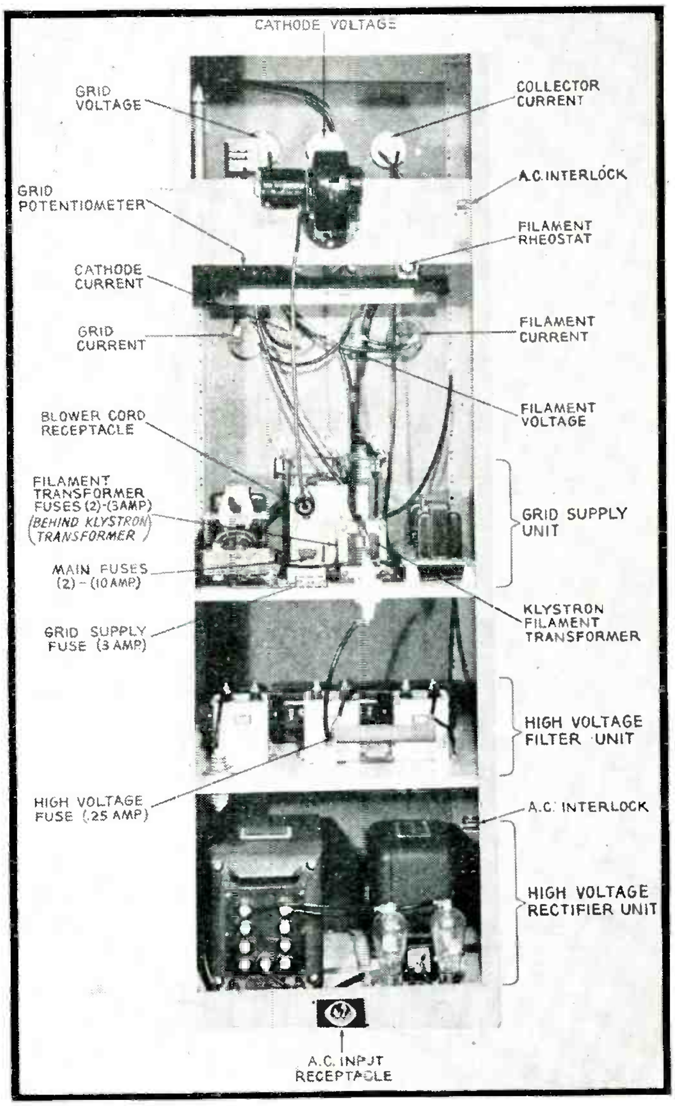


FIG. 21—Rear view of rack and panel mounted klystron oscillator

as for the coaxial collinear antenna of Fig. 16. These are cumbersome where flexible cables are used. The General Radio u-h-f oscillator used to drive an antenna, for example, has a large outside surface which includes the outside of the coaxial cable and the metal case of the oscillator itself. Unbalanced currents due to the field at the end of the coaxial line (at the unsymmetrical antenna coupling unit) may excite this surface so strongly that considerable radiation is observed from it. The surface is large enough to have several possible modes of oscillation, and consequently it is usually not possible to eliminate standing waves on the outside surface of the coaxial line and oscillator.

Two oscillators constructed in the laboratory to avoid this difficulty are shown in Fig. 19 and Fig. 20. The two-tube model in Fig. 19 uses a flexible parallel line feeder. A variable coupling unit in the foreground is connected to this feeder through

(Continued on page 180)

ELECTRONIC APPLICATIONS
A New Curriculum

Industrial electronic applications emphasized in new option for electrical engineering students. Courses in electronic control and measurement and in electrical implementation fit students for broad gauge design and engineering positions in rapidly expanding field

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Highlights of Engineering Course on Electronics

1. The Electronics Option, a new curriculum in electrical engineering, provides instruction in a field of electrical methods of measurement, control, and implementation not now covered by conventional power or communication curricula, but which to some extent overlaps the fields of both these older curricula.

2. The cultural, basic science, and main-stem engineering subjects are identical with the two curricula which the new option bridges, but the special professional subjects use illustrative material that is in the special field of electronics.

3. The Electronics Option culminates in two special subjects: (A) electronic control and measurement, which covers the more important functional methods whereby electronic devices are used in control and measurement applications, and (B) electrical implementation, in which the overall behavior of systems involving control and measurement devices are analyzed, largely by the method of electric-circuit analogy and models.

4. Laboratory work as well as analytical study is carried on in association with those special subjects in which commercial apparatus is utilized liberally, but always for the purpose of illustration of principles rather than the study of details of construction or performance.

DEVELOPMENTS in recent years show a slow but steady growth in the range of electrical engineering, a growth which lies squarely in neither of its traditional divisions, power and communications, yet overlaps both of them to some extent. The economic value of the power utilized by this growth is, in most instances, of minor importance to the user, and the communication of intelligence is usually not an objective. The new field has wider scope perhaps than either of the traditional divisions, for it covers electrical utilization in the home, office, plant, laboratory and farm, and in many modes of transportation.

Since in such utilization a marked trend at present is toward increased use of electronic equipment, the name electronic applications is used hereafter to describe the field. Actually the term *electronic* is too narrow, for the field includes electrical methods of measurement, control and implementation in all types of industry and engineering. It covers the full range of frequencies from direct current to radio frequencies, and the full range of power from the fraction of a microwatt available from a phototube or thermocouple to the hundreds of kilowatts used in induction heating. Instead of the problem of the alternator in power engineering, electronic applications has, for example, the problem of a vibra-

in Electrical Engineering

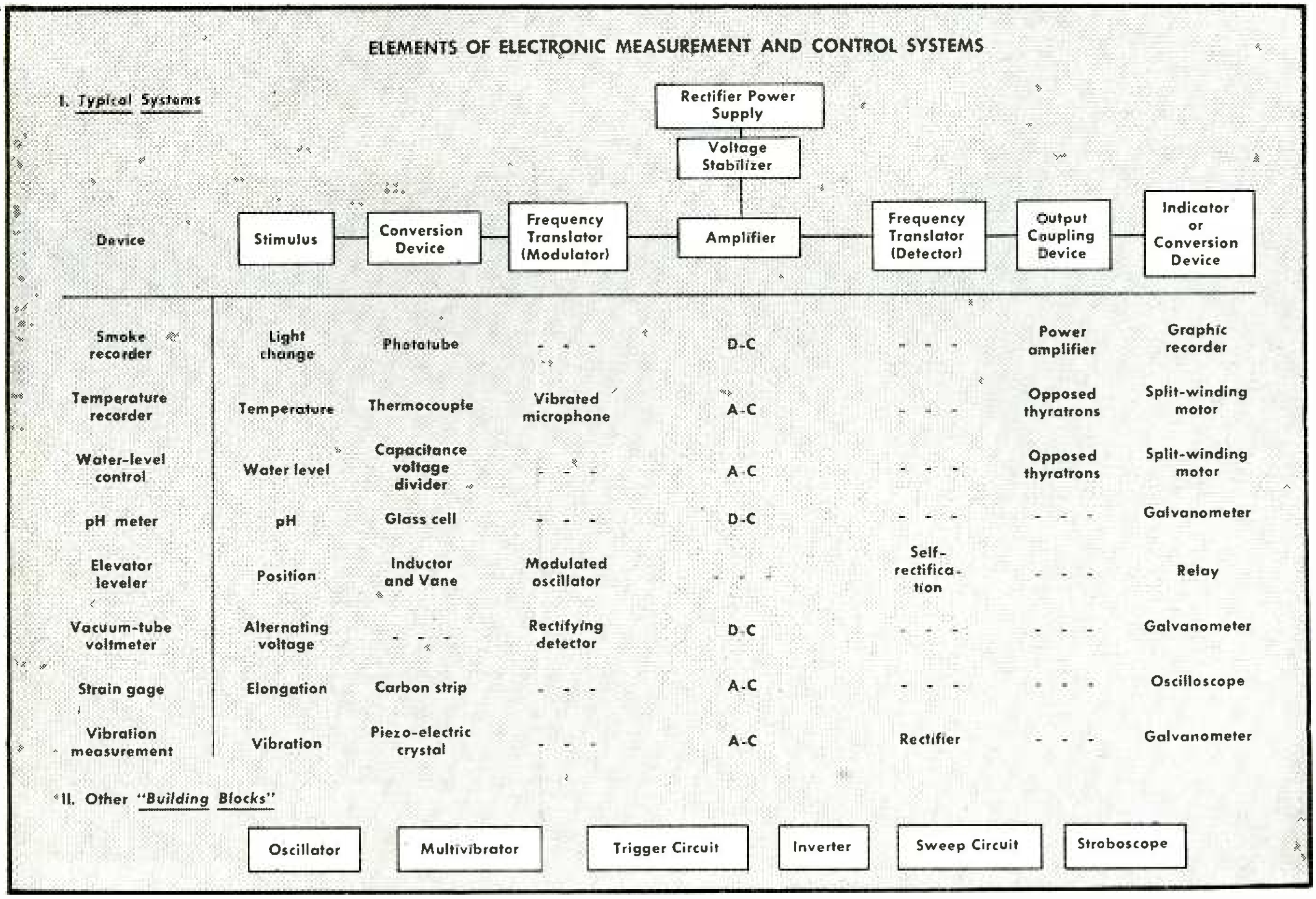

FIG. 1—Outline of some functional elements in a few typical industrial electronic applications

tion pick-up for measurement purposes. Instead of the use of frequency modulation in communication engineering, electronic applications has the use of frequency modulation in a control system. Many other similarities and contrasts, such as that of motors and relays, and that of radio transmitters and induction-furnace oscillators, can be cited.

Post-War Need for Engineers

The unprecedented war demand for engineers trained in electronics and the accompanying tremendous expansion of production facilities have accelerated the growth of the field to an extent that will only be fully realized after the war. Even before the war, most engineering schools had recognized the increasing importance of electronics and many have made a more or less prominent place for it in their curricula. Among these recent educational developments is a new curriculum at the Massachusetts Institute of Technology, a description of which follows.

This new curriculum is part of an expanded undergraduate electrical-engineering course of study requiring four academic years, which now has four options: power, illumination*, communications, and electronic applications. The curricula of these options are identical through the first two years, and have substantial portions in common in the third and fourth years. For present purpose of comparison, consideration of the power, communications, and electronic options seems adequate, since the electronics option straddles certain special elements of the power option and certain special elements of the communications option, but has little in common with the special elements of the illumination option.

During the first two or two and one-half years the three options have in their curricula basic work in general chemistry, general physics (mechanics, heat, electricity, optics), analytic geometry, differential and integral calculus and differential equations, engineering drawing and descriptive geometry, applied me-

* The illumination option has been discontinued for the duration of the war.

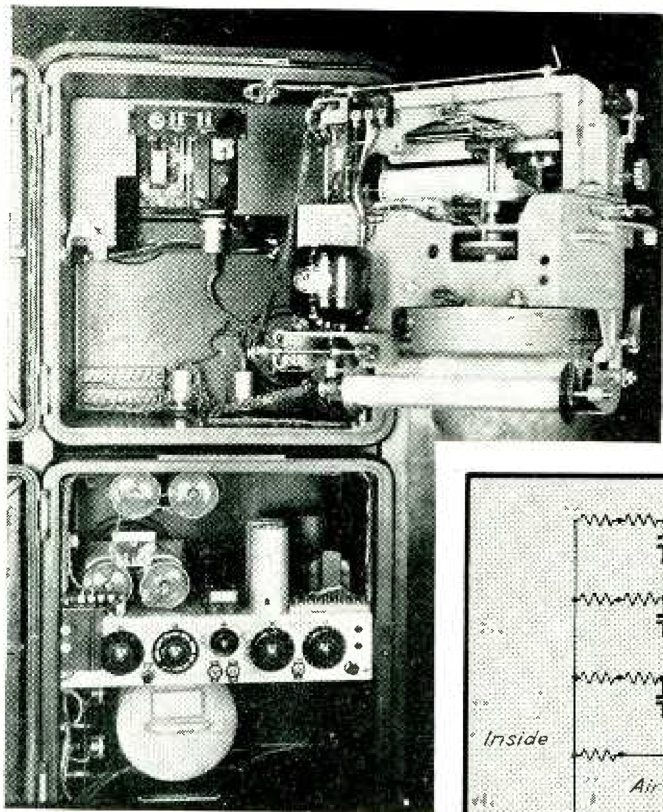

Fig. 2—This Leeds and Northrup recording potentiometer illustrates an important application of electronics to the field of industrial electronics

dynamics emphasizes the kinetic theory of gases, with applications to gaseous conduction, thermionic emission, photoelectric effect, electron optics, radioactivity, and nuclear structure; it includes no additional study of alternating-current machinery, but includes instead additional study of electric circuits, transformers, and electron-tube applications; that is, corrective networks, filters, and other coupling networks, vacuum-tube rectifiers, amplifiers, oscillators, modulators and demodulators,

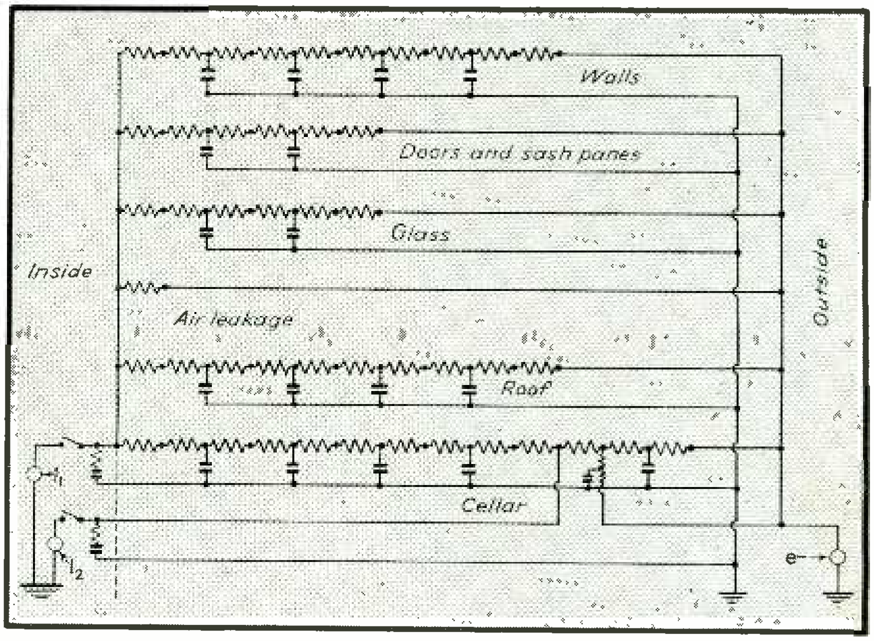

FIG. 3—Electric-circuit view of a house. The current source I_1 represents the heat supply to the house through ducts; the current source, I_2 represents the heat supplied in the cellar by thermal losses. These current sources can be realized by the use of high vacuum pentodes. The series R-C combinations beside these sources represent, respectively, the contents and interior structure of the upper floors and cellar. The voltage source, e, represents the outside temperature. This diagram is an example of the use of electrical methods for studying a wide variety of problems which originate in other fields

chanics (statics, kinematics, dynamics, strength of materials), English and history, economic principles, military science, and physical training. During the last two and one-half years the three options have the same main stem of electrical subjects: steady-state and transient analysis of direct- and alternating-current circuits; magnetic circuits and transformers; applied electronics; direct- and alternating-current machinery; and associated laboratory work with each of these subjects. A thread of subjects of a cultural nature, called general studies also continues through this period. These general studies may be selected by the students from many such subjects offered. Ordinarily, students are not permitted to make substitutions among the basic and main-stem studies. This summary of the common ground of the curricula of the three options serves as a background for pointing out their special elements, all of which are in the last two years.

The power option includes additional study of dynamics, with emphasis on application to rotating and reciprocating machinery of electromechanical construction; hydraulics, including hydraulic turbines and pumps, with emphasis upon flow of water through orifices, nozzles, weirs, pipes, and open channels; thermodynamics, with emphasis upon applications to steam engines and turbines, power-plant cycles, air compressors, and internal combustion engines; additional study of alternating-current machinery; and electric power transmission and distribution. All of these studies have associated with them appropriate laboratory work. Finally the option provides for certain elective subjects in the professional field, called professional electives, and a thesis, mentioned subsequently.

The communications option includes instead of the additional dynamics of the power option, the study of vibrations and sound; it includes no hydraulics; its study of thermo- photoelectric devices and associated laboratory work; transmission lines for communications purposes, electromagnetic radiation and propagation. This option also provides for professional electives and a thesis.

Scope of Electronics Option

The electronic-applications option includes the dynamics of the power option and the thermodynamics of the communications option; instead of the hydraulics of the power option, it includes study of fluid mechanics, which does not emphasize water as a medium, but treats more generally the physical properties of fluids, with application to various hydraulic apparatus; instead of additional study

(*Continued on page* 304)

Graphic Solution of Design Problems Involving SENSITIVE RELAYS

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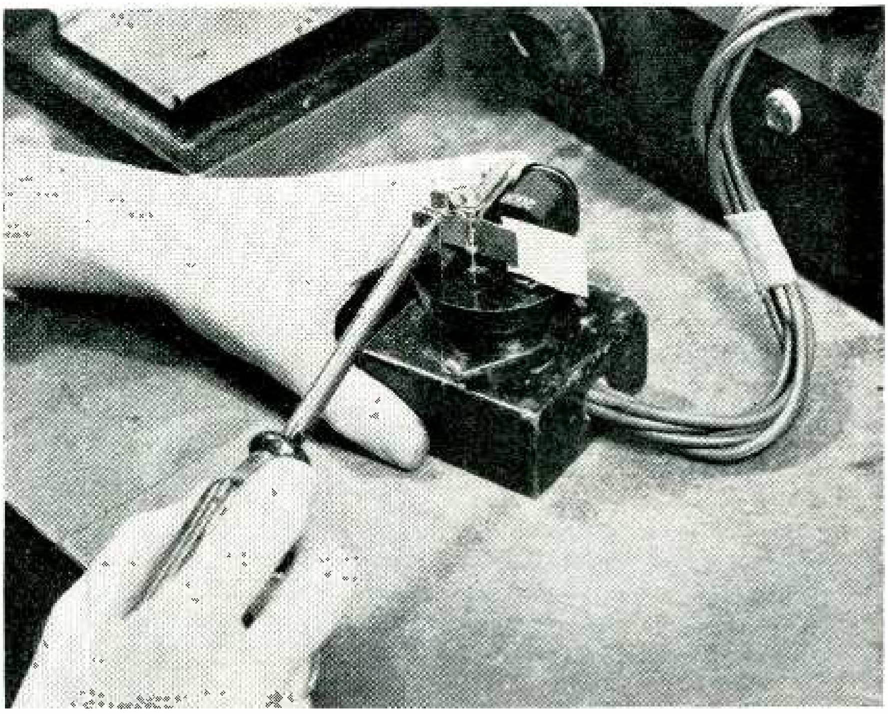

A method of presenting relay data which permits determination of performance under any static electrical condition without resort to experimentation. Proposed system of curves helps both users and designers of relays

THE WAR has greatly increased the demand for sensitive relays and has, at the same time, complicated the problem of design. Users and designers of such relays have frequently found it difficult to meet on common ground.

Attempts on the part of the user to state a relay problem in terms which would permit the designer to produce a satisfactory unit for a special application have not met with universal success. For reasons of military security it has often been considered desirable to hold back certain application details when preparing relay specifications. In other instances there has been a wide divergence of opinion between users and designers as to the completeness of data required.

The relay user may certainly be excused for not always realizing precisely what details a relay designer needs. On the other hand, the relay designer may similarly be excused for failing to request additional data concerning applications where he would have to be psychic even to know that specifications were incomplete. In many cases, however, the resulting dilemma has been resolved only after the production of a considerable number of unsatisfactory relays or, in the case of research projects, after much time has been wasted in blind alleys.

A method of presenting relay performance data in a form useful to users and to designers has been evolved which might go far to correct these difficulties. A complete description of the proposed graphical method of data presentation follows.

Fundamentally, a relay is a remotely controlled switch. As a switch, its purpose is to open and close contacts as dictated by the controlling electric circuit.

Most attributes of switch performance, other than matters controlled by choice of contact materials and arc suppression methods, can be directly related to motion and force. More specifically, with any given design of magnetically operated switch, performance is governed by contact pressure* on the one hand and contact separation on the other.

Fundamental Assumptions

This statement assumes static, or relatively static, electrical conditions. It considers closed contacts as electrical conductors and open contacts as electrical insulators. (Under some conditions, speed of break or make and frequency of operation are important factors in switch performance. These factors are not considered here but static requirements must be met in any case as a prerequisite to successful solution of any further problems that may arise.)

It is not difficult to present tabulated data indicating conservative minimum values of contact pressure

* As used, the term "contact pressure" does not involve the usual concept of unit area. It is used, rather than the term "contact force", to distinguish it from magnetic force, which does not involve physical contact.

and separation which, when obtained on a relay of given design, will yield satisfactory switch performance under different stated circumstances. This has not been done generally because, until now, no practical method of using such data intelligently has been devised. Although engineers could be told that they could expect good contact performance if they used so many grams of contact pressure and so many thousandths of an inch of separation, they could not easily be told what general conditions in the relay input circuit would yield these values.

System of Curves

The essence of the suggested method of presenting relay performance characteristics so that this tabulated data can be put to good use in design work is a system of curves.

The curves represent the space and force relationships that prevail in the relay at various input power levels and various adjustments. They are possible to draw only if an approximate assumption is made. This approximation consists in representing, by a single curve, the force present in the air gap at a given value of input power as the air gap is varied. The force is exactly proportional to the square of the flux density in the gap. The flux density is not, however, governed entirely by the coil power and the gap length, because of the effects of magnetic hysteresis in the iron.

The assumption is valid because, in modern sensitive relays, the iron materials used are highly permeable and have very small hysteresis loops. This means that the magnetic intensity left in the iron when power is removed from the coil is so small that it cannot send any appreciable flux across an air gap. Practically speaking, therefore, no serious error is introduced by the use of a single curve to represent force at a given value of coil power as the gap length is varied.

It is well to recognize at this point the importance of thinking in terms of coil power rather than coil current. This always seems wrong at first, in that the ampere turns in the coil are fundamentally what counts. However, on a given design of relay, although many different values of coil resistance may be offered, the physical dimensions of the coil are usually quite constant. And when certain physical dimensions are given, it is approximately true to state that a given power value will produce a given number of ampere turns irrespective of any change in coil resistance.

As one changes wire size to achieve more turns and resistance, the resistance varies approximately with the square of the turns. The following relationships then obtain:

Let r_1 and r_2 represent the resistances of two different coils with the same physical dimensions. Assume that coil 1 has 100 turns and coil 2 has 141 turns. Then

$$r_1/r_2 = 100^2/141^2 = \tfrac{1}{2}$$
$$2r_1 = r_2$$

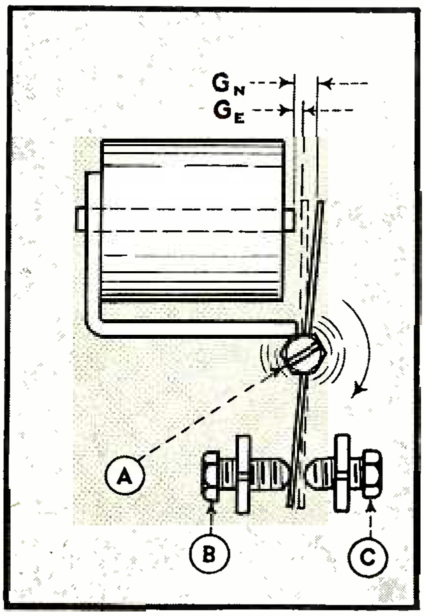

FIG. 1—Type of relay to which this article and the curves in Fig. 2 apply

Let $r_1 = 1$ ohm, $r_2 = 2$ ohms. Then, when the current is one ampere in coil 1, $I^2r = 1^2 \times 1 = 1$ watt dissipated in coil 1. Also, for 1 ampere in coil 1, there will be 100 ampere turns.

Coil 2 will dissipate one watt when $2I^2 = 1$ or $I^2 = \frac{1}{2}$ and $I = \sqrt{2}/2$. For this current in coil 2, the ampere turns will be $\sqrt{2}/2 \times 141$, or 100 ampere turns just as before.

This relationship allows representation of the performance of any relay of a given design, of whatever coil resistance, by a single family of curves. An Ohm's law calculator or slide rule makes their use very convenient. A complete description of the curves and their use in the design of a relay like that shown in Fig. 1 follows.

Each curve in Fig. 2 shows, for one particular value of coil input power, the approximate magnetic force developed at the gap between armature and coil core as the length of the gap is varied.

Graphical Analysis of Performance

If the armature is pivoted exactly half-way between gap and contacts, as it is in Fig. 1, then the contact pressure will always equal this magnetic force less the force of the restoring spring. If this subtraction yields a negative remainder, the spring force being greater, the pressure will be on the normally closed contact (B). The spring force is a torque, as is the magnetic force, and both must be measured at the same distance from the pivot.

In order for the method of using these curves to have general application among different relays a convention is necessary regarding the point at which forces are to be measured. It is suggested that this point be chosen as the contact position. If so, no consideration need be given to the relative position of the pivot. In cases where it is difficult to measure the force at the contacts, it can be measured at some other point and the values corrected to equivalents at the contacts.

It will be noted in Fig. 2 that each curve is marked with two different power values, for two different types of coil construction. The reason for this is that form-wound coils not having paper between layers of turns have a larger volume of copper and, therefore, effectively different and larger physical dimensions and more ampere turns per milliwatt.

The heavy lines and figures, superposed over the curves in Fig. 2 represent a typical relay operation cycle.

Let us assume that it refers to the relay shown in Fig. 1. Note that the armature motion allows the air gap at the coil core to vary from G_n to G_e. Two vertical lines are drawn in Fig. 2 at points which represent the lengths of G_e and G_n, measured from the origin along the horizontal axis. A horizontal line has been drawn from a point on the vertical axis which represents the spring force. (Note that in theory this line should not be horizontal but should slope downward by an amount depending on the force of the

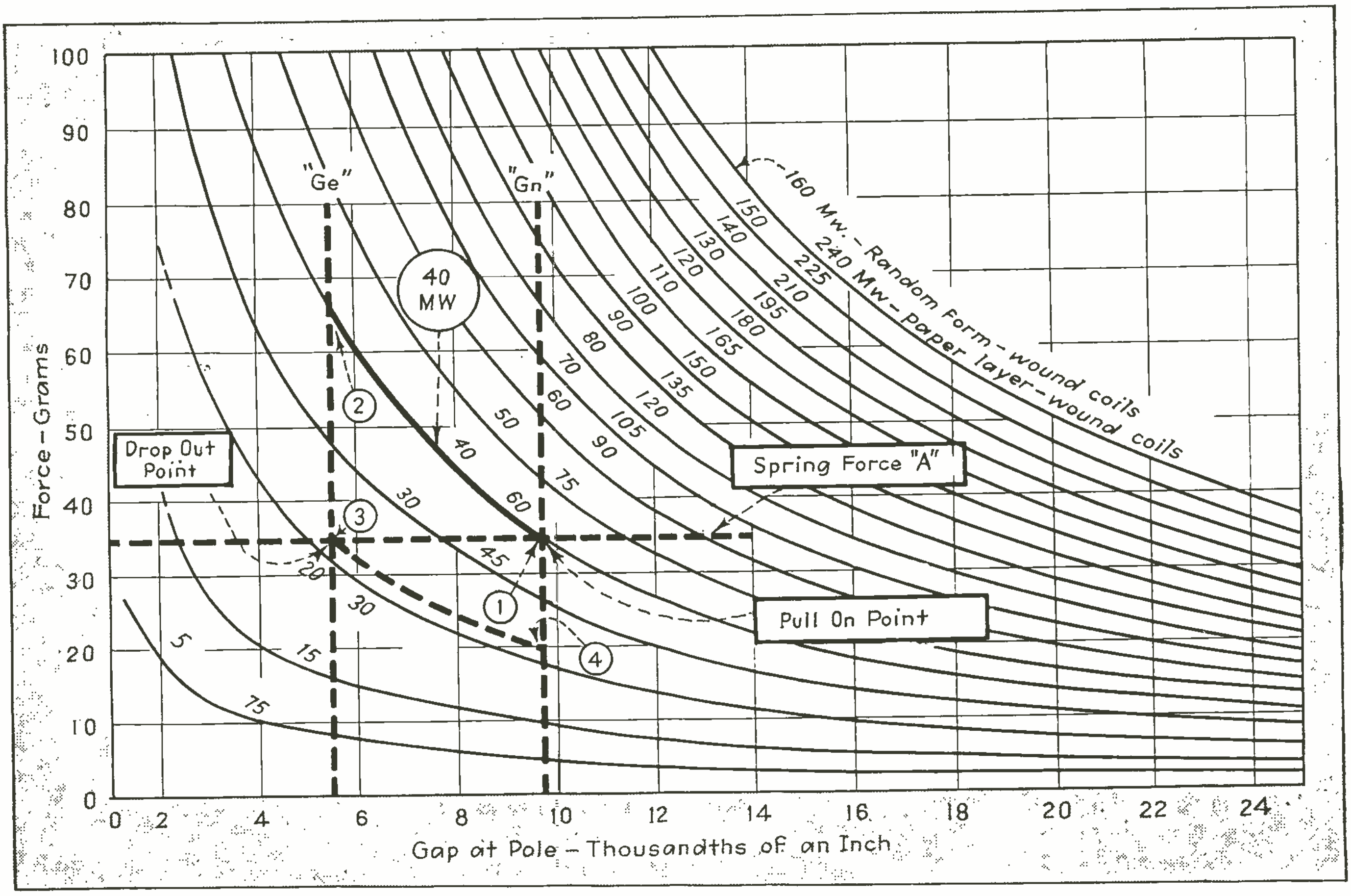

FIG. 2—Heavy lines superposed on this family of curves for a Sigma type 4 sensitive relay are used to analyze the relay operation cycle, as explained in the text

spring. This force is usually less than a gram over the range of operation and is therefore neglected.)

Before current is applied to the coil, the spring will hold the armature in the position G_n with a force of "A". As increasing current is applied to the coil, an increasing magnetic force opposes this spring force. When the coil power reaches a value of 40 milliwatts, the graph shows, that in this particular case the magnetic force will have exceeded the spring force by a small amount above point (1). The result is, of course, that the armature rotates to the other extreme of its travel (the relay pulls on) and the pole gap becomes equal to G_e.

With the gap at this value and the coil power still 40 milliwatts, the graph shows, at point (2), that the magnetic force exceeds the spring force by an amount equal to the distance from point (2) to point (3). This amount is, then, the contact pressure developed on the normally open contact (C in Fig. 1) when the relay has just pulled on.

Now, let the coil power be decreased. When it has dropped sufficiently low the magnetic force will have become slightly less than the spring force, the spring will restore the armature to its original position, and the relay will have "dropped out." The coil power value at which this occurs is indicated by point (3), which is a point on an interpolated curve yielding force "A" at a gap equal to G_e. The power value of this curve is estimated from its position with respect to given curves, and is the drop out value for the adjustment under consideration.

When the armature drops out, restoring the gap to the value G_n, the magnetic force will be determined by point (4), the intersection of the interpolated curve passing through point (3) with the vertical line at gap G_n. The contact pressure immediately after drop out will then be equal to the difference between the magnetic force given by point (4) and the spring force "A", shown at point (1). As the current decreases further toward zero, the contact pressure on the normally closed contact (B in Fig. 1) approaches the value of "A". The cycle has now been completed.

Practical Example

The curves may be used as follows:

1. From data supplied by the relay manufacturer regarding pressures and spacing necessary for good switch performance under various circumstances of electrical load and environment, coupled with an analysis of the particular problem at hand, limiting values of minimum air gap, contact spacing and pressure are determined.

2. A trial cycle is sketched in. The problem of where to start may seem confusing at first, but is really obvious after a little familiarity is gained.

If the problem is expected to tax the sensitivity of the relay, it will probably be advisable to use the

(*Continued on page* 310)

ELECTRONIC CONTROL of D-C Motors . . . . . Part V

Final installment of this series on tube-controlled d-c motors, completing the subject of regeneration by inverter action and treating methods of stopping and control equipment

By E. E. MOYER

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When the load current during inversion in a thyratron circuit is a series of discontinuous pulses, with the anode current through each thyratron being a separate pulse that dies out before the next tube fires, there is no particular problem to inversion. In this instance, the current through the outgoing thyratron is extinguished because the direct voltage generated by the motor is less than the instantaneous values of the negative alternating voltage of the transformer and because the circuit inductance is insufficient to maintain the current flow against the then greater negative alternating potential. In this way, the net tube voltage ultimately becomes negative and current ceases. In Fig. 1, the current and voltage relations existing during inversion are compared with those for rectification. Diagrams E1 and F1 of Fig. 1 are intended to show the effect of an increase in motor emf upon the tendency of the circuit inductance to prolong current flow into the region where the negative alternating potential is greater than the direct potential of the motor. In F1 of Fig. 1 there is yet some margin of safety before the current will exist throughout the complete area and before conduction will be carried over into the region where the going-positive alternating potential will maintain current flow into the succeeding half cycle of rectification. Preventing conduction from continuing into the positive half cycle is one of the problems of inversion; holding the current off after it has been stopped is another.

THIS SERIES OF ARTICLES ON ELECTRONIC CONTROL OF D-C MOTORS HAS INCLUDED:

PART I—Outline of general principles. May 1943 ELECTRONICS

PART II—Reference voltage and speed control methods. June 1943 ELECTRONICS

PART III—Extending speed range by electronic means of field weakening. July 1943 ELECTRONICS

PART IV—Starting, stabilizing, and reversing. Sept. 1943 ELECTRONICS

PART V—Regeneration by inverter action, and stopping. Oct. 1943 ELECTRONICS

Commutation During Inversion

In D of Fig. 2 is shown a condition of continuous armature current such as may readily exist under overload conditions when the inherent inductance of the armature circuit is sufficient to widen out the conducting period of each tube so that successive periods, in effect, overlap. That is, tube conduction is continuous throughout the interval when the negative value of alternating potential exceeds the d-c value, so that the difference of these voltages alone is insufficient to extinguish the tube current. Now, at the time when one tube should cease conduction, its current is not zero, yet the current of the incoming tube must start from zero; hence, the one tube must transfer to the other a certain amount of current. The circuit inductance opposes any abrupt changes in current so that the current through the outgoing tube must be forced to zero by firing the incoming tube as a rectifier at such a time as to cause an a-c short-circuit current to tend to flow around the local a-c circuit comprising the whole transformer winding and the two thyratrons, and to tend to flow in a reverse direction through the outgoing thyratron. This form of commutation may be thought of as a process whereby—for the brief interval when the two thyratrons are simultaneously conducting and the transformer is, in effect, short-circuited on its own leakage reactance—

For purposes of consistency, the symbols employed in this article are those commonly used in communication circuits.—Editor.

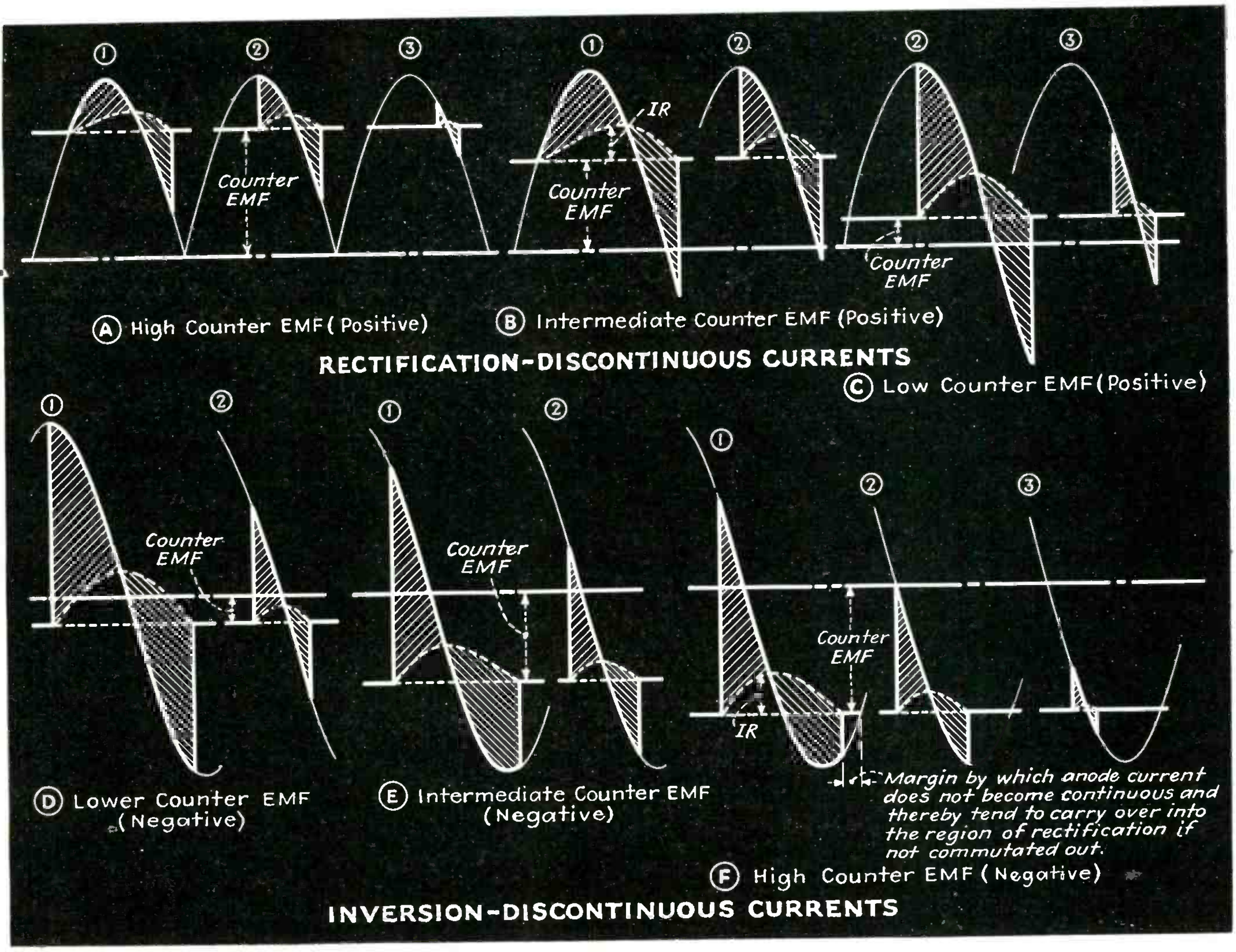


FIG. 1—Effect of firing point and counter electromotive force on magnitude of anode circuit for rectification and inversion

the a-c short-circuit current is "riding backwards" on the normal load current which is keeping the outgoing tube conductive.

This commutating period is shown in diagram E of Fig. 2, where the counter voltage of the inverter is temporarily at zero and the difference in voltage between it and the motor emf is temporarily absorbed by the armature inductance and resistance. At the instant the circulating current and the load current are equal, the net tube current is zero-going-negative and the valve action of the tube prevents its current from reversing; thus, the current merely becomes zero where the negative grid must maintain it at zero by preventing firing until the correct firing point is again reached.

Firing Points in Inversion

The firing point of the incoming thyratron must be sufficiently ahead of the zero-going-negative point of the a-c wave so that the alternating voltage difference between the two tubes can cause an a-c short-circuit current of such magnitude (it is limited mainly by the leakage reactance of the anode transformer) that in the very few electrical degrees during which the armature current must be transferred from the one tube to the other, this commutating current will build up to a value equal and opposite to the armature current in the outgoing tube and will force the current to zero in this tube. Furthermore, the current must be forced to zero at a time when the net anode voltage on the outgoing tube will be negative and will stay negative long enough for the negative grid to regain control and prevent reconduction.

During rectification, as shown in A, B, and C of Fig. 2, there is no problem in keeping the current from re-establishing itself in the outgoing tube because its anode voltage is becoming increasingly negative. But, during inversion, the anode voltage is becoming decreasingly negative and actually tends ultimately to become positive so that a region is reached where, due to a condition of positive anode voltage, a negative grid potential is necessary to prevent conduction.

The firing point of the incoming tube (diagram F of Fig. 2) has been advanced so far toward the rectifier zone that, for an appreciable time after commutation, the anode voltage of the outgoing tube is negative to such an extent that there is ample time for the negative grid to regain control. But, it should be evident that in a region somewhere near, and ahead of, the crossing point of the a-c waves this helpful negative anode voltage does not exist sufficiently long to allow the tube to deionize and its grid to regain control, and hence, inversion fails.

For successful inversion of con-

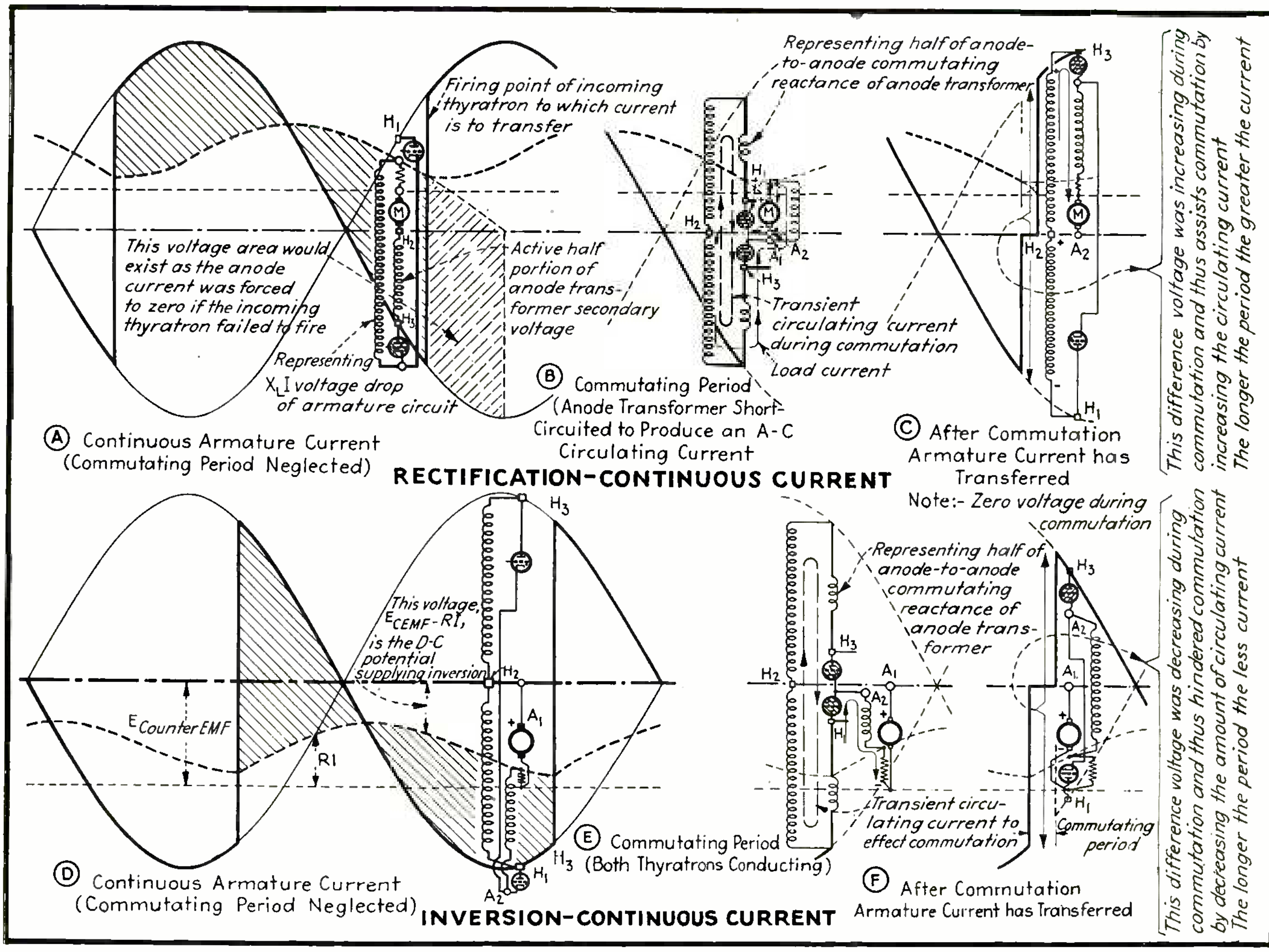


FIG. 2—Comparison of commutation during rectification and inversion

tinuous current, the firing point of the incoming thyratron will have to be advanced toward the region of rectification if the load current, and therefore the current to be commutated, is increased. Phase advancing toward the rectifier region has the effect of reducing the counter voltage of inverter action. This counter voltage opposes the armature generated voltage to limit the very armature current which is being commutated. Hence, there is a definite relation between that value of armature current which is to be commutated, the counter voltage of the inverter corresponding to successful commutation, and the generated voltage of the motor which is the source of current.

Armature Current Limit and Control During Inversion

During the inversion period, the armature current corresponding to a given circuit resistance is determined by a net voltage which is the difference between the generated voltage of the motor and the average negative counter voltage of the inverter. Thus, two voltages govern the magnitude of armature current during the inversion period: (1) the generated voltage of the motor; (2) the counter voltage of the inverter, if it is assumed that the circuit impedance, the motor speed, or the alternating anode voltage are not readily adjustable. The generated voltage of the motor is a function of motor speed and field excitation. The counter voltage of the inverter is determined by the firing point of the armature thyratrons.

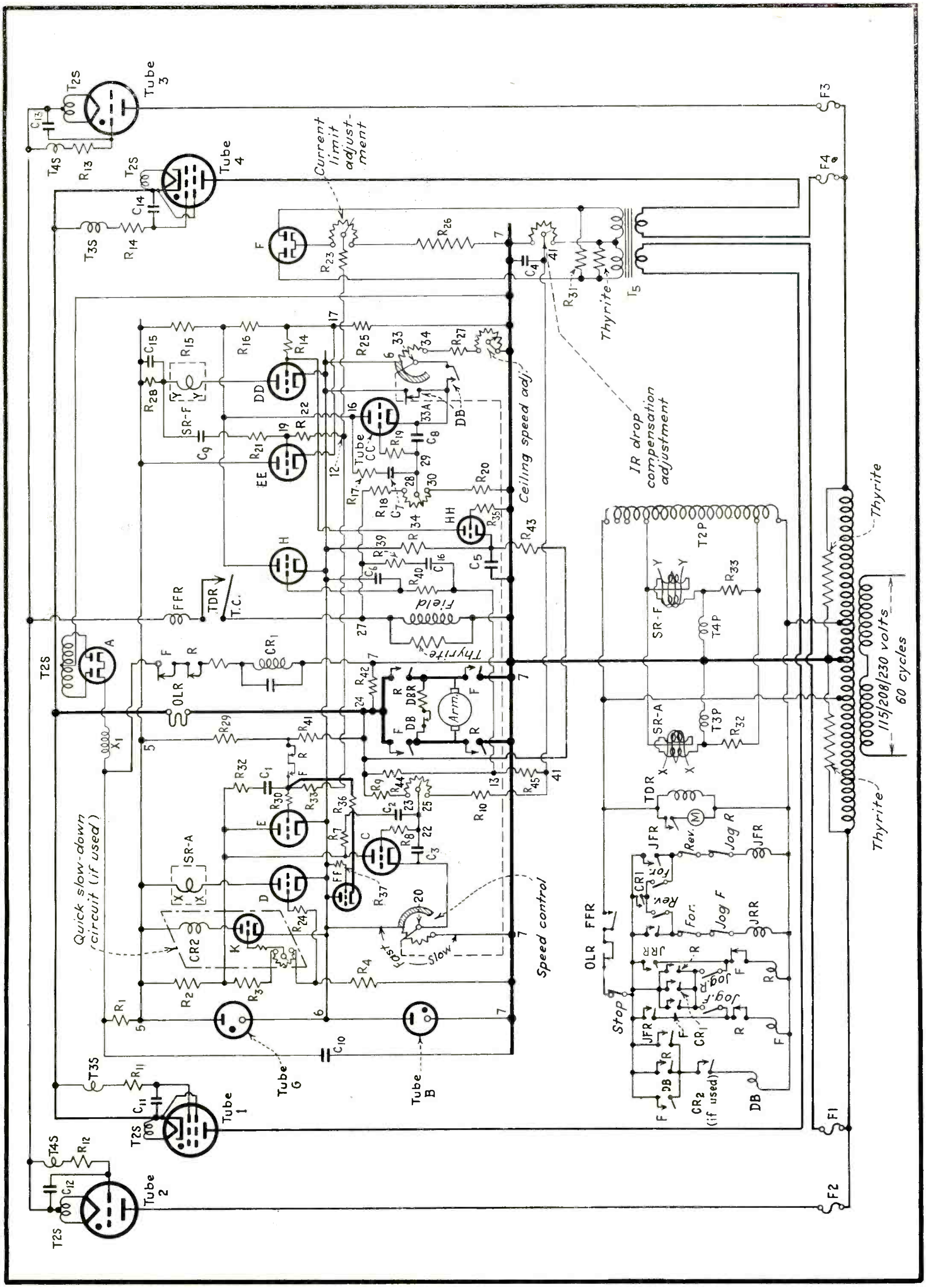
Under certain limited conditions of reversing operation, the armature preconditioning control and the armature current-limit control will also function to maintain a constant current-limit value of armature current during the inversion period of regenerative deceleration. This applies particularly to motors having good commutating ability, operated with a very limited degree of field weakening, and driving a low-inertia load.

It should be noted that, while the armature preconditioning circuit tends to control the thyratron output to a relatively low voltage as a rectifier under open-circuit armature conditions, the firing point corresponding to this low direct potential happens to be in the region of correct firing for successful inversion of 100–150 percent armature current at approximately rated armature voltage. However, this particular operating condition is much more critical with polyphase circuits than with single phase.

Motor Reversing During Inversion

Since armature current, inverter counter voltage, and motor voltage have to be co-ordinated for successful inversion, it is essential that the control shown in Fig. 3, used to rapidly reverse a motor coupled to a high-inertia load and operating from a field-weakened condition, should

FIG. 3—Elementary circuit diagram of complete reversing drive for Thy-mo-trol control


Tube 1
Tube 2
Tube 3
Tube 4
Tube B
Tube G
Tube CC
Current limit adjustment
Ceiling speed adj.
IR drop compensation adjustment
Speed control
Quick slow-down circuit (if used)
Thyrite
Field
Arm.
Fast
Slow
Stop
CR2 (if used)
115/208/230 volts 60 cycles

perform the following functions:

(1) Regulate the initial and subsequent armature voltage of the motor at a preset value, say approximately rated voltage, by control of the rate of increase of field excitation as a function of negative armature voltage (negative in the sense that the voltage of rectification and forward rotation is positive with respect to control bus 7). This assures that the motor voltage will be within the range of counter voltage which the inverter will develop. Tube HH in Fig. 3 performs this function.

(2) Precondition the inverter counter voltage to match the regulated motor voltage. This limits the initial armature current to a value which may be commutated successfully by both motor and inverter. This is also a level of current from which the normal armature current-limit circuit can take over control. The normal preconditioning circuit, plus the additional refinement of tube FF and relay CR_1 in Fig. 3 perform this function.

(3) Reduce the inverter counter voltage by grid phase control to match the decreasing motor voltage (due to a decrease in speed accompanying deceleration). This maintains approximately constant armature current throughout deceleration and on into the region of acceleration in the reverse direction. The normal armature current-limit control performs this function by phase controlling the firing point of the thyratrons toward and into the region of rectification.

The extra refinement of tube HH is necessitated by the fact that too rapid field strengthening at a high-speed condition could raise the emf of the motor faster than a high-inertia load would allow the speed to decrease to reduce this emf. That is, during the initial period of deceleration when tube EE is calling for full field in response to its armature current-limit signal the armature voltage would increase to levels beyond which inverter commutation would be possible. After reversal of the armature connections and prior to, and during, the inversion period, the armature voltage is negative with respect to the negative control bus, point 7. Tube HH receives a signal which is part of this then-negative armature voltage, compares this signal with the standard voltage of tube B, amplifies the difference, and

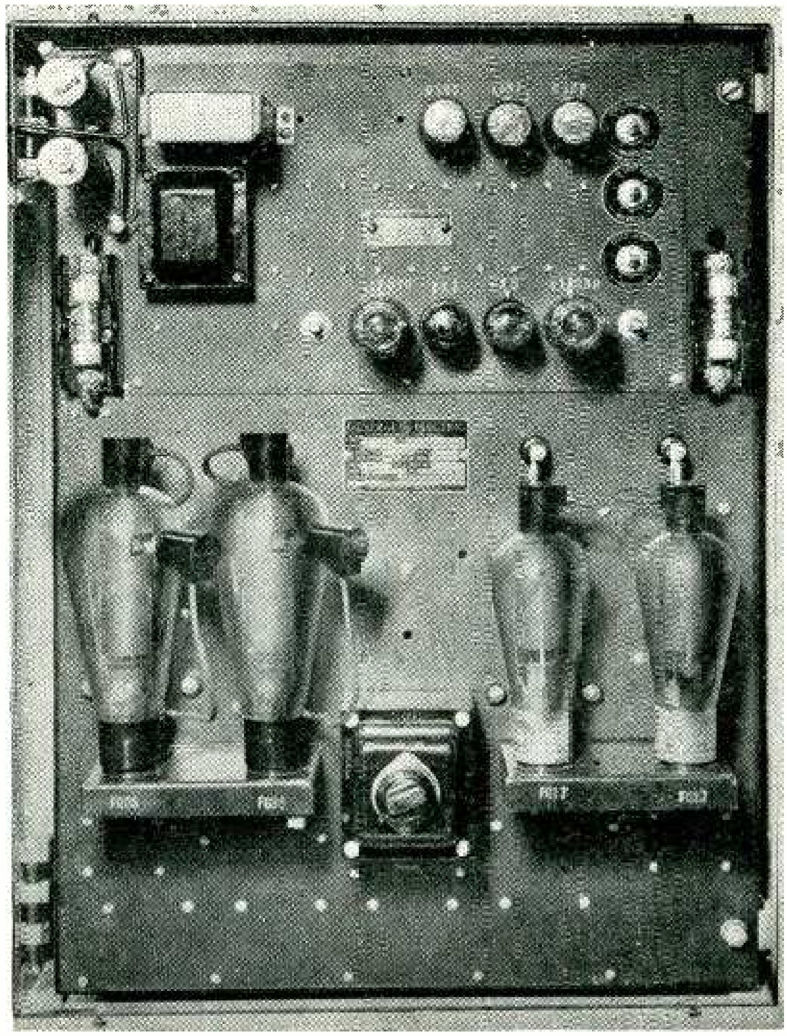


FIG. 4—Control panel for tube-controlled motor unit, with push-button control at left

operates on tube DD so that it regulates the field excitation to maintain a preset armature voltage.

Tube FF serves to precondition the armature current-limit pre-conditioning circuit by anchoring the junction of resistors R_{30} and R_{33} a few volts negative with respect to control bus, 6. That is, the potential of junction R_{30}—R_{33} can be increased positively from this anchoring position but cannot fall below it. These few volts are sufficient normally to maintain tube E nonconducting and yet maintain the grid circuit of tube E very close to its operating level so that the direct-voltage-proportional-to-armature-current does not have to be allowed time to develop the potential between junction R_{30}—R_{33} and bus 7 against the opposition of the antihunting circuit of R_{32} and C_1. The response of the current-limit circuit is therefore made much faster by the absence of this time delay. Another important function of the tube FF is to provide rapid preconditioning for reversals from low speed and light load where the speed is just about at the level at which the preconditioning circuit would, itself, want to regulate armature voltage. Hence the voltage difference available to effect preconditioning is limited and without tube FF more time would have been required to alter the potential across C_1. It is important to have this pre-

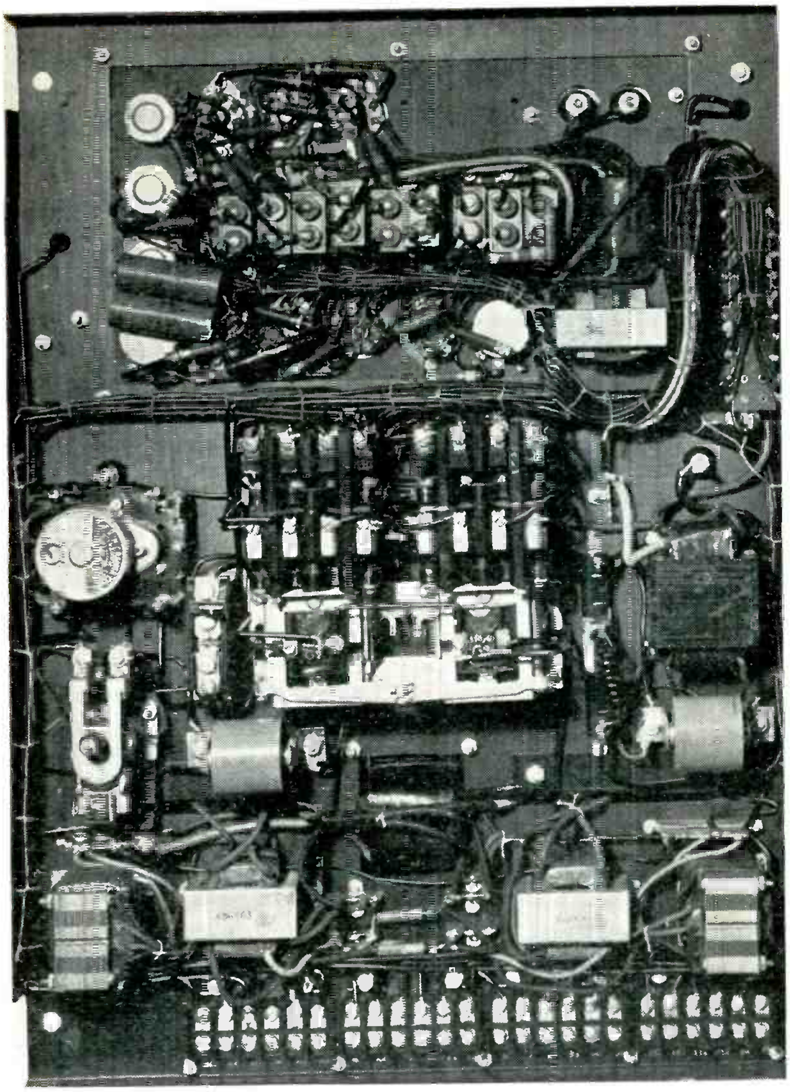


FIG. 5—Interior of reversing panel for armature and field control

conditioning respond rapidly and reach its preset operating level as quickly as possible because this action presets the initial firing point of the thyratrons as inverters to correspond to the armature voltage which is being regulated by the negative voltage-limiting tube (HH).

Auxiliary relay CR_1 is necessary to give added time delay to the reversing operation of the reversing contactors while the preconditioning circuits establish themselves. Only two cycles are required for the reversing contactors to operate whereas four to six cycles are required for the armature preconditioning circuit.

Transition from Deceleration to Acceleration

After the reversing contactors have operated, the open-circuit armature voltage preconditioning circuit will have been disconnected from tube E. This will allow tube E to perform its normal function of regulating the firing point of the armature thyratrons to maintain a pre-selected current-limit value of armature current. Then, as deceleration begins and after full-field is reached, the motor voltage decreases and the armature current reduces. This allows tube E to ease up on its restraint of tube D, which phase-advances the firing point toward the rectifier zone and thus decreases the inverter counter voltage.

When the point is reached at which the inverter voltage is zero, further phase advancing will cause the tubes to begin to act as rectifiers whose output voltage increases as the firing point continues to be advanced toward the beginning of the positive half cycle of anode voltage. The changeover from inversion to rectification reverses the polarity of the tube circuit so that now, acting as a rectifier, the cathode terminal of the tubes is positive in the sense of being a generator and tends to force a current flow against the armature potential. The motor potential will be required to reverse to counter the rectifier voltage, hence the direction of rotation of the motor must reverse to generate this reversed potential. The motor then accelerates in this opposite direction of rotation, under conditions of armature current-limit control, until preset speed is reached.

Regenerative Braking to a Stop

The reversing circuits may also be used to provide a fast and smooth stopping sequence for the motor. All that it necessary is to provide two more relays in the relaying system which will signal for zero speed in

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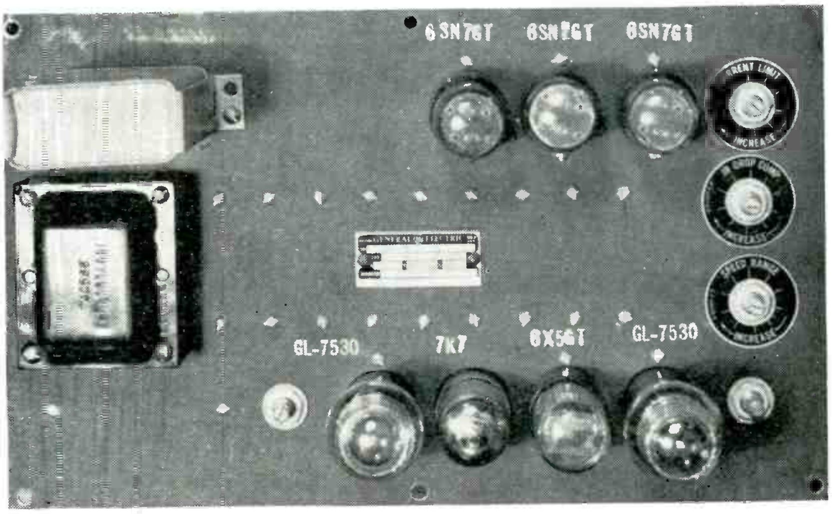

FIG. 6—Thy-mo-trol tube control panel, for d-c motor control. The panel is approximately 8 in. high, 14 in. wide and 6 in. deep, and weighs 10 lb

CRYSTAL

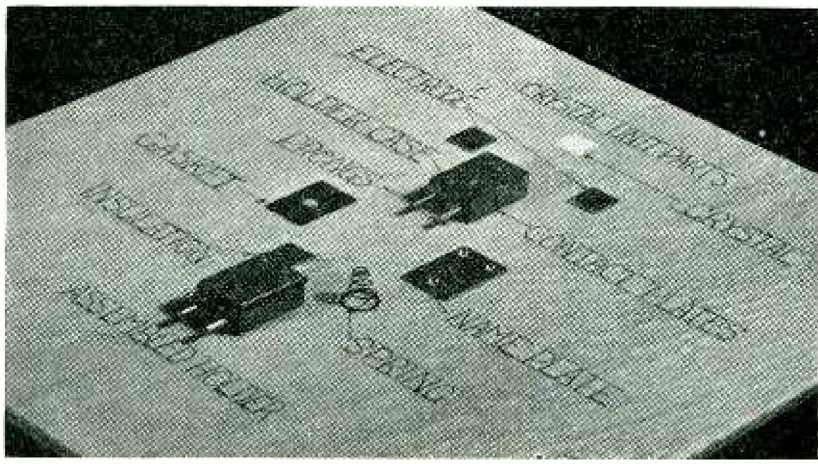

FIG. 1—Crystal holder type in cost common use

By L. A. ELBL
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In order to make a quartz crystal oscillate at a radio frequency, it must be placed in a radio-frequency field. This is accomplished by placing the crystal between two metal electrodes connected to a source of radio-frequency potential.

An assembly consisting of electrodes, terminals or pins used to connect these electrodes to an oscillator circuit, a housing supporting electrodes and pins, a protective covering, and accessory parts is called a crystal "holder" or "mounting." Such a holder serves the combined purpose of incorporating the crystal mechanically into an electronic device and electrically into the circuit. A holder, with a crystal in place, is known as a crystal "unit".

A crystal mounting must be so designed that it permits free vibration of the crystal and also affords adequate protection against dirt and moisture. Care in holder design and manufacture is essential since good crystals, improperly mounted, prove entirely worthless. The type of crystal mounting used is determined by the mode in which the crystal vibrates[1], with modifications for different frequency groupings and specific uses.

General Considerations

The most common type of holder, pictured in Fig. 1, is usually made of some nonconducting plastic, although metal can be used in conjunction with proper insulation. The electrodes are made of pure nickel, duralumin, monel metal, German silver, or stainless steel. The contact plates are usually brass or silver-coated brass. The name plates and prongs are ordinarily made of nickel-plated brass. The spring may be copper or steel. The gasket is generally cork, neoprene, or rubber. The insulation is Bakelite, Isolantite or comparable material.

No matter what type of holder is used, there are several requirements which it must fulfill:

(A) The material used for the holder case and insulation must have reasonably low losses at the frequencies involved and must be physically stable. Any material which contains gases or liquids which are freed when heating occurs in service is not satisfactory. The material must not be too brittle, since external chipping affects the outward appearance of the holder and internal chipping affects the electrical characteristics of the crystal unit.

(B) The electrodes, pins, and contact plates or points must be made of a material which will not readily oxidize or corrode, since either greatly affects the working efficiency of the crystal.

(C) All material used in constructing the holder, such as the flux and solder used in soldering pins and other connections, as well as steel wool used for cleaning, must be completely removed. Recently, these have given considerable trouble to crystal manufacturers. Because some of these materials not visible upon first inspection were freed during the final testing of the crystals (temperature and shake tests) many crystals were made unworkable and had to be rejected. Flux chemically affects both electrodes and contact plates. Rosin and steel wool collect between the crystal and electrodes, preventing free oscillation of the crystal.

(D) The electrode surfaces must be perfectly parallel and free from oil. The latter consideration is very important since oil impairs the activity of the crystal.

(E) The entire assembly must be moisture-proof and free from dirt and dust.

(F) The holder must provide for free vibration of the crystal and at the same time support the crystal with sufficient rigidity so that mechanical shock will not change the characteristics of the crystal.

Although most companies have developed their own particular styles of holders and are constantly modifying them, holders may be grouped into the following general classes: (1) pressure mountings, (2) clamp mountings, (3) air-gap mountings, (4) combined pressure and air-gap mountings, (5) wire-supported crystal mountings, (6) mechanically or hermetically sealed mountings, (7) temperature-controlled or temperature-protected mountings and (8) multiple-type mountings. Most of

HOLDER Design

Piezoelectric quartz plates used for frequency control in various types of electronic equipment must be incorporated in mountings which permit them to be readily and properly inserted, physically and electrically, within such gear. Eight varieties of mountings are described here, each of them having distinct advantages for certain applications

these types are pictured in Fig. 2.

Pressure Types

In the pressure type holder shown in Fig. 3, the electrodes are held in intimate contact with the crystal by means of a spring. This type of holder is particularly useful in applications where the mounting is subject to severe external vibration or shock, since the crystal is held rigidly in place. It can also be operated in any physical position without a change in frequency.

It has been found that there are optimum spring pressures for certain frequency ranges. Thus, where holders are to be used with different crystals covering a wide range of frequencies, variable spring pressure is frequently provided. This is done by placing the spring on a micrometer screw, so that by tightening the screw the spring pressure is increased. Where crystals having

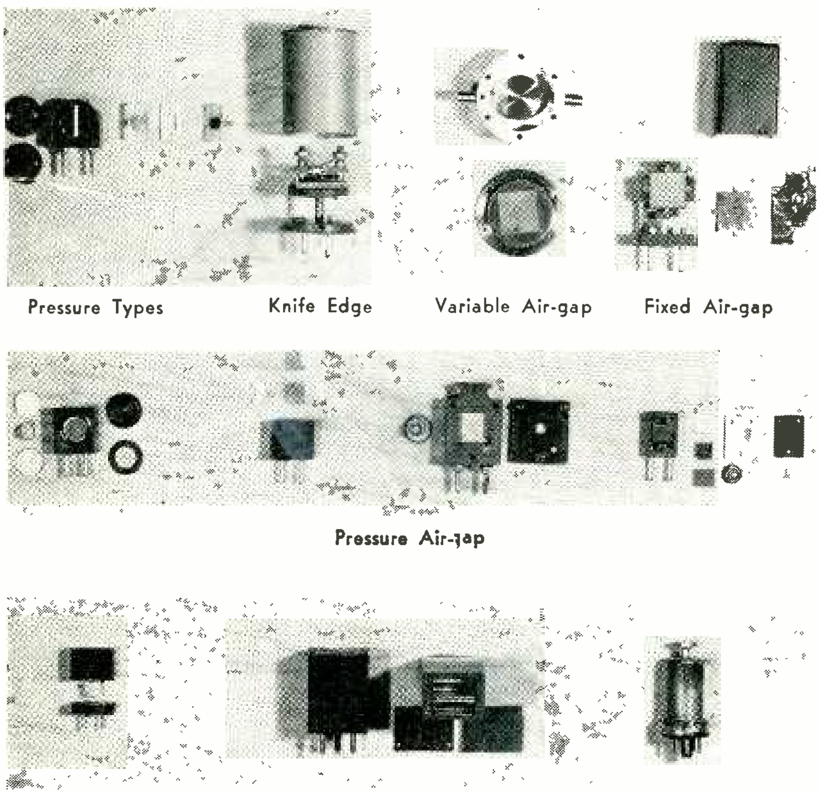


FIG. 2—Mountings of various types discussed in the text

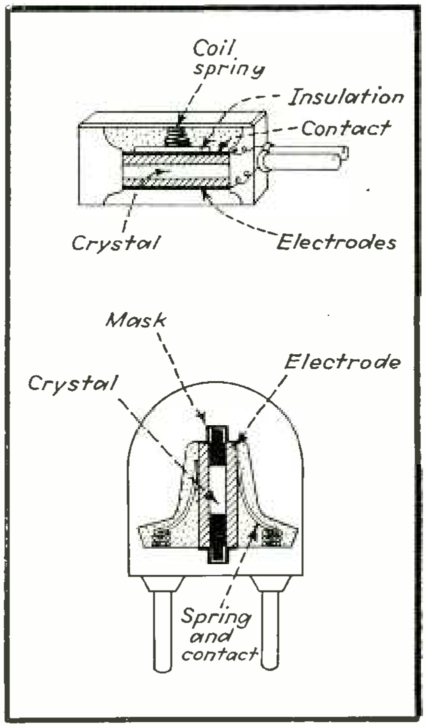


FIG. 3—Typical pressure type holders

closely related frequencies are being manufactured, the best average pressure is predetermined for each frequency group and springs providing this pressure are used during production. Very little spring adjustment is necessary for each individual crystal in this case.

Pressure type holders are used for "thickness" oscillators[1] operating between 1,800 and 30,000 kc. In holders designed to operate at low frequencies within this range the electrodes are usually perfectly flat and are approximately the same size as the crystal. In holders designed for use at higher frequencies within this range the size of the upper electrode is generally decreased to reduce the inter-electrode capacity.

Some companies use a disc as the upper electrode, while others recess a portion of the surface of a rectangular upper electrode, leaving a raised disc in the center and raised feet on the corners. See Fig. 4.

Clamp Types

The clamp type holder is a modification of the pressure type. Quartz crystals do not show equal vibration over their entire surfaces; that is, there are points of maximum vibration called antinodes, and points of minimum vibration called nodes.[1] The theory of the clamp type holder is to clamp the crystal between very small clamp-member areas at the nodal points. Electrodes of the metallic-coated type are used in such holders. A thin metal coating of silver or aluminum is evaporated or "sputtered"[2] onto the quartz crystal faces and is used in place of solid metal electrodes. The clamp then holds the crystal in place and at the same time makes contact with the electrode coatings. A good clamp holder must have small contact point areas, accurate alignment of points, and adequate pressure to hold the crystal in place.

Knife-Edge Holder

One type of clamp holder is the knife-edge holder shown in Fig. 5. There are four knife edges whose dimension along the length of the crystal is small and whose dimension along the width is just large enough to insure a rigid clamp. The nodal point of a longitudinally-vibrating crystal represents a straight line and thus we may use a knife edge instead of a single point.

Clamp Holders for Bar-Type Crystals

This type of holder is used for bar type crystals vibrating longitudinally or flexually[1] and covering the range from 15 to 280 kc. Extreme crystal activity is obtained with this type of holder. The frequency at which the crystal oscillates is less influenced by the characteristics of the holder than with most other types. Also, since the electrodes are formed directly on the crystal, the latter never need cleaning.

The clamp type is also being used for crystals vibrating as thickness oscillators. In this application, the crystal is clamped at the corners, which are the nodal points. Electrodes are plated directly on the quartz. The crystal surfaces are left unplated for short distances on opposite sides, at opposite ends, as shown in Fig. 6. This permits use of a simple combination clamp and contact assembly.

Air-Gap Types

In the air-gap type holder, there is an air-gap between the crystal and one or both of the electrodes. For operation lower in frequency than 1,800 kc, thickness oscillators of convenient size do not work properly when clamped, owing to the abnormal ratio of thickness to length. Such a crystal is conventionally mounted with a slight clearance between the upper crystal face and the upper electrode. Thus the crystal vibrations are not damped by the pressure of the upper plate. A further advantage of a spaced electrode is that the intensity of the electrostatic field across the crystal is reduced due to the use of what is effectively a series condenser in the crystal circuit. This reduced field helps to prevent breakage of the crystal due to dielectric failure of the quartz.

This class of holder can be further subdivided into (a) fixed air-gap holders and (b) variable air-gap holders

Fixed Air-Gap Types

The fixed air-gap type is not widely used except in connection with low-frequency filter crystals. In any type of air-gap mounting it is particularly essential to have the electrodes quite parallel. If this not the case the electric field will be unevenly distributed, tending to strain the crystal. In mounting electrode plates a fixed distance away from the crystal, a plastic mask or quartz spacers are frequently used. These hold the electrode a fixed distance away from the crystal and prevent lateral motion of the crystal at the same time. This type of holder is shown in Fig. 7.

When using a spaced upper electrode, the position of the upper electrode is quite critical. This critical position is a function of the radio frequency involved and the frequency of supersonic vibrations set up in the air of the gap by oscillation of the crystal. The activity of the crystal diminishes when the magnitude of the gap is a multiple of half the wave length of supersonic sound generated at the particular crystal frequency employed. When this condition exists, compressional waves leaving the crystal face encounter compressional waves rebounding from the electrode in such phase that a damping action is exerted on the crystal. The condition described is not serious at low frequencies since the distance between damping points is

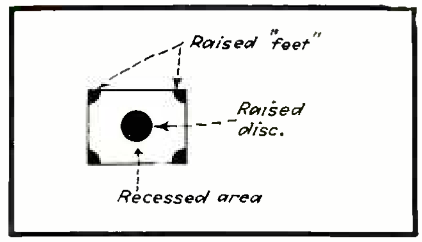


FIG. 4—Disc type electrode

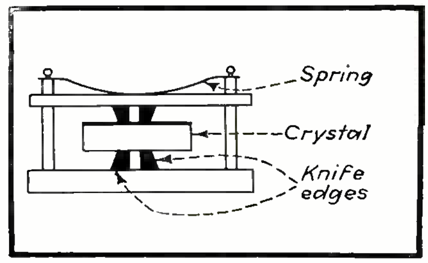


FIG. 5—Knife-edge holder

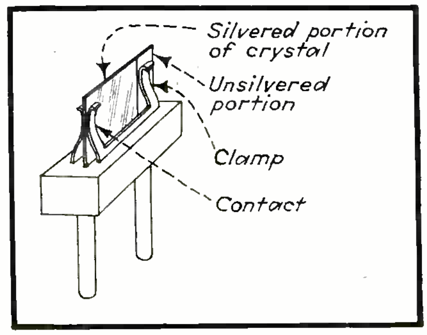


FIG. 6—Clamp type holder

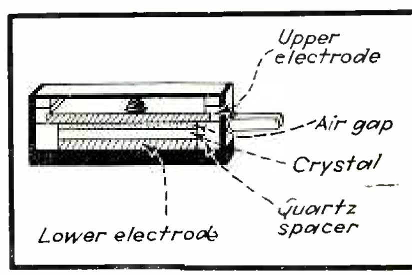


FIG. 7—Fixed air-gap holder

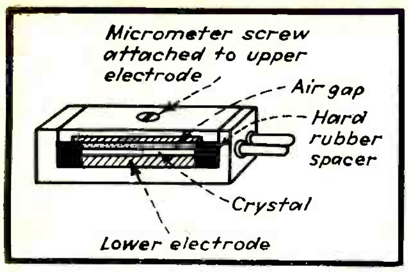


FIG. 8—Variable air-gap holder

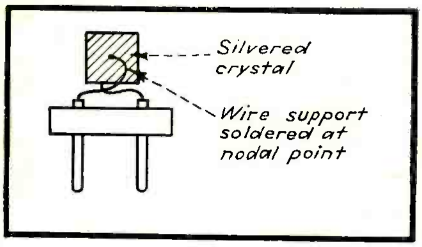


FIG. 9—Wire-supported crystal

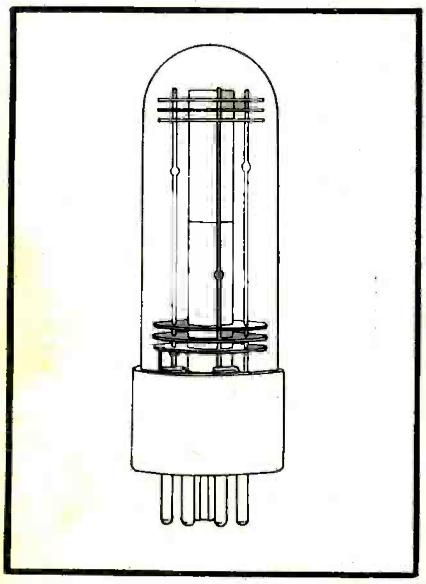


FIG. 10—Hermetically-sealed crystal holder

fairly large, but at high frequencies it becomes a factor.

Variable Air-Gap Types

In the adjustable or variable air-gap type of holder shown in Fig. 8, one electrode is fixed and the other is movable in a direction perpendicular to the major faces of the crystal. This is usually accomplished by permitting the crystal to rest on the lower electrode and attaching the upper electrode to a movable screw. The frequency can be varied over a relatively narrow range by changing the air gap. With a typical 5-Mc crystal the adjustment varies the frequency from 2 to 6 kc.

Reducing the air gap lowers the frequency and increasing it raises the frequency. Of course, this holds true only within certain limits. The air gap can be narrowed or enlarged only to a certain point without seriously reducing the activity of the crystal.

Frequency Range

The maximum frequency adjustment for this type of holder varies with the frequency of the crystal and also with the circuit. Frequency adjustment is particularly useful where the crystal must be maintained at an exact frequency or where the crystal has been ground for use in one type of circuit and is then used in another. This type of holder may conveniently be used to shift the frequency of transmission slightly to eliminate interference. Variable air-gap holders have been commonly ground for frequencies between 100 and 5,000 kc. Some companies manufacture such types that operate as high as 11,000 kc.

Pressure Air-Gap Types

The most common type of holder in use today is the combined pressure air-gap type of holder shown in Fig. 1.

As pointed out previously, a quartz crystal does not vibrate uniformly over its entire surface; that is, there are points of maximum and minimum vibration. In a crystal employing a BT or AT cut, vibrating in a thickness shear, the nodal points are at the corners of the crystal and these are small in area with respect to the surface area. Thus it is possible to clamp the crystal at its corners without impeding its vibration. In this type of holder the electrodes are recessed in the center by adding feet to the corners or stamping a recessed circular center into them.

Circular Pressure Air-Gap Types

One type of electrode is circular with a raised rim. Here the crystal corners are clamped by the rim. In this type of holder the crystal is held firmly in place by the tension of some type of spring. The recessed electrodes furnish the air gap, which is adjusted in manufacture. This type of holder lends itself particularly well to thickness oscillators operating between 1,500 and 9,000 kc. Its particular advantages include ease of manufacture, greater stability and improved performance. Variable air-gap holders are now made in the same design. A ring or frame is used to apply pressure to the corners of the crystal, and the upper electrode is adjustable. The frequency adjustment on such crystals is quite small, however.

Wire-Supported Types

Another type of mounting similar in principle to the pressure type mounting is the wire-supported crystal. See Fig. 9. This type of mounting has been found satisfactory for crystals having CT and DT cuts, which vibrate in a face shear. These have a single nodal point in the center of the face.

The crystals are silver-plated and are supported by wires soldered at their nodal points. The supporting wires also serve as a means of making electrical connections to the electrode coatings on the surfaces. After the supporting wires are attached to the crystal they remain in that position throughout the rest of the manufacturing process. The supporting wires provide a spring mounting even during production, protecting the crystal from shocks. After the wire has been soldered to the crystal, the unit is free from variation in performance due to slight changes in position and changes in contact resistance which prevail in pressure type holders.

Such a crystal unit is difficult to manufacture. The adjustment operations are, however, quite easy and the crystal case is very inexpensive. This type of holder is now, in some instances, being used in place of the knife-edge type and pressure type for low-frequency, bar-type crystals.

Sealed Types

Where crystals have to be absolutely dust-proof and moisture-proof, they are sealed either mechanically or hermetically. Mechanical sealing is generally accomplished with a flexible rubber or cork gasket and a rapid, hard-drying cement such as glyptol. All screws and nuts are covered with the glyptol and the holder is baked. Then the holder is usually tested under water.

Hermetic sealing is usually accomplished by soldering or electrically welding a metal cover and base together to form a case closely resembling a metal tube, using Fernico wire and fused-glass lead-ins. When crystals are sealed in glass, the procedure of mounting a crystal unit on a stem and sealing it is much the same as in the manufacture of a glass radio tube. See Fig. 10. Oxygen gas flames are generally used for sealing, since they are sharp-pointed and have a high temperature. After the glass tubes are sealed they have to be annealed or cooled slowly.

Advantages of Sealed Types

Sealed units have many advantages. They are not subject to variations due to changes in humidity. They have a high degree of stability. They can be made up and stored for periods of time with no worry of getting dirty. One disadvantage is that when crystals are sealed in a vacuum the absence of air around the crystal causes a slight change in frequency when the tube is evacuated. However, this change can be accurately allowed for when grinding crystals.

Some crystals are sealed in an atmosphere of dry air. Others, for high-power transmission, are sealed in neon or some other inert gas.

Temperature-Controlled Types

In temperature-controlled units, employed where the crystal frequency must be held constant over wide ambient temperature ranges, automatic temperature control is often provided in the holder. There is generally an integral heater winding, controlled by a thermostat, which maintains the crystal temperature within close limits.

Temperature-protected types are similar except for the fact that the arrangement used merely prevents the crystal temperature from falling below some fixed point, called the dew point. Usually this type of holder consists of a large temperature-controlled metal block, which encases the holder proper. Other temperature-controlled units are provided by placing any type holder in a box type oven. This arrangement provides very precise temperature regulation but is somewhat bulky.

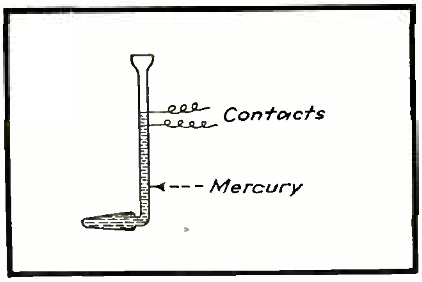


FIG. 11—Mercury thermostat

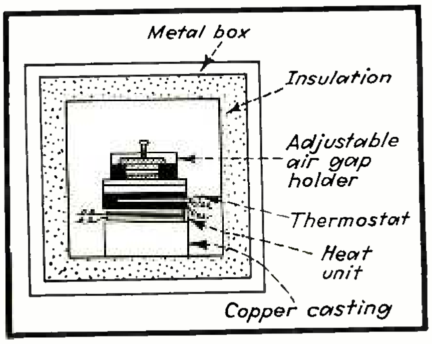


FIG. 12—Temperature-controlled unit

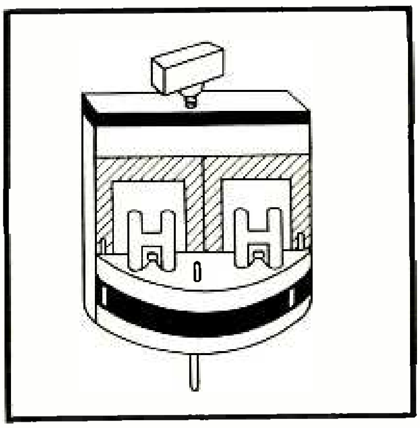


FIG. 13—Holder containing four crystals

It is obviously impossible to maintain a crystal at a temperature approximating room temperature without refrigeration. If a constant temperature is maintained solely by application of heat to the crystal, the fixed temperature is above room temperature, usually around 50 degrees C.

Viewed as a whole, the typical crystal oven comprises a heat-insulated chamber or box in which the crystal and its holder rest, an electric heating element for adding heat and a very sensitive thermostat for maintaining the temperature at a constant value. The oven or metal box is lined with a heat-insulating material. The thermostat is usually a very sensitive mercury-filled thermometer, into the stem of which has been fused two wire electrodes separated a short distance from each other as shown in Fig. 11.

By making the bulb of the thermometer large, so that it contains a relatively large amount of mercury, and by using a very small bore in the stem, a small change in temperature will cause a large change in the height of the mercury in the stem. When the thread of mercury makes contact with both of the electrodes in the stem a circuit is completed from one electrode to the other, which causes current to flow through a relay. This opens the circuit feeding the heating element and allows the oven to cool. The heating element is usually a resistor having a fairly large surface area, insuring uniform heating. See Fig. 12.

The heating and cooling period depends on the design of the oven. Generally, 30 seconds are required for the oven to heat and 1 minute to cool. The usual thermostat responds to changes of 0.1 deg. C. Typical ovens are held to 0.1 deg. C for X and Y cuts, and to 1 deg. C for BT and AT cuts.

Multiple Mounting Types

A recent trend in holders is the incorporation of more than one crystal in a holder. In some portable communication units one holder contains two crystals, one for transmitting and one for receiving. The shift from transmitter to receiver crystal is made by shorting out one of the oscillator circuits. This type holder facilitates construction of a compact electronic unit. As many as four crystals have been placed successfully in one holder. In these, the frequency desired is selected by means of a built-in, low-capacity switch. See Fig. 13.

Most companies are now doing considerable research on holders and several new types will probably "blossom out" after the war.

REFERENCES

(1) Elbl, L. A., Quartz Crystal Cuts. ELECTRONICS, p. 110. July 1943.
(2) Wein, S., Methods of Depositing Metal Films, ELECTRONICS, p. 102, Sept. 1943.

CHARACTERISTICS OF

Resonant Transmission Lines

Elementary characteristics of ideal or low-loss transmission lines are presented in convenient graphical form in this Reference Sheet. Voltage, current and resistance along resonant lines are portrayed, together with the equivalent resonant circuit at quarter-wave sections and the reactance for other lengths of open or shorted lines

By J. B. EPPERSON

Operational Research Branch, Office of the Chief Signal Officer, Washington, D. C.

THE important part which transmission lines play in modern radio communication makes it useful to have available in compact graphical form for ready reference a graphical interpretation of the behavior of such lines. For simplicity of presentation, the curves and diagrams (next page) in this Reference Sheet have been plotted on the assumption that the lines are free from losses. The presence of a slight amount of attenuation will not appreciably affect the general shape of the curves, and hence the diagrams are useful for many practical applications as well as for the ideal loss free case. If the line has appreciable attenuation, however, the curves given here must be modified slightly to apply to actual conditions.

In drawing the curves, the line is assumed to be fed from a generator whose output impedance is equal to the characteristic impedance of the line. With this stipulation, the wave is absorbed and dissipated and is not reflected from the sending end. The curves are drawn for lines whose distant ends are open or shorted, corresponding to infinite and zero resistance termination at the far end.

All of the data for which the chart has been compiled, is available at a glance. For example, the length of line required to produce a high impedance, a low impedance, an inductive reactance, or a capacitive reactance are directly evident.

Reading from top to bottom, the chart shows the following data for transmission lines:

1. The reactance curves for lines of any length. While the curves shown apply for lines whose length is one wavelength or less, the curves are periodically repetitive, and hence may be extended to lines of any length. For lines longer than one wavelength, it is convenient to determine the line characteristics by subtracting an integral number of wavelengths from the line. The remaining length of line will then be less than one wave in length, and its characteristics may then be determined from the graphs.

2. The electrical equivalent reactance for lines of various lengths between exact multiples of a quarter wave line. When the reactance curve is positive, the electrical equivalent reactance is inductive, whereas it is capacitive for lines of such length that the reactance curve is negative. The ideal line, free from attenuation behaves either as a pure inductive reactance or as a pure capacitive reactance within any given quarter wave section. Actual lines, in which some attenuation is present, will also show a resistive component as well as the reactive component, but this is not indicated on the diagram.

3. The resonant circuit characteristics of the line at exactly each quarter wavelength. The ideal line behaves as a series resonant circuit and as a parallel resonant circuit alternately every quarter of a wave long. In the ideal case the line has zero resistance when the series resonant circuit is used to represent it, and has infinite impedance for those quarter wavelengths for which it behaves as a parallel resonant circuit. Actually, real physical lines have more than zero and less than infinite resistance at these points. The line is resonant at 90 deg. intervals for both open and shorted cases, and for quarter-wave intervals, the line behaves alternately as a series and as a parallel resonant circuit.

4. The resistance and the voltage and current distribution for open and shorted lines is given. For convenience the resistance curve is plotted along with the voltage and current distribution along the length.

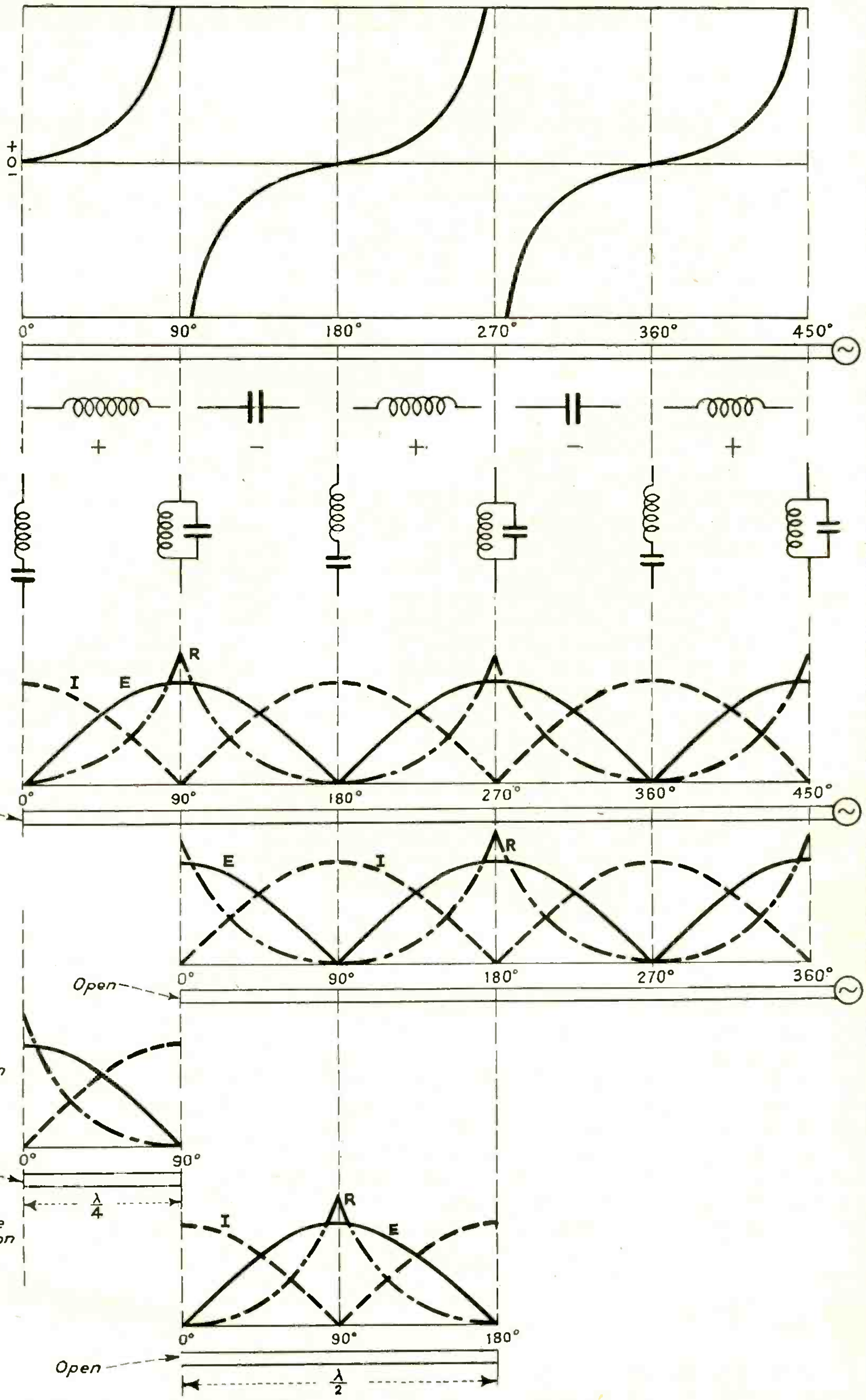
5. For the shorted line, the graphs show that, as measured from the shorted end, the line acts first as an inductance for the first quarter wave section, then as a capacitance for the next quarter wave section, and so on, alternately for each 90 deg. interval.

6. For the open end line, the graph shows that, as measured from the open end, the line acts first as a capacitance and then as an inductance, alternately, for each quarter-wave section.

7. The quarter wave diagram near the bottom of the chart is intended to show that a quarter wave section of line may be considered as a tuned circuit. If the line is slightly less than a quarter wave, it will present inductive reactance, whereas if it is slightly longer than a quarter wave, the section will assume the characteristics of a capacitance.

8. In a similar manner, the lowest diagram is intended to show that a half wave line may be considered as a tuned circuit element. If the line is slightly less than a half wave long, its reactance will be inductive, whereas the reactance will be capacitive if the line is slightly longer than a half wave.

RESONANT LINE CHARACTERISTICS



Tangent curves indicating reactance of line.

Reactance characteristic for each 90-deg. section of line

Resonant properties for line at exact quarter wave intervals. Line acts like alternate series and parallel resonant circuits

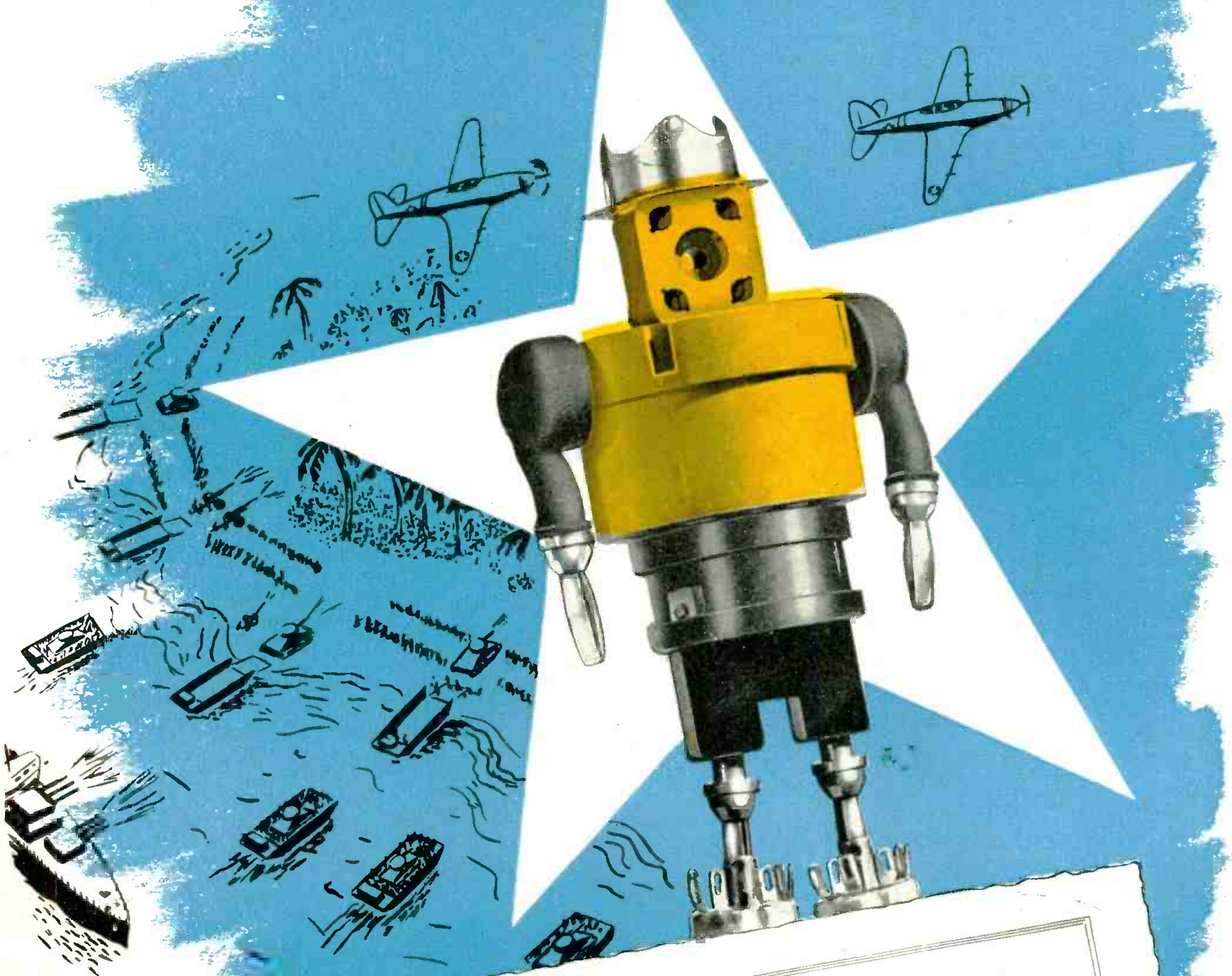
Resistance and voltage and current distribution along line shorted at far end

Resistance and voltage and current distribution along line open at far end.

Resistance and voltage and current distribution along quarter-wave line shorted at far end.

Resistance and voltage and current distribution along half-wave line open at far end.

A "SELF MADE" MAN—with YOUR help



An Appreciation

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THE HORIZONS ARE
OUT OF TODAY'S RESEARCH · · · TOMORROW IS ENGINEERED

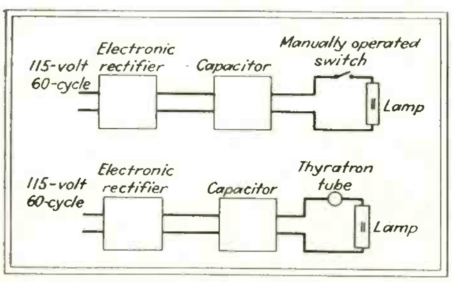
TUBES AT WORK

S. L. Bellinger and the high-speed portable flash unit. In his left hand he holds a phototube accessory for synchronizing the flash with the motion to be analyzed

Four-Microsecond Flash Unit

ANALYSIS OF HIGH-SPEED MOTION is now possible with a flash unit that has a speed of four millionths of a second. In this length of time an object traveling 2,000 feet per second moves but 0.096 inch and is practically "frozen" by a camera used in conjunction with the light.

The flash unit, developed by engineers in the laboratories of the General Electric Co., contains a 100-watt high-pressure mercury vapor lamp about the size of a cigarette. Flashing of the lamp is accomplished by charging a capacitor to a potential of 2,000 volts and then permitting it to discharge through the lamp. The rate of discharge is about 2,000 amperes, with a peak power of 4,000,000 watts, but due to the short duration of the flash the high current does not cause serious heating.



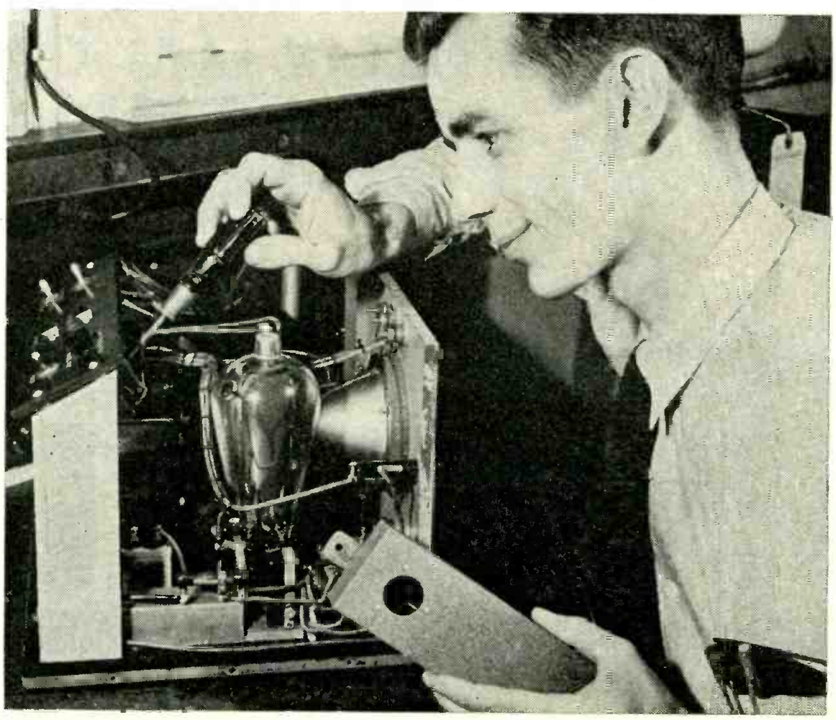
The upper block diagram shows the circuit for manual operation of the high-speed flash unit. The lower circuit includes a thyratron tube for automatic timing

Either of two methods shown in the block diagram may be used to flash the lamp. In one method a switch is placed in the discharge circuit and is operated manually to close the circuit between the capacitor and the lamp. The second method employs a thyratron tube as the switch to control the current through the lamp. With this method the flashing control over the 2,000-volt circuit is obtained by switching a 35-volt low-current circuit supplying the grid of the thyratron.

In order to actuate the thyratron and lamp at the proper moment, various synchronizing procedures may be used. These include making or breaking a light beam, tripping by the impact of sound or other compression waves, or making or breaking a simple electrical contact.

The amount of illumination obtained from the lamp at a distance of fifteen feet is photographically equivalent to over 1,000,000 foot-candles of light from tungsten lamps.

The life of the lamp is not definitely known, but one lamp was flashed at a rate of one flash every five seconds and was still in good operating condition after 330,000



Internal view of the flash unit for high-speed photography. The thyratron triggers 2,000 amperes at 2,000 volts from a capacitor through a mercury vapor lamp

Even the Big Inch Needs IRC RESISTORS

Vital arteries of supply in this mechanized war are America's pipelines. To maintain capacity flow, sludge and gummy deposits must be cleaned out at intervals. For this purpose a screw-type

ANOTHER IRC DEVELOPMENT

scraper propelled by the oil pressure is employed. When occasionally the scraper becomes stuck and plugs the line, the point of stoppage must be located to release the flowing oil.

But where—and how?

With the use of the Geiger-Mueller Counter, hours—and sometimes days—of search are saved. Modern scrapers contain radio-active metal which constantly emits an impulse message. When trouble occurs, these signals are picked up by the Counter, as the line is checked. At the point of greatest intensity the pipeline is tapped and the obstruction cleared away.

IRC engineering ingenuity plays an important part in the functioning of Geiger-Mueller Counters. Many specially designed IRC resistors and controls are employed in their carefully adjusted circuits.

If you have a design or engineering problem involving resistance units and you are seeking unbiased advice, why not come to Resistor headquarters at IRC? We make more types of resistors, in more sizes, for more applications than any other manufacturer in the world.

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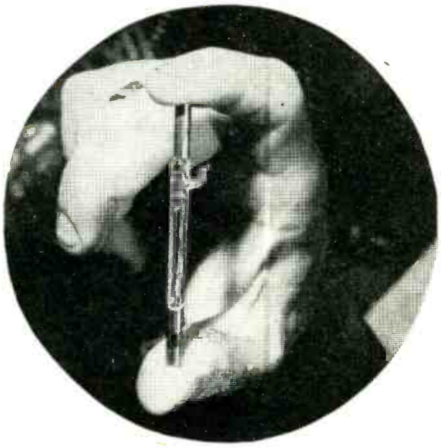
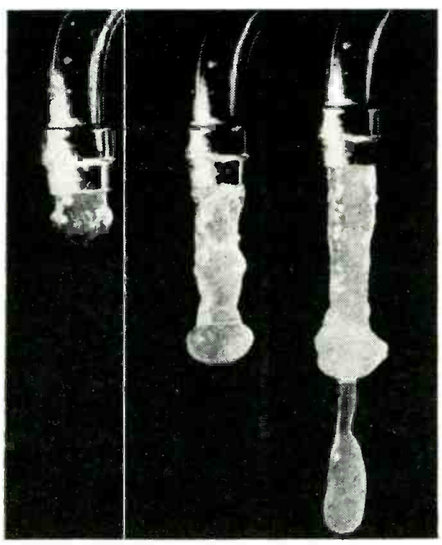


The mercury vapor lamp that burns but one second and has a light intensity equivalent to more than 1,000,000 foot-candles from tungsten lamps

flashes. The total additive time of this number of flashes approximates one second. Despite this brief period of life it is estimated by S. Lawrence Bellinger, who was active in development of the flash unit, that the lamp should last the average newspaper photographer several hundred years.



Three photographs of a faucet that has been suddenly opened. They were taken separately, at different intervals after opening the faucet. The picture at the right indicates that an air bubble was lodged inside the nozzle

Concerning the post-war possibilities of the unit, he further states, "Because of the pressure of war work, for which the unit was made, we have not been able to experiment fully with many fast moving objects. Rather, we have confined our efforts to using the device for studying high-speed machinery."

Electronic Control Developed for Helium-Shielded Arc Welding

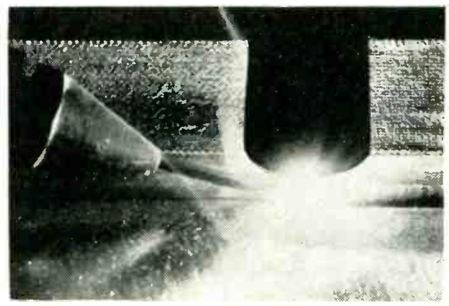
THE DEVELOPMENT of both manual and automatic arc-welding equipment specifically designed for the welding of magnesium, magnesium alloys, aluminum and other high-strength light alloys under a protective shield of helium gas is announced by G-E. Availability of such equipment should make possible the greatly extended use in war production of the lighter metals whose welding demands precise control of concentrated heat and protection of the molten metal from the oxidizing effect of oxygen in the air.

The pioneering work was done years ago by H. M. Hobart and P. K. Devers, G-E engineers, who discovered that fusion welding of magnesium and aluminum could be done in atmospheres of helium and argon, using tungsten and carbon electrodes.

A unit that is completely automatic after preliminary adjustment is now in use in the G-E welding laboratory. It makes a smooth, clean weld under a shield of helium gas at rates up to 40 inches per minute on $\frac{1}{8}$-inch stock. This machine incorporates a new electronic motor control which enables the equipment to hold the proper arc-length even while the arc climbs and descends on curved surfaces.

The filler metal is unreeled into the work at the correct angle through the small nozzle rod. The tungsten electrode used to start and maintain the arc extends through the center of the rod that is perpendicular to the work, and the helium gas is fed in around the electrode.

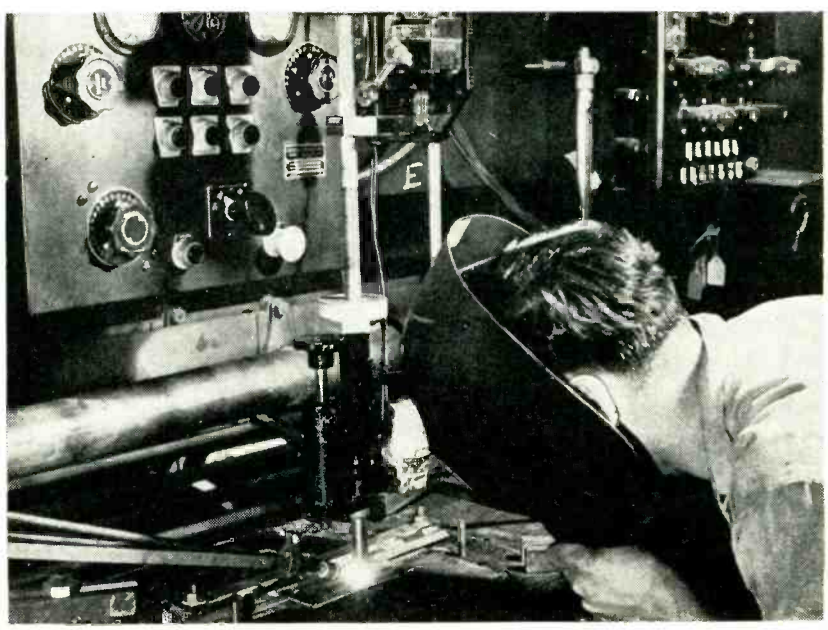
The rate at which filler metal is fed can be adjusted to a constant uniform feed into the arc, or a supple-



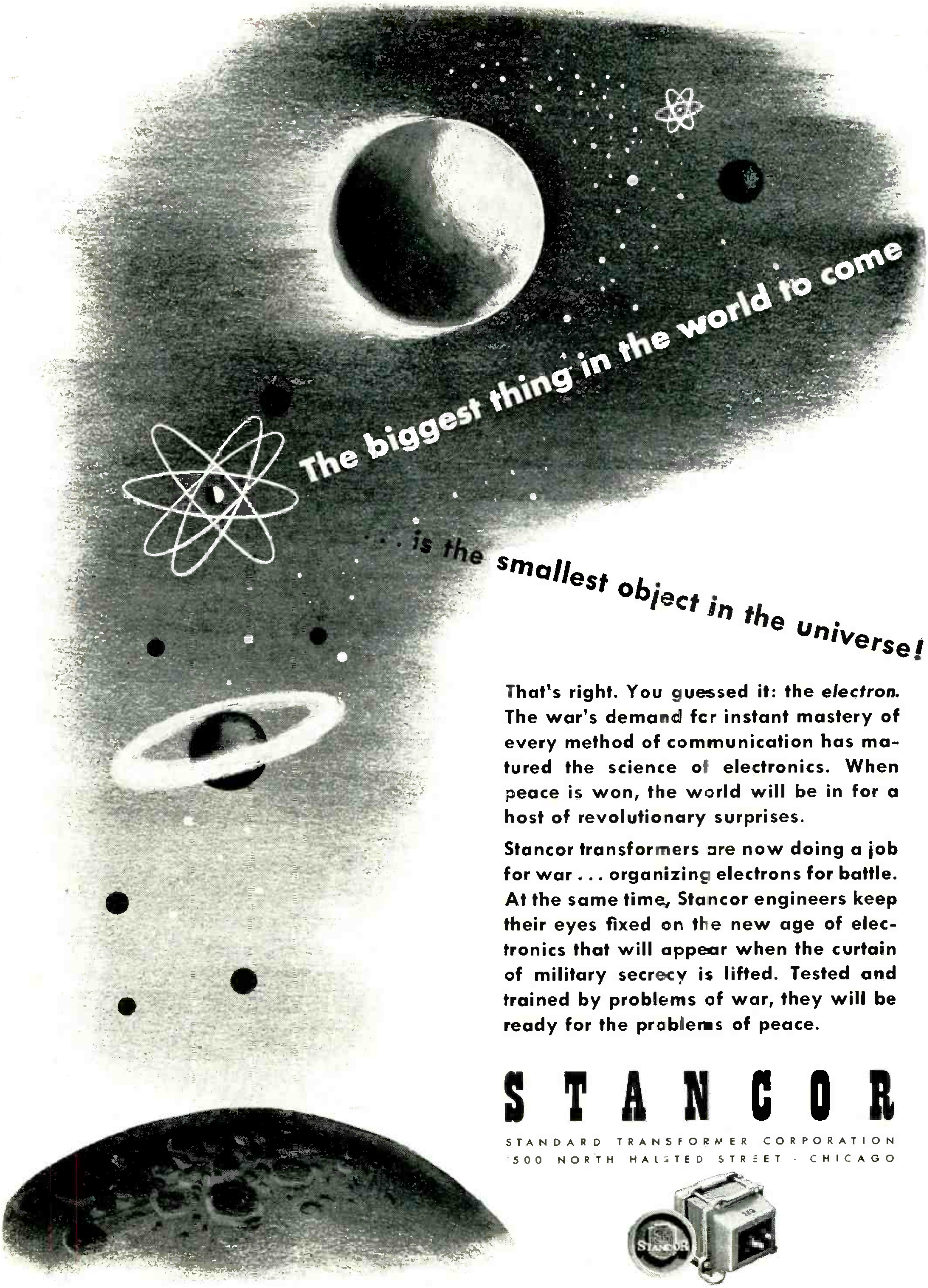
Close-up showing welding of magnesium plate. Extremely accurate control of the rate of feeding the filler wire into the arc zone through the tube at the left results in the uniform bead contour at the right

mentary control can be used to feed wire into the arc, withdraw it, and then feed it in again, all on a predetermined cycle.

The heart of the manual helium-shielded arc-welding equipment is a specially designed electrode holder which is arranged to hold either a



Automatic helium-shielded arc-welding equipment in use. The electronic control panel at the upper right controls arc length, while the main control panel at upper left handles all the other welding operations. The slanting tube at lower left feeds the filler wire into the arc. The tungsten starting electrode and the helium gas nozzle are perpendicular to the work, which is clamped to a moving bed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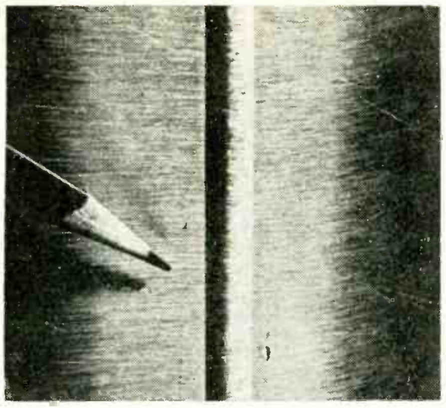


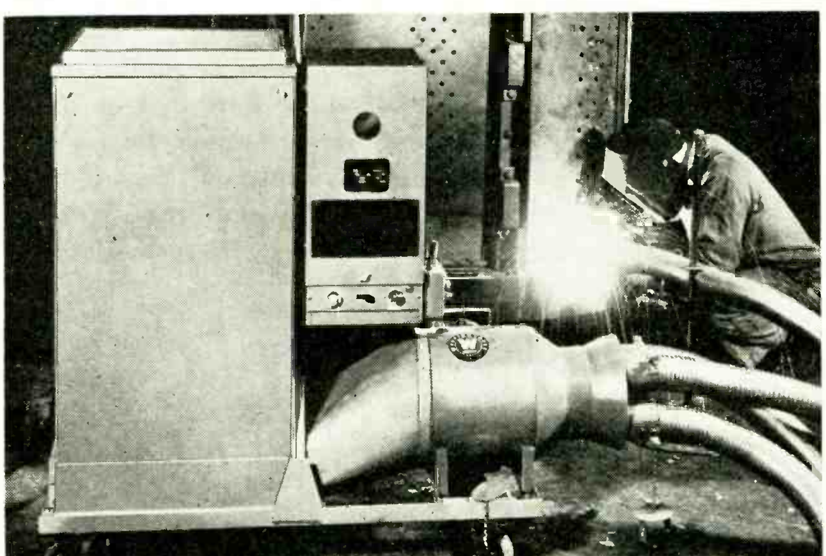
Example of butt joint made in ⅛-inch magnesium plate at rate of 24 inches per minute with G-E helium-shielded arc-welding equipment

tungsten or a carbon electrode, to conduct the welding current to the electrode and to surround the electrode with a stream of helium gas. The source of direct-current power for both manual and automatic welding is a standard G-E d-c arc-welding machine.

Supplies of helium have been made available by the Bureau of Mines for welding, especially for use in war production.

Electronic Welding Fume Remover

THE OBNOXIOUS FUMES produced by welding operations may be removed from the scene of welding activity by electronic means. The fumes are drawn through flexible metal hoses to a portable Westinghouse Precipitron electrostatic air cleaning unit, where 90 percent of the fumes and air-borne particles are removed before the air is returned to the room.



Fumes and air-borne particles may be removed from three welding positions simultaneously with this portable Westinghouse electrostatic air cleaner

Reclaiming Used Flashlight Batteries

By MAURICE E. KENNEDY

Communications Engineer
Los Angeles County Flood Control District
Glendale, California

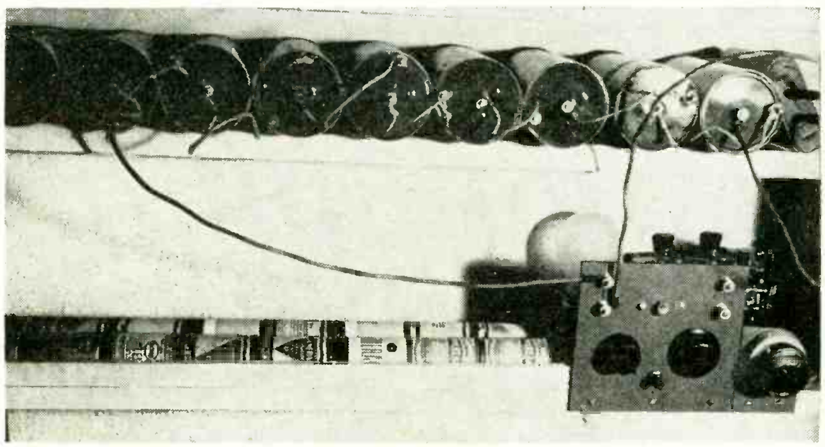
IN THE INTEREST of material conservation, the extension of the useful life of flashlight cells and other forms of dry batteries has considerable merit.

The process of depolarizing and reclaiming dry cells is quite simple and consists of the passage of 150 milliamperes of direct current through a number of the cells in series for a period of four hours or longer.

The charging device may be a simple half-wave rectifier with a suitable voltage control rheostat as shown in Fig. 1, or it may be a more elaborate full-wave rectifier with automatic voltage regulation.

Maintenance of the 150-ma charging current through a given number of cells is the determining factor in designing the rectifier. In large industrial plants, where the turn-over of flashlight cells by night guards and others is fairly great, it may be more economical to build a charger capable of charging a large number of cells at a time.

Battery racks should be built to accommodate the desired number of cells in series somewhat as shown in the photo. Spring contacts are provided at the ends of the cell rows to maintain pressure to provide contact between cells. Some provision should also be made to jump around cell rows when smaller batteries are in need of charging.



The power supply is mounted on one of the battery racks, where cells are held in contact by springs at the end of each row

A d-c milliammeter capable of reading 150 ma should be provided if available, but the substitution of a flashlight bulb of the 300-ma, 3.8-volt size will give a good average check. By using an external meter to set the original values, it is soon possible for the person operating the device to become accustomed to the correct brilliance of the lamp.

Care should be taken in selecting the cells to be reclaimed, as leaking

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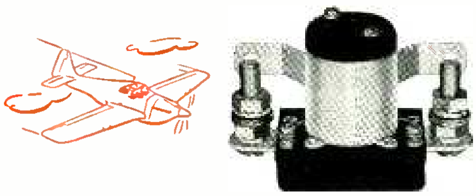

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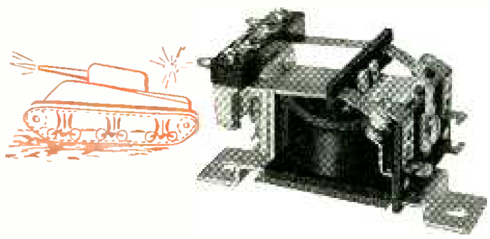

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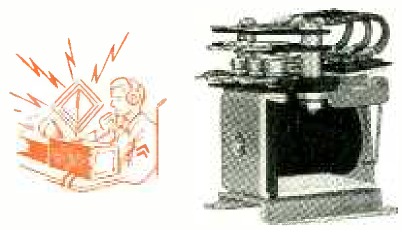
Rating for aircraft is 8 amperes at 24 volts D.C. Available with ceramic insulation for HF and UHF applications.



SERIES 345 RADIO RELAY

A general purpose radio relay designed for aircraft use. Contact combinations up to three pole, double throw. Coil resistances range from .01 ohm to 15,000 ohms. Standard voltage: 16-32 volts D.C. Available with delayed release or delayed attract. Weight: 6½ oz. Also built for A. C. operation (Series 340).

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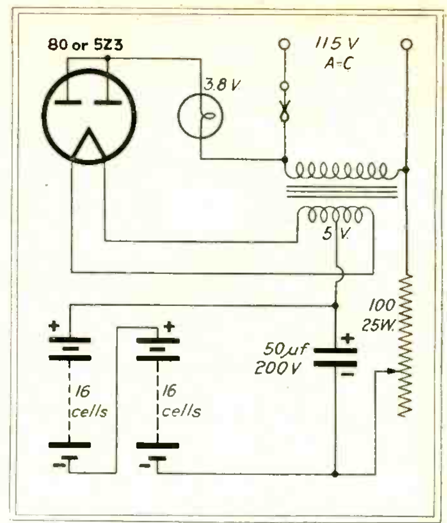

Fig. 1—Circuit used for reclaiming dry cells. The rheostat is used to adjust the charging current to 150 ma when fewer cells are being charged

cell cases will damage the flashlight when returned to service. It is generally good practice to discard any cells with suspicious looking bulges or leaks in the zinc cases.

The rejuvenation period will vary with the individual cell and is no doubt due to the internal moisture condition of the cell, the cell formula used in its manufacture, the age of the cell, the type of service in which it was expended during its first or normal life cycle, and other factors. Most cells will return to above-normal voltage within four to eight hours.

A voltage-stabilizing period of about six hours should be observed following the charging period as a final check on the cell before returning it to service. This shelf period will also permit the cell to return to normal voltage and prevent the burning out of flashlight bulbs often experienced with freshly charged batteries.

Numerous life tests have been made on new and reclaimed flashlight cells of different makes. Typical curves of five life cycles are shown in Fig. 2. These tests were made with three cells connected in series in order to arrive at an average condition for the given type of cell. Placing a 250-ma load on the cells for a 30-minute period, then removing the load for a 15-minute rest period was considered to be a fair approach to actual operating conditions.

Judging from numerous tests with cells of all makes, it has been found

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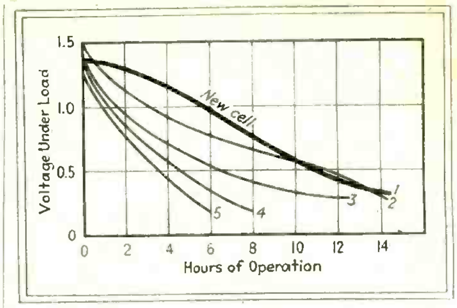

Fig. 2—Life cycle of a flashlight cell with a load of 250 ma when new (curve 1) and after repeated recharging (curves 2, 3, 4 and 5). The load was applied for 30-minute periods and removed for 15-minute periods to simulate operating conditions

possible to repeat the rejuvenation process and corresponding life cycle of the better grades of dry cells about four times. A few cells have been depolarized and reused over thirty times in actual practice. The normal discharge conditions of these were not as severe as the test loads, and the exceptional cells were individuals and not groups of three. Best results were also noted from fresh new cells, expended over periods of about two weeks, reclaimed before they were entirely dead, and reused under similar conditions. Cells that are permitted to stand in a totally discharged condition for long periods can seldom be reclaimed.

It is desirable to keep small numbers of dry cells in rotation through the discharge and recharge cycles in preference to charging large numbers of cells to be expended in shelf life before returning to service.

Other types of dry cells, such as the familiar No. 6, the numerous types of hearing-aid batteries, radio batteries, and others have been reclaimed with somewhat less success. The larger cells take a fairly long charging period but seem to respond in a satisfactory manner if they are not too old. Again it would appear that only the cells with sufficient internal moisture in the electrolyte can be reclaimed.

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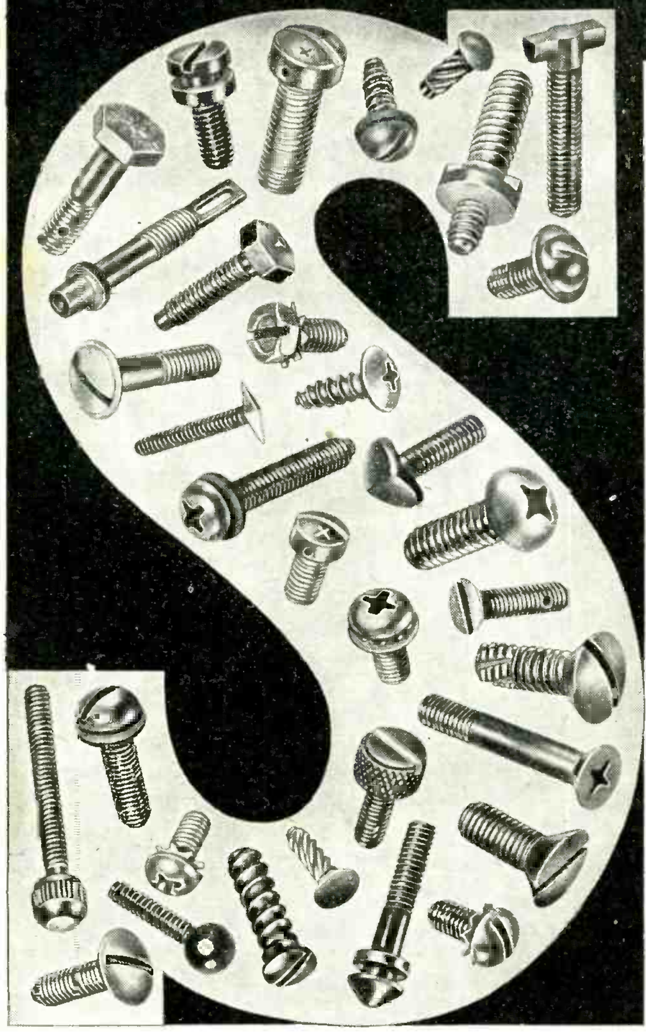

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Variable B Voltage Supply for Lab or Classroom

By A. H. BROLLY, *Senior Instructor* and J. L. LAHEY, *Lab. Instructor*

U. S. Naval Training School (Radio Materiel), Chicago, Ill.

A SOURCE OF VARIABLE B voltage is often required in laboratories, service shops, and classrooms. An important application is found in many of the wartime radio courses where experiments dealing with vacuum tube characteristics are performed by large groups of students.

Variable B voltages can, of course, be provided by means of variable transformers or resistance dividers but cost, present availability and other disadvantages leave room for another approach to the problem.

The device to be described in this article can be put together from simple, inexpensive parts which are obtainable at present. It can be added to any small power supply having a couple of spare filament windings and its performance is ideal for the applications suggested above.

Briefly, the principle involved is to employ a tube having low plate resistance as a variable resistor, its value being varied by means of the grid bias to effect the desired control. In the diagram, Fig. 1, a 6A5G is used as the resistance which is varied from an equivalent value of 900 ohms to practically infinity by a change of bias from zero to −100 volts. The 2A3, 6A3 or 6B4G could be used in lieu of the 6A5G if desired.

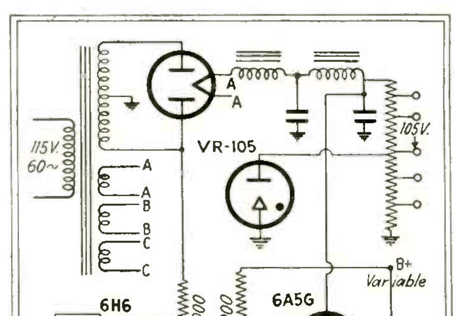

Fig. 1—Circuit of variable-voltage power supply that employs a vacuum tube as the output voltage control

The cathode of the tube in this position is above ground by the amount of the output voltage, hence a separate heater winding is required which can be allowed to assume this potential. One tube of the type suggested is good for an output of 60 to 70 ma. Two or more tubes may be connected in parallel to handle more current. When tubes are paralleled, suppressor resistors must be placed in series with their grid leads to prevent parasitic oscillations. Anywhere from 50 to 500 ohms is satisfactory, but the resistors should be connected directly to the socket pins as close as practicable.

Bias Supply for Control Tube

The bias for the control tube or tubes is provided by separate rectification with a type 6H6 tube. The 6H6 is particularly well adapted to this use because of availability and low cost and because it is designed to allow a difference of potential of 330 volts between heater and cathode. The separate cathodes of the 6H6 make possible an important feature of the circuit, as will be shown later. The cathode of diode T_1, being connected to one end of the main transformer, rectifies the peak negative swings. This rectified current charges capacitor C_1, and, passing through potentiometer R_1, provides the required bias. R_1 and C_1 act as a filter to smooth out the bias voltage. Ripple in this bias affects the plate current of the control tube and in-

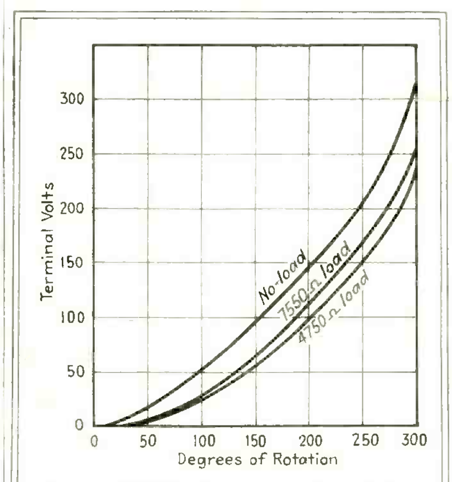

Fig. 2—Voltage changes produced at varying degrees of rotation of control potentiometer. The two lower curves show typical load conditions, and the third shows readings obtained on a 1000 ohm-per-volt meter with no other load

troduces ripple in the output voltage.

The values of R_1 and C_1 given in Fig. 1 were found to introduce a 60-cycle ripple of 5 volts rms. At very light loads this ripple persists down to low d-c terminal voltages where it is appreciable. However, this is not objectionable for tube characteristic measurements and such applications and at even moderate loads it is negligible throughout the range. If less ripple is required, a larger value of C_1 may be used or the control tube can be placed between sections of the main filter. The peak voltage on the capacitor for the circuit shown in Fig. 1 is only 109 volts, so a small capacitor can be used. It may have a tendency to reverse polarity by a few volts under some circumstances so it is advisable to use a paper rather than an electrolytic capacitor.

Effect of Potentiometer Taper

For potentiometer R_1, 1000 ohms is a good value as it gives a value of series resistance in the grid circuit of the control tube which is within the manufacturers' rating. It also permits filtering with economical values for C_1. A linear taper is satisfactory. If any other taper is chosen care should be taken to connect the potentiometer in such a way as to compensate for the typical curvature in the control characteristics illustrated in Fig. 2, otherwise it will exaggerate this slight disadvantage. Some nominally linear potentiometers have considerable taper effect at both ends of the scale. These are particularly unsatisfactory for this application. The dissipation in this potentiometer will not exceed one watt if other quantities are approximately as shown in Fig. 1, hence an ordinary receiver-type volume control potentiometer can be used.

The 125,000-ohm fixed resistor R_2 connecting the bias tube with the transformer serves to drop the high voltage to a value suitable for bias. In ordinary supplies delivering around 250 volts, this resistor should have a rating of 2 to 3 watts. The advantage of placing this voltage-dropping resistor on the a-c side of the rectifier rather than the d-c side will be apparent when the function of diode T_2 is considered. With its inverted connection T_2 passes current when T_1 is inactive, thus pro-

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ducing a voltage drop in R_3 on both halves of the cycle. This accomplishes two purposes. First, it keeps the peak inverse voltage within the rated limit of the tube and second, it keeps the cathode-to-ground potential from rising above the rated cathode-to-heater voltage. This makes it possible to operate the 6H6 heater on a supply that is used for other tubes where grounding the heaters is required. Operation of the 6H6 heater from the same supply as the control tube is not advisable.

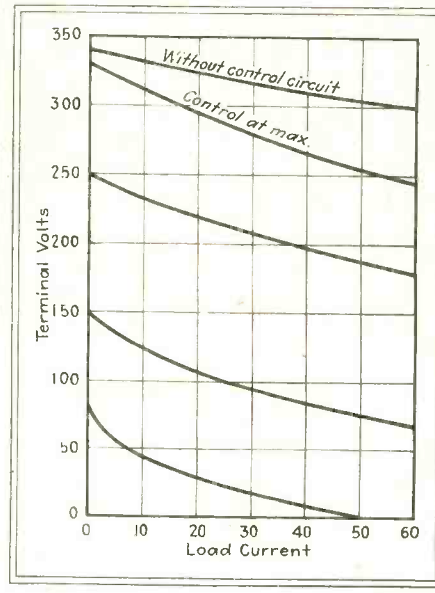

Fig. 3—Regulation curves obtained with voltage control at various settings. The top curve is for the power pack alone, without the control circuit

The currents rectified by the 6H6 are greatest when there is no load on the power supply and when the control is set for maximum output voltage. Under these conditions the direct current in each section of the 6H6 is 3 ma, which is well below the rating for the tube. The peak cathode-to-ground voltage and the peak inverse voltage on section T_1 are only about 120 volts, which is well below ratings, assuring reliable operation.

Balancing Reverse Current Flow

The current through potentiometer R_1 must return either through the control tube or the load. This current is in the reverse direction to the principal load current and tends to develop a small reverse voltage across the load when the control is turned down. This is remedied by finding a balance between R_1 and R_2

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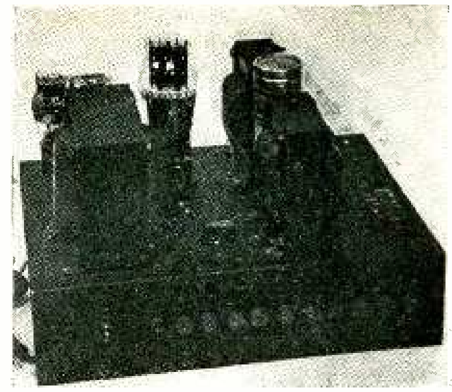

Fig. 4—Complete power supply with vacuum tube voltage control

such that the control tube is never completely cut off. It will then pass enough current to just offset the bias current and bring the terminal voltage down to zero at the extreme setting of the control potentiometer.

Fig. 2 shows the control characteristics with three typical loads. They are not linear but their slope is sufficient near both ends so that the control is reasonably effective at the extremes. This is convenient for work where it is desired to make fine adjustments of voltage throughout the range. Since the device is essentially a series resistance device, it might be expected that its regulation would be very bad but this is not the case, as may be seen from the regulation curves in Fig. 3. Since a supply of this kind will probably not be used for intermittent loads the regulation is quite satisfactory.

Where a supply with this type of control is used for vacuum tube characteristic tests, it is convenient to provide a constant screen supply. This can be done by adding a voltage regulator tube (VR105 or VR150), connecting it with a suitable series resistor to a point ahead of the control tube. A separate output terminal must then be provided for connecting the screen circuit across the VR tube.

A considerable number of these supplies have been built for use in the laboratory of the Naval Training School (Radio Materiel), Chicago, Illinois, where they have been in use for many months and have proved very useful and satisfactory.

A TOTAL OF 144 AM stations plan to file applications for FM transmitters when the war ends or before, according to a recent G-E survey.

A Thermostatic Control System

By JACK G. ROOF

Oregon State College, Corvallis, Oregon

IN AN EARLIER NUMBER of this journal a phototube temperature regulator is described by Weinland[1]. In this controller the emf of a thermocouple is balanced out by the voltage drop along a slide-wire potentiometer attached across a battery. Any change in emf of the thermocouple, due to deviations of furnace temperature from that desired, results in a movement of a galvanometer mirror which reflects a beam of light onto one of two phototubes. An electrical circuit then either turns the heater off or on, depending on which of the two phototubes was activated. With Weinland's regulator, "overshooting" a phototube does not cause a loss of control; thus no mechanical stops are necessary on the galvanometer.

A regulator that operates on the principles mentioned above was devised independently by the author and was used for a time in thermostating a molten lead bath at 400 deg. C. However, the thermocouple-potentiometer control for the galvanometer was soon replaced by a resistance thermometer-Wheatstone bridge system, which offers certain improvement in sensitivity and stability. The circuit used is shown in Fig. 1.

To start heater H, relay S_3 is closed manually. When closed, S_3 locks in due to its sending current through its own coil. As the temperature rises and resistance thermometer R_1 increases in resistance, the bridge approaches balance. The galvanometer swings the light beam in a clockwise direction. While phototube VT_1 is activated, relay S_1 closes, which act would normally close S_3. As the light beam swings from VT_1 onto VT_2, relay S_2 is activated, breaking the circuit through the coil of S_3; when S_3 is open, the heater is turned off. The heat is off until the light beam returns to VT_1. Coasting past a phototube or the presence of vibrations, causing multiple impulses to be sent to the phototubes, does not result in loss of control.

The circuit indicated by amplifiers A_1 and A_2 is described by *RCA*[2] and shown in Fig. 2. The resistances R_2,

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RCA-3EP1/1806P1: Similar to RCA-3BP1, except: a) Neck diameter is 1⅜ inches: b) Magnal base; c) Cathode connected to heater inside of the tube.

RCA-5CP4: A 5-inch, high-vacuum tube with extra high voltage electrode, (anode No. 3). Electrostatic deflection and focusing. Separate leads to *all* electrodes. White fluorescence. Medium persistence. Neck diameter, 2 inches. Overall length 17 inches. Diheptal base. Anode No. 3 brought out to snap terminal on bulb.

RCA-7CP1/1811P1: A short, 7-inch, high-vacuum tube. Magnetic deflection. Electrostatic focusing. Green fluorescence. Medium persistence. Neck diameter, 1⅜ inches. Overall length, about 13½ inches. Octal base. Separate leads for all electrodes. Anode No. 2 brought out to snap terminal on bulb.

RCA Victor Division • RADIO CORPORATION OF AMERICA • Camden, N. J.

The Magic Brain of All Electronic Equipment Is a Tube — and the Fountain-Head of Modern Tube Development Is RCA.

TUNE IN "WHAT'S NEW?" RCA's great new show, Saturday nights, 7 to 8, E. W. T., Blue Network.

RCA ELECTRON TUBES

ASK FOR THESE SHEETS

RCA Commercial Engineering Section
Radio Corporation of America
509 South 5th St., Harrison, N. J.

Please send me the data sheets on the following tubes:

☐ 2AP1 ☐ 3BP1 ☐ 3EP1
☐ 5CP4 ☐ 7CP1

Name ....

Company ....

Street ....

City .... State ....

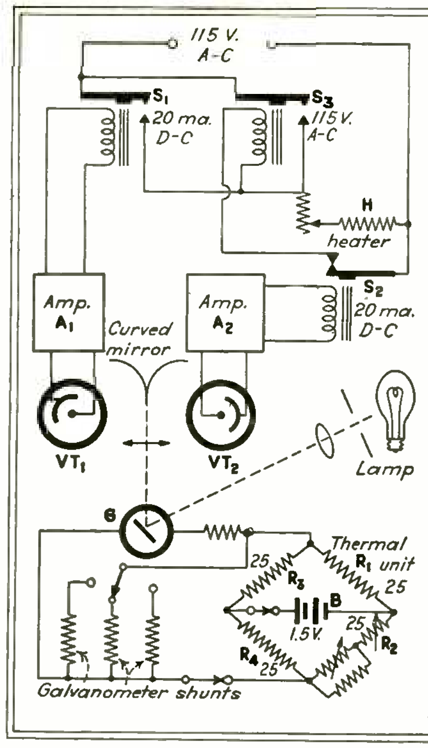


Fig. 1—Complete circuit of thermostatic control. Light from the lamp is reflected to one of two phototubes by a mirror galvanometer that responds to unbalance in the bridge circuit

R_3 and R_4 should be of a material of low temperature coefficient to avoid the necessity of thermostating them at room temperature; nichrome was considered to be satisfactory.

In Weinland's circuit a change in the voltage of the battery opposing the thermocouple would result in a change in the temperature at which the regulator was working. In a Wheatstone bridge a decrease in battery voltage would result in decreased sensitivity of the apparatus, but the controlled temperature would not be affected. This is a rather important item in using a regulator over a long period of time.

The sensitivity of the Wheatstone bridge system described is greater than that of a thermocouple. For an iron-constantan couple the increment of voltage is only about 55 microvolts per degree at 400 deg. C when no load is drawn. To calculate the sensitivity obtainable with a bridge, consider the temperature coefficient of nickel wire. The resistance r_t of a wire at temperature $t°$ C is often expressed as an empirical function of t and r_o, the resistance at 0° C:

$$r_t = r_o(1 + \alpha t + \beta t^2)$$

Differentiation and elimination of r_o gives

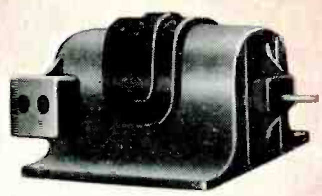
$$\frac{dr_t}{dt} = r_t \frac{\alpha + 2\beta t}{1 + \alpha t + \beta t^2}$$

THE "Wondergift" PALM

Only the gods can read the entire electronic palm, but electronic engineers are learning fast. On their boards already are "wondergifts" to man that almost stagger the imagination.

Each new electronic advance calls for a special motor or generator—often a super-special one. That, implies a motor builder in position to work out the exacting power problems involved. That, means Leland.

Over the last two decades Leland has emphasized special motor designs in many fields—is already serving electronics in a score of ways—shall continue to do so as special drive and power generating problems arise to demand special engineering.



Consult Leland, if possible, forwarding preliminary data with the inquiry.

FOR BETTER DESIGNED POWER GENERATORS

THE LELAND ELECTRIC COMPANY • DAYTON, OHIO

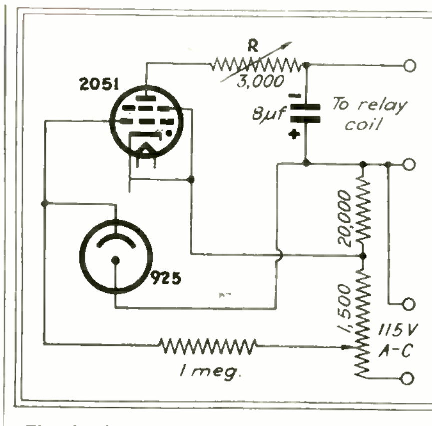


Fig. 2—Circuit of amplifier used at A_1 and A_2 of Fig. 1. Resistor R limits plate current to less than 25 ma, and its value depends on the impedance of the relay

For nickel these coefficients α and β are given [3] as 5.44×10^{-3} and 6.0×10^{-6}, respectively. Thus a nickel wire having a resistance of 25 ohms at 400 deg. C would, at that temperature, have a coefficient of approximately 0.062 ohm per degree.

That such change in resistance is usable with an insensitive galvanometer may be shown from the equation of a bridge out of balance [4]. If we let R be the resistance of each of three equal arms and $R+\Delta$ be that of the fourth, and let V be the emf across the bridge, then by applications of Ohm's and Kirchhoff's laws one can show that the current passing through a galvanometer of resistance R_g will be

$$i_g = \frac{V\Delta}{4R^2 + 4RR_g + 3R\Delta + 2R_g\Delta}$$

or for values of Δ that are small compared to R and R_g

$$i_g \simeq \frac{V\Delta}{4R\,(R + R_g)}$$

If the sensitivity of the galvanometer is given in terms of voltage,

$$E_g \simeq \frac{R_g V\Delta}{4R\,(R + R_g)}$$

With applied emf of 1.5 volts, Wheatstone resistance of 25 ohms, and a temperature change of one degree at 400 deg. C, a galvanometer with coil resistance of 100 ohms would have a current flow of about 8 microamperes or a voltage drop of about 800 microvolts (compared to 55 microvolts for an iron-constantan couple). Galvanometers in the \$25 price range (e. g., the Leeds and Northrup type P) have sensitivities of the order of 0.001 to 0.01 microamperes or about 1.5 microvolts per millimeter at one meter. One degree temperature change would give deflections of the order of 500 to 1000

mm. If this were the limiting factor, temperature regulation of the order of ±0.01 deg. would be possible with such galvanometers by using phototubes only 0.5 meter from the galvanometer mirror. The sensitivity of the system may be doubled [5] by having two opposite arms of the bridge serve as resistance thermometers in the bath (i. e., R_4 as well as R_1).

If a more sensitive galvanometer is used, or even to protect a less sensitive one while approaching the desired temperature, one should use shunts across the galvanometer. The multiple-contact switch should be of the shorting rather than the non-shorting type; thus one will never throw the full emf of unbalance across the galvanometer while switching from one shunt to another.

There is an upper limit to the temperature at which a resistance thermometer may be used because of its oxidation or changes in insulation. Nickel permits higher temperatures than does iron, while platinum withstands still higher temperatures but at the expense of decidedly lower temperature coefficients. The sensitivity of response is greater at lower temperatures. Nickel wires having resistance of 25 ohms at the specified temperatures would have the following coefficients at those temperatures: 200 deg. C—0.084 ohm per degree; 400 deg.—0.062; 600 deg.—0.049.

In the author's use of this controller full benefit of the possibilities was never derived due to the high thermal lag of the air space between the alundum-covered heating coils and the iron vessel holding the molten lead. The lag was so large that a low-resistance shunt was necessary across the galvanometer to prevent overly large swings of that instrument. The extreme variations in temperature as measured on an iron-constantan thermocouple with a potentiometer were less than ±0.25 deg. as read at one-minute intervals over periods of one hour.

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(4) J. C. Maxwell, "Treatise on Electricity and Magnetism," Vol. I, Article 347, 2nd edition, 1881, Oxford Press.
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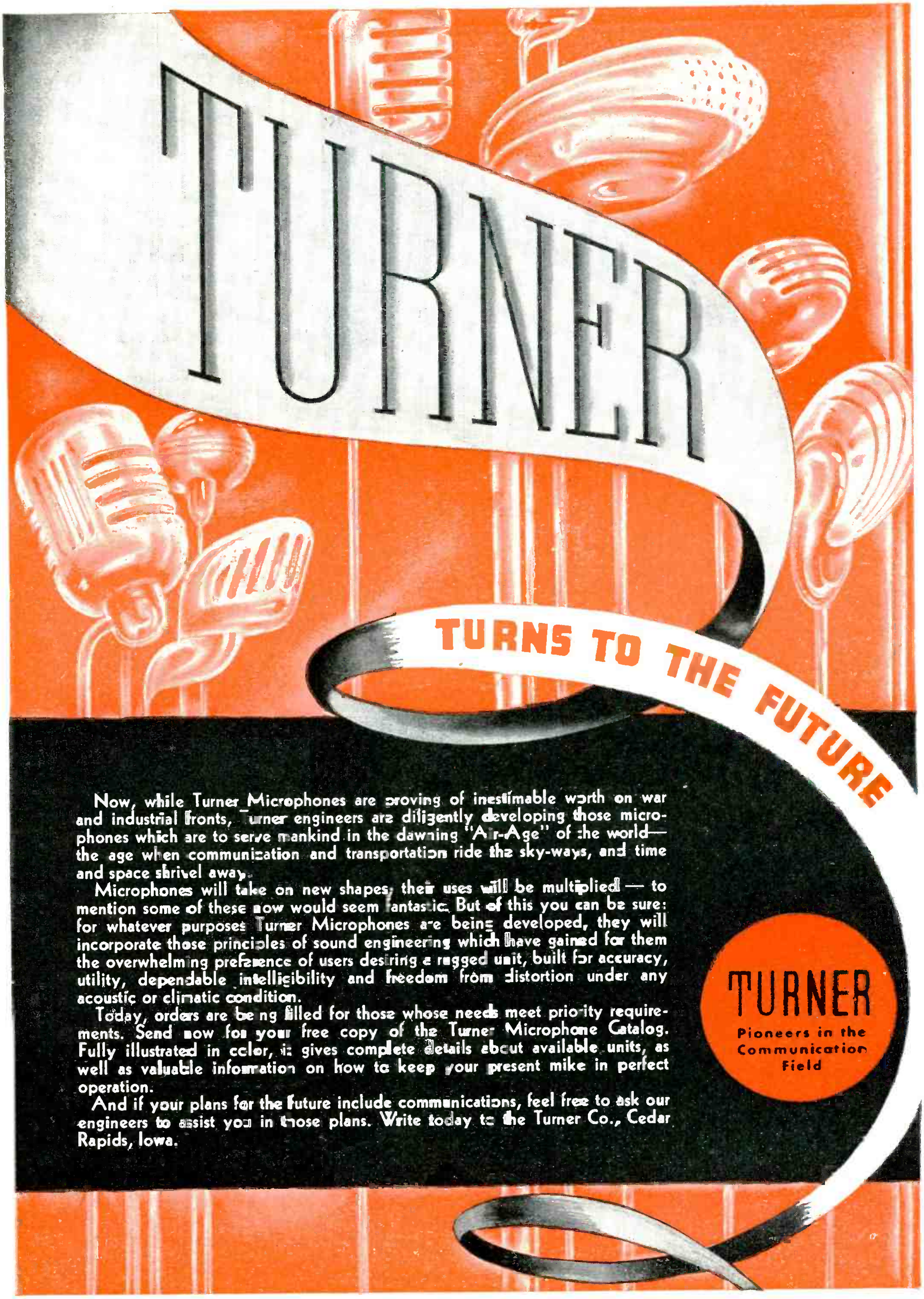
TURNER
TURNS TO THE FUTURE
Now, while Turner Microphones are proving of inestimable worth on war and industrial fronts, Turner engineers are diligently developing those microphones which are to serve mankind in the dawning "Air-Age" of the world—the age when communication and transportation ride the sky-ways, and time and space shrivel away.
Microphones will take on new shapes; their uses will be multiplied — to mention some of these now would seem fantastic. But of this you can be sure: for whatever purposes Turner Microphones are being developed, they will incorporate those principles of sound engineering which have gained for them the overwhelming preference of users desiring a rugged unit, built for accuracy, utility, dependable intelligibility and freedom from distortion under any acoustic or climatic condition.
Today, orders are being filled for those whose needs meet priority requirements. Send now for your free copy of the Turner Microphone Catalog. Fully illustrated in color, it gives complete details about available units, as well as valuable information on how to keep your present mike in perfect operation.
And if your plans for the future include communications, feel free to ask our engineers to assist you in those plans. Write today to the Turner Co., Cedar Rapids, Iowa.
TURNER
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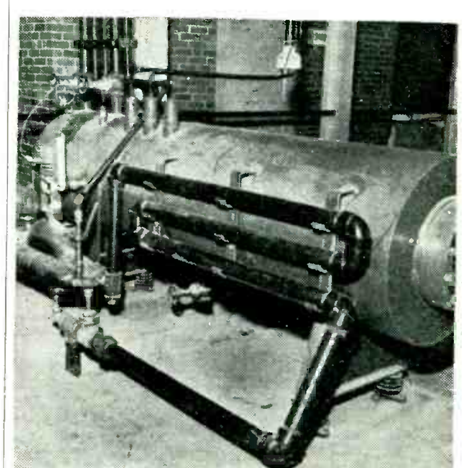
Time Check for Studio Clocks

TIMING ERRORS that occur when switching from local to NBC network programs are eliminated at WOW, Omaha, by a clock-like dial hung on the glass window of the control room. The dial is calibrated in five-second intervals, both clockwise and counterclockwise, from 12 to 6. When the NBC time signal is received the operator notes any discrepancy from the time shown on the studio clocks and moves the pointer to indicate the degree of difference. A clockwise movement indicates a fast correction and counterclockwise a slow correction. A duplicate dial on the back is visible to the announcer in the studio.

• • •

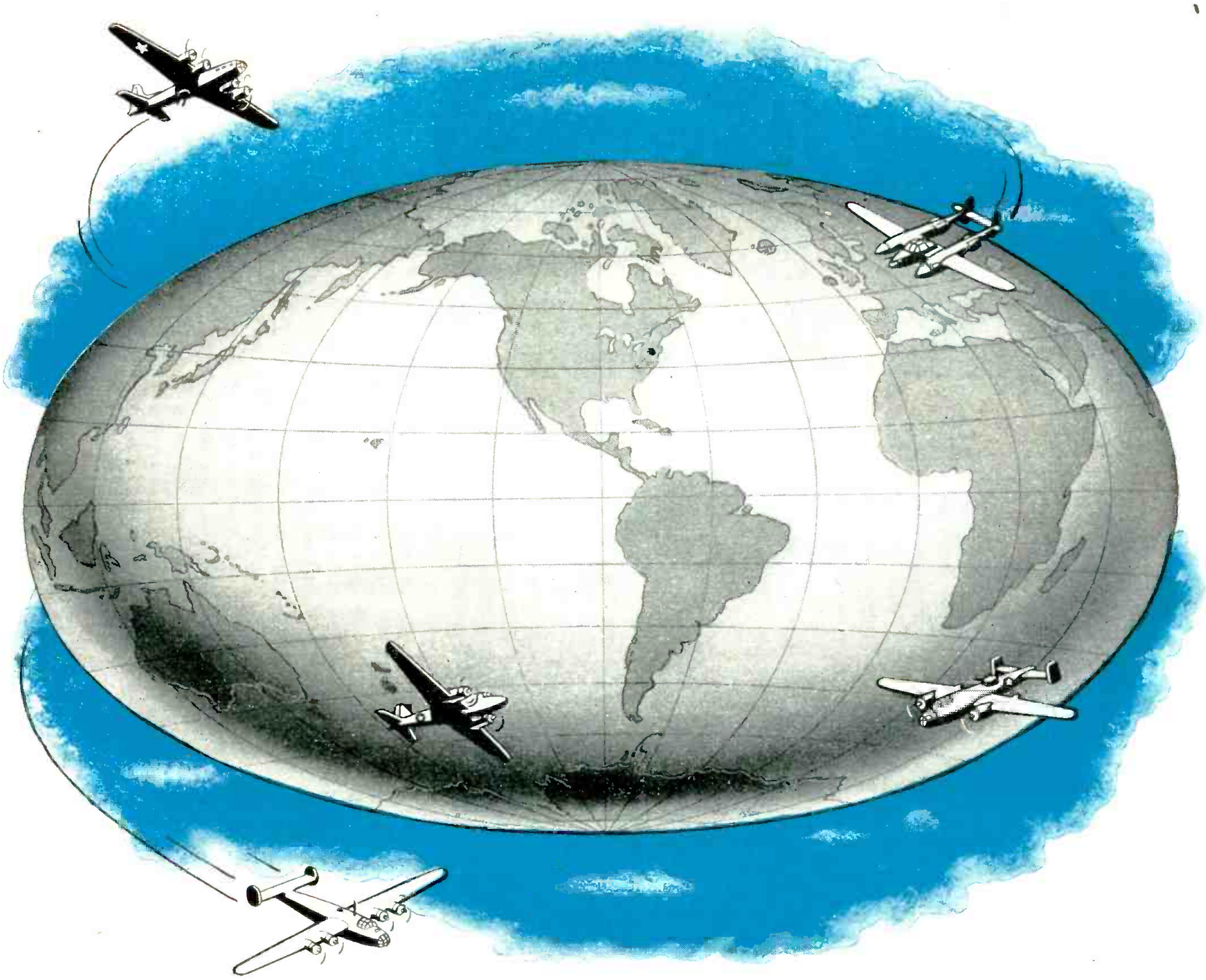
Insulating Pipe for Rectifiers

WATER-COOLED RECTIFIERS are insulated from the water supply by pipes made of saran, a thermoplastic, in the Dow Magnesium Corp. plant in Michigan. The plant produces magnesium metal by the electrolytic method, and each of scores of cells must be supplied with 600 volts to electrolyze the magnesium chloride and produce molten metal.



Water-cooled rectifiers for mass production of magnesium metal are insulated from heat exchangers, shown above, by saran plastic pipe

A rectifying station housing twelve rectifiers and a similar number of heat exchangers is the center of power distribution for each cell building. Power for the plant is supplied at 120,000 volts and is stepped down by a group of outside



Serving the Air Routes of the World
...*TODAY and TOMORROW*

On established passenger and cargo airlines, as well as on military missions, dependable communications are vital. Wilcox Aircraft Radio, Communication Receivers, Transmitting and Airline Radio Equipment have served leading airlines for many years . . . and while, today, Wilcox facilities are geared to military needs, the requirements of the commercial airlines likewise are being handled. Look to Wilcox for leadership in dependable communications!

WILCOX
ELECTRIC COMPANY
Quality Manufacturing of Radio Equipment
14th & Chestnut **Kansas City, Mo.**

transformers to 13,800 volts before feeding rectifier stations where conversion to 600 volts of direct current takes place.

Heat developed in the process of rectification is absorbed by water jackets in each rectifier unit and is carried by a circulating system to heat exchangers on the floor below by saran pipe, a product of Dow Chemical Co. The insulating properties of saran pipe prevent the 600-volt potential of the rectifier water jackets from being grounded through the heat exchangers to the water system.

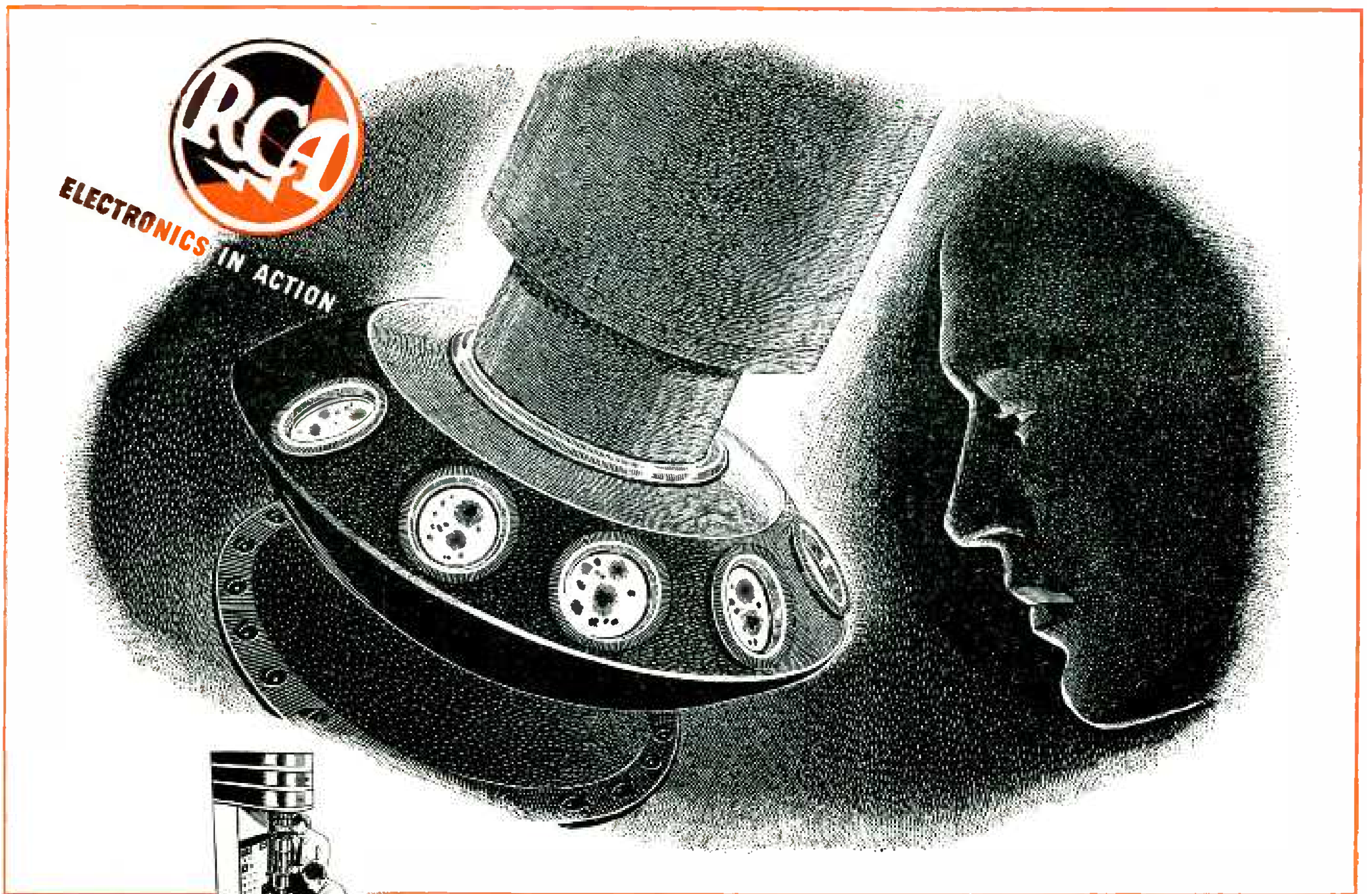
When the magnesium cells are in operation heavy leakage currents may travel to ground through the walls of the building. To prevent this loss a layer of 1/16 inch thick saran sheet was placed between the bricks of the walls, about six feet above ground, and between the metal joints and beams in the building during construction.

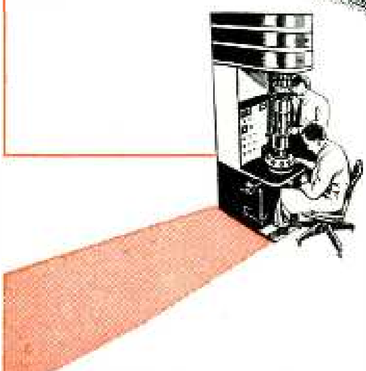
• • •

Selenium Rectifiers for Tin Plating

ONLY MEAGRE STOCKS of tin were on hand when the enemy obtained control of 80 percent of the world's tin supply, but the electrolytic method of deposition of tin on strip steel has helped conserve the dwindling supply. This method, which had been developing slowly for five years before the war, uses only about one third the amount of tin required by other methods and permits control over the thickness of the coating. High values of direct current, ranging up to 50,000 amperes, are necessary for the electrolytic method. These currents can be obtained from selenium rectifiers, according to a story in Vol. 21, No. 2 of *Electrical Communication.*

About 26 continuous strip mills are being installed as part of the tin conservation program. In these, the process is continuous with the strip operating at from 250 to 650 feet per minute. At the latter speed each line requires aproximately 48,000 to 60,000 amperes of direct current. Selenium rectifiers for nine of the 26 lines are being built by Federal Telegraph & Radio Corp., and consist of eighteen 7500-ampere units, three 5,000-ampere units and three 3,000 ampere units, making a total of 159,-





Exploring A New Universe

THROUGH those small round windows—observation ports of an RCA Electron Microscope—this bacteriologist is studying influenza virus—magnified 25,000 times!

For years medical research men have had to fight the devastation of influenza "blindfolded" — for the simple reason that flu germs are invisible even under the most powerful light microscope. *But why invisible?* Why couldn't this virus be seen? The answer is—even the shortest waves of visible light are *far too long* to permit seeing anything so small. Nothing so infinitesimal ever was seen—or could be seen—prior to invention of the Electron Microscope.

But man *needs* to see these smaller things—among which are long-hidden causes of many diseases destructive to human beings, animals and plants. Man *needs* to be able to peer down, down, down into molecular structures—in order to learn what makes rubber behave like rubber, leather like leather, wool like wool, lubricating oil like lubricating oil, or metal like metal. For under the whiplash of war it is imperative to learn now, not tomorrow, *why* one kind of rubber, leather, fiber, oil or metal is more elastic, tougher, stronger, more useful than another.

Every branch of science and industry can benefit through proper use of this extraordinary microscope—which utilizes electrons instead of light for illumination. The RCA Electron Microscope is only one of many RCA applications of *electronics*—the art of harnessing electrons to the service of man. *Every* electronic device of *every* kind depends basically on electron tubes. And RCA is the fountain-head of modern electron tube development.

In addition to our armed forces, the list of industrial firms and scientific institutions now using RCA Electron Microscopes reads like a Blue Book of American Industry and Science. Inquiries regarding this instrument will be welcomed from research men connected with similar organizations, and will be promptly answered. Address Department 131-765, RCA Victor Division, Radio Corporation of America, Camden, N. J.

TUNE IN "WHAT'S NEW?"
RCA's great new show, Saturday nights, 7 to 8, E. W. T., Blue Network.

A new booklet—"RCA ELECTRONICS IN INDUSTRY"—may suggest electronic applications important to your business. Free on request. Please use business letterhead when writing. Address—Dept. 68-211, RCA Victor Division, Radio Corporation of America, Camden, New Jersey.

RADIO CORPORATION OF AMERICA

000 amperes at 12 volts. Output voltage of the units is controlled by saturable-core reactors that permit a variation from 0.75 volts to 12 volts.

The rectifier units have their selenium plates immersed in a liquid that absorbs heat and protects the plates from moisture and corrosive fumes. This permits locating the rectifiers near the plating tanks and reduces the amount of copper necessary for the installation. Further savings of copper over other means of converting a-c to d-c are effected because of the small copper content of the rectifiers.

• • •

Classification Chart of RCA Cathode-Ray Tubes

Type No.	Screen Diam. (in.)	Fluorescence	Heater Volts	Max. Volts on Anode No. 2	Deflection Factor†
Electrostatic Deflection Types					
913	1	Green	6.3	550	598
2AP1	2	Green	6.3	1100	230
902	2	Green	6.3	660	230
3AP1	3	Green	2.5	1650	76
3AP4	3	White	2.5	1650	76
3BP1	3	Green	6.3	2200	110.5
3EP1	3	Green	6.3	2200	110.5
5AP4	5	White	6.3	2200	74.7
5BP1	5	Green	6.3	2200	42.4
5BP4	5	White	6.3	2200	42.4
5CP1	5	Green	6.3	2200	‡46
5CP4	5	White	6.3	2200	‡46
5HP1	5	Green	6.3	2200	42.4
5HP4	5	White	6.3	2200	42.4
905	5	Green	2.5	2200	57.5
914	9	Green	2.5	7700	40
908*	3	Bluish	2.5	1650	76
907*	5	Bluish	2.5	2200	57.5
Electrostatic-Magnetic Deflection Types					
904	5	Green	2.5	5060	63.5
9JP1	9	Green	2.5	5500	37.5
Magnetic Deflection Types					
7AP4	7	White	2.5	3850	....
7CP1	7	Green	6.3	7700	....
9AP4	9	White	2.5	7700	....
12AP4	12	White	2.5	7700	....

Type No.	Mosaic size inches	Heater Voltage	Maximum Anode Volts	Use
Iconoscopes				
1847	1 7/16 dia.	6.3	660	amateur
1848	2¼ x 3	6.3	1320	portable camera
1849	3 9/16 x 4¾	6.3	1320	film pickup
1850	3 9/16 x 4¾	6.3	1320	studio pickup
Orthicons				
1840	1¾ x 2 5/16	6.3	330	film and studio pickup

* Short-persistence screen. All others have medium persistence.
† Rated at an anode No. 2 potential of one kilovolt for all types to permit comparison. Actual deflection values may be obtained by multiplying the deflection factor given above by the operating anode No. 2 voltage in kilovolts.
‡ On basis of a 2 to one ratio between voltages of anode No. 3 and anode No. 2.

Can you use this

new — .0004" — flexible material?

In developing and manufacturing entirely new Electro-Voice Microphones our engineers have had to experiment in nearly all branches of the scientific arts. About a year ago, one important microphone project was delayed because a thin and extremely flexible sheeting material was not available commercially.

Although we aren't chemists, we finally developed, what we believe to be, another Electro-Voice "first" . . . a method of sheeting a flexible material to as thin as four ten-thousandths of an inch. It is a material that can be stabilized, and one that will retain all of its characteristics from —40°F. to +185°F.

We design and manufacture microphones . . . have been doing it for the past 16 years . . . and we intend to stick to our own field. However, if you're in war production and can use this new material, we'll be glad to save you the time and trouble of developing it yourself. Just tell us how much you need. . . we'll fill your order.

Blood donors are needed immediately . . . . see your local Red Cross

Electro-Voice MICROPHONES

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

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

Microwave Plumbing

(*Continued from page* 121)

a double stub. The single-tube model in Fig. 20 very successfully combines the advantages of coaxial and parallel lines. The double-ended parallel line tank circuit is tuned by worm-driven pistons within the cylindrical covers. The entire outside surface is grounded, leaving only the filament leads at high potential. Two coaxial cables have their inner conductors coupled to the plate and grid sides of the tank respectively. Together they form a shielded output line which is suitable for coupling to center-driven antenna loads without detectable currents on the outside surface of the oscillator. A variable-length section on one of the cables adjusts the phases of the currents to be opposite where connection is made to the parallel line.

Finally, at 10 cm, klystron oscillators are used. The last illustration shows a rear view of a complete klystron installation in a movable cabinet.

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Registry Control

(*Continued from page* 99)

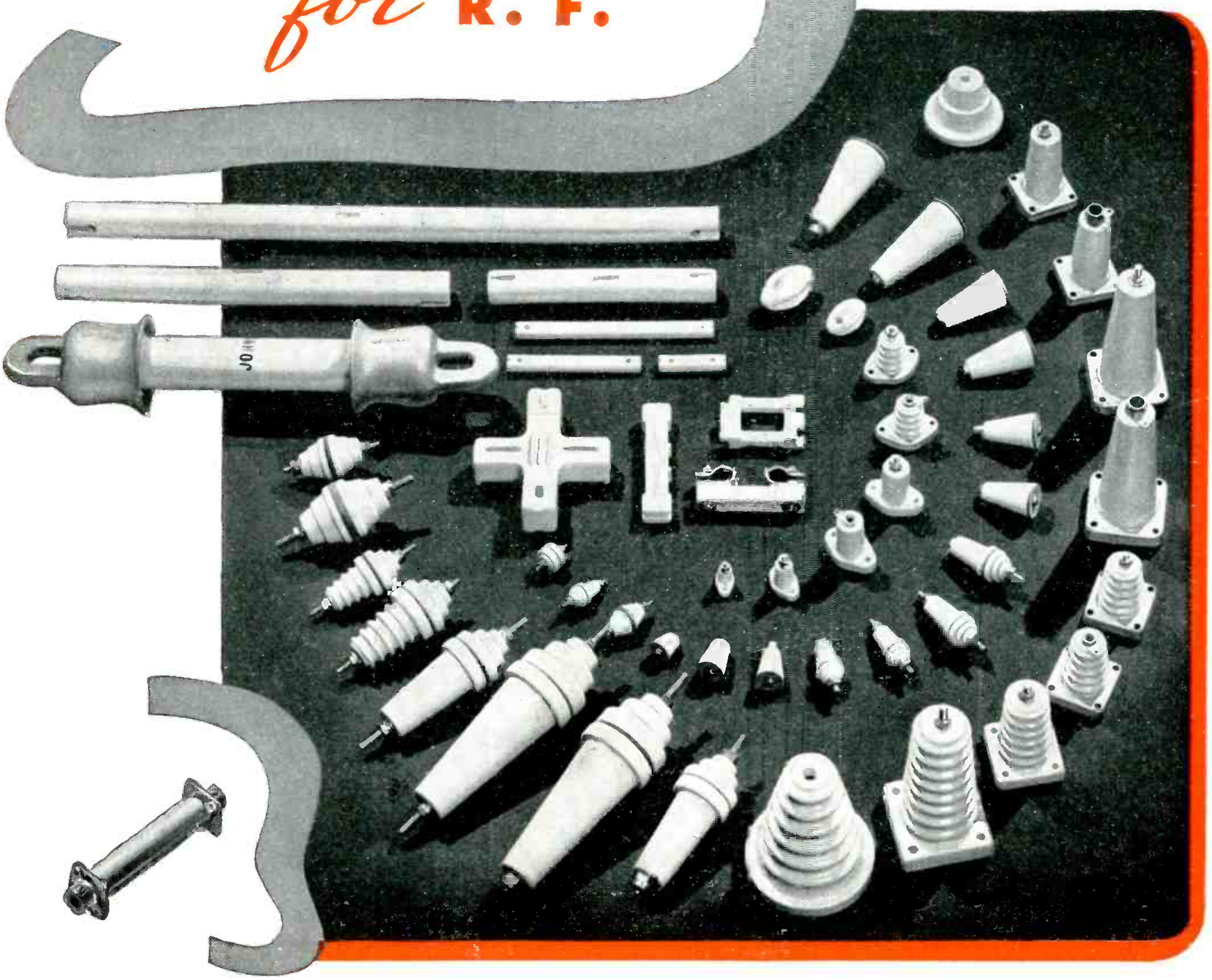
realized, however, that as the speed of operation and the accuracy required become more critical, there is added responsibility on the part of the packaging-machine maker to produce a machine that will hold a fairly constant tension and which will be free from excessive backlash.

All-Electronic Controls

An almost exact electronic equivalent of the magnetic type of space and speed control has been used on some jobs requiring high accuracy at extreme operating speed (1/64-inch at 400 fpm).

A disk having accurately-cut slits is used in place of the mechanical cam on the contact-type rotary selector switch. Light is projected

INSULATORS *for* R. F.



Many commonly used insulating materials function perfectly in low frequency circuits such as audio, 60 cycle power or even the lower radio frequencies. These same materials at medium or high radio frequencies act as high resistances to waste precious R. F. Many porcelains, steatites, glasses and similar materials have this fault and only tests under laboratory conditions will detect it. Johnson insulators were not only designed for high R. F. but the materials were selected only after exhaustive tests to determine the best. Can you afford to take chances? Demand the best—they cost no more—specify Johnson.

Ask for
CATALOG 967D

JOHNSON
a famous name in Radio

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through these slits so it is received by two phototubes, which, with their accompanying amplifiers, act in very much the same manner as the forward and reverse contacts on a rotary selector switch.

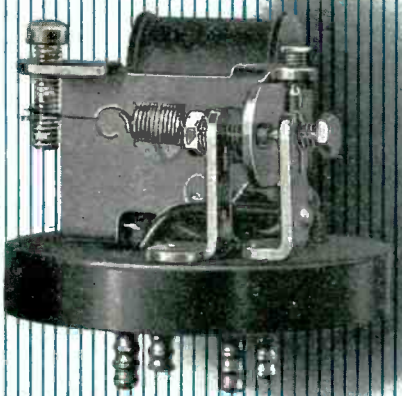
The signals from the web register mark and the disk are compared by "mixer" tubes, which are usually pentodes using both No. 1 and No. 3 grids for control. The field of the correcting generator is supplied by power tubes that operate in parallel. The element that permits a comparatively constant speed to be held (equivalent to the motor-driven rheostat in the magnetic device) is a large capacitor that is charged or discharged quite slowly. A space change is obtained from a smaller capacitor in series, one which may be charged or discharged quickly by the output of the mixer tubes. Therefore, if given sufficient time, even the large capacitor is always discharged to its initial state, and it is possible to have a preset control that will permit starting of the equipment with the optimum generator field current.

This type of equipment has some advantages where the register marks are spaced comparatively far apart (24 inches or greater) and where the machine speed may vary over a wide range. However, it has the same requirements as the magnetic space and speed control, in that the differential generator must be driven from the packaging machine itself and d-c must be supplied for field excitation.

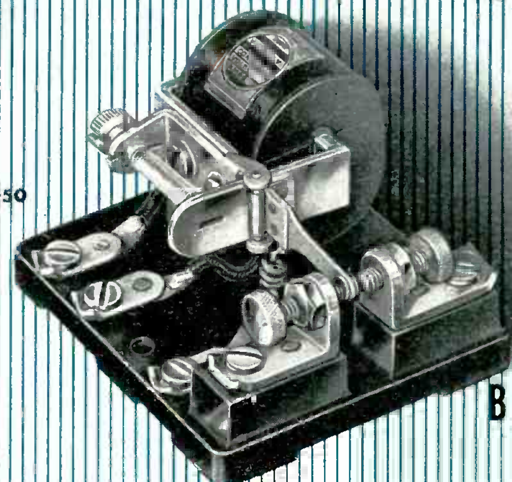
For equipment which is operated at a more uniform speed, and where register marks are spaced fairly close together (less than 4 inches apart), a newer type of all-electronic register control offers a number of advantages. The control makes use of a high-speed d-c exciter, called an "amplidyne". This permits extremely fast response and high accuracy, and eliminates the need for a machine-driven generator. Since amplidyne fields require only a fraction of the power required for the conventional generator, a smaller and less expensive control panel can be used.

OVER 20,000 short-wave radio receivers are now being used by our armed forces overseas for entertainment purposes, along with about 500,000 phonograph records.

ALLIED



G operating wattage 0.050



B operating wattage 0.012

Sensitive and Close Differential RELAYS

Ruggedness and Sensitivity are built into Allied's B and G Sensitive and Close Differential Relays. These essential factors, Stamina and Lightning Response, enable B and G Relays to withstand the grueling punishment of use in air, sea and land equipment.

B Relays have precision bearings with stainless steel shafts. G Relays have watch type pivoted bearings. These exclusive features keep operating friction to a minimum.

B and G Relays are designed to meet Army, Navy and CAA specifications . . . shock and vibration . . . temperature . . . humidity . . . salt spray . . . etc.

OPERATING CHARACTERISTICS

B and G Sensitive and Close Differential Relays are made in Single Pole Single Throw, Normally Open . . . Single Pole Single Throw, Normally Closed . . . and . . . Single Pole Double Throw.

Dimensions: G-1 7/8 x 1 7/16 in.
B-2 3/8 x 2 3/4 x 1 3/4 in.

Weights: G-3 1/2 ounces
B-7 ounces

ALLIED CONTROL COMPANY
INCORPORATED
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FACTORIES: NEW YORK CITY • PLANTSVILLE, CONN. • CHICAGO, ILL.

Moving WJZ

(*Continued from page* 101)

the necessary 2400-volt power line, with duplicate power facilities if possible and with telephone lines and water mains nearby. This meant a site near a town, yet many of the communities in northern New Jersey are now zoned for residential purposes only.

Proximity to airports also had to be considered. CAA requirements specify a lane 2500 ft wide at a distance of two miles from the airport for manual landing and a lane 4000 ft wide for instrument landing, with no transmitting towers permitted in existing or proposed lanes.

The time element was also important, with the move scheduled for completion by the end of this year so that the short-wave transmitters could be placed in operation as soon as possible after they were built.

Advantages of Final Site

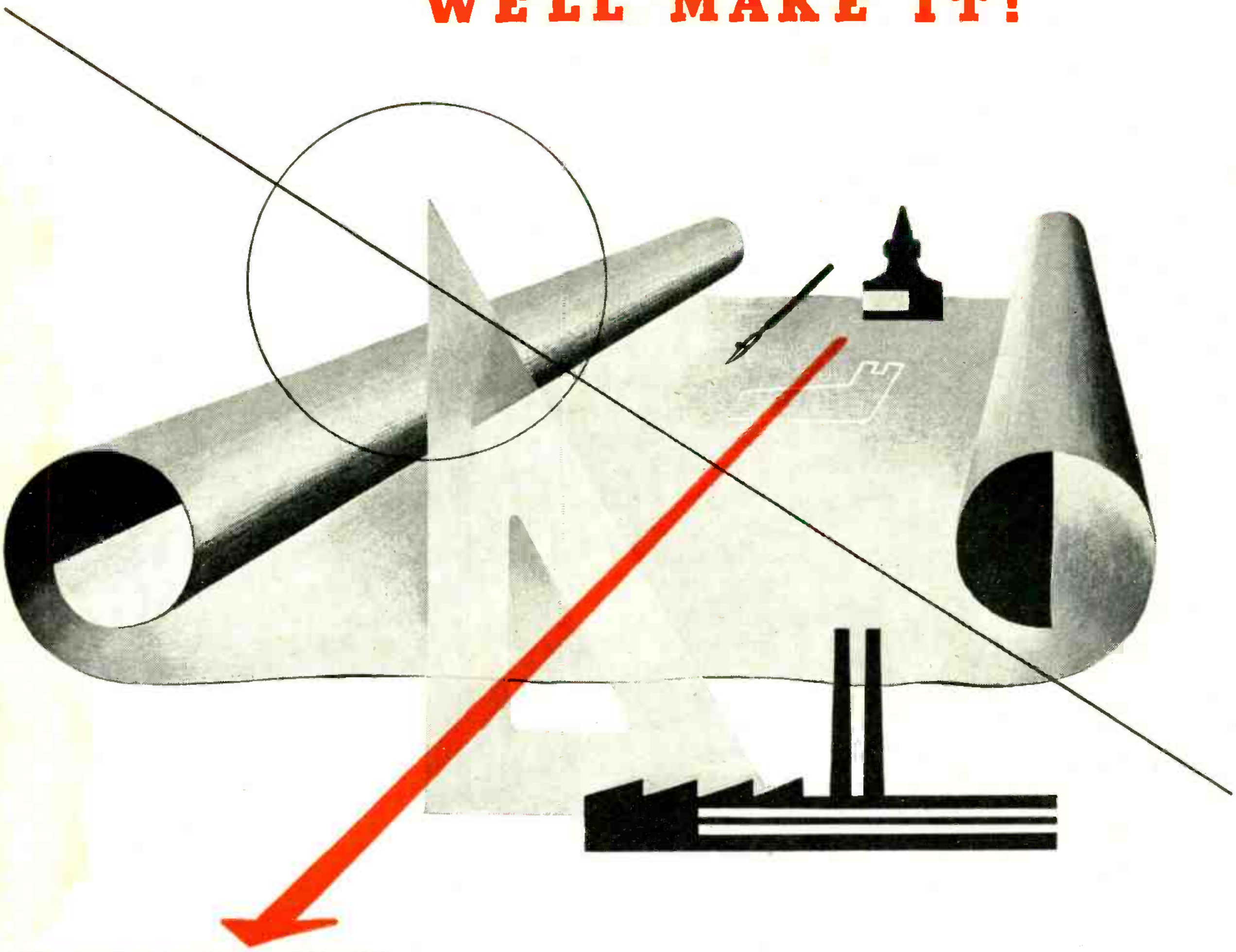
The final decision went to a site near the town of Lodi, New Jersey. This site was far enough away from other stations to prevent serious reradiation, and did not require too great a transmission angle through Manhattan to Brooklyn. It had a 2400-volt power line only one block away, with city water mains one block away and telephone lines two blocks away. All other factors were equally favorable for present needs.

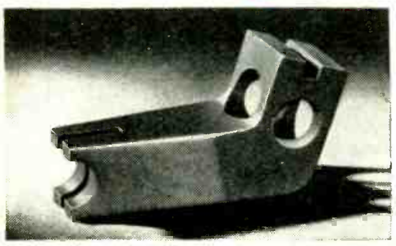
With the WJZ transmitter at Bound Brook, an estimated half-million people were within the 50-milli-

New York City will get better than 25 milivolts when WJZ is in its new location

YOU DESIGN IT...

WE'LL MAKE IT!





If you think of Phenol Fibre as a plastic that can be used only for the simpler types of insulation, look at this high-finished radio slider that is drilled, slotted, and beveled into just about as complicated a piece of equipment as you'll find in any electrical device. Taylor ingenuity and Taylor equipment turn out such pieces by the thousands at remarkably low cost. Before you decide "it can't be done," Take it to Taylor.

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SHEETS, RODS, TUBES, AND FABRICATED PARTS volt signal strength contour. At Lodi, it is estimated that this same contour will include approximately eight million people, with other contours showing equally favorable increases. (Measured old contours and estimated new contours are shown on the front cover.)

Although practically all the large broadcast stations serving the New York City area have improved their coverage by moving their transmitters to new sites and by increasing power during the last ten years, WJZ remained 35 miles outside the city all that time awaiting FCC approval of its request to use a 500-kw transmitter built by RCA. Future prospects for such power being rather nebulous, a move to a close-in location more appropriate to a 50-kw station offers a substantial increase in signal strength with the present power.

Moving Plans

With WJZ operating on a 24-hour-a-day schedule and with wartime shortages precluding erection of a complete new tower and transmitter, moving plans had to meet the prime requirement that there be no loss of air time. Carefully planned steps are involved in transferring operations from Bound Brook to Lodi while meeting this requirement.

First of all, the site at Lodi will be prepared and the complete new transmitter building erected. This will be of modern single-story design.

Secondly, the 50-kw broadcast transmitter at Bound Brook will be connected to its present auxiliary antenna, permitting dismantling of

• • •

"OSCAR" LEARNS RADIO

Sgt. Verlin C. Blackwell, of Miami, Fla. sends out a message from a South Pacific base while "Oscar" a pet wallaby listens to the reply coming from the speaker above his head

the 640-ft vertical steel radiator and re-erection at the new site. The old ground system will have to be dug up and moved also because new copper ribbon cannot be obtained.

Third, the 25-kw auxiliary oscillator and r-f amplifier maintained at Bound Brook for emergency purposes will be moved to Lodi and connected to a 10-kw modulator and rectifier to be removed from the Empire State television station. New construction involved has been kept at the bare minimum essential for satisfactory operation of a 10-kw auxiliary transmitter at Lodi during the time the main 50-kw transmitter is being moved. (At Bound Brook, emergency operation of the auxiliary transmitter was obtained by shutting down one of the short-wave transmitters at the site and using its rectifier and modulator in connection with the auxiliary r-f amplifier and oscillator. The short-wave equipment is now in continuous use and hence could not be moved.)

When the 10-kw job is completed at Lodi and connected to the 640-foot tower and to program lines, WJZ will begin broadcasting from Lodi at the reduced power of 10 kilowatts.

Finally, the existing 50-kw broadcast transmitter at Bound Brook will be moved to Lodi, installed in the new building and connected to its original 640-ft tower. This will complete the moving job and place WJZ on the air again with its normal 50-kw power.—J. M.

• • •

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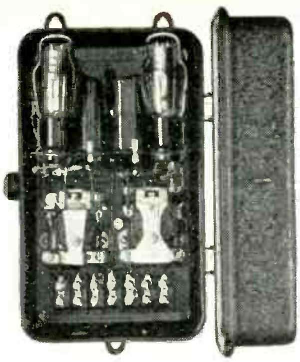
Photoswitch Level Controls are standard equipment on pumps, tanks, stills, refrigerating systems, etc. — control level of any liquid (or powder) electronically. Control is floatless — only metal probe contacts material. Liquid itself, as it makes or breaks contact with probe tip, actuates electronic control relay — automatically operates signals, valves, pumps. Reference Bulletin 1100.



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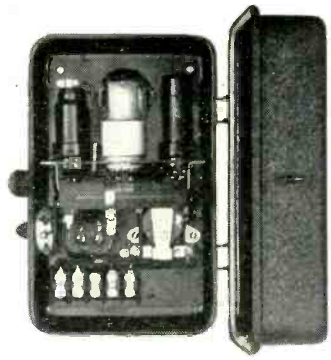
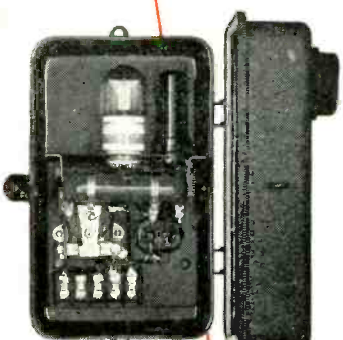
Photoswitch Controls are adaptable to practically all turbidity problems (even when transparency is very low) — actually "see" through liquids, reporting minute turbidity changes invisible to human eye. Densometer in control circuit gives continuous meter indication of turbidity change. Sensitivity adjustment on control may be set so that relay will flash signal, sound alarm, operate valves or pumps — at any predetermined degree of turbidity. Reference Bulletin 315.





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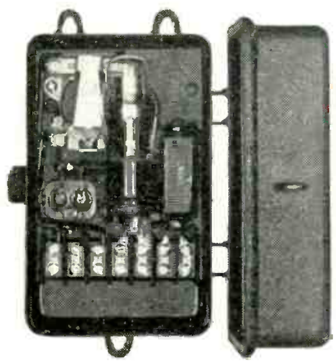

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Photoswitch Pilot Relays make possible the control of large currents by delicate mechanisms, or extremely light contact pressure. Used on textile looms, warpers and winders — also on paper processing equipment for stop motion control on break detection. Monitors feed, keeps production count, on automatic punch presses — also used as limit switch on machine tools. Reference Bulletin 900A.

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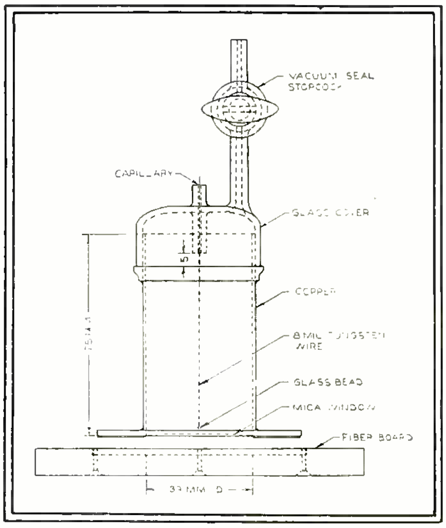
THE ELECTRON ART

Geiger Counter Tube for Soft Radiations

A MICA-WINDOW GEIGER counter tube, which combines the speed of a metal-walled tube with a sensitivity to soft radiations comparable to that of screen-walled tubes, is described by D. H. Copp and D. M. Greenberg in the *Review of Scientific Instruments* for July, 1943. It consists of a treated metal cylinder covered at one end by a thin sheet of mica and at the other end by a glass bell with a central capillary. Through this capillary is sealed a piece of 8-mil tungsten wire with a drop of glass fused over the end. The tube is operated at a pressure of 10 cm of mercury with a mixture of 10-percent ethanol and 90-percent argon.

Artificially induced radioactive isotopes are usually determined with an electroscope, electrometer, or glass or metal-walled Geiger counter tube. Unfortunately the radioactive isotopes of some of the important biological elements, such as Na^{22}, S^{35}, Ca^{45}, and Fe^{55}, have radiations which are too soft to penetrate the metal or glass walls of such counters. To measure such weak radiations a screen-walled counter has been devised by Libby and his associates.[1] Since each sample must be mounted inside the tube, and the tube evacuated and filled with an appropriate gas mixture before the radioactivity may be determined, the method is very time-consuming and a serious disadvantage in measurement of a large number of samples.

To overcome this disadvantage a counter with a mica window was adapted from that designed by R. W. Dodson of the California Institute of Technology. Very thin mica windows, which absorb only part of the soft radiations, still have sufficient tensile strength to maintain the low pressure employed within the counter tube. For example, of the soft radiation of Fe^{55}, 55 percent penetrates a mica window of 0.01 mm, 30 percent penetrates a mica window of 0.02 mm, while only two percent penetrates the thinnest metal walls of 0.1 mm thickness.



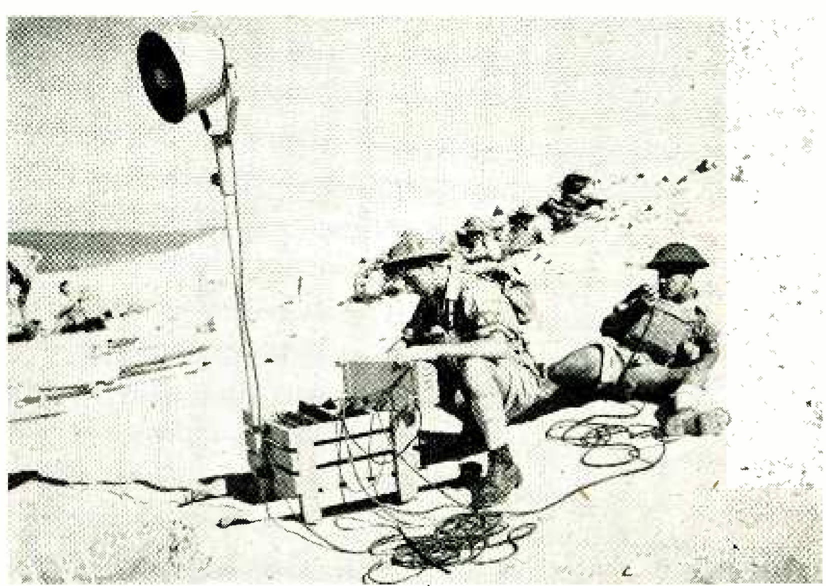
Construction of mica-window Geiger counter tube for soft radiations. The diameter of the metal flange at the bottom of the tube is 75 mm and the fiber ring is 12 cm in diameter and 1 cm thick

Construction of the Tube

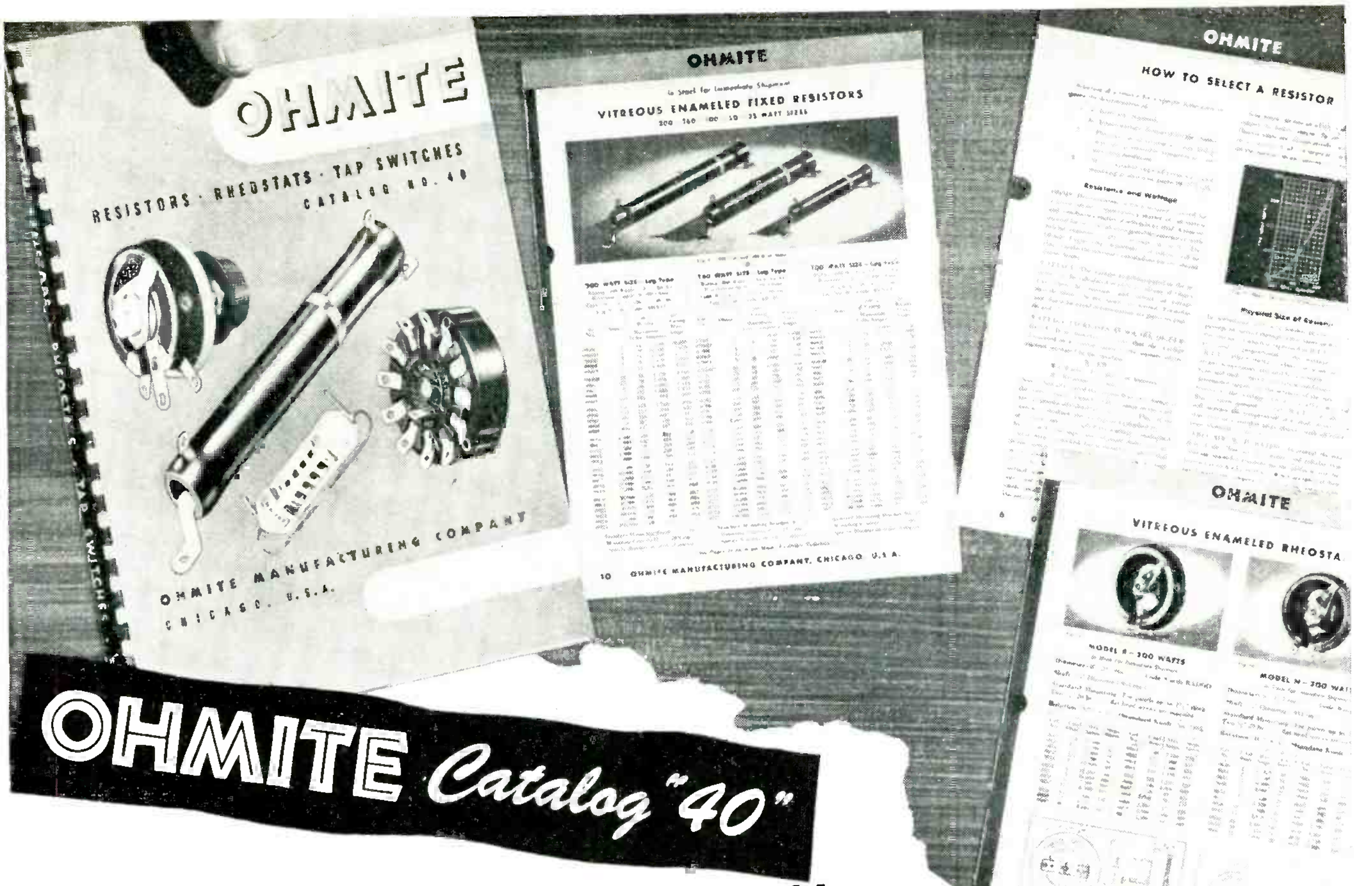
The tube consists of a metal cylinder with a broad metal flange at one end to which the mica window is sealed. The other end of the cylinder is closed by a glass bell with a vacuum seal stopcock and a central capillary. Through this capillary is sealed a straight piece of 8-mil tungsten wire, which extends almost to the mica window but does not touch it. A small drop of glass is fused over the end of this wire so that the tube will not act as a point counter.

The metal cylinder may be made of brass, steel, or copper. Best results were obtained with copper tubes which received a special treatment with NO_2, described in detail in the paper. Sheets of high-grade mica were split with a fine needle having a drop of water around it for the window. For a tube of the size shown in the illustration, mica of about 0.02 mm thickness and weighing about 5 mg per sq cm has been found satisfactory. With smaller tubes even

DIRECTING BEACH TRAFFIC



The Naval Beach Parties are practically the first to be ashore when a British invasion spearhead is made. Here, such a Naval Beach Party is directing operations of beach traffic from what we have been told is a "loud hailer"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thinner mica windows may be used.

To seal the mica in place the metal flange is heated with a Bunsen burner and a thin coating of De Khotinsky cement spread over it. The mica is pressed down on the melted cement, care being taken to maintain even contact while the cement cools and sets. The glass bell is placed over the other end and the tungsten wires adjusted so that the glass bead at the tip is 1 to 2 mm above the mica. They are then sealed in place with De Khotinsky cement.

After cooling, the tube is evacuated and filled with a mixture of 10-percent ethanol and 90-percent argon, to a pressure of 10 cm of mercury. The tube is set in a fiber ring and mounted in a lead shield. The central wire is attached to the high positive potential, the metal cylinder to the negative lead of a Geiger-Mueller counter circuit, and the tube is then ready for use.

Samples to be measured may be mounted in ½-oz metal ointment capsules which are placed directly under the mica window. In the case of Fe^{55}, the metal is plated directly onto the bottom of the capsule. Small Coors ashing capsules are also used.

REFERENCE

(1) W. F. Libby, *Phys. Rev.* 46, 196, 1934; W. F. Libby and D. D. Lee, *Phys. Rev.* 55, 245, 1939.

Elongation Recorder for Single Textile Fibers

PHOTOELECTRIC APPARATUS FOR making a continuous load-elongation record of single fibers of textiles at a constant rate of elongation, as well as a point-by-point record at a constant rate of loading, is described by A. M. Sookne and H. A. Rutherford in research paper RP1546, part of the *Journal of Research* of the National Bureau of Standards for July 1943. The apparatus combines the principles of a hand-operated machine formerly used at the Bureau and an automatic electronic balance developed by Muller and Garman[1]. Phototubes provide sensitive automatic operation and a kymograph makes possible autographic recording of the results of tests in retangular coordinates.

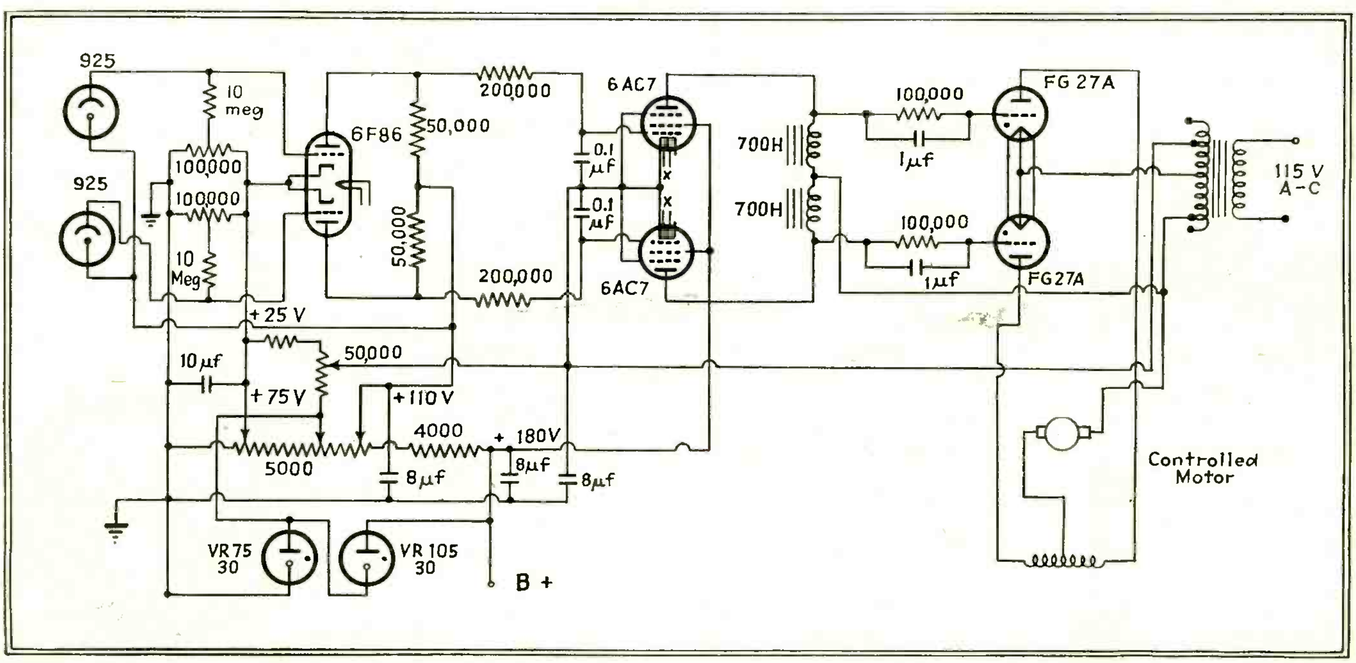
For testing single fibers of textile materials a modified chemical balance has been used to obtain load elongation curves[2]. The fiber was attached between one beam of the balance and a platform that could be raised or lowered by manual operation of a rack and pinion. Increments of load were then added to the other balance pan and the platform adjusted to return the balance pointer to zero. The degree of elongation was determined by measuring the displacement of the platform. Besides being tedious and slow the operation did not allow continuous stretching of the fiber.

The basis of the present apparatus consists of a magnetically damped analytical balance equipped with a Chainomatic column by which a chain is lowered to one side of the balance at a constant rate to provide a constant rate of loading. Elongation at a constant rate is obtained by lowering the platform to which the fiber is attached.

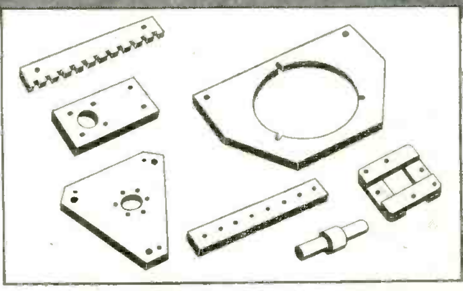
Construction of Instrument

The arrangement of the mechanical and optical components for the phototube control that maintains zero balance is shown in the cross-section diagram. One end of the fiber is attached to platform *H*, which moves dial gage *J* through arm *K* to indicate the amount of elongation, and the other end of the fiber is attached to the left arm of the balance. The platform can be moved manually by means of rack *L* and pinion *M*, or automatically by a constant-speed motor connected to sprocket *R* that drives worm *P* and tapped worm gear *Q* to raise or lower threaded shaft *O*.

Another sprocket drive assembly permits power to be applied to sprockets *X* and *U* to actuate the Chainomatic column *S* and control the amount of chain *E* that is applied to one arm of the balance. A clutch at *V* permits manual control of the



Phototube control circuit employed in autographic load-elongation apparatus for testing textile fibers



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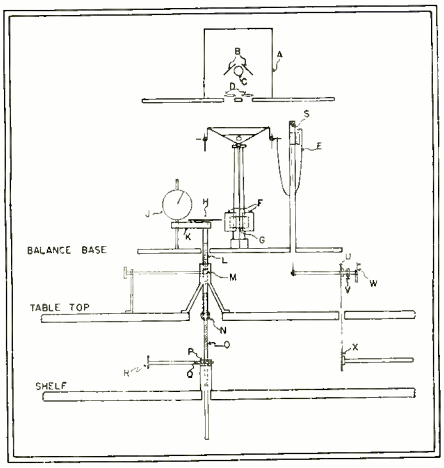

A single textile fiber is connected from one side of the balance arm to the platform *H* for tests of elongation. Motors, controlled by phototubes, lower the platform to stretch the fiber and simultaneously increase the load on the opposite end of the balance arm to maintain the pointer at zero

chain by wheel *W* if desired.

The arrangement of the light source that supplies the phototubes is also shown in the same illustration. A 21-cp lamp, *C*, is housed in box *A* so that two beams are reflected downward by two metal mirrors, *B*, through the condensing lenses *D*. Additional mirrors at *F* are placed symmetrically in front of the target *G* to send the beams past the target to the phototubes. Automatic control over the position of the balance pointer is obtained with the help of the target, which, when the system is in balance, interrupts approximately half of each light beam.

Phototube Circuit

The phototube control circuit is essentially that given by Muller and Garman[1] with the addition of several modifications suggested by Garman. The modified arrangement is shown in the circuit diagram. It consists of a conventional direct-coupled electronic amplifier circuit, and contains two thyratron tubes for control of the motor used to maintain continuous balance. Use of two phototubes makes the circuit independent of fluctuations of the light source. To protect the thyratron tubes from possible damage a time delay circuit is included (not shown in the diagram).

Motors for Mechanism

The controlled motor, used to restore balance, is a series-wound universal type and contains split field

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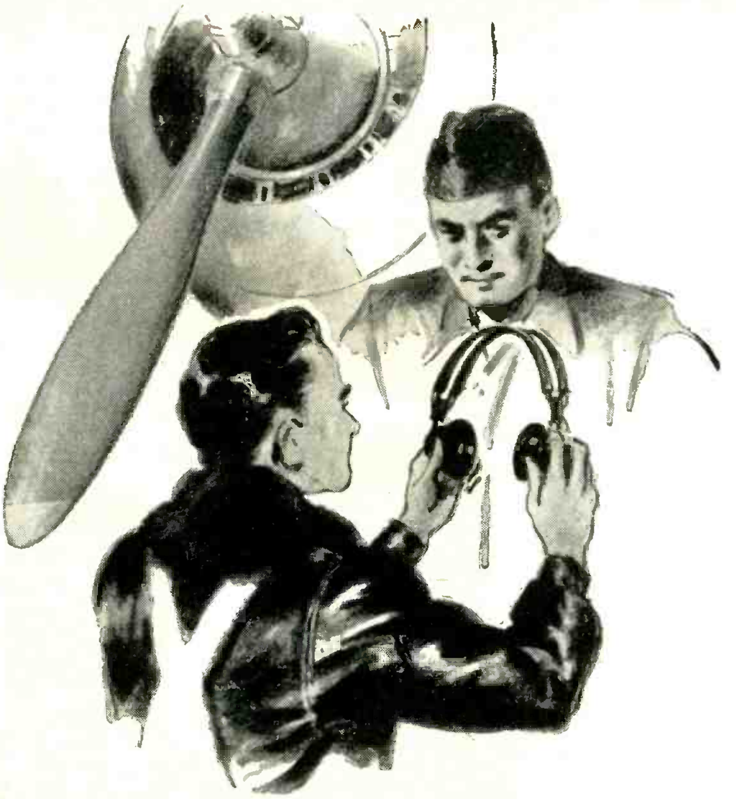

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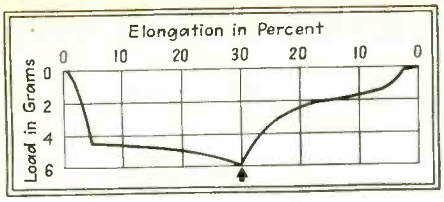
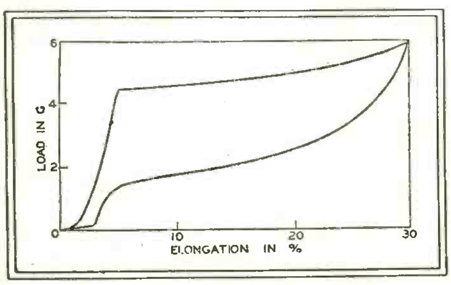


Loading and recovery cycle for a single wool fiber, stretched 30 percent in water. The arrow indicates the point of reversal of the platform motor. Folding the record sheet at the arrow produces a hysteresis loop

windings to allow reversing action. Stopping of the motor is provided by limit switches mounted at both ends of the Chainomatic column and at the lower limit of travel of the platform to prevent damage to the instrument. An additional reversible induction type motor is used to lower the platform and elongate the fiber under test. It provides a constant rate of elongation and also simplifies the problem of automatic recording of results.

A kymograph is mounted on a shelf below the table top for recording of load elongation curves. A constant-speed synchronous motor drives the mechanism and, since both the kymograph and the platform are driven by constant-speed motors, the abscissas of the record are directly proportional to the elongation. A swivel-mounted pen is attached to the Chainomatic column to record the load at any elongation.



Hysteresis loop of wool fiber, obtained by folding the record sheet at the arrow and tracing the curve

The authors state that successful operation of the machine depends upon the proper adjustment of the speed of the platform, the motion of the chain, the size of the chain used, and the sensitivity of the controls. The chain must be capable of moving rapidly enough to take care of the most rapid changes of load (usually in the Hooke's law portion of the curve) and should be light enough so that the scale of the ordinates is not unduly compressed. The scale of the abscissas may be easily adjusted by changing the speed of the kymograph drum.

A load elongation curve is shown for a wool fiber stretched at a constant rate in water. The fiber was elongated to 30 percent and then returned to zero elongation. The arrow indicates the point of reversal of the motor driving the platform. The conventional type of hysteresis loop, with load plotted against elongation, can be obtained from the curve by folding the record paper vertically through the arrow and then inverting the paper. A tracing made in this manner from the elongation curve of wool fiber is also shown.

REFERENCES

(1) R. H. Miller, and R. L. Garman, *Ind. Eng. Chem., Anal. Ed.*, **10**, 436, 1938.
(2) A. M. Soakne and M. Harris, *Bureau of Standards Jrl. of Research*, **19**, 535, 1937, RP1043; *Am. Dyestuff Reptr.*, **26**, 659, 1937.

• • •

New Signal Converter Tube For Television Circuits

A NEW TUBE that can convert a complete television signal into line and frame sweep voltages suitable for direct application to the deflecting plates of the cathode-ray tube in a television receiver is announced in a 27-page article by P. Nagy and M. J. Goddard of International Television Corp. in the June 1943 issue of *Wireless Engineer*, a British publication.

The new tube, called a signal converter by the authors, is slightly longer than an ordinary receiving tube but employs constructional principles similar to those of the electron gun in a cathode-ray tube. It is capable of delivering substantially linear deflection potentials of the order of 1000 volts when fed with input potentials of only a few volts. The complete television signal can be fed to its control electrode, without customary separation of line synchronizing signals from frame synchronizing signals. In one form, the tube will generate both line and frame sweep voltages, making it possible to replace all the synchronizing circuit tubes in a television receiver with just one signal converter tube.

Accuracy of synchronization is greatly enhanced in comparison with ordinary time-base circuits because synchronization occurs at the beginning rather than at the end of each line and frame. This feature is most apparent in connection with synchronization of multiple-interlaced pictures.

In the paper, basic principles of conventional time-base circuits are discussed and compared with those of the signal converter. The various electronic solutions to the problem of converting a signal into its own time base are discussed, and the reasons for adopting the electron optical design of the Nagard signal converter as the best apparent solution to the problem are presented in detail. Design and construction data for the tube are given, uses in cathode ray oscillography and in television are taken up in extreme detail, frequency and output voltage limitations are analyzed, a 19-item bibliography is included, and Laplace's equations for the power of the cylindrical electron lens in the tube are developed in the appendix.

Electronic Principles of Tube

The signal converter and its circuit are shown in schematic form in Fig. 1. The tube symbol closely approximates the actual construction. Instead of rotational symmetry, however, the electrodes have rectangular apertures which set up an electron lens corresponding to a cylindrical lens in optics.

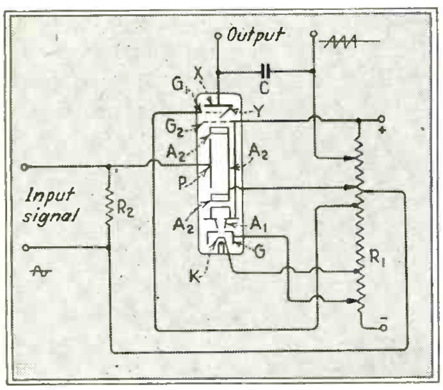


Fig. 1—Basic circuit of a signal converter tube

The cylindrical optical system, focusing the electrons to a line instead of a point, was adopted to increase the total beam current to any required value while retaining sharp focusing in the one required direction. Electrons emitted from indirectly heated cathode K are drawn by the first anode A_1 through negative grid G and are concentrated into a cross-over line near this grid. The resulting narrow divergent beam is then focused into a sharp line image at the tip of member Y by the electron lens formed by anodes A_1 and A_2.

Input signals are applied across resistor R_2 and act on deflecting plate P, causing the electron image to be deflected across output electrode XY. This electrode has two parts, both coated with substances having high secondary electron emission (greater than unity, so that more electrons are emitted than are arriving at the surface).

When the electron image falls on part Y of the output electrode, the electrode becomes positively charged because all its secondary electrons are collected by screen grid G_2; with more electrons leaving than arriving, the output electrode loses electrons at a steady rate and hence becomes increasingly more positive until it reaches an equilibrium potential near the potential of G_2, which is at first anode potential.

The load of the signal converter is the pure capacity C connected between the output electrode and the voltage divider. The output voltage V across this capacitor is determined by the charging current i, the charging time t and the capacity value C: $V = it/C$. This voltage is proportional to charging time if the beam current and the secondary electron coefficient remain constant.

When the electron image falls on part X of the output electrode, suppressor grid G_1 forces the emitted secondary electrons to return to the output electrode, charging it negatively. Equilibrium is attained when the output electrode reaches a value near the potential of G_1, and electrons leaving are then equal to electrons arriving. It is to be noted that the velocity of the electron beam is sufficiently high that essentially the total beam current passes through G_1.

Wave Form of Output

When an alternating potential is applied to the deflection plate, the electron image is made to oscillate between the positive (X) and negative (Y) parts of the output electrode, and a trapezoidal time-base signal of the form shown in Fig. 2 is produced on the output electrode.

It is advantageous that the electron image should fall on the nega-

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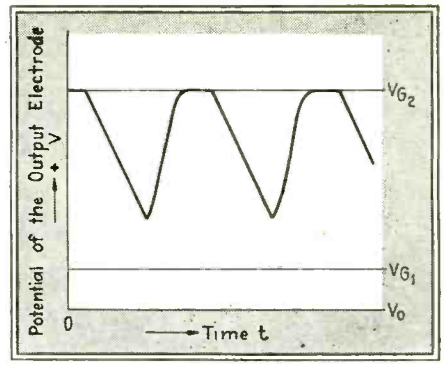


Fig. 2—One type of output wave form obtainable with a signal converter tube

tive part (Y) of the output electrode during the scan period, because here the change in output potential is a direct linear function of charging time (it is independent of secondary emission because all emitted electrons are forced back to the output electrode).

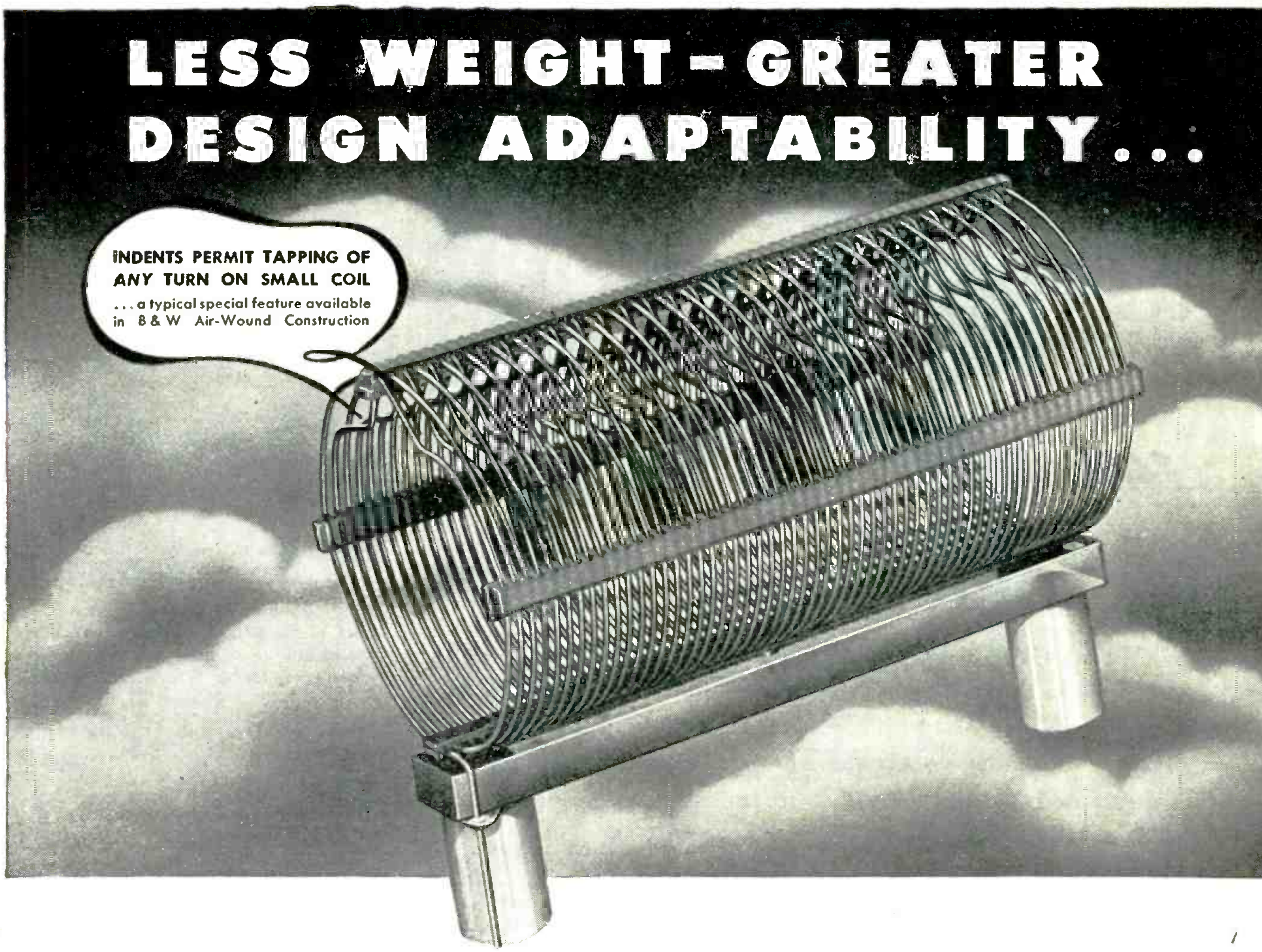
The width of the electron beam is made sufficiently small that the time during each oscillation when the image falls partly on each portion of the output electrode is negligible.

The smallest deflection necessary to produce an undistorted time-base output is theoretically equal to the beam width at the output electrode, but for safety it should be about three times that amount. If the beam width is 0.2 mm, the input voltage should produce a deflection of about 0.6 mm, obtainable with a minimum input amplitude of 0.12 volt. The input signal may increase as much as a hundred times during reception without affecting the constancy of the time-base output.

Television Applications

Advantages of the signal converter in television are greater simplification through elimination of the need for separating synchronizing signals from each other, practically negligible input power requirements of the converter tube itself, the possibility of combining the production of line and frame time bases in one converter tube, the possibility of simplifying the synchronizing signals themselves, the possibility of using multiple interlacing successfully, and the automatic and exact synchronization possible at the television receiver.

When the signal converter is employed, the scan of the time-base output automatically starts in synchronism with the *trailing edge* of



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Air-Wound coils weigh less because no conventional winding form is required.

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Air-Wound coils are ideal for plug-in services. They are not likely to be damaged if dropped—but, even if bent completely out of shape, can easily be repaired. For rough service, they can be further protected with "bumper" rings.

Air-Wound coils have low dielectric loss, can be wound to uniform pitch, offer greater design adaptability (note tapping indents in illustration) and lend themselves to mechanical and electrical revisions in the circuit.

Thus, while not a panacea for all coil problems, B & W Air Inductors spell greater efficiency for most of them. For other applications where form-wound units prove preferable, B & W offers a variety of types.

HOW'S THIS FOR A "DROP" TEST!

There's nothing scientific about it, but when a B & W Inductor is dropped three stories (as illustrated) on to a cement sidewalk without being put out of commission, it at least proves the practical nature of Air-Wound construction. Actually, the only damage was a bent plug-in prong and a cracked ceramic support. The Coil was immediately "repaired" without tools of any kind, and operated perfectly!

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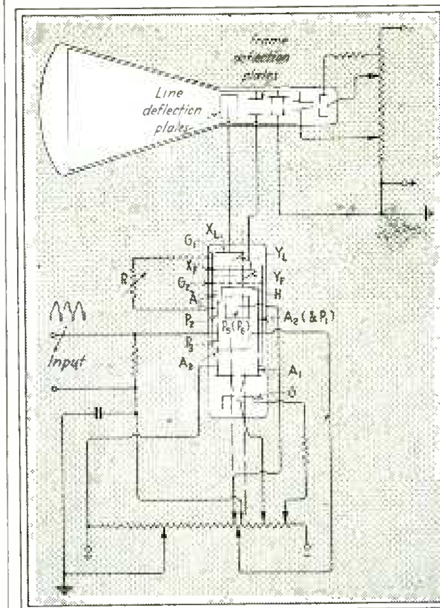

Fig. 3—Method of using a signal converter of the double output electrode type to generate both line and frame sweep voltages for a television receiver

the received synchronizing signal, and hence with the *start* of each line or frame.

In Fig. 3 is shown a circuit in which line and frame time bases for a television cathode-ray tube are produced in one signal converter tube. The line time base is produced on output electrode $X_L Y_L$, while the frame time base is produced on output electrode $X_F Y_F$. These two electrodes are actually side by side, so that a single electron image in the form of a long line falls on both electrodes. The operation of this circuit is fully explained by the authors in their paper.

Asymmetrical deflection, resulting in trapezoid distortion and defocusing of the reproduced picture, may be avoided by use of two conventional amplifiers which permit the use of all four deflecting plates in the picture tube, or by using two pairs of output electrodes in the converter tube, each pair connected to a separate pair of deflecting plates in the picture tube.

The signal converter thus offers excellent promise of simplifying the construction of television receivers while retaining the high quality of present receivers. The authors suggest a complete television receiver consisting only of two or three deflection-modulated cathode-ray tubes as amplifiers, one signal converter, two rectifiers for supply voltages and one cathode-ray picture tube.

Velocity of Radio Waves

A REVIEW OF VARIOUS METHODS that have been employed for measurements of the speed of radio waves is contained in an address by R. L. Smith-Rose, chairman of the Wireless Section of the Institution of Electrical Engineers, published in the journal of the Institution for March, 1943. The paper examines the present knowledge of the speed of propagation of electric waves of all lengths from the visual to the radio-frequency spectrum.

In studying the existence and properties of the ionosphere it is usual to measure the time interval between the emission of a group of waves and the receipt of the corresponding echo signal reflected from the ionosphere vertically above the observer. From this interval the height of the reflecting region is deduced on the assumption that, in the nonionized regions of the atmosphere through which the waves travel, the speed is that appertaining to a vacuum.

Some methods of studying the direction of arrival of radio waves in either the vertical or horizontal plane are based upon the measurement of phase difference of the signal voltages induced in two antenna systems spaced a known distance apart. The phase difference is dependent upon the ratio of this distance to the wavelength, and the latter quantity is directly dependent upon the speed of travel of the waves over the path in question. When this path is along or close to the ground it is important to know to what extent, if any, the speed of propagation is affected by the electrical properties of the ground.

Measurements of Velocity of Light

Various experimenters have shown that the velocity of light in air is in the neighborhood of 3×10^{10} cm per second and that the value is less in water than in air. The most recent and accurate measurements of the velocity of light were published in a paper by Michelson, Pease and Pearson in 1935. They used an evacuated steel tube a mile long and a mirror arrangement shown in Fig. 1.

Light from an illuminated slit *C* is reflected from the upper half of a rotating mirror *D*, through a window *L* into the side of the steel tube. By multiple reflection between the mirrors *G* and *H* the light waves

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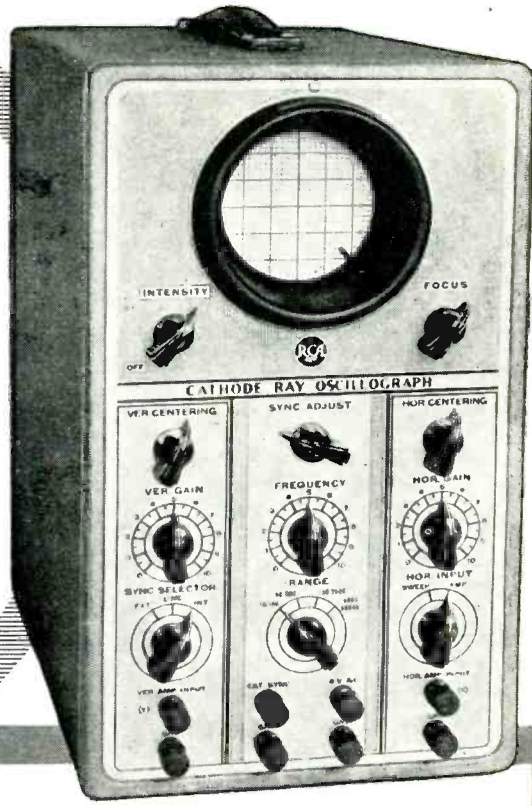

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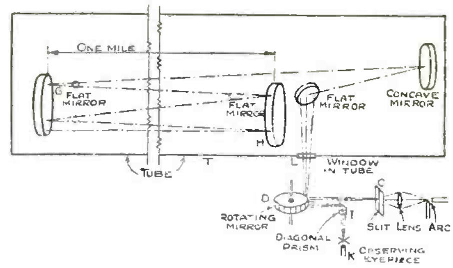

Fig. 1—Optical arrangement for determining velocity of light with a rotating mirror, as used by Michelson, Pease and Pearson. A light beam is passed back and forth in an evacuated steel tube one mile long, before being reflected to a rotating mirror. When the system is properly adjusted the time taken by the light beam to traverse its path is 1/32 of the mirror rotation speed

were caused to traverse a total path of about ten miles before being returned through the window *L* to the rotating mirror *D*. The returning beam of light was reflected from the lower half of the rotating mirror *D*, through the prism *I* to the observing eyepiece *K*. If the speed is so adjusted that the image is in the center of the field of view, the time taken for the light to traverse its path of several miles is equal to 1/32 of the time of rotation of the mirror. Nearly 3,000 determinations of velocity were made over a period of 4 years and the mean value was established as 299,774 km per second with an average deviation of 11 km per second.

Another method, employed by W. C. Anderson[2], utilizes the principle of modulating the light beam with radio-frequency energy by means of a Kerr cell and is shown in Fig. 2. Anderson[3] later corrected for the group velocity delay caused by the lenses and mirrors and reported a mean value in vacuum of 299,776 km per second with a deviation of 14 km per second.

Effect of Air on Velocity

Since for radio purposes we are rarely concerned with wave transmission in a vacuum these values will need to be multiplied by $1/\sqrt{\chi}$, where χ is the dielectric constant of the medium in question. For air under normal atmospheric conditions at the earth's surface in this country (England), the value of χ is about 1.0007 and the corresponding value of the velocity will be reduced to 299,670 km per second.

For transmission of radio waves

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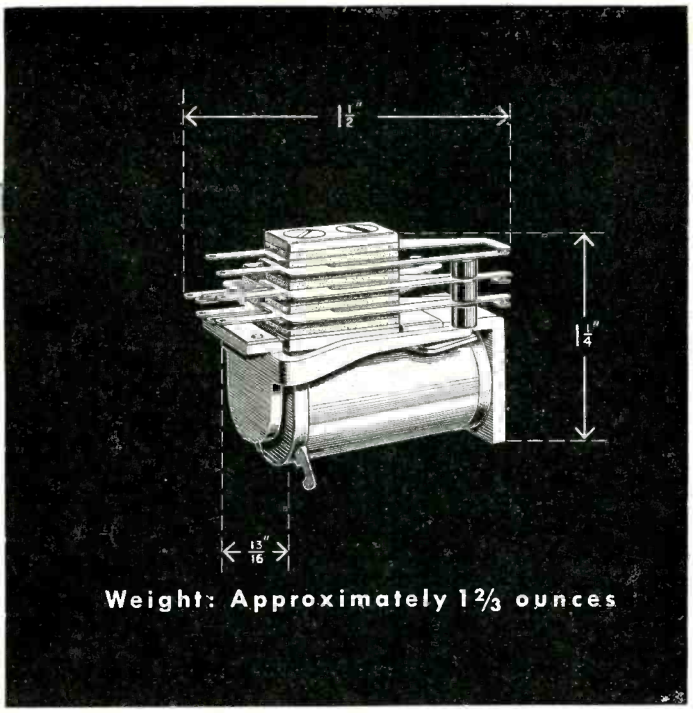

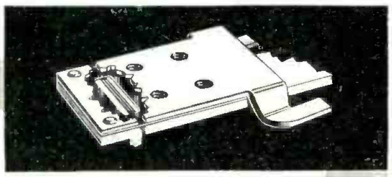

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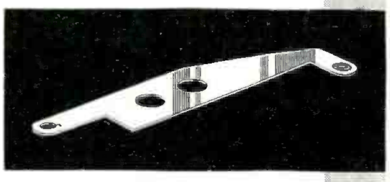

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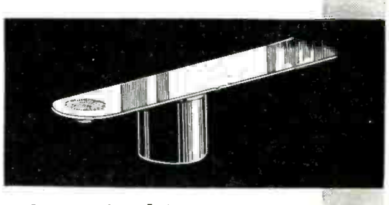

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CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical, Electronic and Industrial Use over land F. T. Farmer and H. B. Mohanty[4] showed that the velocity of propagation for a wavelength of 166 meters (1.8 Mc) is within 6 or 7 percent of the velocity of light. Their measurements were made with high-frequency impulses and therefore refer to the group velocity of the waves; but their results are consistent with the phase velocity measurements of other workers.

Measurement of Phase Difference

A most comprehensive investigation of the velocity of medium radio waves was carried out during the years 1934–35 by a group of workers in the Laboratories of the U.S.S.R. under the direction of Profs. L. Mandelstam and N. Papalexi; the details and results of these investigations were published in a collection of papers in 1937.[5, 6, 7, 8] The method employed comprises a determination of the time of transit of waves between a sending and reflecting station by measuring the phase difference between the two sets of waves the ratio of whose frequencies is rational. The subsidiary investigations included the development of methods and instruments for measuring the phase difference between harmonic oscillations of different frequencies, and the study of the phase displacement introduced by high-frequency amplifiers.

A schematic arrangement of the method employed is shown in Fig. 3. The main station I radiates waves on a frequency f_1, a voltage corresponding to the outgoing frequency

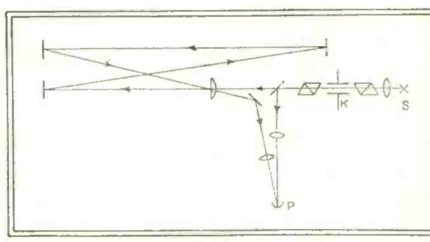
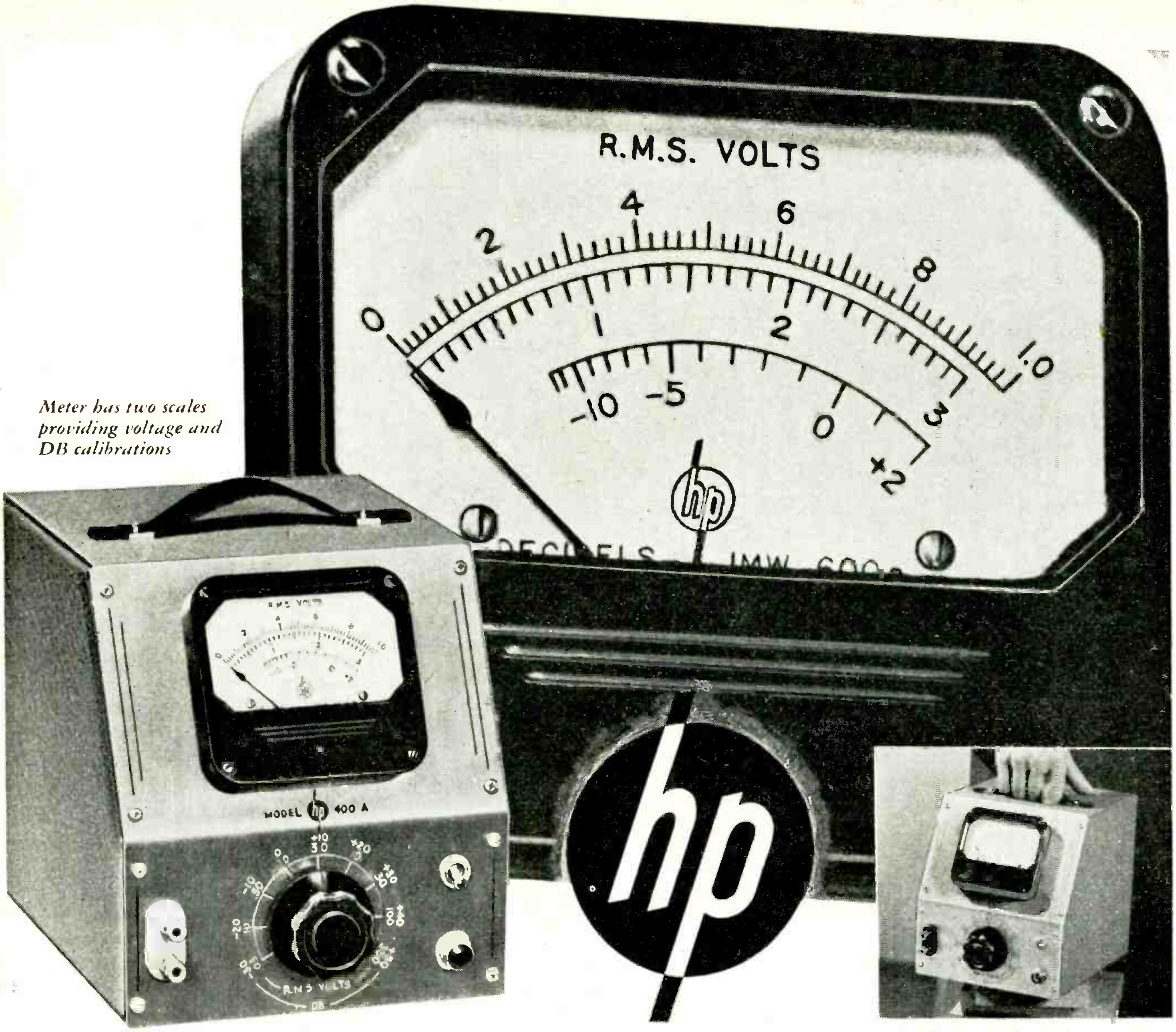


Fig. 2—Method of r-f modulation of light beam used by Anderson for measuring velocity. A light beam from source S passes through lenses and Nichol prisms and is modulated by Kerr cell *K*, that contains a liquid subjected to an alternating field of 14 to 56 Mc. The modulated beam is split into two parts by mirror *M*, one passing to phototube *P*, the other traversing a path of 10 to 20 meters between mirrors. Length of the path is adjusted for minimum output, indicating the beams arrive 180° out of phase. Difference of two paths corresponds to an odd multiple of half wavelengths at the modulation frequency



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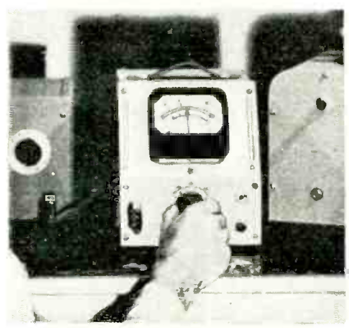

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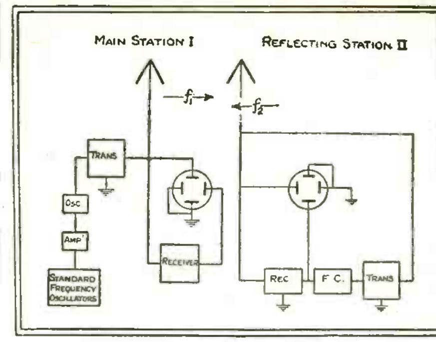

Fig. 3—Arrangement used by Mandelstam and Papalexi for measurements of group velocity of electromagnetic waves. Waves are sent from the main station to the receiving station, where they are changed in frequency and transmitted back to the main station and their phase compared to that of the original waves. The cathode-ray tube at the receiving station is used to maintain constant phase difference between incoming and outgoing waves

being applied to one pair of plates of a cathode-ray oscillograph. At the subsidiary or "reflecting" station II the incoming waves are received, then submitted to a frequency change in a simple but nonharmonic ratio (e.g. 3:2); then the oscillations of the new frequency f_2, after amplification, are transmitted from station II back to station I.

The cathode-ray oscillograph depicted at station II is used for the control of the phase difference between the incoming and outgoing waves, this phase difference being maintained constant during all experimental observations. The waves of frequency f_2 are received at station I and the resulting oscillations suitably amplified for application to the other pair of plates of the oscillograph at this station, so that the phase of the incoming waves may be compared with that of the waves originally emitted on a frequency f_1.

Under the conditions outlined, the trace on the screen of the oscillograph at I will be a Lissajous figure corresponding to the frequency ratio 3/2, its exact form depending upon the total phase difference of the outgoing and arriving waves. This phase difference may be expressed in the form

$$\phi_T = \phi_0 + \phi_1 + \phi_2 + \phi_3 \quad (3)$$

where ϕ_0 = phase displacement suffered by the waves over the return path between stations I and II, ϕ_1 = phase difference introduced by the receiver at II, ϕ_2 = phase difference introduced by the transmitter at II,

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and ϕ_3 = phase difference introduced by the receiver at I.

If we can separate ϕ_0 from the above measurements, we have

$$\phi_0 = 4\pi fd/v \qquad (2)$$

where f is the frequency of the waves, d the distance between aerials I and II, and v the velocity of the waves over the path d.

The separation of ϕ_0 was made by measuring the values of ϕ_1, ϕ_2 and ϕ_3 for the individual components of the apparatus in question, by using a phase-measuring technique which was developed to an advanced stage by E. Schegolev[7] and C. Viller,[8] two of the investigators associated with the group referred to above. An instrument termed a "phase deviometer" was constructed especially for use in the velocity determinations. This instrument includes simple scale arrangements for reading the phase indications directly off the Lissajous figures traced on the screen of the cathode-ray tube.

The phase displacement ϕ_0 will in general comprise several complete cycles and may be expressed in the form

$$\phi_0 = 2\pi(n+m) \qquad (3)$$

where n is an integer and m is a fraction.

In order to evaluate these two quantities, the frequency f_1 of the waves radiated from Station I is varied continuously over a small range, while the frequency of the synchronized waves from II is also changed so as to keep the frequency ratio constant, a matter that is easily checked by observation of the Lissajous figure on the screen at II. This frequency change is carried out between the limits accurately set by two quartz crystal standard frequency oscillators incorporated in the equipment at station I, so that the frequency range covered is known to a high order of accuracy. As the frequency of Station I is varied in this manner between the limits set by the standard-frequency oscillators, the number of complete cycles of phase-angle change is counted on the oscillograph at I, and the final fractional phase angle is also measured. In this way the total phase change ϕ_0 is measured (Eq. 3), and the velocity of transmission of the waves is determined from Eq. 2. This technique is similar to that used in 1925 by E. V. Appleton and M. A. F. Barnett[9, 10] to measure the height of

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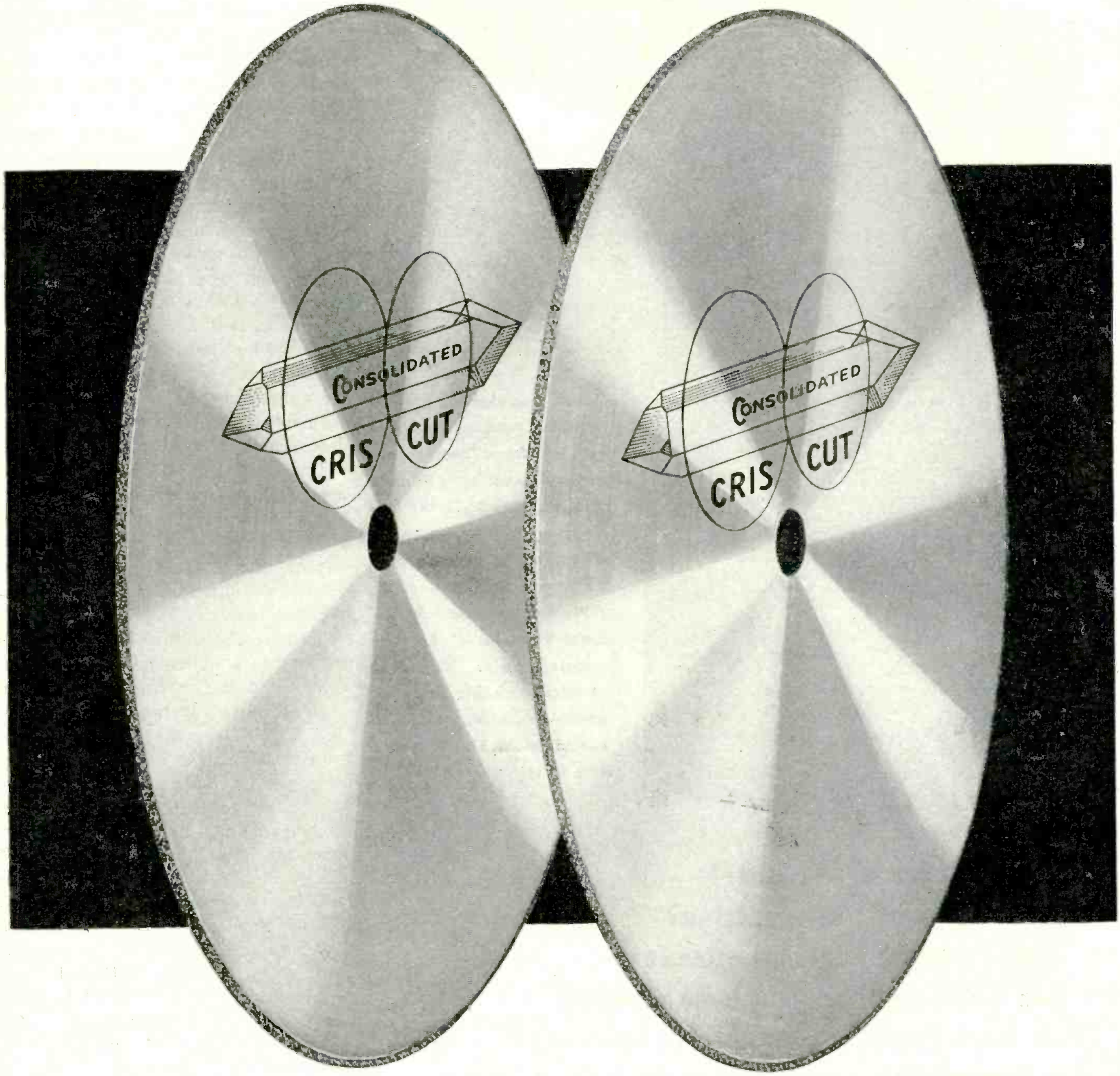

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the ionospheric regions, using a known value for the velocity of the waves.

Accuracy of Measurements

The accuracy of the measurements carried out by the methods described above depends essentially on the measurement of the two quantities, the phase displacement ϕ_0 and the length of path d traversed by the waves between the stations. The total phase displacements during the frequency-change process ranged from a few hundred to several thousand degrees, and the investigators were able to measure these to within 3 or 4 deg.; accuracy of phase measurement was thus of the order of 1 or 2 parts in 1000 in the most favorable cases. The distance measurements were carried out by standard geodetic survey methods, and appear in the most favorable cases to have been determined to an accuracy somewhat better than 1 part in 10^3 (0.1 percent). This implied that the centers of radiation of the antenna systems were known to a high order of accuracy, and to facilitate this the antennas at both stations were of the vertical-umbrella type.

The mean results obtained in the various sets of experiments for the velocity of the medium radio waves used all lie within the limits of 2.990 and 2.995×10^{10} cm per second for transmission over clear air path, or over sea or fresh water. As these limits are within the accuracy of the measurements, no definite conclusions can be drawn as to the effect of a salt or fresh water path on the velocity of propagation. In the case of transmission overland, a somewhat lower value of 2.950×10^{10} cm per second was obtained, although this would appear to be subject to some uncertainty in determining the true path of transmission, owing to various intervening obstacles.

Although the work just described has enabled a valuation for the wave velocity to be obtained, much of this and other investigation work has been directed by Mandelstam and Papalexi towards the development of what is termed an "interference range-finder." More recently than the work referred to above, some papers have been published by J. L. Alpert, W. W. Migulin and P. A. Riasin,[11, 12] in which the nature of the electromagnetic field near an antenna, and the effect of various con-

ditions on the velocity of propagation to various distances, have received special attention. It appears that there is reason to suppose that the phase velocity of radio waves propagated over a flat and uniform surface is not constant, but may vary within a radius of three or four wavelengths from the source; this disturbance gradually disappears until, at a radius of some 50 wavelengths, the velocity is sensibly equal to its free space value.

Experiments have also been carried out to ascertain whether there is any dispersion in the transmission of waves over land and sea, in the range of wavelengths from 120 to 660 meters. The results of such experiments indicate that, for example, the velocity at wavelengths of 300 and 450 meters cannot differ by more than 0.07 percent for oversea transmission, whereas over dry land a difference of a few tenths of one percent is possible.

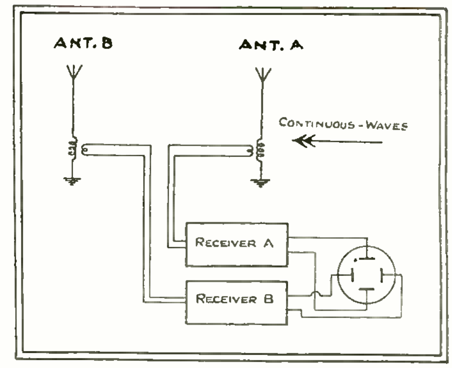
It is stated that balloon experiments have shown that the effect of the earth's surface on the field does not extend beyond a height of four or five wavelengths for the medium waves used. All this work would appear to be closely connected with Sommerfeld's classical investigations of the propagation of electromagnetic waves over the earth's surface, and to warrant considerable further study in connection with various radio problems and applications. It forms an interesting example of the manner in which fundamental investigations conducted from an apparently solely academic viewpoint may, in time, come to have important practical applications.

Conclusions

The velocity of light waves is known with considerable precision, and its value in vacuum may be taken as 2.99775×10^{10} cm per second. The modified value for light propagated through air under normal atmospheric conditions at sea level is 2.99670×10^{10} cm per second. The accuracy of measurement of these values is about 0.5 part in 10^4. It will be observed that the velocity value in air differs from the nominal figure of 3×10^{10} cm per second by about 0.1 percent. Modern radio-frequency technique has proved of considerable use in recent determinations of the velocity.

When we come to the radio-fre-


To all the Valiant



Apparatus used by Ross and Slow[13] for measurement of phase velocity of electromagnetic waves. Continuous waves were received from a source placed in line with the antennas and caused an elliptical trace on the cathode-ray tube. From this it was possible to determine the phase difference between currents in the antennas and the phase velocity of the waves between them

quency portion of the spectrum, the methods so far used for the determination of the velocity are much less accurate than this. It may be stated that within the limits of the experimental accuracy so far attained, which is not better than 0.1 percent, the velocity of propagation of medium radio waves is about 2.990×10^{10} cm per second. The experimental evidence so far available indicates that this value for the velocity is the same for all radio wavelengths within the accuracy specified above. There is some evidence that the phase velocity may be reduced below this value near the transmitting aerial, and it may also be modified when transmission takes place close to the surface of the earth; but it seems doubtful whether this variation from the free space value amounts to more than the experimental accuracy, except where obstacles such as trees and mountains intervene in the path of propagation. In this case it is not necessarily the velocity which has altered, but rather that the path traversed has been increased.

This discussion leaves the problem of the measurement or calculation of the actual time of transit of radio waves between sender and receiver still open to investigation. This type of information may be required for a number of purposes such as the use of time signals for the comparison of chronological standards and for the determination of differences of longitude. For the solution of this problem a knowledge of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the free space speed is only one requirement; it still needs a precise specification of the actual path, rectilinear or otherwise, followed by the waves, and of any modification to the velocity value produced by atmospheric or ionospheric conditions.

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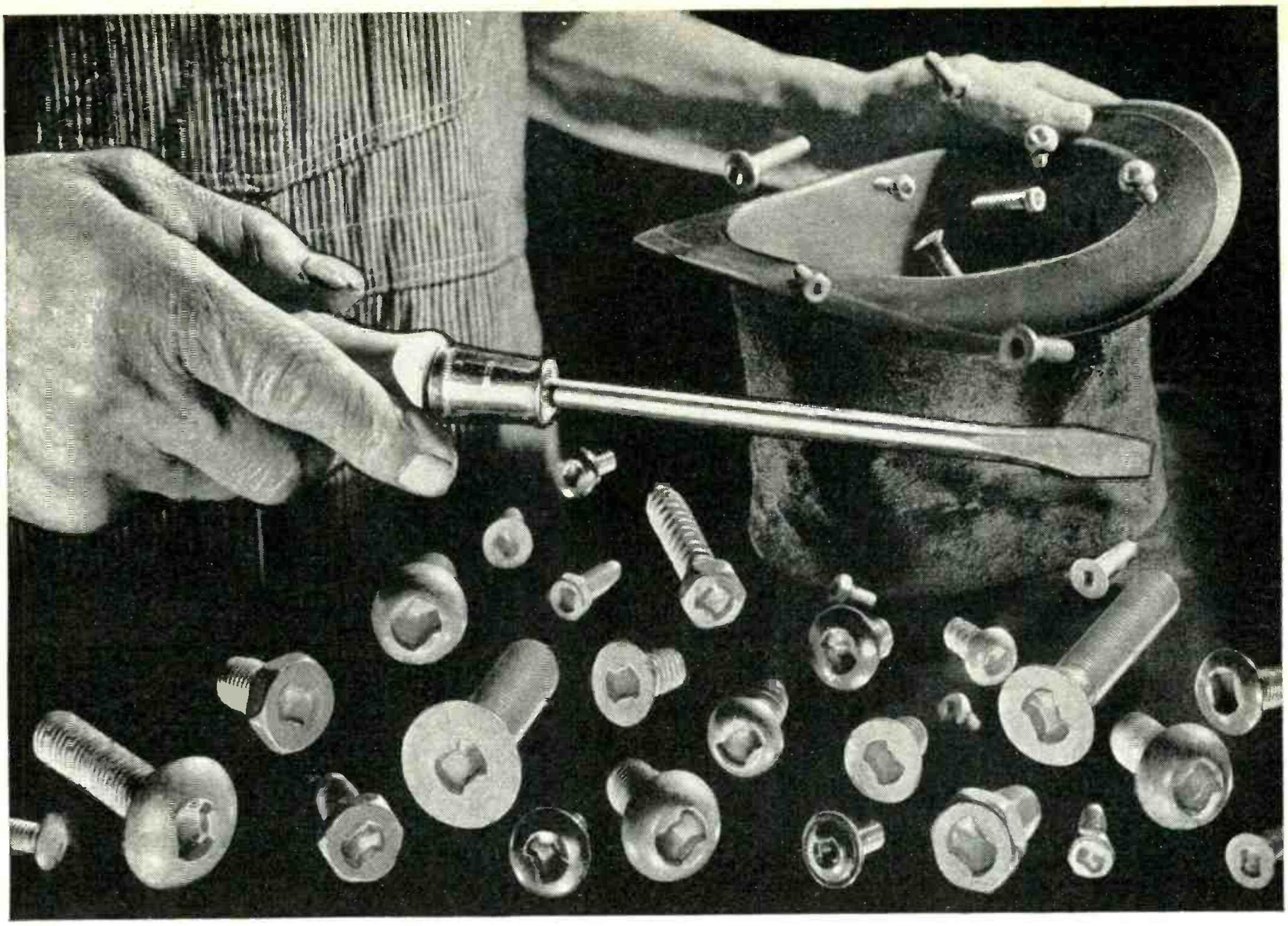
MINE DETECTOR DEMONSTRATION

Workers of a London factory making land mine detectors were able to see them in action in a demonstration in which real mines were used. Photograph shows the sapper in the foreground using the long-handled detector to clear the way for a raiding party



Screwdriver Magic? Yes!

To the man in the field . . . the battle field, the farm field, the flying field; out on the highways and byways of the world . . . the humble screwdriver is a stand-by.

Modern high speed assembly lines, using CLUTCH HEAD SCREWS to "button up" implements and machines of war and peace, do not overlook the problems of this man in the field. They know that the Center Pivot Assembly Bit they use is twin brother to this standard type screwdriver . . . *virtually a magic wand* that unlocks the security of CLUTCH HEAD SCREWS when field repair or adjustment is a critical need.

CLUTCH HEAD SCREWS, as used today in vital war service, meet all the essential demands for speed, safety, security, and lowered costs in modern assembly . . . *plus the exclusive facility that they operate with ordinary type screwdrivers.*

United invites you to send for fully illustrated CLUTCH HEAD Brochure . . . also for package assortment and sample Center Pivot Assembly Bit.

CLUTCH HEADS are the most modern screws on the market today. They have definite exclusive advantages that make them preferred on assembly lines using Standard or Thread-forming types for every purpose.

CLUTCH HEAD - SCREWS -

There is important economy in the long total life of this rugged Center Pivot Assembly Bit. A brief application of end surface to a grinding wheel restores original efficiency. No "back-to-the-factory" shipment for reconditioning.

UNITED SCREW AND BOLT CORPORATION

CHICAGO CLEVELAND NEW YORK

V-T Voltmeter

(*Continued from page* 104)

sible to limit the total current which can flow through the meter, even with a severe overload at the voltage input terminal.

In order to assure that the voltmeter produces an accurate indication at all times, a somewhat unusual method of checking the calibration has been applied. This method consists of using a Mallory grid-bias cell as a standard with which the a-c operated circuit can be calibrated. A bias cell is useful for this purpose because of its very small size and because it maintains a constant terminal voltage over long periods of time. If the cell has first been aged for about 1000 hours, and if no direct currents larger than 10^{-7} ampere flow in the cell circuit, the output voltage of a $1\frac{1}{4}$ volt cell may be expected to be maintained under normal temperatures to within $\pm$ 2 percent of its original value for at least two years.

Two of the range switch positions are labelled "Cal. 1" and "Cal. 2". These are used for checking the calibration of the meter by the method outlined above. When the switch is at "Cal. 1" a known direct voltage from the bias cell is connected between ground and the bottom of the voltage dividing resistor. The adjustable resistor R_4 is varied until the meter deflects to a calibration point on the scale of the moving pointer meter. The range switch is then set to Cal. 2, and the resistor R_5 is adjusted to give a meter indication of zero. These two adjustments are repeated in succession until the meter indicates zero at Cal. 2 and up to the marked point at Cal. 1, at which time the instrument is correctly calibrated. Ordinarily this calibration operation should not have to be done oftener than once each week, even under conditions of heavy service of the meter.

Characteristics of the Vacuum-Tube Voltmeter

The voltmeter constructed on the basis of the circuit of Fig. 4 has been found in practice to be entirely satisfactory. Experimental checks show that changes of $\pm$ 10 percent in line voltage result in variations of less than $\pm$ 2 percent in the indication of the meter throughout all

reading ranges both on the a-c and on the d-c settings.

The input impedance of the instrument with the switch on the d-c position is a resistance of 10 megohms shunted by a capacitance of 15 micro-microfarads. With the switch on the a-c position, the "impedance" is rather complicated because of the rectifier action of the diode, but the loading effect upon most circuits encountered in ordinary laboratory work has been found to be negligibly small.

With a General Radio model 726-A vacuum tube voltmeter as a standard, the a-c operated voltmeter as herein described can be considered to be useful and reliable for frequencies between 50 and 20×10^6 cps. Over this range, the a-c operated voltmeter should be accurate to within 5 percent of full scale deflection.

Any vacuum-tube voltmeter of the peak-reading type, of which the instrument under consideration is an example, is subject to serious errors if a calibration based upon root-mean-square sinusoidal voltage is used to measure voltages of non-sinusoidal wave form. A percentage error, equal to the percentage of harmonic amplitude present in the voltage being measure, is possible.

The a-c operated vacuum-tube voltmeter as constructed measures 6 in. by 11 in. by 4 in., so that it is small enough to carry conveniently. Based upon prewar prices, the total value of the parts used in the voltmeter is less

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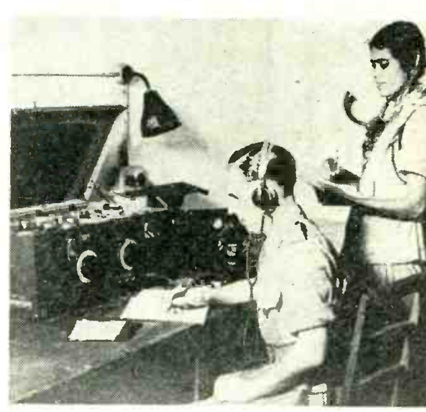
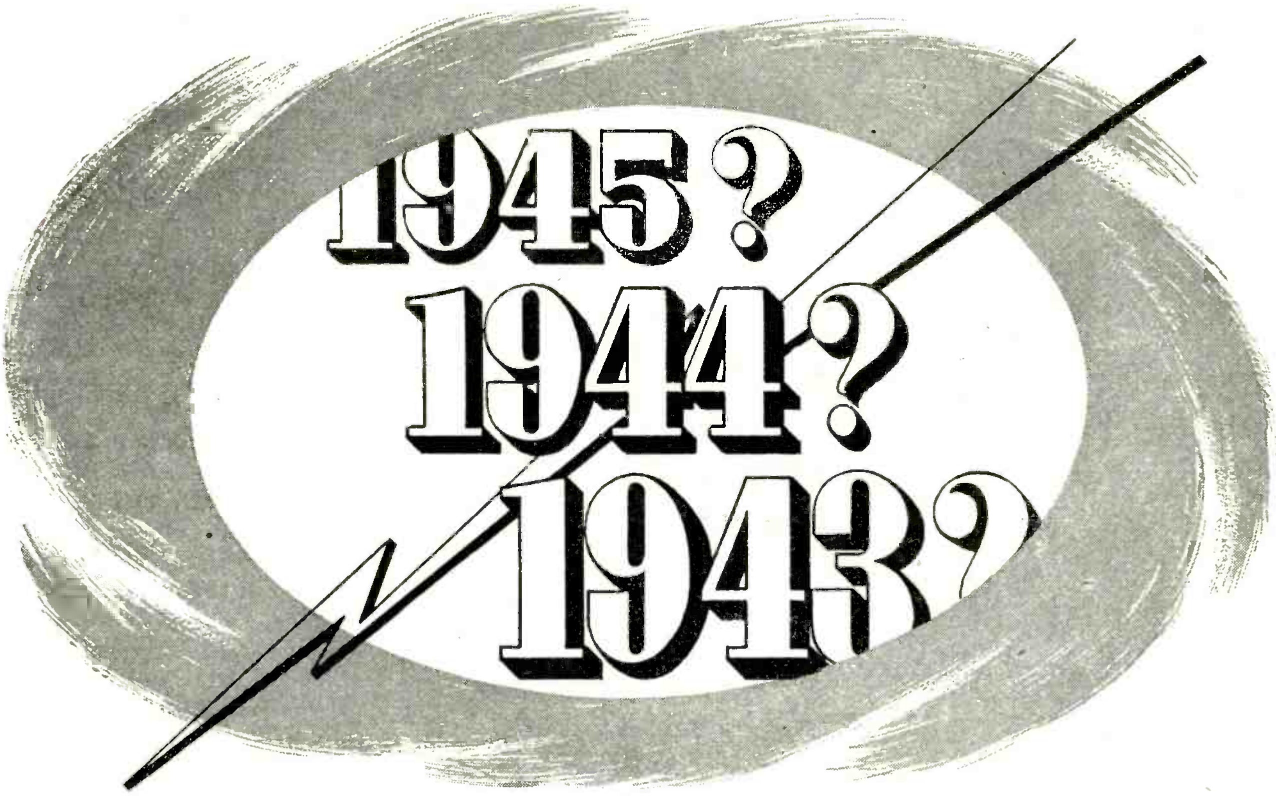
INDIA CONTRIBUTES TO WAR



The Women's Auxiliary Corps in India is playing a vital part in the air war. Certain members have been selected for radio location work and operate with the Royal Air Force in the Indian Air Force. The woman shown here is a radio aide

PERMANENT MAGNETS MAY DO IT BETTER



When Will "The Age Of Electronics" Begin?

THE answer, obviously, is when the war is *won,* for only then can America's scientists and engineers—now concentrating on electronics for war—devote all of their efforts to applying electronics to peacetime uses. But because it's their nature to *prepare* for the unpredictable future, many of them, despite heavy working schedules, are already thinking about post-war products utilizing their electronic discoveries.

If you are one of these men, working on wartime or post-war problems, we'd like to suggest that you consider incorporating the principle of the *permanent magnet,* and that you ask us for any information you need. Because we've specialized in this *one* field for 33 years, we've been able to design and produce permanent magnets that have improved the functions and increased the uses of many vital electronic devices, as well as countless other important products. To these we made a valuable engineering contribution. To *you* we offer the same service.

Though our plant (the nation's largest specializing in the making of permanent magnets) is devoted to war orders, our engineers will be glad to consult with you and give your problems the benefit of their unusual experience.

Write for the address of our office nearest you and a copy of our 30-page "Permanent Magnet Manual".

Let's speed victory these two ways: by more war production and by buying more War Bonds!

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than $25, a reasonable figure. Thus, in both size and cost, the a-c operated instrument is satisfactory when compared with existing commercial vacuum-tube voltmeters, and its stability and accuracy have been found adequate for ordinary laboratory use.

The author wishes to acknowledge his indebtedness to Mr. G. T. Coate, of M. I. T., who did some original work on a-c operated amplifiers and thereby stimulated this research, and to Professor T. S. Gray, of M. I. T. who offered many helpful suggestions during the experimental work.

Appendix

During the study of a-c operated vacuum-tube circuits, it became necessary to have some method for determining the operating conditions of the vacuum tubes. There proved to be very little available literature on the subject,[1, 2] so that it was necessary to develop some new graphical and analytical methods which would apply. Because of their simplicity, the fact that pentodes seemed to offer no particular advantages, and because double triodes were available whereas no applicable double pentodes seem to be manufactured, triodes were used in the vacuum-tube voltmeter which was developed. For these reasons, the following analysis applies to triodes only.

The list of symbols used in the analysis is given below so that the calculations and discussion may be followed more easily. Some of these symbols appear in Fig. 5.

E_c = Direct voltage rise from cathode to grid.
E_{bb} = Direct plate supply voltage.
E_b = Direct voltage rise from cathode to plate.
E_{bo} = "Cut-off" plate voltage for a given E_c, defined by $E_{bo} = \mu E_c$.
E'_{bb} = Peak value of alternating plate supply voltage rise from cathode.
I_b = Direct plate current.
i'_b = Peak value of plate current caused by the application of an alternating plate voltage of magnitude E'_{bb}.
α = The conduction angle, in radians, during which plate current flows when an alternating plate voltage is applied to the tube.
ω = Angular frequency of the applied plate voltage = $2\pi \times 60$ radians/sec in the experimental work.
μ, r_p, g_m = The usual dynamic tube characteristics.

Any other terms used are defined in the body of the analysis.

Tube characteristics of the type shown in Fig. 5 are assumed in this analysis. This is the standard assumption that the triode character-

istics are linear, parallel, and equidistant. A further assumption is made that the alternating plate voltage is sinusoidal. This was tacitly assumed above in the definition of ω. In Fig. 5, the angle is given by

$$\gamma = \sin^{-1}\frac{E_{bo}}{E'_{bb}} = \sin^{-1}\frac{\mu E_c}{E'_{bb}} \quad (1)$$

From the same figure, the conduction angle α is seen to be

$$\alpha = 2\left(\frac{\pi}{2} - \gamma\right) = \pi - 2\gamma \quad (2)$$

Thus

$$\gamma = \frac{\pi - \alpha}{2} \quad (3)$$

In Fig. 5 the plate voltage of the tube for the positive half-cycle is shown as the half sinusoid drawn below the tube characteristics. The amount of this voltage which is effective in causing plate current is determined by the grid voltage of the tube; in Fig. 5, the shaded area represents this effective voltage. The average plate current flowing in a tube operating under the conditions represented by Fig. 5 is simply the average of the plate voltage in the shaded area, divided by the plate resistance of the tube. Careful study of Fig. 5 will reveal that this average plate current is given by

$$I_b = \frac{1}{r_p}\cdot\frac{1}{2\pi}\left\{2\left[\int_{\gamma}^{\frac{\pi}{2}} E'_{bb}\sin\theta d\theta - E_{bo}\frac{\alpha}{2}\right]\right\}$$

$$= \frac{1}{\pi r_p}\left[\left(-E'_{bb}\cos\theta\right)\right]_{\frac{\pi-\alpha}{2}}^{\frac{\pi}{2}} - \mu E_c\frac{\alpha}{2}$$

$$= \frac{1}{r_p}\left[E'_{bb}\sin\frac{\alpha}{2} - \mu E_c\frac{\alpha}{2}\right] \quad (4)$$

Also from Fig. 5 it is seen that

$$r_p = \frac{E'_{bb} - \mu E_c}{i'_b} \quad (5)$$

Also from (1) and (2)

$$\alpha = \pi - 2\sin^{-1}\frac{\mu E_c}{E'_{bb}} \quad (6)$$

Therefore, from (4), (5), and (6),

$$I_b = \frac{i'_b}{\pi(E'_{bb} - \mu E_c)}\left[E'_{bb}\sin\frac{\alpha}{2} - \mu E_c\frac{\alpha}{2}\right] \quad (7)$$

But

$$E'_{bb}\sin\frac{\alpha}{2} = E'_{bb}\sin\left[\frac{\pi}{2} - \sin^{-1}\frac{\mu E_c}{E'_{bb}}\right]$$
$$= \sqrt{(E'_{bb})^2 - (\mu E_c)^2} \quad (8)$$

And

$$\frac{\alpha}{2} = \frac{\pi}{2} - \sin^{-1}\frac{\mu E_c}{E'_{bb}} = \cos^{-1}\frac{\mu E_c}{E'_{bb}} \quad (9)$$

Hence

$$\frac{I_b}{i'_b} = \frac{1}{\pi(E'_{bb} - \mu E_c)}$$
$$\left[\sqrt{(E'_{bb})^2 - (\mu E_c)^2} - \mu E_c\cos^{-1}\frac{\mu E_c}{E'_{bb}}\right] \quad (10)$$

This can be rewritten in a more useful form as given below:

Important Announcement to *Users of Springs*

In the interests of hundreds of engineers, designers, and production executives, to whom better coil and flat springs are of vital importance, Instrument Specialties Company is planning a comprehensive exhibit of "Micro-processed" beryllium copper springs and engineering data—to be shown at the National Metal Congress, Room 713, Palmer House, Chicago, from October 18th through the 22nd.

"Micro-processed" beryllium copper springs are setting new standards for spring design and performance. In the past nine months, Instrument Specialties has had innumerable requests for detailed information on the metallurgical, design, physical and electrical properties made possible by this process. Therefore, we are assembling under one roof in Chicago, the best informed members of our staff, who will be pleased to discuss with you any phase of Micro-processed springs and their most effective use.

The metallurgical director, chief design engineer, and others of the Instrument Specialties organization will be in attendance, backed up by technical information of real value to users of springs. This is our cordial invitation for you and your associates to make it a point to get at first hand the exceptional story of "Micro-processed" beryllium copper springs.

Room 713, Palmer House, Chicago,
October 18th to the 22nd.

INSTRUMENT SPECIALTIES CO., INC.

DEPT. D, LITTLE FALLS, NEW JERSEY

$$\frac{I_b}{i'_b} = \frac{1}{\pi\left(1 - \frac{\mu E_c}{E'_{bb}}\right)}$$

$$\left[\sqrt{1 - \left(\frac{\mu E_c}{E'_{bb}}\right)^2} - \frac{\mu E_c}{E'_{bb}} \cos^{-1}\frac{(\mu E_c)}{E'_{bb}}\right] \quad (11)$$

The form of (11) makes it evident that the result is dependent only upon the ratio $\mu E_c/E'_{bb}$. Thus (11) is a universal equation that can be used for any triode to which are applicable the assumptions previously mentioned.

Since Eq. (11) is somewhat complicated, the relationship between $\frac{I_b}{i'_b}$ and $-\frac{\mu E_c}{E'_{bb}}$ has been plotted in Fig. 6. It will be noticed that this relationship, the solid line of Fig. 6, approximates a straight line rather closely. The assumptions made in the preceding derivation are sometimes rather far from the true state of affairs, so that it seemed justifiable to approximate the calculated curve of Fig. 6 by the dotted straight line. This straight line has the equation

$$\frac{I_b}{i'_b} = \frac{1}{\pi}\left(1 + 0.6\,\frac{\mu E_c}{E'_{bb}}\right) \qquad (12)$$

The form of (12) emphasizes the fact that the ratio of the direct plate current which flows in the tube to the peak current is the average of a half-wave rectified sinusoid diminished by a term which depends upon the magnitude of the grid bias. (Note that E_c is negative for all the cases considered in this analysis.)

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SILICON STEEL samples are inductively heated to 2700 deg F with 500-kc G-E induction heating equipment to determine the carbon content to an accuracy of 0.001 percent. The lower the carbon content, the smaller is the core loss in transformers.

IMPLOSIONS of large cathode ray tubes invariably result in pulverizing of the glass envelop, with startling sound effects but no injury to those nearby and no large flying missiles, according to "Diallist" writing in the British magazine *Wireless World*.


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The Solderless Terminal that
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PERMITS uniform installation with unskilled labor. Provides a strong mechanical joint that withstands severe vibration.
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Cut down installation time and save valuable man-hours by using "Grip-it" Solderless Terminals.
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NEWS OF THE INDUSTRY

Machine gun sound effects; wire recorder for Army; science book for blind; spaghetti aligns filaments; free War courses; new calls for FM stations; standards for glass-bonded mica; wire sizes; I.R.E. Rochester Fall Meeting Program

Machine Gun Trainer with Sound Effects

A MACHINE GUN TRAINER that fires lead pellets instead of real bullets, and allows soldiers to hear sounds that simulate battle conditions, is being used by the Army and was shown to the public in the Army War show given by the Sixth Service Command on tour.

The gun is a mock-up of the regulation M-2 machine gun and contains an electro-hydraulic drive developed by G-E for firing 120 lead pellets per minute. The pellets are white and simulate tracer bullets that appear every five rounds in a standard machine gun. For use at night ultraviolet light and fluorescent bullets can be employed.

In training camps the gun is mounted so that model planes, suspended from wires, travel around and toward the gunner from all directions. The models are scaled and move at a speed to correspond to that of a real plane at 500-yard distance and can simulate plane speeds up to 500 miles an hour.

A phonograph record feeds into an amplifier to reproduce the sound of a standard 50-calibre machine gun amid typical battle noises. The amplifier system, developed by Operadio, supplies two large speakers mounted directly above the gunner's position. About 1,000 of the training guns are in use in army camps and it is estimated that they save a total of $10,800,000 every hour they are used for training.

Wire Recorders for Army

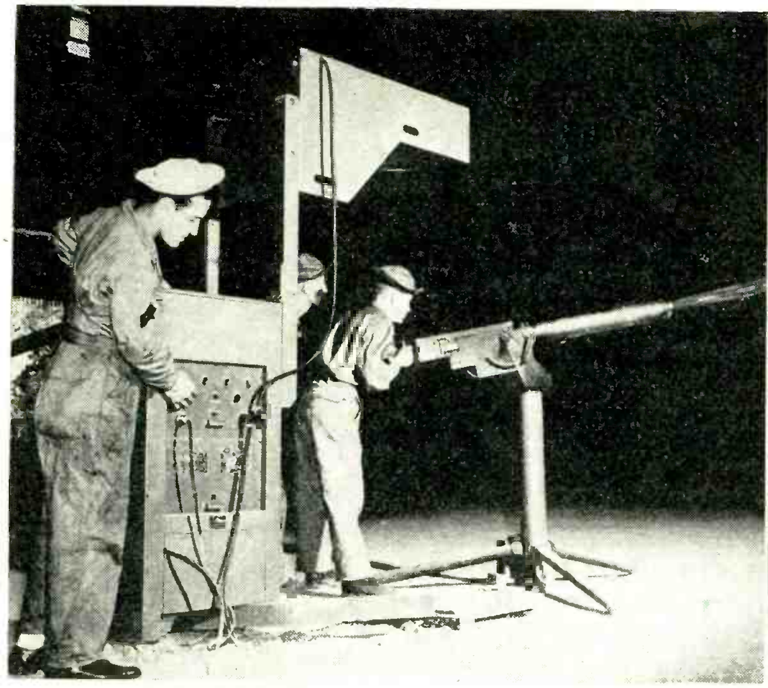
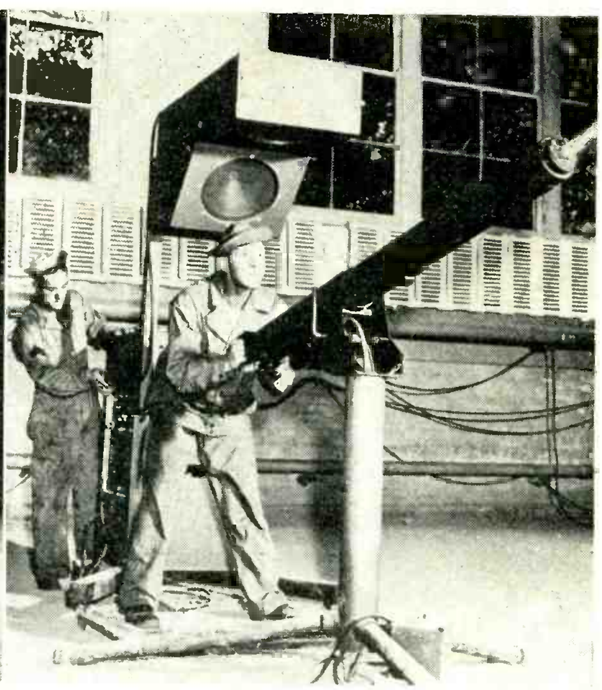
ARMY PERSONNEL in North Africa who cannot pick up U. S. radio programs directly are hearing the Army Hour broadcast and news programs from an electronic sound recorder and playback unit that uses wire instead of the conventional record.

Two news roundups and the Army Hour program broadcast are recorded on the wire each week by G-E engineers. Spools of the wire are then air-mailed to Washington, and from there are flown to Algiers by transport plane.

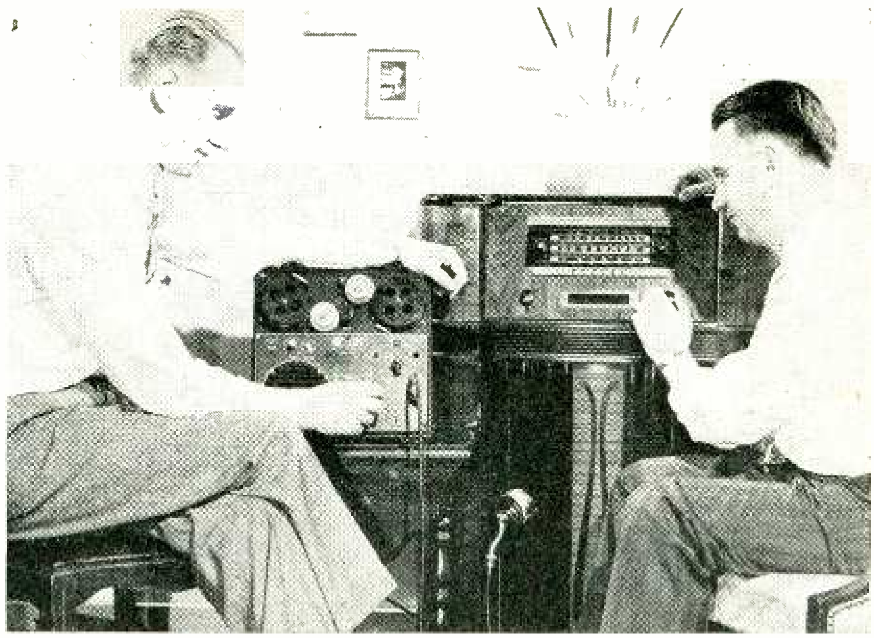
The photograph shows the combination recorder-playback unit in use. It records 66 minutes of continuous sound on 11,500 feet of thin steel wire that is rolled up on a small spool. The unit also permits erasing the recorded sounds from the wire so that it may be used over again.

A portable wire recorder, also in production by General Electric, weighs about nine pounds and operates from batteries. This is designed for field service and has proven sucessful in experiments in jeeps and in planes 30,000 feet above the ground.

The army hopes that the portable recorder will bring a new dimension and flexibility to radio's coverage of

Machine gun trainer consisting of an electro-hydraulic machine gun and a sound amplifier that reproduces the sounds of a 50-calibre gun being fired against background noises of dive bombers, heavy guns and other battle sounds. Edison General Electric Co. engineers made the hydraulic gun, and Operadio Mfg. Co. developed the speaker and amplifier

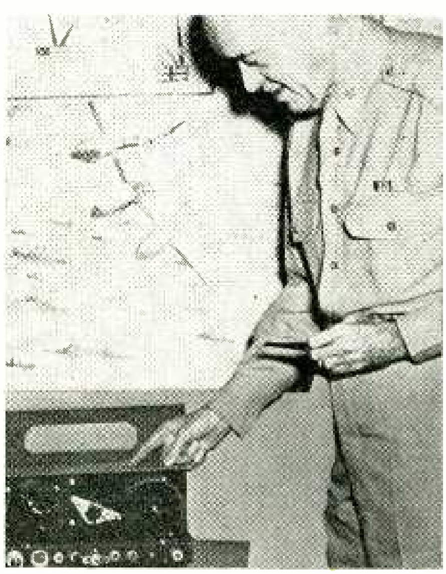


A wire recording of the Army Hour is taken off the air by A. W. Sear and E. A. Malling, G-E engineers. Wire spools, containing 66 minutes of the program, are flown to Algiers and played back to Army soldiers, officers, and war correspondents

the war, according to Colonel E. M. Kirby, Chief of the Radio Branch of the Army's Bureau of Public Relations.

"Radio reporters have been anchored to stationary radio transmitters in a war of movement," said Colonel Kirby. "If they go to the front they cannot broadcast until they return to the transmitters. In the southwest Pacific this means a distance of 1,500 miles both ways. In the Tunisian campaign, it meant several hundred miles, and for Sicily, another hour's plane ride. As a result radio has encountered, for the first time in its history, a limit of time and distance."

The army plans to loan the portable recorders to accredited network correspondents as soon as there are enough to insure even distribution among all the networks. On-the-scene reports from the war fronts can then be recorded for later broadcast to every American home.



Portable model of wire recorder, to be used by war reporters in the field, is examined by Colonel R. Ernest Dupuy, Chief of the News Division of the U. S. Army Bureau of Public Relations

Science Book in Braille for the Blind

STUDENTS IN SCHOOLS for the blind are eagerly reaching out for knowledge of science. In a recent class a demonstration of magnetism was prepared for the students. The teacher covered a horseshoe magnet with a sheet of paper and then sprinkled iron filings over the paper. With a gentle shake the filings arranged themselves into a pattern that reproduced the shape of the horseshoe magnet.

Next, each member of the class in turn placed his sensitive fingers on the paper and traced and retraced the path of the pattern formed by the filings, while the teacher explained the principles of magnetism. After he finished talking the room buzzed with questions and a lively

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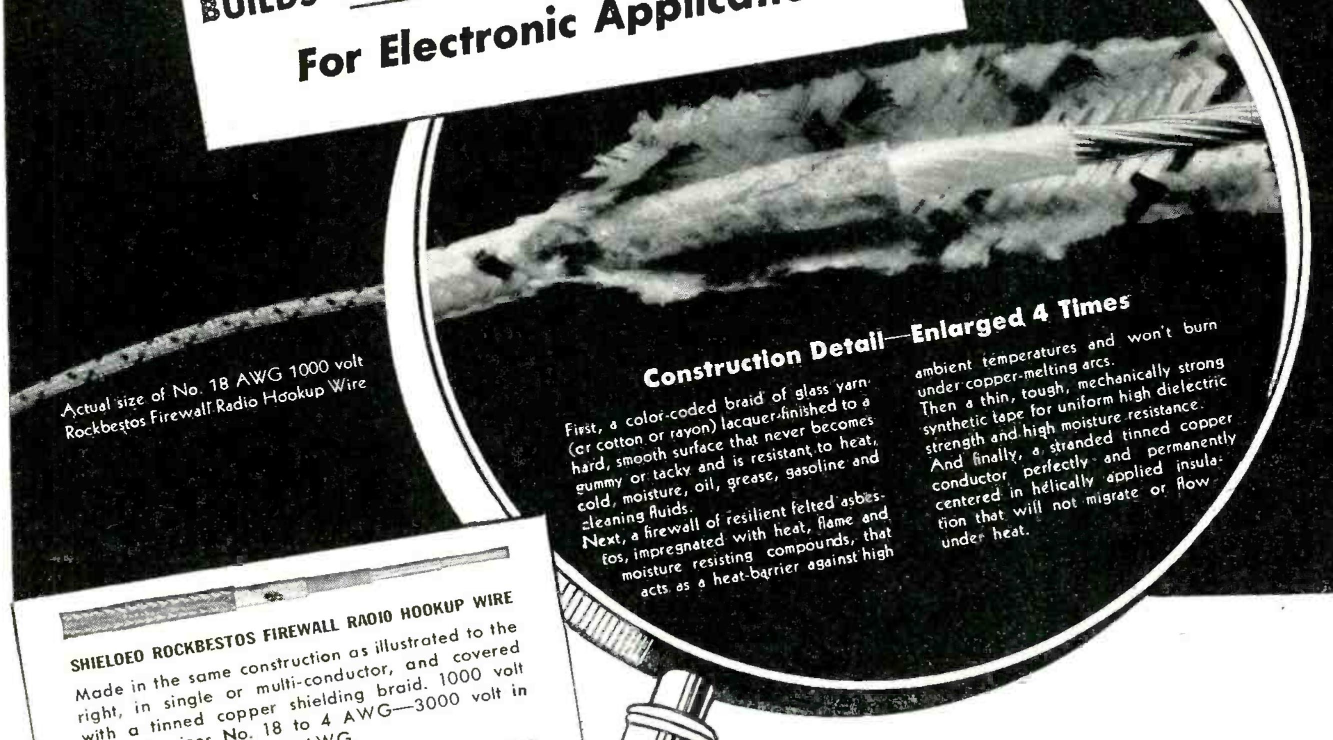

Actual size of No. 18 AWG 1000 volt Rockbestos Firewall Radio Hookup Wire

Construction Detail—Enlarged 4 Times

First, a color-coded braid of glass yarn (or cotton or rayon) lacquer-finished to a hard, smooth surface that never becomes gummy or tacky and is resistant to heat, cold, moisture, oil, grease, gasoline and cleaning fluids.
Next, a firewall of resilient felted asbestos, impregnated with heat, flame and moisture resisting compounds, that acts as a heat-barrier against high ambient temperatures and won't burn under copper-melting arcs.
Then a thin, tough, mechanically strong synthetic tape for uniform high dielectric strength and high moisture resistance.
And finally, a stranded tinned copper conductor perfectly and permanently centered in helically applied insulation that will not migrate or flow under heat.

SHIELDED ROCKBESTOS FIREWALL RADIO HOOKUP WIRE
Made in the same construction as illustrated to the right, in single or multi-conductor, and covered with a tinned copper shielding braid. 1000 volt rating in sizes No. 18 to 4 AWG—3000 volt in sizes No. 12, 14 and 16 AWG.

ROCKBESTOS ASBESTOS INSULATED MAGNET WIRE
Designed for Class B windings, it is suitable for use as bus wire where high dielectric strength is not required. The insulation is non-checking and is unaffected by heat or aging.

ROCKBESTOS ALL-ASBESTOS LEAD WIRE
In sizes No. 20 to 8 AWG. Solid or stranded copper, monel or nickel conductors insulated with .031" or .040" of felted asbestos in black, white or colors. Won't dry out and crack under heat and vibration; rot, swell or flow under contact with oil or grease, and has ample moisture resistance for most applications.

ROCKBESTOS TYPE CA LEAD WIRE
In the same sizes and conductors as the All-Asbestos Lead Wire above and having the same characteristics, plus higher dielectric strength and moisture resistance provided by the synthetic tape beneath the felted asbestos. For applications in hot, humid locations.

A few of the 122 different wires, cables and cords developed by Rockbestos.

Here's a wire that gives you heat and flame resistant characteristics, in addition to unusually high dielectric strength—Rockbestos Firewall Radio Hookup Wire—designed in 1937 to satisfy the requirements of aircraft radio manufacturers for a small diameter, light weight, stable, flame and moisture-resistant construction, and used since in a wide variety of radio equipment and electronic apparatus.

It is resistant to heat, cold, flame, oil, grease, gasoline, moisture, alkalies and corrosive fumes.

It is made in two constructions—1000 volt rated, in sizes No. 22 to 4 AWG and 3000 volt in No. 12, 14 and 16 AWG.

It has a wide operating temperature range—won't dry out in insulation-baking heat up to 125° C., or become brittle in sub-zero cold as low as minus 50° C.

The 1000 volt wire has been subjected to life voltage tests at rated voltage and 125° C. rated temperature for 2500 hours without failure—and at rated voltage and room temperature for 8000 hours.

The 3000 volt wire has been subjected to test at 5000 volts and 125° C. for periods in excess of 700 hours without failure—and at the same voltage at room temperature for periods in excess of 1200 hours.

These are a few of the characteristics that have brought this type of wire into wide use in a variety of applications—characteristics that are basic in many constructions in the Rockbestos line of 122 permanently insulated wires, cables and cords. One of them may be what you are looking for, but if not, Rockbestos Research will do its best to develop a wire for you. Write or phone nearest branch or:

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INVEST IN WAR BONDS • MAKE EVERY PAYDAY A LAY-AWAY DAY

At the Western Pennsylvania School for the Blind, science teacher James Schroder guides the hand of Virginia Wolozyn while Robert Farrell waits his turn. Her fingers will trace the pattern formed by iron filings over a horseshoe magnet. A science textbook, printed in Braille by Westinghouse, is available for her use

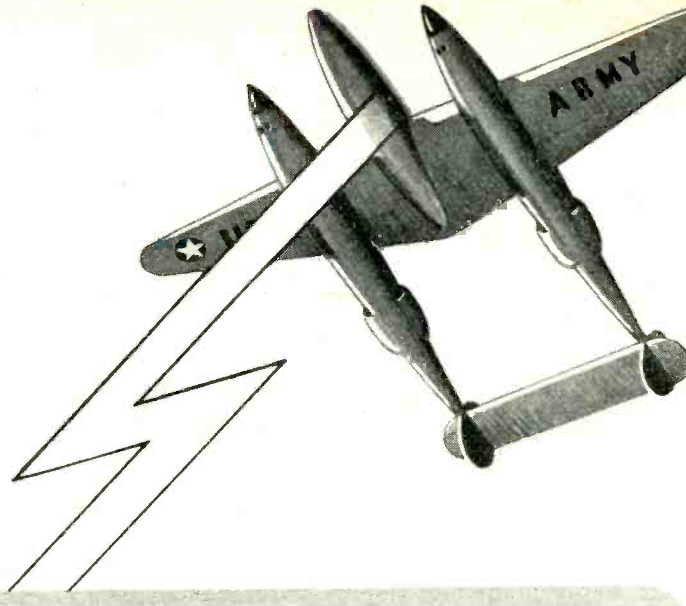
and lengthy quiz of the teacher ensued.

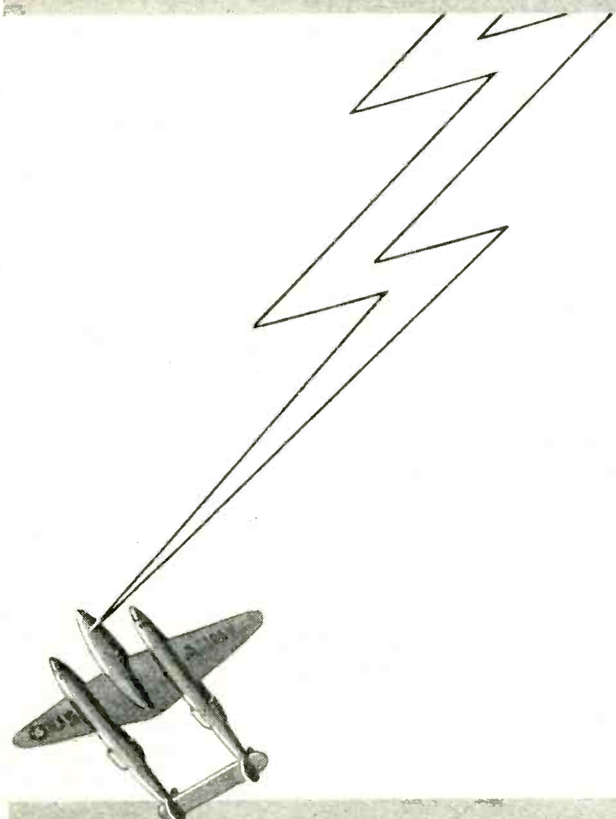
To help blind students explore the world of science a Braille edition of a booklet written by Westinghouse research experts is being distributed to schools for the blind by the School Service Department of the company. The booklet is one of the Little Science series, designed for students of high school age.

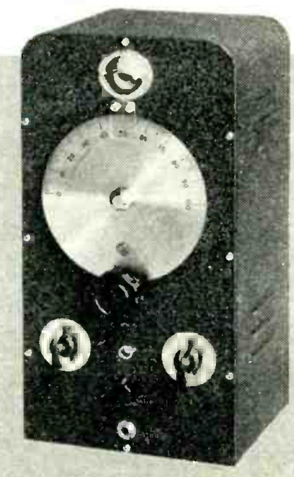
About 600,000 copies of the first four booklets have been printed in ink and supplied to schools throughout the nation. Charles MacLean, manager of the School Service, suggested making the series available in Braille to blind students, to further extend the scope of the series and render useful service. The project is still in the experimental stages, but as soon as the initial booklet has been given a thorough trial, consideration will be given to printing the remainder of the series in Braille.

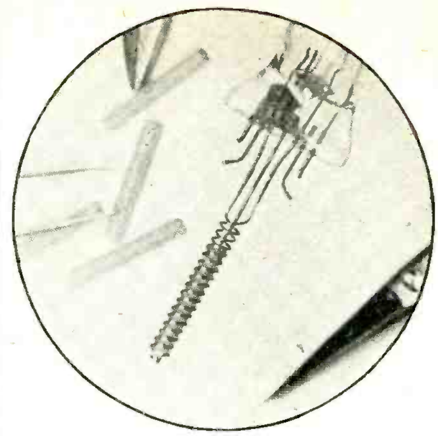
Uncooked Spaghetti Helps Make Vacuum Tubes

TUBE FILAMENTS are being aligned for welding by a piece of spaghetti (the edible kind), which is later burned off. The new technique, developed by William A. Hayes, electronics engineer in the Westinghouse Lamp Division, produces 50 percent more filaments than the old method and permits assembly workers to spend more time on other production jobs. A WPB Award of Individual









Closeup of a piece of uncooked spaghetti at work keeping the filament turns properly aligned. Current is sent through the filament to burn away the spaghetti after welding is completed

Production Merit has been recommended for the inventor.

Filaments for many tubes are made in the form of a small wire spring. Formerly a split steel rod was inserted in the filament coil for support as well as to keep the turns in accurate alignment while the coil was being welded to the rest of the mounting assembly. Since the coil tends to tighten around the steel insert after welding, the removal often requires realignment of the turns.

A small piece of spaghetti replaces the steel rod in the new method. After the filament is welded, current is passed through it to remove impurities in the metal. The heated filament burns up the spaghetti and eliminates the removal problem. The

William Hayes examines the spaghetti-supported filament he developed. The spaghetti is made to exact size by a special die

From blast furnace to battle front...

Constant Voltage guides the Tools of War

NEVER before in the history of warfare has precision production been so important as it is today. From the trigger group of an M-1 rifle to the fire control of a 16-inch battery, split-hair tolerances are demanded in millions of intricate munitions parts. Producing to uncompromising standards requires the finest type of machine tools ever designed—operated at a constant level of electric power.

But *constant voltage* is almost non-existent on today's overcrowded power lines. Wartime consumers are busier. Huge volumes of electrical energy are being intermittently used and released. Heavy sags and destructive surges inevitably occur. For that reason, manufacturers in every field are stabilizing power themselves with SOLA CONSTANT VOLTAGE TRANSFORMERS.

Sola "CVs" equalize voltage sags and surges, absorb variations as great as 30%, feed a controlled flow of power to machines. And they protect the *very life* of sensitive instruments and electronic tubes.

Engineered for long, trouble-free service, Sola "CVs" are instantaneous in action, without moving parts, self-protecting against short circuit. They have a place on *your* production lines —the life lines of American victory.

Note to Industrial Executives: *Sola "CV" transformers are available in standard 10VA to 15KVA units. Special units to specification. Ask for bulletin DCV-74*

SOLA Constant Voltage Transformers

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

whole operation is now done in about one quarter the time previously required.

In the initial experiments with the spaghetti, small pieces were placed on a lathe and machined to the correct diameter. Now the company that makes it turns out precision spaghetti with a die. Although the idea has only been applied to one size of filament, its use is planned for other sizes as soon as possible.

Free War Training Courses

TUITION-FREE COURSES are offered in the fields of radio engineering, electronic engineering, power systems, telephony, illumination engineering and mathematics at Illinois Institute of Technology in Chicago. To accommodate war plant workers on night shifts, some of the free classes are offered during the daytime. Although the program is primarily one of evening courses, elementary radio classes are conducted in the morning and afternoon.

A refresher course for graduate electrical engineers is given on Saturday mornings and one night weekly and is designed to cover modern applications of electronics and recent developments in power systems engineering. The only prerequisite for enrollment in the other courses is a high school education or the equivalent in industrial experience. A total of 3,453 men and women have already completed radio training courses at Illinois Tech.

New York University has an extensive program of 69 free evening courses for men and women and includes several new courses designed to meet the need for expansion in the air transportation field. Additional courses offered in the program are special courses in radio, electronics, VHF techniques, and aircraft electricity and communications.

Although all courses are open to women who meet the requirements for admission, the program includes several that are essentially basic in nature and designed primarily for women. Pre-engineering mathematics, technical drawing, production gaging and inspection, and a full time eight-week program in fundamentals of engineering are among the subjects.

More than 10,000 persons, including about 1,000 women, have been

Photronic Cells now being made for war purposes only, hold many new possibilities for design engineers searching for better methods or new products for post-war markets.

The improved Type 3 photo-cell has a marked increase in sensitivity and can be produced in various outputs and various linearity factors, to meet specific circuit requirements. They can be matched in spectral sensitivity, too; to give practically the same spectral response curve throughout the color spectrum. And since the fatigue factor has been materially reduced, their response is more uniform, and far more rapid.

The development of the Type 3 is the result of continued research and experience in the processing of photo-cells dating back to 1930 . . . the year in which WESTON introduced the first American-made commercial cell of the barrier-layer type.

Type 3 Photronic Cells can be supplied in various styles and cases, as well as unmounted in a variety of shapes and sizes. Complete technical data, in booklet form, available to design engineers on request. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

*PHOTRONIC—*A registered trademark designating the photoelectric cells and photoelectric devices manufactured exclusively by the Weston Electrical Instrument Corp.*

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

WESTON

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

FOR OVER 54 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

enrolled in the various courses since the inception of the program in 1940. Requirements for admission vary, but academic high school graduation is required in all courses. In addition the applicant must be employable at the kind of work toward which the training is directed.

Since many other colleges, universities and high schools throughout the country are offering courses similar to these and also financed by the United States Office of Education through the ESMWT program, it is suggested that local schools be contacted by individuals interested in technical courses of any kind, ranging from elementary theory to the study of Maxwell's equations for VHF design.

Electronic Desk Tests Cathode-ray Tubes

ELECTRONIC TESTING DESKS are being used in the Du Mont Laboratories for routine production checkup of cathode-ray tubes by girls. Although the present production of such tubes runs into thousands, each tube must still be individually tested since spot tests or percentage tests mean little or nothing when dealing with such critical devices.

Production testing of cathode-ray tubes at a special desk that contains the necessary power supplies, controls and meters

Several of the test desks are installed in the Du Mont plant to provide mass testing. Each is composed of a steel cabinet, similar to a flat top desk, and contains an inclined platform to support the cathode-ray tubes under test. A group of meters is mounted beneath the front of the platform for the necessary readings.

Barrow
Nome
ALASKA
Yukon River
Fairbanks
Anchorage
Seward
Kodiak
FOR ACCURATE TEMPERATURE CONTROL
in all latitudes...
in all altitudes
L-R MFG. CO #1½ BLOWER
TORRINGTON CONN
PAT. PEND.
#1½ Blower reduces space requirements for heat dissipation. Unexcelled for applications in electronic equipment.
OUTPUT . . . 15 C.F.M. at 8000 R.P.M.
HOUSING . . . High impact plastic
WHEEL . . . Turbo type 1½" diameter
WEIGHT . . . Housing and wheel 2 ounces
Bulletin including complete performance specifications available on request.
L-R MANUFACTURING COMPANY
TORRINGTON, CONN.
SOLOMON ISLAN
Maravo
Lunga
Henderson Field
Berande
Guadalcanal I.

The test desk resembles a control console used by broadcast stations and provides quick testing of cathode-ray tubes

More meters are mounted on both sides of the writing space on top of the desk.

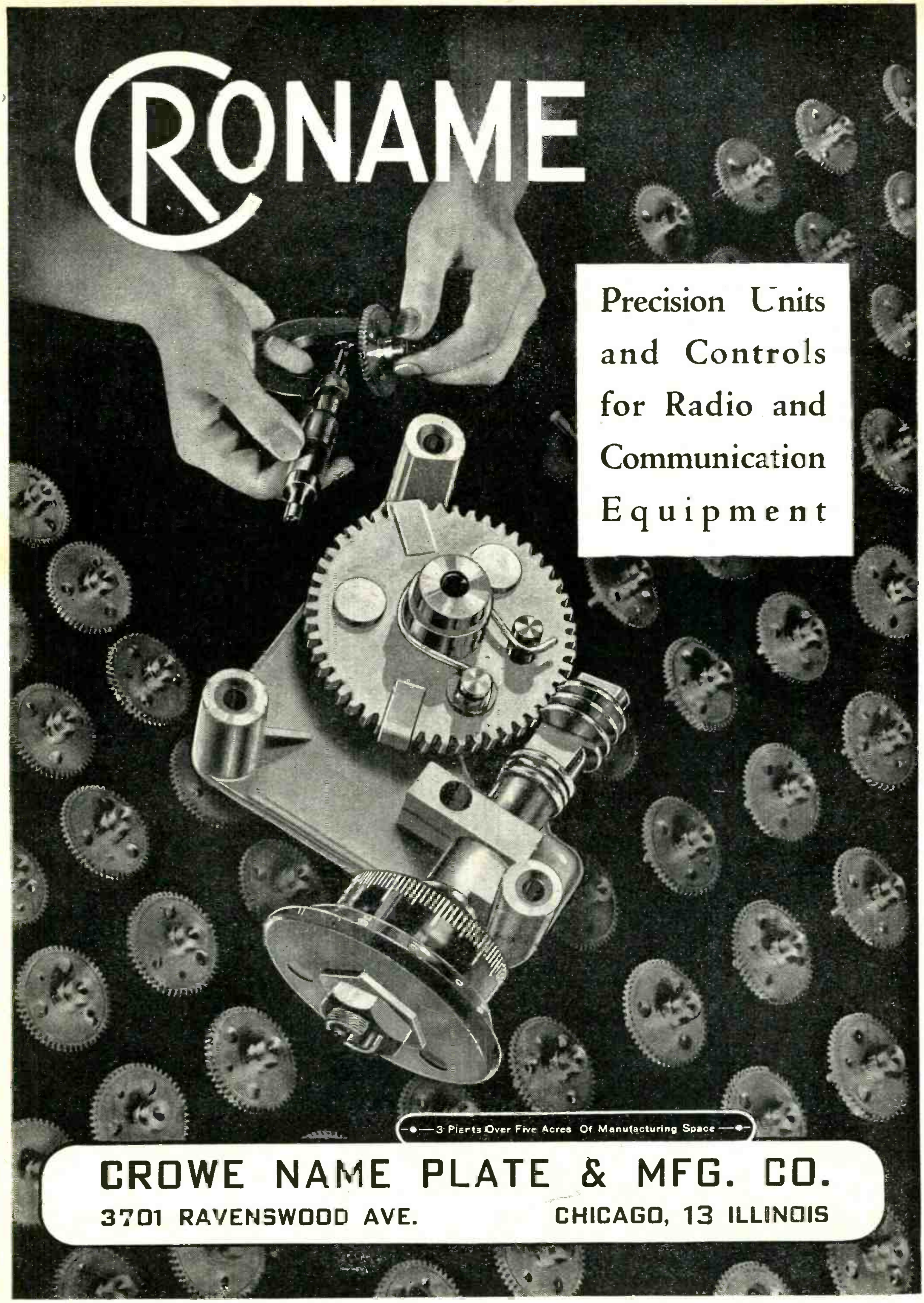
Testing of different tube types requires a large range of voltages from the power supply. These are provided by switches and controls located where desk drawers are normally placed. After these are adjusted the operator checks brilliance, focus, leakage resistance, and other characteristics, and enters the readings on an inspection sheet for each tube. Special notations are made on the face of the tube with a grease pencil.

Dr. Pierce Awarded Franklin Medal

THE HIGHEST AWARD given by the Franklin Institute of Philadelphia was recently awarded by that society to Dr. George Washington Pierce, pioneer radio physicist. Dr. Pierce has occupied the chairs of Rumford Professor of Physics and Gordon McKay Professor of Electrical Communication over a long period of years at Harvard, and his courses in radio telegraphy and electric oscillations were the first to be given in this country.

Dr. Pierce also received a Certificate of Honorary Membership which accompanies the Medal, after being introduced by Stuart Ballantine, who reviewed some of the contributions Dr. Pierce has made to the art. These include:

Early work on the rectifying properties of crystal detectors; invention of a mercury vapor tube which was the prototype of the thyratron, later developed by A. W. Hull; mathematical calculation of radiation from radio antennas; work on electric filters and compensators for underwater signalling and submarine de-


CRONAME
Precision Units and Controls for Radio and Communication Equipment
3 Plants Over Five Acres Of Manufacturing Space
CROWE NAME PLATE & MFG. CO.
3701 RAVENSWOOD AVE. CHICAGO, 13 ILLINOIS

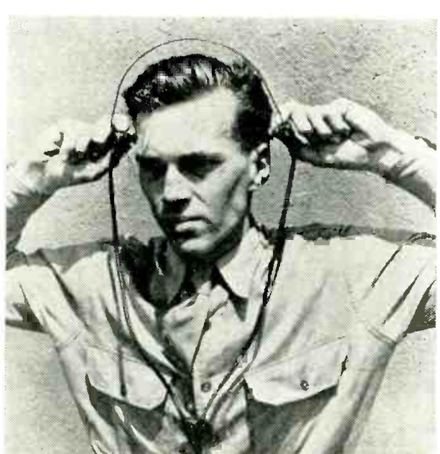
tection. Perhaps his most widely known and used invention is the quartz piezoelectric oscillator, widely used in radio transmitters. He also utilized the magnetostriction effect in nickel and nichrome for the same purpose, this having important applications in submarine detection and signaling.

After expressing his heartfelt gratitude to the members of the Society, Dr. Pierce addressed the gathering on the subject "Songs of Insects." He described an electronic mixer that he has developed as a summer pastime, by which the inaudible high-frequency sounds produced by insects are transposed to an audible frequency for observation. He concluded his remarks with an interesting reference to the successful education of a katydid, accomplished by playing back a record of his song, to produce five pulses of sound instead of the usual two.

Under-Helmet Headset

A NEW HEADSET, adopted by the Signal Corps, can be worn under steel helmets that fit far down over the sides of the head. The larger headsets forced communications men to go into battle zones bareheaded.

Each receiver unit has a soft plug that fits into the outer orifice of the ear in much the same manner that hearing aids are used by civilians. Besides permitting the use of the helmet for protection, the plug forms



A communications man dons one of the new headsets that contains inserts fitting into the ear channels. Strain on the cord is relieved by a clip on the soldier's shirt

Protection from head wounds is provided by GI helmets worn over new type headsets made by Western Electric

a seal that helps keep out battle noises. Since the sound is admitted directly to the ear channel, high sensitivity and fidelity of tone are provided.

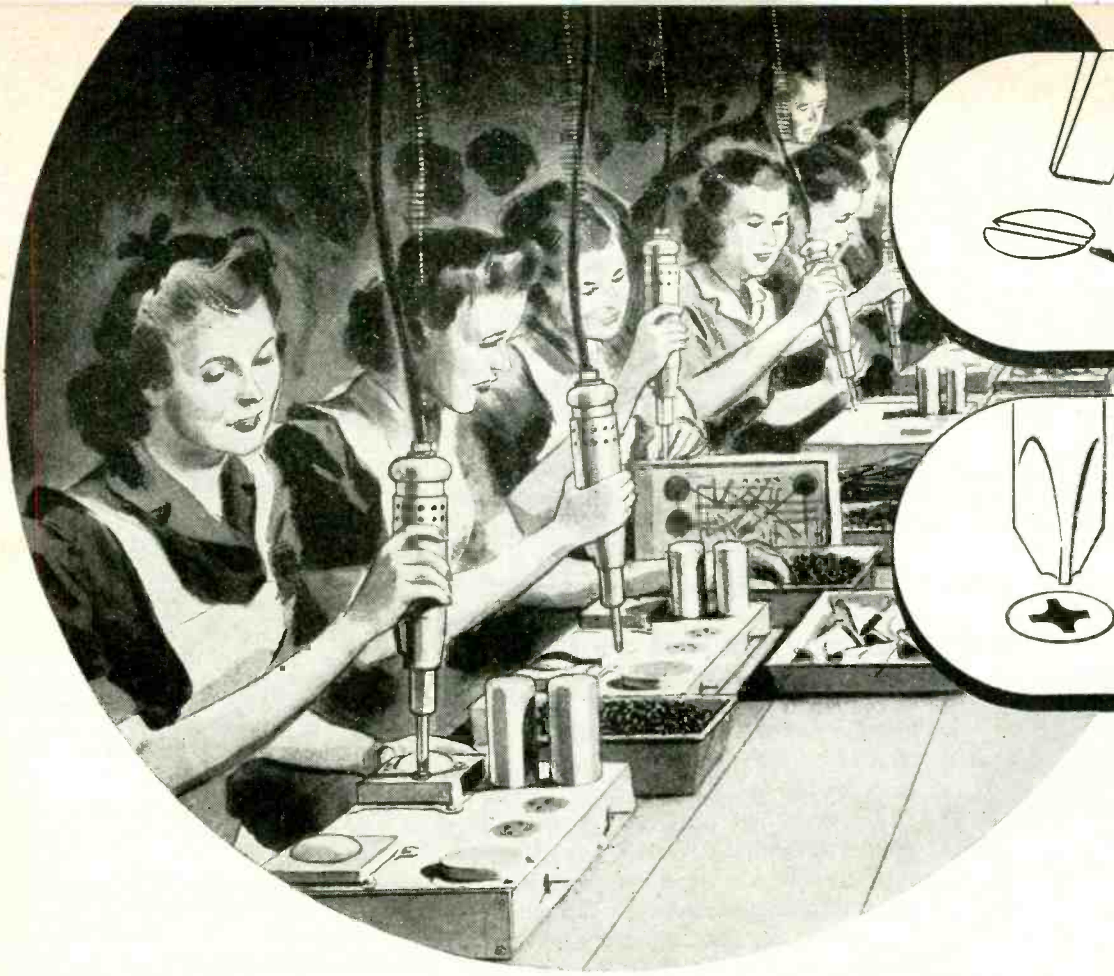
The ear inserts are made of neoprene and are said to be better than rubber. New plugs are issued to each wearer for sanitation.

A clothes clip on the cord is attached to the operator's shirt to keep strain on the cord from being conducted to the receiver terminals. The cord also contains a transformer that matches any high-impedance output circuit.

New Calls for FM Stations

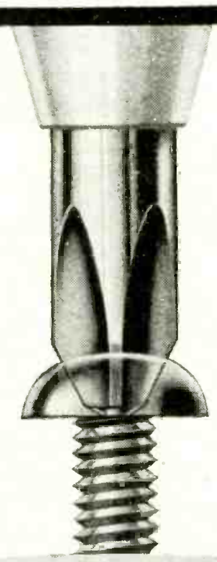
A NEW SYSTEM, using call letters instead of the present letter and numeral arrangement, has been adopted by the FCC for FM broadcast stations. About 4,000 four-letter calls are available for assignment and licensees of FM stations may request the combination of letters they desire. In cases where a licensee also operates a standard broadcast station in the same city he has the choice of using the standard station call with the suffix "FM", or a new four-letter call.

The Commission calls attention to the fact that all three-letter calls are already assigned. The number of four-letter calls appears ample for all additional standard, FM, commercial television, and nonbroadcast stations for some time to come. Calls



End this slow-down: Slotted heads invite fumbling, wobbly starts, skidding drivers, marred parts and burred screws heads.

Speed-up: The Phillips Recess centers driving force, keeps the driver point in place, permits faster and uniformly tighter driving.



Capture EXTRA PRODUCTION with Your Screw Driving Army

PHILLIPS SCREWS DRIVE TWICE AS FAST

Don't just *worry* about lagging production . . . *do something* about it! Boost your output by providing your assembly line with Phillips Screws – the modern speed-screw with the scientifically engineered Recessed Head! The Phillips driver automatically centers in the screw head, utilizes turning power rather than head-on pressure, eliminates the troubles that slow-up driving . . . wobbles, skids, burred screw heads. The result is speedier assembly . . . as much as 50% in some plants.

The skid-proof feature of the Phillips Recess further prevents marred parts and driver-slashed hands. Freed from fear, old timers and newcomers alike can concentrate on fast, faultless driving. Power and spiral drivers can be used to advantage. Switch to Phillips Screws and see how your screw driving army chalks up new assembly records.

Compare the cost of driving Phillips versus slotted head screws. You'll find that it actually costs less to have the many advantages of the Phillips Recess!

KEY TO FASTENING SPEED AND ECONOMY

The Phillips Recessed Head was scientifically engineered to afford:

Fast Starting – Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.

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

Easier Driving – Turning power is fully utilized by automatic centering of driver in screw head. Workers maintain speed without tiring.

Better Fastenings – Screws are set-up uniformly tight, without burring or breaking heads. A stronger, neater job results.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

21 SOURCES

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

beginning with the letter W are assigned to stations east of the Mississippi River, while calls beginning with the letter K are assigned to stations west of the Mississippi and in the territories. About 1100 "W" calls and 2,900 "K" calls are still unassigned.

In the old letter-numeral system, the first letter of an FM call indicated the geographical position of the station in regard to the Mississippi, while the number designated the frequency of the station. The last letters were used to show the city in which the station was located.

The Commission's decision to discard these combination calls for FM stations came about because of several disadvantages and inherent limitations in the system and was based upon the past experience of FM broadcasters and the advisability of making the change at this time when transmitter construction is halted by the war. The licensees found that the letter-numeral call is somewhat cumbersome and does not meet with general public acceptance. In addition a change in frequency of the station involved a change in the call with consequent confusion. It was also felt that as more and more FM broadcast stations were licensed it would be increasingly difficult to identify a station with a particular city by means of the initial letters of the city.

Machining Standards for Glass-Bonded Mica

THE PROCEDURE FOR machining glass-bonded mica radio insulators and recommended practice for the handling and design of such insulators is contained in the recently approved American War Standard C75.6-1943.

The main feature of the standard is that it provides engineers and draftsmen with specific information about the machining of glass-bonded mica items. How corners should be cut, how holes should be tapped, and what thicknesses are available, are some of the questions answered by the design data included. Informative diagrams such as that shown in the illustration indicate the proper manner of working the material.

No standard shapes or type designations are set up in the standard.

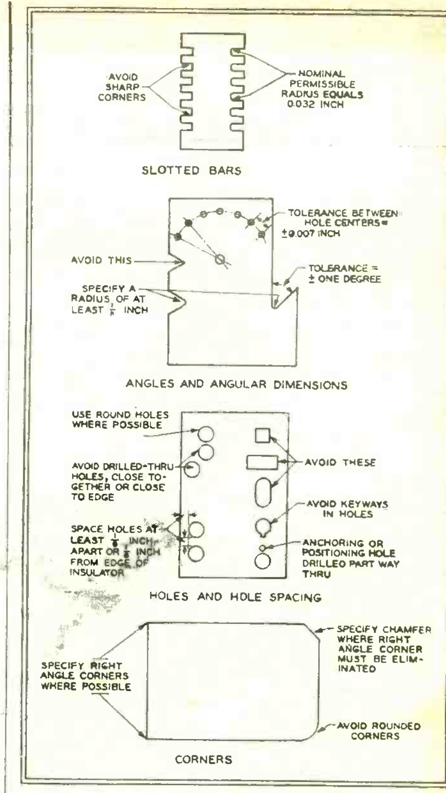
0.00002 to 10,000 VOLTS!

This enormous range of voltages—five hundred million to one—is accurately covered by our Model 300 Electronic Voltmeter and some of the accessories shown above. Frequency range 10 to 150,000 cycles. Accuracy 2% over most of the range. AC operation. Five decade ranges with logarithmic scale make readings especially easy. Uniform decibel scale also provided. Over a thousand of these instruments are giving excellent service in Government, commercial and university laboratories and factories.

Send for Bulletin 8

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U.S.A.



Examples of the diagrams used in the new American War Standard for machining glass-bonded mica

It differs in this respect from other American War Standards.

It is expected that the standard will be used by radio equipment manufacturers and the Armed Forces in designing new equipment and replacement parts to comply with the specifications for greater interchangeability.

The new standard was prepared through the coordinated efforts of the representatives of industry and the Armed Forces at the request of the War Production Board. Copies of the new War Standard, Glass-Bonded Mica Radio Insulators (C75.6-1943), may be obtained from the American Standards Association, 29 West 39th St., New York, at 25 cents each.

Suggested Wire Standards

ALTHOUGH THE MECHANICAL industry has been hampered by the use of several series of gage numbers to designate the thickness of metal sheets, the electrical industry has been relatively free of this complication because of the widespread use of the American Wire Gauge.

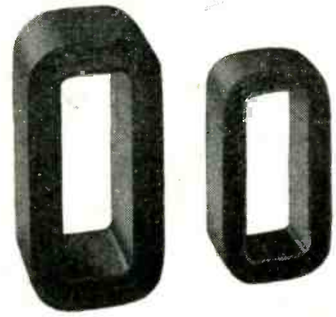
The American Standards Association has set up a standard for pre-

WEIGHT REDUCTION PROBLEMS?

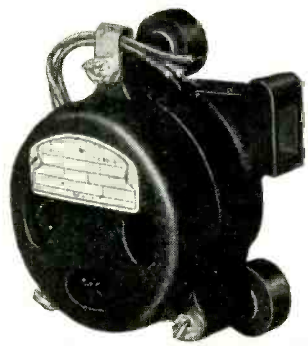
In designing radios for combat service, every ounce counts. Weight reduction is not only an engineering problem—it becomes a matter of fighting efficiency. Westinghouse engineers have co-operated with many designers to work out a variety of solutions, of which the accompanying illustrations are typical examples.

Perhaps these are directly applicable to your problem; or it may be that yours is completely different. In either case, trained and experienced Westinghouse representatives are ready to help you; call them today. Westinghouse Electric & Manufacturing Company, Dept. 7-N, East Pittsburgh, Pennsylvania. J-94565

*Registered Trade-mark Westinghouse Elec. & Mfg. Co.



Hipersil*, the new Westinghouse magnetic steel for transformer cores, increases flux-carrying capacity ⅓ and reduces weight 30 to 50%.



For aircraft and airborne radio, blower and motor combined for maximum air circulation in a weight-saving magnesium housing.

Inerteen capacitors deliver more microfarads per ounce.

INSULATION

Tuffernell, Glasweve and mica insulating materials permit high operating temperatures and consequent savings in weight.

Westinghouse

PLANTS IN 25 CITIES...OFFICES EVERYWHERE ferred thicknesses of flat metals, sponsored by the American Society of Mechanical Engineers and the Society of Automotive Engineers. This has been followed by a suggested standard of preferred sizes for bare and metallic coated round wire in which the following sizes in inches are proposed:

PREFERRED SIZES FOR ROUND WIRE

.....	0.344	0.180	0.090	0.045	0.022	0.011	0.0056		
.....	0.312	0.160	0.080	0.040	0.020	0.010	0.0050	0.0025	0.0012
.....	0.281	0.140	0.071	0.036	0.018	0.009	0.0045		
0.500	0.250	0.125	0.063	0.032	0.016	0.008	0.0040	0.0020	0.0010
0.438	0.224	0.112	0.056	0.028	0.014	0.007			
0.375	0.200	0.100	0.050	0.025	0.012	0.0063	0.0032	0.0016	0.0008

The proposal has been distributed to industry for criticism and comment. Of 139 replies received, 74 indicated approval or were noncommittal and 65 offered comments and suggestions. The principal opposition to the adoption of the proposed standard has come almost exclusively from users of copper wire for electrical purposes, whose design and technical data are all in terms of the American Wire Gauge.

It is suggested by the ASME, in the August 1943 issue of *Mechanical Engineering*, that a careful study be made of the proposed system of sizes to determine if it can be brought into line with the present deeply entrenched usage in the electrical industry. There are some indications that this can be done, but the project has been tabled for the duration of the war to allow correspondence, discussion, and comments from industry.

There is much less standardization in the mechanical uses of wire than there is in electrical applications, and a great deal may be gained by that industry by the general acceptance of a uniform system of numbers based on the inch unit of measure.

PAPER SHORTAGES forced the morning newspaper in Beaumont, Texas to ask 5000 subscribers to drop their subscriptions. Several hundred defense workers offered to do so if they could get an early morning newscast, so station KRIC volunteered with a 15-minute roundup of AP news at 6 a.m., when the morning shift is getting ready for work and the night shift is coming home.

Rochester Fall Meeting

November 8 and 9, 1943
Sagamore Hotel
Rochester, New York

MONDAY, NOVEMBER 8

9:30 A.M.—12:30 P.M.

Technical Session
Review of the problem:

"Demountable Versus Sealed-off Tubes," by I. E. Mouromtseff, Westinghouse Electric & Manufacturing Company

"Recent Advances In Klystron Theory," by W. W. Hansen, Sperry Gyroscope Company

2:00 P.M.

Technical Session

"The Design of I. F. Transformers for Frequency Modulation Receivers," by William H. Parker, Jr., Stromberg-Carlson Company

"Vacuum Capacitors," by George H. Floyd, General Electric Company

4:00 P.M.

Committee Meetings

8:15 P.M.

Technical Session

"The Signal Corps Looks to the Engineer," by Lt. Col. Kenneth D. Johnson, U. S. Army Signal Corps

TUESDAY, NOVEMBER 9

9:30 A.M.

Technical Session

Message of RMA Director of Engineering Dr. W. R. G. Baker

"Operating Characteristics of Ceramic Dielectrics with Constants over 1000," by R. B. Gray, Erie Resistor Corporation

"A Chamber of Commerce War Research Committee," by K. C. D. Hickman, Distillation Products, Inc.

2:00 P.M.

Technical Session

Report of RMA Data Bureau, by L. C. F. Horle

"New Low Loss Ceramic Insulation," by Ralston Russell, Jr. and L. J. Berberich, Westinghouse Electric & Manufacturing Company

"Design of I.F. Systems," by J. E. Maynard, General Electric Company

4:00 P.M.

Committee Meetings

6:00 P.M.

Banquet

Toastmaster—R. M. Wise

An exhibit of the U. S. Army Signal Corps equipment will be a feature of both days.

Radio Business News

A DIFFERENTIAL PRESSURE gage which cuts down testing time of (censored) equipment from 4 hours to 7½ minutes won a WPB War Production certificate for Francis E. Pratt, instrument laboratory engineer for Stromberg-Carlson. The WPB reports that the Office of the Chief Signal Officer regards the device as a definite contribution to the kind of aircraft radio equipment that is not used for navigation or communication.

UNPRECEDENTED EXPORT complications face the Export Committee of the RMA, according to Walter A. Coogan, director of International Division of Sylvania Electric Products Inc., re-appointed chairman of the committee. "It is not difficult to obtain orders today," he explained. "Our most pressing problems are those connected with obtaining licenses from OEW and priority ratings from WPB. The shortage of shipping space has eased up considerably, and space is now available to most countries."

RESEARCH ENTERPRISE LIMITED, a Canadian government-owned company that employs 6,800 people, is working on orders for radio and optical equipment totaling more than 130 million dollars. Output of the radio industry in that country has expanded sixteen-fold since the beginning of the war and has caused the development of three new industries for production of dynamotors, ceramic insulators and crystals.

CBS WILL CONSTRUCT a new international broadcast station at Wayne, N. J., to be added to the new network of short-wave transmitters being used by the OWI Overseas Division to beam American news and programs to all parts of the world. The station will have two short-wave transmitters to furnish two-frequency coverage. The construction cost is announced as $476,150.

ANTICIPATING the resumption of domestic radio production, the Radio Manufacturers Association has set up a special committee for post-war planning that includes many prominent executives of the industry.

The committee, headed by R. C. Cosgrove, vice-president and general manager of the Crosley Corp., will correlate their work on the economic

problems of the industry with that of the technical planning agency organized by the RMA and the IRE.

"Through the organization of subcommittees or panels, the committee will deal with such subjects as: liaison planning with government and industry agencies; reconversion to civilian production; public relations, including promotion and advertising; distribution problems; war contract termination; war inventory disposal; problems in connection with government plants; reemployment and labor relations; market analysis and research; patents and licensing; and export markets," Mr. Cosgrove said.

RMA COMMITTEE MEMBERS planning post-war activities include: W. R. G. Baker, G-E vice-pres.; M. F. Balcom, Sylvania vice-pres.; John Ballantyne, Philco pres.; H. C. Bonfig, RCA Victor vice-pres.; Walter Evans, Westinghouse vice-pres.; A. H. Gardner, pres., Colonial Radio Corp.; Leslie F. Muter, pres., The Muter Co.; J. J. Nance, Zenith vice-pres.; E. A. Nicholas, Farnsworth pres.; Ross D. Siragusa, pres., Continental Radio & Tel. Corp.; Ray F. Sparrow, P. R. Mallory vice pres.; and A. S. Wells, Wells-Gardner pres.

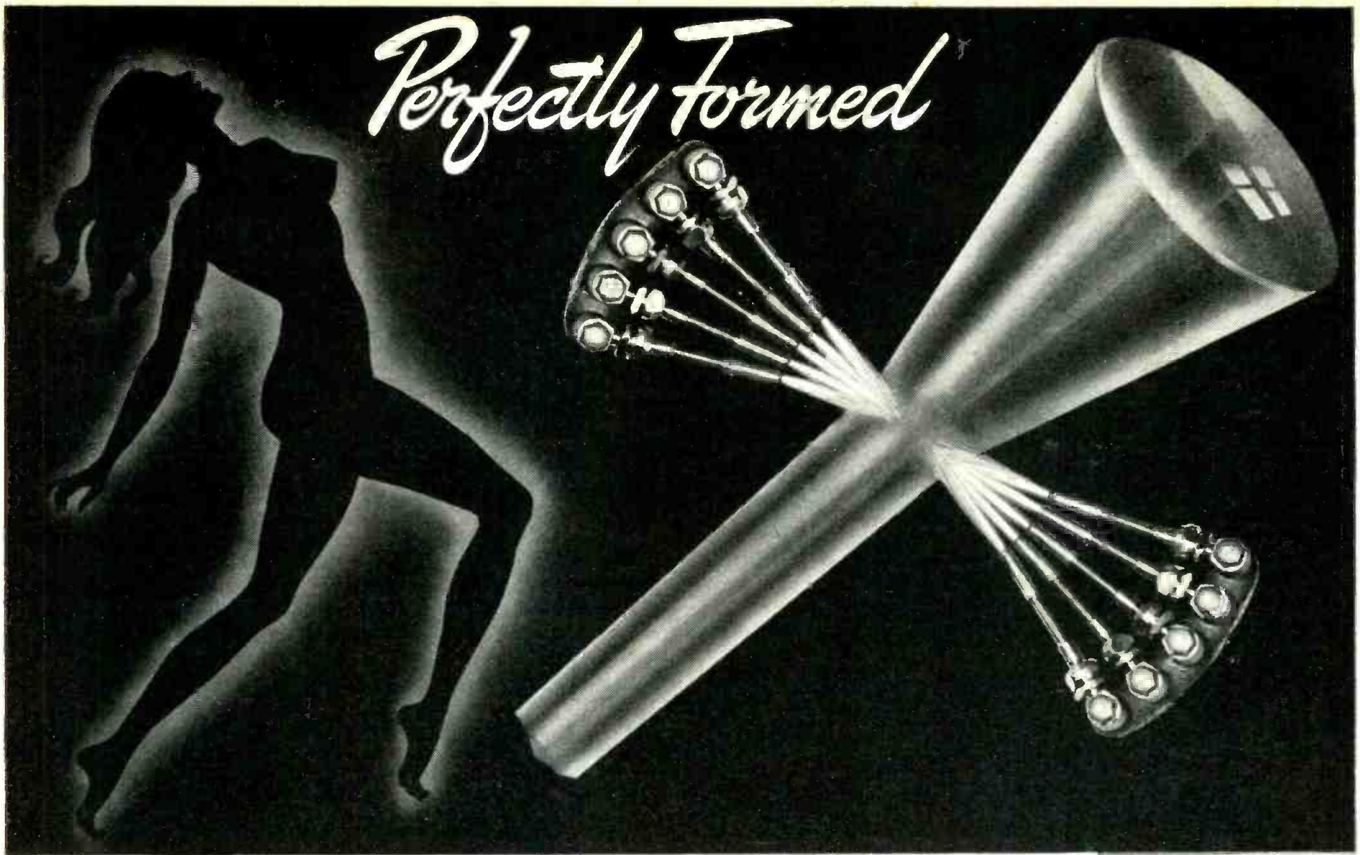
SOLAR MFG. CORP. announces removal of general offices from the Bayonne, N. J. plant to 285 Madison Ave., New York 17, N. Y.

HAYDU BROS., maker of electronic products, has purchased a plant in Plainfield, N. J.

MOTOROLA has supplied some 40,000 radio dealers with a mailing piece that points out the necessity for straight thinking now to protect the post-war market.

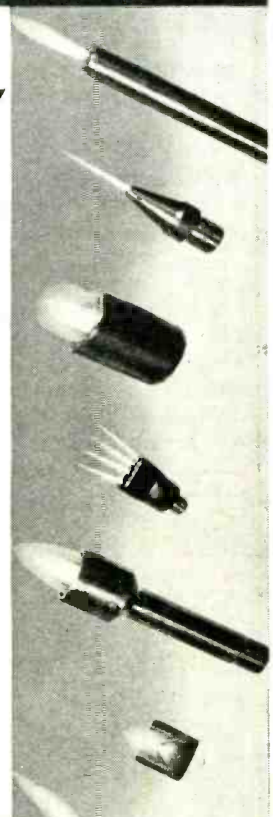
WESTERN ELECTRIC has established a new plant in Haverhill, Mass. for manufacture of communications equipment.

WEBSTER PRODUCTS, 3825 W. Armitage Ave., Chicago, should be added to listing in the June Directory of ELECTRONICS as a manufacturer of the following products: dynamotors, generators, inverters, small motors, voltage regulators and special instruments.



HAYDU BROS

Burner equipment



PERFECT FORM—both in manufacture and performance, is more essential now than ever, if you are driven by war time speed, and the constantly growing need for greater production.

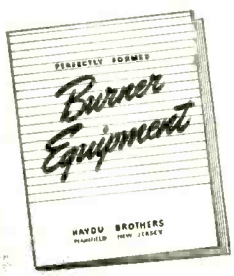
The traditionally dependable performance of Haydu Bros. Burner equipment, has been an assurance of uninterrupted economical production.

Today, thousands of Haydu Bros. Burners, in many styles and sizes, for Gas, Air and Oxygen, are used in plants of the general glass working industry from coast to coast, helping to speed those essential orders.

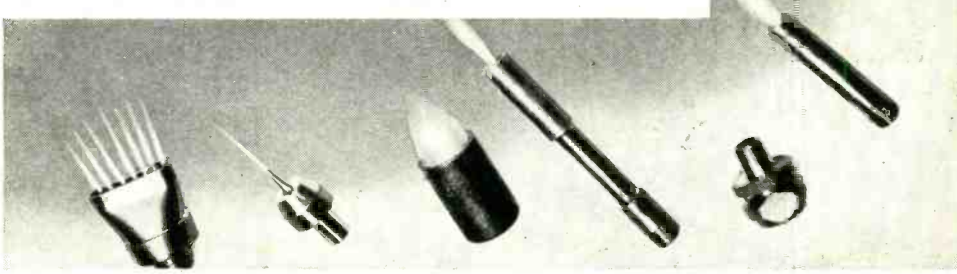
Specially designed Burners, Torches, Cross-fires and Mixers to meet your requirements.

HAYDU BROTHERS

PLAINFIELD, NEW JERSEY



WRITE FOR LATEST BULLETIN



Personnel

Dr. A. H. Rosenthal, physicist and electronic engineer, has been appointed director of research and development of Scophony Corp. of America, manufacturers of television projectors. He will head a group of scientists and engineers engaged in research of fundamental inventions in television and electronics.

Richards W. Cotton, managing director of the British Rola Co. of London, and an American citizen, has been appointed assistant director at the British Air Commission in Washington, in charge of procurement of radio parts and equipment.

James O. Weldon, chief radio engineer of the Bureau of Communications Facilities of the OWI Overseas Branch, has been named chief of the Bureau to succeed Murry Brophy, who recently resigned because of ill health.

Nelson Blount, retired research worker and inventor for Bell Telephone Labs., died recently at the age of 64 in Morris Plains, N. J. He aided in the development of the throat microphone widely used by the armed forces, and the French type handset. He is reputed to have once ridden a torpedo to observe at first hand its reactions.

William D. Terrell, Chief of the FCC Field Division, retired recently at the age of 72. He began his career in government radio in 1911 as wireless ship inspector in the Department of Commerce, serving as chief of the Radio Division from 1915 to 1932 when he became chief of Field Operations of the Federal Radio Commission. He continued in this post, when that body was superseded by the present FCC, for a total of 40 years in government service, and was twice exempted from automatic retirement by executive order of the President.

George S. Turner becomes the new Chief of the Field Division of the FCC's engineering Department. He joined the Commission in 1931, and has been Assistant Chief of the Field Division since 1940.


A GOOD MATCH FOR TODAY'S SPECIFICATIONS
. . . plus a few items for which specifications have not been written
SPRAGUE
ARMY E NAVY
ELECTROLYTIC CAPACITORS—All capacity and voltage ratings and combinations in containers to meet every requirement.
PAPER DIELECTRIC CAPACITORS—Wax or oil-impregnated sections in potted or oil-filled containers, A.C. and D.C.
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SPRAGUE SPECIALTIES COMPANY
NORTH ADAMS, MASS.
SPRAGUE CAPACITORS
QUALITY COMPONENTS • EXPERTLY ENGINEERED • COMPETENTLY PRODUCED

David Grimes, vice president in charge of engineering for Philco Corp., was killed early in September when the transport plane in which he was traveling crashed into a mountain in Northern Ireland. He was abroad on a special war mission and was in the company of Commodore James A. Logan, Commandant of the United States Naval operating base at Londonderry, who was also killed in the crash.

During the World War Grimes saw military service as chief radio officer at Kelly Field, Texas, and in the last months of the war as signal officer attached to the British Air Force in England. After returning to this country, he spent a few years as research engineer in telephony for AT&T, and then established his own organization to do consulting

David Grimes

research engineering for several companies. From 1930 to 1934 he was license engineer for RCA.

He joined Philco in 1934 as engineer in charge of research and engineering for home radio sets, and was named chief engineer in 1939. Since 1942 he has been vice president in charge of engineering.

It was Grimes' belief that a network of relay television relay stations to beam programs from one station to another would make it possible to develop a nation-wide television service. Under his direction Philco put a successful television relay system into operation between New York and Philadelphia in 1941.

Robert Bartley, vice-president of the Yankee Network, has been appointed War Director of the National Association of Broadcasters.

*Detail of finely looped structure greatly enlarged.

Features and Characteristics of METEX METAL MESHES

Metex knitted wire mesh is a new material with a number of interesting possibilities in electronic applications. It is not woven, but is made in continuous tubular form from a single wire.

A large range of choice is available as to the percentage of free area in a given fabric. Both flat or round wires can be used. Sagging and buckling from a rising temperature are avoided, because the increase in length of the wire is taken up by the curvature in the loops.

The material can be manipulated into foraminous structures with a controlled percentage of free volume. Similar structures can be designed for resiliency at temperatures above the range of organic materials. Relatively large openings in ratio to the wire diameter are possible where required, thereby increasing the percentage of free area beyond the amount possible with woven screening.

We are familiar with techniques for knitting fine mesh screens from tantalum, tungsten, molybdenum, nickel, and heat resisting alloys. Illustrative samples are available upon request.

Cooperation of our Engineering Staff is offered for research and development projects.

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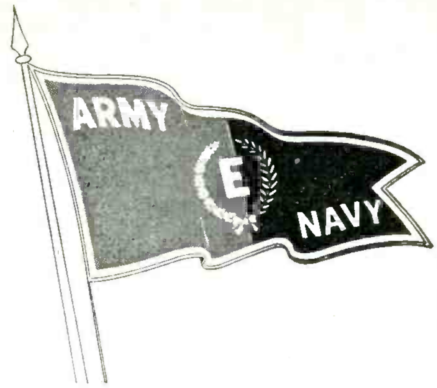
METEX Products



THE CARBORUNDUM CO.,
Niagara Falls, N. Y.

CHICAGO TELEPHONE SUPPLY CO.,
Elkhart Plant, Elkhart, Ind.

EITEL MCCULLOUGH, INC.,
Salt Lake City, Utah

MICRO SWITCH CORP.,
Freeport, Ill.

NATIONAL UNION RADIO CORP.,
Receiving Tube Div., McCarter Highway Plant, Newark, N. Y.

PHELPS DODGE COPPER PRODUCTS CORP.,
Los Angeles, Cal.

TRUSCON STEEL CO.,
Pressed Steel Div., Cleveland, Ohio

WESTINGHOUSE ELEC. & MFG. CO.,
Meter Div., East Pittsburgh, Pa.

A total of 1910 plants and projects have been granted the Army-Navy "E" for excellence in production of war materials. This is the first time since the joint award was inaugurated a year ago that the total number of awards has been made public. No official compilation has been made of the total number of plants in this country, both prime and subcontractors, but on the basis of several statistical reports, it is estimated that less than 2½ percent of the eligible plants have received the award to date. Stringent eligibility requirements account for the relatively small number of plants receiving the honor in comparison with the great number working on war contracts. Of the 1910 plants which have received the "E", 1188 were nominated by the Army and 722 by the Navy.

OVER four-fifths of the 1,833,000 workers added to the payrolls of American factories between April 1942 and June 1943 have been women.

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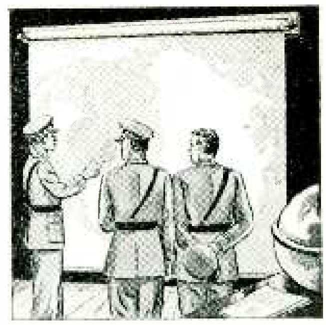
Coated Cloths Filled Gap Between Costly Leather and Flimsy Paper Bookbindings.

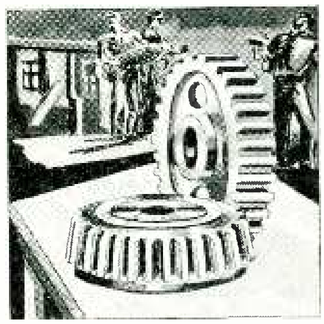
Cloth Gives Fibre Boards Resistance to Abrasion, To Flexing, and to Time.



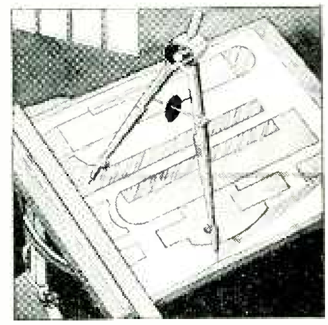
Cloth Assures Durability For Maps In The Field, On The Wall or In Storage.

Impregnated Cloths Made Gas Masks Effective: Overcame Quick Deterioration.

Cloth Protects Photos From Crackling and Tearing; Facilitates Placement in Binders.



Cloth Combines With Plastics To Displace Metals In Gears, Gaskets and Washers.



Cloth Protects Original Designs; Assures Lasting Blueprints.

Do You Really Appreciate

THE AMAZING ADAPTABILITY OF CLOTH?

Immediate demands are that weight, time and costs be reduced, products improved, and new products conceived. Cloth is helping to achieve all these objectives.

Think what inflatable boats and rafts of coated cloth, to serve where wooden boats and metal rafts are impossible, mean in saved lives and lessened suffering. Think what is being achieved with cloth and plastic in lamination, with cloth in adhesion.

An accompanying illustration may suggest how something you may have conceived, could be made a reality. The adaptabilities of impregnated, coated and filled cloths seem limitless.

Whatever your conceptions or problems, let us know. Something we already have done, will probably suggest a solution to us, just as these illustrations of some processings may suggest new possibilities to you.

CURRENT HOLLISTON PRODUCTION includes COATED AND IMPREGNATED FABRICS, mildew proof — fire, weather and water resistant — gas impermeable, etc. INSULATING CLOTH BASE — SEPARATOR CLOTHS, rubber, starch-filled, glazed. TRACING AND BLUE PRINT CLOTHS white and blue, ink or pencil. MAP CLOTH. PHOTO CLOTH, self-adhesive. REINFORCING FABRICS. SIGN, LABEL AND TAG CLOTHS, waterproof to take any ink, meet any inking problem. BOOKBINDING CLOTHS. SHADE CLOTH, impregnated waterproof, opaque, translucent or light proof.

IN DEVELOPMENT: Mildew-proofing and asphalt-impregnating processes; fire and weather-resistant treatments; synthetic resin fillings and coatings applicable from nettings to duck. In general, Holliston can convert any print cloth, sheeting, twill and duck in widths from 30″ to 80″ and can dye, impregnate, coat and fill in any color to specified stiffness or pliability, hand, bond, weight addition and tensile strength, including Elmendorf tear strength, for any trade, commercial or industrial use. We have both the wish and the capacity to cooperate on production problems. We urge you to consider CLOTH; and invite you to consult with us concerning possibilities and developments for your specific requirements.

THE HOLLISTON MILLS, INC.

CONVERTING CLOTHS TO GREATER USE FIELDS

NORWOOD, MASSACHUSETTS

Sales Agents in Principal Cities

Speech Scrambling

(*Continued from page* 111)

from the 6C5 oscillator. A fixed value is shown for R_{14}, but it might be well to use a standard volume control instead to provide for relative adjustment of the amplitudes of the inverting frequency and incoming speech frequencies.

The frequency from the 6C5 oscillator is controlled by means of a variable resistance and capacitor in series. The control is the large dial shown on the front of the panel. The values of the various components comprising the oscillator circuit have been chosen so that a frequency of 3000 cycles is provided with the control near the center position. A Wien bridge or any other well-known type of oscillator may be used for supplying the inverting frequency.

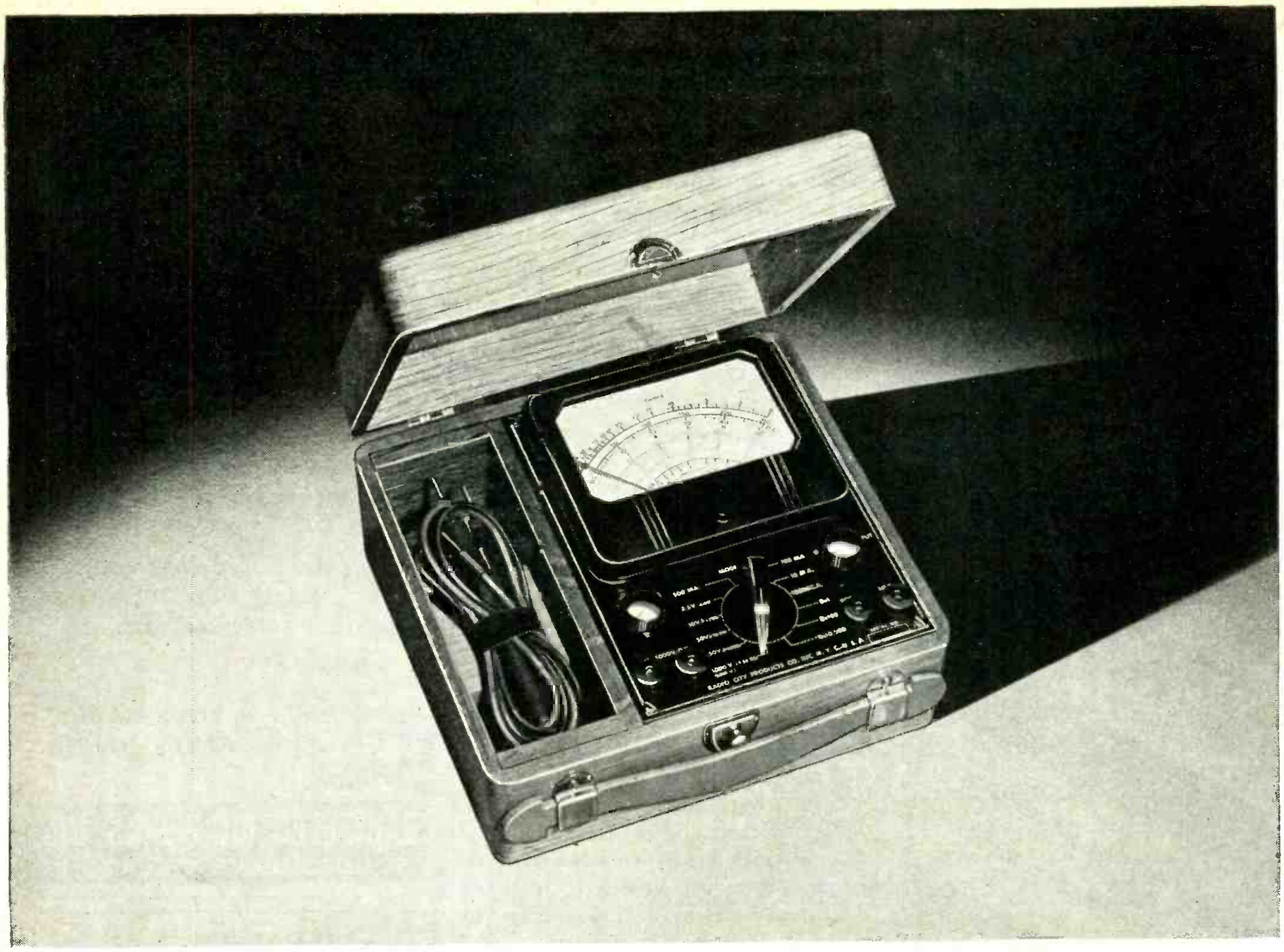
Because of the close proximity of the component parts of the inverter, hum pickup is reduced by isolating power transformer T_4. This transformer is mounted externally in a small can and made a part of the line cord.

In operation, the inverter may be used for both scrambling and unscrambling. If desired, two units may be placed at either end of a two-way circuit with the usual balanced hybrid coils, to provide a complete privacy system for two-way telephone communication.

Band Splitting

To secure privacy of speech by means of band splitting, the speech-frequency band is divided as to frequency into a plurality of sub-bands, some of which may be transmitted without modification. Others first have their frequency order inverted and are then transmitted along with the unchanged sub-bands, or, if desired, each of the sub-bands may be inverted before transmission.

It is preferable in this type of secrecy system that the frequency width of each of the sub-bands be kept narrow enough so as to be incapable of reproducing understandable speech by itself. The maximum width of a sub-band must not exceed certain limits because of the large amount of intelligibility that would be contained in a band only several



ULTRA-SENSITIVE MULTITESTER

20,000 OHMS PER VOLT

The R.C.P. Model 461P Ultra Sensitive Multitester provides a wide range of measurements and features required for general laboratory purposes. It is also ideally suited for field and shop measurements on military, and naval equipment.

Sensitivity of 20,000 ohms per volt on all D.C. measurements results in negligible loading of delicate circuits. Wide scale, 4½" rectangular meter used, with a movement of 50 microamperes. Readings as low as 1 microampere can be made on the 100 microampere scale.

A.C. voltmeter sensitivity is 1,000 ohms per volt. Meter movement is 2% accurate. Shunts and matched pair metallized voltage multipliers accurate to within 1%. A suppressor type copper oxide rectifier is used.

RANGES:

D.C. voltmeter:	0-2.5-10-50-250-1,000-5,000 volts.
A.C. voltmeter:	0-2.5-10-50-250-1,000-5,000 volts.
Output voltmeter:	0-2.5-10-50-250-1,000-5,000 volts.
D.C. microammeter:	0-100 microamps.
D.C. milliammeter:	0-10-100-500 milliamps.
Ohmmeter:	0-1,000-100,000 ohms; 10 megohms.
db meter:	minus 10 to plus 55.

Over all dimensions of the model 461P are 8" x 7¼" x 3¾
Complete with self-contained battery supply and convenient leather handle . . . net.................... $38.50

Other instruments in the complete line of R.C.P. electronic and electrical instruments described in Catalog No. 126. If you have an unusual test problem — either for production or laboratory work—our engineers will be happy to cooperate in finding the most efficient solution.

REASONABLE DELIVERIES ARE NOW BEING SCHEDULED

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MANUFACTURERS OF PRECISION ELECTRONIC LIMIT BRIDGES — VACUUM TUBE VOLTMETERS — VOLT-OHM-MILLIAMMETERS — SIGNAL GENERATORS — ANALYZER UNITS — TUBE TESTERS — MULTI-TESTERS — OSCILLOSCOPES — AND SPECIAL INSTRUMENTS BUILT TO SPECIFICATIONS hundred cycles wide, especially if this portion were chopped out of the spectrum in the neighborhood of 1000 cycles.

The number of sub-bands into which the voice frequency band is divided is dependent on the degree of privacy required. The greater the number of sub-bands, the greater the number of transposition combinations that are possible.

The combination of transposition and inversion of the various sub-bands is accomplished by suitable modulation processes. By using bilateral modulators, the same apparatus may be used for retransposing and reinverting the sub-bands of a speech band that has been rendered unintelligible in the manner described.

Band-Splitting Circuit

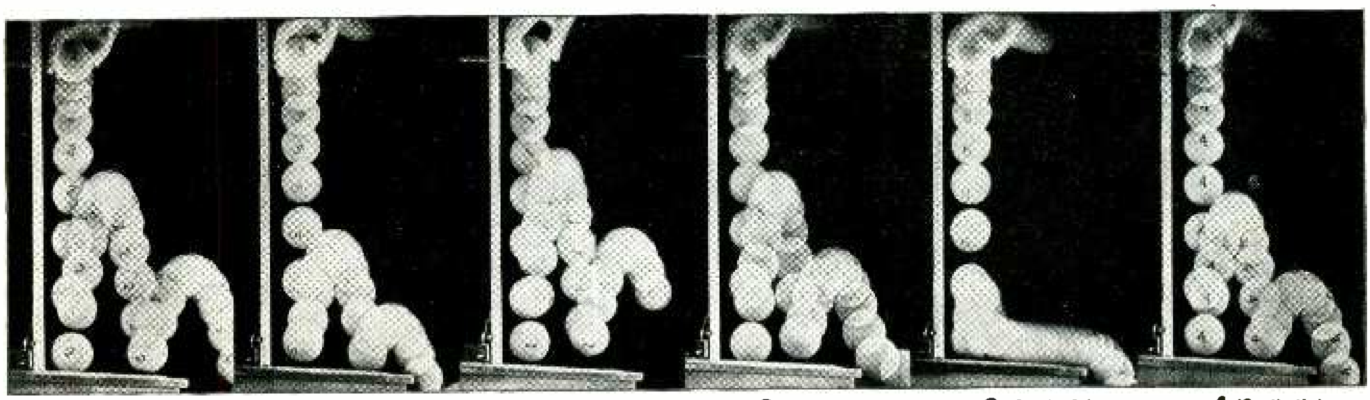
Figure 3 represents schematically a band-splitting privacy system. The normal speech currents are derived from the line L_1 and impressed on the sub-band filters F_1, F_2, F_3, and F_4. These filters serve to divide the speech currents into four equal sub-bands which may each have a width of b cycles. For instance, filter F_1 will pass a range of frequencies f to $f + b$, where f is representative of the lowest essential voice frequency necessary for transmission.

Each input filter is connected to supply selected voice currents to four separate modulators M_1, M_2, M_3, and M_4. These are bilateral modulators of the double balanced copper-oxide type, shown in detail in the case of M_1. Each modulator is essentially a lattice network having a copper-oxide rectifier unit in each of the series and lattice arms, and two transformers each having two windings, one winding of each transformer being connected across one of the two sets of terminals of the network, and the source of carrier current for modulation with the voice frequencies supplied to the other windings of each transformer being connected across the mid-points of the first two windings. However, any of the other known types of bilateral modulators may be used, such as the balanced modulator shown in Fig. 38, p. 550 of Radio Engineering Handbook*.

The carrier frequencies supplied

* Edited by K. Henney. *McGraw-Hill Book Co., New York 18, N. Y.*

BOUNCE, BALLS, BOUNCE!



2 (Synthetic) **5** (Synthetic) **1** (Natural) **3** (Synthetic) **6** (Synthetic) **4** (Synthetic)

SIX SOLID BALLS OF RUBBER caught in the act of bouncing by a high-speed camera that shoots at the speed of 1/6592 of a second. All of them were dropped from exactly the same height...and yet, what a difference there is! One of the balls is made of a compound containing natural rubber. Each of the other five balls contains one of the five major types of synthetic rubber.

Can you pick out which of the balls is made of the rubber used in making Army barrage balloons? Which rubber is being used today for making tires for military and essential civilian cars? Which one is used for bullet-sealing gasoline hose? Which for insulating tape? Which for making lacquer hose? Try your skill. You will find the answers to these questions in the box at the bottom of this page.

SYNTHETIC RUBBER IS NOT JUST ONE NEW KIND OF RUBBER

It is a whole family of new materials each with its own important uses

Bounce the balls as much as you please. One bounces high. One bounces low. One bounces in between. Which one is best? Actually, there is no one "best kind" of rubber for every purpose. Without all of these main types of synthetic and natural rubber, it would be impossible to beat our enemies and bring our victorious men home as swiftly as possible.

The rubber industry, the chemical and petroleum industries, the Government, working as a team, have made this achievement possible. By pooling all their experience with synthetic rubber, their resources, their skill, they have broken the threat of "rubber shortage" the Axis counted on to throw us out of the war. More than that, they have produced types of synthetic rubber that can do special jobs better than they have ever been done before... and for all time declared our independence from any future cut-off of the nation's rubber supply.

That is the true meaning of the synthetic rubber program. We are proud to have contributed our experience and our resources to doing this job...and doing it in record-breaking, history-making time.

What the future holds for synthetic rubber is not yet fully known. Yet this much is certain. When the war is won, the knowledge we are gaining every day through the use of all these synthetic rubbers, alone and with natural rubber, will make peacetime products... whether tires for your car, belts for your factory, waterproof footwear for your children, or gasoline hose for your service station...better and more serviceable than they have ever been before.

THEY MAY LOOK LIKE "SIX OF A KIND" BUT HERE ARE THE ANSWERS TO THE WAR JOBS EACH ONE CAN DO

1. This ball was made with natural rubber...today used in limited quantities in combination with synthetics because of our small reserve stock.

2. Used for tires, conveyor belts, fire hose and many other products. It is most like natural rubber and can be quickly and efficiently processed.

3. Used for making solvent and lacquer hose and other products where the utmost resistance to solvents is needed...better than natural rubber for these purposes.

4. Used for making bullet-sealing fuel hose for planes and for other uses where high resistance to aromatic fuels is essential.

5. Used for coating barrage balloons, tank linings, packings, acid hose, wires and cables. This type does not support combustion and is highly resistant to sunlight and chemicals.

6. Used for insulating tape, molded parts. It is soft, pliable and odorless.

Listen to United States Rubber Company program, featuring New York-Philharmonic Symphony Orchestra, Carl Van Doren, and a guest star, broadcast over Columbia network every Sunday afternoon 3:00 to 4:30 P. M. Eastern War Time

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UNITED STATES RUBBER COMPANY

to these modulators are so chosen that the sub-bands may be transposed with respect to each other in various combinations.

The outputs of each of the four modulators may be variously connected to the output band filters F_5, F_6, F_7, and F_8, as shown in Fig. 3. These output band filters have exactly the same cut-off limits as indicated for the input band filters.

By shifting the connections of the modulators to output filters and employing various carrier frequencies, we alter our different combinations f transposition and inversion of sub-bands.

Transposition in Band Splitting

Transposition of sub-bands with and without frequency inversion is shown in the schematic by the solid-line connections between modulators and output filters. The necessary carriers are provided when the modulator switches are in position 1.

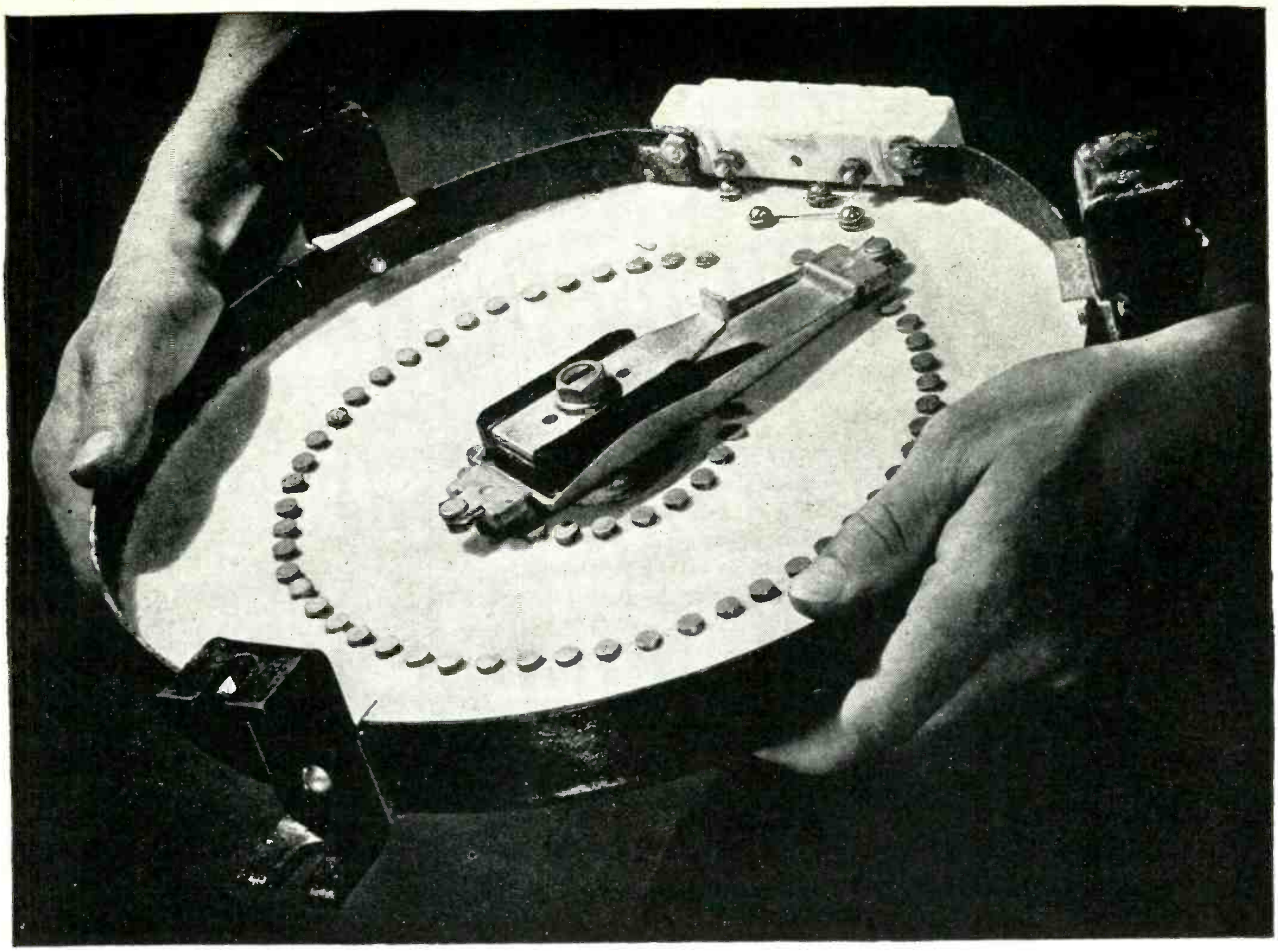
In the case of the dotted-line connections and the carrier switches in position 2, each of the sub-bands is inverted as well as displaced.

With reference to the solid-line connections and the carrier switches in position 1, if a carrier current c is supplied to M_1, with input frequencies of f to $f + b$, there will be produced a lower and upper side-band, namely $c-f$ to $c-(f+b)$ and $c+f$ to $c+f+b$. The range of frequencies $c+f$ to $c+f+b$ is the original band f to $f+b$ raised up in the spectrum by the value of c, and corresponds to the sub-band of the original voice band extending from $f+b$ to $f+2b$. This range of frequencies can then be selected by filter F_6 and transmitted to the output circuit L_2. The action of modulators M_2 and M_3 in this case would be similar to that of M_1.

The original voice sub-band $f+3b$ to $f+4b$ from filter F_4 is displaced down in the spectrum to a position occupied by the original voice sub-band f to $f+b$. Here, in addition to being displaced, the frequency orders of the speech components are inverted, as will be seen by the following action.

With input frequencies of $f+3b$ to $f+4b$ and a carrier of $c+3b$ applied to the modulator M_4, there will appear in the output the side-bands $c+3b+f+3b$ to $c+3b+f+4b$ and $c+3b-(f+3b)$ to $c+3b-(f+4b)$.

It will be seen that the lower side-



IT'S SUBSTANTIAL

A Rheostat is a piece of equipment where substance and quality spell real economy. A good Rheostat properly installed and used will outlast the machine it controls. It is wise therefore to use the best Rheostat obtainable.

Ward Leonard Pressed Steel Rheostats are built on that premise. They are absolutely smooth in operation due to proper design and fine machining. They dissipate heat from both sides keeping temperatures low. Contacts are round or rectangular solid metal ground for perfect fit. These are but a few of their many advantages.

Ward Leonard Rheostats are made in a wide range of sizes in single and multiple mounting for manual or motor drive. Bulletin 60 gives full particulars. Send for a copy.

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Pressed Steel Rheostats are made in 4" to 18", Ring types from 1½" to 4" incl.

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Electric control WL devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 32 SOUTH STREET, MOUNT VERNON, N. Y.

band, $c+3b-(f+3b)$ to $c+3b-(f+4b)$, is an inversion of the original input frequencies $f+3b$ to $f+4b$ which now occupy the position of the original voice sub-band f to $f+b$.

It will be noted in the arrangement of this apparatus that by shifting the connections of the filters and carriers in various combinations from time to time in such a manner that corresponding combinations are simultaneously employed at the two terminals of a receiving circuit at the same time, it will be extremely difficult for an unauthorized listener to obtain an intelligible message.

Shifting from one combination or scheme of interrelation to another can be accomplished by switching relays under control of timing cams associated with an accurately controlled driving means to provide additional secrecy.

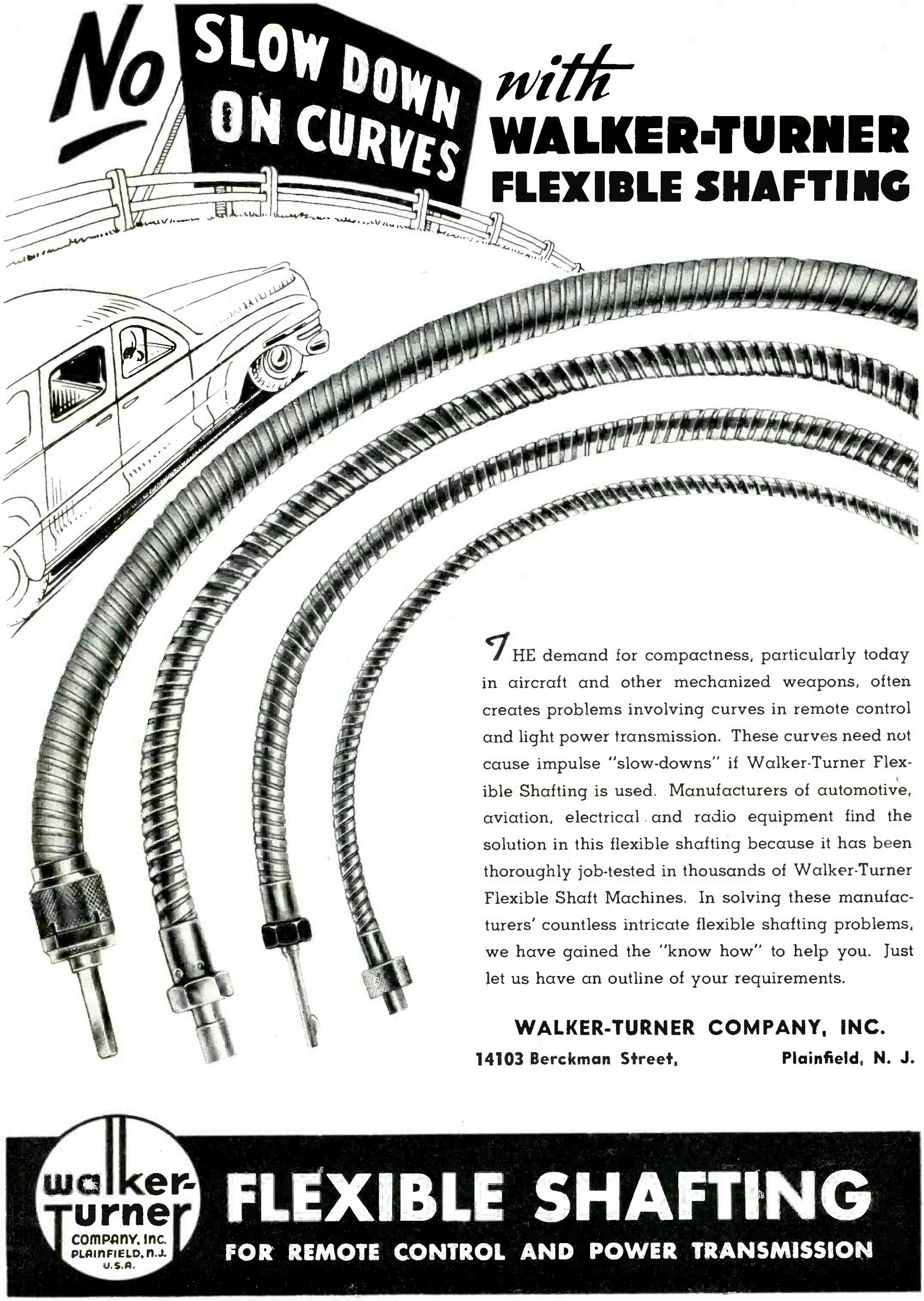
The use of bilateral modulators allows the transmitted and received waves to pass in opposite directions through the same privacy apparatus, to produce a scrambled message for transmission or to unscramble a message from a received secret wave.

Attenuation with Band Splitting

Another type of privacy system proposed is an arrangement whereby the speech band is divided into a plurality of sub-bands, as by filters F_1 to F_4 of Fig. 3. Each sub-band is then subjected to different degrees of attenuation before transmission instead of being displaced by modulation. Accordingly, when the voice is transmitted it will be so distorted as to be practically unintelligible. To restore the voice to normal at the receiving station, the sub-bands of the voice are again subjected to unequal degrees of attenuation, so that all of the sub-bands will be attenuated to the same degree and the distortion removed.

Phase Shift with Band Splitting

Still another arrangement for secret telephony is to alter the order of occurrence of the various frequency components of speech. Briefly, this is accomplished by taking the subdivided waves, as from filters F_1 to F_4 of Fig. 3, and producing a phase or time shift in some of the sub-bands with respect to others before transmission. This phase shift is produced by the use of a storage device such as the telegraphone. The


No SLOW DOWN ON CURVES
with
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FLEXIBLE SHAFTING
THE demand for compactness, particularly today in aircraft and other mechanized weapons, often creates problems involving curves in remote control and light power transmission. These curves need not cause impulse "slow-downs" if Walker-Turner Flexible Shafting is used. Manufacturers of automotive, aviation, electrical and radio equipment find the solution in this flexible shafting because it has been thoroughly job-tested in thousands of Walker-Turner Flexible Shaft Machines. In solving these manufacturers' countless intricate flexible shafting problems, we have gained the "know how" to help you. Just let us have an outline of your requirements.
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FLEXIBLE SHAFTING
FOR REMOTE CONTROL AND POWER TRANSMISSION

various sub-bands are then recombined and transmitted, or they may first be shifted to a different frequency level and then transmitted. At the receiving end employing this system, the various sub-bands are again separated by filters, and such a phase shift is made in the individual sub-bands as is necessary to reproduce the normal speech waves.

Variable Inverting Frequency

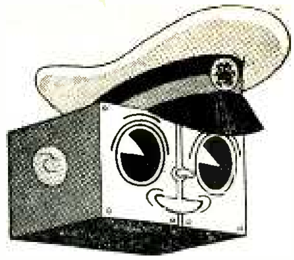
Still another arrangement is one that the writer built and patented in 1939*. In this arrangement, the speech was scrambled as in the process of Fig. 3. Then, to destroy the limits or boundaries between the plurality of sub-bands, the combined frequency bands were inverted by a modulator in which the inverting frequency was caused to vary cyclically in an irregular manner. The varying inverting frequency, combined with a complex scheme of variation, provided a high degree of secrecy. It can be seen that in accordance with such a principle, it would be practically impossible for an unauthorized listener to separate the individual sub-bands as their frequency limits would never remain fixed in the spectrum. To separate the individual sub-bands it would be necessary to know the inverting frequency at any instant and the complex manner in which it varied.

Let us assume that the inverting frequency varies cyclically in any desired manner between the limits c and $c+d$, where d varies between zero and a predetermined limiting value. If the speech frequency band as a whole, such as from L_2 of Fig. 3, is represented by s and if the inverting frequency is modulated by these speech frequency currents, the resulting components will be of frequencies $c+d-s$ and $c+d+s$. The lower side-band $c+d-s$ would be the one selected for transmission.

The receiving station cooperating with such a system would use substantially the identical means used for transmitting but in reverse.

* U. S. patent No. 2,301,455.

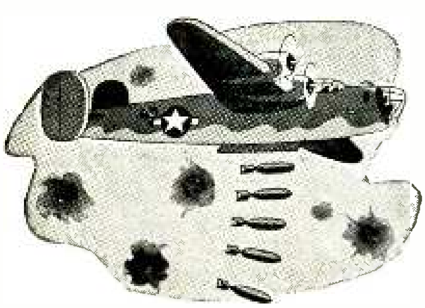
DAILY five-minute war news broadcasts are piped into the Boston Navy Yard from the newsroom of station WBZ, Boston, and broadcast directly to the workers through strategically located loudspeakers.



Song of Elmer...
the pilot who never gets tired

He holds no place in the Officer's Mess
for he does not sleep or eat,
He's the Quietest Birdman ever took
his place in a cockpit seat—
He joins no laughter, nor shoots the breeze,
nor whistles, nor hums, nor sings,
But he's flown more planes than any man
who ever wore pilot's wings...
...has Elmer!

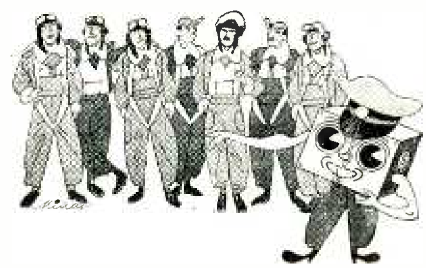
He's an old, old hand, as old hands go
in a young man's game today,
For he circled the globe in 'Thirty-three
with Post in the Winnie Mae—
He's an Army man, he's a Navy man,
and he flies with the R.A.F.,
And the Yankees say, and the British say
of pilots, he's the best...
...is Elmer!



Often when bombers have levelled off
for the last tense bombing runs,
And the bomb-bay doors are opened wide,
and the gunners man the guns,
When the flak comes up as the bombs
go down, and the target zone is clear,
Then who is the pilot who holds the course
set by the bombardier...?
It's Elmer!

He can hold a plane on a chosen course
while the crewmen rest or sleep,
He can level off for a landing glide,
or bank her sharp and steep—
He can spiral up, he can spiral down,
or hold her level and true—
His hydraulic muscles never tire
the way human muscles do...
...not Elmer's!

And so bombing, transport, and cargo
planes, take Elmer on every flight
To spare the pilot and rest the crew
for emergency, storm, or fight—
He needs no rest, for he never gets tired,
being only a cold machine,
Just wheels and wires and gears and cogs,
with brackets and stuff between...
...is Elmer!



He wears no medals, he holds no rank.
Why should he? He cannot feel
The courage that flares in time of need
for he's only alloy and steel!
So when *nerve* is needed, the bombardier,
the pilots, the gunners, too,
The navigator, and all the rest,
are the boys who pull her through...
...NOT Elmer!

SPERRY
GYROSCOPE COMPANY, INC.

is proud to be manufacturing the famous Sperry Gyropilot for the Armed Forces of the United Nations.

SPERRY

Brooklyn, N. Y.
Division of Sperry Corporation

• *Reprints of this poem — suitable for framing, with signature removed — may be obtained without charge by writing the Sperry Gyroscope Company.*

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs. Each month descriptions of these new items will be found here

Drag Cup Motors

THESE DRAG CUP MOTORS are high-speed precision motors for use in applications requiring quick starting, stopping and reversal characteristics. While they were originally designed for use in aircraft as loop driving motors for automatic radio compass units, the motors may be used as a control device delivering quadrature voltage proportional to the speed of the rotation of the shaft. The rotating element of the motor consists of a very light cup attached to a shaft rotating on ball bearings. The field is a two-pole, two-phase stator with phases 90 deg. apart. Reversal of the motor is accomplished by reversal of one phase. Features of the motor are light weight, compactness, quick response, minimum maintenance, no radio interference (the motors contain no brushes, slip rings or rubbing contacts), and an end bell design which permits servicing without unsoldering the lead wires. Any source of two-phase power or single phase with a phase-shifting capacitor or network can be used as power supply.

Three types (776-01, 776-02 and 776-04) of drag cup motors are available. Their characteristics are shown in the following table.

Characteristics	776–01†	776–02	776–04
Frequency	400 cycles	60 cycles	400 cycles
Voltage			
Phase 1*	24 volts	100 volts	125 volts
Phase 2	35 volts	100 volts	110 volts
Number of Poles	6	2	6
Average Impedance*			
Phase 1—Ohms	48 Ohms	1470 Ohms	1250 Ohms
Phase 2	145 Ohms	1590 Ohms	1620 Ohms
Current—Amperes*			
Phase 1	0.50 amps	0.068 amps	0.100 amps
Phase 2	0.24 amps	0.063 amps	0.068 amps
Speed—no load	5700 RPM	3000 RPM	5500 RPM
Torque—stalled	0.70 in/oz.	0.50 in/oz.	0.50 in/oz.
Stopping time	1.35 sec.	0.2 sec.	0.6 sec.
Reversing Time	0.3 sec.	0.12 sec.	0.15 sec.
Temperature Rise	50° C	43° C	40° C
Weight of Motor	12.0 ounces	12.5 ounces	12.0 ounces
Weight of Rotor	0.53 ounces	0.42 ounces	0.42 ounces
Length—over-all	2.750 in.	2.750 in.	2.750 in.
Diam.—max. outside	2.750 in.	2.750 in.	2.750 in.

* Running—no load.
† 776–01 Signal Corps No. Mo-27.

A catalog called "Remote Indicators and Motors with Electronic Applications" contains a page of outline drawings of basic Type 776 drag cup motors. Also in the catalog are detailed descriptions and electrical characteristics of Type 787 rotatable transformers, which were briefly described in this column in August ELECTRONICS. Other units described in the catalog are two-phase generators, micro-horsepower Telegon units, and Teletorque units.

Write to Electrical Development Dept., Kollsman Instrument Division of Square D Co., 80–08 45th Ave., Elmhurst, N. Y.

Automatic Control Aid

"FLASHTRON" DESIGNATES an electronic package unit which serves as a sort of nerve center in automatic control setups and makes it practicable to closely approach zero tolerance in regulating variables occurring in industrial processes such as pressure, temperature, liquid level, flow, speed, motion, voltage, air, fuel relation, specific gravity, gas analysis, etc. It is a buffer control element operating between the primary sensitive element and the power operating control element.

The unit requires negligible power for actuation, and may be operated from super-sensitive primary actuating elements of various types. It furnishes the power necessary for actuation of power operating elements, slower-acting primary control elements. Output circuits accommodate the alternate energizing of loads within the range of the instrument (blower fans, valve control, heating elements, etc.) which may be connected to it.

Advantages claimed for the unit are its high-speed operation and its immediate response to sensitive actuation. One of the two output circuits is always energized but both cannot be energized simultaneously with contactor-type actuating devices. The dual circuit output energizing system is especially suitable for the control of proportioning or positioning control elements such as valves operating from reversible motor drives. Since one or the other circuit must be in operation at any given instant, the valve will be constantly reset to the desired position in exact response to the performance of the primary sensitive element which is actuating the Flashtron unit.

While the Flashtron cannot compensate or correct for lag in any of the other control elements in the system in which it is used, the manufacturer states it does not in any way limit the full utilization of the performance of any of these other elements. The unit is lightweight, measures 11½x7⅓x3⅝ inches, and comes housed in an all-steel box with provision for connecting it to a 115-volt, 60 cps a-c line, the actuating circuit and two control sections.

Thordarson Electric Mfg. Co., 500 West Huron St., Chicago, Ill.

Direct-Reading Frequency Meter

ILLUSTRATED IS A frequency meter which retains an accuray of 2 percent over the entire range of 50,000 cycles. It will drive a recorder without the use of auxiliary amplifiers. An overload cutout protects the recorder from damage. The instrument is also suitable for use as a laboratory test instrument, for testing quartz crystals, for use in a wow meter for phonograph motors, and for experimental work as the base of a frequency modulation indicator. When combined with a phototube, a

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COMPOUNDERS AND EXTRUDERS OF SPECIFIC MATERIALS FOR SPECIFIC USES

FLEXIBLE RUBBERLIKE TUBING

TEST DATA	FT-10 Sub-Zero	FT-11 Transparent	FT-22 Versatile	FT-33 Heat
Dielectric Strength Dry VPM	280	1000	1200	900
Wet VPM	450	910	900	800
Low Temperature Flexibility °F. (°C.)	−85 (−65)	−63.4 (−53)	−59.8 (−51)	−22 (−30)
Impact °F. (°C.)	−70.6 (−51)	−54.4 (−48)	−41 (−40.56)	−5.8 (−21)
Elevated Temperature Continuous °F. (°C.)	150 (65.56)	188.6 (87)	194 (90)	190 (87.78)
*Soldering	Flows	Flows	Flows	Good
**Aging (Baking) at 100°C. (212°F.) good after	100 days	100 days	130 days	50 days
Tensile Strength PSI	2550	3000	3200	2900
Hardness Shore "A"	40-45	55-60	65-70	75-80
Flame Resistance	Do not support combustion			
Water Absorption %	−1.4	+0.4	+0.9	+0.75
Chemical Resistance	Good	Very Good	Very Good	Good

All tests made on Standard #8 Tubing.
*1 minute immersion in molten solder at 450°F.
**Rapid flattening between jaws of a vise to thickness of twice the wall.

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USES

FT-10: Battery drain, pilot relief, window channels, mechanical rubber goods. (Lowest Temperature.)

FT-11: To facilitate circuit and wire code identification, sealing cable ends, conduit, sheath. (Transparency, Low Temperature, and Good Dielectric.)

FT-22: Sheath, sleeving insulation, communications and mechanical rubber goods. (Highly Versatile.)

FT-33: Transformer, communications and electrical manufacturing. (Baking and Soldering Temperatures.)

Sizes: From B.&S. #24 (.021" I.D.) to 2.000" I.D.—Special sizes on request.

Write for Complete Test Methods and Data — Samples

INDUSTRIAL SYNTHETICS CORPORATION

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60 WOOLSEY STREET, IRVINGTON, NEW JERSEY

light source and amplifier, the instrument can be used as a speed indicator to read speeds difficult to determine, such as are encountered with ultra-speed centrifuges.

Maximum frequency is 50,000 cycles in ranges of 0-100; 0-500; 0-1000; 0-5000; 0-10,000; and 0-50,000. Each frequency range can be individually adjusted for maximum accuracy. The frequency is indicated directly on a front panel, or on a separate recorder. The meter has an in-

put impedance of 100,000 ohms or over. It will measure frequency regardless of input signal voltage variations between ½ and 200 volts. Stability is maintained with line voltage variations between 105 and 125 volts. The meter does not use d-c amplifiers. It is available for either relay rack or cabinet mounting.

Industrial Electronics Div., North American Philips Co., Inc., 419 Fourth Ave., New York, N. Y.

Insulation Breakdown Testing Instruments

ALL-PURPOSE INSULATION breakdown testing instruments known as "Hy-pot" are available in standard models (No. 406, 407, 408, 409, 410), as well as in special designs. The instruments are mounted on rubber tires and have handles at the back for easy portability. Features given for these instruments include ample capacity for all testing; easy control from zero to maximum voltage which is indicated on the scale of a large open-scale meter; full 500-ma capacity to meet AIEE specifications; a 1½ kva transformer on standard models, and a 3 kva transformer on models having a "burn" test; completely self-contained and arranged for convenience. Form No. A9-743-2M describes these testers in detail and is available from the manufacturer, Associated Research, Inc., 231 South Green St., Chicago 7, Ill.

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EAST SIDE

WEST SIDE

ALL AROUND THE WORLD

.... Radio Brings Them the Sidewalks of Home

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American radio manufacturers have supplied sturdy little short-wave sets that bring America to any part of the globe. And that's been a big factor in the sky-high morale of our fighting men overseas.

Every day, U. S. radio manufacturers are making huge deliveries of military radio equipment to speed the day of victory. Their war experience, added to their manufacturing skill, is effecting technical advances that will be important to peacetime production.

Your purchase of War Bonds will help supply American fighting men with the world's finest equipment.

SCIENCE SMASHES AT THE AXIS in RCA Laboratories, working unceasingly in radio-electronic research. Proud of the privilege of serving America's great radio industry in its united war against the Axis, RCA will continue to make the fruits of its basic research available to American makers of radio equipment. This will help American manufacturers to provide finer radio-electronic products and services to a world at peace.

RCA Laboratories

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High-Voltage Tubular Capacitors

TYPE '26 HIGH-VOLTAGE capacitors are for use in x-ray, impulse generator and other intermittent d-c or continuous a-c high-voltage applications such as indoor carrier-coupler capacitors, test equipment and special laboratory work. The capacitors are oil-impregnated, oil-filled with Hyvol vegetable oil and are built with insulated and matched sections of uniform capacitance, connected in series. Equal voltage stresses are maintained for all sections with a uniform voltage gradient throughout the length of each capacitor. Aluminum foil with a number of tab connectors provides high conductivity with low inductive reactance. Capacitor sections are dried and impregnated (under high vacuum in a closely-controlled long cycle) to eliminate voids and also provide for high insulation values and lower losses.

The case is of laminated bakelite

tubing, protected by a high-resistance insulating varnish for high dielectric strength and maximum safety from external flashover. The manufacturer states the capacitors will give dependable operation and long service life at rated voltages and ambient temperatures up to 65 deg. C. The terminals are two-piece cast-aluminum end caps with bakelite-treated cork gaskets, which are locked in to provide leak-proof hermetic sealing. Caps are available with mounting feet for space-saving assemblies in series, parallel or series-parallel arrangements. Also obtainable with plain end caps.

Aerovox Corp., New Bedford, Mass.

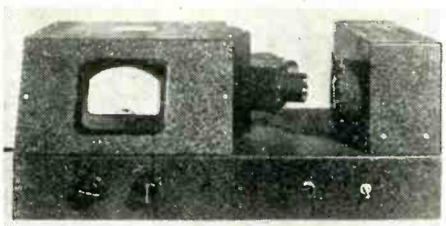
Lightweight Relay for Aircraft

THE MANUFACTURER OF THESE relays (designated as "Bantam") states their characteristics as being powerful, sensitive and lightweight. They are for use in aircraft instruments and come in one to six pole construction. The relays are available in either standard front-connected, screw terminal, solder lug, eyelet, or switchboard mounting. The coil and shading pole assembly are one unit and can be replaced without special tools. If desired, the relays can be treated to preserve them from tropical humidity.

A bulletin containing technical data is available from Kurman Electric Co., Dept. A E, 30–30 Northern Blvd., Long Island City, N. Y.

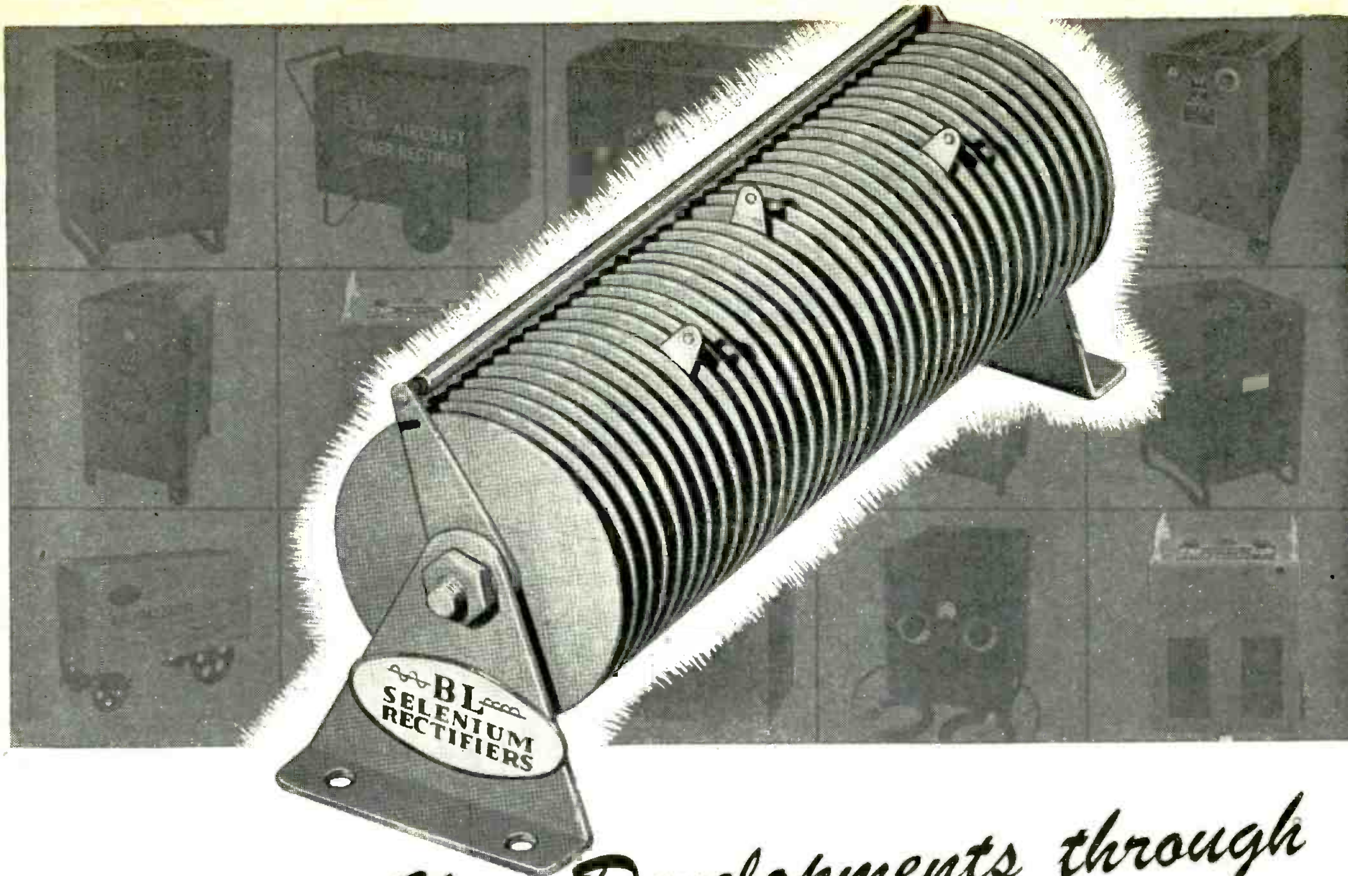
Densitometer for Measuring Transparent Materials

DENSITOMETER SERIES D90, is a photoelectric system for accurate measurement and control of the density of transparent films, filters, plastics, gases and liquids. The system was developed originally for use in the manufacture of extremely dense optical filters to maintain accurate control of transparency during large quantity runs, but it may also be used for constant density control of films and plastics, for turbidity control of liquids in a variety of



processes such as the manufacture of aluminum, and for turbidity control of gases, as in the examination of flue gases.

The densitometer projects two beams of light from a single light source. One beam passes through any standard filter; the other, through the filter or liquid the transparency of which is to be measured. The two light beams are then projected by an optical system to a single phototube. By means of an electronic and mechanical timing system, the instrument constantly measures the ratio of transparency of the sample as compared with the standard



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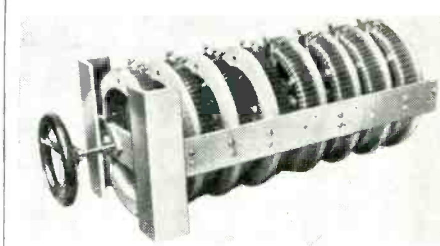
filter. Measurements are accurate and completely independent of circuit constants, supply voltage and other ambient conditions. Variations of ± 10 volts from standard have no effect on readings. Series D90 measures materials up to density 5.

Photoswitch Inc., 21 Chestnut St., Cambridge, Mass.

Tandem Rheostat Assemblies

THE TANDEM UNIT illustrated consists of eight Model U, 1000-watt, 12-inch diameter rheostats mounted in a steel frame. It is controlled by a single hand wheel. Other tandem assemblies can be made up of two, three or more rheostats ranging in power rating from 25 watts to 1000 watts and in diameter from 1$\frac{9}{16}$ inches to 12 inches. Rheostats in tandem are insulated from each other so that they may be used for simultaneous control of several circuits or



phases of a circuit by means of one knob.

Two rheostats can be separately controlled by means of concentrically located knobs to conserve panel space or where it may be desired to use one rheostat as a vernier for another. In this type of unit two rheostats are mounted in tandem with the shaft of the rear unit extending through the hollow shaft of the front unit. For increased capacity, the front or back units can consist of several rheostats connected together. Tandem rheostats are also available in taper windings and the same range of resistance values as individual units.

For details write Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.

INSTEAD OF levelling off, the electronic equipment industry must meet war production quotas 30 to 40 percent greater for 1944 than for the present year, according to the WPB Radio Division.

Here's news for men in radio and electronics—

JUST OUT!

Radio Engineers' Handbook

By Frederick E. Terman

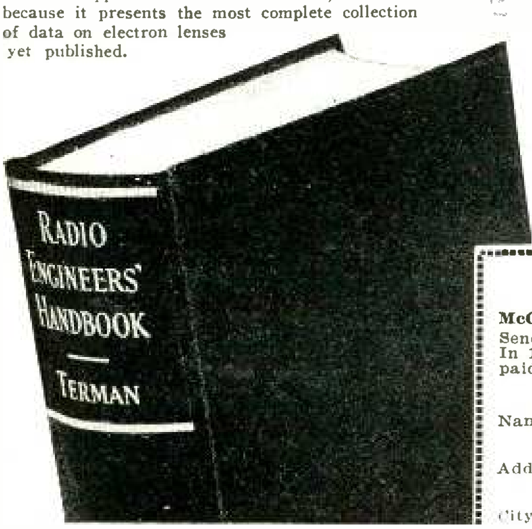
Professor of Electrical Engineering and Executive Head, Electrical Engineering Department, Stanford University (absent on leave), Director, Radio Research Laboratory, Harvard University

More than 1,000 pages, 6 x 9
profusely illustrated
$6.00

Some Features of the Handbook

The formulas and curves on skin effect, inductance, mutual inductance, and capacity represent the most complete collections ever presented in one place. The same is true of the transmission-line equations, the formulas for field patterns and radiation resistance of antennas, the treatment of ground-wave and ultra-high-frequency propagation.

Network theory is covered in a straightforward and comprehensive way that will help widen the understanding of such matters as Foster's reactance theorem, attenuation and phase equalizers, lattice and ladder filters of various types, impedance matching and insertion loss, the relation between attenuation and phase shift, etc. The treatment of electron optics is noteworthy in that it is the first summary of the subject that has appeared in handbook form, and also because it presents the most complete collection of data on electron lenses yet published.



One of the most complete works of its kind ever published, this outstanding reference work presents a wealth of essential theory and up-to-date standards, practice, and data, especially selected and organized to meet the needs of the engineer dealing with practical radio and electronic problems.

13 big sections, covering

1. Tables, Mathematical Relations, and Units
2. Circuit Elements
3. Circuit Theory
4. Vacuum Tubes and Electronics
5. Vacuum-tube Amplifiers
6. Oscillators
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10. Propagation of Radio Waves
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12. Radio Aids to Navigation
13. Measurements

Terman's Handbook concentrates on those topics which the radio man thinks of as constituting radio engineering—presented in concise descriptions, fundamentals, formulas, procedures useful in actual design, tables, diagrams, etc. Consult it for data needed in routine problems of design and practice, or in investigation of special problems or branches of work. Check your methods against best accepted practice. Save time, trouble, and error—get quick, dependable answers to your questions, *when* you need them, from Terman's Radio Engineers' Handbook.

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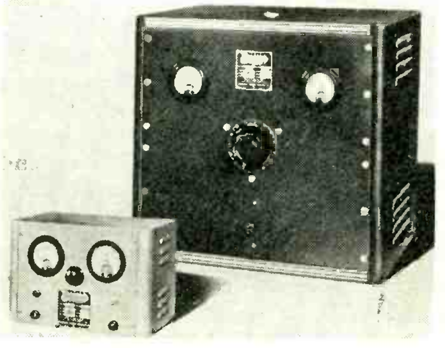
High-Resistivity Insulated Cores

FOR APPLICATIONS CALLING FOR iron cores having high unit resistivity, a core material showing resistance of practically infinity is available. The manufacturer recommends these cores for applications where a resistance of 150 megohms or greater is required, and where voltages do not exceed the breakdown value. The high-resistivity material is designed to reduce leakage currents and noise troubles, as well as voltage breakdown between coils and cores. In cup core applications, the manufacturer states this material avoids the necessity for heavy insulation on lead wires.

Other iron-core types for a wide variety of uses, and for frequencies to 175 Mc and better, are available from the manufacturer, Stackpole Carbon Co., Electronic Components Div., St. Marys, Pa.

Battery Charger Line

THE MANUFACTURER'S selenium rectifiers are used to power these battery chargers which are available in a wide range of voltages and current ranges, as well as in individual designs for special applications. Three general classes of battery chargers are available. The first of these is a portable, low voltage type for automotive, aircraft, or radio uses. It features a wide charging rate control and may be equipped to switch from 6 to 12 volts with equal efficiency at



either voltage. The second unit is a communications type for telephone, telegraph, signaling and alarm systems ranging from 24 to 48 volts. The charger in this unit is provided with a filter to eliminate ripple. The third unit is a general utility type for central power stations, machine tools, control circuits and other general requirements for 110 volts and up. Chargers available are floating or taper charge, multi-rate charging with trickle end rate, and automatic regulated charging.

The selenium rectifiers used in these battery chargers are a-c to d-c conversion units and are capable of charging batteries at either high or low rate. They provide automatic reduction of the charging current as the battery voltage increases, giving a tapered charge which protects batteries from excess temperature or undue gassing without the use of manual or automatic switching equipment.

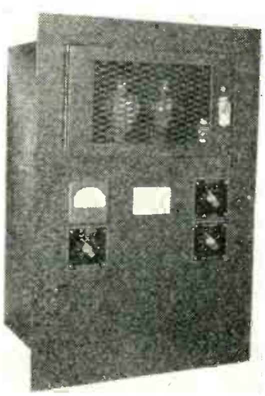
General purpose power supply equipment is also available for powering production lines and for use as components of military equipment.

Selenium Rectifier Div., Federal Telephone and Radio Corp., East Newark, N. J.

Furnace Temperature Control

THE FURNATRON SYSTEM was developed for applications where it is necessary to keep to a minimum the variations of resistance furnace temperatures. This is accomplished by combining a thermocouple type of temperature controller with automatic control of the saturation current of a saturable reactor connected in the supply line of the furnace elements, automatically controlling the power input into the furnace.

The Furnatron may be used for furnace temperature regulation and control of a single or three phase furnace. Where the line or furnace transformer voltage is not suitable to supply a-c to the thyratron tubes, an anode transformer is furnished. Another optional feature is a droop corrector, which may be used in installa-



tions where the rate of material flowing through the furnace changes, thus compensating for heat exchange due to fluctuations in the rate at which the furnace is being loaded. The instrument also includes a compensator for line voltage variations. It is used to minimize the effect of fluctuating line voltage on high thermal inertia furnaces. The complete regulator is arranged for flush panel mounting. Protective devices of the system include a time delay relay, over-temperature mechanisms, surge suppressors, fuses and disconnecting devices.

Department 2-E-54, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

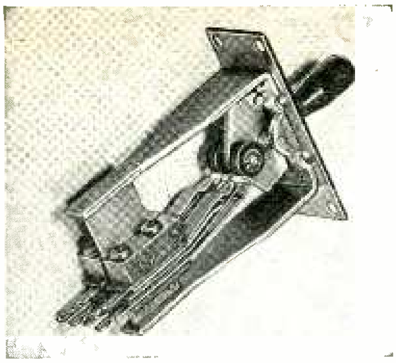
Quartz Wafers and Optical Glass Etching Fluid

A NEW COMPOUND, known as "Quartz Etch", has been developed for etching quartz wafers and optical glass. The odor is mild, something like that of molasses, and no appreciable fumes are given off. Although rubber gloves are required in handling, casual contact with the skin is harmless, according to the manufacturer. No hoods are necessary, and ordinary galvanized metal tanks can be used. The manufacturer also states the fluid is vigorous in its action against glass or quartz, and cites as an example a user's report that a 40-minute immersion in the fluid produced a better pattern on a quartz wafer which was twinned than could have been obtained in several hours with hydrofluoric acid. Another advantage claimed for the new fluid is its effectiveness as an agent for finishing quartz crystals to frequency.

George W. Gates & Co., Hempstead Turnpike and Lucille Ave., Franklin Square, Long Island, N. Y.

Key Switches and Telephone-Type Jacks

KEY SWITCHES, designed for quiet operation in communications circuits, are available for immediate delivery with or without mounting plates. Allowing for a maximum of seven springs in each quadrant of the switch, they provide a wide variety of locking and non-locking switching combinations. Silver alloy contacts are standard. Special contact materials can be supplied when necessary.

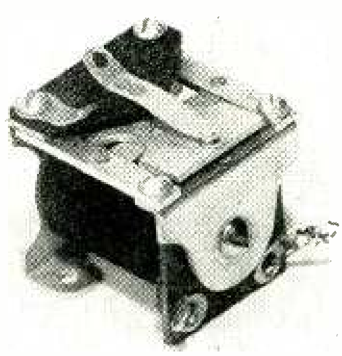


Also available for prompt delivery are telephone-type jacks which feature welded box construction to assure alignment of all parts. Springs provide permanent tension. Additional springs are available for switching auxiliary circuits. The jacks are available for all standard two and three circuit telephone-type plugs.

Audio Development Co., 2833 Thirteenth Ave., South, Minneapolis, Minn.

Relay with Leaf Spring

A TWISTED LEAF SPRING takes the place of a pivot or pin-type bearing in this relay which measures approximately 1 inch on each side and weighs less than 1.4 ounces. The relay is designed to operate at 0.2 watt. The photograph illustrates a normally closed SP contact. SPDT contacts are also availale. Wiping

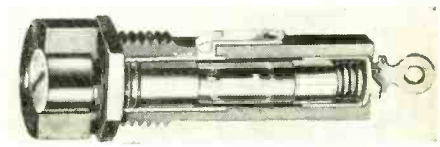


action is accomplished by the use of a resilient mounting of the stationary contact. The armature is mounted on the leaf spring, which twists, acting as the bearing as well as providing the torque to bring the armature to its normal position after the relay coil is de-energized. Contacts are rated at 1 amp at 24-volts d.c., non-inductive.

Control Corp., 600 Stinson Blvd., Minneapolis 12, Minn.

Extractor Post

To keep side terminals of these extractor posts tight and secure against heat and vibration, the manufacturer has welded them to metal shells inside a bakelite body and backed them up with soft solder. The illustration is a cutaway of No. 1075S



extractor post. These posts are used with 3AG ($1\frac{1}{4}$x$\frac{1}{4}$ inches in diameter) fuses for radios, fractional-hp motors, magnets, rectifiers, plate circuits, etc. Overall length measures $2\frac{1}{2}$ inches; length from front panel is $2\frac{1}{8}$ inches; mounting hole measures $\frac{1}{2}$ inch. The maximum current rating is 15 amp. It is available for screwdriver operation meeting Underwriters' specifications, or for finger operation. The knob and body are molded of black bakelite and are impervious to temperature changes and corrosion, and are insulated. Spacing between live parts gives protection against electrical leakage.

Littlefuse Inc., 4747 Ravenswood Ave., Chicago 40, Ill.

Bender

Developed for aircraft and marine work, the Di-Acro Bender No. 3 in-

corporates all of the features of the manufacturer's smaller models (described in past issues of Electronics) but is heavier and more rugged, and has a considerably greater radius-forming capacity. The photograph shows a girl forming a pipe support with this machine. A 7-inch circle and two right-angle bends are obtained in one operation of bender No. 3. Bulletin 19-A is available.

O'Neil-Irwin Mfg. Co., Minneapolis 15, Minn.

Heavy-Duty, High-Voltage Capacitors

Available for military applications are heavy-duty, high-voltage capacitors which may be used in surge and lightning generators. The capacitors are equipped with solder seal terminals for operation at high altitudes and humid weather conditions. The unit illustrated is 28 inches high and weighs 175 pounds. It is rated 0.5 μf, 50,000 volts, d.c., and according to the manufacturer is constructed to withstand 24 hours continuous operation and total submersion in salt water. Units for continuous operation up to 150,000 volts working are also available.

Industrial Condenser Corp., 1725 West North Ave., Chicago, Ill.

Literature

Engineering Data. Seven nonmetallic materials manufactured to meet the requirements of advanced product design are described in a 15-page booklet. The materials described are: vulcanized fibre, cotton cellulose material made in sheets and tubes; Dilecto, cloth fabric, glass fabric and asbestos grades made in sheets, rods and tubes; Dilectene, an aniline-formaldehyde resin product available in sheets and limited sizes of rods; Celoron, a molded fabric base phenolic plastic for mechanical parts; Micabond in sheets, tubes, and tapes of mica splittings bonded together with shellac or synthetic resins; Vulcoid, with good moisture resistance as compared to fibre; Haveg-Saran available in standard sizes covering a wide range of applications. The booklet also includes an application chart. Booklet available from Continental-Diamond Fibre Co., Newark, Delaware.

Engineering Reference Data. This 36-page booklet has been made up for design engineers or the buyer of machine parts, in order to present clear and complete engineering reference data. Material described in this book are: hard vulcanized fibre in sheets, rods and tubes and in fabricated parts, Armite, an improved thin insulation (fish paper) in sheets, strips and coils; Spauldite, a laminated phenolic, in sheets, rods and tubes and in fabricated parts; Spauldo motor slot insulation; flexible fibre, a gasket material; fibre receptacles, boxes and barrels and fibre board. Booklet available from Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N. Y.

Colloidal Graphite. Bulletin No. 431-EE describes "dag" colloidal graphite for impregnation and surface coatings. It includes the reasons for colloidalization of industrial products and methods used to impregnate materials. Bulletin No. 431-EE is available from Acheson Colloids Corp., Port Huron, Mich.

Insulating Varnishes. Synthite PG-1 clear baking varnish for the protection of electrical units is described in a 6-page folder. This insulating varnish may be baked to any degree of hardness and does not resoften under heat developed by some types of units. A copy of this folder is obtainable from John C. Dolph Co., Dept. 22, 168 Emmett St., Newark, N. J.

Resistance Standards and Bridges. Bulletin 100 describes and illustrates standard resistors, standard shunts, mounted individual resistors, type B and type W decade resistance boxes, individual decade resistance assemblies, high-precision Wheatstone bridge, type B Wheatstone bridges, Mueller bridge, portable Wheatstone bridge test sets, high-precision Kelvin bridge, portable Kelvin bridge and limit bridges for rapid production testing. Bulletin 100 is available from Rubicon Co., Ridge Ave. at 35th St., Philadelphia, Pa.

Specification Finishes. Additional sheets to be added to Booklet 619, U. S. Government Finishes, are available from Maas & Waldstein Co., 438 Riverside Ave., Newark, 4, N. J.

Primer on Radio. A 68-page primer to help the beginner understand the fundamentals of radio. The scope of the material is broad, with mathematical and engineering treatment on fundamental theory held to a minimum. Copies available from the Advertising Division, Electronics Dept., General Electric Co., Bridgeport, Conn., for twenty-five cents in coin.

Aircraft Catalog. Catalog 36 presents information on electrical connectors for aircraft wiring. The catalog consists of five sections: sta-kon terminals; wedge-on terminals; tite-bind terminals; bonding jumpers; specialties. For those who already have the first edition of this aircraft catalog, a complete set of the new pages is available to bring their catalogs up to date. Catalog 36 is obtainable from Thomas & Betts Co., Elizabeth, 1, N. J.

Plastic Molding. Bulletin No. K-200 contains information on the custom molding facilities and services of a plastic molding plant. The work of the engineering, mold-making, production and finishing departments is described and some of the molded parts produced are illustrated. A table showing the comparative characteristics of various compression-molded plastics is included. Bulletin No. K-200 is available from Imperial Molded Products Corp., 2925 W. Harrison St., Chicago, 12, Ill.

Hazeltine Functions. In a 41-page book, the Hazeltine Electronics Corp. presents a broad picture of how the organization handles new developments. One section of the book is devoted to telling how some of their electronic devices extend into many phases of life in war and peace. Copies of this book may be obtained from Hazeltine Electronics Corp., 1775 Broadway, N. Y.

Electric Instruments. General Electric's new publication "Electric Instruments, Principles of Operation" presents a discussion of the characteristics of instruments and what makes them operate, and individual limitations of various types. Bulletin GET-1173 is available from News Bureau, General Electric Co., Schenectady, N. Y.

Primer on Electronic Tubes. "How Electronic Tubes Work" is a 24-page nontechnical book. Bulletin GEA-4116 is made up chiefly for industrial engineers. The primer's main emphasis is on how the electronic tube operates. The eight basic types of industrial electronic tubes and their uses are described. Bulletin GEA-4116 is available from Dept. 6-215, Publicity Division, General Electric Co., Schenectady, N. Y.

Fuzed Quartz. A price schedule of fused quartz for standard sizes of ingots, rods and tubing is available from the address below. The fused quartz comes in a variety of sizes, both clear and translucent, which are also listed on the price list. The physical properties and characteristics of fuzed quartz are described in a reprint from an article by P. K. Devers published in *Light* magazine, Send request for above to Mr. P. K. Devers, Lamp Dept., General Electric Co., Cleveland, 12, Ohio.

Level Controls. A four-page bulletin containing information on electronic level controls for liquids and powders. Bulletin available from Photoswitch Inc., 77 Broadway, Cambridge, 42, Mass.

Spot Welding Machines. Bulletin 93-W-43 covers the operating principles, typical standardized arrangements and special applications of small spot welding machines. Several welding tips and fixtures, illustrations of automatic welding timers and contactors and types of transformers manufactured by this company are covered in the booklet.

Bulletin 92-BW-2 lists features, applications, and operations of types and sizes of small and heavy-duty butt welders. These welders are particularly designed for welding wires as small as 0.008 in. diameter of tungsten, molybdenum, nickel and copper. Examples of butt welders combined with contactor and timer suitable for wire-drawing plants are also shown in this manual.

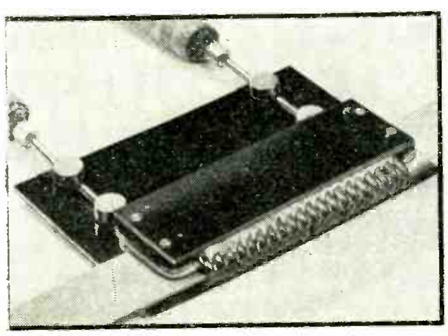
Bulletin 93-W-43 and Bulletin 92-BW-2 are available from Eisler Engineering Co., 740-770 South 13th St., Newark, 3, N. J.

Work Coils

(*Continued from page* 112)

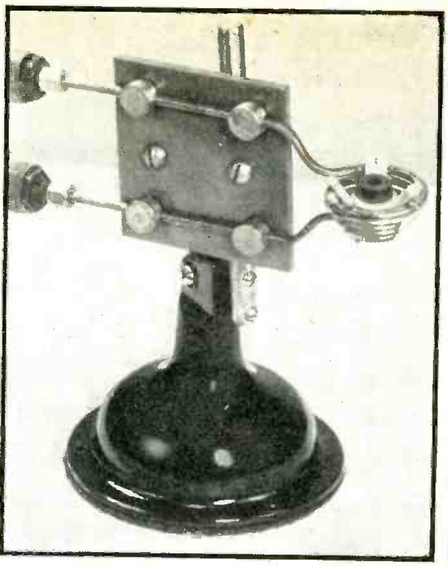
encompass only a portion of the object, or by allowing only the desired portion of the object to project into the coil between its turns.

High-frequency heating permits accurate control over what is heated, how long it is heated, and how much it is heated. This means that inexperienced operators can obtain uniformity of heat treating on production runs far more readily than with conventional heating methods. Once a satisfactory work coil has been constructed and the optimum frequency and time determined for it by experiment, heat-treating merely involves placing the metal part inside the work coil, stepping on a foot control switch for the requisite number of seconds, then either turning on the water spray device which surrounds the coil or removing the part and dropping it in a quenching solution. Asbestos strips or other means can be used to center the object with respect to the coil. The depth to which heat penetrates can be regulated to a small fraction of an inch regardless of the thickness of the object being heated.



Work coil for annealing continuous strip prior to hot stamping and forging

Brazing and soldering by means of induction heating give uniform penetration of heat throughout the joint to be brazed or soldered, eliminating excessive heating on the surface and leaving very little discoloration and practically no scale. Thus, cleaning or refinishing operations can often be omitted. The electronic process also eliminates waste of excess solder or brazing alloy, a vital factor in wartime. The temperature produced is essentially a matter of time, with heat becoming progressively more



Cone-shaped work coil for heating the teeth of a bevel gear preparatory to hardening. The gear is automatically centered by the asbestos strips. The coil is mounted on a movable stand

intense as current is left on, hence brazing alloys right up to those with the highest melting points may be used.

Melting of small masses of metals can be accomplished readily with a small crucible placed inside a work coil. If a conductive graphite crucible is used, most of the heat is generated in the walls of the crucible and is transferred to the metal by conduction. With a ceramic crucible, the high-frequency current is induced in the metal itself, causing a stirring of the mass of molten metal which gives a high degree of uniformity to the melt. The metal can be poured with power on, which practically eliminates freezing of metal at the lip of the crucible.

High-frequency heating has already been successfully applied to several thousand war production problems. The field of economical commercial uses is just being discovered and opened up.—J.M.

ANOTHER FIRST—100,000,000-volt x-rays were produced for the first time on Aug. 21 by the G-E research laboratory, using the recently completed induction electron accelerator. The first few observations show that the characteristics of these x-rays differ radically from those with which physicists are familiar.

Short-Wave Control Center

(*Continued from page* 117)

Two special small rooms are provided especially for transcription broadcasts. In these rooms are three individual turntable channels, each equipped for electrical spotting. During use, a turntable motor runs continuously. The pick-up is set at the desired point on the record while the record is held stationary by an electromagnetic brake, so that the record slips on the turntable until the release button is pressed at the instant the program is to start. In this way the operator in one of the transcription rooms can start three separate transcribed programs simultaneously following a station break.

In addition, there is an announcing microphone in each transcription room, along with complete testing, cuing and monitoring facilities. All microphones used by OWI in New York City at present are Western Electric type 639 cardioid models.

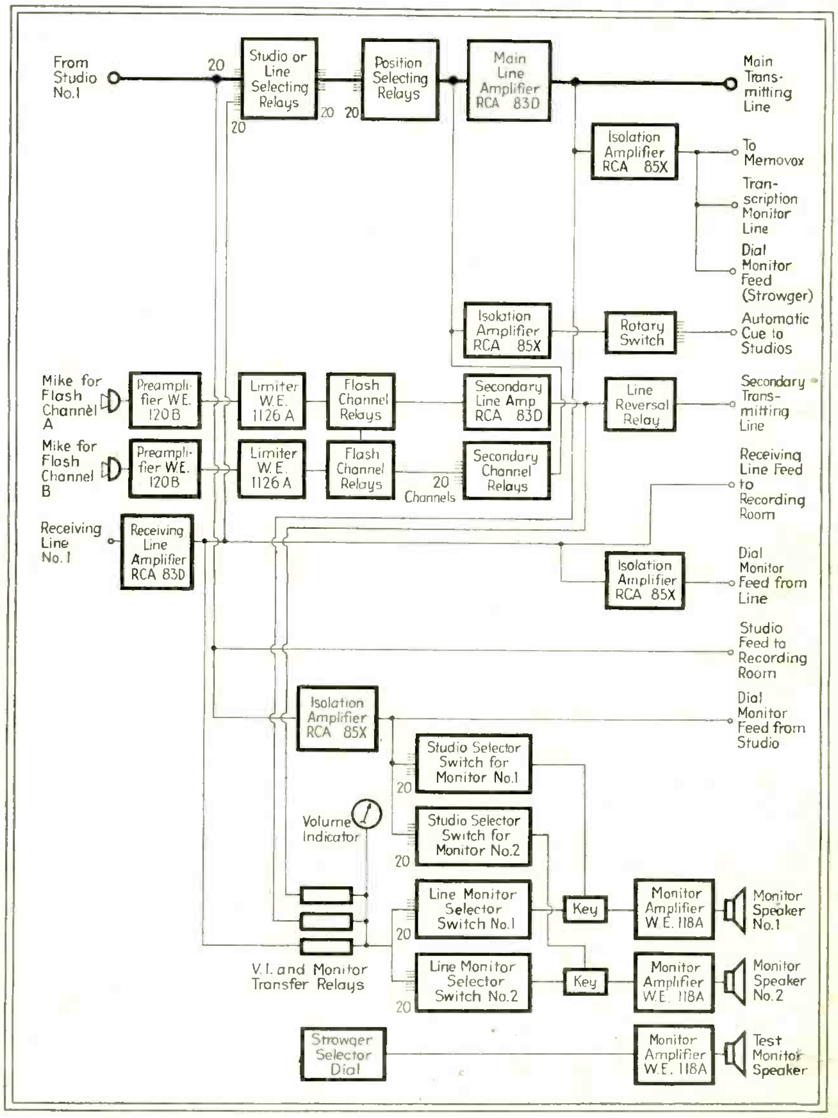
Recording Room

The recording room is believed to be the largest in the world. In it will be 20 complete Memovox machines running continuously and providing embossed recordings of all programs going on the air, for future reference. The machines oper-

One of the 16 control rooms serving the 16 live-talent studios in the new OWI master control center in New York City ate automatically off channels on the control desk, in such a way that whenever a channel is placed in operation, its corresponding Memovox unit starts up. Each Memovox unit contains two turntables, with provisions for automatic switching from one to the other to provide a total of two hours continuous recording without attention. Flexible plastic disks of ethyl cellulose are used here, each being about one-sixtieth of an inch thick. A one-hour program can be embossed on each side of each disk. Constant-velocity drive is used in embossing, to give the same frequency response at all points on the record. Crystal cutters are used, and rough estimates indicate that frequencies up to 5,000 cycles are recorded with this equipment.

Each Memovox unit has its own monitoring loudspeaker, with a pick-up riding directly behind the cutting head. The loudspeaker can be connected across the cutting head to hear what is going into the recorder, or can be fed by the pick-up to check the recording equipment.

Also in the recording room are 14 RCA type 73A recording lathes with automatic equalizers and high-fidelity cutting heads, used to provide high-fidelity transcriptions for future rebroadcasts. Each lathe is rubber-mounted on a 700-lb block of concrete which in turn is rubber-mounted on the floor of the recording room. At each lathe is a control box that permits individual, simultaneous or consecutive operation of a pair of lathes automatically in recording a program for future rebroadcast, for sending to stations not connected by wire lines with the studio, or for conversion into pressings to obtain a



Simplified block diagram of one of the 20 channels on the master control desk, shown in correct relation to the two flash channels and the monitor speaker channels that serve the entire desk

large number of duplicate recordings for rebroadcast from foreign locations.

Chips are removed during recording by a vacuum system located in an adjacent room and connected to each recording location through stainless steel tubing. The chips are deposited in a water tank in the adjacent room, and the cleaned out twice a week.

All programs going through the master control desk also pass through the master recording control desk in the recording room, permitting instant selection of any desired program and routing of it to any recording lathe that is free.

Serving the 14 recording lathes in the recording room are 14 racks of equipment, containing 14 Western Electric type 105 program amplifiers, 16 Western Electric type 118 driving amplifiers and 14 Western Electric type 1087 power amplifiers. With this equipment, recordings are made regularly that provide frequencies up to 10,000 cycles during playback.

With each lathe having its own monitoring loudspeaker and with a total of 40 loudspeakers in the Memovox unit and two more loudspeakers mounted on the wall for general monitoring in the recording room, it is possible to have a total of 56 loudspeakers in operation at one time in the recording room. The normal output of this room will be approximately 100,000 disks per year.

Status of Project

Technical facilities are now approximately 60 percent completed at the master control center. The recording room is complete except for 7 Memovox recorders now being manufactured. Most of the constructional work remaining to be done is on the master control desk, with delays here being due in some measure to difficulties in securing certain required parts. Nevertheless, the control center has been serving its transmitters for some months already, with switching being accomplished normally by means of 100 patch cords on emergency operating panels provided in the master control room for use in case of control desk failure.

Initial construction work was under the direction of Carrol Hauser, now with the Washington office of the OWI Bureau of Communication Facilities. The project is being completed under the direction of George W. Herrick.

Electronic Curriculum

(*Continued from page* 124)

of alternating-current machinery, electric power transmission and distribution, communications networks or transmission lines, communications applications of electron tubes, or electromagnetic radiation and propagation, it includes two subjects especially designed for the option electronic control and measurement and electrical implementation, with associated laboratory work. This option likewise provides for professional electives and a thesis.

The professional electives are scheduled one in each of the two terms of the fourth year. They may be selected by the student from a group of specialized electrical engineering subjects. Other subjects, in the fields of mathematics, physics, mechanical or aeronautical engineering, or economics also may be chosen as professional electives by special arrangement. For example, a student in the electronics option might study additional fluid mechanics. In choosing the professional elective, the student may either increase his specialization by choosing subjects which emphasize the trend of his option, or he may broaden his outlook by choosing subjects which are related more closely to other options than to his own option.

The thesis is expected to be in the special realm of the option which the student pursues, and in general is expected to be experimental as well as analytical, and frequently may incorporate economic studies.

Degree of Specialization

Since the word "specialization" has been used, and since the division of engineering education into courses and then still further into options means to many persons not merely specialization, but over-specialization, that ghost should be laid by taking a final backward view of the curricula outlined. Such a review indicates, (1) the curricula of the three options are identical through about 80 percent of the range, and (2) the differences in the curricula are only differences in illustrative applications of principles studied in all the options. All the curricula are solidly grounded in scientific principles from start to finish, and none is specialized in the sense that it is substantially concerned with passing commercial or technical practices. The apparent specialization has the advantage of capitalizing upon the natural interest of students so as to give greater drive to their study of principles.

The special subjects, electronic control and measurement and electrical implementation, and the associated laboratory work, in which the electronics option culminates, have been under development for only a few years and therefore have not reached the steady state. However, the transient state often is the most interesting and educational to student and instructor alike. In fact, most academic subjects unless exposed to an occasional new impulse drift into the doldrums. Though the subjects about to be described have the educational advantages that accompany the transient state, they are still definitely on the underdeveloped side and so afford a fertile field for investigatory and research work.

Electronic Control

The work in electronic control and measurement is organized to cover the more important functional methods whereby electronic devices are employed in control and measurement applications. A study of the uses of electronics in laboratory and industrial equipment indicates that the electronic devices in most of the equipment can be classified as functional elements under a relatively small number of headings. Among these headings are rectified-power supplies, voltage stabilizers, modulators, amplifiers, detectors, grid-controlled rectifiers, oscillators, trigger circuits, inverters, sweep circuits, stroboscopes, oscilloscopes, and indicator tubes. The topics discussed correspond, for the most part, with the foregoing headings. Various combinations of these functional elements make up a multitude of useful devices; for example, sensitive voltmeters, ammeters, and watt-meters, voltage and speed controls, remote indicators of various types, spot-welding timers, and high-speed graphic potentiometric recorders.

With a few exceptions such as the oscilloscope, stroboscope, and electron-ray indicator tube, which may be called electronic instruments in themselves, the strictly electronic part of most electronic apparatus is a means to an end, one link in a chain, but neither the beginning nor the end. Hence, for useful engineering application, the foregoing functions of electronics are not complete. They must be supplemented by nonelectronic conversion devices at the beginning and end of the chain. Thus in a large number of control and measurement applications a stimulus, which is often nonelectrical in nature must be made to actuate some device such as a meter, motor, or solenoid valve which gives an indication of output suitable as a measure or for control. Typical systems of components in electronic devices are shown in Fig. 1. Hence the electrical problem of conversion of such stimuli as light, temperature, level, pH, position, elongation, and vibration into an electrical quantity suitable for operation of the electronic device is an important problem in this field of electronic applications. Correspondingly, the conversion of the electrical output of the electronic system so as to obtain a chart, pointer movement, or shaft rotation is also an important problem. Many of these conversion problems, and the behavior of the corresponding conversion devices, are discussed in the work on electrical implementation. Others are treated in electronic control and measurement.

An example of an electronic measuring instrument containing a number of functional elements is a particular recording potentiometer. In this device a voltage derived from a source such as a thermocouple drives a motor which, in turn, operates a slidewire so as to maintain balance in the potentiometer circuit. For ease of amplification, the unbalanced direct voltage of the potentiometer is first converted to alternating current through modulation by a time-varying resistor—a carbon-button microphone vibrated by a 60-cycle-per-second solenoid. An alternating-current amplifier supplied by a rectified-power supply amplifies the converted unbalanced voltage. Before it can operate the direct-current motor, however, the amplified unbalanced voltage must be reconverted to direct current. This conversion is accomplished by a pair of thyratrons acting as grid-controlled rectifiers. By this chain of elements, balance is accomplished with a speed that is not even approached by nonelectronic recording potentiometers. The operating parts of such a potentiometer are shown in Fig. 2.

Electrical Implementation

In the subject electrical implementation, the over-all behavior of systems involving electrical and nonelectrical interrelations, including terminal or internal energy conversions, are analyzed. The systems examined may or may not contain electronic elements. Many systems are studied by the use of electric-circuit analogies and models. This method can be used for any problem the equations of which may be taken to represent electric-circuit equations merely by proper redefinition of symbols. The method of electric-circuit analogy is not used exclusively, because it cannot be applied to all types of problems encountered, and because it is not always advantageous even when applicable. However, the situations in which the method is both applicable and advantageous are so numerous that substantial emphasis of the method seems warranted.

The method of electric-circuit analogy can be applied to problems in mechanics, hydraulics, heat flow, acoustics, and especially to problems wherein electrical and nonelectrical phenomena are interrelated. Examples include the mechanical behavior of turboalternators, of spring-and-shock-absorber systems, of governors or other control mechanisms; the flow of water or other liquids in pipes; the flow of heat in walls of buildings, furnaces, or ovens; the design of sound-recording and sound-reproducing apparatus; the transmission of sound in tubes; the behavior of various electrical or mechanical instruments and relays, including seismographs; the behavior of magnetostriction oscillators and piezoelectric crystals. The method is especially advantageous when it can be used to analyze the over-all behavior of an electromechanical, electrothermal, or electrothermomechanical system consisting of a chain of various devices.

The analysis of a purely nonelectrical problem by the method of electric-circuit analogy has no advantage beyond an apparent clarification from the point of view of one schooled to think in terms of electric-circuit quantities rather than in terms of analogous nonelectrical quantities, and the possibility of concise diagrammatic representation of the problem by means of electric-circuit symbols. For a problem wherein electrical and nonelectrical phenomena are interrelated, analysis by the method of electric-circuit analogy has the considerable advantage of reducing the problem to a single set of terms and symbols, and a single diagram by means of which the interrelations can be more readily visualized than from the separate equations and diagrams for the electrical and nonelectrical parts of the system. Analysis by the method of electric-circuit analogy to the point of determining what type of electric circuit to use is a preliminary to the development of an electric-circuit model.

Use of Models

In general, the proper use of models affords a comparatively inexpensive means of studying the behavior of expensive structures or apparatus in the design stage so as to make the ultimate design as near the optimum attainment as is reasonably feasible, or even so as to avoid possible disaster in the ultimate construction. Models also may be used to predict the behavior of existing structures or apparatus if modified or used under conditions that dare not be risked on the actual structure or apparatus. Electric-circuit models especially possess the advantages of cheapness, flexibility and ease of assembly, ease of control over test conditions, speed of response, and accuracy of measurement. For example, the study of heat losses from buildings for various insulating and structural materials used in various combinations and distributions under various temperature conditions is prohibitively costly of time, labor, and materials if carried out on actual full-sized buildings, and is largely dependent on weather for temperature conditions. The use of thermal models reduces the time, labor, and material requirements very substantially; but even so, the thermal model presents certain intracacies of construction, lack of flexibility in assembly, sluggishness of temperature control and response, and difficulties of measurement largely absent in the electric-circuit model. The electric-circuit model consists merely of a collection of resistors and capacitors that can be readily connected in various combinations according to the requirements of the problem, and associated current or voltage sources, voltmeters, ammeters or oscillographs. Measurements of electrical transients can be made in a fraction of a second, and the electric circuit measurements in several minutes.

The circuit of Fig. 3 can be used to study the thermal behavior of a house in considerable detail. Through introduction of grosser approximations, the circuit can be considerably simplified, but simplification to the extent that makes analytic solution practical discards the possibility of obtaining considerable valuable information, and affords no advantage that could not be derived from an analytic attack directly in thermal terms. Therefore, the use of an electric-circuit model is desirable. The principles of behavior of the resistance-capacitance network are elementary, but the design of voltage and current sources and proper switching devices for simulating the outdoor and indoor temperature variation or heat supply, and the problems of measurement require considerable ingenuity and may well involve electronic devices. Here then is a simple example of a problem fundamentally of a nonelectrical nature advantageously attacked by the method of electric-circuit analogy and the use of laboratory models involving electronic devices.

In both of the subjects outlined, commercial apparatus is used to a considerable extent for the illustration of principles. However, the objective is not a study of commercial apparatus, which may be outmoded in a few years, but is the study of the functions which the devices may serve, and the characteristics and limitations of the devices in serving these functions. This study is carried on not only analytically, but also experimentally. In the laboratory, initiative, resourcefulness, and a feeling for experimental solution are developed in the student through encouraging him to plan his own program of experiments.

Increased use of representative commercial electronic apparatus is contemplated as a further development as soon as possible but always from the point of view that the basic principles involved constitute the kernels likely to be of lasting scientific importance.

Sensitive Relays

(*Continued from page* 127)

minimum value for G_e (the air gap when energized) recommended by the manufacturer for the conditions of the problem. The G_e line may therefore be drawn at this point. If there is a definite requirement for drop out, mark off on line G_e the point where it is crossed by the curve for desired drop out power, and draw horizontally through this point the line representing the force of the spring, which will be set to this value.

Bear in mind that what we have done in drawing G_e at a particular point is to say where we shall set the normally open contact, and hence, how close to the core we shall allow the armature to travel. Further, in deciding on the drop out value, we have said that with the armature in this particular position, the spring shall be adjusted to a value such as to equal the magnetic force at the specified drop out value, so that when the power falls below this value, the spring will restore the armature to its normal position.

Where shall the normal position G_n be? It must first be far enough away from the G_e value to permit the contact separation demanded by the particular problem. In addition, as long as the spring is not again changed, position G_n controls the value of power at which the relay pulls on. Pull on will occur at the value of power corresponding to the curve which goes through the intersection of the spring line and G_n line.

Having drawn the G_n line, there remains only to complete the cycle by drawing in the curves corresponding to pull on and drop out values, in case either or both are interpolated values.

3. Inspection of this cycle will disclose whether the requirements of the problem are met. In case they are not (suppose, for example, inadequate contact pressure exists immediately after drop out), the possible remedies will usually be obvious. *The most important thing is that the exact effect of any amount of any particular adjustment can be read off the graph as soon as tentative values for some of the others are chosen.*

In the adjustment of a sensitive relay there are five main variables which may be "independent." That is, any three of them which will locate two points on a cycle can be chosen independently and will fix the other two, subject to deviations of individual relays from the performance of the one for which the curves are plotted.

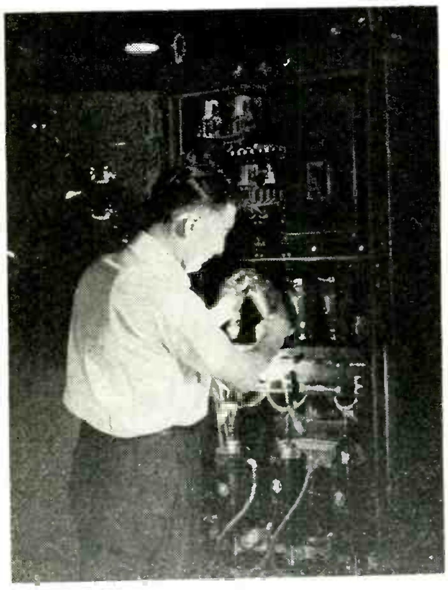
Specifying a Relay Adjustment

The five variables are: 1. Pull on; 2. Drop out; 3. Spring force; 4. Minimum pole gap (G_e); 5. Armature travel or contact gap ($G_n - G_e$ = Travel).

Having specified to appropriate tolerances the values for three variables from the list, one may ask a relay manufacturer to recommend suitable values for permissible variation of the other two. In any case, he must be consulted on this point, for in adjusting the relay he can work for only three.

• • •

ELECTRONIC STITCHING MACHINE



The operator is shown placing a tube into an electronic welding timer at the Pittsburgh plant of the Westinghouse Electric & Manufacturing Co. "Package units" such as this welder have done much to bring electronics to the attention of the industrial user. The welder has been likened to a "sewing machine" and the spot welds for making sheets of aluminum or steel adhere to one another have been likened to the stitches

D-C Motor Control

(*Continued from page* 133)

the reverse direction from that in which the motor is then rotating. The control will cause the armature circuit to be reversed, the thyratron tubes to act as inverters, and the rotational energy of the motor and its load to be pumped back into the a-c system just as on a normal reversal, except that as the motor speed passes through zero, the armature thyratrons will be turned off completely and the motor will remain at zero speed. If the motor is driving a high-inertia load and is being stopped from a high speed, the armature tubes might not be cut off exactly when the motor speed reaches zero and the shaft might make one or two rotations in the opposite direction before coming to rest. In this case, a slight modification of the control scheme will cut off the thyratrons slightly ahead of zero speed to anticipate stopping at zero speed.

Dynamic Braking to a Stop

When it is desired to stop the armature more quickly than it would naturally coast to a stop, either a mechanical brake or dynamic braking, or both, can be used. Dynamic braking consists of disconnecting the armature from the d-c supply, which is done by phasing the armature thyratrons full OFF or by opening the circuit of the reversing contactors and connecting a resistor across the armature terminals so that the generator action of the motor (its field must be excited) will dissipate its mechanical energy in the form of electrical watts of heat in the resistor and thereby decelerate the motor. It should be remembered that at first the braking action is greatest when the armature voltage and current are greatest; but it falls off quickly as the motor speed decreases and armature voltage cannot be maintained at these high levels. It is the mechanical friction which finally stops the armature.

Rapid Deceleration, High Speed to Low Speed in the Same Direction

Some applications, like those involving high-production processes where time is valuable, or profile following where quick response to a signal is important, make necessary a rapid decrease of speed, following a signal calling for operation at a lower speed level.

In many instances, it is only necessary to apply dynamic braking until the lower speed is reached, and then remove the braking effect. This can be accomplished quite simply by a triode (tube K of the "Quick slow-down circuit" of Fig. 3) which controls a small relay (CR_2 in Fig. 3) whose contacts (normally-open, in this instance) control a dynamic-braking contactor (DB) for the armature circuit. This added triode, tube K, takes a measure of the signal voltage applied to the grid of tube D which controls the saturation of the armature saturable reactor. Since tube D is turned off by a signal which calls for a lower armature voltage (as by turning the armature voltage control potentiometer to a lower-speed position or switching to a similar potentiometer preset for a lower speed) and stays off until the armature voltage has reached the new, lower level, so too, will tube K do likewise except that the added positive bias which separates the grid of tube K from the grid of tube D causes tube K to be a little more turned-on than tube D so that its relay will not be chattering during the normal operation of tube D.

A signal which calls for a slower speed will turn off tube K, drop out CR_2, drop out DB and apply dynamic braking via the contacts of DB (normally-closed, in this instance) and the dynamic-braking resistor DBR, and will have already cut off the armature thyratrons. When the speed has been decelerated to the new, low level, the armature voltage will once again cause tubes D and K to conduct current in a normal manner so as to energize relay CR_2 and discontinue dynamic braking, and at the same time turn on the thyratron tubes by the proper amount to drive the motor at the new speed level.

Application to MG Set Drives

For motors of 50- to 400-hp rating and above, it is practicable to modify this equipment so that the thyratron functions associated with variable armature excitation of a 1- or 3-hp motor can, instead, provide field excitation for the generator; the thyratron functions associated with the variable field excitation of the small

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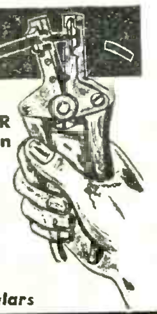

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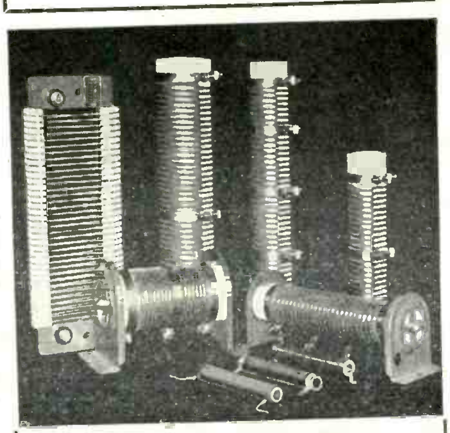

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motor can be adapted to supply field excitation of the large motor. Armature current control (loop current in this instance) becomes more complex, particularly since direct current must be measured directly and its direction ascertained so as to give correct sequence of excitation to the respective fields of generator and motor during acceleration and deceleration. The reversing problem, too, is more complicated because of the necessity of reversing generator field excitation, but all this has been done.

Control Equipment

A typical control panel and push-button station for a 1-horsepower, 230-volt motor is shown in Fig. 4, while Fig. 5 shows a rear view of the same Thy-mo-trol panel. The control unit, or "brains", is a separate sub-panel assembly (Fig. 6) which is attached to the main panel and connected to the circuit of the main panel by means of a plug-in connector. This construction facilitates manufacture, standardization, and maintenance and allows a very flexible combination of control functions to be provided to suit the immediate needs of the user.

For motors of higher horsepower ratings, polyphase power circuits are employed so as to distribute the motor load among more tubes and all three phases of the a-c system. The grid phase control becomes more of a problem during inversion but this is corrected by negative d-c grid bias voltages added to the alternating voltages from the polyphase bridge phase-shifting circuits.

Future Trends

Since thyratron tubes are already commutating armature current from one tube to another under conditions of both rectification and inversion, it is only logical to expect that future electronic drives will combine in these same thyratrons the commutating functions inherent in the d-c motor itself, so that an a-c synchronous-type, commutatorless motor, supplied from a-c through thyratron tubes, will have all the variable-speed characteristics of a d-c machine thyratron motor.

Meanwhile, developments are progressing towards the use of ignitron-type tubes to provide armature excitation for motors of higher horsepower ratings than can now be supplied from the available hot-cathode type thyratron tubes.

(See Opposite Page)

See Additional Position Vacant Ads On Opposite Page

INDEX TO ADVERTISERS

BACK TALK

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment on articles which have been published in Electronics

Critical Distance Valves

SOME INDIGNANT FRIENDS of mine have pointed out to me the date of my work on the critical distance valve which was stated incorrectly on page 86 of the March 1943 issue of ELECTRONICS. Whilst appreciating the inclusion of my valve in the list of Highlights, may I please point out that this valve was put on the market by the High Vacuum Company in England in 1935; that British patents No. 380,429 and No. 385,968 were applied for in 1931, equivalent American applications being made at the same time.

J. A. OWEN HARRIS
Rediffusion, Ltd.
London, England

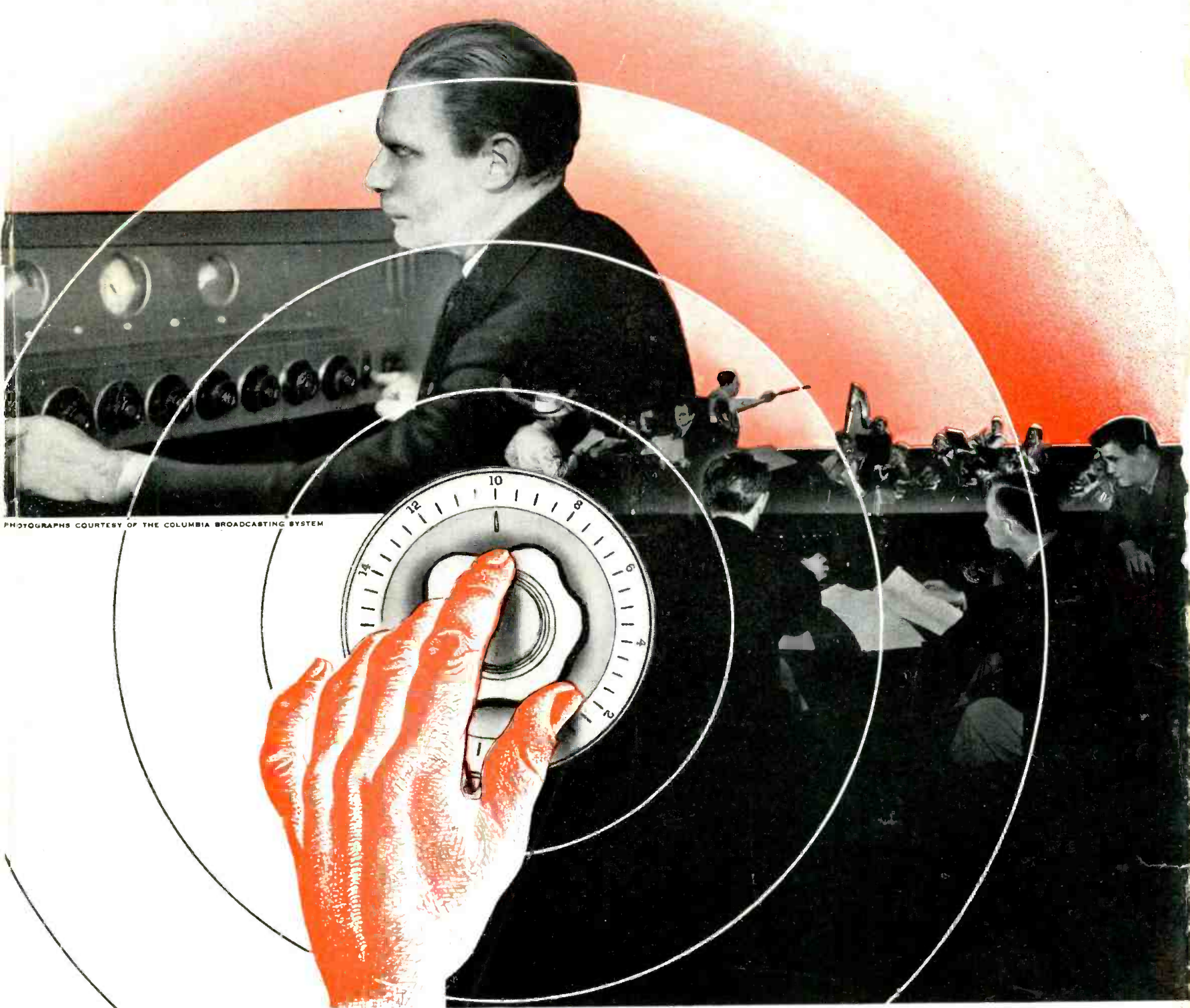
Manpower

ALLOW ME TO EXPRESS a word of appreciation for the comment at the end of Crosstalk in the August issue. Most people claim it is self evident that "you get what you pay for" and a fair number act on this basis when selecting a doctor or a corporation lawyer—or a beauty parlor. It is when a technical staff or a school faculty is being assembled that it receives scant attention. Some spiritual stimulant other than money seems to be thought to apply.

J. A. D.
Texas City, Texas.

Editor's Note. Glenn L. Martin Company, Baltimore, has recently set up an employees' patent remuneration plan under which employees are given equitable shares in any income derived from invention through the licensing of outside manufacturing rights. This sharing starts at a rate of 10 percent and continues until the inventor has received $5000 when the scale changes somewhat.

Other companies may have similar profit sharing schemes; but in general the difficulty of judging exactly who in a large company deserves credit for an invention makes the problem of just payment a very serious one indeed. Most inventions which result in patents made in large organizations are the result of cooperative efforts in which many engineers may be involved, including many who have done their work years before. The Editors will be interested in hearing of other schemes which offer the employee a share of profits from inventions made on the company's time.



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