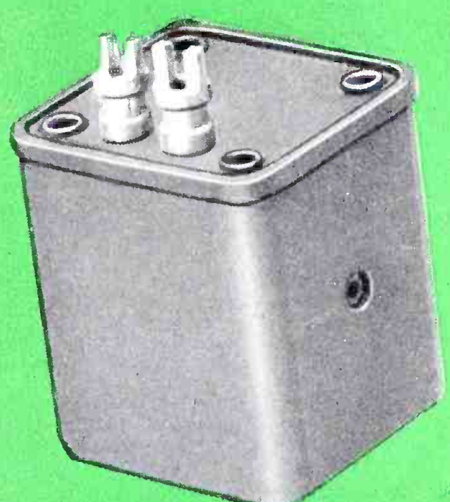
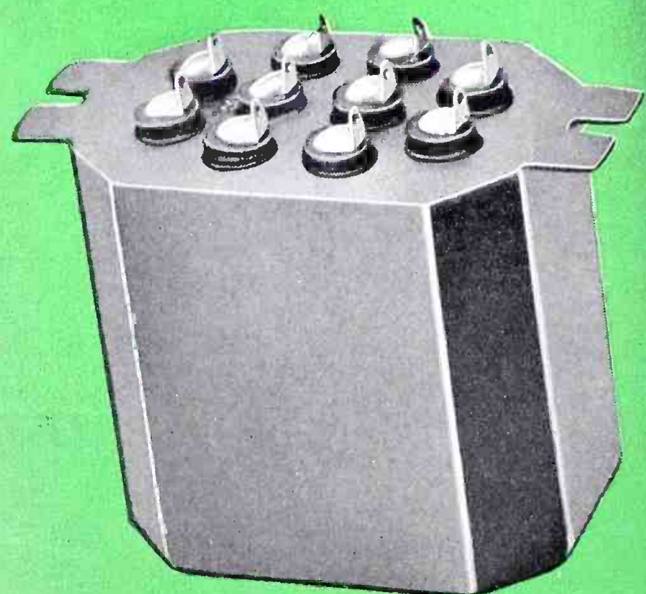
electronics

JULY • 1943

BUY WAR BONDS
AND STAMPS
FOR VICTORY





DRAWN .... DIE CAST.... FORMED..... MOLDED..... EXTRUDED...?

No one type of housing structure is suitable for all transformer applications. UTC units are housed in structures ranging from heavy sand castings to bakelite cases made in 30 cavity molds. A few structures, with their relative advantages for specific functions, are illustrated below.

This unit is a tunable inductor in a die cast housing. The casting itself incorporates facilities for the internal mounting of the unit, mounting of the terminal board, tapped mounting facilities, and tapped set screw hole. The only screw used in this entire item is that for setting the inductance.

Drawn round cans are ideal for many applications. The type illustrated effects small base dimensions with screw mounting. The cylindrical shape lends itself ideally to hermetic sealed units.

Drawn octagonal cans are simple in construction, and effect a minimum of volume. The two hole flange type mounting permits the construction of a unit poured with compound, having the same overall and mounting dimensions as an equivalent open channel mounting unit. Four hole mounting octagonal cases are used where additional mounting strength is required.

The extruded can used on the now famous UTC Ouncer unit affords submersion test construction a minimum of weight, and sufficient metal thickness in the base opposite the terminal board for tapped mounting holes. Pioneered by UTC, the Ouncer unit is probably the most popular item in aircraft communication equipment.

May we design a unit to your war application?

UNITED TRANSFORMER CO.

150 VARICK STREET ★ NEW YORK, N. Y.

EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"

electronics

JULY • 1943

McGRAW-HILL PUBLISHING COMPANY, INCORPORATED
JAMES H. McGRAW, Founder and Honorary Chairman
Publication Office 99-129 North Broadway, Albany, 1, N. Y., U. S. A.

EDITORIAL AND EXECUTIVE OFFICES 330 West 42nd St., New York, 18, N. Y., U. S. A. James H. McGraw, Jr., President; Howard Ehrlich, Executive Vice President; Mason Britton, Vice President; B. R. Putnam, Treasurer; Joseph A. Gerardi, Secretary. Cable address: MCGRAWHILL, New York. Member A. B. P. Member A. B. C.

ELECTRONICS, July, 1943. Vol. 16; No. 7. Published monthly, price 50c a copy. Allow at least ten days for change of address. All communications about subscriptions should be addressed to the Director of Circulation, 330 W. 42nd St., New York, 18, N. Y.

Subscription rates—United States and possessions, Mexico, Central and South American countries, $5.00 a year, $8.00 for two years, $10.00 for three years. Canada (Canadian funds accepted) $5.50 a year, $9.00 for two years, $11.00 for three years. Great Britain and British possessions 36 shillings for one year, 72 shillings for three years. All other countries, $6.00 for one year, $12.00 for three years. Entered as Second Class matter, August 29, 1936, at Post Office, Albany, New York, under the Act of March 3, 1879. BRANCH OFFICES: 520 North Michigan Avenue, Chicago, 11; 68 Post Street, San Francisco, 4; Aldwych House, Aldwych, London, W. C. 2; Washington, D. C., 4; Philadelphia, 2; Cleveland, 15; Detroit, 2; St. Louis, 1; Boston, 16; Atlanta, 3, Ga.; 601 West Fifth Street, Los Angeles, 13.

A McGRAW-HILL PUBLICATION

DEPARTMENTS

CHANGE OF ADDRESS

McGRAW-HILL PUBLISHING COMPANY
330 West 42nd Street, New York, 18, N. Y.

Director of Circulation:
Please change my address on Electronics

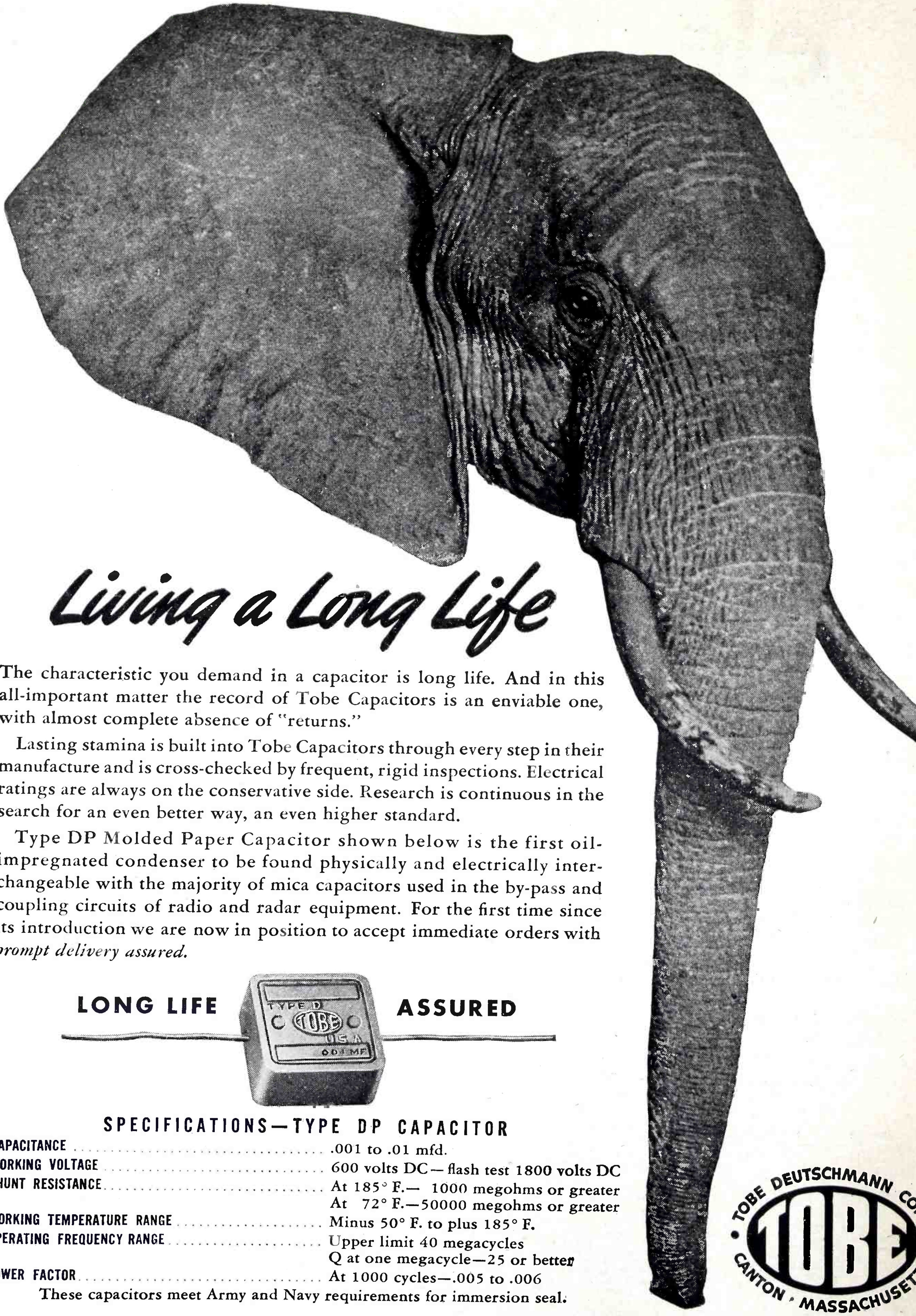
From ....

To ....

Signed ....

....

....



Living a Long Life

The characteristic you demand in a capacitor is long life. And in this all-important matter the record of Tobe Capacitors is an enviable one, with almost complete absence of "returns."

Lasting stamina is built into Tobe Capacitors through every step in their manufacture and is cross-checked by frequent, rigid inspections. Electrical ratings are always on the conservative side. Research is continuous in the search for an even better way, an even higher standard.

Type DP Molded Paper Capacitor shown below is the first oil-impregnated condenser to be found physically and electrically interchangeable with the majority of mica capacitors used in the by-pass and coupling circuits of radio and radar equipment. For the first time since its introduction we are now in position to accept immediate orders with *prompt delivery assured.*

LONG LIFE **ASSURED**

SPECIFICATIONS—TYPE DP CAPACITOR

CAPACITANCE	.001 to .01 mfd.
WORKING VOLTAGE	600 volts DC—flash test 1800 volts DC
SHUNT RESISTANCE	At 185° F.— 1000 megohms or greater At 72° F.—50000 megohms or greater
WORKING TEMPERATURE RANGE	Minus 50° F. to plus 185° F.
OPERATING FREQUENCY RANGE	Upper limit 40 megacycles Q at one megacycle—25 or better
POWER FACTOR	At 1000 cycles—.005 to .006

These capacitors meet Army and Navy requirements for immersion seal.

TOBE DEUTSCHMANN CORP.
TOBE
CANTON, MASSACHUSETTS

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

K+E
TRADE MARK

HANDS OFF!

Our valuable original drawings are carefully *preserved* —filed away for record purposes

Our duplicates are made from PHOTACT *prints. They do the heavy work — take the wear*

Every smudged drawing means time lost on the production line.

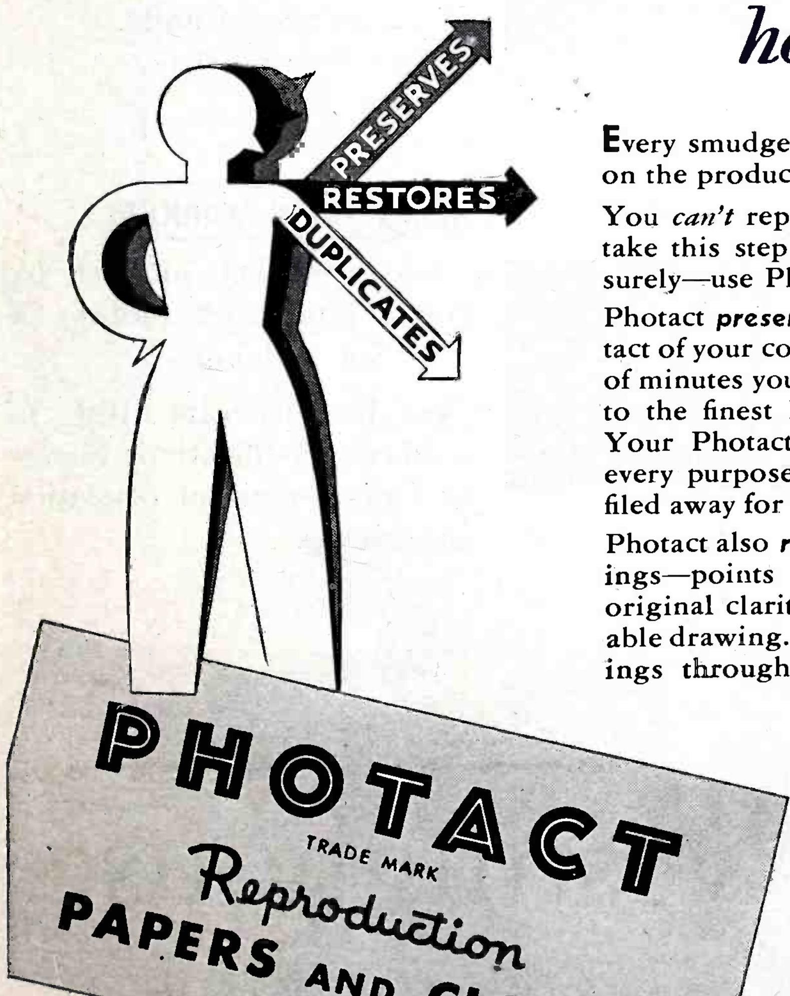
You *can't* replace that loss. But you can take this step to prevent it, quickly and surely—use Photact, because . . .

Photact ***preserves*** originals. Make a Photact of your costly original and in a matter of minutes you have a reproduction down to the finest line—sharp, clear, opaque. Your Photact is now the "master" for every purpose, and your original can be filed away for safekeeping.

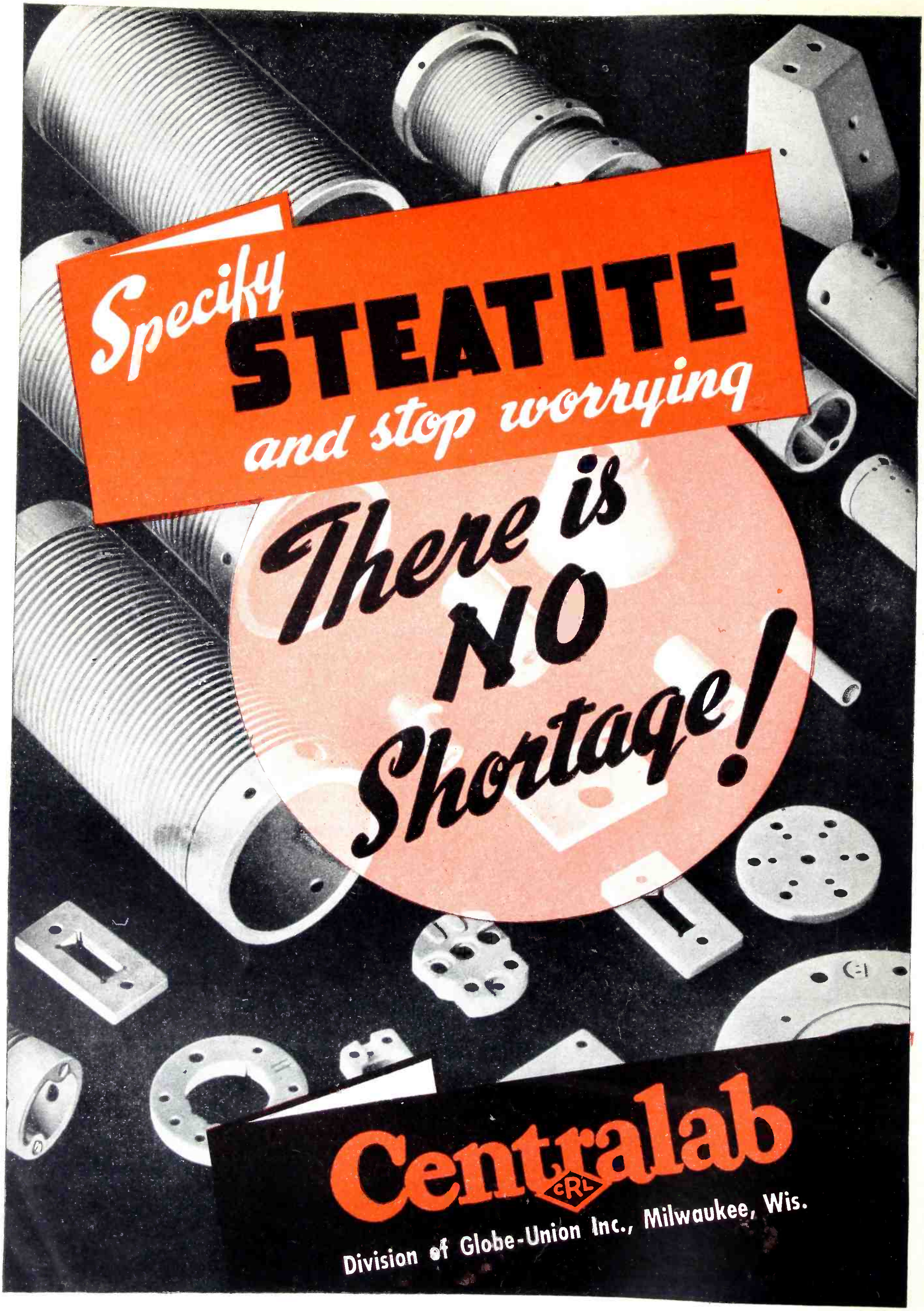
Photact also ***restores*** old, worn-out drawings—points up blurred lines to their original clarity—gives you a fresh workable drawing. Put the old "veteran" drawings through the Photact process and come out with a new "master."

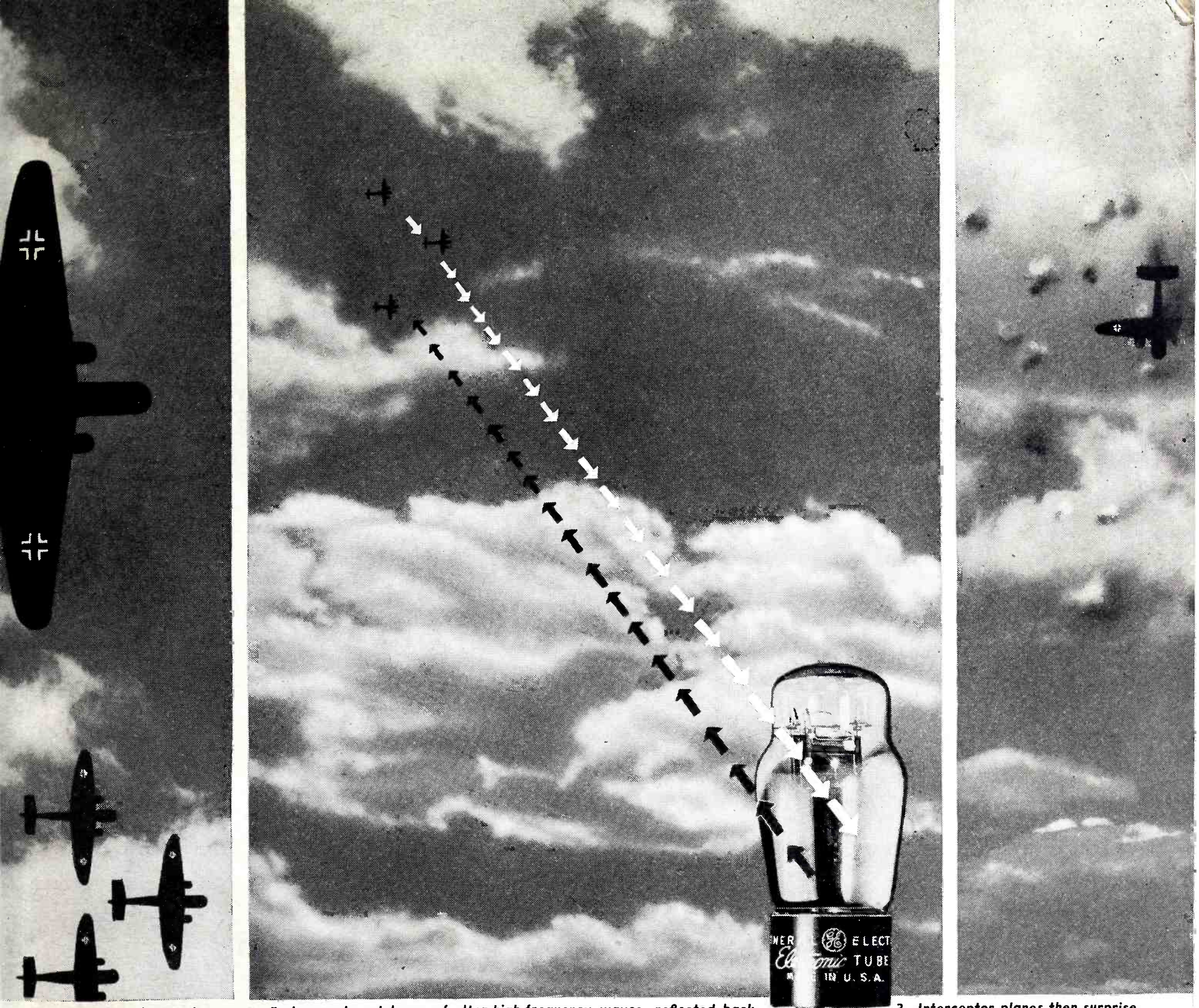
Photact ***duplicates*** originals. From your negative you can make as many prints as may be needed on either Photact paper or cloth. And Photact duplicates, even when made from pencil drawings, will be sharper and clearer with ink-like lines. There are no "absentee" lines in a Photact duplicate. That's why sub-contractors and branch managers welcome Photact prints. They can make an unlimited number of sharp black-line or blueprints from Photact "masters."

For complete information about Photact papers and cloths and the Photact process, write: KEUFFEL & ESSER CO., Photact Department, Hoboken, N. J.



EST. 1867
KEUFFEL & ESSER CO.
NEW YORK • HOBOKEN, N. J.
CHICAGO • ST. LOUIS • SAN FRANCISCO • LOS ANGELES
DETROIT · MONTREAL


Specify STEATITE
and stop worrying
There is NO Shortage!
Centralab
CRL
Division of Globe-Union Inc., Milwaukee, Wis.



1. *Enemy planes rise from distant airfields.*

2. *Radar sends out beam of ultra-high-frequency waves, reflected back to instruments which determine planes' location, speed, and direction.*

3. *Interceptor planes then surprise and destroy the advancing enemy.*

The facts about RADAR

"The whole history of Radar has been an example of successful collaboration between Allies on an international scale."

THE NEW YORK TIMES, MAY 16

THIS amazing electronic invention that locates distant planes and ships despite darkness and fog is a great co-operative achievement of Science and Industry.

In this country and in the British Isles, over 2000 scientists and engineers, some working alone, some in the Army and the Navy, many in research laboratories of colleges and industrial firms, joined eagerly in the search for Radar knowledge.

Team-work that succeeded. Once this electronic device had been perfected, industry after industry rallied to the nation's call to manufacture Radar. General Electric is proud to have played a large part, with other manufacturers, in supplying to the Army and Navy this key weapon whose peacetime applications hold so high a promise.

As early as the Twenties, G-E engineers and scientists were developing the kind of high-frequency tubes, circuits and apparatus that make Radar possible. Thus long before Pearl Harbor, G.E. was able to build Radar equipment.

Post-war applications will be many. Radar will guard and guide the flight of great commercial transports. Planes will land blind. Transoceanic liners will slip safely into fog-bound harbors — all with Radar detection equipment.

In addition to Radar, General Electric is supplying to the Army, Navy, and Marines radio transmitters, antennae and receivers, carrier-current equipment, all kinds of electronic measurement equipment, and monitors. *Electronics Department, General Electric, Schenectady, N.Y.*

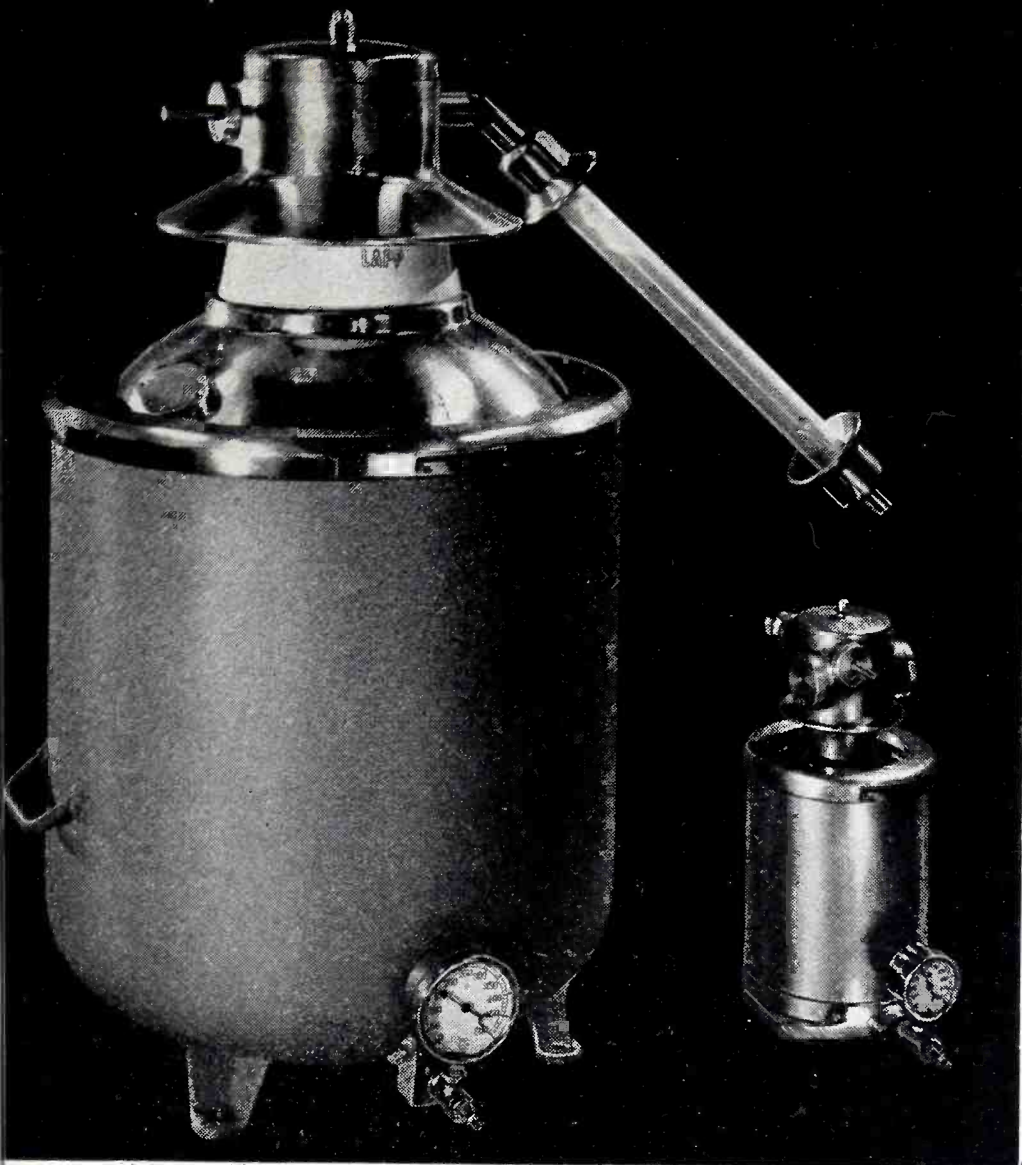
Tune in General Electric's WORLD TODAY and hear the news from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over C.B.S. . . . On Sunday evening listen to the G-E Mazda Lamp program over N.B.C. network.

GENERAL ELECTRIC

160-B5

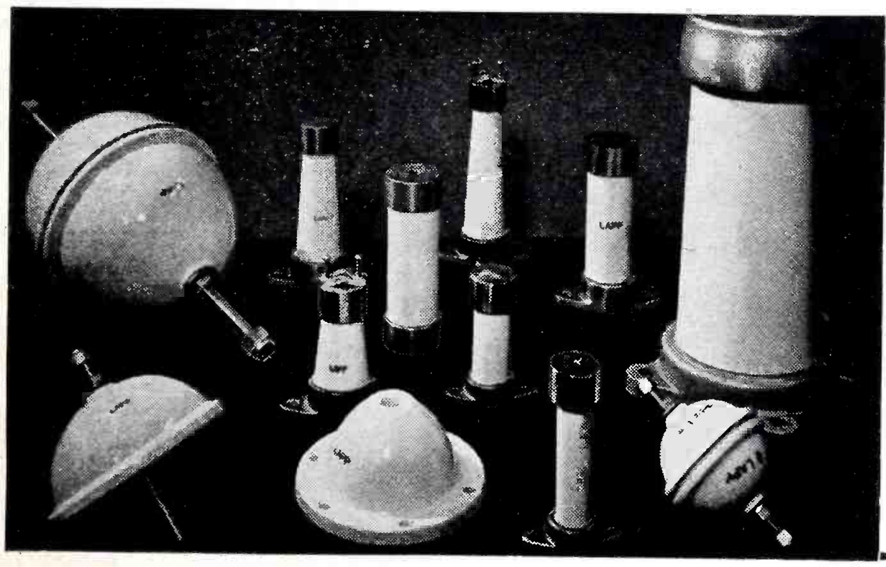
G-E employees are now purchasing over $1,000,000 in War Bonds weekly

FOR HIGH-FREQUENCY POWER SOURCES



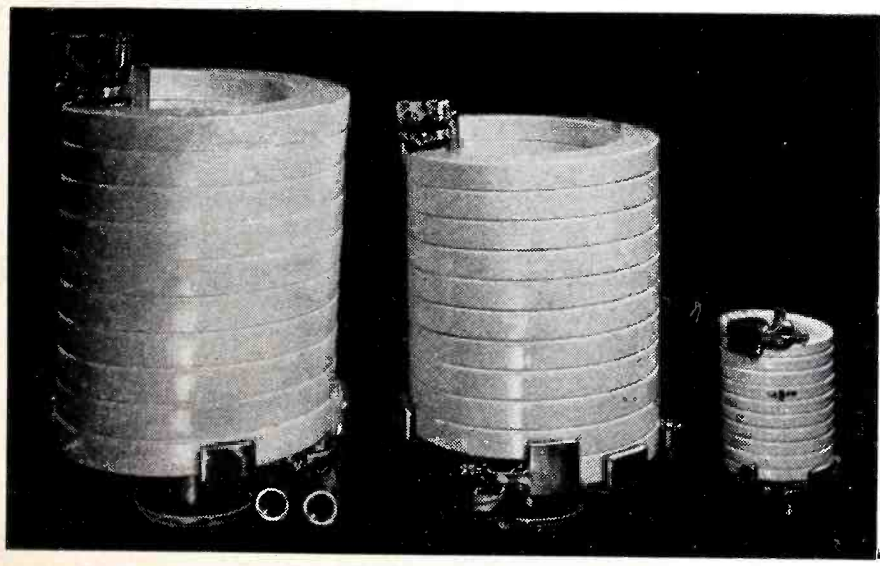
LAPP GAS-FILLED CONDENSERS

In any electronic circuit, wherever lump capacitance is needed, Lapp condensers will save space, save power and save trouble. Available for duty at almost any conceivably-useable voltage rating and capacitance, they bring to any application notable mechanical and electrical advantages: practically zero loss, smallest space requirement, non-failing, puncture-proof design, constant capacitance under temperature variations. *Shown, at left, Unit No. 25934, rated at 200 amp., 6500 volts, capacitance variable 4300 mmf. to 11000 mmf.; right, Unit No. 23722, rated at 50 amp., 7500 volts, capacitance 45 mmf. to 75 mmf.*



STANDOFF, BOWL, ENTRANCE INSULATORS

Standoff, bowl, entrance and other special-purpose insulators are available in wide range as standard Lapp catalog items. Other insulators of special design are easily produced by Lapp methods, either in porcelain or steatite. The wide choice of such insulators available from Lapp simplifies the design of high-frequency equipment. Also, Lapp is equipped for production of many special assemblies, of porcelain or steatite, and the associated metal parts.



LAPP PORCELAIN WATER COILS

For cooling of high-frequency tubes in radio transmitters and other electronic power sources, Lapp porcelain water coils have been widely used. With nothing about the porcelain to deteriorate, sludging is eliminated, and with it the need for cleaning and water changes. Porcelain pipe and fittings in any needed size are also available as catalog items. We welcome inquiry on any Lapp equipment for experimental or industrial electronic application.

Lapp INSULATOR CO., INC.
LEROY, N. Y.

MAGNAVOX SAVED YOUR GOVERNMENT EIGHT MILLION DOLLARS

EXCERPTS from Ford Motor Company's broadcast, "Watch the World Go By," April 5, 1943, in which Earl Godwin paid respects to American free enterprise.

"Take the folks at the Magnavox Company of Fort Wayne, Indiana . . . that before the war made superbly-toned radio-phonograph combinations. Today they're building Solenoid firing controls for aircraft-mounted machine guns for Ford-built Liberator bombers and Army and Navy planes . . . Within fifteen days of the time Uncle Sam asked Magnavox for these controls, working models were completed and firing tests furnished. Thirty more days and the controls were being turned out . . . Increased firing pressure 180%, decreased weight 18% and reduced battery drain 50%, and the mass production techniques developed by Magnavox have saved the government approximately eight million dollars in manufacturing costs."

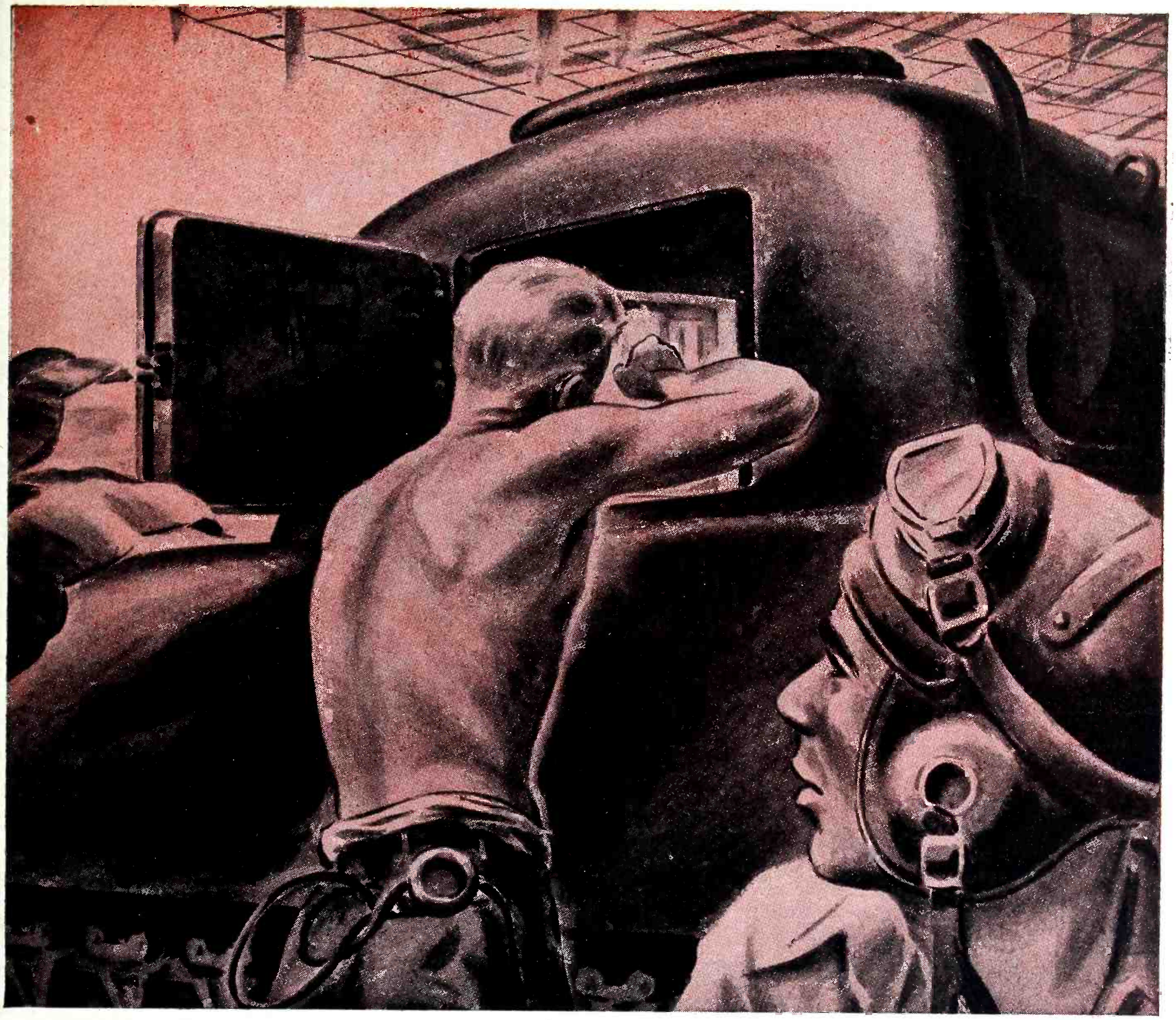
We are making equipment for Army, Navy, Coast Guard, Marine Corps and Maritime Commission, in our new six acre factory, on prime and sub-contracts. Facilities for additional contracts become available from time to time. Write, wire or phone The Magnavox Company, Fort Wayne, Indiana.

The skill and craftsmanship which won for Magnavox the first Navy "E" award (and two White Star Renewal Citations) among radio receiver manufacturers, have served the radio industry capably for a span of thirty-two years.

Magnavox

THE GREAT VOICE OF RADIO

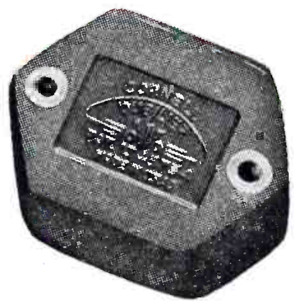
COMMUNICATION AND ELECTRONIC EQUIPMENT



"Hmm! Nothing wrong with the Capacitors anyhow"

In steaming swamps, icebound wastelands and arid desert—the fighting fronts of global war—Cornell-Dubilier capacitors are revealing the stout-hearted stamina that's in them. Today, as in peacetime, there are more C-D capacitors in use than any other make.

You can give your product this same measure of dependability by using C-Ds whenever the design calls for capacitors. Engineered by specialists and backed by 33 years of manufacturing experience, the C-D capacitor—as a *fighting tool* of World War II—is more reliable than ever. Cornell Dubilier Electric Corporation, South Plainfield, New Jersey.



MICA CAPACITORS
for low power transmitter applications
The Type 9 Moulded Mica Capacitor series is designed for r.f. bypass, grid and plate blocking purposes in low power transmitters and amplifiers.

CHECK THESE FEATURES:

Moulded in Bakelite—strong mechanically, well insulated, moisture resistant.

Short, heavy terminals—minimum r.f. and contact resistance.

No magnetic materials used—reduces losses at all frequencies.

Special impregnation—assures stable capacity characteristics and high insulation resistance.

The Type 9 capacitors, as well as others in the complete C-D line, are described in Catalog No. 160T free on request.

Cornell Dubilier capacitors

MICA • DYKANOL • PAPE
WET & DRY ELECTROLYTI

MORE IN USE TODAY THAN ANY OTHER MA


THE *Ability* TO GO TO WAR!
In 1929, fourteen years ago, the first JENSEN Auditorium speaker was introduced. The first of its kind, it has during all the succeeding years faithfully served the public and professional need for a heavy duty, high quality loud speaker. We think it is undeniably the world's best known and respected loud speaker product. Now, this fourteen year old JENSEN product goes to war. Naturally it incorporates the refinements and improvements which have been steadily added, but the basic design and function remains the same.
Many other JENSEN products are thus endowed with the ability to go straight to war.
Jensen
Auditorium
Speaker
Jensen
Jensen
RADIO MFG. CO.
6601 SOUTH LARAMIE AVENUE
CHICAGO, U. S. A.

KEEP POSTED WITH THIS NEW PAGE OF INFORMATION ON

SYNTHANE Molded-Laminated and Molded-Macerated Products

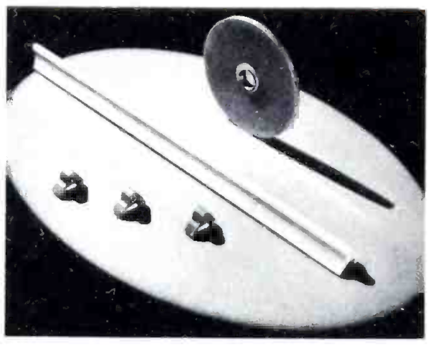
Many of you are already familiar with the manufacture, uses and properties of SYNTHANE Bakelite-laminated. You perhaps know that it is made from paper or fabric impregnated with a plastic resin and transformed under heat and pressure into a hard, dense material of many combined properties.

Laminated materials are produced in the form of sheets, rods and tubes, usually requiring some machining to finished form.

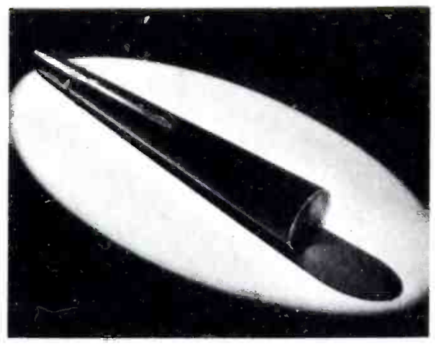
There are two associated forms of SYNTHANE which reduce or eliminate the necessity for machining—known as molded-laminated and molded-macerated SYNTHANE.

Molded-Laminated

Frequently it is economical to produce finished products by a combination of molding and laminating techniques. Laminations of the impregnated paper or fabric are cut to the rough outline of the desired piece and molded under heat and pressure to finished form. The result is a product with approximately the strength of SYNTHANE Bakelite-laminated without machining time or expense. Obviously, the quantity of pieces required must be sufficient to justify the costs of molding, including the cost of the mold itself, as compared with the costs of regular laminated material and machining. Obviously, too, there are certain limitations to the application of the molded-laminated process. If shapes are intricate, it may not be practical to cut the laminations to fit the mold. Molded-macerated construction may then be the answer.



Combination molded-laminated-macerated wheel. Molded-laminated distributor arms.



Molded-laminated horn for carbon dioxide fire extinguishers.

Molded-Macerated

The molded-macerated procedure is similar to molded-laminated except that the impregnated paper or fabric is chopped into small flakes or chips before the mold is charged. The flakes, being comparatively small, allow considerably more latitude in the shape and complexity of the mold than is possible with the molded-laminated process.

Naturally, impregnated flakes do not have the flow characteristics of molding powder. Therefore, it is wise to avoid undercuts or pins which are perpendicular to the direction of the molding pressure (generally vertical). Side holes and undercuts may be more satisfactorily machined.

Properties

Both the processes described bear some resemblance to powder molding except that molded-laminated or molded-macerated articles have far greater mechanical strength than powder moldings. Molded-laminated material approaches laminated material in strength; molded-macerated has about 50 to 75% of the mechanical strength of corresponding laminated grades. The mechanical, electrical, physical and chemical properties can be varied over a wide range or adjusted one against the other to meet specific needs just as is the case with laminated materials.

Combination Molded-Laminated-Macerated

It is possible to combine the benefits of molded-laminated and molded-macerated into one molding where maximum strength in one section and maximum resin flow in another are necessary.

Methods Used for Testing Synthane

(1) Tests were made on ⅛" thickness, at room temperature, approximately 25 deg. C., following the American Society for Testing Materials Method D-229-42.

(2) Tests were made on tension test specimen, at room temperature, approximately 25 deg. C., following the American Society for Testing Materials Method D-48-42T.

(3) Tests were made under oil on 1/16" thickness, according to American Society for Testing Materials Method D-149-40T.

(4) Tests were made under oil on disc 4" diameter and ⅛" thick, according to American Society for Testing Materials Method D-48-42T.

(5) Tests were made on pieces 3" x 1" x ⅛" thick according to the American Society for Testing Materials Method D-229-42 after immersion in water for 24 hours at approximately 25 deg. C. plus or minus 2 deg. C.

(6) Tests were made on molded discs 2" diam. x ⅛" thick according to the American Society for Testing Materials Method D-48-42T.

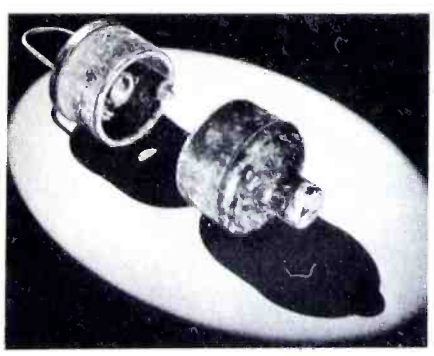
(7) Tests were made on notched specimens 2½" x ½" x ½" thick according to the American Society for Testing Materials Method D-256-41T.

(8) Tests were made on specimens used for water absorption tests according to the American Society for Testing Materials Method D-634-41T.

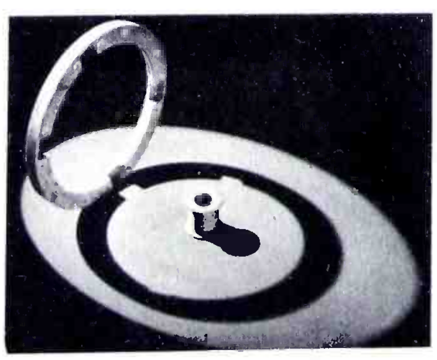
(9) Tests were made on specimens 1" x 1" x ½" thick according to the American Society for Testing Materials D-229-42.

Comparison of Synthane Molded-Laminated and Molded-Macerated with Synthane Standard Grade C Laminated

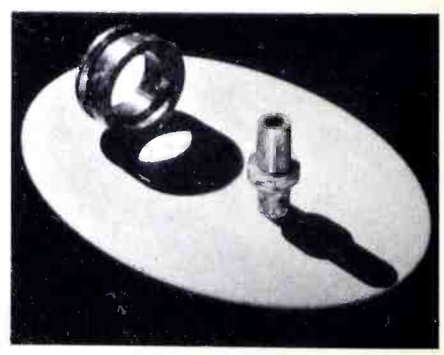
	GRADE C LAMINATED	GRADE C MOLDED-LAMINATED	GRADE C MOLDED-MACERATED
TENSILE STRENGTH Lbs./Sq. In.	(1) 9,500	(1) 8,200	(2) 7,800
FLEXURAL (TRANSVERSE) STRENGTH Lbs./Sq. In.	(1) 20,000	(1) 17,000	(2) 12,000
COMPRESSIVE STRENGTH Lbs./Sq. In.	(1) 38,000	(1) 32,000	(2) 27,000
DIELECTRIC STRENGTH Volts per Mil (.001") Short-Time Test / Step-by-Step Test	(3) 200 / 120	(3) 180 / 110	(4) 180 / 110
% MOISTURE ABSORPTION	(5) 1.7	(5) 1.9	(6) 1.0
IZOD IMPACT STRENGTH (Flatwise) Ft.-Lbs./In. of notch / (Edgewise)	(7) 3.2 / 2.0	(7) 2.7 / 1.7	(7) 2.2 / 1.7
SPECIFIC GRAVITY	(8) 1.36	(8) 1.36	(8) 1.36
ROCKWELL HARDNESS	(1) M110	(1) M110	(1) M110
BONDING STRENGTH—Lbs.	(9) 2400	(9) 2000	(9) 2000



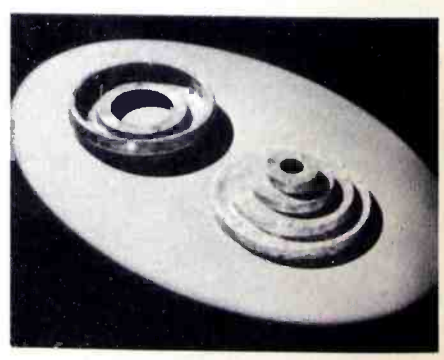
Molded-macerated cap and base for explosives container.



Molded-macerated gasket and spool.



Molded-macerated collar and spool.



Molded-macerated handwheel and form for V-belt pulley.

PLAN YOUR PRESENT AND FUTURE PRODUCTS WITH SYNTHANE TECHNICAL PLASTICS

SYNTHANE

Bakelite — laminated

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

SYNTHANE CORPORATION, OAKS, PENNA.

REPRESENTATIVES IN ALL PRINCIPAL CITIES

The revelations concerning RADAR and its part in the war came as no surprise to those whose job is to supply our fighting forces with modern electronic equipment. Since before Pearl Harbor these Americans have been working shoulder to shoulder with our armed forces in applying the power of electronics to the art of war. Out of this united effort have come fighting weapons never before known—on land, at sea or in the air. In this pioneering work it has been National Union's privilege to play a progressively increasing part. A greater National Union has been built to cope with vastly larger responsibilities. Today, National Union is ready to consult with and assist other manufacturers in the use of electronic tubes. Tomorrow, when peace comes—when the industrial usage of electronics gets the green light—engineers and production men will find at National Union unexcelled service and cooperation in perfecting new electronic applications for the production, testing and packaging of their products.

NATIONAL UNION RADIO CORPORATION • NEWARK, N. J. • LANSDALE, PA.

NATIONAL UNION

RADIO AND ELECTRONIC TUBES

Transmitting Tubes • Cathode Ray Tubes • Receiving Tubes • Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Exciter Lamps • Panel Lamps • Flashlight Bulbs

Out of the test tubes RESEARCH EXPERIENCE AND SERVICE . . .

. . . was developed the Mitchell-Rand line of electrical insulations

VARNISHES

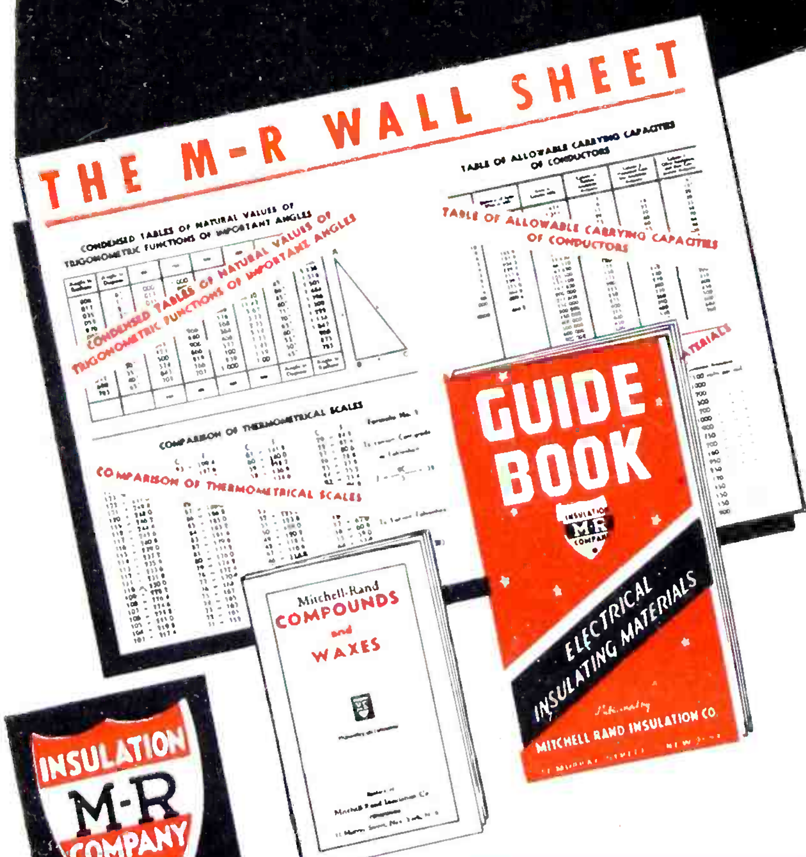
MICA, PAPER and TWINES

MORE THAN 3500 WAX and COMPOUND FORMULAS

5 GRADES OF VARNISHED TUBING and SLEEVING

TAPES, WEBBINGS and CLOTHS

MITCHELL-RAND *for* 54 YEARS THE ELECTRICAL INSULATION HEADQUARTERS



54 years of specialized service to the Electrical and Electronic Industries brought us countless electrical insulation problems.

The experience and research necessary to solve the progressively difficult electrical insulation problems was of inestimable value in the development of the complete line of Mitchell-Rand Electrical Insulations.

Today as yesterday our experience and research is at your service . . . send us your electrical insulation problems . . . or your requirements for any of our extensive and proven line of electrical insulations.

FREE FOR THE ASKING!

Write today for your Free Card of Varnished Tubing with samples ranging from size 0 to 20 to fit wires from .032 to .325 inches . . . other valuable aids, are the M-R Guide Book of Electrical Insulation . . . the Wall Chart with reference tables, electrical symbols, allowable capacities of conductors, dielectric averages, thicknesses of insulating materials and tap drill sizes . . . and the M-R Wax and Compound Guide Book . . . they are full of valuable information . . .

WRITE TODAY ON YOUR COMPANY LETTERHEAD!

INSULATION M-R COMPANY EST. 1889

MITCHELL-RAND INSULATION COMPANY, INC.

51-A MURRAY STREET   COrtlandt 7-9264   NEW YORK, N. Y.

A PARTIAL LIST OF M-R PRODUCTS

Fiberglas Varnished Tape and Cloth
Insulating Papers and Twines
Cable Filling and Pothead Compounds
Friction Tape and Splice
Transformer Compounds

Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevings
Impregnated Varnish Tubing
Insulating Varnishes of all types

Fiberglas Saturated Sleeving and Varnished Tubing
Asbestos Sleeving and Tape
Extruded Plastic Tubing
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth and Tubing

In that *Better World* which you are Electroneering, substitute materials of lesser performance have no place.

It is a well known fact that the properties of steatite for high frequency insulation are not duplicated.

AlSiMag lifts the properties of steatite to highest levels of dielectric and mechanical strength. AlSiMag Steatite Ceramic insulators are custom made to your design.

Do your Electroneering . . . your planning, thinking and designing with AlSiMag steatite in mind. Our research people will gladly cooperate in today's blueprint or tomorrow's production.

ARMY E NAVY
AWARDED JULY 27, 1942

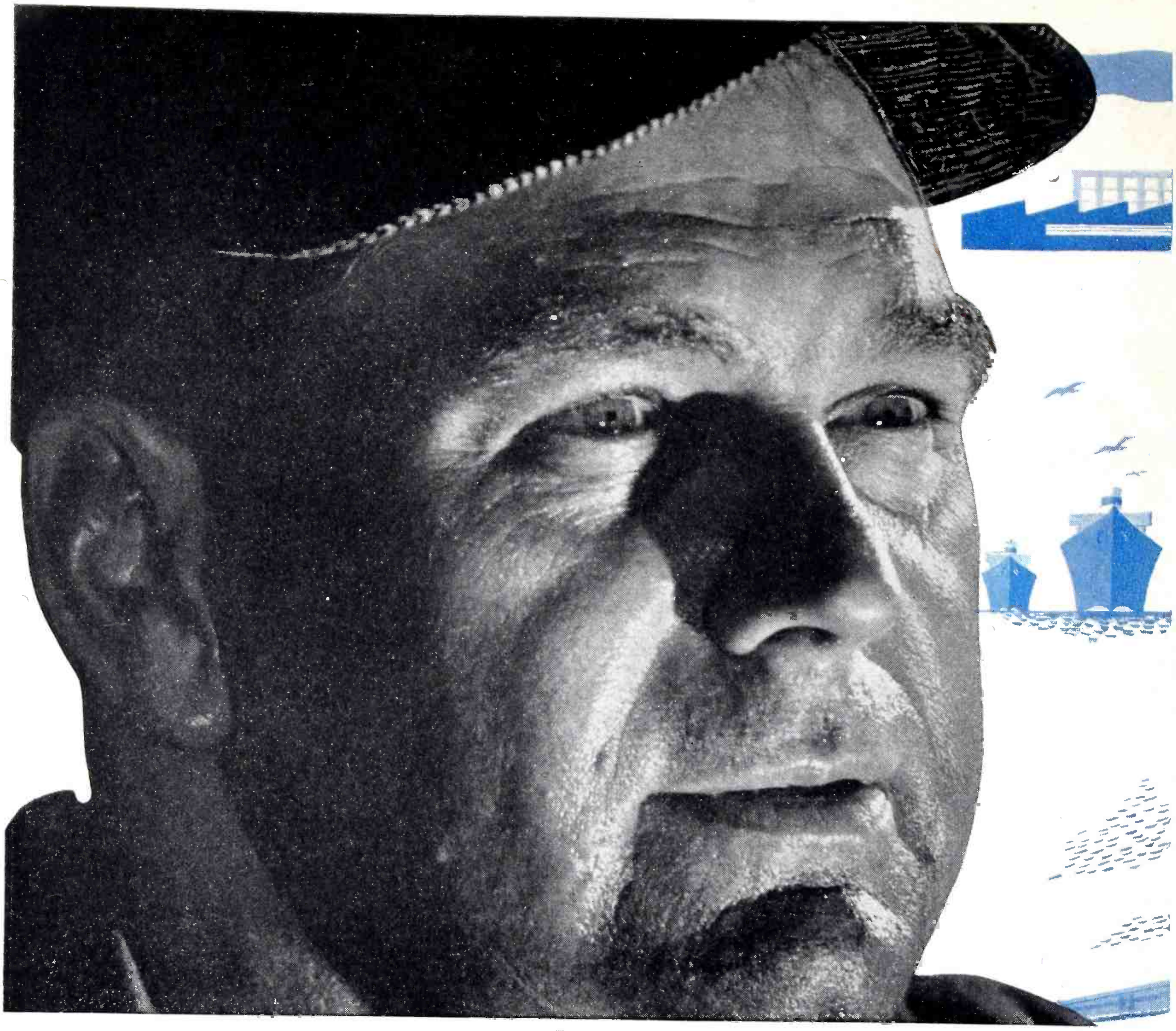
41st YEAR OF CERAMIC LEADERSHIP

ALSIMAG

TRADE MARK REGISTERED U. S. PATENT OFFICE

AMERICAN LAVA CORPORATION
CHATTANOOGA, TENNESSEE


ARHCO Varieties of 1943
2008
Wartime Essentials
We do stamping, screw machine work, moulding, and general Radio and Radar communications assemblies. Illustrated are but a mere handful of the 2008 wartime essentials which we are now manufacturing. Your inquiries will receive prompt attention.
Now, more than ever, it is important that you keep on buying War Bonds and Stamps.
ARHCO RADIO PRODUCTS
American Radio Hardware CO., INC.
476 BROADWAY, NEW YORK, N. Y.
MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT
CMA-49021A
CRN-107
PL-55
JK-33
PL-68
SW-141
PL-112
PL-118
PL-122
J-38
ANT.
1st RF
2nd RF
OSC.
LINE
TEL



Everyday, electronics and manpower become closer allies.

Today, Westinghouse Electronic Tubes are hard at work on hundreds of industrial and military fronts, adding their own power to manpower. By helping to perform many tasks better, they are speeding up production, improving quality and extending man's control into the realms of the impossible.

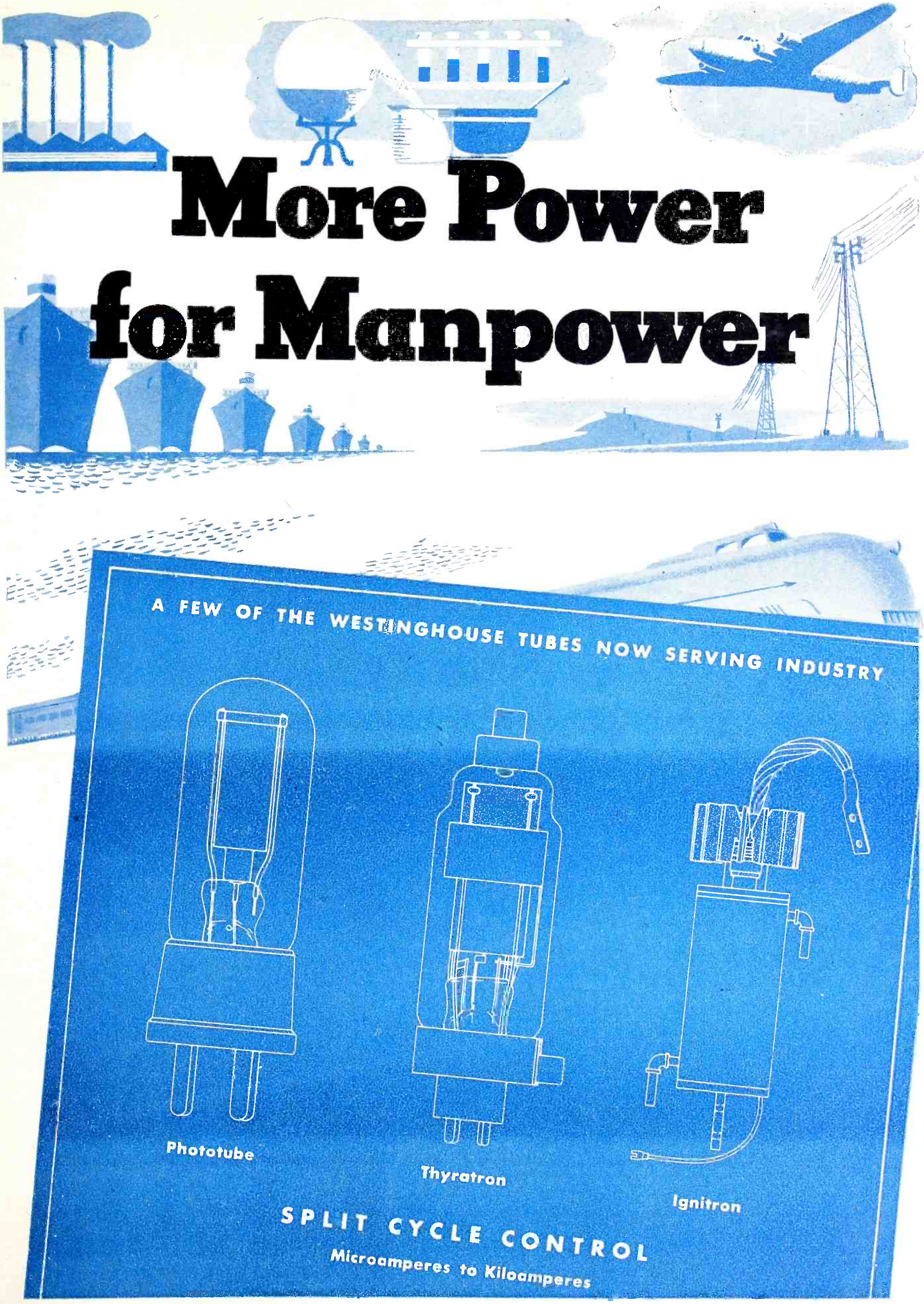
For example, you will find Westinghouse tubes saving time and work on jobs such as these: vibration detectors for rotors, heat treating, welding and dust precipitation. You'll also find them as part and parcel of amazing developments which enable men to "see" in darkness, land planes at "ceiling zero," keep ships off rocks in fog-bound harbors and detect planes at great distances.

All of these are today's developments, jobs in which Westinghouse tubes are building a reputation for perfection of design and construction.

In your thinking and planning for today and tomorrow, include the use of electronic tubes. Westinghouse . . . pioneers in electronic "know how" are at your service. Westinghouse Electric and Manufacturing Company, Bloomfield, N. J.

Westinghouse

Electronic Tubes *AT WORK*


More Power
for Manpower
A FEW OF THE WESTINGHOUSE TUBES NOW SERVING INDUSTRY
Phototube
Thyratron
Ignitron
SPLIT CYCLE CONTROL
Microamperes to Kiloamperes

Facts about STEATITE LOW LOSS INSULATORS

NO SHORTAGE EXISTS

in STEATITE parts so necessary in Radio and Radar Equipment for the war effort—the demand is being met.

AMPLE FACILITIES

—are available for producing precision made extruded, pressed and machined STEATITE parts —NO SHORTAGE exists of production facilities.

EXPERIENCED ENGINEERING STAFF

—with years of training in research and the development of methods and processes—so necessary to produce precision made STEATITE parts of rigid and exacting specifications.

SUBSTITUTES

—for STEATITE are no longer necessary—STEATITE parts *are available* for prompt delivery in all sizes, shapes and quantities.

For the duration 100 per cent of our attention—all personnel and equipment—is being used to hasten Victory.

BUY WAR BONDS

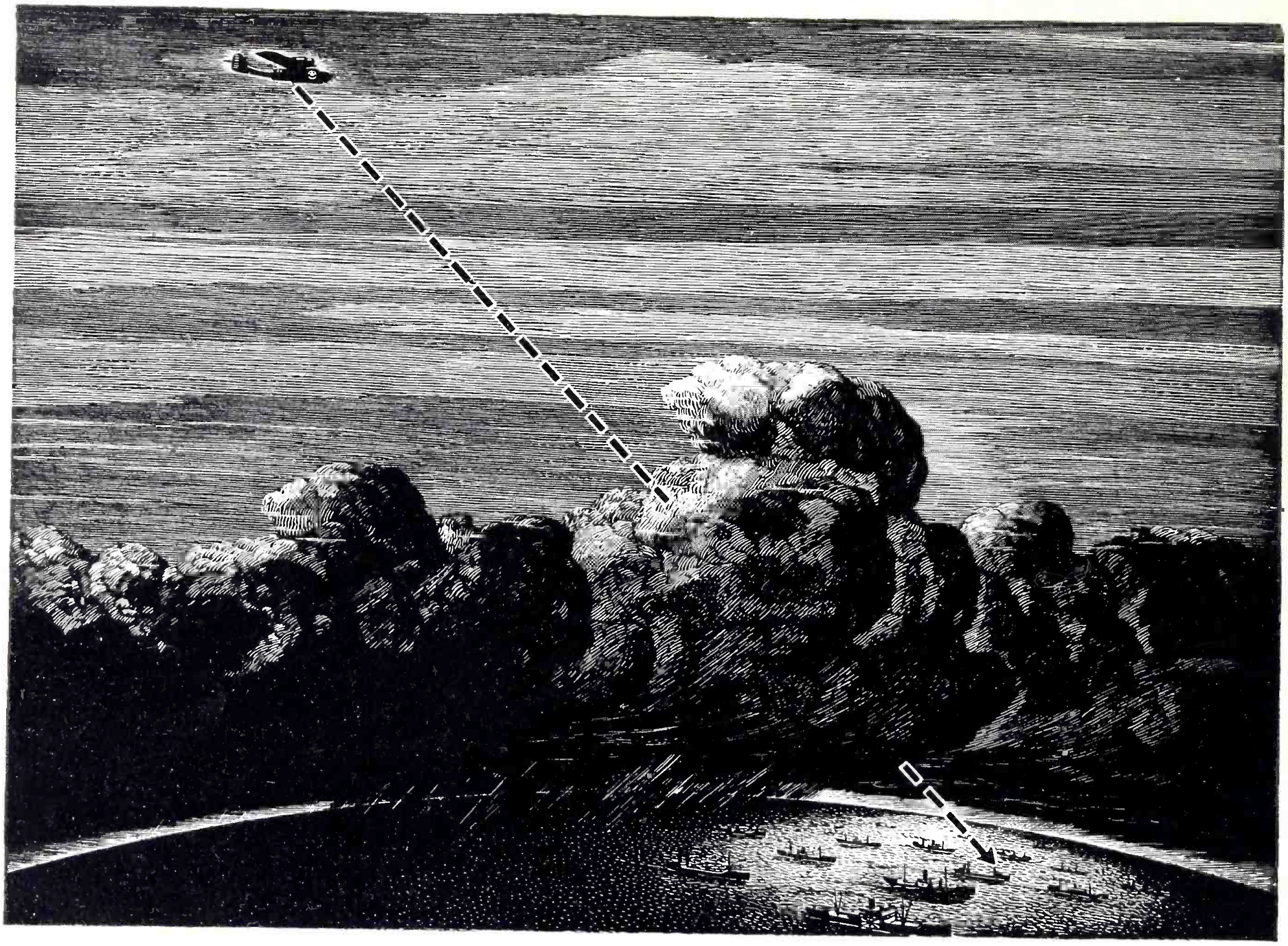
STUPAKOFF *Steatite* INSULATORS

ARMY E NAVY "for great achievement"

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Ceramics for the World of Electronics


Tool up for peace
Tooling up for Victory—the conversion of more than 30,000 American plants into war production was the most gigantic achievement in industrial history. Will the business of tooling up for peace present like difficulties? Not if we plan ahead! General Instrument's research and engineering facilities are now devoted to war efforts, but we are looking to the future when the accumulated skill and experience of today will be diverted to solving the mechanical and electrical problems of tomorrow. How about that idea of yours? Why not bring that brain child to us NOW?
In big cities and remote towns all over the land, for more than a quarter century, millions of owners of home radio sets have enjoyed better reception because of General Instrument precision equipment.
General Instrument
CORPORATION
Executive Offices: 829 Newark Avenue, Elizabeth, New Jersey



RADAR, the secret weapon, tells the story of PHILCO at war!

When the Army and Navy released the secret of *Radar*, the sensational story of Philco's vital contribution to victory was officially revealed. Radar, the fabulous weapon that pierces fog, storms and darkness and seeks out the enemy beyond the range of human eyes and ears, is one of Philco's major war assignments.

Throughout its overwhelming leadership in radio, Philco laboratories *pioneered* in the science of ultra-high frequency radio waves, upon which Radar is based. When the Jap struck, Philco was ready to answer the call of our fighting forces for *"impossible"* deeds of Radar development and production. Today, theirs is the most dramatic story that has yet been told from the annals of war production.

Even more important will be the peacetime sequel to these Radar achievements. Wherever Radar and electronic principles may be applied, Philco research and experience will be ready, again, to serve the field of industry. And in home appliances, only the future can reveal the untold progress that will appear under the famous Philco name.

PHILCO CORPORATION

ARMY E NAVY

OUR WAR PRODUCTION PLEDGE: *MORE • BETTER • SOONER*

MEN OF ELECTRONICS CAN PICK THEIR OWN INDUSTRY IN POSTWAR!

Aviation? When the war is over, giant transport planes will fly almost with the speed of sound, and, through electronics, fly more safely. Radio? To FM will be added the wonders of seeing what is happening miles away, by means of electronic television. Agriculture—steel-making—medical science... Tomorrow the doors to all of these may be open to the electronic engineer.

Almost every day new uses and potentialities for the science of the future unfold, many in the ultra-high frequency ranges where, a few years ago, it was thought electronics could serve no practical purpose. Within the "narrow" 100 to 1000 megacycle range of the spectrum, particularly the former *No Man's Land* beyond 300 MC, a host of applications has been discovered for this new science—for example, in the aircraft industry—itself limitless in peacetime possibilities.

With the opening up of new portions of the frequency spectrum for practical use, men wise in the ways of electronics, or familiar with the theory of harnessing the electron, will be in demand everywhere.

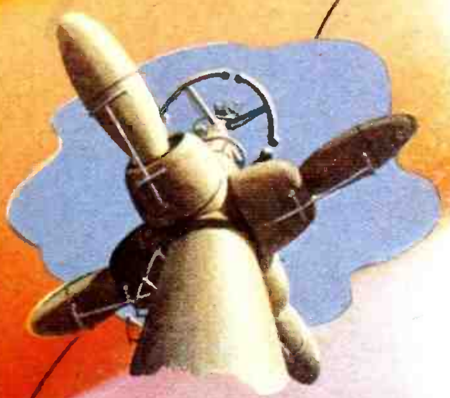
For the practical application of the electronic principle is going to require a new engineering of products, as well as the development of special devices and machines that speed up production...increase accuracy, or measure, control, record and perform the countless other things envisioned in the coming Era of Electronics. And each of these represents opportunity—careers for the men in laboratory and field today hastening this stupendous new age.

Spurred by war's demand for electronic devices, Isolantite is busy preparing for the vastly accelerated application of the electron tube at war's end. For it has been demonstrated in the crucible of war how important is insulation—*high-grade* insulation—to the performance of this equipment designed to accomplish things which man cannot.

ISOLANTITE

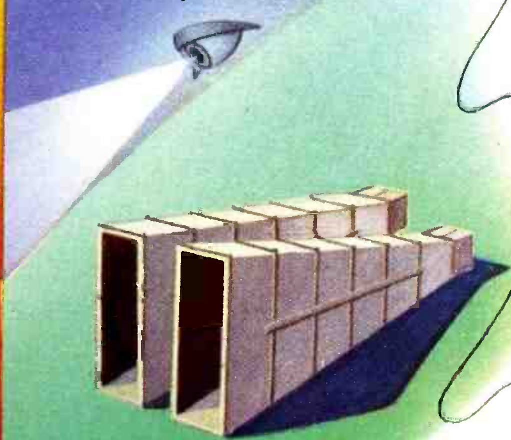
CERAMIC INSULATORS

ISOLANTITE INC., BELLEVILLE, N. J.



TELEVISION
Now a practical reality, electronic television has unlimited commercial possibilities at war's end.

AIRCRAFT RADIO
Operating at 500 MC, radio altimeters indicate plane's height over terrain by means of electronics.



700-MC BLIND LANDING
Action of these high-frequency waves in guidance of planes may lead to other electronic applications.

Engineering begins here...

FOR THE SOLUTION OF YOUR TRANSFORMER PROBLEMS

Grey matter—as measured in terms of Victory in war, or progress in peacetime—is a decisive, tangible factor Strategies, techniques and analyses —whether for military or commerce—are its by-products. Success is directly proportionate to the quality involved.

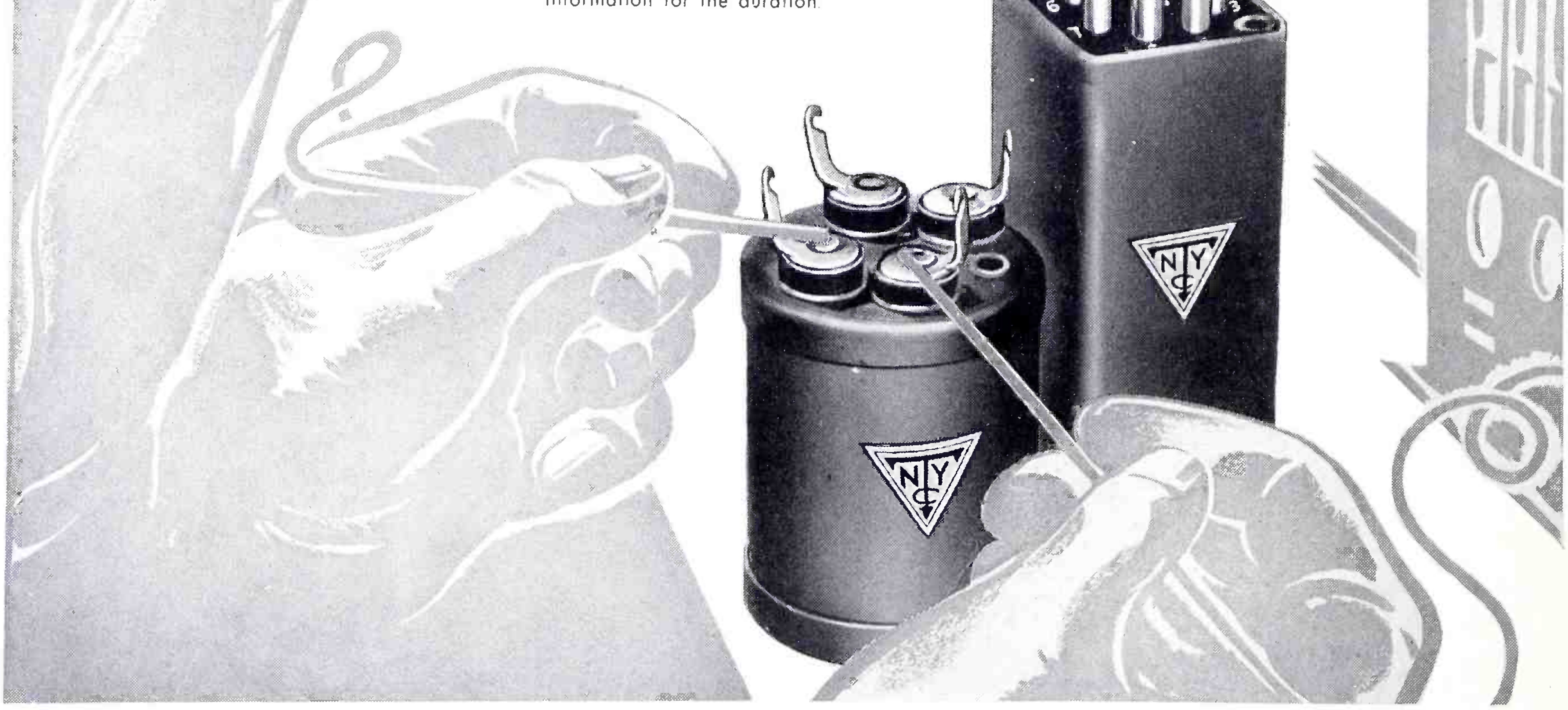
The calibre of N-Y-T engineering is proved by the thousands* of new transformer designs evolved to individual requirements over the past few years. These audio and power components are now assuming a vitally important role in World War II, in Army, Navy and Air Corps applications.

When the world crisis is over, and our present 100% Victory effort terminates, N-Y-T engineers and technicians will be available for collaboration in the solution of your transformer problems. The vast experience gained now, should be of tremendous value then.

NEW YORK TRANSFORMER CO

26 WAVERLY PLACE NEW YORK, N. Y.

*The exact number is confidential information for the duration



If you believe in the future of America as we do, then we're asking for an appointment immediately after the victory has been won . . . when a bright new era awaits us all.

Perhaps we can talk about a coil problem . . . how thoroughly we're organized to help you on such a problem only military censorship forbids telling now. Or it may be that you manufacture your own coils and will be interested in discussing magnet wire—any shape —any insulation that your operations require.

As a matter of fact, perhaps we can get together now, but if it happens we can't, remember we have a date in and for the future. When we both can keep it, you can again take advantage of Anaconda service and the benefits derived from the single product control "from mine to consumer" backed by years of continuous metallurgical experience.

43231

ANACONDA WIRE & CABLE COMPANY
General Offices: 25 Broadway, New York
Chicago Office: 20 North Wacker Drive
Subsidiary of Anaconda Copper Mining Co.
Sales Offices in Principal Cities

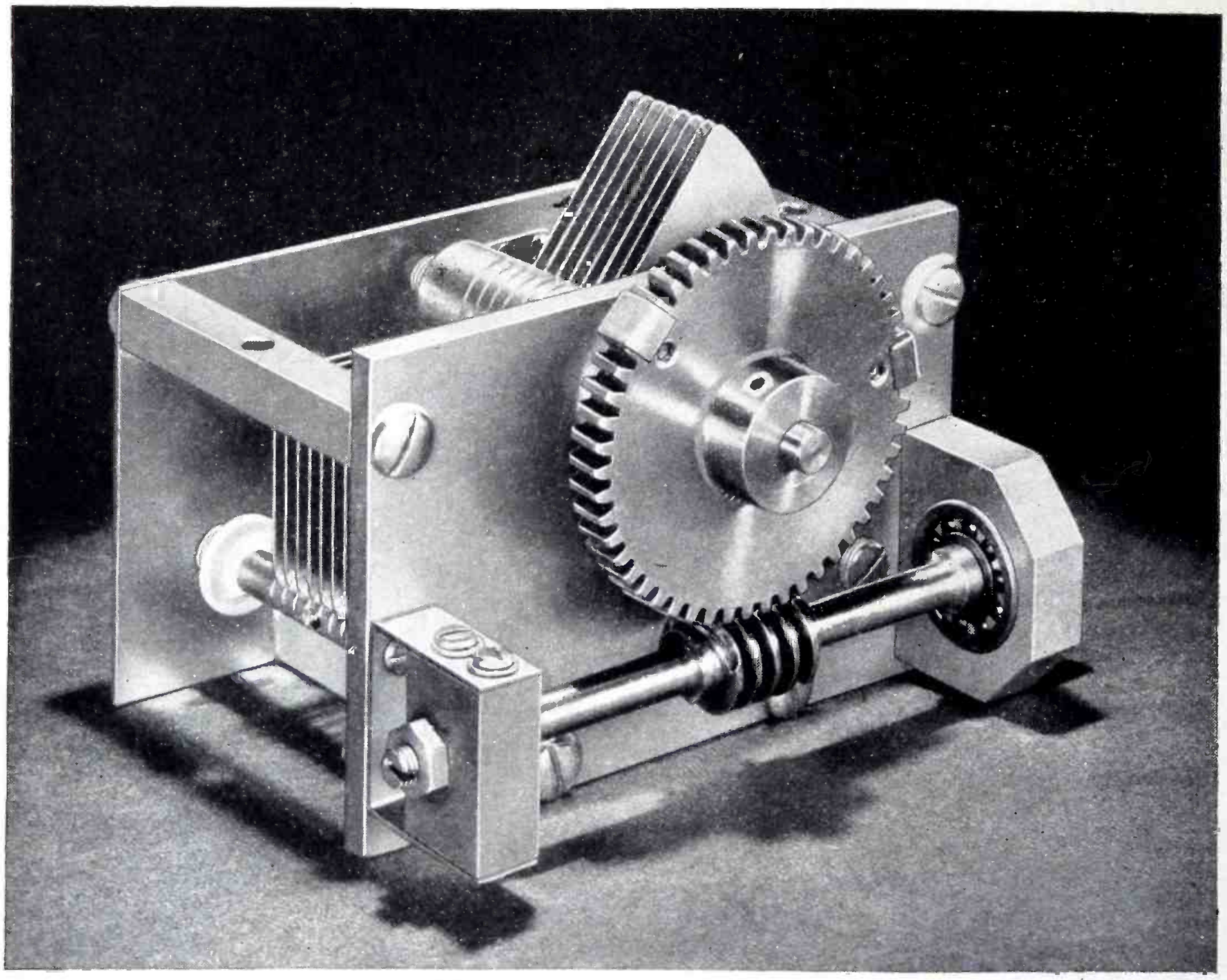
ANACONDA

This familiar trade-mark symbolizes the best efforts of modern research and production.

magnet wire and coils

ANACONDA WIRE & CABLE COMPANY

RESETABILITY



High-stability Variable Condensers

DAY AFTER DAY intricate military radio equipment responds to the layman's touch . . . a transmission frequency is chosen on a moment's notice — a crank is turned — hairlines blend into one—a command is given, and victory is one step nearer. "Resetability" is an important feature of all Hammarlund variable condensers.

THE SIGN OF QUALITY IN RADIO

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

HAMMARLUND

BLUEPRINTS OF SAFETY

BRINGING 'EM BACK... ALIVE!

Smash the objectives—then high-tail for home—that's the job of our Bomber Command . . . And because the use of quartz crystals, in radio transmitting equipment is the only way to insure the stability of prearranged frequencies, so vital in guiding pilots there and back, the A. A. C. method of manufacturing them is of particular importance. . . Among other rigid specifications, our "Blueprints of Safety" demand, that A. A. C. Crystals be ground to —.0001 of an inch tolerance. P. S.: Check our interesting story on deliveries!

ELECTRONICS DIVISION

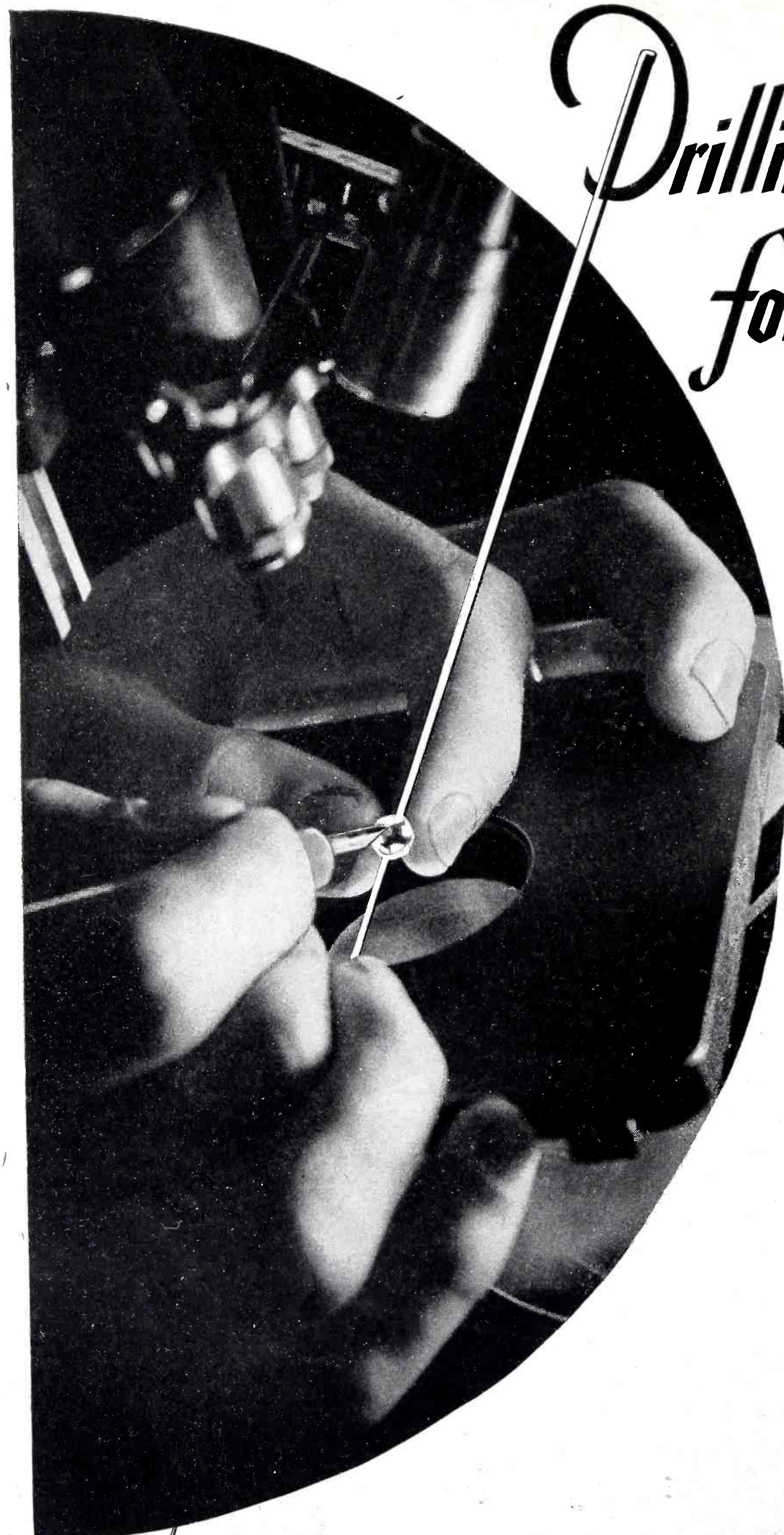
AAC Products

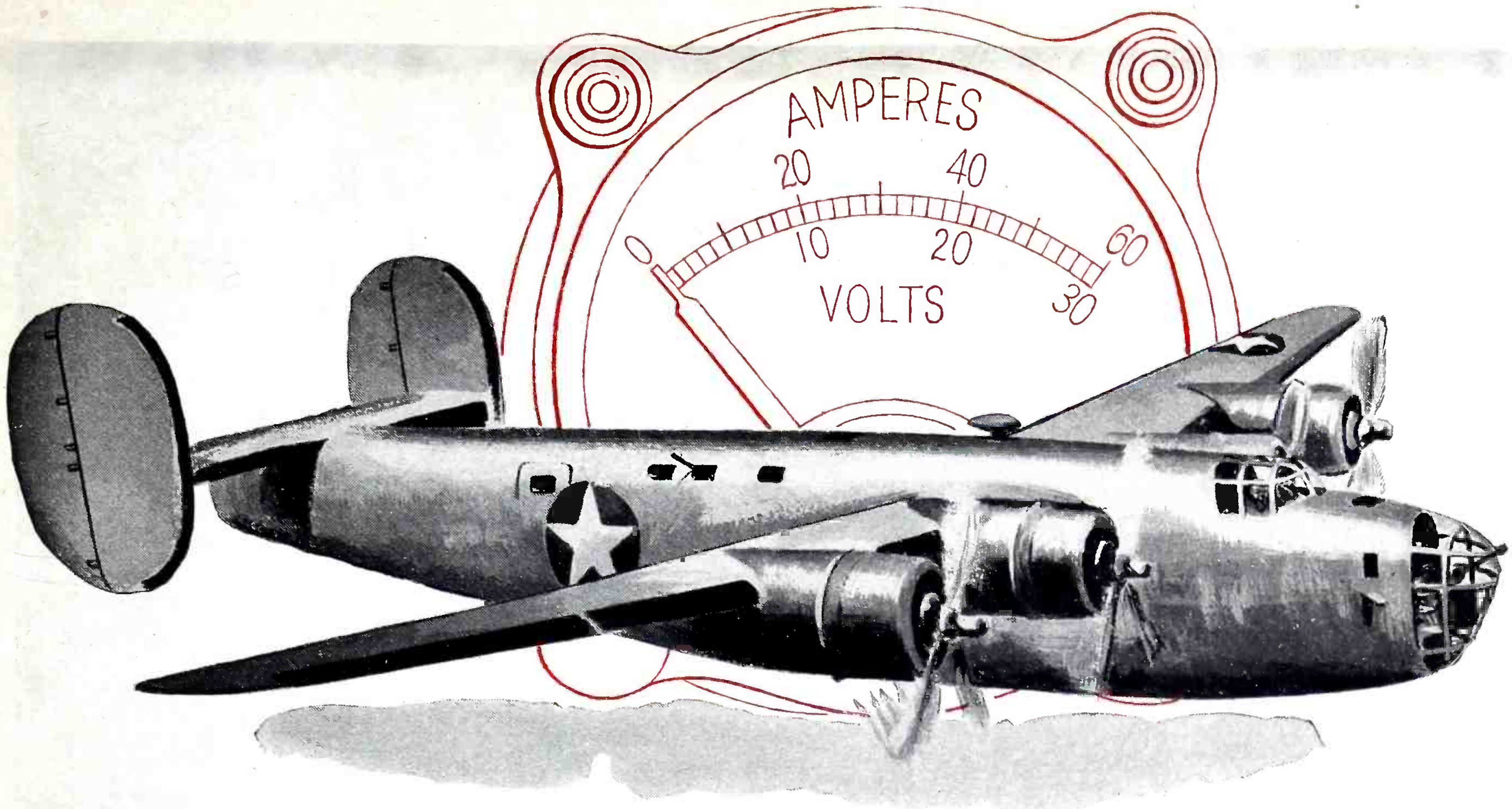
Aircraft Accessories Corporation

MANUFACTURERS OF
PRECISION AIRCRAFT EQUIPMENT
HYDRAULICS . . . . ELECTRONICS

BURBANK, CALIF. • KANSAS CITY, KANS. • NEW YORK, N. Y. • CABLE ADDRESS: AACPRO

Randolph C. Walker PRES.





HELPING "DEALERS IN DEATH" *save lives*

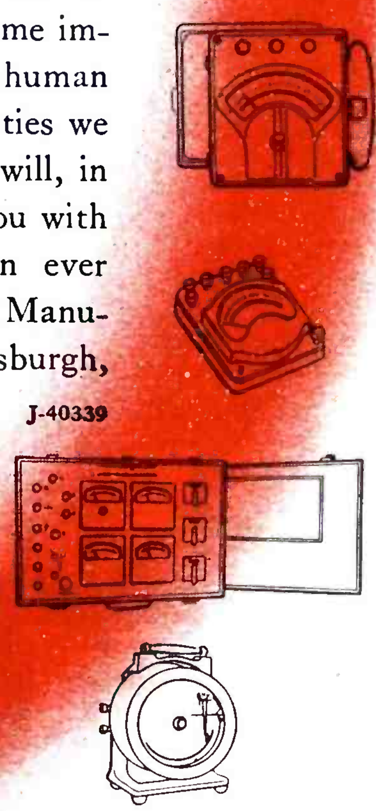
When the accuracy of instruments means Victory . . . or death . . . instruments must be precision-built for battle duty. Today, in ships . . . planes . . . tanks, the accurate, positive calibration of Westinghouse instruments is guiding our warriors into battle . . . and out . . . in spite of searing heat, congealing cold or shock of bursting shells.

THE PIVOT PROTECTS THE ACCURACY

One reason for this dependable accuracy is the tough hard pivots used in all Westinghouse instruments. Made by a special process, they resist blunting . . . protect careful calibrations. Every manufacturing step is carefully controlled.

Honing pressure is precisely regulated . . . pivots are tumbled to relieve stress and set grain structure . . . a 500-to-1 contour enlargement of each point is carefully inspected . . . photomicroscopic studies and hardness tests check uniformity.

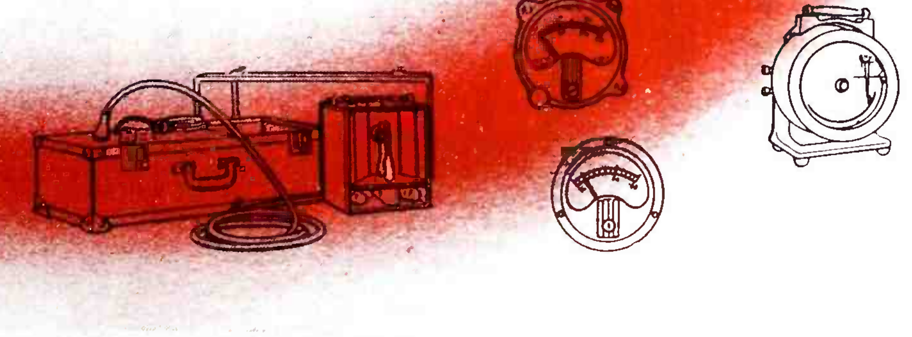
Casting "shadows" of Victories to come . . . these details are of prime importance today. For, on them, human lives depend. The skills and abilities we are now directing to war work, will, in peacetime, enable us to supply you with electrical instruments finer than ever before. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania, Department 7-N. J-40339



THIS IS A WAR OF INSTRUMENTS

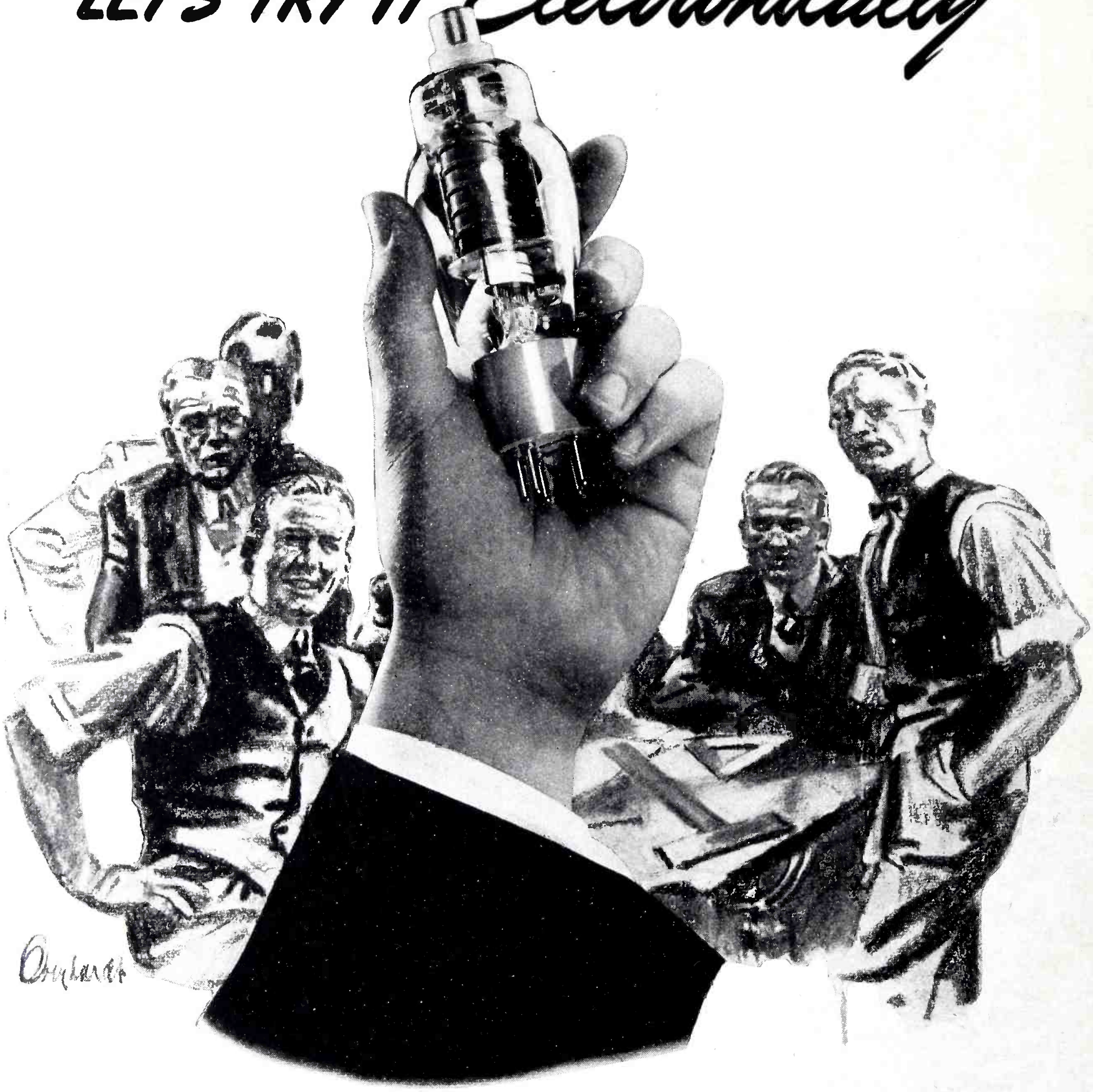
Westinghouse INSTRUMENTS

PLANTS IN 25 CITIES... OFFICES EVERYWHERE




On Sea-
Land-
and Air-
Stewart
is "there"
TERMINALS, LUGS, BRACKETS, CLIPS
AUTOMATIC WIRE FORMING AND METAL STAMPING
Odd Shaped Pieces Stamped and Formed from Wire or Strip on High Speed Machines.
Hundreds of items in stock to meet practically every installation requirement.
Complete Hot Tinning and Plating facilities for handling large orders.
Send for samples and quotations. Let us have your prints and specifications.
QUICK RESPONSE TO INQUIRIES!
STEWART STAMPING COMPANY
621 East 216th Street
New York
TERMINALS
by STEWART
Built to Highest Precision Standards

"LET'S TRY IT *Electronically*"



It is surprising how frequently electronics are mentioned when new products are being planned.

Those who are in a position to see the accomplishments of electronics in the war, can appreciate how this science is bound to affect our post-war world. The added flexibility and scope that electronics impart to many products gives them new and wider horizons. Today no product planning is complete without consideration of electronics.

Here at TUNG-SOL we see our post-war job as adapting to peacetime uses the many transmitting, receiving and amplifying tubes developed for war.

The services of our staff of research engineers are at the disposal of manufacturers who intend to employ electronics. When you want to "Try it electronically" TUNG-SOL is ready to help you.

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 THERMAL SWITCHES

HERE IS THE INSULATION TO MEET ALL YOUR NEEDS

TURBO

. . . offering specifically-designed types with the flexibility and qualities to meet dielectric and physical requirements for present and post-war applications. Whether you design or manufacture machines, apparatus, equipment or accessories, the new advantages now available in TURBO will effect even greater efficiencies. The complete TURBO line includes Mica Plate and Products, Varnished Cambric, Tapes, Cloths and Composites.

Varnished Glass Tubing

Resistant to extremely high heat, is perfectly suited for heavy duty operating conditions, confined areas where ventilation is at a minimum, and other similar applications.

Flexible Varnished Oil Tubing

Resistant to deteriorating influences and meeting the diversity of requirements essential to withstand general breakdowns, moisture absorption, acids, alkalis, etc.

Extruded Plastic Tubing

Incorporating the most advanced developments of the plastic art as applied to electrical insulation. Especially applicable to conditions wherein embrittlement from the effects of sub-zero temperatures must be met.

Wire Identification Markers

To meet rigid ordnance specifications, are available in any size, length or color, with any marking. Made of standard TURBO tubing, thereby conserving the use of critical materials such as rubber, metal, vinlyte, etc. Non-projecting, snug-fitting.

Specimen boards, with representative samples of Varnished Tubing, and a list of standard sizes, will be sent promptly on request; write today.

WILLIAM BRAND & CO.

IF ITS TURBO IT SAFE GUARDS

276 FOURTH AVENUE, NEW YORK, N.Y. • 325 W. HURON STREET, CHICAGO, ILL.


TAYLOR TUBES
Taylor Tube
CUSTOM BUILT
T40
Efficiency in Action...
As always, Taylor is building the finest tubes possible to produce. Every Taylor Tube is designed and engineered to deliver maximum service under strenuous battle conditions. Unfailing, "on the air" performance is their keynote—extra power for vital communications is their heritage. You can rely on Taylor Tubes "More Watts Per Dollar" service in any situation.
Taylor HEAVY CUSTOM BUILT DUTY Tubes
TAYLOR TUBES INC., 2312-18 WABANSIA AVE., CHICAGO, ILLINOIS

OFFICIAL U. S. NAVY PHOTO

On United States Naval Vessels

AmerTran Transformers, Reactors and Rectifiers are used in Radar, fire control, searchlight control, communications and other applications.

IN THE beginning the enemy had a field day. But it's the end of a war that determines the victor.

Already, the United States Navy has proven that it is master of the best the Axis can produce. That goes for personnel, for ships and for equipment.

Take Radar, for example. Only a nation of the greatest inventiveness and highest technical development could have produced the quality of Radar equipment that helped to smash the Jap at Midway, Coral Sea and elsewhere.

We contemplate the future of the war and of our Country with complete confidence. Our Armed Forces, assisted by American technical knowledge and industry, will win in the end.

•

AMERICAN TRANSFORMER COMPANY
178 EMMET STREET, NEWARK, N. J.

PIONEER MANUFACTURER OF
TRANSFORMERS, REACTORS AND RECTIFIERS
FOR ELECTRONICS AND POWER TRANSMISSION

AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

THEY PUT THEMSELVES IN THEIR WORK

Look at a United Tube! Where you see a filament, we see *faces* . . . faces of United employees. Men and women of United are putting not only their skilled hands, but their very *selves* into their product.

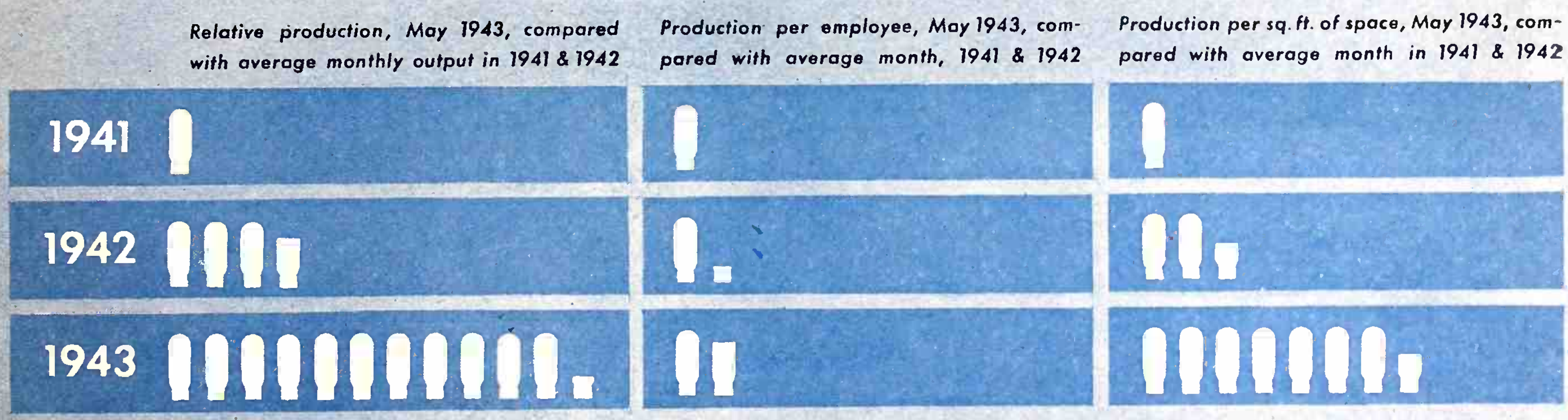
BY SO FEW

UNITED Tubes for the United Nations are pouring out in a ceaseless stream touching every shore of this warring world. So *much* material of victory for so *many* . . . from the hands of so *few!*

Almost before the echoes of Pearl Harbor died away, United had swung 100% of its labor and facilities into production of transmitting tubes of Army and Navy specifications. And tubes of some of the first Radar and other devices used to protect our ships and shores came from the hurrying hands of United employees.

United men and women number hundreds, not thousands. Yet in terms of production per employee, as well as overall company output, United has achieved a record which we believe is unique in the nation.

HERE IS THAT RECORD:



Significantly, this achievement has added meaning because it is superimposed on an already established, high normal output. Moreover, United production volume has been accompanied by parallel progress in the development of new, improved and special types of electronic tubes. At the same time, United ingenuity has made important contributions to efficiency by effecting substitutes for many scarce, critical materials.

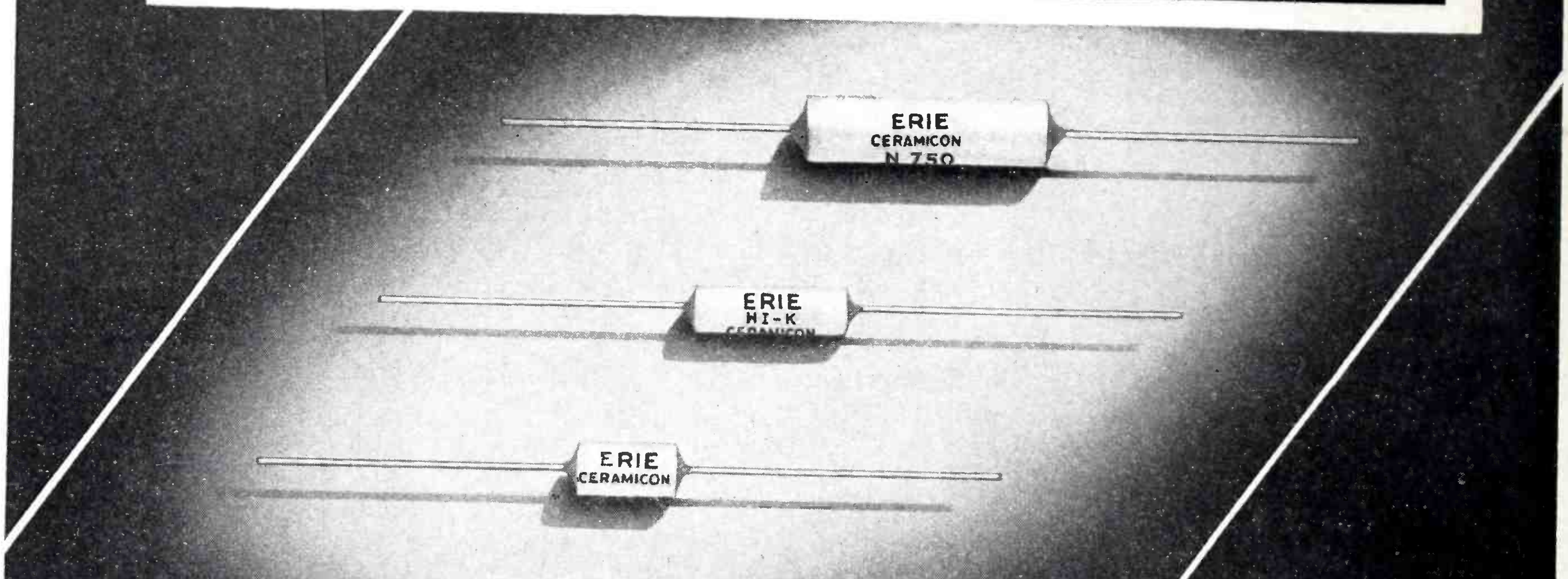
In grateful acknowledgment of a job well done, the management of this company salutes its heroes and heroines of the production front. These men and women are rendering truly distinguished service in the defense and freedom of our country. We know our country will share this glow of pardonable pride.

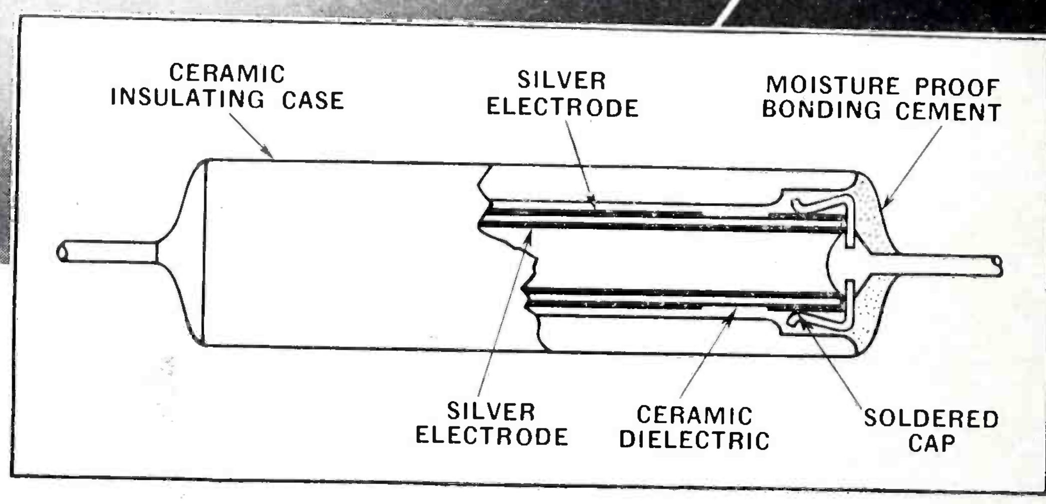
UNITED

ELECTRONICS COMPANY
NEWARK NEW JERSEY

ERIE *Insulated* CERAMICONS

REG. U.S. PAT. OFF.





for MODERN ELECTRONIC DESIGNS . . .

THE modern trend toward more compact electronic assemblies necessitates the use of *insulated* components. Fully appreciating the inherent advantages of insulated components, we have concentrated on the production of Insulated Ceramicons, since we first introduced ceramic condensers in this country nearly seven years ago.

Details of construction are shown in cross sectional drawing above. The ceramic case is sealed with a resin-bonded cement and unit is vacuum-impregnated with a specially developed wax. These units possess greater mechanical strength, provide better protection against humidity, a more direct and uniform electrical path, and can be located anywhere in the chassis regardless of proximity of other components.

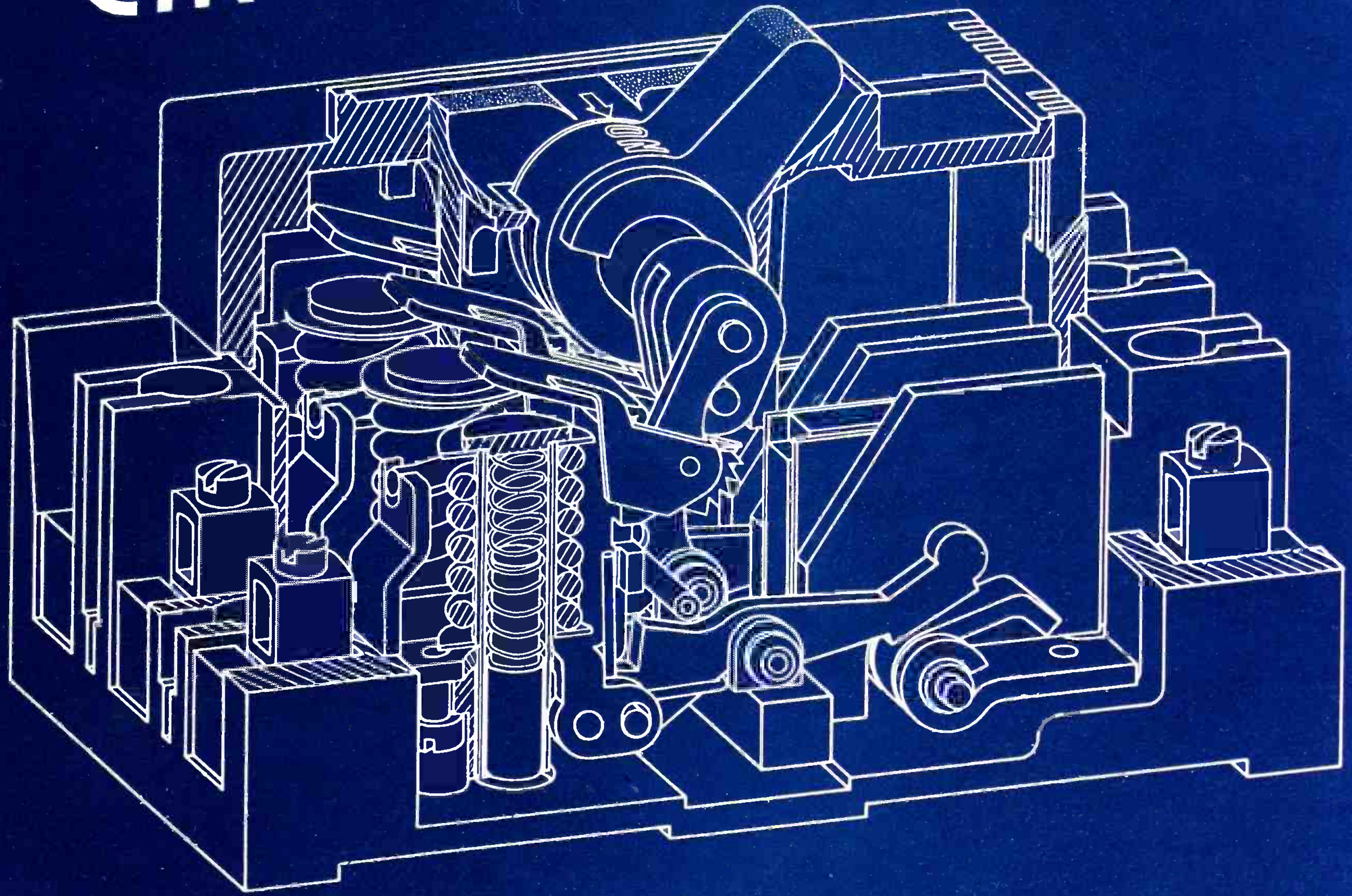
Erie Insulated Ceramicons are made in nine temperature coefficients ranging from +100 parts per million per °C to −750 parts per million per °C, and in capacities up to 375 mmf in the latter temperature coefficient. Erie "Hi-K" Ceramicons are made in insulated styles up to 5,000 mmf. Where choice of capacitors lies within these ranges, the use of Insulated Ceramicons is advantageous.

For greater protection and better design, specify Erie Insulated Ceramicons when available capacities meet your requirements.

For complete information covering operating characteristics of Erie Insulated Ceramicons write for data sheet.

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

FLEXIBLE but UNFAILING CIRCUIT PROTECTION



HEINEMANN

MAGNETIC CIRCUIT BREAKERS

Drawing shows cross section of time delay type breaker, designed to prevent nuisance trips on transient overloads and starting surges, while opening rapidly on sustaining and heavy overloads and instantaneously on short circuits. Same breaker can be made without the time delay arrangement as straight instantaneous trip type. Magnetic blowout provides high and fast interrupting capacity.

HEINEMANN CIRCUIT BREAKER CO.

Subsidiary of Heinemann Electric Co., Est. 1888

TRENTON • NEW JERSEY

DESIGNERS — here is a NEW CHART that gives you at a glance data on four essential NON-metallics.

USE CONTINENTAL-DIAMOND
LABORATORY RESEARCH and MANUFACTURING EXPERIENCE
To Help You Adapt C-D Non-Metallics to Your Design and Production Problems

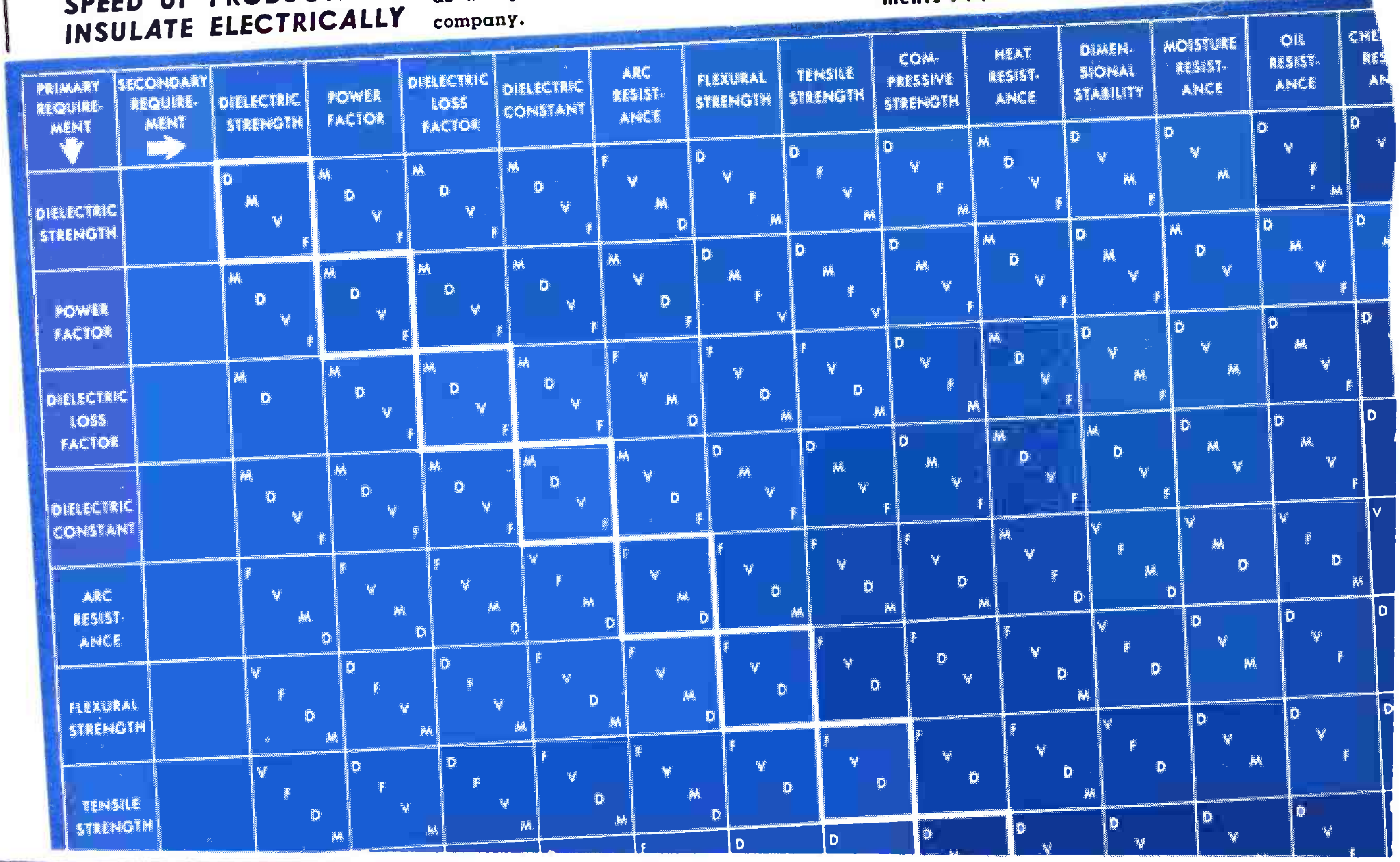
to STRENGTHEN
LIGHTEN WEIGHT
ABSORB VIBRATION
PREVENT CORROSION
INCREASE EFFICIENCY
SPEED UP PRODUCTION
INSULATE ELECTRICALLY

C-D laboratory research is not a product of the present emergency — this service was established and used extensively by our customers as early as 1914—today it offers you a wealth of experience gained in solving thousands of material problems. Use it as though it were a division of your own company.

HOW TO USE THIS CHART

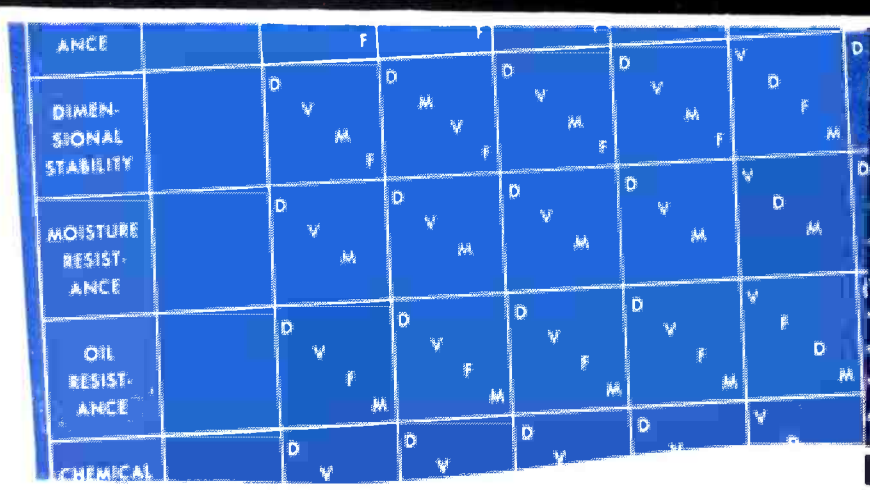
C-D products are indicated

D for **Dilecto** . . . M for **Micabond**
F for **Vulcanized Fibre** . . . V for **Vulcoid**
THEY ARE ARRANGED FROM UPPER LEFT TO LOWER RIGHT in order of their suitability for problems involving two known requirements . . .



Continental-Diamond FIBRE COMPANY

"Manufacturers of Laminated Plastics Since 1911" — NEWARK • DELAWARE



C-D, No. 12 Chapel Street, Newark, Delaware

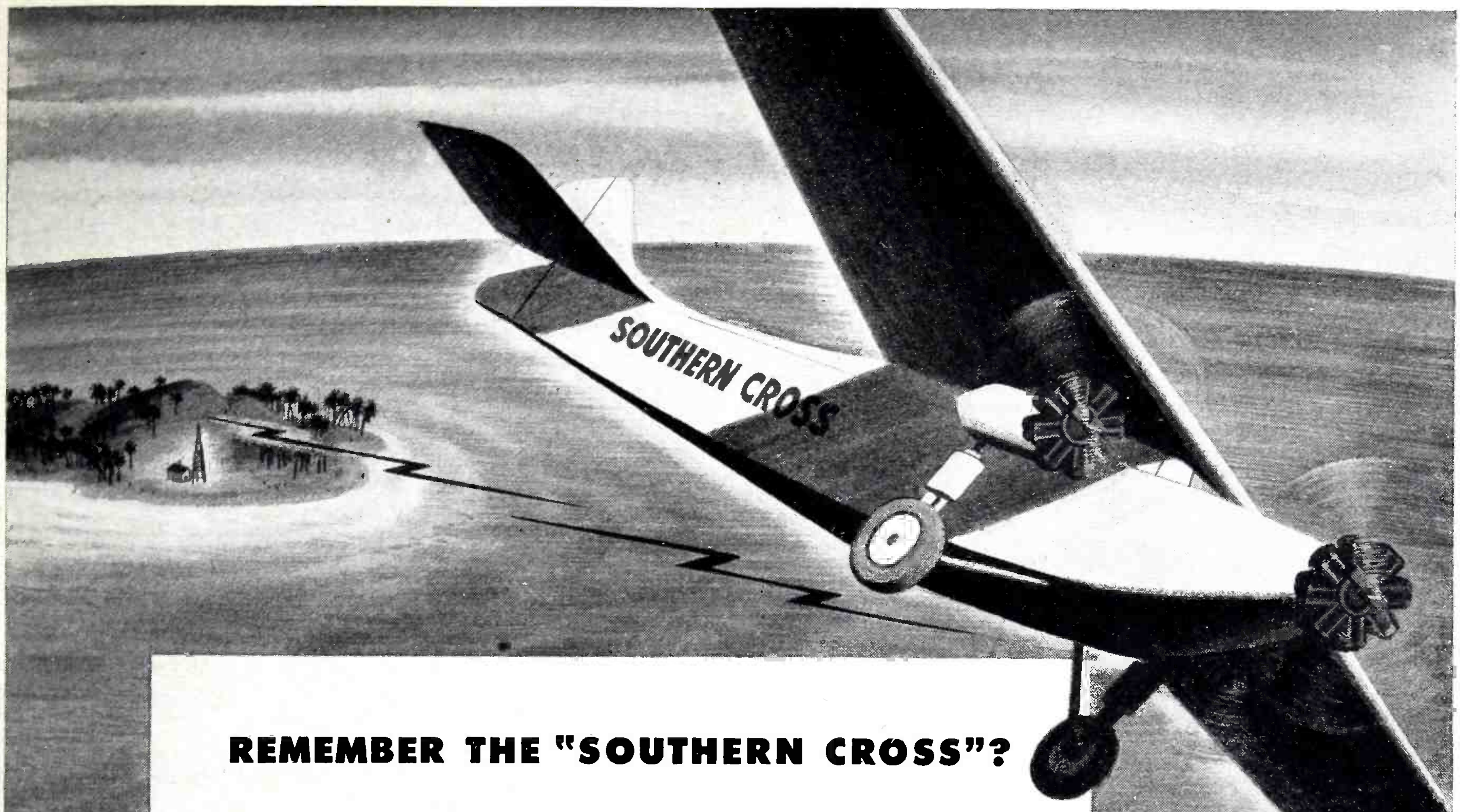
Send me the 20" x 26" wall chart on C-D non-metallic materials and the booklet "What Material?"

NAME ....

COMPANY ....

ADDRESS ....

....



REMEMBER THE "SOUTHERN CROSS"?

CAPTAIN Charles J. Kingsford-Smith on the morning of May 31, 1928, lifted the *Southern Cross* off the runway of the Oakland Airport and headed home for Australia. Eight days later his tri-motored Fokker monoplane landed at Brisbane after a three-legged trans-Pacific hop of 7362 miles.

"This trip," according to the *New International Year Book*, "was notable for the accuracy of the navigation and the fact that the radio operator was constantly in communication with either shore stations or ships throughout the flight."

The transmitter then aboard the *Southern Cross*, and now on display in the Smithsonian Institute, was designed by Ralph M. Heintz, co-founder of Heintz and Kaufman, Ltd. Its signal on 33.1 to 33.5 meters never faltered during the 83 hours and 19 minutes of flying.

The experience gained by Heintz and Kaufman, Ltd. while pioneering memorable events in radio history is reflected in the Gammatron tubes today serving the military, naval and air arms of the United Nations. The efficiency of modern Gammatrons at high frequencies, their long operating life and high stability, spring from 17 years of continuous and often brilliant research and development by Heintz and Kaufman engineers.

HEINTZ AND KAUFMAN, LTD.

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

HK-454

GAMMATRON TUBES... The grids and plates in Gammatron tubes are made of tantalum, a unique metal which eliminates the need for unstable getters, and protects Gammatrons from the release of gas even when heavily overloaded. Other Gammatron advantages: low driving power, easy neutralization, freedom from parasitics, and high efficiency at radio and very high frequencies.

LEADERS IN ELECTRONICS YESTERDAY, TODAY AND TOMORROW

Like a phone in your car?

After the war..

. . . the two-way radiotelephone will be employed by American industry as a convenience, a safeguard and a business requirement. This modern method of communication has many proven applications in the following fields:

Aviation	Railroading
Marine	Public Utilities
Police Patrol	Fire Fighting
Trucking	Engineering
Mining	

If you think you may be able to employ two-way radiotelephone communication in your field, we would be pleased to discuss your problem without cost or obligation. We have nothing to sell since our entire output has been placed at the disposal of the United Nations all over the world!

•

Requests for information and literature from responsible parties may be addressed to Jefferson-Travis Radio Manufacturing Corporation, 380 Second Avenue, New York.

THE development and production of two-way radiotelephone equipment for military purposes is convincing evidence that you will employ this unique form of communication in many undreamed-of ways after the war. Long before Pearl Harbor, Jefferson-Travis was making superior two-way radiotelephone equipment for ship-to-shore and plane-to-ground communication. With Victory, it will again be used for these and a great many other peacetime purposes by all nations in Tomorrow's World!

JEFFERSON-TRAVIS

RADIOTELEPHONE EQUIPMENT

NEW YORK • WASHINGTON • BOSTON

BOMBER crews and fighter pilots' chances of "flying them home" are limited if pulleys fail and jam the controls.

Formica control pulleys and cable fairleads are preferred parts because of their high strength to weight ratio, and ability to reduce cable wear.

Formica control pulleys are the result of good engineering and progressive production methods.

Other aircraft parts made of Formica are instrument panels, ignition breaker arms, radio coil forms, sub panels and tube bases, antenna insulators, propeller blades, guide blocks and vibration frequency change collars.

THE FORMICA INSULATION CO., 4661 SPRING GROVE AVE., CINCINNATI, O.

the *unusual* in Springs is *not unusual* at Muehlhausen

★ Muehlhausen has provided the answers to many challenging spring problems—provided them at a speed in keeping with war-time demands. Unusual spring requirements have been successfully met with unusual spring designs—made possible by this company's widely varied experience, plus engineering skill and extensive production facilities.

Springs of every shape and size, in quantities large and small, are part of everyday production. Muehlhausen craftsmen are able to produce the correct spring for every requirement—whether a tiny compression spring that will be flexed a hundred times a minute; or a large, hot-formed spring that must withstand extreme operating temperatures.

This ability of Muehlhausen to design and fabricate unusual springs has permitted greater latitude in designing war products now, and will enable engineers to plan, with greater free dom, the products of tomorrow.

MUEHLHAUSEN SPRING CORPORATION
Division of Standard Steel Spring Company
760 Michigan Avenue, Logansport, Indiana

MUEHLHAUSEN
SPRINGS
EVERY TYPE AND SIZE

SEND FOR TWO NEW FOLDERS—FREE

New Die Spring Bulletin illustrates, describes 206 sizes and types of die springs.

New Armament Bulletin shows importance of springs for many types of war equipment.

Dependable

DUNCO MERCURY RELAYS

NON-WELDING, DIRT-FREE CONTACTS

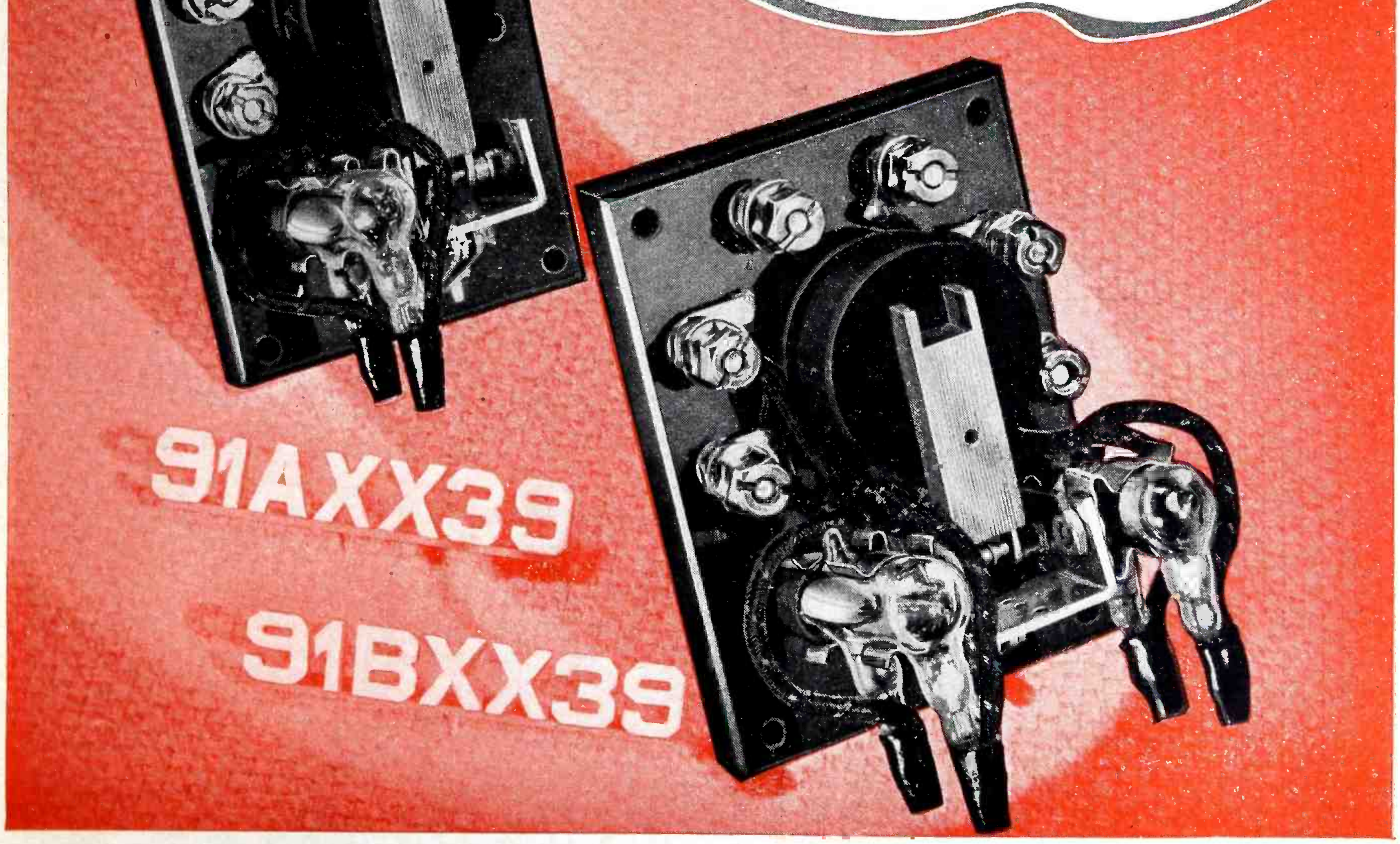
Dunco Mercury-Contact Relays have established enviable standards of performance on applications where high inrush loads, such as on lamps and motors, must be controlled, or for use where dust and fumes might foul ordinary contacts.

Rugged, heat-proof glass tubes keep the mercury in perfect condition, guarding it against fouling from contact with metal parts. On the Dunco Laminated Clapper Type Relays (Series 91), these tubes tilt over a wide angle, assuring positive contact without the need for any unusual mounting precautions. Dunco Mercury Swing Types (Series 22) require level mountings. These units have the advantage of making noiseless contact, and being lower in price.

Other Dunco Relay-Timer Types

30 ampere—Sensitive—Instrument Controlled—Low Voltage, Heavy Current, D.C.—Mechanical Latch-in (Electrical Reset)—Telephone Auxiliary—Lamp Controlling—Polarized—Overload—Timing—Industrial Control and Power Transfer—Sequence, Ratchet Type—Motor Reversing, and many others.

Write for the New Dunco Catalog and Relay Data Book.



STRUTHERS DUNN, Inc.

1321 ARCH STREET **PHILADELPHIA, PA.**

LET DUNCO DISTRICT ENGINEERS IN 28 STRATEGICALLY LOCATED CENTERS HELP SOLVE YOUR RELAY PROBLEMS

1/4 WATT OR 1,000 WATTS E·L VIBRATOR CONVERTERS

give higher efficiency . . . require no service

The vibrator is the most efficient means yet developed for changing DC current to AC.

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

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

This is an inherent characteristic of the vibrator, because electrical and mechanical losses as well as wear are negligible. Building on this fundamental, Electronic Laboratories have extended the vibrator's field of usefulness by developing vibrator type power supplies which provide extraordinary adaptability, for all types of current conversion, together with unusual efficiency and service life.

Ingenuity of design and precision of manufacture make possible load capacities up to 1,000 watts in *E·L* Vibrator Power Supplies. The 450-watt capacity, 120-cycle vibrator, illustrated above, for instance, has eight sets of contact points. Each of them must make 120 contacts per second, and each synchronized perfectly with every other contact. Adjusted and locked, that is exactly what they do—for life!

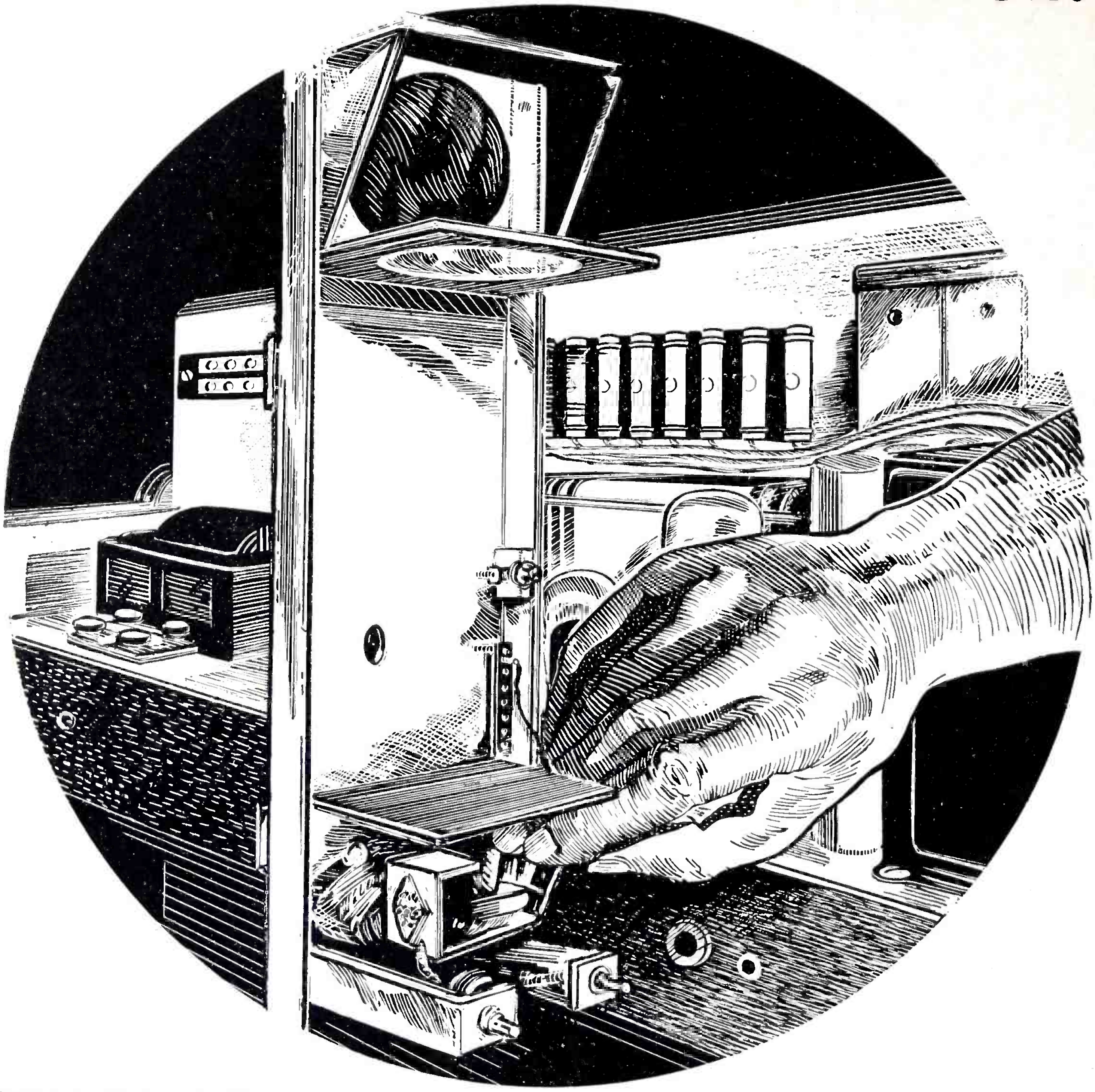
Growing use of *E·L* Vibrator Power Supplies in war equipment—land, sea and air—is evidence of their efficiency and reliability under the most severe operating conditions. Wherever you have a problem of current conversion, *E·L* engineers will be glad to work with you to meet it most effectively, and most economically.

Electronic LABORATORIES, INC.

INDIANAPOLIS

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

ON GUARD AGAINST SABOTAGE!



ELECTRONIC TUBES AID PLANT PROTECTION

America's war production plants are carefully guarded . . . night and day electronic tubes guard against intrusion. Units that transmit a virtually invisible light beam are powered by tubes that are constantly on the job . . . guarding against sabotage! . . . Raytheon's experience during its war time production of tubes for our armed forces will prove an invaluable factor when these new developments can be released for general domestic uses.

RAYTHEON

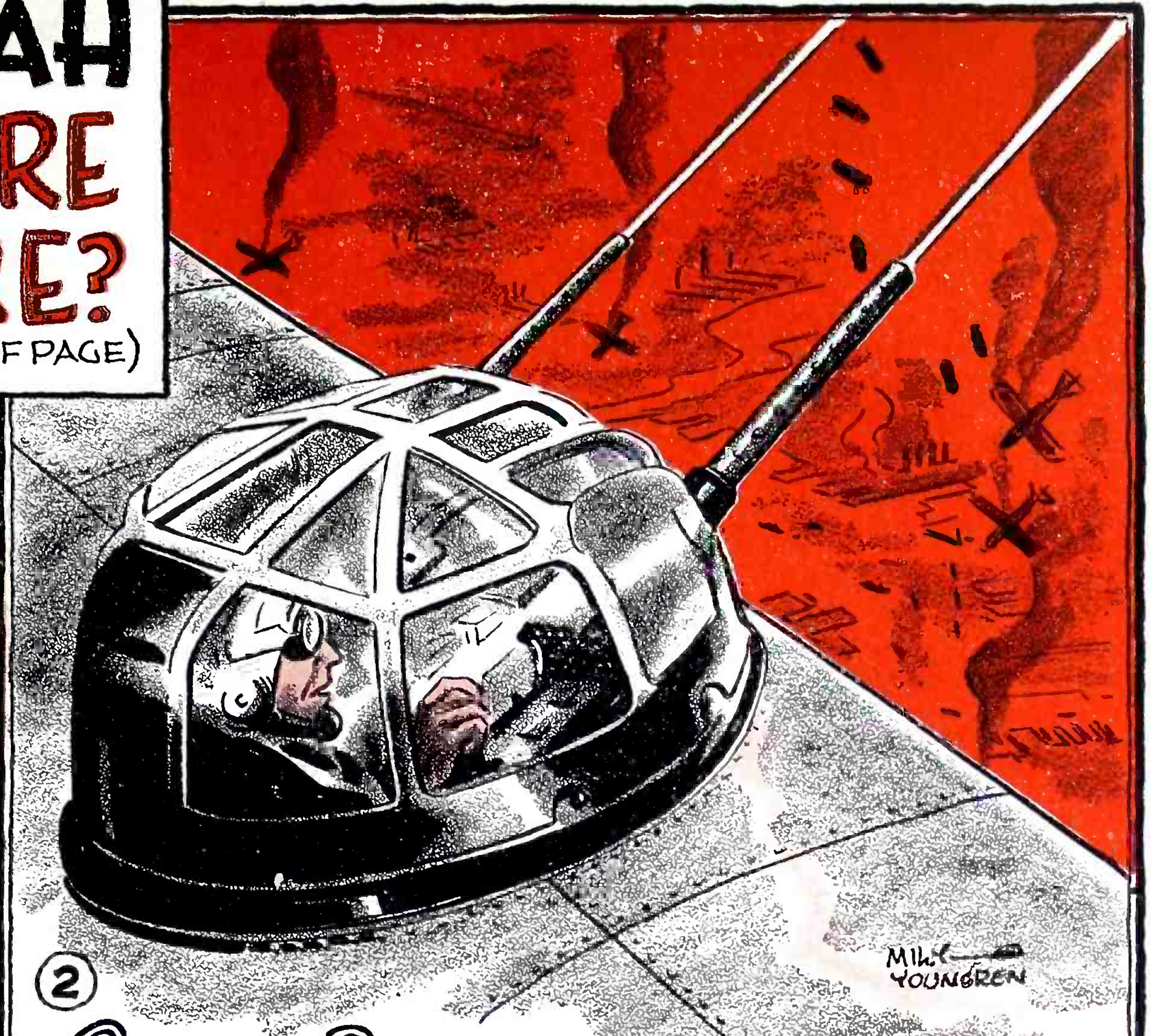
Raytheon Manufacturing Company

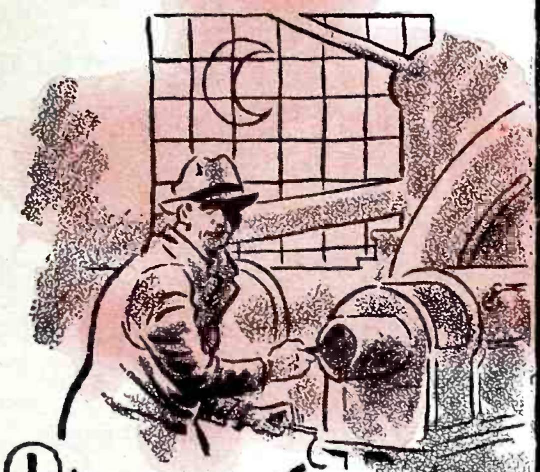
Waltham and Newton, Massachusetts

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

WHAT UTAH PARTS ARE USED HERE?

(ANSWERS AT BOTTOM OF PAGE)





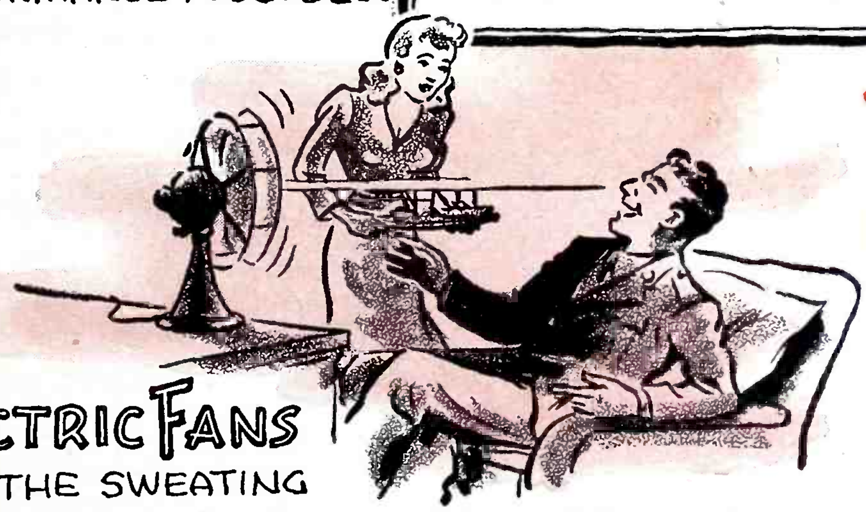
① ALARM SYSTEMS

SABOTEURS AND OTHER MARAUDERS ARE STOPPED IN THEIR TRACKS BY INCORRUPTIBLE MECHANICAL GUARDIANS THAT NEVER SLEEP. A UTAH PART HELPS MAKE THEIR NON-FAILING PERFORMANCE POSSIBLE.

② POWER-DRIVEN

MACHINE GUN AIRCRAFT TURRET

LIKE THE TWO-GUN MAN OF FRONTIER DAYS, THIS GUNNER HAS HIS WEAPONS READY TO SPIT FIRE IN A SPLIT-SECOND... NO MATTER FROM WHICH DIRECTION THE ENEMY MAY ATTACK. A UTAH PART PLAYS A VITAL ROLE.



③ ELECTRIC FANS

COOL THE SWEATING BROW OF THE WAR WORKER IN HIS HOME... INVIGORATE THE WEARY SOLDIER OFF DUTY. UTAH PARTS PROVIDE DEPENDABILITY AND LONG LIFE.

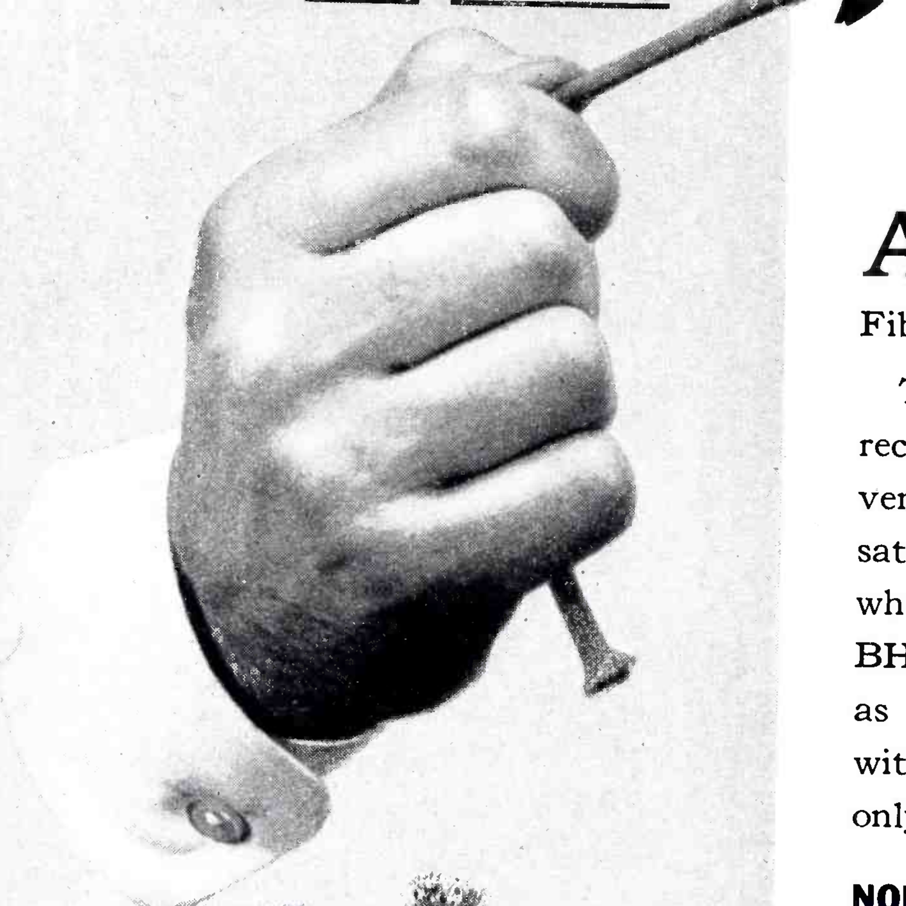
THESE ARE ONLY A FEW OF THE MANY PRODUCTS NOW USING PARTS MADE BY UTAH. YOUR PRODUCT, TOO, CAN PROBABLY BENEFIT FROM UTAH'S EXTENSIVE EXPERIENCE IN SOLVING WARTIME ELECTRICAL PROBLEMS. UTAH MAKES A WIDE LINE OF PRODUCTS FOR ELECTRICAL AND ELECTRONIC DEVICES. WRITE US TODAY FOR FULL INFORMATION — GET THE FACTS BEHIND UTAH'S PRECISION MANUFACTURING AND ADVANCED ENGINEERING AND SEE HOW THEY CAN BENEFIT YOUR PRODUCT.

UTAH RADIO PRODUCTS COMPANY, 837 Orleans Street, Chicago, Illinois • Canadian Office: 560 King Street, West, Toronto
In Argentine: UCOA RADIO PRODUCTS CO., S. R. L., Buenos Aires • Cable Address: UTARADIO, Chicago

① RESISTORS, RHEOSTATS ② RESISTORS, HEADSETS, RESISTORS, POTENTIOMETERS ③ RESISTORS

AT LAST!

A New Sleeving— Flexible as String and Non-Fraying



AFTER many experiments, we have developed a super-flexible Fiberglas Sleeving which will not fray.

This sleeving is made by an entirely new, recently-discovered process. Formerly, to prevent excessive fraying, it was necessary to saturate the sleeving, sometimes to a degree where stiffness became objectionable. The new BH Fiberglas Sleeving is as limp and flexible as string—you could tie any kind of a knot with it—yet the severest handling will produce only the merest fuzz at the end.

THIS – NOT THIS

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

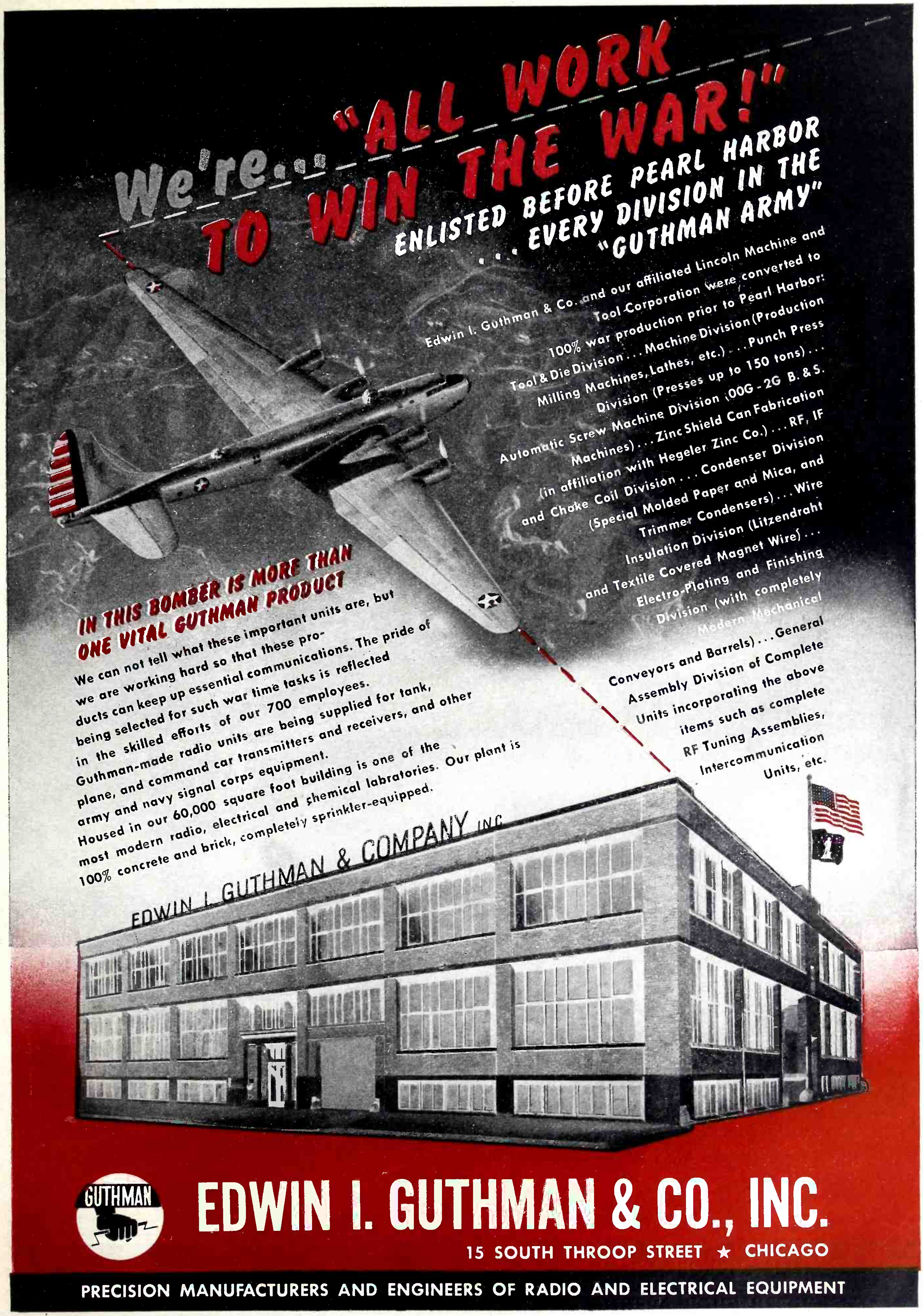
The new BH Fiberglas Sleeving is woven from the choicest continuous-filament Fiberglas yarns. It possesses extremely high dielectric strength, is water-resistant and, like all BH Sleeving and Tubing—is non-inflammable.

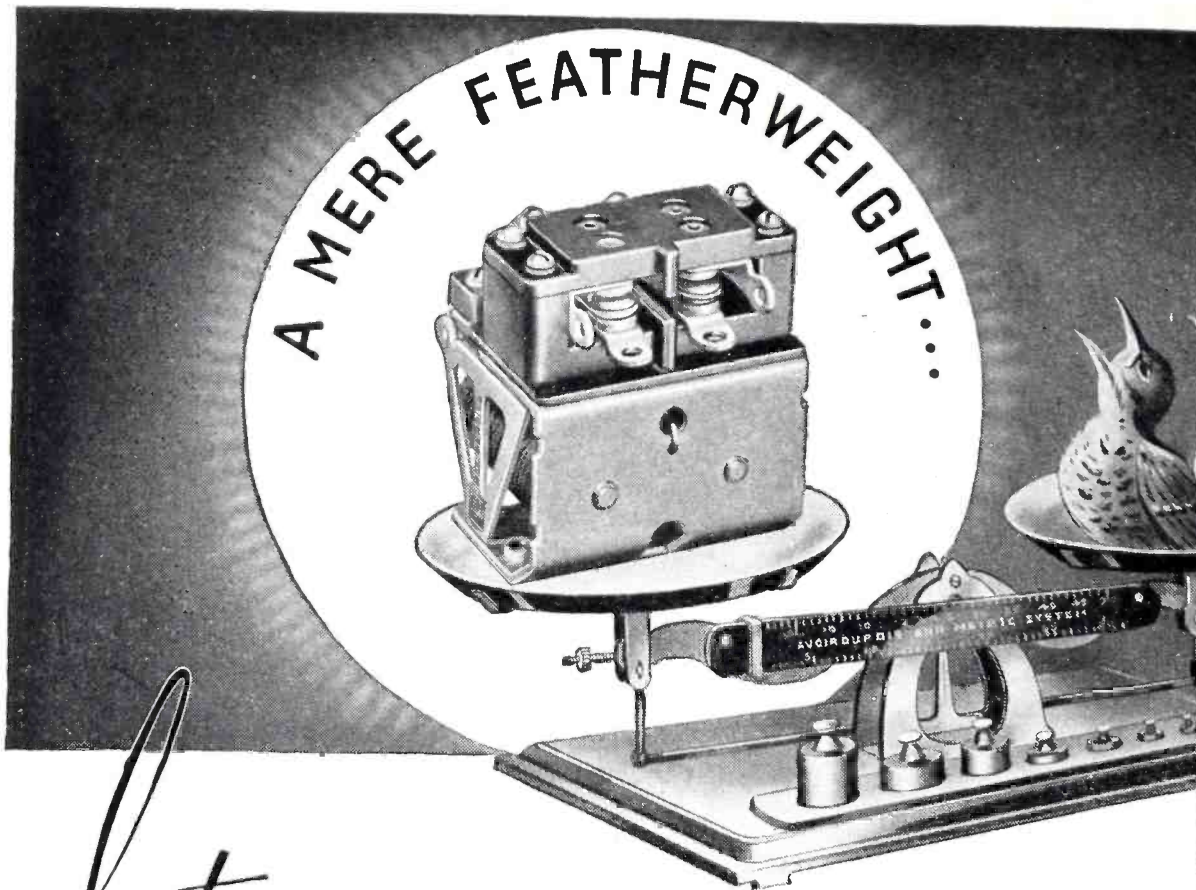
All sizes, from No. 20 to 5/8″, inclusive, are available. Write for samples of this radically new and different sleeving today—in the sizes you desire. Seeing is believing! Bentley, Harris Manufacturing Co., Dept. E, Conshohocken, Pa.

BH PRODUCTS

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

BENTLEY, HARRIS MANUFACTURING CO.
Conshohocken, Penna.


We're... "ALL WORK TO WIN THE WAR!"
ENLISTED BEFORE PEARL HARBOR . . . EVERY DIVISION IN THE "GUTHMAN ARMY"
Edwin I. Guthman & Co. and our affiliated Lincoln Machine and Tool Corporation were converted to 100% war production prior to Pearl Harbor: Tool & Die Division . . . Machine Division (Production Milling Machines, Lathes, etc.) . . . Punch Press Division (Presses up to 150 tons) . . . Automatic Screw Machine Division (00G - 2G B. & S. Machines) . . . Zinc Shield Can Fabrication (in affiliation with Hegeler Zinc Co.) . . . RF, IF and Choke Coil Division . . . Condenser Division (Special Molded Paper and Mica, and Trimmer Condensers) . . . Wire Insulation Division (Litzendraht and Textile Covered Magnet Wire) . . . Electro-Plating and Finishing Division (with completely Modern Mechanical Conveyors and Barrels) . . . General Assembly Division of Complete Units incorporating the above items such as complete RF Tuning Assemblies, Intercommunication Units, etc.
IN THIS BOMBER IS MORE THAN ONE VITAL GUTHMAN PRODUCT
We can not tell what these important units are, but we are working hard so that these products can keep up essential communications. The pride of being selected for such war time tasks is reflected in the skilled efforts of our 700 employees. Guthman-made radio units are being supplied for tank, plane, and command car transmitters and receivers, and other army and navy signal corps equipment.
Housed in our 60,000 square foot building is one of the most modern radio, electrical and chemical laboratories. Our plant is 100% concrete and brick, completely sprinkler-equipped.
EDWIN I. GUTHMAN & COMPANY INC.
GUTHMAN
EDWIN I. GUTHMAN & CO., INC.
15 SOUTH THROOP STREET ★ CHICAGO
PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT



but **BUILT TO DO A HERCULEAN JOB**

The Type 27
SUPER AIRCRAFT RELAY

Expert design . . . Small size . . . Light Weight . . . yet a powerful Aircraft Relay possessing a number of noteworthy characteristics, which can be varied over a wide range to suit the requirements of different applications.

The box frame construction gives the Type 27 Relay superior strength and sturdiness . . . yet it weighs only 5 ounces. The above illustrated relay is capable of withstanding 15g or more without a tremor . . . has a contact pressure of 60 grams (double make-double break) and a contact capacity of 20 amperes at 30 volts d.c. (100 ampere inrush). The pickup is 6.5 volts (.61 watt) at 20° C. The nominal coil voltage is 12 volts d.c. Coil wattage at 12 volts d.c. is 2.1 watts at 20° C. Temperature range is from —40 to 90° C. Size 1½ x 1⅝ x 1⅞".

Free samples of the above Type 27 Relay (SPDT double make-double break in 2 pole construction) are available to relay users if request is accompanied by a priority of AA-4 or better. Write or wire today requesting relay No. 12723.

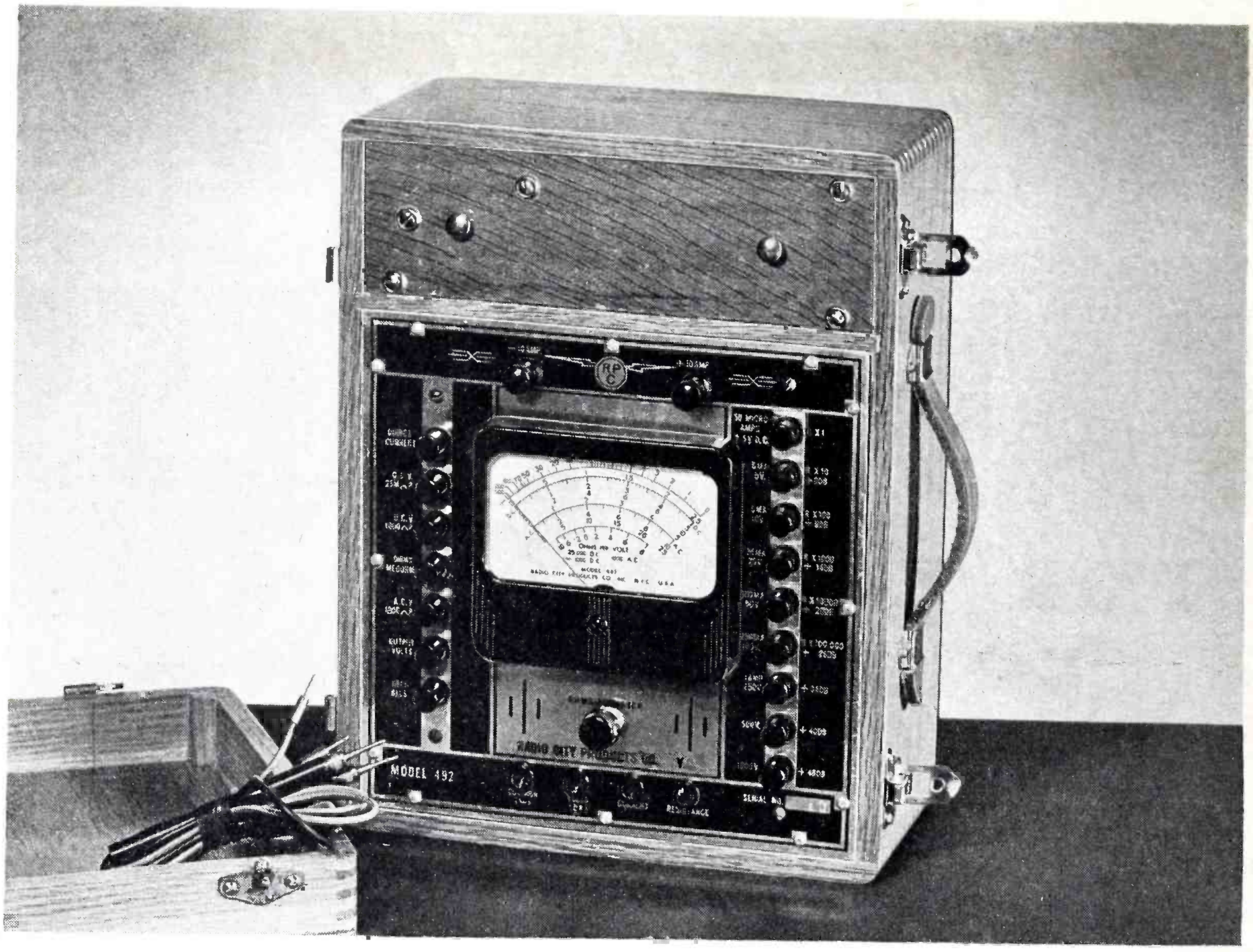
VISITRON PHOTOTUBES

are available in quantity in numerous sizes. Made by G-M, pioneer in development and manufacture of quality phototubes.

G-M LABORATORIES INC.

4313 NORTH KNOX AVENUE, CHICAGO, ILLINOIS

Buy WAR BONDS & STAMPS



ULTRA-SENSITIVE MULTITESTER

25,000 Ohms per volt • Push-button operated

Designed for the needs of Today, this R. C. P. Model 492 Multitester provides the wide range of measurements and features required for general laboratory use. Its rugged construction and sturdy carrying case also make it an ideal unit for field and shop measurements on military, naval and radar equipment.

OUTSTANDING FEATURES

Dual D. C. sensitivity of 25,000 ohms per volt and 1,000 ohms per volt.

A. C. sensitivity of 1,000 ohms per volt.

All shunts and multipliers are matched and 1% accurate.

Wide-scale 4½" rectangular meter with a movement of 40 microamperes.

Readings as low as 1 microampere can be made.

Push-button operated. Meter circuit automatically opened if two or more buttons are actuated inadvertently.

Over-all dimensions of Model 492: 12½" x 10" x 6¼". Supplied ready to operate, complete with self-contained battery, test leads and a convenient carrying case with removable cover.

RANGES

D. C. Voltmeter:
0-2.5-5-10-25-50-100-250-500-1,000 volts.

A. C. Voltmeter:
0-2.5-5-10-25-50-100-250-500-1,000 volts.

Output Voltmeter:
0-2.5-5-10-25-50-100-250-500-1,000 volts.

D. C. Microammeter:
0-50-500 microamperes.

D. C. Milliammeter:
0-5-25-100-250-1,000 milliamperes.

D. C. Ammeter:
0-10 amperes.

Ohmmeter:
0-500-5,000-50,000-500,000 ohms, 5-50 megohms.

Decibel meter:
minus 10 db. to plus 54 db.

RADIO CITY PRODUCTS COMPANY, INC.

127 WEST 26th STREET — NEW YORK CITY

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


WEIGHT 2 LBS., CHRISTENED RADIOSONDE
... talks fluently from birth!
This tiny brainchild of meteorologists renders an invaluable service for all its short-lived existence!
Upper air soundings—to determine the pressure, temperature and relative humidity at various altitudes—are obtained by the use of the Radiosonde. It is carried aloft by a free balloon, and radio signals are transmitted to a ground receiving station where the signals are converted into respective readings.
When the balloon bursts—usually in the 20,000 feet vicinity—the instrument is carried down by means of a small parachute. Some thirty-odd stations throughout the U. S. make observations by this method.
This is only one of the innumerable peacetime applications of electronic tubes. With the advent of new advancements in the field of electronics, ELECTRONIC ENTERPRISES can be expected to achieve an important position — equal to that now assimilated in war work—in the development and production of these vital units. Inquiries are invited.
ELECTRONIC ENTERPRISES, INC.
GENERAL OFFICES: 65-67 SEVENTH AVENUE, NEWARK
NEW JERSEY

3 Plants ... 2 Flags ... ONE PURPOSE

To beat the band of Axis bandits, three Solar factories are now operating "round the clock". The men and women of Eastern Plants 1 and 2 were told "Well Done" by the Army and Navy; they proudly wear the Army-Navy "E".

The Midwestern Plant has just started production; the men and women of this modern air-conditioned factory are ready to help you speed the day of Victory.

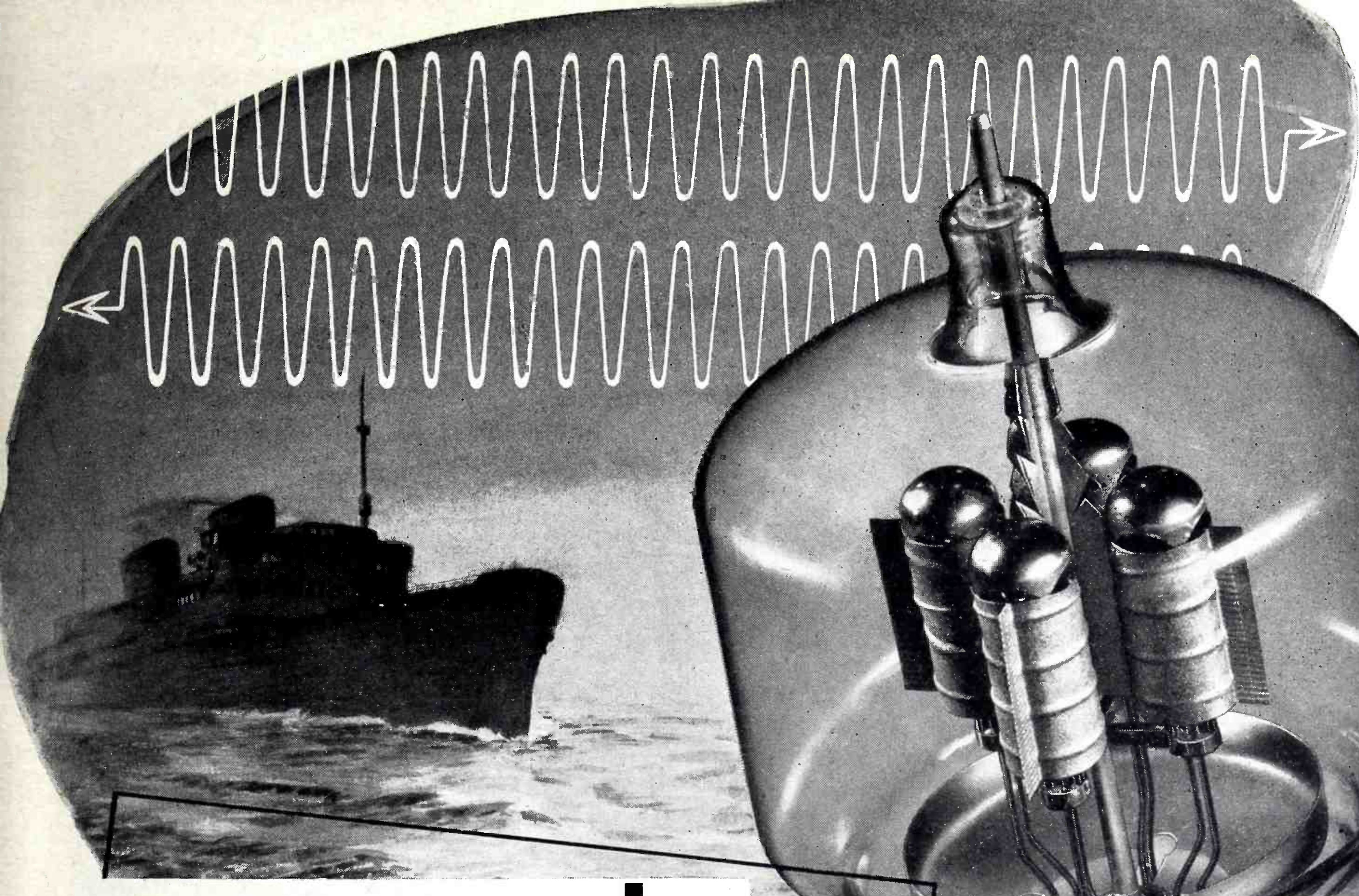
If your capacitor or filter problem is made ours, you can be certain of "Quality Above All".

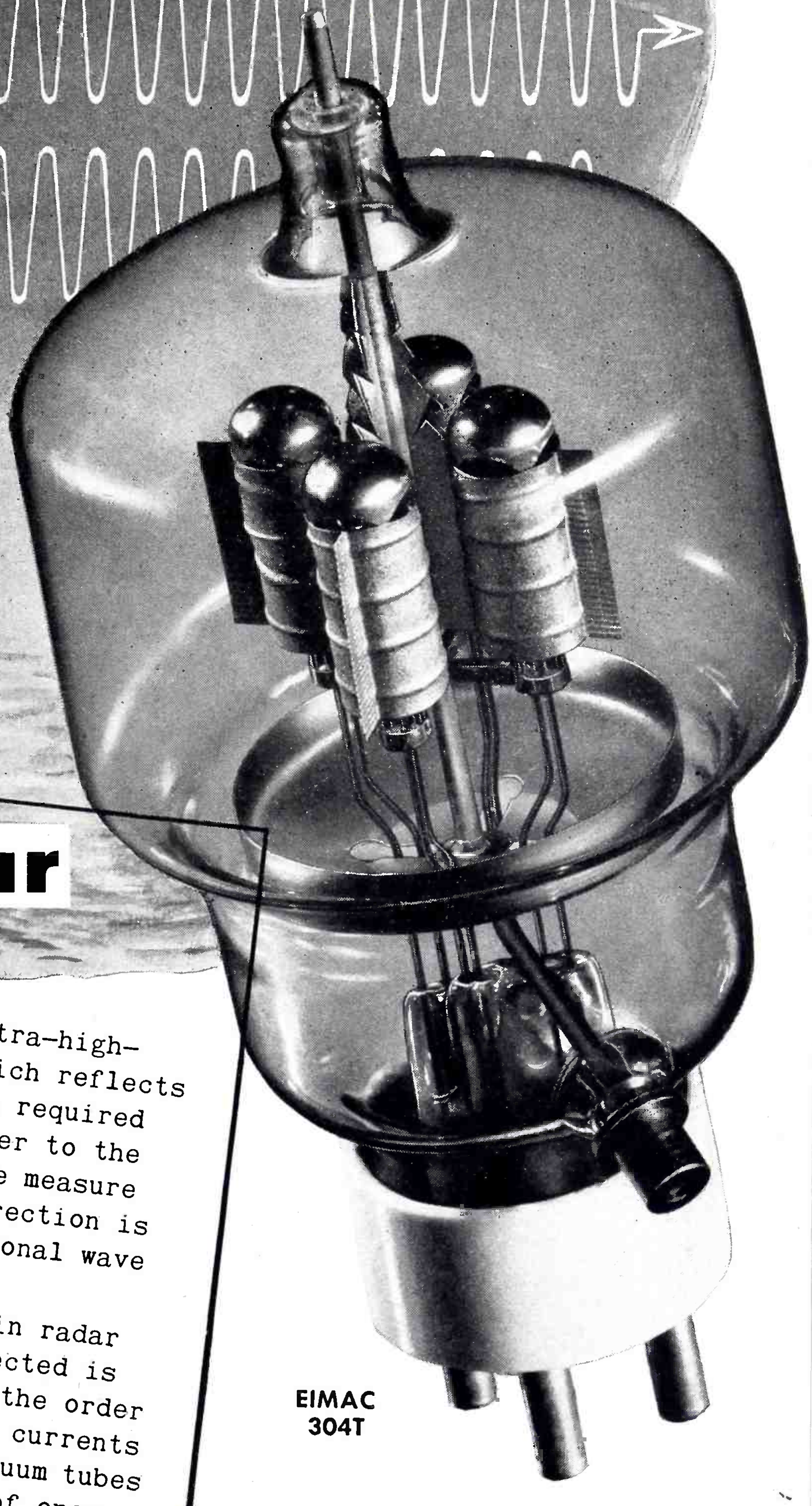
Solar Manufacturing Corporation, General Offices: Bayonne, New Jersey.

3762

Solar SOLAR CAPACITORS

CAPACITORS and RADIO NOISE-SUPPRESSION FILTERS





EIMAC 304T

electronic briefs: **radar**

Radar is a method of transmitting ultra-high-frequency radio waves to an object which reflects the wave back to its source. The time required for the round trip from the transmitter to the object and back to the receiver is the measure of the distance to the object. The direction is established through the use of directional wave transmission.

High transmitter power is essential in radar for the amount of energy which is reflected is extremely small. Plate voltages are in the order of tens of thousands of volts and plate currents are measured in tens of amperes. The vacuum tubes used in such equipment must be capable of operating efficiently and dependably over long periods under extremely heavy loads.

High voltage, high frequency, operation at absolute peak emission...ability to stand momentary overloads of as much as 400%...unconditional guarantee against emission failure due to gas released internally...are the features which marked Eimac tubes as ideal for this important application. These are some of the reasons why Eimac has been "Standard" in Radar transmitters for the past number of years. Just one more proof that Eimac tubes are first in the important new developments in electronics.

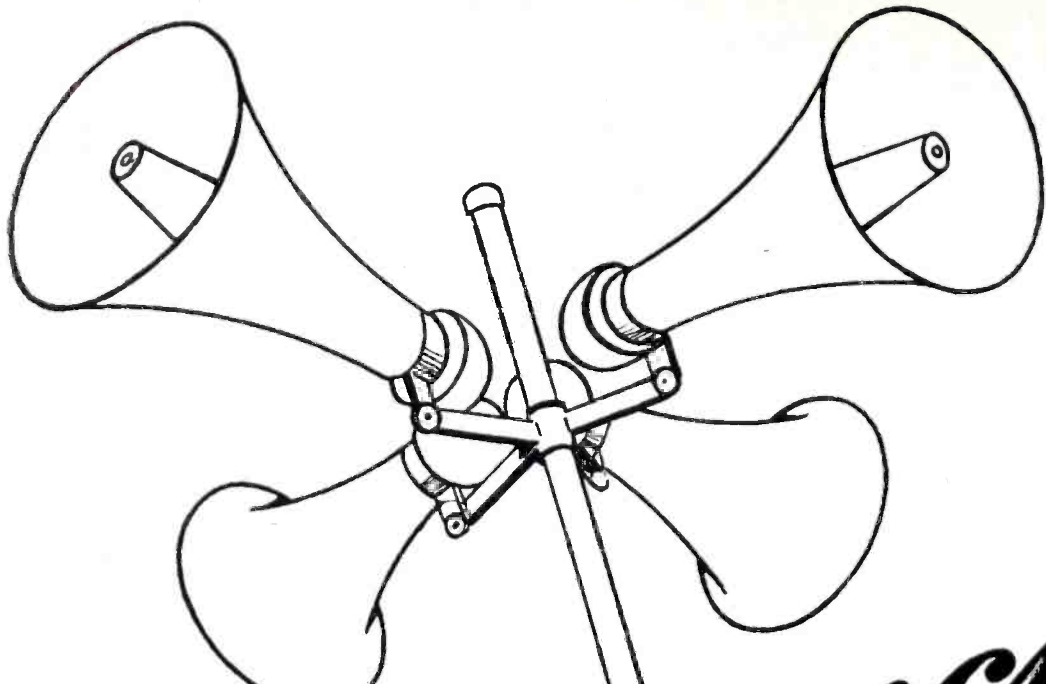
EITEL-McCULLOUGH, Inc.
SAN BRUNO, CALIFORNIA
Export Agents: Frazar & Hansen
301 Clay Street, San Francisco, California, U. S. A.

Follow the leaders to

Eimac REG. U. S. PAT. OFF.
TUBES

ARMY E NAVY

Awarded for high achievement in the production of war materials.



Announcing WEBSTER PRODUCTS

ELECTRICAL, RADIO, PHONOGRAPH, AIRCRAFT APPARATUS

EFFECTIVE APRIL 1st, 1943

Precision WEBSTER PRODUCTS

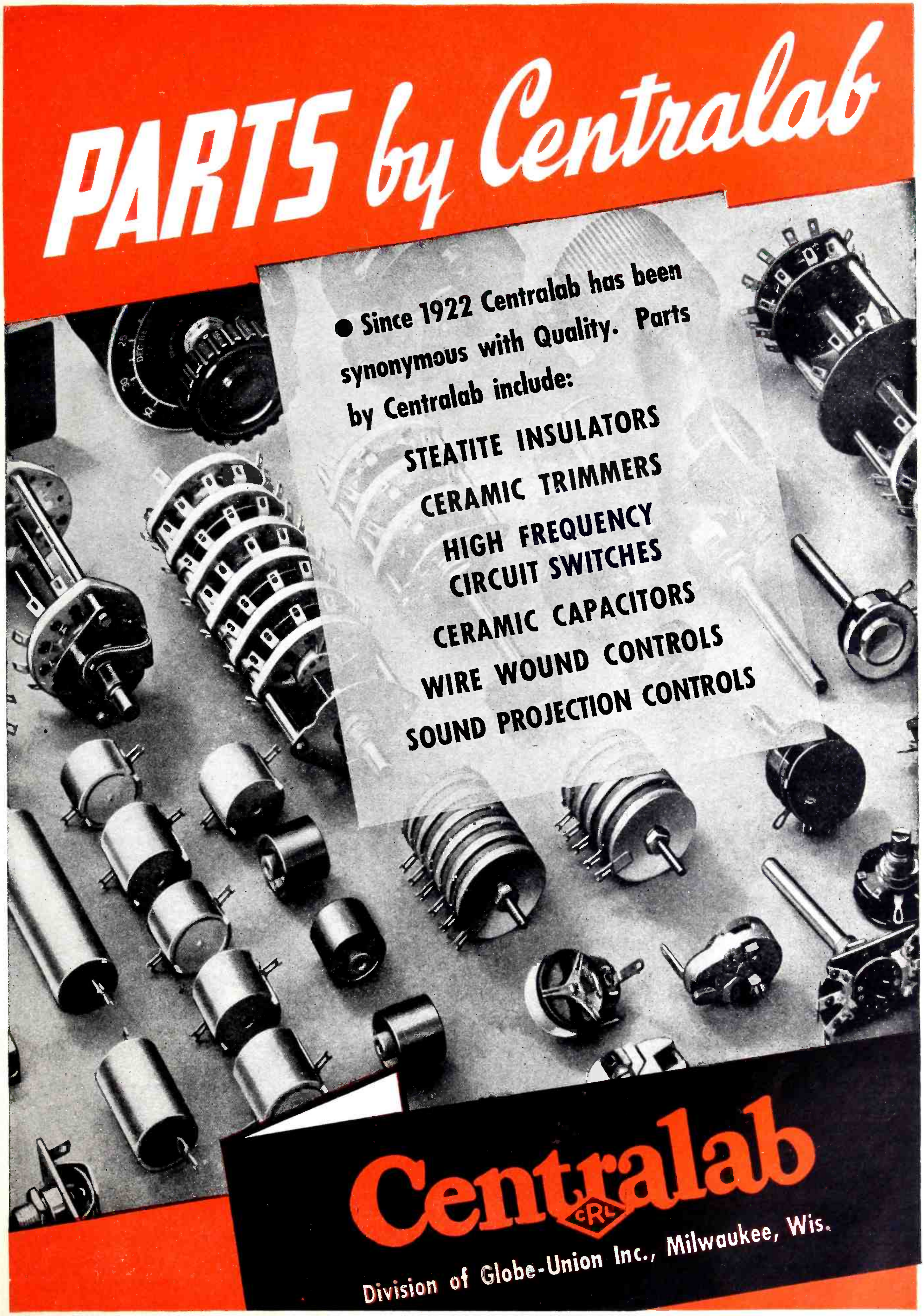
- DYNAMOTORS
- GENERATORS
- INVERTERS
- SMALL MOTORS
- VOLTAGE REGULATORS
- SPECIAL INSTRUMENTS

Webster Products has purchased and will continue operation of the business of the Armitage Avenue Plant of Webster-Chicago Corporation. With *all* of the personnel and facilities previously used in operation of the Armitage Avenue Plant, additional engineers, *plus* newly acquired machinery and equipment . . . Webster Products is fully qualified to continue the business on the highest standards of quality and service.

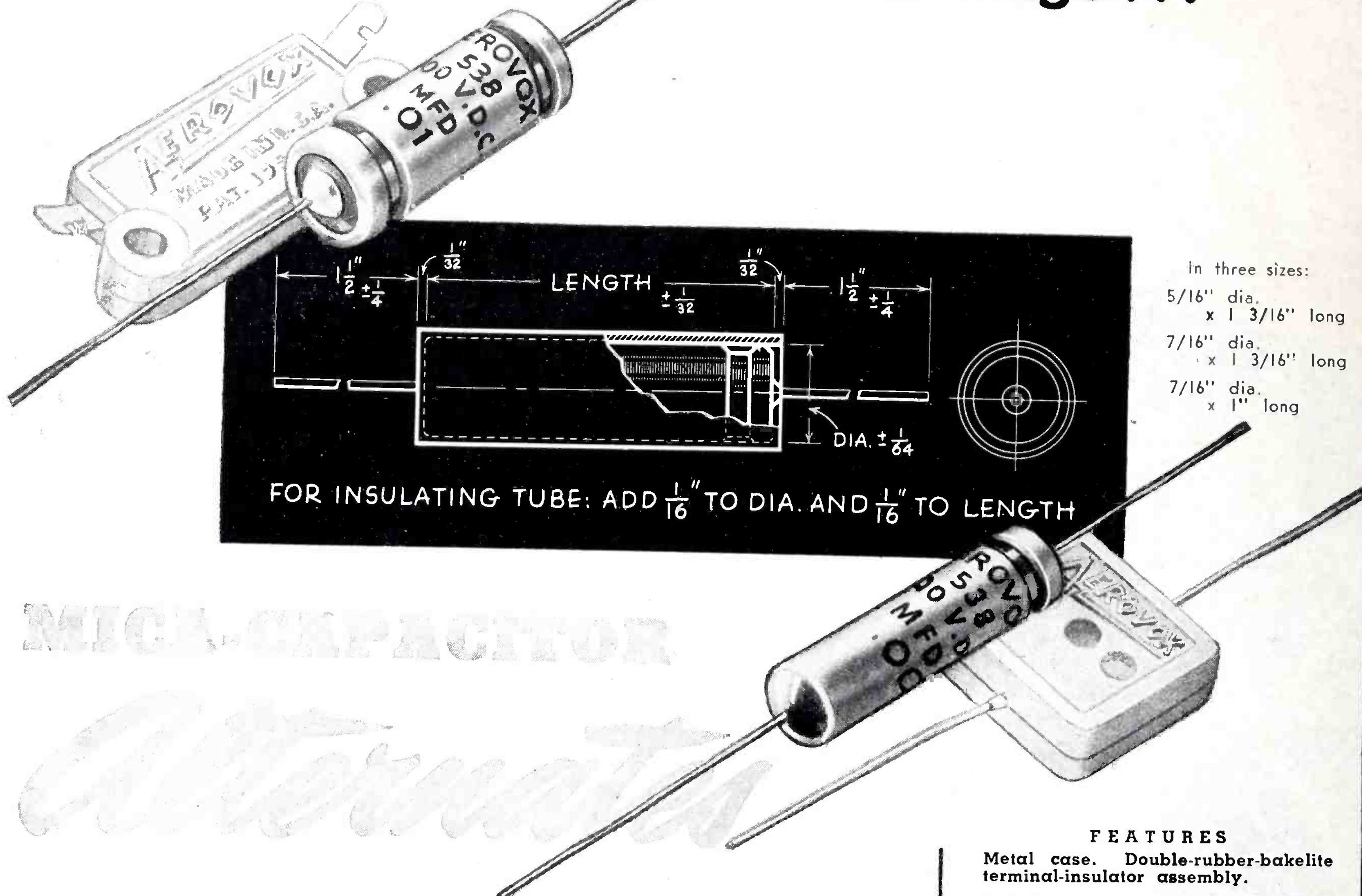
We invite your inquiries and will welcome your detailed investigation of our facilities.

WEBSTER PRODUCTS

3825 ARMITAGE AVENUE · CHICAGO


PARTS by Centralab
● Since 1922 Centralab has been synonymous with Quality. Parts by Centralab include:
STEATITE INSULATORS
CERAMIC TRIMMERS
HIGH FREQUENCY CIRCUIT SWITCHES
CERAMIC CAPACITORS
WIRE WOUND CONTROLS
SOUND PROJECTION CONTROLS
Centralab
CRL
Division of Globe-Union Inc., Milwaukee, Wis.

Meeting the mica-capacitor shortage . . .



In three sizes:
5/16" dia. x 1 3/16" long
7/16" dia. x 1 3/16" long
7/16" dia. x 1" long

● An alternate choice for those hard-to-get mica capacitors in most applications—that was the problem put up to Aerovox engineers.

Various applications were studied. Voltages, capacitances, frequencies, power factor—these and other factors were considered along with dimensional limitations, after the manner of A.A.E.* Out of it all evolved this new Aerovox Type 38 mica-capacitor alternate now in production.

Here is a miniature oil-filled metal-case tubular. Ideal for assemblies where both space and weight are at absolute minimum. Requires no more space than mica capacitor it replaces. Conservatively rated. No skimping of insulation or oil-fill despite minute dimensions (see drawing). Meets all standard specifications for paper-dielectric capacitors used as mica alternates. (See brief specifications)

Type 38 mica-capacitor alternate is but one of several new wartime capacitors described and listed in our latest Capacitor Catalog. Write on business letterhead for your registered copy.

*Aerovox Application Engineering.

FEATURES

Metal case. Double-rubber-bakelite terminal-insulator assembly.

Both terminals insulated or with one terminal grounded to case. Pigtail terminals.

Normally without outer sleeve. Can be had with insulated sleeve, adding 1/16" to diameter and length. Note dimensional drawing.

Vegetable (Hyvol) or mineral oil impregnant and fill.

300 to 800 v. D.C.W. Capacities of .001 to .01 mfd.

DIMENSIONS

Capacitance tolerances up to but not including .01 mfd. —20% +50%; .01 mfd. —10% +40%.

OUR WAR EFFORT

From January 1941 to December 1942, Aerovox . . .

- Stepped up production output 500% for our armed forces.
- Increased production floor space 300%.
- Sought, hired, trained and put to work additional workers—a 300% increase in productive personnel.
- Opened second plant in Taunton, bringing work to available workers there.
- And—doing more and more; growing week by week!

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.

LUMARITH* Foil

LUMARITH, because it is resistant to electrochemical oxidation, does not promote corrosion—the Black Hand that cuts short the life of coils and transformers, crippling vital military and industrial equipment.

Corrosion of copper wire induced by many insulating materials represents a "built-in" hazard. Copper wire wound in a coil insulated with LUMARITH foil has been found to be as free of the hazard of corrosion as if it were suspended in free air.

Major manufacturers are finding LUMARITH the answer to an increasing number of insulation problems. LUMARITH is non-corrosive. It has high dielectric strength and high resistivity.

Celanese Celluloid Corporation, *The First Name in Plastics*, a division of Celanese Corporation of America, 180 Madison Ave., New York City. *Representatives:* Cleveland, Dayton, Philadelphia, Chicago, St. Louis, Detroit, Los Angeles, Washington, D. C., Leominster, Montreal, Toronto, Ottawa.

a Celanese* Plastic

*Trade Marks Reg. U. S. Pat. Office

WIRELESS INC.

Developers and Manufacturers of

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

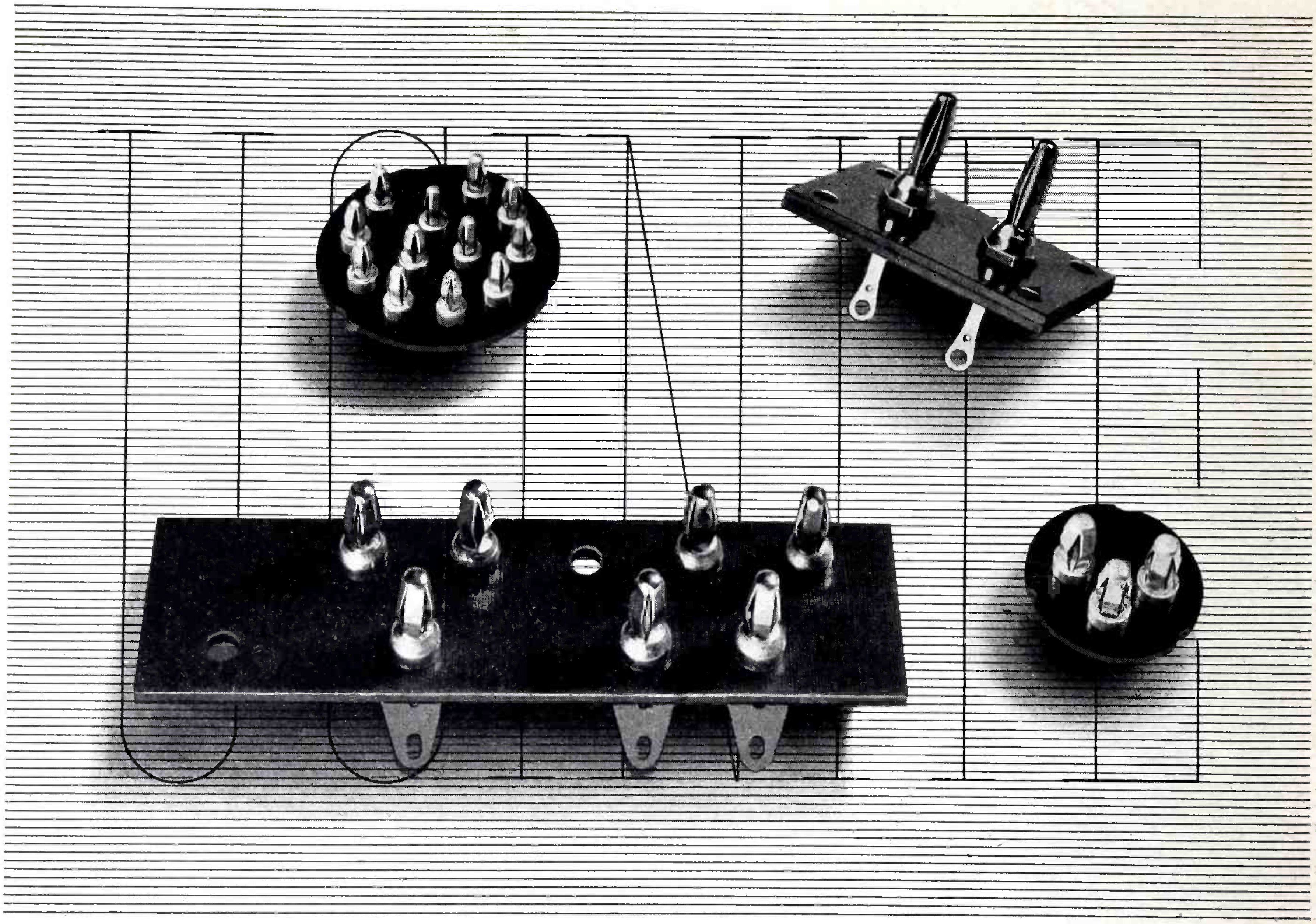
AND OTHER TYPES OF RADIO AND COMMUNICATION EQUIPMENT.

Awarded to our Hicksville, Long Island plant for outstanding achievement in war production.

Sales Offices, Manufacturing Division

1475 BROADWAY, *NEW YORK CITY*

• RIO DE JANEIRO • MONTEVIDEO • SANTIAGO DE CHILE



SCHEDULED FOR DELIVERY SOME TIME IN 194?

A GREAT NEW Motorola FM PHONOGRAPH-RADIO COMBINATION

A new and distinctly *better* type of home radio combination was about ready to make its bow to the American public when war drafted the complete Motorola facilities. Had this *static and noise-free* F-M receiver been seen and heard by the general public, it would have aroused unqualified enthusiasm . . . whetted an appetite that will have to be satisfied when Peace once again releases electronic talents and skills war-sharpened for radio's greatest progress and achievement. In the interests of national defense, Motorola is now delivering the finest in F-M emergency broadcast and receiving equipment. You may look for notable scientific developments in F-M radios from Motorola engineers. We can't say *when* . . . but we *can* say that no one will be ready sooner.

Expect big things from Motorola!

THE ARMY-NAVY "E"—Awarded for excellence in the production of Communications Equipment for America's Armed Forces

Motorola Radio Communications Systems Designed and Engineered to Fit Special Needs

GALVIN MFG. CORPORATION • CHICAGO

Are you having trouble obtaining PRECISION PLASTIC PARTS?

NEW METHODS ENABLE US TO MACHINE PLASTICS TO TOLERANCES AS CLOSE AS .0005

SMALL QUANTITY EXPERIMENTAL PIECES OR LARGE PRODUCTION RUNS

ALL FIXTURES, TOOLS, JIGS and DIES MADE IN OUR MODERN TOOL ROOM

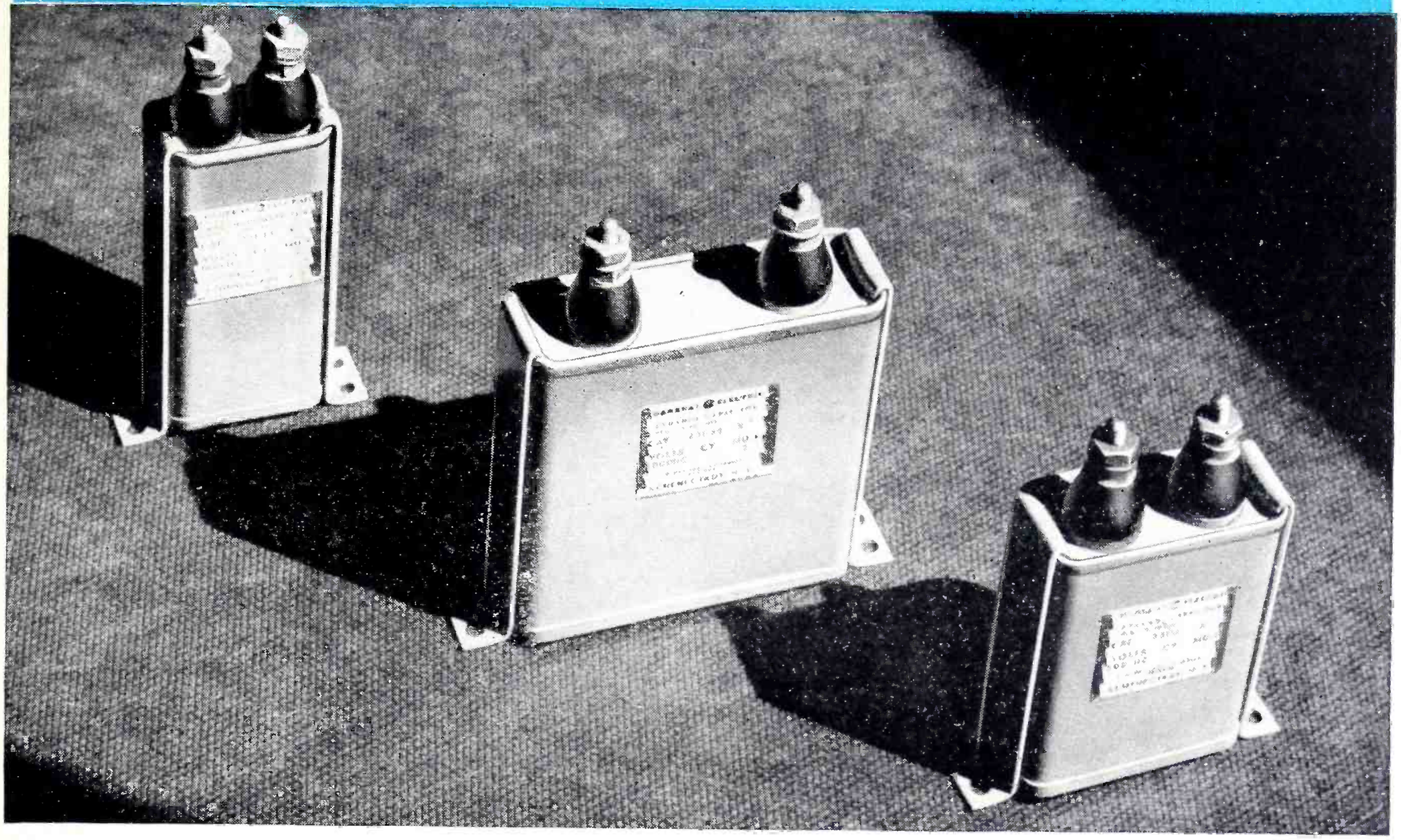
LET *Us* WORK OUT *Your* PROBLEMS

ALSO SPECIALIZED INJECTION MOLDING OF SMALL PARTS, INTRICATE INSULATING and INSERT WORK

Quotations submitted upon receipt of print *(Include priority ratings)*

ARNOLD BRILHART Co. 435 MIDDLENECK RD. GREAT NECK, N.Y.

It's easy for you to design with
PYRANOL CAPACITORS



More than 350 *standard* ratings to choose from, in sizes and shapes to meet your requirements *best*

COMPACTNESS— High capacitance per cubic inch, because of Pyranol's unusual dielectric properties.

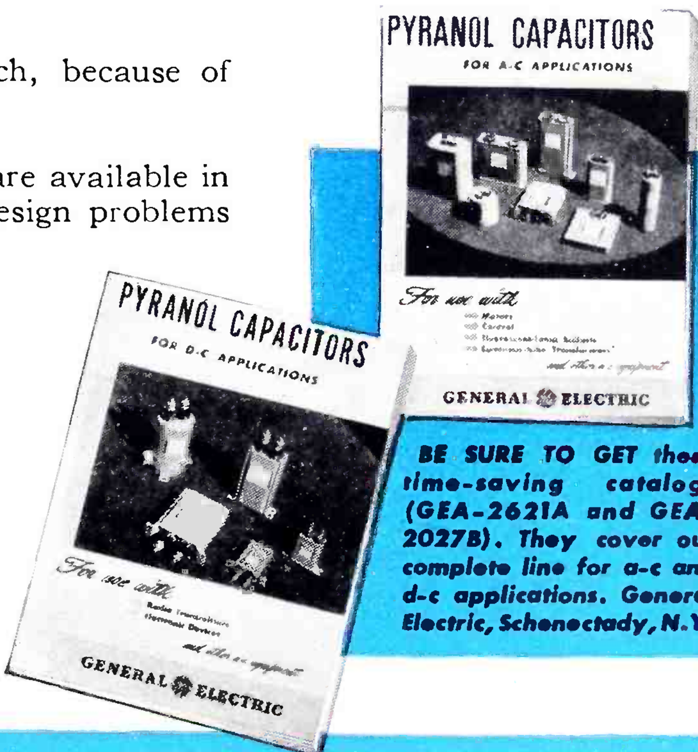
SPACE-SAVING SHAPES— Many of the ratings are available in oval, cylindrical, or rectangular cases to make your design problems easier.

CONVENIENCE— They will work equally well mounted in any position.

DEPENDABILITY— Hermetically sealed for permanence and uniformity of characteristics.

LONG LIFE— Ensured by superior materials, supervised manufacture, individual testing.

Pyranol is the G-E trade name for askarel, a synthetic, noninflammable liquid used in treating G-E capacitors.



BE SURE TO GET these time-saving catalogs (GEA-2621A and GEA-2027B). They cover our complete line for a-c and d-c applications. General Electric, Schenectady, N.Y.

GENERAL ELECTRIC

407-68-6700

LOOK

to TINNERMAN

for newer and faster fastenings

Many New Types Just Released

• Turn your beam on the steady stream of new SPEED NUT shapes and sizes. High-precision production is turning them out at machine gun speed. Demand is spreading to more and more applications. Why? Because Speed Nuts drastically reduce weight and cost. Because they lock on screws with a firm spring tension grip that prevents vibration loosening. And because they can be applied with a speed that breaks all previous records.

Many self-retaining Speed Nuts are snapped into position for blind location assembly requiring no riveting or staking. They need not even be touched or seen while making the attachment. Approved, too, by the U. S. Army Air Forces and the Navy Dept. Bureau of Aeronautics for most non-structural attachments.

Write for our new 20-page book No. 185 for complete description of our latest developments.

TINNERMAN PRODUCTS INCORPORATED
2106 FULTON ROAD, CLEVELAND, OHIO

IN CANADA: Wallace Barnes Co., Ltd., Hamilton, Ontario

IN ENGLAND: Simmonds Aerocessories, Ltd., London

THE FASTEST THING IN FASTENINGS!

Engineering Design
—Creator of America's Mechanized Might

In war, as well as in peace, the design engineer is the vital link between the inventive mind and the mass-production reality

It is gratifying and interesting to note that reports of new "secret weapons" not only have reversed their course during the past few months . . . they also have increased in frequency. Once they filled us with dread and misgiving. Today the enemy does the worrying.

Word about the latest new Army weapon reached us as this was being written . . . a 2½ ton truck that performs on water as well as on land with equal efficiency. "The Duck", resembling an overgrown amphibious jeep, is particularly suited to landing operations where docks are lacking. Loaded with 20 fully equipped soldiers or their equivalent in supplies, its propeller runs it ashore. It climbs the beach on its six-wheel drive and continues the trip on land.

This important addition to our "second-front" fighting equipment, coming so closely on the heels of the now famous tank-killing "Bazooka", is one of many history making contributions of American design engineers — the men who transform nebulous ideas into practical realities — the men who make our war machines superior to those of our enemies.

Invasion and eventual victory became a certainty as soon as America's design engineers threw their full effort into the war against aggression. Adapting intricate ordnance designs to mass production, these men developed weapons such as the M-10 destroyer of Rommel's tanks and brought out the new fighting planes and bombers that have won the air superiority that has turned the tide against the Axis. Taking ideas and giving them form, selecting the materials of construction, deciding upon the method of fabrication, adapting the electrical and mechanical parts that power the product, specifying the finish that protects and beautifies it . . . these men are the focal point of American production. Their ingenuity has no parallel. Once they put automobiles on a mass production basis and within the reach of all. Today, after less than three years and with little previous experience in armament design, they have brought America's war weapons to the highest efficiency . . . surpassing Hitler's weapons despite all the vaunted scientific wizardry of the Germans and their ten year start.

At this point it is well to remember that while Germany's military might is traceable to its superiority in armament, many of the basic technological discoveries (including the airplane and the submarine) are the products of American genius. The Germans always have been aware of the military advantages of technological superiority and have forced its expansion with all their might. They knew that mobility and surprise play a decisive role in modern warfare and their design engineers were kept busy, with unique intensity, to achieve unprecedented results in fast-moving, hard-hitting fighting equipment. Our own military and industrial engineers did not go into action until it became certain that we would be involved in the conflict. But even before our country actually embarked on its Preparedness Program they were busily engaged in developing the designs of our war equipment. Tanks, planes, guns, ships and hundreds of other apparatus and machines of war were studied. Carefully selected committees of our national engineering societies were organized under the leadership of the Army Ordnance Department to serve as advisors and consultants in the development of advanced designs of tanks and other motorized equipment of war. The above mentioned "Duck" and the now famous Sherman tank are just two of the many results of these efforts.

After the Preparedness Program had officially been launched and Congress had made its initial appropriation, it was necessary to create the manufacturing blueprints from which the engines of war could be built. Because the designs of the machines of production, as well as the designs of the products themselves, determine the speed and economy with which anything can be manufactured,

This is the thirteenth of a series of editorials appearing monthly in all McGraw-Hill publications, reaching more than one and one-half million readers. They are dedicated to the purpose of telling the part that each industry is playing in the war effort and of informing the public on the magnificent war-production accomplishments of America's industries.

the capacity of our industrial system is dependent, to a considerable extent, upon the ability and ingenuity of American design engineers. Germany's military might was successfully mechanized because Germany, for more than 10 years preceding the war, was riding the wave of a world-wide technological revolution. This revolution was as far-reaching as the advent of the electric motor and the internal combustion engine. It was born of the profusion of inventions and discoveries since the last war. German design engineers took advantage of every one of these.

If we are to defeat our enemies and if we are to continue to play the leading role in the post-war world we must make better use of the new technology than do our enemies. The job is up to American product engineers who already have made tremendous strides in designing the intricate machinery of production and of war equipment. Much remains to be done however.

It has been said that the Germans have not developed one single item that can be classified as basically original, nor are there indications that any so-called "secret weapon" will henceforth be developed by them. Today the Nazis are completely outclassed by the tremendous manpower of engineering brains that is at the disposal of American industry. Although we were faced by the same fundamental problems of shortages in materials, manpower and time, our engineers not only solved these problems quickly and effectively, but they outstripped the enemy by the preponderant weight of talent which we were able to bring to bear upon our problems. As is evidenced by studies of the designs of captured German war equipment, our airplanes are faster, carry heavier loads, have superior protective armor and heavier armament. Our tanks, especially the Shermans, stand unmatched. Our tractor-mounted artillery excels theirs in fighting power. Our automotive vehicles are the envy of the world. Our battleships are supreme. Our signal and detection devices are frustrating all of our enemies' attempts to dominate the seas.

And as we approach the end of the conflict, the pattern of which already has been set, the forces that converted American industry from peace to war-production will again be brought into play, and the product engineer will continue to be the fulcrum. Our post-war industry will grow from his blueprint. Nor will his job be any less urgent, any less responsible, any less sweeping in its effects than were his efforts during the war-preparedness program.

Since the cessation of the manufacture of peace-time goods, many new materials and production techniques have been developed. Plastics, synthetic rubber and magnesium in the field of materials were relatively new and restricted in their uses when war came. So were powder metallurgy, induction heating, electrostatic heating, adhesives for joining metals and compressed resin-impregnated wood. The new possibilities in product design created by the electronic devices and applications developed during the war period virtually stun the imagination and the "atomic revolution" promises to change the entire pattern of manufacturing operations.

Never before has there been so much speculation about the future as there is today. Looking forward, who can doubt our limitless capacity to continue our industrial world leadership?

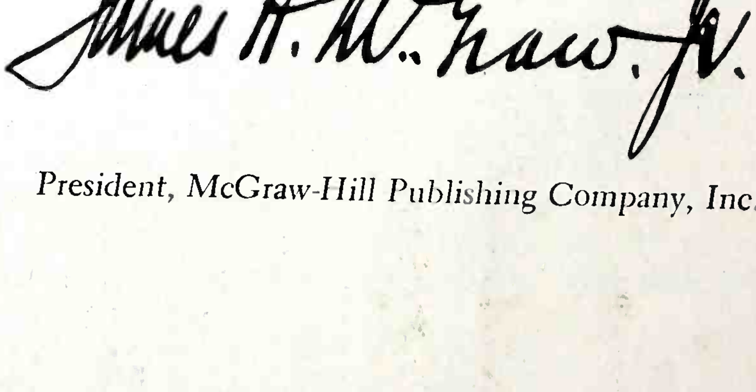
While no one can predict developments in product design in the post-war period, certain it is that they will be so vastly different and so far superior to existing designs that they will obsolete most products as we know them today. With engines of vastly superior metals, designed to burn 100 octane gasoline and built to a precision ten times greater than that of pre-war engines, our post-war automobiles will give from 40 to 60 miles to the gallon. Tires will last from forty to fifty thousand miles. The comfort and smoothness with which these cars of tomorrow will glide along are undreamed of today. Polaroid windshields will eliminate the glare of oncoming headlights and the driver will need to give but scant attention to the manipulation of his simplified gear shifts.

According to no less an authority than Igor Sikorsky, we stand on the threshold of a new air age in which the helicopter will contribute to the greatest prosperity we have ever known.

Prophecies are hard to make at a time like this but speedy house building seems to be a certainty in the world of tomorrow. Air conditioning, new methods of heating, humidifying and drying, promise to be necessities in the post-war home. Vacuum sweepers will be much lighter, less noisy and easier to manipulate. Washing-machines will be fully automatic and practically free of noise and vibration. Not only will our homes and most of the furnishings be of radically new design, but so will the factories and machines that produce them.

Only one factor can prevent the fulfillment of the dream of the product designer. His job is not accomplished over night. To convert sound ideas into production blueprints involves a great deal of time and money. The building of test models is an expensive and tedious procedure. An abundance of seed money is required to perfect the product, to develop mass-production methods and to bring it to fruition as a finished saleable product.

It is the patriotic duty of every industrial leader to hasten these developments so that the material benefits created by them may speed our progress along the road of abundance.



President, McGraw-Hill Publishing Company, Inc.

30 TO 50% WEIGHT

IN RADIO TRANSFORMERS AND OTHER ELECTROMAGNETIC APPARATUS WITH

HIPERSIL* CORES

On a soldier's back or in a plane, ounces quickly become pounds. That's why a new material that can cut weight *and* increase efficiency is important news.

Hipersil, the new magnetic steel, does just this. It increases flux-carrying capacity ⅓ . . . *saves 30 to 50% weight.*

At present, Hipersil cores are used in a steadily increasing variety of communication applications . . . in radio transformers, chokes, relays, reactors and loading coils. They should be used wherever high permeability is wanted at both high and low densities, and where high fidelity and light weight are of greatest interest.

Hipersil makes possible these design improvements:

SMALLER SIZE of core cross sections and coils . . . ideal for airplanes, tanks, submarines, "walkie-talkie" sets . . .

WIDER RANGE OF LINEAR RESPONSE. Knee of the saturation curve for Hipersil is higher than for ordinary silicon steel. It gives approximately ⅓ greater straight-line response for winding and core cross section.

SIMPLIFIED CONSTRUCTION. Split-core design makes coil and core easy to assemble, saves man-hours. No laminations—just two or four pieces to handle.

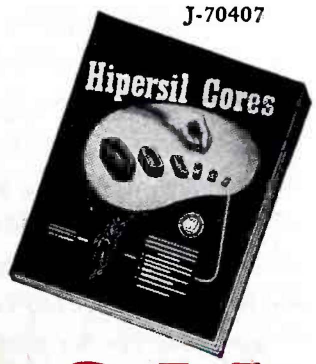
Ask your Westinghouse representative about standard Hipersil core sizes now available.

J-70407

*Registered trade-mark, Westinghouse Electric & Mfg. Co., for HIgh PERmeability SILicon Steel.

GET THE FACTS ABOUT HIPERSIL

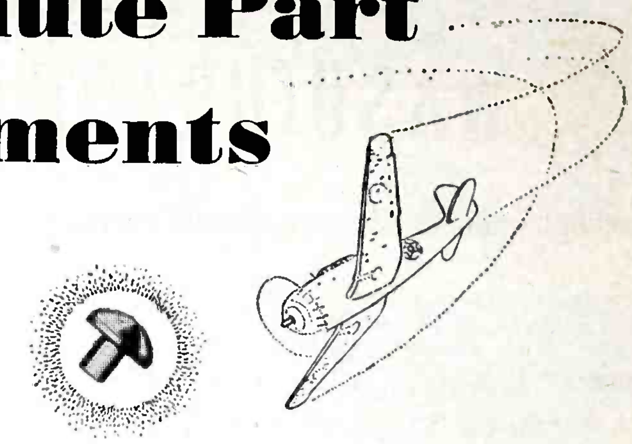
Write for B-3223, a data book crammed with application and performance facts about Hipersil. Address: Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.



Westinghouse HIPERSIL

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Even the Most Minute Part Has Its Big Moments



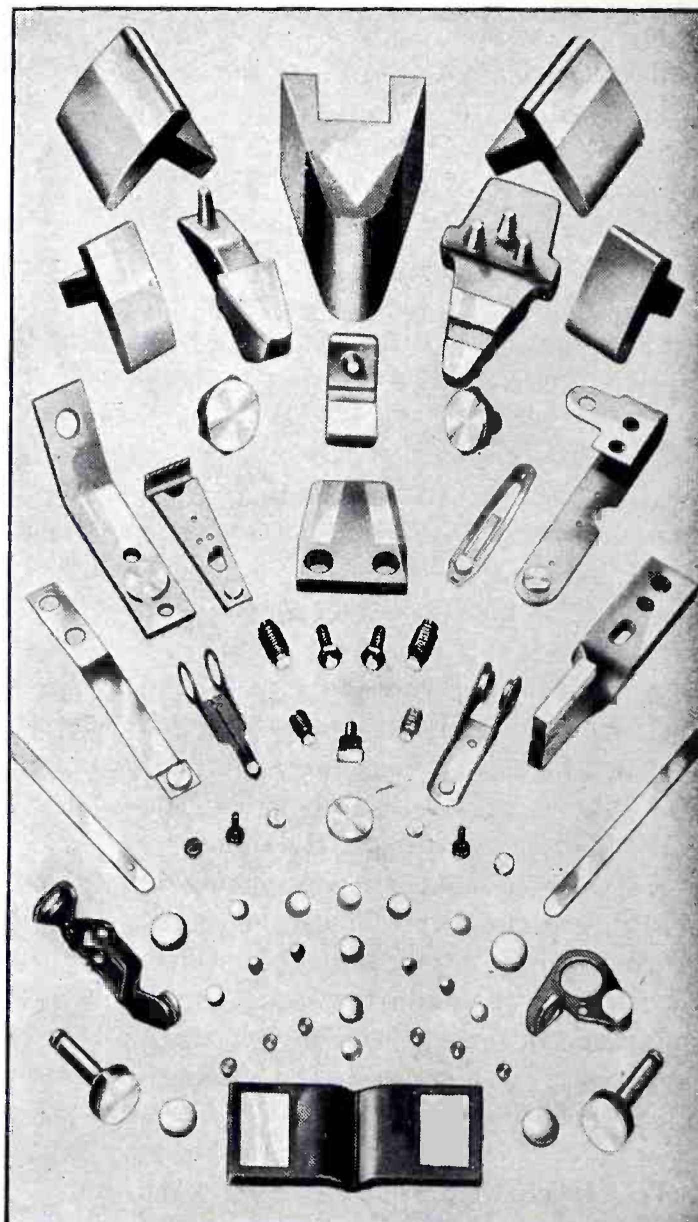
The contact points in a fighter plane's "turn and bank" indicators are not much for size, but they must be brutes for action. Like all component parts in a plane's electrical apparatus, they must function perfectly or spell trouble for the pilot. Always, he must be sure of his maneuver.

Under war need's pressure, a new type "turn and bank" indicator—an instrument in which the pointer remains stationary to show the degree of deviation from normal flight—called for contacts capable of operating 75 times a second, but extremely sensitive. Tiny contacts they are, less than a tenth of an inch in diameter, but they make and break the circuit that controls the speed of the gyroscopic motor.

Early in the designing, Mallory contact experience was sought. Standard contact materials set up excess arcing, creating unwanted radio interference. Then Mallory metallurgists, working against time, developed a combination of metals—standard tungsten for one point, Elkonium-34 for the other—that licked the problem in jig time. Just one contribution to the development of accurate combat maneuvers, to be sure, but an excellent example of how concentrated cooperation is functioning to insure that even the most minute part does its bit at the critical moment.

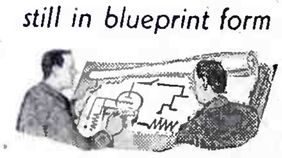
Mallory's years of contact experience and "know how," stimulated by war production demands, are furnishing innumerable solutions to perplexing problems of contacts and contact assemblies. Many of the applications developed in the Victory effort have significance for the future.

When you have contact problems, bring them to Mallory.



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

While the design is still in blueprint form



CONSULT MALLORY
for Contacts and Contact Assemblies

P.R. MALLORY & CO., Inc.
MALLORY

ELECTRICAL CONTACTS AND CONTACT ASSEMBLIES
NON FERROUS ALLOYS
POWDERED METAL ALLOYS

CROSS TALK

▶ **TRIVIA** . . . Outfit in Connecticut industrial city is having great trouble holding labor. It seems that this company does its government work on straight contract basis. Other outfits in same city, however, work on cost plus basis and are quite willing to pay fancy prices for labor. First company trains the men; second outfit hires them away.

In one of the high-powered laboratories working for the Government, bright engineers have been requested to keep their new ideas to themselves; not to tell armed forces about them. It seems that the boys can think up swell ideas faster than they can be put into production with the result that government men are always ecstatic about some new device which would win the war if they could get it. In meantime war goes on and men in field must fight with what we can produce right now. A thousand units today, no matter how much better they could be made later, are worth far more than the promise of a thousand deluxe units six months from now.

From a New York City plant making communication equipment for Signal Corps and Bureau of Ships, local draft boards take trained men so fast the owner of the place is about to give up and quit. Unable to get men and train them as fast as they are required to fill local quotas he is falling down on contracts. In spite of representations by both service branches stating how important to the war is the material being manufactured, men are being taken away steadily.

▶ **CAMPAIGN** . . . Now that the United States Rubber Company has bought the rights to broadcast the New York Philharmonic-Symphony orchestra over CBS, an opportunity exists for both sponsor and broadcaster to cultivate the vigorous and enthusiastic market residing in thousands of FM receiver owners. This No. 1 high-quality program should be put on FM stations; and somebody has done a bum selling job if this celebrated orchestra with its many years of CBS broadcast history is not on FM stations.

▶ **EXPEDITING** . . . There is no substitute for brains when it comes to breaking production bottlenecks and getting out gear needed for the war effort. But a fresh viewpoint helps too. Some of the expediting boys who are not hampered by too intimate a knowledge of how things have always been done before are proving it.

A good example of what can be accomplished is the case of the assembler who ordered a hundred ten-foot lengths of coaxial from a cablemaker. He waited five months for delivery and then became impatient. A man was sent over to the busy plant. He didn't find any cable ready to ship but he did spot, over in a corner, miles of the stuff that had apparently been discarded.

"What's that cable?" he asked. "Oh," he was told, "that stuff was rejected because the outside diameter is not uniform." Momentary silence on the part of the expediter, and then: "It may not have uniform o.d. in long lengths, but how about checking it to see if you can't get a hundred ten-foot pieces out of it?"

Result: 85 cables were shipped in the next two weeks!

The ENGINEER'S PLACE in

New industrial electronic applications will make it necessary for designers to maintain closer contact with prospective customers. Equipment manufacturers will, of necessity, lean more heavily upon their top technicians for administrative and marketing help

By S. S. EGERT

NEW APPLICATIONS of tubes will undoubtedly bring about radical changes in the responsibilities of electronic engineers after the war. They will simultaneously create new administrative opportunities for such engineers.

In the past, much of our industry's business consisted of radio receivers designed for the man in the street. Most of the ultimate customers for industrial electronic equipment will be technicians of one kind or another, instead of laymen having little technical background. This difference in the character of an important new group of customers, and the varied nature of industrial jobs they want done, will make it desirable for the electronic engineer to maintain much closer contact with the field. It will be necessary for electronic equipment sales organizations aiming at this group to lean more heavily upon their engineers for marketing help.

New responsibilities will involve additional work, not directly associated with the laboratory. Let us examine some of these extra functions and speculate concerning their probable influence upon the development of the industrial electronics field and, particularly, upon the future of electronic engineers.

Designing Products for Industry

The electronic engineer will find it necessary to assume more of the responsibility for the physical appearance and mechanical design of equipment. In industry, physical design cannot be dictated by mere saleability of appearance. This contrasts sharply with recent practice in the radio receiver field.

Obviously, the answers to physical and mechanical design problems involving functional effectiveness, ability to "take it" and safety in operation are not in the laboratory. They are out in the field. It would be well for the engineer designing industrial electronic equipment to take this point seriously as it is of great importance. The future may otherwise see many excellent circuits fail because they are improperly housed and protected for industrial requirements. Two identical devices may have to be housed differently, depending upon the industry they are to go into.

Assisting the Sales Department

Advertising managers and agencies will lean more heavily on the electronic engineer in the future. Industrial literature, to be effective, must give facts and only the engineer can supply these facts.

Engineers who are in administrative positions should study literature of other established industries as well as that of their own. Great savings in correspondence about a company's industrial electronic products can be made if questions are anticipated and answered in printed data sheets. The engineer will not only aid his sales department by cooperating in the preparation of printed matter of all kinds but will also conserve much of his own time thereafter.

Five suggestions which may prove helpful are listed below:

(1) Make descriptions short and to the point. A set of specifications with short summations is often more helpful to the industrial prospect than a lengthy description.

(2) Graphs and curves are highly descriptive. They tell more about the performance of certain types of equipment than any number of words. Use them freely and whenever possible.

(3) Large and clear illustrations should be used. Good photographs are much more than just advertising. They can effectively and usefully illustrate constructional details and physical layouts.

(4) Use the language of the industry you are particularly interested in influencing. Realize that terms and definitions may vary widely from one industry to another.

(5) Dimensional line-drawings of components and complete units are of the utmost importance. They tell the industrial engineer immediately if a component or unit can be readily fitted into an available space.

Training of Service Specialists

The problem of servicing industrial electronic equipment is entirely different from that in the radio receiver field.

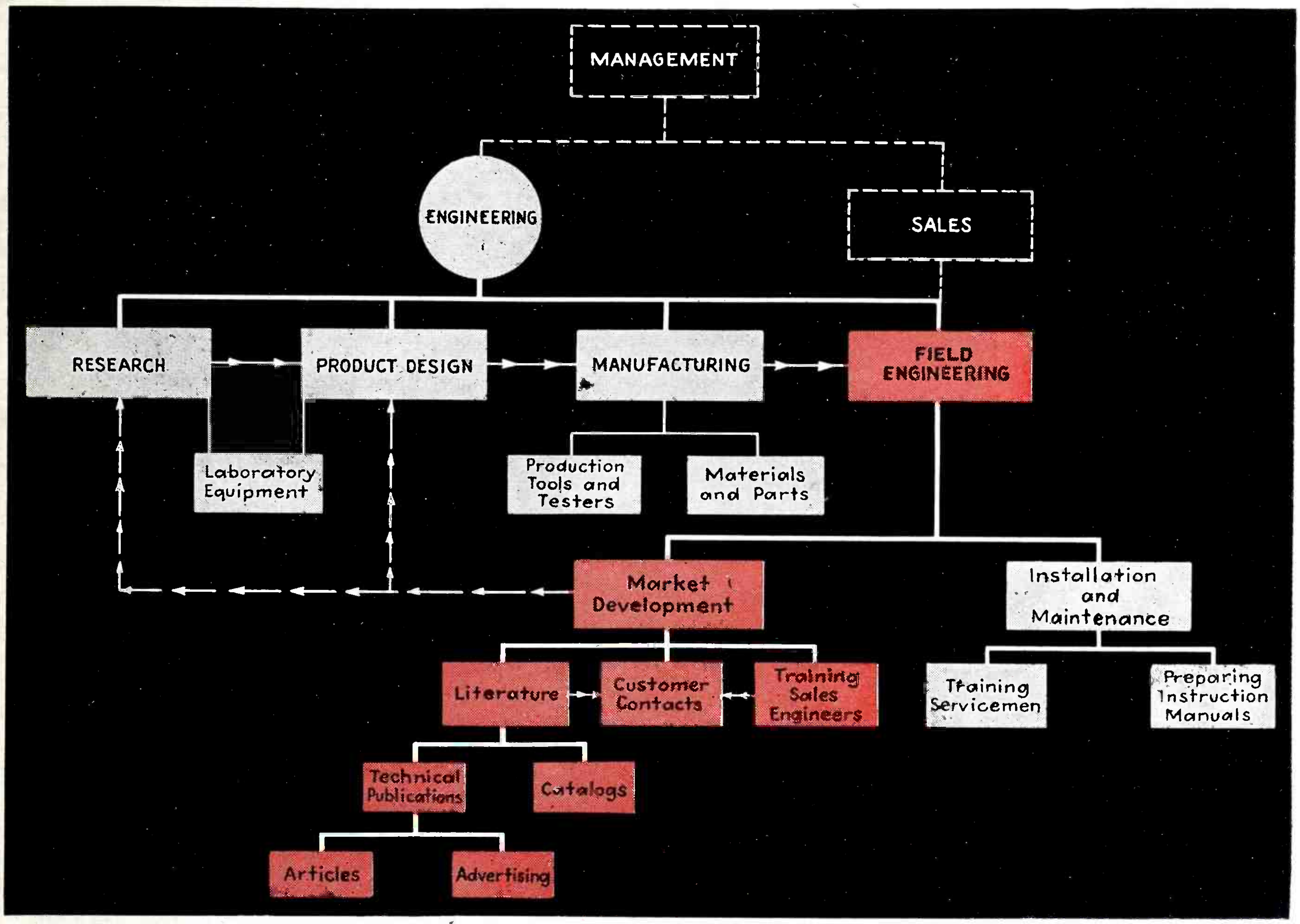
In industry, and particularly in connection with production machinery, a slight delay in making electronic apparatus repairs might involve tremendous cost to the customer if he has to shut down while the machine is idle. Therefore, highly-trained service specialists must be

From the FIRING LINE

THE AUTHOR is a salesman of electronic apparatus, with a technical background and considerable experience among both communications and industrial accounts

He passes along a few suggestions to the "boys back in the laboratories" concerning development of the industrial market as contrasted with the radio receiver market, based on personal observation of important differences between the two

the POST-WAR PICTURE



Functions shown in red are particularly important factors in the development of the industrial market

created to perform this duty quickly and properly. It will be the responsibility of the industrial electronic engineer to select, train and supervise these men.

The background of servicemen will vary from that afforded by a trade school to the preparatory education obtained in an engineering college, depending upon the service to be rendered in the field and the nature of the equipment. The reservoir of suitable men is at present so dry as to be almost non-existent. So the training of servicemen will have to be started from scratch in many instances, after the war. Field maintenance work will be excellent basic training for younger men starting in the industrial electronics field and aiming at eventual engineering and administrative jobs.

A word is desirable here about the writing of instruction manuals. All engineers, and particularly those in administrative posts, must realize the value and importance of clear, concise and accurate instruction booklets. To a large extent the suggestions for sales literature preparation listed above also apply to the writing of manuals. Engineers will, of course, have to cooperate in their preparation, or handle the entire job.

Developing New Applications

The industrial electronic engineer of the future will of necessity be more concerned with marketing problems than he has wanted to be, or has been permitted to be, in the radio receiver business.

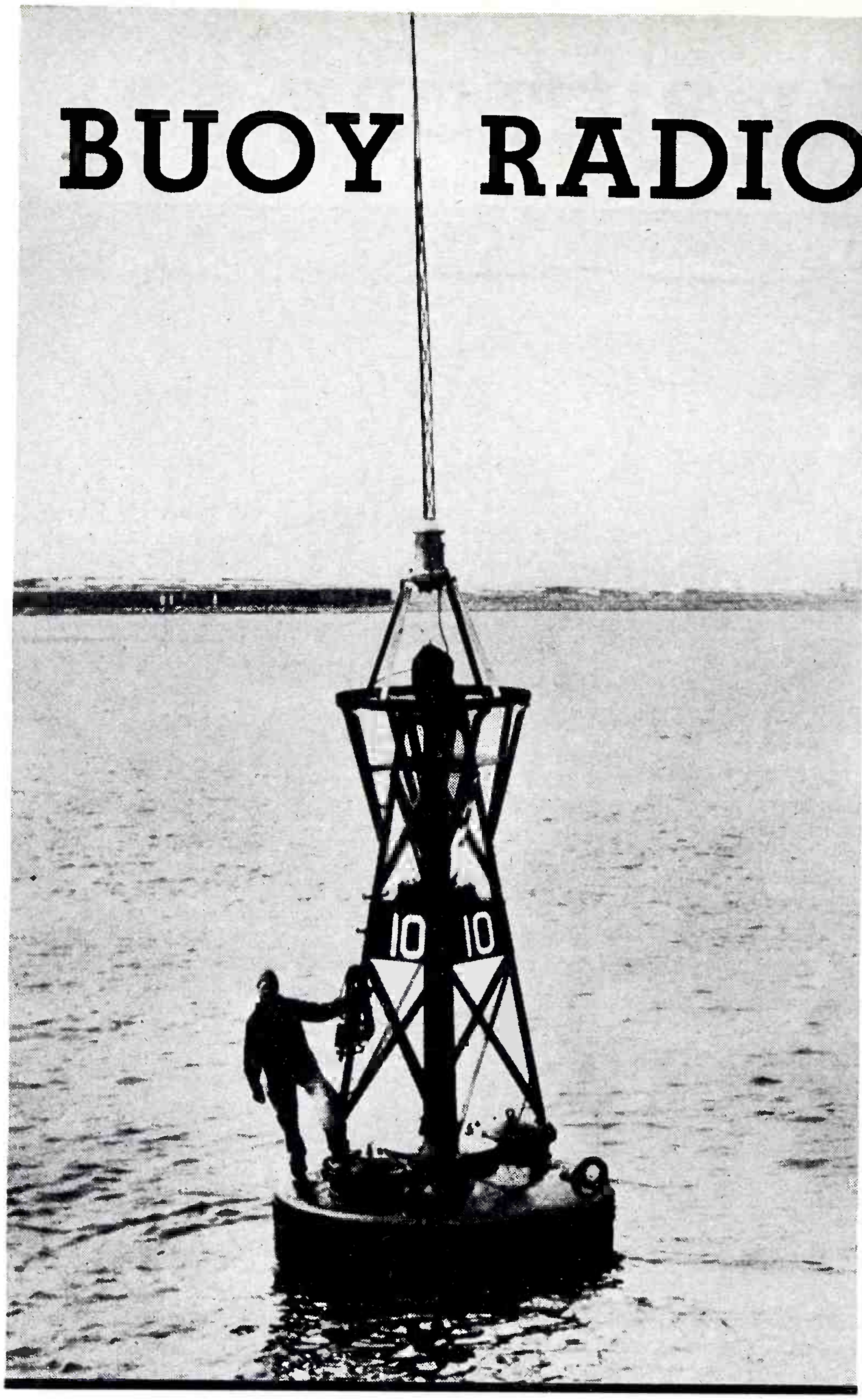
Problems which only the engineer can solve will arise frequently in the coming search for industrial markets and in the later efforts to capture these markets. It is well-known that the potential market for industrial electronic equipment is very extensive. Many applications, however, are so deeply hidden in a labyrinth of complex mechanisms that only the trained engineer will be able to uncover them.

Constant reading of industrial publications can lead the engineer to added markets. Preparation of papers concerning new developments by the engineer himself can also be of great value in the search for new applications. For example, publication in ELECTRONICS of a paper describing new methods for the high-frequency-heating of wood adhesives would carry the message broadly to all industry. This would not only reach prospects in the wood product manufacturing field but would also,

(*Continued on page* 156)

BUOY RADIOBEACONS

Unattended transmitters, housed in buoys anchored near channel and harbor approaches before the war, aided ships through difficult waters when abnormal conditions reduced the effectiveness of lights, bells and horns. Pilots identified buoys by their emitted characteristic codes. Radio direction finders were then used to "run them down"



A radio-equipped buoy "on station." The storage-battery-operated transmitters stow away below waterline in a sealed "pocket" within the hull. A flexible coaxial cable carries r-f output up to an antenna coupling unit at the top of the superstructure. The 15 ft. monel-metal radiator mounts directly on a ceramic insulator included in the antenna coupling unit protective case design

SHIPS navigating in open waters offshore, near populated coasts, have long been able to get a good position "fix" by radio.

Originally, they turned on their transmitters, called land stations having direction-finding equipment and held their keys down while these stations manipulated loop receiving antennas. When the shore stations had determined the compass bearings of the ships with respect to their own positions in this manner they passed the information along by radio. Navigators then plotted bearings received from two or more widely-separated land stations on their charts and placed their vessels where these lines intersected.

Later, many ships were equipped with their own radio direction-finders and the process was exactly reversed, rendering unnecessary special transmissions between ships and shore. The ships merely tuned in identifiable radiobeacon shore stations, determined the bearings of such stations and plotted their positions from this data. Certain selected shore stations and lightships transmitted continuously for this purpose during fog or thick weather, constituting radio "lighthouses" or radiobeacons. During clear weather these radiobeacon signals were broadcast every half hour on scheduled operation to permit navigators to obtain position fixes frequently, thus minimizing chances of observational error by reason of lack of practice and familiarity with radio direction finders.

Ships operating in confined waters inshore, and particularly those attempting in abnormal weather to locate the entrances to narrow channels, could theoretically use their radio direction-finders in this same manner. Location of position by the intersecting line method is, however, often too slow where distances to be sailed are short and land is near at hand, or in restricted channels. Obviously, the inshore piloting problem would be very much simplified if radiobeacon transmitters could be installed in buoys anchored at or near channel entrances. Ships equipped with direction-finders might then tune in such radiobeacon buoys and use the signals emanating from them to "home" on, riding down the radio waves to their source, using caution

for Inshore Navigation

to set course to pass safely clear of the buoys and avoid collision with them.

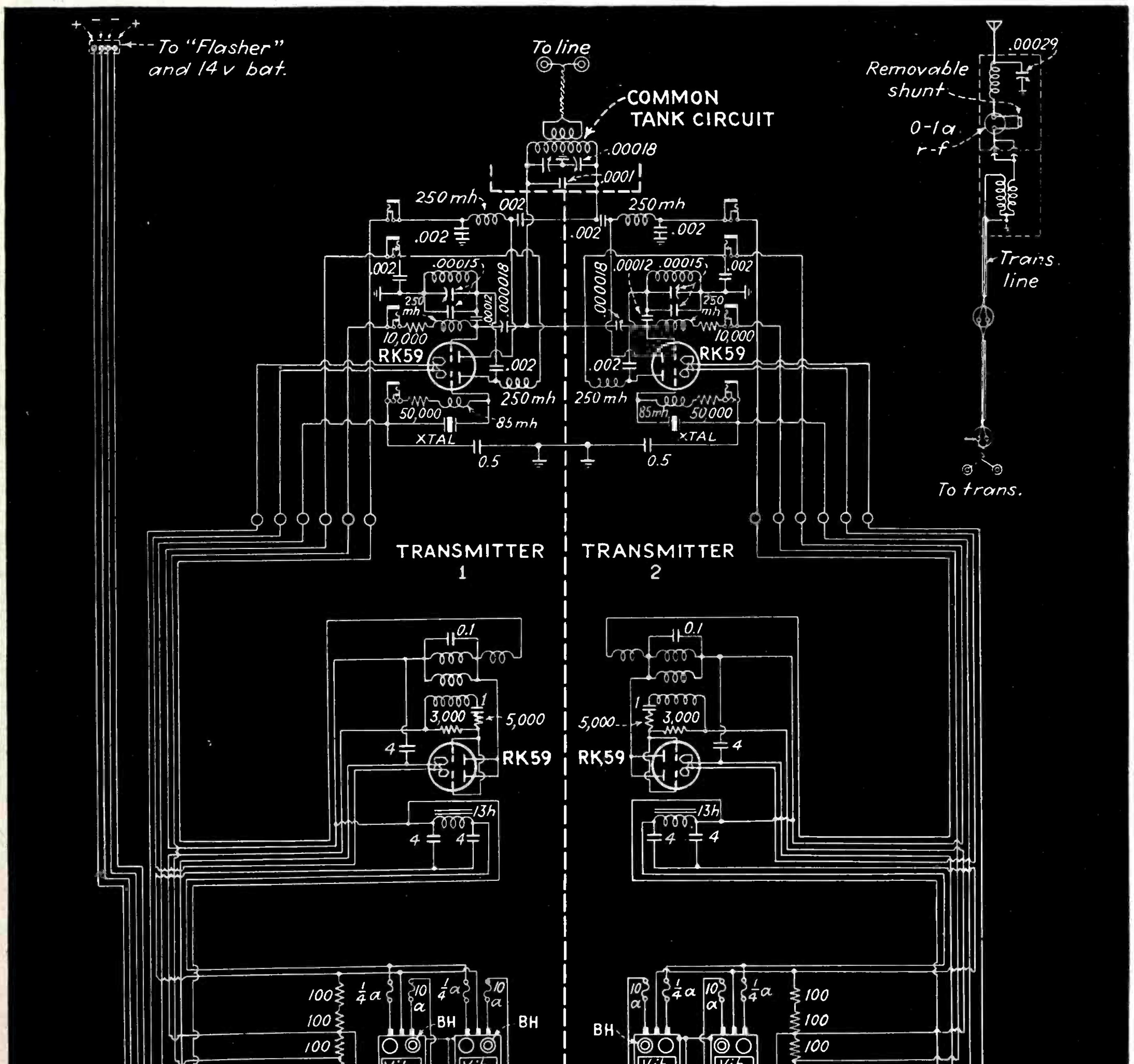
This is precisely what was planned just before the war. The type TB-113 buoy radiobeacon units described here were designed by Coast Guard radio engineers, developed by the U. S. Coast Guard Radio Laboratory, built by the Transmitter Equipment Mfg. Co., Inc., of New York and Erco Radio Laboratories, Inc., of Hempstead, N. Y., and installed in buoys marking the entrances to harbors.

General Description

The radiobeacon signalling equipment for one buoy consists of the following interconnected units:

(1) A 14 v bank of low-discharge type storage batteries supplying all necessary operating power and capable of running the apparatus for three to four months without removal for recharging. Radio equipment battery drain, exclusive of power required for the operation of the buoy light and of a "flasher" or automatic switching and keying device, is nominally six amps while keying. The overall power drain is about 900 amp-hours per month.

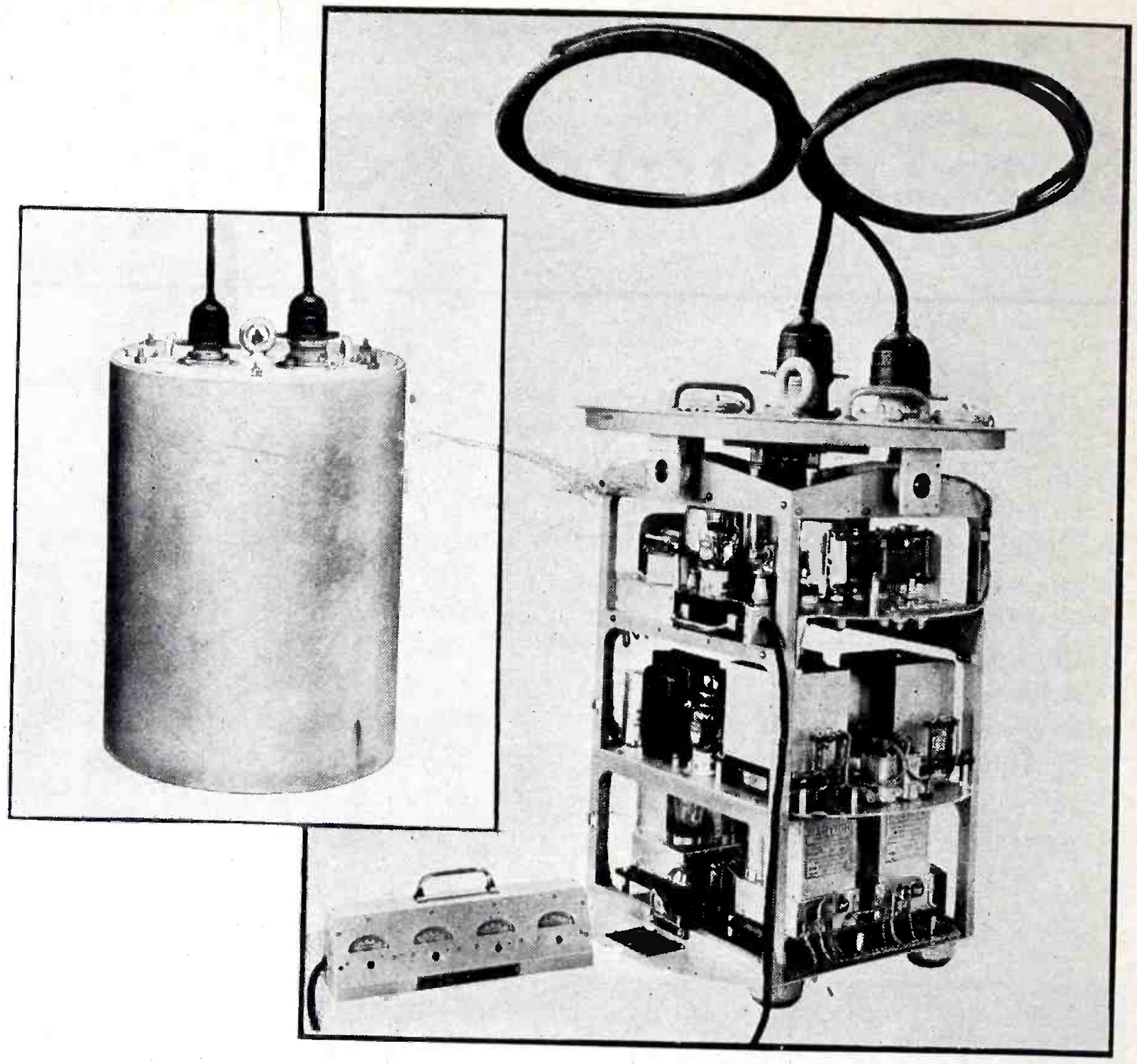
(2) A "flasher" mechanism consisting of motor-driven cams, connected in series with the storage-battery-bank positive output leads and performing two distinctly separate functions, namely (*a*) the keying of



Schematic of the "twin" transmitter and, at the upper right, of the common antenna tuning unit. High voltage Vibrapacks are diagrammed in simplified form at the bottom, with modulator circuits appearing immediately above and oscillator-amplifier circuits at the top. Power required to operate the equipment, alternately switched from transmitter to transmitter by a motor-driven cam mechanism not shown here, is connected to the receptacle at the upper left. In the design diagrammed motor-driven cams also keyed the transmitters, simultaneously interrupting both filament and plate voltages. Recently modified units key by means of cam-operated relays in Vibrapack positive leads. Filament voltages are not interrupted each transmitter, automatically and alternately at intervals, and (b) the control of the buoy light characteristic. Automatic keying of the transmitters is accomplished as follows: When a flasher cam closes the circuit to one of the transmitters this sets up the proper relay sequence, lights the tubes and closes all circuits for keying in the positive lead of the Vibrapacks. This operation is repeated alternately for each transmitter. A normal schedule consists of groups of quarter-second dashes for seven or more seconds, followed by a silent period of about the same length of time. The tube filaments are heated continuously during the keying period. Use of transmitting tubes having directly-heated cathodes with suitable thermal characteristics, and cold-cathode high voltage pack rectifier tubes, aided design.

(3) The TB-113 transmitter unit proper consists of two identical transmitters. Each transmitter is complete in itself, comprising high-voltage power packs, audio tone-generating modulator, crystal-controlled oscillator and single-ended r-f amplifier—complete except for the use of a common final amplifier tank circuit. Only one transmitter operates at a time, due to the functioning of the automatic switch gear already mentioned. Thus failure of either transmitter would not put the buoy off the air and such failure would be apparent when listening only if it was noted that there were longer-than-normal periods of silence between transmissions. This is true since both transmitters are tuned to the same frequency somewhere between 286 and 315 kc, use class A2 emission having a 1000 cps modulation tone and each turns out five watts of radio frequency power. The r-f power is picked up by a coil mounted in fixed inductive relationship to the final amplifier tank coil and fed into a 25 ft. length of coaxial transmission line having a characteristic surge impedance of 73.5 ohms.

(4) The MR-118 antenna coupling unit consists of a combination impedance-matching transformer and antenna base-loading coil. When properly adjusted by means of a variable capacitor included in the assembly (as indicated by maximum reading on a 0-1 amp r-f ammeter, also included), this unit tunes the antenna to resonance and simultaneously eliminates the possibility of standing waves on the transmission line by terminating the line in a value equivalent to its own surge impedance.



Open and sealed views of the twin transmitter, less antenna tuning unit, batteries and automatic switching and keying mechanism. Note use of vibration mountings to "float" the apparatus within its protective can. Adjustments are made before the equipment is sealed and stowed away. The special circuit-analyzer shown connected and ready for use in the open view was supplied as an accessory

(5) The antenna itself, consisting of a 15 ft. monel-metal tripod mounted on ceramic bowl type insulators forming the top of the antenna coupling unit.

Circuit Details

Except for the use of a common final r-f amplifier tank circuit which facilitates their operation into one antenna, both transmitters within a single buoy radiobeacon unit are identical and are mounted on the same chassis. A description of one transmitter therefore suffices for both.

In the r-f section, one triode of a type RK59 twin-triode tube serves as a shunt-fed crystal-controlled oscillator. Oscillator bias is a combination of voltage obtained from a grid leak and voltage obtained from a power-supply bleeder-resistor tap, insuring stable operation. Crystals having high activity are used.

The plate circuit of the oscillator is capacitively tuned and coupled by means of a fixed capacitor to the grid of the other triode within the same RK59 envelope. This triode operates as a class-C r-f amplifier.

The class-C r-f amplifier uses a combination of grid leak and fixed bias, the latter being obtained from a power supply bleeder resistor tap. The plate is shunt-fed. The stage is plate-circuit neutralized. At the low operating frequency involved no complications developed with respect to either neutralization or final amplifier tuning despite the use of a common tank circuit for two final amplifiers and the resulting equivalent connection of operative and non-operative tube output circuits in parallel.

It should be noted that no metallic connection exists between d-c plate and grid circuits and the transmitter frame, capacitive r-f grounding being used throughout. The outer conductor of the r-f transmission line between transmitters and antenna coupling unit is, on the other hand, directly grounded to the transmitter frame.

The class-C r-f amplifier is plate-circuit modulated. The modulator consists of another RK59 tube with its plates and grids connected in parallel and operating as a single triode. Special air-core coils connected in this circuit introduce feedback, causing the modulator stage to oscillate and generate a 1000 cps audio tone. Thus one tube serves as a combination modulator and audio tone generator.

High voltage d-c required for oscillator, r-f amplifier and modulator plates and grids is supplied by two Vibrapacks connected in parallel. Each of these uses a type BH full-wave cold-cathode gaseous rectifier tube.

The entire transmitter unit uses a total of eight tubes, four in each transmitter.

Operating Data

The buoy radiobeacon transmitter units were tuned ashore, placed in their protective cans and later lowered into buoy pockets. Tuning adjustments made with protective cans removed were not appreciably affected by installation of the units in the cans and installation of the cans within buoys. Typical operating conditions, with a 14.2 volt primary battery supply, were as follows:

Circuit	*286 kc*	*314 kc*
Cryst. Osc. grid current	1.5 ma	1.4 ma
Cryst. Osc. plate current	21.0 ma	18.0 ma
R-F Amp. grid current (no load)		
R-F Amp. grid current (loaded)	45.0 ma	44.0 ma

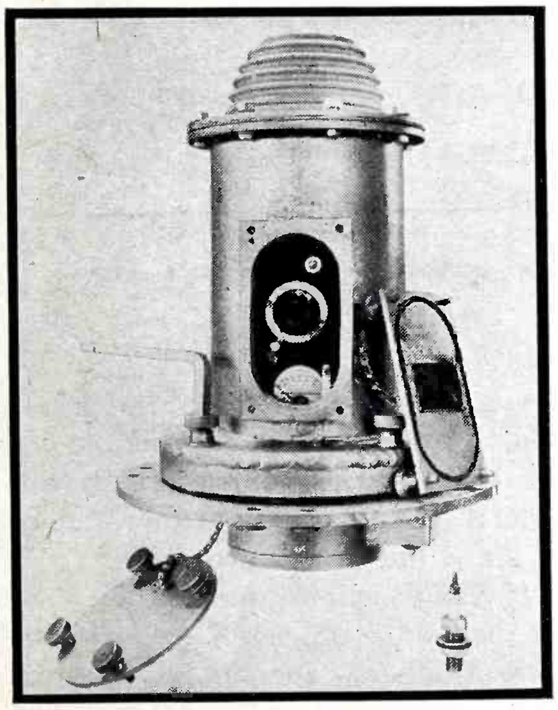
All of these readings were conveniently taken by inserting the connector-cable plug of a special test-analyzer accessory containing four panel instruments into closed-circuit jacks provided in the transmitter unit for this purpose.

Antenna tank circuit r-f currents normally measured 450 ma at 286 kc and 445 ma at 314 kc, with the antenna connected and tuned to resonance, as indicated by the 0-1 r-f ammeter permanently included in the antenna coupling unit. Antenna tank r-f current readings, unlike transmitter unit readings given in tabular form above, could be taken either in the shop or while the buoys were on station. Antenna tuning adjustments were, however, invariably made with the antenna itself "out in the clear" and with no metal objects other than the buoy itself in the immediate field. When tuned on station, for example, a man "marooned" on a buoy would make such adjustments while the cutter conveying him to the station stood off 100 ft. or more. Performance of the equipment modulators was in this case noted aboard the distant cutter by listening in on a suitable receiver.

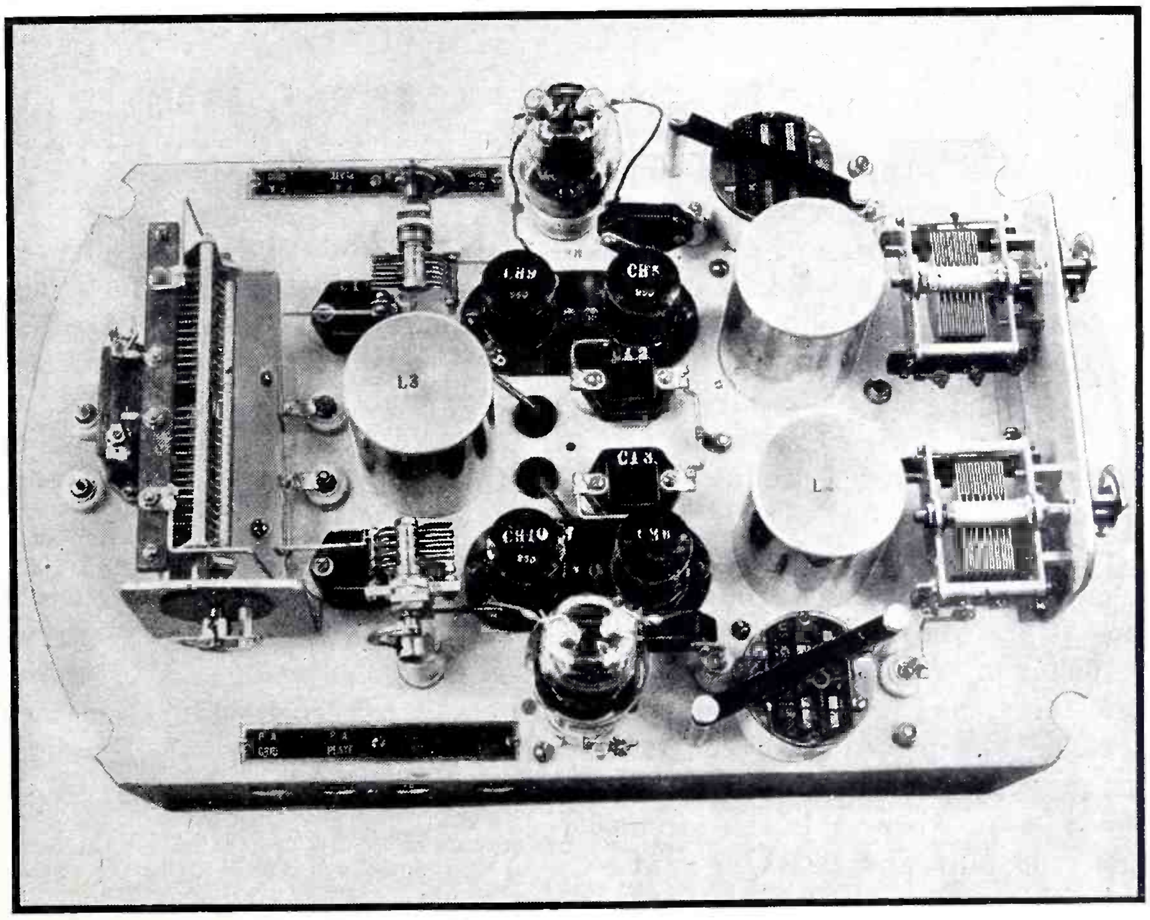
Where r-f transmission line performance checks seemed desirable this was done in the shop ashore by connecting a 0-1 r-f ammeter temporarily in series with one leg of the line. Normal readings, with the antenna connected and tuned to resonance, were 320 ma at 286 kc and 300 ma at 314 kc.

Overall outside dimensions of the type TB-113 buoy radiobeacon transmitter unit are: 23 inches in diameter and 36 inches high to the top of the r-f transmission line and battery power connector plugs. The total weight of the transmitter unit, in its protective can, is 257 lbs. The transmitter unit chassis alone, without the protective can, weighs 132 lbs.

Laboratory investigation is now under way to improve certain features of the buoy radiobeacon equipment, based on experience gained thus far. It is intended to improve the present 5 to 8 mile effective range by the use of a longer antenna. Two experimental antennas 25 ft. long have been prepared and are now awaiting test.—W. MacD.



Antenna coupling unit, with gasketted inspection-port cover removed. This part of the gear is conveniently adjusted while the buoy radiobeacon is on station



Top view of r-f chassis. Tuning capacitors are wrench-adjusted and locked. Crystals and tubes are clamped in their sockets. Labelled jacks at top and bottom edges permit the two separate oscillator-amplifiers to be independently metered. Note careful labelling of parts to facilitate maintenance

Transmission Line Charts

Graphs enable simple computation of voltage, current, and impedance distribution for any point on a long transmission line, and for any termination producing standing waves

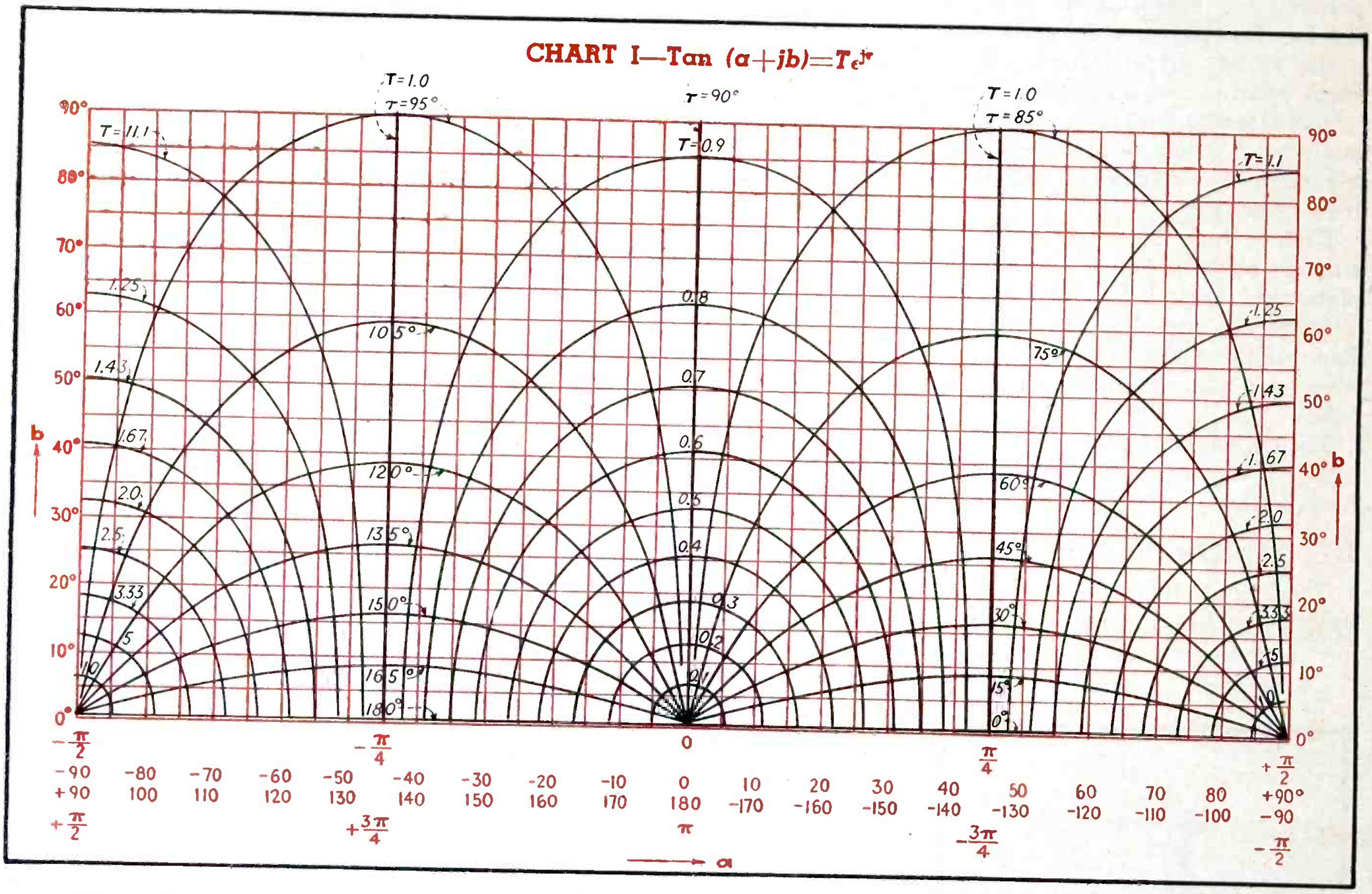


FIG. 1—This chart enables transferring tangent of complex quantity from rectangular to polar form and vice versa

By R. F. BAUM

Industrial Instruments
Jersey City, N. J.

Two charts are given for a quick determination of the value of sin Z and tan Z where Z is a complex number. The same charts can be used for the valuation of other trigonometric or hyperbolic functions. The charts are useful in determining the voltage, current and impedance distributions on electric lines of any load with the exception of that equal to the characteristic impedance of the line.

The equations of electric lines represent current, voltage, and impedance at any point on an electric line by means of trigonometric or hyperbolic functions of a complex number γ, called the propagation constant. The propagation constant is given by $\gamma = \alpha + j\beta$ where α is the attenuation constant and β is the wave-length constant. It is desirable to have a clear picture of the values these functions can possibly take and to have at hand charts to avoid complicated numerical computations.

There is a close relationship between the trigonometric and hyperbolic functions

$$\sin jZ = j \sinh Z \text{ or } \sinh jZ = j \sin Z \quad (1)$$
$$\cos jZ = \cosh Z \text{ or } \cosh jZ = \cos Z \quad (2)$$
$$\tan jZ = j \tanh Z \text{ or } \tanh jZ = j \tan Z \quad (3)$$

These formulas enable us to transform any hyperbolic functions into trigonometric functions. Furthermore,

$$\cos Z = \sin (Z + \tfrac{1}{2}\pi)$$
$$\cot Z = 1/\tan Z$$

reducing the number of necessary charts for all trigonometric and hyperbolic functions of a complex variable, Z, to two. In this paper a chart of sin Z and tan Z are given.

If Z is a complex number, $Z = a + jb$, then sin Z and tan Z are also complex numbers, and may be represented by their absolute magnitudes, S and T, respectively, and their phase angles, σ and τ, respectively. Thus,

$$\sin (a + jb) = S\,\epsilon^{j\sigma}$$
$$\tan (a + jb) = T\,\epsilon^{j\tau}$$

In the coordinate system used on the attached charts, the point Z is found by going a distance a from the origin in the direction of the horizontal (real) x-axis and then a distance b in the direction of the vertical

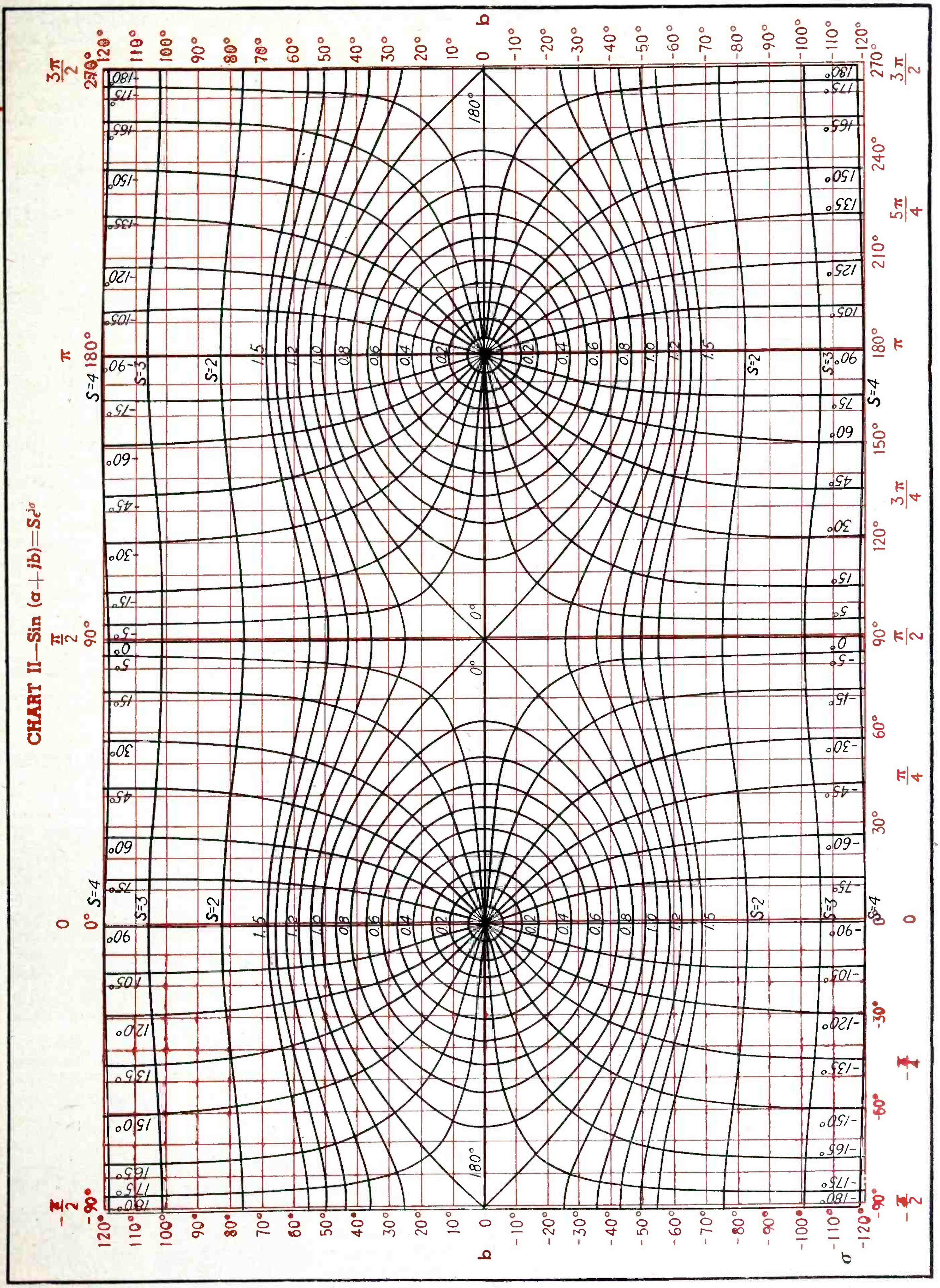


FIG. 2—Graphical chart for transforming sine of complex quantity from rectangular to polar form and vice versa

(imaginary) y-axis. The values of S and σ or T and τ respectively can be taken immediately or after interpolation between adjacent values. Both coordinates are counted in degrees (90 deg. $= \frac{1}{2}\pi$ radians).

If a voltage is applied to a line of length, l, then the voltage, V_y, the current I_y and the impedance Z_y at a point a distance y from the load end of the line is given by

$$V_y = C_v \sin(Z + \gamma' y + \tfrac{1}{2}\pi) \qquad (4)$$

$$I_y = C_I \sin(Z + \gamma' y) \qquad (5)$$

$$Z_y = V_y/I_y = C_Z \tan(Z + \gamma' y + \tfrac{1}{2}\pi) \qquad (6)$$

where

C_i, C_v and C_z are complex constants,

Z_l is the load impedance

Z_c is the characteristic impedance of the line,

$\gamma = \alpha + j\beta$ where α is the attenuation constant and β is the phase constant

$\gamma' = j\gamma = -\beta + j\alpha$, and

Z is determined by $\tan Z = j Z_c/Z_l$ or

$$Z = \tan^{-1} jZ_c/Z_l \qquad (7)$$

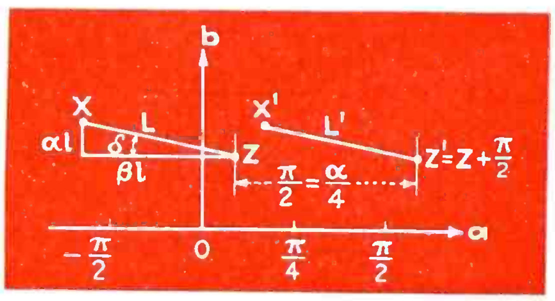


FIG. 3—Lines L and L', constructed as indicated in text, enable determination of voltage, current and impedance for any position on the line

In general, Z and γ' are complex and we may therefore use the charts.

The expression $(Z + \gamma' y)$ appearing on the right side of Eq. (5) represents a straight line, L, in our coordinate system originating at point Z (in Fig. 3) where $y = 0$ (load end) and extending up to point X where $y = l$ (feeder end of the line).

As $\gamma' = -\beta + j\alpha$ the line $(Z + \gamma' y)$ points to the left at an angle of inclination, $\delta = \tan^{-1} \alpha/\beta$. A half wave on the line is given by $\beta y = \pi$ which means that the projection of the line $X-Z$ upon the axis is π for a half wavelength line. A longer (or shorter) line will have a proportionally longer (or shorter) projection, and any point between feeder and load end of the electric line can easily be identified on the straight line, L by dividing its length proportionally.

The expression $(Z + \gamma' y + \frac{1}{2}\pi)$ in Eqs. (4) and (6) represents a straight line, L', parallel to line L and originating in point $Z' = Z + \frac{1}{2}\pi$ which lies 90 deg. or $\frac{1}{2}\pi$ radians to the right of point Z, in Fig. 3.

The first step in the application will be to find the point Z by means of Eq. (7). The position of this point depends only upon the load Z_l or more exactly upon the ratio of the characteristic impedance to the load:

$$\tan Z = j Z_c/Z_l = T\,\epsilon^{j\tau}$$

Chart I gives Z immediately for any value of T and τ.

In Charts I and II draw the lines L and L'. According to Eqs. (4), (5), and (6). They furnish current, voltage, and impedance distribution along the line.

The constant C_v is easy to find from Chart II.

$$C_v = V_o/[\cos(Z + \gamma' l)]$$

Then $C_I = C_v/j Z_c$

$$C_z = -j Z_c$$

where V_o is the voltage applied to the line.

The location of point Z for different loads, Z_l and for characteristic impedance, Z_c, a pure resistance is shown in Fig. 4.

Examples indicating the use of these charts will help indicate their application.

Example 1. To calculate the value of sin $(2.3 + j\,1.5)$ where the values are given in radians, it is first necessary to convert radians to degrees. Thus,

$$\sin(2.3 + j\,1.5) = \sin(132^\circ + j86^\circ)$$

Enter Chart II 132 deg. to the right of the origin, and project up 86 deg., and find a point between lines $S = 2$ and $S = 3$ and between lines $\sigma = -45$ deg. $= 315$ deg. and $\sigma = -30$ deg. $= 330$ deg. Interpolating gives this point as $S = 2.3$ and $\sigma = 320$ deg. and hence

$$\sin(2.3 + j\,1.5) = 2.3\,\underline{/320^\circ}$$

Example 2. Find tan $(2.3 + j\,1.5)$ $=$ tan $(132^\circ + j\,86^\circ)$. Entering Chart I at a point 132 deg. to right of origin and 86 deg. upward, it is found by interpolation that $T = 1.05$ and $\tau = 100$ deg. Therefore

$$\tan(2.3 + j\,1.5) = 1.05\,\underline{/100^\circ}$$

An exact calculation, which is quite laborious, given $1.06\underline{/96^\circ}$, illustrating that the error is no more than may be expected from any graphical computation.

Example 3. A cable 75 meters long is fed with 10 volts applied at 1.5 Mc. The characteristic impedance is $Z_c = 75$ ohms. The attenuation and phase constants per 100 meters of line are, $\alpha = 0.013$ and $\beta = 3.5$ so that $\alpha l = 0.013 \times 0.75 = 0.0098$ radian or 0.6 deg. while $\beta l = 3.5 \times 0.75 = 2.63$ radians or 151 deg. The load is given as $Z = R + j\omega L = 55 + j\,125 = 136.5\underline{/66^\circ}$. From this data we find that

$$\tan Z = j Z_c/Z_l = j\,75/\,(136.5\,\underline{/66^\circ})$$

$$= 0.55\,\underline{/24^\circ} = T\,\epsilon^{j\tau}$$

Now, looking up in the Chart I the intersections $T = 0.55$ and $\tau = 24$ deg. we find $Z = 28 + j\,10$ deg. The point X is given by:

$$X = Z + \gamma' l = Z + j\alpha l - \beta l)$$

$$= 28 + j\,10 - 151 + j\,0.6$$

$$= -123 + j\,10.6 \text{ deg.}$$

A line connecting X with Z gives the current distribution on Chart II. A parallel line displaced 90 deg. to the right gives the voltage and impedance distribution. This line connects the point $X' = -33 + j\,10.6$ with $Z' = 118 + j\,10$. These lines are substantially horizontal at the inclination, $\delta = \tan^{-1} \alpha/\beta$ is only 0.004.

Point X' in Chart II reads $S = 0.58$ and $\sigma = 165$ deg. corresponding to an input voltage $V_o = 10\underline{/0^\circ}$ volts. Therefore,

$$C_v = V_o/(S\underline{/\sigma}) = 10/(0.58\,\underline{/165^\circ})$$

$$= 17.25\,\underline{/-165^\circ}$$

Point Z in Chart II reads $S = 0.95$, and $\sigma = -3$ deg. and therefore the output voltage is

$$V_l = C_v S\,\underline{/\sigma}$$

$$= [(17.25)\,\underline{/-165^\circ}][(0.95)\,\underline{/-3^\circ}]$$

$$= 16.4\,\underline{/-168^\circ}$$

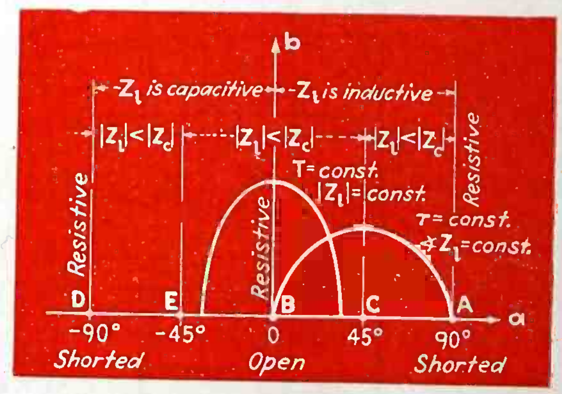


FIG. 4—Diagram showing reactance of line for various loads and for line whose characteristic is a pure resistance

Going along the line $X'Z'$ the point of minimum voltage is obtained at $0 + j\,10$ with $S = 0.17$ and $\sigma = 90$ and the point of maximum voltage at the point $90 + j\,10$, with $S = 0.99$ and $\sigma = 0$. Therefore

$$V_{min} = 0.17 \times 17.25\,\underline{/90^\circ - 165^\circ}$$

$$= 2.95\,\underline{/-75^\circ} \text{ volts}$$

$$V_{max} = 0.99 \times 17.25\,\underline{/0^\circ - 165^\circ}$$

$$= 17\,\underline{/-165^\circ} \text{ volts}$$

(*Continued on page* 158)

Fluorescent Inspection of Tungsten

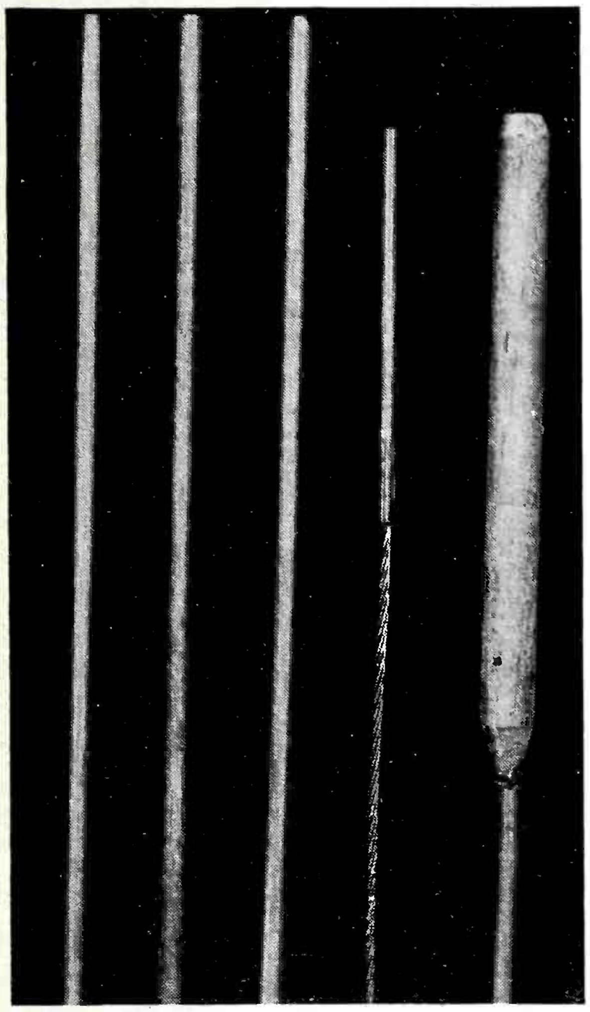


FIG. 1—Typical tungsten leads photographed under white light. These leads are for glass envelopes of power tubes

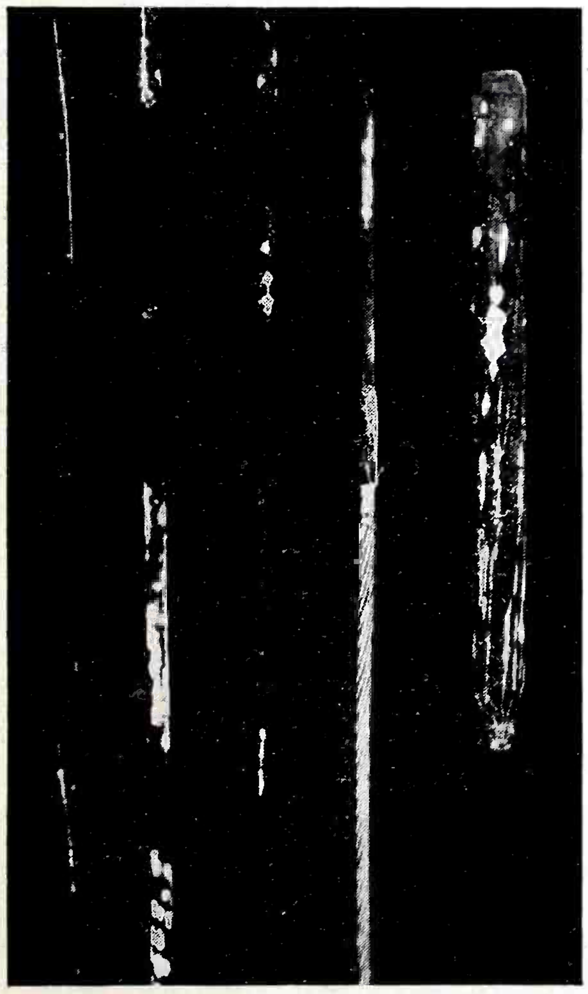


FIG. 2—Same tungsten leads after treatment with fluorescent penetrant, photographed under ultraviolet light

Minute longitudinal cracks in tungsten leads passing through glass are a major cause of gassy electronic tubes. A fluorescent penetrant method applicable to large quantities of tungsten parts is described. It makes cracks glow under ultraviolet illumination

By S. ANDREW KULIN

Metallurgist, Power Tube Division Raytheon Mfg. Co., Waltham, Mass.

A LARGE percentage of unexplained leaks in vacuum tubes have undoubtedly been caused by longitudinal cracks in tungsten leads sealed into the glass envelopes. Many of these cracks can be detected by visual inspection with binocular microscopes, but this method is tedious and is quite slow since the field of vision is small. Furthermore, microscopic inspection does not permit differentiation between cracks and harmless scratches.

The fluorescent penetrant method of inspection known commercially as "Zyglo*" has been successfully applied to the problem of inspecting large quantities of tungsten leads. The tungsten to be inspected may be in either ground or ground and etched condition, may vary over a wide range of lengths and diameters, and may be plain tungsten, tungsten welded to nickel and stranded copper or tungsten welded directly to stranded copper.

In the new method, the tungsten parts are first cleaned to remove oil and grease which might cover surface discontinuities and prevent the penetrant from entering small crevices. The cleaned parts, in fine mesh baskets, are then immersed in the special fluorescent penetrant. The parts are allowed to stand for two hours or more, during which time the low-viscosity water-emulsifiable penetrating oil flows by capillary action into all cracks and pores and surplus oil drips into a recovery pan.

When tungsten rods are welded to stranded wire, the parts are bundled together in such a way that only the tungsten is immersed. Immersion of stranded wire would present a difficult cleaning problem.

The next step is washing with a spray of warm water (120 to 140 deg. F) under ultraviolet light so the operator can see when excess penetrant on the surface has been removed. The parts are agitated during washing. A higher water temperature is to be avoided because it would remove the penetrant from the shallower surface cracks.

After all penetrant except that in the cracks has been washed off, the parts are dried in a recirculating air drier in which the temperature is carefully controlled. Excess heat here would allow the penetrant to escape from the cracks in the tungsten, and flaw indications would lose their sharpness or disappear.

The thoroughly dried tungsten rods are arranged in tiers and completely covered with an absorbent yellow powder for one hour. This powder draws the penetrating oil out of the cracks and spreads it out from the cracks to give magnification of the defects. The fluorescent indication will be proportionately wider than the actual defect.

Surplus powder is removed by shaking, sifting or compressed air, and the rods are inspected under ultraviolet light (approximately 3600 Angstroms). The defective parts in Fig. 1 would appear as in Fig. 2

(*Continued on page* 160)

* Available through the Magnaflux Corp., Chicago; a patened method.

V-H-F
Receiver Oscillator Design

Secular stability — Unitary construction — Choice of materials — Tuned circuit types — Circuit Q — Series resistance — Voltage stability — Selectivity — Tube characteristics — Interelectrode variations — Transit time and inverse feedback loading

By S. YOUNG WHITE

It is safe to predict that great activity in further opening up the frequency range from 50 to 250 Mc will be a feature of the radio art after the war.

This range contains 20,000 of our familiar 10 kc broadcast channels. If wide-band frequency modulation is used there will be substantially fewer channels available but for a number of commercial services a swing of 25 kc may be sufficient and this still provides a lot of channels.

After the war it will be desirable to have as many channels as possible in this region. Obviously, many ideas concerning the precision-tuning of receivers will have to be revised. The problem of designing a dial readily set to five figures by unskilled users will, alone, tax our ingenuity. The apparatus behind the dial will have to perform with astronomical accuracy.

The purpose of this paper is to discuss some of the major problems associated with accurate tuning and the maintenance of calibration at very high frequencies. Since the calibration of receivers of the superheterodyne type, which will undoubtedly be used, largely involves oscillator design, oscillator circuits only will be considered in the following discussion.

General Considerations

There is apparently no royal road to stability. Each component of the high frequency oscillator of the future will have to be completely stable, or will have to cooperate with some other element to cancel out overall circuit instability. Warm-up drifts and those caused by line voltage changes will have to be held within assigned channels and, if we design for mobile, aircraft or equivalent use then temperature, humidity and vibration effects will have to be similarly limited.

Such results can most readily be expected of simple, rugged and compact designs where, in effect, every part "flows" mechanically and electrically into another part and we tend to have a homogenous unit rather than an inter-connected aggregation of conventional components. It will be a mark of good design to have some "imaginary" components, i.e., certain details of construction performing circuit functions without the specific inclusion of parts recognizable as such. Any wiring at all in r-f circuits is unthinkable.

When we begin to consider maintained accuracies of the order of 0.01 percent to 0.02 percent we must place first on the list of requirements that of "secular" stability. This is a phrase the writer recently came across in an article on coils, written by a British engineer. "Secular" has to do with the ages, or long periods of time. If you build a pyramid well of the right materials and come back in a few thousand years it will still be the same old pyramid. The word seems to express our primary need better than the usual term, "aging." This requirement allows us to consider the use of no constructional material subject to appreciable cold-flow or change in cubic volume with age.

PRESENT and FUTURE

THE AUTHOR, in this timely paper, sets out primarily to stimulate thinking on the part of engineers concerning tomorrow's equipment designed to operate between 50 and 250 Mc

He includes, however, considerable data which not only supports his predictions but should also prove immediately useful in the design of very-high-frequency gear for the war effort

Circuit Resistances

Since this paper has to do with tunable equipment and so many of the tuning means we shall have to consider involve sliding or switching contacts, let us consider the order of circuit resistances involved.

Round figures for the Q values of oscillator tuned circuits would be as follows: A two-inch coaxial line would have a Q of about 1700. "Cups", depending upon size, would be about 1200. A parallel line would average 1000. A concentrated coil, capacitor-tuned, 650. A coil and fixed ceramic capacitor, ready for insertion of a movable core, 700 (from which must be subtracted the core-losses, giving resultant Q's from 28 to 400, depending upon core material). A sliding-contact coil, 300, lowered to some extent by the tuning mechanism contact resistance.

These Q values, by simple calculation, show an r-f resistance range from a little over 20 milliohms (0.020 ohm) to 50 milliohms. Any external resistance we place in series with such circuits must therefore be negligible in relation to these values. This introduces a number of design problems. For example, a band-change switch that is consistently lower than one milliohm resistance is a pretty large object and if we use concentrated circuits we cannot readily use units of large dimensions. The sliding-contact to the rotor of most variable capacitors must, similarly, be viewed with suspicion as to its ability to maintain low resistance under service conditions.

Q of Tuned Circuits

Further speculating regarding future design, let us compare the Q values and dynamic impedances of two typical lumped circuits, one designed to operate at 1 Mc and the other at 150 Mc.

The designer is thoroughly at home at 1 Mc and, when called upon to design a stable oscillator for that frequency, might readily choose a tuning capacitor value of 300 $\mu\mu$f. The oscillator tube inter-electrode capacitance would be, say, 10 $\mu\mu$f, or only one-thirtieth of the total. The reactance of the selected capacitor is approximately 530 ohms and, when multiplied by a Q of 100, gives a dynamic impedance for the circuit of 53,000 ohms. This is indeed a nice load for the tube to work into.

To have the same capacitive reactance at 150 Mc, the tuning capacitor would have to be about 2 $\mu\mu$f, or less than the inter-electrode capacitance of an "acorn" type tube. Since the tube would therefore be virtually the whole tuned circuit insofar as capacitance is concerned, we can only shudder at the effects of any variations in tube characteristics. These might include varying glass losses, mica losses, input resistance losses. They might also include variations in electrode geometry with changes in wattage dissipation. Such changes would be the very reverse of secular stability.

Now, suppose we try to "swamp" the tube capacity by increasing the tuning capacitor size thirty times,

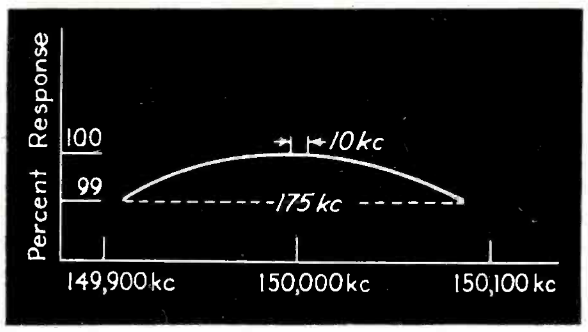


FIG. 1—Resonance curve of typical v-h-f receiver circuit having a Q of 100, showing relatively poor frequency descrimination. Note that the curve is nearly flat insofar as 10-kc selectivity is concerned even at the peak and that acceptance is 175 kc wide only one percent down

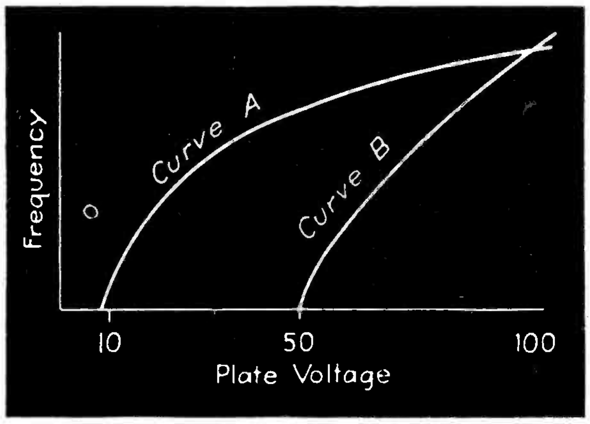


FIG. 2—Curves showing striking-voltage characteristics of two oscillators, one (*A*) having a 15 $\mu\mu$f tuning capacitor and the other (*B*) a 60-$\mu\mu$f tuning capacitor. The oscillator of curve *A* starts at 8 volts and will obviously be much more stable with changes in plate voltage above 100 volts

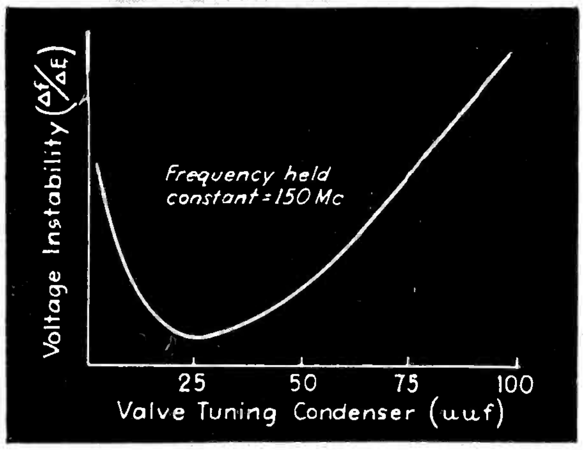


FIG. 3—Voltage stability curve of a typical oscillator. Note that maximum stability occurred with the tuning capacitor around mid-range. At capacity settings under 25 $\mu\mu$f the tube constituted an appreciable part of the circuit capacity and so tube variations reduced stability. At capacity settings over 25 $\mu\mu$f dynamic impedance of the circuit was lowered sufficiently to cause a poor match between tube and load, again reducing stability

as we can so readily do at 1 Mc. The resultant capacitance would be 60 $\mu\mu$f, with a reactance of only 18 ohms at 150 Mc. It would take a Q of about 3,000 to produce a dynamic impedance equal to the 53,000 ohms we obtained with the low coil Q value of 100 at 1 Mc.

To further complicate matters at high frequencies, the tube is apt to be working under difficulties due to transit-time loading and inverse-feedback loading caused by the inductance of the cathode lead.

Tube Characteristics

The importance of Q in maintaining oscillator frequency despite change in supply voltages is generally appreciated. There are, however, several separate effects involved and all of them must be considered at very high frequencies.

One effect is the change in tube element dimensions and the physical relationships between elements with changes in wattage dissipation. Such changes occur when the heater and plate voltages are, for any reason, altered. This results in changes in inter-electrode capacity.

Another consideration is the change in tube impedance and the change in phase-angle due to varying electron transit-time as heater and plate voltage vary.

There is also a change in reflected impedance when the G_m of the tube is changed. This occurs, for example, where a tickler coil having large leakage-inductance is used. Tube charging-current passing through such a tickler is phased, amplified by the tube and reintroduced into the tank circuit, where it appears as a reactance. The amount of reactance generated in the tank circuit is proportional to the amplification of the tube. This effect is always troublesome and can best be avoided by designing the circuit so that the tube generates no phase-angle, which almost entirely precludes the use of a tickler-type oscillator.

Resonance Curves

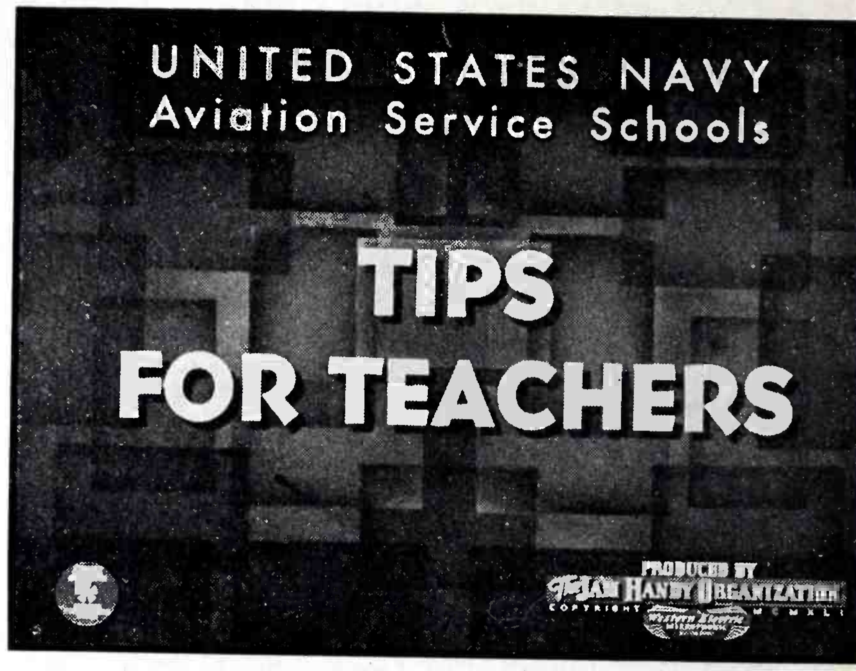
Still another problem is involved. We usually think of the peak of a resonance curve as being the point of highest circuit impedance, and zero phase-angle. Consequently, the critical frequency of oscillation is normally defined by the peak. But,

(*Continued on page* 206)

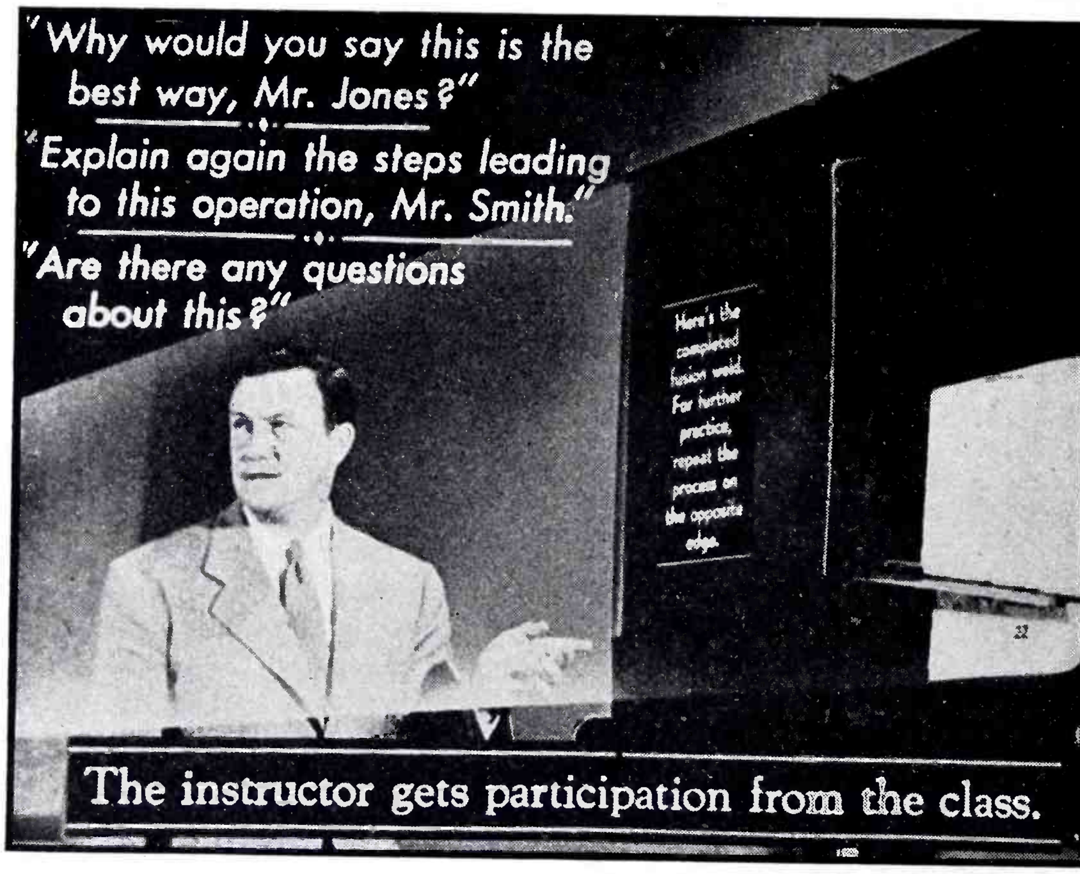
MOVIES and SLIDEFILMS Speed

By LYNE S. METCALFE

An analysis of sound movies and slidefilms available to engineers newly confronted with the problem of teaching electronic manufacturing techniques to war workers. Some films show how to teach effectively, while others supplement standard instruction methods



Title slide for slidefilms prepared for U. S. Navy



Scene from "Tips on Slidefilms", which shows instructors how to use visual teaching aids with maximum effectiveness

To train new war workers in skills and vocations essential to war production in the shortest possible time, something more than routine factory instruction is necessary. This is particularly true in the fields of electricity and electronics, where the training usually involves complicated and technical information.

The training-within-industry program, necessitated and expanded by the Government early in the war production effort, has taken a definite place in our war economy. As a result, heavier and sometimes new burdens are thrown on the personnel training department, on foremen and particularly on electronic engineers.

In an industrial training class which includes a large percentage of untrained or partly trained beginners, the technique or quality of the instruction has a great deal to do with the speed and effectiveness with which the classes are conducted and the facility with which apprentices are moved into actual work at the bench or machine.

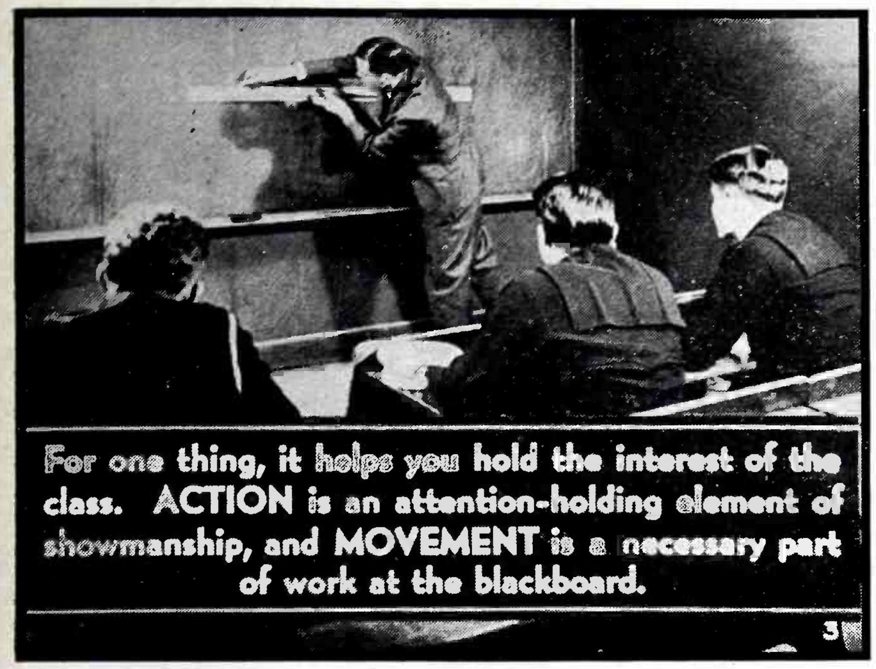
Movies Teach Engineers to Teach

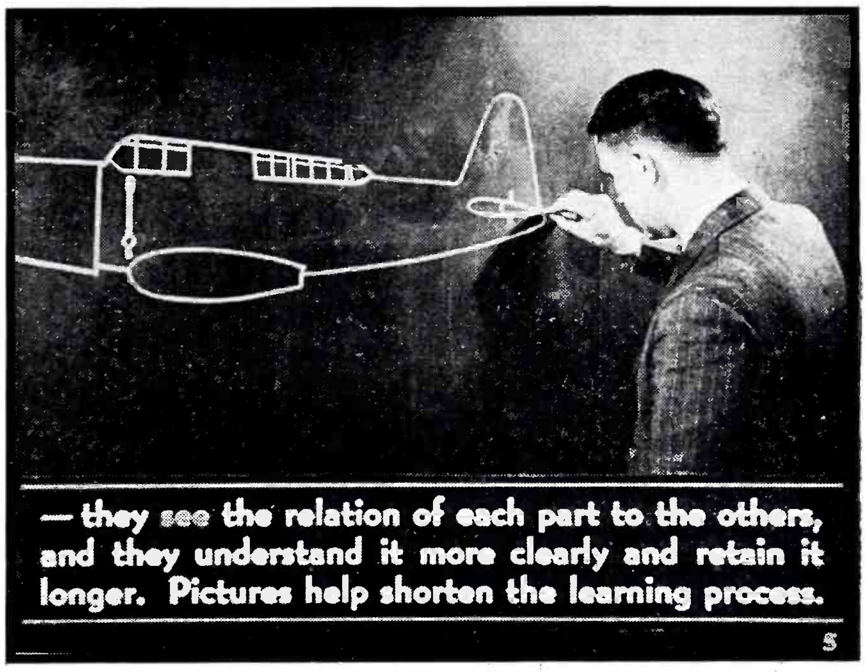
To supply a measure of teaching technique to these groups, the picture screen, already a powerful force in the war production training program, has been tried out with considerable success. Motion picture films and slidefilms show the instructors how to teach what they know—by grounding them in the basic principles of educational techniques. This program is particularly aimed at the skilled mechanic or workman, fully competent in his specialization, but too often without experience or knowledge in how best to pass it along to others.

One recent film designed to help the experienced worker break in a new worker is titled "Passing the Know-How Along." It is a 16-mm sound motion picture approximately 15 minutes long, based upon material in Bulletin 2-C of the Training-Within-Industry Section of the WPB. This motion picture demonstrates seven tested and logical steps that help in passing along how-to-do-it information in terms so simple that anyone may improve his or her performance after seeing it. It applies to any kind of manufacturing because it deals with basic procedures and with the psychology of the process of transmitting information at the workbench.

Another 16-mm sound motion picture is titled "Giving a Shop Demonstration." It is a two-reel subject with a screen time of about 20 minutes. The objective of this picture is

Wartime Training of Technicians





Scenes from "Tips for Teachers", a visual training kit for engineers who are training war workers. It consists of nine slidefilms and a series of 33⅓ rpm phonograph records containing accompanying sound

to show the best basic procedures in demonstrating a shop job by actual before-the-eye demonstration. The material covers the shop demonstration by the instructor which must precede practical work on the part of the class. This picture was planned and produced in cooperation with the Aviation Service Schools of the Bureau of Aeronautics of the United States Navy.

Slidefilms Give Tips for Teachers

Recently, a series of nine sound slidefilms (or filmstrips) has been made available under the title "Tips for Teachers." These nine films comprise a total of 701 individual pictures, photos, graphs, charts, drawings and exhibits. (The two motion pictures reviewed above may be used along with these slidefilms if desired, inasmuch as they are supplementary.) The nine subjects in the slidefilms are:

(1) The Teacher
(2) Some Principles of Teaching
(3) I Want to Learn
(4) The Lesson Plan
(5) Make Your Chalk Talk
(6) Teaching—a Vocation
(7) Shop Teaching
(8) Designing Examinations—Part I
(9) Designing Examinations—Part II

The slidefilm (or filmstrip) is a strip of 35-mm safety motion picture film, on each segment or frame of which is a picture. These individual pictures are arranged in logical sequence in order to show a given procedure pattern, while the accompanying disc record provides the verbal commentary, lecture or miscellaneous sounds. Slidefilms are more economical and more convenient than movies when each scene is to be studied for some time by the audience.

When the picture screen is used, certain factors not present in the ordinary blackboard talk or study session appeal may nullify the best efforts of the most skilled instructor. Modern projection equipment is simplicity itself, yet there are certain precautions that can be taken which will avoid interruptions, digressions and failure.

A discussional type slidefilm which points out to instructors how seemingly simple hazards to a smooth running session may be circumvented has been made available to war production plants. This subject is called "Tips on Slidefilms" and comprises a total of 80 individual pictures with text superimposed on the films.

Picture-Screen Training is New Tool

The purpose of picture-screen war production training is not to substitute for or supplant any form of instruction which has proved its value over the years. The screen is not used as a substitute for textbook study, lectures, demonstration or shop-work. Rather, it is intended to provide the instructor with a new tool which has the power to save his or her time and labor by more rapidly conveying the fundamentals of a skill, its purpose, tools, equipment and basic techniques, leaving more time for the instructor to carry on actual demonstration. In achieving this purpose it has been signally successful.

List of Films Available

Some of the training slidefilms and motion pictures now available to the electronic field as supplements to standard training methods are:

Basic Electricity: A series of 12 discussional-type slidefilms, comprising 888 individual pictures, drawings, photos, charts, graphs and exhibits. The Jam Handy Organization, 2900 E. Grand Blvd., Detroit, Mich.

Excursions in Science No. 3: A single-reel sound motion picture covering the fundamentals of magnetism. The General Electric Co., Schenectady, N. Y.

Electrochemistry: A single-reel sound motion picture. Erpi Classroom Films Inc., New York, N. Y.

Elementary Science (Physics): A series of eleven reading-type slidefilms. The Society for Visual Education, Chicago, Ill.

Introduction to Machining: A series of sixteen discussional-type slidefilms with a total of 701 individual pictures. The Jam Handy Organization, Detroit, Mich.

Fundamentals of Bench Work: Ten discussional slidefilms. The Jam Handy Organization, Detroit, Mich.

Electricity at Work: A single slidefilm subject. The Society for Visual Education, 100 E. Ohio St., Chicago, Ill.

The following have been prepared to present effective modern teaching techniques to engineers themselves:

Passing the Know-How Along: A 16-mm sound film 1½ reels long. The Jam Handy Organization, Detroit, Mich.

Giving a Shop Demonstration: A 16-mm sound film 2 reels long. The Jam Handy Organization, Detroit, Mich.

Tips for Teachers: A series of 9 slidefilms totalling 701 frames, with accompanying sound film 2 reels long. The Jam Handy Organization, Detroit, Mich.

Tips on Slidefilms: A slidefilm with 80 frames. The Jam Handy Organization, Detroit, Mich.

Recording Audio Analyzer

A heterodyne audio frequency analyzer and a high-speed graphic level recorder together trace on a chart the level of each frequency in the audio spectrum from 10 to 9500 cycles. permitting accurate determination of predominant frequencies causing noise or vibration

In general, the sound produced by any mechanical device includes the fundamental frequency at which the device is operating and the various harmonics thereof, along with the natural resonant frequencies and harmonics of parts which are set into vibration by shock excitation. The operating frequencies are readily calculated, and many of the resonant frequencies can likewise be calculated by various methods. Once the chief frequency components of noise have been found for a device, the problem of reducing or eliminating the noise is already half solved.

A sound-level meter measures the over-all level of a sound without telling which frequencies are responsible for that sound. A sound analyzer, on the other hand, gives the level or amplitude of each individual frequency component in a sound, permitting a determination of the frequencies chiefly responsible for the noise.

The audio analyzers in common use today can be classified according to their selectivity characteristics. The degenerative type is an example of those having a constant-percentage characteristic, wherein the band width being analyzed widens proportionally as frequency is increased. The heterodyne analyzer described in this article is an example of the other type, in which the band width being analyzed remains the same for all frequencies and hence gives almost razor-sharp selectivity at higher audio frequencies.

Recording-Type Analyzer

In many sound problems it is highly desirable to be able to secure a complete graphic record, in a few minutes, of the sound level at each frequency in the audio range being studied. This eliminates tedious plotting of graphs after test runs, and gives an instantaneous picture of how a change in design affects all frequency components.

A recording audio analyzer of the heterodyne type was developed by Western Electric Co. to meet this industrial demand for a recording instrument.

The complete unit, known as the Western Electric Model RA-281 recording sound frequency analyzer, consists of a pickup device, a heterodyne analyzer with associated a-f amplifier, and a special graphic level recorder which automatically plots the response at each frequency over the range being studied. The complete record is produced on wax-coated paper in two minutes or less, with no processing being required either before or after the test run.

Heterodyne Analyzer

A quick understanding of the operation of the audio analyzer circuit can be obtained with the aid of the block diagram in Fig. 1. For simplicity, assume that the microphone is picking up only a 1000-cycle (1-kc) sound. After amplification, this 1-kc a-f signal is combined with the 49-kc signal from a local r-f oscillator to produce sum and difference frequencies of 48 and 50 kc along with the 49-kc signal. The crystal filter passes a band a few cycles wide centered on 50 kc, hence only the 50-kc component (the upper side frequency) gets through. This is amplified and combined with the 49-kc local oscillator signal in the demodulator to produce the original 1000-cycle signal again.

Essentially the same picture holds true if the microphone is picking up a complete audio spectrum. All of the audio components beat with the 49-kc oscillator signal to produce sum and difference frequencies, but only the 50-kc component due to the 1000-cycle input frequency will get through the crystal filter.

Now suppose that the local r-f oscillator is slowly varied from about

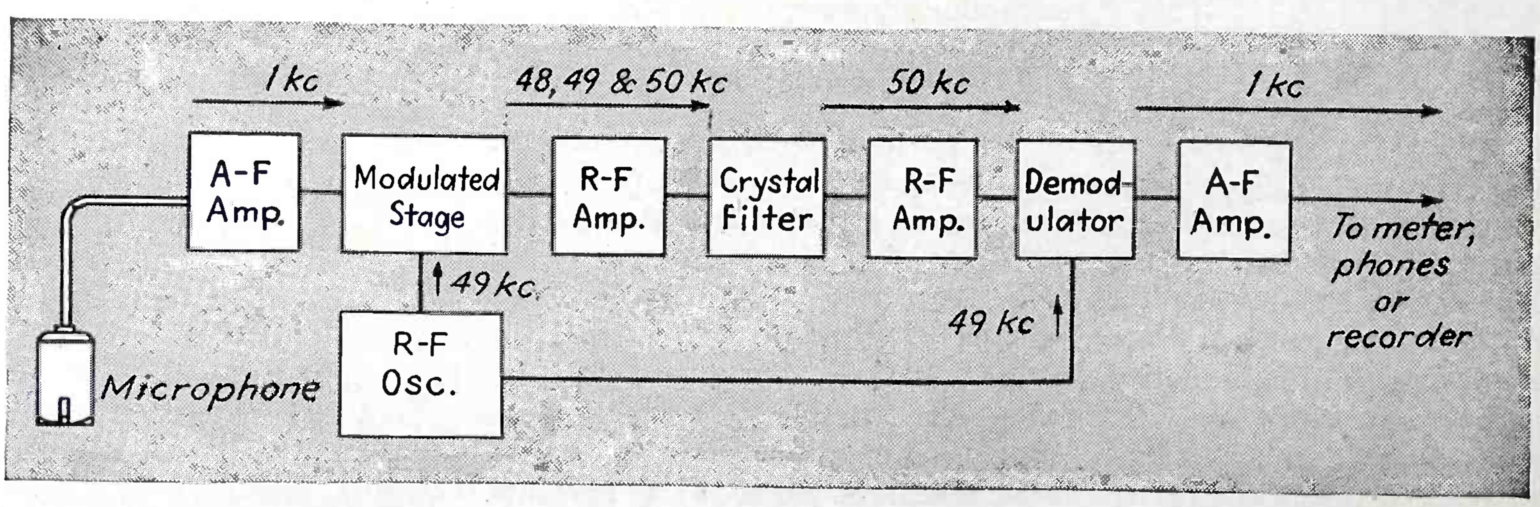
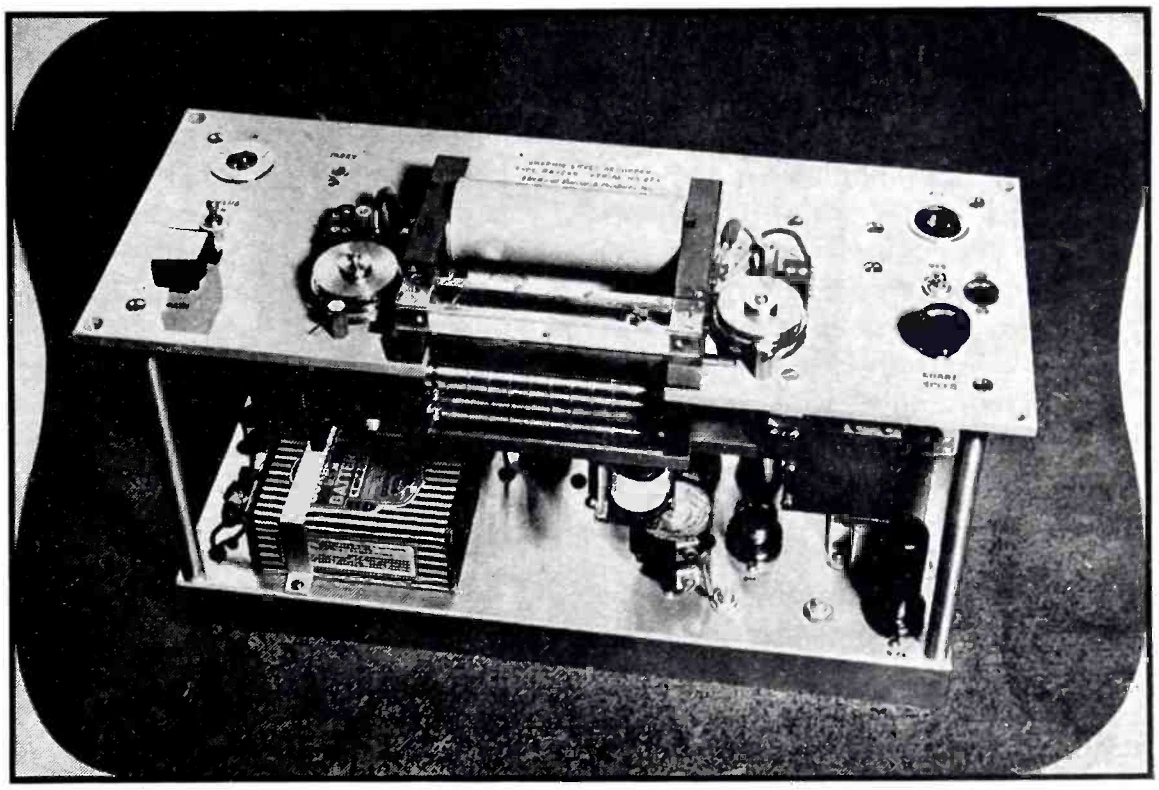


FIG. 1—Block diagram of the audio analyzer, with frequencies present in each section during analysis of a 1000-cycle sound

ABOVE

Complete audio analyzer system, consisting of the analyzer unit (at the left, with driving motor being lowered over tuning knob) and the graphic level recorder (at right)



RIGHT

Exposed view of the graphic recorder chassis. The discs on each side of the paper roll are the Permalloy magnetic clutches. They rotate continuously in opposite directions. The scriber is attached to an endless wire cable which goes around these discs, but moves only when one of the clutches is engaged

40 kc to 50 kc while the microphone is picking up all audio frequencies. At 40 kc, the 10,000-cycle component will give a 50-kc beat which can get through the filter, while at 49.99 kc the 10-cycle component will produce the required 50-kc beat. Thus, as the sweep is made from 40 to 50 kc, each audio component in turn will produce its own frequency in the output of the analyzer.

The complete schematic circuit diagram of the analyzer is given in Fig. 2. The audio input signal to be analyzed, obtained either from a dynamic microphone or a moving-coil type vibration pickup, is applied to tube V_1 in the first a-f amplifier stage through matching transformer T_1. This stage is highly stabilized, with R_6 and C_1 providing feedback from plate to grid for this purpose.

With key K_1 in the position shown, the output of the first a-f stage is fed to the control grids of tubes V_6 and V_7 in the balanced modulated stage through the triode sections of V_5, which provide a-f amplification and phase inversion respectively. The 40–50 kc signal, produced in the self-excited oscillator stage containing triode-pentode tube V_9, is fed to the parallel-connected third grids of the modulated tubes to give electronic mixing of r-f and audio signals. The r-f carrier component cancels out in plate load resistors R_{61} and R_{62} because it is fed to the two modulated tubes in phase, but sideband components produce voltages across these resistors for application to the crystal filter because the a-f signal is fed to the two modulated tubes 180 degrees out of phase.

The Quartz Crystal Filter

The filter unit passes only the desired narrow band of frequencies centering on 50 kc. The standard filter unit supplied with the instrument has a band width of 5 cycles, and suppresses frequencies outside this range at the rate of approximately 45 db in the first 55 cycles. Additional filters with 20, 50 and 200-cycle band width are available, and up to three can be built into the unit and connected to a suitable selector switch. Filters with widths of 2 or 10 cycles are available on special order.

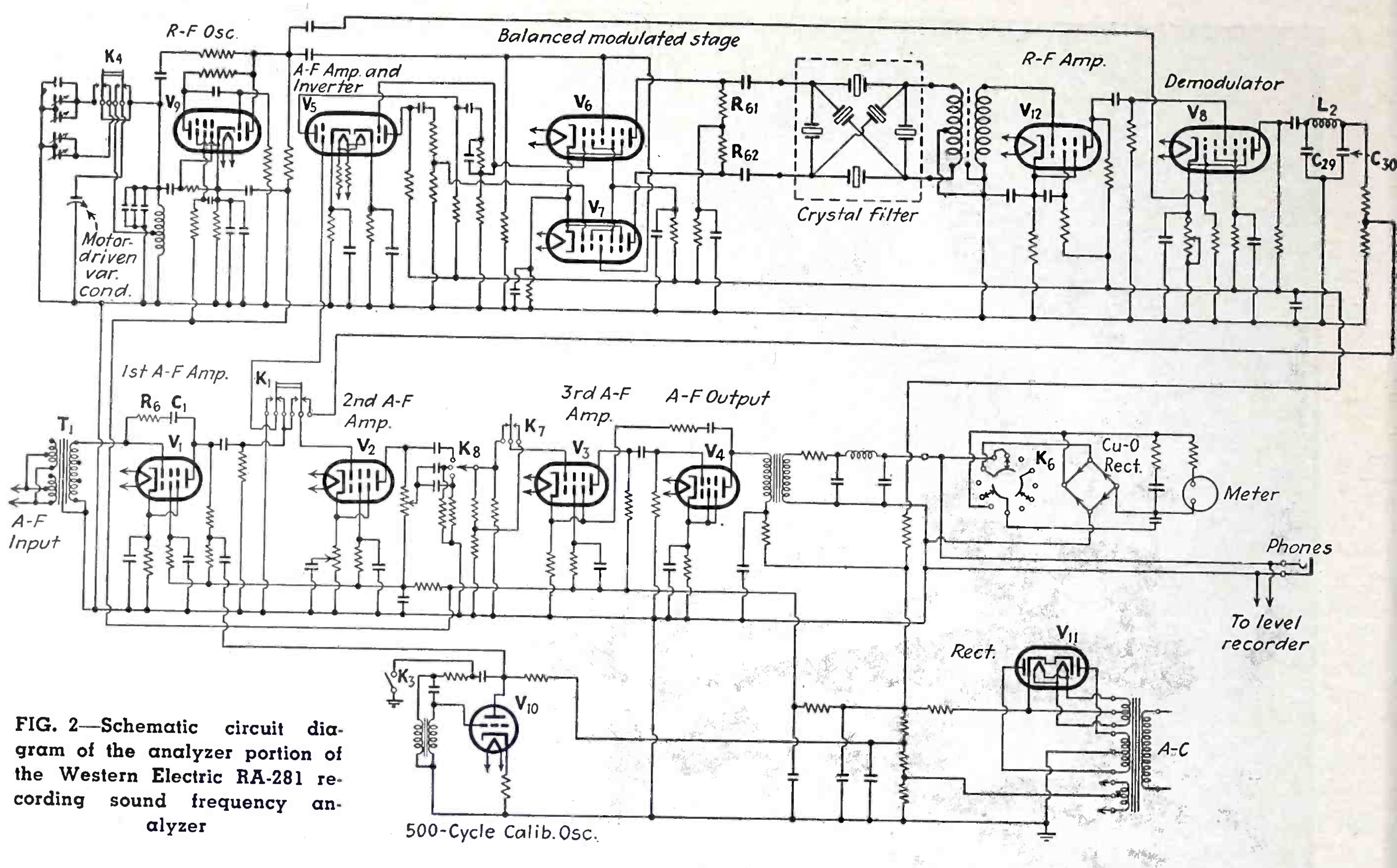


FIG. 2—Schematic circuit diagram of the analyzer portion of the Western Electric RA-281 recording sound frequency analyzer

The crystal filter used in the audio analyzer contains a lattice network of quartz crystals. The pass band determines the exact type of lattice circuit and the number of crystals to be used. The wider the band, the more crystals are needed.[1,2,3]

Each crystal must be ground accurate to a fraction of a cycle so as to build up the desired band width. The crystals collectively must provide a flat-top response centered on 50 kc, with almost straight sides outside the desired band. All crystals in a given filter are ordinarily ground from the same mother crystal so as to have identical characteristics.

The crystals are usually mounted in individual hermetically sealed containers. In some applications, however, it has been found desirable to mount each crystal individually in a vacuum tube, to eliminate air damping and further improve the crystal as a filter element.

Demodulator and A-F Amplifier

The output of the crystal filter is amplified in r-f amplifier stage V_{12}, then combined with the r-f oscillator signal in the demodulator stage by means of electronic mixing. This gives in the output circuit of demodulator tube V_8 a difference frequency corresponding to the audio frequency being analyzed. Pi filter $L_2C_{29}C_{30}$ passes only frequencies below 15 kc, hence suppresses the original r-f components in the demodulator.

From the demodulator, the single audio frequency component being analyzed at the moment is fed through the other section of key K_1 to the second a-f amplifier stage, and thence through the third a-f and output stages to headphones and the graphic level recorder. Aural monitoring simplifies the selection and identification of peak components during manual tuning.

In the position shown, key K_6 connects the copper-oxide rectifier and meter across the output. In another position it places a condenser across the meter circuit for additional damping when dealing with fluctuating noise components, and in the third position it disconnects the meter and rectifier.

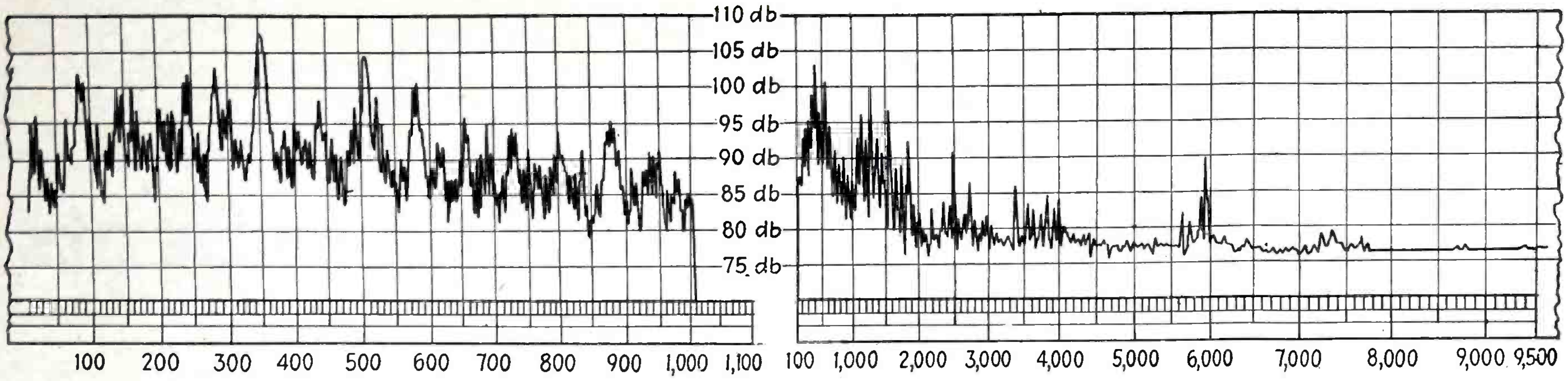
Key K_1 permits feeding V_1 directly to the remainder of the a-f amplifier, giving a conventional type of sound level meter which is responsive to all frequencies. Either the graphic level recorder or the meter can be used for output indications. When the analyzing section is switched out of the circuit in this manner, key K_8 provides a choice of flat, ear-40 and ear-70 frequency responses as called for in ASA specifications for sound-level meters.

Key K_7 in the a-f amplifier permits inserting a 20-db pad when it is desirable to reduce output signal level a definite known amount.

A 500-cycle calibrating signal is fed into the output of the first a-f amplifier stage from triode V_{10}, for checking the frequency and gain calibration of the analyzer before making a series of tests. When not desired, it can be removed by closing key K_3, which in effect grounds the a-f output of V_{10}.

Key K_4 provides a choice of two different r-f ranges in the local oscillator, thereby giving audio frequency ranges of 10–1000 cycles and 100–9500 cycles for analysis. For special requirements the analyzer can be modified to operate up to 25,000 cycles.

The synchronous motor which is



Example of a frequency analysis record of the gear noise in a marine engine. The frequency scales are separate; they are placed on the tape and the vertical lines drawn up from the scales for convenience in studying the results

supplied to drive the tuning dial of the analyzer requires approximately two minutes to cover one of the ranges. The motor speed was selected to give a complete analysis as quickly as possible without missing important audio components. In use, it plugs into an outlet on the analyzer panel and engages the dial knob through prong coupling, so that the motor can readily be removed when manual tuning is to be used.

The graphic recorder was developed simultaneously with the sound frequency analyzer because no existing recorder could be found which would meet the special requirements of this application. The recorder had to be rugged to permit use in a moving automobile or any other location subject to severe vibration. It had to have a linear decibel scale, had to respond accurately to sudden changes in level, and had to produce an economical permanent record requiring no processing after test runs are made.

Recorder Plots Level vs. Frequency

The recorder utilizes a special bridge circuit developed by Swartzell and Bedell[4] for the clutch mechanism driving the marking scriber. The final circuit arrangement is shown in Fig. 3.

The a-f signal from the a-f output stage of the analyzer is applied to a five-stage a-f amplifier in the recorder (V_1, V_2, V_3, V_4 and V_5), through potentiometers P_1 and P_2. The resulting a-f signal is applied to a bridge circuit arrangement employing full-wave rectifier V_7 in two legs and clutch coils L_1 and L_2 in the other two legs.

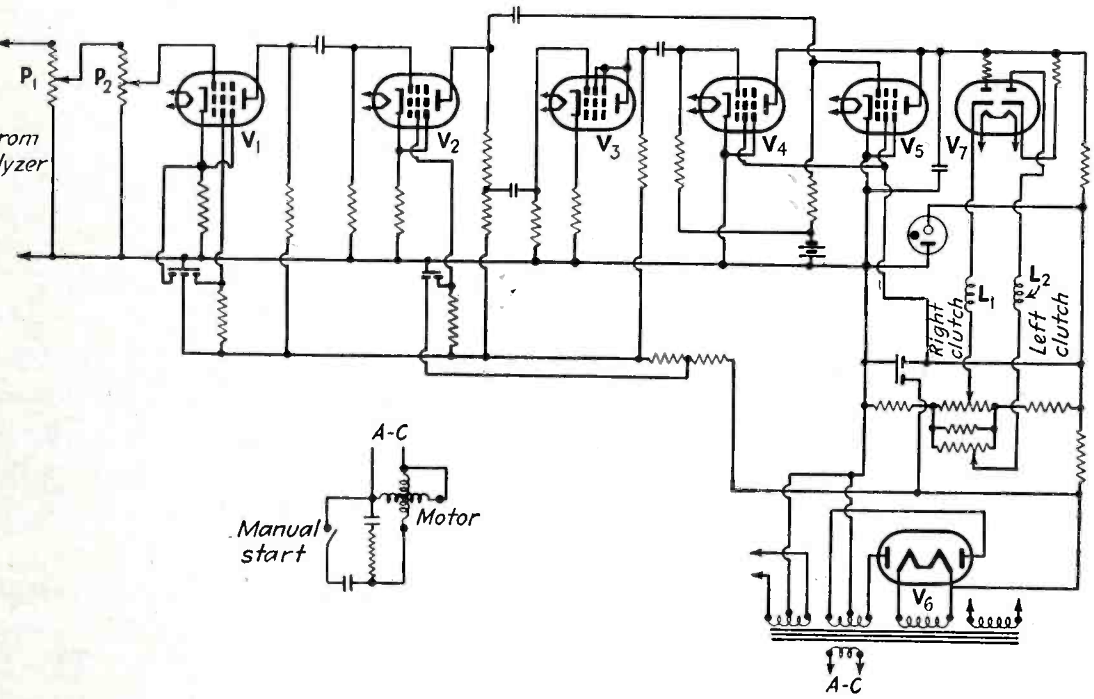


FIG. 3—Schematic circuit diagram of the graphic level recorder

The movable contact arm of potentiometer P_2 is mechanically linked with the scriber arm, with the combination being driven by a small electric motor. The scriber or stylus is engaged to the constantly moving drive system through a magnetic clutch only when motion is required.

Initially, P_1 is adjusted so that equal currents will flow through both clutch coils for a particular desired scriber position and corresponding setting of P_2. Now, if the a-f input level increases above this initial value, more current will flow through the left clutch, for instance, causing this clutch to attract a rotating Permalloy disc which clamps on the endless wire belt which moves the scriber. The action of the clutch thus moves the scriber in the direction selected for higher signal level. The movement stops when P_2 has been moved sufficiently to balance the clutch currents again, under which condition both Permalloy discs just clear the wire. If the a-f level drops, the right-hand clutch engages and the scriber is pulled in the opposite direction.

The action of this particular clutch circuit is so fast and so sensitive that it is possible to make the scriber move completely across the recording paper in less than one second, and respond to changes as great as 58 db per second. The electric motor which drives the scriber through the clutch mechanism also moves the paper. A gear shift on the panel gives a choice of three different paper speeds.

The paper used is ordinary colored paper 4½ inches wide, with a coating of wax. A white wax coating on red paper has proved highly satisfactory and provides clear photostats. Scraping away of the wax by the scriber allows the red paper to show. The paper moves between ridged cylinders which impress longitudinal decibel level lines automatically on the strip chart, thereby permitting the use of inexpensive unprinted paper.

(*Continued on page* 210)

Detecting
Small Mechanical Movements

An improved vacuum tube circuit for detecting mechanical movements as small as a millionth of an inch, by converting them into capacitance changes of the order of 0.01 μμf. Accuracy is high because variations in oscillator and cable characteristics are nullified

By Joseph C. Frommer

Rolling & Engraving Mills, Inc.
Chicago, Ill.

OSCILLATOR circuits have been used for some time in the measurement of extremely small mechanical movements, by transforming the movements into changes in electrical capacitance between a fixed and a moving plate. This varying capacitance is connected into the tuned circuit of the oscillator, causing a corresponding change in output which can be measured, recorded, or made to actuate a relay. The chief drawback of these systems, however, has been the fact that any changes in the circuits themselves are equivalent to changes in the capacitance being measured and hence constitute a source of error.

The seriousness of this problem is readily understood if we consider that the maximum variation in capacitance between movable and fixed plates is often less than 0.1 μμf, and the normal variations in capacitance are of the order of 0.01 μμf, whereas the tuning capacity of a tuned circuit is usually 50 μμf or more. A change of 0.2 percent in the tuning capacitance would thus simulate the full movement of the movable plate. Another source of error is introduced when the displacement unit, i.e. the condenser consisting of the movable and fixed plates, has to be connected to the amplifier by a flexible cable. This cable has to be shielded. The capacitance between shield and lead will vary somewhat when the cable is moved, even if highest grade concentric cable is used, and this variation will simulate an equal variation of capacitance in the displacement unit.

The circuit to be described, on which patent application has been made, is essentially free from these drawbacks. It is based on insertion of the displacement unit between an r-f oscillator and an r-f amplifier, as shown in Fig. 1(a). If the capacitance decreases, the input will decrease. The resulting arrangement is highly independent of variations in circuit constants.

For practical reasons, it is in most cases desirable to connect one plate of the displacement unit to ground. If this is done, the other oscillator terminal and both amplifier input terminals must be removed from ground, as indicated in Fig. 1(b).

The circuit diagram of the entire system is given in Fig. 2. Oscillator tube V_2 holds its plate and line H at an r-f potential with respect to ground. The first tube of the amplifier, V_3, derives its plate supply from these lines. Displacement unit

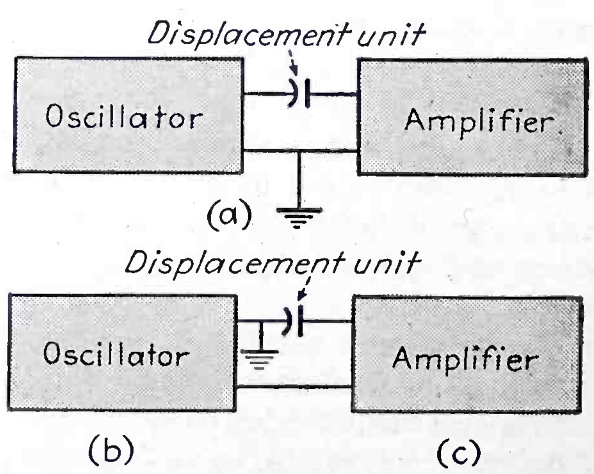


FIG. 1—Block diagram showing position of displacement unit and two possible grounding arrangements

D is connected between ground and a tap on the coil of tuned input circuit T_2. Radio frequency current will flow from ground to line H through the capacitance of D and the tapped part of tuned circuit T_2.

The impedance of D is high compared to the impedance of the tapped center section of tuned circuit T_2, and therefore the r-f current flowing through these impedances is essentially proportional to the capacitance of D. This current causes an r-f voltage difference between the grid and cathode of V_3, and a corresponding r-f plate current flows through T_3. The resulting induced r-f voltage in the secondary of T_3 is rectified in full-wave detector V_4. The d-c potential thus obtained across 0.5-megohm resistor R is filtered and applied to the grid of V_5. The plate current of V_5 can be fed to a meter, recording galvanometer, oscilloscope, relay, etc.

The lead between displacement unit D and tuned circuit T_2 is surrounded by two shields. The inner shield is connected to the cathode of V_3 because a grounded shield around that lead would form an undesirable capacity in parallel with the displacement unit. The inner shielding is surrounded by an outer, grounded shield to eliminate radiation and to diminish changes in capacitance between inner shielding and ground when the flexible cable is moved.

The at-rest capacitance of the displacement unit can be compensated by variable capacitor C, which is connected between H and ground through a coil coupled to T_2 in the proper direction. The gain of the

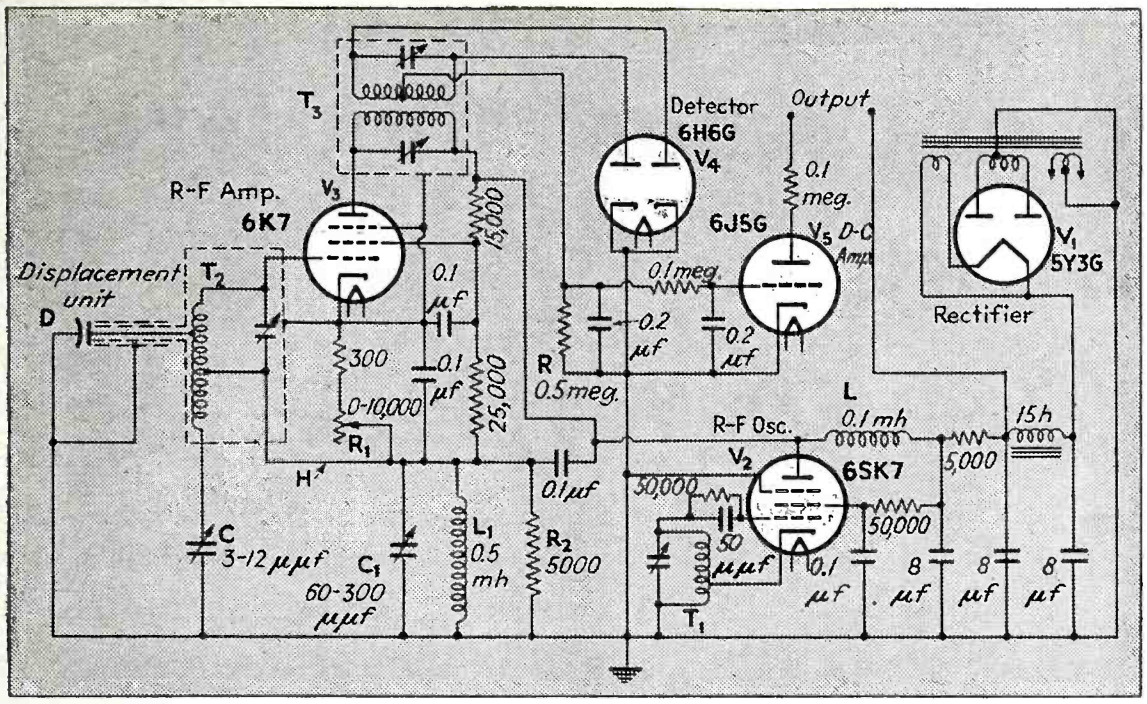
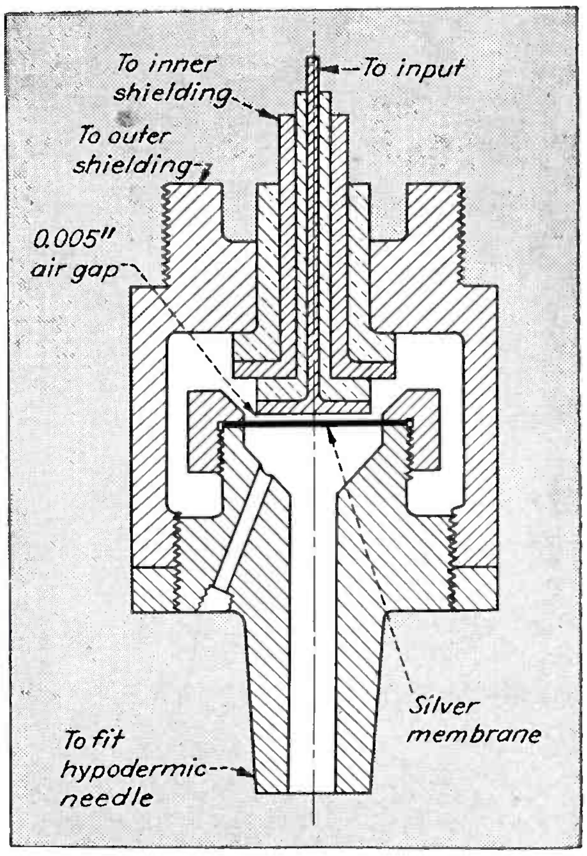


Fig. 2—Complete circuit diagram of oscillator and amplifier used to detect small capacity changes in the displacement unit independently of circuit variations

Fig. 3—Cross-section of displacement unit used for converting arterial blood pressure variations into corresponding changes in capacity



amplifier can be controlled by R_1.

The circuit was designed to be insensitive to changes in capacitance between lead and inside shielding (of the order of 1 μμf for an unusually severe punishment) and to changes between inside shield and outside shield (of the order of 10 μμf for an unusually severe punishment). The oscillator is of the electron-coupled type, so that detuning of the plate circuit does not affect the frequency of oscillation. The r-f voltage obtained at the plate is proportional to the plate load impedance, however. To make this voltage independent of the capacitance between inner and outer shielding (which forms part of the plate-to-ground capacitance), r-f chokes L and L_1 and adjustable capacitor C_1 are tuned to the frequency of oscillation, and the resonant impedance of this tuned circuit is artificially decreased by resistor R_2.

The oscillator signal is fed to a tap rather than to the top of tuned circuit T_2 because any changes in capacitance between lead and inner shielding are reflected to the top of the tuned circuit in proportion to the square of the ratio of turns. In addition, if we slightly detune a tuned circuit, its impedance varies in proportion to the square of the detuning capacitance. Accordingly, the effect of changes in the capacitance between lead and inner shield will decrease with the fourth power of the ratio of turns. At the same time the input sensitivity will decrease in proportion to the ratio of turns (the impedance of D being higher than the resonant resistance of T_2).

If a substantial power output is necessary, the output tube can be fed from a separate power pack, or a class A push-pull arrangement can be used in which the plate current of one tube increases by the same amount as the plate current of the other tube decreases.

The construction of a displacement unit responsive to arterial blood pressure is shown in Fig. 3. It is designed to fit a hypodermic needle which can be inserted in an artery. A silver membrane 0.0015 inch thick and ¼ inch in diameter serves as the diaphragm, and can be moved to its extreme limit by the pressure of a 100-inch water column, corresponding to the peak pressure in the artery of a dog. The actual movement of the membrane under this pressure is less than a thousandth of an inch, too small to be detected with an ordinary indicator.

Calculations and experimental results both indicate that diaphragm movements as small as a millionth of an inch can be reliably detected. With an additional stage of amplification, there is a good possibility that the sensitivity can be still further increased. The response time of the system is limited only by the inert mass of fluid between the diaphragm and the pressure source (in the needle and on the needle side of the diaphragm in the displacement unit).

The selectivity of the whole amplifier can be kept as low as desired to exclude errors due to shifting of the resonant frequency of either the oscillator or amplifier circuit. Practically the only remaining source of error is the fluctuation of line voltage, which can be eliminated by the use of a voltage-regulating transformer.

The amplifier described here has already been used successfully in connection with the recording of blood pressure curves. In addition to this and similar medical applications, the system lends itself to the detection of other mechanical movements, particularly in industry. It can be applied where the displacement is made accessible only by a flexible cord or where response to rapid changes is essential. Possible applications are checking the eccentricity of rotating shafts, detecting small pressure variations in internal combustion engines, and detecting deformation due to stresses in machine or structural parts.

BIBLIOGRAPHY

Wiggers, C. J., "The Pressure Pulses in the Cardiovascular System," Longman, Green & Co., New York, 1928.

Lilly, John C., The Electrical Capacitance Diaphragm Manometer, *Rev. Sci. Instr.* **13**, p. 34, Jan. 1942.

Roess, L. C., Condenser-Type High-Speed Engine Indicator, *Rev. Sci. Instr.*, **11**, p. 183, 1940 (with extended bibliography).

Gilson, W. E., Applications of Electronics to Physiology, ELECTRONICS, p. 86, Jan. 1943.

Gilson, W. E., Photoelectric Manometer (improved design), ELECTRONICS, p. 112 April 1943.

Calibration of Camera Shutters with the Cathode-ray Oscillograph

Simple photographic methods, using stock apparatus, are outlined for testing individual shutters of the focal-plane and inter-lens type. All essential shutter characteristics can be determined. Methods for production testing and control are suggested

By THEODORE H. BULLOCK

Section of Neuro-Anatomy, School of Medicine
Yale University, New Haven, Conn.

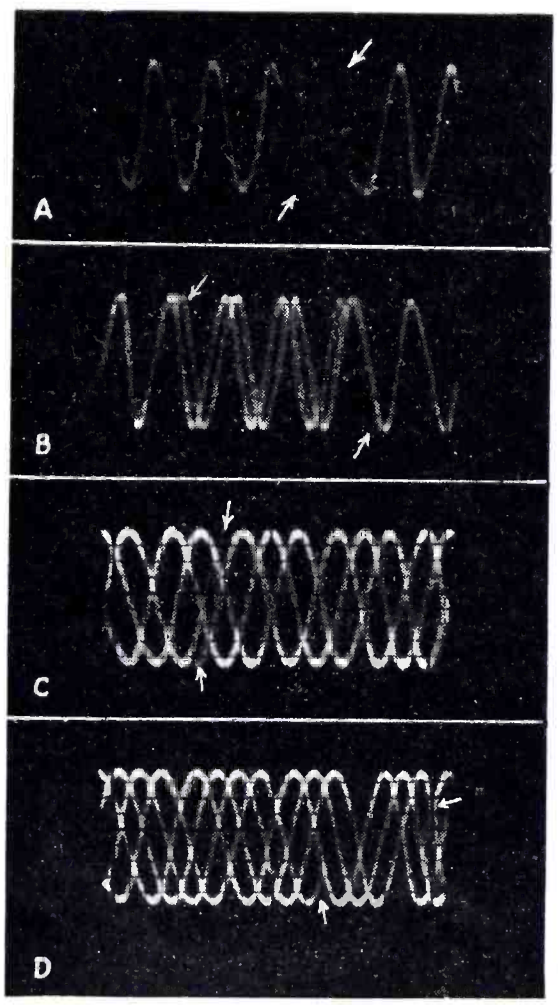


FIG. 1—Sample tests on inter-lens shutters. Arrows indicate beginning and end of photographic traces and hence determine shutter opening and closing. (*A*) 720 cps vertically with sweep slightly differing from 120 cps. Nominal exposure, 1/200 sec.; actual exposure, 1/125 sec. (*B*) Same as (*A*) except shutter set between 1/100 and 1/50 sec. Actual exposure, 1/72 sec. (C) 240 cps vertically with sweep just above 60 cps. Nominal exposure 1/25 sec.; actual exposure 1/20.5 sec. (*D*) 120 cps vertically with sweep just above 30 cps. Nominal exposure 1/10 sec.; actual exposure, 1/8.4 sec.

MANY methods have been devised for checking the accuracy of shutter speed settings and with them evidence has been obtained that significant errors are common, even in new and high priced cameras.[1] The extensive use of color film has greatly increased the importance of testing shutter speeds, since this factor in exposure seems more likely to be in error than either diaphragm setting or film speed. The two methods whose description occupies most of this article are adapted to the testing of inter-lens and focal plane shutters, respectively, wherever the reading of the result can wait upon the development of a negative, as in the calibration of individual or occasional cameras. It is felt, however, that an even more important application of testing procedure is in large scale testing in factory and service shop. Here direct reading apparatus, designed for the job, is necessary. Electronic methods offer perhaps the best possibilities of solution of this problem and since the problem is chiefly an engineering one, this article will attempt only to call attention to the opportunity for such application and point out a few of the available principles on which a method might be based.

The calibration of inter-lens shutters by measuring the arc described on a film by an image of a point moving in a circle at a predetermined rate is well known. This method has been used with the cathode-ray oscillograph as the source of the moving image,[2] taking advantage of the flexibility of control of the rate of rotation and the ease of measuring that rate precisely with this instrument.

But a still simpler method is possible with the same equipment, namely, a source of audio-frequency sine wave voltage such as a beat frequency oscillator, and the cathode-ray oscillograph. An ordinary oscilloscope is satisfactory except that the usual green fluorescent screen is much less photoactive with ordinary fast films than the blue screen and the persistence of image in the green screen is sufficient to introduce an uncertainty in the reading of the records.

Employing the same principle of measuring the length of the line described on the film by a spot of light moving at a known rate in the interval during which the shutter is open, one may use other than circular motion. Much simpler than to obtain a perfect circle at various frequencies of rotation with stock apparatus, is the tracing of a sine-wave (or other regularly recurring wave form) against time on the screen of the cathode-ray tube oscilloscope. The usual sweep circuit suffices for providing the time axis since accurate linearity of sweep is unimportant. It is set at a conveni-

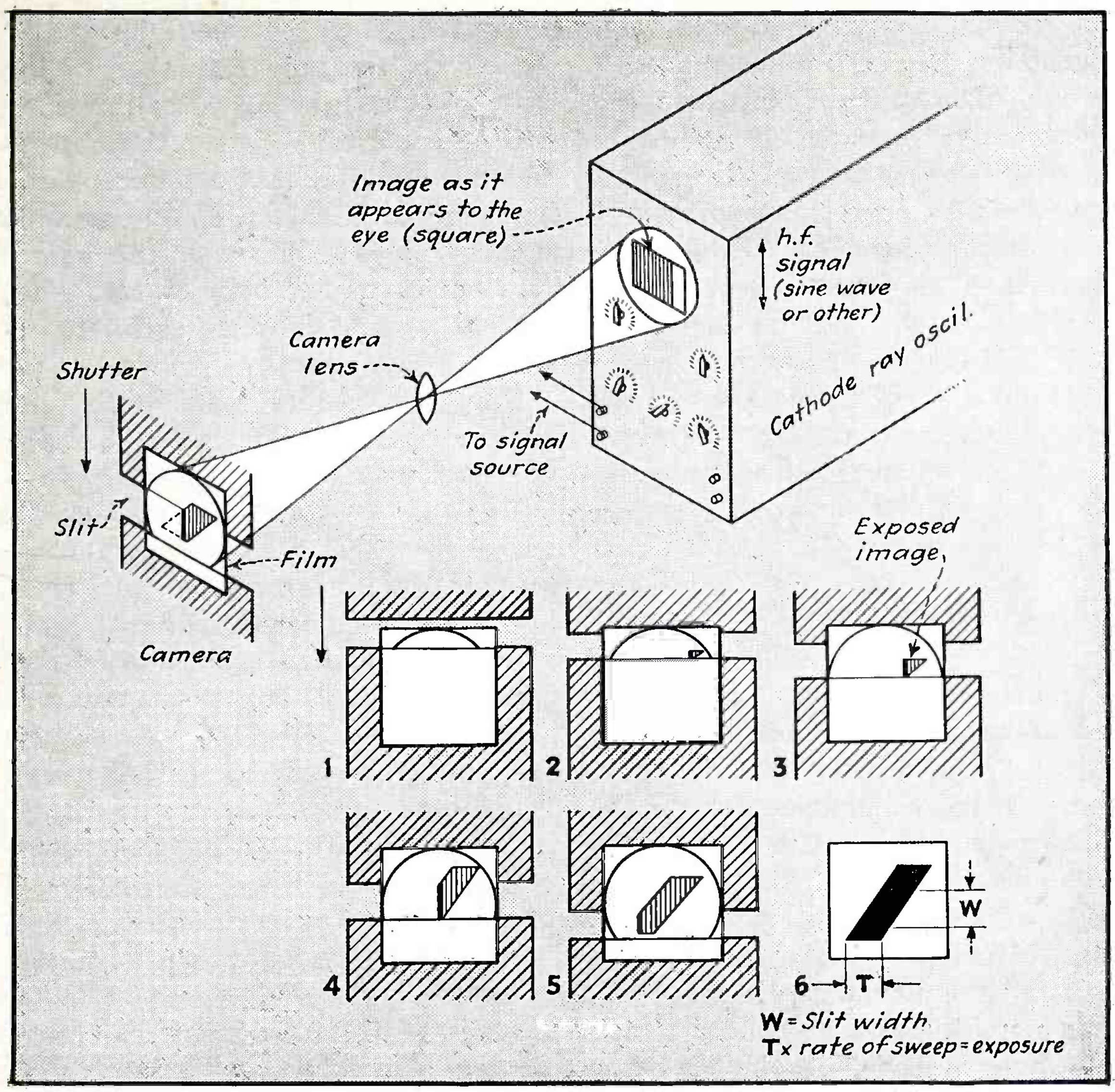


FIG. 2—Diagram (above) illustrating development of rhomboidal figures during exposure and (below) six steps in generation of the parallelogram

ent sweep rate, for example, about twice that of the shutter speed under test. The source of alternating voltage is set at a carefully calibrated frequency (the line frequency is a sufficiently accurate standard) of some convenient value, for example, about six times the sweep frequency. Thus for 1/10 sec. shutter speed a sweep frequency of 20 cps and a frequency on the vertical deflection plates of 120 cps is convenient; for 1/200 sec. shutter speed a sweep of 240 cps and vertical signal of 1440 cps is adequate and easy to calibrate from a 60 cps standard. The vertical deflections will be used as the standard and should be accurately known. The horizontal need not be maintained at the figures suggested, indeed, it is preferably altered just enough that the standing image used for calibrating the oscillator is set in rapid motion. An exposure is then made on fast film, with the camera under test mounted fairly close to the screen. The screen need not fill the negative but should be large enough to permit ready resolution of the individual waves. The shutter is snapped at a random moment without regard to the phase of the sweep, since the pattern recurs without appreciable loss of time.

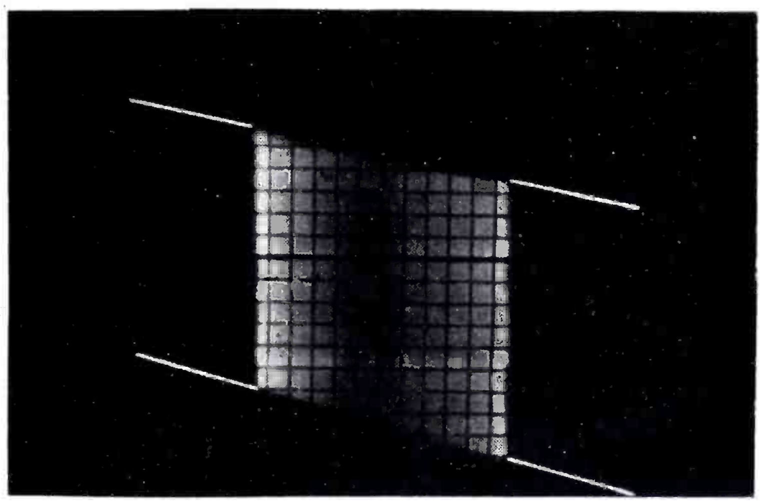


FIG. 3—Bar of light (720 cps) moving downward 20 divisions (2 in.) every 1/60 sec. with 60 cps sweep. Slit moving right to left in camera. Effective exposure in center of frame is 1/100 sec. since 12 divisions are shown. Slope of upper edge is less steep than that of lower edge

By this procedure there will result on the negative a pattern of about two sweeps with six vertical waves each, as shown in Fig. 1. Due to setting the standing image in motion they will not be superimposed but will easily be counted. Such sine waves can be estimated to $\frac{1}{8}$ cycle so that counting approximately 12 cycles an overall accuracy of 1 percent is obtained. This is more than necessary for shutter calibration and at high speeds other errors, such as the uncertainty of the beginning and end of the trace due to the closing and opening time of the shutter, become much larger than this. Because of the much greater distance travelled by the spot in this method than in the method of circular motion, its available accuracy is greater. A saw tooth signal or one of some other shape producing an image of uniform density would be preferable to the sine wave but the latter is quite adequate.

While this method is satisfactory* for shutters which expose the whole picture area at once, it is applied only with difficulty to the focal plane shutter. Here the exposure is effected by the slow movement of a slit across the picture area. At low shutter speeds the slit is often as wide as, or wider than, the entire picture area, the leading and trailing edges of the slit each occupying the entire nominal period of the exposure in their movement or less than that period. In this case each edge of the slit is motionless while the other edge is in motion. They do not necessarily move at the same rate, in some cameras and it is possible to obtain uneven exposure of the negative from this cause. At high shutter speeds the slit is narrower than the picture area, the time of traverse is longer than the nominal period of exposure and the two edges have to move at the same rate, but may accelerate and pro-

* The difference between motion stopping capacity and light passing capacity in non-focal plane shutters makes it difficult to say that any simple method is entirely satisfactory. This method, like most usually used, is primarily designed to measure motion stopping capacity. Light passing capacity can only be estimated roughly. The interrelation between these properties, which is different at different shutter speeds makes it necessary for practical purposes to adopt a more or less arbitrary definition of effective motion stopping exposure. Because of the efficiency of focal plane shutters both properties are easily measured at once in these shutters as by the method described here.

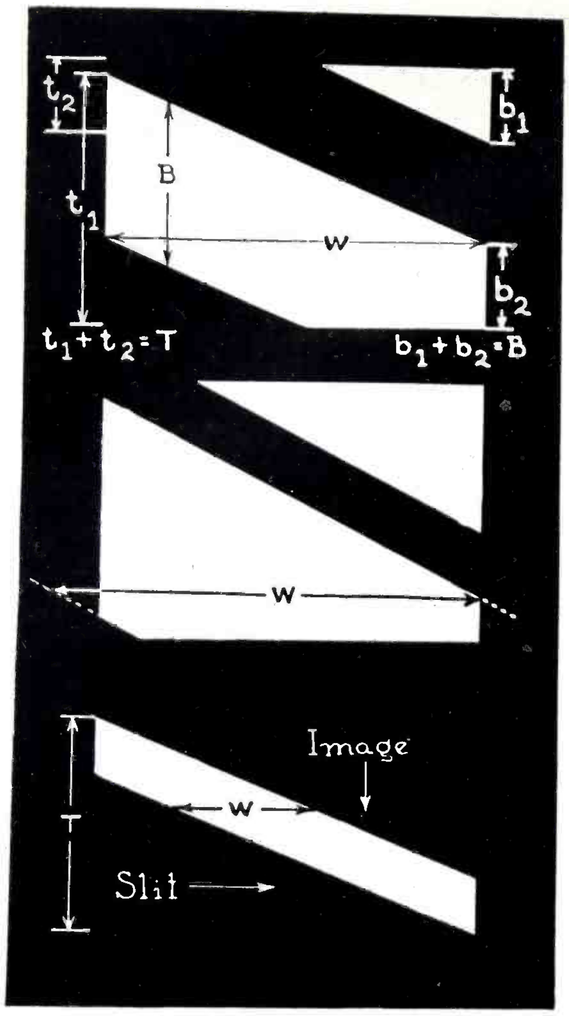


FIG. 4—Diagrams of three possible types of records. (*A*) Slit width equal to width of negative. (*B*) Slit width greater than width of negative. (*C*) Slit width less than width of negative, and elapsed time of exposure time = B/nf where B is width time of each spot. Actual exposure at that point on the film is calculated by exposure time = B/nf where B is width of figure in axis of image motion, n is distance traversed per sweep, and f is sweep frequency

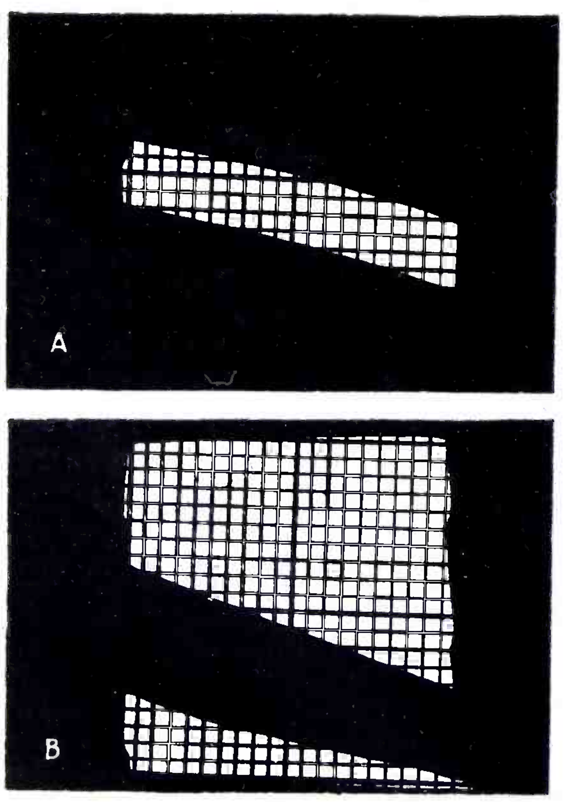


FIG. 5—Tracings of actual records made as in Fig. 3. Bar of light moving 20 divisions vertically in 1/15 sec. (above) and 1/20 sec. (below). (*A*) Nominal exposure, 1/100 sec.; actual exposure 1/75 sec. (*B*) Nominal exposure, 1/30 sec.; actual exposure, 1/29 sec. Wavy edges are due to 60 cps pick-up. Wedge shape distortion at (*B*) due to oscillograph characteristics

duce uneven exposure in this way. A good method of calibrating such shutters should, then, measure the effective exposure at all points in the picture area, that is at each point along the axis of slit movement.

The usual methods of calibrating focal plane shutters either accomplish this result only with great difficulty or by repeating the whole test for each region of the negative. They further involve, in most instances, removal of the back of the camera, sometimes an awkward or impossible procedure.

All Shutter Characteristics Easily Determined

Perhaps the simplest method of measuring all the significant properties of such shutters at once would be to expose a negative during the uniform linear motion, at right angles to the axis of shutter movement, of a bar of light the length of the field of view. The rate of movement of the bar must be precisely known and linear and should be variable over a considerable range in order to be adapted to the entire range of shutter speeds to be tested.

These requirements are easily met by the cathode-ray oscillograph. The only additional piece of equipment necessary is some source of alternating current at a frequency anywhere between 1000 and 20,000 cps, such as the a-f signal generator mentioned in the first described method. This signal is applied to the input of the vertical deflection plate amplifier and provides the bar of light. The saw tooth time base oscillator built into the oscilloscope is used to move this bar at a known, linear, variable rate across the screen. Since the direction of this movement will be horizontal, the camera should be held so that the shutter moves vertically—either up or down (it is not necessary to know which). Any deviation from 90 deg. in the angle between axis of image movement and axis of shutter movement will create an error in the measurement. The camera is fitted with any necessary close-up attachment to make it possible to fill the whole negative area with the image of the screen. The distances chosen, the focal lengths, the degree of reduction, are uncritical as all measurements are made in terms of the ruled celluloid facing provided on the screen of the oscilloscope. If there is a significant distance between the shutter and the focal plane, as there is in some cameras, the speed calibration will be accurate only for the object distance and diaphragm setting used in the test. Greater distances and smaller stops will make the same shutter speed effectively faster. The present method gives an estimate of whether this effect is serious.

The exposure is made with the shutter speed under test, the diaphragm wide open, the sweep frequency of the oscilloscope adjusted to some value conveniently calibrated against a-c mains (or other available frequency standard) and a little lower than the value of the shutter speed. Thus, when testing a shutter speed of 1/25 sec. a 20 cps sweep would be satisfactory. Finally, the amplitude of the sweep is carefully adjusted to some convenient value and recorded in terms of the celluloid ruling. The exposure is made without regard to the phase of the recurring cycles of motion of the bar of light, but if several exposures are made, one negative is likely to contain all of one cycle. This will be more likely the slower the sweep, but it is not necessary for accurate measurement, since the cycles recur without appreciable loss of time.

Analyzing the Diagrams

A rhomboidal figure is obtained. Two of its sides are horizontal (parallel to some edge of the negative) and are defined by the amplitude of the vertical deflecting signal. The other two edges are diagonal and may be parallel or not quite parallel. These are the edges that matter. They are identified as the edges that are not parallel to any edge of the negative. They were defined by the two motions, at right angles to each other, of the sweep and of the shutter slit. One of them represents the resultant of the sweep of the bar of light and the opening or leading edge of the slit, the other represents the resultant of the sweep of the bar of light and the closing or trailing edge of the shutter. Their slant is a function of the rates of these two motions. The schematic Fig. 2 will show how the rhomboid is formed in the ideal case where the sweep happens to begin just as the shutter reaches the margin of the image. A little experimenting with a pencil will show the effects of varying the parameters involved. Some of the possible figures are reproduced here (Figs. 3 to 6). To obtain the actual exposure at any point in the negative it is only necessary to count the number of rulings exposed between the diagonals in the axis of motion of the bar of light passing through this point. Knowing the rate of motion of the bar of light the calculation of exposure time is:

$E.T. = B/nf$

where t is exposure time in seconds
B is number of rulings counted
n is number of rulings per sweep
f is sweep frequency in cps.

Thus in Fig. 3 the camera shutter was set at 1/100 sec. the sweep at exactly 60 per second and 20 divisions of the ruling. It will be seen that the shutter allowed 12.5 divisions to be exposed at the right edge of the image and the exposure at this position was therefore $t = 12.5/(20 \times 60) = 0.0104 = 1/96$ sec.

It was found in practice that a stock Model 164 Dumont oscillograph with a short-persistence blue screen** gave usable density on Eastman Super XX film at high shutter speeds, an aperture of $f/3.5$. The linearity of the sweep was satisfactory. A model with higher intensity, still better linearity, and larger screen area would increase precision and usefulness. A sawtooth signal on the vertical plates would be, of course, the best but a sine wave proved satisfactory even though it gives less density of the negative in the center than at the ends of the figure.

By this method it will be noted that the exact effective exposure at every point in the picture area can be obtained. Thus, inequalities in the rate of movement of the leading and trailing edges of the slit are recorded as lack of parallelism of the diagonals and can easily be measured as a difference in the number of rulings exposed at the two ends of the negative.

From the figure obtained it is also possible to determine: (1) the direction of movement of the slit, (2) its width at each setting, and (3) the total elapsed time during an exposure. The first is easily derived from the direction of slope of the diagonal on the film, knowing the direction of movement of the bar of light on the screen. The second is measured directly on the negative as the width of the diagonal band in the axis of shutter movement. If an insufficient fraction of the whole parallelogram appears on the negative, due to a very wide slit or an image that does not fill the picture area, projections of the slopes are drawn as in Fig. 4. The total elapsed time (for exposure of the whole negative) is the distance T (Fig. 4) calculated as seconds from the known rate of movement of the image.

Shutter Efficiency

Still another characteristic of the camera is revealed in the same record. The efficiency of the focal plane shutter, that is the degree to which agreement exists between the total time of exposure of any point of the film and the time during which that point is receiving all the light admitted by the lens, depends on the distance between the shutter and the actual focal plane. A good focal plane shutter is built close to the plane of the film, casts a sharp shadow on that plane and approaches 100 percent in efficiency. But many cameras are constructed with an appreciable distance between the plane of the curtain and that of the film, reducing the efficiency markedly. Any significant loss of efficiency will show itself in the negative of the moving bar of light as a graded rather than a sharp margin on the diagonals. If the zones of graded intensity at both margins amount to less than 5 to 10 percent of the total width of the rhomboidal figure, the inefficiency is negligible, and the shutter must be close to the focal plane. Of course, this estimation presupposes that the spot on the cathode-ray tube is sharply focused both on its screen and on the film. If the margins are sharp nothing further need be done, but if there is a significant fuzziness it should be validated by comparison with the vertical margins of the figure and with the diagonals of figures of very slow shutter speeds.

This method is usable not only for focal plane shutters but for interlens shutters. In this case the resulting figures will not be rhomboidal

(*Continued on page* 250)

** A medium persistence screen would give graded rather than sharp margins on the diagonals reducing the accuracy of measurement, and is not sufficiently photoactive for adequate density of the negative.

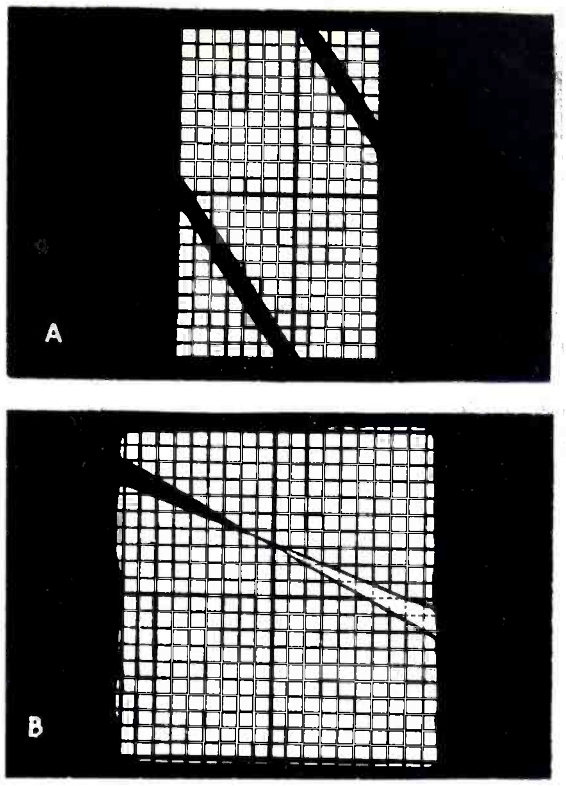


FIG. 6—Same as Fig. 5 (*A*) Shutter set for 1/200 sec. Sweep, 120 cps. Actual exposure 1/130 sec. (*B*) Shutter set for 1/30 sec. Sweep, 30 cps. Actual exposure 1/30 sec. in center of picture, but 13 percent less at left edge and 13 percent greater at right edge since leading edge of focal plane shutter moves faster than trailing edge of focal plane shutter. Triangle at right (*B*) represents region of double exposure, shown as area of greater density on original film

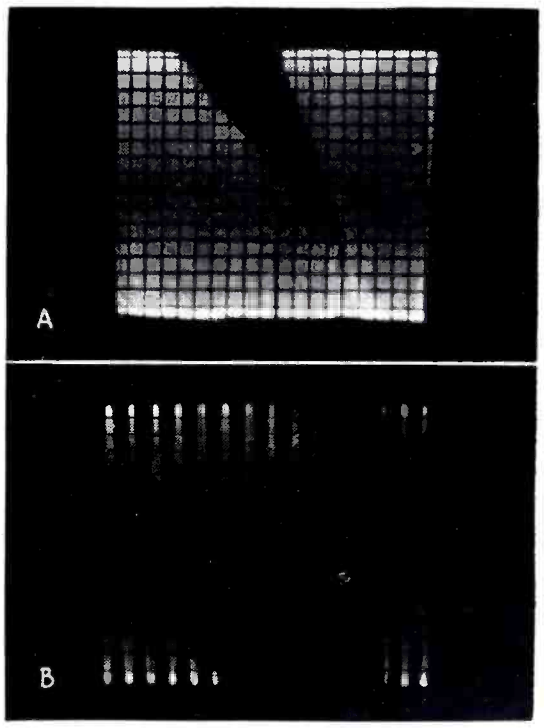
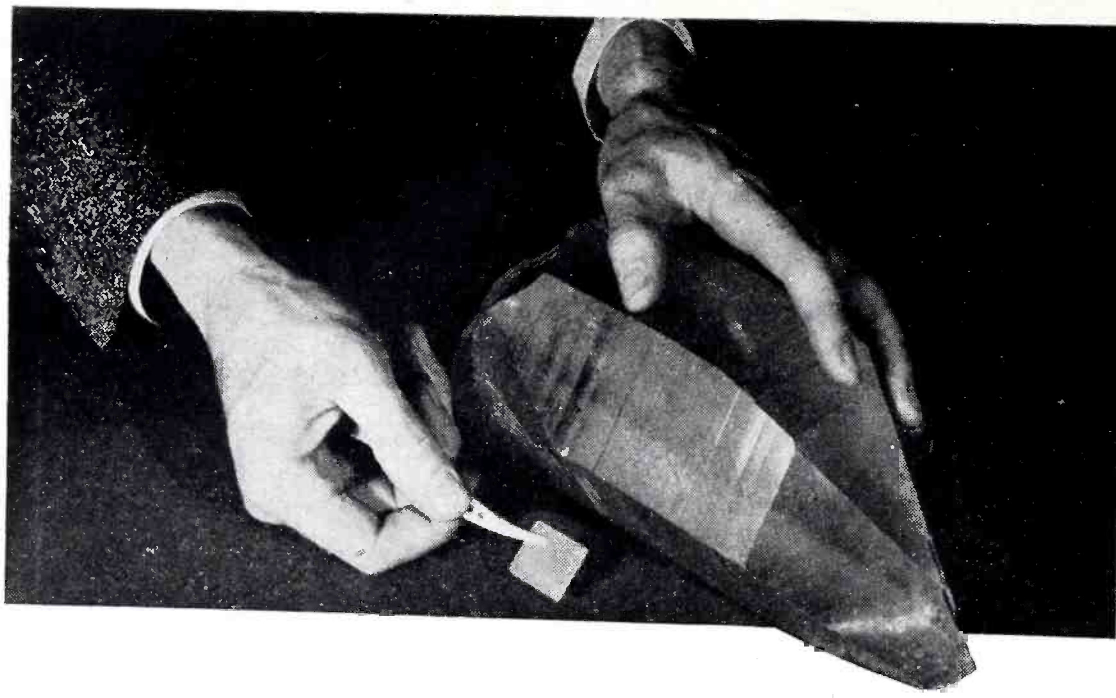


FIG. 7—Records made with 35-mm focal plane camera. (*A*) Bar of light moving left to right 20 times per sec., shutter slit moving from top to bottom. Nominal exposure, 1/25 sec. Actual exposure 1/25 sec. in center, but varies considerably above and below center due to leading edge of slit moving faster than trailing edge. (*B*) Sweep, 120 cps, left to right, illustrating use of slower vertical signal to give separate waves instead of bar of light. Vertical signal is 1,920 cps. Shutter set for 1/200 sec. Actual exposure varies from 1/160 to 1/215 sec.



QUARTZ

By L. A. ELBL

Engineering Dept., Crystal Products Co., Kansas City, Mo.

QUARTZ CRYSTALS or, more correctly, "quartz oscillator plates," have numerous peacetime as well as wartime uses.

Today quartz oscillator plates fix the frequency of transmitters and receivers used by the Army and Navy on land, at sea and in the air, playing a vital part in the performance of military communications equipment. They are used in the recently publicized radar devices. They also perform important functions in connection with artillery range-finding and submarine-detecting gear and permit the internal pressures within gun-barrels and combustion engines to be readily measured and indicated.

Military uses cannot be detailed at this time. It is desirable, however, to call attention to the expanding scope of quartz oscillator plate applications for the peacetime world to come.

Expanding Uses

Quartz oscillator plates serve many useful purposes on the home front. Broadcasting, police and other radio stations make use of them for frequency control. Through their use it is also possible to send hundreds of telephone calls over one wire line with no interference. Perhaps in the not too distant future, all telephone systems will make use of such plates.

Our most accurate timepieces or chronometers, as well as seismographs for locating earthquake disturbances, contain vibrating plates. By the use of such oscillating plates man has bettered the constancy of the earth's rotation. A quartz plate may vary less than one part in 10,000,000 in frequency, which figures less than 1/100 of a second per day.

Other rapidly developing applications of quartz plates are in the field generally known as "ultrasonics." Plates are now used in the dairy industry to homogenize milk. Milk is passed over a vibrating quartz plate and, under the action of pressure-waves, cream droplets are broken up and dispersed, making a uniform liquid. There is no cream separation and a smoother, more consistent, and more easily digested product results. A similar application is being tried in the petroleum industry. Gasoline is being produced from crude oil by splitting the large hydrocarbon molecules by means of vibrating plates. This process is termed "cracking."

The dispersing ability of ultrasonic waves is finding numerous other uses. New alloys are being prepared from metals, such as aluminum and lead, which ordinarily do not mix when melted together. Another metallurgical application of ultrasonic waves is the detection of flaws and blowholes in castings, by means of wave-patterns. Because a solid conducts the wave in unbroken fashion, breaks or flaws in the interior can be detected by variations in the wave-pattern.

In the field of chemistry, research engineers have found that starch can be converted into dextrine, and cane sugar into glucose, by ultrasonic vibrations. Photographic chemists are now turning out better film because homogenization of the emulsion has made possible greater concentration of silver compounds. Not only can particles be broken up and dispersed, but a reverse action enables ultrasonics to condense vapors, smokes, and fumes. This principle has been used to eliminate the smoke hazard in some of our cities.

Ultrasonic waves are even being used in medicine. When these vibrations are sent through an arm or leg, the flesh and bone-marrow get warm while the bone stays cool. This is due to the fact that flesh and marrow are poor vibration conductors, while bones readily conduct the vibrations. Flesh and marrow absorb ultrasonic energy and convert the vibrations into heat. Thus, we have a method of treating certain internal diseases. Experiments of this type are now in progress in many clinics throughout the country.

It has also been found that ultrasonic waves act as a "death-ray" on certain microscopic plants and animals. Tiny organisms are literally shaken to death. Thus we can make from quartz plates practical devices for killing disease-producing bacteria.

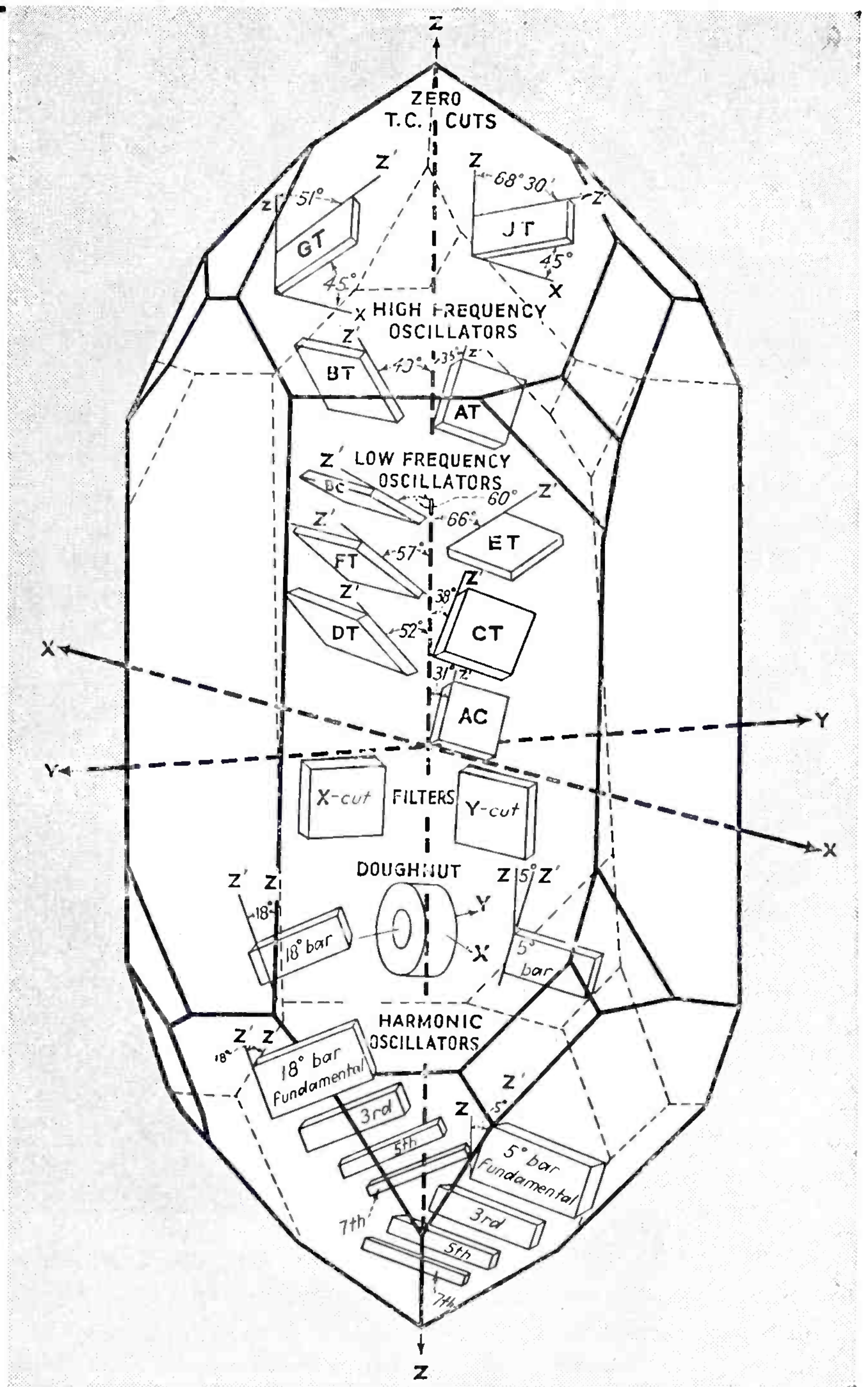
Piezo-electricity Principle

The above uses of quartz plates come about because such plates possess "piezo-electric" characteristics. This phenomenon was discovered by Pierre Curie about 1881.

Piezo-electricity may be briefly explained as follows: When properly cut quartz plates are distorted by compression or elongation along certain axes, electric charges are produced on opposite faces. The reverse effect is the production of a mechanical distortion by the appli-

CRYSTAL CUTS

By preserving certain angular relationships with respect to the various axes of a mother crystal, oscillator plates may be given characteristics most suitable for specific jobs. Modes of vibration in basic cuts and recent modifications are discussed. Present-day and future applications of quartz oscillator plates are broadly outlined



Quartz oscillator plate cuts, showing their angular relationship with respect to the X (electrical) and the Y (mechanical) and the Z (optical) axes of a mother crystal

cation of an electric charge to the plate.

By applying an alternating voltage to the surface of the plate, it may be made to expand and contract very slightly in time or in tune with the alternations. In other words, by stimulating the plate with alternating voltage of approximately the same frequency as its natural vibration period the plate may be made to vibrate mechanically at a frequency determined by its size and shape.

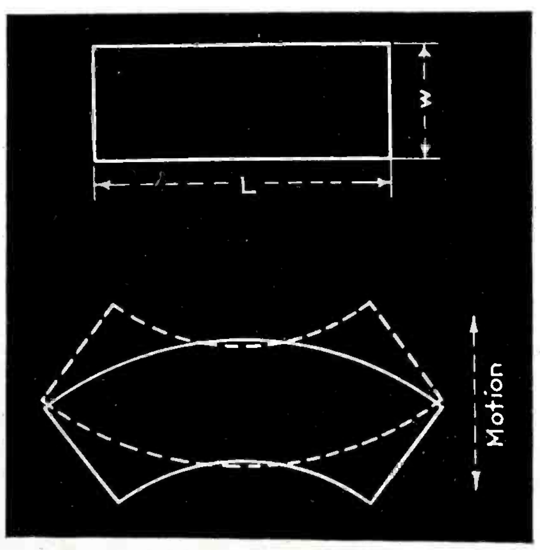
By very accurate cutting and grinding, a quartz plate can be made to oscillate at a frequency which is very constant.

Modes of Vibration

Quartz plates may vibrate in several different ways. Vibration patterns are frequently studied by placing lycopodium powder on the vibrating plate. Patterns are sometimes quite complicated but, in general, may be classified into three simple types: (1) flexure, (2) longitudinal, and (3) shear. A fourth classification, which may be a modification of any of these three, is the "harmonic" type.

In the flexure type of motion (Fig. 1) we have the plate vibrating on the width, with the displacement upon the width and the wave propagated along the length. The plate is distorted first in one direction and then in the other.

FIG. 1 — Plate vibrating "in flexure"



In the longitudinal type (Fig. 2) the displacement is on the length and the wave is propagated along the length.

The shear type of motion is more complicated (Fig. 3) and consists of an expansion and contraction in opposite phase along two diagonals of either the face or the thickness.

Just as a string can be made to vibrate as a whole, giving a fundamental tone, or in higher frequency "segments", so we may have quartz plates vibrating on harmonics. Such plates (Fig. 4) are the same general types as those used for fundamental frequency vibrations but, by utiliz-

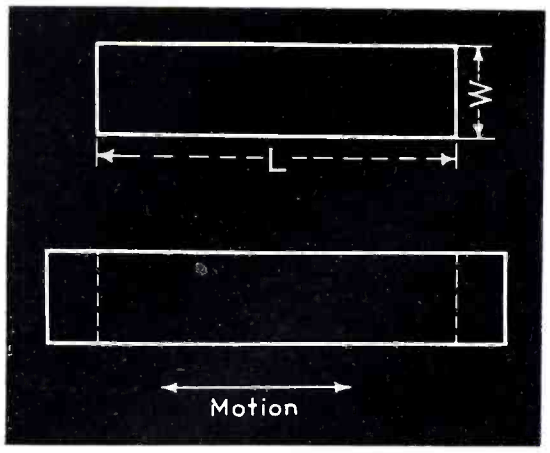


FIG. 2—Plate vibrating longitudinally

ing a different grinding and mounting technique and different circuits, are caused to vibrate on a harmonic. Odd harmonics are much more commonly used than even ones. The working frequency is usually but not always three times the fundamental. It may vary as much as 50 kc from a calculated frequency, depending upon the manner of vibration.

Quartz plates may have two, or even three, modes of vibration. It is the task of the manufacturer to determine what mode of vibration is to be used for a particular frequency and eliminate all others. This is accomplished by correct dimensioning of the plate and precise grinding technique. Generally speaking, in the low frequency range from 15 to 400 kc, bar-types vibrating on the length, or plates vibrating in flexure on the width are used. In the range from 400 to 11,000 kc, plates vibrating on a thickness shear are commonly used. From 11,000 to 30,000 kc harmonic crystals are employed. At present there are several modifications of these classes being used for special military purposes.

Early Cuts

In manufacturing a quartz oscillator plate, one must first consider the purpose for which it is to be used. In plates used to control the frequencies of radio transmitters and receivers, the most important single property is the temperature coefficient. In plates used for ultrasonic applications, the temperature coefficient is not as important as the activity of oscillation and mechanical output efficiency. In plates used as tuned filters, for the most part, the activity is not as important as in the service mentioned above. Activity can always be low. In some cases a low temperature coefficient is required.

First of all, let us consider the temperature coefficient. This is defined as the fractional change in frequency per unit change in temperature. If quartz plates are to be used in radio transmitters and receivers in any part of the world—at the poles or at the equator—there must be very little change in their frequency with change of temperature if the equipment is to be efficient. In our recent African Campaign, ground troops in a torrid region had to be in constant communication with bombers and observation planes up in the stratosphere at sub-zero temperatures. Obviously, if the frequency of the quartz plates used in communications gear changed excessively with temperature, the different units of the army would have been unable to communicate.

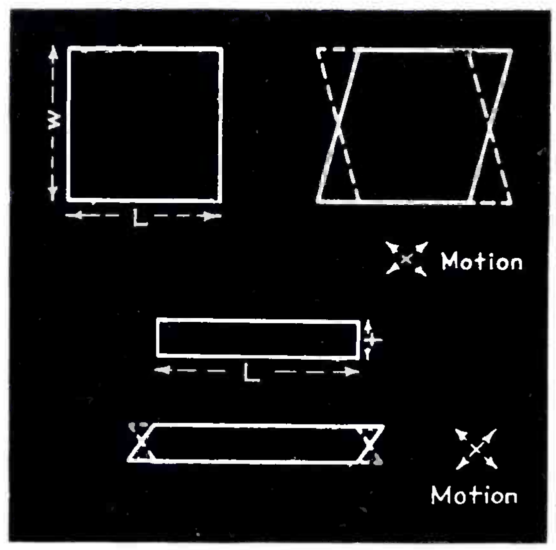


FIG. 3—Quartz plate vibrating "in shear" on face and "in shear" on thickness

To calculate the t.c., we divide the change of frequency in cycles by the product of the frequency of the plate in cycles and the Centigrade change in temperature in degrees. If the change is in the same direction as the temperature (i.e. an increase in frequency with rising temperature or vice-versa) the t.c. is positive. If the frequency and temperature go in opposite directions, the t.c. is negative.

To be a good radio frequency control device, the temperature coefficient should not exceed 2×10^{-6} per degree. Thus, a 4 Mc plate operating from -30 to $+70°$ C with a change of 800 cycles would have a temperature coefficient

$$t.c. = \frac{\text{frequency change in cycles.}}{\text{frequency of plate in cycles times temperature change in degrees centigrade.}}$$

$$t.c. = \frac{800}{4 \times 10^6 \times 100} = 2 \times 10^{-6}$$

In general, the temperature coefficient is determined by the angle of cut, the size and shape of the plate, and the precision of grinding and mounting. Most emphasis is placed on the angle of cut.

To produce piezo-electric charges, one must exert stress either in the direction of the *X* (electric) axes, or the *Y* (mechanical) axes. This knowledge was used in cutting the first quartz oscillator plates, which were *X*-cut plates cut perpendicular to the *X*-axis, and *Y*-cut plates cut perpendicular to the *Y*-axis.

The first plates produced were longitudinal oscillators, but it was not long before thickness oscillators were used for the high frequencies. The *X* and *Y* cuts had very poor t.c.'s, the *X*-cut running as high as 50 parts and the *Y*-cut as high as 100 parts. Both types did have good activity and are still used for certain types of crystal calibrators and filters and are useful in ultrasonic applications.

Two other cuts similar to the *X* and *Y* cuts are the *AC* cut ($-31°$ to the *Z*), and the *BC* cut ($+60°$ to the *Z*). The *AC* type has a temperature coefficient of $+20$ and the *BC* a temperature coefficient of —20. They are used for the same general purposes as *X* and *Y* cuts.

Newer Cuts

Numerous attempts have since been made to improve the performance of quartz oscillator plates. It was soon found, for example, that crystals cut at $+35°15'$ to the *Z* axis, or $-49°$ to the *Z* axis, with one side kept along the *X*-axis, had the very low temperature coefficient of $\pm 3 \times 10^{-6}$. The first of these is known as an *AT* and the latter as a *BT* cut. Both are used as high-frequency radio oscillators, vibrating on a shear of the thickness. The *AT* is commonly used in the range from 400 to 4000 kc and the *BT* from 4000

(*Continued on page* 252)

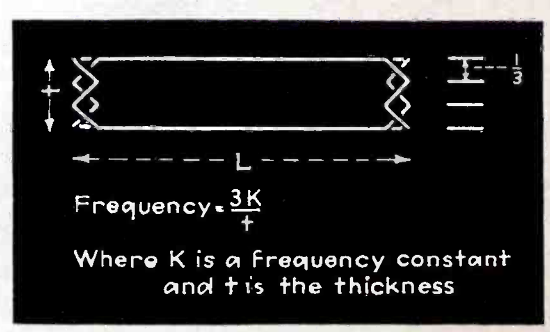
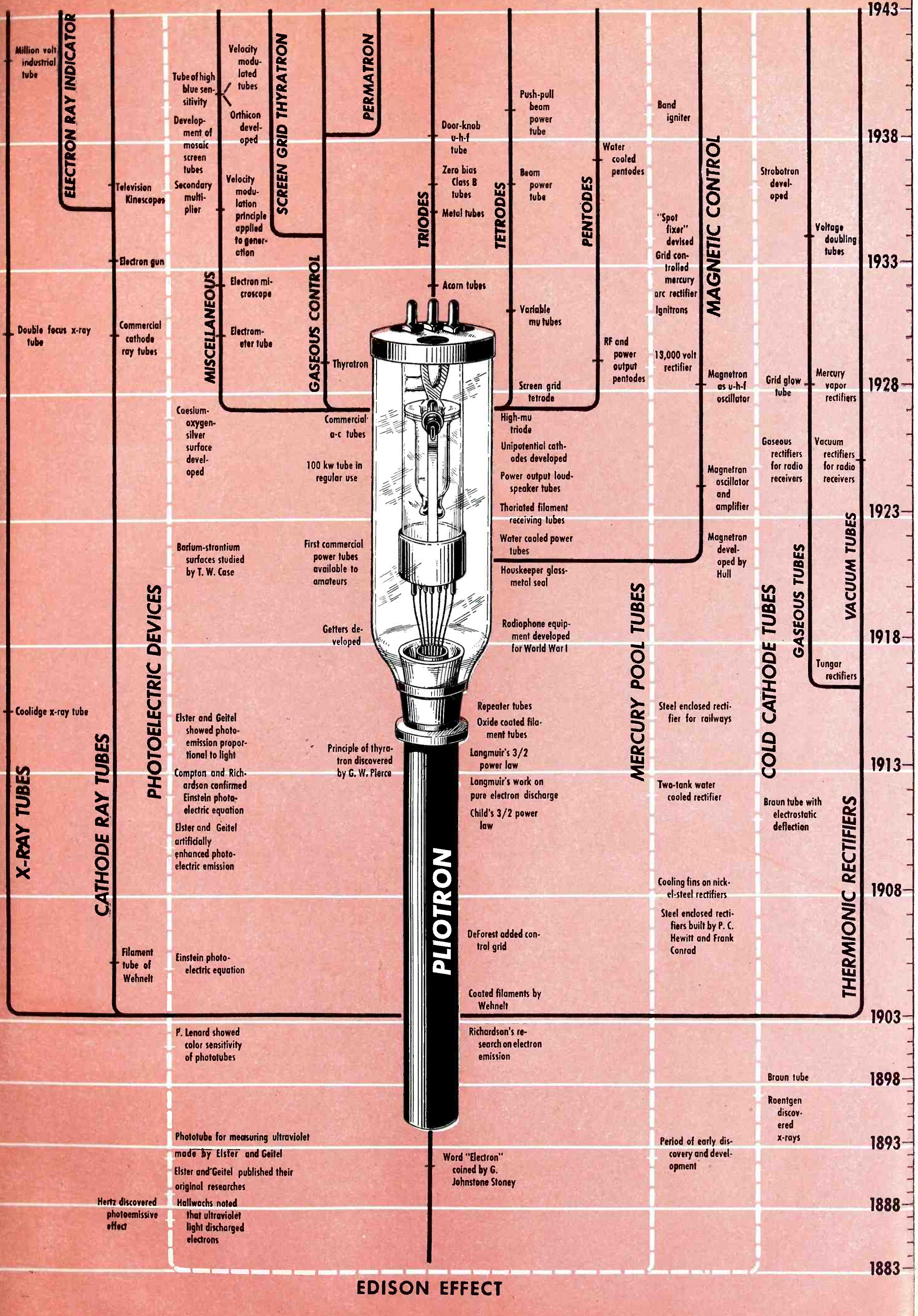


FIG. 4—Quartz plate vibrating "in shear" on thickness, at third harmonic

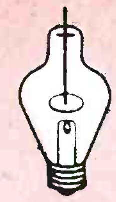
SIXTY YEARS OF ELECTRONICS 1883-1943



electronics
July, 1943

ELECTRON TUBES FOR

TYPICAL APPLICATIONS


TUNGAR OR RECTIGON

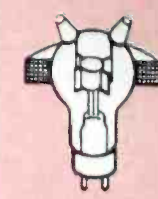
1. Battery charging installations. 2. Low voltage, high current rectifiers. 3. Relaxation oscillators. 4. Voltage rectifiers for a-c generator sets.


KENOTRON

1. High voltage, low current rectifiers for radio receivers. 2. Vacuum tube voltmeters. 3. Power supplies for broadcast and television stations and apparatus.

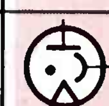
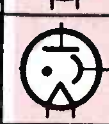

PLIOTRON

1. Amplifiers and oscillators for communication. 2. Induction heating. 3. Industrial control applications. 4. Frequency multipliers and dividers. 5. Diathermy uses.


MAGNETRON

1. Magnetically operated switch. 2. Generator of very high frequency oscillations whose frequency depends on external circuit or on transit time of electrons.

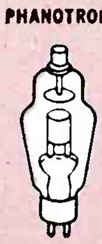
CLASSIFI

INPUT	ELE							
OUTPUT	ELECTRICAL ENERGY							
SOURCE OF ELECTRONS	Thermionic Cathode							
METHOD OF CONTROL	None			Electrostatic		Electromagnetic		None
CHARACTER OF CONTROLLED REGION OR SPACE	High Pressure Gas	Low Pressure Gas	Vacuum	Gas or Vapor	Vacuum	Gas or Vapor	Vacuum	Vapor
TUBE NAME	Tungar or Rectigon	Phanotron	Kenotron	Thyratron	Pliotron	Permatron	Magnetron	Pool Tube
FUNCTION: RECTIFIER OR SWITCH								
FUNCTION: CONTROLLED RECTIFIER								
FUNCTION: AMPLIFIER								
FUNCTION: OSCILLATOR, GENERATOR OR INVERTER								
FUNCTION: VOLTAGE REGULATOR								
FUNCTION: WAVE FORM ANALYSIS								
FUNCTION: LIGHT DETECTION AND MEASUREMENT								
FUNCTION: PRODUCTION OF RADIANT ENERGY (Usually Light)								

TYPICAL APPLICATIONS

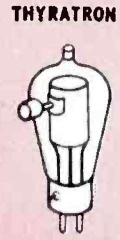
1. Voltage limiting or breakdown devices. 2. Pulse generators. 3. Trigger devices. 4. Relaxation oscillators. 5. Visual indicators. 6. Rectifiers.

PHANOTRON



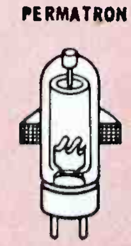
1. Voltage or phase controlled rectifier. 2. DC to AC inverter. 3. Electronic welding. 4. Commutation and switching. 5. Motor speed control. 6. Electrical timing.

THYRATRON



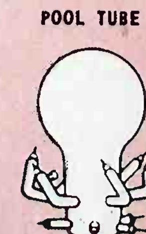
1. Magnetically operated switch. 2. Control of large currents by external magnetic field.

PERMATRON

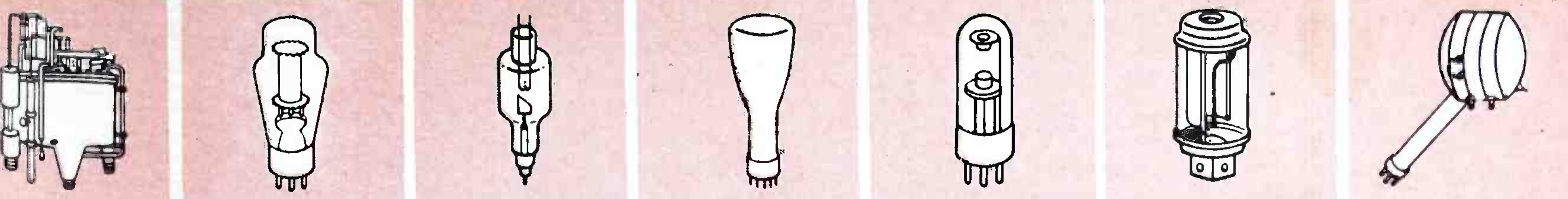


1. High voltage, high current rectifier. 2. Commutation and switching. 3. Power supply for railway and street car systems. 4. Current and power control.

POOL TUBE



INDUSTRY AND COMMUNICATION

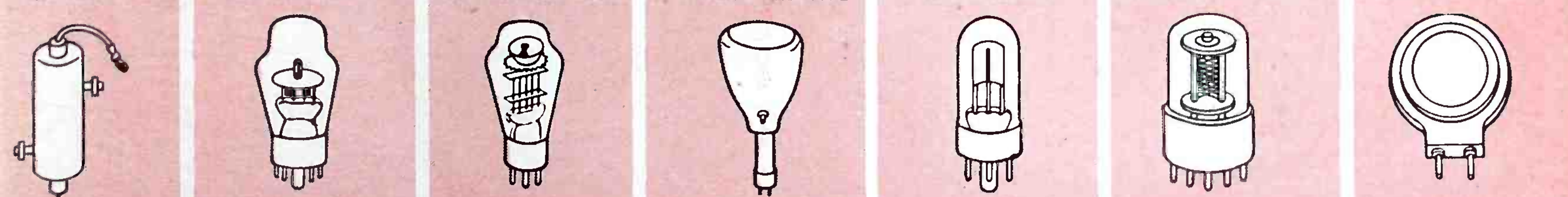


RID POOL TUBE	GLOW TUBE	X-RAY TUBE	CATHODE RAY TUBE	STROBOTRON	VACUUM PHOTOTUBE	MOSAIC SCREEN TUBE
High voltage, high ent controlled rec- er for large power lications. 2. Rail- ʸ power supply. 3. tching and commu- on. 4. Current and ver control.	1. Voltage regulator and stabilizer. 2. Visual indicator. 3. Relaxation oscillator. 4. Production of light. 5. Rectification. 6. Protection of circuits.	1. Medical examinations. 2. Industrial examinations of products. 3. Crystal examination. 4. Detection of forged or altered paintings. 5. Diffraction studies.	1. Television receiving tube. 2. Visual indicator for electrical measurements of all kinds. 3. Application to industrial measurements. 4. Brain wave studies.	1. Control tube for photographic uses. 2. Source of intermittent light flashes. 3. Stroboscopic measurements. 4. "Slowing action" of recurrent moving mechanisms.	1. Measurement of light and color. 2. Picture transmission. 3. Spectro-photometers. 4. Measurement and control of high temperature. 5. Measurement of glare.	1. Television camera and pick-up tubes. 2. Transmission of pictures over wires or radio circuits. 3. Picture monitoring and remote control over radio or wire circuits.

ATION OF ELECTRON TUBES

AL ENERGY									RADIANT ENERGY (Light)				
				RADIANT ENERGY (Light)					ELECTRICAL ENERGY				
athode		Cold Cathode		Thermionic Cathode				Cold Cathode	Photoelectric Cathode				
ctro-atic	Igniter Electrode	None	Electro-static	None	Electro-static	Electro-static	Electro-magnetic	Electro-static	Radiant Energy (Light)				
apor	Vapor	Gas	Gas	Vacuum	Vacuum	Vacuum	Vacuum	Gas	Gas	Vacuum	Vacuum	Vacuum	Metallic Contact
d Pool ube	Ignitron	Glow Tube	Grid Glow Tube	X-Ray Tube	Electron Ray Tube	Cathode Ray Tube	Cathode Ray Tube	Strobo-tron	Phototube	Phototube	Secondary Multiplier	Mosaic Screen Tube	Barrier Layer Cell
							MAG DEF						

IGNITRON	GRID GLOW TUBE	ELECTRON RAY TUBE	CATHODE RAY TUBE	GAS PHOTOTUBE	SECONDARY MULTIPLIER	BARRIER LAYER CELL
Spot welding con- l. 2. Illumination ntrol. 3. Motor com- tation. 4. Frequen- transformation. 5. gh voltage, high cur- nt rectifier. 6. DC to inversion.	1. Controlled voltage regulator and stabilizer. 2. Relaxation oscillator. 3. Remote control applications. 4. Production of light. 5. Current or power control.	1. Visual indicator of voltage. 2. Bridge balancing indicator. 3. Tuning indicator on radio receivers. 4. Measurement of voltage, current or power.	1. Television tube. 2. Measurement of e/m of electron. 3. Visualizing electrical phenomena. 4. Industrial and electrical measurements. 5. Medical applications.	1. Industrial counting, sorting, weighing. 2. Light control element. 3. Industrial protection and control. 4. Intrusion detector. 5. Sound-on-film uses.	1. Measurement and control of light and color. 2. Measurement of density, transmission, opacity, glare. 3. Light control device of high sensitivity.	1. Photographic exposure meter. 2. Portable light meter. 3. Industrial protection. 4. Measurement of high temperature. 5. Conversion of light into electricity.



ELECTRONICS Applied to Heat Transfer Tests

By ROBERT V. BROWN
Case School of Applied Science
Cleveland

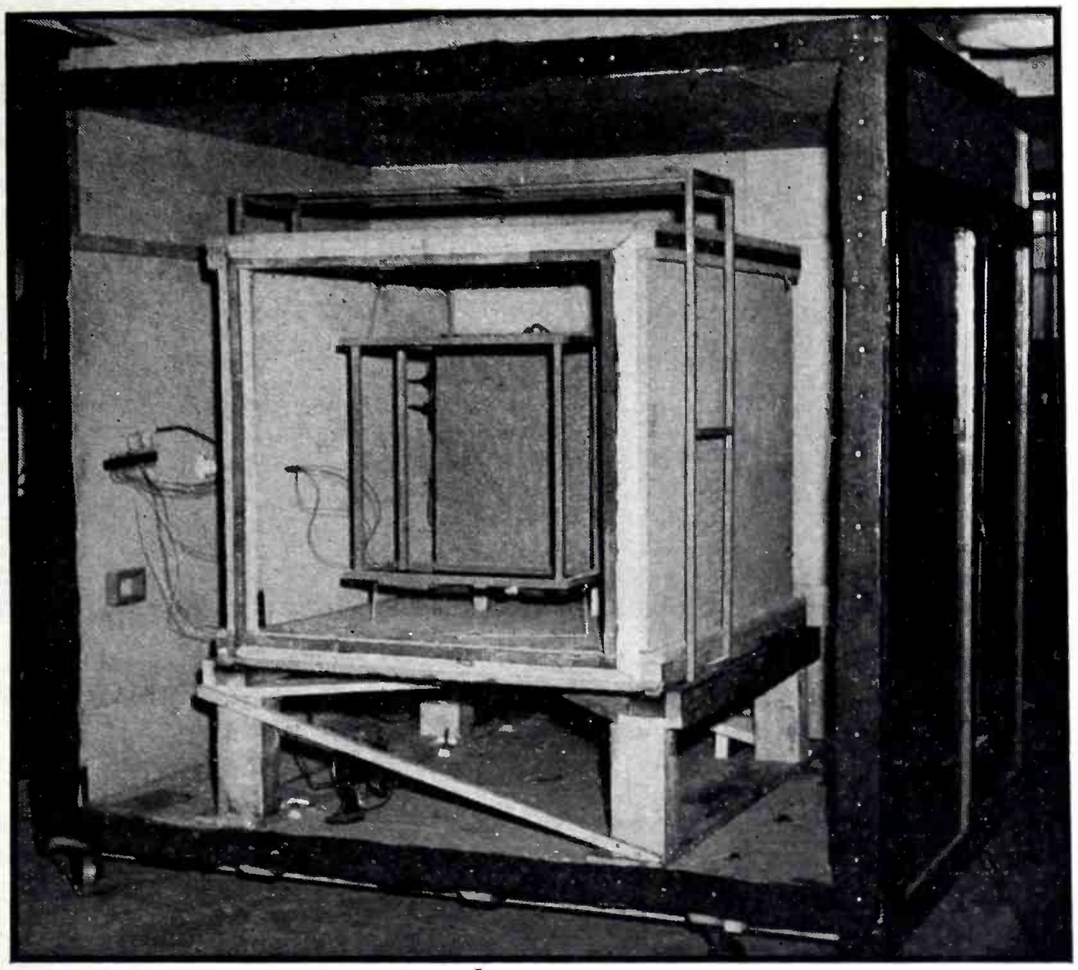


FIG. 1—Guarded hot box test unit. The outer and inner boxes are made flush with section of wall under test. The wooden frame carrying bridge wires in the inner box and between inner and outer boxes are evident. Fans are used to provide air circulation and prevent stratification

Electronic circuits for maintaining temperature of heat box constant employ Wheatstone bridge and photoelectric relay circuits. Accurate temperature control provided. Power for heating is measured by phototube operated trigger circuit which actuates electric counter. Two units described applicable to other measurement and control problems

One of the most important properties of materials affecting their use as heat conducting or heat insulating elements in building or equipment construction is their coefficient of heat transfer. This coefficient expresses the time rate of heat transfer of the particular material or assembly in terms of a unit area and a unit temperature difference and, for certain types of materials, in terms of a unit thickness. To determine these coefficients, two types of test equipment are used and are specified in Codes set up by the American Society of Heating and Ventilating Engineers and others.*

Since it is the primary purpose of this article to describe two instruments developed in the Heat-Transfer Laboratories of Case School of Applied Science for use on these units, a brief description of only one of these units, the guarded hot box, will be included. For further information on either method of test, the above references may be consulted. While the heat transfer tests for which the instruments were primarily designed may appear to have limited application, the principles they embody are applicable to a wide variety of different uses.

The guarded hot box unit, shown in Fig. 1, consists of an inner box open on one face and about 3 feet in all dimensions with walls of heat insulating material. This box is placed centrally in a similarly open faced guard box with insulated walls and with its open face in the same plane as the open face of the guard box. The wall whose heat transfer characteristics are to be determined is constructed according to specifications and is used as one wall of a cold room which is well insulated on its other walls and is kept cool by refrigeration. In use the double box unit is clamped to the wall under test with the test wall thus forming the sixth wall of the two boxes. The test is carried out by lowering the temperature of the cold room while maintaining the temperature in the

* The two types of equipment are described in the *Jour. Am. Soc. Heat. and Vent. Engrs., Vol.* 26, No. 7, Oct. 1920 and Vol. 32, No. 5, May 1926. The former reference describes the guarded hot plate used for determining the heat transfer coefficients for homogeneous materials such as asbestos or plywood sheets. The latter reference describes the guarded hot box unit which is used to determine the overall heat transfer coefficients or characteristics of samples of wall construction such as typical brick or frame construction.

guard and inner boxes at or above room temperature by means of electrical heating elements placed in the two boxes. With these conditions maintained, a flow of heat from the boxes to the cold room is set up through the wall.

Description of Guarded Hot Box Equipment

The need for the guard box surrounding the inner box may be understood if it is noted that without the guard box all of the heat (electrical energy) entering the inner box will flow through the wall to the cold room only if the inner box is at the same temperature as the room in which the box is used. If this is not true and the room is at some lower temperature, for instance, some of the energy supplied to the inner box would flow to the room and not through the wall under test. Since it is sometimes desirable to maintain the inner box at temperatures other than room temperature, a guard box whose temperature can be maintained at the temperature of the inner box is necessary. The guard box, if held at this same temperature, thus serves as a perfect insulator between the inner box and the room in which the equipment is used.

From the above it is evident that such a test can be conducted accurately only if the guard box is maintained at the same temperature as the inner box. In addition to maintaining the above condition, it will be necessary in conducting such a test to measure accurately the energy supplied to the inner box, to measure the temperature of the air and test wall surfaces in the inner box and cold room and to know the area of the wall covered by the inner box. Thermocouples are used for the temperature measurements. The two instruments to be described were designed to hold the guard box temperature the same as the inner box temperature and to permit the accurate measurement of the energy to the inner box.

Control of Guard Box Temperature

The inner box contains an electrical heating element with taps from 5 to 125 watts, in steps of 5 watts each, while the outer box contains two fixed heaters of 400 and 80 watts maximum respectively. Both of the outer box heaters are supplied through variable auto-transformers or Variacs, while the tapped inner box heater uses the full 110 volts a.c. for all settings. The inner heater is set to maintain any desired temperature in the inner box while the 400 watt heater transformer is set to hold the outer box temperature slightly below the temperature of the inner box. The 80 watt heater in the guard box temperature has, as its maintain the temperature in both boxes the same.

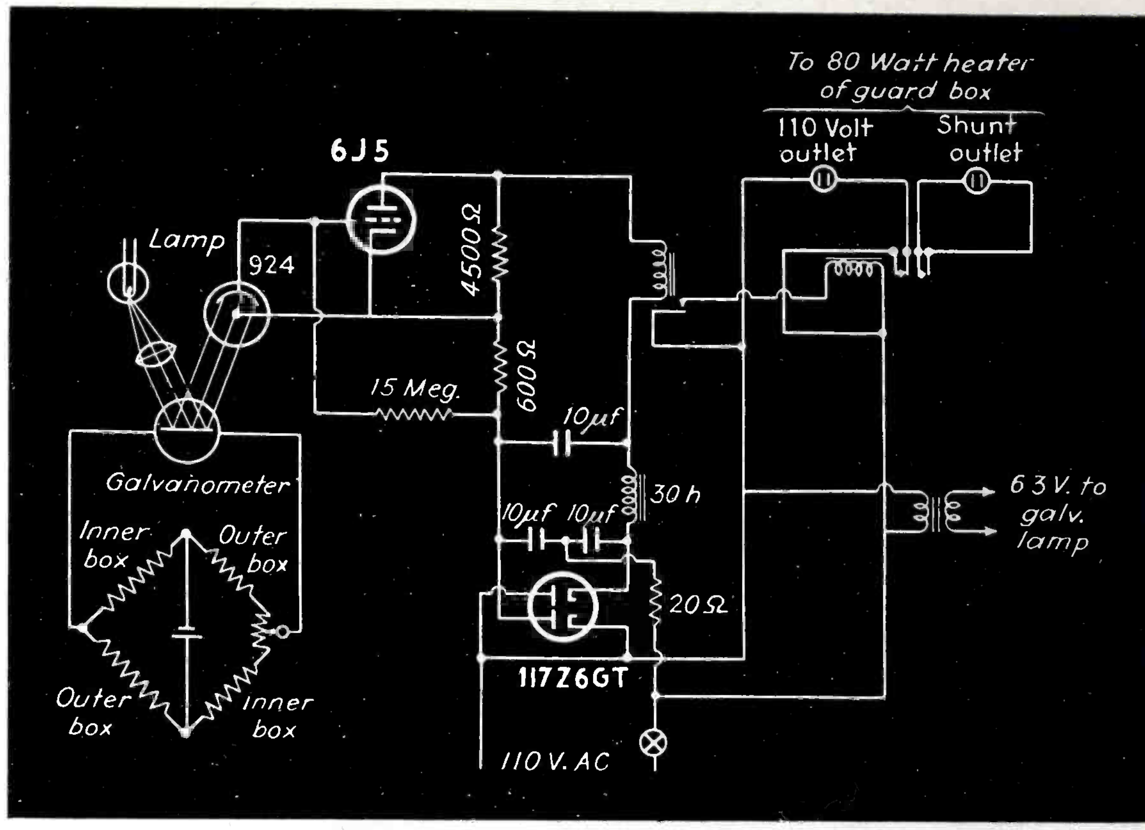


FIG. 2—Phototube relay circuit for maintaining constant temperature. Any unbalance of temperature unbalances the bridge, cutting off light from phototube and actuating plate circuit relays

The instrument which controls the guard box temperature has, as its detecting element, a Wheatstone bridge of four equal arms of approximately 100 ohms each made up of enamel covered iron thermocouple wire. Two of the opposite elements or arms, as shown in Fig. 2, are wound on a light wooden frame and hung in the inner box while the other two arms are similarly placed in the guard or outer box. A balancing resistor is also placed in the circuit to correct for slight inequalities in the resistance of the four arms of the bridge. This type of detecting element has a particular advantage in its low heat capacity making it ideal for rapid and sensitive response to slight temperature changes. In addition, since the four arms may be wound with comparatively wide spacings, the elements fill a reasonably large volume of the boxes assuring a good average temperature for each of the boxes.

The bridge is supplied from a single dry cell while the unbalance across the bridge is detected by a Leeds and Northrup Type 2420 lamp and scale galvanometer. For control purposes this galvanometer has been fitted with an RCA 924 phototube which has been mounted inside the galvanometer box in such a manner that it intercepts the light beam when the galvanometer deflects in one direction. A six-prong socket has been provided on the side of the galvanometer box and carries the six wires of the lamp, galvanometer and phototube circuits. This arrangement and also the fact that the phototube is removable permit plugging the operating control circuit into the galvanometer box with the least difficulty and still leaves the galvanometer free for other uses.

The operating control circuit shown in Fig. 2 consists simply of an electronic phototube relay which, under control of the galvanometer light beam, operates or releases a sensitive relay. This relay in turn controls another heavier duty relay with two poles. One of the poles is used to supply or disconnect 110-v power to a suitable outlet on the control box which in use is connected to the 80-watt heater of the guard box. The other pole is used as a shunting or short-circuiting device across a similar outlet on the box. This shunting arrangement is used when work-

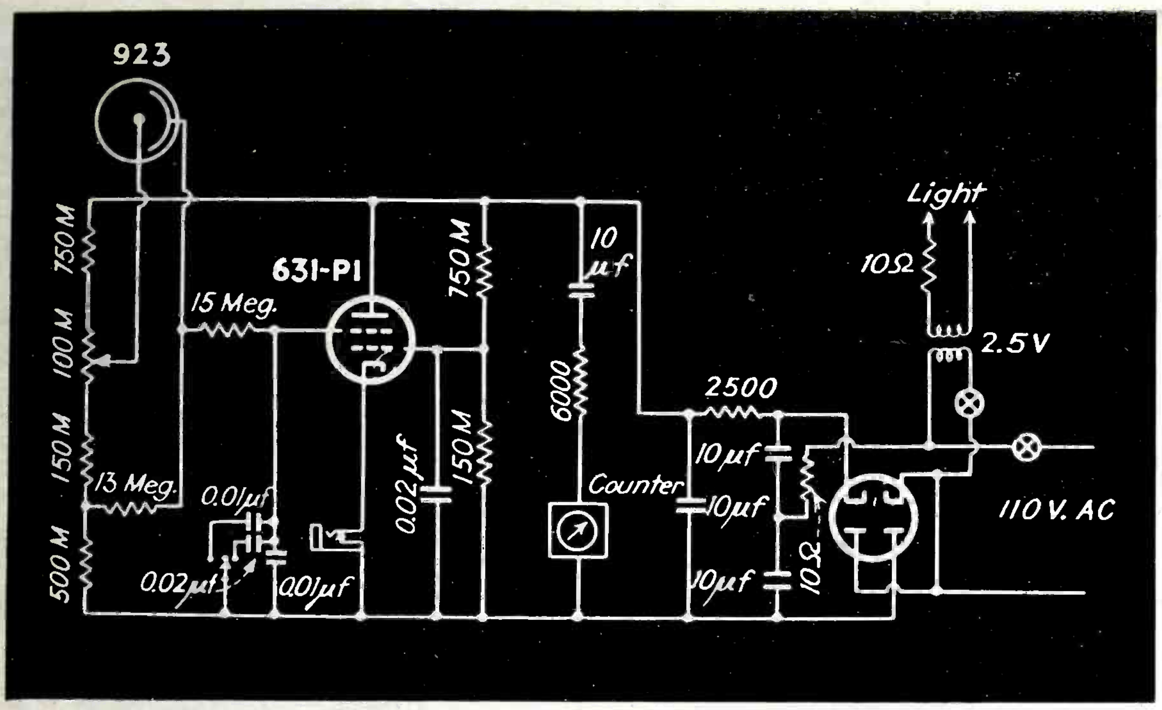


FIG. 3—Schematic diagram of light actuated impulse counter, used with small wattmeter to record total amount of energy for heating the test boxes

FIG. 4—Photograph of power measuring instrument. Phototube and light source are mounted within glass case of meter which is painted black

ing with the guarded hot plate unit whose heater circuits differ slightly from those of the guarded hot box unit. The operating control circuit includes a voltage-doubler rectifier and power supply for the phototube and vacuum tubes, a 6-v transformer power supply for the galvanometer lamp, a battery and switch for the bridge circuit (not shown in the figure) and a rheostat for varying the galvanometer sensitivity (also not shown). In operation the control system is so connected to the hot box bridge that if the guard box is warmer than the inner box, the power to the 80-watt heater in the guard box is cut off. If the reverse, heat is added to the guard box.

In addition to the above arrangement which applies to the hot box unit, the control box also has a set of binding posts connecting directly with the galvanometer which permits the unit to be used with a thermocouple. This makes the unit rather general in its applications and not limited to use with the above equipment since either a d-c bridge or a thermocouple may be used as a detecting element.

Measurement of Power

It may be seen that in the use of the guarded hot box it is necessary to measure the power to the inner box accurately since this power represents the energy passing through the test wall in the form of heat. In addition, since such tests usually take a comparatively long time to run, it is also most convenient if the power can be measured continuously and cumulatively. It is unnecessary to measure the power to the guard box although all the heater circuits have been wired through 4-prong sockets into which wattmeters may be plugged to read and adjust the power to the different heaters.

The other instrument to be described was developed to measure the power to the inner box continuously and accurately. It consists essentially of a General Electric Type I-30-A watthour meter. This meter is of the type normally used with current transformers and has a 2.5 ampere current coil which is used directly in this case giving the low watthour meter constant of 0.3 watthour per revolution. As used in this application, the register dials were removed and a small plane mirror glued to the rotating shaft of the meter. In the place occupied by the register dials, a small light source and phototube were mounted. The light source is a 2.2-v "Penlite" or "Lenslite" flashlight bulb which has a fairly concentrated beam. The phototube used was an RCA 923 with the base removed although the 924 type might be preferable due to its smaller size. Both the light source and the phototube are mounted within the glass case of the meter which was painted on its inner surface with black paint. The phototube is connected to a suitable electronic amplifier and counting circuit, Fig. 3, which counts the revolutions of the watthour meter as detected by the rotating mirror. The main features of the counting circuit include a General Radio Type 631-P1 Strobotron tube which is of the cold cathode trigger type and a Cenco No. 73511 high speed high resistance counter. The operation of the circuit is such that for every revolution of the meter disc and mirror, the phototube initiates an impulse which triggers the Strobotron and registers on the counter. An adjustment is necessary and is provided in the circuit to adapt the counting circuit for measurements of small powers (25 watts or less) where the disc rotates very slowly and of larger powers (300 watts) where the meter rotates much more rapidly.

In use on the guarded hot box test, the meter measures the power to the inner box only and it does so continuously and automatically. The adjustment of the inner box heater by taps rather than by transformer control was to permit the meter to measure at its rated voltage of 110 volts at all setting of the heater.

This equipment, watthour meter, counter, power supply and tube circuit all mounted as a single unit as shown in Fig. 4 may be used for any other power measurements within its range. As such it is a relatively inexpensive and rugged power measuring instrument which may be easily calibrated against the more expensive rotating watthour meter standard which would be necessary in its place.

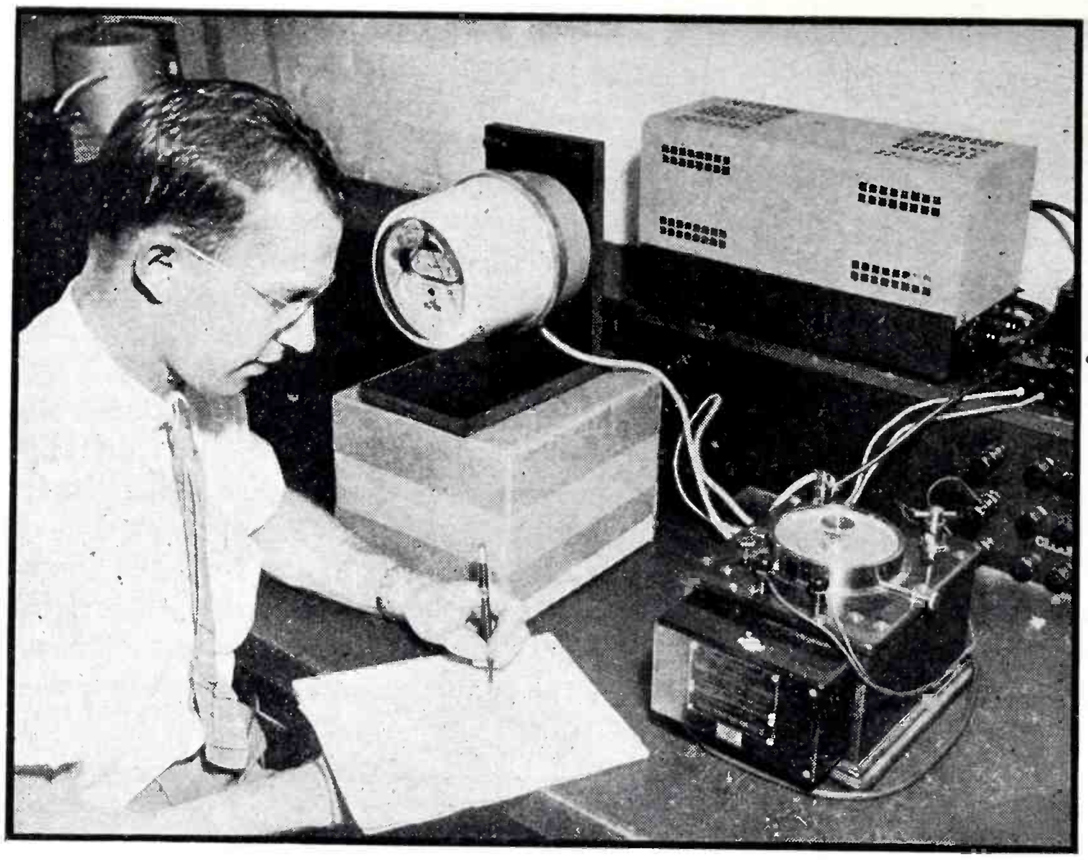


FIG. 1—Using electronic method, one operator replaces two previously needed for testing demand meters

Electronic

By
B. E. LENAHAN
Westinghouse Electric and Manufacturing Co., Newark, N. J.

ELECTRICITY meters, commonly used for measuring electrical energy sold to users, measure the product of power and time. To test such a meter for basic accuracy requires measuring two quantities. Since time is easily measured to high accuracy, it is common practice to hold power constant and measure time. This practice is also justified by the fact that errors are a function of the power measured rather than time.

Some types of demand meters may require test periods up to fifteen minutes, other types to one hour. When such tests are performed manually, an operator observes the motion of the pointer on a standard wattmeter and by adjusting a rheostat controls a portion of the total test load to correct for the small variations arising from voltage fluctuations, resistor heating, and other causes.

The operator learns by experience that in order to keep the average of the load constant he must try to compensate for the transient variations by briefly applying a greater correction than the deviation, the operator thus mentally averaging the peaks and dips. This is a somewhat tedious operation involving both judgment and eye-strain. The result is that the accuracy of the test is somewhat lower than the accuracy of the standard used.

The device to be described performs the required operations automatically by electronic means.

Basic System

The apparatus illustrated in Fig. 1 is applied to a standard wattmeter of the null deflection type and may be said to contain three functional parts, corresponding to an operator's eye, brain, and hand. The same principle is readily applied with structural variations to other forms of a-c wattmeters or to direct current calibration problems. A diagram showing the complete circuit is shown in Fig. 2.

The "eye" part consists of a mirror which receives a beam of light from a lamp, two phototubes and a shutter vane which is carried on the meter mechanism. This vane swings in front of the mirror close to the lamp, forming an optical lever to magnify the motion of the moving coil, and controls the light on the phototubes. The distance between the lamp and phototube is made small in order to give good illumination with a small, long-life lamp. The shutter width, and spacings, are chosen so that each tube is just half-illuminated when the load is normal.

The phototubes are connected in series and the lamp position is adjusted until no current flows from

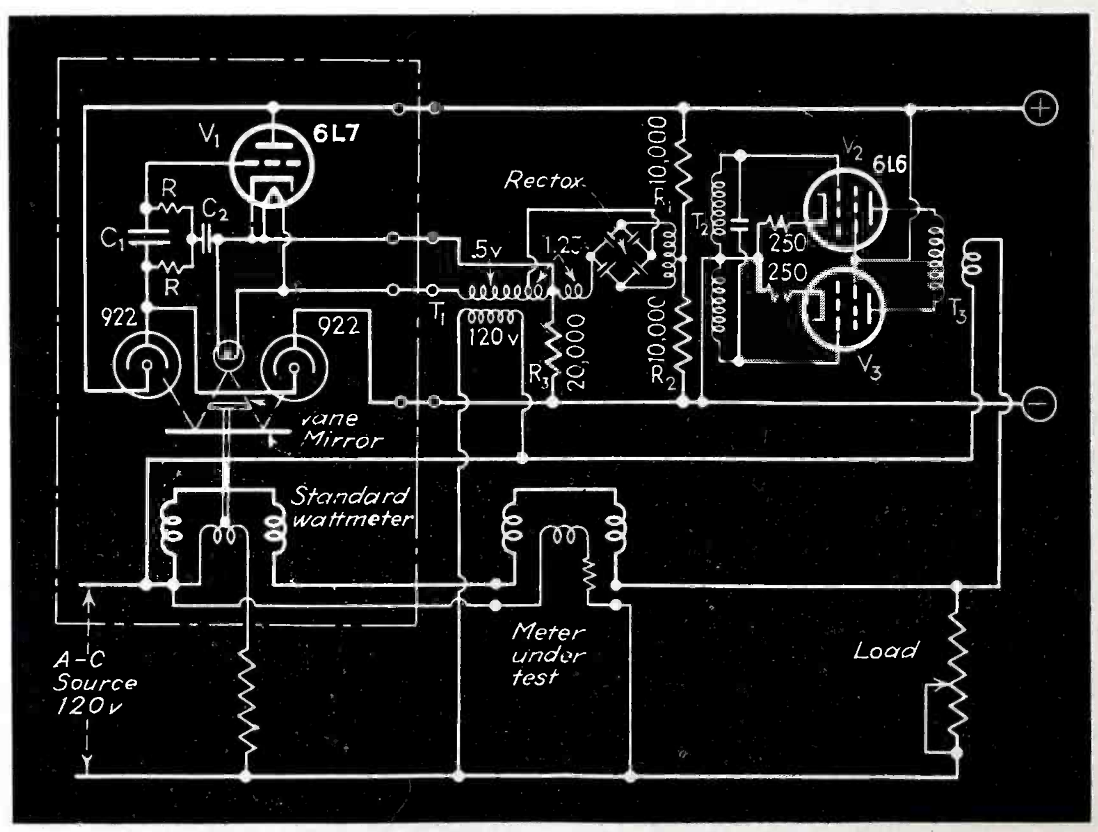


FIG. 2—Schematic wiring diagram of the electronic circuit for testing and calibrating meters

Load Regulator for METER TESTING

Electronic method of calibrating watt-hour meters saves manpower and increases precision of calibration. Method employs phototube and amplifying circuit for making comparisons between meter under test and precision instrument

the junction of the phototubes when the wattmeter is in the normal position for the load desired. With this arrangement, the current output of the phototubes is proportional to the displacement of the wattmeter element from the normal position. Thus the electric eye converts a mechanical deviation into a current.

The "brain" of the device is a network of resistors and capacitors, connected between the junction of the phototubes and the grid of the tube V_1 as shown in Fig. 2. The current flowing through this circuit sets up a potential difference which operates the remainder of the device.

Circuit Details

The tube V_1 and the parts following it in the circuit produces a correction component for the variation in the load on the meters, the correction being proportional to the change in grid voltage of the tube from its normal value.

Since the meter illustrated is a wattmeter the correction can be applied either to the voltage or the current circuit. In practical use the voltage is kept relatively constant while the current is the variable element. By applying the correction in the current circuit, the correcting torque on the moving element can be made proportional to the correction. This means that the torque resulting from a correcting current will be dependent upon the product of the correcting current and the voltage and thus will be proportional to correcting current but independent of load current value. This simplifies the operation considerably as the gain of the amplifier does not need to be re-adjusted for every load change.

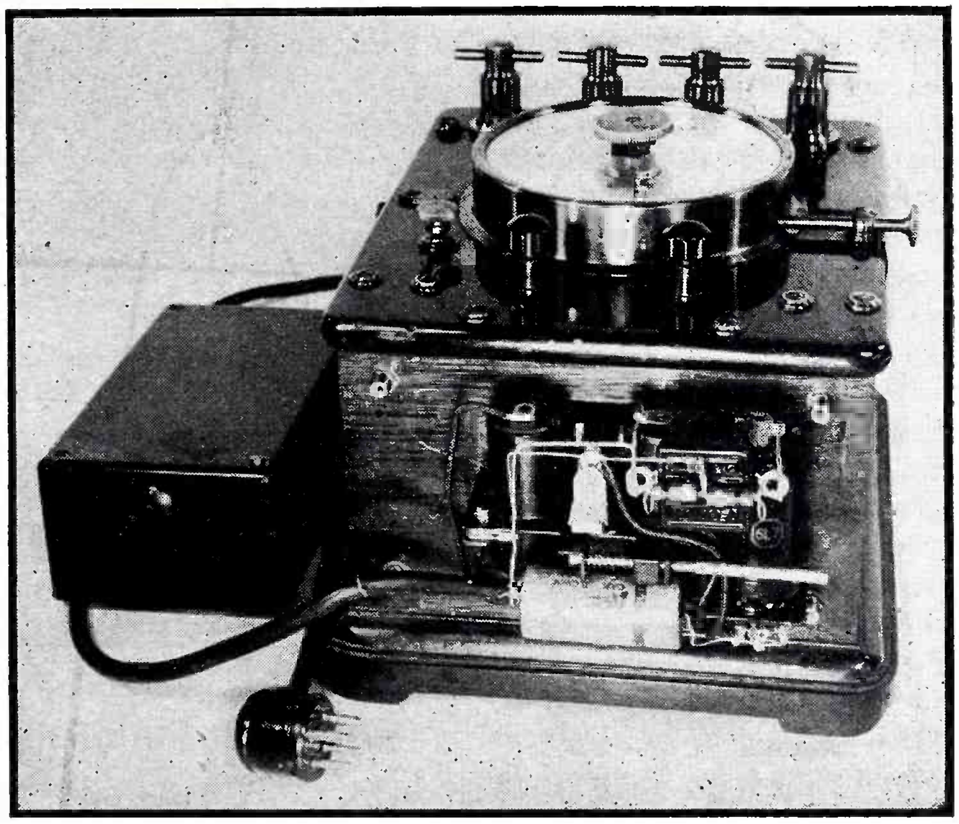


FIG. 3—Detail view of the electronic calibrating device

The tube V_1 is part of a bridge circuit made up of its cathode resistor R_3 and the resistors R_1 and R_2. Normally the cathode is at about the same potential as the junction of R_1 and R_2 and the grid bias is at a value corresponding to a plate resistance of 20,000 ohms.

Any change in grid bias causes a direct current to flow from the center tap of the 2.5 volt winding of the transformer T_1 to the center tap primary of T_2. This current unbalances the Rectox bridge through which it flows, and the a-c voltage is applied to T_2 primary. When the direct current input on the Rectox bridge reverses, this bridge which has non-linear resistance characteristics becomes unbalanced in the opposite direction. The output of the amplifying tubes V_2 and V_3 is made proportional to the grid voltage of V_1 by a choice of operating conditions and the output transformer T_3 steps up the alternating voltage to a value suitable to apply to the meter coils. The secondary side of this transformer is connected across the current coils of both the standard and the test meters, where an electromotive force of only a few volts is required. With this connection most of the correction current component flows through the meter coils and but little through the load impedance.

The condenser shown across the secondary winding of T_2 is to correct the phase angle error and improve the wave form. It will be noted that the cathode resistors for tubes V_2 and V_3 are not by-passed. This is to provide current feed-back to insure a good wave form in their

(Continued on page 254)

By E. E. MOYER

Electronic Section
Industrial Control Engineering Department
General Electric Co., Schenectady, N. Y.

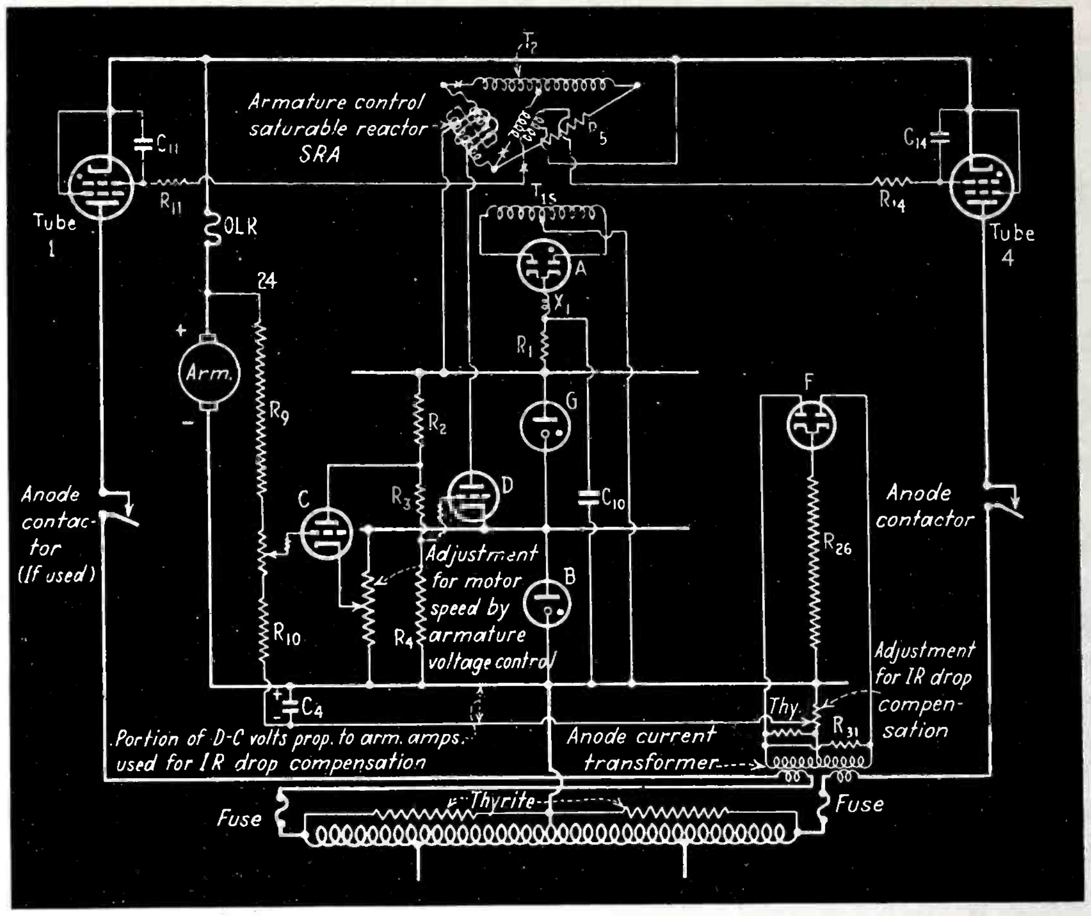


FIG. 1—Armature and excitation control circuits with voltage drop compensation

FIG. 2—Field excitation and control circuits

Electronic Control of

The third installment of this series on industrial electronics deals with methods of extending the speed range of d-c

When a shunt motor is designed to be operated at higher than base speed by reduced field current, the field may be supplied with variable excitation from a grid controlled thyratron rectifier similar to that of the armature circuit and independently adjustable.

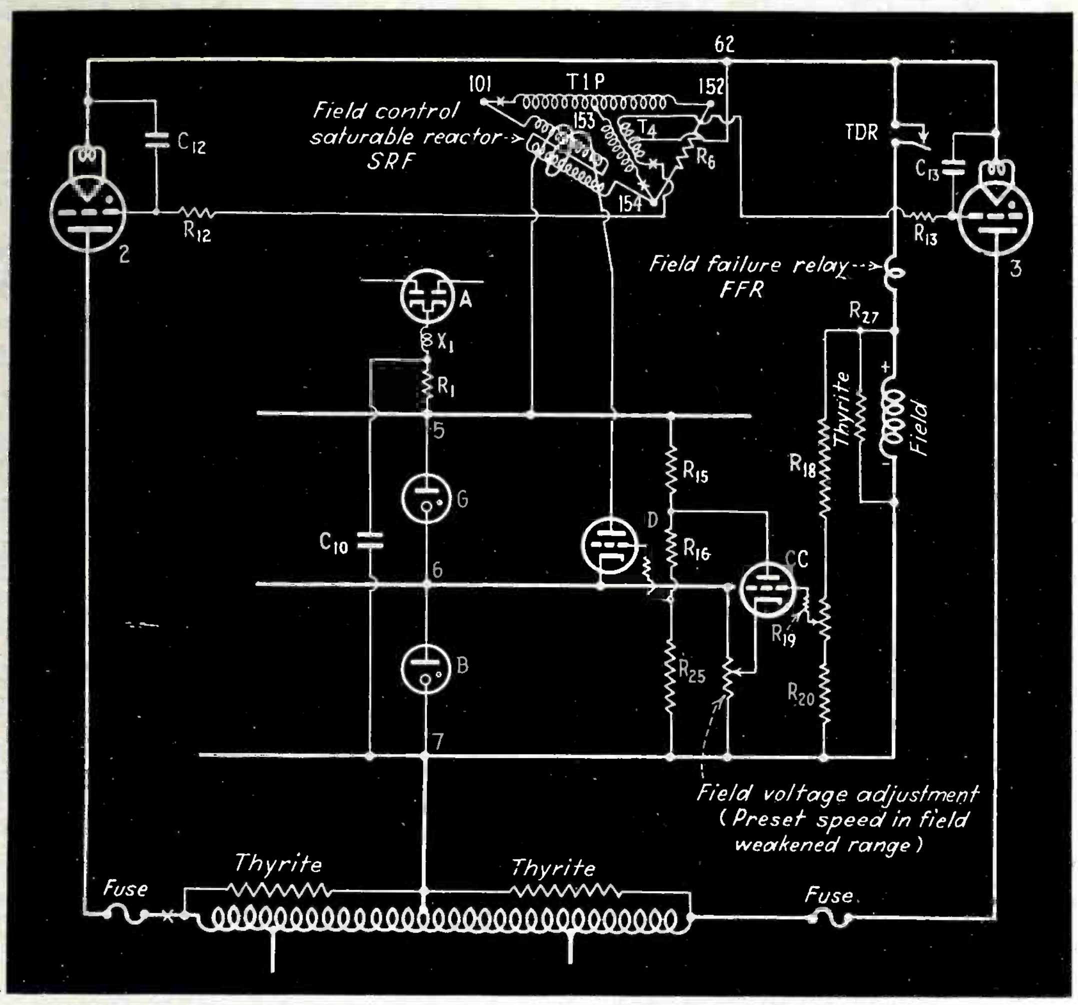
If the field voltage be accepted as an indication of field flux (which is not an exact relation because of the non-linearity between flux and current due to saturation, because of field distortion due to armature flux, and because of field resistance change with temperature) then the means for controlling the reduction in field excitation may be patterned after the armature voltage control circuit which is shown in Fig. 1. Grid phase control of the output voltage of the field thyratrons, and hence field excitation, may be varied by using another saturable reactor-resistor bridge circuit and exciting the d-c winding of the saturable reactor through a vacuum tube from the 150/75 volt control bus. This field control circuit is shown in Fig. 2. Electrical feed-back of the field voltage signal will serve to maintain a preset level of field excitation independent of a-c line voltage variations. For more precise control, field current instead of field voltage should be used as the signal; this could be done by an anode current transformer and rectifier connected to read anode current in the field thyratrons.

When the field excitation is reduced, the ratio between speed and armature counter electromotive force is changed in such a way that the armature must rotate at a higher speed in the weaker field in order to generate the same counter emf. It is the reduction in counter emf accompanying a reduction in field strength which allows an excess of current to flow in the armature conductors and produces the extra torque necessary to increase the motor speed to the new level at which speed the counter emf is again sufficient to limit the armature current to the value required to maintain this speed. A given preset speed level is maintained relatively constant by grid phase control of the armature thyratrons as they automatically phase advance to compensate for voltage drop accompanying changes in armature current. Speed is not regulated by changes in field excitation; speed is only preset to new levels at which it is regulated by armature voltage control. Hence, when the armature thyratrons are phased full on and the armature voltage has been increased to the limit determined by the a-c anode voltage there can be no further speed regulating action.

Single Dial Control of Over-all Speed Range

When the speed of the motor is controlled by variations in armature voltage only, as determined by the setting of the armature voltage control potentiometer, the motor field excitation should be maintained at rated value if the motor is to develop rated torque. Then, when the speed range is extended by field weakening as determined by the setting of the field voltage control potentiometer the armature counter emf should remain at rated value if the motor is to develop constant rated horsepower. Except for special control characteristics there is no occasion to have these two controls overlapping so that, for example, the field is weakened long before the armature counter emf is brought up to rated value. Therefore, the two control potentiometers can be ganged on one shaft if the armature voltage control potentiometer is so constructed that its entire variable resistance range is compressed within the first 150 deg of shaft rotation and the slider connects to a conducting segment over the remaining 150 deg of shaft rotation, and if the field-voltage con-

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



D-C Motors—Part III

motors through the use of automatic electronic devices for field weakening

trol potentiometer is so constructed that its slider rides on a conducting segment during the first 150 deg of shaft rotation and rides on the resistance portion during the remaining 150 deg. These dual potentiometer circuits are diagrammed in Fig. 3.

One objection to the dual speed control arrangement, if used without supplementary control devices, is that if the speed control were preset for a speed in the weak-field range, the field excitation would be maintained at this reduced value, so that to develop rated torque while accelerating a load the armature current would have to be excessively, if not prohibitively, high. Also, full voltage would be applied to the armature at standstill which would result in abnormally high starting current.

Armature Current Limit

An armature current-limit control is provided so that the speed control potentiometer can be preset to any desired speed, the starting sequence initiated, and the motor brought up to that speed level smoothly without exceeding a predetermined armature current. In other words, the motor is accelerated uniformly from standstill to preset speed under conditions of constant armature current in the quickest possible time consistent with that value of armature current and the load on the motor. This same current limit functions on overload to prevent the armature current from exceeding this maximum value even under stalled conditions. (The overload relay or fuses open the armature circuit before damage to the motor if the stalled or overload condition is maintained.)

If a d-c shunt motor is to be used to accelerate a high-inertia load as quickly as possible, from standstill to maximum motor speed, the field should initially be at full excitation and the armature voltage should be initially at that reduced value which will permit the flow of only the maximum armature current for which the motor is rated. Assuming that this value of armature current will be sufficient to break-away the load, the armature will begin to rotate and the armature current will tend to be reduced due to the increasing counter emf generated by the rotation of the armature conductors. To maintain this maximum permissible current level, the armature voltage should be increased in proportion as the armature counter emf tends to reduce the current; in other words, as the speed increases the armature voltage should be increased in proportion. This process should continue until rated counter emf is reached, at which point the armature current tends to decrease to the level demanded by the load at this "basic" speed. If the field current is now weakened, which reduces the counter emf at that speed, the armature current will increase and will tend to cause the motor speed to increase until the armature counter emf is again sufficient to limit the armature current to the value necessary to drive the load at this increased speed level. Hence, to increase the motor speed by field weakening and yet maintain that maximum permissible armature current for which the machine is rated, the field should be weakened only in proportion as the increase in speed builds up the counter emf which tends to reduce the armature current. When the field weakening process is halted, the motor will operate at that speed level which corresponds to the reduced value of field current. These optimum accelerating conditions are fulfilled: (1) When an armature-current signal is used to force and maintain full-field excitation, regardless of any weak-field setting of the field-voltage speed-control potentiometer. (2) At the same time, the armature current is maintained at the constant current-limit value throughout the armature voltage control range. (3) When this same armature current signal is used to govern the decrease

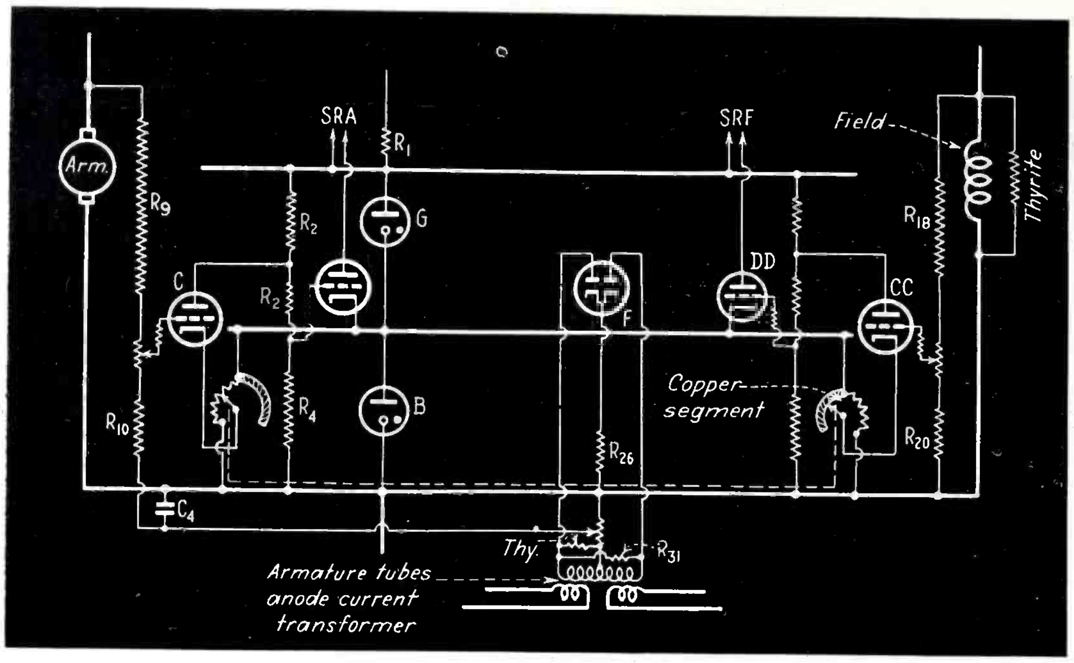


FIG. 3—Single dial, dual unit speed control potentiometers for armature and field circuits

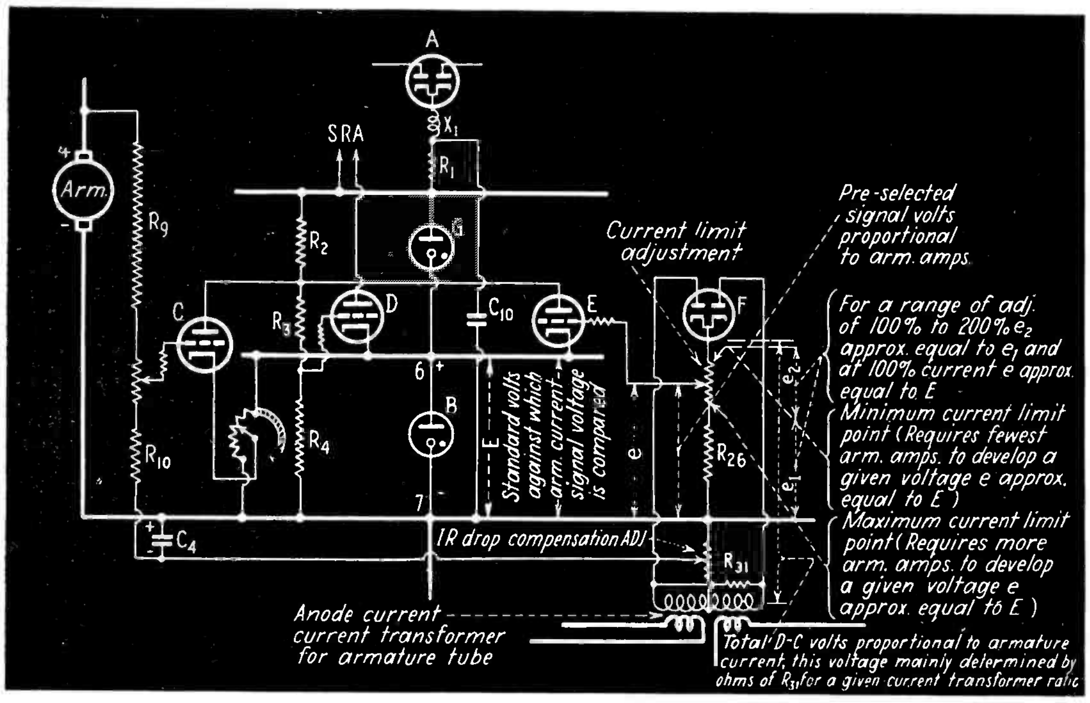


FIG. 4—Current limiter added to armature voltage control

in field current as the acceleration continues into the field-weakened range.

This current-limit control is one which is inoperative from zero current up to the preselected current at which current limit is to become effective; otherwise, the amount of current would be continually tapering the constant-speed control. When it comes into play the current-limit action takes over sharply, that is, as near the preselected value of current as possible, and exercises its control function from top speed to stall with only a small increase in armature current above the preselected level. The value of current at which current limit becomes effective is usually adjustable over a band of, say 100 percent to 200 percent rated armature current so as to provide for different motor applications.

Since a signal of d-c voltage proportional-to-armature-current has been made available for *IR* drop compensation, this same voltage source can be used for armature current-limit control. In Fig. 4 is shown the method by which current limit is added to the armature control circuit. To make the current limit inoperative until a certain value of armature current is reached, a preselected portion, *e*, of the d-c volts-proportional-to-armature-current signal is compared against the voltage standard, *E*, of tube *B*. Then, the voltage difference between the signal voltage and the standard voltage is "sensed" (signal less than standard, equal to standard, or greater than standard) by the grid action of tube *E* and amplified by this same triode. Finally, the amplified signal is superimposed on the armature voltage control triode, tube *C*, by connecting the anode of tube *E* to the anode of tube *C*. Whichever of tubes *C* or *E* "works the hardest" controls the shutting-off action on tube *D* which controls the armature voltage (and hence the current).

In the circuit of Fig. 4, the cathode of tube *E* is connected to the positive end of voltage standard tube *B*, and the negative terminal of tube *B* is common to the negative end of the d-c voltage signal of volts-proportional-to-armature-current, and the positive end of this d-c signal voltage is connected to the grid of tube *E*. Whenever the d-c volts-proportional-to-armature-current is less than the voltage of tube *B*, the grid of tube *E* will be very much negative relative to its cathode and tube *E* will be nonconducting and inoperative. Limitation of current to 150 percent rated armature current requires that, at 150 percent armature current, the signal voltage *e*, of d-c volts-proportional-to-armature-current, must be preselected to be approximately equal to the 75 volts drop, *E*, across regulator tube *B*. As this chosen value of armature current is reached, and hence as the d-c signal voltage, *e*, proportional to armature current approaches 75 volts, a point will be reached when the grid of tube *E* will be sufficiently less negative that tube *E* begins to conduct current through resistor R_2. This is the same resistor through which the armature voltage control triode, tube *C*, conducts current to control tube *D*, so that additional current through R_2 via tube *E* has the same effect as though tube *C* conducted more current, i.e., it makes tube *D* less conducting, which desaturates the saturable reactor of the armature thyratron and retards grid phase so as to reduce the armature voltage and current. Thus, the tube (*C* or *E*) which determines the controlling current through R_2 also governs the degree of saturation of the armature saturable reactor, *SRA*. The two controls, armature voltage vs armature current limit, are only additive in the sense that, in a very small region of overlapping functions, tube *C* gradually gives up what tube *E* takes over; this because tube *C* is operative most of the time and tube *E* takes over only after the armature current has increased to the preselected value. Of the two control signals, voltage vs current, only that which is dominant does the controlling. Also, the armature voltage control triode, tube *C*, cannot take control away from the current limit triode, tube *E*, until the armature current has dropped below current limit value and has thus rendered tube *E* inoperative.

The circuit of Fig. 5 shows how armature current limit is applied to the field-voltage-control. The general scheme is similar to the armature current limit control of Fig. 4 in that the d-c voltage-proportional-to-armature-current is compared against a reference voltage and the difference voltage is applied to tube *EE* which acts on the saturating circuit of the saturable reactor of the field thyratron. However, in this instance of field weakening control there are two distinct differences in the action of tube *EE* compared to tube *E:* (1) an increase in armature current beyond a predetermined amount must increase the field strength by saturating the saturable reactor of the field thyratron (whereas with armature voltage control an increase in armature current necessitated a decrease in saturation of the reactor of the armature thyratron); and (2) the reference voltage against which the signal of d-c volts-proportional-to-armature-current is compared is not the constant voltage, *E*, of regulator tube *B* but rather is the slightly variable voltage, *e*, between the grid of tube *DD* and the negative bus, which voltage is in itself referred to the standard voltage, *E*, of tube *B*. In Fig. 6 are compared the current limit controls as applied to armature voltage and field voltage control circuits.

Referring again to Fig. 5, the field-forcing triode, tube *EE* (which is associated with armature current control of field weakening), has its plate connected to the positive control bus and its cathode connected to the grid of tube *DD* and the voltage divider composed of R_{16} and R_{26}. Turning on field forcing tube *EE* will cause point 17 to become more positive with respect to point 6 so as to make tube *DD* and the field thyratrons more conducting to increase the saturation of the field reactor and strengthen the field.

During normal operation and prior to current limit the grid of tube *DD* is a few volts negative with respect to its cathode, which cathode is at the potential of the neutral control bus, point 6. How much or how little negative this is depends on the extent to which tube *DD* is rendered conductive as determined by the setting of the field voltage control potentiometer. Hence, the grid of tube *DD* is positive with respect to the negative control bus, point 7, by a voltage which is almost, but not quite, equal to the voltage drop *E* across tube *B*. Since the cathode of tube *EE* is connected to the same point (17) as the grid of tube *DD*, the cathode of tube *EE* is maintained positive with respect to common point 7 by a voltage almost equal to *E*. The grid of field forcing tube *EE* is connected to the armature current signal voltage, *e*, so that whenever *e* is less than the reference voltage, across R_{26}, the grid of tube *EE* is highly negative with respect to its cathode and tube *EE* is rendered sufficiently non-conducting to be inoperative. Only when the signal voltage *e*, has increased to within a few volts of the reference voltage across R_{26} will tube *EE* commence to operate. As the signal voltage, *e*, continues to increase, the field forcing tube *EE* is made more conducting which tends to make the grid of tube *DD*, more positive and thereby cause an increase in saturating current in *SRF*. Thus, an increase in armature current beyond a preselected limit will cause the field excitation to be increased regardless of the setting of the field-voltage control potentiometer.

Overload

Figure 6 is constructed to exaggerate the fact that the cathode, (point 17) of field forcing tube *EE* is normally at a less positive potential than the cathode (point 6) of armature current limit tube *E*. By this means, field-forcing tube *EE* is caused to act slightly ahead of armature current-limit tube *E*. That is, as the signal portion, *e*, of the d-c voltage-proportional-to-armature-current increases in a positive direction with respect to the negative control bus (point 7) the grid of the triode whose cathode voltage is nearest to that of point 7 (triode *EE* in this instance) will first become less negative. The triode with the greater cathode-to-negative-bus voltage will become less negative later and hence will become operative later in the sequence of events.

Assume the motor to be operating in the week-field region due to the setting of the speed-control potentiometer, and also that the armature current-limit is set at 150 percent rated armature current, but that the nature of the load is such as to require less than 100 percent rated armature current. Then, as the load

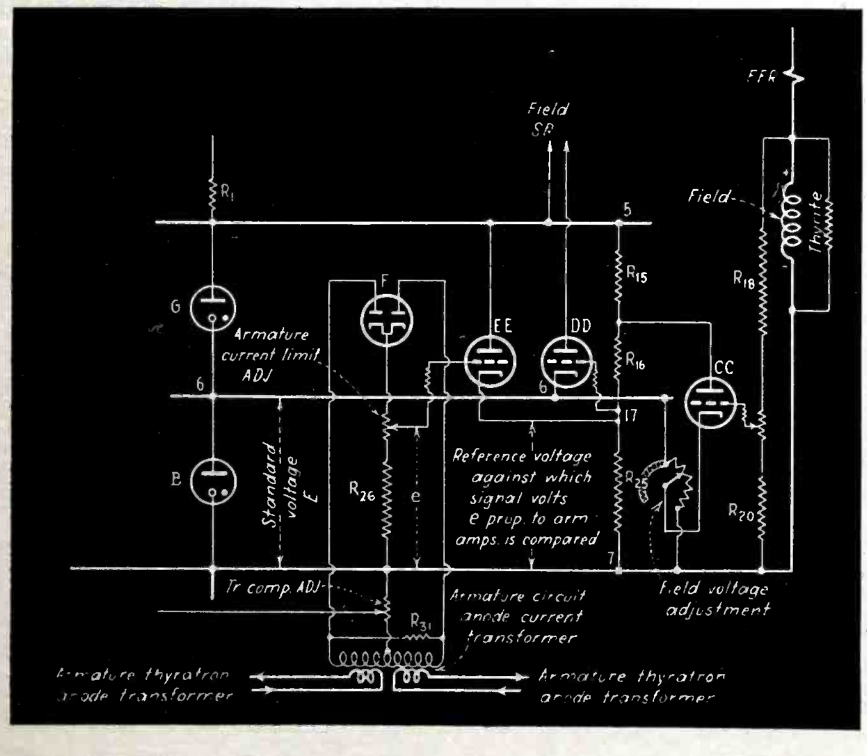
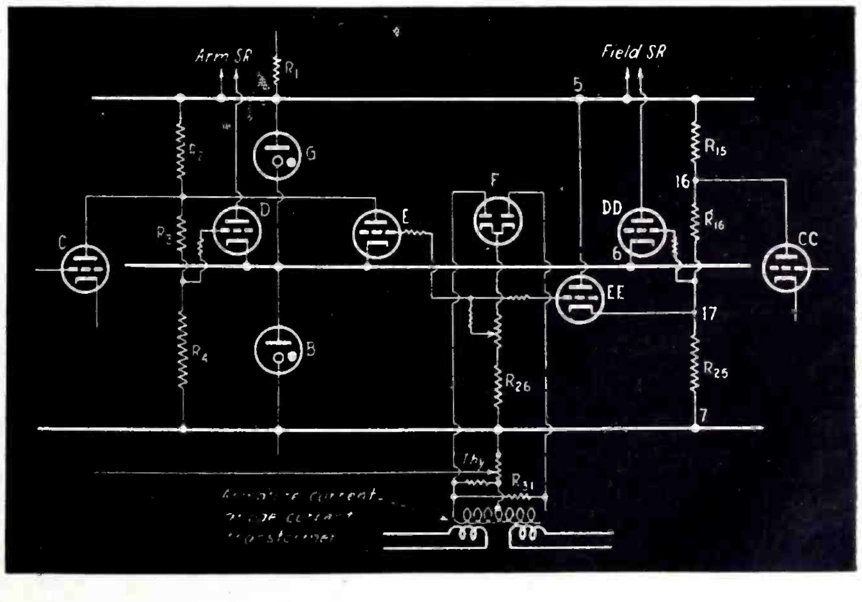


FIG. 5—Armature current limit added to field voltage control

FIG. 6—Comparison of armature current limit as applied to armature and field circuits



is gradually increased toward the 150 percent armature current limit, the field-forcing tube *EE* will first begin to take effect a few percent ahead of the 150 percent point. A continued slight increase in armature current will bring the field up to full excitation, meanwhile causing the motor speed to decrease to basic value. A continued increase in armature current of a few more percent will cause the armature current-limit tube *E* to take effect and reduce the armature voltage, and consequently the motor speed, to whatever extent is necessary to prevent the armature current from exceeding the preset 150 percent limit. This current-limit process is continuous down to zero speed (stalled armature) where the armature voltage is the IR drop of the armature circuit at this 150 percent value of armature current. If the nature of the load allows, the motor will operate at constant current and will run current limited at any speed in the current-limit region. As the excess load is removed, the speed will increase towards the preset speed at which it will be maintained if the current drops below limit value.

On a quickly applied load, the commutating ability of the motor might be overstressed if the armature current-limit tube *E* had to await prior action of field-forcing tube *EE*. However, this control acts on both tubes *E* and *EE* independently; it merely acts on tube *EE* at a current-limit value which is a few percent less than that of tube *E*. On a quickly applied load the tendency for the armature current to exceed a preselected current-limit value gives a signal to the field to increase, and, almost simultaneously, without awaiting results from the field, gives a signal to the armature voltage to decrease to whatever value necessary, to maintain no more than current-limit value of armature current.

Acceleration

Assume that the speed-control potentiometer has been preset to call for a speed of four times basic speed. The motor is assumed to be current-limit accelerated at 150 percent rated armature current in that portion of the speed-control range where the speed is determined by variable-armature voltage. Also the field is forced to full-field excitation irrespective of the weak-field setting of the speed-control potentiometer.

The motor speed will increase at a rate which is determined by the inertia of the load and by the respective values of armature current and field current. This increase in speed will continue until the armature counter emf reaches rated value corresponding to the maximum speed setting of the armature voltage-control potentiometer. As this point, the armature-voltage control would begin operating to prevent the counter emf from increasing any further so that the tendency is for the speed to remain at this value and the armature current to decrease to the amount necessary to furnish the required torque at this speed.

A slight decrease in armature current below the preset 150 percent current-limit value causes tube *EE* to ease up, in a magnified sense, on its field-forcing action. This allows the field excitation to decrease just enough to require an increase in speed to restore the armature counter emf to its former rated value.

At rated counter emf, the armature-voltage control once again tends to prevent the counter emf from rising further so that the armature current again tends to decrease, whereupon the field-forcing tube *EE* eases up a bit more, allows the field current to decrease another small increment, and requires an increase in speed to restore approximately rated counter emf. This process continues until tube *EE* has completely eased up on its field-forcing effect, at which point the field voltage is determined by the setting of the field-voltage control potentiometer, acting through tubes *CC* and *DD*.

The sensitivity of the control action on tube *E* and *EE*, (whereby these tubes take over sharply at the current-limit value and exercise their control with very little change in armature current) assists in obtaining the maximum output from the motor consistent with the nature of the load at the preset current limit value of armature current. The current-limit feature of a circuit such as that of Fig. 6 is such that when set for a stalled armature current limit of 5.8 amperes (average current) the field-forcing tube *EE* first begins to ease up at 5.2 amperes and has almost fully strengthened the field when a current of 5.35 amperes is reached. Then, these particular circuit constants are such that the current has to increase from 5.35 to 5.75 amperes before the armature current-limit tube *E* takes appreciably control over the armature voltage. Thereafter, an increase of armature current from 5.75 to 5.8 amperes is sufficient to reduce the armature voltage to the stalled level of IR drop at 5.8 amperes. The break between 5.35 and 5.75 amperes is probably due to the difference in potential between point 17 and point 7. So that the operation of tube *E* will follow more closely upon the completion of operation of tube *EE* and narrow the break in the current limit characteristic, it would be necessary to adjust the cathode connection of tube *EE* closer to point 16 along resistor R_{16}. That is, tube *EE* will alter the bias of tube *DD* such that full field is established when tube *E* becomes operative to reduce the armature voltage via tube *D*.

Many modifications of armature-current limit will undoubtedly be made as the applications suggest themselves. One interesting variation is a constant horsepower drive for wire-reeling and similar constant tension, variable-speed loads wherein the armature circuit is operated at constant-armature current and the speed is varied by armature current-limit control of the field excitation.

The use of dual speed-control potentiometers also necessitates some means of limiting the armature current upon starting and some means of limiting the high armature voltage which can result when changing quickly from a high speed to a low speed adjustment. Then, there is the matter of filtering and stabilizing components of the various circuits, the stopping sequences, and inverter action associated with a reversing drive. These will be discussed in the next and final article of this series.

REFERENCES

Emeleus, K. G., "The Conduction of Electricity Through Gases," E. P. Dutton & Co., Inc., New York.

Marti, O. K., and Winograd, H., "Mercury Arc Power Rectifiers," McGraw Hill Book Co., New York.

Gulliksen, F. H., and Vedder, E. H., "Industrial Electronics," John Wiley & Sons, Inc., N. Y.

Reich, H. J., "Theory and Application of Electron Tubes," McGraw Hill Book Co., New York.

Millman and Seely, "Electronics," McGraw Hill Book Co., New York.

Cobine, J. D., "Gaseous Conductors," McGraw Hill Book Co., New York.

Everitt, W. L., and Assoc., "Fundamentals of Radio," Prentice-Hall Inc., New York.

Muller, R. H., Garman, R. L., Droz, M. E., "Experimental Electronics," Prentice-Hall Inc., N. Y.

Alexanderson, E. F. W., and Mittag, R. H., The "Thyratron" Motor, *Electrical Engineering*, Nov., 1934.

Chambers, D. E., Application of Electron Tubes in Industry, *Electrical Engineering*, Jan. 1935.

Design for
DISSYMMETRICAL T PADS

Graphs for determining the resistance of the three elements of T-pad networks facilitates the design of pads having attenuation of as much as 25 db, and impedance mismatch ratios up to 5 to 1. Graphs are also adaptable to design of symmetrical pads with matched loads

By EDWIN Y. WEBB, Jr.,
American Telephone and Telegraph Co.
Atlanta, Ga.

In radio and communications work the necessity for "pads" or attenuators of definite electrical loss and definite terminal impedance often arises. It is the purpose of this article, and attached curves, to facilitate the design and construction of such pads of symmetrical or dissymmetrical T configuration, through simple, rapid, graphical methods, without making necessary recourse to the usual mathematical design equations.

In the following discussion a and b will refer to the series impedances and c the shunt impedance of the three-element T network. As pads with elements other than pure resistances are seldom encountered, only the case of a pure resistance network will be discussed, although the symbol Z will be used. If a balanced pad is desired, it is necessary merely to place half of the value of a and half of the value of b in the two lower branches of the pad.

Three individual graphs are given, one for each of the impedance element in a T network. Each graph contains a family of curves, one for each of several different values of attenuation or loss in decibels. The family of curves is plotted to show the normalized resistance (for the element a, b, or c of the T for which the curve applies) as ordinates, against the ratio of impedance transformation as abscissa. Since the curves are plotted for the normalized impedance of 1 ohm, the resistances found from the curves must be multiplied by the actual impedance value of the input circuit to obtain the true values of resistance for the elements of the desired T network. By plotting normalized impedances, only one set of curves is required no matter what the impedance value may be. It should be noted that while the curves are plotted for a dissymmetrical T network, which is useful in matching unequal impedance, the curves are equally useful for the symmetrical T network for matching equal impedances since in the latter case the impedance transformation is 1/1, and a and b are equal.

The graphs can be used for any impedance ratio normally encountered in practice. If an impedance ratio less than 1 is encountered, the T network can be reversed, for purposes of analysis, to obtain a transformation ratio greater than 1. The curves can of course be used for uneven ratios, such as 2.5/1 or 3.7/1. The curves can likewise be used for symmetrical T pads, for in this case the terminal impedances, Z_1 and Z_2 will be alike. The network impedances a and b will also be alike, and hence we need only use the curves for determining two separate constants, a and c. The curves are plotted more occurately than the accuracy of commercial resistors, and consequently errors involved from the graphical design method will be negligible for ordinary purposes. Care should be exercised in reading the curves, however, to ascertain that the scales are not misinterpreted.

It is to be particularly noted that the actual values of Z_1 and Z_2 (the terminal impedances) do not affect in any way whatever the values used in plotting the curves as only their ratios were used. Therefore, for a 10-db pad of terminal impedances 5 and 10 ohms the identical points on the curves will be used as if the terminal impedances were 300 and 600 ohms, as in both cases the ratio of Z_2 to Z_1 is 2 to 1.

The loss of the pad is obtained by calculating the ratio of the power transferred from Z_1 to Z_2 with the pad in the circuit and again with the pad removed from the circuit. Assuming 1 volt applied, and impedances of 100 and 200 ohms, the power transferred when the pad is out of the circuit is

$$P_0 = I^2R = \left(\frac{1}{300}\right)^2 \times 200$$

With the pad in the circuit, the power absorbed by Z_2 is

$$P_1 = I^2R$$
$$= \left[\left(\frac{1}{200}\right)\left(\frac{99.2}{200 + 145 + 99.2}\right)\right]^2 \times 200$$
$$= \left[\left(\frac{1}{200}\right)\left(\frac{99.2}{444.2}\right)\right]^2 \times 200$$

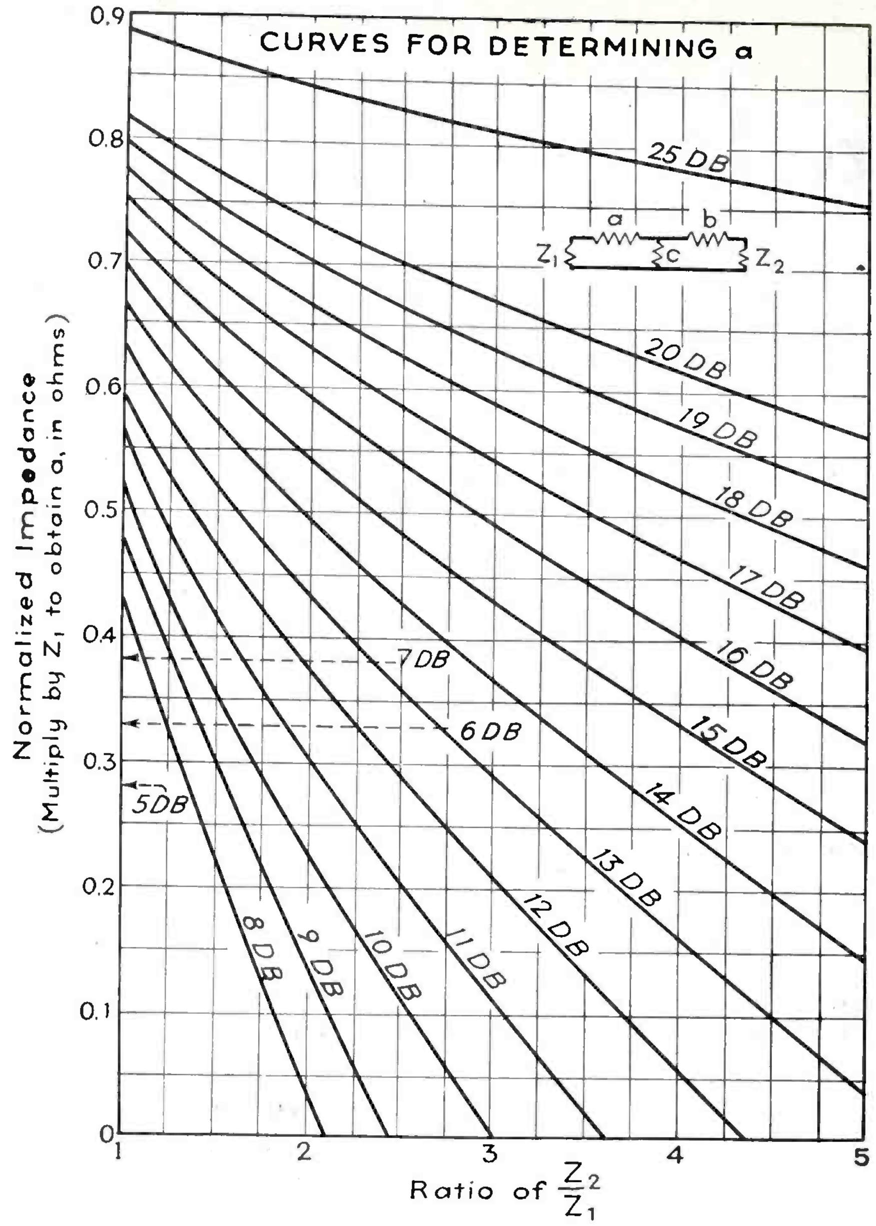
The loss in decibels is then

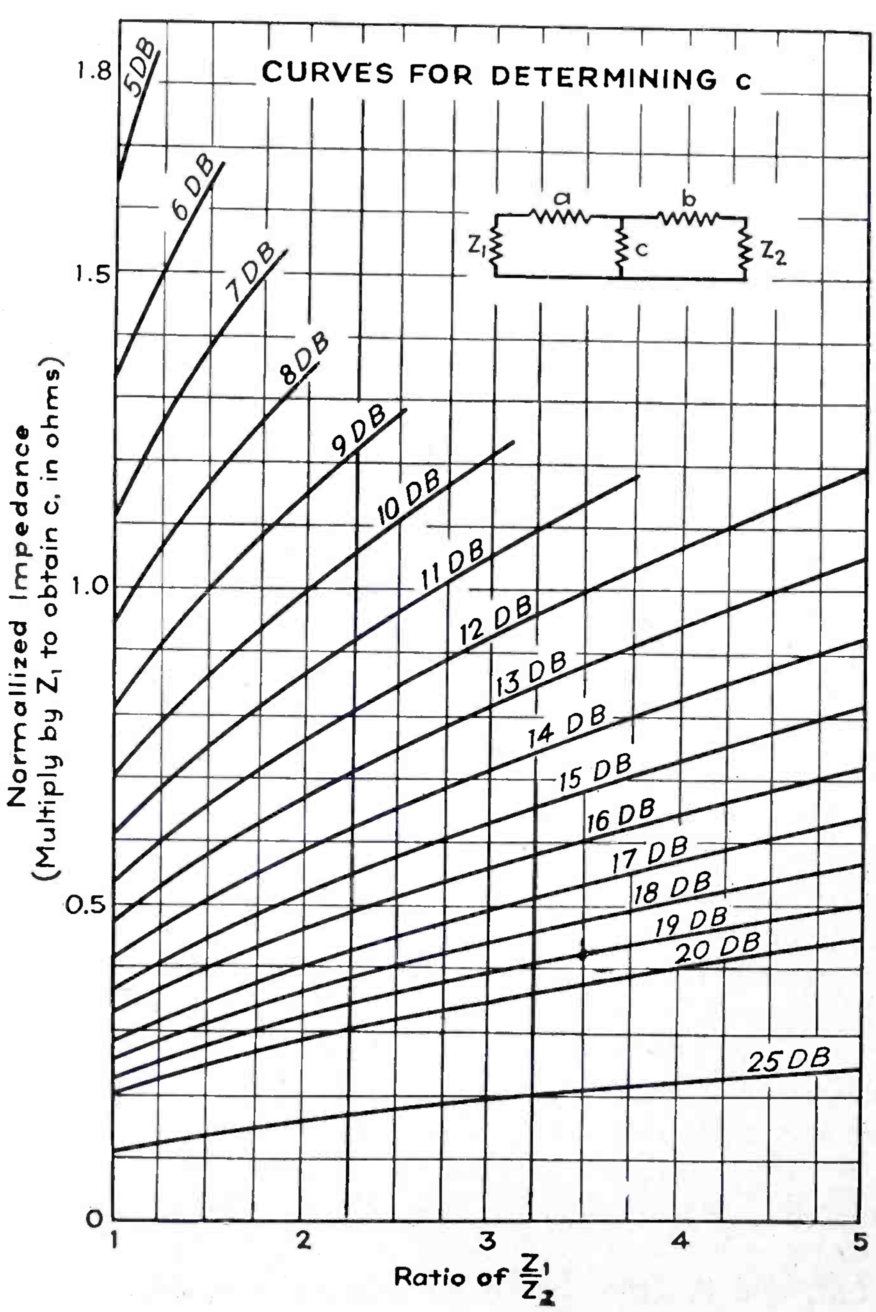
$$db = 10 \log_{10} (P_0/P_1)$$
$$= 10 \log_{10} \frac{\left(\frac{1}{300}\right)^2 \times 200}{\left[\left(\frac{1}{200}\right)\left(\frac{99.2}{444.2}\right)\right]^2 \times 200}$$
$$= 10 \log_{10} \left[\left(\frac{200}{300}\right)\left(\frac{444.2}{99.2}\right)\right]^2 = 9.5 \text{ db.}$$

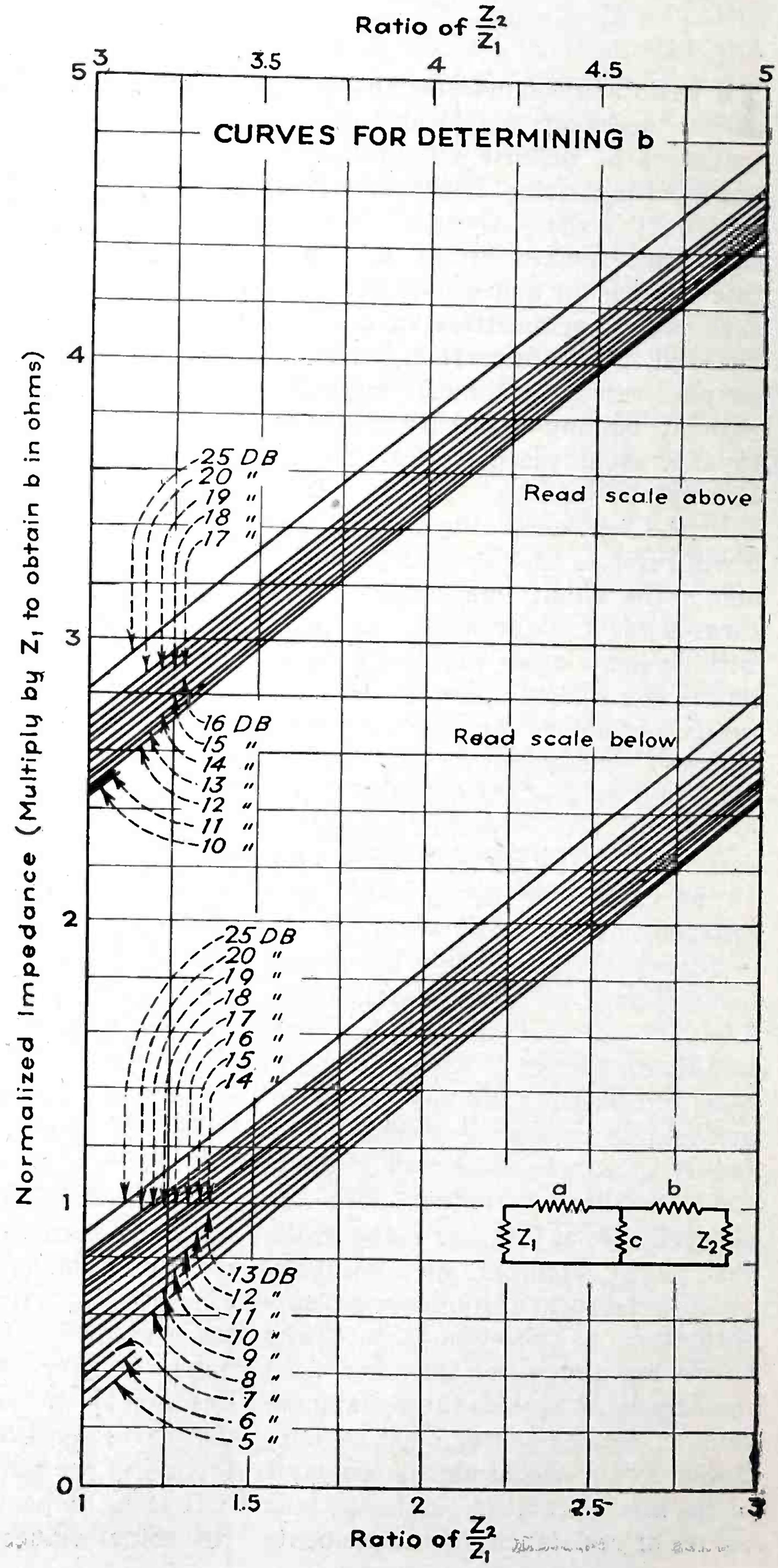
Hence, the terminal impedances as calculated from the graphs are correct. The loss of the network is actually 9.5 db instead of the 10 db for which it is designed, but the error is sufficiently small to be neglected for nearly all practical purposes.

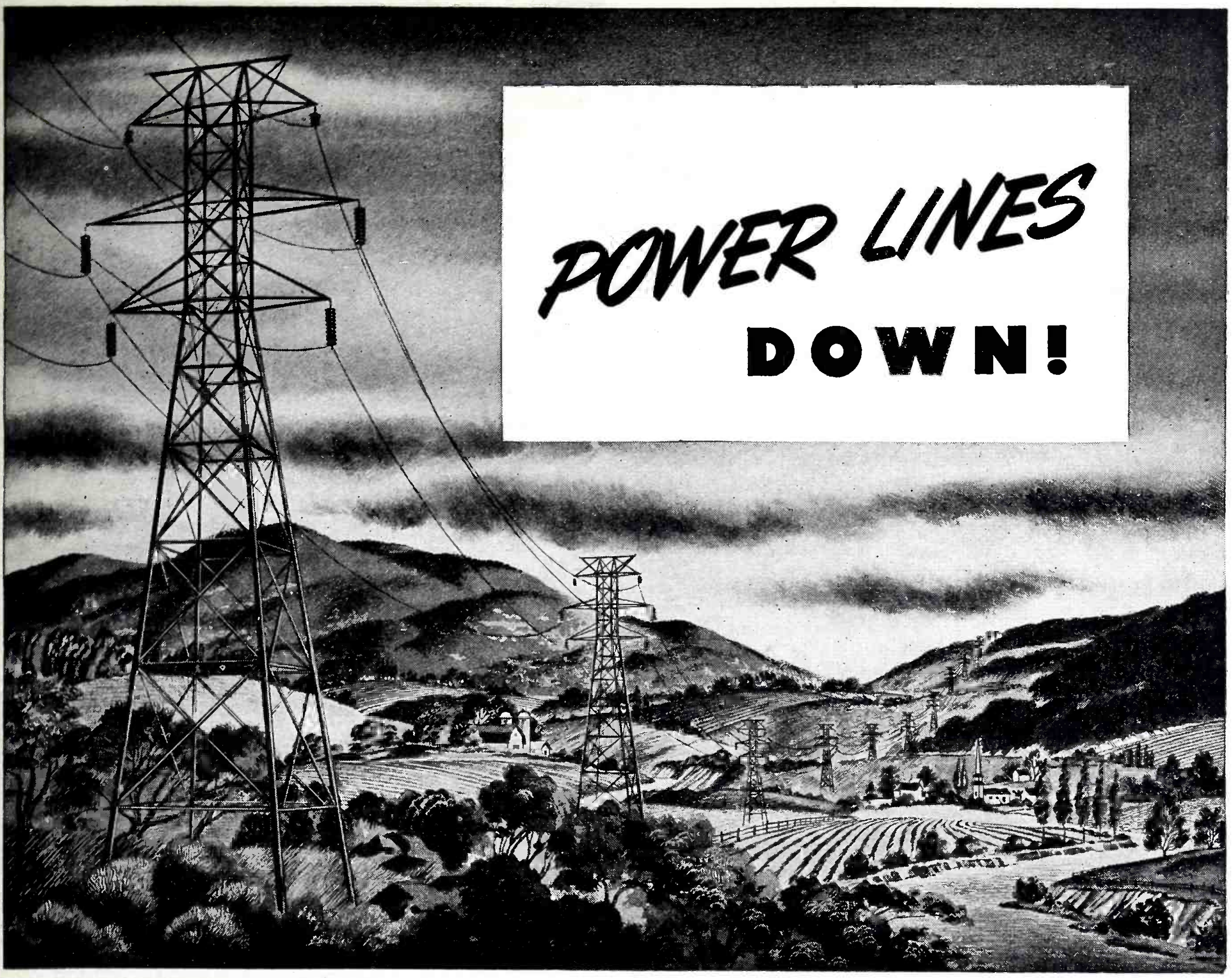
Design for Dissymmetrical T Pads

To use the graphs it is necessary to know: (1) the attenuation or loss, in decibels, which the network is to provide; (2) the impedance, Z_1, from which power is fed to the *T* attenuator, and (3) the impedance, Z_2, into which the *T* network feeds. The first condition specifies the network loss, and hence indicates which curve of the three families is to be selected for any particular problem. The second and third conditions determine the impedance transformation ratio, and hence determine at what point on the abscissa the graph is entered. From this point of entry, project vertically upward until the desired curve is reached; then project to the left and read the normalized resistance for the specified conditions for the element for which the chart applies. Multiply this reading by Z_1 to obtain the true resistance of the element for the specified conditions.









IRC RESISTORS Send the Signal

When trouble develops on a high voltage power line, time is of greatest essence. For in our fast-moving electro-mechanical age, minutes quickly translate themselves into countless man-hours. Communications go "dead" . . . lights snuff out . . . vital production grinds to a sudden halt . . . and it's "taps" for a busy world.

Another IRC Contribution

Until comparatively few years ago, when power transmission interruptions occurred, it often required hours to locate the trouble. Today, thanks in part to the contribution of I R C research engineers, the point of disruption in any electrical circuit—whether power or communications—can readily be spotted in a matter of moments.

Specially designed, IRC high voltage power resistors dependably dissipate the heavy loads and deliver the voltage required to operate trouble-signalling mechanisms. On receipt of signal, other instruments in which resistors play an important role accurately locate the point of disturbance within a few feet.

Here at I R C we welcome—and usually solve—unusual problems in the field of resistance devices. And because I R C makes more types of resistance units, in more shapes, for more applications than any other manufacturer in the world, many leading engineers make it a point to seek our unbiased counsel. There is no obligation, of course.

PREFERRED FOR PERFORMANCE · IRC · FIXED & VARIABLE RESISTORS

INTERNATIONAL RESISTANCE COMPANY

403 N. BROAD STREET · PHILADELPHIA

TUBES AT WORK

Method of checking spark gap with a feeler gauge and adjusting gap thickness with a wrench. The loops of copper tubing carry cooling water between holes drilled transversely through the brass cylinders which support the tungsten electrodes

Spark Gap Circuits Used in Induction Heating Units

SPARK-TYPE high-frequency oscillator circuits as well as vacuum tube units are today generating high-frequency power for industrial induction heating purposes.

One basic spark circuit is shown in the accompanying diagram. It resembles in many ways the old Tesla coil and the spark gap transmitters of the first world war. This circuit has been found highly effective and reliable for generating frequencies in the range from 100 to 300 kc, and is used by Lepel High Frequency Laboratories of New York City in units having power inputs ranging from 3½ kw to 30 kw.

Rugged, adjustable water-cooled spark gaps with pure tungsten discs about an inch in diameter are used, with as many as 30 gaps connected in series in higher-power units so as to distribute the heat over a greater area. Ordinarily the gaps are checked with a feeler gage and readjusted to a spacing of 0.004 inch about every 50 working hours, as shown in the accompanying photograph, to maintain peak efficiency and keep the heating time uniform on production runs.

Each unit will generally have a few air-cooled gaps in series with water-cooled gaps, to insure starting of the spark even though condensation on the water-cooled gaps shorts them out for a time after cooling water is turned on. A few minutes of operation will heat the gaps enough to drive off this external condensation of moisture.

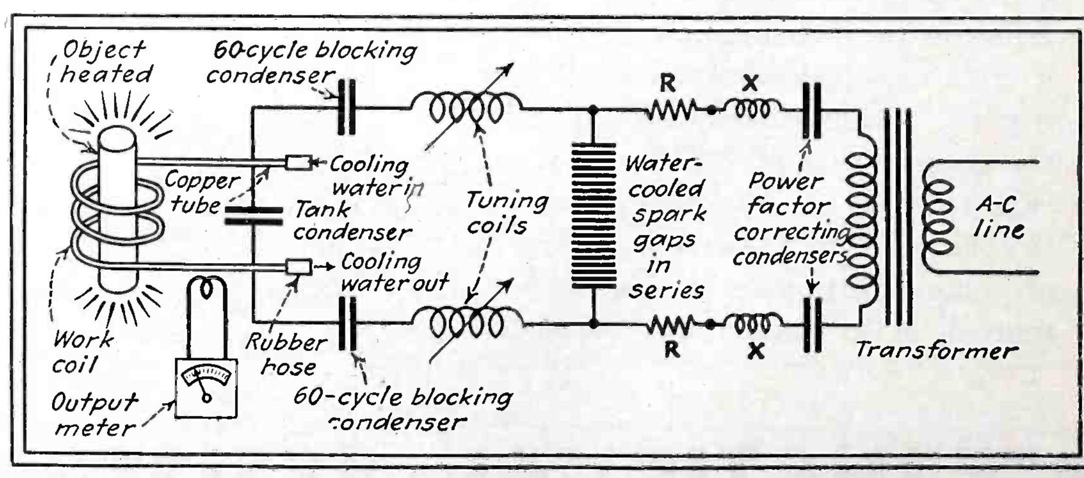
The work coil and tank condenser form a parallel resonant tank circuit which is in turn connected into a series resonant circuit across the spark gap. Tuning involves adjusting the series tuning coils for maximum output current in the work coil as determined by an r-f ammeter loosely coupled to the output circuit.

Circuit Details

Maximum output current is obtained when the series resonant circuit is tuned to the same frequency as the output tank circuit. This frequency will be somewhere between 100 and 300 kc, but its value is ordinarily not important. If a particular frequency is required, the series tuning coils can be set for this frequency rather than for resonance if there is sufficient reserve of power to permit operating the tank circuit off its resonant frequency.

Work coils are made from flattened copper tubing shaped to provide the necessary number of turns either around or inside the object to be heated. The majority of coils have from one to ten turns. Cooling water is forced through the work coil and its connecting leads to prevent overheating during operation, since a coil may carry up to 1000 amperes of r-f current. Rubber hose connections to an ordinary city water supply provide adeqaute cooling water for both the coil and the gap electrodes.

In spark gap units made by Lepel the radio frequency output power can be adjusted by means of a capacitive-type input control. The entire unit can be switched on and off by a remote-control magnetic switch operated by an automatic timer, automatic temperature control unit, foot switch or small pilot switch. The work coil has only a few turns and the high-frequency circuits are balanced to give zero potential to ground at the center of the coil, hence the work coil can be safely handled by the operator while power is on. Mica blocking capacitors prevent the high



Basic spark-type circuit used for generating large amounts of high-frequency energy for induction heating purposes

60-cycle voltage across the spark gaps from reaching the work coil.

There is no appreciable r-f radiation from the work coil and its leads, and the radiation from the spark gap is spread over such a wide portion of the frequency spectrum that the radiated energy at any particular frequency travels only a short distance. In one instance where interference was observed at 35 Mc due to a peculiar combination of circumstances, the radiation was readily eliminated by placing a metal screen around the unit.

Thyraton Tube Tester

By V. P. McKinney
Douglas Aircraft Co., Inc.
Santa Monica, Calif.

The accompanying circuit has proved highly satisfactory for checking FG57 and FG95 thyratrons, FG32 phanotrons and 872-A rectifier tubes for shorts, low ionizing potential, erratic operation and low emission.

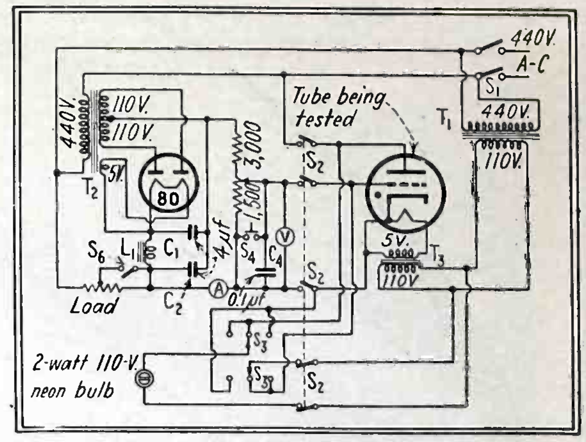
The tester operates from a 440-volt, single-phase, 60-cycle a-c line. This voltage was used because it happened to be available and was more economical than stepping up a lower voltage in view of the heavy load current demand for testing these tubes.

Assuming switch S_2 to be in the position which disconnects the anode, grid and cathode from their respective circuits, and assuming switch S_1 is closed, the filament of the tube under test is being heated by the secondary of transformer T_3, which in turn is supplied by the secondary of transformer T_1.

With S_1 and S_2 in the above positions, switch S_3 is rotated to apply 110 volts in series with the neon tube between grid and cathode, grid and plate and cathode and plate in turn of the tube being tested, as a shorted-electrode test.

Throwing switch S_2 to its other position applies all voltages to the tube under test and permits regular tests on the tube. The grid potential at the instant the tube becomes conductive is read on the voltmeter. The plate current is then read on the 10-amp d-c ammeter in series with the load resistor, which is of such value as to allow the passage of rated load current for the tube. The tap and switch S_6 are provided because some of the tubes tested have a different plate current rating.

Under the foregoing conditions transformer T_2 is also energized. It applies a rectified voltage between the grid and cathode of the tube under test, through the type 80 rectifier tube and the brute-force filter consisting of condensers C_1 and C_2 and choke L_1. The grid is negative with respect to the cathode here, and the value of the grid-cathode voltage is determined by the setting of the potentiometer in series with the 3000-ohm resistor, which together serve as voltage divider and bleeder. The value of this voltage is indicated by a 25-volt d-c voltmeter. Condenser C_4 maintains the grid at a constant potential, independent of ripple voltage or surges. S_4 is a normally open push-button switch, serving to bring the grid to zero potential as a check for intermittent operation of the tube.



Circuit for testing thyratron and similar tubes. Two types of sockets are required for the tubes being tested, with their corresponding terminals connected in parallel

Test Procedure for FG57 Thyratron

1. Make sure all switches are in off positions, and the potentiometer is in its minimum-voltage (counter-clockwise) position.

2. Insert FG57 tube in left-hand socket, and connect red (grid) lead to cap on top of tube.

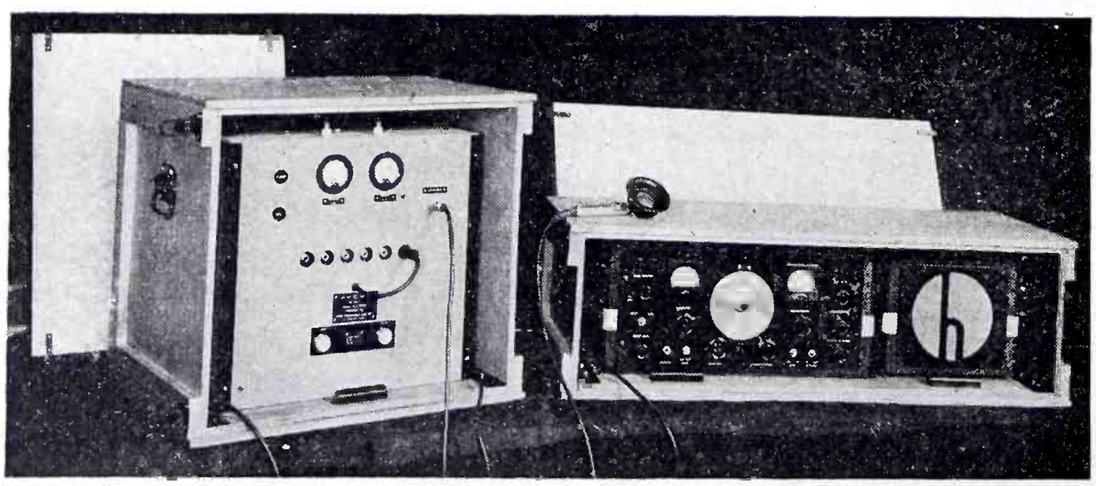
3. Close switch S_1 and wait until condensation has cleared from sides of tube.

4. Rotate switch S_3 through its three positions and observe the neon tube. If both sides of tube light simultaneously, a short circuit is indicated, and the tube should be discarded without further test.

5. Close switch S_2, and rotate the potentiometer slowly in the clockwise direction while watching the grid voltage meter. The tube should ionize when the grid meter reads 5 volts. If the reading is appreciably lower, a weak tube is indicated, and the tube should be discarded or marked weak. After the tube has ionized, advance the potentiometer to its extreme clockwise position, and observe the reading of the plate current meter. This reading should be 2.4 amperes. A lower reading indicates low emission, and consequently a weak tube.

6. Press push-button switch S_4 to short-circuit the grid to the cathode. The tube should ionize each time this switch is depressed, regardless of the setting of the potentiometer. This switch is incorporated to facili-

Plywood Cases Protect Emergency Gear



By enclosing transmitters and receivers in plywood cases of rugged, weatherproof design, such as those illustrated here, gear intended for use in the field may be more readily transported. In this instance one case houses a REL 50-watt radiphone while the other contains a Hallicrafters communication receiver and speaker

STOUT HEARTS

are carrying it through

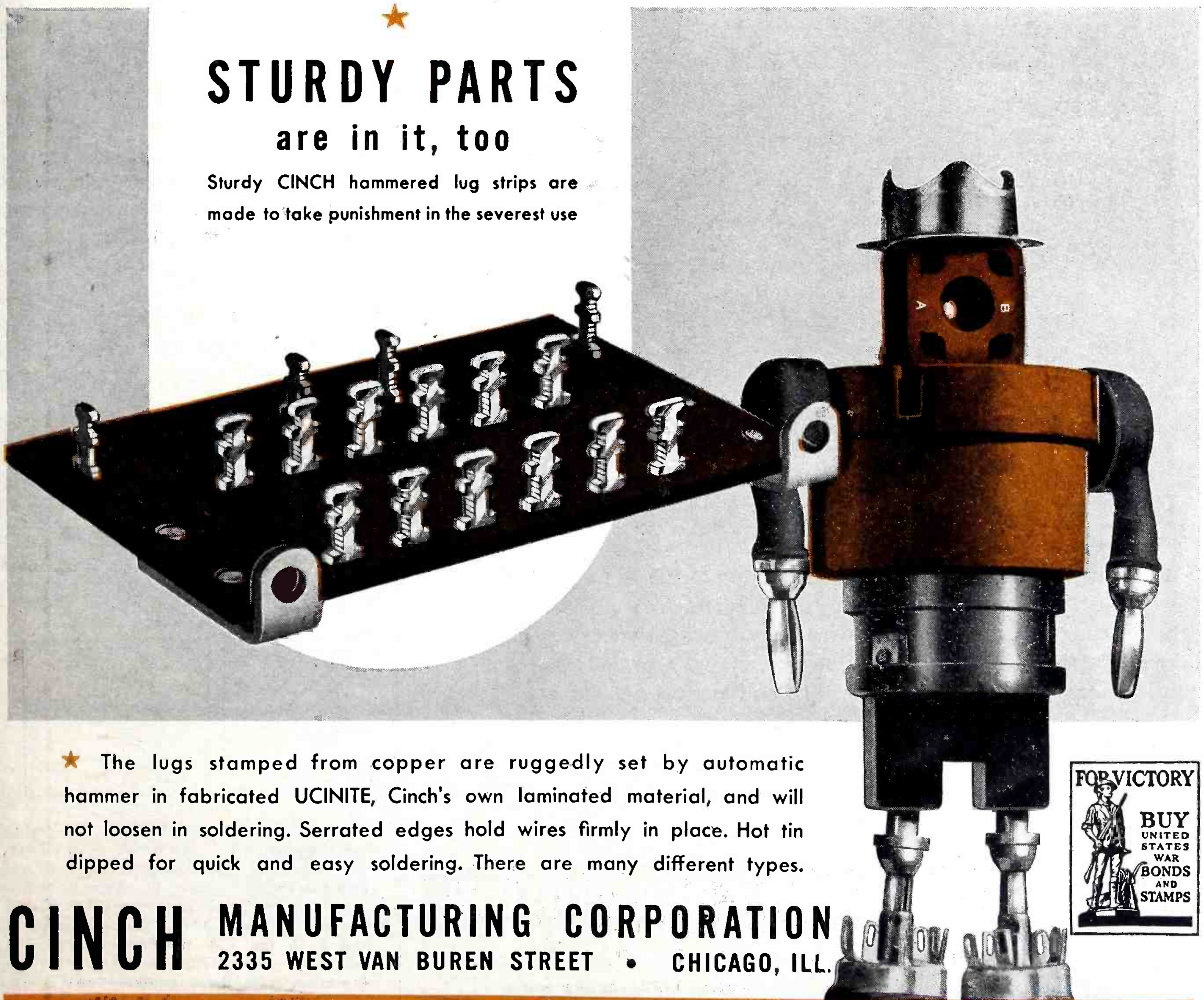
Guardians of the sea—out across the North Atlantic, Coast Guard cutters help guard our life-lines

★

STURDY PARTS

are in it, too

Sturdy CINCH hammered lug strips are made to take punishment in the severest use



★ The lugs stamped from copper are ruggedly set by automatic hammer in fabricated UCINITE, Cinch's own laminated material, and will not loosen in soldering. Serrated edges hold wires firmly in place. Hot tin dipped for quick and easy soldering. There are many different types.

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

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

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

tate locating tubes which may be erratic in operation.

Test Procedure for FG95 Thyratron

1. Make sure all switches are in off positions, and potentiometer is in minimum-voltage position.
2. Insert FG95 tube in right-hand socket, connect red lead to cap on top of tube, and connect black lead to cap on side of tube.

Remainder of procedure is identical to that given above.

Test Procedure for FG32 Phanotron

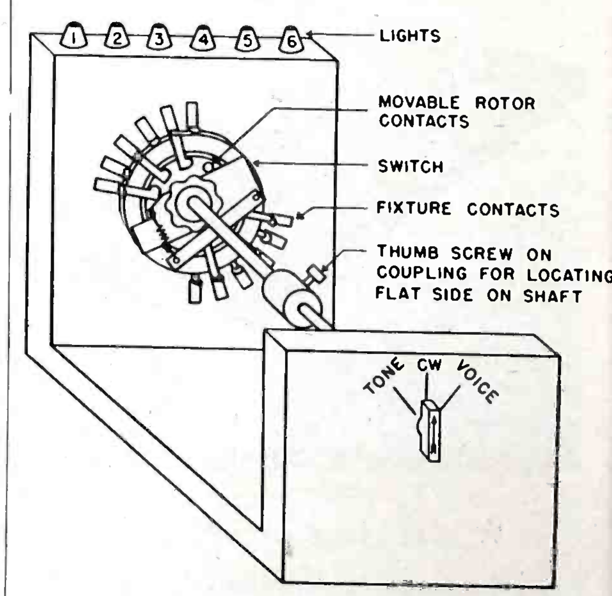
1. Make sure all switches are in off positions, and S_0 is in open position.
2. Insert FG32 tube in left-hand socket and connect red lead to cap on top of tube.
3. Close switch S_1 and wait until condensation has cleared from sides of tube.
4. Make leakage test as outlined in step 4 for FG57.
5. Close switch S_2 and observe reading on plate current ammeter, which should be 2.4 amperes.

Test Procedure for 872-A Rectifier

The procedure for testing this tube is exactly the same as for the FG32 thyratron except that switch S_0 must be in its closed position, and the plate current should read 1.4 amperes.

• • •

SELECTOR SWITCH TESTER



Testing jig developed by Mrs. Catherine Marchewka of G-E for making simultaneous electrical and mechanical tests of selector switches used in radio transmitters. For good switches, lamps 2, 3, 4 and 6 light in the TONE position; lamps 3 and 5 in the CW position; lamps 1, 4 and 6 in the VOICE position. If any deviation from these combinations is obtained, the switch is rejected

Balancing 50-ton Marine Gears

AUTOMATIC CONTROL of the accelerating rate in bringing 17-ft. diameter marine propulsion gears up to full speed of 200 rpm for dynamic balancing is obtained with G-E Thymo-trol type electronic control for the 200-hp driving motor. The 50-ton gear to be tested is mounted on a 24-inch diameter shaft supported by bearings which permit the gear to vibrate freely in a horizontal direction. Conventional pick-up coils convert this movement into electrical impulses which energize a wattmeter in a conventional dynamic balancing circuit which indicates the points at which correction of unbalance is required.

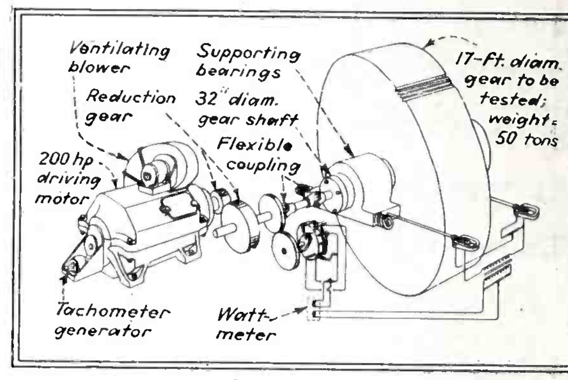
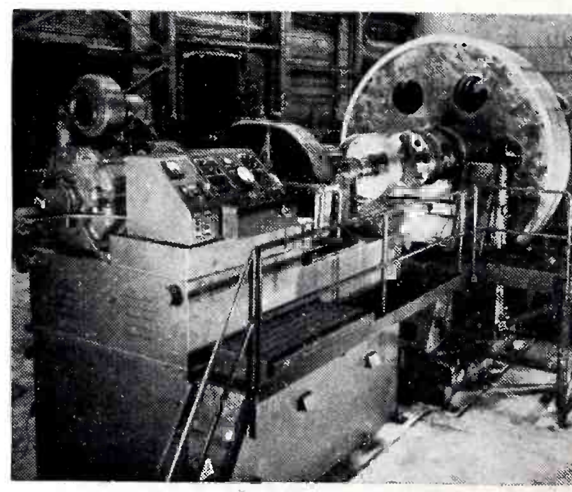


Diagram and photo of dynamic gear-balancing machine using electronic motor control



Electronic control equipment was chosen because both squirrel-cage and wound-rotor induction motors heated excessively during the required long acceleration time of 10 minutes. The arrangement finally selected consists of a 200-hp, 650/1300 rpm shunt-wound d-c motor and a motor-generator set for the motor field current, with electronic control for both the motor and generator to provide high breakaway torque for starting, smooth, constant-torque acceleration and deceleration, and simple, accurate setting of the operating speed.

ONE *Expert* TO SEND THE MESSAGE

ONE *Expert* TO PROVIDE THE EQUIPMENT

VR105-30 and VR150-30
Gaseous voltage-regulator tubes

Specialists on the Factory Front must back up those on the Fighting Front. As an American, you would be proud to see at Hytron carefully trained girls holding down important supervisory and technical jobs, and displaying manual dexterity on fine work which a watchmaker would admire.

Here at Hytron we realize fully our responsibility for fashioning well the radar, radio, and electronic tubes upon whose performance the lives of our fighting men depend. To fulfill this trust, we have gone all out to train hundreds of new specialists capable of building to exacting standards countless dependable War tubes. That their skills may help bring closer the day when our boys come marching home, is the sole purpose of all Hytron employees.

Oldest Exclusive Manufacturer of Radio Receiving Tubes

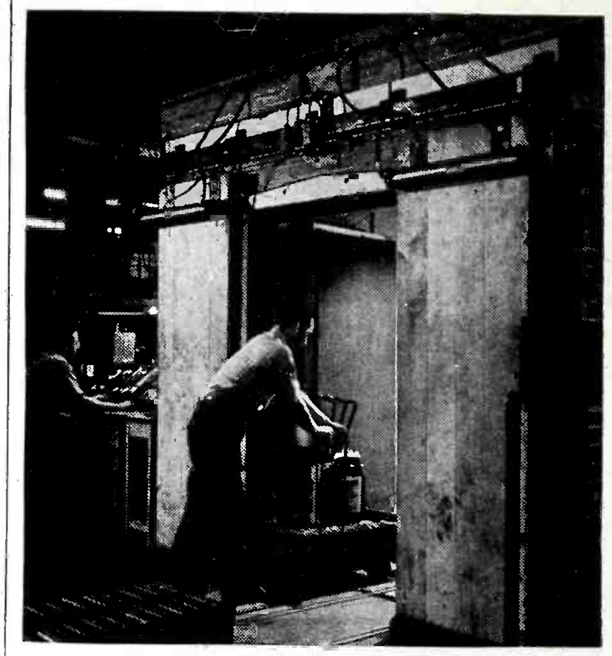
Hytron ELECTRONIC AND RADIO TUBES **Corporation**

HYTRON RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

Measuring Transformer Noise Level

TRANSFORMER NOISE LEVELS are scientifically measured and compared in a special accoustically treated noise level room built into the Sharon transformer works of Westinghouse. For comparison tests, two trucks, each carrying a transformer, are wheeled into position in the room. Flexible clip-leads on the truck are readily attached to the transformer terminals. These leads go to contact blades on the truck which fit into corresponding jacks inside the room, so that power connections are made automatically when the trucks are pushed into position.



Pushing a power transformer into the Westinghouse noise-level room. The control panel is at the left, outside the room

A microphone mounted on an adjustable stand inside the room picks up the sound. Outside the room is a control panel at which the exact value of the sound can be read, or the relative values of sounds produced by two transformers can be determined.

• • •

Trouble-Shooting in Electronic Equipment

ALTHOUGH MAINTENANCE is minimized in electronic equipment because there are few or no moving parts, faults can occur as in any other electrical device. The following suggestions taken from G-E bulletin GEH-1173 on photoelectric relays will permit quick location of the trouble in the majority of cases.

First isolate the electronic equipment and observe its output when

—so we brought the jungle to Chicago

Sweltering jungle heat and ever-dripping moisture is a real test of endurance for our fighting men. But how about the *Communications* equipment upon which their very lives often depend? To find the answer, RAULAND engineers brought the jungle right into our laboratories! They built a large, glass-enclosed, air-tight cabinet . . . provided it with the dripping wetness of saturated, super-heated air and tropical plants and lush vegetation, deep rooted in mossy loam. Into this "torture chamber" went RAULAND Communications equipment . . . to finally emerge with the correct answers to some very vital questions. A typical example of RAULAND engineering thoroughness in making certain that its precision instruments serve dependably under even the most trying conditions.

RADIO . . . SOUND . . . **Rauland** . . . COMMUNICATIONS

Electroneering is our business

THE RAULAND CORPORATION . . . CHICAGO, ILLINOIS

Buy War Bonds and Stamps! Rauland employees are still investing 10% of their salaries in War Bonds

the usual input signal is artificially applied. If the correct output signal is obtained, the trouble is not in the electronic equipment.

If the trouble is electronic and is not obvious on careful inspection after the housing is removed, turn on the power and adjust the equipment for proper operation as outlined in the instructions. Observe tubes and light sources to see if filaments are heated. See if metal tubes are warm. If ignitrons with metal tubes are used, however, turn off power before touching them, because the envelopes may be at line potential.

If there is a contactor on the panel, close it manually to check proper operation of its contacts.

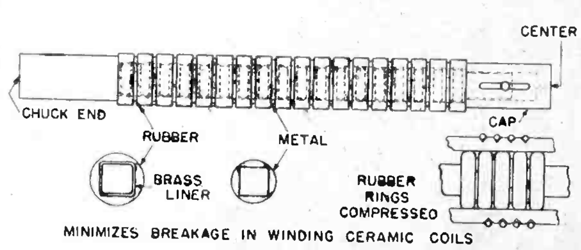
If spare tubes are available, they may be inserted to check tube operation. Receiving type tubes may be checked with an ordinary tube tester, while thyratrons and phototubes are tested according to procedures described in bulletins in the tube cartons.

Inspect wiring near terminals, as vibration will often cause breaks which are not readily visible. Look for blown fuses, burned-out resistors and damaged parts.

Before proceeding any further, study the wiring diagram and instruction book for the equipment, then check circuit voltages with an ordinary multimeter or 1000-ohm-per-volt voltmeter, with particular attention to d-c electrode voltages of tubes. Other measurements can also be made, in much the same manner as for servicing radio receivers and transmitters. As a rule, electronic equipment is far easier to service than radio equipment, once the circuit is understood.

• • •

ARBOR FOR CERAMIC COIL FORMS



Alternating metal and rubber washers on a square shaft form an arbor which minimizes breakage of ceramic coil forms during winding. Pressure is applied longitudinally by moving the tailstock center against a sliding cap which fits over one end of the arbor. The arbor was devised by A. C. Schlansker, G-E Electronics Dept. foreman

Where was RCA on the night of January 2, 1940?

● January 2, 1940 — 23 months and 5 days before Pearl Harbor — where was RCA on that night?

● It was at the point of launching a peace-time program that was to be recognized eventually as an important military measure. For that program was one of *simplification.*

● It was called the *RCA Preferred Type Tube Program* and was inaugurated because the several hundred different tube types then in existence resulted in short, uneconomical manufacturing runs, complex problems of warehousing and replacements, and other inefficiencies which made it impossible to give the ultimate customer the maximum of dependable service and the greatest value for his money.

● With the advent of war, the government recognized the advantages of such a program and issued an "Army-Navy Preferred List of Tube Types." The latest revision of this list is dated March 1, 1943. We will be glad to send you a copy on request.

● The urgent requirements of war are proving the worth of this program in releasing for other purposes the large quantities of materials ordinarily tied up in many types and styles of tubes. Also, the principle of Preferred Type Tubes is proving a blessing on the fighting fronts— where vital replacements can be expedited for equipment designed to use standard types of tubes.

★ *Buy United States War Bonds and Stamps* ★

RCA

RCA ELECTRON TUBES

RCA VICTOR DIVISION • RADIO CORPORATION OF AMERICA
CAMDEN, N. J.

TUBE RECOMMENDATIONS FOR POST-WAR DEVELOPMENTS

The advantages of the Preferred Type Tube Program are so far-reaching that it is only logical to assume that we will continue the program after the war. Our applications engineers will be glad to consult with equipment manufacturers concerning the tube types most likely to be on our list of post-war preferred types.

Today this flag flies over

From this world headquarters for radio-electronic research flow new weapons, new discoveries and inventions vital to the winning of an Allied victory!

TODAY, over RCA Laboratories, flies a new distinguished battleflag—the coveted Army-Navy "E" Award.

One of the few laboratories in America to receive this award, RCA is at once proud of this distinction, and humbly aware of the responsibilities that it imposes. For much of the progress of the entire radio-electronic industry stems from the work done in these laboratories.

It was perhaps with this thought in mind that —at the dedication of the RCA Laboratories in Princeton—the Chief Signal Officer of the Army called them "The Hidden Battlefront of Research."

HIDDEN—because, for the duration of the war, this magnificent building of 150 separate laboratories must be closed to all but the scientists and research technicians who are working on radio-electronic instruments important to our military effort.

BATTLEFRONT—because in the waging of modern warfare, radio-electronics is of first importance. It follows the flag and the fleet—locates the enemy—flashes urgent orders—safeguards the convoy—guides the bombers—directs the artillery—maneuvers the tank. This science fights on every front.

And when that certain day of Victory comes, RCA Laboratories will be devoted to the happier task of making our peacetime world richer, safer, more enjoyable and more productive—through new and finer products of radio, television and electronic research.

OTHER SERVICES OF RCA WHICH HAVE EARNED OUR COUNTRY'S HIGHEST WARTIME AWARDS

The Army-Navy "E" flag, with two stars, flies over the RCA Victor Division plant at Camden, New Jersey.

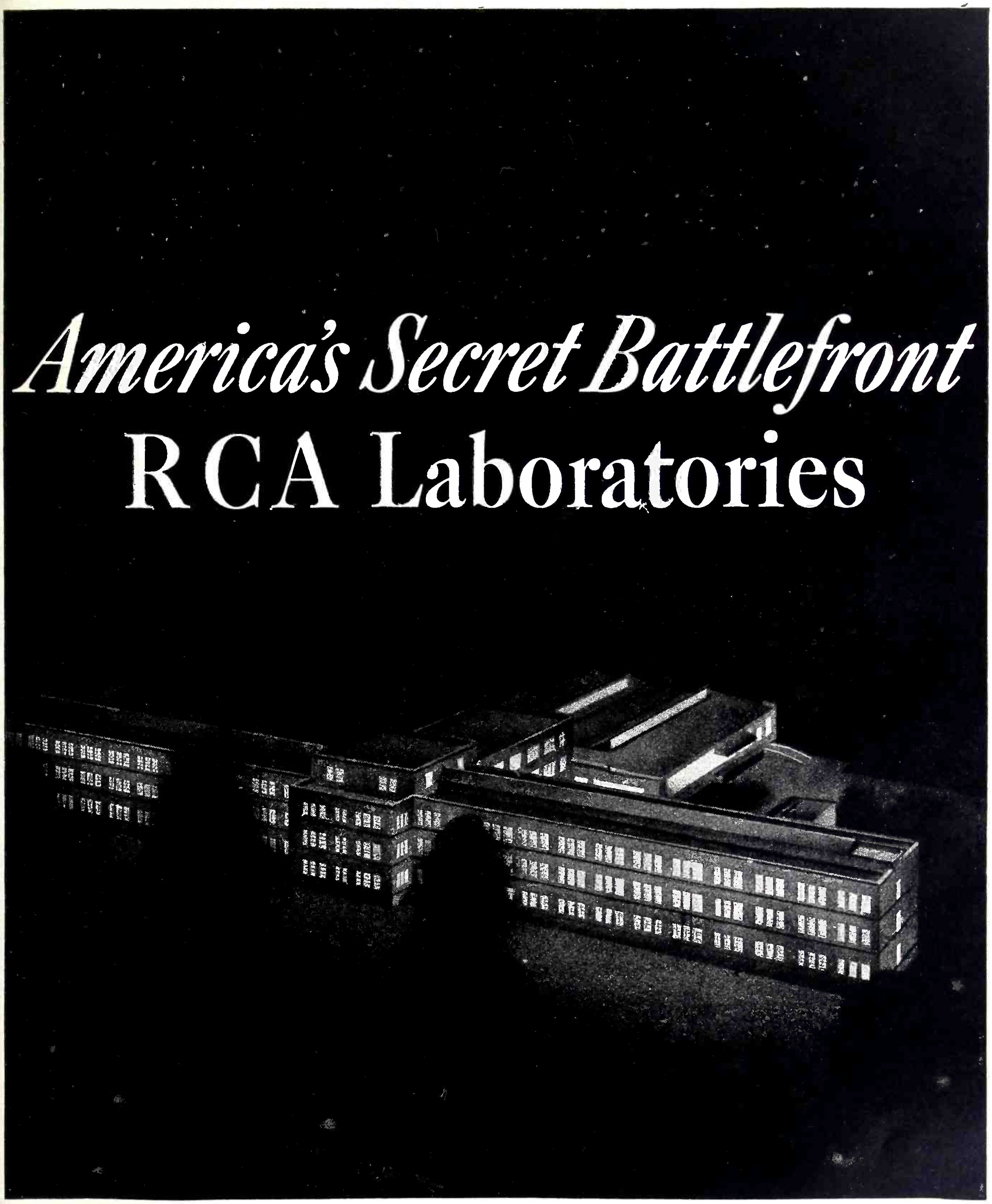
The Army-Navy "E" flag, with one star, has been presented to the RCA Victor Division at Harrison, New Jersey.

The Army-Navy "E" flag, with one star; also the U.S. Maritime Commission "M" Pennant and Victory Fleet Flag have been awarded to the Radiomarine Corporation of America in New York City.

A Service of
Radio Corporation of America

RCA

WORLD HEADQUARTERS



Laboratories

FOR RADIO-ELECTRONIC RESEARCH

Hundred Million Volt X-rays

WITH AN INDUCTION ELECTRON accelerator now nearing completion in the G-E Research Lab. in Schenectady, voltages up to a hundred million volts will be available for the production of x-rays and cathode-rays. One purpose of the project is to determine what radiographic and other useful results can be accomplished with such high-voltage radiation.

The high-voltage cathode-rays offer promise in the treatment of deep-seated tumors, since these rays will have sufficient penetration and have maximum effect only near the end of their range. This property may facilitate destruction of a tumor without damage to overlying tissues, according to Dr. William D. Coolidge, G-E vice-president in charge of research.

• • •

Electrostatic Precipitators Remove Oil Mist in Machine Shops

HIGHER OPERATING SPEEDS of modern machine tools and resultant increased breaking up of coolant oil into mist, coupled with increased machine-hours per day and increased numbers of machines in a given space, create a serious oil smoke and mist problem in many machine shops today. Efficiency of lighting equipment is lowered, visibility is reduced,

• • •

MOBILE MOUNTING

Two metal brackets bolted within the trunk compartment, plus a metal plate forming a shelf, accommodate REL emergency radio gear in rigid, workmanlike style and still leave room for the spare tire

and a fire hazard is created due to condensation of oil on electrical insulation and inflammable materials.

Although simple ventilation can overcome the problem to some extent, it is prohibitively expensive in many cases because the required large volumes of air cause excessive heat loss in winter and excessive refrigeration loss in summer.

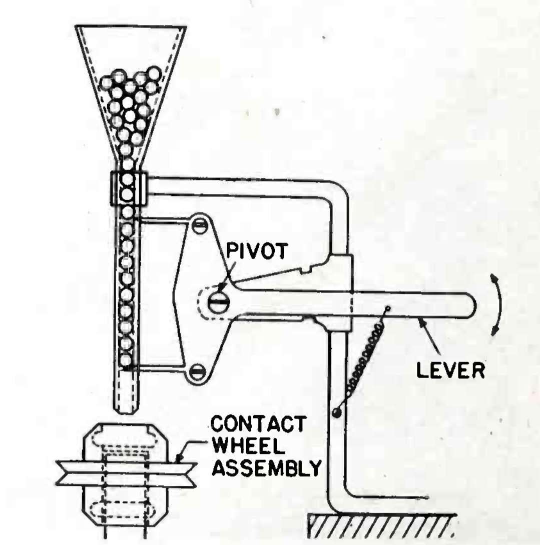
Electrostatic precipitation of oil mist offers a more satisfactory solution in many respects. Modern precipitators have greatly increased efficiency, and now produce so little ozone and oxides of nitrogen that cleaned air can be recirculated for ventilation. Furthermore, the coolant removed from the air is recovered as a liquid and can be used again. The average amount of oil recovered per machine is about two gallons per 24 hours, or 100 gallons per day for a 50-machine plant.

When machines are already in use, sheet metal hoods and ducts should be used at each machine to collect the mist before it has a chance to circulate throughout the room. In some cases, however, it would be possible to design machines to incorporate the ventilating ducts and electrostatic air cleaner within the housing of the machine.

In a comparison test of a Westinghouse Precipitron and a standard mechanical air cleaner, both operating at a volume rating of 600 cfm, photographs were made of a light beam directed inside a dark space at the exhaust end of each unit. The

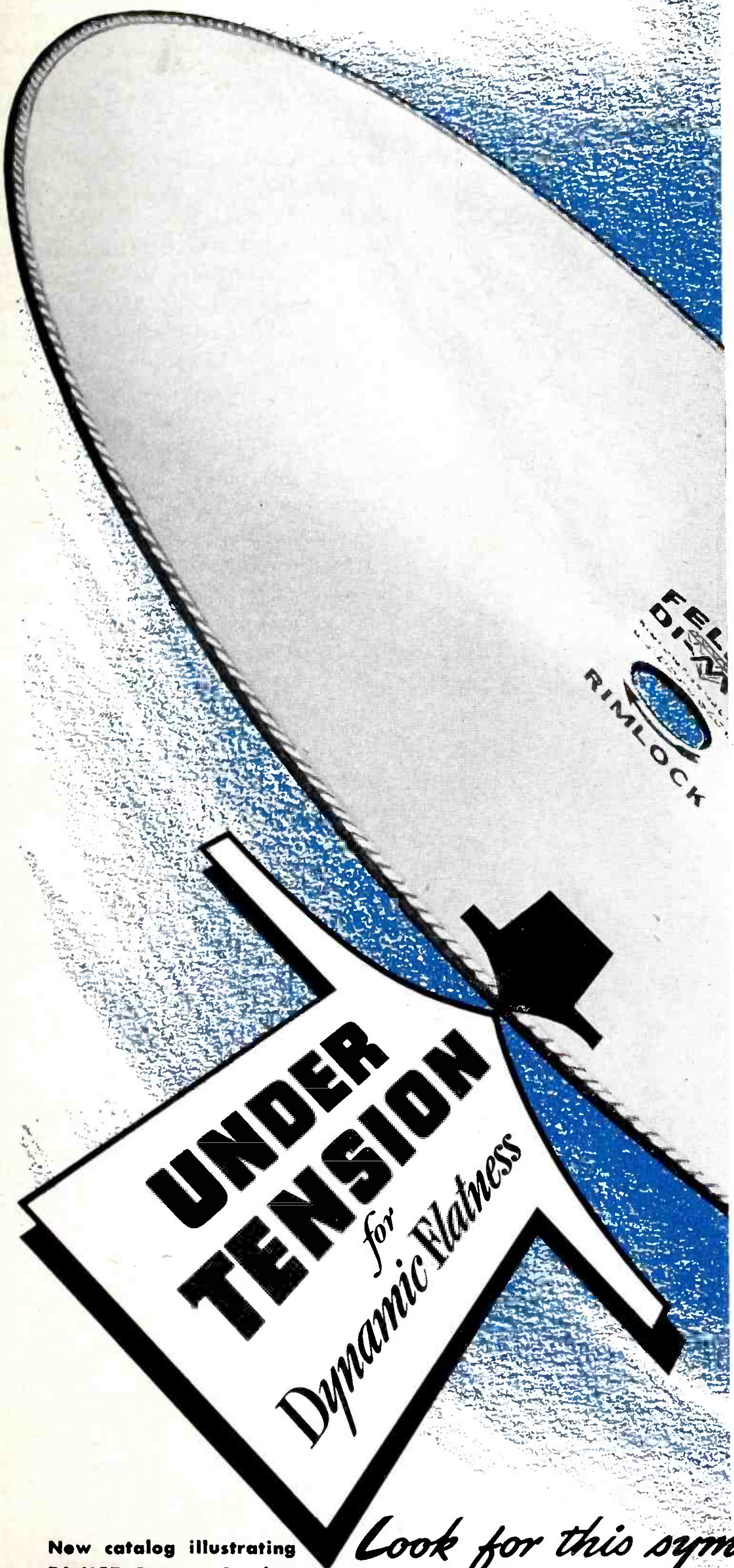
• • •

BALL BEARING DISPENSER



This simple lever and funnel arrangement for feeding exactly nine ball bearings to the contact wheel assembly of a radio transmitter was devised by W. D. Simpson, an assistant general foreman in the G-E Electronics Dept.

FELKER DI-MET



QUARTZ SHORTAGES are effecting important improvements in cutting methods and equipment. DI-MET's contribution in this direction is DYNAMIC FLATNESS, a method for keeping diamond abrasive wheels flat under high speed rotation. This new perfection aids in obtaining a greater number of usable quartz blocks per pound of raw material by reducing runouts, chipping, wafer breakage, and other defects caused by rim wobble.

Experiments prove that all blades which test flat do not always operate flat. This variation is due to unequalized strains within the blade which are released during operation and reassert themselves to cause blade warpage and rim wobble.

DI-MET engineers have overcome rim wobble by a new process for obtaining dynamic flatness! Strains are first equalized throughout the blade — and the rim then placed under a balanced, radial tension. The tension is uniform throughout the circumference and prevents run-out due to normal temperature rise and nominal pressure variation during cutting.

With proper care, DI-MET dynamically flattened blades stay flat for the life of the blade — not only reduce the number of blades required — but produce more crystals per pound of quartz! Try dynamically flattened DI-MET Rimlocks. You pay no premium for this BETTER cutting tool!

Look for this symbol (A) of dynamic flatness

New catalog illustrating DI-MET Quartz Cutting Machines is now available. Have you received your copy? Write for it!

FELKER MANUFACTURING COMPANY

1116 BORDER AVENUE • TORRANCE, CALIFORNIA

MANUFACTURERS OF DIAMOND ABRASIVE TOOLS

light beam was visible in proportion to the number of foreign particles reflecting light in the air. The light beam was not visible on the film exposed while the Precipitron was operating, and densitometer measurements on the negatives indicated that the electrostatic filter was 7.3 times as efficient as the mechanical filter.

In an electrostatic precipitator, a d-c voltage of the order of 12,000 volts is produced by a power pack using high-voltage rectifier tubes. This voltage is applied to a fine wire mesh through which the dust particles first pass, thereby charging the particles. The dust-laden air then passes through a system of parallel plates, alternate plates being grounded and the remaining plates connected to a 6000-volt d-c terminal of the power pack. The charged particles are pulled to plates of opposite polarity and thus removed from the air.

• • •

Using Phone Line for Remote Indication of Overmodulation

By ALVIN LEEMAN
Chief Engineer, Station WKBH

THE SIMPLE CIRCUIT arrangement in Fig. 1 permits one modulation monitor unit to provide indications at both transmitter and studio of a radio station.

The output of the modulation monitor at the transmitter location is fed to a d-c relay arranged to close its contacts on overmodulation. The studio-transmitter order line and ground provide a complete circuit for these relay contacts to the grid

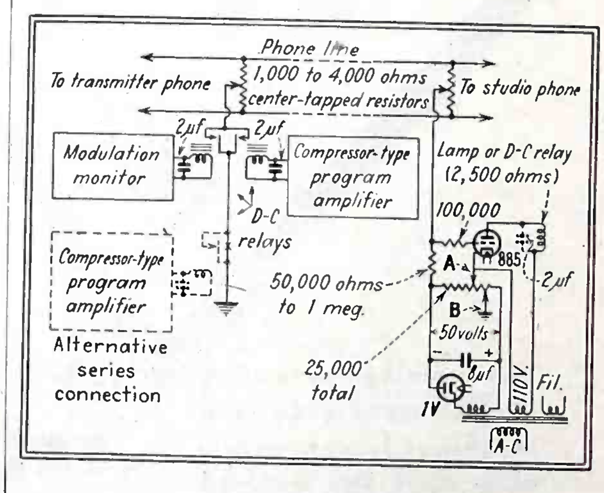
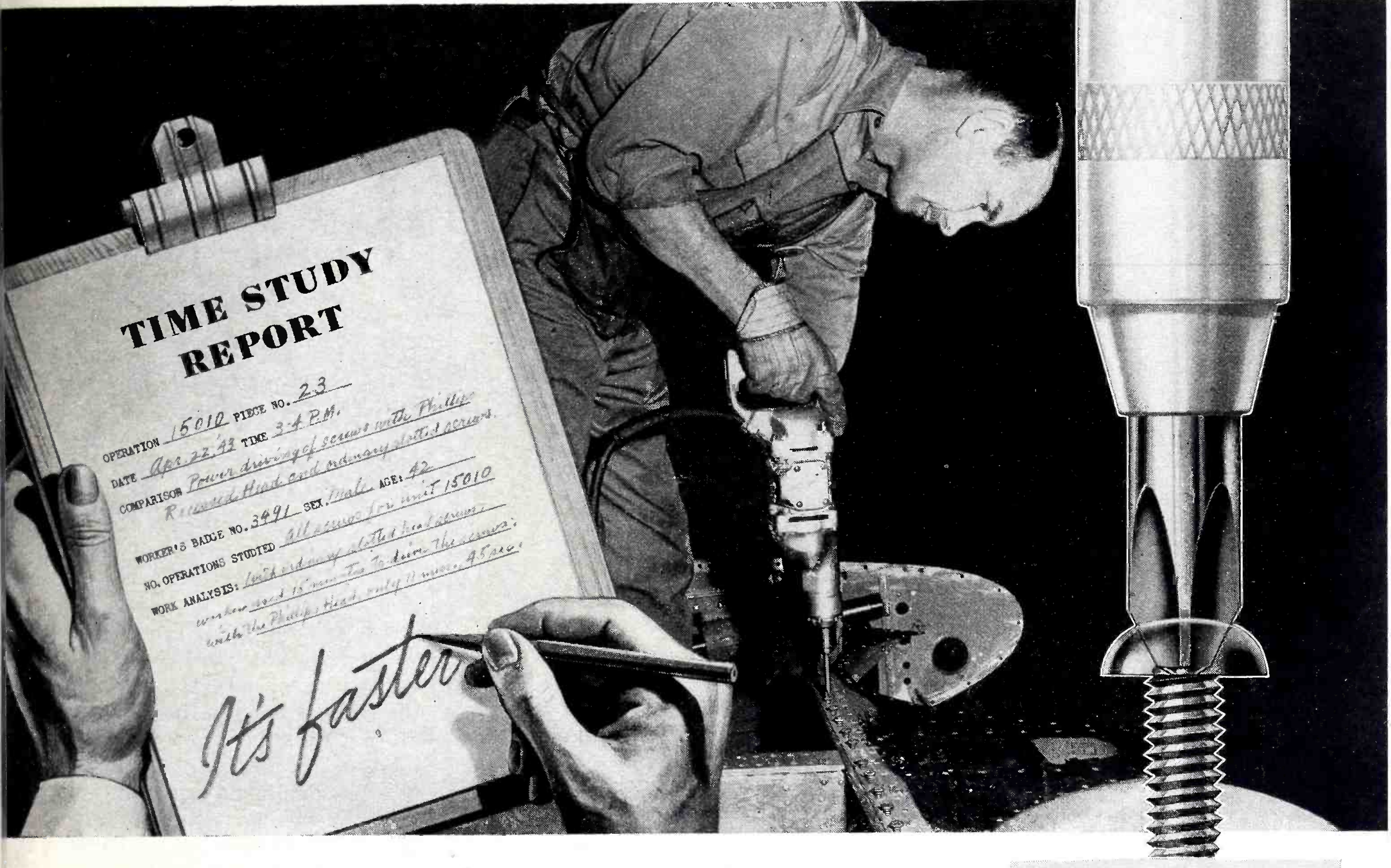


Fig. 1—Overmodulation indicator circuit and phone line connections. Ordinarily only the modulation monitor will be connected to the transmitter end of the line

Arm Your Screw Driving Army for SPEED TACTICS



SPEED-UP WITH PHILLIPS SCREWS!

Give your assembly line Phillips Recessed Head Screws and you'll give them the ammunition to clean up lagging assembly jobs on the double-quick!

In most cases, change-overs to Phillips Screws have cut driving time in half! All of the screw driving troubles that slow-up work are eliminated by the Phillips Recessed Head. The scientific recess, by automatically centering the driving force, prevents fumbling, wobbly starts . . . prevents slant-driven screws . . . burred and broken screw heads . . . dangerous screw driver skids.

The Phillips Recess lends "old-hand" skill to the newest newcomer . . . makes fast, faultless driving automatic. It permits power or spiral driving on almost any job.

They cost less to use! Compare the cost of *driving* Phillips with that of slotted head screws. You'll realize that the price of screws is a minor item in your total fastening expense . . . that it actually costs less to have the many advantages of the Phillips Recess!

KEY TO FASTENING SPEED AND ECONOMY

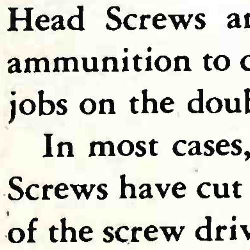
The Phillips Recessed Head was scientifically engineered to afford:

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.

circuit of a gas triode at the studio. Closing of the contacts lowers the bias on the tube enough to energize the relay or lamp in the plate circuit and give the desired indication.

The center-tapped resistor across the phone line at each end should be made high enough in resistance to prevent it from affecting normal use of the telephone line. Satisfactory operation can be obtained with less than 1 ma of relay current in the line circuit.

As some of the compressor types of program amplifiers also have facilities for operating relays at some predetermined level, they can be used in place of the modulation monitor, or the contacts of the relays of each unit can be connected either in parallel or in series to indicate a predetermined program condition. In parallel, either the modulation monitor or the program amplifier can produce an indication at the studio. In series, the relays of both monitor and amplifier must operate to give a studio indication.

In adjusting the device for operation, first see that the relay contacts at the transmitter end of the order wire stay open. Decrease the bias voltage at movable contact *A* until the relay or lamp in the plate circuit of the 885 tube is energized, then increase the bias voltage until the relay or lamp is no longer energized. Increase the bias slightly more so that induced voltage on the telephone line will not operate the indicator.

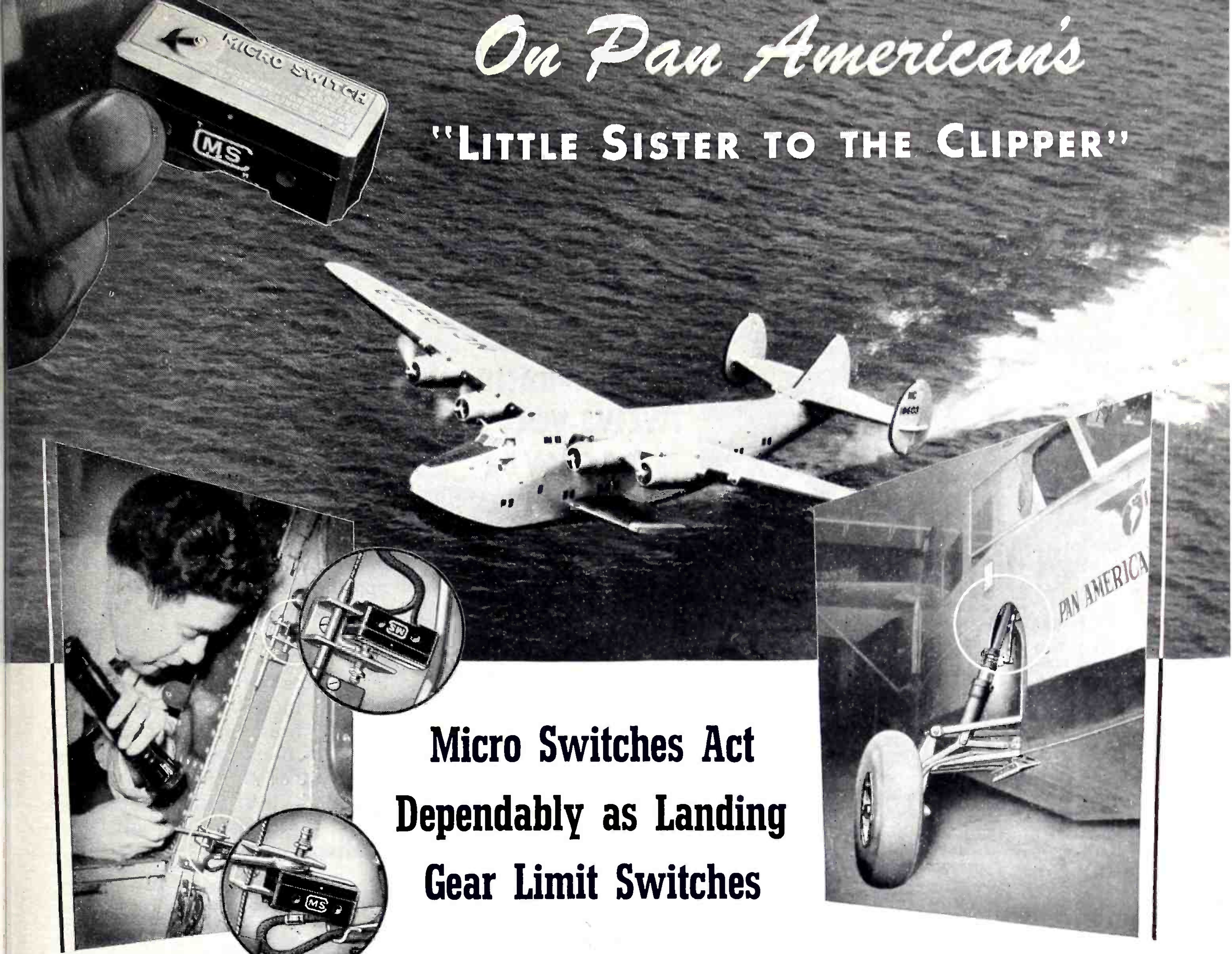
For the adjustment of *B*, close the relay contacts at the transmitter end of the order wire and move sliding contact *B* toward the negative side of the voltage divider until the relay or indicating lamp is deenergized, then move this contact toward the positive side until the relay or lamp is again energized. Slide the contact a little further in the same direction so that positive operation of the device is assured.

In the circuit as shown in Fig. 1, the relay in the plate circuit of the 885 tube will operate as a buzzer-type indicator. A 2-μf capacitor across the relay coil will cause this relay to operate as a straight relay, however, and its contacts can then be used to make or break other circuits as desired.

For those desiring to use a neon bulb as a peak indicator and a lamp or buzzer as an overmodulation indicator, the arrangement shown in Fig.

On Pan American's

"LITTLE SISTER TO THE CLIPPER"



Micro Switches Act Dependably as Landing Gear Limit Switches

Illustrated here is one of the Pan American Airways' huge 42½ ton Transocean Clippers. In the inserts are shown the landing gear and the Micro Switches which are used as limit switches on Pan American's Grumman Widgeon trainers. This plane is often referred to as the "Little Sister to the Clipper."

These trainers are used for training the intrepid pilots who fly the giant Clippers over the seven seas. Because of the nature of the work performed, it is obvious that every precaution must be taken, every contingency provided for. That is why Pan American depends on the rugged dependability of Micro Switch.

Thumb-size and feather-light, Micro Switch is amazingly rugged, resists vibration, and requires no leveling. It operates precisely at the same point for millions of operations with lightning-fast contact action. It is accurately built to exact standards from precisely made parts. Its performance characteristics can be changed to meet functional requirements.

Micro Switches are used to perform many different functions in aircraft. Special brackets, actuators, and aluminum housings are available for this purpose. For heavy duty service such as machine tools, there are Micro Switches enclosed in steel which can be sealed against dirt, dust, water, oil, metal chips and other foreign particles.

All Micro Switches can be supplied with a variety of actuators to meet all needs. Micro Switches operate on pressures as low as one ounce and movements as low as .0002". Micro Switch is listed by Underwriters' Laboratories with ratings of 1200 V.A. loads, from 125 to 600 volts A.C.

Every engineer should have a copy of Micro Switch Handbook Catalogs which tell and illustrate the principles and applications. Handbook Catalog Number 60 deals with Micro Switch in general, and Number 70 is written specifically for aircraft applications.

Micro Switch Corporation, Freeport, Illinois
Branches: 43 E. Ohio St., Chicago • 11 Park Place, New York City
Sales and Engineering Offices: Boston • Hartford • Los Angeles

The trademark MICRO SWITCH is our property and identifies switches made by Micro Switch Corporation

MICRO SWITCH

Made Only By Micro Switch Corporation . . . Freeport, Illinois

Converting Capacity Changes Into Current or Voltage Changes

A DUAL-OSCILLATOR CIRCUIT for converting small changes in capacity into corresponding electrical changes is described by E. V. Potter in the May 1943 *Review of Scientific Instruments*. It has low background noise, high sensitivity, and is relatively free from interference by local electrostatic and magnetic fields. The circuit can be used to study vibrations or capacity changes having frequencies ranging from 0 to over 200 kc, and has been found particularly useful by the U. S. Bureau of Mines in connection with seismometers for recording earth vibrations, in studies of the motion of large vibrating surfaces, in measurement and recording of the elongation of test specimens being stretched, and in a host of other machines used in metallurgical research.

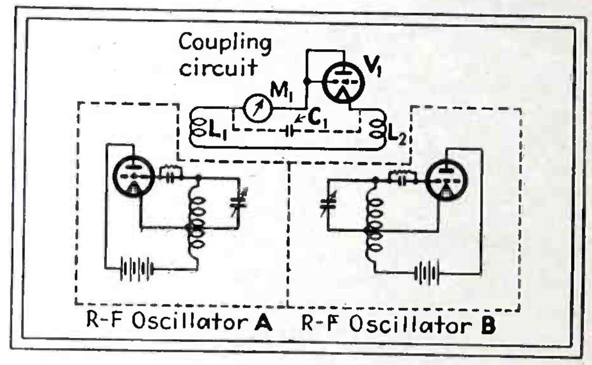
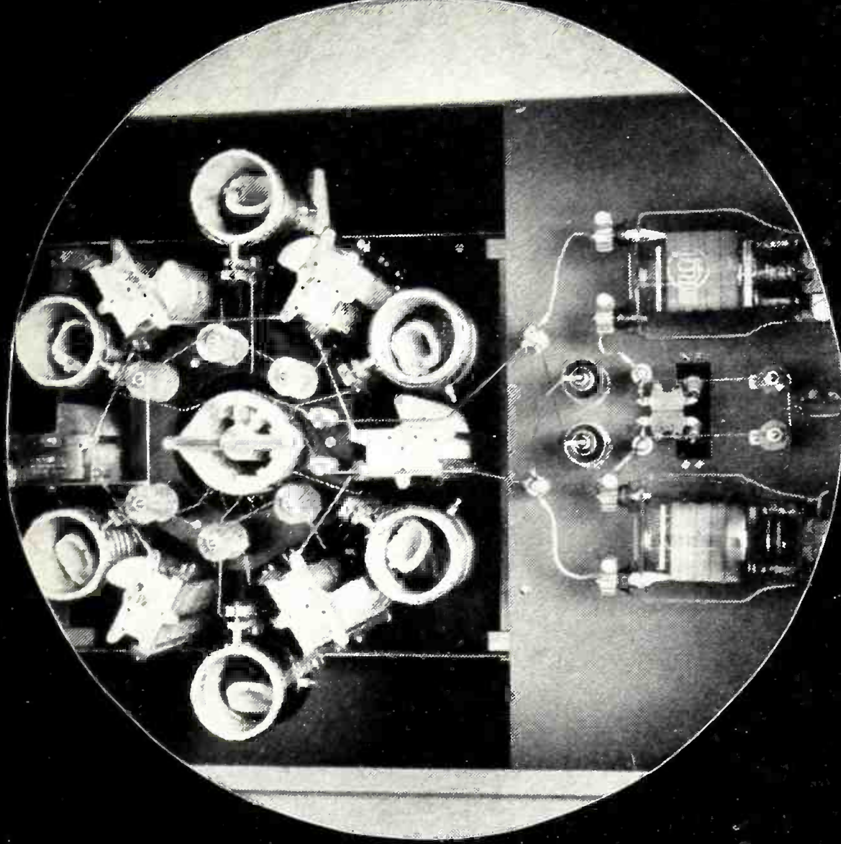


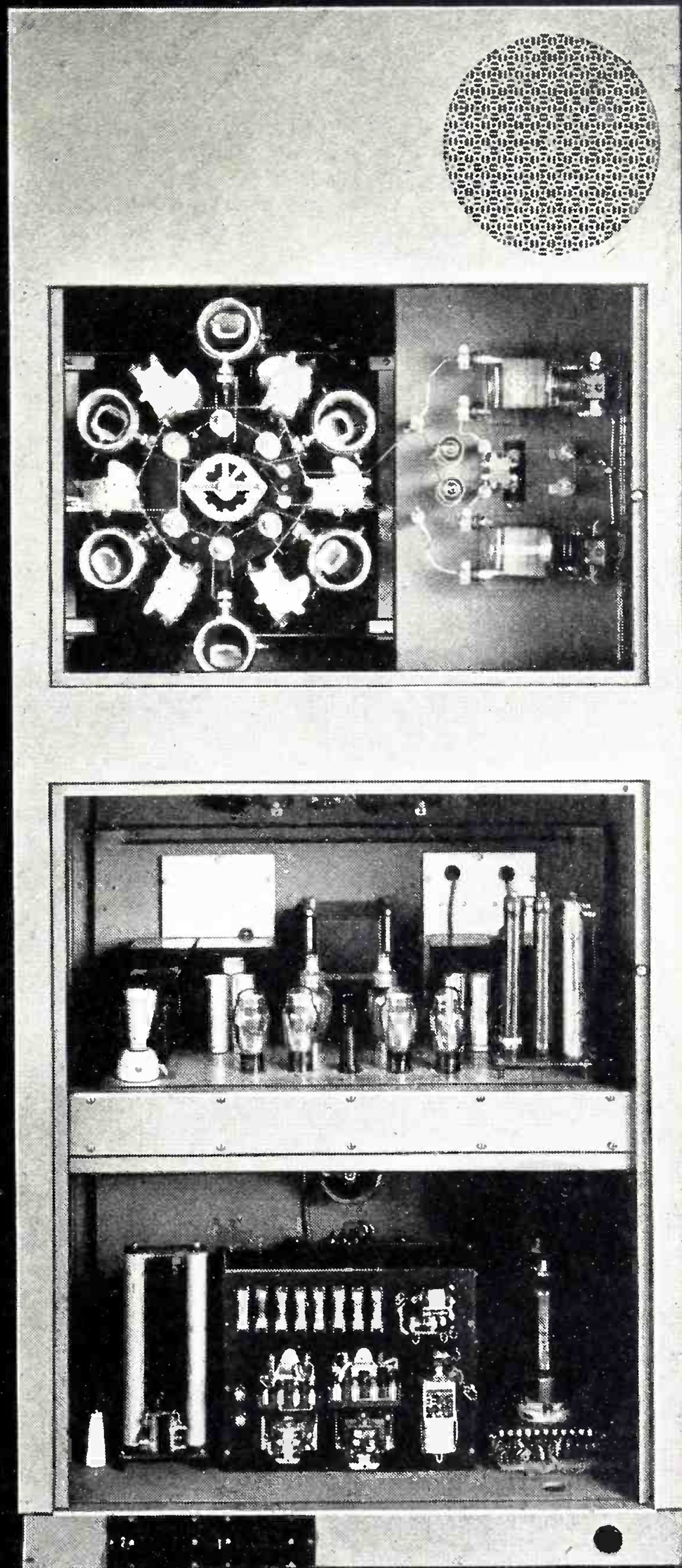
Fig. 1—Essential parts of a circuit for changing capacity variations into current variations. It is often referred to as a transducer circuit

The basic circuit arrangement is shown in Fig. 1. The two r-f oscillator circuits are isolated from each other as much as possible, so that the only path for interchange of signals is through the coupling circuit consisting of rectifier V_1, d-c milliammeter M_1 and coils L_1 and L_2 which are closely coupled to the tuning circuits of r-f oscillators A and B respectively. These oscillators are as nearly alike as possible, and are normally operated so they would oscillate at virtually the same frequency if the coupling circuit were removed.

The coupling provided through the coupling circuit is adequate to make the oscillators synchronize, even when the frequency of one oscillator is changed within certain limits. R-F current in the coupling circuit is a minimum when both oscillators are tuned to the same frequency, and



Detail view of final amplifier tube circuit construction.



Model #1000 AG-CW 1000 Watt telegraph transmitter with motor drive frequency selector.

Product of

UNEXCELLED CRAFTSMANSHIP

Radio communications equipment is a highly specialized and technical product. Its successful performance is largely dependent upon the qualifications and ability of the men responsible for its design and construction. TEMCO engineers, designers and technicians never lose sight of their individual responsibility. This is one reason why TEMCO continues to enjoy an unexcelled reputation in radio communications engineering.

Underside view of low voltage and relay control chassis, Model #1000 AG-CW transmitter.

TEMCO

STANDARD AND CUSTOM-BUILT RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MANUFACTURING CO., INC.
345 Hudson Street, New York, N. Y.

increases with detuning of either oscillator as power is transferred between oscillators to keep them in synchronism. The coupling current is a maximum near the point where further detuning will cause the oscillators to drop out of synchronism.

The actual current values will depend on the amount of power being transferred, the resistance of the coupling circuit, rectifier tube and meter, and the amount of coupling between the tuning coils and the coupling coils. The shape of the current-capacity curve can be controlled by changing the arrangement of coils.

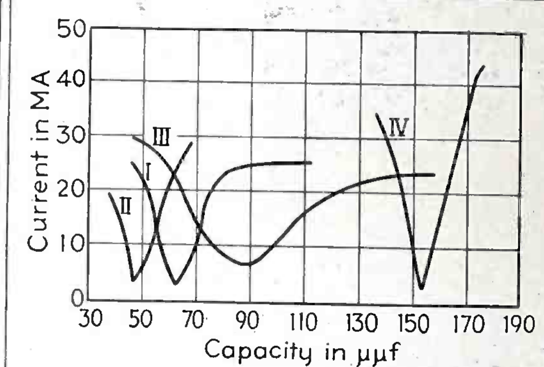


Fig. 2—Typical curves showing variation of synchronizing current in coupling circuit with tuning capacity for various coupling coil arrangements. These curves were obtained with the circuit in Fig. 3

Examples of curves for various coupling coil arrangements are shown in Fig. 2. These were obtained by plotting coupling circuit current against change in capacity of one of the oscillator tuning condensers. Curve IV is best for general use because it has a high sensitivity (about 2 ma/$\mu\mu$f) and a large region in which current is a straight-line function of capacity. The coil arrangement giving this curve is shown in Fig. 3 along with the actual transducer circuit now being used by the Bureau of Mines.

Circuit Data

The circuit in Fig. 3 is essentially the basic circuit of Fig. 1 arranged for operation from a single 60-cycle a-c power pack, with a 4-pole double-throw switch in the coupling circuit to provide a more flexible output. The input terminals are arranged so the capacity pick-up device can be connected in parallel with the tuning capacitor of either oscillator or, when the pick-up provides two capacities one of which decreases as the other increases, one can be con-

THIS IS WHAT COUNTS!

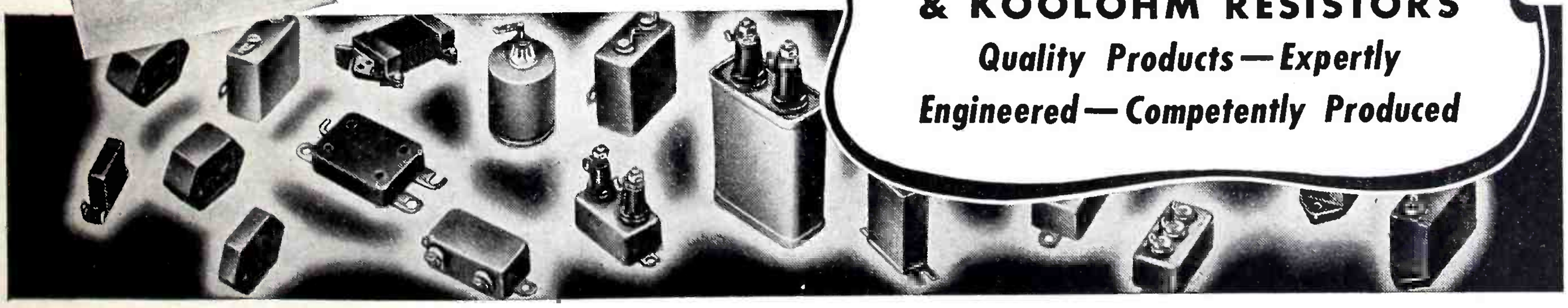
There's a difference between working on "gadgets" and being an integral part in the manufacture of quality products that are a matter of intense pride throughout the community in which you live. That difference represents the extra "plus" factor of goodness you find in Sprague Capacitors.

North Adams is not a large city. It doesn't produce a great deal by big-city standards—but what it does produce it believes in producing right. And Sprague Capacitors and Koolohm Resistors by the hundreds of thousands are among its chief products.

SPRAGUE SPECIALTIES COMPANY, North Adams, Mass.

WORKING TOGETHER FOR VICTORY
Sprague Army-Navy "E" presentation day was a holiday in North Adams—but a holiday on which everyone still worked. At right is one of many congratulatory window displays made by North Adams merchants. At left is the day's North Adams Transcript with a 16-page section devoted to the event.

SPRAGUE
CAPACITORS
& KOOLOHM RESISTORS
Quality Products—Expertly Engineered—Competently Produced



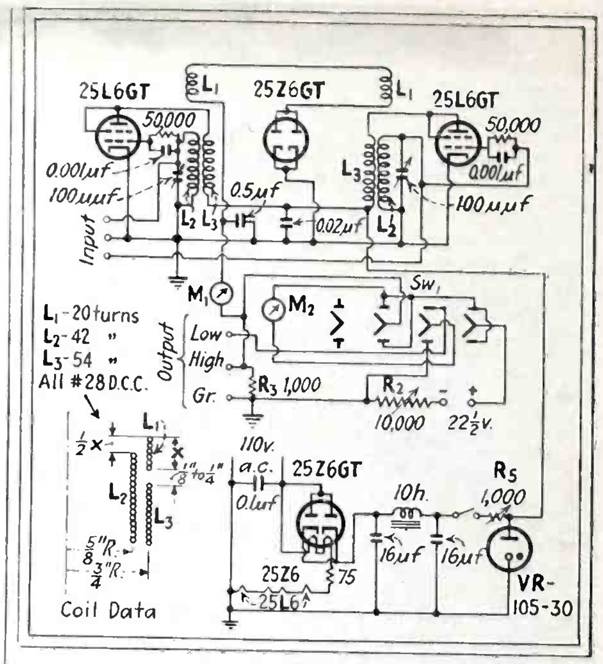


Fig. 3—Complete transducer circuit, with coil construction data

nected to each oscillator for doubled sensitivity.

The circuit fundamentally provides a low-impedance ouput, making it adaptable for use with a low-impedance, current-operated measuring or recording instrument. This is connected between the LOW and GR. output terminals, with switch SW_1 in the upper position. The minimum current value (or the normal value if the operating point is chosen somewhere near the middle of the linear region of the curve) may not be desirable in some applications because of its effect on sensitivity and range. For this reason, a battery and rheostat R_2 are provided in a bucking circuit to permit reducing to zero the initial current in the external circuit. Meter M_1 (0-50 ma.) then reads the total d-c synchronizing current, and meter M_2 (3-0-3 and 30-0-30 ma.) reads the actual current in the external circuit.

It is sometimes desirable to use a high-impedance voltage-operated device such as a cathode-ray oscilloscope, or to amplify the output signal before it is measured or recorded. To obtain the required voltage output for this purpose, switch SW_1 is thrown to its lower position, which inserts 1000-ohm resistor R_3 in the coupling circuit. The HIGH and GR. output terminals are used.

A well-regulated power supply is required to eliminate effects of line voltage variations. Satisfactory results were obtained with the universal half-wave rectifier shown in Fig. 3, with a voltage regulator tube across the output.

Post-War Picture

(*Continued from page* 87)

inevitably, help unearth other industrial applications for the same or similar gear.

Importance of Field Work

The best possible method by which the engineer may obtain accurate information regarding required industrial electronic equipment design features, perhaps the only one, is to go where the problems exist. The electronic engineer of the future will spend more time in the field since in many cases the machines he will have to control electronically cannot be brought to the laboratory.

A desire on the part of the engineer to go out into the field for the practical answers to his problems can bring surprising results. It not only provides practical answers to industrial design problems but also stimulates the creative talents in other profitable directions.

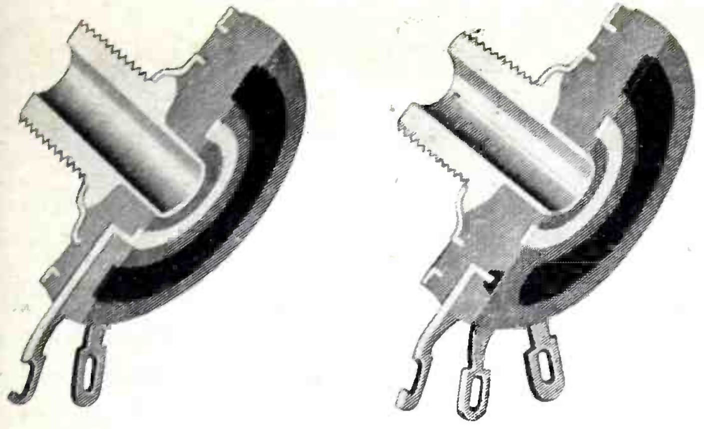
Training of Sales Engineers

The problem of educating sales engineers and sales representatives to properly present specialized components and equipment to engineers of other industries will be a most difficult task and one which must be shouldered by the electronic engineer.

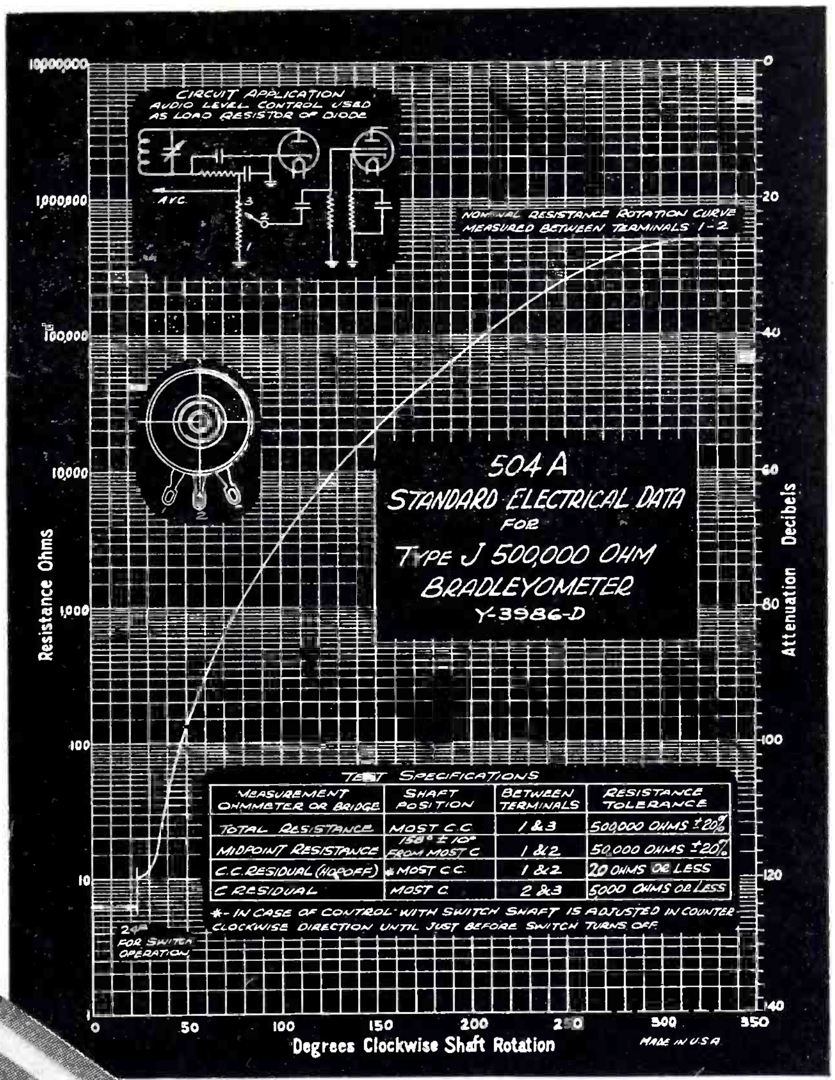
The future educational program to be worked out requires a high order of engineering knowledge as well as creative sales talents, an executive combination which is difficult to find. Engineers of this calibre will be in greatest demand.

The need for sales engineers and sales representatives who have been trained as specialists in certain industrial fields will also be very great since only men thoroughly conversant with the relatively complicated equipment they are selling and the problems of their prospects will be accepted by engineers in other industries.

Sales engineering as well as design engineering will be a highly important field of endeavor in the industrial electronic market of the future. It has long been a lucrative field for engineers in other industries, but it is only now that the real need for capable sales engineers in the electronic field is being born.



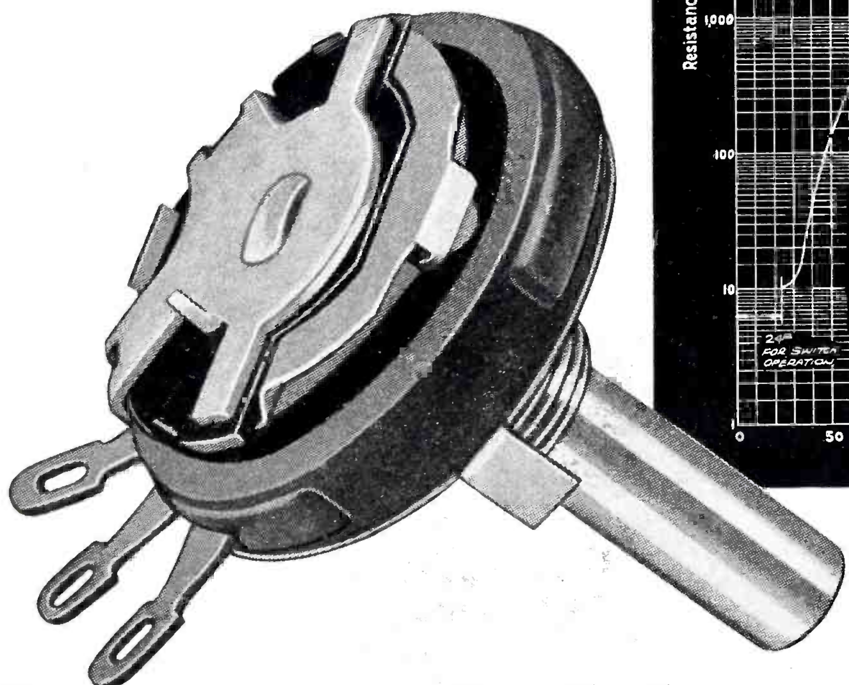
Cross-section views of Type J Bradleyometers showing how terminals are connected to the solid, molded resistor element.



TEST SPECIFICATIONS

MEASUREMENT OHMMETER OR BRIDGE	SHAFT POSITION	BETWEEN TERMINALS	RESISTANCE TOLERANCE
TOTAL RESISTANCE	MOST C.C.	1 & 3	500,000 OHMS ±20%
MIDPOINT RESISTANCE	158° ± 10° FROM MOST C	1 & 2	50,000 OHMS ±20%
C.C. RESIDUAL (HOPOFF)	* MOST C.C.	1 & 2	20 OHMS OR LESS
C RESIDUAL	MOST C	2 & 3	5000 OHMS OR LESS

*- IN CASE OF CONTROL WITH SWITCH SHAFT IS ADJUSTED IN COUNTER CLOCKWISE DIRECTION UNTIL JUST BEFORE SWITCH TURNS OFF.



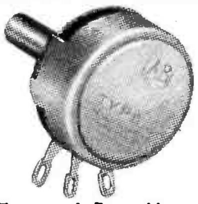
Here's a variable resistor

with the highest safety factor for war service

There's a big margin of safety in the conservative two-watt rating of the Type J Bradleyometer. No other variable resistor of comparable size can meet it. The resistor element is solid and has substantial thickness. It is molded with the insulation, terminals, face plate, and bushing as a single unit, making an exceptionally simple, rugged, and reliable resistor . . . with no rivets, soldered or welded connections, or painted resistor elements.

During manufacture, the resistor material can be varied throughout the length of the element to provide practically any resistance-rotation curve. Once the unit has been molded, its performance is not affected by heat, cold, moisture, or hard use.

Type JS Bradleyometer with switch.



Type J Bradleyometer without line switch.

The low-resistance carbon brush, which makes a smooth contact with the surface of the molded resistor, assures long life and permanently quiet operation. All these factors make Bradleyometers especially suited for the war conditions, where space is limited and absolute reliability is needed.

Bradleyometers can be used separately or assembled to give dual or triple construction to fit any particular control need. They can be supplied for rheostat or potentiometer applications, with or without a switch. Write for specifications today.

Type E ½-watt non-insulated Bradleyunit molded fixed resistor.

Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee, Wis.

ALLEN-BRADLEY

FIXED & VARIABLE RADIO RESISTORS

QUALITY

Inspection of Tungsten

(*Continued from page* 95)

during this "black light" inspection, with each crack showing as a brilliant green indication against a purple background. Figure 3 shows how one of these cracks appears in cross-section when enlarged 200 times.

Rejections range from rods having only one short and very fine indication to rods almost completely covered with cracks. Even when the only crack is not in the area to be beaded, the rod is rejected because experience has shown that these cracks often spread to the glass seal upon heating during subsequent glass work.

Defects which are not revealed by fluorescent inspection are chiefly of the irregular type shown in Fig. 4, which produce one or more bubbles in the glass when the tungsten is beaded over the defect. It is believed that cracks like this are filled with oxide which prevents entrance of the penetrant. The number of tubes found with bubbles in the beads is now only a small fraction

FIG. 3—Etched cross-section of tungsten lead, magnified 200 times, showing crack revealed by fluorescent method

NEW DATA ON IMPROVED PLAX POLYSTYRENE

Plax is one of the biggest producers of commercial polystyrene products in this country — and, so far as we know, uses more polystyrene for experimental purposes than any other company.

Out of this experience Plax presents these new data, suggesting how much better Plax Polystyrene can meet your own high-frequency insulation problems.

Compare its electrical characteristics with those of high-grade mica and fused quartz, add features unusual in any plastic, and you'll agree with other leaders in your field that Plax Polystyrene is one of the best high-frequency insulations ever known.

In addition to offering polystyrene sheets, rods and tubes themselves, Plax machines them into a wide variety of standard and special electronic parts.

From polystyrene, Plax now makes Polyflex Sheet. Tough and flexible, it is easily punched and has obvious uses for condensers, cable, storage batteries, etc.

Also new is Polyflex Fiber, proved in production and in the field as a cable wrapping and in other high-frequency applications.

Ask Plax for more data on these products, for engineering help in applying polystyrene to your products, and for a bulletin on machining polystyrene. In other words, "When it comes to polystyrene, come to Plax."

PROPERTIES OF PLAX POLYSTYRENE

MECHANICAL

Tensile strength, lbs. per sq. in. (A.S.T.M. D 48-37) 5,500-7,000

Tensile proportional limit, lbs. per sq. in. (.01% offset)
−38 F=3,700
0 F=2,800
78 F=2,500

Modulus of Elasticity in tension, lbs. per sq. in.
−38 F=554,000
0 F=536,000
78 F=469,000

Compressive proportional limit, lbs. per sq. in. (.01% offset) 2,600

ELECTRICAL

Volume resistivity, ohm. cm. 10^{17}

Arc resistance (A.S.T.M. D 495-38T) sec. 240-250

Dielectric strength, volts per mil
.005" thickness=3,500
.010" thickness=2,500
.015" thickness=2,200
.125" thickness= 500-700

Frequency Cycles	Dielectric Constant	Power Factor
60	2.5-2.6	.0001-.0002
10^3	2.5-2.6	.0001-.0002
10^6	2.5-2.6	.0001-.0004
10^{10}	2.5-2.6	.0002-.0004

THERMAL

Distortion temperature (A.S.T.M. D48-37), F (C) 176-194 (80-90)

Transition temp. F (C) 180 (82)

Softening point, F (C) 220-240 (104-116)

Ignition point, F (C) 1350 (732)

Specific heat, cal. per gr. per degree C. .32

Thermal expansion coefficient per degree C 7.2×10^{-5}

Thermal conductivity — cal. per sec. per cm. per degree C 3.2×10^{-4}

CHEMICAL

Effect of:

*Weak and strong acids	none
Weak and strong alkalis	none
Alcohols	none
Esters	soluble
Ketones	swells
Aromatic and chlorinated hydrocarbons	soluble

*Except oxidizers which discolor.

PLAX CORPORATION 133 WALNUT ST. HARTFORD, CONN.

Transmission Line Chart

(*Continued from page* 94)

Going along the line $X'Z'$ in Chart I, we have for point X', the values $T = 0.58$ and $\tau = 157$ deg. which must be multiplied by $-jZ_c$ to obtain the input impedance. Thus

$$Z_s = jZ_c T \underline{/\tau} = (75 \underline{/-90°}) (0.58 \underline{/157°}) = 43.5 \underline{/67°} \text{ ohms}$$

Now point Z' must correspond to the load impedance, and at this point we find, $T = 175$ and $\tau = 158$ deg. The load impedance is therefore,

$$Z_l = (75 \underline{/-90°}) (1.75 \underline{/158°}) = 131 \underline{/66°} \text{ ohms}$$

which differs slightly from the true value of $136.5 \underline{/66°}$ ohms.

Knowing the input impedance and the voltage, the input current will be

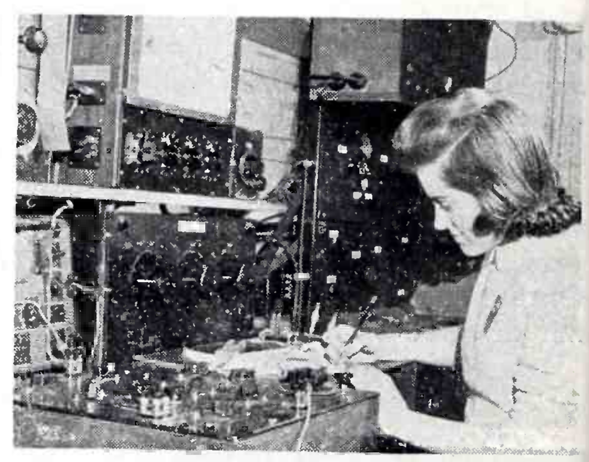
$$I_s = \frac{V_s}{Z_s} = \frac{10}{43.5 \underline{/67°}} = 0.23 \underline{/-67°} \text{ amp.}$$

The current distribution can be followed on line XZ in Chart II.

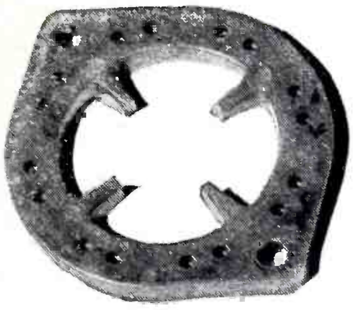
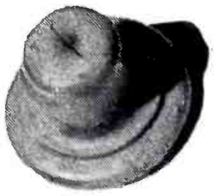
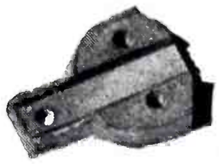
The author is indebted to Prof. C. Breitfeld, University of Prague, for the principles of this method which were outlined in lectures on electric power lines in 1933.

• • •

FIRST WOMAN RADIO ENGINEER AT G.E.



The first woman to work in General Electric's radio receiver engineering section at Bridgeport, Conn., is 21 year old Margaret Allen. Miss Allen joined G. E. when the company started a special training program for women college graduates similar to the company's training course for graduate men engineers. She is one of the graduates who are replacing men in the testing of some war equipment and giving skilled assistance to engineers in laboratories and factories

INSULATION

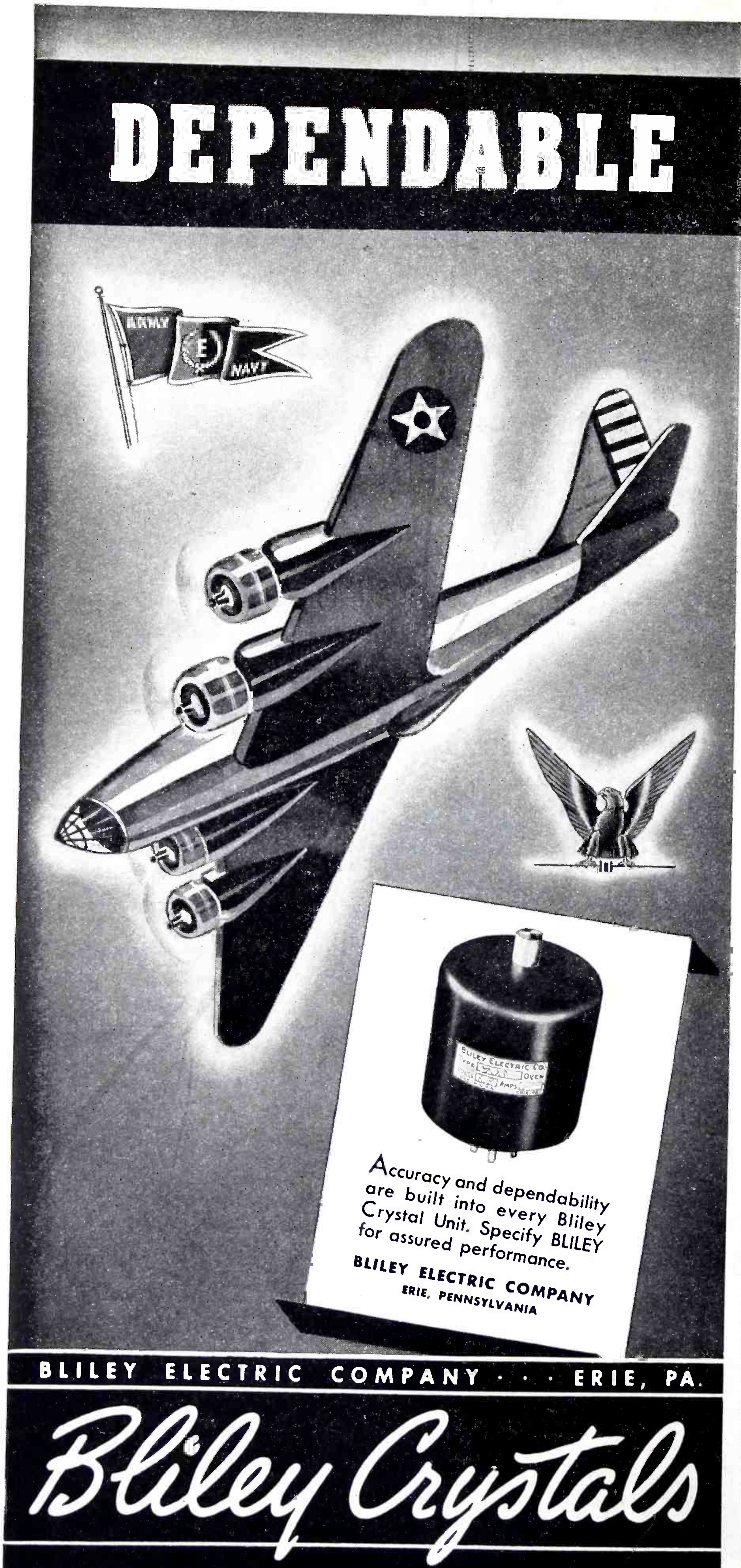
GENERAL ELECTRIC MYCALEX is an electrical insulator possessing a combination of features not found in any other single material. G-E mycalex, because of its high dielectric strength and low power factor, is ideally suited for use as a high frequency insulator in radio equipment and for ignition assemblies in high altitude aircraft. Arcs occurring at high altitudes do not cause permanent conductive tracks.

Because intricate shapes may be molded with G-E mycalex with "molded-in inserts", because these parts are made to extremely close tolerances and because their dimensional stability is high, G-E mycalex is a superior material for assemblies which must stand up under severe operating conditions. Although G-E mycalex can be drilled, milled, and ground, these operations are seldom necessary due to the fact that parts can be molded to shape.

For further information write section M-4, One Plastics Ave., Pittsfield, Mass.

PLASTICS DIVISIONS
GENERAL ELECTRIC
PD-84





Inspection of Tungsten

(*Continued from page* 95)

during this "black light" inspection, with each crack showing as a brilliant green indication against a purple background. Figure 3 shows how one of these cracks appears in cross-section when enlarged 200 times.

Rejections range from rods having only one short and very fine indication to rods almost completely covered with cracks. Even when the only crack is not in the area to be beaded, the rod is rejected because experience has shown that these cracks often spread to the glass seal upon heating during subsequent glass work.

Defects which are not revealed by fluorescent inspection are chiefly of the irregular type shown in Fig. 4, which produce one or more bubbles in the glass when the tungsten is beaded over the defect. It is believed that cracks like this are filled with oxide which prevents entrance of the penetrant. The number of tubes found with bubbles in the beads is now only a small fraction

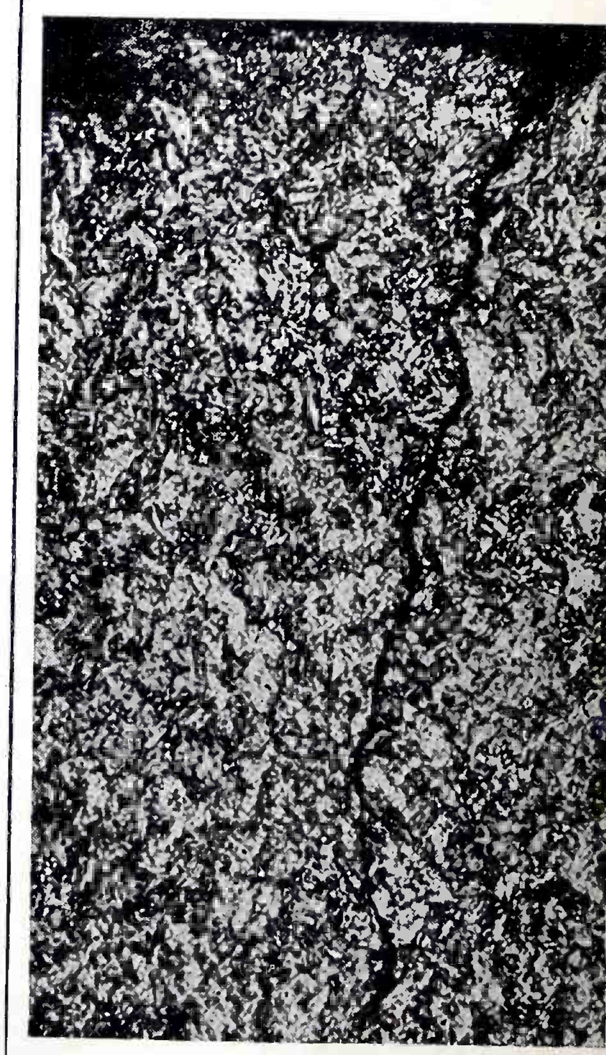


FIG. 3—Etched cross-section of tungsten lead, magnified 200 times, showing crack revealed by fluorescent method

NEW DATA ON IMPROVED PLAX POLYSTYRENE
Plax is one of the biggest producers of commercial polystyrene products in this country — and, so far as we know, uses more polystyrene for experimental purposes than any other company.
Out of this experience Plax presents these new data, suggesting how much better Plax Polystyrene can meet your own high-frequency insulation problems.
Compare its electrical characteristics with those of high-grade mica and fused quartz, add features unusual in any plastic, and you'll agree with other leaders in your field that Plax Polystyrene is one of the best high-frequency insulations ever known.
In addition to offering polystyrene sheets, rods and tubes themselves, Plax machines them into a wide variety of standard and special electronic parts.
From polystyrene, Plax now makes Polyflex Sheet. Tough and flexible, it is easily punched and has obvious uses for condensers, cable, storage batteries, etc.
Also new is Polyflex Fiber, proved in production and in the field as a cable wrapping and in other high-frequency applications.
Ask Plax for more data on these products, for engineering help in applying polystyrene to your products, and for a bulletin on machining polystyrene. In other words, "When it comes to polystyrene, come to Plax."
PROPERTIES OF PLAX POLYSTYRENE
MECHANICAL
Tensile strength, lbs. per sq. in. (A.S.T.M. D 48-37) 5,500-7,000
Tensile proportional limit, lbs. per sq. in. (.01% offset)
−38 F=3,700
0 F=2,800
78 F=2,500
Modulus of Elasticity in tension, lbs. per sq. in.
−38 F=554,000
0 F=536,000
78 F=469,000
Compressive proportional limit, lbs. per sq. in. (.01% offset) 2,600
ELECTRICAL
Volume resistivity, ohm. cm. 10[17]
Arc resistance (A.S.T.M. D 495-38T) sec. 240-250
Dielectric strength, volts per mil
.005" thickness=3,500
.010" thickness=2,500
.015" thickness=2,200
.125" thickness= 500-700
Frequency Cycles | Dielectric Constant | Power Factor
60 | 2.5-2.6 | .0001-.0002
10[3] | 2.5-2.6 | .0001-.0002
10[6] | 2.5-2.6 | .0001-.0004
10[10] | 2.5-2.6 | .0002-.0004
THERMAL
Distortion temperature (A.S.T.M. D48-37), F (C) 176-194 (80-90)
Transition temp. F (C) 180 (82)
Softening point, F (C) 220-240 (104-116)
Ignition point, F (C) 1350 (732)
Specific heat, cal. per gr. per degree C. .32
Thermal expansion coefficient per degree C 7.2 x 10-5
Thermal conductivity — cal. per sec. per cm. per degree C 3.2 x 10-4
CHEMICAL
Effect of:
*Weak and strong acids none
Weak and strong alkalis none
Alcohols none
Esters soluble
Ketones swells
Aromatic and chlorinated hydrocarbons soluble
*Except oxidizers which discolor.
PLAX CORPORATION
133 WALNUT ST.
HARTFORD, CONN.

of that encountered prior to use of the new inspection method, however.

The penetrating oil used in the inspection process caused dermatitis on the hands and face of the worker who first processed large quantities of parts. This has been eliminated by having workers wear rubber gloves to avoid skin contact with the penetrant. Some of the inspectors at first complained of eyestrain and

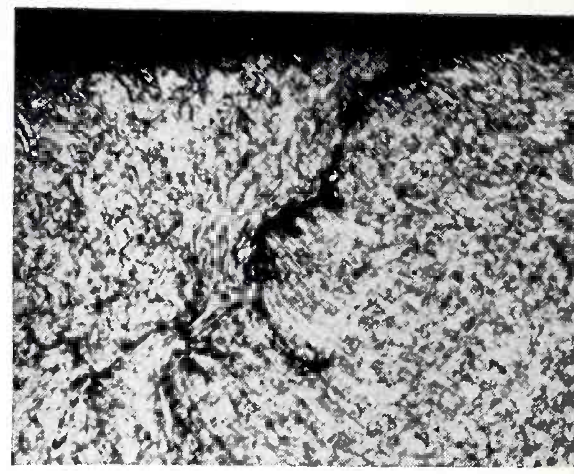
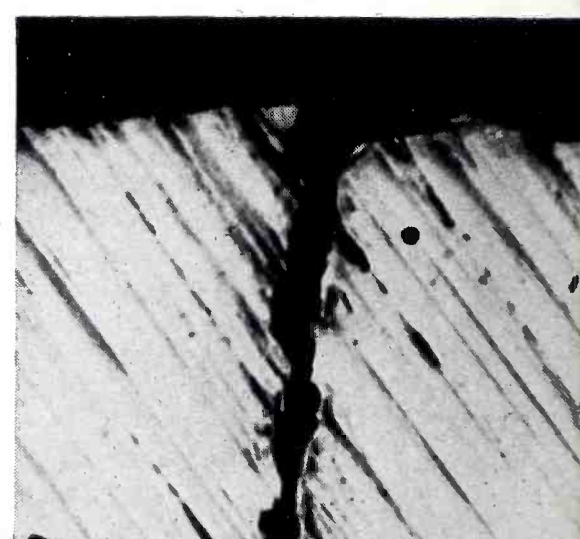


FIG. 4—Irregular cracks like this (etched cross-section magnified 200 times) may not be revealed because oxide prevents entrance of flourescent penetrant

headaches; these were given two Vitamin A capsules daily, each containing 25,000 U.S.P. units, clearing up the trouble.

The fluorescent penetrant method of tungsten inspection should prove of great value during war time when materials and manpower are so critical. The sooner a defect is located during production of a tube, the less material and time is wasted.



Rough polished section of 0.06-inch diam. tungsten rod, magnified 693 times to show longitudinal crack which can allow air to enter a tube through its tungsten lead

THE ELECTRON ART

Generation of Short Waves

Behind any engineering development and practical application lies a vast storehouse of past experience, trial and error, and theory. As science progresses and becomes more organized—and more complicated—theory forms a larger and larger portion of the background of engineering.

Back of many modern tubes used for the generation of very short waves lies the theory of the utilization of velocity modulated and directed streams of electrons, for which the background was laid by A. Arsenjewa-Heil and O. Heil in *Zeitschrift für Physik*, Vol. 95, p. 762, 1935. Considerable interest has been expressed in this article, notwithstanding its comparative age. The translation of this article, from the German, has been prepared by Theodore J. Wang, and is presented to meet the many expressions of the need for having this material readily available in English.—Ed.

THE PRODUCTION of undamped electromagnetic waves of high intensity in the wavelength region from 1 meter down to a few centimeters* still offers difficulties today. That we cannot produce in this wavelength region the intensities common with longer waves depends, in general, upon two kinds of difficulties: (1) The electrons move too slowly. The transit time of the electrons between the electrodes is comparable with a period of oscillation or even greater than this. (2) For short waves the electrodes of the tube must be as small as possible as they form the capacity of the oscillatory circuit. For the generation of large energy, on the other hand, the electrodes must be as large as possible so that they can radiate the heat produced by the electron bombardment. Thus both demands, short waves and high energy, cannot be fulfilled simultaneously; they are incompatible.

In the generator principle herein described these difficulties are circumvented in the following ways: (1) The finite transit time of the electrons, which formerly caused trouble, is actually made use of now, in order to control the electron stream. (2) The electrons do not strike the oscillating electrodes at all. An electron stream flows through these electrodes, and the oscillation energy is taken out of the electron stream. In this way the heating of the small oscillating electrodes is entirely avoided.

* Collected papers: K. Kohl, *Ergebn. d. exakt. Naturwiss.* 9, 1930; H. E. Hollmann, *Hochfrequenztechnik und Elektroakustik* 44, 37, 1934.

The Generator Principle

The generator principle is illustrated in the schematic diagrams of Fig. 1. Figures 1(a) and (b) show the electrode arrangement, and Fig. 1(c) shows the corresponding potential variation. The negative potential is drawn upward so that we can represent the electrons as balls which roll along the potential curve. Electrons are emitted from the cathode A and accelerated to electrode B, which is maintained at a constant positive potential. The electrons are then retarded as they enter electrode C, which forms a Faraday cage. After the flight through the cage the electrons are again accelerated by means of electrode D, which is directly connected to electrode B and thus has the same potential as B. Electrons passing beyond electrode D can again be retarded and collected.

The mechanism of oscillation generation takes place in the space between electrodes B and D. C is the electrically oscillating electrode, which is illustrated in the figure by the schematically drawn oscillatory circuit. Electrons flowing from B to C form an influx of negative charge into the cage, while electrons flowing from C to D form an outflow of negative charge from the cage. Electrons in the interior of the cage act, toward the outside, as though they reside in the metal wall of the cage. The time of stay of electrons in the interior of the cage is important, for through this the current is controlled. The time of stay depends upon the velocity of the electrons, i.e., it is dependent upon the potential of the cage at the moment of the electrons' entrance.

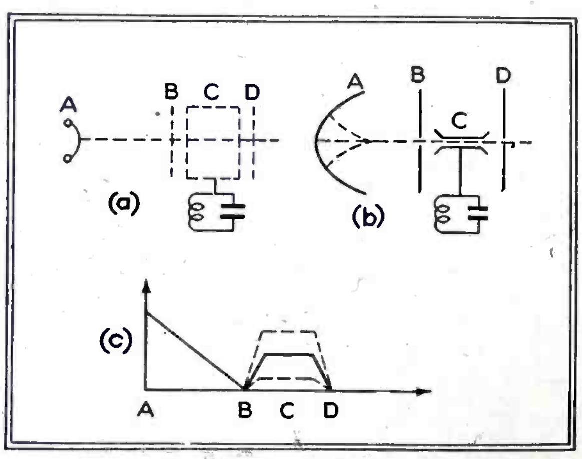


Fig. 1—Electrode arrangements of generators utilizing beams are shown at (a) and (b). Potential variations of electrodes are shown at (c). Mechanism of oscillation takes place between electrodes *B* and *D*

Let us consider that the circuit is oscillating and that the potential of the cage is varying sinusoidally in time. The potential of the cage then varies back and forth as between the dotted lines shown in Fig. 1(c). With a properly chosen cage length we can obtain the condition that the slow electrons, which enter the cage during the negative half cycle, leave the cage for the most part in the following positive half cycle; while the fast electrons, which enter the cage during the positive half cycle, leave the cage for the most part in the same positive half cycle. Accordingly, during the positive half cycle there is a net electron current out of the cage, and during the negative half cycle there is a net electron current into the cage. This means a building up and damping down of the existing oscillations. Or in other words: as a consequence of the different time of stay of the electrons, there is a pulsating space charge in the inside of the cage, and this pulsating space charge adds to and detracts from the oscillations. One can figure how much energy is supplied to the oscillatory circuit in this manner by calculating the energy loss of an individual electron and summing over the course of a period.

The theory shows that a maximum of 35 percent of the energy of the electron stream is converted into energy of oscillations. The efficiency can conceivably approach 100 percent, since the electron stream can be slowed down to a halt with the opposition field. The theory shows that the generator is self-oscillating and stable.

The theory of the generator is given herewith. The following nomenclature is employed:

Let e = charge on the electron
m = mass of the electron
v = velocity of the electron
p = potential of the Faraday cylinder
p_1 = potential at the electron entrance
p_2 = potential at the electron exit
V = average potential of the Faraday cylinder (applied voltage)
A = amplitude of the oscillations (potential)
$\omega = 2\pi\nu$ = angular frequency
T = time of stay of electrons in the Faraday cylinder
l = path length of the electrons in the Faraday cylinder
C = capacity of the oscillatory circuit
J = magnitude of the electron current
N = energy conversion efficiency
E = reinforcement

OHMITE RESISTANCE UNITS

Consistent Performance in Every Part of the World

Years of world-wide service in all types of applications, under all kinds of operating conditions, have proved the sterling qualities of Ohmite Products. During this time, we have helped pioneer many applications of resistance units in electronic and electrical devices. As a result, we have developed and produced the widest range of types and sizes in power rheostats, resistors, and tap switches to meet every need.

Today, Ohmite Units serve in plant and laboratory—and on every battle front, from below the sea to the stratosphere, and from "down under" to the top of the world. Tomorrow, they will be ready and eager to meet new postwar requirements.

Send for Catalog and Engineering Manual No. 40

Write on company letterhead for helpful 96-page guide in the selection and application of rheostats, resistors, chokes, tap switches and attenuators.

BE RIGHT WITH OHMITE
RHEOSTATS · RESISTORS · TAP SWITCHES

OHMITE MANUFACTURING COMPANY
4816 Flournoy Street, Chicago, U. S. A.

The problems involved are:

(1) To find the optimum values of V, A, and l, and to obtain a numerical value for the energy conversion efficiency N (hereinafter designated e.c.e.), defined as the ratio

$$N = \text{e.c.e.}$$

$$= \frac{\text{oscillation energy gained}}{\text{average electron stream energy } (J.V)}$$

(2) To determine if the generator self-oscillates and if it is stable at the operating point. Toward this end we introduce the concept of reinforcement, E, and we seek to obtain E as a function of V and A. We define E as the ratio.

$$E = \frac{\text{energy fed to oscillatory circuit per period}}{\text{existent energy in oscillatory circuit}}$$

Theory

The instantaneous potential of the Faraday cylinder (see Fig. 2) is

$$p = V + A \sin \omega t$$

The electron velocity v, as a function of the time of the electron's entrance into the Faraday cylinder, may be obtained from

$$\frac{mv^2}{2} = e\,(V + A \sin \omega t$$

$$v = \sqrt{2e\,(V + A \sin \omega t)/m}$$

The time of stay, T, of the electron in the Faraday cylinder is

$$T = \frac{l}{v} = \frac{l}{\sqrt{2e(V + A \sin \omega t)/m}}$$

The electron exit potential, p_2, as a function of the entrance time, is

$$p_2 = V + A \sin \omega\,(t + T) = V + A \sin \omega \left(t + \frac{l}{\sqrt{2e\,(V + A \sin \omega t)/m}} \right)$$

The energy loss of the electron is equal to the energy gain of the oscillatory circuit

$$e\,(p_2 - p_1) = eA\,[\sin \omega\,(t + T) - \sin \omega t]$$

A constant stream of electrons flows into the Faraday cylinder (n electrons per second). The total energy gain of the oscillatory circuit during a period is then

$$neA \int_0^{2\pi/\omega} \Big[\sin \omega\,(t + T) - \sin \omega t) \Big]\, dt$$

$$= JA \int_0^{2\pi/\omega} \sin \omega\,(t + T)\, dt$$

$$= JA \int_0^{2\pi/\omega} \sin \omega \left(t + \frac{l}{\sqrt{2e\,(V + A \sin \omega\, t)/m}} \right) dt$$

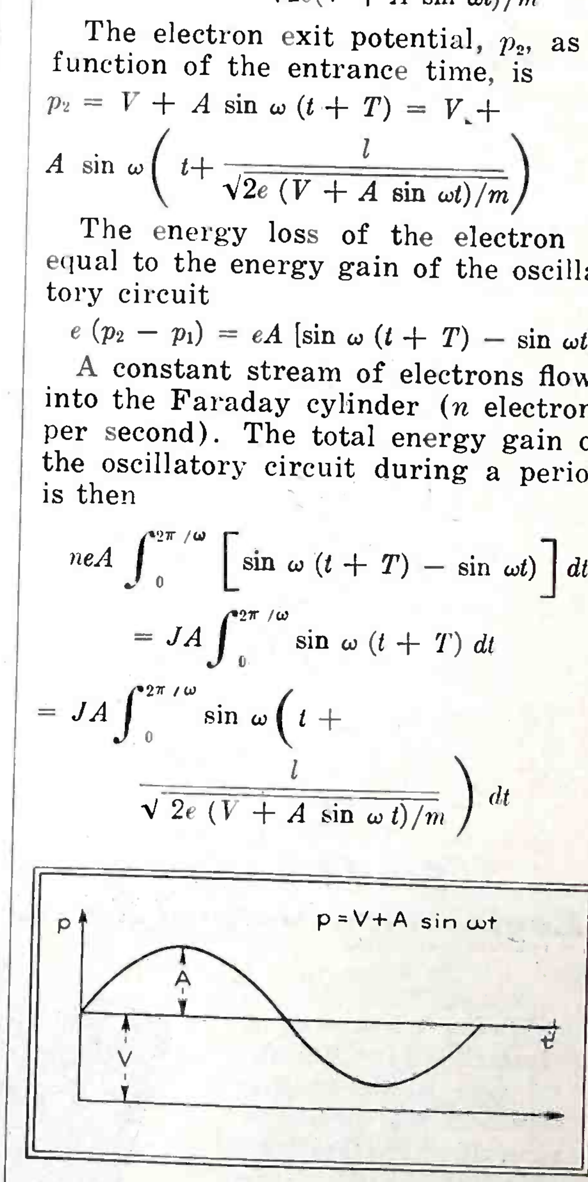


Fig. 2—Instantaneous potential in Faraday cylinder

When There's No Time For Fumbling

When orders must get through quickly, FREQ-KC crystal units select the right channel, instantly and reliably. Absolute frequency specifications and protection from heat, cold or shock guard against communication failure or miscarriage of vital messages. This war-proved accuracy and dependability one day will be available to manufacturers of peace-time products. In the meantime, our electronic engineers are at your service to help design and specify crystal-controlled applications for essential products or ahead-of-competition models.

Gentleman Products Division of

HENNEY MOTOR COMPANY

Home Office at FREEPORT, ILLINOIS — Factory at Omaha, Nebraska

The energy flow into the oscillatory circuit per second is

$$\frac{\omega}{2\pi} JA \int_0^{2\pi/\omega} \sin\omega\left[t + \frac{l}{\sqrt{2e\,(V + A\sin\omega t)/m}}\right] dt$$

We are interested in the e.c.e., N, which now is the ratio of the energy of the electron stream which is absorbed by the oscillatory circuit, to the total energy brought in by the electron stream:

$$N = \left\{ \frac{\omega}{2\pi} A \int_0^{2\pi/\omega} \sin\omega\left[t + \frac{l}{\sqrt{2e\,(V + A\sin\omega t)/m}}\right] dt \right\} / V$$

and we are also interested in the reinforcement, E, which is the ratio of the energy introduced into the oscillatory circuit per period, to the existent energy in the oscillatory circuit:

$$E = \left\{ J \int_0^{2\pi/\omega} \sin\omega\left(t + \frac{l}{\sqrt{2e(V + A\sin\omega t)/m}}\right) dt \right\} / \tfrac{1}{2}\, CA$$

wherein C denotes the effective capacitance of the oscillatory circuit.

Results of the Calculations

In Fig. 3 are shown some curves which portray the energy loss of the electrons over the course of a period. This energy loss of the electrons is equal to the gain of the oscillatory circuit. Averaged over a period it is positive and equal to the difference of the positive and negative portions of the cross-hatched areas under the curves. The different curves in Fig. 3(a), (b), (c), and (d) are for different values of amplitude A and of average cylinder potential V. Curve c represents the case of the maximum e.c.e. of 35 percent. Curve d represents a special case in which the slowest electron remains three half periods within the cylinder, and the fastest remains one period.

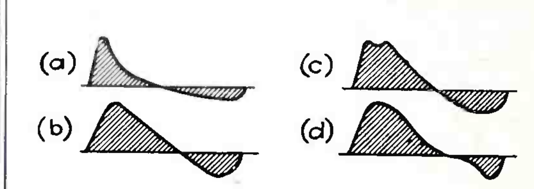
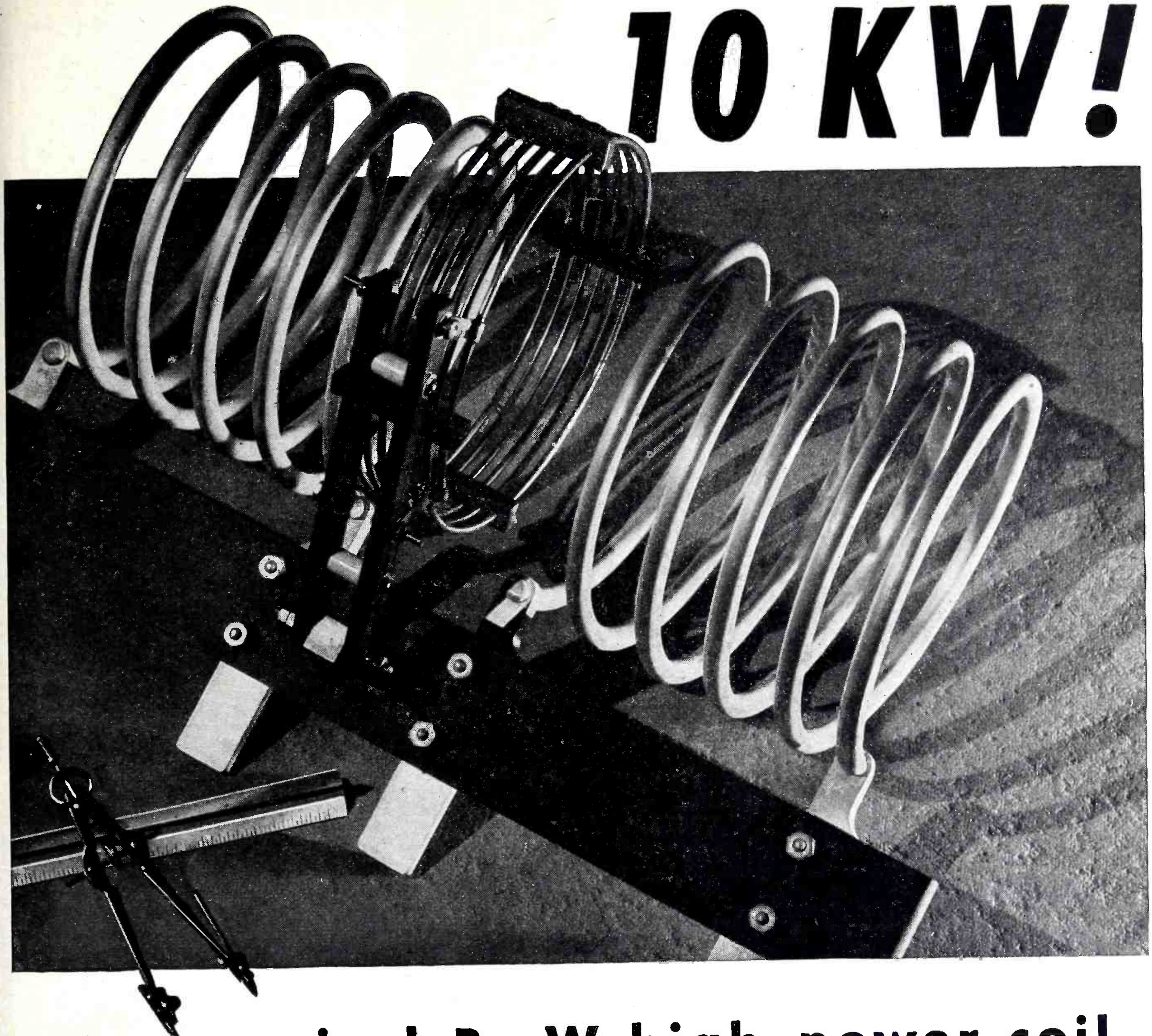


Fig. 3—Typical curves showing energy loss for a cycle of operation, for electrons in the region between B and D of Fig. 1. The various curves are for different amplitudes and cylinder voltages

We can build up a working diagram of the generator if we know the e.c.e. and reinforcement for all values of A and V. The e.c.e. and reinforcement have been calculated and are shown in Figs. 4, 5, 6, and 7.

In Fig. 4 the e.c.e. is shown in percentage as a function of A and V. In

10 KW!



...a typical B & W high-power coil

Over 10" in diameter by 20" long, and designed for 10 KW. service, this variable-link final amplifier, plate coil, is a good example of B & W engineering at work on the job of matching modern inductor requirements. B & W Inductors of this general type are available in all standard frequency ranges. Coils are bolted in place, and may be switched for band-changing with a minimum of time and effort. Connections are silver-soldered, and all metal parts, including coils, are heavily silver-plated. Coils in the unit illustrated are of ⅝ copper tubing. Other B & W Air Inductors of this type utilize tubing as large as 1".

FAST DELIVERIES on all B & W Air Inductor types are assured by our greatly expanded facilities, and straight-line production on most smaller types. Engineering data on any type upon request.

BARKER & WILLIAMSON, 235 Fairfield Ave., Upper Darby, Pa.

Air Inductors
"BABIES AND JUNIORS" *(25 to 75 watts)*
STANDARD TYPES *(100 watts to 1 KW.)*
SPECIAL HIGH-POWER TYPES *(to 10 KW. and above)*

B & W

TURRETS — BAND HOPPERS — SWINGING LINK ASSEMBLIES, ETC.
SPECIAL RADIO AND ELECTRONIC EQUIPMENT ASSEMBLIES
Variable Air Condensers
(Integral neutralizing types)

MANUFACTURERS OF QUALITY ELECTRONIC COMPONENTS FOR OVER A DECADE

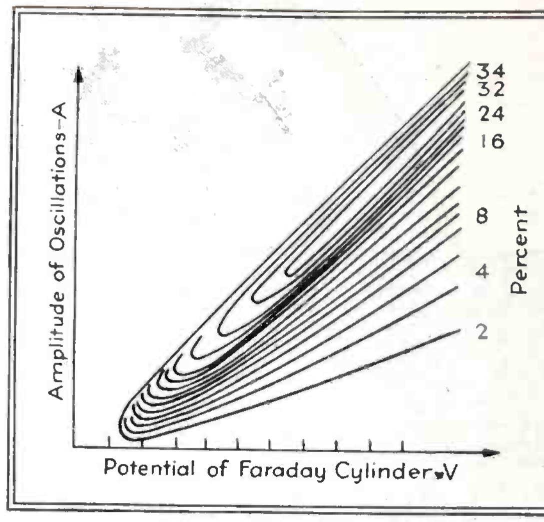


Fig. 4—Family of curves of amplitude of oscillation plotted against potential of Faraday cylinder, with various values of energy conversion efficiency as parameter

this representation the lines of equal e.c.e are shown as contours. A cross section through this mound for different values of V is shown in Fig. 5. The points through which the cuts were made are shown marked on the V-axis in Fig. 4. For the maximum values of the e.c.e.

$$e.c.\ e_{max} = \frac{vl}{\sqrt{2eV/m}} = 0.173$$

In Fig. 6 the reinforcement is represented by contours as a function of A and V. Figure 7 shows cross-sections through this surface for different values of V. The points through which the cuts were made are marked on the V-axis in Fig. 6. The reinforcement is here given only relatively. The actual value of the reinforcement for any particular condition may be obtained from

$$E = 4\pi\ NVJ / A^2\ \omega\ C$$

Discussion of the Results

The course of the reinforcement determines the behavior of the generator. The condition for equilibrium is that for which the reinforcement is equal to the damping, wherein the damping includes both the useful, energy-conversion damping of the electron stream and the wasteful, inherent damping of the circuit elements. The useful damping is large compared with the inherent damping.

The requirement for stability is that $dE/dA < 0$. Oscillations cease whenever dE/dA becomes positive and the equilibrium

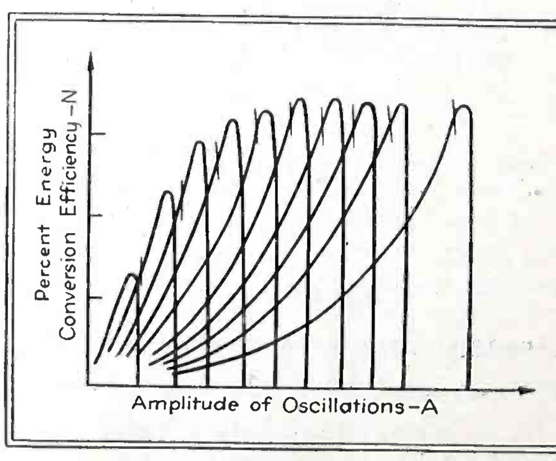


Fig. 5—Energy conversion efficiency, N, plotted against amplitude of oscillation for various values of voltage

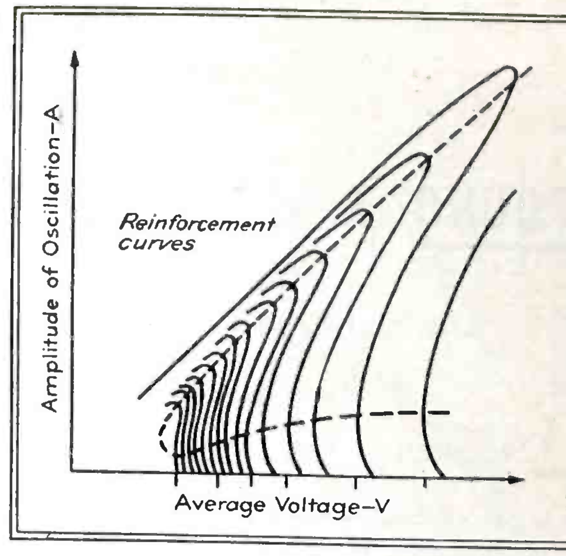


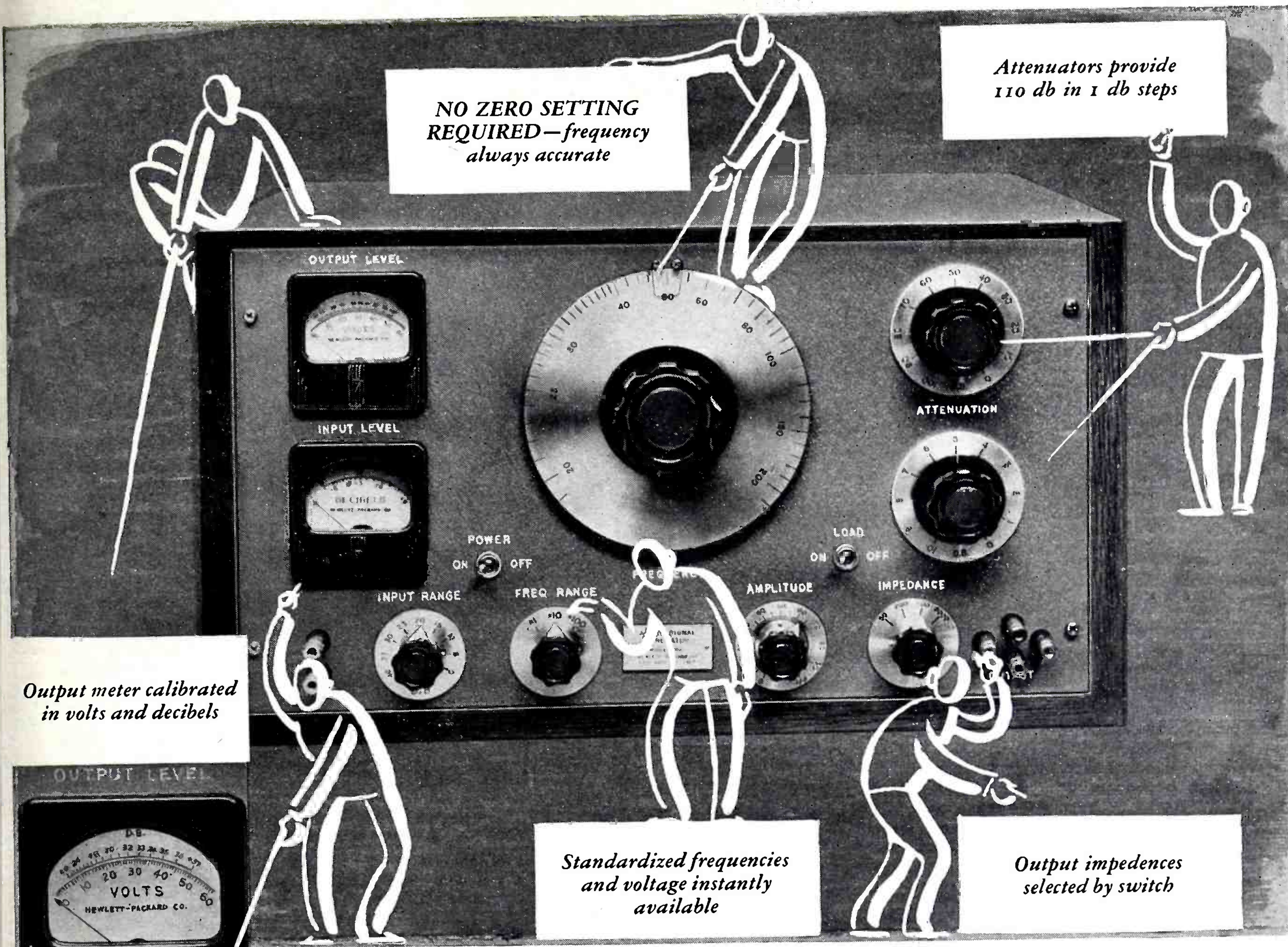
Fig. 6—Reinforcement, represented by contours as function of amplitude of oscillation, *A*, and voltage, *V*

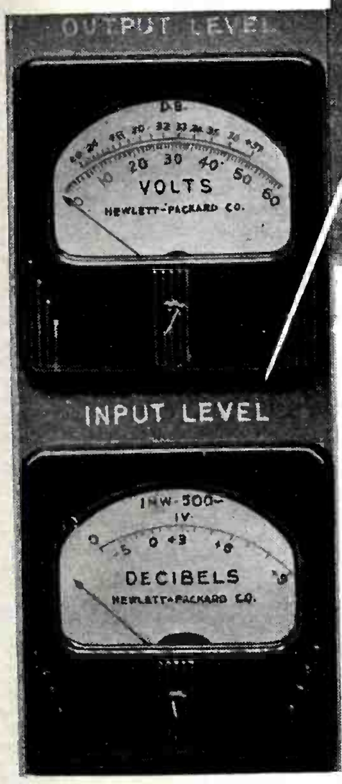
condition is satisfied. The behavior of the generator may be deduced completely from these conditions and from the diagrams of Fig. 6 and Fig. 4.

With a particular arrangement it is possible to make V dependent on A through the use of the retarded electron stream. However, in general, V will be independent of A. For the latter case we get two regions of stable equilibrium in the A-V diagram, one for small amplitudes, which does not interest us, and one for large amplitudes. Both regions overlap in the range of small amplitudes and small voltages. The dotted line of Fig. 6 represents the boundary of these regions. In the middle region of the A-V diagram stable oscillations are possible. In this region the amplitude can increase in case the reinforcement exceeds the damping, or the amplitude can decrease in case the damping is equal to, or greater than, the reinforcement. The upper stable region contains the maximum of the e.c.e. The boundary of the stable domain is marked with strokes on the curves of Fig. 5. These markings correspond to the maxima of the associated curves in Fig. 7.

By way of example the behavior of the generator for constant V and variable load can be shown with the aid of Fig. 8. The two curves correspond to reinforcement and e.c.e. At small loads the generator action corresponds to the points a and a' respectively. With an increase of load the output climbs to the maximum of e.c.e. at points b' and b respectively, and falls again to the maximum of reinforcement at points c' and c respectively. At these last points the oscillations cease.

We can see also from Fig. 6 how the generator oscillates when it is first turned on. We first apply the operating voltages to all the electrodes except the cylinder. When the cylinder potential V is applied, it rises slowly because of the self-induction of the supply leads. The generator is in equilibrium at each moment of this potential rise. Since the damping remains always constant, the generator





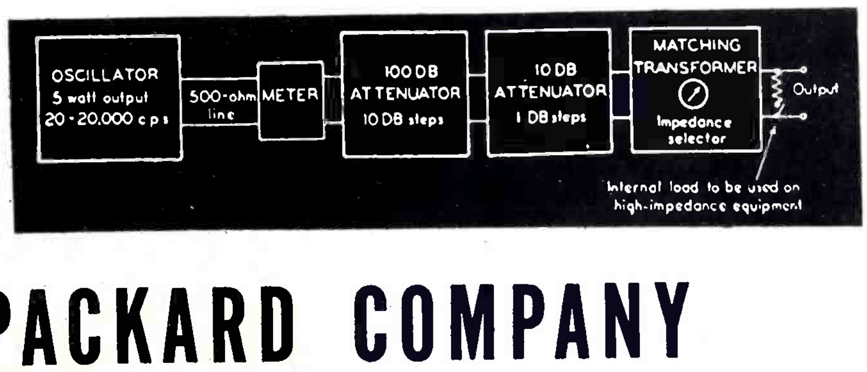
Separate input meter for making gain measurements

Six reasons why this
AUDIO SIGNAL GENERATOR
saves your time and insures better accuracy

This all-in-one combination of instruments insures the utmost of speed without sacrifice of accuracy in making certain laboratory and production measurements. The model 205AG consists of an *-hp-* Resistance Tuned Audio Oscillator, an output meter, attenuator and an impedence matching system. In addition a separate input meter is provided. Thus no auxiliary equipment is required in making gain measurements. It is ideal for general laboratory applications because it supplies a known voltage and a known frequency at the commonly used impedence levels.

Of outstanding importance is the fact that the Resistance Tuned Oscillator requires no zero setting. The frequency drift is negligible even during the first few minutes of operation. The constant output of this oscillator makes it ideal for checking frequency response of apparatus. Waveform distortion is very small, hence this instrument provides an excellent source of voltage for distortion measurements.

Below is a block diagram showing the arrangement of the components in the Model 205AG Audio Signal Generator. Get full information about this and other *-hp-* laboratory instruments. Ask for your copy of the 26-page fully illustrated catalog which gives valuable data on making tests and measurements as well as details of the *-hp-* line of instruments.



HEWLETT-PACKARD COMPANY

Box 1135 K Station A, Palo Alto, California

672

works along a curve of constant reinforcement, and actually upon the upper, almost straight, branch of the curve (Fig. 6). The oscillations begin to fall off only after V is raised up to the reversal point of this curve.

As a consequence of the linearity of the above mentioned curve branch one can, through variations of V, modulate the amplitude almost proportionately to V, i.e., almost without distortion.

The above described method of oscillation production has its limitations with respect to the shortness of the waves and with respect to the power output. The limitations are apparent:

(1) From the equation for the reinforcement, we have

$$E = \frac{\pi NVJ}{A^2\omega C}$$

From the equation one observes the following: The reinforcement remains constant as the wavelength is reduced, only if at the same time the capacity is proportionally reduced and the magnitude of the electron current remains uniform. This means an increase of the electron current density which is proportional to the decrease in wavelength. Other conditions fixed, the capacity increases approximately in proportion to the electron stream cross-section. Thus we can produce shorter waves insofar as we are able to produce high electron current densities. We apply the usual methods of electron optics to achieve concentration of the beam.†

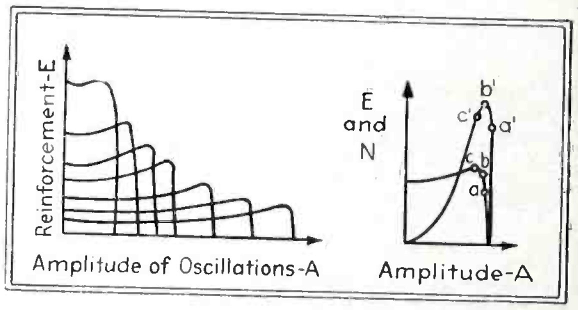


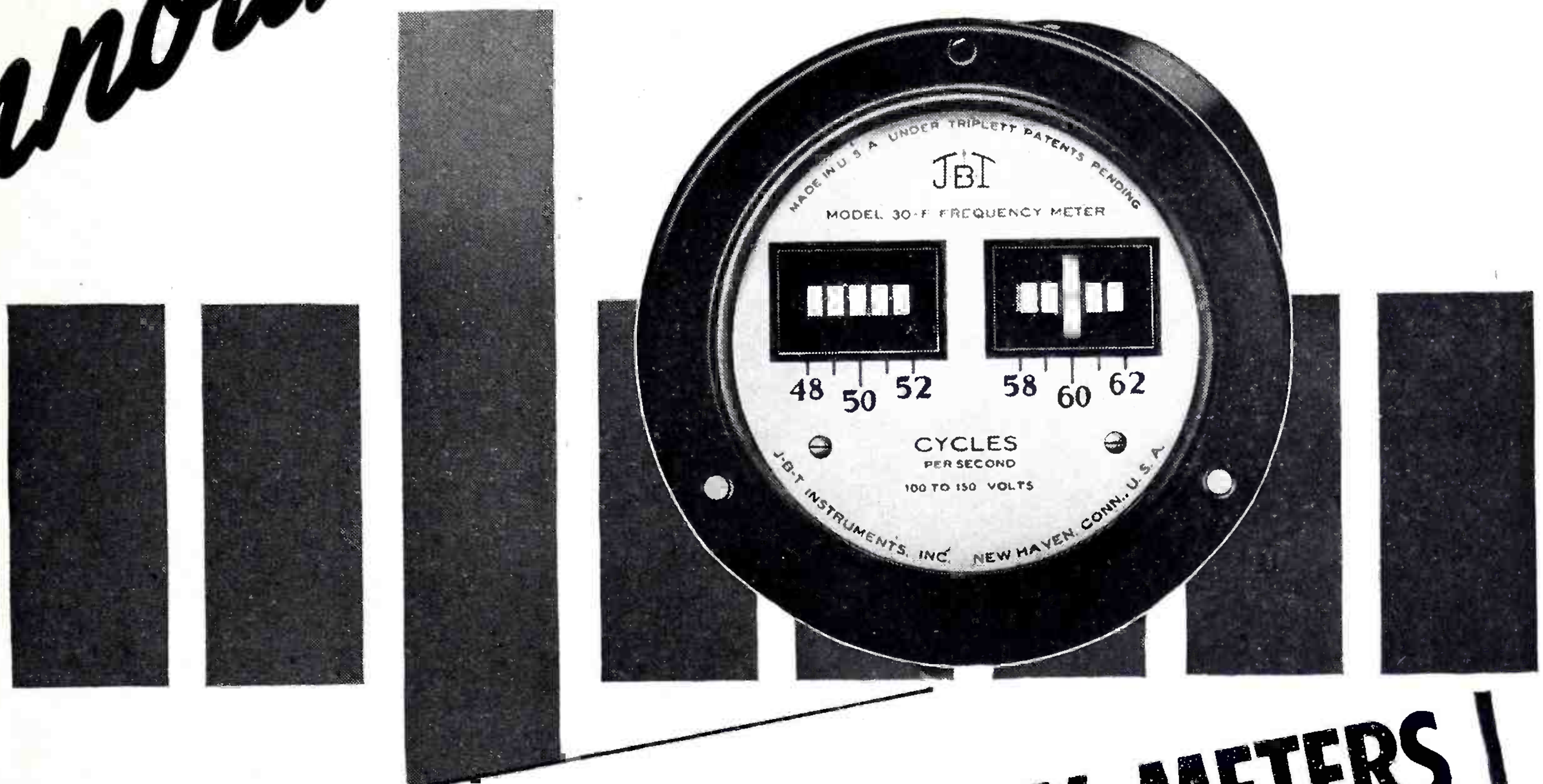
Fig. 7 (left)—Cross section through Fig. 6 for various values of voltage, V

Fig. 8 (right)—Energy conversion efficiency and reinforcement for two different conditions of load

(2) Another limitation is the condition that the reinforcement must be as large as possible compared with the inherent damping of the oscillatory circuit. The reinforcement must be as large as possible, the damping as small as possible. The inherent damping of the oscillatory circuit is composed of both ohmic damping and dielectric loss. The beam damping includes only the useful, energy-conversion damping. The ohmic resistance is minimized through the use of broad metal hoops or tubular metal hoops for self-induction. The dielectric loss is avoided by enclosing the oscillatory circuit entirely within the tube. Only experiment can show to what extent one can raise the electric density and reduce the inherent damping.

† See, for example, B. E. Brüche and O. Scherzer, *Geometrische Elektronenoptik*. Berlin, Julius Springer, 1934.

Announcing A NEW LINE



VIBRATING REED FREQUENCY METERS

Sturdy and Simple in Design, Permanently Accurate

Important new features of this line are—simplified construction, with fewer parts—individual reed activation so that the whole bank does not vibrate—great variety of cases and sizes. Vibrating reed type of frequency meter offers these advantages:

- **easy to read**
- **needs no adjustment in service**
- **low in power consumption**
- **exceptionally accurate**
- **not affected by wave form**
- **not affected by normal temperature change or external magnetic fields**

Available in full range of frequencies—full range of types and sizes—full or half-cycle increments—sharp or broad response—wide voltage range.

(Manufactured under Triplett Patents and/or Patents Pending)

Bulletin VF-43 just off the press. Write for your copy now.

J-B-T INSTRUMENTS, INC.

441-H CHAPEL STREET • NEW HAVEN, CONNECTICUT

7-JBT-1

The time of approach and of recession of the electrons to and from the Faraday cylinder was not considered in the theory. Likewise the force of the exterior field of the Faraday cylinder was neglected. An investigation leads to the following: The effect of the exterior field is as though the distances of approach and of recession of the electrons were greater. The approach and recession times cause:

1. An apparent increase in l. This apparent increase in l is greater for slow electrons than for fast electrons. The time of flight of the slow electrons is consequently increased more than that of the fast ones. This can be made to aid the e.c.e. by proper dimensioning.

2. A "washing out" of the electron velocities. The electrons do not have the velocities which correspond to the existing entrance potential. The velocities correspond more nearly to an unsymmetrically flattened sine curve. With correct dimensioning this too makes for an enhanced e.c.e., since a larger part of those electrons which enter the Faraday cage in the negative half period leave it during the positive voltage maximum. The diagrams of Fig. 4 to 7 are somewhat in error because these factors have been neglected; however, the essential features of the diagrams are correct.

Design Considerations

To reduce energy losses in the connections one should use two systems working in reciprocal fashion within a single chamber. A section through such an arrangement is shown in Fig. 9. Both electrodes C are joined to one another through a self-induction loop. The voltage connection must tie into the midpoint of this loop. The passage from electrode B to C and from C to D acts as a convergent lens on the electron stream and increases the electron concentration. Toward this end one can apply the usual Braun tube technique of gas concentration.‡

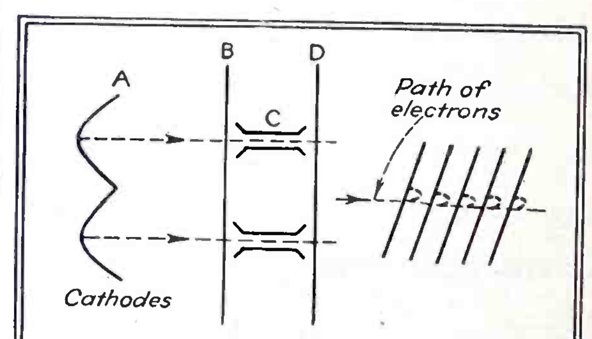


Fig. 9 (left)—Double system of electrodes in parallel to reduce losses

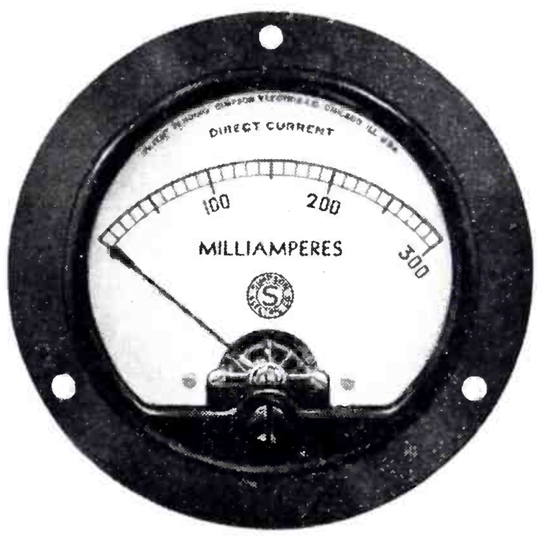
Fig. 10 (right)—Path of electrons (dotted) between inclined metal plates for slowing and collecting electrons

The electron stream on leaving electrode D includes electrons of various velocities. With an arrangement as shown in Fig. 10 one can slow the electrons down in steps and collect them.

‡ See previously cited references to K. Kohl and H. E. Hollman.

MEN *and women* AT WORK

WINNING a war is not an easy job. Victory goes to the side that *fights* harder, and *works* harder. ★ From all reports our fighting men will stand up to anybody, anywhere. It is our job, here at home, to prove that we can work as hard as they can fight. ★ The way the women of America have accepted this responsibility is worthy of tribute. Here at Simpson much of our *man*power has changed to *woman*power—good soldiers all, taking the place of husbands, brothers and sweethearts. ★ Like all men and women in American industry, we know but one resolution—to make *all* the electrical instruments and testing equipment we can, the *best* we can, as *fast* as we can.



SIMPSON ELECTRIC CO.
5200-5218 Kinzie Street, Chicago, Illinois

Simpson

INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory

A system of parallel metallic plates is mounted somewhat inclined to the direction of the electron stream. From left to right the plates are maintained increasingly negative in steps. The dotted lines show the tracks of the electrons of different velocities. One could also permit the electrons to fall with full velocity onto a water-cooled electrode. The principal concern is, however, that the development of heat from the electron bombardment takes place sufficiently far from the small oscillating electrodes.

Let us give just one example in conclusion. Suppose that within one tube we maintain two concentrated electron streams of 50 milliamps each. The potential of the accelerating electrodes is 10,000 volts, that of the two oscillating electrodes, 4000 volts. The electron stream has an operating energy of 100 milliamperes × 4000 volts, or 400 watts. With an e.c.e. of 35 percent we would get 140 watts oscillatory power output. One can count on 25 percent e.c.e. in practice. This means an output of 100 watts. Length of the Faraday cylinder figures about 5 mm for a 20-cm wave.

• • •

Photoelectric Timer Controls X-ray Film Exposure

An electron multiplier phototube, a thyratron and several ignitrons in a simple electronic circuit make correct exposure of x-ray film an entirely automatic process. Calculations, technical factors, critical adjustments of x-ray tube voltage and adjustments of mechanical or motor-driven timing mechanisms are entirely eliminated.

The photoelectric timing mechanism utilizing this arrangement was developed by Dr. Russell H. Morgan of the Division of Roentgenology of the University of Chicago, and is described by him in the *American Journal of Roentgenology and Radium Therapy*, Vol. 48, No. 2. It is essentially a modification of the x-ray exposure meter which he previously developed[1, 2], providing automatic control features rather than a meter indication.

It is highly essential in the production of diagnostically excellent radiographs that the method by which exposure is determined be consistently reliable. The principal guides are measurements of the thickness of the anatomical structure under examination and occasionally the age and weight of the patient.

X-ray Exposure Meter

The first step in mechanization of this important process was the de-

velopment of the exposure meter. This is similar in basic design to photographic exposure meters of the photoelectric type. The glass envelope of a phototube is coated with a fluorescent material, and its output is fed through an amplifier to a microammeter. The phototube assembly is placed underneath the structure to be studied, an x-ray beam is projected through the structure, and the meter deflection is observed. The meter scale can be calibrated directly in terms of exposure time.

One objection to the meter is the need for two exposures, one for taking the reading and the other for exposing the film. The newly developed phototimer completely eliminates this objection by checking exposure time concurrently with exposure of the film, and shutting off the machine automatically when the proper quantity of radiation has been delivered to the film.

Basic Arrangement of Timer

The basic components of the phototimer are designated in Fig. 1. When the x-ray machine switch is closed, a roentgen beam passes through the patient, exposes the film, and excites the fluorescent screen. The resulting light, proportional to the intensity of the radiation passing through the film, is picked up by the phototube and converted into a voltage which charges a capacitor.

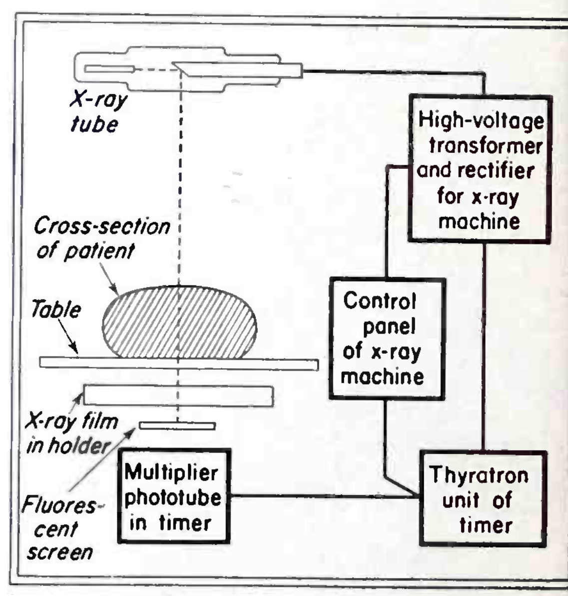


Fig. 1—Block diagram of electronic method for securing correct exposure of x-ray film automatically

When the capacitor voltage reaches a predetermined level, it triggers off a thyratron, which in turn energizes relays which turn off the x-ray machine, terminating the exposure.

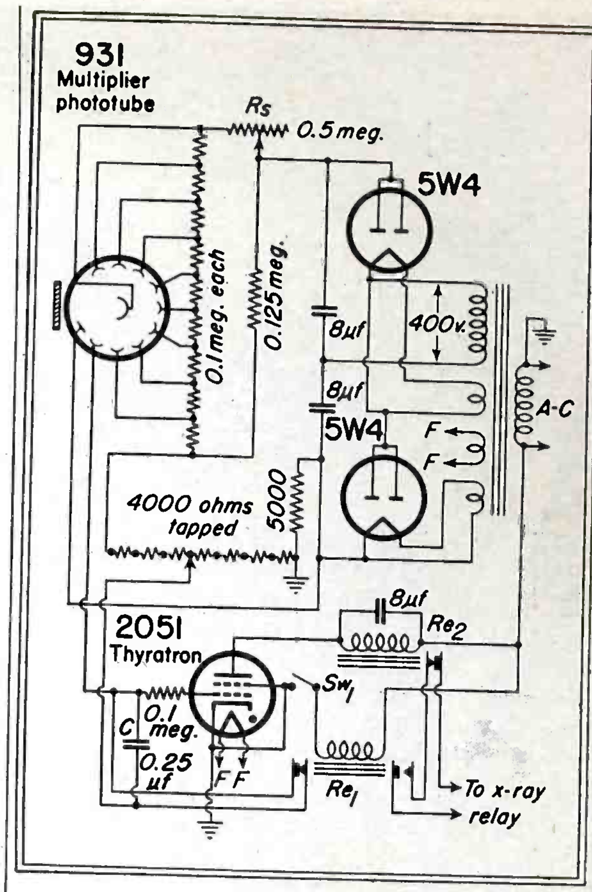


Fig. 2—Complete phototimer circuit

The original article develops the equation for proper exposure of the film. This is $CV/k = a_c$, where k is a constant depending upon phototube sensitivity, a_c is a constant depending on the speed of the film emulsion, C is the capacitance and V is the voltage across the capacitor.

The current output of ordinary phototubes is so small under roentgenographic conditions that stray charges collected through the insulation of the phototube and wiring system and from the control grid of the thyratron can become an appreciable portion of the total charge reaching the capacitor and can hence make the phototimer act prematurely. The multiplier phototube eliminates this difficulty, giving a current output of several microamperes when activated by the ratiation intensities employed[3, 4].

Analysis of Complete Circuit

The schematic diagram of the complete phototimer circuit is given in Fig. 2. The type 931 multiplier phototube contains nine dynodes in addition to the conventional photocathode and anode. The number 9 dynode is employed as the control electrode of the circuit in place of the anode, because the charge delivered to capacitor C by the anode would be of the wrong polarity to activate the thyratron. Although the potential of this dynode with respect to the photocathode increases as the capaci-

HORN-TOOTING

We have never boasted of our accomplishments. We knew we were doing a good job . . . our customers knew it, too.

The smaller, but paradoxically more publicized division of our organization, was devoted to the manufacture of **FEDERAL ENLARGERS** . . . precision optical and mechanical instruments for the photographic market. The major portion of Federal facilities has been serving the Signal Corps and leading radio equipment manufacturers for more than fifteen years.

Came Pearl Harbor . . . and our **entire** productive capacity immediately was placed at the disposal of the Armed Forces. With justifiable pride we can say that we were among the first to receive the coveted Army-Navy "E".

With production efficiently geared, we are now sufficiently far ahead of all current schedules to permit us to solicit additional contracts. We invite orders for the manufacture of large and small assemblies to precise tolerances . . . electrical and mechanical.

At this time, would an occasional "horn toot" be excusable?

FEDERAL

Electronics

Division of

FEDERAL MANUFACTURING AND ENGINEERING CORPORATION

Manufacturers of FEDERAL ENLARGERS

209 Steuben Street — Brooklyn 5, New York

ARMY E NAVY

★ ★ ★ ★ AWARDED TO FEDERAL MANUFACTURING & ENGINEERING CORP. FOR HIGH ACHIEVEMENT

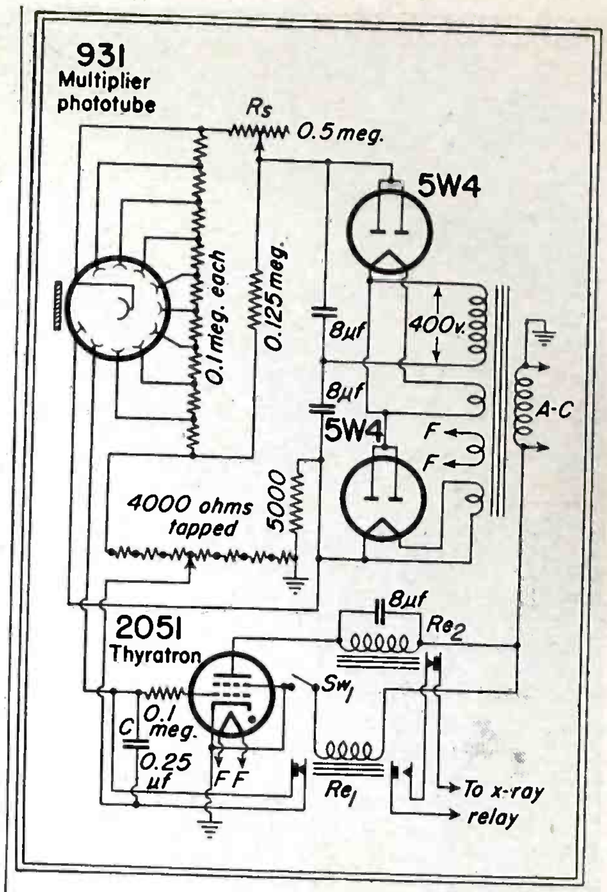


Fig. 2—Complete phototimer circuit

The original article develops the equation for proper exposure of the film. This is $CV/k=a_c$, where k is a constant depending upon phototube sensitivity, a_c is a constant depending on the speed of the film emulsion, C is the capacitance and V is the voltage across the capacitor.

The current output of ordinary phototubes is so small under roentgenographic conditions that stray charges collected through the insulation of the phototube and wiring system and from the control grid of the thyratron can become an appreciable portion of the total charge reaching the capacitor and can hence make the phototimer act prematurely. The multiplier phototube eliminates this difficulty, giving a current output of several microamperes when activated by the ratiation intensities employed[3, 4].

Analysis of Complete Circuit

The schematic diagram of the complete phototimer circuit is given in Fig. 2. The type 931 multiplier phototube contains nine dynodes in addition to the conventional photocathode and anode. The number 9 dynode is employed as the control electrode of the circuit in place of the anode, because the charge delivered to capacitor C by the anode would be of the wrong polarity to activate the thyratron. Although the potential of this dynode with respect to the photocathode increases as the capaci-

HORN-TOOTING

We have never boasted of our accomplishments. We knew we were doing a good job . . . our customers knew it, too.

The smaller, but paradoxically more publicized division of our organization, was devoted to the manufacture of **FEDERAL ENLARGERS** . . . precision optical and mechanical instruments for the photographic market. The major portion of Federal facilities has been serving the Signal Corps and leading radio equipment manufacturers for more than fifteen years.

Came Pearl Harbor . . . and our **entire** productive capacity immediately was placed at the disposal of the Armed Forces. With justifiable pride we can say that we were among the first to receive the coveted Army-Navy "E".

With production efficiently geared, we are now sufficiently far ahead of all current schedules to permit us to solicit additional contracts. We invite orders for the manufacture of large and small assemblies to precise tolerances . . . electrical and mechanical.

At this time, would an occasional "horn toot" be excusable?

FEDERAL
Electronics

Division of
FEDERAL MANUFACTURING AND ENGINEERING CORPORATION
Manufacturers of FEDERAL ENLARGERS
209 Steuben Street — Brooklyn 5, New York

ARMY E NAVY
★ ★ ★ ★ AWARDED TO FEDERAL MANUFACTURING & ENGINEERING CORP. FOR HIGH ACHIEVEMENT

tor becomes charged, this does not appreciably change the sensitivity of the phototube over the normal operating range.

Operating potentials for the phototube and for the grid of the thyratron are provided by a voltage-doubling circuit using two 5W4 tubes fed by the 400-volt secondary of the power transformer. It is desirable to connect the primary of this transformer to a stabilized 115-volt a-c source, such as the primary filament circuit of the x-ray machine. The same source may also provide plate voltage for the thyratron, which is self-rectifying.

The timing mechanism controls the x-ray machine through the two relays, Re_1 and Re_2. After a film has been inserted in the film tray and the patient has been properly positioned, the machine is adjusted to any reasonable voltage for the anatomical structure under examination, potentiometer R_s is set to the speed number of the film to be exposed, and starting switch Sw_1 is closed. This energizes the main relays or ignitrons of the x-ray machine, beginning the exposure. When exposure is completed, as determined by charging of C to the value required for triggering the thyratron, the resulting thyratron plate current energizes relay Re_2, opening its contacts and thereby breaking the circuit to the x-ray machine. At any convenient time thereafter, switch Sw_1 is opened manually, de-energizing relay Re_1. Condenser C then discharges through the closed contacts of this relay and the thyratron deionizes, preparing the timing mechanism automatically for the next exposure.

The initial voltage on the control grid of the thyratron is governed by the setting of the tapped voltage divider. This adjustment permits compensation for changes in the response k of the phototube and its fluorescent screen when the voltage of the x-ray tube is altered and a Potter-Bucky grid or an intensifying screen is used. Only the basic divider circuit is shown in the diagram; in the actual unit two dividers and a switch are used, with the dividers mechanically coupled to the voltage control of the x-ray machine to make this adjustment entirely automatic. When films are exposed without screens or grids, no compensation for changes in x-ray tube voltage is needed.[6]

The phototube, its fluorescent

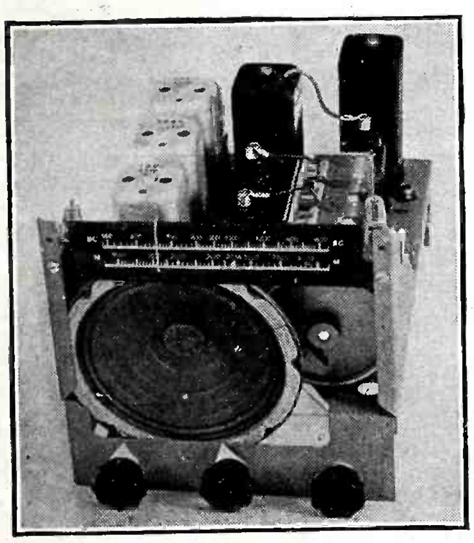
RADIO
RECEIVER AND TRANSMITTER CHASSIS
FOR *Your* APPLICATION

SMALL: — Various types of Receivers and Transmitters require a space only 7″ wide, 10½″ deep and 7½″ high.

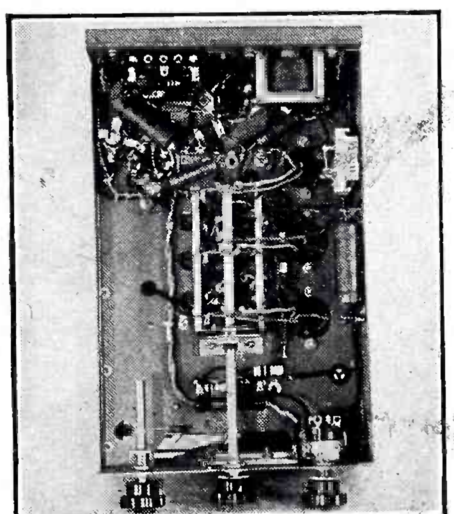
PERFORMANCE: — ***Receivers*** with 1 microvolt sensitivity, high selectivity with a band width of only 16 KC at 30 DB down. Tunable, multi-channel crystal controlled or combination models available.

Transmitters with up to four crystal controlled channels, built-in antenna matching network, 20-25 Watts power output with 100% modulation capability on phone. 10 watt model with power supply on same small chassis also available.

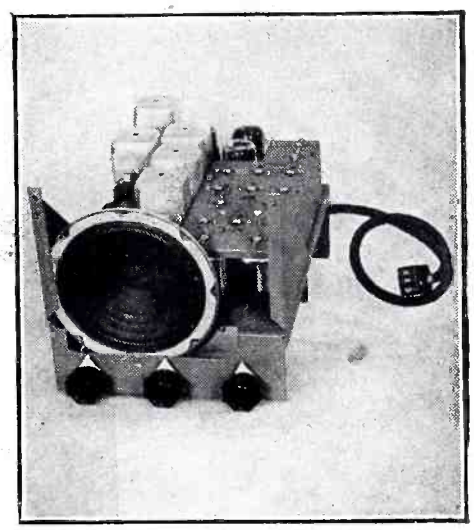
VERSATILE: — Operation on 6, 12, 32, 110 volts DC; 117 volts AC or various DC-AC combinations. Dynamotor or Vibrator power supplies available for operation of transmitters and receivers.



Series 6 tunable receiver. 2 band model illustrated, range 550-4000 K.C.



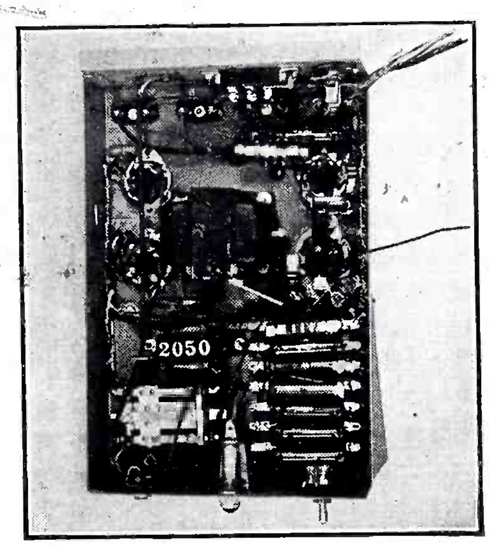
Under chassis view Series 6 tunable receiver.



Series 6, five channel fixed tuned receiver. Model illustrated not crystal controlled.

★ ★ ★ ★ ★

Series 20, 4 channel 1600-6000 KC, 20 watt transmitter.



Under chassis view Series 20 transmitter.

★ ★ ★ ★ ★

KAAR ENGINEERING CO.
PALO ALTO, CALIFORNIA

Manufacturers of High Grade Mobile and Central Station Radiotelephone Equipment screen and the dynode resistor network were mounted in a light-proof case 6x1.5x1.5 inches for one typical application, and positioned directly beneath the center of the film tray. An opening several inches in diameter was drilled through the tray to permit free passage of the radiation to the phototube assembly. The rest of the timer was built into the control stand of the x-ray machine.

In chest radiography two phototubes, each scanning separate lung fields, are used in the phototimer circuit.

The main switches of the x-ray machine should be of the ignitron type, to insure beginning and ending of an exposure at a zero point in a cycle.

REFERENCES

(1) Morgan, R. H., An Exposure Meter for Roentgenography, *Am. J. Roentgenol. & Rad. Therapy*, 47, p. 777–784, May 1942.

(2) Morgan, R. H., Studies in Roentgenographic Exposure Meter Design, *Am. J. Roentgenol. & Rad. Therapy*, 48, p. 88–89, July 1942.

(3) Rajchman, J. A., An Electrically Focused Multiplier Phototube, ELECTRONICS, 13, p. 20–24, Dec. 1940.

(4) Zworykin, V. K., and Rajchman, J. A., Electrostatic Electron Multiplier, *Proc. I. R. E.*, 27, p. 558–566, 1939.

(5) Wilsey, R. B., Photographic Photometry of Roentgen Rays, *Am. J. Roentgenol. & Rad. Therapy*, 32, p. 789–804, 1934.

• • •

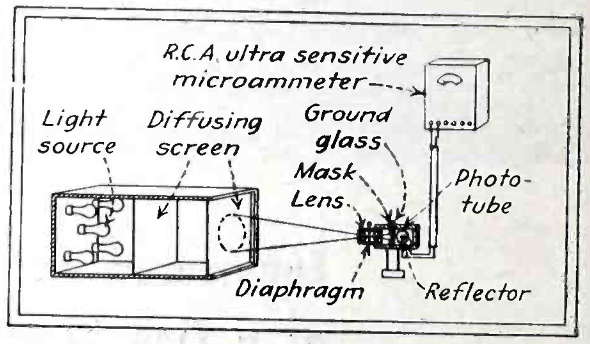
Calibrating Stop Values Of Lenses

WRITING IN THE APRIL 1943 issue of *American Cinematographer*, Daniel B. Clark points out that the transmission of lenses may be as much as a full stop in error when diaphragm openings are calibrated by the conventional formula $f = F/D$, in which f is the numerical value of the f-stop in question, F is the focal length of the lens and D is the diameter of the aperture at the stop indicated by f. The reason for this error is failure of the formula to take into account the type of glass used in constructing each element of the lens, the number of elements and their respective transmission factors, the number of glass-air surfaces and the presence of a coating on the lens.

The solution offered is photoelectric measurement of actual transmitted light through the lens itself, using a known standard light source. The equipment is arranged as shown in the diagram, and a calibrated master lens is screwed into one end of a light-tight tube having at its opposite end a phototube. The image

of the lens is accurately focused on the cathode of the phototube. In front of the lens is a suitable light source, mounted behind a ground glass diffusing panel and connected to the power line through an accurate voltage control and meter. The phototube is connected to feed an ultrasensitive microammeter.

With the diaphragm of the master lens set at $f/3.2$ (or some other opening in the middle range), the voltage of the light source is adjusted until a convenient reading near mid-scale is obtained on the microammeter. Use of the master lens in this manner eliminates errors due to variations in the light source, phototube or meter.



Photoelectric set-up for calibrating stop values of a lens

The lens to be calibrated is now substituted for the master lens and its diaphragm is manipulated to give the same meter reading. This diaphragm setting is calibrated as $f/3.2$. Mathematically correct transmission values are then computed for each stop above and below this median value and are converted into microammeter readings based on the reading for $f{:}3.2$, after which other stops are calibrated by their actually measured transmission. The resulting calibration is correct, stop for stop, regardless of the design and construction of the lens. Steps are under way to establish this procedure as a national standard for calibrating lenses.

• • •

Protecting Meters with Fuses

METER SHORTAGES and greatly increased use of meters by relatively untrained personnel in industrial plants and the military training program make protection of meters highly advisable today whenever possible. For this reason, portions of an

article "When Meters Blow' by Louis J. Fohr, Jr., of Littelfuse Inc. are abstracted here from the Jan. 1937 issue of ELECTRONICS, with additions to include the latest developments along instrument protection lines.

Fusing of the meter circuit can provide simple, fast and effective protection against overload. Standard sizes of fuses are available and are quite low in cost. Whereas a 1/100 amp fuse was the smallest available in 1937, today vacuum-enclosed meter fuses are available in sizes down to 1/1000 amp.

Whenever possible, the fuse should be inserted before the meter shunt or multiplier. In most cases, the added resistance of the fuse will add negligible error to the meter reading. If the error is greater than the permissible tolerance, however, a push-button switch may be shunted across the fuse to short it out for final readings only.

The time required for an instrument fuse to blow is an inverse function of the degree of overload. An overload of 0.02 amp will blow a 1/100 amp fuse in 0.1 sec, an overload of 0.1 amp will blow the fuse and interrupt the circuit in 0.0002 sec, and an extreme overload will make the blowing time practically instantaneous. This is an important and desirable characteristic when protecting the calibration and balance of a delicate instrument.

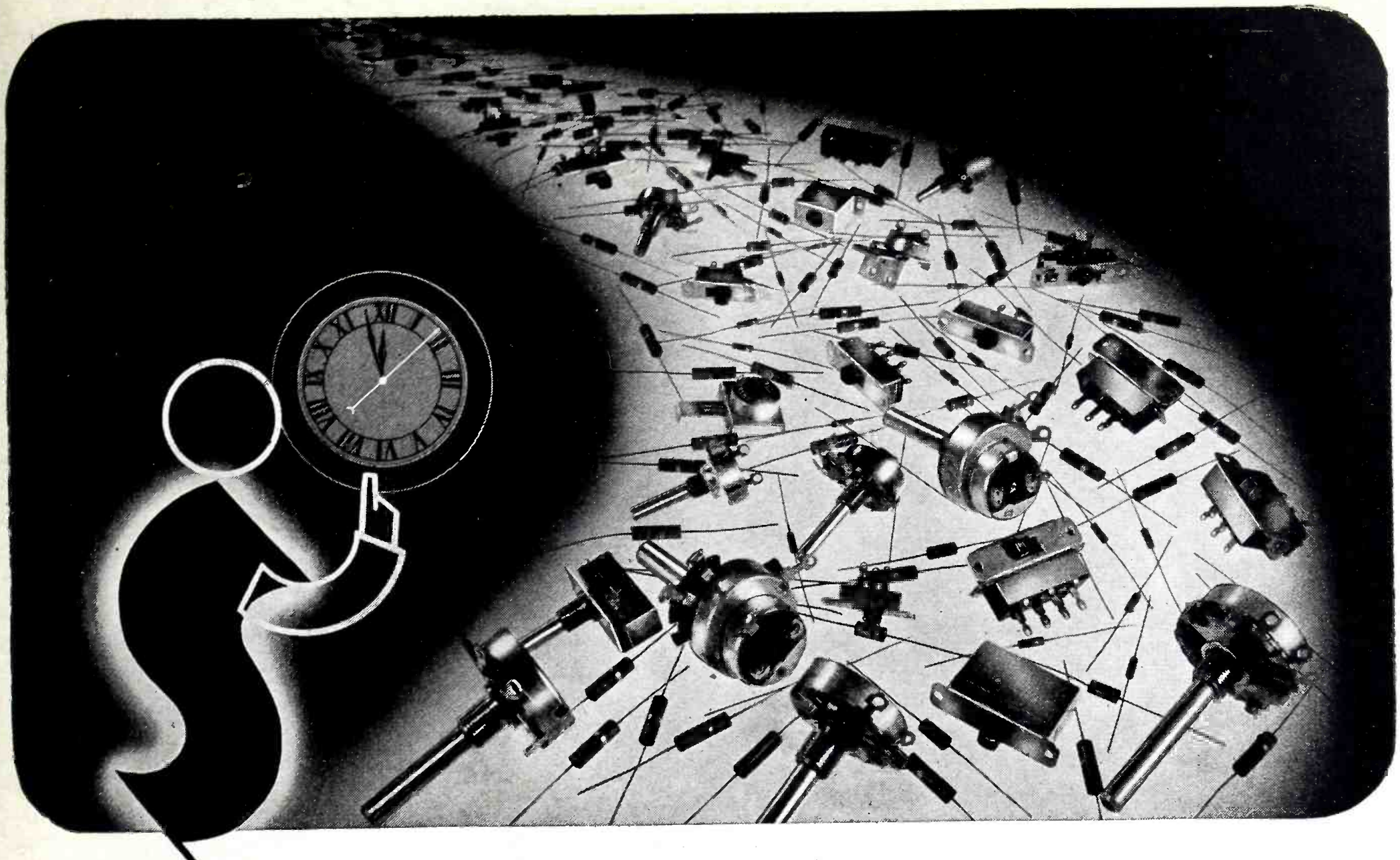
• • •

Recording Blood Flow in Stomach with Thermocouples and Phototube

THE MEASUREMENT of blood flow in the intact human stomach and intestine presents an interesting and important problem, applicable among other things to an investigation of the mechanism underlying the development of peptic ulcers.

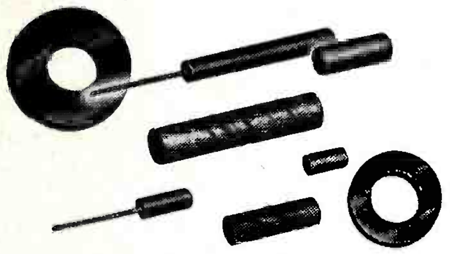
In the past many studies of intestinal blood flow have been made, all of which involved rather extensive surgical procedures and cannulation of the arteries and veins. The results of these studies have been variable and at times contradictory, possibly because of the different amounts of trauma (injury) produced by different operators. In any case, these methods could not be applied to man.

In *The Journal of Clinical Investi-*



HUNDREDS OF COMPONENTS A MINUTE

...EVERY MINUTE—EVERY DAY!



IRON CORE PROBLEMS ANSWERED

Stackpole *knows* iron cores—*knows* their applications—and *knows* how to make units of the proper characteristics and shapes to match today's requirements. High among more recent developments in this line are Stackpole Iron Cores for modern high frequency equipment. When you need cores, it pays to try Stackpole first!

Every minute, every day, Stackpole electronic components to the tune of hundreds of units are being completed—each one ear-marked for an inconspicuous but highly important part in the war effort.

These Stackpole items include iron cores, line switches, slide-action switches, fixed resistors, and standard variable resistors as well as those designed for dusty, extremely humid, or salt spray conditions.

Stackpole facilities—long among the very largest—have been greatly expanded. Stackpole engineers have the all-essential "know how" to help solve your resistance problems. Stackpole service assures personalized attention to your requirements.

STACKPOLE CARBON COMPANY

Electronic Components Division • **St. Marys, Penna.**

STACKPOLE MAKES THESE PRODUCTS

Brushes for all rotating equipment • Carbon, Graphite, Molded Metal, and Composition Contacts • Powder Metallurgy Components • Bearings • Anodes • Electrodes • Power Tube Anodes • Brazing Blocks • Welding Rods, Electrodes and Plates • Packing, Piston, and Seal Rings • Flashlight Battery Carbons • and numerous others.

STACKPOLE

MOLDED METAL POWDER AND CARBON PRODUCTS

gation, 21, p. 551/557, 1942, Charles H. Richards, Steward Wolf, and Harold Wolff of the Cornell University Medical College describe a thermal gradientometer which they have constructed with the assistance of William A. Geohegan. This method, which is conveniently applicable to man, depends on the cooling effect of the flowing blood on a group of heated thermocouples.

Balloon Device is Swallowed

The apparatus consists of a balloon, about 8 cm long and 2.5 cm wide at its greatest diameter, through which passes a duodenal tube. Six constantan-copper thermocouples are moulded into the wall of the balloon at its greatest diameter. The duodenal tube at the center of the balloon has wound around it a heating coil with the reference thermocouples beneath it. The heater temperature is about 10 deg. C above that of the body, and heat is radiated to the whole surface of the balloon. The tissue in contact with the balloon is consequently warmed slightly above body temperature. Small contact variations are of little importance, as the indicated temperature is the average obtained from six points.

The device measures the flow of blood through the tissues, not the amount of blood in the tissues. Thus a decreased flow would be indicated from a congested area, as the relatively motionless mass of blood would be unable to carry away as much heat as a normal flow.

Photoelectric Recording Is Used

The apparatus was arranged to record on a kymograph recorder drum with a moving pen both the temperature gradient, indicating the relative flow, and the contractions of the stomach. In both cases the phenomena were photoelectrically recorded. A sensitive galvanometer was used with the thermocouples, its light beam so arranged that a larger deflection would cause a greater illumination of a phototube. The phototube anode voltage is a.c., regulated on the effective half cycle by a 4005CL neon lamp. Thus an increased temperature gradient causes an increased illumination of the phototube which produces a half-wave 60-cycle voltage which is amplified by a

condenser-coupled amplifier and rectified. The rectified voltage is applied to the grids of parallel 6L6G tubes which have in their plate circuit a solenoid which actuates the recording pen.

To record contraction the balloon in the stomach is inflated and the tube leading to it attached to a U-tube mercury manometer. A beam of light is passed across the surface of the mercury onto a phototube connected as described above. Gastric contractions cause an increase of pressure in the balloon, elevating the mercury and, somewhat indirectly, the recording pen.

Discussion of Results

As would be expected, it was found that with the onset of each strong contraction of the stomach there was a sudden increase in blood flow, followed by a decrease during the continued contraction. With the thermal gradientometer in the duodenum, it was found that showing the subject appetizing foods or even discussing them produced strong contractions within thirty seconds and an increased blood flow within ninety seconds. When distasteful foods were shown there was no effect, or an actual decrease in blood flow would occur.

An interesting finding was that anxiety, tension, and resentment were associated with an increased blood flow. It has long been known hat these emotions produce increased contractions, while fear and mental shock lessen the contractions. Probably further use of the device will bring out the response of the blood flow to the latter emotions as well.

This apparatus shows again that almost any physiological phenomenon which is not already electrical can be transformed by a phototube into electricity and then handled and recorded easily.—W.E.G.

• • •

Momentary Contact for Time Clock

MOMENTARY CLOSING of a circuit with the hour hand of an electric clock for a time interval as short as one second is readily obtained with a roller and contact arrangement described by Max L. Yeater on page

146 of the May 1943 *Review of Scientific Instruments.*

A spring brass arm is mounted on the hour shaft of an electric clock, with the end of the arm machined longitudinally to serve as a shaft for a small metal wheel which rolls over one or more pairs of closely spaced contacts set into the face of the clock. The roller describes a circular path and passes over each pair of contacts once each hour, shorting them.

The time interval during which a pair of contacts will be shorted and its circuit closed can be predicted (assuming ideal mechanical construction) from the equation $t = ks/\omega_r r u$, in which r is the length of the roller arm, s is the radius of the roller, ω_r is the angular velocity of the roller arm, u is the spacing between the contacts and k is the gap required to break the arc between two contacts at the voltage and current involved.

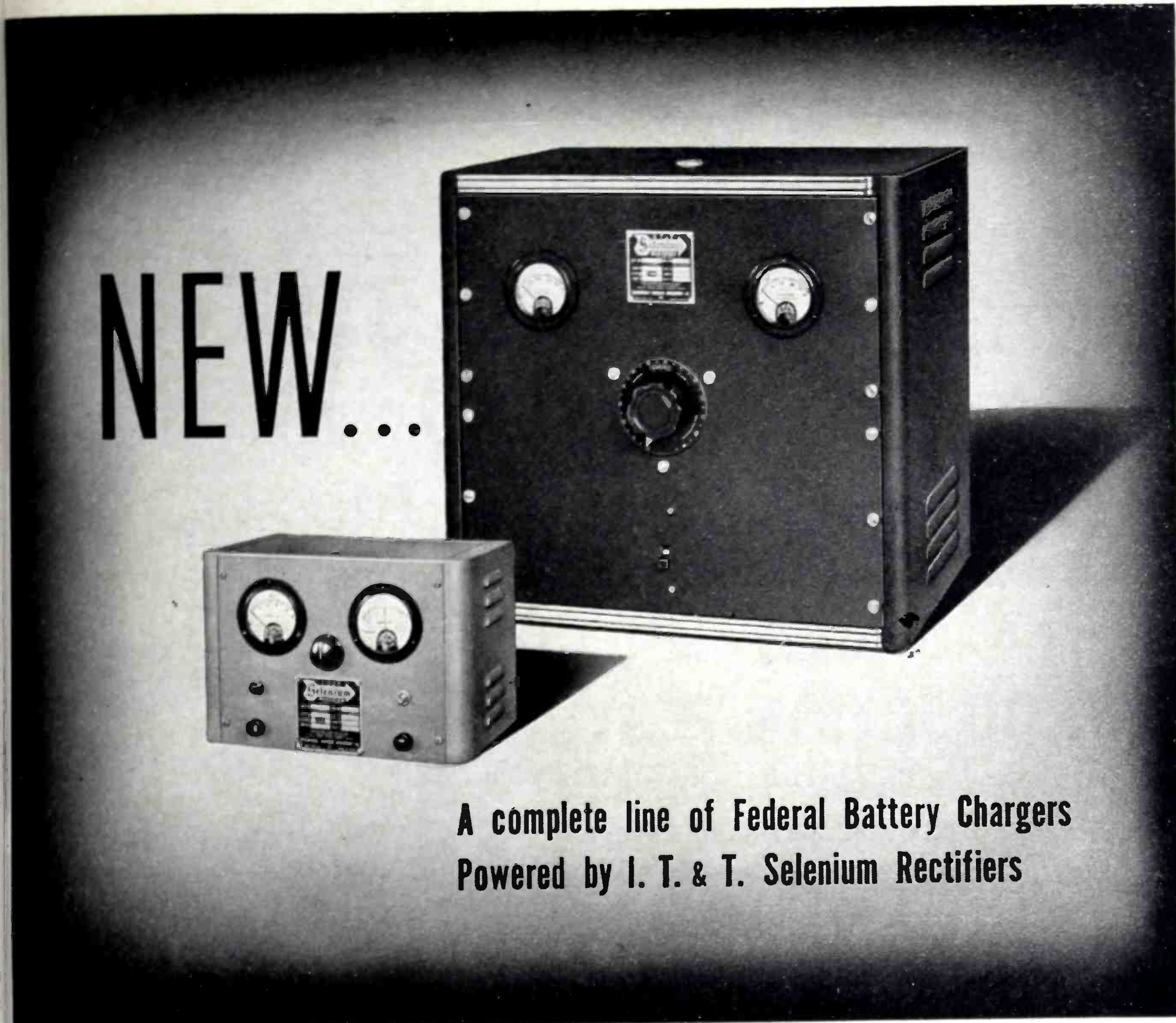
This method makes it possible to control both the duration of contact and the interval between successive contacts in a revolution with a high degree of accuracy.

• • •

Magnetic Control Switch

ONE PURPO E of electronic control is to open or close a circuit without the actuating element coming into physical contact with the switching element. Capacity control circuits accomplish this by using a metal vane as an actuating element and causing it to change the capacity in a vacuum tube oscillator circuit. In applications where there is ample actuating power, however, a magnetic control switch developed by Harry Fuchs of New York City offers a simpler solution which still meets the requirement that there be no physical contact.

The principle is essentially that which causes the pointer of a magnetic compass to follow a piece of iron which is moved around the outside of the compass case. A slender iron armature pivoted between the poles of a horseshoe permanent magnet is magnetized by induction (or may be hard steel previously magnetized), and assumes a position according to the law that unlike poles attract. One end of the armature projects slightly beyond the horse-

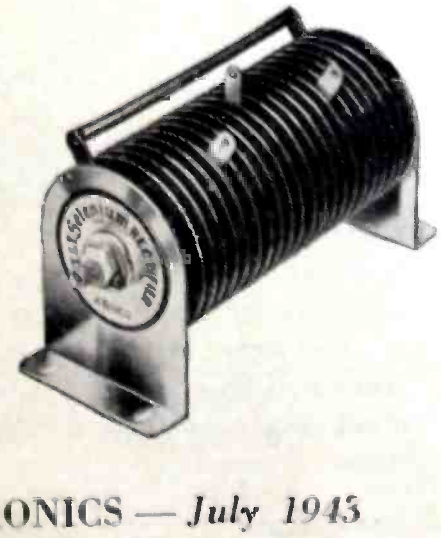


Now – to users of battery charging equipment – we present a complete line of Federal battery chargers, of wide voltage and practically unlimited current range, covering every need and purpose.

And – to the manufacturer requiring battery chargers of special design – we offer our complete Federal design and manufacture service, geared to handle your requirements promptly.

All Federal battery charging equipment is powered by long-life, trouble-free I. T. & T. Selenium Rectifiers – accepted as standard by the electrical industry.

For powering production lines and for use in military devices, Federal also manufactures a complete series of general purpose power supply equipment. Consulting Engineering service available. For descriptive bulletins write *Department H.*



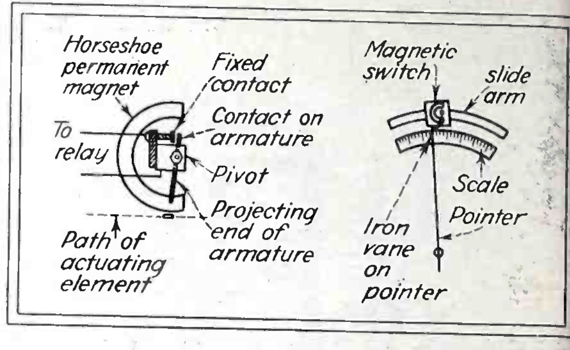
SELENIUM RECTIFIER DIVISION

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

1000 Passaic Ave.
East Newark, New Jersey

shoe magnet, and the other end has a contact which will line up with a fixed contact when the armature is rotated, as shown in the diagram.



Construction of magnetic control switch, and use for automatic weighing

When an iron object or small permanent magnet is brought near the projecting end of the armature, the armature tends to follow the object, just as a compass needle follows an iron object. Motion of the actuating element in the proper direction will thus close the contacts, which in turn can close a relay circuit or perform any other desired electrical function.

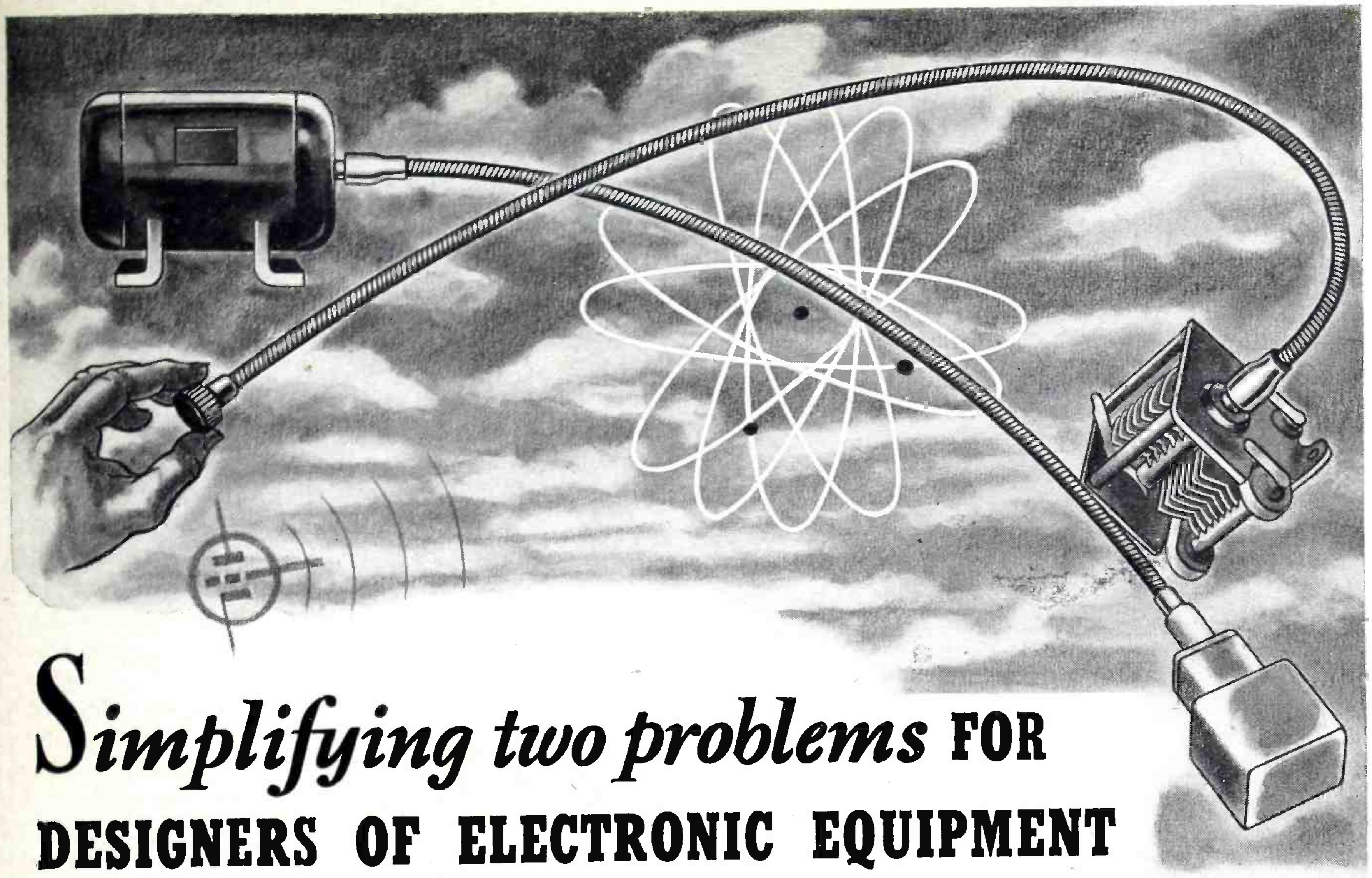
Possible Applications

By mounting the magnetic switch on a curved slide arm above the pointer of a scale and placing a suitable piece of iron on the end of the pointer, automatic weighing action can be obtained for filling containers one after another. The switch is positioned so the projecting armature

Experimental model of magnetic control switch. The knob rotates a wire rod having at its end a piece of iron simulating the actuating element in a practical application

is at the desired weight value. When the scale pointer reaches this value, it will actuate the switch and close the relay circuit, initiating a mechanism which stops the flow of material.

Other applications might include counting of freshly painted iron or steel objects on a belt conveyor, detection of iron slugs in coin-operated machines, automatic levelling of ele-



Simplifying two problems FOR DESIGNERS OF ELECTRONIC EQUIPMENT

Imagination and ingenuity in the highest degree are needed to solve many of the new and complex problems confronting the electronic equipment designer.

But there is a thoroughly tried and proved answer always at hand to two mechanical problems which often arise. These problems are:

(1) **Power Transmission** from small motors to driven parts, or from one driven part to another.

(2) **Remote Control** of electrical circuit or other elements requiring adjustments or manipulation.

And the answer to these two problems, in many cases, is found in S. S. White Flexible Shafts. It is a highly satisfactory answer because it offers these important advantages.

SIMPLICITY—It takes only a single, easily applied unit to carry power or remote control between any two points, regardless of the relative positions of the two points. This means fewer parts, simplified assembly, faster production, lower costs.

BETTER DESIGNS—Because a flexible shaft removes all limitations on the placing of driving and driven or controlled elements. They may be located wherever desirable to satisfy the requirements of electrical circuit efficiency, space conditions, easy assembly, convenient operation and servicing.

ECONOMY—In addition to the economy of simplicity, the fact that a flexible shaft makes accurate alignment of connected elements unnecessary, adds further to the saving in manufacturing costs.

S. S. White Flexible Shafts come in a wide range of diameters and physical characteristics—a range that will meet the operating requirements of practically any application in the electronic field.

CONSULT S. S. WHITE when you have a power drive or remote control problem.* The cooperation of our engineers may mean a quicker, and possibly a more effective, solution.

Flexible Shaft Data For Engineers

BULLETIN 1238
Flexible Shafts for Power Drives

BULLETIN 38-42
Flexible Shafts for Remote Controls

BULLETIN 43
End Fittings for Shafts and Casings

Copies of these bulletins will be mailed on request. Write for yours today.

ARMY E NAVY

** The need of our shafts in war equipment confines our production and service to war work until Victory is won.*

S. S. WHITE

The S. S. White Dental Mfg. Co.

INDUSTRIAL DIVISION

Dept. E, 10 East 40th Street, New York 16, N. Y.

FLEXIBLE SHAFTS • AIRCRAFT ACCESSORIES • MOLDED RESISTORS • CONTRACT PLASTICS MOLDING

vators and other moving objects, monitoring of fuel or liquid level from the outside of an alumium or plastic tank or container, and initiation of any other action which is dependent upon motion of an iron object near the projecting end of the armature.

• • •

Eating Marked Atoms

AN UNUSUAL and interesting application of the Geiger-Muller counter is reported by W. T. Pommerenke and P. F. Hahn in *The Proceedings of the Society for Experimental Biology and medicine,* 52, p. 223-224, 1943. Within recent years there has been considerable use of substances artificially made radioactive to trace labeled particles through the body. The influence on the breast-fed child of substances imbided by the lactating mother has been of considerable interest to physiologists and clinicians, as well as providing a certain amount of discussion for bridge club clinical symposia. It has been shown that nicotine is excreted in the milk of cigarette-smoking mothers.

By the use of radioactive sodium

• • •

AMATEURS DO THEIR PART

Many of the 50,000 radio "hams" in this country have offered their services as radio operators for the Armed Forces, hundreds of them are on the air as volunteer members of the War Emergency Radio Service. Under this service a system of short-wave radio communication has been made available for civilian defense use. Mrs. Joyce Bonar, is shown tuning a WERS transmitter-receiver in a civilian defense control center to pick up reports of walkie-talkie sets operating at the scene of an incident

TOUGH BABIES

Klixon Controls are small, sensitive and Rugged

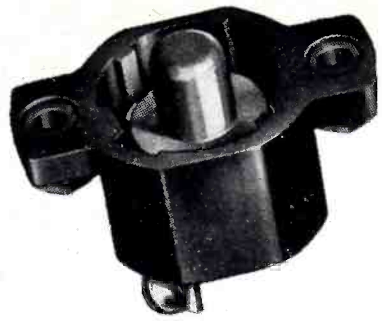
The big advantages of Klixon Control can be traced right down to their actuating element . . . the Spencer Thermostatic Disc. This disc . . . scientifically calibrated . . . does the work of far more complicated elements, toggles, relays, magnets and other fussy and space consuming parts. And being snap-acting in performance provides a solid make or quick, complete break which cannot be affected by vibration or shock..

Whether you want motor and transformer overheat protection, or electrical circuit overload protection, or temperature control, or controls for radio equipment, specify Klixon Controls. They are the smallest, simplest, surest, and sturdiest controls you can find.

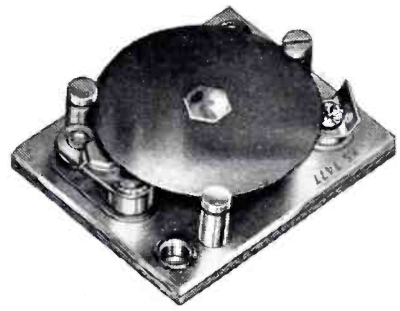
KLIXON

Spencer Thermostat Company

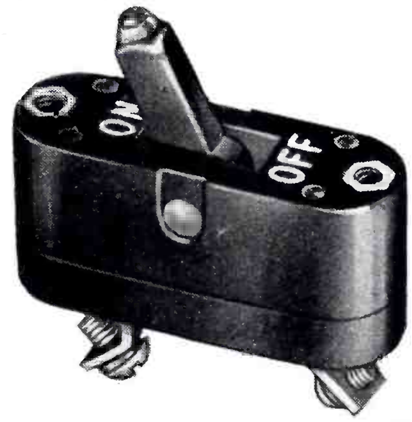
ATTLEBORO, MASS.



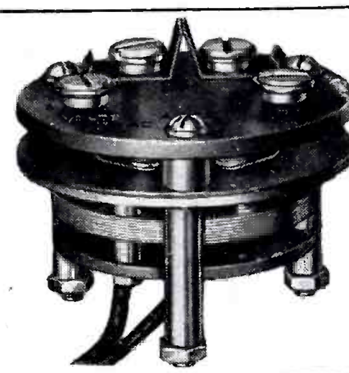
Type PM (NAF-1131) Circuit Breaker



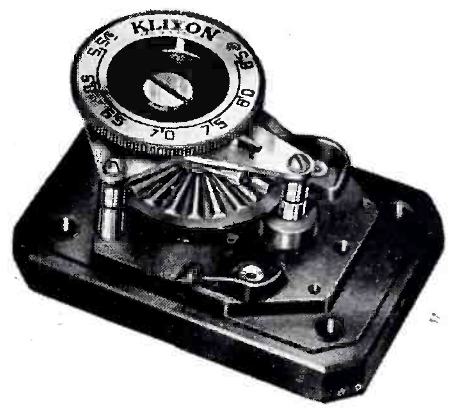
Type B-3120 Crystal Dew Point Control



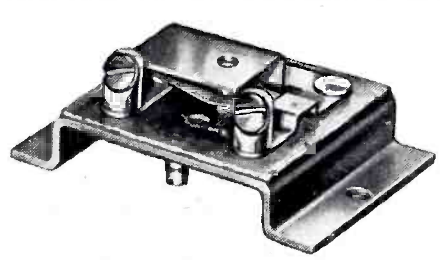
Type C-6363 Switch Circuit Breaker



Type ER Series Ambient Compensated Time Delayed Relays



Type RT Adjustable Crystal Temp. Oven Control



Type C-4351 Series Used for Tube Warming Tube Cooling, and High Limit Controls

Type C-2851 Series, Used as Roughing Controls on Outer Crystal Ovens the authors have determined quantitatively the rate of excretion in the milk of substances taken orally by lactating women. At the beginning of each experiment the selected breast was emptied with an electric pump. Sixty-five milligrams of radioactive sodium, such as the chloride, were then dissolved in orange juice and given to the subject. Samples were pumped from the breast at frequent intervals and the radioactivity of the milk determined by means of the Geiger-Muller counter. It was found that the radioactive sodium could be detected in the milk within twenty minutes, and that the peak concentration was reached in about two hours. The amount then slowly decreased, in some cases being detectable after ninety-six hours.—W.E.G.

• • •

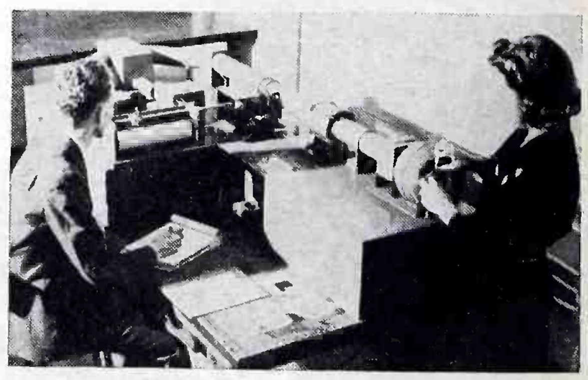
Precision Temperature Control for Electric Furnaces

IMPORTANT EXPERIMENTAL details involved in successful application of A. W. Hull's photocell-thyratron circuit (*Gen. Elec. Rev.* 32, p. 394, 1933) to precise automatic control of temperature in electric furnaces are given by C. E. Waring and G. Robision in the May 1943 *Review of Scientific Instruments.*

In the Hull circuit, a platinum resistance thermometer is placed in the furnace to be controlled and used as one arm of a Wheatstone bridge having a mirror galvanometer as the indicating instrument. The bridge is balanced for the desired

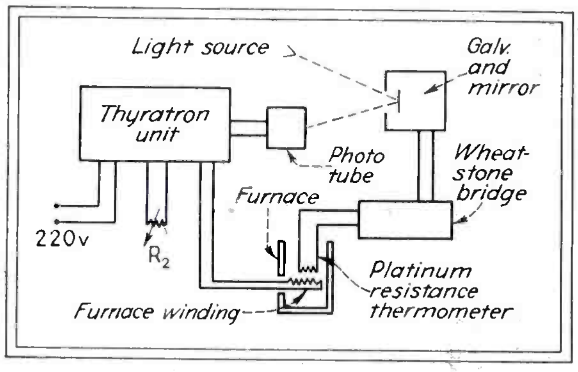
• • •

SPECTROPHOTOMETER



Photoelectric recording spectrophotometer being used to measure color of sample of yellow paper. The spectrophotometric curve is being drawn automatically on drum at left. Originated by Dr. A. C. Hardy and built by General Electric, this photoelectric device permanently and accurately records and specifies all colors the human eye can see

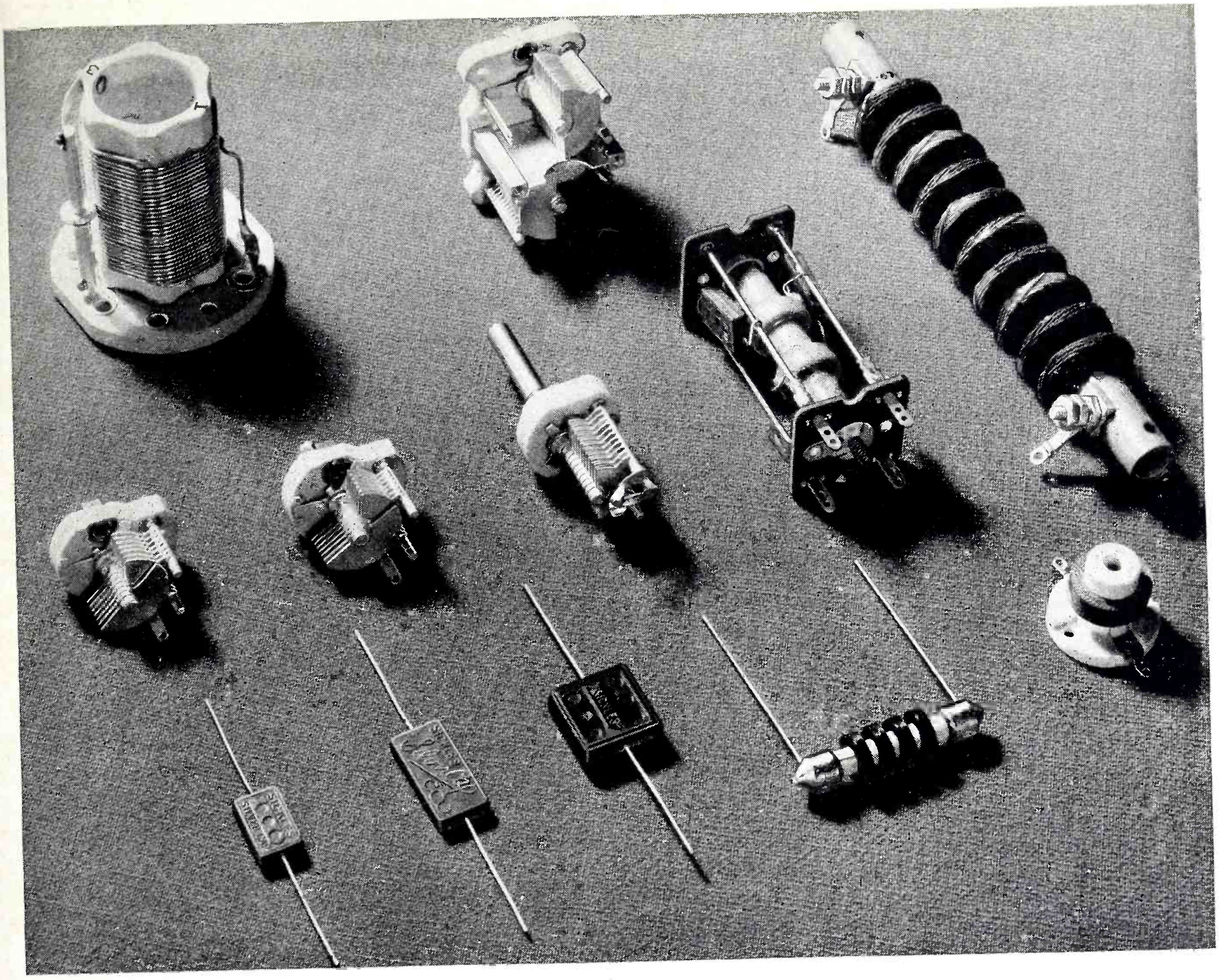
temperature and the light beam reflected from the galvanometer mirror is permitted to fall on a phototube whose internal resistance controls the phase of the grid voltage of an FG-57 thyratron with respect to its plate voltage. When balanced, the beam covers most of the active surface of the phototube. When the temperature drifts, the bridge goes off balance, and either more or less light falls on the phototube. This causes continuous regulation of the power passing through the thyratron to part or all of the furnace winding, thereby giving constant temperature.



Block diagram of original circuit developed by A. W. Hull for controlling high-temperature furnaces

The paper bridges the gap between presentation of an electronic circuit and actual application of the circuit by the average scientist or engineer, by describing in detail the various precautions required to insure satisfactory operation. It tells which photocell gave best results, gives construction data for the platinum resistance thermometer, specifies batteries which give sufficiently stable voltages for the purpose, and indicates exactly where Isolantite insulation is required. A step-by-step procedure for making initial tests and adjustments is followed by operating instructions such as would be found in a factory manual of a commercial product. Important factors affecting precision over long operating periods are given.

By following the procedure outlined, it was possible to hold an electric furnace at a temperature of 600 deg. C automatically for a one-hour period with maximum deviation of only 0.05 deg. from this value. One unit maintained this temperature constant to within 3 deg. without adjustment for a period of eight weeks.



V-H-F Receiver

(Continued from page 97)

when we plot the shape of a high-frequency oscillator curve, and examine the peak, we find that in terms of the 10 kc unit of drift we may want to establish as a desirable maximum the peak is practically flat at the top.

Figure 1 shows the poor frequency discrimination afforded by a 100-Q circuit at 150 Mc. The curve is 175 kc wide only 1 percent down.

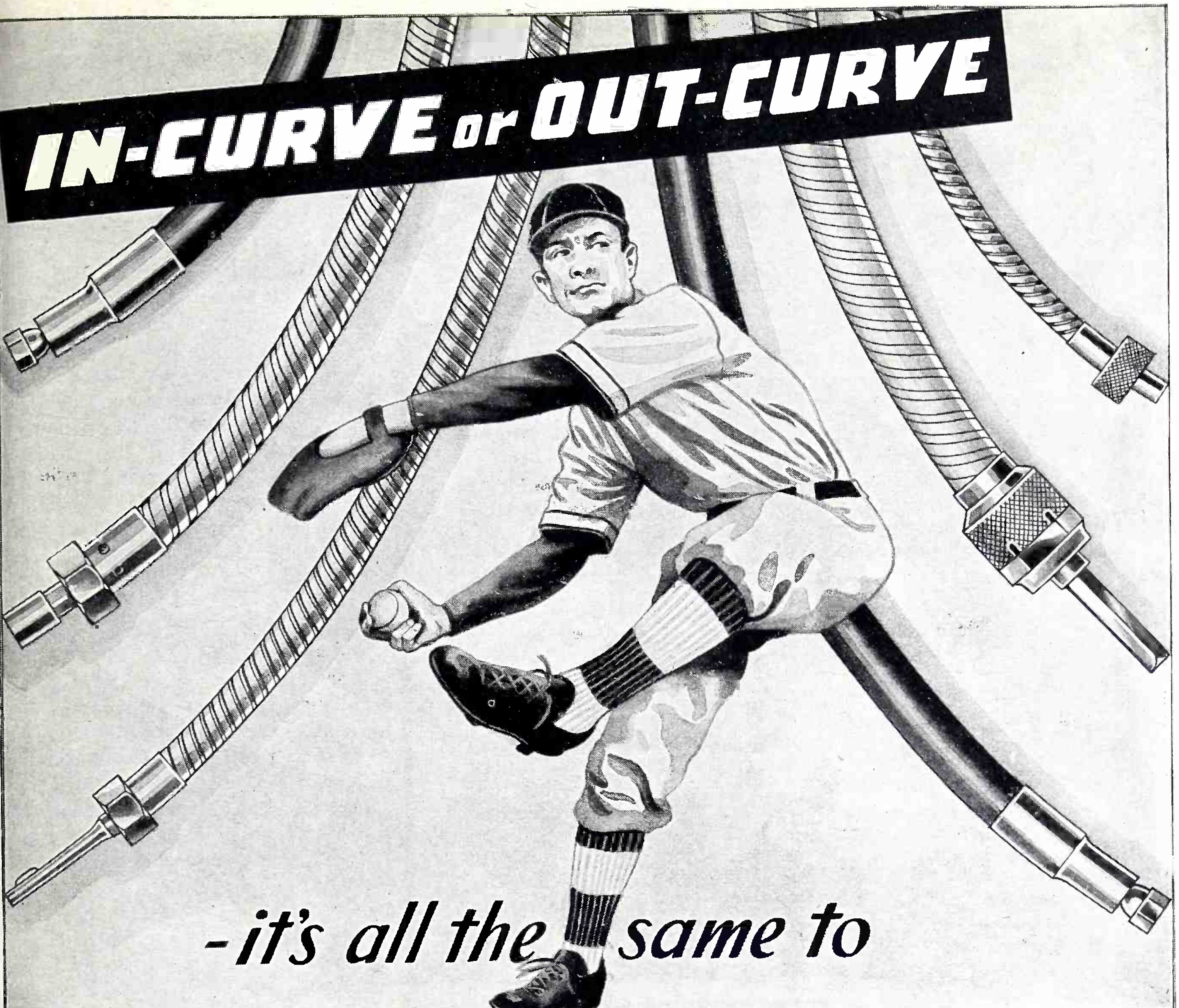
Voltage Stability

In the past it has been assumed that the higher the Q the higher the voltage stability of the oscillator. After full investigation of this point the writer is convinced that there is no such direct relationship. It is true, merely, that the higher the Q the larger tuning capacitor you can use to swamp out tube capacitance with its host of variables. This is not quite the same thing. Also, in a distributed type of circuit such as a parallel line you can slide the tube down the circuit so that it is across just a small portion of the line and still obtain enough impedance at this point to load the tube up nicely.

Striking Voltage

Figure 2 brings out one practical aspect of this effect. It may be said of any oscillator that if the phase-angles, impedances and Q are all good the oscillator will "strike", or start to oscillate, at a very low plate voltage if the tube has very small G_m. Curve *A* is that of an average type 955 acorn triode in a 400-Q circuit, using a tuning capacitor of 15 $\mu\mu$f in a concentrated tank circuit. It strikes at 8 v on the plate and the frequency changes rapidly as the voltage increases. At 100 v it is nicely flattened off. Curve *B* is the same type circuit with the 60-$\mu\mu$f tuning capacitor, with a similar coil reduced in inductance to allow oscillation at the same frequency as that of the oscillator in curve *A*. In this case it will be seen that the plate voltage must increase to 50 v to cause the oscillator to strike.

It will be noted that at 100 v curve *B* is still quite steep and shows little tendency to flatten off.



WALKER-TURNER FLEXIBLE SHAFTING

In plane, tank, ship and many other weapons of war, Walker-Turner Flexible Shafting is in there pitching. And it never goes to pieces in the pinches, either. For transmission of power in small amounts and for remote control between two points in line or out of line, this flexible shafting has shown itself to be the logical answer to many difficult problems.

The design of Walker-Turner Flexible Shafting is based on the construction and use of thousands of Walker-Turner Flexible Shaft Machines in a wide variety of industries throughout the country. In addition, we have worked out special problems in power transmission and remote control for many products made by other manufacturers. Perhaps we can help you, too. Ask us.

WALKER-TURNER COMPANY, INC. 1473 BERCKMAN STREET, PLAINFIELD, N. J.

walker-Turner
COMPANY, Inc.
PLAINFIELD, N.J.
U.S.A.

FLEXIBLE SHAFTING

FOR REMOTE CONTROL AND POWER TRANSMISSION

At zero plate voltage an oscillator tube has zero G_m and almost infinite plate impedance. As we gradually apply plate voltage the mutual conductance increases and at the same time the plate impedance decreases. At 8 v the G_m is very small and the plate impedance very high. Yet the tube in curve *A* strikes. As we continue to increase the plate voltage we change both these parameters by a large factor. We bring the tube plate impedance down to a value which is a very good match to the dynamic impedance of the tuned circuit and increase the G_m to a much higher value than at 8 v. Thus at 100 v the tube is working under the best possible conditions. Beyond 100 v the plate impedance and G_m change very little.

Other Effects

An interesting variation in voltage stability will be noted in variable capacitor-tuned oscillators. At low frequencies we normally expect that the oscillator will be most stable with the tuning capacitor set at maximum capacitance value. In the very high frequency region under discussion the maximum voltage stability will usually occur somewhere around the mid-capacitance value, since at low capacitance values the tube will be the larger part of the tuned circuit and will contribute its variable parameters, while at the maximum value of the tuning capacitor the tube capacity will be swamped but the dynamic impedance will be so low that the striking voltage will be excessive, with resultant instability.

This effect frequently limits the tuning range in a "disciplined" receiver designed for very high frequency operation and is brought out in Fig. 3, wherein the ordinate represents the voltage instability in terms of kc change in frequency for a given change in supply voltage and the abscissa represents the *L/C* ratio expressed in terms of the tuning capacitor value. That is, the oscillator frequency in this case was held constant at 150 Mc by reducing the inductance as the tuning capacitor value was increased and vice-versa. It will be noted that the maximum stability occurred in the neighborhood of 25 $\mu\mu$f.

The designer can, by taking advantage of the above mentioned points, go far toward maintenance of secular stability.

Audio Analyzer

(*Continued from page* 103)

The chief value of this recording-type analyzer in the field of sound and vibration analysis lies in the fact that a complete chart showing the intensity at each frequency can be obtained in only two minutes. This chart shows at a glance the predominant frequencies, and knowing these, an engineer can generally make quick calculations to determine which parts could have such resonant values. Adjustments can then be made and new charts run off until a combination of conditions is found which gives minimum peak amplitudes and hence minimum noise. If the nature of the test permits, the analyzer can be set to each peak frequency in turn while the meter is connected in place of the recorder, and adjustments made on the noise-producing equipment to eliminate individual peaks.

Industrial Applications

In one instance, engineers were using the analyzer to check the noise produced by a vacuum cleaner. The resulting chart indicated a predominant noise frequency which was almost instantly identified as being produced by the fan blade.

When used on the French liner Normandie some time ago, the analyzer pointed to the propellers as a major cause of the severe vibration experienced during early runs. A change of propellers materially reduced the vibration, confirming the results obtained with the instrument.

Many recording audio analyzers have been ordered by governmental agencies for military purposes. Reduction of noise in marine engines of surface vessels to minimize chances for detection by submarines, and in submarines to prevent detection by enemy ships with listening apparatus, are just a few important military applications.—J.M.

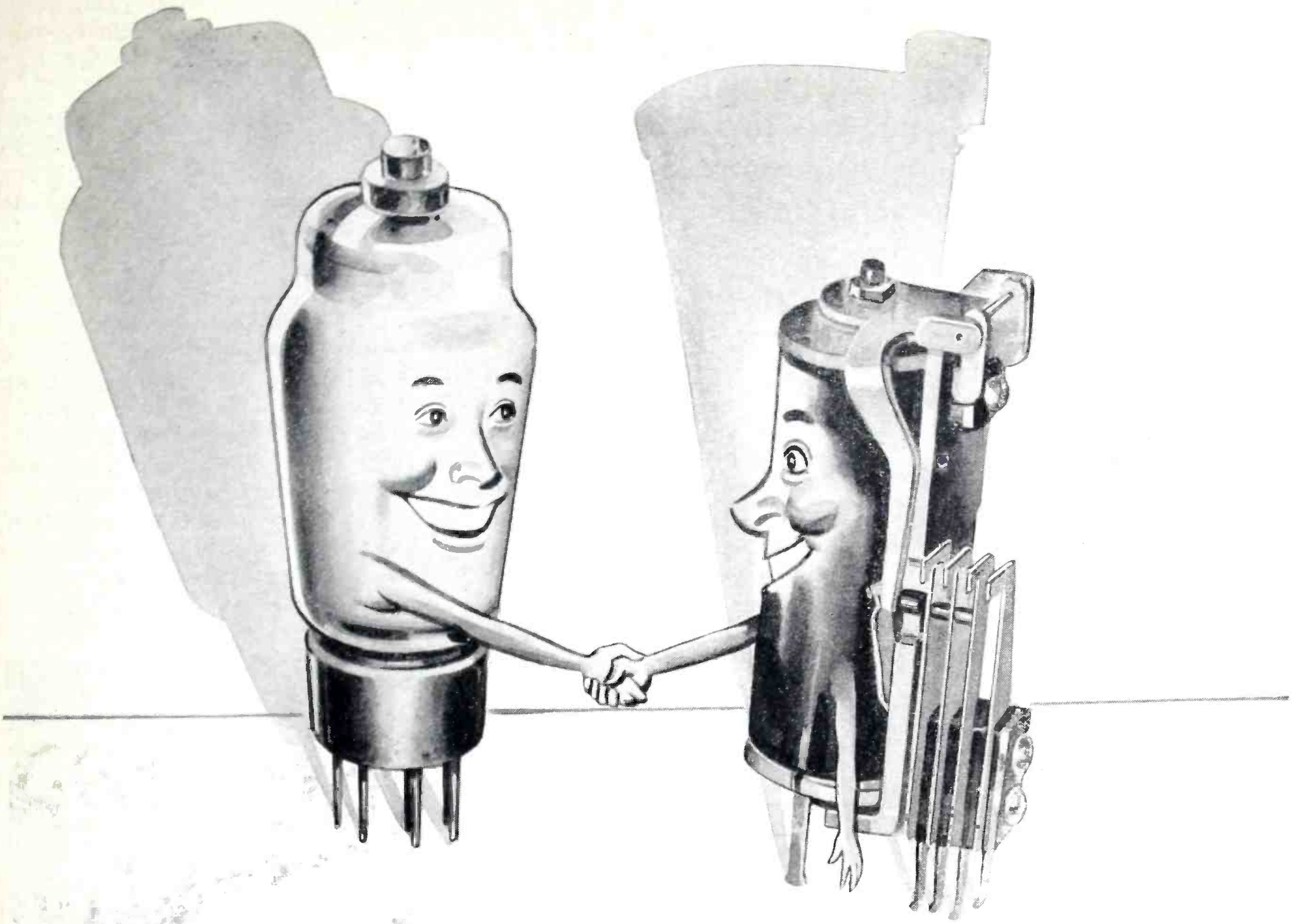
REFERENCES

(1) Mason, W. P., Electrical Wave Filters Employing Quartz Crystals as Elements, *Bell System Tech. Jrl.*, p. 405, 13, July 1934.

(2) Mason, W. P., Resistance-Compensated Band-Pass Crystal Filters for Use in Unbalanced Circuits, *Bell System Tech. Jrl.*, p. 423, 16, Oct. 1937.

(3) Mason, W. P., and Sykes, R. A., Electrical Wave Filters Employing Crystals with Normal and Divided Electrodes, *Bell System Tech. Jrl.*, p. 221, 19, Apr. 1940.

(4) Wentz, E. C., Bedell, E. H., and Swartzell, K. D., A High Speed Level Recorder for Acoustic Measurements, *Bell System Tech. Jrl.*, p. 121, 14, Jan. 1935.



NEWS OF THE INDUSTRY

Early history of radar; future of electronics; IRE news; new commercial communications agency; Wall St. looks at electronics; college courses in electronics; WPB news; radio business news; personnel changes; E awards

Recent Developments in Military Radio Communication

ONE POTENT WEAPON in the continuous propaganda battle raging over the air waves is "blind broadcasting" of news photographs by short-wave stations, for reception by anyone with the necessary receiving equipment. The OWI now leases 2½ hours of short-wave radio time daily for four news picture broadcasts, to Northern Europe from Sweden to Bombay, to Central Europe from London to Cairo, to North Africa, and to Central and South America. Previously, photographs moved only over controlled circuits of established commercial radio channels, and transmission did not begin until code contact had been made with the receiving operator.

Six super-power radio stations operated by the Civil Aeronautics Administration provide direct communication with a plane in flight anywhere on the globe, according to William Burden, Special Aviation Assistant to the Secretary of Commerce. This means that passengers in post-war airliners can talk to the folks back home even though flying over China, the North Pole or any other remote portion of the globe.

Units of the Army Air Forces, maintaining 24-hour vigil atop mountain peaks of India, are using radio and undoubtedly also radar to notify American air bases of the approach of Jap planes.

Kite string made from continuous filaments of glass wound with fine copper wire is used with a box kite to carry aloft the antenna of the emergency radio transmitter developed by the Army Air Forces for its life rafts. The yarn has great strength in proportion to its weight, and is not weakened by salt water, tropic sunlight, rain or dampness. The transmitter automatically grinds out the SOS signal on the international distress frequency of 500 kc when the power-generating crank is operated.

Wavemeters built by Philco for calibration of Army and Navy radio transmitters contain a self-compensating device, thermostatically operated, which automatically changes the effective length of the wire in the tuning coil as temperature varies. E. O. Thompson and David Sunstein, of the Philco Engineering Dept. and Factory Organization respectively, were officially cited by WPB for this wavemeter improvement.

Navy's History of Radar

Editor's Note: The second Navy press release on radar, issued May 23, 1943, is a testimonial to the perseverance of the men and manufacturers who successfully bridged the gap between observance of a phenomenon and practical development into the outstanding scientific contribution to the war effort. The release is given here just as released by the Navy, because of its reference value.

Reflection of Signals is Noticed

In mid-September 1922 two research scientists Dr. A. Hoyt Taylor and Mr. Leo C. Young working in the Naval Aircraft Radio Laboratory Anacostia, D. C., observed that certain radio signals were reflected from steel buildings and metal objects. They also observed that ships passing by a transmitter and receiver at such frequencies gave a definite interference pattern. These observations gave rise to the suggestion that:

> *"Possibly an arrangement could be worked out whereby destroyers located on a line a number of miles apart could be immediately aware of the passage of an enemy vessel between any two destroyers in the line, irrespective of fog, darkness or smoke screen."*

The discovery by Dr. Taylor and Mr. Young, more than 20 years ago, was the birth of radar. Their imaginative, searching preliminary suggestion marked its first possible military application.

As announced in the joint Army-Navy press release of April 25, 1943 (given on p. 274, June 1943 ELECTRONICS), the term "radar" means radio-detecting-and-ranging.

Research Begins

Dr. Taylor and Mr. Young have been connected intimately with the development of radar ever since those fateful days in September, 1922. For like most discoveries which shape the path of mankind, as has radar in the present war, the chronological development of radar is mainly the story of unceasing human endeavor. Their early equip-

Dr. A. Hoyt Taylor

Mr. Leo C. Young

THE SKILL *and* THE WILL

. . . today and tomorrow

Only one American in many thousands is privileged to wear the "E" pin, symbolic of high achievement on the production front. It symbolizes skill and determination above and beyond the high average standard set by American Industry. ✓✓✓ The men and women of Connecticut Telephone & Electric Division have been honored by the Army-Navy Production Award twice in a period of six months. This symbol of a job being well done in the cause of Victory is evidence, too, of what may be expected when the war is won. ✓✓✓ The manufacturer seeking cooperation in product engineering and improvement, the development of production control, or any problem involving the application of advanced electrical or electronic knowledge, is cordially invited to discuss the matter with our engineering staff.

ARMY E NAVY

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

MERIDEN — GREAT AMERICAN INDUSTRIES INC. — CONN.

DESIGN, ENGINEERING & PRODUCTION OF PRECISION ELECTRICAL EQUIPMENT

ment difficulties were almost unbelievable, but the continuing faith of Dr. Taylor and Mr. Young enabled them to drive forward their development to a degree whereby radar has changed markedly the tactical science of modern warfare.

Dr. Taylor is now Superintendent of the Radio Division of the Naval Research Laboratory. Mr. Young is now Assistant Superintendent of the same Division.

On September 27, 1922, a report on Dr. Taylor and Mr. Young's initial findings and their suggested implications was forwarded to the Bureau of Engineering, Navy Department, Washington, D. C.

Despite the pressure of their other work and the discouraging factors which face the pursual of most research work, Dr. Taylor and Mr. Young continued their trail. Between 1925 and 1930 the reflection phenomena observed in 1922 was used to measure the height of the Kennelly-Heaviside layer, an atmospheric formation which acts as a reflector for certain beams. Dr. Taylor and Mr. Young did this work in conjunction with Dr. Gregory Breit and Dr. Merle A. Tuve, of the Carnegie Institute. Their associates during this period included Mr. L. A. Gebhard and Mr. M. H. Schrenck.

During this period, Dr. Taylor and Mr. Young also measured the time required for radio signals to go around the world by reflection from the Kennelly-Heaviside layer. For this purpose extremely brief radio signals were employed, and apparatus was designed to both transmit and receive such brief signals. Mr. L. A. Hyland, now with the Bendix Corporation, was one of Dr. Taylor's associates during this early work.

On June 24, 1930, Mr. Hyland, working under Dr. Taylor, observed that aircraft crossing a line between a transmitter and receiver operating directionally gave an interference pattern clearly indicating the presence of such aircraft.

Dr. Taylor Makes Detailed Report

On November 5, 1930, the Director of the Naval Research Laboratory submitted to the Chief of the Bureau of Engineering, Navy Department, a detailed report, prepared by Dr. Taylor, on "radio-echo signals from moving objects." This report summarized all observations made prior to that date, presented the theory underlying the observed phenomena and concluded with the recommendation that the investigation be continued and intensified.

Dr. Taylor's report having been thoroughly studied, the Radio Division of the Bureau of Engineering on January 19, 1931, assigned the Naval Research Laboratory the following problem:

> *"Investigate use of radio to detect the presence of enemy vessels and aircraft. Special emphasis is placed on the confidential nature of this problem."*

On October 21, 1931, Captain Harold G. Brown, U.S.N., then Assistant to the Chief of the Bureau of Engineering, (now Rear Admiral, Special Assistant to the Under Secretary of the Navy), forwarded for comment and consideration to the Naval Research Laboratory certain radio proposals of Lieutenant (now Commander) Joseph N. Wenger, U.S.N. Two weeks later, on December 20, 1931, Dr. Taylor replied that all of Lieutenant Wenger's proposals had already been demonstrated in previous work at the Naval Research Laboratory to have practical possibilities, and again Dr. Taylor recommended that this research be given a high priority.

Meanwhile the theory of reflection from moving objects had been confirmed by experiments conducted in cooperation with the dirigible Akron.

War Department Gets First Report

At this stage in radar's development the Navy's findings were brought to the attention of the War Department. On January 9, 1932, the Secretary of the Navy wrote the Secretary of War describing the work carried on at the Naval Research Laboratory. This letter contained the following suggestion:

> *"Certain phases of the problem appear to be of more concern to the Army than to the Navy. For example a system of transmitters and associated receivers might be set up about a defense area to test its effectiveness in detecting the passage of hostile aircraft into the area. Such a development might be carried forward more appropriately and expeditiously by the Army than by the Navy."*

A copy of Dr. Taylor's report of November 5, 1930, was enclosed with the Secretary's letter, and the War Department was offered the assistance of the Naval Research Laboratory and the Bureau of Engineering in any investigations that Department might desire to make.

Airplanes Detected 50 Miles Away in 1932

By this time airplanes in motion nearly 50 miles from the transmitter had been detected under certain conditions. On July 1, 1932, in one of Dr. Taylor's reports of progress made on the problem assigned January 19, 1931, he described certain tests of aircraft detection at such distances and added that the object of the investigation now was to develop instruments for the collection, automatic recording and correlating of data to show position, angle and speed of the approach of objects in the air. The first instruments of this nature were developed by Mr. Robert M. Page, of the Naval Research Laboratory, assisted by Mr. Robert C. Guthrie.

Mr. Page and Mr. Guthrie, since this time, have been constantly engaged in radar research, and many of the radar developments now in use in the Naval service are credited by the Navy Department to the efforts of these scientists.

By March 28, 1933, various types of apparatus and systems for detecting enemy aircraft and vessels had been developed to a degree which enabled the Naval Research Laboratory to outline in detail the theoretical military applications.

In 1935 the Naval Appropriations Committee of the House of Representatives on its own initiative allotted $100,000 for research purposes to the Naval Research Laboratory. This Committee has been intensely interested in the development of radar. The Committee repeatedly has made inspections at the Naval Research Laboratory and has given special financial support to its work. During most of this period Representative James E. Scrugham, of Nevada, a former engineer, was Chairman of the Committee. Mr. Scrugham is now a member of the U. S. Senate.

By this time the Bureau of Standards had been advised of the radar work of the Naval Research Laboratory, and the Bureau of Standards and the Naval Research Laboratory were cooperating with representatives of the Army regarding methods of detecting aircraft by utilizing ultra-high-frequency radio waves. The War Department had emphasized the importance of this project, and constant liaison has been maintained between the Services.

In June, 1936, representatives of the Bureau of Engineering witnessed a demonstration of aircraft detection equipment at the Naval Research Laboratory, and Rear Admiral Bowen, then Chief of the Bureau, directed that plans be made for the installation of a complete set of radar equipment, as then existed, aboard ship.

First Ship Installation is Ordered

As result of studies made during the tactical maneuvers of the U. S. Fleet in the Pacific during the Fall of 1936, Admiral A. J. Hepburn, U.S.N., Commander in Chief of the U. S. Fleet (now Chairman, General Board, Navy Department), advised Rear Admiral Bowen of the importance of having radar equipment tested with the Fleet.

On February 17, 1937, visiting the Naval Research Laboratory, Assistant Secretary of the Navy Charles Edison (now Governor of the State of New Jersey) and Admiral William D. Leahy, U.S.N., Chief of Naval Operations (now Chief of Staff to the Commander in Chief of the Army and Navy) witnessed a demonstration of the detection of aircraft by the first radar set developed in this country.

The next two years were spent in designing and manufacturing a practical shipboard model. After continual trials, a set of radar, manufactured by the Naval Research Laboratory, was installed on the USS New York late in 1938. During January, February, and March, 1939, this equipment was given exhaustive tests at sea during the winter cruise and the battle maneuvers carried on at that time. The Commanding Officer of the USS New York was most enthusiastic and recommended that the work be continued. Vice Admiral Alfred F. Johnson, U.S.N., commanding the Battleship Division, stated, "The equipment is one of the most important radio developments since the advent of the radio itself."

Decision was made to develop additional radar sets, while, at the same time, it was emphasized that the immediate procurement of this material must not interfere with the progress of the development.

Bell Labs and RCA Cooperate in Research

In October, 1939, contracts, on a bid basis, were awarded the Radio Corporation of America for manufacture of six sets of aircraft detection equipment patterned after the original model which had been built at the Naval Research Laboratory and installed in the USS New York.

Two of the major electronic laboratories of the Country, Bell Laboratories and RCA, by this time were working in cooperation with the Naval Research Laboratory on radar research and development.

General Electric Converts to Radar

In August, 1940, realizing that this Nation was faced with limited radar production facilities in the event of war, Rear Admiral Bowen persuaded Mr. Charles E. Wilson, president of the General Electric Company (now executive vice chairman of the War Production Board) to institute radar manufacturing at the General Electric plants. Within two weeks Mr. Wilson sent 20 scientists from Schenectady to inspect the Navy's radar equipment at the Research Laboratory. The company's representatives were most enthusiastic.

Two weeks later Mr. Wilson, himself, headed another inspection party and was so impressed that he directed Dr. Walter R. Baker, head of the Radio Division of the General Electric Company, to take the necessary actions to enable General Electric to catch up with the Naval Research Laboratory's radar program. Mr. Wilson additionally reorganized General Electric's Radio Division. Dr. Baker was made vice president of General Electric, and General Electric became the first radio company to transfer all of its radio engineers to radar work. Additional radar manufacturing facilities were started immediately.

The General Electric Company subsequently was awarded a large contract for radar equipment for Naval vessels.

Westinghouse Enters Picture

On October 16 1940, Admiral Bowen appealed to Mr. A. W. Robertson, Chairman of the Board, and Mr. George Bucher, president of the Westinghouse Electric Company, to participate in the Navy's radar program. Westinghouse representatives visited the Naval Research Laboratory and subsequently immediately reorganized their own radio division and were awarded a large Navy contract for radar manufacture.

Radar Data Exchanged With British

In September 1940, representatives of the British Technical Mission held a series of conference with representatives of the Navy Department and the Naval Research Laboratory at which time much technical information relating to radar was exchanged. Previously it had been known that Great Britain was in possession of a system for detecting aircraft but most of the details of the British system were unknown here. During this conference with the British Technical Mission, it was found that the British equipment was similar in many respects to the equipment developed by the Naval Research Laboratory, and members of the British Mission stated that the British development had resulted from articles reporting the preliminary work between 1926 and 1930 of Dr. Taylor and Mr. Young, of the Naval Research Laboratory, and Dr. Breit and Dr. Tuve, of the Carnegie Instiute, studying the height of the Kennelly-Heaviside layer. With this preliminary study as a base, the British independently had developed their radar system and independently had arrived at frequencies and circuits very similar to those developed in this country.

In October, 1940, Rear Admiral Bowen, then head of the Navy Research Laboratory, was designated coordinator of all phases of the Navy's radar program.

Commercial Production Under Way in 1941

By the beginning of 1941, the General Electric, Westinghouse, RCA, and Bell Telephone laboratories were carrying on research and undertaking commercial production.

Lieutenant Commander (now Commander) David R. Hull, U.S.N., Assistant to Admiral Bowen, was put in immediate charge of Naval contacts with all private, commercial, and governmental activities engaged in radar research and development, and in this capacity he supervised the development of models which resulted in the first quantity production of many types of radar equipment.

Commander (now Captain) Jennings B. Dow, U.S.N., spent the greater part of 1941 in England obtaining information on British radar methods. Upon his return to the United States, Commander Dow organized the Radar Branch in the Radio Division, Bureau of Ships. Radar procurement and design work in the Bureau of Ships prior to that time had been conducted by Lieutenant Commander (now Commander) Samuel M. Tucker, U.S.N. Major contributions in the radar field also have been made by Lieutenant Commander (now Captain) M. E. Curts, U.S.N., Lieutenant (now Commander) William S. Parsons, U.S.N., and Lieutenant Commander John F. Mullen, Jr., U.S.N.

Radar research is continuing and new developments are constantly being made—by the Government and by private industry. Every manufacturer of any size in the electronic industry is participating. Radar procurement is one of the Navy's prime projects.

Jap Battleship Sunk at Night By Radar-Aimed Salvos

SPEAKING in Spartanburg, S. C. on Memorial Day, James F. Byrnes, Director of War Mobilization, cited the following example of the effectiveness of radar:

"History will some day record the part radio and radar have played in giving us fighting superiority over the Axis. But let me give you one instance. On the night of Nov. 14, off Guadalcanal there lay a Japanese battleship. It was a stormy night. Eight miles away was a ship of our own fleet. With the use of radar our ship, with its second salvo, sank the Jap battleship in the blackness of the night, eight miles away."

No Limitations to Electronics

SPEAKING ON THE SUBJECT "Rediscover the Rainbow" at Columbia University on May 20, Dr. Willard H. Dow made reference to the great future of electronics in his theme that recognition of immutable, natural scientific laws in relation to world-wide ways of living is the one way out for erring, squabbling, dreaming humanity.

The following is an excerpt from the talk he gave upon receipt of the Chandler Medal for distinguished service in science as president and general manager of The Dow Chemical Co.:

"The idea of one scientific development being a tool which helps in another development is clearly understood and appreciated by those with scientific experience, and but slightly understood by others.

The radio is probably considered by the public as one of the most necessary means of entertainment and communication, but the whole physical science of radio development is one of the most vitally necessary tools in all sorts of commercial operation. It permits automatic control where human hands cannot reach. The electron microscope in turn permits magnification that lenses cannot produce. It would be an unwise prophet who would attempt to define the probable limitation of electronics, or what it will do in aiding all science to further understanding and benefit."

Philco Will Train 60 "Radarettes"

A 50-WEEK COURSE including mathematics, elementary electricity, radio, television, radio laboratory technique, electrical drafting, industrial orientation and production processes is being given at Temple University to a selected group of sixty young women, all recent high school graduates selected from the Philadelphia area by Philco Corp. The training plan, involving full scholarships with pay, was initiated to meet the needs of the war emergency and help qualified girls to obtain the needed technical training for research work at Philco.

Upon completion of the course, the girls will be known as "Radarettes", and will serve as assistants to Philco engineers engaged in radar and other military radio work. According to Philco engineering vice-president David Grimes, women are more important today in the radio industry than ever before.

IRE Opposes Kilgore-Patman Bills

IN THE FOLLOWING RESOLUTION adopted on June 2, 1943, by the IRE Board of Directors, this engineering society took a firm position against socialization of engineering research:

"Whereas, The Board of Directors of The Institute of Radio Engineers is of the opinion that the scientific and technical resources of the Nation and in particular the radio personnel and facilities of the country are mobilized to a high degree and are working efficiently in the war effort; and

"Whereas, It appears that enactment of The Kilgore-Patman Bills S-702, HR-2100 to mobilize the scientific and technical resources of the Nation, to establish an Office of Scientific and Technical Mobilization, and for other purposes, would actually endanger the war effort by a reorganization of these resources along totally untried lines, and

"Whereas, It is the opinion of the Board of Directors that the premises given in the declaration of policy of S-702 are unsound and not representative of the facts; and

"Whereas, The enactment of these bills would establish a post-war bureaucracy inimical to the best interests of scientific and technical progress and thus also to the best interests of these United States; therefore, be it

"Resolved, That the Board of Directors of The Institute of Radio Engineers finds no valid reason for enactment of Senate Bill S-702 and House Bill HR-2100 and strongly opposes such enactment because these bills if enacted will result in confusing the war effort; and furthermore be it

"Resolved, That the Board of Directors of The Institute of Radio Engineers expresses its general opposition to any proposals which would have the effect of placing the scientific and technical personnel and facilities of the Nation under government supervision and control."

Status of Telegraph Merger

THE FIRST AND MOST IMPORTANT step toward merging of telegraph facilities in this country came on May 13 when heads of Western Union Telegraph Co. and Postal Telegraph Inc. signed a purchase agreement. The purchase is subject to approval of the FCC, stockholders of the two firms, and various other governmental groups. The purchase is to be effective at the earliest possible date, but in no event later than Oct. 1, 1943. Under its terms, Western Union will acquire all the assets and business of Postal, and assume its liabilities.

FCC Chairman James Lawrence Fly promised speedy consideration by the Commission in the following statement: "I am confident that a genuine public benefit, in terms of improved service during the war period, will result from a sound plan of merger between Western Union and Postal Telegraph. Our own Committee, composed of Commissioners Payne, Wakefield and Durr, I am sure, will continue to devote themselves assiduously to the task of studying the merger problem and of cooperating on the necessary procedures with all interested parties and agencies."

Supreme Court Strengthens FCC

A FAR-REACHING COURT decision which turns over to the Federal Communications Commission almost limitless control of all phases of broadcasting came when the Supreme Court, on May 10, upheld the restrictions which the FCC had ordered for chain broadcasting. The court opinion was 5 to 2, with Justices Frankfurter and Roberts dissenting. Networks are resigned to operation under the new rules, though some still refer to the rules as "a death blow to nation-wide broadcasting".

Signal Corps Establishes New Commercial Communications Agency

ALL RELATIONS between commercial communications services and the Army, with the exception of functions procured and administered by service commands, will be handled from now on by the Army Communications Commercial Agency, with offices at 50 Broadway, New York City. It will function as a field installation under the control of Col. I. W. Treest, Director of the Army Communications Division.

Wall St. Watches Electronics

REPORTS BY FINANCIAL FIRMS, articles in financial magazines and presentation of a lecture series on electronic subjects in the Governing Room of the New York Stock Exchange indicate serious interest in the post-war possibilities of the electronic industry from a financial standpoint.

A 42-page analysis of recent developments and post-war possibilities of electronics, prepared for its customers by Kidder, Peabody & Co. of New York City, is by far the most complete financial survey seen to date. It divides electronics into six fields primarily for convenience of analysis. Concrete facts and statistics are presented on pre-war, present and post-war activities in (a) radio fields, (b) radio frontiers of FM, facsimile and television, (c) communication fields, (d) lighting and related fields, (e) industrial fields, and (f) the electrical manufacturing industry. Products and applications are cited in each group, with yearly production figures where available. Leading manufacturers are named. Ten pages are devoted to financial descriptions of selected leading companies, and investment recommendations are made. Summarizing statements: (1) Investors should give little weight to war-time developments since present earning power is inflated; (2) The next important development will be widespread use of FM, with radio facsimile and television coming later; (3) Don't expect too much too quickly after the war since the electronic industry in general is concentrating now on winning the war; (4) Probably no other section of our industrial economy presents broader horizons during the next decade, (5) A substantial drop in earnings is to be expected after the war, followed by resumption of pre-war growth but probably at an accelerated rate; (6) Current publicity over-emphasizes the immediate potentialities in the field of electronics.

No. 2 in the series of "Industries of Tomorrow" bulletins by C. B. Richard & Co. of New York City is a four-page leaflet on the electronic industry, describing a few electronic developments and giving data on the shares and the capitalization of radio, television and of electronic concerns.

Weekly lectures under the auspices

of the New York Institute of Finance have been given at 11 Wall St. in New York for members of the Stock Exchange and officials of investment concerns, with outstanding engineers and scientists as speakers.

How a Bat Flies

John Mills of Bell Telephone Laboratories discussed "The Scientific Method", describing as examples the procedure used by scientists in determining how bats avoid obstacles when flying at night, how Bell developed the telephone, and how Bell Labs improved the DeForest audion through painstaking research. Quotes are: "Pin your faith to companies that have good research departments and are really doing research and not merely testing"; "If you know how a bat flies wou will know all you need to about the radio locators or radar".

Dr. K. K. Darrow, also of Bell Labs, covered "Transmutation and Radioactivity", starting with the structure of the atom and the use of neutron projectiles for changing atoms. He stated that it is now possible to change every atom into at least one other, and every element can be produced by directing neutrons at some other atom. Radioactivity produced artificially with a cyclotron makes it possible to mark certain atoms and trace them through the human system or through plants. Thus, water containing radioactive sodium can be detected at the tip of your finger 20 minutes after drinking it. Radioactive methods of exploring oil wells have recently been developed.

Dr. Willard F. Libby of the Univ. of Calif., speaking on "Chemistry and Electronics", continued the subject of nuclear physics with an explanation of how isotopes like heavy hydrogen are produced, and how an atomic isotope with almost any desired radioactive life can be obtained. He cited practical applications of the newly-gained knowledge, and prophesied that important advances would be made in the fields of biochemistry and medicine in the next few years through use of natural or radioactive isotopes. He pointed out that no business or industrial concerns are as yet producing radioactive substances for sale, and this factor is holding up industrial applications of radioactive techniques.

Ralph S. Beal, RCA Research Director, reviewed "Radio-Electronic

Research", predicting that electronic television would become a vast post-war industry giving employment to many people, and reporting on latest RCA developments such as high frequency heating and the electron microscope. Reviewing the part played by RCA Laboratories in radar development, he stated that basic research on apparatus and techniques had been started by RCA as early as 1932, and that RCA had installed collision-prevention equipment in its own airplane in 1937. Production of experimental radar units for the Navy and Signal Corps began shortly afterward.

Dr. David Grimes, Philco vice-president in charge of Engineering, addressed the group on "Electronics, FM and Television", pointing out first that electronics covers just as wide a field of endeavor as does sound vibrations. He explained basic principles by analogy: If we could see at a frequency corresponding to that of radio waves, each transmitting antenna would be like a huge lighthouse having a definite color. Everything radio waves pass through would be transparent, so that buildings would be invisible except for their metal frameworks. Suppose a particular transmitter produced green light; with AM modulation, this green light would flicker with modulation without changing color, but with FM modulation the color would vary while the brilliance would stay constant. Introducing television, he pointed out that we must transmit pictures as a series of impulses in much the same way that we transmit thoughts vocally as a sequence of syllables. Today, he said, television is equivalent in quality to 16-mm movies.

The remaining two scheduled lectures in the series, by A. C. Monteith of Westinghouse on "Electronics as Applied to Industry" and by Dr. W. R. G. Baker of General Electric on "Advance and Future Thinking", will be reported later.

The May 19, 1943 issue of *Financial World* contains a two-page feature article, "Electronics in the War —and Afterward", briefly describing some routine and spectacular applications of electronics, including a new healing ray that increases the speed of nature in repairing wounds by inducing erythema (reddening) of exposed flesh.

Manpower

THE INDUSTRY according to Ray C. Ellis, is faced by some currently acute problems. One of the most critical is the difficulty of securing and holding skilled employees.

The production of military radio and radar, although based on prewar radio industry manufacturing facilities, is virtually a new field—one employing a large number of young technicians who are now being called into the armed services in great numbers. The colleges to which the industry must look for skilled recruits to put new developments and discoveries into practical application—physicists, chemists and engineers—are subject to the same drain.

Use of still more women in the industry is one solution seen by Mr. Ellis, who points out that in some phases of manufacture women are more adept than men, as in the handling of delicate tube elements.

Already some 50 percent of the inspectors employed by the Signal Corps are women.

College Courses in Electronics

WRITING IN THE May 1943 issue of *The Journal of Engineering Education,* S. G. Lutz of Naval Research Laboratory analyzes college training in electronics thusly:

"Electronics still seems to constitute one of the weak links in most curricula. Much of the trouble students experience may be attributed to the way we must crowd a host of new and seemingly unrelated concepts into a single three or four semester-hour course. Practically all other electrical courses are based upon a very few fundamental principles which are developed in a sufficiently leisurely manner for the student to correlate them.

"In electronics, we may start with an orgy of modern physics associated with electron emission and space charge flow, introduce a host of new symbols for our discussion of the characteristics of diodes, triodes, etc., rush through an inadequate treatment of the application of these tubes in amplifiers, oscillators, etc., jump to phototubes with new concepts of electron emission, then to cathode-ray tubes and a smattering of electron optics, give passing mention to microwaves and end by spending most of the time on the industrial applications of hot and cold cathode gas tubes!

"Another factor which must be considered is that many of our concepts of electronics are changing and expanding very rapidly, just as they did during the last war, and many topics which we now pass over lightly soon will assume unusual importance. Many of our graduates now entering wartime communication work are coming in contact with electronic equipment which involve principles they have never heard of. This condition may continue after the war unless we are prepared to reorganize our treatment of electronics.

"In view of these deficiencies, eight semester hours seems the minimum time which communication men should be required to devote to electronics if they are to obtain a sufficient knowledge of this subject to begin to follow its progress in the literature."

New List of American Standards

MORE THAN 600 STANDARDS, 94 of which represent new and revised standards approved since the August 1942 issue, are listed with prices in the new list of American Standards published by the American Standards Association. The 20-page list for 1943 can be obtained free of charge by writing to the American Standards Association, 29 West 39th St., New York City.

A special section of the list is devoted to American War Standards, including those on fixed mica capacitors, meters, and radio receiver replacement parts.

IRE Post-War Planning Committee

A SPECIAL COMMITTEE under the Chairmanship of Haraden Pratt, Vice-President of Mackay Radio and past president of IRE, was delegated by the IRE Board of Directors with drafting of a plan for setting up a technical body to provide for post-war development of radio, television and electronic applications. The association is to be representative of a broad cross-section of the entire radio industry, and one of its objectives is to recommend methods of introducing new radio developments.

FM Oddities

A MUNITIONS PLANT in Detroit picks up the programs of FM station W45D daily and relays them via loudspeakers to about 6000 workers in its three plants. The station provides a special show at certain hours for stimulating worker's morale, consisting of appropriate melodies with no vocals and infrequent announcements. Other local war plants are showing interest also. Each war worker hearing FM is a good prospect for an FM receiver after the war.

During a luncheon in Philadelphia at which Lowell Thomas was awarded a medal by the Poor Richard Club, soft music came from the public address system. It persisted after the speeches started, giving a certain poetic grandeur to some of the duller phrases. Listeners thought the music a nice touch until an announcer broke in and gave the call letters of a local FM station. By some hard-to-explain circuit peculiarity, the public address system was acting like an FM receiver and picking up the signal.

Police Radio Convention

THE 1943 NATIONAL CONFERENCE of the Associated Police Communication Officers will be held at Madison, Wisc., Aug. 31 to Sept. 2. Discussions on war-time police radio operations, WERS, OCD, priority problems and similar war topics will occupy most of the time. Ray Groenier, Chief Radio Engineer of the Madison Police Dept., is Chairman of the conference.

WPB News About Quartz Crystals, Batteries, Steatite and Radio Sets

QUARTZ CRYSTALS are needed. Citizens who own property on which the crystals may be found, or know where any can be found, are requested to get in touch with the Miscellaneous Minerals Division, War Production Board, Temporary "R" Bldg., Washington, D. C. Only separate individual crystals weighing at least half a pound, at least three inches long and an inch thick are desired. They must be clear and color-less or have a light smoky color. Milky quartz, rose quartz and purple quartz (amethyst) are useless.

BATTERY PRODUCTION has been boosted to 425,000 per month to bring relief to rural dwellers who depend upon battery radio sets for daily war and food program news and for entertainment. This exceeds pre-war production, but the existing backlog of requirements means it will take quite some time to balance supply and demand. Furthermore, batteries require critical materials, facilities and manpower all subject to prior claimants, including the Army and Navy, hence the present rate may have to be cut back again.

STEATITE is plentiful now, along with a new product called multiform glass, hence the WPB Radio and Radar Division is encouraging their use by manufacturers for moulded insulators in electronic equipment. Phenolic plastics will probably be available for new uses later this year. Producers are urged to watch for changes in supplies and use their own initiative in switching quickly from materials becoming scarcer to those becoming less critical.

HOME RADIO SETS will soon be repaired with component parts standardized by WPB Limitation Order L-293. Production of dry electrolytic and paper capacitors, power and audio transformers and choke coils according to the new standards will start July 1. The new parts require minimum use of critical materials. According to latest information, they will carry brand names of manufacturers.

RADIO TUBES not on the preferred list will henceforth require a minimum rating of AA-1 instead of A-1-J. This applies chiefly to obsolete types.

Radio Business News

DETROIT ELECTRONIC LABORATORY, a new firm with headquarters at 10345 Linwood Ave., Detroit, Mich., announces a "Victory Repair Service" for hard-to-get ignition tubes, including the General Electric GL and GF series and the Westinghouse WL series. The new company is directed by John D. Gordon as General Manager, and will also develop and manufacture special-purpose electronic tubes such as those used for control equipment for resistance welding.

WEBSTER PRODUCTS has purchased the Armitage Ave. plant of Webster-Chicago Corp. in Chicago, and will continue the manufacture there of dynamotors, generators, inverters, voltage regulators, small motors and special instruments.

COOK ELECTRIC CO. has opened a new plant for its Bellows Division at 909 Diversey Parkway, Chicago, containing a modern testing laboratory with newest facilities for altitude tests on aircraft equipment.

EIMER AND AMEND have moved to new headquarters at Greenwich and Morton Sts. in New York, with manufacturing shops, laboratories, stock rooms and offices all in a single building.

WESTINGHOUSE has opened a new four-acre blackout plant on the East Coast for production of special Army radio equipment. Illumination is provided by nearly two miles of fluorescent lamps simulating daylight conditions, and huge electric fans provide ventilation in the windowless structure. Interior traffic flows along the side walls, leaving central areas available for machinery.

RADAR EQUIPMENT for a single large airplane costs about $30,000, and radio communication equipment for large planes costs about $20,000, according to testimony presented before the House Appropriations Committee.

PERMO, INCORPORATED is the new name adopted by Permo Products Corp. of Chicago, manufacturers of pivots for precision instruments.

London News Letter

By JOHN H. JUPE,
London Correspondent

Rediffusion. The British Post Office Engineering Department has carried out some advanced experiments in the transmission of broadcast programs over the usual telephone lines, using radio frequency methods. Plans have more or less been completed whereby it will be possible to give a choice of six programs. Like many more things, however, it seems highly probable that no general offer will be made to telephone subscribers until after the war.

The cost of the audio frequency rediffusion service which is so common in this country is about 30 to 50 cents per week depending on whether a loudspeaker is hired from the company or supplied by the subscriber. There is no standard charge, as all the present systems are in private hands.

Electrical Brain Writing. Some weeks ago, considerable interest was aroused in this country by the introduction of "brain writing" in a murder trial. A young man who committed a murder seemed definitely abnormal, so tests were made on him by means of a direct ink-writing electroencephalograph. The case was featured in the daily press as it was the first time in British legal history that such an instrument had been used as a means of obtaining evidence.

Industrial Uses for X-Rays. An x-ray machine designed by the British Post Office is being used to find pins and paper clips in waste paper. Bundles of paper are taken in five at a time, and the presence of any metal is shown at once on a screen. Good bundles are thrown into a basket; bad ones are laid aside for hand sorting. The pulping plant is no longer damaged by pieces of metal, and the time taken to sort the scrap has been reduced by one tenth.

Personnel

John K. Hilliard has joined Altec Lansing Corp. of Los Angeles as chief engineer of their Radar and Motion Picture Division. He was formerly chief transmission engineer of the M-G-M sound department, and recently served as consultant to the Radiation Laboratories at MIT.

Frederick S. Rowe will be responsible for scheduling and coordinating production of electronic tubes in all plants of the Westinghouse Lamp Division, in his new position as manager of electronic tube production and stocks. He joined Westinghouse in 1913 as a production clerk, at the age of 16.

Mr. H. B. Crouse, president of the Crouse-Hinds Co., Syracuse, N. Y. manufacturers of electrical equipment since 1897, died of a heart ailment on June 12, at the age of 70. The firm is one of the largest manufacturers of electrical appliances in the country, was among the first to manufacture electric traffic signals, and is now engaged in war production.

Mr. Crouse was a graduate of Phillips Andover Academy, from which he was graduated in 1891. After spending several years in industry, Mr. Crouse organized the Crouse-Hinds Co. with J. L. Hinds in 1897, and has always been extremely active in that organization.

The J. H. McGraw Medal "for signal contributions to the advancement of the manufacturing branch of the electrical industry" was awarded to Mr. Crouse in 1940. Long a member of the National Electrical Manufacturer's Association, Mr. Crouse was also a director of the New York Telephone and Telegraph Co. and also of the Massachusetts Mutual Life Insurance Co. In February he was named a member of the War Department's Advisory Committee on Procurement and Policy. In addition he was an active participant in many civic organizations in Syracuse, N. Y.

Thaddeus Niemiec becomes chief engineer of General Control Co. His previous experience includes electrical and electromechanical work at Westinghouse, along with electronic engineering.

Leslie G. Thomas steps up from works manager to vice-president in charge of production at International Resistance Co. His pioneer production activities in radio manufacturing date back to 1920.

David E. Chapman, formerly vice-president of Airadio in Stamford, Conn., is now chief engineer of United Cinephone Corp. of Torrington, Conn.

Col. William O. Reeder and **Col. John H. Gardner** of the Signal Corps were among 52 colonels recently elevated to the rank of Brigadier General. Both have long records of achievement in military communication. Officers in the field received more promotions than those in Washington.

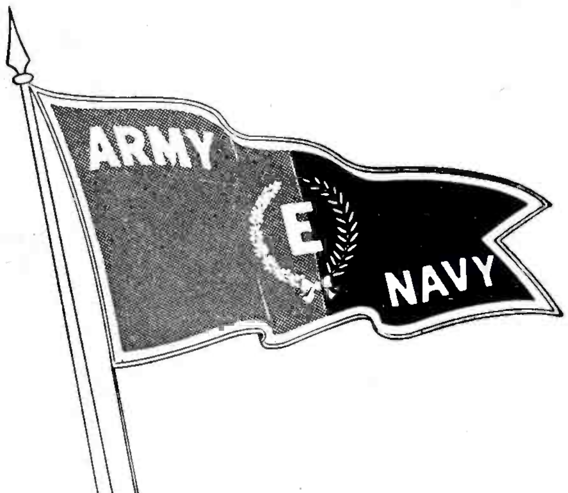
Carl A. Frische has been named chief research director of the Sperry Gyroscope Co., and assumes charge of the company's Garden City, Long Island laboratory, which designs, develops and tests military, marine and aircraft precision instruments. He has made notable contributions to the development of automatic pilots and bombsights and to the soundproofing of airplanes since joining the Sperry organization in 1933.

Comdr. D. F. Shea and **Lieut. Comdr. Ralph T. Brengle** have been appointed assistants to the Head of the Radio Division of the Bureau of Ships. Comdr. Shea has had communications engineering experience, and was in charge of procurement before his present duty. Cmdr. Brengle is widely known in the radio industry as head of the Ralph T. Brengle Sales Co. of Chicago.

Thomas A. Morgan, president of the Sperry Corp., received an honorary Doctor of Science degree from Duke University in recognition of his leadership in building up the Sperry Gyroscope Co. and two associated firms. His firm developed the highly important Klystron velocity-modulated tube following initial research at Stanford University.

Meredith L. Koerner, formerly with the Radio Intelligence Division of the FCC, has joined the OWI Wire and Overseas Communications Facilities Division as associate engineer, and will have charge of the purchasing and inspection of communications equipment. He had previously served for six years as assistant chief engineer of station WSBT in South Bend, Ind.

FM Broadcasters, Inc., reelected Walter J. Damm of W55M in Milwaukee as president, T. C. Streibert of W71NY in New York City as vice-president, Robert T. Bartley as secretary-treasurer, and F. M. Doolittle of W65H in Hartford, Conn., as a director. Newly elected directors are George Lang of W59C in Chicago, Walter Evans of W57PH in Philadelphia and Arthur B. Church of W9XER in Kansas City, replacing Carl J. Meyers (now in the Navy), John Shepard, 3rd, and Paul Morency. Remaining directors (not up for election this year) are J. H. DeWitt, Jr., of W47NV in Nashville, John V. L. Hogan of W2QXR in New York City and Ray H. Manson of W51R in Rochester, N. Y.



ARMY-NAVY AWARDS

AMERICAN CYANAMID & CHEMICAL CORP., SELDEN DIV.
Bridgeville, Pa.

D. W. ONAN & SONS
Minneapolis, Minn.

RADIO SPEAKERS, INC.
Chicago, Ill.

RAYTHEON MFG. CO.
Newton and Waltham, Mass.

R. C. A. LABS
Princeton, N. J.

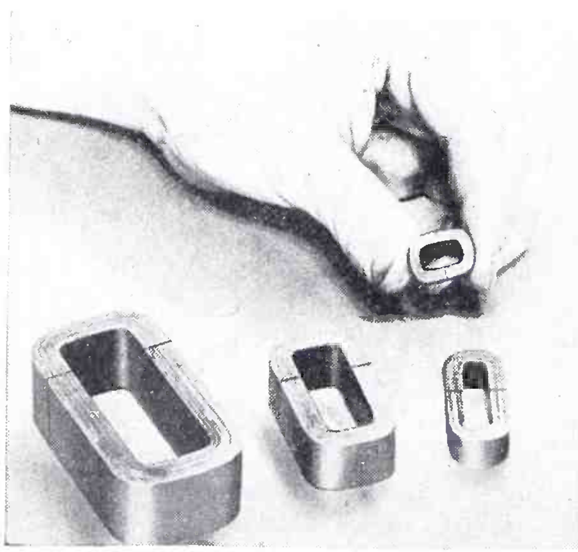
WORCESTER MOULDED PLASTICS CO.
Worcester, Mass.

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

Hipersil Cores for Communication Components

DESIGNED FOR use in radio transformers, chokes, relays, reactors and loading coils, a new line of Type "C" Hipersil cores are available in a wide range of sizes. The manufacturer states these steel cores have one-third more flux-carrying capacity than conventional cores of the same size and weight, and that assembling and replacement are simplified because only 2 to 4 pieces are involved. Construction of cores consists of winding a Hipersil strip continuously on a mandrel of desired dimensions. It is annealed at high temperature and vacuum-impregnated with a plastic compound to make it a solid unit. It is then cut into two segments, the ends of which

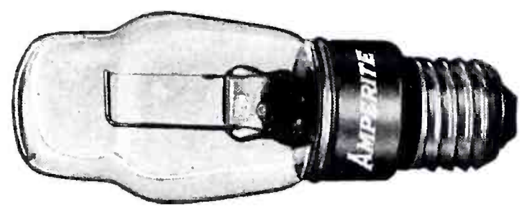


are machined and worked to produce coinciding surfaces when reassembled. A check test for fidelity of performance is made. Cores are assembled on coils by means of metal bands tightened to insure correct tension. The butt joint eliminates cross-fluxes or masking effect and does not increase core loss. Each joint is equivalent magnetically to a 0.0005 air gap. Hipersil steel cores of nominal gauge are used for frequencies up to 400 cps; thinner Hipersil steel is available for frequencies higher than 400-cps; and a still thinner gauge is available for very high frequencies and exceptional fidelity.

Department 7-N-20, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., or any Westinghouse office will supply further information.

Regulator Tube

THIS REGULATOR TUBE (for use in industrial applications and railroad signals) decreases the 40 percent voltage variations on railway signal systems to 5 percent. It is not affected



by temperature or humidity and has no moving parts. Standard screw or standard radio octal bases can be supplied by the manufacturer, Amperite Co., 561 Broadway, New York, N. Y.

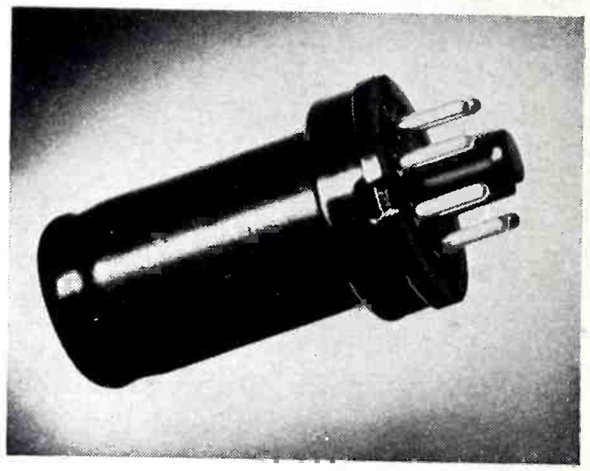
Coaxial Antenna

SUITABLE FOR FIXED station use, and pre-tuned at the factory to the desired operating frequency, Type 899 vertical coaxial antenna is easy to install, and provides an inexpensive half-wave radiator in the frequency range of from 30 to 200 Mc. The upper half of the antenna is a whip of conventional design. The lower half, or skirt, is a 2½ inch tube. The entire assembly is supported by a 1$\frac{5}{16}$ inch support pipe 12 ft. long, which is attached to a mast with a clamp. Overall length, including support pipe, is about 20 ft. and the weight is 48 lb. No impedance matching devices are required. The whip and skirt are cut to length at the factory for the exact operating frequency. The unit is designed to be fed from a 70 ohm coaxial transmission line. Fourteen feet of $\frac{7}{8}$ inch coaxial cable are provided with the antenna.

Victor J. Andrew Company, 363 East 75th St., Chicago, Ill.

Tube Type Quartz Crystals

ADDED TO THE LINE of the manufacturer's piezoelectric quartz crystals is a new special-purpose type which comes housed in a conventional metal tube case. By means of this mounting, freedom from moisture and atmospheric changes are secured.



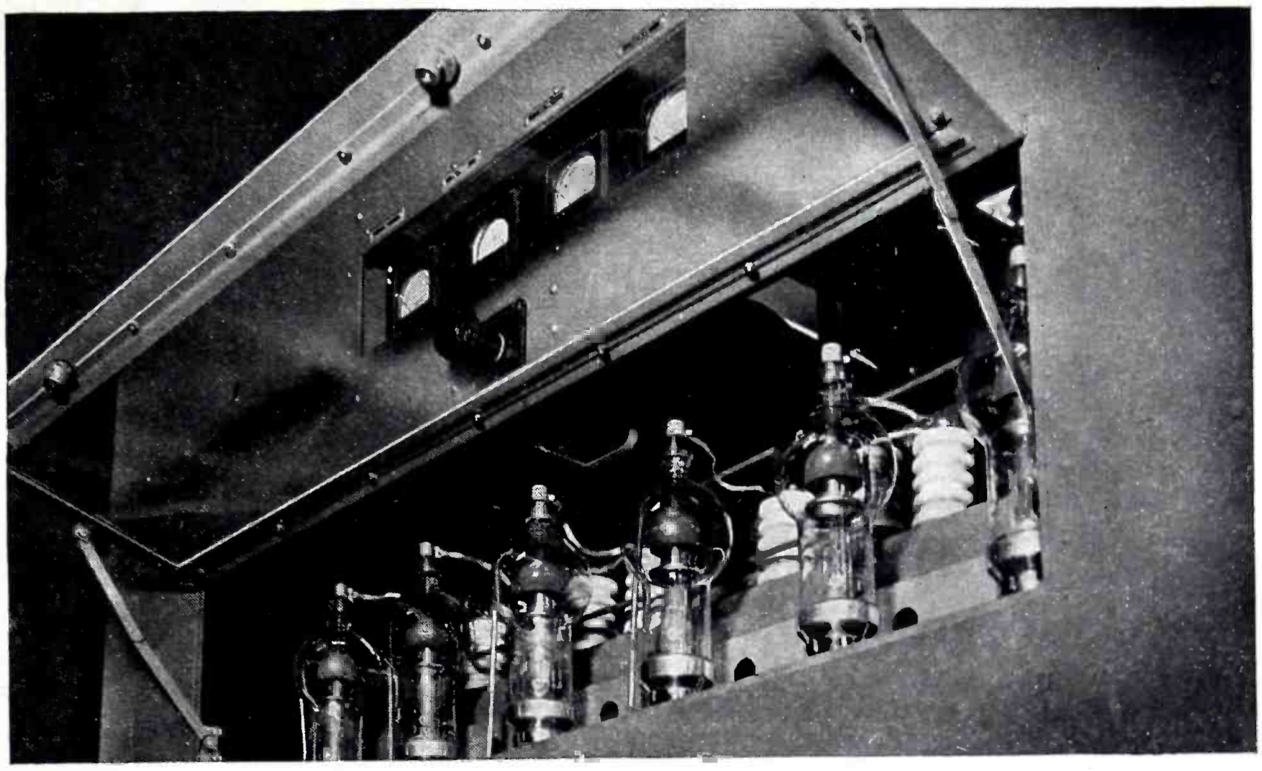
Another service the manufacturer offers is their facilities to fabricate all crystal oscillators and resonators completely from the raw quartz.

John Meck Industries, Plymouth, Ind.

Vibration Fatigue Testing Machine

MODEL 100 VIBRATION fatigue testing machine is similar in appearance and operation to Model 25, which was described in April ELECTRONICS. The main difference between the two models is the greater capacity of Model 100. Its specifications are: Horizontal table movement; table area of 15x18 ins; table load capacity, 100 lbs; table mounting holes (115) $\frac{3}{8}$ inch-16 thread; total displacement, 0 to 0.125 ins. (adjustable); maximum capacity is approximately 23 G; frequency is rated at 10 to 60 cps (adjustable); base measures 24x42 ins; base mounting hole dimension measures 20x38 ins; total height is 12$\frac{3}{8}$ ins; net weight is 550 lbs; the motor is rated as 1½ hp, 220 volts, 60 cps, a.c., 3-phase.

All American Tool & Machine Co., 1014 Fullerton Ave., Chicago, Ill.



Since 1878

THROUGH *the growth of years* of the communications industry in all its phases, the pioneers have depended upon equipment of Bunnell design and manufacture. Today the industry broadens its horizons; its developments will revolutionize untold hundreds of industrial processes. Again the pioneers will look to the technical assistance of the Bunnell Engineering Group. Their experience is at your disposal.

B SINCE 1878

J. H. BUNNELL & Co.

GENERAL OFFICES: 215 Fulton St., New York City · FACTORIES at Brooklyn, N. Y.

Designing Engineers and Manufacturers of:

ELECTRONIC INDUSTRIAL DEVICES ★ INDUSTRIAL RECTIFIERS
HIGH POWER RADIO FREQUENCY GENERATORS ★ TRANSMITTERS
RECEIVERS ★ AUTOMATIC TELEGRAPH EQUIPMENT

Photoelectric Protection System

THIS PHOTOELECTRIC protection system projects a fence of invisible light over distances of 1500 ft. and gives instant local or central-station alarm if an intruder enters the protected area. The instrument may be used to protect harbors, docks, industrial properties, airports, and similar large areas. It consists of a light source, Type L60M, which is aligned with a receiver, Type A30M, to which it focuses a modulated beam of infrared light. The receiver is not affected by other artificial light or by day-light. In applications where infrared light is not required, the system exceeds a protection area of 2000 ft. A fan in the light source serves as a light chopper to produce rapidly fluctuating light of the desired frequency, and also cools the heavy-duty lamp. Once the invisible beam of light projected to the receiver is momentarily broken, the alarm circuit latches in operation. Either power or tube failure will cause the alarm circuit to operate as though the light beam had been broken. Supplied with the receiver and the light source is an auxiliary latching relay with a reset button. The equipment is designed for operation on 105 to 125 v., a.c.

Photoswitch Inc., 77 Broadway, Cambridge, Mass.

Choke Coils

CHOKE COILS rated at an inductance up to 22 henries, maximum, may be had wound and adjusted to suit individual requirements.

Union Electric Products Co., 7 Liberty St., Newark, N. J.

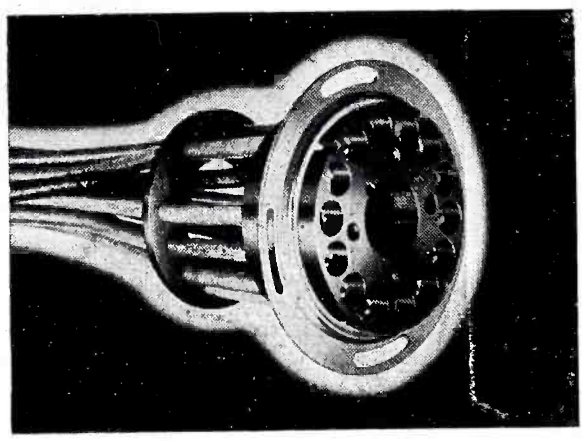
Jacks for Mobile Field Units

TYPE JK-37 JACKS are U. S. Army Signal Corps approved, and are available for prime and sub-government contractors. The jacks (of a telephone switchboard extension type) have coin silver contacts, and are actually a three-way, heavy duty, three-prong type with high impact phenolic body and steel bracket attachments.

Universal Microphone Co., Inglewood, Cal.

Cathode-ray Tube Socket

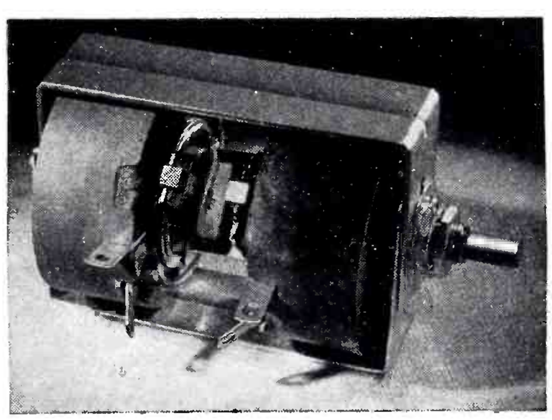
THESE ONE-PIECE MOULDED construction cathode-ray tube sockets were designed to completely enclose and seal the contacts against temperature and humidity conditions, and to provide high voltage flashover at high altitudes, and high resistance between adjacent pins. Another feature is a strain relief ring which protects the soldered joints against vibration pull, or twist of the wires. The sockets are supplied in either assembled units complete with cable, or ready for assembly.



Franklin Mfg. Co., 175 Varick St., New York, N. Y.

Tandem Power Rheostats

COMPACT, TANDEM POWER rheostat assemblies, of two or more sections, are made up of two 25-watt or two 50-watt rheostats coupled together and held in a metal cradle. One-hole mounting and locking-projection are used. The individual rheostats can be of any standard resistance value, taper, tap and hop-off, and all units go through the same degree of rotation as the single shaft is turned. The units are fully insulated from each other and from the ground. These assemblies are made only on special order.



Clarostat Mfg. Co., Inc., 285 North 6th St., Brooklyn, N. Y.

Half-Wave Type Rectifier

A HALF-WAVE RECTIFIER of the selenium type, designated as N type, is given a special forming process to assure long life. It has a working temperature range which extends from –70 deg. C to +75 deg. C, and a negative temperature coefficient. All associated equipment, such as meters, relays, etc., have positive temperature coefficients with resulting compensation when used with selenium rectifiers.

Type N-2 consists of two rectifying elements 5/32 ins. in diameter assembled in a tubular plastic case 15/64 ins. and is rated 10 volts a-c. The rated voltage is 5 volts a.c. per rectifying element. The d-c rating for continuous load is 1 ma; for instantaneous load, 3 ma. Impedance in the forward direction is 1000 ohms. Impedance in reverse direction is 1 megohm per plate. All units are hermetically sealed with special sealing compound so that the assembly is independent of atmospheric changes and impervious to moisture. Two soldering terminals are provided.

Selenium Corp. of America, 1800 W. Pico, Los Angeles, Cal.

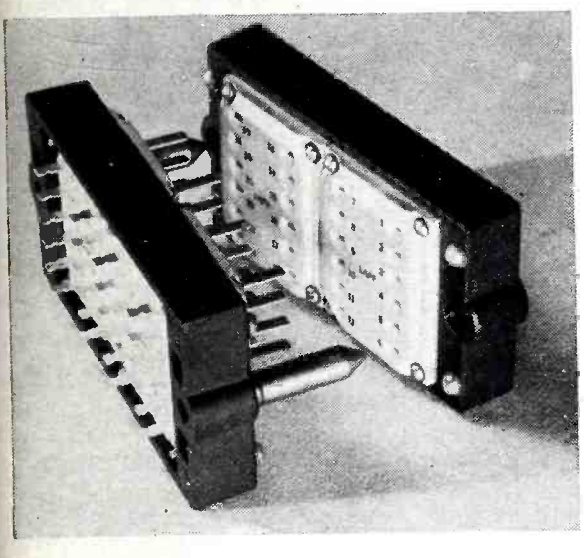
Kettles for Melting Electrical Compounds

CALLED "HEET-MASTER", these kettles are insulated on the outside, and heated from the inside by any gas line. They are designed to heat quickly with minimum fuel. A removable immersion tube heating unit makes cleaning easy. Accurate temperature control is achieved by the use of an electric magnetic valve and thermostat with a range of 150 deg. to 550 deg. F. The draw-off valve which is used for filling transformers, batteries, condensers and other electrical equipment is controlled by lever action outside and on top of the unit. It is a non-drip type, and opens inside the kettle. A hand control rod or foot pedal can be attached for convenient operation. Four valve reducers are furnished with the unit to reduce the stream of melted compound to 3/4, 1/2, 3/8 and 1/4 inch, as desired. The kettles are compact, and come in sizes of 5, 10 and 25 gallons.

Aeroil Burner Co., Inc., West New York, N. J.

Plug Receptacle Assembly

A PLUG-RECEPTABLE ASSEMBLY, for use with panel-rack type of radio equipment, features mechanical precision; rugged construction to withstand mistreatment in the field; full-floating contacts; and steatite insulation which resists flashover and surface tracking. Each plug and receptacle is constructed of a zinc die-casting on which are mounted



four ceramic plates, which hold the metal contacts in full floating position. At the ends of the male plug are machined steel pins, which engage corresponding holes in the female receptacle, to provide positive and accurate alignment. The standard design of these plugs provides 24 contacts, but units carrying contacts in any multiple of 12 can be produced.

Lapp Insulator Co., LeRoy, N. Y.

Humidity Test Chambers

STANDARD LOW AND HIGH temperature test chambers are available with automatic humidity control. The units have standard refrigeration equipment and a new attachment for humidity control. The standard relative humidity range is at temperatures from ambient to 140 deg. F. Special adaptations can be made for humidities below ambient if the requirements are known. The exterior overall measurements are 95 x 91 x 42 inches. Usable space measures 52 x 27½ x 30 inches. The interior cubical content is 25.9 cu. ft.

Model RTCI-H embodies, as an integral part, equipment for mechanical refrigeration and electric heating. Its temperature range is minus 55 deg. C. to plus 70 deg. C. Other features include the use of a two-stage Freon condensing unit and special refrigeration accessories that make possible flexible operation at various loads and temperatures. Positive forced air circulation, that can be varied in volume, and temperatures with thermostatic control are used for tests on delicate mechanisms and precision equipment. Observation of products under test is provided by a door having five sealed and dehydrated panels of glass measuring 46 x 21½ inches. The steel frame door has a clear opening which measures 51½ x 26½ inches.

American Coils Co., 25 Lexington St., Newark, N. J.

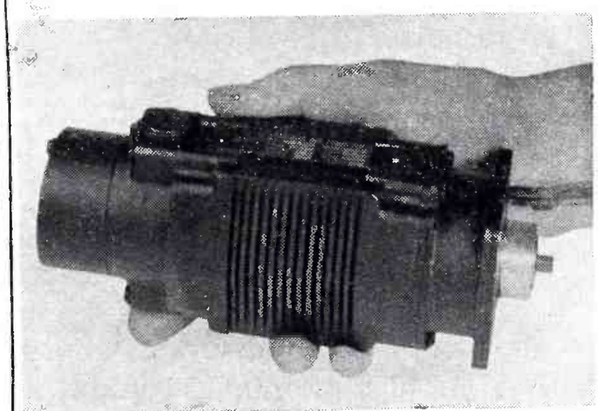
Optical Comparator

THIS COMPARATOR is an instrument for quickly and accurately measuring and comparing intricate shapes for inspection purposes. It checks such items as screw threads, parts for instruments, dies, gears, etc., for height, width, thickness and radius. It may also be used in industrial applications as a surface illuminator, strain finder, opaque projector, or stereo projector. The instrument is particularly useful for inspection of mass production parts which are not easily checked with ordinary gauges. After a preliminary adjustment, the instrument will check an unlimited number of similar objects in rapid succession. The comparator operates by the use of a 32-candle power incandescent lamp which is focused into a powerful beam by an aspheric condenser lens system which operates in conjunction with a projection lens. A clear image of the part under examination appears on a ground glass screen which measures 9x15 ins. On the same screen is placed a sketch of a perfect model which has been drawn in the same scale of magnification on a transparent sheet. A centering device aligns the drawing with the contour of the projected object and permits a detailed comparative examination. The instrument operates on 110–115 v., a.c., and may be used in any room under normal lighting conditions. Overall dimensions are 16½x17½x40 ins.

Fish-Schurman Corp., 230 East 45 St., New York, N. Y.

Electric Motors for Remote Control Devices

THESE LIGHTWEIGHT MOTORS incorporate the manufacturer's "Fastop Clutch" which stops the driven member in 1/50th of a second from 8000 rpm. These are for use in aircraft. The controls are flexible and operate efficiently at low temperatures. The

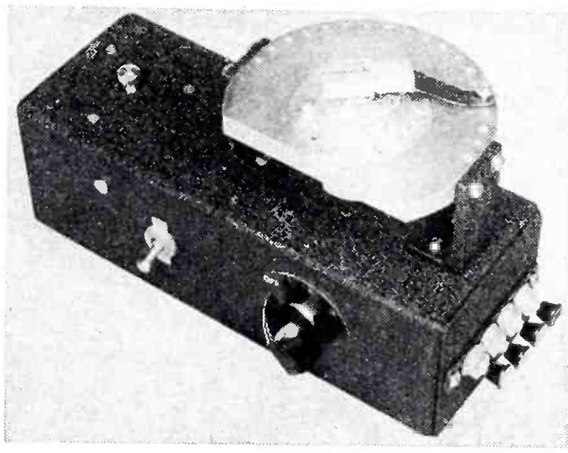


manufacturer recommends the use of this patented clutch in applications where instantaneous braking is desired. Illustrated is DD-20 electric motor with a Fastop clutch and burn out protection. It has a peak power output of $\frac{8}{10}$ hp and weighs 5.56 lbs. It is patented by the manufacturer, Lear Avia, Inc., Piqua, Ohio.

Aircraft Autosyn Voltage Calibrator and Polarity Indicator

MODEL NO. 7 is an instrument used in the production-testing of aircraft autosyn indicating motors. It may also be used by military inspection stations and repair depots. The autosyn, being the heart of the instrument panel on aircraft, requires a quick method of checking its calibration and polarity against a known standard.

To operate the unit it is necessary to insert the autosyn motor in the frame. No clamps are required; all fits are held to 0.001 in. The positioning arm is then slipped over the rotor shaft which ordinarily receives the indicating pointer. To check calibration, the positioning arm is set at 90 deg. or center scale by letting a spring arm snap into position. The unit is then connected to a vacuum tube voltmeter and a power source of 400-cycle. A standard autosyn, an integral part of the instrument, is then rotated by means of a knurled thumb screw until the vacuum tube voltmeter reads zero. To check calibration the positioning arm from the



center scale position is lifted and moved clockwise or counter-clockwise one position. Each position from center is equal to 10 deg. with an accuracy of plus or minus 3 minutes. The vacuum tube voltmeter will then read voltage deviation from standard and can be checked progressively every 10 deg. after balance to zero is made. The price of the instrument is approximately $319.00. It measures 10x6x3 ins., and weighs 6 lbs. All pin positioning tolerances are held to plus or minus 0.0002 in.

Televiso Products Co., 6533 Olmsted Ave., Chicago, Ill.

Removable Terminal Stud

An addition to the line of the Rosan Locking System, used in airplane manufacturing and in the electrical field, are Rosan Terminal Studs which are stud-locked in material but are removable because the locking ring is furnished with a flange by which it may be pried out, the stud replaced, and the ring reinserted in its original position. This may be accomplished without disconnecting wires or removing a panel from a ship when repairs are necessary.

The Rosan Locking System itself consists of a steel stud which is locked in the softer material by means of a steel locking ring, serrated inside and out. When the ring is driven into place, its inner teeth engage the teeth of a serrated collar on the stud. The outer teeth broach their way into the material. Pressure of surrounding material causes the ring to close in on the serrated collar, making a solid unit of the whole.

Bardwell & McAlister, Inc., Hollywood, Cal.

General Purpose Radio Relay

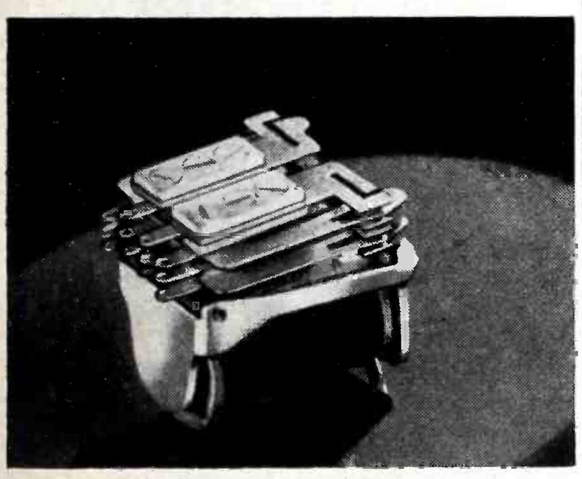
A GENERAL PURPOSE RADIO relay, Series 345, for aircraft, is available in contact combinations from SP, ST, up to three PDT. It has a large coil winding area and measures $2\frac{3}{8}$x$2\frac{1}{32}$x$1\frac{11}{16}$ ins. Contacts, rated 12 amps at 24 v. d.c., are arranged to withstand 10 g acceleration and vibration in all positions. Coil resistances range from 0.01 ohm to 15,000 ohms. Standard voltages are 16 to 32. Other values are also available. The bearing is a pin type of hardened, non-magnetic, stainless steel and is staked to the armature hinge. The armature return spring is a torsion type and maintains an even spring pressure. Relay parts are plated to resist deterioration under conditions of high humidity.

Circular No. 345 describes these relays which are available from Guardian Electric Mfg. Co., Dept. 345, 1625 W. Walnut St., Chicago, Ill.

Tiny Relays

CLASS "S" DESIGNATES a line of tiny, sensitive and rugged new relays which provide twin contacts, built-in vibration resistance, and a range of operating and release speeds.

Typical assemblies, having a maximum of six contact springs, measure $\frac{3}{4}$ x $1\frac{1}{2}$ x $1\frac{3}{8}$ ins. in size, and weigh $1\frac{2}{3}$ oz. Assemblies with maximum capacity of 12 springs are



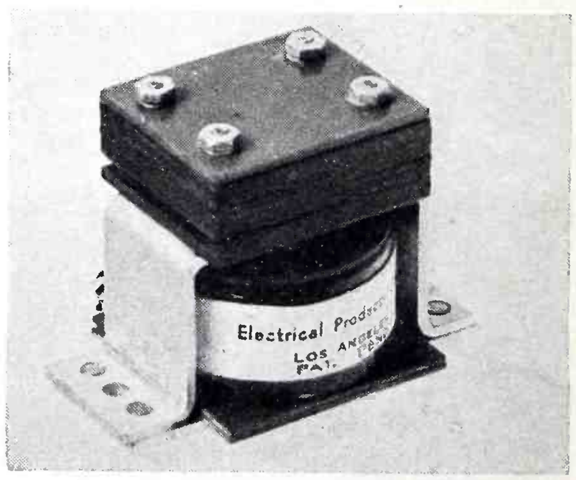
slightly larger, and weigh about 2 oz. Relays can be supplied with any number of springs up to the maximum and with any combination of make, break and break-make contact arrangements. Vibration resistance (provided by torsion) insures against false operation or release of contacts at up to 10.5 g's ($\frac{1}{16}$ in. excursion at 60 cps), as determined by a cathode-ray oscillograph and stroboscopic examination. Twin contacts assure positive contact operation, and will make or break 1 amp non-inductive, or ½ amp inductive load, and carry 2 amps.

Operating speeds range from 2 to 16 milliseconds, release speeds from 5 to 85 milliseconds; coils are available from 150 to 3500 ohms, for d-c operation up to 48 volts. Other features include resistance to humidity, to temperatures from −40 to +130 deg. F, and to insulation test voltages up to 500 volts (a-c test current).

Automatic Electric Co., 1033 Van Buren St., Chicago, Ill.

Sealed Relays

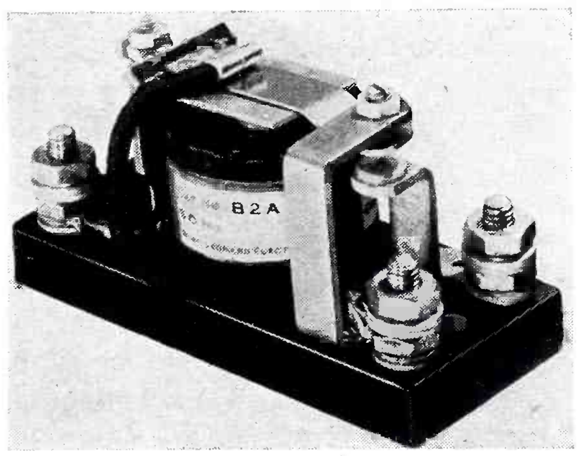
A SEALED CHAMBER is one of the safety features of a new midget relay which is a light, compact and sturdy instrument designed to withstand hard usage. The sealed chamber serves as an effective arc quench and reduces fire and explosion hazards. While rated at 25 amps, the manufacturer states the new relay operates satisfactorily at 50 amps and has been tested without failure at 120 amps, inductive load. An overtravel spring insures positive contact pressure and instant break release. The relay is factory adjusted and sealed. Army tests which the relay has withstood include overload; vibration at 55 cps with 0.06 inch excursion; acceleration of 10; and salt spray tests of 240 hours duration. Another feature of these relays are reversible contacts. If worn with excessive use, the contacts may be reversed in the field to provide new surfaces without disturbing adjustment.



Electrical Products Corp., Los Angeles, Cal.

Relays for Aircraft Power Circuits

BULLETIN NO. 103 describes relays which are designed particularly for aircraft power circuits. The armature and contact assembly of the relays retain either position under conditions of vibration and shock and at high values of acceleration of gravity. The normally-open, SP contacts are rated 25 amps at 24 v., d.c., non-inductive load. The contact gap and tail spring tension are adjustable. Molded bakelite, nearly ⅜ inch thick, forms the base which measures 1⅜x3⅛ ins. Two holes are provided in the base for mounting.



Ward Leonard Electric Co., Mount Vernon, N. Y.

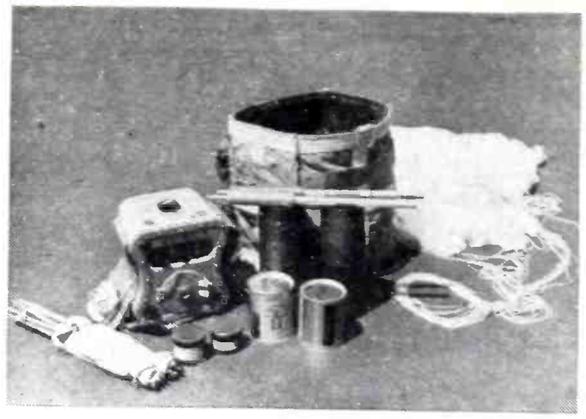
Plastic Battery Retainer

A PLASTIC STORAGE BATTERY, for use in certain types of Exide batteries, is now being manufactured from slotted polystyrene. The manufacturer states that the retainer has, in addition to technical advantages, more permanence than former types of retainers.

The Electric Storage Battery Co., Philadelphia, Pa.

Emergency Radio Transmitter and Glass Kite String

A PRECISION EMERGENCY radio transmitter which automatically sends out SOS signals is called the Gibson Girl and was developed by Bendix Aviation Ltd., of North Hollywood, Cal., in collaboration with the Signal Corps' Aircraft Radio Laboratory. The equipment is for use of fliers forced to make crash landing at sea. The transmitter is waterproof. It weighs 33 lbs. with its accessories, and is capable of sending the distress signal over thousands of square



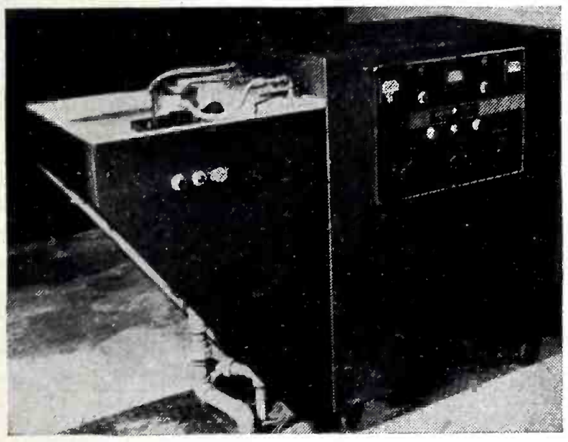
miles. Rotation of a hand crank operates a keying device which automatically spells out the SOS and also produces the necessary power through a generator. The voltage output of the generator remains constant. The device is pre-tuned to the International distress frequency of 500 kcs and is capable of tripping tuned automatic shore alarm stations. Controls on the front panel enable the user to operate the set manually for sending messages in code. The transmitter kit, colored a vivid yellow so that it may be easily discernible in water, consists of the transmitter, kite, two deflated balloons in sealed cans, two hydrogen generators, two spare reels of antenna wire, and a signal light.

Glass yarn, used as the kite string, is manufactured by Owens Corning Fiberglas Corp., Toledo, Ohio. The yarn has great strength in proportion to its weight, and does not rot or deteriorate from the effects of salt water, tropical sunlight, rain or dampness. The yarn is twisted and plied from continuous filament glass fibers which can be drawn to indefinite lengths.

General Electric Products

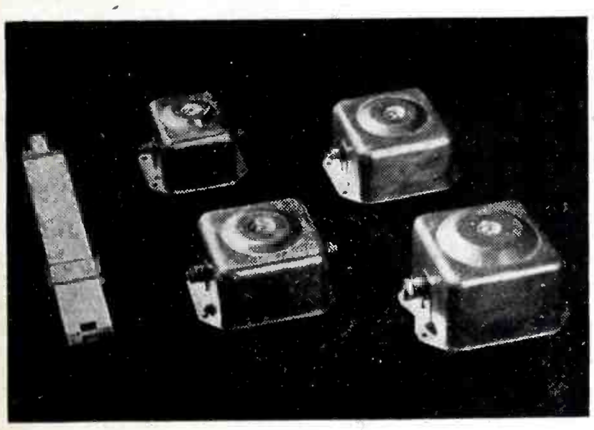
A NEW LINE OF electronic heaters for h-f induction heating and radio-noise filters for aircraft have been announced by the General Electric Co., Schenectady, N. Y.

THE HEATERS are for induction heating of metal parts for brazing, soldering, and selective heat treating, and are essentially power oscillators which convert 60-cycle power to high-frequency power at approximately 500,000-cycles. Two standard sizes are available; the first has an output of 5 kw and the other an output of 15 kw. Simple circuits are employed and the electronic tubes, controls and other equipment are arranged in compact, completely enclosed cabinets. The manufacturer states that the use of conservatively rated elements reduces maintenance to the periodical replacement of tubes, which when properly applied have an average life expectancy of 5000 to 10,000 hours or more. Attached to the electronic heater is a work table with water-cooled coil, or coils, connected to the heater terminals. Among the advantages given for the heaters are: Heating is rapid



and can be confined to the area desired; operation can be carried on by unskilled operators after preliminary adjustments have been made; and the amount of heat and its distribution is controlled accurately and automatically.

THE RADIO NOISE filters have high attenuation characteristics and are



for use in suppressing noise, especially from 200 to 20,000 kc, in aircraft electric systems (circuits with such equipment as generators, amplidynes, inverters, and dynamotors). The filters are compact and lightweight—for example, in the 100 amp rating the unit weighs 2½ lbs, and measures 5 x 4 x 2½ ins. They can be mounted in any position, and will operate over a temperature range of ±50 deg. C. Available in ratings of 20, 50, 100 and 200 amps, d-c at 50 v, the filters comply with U. S. Army Air Forces specifications, including the requirements of vibration and acceleration. Complete information is contained in bulletin GEA-4098.

Literature

Tube Substitution Chart. War time tube substitution chart giving approved government types for 288 types available prior to the government limitation order. Preferred substitutions are shown and types are coded to indicate necessity of changes such as changing sockets, changing bias, using external shield, using filament shunt and rewiring sockets. A functional cross index shows the replacement with regard to functional considerations vs. heater considerations. Available from National Union Radio Corp., Newark, N. J.

End Fittings. Bulletin 43 deals with end fittings for shafts and casings. These fittings cover a wide range of application requirements and are grouped according to the size of shaft or casing with which they can be used and should be selected accordingly. This bulletin also includes flexible shaft data and flexible casing data. Bulletin 43 available from S. S. White Industrial Division, 10 E. 40th St., New York, N. Y.

Spot Welders. Electric welding equipment and transformers are described in Bulletin 42-W. Spot welders for aircraft production, air operated projection spot welder, butt welders, push and gun welders are among the several welders illustrated in this booklet. Also illustrated are several manual operated, motorized, air operated and variable speed welders. Bulletin 42-W available from Eisler Engineering Co., Inc., 750 S. 13th St., Newark, N. J.

Communication Receivers. "Unitized" communication receivers are explained and ilustrated in this 4 page folder. In this system there are three basic cells; r-f, i-f, and audio, each is assembled in a standardized protective metal case. Cell components are arranged so that 75 percent less hook-up wire is required. Available from Harvey Machine Co., Inc., 6200 Avalon Blvd., Los Angeles, Calif.

Transformers. Bulletin 160 describes air-cooled transformer applications in war production industry. The types of air-cooled transformers manufactured are described and illustrated. The range of 55 deg. ratings of auto, two winding, three winding and four winding type transformers up to 50 kva are listed. "Power Where You Need It" available from Acme Electric and Mfg. Co., Cuba, N. Y.

Relays. Bulletin 800 describes relay type TD1C and type TD3C. These relays provide an adjustable or fixed time delay between the closing of a control circuit and later closing or opening of a load circuit. The uses, features, housings, construction, time scale and price list are included. Bulletin 800 available from R. W. Cramer Co., Inc., Centerbrook, Conn.

Home Study Courses. Home study courses in practical radio engineering and television engineering are covered in this 32 page booklet. A detailed description of the various courses presented to the student are given, the various lessons are outlined and a schedule of courses, tuitions and terms are given. Booklet available from Capitol Radio Engineering Institute, 3224 16th St., N. W., Washington, D. C.

Industrial Music. "Music and Manpower" tells how music has made mahours more effective. This booklet describes music as the mental vitamin, tells what music does as far as morale and fatigue are concerned, the various types of music to use and the results that have been obtained from the use of it. Available from Operadio Mfg. Co., St. Charles, Ill.

Production Facilities. A 24 page booklet outlining the production facilities and equipment available in two plants of the Ward Products Corp. This company is active in the field of radio and electronics but will consider any kind of manufacturing which requires the production equipment and assembly qualifications described in this booklet. Available from Ward Products Corp., 1523 E. 45th St., Cleveland, Ohio.

Calibration of Camera Shutters

(*Continued from page* 109)

but rectangular; the margins will not be shadows of the shutter, but the width of the figure in the axis of movement of the bar will measure the effective exposure and the fuzziness of those margins at high speeds will roughly indicate the opening and closing times and hence the inefficiency of the shutter. The method will not be as accurate as that first described for inter-lens shutters since less total linear movement of the spot is measured. Many variations of these methods to emphasize one or another factor are possible but cannot be elaborated here.

Some Suggested Production Methods

While the methods described above lend themselves to small scale testing since they require no special construction, assembly or capital expenditure,† they are not suitable for production control in factory or service shop. Here a direct reading rather than a photographic method is desirable. The requirements are well within the possibilities of modern electronics.[3] A few of the workable methods can be mentioned, the engineering and the relative practicabilities of which are out of the scope of this article.

If we begin with a phototube which receives from a suitable source, light passed by the shutter under test, the single, approximately square pulse put out by the phototube can be used in various ways, to determine either light-admitting capacity or motion-stopping capacity of the shutter. Thus if the total charge (milliampere-milliseconds, or area under the curve of amplitude against time) is measured, as by a ballistic galvanometer or an electronic integrator, the light admitting capacity is measured. For example, a device with a pre-set tolerance, and indicating simply by the glow of one or both or neither (passing, too high, too low, respectively) of a pair of thyratrons, could be used. The phototube output, suitably amplified,

† Arrangements could doubtless be made with many of the better equipped radio service shops to perform the simple manipulations of oscillator and cathode-ray oscillograph called for, thus making such tests possible for the photographer to whom electrical equipment is unfamiliar or unavailable.

would charge up a large condenser with a high resistance leak, converting the round cornered or tapering square wave into peak voltage. The voltage across the condenser would control the grids of two thyratrons biased below the firing threshold but above the extinction point and adjusted so that the two limits of tolerance will each just fire one of them. A cathode-ray stop watch can be adapted to measure either of the two properties of the shutter. If a signal of a known frequency is swept across the screen (or in a circular path for greater accuracy), and triggered on and off by the unknown pulse, either through control of the deflection amplifiers or of the cathode-ray grid, the operator needs only to count the number of waves (of known frequency) which are allowed to appear, in a single sweep on a long persistence screen. The controlling pulse may be the effective motion stopping exposure—the duration of the photocell output above a chosen threshold amplitude, or some function of the integrated output to measure total exposure.

The cathode-ray may also be used to visualize further the actual form of the light intensity time curve described by the shutter, either with a long persistence screen or with the aid of one of the endless magnetic tape devices which repeat the phenomenon over and over, permitting unhurried study of a standing wave. This may be compared in each of its dimensions with a standard curve drawn on the face of the tube or otherwise utilized.

Any circuit developed for measurements on the basis of the photocell and a light source would include switching and zero setting arrangements to compensate for different light intensities, lens speeds (shutter calibrations at various diaphragm settings are instructive in inter-lens shutters), and mechanical and electrical fluctuations. Calibration of these devices is easily effected with rotating discs or similar standards. Inter-lens shutters would be set up simply with light source on one side, phototube on the other, using all or any part of the light passed. Focal plane shutters would be set up with a narrow slit at right angles to the axis of shutter movement and just behind the shutter—in the position of the film. Light would pass to the phototube only while the moving and the stationary slits coincide. The latter may be moved to various parts of the negative area to measure the inequalities in exposure across the field. This stationary slit must be narrow for the calibration will be in error by the ratio of its width to that of the shutter slit. In the case of focal plane shutters which are not significantly "inefficient," i.e., are close to the focal plane, the pulse of phototube output will be virtually a square wave and the problem of calibration is much simpler than for the inter-lens shutter. No integration of sloping ends is necessary and a simple electronic stop watch, such as the cathode-ray device mentioned, is adequate.

With these and other possibilities open to makers of cameras for rapid, unskilled, inexpensive testing of shutters it may be hoped that, even though expense prohibits accurate setting of every shutter, an individual calibration may be furnished with each camera, for use in critical work. At the same time, if service shops in many localities are equipped to perform shutter tests in a few minutes, at nominal expense, it may be expected that a wider realization of inherent shutter inaccuracies will result and a significant factor in badly exposed color photographs will be brought under anyone's control.

REFERENCE

1. English, F. L. *Amer. Photog.*, Dec. 1939; Jan. 1940.
2. Brailsford, H. D., *Du Mont Oscillographer*, June-July, 1940.
3. Bradford, C. I., ELECTRONICS, Nov. 1940.
4. Marsal, P. A., ELECTRONICS, Jan. 1942.

• • •

Quartz Crystals

(*Continued from page* 112)

to 11,000 kc. For low frequencies modifications of these two cuts are often used. The *CT* type, cut at −38° to the *Z*, and the *DT* type, cut at −52° to the *Z* are in this category. They vibrate in a shear on the plane of the plate. Two other similar low frequency oscillator plates are the *ET* type cut at + 66° to the *Z* and the *FT* type cut at −57° to the *Z*.

A still newer cut is the *GT*, which has a zero temperature coefficient over a large temperature range. When properly cut the t.c. of this plate is less than one part over a 100° temperature range. The plate is cut at $-51°$ to the Z-axis and at 45° to the X-axis. It vibrates in a face shear which is really two strongly coupled longitudinal modes and is used primarily in the low frequencies. It has been extensively used in frequency and time standards devices. Another cut similar to the *GT* is the *JT*, cut at 68°30′ to the Z and 45° to the X axis.

As has been stated previously, X and Y cuts are used for non-critical filters. When low temperature coefficient filter plates are required the two most common ones are the $-18°$ filter plate, tipped $-18°$ to the Z, and the $+5°$ filter plate, cut at $+5°$ to the Z axis. The former has a longitudinal motion and the latter both a flexure and longitudinal vibration which are coupled together to obtain a low t.c. Both types are commonly used as filters for pilot channel work.

Low temperature coefficients obviously can be attained by coupling two modes of vibration as in the case of the last mentioned plate. This scheme is used in the so-called "doughnut" type of oscillator. Here, a shear motion is coupled to a flexure in the quartz ring. Due to the fact that the t.c.'s of the two modes are opposite in sign, a zero temperature coefficient is obtained. Coupled types of plates have not, in the main, found wide use outside of frequency standards because of the relative difficulty of mounting and adjusting, and the frequent presence of spurious responses near the desired frequency.

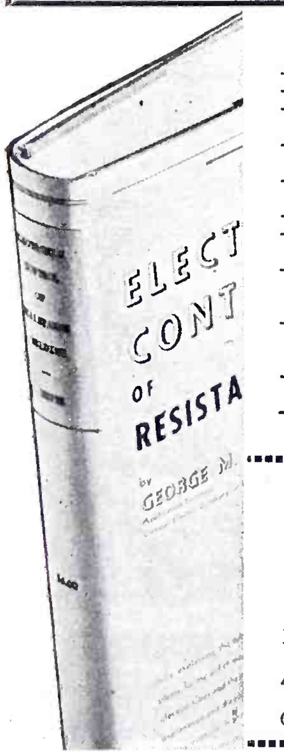
As already stated, harmonic oscillator plates can be made from fundamental type plates. They can be made from $-18°$ plates and 5° plates, or from *AT*, *BT*, and other types suitable for extremely high frequencies.

Many of the cuts mentioned above were developed by the Bell Telephone Laboratories.

Finishing and Mounting

After quartz oscillator plates have been properly cut, they are still a long way from precision devices.

They have to be very delicately and precisely finished to specified frequencies. In addition to worrying about frequency, one must also watch the activity, or oscillating strength during manufacture. This is largely determined by geometrical dimensions and absence of impurities. Charts are usually followed to arrive at the correct dimensions and



before plates reach the finishing department they are put through a very rigid examination during which all with impurities are removed.

After the plate is correctly finished it must be properly mounted in a holder. Mounting is an art in itself and beyond the scope of this paper. The type and construction of the holder is determined by the mode of oscillation and intended use. In its final mounting, the quartz oscillator plate must be held firmly in place and be absolutely free from dust, dirt and moisture since any of these will adversely affect and may completely prevent its performance.

Fabricating quartz oscillator plates is a scientific job which is still in its infancy. New discoveries are being made every day. Methods which were considered satisfactory yesterday may be completely out of date a week hence.

• • •

Meter Testing

(*Continued from page* 117)

current output, under all conditions.

In any device of this kind it is absolutely essential to prevent hunting or oscillation. Any mechanism such as a wattmeter movement which has inertia and spring troque, must be controlled for stable equilibrium by damping or anti-hunting means in order to avoid oscillation.

The motion of the meter is reproduced in currents by the phototubes, and the "brain network" must produce a voltage to stop the motion at normal pointer position and keep it there. The means provided for doing this is really the brain of the outfit, the action being as follows:

A change of current acts through C_1 to cause an over-correction to be applied, and this is reduced as the condenser C_1 becomes charged. The condenser C_2 has comparatively high capacitance and accumulates the photoelectric current, building up a voltage which will correct for any slow drift of load current, and also provides the response characteristics of holding the average value constant while correcting the instantaneous swings in values as well. These values of C_1, C_2 and R_1 are critical and dependent upon the

CONTACTS
FOR THE FIELD of ELECTRONICS

CRYSTALS by HIPOWER

Thousands of vital transmitting installations rely on the accuracy and dependability of Hipower Precision Crystal units. With recently enlarged facilities, Hipower is maintaining greatly increased production for all important services. When essential demand begins to return to normal, Hipower will be glad to help with your crystal needs.

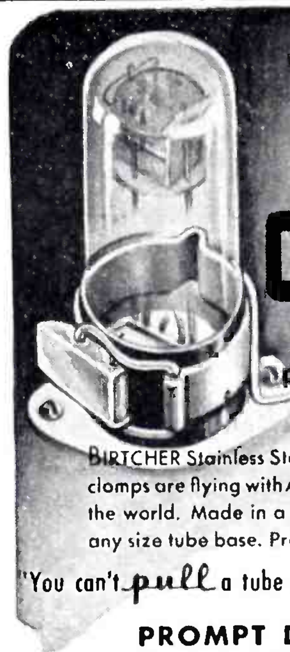
HIPOWER CRYSTAL CO.
Sales Division—205 W. Wacker Drive, Chicago
Factory—2035 Charleston Street, Chicago, Ill.

FADA

FACTORY SERVICE DEPT. has a large stock of Record Changer Parts. Also replacement parts for all FADA MODELS as well as a completely equipped SERVICE DEPARTMENT.

FADA OF NEW YORK
928 Broadway, New York, N. Y.
Tel.: GRamercy 7-0951-2

Locking-type TUBE CLAMPS



for AIRBORNE RADIO & RADAR EQUIPMENT

BIRTCHER Stainless Steel, locking-type tube clamps are flying with Allied Aircraft all over the world. Made in a variety of sizes to fit any size tube base. Precision workmanship.

"You can't *pull* a tube out of a BIRTCHER clamp!"

PROMPT DELIVERY
SAMPLES AND PRICES UPON REQUEST

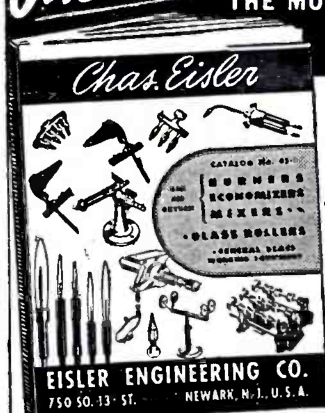
The Birtcher Corporation
RADIO & AIRCRAFT SPECIALTIES
PLASTIC FABRICATION & MOULDING
5087 HUNTINGTON DR. · LOS ANGELES, CALIF.

ELECTRON TUBE MACHINERY

of every type,—standard, and special design
KAHLE ENGINEERING COMPANY
Specialists in Equipment for the Manufacture of Radio Tubes, Cathode Ray Tubes, Fluorescent Lamps, Incandescent Lamps, Neon Tubes, Photo Cells, X-ray Tubes and other glass or electronic products, on production or laboratory basis.
1307-1309 Seventh St., North Bergen, N. J.

JUST OFF THE PRESS!

THE MOST COMPLETE CATALOG OF ITS KIND



CHAS. EISLER'S NEW 94 PAGE CATALOG INCLUDES
GAS·AIR·OXYGEN
· BURNERS
· ECONOMIZERS
· MIXERS
· GLASS ROLLERS
· GENERAL GLASS WORKING EQUIPMENT

WRITE FOR YOUR COPY TO-DAY!

Ask for CATALOG No. 43-B

CHAS. EISLER
EISLER ENGINEERING CO.
751 SO. 13th ST. Near AVON AVE NEWARK N. J.

RADIO AND ELECTRONIC DEVICES

BURSTEIN-APPLEBEE CO.
1012-14 McGee St. Kansas City, Mo.

MICROMETER FREQUENCY METER

for checking transmitters, from 1.5 to 56 mc., within 0.01 per cent

LAMPKIN LABORATORIES
Bradenton, Fla., U. S. A.

FINE RIBBONS of Tungsten and Molybdenum

Molybdenum in widths .006" to 1"
in thickness to .0005"
Tungsten Ribbon to specification

H. CROSS
15 Beekman St. New York

A STEADY SOURCE OF ALL ELECTRONIC EQUIPMENT

TERMINAL RADIO CORP.
Telephone: WOrth 2-4416
85 CORTLANDT ST., NEW YORK, N.Y.

TO: *Your Plant*

FOR ACTION·
PHONE! WIRE! WRITE!
BULLETINS AND CATALOGS ON REQUEST

MICA CONDENSERS—

Harrison has 203,520

FILTER CAPACITORS— Harrison has 37,460

TRANSFORMERS— Harrison has 2,170

TUBES— Harrison has 26,540

RESISTORS— Harrison has 59,271

OTHER ELECTRONIC SUPPLIES— Harrison has plenty!

FOR IMMEDIATE DELIVERY

HARRISON RADIO CORP.
12 West Broadway • New York City
Phone WOrth 2-6276

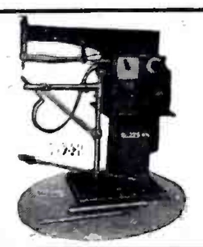
HARVEY RADIOLAB'S, Inc.

Manufacturers of Radio Transmitters
ELECTRONIC APPARATUS
447 Concord Ave. Cambridge, Mass.

We manufacture a complete line of equipment

SPOT WELDERS, electric, from ¼ to 500 KVA
TRANSFORMERS, special and standard types
INCANDESCENT LAMP manufacturing equipment
FLUORESCENT TUBE MAKING EQUIPMENT
ELECTRONIC EQUIPMENT, vacuum pumps, etc.
WET GLASS slicing and cutting machines for laboratory use
GENERAL GLASS working machines and burners
COLLEGE GLASS working units for students and laboratory

AC ARC WELDERS From 100 to 400 Amps.



EISLER ENGINEERING CO.
731 So. 13th St. (near Avon Ave.) Newark, New Jersey

FOUR-RANGE RHEOSTATS

Lubricated Contacts

WRITE FOR CATALOG

?

Find what you are looking for? If this or other advertising in this issue does not supply the information wanted, of products or services write

Electronics
330 W. 42d St., New York, N. Y.

?

SEARCHLIGHT SECTION

EMPLOYMENT • BUSINESS • OPPORTUNITIES • EQUIPMENT—USED or RESALE

UNDISPLAYED RATE:
10 cents a word, minimum charge $2.00.
(See ¶ on Box Numbers.)
POSITIONS WANTED (full or part-time salaried individual employment only), ½ above rates.
PROPOSALS, 50 cents a line an insertion.

INFORMATION:
BOX NUMBERS in care of any of our New York, Chicago or San Francisco offices count 10 words additional in undisplayed ads.
DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:
The advertising rate is $6.50 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.
AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page.
E.

NEW ADVERTISEMENTS received by 10 A. M. July 14th will appear in the August issue, subject to limitation of space available.

FORWARD-LOOKING COMPANY NEEDS ENGINEERS

A progressive company with an expanding engineering department is seeking several good men—but of course cannot take men now employed at their highest skills in war industry.

One should have a good theoretical knowledge of acoustics and experience with magnetic circuits and acoustical measurements.

Another is needed for laboratory measurements on a-f communications apparatus. He will design and supervise equipment for production testing, maintaining laboratory standards, and he should be familiar with government specifications and inspections procedure.

A third man must be familiar with the application and molding techniques of plastics. He should have several years of design experience on small electrical apparatus and an understanding of magnetic and electrical circuits.

These men will be concerned now with war contracts and planning post-war developments in a technically expert organization that's going places. Write, phone or wire the Chief Engineer, giving background and salary requirements.

GREAT AMERICAN INDUSTRIES INC.
70 Britannia St., Meriden, Conn.

WANTED ELECTRO-ACOUSTIC ENGINEER

Experienced in laboratory development, research, etc., for development of war production items. Offers excellent post war opportunities. Write,

Personnel Manager

UNIVERSAL MICROPHONE CO., Ltd.
Box 299 Inglewood, Calif., U.S.A.

BEST QUALITY, USED ELECTRON TUBE MACHINERY

Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

AMERICAN ELECTRICAL SALES CO., INC.
65-67 East 8th St. New York, N. Y.

FOR SALE

HAVE QUANTITY of used Weston meters and relays, also test equipment. No priority. FS-537, Electronics, 330 W. 42nd St., New York, N. Y.

FOR SALE OR TRADE—6 Jensen all-weather horns less speakers. 2 professional full-frequency cutting-heads, Universal 15-ohm. New RCA 167 R-F Oscillator. Shure Transcription pick-up. 12-inch Audak pick-up. 4 new 807 tubes. Need condenser-analyzer, what have you? Damon Transcription Lab., Midland Bldg., Kansas City, Missouri.

WANTED Electrical or Electrochemical Engineer

thoroughly versed in the theory of liquid and solid dielectrics. To direct a research and development program in the development and application of dielectrics to capacitors. This is an unusual opportunity for a capable engineer interested in his present and post-war future.

Industrial Condenser Corp.
1725 W. North Ave., Chicago, Ill.

Permanent Employment ELECTRONIC DEVELOPMENT ENGINEERS

Well-established Eastern Massachusetts concern desires graduate electronic engineers with flair for research and eye to future. Permanent position concerned at present with important development work for government, with increased opportunities after the war. Unusual openings for men with capacity and initiative. Must be U. S. Citizens.

P-510, Electronics
330 West 42nd St., New York City

POSITION VACANT

HAM'S PARADISE

With $3000-$5000 Per Year Pay

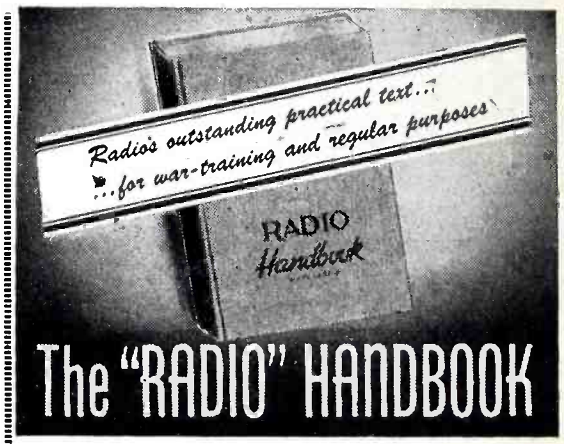
If you have at least a Class A ham license, good electrical background, know how to build your own transmitter, receivers and test equipment—and are not now employed at your fullest capacity or can get a release:—

We can use you in our lab or in test or design work!

Send full data, including a small photo (which will not be returned), also draft status, salary required, etc. We are located in the Middle West and are engaged 100% in war work.

P-535, Electronics
520 No. Michigan Ave., Chicago, Ill.

For Every Business Want
Think "Searchlight" First!



Basic electrical and radio theory in the simplest possible language, written especially for those without mathematical or technical training.

Dozens of complete how-to-build-it descriptions of many types of receiving, transmitting, and test equipment show practical applications. Hundreds of diagrams and large photographs.

Enlarged war-training chapters include: expanded basic principles, more test equipment which can be field-built, and mathematics for solving simple radio problems.

Over 600 pages, durably clothbound, gold-stamped. From your favorite dealer, or from us, postpaid; please add any applicable taxes.

$2.00 in Continental U.S.A. Elsewhere, $2.25

EDITORS AND ENGINEERS
1418 North Highland Avenue, Los Angeles

INSTRUCTION MANUALS

Technical manuscripts prepared, checked, printed. Experienced in government TM manual work. Former S.C. engineer, extensive technical radio background, author of many radio books and articles.

M. N. Beitman
Supreme Publications
328 S. Jefferson St. Chicago, Ill.

FREELAND & OLSCHNER, INC.

REBUILDERS OF RADIO TRANSMITTING TUBES

Let Us Help You Solve Your Tube Problems

250 W up

611 Baronne St. New Orleans, La.

WANTED FOR CASH

New or used radio equipment, meters, oscillographs, oscillators, galvanometers, laboratory equipment, etc. Also radio receivers, parts, tubes, etc.

Wire, Write or Phone

UNITED RADIO CO.
Dept. T Newark, 1, N. J.

Have quantity used Weston Meters and Relays also Test Equipment. *No priority.*

FS-536, Electronics
330 West 42nd St., New York, N. Y.

INDEX TO ADVERTISERS

mechanical constants, spring strength, damping and moment of inertia and the amplifier gain.

The requirements for non-oscillation may be mathematically expressed by the stability conditions for the fourth degree differential equation of motion for the mechanical system, including forces produced by the amplifier output current.

The system may also be considered as a form of feed-back amplifier, for which the requirement of non-oscillation has been stated by Nyquist to the effect that the gain versus phase angle polar curve, as frequency is varied, must not encircle the point (1, 0).

These two versions of the requirements are identical. The frequency region near the mechanical resonant frequency of the meter element is the only one where gain is large around the circuit but here the phase angle also changes very rapidly. The gain must be large in the negative or restoring direction and be less than 1 at any frequency in the positive or oscillating direction.

The time of response may be greatly reduced over that of the meter element alone as the amplifier output forces act to reduce the periodic time and increase the damping.

It is not possible to obtain any greater degree of load holding accuracy than that represented by the mechanical pivot friction of the standard meter, since the unbalanced force must move the meter element before a correction can follow, although the amount of motion may not be observable to the eye.

Several devices of the type are in use in the Development Laboratories of the Westinghouse Electric and Manufacturing Company's Meter Works at Newark, New Jersey. As constructed they form an attachment applied to the "precision type" standard wattmeters, and allow full advantage to be taken of the inherent accuracies of these instruments. Furthermore errors of observation, and inconvenience of use under unsteady supply conditions, are entirely eliminated. After an instrument is set to maintain a required load the observer may concentrate his attention upon the test instrument. The use of two observers (one to read each meter) is eliminated.

So that it won't happen again...

Now, more than ever, let us draw inspiration from our fighting men. Let us work even harder . . . make every required sacrifice . . . give even more of our minds and muscles and means. To pin casualty lists down to minimum, to hasten victory, to perpetuate the peace should be our one and only consideration. Remember—once before we said, "never again"—this time, let's make it stick.

To boost efficiency and secure victory has been, and still is, the job of every DAVEN component. On the battlefront, DAVEN products furnish precise and dependable control for America's fighting might. In the electrical, television, broadcast and sound picture fields, DAVEN meets all critical standards for accurate and consistent service.

We provide American industry with more than eighty models of laboratory test equipment, and the most complete line of precision attenuators in the world. A copy of our comprehensive catalog should be in your reference files. Ordering standard components from this catalog may expedite deliveries.

THE DAVEN COMPANY

158 SUMMIT STREET NEWARK, N. J.

HELP SUPPORT THE WAR EFFORT . . . BUY MORE WAR BONDS AND STAMPS