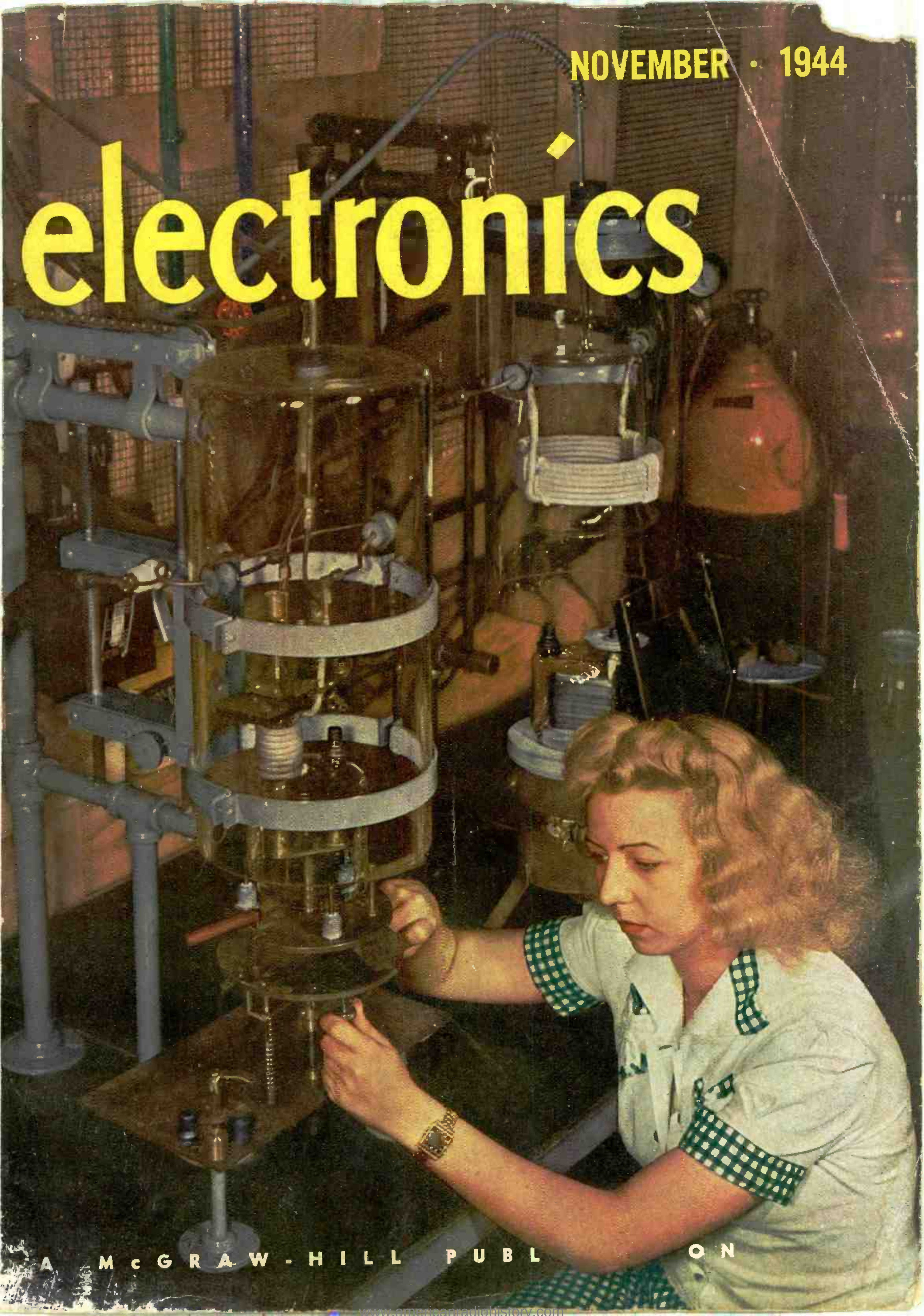
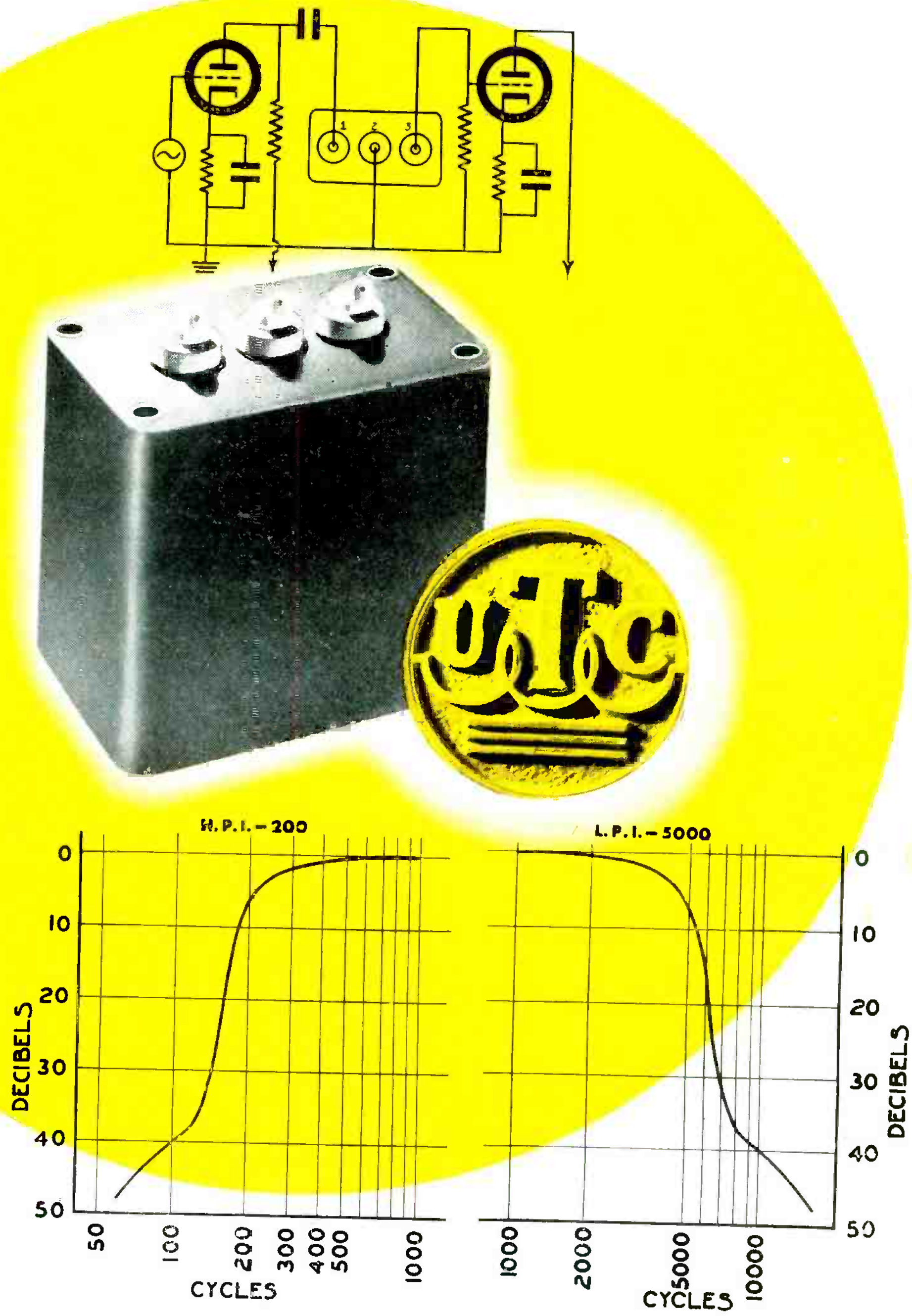

NOVEMBER · 1944
electronics
A McGRAW-HILL PUBL ON

LOW PASS (TYPE L. P. I.) HIGH PASS (TYPE H. P. I.) FILTERS



New additions to the UTC Interstage Filter family are now available in the type HPI and LPI units, respectively high pass interstage and low pass interstage filters.

The units are designed with a nominal impedance of 10,000 ohms to be used in a circuit as illustrated. Typical curves obtainable are shown above. Loss at cutoff frequency is less than 6 DB. At .75 times cutoff or 1.5 cutoff frequency respectively, the attenuation is 35 DB, and at one-half or twice cutoff frequency respectively, the attenuation is 40 DB.

These units employ a dual alloy magnetic shield which reduces inductive pickup to 150 Mv. per gauss. The dimensions in hermetically sealed cases are 1½" x 2½" x 2½". Filters of the HPI and LPI type can be supplied for any cutoff frequency from 200 to 10,000 cycles. Specify by type followed by frequency, as: LPI-2500.

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

United Transformer Co.

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electronics

NOVEMBER • 1944

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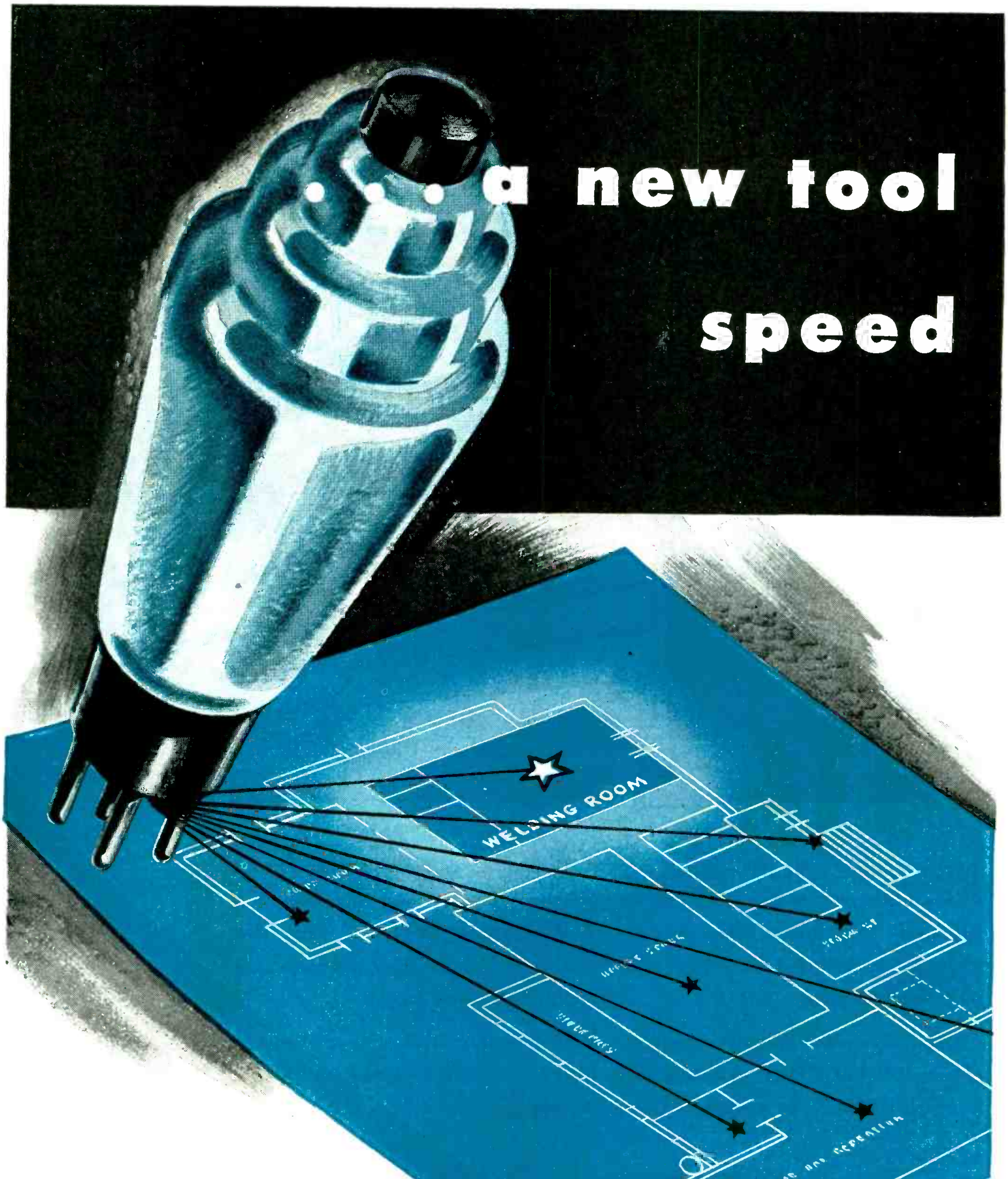


QUICK LOCAL SERVICE ON INDUSTRIAL ELECTRONIC TUBES

Looking ahead to continued development of electronic equipment in industry, postwar, we now have a plan to make Westinghouse Electronic Tubes quickly and easily available. Stocks of the most widely used tubes are now available through Westinghouse Electronic Tube Distributors and Westinghouse District Warehouses. As rapidly as possible additional types will be added to local stocks to make a complete line of Quality Controlled Westinghouse Electronic Tubes available to everyone.

# of incredible

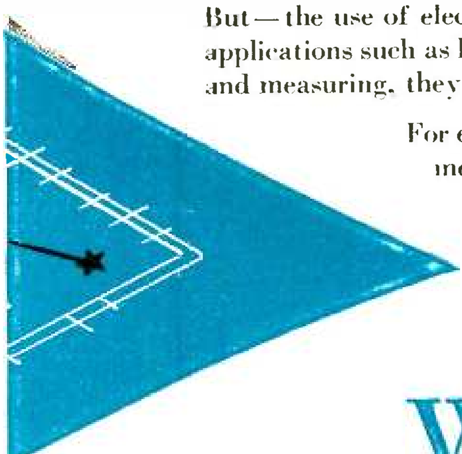
and versatility . . .

The electronic tube may easily prove to be one of your most useful tools when you are confronted with reconversion headaches. Electronic tubes have proved that they save money in innumerable operations by increased speed and accuracy.

Take welding for example. For years resistance welding was limited to steel fabrication, permitting a considerable tolerance for electrode marking, discoloration and warping. Today—with the introduction of Westinghouse Electronic Tubes in welding and timing circuits—spot, seam, butt and projection welding is accomplished accurately, efficiently and quickly. This modern welding technique can be applied to stainless steel, aluminum and a wide variety of alloys in varying sheet thicknesses.

But—the use of electronic tubes is not confined to welding. In countless other applications such as heat treating, speed control, current regulations, conversion and measuring, they help do a better job.

For electronic devices you now have in service, or for new equipment you are planning, *always* specify and insist on Westinghouse Electronic Tubes—the tubes of assured uniformity and dependable performance.



Westinghouse

PLANTS IN 25 CITIES — OFFICES EVERYWHERE

Quality Controlled Electronic Tubes

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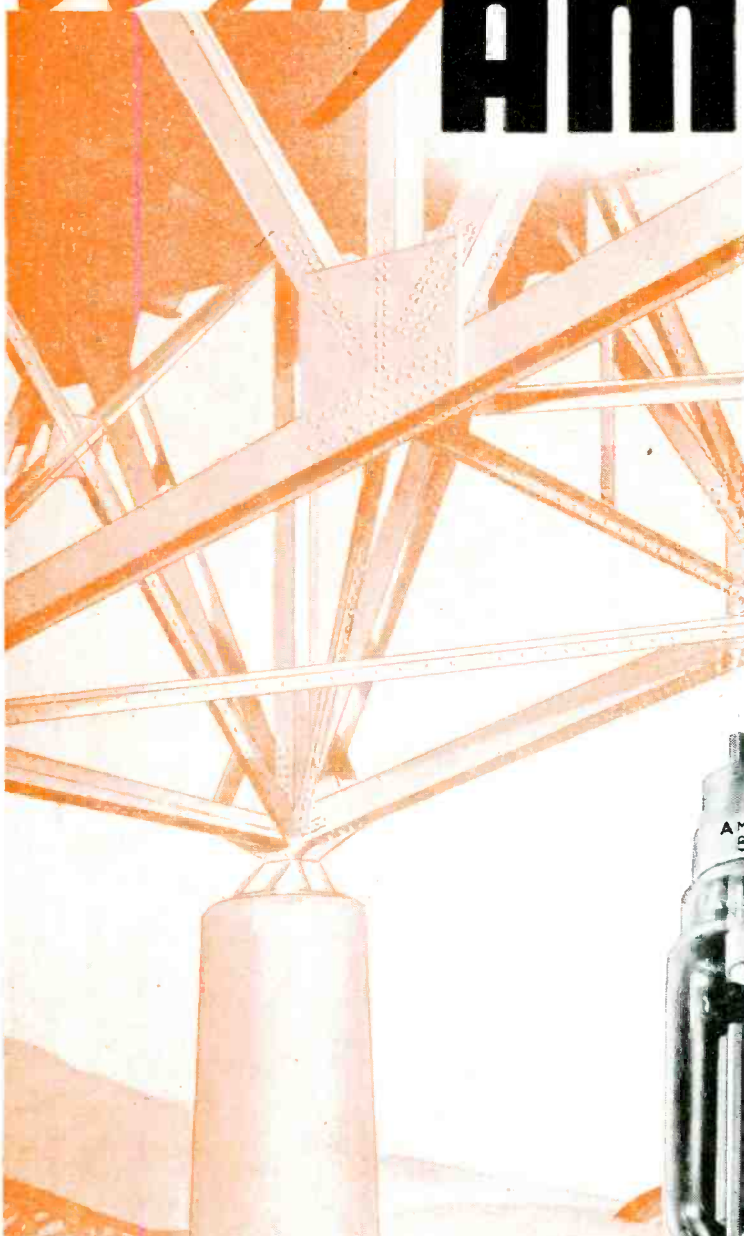

Why AMPEREX

WATER and AIR COOLED TRANSMITTING and RECTIFYING

TUBES

Of exclusive Amperex design! These four words, denoting an "Amperextra" reflected in better performance, have been used in a number of instances when describing our products. Of exclusive Amperex design, for example, is the channel support of our transmitting tubes. This feature results in more rigid support of tube elements. Exact inter-element alignment is assured. This, in turn, means absolute freedom from change in characteristics that might ordinarily arise from shock and vibration either in shipment or service.

There are more than 100 different types of ***Amperex*** tubes for broadcasting, industrial and electro-medical applications. An ***Amperex*** engineer will gladly assist you with your present or postwar problems.

AMPEREX . . . *the high performance tube*

Keep Buying . . .
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More War Bonds

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Production of units of this type is part of the Press Wireless program which includes the manufacture not only of radio communications equipment of the highest efficiency but also of a diverse range of radio instruments and installations for ground use in modern aviation.

Press Wireless recognizes that communications and aviation go hand in hand and invites inquiries now concerning the products it plans to have available when peace comes.

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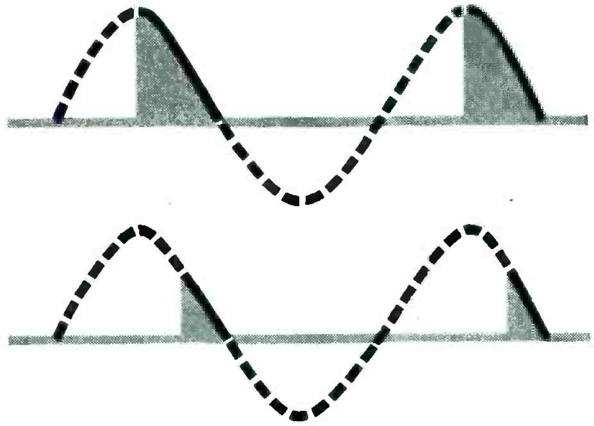
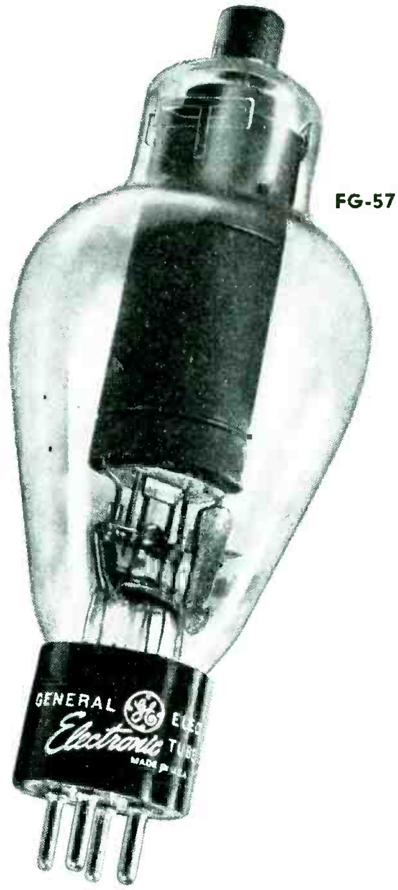




FG-57

THYRATRON

the trigger tube that made precision control of industrial equipment possible

another G-E electronic **FIRST!**

Developed by General Electric, the thyratron is often credited with being "the most versatile electronic tube in industry."

It is the tube which triggers the current supplied through such other tubes as the ignitron.

It is the tube which, as a synchronous switch, times the shots with split-cycle precision in high-speed resistance welding. It offers control so accurate that it can be fired at any point in the a-c half-cycle (see examples above), time after time in predetermined and automatic sequence.

The thyratron can also act as a self-controlled power tube. It can run d-c motors directly from a-c lines, feeding current in exactly the right amount to maintain a constant preset speed in machine-tools regardless of load variations.

The thyratron executes the orders of the phototube, or electric eye, in sorting, grading, counting, detecting flaws in steel plates, operating doors, burglar alarms and safety devices.

General Electric is the manufacturer that can provide thyratrons, or any other electronic tubes, in quality that is unsurpassed for dependability, long life and economical operating.

OTHER G-E TUBES ARE WIDELY USED IN INDUSTRY, TOO! The ignitron, for example—frequent teammate of the thyratron—is the rugged steel-jacketed water-cooled tube that is capable of handling the heavy shots of current in resistance welding. It is also used in place of rotating machinery for changing alternating current into direct current.

Write for Bulletin ET1-12, a convenient listing of all G-E electronic tubes for industrial applications. Address *Electronics Department, General Electric, Schenectady, N. Y.*

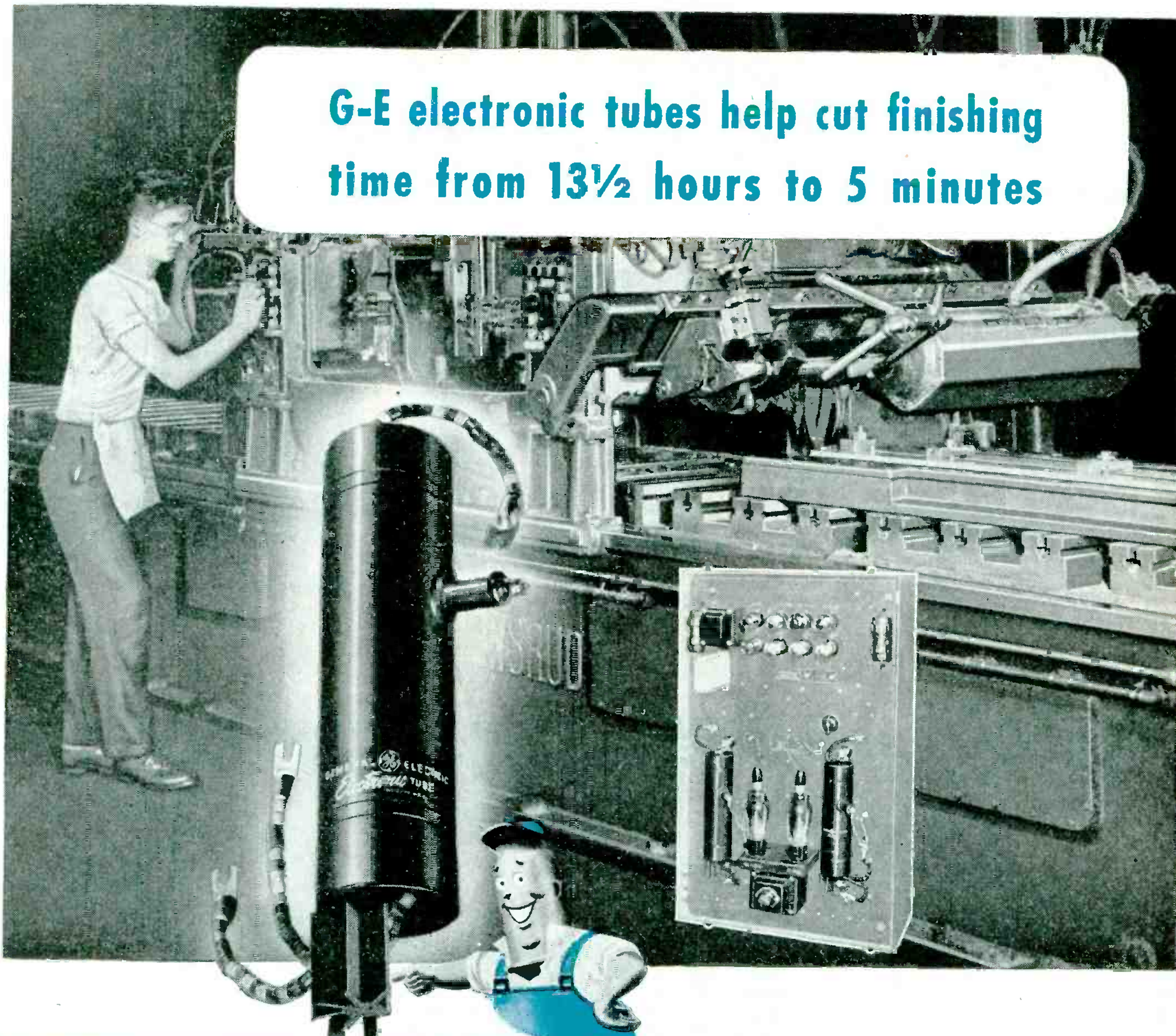
• *Tune in* "The World Today" *and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E* "All Girl Orchestra" *at 10 P. M. E.W.T. over NBC.*

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

GENERAL ELECTRIC

161 C8—885

G-E electronic tubes help cut finishing time from 13½ hours to 5 minutes



The G-E all-metal thyratron tube is the "heart" of the Thy-mo-trol unit that maintains correct machine speed for every load.

G-E electronic tubes in the G-E Thy-mo-trol Drive provide the multiple-timing control that has speeded up finish time on milling of aluminum spar beams for aircraft wings from one unit in 13½ hours to one unit in 5 minutes!

Onsrud Machine Works, Inc., met the requirements for increased production by designing its giant contour milling machine to include the G-E Thy-mo-trol Drive—the electronic-tube control unit that provides the smooth, stepless motor control for handling such complex factors as varying feed speeds for synchronizing with tool-cutting depths, controlling changing feeds, and high accelerations for fast "skips" when no cutting at all is required.

Electronic-tube control of d-c motors is applicable to drill presses, pump drives, lathes, boring mills, screw machines, and all other motor-driven machinery where a *right* speed is required for the job.

The heart of the electronic motor control, the G-E Thy-mo-trol Drive, is the G-E thyratron tube. This tube is a virtual stepless rheostat that controls with no moving parts the flow of current to give smooth, stepless control of motor speed from almost zero speed up to its maximum rating. The thyratron is but one of the complete line of G-E electronic tubes for industrial applications. Through its nation-wide distributing system, General Electric is prepared to supply users of electronic devices with replacement tubes. Ask your distributor for information on G-E thyratrons or any other type of industrial tube, or write *Electronics Department, General Electric Company, Schenectady, N. Y.*

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

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

GENERAL ELECTRIC

162-C12-8850

Specify

C. T. C.

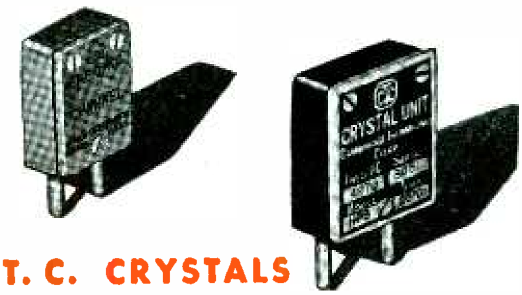
CRYSTALS

I-F TRANSFORMERS

TURRET TERMINAL LUGS

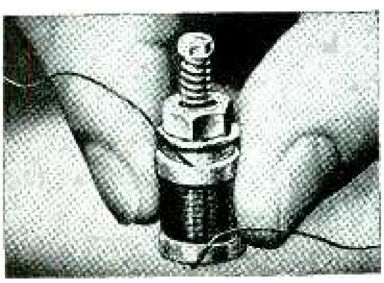
SPLIT LUGS

DOUBLE END TERMINAL LUGS



C. T. C. CRYSTALS

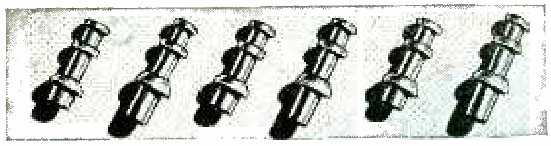
Accurate cutting of each slice — thanks to X-RAY ORIENTATION — insures constant frequency over a wide temperature range. Multiple mechanical lapping operations; dimensioning by edge lapping and finishing to final frequency by etching, are other important steps in the manufacture of C.T.C. Crystals that guarantee high activity and constant frequency throughout their entire life.



I-F TRANSFORMERS

These tiny, *ultra-high frequency*, slug tuned I-F Transformers are doing an efficient, thoroughly dependable job in many important radio and electronic applications.

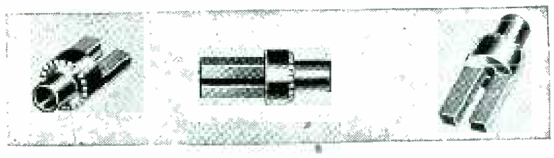
Ask us about LS-1 (pictured above actual size) and LS-2 transformers.



C. T. C. TURRET TERMINAL LUGS

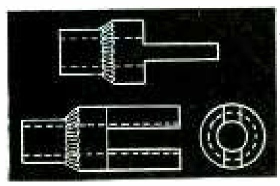
Just swage these heavily silver plated Turret Terminal Lugs to the board and in a jiffy you have a good, firm turret terminal. Quick soldering, too. Sufficient metal is used in the Lugs to give them strength but not enough to draw heat thus increasing soldering time.

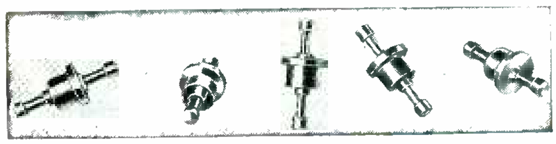
C. T. C. Turret Terminal Lugs are stocked to meet 1/32", 2/32", 3/32", 4/32", 5/32", and 6/32" board thicknesses.



C. T. C. SPLIT LUGS

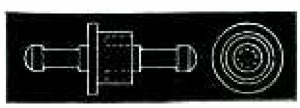
A .050 hole through the shaft permits wiring to these Split Lugs from either top or bottom without drilling or cutting. Just swage them to the board, then wire. Made of brass, heavily silver plated, C. T. C. Split Lugs are available in two sizes to fit 3/32" and 5/32" boards.





DOUBLE END TERMINAL LUGS

Use these Double End Terminal Lugs when you need terminal posts on both sides of the board. Like C.T.C. Turret Terminal and Split Lugs, C.T.C. Double End Lugs simply swage to the terminal board — provide twin terminal posts which may be wired from top and bottom. Heavily silver plated brass. Stocked to fit 3/32" terminal boards.



For complete information get in touch with

CAMBRIDGE *Thermionic* CORP.

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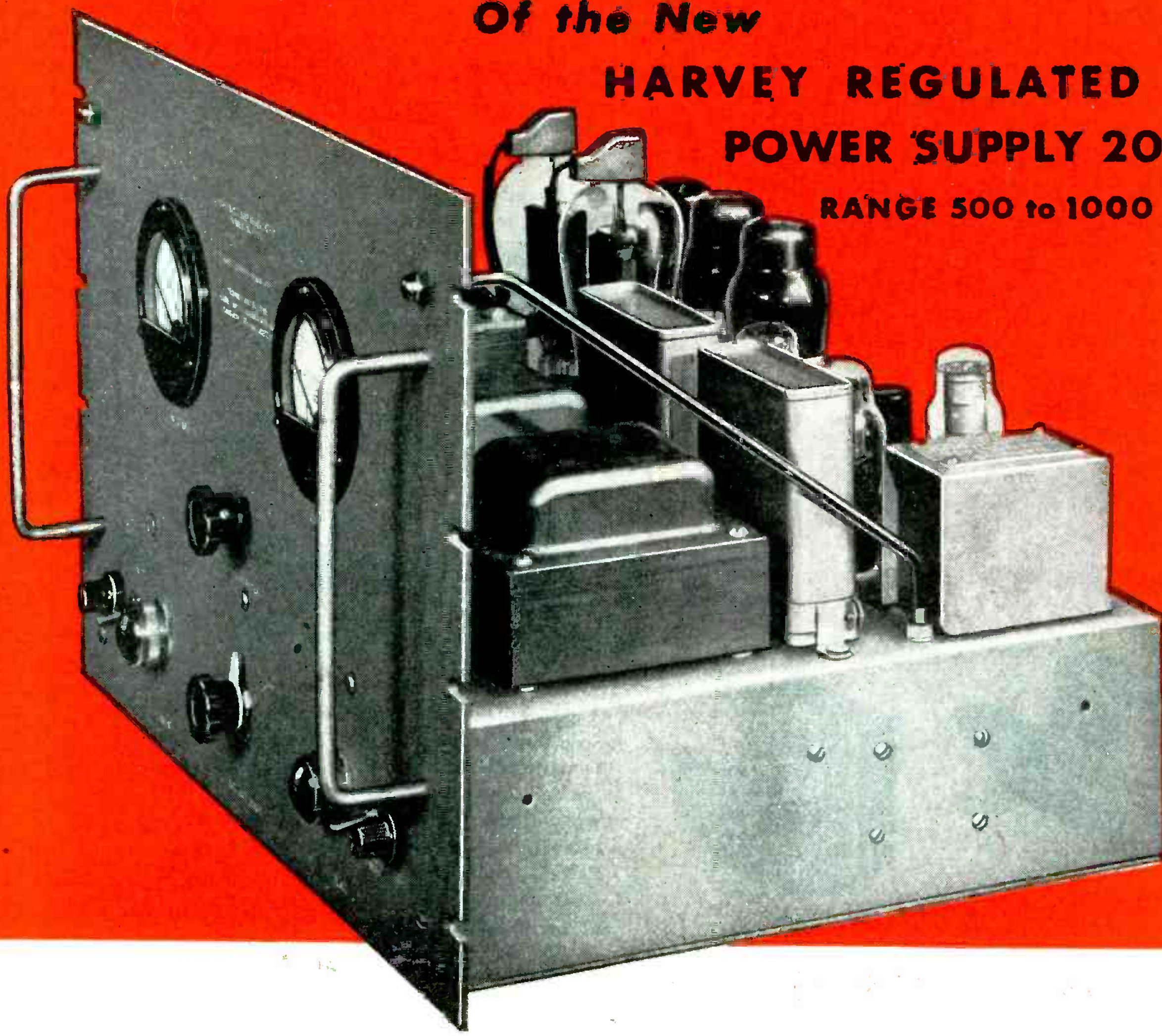
FIRST OFFICIAL PICTURE

Of the New

HARVEY REGULATED POWER SUPPLY 206 PA

RANGE 500 to 1000 VOLTS



Look It Over! You'll see the quality craftsmanship and compact construction of this new HARVEY 206 PA—its sound design, precision assembly and easy accessibility. Notice the gray, crackle-finish panel and the copper plated chassis.

The new Harvey 206 PA is equipped with spare fuses, a generous 6 ft. heavy duty Typex cord, two interlocks for safety, overload and time delay relays—everything to make it a thoroughly dependable, easy-to-operate source of laboratory D. C. power.

Although the picture gives you an indication of why the HARVEY 206 PA operates smoothly and efficiently, it can't show you how this precision instrument operates in two ranges—500 to 700 volts at ¼ of an ampere; 700 to 1000 volts at .2 of an ampere—with both ranges accurately regulated within one per cent. That's up to the instrument and us. We'd like nothing better than the chance to show you just what this important new development can do. Get in touch with

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HARVEY RADIO LABORATORIES, INC.

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TRAVELING WITH YOU ON THE STRAIGHT ROAD OF POST-WAR PLANNING

The period after the war may well become known as the "Electronic Era". In the development of the many ingenious post-war products, there will be a need for specialized engineering of precise and intricate high frequency components. This is our field. Our organization, with years of experience designing and making such products is at present devoting its manufacturing facilities 100% to war work. These unusual facilities will soon be available for the peacetime needs of our industry, and our engineering "know-how" is at your service now to help you with your post-war planning.

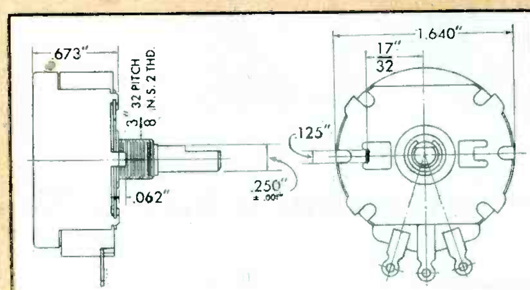
MEC-RAD

DIVISION-BLACK INDUSTRIES

1400 EAST 222ND STREET ☆ CLEVELAND 17, OHIO

★ Chicago Telephone Supply Company now offers a new 1⅝" diameter, wire wound variable resistor, 352 Series, with resistance value up to 20,000 ohms linear and with the same bakelite housing and grounded metal construction as the popular 1¼" 252 Series. This potentiometer may be used with switches attached and in tandem construction.

This new resistor is another expression of the many years of intensive research and development behind Chicago Telephone Supply Company, a scientific manufacturing organization devoted to high standards in the mass production of variable resistors, both wire wound and carbon types.



NO. 352 SERIES VARIABLE WIRE WOUND RESISTOR

Manufacturers of Quality Electro Mechanical Components Since 1896

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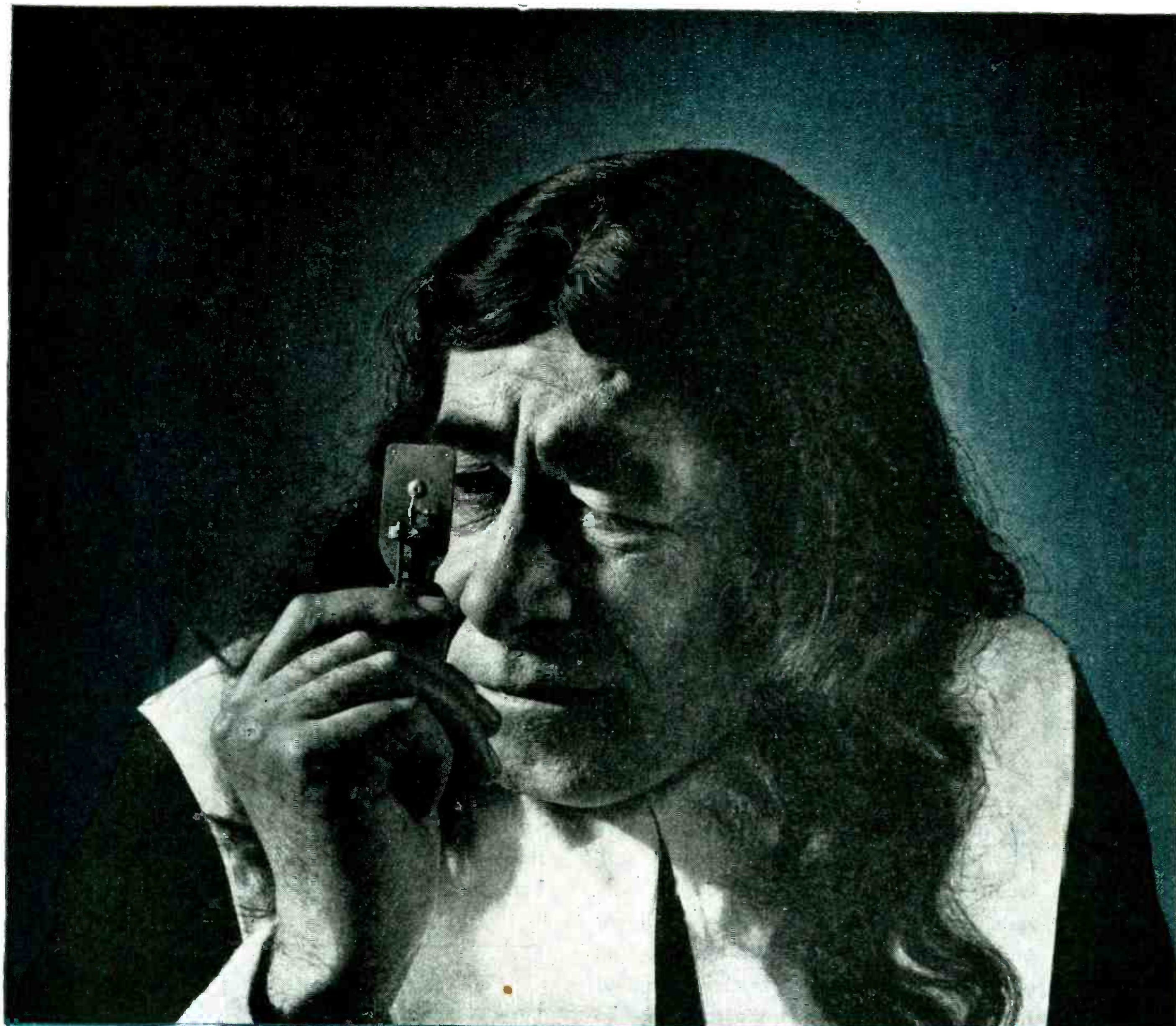
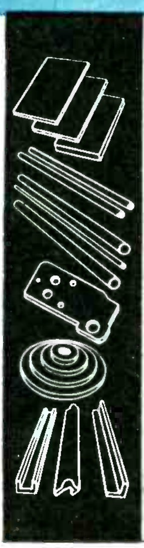


Leeuwenhoek Saw a New World in a Tiny Bead of Glass



HISTORY does not reveal who invented the microscope. But it was a Dutch merchant, Anthony Van Leeuwenhoek, who made it practical. Peering through a tiny bead of glass he ground into a lens, he became the first to see the organisms of the microscopic world.

This kind of inquisitiveness still pays. For example, present-day investigators are bringing into view many practical new uses for plastics. You may initiate and benefit from these newer or wider uses. Here's how. You know best what properties—physical, electrical, chemical or mechanical you require of a material. Give us this information to start on and we'll be glad to let you know whether our type of technical plastics can help you in current or future plans. In any case, write today for the complete catalog of Synthane technical plastics.

Synthane Corporation, Oaks, Penna.

SYNTHANE TECHNICAL PLASTICS

SHEETS • RODS • TUBES • FABRICATED PARTS **SYNTHANE** MOLDED LAMINATED • MOLDED-MACERATED

Plan your present and future products with Synthane Technical Plastics

THERE ARE A THOUSAND USES FOR SYNTHANE LAMINATED PLASTIC TUBING

Tubing is the start in the production of many products

SYNTHANE TUBING is produced in various shapes, diameters, wall-thicknesses, lengths, colors and finishes. The uses of tubing, simply as tubing, however, are obviously limited. It is imagination and machining plus a combination of many desirable properties that make Synthane tubing the useful material it is. Tubes can be easily and quickly machined into coil forms, fuse cases, chemical piping, motor brush holders, bushings, ferrules, ball bearing retainers, pump valves and a legion of other products. Tubing, then, is the first step in the ready and economical production of many parts.

Machining can be done by you or by us. Many prefer us to handle the complete job to relieve them of the responsibility for dies, jigs, tolerances, and other production details.

PROPERTIES—GENERAL (Varies with grades)

PHYSICAL: Hard, Rockwell M-60 to M-100, dense, uniform. Light in weight (specific gravity 1.1 to 1.3), non-hygroscopic, (24 hour water absorption 0.5 to 5.0 per cent). Stable over wide temperature range. Low coefficient of thermal conductivity.

MECHANICAL: High tensile, compressive and crushing strength. High resistance to rupture (under internal pressure). May be easily sawed, turned, punched, riveted, drilled, reamed, milled, threaded, tapped or polished.

ELECTRICAL: High dielectric strength, low dielectric constant, low power factor, low loss factor.

CHEMICAL: Resists common solvents, oils, weak acids. Will not corrode metal inserts, bushings, ferrules, etc.

Kinds of stock, properties

There are three principal kinds of SYNTHANE tubing, classified according to the materials used in their manufacture:

1. The paper base grades—X and XX.
2. The fabric base grades—C, CE, L and LE.
3. The asbestos base grades—A and AA.

The properties and characteristics of SYNTHANE tubing depend mainly upon the base used, the type of resin and the time of cure. By combining the raw materials and varying the method of manufacture, it is possible to alter the physical, mechanical, electrical or chemical properties, strengthening one without wholly sacrificing the others, to secure the exact balance of properties required.

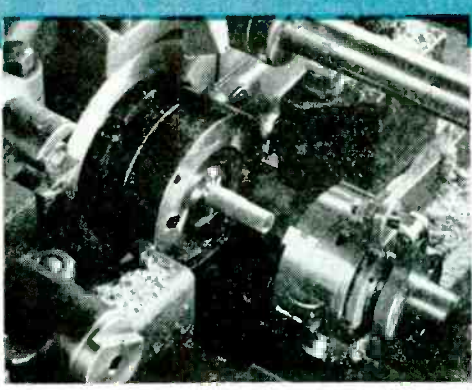
The services of SYNTHANE engineers are at your disposal to aid in selecting or developing tubing to meet your particular needs.

Special shapes

Special tubular sections can be produced in a wide variety of forms by applying the basic principles of tube molding. SYNTHANE sections, being laminated, are considerably stronger than ordinary powder molded shapes.

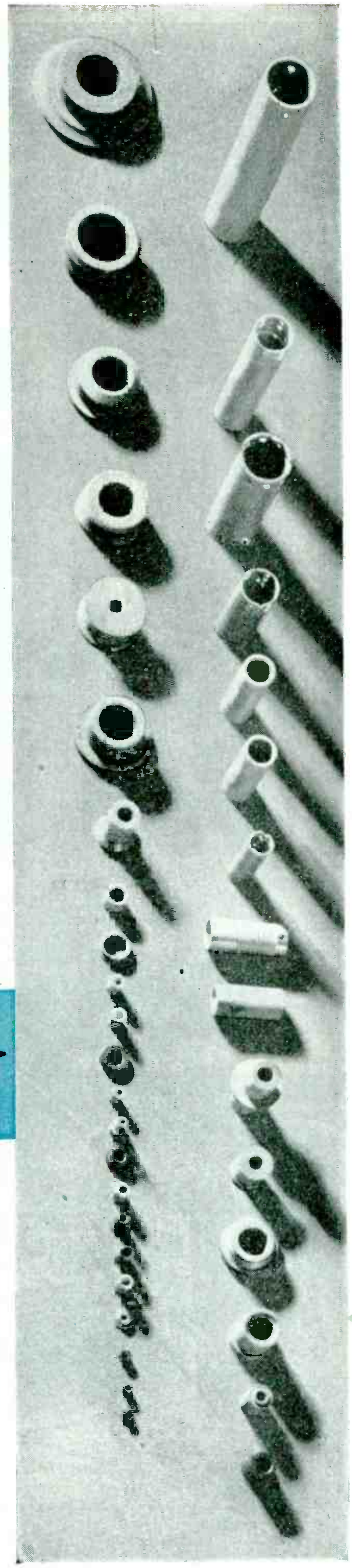
The simplest molded-laminated shapes are square, rectangular or oval. More intricate examples include horns, cones and irregular inside or outside contours.

Automatic screw machining can be advantageously used for low cost quantity production of numerous parts from Synthane tubing.



From tubes like these . . .

products like these →



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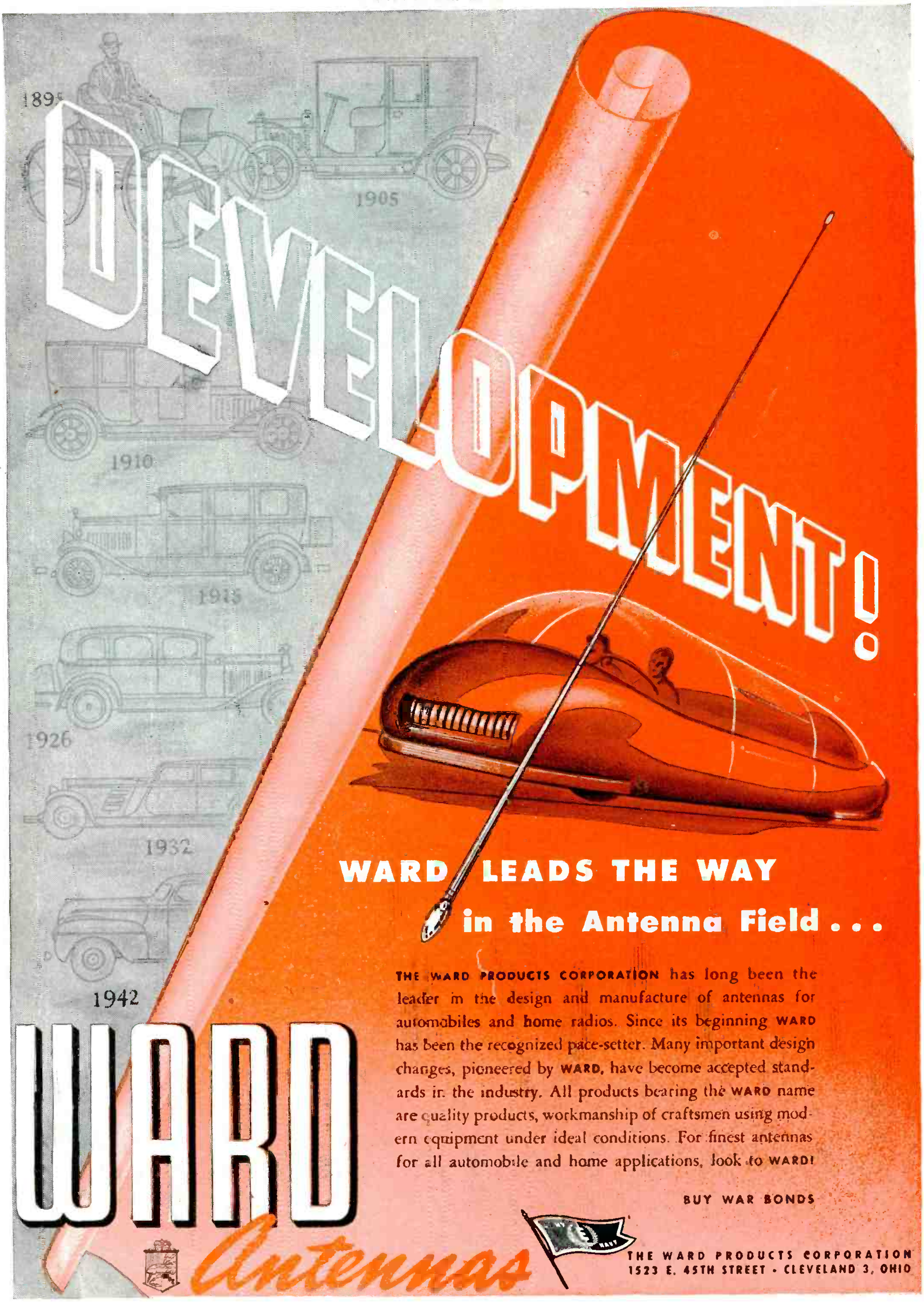
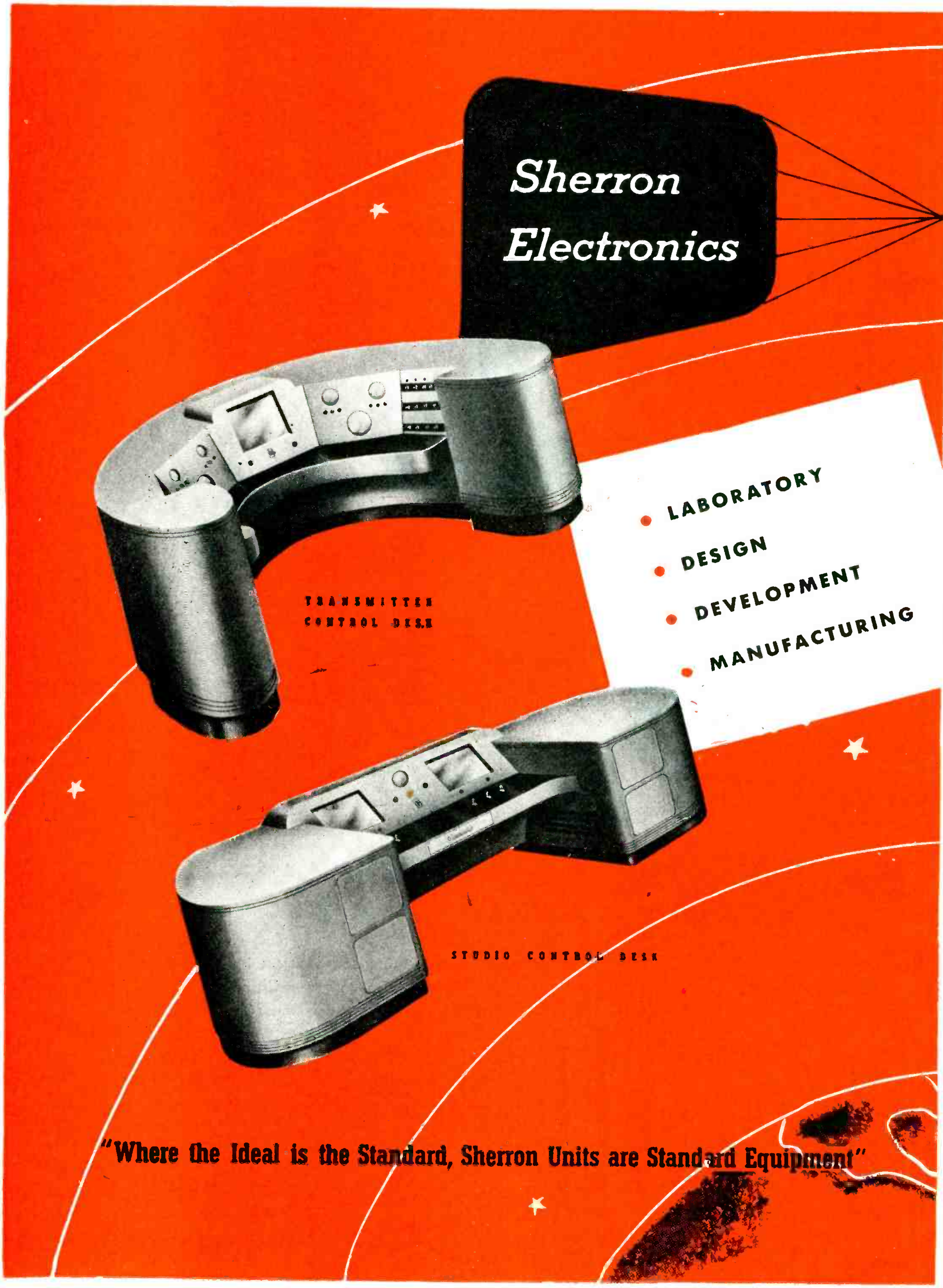

1895
1905
1910
1918
1926
1932
1942
DEVELOPMENT!
WARD LEADS THE WAY
in the Antenna Field . . .
THE WARD PRODUCTS CORPORATION has long been the leader in the design and manufacture of antennas for automobiles and home radios. Since its beginning WARD has been the recognized pace-setter. Many important design changes, pioneered by WARD, have become accepted standards in the industry. All products bearing the WARD name are quality products, workmanship of craftsmen using modern equipment under ideal conditions. For finest antennas for all automobile and home applications, look to WARD!
BUY WAR BONDS
WARD Antennas
THE WARD PRODUCTS CORPORATION
1523 E. 45TH STREET • CLEVELAND 3, OHIO


Sherron Electronics
LABORATORY
DESIGN
DEVELOPMENT
MANUFACTURING
TRANSMITTER CONTROL DESK
STUDIO CONTROL DESK
"Where the Ideal is the Standard, Sherron Units are Standard Equipment"

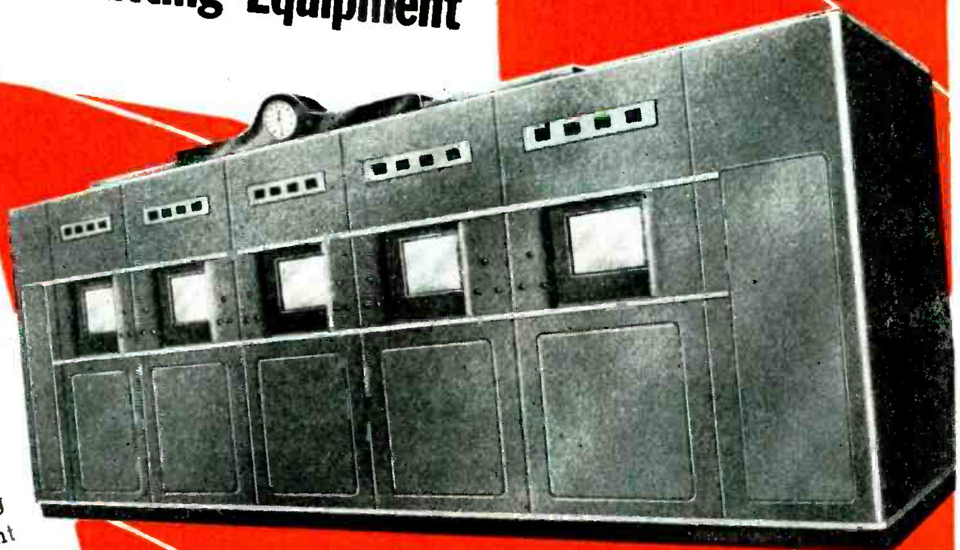
TELEVISION

Studio and Transmitting Equipment

As a source of supply for television equipment manufacturers, we are prepared to design, develop and manufacture—to their specifications—the full range of units shown on these pages.

Notable for its quality-protecting dependability, Sherron equipment is serving many of America's most vital manufacturers in the fields of electronics and radionics.

We are an intensively specialized organization, expertly staffed in all departments—laboratory through manufacturing. All our equipment is custom built exclusively for manufacturers. Our laboratory and engineering staff are at your disposal for consultation.



VIDEO - AUDIO TRANSMITTER

MASTER CONTROL BOARD

SHERRON ELECTRONICS CO.

Subsidiary of Sherron Metallic Corp.

1201 Flushing Avenue • Brooklyn 6, N. Y.

BUY WAR BONDS

AUTO-LITE Wire AND Cable

Custom made to fit your wire job

Supplying the precise type of wire and cable to meet the specific problem of your product is a speciality of Auto-Lite. Years of experimentation to achieve characteristics like increased heat resistance and improved performance lie behind every reel of Auto-Lite's electrical wire and cable.

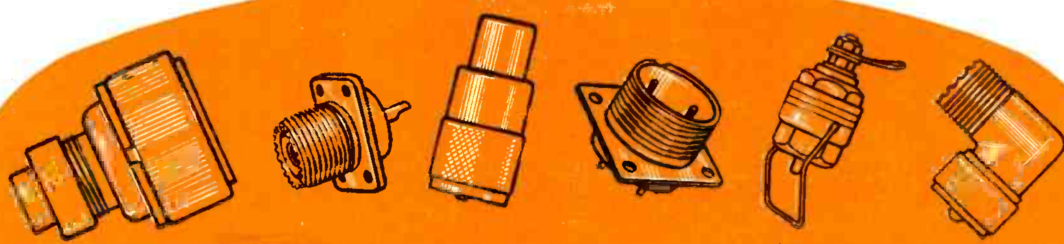
Ample manufacturing facilities permit custom-made production whenever necessary, and a firmly established reputation for dependability assures specified performance.

For help on any wire or cable problem that you may have, write to

THE ELECTRIC AUTO-LITE COMPANY

SARNIA, ONTARIO — *Wire and Cable Division* — PORT HURON, MICH.

TUNE IN "EVERYTHING FOR THE BOYS" STARRING DICK HAYMES—EVERY TUESDAY NIGHT—NBC NETWORK



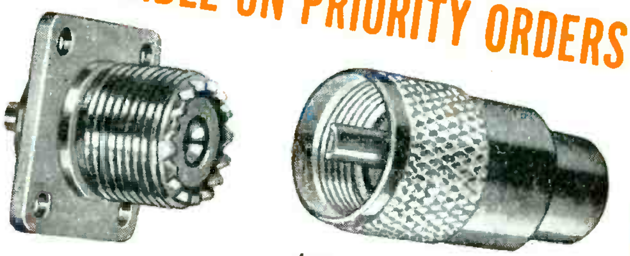
For Your Postwar Needs in Connectors and Related Units

Will coaxial cable connectors, cable plugs or special design parts in this general category, play roles in your postwar products? If so, we suggest you carefully consider both our offerings and exceptional facilities.

Connector Division, in addition to making a representative line of standard units, is uniquely staffed and equipped to serve your needs in this field on a mass production basis.

Our engineers will be happy to consult with you on specific problems or send you more detailed information.

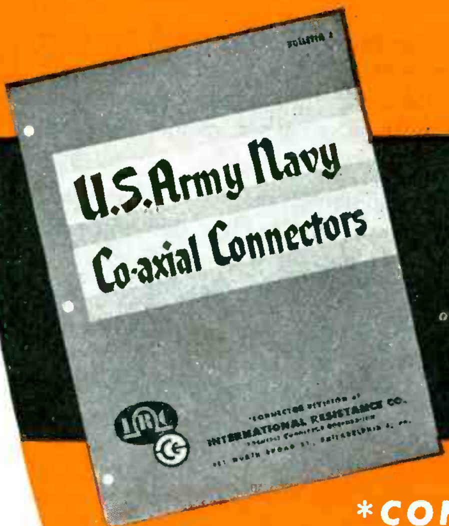
AVAILABLE ON PRIORITY ORDERS



(Actual Size)

U. S. ARMY-NAVY COAXIAL CONNECTORS

Built in accordance with U. S. Army-Navy designs and specifications, these precision units interlock firmly, when coupled, to assure positive, vibration-proof contact. The die cast, zinc housings and other metal parts are heavily silver plated. Contact parts (both pins and sockets) are made of specially tempered spring-brass. Cable plugs and receptacles alike are insulated with low-loss mica filled bakelite. Plugs may be had in either Signal Corps #PL-259, or Navy #C1-49195 models. Connector receptacle #50-392-1 is standard for each of these designs.



Write for Bulletin 4

***CONNECTOR DIVISION OF**

INTERNATIONAL RESISTANCE CO.

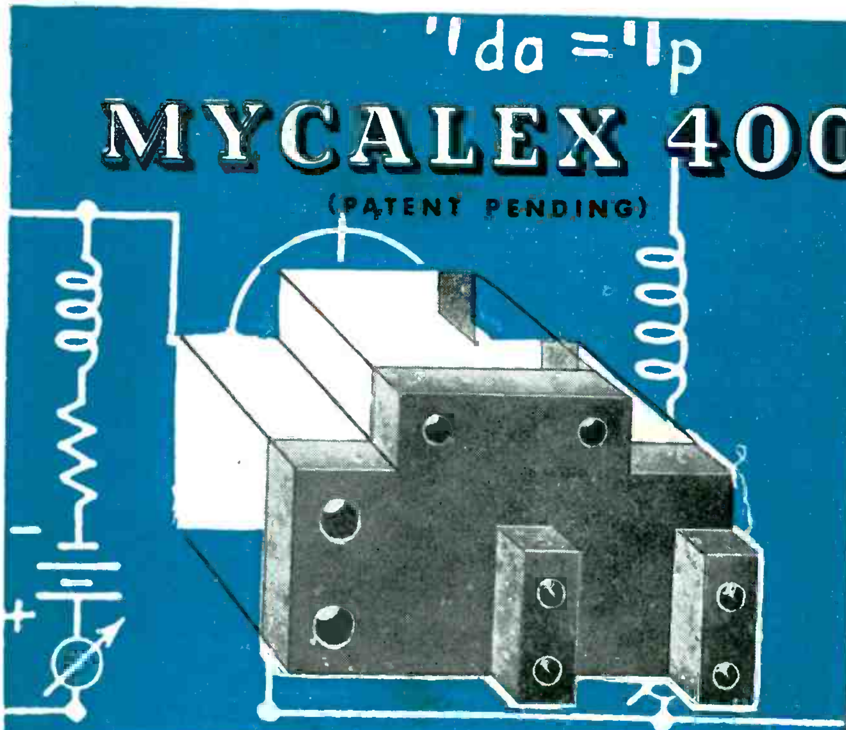
401 N. BROAD ST., PHILADELPHIA 8, PA.

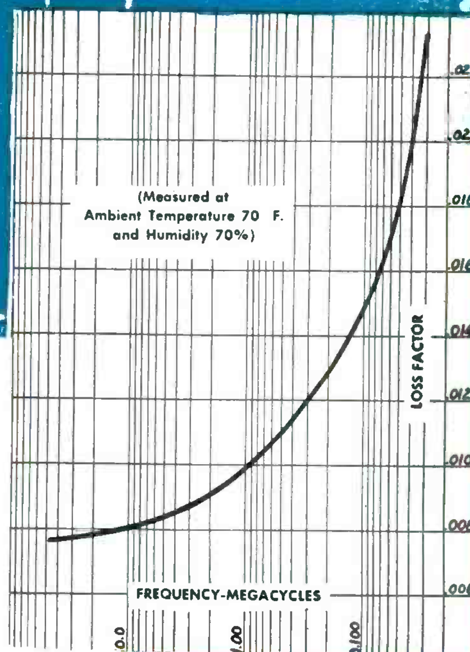
*FORMERLY CONNECTOR CORPORATION

MYCALEX 400

(PATENT PENDING)

The 'Last Word' in Low-Loss Insulation—Perfected after 25 years of Research Leadership





FITS PERFECTLY *Into High Frequency Design*

AT last designers of tomorrow's high frequency apparatus have an improved type of glass-bonded mica insulation to specify where new advancements in low-loss characteristics are desired, as in ultra high frequency applications.

Behind this new product is a history of 25 years of research leadership. Just as the original MYCALEX, developed by the MYCALEX (Parent) Company of Great Britain 25 years ago, was a vast improvement over other ceramics, so the new MYCALEX 400, developed exclusively by the MYCALEX Corporation of America, is a comparable advancement over all early forms of glass-bonded mica.

MYCALEX 400 meets government specifications for L-4 characteristics, by virtue of its pronounced low-loss factor of 0.013 at 1 megacycle. Its surface resistivity is 300,000 megohms. Its power factor is 0.0018 at 1 megacycle, in accordance with American War Standard C-75.1—1943 (Jan. 1-10). Its dielectric constant is unchanged from 50 kilocycles to 10 megacycles. MYCALEX 400 can be machined with greater precision . . . drilled, tapped, milled, sawed, turned and threaded.

Improved postwar h-f equipment deserves this newly refined and perfected electronic insulation. Let us supply your stock requirements in sheets and rods; or have us fabricate component parts to your specifications. Write for full details and samples.

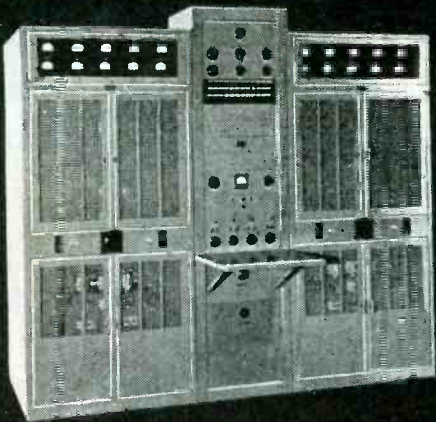
MYCALEX THE INSULATOR
TRADE MARK REG. U. S. PAT. OFF.

MYCALEX CORPORATION OF AMERICA

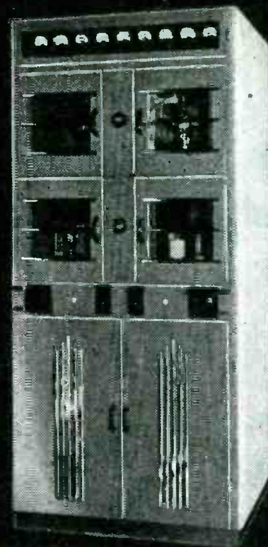
"OWNERS OF 'MYCALEX' PATENTS"

CLIFTON, NEW JERSEY

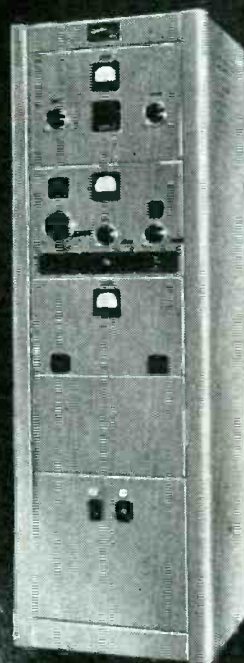
Executive Offices: 30 ROCKEFELLER PLAZA NEW YORK 20, N. Y.



BROADCAST STATION EQUIPMENT

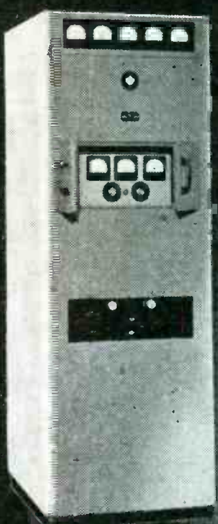


AVIATION GROUND STATION EQUIPMENT



COMMERCIAL POINT-TO-POINT TRANSMITTERS

Coming Soon



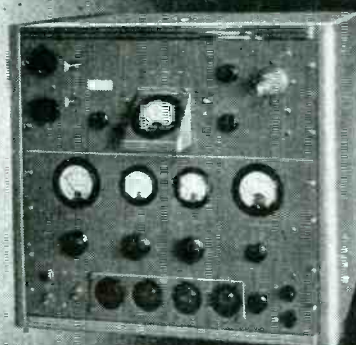
MUNICIPAL SERVICES CENTRAL STATIONS

The Army and Navy have found Temco to be a dependable source for the development and production of technically advanced communication equipment. Because Temco is one of the very few organizations endowed with that rare combination . . . *engineering versatility — production flexibility plus peerless standards of craftsmanship,* our war contribution has stationed us at the forefront of advanced radio communication research.

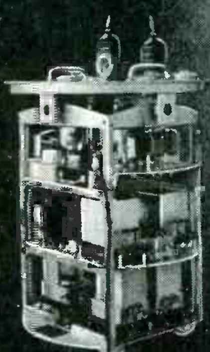
Radio is no longer simple! As a result of war-born Radar requirements which have introduced mechanical and electrical complexities of the highest standards—Temco post war equipment will reflect and incorporate great technical achievements.

As rapidly as our war program draws to completion our efforts are turning to peacetime production. New types of Temco communication equipment are under way—will be ready for delivery at an early date.

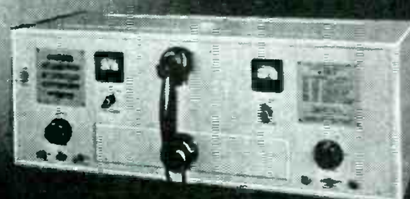
Watch our advertisements for announcements about new models.



SPECIAL VHF LABORATORY TEST EQUIPMENT



MARINE RADIO BEACONS



MARINE RADIO TELEPHONES

TEMCO

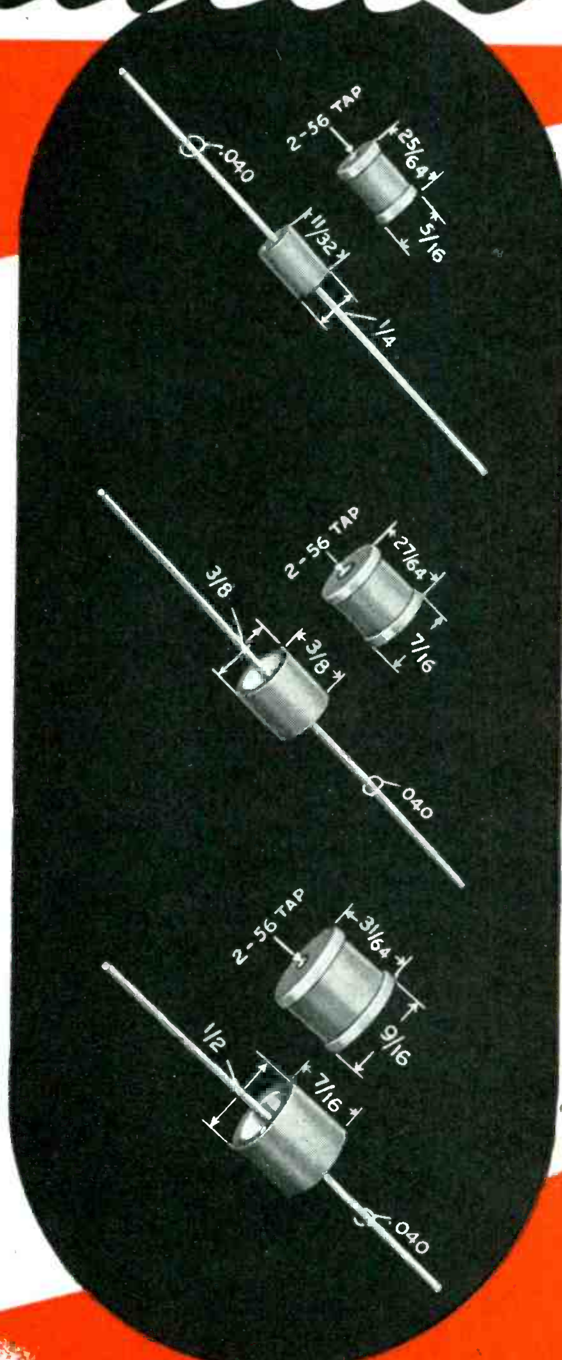
RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.
345 Hudson Street, New York 14, N. Y.

MUNICIPAL MOBILE COMMUNICATIONS

Centralab

CERAMIC CAPACITORS *for* HIGH VOLTAGE



These capacitors are engineered by Centralab for special applications . . . accumulative capacities ranging from 2MMF to 20MMF in zero temperature coefficient . . . to 4MMF to40MMF in maximum negative (N750 PPM) temperature coefficient.

Individually the capacity ranges are as follows:

855	2MMF to 5MMF in zero T. C. 4MMF to 10MMF in N750
854	5MMF to 10MMF in zero T. C. 10MMF to 20MMF in N750
853	10MMF to 20MMF in zero T. C. 20MMF to 40MMF in N750

Working voltages from 8,000 to 10,000 D.C. Energy dissipation up to 2 KVA with 15°C rise.

End lead or axial screw terminals available.

Send for Bulletin No. 814.

Producers of Variable Resistors • Selector Switches • Ceramic Capacitors, Fixed and Variable • Steatite Insulators.

Centralab

Division of GLOBE-UNION INC., Milwaukee

Here's an ESSENTIAL TOOL for Radio-Electronic Engineers, Designers, Equipment Builders, Manufacturers...

NEW 152-PAGE CAPACITOR CATALOG

Contains Application Engineering Data and Separate Sections on MICA, PAPER, and ELECTROLYTIC CAPACITORS

● Why essential? That's a big statement. Let us qualify:

This new Aerovox Catalog contains that information which is essential to those who design and build radio-electronic equipment. Here is general and specific engineering data on capacitors and their applications; detailed specifications on various types; listings of recommended types and ratings; special notes covering special features and special types; color codes; etc.

For greater convenience, the catalog is divided into four sections, each with its tab-indexed cover. These sections comprise Mica Capacitors, Application Engineering Data, Paper Capacitors, Electrolytic Capacitors. The plastic binding permits pages to lie absolutely flat.

In preparation for a year and a half—involving widespread gathering of data and intensive compilation—this combination manual-catalog represents an outstanding contribution to the working library of the radio-electronic engineer and executive. It was prepared BY engineers FOR engineers; contains absolutely no advertising—just information on capacitance and capacitors. And because of cost, its circulation is strictly limited to engineers and executives.

● **Write for Your Copy...**

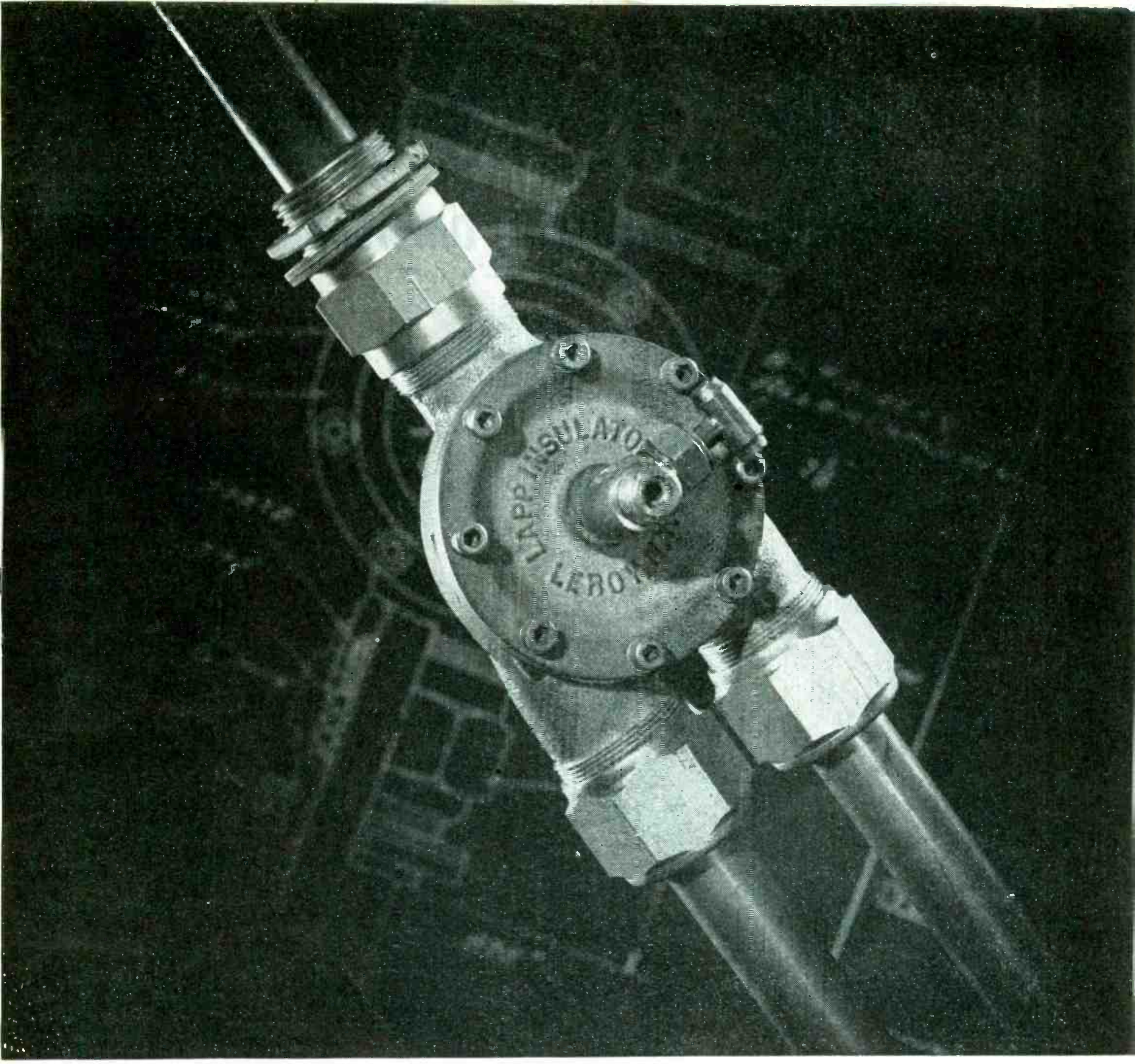
If you are engaged in designing or building radio-electronic equipment of recognized standing, write on your business letterhead for your registered copy. Also submit your capacitor problems and requirements for our collaboration.

AEROVOX Capacitors

INDIVIDUALLY TESTED

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

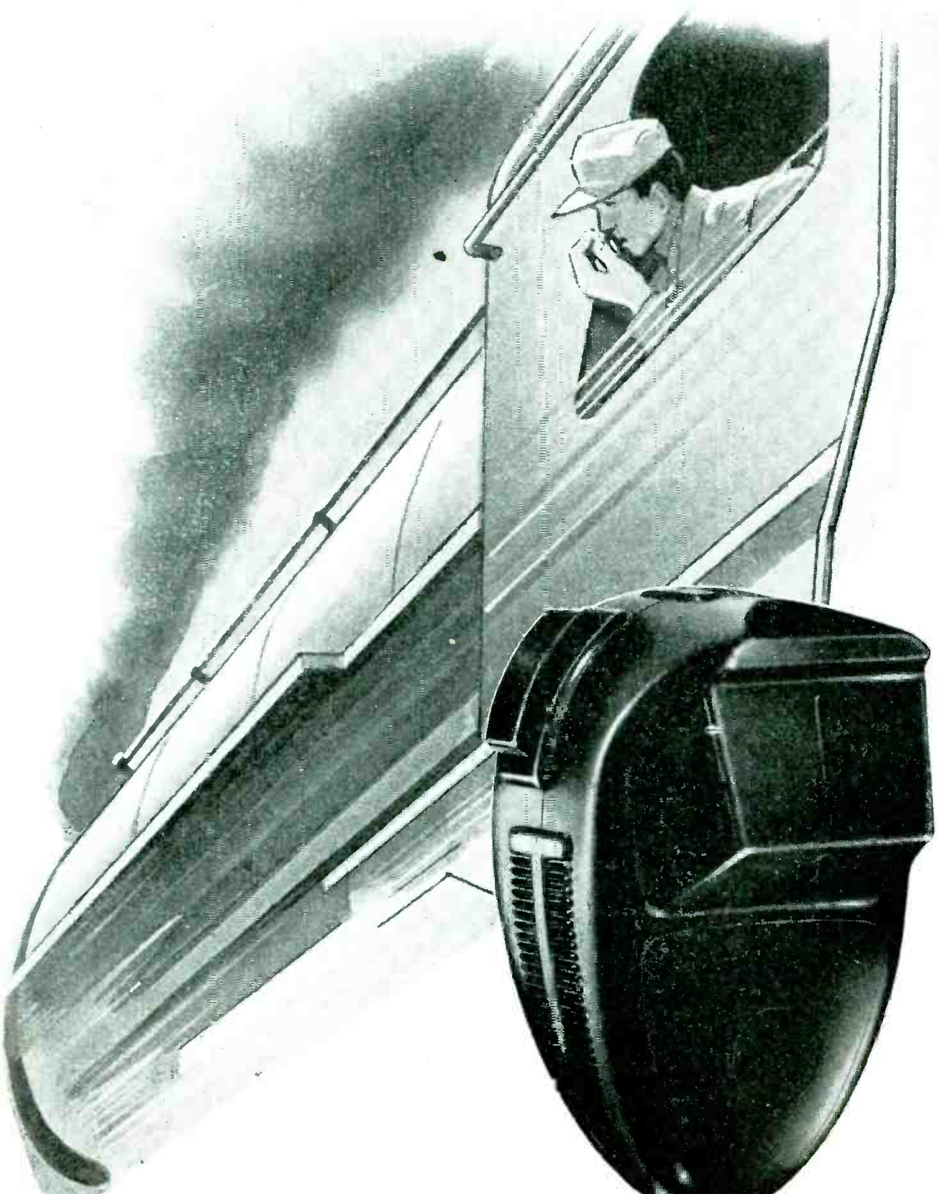
Export: 13 E. 40 St., New York 16, N. Y. • Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.



FOR SAFETY'S SAKE!

Electro-Voice Hand-Held Differential Microphone

Model 205-S



The appalling number of railroad accidents in recent months has stimulated the demand for installation of radio communications on railway lines. Eventually, all lines will be thus equipped. Splendidly suited "for safety's sake" is the Electro-Voice Differential Microphone Model 205-S. A noise-cancelling microphone, it enables the transmission of voice clearly and distinctly, unaffected by shrieking whistles or grinding wheels. Ruggedly constructed, it can "take" the punishment of a hard-riding locomotive.

FREQUENCY RESPONSE: substantially flat from 100-4000 c.p.s.

LEVEL: —20 DB (0 DB = 1 volt/dyne/cm^2)

ARTICULATION PERCENTAGE: 97% under quiet. 88% under 115 DB ambient noise

TEMPERATURE RANGE: —40° to +185°F

WEIGHT: Less than eight ounces

INPUT REQUIREMENT: standard single button input

BUTTON CURRENT: 10-50 milliamperes

MECHANICAL DETAILS: molded, high impact phenolic housing. Minimum wall thickness, 1/8". Vinylite carbon retainer.

SWITCH: press-to-talk, with or without hold-down lock. Double pole double throw contacts provide an optional wide assortment of switch circuits. Standard circuit provides closing of button circuit and relay simultaneously.

THERMAL NOISE: Less than 1 millivolt with 50 milliamperes through button

IMPACT RESISTANCE: capable of withstanding more than 10,000 drops

POSITIONAL RESPONSE: plus or minus 5 DB of horizontal

CABLE: 5' three conductor, overall synthetic rubber jacketed

BACKGROUND NOISE REDUCTION: 20 DB and higher, depending on distance from noise source

The Model 205-S may also be successfully used for such applications as aircraft, industrial, police and emergency services.

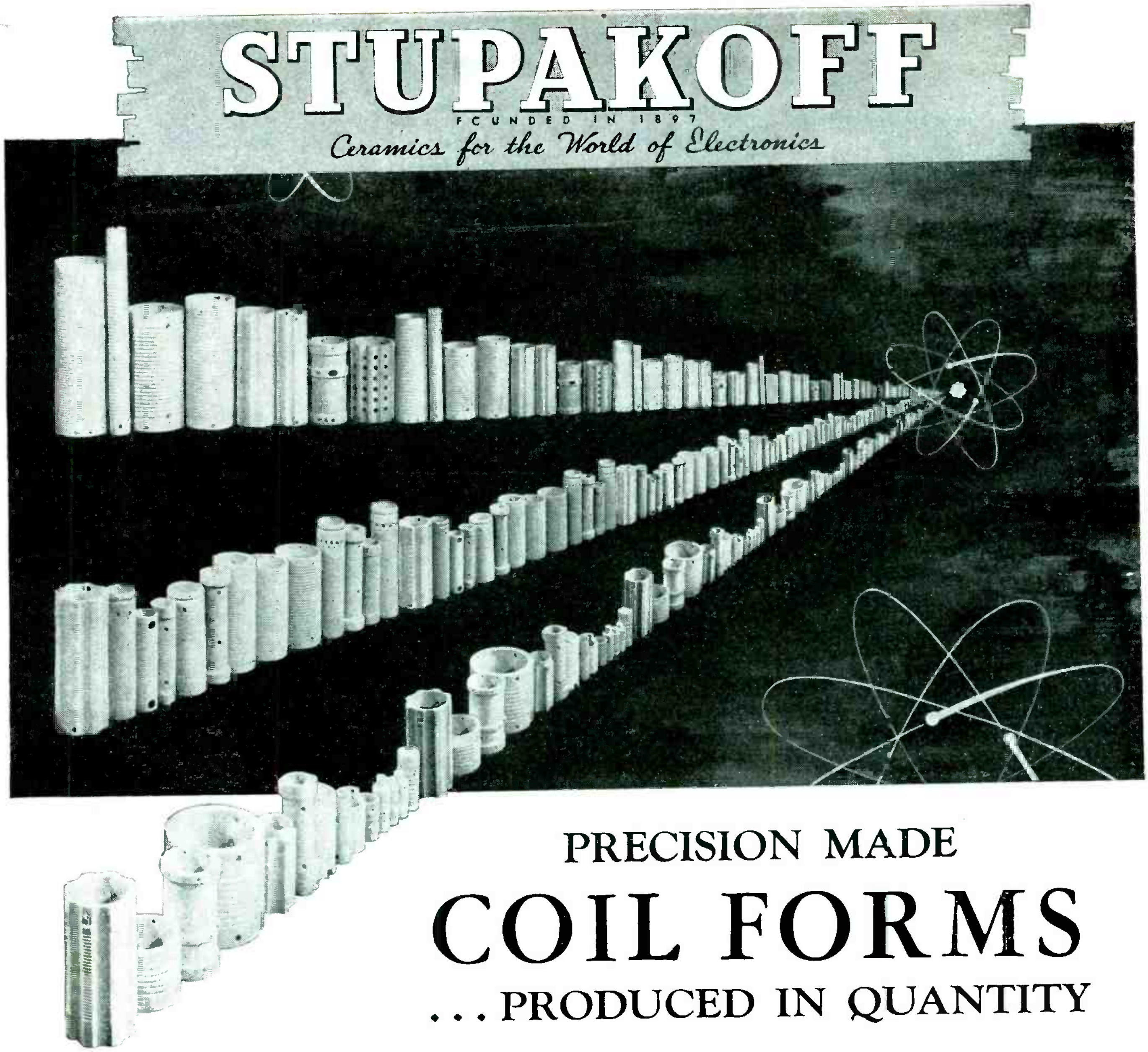
If your present limited quantity needs can be filled by this Model 205-S or any of our other Standard Model Microphones, with or without minor modifications, please contact your nearest Electro-Voice distributor.

Electro-Voice MICROPHONES

ARMY E NAVY

ELECTRO-VOICE CORPORATION • 1239 SOUTH BEND AVENUE • SOUTH BEND 24, INDIANA

Export Division: 13 East 40th Street New York 16, N. Y., U. S. A. Cables: Arlab



PRECISION MADE
COIL FORMS
... PRODUCED IN QUANTITY

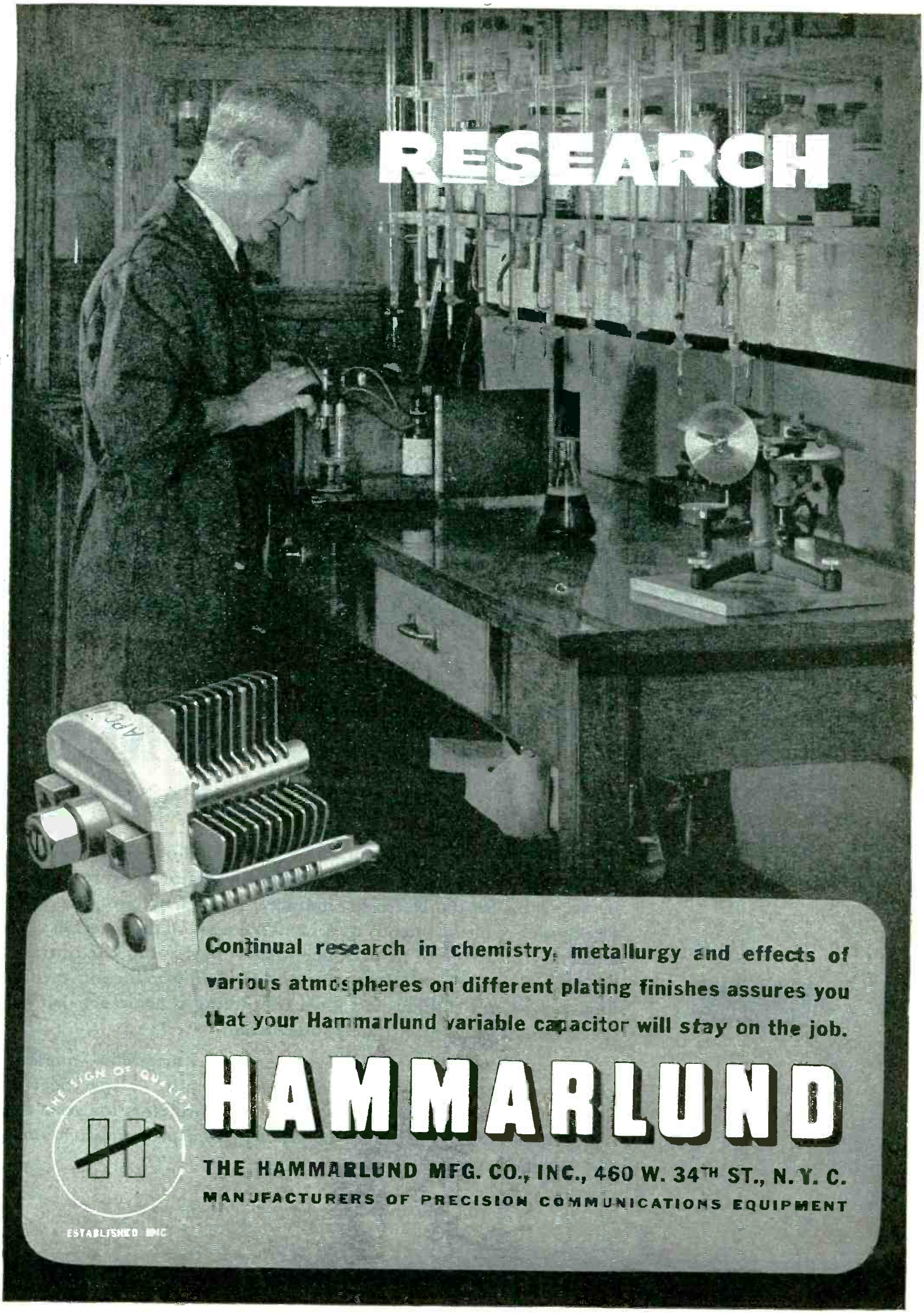
LIMITLESS styles and sizes of coil forms, embodying the exacting specifications required of this type of insulator, are manufactured by Stupakoff for the electronic industry. Backed by two generations of experience in the science of ceramics, Stupakoff engineers have the necessary knowledge to produce insulators having the optimum mechanical and electrical properties. Modern production facilities plus trained and efficient personnel are additional assurance that your specifications will be accurately interpreted.

ARMY E NAVY
"FOR GREAT ACHIEVEMENT"

Stupakoff coil forms of steatite and other materials—unglazed, glazed or metallized—can be delivered promptly. Write today for dependable assistance in developing correct insulators for your electronic apparatus. Your inquiries will be given prompt attention by our technical staff.

Do More Than Before—Buy EXTRA War Bonds

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

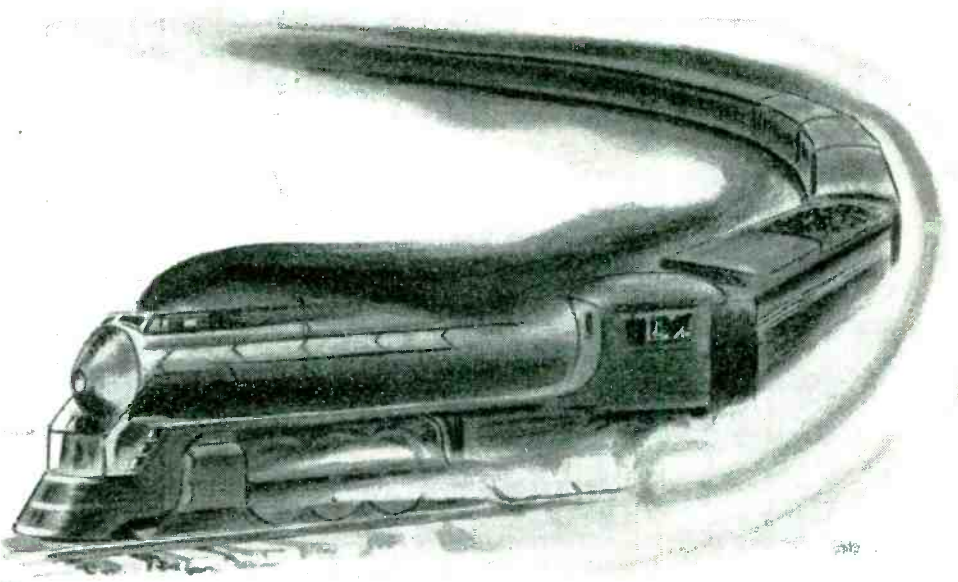

RESEARCH
Continual research in chemistry, metallurgy and effects of various atmospheres on different plating finishes assures you that your Hammarlund variable capacitor will stay on the job.
HAMMARLUND
THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., N. Y. C.
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT
THE SIGN OF QUALITY

AMERICAN *Phillips* SCREWS

drive with Straight-Line *SPEED* to Keep Production Rolling at "Full Throttle"

Are you slow-poking along with the same old outdated, slotted screws? . . . Or are you using the modern, streamlined American Phillips Screw Driving method which drives you straight to new speed records in production, without accidents either to workers or their work?

All that *any* worker . . . skilled or unskilled, man or woman . . . has to do is this: Fit the recessed head of an American Phillips Screw onto the 4-winged Phillips bit of a power-driver. Aim this *automatically self-aligned* driving unit at the work, and pull the trigger. *That's all.* Every American Phillips Screw sets up straight, flush, and tight, with its head unburred . . . and with no gouges on surrounding work-surfaces. And that's why so many plants in every industry keep on using American Phillips Screws *right from the first time they tried them* . . . because with this straighter, speedier method, it costs less to do more and better work.



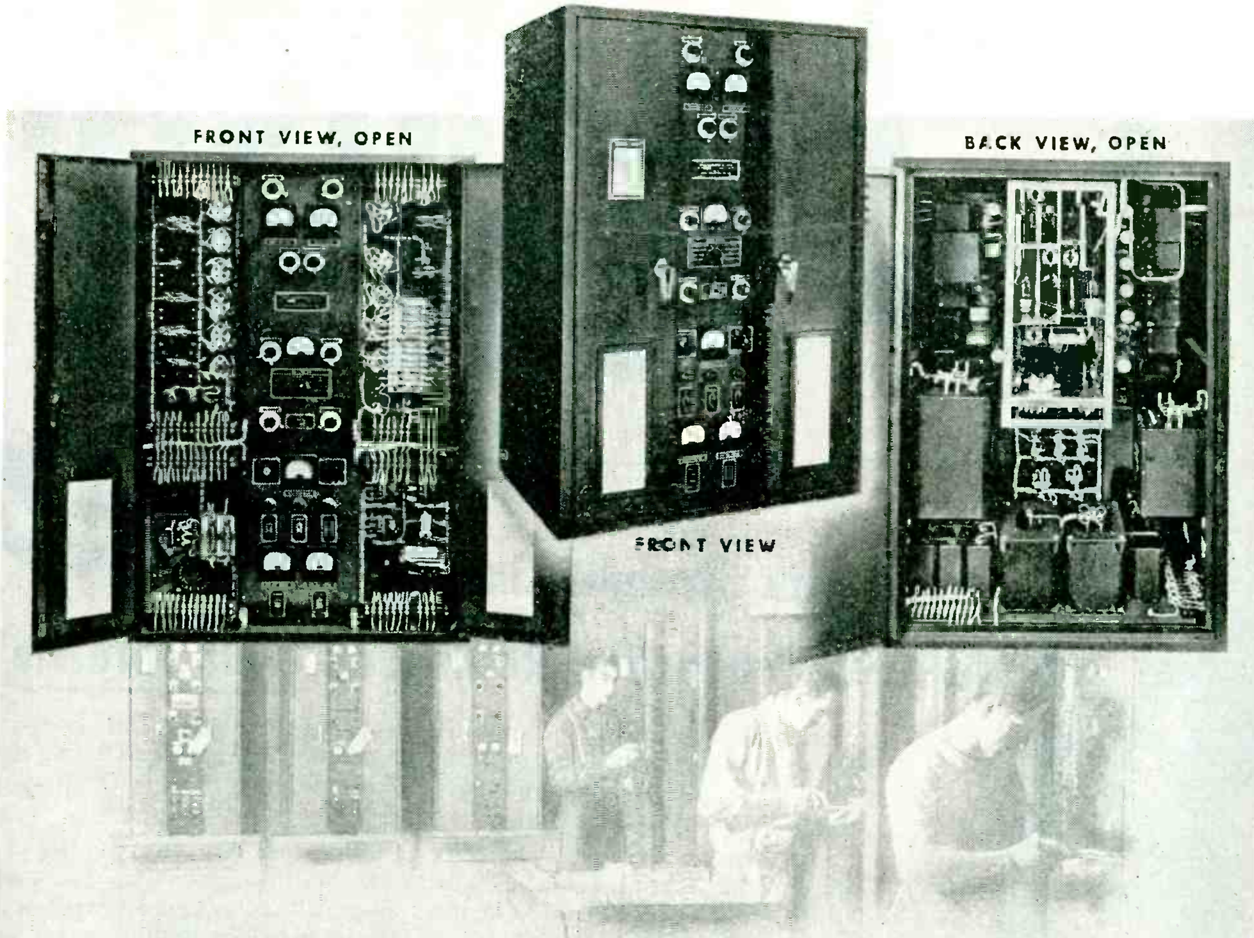
4-WINGED DRIVER CAN'T TWIST OUT OF ENGINEERED TAPERED RECESS IN AMERICAN PHILLIPS SCREW HEAD

AMERICAN SCREW COMPANY

PROVIDENCE 1, RHODE ISLAND

Chicago 11: 589 E. Illinois Street   *Detroit 2.* 502 Stephenson Building

Put the Screws on the enemy . . . BUY BONDS!



AIRPORT TRAFFIC CONTROL TRANSMITTER

Type U-459—50 watt—116-145 mc. range

Type U-459 is a ground station transmitter intended for airport traffic control, airline and itinerant communication. It can be supplied with 125 watt output and other frequency bands. A similar transmitter, supplied by us for the use of the Army Air Forces, is meeting severe service in all sections of the globe.

PRINCIPAL OPERATING CHARACTERISTICS

- **Power Supply** ...... 110-120 v., 60 cycle single phase
- **Power Input, Unmodulated** .... 690 watts
- **Power Input, 100% Modulated** .... 750 watts
- **Unmodulated Carrier Output** .... 45 watts
- **Output Frequency in Bands** .... 116 to 145 mc.
- **Antenna Load Impedance** ... 72 ohm concentric transmission line
- **Permissible Modulation** 100%
- **Distortion of 1000 cycles at 90% modulation** .... Less than 7%
- **Distortion of other frequencies at 90% modulation** .... Less than 12%
- **Frequency Response from Line Input** .... ±1 db from 100 to 3000 cycles
- **Operating Temperature Range** .... —15 to ±50° c.
- **Operating Humidity Range** .... 0 to 100%
- **Carrier Noise with Audio Input shorted and Gain Control at maximum** .... Less than 2%
- **Effective Operating** .. To the horizon. Depends on height of transmitting and receiving antennas

ACCESSORY EQUIPMENT — ***Also available:*** Remote Control Unit; Microphone push-to-talk, release-to-listen type for local control without amplification; Horizontally and Vertically Polarized Antennas.

COMPLETE DETAILS, PRICE AND DELIVERY ON REQUEST

RADIO RECEPTOR COMPANY, INC.

251 WEST 19th STREET • NEW YORK 11, NEW YORK

AIRWAY AND AIRPORT RADIO • SOUND SYSTEMS • INDUSTRIAL ELECTRONICS • ELECTRONIC H. F. HEATERS

SINCE 1922 IN RADIO AND ELECTRONICS

This Audio Oscillator Transformer Meets 5-Cycle Temperature Test Requirements

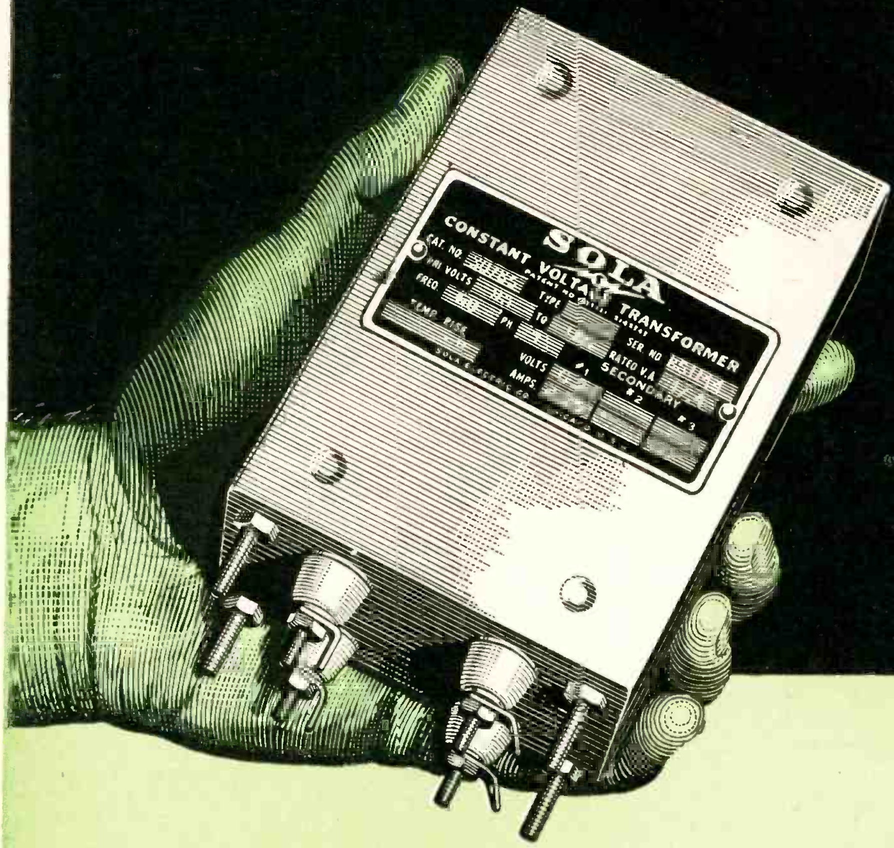
STURDY TERMINALS ASSURE SECURE CONNECTIONS

HI-MU alloy plus a special sealing process! There, in a nutshell, is the reason why this capsule-size transformer operates with great stability under all climatic conditions . . . This is only one of our complete line of midget audio transformers and filter reactors . . . Our many years of pre-war experience has not only helped us solve the problems of war demands, but also prepares us to serve in the postwar future.

SUPER ELECTRIC PRODUCTS CORP.
1057 Summit Ave., Jersey City, N. J.

Manufacturers of Transformers for Power, Audio Frequency, Luminous Tube, Testing

This SOLA CONSTANT VOLTAGE TRANSFORMER has an important postwar future in *YOUR*



HEATING CONTROLS • REFRIGERATION CONTROLS • TELEVISION SETS • F-M RADIO • VACUUM TUBE VOLTMETERS • ELECTRONIC GAUGING AND INSPECTION EQUIPMENT • PHOTO-METRIC INSTRUMENTS...*there are other applications of course*

Here is a SOLA Constant Voltage Transformer that should be a built-in part of your equipment—

First: because it will stabilize output voltage at your rated requirements regardless of line voltage fluctuations as great as ±12 to 15%.

Second: because its small, compact size is ideal for chassis mounting.

Third: because of its low, economical cost.

Fourth: because of the saving that can be made through the elimination of other components.

Fifth: because a majority of anticipated service calls can be eliminated from your cost calculations.

Sixth: because the users of your product will get greater satisfaction from trouble-free service.

This particular transformer is rated at 6.3 volts, 17VA output and is designed primarily for the stabilization of vacuum tube filament and heater voltages. Other voltages and capacities for chassis mounting can be supplied on the same low cost, economical basis to meet your exact requirements.

SOLA Constant Voltage Transformers

To Manufacturers:

Complete specification details covering this new Constant Voltage Transformer will be furnished at your request.

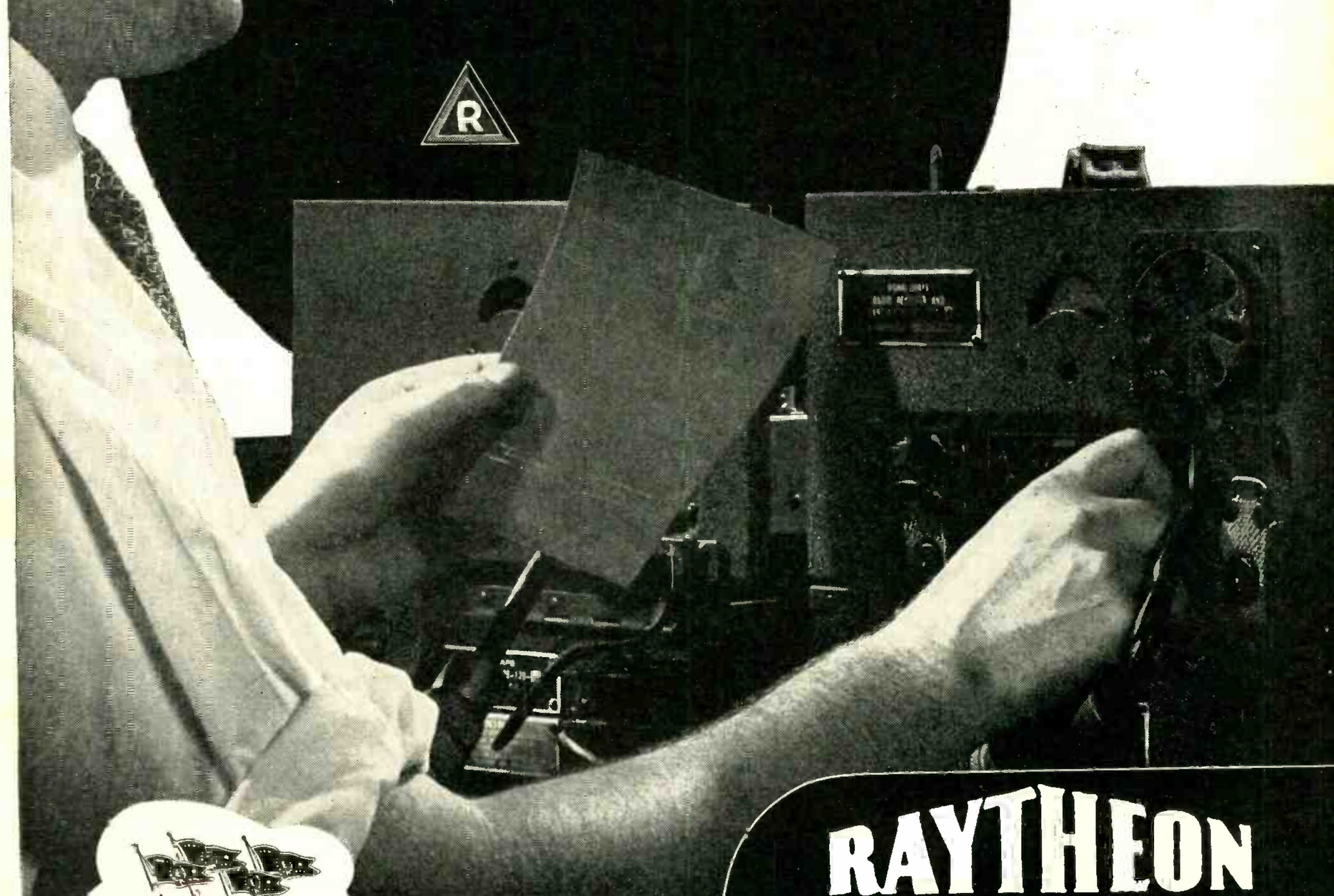
Ask for Spec. No. DCV-103

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.**

pioneer for tomorrow

The world of tomorrow will be one of electronics. Pioneer for that world is the electronic engineer. His vitally important effort during this wartime period in devising electronic equipment is helping to defeat the enemy. Tomorrow, he devotes his specialized scientific knowledge to aid peacetime industries.

Raytheon is applying its efforts to the development of advanced electronic tubes and equipment for the war effort. When that job is done, the knowledge that has been gained will be used to guarantee that post-war radio, industrial and electronic equipment manufacturers will receive Raytheon tubes and equipment with even greater "Plus-Extra" quality.



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

RAYTHEON
Raytheon Manufacturing Company
ELECTRICAL EQUIPMENT DIVISION
Waltham and Newton, Massachusetts

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

Catalin

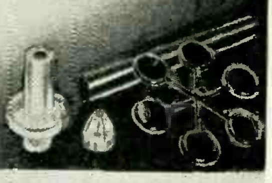
PLASTICS

CAST RESINS

"Catalin" Cast Phenolic Resins offer the most complete and beautiful range of gem-like colors, from crystal-clear through every conceivable hue, to jet black. It is not a molding powder and does not require the construction of expensive molds. Because of Catalin's unexcelled machinability, an infinite variety of products may be fabricated to precision specifications from standard sheets, rods, tubes or shapes. Catalin has excellent physical properties.

MOLDING COMPOUNDS

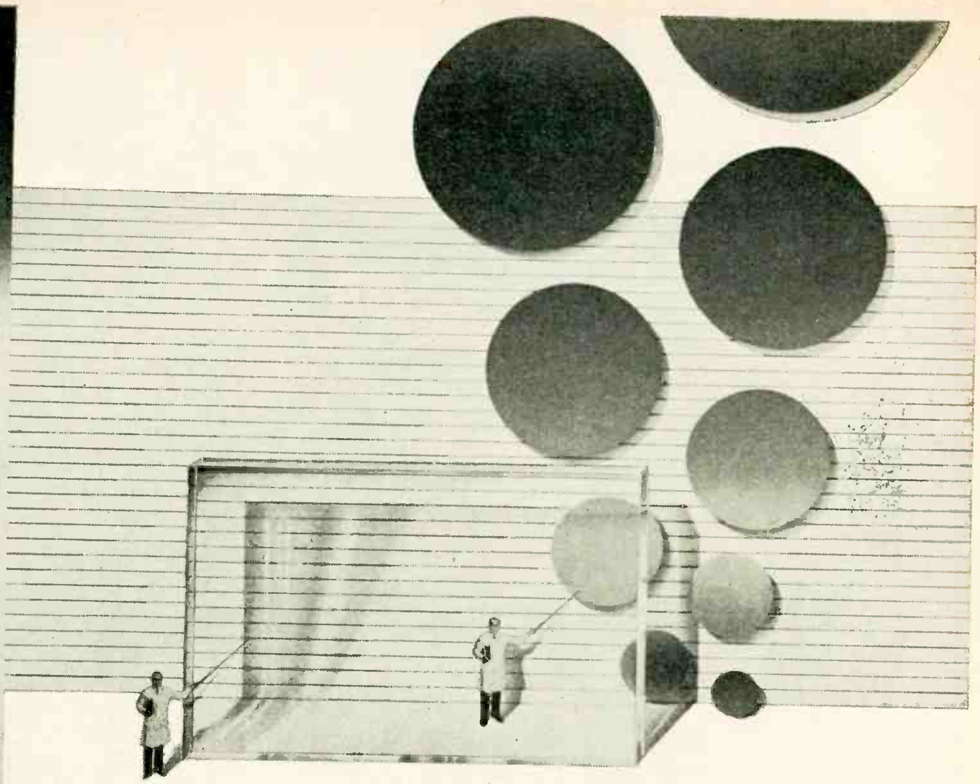
"Loalin" is Catalin's Polystyrene extruding and molding compound. A thermoplastic material, it possesses many outstanding properties . . . among them, its low cost and zero water-absorption, high dielectric strength, excellent chemical resistance and unrivalled dimensional stability. In addition to these, "Loalin" is the lightest in weight of all the plastics.



LIQUID RESINS

"CATABOND" and "CATAVAR", "LOABOND" and "LOAVAR" identify a wide variety of thermosetting and thermoplastic liquid resin formulations employed in coating, laminating, glueing, bonding and impregnating wood, plywood, abrasives, paper, sisal, glass fibres, leather, cloth, cork, etc. All embody special properties and are designed to do a specific job in some particular industry. There is no evident limit to their useful application.

CATALIN CORPORATION
ONE PARK AVE., NEW YORK 16, N.Y.



transparency :: color

Probably no two physical characteristics have played more important roles in the original and increasing acceptance of Plastics than have the properties of transparency and color.

The acknowledged sales-appeal and design-potentials of color and the many decorative and practical applications for crystal-clear, tough materials helped write the history of the early years of this Plastic Age. When war replaced the automobile with the airplane and the luxury liner with the "PT" boat and submarine, lightweight colored and transparent plastic handles, knobs, signal dials, instrument panels, etc., brought the quick identification of controls so essential to fighters and war-workers.

Fabricators of "CATALIN", our cast phenolic resin, and molders of "LOALIN", our polystyrene compound, know them for their unlimited range of pure, gem-like colors and their brilliant transparency. No other plastic can match Catalin's depth and richness of color—not only in opaque and transparent forms, but in various degrees of translucency, as well. Its refractive index is 1.58-1.62...Loalin's is 1.59. Catalin's light transmission (in crystal-clear) is 80-90% . . . Loalin's is 88-90%. In addition, Loalin possesses the unique advantage of "bending" light around curves—of especial interest in current scientific applications and for industrial and home lighting in the immediate future.

Whatever else that future holds, we may be certain that the technical assets of the transparent plastics and the refreshing and stimulating properties of the color these miracle materials will bring into our everyday lives in homes, offices and factories, alike, will make important contributions to our fuller enjoyment of the fruits of Peace.

Catalin — *Cast Resins* / *Molding Compounds* / *Liquid Resins*

CATALIN
CORPORATION

ONE PARK AVENUE • NEW YORK, N. Y.

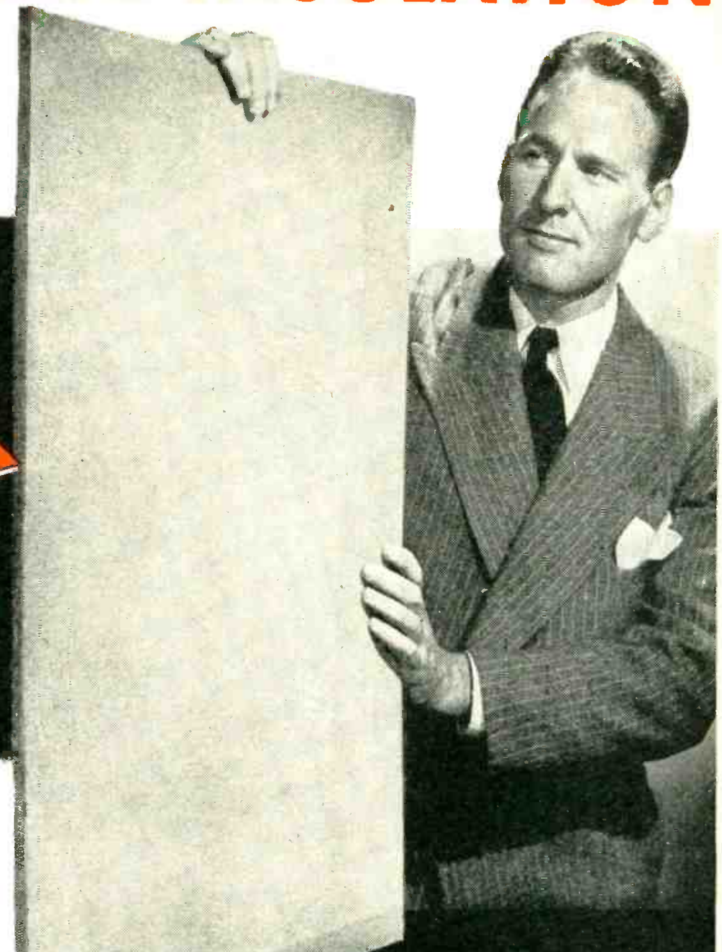

Speed
REVOLUTIONARY RADIO TUBE DESIGN
WITH D H METALS
Frequencies of 2000 Megacycles and more—Electronic Heating—Frequency Modulation—Television—Radar . . . these and other phenomenal radio inventions have brought about radical changes in radio tube design like these.
New concepts of tube function and revolutionary methods of construction have necessitated equally new developments in radio metallurgy.
In Driver-Harris research laboratories and factories are being produced the radio alloys essential to the speedy and successful manufacturing of these tubes . . . in quality controlled quantities adequate for the great demands of war.
Whether you are striving to make standard tubes rate higher and last longer—or are engaged in the development of new types, depend on Driver-Harris to supply you with the radio metals required. Send us your metal specifications.
Driver-Harris makes these and other time-tested alloys for every radio and vacuum tube requirement:
*NICHROME *GRIDNIC ALLOYS NICKEL "A," "D," "E," "Z" *NILVAR
*FILNIC ALLOYS #42 ALLOY #52 ALLOY
*Trade Mark Reg. U. S. Pat. Off.
ARMY E NAVY
D H
SPECIAL PURPOSE ALLOYS SINCE 1899
Driver-Harris COMPANY
HARRISON, NEW JERSEY
BRANCHES: CHICAGO • DETROIT • CLEVELAND • LOS ANGELES • SAN FRANCISCO • SEATTLE

LARGEST SHEET
OF MICA CERAMIC INSULATION
ever made

19¼" x 29¾"

MYKROY SHEETS

now ready



THIS new size plate of MYKROY glass-bonded mica ceramic insulation is ***more than 2 times LONGER*** than the maximum size available heretofore affording Production and Design Engineers many important new application advantages:

1. Because of increased size MYKROY can now be used for: Switchboard panels—Large inductance bars—Insulated table tops—Large meter panels—Transformer covers—Switch connecting rods—Bases for Radio Frequency or Electrical Equipment assemblies and structural members in R. F. equipment where low-loss insulation is indispensible.

2. Lower cost per square inch of MYKROY in the 19¼" x 29¾" sheet makes possible savings as high as 33⅓% depending upon workpiece size, considerably reducing the cost per fabricated unit.

3. Better cutting efficiency in the new plate lowers unit cost still further and permits employing the superior insulating properties of MYKROY in a broader range of electronic applications.

All fabricators of glass-bonded mica materials should seriously consider the use of these larger plates to reduce costs and amount of time required in filling their orders. Ready for Immediate Delivery. Most thicknesses carried in stock.

WRITE FOR MYKROY SHEET BULLETIN #102

Just off the press, Bulletin #102 is a complete engineer's data book which combines practical data with a brief account of the dramatic story behind the development of the 19¼" x 29¾" sheet. It is replete with working data and comparison charts on the various sizes of MYKROY sheets. Write for your copy NOW!

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

MADE EXCLUSIVELY BY ELECTRONIC MECHANICS INC.
70 CLIFTON BOULEVARD • CLIFTON, NEW JERSEY
Chicago 47: 1917 NO. SPRINGFIELD AVENUE . . TEL. Albany 4310
Export Office: 89 Broad Street, New York 4, N. Y.

Life Testing ON THE GRAND SCALE!

One of the most elaborate cathode-ray tube test racks in this country operates day and night, seven days a week at National Union. For, at N. U., cathode ray tube production is now reaching heights undreamed of in pre-war days. To achieve this production, entirely new testing techniques, on an unprecedented scale, have been developed.

Examples of the newest tried and proven N. U. products are the four cathode-ray tubes illustrated. All of these N. U. cathode ray types can be produced in a variety of screen materials, which will have various postwar applications in television and industrial electronics.

Here at National Union are many such ultra-modern products ready to serve your peacetime needs. Ready, yes, in large volume—and backed by as fine an electronic tube research service as has ever been available to industry. Ready, indeed, from the day our present obligations are fulfilled and reconversion can get under way. Count on National Union.

NATIONAL UNION RADIO CORPORATION, NEWARK, N. J.
Factories: Newark and Maplewood, N. J.; Lansdale and Robesonia, Pa.

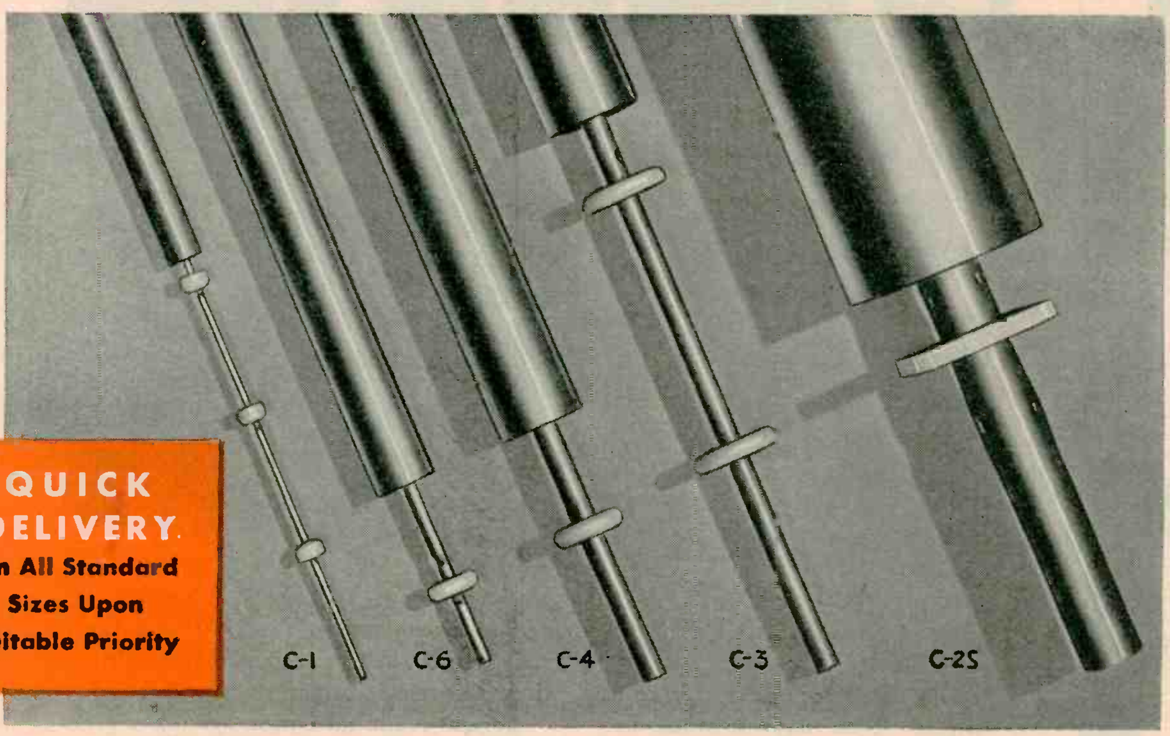
NATIONAL UNION
RADIO AND ELECTRONIC TUBES

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

Concentric Transmission Line

by Doolittle

A Standard Product Since 1934



QUICK DELIVERY
On All Standard Sizes Upon Suitable Priority

Ten years of experience in building concentric transmission line and associated impedance matching equipment assures you highest quality and workmanship.

Seven standard sizes of Doolittle Lines are listed below. Each line uses seamless copper tubing for the outer and inner conductor, except Types C-1 and C-6 which use solid inner conductors. The insulating heads are made of low loss ceramic—impervious to moisture—spaced and fastened securely for maintaining proper electrical and mechanical characteristics. Carefully designed fittings and accessories for any requirement are also available.

Special sizes are made to order. For engineering information concerning installation and use, feel free to consult our engineering staff.

WRITE FOR CATALOG AND PRICES

Type of line	C-1	C-2	C-2S	C-3	C-4	C-5	C-6
Diameter of outer conductor	⅜ in.	2 in.	2 in.	1 in.	⅞ in.	3 in.	⅝ in.
Diameter of inner conductor	.081 in.	⅝ in.	½ in.	¼ in.	¼ in.	¾ in.	.144 in.
*Standard section length, feet	50	20	20	20	20	14	50
Net weight per ft.	2 oz.	10 oz.	1 lb. 1 oz.	8 oz.	8 oz.	1 lb. 10 oz.	4 oz.
Power rating-kilowatts	1	50	50	10	10	100	5
Surge impedance-ohms	70	100	82	75	66	80	73
Loss per 1000 ft. at 1 mc. decibels	.94	.156	.083	.31	.33	.095	.55
Capacity per ft. mmfds.	19.8	10.5	12.5	14.1	16.0	12.8	14.8

*A set of couplings for the inner and outer conductors is furnished with each length.

Doolittle RADIO INC.

Builders of Precision Communications Equipment

7421 SOUTH LOOMIS BLVD.
CHICAGO 36, ILLINOIS

We knew what you wanted!

A QUICK DIGEST OF THE REINER No. 450

Vacuum Tube Voltmeter

The Model 450 Vacuum Tube Volt-Ohm Milliammeter offers: Wide frequency range AC Voltmeter; One linear scale for all voltage and current scales; Freedom from the effects of temperature and humidity; single zero adjust for all AC and DC ranges. Measure 100 ohms to 1,000 megohms without battery—the latter used only for measurements below 100 ohms. Voltage regulated supply—stable operation. No more mislaid or lost test probes and connectors—convenient, adequate storage space in case.

AC VOLTAGE RANGES — .005 to 250 volts, 5 ranges 0—2.5—10—25—100—250 v; Linear scale all ranges. Frequency range—50 cps. to 50 megacycles; Input resistance 1 megohm at 1000 cps. all ranges; Input capacitance—10 mmf. Diode probe with 4-foot cable; Accuracy 2% of full scale values; maximum frequency error to 50 megacycles—5%. Single zero adjust for all ranges.

DC VOLTAGE RANGES — .005 to 1000 volts; 6 ranges 0—2.5—10—25—100—250—1000 volts. Linear scale; Input capacitance—less than 2 mmf. Input resistance—11 megohms all ranges. Accuracy 2% of full scale values.

DC CURRENT RANGES — 50 microamperes to 1 ampere; 6 ranges 0—2.5—10—25—100—250—1000 milliamperes. Accuracy 2% of full scale values. Effective resistance at 1 ampere—.45 ohms; at 2.5 milliamperes—180 ohms.

OHMMETER RANGES — 6 ranges—.1 ohm to 1000 megohms. Center Scale Resistance—10^1, 10^2, 10^3, 10^4, 10^5, 10^7 ohms. Center Scale Accuracy—2%. 3 low ranges battery operated. 3 high resistance ranges internally powered

Complete, with all accessories, as illustrated, ready to operate, Model 450 costs only **$135.00**

IT'S THE REINER VACUUM TUBE VOLTMETER

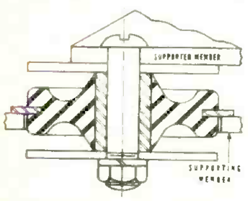
It's as if we had been reading your mind. You thought that some day some one would devise one all-purpose instrument that would be simpler, more flexible — cover a wider range of functions and applications than any of the usual commercial vacuum tube voltmeters. Well, here it is — the complete answer to your needs — the new Reiner Model 450!

Look at its special features! You'll discover we have anticipated your every requirement. In the Reiner Model 450, you'll find that somehow we knew exactly what you wanted when we designed this superb instrument.

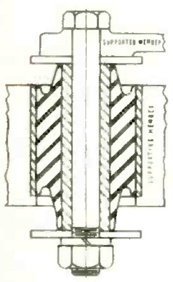
For more information on this and other Reiner equipment such as square wave generators, oscilloscopes, and signal generators, write Reiner Electronics Co., Inc., 152 West 25th Street, New York 1. N.Y

Reiner
ELECTRONICS

Plan now for future design . . .



LORD PLATE FORM MOUNTING



LORD TUBE FORM MOUNTING

What are you going to do—what are you going to make—how are you going to make it—in the post-war world?

It's going to be a different, and we hope a better world. But it's going to be a faster-moving world; nerves, more than ever, are going to be under strain.

Faster trains, faster cars, faster planes—and more of them; faster machinery, faster production lines—it all means more vibration, more strain on the nervous system; and much greater need for vibration control.

For over twenty years the Lord Manufacturing Company has pioneered the application of shear type rubber mountings for the control and isolation of vibration. The war has greatly accelerated both the science of vibration control and the recognition of its practical necessity and financial economy. Every U. S. military plane, as an instance, has many units, from the giant engines to the most delicate instrument, protected from harmful vibration with Lord Shear Type Mountings.

Whatever you manufacture or plan to manufacture, if its efficiency is affected by vibration, internal or external, Lord engineers can help you. In the meantime, our free literature will bring you up to date in your general information on vibration control.

LORD
BONDED RUBBER
Shear Type
MOUNTINGS

Buy More War Bonds

IT TAKES RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

SALES REPRESENTATIVES
NEW YORK - - 280 MADISON AVE.
CHICAGO - 520 N. MICHIGAN AVE.
DETROIT - - 7310 WOODWARD AVE.
BURBANK, CAL. - 245 E. OLIVE AVE.
CANADIAN REPRESENTATIVES
RAILWAY & POWER ENGINEERING CORP., LTD.
TORONTO, CANADA

Originators of Shear Type Bonded Rubber Mountings

KARP Sales Representatives

are strategically located all over the country. A card to this office will bring our representative in your district to consult with you.

Give us the specifications or plans for your sheet metal requirements, and KARP will produce a superior finished product because . . .

★ **We have engineers and craftsmen with a "golden touch" to create anything in sheet metal.**

★ **We have complete metal working facilities, including hundreds of stock dies to lower or eliminate die costs.**

★ **All orders are custom built with typical KARP ingenuity.**

★ **Competitive prices! Prompt deliveries!**

SUPPORT THE SIXTH WAR LOAN DRIVE

KARP METAL PRODUCTS CO., INC.

124 30th STREET · BROOKLYN 32, N. Y.

-30°F

210°F

High or Low Temperatures—
There's Little Viscosity Change

Small change in viscosity over a wide temperature range is one of several important properties that distinguish Dow Corning Fluids. These new silicone products are available in two series, depending on the viscosity grade and freezing point required. In both Type 200 and Type 500 the viscosity change is much smaller than that of any known liquids of equivalent viscosity.

The simplified graph above shows the viscosity grade and temperature slope of Type 200 Fluids compared with hydraulic oils over a temperature range of –30°F. to 210°F. Note the flat slope of the DC Fluid. This illustrates a characteristic that has awakened keen interest. Here are fluids that *stay fluid*, even at temperatures far below zero. Such remarkable properties indicate that these new inert liquids are ideal for many precision instrument damping applications.

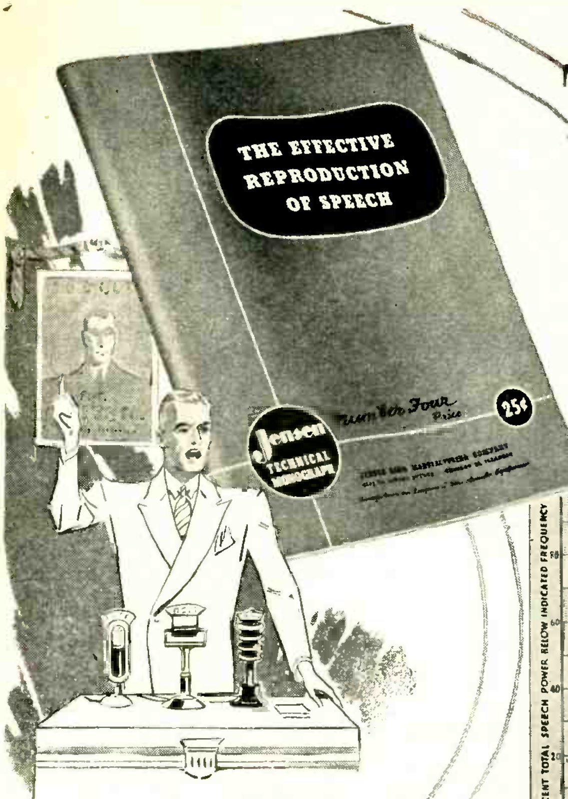
DOW CORNING CORPORATION
BOX 592, MIDLAND, MICHIGAN

DOW CORNING SILICONE PRODUCTS INCLUDE:

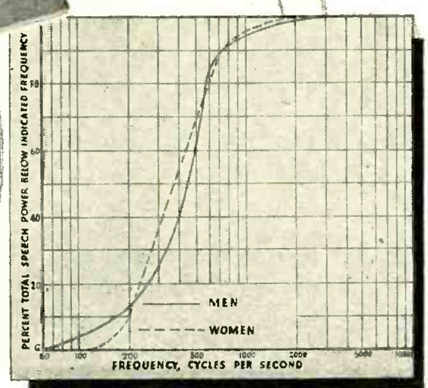
RESINS—High temperature insulating varnishes for use with heat stable electrical insulating materials.

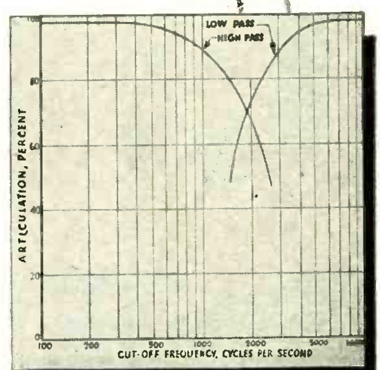
GREASES—For lubrication of valves in high temperature or corrosive chemical services. Plug Cock Grease—for metal valves. Stopcock Grease—for glass and ceramic valves.

Dow Corning



THE EFFECTIVE REPRODUCTION OF SPEECH...





When casually considered, the reproduction of speech may appear to present less exacting requirements than the reproduction of music. Yet *faithful* speech reproduction requires a frequency band almost as wide as for music. Amplified speech for strictly *communication* purposes usually presents a different requirement. Here, such matters as articulation, loudness, masking, power requirements and the ability to deliver the message through noise, become the more important considerations.

"The Effective Reproduction of Speech"—Number 4 in the series of JENSEN Technical Monographs—presents much up-to-date data on this important subject in convenient form, together with useful conclusions and practical information for everyone interested in sound reproduction. Get your copy from your JENSEN jobber or dealer, or fill out the coupon and mail it with 25c for each copy ordered.

The Series So Far Issued

No. 1. Loud Speaker Frequency-Response Measurements.
No. 2. Impedance Matching and Power Distribution.
No. 3. Frequency Range in Music Reproduction.
No. 4. The Effective Reproduction of Speech.

FREE to men in the Armed Services, and to Technical Schools, Colleges and Libraries.

Jensen

RADIO MANUFACTURING COMPANY
6607 South Laramie Avenue
Chicago 38, Illinois

Send me ☐ The Effective Reproduction of Speech.
☐ Frequency Range in Music Reproduction.
☐ Impedance Matching and Power Distribution.
☐ Loud Speaker Frequency-Response Measurements.

(Check one or more. Send 25c for each book ordered.)

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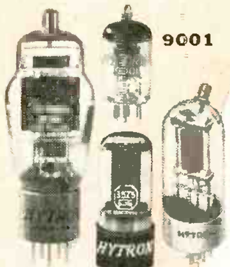
ADDRESS ________________

CITY ________ ZONE ____ STATE ______

Some INTERESTING FACTS ABOUT HYTRON



9001

HY69 35Z5 GT/G HY75

★ Hytron is the oldest manufacturer in the United States specializing on radio receiving tubes. The first Hytron tube was made by hand in 1921.

★ The now standard BANTAM GT receiving tube is a Hytron origination. Hytron designed and developed over 70 of the popular GT types. These small glass receiving tubes contributed to the development of the miniature table radio and to large scale production of radio and radar equipment for the Services.

★ The tiny BANTAM JR. tubes originated by Hytron were the first subminiatures. They made possible hearing aids and pocket radio sets. Similar Hytron tubes serve in wartime electronic devices.

★ Hytron has pioneered transmitting and special purpose tubes for the radio amateur and for police radio. Its very-high-frequency tubes and its instant-heating r.f. beam tetrodes for mobile communications, have also become extremely popular with the Services.

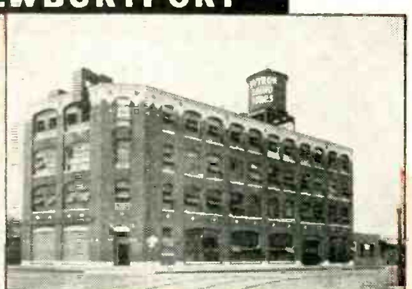
★ Hytron combines long experience in high-speed receiving tube techniques with the know-how of special purpose tube engineering. The result is economical mass production of special tubes.

★ First of the receiving tube manufacturers to convert 100% to war production, Hytron will be just as alert in serving the post-war market.

BEVERLY

LAWRENCE

NEWBURYPORT



SALEM

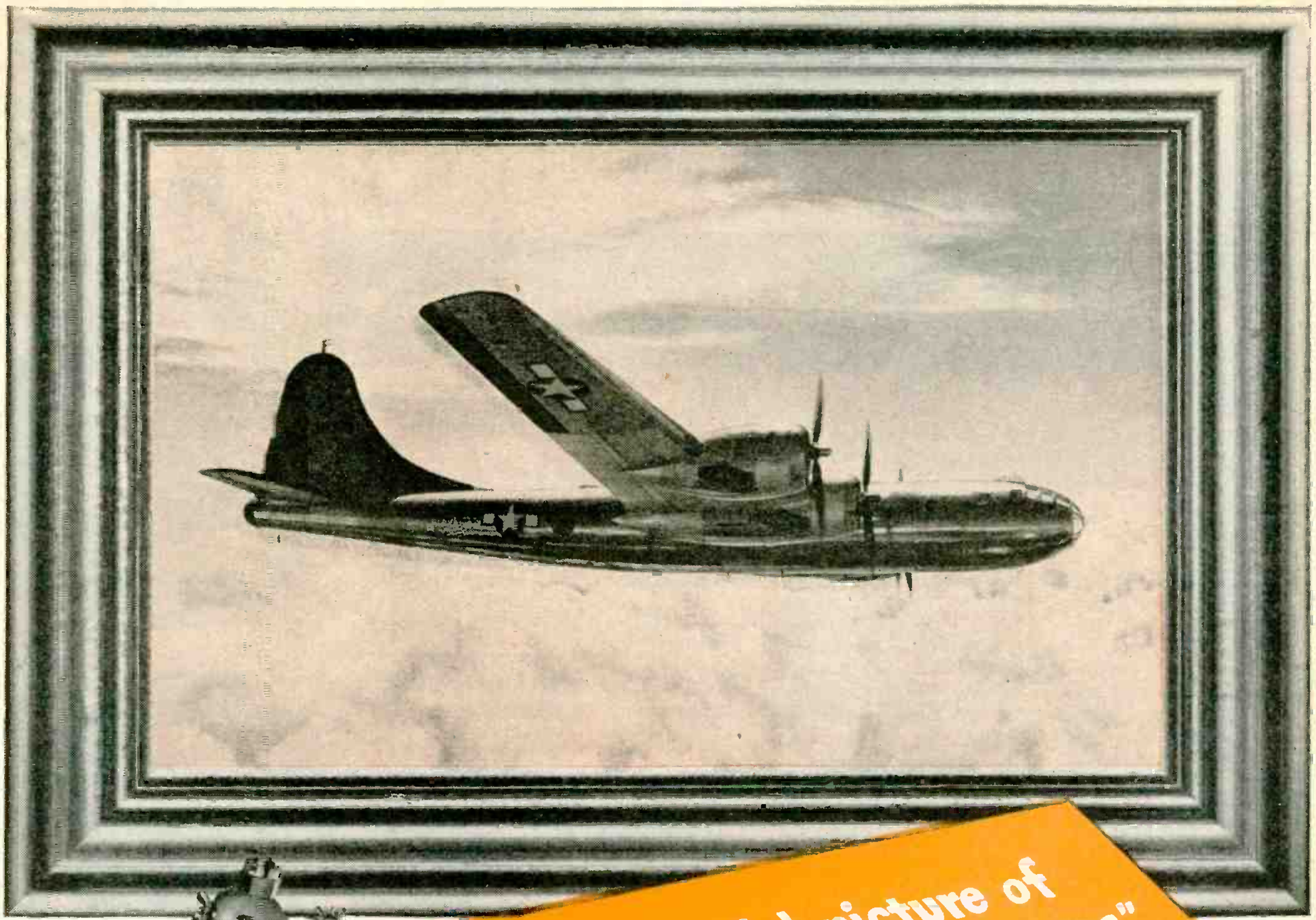
CONSULT HYTRON regarding your needs for these tubes: receiving, ballast, hearing aid, very-high-frequency triodes and pentodes, miniatures, medium and low-power transmitting triodes, r.f. beam tetrodes (particularly instant-heating), r.f. pentodes, gaseous voltage regulators, and rectifiers.

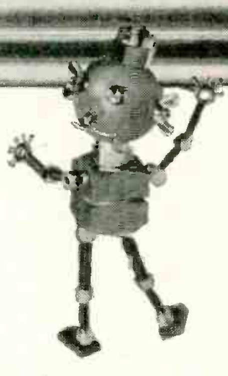
OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

BUY ANOTHER WAR BOND





a beautiful picture of "MILLIONS OF FASTENERS"

Photograph shows National Screw AN hex head and NAS close tolerance bolts being used in fabrication of a main structure of the Boeing B-29 Superfortress.

A sizable segment of American industry shares in the production of the Boeing B-29. Like the old fable of the blind men and the elephant, the Superfortress means many things to many people. To us at National Screw it means the last word in fasteners.

Throughout this giant plane, both in the airplane proper and in the instruments and armament, *National* screws, bolts, nuts, studs, rivets, cotters and many special fasteners are used by the thousands.

Following are a few of the *National* fasteners in the B-29:

NAS and BAC close tolerance bolts.
NAS internal wrenching bolts.
BAC bearing bolts.
AN bolts, nuts and screws—complete line.
Carburetor Studs.
Instrument Screws.

National
HEADED AND THREADED PRODUCTS

THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

"INSIDE" DEPENDABILITY

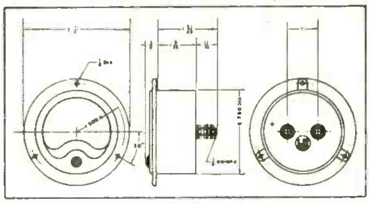
De JUR Electrical Indicating Instruments

These instruments are normally calibrated for mounting on non-magnetic materials. If desired, instruments will be calibrated for use on magnetic panels. Thickness of the panel should be stated. Scales other than standard type can be supplied and prices will be sent upon request. Special divisions, markings and color combinations are available. Spade pointers are standard equipment. Knife-edge pointers can be supplied at additional cost. Should it be desired to shield the instrument from external magnetic fields, shields can be supplied. These shields increase the body diameter by 3/32 of an inch. Provisions can be made for rear-illumination. For this purpose, translucent scales are necessary. Instruments can be modified to special requirements on orders where the quantity permits such special work. Where these modifications are external, prices will depend upon the instrument sensitivity and range.

Models No. S-210 and No. S-310 are designed to comply with the standards adopted by the American Standards Association for electrical indicating instruments (2½" and 3½" round, flush mounting, panel type).

THREE AND ONE-HALF INCH METERS

ROUND, SQUARE AND RECTANGULAR TYPES

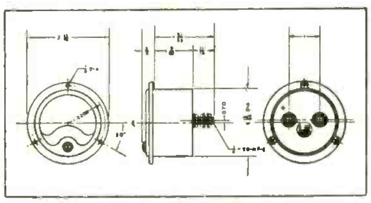


Cross-Section — S-310

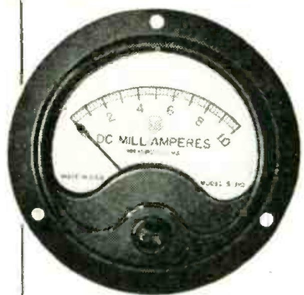
Model S-310 MR 25 I DCMA

TWO AND ONE-HALF INCH METERS

ROUND, SQUARE AND RECTANGULAR TYPES

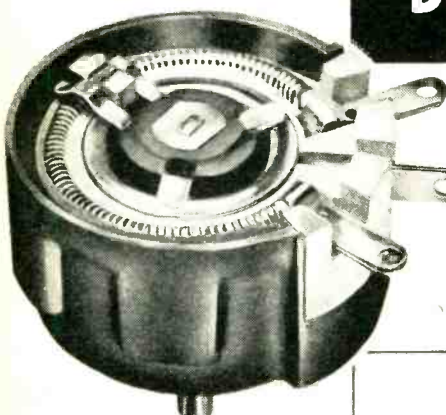


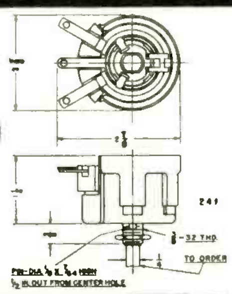
Cross-Section — S-210



Model S-210 MR 25 WOO I DCMA

De JUR Rheostat-Potentiometers

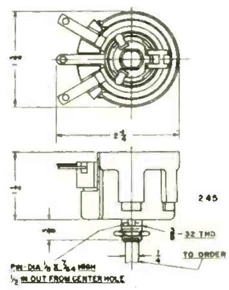




MODEL 241

SPECIFICATIONS

50 WATTS	RANGE IN OHMS	MODEL No.
RANGES—10 to 10,000 Ohms.	0- 10	241
	0- 50	241
	0- 100	241
MECH. ROTATION—300°	0- 500	241
ELEC. ROTATION—270°	0- 1,000	241
	0- 5,000	241
WEIGHT—7 OZ.	0-10,000	241



MODEL 245

SPECIFICATIONS

25 WATTS	RANGE IN OHMS	MODEL No.
RANGES—10 to 10,000 Ohms.	0- 10	245
	0- 50	245
	0- 100	245
MECH. ROTATION—300°	0- 500	245
ELEC. ROTATION—270°	0- 1,000	245
	0- 5,000	245
WEIGHT—7 OZ.	0-10,000	245

De Jur-Amsco Corporation

GENERAL OFFICE: NORTHERN BLVD. AT 45th ST., LONG ISLAND CITY 1, N. Y.

WHY HOURS?

✓ HEAT IT

✓ DRY IT

✓ CURE IT

✓ OR GLUE IT

in minutes!

That's right—*minutes*—for radio frequency heating makes minutes do the work of hours. To cite an example: one heating operation that used to take six hours is now being done *in less than 9 minutes!*

The answer is Westinghouse Radio Frequency Heating . . . it creates the heat within the material itself—instantly—uniformly—and under precise control. No waiting for heat to "soak in" . . . no rejects due to heat-damaged surfaces. Applications include wood, chemicals, plastics, paper, rubber, textiles and foodstuffs.

Westinghouse design "packages" all the radio frequency generating equipment and controls into a single, safe, space-saving cabinet.

These units are available in output capacities of 1 kw to 200 kw : : : at a range of frequencies wide enough to meet most dielectric and induction heating needs.

The highly-developed automatic operation turns tricky heating operations into simple "push button" jobs requiring no skilled help.

For more information, ask for Booklet B-3261-A and Descriptive Data 85-800, which describes radio frequency applications, benefits and Westinghouse equipment available. Or, for aid on a specific application, ask for a Westinghouse engineer to call. Westinghouse Electric & Mfg. Co., P.O. Box 868, Pittsburgh 30, Pa.

J-08085

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

RADIO FREQUENCY HEATING

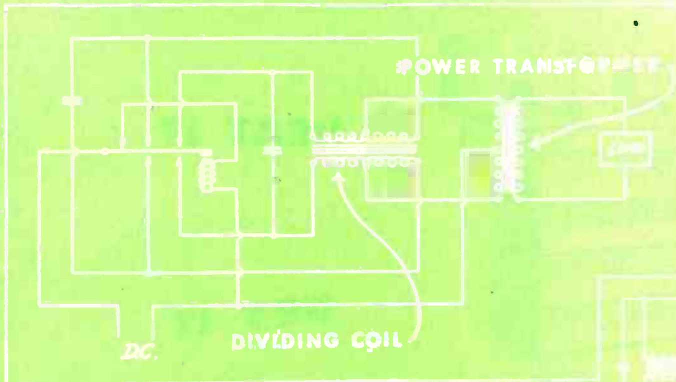
Electronics at Work

Westinghouse 2 Kw Radio Frequency Generator

This unit is ideal for small work. The "table top" work surface eliminates the need for special worktables, and the controls are conveniently located on the protected sloping panel. Mobility—often highly desirable—is provided by large, sturdy casters.

- Single unit construction
- Automatic operation
- "Long life" air-cooled tubes
- Shielded to minimize radio interference
- Move into position—plug in—and use
- Sturdily built cabinet

NEW VIBRATOR CIRCUIT BY ELECTRONIC



Triples POWER SUPPLY *Capacity!*

Typical E-L Circuits Which Divide Current Equally Between Multiple Vibrator Contacts

Electrical Current Division Circuit Between Contacts

A tremendous increase in wattage output is one of the striking advances made by Electronic Laboratories in Vibrator Power Supplies in the last few years. Now, 1,000 watts output capacity is easily attainable for Heavy-Duty use while still maintaining all the inherent advantages of vibrator power supply.

The *crux of the problem* was the development and perfection of a *current dividing circuit* which *actually distributes the current equally* between the vibrator contacts. This was necessary because the wattage output of vibrator power supplies depends on the volt-ampere capacity of their vibrators. This in turn is determined by the ability of the electrical contacts which make and break the current at each cycle to resist disintegration. E-L engineers found that *multiple and enlarged contacts operating in parallel were not enough.* The contacts could not be adjusted with sufficient precision to assure striking at the same instant. Therefore, the first contact which closed received the full burden of the electrical load which caused pitting and burning.

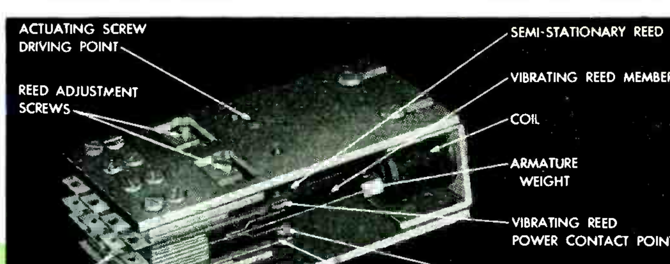
Equal division was finally accomplished with a special *electrical current dividing circuit* which incorporates a balancing reactor of small inductance relative to that of the main transformer of the power supply. When properly combined with the buffer network, this reactor effectively forces the *equal division* of the make and break energy in each cycle and at the same time retains the economic advantage of a *single large transformer.*

The current limiting reactor in the typical circuits shown above, *limits by reactance* the current which flows in the leg which has the completed circuit. When the second contact closes, the reactive effects are *cancelled* and the current is limited only by the DC resistance of the reactor. In the tandem type vibrator the division is carried out by first equalizing the current between the pairs of contacts. Then, by additional reactors, the current is equally divided between the individual contacts. This exclusive and patented* E-L development opens many new fields and applications to the benefits and advantages of Vibrator Power Supplies. Consider your needs in the light of this increased capacity.

E-L Vibrator Power Supplies have wide application in many fields: radio, marine, railroad, electronic and electrical. Their high versatility with multiple input and output voltages enables them to meet many power supply needs. They may be designed to provide any wave form needed for specific equipment. Another important and exclusive E-L feature that can be built into your vibrator power supply is constant output voltage, despite wide fluctuations of input voltage . . . economy is assured because of long, efficient service with minimum maintenance. E-L Engineering Service is available to discuss your power supply problem and to design a vibrator power supply to meet specific voltage, power, size and weight requirements.

(Below: A typical tandem type vibrator, which, used in conjunction with the electric current division circuit (see write-up above) has an input capacity of 1,000 volt-amperes at 110 volts DC.)

*Patent Number 2327577



Electronic

LABORATORIES INC. INDIANAPOLIS

VIBRATOR POWER SUPPLIES FOR LIGHTING, COMMUNICATIONS, AND ELECTRIC MOTOR OPERATION • ELECTRIC, ELECTRONIC AND OTHER EQUIPMENT

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CONTROL FLUCTUATING VOLTAGE TO ± ½%

A MAGNETIC UNIT WITHOUT MOVING PARTS

Nothing to replace or adjust

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New Stabilizer bulletin DL48-537. Contains operating characteristics, graphs and complete specifications. Write for your copy, today.

Constant AC voltage is essential for reliable, accurate operation of a wide variety of electrical equipment. When these devices are connected to ordinary supply mains, the unstabilized input voltage often varies as much as from 95 to 130 volts thus impairing the accurate operation of the equipment. A Raytheon Voltage Stabilizer, incorporated into the product, overcomes the disadvantages of fluctuating line voltages by providing an accurately controlled source of power held to ± ½%.

Entirely automatic in operation, the Raytheon Voltage Stabilizer has no moving parts . . . nothing to wear out, consequently requires no maintenance. Simply connect it to line and from there on it will take care of itself.

Raytheon Voltage Stabilizers built-in new equipment or offered as an accessory not only improve the performance but also increase the salability of the product.

Users of many types of electrical equipment not having voltage stabilization will find that Raytheon Voltage Stabilizers improve the performance and reliability of their equipment.

Raytheon Voltage Stabilizers are equally suitable for use in equipment for the laboratory, production or unattended locations.

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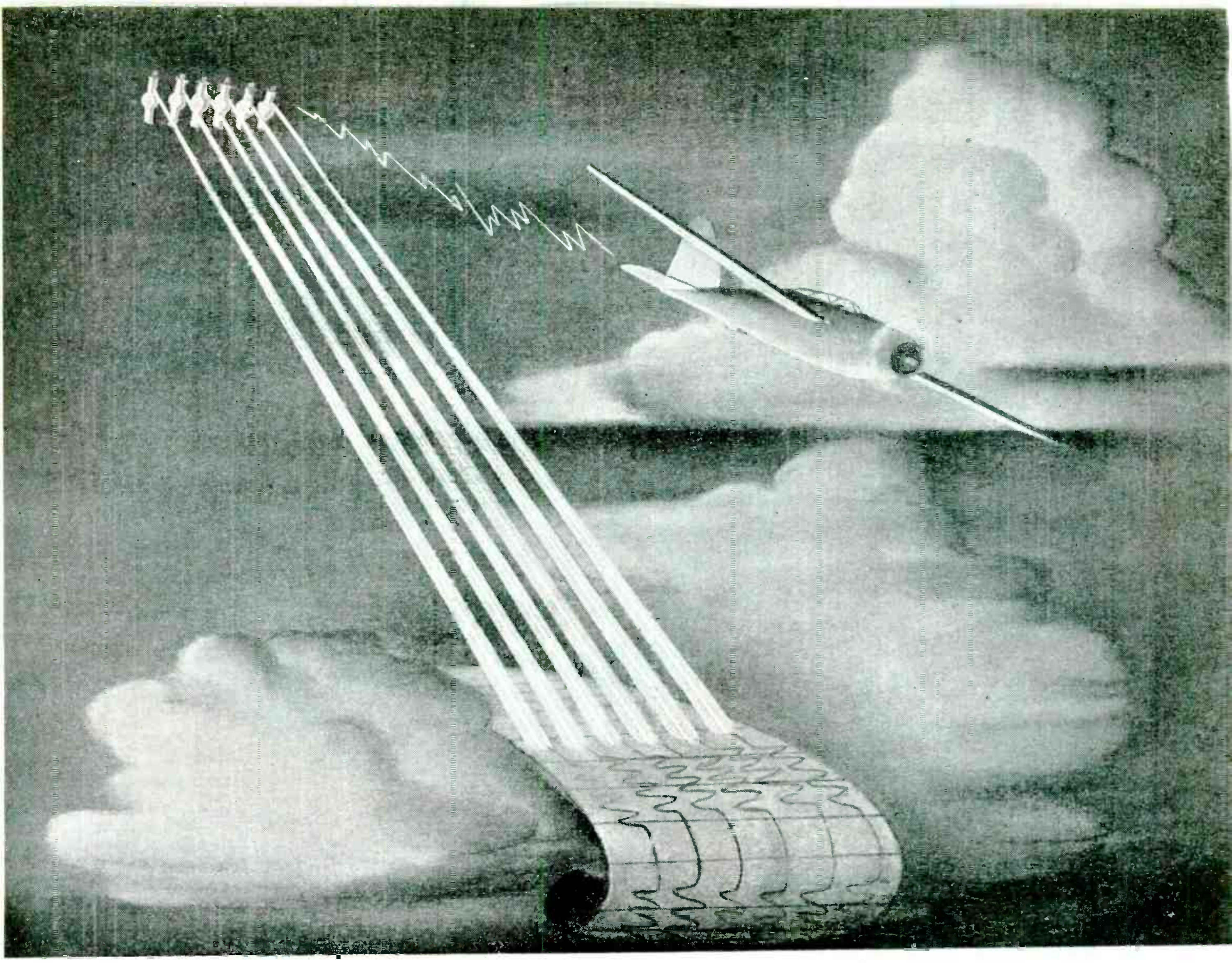
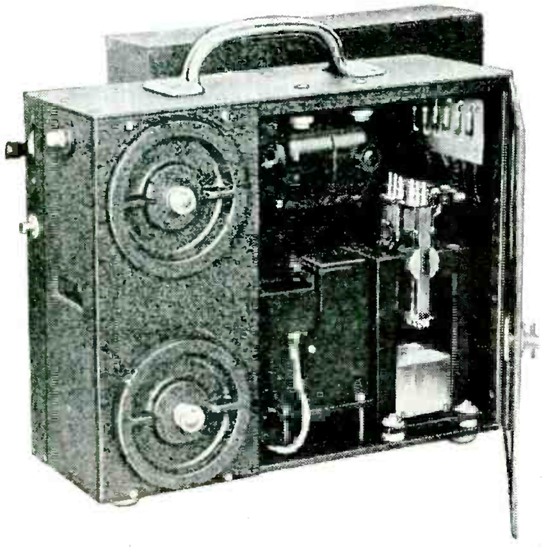
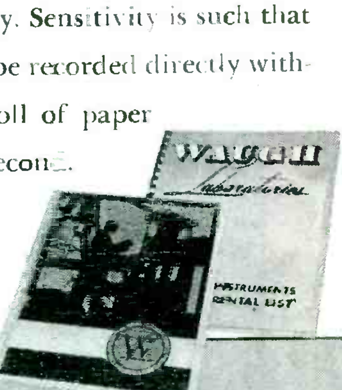


WRITES WITH BEAMS OF LIGHT



For recording dynamic strains and vibrations of *aircraft in flight*, we offer an extremely sensitive and accurate six channel Oscillograph, weighing less than 20 lbs., exclusive of battery, occupying less than ⅔ of a cubic foot of space and selling for only $1500. Operates from its own or the plane battery. Sensitivity is such that many dynamic strains and vibrations can be recorded directly without amplification. Takes hundred foot roll of paper 2″ wide operating at 3, 6 or 12 inches per second. Write for further details.



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The constant and exacting test of experience has proved the high quality of Ohmite Rheostats. Special Ohmite design features assure permanently smooth, gradual, close control under varying conditions of shock, vibration, temperature, humidity and altitude. The Ohmite series of 10 wattage sizes illustrated here is the most extensive made today—ranging from 25 to 1000 watts, from 1$\frac{9}{16}$″ to 12″ diameter, in a wide range of resistance values. This assures the best unit for each application. As a result—Ohmite has produced more close-control power rheostats for war equipment and war industries than any other manufacturer.

Consult Ohmite Engineers on your war or postwar rheostat-control problem. Get the benefit of Ohmite experience.

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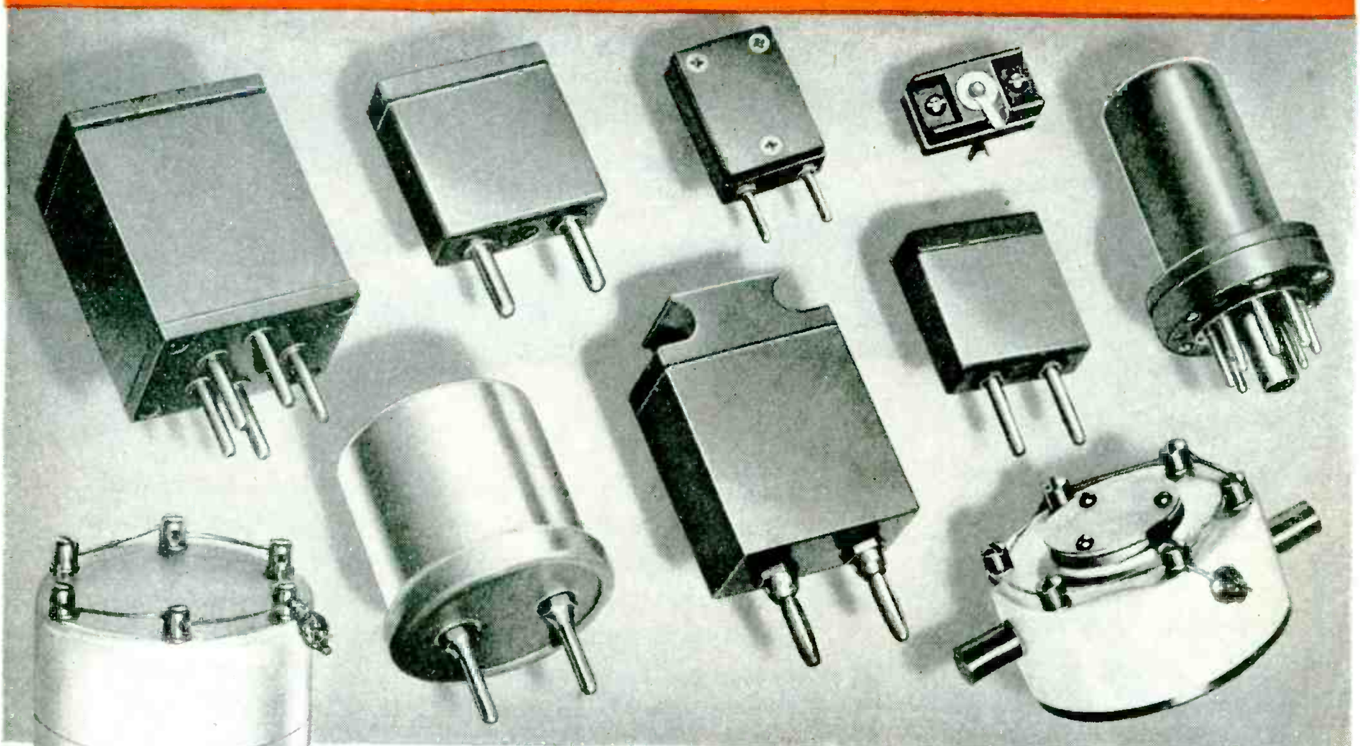
Write on company letterhead for Industrial Catalog and Engineering Manual No. 40. Gives helpful data on Rheostats, Resistors, Tap Switches and Chokes.

In QUARTZ CRYSTALS, the most significant advancements have been introduced by *Bliley*



This is a message from Bliley to the thousands of amateurs and professional engineers who are now serving their country in the armed forces and in essential communications industries. Bliley "grew up" with them.

To these men and women Bliley crystals are still a familiar sight. They recognize, in the military crystal units used by our armed forces, many basic features that were pioneered by Bliley for application in peacetime services.

When tremendous production was demanded by our armed forces Bliley had the engineering background, the facilities and the production experience to provide a firm corner stone on which this volume production of radio crystals was successfully built. And, from the ranks of talented amateurs and radio engineers came a host of long-time friends who knew exactly how to use them.

But research has continued and experience has grown mightily to meet the challenge of war requirements. With the return to peace, and relaxation of wartime restrictions there will be better Bliley crystals for every application as well as new Bliley crystals for the new services that loom on the horizon. That's a promise.

To our old friends, amateurs and professional engineers, we say, "Look to Bliley for crystal units that embody every advanced development."

ARMY E NAVY

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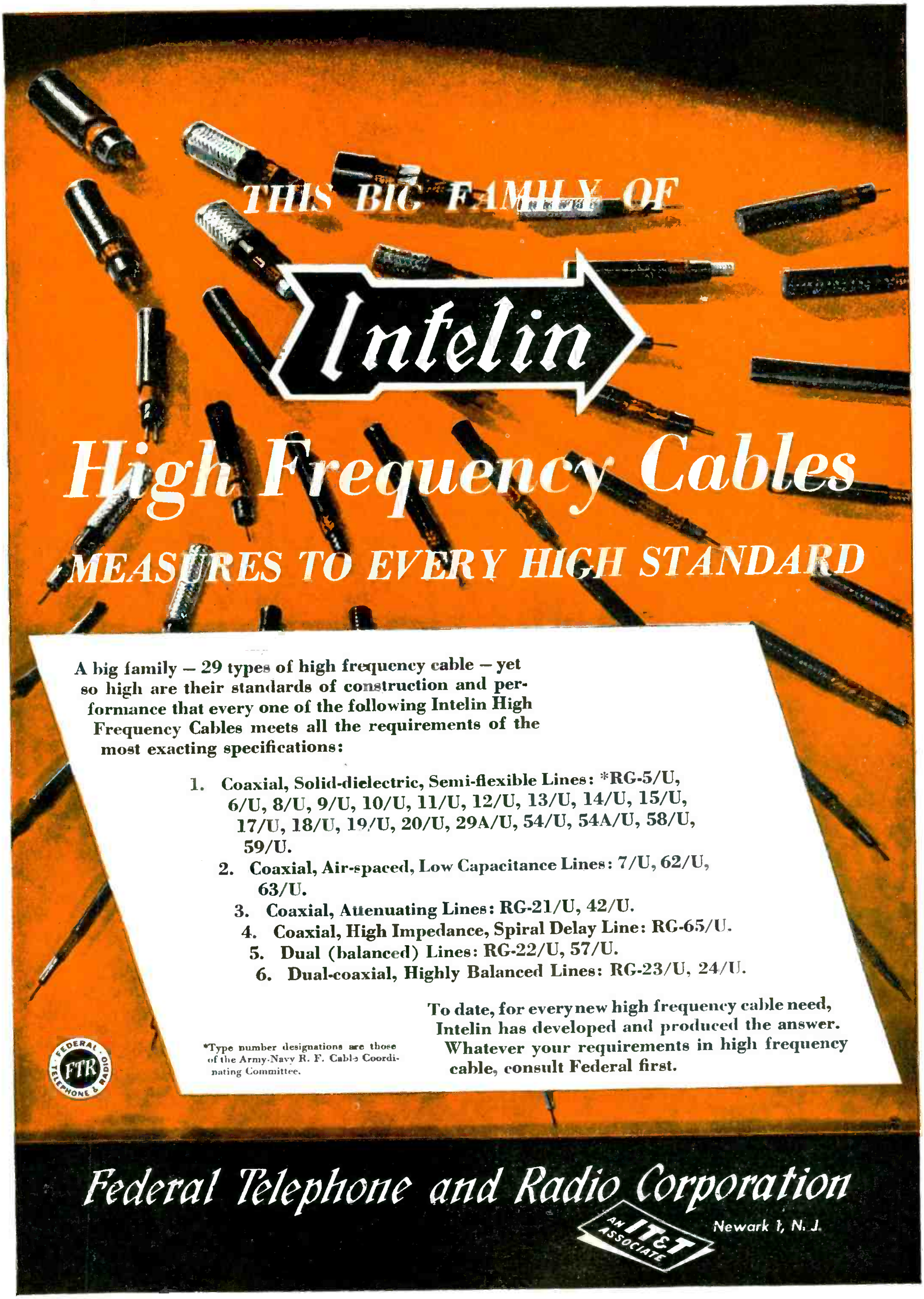
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A big family — 29 types of high frequency cable — yet so high are their standards of construction and performance that every one of the following Intelin High Frequency Cables meets all the requirements of the most exacting specifications:
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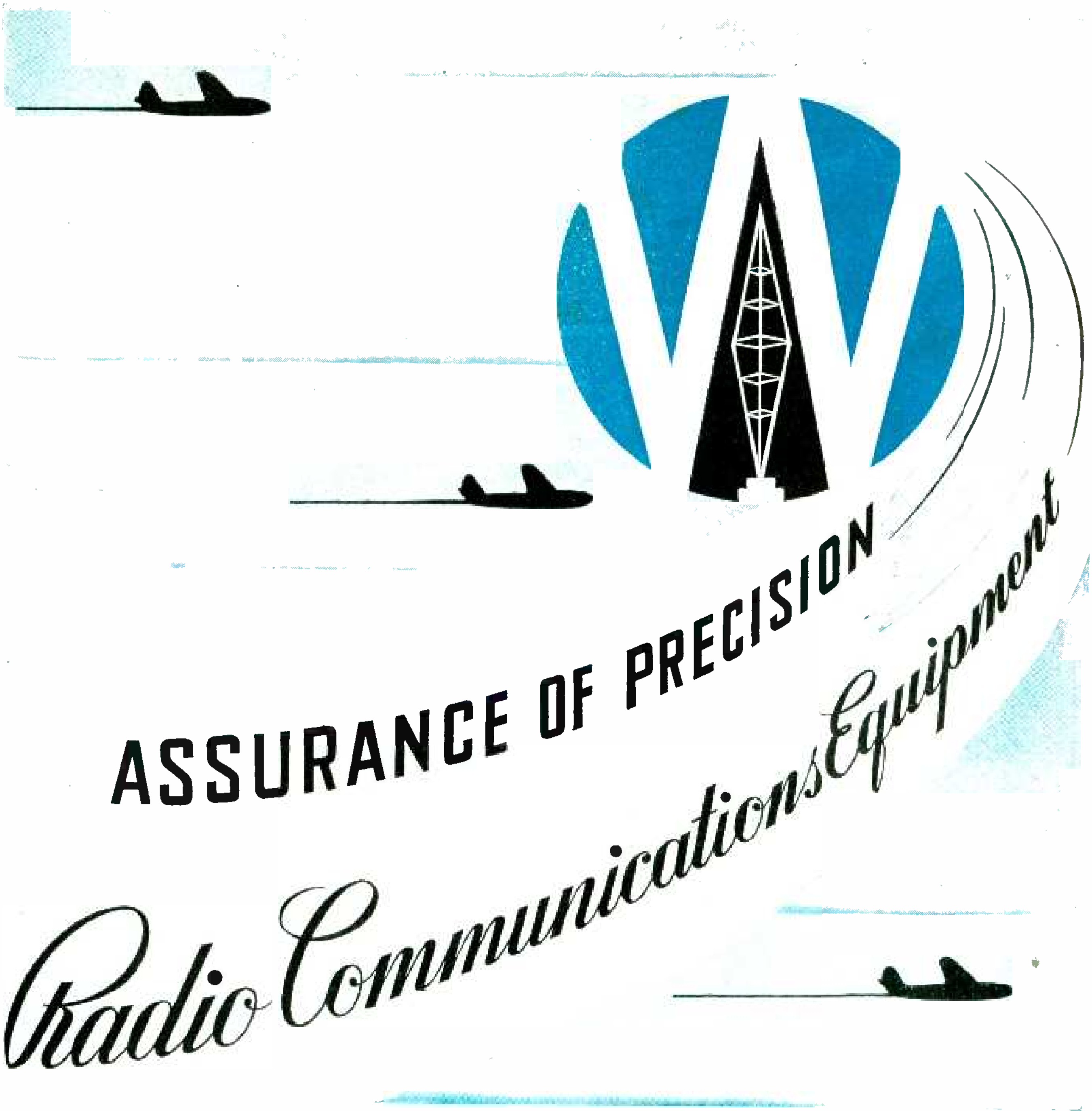

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The Wilcox trademark on aircraft radio, communications receivers, transmitters and other radio equipment is a symbol of advanced engineering, precision manufacturing and proved performance. Today, Wilcox equipment is in use all over the world in military operations and for the major airlines of the United States. In postwar developments, you can depend on Wilcox for continued leadership in radio communications!

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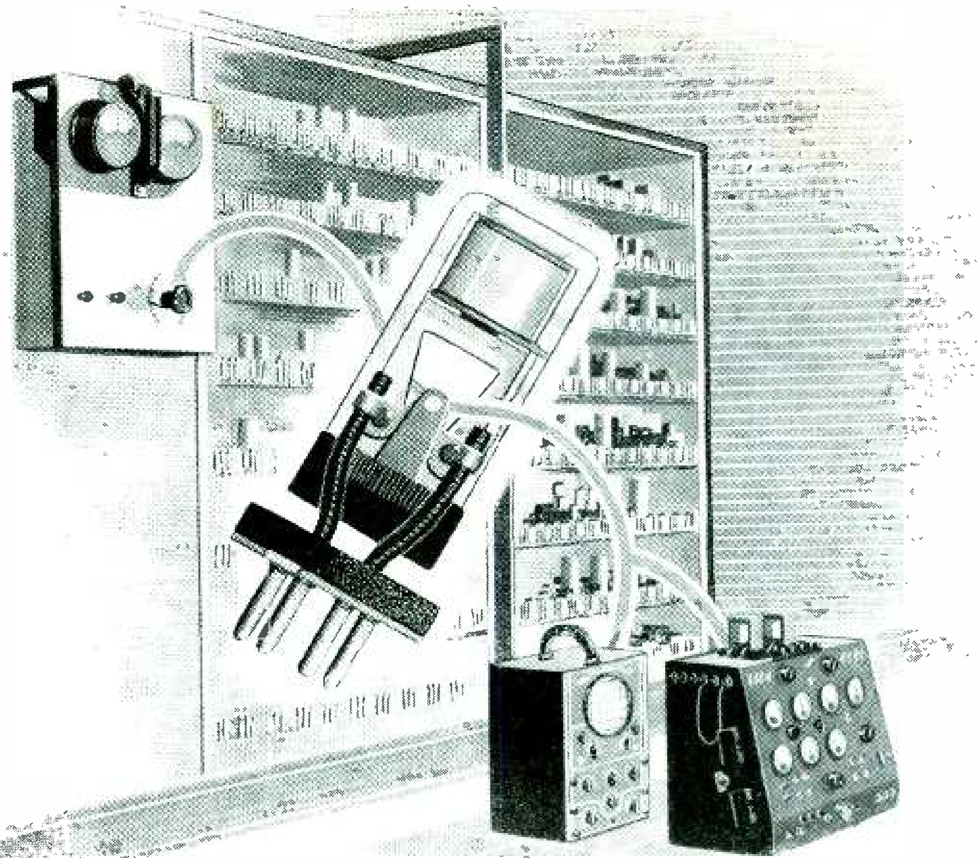

object — longer life

Here in our laboratory on a test rack these Utah Vibrators are placed in continuous operation against the time-clock . until they finally break down.

Thus Utah engineers prove the worth of design and the quality of materials that give their product such an enviable record of long, trouble-free service.

Such tests as this have been the reason for Utah reliability in war—and are the Utah guarantee of industry and consumer satisfaction in peace.

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

Keyed to "tomorrow's" demands: Utah transformers, speakers, vibrators, vitreous enamel resistors, wirewound controls, plugs, jacks, switches and small electric motors.

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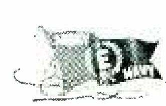

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BATTERY SOCKETS
for the Battery Industry!
In the electrical as in the electronic field, National Fabricated Products has engineered receptacles to meet every specialized need. High speed production soldering, rugged construction and positive electrical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

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Electronic controls of high speed welding equipment rely on the efficiency of thyratron tubes to minimize transient currents, the cause of non-uniform welds. The Cetron grid control rectifier tube, Type CE 306, a precision timer, provides maximum rectifier efficiency with minimum internal heating. The Cetron thyratron is a long life product built to stand the "gaff" of industrial use in handling primary currents of small resistance welders, light control, arc welding control, motor control, etc.

The Continental Electric Co. of Geneva, Ill., uses Callite thoriated tungsten filaments and grids for their extra quality and stamina in the manufacture of CE 306 tubes. Callite research has developed many improvements in the processing of tube components. That's why the electronic industry looks to us for dependable hard glass leads, tungsten and molybdenum wire, rod and sheet, formed parts and other components. Callite Tungsten Corporation, 544 Thirty-ninth Street, Union City, New Jersey. Branch Offices: Chicago and Cleveland.

CALLITE TUNGSTEN CORPORATION CT

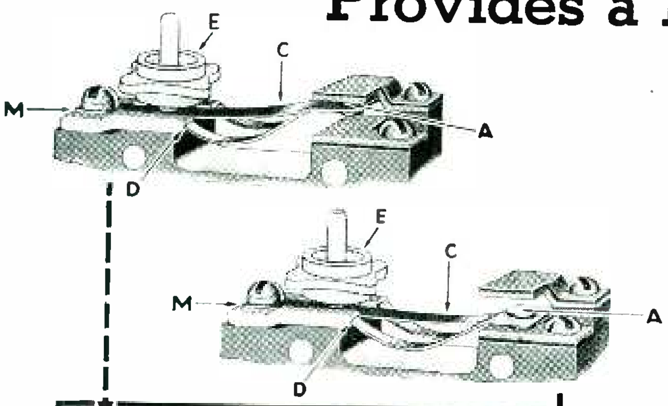
Callite tube components

℞ FOR R*-DAY (*Reconversion)

Discuss your post-war products with a C-T development engineer now. We may be able to help you in the selection of materials or in cutting your production costs. Write today.

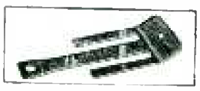
Why MICRO SWITCH

Provides a Long Snap-Act.

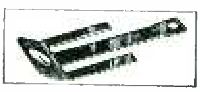


Micro Switch Operating Principle

The operating principle of the Micro Switch as illustrated here is simple and fundamentally correct. The long member of the one-piece spring "C" is supported as a cantilever at "M". The two shorter compression members of the spring rest in specially shaped (patented) V's. When the plunger "E" deforms the long tension member, the cantilever force overcomes the vertical force supplied by the compression members and the free end of the spring "A" snaps the contact from one stop to the other with lightning-fast speed. Snap action in the reverse direction occurs when the deformation of the tension members of the spring by plunger "E" is removed.



This one-piece beryllium copper spring is heat treated to provide the high fatigue resistance necessary to insure a minimum of 5,000,000 trouble-free mechanical operations, at full overtravel.



The rivet type contact is of superfine silver 99.95% pure.

The operating plunger is a highly polished, hard, stainless steel pin molded into an accurate Bakelite head. This head is so shaped that it cannot rotate, hence bears on the switch spring at the same point through millions of operations.

Micro Switch provides lightning-fast, control of electric circuits with reliable operation accurately repeated over millior

This performance is made possible by u unique, field tested, and proven operating p of the Micro Switch. The snap motion of tl Switch contact is in the same direction as tha operating plunger. There are no reverse bends Micro Switch spring, and there is no life-lin "oil can" action.

The experience of design engineers with million Micro Switches in a great variety of applications i shown performance ability and operating characte istics never before found in snap-action switches.

Its small size, its high electrical rating, its ability to operate satisfactorily for millions of operations on minute movement and force differentials, its availability in various types of housings and a wide range of actuators . . . have made Micro Switch the choice of design engineers for precise operation of many types of plant equipment.

Micro Switch Handbook-Catalog No. 60 will give you complete details as to electrical characteristics, construction, applications and dimensions. If you happen to be specializing in aircraft equipment, also send for Handbook-Catalog No. 70.

The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate repeat performance is experienced over millions of operations. Wide variety of basic switches and actuators meets requirements varying from high vibration resistance to sensitivity of operating force and motion as low as 2/1000 ounce-inches. Many types of metal housings are available.

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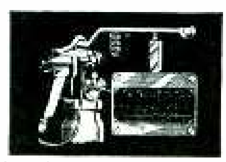
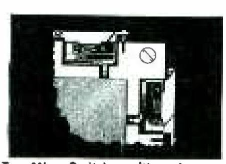
HUNDREDS OF SPOTS FOR MICRO SWITCHES

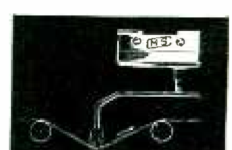


An explosion-proof Micro Switch is used with a spray gun to cut off the ventilating system of the spray booth automatically when the gun is hung up.

Micro Switches are used as safety switches on high tension cabinet doors. A normally open switch breaks circuit as door is opened.



Two Micro Switches with spring type plungers are used to insure correct position of material in jigs and fixtures.



Spring plunger Micro Switches serve as break indicators in textile and paper mills.

MICRO TRADE **MS** MARK **SWITCH**

A DIVISION OF FIRST INDUSTRIAL CORPORATION

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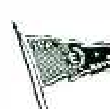
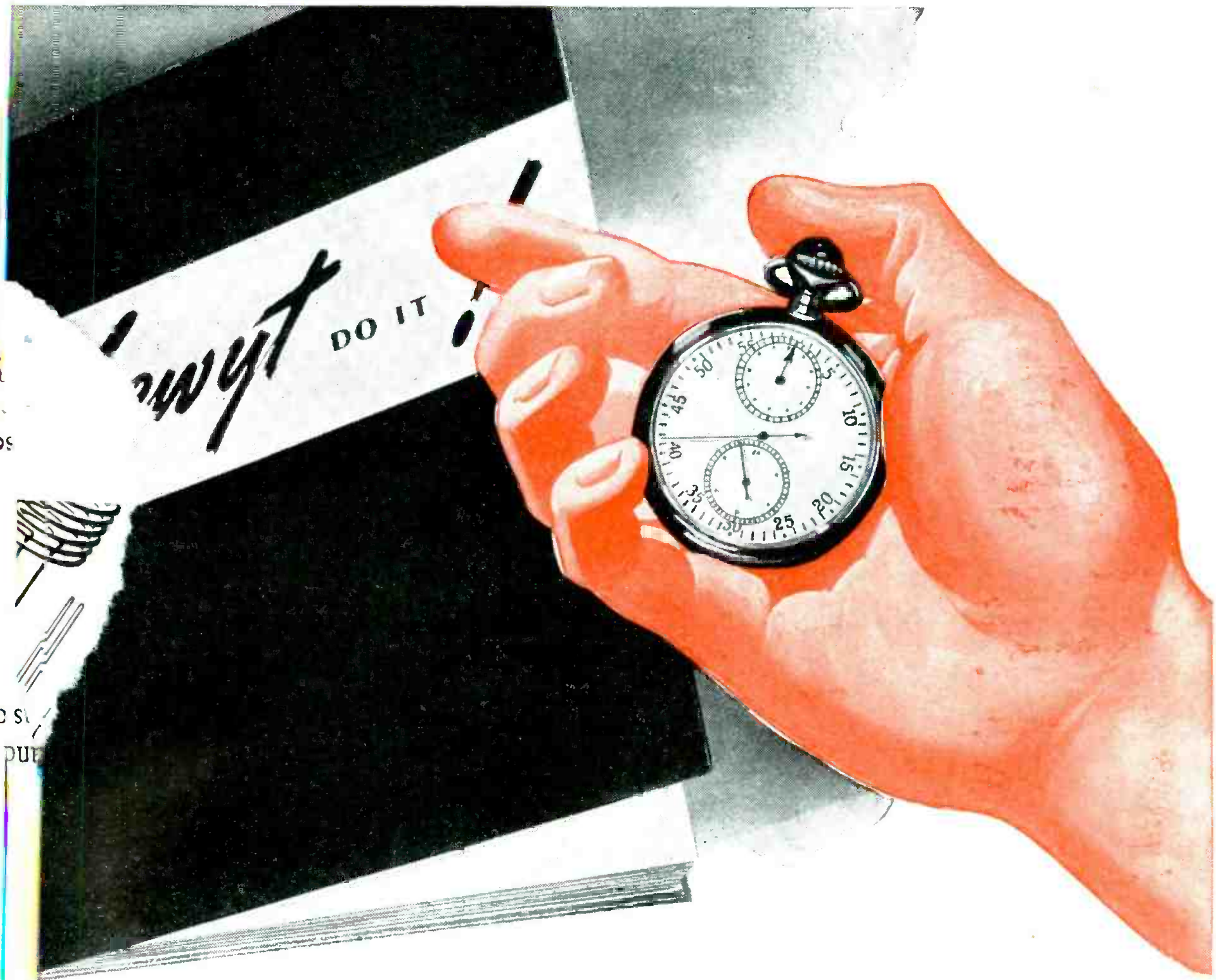
. . . . USES  **UNLIMITED**

"Uses Unlimited"—a dramatic talking motion picture of Micro Switches, in color, is available to industrial groups, training classes, schools and colleges, through Y.M.C.A. Motion Picture Bureau, New York, Chicago, San Francisco. Size: 16 mm. Length: 40 minutes. Write us for details.

A star has been added to our "E" flag as further recognition to the men and women of Micro Switch for maintaining our war production standards.



Let's All Back the Attack—Buy Extra War Bonds



Y WILL HOLD A STOP WATCH...

THIS BOOK is designed to help you prepare for CONVERSION DAY . . . it presents the story of a unique institution that may have the answer to your production problem . . . it suggests a plan for putting your new product development *in training* for the post-war starter's gun.

When materials are no longer ear-marked for war . . . when civilian goods are price-marked for peace . . . there will be no glory or profit at the *finish line* for any but the *winners!*

"Cost-Plus" profits will be outlawed . . . wartime regulations will give place to time studies . . . the stop watch will take over control in the competitive race for manufacturing economies.

Lewyt has set the pace in contract manufacturing ingenuity through two post-war periods of business readjustment. We've had long training in cost-sensitive specialization. We're ready to partner with other manufacturers in producing their component electrical and electronic assemblies, chasses and housings . . . or complete units.

With our exceptional facilities and skills in electrical and mechanical parts manufacture carefully developed through 56 years, it will pay you to talk with us . . . at least write for this 48-page book. Ask for "Series B". There is no cost or obligation.

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ARMY E NAVY

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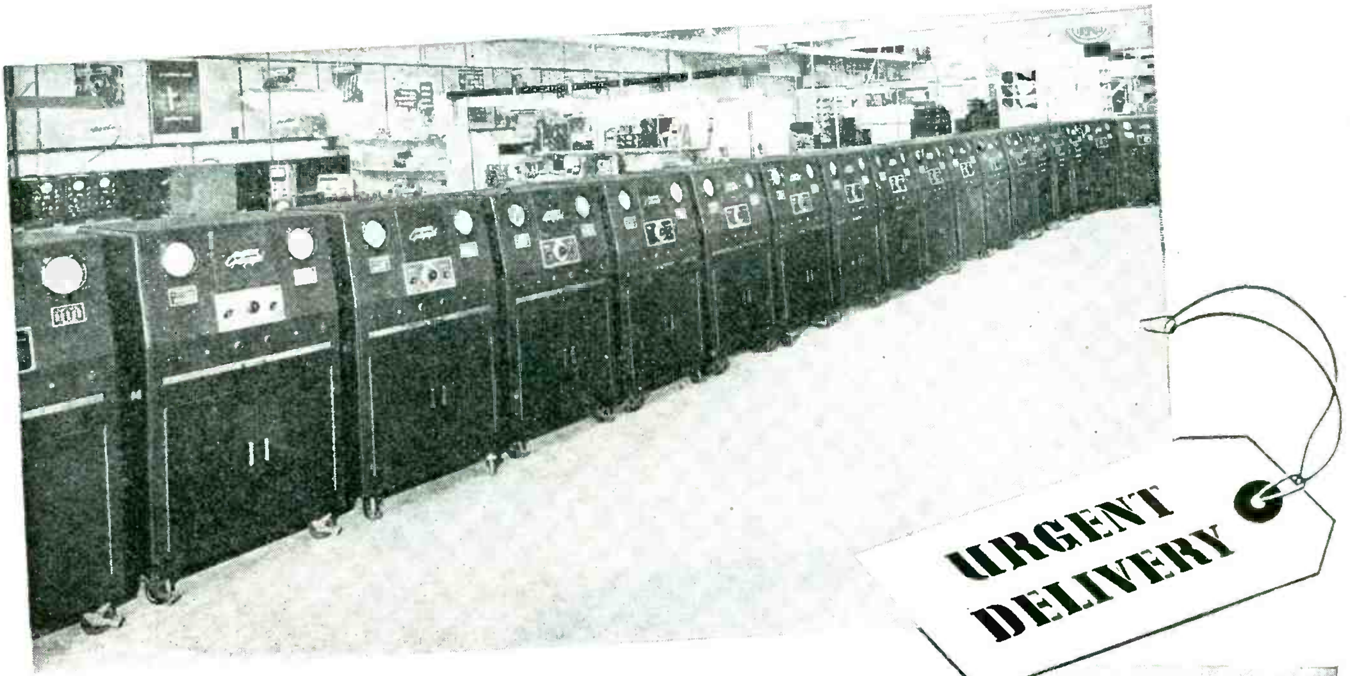
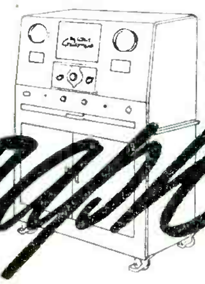


When you have urgent need for this 100% quality inspection, present production of instruments now assures early delivery and installation of your

DuMONT Cyclograph



DuMont Cyclographs are rolling off the production line. With details and circuits refined and set, the building of these instruments has now passed to our manufacturing plant. Early delivery and installation is now assured for those who have real need for this 100% quality inspection means.

Meanwhile, the Cyclograph is proving indispensable in one plant after the other. This technique is making a notable contribution to the war effort in manpower and material savings, in product uniformity, and in production speedup. Likewise in the postwar industrial situation, the Cyclograph promises to be a vital factor in reducing production costs and increasing product uniformity.

From now on it's PROMPT delivery and installation — when you need 100% quality testing.

Write for Literature . . .

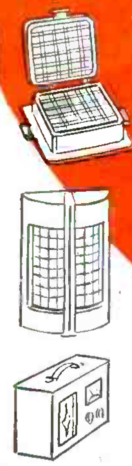
TYPICAL CYCLOGRAPH 100% QUALITY TESTING . . .

- ✓ Non-destructive testing for machinability of metal stock to be machined in automatic high-speed equipment.
- ✓ Pre-checking iron castings for machinability.
- ✓ Sorting of mixed lots of forged steel.
- ✓ Inspecting 150,000 pounds of packaged welding electrodes for critical magnetic properties, *without opening packages*.
- ✓ Automatically sorting six and a half million copper-clad steel cups to discard those accidentally reversed in the stamp.
- ✓ Sorting large quantities of mixed bolts according to their SAE analyses.
- ✓ Checking gears for case hardening.
- ✓ 100% quality inspection and control of incoming materials and outgoing products, according to metallurgical analyses, case depth, depth of decarburization, amount of cold working, brittleness (stress gradients), structure, etc., on either non-ferrous or ferrous metals.

DUMONT *Precision Electronics & Television*

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

INSULATION 'MUSTS' for future product *efficiency*



Industry—by unqualified fulfillment of its war-time obligations in quality, efficiency and dependability — has set a particularly high standard for future manufacture. Post-war products, appliances and equipment must be good . . for it's the repeat sale that counts. TURBO insulation materials — Flexible Varnished Tubing, Saturated Sleeving, Extruded Tubing, Varnished Glass Tubing, Wire Identification Markers, etc.—offer the essentials for later design, manufacture and service-life. All the advantage-factors, properties and characteristics evolved by rigorous research and experimentation are embodied in TURBO products—your guarantee of a peacetime quality comparable to present military exigencies. Whether your particular requirements are high dielectric strength, great mechanical strength, resistance to abrasion, sub-zero temperatures, high heat, corrosion, acids, fumes, etc.—there's a TURBO product to do your job . . . economically and efficiently.

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Free Specimen Board with samples and sizes of each will be sent promptly on request on company letterhead. Write today.

WILLIAM BRAND & COMPANY

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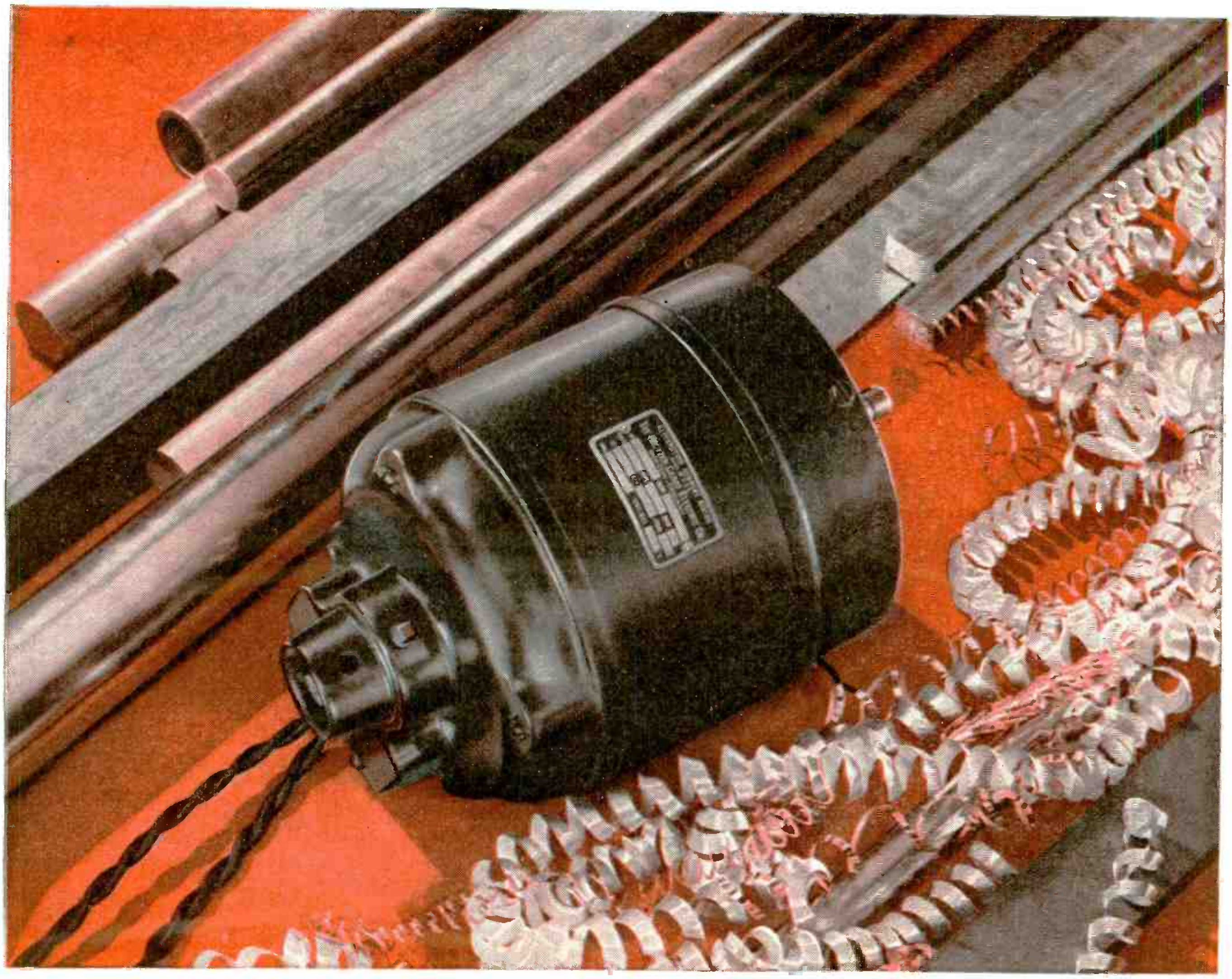
IF IT'S TURBO IT SAFEGUARDS

FLEXIBLE VARNISHED OIL TUBING: this TURBO insulation meets the diversity of requirements necessary to stand up against breakdowns, impairment through moisture absorption, and the general deteriorating influences caused by acids, alkalis, fumes, corrosion, etc.

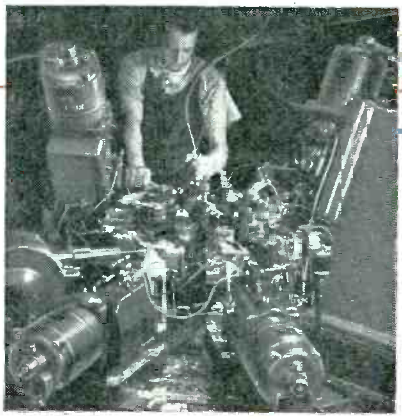
VARNISHED GLASS TUBING: the extensive use of this TURBO product is directly attributable to its excellent characteristics under high heat conditions. Heavy duty operating conditions, confined areas where ventilation is minimized and other similar problems are solved.

EXTRUDED TUBING: where the effects of temperatures are apt to induce insulation embrittlement, TURBO Extruded Tubing is especially suited. Sudden climatic changes, wide fluctuations in temperature, or refrigerant operating conditions will not affect its dependability.

WIRE IDENTIFICATION MARKERS: the facilitating of production and assembling operations, with corresponding increases in functional efficiency, are effected with this TURBO insulation product. Available in any size, length or color. TURBO markers meet UL requirements.



Meet Design and Performance Requirements in Machine Tools



The motor requirements for the precision machine tool, illustrated at the right, called for motors that met certain performance characteristics and special mechanical requirements.

Holtzer-Cabot motor development engineers solved the problem by designing a special motor that exactly met all the operating and design conditions . . . and today these machine tools are operating at peak efficiency because of the dependability of the motors.

Whether you build machine tools or cash registers, it will pay you to investigate Holtzer-Cabot special fractional HP motors.

Our engineers will gladly cooperate with you on your motor problems for post-war products. There is no obligation.

SPECIAL MOTORS DESIGNED TO FIT THE APPLICATION

HOLTZER-CABOT

Division of First Industrial Corporation

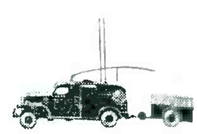
Designers and Builders of Special Fractional HP Motors and Electrical Apparatus

125 AMORY STREET, BOSTON 19, MASSACHUSETTS • CHICAGO, ILLINOIS • NEW YORK, NEW YORK • PHILADELPHIA, PENNSYLVANIA

The United States Navy has awarded the men and women of Hallicrafters a special "Certificate of Achievement"... first award of its kind... for outstanding service with the radar-radio industries of Chicago in speeding vital war material to the Navy. Added to the four Army-Navy "E" awards, this makes five times Hallicrafters workers have been cited for distinguished service. They promise that this kind of service will be continued until total victory is ours.

★ **BUY A WAR BOND TODAY**

hallicrafters RADIO



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

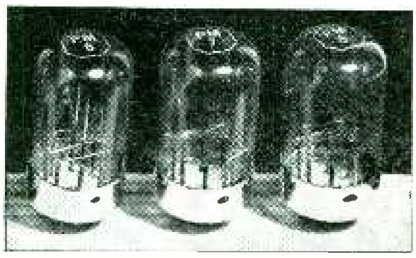
SYLVANIA NEWS

ELECTRONIC EQUIPMENT EDITION

NOVEMBER — *Published in the Interests of Better Sight and Sound* — 1944

PM Lamps Offer Easy Way of Measuring RF Power Output

The group of Power Measurement Lamps introduced by Sylvania a little over a year ago have fully demonstrated their merits as a simple, accurate means of measuring the high-frequency power output of radio equipment.



3 of the 6 Sylvania PM Lamps

The present series consist of 6 lamps, with which power outputs ranging from 0.05 to 25 watts can be measured directly, with the aid of ordinary meters. Accuracy of the measurements is within 5%, without any special calibration of the lamps.

Full information on the principle of operation of these lamps, and on their ratings and characteristics, is available from Sylvania.

DID YOU KNOW...

That fluorescent lights are now helping with the job of guiding Pan American Clippers to port? They illuminate seadrome landing strips which were developed by Sylvania in cooperation with Pan American.

* * *

That 7½-watt ruby lamps have been developed by Sylvania for use in Army photographic printing equipment? Smaller than most lamps of its type, the 7½-watt size is easily installed in portable printers.

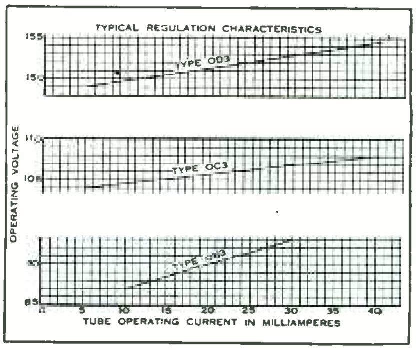
* * *

That the Army Medical Corps' new ten-car hospital train is fluorescent lighted throughout? Patients in the tropics will be more comfortable under these lights, which radiate little heat.

Regulator Tube Maintains Voltage within Narrow Limits

Maximum Regulation of Type OC3/VR105 Is 4 Volts over Operating Current Range

A voltage regulator tube, for applications where practically constant voltages must be delivered to a load, was recently placed on the market by Sylvania. Like previous tubes in the Sylvania line of voltage regulators, the new tube, designated as Type OC3/VR105, is of the gas filled, cold cathode type. It's outstanding difference from earlier types lies in its lower voltage regulation. With a design center operating voltage of 105, the OC3/VR105 has a maximum regulation of 4 volts over the operating current range from 5 milliamperes minimum to 40 milliamperes maximum. Characteristics of the new tube are compared with those of the OB3/VR90 and OD3/VR150 in the accompanying curves.



Comparative regulation characteristics of Sylvania voltage regulator tubes.

It should be noted that individual tubes may not deliver identical voltages to the load. However, the voltage will be within the specified operating limits of 105-112 volts, and the regulation 4 volts or less for any tube.

The tube is mounted in an ST-12 bulb with a standard small 6-pin octal base.

Base diagram of OC3/VR105

A current-limiting resistor should always be used in series with the OC3/VR105, to keep the operating current through the tube down to 40 milliamperes if the load should be disconnected.

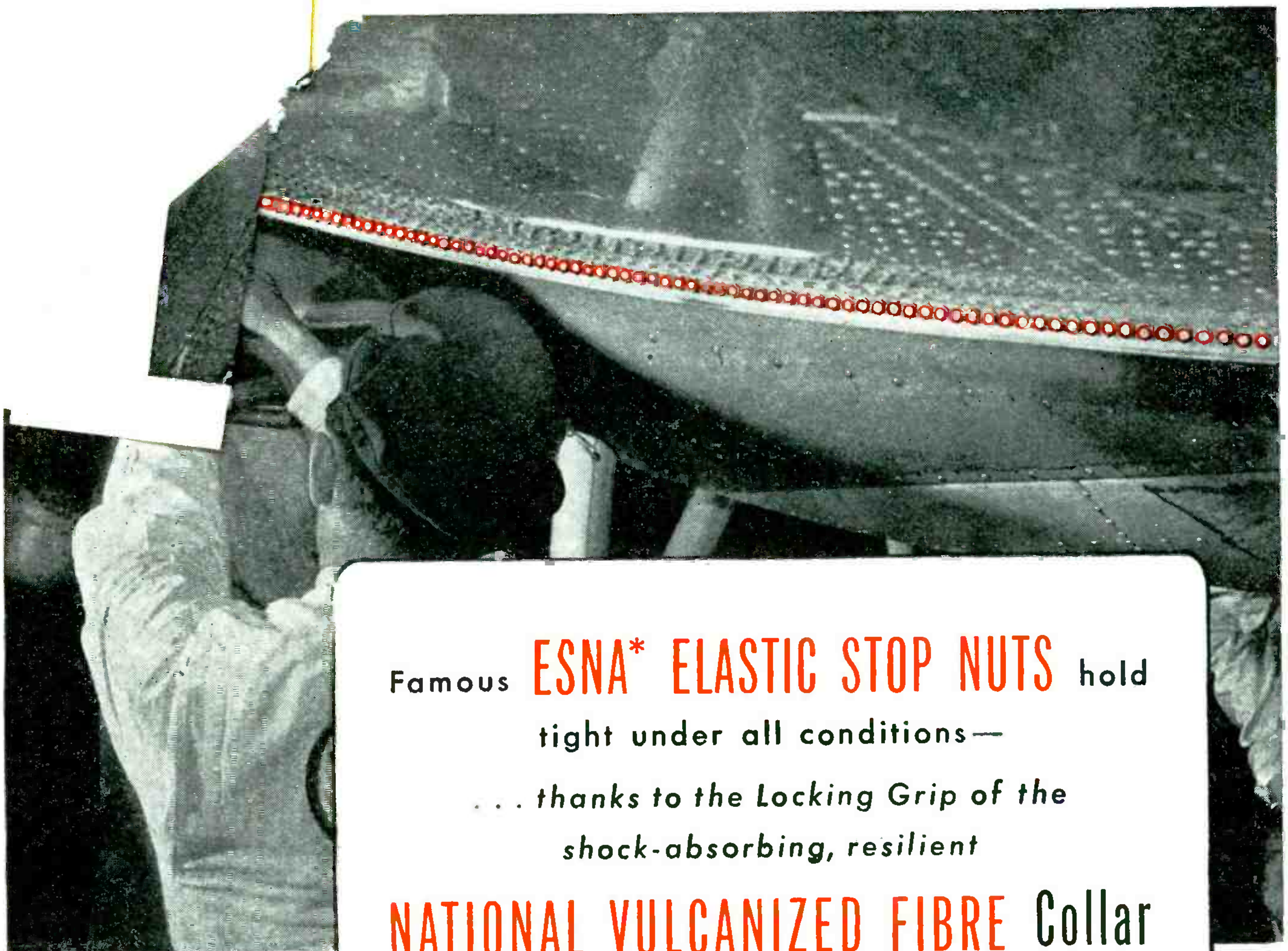
28D7 USEFUL AS VOLTAGE BOOSTER

With 28-volt operation of radio equipment attracting increasing interest in its current aircraft applications, and in its commercial potentialities, the Sylvania Type 28D7 is finding new fields of usefulness.

The 28D7 is a Lock-In output tube specifically developed for operation direct from a 28-volt source. The 28D7 can be used as a convenient voltage booster. This feature is particularly important where the 28-volt supply may drop too low to operate tubes having a critical minimum voltage.

For voltage boosting, the 28D7 is coupled as an oscillator to a load coil of the required characteristics, and the output rectified by a diode. Output voltages up to 500 to 600 volts can be obtained in this way.

"Car 54 go to 8th and Main—Signal 17 and doesn't the transmitter sound swell since I put in those Sylvania tubes? That is all."



Famous **ESNA* ELASTIC STOP NUTS** hold tight under all conditions—

. . . thanks to the Locking Grip of the shock-absorbing, resilient

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In thousands of applications—in countless industries, can be seen the familiar red collar that marks Elastic Stop Nuts. This well-known red collar is National Vulcanized Fibre, the remarkable material that possesses such an unusual combination of properties. These properties are toughness, great mechanical strength, resilience, light weight, good machinability and forming qualities, high dielectric strength, exceptional durability.

Because of these combined, outstanding qualities, National Vulcanized Fibre will, as it does in the ESNA nut, help make needed peacetime products safer, stronger and longer-lasting. Your inquiry on your use of this material will receive the prompt attention of our trained technical men.

Send for Free Copy of National Vulcanized Fibre Hand Book. Please write on your company letterhead.

*ESNA is the trade mark of Elastic Stop Nut Corporation of America.

Here's why the ESNA ELASTIC STOP NUT locks fast and stays put even under shock or severe vibration.

This nut and its mating bolt are put together like any ordinary nut and bolt—up to a point. This point is where the bolt meets the unthreaded compression-locking National Vulcanized Fibre Collar.

The bolt then impresses its own thread path into the elastic National Vulcanized Fibre compression collar. In passing through the collar the bolt threads squeeze the locking fibre—the locking fibre collar squeezes back. Thus the compresssed fibre collar, in its confined pocket, grips the bolt threads on both sides—with a grip which never relaxes.

This grip keeps the nut from turning loose. Only when the nut is removed is the gripping action relieved. When this happens, the fibre collar goes back to an "undersize thread" condition. So the nut can be used again and again.

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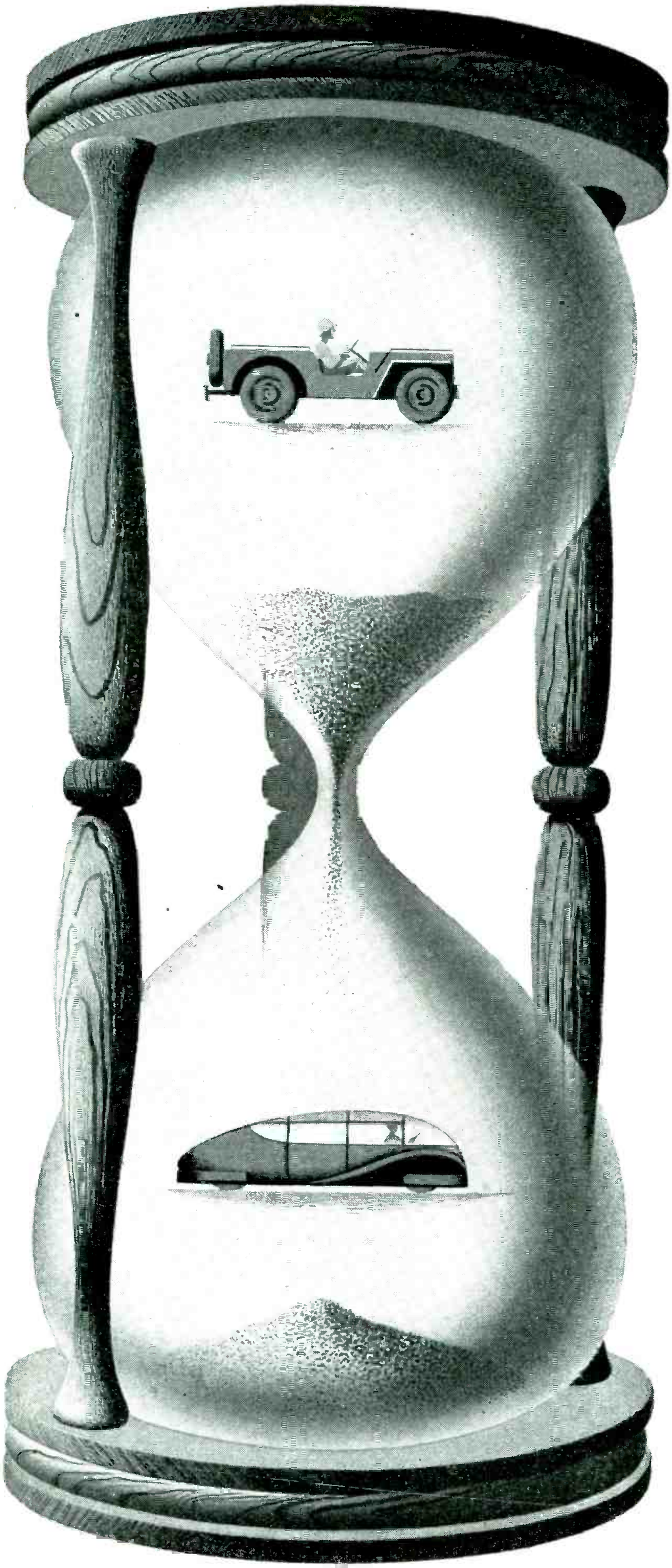
Wilmington 99, Delaware *Offices in Principal Cities*



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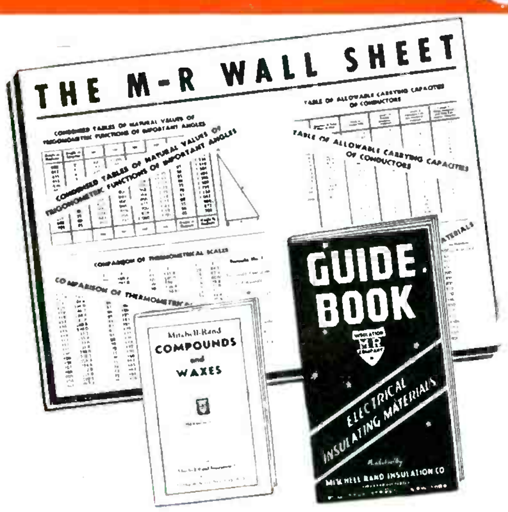

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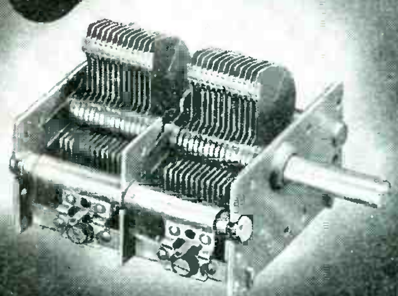

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RUSSIA

Threat . . . or Promise?

WHEN this war is ended, two nations—the United States and Russia—will possess the bulk of the world's military and industrial might.

Whether this new situation will hold seeds of catastrophe or of unprecedented opportunity will be determined by policies . . . still to be formulated.

If this concentration of power leads to a bitter struggle for supremacy, then the world will be turned into a giant munitions factory.

If it is used cooperatively to maintain order, then, I believe, the stage is set for a long era of prosperity . . . and peace.

It is time that Americans, whether of the Right or the Left, face this basic issue squarely and open-mindedly.

☆ ☆ ☆

No group in this country has a greater stake than have business and industry in seeing that a satisfactory Russian-American understanding is reached.

Without such an understanding there can be no reasonable hope for more than a temporary and insignificant reduction of our crushing wartime tax burden. If the threat of a clash between these two giants impends, neither bankers nor governments will run the risk of lending on a scale adequate to maintain international trade at levels necessary for our future prosperity. Potential international customers, instead of buying freely in open world markets, will be forced—as during the dangerous period introduced by Hitler in the early 1930's—into the trading camp of whichever power they fear most.

If, however, Moscow and Washington will agree on cooperative plans for maintaining the peace, American business will enjoy enormous new trade opportunities after the war.

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Russia, during the three and one-half years since it was attacked by Hitler, has conclusively proved to a doubting world that it is a top-flight military power.

Soviet railroads did not break down under the strain of war.

Regions accounting for nearly 70 per cent of Stalin's key industries were engulfed by the invading Nazis, but before they fell, Soviet management engineers performed a near miracle by transplanting entire industries a thousand miles to the Urals with the loss of as little as four months' production in many cases.

Though American planes, trucks, and medical supplies have been welcomed by Moscow, fairness demands the admission that more than 98 per cent of American production has *not* gone to the Russian front.

Russian planning and *Russian* equipment won the victories of Leningrad, Stalingrad, and the Caucasus.

☆ ☆ ☆

But these measures of Soviet military strength—indicative as they are of an unsuspected economic development—fail to picture in adequate detail the startling potential of the Russian market after the war.

Russia, for instance, has two and one-half times the area of the United States.

It has a population of nearly 200,000,000, and this is increasing at the rate of 2,500,000 a year.

And statistics just released show that Russia has three times as many youngsters under 16 as has the United States. This is a measure both of war potential and of a vast commercial market.

And remember that in no part of the world before the war was per capita production rising as rapidly as in the Soviet Union.

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German armies occupied a region in Russia roughly equivalent to the territory in the United States north of Richmond, Virginia, and east of the Mississippi.

This huge area—with its counterparts of Pittsburgh, Buffalo, and Bridgeport; of Illinois corn fields, New York dairy farms, and Maine potato harvests—was *twice* subjected to the most withering destruction; first by the Russians themselves when they retreated before the Germans, and then by the Germans when they withdrew before the victorious Russians.

As a result, 30,000,000 people are in urgent need of complete reoutfitting. They need houses and shoe laces, trolley cars and baby carriages, tractors and livestock, hydroelectric plants and electric light bulbs.

Many of these needs will be met at home. It is doubtful, for instance, if Moscow will import cooking utensils or sewing machines, for many of Russia's huge war factories can quickly be converted to peacetime production of such consumer goods.

But for the rebuilding and expansion of her industries Russia looks to the United States for equipment.

Soviet representatives already are in this country with authority to negotiate for technical men and the equipment necessary to rebuild the great Donbas coal mines according to the most modern American methods.

It is important to remember that Russia's whole iron and steel industry, its non-ferrous mining and processing, some of its chemical production, much of its coke roasting and gas recovery, practically its entire automobile and tractor industry, and the largest of its hydroelectric plants, are based on American machinery and processes.

It is known among manufacturers that Russia recently has asked for bids on shipbuilding equipment, construction and roadbuilding machinery, alloy steels, textile machines, plastics, and a long list of rail, air, and water transport supplies.

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The Soviet Union, however, has more than a rehabilitation job on its drawing boards.

The first Five-Year Plan, which, as we all remember, was completed ahead of time in 1932, was devoted almost exclusively to heavy industry. Russia set out to build for itself the machines and the factories which, in later years, could turn out, at home, modern equipment for a vast range of light industries.

Stalin, when he inaugurated the second of his famous Five-Year Plans, promised that before it was completed Soviet factories would begin to turn out a flow of consumer goods—ready-made dresses, canned foods, soap, cosmetics, shoes, kitchenware, automobiles, telephones, and modern houses.

But, by 1935, Moscow realized that Russia could not afford to enjoy such luxuries in the face of growing political tension in Europe. So, when the third Five-Year Plan was launched, there was no fanfare. Russians continued to wear their old clothes, to eat whatever simple food was available, and began grimly to build the industries which ultimately produced enough tanks, planes, and guns to turn the tide of battle at Stalingrad.

It is characteristic of Moscow that even before the last battles with the Nazis are over, Russia is planning to pick up its Five-Year Plans where the war had interrupted them.

Invitations to participate in a permanent exhibition in Moscow already have been mailed to American manufacturers. Soviet officials want their public to see samples of our new machine tools, aluminum and alloy products, oil-drilling machinery, bulldozers, and prefabricated kitchen equipment. Russia already is projecting specific plans to resume the job (1) of making the country an industrial giant comparable to the United States, and (2) of making life more pleasant for a long-suffering people.

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What is the measure of this postwar market in the Soviet Union?

Some estimates place the total quantity of goods which Russia might take from the United States during the first two or three years after the war as high as \$5,000,000,000 a year. Then, as Russian industry is restored, imports from the United States might taper off perhaps to \$2,000,000,000 a year.

Actually, these estimates are far too optimistic, unless the United States is prepared (1) to help Russia pay by buying vast quantities of Soviet raw materials, and (2) to provide large credits to handle the purchases during the first few years of rehabilitation.

The relations of American exporters with Russia during the period covered by the three Five-Year Plans have been eminently satisfactory. Moscow has met all of its obligations punctually; fifteen years of experience have reduced contract forms to the point where they cause a minimum of misunderstanding between the Russian representatives and the American producers; individual American companies with extensive prewar experience in handling Soviet business already are offering large credits on initial postwar orders though these may yet be replaced by large government credits at lower interest rates.

But the volume of trade with Russia after the war hinges upon Moscow's ability to pay. Never before the war did the United States buy more than \$30,000,000 of goods a year from Russia. As late as 1938, Soviet exports to this country amounted to as little as \$23,500,000, far less than enough to pay even the service charges on the credits which would have to be extended in connection with exports of several billion dollars a year. Only South Africa produces more new gold each year than the Soviet Union. But the United States does not want gold; more of it would only complicate the problem of controlling prices here.

If the United States, however, is to achieve, after the war, the high level of national income which is necessary (1) to keep our expanded factories in operation, and (2) to service the national debt, it might absorb from \$90,000,000 to \$100,000,000 a year of the kind of goods bought from Russia before the war—furs, timber, manganese, chromium, and handicrafts. But unless this volume of purchases from Russia can be boosted by another \$50,000,000 annually, credits of the size necessary to fill immediate Russian needs could not be serviced without large supplemental importations of undesirable gold.

The nub of the situation is that Russia offers an extraordinary potential market particularly for our heavy industries which have grown so enormously during the war. But if this sales outlet is to materialize, then the United States must find a way to import from Russia (or from Russia's debtors if any) from ten to twenty times as much as we did before the war. Instead of merely going after the export business, American businessmen must explore with the Russians the possibility of buying bigger supplies of Soviet products.

☆ ☆ ☆

But more than the Russian market itself hinges upon sound cooperative action by the world's two leading military-industrial nations.

If trade between them is held to a minimum and if relations are strained, the flow of trade all over the world will be adversely affected.

Europe, long this country's biggest export outlet, certainly will never take the bold steps necessary to reconstitute its economy on a peacetime basis if Russia and the United States drift into a race for military supremacy.

The Balkan states, which may be industrialized by Moscow in order to reduce their dependence on Germany, and the Arab world with its huge need for transportation, irrigation, and sanitation, will not dare accept American credits or make big contracts with American engineers if Moscow frowns on the deals.

And refusal of Russia and the United States to work cooperatively to maintain the peace would kill, in their present embryonic stage, all dreams of a vast industrialization program for China.

☆ ☆ ☆

The opportunity to make a major change in the trade map of the world and at the same time to achieve a sharp rise in our own standard of living is before us.

It demands of American business leaders the kind of boldness and imagination that their predecessors displayed when they pioneered this country's unknown West.

It demands realistic action by men who know that the solution to this country's *real* foreign trade problem under today's conditions lies in boosting *imports* not exports alone . . . men who are not afraid of being paid for what they sell.

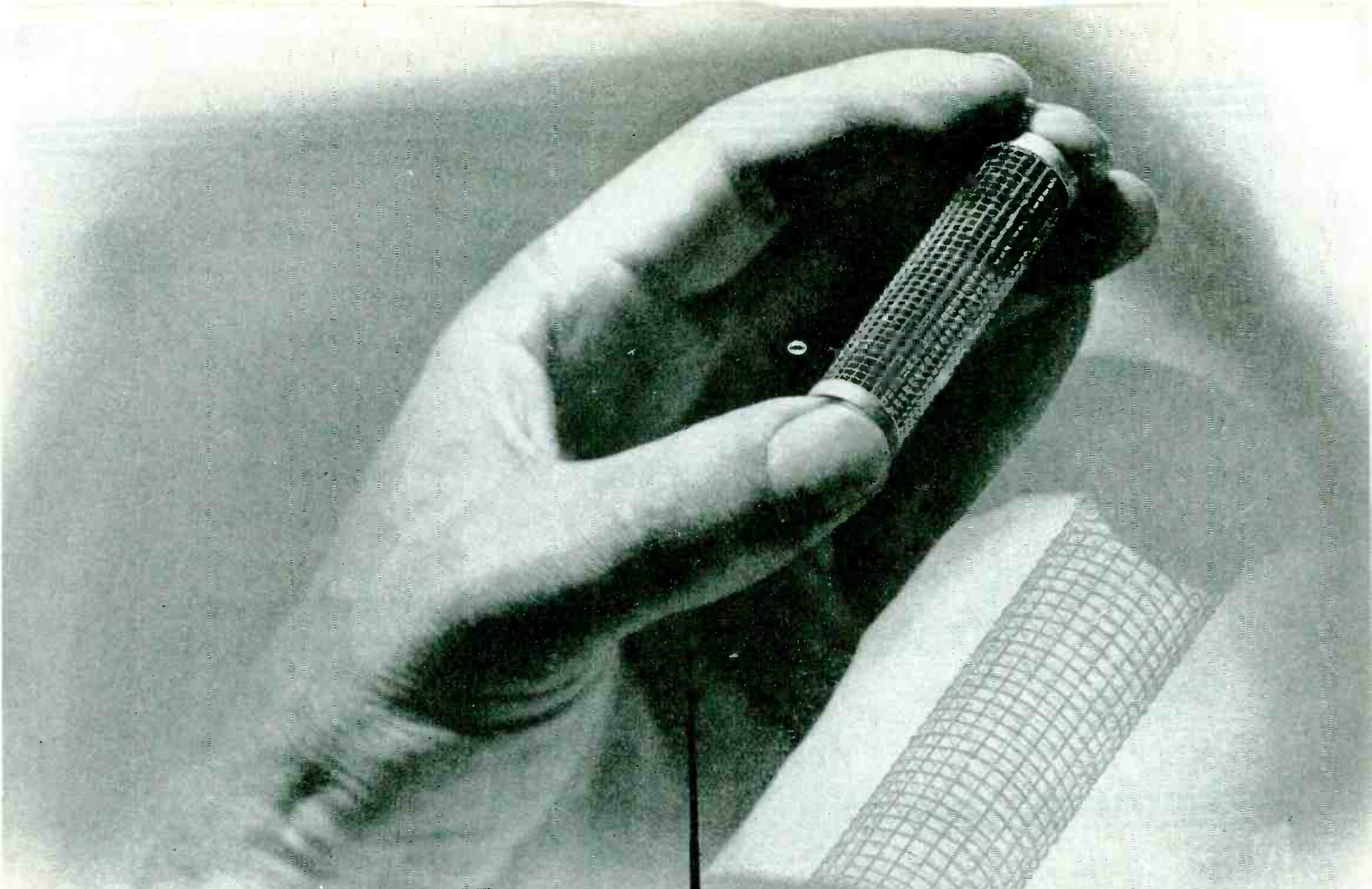
It calls for leaders who will approach Moscow and other major customers at once with constructive plans that would parallel in scope those on which this country is waging war . . . leaders who will make it clear at the outset that this bid for cooperative action emphatically demands that each nation shall have complete freedom to determine its internal political and economic organization without interference from the other.

It is *this* caliber of leadership upon which our future hinges.

James H. McGraw, Jr.

President McGraw-Hill Publishing Company, Inc.

THIS IS THE 29TH OF A SERIES



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Grid emission, with the resulting instability of operation, parasitic oscillations and prematurely burned out filaments, has become a thing of the past. The new Eimac "X" grid will not emit electrons even when operated at incandescent heat.

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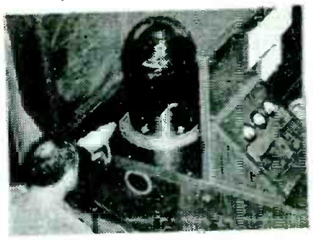

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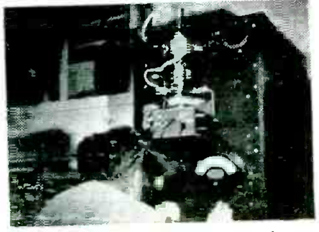
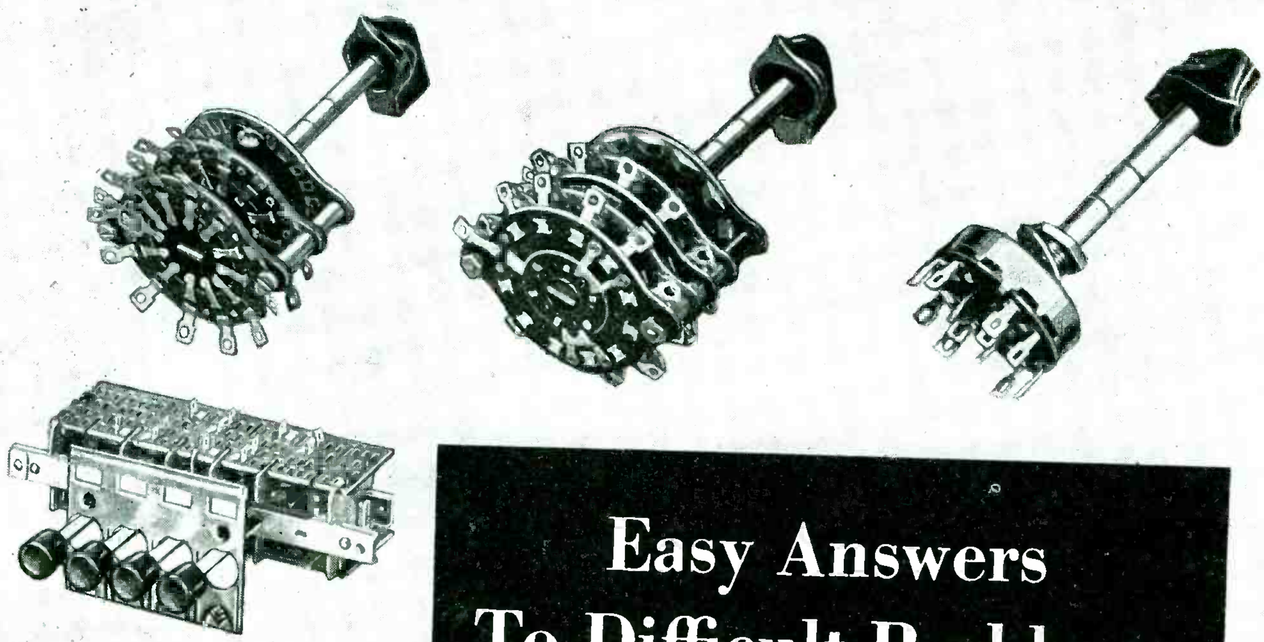


ELECTRONICS . . . *Determining facts about and recording data on vacuum tube capabilities.*



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Mallory standard stock switches not only have a reputation for dependability and long life—they've shown an amazing adaptability to new and unusual requirements.

That's why Mallory standard single gang, multi-gang and push button switches—longtime favorites in the radio and industrial fields—are serving wartime needs in tanks, ships, planes and in many types of industrial and electronic equipment.

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CROSS TALK

►**SHARE** . . . From a service man in the South comes the plea: "I am seeing so much that is electronic in my work that I wish to supplement my work with reading in this field. I wonder if some of your readers who do not file their copies could forward them to me after they are through? In this manner they will help keep another soldier boy's intellect alert."

Seems like a marvelous idea. Anyone want Pvt. So-and-So's real name?

►**ADJUSTMENT** . . . Not all of the adjustments, post-war, are going to be made by industry nor by returning service men. Many of the adjustments will have to be made by men who have stayed at home, making their contribution in any one of a dozen ways which have very little in common with their jobs before the war.

Consider the college professor, perhaps from a small and not too rich institution, who will be constantly surrounded by youngsters taking his courses because the curriculum requires it; always wishing for more apparatus than his department budget will tolerate, apparatus not only for demonstration but for some of his own research.

During the war he has been surrounded by colleagues whose intellectual background and interests and scientific attainments may not only equal his own but may even surpass them so that he learns while working; whose every request for research equipment is quickly gratified.

Or, consider a small-company engineer or scientist who will have limited funds for research, with a small staff, under the constant necessity of producing profitable items, never quite free to work on his own ideas because they are not right down the company line.

During the war he has unlimited funds, his staff may be numbered in the scores of hundreds, and his sole aim is to produce devices the success of which is gaged solely by their excellence for the job.

Colleges and industry must be cognizant of the emotional problems of such men when they return to our humdrum world; must remember that their returning personnel may have had visions which cannot possibly be duplicated on the home grounds. Somehow, means must be found to condition favorably the atmosphere in which these war-time contributors do their peace-time work.

►**MAKEUP** . . . In all businesses there are exigencies; unexpected things that crop up to plague an otherwise pleasant setup. In the publishing business, one of the exigencies is the article that is a column or two too long to fit into the allotted space. One way out of the difficulty is to "turn-over" the extra column or two into the rear of the book.

ELECTRONICS readers are particularly busy at this time and should not have to paw through the rear of the book to read the end of any technical article. Beginning in this issue, the editors intend to make articles "break even" up front, to end them in the feature section where they start if this is humanly possible. Only in makeup emergencies and to avoid emasculating material will they diverge from this new policy.

►**FIRE** . . . It seems to be a normal male desire to chase fires. Well, out in Ohio several electronic engineers enjoyed this pastime so much they got busy and developed a whole fire alarm system for their particular town, presented it to the town and had themselves cut in on the circuits so they could really chase fires efficiently!

INTERNATIONAL Radio Frequency Proposals

Preparing for forthcoming Treaty Conferences, a committee of industry and government representatives is currently meeting under the sponsorship of the State Department. Its work is far from completed but some of the initial suggestions do point toward things to come

INTERNATIONAL ASPECTS of the radio art are attracting the close attention of post-war planners in a series of meetings currently being held in Washington.

The State Department, which is charged with the preparation of proposals for international treaties in the telecommunications field, has undertaken to obtain the advice and guidance of other government departments and the industry, looking toward the next Treaty Conference at which existing international law and regulations will be revised to meet new technical and economic conditions. Such a revision is long overdue.

Major Committee Objectives

The present international radio law rests in the International Telecommunications Convention formulated at Madrid in 1932, and the General Radio Regulations as revised at the Cairo Conference in 1938.

Since 1938, much water has gone over the dam. New regions of the ether spectrum have been opened to extensive use. Existing allocations and services have assumed new relative positions of importance. The interference problem, due in part to disregard of international service assignments, has become so acute that it borders on the chaotic. The war has brought with it many new developments in aviation and long-distance communication, many of which will continue in peacetime.

Many of the aspects of the work now in progress are legal in nature, particularly the delicate questions of the sovereign rights of nations and the enforcement of treaty agreements. But an equally large part of the work is technical, and it is this task which has been assigned to a committee under the chairmanship of Dr. J. H. Dellinger.

The committee consists of members from industry, including many active in the Radio Technical Planning Board, and from government departments including the Army, Navy, and the FCC. The meetings began August 11 and 12, were resumed on September 20 and 21, and later meetings are scheduled to follow the Allocation Hearings of the FCC which began on September 28.

The Technical Committee has been charged with two main investigations: (1) A general survey of the definitions and standards which should govern international allocation and standardization of frequency assignments, and (2) a specific study of frequency allocations to particular services.

The work has by no means been completed, so it is not possible to report official conclusions. But at the initial meeting, representatives of the State Department stated that the proceedings might be reported in the press as they proceeded provided that no direct quotations were made from the draft proposals and minutes.

Definitions and Standards

The first portion of the work of the technical committee, relating to definitions and standards, is concerned with proposed changes in the Radio Regulations (Cairo, 1938). Changes may be extensive.

It is evident that the introduction of frequency modulation has changed concepts in a number of particulars. It is proposed, for example, to classify the emission of a transmitter as "A" for amplitude modulation, "F" for frequency modulation (and phase modulation) or "AF" for emissions combining the two types. Following this designation is a number which denotes the bandwidth occupied by the transmissions, expressed in kilocycles. Thus a standard broadcast station would bear the designation A10, and a standard frequency modulation station F150. (The symbol "T" has also been suggested for keyed signals.)

The methods of calculating the bandwidth of given classes of station are stated in the proposed regulations as follows: A pure cw telegraph station has a bandwidth in kc equal to 0.0005 BW, where B is the average bauds per letter (a number ranging from 5.0 for a five-unit teleprinter signal to 8.4 for international Morse code), and W is the number of words per minute transmitted. The bandwidth of a modulated cw telegraph station is equal to the above expression, plus twice the modulation frequency. An amplitude-modulated station (voice or music) has a bandwidth equal to twice the modulating frequency. A frequency-modulated station (voice or music) has a bandwidth of twice the maximum frequency swing, in kc, provided the swing is equal to or greater than the highest modulating frequency, which it is in nearly all practical cases.

To assist in comparing various transmissions on an equal footing it is proposed to rate transmitters in terms of the peak power supplied to the antenna in normal operation.

Emissions outside the authorized bandwidth must be at least 26 db below the maximum radiated field within the authorized band, and if interference is caused by such "extra-band" emissions they must be further reduced.

Only two types of services are defined, "fixed" and "mobile." A portable station assumes the classification of the service in which it operates, even if such operation is on a temporary basis. Thus a portable station temporarily operating from a specified fixed location is a fixed station. If used while in motion, or at unspecified fixed locations en route, it is a mobile station.

It is proposed that in the future, station assignments be specified in frequency, in kilocycles or megacycles, and not in terms of wavelength.

Specific limits to the permissible amount of radiation on harmonics of the assigned frequency are proposed; the peak power of the radiated harmonic is to be 40 db below the peak power of the fundamental, and in no event greater than 200 milliwatts.

It is proposed that the use of damped radio-frequency oscillations be specifically forbidden.

Proposed Table of Allocations

The proposal most of interest to the readers of ELECTRONICS is the Frequency Allocation Table. This table is in no sense in final form, and was offered to the Committee primarily as a means of "starting the argument."

The table was drawn up by the Inter-Department Radio Advisory Committee (IRAC), the official government committee on radio allocations. The proposed table may be viewed as a preliminary statement of the government interest in frequency allocations. The interest of the industry, in contrast, is being formulated by the Radio Technical Planning Board, and its recommendations have been separately presented before the Allocations Hearings of the FCC.

The IRAC set up the various radio services in general order of priority as follows: (1) Services concerned with the preservation of life and property, particularly navigation aids and distress calling service, (2) communication services of an essential nature which cannot be supplied by non-radio means, such as maritime and aeronautical communications not covered in the first classification, (3) broadcasting, including standard, fm, television and facsimile, (4) communication services using radio because the use of wire lines is not expedient, such as transoceanic telegraph and telephone, and (5) other radio services.

Amateurs Well-Protected

A most important aspect of the table is the extent of the spectrum covered, from the lowest frequencies, about 10 kc, to an upper limit at 30,000,000 kc (30,000 Mc, or 1-centimeter wave length).

The highest specific service proposed is a band from 21,000 to 22,000 Mc for amateur service. The amateur bands, which are of outstanding interest to an industry composed largely of amateurs and ex-amateurs, are proposed as follows: 3500-3900 kc, 7000-7400 kc, 14,000-14,400 kc, 21,000-22,000 kc, 28,000-30,000 kc, 144-149 Mc, 218-225 Mc, 420-460 Mc, 1125-1225 Mc, 2500-2700 Mc, 5200-5750 Mc, 10,000-10,500 Mc, ad 21,000-22,000 Mc, The pre-war bands at 15 meters and 5 meters are deleted, and a new band at 15 meters is proposed, as well as six new bands at wavelengths less than one meter.

No provision is made for international high-frequency broadcasting in the IRAC Table. This omission has caused considerable opposition on the part of the industry representatives, who feel that space must be found for this activity.

FM and Television Proposals

Frequency modulation and television receive an unbroken assignment from 42 to 108 Mc, divided in two regions, 42 to 54 Mc for fm, and 54 to 108 Mc for television. This proposal conflicts with that of the RTPB Television Panel which recommends assignments of six-megacycle channels from 50 to 246 Mc, excluding the 56-60 Mc region. The RTPB Panel on v-h-f Broadcasting recommends the region from approximately 40 Mc to approximately 56 or 60 Mc for fm.

The IRAC Table also makes provision for television on higher frequences, presumably with wider bandwidths than the 6 Mc currently used. These television assignments lie in the bands 460–508 Mc and 524–956 Mc.

Standard Broadcasting and Aviation

In the standard broadcasting band it is proposed to add one additional 10-kc channel at 540 kc.

Standard frequency broadcasting (of the WWV type) is proposed for international standardization at 2500 kc, 5000 kc, 10,000 kc, 15,000 kc and 20,000 kc.

Aviation radio in all its forms occupies a large place in the Table, as indeed it must in any post-war plan. It is proposed that all purely domestic aviation traffic control, airport communication and plane-to-plane and plane-to-ground communication be carried out on the u-h-f bands where no interference will be caused.

Navigation and Safety Devices

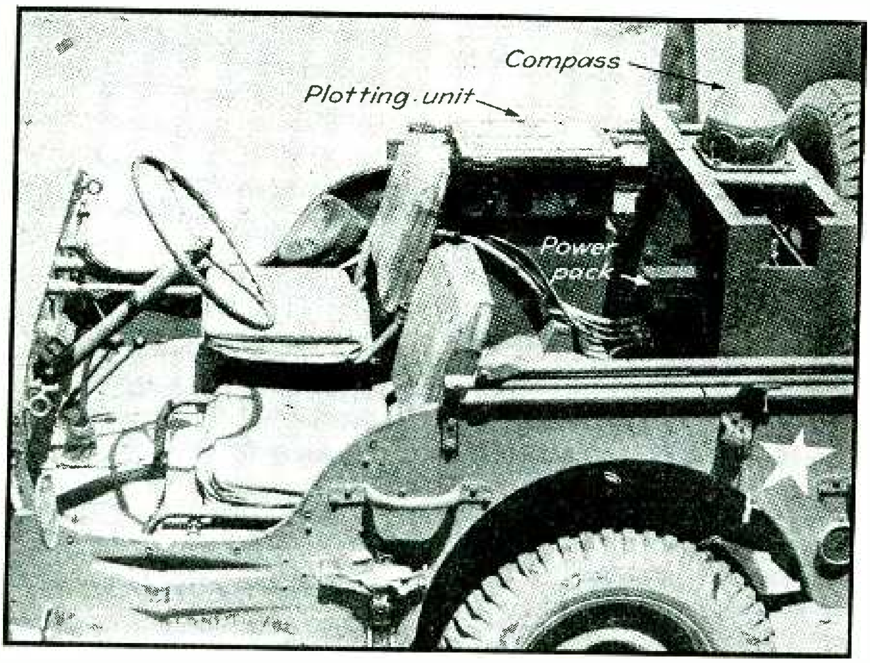
It may be wondered why the region of the spectrum above 30 Mc should be allocated definitely in an international agreement, since direct interference between nations is restricted to on such frequencies is restricted to over-the-border cases, which could be solved by regional agreements within continental areas.

This fact is generally admitted. But it is equally evident that the maritime and aeronautical mobile services will employ v-h-f and u-h-f equipment for traffic control, instrument landing, harbor approach, navigation, collision prevention, and the like. Such "common carriers" engaged in international trade must be able to use the same equipment in any harbor or airport in the world.

Whether or not the proposed Table will remain in its present form when the Treaty Conference meets depends on the action taken by the State Department Committee, as well as on such action as the FCC may take following the presentation of the RTPB proposals.

Automatic Map Tracer

The odograph, now in production for installation in jeeps, utilizes phototubes and thyratrons to transfer the indications of a precision magnetic compass to a plotting unit actuated by a speedometer drive cable, causing a pencil to trace on an appropriate map the exact course taken on roads or on cross-country movements



Land odograph, M-1, installed in a ¼-ton Army truck for road reconnaissance. Installations in this type of vehicle have given the most satisfactory performance so far because the compass can be mounted away from large magnetic masses

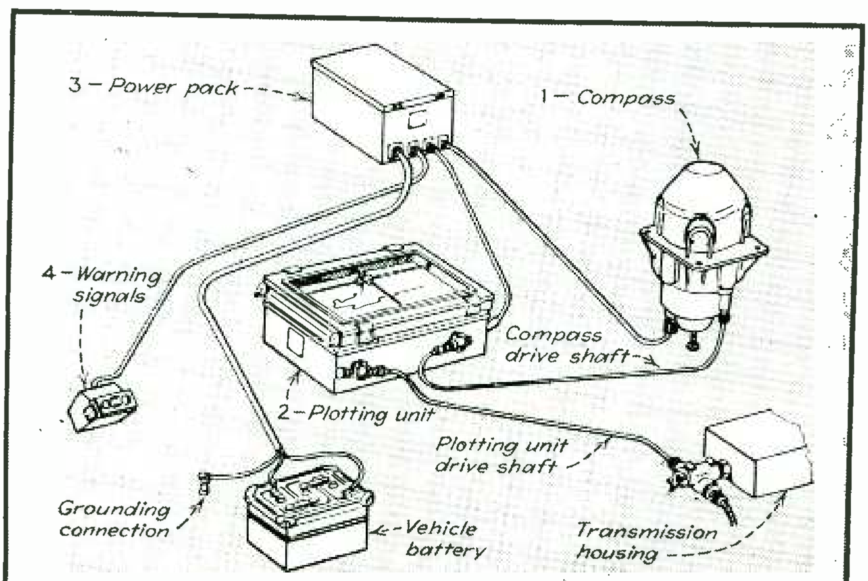


FIG. 1—Interconnection of units in an odograph installation. One warning signal blinks continually while the instrument is in operation. The other signal lamp flashes when the tracing pen is about to go off the map table, indicating that the vehicle is moving out of the area covered by the map being used

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In military use the Odograph, Land, M-1 is installed in ¼-ton trucks (jeeps), to achieve two basic purposes: (1) Map making, or plotting the positions of objectives relative to a given base; (2) Navigation, or finding objectives whose position relative to a given base is known. These two functions are often combined.

Since the odograph automatically plots the course taken by a moving vehicle, unknown terrain is readily mapped by driving over it. In addition to obtaining maps of the roads, it is possible to plot locations of important points or objects either by driving the vehicle to the point, or estimating its distance and azimuth from a known location of the vehicle with a range finder. In transport or reconnaissance, a map having the desired course can be placed directly on the odograph map table and the trace formed by the plotting pencil can be watched to make sure the correct route is being followed.

When travelling to a given objective whose position is known relative to the starting point, it is possible to plot the objective on the odograph map table and then drive the vehicle in the general direction of the objective by following roads or other convenient routes. Since at any given time the relative locations of the objective and the vehicle are always shown on the odograph map, the vehicle can reach the objective even though the driver has no previous knowledge of the road net and terrain.

Mapmaking and navigational

for Land Navigation

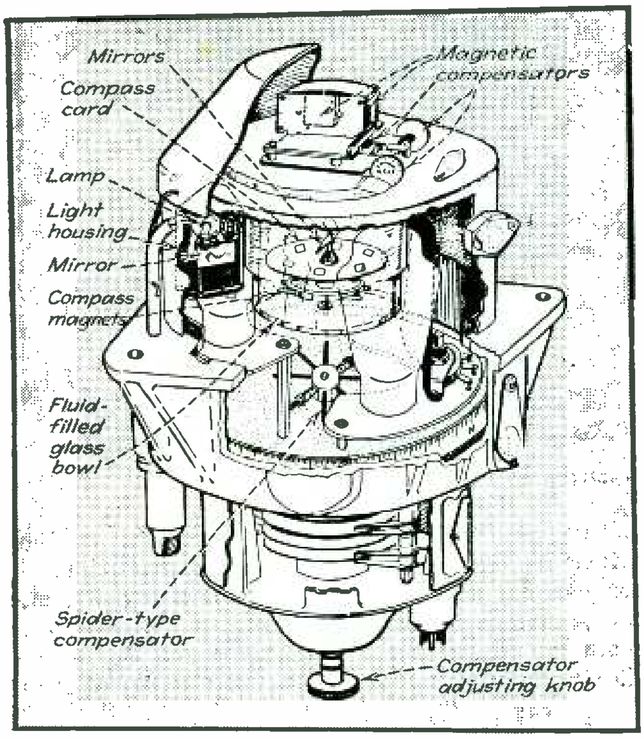
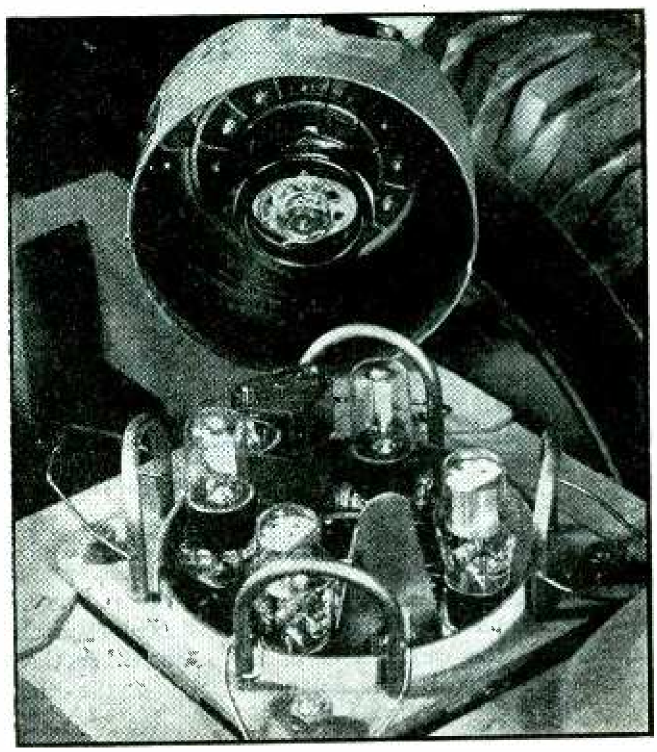


FIG. 2—Cutaway drawing of magnetic compass unit, which also contains the phototubes and thyratrons with their associated light source and deflecting mirrors



Lifting of compass bowl assembly exposes phototube-thyratron follow-up system that transfers compass indications to the plotting unit

functions of the odograph are often combined by using either the same or different instruments. Thus, maps made by one or more odographs can be used by other odograph-equipped vehicles. The unit is particularly valuable at night when guiding landmarks are not readily visible.

Some of the more important uses of the odograph may include tactical reconnaissance by armored and cavalry forces, navigation in unmarked terrain, rendezvous of units by various forces, surveys by field artillery forces, and reconnaissance and mapping by engineer forces.

The word odograph comes from the Greek, and literally means "writes the way" ("hodos" means "way" and "graph" means "write").

General Description of Installation

The installation involves three component parts: (1) A magnetic compass with its electronic conversion system; (2) A plotting unit with its 8½ by 11-inch map table, tracing pencil and mileage dials; (3) A power pack operating from the vehicle storage battery. Interconnections but not positions of these units are shown in Fig. 1; when installed, the plotting unit is positioned for accessibility and the compass for good magnetic conditions.

The plotting unit is actuated by the vehicle speedometer drive. The azimuth indication of the compass is transmitted to the plotting unit through the electronic control circuit. The total distance traveled and the proper directions are combined in the plotting unit to give a record of the course. A magnetic compass is used because of the relative complexity and size of a complete self-directing or north-seeking gyroscopic compass, and because the shock and rapid changes in direction involved in land operation are too severe for such an apparatus.

Details of the Compass

In order to plot a course, both the distance traversed and the direction must be known. Direction sensing in the odograph is accomplished by the compass, which has for its basic element a magnetic card assembly inclosed in a glass bowl, as illustrated in Fig. 2. The bowl is filled with a petroleum fluid which exerts a retarding influence on fins which project downward into it from the compass card proper. This gives damping to prevent erratic motion.

Mounted at the center of the card are two mirrors which are assembled at a dihedral angle having a horizontal axis as shown in Fig. 2. Response of the magnetic card to the influence of the earth's magnetic poles causes the card mirrors to face in a northerly direction immediately following any displacement of the compass housing.

The rest of the compass unit is related to the card only by optical means. A focused beam of light shines through the glass bowl onto the center point of the compass-card mirrors and is reflected back toward mirrors on the outside of the light housing, as shown in Fig. 3. The housing and the phototubes and thyratrons are mounted on a revolv-

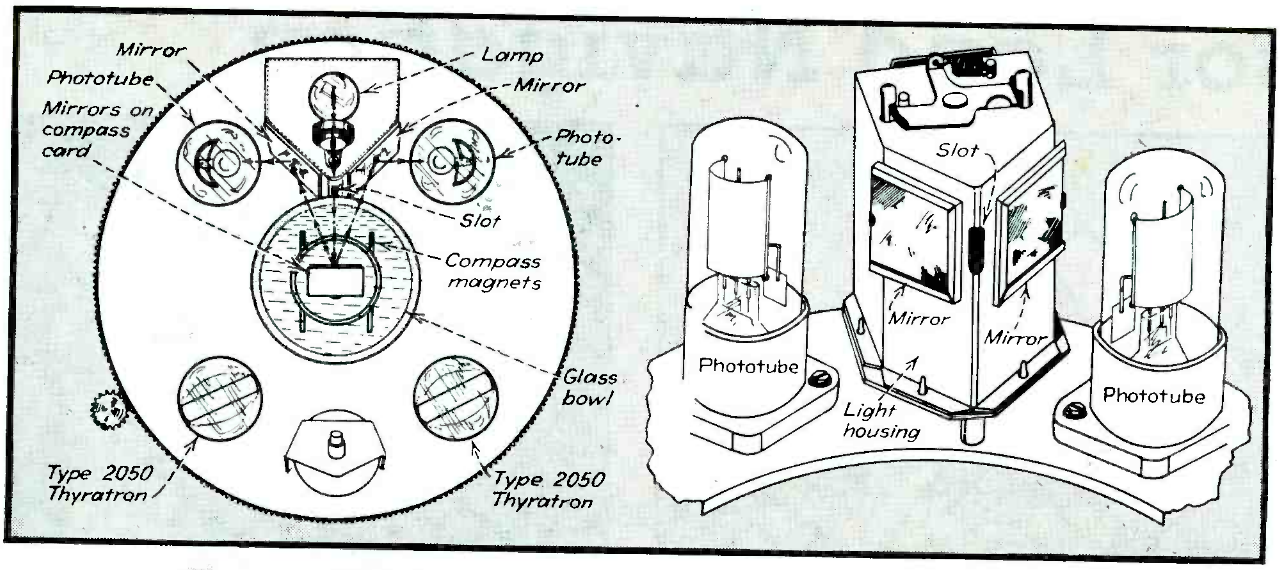


FIG. 3—Details of optical system employed in the compass unit

ing table geared to a flexible shaft which connects the compass with the plotting unit.

If this table is in correct alignment with the compass card, the light is reflected by the north-facing mirrors directly back into the aperture from which it comes. However, if the compass card is deflected by a change of heading of the vehicle, the beam of light strikes one or the other of the two mirrors mounted on the outside of the light housing and is reflected onto the cathode of one of the two phototubes. This fires the related thyratron, which energizes one of the electromagnetically operated clutch

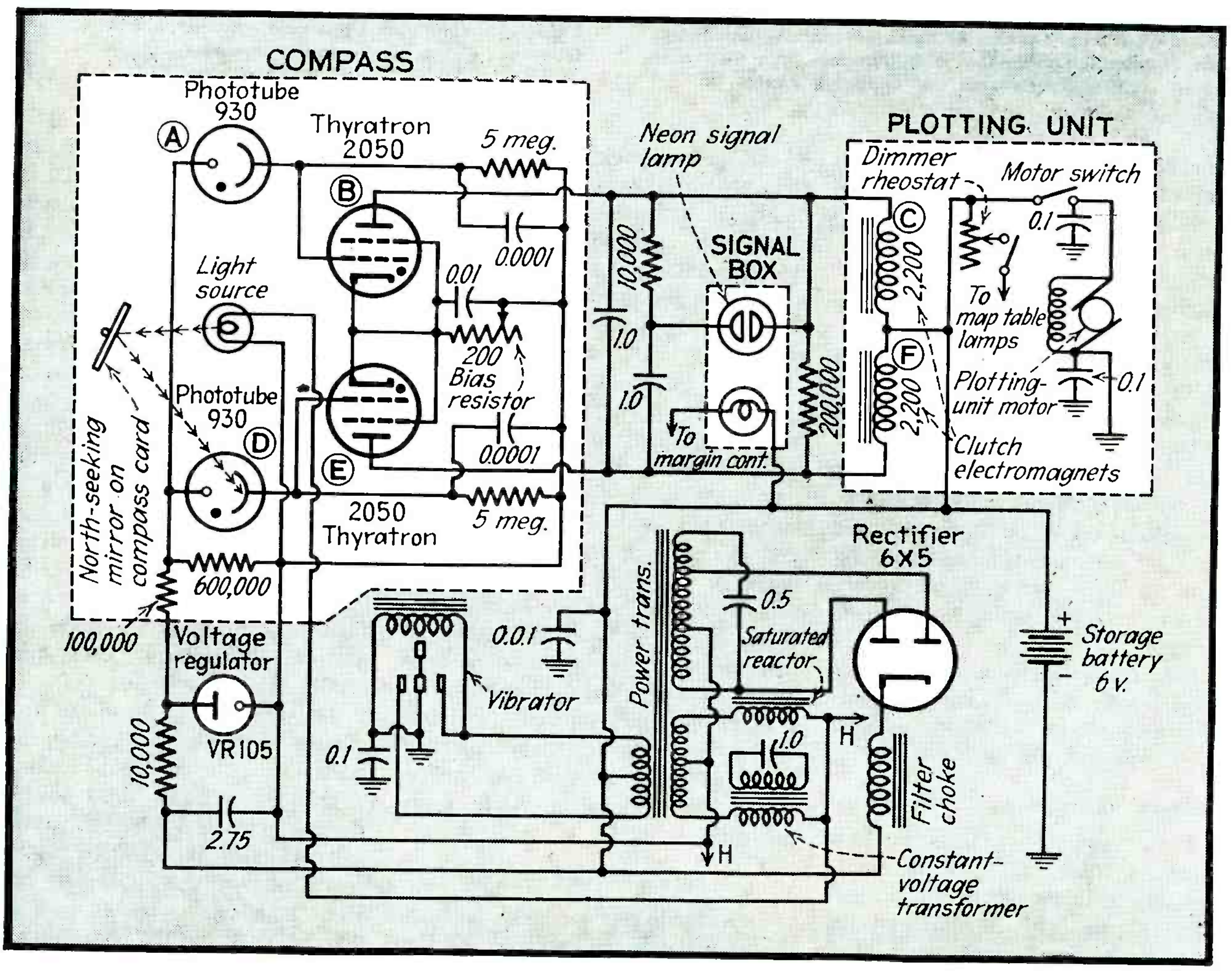


FIG. 4—Schematic circuit diagram of odograph. All parts not in the labelled boxes are in the power pack unit

yokes in the plotting unit and thereby causes the driving motor in that unit to rotate the flexible shaft until the compass table is back in alignment with the compass card.

Functioning of Electronic Circuit

The complete electronic circuit of the odograph is shown in Fig. 4. When plate voltage is first applied to the thyratrons by the power pack, no current is flowing through the 200-ohm rheostat serving as cathode bias resistance, and one of the thyratrons will fire. (Theoretically, both tubes should fire simultaneously, but in practice one tube will nearly always fire first since it is practically impossible to build two tubes with identical characteristics. If both do fire, the power switch is momentarily turned off.)

Assume that thyratron *B* fires first. It permits current flow through the bias resistor, providing a voltage drop that prevents the other thyratron from firing. Plate current of thyratron *B* flows through clutch electromagnet *C*, actuating the clutch and causing the plotting-unit motor to rotate the compass table in one direction. At the same time, the 1.0-μf capacitor connected between the thyratron plates becomes charged to approximately 185 volts.

Rotation of the compass table in the direction associated with clutch *C* soon results in light being reflected from the compass card mirror onto phototube *D*, which controls nonconducting thyratron *E*. This light reduces the resistance of the phototube, allowing current to flow through the 5-Megohm resistor in the grid circuit of thyratron *E* in such a direction as to make the grid of *E* positive with respect to its cathode. As a result, this tube fires, and its plate-cathode voltage drops from 200 volts to 15 volts. For an instant both thyratrons are conducting, but the plate-to-plate capacitor discharges, placing a negative voltage of minus 170 volts on the plate of thyratron *B* long enough to block this tube and enable its grid to gain control.

Now thyratron *E* sends plate current through clutch *F*, causing the compass table to rotate in the opposite direction. Rotation continues until the light beam has swung over onto phototube *A*, triggering off thyratron *B* and thereby starting a new hunting cycle. This hunting action goes on continually while the odograph is in use, and circuit adjustments are normally such as to give a 5-degree hunt on each side of the compass course at a rate of approximately 100 to 115 complete cycles per minute.

The hunting action eliminates back-lash in the flexible shaft and associated gearing, and is also valuable in connection with the design of the plotting unit.

Sensitivity of the thyratrons is controlled by adjusting the 200-ohm bias rheostat. Since a tube will fire on zero grid bias, if the resistance of the bias rheostat is entirely out of the circuit the tube will fire regardless of the signal from the phototube.

At the other extreme, if the entire 200 ohms is in the cathode circuit, the thyratron will never fire. In practice, a setting is used between these two extremes or at about 120 ohms. A lower resistance than this will tend to speed up the hunting cycles of the apparatus and reduce the angle of hunt, while higher resistance will have the opposite effect.

So that the operator of the vehicle can observe the operation of the unit, a signal box is located on the dashboard. It contains a ¼-watt neon lamp which, in normal operation, glows on alternate electrodes in synchronism with the hunting

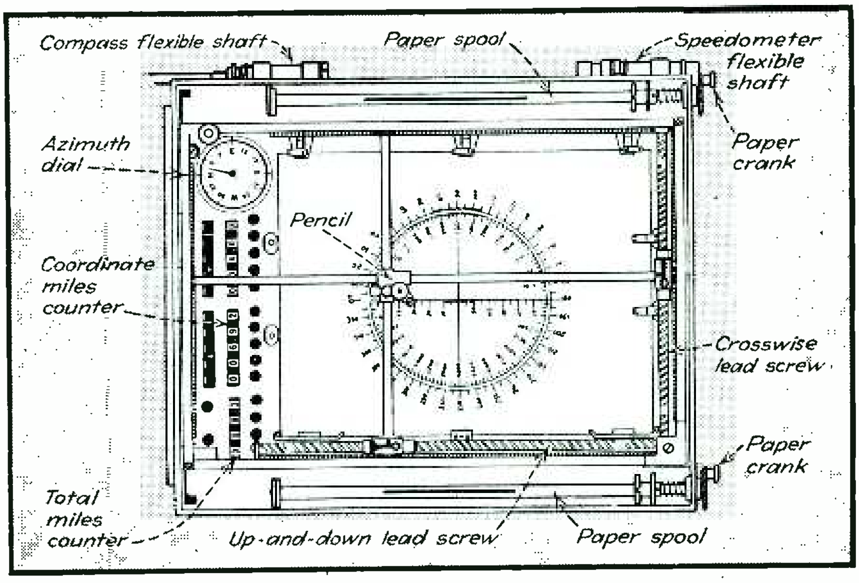
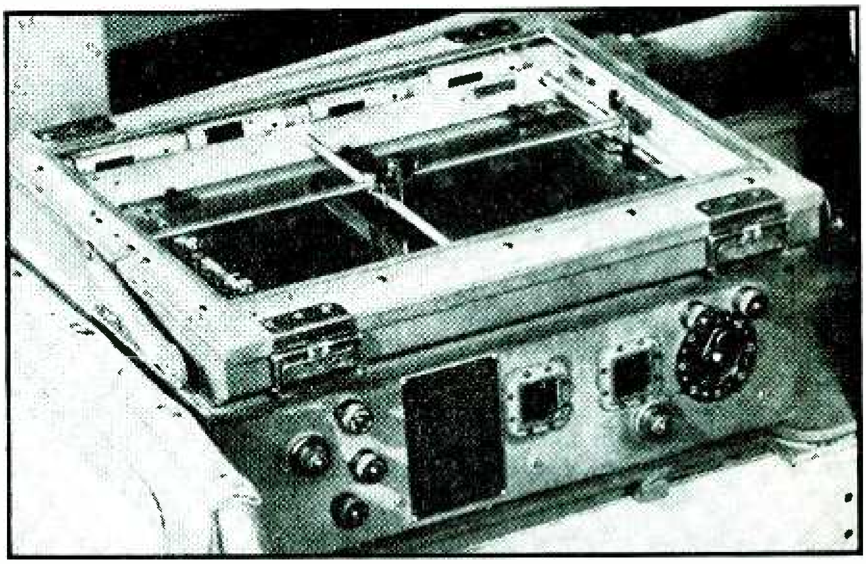


FIG. 5—Top view of plotting unit



Closeup of plotting unit with glass cover in place. A stubby automatic pencil is moved over the map table by the lead screws speed of the system. On d-c power, only the negative element of the neon lamp glows. As shown in Fig. 4, this indicator lamp is connected so that a 1-μf capacitor discharges through it with opposite polarity as the polarities of the two thyratron plates alternate in the hunting cycle. Thus one cathode of the neon lamp represents one of the thyratrons and its electromagnet, and the other cathode represents the other combination. Any variation in hunting action can be detected by observation of this signal lamp.

The signal box also contain an incandescent lamp which comes on to signal the approach of the tracing pencil to the margin of the plotting table. Other lights are provided for illuminating the map table, and can be controlled in brilliance by a dimmer resistance to provide operation on a brightly lighted street or, at the other extreme, in complete darkness where light must not be visible from the air.

Power for the recording odograph is obtained from the storage battery of the vehicle. When the main switch is closed, the drive motor in the plotting unit is energized directly by the battery. A power pack relay is also energized, connecting the vibrator to the battery. Power supply switching circuits are omitted from Fig. 4, for simplicity.

Two voltage regulators are incorporated in the power pack. A VR105 regulator tube keeps phototube anode voltages constant at approximately 105 volts despite battery voltage variations from 6 volts up to 8 volts. A resonant-type transformer in series with a saturated reactor holds the voltage of the light source and the thyratron heaters constant at 6.3 volts.

The Plotting Unit

The plotting unit shown in Fig. 5 has four functional purposes: To draw a map showing the course taken by the vehicle in which it has been installed, to register on counters the distances traveled by the vehicle, to actuate the azimuth dial indicator to show the direction the vehicle is traveling at a given instant, and to actuate the compass drive shaft for rotation of the compass table.

To achieve these purposes, the plotting unit must combine the information given by the odometer (the speedometer drive from the vehicle transmission) and by the compass in such a way that the motion is separated into north-south and east-west components. In other words, the plotting unit must perform the mathematical operation of integrating the components of $S \sin \alpha$ and $S \cos \alpha$, where S is the distance traveled and α is the angle of azimuth or heading with respect to the reference direction—usually north—maintained by the compass. This operation is achieved by means of a sine-disk and two Scotch yokes controlling an elaborate transmission and gear train arrangement serving to couple the distance input from the speedometer drive to the two lead screws controlling the movement of the pencil on the map table.

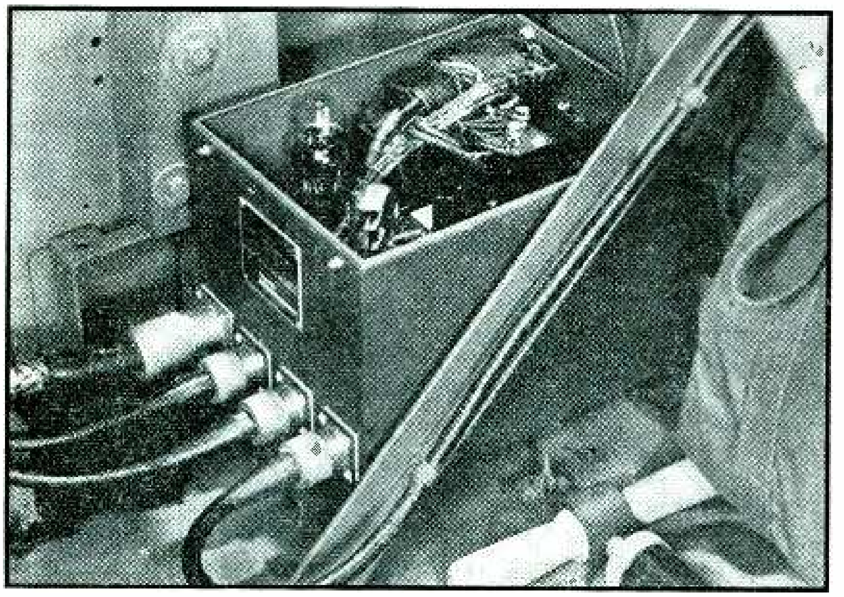
Alongside the map table on the plotting unit is a dial or azimuth indicator which repeats the reading of the completely enclosed and remotely located compass. Also on the plotting unit are counter dials that algebraically add up the two components of motion. These are calibrated in miles to give the total distance north or south and east or west of the starting point at which they were set at zero. Another set of dials is used to give the total distance travelled by the vehicle.

The scale of the map produced ranges from 1:20,000 to 1:500,000, depending on which of the available gear ratios is selected.

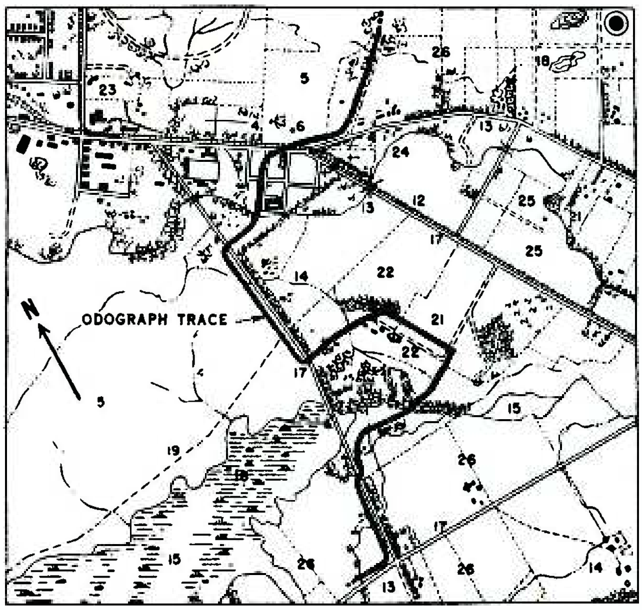
The compass is installed far enough away from the generator and other electrical equipment and wiring of the vehicle so that magnetic deviation due to these sources is eliminated. However, it is necessary that auxiliary units such as radios installed near the compass be double-wired from the battery instead of grounded to the vehicle frame, to maintain balanced magnetic fields which cancel each other.

In a vehicle containing an odograph, standard magnetic conditions are established. There are fixed positions for all tools, metal containers, and other metal objects usually carried in the vehicle and armament, and loose metal objects must be kept at least three feet away from the compass. Parking of the vehicle for a period as long as overnight requires that it be kept 15 feet away from other vehicles or else excessive changes in magnetism will result, and any changes such as removing the top or the spare tire make it necessary to recheck the compensation.

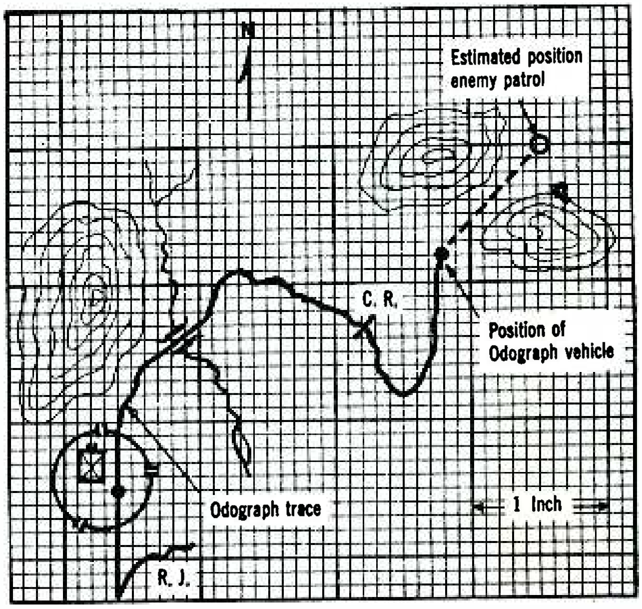
Checking of the compensation of the odograph is done by driving the



Power pack unit, containing voltage regulators, a type 6X5 rectifier, power transformer, vibrator, and reactors. Note rigid clamp for tire pump. All movable magnetic objects must be in fixed positions during operation of the odograph



Use of odograph with accurately detailed map. to reach a given objective by traveling in its general direction as necessity dictates



Use of odograph to plot on cross-section paper a rough map from which observed landmarks or enemy positions can be determined

vehicle approximately north by the azimuth dial for a distance of $\frac{3}{4}$ mile or more. The vehicle is then turned around and driven back over the exact route to the starting point. A compensator adjusting wheel is then turned to rotate the azimuth dial through half as many degrees as the angle between the north- and south-drawn traces. This procedure is then repeated on an east-west heading. When the compensation is correct, the plotting unit will exactly retrace its path on a north-south run and an east-west run.

Sources of Inaccuracy

In use, the odograph is subject to distance error, direction error, and slope distance error. The first of these, distance error, will be at a minimum when the vehicle is operated on a hard surface with standard tires at the recommended air pressure. Changes in size of tires or operations on loose or rough surfaces introduce factors which reduce the accuracy of the unit. When a vehicle becomes stuck in sand or mud, the wheels may spin considerably before the vehicle gets out. In such a case the practice is to turn off the unit until the vehicle is free. The distance input error may amount to as much as two percent under bad conditions of weather or terrain which cause an unusual amount of slippage.

Constant errors, such as those brought about by changes in tire sizes or pressures, are taken care of by a correction factor which is calculated by the average of a number of trial runs over accurately measured distances. After that, operations performed with the odograph are modified by the previously established correction factor being set in permanently as a scale change.

Direction errors are those caused by deviation from standard magnetic conditions in the vehicle, or by errors in compensation. Their correction is accomplished with appropriate compensators like those used on ship compasses. Slope-distance error is the difference between the actual distance traveled over the ground and the distance indicated by that projection on the map. In terrain with a great many hills, the odograph will show a slightly greater distance than the mileage scaled from the map. Unless an unusual series of up and down grades is involved, the error is small.

Overall accuracy on paved, unpaved, straight or crooked roads can be kept to one mile of error over 50 to 150 miles of travel. Over rough terrain, the error may be twice as great. Overall error is computed by running a closed course and observing the distance by which the trace fails to return to the starting point.

Future Uses

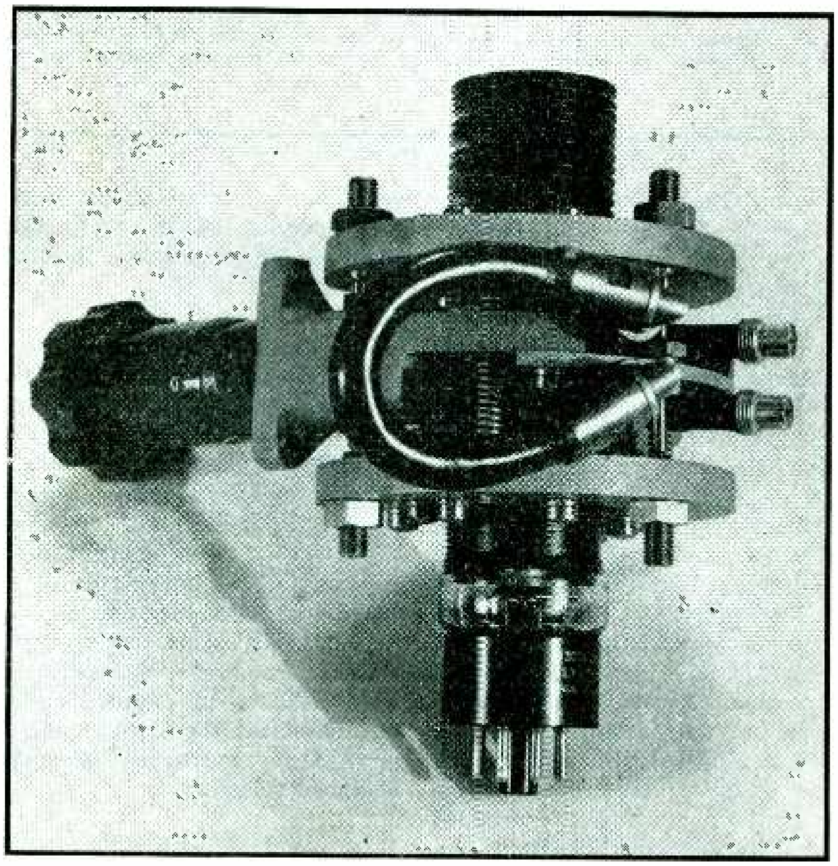
As a rapid means of surveying unfamiliar territory for the purpose of making maps, locating most favorable highway or rail routes, or simply traveling to a desired destination without the aid of landmarks, the odograph offers many post-war commercial and governmental applications. Examples are for survey, mineral exploration or rescue work in sparsely populated territory, charting of possible oil-producing sites in the desserts, and exploring polar wastes with odograph-equipped vehicles.

Acknowledgements

Research and development work on the odograph was carried out by three agencies: The Department of Terrestial Magnetism of Carnegie Institute in Washington, the Monroe Calculating Machine Co. of Orange, N. J., and the International Business Machines Corp. of Endicott, N. Y. The work was directed and coordinated by the War Department, The Office, Chief of Engineers, Engineer Board, Ft. Belvoir, Va. and the National Defense Research Committee.

KLYSTRON OSCILLATORS

Operation of velocity-modulation oscillators is explained by correlating the theory of electron bunching with the performance of two coupled tuned circuits. Effects of resonator tuning, feedback and electrode voltages are analyzed and compared with experimental results obtained with a type 410-R/2K30 tube. Similarity to triodes is shown



Type 410-R/2K30 Klystron in tuning mount, showing coaxial feedback loop, coaxial output connectors, and cooling fins

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THAT Klystron* oscillators and other velocity - modulation tubes utilize electron transit-time effects to convert an electron beam into radio-frequency energy introduces certain characteristics which will undoubtedly be of interest to radio engineers. This dependence upon transit time in a Klystron oscillator causes the frequency of such tubes to be affected by the voltage applied to the tube. Another equally important characteristic which is due to the dependence upon the transit time is the occurrence of voltage modes, i.e., a Klystron oscillator will operate at certain voltages for a given adjustment of the other variables, but is inoperative in the voltage region between these modes.[1] In other respects these newer types of tubes are quite similar to the more familiar triode oscillators, and it will be convenient to use these comparisons in an explanation of the characteristics described above.

Review of Bunching Theory

A brief review of the principle of electron bunching will be made in order to compare the characteristics of velocity-modulation tubes with the plate current characteristics of more conventional vacuum tubes. The results from an analysis of coupled tuned circuits can then be combined with the tube characteristics obtained from the electron bunching theory to explain the behavior of Klystron oscillators as adjustments are made of the tuning of the resonators, or as the voltage applied to the tube is varied. The effect of the phase and the magnitude of the feedback will also be considered, and the theoretical conclusions will be compared with experimental results obtained from

* Registered Trademark of the Sperry Gyroscope Company, Inc.

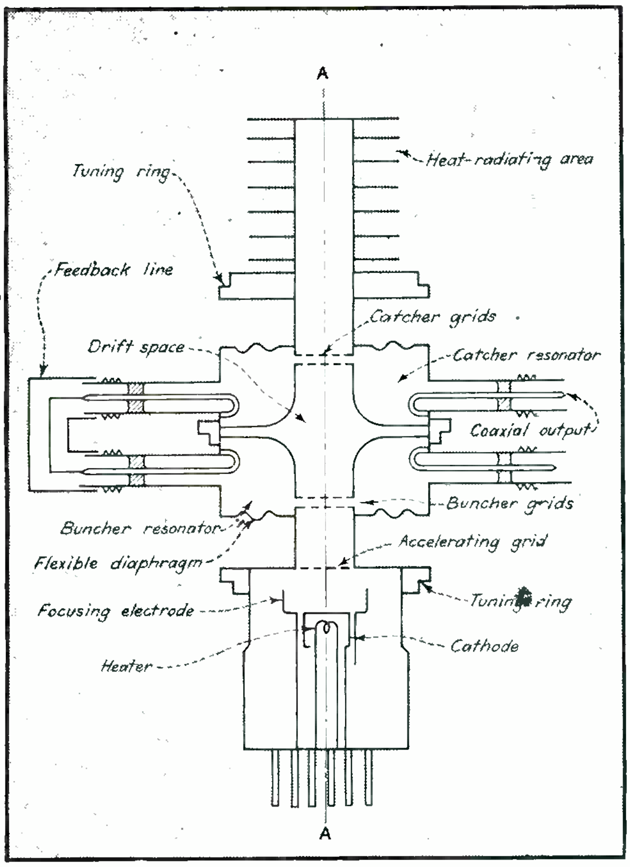
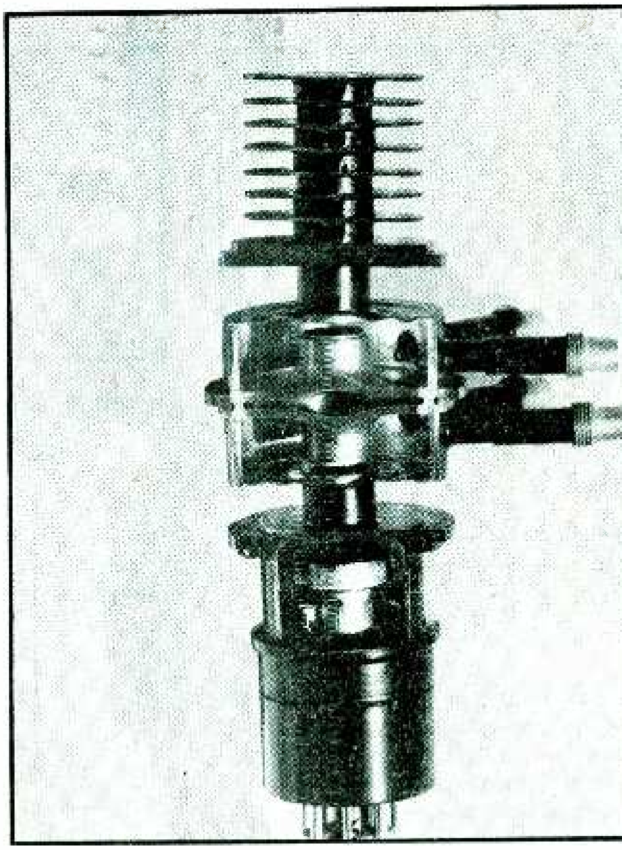


FIG. 1—Sectional view of the double-resonator Klystron of the type discussed in the text



Cutaway photograph of the interior of the 410-R/2K30 Klystron. The electron gun projects partly into the standard octal base

the operation of a type 410-R/2K30 Klystron used as an oscillator.

References to the theory of electron bunching have appeared in a number of publications[2,4]. A short review of this material will aid in the understanding of velocity-modulation tubes.

The sectional view of one type of Klystron which is shown in Fig. 1 will be used to explain the theory of electron bunching. The tube is a figure of revolution about the axis AA. An electron gun furnishes a beam of electrons which are accelerated in the space between the cathode and the accelerating grid. The beam continues to move beyond this grid with a high average velocity, and therefore the transit time of the electrons past the resonator grids corresponds to a small fraction of a cycle. The fact that the electrons are accelerated to a high velocity before being acted upon by a radio-frequency field overcomes one of the disadvantages of triodes at ultrahigh frequencies.

A radio-frequency field in the buncher resonator produces an alternating electric field between the buncher grids. This field will speed up certain electrons and slow down other electrons which pass the buncher grids during a different part of the cycle. Consider a group of electrons which pass the buncher grids at the time when the field is changing from a retarding field to an accelerating field. An electron which leaves early in the cycle will be slowed down and will continue along the drift space with less than average velocity. An electron which passes the grids when the field is zero will not be affected and will continue with average velocity. Other electrons which leave later in the cycle will be accelerated and will move along the drift space with greater-than-average velocity. The variation of velocity will be small compared to the average velocity.

As a result of this velocity modulation, electrons which leave later in the cycle travel faster and overtake the slower electrons which left earlier in the cycle. The electron beam is given an alternating component of its electron density as it travels along the drift space. This conversion process requires time; a transit time in the drift space corresponding to several cycles is typical. This transit time is quite important in the analysis of a Klystron oscillator, and the number of cycles corresponding to the transit time in the drift space will be designated by N. The electron bunches center around those electrons having average velocity, and therefore the value of N is determined by the average velocity. The following relations between the frequency f, drift distance s, transit time T, transit angle τ, average velocity v_0, and the acceleration voltage E_0 will be used frequently.

$$N = \tau / 2\pi \qquad (1)$$

$$N = fT = f\, s/v_0 \qquad (1a)$$

The average velocity is related to the acceleration voltage by

$$v_0 = \sqrt{\frac{2e}{m} E_0} \qquad (2)$$

where e and m are the charge and

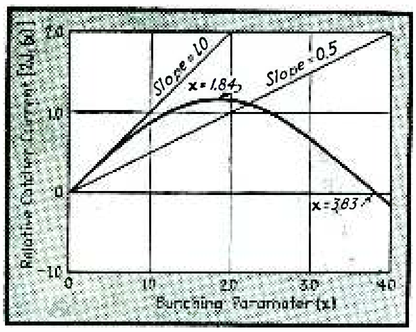


FIG. 2—Klystron bunching characteristic curve, analogous to E_g-I_p curve of ordinary tubes

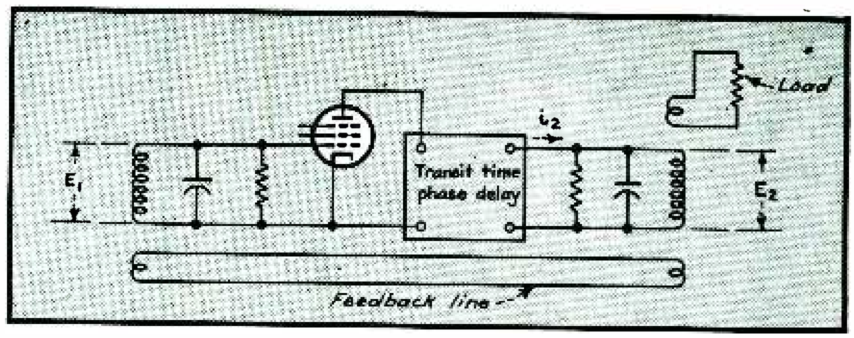


FIG. 3—Equivalent circuit for a Klystron oscillator. The pentode is used to indicate that only electron coupling exists between input and output in this velocity-modulated tube, of which the 410-R/2K30 is a typical example

mass of an electron. Therefore Eq. (1a) can be rewritten

$$N = \frac{fs}{\sqrt{\frac{2e}{m} E_0}} \qquad (1b)$$

The degree of bunching is directly proportional to the transit time in the drift space and is also proportional to E_1, the peak radio-frequency voltage between the buncher grids. E_1 will also be referred to as the buncher voltage. The degree of bunching is expressed by a bunching parameter which will be designated x, whose value is given by

$$x = \pi N \frac{E_1}{E_0} \qquad (3)$$

which with Eq. (1b) gives

$$x = \frac{\pi f s}{\sqrt{\frac{2e}{m}}} \frac{E_1}{E_0^{3/2}} = \sqrt{\frac{m}{8e}} \frac{\omega s E_1}{E_0^{3/2}} \qquad (3a)$$

The radio-frequency component of the bunched beam current, frequently called the catcher current, will be designated i_2 and is related to the bunching parameter by the expression

$$i_2 = 2 I_0 J_1(x), \qquad (4)$$

where I_0 is the d-c beam current and J_1 is a Bessel function of the first order and first kind. This relation is illustrated by Fig. 2. The curve will be recognized as the Klystron bunching characteristic which has been described frequently.[2,4] This curve may be considered analogous to an I_p vs. E_g characteristic for a conventional vacuum tube where relative catcher current corresponds to I_p and the bunching parameter corresponds to E_g, although it differs in appearance because the output reaches a maximum at a bunching parameter of 1.84, and then decreases as the bunching parameter increases. Underbunching refers to values of less than 1.84, usually very small values, and the term overbunching is used to describe the conditions when the bunching parameter is greater than this optimum value.

Phase Relations in a Klystron Oscillator

These principles of electron bunching will now be applied to the analysis of a Klystron oscillator. Any amplifier will oscillate if the gain of the tube is greater than unity and sufficient energy to overcome tube losses is returned from the output to the input in the proper phase.

An equivalent circuit for a Klystron oscillator is shown in Fig. 3. A multiple-grid tube is shown to emphasize the fact that only electron coupling exists between the elements of this type of velocity-modulation tube. The input and output circuits are completely isolated unless a means of feedback is supplied. The voltage between the grids of the buncher resonator is E_1 and this voltage is also indicated as the voltage across the input circuit of the equivalent diagram. A voltage E_2 is shown across the output circuit, and represents the voltage between the grids of the catcher resonator.

A current i_2 is shown flowing into the output circuit. This current represents the radio-frequency component of the bunched beam current, and is related to the input voltage E_1 by Eq. (3) and (4). A four-terminal network is used to represent τ, the transit-time phase-angle. A means of feedback is indicated as a link circuit between the output and input circuits, and an output load is also coupled to the circuit.

Oscillation will occur when the sum of the phase angles around the complete loop is equal to some integral number times 2π radians, provided the magnitude of the feedback is sufficient to maintain oscillation. J. R. Ragazzini has suggested the diagram in Fig. 4 to illustrate these phase angles and the relations between them. The electrons which passed the buncher grids at zero phase (i.e., when E_1 was zero and changing from deceleration to acceleration) become the center of the bunch. These electrons correspond to a maximum value of the electron current and arrive at the catcher grids after a phase delay equal to τ. This phase delay corresponds to slightly less than $2\frac{1}{4}$ cycles in Fig. 4 and is indicated by an oblique line connecting the zero axes of the E_1 and i_2 curves.

In order to transfer maximum energy to the resonator field, the electrons in the bunch must pass the catcher grids when the resonator field is a maximum and in a direction which will decelerate the electrons. The current in the equivalent circuit must be in phase with the voltage if maximum power is to be transferred. This means that i_2 is a minimum when the electron current is a maximum. The transit phase angle τ corresponds to the phase between a zero value of E_1

and a negative peak of i_2 and therefore the phase angle between E_1 and i_2, introduced by the transit time and bunching considerations, is equal to $(\tau + \pi/2)$.

A phase angle ϕ_2 between i_2 and the catcher voltage E_2 is shown because E_2 need not be in phase with i_2. However, this phase angle is not used in this analysis of oscillator theory. The angle ϕ represents the phase between i_2 and E_1, introduced by the two coupled circuits. The phase relation which must be satisfied for oscillation can be written

$$\tau + \pi/2 + \phi = 2\pi n \qquad (5)$$

where n must be an integer. The value of n in Fig. 4 is 3 cycles. If τ is changed by varying the acceleration voltage, a corresponding change in ϕ must occur.

Coupled Circuit Theory

An analysis[5] of the phase relations in two tuned coupled circuits shows that ϕ will change if the frequency of oscillation is varied. These conditions explain the fact that the frequency of a velocity-modulation oscillator varies when the acceleration voltage is changed, in order to maintain the necessary phase relations.

The equivalent circuit in Fig. 3 shows that a Klystron oscillator may be considered as two parallel resonant coupled circuits, fed by a constant-current source i_2. The analysis of such a circuit to obtain the phase and magnitude of the voltage across the primary and secondary can be obtained, with some slight modifications, from radio engineering handbooks and other sources.[5,6,7] This information about the phase and magnitude of the feedback can then be combined with the bunching characteristic of a Klystron tube, as illustrated by Fig. 2 and Eq. (4), to obtain a prediction of the output characteristics of a Klystron oscillator as the acceleration voltage is varied.

Certain assumptions will be made to simplify the analysis. The resonant frequencies of both circuits will be considered identical; this assumption will make the characteristics symmetrical with respect to frequency. A feedback line of zero length will be assumed so that the analysis for lumped constant circuits at low frequencies can be used. The Q of the two circuits will not be equal because one circuit has been loaded. The Q of the output circuit in Fig. 3, which corresponds to the primary of the two coupled circuits, will be considered half as great as the Q of the input circuit, which corresponds to the secondary. Calculations will be carried out for two degrees of coupling between the two circuits. In one case the coupling will be assumed five times greater than the value for critical coupling, and critical coupling will be assumed for the second case.

Curves of primary and secondary voltage as a function of frequency are usually given in the reference texts[5]. The curves in Fig. 5 will be recognized as typical illustrations of these characteristics for two coupled tuned circuits. Ratios of E_1/i_2 and E_2/i_2 are plotted so that unit coordinates may be used, and the maximum ratio of E_1/i_2 is indicated by a value of unity. Increasing the value of i_2 will increase the value of voltage across the circuit but will not affect the ratio. The phase relation between i_2, the constant-current source in

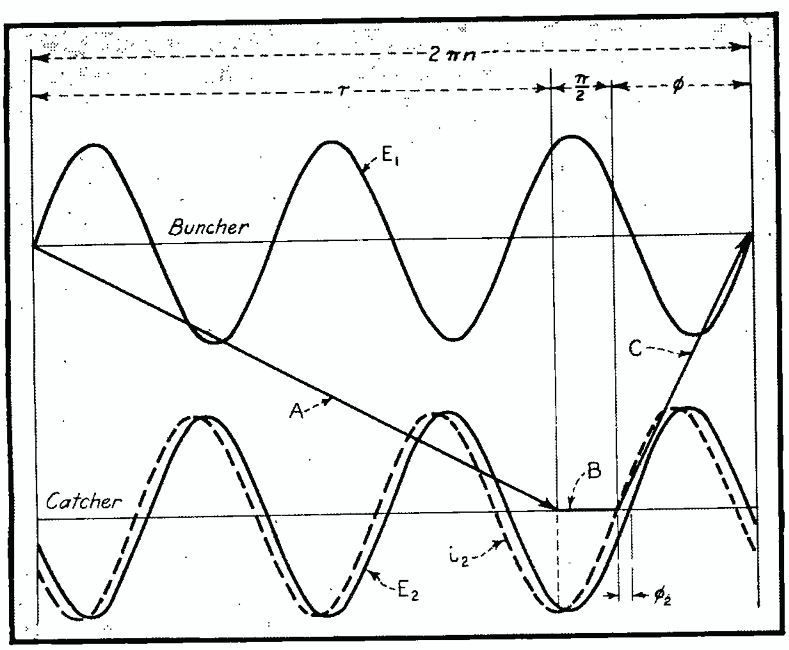


FIG. 4—Phase relations in a Klystron oscillator. The phase change from buncher to catcher along the electron beam drift is represented by vector A. The phase shift between the bunched electron stream and the catcher resonator-field current component is represented by vector B. The phase shift due to the coupling from the catcher to the buncher is represented by vector C. The transit-time phase-angle is represented by the angle τ

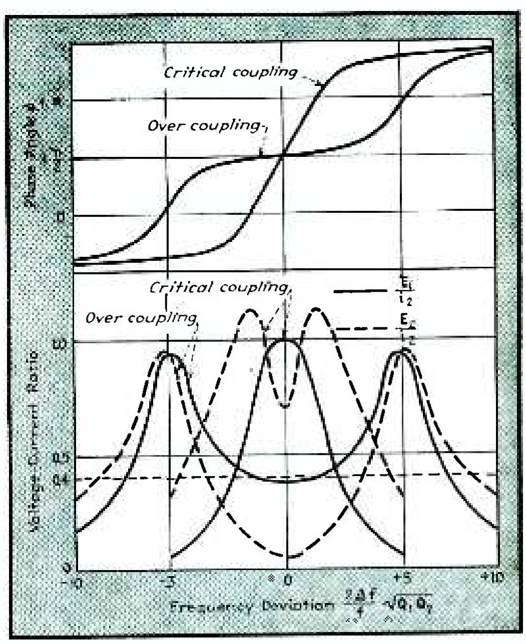


FIG. 5—Phase and voltage relations in coupled circuits where the primary Q is half the secondary Q. The over-coupling condition is for five times critical coupling. The phase angle at the top of the graph is that between primary (catcher) current and secondary (buncher) voltage

the analysis, and secondary voltage E_1 is also shown as a function of frequency.

The form of the curves in Fig. 5 is not ideally suited to the analysis of a Klystron oscillator where the frequency is dependent upon the beam voltage as well as upon the tuning. To examine the behavior of such an oscillator as the acceleration voltage is changed, it will be convenient to replot the frequency as a function of voltage. This step is illustrated by the frequency vs. voltage curves in Fig. 6, which correspond to Fig. 5.

The previous discussion has concerned only the coupled circuit theory. It is necessary to relate these results to the bunching characteristic of a Klystron tube, shown in Fig. 2, in order to complete the analysis and obtain the power output curves shown in Fig. 7.

The Klystron oscillator characteristic illustrated by Fig. 8, which has been obtained by modifying the presentation of the information in Fig. 2, has been used to convert the data in Fig. 6 into the Klystron output characteristics in Fig. 7. Frequency curves have been transferred directly to the corresponding figures, for the values of acceleration voltage which permit oscillation.

Oscillator Characteristics

Calculations for the procedure described briefly in the preceding paragraph are quite simple, and the steps will be outlined in detail. The relation between voltage and frequency is obtained by evaluating τ in terms of E_0, the acceleration voltage, and correlating the values of τ with values of ϕ in Fig. 5. Separate calculations must be made for each value of coupling. Values of τ for chosen values of E_0 are tabulated from

$$\tau = \frac{2\pi f s}{\sqrt{\frac{2e}{m} E_0}} \qquad (6)$$

which is obtained by equating Eq. (1) and (1b). The percent change in frequency is small, and therefore all factors except E_0 may be lumped into a single constant. Corresponding values of ϕ are obtained by substituting the values of τ into Eq. (5). These values of ϕ are used to determine the frequency which corresponds to the acceleration voltage chosen for the tabulation. Then these data are replotted to give the frequency curves in Fig. 6, and the values of E_1/i_2 and E_2/i_2 are transferred from Fig. 5 to Fig. 6, using this f-vs.-E characteristic.

The necessary correlation between the feedback circuit and the bunching characteristic of a Klystron tube (see Fig. 2), can be obtained by evaluating E_1/i_2 in terms of the bunching parameter defined by Eq. (3) and (4). Equation (3), which relates E_1 and the bunching parameter x, can be rewritten

$$E_1 = E_0 x/\pi N \qquad (7)$$

Substitution of Eq. (7) and (4) in the ratio E_1/i_2 gives

$$\frac{E_1}{i_2} = \frac{E_0}{\pi N I_0} \frac{x}{2 J_1(x)} \qquad (8)$$

The ratio E_0/I_0 may be replaced by R_0, which is known as the beam resistance of the tube. Equation (8) can be rewritten

$$\frac{x}{2 J_1(x)} = \frac{\pi N I_0}{E_0} \frac{E_1}{i_2} = \frac{\pi N E_1}{R_0 i_2} \qquad (9)$$

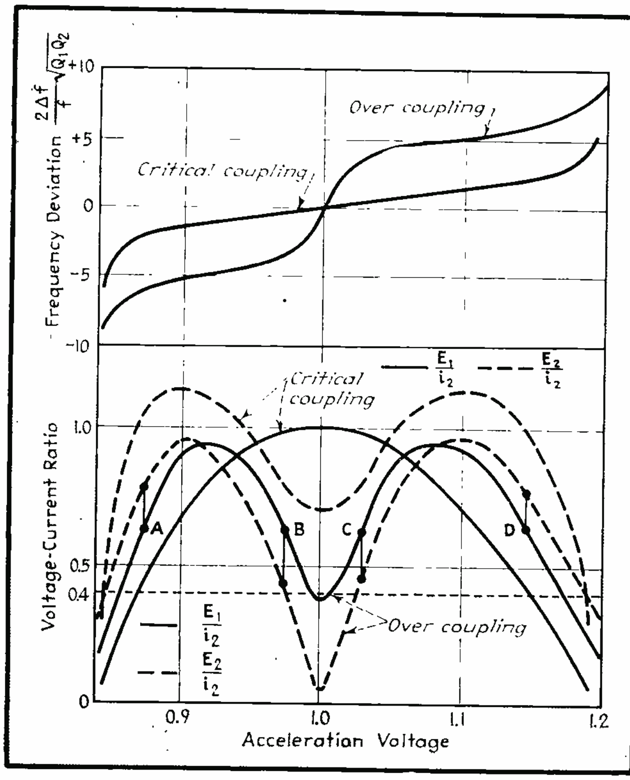


FIG. 6—These curves are for the same conditions as in Fig. 5 but are plotted against accelerating voltage, which is related to frequency by Eq. (5) and (6). The upper curves give the relative frequency deviation vs. accelerating voltage

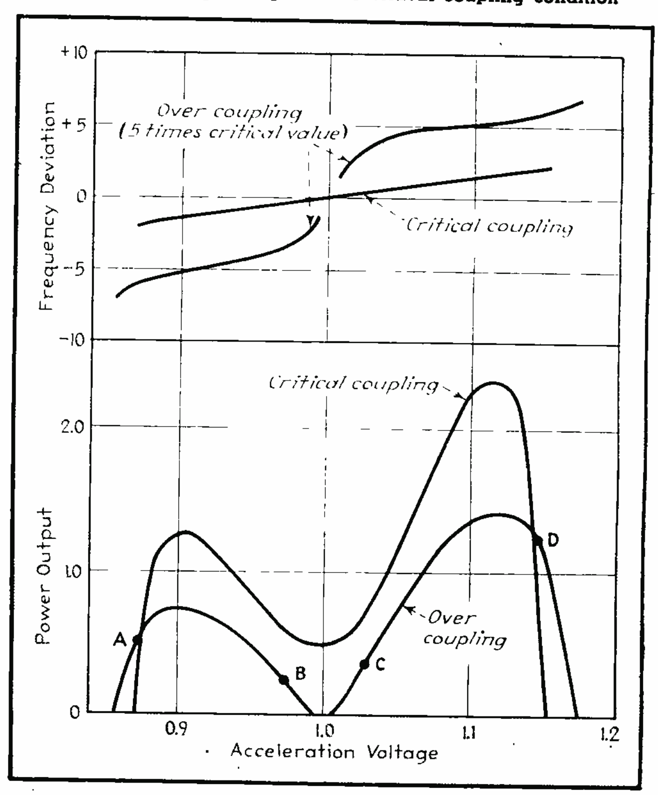


FIG. 7—Taking the power output as proportional to the catcher voltage squared, these curves are obtained from the curves of Fig. 6. Note the linearity between frequency deviation and accelerating voltage for the critical coupling condition

These equations furnish the correlation between the feedback circuit characteristic which determines E_1/i_2, and a modification of the bunching parameter.

The significance of the factor $x/2J_1(x)$ can be illustrated by reference to Fig. 2. This factor is merely another form of bunching parameter. Any line from the origin with a slope less than unity will intersect the curve at some point other than zero and less than $x = 3.83$, where the Klystron output again becomes zero. A line with a slope of 0.5 is shown, and this line intersects the curve at a point somewhat beyond the maximum. Another line with a slope of unity is tangent to the curve at the origin. This line does not intersect the curve, and represents the conditions when oscillations start. This starting-characteristic line with a slope of unity corresponds to a unity value $x/2J_1(x)$. Lines with slopes less than unity correspond to values of $x/2J_1(x)$ greater than unity, since the slope of a line is equal to the reciprocal of $x/2J_1(x)$.

Each point on the curve in Fig. 2 corresponds to some operating condition for a Klystron oscillator. It will be convenient to replot $2J_1(x)$, which is proportional to i_2, as a function of $x/2J_1(x)$. This modification of the bunching characteristic makes it possible to obtain the value of i_2 from a value of E_1/i_2, since Eq. (9) shows that $x/2J_1(x)$ is proportional to E_1/i_2. Figure 8 shows such a characteristic, and has been obtained by plotting the ordinate of a point on the curve in Fig. 2 as a function of the reciprocal of the slope of a line drawn from the origin to that point on the curve. The curve in Fig. 8 is used to obtain the value of E_2 from the information in Fig. 6.

Figure 8 is used to obtain data for the curves of power output vs. acceleration voltage in Fig. 7 in the following manner. Typical operating conditions would determine the starting conditions for the Klystron oscillator. We will assume that E_1/i_2 equal to 0.4 corresponds to these starting conditions. For this assumption, Eq. (9) can be rewritten

$$x/2\,J_1(x) = 2.5\,E_1/i_2 \qquad (10)$$

The dash lines in Fig. 6 represent the starting conditions for the Klystron oscillator. The acceleration voltage corresponding to the intersection of the dash line and the E_1/i_2 curve in Fig. 6 is noted. The output for this value of acceleration voltage is zero. A higher value of E_1/i_2 for a different acceleration voltage is substituted in Eq. (10) to obtain the value of $x/2J_1(x)$, and a corresponding value of $2J_1(x)$ is determined from Fig. 8.

The beam current I_0 is computed from the 3/2 power law and the acceleration voltage. The value of i_2 is then obtained by substitution of I_0 and $2J_1(x)$ in Eq. (4). E_2 is calculated from i_2 and the value of E_2/i_2 from Fig. 6 corresponding to

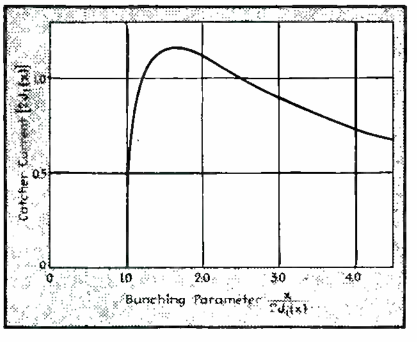


FIG. 8—A change of abscissa converts the bunching characteristic of Fig. 2 to this more convenient form

the acceleration voltage which was chosen. The power output is proportional to the square of E_2 and is plotted as such in Fig. 7. The frequency curve is transferred directly from Fig. 6 to Fig. 7.

The two sets of theoretical output curves in Fig. 7 are typical of two different types of Klystron oscillators. The curves for five times critical coupling represent a tightly coupled oscillator and exhibit the familiar pair of voltage modes. The maxima of the two modes occur when the frequency has values corresponding approximately to $\phi = 0$ and $\phi = \pi$ in Fig. 5. If these values of ϕ are substituted in Eq. (5), the value of τ is given by

$$\tau \cong 2\pi\,(n \pm 1/4) \qquad (11)$$

Equation (11) is often stated in the form, "The number of cycles of oscillation during the transit of an electron from the buncher to the catcher is an integer plus or minus one quarter." It should be noted that this statement is a special case which does not apply to all Klystron designs.

The more loosely coupled oscillator illustrated by the critical coupling curves of Fig. 7 has the two modes merged into continuous output. The latter characteristic is typical of the type 410-R/2K30 Klystron oscillator, and differs from overcoupled types which exhibit two separate families of voltage modes.

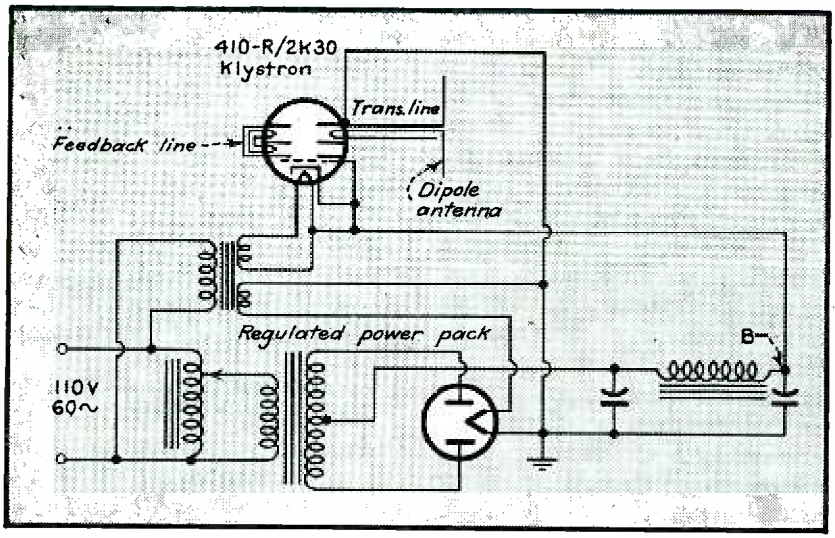
Comparison of Experimental Results with Theory

Experimental curves for a number of voltage modes in a type 410-R/2K30 Klystron oscillator are shown in Fig. 9 and 10. These curves were obtained by a dynamic method which eliminated tuning changes due to thermal variations caused by changing the power input to the tube. The similarity of Fig. 9 to the theoretical curve in Fig. 7 for critical coupling indicates that the assumptions used in obtaining the theoretical curve are reasonably good. The equal height of the two peaks of each mode in Fig. 9 was obtained by purposely detuning the tube to produce the flattest characteristic, and does not represent a deviation from theory. Detuning the tube in the opposite direction emphasizes the higher voltage peak and produces maximum power output and efficiency. This effect is illustrated by Fig. 10.

Note that the frequency deviation characteristic in Fig. 9 is almost linear with accelerating voltage over the useful range of output. This characteristic is gained by some sacrifice in power. (Compare with Fig. 10). Because of this, the type 410-R/2K30 Klystron is quite useful as an oscillator in frequency-modulation circuits. The frequency modulation is obtained by varying the acceleration voltage. However, considerable modulation power is required.

Effect of Tuning the Klystron

The effect of tuning the Klystron oscillator, as described in the discussion of the output characteristics in Fig. 9 and 10, can be derived from circuit theory but the details will be omitted. Certain important conclusions can be obtained from a qualitative analysis of the over-



Basic Klystron oscillator circuit, showing the extreme simplicity of the voltage requirements. Like all electron oscillators the frequency is affected by the power pack voltage, but in the case of the Klystron the effect is large (shown in Fig. 9). A coaxial transmission line delivers the uhf energy from the oscillator to the load, which is an antenna in this case

coupled case, and the general nature of these results applies equally well to the behavior of the type 410-R/2K30 Klystron. However, electron bunching theory must be considered in some detail before returning to a discussion of the effect of tuning.

One of the principal factors in the explanation of Klystron oscillator power output characteristics is introduced by the variation of i_2, the radio-frequency component of the bunched beam current, as the value of E_1 is increased. Figure 2 and Eq. (3a) and (4) illustrate this variation of the radio-frequency current. The term overbunching is applied when the current is decreased from the maximum value because the voltage E_1 is too great. It is more important to analyze overbunching in a diagram similar to Fig. 8, since $x/2J_1(x)$ is more useful than the bunching parameter x in analyzing an oscillator. Optimum bunching in Fig. 8 corresponds to the maximum in the curve when $x/2J_1(x)$ is equal to 1.59, which corresponds to a value of 0.635 for E_1/i_2. Larger values of E_1/i_2 cause overbunching.

Overbunching does not necessarily reduce the output. Note in Fig. 6 that the ratio E_2/i_2 is increasing rapidly at the acceleration voltages corresponding to points A, B, C, and D, which represent the ratio of E_1/i_2 required for optimum bunching. Increasing the ratio of E_1/i_2 above the optimum value does not reduce i_2 very rapidly, since i_2 is proportional to $2J_1$ (x), and Fig. 8 shows that this factor decreases slowly beyond the point of optimum bunching. The increased E_2/i_2 ratio allows the output to increase in the region between A and B, also in the region between C and D. Corresponding points have been marked on Fig. 7 to illustrate this effect.

Any deviation from identical tuning will decrease one peak in the E_1/i_2 curve when the losses in the two resonators are unequal. The other peak may remain approximately the same, or it may increase slightly, depending upon the ratio of the losses in the two resonators. The effect of detuning the buncher resonator to a lower frequency, leaving the catcher resonator tuned to the frequency corresponding to the identical tuning represented in Fig. 5, is illustrated in Fig. 11 for the case when the losses in the catcher resonator are twice as great as the losses in the buncher resonator. Both patterns are moved in the direction of lower frequency and the patterns are no longer symmetrical. The higher-frequency peak in E_1/i_2 is reduced and the corresponding peak in E_2/i_2 is increased.

As a result of the detuning, the degree of overbunching in the high-frequency mode will be less and i_2 will increase. Since E_2/i_2 has also

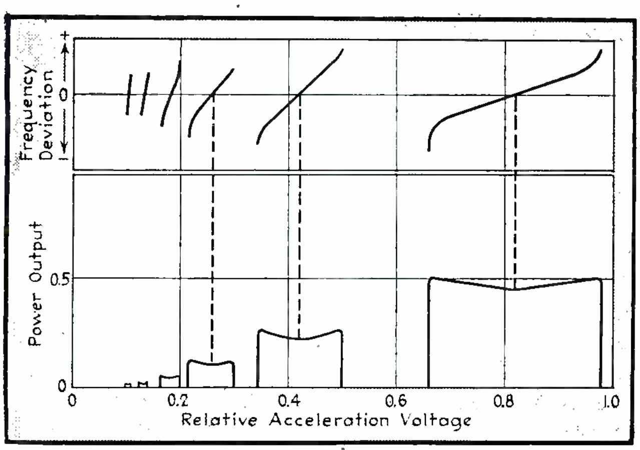


FIG. 9—Experimental characteristics for 410-R/2K30 Klystron oscillator with critical coupling. The tuning was adjusted to give flat output. Compare these curves with the critical coupling curves of Fig. 7

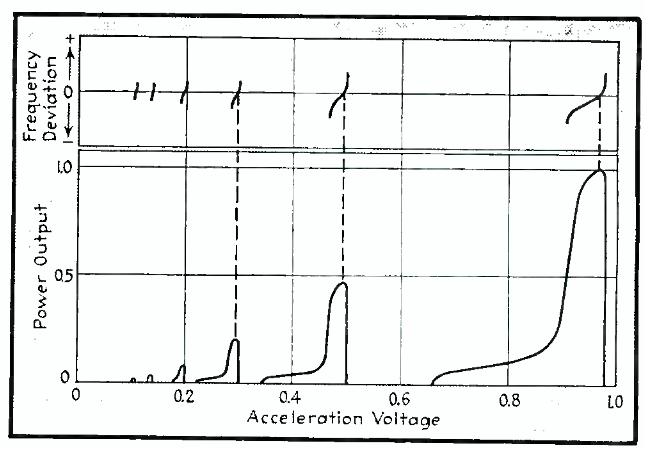


FIG. 10—By adjusting the tuning, the output can be made a maximum. This has been done to obtain these experimental curves. One peak is accentuated at the sacrifice of the other. Operation is more critical of accelerating voltage

been increased by the detuning, the output of this mode will increase considerably. In contrast, the over-bunching remains about the same in the lower-frequency mode but the ratio of E_2/i_2 is decreased, and therefore the output of this mode decreases slowly. However, the ratio of E_1/i_2 for the higher-frequency mode can be reduced to the value corresponding to the starting conditions while the lower-frequency peak in E_1/i_2 remains greater than this value. This relation means that continued detuning of the buncher resonator to a lower frequency causes the higher-frequency mode to increase at first, then disappear before the lower-frequency mode is eliminated. The frequency of the higher-frequency mode approaches the frequency of the tuning of the catcher resonator. The lower-frequency mode can be accentuated by detuning the buncher resonator to a higher frequency than the tuning of the catcher resonator.

Effect of Length of Feedback Line

The previous discussion has been based upon a zero length of feedback line. This assumption obviously does not apply to a type 410-R/2K30 Klystron, since an external feedback line of considerable electrical length must be used. The problem is complicated when the line is not terminated with its characteristic impedance. However, it is fairly satisfactory to assume that the phase shift in the line can be represented by an angle ϕ_L, and rewrite Eq. 5 in the form

$$\tau + \frac{\pi}{2} + \phi + \phi_L = 2\pi n. \qquad (12)$$

The logical conclusion from Eq. (12) would be that the acceleration voltage, which determines τ, could be arbitrarily chosen by adjusting the length of the feedback line. Some choice of the operating voltage is permitted by such an adjustment. However, the feedback line is not usually matched, and certain line lengths prevent operation at the frequency which may be required. Therefore, it is not always possible to correct for changes in the transit time by changes in the length of the feedback line. As a result, there are some regions of acceleration voltage where oscillation can not be obtained by any simple adjustment of the tube or feedback line.

All of the previous discussion is influenced by the output load which is connected to the tube, but this effect has been included implicitly in the assumption that the losses in the output resonator were twice as great as the losses in the buncher resonator. This assumption is equivalent to the statement that the resonators are identical and that the power transferred to the load is equal to the power losses in the output resonator itself.

Power Output

Data have been obtained which relate the output power which can be transferred from a Klystron oscillator to a given load resistance. These data are shown by the points in Fig. 12. The curve in Fig. 12 represents a constant-current source feeding a parallel resonant circuit with internal losses and a coupled load. The theoretical curve was made to coincide with the observed maximum output from the Klystron oscillator. Zero load resistance in this illustration corresponds to a light load, i.e., the load resistance is an equivalent series resistance. The agreement between the experimental points and the theoretical curve in the region beyond the maximum output fails because the Klystron does not oscillate when the load becomes too great.

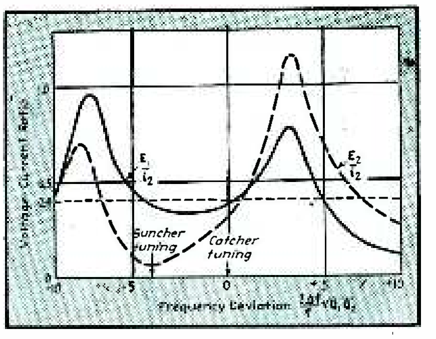


FIG. 11—Detuning the buncher to a lower frequency shifts the peaks to lower frequencies. Except for this detuning of the buncher, these curves represent the same conditions as those illustrated by the over-coupling curves of Fig. 5

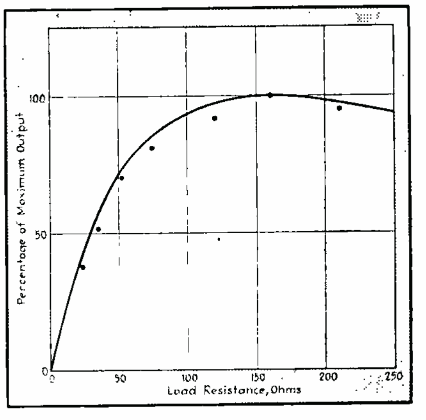


FIG. 12—Theoretical output curve and experimental output points measured for the 410-R/2K30 Klystron oscillator

Conclusions

It is apparent that the characteristics of velocity-modulation tubes must be considered carefully when equipment is designed to use these tubes. In some respects these tubes are similar to the more familiar types of vacuum tubes. They can be used as oscillators or amplifiers, and when equipped with the proper resonators, they can also be used as frequency multipliers. Klystron oscillators are more dependent upon the voltage applied to them than triode vacuum tubes, and both frequency and output will vary if the voltage is changed. Operation is possible at a number of different voltage modes, but oscillation does not occur in the region between these modes. When these characteristics are either used or circumvented in the design of the equipment, these factors do not limit the application of the tubes and actually make it possible to accomplish results which are difficult to achieve in any other way.

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Dual Time

Ingenious method of automatically broadcasting an hourly chime signal and synchronizing a remote transmitter clock with the studio clock. Both operations are initiated by a pulse from a Western Union master clock line without making any direct connections to the circuit

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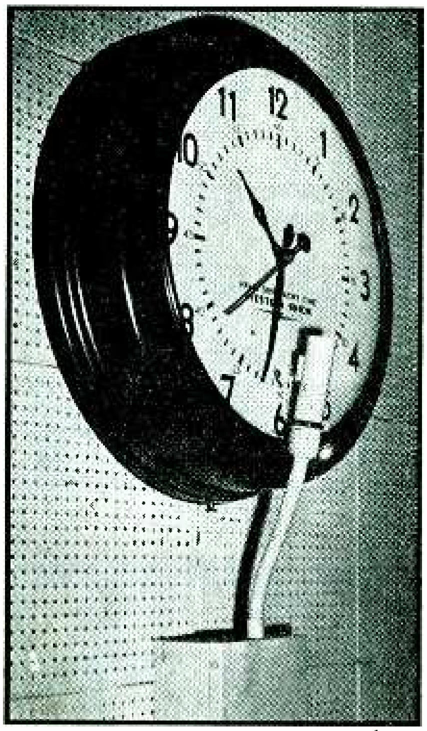


Mounted on a gooseneck, the phototube intercepts the light from the red lamp on the clock when the hourly reset pulse is received

ABOUT a year ago, WQXR decided to include in its program services an hourly time signal. It was felt that this time signal should not be the customary harsh "beep," but rather a musical chime consistent with the station's classical programs.

Finding a suitable tone at first posed a problem. Numerous schemes were tried and discarded for one reason or another. Finally a single-plate electromagnetic door chime provided the answer.

As shown in Fig. 1, a hole was cut in the top of the chime case to accomodate a 2000-ohm headphone. With the cap and diaphragm removed, the headphone functions as an inductive microphone, with the chime plate serving as a diaphragm. The headphone should be mounted fairly close to the chime plate, the distance between them in a large measure determining the output.

The degree of damping or hangover of tone is controlled by means of a set screw and lock nut which is threaded through the top of the chime case to one end of the chime plate. The surface of the plate at the point of contact is covered with a thin layer of felt.

A variable resistance, placed in series with the chime solenoid, is adjusted to give positive operation and reduce the thump which occurs if too high a voltage is applied. Proper spacing between the chime plate and phone, the correct amount of damping, as well as application of the required solenoid voltage, will result in a rather pleasing tone. Construction of this signal source is simple and inexpensive.

Hourly Pulse Problem

To operate the chime, Western Union was asked to supply a line similar to the one used to pulse-reset WQXR's master control room clock. Western Union was prepared to do this but pointed out that WQXR is on a "master clock circuit" which includes an additional pulse fifteen minutes after the hour. The clock reset mechanism is so designed that the fifteen-minute pulse does not operate the reset relay. They said that in most stations using the service for time signals the engineer manually opens the circuit after the hourly pulse and closes it again some time after the fifteen-minute pulse.

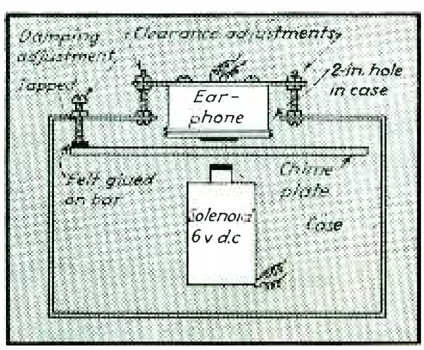


FIG. 1—Method of mounting the headphone on the case of the door chime

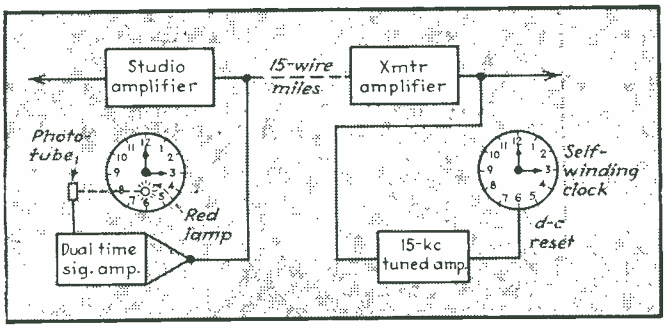
Since it was desired to make our time signal completely automatic as well as distinctive, this method was deemed unsatisfactory.

The control room clock contains a red lamp that lights only on the hourly reset pulse. If the chime could be connected to the lamp circuit, a ready answer to the pulse problem would be provided. For some reason, however, Western Union was unable to supply, or grant permission to connect a pair of wires from the lamp circuit to operate the chime.

Speculating on the matter further, we thought, "Well, there's nothing wrong with looking at the red light!" This we did, and with a phototube.

As can be seen from the diagram of Fig. 2, the time signal picked up by the phototube is amplified and energizes a sensitive relay; this in turn operates the chime. The tone is picked up in the headphone and then fed to the WQXR

Signal at WQXR



Block diagram of complete system for transmitting an hourly chime signal and pulsing the transmitter clock at the same time

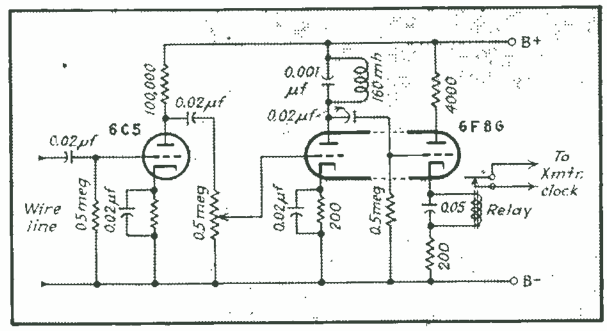


FIG. 3—This bridging amplifier closes the transmitter clock reset circuit when the 15-kc signal comes over the studio line

transmitter over the wire line.

For years we had wanted a Western Union clock at the transmitter for time synchronization with the studio. The idea had to be abandoned, however, as no reset pulse circuits were available at our transmitter location.

Synchronizing Studio and Transmitter Clocks

After the Western Union red-light phototube-controlled time signal was put into operation, the thought occurred that the phototube might simultaneously be put to work to reset a clock at the transmitter.

Using the phototube as the motivating force to bring a pulse from the studio in New York to the transmitter in Long Island was a relatively simple matter. This was accomplished by installing at the studio a 15-kc RC oscillator combined with a dual amplifier so that both the time tone and the transmitter clock-reset tone (15-kc) are sent simultaneously over the speech line to the transmitter. The circuit of both of these units is shown in Fig. 2.

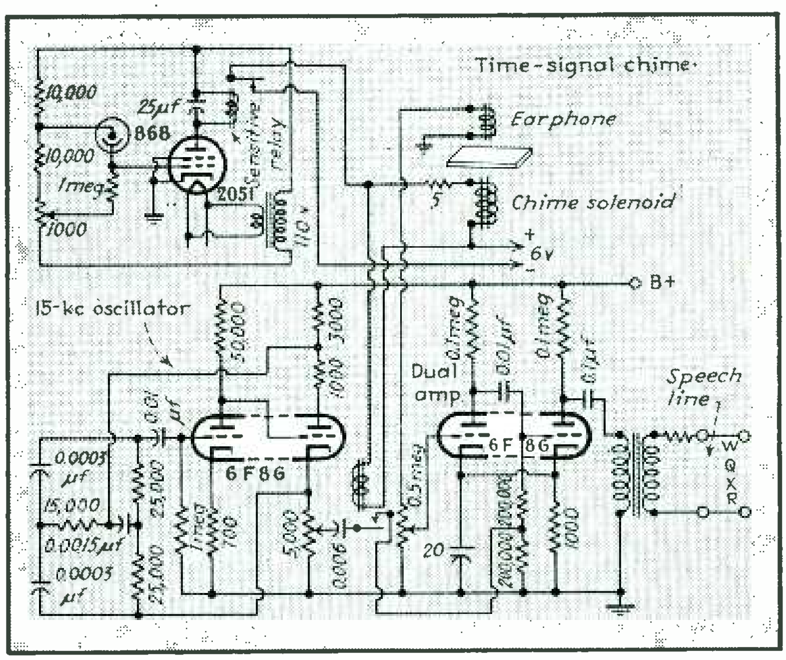


FIG. 2—Complete circuit of equipment installed at the studio. When the red lamp flashes on the clock, the phototube amplifier operates the chime and permits the 15-kc oscillator to feed a signal to the transmitter

The time tone is thus fed directly to the transmitter through the transmitter speech equipment. The 15-kc clock-reset tone is picked up at the output of the transmitter line speech amplifier through a 15-kc tuned bridging amplifier. This unit is shown schematically in Fig. 3. A plate-circuit relay in the bridging amplifier serves to close the transmitter clock reset circuit.

Independent volume controls are used on the time-tone and the 15-kc signals, with both set to leave the studio at −10 vu. This level for the time tone is not too loud, yet permits the signal to be heard through voice. At this line input level, the 15-kc signal arrives at the tuned bridging amplifier with sufficient amplitude for positive relay operation. Power for the amplifiers is obtained from the regular speech-amplifier power supplies.

Those stations not using a high-quality line could still reset a transmitter clock from the studio by use of an 8 to 10-kc pulse and possibly a slightly higher level. The 15-kc tone can be heard over WQXR if a good receiver and loudspeaker are used. The system has given fool-proof and maintenance-free service since its installation a year ago.

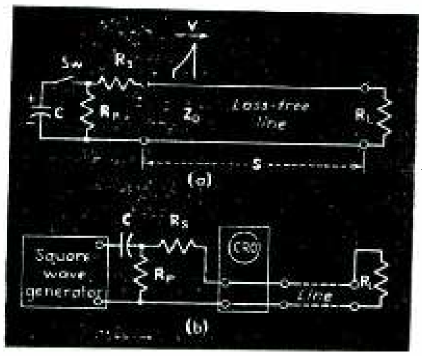


FIG. 1—Basic circuit (a) and measuring circuit (b) used in pulse measurements on transmission lines

LOCATION

A pulse technique determines location and nature of transmission line faults. The reflected pulse, as shown on an oscilloscope, indicates the condition of the line. Photographs of test results on artificial and actual open-wire lines indicate the utility of the method

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Many techniques have been developed for the location of faults on transmission lines. Each specific method presents certain advantages for the location of a particular type of fault.[1] With the exception of continuity tests, most of the fault location techniques involve the use of a bridge. A well-known impedance measurement method for locating a fault on a transmission line was recently described in the literature.[2]

The Pulse Method

A highly informative method for measuring the distance to discontinuities on transmission lines utilizes the familiar pulse technique used to measure the height of the ionosphere.[3] This technique requires the use of a pulse-modulated carrier when applied to measurements in free space, and hence elaborate transmitting and receiving apparatus are usually necessary. Fortunately, the pulse method may be utilized to make measurements on transmission lines with comparatively simple apparatus.

This paper describes an experiment originally developed to give students a background of visual experience with travelling waves and reflection phenomena. Tests on a 146-mile open-wire line from Atlanta to Birmingham indicate that the pulse technique will accurately measure the distance to several discontinuities simultaneously present on a line.

Travelling Waves on an Ideal Line

A lucid treatment of the subject of travelling waves on transmission lines is presented in standard texts.[4]

Referring to Fig. 1(a), if a charged capacitor is momentarily connected to the resistor R_P, a voltage wave of the type shown will travel along an ideal, loss-free transmission line with a velocity V equal numerically to the velocity of propagation of light in free space. At the end of an interval of time $T = S/V$ seconds, the voltage wave will travel the length of the line and will impinge upon the load resistor R_L.

If R_L is equal to the surge impedance $Z_0 = \sqrt{L/C}$ of the loss-free line, the energy of the wave is completely absorbed by R_L, and no reflection takes place. On the other hand, if R_L is not equal to Z_0, there will be a partial reflection of the incident wave by R_L. The magnitude and phase of the reflected wave depends upon the magnitude of the departure of R_L from the value of Z_0 according to the equation

$$e_R = e_I\,(R_L - Z_0)/(R_L + Z_0) \quad (1)$$

It is apparent that if R_L is greater than Z_0, the reflected voltage wave is not reversed in sign; but if R_L is smaller than Z_0, the reflected voltage wave is reversed in sign. In the limiting cases, when the line is open-circuited, R_L is infinite in magnitude, and $e_R = e_I$; when the line is short-circuited, R_L is zero, and $e_R = -e_I$.

The voltage wave is necessarily accompanied by a current wave directly related to the voltage wave by the equation

$$e/i = \sqrt{L/C} = Z_0 \quad (2)$$

The magnitude and the phase of the reflected current wave is obtained from the relation

$$i_R = -i_I\,(R_L - Z_0)/(R_L + Z_0) \quad (3)$$

Continuing with the observation of the voltage wave, if reflection takes place at the load, the reflected voltage wave e_R travels to the sending end of the line in the time $T = S/V$. Here again there will be either complete absorption or partial reflection of this returning voltage wave, depending upon the magnitude and nature of the sending-end impedance encountered by the re-

Nomenclature

e—Voltage at any point along the line.
e_I—Incident voltage at receiving end of line.
e_R—Reflected voltage at receiving end of line.
e_S—Reflected voltage at sending end of line.
e_L—Resultant voltage due to e_I and e_R at end of line.
i—Current at any point along the line.
i_I—Incident current at receiving end of line.
i_R—Reflected current at receiving end of line.
C—Line capacitance per mile.
G—Line-to-line conductance per mile.
R—Line resistance per mile.
L—Line inductance per mile.
R_G—Sending-end impedance.
R_L—Load resistance.
R_P—Pulse generator impedance.
R_S—Calibrated variable resistance.
S—Length of transmission line in miles.
T—Time in seconds required for wave to travel BS miles.
T_1—Period of a half cycle of pulse signal.
T_2—Period of pulse signal in seconds.
V—Velocity of propagation of pulse in miles per second.
Z_0—Line surge impedance.

# of LINE FAULTS

turning voltage wave. The magnitude and phase of the wave reflected from the sending end are obtained from an expression identical in form to Eq. (1):

$$e_S = e_R\,(R_G - Z_o)/(R_G + Z_o) \quad (4)$$

It now becomes apparent that if both R_G and R_L are not identically equal to Z_o, many successive reflections take place on the line until the total energy in the travelling wave is dissipated in the terminating resistors. In a practical case, the wave is also attenuated by the line losses as it travels back and forth.

Wave Velocity

The velocity of propagation of the travelling wave depends upon the characteristics of the transmission line. The velocity of propagation of the wave front is given by the expression[4]

$$V = 1/\sqrt{LC} \quad (5)$$

where L is the inductance per unit length and C is the capacitance per unit length. On the usual open-wire line with a conductor spacing which is much greater than the conductor diameter, the velocity of propagation of travelling waves approaches the free-space velocity of propagation of light. The velocity of propagation of travelling waves on cable circuits is, however, much lower than that on open wire lines. In the discussion to follow, it will be seen that the apparent velocity of propagation of a particular pulse wave on a line can be determined by placing a discontinuity at a known distance from the sending-end of the line.

Examples of Reflection

The reader is now in a position to predict the type of picture to expect on the screen of a cathode-ray oscilloscope connected to any point along an ideal transmission line. As an example, assume that $R_G = Z_o$ and that $R_L = Z_o/2$. Upon substituting these values in Eq. (4) and (1) respectively, it is seen that $e_R = -e_I/3$ and that $e_S = 0$.

If the original pulse sent out on the transmission line has a magnitude of six volts, and assuming no attenuation or distortion of the pulse in its travel, the wave impinging upon the load has a magnitude of six volts. As a result the reflected voltage wave e_R has a value of -2 volts. The picture seen on the screen of an oscilloscope connected across the load resistor R_L is that of a single resultant pulse with an amplitude of $e_L = 6 - 2 = 4$ volts.

A simple calculation reveals that the polarity of the resultant pulse at the receiving end of the line is the same as that of the incident pulse irrespective of the magnitude of R_L, according to the equation

$$e_L = e_I + e_R = e_I\,(2R_L)/(R_L + Z_o) \quad (6)$$

Thus, it is evident that the pulse viewed at the receiving end is always of the same polarity as the incident pulse and has a magnitude in the range from zero to $2\,e_I$, depending upon the relative values of R_L and Z_o.

It is apparent that the reflected voltage wave of the preceding example, $e_R = -2$ volts, travels back to the sending end of the line. There it encounters a resistance $R_G = Z_o$ which completely absorbs the returning wave.

The picture viewed on an oscilloscope connected across the sending end of the line consists of the original six-volt positive pulse, and a two-volt negative pulse displaced from the initial pulse by a time interval $T = 2S/V$. Of course, if R_G were not equal to Z_o, reflection would take place at the sending-end as well as at the load end of the line, and many reflected pulses would appear on the oscilloscope screen.

Distortion of Waves

There is always a finite amount of attenuation of a wave on a transmission line due principally to the effective resistance R of the conductors and to the conductance G between the wires. If the line con-

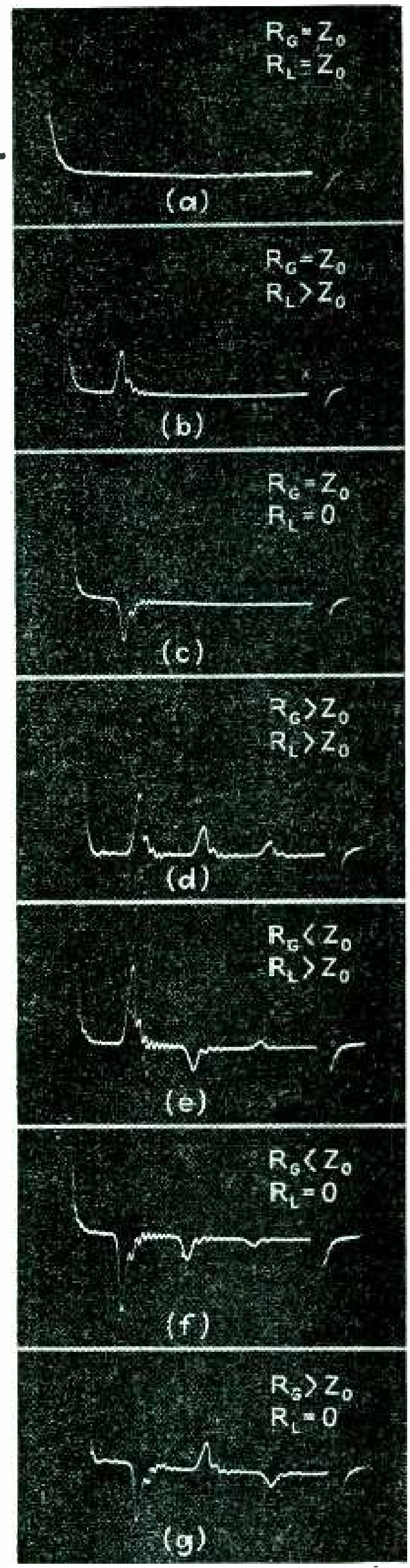
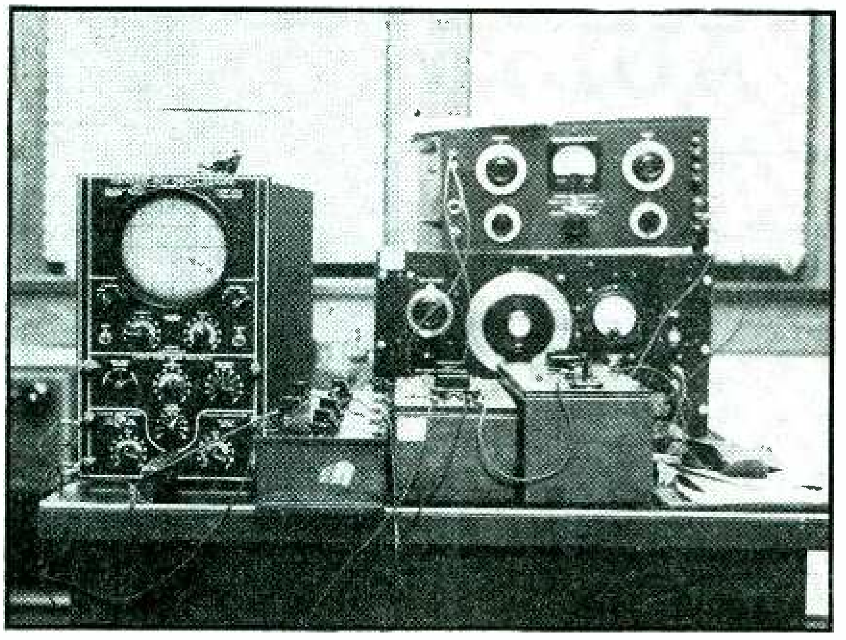


FIG. 2—Oscillograms illustrating the reflection phenomena on an artificial transmission line. In (a) where both ends of the line are terminated in the line's characteristic impedance there are no reflections. In (b) and (c) the sending end of the line is terminated in its characteristic impedance. The others have repeated reflections from both ends



Equipment used to test transmission lines by the pulse method. The output of the square-wave generator (top right) is differentiated, the resulting pulse is fed to the line, and reflected pulses are observed on oscilloscope

stants are so proportioned that RC equals GL, the line is distortionless. A wave travelling on this line is attenuated as it moves along the line, but it retains its original shape as a function of time as viewed at any point along the line.

Laboratory Arrangement

The constants of the usual power and telephone transmission lines do not satisfy the condition for a distortionless line. The type of wave distortion to be expected on these lines is a rounding of sharp points on the wave and a sloping-back of the wave front.[4] From the Fourier viewpoint, the component frequencies in a recurrent pulse travel with different phase velocities and undergo different degrees of attenuation, with the result that the pulse is distorted. This type of distortion is present in the photographs described later. Additional distortion in the form of a damped oscillation trailing each pulse is apparent in the photographs taken on an artificial lumped constant line. This transient oscillatory distortion of pulses is absent on all observations made on an actual open-wire line where the impedance is uniformly distributed along the line.

The artificial laboratory line used to check the pulse technique consists of 25 balanced-H sections of inductance and capacitance, and simulates a non-loaded open-wire line of No. 12 wire approximately 200 miles long. The characteristic impedance of the line measured at 800 cps is 669 − j19 ohms. The line is reasonably well terminated over a wide band of frequencies by a resistance of 670 ohms.

The laboratory arrangement used to obtain the photographs is shown in Fig. 1(b). The sending-end impedance R_G consists of R_S in series with the pulse generator impedance R_P. The square-wave generator internal impedance is large compared to R_P. It is desirable to make R_P much smaller than Z_0 in order that R_G will be essentially equal to R_S. The sending-end impedance is then conveniently changed simply by changing the value of the resistor R_S.

The pulse signal is obtained by differentiating a square wave using the coupling capacitor C and the resistor R_P. Thus, the fundamental frequency of the pulse wave is the same as that of the square wave, and the pulse width is varied by changing the RC values of the differentiating circuit. Other types of pulse generators are suitable.

Laboratory Photographs

The series of photographs in Fig. 2 demonstrate clearly the behavior of the pulse wave on a transmission line. In examining the photographs, it is well to remember that the oscilloscope connected across the sending end of the line gives a picture of the resultant pulse at the sending end, and that this resultant pulse is of the same polarity as the returning pulse incident on the generator. The duration of the traces of Fig. 2 is 1/120 second, and therefore a half cycle of a differentiated 60-cycle square wave is shown.

In Fig. 2(a) no reflected pulse is present, because the line is properly terminated in its surge impedance. Only one reflected pulse is present in Fig. 2(b) and in Fig. 2(c), as the sending-end impedance is equal to Z_0 so that the returned pulse is absorbed by this impedance. In the remainder of the photographs, three reflected pulses appear. Note that the pulses are spaced at equal intervals representing the time required for the pulse wave to travel twice the length of the transmission line.

The following detailed explanation of the excursions of the pulse shown in the oscillogram of Fig. 2(g) assists in an understanding of the other oscillograms. The initial positive pulse travels the length of the line and impinges upon a short-circuit at the receiving end of the line. Hence, the first reflected pulse is of negative polarity and travels back to the sending end where it is seen as a downward pulse. This first-returning wave encounters a sending-end impedance which is greater than Z_0, and therefore a negative reflected pulse is sent out on the line. This negative pulse is reversed in polarity at the load end of the line, with the result that it is seen as a positive pulse on its second return to the sending end. From here on, the previously-

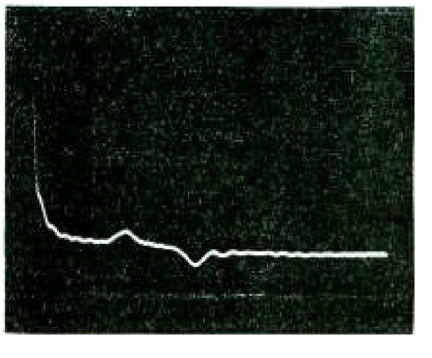


FIG. 3—Irregularities on a lumped-constant artificial line are quickly determined by their oscilloscopic trace

described action takes place so that alternate pulses are of like polarity.

The photograph in Fig. 3 shows the effect of two different types of discontinuities simultaneously present on the transmission line with both the sending-end and load resistances equal to the line surge impedance. The positive pulse is caused by a 74-ohm resistor inserted in series with each side of the line at the 13th section, while the negative reflected pulse is caused by a 2,500-ohm resistor shunted across the line at the 22nd section. The multiple reflections which occur between the two discontinuities are distorted and of minor magnitude, hence they are not visible in the photographs.

Convenient lattice diagrams of great assistance in the calculation of the reflections to be expected at any point and at any instant of time on a transmission line containing several discontinuities are described by Bewley.[5]

The length of a transmission line, or the distance to a discontinuity, is easily determined by measuring the time interval between the initial pulse and the particular reflected pulse in question. This measurement is made by any of the standard methods. The most primitive method is to measure both the length of the entire trace as well as the length from the initial pulse to the reflected pulse with a rule, or with the cross-section coordinates on the oscilloscope screen.

Information for a calculation of this type is presented in Fig. 4. The fundamental frequency is 600 cps. The pulse is traveling on an open-wire line and therefore its velocity V is very nearly 180,000 miles per second. From the figure, T is measured to be $(2/3)T_1 = (2/3)(1/2F) = 1/1800$ second. Therefore the length of the line S equals $(1/2)\ VT = (1/2)\ (18 \times 10^4)\ (1/18 \times 10^2) = 50$ miles.

More rapid methods of measuring the distance to a discontinuity involve the use of a Z-axis timing signal, or a timing signal flashed over the pulse trace by an electronic switch.

Tests on an Open-Wire Line

Through the courtesy of Mr. L. C. Bomar of the Southern Natural Gas Company, the writer had the opportunity to check the pulse technique on an open-wire line 146 miles long paralleling a gas pipeline from Atlanta to Birmingham. Figure 5 is a pulse panorama of the entire line. The last reflected pulse of positive polarity is caused by the Birmingham end of the line, where the line is terminated in a 2500-ohm relay. The remainder of the reflections are due to similar relays shunted across the line at various stations, and due to several short lengths of cable circuit interposed in the line.

Figure 6 shows the reflected pulse obtained upon open-circuiting the line at a point 80 miles from the sending end. When the line is short-circuited at the same point, the identical pulse appears but with a negative polarity.

Conclusion

The pulse technique appears promising as a method of measuring the distance to a discontinuity on a transmission line. If the normal pulse history of a particular line is photographically recorded, any new discontinuity can be readily detected by placing the negative of the photograph over the oscilloscope screen.

An advantage of the pulse technique over other methods of measuring the distance to discontinuities is that a complete instantaneous picture of the entire line is revealed at a glance. In addition, the nature of the discontinuity is immediately apparent.

Possible applications of the pulse technique are: (1) To measure the distance to an open or short-circuit on transmission lines. (2) To measure the distance to irregularities on lines. (3) To measure the velocity of propagation of pulse signals on transmission lines of known length. (4) To rapidly check the value of the characteristic impedance of a transmission line, or to determine whether or not a line is terminated in its characteristic impedance. (5) To continuously monitor a line to determine where and when a break occurs during inclement weather, or during periods when sabotage is expected.

A fruitful field for research exists in the use of pulse-modulated carriers as a test for discontinuities on transmission lines. The writer believes that the pulse technique can be advantageously used to locate discontinuities on telephone, telegraph, and power lines in areas stricken by wind and ice storms.

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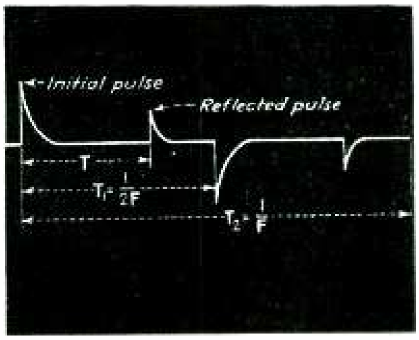

FIG. 4—The length of line is found by correlating an oscilloscopic trace with the fundamental pulse frequency

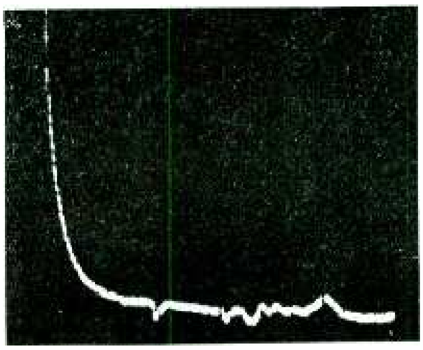

FIG. 5—This panoramic pulse view taken from Atlanta shows the Atlanta-Birmingham telephone line in its normal state

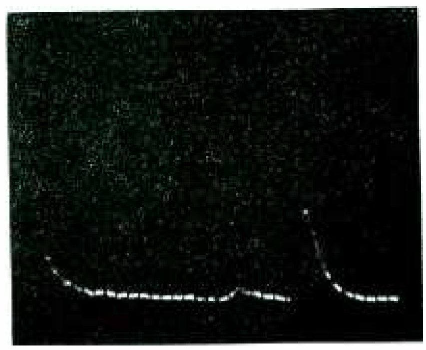

FIG. 6—An open circuit 80 miles from Atlanta on the line shown in Fig. 5 produces the positive pulse shown here

CAPACITOR-MATCHING

Construction and calibration of a direct-reading beat-frequency oscillator for use in production matching of variable capacitors. Principle involves comparing frequencies of two duplicate oscillators, one containing the standard capacitor, the other containing the production capacitor

PRECISION calibrating and matching on a mass-production basis is one of the greatest problems in the manufacture of variable capacitors. The trend in recent years toward higher frequencies, compactness, and higher standards in receiver design has resulted in corresponding limitations in capacitor tolerances.

Any limitations on the tolerance of the capacitance curve require closer control throughout the stages of production. Today the tolerances have approached such narrow limits that the manufacturer has to hold to rigid standards on the mechanical structure in order to approach as closely as possible the specified capacitance curve. Only when great mechanical accuracy exists can the capacitor be calibrated and matched with any success.

Calibration Techniques

Calibration of a capacitor is a tedious job, whether for experimental work or for a production run. The term calibration as used in the variable-capacitor field applies to adjusting the capacitance of the unit to the required capacitance curve by bending serrations on the rotor plates of a single-section variable capacitor, or in the case of a ganged capacitor, the one section which is generally used to tune an oscillator.

Calibrating in the past was accomplished by taking readings at specified degrees of rotation and comparing them to the original curve in order to determine the necessary loss or gain in capacitance, and then bending the serration at each reading to produce the required results. The operation was speeded up by the use of a simple beat-frequency oscillator and a standard capacitor adjusted to the desired curve. This method, although much faster, was still handicapped because of the necessity for continuously switching between the standard and the capacitor being calibrated.

Matching a ganged capacitor which consists of adjusting the remaining sections to conform to the calibrated section was handled in the same manner. It will readily be seen that if the tolerances were held to comparatively small limits, 0.5 $\mu\mu f$ or smaller, a continual switching between the capacitor being calibrated and the standard would be necessary.

To solve this problem, Hammarlund engineers decided to limit the switching to an absolute minimum. To do this, of course, means taking a comparison reading of the capacitance directly from a dial on the test instrument. With this object in mind, a search was made for a design that would answer the purpose.

Improved Method

It was discovered that with some modification, existing beat-frequency oscillators could be made to serve for calibrating and matching capacitors, and greatly speed production over existing methods.

In order to check by direct comparison it is necessary to have two variable oscillator circuits beating against each other. The final circuit is shown in the schematic diagram, Fig. 1. The standard capacitor C_{X1} is placed across one oscillator, and the capacitor to be calibrated (C_{X2}) across the other oscillator. Both capacitors are set to minimum capacitance and locked to a single shaft as shown in Fig. 2. By means of trimming capacitors C_2 and C_3 the oscillators are brought to zero beat as indicated by a null reading of meter M. The capacitor under test and the standard are then rotated together and the oscillators held at zero beat by means of the calibrated capacitor C_1. The change in C_1 necessary to accomplish this is a direct indication of the difference between the curve of the capacitor being calibrated and the required capacitance curve.

Design of Tester

The inductors L_1 and L_2 are variable, having movable iron core slugs. The shielding effect obtained with L_2 mounted above the chassis and as far away from L_1 as possible, is sufficient for all practical purposes. C_1 is a straight-line capacitor whose value depends on the capacitance to be covered in the tolerance specifications for the required capacitor curve. C_1 should be sufficiently rugged mechanically to withstand constant use during production tests. It was found that a total value of approximately 15 $\mu\mu f$ gave the required swing of 10 $\mu\mu f$ without using the full 180 deg

OSCILLATOR

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swing of the capacitor, thereby using only the linear portion of the capacitance curve. A value of 5 $\mu\mu$f each side of zero gave sufficient capacitance variation so that all tolerances could be met. C_2 and C_3 are trimming capacitors used to bring the two oscillators to zero beat. C_2 is used for making coarse adjustment in trimming whereas C_3 is used for final adjustments. Consequently, C_3 has a smaller capacitance than C_2. These trimmers are connected in parallel with one oscillator circuit to correct for small differences in capacitance that might exist between the capacitors under test due to their minimum capacitance and the leads.

C_4 and C_5 are loading capacitors which give a total base capacitance in each oscillator circuit of approximately 2000 $\mu\mu$f. They are added so that the frequency of the oscillator circuits would be relatively low, approximately 400 kc without external load, thereby minimizing the inductive effects of test leads. Care must be taken to keep the values of C_4 and C_5 as nearly alike as possible so that trouble will not be encountered in balancing the inductances L_1 and L_2.

The capacitors C_6 and C_7 couple the oscillator plates to the detector. These capacitors should have relatively small values (in the order of a few $\mu\mu$f) so that the coupling between the two oscillators will not be great enough to cause the oscillators to lock. They should be as closely matched as possible.

Construction of Tester

Both oscillator circuits must be kept as nearly alike as possible in the values of their component parts as well as in their wiring. Any great differences may cause serious unbalance between the circuits. All precautions should be taken in the matter of placement of parts in order that coupling effects will be a minimum. If too much coupling is present the lock-in between the oscillators will be such as to decrease the sensitivity of C_1. Either the capacitor under calibration will appear to track perfectly because the two oscillators lock, producing a permanent null indication, or the change in C_1 necessary to upset the balance will be abnormally large because of the tendency of the oscillators to remain at zero beat until tuned to widely different frequencies.

The mechanical structure of the beat-frequency oscillator must be sufficiently rugged so that momentary strains set up by external sources will not throw the instrument off calibration due to variations in the inductances. All points of ground contact in the wiring as

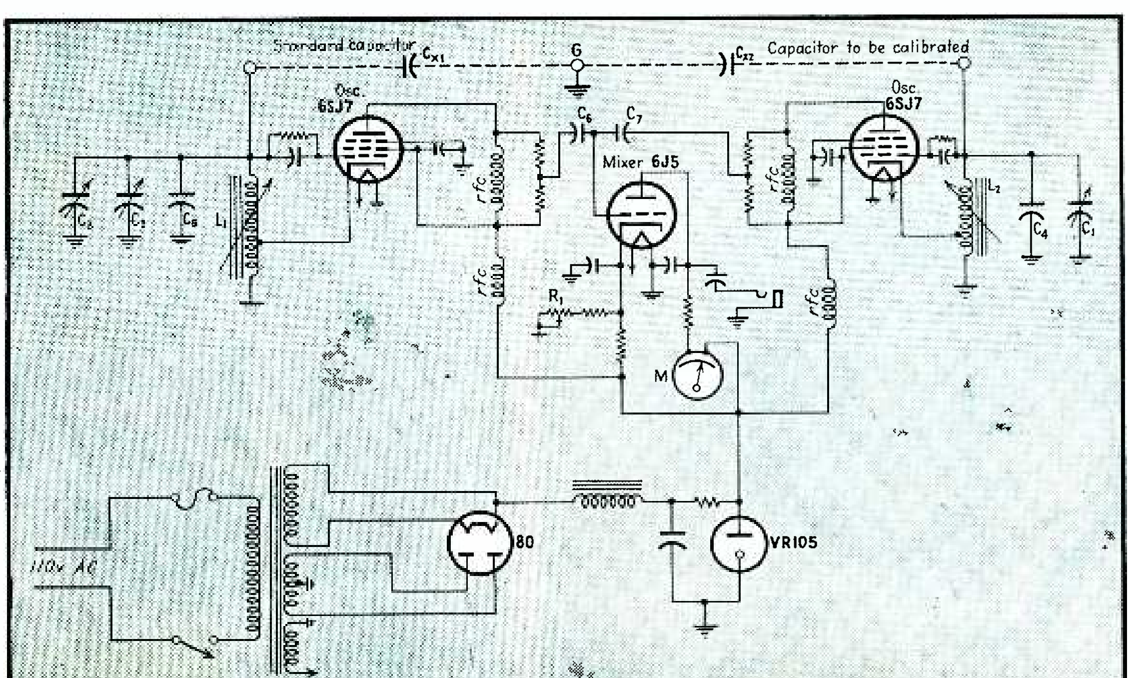


FIG. 1—Circuit diagram of the capacitor-matching oscillator. The outputs of the two oscillators are heterodyned in the 6J5. When both frequencies are the same the meter M gives a null indication. If the capacitor under test differs slightly from the standard, capacitor C_1 in the oscillator containing the unknown capacitor is adjusted to give a null on the meter. This change in C_1 gives directly the error in the unknown capacitor

well as in the fastenings of the dust cover and bottom plates should be made as secure as possible in order to overcome any difficulties from this source.

Calibration of Tester

Before the beat-frequency oscillator is calibrated, a simple balancing set-up will be required. The set-up consists of two fixed capacitors which have three or four times the maximum capacitance of the capacitors that will be calibrated in production. One should have a capacitance of from 1 to 2 $\mu\mu f$ greater than the other. The use of a much greater capacitance for balancing, over the values to be used during the production test, proportionately reduces the final errors.

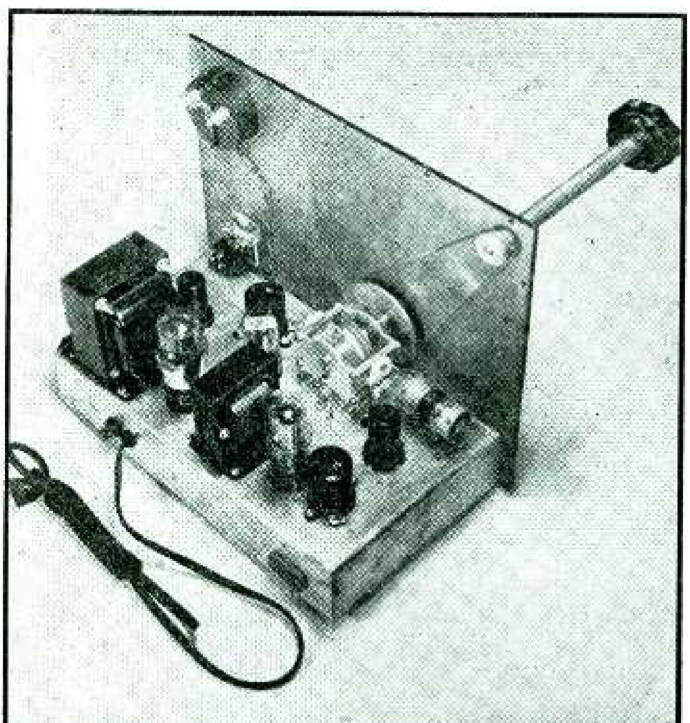
The two fixed capacitors should be tied together and the common point fastened to the binding post at G on the front panel. The remaining terminal of the standard capacitor is fastened to C_{x1}, and the terminal of the other capacitor is fastened to C_{x2}, as shown in Fig. 1. The leads fastened to C_{x1} and C_{x2} should be checked for length and symmetry. When the balancing set-up has been made as symmetrical as possible it is removed from the binding posts and placed to one side until some preliminary adjustments are made, prior to final balancing.

The next step is to set the movable slug in L_2, which is above the chassis. This is done by backing it out as far as it will go and then screwing it in approximately three or four turns. The dust cover is then put in place and securely fastened, using lock-washers under the screw heads to give good ground contact and rigidity. The variable potentiometer R_1 is of sufficient resistance to cause a full-scale deflection of meter M, which is preferably a 200-microampere meter. R_1 is set so that the meter shows half-scale deflection. The bottom plate is then placed in position and fastened securely.

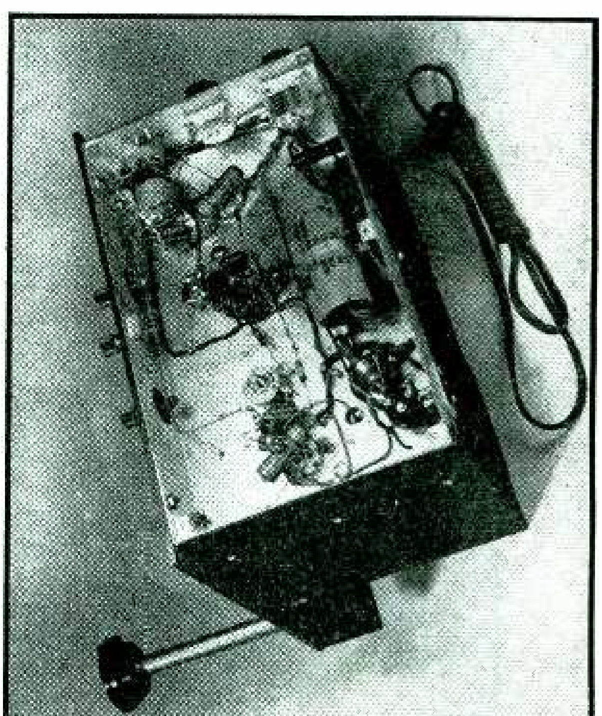
The oscillator is now ready to be balanced. The pointer of C_1 is set in the center of the dial, where a reference line is drawn. C_2 and C_3 are set so that their rotor plates are half-way out of mesh. L_1 is then adjusted by means of the movable slug until the meter deflection takes the lowest dip. A pair of headphones plugged into the phone jack will come in very handy to listen for the decrease of the beat pitch and to detect the null.

Unique Balancing Technique

The fixed capacitor set-up that was made previously is now fastened between C_{x1} and G and C_{x2}. C_1 is then turned to the right or left, as the case may be, until the meter indicates the null point and the distance of the pointer on C_1 from the reference line measured. Here use is made of the 1 to 2-$\mu\mu$f difference between the two capacitors of the balancing set-up. Remove the set-up from the test terminals and reverse its position. The lead formerly connected to C_{x1} should now be connected to C_{x2} and vice versa. Measure the deviation of C_1 as outlined above. The inductance value of L_1 is then adjusted by means of its movable slug until, with the oscillators balanced, the pointer on C_1 is the same distance from the center line on the one side as it was on the other before the test set-up was reversed. Note that it is necessary to re-bal-



Chassis assembly, showing the iron-core inductor of one oscillator at the right on top of the chassis, and the straight-line error-measuring capacitor at the center



Under-chassis wiring, showing the similarity between the two oscillator circuit lay-outs. The balancing capacitors, C_2 and C_3, are at the top in this view

ance the equipment each time the inductance value is changed, by means of C_2 or C_3 with the capacitor set-up disconnected.

Some means should be made for locking the inductor adjustment once balance is reached. The headphones prove very useful in checking the unbalance between the oscillators because occasionally the unbalance is of such a nature that no deflection is shown on the meter, the capacitance of C_1 at the moment being either too great or not great enough. An increase or decrease in the frequency of the audio signal as heard over the earphones is noted when C_1 is rotated. The movable slug of the inductor is then adjusted so that there is a constant decrease in the frequency of the signal until with C_1 set somewhere near the reference point a null is obtained. The final balance can be made without the headset inasmuch as the balance between oscillator circuits has been determined to fall on the dial of C_1.

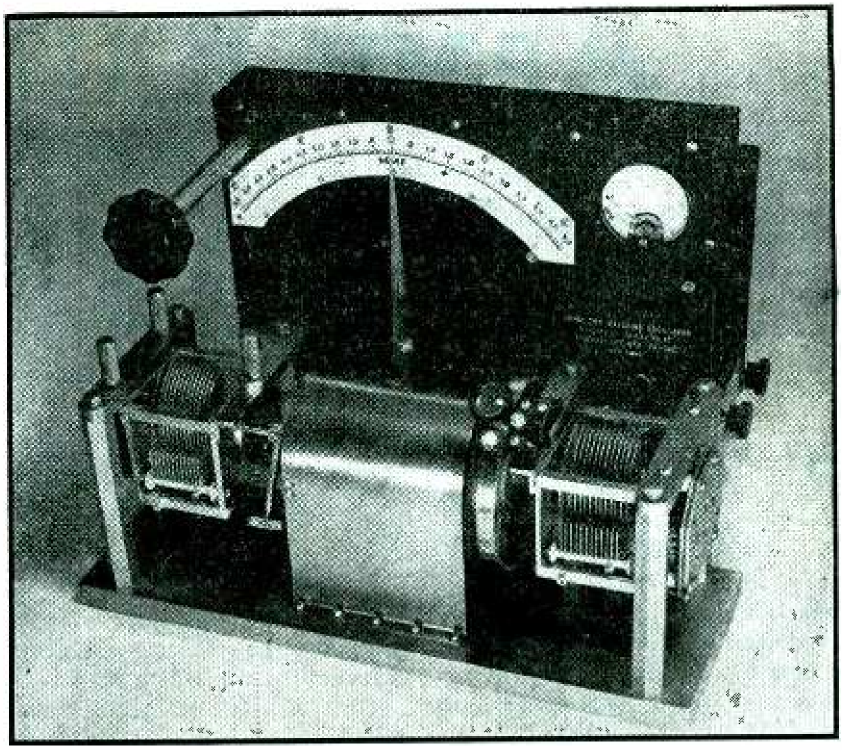


FIG. 2—The production capacitor is ganged to the standard capacitor, and connections are made to the terminal posts on the matching oscillator. The two capacitors are rotated, and the oscillators are kept in balance (as indicated by the meter) by adjusting the straight-line capacitor. The error between the unknown and the standard capacitor is read directly from the scale. The controls at the right balance the oscillators before measurements are made. This capacitor-matching oscillator was designed and built in the Hammarlund Laboratories

Dial, Calibration

The beat frequency oscillator should be perfectly balanced with the pointer of C_1 in the center of the dial. However, there are two values which will have to be precisely determined in order to calibrate the instrument accurately. These values are the base frequency and base capacitance with the instrument set and balanced at the reference point. These values need only be determined for the oscillator circuit in which C_1 is included, because the other oscillator circuit is balanced to it. The base frequency can be determined by any of the standard frequency-measuring methods.

Substitution Determination of Capacitance

The base capacitance can be determined by selecting two silvered mica capacitors whose capacitance values differ from each other by at least 1000 $\mu\mu$f. These capacitors should be measured accurately and marked and their readings recorded. They are then fastened separately across the C_{x2} and G terminals, and the frequency produced by the addition of each capacitor is determined by the same method used in determining the base frequency. Then by use of the two-frequency method the base capacitance can be calculated from the following equations:

C_x = base capacitance to be found
f_1 = the higher frequency in kc
f_2 = the lower frequency in kc
C_{V1} = the capacitance added to produce f_1
C_{V2} = the capacitance added to produce f_2

$$\left[\frac{f_1}{f_2}\right]^2 = \frac{C_X + C_{V2}}{C_X + C_{V1}} = FR^2$$

Writing $\left[\frac{f_1}{f_2}\right]^2$ as the frequency ratio, FR^2, the following formula is derived:

$$C_X = \frac{C_{V2} - FR^2 C_{V1}}{FR^2 - 1}$$

The base frequency and base capacitance for the oscillator circuit whose tuning capacitor is to be calibrated are now known. When the pointer of C_1 is set on the reference line the equipment should be in balance.

Calibration of C_1

A good audio oscillator and an oscilloscope will be needed to do the final calibrating. The audio signal from the beat-frequency oscillator can be picked up from the phone jack.

The method of calibrating C_1 is to compare the beat frequency of the matching oscillator to the frequency of an audio oscillator by means of the oscilloscope and Lissajous figures. The minimum change in frequency which can be measured in this manner depends on the calibration and stability of the audio oscillator, but this consideration need not limit the size of divisions to which the scale of C_1 can be calibrated. As was stated previously, the capacitor C_1 has a straight-line characteristic, and is only used over the central portion of its range where its linearity is highly reliable. If in addition it has a substantial air gap, it can be calibrated every 0.5 $\mu\mu$f, for example, and subdivisions every 0.1 $\mu\mu$f added. It was found at Hammarlund that by using this method the errors were so small as to be negligible. With C_1 calibrated, the capacitor-matching oscillator is ready for use.

ARMY RADIO D-F

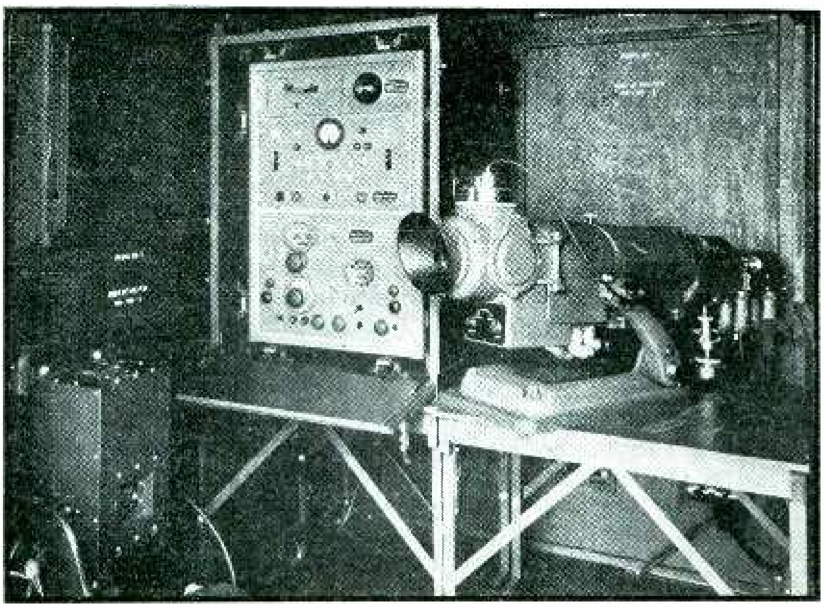
Description of SCR-291 radio direction finder, used by AACS to provide accurate bearings for military pilots on world-wide air routes. Indications appear on a cathode-ray tube screen. Operating procedures and factors affecting choice of sites are covered

RADIO DIRECTION-FINDING is a method employed to determine in degrees the direction of a transmitting agent, such as an off-course airplane, from a direction-finder station. Such operation is accomplished by the use of a receiver coupled to a specialized type of antenna with which the horizontal angle of incidence of incoming signals from a remote transmitter can be found relative to some predetermined standard, usually true or magnetic North.

Because the individual d-f station is capable of obtaining directive bearings only, a number of stations, properly located with respect to the distances over which operation is desired, can be grouped together in a d-f net for the purpose of determining geographical positions. These positions, or "fixes" as they are commonly called, are determined by the central or control station of the net. Individual bearings are obtained from each satellite station and plotted on a chart. Proper evaluation of the point of intersection of the collected bearings results in the fix, which may be reported back to the original transmitting agent or to rescue forces, depending on the circumstance.

The direction finder is a natural outgrowth of radio development and radio control. For many years surface vessels and aircraft controlled their movements visually, as no other method was available. Visual control, however, is obviously limited by the surrounding terrain, the prevailing atmospheric conditions, the spherical construction of the earth's surface, and many other factors that tend to restrict its usefulness to the immediate surroundings of the observer. With the advent of wireless communications, these limitations were greatly minimized, and the use of direction finding became increasingly important.

This discussion is concerned chiefly with the use of direction finding as a radio navigational aid operating in the field of military aviation. While the direction finder is not infallible, nevertheless it has proved itself a vital element in the safe conduct of airplanes over our farflung Army Airways.



Direction indicator is at the right in this interior view of an SCR-291 direction-finder shack. Receiver, control panel, and telephone panel are rack-mounted at the left

The Actual Equipment

There are many types of d-f equipment in use throughout the world—most of them employing a loop or Adcock-type antenna array. Generally speaking, the choice of equipment is determined by the operating characteristics desired and the circumstances and conditions peculiar to the sphere of operation. Surface vessels, for example, ordinarily make use of a direction finder whose antenna is of modified loop design, whereas shore-based units usually employ an Adcock arrangement.

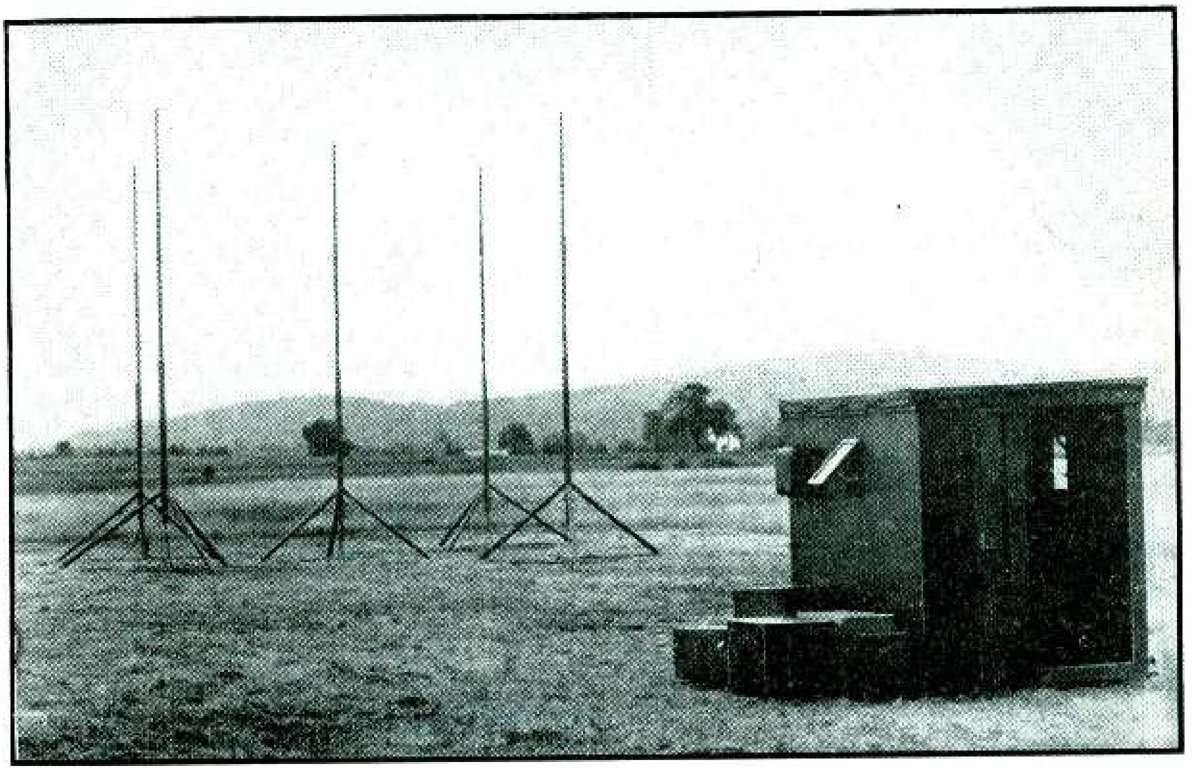
As Army aircraft radio operation is normally confined to a frequency range between 2 and 12.5 Mc, d-f equipment must be capable of supplying continuous bearing coverage within these limits.

Another requirement of satisfactory equipment is the need for obtaining bearings rapidly and with a minimum of the human element involved. Then, too, there are definite advantages in semi-portable equipment which can be installed quickly and disassembled with relative ease.

A direction finder manufactured by Federal Telephone and Radio

NETWORKS

By Major Giltner Twist, A.C.
Army Airways Communications System
Asheville, N. C.



Complete installation of direction-finding station. It can be disassembled for air transportation in 23 chests and crates. To the left of the operating shelter are the five masts of the modified U-Adcock antenna, each with its ground mat below

Corp. is used by the AACS. It possesses desirable features for this operation. It is semi-portable and employs a U-Adcock antenna designed for fixed station use. A cathode-ray tube and a motor-driven goniometer provide instantaneous bearings with a minimum of the operator's time and attention.

The set is built to withstand the effects of vibration, concussion from gunfire, and general rough use. When used for direction finding, the equipment is continuously variable over a frequency range of from 2 to 10 Mc, while its average sensitivity is approximately 5 to 15 microvolts per meter for a ±2-deg bearing reliability. The indications of the d-f set are continuous and automatic—automatic in the sense that if the direction of the received signal should shift with respect to the azimuth, the indication on the cathode-ray screen would shift accordingly without further tuning on the part of the operator.

Through the operation of the goniometer, the cathode-ray tube, and their associated electrical network, a visual trace pattern is projected on the face of the tube. The operator tunes the signal in, reads the two directions indicated, determines the true direction by pressing the sense switch, and reports his findings. As the signal is reproduced in visual form, all searching for aural nulls is eliminated. The operator can read the signal as he takes the bearing, and thus determines the type of transmission, the strength of the signal, the existing noise level, and numerous other wave characteristics common to radio transmission.

The modified U-Adcock-type antenna used with the set consists of five antenna masts. Four are installed on the corners of a square measuring approximately 25 ft. on each side, and provide two directional pairs of antennas. The fifth mast is placed on the intersection of the diagonals between the corner masts. The five antennas are connected to the goniometer by phase-inverter coupling units and r-f transmission lines. Each phase-inverter coupling unit is installed between the twin coaxial transmission lines and the antenna to combine impedance matching and aperiodic operation. It thus provides a uniform transfer of energy throughout the entire frequency range of the equipment with minimum attenuation from the long transmission lines.

The goniometer is a series of r-f transformers which eliminate the necessity for revolving the antenna. It is composed of six specially designed coils, the coils being wound at critical angles on a special stator. The coils are connected to the two pairs of balanced coaxial transmission lines, which in turn are connected to the antenna.

The coils, arranged so as to eliminate the need for slip rings and brushes, which are often delicate and troublesome, operate in conjunction with the motor-driven rotor to provide the same effect as that obtained by rotating the antennas manually. With the signal properly tuned and the sensitivity adjusted, there appears on the cathode-ray screen a pattern similar to a twin leaf.

The sharpness of the points of this pattern depends on the signal polarization and the effect of surrounding structures on this polarization. The twin-leaf pattern on the screen shows both the true bearing and its 180-deg reciprocal. To distinguish the true bearing from the reciprocal, the fifth antenna is connected through the goniometer so as to change the appearance of the pattern when the sense switch is pressed. It is this pattern change which indicates the true or actual direction of the transmitting agent.

While this equipment is subject to errors resulting from conditions of atmosphere and terrain, it has proved quite satisfactory from a mechanical point of view, and is so simple in operation as to perform reasonably accurately even when operated by relatively inexperienced personnel.

Determinations Possible

The operations of a d-f system are usually such as to provide one or more of the five following types of bearing: A true bearing from the d-f station to the transmitting agent, a true bearing from the transmitting agent to the d-f station, a magnetic bearing from the d-f station to the transmitting agent, a magnetic bearing from the transmitting agent to the d-f station, and a geographical fix.

The first of these are two bearings secured with respect to true north; the third and fourth are obtained with respect to magnetic north. Since greater simplicity of net operation is realized when reported bearings are true rather than magnetic, AACS d-f stations are being installed and oriented so that the equipment automatically furnishes a true bearing.

When a magnetic bearing is desired, the operator must compute it from the true bearing obtained by the equipment. In order to guard against mistakes on the part of operating personnel, there is being developed a simple computer which, once it has been set to the magnetic declination existing at the station where it is used, will automatically indicate the magnetic bearing.

The ideal site for a direction finder would be the center of a uniform plane of good conductivity. This type is rarely found in practice, but good operation can be obtained from the average site if the operator is acquainted with the compromises that can be made.

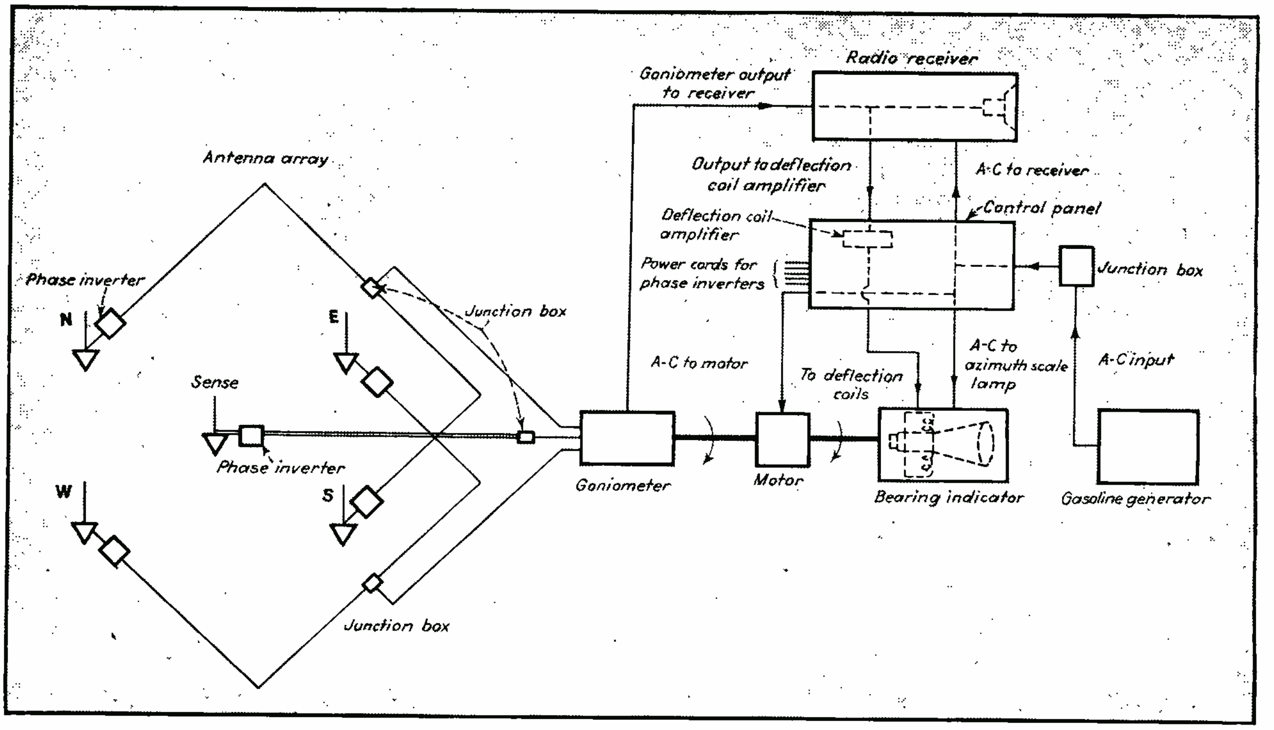
Installation Factors

In selecting a site, the final criterion is, of course, the actual performance of the d-f station. To save time, the best site within the area in which the d-f station is to be installed is selected by visual inspection. Such inspection takes into consideration the suitability of the site with regard to its size and shape, its receiving qualities and capabilities, the character and homogeneity of the soil, and the signal-to-noise level.

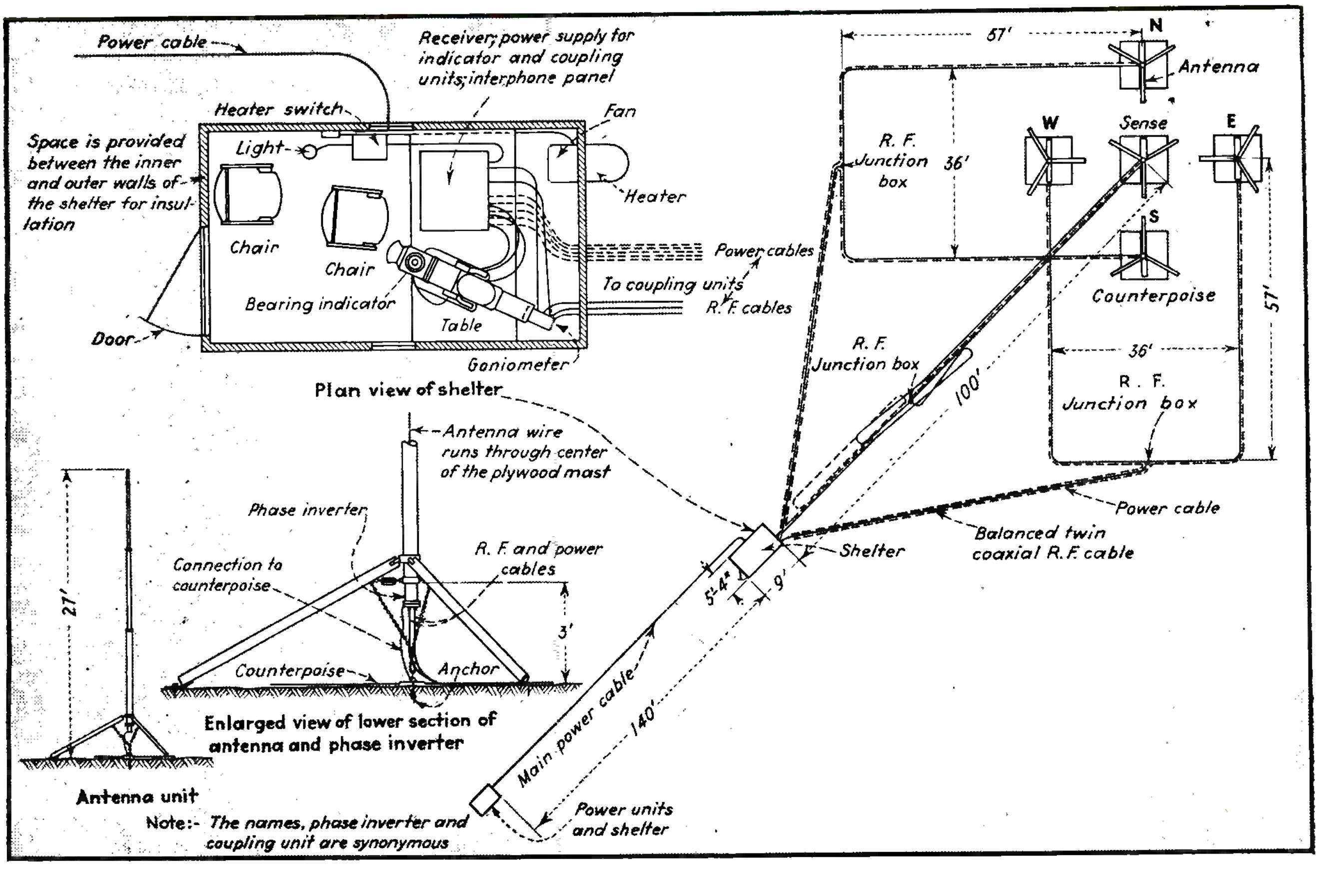
Proper selection of the d-f site is of utmost importance to the accurate operation of the equipment. The following notes will serve to illustrate the types of serious error that may result under certain conditions:

Coastal Effects. A station located a few miles inland will find unreliable such bearings as are secured on radio waves which cross the coast line at acute angles.

Topographical Features. Hills or



Functional diagram shows connections between parts of AACS direction-finder station. Signals from the antenna array pass through the goniometer to the receiver and from there to the deflection coils and the indicator which provides the bearing required



Plan of direction-finder site, giving detailed disposition of components with dimensions

mountains adjacent to d-f stations often produce constant or fluctuating bearing errors. Sites within one wavelength of cliffs or large rocky out-croppings will render bearings inaccurate with respect to wave-length, angle of elevation, and azimuth.

Adjacent Structures. Large buildings, overhead wires, metallic fences, and trees can have a very appreciable effect on the accuracy of d-f bearings. Every effort is made to install the equipment such a distance from obstructions of this nature as to avoid the possibility of error.

Ground Characteristics. A uniform, highly-conductive soil acts as a mirror for radio waves, thus attenuating the abnormally polarized components of the wave and preventing path distortion of the incoming wave. For this reason flat, salt marshland is far more desirable for d-f purposes than other types of soil. Practical difficulties normally encountered in such areas, however, usually preclude their use as d-f sites. Rocky or sandy soil is most unsuitable for d-f work by reason of changes and non-homogeneity in its electrical conductivity.

In addition it frequently has been found that sites which visual inspection would indicate to be inadequate furnish quite satisfactory bearings, and that sites which seem to be ideal produce large bearing errors. This is due to a number of technical considerations which are too involved to be discussed here.

After the equipment is installed, it is calibrated before being put into regular operation. This calibration is effected by means of either a target transmitter, distant fixed radio stations, aircraft, or any combination of the three.

The equipment at AACS d-f stations is calibrated by having an airplane circle the set at a distance of approximately 10 miles. The bearing of the airplane is observed visually through a surveyor's transit or a theodolite, and a d-f bearing is obtained at the same time. This process is completed at 4 or 5 degree intervals for 360 degrees of the compass, after which an error curve is prepared from the differences noted in the two sets of bearings.

It is readily apparent that the proper selection of sites constitutes a most serious problem for the AACS. Its stations must be situated along the air routes—in mountainous areas, or sandy beaches, in ice-covered regions, and desert expanses. Operating personnel often find it necessary to install and disassemble d-f equipment many times in an area before a satisfactory site can be found.

Scope of Operation

As the AAF air routes encircle the world, the AACS expands with them. These routes include long flights over both tropical and artic oceans, as well as overland flights through dangerous jungle and mountainous countries.

Installation of the individual stations has progressed to such a point that in the very near future an army pilot will be able to fly almost anywhere in the world and expect a reply to his request for a bearing.

One of the major problems concerns the communications system to be employed for collecting the individual bearings for plotting purposes. It goes without saying that such a system must be rapid and efficient if it is to provide a fix to an airplane before the ship has traveled too far from the point at which individual bearings were taken. While the most satisfactory method would prescribe separate communications facilities for each net installed, in terms of world-wide coverage this becomes impractical, expensive, and undesirable, particularly where there are already in existence AACS radio stations which might be used for this purpose.

Procedures have been established to permit certain existing radio stations to act during d-f operations as communication agents for d-f nets in addition to fulfilling their regular operational requirements. This has worked quite satisfactorily up to the present.

It should require usually only a matter of a few minutes—seldom over ten—from the time an aircraft requests a geographical fix to the time the fix is delivered to it.

Further difficulties involve the proper interpretation of ionospheric effects on the incoming signals. While this problem can never be completely solved, action has been initiated which will lessen these effects.

The program planned by the AACS is concerned primarily with long-range operation employing the sky wave. The ionospheric or Heaviside layer reflects the high-frequency waves back to the earth and certain disturbances in this region tend to affect these reflections by distorting or blocking them. As it will at once be seen, this is of great importance since d-f equipment, which indicates only the direction from which the incoming signal is being received, will translate into bearings both accurate signals and those that are reflected inaccurately from the ionospheric regions.

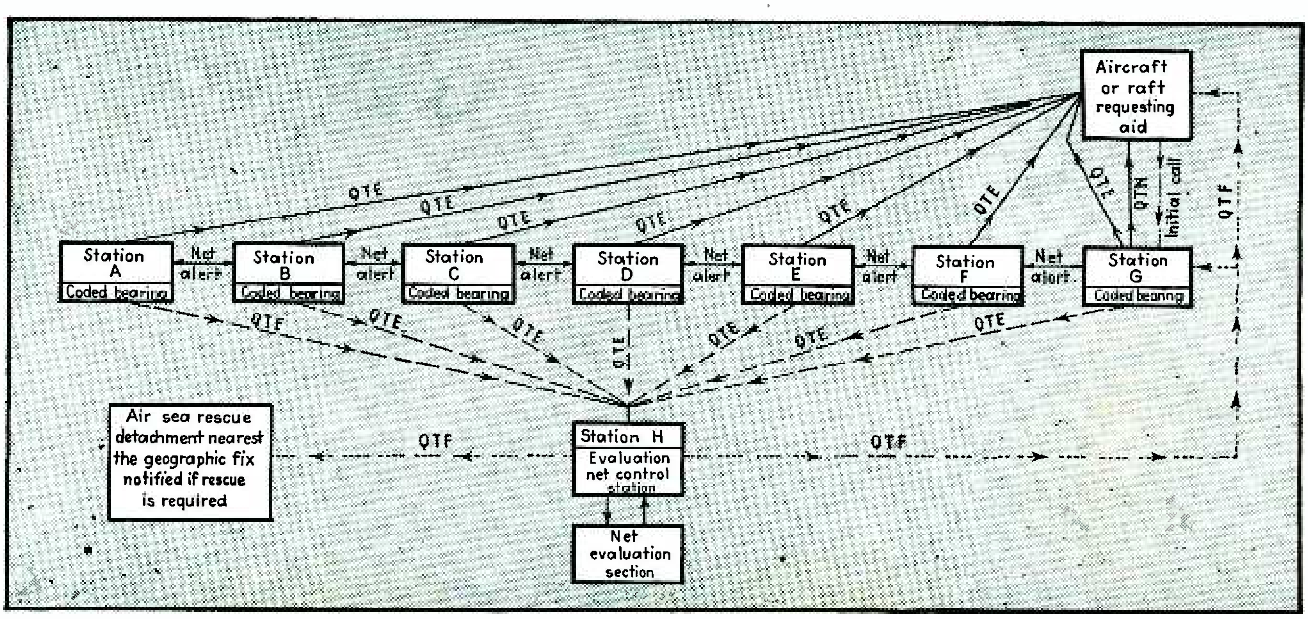
Ionospheric sounding stations located strategically throughout the world will aid in solving this problem by providing forecasts of ionospheric conditions to be expected in various areas and thus permit a more accurate interpretation of bearings affected by these conditions.

Still another major problem was presented with regard to the proper frequencies for d-f operation. The distance between the end of the ground wave and the beginning of the reflected sky wave is called the skip zone. Within this skip zone, communications are said to be impossible, but sporadic E conditions, scattered reflections or ionospheric storms often permit communication in part or all of the zone. Bearings obtained from transmissions within this space, however, are faulty and require correction by means of skip distance charts predetermined for each frequency during each of the six four-hour periods of the day.

Most reflections are controlled by the F_2 layer. This is the layer nearer the sun and for that reason is ionized to a greater degree. Sometimes during daylight hours, however, the E layer (the one nearer the earth) controls these reflections. In plotting frequency-skip curves, the maximum usable frequencies and the optimum working frequencies are first found for each ionized layer. The optimum working frequenceis for each four-hour period are then compared. The layers possessing the larger number of optimum working frequencies are then selected as the controlling layers for the various four-hour periods.

Skip-distance charts are being prepared to enable d-f evaluators of each net plotting station to ascertain the frequency characteristics of the satellite stations whose bearings it receives for evaluation.

As previously stated, the greatest benefit to be derived from direction finding is the position fixing of air-



Typical action sequence of a d-f net follows the notations on this chart. Aircraft at upper right makes initial call for d-f fix, and station G alerts all other stations in the net on point-to-point frequencies or land lines. Next, the called station (G) requests the aircraft to transmit call signs and dashes (QTN) by which all net stations obtain bearings (QTE) and report them to the evaluation net control station (H) where geographical fix is plotted. Finally, the fix is reported (QTF) directly to the aircraft if contact can be established, or otherwise to the originating station. If the plane has crashed or if the transmitter is on a life raft, the fix is reported directly to the air-sea rescue detachment nearest the fix (QTF)

craft in flight. In order to use its equipment to the fullest in the accomplishment of this, the AACS first assigns to the various air routes, areas of 1000 to 1500 miles in diameter. It then establishes within each area a net consisting usually of five or six strategically-located individual reporting stations and a central plotting station.

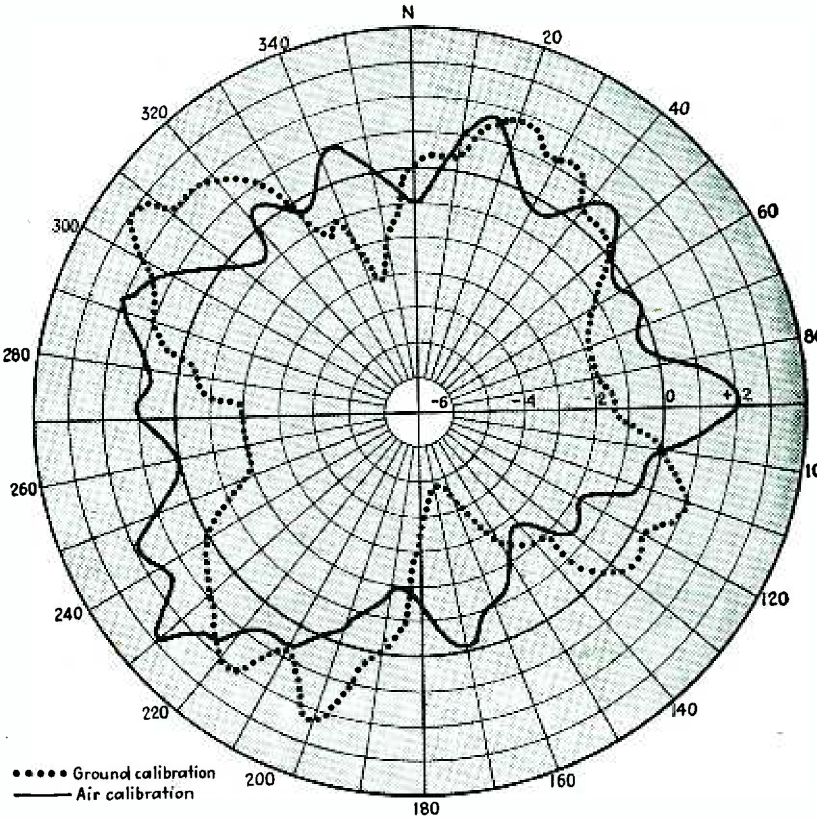
The reporting stations will be from 100 to 600 miles apart, depending upon the size of the area. In many cases, of course, it is impossible to install these individual stations at ideal distances, either because locations cannot be found (as in mid-ocean) or because point-to-point communications do not exist or cannot be used.

Operation of Nets

The most desirable arrangement for net stations in an operational area 1000 miles in diameter consists of a reporting d-f station installed on each corner of a square measuring 600 miles on each side. The evaluation station with its adjacent d-f reporting station (the fifth in the net) should be located at the intersection of the diagonals between the corners. Such an arrangement is seldom if ever possible in actual practice, and over long ocean routes and in foreign countries the right-angle bearings so important to plotting a fix are sometimes unobtainable.

A geographical fix, to be accurate, must have a series of intersecting base lines (individual bearings) from angles as widely separated as possible. If each of them is accurate, only four or five bearings are needed to provide an excellent fix. A larger number of bearings would prove cumbersome and retard the speed of net operation. On the other hand, if the direction finders furnishing these four or five bearings are not properly located, the resultant fix will suffer in accuracy.

For example, let us assume that a net of six stations has been placed in operation and that these stations are spaced from 200 to 400 miles apart in a fairly straight line. A very satisfactory fix could be given to an aircraft located approximately 300 miles out on a line perpendicular to the axis line drawn between the stations—if a majority of the stations obtained accurate bearings.



Ground and air calibration procedures produce two sets of figures which are plotted on circular or linear forms to show error in degrees around station. A third curve is later added to represent computed average error

On the other hand, if the aircraft were 800 miles from the axis line, a poor fix would result unless other nets were employed to provide the necessary right-angle base lines.

In this assumed net an airplane proceeding along the axis line joining these stations would be in such a position that it would be almost impossible for the stations to secure a good fix, again because of absence of right-angle base lines.

It is clear, then, that care must be taken to locate the various installations so that they can provide multilateral coverage. To obtain this coverage it has been necessary to set up installations at points located well off the established air routes. This provides sufficient depth to offset the detrimental factor of skip distance and provide right-angle base lines in a greater number of cases.

It is possible, of course, that more than one net may be operating along the same air route. Under these conditions it will sometimes happen that an aircraft requesting a fix is so located that its position cannot be accurately determined unless bearings are obtained from two or more nets. The procedure governing operation of nets has therefore been developed to include regulations for inter-net coordination.

It thus becomes possible to obtain individual bearings necessary for a fix from all d-f stations receiving the transmitted signal and to report such bearings to the plotting station concerned. Inter-net operation does, it is true, involve a greater time loss, but this delay is justified by the importance of satisfactory operating coverage.

Tracking Charts for Plotting Fixes

The success of a d-f net system depends in large measures on the type of chart employed in plotting the individual bearings. As AACS operations were planned to cover larger distances, the gnomonic projection type chart was selected for this purpose.

A gnomonic chart is a projection of a given area of the surface of the world as it would appear if viewed from the center of the earth.

Direction-finding stations are shown in their proper locations in a particular area and provided with compass roses arranged so that a straight line drawn from any station through its corresponding compass rose will result in a true great circle path.

The evaluating or plotting station of each net is furnished with gnomonic tracking charts which represent the area covered by its net and include the d-f stations with their compass roses. As the bearings are reported by the reporting stations they are entered on one of these tracking charts and evaluated into a fix. Since a new copy of the chart is used for each fix requested, there is provided a permanent record of all fixes evaluated by each plotting station.

The making of these tracking charts is a most complicated and detailed process. The AACS is fortunate in having its charts prepared by both the Hydrographic Office of the Navy Department, and the Aeronautical Chart Service of the Army Air Forces, to which it sends data as new charts are required.

Things to Come

Since the beginning of the war, stories have been told in great number of people drifting helplessly for days on a tiny life raft in the middle of the ocean. Happily, some of them have lived to recount the horrors of their experiences. When a ship is sunk or an airplane forced down on the water, the survivors can only wait in lifeboats or rafts until they are discovered by searching parties or a passing ship.

Imagine then what it would mean under such conditions to have an emergency transmitter, capable of long distance communications, particularly if shore-based direction finders could obtain a fix on its transmission. The AAF is developing a program to provide such transmitters.

The apparatus is powered by a manually-operated generator, and when used on a high frequency will operate over considerable distances. Equipped with this set, a party in a life raft will be able to transmit signals from which shore-based direction finders can compute a geographical fix—to be sent immediately to the nearest sea rescue organization.

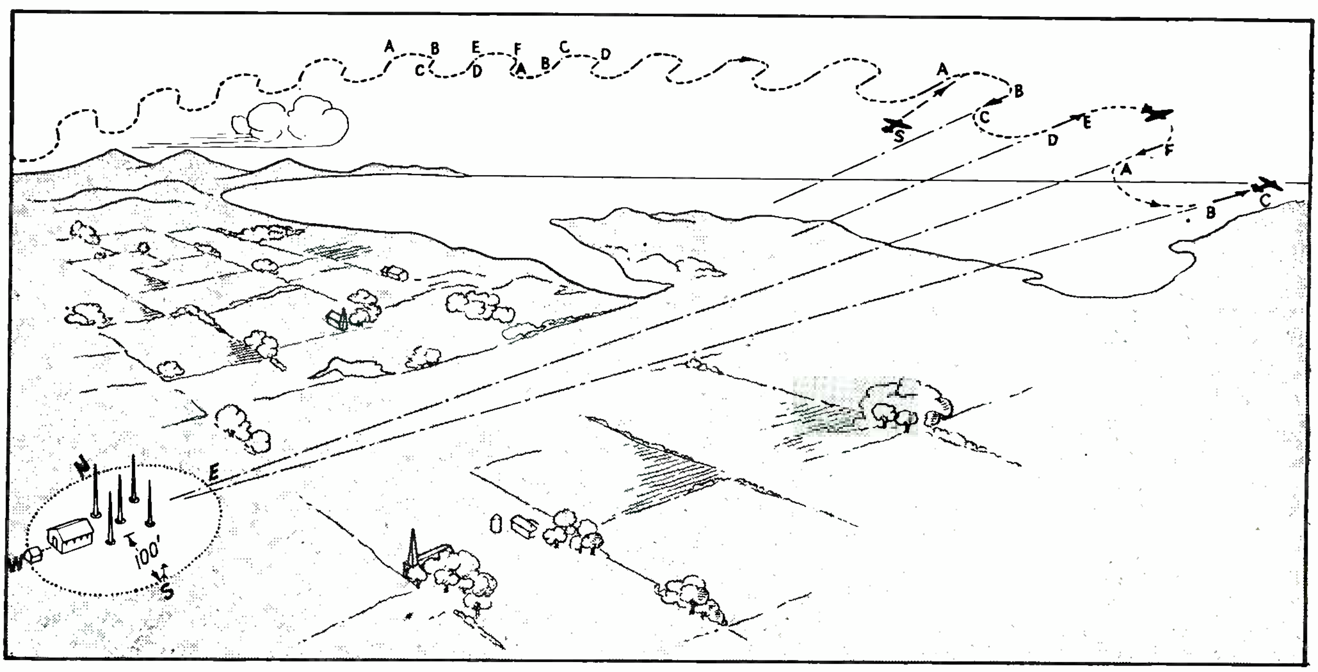
The same method is employed to secure bearings and determine a geographical fix on a life raft as on an aircraft in flight, and the large-scale production of the proposed emergency transmitters will unquestionably prove of tremendous assistance to the men who must make the long, dangerous flights that are inevitable in this war.

Conclusion

The many and complex problems inherent to the placing in effect of such a huge program are too detailed to be treated at any length in this discussion. By the very nature of its operations, which must be accurate in the extreme, radio direction-finding suffers from conditions which do not prove deleterious to the efficiency of ordinary radio communications.

Some of these conditions can in certain instances be anticipated and thus corrected or minimized. Others must remain factors constantly limiting the consistent accuracy and efficiency of the equipment.

Fully conscious of these limitations and the difficulties it will have to face, the AACS continues to expand its facilities. The value of direction-finding in emergencies, in aiding disabled or lost aircraft, more than compensates for every expenditure of time, money, and energy incidental to the installation and operation of the equipment.



Method of air-calibrating a d-f station involves a theodolite at point *S* and an aircraft flying at 5000-ft. altitude 10 miles from the d-f station. Sequence, which is repeated throughout, is as follows: From *A* to *B*, aircraft transmits a series of single dots while approaching course. From *B* to *C*, *D* to *E*, and *F* to *A*, while on course, ten-second dashes are sent. From *C* to *D* are transmitted a series of two dots and from *E* to *F*, a series of three dots

RTPB on FM

Panel 5 reaffirms existing standards of transmission, and proposes allocation of a continuous band of 80 to 100 channels, each 200 kc wide, from 40 Mc upward. "Bursts" and multipath distortion are found to be of minor importance

THE V-H-F Broadcasting Panel of the Radio Technical Planning Board has issued its report on post-war plans for frequency modulation. The Panel recommendations make no break with past practice, since all the basic standards of transmission are reaffirmed, and one additional standard proposed. In the matter of proposed frequency assignments, a conflict arises with the previous recommendations of the RTPB Television Panel, in the region of 50 to 60 Mc. Here the proposals of the two groups overlap somewhat, with the amateurs sandwiched in between.

Recommendations

The specific recommendations of the FM Panel are as follows: (1) Frequency modulation is the system best suited for v-h-f broadcasting. (2) The f-m broadcast band should extend upward from approximately 40 Mc. (3) The width of each f-m channel should be 200 kc (this implies 75 kc maximum frequency swing and 15,000 cps maximum audio frequency). (4) From 80 to 100 channels are necessary for a national allocation, allowing for educational stations as well as commercial broadcasters. (5) The direction of polarization should be horizontal.

Sudden increases of signal strength lasting from a fraction of a second to several seconds have been noticed recently on distant stations operating in the 40 to 50-Mc band, due possibly to reflections from ionized patches caused by the passage of meteors. It was argued that the existence of such bursts of interference, as well as the probable increase of long-distance propagation at times of sunspot maximum (every eleven years) would cause difficulty to f-m service if the present region between 40 to 50 Mc were preserved for future use. The issue was finally referred to Dr. J. H. Dellinger of the Bureau of Standards, who reported that the existence of short bursts of long-distance interference is probably closely connected with sporadic E reflections in the ionosphere, and thus not connected with the sunspot cycle. In any event, he stated, the effects were not prevalent enough to impair the value of the frequencies seriously. He stated further that no frequency in the spectrum can be said to be free of transmission vagaries.

The Panel discussed at some length the multipath distortion effects reported by DuMont, which arise when a wave reflected from a building or other structure arrives at a receiver in strength comparable to that of the directly propagated wave, causing wave cancellation and a-f distortion. The panel came to the same conclusion reached earlier by the Television Panel, namely that such effects could be found, but that they were not sufficiently prevalent to warrant any change in the method of modulation or in the frequency swing.

Channel Width

A reduction of the channel width from 200 kc to 100 kc was discussed at length. The advantages claimed are reduction in the amount of ether space for the required 80 to 100 channels, consequent improvement in image rejection, reduction in multipath interference effects, and higher gain per stage in i-f amplifiers without loss in interchannel selectivity. The disadvantages are a loss of 6 db in signal-to-noise ratio throughout the service area, a reduction of the service area within which 60-db maximum signal-to-noise ratio could be realized at the receiver, and a two-to-one decrease in the permissible frequency tolerance of the local oscillator in push-button operated receivers. The possibility of multiplex operation on the f-m channel would also be removed if the channel were reduced.

It was brought out that the optimum frequency swing for 60-db maximum signal-to-noise ratio (assuming a maximum modulating frequency of 15,000 kc) is about 125 kc, a figure considerably greater than the 75-kc swing now used and proposed for future standardization. The 125-kc swing permits the greatest area to be served with 60 db signal-to-noise ratio. Smaller swings, e.g., 75 kc, serve a smaller area with this signal-to-noise ratio, but a larger area with somewhat lower signal-to-noise ratio. The choice is thus a compromise between space used in the spectrum and area covered with the desired low level of noise interference.

The proposed number of channels for a national allocation, 80 to 100 channels, is based on a service comparable in scope to the present system of standard broadcasting, in which 105 channels are available. The greater interference radius of the standard broadcasting frequencies makes it impossible to provide noise-free service from all stations, particularly at night. Therefore a smaller number of f-m channels can be expected to give an equal or greater choice of program with virtually no interference at any time. Of the channels proposed, about 15 are expected to be reserved for educational stations.

The proposal to standardize on horizontal polarization is a distinct step forward, and should ultimately correct the present situation in New York, where eight f-m stations are about equally divided between vertical and horizontal polarization, making it difficult if not impossible to obtain optimum reception from all stations with a single receiving antenna.

FREQUENCY-SHIFT Radiotelegraph

Frequency-shift transmission of telegraph, teletype, facsimile and radio-photograph signals provides the advantages of f-m over a-m without the usual increase of bandwidth. A special circuit eliminates the effect of mean-frequency drift. A limiter that is free from loading and transients is described

COMMERCIAL radio communication by Morse Code has been standard since the advent of radio. The dot-dash system has never been entirely superseded by voice. Though code has its drawbacks and is subject to error in transmission, and requires highly schooled personnel, it is still the basic means of handling high-speed commercial and press traffic.

Anyone who has operated on noisy long-distance circuits realizes how much more accurate it is to receive by ear than by automatic slip recorders. When the signal is strong and no noise is present, tremendous speeds may be attained by using automatic equipment, but if the noise level rises, automatic equipment fails, speeds decrease and manual operation must take over; traffic piles up.

Developments over the past five years have produced a new system of automatic code transmission and reception which performs electronically what the human ear or brain does with a signal in the presence of noise. This system reaches in and picks out the signal despite the noise.

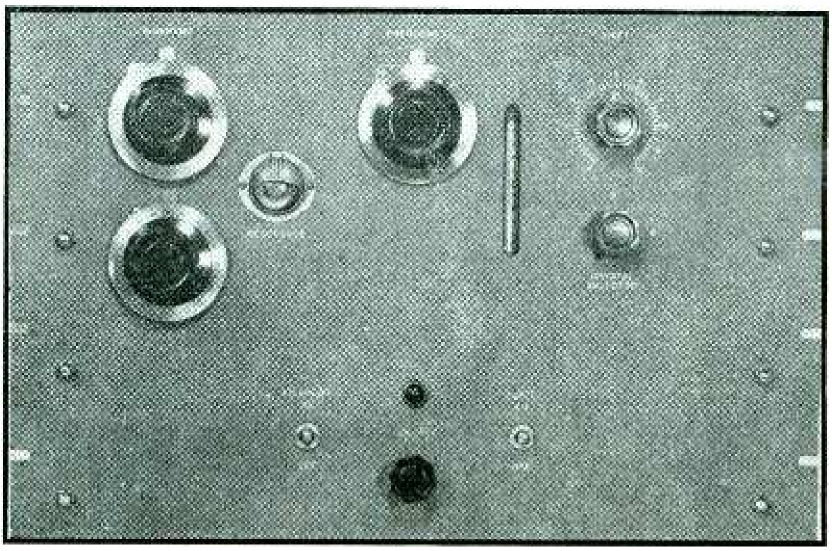
Noise Suppression Without Increased Bandwidth

Everyone is familiar with the improvements in signal-to-noise level in broadcasting that frequency modulation provides over amplitude modulation. Frequency modulation presents only one disadvantage, the required bandwidth is over ten times that required for a-m systems. Developments in the transmission of telegraph signals are now being made which are analogous to f-m broadcasting. Instead of keying a carrier on and off to designate the mark and space of telegraph signals, the transmitter maintains radiation at full power, but the carrier is shifted back and forth between two distinct frequencies to designate mark and space. The same beneficial reduction in signal-to-noise ratio is derived in transmitting telegraphy in this manner as is derived from f-m broadcasting. However, in regard to bandwidth the analogy fails. The bandwidth required by frequency-shift transmission is no greater than that required by the carrier make and break system.

This new type of transmission is not only applicable to the transmission of telegraph signals, but can also be used for transmission of teletype mark and space signals, or for facsimile where one radiated frequency corresponds to black and the other to white. This system can be extended further to the transmission of radio photographs. In this application the half tones are represented by frequencies intermediate between the extreme black and white frequencies.

Early Use of Frequency-Shift

Frequency-shift transmission was used long before it was recognized as such. In the days of arc transmitters it was impossible to interrupt the arc in accordance with telegraph signals, so instead the frequency of the transmitter was shifted during the space. Here



Front panel of frequency-shift transmitter terminal equipment used by Press Wireless, Inc.

By ROBERT M. SPRAGUE
Director of Research
Press Wireless, Inc.
Little Neck, New York

and Teletype System

was true frequency-shift transmission, but at the receiver no use was made of the all-important space wave. By the late 1930's the advantages which seemed inherent in this system were being developed in the laboratory.

When the Byrd South-Pole expedition of 1939–1940 was about to leave, equipment from Press Wireless laboratories was rushed into readiness and, with Times Wide World wirephoto equipment, was sent along with the expedition. Pictures published in daily newspapers during the expedition gave ample proof of the effectiveness of this type of transmission. Pictures coming over 8000 miles from a small 500-watt transmitter were received with the clarity of standard wirephoto pictures. Further developments were made over circuits from Berlin, Moscow, London and Chungking. Such transmissions are now commonplace.

Frequency-shift transmission for radio telegraph was slower in coming, but when it was proved that a 20-db increase in signal-to-noise ratio was available, the system was applied to this service. Now many commercial circuits are operating both telegraph and teletype by means of carrier shift.

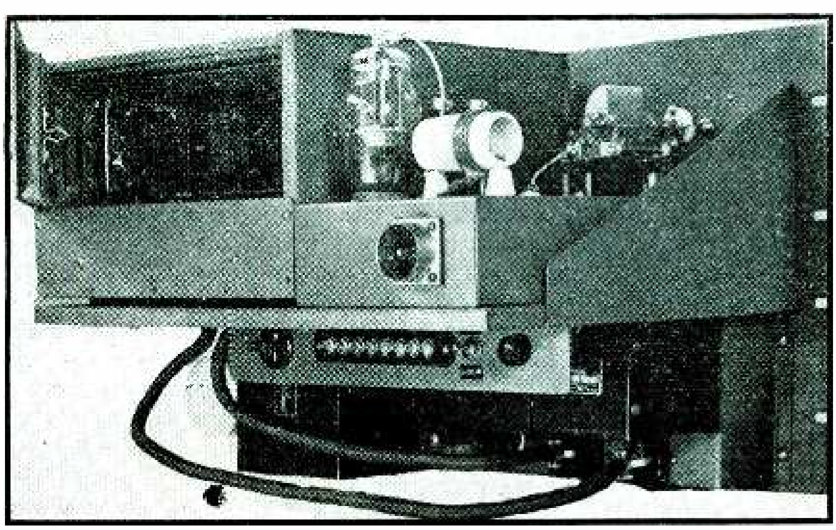
Frequency-Shift Transmitter

Several types of carrier-shift equipment are being used. The transmitting equipment developed by Press Wireless, Inc. takes energy from a crystal oscillator and beats it against an extremely stable self-excited 200-kc oscillator. The frequency of the self-excited oscillator is shifted by the signal which is to be transmitted, being increased in frequency on mark and decreased on space.

The incoming signal, usually in the form of a square wave, is filtered to eliminate frequencies higher than the third harmonic of the highest keying frequency required. The filter must be designed so that the fundamental to third harmonic phase relation is not changed. Such filtering introduces only 1.35 percent characteristic distortion, and aids in reducing the bandwidth which must be transmitted.

From the output of the mixer stage of the crystal oscillator and the self-excited oscillator, the upper side band is selected and applied to doublers and power amplifier stages of the transmitter, and radiated on frequencies varying symmetrically about the assigned frequency.

A frequency shift of 850 cycles has been adopted as standard because it gives the best compromise between signal-to-noise level and bandwidth. However, this shift is varied between 400 cycles and 1200 cycles for special services. For example, high-speed facsimile and photograph services use a 1200-cycle shift.



Rear view of frequency-shift transmitter unit showing crystal oven and shifting oscillator

Transmission Bandwidth

Consider the bandwidth for the case of teletype, the signal for which is a 23-cycle fundamental and a third harmonic of one-third the fundamental amplitude. If the carrier were keyed make and break by this signal, the ideal bandwidth would be twice the third harmonic frequency, or 138 cycles. Such a narrow band is never attained because the amplifier stages of the transmitter tend to square the keying signal. The best possible transmitter adjustment will require a bandwidth of approximately 1200 cycles. Only side bands greater than 40 db below the unmodulated carrier level are considered in this value. If, on the other hand, the carrier is shifted 850 cycles by the teletype signal, the emitted bandwidth is 1100 cycles. Were the carrier shift reduced to 250 cycles with the same signal, the emitted bandwidth would be only 480 cycles. Thus frequency shift can result in a much lower bandwidth than carrier make-break.

The calculation of frequency-shift bandwidth is comparatively simple. Assume that the carrier is shifting from mark to space frequencies sinusoidally, for teletype at a frequency of 23 cps. This is equivalent to frequency modulation

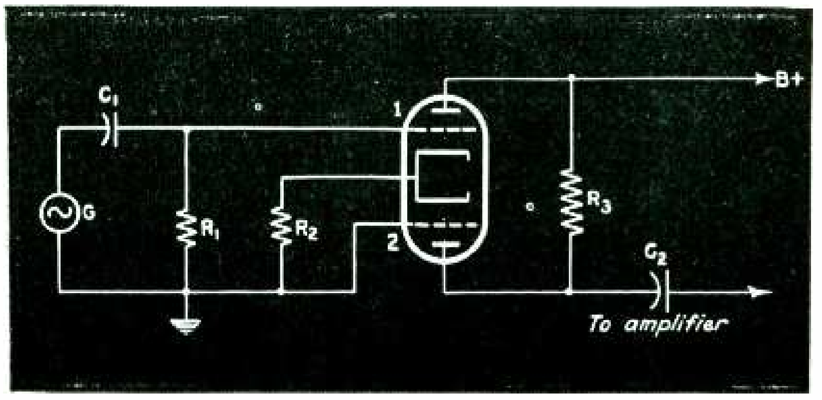


FIG. 1—Transient-free limiter in which the first section of the double triode limits the negative peaks, and the second section, cathode-coupled to the first, limits the positive peaks

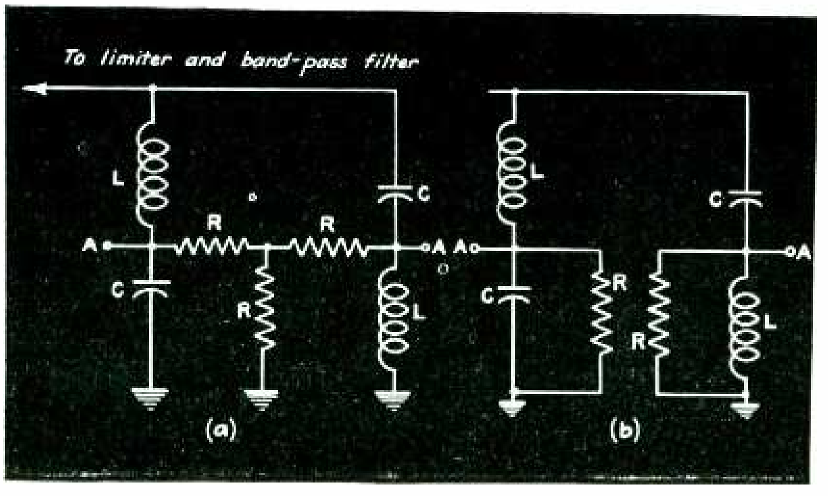


FIG. 2—Two forms of discriminator. The discriminator for frequency-shift reception must be flat over a band far wider than the deviation limits, so as to avoid amplitude modulation in the output produced by the noise in the input

of a carrier whose frequency lies midway between the mark and space frequencies, by a 23 cps signal. The modulation index B is the deviation from the carrier frequency divided by the modulation frequency. For a total shift of 460 cycles, $B = 230/23 = 10$. Under this condition there are 14 pairs of side frequencies greater than 40 db below the unmodulated carrier level. Therefore, the bandwidth is $23 \times 28 = 645$ cycles.

Now consider the third harmonic along with the fundamental. The keying wave is a signal of varying frequency and amplitude. At any instant the transmission band is determined by the instantaneous frequency and amplitude of the keying wave. Therefore, the transmission band varies between maximum and minimum values. The maximum instantaneous keying frequency, with its corresponding amplitude, determines the transmission bandwidth. This maximum instantaneous frequency in this case is 1.5 times the fundamental frequency, and its amplitude is equal to the amplitude of the keying wave. Therefore, the deviation is the same as for the actual keying signal.

The corresponding modulation index is $B' = \Delta F/1.5 f$. This value can be used to calculate all bandwidths where the keying wave is composed of a fundamental and its third harmonic. Returning to the original example, $B' = (B/1.5) = 6.67$, and the maximum instantaneous frequency is $f' = 1.5 f = 34.5$. For a B of 6.67 there are ten significant pairs of side frequencies, and therefore the maximum bandwidth is $20 \times 34.5 = 690$ cycles.

Frequency-Shift Receiver

The receiving systems of various commercial companies using frequency-shift transmission are similar in principle, but use different types of equipment.

Press Wireless, Inc. uses an a-m communications receiver which receives the radio signal and delivers an audio beat note to a band-pass filter. The beat note shifts in frequency about a mean frequency of 2550 cycles in accordance with the transmitter frequency variations. The band-pass of the filter must be wide enough to pass not only the two frequencies between which the audio beat-note shifts, but also all sidebands produced by the frequency modulation which are one-tenth or more of the carrier level. It must also be wide enough to tolerate possible transmitter or receiver drift. Noise signals outside the band are not completely eliminated but, due to filter transients, are reintroduced as signals of much lower amplitude and at frequencies within the filter pass-band.

Transient-Free Limiter

From the filter, the signal goes to a power limiter. The requirements of this limiter are much more stringent than those of the rf limiter used in f-m broadcasting because the carrier and intelligence frequencies are comparable. Thus transients must be extremely short compared to both carrier and intelligence frequencies.

Such a limiter is shown schematically in Fig. 1. The tube is a dual high-mu triode. Consider the effect of a high-amplitude signal applied through capacitor C_1 to the grid of the first section. Small negative voltages cut off the tube and so the voltage across R_2 due to current in the first triode is zero during most of the negative half cycle. The load resistance of the generator is only R_1. As the grid swings positive with respect to ground, the tube space current increases, increasing the voltage across R_2. R_2 is made sufficiently large so that at no time does grid voltage exceed cathode voltage. Thus the grid never goes positive with respect to its cathode, and the generator load is still only R_1. Since no grid current flows, no charge appears on C_1 which must leak off through R_1 in accordance with the time constant $R_1 C_1$. Therefore the circuit is instantaneous in its action and no transients result.

Also, the load presented to the generator remains constant.

As the voltage across R_2 increases because of positive swing of the first grid, the second triode is cut off. This second triode is essentially a cathode drive stage excited by the first triode acting as a cathode follower. The gain of the second triode is low because its plate resistor R_3 is small. It cuts off at about the same positive swing of the first triode grid as does the first triode for negative swings of its own grid. Therefore the action of the limiter is symmetrical about the zero axis, and is both transientless and instantaneous for any abrupt level or frequency change. The limiter gives about 30 db of limiting. Two limiter stages separated by a class A amplifier supply the needed 60 db of limiting.

Discriminator Requirements

Once the signal has been limited, it is fed into a sloping discriminator circuit prior to detection. The requirement of the discriminator is that it be linear over a frequency range far in excess of the deviation band. It need not be the back-to-back variety which is symmetrical about zero, zero voltage corresponding to the mean frequency. Following is the argument for these statements.

In f-m receivers, the tuned circuit following the limiter is usually part of the discriminator circuit. The circuit is linear only over the deviation band. Beyond this band, the response of the tuned circuit falls rapidly to zero. Therefore, any signal outside the deviation band is not received by the detector. With an input level variation of 60 db the limiter delivers a constant output. Whether the input consists of one or a thousand frequencies, the output energy is constant and is made up of one or a thousand frequencies. With one frequency fed into the limiter, the output is of the same frequency, plus its odd harmonics due to the wave squaring of the limiter. But when noise is present, side bands of the original signal become evident, and these side bands extend far beyond the band-pass filter, which accepts noise at the input of the limiter. The greater the intensity of noise in relation to the desired signal, the greater the amplitude of these side bands, and the greater their coverage of the spectrum beyond the deviation band.

In f-m receivers the tuned circuit following the limiter eliminates these frequencies which lie outside the deviation band. Since the energy output of the limiter is constant, the output of the tuned circuit following the limiter must change in amplitude as noise is impressed with the signal on the limiter input. This amplitude change will be as evident after detection as will be the desired change due to frequency modulation. Therefore, a back-to-back discriminator is required.

Such a discriminator operates in push-pull for frequency changes, but in push-push for noise-caused amplitude changes. These latter, therefore, tend to balance and be eliminated. The discriminator need not be linear beyond the deviation band, as no side bands are present, having been filtered out by the tuned circuit following the discriminator. Notice that the back-to-back discriminator is superior to a single-ended non-symmetrical discriminator only in suppressing the amplitude-modulation effects of noise, and not phase or frequency-modulation effects. These latter effects are additive in each half of the back-to-back discriminator and no noise reduction results.

Single-Ended Discriminator Preferred

In many commercial types of converters, the limiter is followed by a single-ended slope circuit. No attempt is made to eliminate noise sidebands outside the deviation spectrum. When such a discriminator is used, it must be of the extended range type, i.e., it must be linear far beyond the deviation band so as not to discriminate against noise components. Otherwise, amplitude modulation resulting in noise will result. Under these conditions, no advantage whatsoever accrues from the use of a back-to-back discriminator. After the discriminator and detector, the signal should be fed through a low-pass filter to eliminate noise caused by phase modulation of the signal at frequencies higher than the desired intelligence frequency. For teletype this filter passes the third harmonic, which may be 70 to 100 cps; for high speed Morse, 250 cps, and for photograph and facsimile, 600 cps.

An extended-range, single-ended discriminator eliminates all amplitude modulation due to noise, but

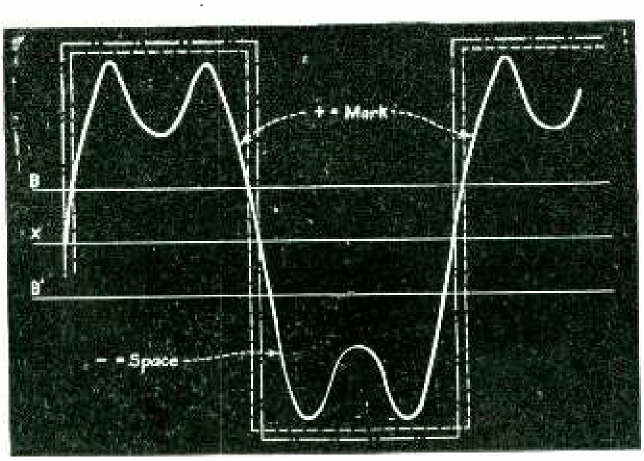


FIG. 3—The pulse consists of the fundamental and third harmonic. Pulses should vary about the central axis

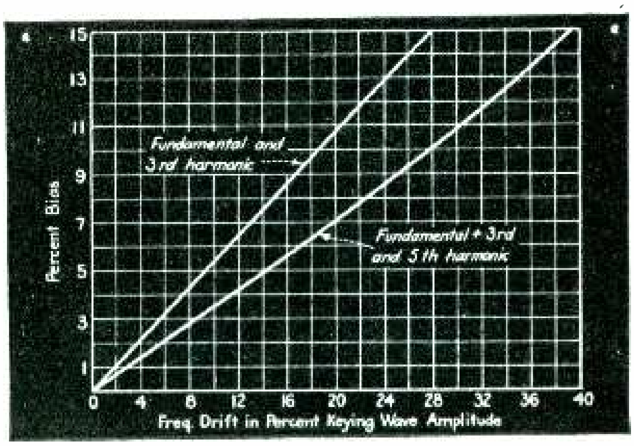


FIG. 4—Bias introduced by transmitter or receiver frequency-drift for two types of keying waves

accepts a wider band of noise to phase-modulate the signal, whereas the pre-filtered back-to-back discriminator only partially eliminates amplitude modulation due to noise, but limits the band of noise to phasemodulate the signal. Experiments have shown a small but definite advantage in the latter type; therefore its use is recommended in all types of terminal equipment for teletype, photo and facsimile.

Such a discriminator is shown in Fig. 2(a). The differential voltages to be detected are taken off at points A. In both Fig. 2(a) and 2(b), the input impedance of the discriminator is a constant over the band equal to R. L and C are given by

$$LC = \frac{1}{\omega^2} \qquad \frac{L}{C} = 2R^2$$

where ω is 2π times the cross-over frequency. The configuration of Fig. 2(a), although it does not give linear response over as wide a frequency range as does that of Fig. 2(b), delivers a higher output voltage and is perfectly symmetrical.

Frequency-Drift Compensation

The output of the detector and noise filter is the recreated pulse that originally keyed (frequency-shifted) the transmitter. If the mean frequency of the signal being fed to the converter equals the cross-over frequency of the discriminator, the pulse will alternate symmetrically about a zero axis. The solid curve of Fig. 3 represents such a keying signal, composed of fundamental and third harmonic, oscillating about the X axis. A local oscillator may be arranged to key on and off around this zero axis. However, if the frequency of the receiver or transmitter drifts so that the mean frequency no longer corresponds to the discriminator cross-over point, the local oscillator will no longer key on and off symmetrically about the axis, but about some other axis B.

When keying takes place about the X axis, a square wave shown by the dot-dash line results from the fundamental-third harmonic keying wave. This square wave is unbiased. That is, for equal mark and space of the transmitted wave, the square-wave mark and space are equal. However, when keying about the B axis, it can be seen that mark and space are no longer equal and a bias (expressed in percent as 100 times mark-length minus space-length, divided by mark-length plus space-length) results. For an acceptable minimum number of errors, teletype signals can contain no more than 5 percent bias; therefore, any frequency drift will result in more errors.

Figure 4 shows the bias introduced by transmitter or receiver drift expressed as a percent of the frequency shift for the fundamental-third harmonic keying wave and for a fundamental plus third and fifth harmonic keying wave.

To eliminate bias due to frequency shift, the circuit shown in Fig. 5 is used. Here the keying

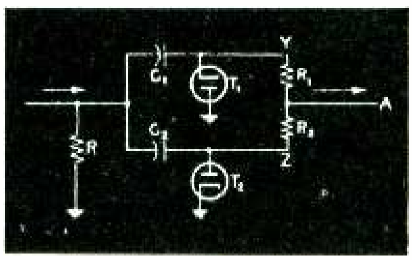


FIG. 5—Balancing circuit used to center the received pulse about the zero potential axis in the event that frequency drift throws it off

wave is developed across R, which is capacitively coupled through C_1 and C_2 to rectifiers T_1 and T_2 connected as shown. The load circuit consists of equal resistors R_1 and R_2, with the keying signal taken off at their junction, point A. As the signal across R increases positively, capacitor C_2 charges through rectifier T_2 thus holding point Z at zero potential. At the same time this positive potential is passed through capacitor C_1 to point Y. Rectifier T_1 is non-conducting for this polarity. As the voltage across R falls to zero and swings to its negative value, the charge on C_2 is applied to point Z and the full peak-to-peak voltage appears at Z. The voltage at point Y falls to zero and capacitor C_1 is charged through rectifier T_1 to the negative value of the voltage across R.

On the next positive swing of the cycle, the full peak-to-peak voltage is applied to point Y. Thus, point Y is varying between a positive value equal to the peak-to-peak voltage across R and zero, while the voltage at Z is varying between zero and this same peak-to-peak value, but in a negative direction. Therefore, the voltage at point A is always varied symmetrically, plus and minus, around zero. Any direct component in the voltage across R is not transmitted to point A.

The conditions to be satisfied in this circuit are that the time-constant RC_1 or RC_2 be small in comparison with the length of the keying pulses, and that the time constant $C_1(R_1 + R_2)$ is large in comparison with the time interval between pulses. With this circuit, the system is always operating essentially about the X axis of Fig. 3.

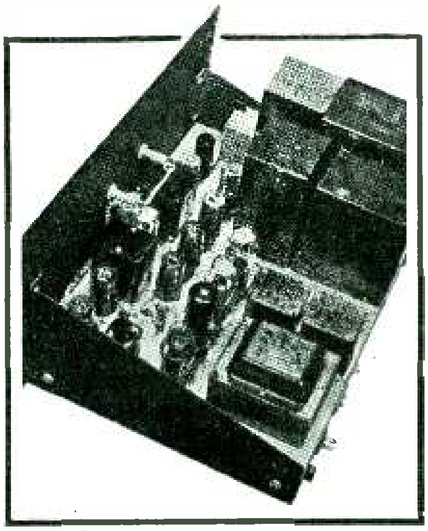
Gas Tubes Block Noise

The keying pulse, as shown in Fig. 3, is now set to key on and off around axis X. However, if the crest of the signal has been reached and is holding the local oscillator in its mark position, a noise crash which causes the voltage to drop below the X axis will shift the local oscillator, causing it to record a false space. Much greater signal-to-noise ratio can be obtained by using gas control tubes, which strike on and off only after a critical voltage is reached. Under such conditions, these tubes can be adjusted to key the mark signal on at, say, level B of Fig. 3, and off at level B'. Thus, when the keying voltage is on its positive swing a noise crash must force the keying wave to pass the X axis and deviate all the way to the B' axis before a false space will be recorded. Similarly, when the keying wave is on its negative half-cycle a noise crash must force the voltage beyond the B axis before a false mark will be recorded. The use of gas tubes does not introduce bias, but merely displaces the keying wave slightly, and gives a much greater signal-to-noise ratio.

Combining Circuit for Diversity Reception

Still more faithful reproduction is had by using diversity reception. However, the receiver output in a two-receiver diversity system cannot be combined directly, as fading and phase shift would cause the resultant signal to fluctuate violently in level. Furthermore, a signal fading in relation to noise on one circuit would, because of the limited action, result in a high noise output of the limiter. Instead, the signal from each receiver is fed through two similar channels, each consisting of an input filter, limiter, discriminator, detector and noise filter. Combination of the signals takes place at this point, where the frequency is low and time delay effects are at a minimum.

Referring to Fig. 6, the keying wave appears across R_1 for one channel and across R_1 for the second channel. These keying waves are varying symmetrically around the zero axis. The voltage across R_1 and R_1' are combined through four rectifiers poled as shown in Fig. 6. R_2 and R_2' are the load resistors for these rectifiers. The centers of the rectifier circuit are also connected by resistors R_3 and R_4, and the combined voltage taken out at their junction point A. With either a positive or negative voltage simultaneously on R_1 and R_1', half this voltage appears at point A. However, if due to diversity action the voltage across R_1' drops to zero, while the voltage across R_1 remains constant, the voltage at point A will also remain constant, thereby giving full diversity effect. Even though the voltage across R_1' should go negative when a positive voltage is desired, the voltage at point A will not drop to less than zero. Using the gas tube action outlined above, no false signal will be recorded as long as one circuit maintains its full voltage. Use of this type of diversity combination results in 10 to 20-db increase in signal-to-noise ratio. In the circuit shown, R_2 must be large compared to R_1, and R_3 and R_4 large compared to R_2.



Frequency-shift, converter for receivers

Cause of Lower Signal-to-Noise Ratio

The signal-to-noise improvement using frequency-shift transmission occurs for the same reasons that such improvement is obtained in f-m broadcasting. The following remarks may serve to clarify the reasons why there is such improvement. With constant-frequency carrier make-break transmission, noise in the presence of the mark signal tends to amplitude-modulate the signal in direct relation to the signal-to-noise ratio. Noise in the presence of no signal will cause interference depending only on the amplitude of the noise. Where a large mark-to-space signal-ratio is required for automatic recording, a small amount of noise will, therefore, introduce false mark and space signals.

In frequency-shift transmission, however, the signal is first fed through a limiter. This limiter eliminates all amplitude modulation caused by noise. There is always a signal feeding the limiter whether it be of mark or space frequency, and thus noise effects will act the same on mark as on space. If noise is fed into a limiter simultaneously with the signal, only phase modulation of the signal results. If this noise consists, for the purpose of analysis, of only one frequency, the phase modulation of the signal is given by

$$\frac{r^2 + r\cos\phi}{r^2 + 2r\cos\phi + 1}$$

where r is the noise-to-signal voltage ratio and is less than 1, and ϕ equals $2\pi ft$, f being the difference between the noise and signal frequencies. In the case of noise consisting of many frequency components, only those components whose vector sums are frequencies lying within the band passed by the noise filter following the detector need be considered. All other components are eliminated by this filter.

From the above expression it can be shown that in the case where the vector sum of the noises is as much as half that of the signal there is only one radian of phase modulation. But frequency-shift transmission employs many radians of shift. The modulation index B is often as high as 10 or 20. Therefore, noise, even though it be half that of the desired signal ($B = 1$) will, after detection, be small in comparison to the signal.

As much as 20 db signal-to-noise increase can be expected using frequency-shift transmission. A small, mobile 400-watt frequency-shift transmitter on the beachhead in France is transmitting press traffic to this country at a rate of 500 words a minute, over a million words a month, where in former days a 50-kilowatt transmitter had trouble in maintaining the circuit.

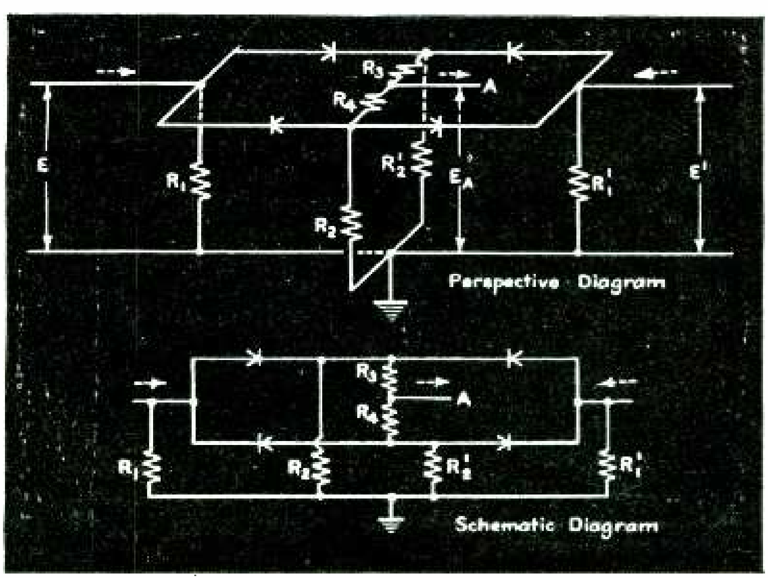


FIG. 6—Coupling circuit used between the outputs of two diversity receivers and the recording apparatus

Frequency-Modulation Phonograph Pickup

Description of a phonograph pickup having a flat frequency characteristic over the audio range, with self-contained volume expansion and less than one ounce of needle weight. Needle varies capacitance in tuned circuit of oscillator, causing frequency modulation

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Morristown, N. J.

To reduce the mass of the moving part of a phonograph pickup, the principle of capacitance translation has been adapted to pickup design. The needle alone is the moving member. Although the variation in capacitance between the vibrating needle and a fixed electrode is small, it is sufficient to frequency-modulate an oscillator operating in the very-high-frequency range. This reduction in mass of the moving part improves the mechanical properties of the phonograph. The frequency-modulation method of translation, being independent of the rate at which the needle vibrates, gives flat frequency response over a wide audio range.

Mechanical Construction

In a simple frequency-modulation pickup the needle constitutes a part of the electrical circuit and therefore should not require replacement more often than absolutely necessary. A semi-permanent needle having a sapphire tip meets the requirements. The upper end of the needle shaft is ground to a point and presses upward into a conical metal socket of slightly larger taper than the shaft point, as shown in Fig. 1. The needle is maintained in position by a soft rubber disk mounted in the bottom of the pickup head and through which the needle passes. A small shoulder on the needle causes the rubber to belly slightly downward so that it exerts an upward force on the needle to hold it in the conical socket. The needle is thus free to move in any horizontal direction. The upper point and socket act as a pivot of microscopic size, with only the slight compliance of the rubber disk restricting the needle motion.

The pickup electrode is mounted to one side of the needle shaft near the lower end, and is roughly parallel to the record groove. Lateral movements of the needle, caused by the record groove, serve to vary the distance between the needle and the electrode.

The only work required of the record groove is to vibrate the minute mass of the needle and overcome the small compliance of the rubber disk, hence needle pressure can be low. This reduces surface noise. Many conventional pickups require three to four ounces of tone arm and pickup head weight on the needle, but this f-m pickup requires only about one-half to one ounce of weight on its needle.

Automatic Volume Expansion

A unique feature of this pickup is its volume expansion. Since the needle is free to move in all directions perpendicular to its axis, there is motion in the direction of the record groove caused by the drag of the record on the needle. This drag is nearly proportional to the deviation of the groove. The groove undulations for stronger sounds are larger than for weaker ones, although not as large as they should be for full dynamic reproduction because of the volume compression used in the recording.

With the pickup electrode at an angle to the groove as illustrated in Fig. 2(a), the increased drag on the needle caused by the larger groove undulations of Fig. 2(b) and 2(c) serves to decrease the average spacing between the

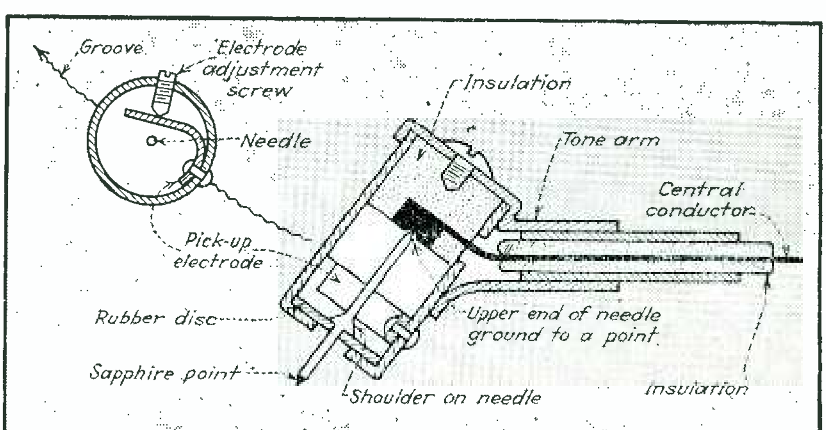

FIG. 1—Head assembly of the f-m phonograph pickup. The arrow indicates the direction of record groove movement

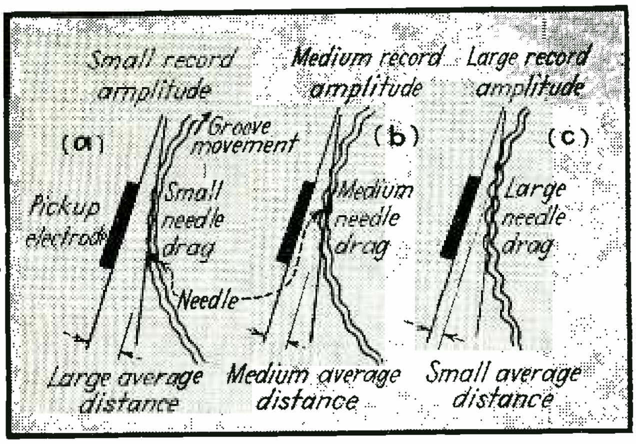

FIG. 2—Volume expansion is obtained by placing the pickup electrode at an angle to the record groove motion. The movement of the needle by groove drag produces volume expansion

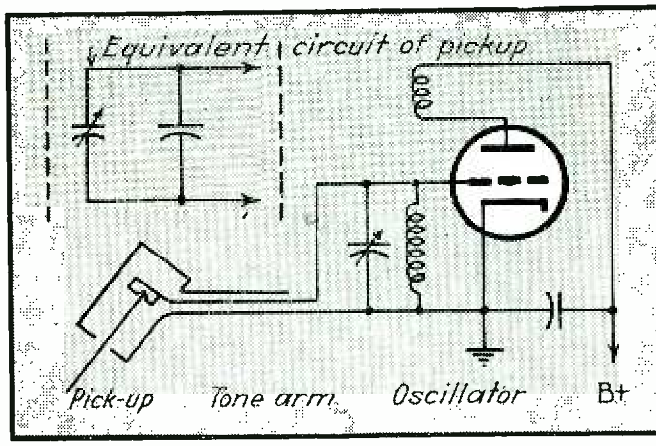

FIG. 3—Schematic diagram of a simple oscillator, showing the connection to the pickup. The equivalent electrical circuit of the pickup is a fixed capacitor paralleled by a variable capacitor

needle and the electrode. Under this condition the variation in needle-electrode capacitance becomes a greater part of the average needle-electrode capacitance, and the translation efficiency is increased. In this manner the recording is volume-expanded to recover the original compression.

The degree of volume expansion can be regulated by adjusting the angle of the electrode surface to the record groove. An angle of thirty degrees gives a realistic degree of expansion. If the electrode surface is parallel to the record groove at the point of needle contact, there will be no expansion.

Surface noise is already much decreased by the low needle pressure on the record groove, and volume expansion gives further reduction. As a result, surface noise is hardly audible with the weakest sounds, and is inaudible with stronger sounds. Amplifier gain control as a means of volume expansion maintains the reproduced signal-to-noise ratio at the recorded ratio, whereas this volume-expansion method of translation-efficiency control reduces the relative noise level as the signal is increased.

Flat Wide-Range Frequency Response

Another contribution to the fidelity of reproduction is given by the flat frequency response characteristic of the pickup itself. For a given needle deflection in the audio range, no matter whether it be at a rate of ten or ten thousand cycles per second, the frequency deviation of the oscillator is the same amount. Thus the frequency characteristic of the system is not influenced by the pickup itself.

The needle is locked at its upper end in the fixed socket, is locked into the record groove at its lower end, and is itself extremely stiff in comparison to the stiffness of the rubber centering disk, hence the needle can have no mechanical resonances in the audible range. This feature eliminates mechanical resonances and the distortions which they introduce, and thus contributes further to reproduction fidelity. Conventional pickups have one or more resonance periods due to freely swinging parts such as a crystal or armature.

Since the needle scratch is very low, no scratch filter is required. Full use can be made of the high-frequency response of the pickup.

Circuit and Operation

An f-m receiver is used for reproduction of the output of the f-m phonograph. To change from station reception to the phonograph, the receiver is tuned to the f-m phonograph oscillator, a simple form of which is shown in Fig. 3. The tube and circuit components can be located in the mounting box containing the gimbals for the tone arm. The tone arm is a tube with a central conductor wrapped with cotton or other electrical insulation. The insulated conductor should be pulled tightly into the tone arm, to maintain constant capacitance between the central conductor and the tone-arm tube. The wrapping effectively damps any tendency of the inner conductor to vibrate. Lower-loss insulation may be used, but it should have mechanical damping properties.

The central conductor connects with the phonograph needle through the conical metal socket. The pickup electrode connects to the tone arm, which is grounded to provide shielding and to minimize stray capacitance effects. The capacitance of the central conductor to the tone arm is in parallel with the pickup capacitance between the needle and the pickup electrode, hence this capacitance should be minimized for highest percent frequency modulation by the needle vibrations. A tube with an inner diameter of 3/8 inch is satisfactory. Condenser microphone cable with the shield removed serves satisfactorily for the inner conductor.

To decrease variations of the oscillator mean frequency due to movements of the tone arm, and to reduce to a minimum the shunting capacitance of the line through the tone arm, the oscillator can be built into the tone arm or the pickup head.

For a complete f-m receiver with audio amplifying and reproducing systems already available, only the pickup assembly and f-m oscillator of very low power, together with switching arrangements for starting the oscillator, are required. The f-m phonograph oscillator is set for some unused part of the f-m band and tuned in on the receiver as are broadcast stations. The phonograph unit may be separate and remote from the receiver.

QUALITY

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Operator preparing to apply a static quality test to a type 833A transmitting tube

PRESENT-DAY mass production lends itself admirably to quality engineering practices. Although this article is centered on vacuum-tube manufacture, the approach and much of the technique are directly applicable to other phases of industry.

Quality Tests

In order to determine vacuum-tube *quality*, it is necessary to have a criterion of acceptability; in other words, the tube must pass some sort of a test. One method tests a random sample (typical of the day's production) for static characteristics and dynamic performance. All conditions of the test are recorded and readings are meticulously observed, with the exact nature of the test depending on the type of tube involved.

For the usual transmitting or receiving tube, test instructions should specify voltages for filament, plate, control-grid, screen-grid, and suppressor-grid as required to observe filament, plate, control-grid, and screen-grid currents. Emission, plate resistance, amplification factor, and mutual conductance should be determined; furthermore, it is desirable that interelement capacitances be measured also.

Cathode-ray tubes should be checked for light output, line width, deflection sensitivity, focusing voltage, leakage, gas ratio (or cross), interelement voltage breakdown, and anode currents.

Specifications for dynamic testing should include load resistance (or impedance), signal voltage, and power output at normal and reduced filament voltage. In addition, specifications should give operating voltage and current ranges for all other tube elements.[1]

Measurement of Interelectrode Capacitances

For the measurement of capacitances of 1 $\mu\mu$f or less, several methods are available. Perhaps the most accurate procedure uses a precise capacitance bridge. Another satisfactory method uses a vacuum-tube voltmeter to measure the voltage developed across a capacitance at a fixed frequency. Alternative methods are:

(1) Capacitance can be measured as part of a resistance-capacitance discharge circuit in which the tube capacitance discharges through a known resistance. Since $C = t/R$, the capacitance is easily determined. Both time (in the order of microseconds) and resistance (in the order of megohms) can be determined with reasonable accuracy.

(2) Capacitance can be measured as the terminating impedance of a coaxial transmission line. The reactance is measured by placing the tube in the transmission line as a terminating element. The line is then tuned to resonance by varying its length.[2]

Mechanical Performance Tests

Tubes must perform satisfactorily and must possess reasonable life; in addition, they must be rugged. This does not imply that it is permissible to play hockey with a two-inch u-h-f transmitting tube. On the other hand, it should not be necessary to transport the tube in a plush-lined case. The usual points of mechanical weakness can be divided into four main headings:

(1) Metallic bodies (filaments, grids, plates, etc.)
(2) Metallic joints (welds)
(3) Glass bodies (glass envelopes, beads)

QUALITY ENGINEERING
Articles to Come

Shrinkage Analysis in Tube Manufacture
DECEMBER 1944 ELECTRONICS

Quality Control in Tube Manufacture
JANUARY 1945 ELECTRONICS

ENGINEERING in Tube Manufacture

Testing of random samples can indicate when vacuum-tube production deviates from quality standards. Procedures given, applicable to other products as well, cover static and dynamic performance tests, life tests, mechanical tests, and checking of appearance

(4) Glass joints (either glass-to-glass or glass-to-metal)

Among the methods used for checking the mechanical durability of the tube are: 1. Bump tests; 2. Vibration tests; 3. Thermal shock tests.

In a bump test, a pendulum of prescribed weight and length is allowed to strike the tube, which is so suspended that it swings freely on impact. The tube is then tested for mechanical failure, static characteristics and interelement capacitance (revealing changes in electrode spacings).

The vibration test is essentially the same as the bump test. Instead of causing acceleration through impact, the tube is placed on a shake table and is subjected to acceleration values that are several times that of gravity. Both of these tests can be made with voltages on the elements, so that results can be observed on a cathode-ray-tube oscilloscope. In this way, temporary interelement shorts and undue voltage excursions can be observed.

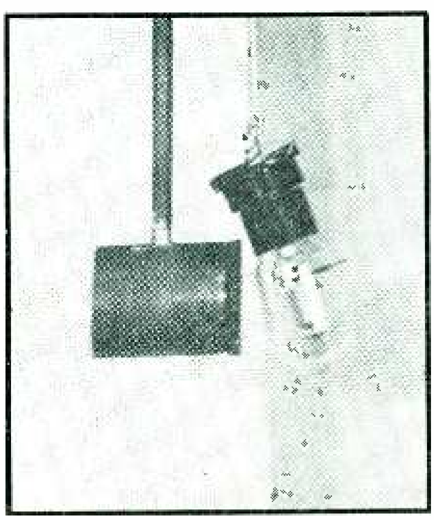
Thermal shock tests are concerned with the condition of the glass. In general, they reveal improper annealing or defective sealing.

The foregoing are the most common mechanical performance tests. It is possible to make as many tests as there are mechanical performance weaknesses.

Life Testing of Tubes

Tube life can be determined on the basis of either static or dynamic performance. In any event, the life will depend (among other factors) upon: 1. Filament voltage; 2. Tube operating temperature; 3. Amount and nature of the free residual gases in the tube and in the metallic parts.

Within a thoriated tungsten filament, thorium is diffused to and evaporated from the surface at a definite rate. The ideal filament voltage is one which causes a current flow of such magnitude that the heat produced establishes an equilibrium between these two rates.[3]

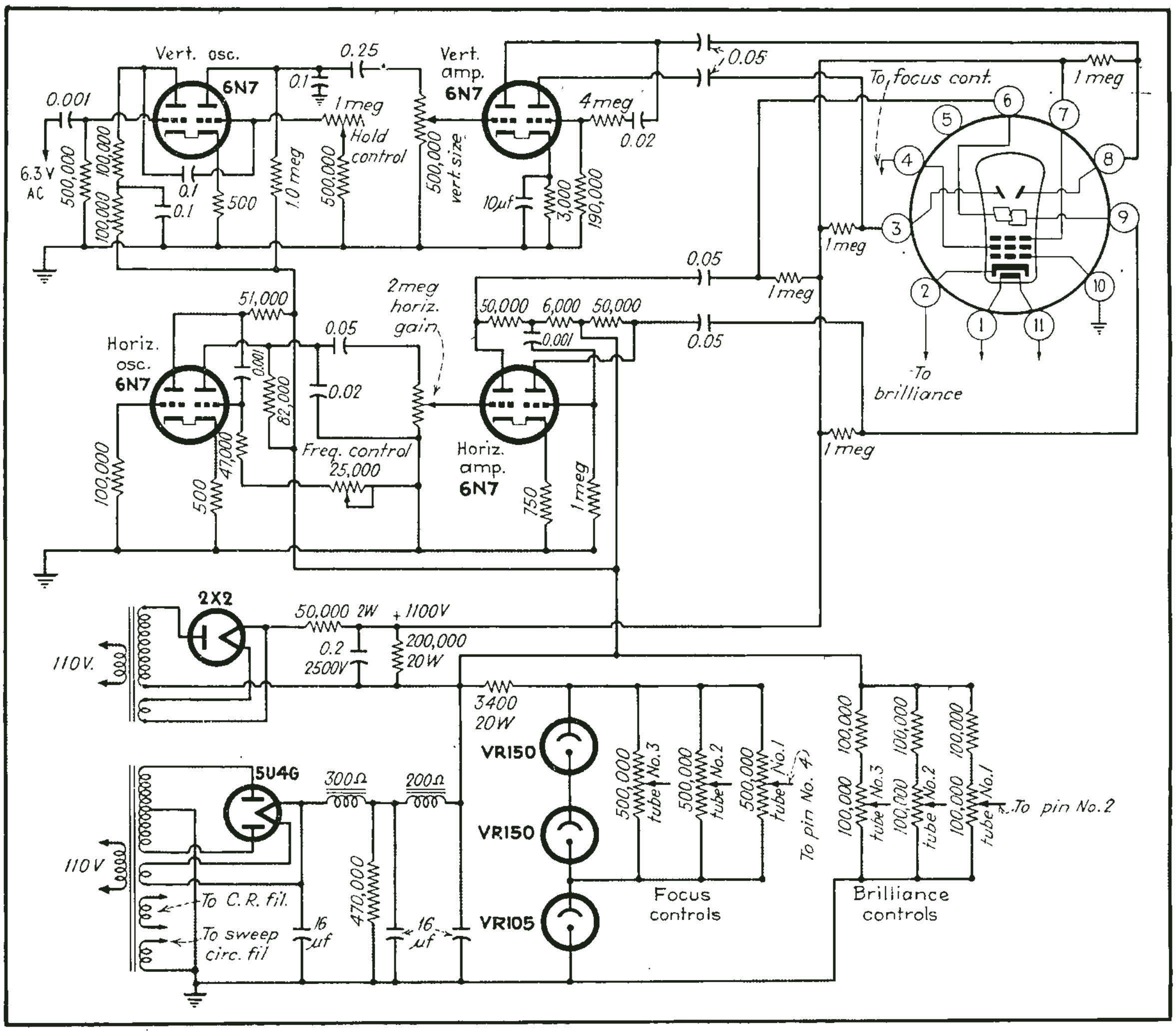


Type 24G tube an instant after being struck by the pendulum hammer used in the bump test

If the filament temperature is too low, insufficient emission will result. If filament temperature is too high, the rate of evaporation will exceed the rate of diffusion. Under this condition, the surface is stripped of its thorium and soon acquires the properties of a pure tungsten emitter, which is about 1/1000th the emission of a thoriated tungsten filament operated at equivalent temperature. As a result, the emission drops rather sharply and the tube ends its useful life abruptly and prematurely.

Such a tube can be brought to life again by means of the so-called "hot shot" treatment, which consists of operating the filament at a rather high temperature (2800 deg K) for a few minutes. This reduces some of the thoria (thorium oxide) within the filament to metallic thorium. Then, operation of the fila-

Laboratory assistant placing a type 24G tube in a static life test rack



Schematic circuit of three-position life test set for use on type 2AP1 cathode-ray tubes

ment at a lower temperature (2200 deg K) diffuses the newly reduced thorium to the surface. However, life obtained by rejuvenation is not a true test of life, but rather is a test of the renewing process.

It has been pointed out that the voltage at which a filament is operated determines its temperature. Temperature determines the fraction of the surface which is covered with a monatomic layer of thorium. Emission may drop below acceptable limits as the fraction of the covered surface is reduced. Since good life depends upon good emission, any factors which disturb or deteriorate the emissive properties of the filament contribute to the early demise of the tube. Operation at excessive filament voltage is one such factor.

Another factor which can result in reduced emission is the presence of excessive amounts of oxygen in the tube. Should this highly-active gas be available to form a chemical union, layers of thorium and tungsten oxides are formed. If this happens, emission quickly drops to the vanishing point.

If the power supply voltage varies over a considerable range, the life test will operate at various temperatures; in other words, anode and filament power dissipation will vary. It is therefore necessary that the power line voltage for life test equipment be regulated within close limits.

Complete and carefully prepared records should be kept of all test conditions and causes of failure. This latter point cannot be overemphasized since one of the primary objects of all life tests is to reveal the weaknesses which cause tube failure. For example, to state that a cathode-ray tube failed due to low light output is not enough; it is much more significant to point out that the low light-output was caused by a deteriorated cathode surface which resulted from the failure of a metal-to-glass seal.

The tube that performs properly is interesting and indeed welcome; nevertheless, it is the defective tube that uncovers weaknesses and helps us evolve new and better production techniques.

Other Tests

Samples should be selected and tested at periodic intervals, in order to ascertain the life of the shipped product. Factory engineers, design engineers, and persons responsible for maintaining production should be advised of all failures occuring in non-experimental tubes. All innovations in processing or structure should be successfully life-tested before becoming a regular part of the manufacturing procedure.

Appearance Tests

A sizeable quantity of tubes should be selected at random from the packing room and should be examined for appearance. This inspection should answer the following questions:

(1) Is the tube clean?
(2) Is the tube identification brand clean and legible?
(3) Is the company trademark clean and legible?
(4) Are the base pins neatly soldered? Has extra flux been wiped away?
(5) Is the tube base on straight?
(6) Are the critical dimensions within specification?
(7) On the basis of the perfect tube being rated as 100 percent, what is the rating of the average of these tubes?

The basic purpose in making this type of examination is to rate the tube's appearance from the standpoint of saleability.

Maintenance of Primary Standards

It is inadequate to say that the vacuum-tube industry sells "tubes". We are offering measurements when we offer tubes. Some assurance must be given that the meters which check those measurements are correctly calibrated.

Tubes are saleable because they have certain characteristics—characteristics which are measureable by meter. Quality, as determined by electrical testing, implies the use of meters, and the testing is no better than the meters that perform the work. Improperly calibrated meters give rise to three risks:

(1) The possibility that acceptable tubes may be rejected.
(2) The possibility that rejectable tubes may be accepted.
(3) The possibility (almost certainty) that the quality will be indeterminate.

Proper calibration of test meters is normally a function of a meter maintenance unit, acting under the jurisdiction of an equipment section. This meter-maintenance unit will generally have a set of secondary standards. However, the quality control activity is so definitely tied up with measurement problems that it is advantageous to have the primary standards retained by the quality engineering division.

Certified standard cells, high-precision potentiometers, volt boxes, current and voltage transformers, highly sensitive galvanometers and accurate wavemeters are a few of the primary standards which should be available to the quality control engineer. Then, when a question comes up involving the accuracy of factory readings, unquestionable evidence can be produced by the quality engineering laboratory. Unless a standards laboratory is set up to do the job, the quality engineering department should act as the "Bureau of Standards" for the factory.

With a test procedure set up, the next step in utilization of quality engineering is analysis of the test results to determine exactly where the trouble is when shrinkage (loss during production) exceeds permissible manufacturing limits. This subject will be taken up in the next issue, and will be followed by the final article covering process control charts and other statistical methods of controlling quality during manufacture.

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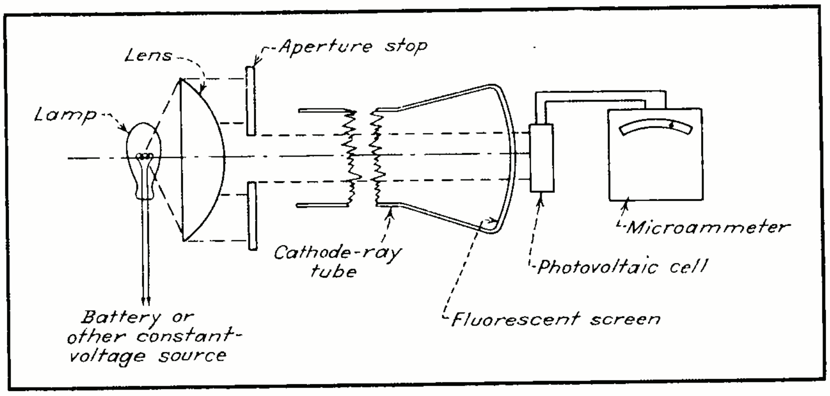
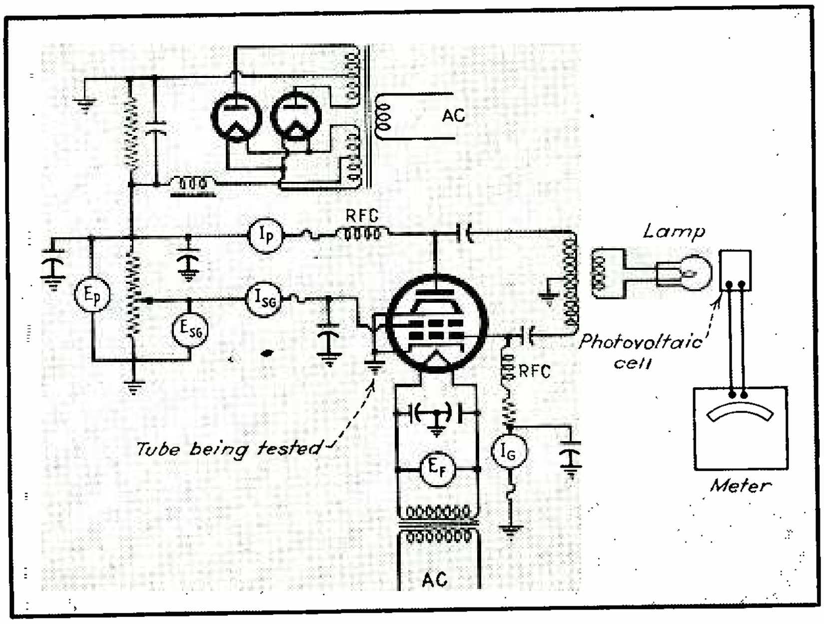


Arrangement used for measuring light transmission of a cathode-ray tube screen



Simplified schematic of oscillator used to determine power output of a beam-power tube. The circuit is essentially a Hartley oscillator in which the interelectrode capacitances of the tube under test serve as the capacitive elements of the tank circuit. The cathode is grounded to complete the plate circuit

DIFFERENTIATING and

Engineering and laboratory applications of differentiating and integrating circuits are described, including anti-hunting circuits for servo mechanisms and other control systems. Practical circuits are developed from a mathematical basis and test results are given

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THE need for an electrical circuit to differentiate a wave of voltage with respect to time often arises in various types of problems. As an example, it is desired to determine the sequence of arrival of several overlapping impulses. The sharper the impulses the more easily they can be separated. Since the rate-of-change of a received impulse will start at zero, rise to a maximum, and fall back to zero in the same interval of time that the impulse itself rises from zero to its maximum, the wave-front of the differentiated impulse is shorter and sharper than that of the original impulse. This is demonstrated in Fig. 1. The signal announcing the arrival of the original impulse can be made as short and sharp as desired by taking successive derivatives of the original impulse by cascading several differentiating circuits.

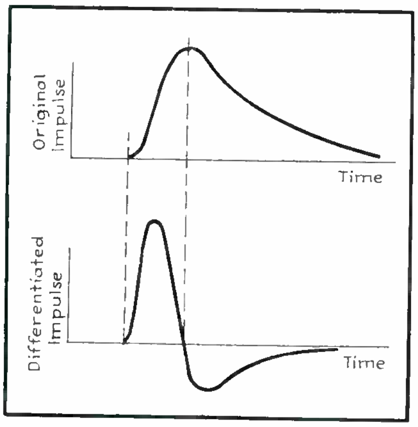


FIG. 1—One application of differentiating circuits is to sharpen impulses

Anti-Hunting Applications

Differentiating circuits can also be used to prevent servo-mechanisms and other control systems from hunting. As an elementary example of this, consider the speed-governing system shown in Fig. 2(a). The speed of the turbine is to be held constant at the value N_0 which makes the voltage of the magneto-tachometer equal and opposite to a selected portion of the battery voltage. If it is not, the difference voltage drives a motor (probably through an amplifying system) which actuates the valve to correct the speed of the turbine.

A sudden load of short duration can cause the turbine speed to be low, as shown at the time t_1 on the curves of Fig. 2(b). Under this condition the difference voltage drives the motor to open the valve, accelerating the turbine until the time t_2. At t_2 the turbine speed has been corrected and, as there is no difference voltage, the motor stops. However, the valve is open too wide and the turbine continues to accelerate, so that the motor reverses to close the valve. At t_3 conditions are set to reverse and the oscillations continue. These oscillations, which are desirable in many applications, are usually kept small by damping the motion of the valve with a dashpot. The valve is in its equilibrium position when the rate-of-change of its displacement is greatest. The dashpot opposes the motion of the valve with a force which is proportional to the rate-of-change of its displacement.

From the curves, it is seen that the difference voltage also has its greatest rate of change when the valve is at its equilibrium position. This offers the possibility of introducing an electrical circuit to produce an effect similar to the dashpot. Let a voltage proportional to the difference voltage be put into a differentiating circuit, and the output of the differentiating circuit be placed in series with the voltages of the speed-control circuit of Fig. 2(a). By adjusting the magnitude of this voltage, the oscillations may be critically damped, over damped, or under damped, whichever is the more desirable.

Research Applications

Integrating circuits can be used in many measurement and research problems where the summation of some function is required at every instant. Mechanical methods of integration are most convenient when the function being integrated is fairly constant and uni-directional. However, for alternating and rap-

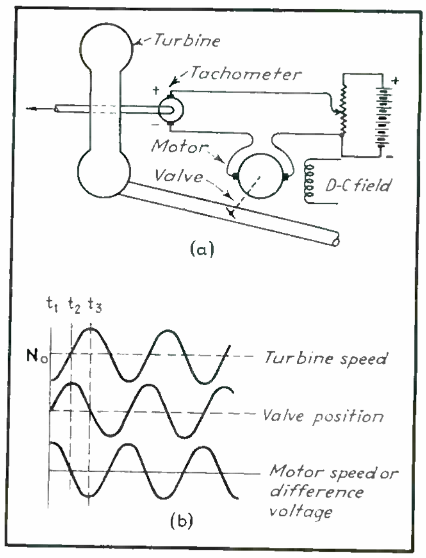


FIG. 2—Instead of damping the valve in the turbine steam-line with a dash pot, a differentiated voltage can be applied to the motor to prevent the system from hunting

INTEGRATING CIRCUITS

idly changing variables, electrical integrating circuits such as are described in this paper are more satisfactory.

A common application is in oscillographic studies of magnetic flux. To obtain an oscillogram of the magnetic flux linking a search coil, the voltage induced in the search coil can be applied to an integrating circuit, and the output of the integrating circuit delivered to the oscillograph. The integrator voltage is proportional to the flux because the induced voltage is proportional to the rate of change of flux;

$$E_{ind} = -N\frac{d\phi}{dt}\times 10^{-8} \text{ volts} \qquad (1)$$

The flux is then proportional to the integral of the induced voltage:

$$\phi = \int d\phi = -\frac{10^8}{N}\int E_{ind}\, dt \text{ lines} \qquad (2)$$

Figure 3 shows hysteresis loops that were taken using an integrating circuit. These loops and the associated exciting current waves are for the iron-cored inductor of a series *R-L-C* circuit experiencing subharmonic oscillations.[1]

Similarly, an oscillogram of the displacement of a moving object can be obtained with a dynamic pickup if the object moves the conductors of a coil perpendicular to a magnetic field. The voltage induced in the coil is applied to the integrator, and the voltage from the integrator is applied to the oscillograph. This integrated voltage is proportional to displacement because the induced voltage is proportional to the velocity of the coil;

$$E_{ind} = BlV \times 10^{-8} \text{ volts} \qquad (3)$$

Displacement is then equal to the time integral of the velocity.

$$\text{Displacement} = \int (\text{Velocity})\, dt = \frac{10^8}{Bl}\int E_{ind}\, dt \text{ cm} \qquad (4)$$

This is useful in various mechanical problems, such as studying the vibration of a piece of machinery, or following the motion of a moving part such as the intake valve on a diesel engine.

In physiological studies, nervous activity or other responses can be integrated to compare total activity or response under various conditions. If the signal being integrated is not uni-directional, it is usually necessary to rectify the signal before it is integrated.

Integrating circuits can be used in many other applications requiring the totalling or the summation of some variable.

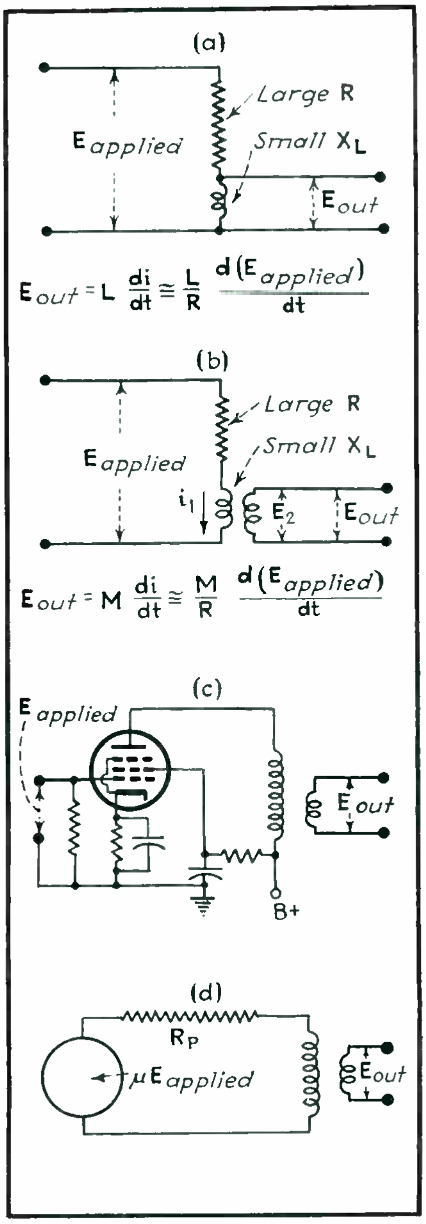
Inductance as a Differentiating Circuit Element

To perform differentiation electrically, the function which is to be differentiated must first be made proportional at every instant of time to some electrical quantity. This can then be impressed on some circuit element which yields another electrical quantity which is proportional to the derivative of the impressed quantity.

The voltage applied to an inductance is

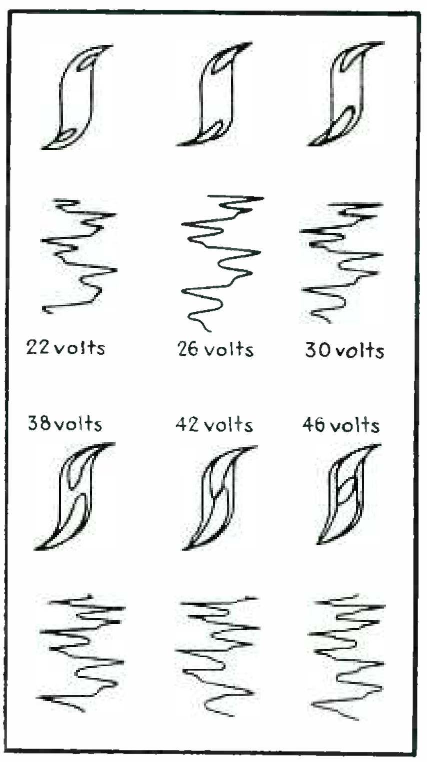
$$E_L = L\frac{di}{dt} \text{ volts} \qquad (5)$$

If the current through the inductance can be made proportional at every instant to the function



ABOVE

FIG. 4—(a) An inductance in series with a large resistance forms a voltage differentiating circuit. (b) The use of a mutual inductance to couple to the output improves the differentiating action of the circuit. (c) A pentode replaces the series resistance of the above circuits, and also provides amplification. (d) The equivalent circuit of (c)



AT LEFT

FIG. 3—Exciting current and resulting hysteresis loops for an iron-cored inductor in an *R-L-C* circuit undergoing subharmonic oscillations. The hysteresis curves were obtained by differentiating the voltage induced in a search coil

which is to be integrated, the voltage across the inductance will be proportional to the derivative of the function.

In general, however, a voltage wave which is proportional to the function is available rather than a current wave. Several methods are available by which this voltage wave will cause a current that is proportional to the voltage function to flow in the inductance. In the basic circuit shown in Fig. 4(a), a resistor is connected in series with the inductor. If the resistance is large compared to the reactance at the highest-frequency component of the impressed wave, the voltage across the coil will be negligibly small, and the current will be nearly proportional to the applied voltage:

$$i \cong \left(\frac{E_{applied}}{R}\right) \text{amperes} \qquad (6)$$

Since the voltage across the reactance is small compared to the voltage across the resistance, the output of the integrating circuit is necessarily much smaller than the impressed voltage. The minimum ratio of resistance to reactance which is permissible is discussed later.

If the voltage of Eq. (5) is to be measured across the coil directly, the resistance of the coil must be quite small to insure that the iR_L voltage drop is negligibly small. This iR_L voltage drop can be completely eliminated if the output voltage is obtained by mutual inductance from a second coil on the same core as the first, as shown in Fig. 4(b). This is a much more desirable circuit in most applications, because the resistance of the first coil does not distort the output wave-form. It simply aids the series resistor in making the current proportional to the applied voltage. The output voltage induced in the second coil is

$$E_2 = M\frac{di_1}{dt} \text{volts} \qquad (7)$$

Its magnitude can be adjusted by adjusting the turns on the secondary coil.

The current through the inductance can also be made proportional to the applied voltage by using a tetrode or pentode vacuum tube. The plate current of these tubes is almost independent of the

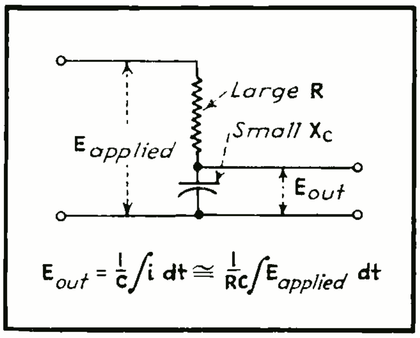


FIG. 5—A large inductance in series with a small resistance forms an integrating circuit

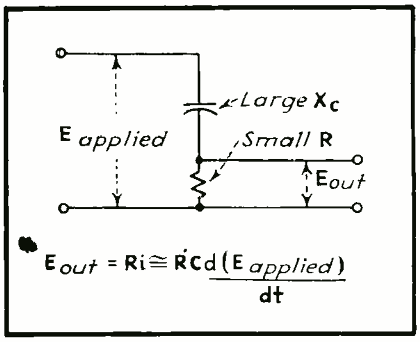


FIG. 6—If the voltage to be differentiated contains only a-c components, a capacitor can serve for differentiating

plate voltage. If the signal to be differentiated is applied to the control grid, the resulting plate current will be proportional to the signal and nearly independent of the load impedance. As shown in Fig. 4(c) and 4(d), this is equivalent to substituting the plate resistance of the vacuum tube for the series resistance used in the basic circuits of Fig. 4(a) and 4(b). These circuits offer two advantages over using the tube as a conventional amplifier with the basic circuit: First, more voltage is available at the output for a given input voltage; second, a greater swing of plate voltage is permissible for a given battery voltage.

Inductance as an Integrating Circuit Element

Inductance can also be used to integrate. From Eq. (5), it is seen that

$$di = \frac{1}{L} E_L\,dt \text{ amperes} \qquad (8)$$

and

$$i = \frac{1}{L}\int E_L\,dt \text{ amperes} \qquad (9)$$

Thus if the voltage that is to be integrated is applied to an inductance, the resulting current is proportional to the integral of the applied voltage. If the integrated function is to be amplified or applied to an oscillograph, this current must be converted into a proportional voltage by passing it through a resistance as shown in Fig. 5.

If it is to be assumed that the applied voltage is the voltage across the inductance, the total resistance of the circuit must be negligibly small compared to the reactance of the coil at the lowest-frequency component of the applied voltage. This means that the output voltage is again very much smaller than the impressed voltage.

The inductance is best suited for use as a differentiating and integrating circuit-element when this portion of the circuit must carry a direct component of current. It is unsatisfactory for use in many applications. At low frequencies, a large coil is necessary to give a reactance which is high compared to its own resistance. At high frequencies, the current through the distributed capacitance of the coil becomes large, so that Eq. (5) and (7) are no longer valid. If an iron core is used, an air-gap should be inserted to insure that the self inductance and the mutual inductance remain essentially constant.

Capacitance as a Differentiating Circuit Element

Because of their low cost, small size and freedom from residual resistance and inductance, capacitors are generally more satisfactory than inductors for differentiating or integrating circuit elements. However, they cannot carry direct components of current, as the inductors do, which is a disadvantage in some applications.

The charge on a capacitor of C farads and the current through the capacitor are

$$q = CE_C \text{ coulombs} \qquad (10)$$

$$i = \frac{dq}{dt} = C\frac{dE_C}{dt} \text{ amperes} \qquad (11)$$

This enables the capacitor to be used as a differentiating circuit element. If the function to be differentiated is proportional to the voltage applied to the capacitor, the resulting current through the capacitor is proportional to the derivative of

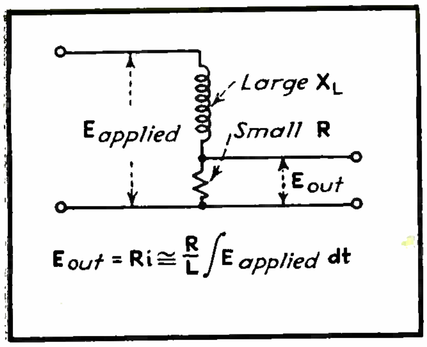


FIG. 7—Compare this capacitance integrating circuit with the inductance differentiating circuit of Fig. 4(a)

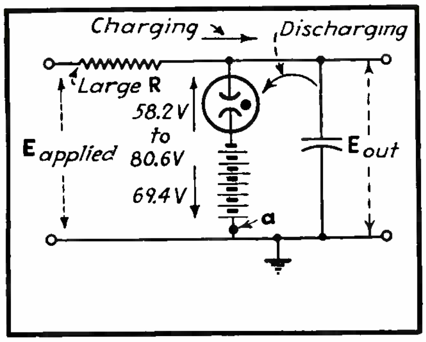


FIG. 8—Neon lamp circuit used to periodically discharge the integrating capacitor when charging is unidirectional

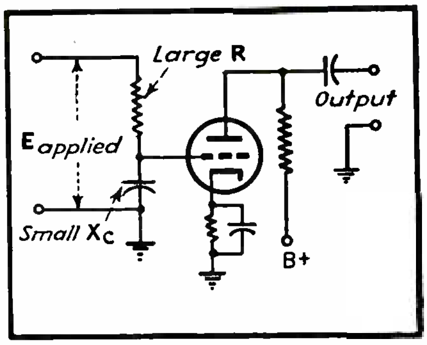


FIG. 9—Basic integrating circuit using a capacitor and amplifier. The signal source provides a d-c path to ground

the applied voltage. As shown in Fig. 6, a small resistance can be placed in series with the capacitor to give an output voltage proportional to this current.

Capacitance as an Integrating Circuit Element

The charge, q, which is delivered by a current is, from Eq. (11),

$$q = \int i\,dt \text{ coulombs} \qquad (12)$$

Any circuit element which yields a measure of the charge when a current is passed through it can be used in an integrating circuit. An example of this was the old electrolytic ampere-hour meter, which measured the ampere-hours taken by a customer in terms of the change of weight of a plate in an electrolytic cell.

Several circuits, which can be adapted for use over a wide range of frequencies, measure the charge delivered by the current in terms of the voltage across a capacitor. From Eq. (10) and (12), it is seen that the voltage across a capacitor is

$$E_C = \frac{1}{C}\int i\,dt \text{ volts} \qquad (13)$$

Thus if the current through the capacitor is made proportional at every instant to the function which is to be integrated, the voltage across the capacitor is proportional to the time integral of the function. To obtain a current which is proportional to the function from a voltage which is proportional to the function, connect a resistor in series with the capacitor as shown in Fig. 7. If the resistance is large compared to the reactance of the capacitor at the lowest-frequency component of the impressed wave, the voltage across the capacitor will be negligibly small, and the current will be nearly proportional to the applied voltage at every instant.

$$i \cong E_{applied}/R \qquad (14)$$

If the current being integrated is uni-directional, or has an average value predominantly in one direction, the voltage across the capacitor will rise continuously, so that it will not remain small compared to the voltage across the resistor. Under these conditions, the capacitor can be discharged through a thyratron or glowtube when its voltage reaches a predetermined value. The discharge current can be made to operate a counter by passing it through a small resistance inserted at *a* in Fig. 8, and applying the resulting positive pulse of voltage to the grid of a thyratron. The plate current of the thyratron can actuate a solenoid-operated counter. In this way the counter indication times the charge accumulated before each discharge gives the total integral.

The bias battery used in series with the gas-glow tube should have a voltage approximately half-way between the voltages at which the glow tube ignites and extinguishes. With this bias voltage, the average leakage through the tube and capacitor will be zero. Circuits of this kind can be used to measure very small currents by integrating the current to evaluate the charge delivered in a measured interval of time.

Practical Circuits

As with the inductor, the output voltage from circuits using a capacitor to integrate is much smaller than the applied voltage. If the output voltage is to be amplified by a conventional amplifier, the voltage across the capacitor should be applied directly to the grid of the amplifier, without a grid resistor, as shown in Fig. 9. A grid resistor would be in parallel with the capacitor, and would tend to disturb the integral relationship between current and charge. To prevent the grid from floating, the input circuit should provide a d-c path to ground.

As was discussed earlier, the plate resistance of a tetrode or pentode vacuum tube can be substituted for the series resistor used in the basic circuit of Fig. 7. The ideal load impedance, Z, in Fig. 10(a) and 10(b) would carry only the direct component of the plate current, so that all variations of the current which were caused by the signal on the control grid would be forced to flow through the capacitor. The best impedance to use depends chiefly on the frequency of the signal being integrated. Since the signal component of the current in Z should be small, the impedance of Z must be large compared to the reactance of the capacitor at the lowest-frequency component of the impressed wave.

A resistor is generally unsatisfactory for use as the load impedance Z, because if it is large enough to prevent the flow of an appreciable portion of the signal current, an excessive battery voltage is required to give a reasonable plate voltage. Since a pentode vacuum tube with constant control-grid voltage carries a plate current which is nearly constant and independent of plate voltage, a pentode could be used for this load impedance, as shown in Fig. 10(c);

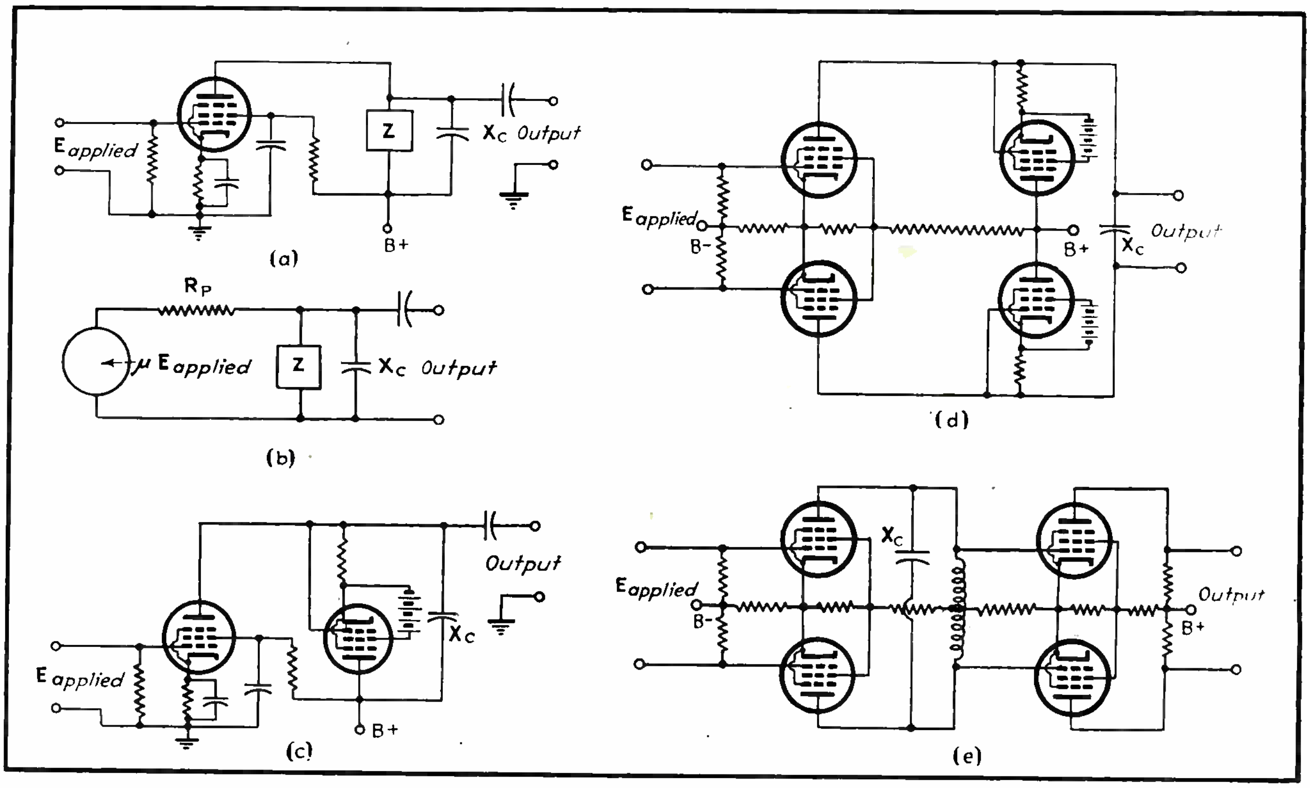


FIG. 10—(a) The large resistor of Fig. 7 can be replaced by a pentode if integrating capacitor X_c can be bridged by an impedance Z which will pass direct current, but will have a very high (ideally infinite) impedance to alternating current. The equivalent circuit is shown at (b). (c) A pentode can be used for the impedance Z. (d) Push-pull version of the circuit of (c) eliminates the need for by-pass capacitors, thereby providing unlimited low-frequency integration. Where the wave to be integrated does not contain an extremely low-frequency component, the circuit at (e) can be used. The inductor is the impedance Z of (a). The circuit shown has been designed for direct coupling to an amplifier stage

this is equivalent to using the plate resistance of the pentode for a load impedance. If the cathode bias resistor is made large, its degenerative effect will help maintain a constant current through this tube. This circuit is somewhat similar to the Schmitt[2] amplifier.

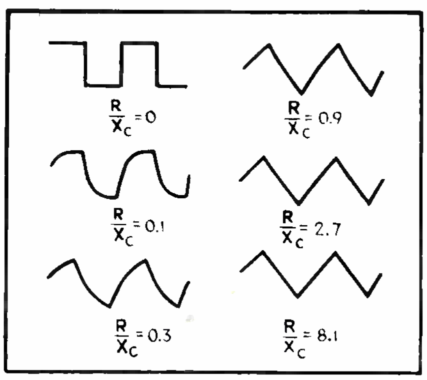


FIG. 11—Using the integration circuit of Fig. 7, with $R = 10{,}000$ ohms and the impedance of X_c at the lowest frequency component of the applied square wave related to R as tabulated above, it is seen that a ratio of $R/X_c = 8$ provides effectively perfect integration

If these circuits use tubes in push-pull, as shown in Fig. 10(d) and 10(e), they are much more stable, and have the many other advantages of push-pull circuits. Wider voltage swing is permissible. Distortion from non-linearity of the characteristics is balanced out. No net direct current magnetizes the core of an iron-core inductive load. No net direct voltage appears across the integrating capacitor.

Tests

The output of the various circuits discussed in this paper is only approximately proportional to the derivative or the integral of the impressed quantity, depending on the ratio of the selected reactances and resistances. The differentiation or integration becomes more accurate as the impedance from which the output voltage is taken is made smaller. However, the output voltage is also made smaller as this impedance is decreased.

To serve as a guide in selecting the ratio of resistance to reactance, the R-C integrating circuit shown in Fig. 7 was tested with a rectangular wave input. The resistance was 10,000 ohms. Since

$$\int K\,dt = Kt \qquad (15)$$

the integral of the rectangular wave should be a triangular wave.

For the first curve of Fig. 11, the capacitance was set at zero, so that the square-wave input appeared across the output. For the following curves, the capacitance was set to give the values of R/X_c that are indicated, where X_c is calculated for the lowest-frequency component of the square-wave input. It was necessary to increase the gain of the oscillograph to hold the pattern at approximately the same size when the capacitance was increased.

These tests indicate that a ratio of R to X greater than eight is satisfactory for most oscillographic work.

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(1) Spitzer, Charles F., Subharmonic Response in Non-Linear Series Circuits (paper, Yale University, New Haven, Conn.). Accepted for publication by *Jour. Applied Physics*.

(2) Schmitt, Otto H. A., A Method of Realizing the Full Amplification of High-Mu Tubes, *R. S. I.*, December, 1938.

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Sixteen years ago Cinch started manufacturing sockets for radio sets. As the years went along we kept expanding and adding to our line. Continual pioneering on socket development as new tubes were designed has always been the Cinch policy. In addition to original research on sockets, both laminated and molded, we were first in the field with a complete line of miniature socket assemblies together with nut straps, shields and associated items. Special types, too, have been an important contribution to the electronic program. Such a performance indicates socket engineering KNOW HOW and the Cinch socket line is as complete as practical volume considerations would warrant.

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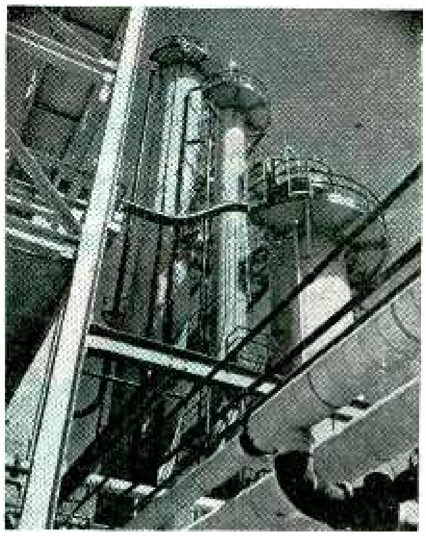
INDUSTRIAL CONTROL

Electronic Indicator for Oil Refining Plant

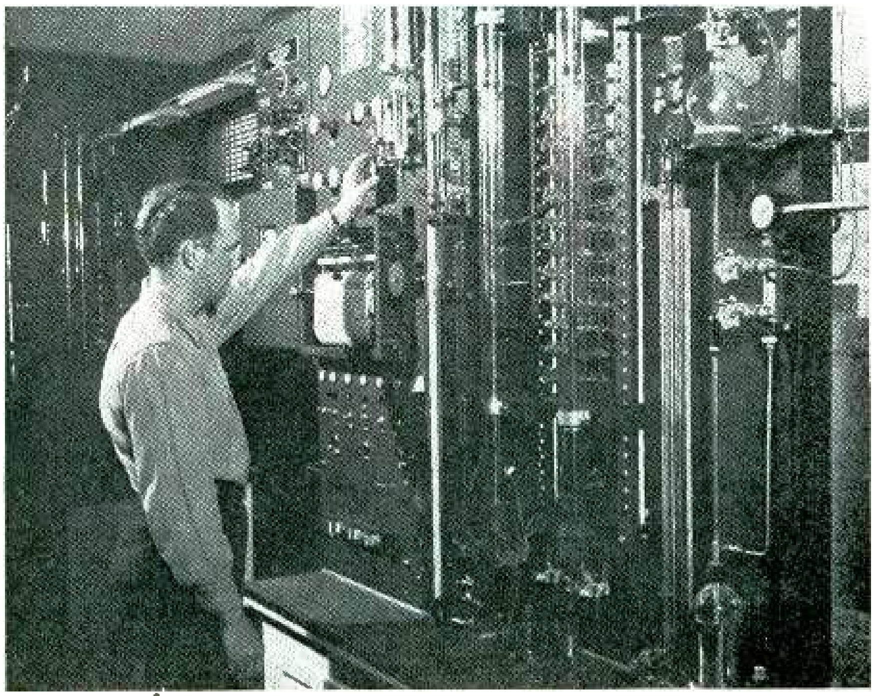
In modern oil refinery methods, accurate boiling points of the various vapors, to be separated in fractionation, must be pre-determined in the laboratory. This is now accomplished with electronic equipment.

The instrument, manufactured by Brown Instrument Co., is a continuous balance potentiometer pyrometer, which utilizes electron tubes to magnify a small temperature gradient. This is mechanically connected to a conventional Brown recording potentiometer. A special high-sensitivity fine wire thermocouple, consisting of six individual couples spaced about one-half inch apart, is located in the reflux zone of the fractionating column. The electromotive forces produced by these thermocouples are amplified by the electron tubes and recorded continuously by pen on a time-temperature strip chart.

The instrument finds particular application at present in the rapid and accurate analyses of four and five-carbon hydrocarbons. The special thermocouple covers all possible positions of a wandering condensation ring, which is known to vary several inches up or down in the fractionating column. Thus the true boiling point of a compound is accurately recorded no matter which couple is located in the coldest zone. This could never be accomplished by a single-junction thermocouple. The electronic recorder and the special Podbielniak fractionating column make possible rapid and accurate separation of compounds whose boiling points are only one and one half degrees apart, a feat which cannot be accomplished by the older type of apparatus.



Towers of the alkylation unit at the Richfield refinery where electronic apparatus is used to indicate the boiling point of the various vapors. In the unit above, iso-pentane and iso-butane are combined into alkylate, the blending agent that puts long range into super-octane aviation gasoline



The boiling point of any hydrocarbon fraction an oil refiner desires to separate can be determined by electronic apparatus used in conjunction with this pilot fractionation tower recently installed at the Richfield 100-plus octane refinery. In the photo above, the engineer is adjusting the equipment while noting readings on the Brown Instrument recorder

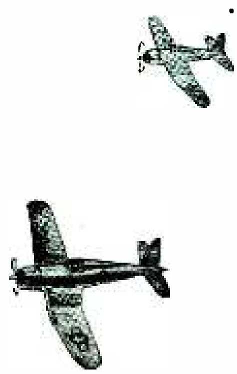
The new development considerably reduces distilling time, with increased accuracy, and opens up a new field in fractional distillations. To accomplish the perfect blendings necessary in producing the new "100-plus" octane gasoline used in war planes, Richfield Oil Corp. has installed this electronic equipment in its newly expanded refinery near Los Angeles.

Electronic Heating in Textile Industry

Tests conducted with electronic heating have shown that resin-impregnated fabrics may be cured in roll form. Curled selvages are eliminated by this form of drying, and uniformity of curing is obtained because temperature may be controlled accurately. Resin which is deposited on the innermost section of the fabric structure receives the same degree of heat as that on the outside. Laminated fabrics may also be cured in roll form.

Successful setting of twist in rayon and in nylon, handling yarn

This Vibrator Carries Its Own Air Protection



"FIGHTING" vibrators must be dependable—now or after months of storage—and under a variety of conditions ranging from the chilling near-vacuum of the stratosphere to the moist, corrosive atmosphere of a submarine. Ordinary peacetime vibrators just can't meet these war requirements. Their containers breathe and admit trouble-making fumes. They fail to function in some types of high-altitude aircraft equipment, because lack of internal air pressure causes ionization breakdowns.

That's why this Mallory vibrator is enclosed in a specially designed case, hermetically sealed to keep it air-tight. This is double assurance that fine tungsten contacts and other precision parts will function perfectly under the toughest assignments.

Today, Mallory hermetically sealed vibrators flow from the production line to every battle front. They're used on ships and planes and tanks—and they take their own three cubic inches of normal atmosphere with them. To test this "breathing space," each vibrator is subjected to an internal pressure of twenty pounds per square inch.

If you manufacture receivers or transmitters for wartime use—or any other battery-powered equipment subject to unusual atmospheric stresses—get the complete facts about Mallory hermetically sealed vibrators. See your Mallory distributor, or write direct.

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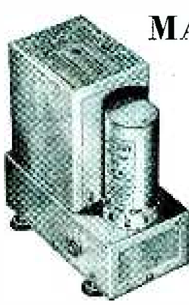

Flexible heavy-duty vibrator power supplies, built to take rough handling and to operate under great extremes of heat, cold and humidity. Widely used under war conditions: ideal for peacetime products.

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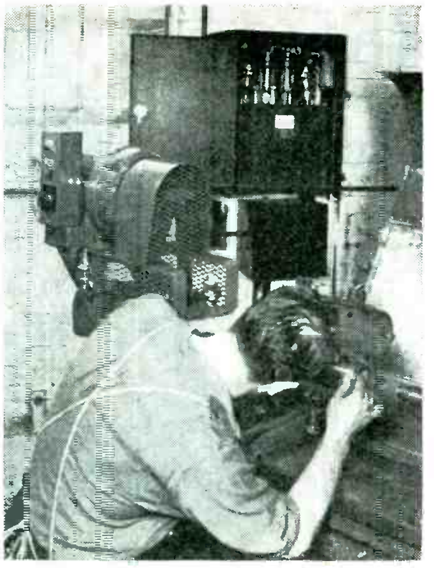
★Advt. No. 529—2nd Cov., 2 cols.—Electronic Industries—December, 1944
★Advt. No. 529-A—1 page, B&W—Electronics—November, 1944

on cones as large as 18 lb, was reported in ELECTRONICS for September, 1944.

Rayon cakes may also be dried with high-frequency equipment and can be handled in throwing mills after tinting or other processing operations where it is advisable to handle the yarn in cake form. This type of drying permits dyeing of rayon in cake form as the cakes may be dried either in a vacuum or at atmospheric pressure. Handling rayon in cake form eliminates skeining and other handling operations.

Electronic heat for drying in slashing operations holds possibilities, and other uses suggested by *Textile World* include the drying of heavy paper-makers' felts, heavy carpets, and other textile fabrics of great bulk, either in roll or in sheet form.



Electronic equipment in the cabinet supplies current to the shunt-wound motor at left. The pushbutton and speed control panel permits stepless operation over a 20-to-1 range while the grinder is running

30-Year Old Grinders Use Electronic Control

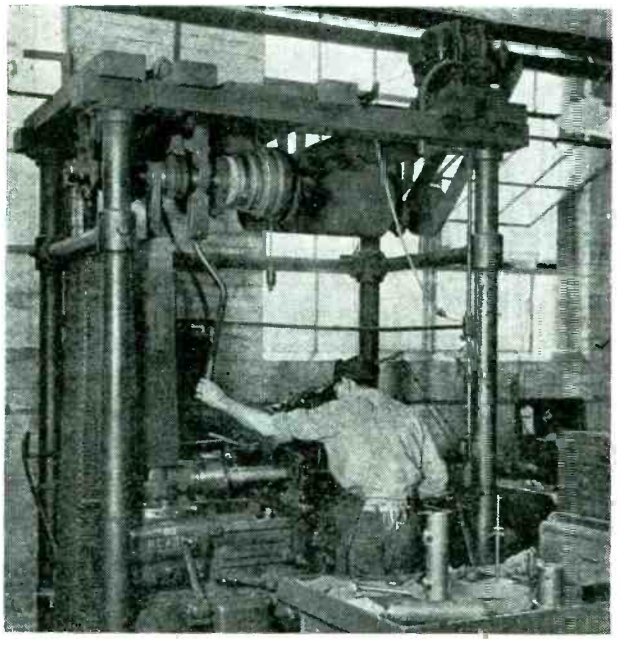
ELECTRONIC CONTROL can provide old machines with greatly improved operating characteristics when it is impractical to obtain new machine tools. Use of electronic motor drives on three 30-year old Heald grinders resulted in improved quality of precision finishing, vibration-free, stepless speed control over a 20-to-one speed range and better working conditions. The electronic drive (called Mot-O-Trol by Westinghouse) consists of an electronic rectifier to change alternating current to direct current, plus a d-c driving motor whose stepless speed is controlled by a potentiometer in the pushbutton station.

At the Axelson Manufacturing Company, problems in machining hardened pump liners were augmented by specifications which require a finished tolerance of 0.001 of an inch. The variation in liner sizes and materials used required grinding speeds over a wide, closely regulated stepless range in order to secure the desired tolerance and finish. This stepless quality in speed regulation permits the operator to choose just the right speed for size of hole material to be finished and grade and grit of the wheel. This helps to eliminate vibration and chatter marks in the work and gives a straight, true, round hole, an ideal condition for the honing operations that follows, for unless a perfect hole is presented to the hone it is apt to follow any irregular conditions of the ground hole.

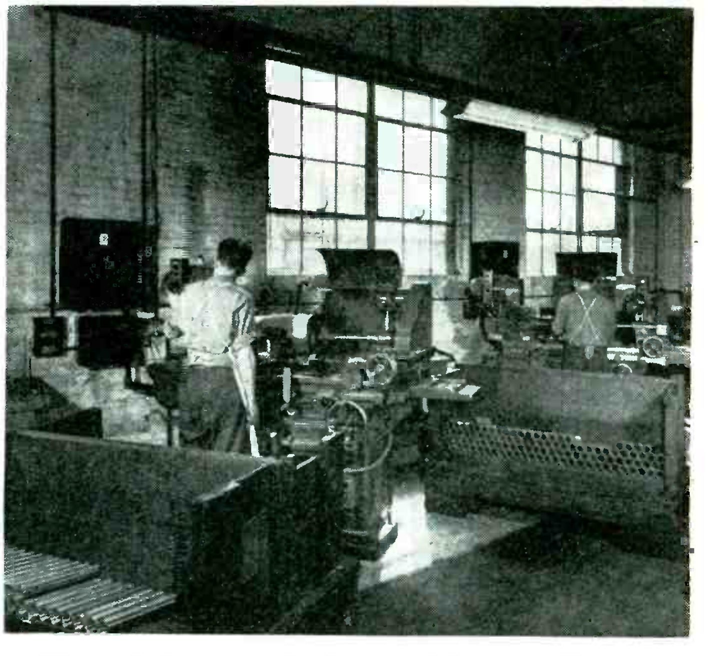
Advantages

In addition to the advantages gained by providing stepless adjustable speed over a wide range, physical advantages were gained by new layouts of the machines. The three grinders were reset on a 35-degree angle with a saving in floor space of about one-third. Removal of all overhead pulleys, belts and shafting resulted in increased safety, improved illumination and elimination of vibration.

The time study department at Axelson reports that an appreciable



Before the advent of electronic control, these 30-year old Heald grinders were powered by belt-and-pulley drive that allowed only four speeds to machinists, occupied considerable space on the floor and blocked light and ventilation



After replacing the overhead countershaft with a Westinghouse electronic drive, additional working space, smooth speed change over a 20-to-1 range and pushbutton speed adjustment were provided for the grinders

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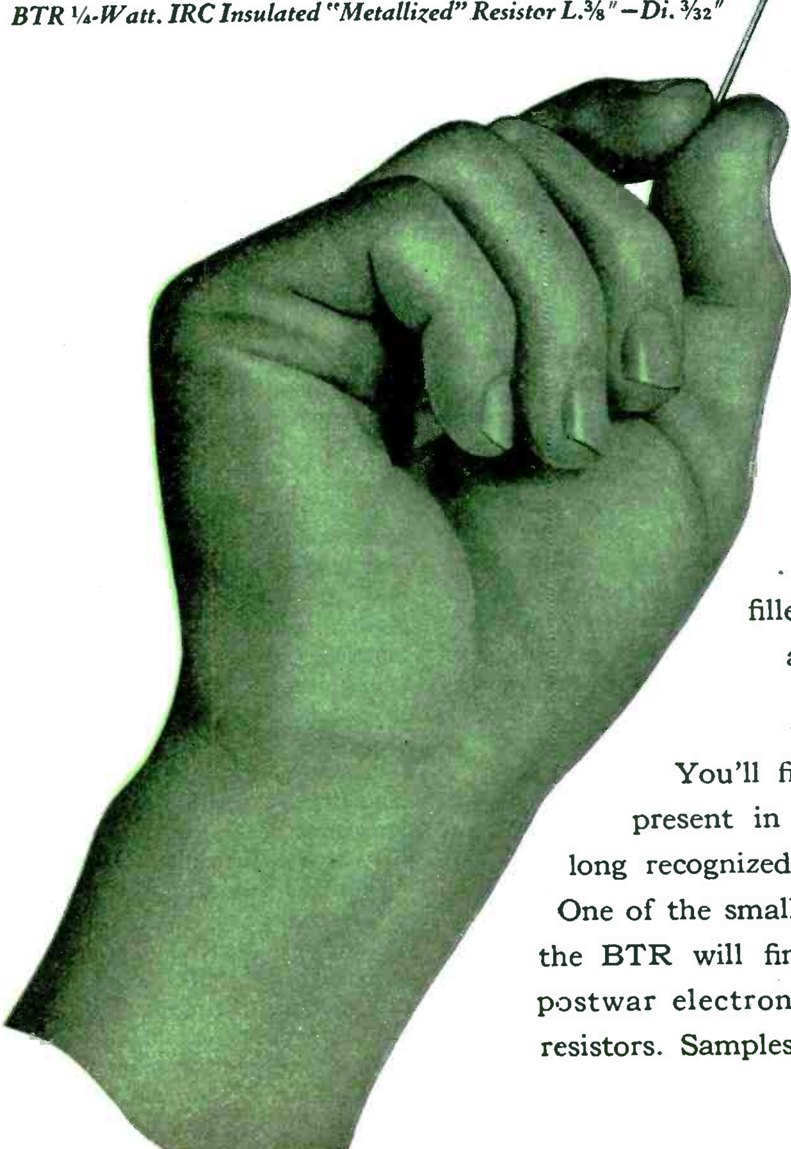

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You'll find the same high quality standards present in these tiny trojans that you have long recognized in the popular I R C type BT's. One of the smallest insulated resistors on the market, the BTR will find wide application in all types of postwar electronic equipment requiring low-power resistors. Samples and technical data sent on request.

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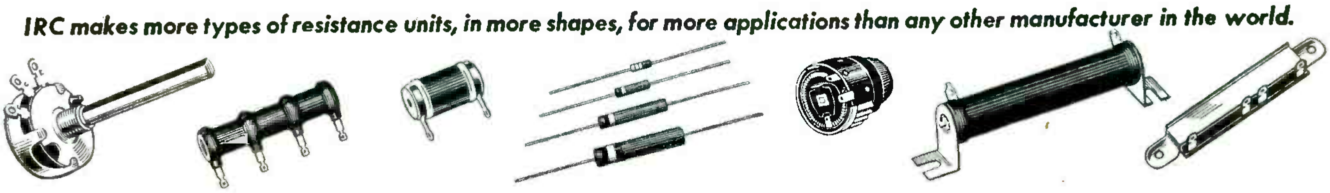
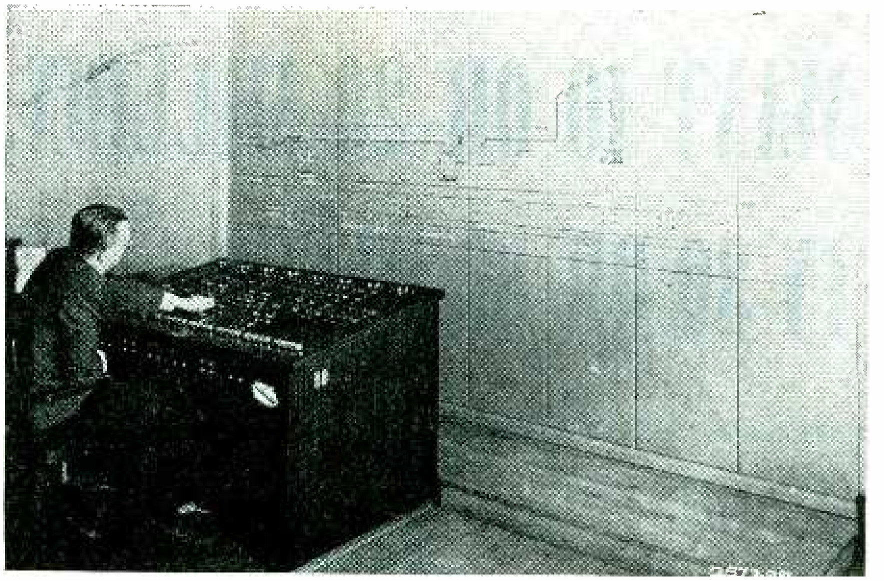


saving in set-up time has been effected. V. Mancuso, works manager, believes this is due largely to the better illuminated working area, plus less complicated controls and speed changing apparatus on the grinders. The machinist can preset work speed either before starting work or change speed while the motor drive is running. Since speed change can be made smoothly, this can be done without danger of spoiling the work in process.

Besides a wide speed range, the Mot-O-Trol provides regulation that is effective in maintaining a constant motor speed with wide changes in load and limits the motor current to a definite maximum safe value. Speed control rheostats are so small that they can be built into a pushbutton station.



The photo above shows a Westinghouse electronic control desk and monitoring panel in a utility company office where it is used with power-line carrier equipment for supervisory control and fault correction

Five Uses of Electronics in the Electric Light and Power Industry

UTILITY COMPANIES have used the following five applications of electronic apparatus to extend and assure continuity of electric service, as well as conserve electric energy by reducing the time normally required to perform the operation.

1—Hi-speed power line carrier relaying to disconnect the circuit in case of faults in the protected section.

2—Power-line carrier intersystem communication.

3—Telemetering to expedite load dispatching or load control so as to assure adequate power when and where needed.

4—Supervisory control using power-line carrier equipment.

5—Meter and instrument testing, plus load-regulating equipment.

Carrier Relaying

Supplying more kilowatts on existing transmission lines is one of the many problems faced by utilities; not only more kilowatts, but better and faster clearing of line faults as well as high-speed opening and closing of circuit breakers. To do this, many schemes have been proposed. Electronic equipment has provided the answer in the form of power-line carrier relaying.

For good system operation, the high-speed clearing of faults on transmission lines is important. The best overall protection is provided by the method known as differential relaying, in which conditions at the two ends of the line are compared. This determines whether the fault is on the line section or external to the protected zone and assures simultaneous tripping of circuit breakers in 1 to 3 cycles. Such action is desirable from the standpoints of stability, continuity of service, quick reclosing, and minimum damage to equipment.

Power-Line Carrier

Power-line carrier provides a highly reliable type of communication by utilizing the power line for the communication channel.

Improvements and developments such as electronic switching, high-voltage line-coupling equipment and other refinements have been given an impetus unequalled in more normal times.

The frequencies usually utilized range from 50 to 150 kc. The r-f energy is confined almost entirely to the wire lines and not radiated into space as is common in radio broadcasting. This results in greater efficiency and makes it possible to transmit greater distances with less high-frequency energy.

An important application of power-line carrier is to provide reliable, high-quality voice communication between various points on the system, such as generating stations and dispatchers offices, or between dispatchers offices of interconnected systems.

Telemetering

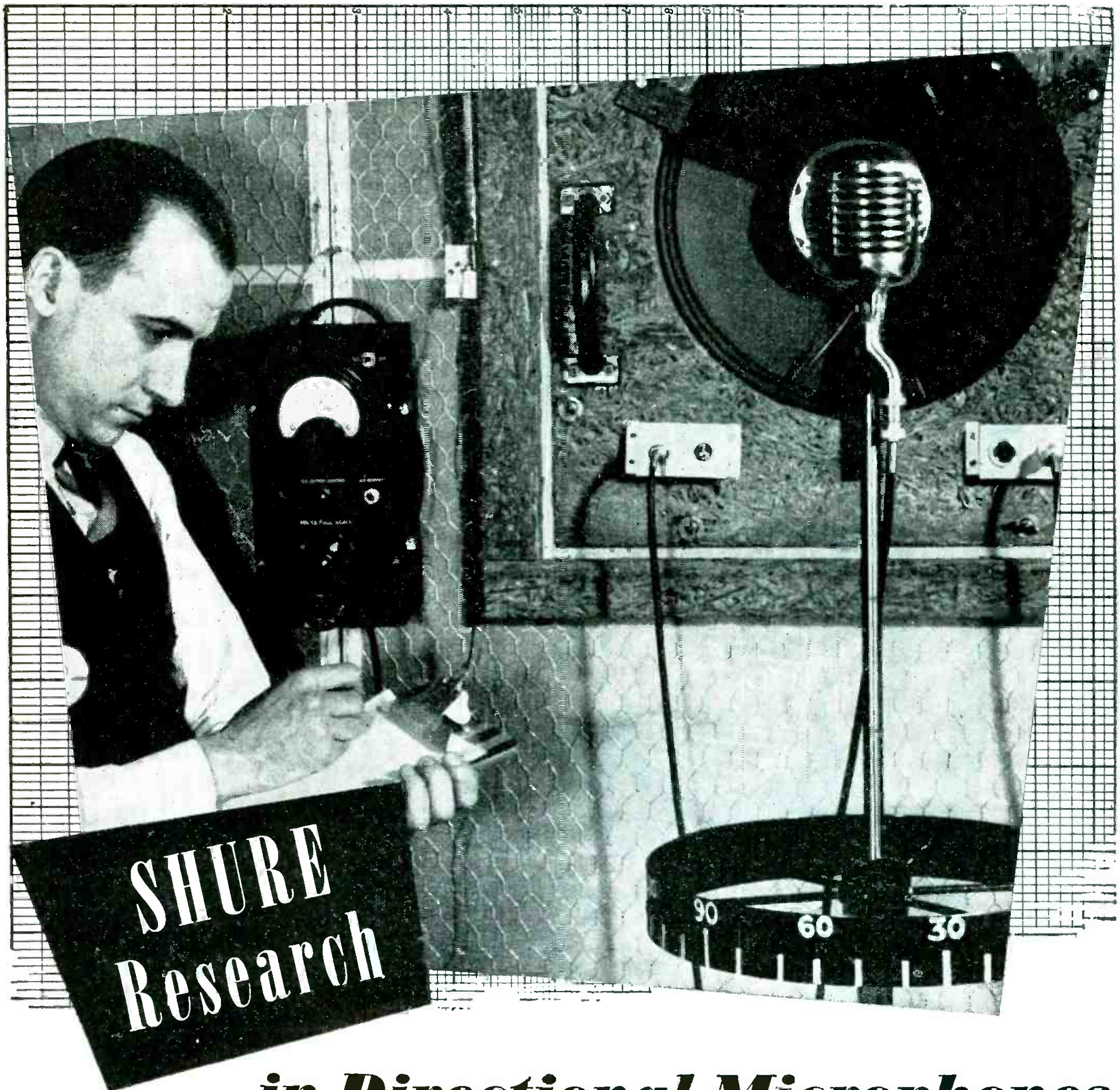
Transmitting electrical values from remote points on a transmission system to a central point where they are summed up and interpreted, then sent back as control impulses to the point of origin or to any other point on the system, is called telemetering. With electronic apparatus, speed and accuracy are obtained, coupled with the advantage of not having parasitic burdens imposed on the measuring devices such as watthour meters, indicating and recording instruments.

Electronics has made the transmission of essential operating intelligence not only accurate and fast, but also brings together significant quantities which can be used independently for manual system control or totalized to initiate automatic load-control equipment.

Supervisory Control

Essential circuit breakers serving vital power areas, when disturbed by line faults, can be rapidly restored to normal service by power-line carrier systems. Apparatus switching at distant generator, transformer or conversion stations are all electronic functions.

The cost of older but well ac-



. . . *in Directional Microphones*

It is not enough to design a Microphone that merely converts sound waves into electrical impulses. A Microphone, to be truly useful in modern broadcasting, should be discriminating enough to accept wanted sounds —and reject unwanted sounds. Shure Research was the first to develop a single unit uni-directional Microphone, both crystal and dynamic.

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SHURE MICROPHONES

cepted systems was a function of distance because of cables, telephone lines and other associated apparatus. Powerline carrier circumvents these costs by using existing transmission lines, leaving only terminal facilities to be installed. Since distance is no longer a controlling limitation, power-line carrier operates over greater distance than pilot wire, and permits wider application for this type of control.

Meter Calibration

Meter and instrument testing has always been an essential part of any electric light and power company. By the use of electronic apparatus, the human element is minimized and greater speed and accuracy are obtained.

Under the present system of manual testing of watthour meters, a good meter laboratory can average approximately 50 meters per eight hour day per man.

With visual types of electronic equipment, as many as 135 meters per day are being tested.

Load Control

The bug-a-boo of indicating instrument and integrating meter testing has been load control. Automatic electronic load regulators now speed up instrument testing and increase accuracy with subsequent conservation of manpower. In addition, a reduction of electrical energy is effected by cutting down the time previously required to make the test.

That electronic devices have and will continue to perform an important part in the distribution and control of electrical energy was also predicted by Amos J. Germaine, of the electronics section of Westinghouse, in addressing members of the Iowa State Utilities Association at a recent meeting.

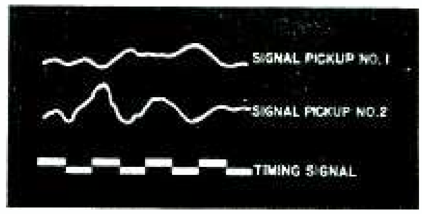
• • •

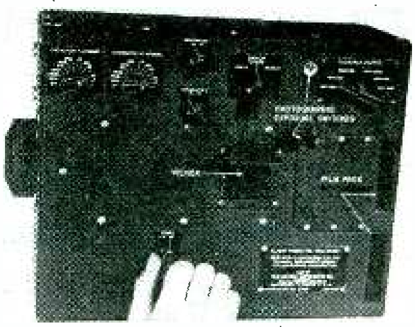
Portable Flutter Recorder for Planes

FLUTTER CAN BE, and in most cases is, avoided in designing planes. Especially in large planes, it rarely appears in the first model, in any severe form. Sometimes it appears in a particular plane after months of use where it did not exist in the prototype. With a new flight vibration recorder, velocity or acceler-

ometer type pickups can be placed at many places about the plane and two of these can be operated simultaneously. A selector switch permits many points to be studied in the same flight. The recorder contains its own batteries, amplifier, electronic switch, and cathode-ray tube as well as a camera to photograph the oscillograph record.

For exhaustive flutter study, equipment weighing between 300 and 500 pounds previously has been used. Installation and tests by this method required about two weeks. Frequently, after the equipment





Panel view of the portable flight recorder and a typical photograph of the vibration encountered by pickups located at two positions of stress in the plane

was removed, additional information was needed during analysis of the observations, and the new recorder is ideal for such re-examination. Light enough to be held on the lap of the observer, it can be installed and put into use in a few hours. The machine is also useful in studying vibration in motor mounts, cowling and small accessories, where its ease of installation as a special-purpose instrument is important.

Present knowledge of flutter has been built up over years, and has been gathered from experiments on the ground and in flight. Vibrating machines are still used to simulate flight conditions on the ground. In a few cases, radio-controlled planes have been used with recordings transmitted to the ground during

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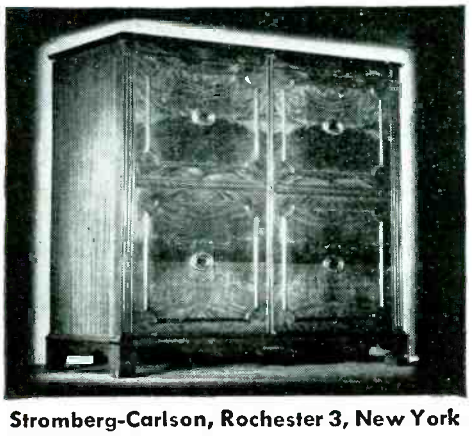
STROMBERG-CARLSON'S WARTIME ADVERTISING—
AND STROMBERG-CARLSON'S POSTWAR RADIOS!



Stromberg-Carlson, Rochester 3, New York
Radios, Television, Telephones, and Sound Equipment

What wartime radio advertising can show such a record of dealer approval—and of public readership—as the current Stromberg-Carlson pages in the national magazines? *None*—the Daniel Starch advertising check-ups have proved that, *plenty!*

And the postwar Stromberg-Carlson FM and AM radios, radio-phonographs, and television sets will be equally far out in front. Tailor-made to the postwar market—as established by our recent 5,000-radio home market survey—they will give the public exactly what it's looking for.

This 5,000-radio home survey brings home clear as a bell the buyers' tremendous insistence on top quality in radio equipment. They expect and will seek out the very best...and back up their insistence with plenty of cold cash.

The distribution of your radio sales promises some important changes, too. Changes in the ratios between radios and radio phonographs, between consoles and table models. Changes and improvements which people want, and which will be reflected in all postwar Stromberg-Carlson equipment... a pretty pleasant prospect for every Stromberg-Carlson dealer!

HERE'S THE STROMBERG-CARLSON POSTWAR SET-UP IN 21 SECONDS READING TIME!

1 We will have—soon after Victory—a fine line of Stromberg-Carlson FM and AM radios, phonograph combinations, and television receivers in a wide range of prices.

2 We will have a policy of distribution planned to give every Authorized Dealer a good profit opportunity on the Stromberg-Carlson line.

3 And the Stromberg-Carlson name will be even more widely and more favorably known than ever before.

flight, and test pilots have flown planes equipped with recorders which transmit their reports by radio to the ground. For all of these methods, the new recorder is a valuable auxiliary.

Development of the new recorder was made by the CAA in cooperation with Brown Instrument Company.

• • •

10,000-kw Electronic Converters in Steel Plant

AN ELECTRONIC POWER converter designed to exchange power, reversibly, between 25-cycle, 44-kv and 60-cycle, 69-kv systems has been installed as two complete 10,000-kw units at a plant of Carnegie-Illinois Steel Co. The arrangement permits operation at 125 percent load for one hour and 200 percent load for one minute.

Twelve tubes form the rectifying element for converting 10,000-kw a.c. to d.c. and twelve additional tubes convert the d.c. back to a.c. The direct-current link operates at approximately 30,000 volts. When changing from rectifier to inverter operation for reverse power flow, the phase position of the grid voltage is shifted by a phase-shift network approximately 150 deg.

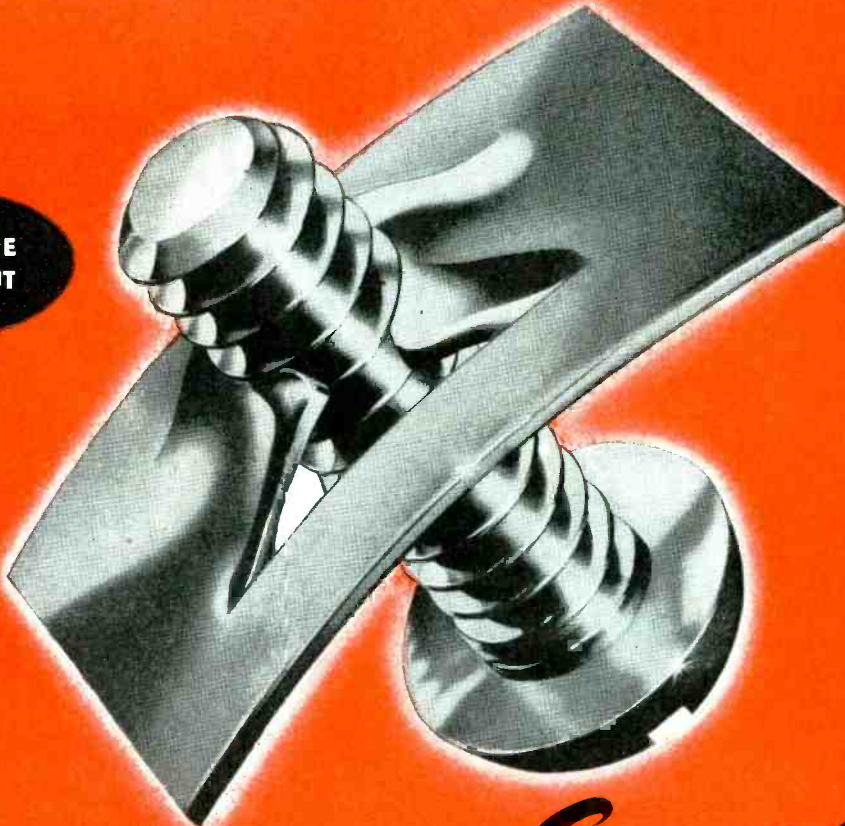
In operation, the electronic converter is held to a constant power output independently of relative system frequencies and voltages. It contributes no current to faults in the supply system, little more than load current to receiving system faults, while controls suppress power flow to internal faults. Switching is resorted to only for persistent faults. Reactive overexcited current is supplied by synchronous apparatus of both systems, excess losses of which are chargeable to the converter. Efficiencies remain high throughout the load range.

Suppression of Faults

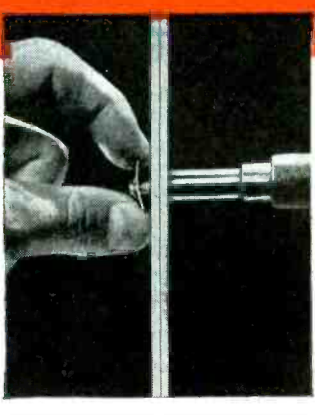
As a result of practical experience with electronic converter systems in the operation of a direct-current power transmission, it has been learned that the electronic converter is subject to occasional faults such as arc backs which apparently cannot be entirely avoided. However, the practical effect of electronic faults can be suppressed so that they do not interfere with

ONE OF A SERIES PORTRAYING THE "SPEED NUT FAMILY OF FASTENINGS"

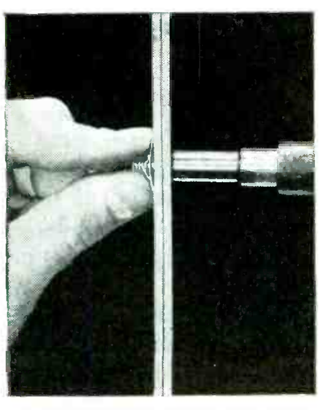
FLAT TYPE SPEED NUT



"...AND WE DO MEAN *Speed!*"



STARTING POSITION



LOCKING POSITION

Greater *Speed* Reduces Assembly Time
Greater *Speed* Cuts Assembly Costs

● This ad is devoted to speed. The word appears 5 times in this message because we want to stress speed first and foremost.

Why? Because you will need better and faster assembly speed in order to win postwar markets in big volume on any product—metal, wood, or plastics.

Designing beautiful postwar products is only the beginning. The winners will be those good looking products that are engineered for better and faster assembly. We have already produced over 2,000 shapes and sizes that have drastically cut assembly time, reduced costs and improved the quality of the finished product. Write for literature.

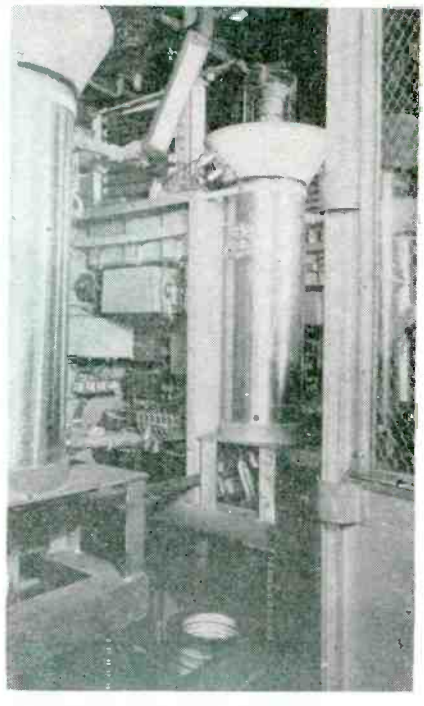
TINNERMAN PRODUCTS, INC.
2106 Fulton Road, Cleveland 13, Ohio
In Canada: Wallace Barnes Co., Ltd., Hamilton, Ontario
In England: Simmonds Aerocessories, Ltd., London

*Speed Nuts**
Patented
*Trademark Reg. U. S. Patent Office

FASTEST THING IN FASTENINGS

operation but can be detected by sensitive instruments. The means developed to suppress electronic faults have incidentally introduced the ability to suppress the effects of lightning so that the direct-current power transmission has a remarkably good record for reliability during lightning storms.

Four pentode ignitron groups of 6 tubes each make up a converting equipment. The pentode tube, es-



A portion of the electronic power converter unit at Carnegie-Illinois Steel Corp. The large cylinders are pentode-ignitron inverter-rectifier tubes. Grid control equipment is in the background

pecially developed for rectifier and converter service, is an ignitron of the permanently evacuated, sealed steel type having the control characteristics of a thyratron tube. One or more grids control the starting of current conduction, aid in deionization at the end of conduction, and reduce the time required to regain control.

Tube Data

Physically, the tube is of a cylindrical shape approximately 10 in. in diameter, 45 in. in length, and weighs 100 pounds. Two concentric stainless steel cylinders form the enclosing envelope. Water circulates in the space between the cylinders to remove the losses. Tube losses are a fraction of one percent at the usual operating voltage.

Development, design, operating

LUMARITH insulation protects against the

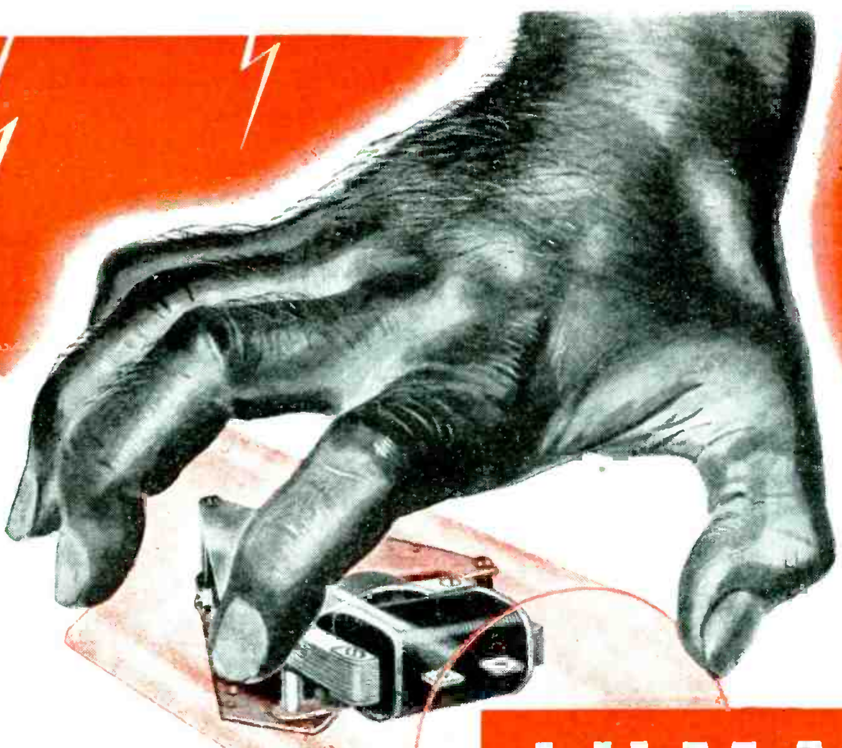
BLACK HAND OF CORROSION!

LUMARITH insulation is effective protection against electro-chemical corrosion even under severe conditions—for example, applications involving fine wire under conditions which ordinarily cause electrolysis, such as the presence of moisture and direct current.

Lumarith isn't subject to that built-in hazard of many types of insulation—organic decomposition. Lumarith resists moisture and contains no materials which combine with moisture to form free acids. It is outstanding for high dielectric strength, and its softening point makes it applicable for many types of coils.

Available in films, sheets, rods, tubes and molding materials. Films are supplied in plain or in special mat finish that reduces slippage and increases visibility for easier winding.

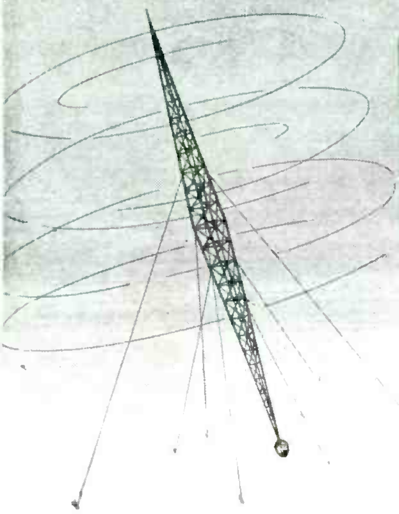
*Reg. U. S. Pat. Off.



Send for "Lumarith for the Electrical Industry" a valuable reference booklet. Celanese Celluloid Corporation, a *division of Celanese Corporation of America*, 180 Madison Avenue, New York 16, N. Y.

LUMARITH*

A Celanese Plastic*



BROADCASTERS

COMPACT... COMPLETE... ECONOMICAL... that's the 76-B2 Speech Input Consolette.

The ease of its push-button control, the completeness of its amplifying and control equipment and a host of other features have made this equipment the favorite of small and medium-sized stations the country over. (We venture to say even a postwar visionary would have difficulty in visualizing a better speech input system!)

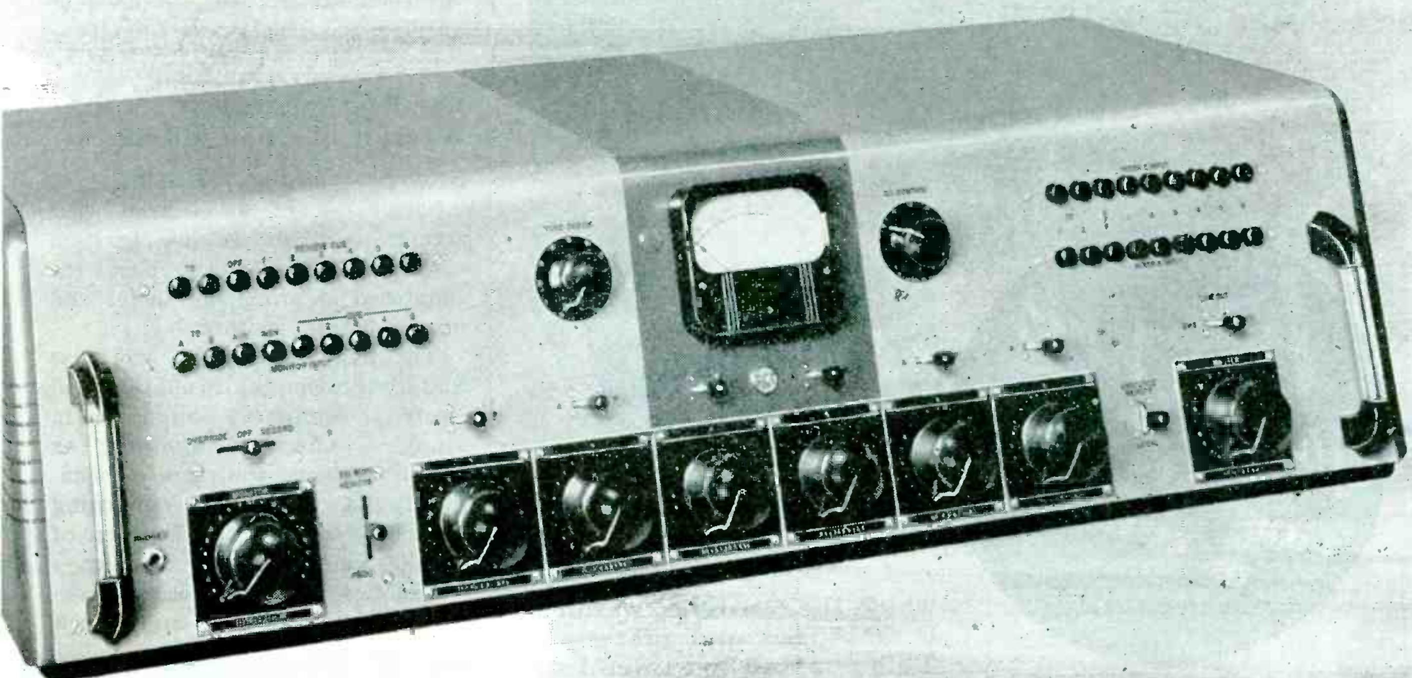
Here are some of the features which have made the 76-B2 Consolette so popular:

* *Includes all amplifying and control equipment for operating one studio, two studios or two studios and an announce booth, six remote lines and two turntables.*
* *Frequency response 30 to 15,000 cycles.*
* Push-button control *of monitoring, auditioning, remote lines, cueing and talk-back.*
* *Independent auditioning and program channels.*
* High-fidelity *program channel affords 6 mixer controls, 4 microphone pre-amplifier input channels with switching control for up to 6 microphones.*
* High-fidelity *monitoring channel operates control room and studio loudspeakers.*
* *Emergency amplifier and power supply circuit.*
* *Meets all FCC requirements for* AM and FM *broadcasting.*

The 76-B2 Consolette at Station WBOC, Salisbury, Md.

TELL US....

"That 76-B2 is a honey!"



COMPACT... Console measures 39" wide, 17" deep and 10½" high.

COMPLETE... Answers every speech input need of the small and medium-sized broadcast station.

ECONOMICAL... At a price the smallest station can afford.

Perhaps your station lacks the efficient service of an RCA 76-B2 Speech Input System. For further information on its advantages and availability, please address the Broadcast Equipment Section of RCA at Camden, N. J. (Interested in reserving a postwar AM, FM or Television Transmitter? The RCA Broadcast Equipment Priority Plan will interest you. Write today for details.)

War Bonds... Your Best Investment

1919
1944

RCA

25 Years of Progress
In Radio
and Electronics

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION • CAMDEN, N. J.

In Canada
RCA VICTOR COMPANY LIMITED, MONTREAL

results and possible applications for the 20,000-kw electronic power converter installed by General Electric were discussed at the AIEE summer meeting in St. Louis. Switchgear, control and pentode ignitron tubes for the converter were also reported upon at the symposium.

The electronic converter is applicable to certain cases requiring control of power flow between systems of like or dissimilar frequency and voltage or, with suitable modifications, to systems furnishing power to isolated loads which have sufficient synchronous capacity for commutation, etc., at fixed or variable frequencies.

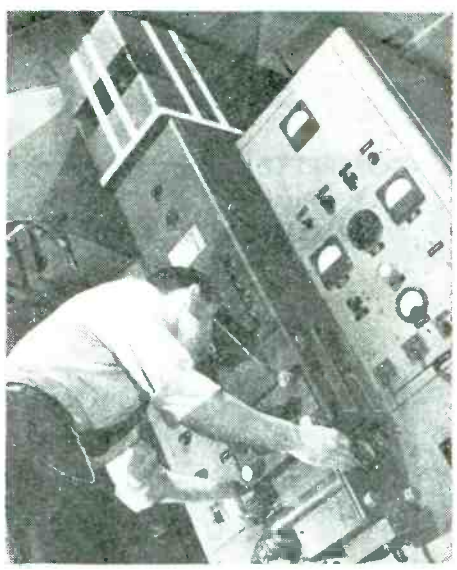
• • •

Oscillograph Checks Aircraft Engine Ignition

STOPPING SPARK FLASHES at 0.0000001 second, an electron beam records airplane engine ignition actions to help control problems encountered in producing faster and more powerful motors.

The new oscillograph will also find application in insulation and electrical equipment design and in study of effect of lightning on power systems and transmission-line faults. War plants now using it include the Scintilla Division of Bendix and the Bosch Company.

The new electronic oscillograph that is giving aircraft engine men



A Westinghouse engineer checks the positioning of the film pack in the new oscillograph being used in plane plants to photograph ignition sparks traveling 5000 miles an hour. It will also be useful in insulation and electrical equipment design

Micarta antenna masts to "HIT THE BREEZE" at 600 mph!

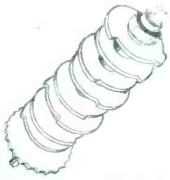
Another Example of Versatile Micarta *at work*

That thin, long mast rides outside in the fury of a 600 mph gale. It is made of Micarta—the light, tough plastic.

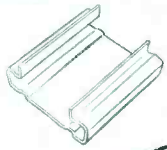
Requirements for antenna mast performance are exacting. The mast must withstand extremes of air pressure and temperature. It must be rigid, hold the antenna taut without yield or wobble.

Micarta's unusual combination of characteristics—strength with lightness, resistance to heat, cold, humidity and chemicals—has been of particular interest to the Communications Industry for many years. All these same properties are retained in Micarta "444"—a new development in plastics—a process of manufacture permitting the formation of structural shapes from completely cured flat sheets. A versatile product . . . suited to simple and low-cost fabrication . . . with unlimited application possibilities in the Communications Industry.

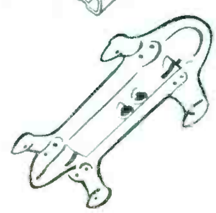
Investigate Micarta and the new "444" product—write for the new Micarta Data Book—B-3184A. Westinghouse Electric & Manufacturing Co., P. O. 868, Pittsburgh 30, Pa. J-06347-B



CAMS, made of Micarta, are used where high dielectric plus long wear are important. Other applications include terminal blocks, coil forms, switch spacers and tube sockets.



AMMUNITION FEED CHUTES made of the new Micarta "444" guide bullets accurately into firing position. It is thin, light, strong, easily formed with inexpensive dies.



BOMB RACKS have been successfully molded with Micarta . . . furnish an excellent example of Micarta's strength and the skill of Westinghouse engineers in intricate molding assignments.

OFFICES EVERYWHERE

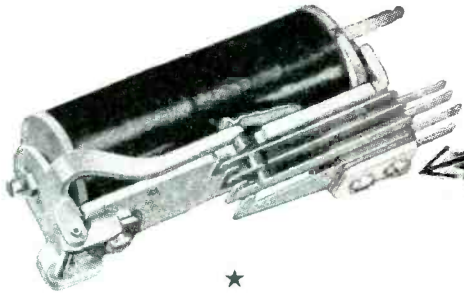
Westinghouse

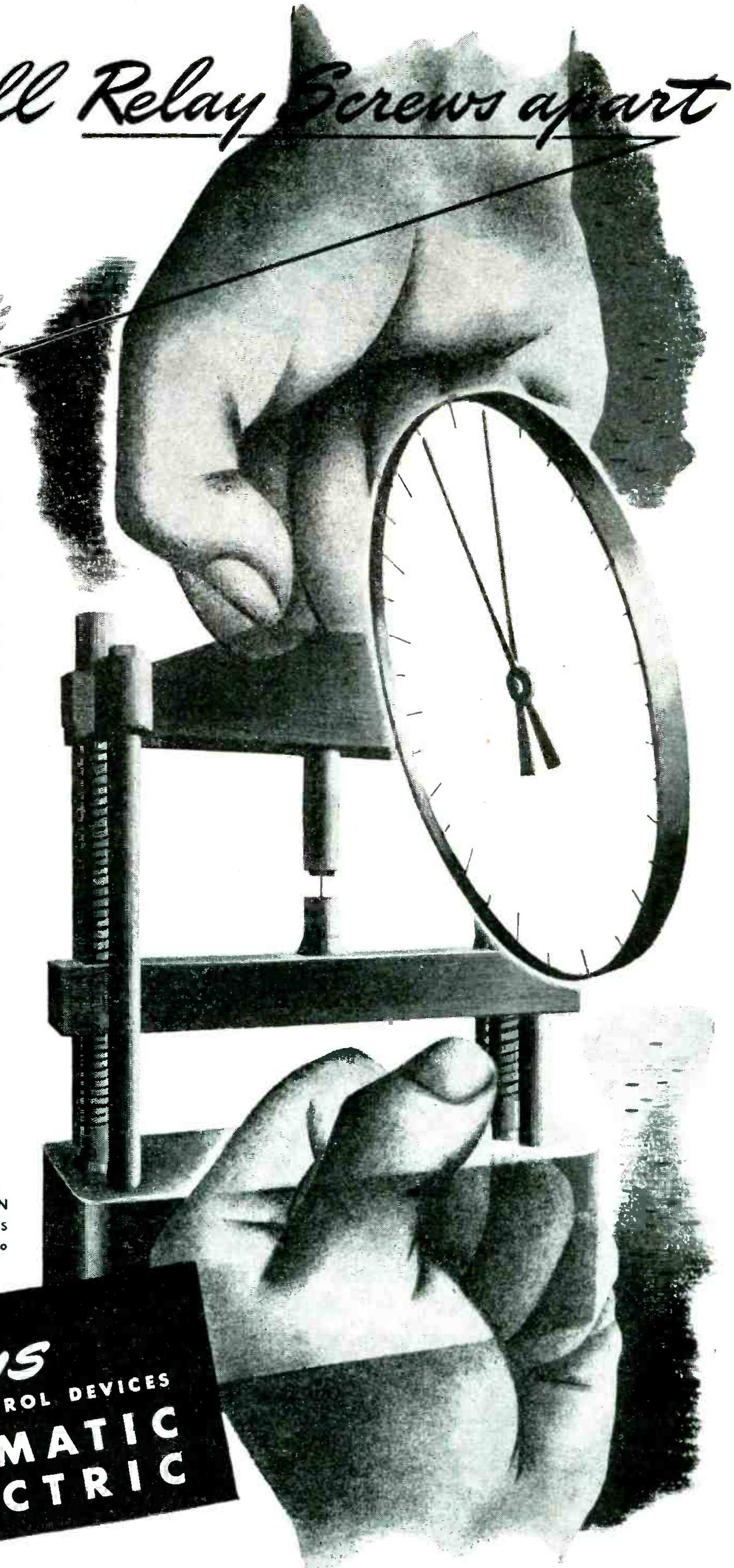
Micarta

THE INDUSTRIAL PLASTIC

PLANTS IN 25 CITIES

Why we pull Relay Screws apart





★

Vibration, humidity and extremes of temperature can be bitter enemies of relay dependability. That is why the contact springs on Automatic Electric relays are clamped by special screws, which exert the necessary pressure without breaking or stretching. Such screws must meet the exacting tensile tests prescribed by our designers.

These tests, and scores of others like them, are vital contributions to the long life and dependability for which Automatic Electric relays are famed.

When you need relays or other electrical control devices, take advantage of our unique fund of design data and experience. First step is to write for the Automatic Electric catalog. Then, if you need sound technical advice on your problem, call in our field engineer. He will be glad to put his knowledge to work for you.

AUTOMATIC ELECTRIC SALES CORPORATION
1033 WEST VAN BUREN STREET • CHICAGO 7, ILLINOIS
In Canada: Automatic Electric (Canada) Limited, Toronto

Relays AND OTHER CONTROL DEVICES *by* AUTOMATIC ELECTRIC

PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED

Marvels of Electronics—

and the steelmaking

skill of Follansbee

Many of the electrical and electronic devices which are providing a margin of superiority to our fighting men are necessarily closely guarded military secrets. But it is no secret that their manufacture requires new standards in the production of Electrical Sheets.

The need for such combinations in high silicon steels as thin sheets to close gauge tolerances, exceptionally clean surfaces and excellent punching qualities, together with essential magnetic characteristics, created problems never before encountered in the tonnage production of Electrical Sheets.

The success of Follansbee in quickly meeting these new standards is evidence of the skill of its compact, highly trained organization. It is an important reason why you can entrust these and other difficult steelmaking jobs to Follansbee.

FOLLANSBEE STEEL CORPORATION

GENERAL OFFICES · PITTSBURGH 30, PA.

Sales Offices—New York, Philadelphia, Rochester, Cleveland, Detroit, Milwaukee. *Sales Agents*—Chicago, Indianapolis, St. Louis, Nashville, Los Angeles, San Francisco, Seattle; Toronto and Montreal, Can. *Plants*—Follansbee, W. Va. and Toronto, O.

ALLOY BLOOMS, BILLETS, BARS, SHEETS & STRIP · COLD ROLLED SHEETS & STRIP
POLISHED BLUE SHEETS · ELECTRICAL SHEETS & STRIP · SEAMLESS TERNE ROLL ROOFING

more data about the ignition systems of high-powered airplane engines than has ever existed before takes pictures on camera film in much the same manner as an x-ray.

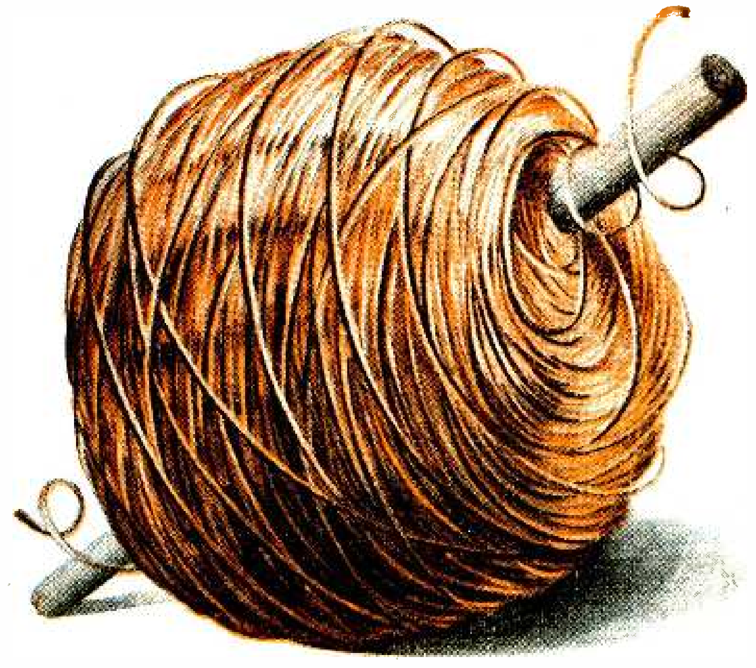
To prevent the beam from registering on the film before the ignition study is made, the unit incorporates a beam trap that deflects the electrons out of the photographic channel. Periods as short as 0.00000001 of a second are photographed on a stationary film strip. Slower speeds, less than 0.000008 second, are recorded on a revolving drum that turns 7,000 times a minute. The rotating film drum is necessary for certain uses because stationary film does not register intervals of 0.02 second.

Westinghouse research engineers collaborated with warplane engine manufacturers in testing ignition systems with the oscillograph and the results pointed the way to better engines by making ignition improvements.

• • •

AMERICAN MINE DETECTOR

Now operating in Europe, this mine detector made by International Detrola Corp. contains three coils in the search head. Two of these are connected in series opposition so that the combined mutual inductance to the third coil is nearly zero. Complete balance is provided by tuned compensator coils in the control box on the handle. Any metallic mass in the coils' field changes the mutual inductance, affecting a meter and an earpiece to provide both audible and visual indication



A Coil is more than just a bundle of wire

ANACONDA COIL ENGINEERS have designed over 15,000 individual types of coils during their many years of experience. Some have weighed as little as 1/100th of a pound; others as much as a quarter of a ton.

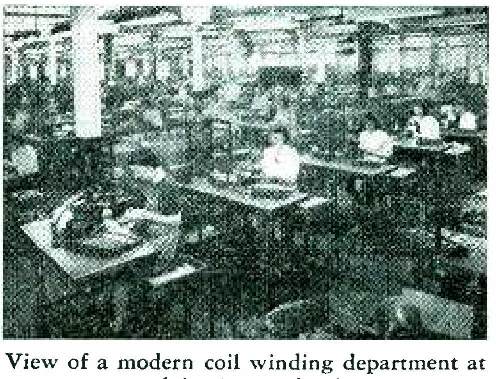
But each coil began with a blueprint. Type, shape, size, winding, insulation, treatment, cost—every factor entering into designing the best coil for the use intended was pre-determined by Anaconda engineers.

Anaconda Coils derive dependability from still another advantage. The magnet wire used for winding them is also a product of Anaconda engineering—with quality carefully controlled from ore to finished wire.

It is a highly effective combination: Coil producers who can command the complete experience of magnet wire specialists! Magnet wire producers who enjoy the close cooperation of coil experts!

And back of each are exceptional manufacturing facilities. Modern plants . . . efficient equipment likewise engineered . . . experienced, skilled personnel.

Any Anaconda sales office will be glad to refer inquiries on coils or magnet wire to our engineeering staff. 44239



View of a modern coil winding department at one of the Anaconda plants.

magnet wire and coils

ANACONDA WIRE & CABLE COMPANY

GENERAL OFFICES: 25 Broadway, New York 4

Subsidiary of Anaconda Copper Mining Company

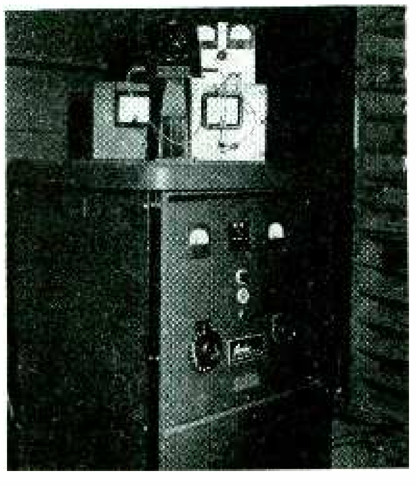
CHICAGO OFFICE: 20 North Wacker Drive 6 • Sales Offices in Principal Cities

TUBES AT WORK

X-Rays Lower Frequency of Quartz Plate

A NEW TECHNIQUE for precisely adjusting the frequency of quartz oscillator plates downward was disclosed recently by the announcement of x-ray equipment designed for this application.

Depending on the original characteristics of the quartz plate, frequency may be lowered in the x-ray unit at a rate of 30 to 50 cps per minute. Plates in the 6-8 megacycle range can be changed from 2 to 3 kilocycles lower in frequency. This is the saturation value of such crystals. Plates of higher frequency can be changed over a larger range.

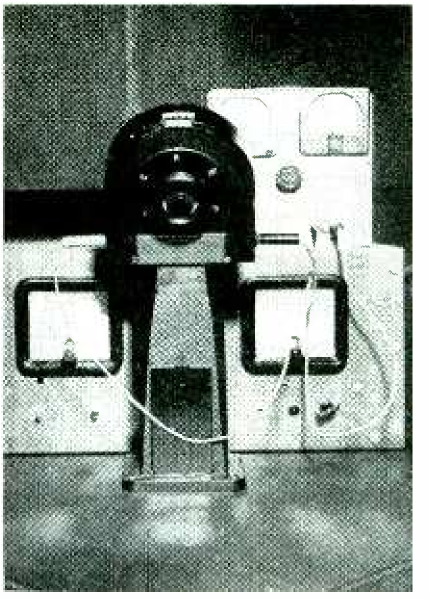


Complete equipment for lowering the frequency of quartz oscillator plates by subjecting the quartz to an x-ray beam. The irradiator was developed by North American Philips in cooperation with the Signal Corps

The x-ray equipment, designed by engineers of North American Philips Co., employs a new high-capacity water-cooled tube that produces an intense beam of x-rays. Intercepting this beam is the crystal holder shown in the photograph, which accommodates two crystals from 0.4 to 0.75 in. in size. One is rotated into the path of the x-ray beam while the other is being loaded. Two crystal holders are provided, one for each window of the x-ray tube.

Leads to the holder in front of the x-ray window may be connected to an oscillator for frequency checking. Thus the degree of downward drift of frequency can be readily monitored and the crystal removed from the beam when the required change is accomplished.

The x-ray equipment for irradiating crystals was developed at the request of the U. S. Army Signal Corps. Experiments made by Dr. Frondel of Reeves Sound Laboratories show that the change in frequency is permanent throughout and beyond any temperature range that the crystal is apt to experience. Factory applications of the technique include: recovery of overshot crystals that have been carried too far in finishing; precise adjustment of standard crystals for use in calibration and in testing; manufacture of precision crystals for frequency and time standards; for a crystal which is considered stable, precise adjustment to final frequency by this method without the possibility of further aging.



This double crystal holder rotates to carry the quartz plate into the x-ray beam while another plate is being loaded aboard. Action of the Norelco x-ray unit lowers the frequency

A Private Electronic Telephone System

PAUL F. MAGEE

Cross Roads Auto Service
Berlin, Md.

THE BUILDINGS OF this company are spread over about a city block, with a main highway separating the various buildings into two groups. To

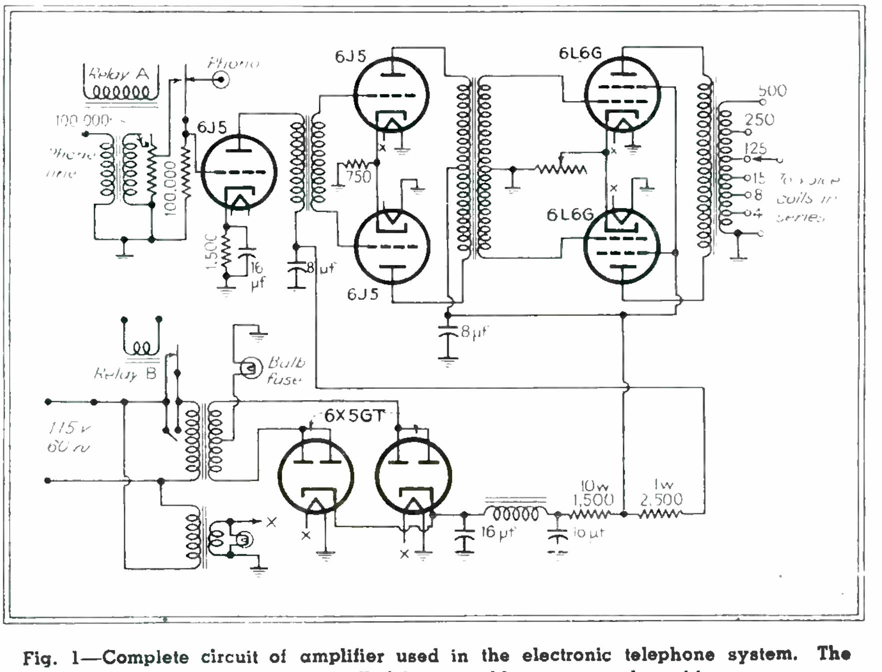


Fig. 1—Complete circuit of amplifier used in the electronic telephone system. The two relays are controlled by a pushbutton at each position

wherever a tube is used...

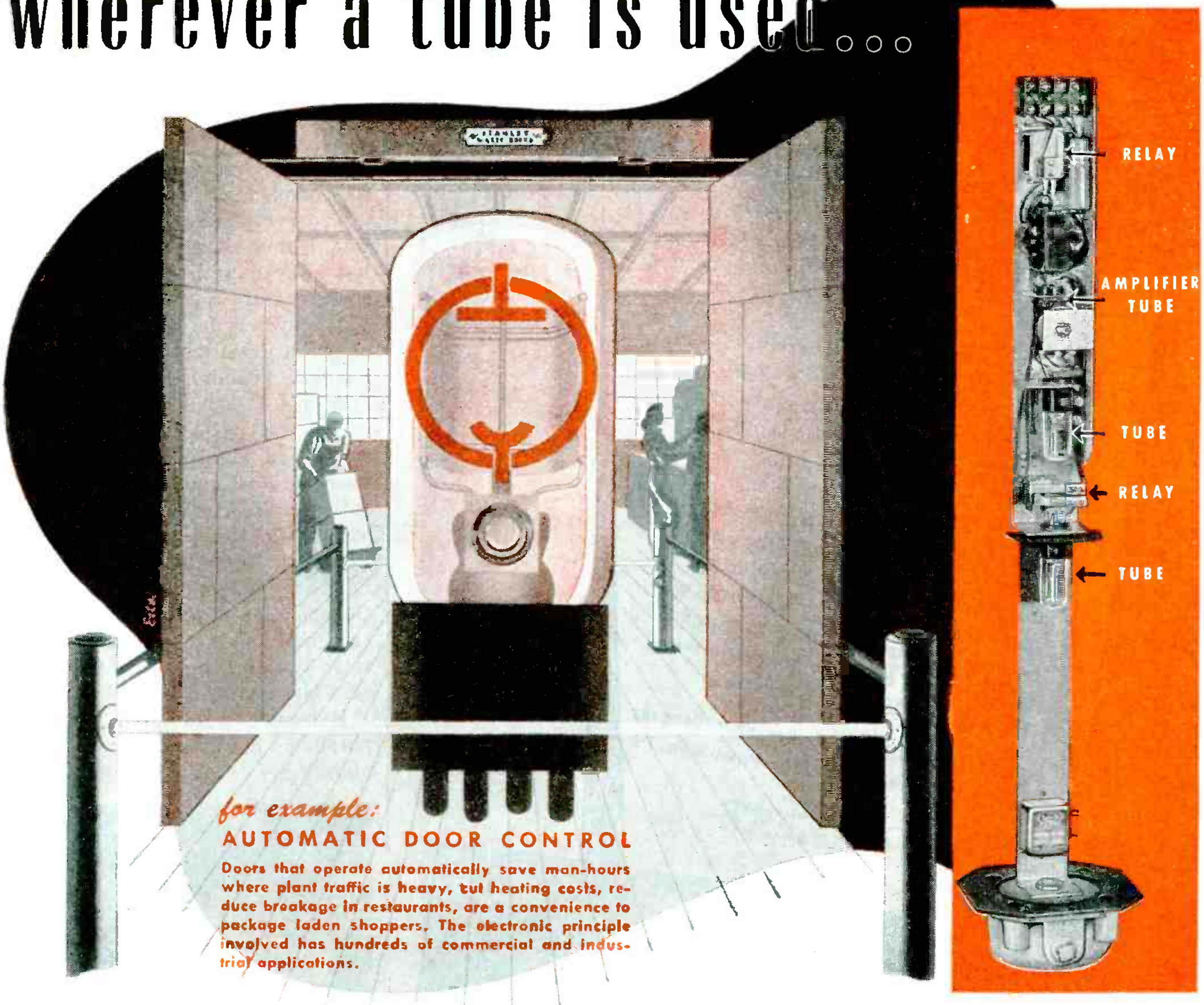


PHOTO-ELECTRIC DOOR CONTROL
Above unit manufactured by General Electric Co., is a part of STANLEY "MAGIC DOOR" CONTROLS.

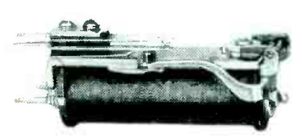
THERE'S A JOB FOR

Relays BY GUARDIAN

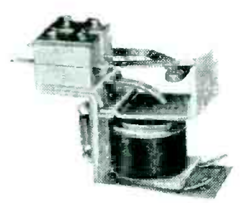
★ The "Magic Door" made by The Stanley Works of New Britain, Conn., uses a General Electric control unit which operates automatically at the approach of a pedestrian or vehicle. In this unit a beam of light focused on the cathode of a phototube causes a tiny current to flow. Enlarged through an amplifier tube this current operates a sensitive telephone type of relay such as the Guardian Series 405. Another phototube with an auxiliary relay, Guardian Series R-100, is employed to hold the doors open for anyone standing within the doorway.

The telephone type of relay is extremely sensitive and able to operate on the small current supplied through the electronic circuit. The auxiliary relay, Series R-100, is required to handle a greater current. It is a small, efficient relay having a contact capacity up to 1 KW at frequencies up to and including 28 megacycles. Contact combinations range up to double pole, double throw. Standard coils operate on 110 volts, 60 cycles, and draw approximately 7 V. A. Coils for other voltages are available. For further information write for Bulletin R-6.

Consult Guardian whenever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.



Series 405 Telephone Type Relay



Series R-100 H. F. Relay

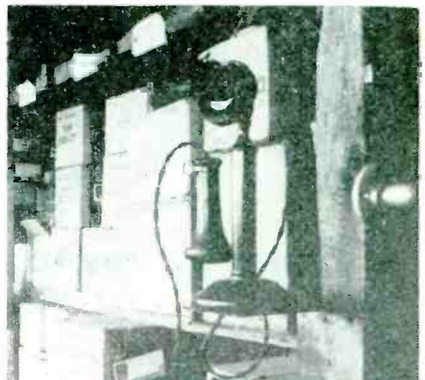
GUARDIAN ELECTRIC
1625-M W. WALNUT STREET CHICAGO 12, ILLINOIS
A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

communicate with all departments, twenty-one telephone stations are used.

During the past ten years a number of electronic telephone systems have been tried, but with limited success, due mainly to the fact, that after a system was installed it was too complicated for the majority to use, or was not entirely practical. The system diagrammed, however, has proven satisfactory for over three years.

The system is designed for ease of operation. Pushbuttons on each handset permit calling over all speakers at one time. After the initial call is made, consisting usually of one or two words, the pushbutton is released and conversation is carried on by means of handsets located in all the buildings. Feedback between speakers and handsets is eliminated by placing the speakers at the opposite end of each building away from the handsets. The amplifier is located on top of a large safe in the office.

Handsets were used wherever possible, however, some of the phones are from a salvage lot and



One of the telephone installations in a stock-room. Not shown in the photo, a loudspeaker is used for paging employees and then cut off during the phone conversation

are the vertical type with receiver hanging on a hook on the side. These are mounted by means of an L-shaped piece of steel to the building wherever used. In the beginning, several of the "toy" type phones were installed, but these were none too successful.

Relay-Controlled Amplifier

A jack is provided in the amplifier for "phono" use for keeping the amplifier on at all times. Two 6-volt d-c relays are controlled by the pushbuttons. Relay *A* switches the amplifier into the telephone circuit without the phono in use, and relay *B* applies the line voltage to the primary of the high-voltage transformer. A battery of 12 volts was necessary to operate the two 6-volt relays as they are connected in series, but they operate without fail from the pushbutton switch most distant from the amplifier.

The microphone input transformer permits matching from a 50–100–150–200 ohm source to the grid of the tube. The 50-ohm tap is used, as there are always at least two phones in the circuit at one time, and at many times several. There seems to be no difference in the level of conversation.

Use of the primary winding of the microphone transformer permits the phones to operate. Almost any iron-core choke would work as

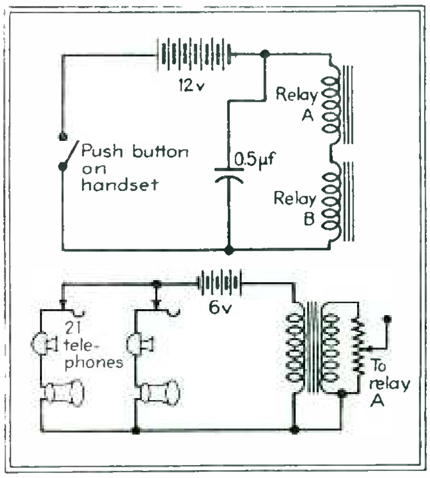


Fig. 2—Battery circuits for operating the relays and telephones

a substitute if telephone conversation alone was all that was required, but since it is also needed for the amplifier, this primary winding serves a dual purpose.

The filament transformer case was bored full of holes for freer circulation of air around the core. It is left on the line continuously to keep moisture out of the amplifier. No trouble has been experienced from burnout.

Two Types of Lines

The wire lines between buildings are run on 25-foot creosoted poles except for one 125-foot section that is underground. This section consists of a lead cable in 4-in. tile. The overhead lines are No. 14 sin-

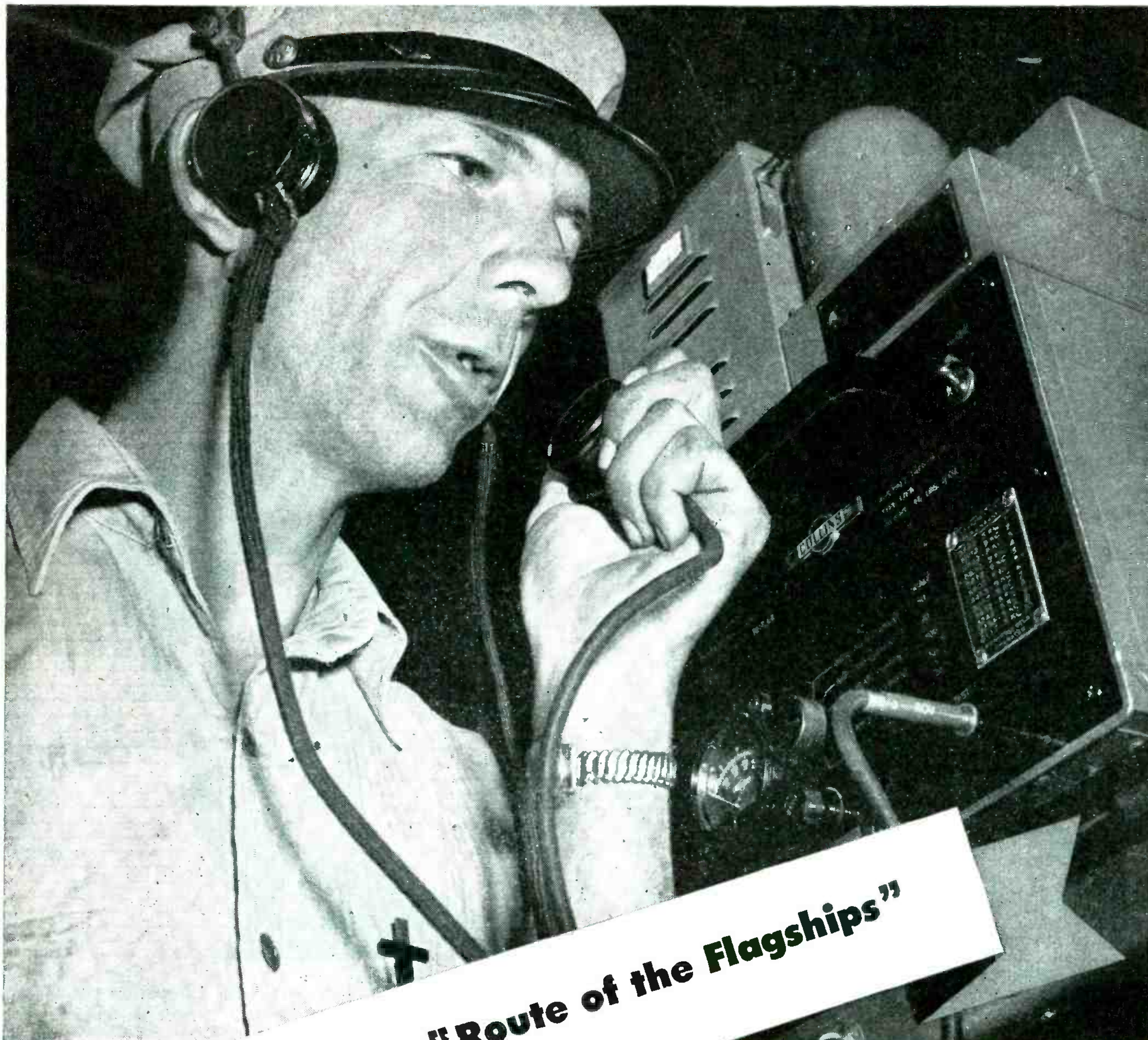
Sangamo Capacitors Can Take It!

Mica capacitors play a vital part in the correct functioning of many types of equipment. Radio receivers, transmitters, hearing aids, underwater sound equipment, induction heating, and many other devices depend upon the faithful performance of capacitors to enable them to function properly.

Many applications of capacitors in these various equipments necessitate a wide range of sizes, shapes, voltages, and current carrying ability in order that the proper capacitor may be used, depending upon the physical space limitations and electrical characteristics to be met.

As Illustrated, Sangamo manufactures a large variety of capacitors from the small wire lead type having a body size of only 23/32" in length, 15/32" in width, and .20" thick to the large ceramic case type capable of operating at voltages up to 35,000 and handling large amounts of radio frequency current. This wide variety of capacitors insures the availability of the proper unit for almost any mica capacitor requirement.

SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS



Standard on the "Route of the Flagships"

IN 1939, American Airlines adopted the Collins 17F Autotune* aircraft transmitter as standard equipment for its entire fleet.

Previous experience on a lesser scale had indicated the wisdom of this step. Succeeding experience has confirmed it.

Compared with previous equipment, the 17F's doubled the power output (to 100 watts) with slight increase in weight, and the Autotune* provided thirteen quickly available operating frequencies instead of three.

Daily through the years, these rugged, uniquely efficient airborne 17F's and powerful Collins ground transmitters have given trustworthy support to a superb Operating Department in maintaining the great American Airlines tradition of safety and dependability.

After the war, Collins will again specialize in the development and production of advanced types of communication equipment for commercial aviation.

Its designs will bear the fruit of intense research and outstanding engineering achievement now engaged in meeting the hard demands of military service all over the world. Collins Radio Company, Cedar Rapids, Ia.

*The Collins Autotune is a repositioning mechanism which quick-shifts all transmitter or receiver controls simultaneously and with extreme precision to any one of a number of pre-determined frequencies. U. S. Patents issued and pending.

COLLINS

HOW ELECTRONIC PREHEATING INCREASES PLASTICS OUTPUT

Complete Softening of Plastic Before Molding Speeds Press Operation; Improves Quality

Compression and transfer molding of plastic materials is greatly speeded, rejects are reduced, heavier or more intricate parts can be made, and mold damage is practically eliminated when the molding material is preheated electronically. Some users have reported overall increases in output of as much as 1300% (including increases due to improved quality); a 50% increase in the output of a compression press is a fair average!

WHAT ELECTRONIC HEAT DOES: These remarkable improvements in plastics output are due to the uniformity and speed of heating possible when high-frequency electricity is passed through the plastic material. Although at ordinary frequencies (60 cycles, for example) most plastics are insulators, at high frequencies (million of cycles) they behave like conductors.

The high-frequency current, produced by electron tubes, flows uniformly through the plastic, and is instantly converted to heat. Thus the inside receives as much heat energy as the outside—and at the same time. Temperature increases quickly and evenly. This same heating method can be applied to many other substances—wood, glue, paper, textiles, glass, ceramics, foods, rubber, etc.

RESULTS: Because the plastic material is heated to molding temperature quickly, it has no time to "set" prematurely. The plasticity is high, hence flow into even intricate molds is quick, and molding pressure usually is greatly reduced. This, together with freedom from hard "cores," means less stress on the mold, and virtual elimination of mold damage! Thus runs can be continuous, without shutdowns and expense for mold repairs.

Mold closing is usually speeded, and since heat supplied through the mold has only to advance the temperature relatively little to the "cure" point, the curing time in the mold is reduced. Uniform curing tends to reduce internal stresses, and thus increase dimensional stability and reduce cracking and other rejects. The easy flow of the molding material puts less stress on molded inserts, and is less likely to displace them during molding.

With electronic preheating, no ovens are needed, and the molding material can be heated as needed instead of in batches; heating time totals only a few seconds—usually under one minute—hence molding can begin as soon as the presses are up to temperature in the morning.

IS EQUIPMENT AVAILABLE? Yes. RCA can supply electronic generators for plastics molding, and for many other applications—on priority, of course. If you have a problem, please write us about it in detail. (We'll keep it in confidence.) The coupon will bring you further information. Address: Radio Corporation of America, Electronic Apparatus Section, Box 70-49H, Camden, N. J.

THIS 4-OZ. PIECE of plastic was thoroughly softened for molding in about 15 seconds by an RCA 2000-watt electronic generator.

EASE OF OPERATION is a feature of the RCA 2-kw generator. When plastic material is thoroughly heated, power goes off and cage pops open.

RCA ELECTRONIC HEAT

BUY WAR BONDS

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION • CAMDEN, N. J.

WANT ADDITIONAL INFORMATION?

RCA, Electronic Apparatus Section, Box 70-49H, Camden, N. J.

☐ Please send me "Electronic Heat Speeds Plastics Molding"

☐ Please send me information on heating........................by RCA electronic heat.

I understand that this places me under no obligation.

Name ....

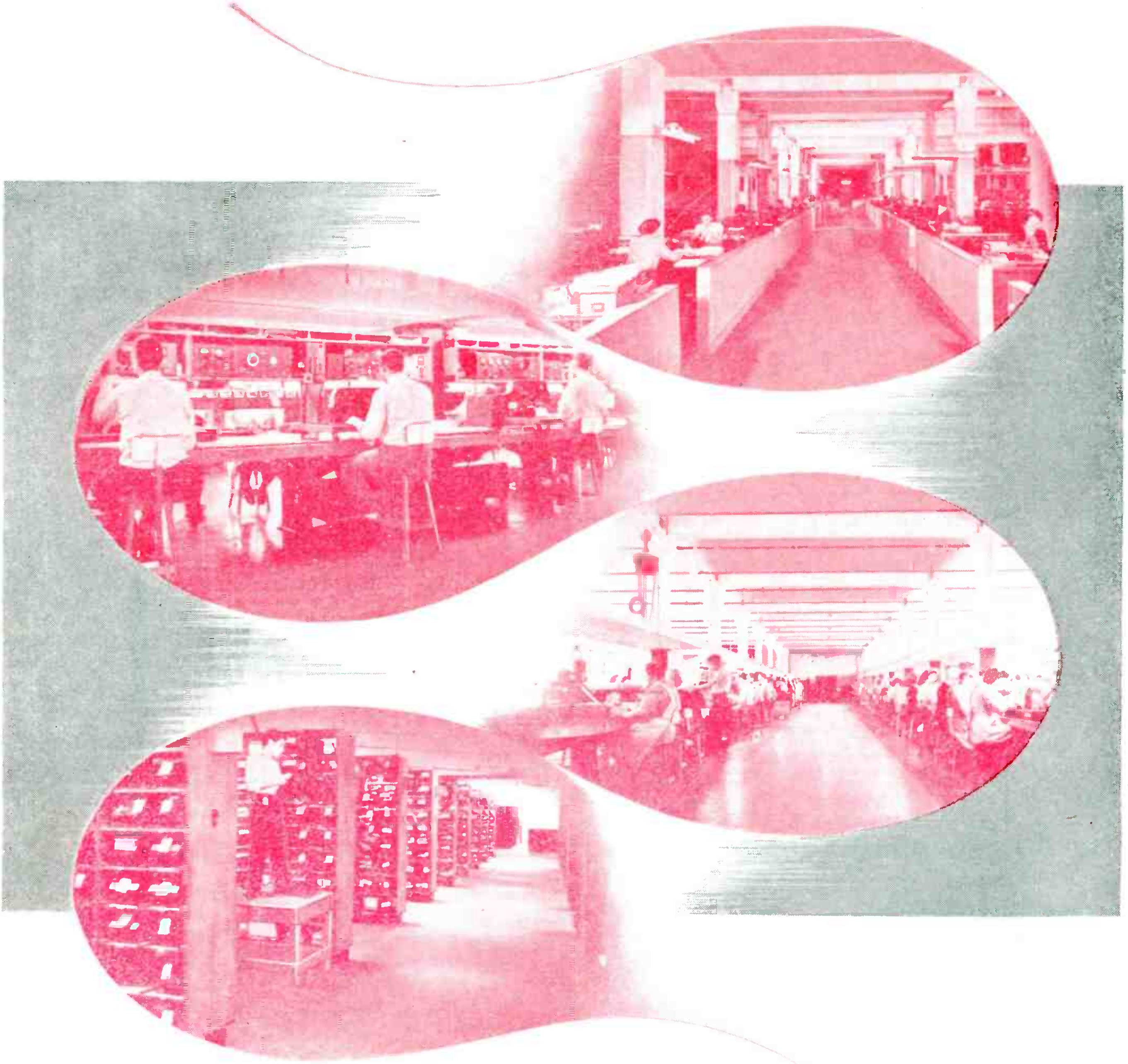
Company ....

Address ....

City.. Zone..............State....................

70-6231-49

DESIGN FOR ~~WAR~~ *peace* PRODUCTION

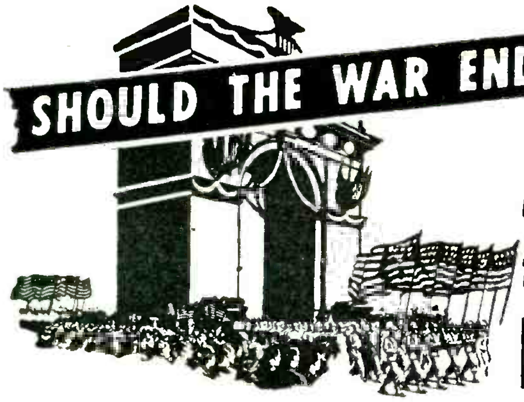


During the war, all departments of International Detrola's great radio-electronics plant have been brought to peak efficiency for volume manufacture of vital military equipment. Hundreds of thousands of square feet of production space have been re-allocated. Interiors and fixtures have been modernized, streamlined. These improvements have enabled skilled workers to chip precious minutes from production time while maintaining highest quality. All this will contribute to the excellence of manufacture *in quantity* of radio receivers, automatic record changers, television receivers and other peacetime electronic products. *Keep Buying War Bonds.*

DETROLA RADIO

DIVISION OF INTERNATIONAL DETROLA CORPORATION • BEARD AT CHATFIELD, DETROIT 9, MICH.

C. RUSSELL FELDMANN dr PRESIDENT



SHOULD THE WAR END tomorrow . . .

ELCO WOULD CONTINUE

to produce and deliver promptly

PRECISION *wire-wound* RESISTORS!

ELCO, too, awaits the go-ahead signal to start producing those "battle-tested" resistors for America's new Electronic industries.

Whatever the application—no matter how exacting the specifications—ELCO will deliver resistors as you want them—when you want them.

FOR TODAY'S WAR REQUIREMENTS–
FOR TOMORROW'S PEACE NEEDS–

specify **ELCO!**

SPECIFICATIONS:

"A-1"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—½% standard accuracy—non inductive pie wound—½ watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A-R"—Same as A-1, with leads reversed.

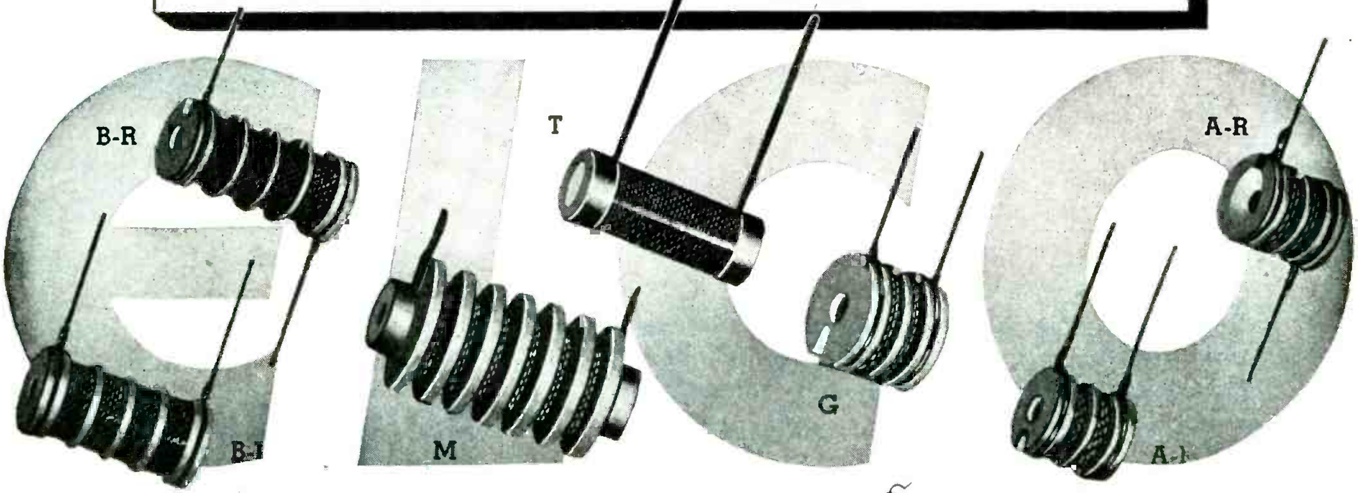
"B-1"—15/16 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—½% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—⅛ x .015 strap terminals—35 to 35,000 ohms—2 watts, 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

"M"—1-13/32 long x ¼" dia.—Mountable with 6-32 screw—⅛ x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy Baked varnish finish.

"G"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. ½% standard accuracy—non inductive pie wound .8 watts, 30° temperature rise in free air. 100° C. maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.

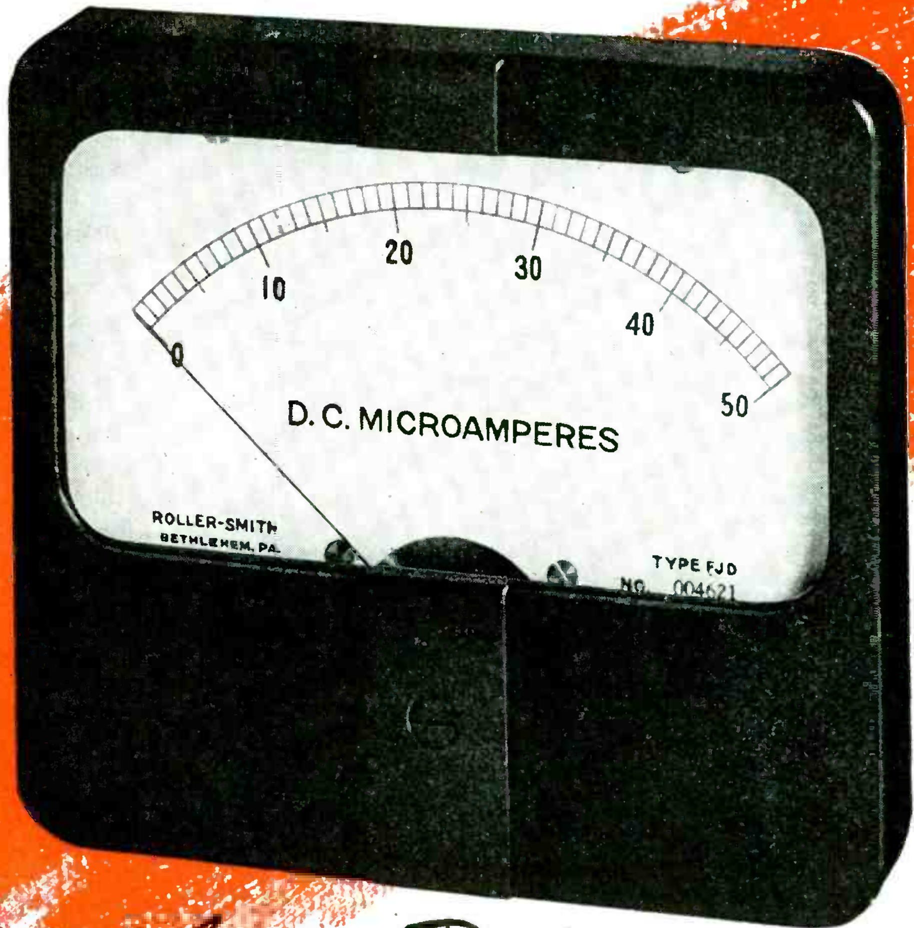


Get to know **ELCO RESISTORS COMPANY**

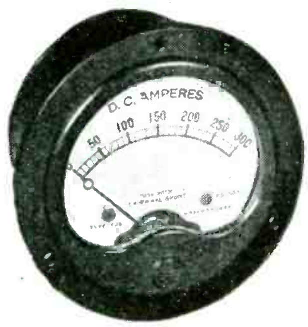
114 West 18th Street, New York, N. Y.

Telephone - Watkins 9-4774-5

ROLLER-SMITH 4.5" PANEL INSTRUMENTS...



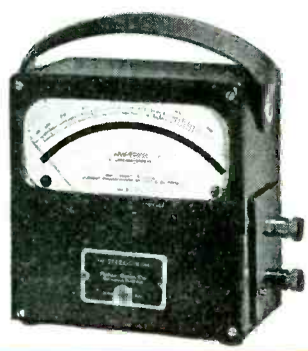
for Quick and Accurate Readings



Where panel conditions permit their installation these 4.5" semi-flush Bakelite case instruments provide maximum readability. Scale length of d-c instruments is 3⅞ inches and for a-c instruments is 3²¹⁄₃₂ inches. All instruments except rectifier types are accurate within 1% of full scale value at any point on the scale. Rectifier types, approximately 5%.

Incorporating the long life and dependability developed during 40 years of fine instrument manufacture, R-S 4.5" panel instruments have a diversified field of application which includes: Radio Transmitters; Control Panels; Battery Testers and Chargers; Electronic Tube Testers and Analyzers; Automotive Analyzers: Instrument Test Units; Sound Movie Equipment; Motion Picture Control Panels: Arc Welding Equipment; Experimental and Amateur Radio; General Electrical Laboratory Testing; General Communications, etc.

Any practical range can be supplied on short notice in d-c and a-c (Repulsion iron-vane and Rectifier type) models, with single or multi-range scales. Correspondence is invited.



OTHER R-S INSTRUMENTS: *Panel, switchboard and portable instruments of practically every standard size, shape, capacity, type and style are included in the R-S line of electrical instruments. Shown here are (upper) 3.5" Miniature Panel Ammeter conforming to American War Standard C39. 2-1944 and (lower) "Steel-Six" Portable Ammeter.*

***and don't forget . . .* BUY WAR BONDS**

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Canadian Plant: ROLLER-SMITH MARSLAND, LTD., Kitchener, Ontario

Sales Representatives In all Principal Cities

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS • AIRCRAFT INSTRUMENTS • SWITCHGEAR • AIR AND OIL CIRCUIT BREAKERS • ROTARY SWITCHES • RELAYS • PRECISION BALANCES gle-strand wire spaced about 6 to 10 inches apart. Colored wires were used for coding the six wires needed.

In connecting the overhead line to the underground line, a special transformer was found necessary. A transformer of the type used to match the plate of a vacuum tube to a 500-ohm line was found suitable. Without the transformer, the capacitance of the line was 0.01 μf and speech signals were considerably distorted. There seemed to be no noticeable difference when the line was connected or disconnected after the transformer was installed.

Total length of the lines has not been measured, but it is estimated to be $\frac{1}{4}$ mile. There are no ground connections to the various lines anywhere except at the amplifier and this is tied to a $1\frac{1}{2}$-inch water main.

Each station is set up with two-wire terminal blocks. The lines are wired to one side of the blocks and the phones, pushbuttons and speakers wired to the other side. This facilitates quick change of units without disturbing the lines. All joints in the lines were soldered.

Since the voice coils are connected in series, each speaker is supplied with a short-circuiting switch for testing. So far, none of the voice coils has failed. Resistance may be inserted in series with the speaker line to compensate for mismatch with the output transformer.

Additions to the installation were made gradually over a period of two years and no improvements have been made recently.

• • •

Production Tester for Mica

THE BEST RUBY MUSCOVITE mica has come from India, but there are large deposits of ruby and other types of muscovite mica in the United States, South America, and Canada. If these were available for mica capacitors, not only would the supply be greatly increased, but the transportation difficulties would be lessened.

Because of this situation, the War Production Board appealed to Bell Laboratories in the fall of 1942 to devise a method of testing and classifying mica that would give more positive results and insure that no good mica of any type was rejected. What was urgently needed was a quick and easy method of detecting conducting regions, and for

POLYETHYLENE

A "Carbide Chemicals" Production Achievement for the Navy

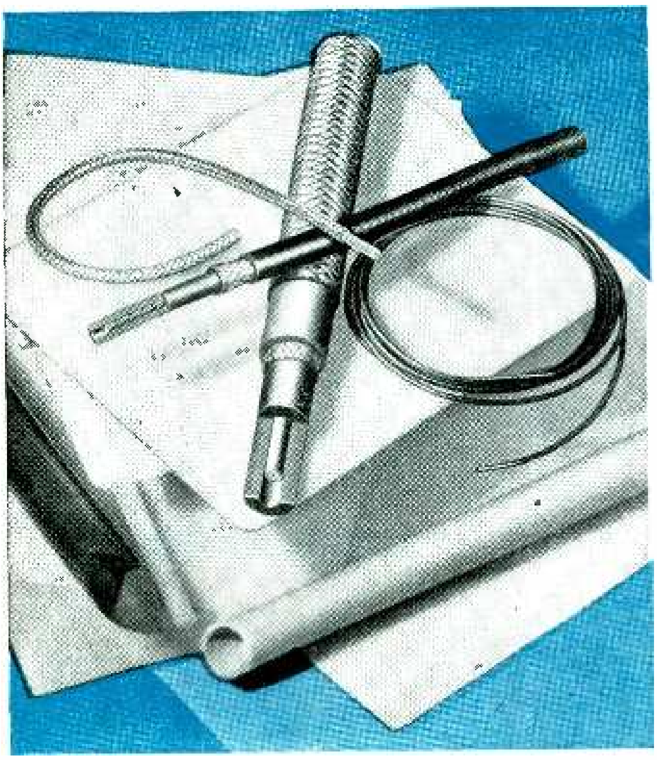
Important New Plastic Has Many Unusual Properties

A little over two years ago, the U. S. Navy learned that Carbide and Carbon Chemicals Corporation in collaboration with an associate company, The Linde Air Products Company, had developed a high pressure synthesis of a new material, Polyethylene, and it was found that this material was exactly suited to meet the Navy's requirements of an insulation for coaxial cable used in radar equipment.

At the Navy's request, these two companies, working together but entirely independent of anyone else, designed in their own Engineering Department and built with their own Construction Organization a plant to produce polyethylene by a process different from any other commercial polyethylene process.

Within thirteen months from the date the project was authorized, this plant was producing at 180 per cent of rated capacity.

At the conclusion of the first full year of production the Navy Department told the plant:



"One year ago your plant commenced the production of polyethylene, a component of radio cable essential to the efficiency of electronic communications units and, therefore, vital to the success of naval operations. Production for the year has equalled 240 per cent of the rated output for the facilities. Everyone engaged in developing the product, planning, engineering, and managing the plant, and each of you engaged in producing polyethylene may be justly proud of a valuable contribution to the war effort."

Today, approximately two years after Carbide was given the assignment, this plant is producing polyethylene at 600 per cent of rated capacity and is providing the Navy's requirements of this material for use in coaxial cable.

THE IMPORTANT NEW PLASTIC! Polyethylene resins have the most favorable electrical characteristics of any plastic material for use in this electronic application. In addition, this new plastic material has many other exceptional characteristics, which suggest widespread application in many different fields. Polyethylene plastics are tough and impact-resistant. They are inherently flexible and extensible. They have an extremely low water vapor transmission coefficient and will absorb an unusually low percentage of water. Their chemical resistance is outstanding. Polyethylene is one of the lightest plastics, so light that it will float in water. It maintains its valuable properties over a wide range of temperature. It remains usable at temperatures lower than 90 degrees below zero, Fahrenheit, and is sufficiently rigid for use in temperatures up to 230 deg. F.

Polyethylene is colorless and translucent as originally manufactured but it can be formulated to produce colored products of exceptionally high lustre. These products can be fabricated by standard processes on existing plastics equipment.

Molded and extruded products, cloth coatings, flexible sheeting and film, and monofilaments are among the polyethylene plastic products which will be available in the future.

Polyethylene plastics are now restricted to applications covered by WPB Limitation Order No. 348. Technical data and samples for controlled end uses can be obtained by manufacturers with plastic-processing equipment by writing Department 18.

BAKELITE CORPORATION, 30 E. 42 St., New York 17, N.Y.

Unit of Union Carbide and Carbon Corporation

UCC

(This advertisement has been reviewed and approved by the U. S. Navy Department)

This is the APPROVED
MINIATURE TUBE SOCKET
THAT MEETS
ARMY-NAVY SPECIFICATION
JAN-S-28

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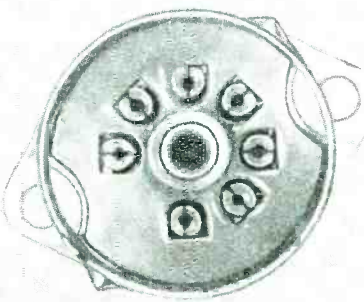
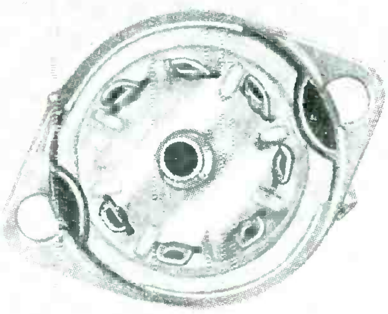
TWICE SIZE





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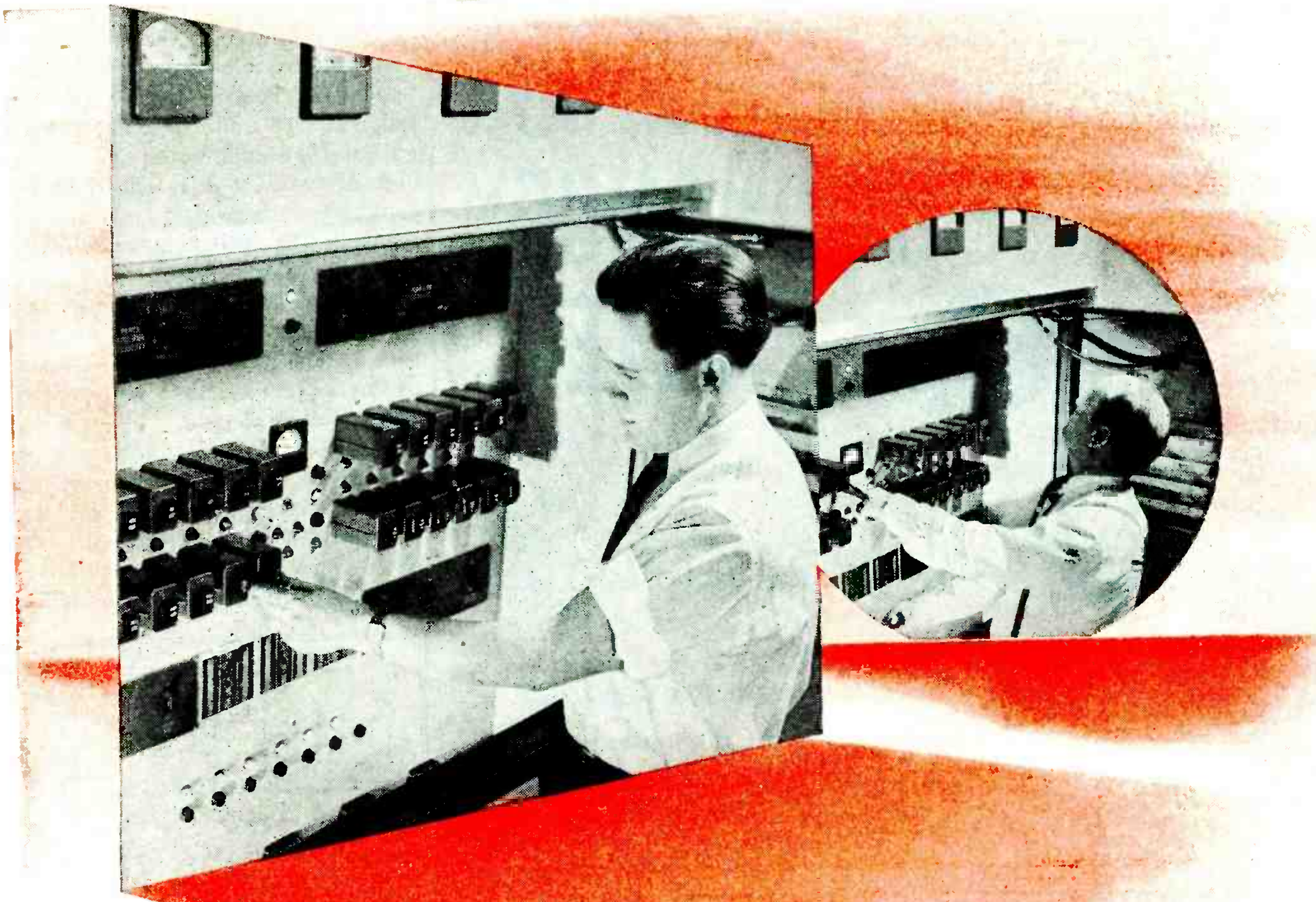

CONSIDER *Ease of Maintenance*

WHEN YOU SELECT A NEW TRANSMITTER

Modern transmitters require little maintenance—but when they do, *ease* of maintenance is important.

In Westinghouse Transmitters all *units are easily accessible,* both for inspection and maintenance.

Complete protection to operators is assured by interlocks on doors to all compartments in which dangerous voltages are present. Controls are of the dead front type, instruments at ground potential for maximum safety.

Indicator lights flash circuit conditions to the operator in case of overload, making it easy to check up for the possible cause of the interruption.

We will gladly furnish complete information on these and other advantages of the HG-5-KW and HG-50-KW Transmitters, such as: *Low Operating Cost, High Fidelity Signals, Continuity of Operation, Simplicity of Control.*

PLACE YOUR ORDER NOW FOR YOUR POSTWAR TRANSMITTER

By placing your order today for a Westinghouse Transmitter, you assure yourself of the fastest possible delivery following the lifting of wartime manufacturing restrictions. We are scheduling deliveries in the sequence in which orders are received. For details, write Westinghouse Electric & Mfg. Company, Dept. 1NB, P. O. Box 868, Pittsburgh 30, Pa.

J-08078

Westinghouse RADIO DIVISION

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A M • E L E C T R O N I C S • F M

determining the dielectric loss under the influence of the alternating voltages the mica would encounter in service. To meet these needs, the Laboratories undertook an investigation that culminated in the design of two test sets: one to detect conducting regions, and one to measure the dielectric loss of raw mica in "block" form. This term applies to sheet mica ranging from 7 to 30 mils in thickness. The test sets are described by K. G. Coultee in the September, 1944 issue of *Bell Laboratories Record.*

One test set determines loss by measuring the power factor of the current flowing through the mica when high-frequency voltage is applied across it. Since ordinary methods of measuring power factor

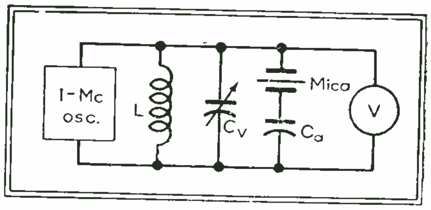


Fig. 1—Simplified circuit illustrating the principle of operation of the tester for measuring the dielectric loss of raw mica

are too slow for a commercial test of this type, a circuit was designed that gave a suitable measure of loss as a single reading of a voltmeter. The principle of the circuit employed is illustrated in Fig. 1.

A high-frequency oscillator is coupled to a circuit consisting of an inductance L, an adjustable capacitor C_v, and a fixed air capacitor C_a of negligible loss. The mica sheet to be tested is placed in series with the air capacitor C_a. A voltmeter across the circuit measures the voltage both before and after the mica is in place. Prior to a series of tests, and before any mica has been inserted in series with C_a, the circuit is tuned to the applied frequency, and the input is adjusted to give full scale reading on the voltmeter.

Operation

When a sample of block mica is now inserted in series with C_a, it detunes the circuit, which is retuned to resonance by adjusting C_v until a maximum reading is obtained on the voltmeter. If there were no loss in the mica, that is, if the power factor were 0, the meter

Franklin's 39

RADIO SOCKET

The favorite yesterday, the favorite for tomorrow

THE MANY MILLIONS INSTALLED IN 1941 IS

Positive Testimony to its

POSTWAR VALUE

The story of Franklin's series 39 Radio Socket, with patented "U" shaped bow spring action contacts, is most remarkable ... developed and patented early in 1938 it received immediate acceptance and approval by practically all the radio set manufacturers and became standard equipment with most.

Series 39 sockets should be riveted to the chassis to become a permanent part of the set ... no replacement will be necessary as the socket will outlive the set.

Series 39 sockets were the favorite yesterday and will be the favorite tomorrow for standard broadcast receivers.

This series 39 socket has a 39G contact with a soldering tab which eliminates wiring to ground.

Illustrating the "U" shaped bow spring action contacts...39H and 39G...used in Franklin's series 39 Sockets.

Bow spring action maintains resiliency even after installation of oversize pins

Direction of metal grain prevents breaking of soldering tail and permits rough handling in production

"U" shaped contact provides separate soldering tail which prevents solder from flowing into contact body

The 39G contact has a soldering tab to eliminate wiring to ground ... can be inserted in any position where grounding is desired.

For the details of the 39, Diheptal, Miniature, Lock-in, Battery and Sockets for other applications, moulded or ceramic...and a complete line of Radio Components...write for the New Franklin Catalog with which is included a complete Buyers Guide for the Electronic Industries.

A.W. FRANKLIN MANUFACTURING CORP.

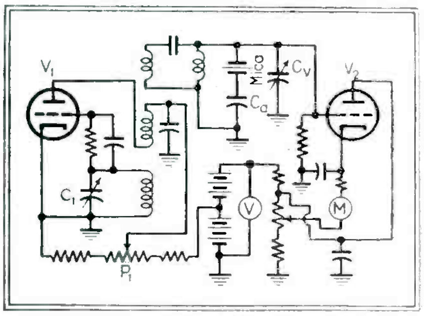
SOCKETS • TERMINAL STRIPS • PLUGS • SWITCHES • PLASTIC FABRICATION • METAL STAMPINGS • ASSEMBLIES

175 VARICK ST., NEW YORK 14, N. Y.

reading would be at full scale as before. Any loss in the mica appears as a series resistance and less current flows causing the voltmeter to indicate less than full scale.

The circuit actually employed is shown in Fig. 2. Tube V_1 is in the oscillator circuit, which is adjusted to a frequency of one megacycle and proper output power by adjusting C_1 and P_1. Tube V_2 forms part of a vacuum-tube voltmeter. Its reading, taken on meter M, is used for classifying the mica in terms of power factor.

On the panel of the tester is a knob used for raising and lowering C_a so that a sheet of mica can be inserted between it and the lower electrode. This dial is also arranged to



indicate the thickness of the sample of mica under test. For each test, the sheet of mica is placed between C_a and the lower electrode, and the sheet of mica is placed between C_a and the lower electrode, and the knob is turned to clamp it in place. Capacitor C_v is then adjusted to give a maximum reading on the meter.

It was found possible to correlate the results obtained from the tests with the power factor indication of the test set. As a result of the correlation, three ranges of power factor were established, each lying between certain pointer readings on the test set. These ranges appear as diagonal lines on the scale of the meter. The reading of the test set also varies with the thickness of the mica as shown by the clamping dial, and the scale of the meter is arranged to permit this factor to be taken into consideration. With the unit, it is possible to test as many as fifteen samples of block mica per minute, while with the more conventional methods at least fifteen minutes would be required for each test.

To discover conducting regions in stained mica prior to the power fac-

A new member of the Family

Rauland VISITRON Phototubes

now identified with this well-known group:

- ★ **Rauland AMPLICALL Intercommunicating and Sound Systems**
- ★ **Rauland Microphones**
- ★ **Rauland Cathode Ray Tubes**

RAULAND VISITRON TUBES ARE NOW IN PRODUCTION AND AVAILABLE

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Buy War Bonds and Stamps! Rauland employees are still investing 10% of their salaries in War Bonds

a 4th CITATION

for continuing leadership in war instrument production

This succession of citations and stars awarded to WESTON is recognition of WESTONS unremitting war effort . . . and their record in supplying instruments to the *exacting standards* essential for the most vital assignments of our armed forces.

That WESTON has been *first* in this highly specialized instrument field to receive each of these successive honors is the inevitable consequence of a *leadership* acknowledged throughout the years by governments and industry alike. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

Weston

FOR OVER 56 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

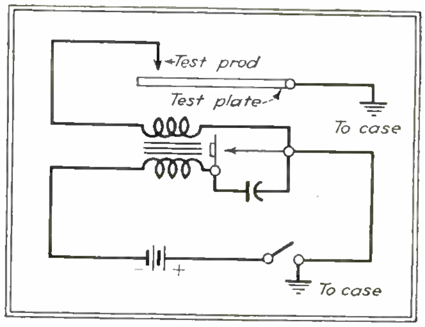


Fig. 3—This spark coil setup shows conducting regions in mica when a sheet of it is placed on the test plate and the test prod moved over the surface

tor test, a battery-operated spark coil was arranged as shown in Fig. 3. A sheet of mica is placed on the test plate and the test point is moved over its surface. Any defective regions are indicated by sparking at or in the vicinity of the point. Only a few seconds are required for each test.

By the use of these two test sets, a large quantity of block muscovite mica, considered unusable for capacitors by the previous methods, was selected and used in about 40,000 capacitors by several manufacturers. These capacitors fully met thorough performance and life tests made by the manufacturers, and proved the reliability of the test set classification. As a result of this commercial trial, an increase of about 50 percent in the muscovite mica suitable for use in capacitors has been realized.

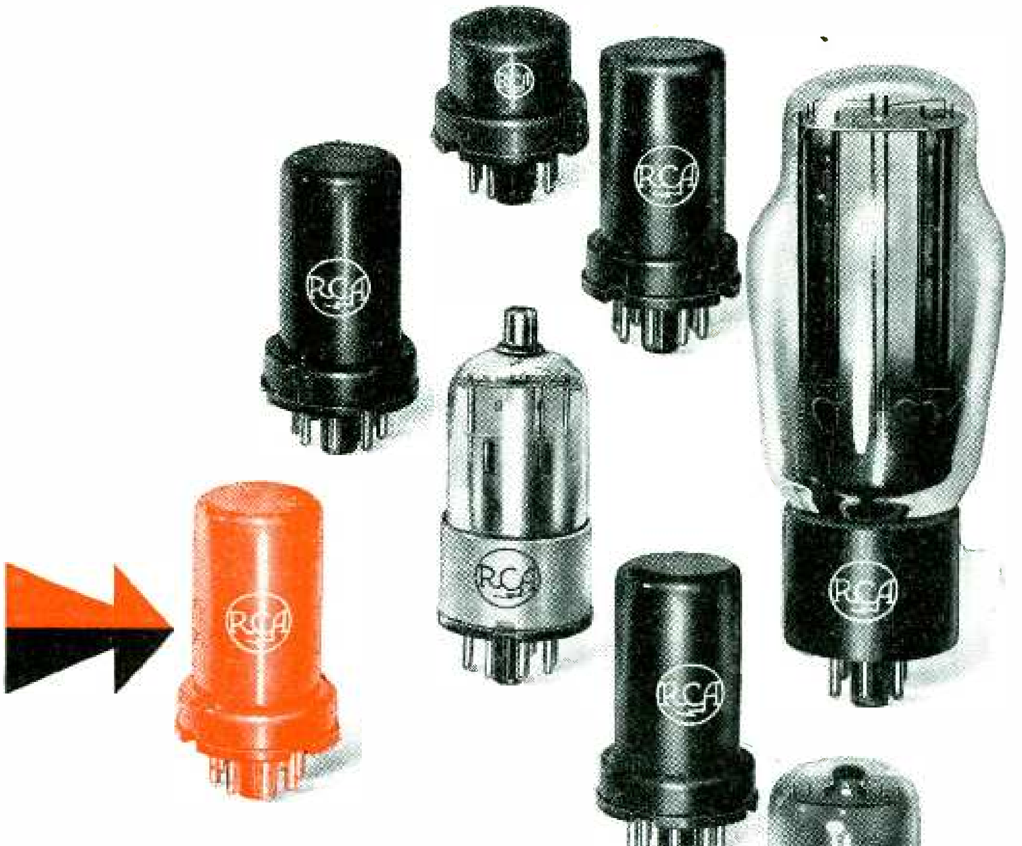
• • •

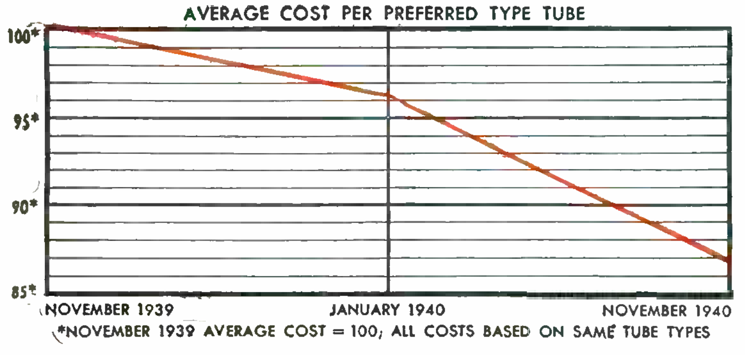
Tester for Invasion Telephone Wire

FIELD TELEPHONE WIRE at a U. S. Army invasion base in southern England is tested for breaks and salvaged for further use by an ingenious device designed by Staff Sergeant Pasqual L. Wamil of Santa Barbara, Calif.

The tester consists of pipes through which the wire passes while being wound onto spools, and a control box with a bell. When a break in the insulation is encountered, a spark jumps between the pipe and the wire and causes the bell to ring. After the original model operated successfully, three additional pipes were added. Drop-out annunciator tabs show which pipe is carrying the defective wire.

THIS ONE'S "ON RCA"





Here's Why— RCA's Preferred-Type Program Slashed Tube Costs to Manufacturers More Than 13% During Its First Year . . . Giving You One Tube in Eight "On the House" by Former Price Standards

The Preferred-Type Idea makes sense. And, it works!

Introduced by RCA in January, 1940, the Preferred-Type Program aimed at concentrating a larger demand and production on fewer tube types. This would allow greater manufacturing efficiency, because of longer runs, and would mean higher-quality, lower-cost tubes for you.

Even before civilian radio manufacturing was suspended by war, the program paid off. By November, 1940, the average cost to you of tubes on the RCA preferred list was lower by 13% than the average cost of the same tubes in November, 1939 . . . before the program started.

Yet all the time their cost was being lowered, the tubes improved in quality and performance. And the way was being cleared for simplified tube warehousing and stocking.

Since Pearl Harbor, the value of the "preferred-type" idea has been proved beyond a doubt on the world's battlefields. Most military electronic equipment has been designed around an Army/Navy Preferred List of Vacuum Tubes . . . and our fighting men on every continent are assured speedy replacements of high-performance tubes as a result.

Will RCA continue the Preferred-Type Program after the war? You bet it will! If you already have specific tube complements in mind for postwar and would like to know if the tubes you need will be on the preferred list, let us know what they are. Write to Radio Corporation of America, Commercial Engineering Section, Dept. 62-12E, Harrison, New Jersey.

The Magic Brain of all electronic equipment is a Tube . . . and the fountain-head of modern Tube development is RCA.

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THE ELECTRON ART

Technical Papers Delivered at National Electronics Conference

DESIGNED TO SERVE as a national forum on electronic developments and their application, the National Electronics Conference was held at the Medinah Club, Chicago, early in October. To the 2300 in attendance, about 50 technical papers and addresses were delivered by leading electronic engineers. Besides use in communications, the subjects discussed covered electronic applications in measurement and control, high-frequency heating of dielectrics and metals, aviation, industrial uses, power generation and distribution, industrial radiography and medicine.

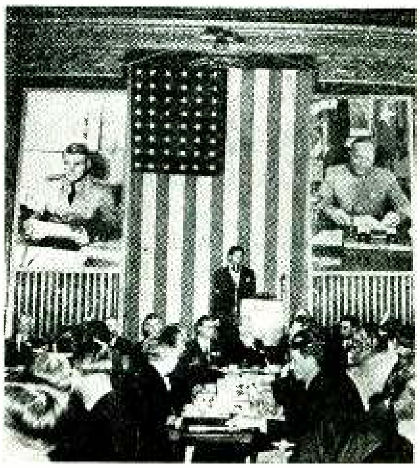
The Conference was sponsored by the Illinois Institute of Technology, Northwestern University, the Chicago Section of IRE and the Chicago Section of AIEE, with the cooperation of the Chicago Technical Societies Council. Proceedings of the Conference will be printed in booklet form. Abstracts of some of the papers delivered at the technical meetings and forums follow.

In a paper entitled "Audible Audio Distortion," H. H. Scott of General Radio Co. pointed out that the non-technical listener judges the quality of sound reproduction subjectively and that such listening evaluations do not always agree with the result obtained by engineers from various methods of measurements.

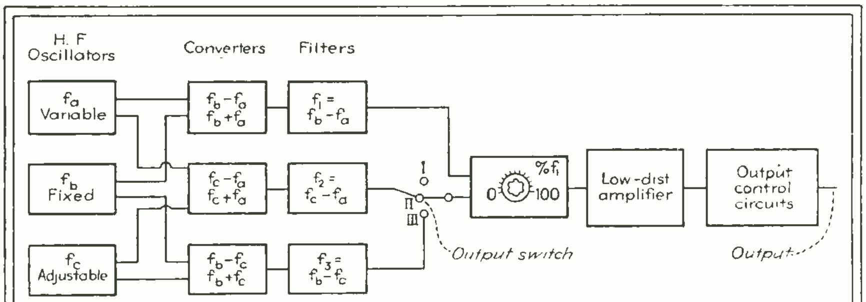
In his opinion, too much attention has been paid in the past to the amplitude-frequency characteristics and harmonic distortion measurements on sound equipment and serious intermodulation products resulting from so-called harmonic distortions have not been adequately evaluated in determining the engineering characteristics of such systems. While moderate deviations from a flat frequency response and small variations in the level of harmonics are not considered by the non-technical listener to represent distortion, they do represent undesirable attributes to the engineer. It was pointed out that within given price limits, electro-acoustic equipment can be designed and built to give considerably better performance with respect to subjective evaluations than has been usual in the past. To substantiate this point of view, Mr. Scott reviewed various measurement techniques and the results which have been achieved by numerous workers in the field.

New Oscillator

The use of a double-beat oscillator for intermodulation measurements was advocated. A block diagram of such an oscillator is shown in the illustration; it consists of one fixed oscillator, a variable oscillator and an adjustable high-frequency oscillator. The output from these oscillators may be heterodyned in various combinations so as to provide a single variable output frequency, two variable output frequencies having a constant sum or a constant difference, or two independently variable output frequencies. Mixing controls for adjusting the relative amplitudes of the two output frequencies, as well as the usual output circuits for varying the total output over wide ranges, are useful adjustments in the measuring technique. The result of measurements made with such a double-beat oscillator technique were shown.



At the Conference, the speakers' table was flanked by enlarged photos of (left) Joseph R. Redman, chief of Naval Communications, and Major General H. C. Inglis, Chief Signal Officer of the Army. Speeches from the two officers were recorded in Washington on a General Electric magnetic wire recorder and played back at the banquet

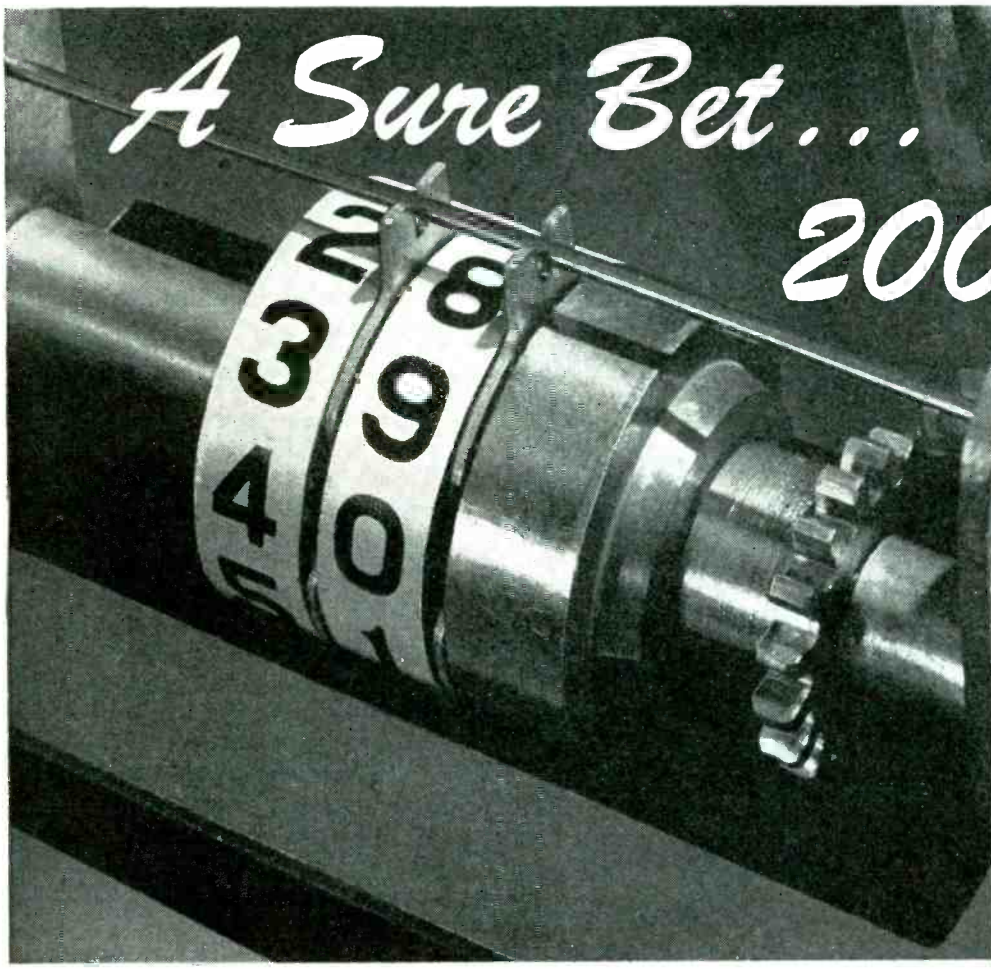


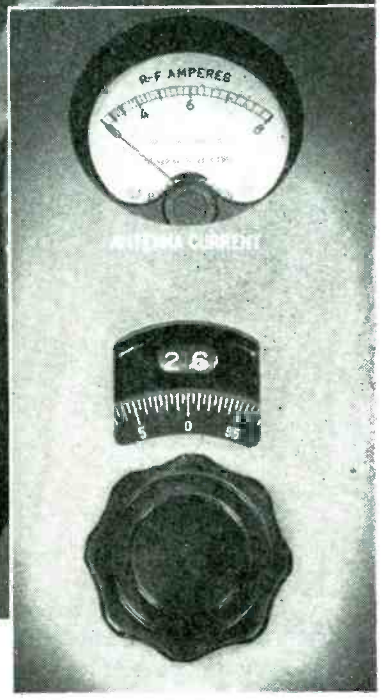
Output switch Position	Output Frequences	Relationship
I	f_1	f_1 Variable
II	f_1, f_2	$f_1-f_2=K$ or $f_1+f_2=K$
III	f_1, f_3	f_1 Variable $f_3=K$

Block diagram of a double-beat oscillator arrangement for measurement of intermodulation. The chart shows the various outputs that are provided

G. L. Beers described "A Frequency Dividing Locked-In Oscillator F-M Receiver" in which a continuously operating local oscillator is frequency modulated by the received signal. The frequency of the oscillator is locked-in with the received signal at one-fifth of the intermediate frequency. With this five-to-one relationship between the intermediate frequency and the oscillator frequency, an equivalent reduction in the frequency variations of the local oscillator is obtained.

The locked-in oscillator circuit diagram is shown herewith. The tube generally used in this circuit has been an A-5581, an experi-





The counterdial in an antenna network application

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The Techrad counterdial is extremely simple mechanically, having no parts to get out of adjustment. Movement is transmitted through a simple gear mechanism, without the customary use of worms. The interpolating dial is graduated from 0 to 100 and each graduation has two divisions, giving a total of *200 parts* on the dial. *One revolution of the dial thus breaks significant counter figures into 200 readable parts.*

The counter can be supplied in two digit (00 to 99) or three digit (000 to 999) numbers. Stock models drive directly through stem shaft without gear ratio. The numbers on the counter scale read horizontally, making for speed and accuracy in reading. This new Techrad Interpolating Counterdial is sure to find valuable application in your particular field. Write now for complete information and price data. *Master Engineering takes nothing for granted.*

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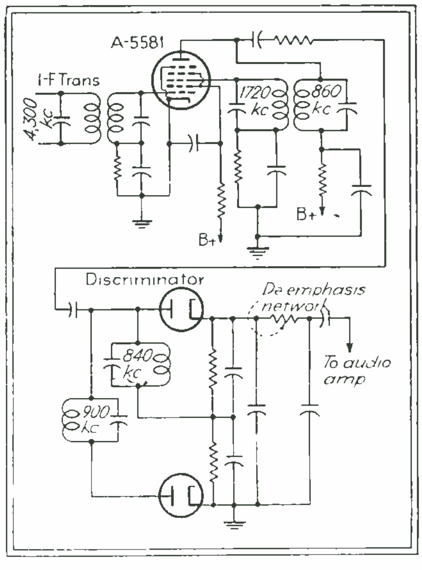
mental converter tube which is similar to the 6SA7 but has a higher transconductance. The oscillator tuned circuit is connected to the plate of the tube and the feedback coil is connected to the No. 3 grid. This grid is operated with self bias. The received signal is applied to the No. 1 grid of the tube from a 4300-kc i-f transformer. The No. 1 grid is likewise operated with self bias.

Discriminator

The output of the local oscillator is fed to the discriminator as shown. This circuit has a pair of diodes connected with the load resistors in opposition so the discriminator is balanced at the center frequency. One diode has a tuned circuit in series with it and the other has a tuned circuit across it. The audio frequency output of the discriminator is fed through a de-emphasis network to the audio amplifier.

The oscillator is designed to



At the top of the diagram is the oscillator which is locked in with the received frequency. Output of the oscillator feeds directly to the discriminator at bottom

lock in only with frequency variations which occur within the desired signal channel and is therefore prevented from following the frequency variations of a signal on an adjacent channel. A substantial improvement in selectivity is thus obtained. The voltage required to lock in the oscillator with a weak signal is approximately 1/20th of the voltage applied to the discriminator. Since this voltage gain is obtained with a different and lower frequency than the intermediate frequency, the stability of the re-

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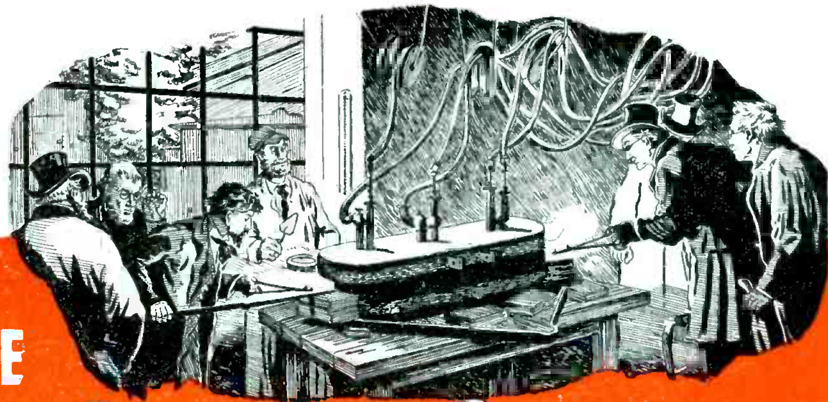

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60	68	112	149		

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
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ceiver from the standpoint of overall feedback is materially improved. Not only is adjacent-channel selectivity increased but reduction in noise is also obtained.

Advantages

Theoretical and experimental investigations indicate that the system has the following advantages:

(1) By restricting the locked-in range of the oscillator to follow only the frequency variations which occur within the desired signal channel, a material improvement in selectivity is obtained.

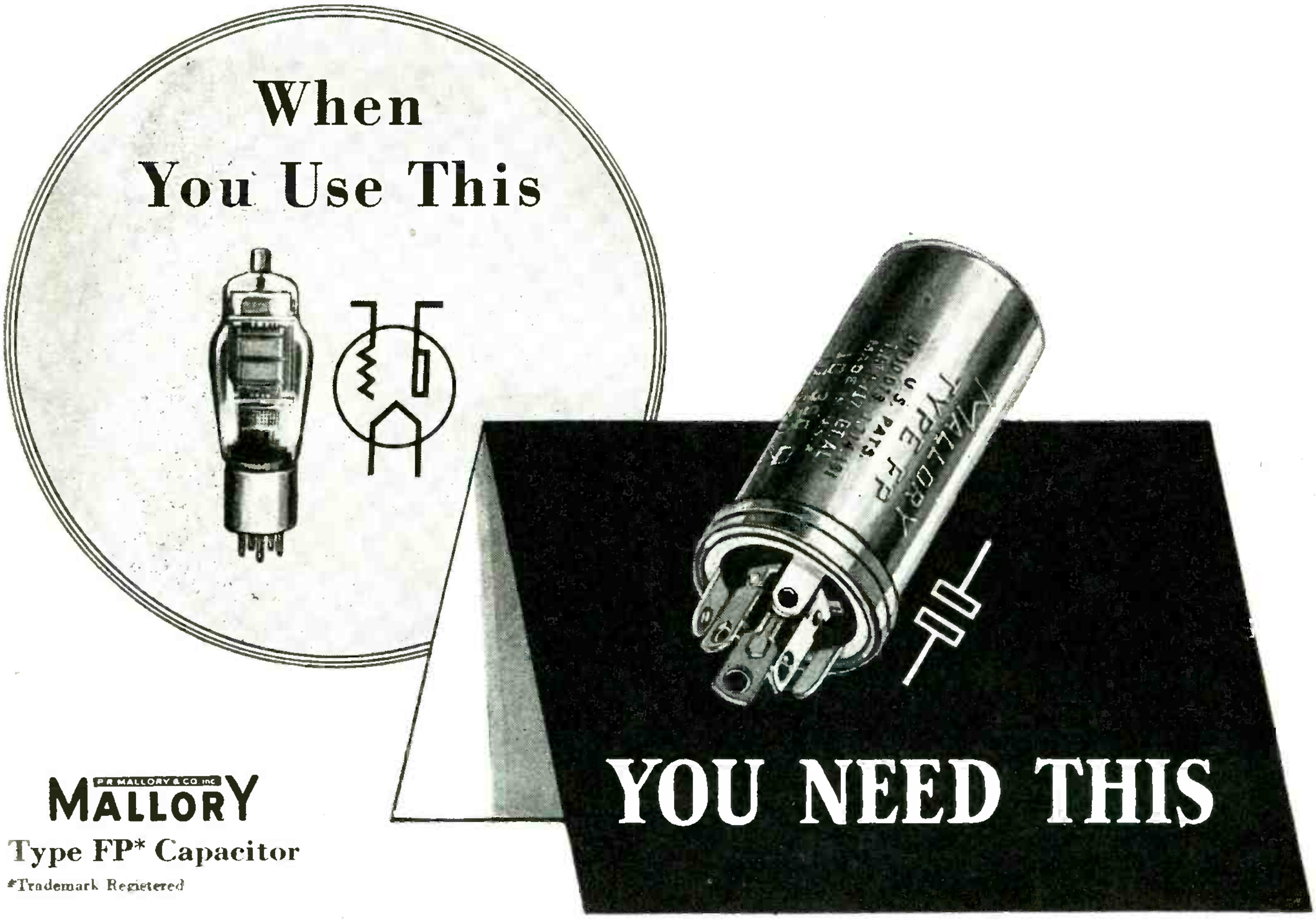
(2) An equivalent voltage stepup is secured at a different and lower frequency than the intermediate frequency and a corresponding improvement in freedom from overall feedback is secured.

(3) The constant voltage is applied to the discriminator irrespective of the strength of a received signal, and arrangement for minimizing amplitude variations in a received signal are therefore not required.

(4) The system provides a means for incorporating in a f-m receiver a type of selectivity which can be used to discriminate between the desired signal modulation and frequency modulation noise component.

The following characteristics should also be considered in evaluating the system: (1) Adequate receiver gain ahead of the locked-in oscillator must be provided if distortion of the weaker signals (due to oscillator falling out of step) is to be prevented. (2) When the receiver is tuned to a signal, more noticeable distortion occurs at the edges of the receiver response characteristic than is obtained with the corresponding conventional receiver.

A paper by Dr. Leon Brillouin of Columbia University and the Federal Telegraph Radio Laboratories of New York emphasized the importance of a well-known theorem originally due to Larmor. This theorem permits a definition of "momentum" and "moment of momentum" for electrons in the magnetic field. As typical examples of application two special cases were discussed: (1) a plane electron beam; (2) a cylindrical electron beam with longitudinal magnetic fields. In



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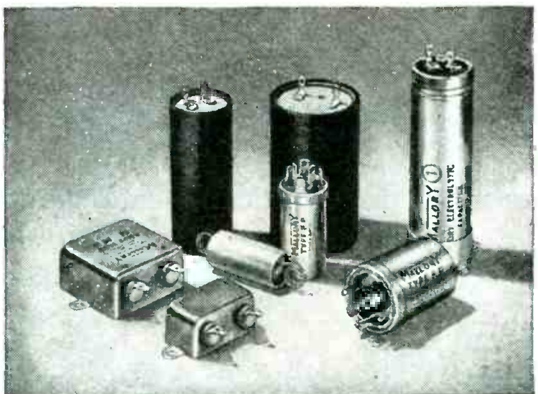

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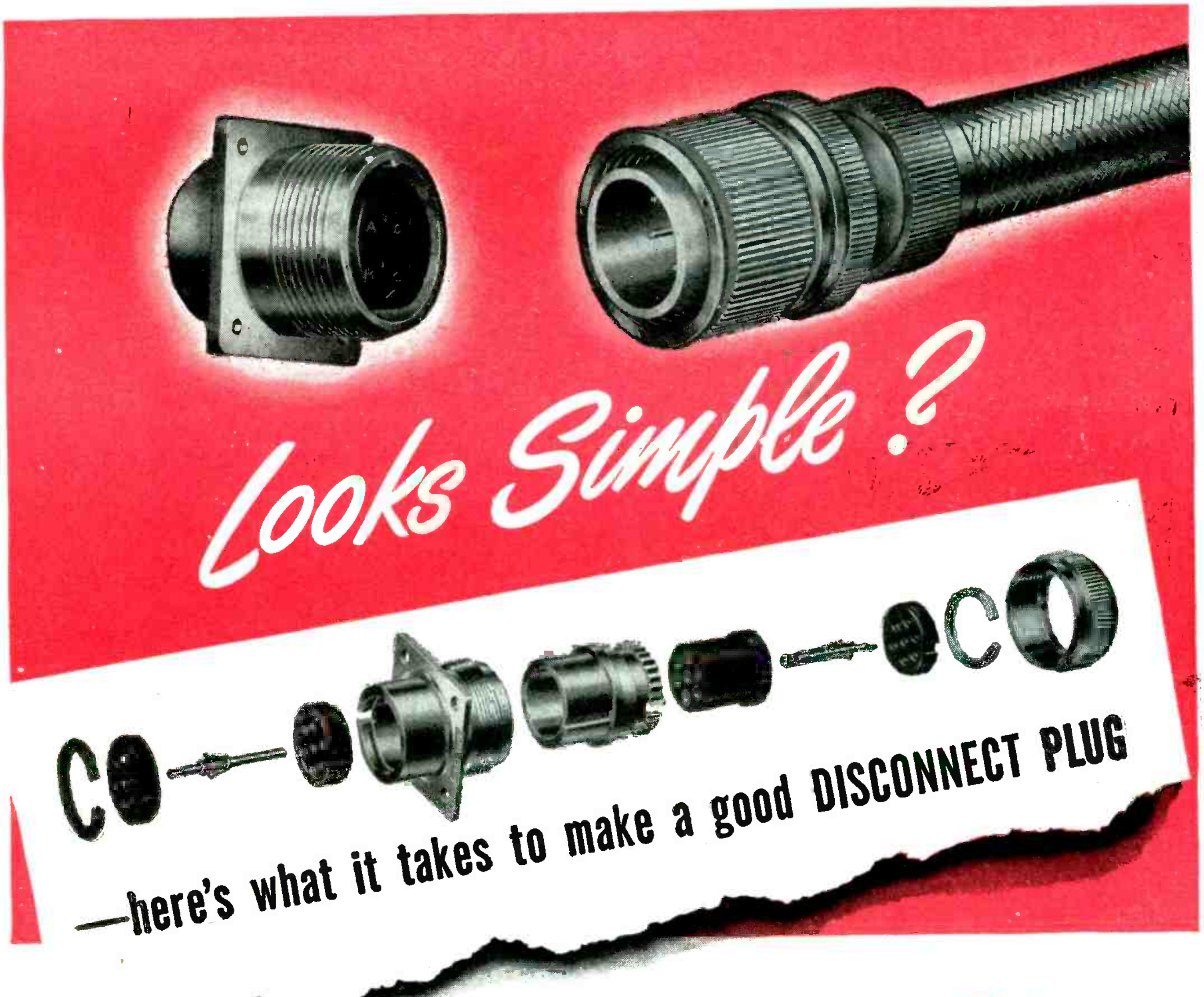

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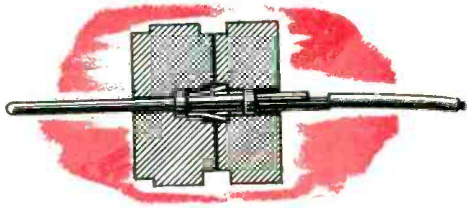
Socket construction features spring-loaded contact for positive electrical connection with pin.

Both pin and socket feature spring snap for ease of assembly in housing insulators after soldering.



Cross-section illustrating how contact pin is snapped into place after soldering on lead wires.

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PRODUCTION FOR VICTORY — PRODUCTS FOR PEACE both cases, it was found that the space charge density of the beam is entirely controlled by the magnetic field, and the maximum current is obtained for a suitable optimum magnetic field.

Space Charge and Magnetic Field

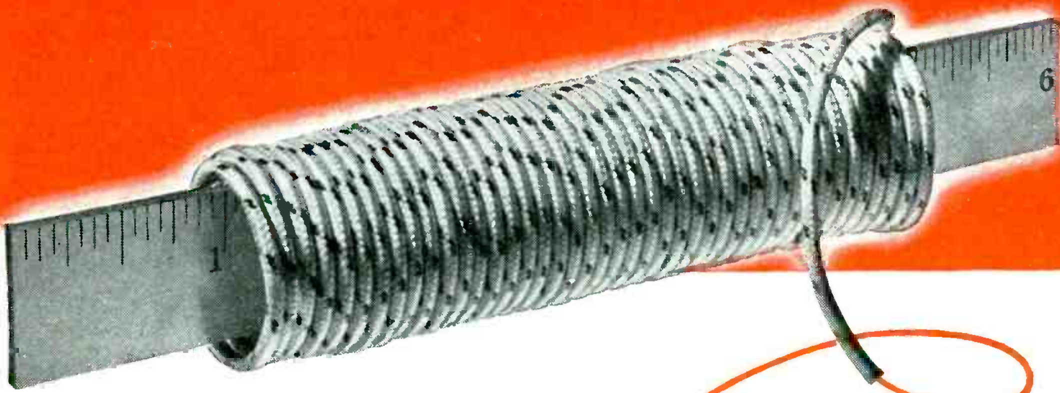
Dr. Brillouin's general conclusion, as the result of a mathematical treatment, is that such problems as Larmor's theorem introduces an additional condition of conservation for either the momentum or the moments of momentum which has been too often overlooked. If taken into account, it shows that the space charge density is entirely conditioned and controlled by the magnetic field. Caution is therefore urged not to introduce in a discussion separate assumptions about space charge and magnetic field. It it especially advised not to speak of the behavior of a device under an infinite or arbitrarily large magnetic field, since this would also mean infinite space charge density, a very troublesome factor.

"The Supersonic Reflectoscope, An Instrument for Inspecting the Interior of Metal Parts by means of Sound Waves" was the title of a paper by Dr. F. A. Firestone, University of Michigan.

The supersonic reflectoscope sends into the metal part to be inspected a short train of supersonic sound waves. Any flaws on the interior give reflections back to the sending point before the reflection is received from the other side of the piece. Many feet of metal can be penetrated.

In addition to the detection of flaws, the thickness of a piece can be measured when its opposite side is inaccessible, and discontinuities of bond of plated or soldered surfaces can be detected.

A paper by Dr. E. U. Condon, of the Westinghouse Research Laboratories, gave an elementary discussion of the way in which the behavior of class C oscillators, intended for use at microwave frequencies, is limited by the speed of electron motions. The paper, entitled "Microwave Oscillation Generators Using Velocity Modulated Electron Beams," presented the main results of the elementary theory of three kinds of velocity-modulated tubes, namely, the monotron, the Klystron, and the reflex Klystron. The mono-



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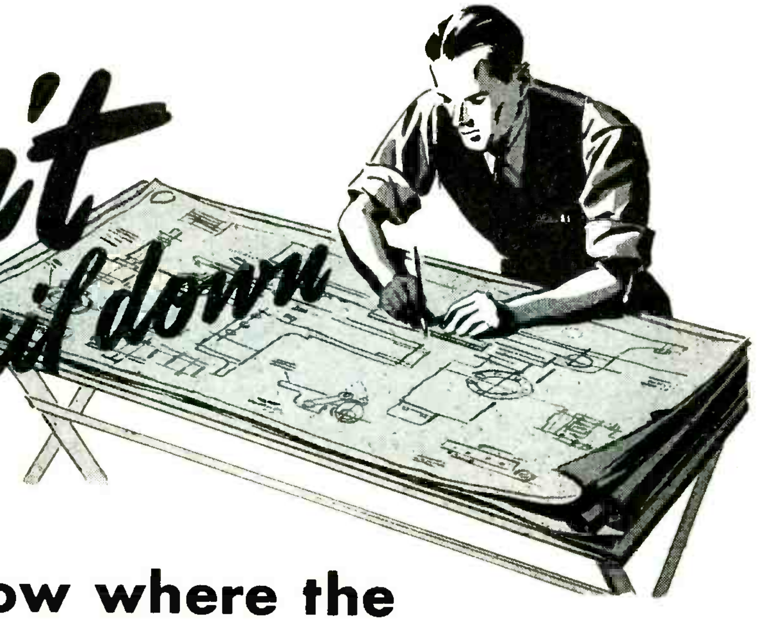

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Choosing the fastening device for use in the assembly of your post-war product is a very important decision. It should be settled now, while the product is still in the design stage. Too many products are tooled up and ready to go into production before somebody starts to really question fastening methods. This frequently leads to needless expense, troublesome delays, and costly changes.

You will want to use P-K Self-tapping Screws wherever possible, because this *short cut fastening method* **can save you from 30% to 50% in assembly time and labor! It is the *simplest* way to make most assemblies.** You eliminate tapping for machine screws, and tap expense – fumbling with bolts and nuts – costly inserts in plastics – riveting in hard-to-reach places.

Whether you are working with light or heavy steel, cast iron, aluminum, brass, plastics – you'll find you can use P-K Screws to advantage in 7 out of 10 cases.

A P-K Asembly Engineer will help you plan ahead for savings, and you'll find his advice unbiased. He'll recommend only the best Self-tapping Screw for the job, because Parker-Kalon makes *all* types. Write and tell us when you would like him to call, or send details of your fastening jobs for recomendations.

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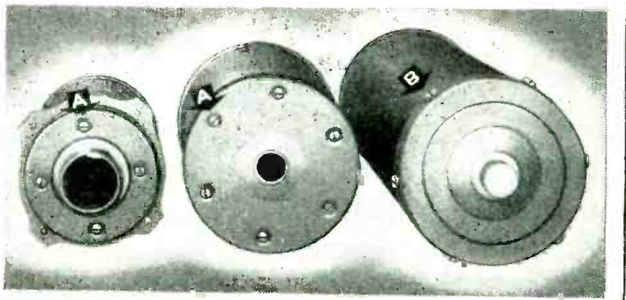

(A) 4 Type "Z" Screws fasten sheet metal cap to steel (or aluminum) frame.

(B) 6 Type "Z" P-K Screws fasten the cast iron cap to steel tubing wall.

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Purolator Products, Inc., make a wide variety of filters for gasoline, oil, air, etc., which are standard equipment on many vehicles, vessels, and airplanes.

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The P-K "User's Guide" is crammed full of information on where and how to use P-K Self-tapping Screws, arranged so you can find the facts you need quickly. Write for it. Parker-Kalon Corp., 208 Varick St., New York 14.

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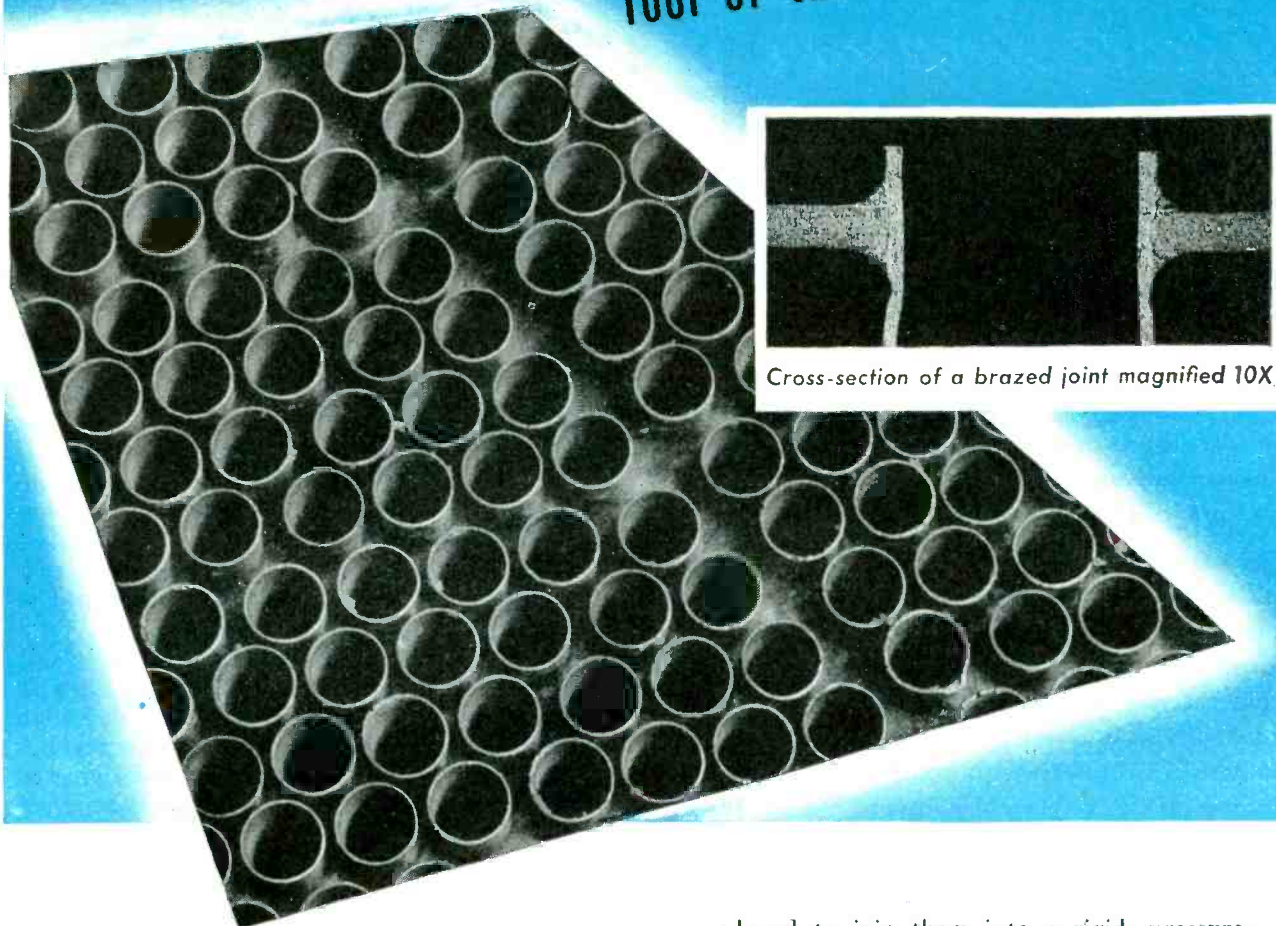

Cross-section of a brazed joint magnified 10X

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tron is a tube in which a cavity resonator is placed between the grid and plate to act as a tank circuit, and a steady unmodulated electron beam is sent through the grid from the cathode with no attempt at any kind of modulation of the beam before it arrives at the control grid. In the Klystron, electrons are emitted from a thermionic cathode and are accelerated by means of a cathode potential in a beam, through the grid or cavity resonator, the buncher. After traversing these grids, electrons travel through the axis of the tube to another cavity resonator, the catcher.

Use of Reflex Klystron

The reflex Klystron has been used principally as a low-power tube and is especially useful as the local oscillator of a heterodyne receiver. Electrons are accelerated from the cathode by a voltage between the cathode and a single cavity resonator, where they experience velocity modulation. They are then repelled by a negative reflector voltage and revert back to the grid of the resonant cavity.

After a mathematical analysis, it was shown that the slowness with which electrons travel at ultra-high frequencies rules out the possibility of making oscillators designed on the principle of a class C amplifier or oscillator. It is for this reason that oscillators using velocity modulated beams have been so thoroughly investigated within recent years.

A paper, "The Principles of Klystron Amplifiers," by Dr. R. O. Haxby of Sperry Gyroscope Co., dealt with the fundamental principles governing the operation of Klystron amplifiers rather than the description of any particular tube. It was shown that there are two principal reasons for the unsatisfactory operation of amplifiers at very high frequencies: (1) the transit time of electrons to pass the control grid takes an appreciable part of a cycle of the high frequency, thereby causing loading and loss of gain; (2) the size of the electrodes and circuit becomes comparable to a wavelength, making it difficult to design efficient circuits and obtain radio-frequency power.

In the Klystron amplifier, the transit time of electrons is used to advantage rather than to disadvan-

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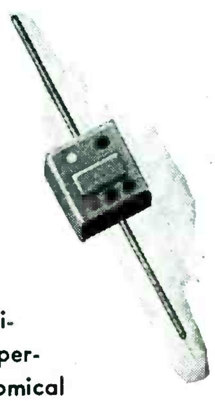
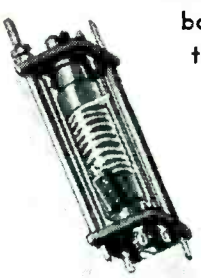
Any variation in magnitude which can be converted to a variation in frequency—quantities such as length, permeance, volume, and height—can be more quickly and accurately measured by the PANORAMIC COMPARISON TECHNIQUE. Capacitors, inductors, resistors, and crystals are "naturals" for PANORAMIC production testing. A simple jig and a PANORAMIC COMPARATOR will provide your tester with an unbeatable combination for speed and accuracy on the production line.



In application, the component under test is placed into the jig containing the standard. The chosen tolerance may be established quickly by means of the panel control on the PANORAMIC COMPARATOR. From the deflections which appear on the PANORAMIC screen, deviations from the standard become immediately apparent both as to percentage and type. The instrument is usually adjusted so that a visible deflection indicates that the production unit is within the predetermined tolerance range, while the absence of deflection indicates an error in excess of the permissible tolerance. Coincident deflections indicate zero error; displaced deflections tell their own story regarding the percentage of error. PANORAMIC COMPARISON TECHNIQUE is economical in time and energy . . . but extremely accurate in results.



Our engineers will gladly suggest simple jigs for use in any type of production testing.

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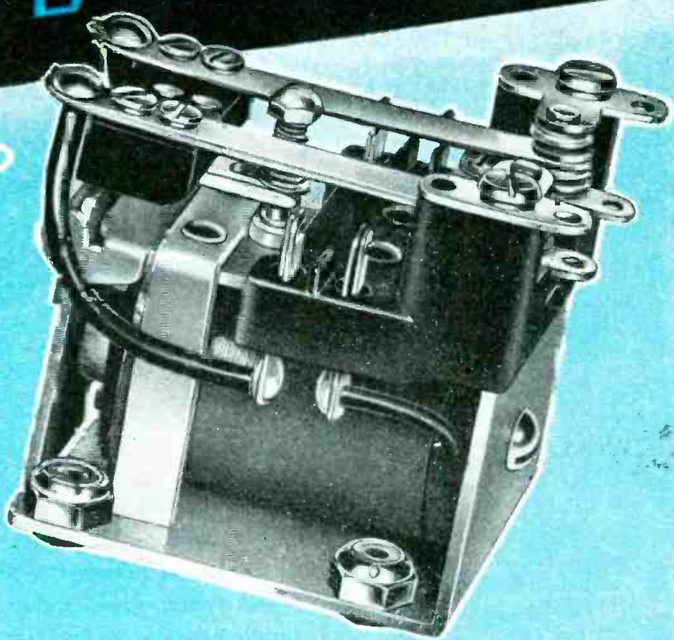
POWER RELAYS



MODEL

"BOL"

RELAY

The Allied BOL relay—a power relay built to operate on 2.5 watts and to withstand 5.0 watts continuously applied.

Can also be supplied as a time delay relay slugged for slow operation—slow release or slow-action.

Now available in 2 pole construction. 3 and 4 pole construction available shortly.

Overall size 2¼" x 1⅝" x 1⅞"
Weight 8 ozs.

Write for the latest Allied catalog describing type BOL and other precision-built relays.

ALLIED CONTROL COMPANY, INC.

2 EAST END AVE. *(AT 79th STREET)* **NEW YORK, N.Y.**

FACTORIES: NEW YORK • PLANTSVILLE • CHICAGO • LOS ANGELES tage, with the resonant circuits designed as an integral part of the tube. The Klystron consists of an electron emitting gun, a smoother grid, a pair of buncher grids in one cavity resonator, a pair of catcher grids in another cavity resonator, and output and input terminals to the two cavity resonators.

Operation

In the operation of this tube, a small amount of power is fed into the buncher resonator through its coupling loops. This power builds an alternating voltage across the buncher gap. Assuming that the electrons in the beam take only a very small fractional of a cycle to get through the resonator, they either gain or lose an amount of energy equal to the electronic charge times the instantaneous voltage across the gap. Consequently, each electron is speeded up or slowed down as it passes through the grid, by an amount depending upon the instantaneous voltage of the resonator. This process is called "velocity modulation."

Bunching

A beam of electrons which has been velocity modulated will be density modulated or "bunched" at some point within the tube. This bunched grouping of electrons travels down the tube until it reached the grid of the catcher, where the electrons are slowed down in going through the catcher when the voltage is in a direction to slow them down. That is, the electron beam has lost energy, on the average, because of interaction with the field of the resonator. This energy loss by the beam must have gone into the catcher resonator to maintain its oscillation and supply power to an external load. Thus the catcher resonator extracts some energy from the beam. Since there are always some electrons which are not in the bunch, there will always be some electrons speeded up by the catcher, so the efficiency of the tube is limited to a value considerably less than 100 percent. A mathematical derivation of the process shows that it cannot exceed 58 percent.

Dr. Haxby provided a mathematical and graphical analysis of the behavior of the Klystron amplifier, noted some of the factors which

Proving ground for Norelco Cathode Ray Tubes

Reg. U. S. Pat. Off.

Uniformly bright spot on screen of 5CP1 cathode ray tube in test set indicates perfectly formed cathode.

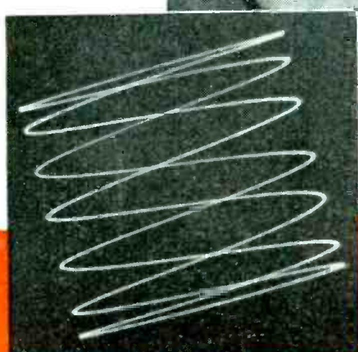
THE uniform characteristics, long life and outstanding performance of NORELCO Cathode Ray Tubes are the result of exceptional manufacturing skill supplemented by rigid tests applied to each tube as it comes off the production line.

As an example of the care exercised, the electronic test set, shown here, subjects every cathode ray tube to 30 different checks, such as line width, light output, plate alignment, base-to-shell alignment, uniformity of cathode surface, astigmatism, presence of gas, and screen condition. A total of 90 exacting tests of raw materials, parts, sub-assemblies, assemblies and performance guard cathode ray tube quality.

This is typical of the great lengths to which North American Philips goes in producing high performance NORELCO electronic tubes. Behind this company is an organization with world-wide experience resulting from over fifty years of electrical research and development.

Although all the tubes we produce now go to the armed forces, we invite inquiries from prospective users. A list of tube types we are especially equipped to produce will be sent on request.

Pattern used for measuring light output by means of photoelectric cell. Frequency—60 x 2940 cycles.



Trace showing absence of astigmatism. Frequency—60 x 420 cycles.

Write today for interesting booklet, describing the background of North American Philips in the science of electronics.

NORELCO PRODUCTS: Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes; Searchray (X-ray) Apparatus; X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Electronic Measuring Instruments; High Frequency Heating Equipment; Communications Equipment; Tungsten and Molybdenum products; Fine Wire; Diamond Dies. When in New York, be sure to visit our Industrial Electronics Showroom.

Norelco Electronic Products by **NORTH AMERICAN PHILIPS COMPANY, INC.**

Reg. U. S. Pat. Off.

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Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Div.); Lewiston, Me. (Elmet Div.)

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Users of Foote, Pierson contract service increase their output in a way that's sure, practical. Like adding a wing to a plant . . . like bringing a force of skilled craftsmen to a factory in the manpower doldrums . . . F-P assistance can give many a manufacturing company just the lift it needs to welcome post-war competition instead of dreading it.

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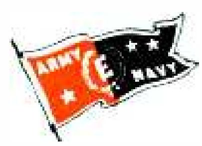
Sound executive leadership gives proper direction to every operation. At Foote, Pierson, this starts with engineering and planning, extends through metal-forming, plating and finishing. It covers not only assembling, inspection and packaging but also packing, storage and shipping by rail, air and water.

Whether you're making a new product now or planning to make it . . . whether you're making a complete article or a component . . . Foote, Pierson can help in manufacture. It costs nothing to get acquainted.



"like adding a wing to your plant"

FOOTE • PIERSON & CO • INC

6327

MANUFACTURERS OF PRECISION INSTRUMENTS SINCE 1896

73 Hudson Street — Newark 4, N. J.

were not taken into the mathematical theory and explained how these would modify the behavior of the Klystron amplifier.

Cascade Resonators

Since the gain of a Klystron amplifier may be increased by adding more resonators, a very high gain amplifier may be constructed, using a single cathode and electron beam. An n-stage cascade amplifier with $n + 1$ resonators will have a gain which is approximately the nth power of the gain of a single-stage amplifier. The last stage of a cascade amplifier is used as a power amplifier with optimum bunching in the last drift space. Thus, a Klystron tube may serve as a combined high-gain amplifier and power amplifier.

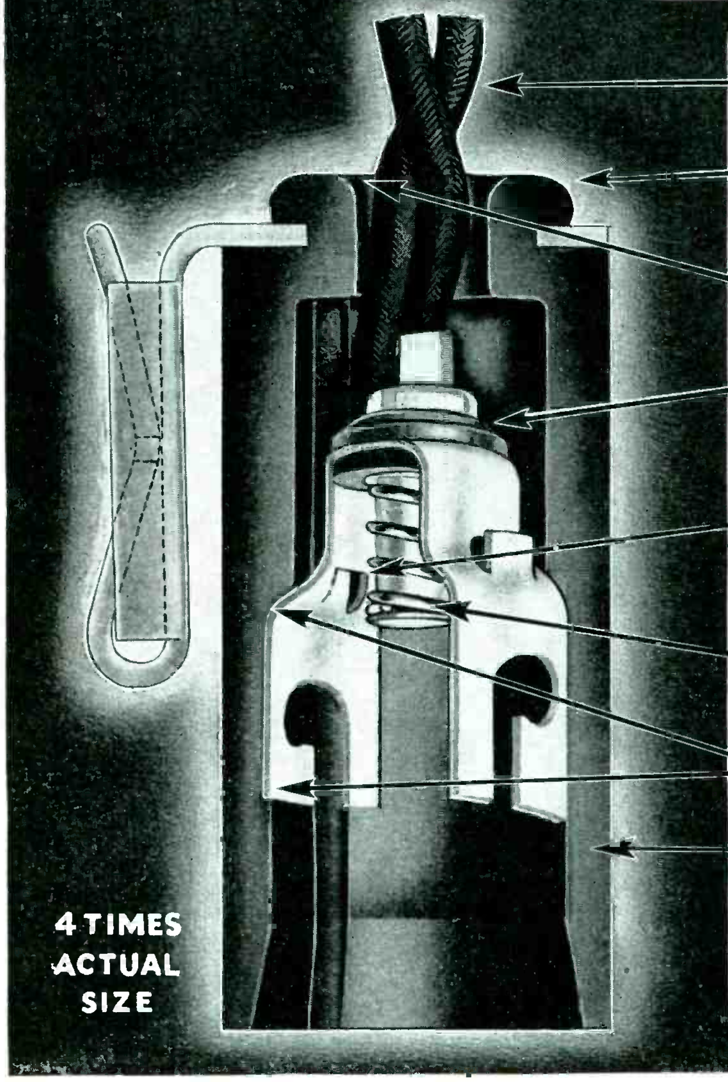
Amplitude modulation may be produced by changing the magnitude of the beam current, and phase modulation is produced by varying the beam voltage around the point of optimum bunching. Phase modulation is also accompanied by a small amount of amplitude modulation unless special precautions are taken to avoid the latter.

A thorough analysis of vacuum-tube frequency-converting devices for use at moderately high frequencies was given by Dr. Harry Stockman, Cruft Laboratory, Harvard University, in a paper, "U-H-F Converters and Conversion Diagrams." Using mathematical as well as graphical methods of analysis, Dr. Stockman showed that a broadcast frequency converter functions as a fixed path-of-operations device or as a changing path-of-operations device. As the frequency is increased, the conventional changing path-of-operations device ceases to function properly, and the action of the other type of converter becomes more and more intricate. This action usually cannot be explained by a few measured characteristics and simple additional mathematical analysis.

Present Design

Modern converter theory deals with the transconductance characteristics of the mixer-oscillator combination rather than the current-voltage characteristics of the mixing device. The variation of

a New and Superior DIAL LIGHT SOCKET



Tensile strength of leads and connections far in excess of requirements.

Tough, plastic shell molded around bracket providing a secure bond with mechanical strength far beyond any normal requirement.

Rounded edge will not cut or fray wire insulation.

Voltage Breakdown between contacts—1200 Volts. Voltage Breakdown to ground—5000 Volts.

Lug on contact fits in groove in shell so that contact cannot be turned or twisted when inserting lamp.

Center contact mounted so that it cannot protrude from shell and short on chassis when lamp is removed.

Plastic shell is recessed for contacts, which cannot be pushed or pulled out of position.

Stronger, tougher, heavy walled plastic shell.

A variety of different mounting bracket styles available, suitable for practically any mounting.

For Your Present and Post-War Production

40th ANNIVERSARY
1904—1944

This year Lenz celebrates its 40th year of service to the communications industry.

Lenz Dial Light Sockets have always been known for their superior mechanical qualities and electrical characteristics.

Now these sockets are still further improved, with even greater mechanical strength. A stronger, tougher plastic shell is attached to the bracket with a new type of construction that provides a virtually unbreakable bond between shell and bracket. Its excellent electrical characteristics are maintained.

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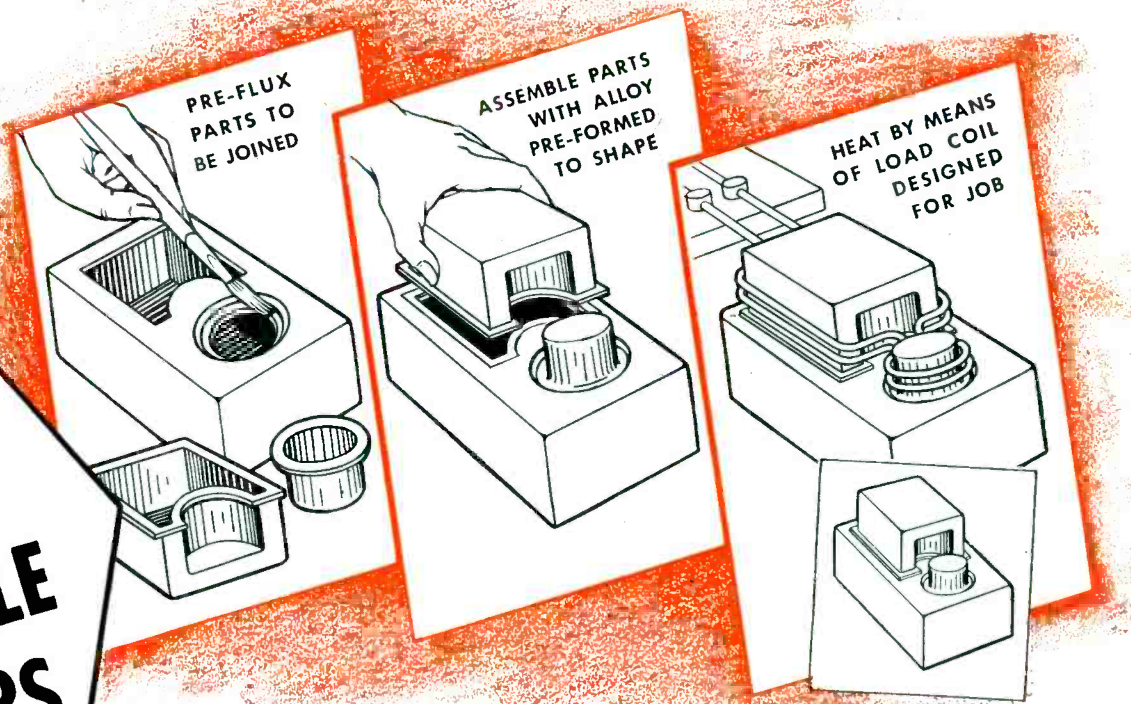

to BETTER METAL JOINING — FASTER and at LOWER COST

Many manufacturers, seeking faster and better methods of assembling metal parts to meet war production demands, have found the answer — and important economies — in brazing and soldering by the Lepel Induction Heating process.

Using brazing and soldering alloys of any melting point, Lepel Induction Heating reduces the most intricate metal joining jobs to three simple operations, so easy that women or unskilled workers can perform them with a minimum of training. Frequently, intricate jobs, impractical by other metal-joining methods, can be performed in a few seconds — often with gang set-ups that raise production to astounding levels.

Quality is improved because the human element is eliminated, time cycles are automatically controlled, and the heat is generated within the metal, assuring thorough penetration of the alloy.

"Runs" are rare since only the required amount of alloy is used and, since excessive heating is impossible, discoloration is minimized and scaling practically eliminated. Thus, little, if any, cleaning up or refinishing is necessary.

If you have a metal joining problem — present or projected — involving ferrous or non-ferrous metals, or both, a Lepel field engineer will be pleased to call to discuss the advantages and possibilities for economy which Lepel Induction Heating offers.

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PIONEERS IN INDUCTION HEATING

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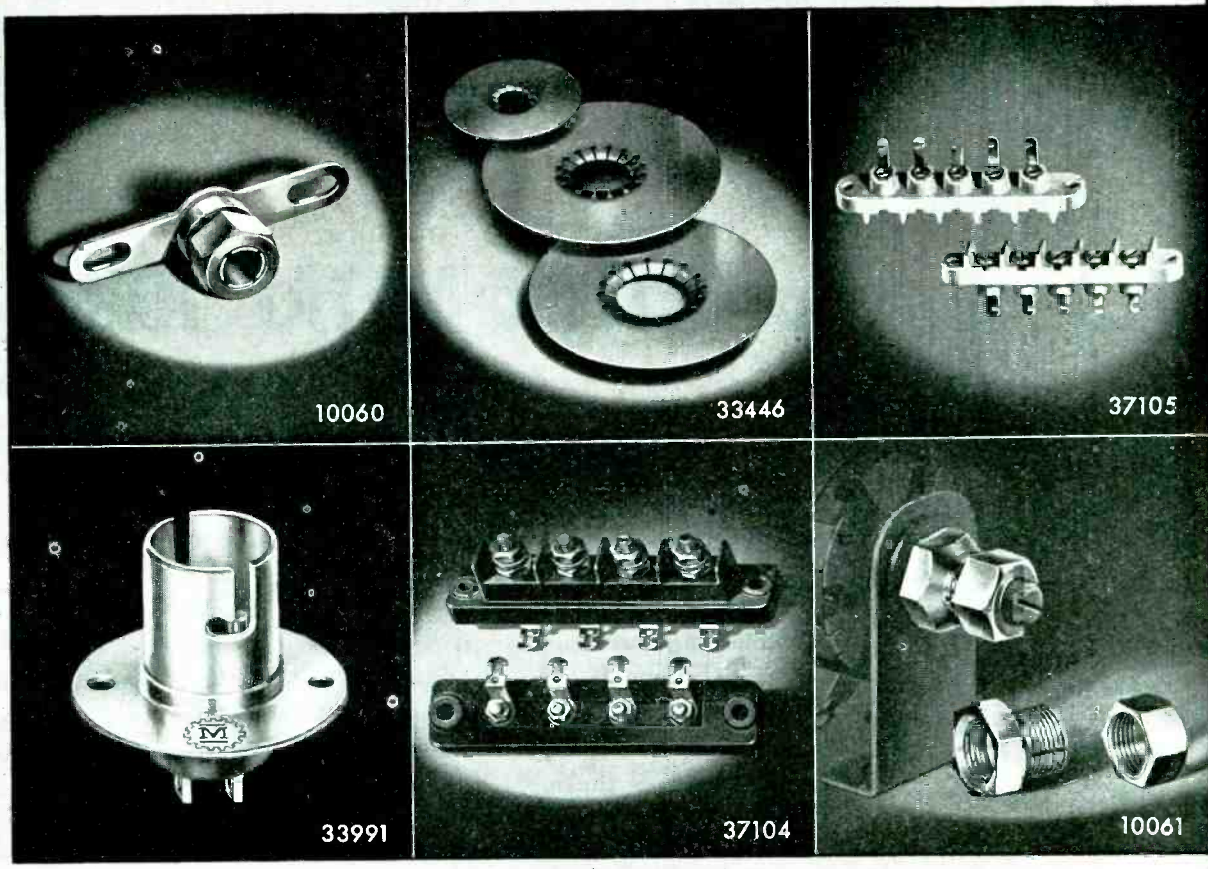
Designed for Application

Millen "Designed for Application" components are different! As a designer and manufacturer for many years of complex electronic and communication equipment, we are our own best customer for component parts. Consequently, we have to perform an outstanding job of designing and manufacturing such parts in order to satisfy our own applications. Our parts are "different", also, because as symbolized by the "Gear wheel" of our registered trade mark, they are designed by mechanical engineers working in close cooperation with our electronic circuit group. Below are illustrated a typical half dozen of the thousand-odd items we manufacture. Unfortunately, at this time, it is not possible to list herewith some of the intriguing "classified" components developed in connection with our ultra high frequency war production work. Our new 1944 general catalogue of non-classified parts has just been released.



Illustrated above, left to right; Top Row: No. 10060 shaft lock with Universal mounting bracket; No. 33446 socket contact discs for use with GL446 lighthouse ultra high frequency tube; No. 37105 steatite barrier style terminal strip with through bushings. Bottom Row: the No. 33991 tube socket for neon voltage regulator tube; No. 37104 molded bakelite terminal strip; and the No. 10061 combination shaft lock and mounting nut for converting standard type potentiometer etc., to shaft locked type.

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SALES OFFICES IN ALL OTHER PRINCIPAL CITIES transconductance from this point of view may be written in the form of a Fourier analysis containing a constant term and an infinite number of harmonically varying terms whose frequency components are integral multiples of the oscillator frequency. Accordingly, a frequency converter may be considered as a device with periodically varying transadmittance or transconductance, the periodicity of which determines the frequency of each possible output component.

Converter design is frequently carried out by means of measurements only, or by means of cut-and-try methods backed by experience. The amount of computation that enters into such a procedure depends upon the nature of the work, the importance of this design, and similar factors of engineering importance. An experimental method, using conversion diagrams, make possible the theoretical investigation of the behavior of mixer circuits under various conditions of operation. The experimental and graphical techniques for establishing such conversion diagrams were outlined, and the result of measurements on diode converters at a frequency of 7 Mc or higher were presented. The paper was primarily concerned with a discussion of the mechanism by which satisfactory frequency conversions at ultrahigh frequencies could be accomplished by a combination of mathematical, experimental, and graphical methods of analysis.

The making of ultra-high-speed radiographs, using exposures of the order of one microsecond, requires the passage of electron currents of from 2,000 to 3,000 amperes, according to Dr. C. M. Slack of Westinghouse and Edward R. Thilo of Frankfort Arsenal, Philadelphia, who delivered a paper, "Field Emission Applied to Ultra Speed X-Ray Technique." It is not practicable to obtain such large currents from a tungsten filament, but such currents can be supplied by an electron source utilizing field emission from a cold-cathode electrode in a high vacuum. While investigating the phenomena of spitting or backfiring, with a capacitor discharge machine, it was found that the magnitude of bursts of current were surprisingly large. The problem of controlling these currents so that


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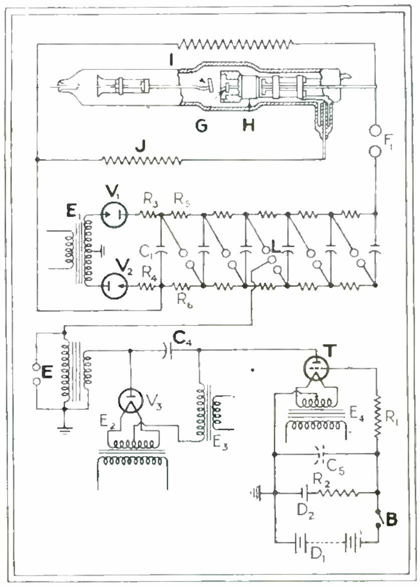
the electron stream would strike a suitable anode with the necessary velocity to produce x-rays was next undertaken.

Arc as Cathode

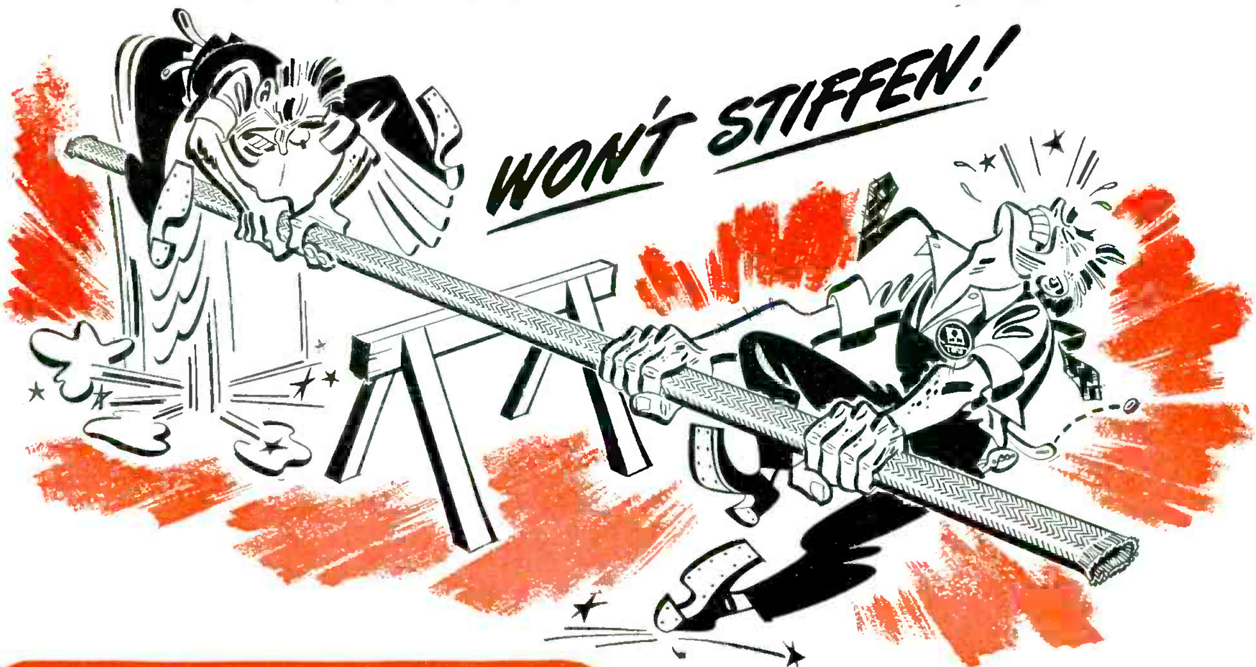
A control electrode placed in close proximity to a sharp edge gave promise of fulfilling the necessary conditions. The diagram shown may be used to explain the method of operation of the device. The capacitors are charged by the transformer E_1 through rectifiers V_1 and V_2 to a voltage somewhat less than that required to break down the spark gap L. Simultaneously, capacitor C_4 is charged to about 1,000 volts. When the circuit is broken



Circuit developed for utilizing field emission to provide heavy electron currents in high-speed radiography

at point B, the charge on the grid of thyratron T leaks off, permitting C_4 to discharge through the primary of induction coil E, which gives a sufficient impulse to the high-voltage circuit to cause the gap L to flash over. This causes the surge generator gaps to break down, which impresses a high voltage inside the x-ray tube between points G and H. Electrons are drawn from G and this initial discharge becomes an arc between points G and H which spreads out into the focusing cup and becomes a virtual cathode at apparently unlimited current-carrying capacity. Due to the action of resistance J, the discharge transfers to the anode, I, with consequ nt production of x-rays. The properties of

BH NON-FRAYING FIBERGLAS SLEEVING

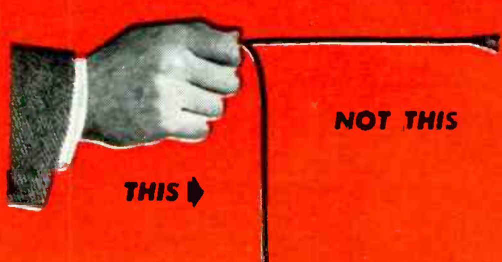


BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

2 WAYS BETTER

THIS NOT THIS

NON-FRAYING



NOT THIS

THIS

NON-STIFFENING

ASSEMBLERS and electricians don't have to be contortionists when working with non-fraying BH *Extra Flexible* Fiberglas Sleeving. Remarkably resistant to stiffening, this always supple insulation won't crack or rot with age. Whether in tough, active service or dead storage, it remains "fresh" and easy to work, retaining its full insulating efficiency *indefinitely*.

This special-processed sleeving won't burn and is non-crystallizing at low temperature. It offers all the natural advantages of Fiberglas—high dielectric and tensile strength—chemical and moisture resistance—and many more—in addition to its own unusual properties.

You'll want to see for yourself the cleaner cutting, non-fraying and non-stiffening features of the sleeving that simplifies assembly, lasts longer and cuts repair costs. BH *Extra Flexible* Fiberglas Sleeving is available in all standard colors. Sizes from No. 20 to 5/8″, inclusive. Write for *your* samples today and compare!

BH SPECIAL TREATED FIBERGLAS SLEEVING FLEXIBLE AS STRING!

Here's another high quality BH Fiberglas Sleeving. Due to the BH exclusive process no saturant is used, yet it will not fray out when cut and will withstand heat up to 1200°F. Made in natural color only—all standard sizes. Test it and try it!

BH PRODUCTS

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

BENTLEY, HARRIS MANUFACTURING CO.

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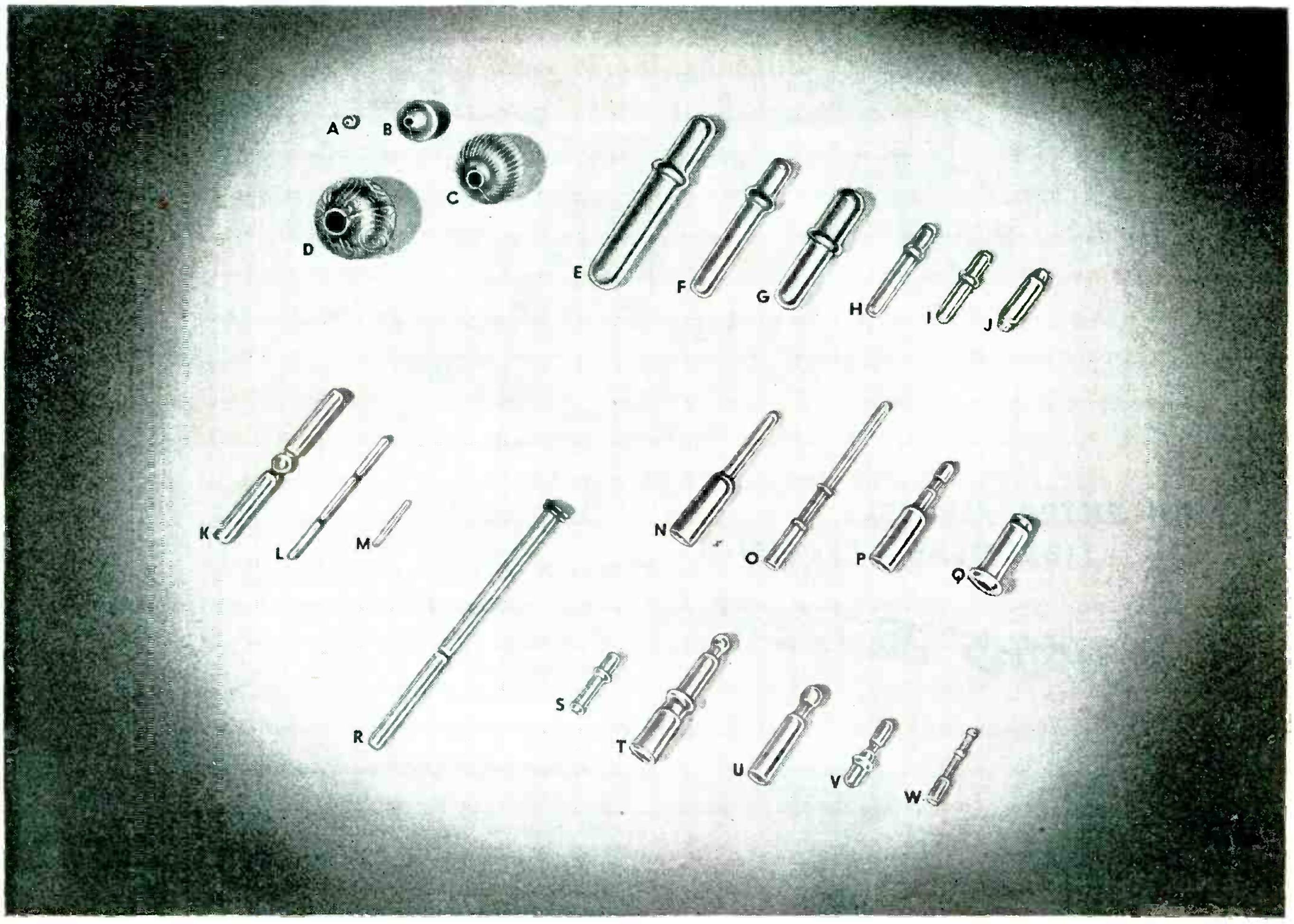

THESE ITEMS, PICTURED ACTUAL SIZE, ARE TYPICAL MULTI-SWAGE PRODUCTS. THEY SHOW THE APPROXIMATE LIMITATIONS OF THE PROCESS AS TO DIAMETERS AND LENGTHS

MULTI-SWAGE is an advanced swaging process which forms hollow or solid parts from flat stock, seamless tubing, rod, or wire, without scrap. Tolerances are maintained accurately and most metals can be worked. Quantity is a factor to be considered. Because MULTI-SWAGE is a high speed process, 100,000 pieces on other than stock items are usually necessary to justify tool and setting up costs. Compare any small parts you use to those shown above. If the nature of the parts and the quantities indicate they can be made by MULTI-SWAGE, it can be well worth your while to consider the BEAD CHAIN MULTI-SWAGE PROCESS.

Send Samples and Specifications of Your Parts for Specific Information

ARMY E NAVY

BEAD CHAIN **multi·swage** PROCESS

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BUY MORE WAR BONDS

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Experts!
Whitaker Can Wire It

such a field emission should find application to electronic devices other than x-ray tubes, particularly where pulse techniques are important.

X-Ray Stress

The very short exposures possible with this tube and generator have permitted sharp radiographs to be made of extremely rapidly moving objects. The chief use of this development so far has been in ballistics research to observe the realignment of component parts inside a bullet when it is fired. A stationary x-ray picture is taken of the bullet, which is then fired and a high-speed x-ray picture taken of this same bullet in flight. A comparison of the two x-ray pictures reveals any shift of the component parts which has taken place.

Dr. Wesley Roberds, in a talk "The Use of Radio Frequencies to Obtain High Power Concentrations for Industrial Heating Applications," stated that the use of radio frequencies makes possible the application of power to metal objects in concentrations up to 100 kw per sq in. Under favorable conditions, this may represent the expenditure of 2,000 kw of power per cu in. of material being heat treated. A study of heat distribution in metals treated by high-frequency furnaces illustrates two important facts: (1) the heating time must be very short (in the order of microseconds) if the high temperatures are to be closely confined to the volume occupied by the induced current; (2) the greatest heating effect occurs at the boundary between magnetic steel and its nonmagnetic form when magnetic materials are treated. As the steel is heated above the Curie temperature, the maximum heating effects move inward.

Practical Conditions

The optimum frequency is determined principally by the size and shape of the work to be heated. In general, the smaller the piece, the higher is the frequency which should be used. Power concentration is obtained with the use of electronic generators having output powers up to 200 kw at 400 kc. For dielectric heating, the power concentrations are much lower than in induction heating but it is usually

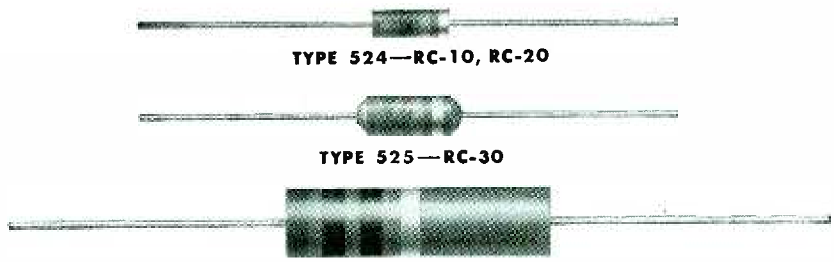
TWO *New* LINES OF

TYPE 504B—RC-21

TYPE 518B—RC-31

ACTUAL SIZE

ERIE RESISTORS



TYPE 524—RC-10, RC-20

TYPE 525—RC-30

TYPE 526—RC-40

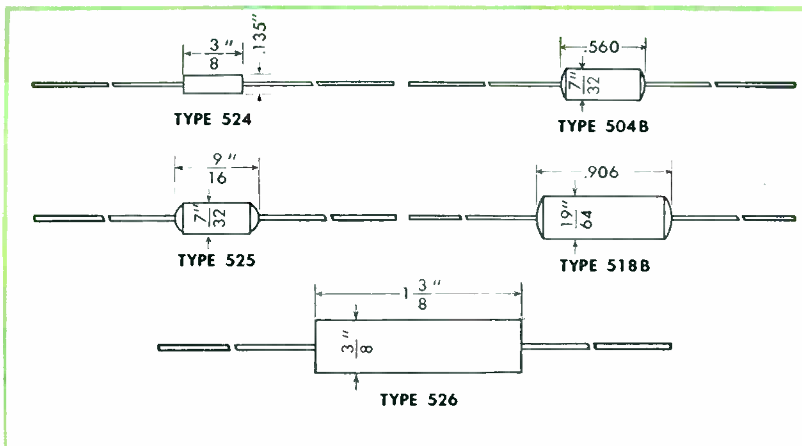
ACTUAL SIZE

ERIE Resistor announces two new lines of insulated carbon resistors, covering six different A.W.S. ratings, RC10, RC20, RC21, RC30, RC31, and RC40.

The well-known Types 504 and 518, ½ and 1 watt units with ceramic insulation, have been replaced with Types 504B and 518B. These new units are identical with the Types 504 and 518 with the exception that they have a one-piece, natural brown, molded phenolic case, instead of the ceramic insulation. The molded construction results in better protection against humidity and salt water immersion. Types 504B (RC21) and 518B (RC31) are available in resistance values from 0.5 ohm to 100 megohms.

In addition, Erie has a new line of compact, hot molded, insulated resistors in ¼, ½, 1, and 2 watt ratings. The resistance mix and insulation material are molded simultaneously as an integral unit. These resistors are manufactured only in RMA preferred values from 220 ohms up to and including 4.7 megohms. Type 524 (RC10 and RC20), and Type 525 (RC30) are now in production, and Type 526 (RC40) will be available shortly.

Nominal dimensions of these Erie Resistors are given above. Samples will be sent to interested engineers on request.



DO MORE THAN BEFORE—BUY EXTRA WAR BONDS

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FOR HIGH ACHIEVEMENT IN WAR PRODUCTION

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

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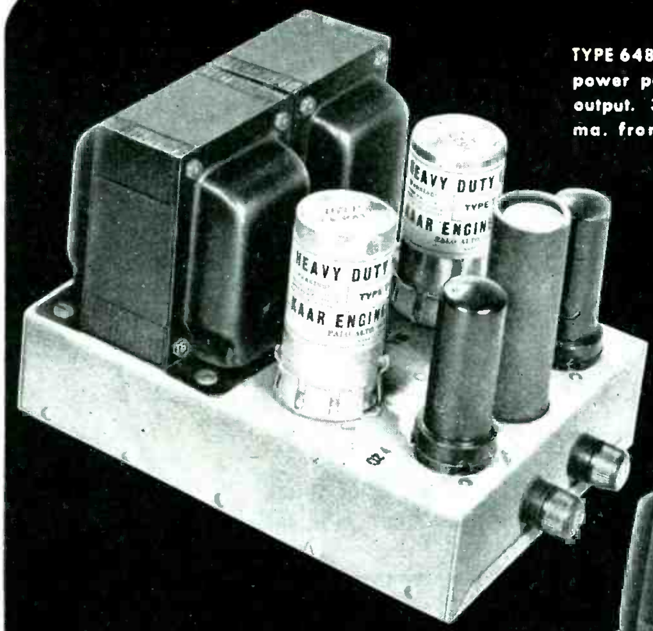
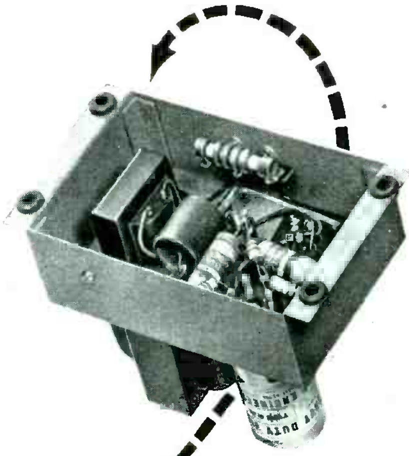
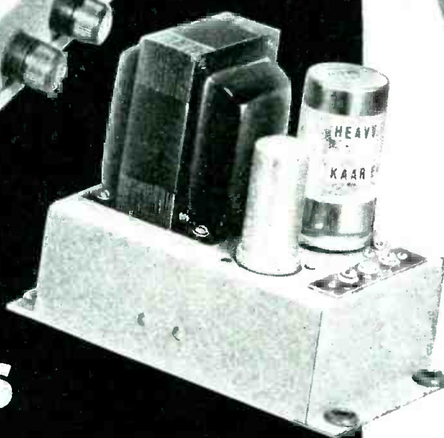


TYPE 648—Heavy duty dual power pack with parallel output. 300 volts at 200 ma. from 6 volt battery



TYPE 650—Standard: 200 volts at 50 ma. Optional: 200 volts at 75 ma. This type available for 6, 12, or 32 volt operation. Has built-in filter. Notice simplicity of construction.



KAAR
POWER PACKS
Engineered for
✓ SIMPLICITY
✓ EFFICIENCY
✓ DEPENDABILITY

TYPE 649—Provides 240 volts at 50 ma. Available at other standard ratings, and for operation from 6 or 12 volt batteries. Type 647, not illustrated, provides 240 volts at 75 ma.

Use this West Coast source for vibrator power packs

Kaar Engineering Company offers prompt delivery of standard and special types of vibrator power packs for operation from 6, 12, or 32 volt sources. In addition, laboratory facilities are available for a variety of power packs designed to your own specifications.

Take advantage of this convenient West Coast source of exceptionally efficient low-drain packs, designed for simplicity and dependability.

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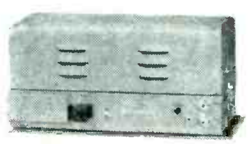
MOBILE RECEIVERS—Crystal controlled superheterodynes for medium and high frequencies. Easy to service.

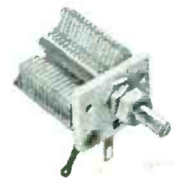
CRYSTALS—Low-drift quartz plates. Fundamental and harmonic types available in various holders.

TRANSMITTERS — Mobile, marine, and central station transmitters for medium and high frequencies. Instant heating, quickly serviced.



MICROPHONES—Type 4-C single button carbon. Superb voice quality, high output, moisture proof.

CONDENSERS—Many types of small variable air condensers available for tank circuit and antenna tuning.



CHALLENGE!

As you look through the ads in this magazine...

FIND THE GLASS PARTS NOT MADE AT CORNING

IT'S really not much of a gamble on our part. The truth is that most of the electronic glass equipment built today comes from Corning Glass Works.

Bulbs, flares, insulators, transformer bushings, tubing, resistor tubes, coil forms, are just a few of the hundreds of electronic glassware products produced under our Army-Navy "E" flag. Here you will find glasses with high electrical insulating qualities; glasses with an expansion coefficient practically equal to that of fused quartz; glasses extremely resistant to mechanical shock; glasses that can now be made into intricate shapes formerly considered impossible. And behind them all, 75 years of pioneering in glass research and experience gained in the development of more than 25,000 glass formulae.

We hope this doesn't scare you. All it means is this: If you have a problem you think glass might be helpful in solving, feel free to call on Corning! Everything we know about glass is at your service. Just to get started we'd like to send you a copy of an informative new booklet, "There Will Be More Glass Parts In Postwar Electrical Products." If interested, write Electronic Sales Dept. E-11, Bulb and Tubing Division, Corning Glass Works, Corning, New York.

CORNING *means* Research in Glass

Electronic Glassware

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possible to apply energy at far higher levels. Since the electrodes are good electrical conductors, they are not heated by the current and therefore are generally cooler than the work. Thus the surfaces of the work are usually kept cooler than the interior and the conduction of heat from the work to the electrode is one of the limiting factors in producing high energy concentration of work.

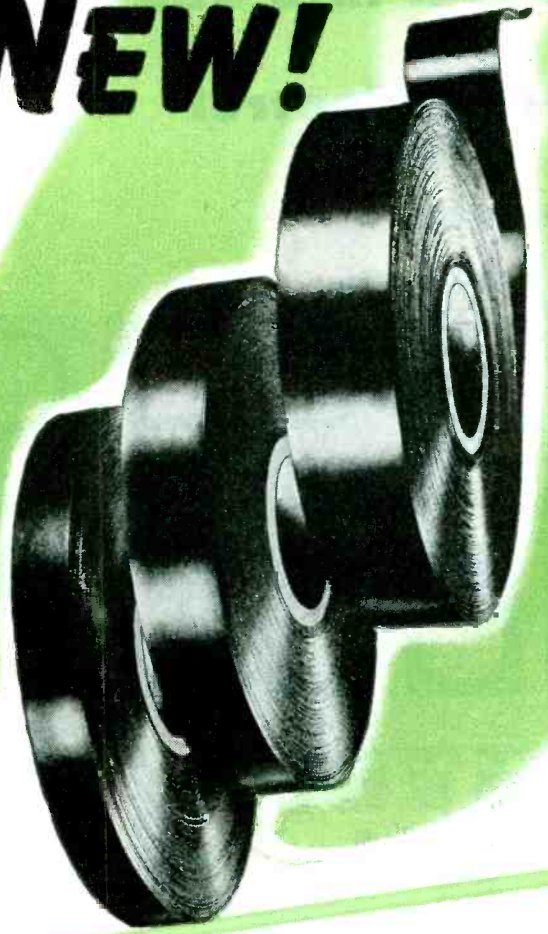
A complete description of a two million volt mobile x-ray unit was described in a paper by Dr. E. E. Charlton and W. F. Westendorp of the Research Laboratory of General Electric Co. The new unit consists principally of a low-frequency resonance transformer with a coaxially mounted multi-section x-ray tube within, both contained in a steel tank and insulated with compressed gas. The x-rays are generated at a target mounted in the end of a chamber projecting from one end of the tank. The unit is 5 ft in diameter and 8 ft in length and weighs 5,000 lb. It is mobile in the sense that it can be readily moved by crane and positioned for operation at any angle by pushbutton control of fractional-horsepower motors.

Transformer Construction

The transformer has a low-voltage winding consisting of two flat coils of rectangular wire, and a high-voltage coil consisting of 243 thin flat sections spaced apart for cooling. The resonance principle of operation makes an iron coil unnecessary in this type of transformer and the central space of the high-voltage coil is occupied by the x-ray tubes, thus facilitating the making of connections to various tube electrodes and providing the benefit of electrostatic shielding by the transformer coil. The multi-section high-voltage coil serves a quadruple purpose; (1) to generate voltage; (2) to grade the potentials so as to prevent creepage; (3) to shield the x-ray tubes electrostatically from the grounded tank; (4) to support the grounded shield mechanically.

A 24-section x-ray tube, which seals off the pump for operation at two million volts, was especially designed for this resonant transformer. It has a filamentary cathode, a copper-backed tungsten tar-

NEW! Fibron THE "ALL-PURPOSE" Tape



FOR INSULATING wires, cables and electrical equipment . . . **FOR PROTECTING** electrical wires and cables exposed to caustic or corrosive fumes, oil, grease, acids, alkalies, or moisture...**FOR SPLICING** cables with a continuous, protective covering . . . **FOR COVERING** exposed piping in chemical plants, equipment exposed to moisture or severe atmospheric conditions.

These widely diversified applications of FIBRON TAPE No. 1 are made possible by its combination of outstanding electrical, physical, and chemical properties. (See adjacent panel.) This *flexible, elastic,* "Vinylite"* resin tape is heat sealing, flame resistant, high in dielectric strength, strong mechanically, and highly resistant to oils, acids, alkalies, moisture, and normal variations in temperature and climate.

FIBRON TAPE is a new addition to the already extensive line of Irvington products. It is offered with the usual guarantee that applies to all Irvington Insulation — to protect equipment in accordance with specifications.

Plan now to test the new FIBRON TAPE. A generous sample will be sent on request — without obligation. For further information on FIBRON, or other IRVINGTON INSULATION, write Dept. **106.**

*Reg. Trade Mark—CARBIDE & CARBON CHEMICALS CORP.

OUTSTANDING PROPERTIES
FIBRON TAPE No. 1

Tensile strength	1700 lb. per sq. in.
Dielectric strength	1000 VPM (.012")
Low temperature flexibility	–40° C.
Elongation	250% – 400%
Power Factor @ 30° C.	(60 cycles)—6.5%
	(1 kilocycle)—6.2%
Dielectric Constant @ 30° C.	(60 cycles)—7.6%
	(1 kilocycle)—6.9%
Bonding temperature	Approximately 150° C.

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EXTRUDED PLASTIC TUBING
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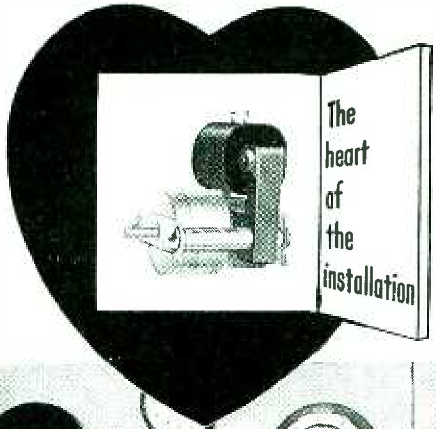
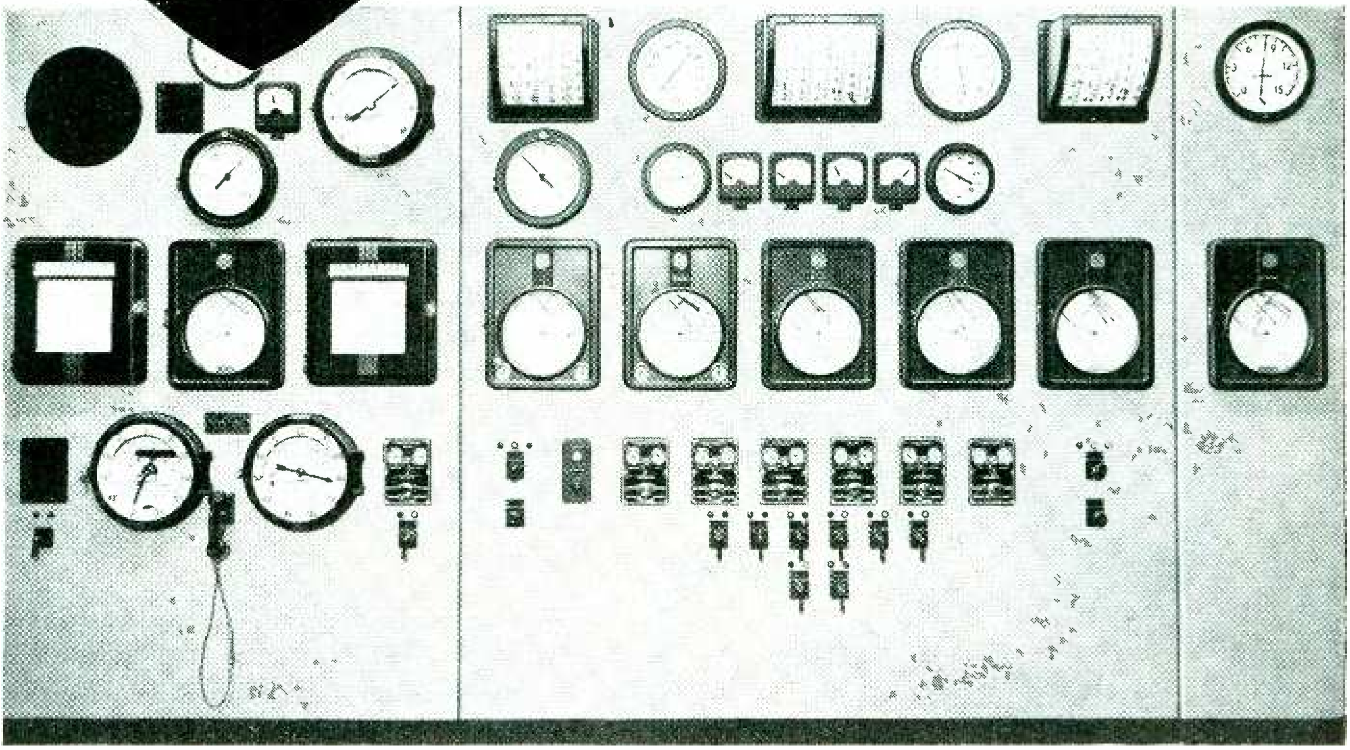


Turning coal into kilowatts—with Record Control by Telechron



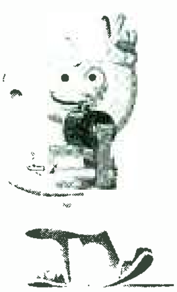
UP TO 30,000 pounds of pulverized coal an hour is economically converted into electricity under the supervision of this automatic boiler control panel in a large generating plant. And each of the recording meters is *equipped with self-starting, synchronous Telechron motors.*

They record steam pressure, control fuel and water flow to the boilers, and indicate and record various factors affecting fuel efficiency. Accurate and dependable, their smooth, constant speed helps to keep furnaces at peak performance, no matter what the load.

And Telechron motors are adaptable, too, to all kinds of controlling, timing and recording functions in many different fields. They are available in sizes from 12 to 250 volts for all commercial frequencies — and from 1 to 1800 rpm. Among their industrial applications are:

Timing	Cycling operations	Gaging
Controlling	Signaling	Regulation
Metering	Fixed process controlling	Communications
Recording	Measuring	
Switching		

We're the largest and oldest makers of synchronous, self-starting motors for instrumentation. Our experience in the field may be of use to you. If you think we can help, just write Motor Advisory Service, Dept. C.



Telechron

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WARREN TELECHRON COMPANY, ASHLAND, MASSACHUSETTS

MAKERS OF TELECHRON ELECTRIC CLOCKS AND SYNCHRONOUS ELECTRIC MOTORS

get and accelerating cylindrical electrodes in each of the intermediate sections.

In a broad survey of recent developments in the electronics field, M. J. Maiers of the Commonwealth Edison Co., Chicago, outlined the characteristics of dielectric heating and gave a list of applications for which dielectric heating has been proved economically successful, or on which extensive research work has been done.

A survey of the role which electronics plays in the laboratory and industrial instrumentation was given by H. D. Middel of General Electric Co. One of the first applications of electronics was the measurement of potentials produced by the dissociation of acids and known as pH or hydrogen ion concentration meters. With the introduction of low grid current tubes, such as the FP-54, it became possible to preamplify the output of the glass electrode and utilize it to drive more or less conventional forms of automatic potentiometers, thus making continuous measurements of pH and subsequent control possible. Meters of this type are being used in the manufacture of penicillin.

Electronics has made possible a wide variety of servo-mechanisms or follow-up systems which will amplify small torques so that the motion of a heavily loaded output mechanism will correspond closely without imposing any restraint or reaction upon its motion either in the direction of its rotation or axially.

Gas Analysis

Electronics has introduced an entirely new principle of gas analysis and has provided a means for obtaining higher accuracy and precision as well as automatizing the measurements. One method of analyzing gas is by means of the mass spectrometer, described by Hipple in the November 1943 issue of ELECTRONICS. To the other forms of gas analysis, using absorption in the infra-red and ultraviolet regions and variation of thermal conductivity, may be added a new method depending upon the variation in molecular weight or density of the gas with changes in its constituents. A column of the gas under analysis is excited by the output of an audio oscillator, and the frequency at res-

THE READILY-WORKABLE GAS GETTER

INCREASING PRODUCTION of pure Ductile Zirconium by the Foote Process (decomposition of zirconium tetraiodide in vacuum) brings close to realization commercial quantities of a workable gas getter for vacuum tubes.

Now you can enjoy the recognized advantages of Zirconium in a form readily workable into anodes, grids, supports and other shapes requiring structural strength.

Ductile Zirconium is a continuous getter at high temperatures, sorbing all except the rare gases. A better vacuum is produced in less pumping time. Oxygen, nitrogen and hydrogen can be sorbed in large quantities without forming new phases—up to 40 atomic per cent of oxygen and 20 atomic per cent nitrogen without X-ray detection of a compound. And, except with hydrogen, the process is not reversible. Sorbed oxygen or nitrogen are not released even at temperatures above 1500°C.!

Ductile Zirconium will act as a continuous getter if it can be located in the tube so that a temperature of approximately 500°C. or over is maintained. A small piece of .005" sheet Zirconium spot welded to the anode is all that is needed in many tubes.

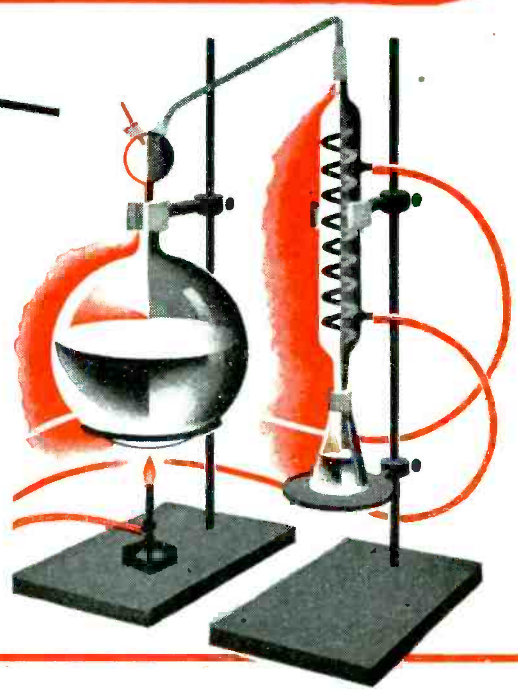
In cathode-ray and other tubes where plate temperatures are low, it is possible to use a separate gettering filament of Zirconium, electrically heated, or sometimes a Zirconium slip coil over one filament lead will serve the purpose.

Foote Ductile Zirconium, because of the way it is produced, is extremely pure, free from compounds such as zirconium oxide or nitride. Freedom from volatile contaminating substances prevents mirroring of tube surfaces and consequently reduces inter-element leakage and losses. Tube quality and life are greatly increased by pure Ductile Zirconium.

If you are not already using Foote Ductile Zirconium for electronic tubes, investigate the advantages of this new development now. Experimental and production quantities of Ductile Zirconium sheets and wire are available.

THE ESSENCE OF THINGS TO COME

Our business is to locate and process ores and minerals and keep an eye open for ways to use them. This means research in cooperation with others and original research in the Foote laboratories. From recent investigations have come pure Ductile Zirconium, a Lithium base for greases that will withstand brutal temperatures, and better ceramics with Strontium salts. Other possibilities are brewing—perhaps for your industry. Get in touch with us and we'll keep in touch with you.



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MINERAL COMPANY

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Perfection is Our Aim!

In every industry there are various methods of turning out products for similar use requirements. Usually there is ***one best way*** — a way based on developing and following certain tested techniques — proved processes that in themselves guarantee uniform quality every step of the way.

James Knights owes its reputation for unquestioned dependability to a steadfast determination of finding the ***one best way*** of carrying out every manufacturing operation. The culmination is a certainty — the positive assurance of better operating performance for every James Knights Crystal.

The *JAMES KNIGHTS* Co.
SANDWICH, ILLINOIS

JK CRYSTALS

CRYSTALS FOR THE CRITICAL


Fine ceramics by
ARMY NAVY
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Division of GLOBE-UNION INC., Milwaukee

onance or the phase shift is measured by electronic means. Through the use of such an instrument, explosive mixtures may be avoided in the operation of the hydrogen cooled alternator.

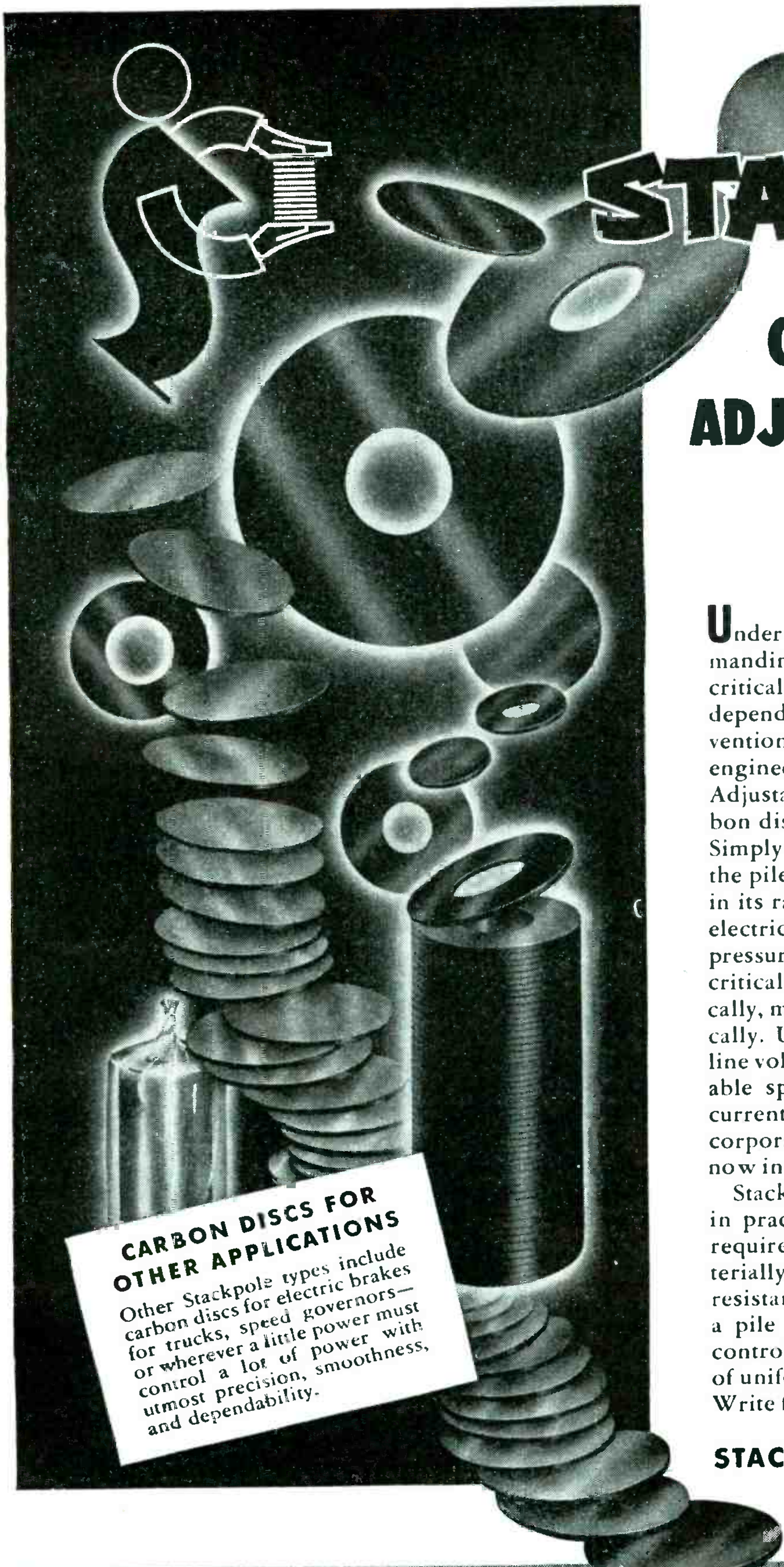
Measuring Pressure

Pressure may be measured by any one of the following three methods: (1) by balancing an unknown pressure against a known force; (2) by measuring the deformation of an elastic membrane; (3) by utilizing a quantitative change in the physical properties of materials. Electronic devices may be applied to any or all three of these methods of pressure measurements. One interesting application of the third group is that in which the thermal conductivity of a gas varies with pressure to effect a change in resistance or temperature of a wire filament supplied with a constant current and immersed in the gas.

Mr. Middel pointed out that it is not improbable that a pressure-responsive element like a spring-loaded bellows or a diaphragm might be incorporated in an electronic tube to modify the plate-to-grid and cathode spacing and provide a plate output proportional to pressure. Attempts have also been made to produce variable-mu tubes by moving the grid within the tube by mechanical means.

In measurements of the flow of fluid, the pressure differential may be measured by a bellows type of pressure-measuring element in which the motion of the free end of the bellows may be used to alter the inductive relations in an adjustable iron-core transformer. The variation thus produced may be regarded as a signal which may be transmitted over a pair of wires to an electronic servo mechanism to accomplish any desired result.

A considerable portion of the paper was devoted to the measurement of temperature by means of the thermocouple, resistance thermometry, radiation pyrometry, self-balancing potentiometers, photoelectric and electronic potentiometers. A photoelectric potentiometer using a reflecting-type galvanometer and phototube combination is shown in the circuit diagram. Light variations on the type 930 phototube produce grid voltage variations on the 6J5 triode which in turn deflects



STACKPOLE

CONTINUOUSLY ADJUSTABLE CARBON RHEOSTATS

(CARBON PILES)

Under impetus of war requirements demanding resistance adjustments for more critical, more precise, smoother, and more dependable control than is possible with conventional variable resistance units, Stackpole engineering has developed the Continuously Adjustable Carbon Rheostat formed of carbon disc piles to a high degree of efficiency Simply by changing the pressure applied to the pile, every possible resistance value within its range is available without opening the electrical circuit in which it is connected. The pressure to vary the resistance to the most critical adjustment may be applied electrically, mechanically, centrifugally or hydraulically. Uses range from both generator and line voltage regulator applications to remarkable speed control through governed field current on motors. Many other projects incorporating the Carbon Pile Resistor are now in the development stage.

Stackpole regularly supplies Carbon Piles in practically any length pile and diameter required. Resistance ranges have been materially expanded and a greater degree of resistance variation may now be obtained in a pile of a given size. Careful engineering control of manufacture assures a high degree of uniformity on a quantity production basis. Write for bulletin giving complete data.

STACKPOLE CARBON COMPANY

St. Marys, Pa.

OTHER STACKPOLE PRODUCTS

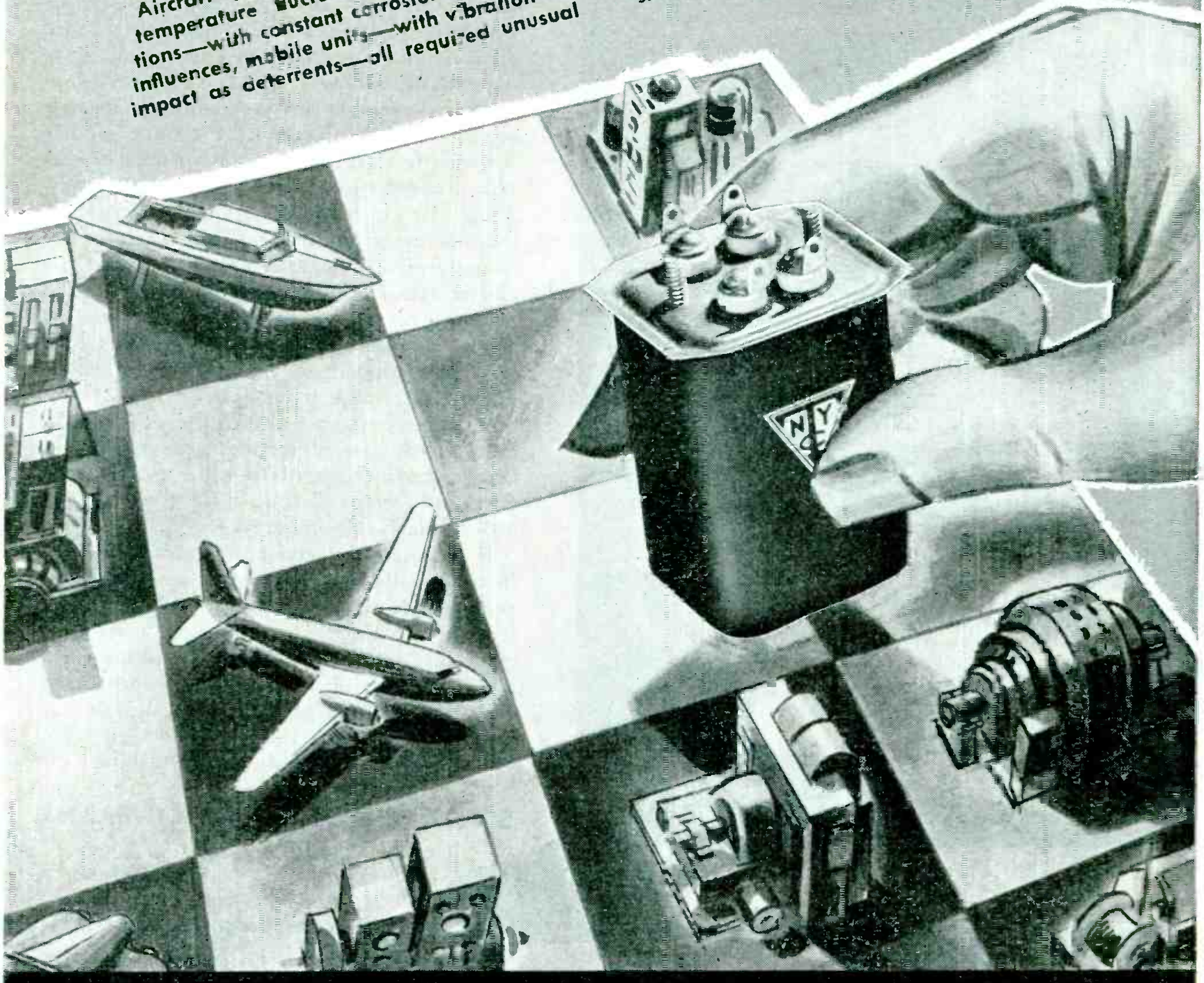
BRUSHES - CONTACTS *(All carbon, graphite, metal, and composition types)* IRON CORES RARE METAL CONTACTS
WELDING CARBON PRODUCTS VOLTAGE REGULATOR DISCS BATTERY CARBONS
PACKING, PISTON, and SEAL RINGS POWER TUBE ANODES, etc.

THE N-Y-T SAMPLE DEPARTMENT will check-mate your post-war transformer problems too!

Diversification in transformer engineering, for vital equipment and apparatus, has been a "must" in this highly-specialized field ever since electronics superseded the human element in various operating phases. Aircraft applications—with attendant drastic temperature fluctuations, marine installations—with constant corrosion and moisture influences, mobile units—with vibration and impact as deterrents—all required unusual transformer design technique.

The N.Y.T. Sample Department has aided materially in forestalling or solving problems for the Army, Navy and Air Forces. Practically every conceivable obstacle to efficient transformer performance has been overcome—unequivocally—by N.Y.T.

Your post-war transformer, rectifier or solenoid perplexities can be check-mated in similar immediate manner.

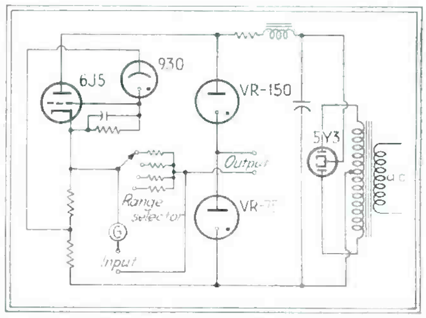


NEW YORK TRANSFORMER COMPANY

26 WAVERLY PLACE, NEW YORK, N. Y.

the pointer of the galvanometer, *G*.

The tube is used as a variable resistance in one arm of a Wheatstone bridge. Light variations on the phototube thus unbalance the bridge. In series with the load is a resistor so arranged that a voltage proportional to output current is fed back in opposition to the input voltage. This causes the galvanometer to take up a stable position as some function of the remaining unbalanced current. The magnitude of this current is not constant, but varies with the basic element sensitivity, the kind of optical system and input voltage.

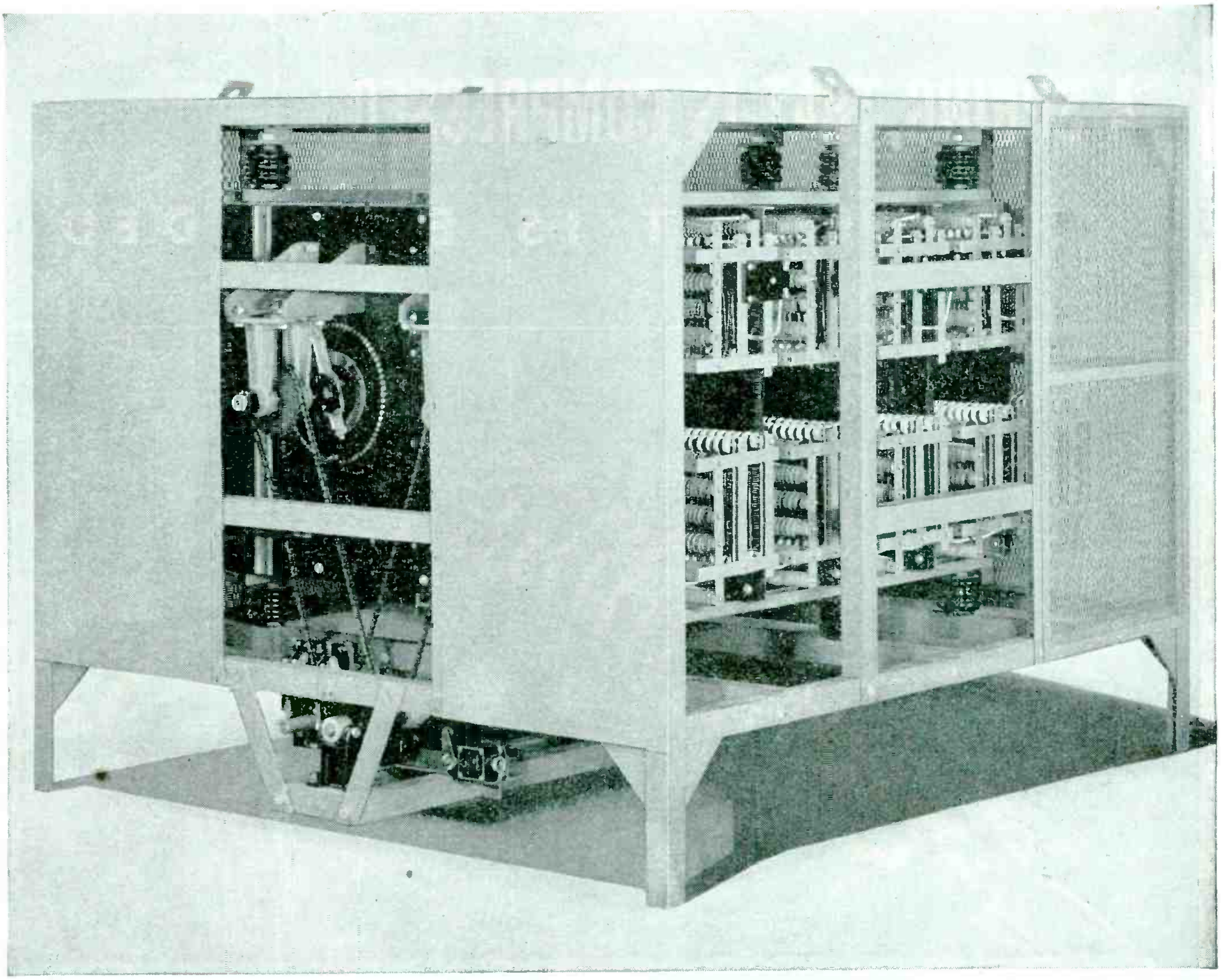


Circuit of a photoelectric potentiometer that operates on light variation for measuring temperature

The present status of the use of fluoroscopic rather than radiographic methods of examining industrial products was reviewed by Dr. Scott W. Smith of Kelley-Koett Mfg. Co. in a paper, "Industrial Fluoroscopy of Light Materials," in which attention was directed to various factors contributing to the success of this method, and the outlook for future developments was discussed. It was pointed out that the possibility of using fluoroscopy as a means of relieving radiography of part of the burden of industrial inspection, where the degree of sensitivity required is within its limitations, is being given serious consideration. It seems quite reasonable to expect fluoroscopy to augment rather than to supplant radiography.

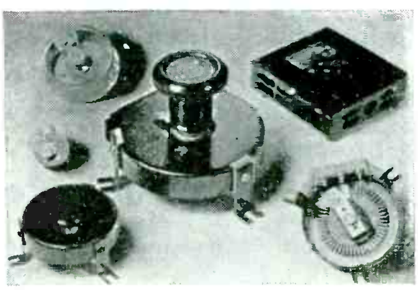
Present Applications

Since industrial specimens do not necessarily require a short exposure, and are not subject to movement during exposure, these advantages have permitted the development of fluoroscopy for many industrial applications. In fact, the fluoroscope has been used for quite a



ASSEMBLED RHEOSTATS

Here is a Ward Leonard assembled rheostat designed for production testing of grid-controlled rectifier tubes. It consists of five face plates with each face plate composed of two rheostats. Each rheostat will drop from 0 to 375 volts at any current between 15 and 0.15 amperes. The rheostats are mechanically connected but electrically independent. They may be connected in series to give a maximum drop of 3750 volts or in parallel to give a maximum current of 150 amperes. The assembly is tested at 10,000 volts to ground and 2,000 volts between rheostats. Whenever you have an electric control problem Ward Leonard engineers are at your service.



The Ward Leonard line of rheostats includes steel plate types, porcelain ring types and ribohm face plate types. These rheostats provide control for the minute current requirements of the laboratory and the heaviest current demands in industrial applications. ***Send for rheostat bulletins of interest to you.***

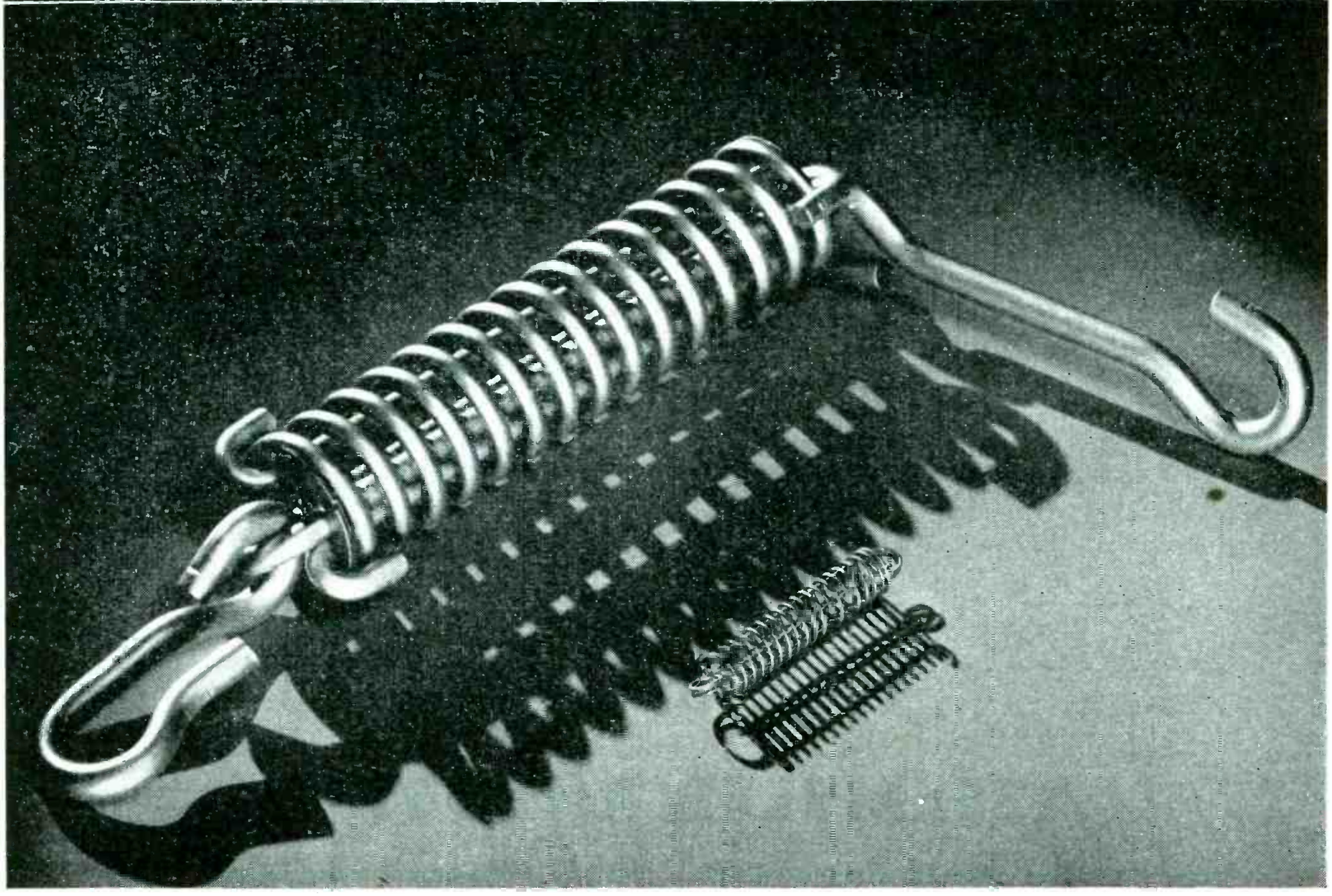
WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control (WL) devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 32 SOUTH STREET, MOUNT VERNON, N. Y.

A SPRING THAT IS COMPRESSED
WHEN IT IS EXTENDED

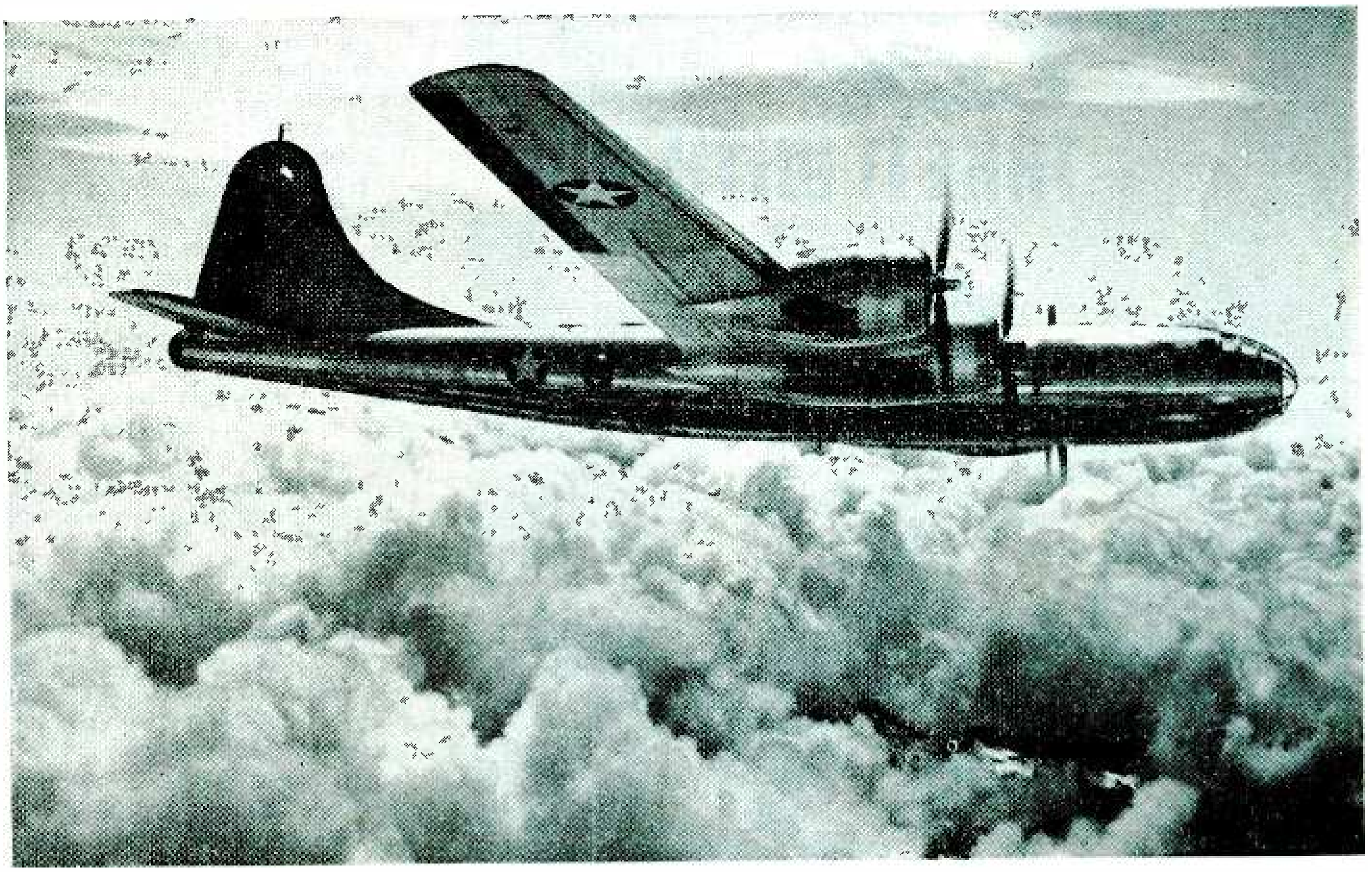


TYPICAL of the many unusual springs made by Muehlhausen is this *compression* spring which serves as an *extension* spring—designed for applications requiring an unusually high factor of safety. Interlocking drawbars—passing through the spring and looping around opposite ends—absorb the pulling force by compression instead of extension, and prevent a total separation of the suspended parts, should an extreme overload cause spring breakage.

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

MUEHLHAUSEN
SPRINGS
EVERY TYPE AND SIZE

PERMANENT MAGNETS MAY DO IT BETTER



America's Pride Flies with the B-29!

As the giant Boeing B-29 Superfortress carries destruction to Japan, the pride of America echoes in the roar of her mighty engines. And to the ingenious Boeing engineers who created her, the Nation owes a great debt.

We have special reason to be proud of the B-29's performance, for Boeing incorporated no less than 300 permanent magnets in her magnetos, instruments, compasses, audio speakers, radio equipment, automatic pilot, remote gun controls and other vital devices.

It is our job to manufacture a large portion of these permanent magnets, as well as those for other types of war equipment. And our specialized designing skill has often resulted in increased efficiency and lower costs.

Our engineers are in an excellent position to help solve your permanent magnet problems. Write for a copy of our "Permanent Magnet Manual."

ARMY E NAVY

The
INDIANA STEEL PRODUCTS
Company

★ SPECIALISTS IN PERMANENT MAGNETS SINCE 1910 ★

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long time for such applications as spotting a foreign body in packaged food, candy and tobacco, as well as sorting fruits, determining the filling level in cans, the shape and position of the core of golf balls, or the alignment of the elements in electron tubes.

After a historical resumé of fluoroscopic methods and screens, it was shown that an improved zinc sulfide screen, treated in such a way as to reduce afterglow, is commonly used at the present time and that photographs of the fluoroscopic image on small films has been generally employed in induction centers during the war with a considerable saving in film over the usual 14 x 17-in. radiograph previously employed.

It was concluded that the widespread use of radiography for the control of foundry technique and the inspection of light alloy castings can be further augmented by the use of fluoroscopy with a reduction in the cost factor.

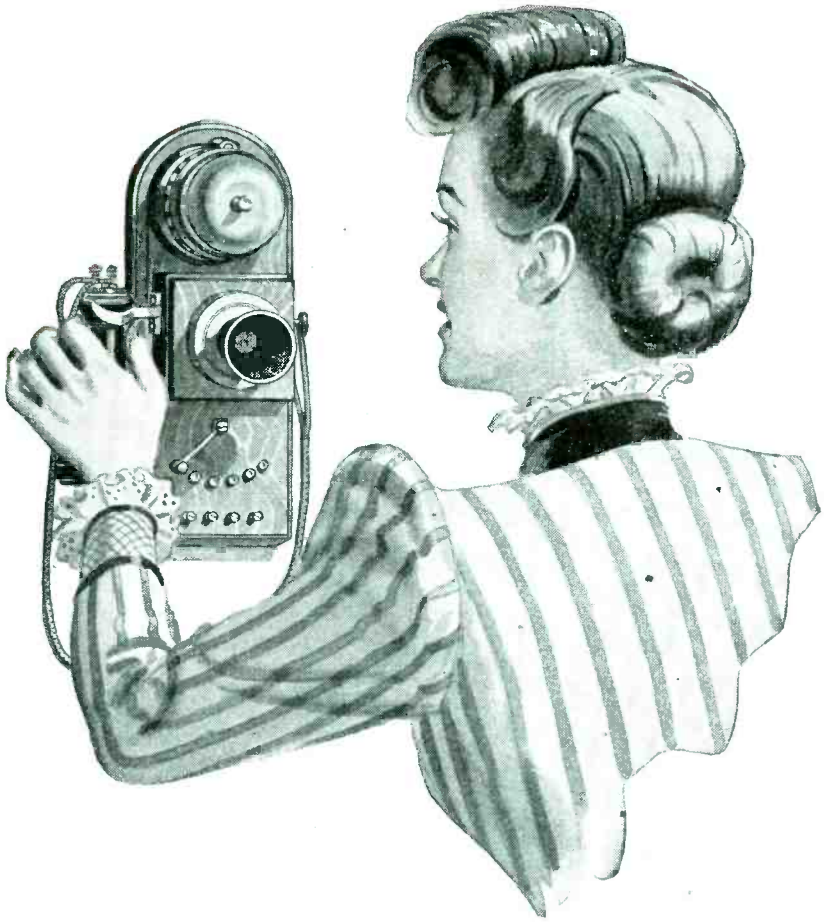
In a paper entitled, "Aircraft Electronic Applications" A. P. Upton, Minneapolis-Honeywell Regulator Co., described a complete electronic control system as used in modern aircraft. The electronic turboregulator and the electronic autopilot forming the major parts of this system were described in detail in the May 1944 and Sept. 1944 issues of ELECTRONICS respectively.

A paper was presented by John M. Cage of Allis-Chalmers Mfg. Co. entitled "Negative Feedback Amplifier Theory Applied to Regulators." The paper considered the mechanical problem of regulator operation, which may be most conveniently solved by the mathematics originally developed in connection with electrical theory. Such a procedure requires the necessary transformations of the terms of the dynamical differential equations from the physical concepts of one system to the physical concepts of another.

The paper also outlines an experimental procedure for measuring and studying the frequency responses of actual systems employing regulators.

W. R. Mehaffey, of Armour Research Foundation, opened the treatment of his paper, "Strain Gage Amplifier Design," by a discussion of the advantages of resis-

. . . "Among their Latest Triumphs is an inter-communicating telephone for interior use in buildings, which furnishes in itself, by pressing buttons, complete exchange connections, with all parts of the building, and releases the same automatically and comprises the only successful system of its kind of the present age."



The glowing phrases above, written not long after the turn of the century, describe a Connecticut Telephone and Electric "First" which doubtless caused grandpa to wonder, "What won't they think of next!"

The things our engineers are thinking up today in cooperation with U. S. Army engineers are full of interest and promise, but they can't be talked about now. You can count on better communications...in fact, you can confidently expect war-born improvements in all branches of electrical and electronic science.

If your product-development plans involve a problem of electrical or electronic engineering and manufacturing, perhaps we can be of assistance. We also invite preliminary inquiries connected with inter-communicating and signalling systems for postwar buildings now in the design stage.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES, INC.

MERIDEN, CONNECTICUT

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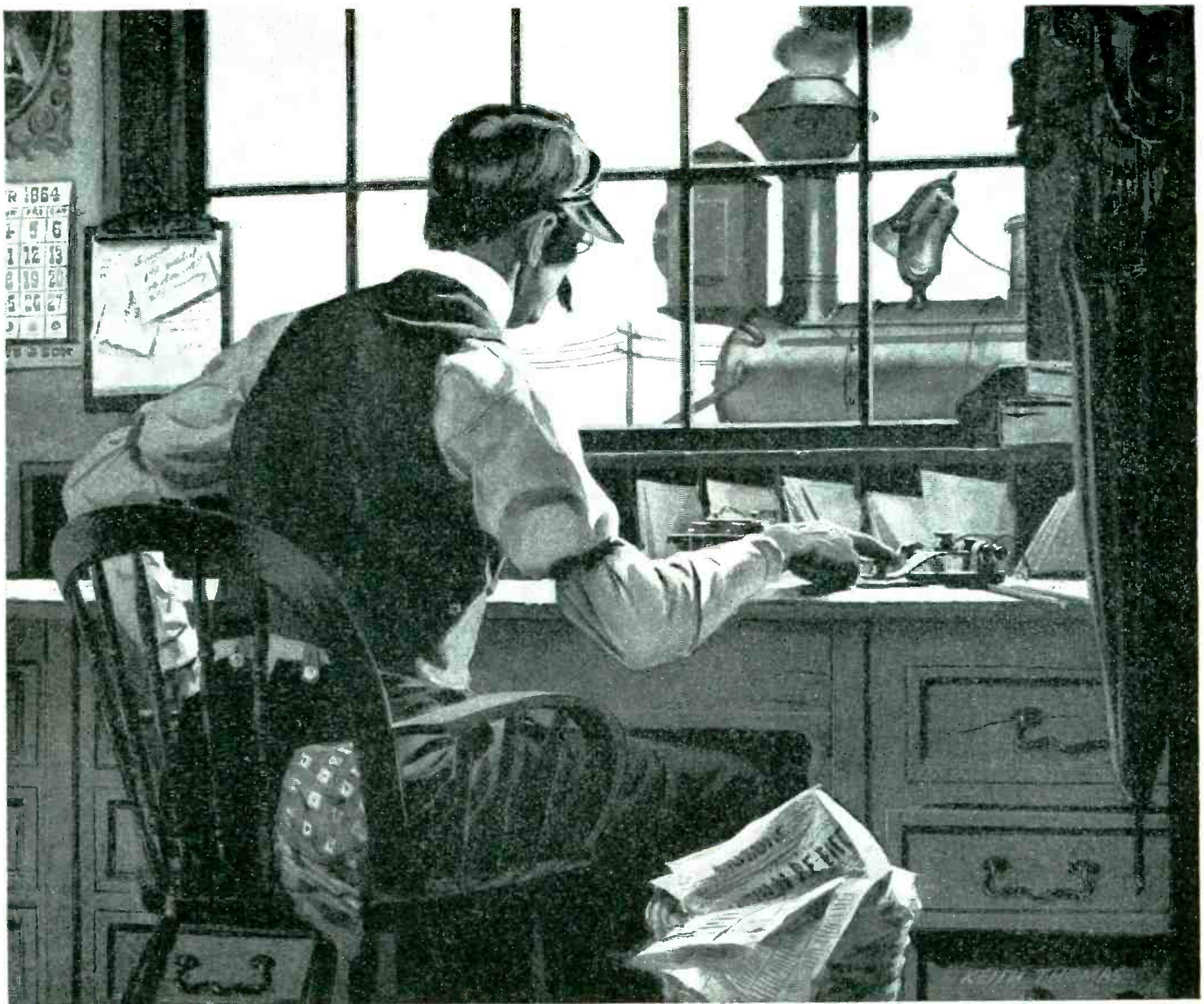

History of Communications. Number Eight of a Series

EARLY RAILROAD COMMUNICATIONS BY TELEGRAPH

MODEL
1700-UB

Communication by telegraph was probably one of the first of the electronic arts which met with commercial success in America. Of constant interest to every boy in a small town, the telegrapher down at the depot was a hero — a man of great science. With the advent of faster locomotives, telegraphy was a speedy method of traffic control.

Today, and for the postwar period, the picture will include electronic voice communications for the streamlined trains which travel one hundred miles per hour. There must be a more flexible control via electronics, plus the added possibility of passenger luxury in radio telephones. Universal stands ready as an electronic manufacturer to serve in the era of applied electronics.

< Model 1700-UB, illustrated at left, is but one of several military type microphones now available to priority users through local radio jobbers.

WEST COAST ELECTRONIC MANUFACTURERS ASSOCIATION MEMBER

UNIVERSAL MICROPHONE COMPANY
INGLEWOOD, CALIFORNIA

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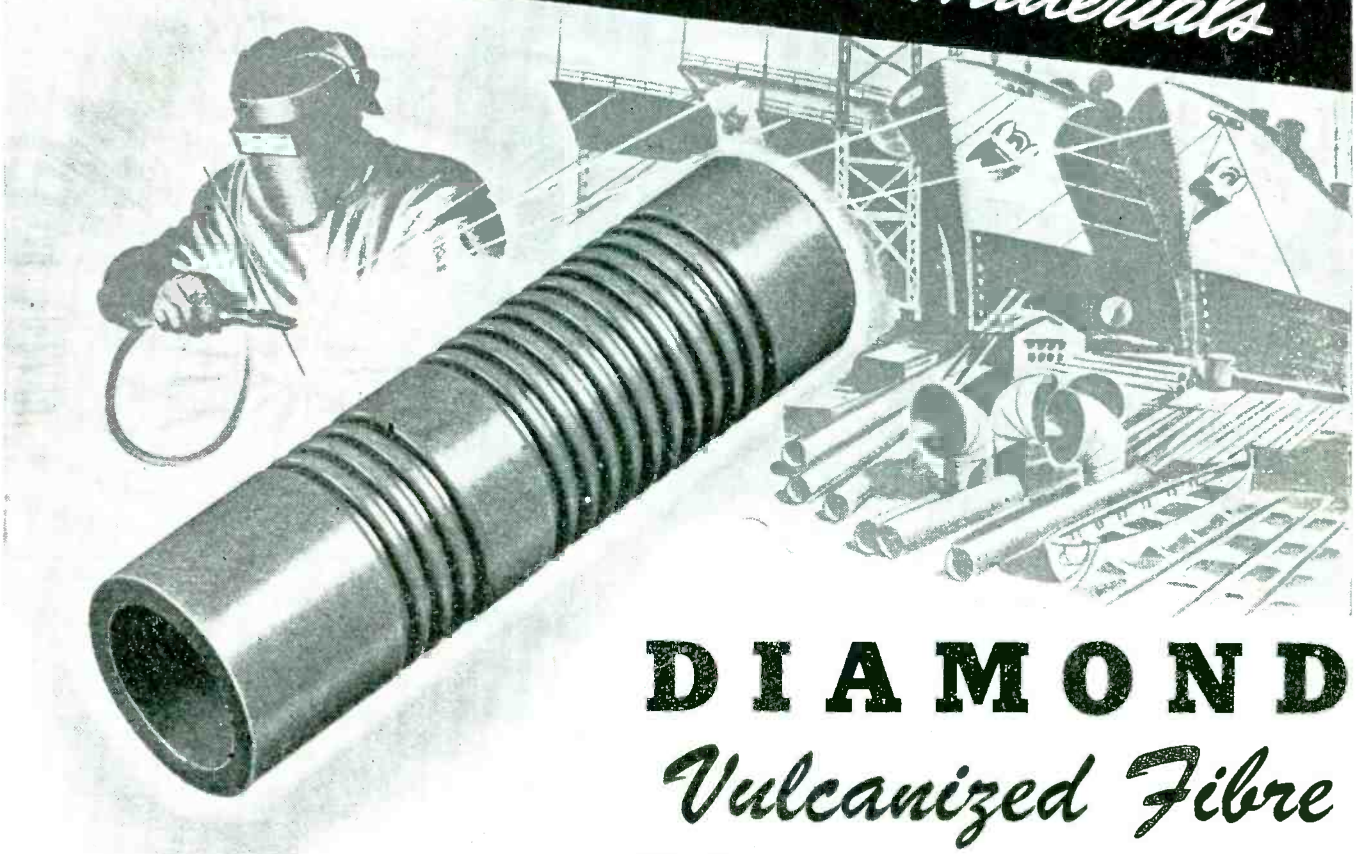
Continental-Diamond
Engineered Dielectric Materials



DIAMOND
Vulcanized Fibre

The DIAMOND Vulcanized Fibre part illustrated is a handle for a welder's torch. It is made from tubing. DIAMOND Vulcanized Fibre is used for this part because DVF is tough, strong and light in weight . . . because it insulates electrically and thermally. The handle is economically made from DVF because DVF is readily machined, formed, spun, sawed or otherwise fabricated. For complete technical data on this C-D NON-Metallic, write for catalog DF.

KA-44

C-D PRODUCTS

The Plastics

DILECTO—A Laminated Phenolic.
CELORON—A Molded Phenolic.
DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.
HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

The NON-Metallics

DIAMOND Vulcanized FIBRE
VULCOID—Resin Impregnated Vulcanized Fibre.
MICABOND—Built-Up Mica Electrical Insulation.

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Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

Descriptive Literature

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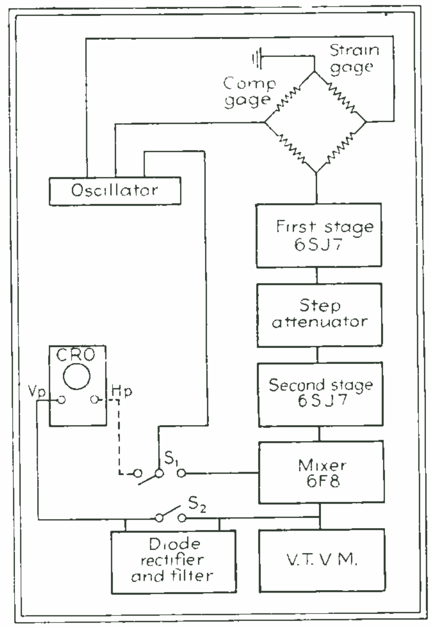
Established 1895. . Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE

tance strain gages for indication.

The electrical circuits used with strain gages are of two general types, the amplitude-modulated system and the a-c potentiometer circuit. The amplitude-modulated system is used at low frequencies and for static measurements, whereas the potentiometer system is primarily used for dynamic impact studies.

A block diagram of a circuit suitable for measuring mechanical strain by means of strain gages in a bridge circuit is shown. The resistance in one arm of the bridge is the strain gage, while a complemen-



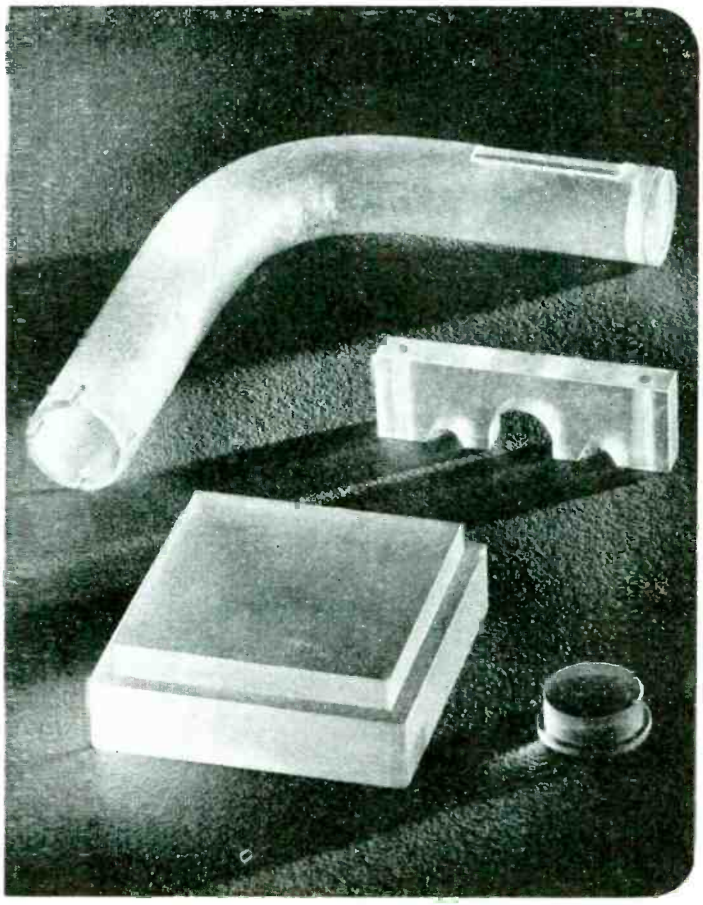
Block diagram of units forming a gage for measuring mechanical strain

tary gage is located near the measuring gage but is mounted in such a way that it does not measure strain. A resistance could be used but the use of a complementary gage permits temperature compensations to be easily obtained. Both capacitance and resistance balance must be provided in this bridge circuit if a sharp null indication is to be achieved. The transformer for supplying power to this bridge must be carefully shielded and have balanced construction. The output from the bridge may be coupled directly to the grid of the first stage of amplification.

Methods of Operation

In general, there are three basic methods of operation of this bridge circuit. In the first, adaptable particularly to static conditions, the

NOTES ON DESIGN AND ASSEMBLY OF PLAX POLYSTYRENE



Other PLAX POLYSTYRENE bulletins — entitled Fabricating, What to Tell Machinists, How to Use Coolants When Machining, and How to Cement — have been published in preceding months. They will be sent as you request them.

Plax supplies polystyrene in sheets, rods, tubes and in the famous Polyflex* Sheet and Polyflex Fiber — tough, flexible extruded forms with wide insulation possibilities.

Machined parts such as those shown above are produced by Plax to your exact specifications. Plax also supplies a polystyrene cement and anneals machined parts.

Write for bulletins which interest you, and for complete details of polystyrene's properties.

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

DESIGN. Engineers have recently found it fairly simple to design around the limitations of polystyrene at service temperatures greater than 75°C or 167°F, above which temperature polystyrene's exceptional electrical characteristics lose constancy. For instance, instead of using a solid coil form, polystyrene slabs are cemented to the coil, thus giving a lighter unit with greater heat dissipation.

When used for low loss dielectric plates and insulating film, polystyrene is positioned away from heat sources and exposed to air circulation wherever possible. The use of polystyrene for stand-off insulators, cable heads and spacers, high-voltage bushings and shields offers little difficulty.

ASSEMBLY. Screws tapped into polystyrene should not be more than hand tight, so as to prevent deformation of the material to more than ¼ to ½ percent. If the screw must be held tight against vibration, a cement is usually used, though in some cases a cork or rubber washer will hold the screw tight.

When a flat panel is fastened in place, the holding channel or frame should be kept flat, to avoid bending the panel. A channel is preferred to bolting. If bolts are used, they must be placed to distribute the load equally, and all of them should be under the same tension. Using a cork or rubber washer makes it easy to obtain uniform tension. In general, all sources of stress concentration greater than 1200 p.s.i. should be avoided. This means eliminating direct clamping, riveting, or re-entrant angles.

Polystyrene strips may be welded together or around coils by heating to 230°F and pressing. Rod may be bent to any shape by pre-heating to 230°F and cooling in position. Any machining should be done before heating and bending.

PLAX FOR PLASTICS

NOT SUBSTITUTES — IMPROVEMENTS

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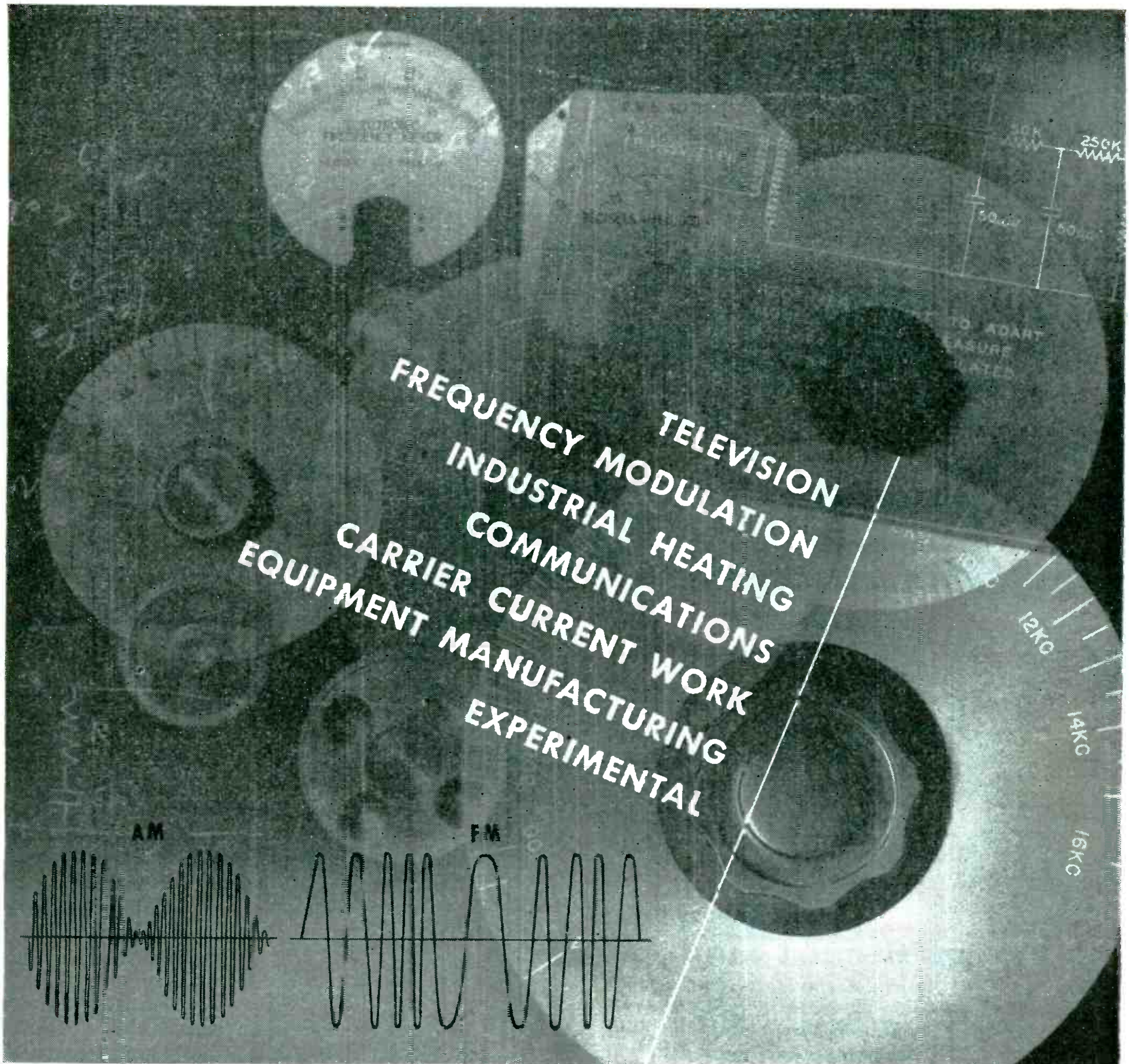

Post-war electronics demands new instruments

As the "era of electronics" approaches, it is increasingly evident that the need for more accurate, highly specialized instruments becomes greater. Many of the forerunners of such instruments are already perfected and in use today, but they are still under cover of strict military censorship. When these new developments and others now in the process of development are released—not all, but certainly a good many of the commonly known instruments will instantly become obsolete. In your plans for post-war activity you should make careful note of this fact, for it may save you valuable time in future plant or product conversion.

-hp- instruments are in the vanguard of these new developments. New *-hp-* oscillators, signal generators and vacuum tube voltmeters are setting new standards for rugged construction and split-hair accuracy. Technical data on these and others not yet perfected are, of course, not available today, but the time is not far off when they can be released.

In contemplating the improvement of your laboratory or the alteration of your production with post-war activities in mind, it will pay you to consult *-hp-* engineers. These new instruments may be the answer to your problem. Please give us full details so we can be of maximum assistance.

HEWLETT-PACKARD COMPANY
BOX 931A STATION A • PALO ALTO, CALIFORNIA
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931

bridge is initially balanced before the member is strained, then rebalanced after the member is strained, the change in the reading of the calibration dial on the slide wire is then proportional to the deflection or strain. The second method of operation is the so-called voltage unbalance method in which the bridge is initially balanced before the application of the strain and the unbalanced voltage as indicated by a metering circuit is used as a measure of the strain. The third method is that in which the bridge is usually operated with an off-balance initial condition to provide an indication that the strain is either tension or compression.

The author concluded that the amplitude-modulated system provides a simple and reliable means for amplifying the output from electrical strain gages without the need for direct-coupled amplifiers. The basic problems in the design of this type of equipment for use as null system or a voltage unbalance system were treated in the paper.

Tube History

A rather comprehensive outline of the development of electron tubes was given by I. E. Mouromtseff of the Westinghouse Electric & Mfg. Co. He pointed out that although beam tubes are usually considered to be a recent development, the first practical result of electron tube research was the production of x-ray tubes in 1895 making use of the electron emission as a beam.

In discussing high-frequency tubes, it was pointed out that the first vacuum tube used in high-frequency circuits was built in 1892 by Zehnder for demonstrating Hertzian waves to large audiences. The Zehnder tube was a small gas-filled tube in which the gas discharge was triggered by high-frequency oscillation. The development of high-vacuum pumping techniques and the invention of the glass-to-copper seals by Houskeeper in 1922 gave a new impetus to the development of radio tubes. Mr. Mouromtseff anticipates tubes of 500 kilowatts as perhaps representing the ceiling for practical rating of individual sealed-off tubes, for at power greater than this, the cost of the tube will probably be out of proportion to their advantages because of design difficulties.

Another modern electrical development pioneered and perfected by Sprague

Pioneered many months ago by Sprague, glass-to-metal seals for Sprague Capacitors and hermetically-sealed *Koolohm Resistors have progressed far beyond any "laboratory curiosity" stage. Not only are they being produced commercially at better than 10,000 seals per day, but they have proved highly efficient both electrically and mechanically. Seal sizes range from very small up to 3" diameter. They work equally well with practically any metal including steel, brass, and monel metal, and do not require the use of glass bushings and adjacent metal rings with "matched" temperature coefficients of expansion.

There are, of course, plenty of "scientific" reasons why glass-to-metal seals of this type are not feasible. Here again, however, the allegedly impossible has simply provided the incentive for another outstanding Sprague engineering achievement. Actually, the only disadvantage to the seals so far uncovered is the fact that corona voltages are a little lower than we'd like them to be—yet this limitation only becomes a factor at voltages upwards of 25 KV. In all respects, the Sprague glass-to-metal seal answers the old problem of guarding Capacitors and Resistors adequately against leaks and moisture—and without organic bushings or other materials which might be attacked by fungus.

Today, glass-to-metal sealed Sprague Capacitors and *Koolohm Resistors are available in 8,000 electrical characteristic combinations—which is another way of saying that there is a sealed unit for every application that needs one. Details gladly sent on request.

SPRAGUE ELECTRIC COMPANY, NORTH ADAMS, MASS.

(Formerly Sprague Specialties Co.)

ARMY E NAVY

* T. M. REG. U. S. PAT. OFFICE

SPRAGUE

PIONEERS OF ELECTRICAL-ELECTRONIC PROGRESS

NEWS OF THE INDUSTRY

Conference notices; new television studios opened; Washington News on transformers, production of electronic equipment, broadcast power, tubes and parts

Collective Bargaining for Engineers

PROTECTION OF THE INDIVIDUAL engineer, suggests C. A. Powel, newly-elected president of AIEE, could probably be provided most effectively by an overriding association embracing all engineering and devoted specifically to the welfare of the profession as a whole and the individual members comprising it.

Speaking before the Los Angeles Section Meeting of AIEE, Mr. Powel, who is manager of headquarters engineering at Westinghouse Electric and Manufacturing Company, said that such an organization must have constant and intimate contact with the rank and file of engineers and must bring its weight to bear in community and civic affairs. "The desire for collective action," Mr. Powel stated, "is as powerful among engineers as it is among members of labor or white-collar unions." Two other plans of joint action have already been tried, but had serious shortcomings. One is the move of the American Society of Civil Engineers to have local sections act as bargaining units, while the other favors the inclusion of engineers in the general white-collar unions. However, as Mr. Powel pointed out, the first presents a number of legal obstacles and the second subjects the engineers to many decisions and rules which are clearly intended for a great majority of people doing an entirely different class of work.

Therapeutic Music

THE EFFECTS OF MUSIC on certain types of mental and nervous disorders is being determined by experiments conducted through the surgeon general of the U. S. Army and

ARMY-NAVY PREFERRED ELECTRON TUBES—SUPERSEDES PREVIOUS LISTS

RECEIVING TYPES

Filament Voltage	Diodes	Diode Triodes	Triodes	Twin Triodes	PENTODES Remote	PENTODES Sharp	Converters	Power Output	Indicators	Rectifiers
1.4	1A3	1S5†	1LE3	3A5	1T4	1L4 1LN5 1S5⊕	1LC5 1R5	1LB4 3A4 3S4		1006
5.0										5U4G 5Y3GT
6.3	6AL5 6H6* 559	6AQ6 6SQ7* 6SR7*	2C22 2C40 6C4 6F4 6J4 6J5* 7E5/1201 9002	6J6 6SL7GT 6SN7GT 7F8	6AB7 6AG7 6SK7* 9003	6AC7 6AG7 6AJ5# 6AK5 6AS6 6SJ7* 7W7 9001	6SA7	6B4G 6G6G 6L6GA 6N7GT/G 6V6GT/G 6Y6G	6AF6 6E5	6X5GT/G 1005
12.6	12H6*	12SQ7* 12SR7* 14E6**	12J5GT	12SL7GT 12SN7GT 14N7**	12SG7* 12SK7* 14R7**	12SJ7* 14H7# 14W7	12SA7* 14J**	12A6*	1629	
25 and above								25L6GT/G 28D7**	991	25Z6GT/G

MISCELLANEOUS

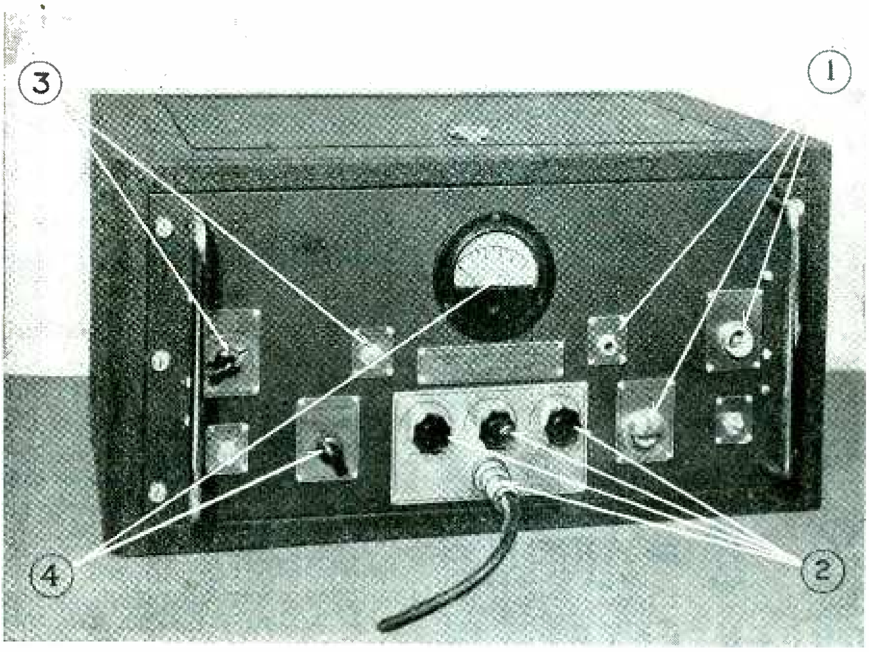
Cathode Ray	Crystals
2AP1 3BP1 3DP1 3FP7 5CP1 5CP7 5FP7 5JP1 7BP7 12DP7 12GP7 913	1N21B 1N23B 1N25 1N26 1N27 1N28 **Phototubes** 927 929 930 931A **Voltage Regulators** OA3/VR75 OC3/VR105 OD3/VR150

TRANSMITTING TYPES

Triodes		Tetrodes	Twin Tetrodes	Pentodes	Pulse Modulators	RECTIFIERS Vacuum	RECTIFIERS Gas	RECTIFIERS Grid Control	Clipper Tubes	Gas Switching
2C26A 2C39 2C43 3C24 CV92 (Br.) 100TH 250TH 304TH 527 811	826 833A 862A 880 889R 893A 1626 8025	807 813 814 827R 1625	815 829B 832A	2E22 4E27 803 837	3D21 3E29 6C21 715C	2X2A 3B24 5R4GY 371B 705A 836 1616 8016 8020	4B25 83 857B 866A 869B 872A	2D21 3C23 3C31/C1B C5B 6D4 394A 884 2050	3B26 719A	1B32/532A

*Where direct interchangeability is assured "GT" and "L" counterparts of the preferred metal tube may be used.
†Diode Pentode.
**These tubes are the only types with characteristics specified for 28-volt plate supply, and may be used in this type of application. Any of the types listed under "Receiving Diodes" may be used for 28-volt plate supply applications.

• Recommended for Fast, Easy, ACCURATE Calibration of Wavemeters, Signal Generators, Oscillators, Receivers, etc.



* * *

High Lights

1. BEAT DETECTOR UNIT provides easy calibration with either aural or visual indication of zero beat.

2. OUTPUT and ADJUSTMENTS give crystal-controlled harmonic frequencies up to 2000 megacycles.

3. MODULATION CONTROLS permit selection of either modulated or unmodulated output as well as degree of modulation.

4. MILLIAMMETER and SELECTOR SWITCH facilitates easy adjustment of output controls.

* * *

The Secondary Standard

LAVOIE C-200 CALIBRATOR

The LAVOIE C-200 Calibrator is an instrument that establishes *crystal-controlled* frequencies at UHF up to and beyond 2000 megacycles. By means of a switch it cuts out 10's and produces only 40's on the megacycle frequency range . . . or by means of an Identifier, selects any ONE of these frequencies for purposes of identification. A detector and amplifier on the panel expedite the calibration of signal generators, etc. Detailed information promptly upon request.

U H F

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.

Specialists in the Development of* UHF *Equipment

the Institute of Applied Music. Music as an aid to treatment has been tried before, but has never been properly or adequately controlled nor has its application been evaluated scientifically.

The music itself, which in this experiment is regarded solely as an aid to treatment and not as entertainment or recreation, will be presented by the highest type of professional musicians. Presumably, successful results from these tests will point the way to wider use of recorded and transcribed presentations.

Television on SMPE Agenda

A PAPER ON PROJECTION TELEVISION delivered, at the 56th Semi-Annual Technical Conference of the Society of Motion Picture Engineers, by Dr. D. W. Epstein of RCA Laboratories and Dr. I. G. Maloff of RCA Victor Division, Radio Corp. of America. The conference, held in the Hotel Pennsylvania, New York, on Oct. 16, 17, and 18, also included a talk on coaxial cable and other facilities for television networks, by H. S. Osborne, chief engineer, AT&T.

CONVENTIONS TO COME

Nov. 2-3. National Time and Motion Study Clinic, Chicago, Ill. INDUSTRIAL MANAGEMENT SOCIETY, C. S. Becker, vice president, 205 West Wacker Drive, Chicago 6, Ill.

Nov. 9-10. Fall Meeting, Dayton, Ohio. INSTITUTE OF THE AERONAUTICAL SCIENCES, Robert R. Dexter, secretary, 1505 RCA Bldg. West, Rockefeller Center, New York 20, N. Y.

Nov. 13-14. Rochester Fall Meeting & War Radio Conference, Rochester, N. Y. ROCHESTER FALL MEETING COMMITTEE, Virgil M. Graham, chairman, PO Box 750, Williamsport, Pa.

Nov. 13-14. Annual Fall Convention, New York, N. Y. SOCIETY OF THE PLASTICS INDUSTRY, C. S. Shoemaker, meeting chairman, Dow Chemical Co., 30 Rockefeller Plaza, New York 20, N. Y.

Nov. 15-19. AMERICAN CHEMICAL SOCIETY, Chicago section. Third Bi-

Great Events in the History of...

COMMUNICATIONS!

The Telephone Talks! "Mr. Watson, come here, I want you!"—this sentence uttered by Alexander Graham Bell on the evening of March 10, 1876, was the first ever transmitted by telephone. This great event soon led to the beginnings of the Bell Telephone System—for which Western Electric has been the manufacturer ever since 1882.

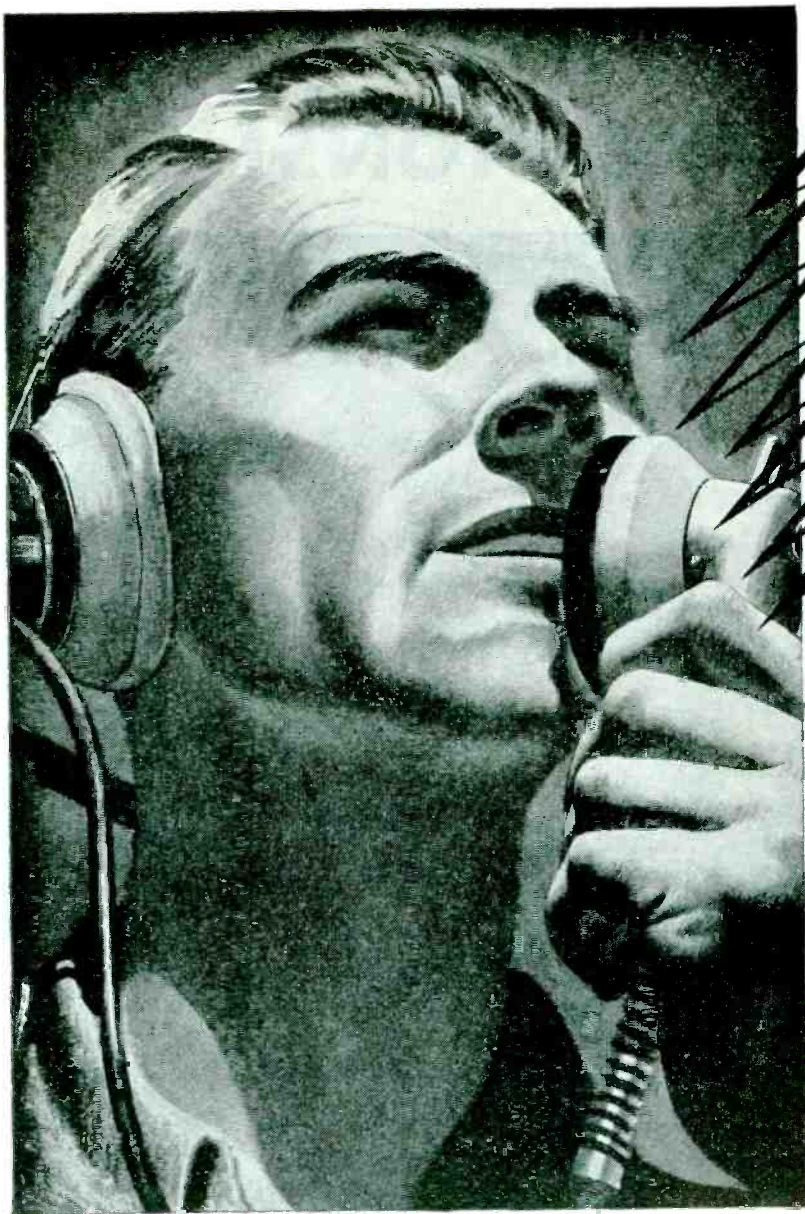
The Telephone Spans the Continent! On January 25, 1915, Alexander Graham Bell talked once more to Thomas A. Watson on a momentous occasion—the first time a telephone message crossed America. This great advance was made possible by the use of Western Electric vacuum tube repeaters—the first of many millions we have produced for the Bell System.

EVEN BEFORE the first of these events Western Electric—founded on November 18, 1869—was making electrical communications equipment. Bell Telephone maker since '82—pioneer in radio since its beginning—the Company today is the nation's largest producer of electronic and communications apparatus for war. In the peace that's coming, count on Western Electric—with its unique 75-year experience—for continuing leadership.

During the 6th War Loan Drive, buy more Bonds than ever!

Radio Telephone Spans the Atlantic! Just before dawn on October 21, 1915, the first spoken words spanned the Atlantic—transmitted from Arlington, Va., and received in Paris by radio telephone apparatus designed and made by Western Electric. Out of this pioneering came world-wide telephony—broadcasting—aviation, marine and mobile radio.

75TH ANNIVERSARY
Western Electric
ARSENAL OF COMMUNICATIONS EQUIPMENT



VOLTAGE REGULATORS "VIBRATION PROOFED"

How can a Voltage Regulator be made to operate efficiently in spite of vibration?

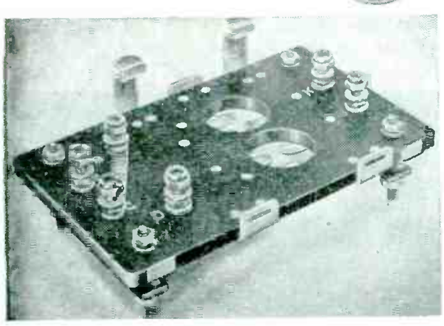
That's a question which faced design engineers responsible for the communications systems on our fighting planes. The answer was found in a little piece of scientifically compounded rubber safely bonded between two pieces of metal. When the regulators were mounted on these, the trouble was over.

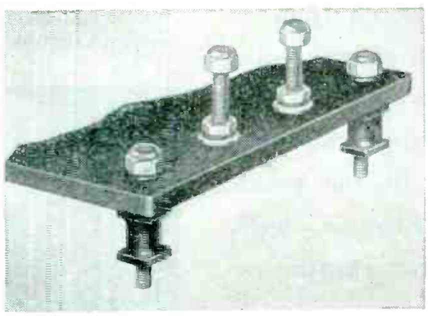
The mountings themselves look quite simple—but behind them is a backlog of scientific knowledge—the Science of Smoothness. By this is meant the science of engineering rubber and metal into resilient supports which will isolate vibration and shock.

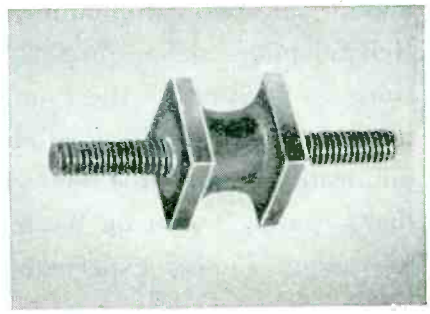
Men of the engineering staff of United States Rubber Company have been working in this particular field of science for many years. They have helped to solve a wide variety of difficult problems for engineers confronted with the necessity of preventing vibration and shock from interfering with the operation of their equipment.

They will be glad to work with you.

SERVING THROUGH SCIENCE







ONLY WHEN ISOLATED FROM VIBRATION can aircraft-type voltage regulators keep the flow of electricity constant for more efficient communication. This is accomplished through the use of "U.S." engineered rubber mountings designed specifically for each type of base. Quality of performance is predetermined before installation.

THIS VOLTAGE REGULATOR MOUNTING is only one of many types designed by "U.S." engineers for mechanisms ranging from sensitive electronic instruments to heavy industrial equipment.

Listen to the Philharmonic-Symphony program over the CBS network Sunday afternoon, 3:00 to 4:30 E.W.T. Carl Van Doren and a guest star present an interlude of historical significance.

UNITED STATES RUBBER COMPANY

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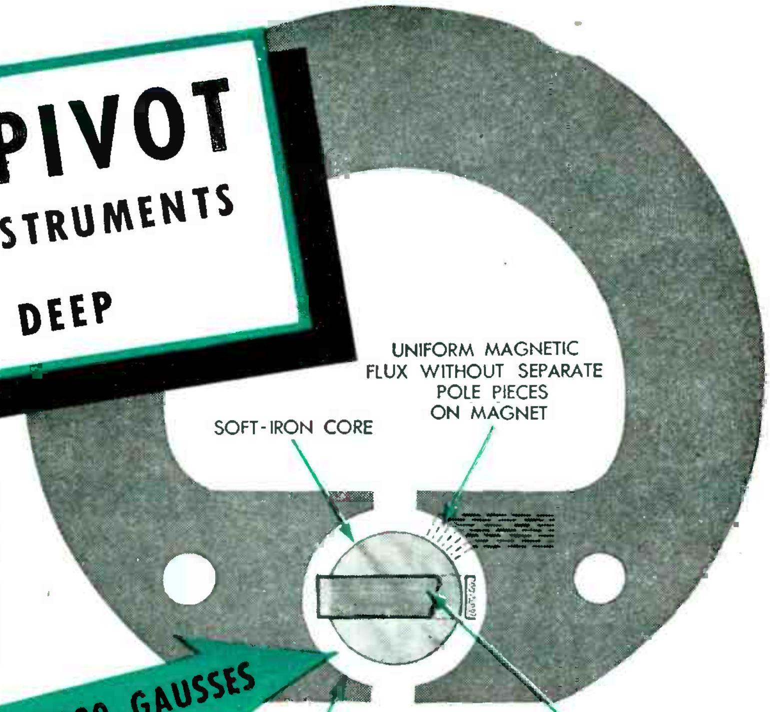
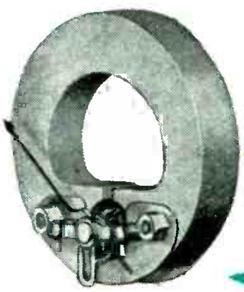
New INTERNAL-PIVOT

2½-INCH PANEL INSTRUMENTS ...1 INCH DEEP



Designed for thinness—but G-E engineers took advantage of the new magnetic materials to improve performance and add unusual values. Comol was selected for the magnet, and it thus became the basic part around which the internal-pivot element was designed.



Moving element mounted on one-piece comol magnet

Extra Values That the Comol Magnet Gives You

AN air-gap flux density of approximately 2000 gausses—made possible by the comol magnet—means a magnetic field some 50 per cent stronger than that of the conventional chrome-steel magnet.

Higher Torque This greater magnetic strength provides a substantial increase in torque. Since the weight of the moving element is about the same as that of other designs, the torque-to-weight ratio is much higher.

Faster Response The greater flux density also allows the use of a larger air gap, which minimizes any tendency toward stickiness. Faster response, which is assured by the high torque and lightweight moving system, enables accurate readings to be taken more quickly.

Improved Performance Large-radius pivots and good damping are among the other good features in the internal-pivot design—a design that packs all-round fine performance in a small space. They all add up to an instrument that is well able to withstand abnormal vibration and shock and maintain its rated accuracy.

For complete information, ask our nearest office for Bulletin GEA-4064, which covers instruments for use in radio and communications equipment; or Bulletin GEA-4117, which describes those suitable for naval aircraft. *General Electric Company, Schenectady 5, N. Y.*

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

GENERAL ELECTRIC

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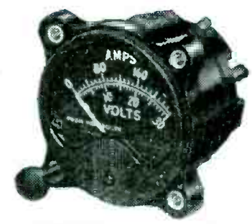

Type DW-53 d-c voltmeters, ammeters, and volt-ammeters. Designed to measure voltage and current in battery and battery-charging circuits on naval aircraft. Designed to meet all applicable Navy specifications.

For radio and other communications service: Type DW-51 d-c voltmeters, ammeters, milliammeters, microammeters; Type DW-52 radio-frequency ammeters (a-c thermocouple type). Cases are brass or molded Textolite.

HEADQUARTERS FOR ELECTRICAL MEASUREMENT

ennial National Chemical Exposition & National Industrial Chemical Conference, Coliseum, Chicago, Ill. Marcus W. Hinson, manager, 330 South Wells St., Chicago 6, Ill.

Dec. 11-12. First Annual Conference New York, N. Y. TELEVISION BROADCASTERS ASSOCIATION, Will Baltin, secretary, 500 Fifth Ave., New York 18, N. Y.

Jan. 22-26. AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Winter Technical Meeting, New York, N. Y. H. H. Henline, secretary, 33 West 39 St., New York 18, N. Y.

Jan. 30-Feb. 1. INSTITUTE OF THE AERONAUTICAL SCIENCES. Thirteenth Annual Meeting, Pupin Physics Laboratory, Columbia University, New York, N. Y. Meetings Committee, 1505 RCA Building West, 30 Rockefeller Plaza, New York 20, N. Y.

Multi-Studio Television

FACILITIES of the DuMont television station in New York, WABD, have formerly consisted of a single studio alongside the transmitter, film projection room, and laboratory on the 42nd floor of a Madison-Avenue building. Recently a new studio on the second floor of the same building was put into service. Larger than the first, it still follows the principle of low-cost, small-staff, and minimum-space operation—showing the possibilities of television broadcasting for the relatively small operator.

Among problems which proved troublesome to company engineers installing the new studio were vibrations from the subway under the building and magnetic fields from the passing trains. These deflected the cathode-ray pictures three-quarters of an inch and required special shielding. A coaxial link was used between the 2nd and 42nd floors.

WASHINGTON NEWS

TRANSFORMERS. Officials of WPB have asked transformer makers to refuse orders when they cannot deliver and to notify WPB of the fact. The board will then aid in passing the orders on to other manufacturers with available capacity. Ade-

2 POPULAR RCA INSTRUMENTS

for high-precision measurement work

RCA High-Frequency Wide-Band Sweep Generator

Type 709 B

RCA Ultra-High Frequency Signal Generator

Type 710 A

THE big job is done—valuable development, production and field test experience are combined in two quality products—the 709 B Sweep Generator and the 710 A Signal Generator. Here are two instruments every Television, FM and H.F. Laboratory can rely on for postwar design applications.

The 709 B Sweep Generator covers the frequency band of 5 to 65 megacycles (center frequency). It is ideal for high frequency I. F. curve response study. Its calibration marker permits constant checking of band width characteristics.

The 710 A Signal Generator, with a frequency range of 370 to 560 megacycles, is widely used for checking high frequency devices. This instrument provides smooth and complete attenuation throughout its range, plus precision frequency control.

Planning your postwar activity means planning your laboratory facilities as well. Now is the time to investigate the characteristics of these reliable RCA instruments.

RCA bulletins containing complete descriptions and specifications of the 709 B Sweep Generator and the 710 A Signal Generator will be sent promptly on request.

Please note that deliveries of these instruments are subject to regulations of WPB General Scheduling Order M-293.

Buy More War Bonds

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RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION • CAMDEN, N. J.

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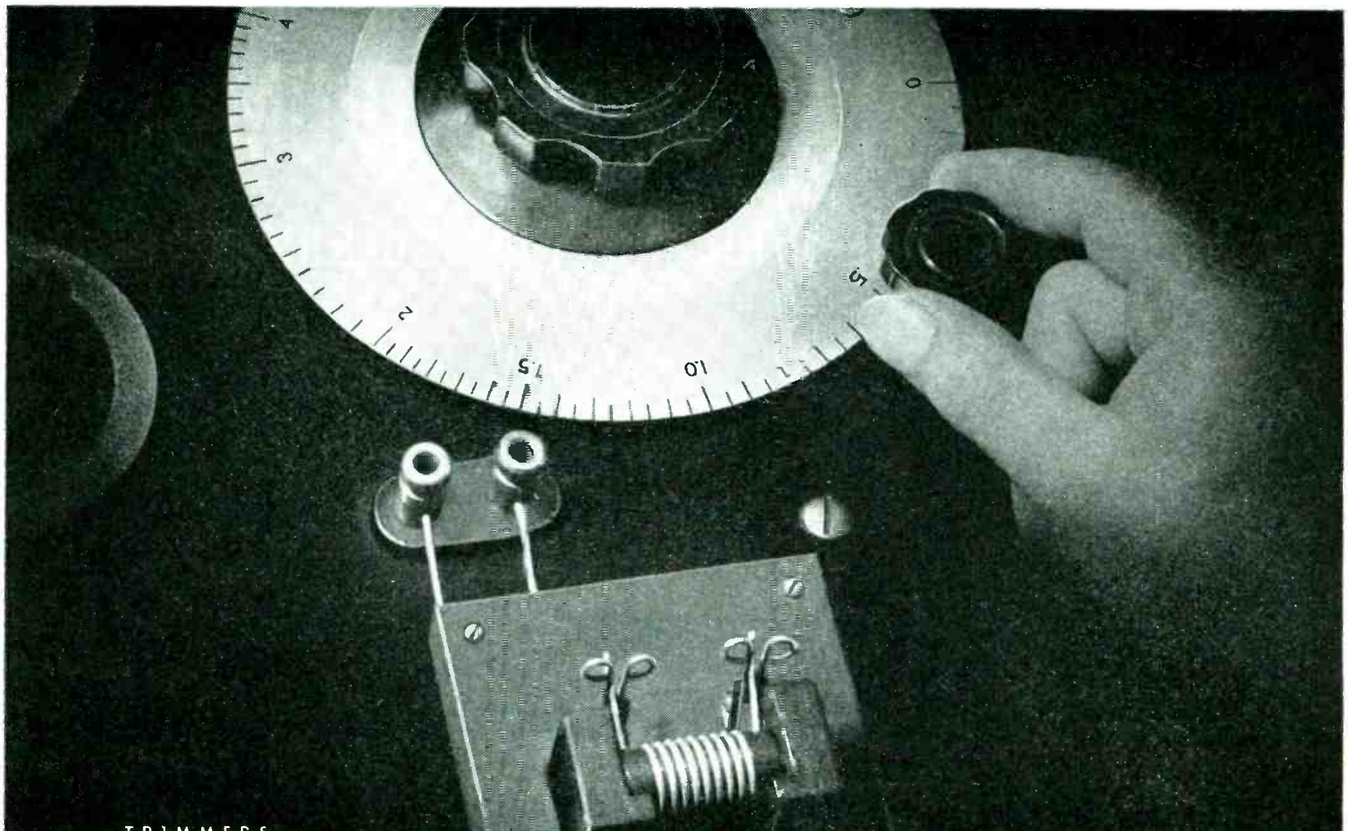


MEETING THE HIGHEST INDUSTRIAL STANDARDS

Nationally recognized engineering talent . . . sharpened by intelligent specialization . . . broadened by the exacting tests of war . . . explains, in part, PLASTIC'S amazing progress in the field of thermoplastic insulation. Also responsible are latest equipment, careful materials control, and a personnel whose loyalty and devotion is "above and beyond the call of duty." You can utilize to advantage . . . in today's planning and tomorrow's production . . . this experience and ability. Available for the asking is the "know how" which can make your product a BETTER product. You can DEPEND on PLASTIC for design . . . development . . . delivery.

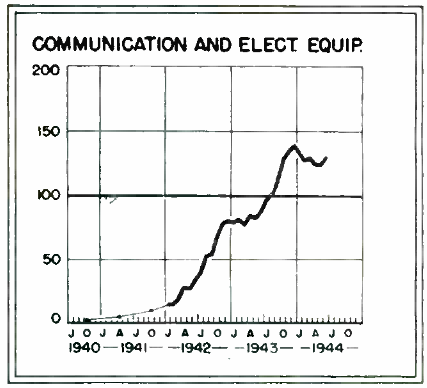
THERMOPLASTIC SPECIALISTS

PLASTIC WIRE & CABLE CORPORATION

NORWICH · CONNECTICUT

L. W. LORD, President   M. H. PHILLIPS, Vice President and Treasurer   A. O. BLADES, Plant Manager quate supplies of components will be available if manufacturing facilities are thus distributed. Backlogs of transformer orders were described as slowly decreasing in most plants and reductions in delivery time anticipated. In connection with cutbacks related to VE day, even though quantities might be reduced as much as 30 percent, much of the remaining production would involve tropicalization with attendant production problems.

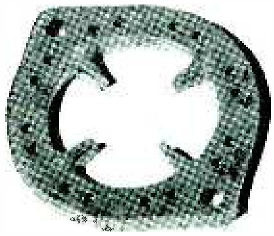
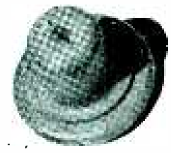
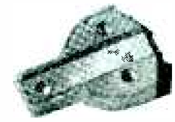
PRODUCTION INDICES. Figures released by WPB reveal June production figures in communication and



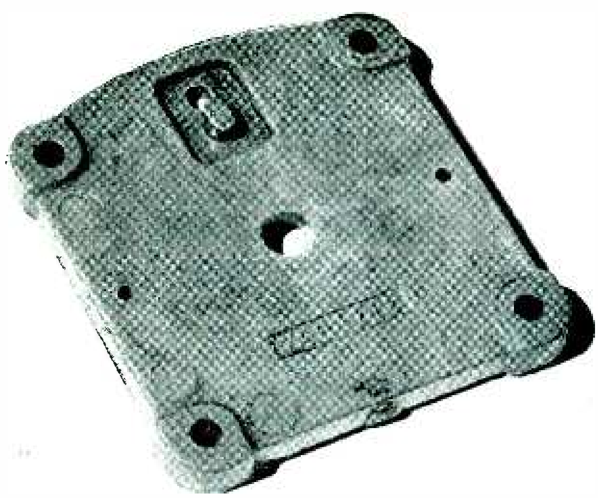
electronic equipment increasing 4 percent over May and raising the index 6 points to 130. See chart. Airborne equipment led the way with an increase of 8 percent. Ship equipment remained at the May level while ground equipment went up 4 percent.

RADIO PARTS COMMITTEE. OPA announces a radio parts manufacturers' industry advisory committee consisting of: Octave Blake, Cornell-Dubilier Electric; Samuel I. Cole, Aerovox Corp.; Monte Cohen, F. W. Sickles; Russell E. Cramer, Radio Condenser; Allen Fritzche, General Industries; Robert C. Sprague, Sprague Electric; Leslie F. Muter, Muter; W. G. Roby, Cinch Mfg.; J. H. Stackpole, Stackpole Carbon; Thomas A. White, Jensen Radio Mfg.; A. Blumenkranz, General Instrument; George Fraser, Astatic Microphone; Hugh H. Eby, Hugh H. Eby, Inc.; L. W. Howard, Peerless Electrical Products; Jerome J. Kahn, Standard Transformer; Harry E. Osmun, Centralab; Harry Ehle, International Resistance; and C. L. Walker, Utah Radio Products.

BROADCAST POWER. By an amendment to section 3.64 of its rules governing standard broadcast stations,

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.

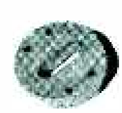
Because intricate shapes may be molded with G-E mycalex with "molded-in inserts", because these parts are made to extremely close tolerances and because their dimensional stability is high, G-E mycalex is a superior material for assemblies which must stand up under severe operating conditions. Although 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 N-253, One Plastics Ave., Pittsfield, Mass.

PLASTICS DIVISIONS

GENERAL ELECTRIC

PD-253


FCC makes it possible for a station operating with different power day and night to get a license authorizing the use of alternate transmitters. Requirements are that both be located at one place and that both be substantially the same as to frequency stability, reliability of operation, radio harmonics and other spurious emissions, audio frequency range, and audio harmonic generation.

AUTOMATIC PHONOGRAPHS. The following individuals have been appointed by WPB to constitute the commercial automatic phonograph industry advisory committee: J. E. Broyles, Rudolph Wurlitzer; Robert Gabel, John Gabel Mfg.; Carl T. McKelvy, J. P. Seeburg; David C. Rockola, Rock-Ola Mfg.; E. E. Rullman, Automatic Instrument; and V. G. Wahlberg, Mill Industries.

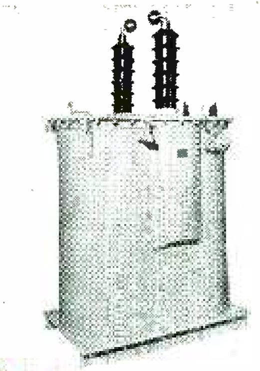
TUBES AND RADIO PARTS. Changing conditions have made it possible for the radio and radar division of WPB to revoke two limitation orders. Since distribution and production of several hundred types of tubes are now scheduled under M-293, their limitation by L-76 is no longer necessary. Replacement parts for home radios have been subject to L-293 which was designed for maximum conservation of materials without regard to the most efficient use of production facilities. Its removal will allow production of these components on the same lines that are running other parts.

APCO Conference

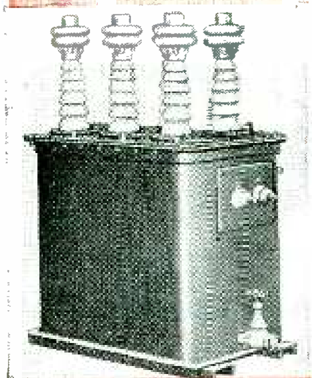
ACCENT ON the importance of retaining present police radio channels and providing for additional radio frequencies in the postwar period was made at the 11th annual national conference of Associated Police Communication Officers in a three-day session at Toledo, Ohio, during September.

Selection was made by the 300 members present of a large police radio committee to appear at the FCC allocations hearing in Washington in October.

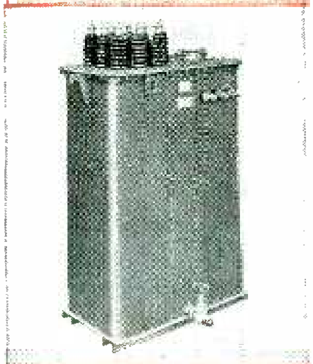
Acclamatory re-election of the principal officers for 1945 included: president Frank W. Walker; first vice-president Ray S. Groenier; *Bulletin* editor Capt. J. M. Wherritt



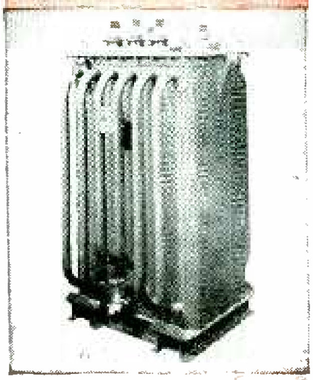
Single phase, half wave rectifier plate transformer, 60 cycles, 220 volts primary, 110,000 volts secondary.



300 VA Filament transformer, single phase, 60 cycles, 6 secondary windings of 5 volts each; 3 secondary windings operating [illegible] KV above ground and 3 secondaries operating 20 KV above ground.



60 KVA, three phase, 60 cycles, 211 volts, Delta primary, 3900 / 6755 / 7800 / 13510 volts Wye secondary.



150 KVA Distribution transformer, single phase, 600 high voltage, 240/120 low voltage.

Fire!

REDUCE THE HAZARD WITH

AMERTRAN ABESTOL IMMERSED TRANSFORMERS

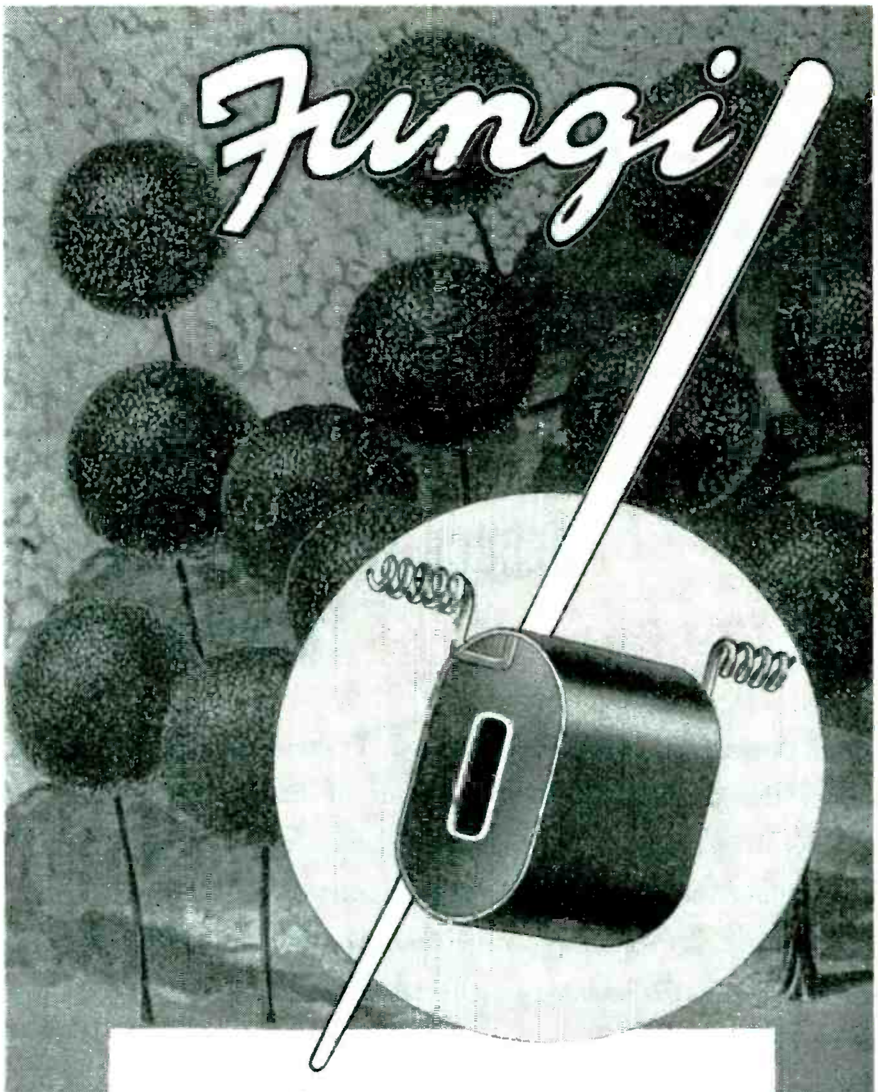
Fireproof AmerTran Abestol Immersed Transformers reduce both the possibility and the extent of fire damage. That's why they earn lower insurance rates and permit vaultless indoor installation, with its convenience, flexibility and accessibility. To industry, AmerTran Abestol Immersed Transformers offer the advantages of load center installation: copper savings, finer voltage regulation, lower line losses and improved motor performance. If necessary, they may be mounted overhead because the chemically inert Abestol, which requires no maintenance, is sealed. In comparison to transformer oil, Abestol possesses higher insulating properties and similar heat transmission characteristics.

Send for further information.

AMERICAN TRANSFORMER COMPANY
178 EMMET STREET, NEWARK 5, NEW JERSEY

AMERTRAN
MANUFACTURING SINCE 1901 AT NEWARK, N. J.

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



and secretary-treasurer Ero Erickson. D. J. McFarlane is new second vice-president and C. H. Knudel was chosen sergeant-at-arms.

Meeting in full session during the APCO conference, and prefaced by an address by RTPB chairman Dr. R. G. W. Baker, RTPB Panel 13 was headed by D. E. Noble and formalized all of the 9 committee reports by approving the frequency allocations already resolved within the Panel and transmitted the findings to the Planning Board.

A police allocations sub-committee agreed to support an interspersed frequency allocations scheme in preference to a block system of assignments and emphasized the need of low-frequency police radio channels in mountainous regions of California and the east, in addition to the retention of essential point-to-point radiotelegraph and voice channels now in use.

Experimental Canadian FM

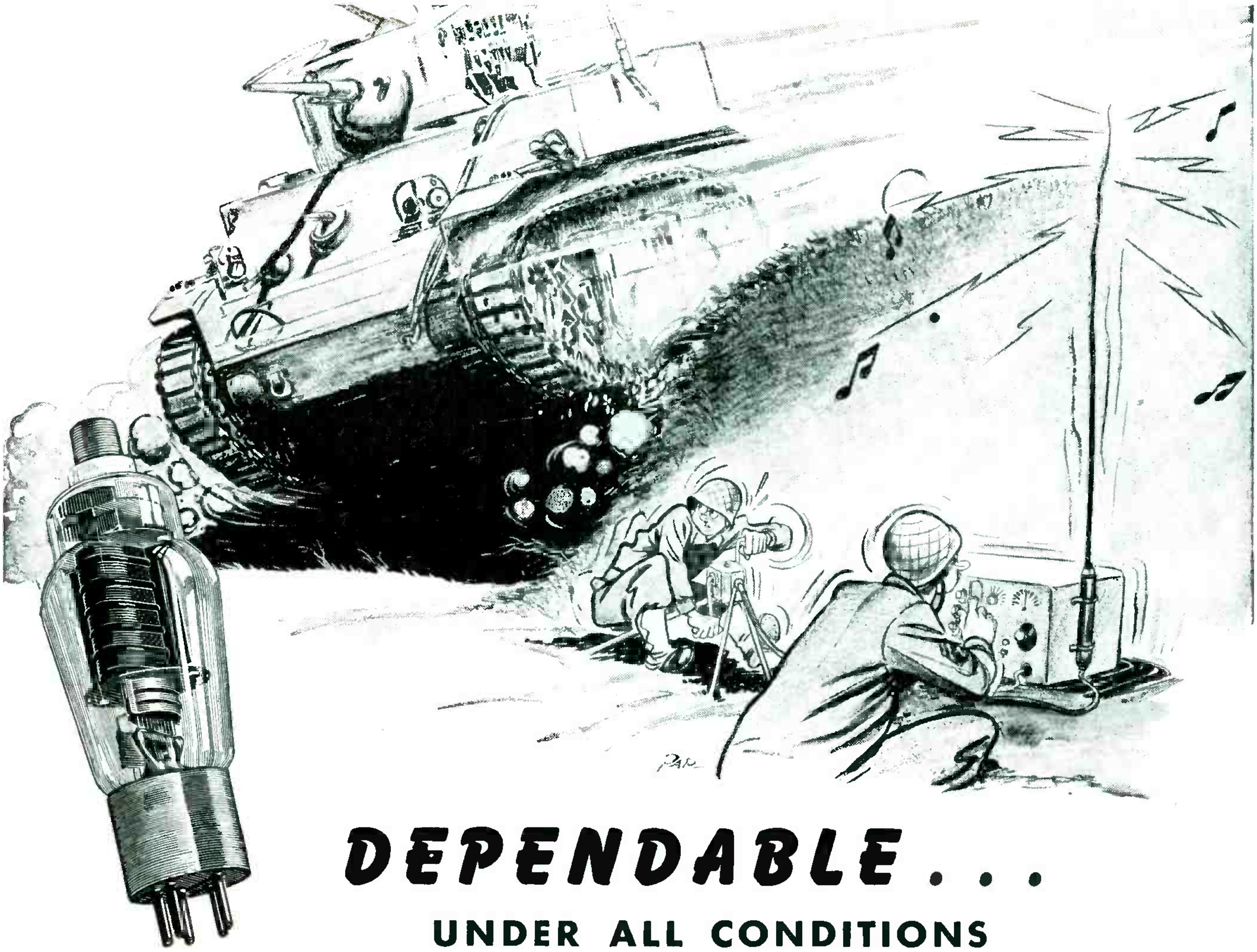
FOLLOWING UP EXPERIMENTS which had previously been made at Montreal, Canadian Broadcasting Corp. plans to establish an experimental f-m transmitter in that city. Funds will come from the $100,000 reserves of the Corporation, according to Dr. Augustin Frigon, assistant and acting general manager.

Electronics on the Super-Fortress

COMMUNICATION AND navigational aids have an outstanding importance to the AAF's 20th Air Force, operators of the B-29 Boeing Superfortress task force. Communications are under the direct command of Brigadier General Harold M. McClelland, air communications officer for the AAF.

When each of the Superfortresses takes off on bombing flights over Japan it carries approximately 2,000 lb of Signal Corps aircraft radio equipment.

Composed of many different radio sets and devices, all of which were either developed or improved in the Signal Corps' aircraft radio laboratory at Wright Field, the radio complement for this superbomber was the largest single installation job ever undertaken by the laboratory, according to Col. Hobart R. Yeager, commanding of-



DEPENDABLE . . .

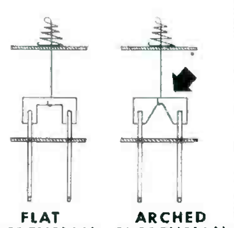
UNDER ALL CONDITIONS

By concentrated abuse, the war has proved the relative merits of materials and construction in many kinds of equipment. This is particularly true in the case of Electronic Tubes.

The fact that TUNG-SOL Tubes have given long and efficient service in all kinds of electronic devices is no happy accident. It is the result of many years of intensive research . . . tests for performance in screen rooms by radio scientists . . . tests for ruggedness by engineers to find possible weaknesses . . . redesigning to make sure that tubes meet the most exacting requirements of use. For instance, in one particular transmitting type, the tendency of the filament wires to go out of alignment from vibration was a common shortcoming. This was remedied by a change in one simple construction feature as shown below.

HOW TUNG-SOL FILAMENTS STAY IN ALIGNMENT

One method of holding the filament wire in tension was to hook the tension wire to a flat suspension bar. However, TUNG-SOL engineers found that vibration often caused the spring connection to shift along the bar, thus forcing the filament out of alignment. The improved suspension arch eliminated this possibility.



Manufacturers and users of electronic devices may be assured that the sending, receiving and amplifying TUNG-SOL Tubes they buy for initial equipment and replacement are as uniform and as dependable as it is humanly possible to produce them. TUNG-SOL's engineering development staff is ready to work with you on your Electronic Tube requirements.

ARMY E NAVY

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS ficer of Signal Corps Aircraft Signal Agency.

Installations in the B-29 nearly double the number normally carried by the Flying Fortress, the Liberator, or other heavy bombers in actual operations, he added. These radio sets range in weight from one-half pound, to 550 pounds.

None of the radio equipment in the B-29 was designed specifically for it as most of the sets have been used in both fighter and bomber aircraft. Wherever a choice existed between two or more different sets of a similar type, a selection was made after exhaustive tests of the equipment to determine which would give maximum performance on long-range flights.

Communication equipment provides for conversations between aircraft in flight, between the bombers and their far-distant bases and between crew members within a plane.

Navigational devices allow the pilot to fly a direct or diverse route as desired, to locate bases on return with the precision of a homing pigeon, and to execute safe landings. Devices to guide rescuers in are included in the B-29 radio installation.

Technical problems encountered by Aircraft Radio Laboratory were numerous because of the great number of different types of radio equipment which had to be installed and made to operate without conflicting with or neutralizing each other.

PERSONNEL

L. J. Chatten, formerly assistant director, has been made director of the radio and radar division, WPB. He succeeds **Ray Ellis** who is returning to his post at General Motors Corp.

Head of research on electronic products at Littelfuse Inc., Chicago, Ill., is **Bernard F. McNamee,** previously in charge of the engineering department of Consolidated Engineering Co.

Harold Hadden, control and studio supervisor at WOR, New York, N. Y., is coordinating technical assignments and operations between that station and WABD on television productions.

At Philco Corp., Philadelphia, Pa.,

ANNOUNCING

The New General Plate Laminated Metal

* PAT. PENDING

- **FOR TINY SWITCH BLADES TO HEAVY STRIPS**
- **FOR EXTRA CONDUCTIVITY**
- **SILVER CLAD (NOT ELECTROPLATE)**

First in the parade of new General Plate Metals for post-war use is the new laminated combination of *Silver on Beryllium Copper*.

Made by permanently bonding silver to beryllium copper, it gives you the extra conductivity of silver . . . so badly needed where only beryllium copper meets the requirement . . . plus the springiness of beryllium copper.

No matter whether your requirements call for tiny switch blades or heavy strips, General Plate laminated *Silver on Beryllium Copper* will provide better performance. It is available in combinations of silver on one side or both sides in any thickness—or centre-lay (silver between two layers of beryllium.)

Find out about this new General Plate laminated metal . . . Silver on Beryllium Copper. Write for full information today.

GENERAL PLATE DIVISION
OF METALS & CONTROLS CORPORATION
50 Church St., New York, New York 205 W. Wacker Drive, Chicago, Illinois
2791 Kensington Place East, Columbus, Ohio
2635 Page Drive, Altadena, California
ATTLEBORO, MASSACHUSETTS

William Balderson goes from vice president in charge of the commercial division to take charge of operations and become a member of the executive committee.

Allen B. Du Mont has been made honorary doctor of engineering by

Rensselaer Polytechnic Institute. Dr. Du Mont is head of Du Mont Laboratories, Inc., Passaic, N. J.

C. W. La Pierre has been made assistant engineer of the general engineering laboratory at General Electric Co., Schenectady, N. Y. He was formerly in charge of the electro-mechanical section there.

John H. Miller has been made chief electrical engineer at Weston Electrical Instrument Corp., Newark, N. J. He was formerly assistant chief electrical engineer.

Philip F. Siling has been made engineer in charge of the frequency bureau of Radio Corp. of America. He was formerly assistant chief engineer in charge of broadcasting for FCC.

Frank J. Hajek has been made president of Taylor Tubes Inc., Chicago, Ill. He was formerly secretary-treasurer.

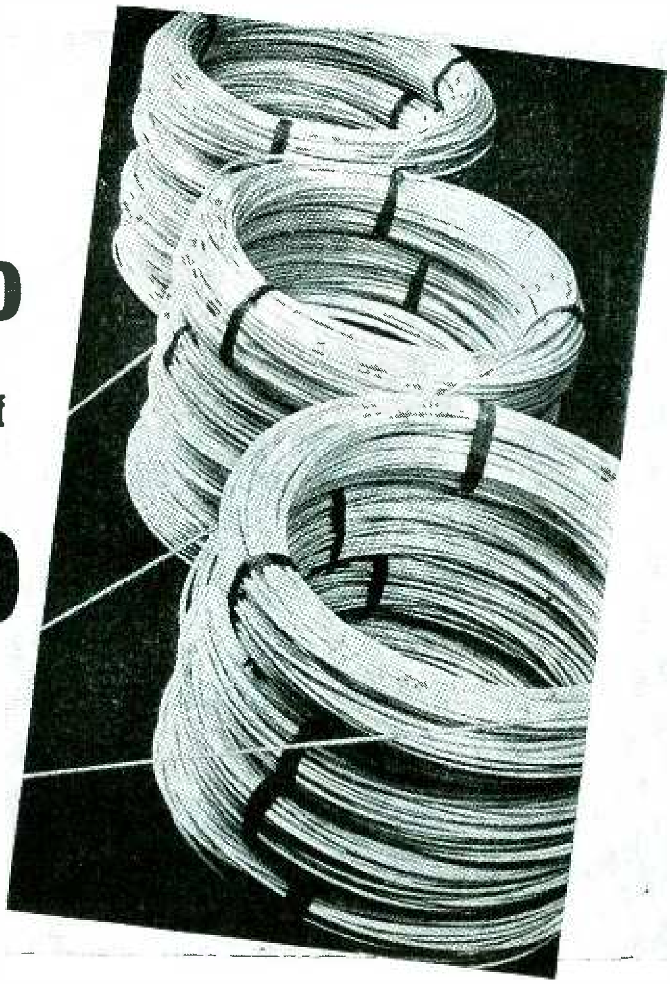
James C. Filmer has been made vice-president in charge of engineering at Taylor Tubes Inc., Chicago, Ill.

Dr. Lee de Forest has been active in the organization of a center for electronic research, a factory for the production of radio

WILCO
NOW EQUIPPED

for large scale production of

JACKETED WIRE



WILCO wire, tubing and other products are used in various electronic applications for the Army and Navy. In response to the wartime demand for these various products, the H. A. Wilson Company has enlarged its plant, increased its manufacturing facilities, added essential new equipment and developed new products and techniques. Both present and future customers will find these new WILCO developments of great advantage.

The H. A. Wilson Company manufactures and is interested in receiving inquiries regarding the following typical products—

WILCO JACKETED WIRE

Silver (Fine, Sterling or Coin)
Silver Jacketed Copper
Silver Jacketed Invar
Silver Jacketed Brass
Silver Jacketed Steel
Gold Jacketed Silver (Fine, Sterling, Coin)
Gold Jacketed Brass or Bronze
Copper Jacketed Monel
Nickel Jacketed Copper

WILCO JACKETED TUBING

Silver Tubing (Fine, Sterling or Coin)
Gold Tubing (any Color or Karat)
Silver Jacketed Brass or Bronze (one or both sides)
Gold Jacketed Silver (one or both sides)
Gold Jacketed Brass or Bronze (one or both sides)

WILCO STRIP MATERIAL

Silver (Fine, Sterling or Coin) on Brass or Bronze (Inlay or Overlay)
Gold on Silver (any Karat on Fine, Sterling or Coin)
Gold on Brass or Bronze

Other WILCO products include Electrical *Contacts*—

Silver, Platinum, Tungsten, Alloys, Powder Metal. *Thermostatic Bimetal* (High and Low Temperature with new high temperature deflection rates.) *Precious Metal Collector Rings*—For Rotating controls. *Silver Clad Steel. Rolled Gold Plate. Special Materials.*

Let us analyze your problems.

THE H. A. WILSON COMPANY

105 Chestnut Street, Newark 5, N. J.

Branches: Detroit · Chicago

and television equipment, and a commercial television station, all at Mexico, D. F., Mexico.

Maurice H. Hobbs has been made manager of the engineering department in the switchgear and control division at Westinghouse Electric & Mfg. Co.

William Vassar has been made administrative assistant to the vice-president in charge of engineering and production at Emerson Radio & Phonograph Corp., New York, N. Y. He was formerly an executive engineer at Crosley Corp.

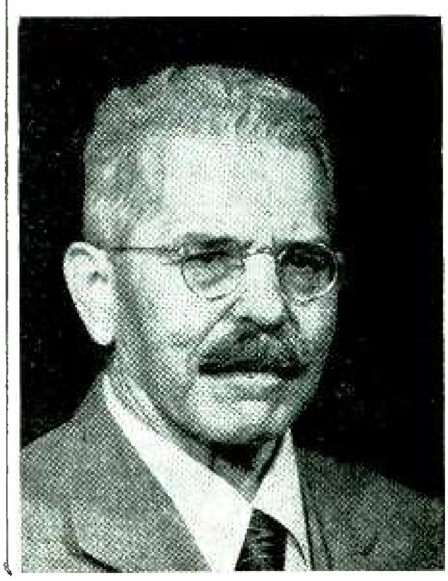
Frank X Lamb has been made assistant chief electrical engineer at Weston Electrical Instrument Corp., Newark, N. J. He was formerly a project engineer.

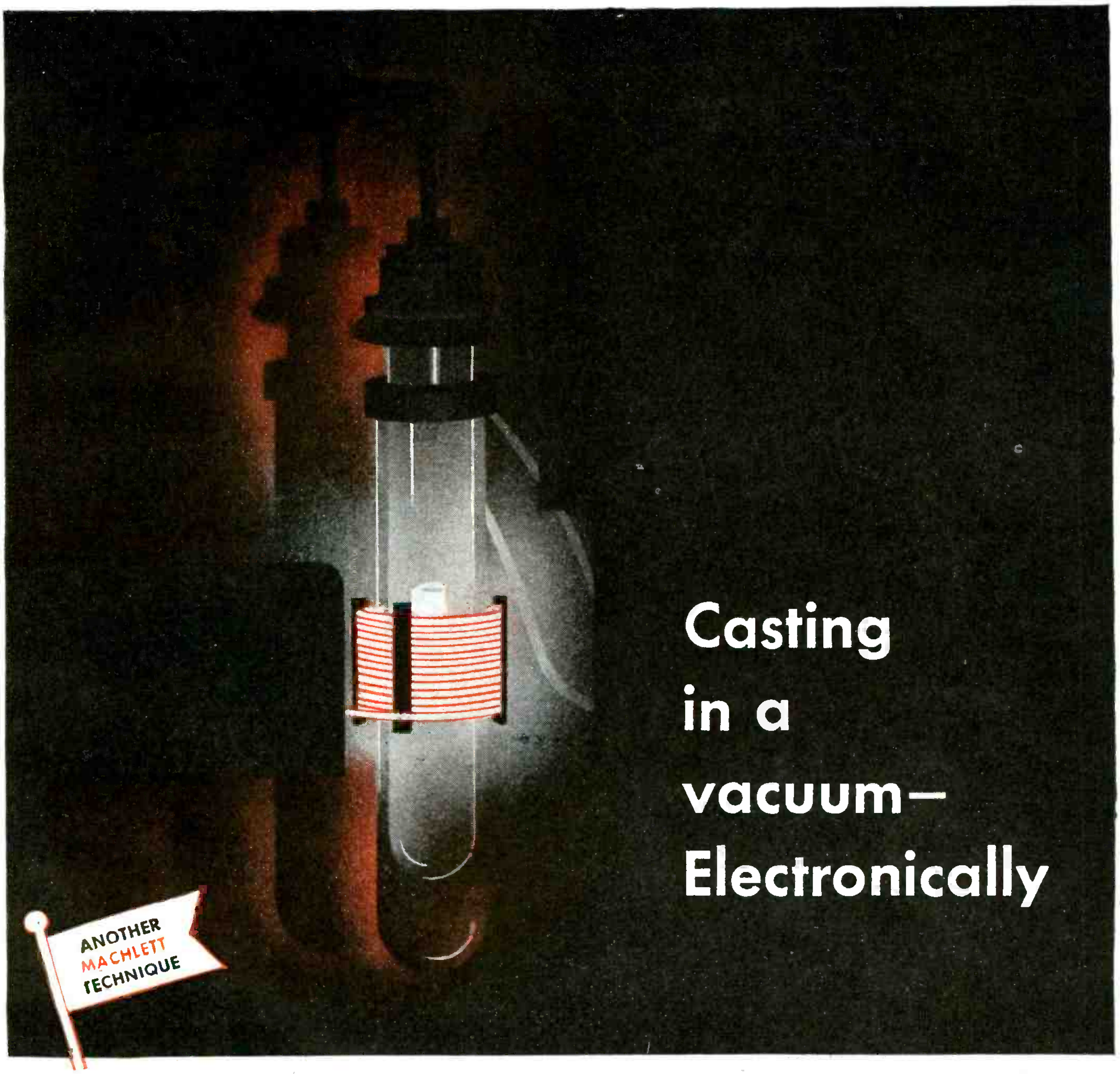
Charles F. Kettering has been made a member of the subcommittee on applied cyclotronics of the post-war program committee of the State of Ohio. He is head of General Motors Corp. research.

Wendel C. Fowler has been made president of the Fort Worth Electronics Club, Fort Worth, Tex.

Roy Siren has been made engineer in charge at Milwaukee Industrial Designers, Milwaukee, Wis. He was formerly with Nordberg Mfg. Co.

Karl M. Lederer has been made assistant director of research at Weston Electrical Instrument Corp., Newark, N. J. He was formerly assistant chief engineer.

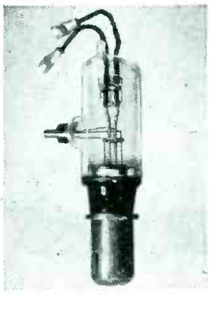




One of the many vital processes that give Machlett vacuum tubes their remarkable quality is a novel method of casting electrodes in a vacuum. Complex parts of high-frequency oscillators, as well as X-ray tube anodes, are made by this unusual technique. Purified copper rod is placed over a mould in a graphite crucible, and the whole enclosed within a double-walled water-cooled quartz-silicon tube, which is encircled by a high-frequency coil. A vacuum of about 10^{-5} mm. of mercury is maintained.

When the current is turned on, the metal melts and flows into the mould. Cooling is precisely controlled by adjusting the position of the heating coil, so that crystals form longitudinally, for maximum heat transfer under operating conditions.

This method accomplishes a number of things, quickly and simply. No gases can be occluded in the metal to shorten tube life by reducing the vacuum. Oxides cannot form. There are no "pipes" in a casting thus poured. Dimensions can be held to about 1/10,000th of an inch—and accurate dimensions are as important as metal purity in protecting transmitting tube performance, both assuring the maximum designed performance and long life. Techniques such as this make possible the production of the tube shown above . . . Machlett Laboratories, Inc., Springdale, Connecticut.

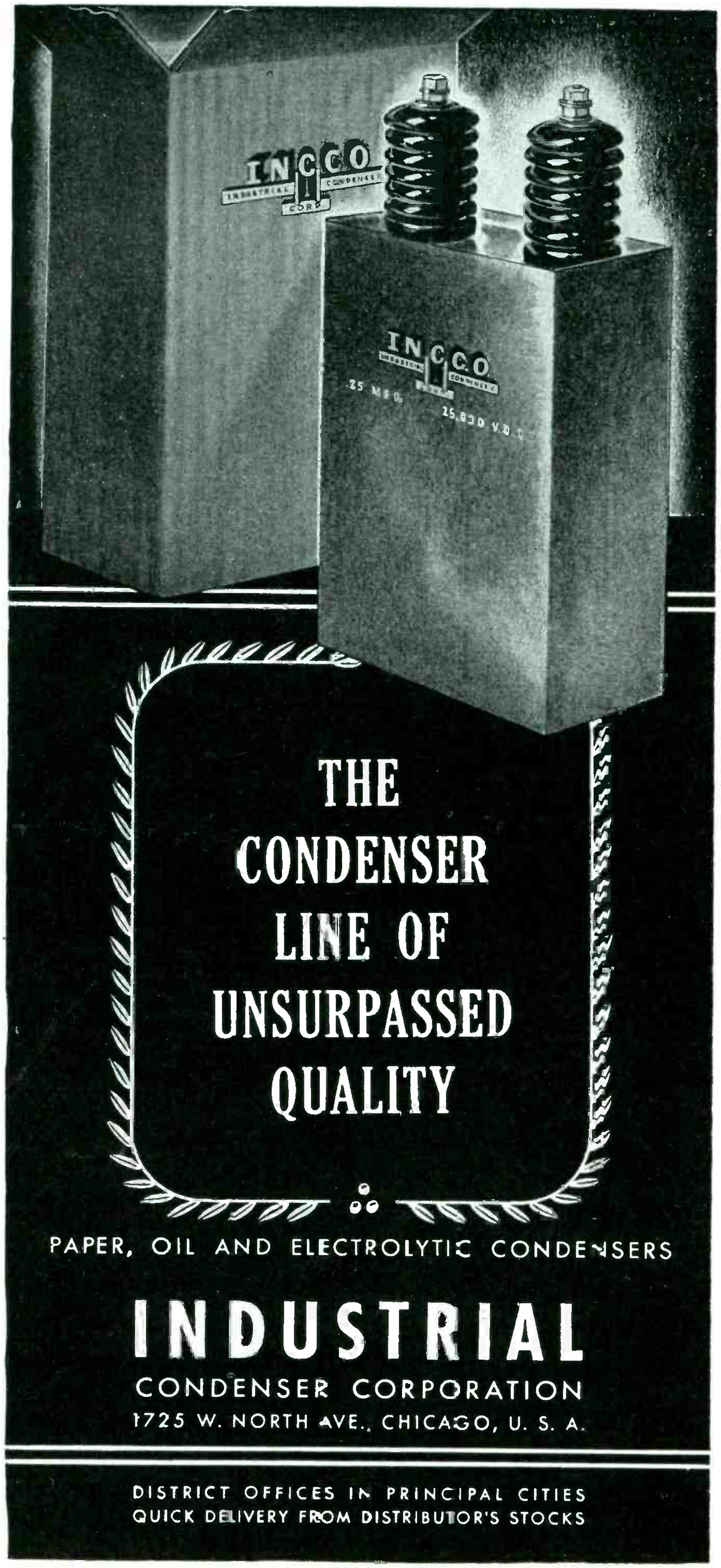


ML-846—An U. H. F. transmitting tube for television and F. M and short wave broadcasting.

MACHLETT

X-RAY TUBES SINCE 1898

TODAY THEIR LARGEST MAKER



At Westinghouse Electric & Mfg. Co. **R. T. Muench** is made manager of the x-ray products department. Since 1942 he has been manager of the Detroit x-ray office.

I. Walter Wyckoff has been made president of Electronics Manufacturers Association, New York, N. Y. He is connected with Pilot Radio Corp.

AWARDS

ON THE SECOND ANNIVERSARY of the presentation of the first Army-Navy "E" Awards, the War Department announces that the award had been granted to 3,097 plants. Based on various statistical reports, it has been estimated that approximately $3\frac{1}{2}$ percent of the Nation's eligible plants have received the award.

Adel Precision Products Corp.
Huntington Precision Prod. Div.
Huntington, W. Va.

Aerovox Corporation
New Bedford, Mass.

Eagle Signal Corp.
Moline, Ill.

Electrical Research Labs., Inc.
Evanston, Ill.

Electro-Voice Mfg. Co., Inc.
South Bend, Ind.

General Electric Co.
Transmitter Div.
Syracuse, N. Y.

Hytron Corp.
Salem, Mass.

The Indiana Steel Prods. Co.
Valparaiso, Ind.

Litton Engineering Labs.
Redwood City, Calif.

Sonotone Corporation
White Plains, N. Y.

Union Aircraft Products Corp.
New York, N. Y.

CHIEF SIGNAL OFFICER'S CERTIFICATES OF APPRECIATION

These awards are testimonials to the contribution of individuals and organizations not eligible for Army-Navy recognition.

Louis H. Lamotte
International Business Machines Corp.

Chester W. Latimer
Vice-Pres. and Chief Engineer
RCA Communications

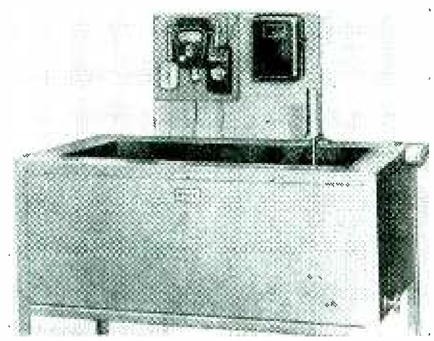
Samuel Ruben
New Rochelle, N. Y.

George E. Smith
Vice-President
Crosley Corp.

William A. Winterbottom
Vice-Pres. and General Mgr.
RCA Communications, Inc.

Wax Dipping-Baths

NEW AND IMPROVED electrically-heated and automatically-controlled wax dipping-baths are available which permit fast, efficient and economical wax-coating of coils, resistors, capacitors, panels and other

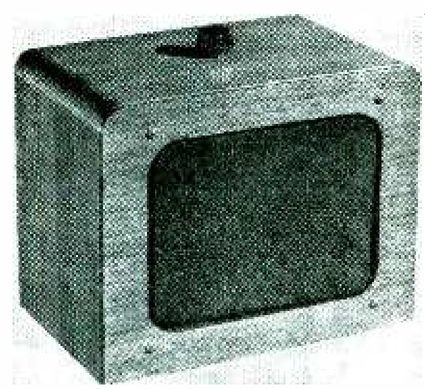


electrical parts. The units may also be used to wax-coat packages to guard against moisture absorption. Bath temperatures can be adjusted from 100 to 550 deg F. The baths are built to order.

Barnstead Still & Sterilizer Co., Forest Hills, Boston, Mass.

Sound Reproducer

MODEL NO. HF-6 is a new baffle-type reproducer unit which provides duo-directional high fidelity reproduction of both voice and music for plant broadcasting. The speaker is a 6-in. permanent magnet type with a 6-ohm voice coil. It delivers from 4 to 6 watts of output power, and is especially adaptable



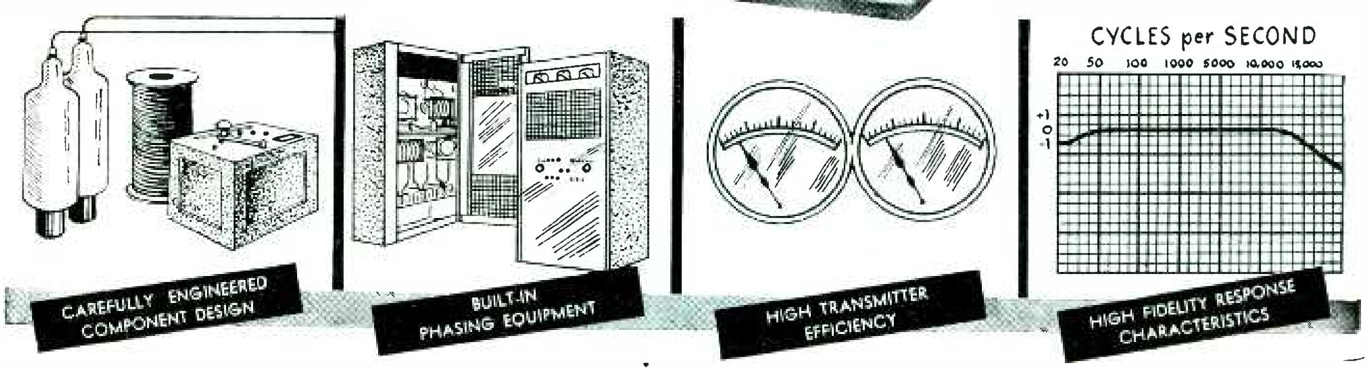
for wide-angle coverage of medium and low noise level areas. A bass compensation circuit progressively increases the bass response with each decrease of volume. The unit measures $9 \times 10\frac{1}{2} \times 6\frac{1}{2}$ in. and is suitable for desk or wall use.

Executone Corp., 415 Lexington Ave., New York 17, N. Y.

From GATES Engineering Laboratories—A Preview of New Transmitter Designing for the Post-War Radio Industry

Gates "BC-10"

5-10 KW BROADCAST TRANSMITTER



Here is one of the new things to come from Gates! Our engineers have already developed and approved engineering designs for this transmitter to be produced as quickly as the demands by the military on Gates' production no longer exist. The "BC-10" may be used for either 5,000 or 10,000 watt carrier. It is high level modulated and will be available complete with built-in phasing equipment.

May We Send You Details Regarding the Gates Priority System for Prompt Post-war Delivery

(Wartime restrictions do not allow the sale of new broadcasting equipment without priority; therefore, this equipment is presented merely to acquaint you with Gates' developments.)

Gates

RADIO and Supply CO.

QUINCY, ILLINOIS, U.S.A.

MANUFACTURERS OF RADIO BROADCAST TRANSMITTERS, SPEECH EQUIPMENT, RECORDING APPARATUS AND ALLIED EQUIPMENT IN THE ELECTRONICS FIELD

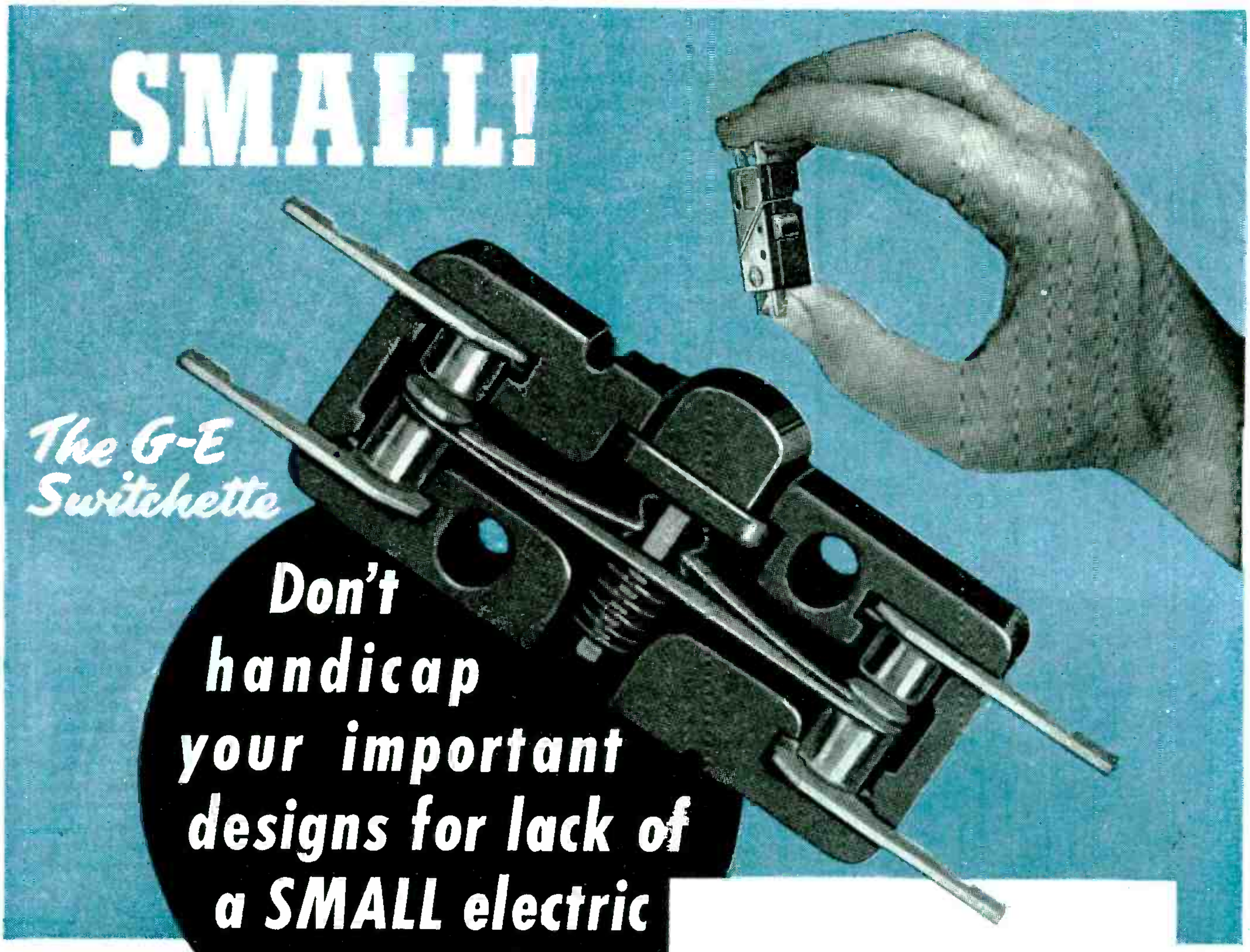
Technical Monograph. "Loud Speaker Frequency Response Measurements" is the first publication of a series of technical monographs to help the amateur and the professional in the field of acoustics. Each publication will be devoted to one important aspect of the science of sound as applied to loud speakers. The first booklet (available for 25c) explains how one can use measured frequency response as essential data in development and design work, and describes some of the equipment and methods that may be used. Technical Service Dept., Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago 38, Ill.

Altitude Chambers. Altitude chambers for controlled temperature, humidity and pressure are described and illustrated in a 12-page booklet which contains a page of general specifications, plus information about Models AC-107, ACR-262, AC-36, 2000V, ACR-20, AC-8. Parts, instruments and accessories are also illustrated and described. Kold-Hold Mfg. Co., 424 N. Grand Ave., Lansing, Mich.

R-F Coils and Assemblies. This manufacturer makes coils for every application in the r-f spectrum, including radar and television, and has issued a 4-page bulletin entitled "Radio Frequency Coils and Associated Assemblies" as introductory literature. Stanwick Winding Co., Newburgh, N. Y.

General Products Catalog. Variable capacitor, plugs, jacks, inductors, chokes, terminals. tube sockets, couplings, antenna equipment and r-f insulators are all illustrated and described in Catalog No. 968 available from E. F. Johnson Co., Waseca, Minn. Another booklet, available from this manufacturer, is entitled "Johnson..In War and Peace" and it also illustrates and describes the types of products listed above, plus the particular catalogs which are available on these products.

Facsimile. This 12-page booklet is designed to bring about a better understanding of facsimile and its possibilities. The booklet contains actual reproductions as reproduced from receiver copy. Radio Station WELD, Columbus, Ohio.



● Here's an inside view of the tiny, versatile G-E Switchette, enlarged to show you the double-break contact construction, which makes possible many ingenious wiring arrangements to solve tricky circuit problems. This is a standard form for controlling one normally open and one normally closed circuit. Variations of this arrangement are available to provide control of a single circuit, either normally open or normally closed. Other modifications include a form for simultaneously opening two circuits and closing one, or vice versa; also single-break forms for more sensitive operation.

BECAUSE of its unusually small size and light weight, its lightning-fast snap action, and its long life, the G-E Switchette is becoming more and more popular with designers for circuit control where space is at a premium.

Switchettes are available in ratings up to 10 amperes at 24 volts d-c (230 volts a-c), are provided with solder-lug terminals for wiring. They meet government specifications covering corrosion and vibration resistance, and operate at altitudes up to 50,000 feet and in ambient temperatures from 200 F to −70 F.

More than 200 modifications have already been developed to meet special circuit requirements and to fit into special mechanical arrangements. Dimensions, operating characteristics, and ordering directions for standard Switchettes and many typical modifications are given in our new catalog, No. GEA-3818C. For your copy, mail the coupon. If you don't find the forms you need in the catalog, our engineers will be glad to work with you in adapting Switchettes to meet your requirements.

GENERAL ELECTRIC

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

SWITCHETTES

GENERAL ELECTRIC COMPANY, SECTION C676-141
SCHENECTADY 5, NEW YORK

Please send me Bulletin GEA-3818C giving dimensions, ratings, and operating characteristics of Switchettes

NAME ....

COMPANY ....

ADDRESS ....

CITY .... STATE ....

8930

Switches. Catalog MC 448 is designed to simplify the selection of this manufacturer's multi-circuit switches for simultaneous operation of independent or interconnected electrical circuits. Twenty standard contactors are listed. Metallic Arts Co., 243 Broadway, Cambridge 39, Mass.

Tubes. The "1944–1945 Catalog and Manual" contains full information on all tubes manufactured by this firm, as well as some of the new tubes developed for war uses. Sixteen pages are devoted to tube characteristics. Another section is devoted to pertinent technical information on transmitters and transmitter tubes. The catalog is available, without charge, at local distributors, or may be obtained at a cost of 25¢ from Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill.

Frequency Modulation Bulletin. This is the name of a bulletin which is published as source information on fm. Volume 1, No. 4 contains an article entitled "FM for 100,000,000 Americans" which states that more than 150 of the 210 applications for

WADSWORTH SKILLS

. . . built up through half a century of leadership in the exacting Watch Case Industry will be available soon to many manufacturers who will require large quantities of small precision parts for their postwar assemblies.

Work of this character is now being supplied to many leading companies which normally produce radio equipment, refrigerators, automotive parts, precision instruments.

Illustrated are nine small components of an Ordnance assembly which Wadsworth furnishes in great numbers. The production of these pieces, which are held to very close tolerances, brings a score of special Wadsworth facilities into play.

Wadsworth workers' feeling for precision and their ability to get work out on time will ease postwar headaches for many producers.

WADSWORTH FACILITIES

Die Making
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CURRENTLY SERVING THESE INDUSTRIES

Aircraft
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SMALL PARTS DIVISION

THE *Wadsworth* WATCH CASE CO., Inc.
DAYTON, KENTUCKY, SUBURB OF CINCINNATI, OHIO
PHONE COLONIAL 8194 • (CINCINNATI EXCHANGE)

★

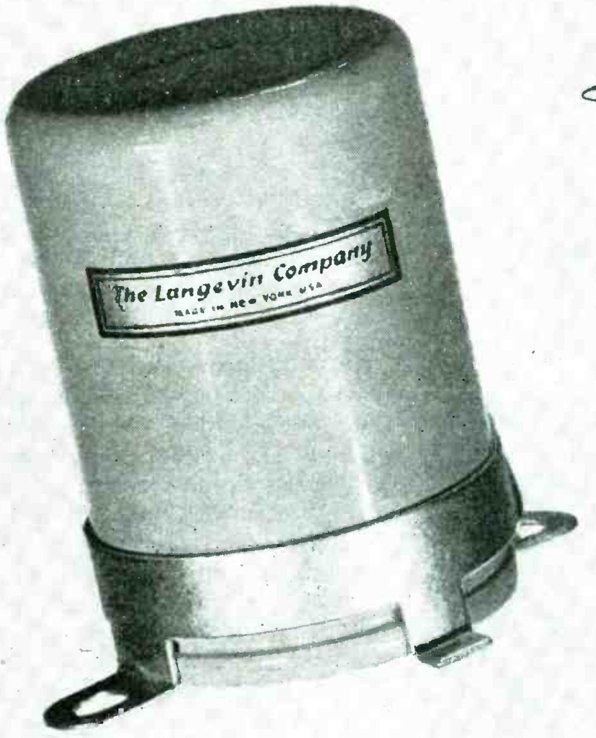
fm broadcast stations now in the hands of the FCC have been filed since the first of the year. The article further states that a comparison of requests for new broadcast services reveals that fm has maintained a 3-to-1 ratio over standard broadcast applications and a 3½-to-1 ratio over television applications. Three pages of this 4-page bulletin are devoted to a geographic listing showing frequencies, coverage, power and transmitter-studio locations. FM Broadcasters, Inc., 711 Colorado Bldg., Washington, D. C.

Phenol and Vulcanized Fibre. Data and information for the correct specification of this manufacturer's phenol and vulcanized Fibre is contained in a 6-page leaflet. N. S. Baer Co., 9-11 Montgomery St., Hillside, N. J.

Plastics. A booklet called "Precision-Made Plastics" describes and illustrates the many types of prastics products which have been fabricated to close tolerances by The Sillcocks-Miller Co., South Orange, N. J.

THE 400 SERIES

Input Transformers



Designed to occupy minimum space with excellent frequency response, the 400 Series Input Transformers are intended for high quality amplifier requirements. Combines high permeability shield with rotatable strap mounting for minimum stray field pick-up. Equipped with 10" Surprenant color-coded leads. 2" center to center mounting, 1½" O.D. x 2¼" high. Baked gray enamel finish. Available for immediate delivery.

TYPE 400-C BRIDGING INPUT TRANSFORMER

Nominal impedance 600/15,000 ohms to 60,000 ohm secondary. With proper input circuits, input impedance range 0/25,000 ohms. Maximum operating level +10 V.U. at .001 milliwatt reference level.

TYPE 401-A INPUT TRANSFORMER

30/250/600 ohms to 30,000 ohm secondary center tapped. Maximum operating level +10 V.U. at .001 milliwatt reference level.

TYPE 402-A INPUT TRANSFORMER

Nominal 30/120 ohm primary to 50,000 ohm secondary. Input impedance range 0/250 ohms. Maximum operating level +10 V.U. at .001 milliwatt reference level.

Frequency response characteristics as usually expressed for input transformers of wide frequency response are not complete due to variables in circuit constants. Therefore we have prepared an engineering bulletin illustrating exact operating measurements, which is available upon request.

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SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK
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1050 Howard St., 3

LOS ANGELES
1000 N. Seward St., 38

Fungus Proofing Booklet. "Fungus Proofing for the Electronics Industry" is the name of a booklet which tells about this manufacturer's types (25-A, 25-X, 200-T, 95-T, 85-T) of fungus-proofing materials. A page is devoted to a discussion of fungus prevention facts. Also available is a reprint of an article "Fungus Proofing Procedure" which appeared in June 1944 issue of ELECTRONICS. The Insl-X Co., Inc., 855 Meeker Ave., Brooklyn, 22, N. Y.

Western Electric Publication. Western Electric's publication published before the war is now being published again under the new name of The Western Electric Oscillator. The first issue of this new publication contains several articles on radio in the war. There is also a spread of pictures devoted to "75 Years of Pioneering by Western Electric." Another editorial is an article on "AT & T Plans for Television." Western Electric Co., 195 Broadway, New York, N. Y.

Radio Transmitters. Two separate 12-page booklets on radio transmitters are available. The first booklet tells about a 10-kw, low frequency transmitter (designated as Model LF) which is crystal-controlled and designed for point-to-point communication circuits. The second booklet illustrates and describes a 50-kw standard broadcast radio transmitter (designated as Type 162) which is designed for metropolitan broadcasting stations. Federal Telephone & Radio Corp., Newark, N. J.

Electronic Heating. A new job service specializing in electronic heat treating is the subject of a 6-page, illustrated folder. The folder points up the fact that this company's electronic heat treating department is available to industry as a new shop service. Central Boiler & Mfg. Co., 5818 Rivard St., Detroit 11, Mich.

Electrical Test Equipment. Instruments available for production testing are illustrated and described in a 16-page catalog (No. 10). Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.

METAL INSERTS FOR STRONGER MECHANICAL ASSEMBLIES

Where extra strength is required or where insulators or assemblies are subjected to unusual mechanical strains and stresses, greater strength can be had by using General Ceramics metal inserts. These threaded metal inserts are *permanently bonded* into the steatite body, thus assuring an extremely solid construction. The metal inserts are drilled and tapped so that a perfect thread is obtained.

Our engineers will be glad to cooperate with you in designing steatite insulators with metal inserts for your special use.

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NEW BOOKS

Electrical Essentials of Radio

By MORRIS SLURZBERG AND WILLIAM OSTERHELD, *McGraw-Hill Book Co., 330 W. 42ND ST., NEW YORK 18, 530 pages, price $4.*

STUDENTS, as young as high school age with limited mathematical background, can obtain an understanding and solid foundation of electrical principles from this book either at home or with classroom instruction. The questions and problems at the end of each chapter are designed to increase familiarity with the subject.

The material is covered in an interesting manner with many helpful illustrations. Its orderly arrangement is particularly noteworthy. The opening chapter gives an inspirational overall picture of communication down through the ages, finally bringing out the importance of a knowledge of electricity for present communication methods. This is followed by a chapter on the fundamentals of electricity, then by chapters dealing

with particular phases of electricity: batteries, electric circuits and their computation, and magnetism. Two chapters describe electrical instruments and their operation, and the application of electricity in motors, generators and transformers. In preparation for the final chapter on basic radio circuits and resonance, the book devotes three chapters to inductance, capacitance, and alternating current circuits. It should be emphasized that this book adheres rigidly to the scope implied by its title, and hence no complete practical radio circuits are given. Miscellaneous information and tables are given in a 32-page appendix.—M.G.V.

• • •

Communication Circuits

By L. A. Ware and H. R. Reed, *State University of Iowa. John Wiley and Sons, New York, 2nd ed., 1944, 330 pages, price $3.50.*

To those whose primary interest is in filters, transmission lines, four terminal networks, and wave guides, this book should fill the requirements for an analytical treatment of these topics. It is written to serve as first-course material for those interested in communication engineering, but a knowledge of Maxwell's equations and Bessel functions is necessary for an understanding of all parts of the text.

The subject matter is divided into the following broad topics: networks, transmission lines, filters, impedance transformation, and wave guides. One chapter is devoted to transmission line experiments, and there are nine appendices of mathematical character. Throughout, emphasis has been placed on the concepts at extremely high frequencies.

Three chapters on wave guides constitute the largest section devoted to a single topic. The first chapter lays the general groundwork and physical interpretation of wave guides in general. The remaining chapters deal, respectively, with rectangular and cylindrical wave guides.

Chapter XV outlines the electromagnetic theory of coaxial lines. In Chapter XVI will be found a brief outline of a dozen experiments which may be made on wave guides and transmission lines. Problems are provided.

Since the volume emphasizes

A COMPLETED POSTWAR PLAN

Based on Mutual Experience

Two kinds of experience went into the formulation of our postwar plan.

1 **Our Customers' Experience** with our wartime services. So far as we can determine, it has been thoroughly satisfactory. Our prewar customers called upon us for stepped-up quality and quantity in communication and electronic specialties for wartime. We met that demand promptly.

Many new customers who, before the war, manufactured all parts of their equipment, placed their problems in our hands. We believe that their experience will point to the continued use of our facilities after Victory.

2 **Our Own Experience** with wartime production has been tremendous. No one can say whether the past three years have been worth six, twelve or twenty years of normal peacetime experience. But the fact is clear that it has helped us develop production "muscles" that enable us to carry greater loads than ever before.

So, based upon our customers' and our own experiences, we have a very simple postwar plan. It is to continue to serve our host of customers with our facilities, skills and experience in producing equipment to meet their specialized needs for performance, quality, quantity and low cost. We are confident that our customers' wartime experiences assure us a sound future.

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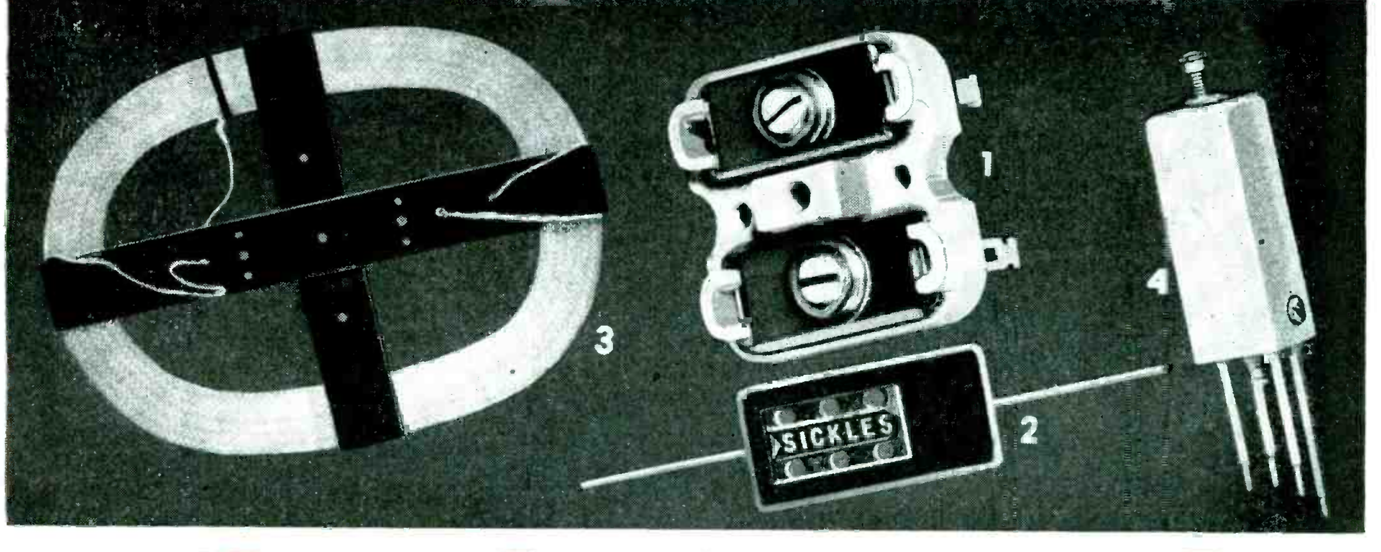
5. 194V—More Coming

* *Patented*



SICKLES

Radio and Electronic Specialties for Today and Tomorrow u-h-f techniques and principles, it should be a welcome addition to the library of anyone working in that field. However, the omission of any treatment of vacuum tubes and of lumped circuits precludes it from serving all engineering needs of the communication engineer.—B.D.

• • •

Shop Job Sheets in Radio Book II—Service Problems

BY ROBERT N. AUBLE, *The Macmillan Co., New York, 1944, 128 pages, 11x8½ in., paper covers punched for standard binder, price $1.50.*

TWENTY-FIVE JOB SHEETS are provided, similar in format and designed as a follow-up to the radio fundamentals covered in Book I (reviewed in August 1944 ELECTRONICS). The first five job sheets cover testing radio resistors, condensers, transformers, filter chokes, and vacuum tubes. The next three are lessons in the construction of a power supply, a high-gain audio amplifier stage, and a power amplifier with phase inverter driver. One job is an overall test of an audio amplifier. There are nine jobs dealing with the superheterodyne receiver. The last seven of the job sheets deal with transmitters and cover the Hartley oscillator, electron-coupled oscillator, quartz-crystal oscillator, radio-frequency amplifiers, frequency-doubler circuits, the power supply, and modulation.—J.K.

• • •

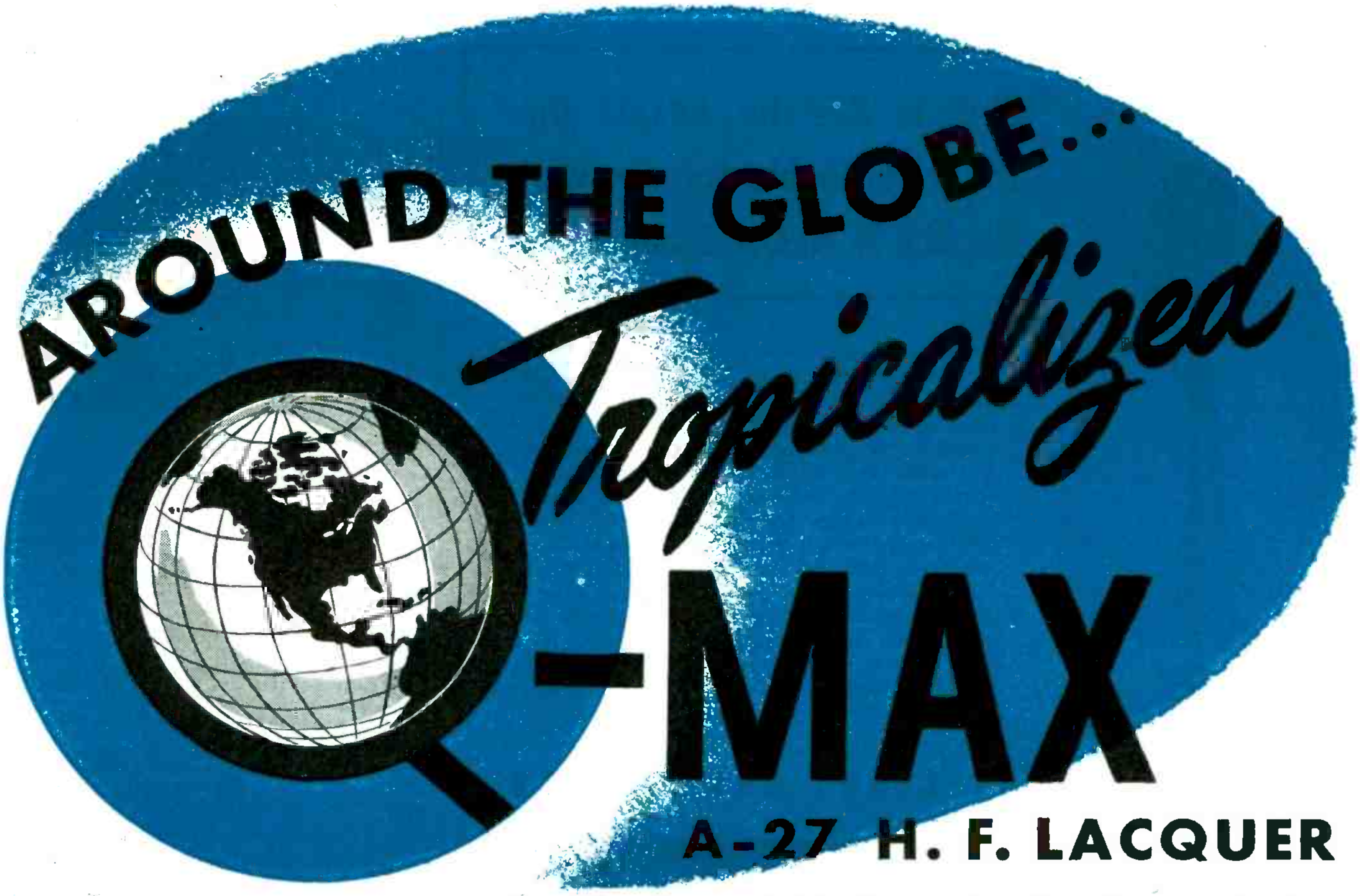
Books Received for Review

MAINTENANCE AND SERVICING OF ELECTRICAL INSTRUMENTS. By James Spencer; edited by Major M. F. Behar, editor of *Instruments*. The Instruments Publishing Co., Inc., Pittsburgh, 1944, 256 pages, $2.00. Reprint of serialized articles published since Aug. 1941 in *Instruments* magazine; practical and well illustrated.

METHODS OF ADVANCED CALCULUS. By Philip Franklin. McGraw-Hill Book Co., Inc., New York 18, 1944, 486 pages, $4.50. Arranged for use as college text, but suitable for reference or self-study by practicing engineers. Covers partial derivatives of implicit functions and Jacobians, vector notation, Fourier analysis, calculus of variations, Bessel functions and related topics.

TECHNIC OF ELECTROTHERAPY. By S. L. Osborne and H. J. Holmquest. Charles C. Thomas, Publisher, Springfield, Ill., 1944, 780 pages, $7.50. Medical electronics and electricity, presented essentially as taught to classes for physicians, medical students and technicians at Northwestern University Medical School. Divided into four major sections: Effects and technical application of direct current; electrical muscle stimulation, with new technic for stimulating vocal cords; radiation—physics and application, both heat-producing and ultraviolet; high-frequency currents, occupying over half the book and covering circuit theory, generation, general diathermy applications and surgical diathermy including electrodessication, electrocoagulation and electrocutting.

DIRECT-CURRENT CIRCUITS. By Earle M. Morecock. Harper & Brothers, New York



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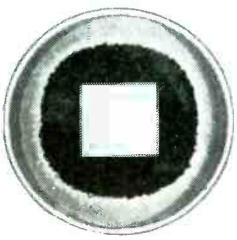
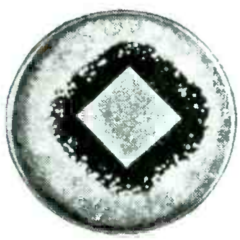


PENICILLIUM DIGITATUM



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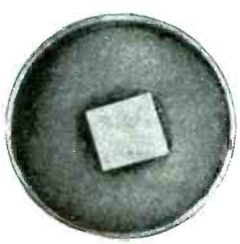

RHIZOPUS NIGRICANS

Our armed forces fight on many fronts in this global war, but in some, notably in Burma and the South Pacific, they must often face another insidious foe—the ever-present mold and fungus growths that impair the successful operation of radio, electronic and electrical equipment.

Manufacturers of such war matériel, disturbed by this dangerous field interference to their carefully built-in factory precision performance, came to us with their problem. After months of experimentation, our chemists found the ideal fungicide to blend with Q-Max A-27 H.F. Lacquer, the outstanding dielectric coating material. Other fungicides had failed because they interfered with electrical characteristics or caused corrosion of metals.

Now Tropicalized Q-Max A-27 H.F. Lacquer offers dependable protection against all fungi illustrated on this page, the prevalent types. No mixing is necessary, for Q-Max is blended at the factory for you. Just look for the word TROPICALIZED on the Q-Max label.

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Communication

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Coaxial Transmission Line & Fittings • Sterling Switches • Auto-Dryaire
Antenna & Radiating Systems • Q-Max A-27 Radio Frequency Lacquer

18, 1944, 387 pages, $3.25. For use in technical institutes, junior colleges, industrial and extension schools. Questions, problems, lab experiments. Elementary circuits, magnetism, instruments and measurements, power, conductors, batteries, Kirchhoff's laws, magnetic circuits, d-c motors and generators, capacitors and electrostatic fields.

THERMIONIC VALVE CIRCUITS. By Emrys Williams. Sir Isaac Pitman & Sons, Ltd., London, 1944, 207 pages, 12s. 6d. Second Edition. Theory of operation and design of thermionic tube circuits, primarily for third-year electrical engineering students, with new material in this edition on f-m circuits, gaseous tubes, time bases, multivibrators, cathode followers and v-t voltmeters.

MARINE RADIO MANUAL. Edited by M. H. Strichartz. Cornell Maritime Press, New York 11, 1944, 518 pages, $4.00. One-volume guide for beginners, students and experienced radio operators, covering operation, maintenance, repair, laws, regulations, radio navigation, code, signals, calls, auto-alarms, bookkeeping, sample messages, radio medical aid.

INTERNATIONAL TELECOMMUNICATIONS. By Osborne Mance. Oxford University Press, New York 11, 1944, 90 pages, paper cover, $1.00. Discussion of problems of last 20 years, with suggestions for handling some of the present unsolved international communications problems.

RADIO—FUNDAMENTAL PRINCIPLES AND PRACTICES. By F. E. Almstead, K. E. Davis and G. K. Stone. McGraw-Hill Book Co., Inc., New York 18, 1944, 219 pages, $1.80. Foundation training, for high-school classes, evening classes for adults, and Armed Forces schools.

MEET THE ELECTRON. By David Grimes. Pitman Publishing Corp., New York 19, 1944, 120 pages, $2.00. The story of 20 years of electronics, interestingly presented for non-technical readers. Based on lectures given before the author's fatal airplane crash in Ireland.

SAMPLING INSPECTION TABLES. By H. F. Dodge and H. G. Romig. John Wiley & Sons, Inc., New York 16, 1944, 106 pages, $1.50. Three papers that appeared originally in *Bell System Technical Journal*, describing sampling inspection tables developed for use in manufacture of communication apparatus and equipment for the Bell Telephone System, reprinted with a brief introduction covering advantages and shortcomings of sampling as contrasted to complete inspection of production output.

SHOP JOB SHEETS IN RADIO; BOOK II—SERVICE PROBLEMS. By R. N. Auble. The Macmillan Co., New York, 1944, 128 pages, $1.50. Twenty-five job sheets covering testing of radio components, construction of basic receiving and transmitting circuits, and circuit experiments.

MODERN OPERATIONAL MATHEMATICS IN ENGINEERING. By R. C. Churchill. McGraw-Hill Book Co., New York 18, 1944, 306 pages, $3.50. Solution of differential equations of engineering and physics by Laplace transformations and other methods.

THE LIQUIDATION OF WAR PRODUCTION. By A. D. H. Kaplan. McGraw-Hill Book Co., New York 18, 1944, 133 pages, $1.50. Recommendations of an economist for contract cancellations, disposal of surpluses and plant conversions.

ALTERNATING CURRENT BRIDGE METHODS. By B. Hague. Isaac Pitman & Sons, New York, 1943, 616 pages, $8.50. Fifth edition, with minor changes and addition of material on copper-oxide and cathode-ray detectors and an appendix on bridge circuits.

MATHEMATICAL AND PHYSICAL PRINCIPLES OF ENGINEERING ANALYSIS. By W. C. Johnson, McGraw-Hill Book Co., New York 18, 1944, 345 pages, $3.00. Essential physical and mathematical principles needed for analysis of practical engineering problems, with emphasis on methods of attack, setting up equations and interpreting results.

AIRCRAFT INSTRUMENTS. By G. E. Irvin. McGraw-Hill Book Co., New York 18, 1944, 607 pages, $5.00. Second edition, with new material on many newly developed electrical aircraft instruments.

SPEAK WELL—AND WIN. By W. P. Sanford. Whittlesey House, New York 18, 1944, 176 pages, $2.00. Practical advice on speaking convincingly and clearly, for those who must present technical problems to the public.

AIRCRAFT PRODUCTION ILLUSTRATION. By G. Tharratt. McGraw-Hill Book Co., New York 18, 1944, 201 pages, $2.75. Presentation of the various illustrative techniques available to all industrial drafting departments, with aircraft problems serving as examples.

Light? We call it "LIGHT FANTASTIC"!

. . . a transformer headed for 65,000 feet "altitude" . . . at 350 degrees temperature!

And to top it off, it had to be "lighter than anything on the market," *they said. What, we asked, was it for? They couldn't tell us, and we don't know to this day, but we do know it was badly needed.

"It has to operate not only on a 60-cycle current at ground level, but from 400 to 2600-cycle current, and what's more, at a simulated altitude of 65,000 feet."

Thermador built this special transformer equipment. It passed the above mentioned requirements. That wasn't enough. They gave it another test, in which they changed the temperature from ambient (the temperature of a fairly warm room) to 350—in two hours. It passed that test, too. This is all we know of one of the most mysterious jobs we ever did, in the not-mysterious method in which we built all of our tansformers.

*For reasons of military security names cannot be given.

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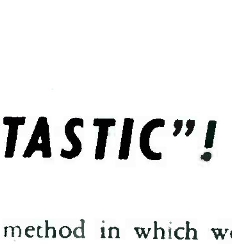
THERMADOR TRANSFORMERS

DEFEAT HEAT • COLD • HUMIDITY



THERMADOR ELECTRICAL MANUFACTURING CO.

5119 SOUTH RIVERSIDE • LOS ANGELES 22, CALIFORNIA

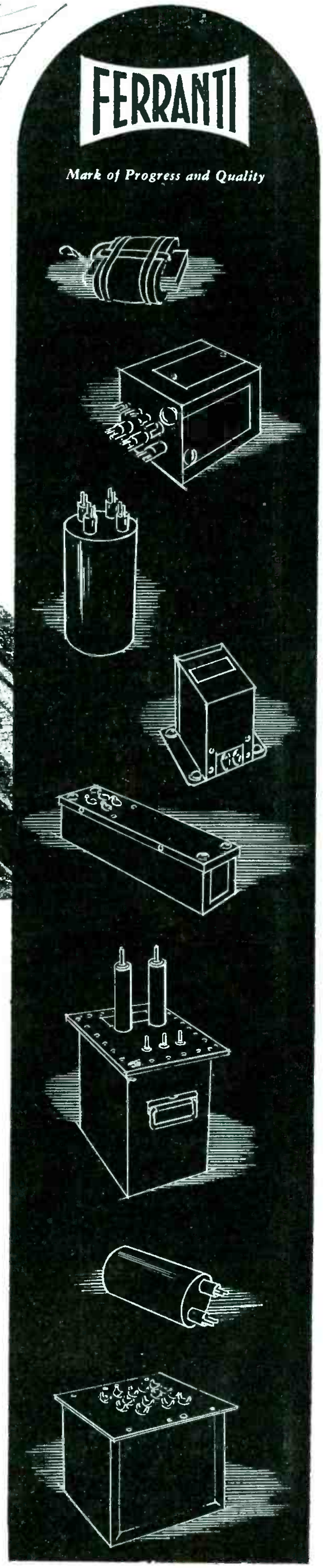
Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronic industry or comment on articles which ELECTRONICS has published.

On Frequency Recommendations

Dear Sirs:

I AM MOST UNPLEASANTLY surprised to notice in your August report on the plans of the television committee of the RTPB for frequency allocation that you have not brought it to the attention of your readers that the 50-56 Mc channel is disputed territory. As you probably know, Frequency Modulation Broadcasters, Inc. has proposed that this band be allocated to frequency modulation. You state, "Since the report



In the modern industrial plant

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

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

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

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

PLAN WITH *Ferranti*

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should be given for the fullest discussion of the issue.

L. B. ARGUIMBAU
Assistant Professor
Massachusetts Institute of Technology
Cambridge, Mass.

See RTPB on FM, in this issue. Statements of position and other comments are most welcome. (Ed.)

• • •

Polarized Speech

Dear Sirs:

MR. LEE CLOUGH'S letter in Backtalk of the April 1944 issue of ELECTRONICS inquired about subject matter relating to polarized speech and commented on the lack of information on this subject in current manuals and texts. . . . .

Information on this subject can be found in an article by Mr. J. L. Hathaway in the October 1939 issue of ELECTRONICS, dealing with the effect of microphone polarity upon modulation percentage.

It may also be possible Mr. Clough has reversed leads in some studio or line amplifier input circuit. An article in December 1939 issue of *Radio*, dealing with extended positive peak modulation, points out how this condition may

SHARING THE RESPONSIBILITY OF
Security at Sea
• Today and for all tomorrows, ships at sea everywhere—and airships, trains, police cars—will be in constant touch with the home port or base. The long wartime strides of electronics' progress have assured this for the world.
Lifeline of this instant constant contact is the high frequency (low-loss) cable. Amphenol R G type is an outstanding example which is serving today on the ships of every sea and flying in every formation.
Amphenol has been closely allied to the development work and pioneered the manufacturing processes of solid dielectric ultra-high-frequency cables. The result is quite naturally a cable of unusual quality built in many sizes and with vinyl or armored outer jacket—a husky, serviceable high frequency cable built to the needs of shipbuilders, and manufacturers of electrical equipment for every type of service. Write for Amphenol Catalog Section D.
Amphenol R.G., U.H.F. Cable, in full range of sizes, solid dielectric, braided metal shield, tough vinyl and armored jacket.
Amphenol, approved design, ultra low-loss connectors.
Depend upon AMPHENOL Quality
Connectors (AN, British, U. H. F.)
Cable Assemblies
Conduit (Flexible)
AN Fittings
UHF Cable
Radio Parts and Equipment
Plastic Products
AMERICAN PHENOLIC CORPORATION
1830 S. 54th AVENUE, CHICAGO 50, ILLINOIS

markably well as contrasted with similar unpainted tubes.

Perhaps this is attributable to the fact that a black body radiates heat more effectively, thus permitting the internal elements of such tubes to operate at a lower temperature.

PHILIP ROSS
Staff Engineer, WBNX
New York, N. Y.

• • •

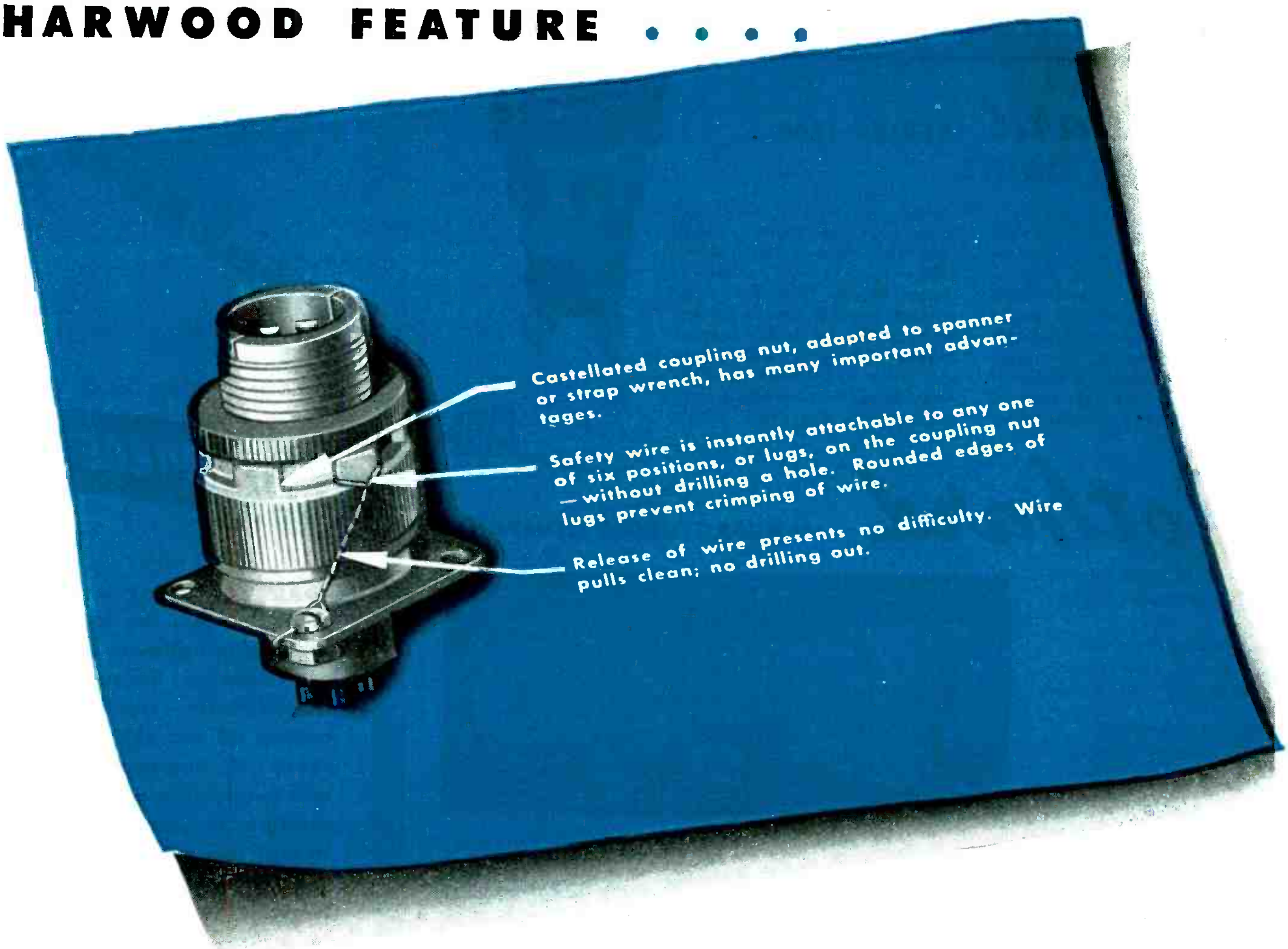
A Correction

Dear Mr. Henney:

RECENTLY I have belatedly been going over an interesting article in the July 1943 issue of ELECTRONICS, Transmission Line Charts, by R. F. Baum. One point puzzled me until I became convinced it must be an error.

At the top of page 158 is the statement, "going along the line $X'Z'$ in Chart I we have for the point X', the value $T = 0.58$ and $\tau = 157$ deg. X' is previously given as, $-33 + j10.6$ on page 94 and it corresponds to approx. $T = 0.64$, $\tau = 157$, on Chart I, which I believe to be the correct value. The value given as $T = 0.58$, appears to correspond to X' on Chart II instead

LOOK AT THIS EXCLUSIVE HARWOOD FEATURE . . . .



FIELD CHECKS for a "short" or an "open" are quick and easy jobs if the connectors are Hardwood with castellated coupling nuts. Simply cut the safety wire, untwist and pull out. It comes away clean, as it has not been crimped on the sharp edges of a tight-fitting drilled hole

Reassembly is as easy. No holes to drill. Just loop the wire over a lug on the castellated coupling nut, which will be in correct locking position when the nut is tightened, then secure. This Hardwood feature is an advantage in shop assembly, too. Write for details today.

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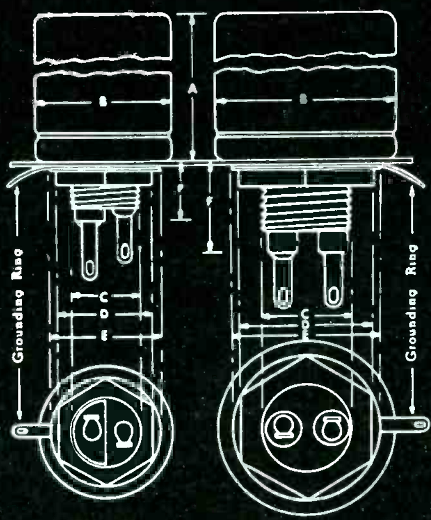
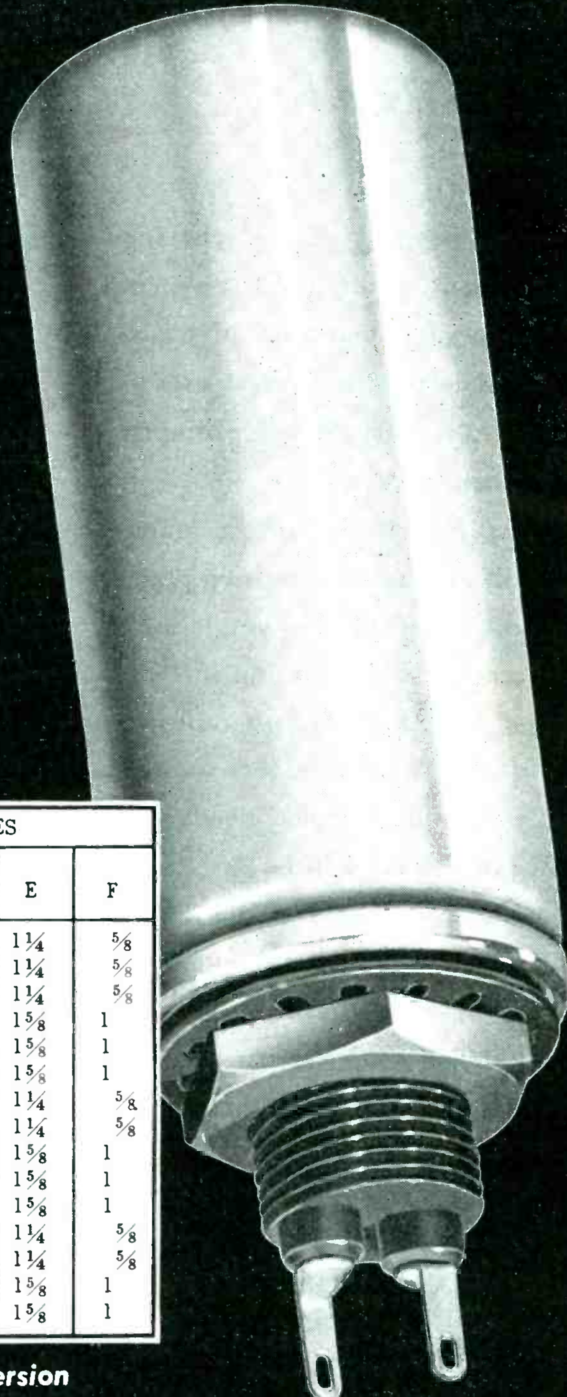


1½" Diameter Container

2" and 2½" Dia. Container

Catalog Number	Capacity in Mfd.	Working Voltage D.C.	DIMENSIONS IN INCHES					
			A	B	C	D	E	F
6EC200	2.0	600	2¾	1½	¾x16thd	1	1¼	⅝
6EC300	3.0	600	4½	1½	¾x16thd	1	1¼	⅝
6EC400	4.0	600	4½	1½	¾x16thd	1	1¼	⅝
6EC600	6.0	600	4	2	1x14thd	1 7/16	1⅝	1
6EC800	8.0	600	4½	2	1x14thd	1 7/16	1⅝	1
6EC1000	10.0	600	4	2½	1x14thd	1 7/16	1⅝	1
10EC100	1.0	1000	2¾	1½	¾x16thd	1	1¼	⅝
10EC200	2.0	1000	4½	1½	¾x16thd	1	1¼	⅝
10EC400	4.0	1000	4	2	1x14thd	1 7/16	1⅝	1
10EC600	6.0	1000	4	2½	1x14thd	1 7/16	1⅝	1
10EC800	8.0	1000	5	2½	1x14thd	1 7/16	1⅝	1
15EC50	.5	1500	2¾	1½	¾x16thd	1	1¼	⅝
15EC100	1.0	1500	4½	1½	¾x16thd	1	1¼	⅝
15EC200	2.0	1500	4	2	1x14thd	1 7/16	1⅝	1
15EC400	4.0	1500	4½	2½	1x14thd	1 7/16	1⅝	1



All of the Above A.W.S. Army-Navy Submersion Proof Units Available in Production Quantities for Prompt Delivery. Write, Wire or Telephone — Now!

Telephone: MIChigan 9656

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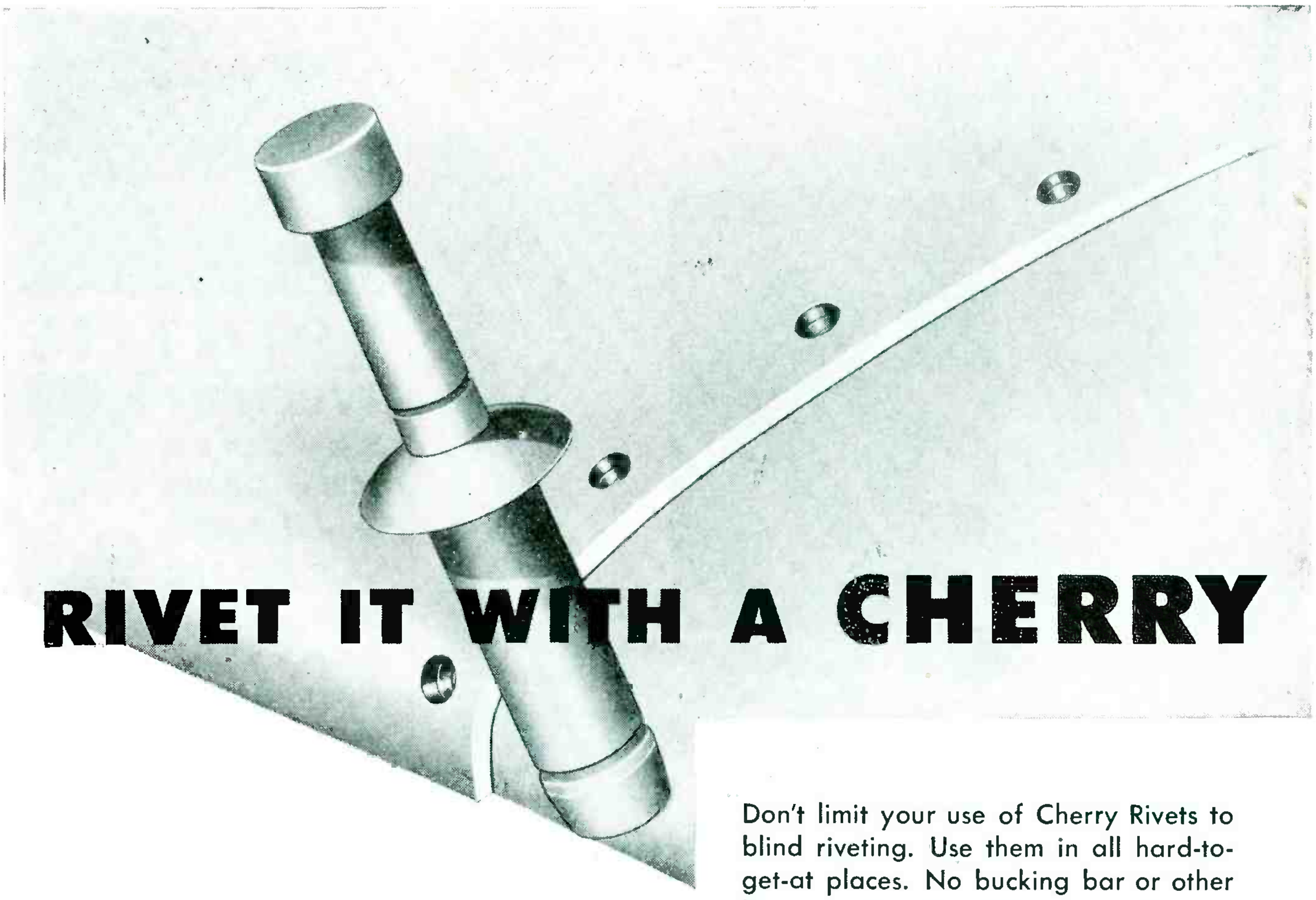
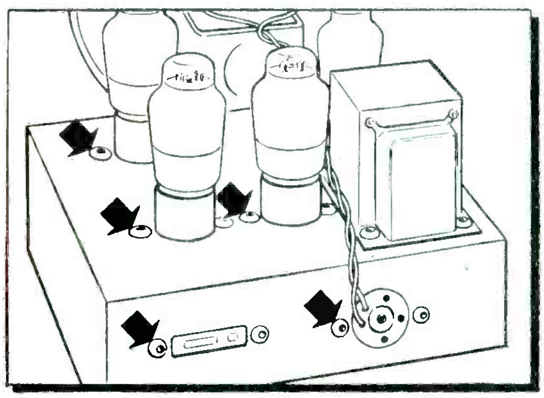
318 West Schiller St. Chicago 10, Illinois



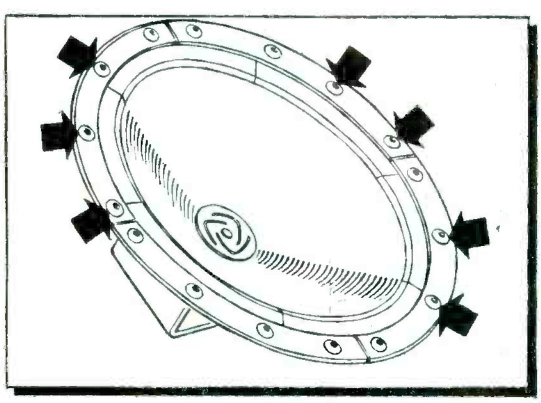
RIVET IT WITH A CHERRY

Don't limit your use of Cherry Rivets to blind riveting. Use them in all hard-to-get-at places. No bucking bar or other backing required. Use Cherry Rivets in soft and brittle material as well as metal. They are upset with a pulling force so they don't bend, buckle or spread. Use them for short runs or experimental work. No special tool-up or make-ready needed.

Cherry Rivets are easy and fast to apply. Working "blind" from one side of the job only, one man does it alone. They hold tight with a strong, firm clinch. And for blind rivets they are not critical as to hole size or material thickness. Figure out for yourself how Cherry Rivets will help cut your production costs. Or if you would like some help, put the matter up to the Cherry Rivet engineers.



Rivet the parts to the radio chassis. It's sound production practice—and economical, too—when Cherry Rivets are used.



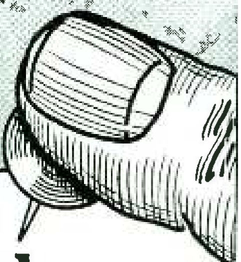
For fastening soft or brittle materials—rubber, plastics, fabrics, porcelain surfaced metal—use Cherry Rivets for sure success.

Get this book—Cherry Handbook No. A-43—that describes the many uses of Cherry Blind Rivets. Write to Department A-120, Cherry Rivet Company, 231 Winston Street, Los Angeles 13, California.

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

Cherry Rivet
Company
LOS ANGELES, CALIFORNIA

TO THE POINT



Perhaps We Can Help You With Your Post-War Electronic Control Problem

Do your post-war production plans call for some electronic device or sub-assembly in quantity? Perhaps we can apply our broad experience in the development and manufacture of electronic controls and equipment to your problems. Your inquiry will put you under no obligation.

• Electronic Sound Devices • Intercommunicating Systems • Industrial Voice-Paging and Broadcasting Equipment • Permanent and Portable Amplifying Systems • Recording and Disc-Playing Units • Electronic Controls • Operating Sequence Recorders • Other Special Electronic Devices.

BELL SOUND SYSTEMS

BELL SOUND SYSTEMS, INC.
1189 Essex Ave. Columbus 3, Ohio
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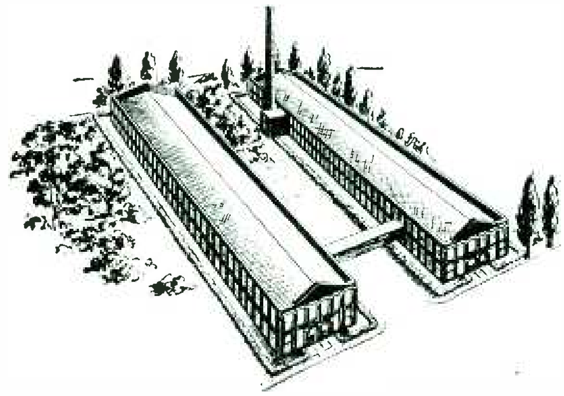


The new and larger Templetone plant at New London, Conn.

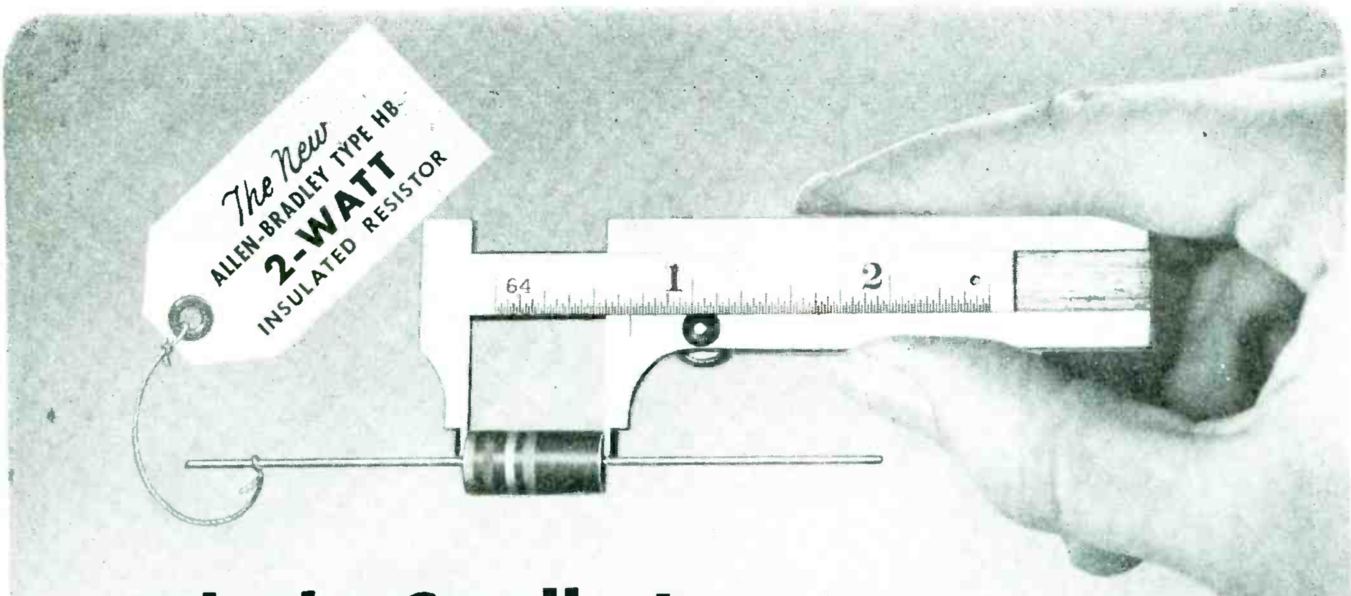
Within a few weeks our entire Electronics Division will move into new quarters—affording not only greater facilities to meet ever-expanding wartime production, but also greater scope to anticipate the great electronics developments of peacetime. From this vast, new plant—containing 100,000 square feet of space—will come rich contribution to the vast commercial requirements at war's end.

Temple

Electronics Division

TEMPLETONE RADIO MFG. CORP.

New London, Conn.



It's the Smallest 2-Watt Fixed Resistor

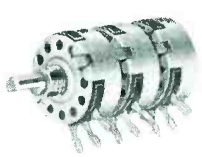
BRADLEYOMETER

The World's Finest Continuously Adjustable Resistor

The only continuously adjustable composition type resistor (only 1 inch diameter) having a rating of 2 watts with substantial safety factor. Has solid molded resistor unit . . not a film, spray, or paint type. Any resistance-rotation curve available.

Type JS Bradleyometer with built-in line switch. Not affected by heat, cold, or moisture.

Type J Bradleyometers may be used singly or assembled into multiple controls.



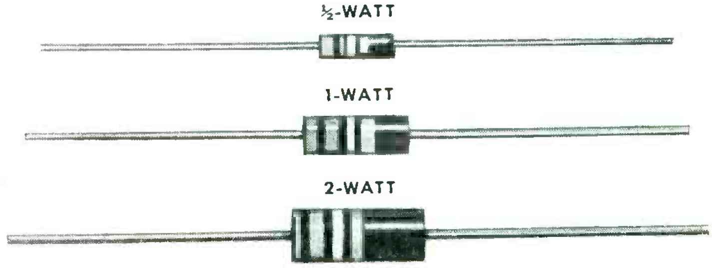
Low resistance carbon brush makes contact with surface of molded resistor.

ONLY $\frac{11}{16}$-inch long . . and $\frac{5}{16}$-inch diameter . . those are the remarkably small dimensions of the NEW Type HB Bradleyunit. It is the smallest 2-watt insulated fixed resistor ever produced, but you can use it safely right up to its listed rating. You don't have to derate it for even the toughest application.

The Type HB 2-watt Bradleyunit will pass all American War Standard tests: It is outstanding in its humidity and temperature characteristics. It matches in dependability and fine appearance the Allen-Bradley ½-watt and 1-watt Bradleyunits (see below) which are recognized as "tops" by all radio and radar men.

Available in R. M. A. standard values from 10 ohms to 0.47 megohms in tolerances of 5, 10, and 20 per cent. Specify the Type HB 2-watt Bradleyunit and be safe in your engineering.

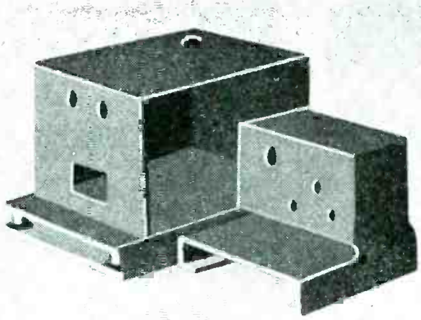
Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis.

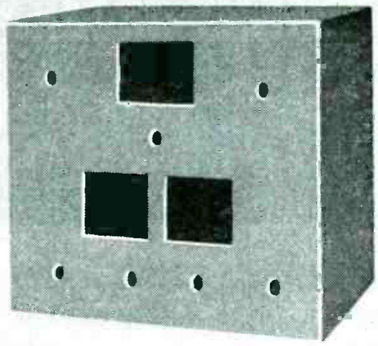


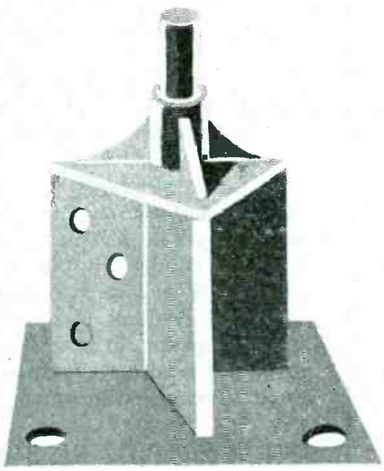
A-B Quality ALLEN-BRADLEY

FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY







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Long before the war, "Cole Steel Equipment" had earned its reputation for quality. Tough assignments are part of our everyday job... instrument housings... boxes... and chassis. If your blueprints call for close tolerance sheet metal fabrication, send us your specifications.

Send for our Brochure
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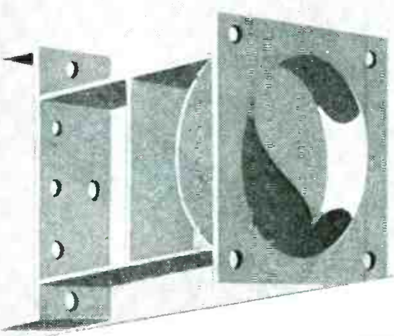
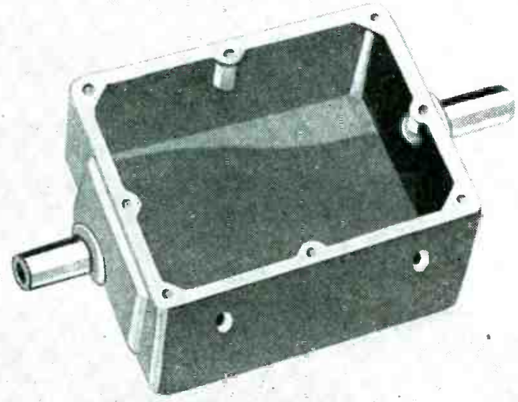


COLE STEEL OFFICE EQUIPMENT
will again be available after the war



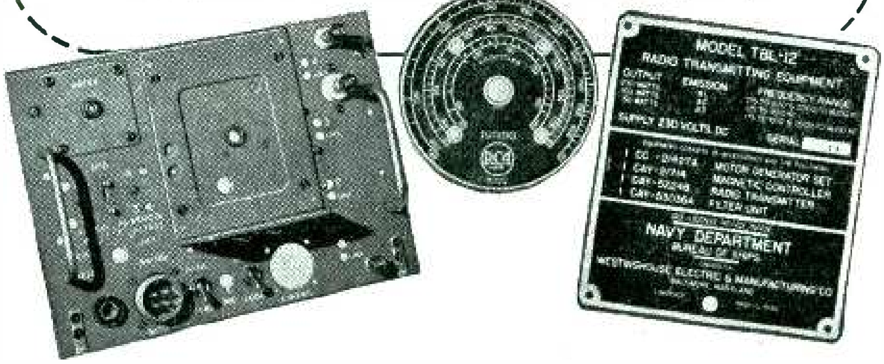
"PACKAGED METAL ENGINEERING*"

saves you *time, money, labor* on

INTRICATE, UNUSUAL, COMPLEX JOBS

ETCHED PANELS, DIALS, AND INSTRUCTION PLATES

with *precision* fabrication and *decorative* ingenuity



Grammes unique and complete facilities produce intricate, varied, and unusual Etched Panels, Dials, Name and Instruction Plates, Escutcheons, and Bezels. The Radio Panel shown has combination metal etching, decorative enamel finish, contrasting color fill-in of letters, 62 accurately positioned holes, entailing the manufacture of separate parts, and assembly of parts to panel.

With 69 years of precision fabricating skills, broad "know-how," and cleverly devised assembly methods, Grammes can save you time, money, and materials on your parts or product ...centralized facilities provide economical production.

GRAMMES CONTRACT SERVICE—*your* COMPLETE *manufacturing source*

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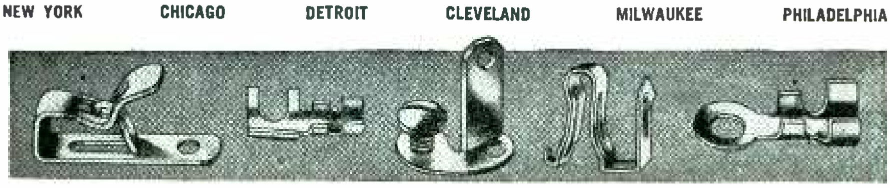

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A STRONGER FACTOR in TODAY'S NEW COMPLETE CIRCUIT PROTECTION

EXTRACTOR POSTS

WITH WELDED ANTI-VIBRATION SIDE TERMINALS

NOW UNDERWRITERS' APPROVED

Resistance to extremes of shock, vibration and temperatures is provided by the new Littelfuse Extractor Posts with electrically welded side terminals. By Littelfuse process, terminals are made integral with inside metal shell. Maximum conductivity is insured. Other Littelfuse improvements for dependability, durability, and convenience make these extractor posts outstanding examples of Littelfuse *complete circuit protection.*

EXTRACTOR POST No. 342001 for 3 A G Fuses

Finger-operated. Welded side terminals. Knob and body black bakelite. Positive fuse grip. Full visual shock-proof inspection. Spring-activated cup. Specially designed grip prevents fuse from dropping out.

Also furnished screw-driver operated (341001), *meeting Underwriters' specifications.*

Send for B/P and ENGINEERING DATA
Ask for Samples

Safeguard new equipment, or irreplaceable *present* equipment. Fuses, Fuse Clips, Fuse Panels, Circuit Breakers, Thermocouples, Fine Wire Products, Indicators, etc.

LITTELFUSE INCORPORATED

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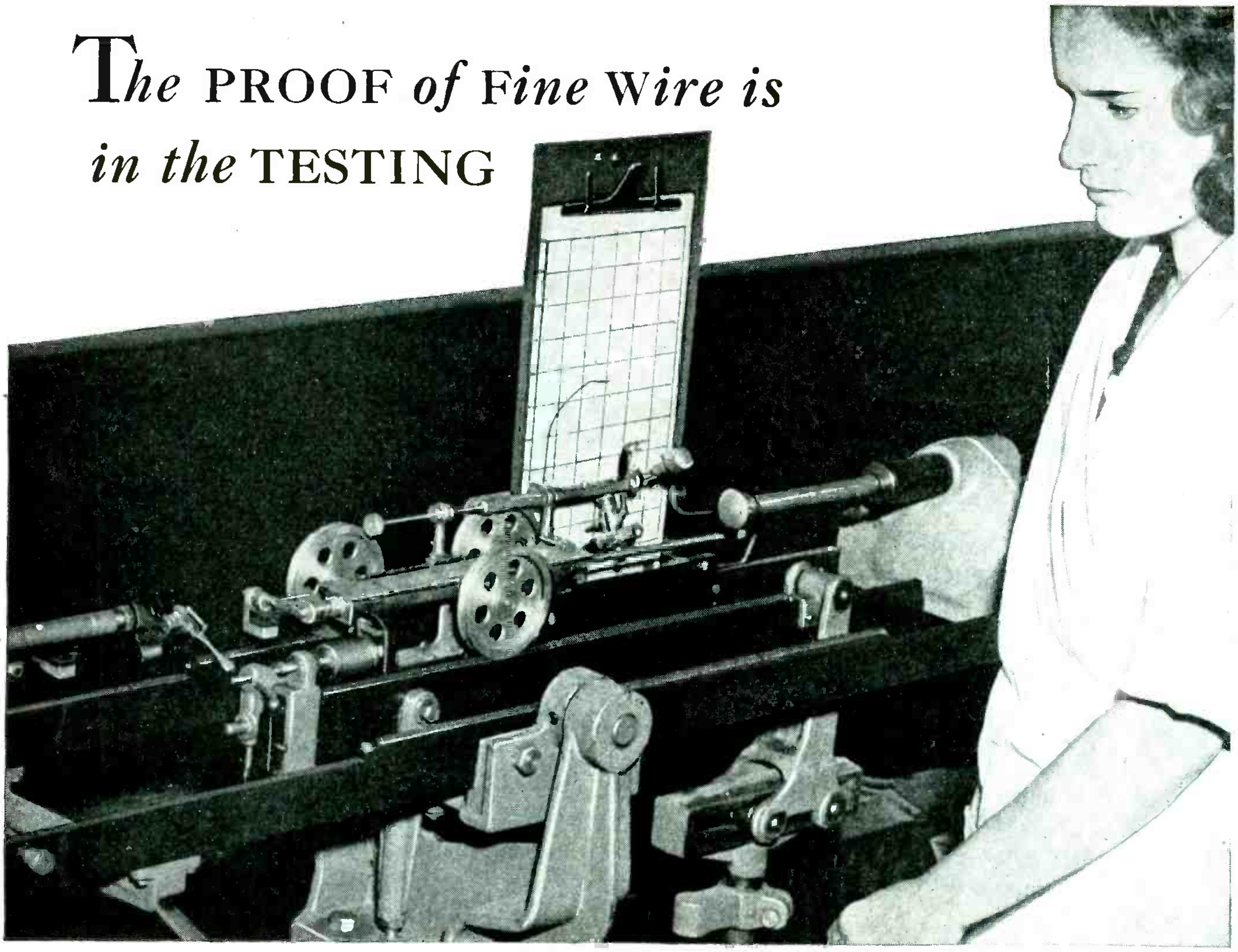
The PROOF of Fine Wire is in the TESTING



As specialists in the drawing of fine wire of close tolerances, perfect roundness and faultless surface condition, North American Philips have set up their own exacting specification standards, meeting the most rigid customer requirements.

To maintain these standards, special test equipment is in constant use, such as the Scott Tester, illustrated, that provides a precise measure of wire elongation, yield point and tensile strength. This relentless pursuit of perfection is your guarantee of a quality product.

North American Philips manufacture fine wire below .003″ diameter in silver, nickel, copper, nickel chrome and aluminum alloy—bare or enameled.

We also plate many types of wire, such as silver, tungsten, molybdenum and alloys up to .010″ with gold, copper or other metals.

Many manufacturers have found our unusual skill of great value in helping them meet wartime production schedules and in developing new instruments and apparatus. North American Philips have the knowledge of processes and techniques developed by a technical organization with a background of over fifty years' experience in its fields.

Call on our specialized engineering service whenever you have a fine-wire problem.

WHERE NORELCO FINE WIRES ARE USED IN THE ELECTRONICS FIELD

Precision wire-wound resistors · Hearing Aids Radio headphones · Sensitive recording and indicating meters · Sensitive relays · Electronic tube grids and filaments · Sound recording on steel wire · Fractional horsepower motors · Wire braid and cloth · And hundreds of other uses wherever very fine wire is required.

NORELCO PRODUCTS: In addition to fine wire and diamond dies for our own drawing, we make: Tungsten and Molybdenum products; Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes; Searchray (Industrial X-ray) Equipment; X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Electronic Measuring Instruments; High Frequency Heating Equipment: Communications Equipment. • When in New York, be sure to visit our Industrial Electronics Showroom.

Norelco Reg. U. S. Pat. Off. Electronic Products by **NORTH AMERICAN PHILIPS COMPANY, INC.**

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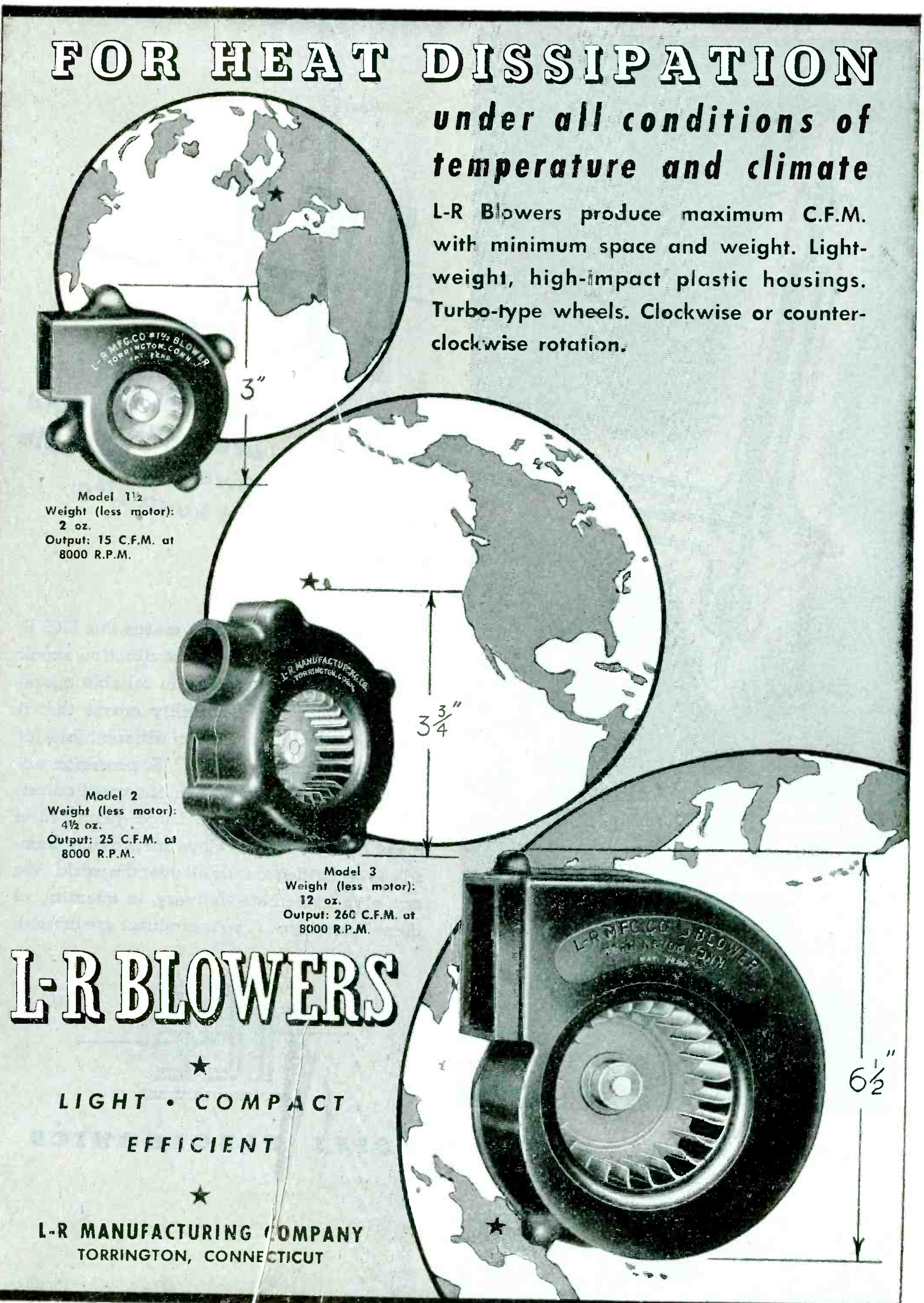
Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Div.): Lewiston, Me. (Elmet Div.)



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under all conditions of temperature and climate
L-R Blowers produce maximum C.F.M. with minimum space and weight. Lightweight, high-impact plastic housings. Turbo-type wheels. Clockwise or counter-clockwise rotation.
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Model 1½
Weight (less motor): 2 oz.
Output: 15 C.F.M. at 8000 R.P.M.
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Weight (less motor): 4½ oz.
Output: 25 C.F.M. at 8000 R.P.M.
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Weight (less motor): 12 oz.
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L-R BLOWERS
LIGHT • COMPACT
EFFICIENT
L-R MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT

PLYTUBE OFFERS YOU . . .

- High Mechanical Strength
- Corrosion Resistance
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- Wide Variety of Sizes
- Easy Workability
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MEET INDUSTRY'S NEW LIGHTWEIGHT MATERIAL PLYTUBE

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and explore its unlimited possibilities in design, fabrication and application

To know about PLYTUBE* is but a first step in a search for applications where its many unique advantages can be put to practical, effective use.

PLYTUBE is plywood tubing made by building up veneers by automatic wrapping in such a way that stress or strain in any direction acts on the total grain fibres of the total structure of the column. By varying the angle of wrap, the strength characteristics of the tube section can be determined. These angles of wrapping can be combined to produce a tube column of maximum strength.

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Our engineers are prepared to study all possible applications and help you apply this new, lightweight tubing to meet your requirements. Use coupon below for further information.

*Manufactured under U. S. Pat. No. 2,352,533, exclusively by PLYMOLD CORP.

PLYMOLD CORPORATION

Lawrence, Mass.

PLYMOLD CORPORATION
Lawrence, Mass.

Please send me further engineering data and information about Plytube.

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Company ....

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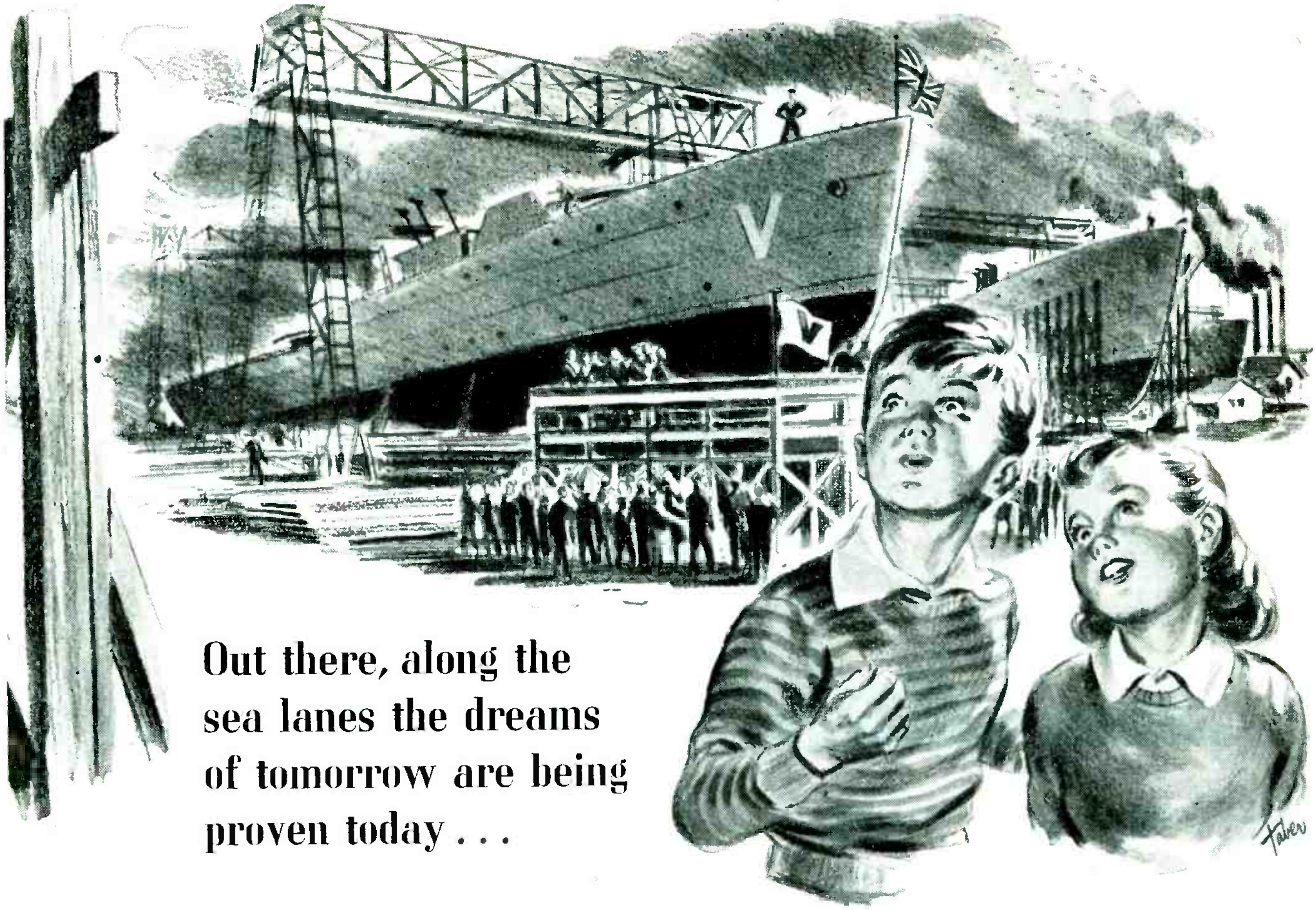
WHERE TOMORROW MEETS TODAY



Out there, along the sea lanes the dreams of tomorrow are being proven today . . .

CORVETTES "turn on a dime"—destroyers race at abnormal speed—that's the navy of today! Mastery of the sea depends on new and ever-improved equipment.

Today on our fighting ships, many pieces of electrical apparatus are designed and produced by Small Electric Motors (Canada) Limited. At the moment we are devoting all our efforts to turning out material of an advanced scientific nature. Research, engineering and inventive genius work hand in hand to produce equipment that normally would be much longer in developing.

In the days to come you may wish to benefit by this "know-how." These experiments and achievements in technical war contributions will be reflected and recognized in the electrical world of tomorrow. Small Electric Motors plan with confidence a noteworthy role in the post-war era.

DESIGNERS AND MANUFACTURERS Of All Types of Precision Electrical Apparatus Including:

D.C. & A.C. Motors for Specialized Purposes
Aircraft Generators
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2-44

SMALL Electric Motors
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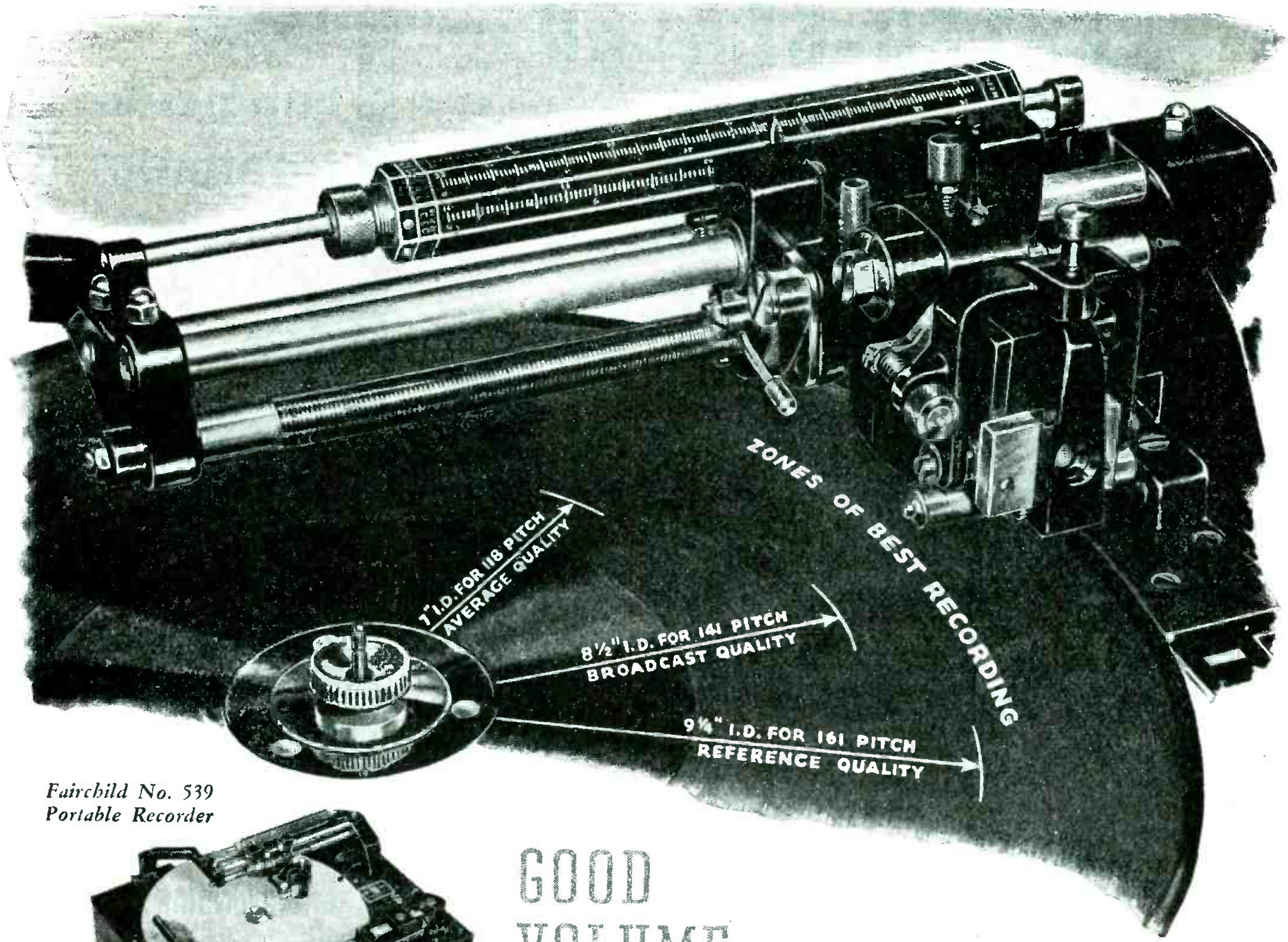
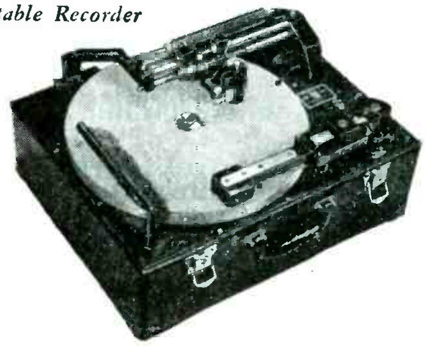
SOUND EQUIPMENT—*precisionized*—**mechanically and electronically**—*for finer performance*



Fairchild No. 539
Portable Recorder



GOOD VOLUME LEVEL

as high as 161 lines per inch

Good volume level is the direct result of uniform cutting . . . uniform cutting at each pitch, speed, direction . . . uniform cutting controlled by the distinctive design of Fairchild's precision-built carriage mechanism and lathe.

Study these design features:

Two accurately ground and polished stainless steel guide rods. Each securely anchored to provide a rigid framework, not only to guide the cutterhead carriage travel, but also to carry its entire weight.

One feed screw with a single task to perform: To move the cutterhead carriage transversely across the turntable by means of a split nut which engages *six* accurately ground threads *instead of the usual one or two.*

The convenience of disc handling without disturbing the feed screw and carriage mechanism.

The convenience of a calibrated reading scale that shows the minutes of recording completed; the minutes remaining for each pitch, speed, direction.

The Fairchild No. 539 Portable Recorder is built with long practiced precision skill to meet the exacting demands of radio and communications for studio-quality recording in the field. Descriptive and priority data are available. Address *New York Office:* 475 – 10th Avenue, New York 18; *Plant:* 88-06 Van Wyck Boulevard, Jamaica 1, N. Y.

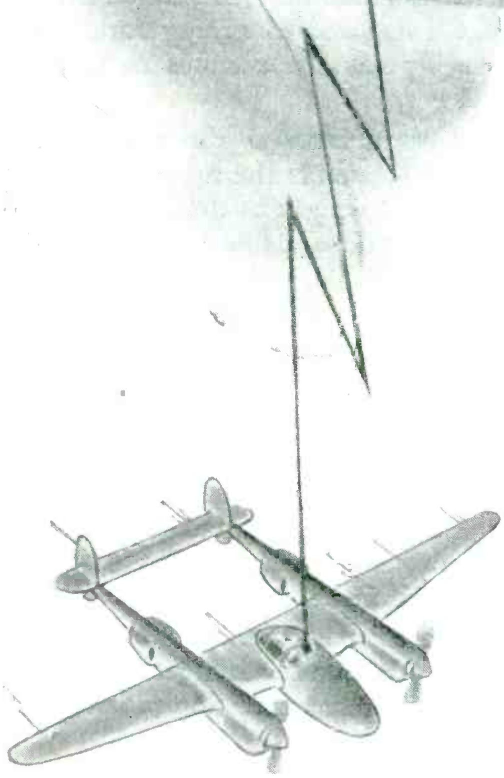
SOUND EQUIPMENT

Fairchild **CAMERA**
AND INSTRUMENT CORPORATION

Confidence...

IN HIS COMMANDER *and his* EQUIPMENT

In this highly mechanized war, the fighting man must have as much faith in his equipment as he has in his leaders. Harvey-Wells electronic units are precision war machines which have earned the full confidence of the Armed Forces under battle conditions. In addition to rugged construction and dependable service, the many exclusive features developed entirely in Harvey-Wells laboratories will be found in all our products designed for commercial and civilian use. If you are interested in high-grade equipment covered by factory service, we solicit your inquiries.



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Aids to Navigation
Electronic Safety Devices

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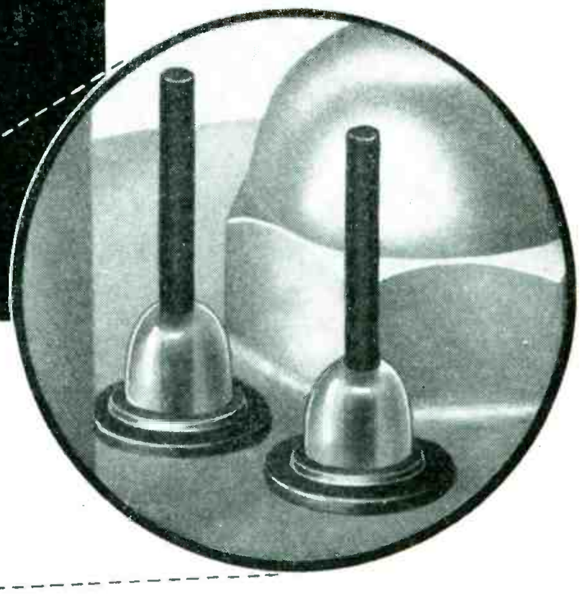
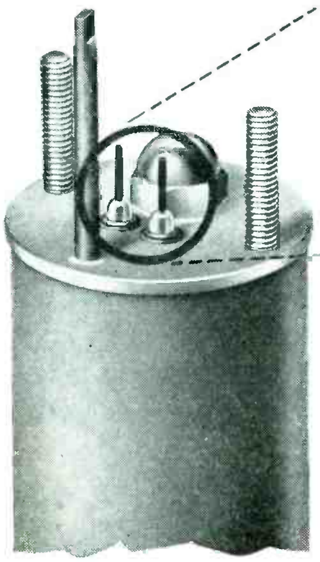
METAL-GLASS TERMINALS
Engineered for
IMPROVED PRODUCTION AND PERFORMANCE . . .





TEMPERATURE COMPENSATED TUNING FORK
Courtesy American Time Products Inc.

Use KOVAR* for sealing

- ELECTRONIC TUBES
- TRANSFORMERS
- RESISTORS
- CAPACITORS
- CONDENSERS
- VIBRATORS
- SWITCHES
- RELAYS
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BUILT into an evacuated container (illustrated on the left) is a temperature compensated tuning fork, component of a multi-frequency generator, accurate to 10 parts in 1,000,000 per degree C.

Kovar-glass terminals contribute to the maintenance of the vacuum required. They enable the manufacturer to effectively reduce the size and weight of the cylinder, and facilitate quicker, easier, more dependable and more economical assembly of the unit.

Kovar, a cobalt, nickel iron alloy, forms a chemical bond with hard glass through a heating process, in which the oxide of Kovar is dissolved into the glass. The result is a permanent vacuum and pressure tight seal, effective under the most extreme climatic conditions.

Stupakoff manufactures Kovar-glass seals with single or multiple, solid, or tubular electrodes. For those equipped to do their own glass working, Stupakoff supplies Kovar as sheet, rod, wire or tubing or fabricated into cups, eyelets, etc.

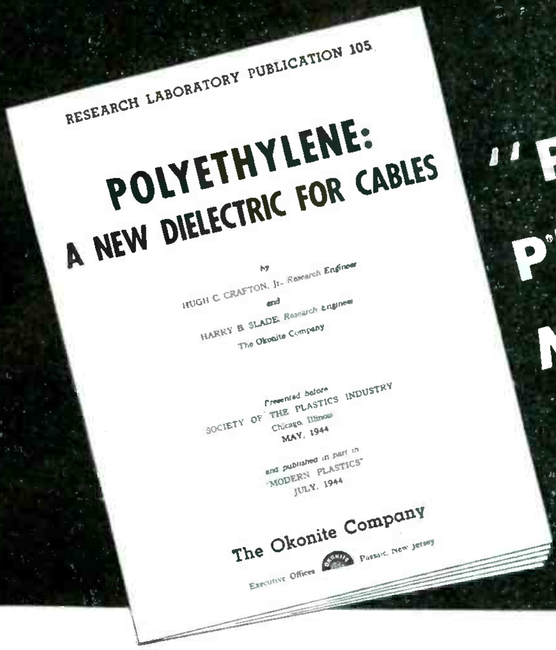
Write Stupakoff today for more information on the advantages of Kovar-glass seals for electronic components.

"FOR GREAT ACHIEVEMENT"

Do More Than Before— Buy EXTRA War Bonds

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

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.



"POLYETHYLENE... PROMISING DIELECTRIC MATERIAL FOR CABLE INSULATION"

As electrical cable manufacturers, The Okonite Company is thoroughly familiar with all types of cable insulation. Okonite Research is constantly working on new dielectrics and has found a considerable interest in polyethylene among electronic engineers. To answer the many queries received, we have reprinted a paper, prepared by two Okonite Research engineers for the annual convention of the Society of Plastics Industry.

Of polyethylene, this paper says "At the present time polyethylene is being used principally for high-frequency cables where its low losses and general physical and chemical properties are unequalled by any other material. As the production of polyethylene is now greater than the demand for high-frequency cable, many other uses are being developed. Foremost among them are radio, communication, control and submarine cables — all for military use. It is quite possible that power cables and outer protective jackets may be made from the material because of its excellent dielectric properties, ozone resistance, moisture resistance and chemical stability . . . It is probably safe to say that polyethylene is the most promising dielectric material for cable insulations developed in many years."

There are, however, many other potential uses for cables insulated with polyethylene suggested by the data in this paper. A copy will be sent you on request. The Okonite Company, Passaic, New Jersey.

MEMO
TO: X-Ray Cable Users

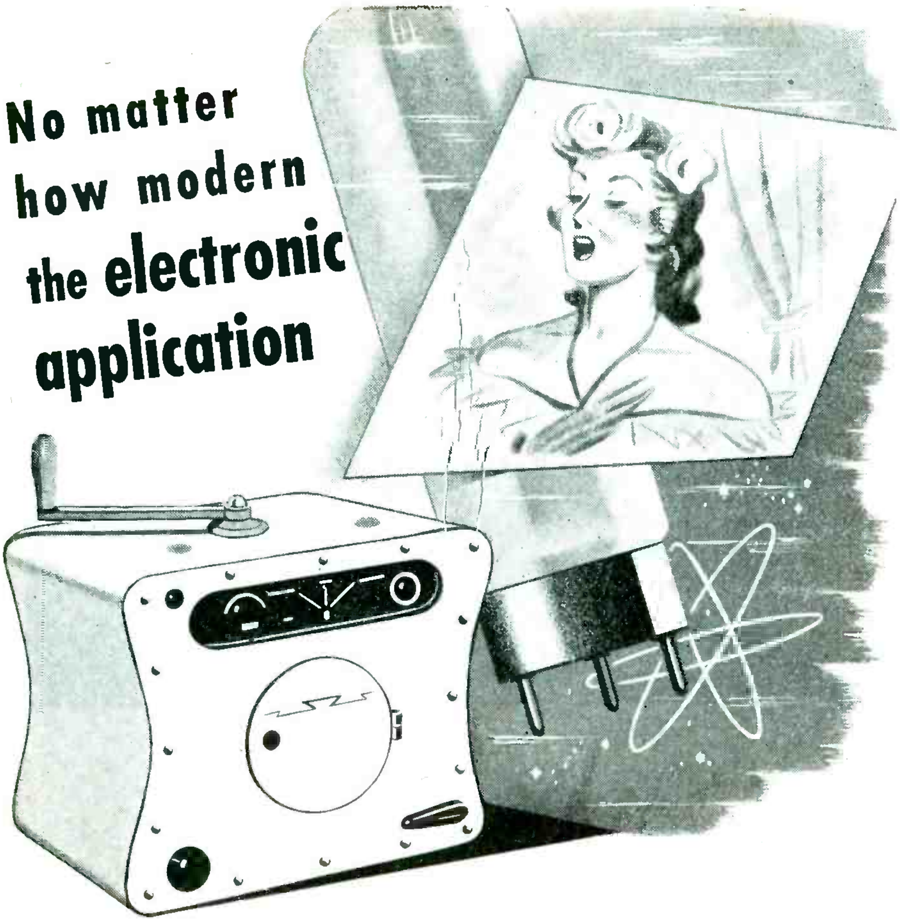
WE HAVE CAPACITY AVAILABLE for manufacture of x-ray cables for delivery early in 1945, but because of the complexity of production and the care required in making this important type of cable, <u>orders should be placed NOW.</u>

Sizes—all customary two-or three-conductor sizes.
Voltages—Up to 110,000 volts.
Finish—any desired, such as dry, weatherproofed or lacquered braids and synthetic sheaths.

OKONITE

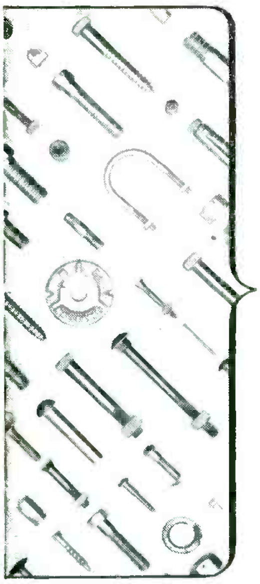
insulated wires and cables

No matter how modern the electronic application



its performance depends on

BOLTS-NUTS-SCREWS-RIVETS-WASHERS



Obtain the rated performance of your electronic equipment by using fastening devices supplied by Sterling. Sterling Bolt Company products are accurate, uniform, with clean threads, uniform heads, true-centered slots, straight shanks, free from scale and burrs. These assure dependable performance, quick assembly and increased production.

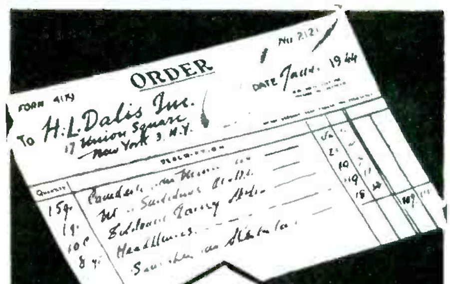
Sterling Bolt Company is a reliable, single source of supply for bolts, nuts, screws, rivets and washers of every type and size, of every metal, plain or plated, for every fastening purpose. Try Sterling's prompt, dependable service for your fastening needs.

Write today for quotations

PRECISION MADE FOR PRECISION FASTENING

STERLING BOLTS

STERLING BOLT COMPANY • 211 W. JACKSON BLVD., CHICAGO 6, ILL.

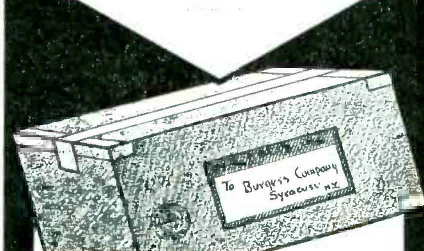


FAST WORK ON YOUR WAR ORDERS

• If your needs are urgent, take advantage of our exceptionally large and complete stock of radio-electronic supplies and parts. Most orders can be filled immediately from stock, and shipped the same day received.

And to help you order just what you need, we have the big Dalis catalog which is yours for the asking. Write on your business letterhead for your copy.

• *Try Dalis—just wire, 'phone or write . . .*



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H. L. DALIS, INC.

Wholesale Distributors
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THIS SOLVES OUR PROBLEM ON POST-WAR PRECISION PARTS!

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It paints the way to a dependable source of supply for precision parts and assemblies for your post-war requirements on a contract basis. As specialists in close-tolerance production, the Adeco organization offers complete facilities to meet your most exacting specifications—particularly in the field of hydraulics.

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AIRCRAFT & DIESEL EQUIPMENT CORP.

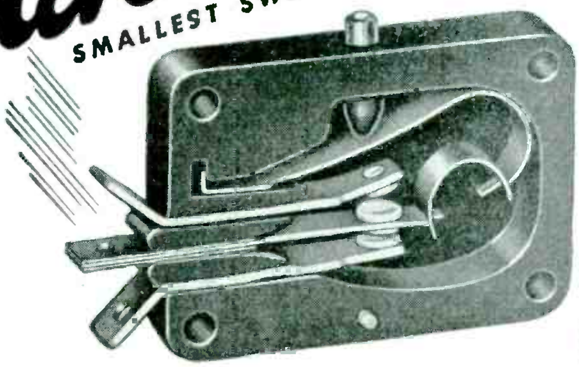
4405 North Ravenswood Avenue

Chicago 40, Illinois

Your Partners in Precision

THE Acro Miniac

SMALLEST SWITCH MADE



Greater Resistance to VIBRATION

Engineered with the patented ROLLING SPRING, the ACRO MINIAC has a faster snap-action which holds arcing to a minimum. This ROLLING SPRING also gives a steeper contact angle which produces contact pressures having greater resistance to vibration. Beautifully adapted to stacking in multiple assemblies. Only 1-3/16" long, 13/16" wide, and ¼" thick. Fully enclosed in Bakelite case. Four mounting holes 3/32" diam. All parts are non-corrosive. Contacts of fine silver. Blades and rolling spring are beryllium copper. Single pole normally open or closed and double throw. Made with air gaps of .010" to .040". Operating pressures in 3 ranges from 5 oz. to 20 oz. Rated at 15 amps., 115 volts A.C. Weighs only .016 lbs. Write for details.

THE ACRO ELECTRIC COMPANY

1316 SUPERIOR AVENUE CLEVELAND 14, OHIO

The New "Midget"

THE LIGHTEST LEVER SWITCH MADE... GENERAL CONTROL COMPANY'S NEW MODEL MCL-MT WEIGHS BUT $3\frac{1}{2}$ OZS.

PHOTO IS ACTUAL SIZE

The NEW General Control Company "Midget" is designed especially for electronic and communications circuits in aircraft, and for other light duty applications. It is a "Midget" in both size and weight . . . it saves precious space and weight, yet is so ruggedly constructed that it will stand severe use.

Like other General Control lever switches, the contact possibilities are unlimited . . . contact assemblies can be removed from the frame by removing a single bolt . . . all parts are non-corrosive . . . easy, positive roller action, regardless of number or arrangement of contacts on each side of the switch . . . rated from 5 to 10 amperes, 125 volts A. C.

The standard "Midget" has either three positions as shown in illustration, or can be supplied with two positions (no neutral).

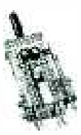
General Control Company will be pleased to send complete information, and arrange delivery schedules to meet your requirements.

The New "Midget" is a "featherweight," designed especially for aircraft and other light duty applications. It weighs only 3½ ozs. *with* 12 contact springs!

The New "Midget" is compactly constructed for restricted space. It is only 2¾" *long* x 1¼" *wide* x 1¼" *thick.*

The New "Midget" has all the quality construction features of the well known "Master" Line of MCL Cam Lever Switches built by General Control Company.

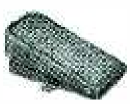
OTHER GENERAL CONTROL COMPANY PRODUCTS



MODEL MCL-CS
Coil spring construction gives perfect balance regardless of contact arrangements. For all electronic applications.

MODEL MCL-MR
For one to six index positions. Actuates practically any number of circuits in sequence with single control knob.

MC

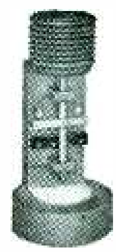


MI

MH

MF

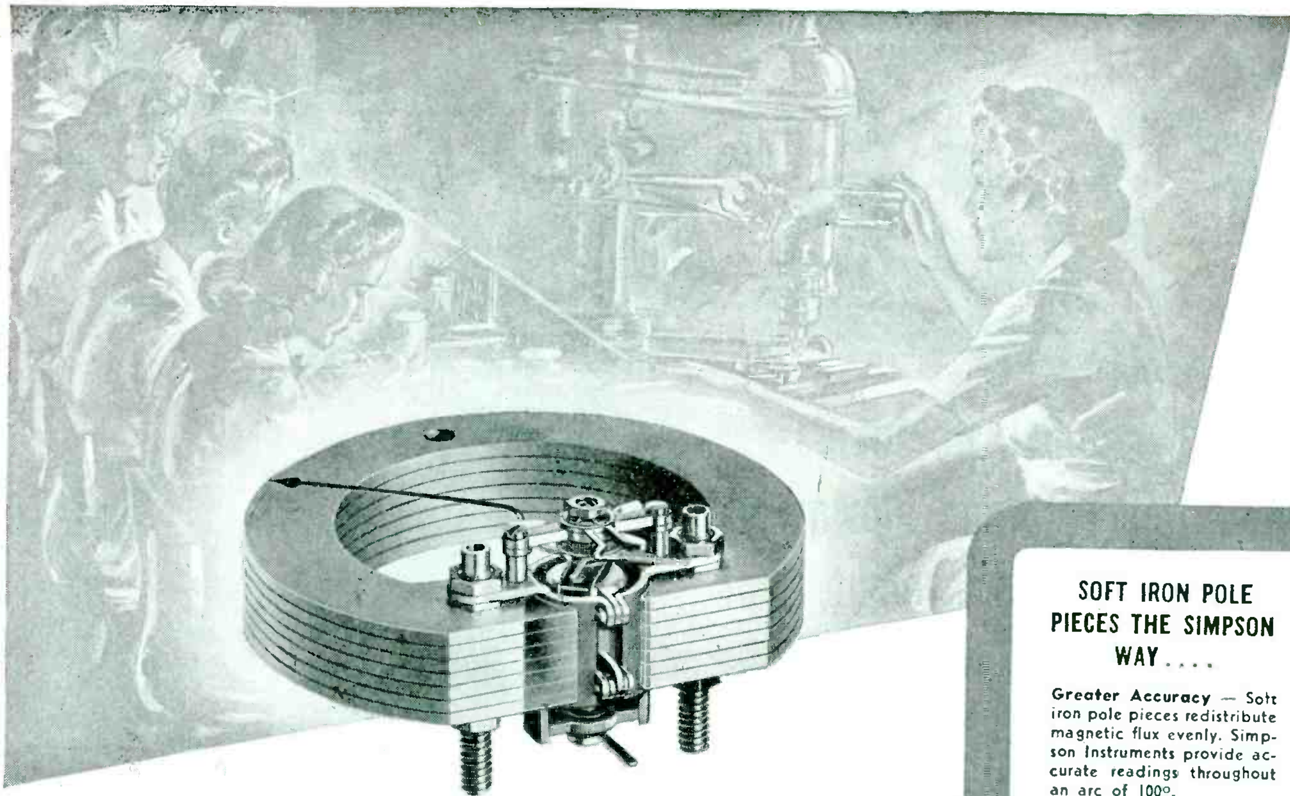
MANUALLY OPERATED (FOOT) SWITCHES
These switches relieve the machine operator, prevent fatigue, increase production and safety. The 35 types cover every application. Send for catalog No. 441.



SEMI-AUTOMATIC GAGES
For high speed, automatic acceptance and rejection of production parts to desired tolerances. Also available for manual operation.

GENERAL CONTROL COMPANY

1202 SOLDIERS FIELD ROAD, BOSTON 34, MASS.



These soft iron pole pieces tell the story—

EXPERIENCE is a much used, and too often abused, word. Yet in any field experience is the only source of practical knowledge—the only sound basis for further advance.

Measured in terms of time alone, the experience of the Simpson organization is impressive enough. For more than 30 years this name has been associated with the design and manufacture of electrical instruments and testing equipment. But the real value of this experience is to be found in the many fundamental contributions Simpson has made to instrument quality.

The use of soft iron pole pieces in the patented Simpson movement serves as an example. An admittedly finer type of design, these soft iron pole pieces have been employed by Simpson to provide maximum strength as well as accuracy, and to achieve a simpler assembly that permits faster, more economical manufacture.

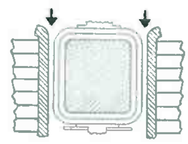
For today's vital needs, this experience enables Simpson to build "instruments that stay accurate" in greater volume than ever before. For your postwar requirements it will insure the correct interpretation of today's big advances.

SOFT IRON POLE PIECES THE SIMPSON WAY . . . .

Greater Accuracy — Soft iron pole pieces redistribute magnetic flux evenly. Simpson Instruments provide accurate readings throughout an arc of 100°.

Greater Strength — Pole pieces are used to anchor full bridges across top and bottom of movement. Moving assembly is locked in permanent alignment.

Smooth Walled Air Gap No cracks or irregularities to invite dust or other foreign particles, which might interfere with movement of armature. Reamed to accurate dimensions after assembly.



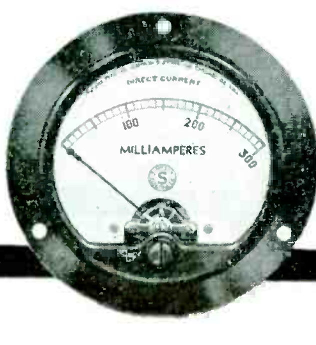
Speed and Economy—Pole pieces are stamped, not machined. This is one of many ways Simpson has speeded construction, and lowered costs, of this basically better movement.

SIMPSON ELECTRIC CO.
5200-5218 Kinzie St., Chicago 44, Ill.

Simpson

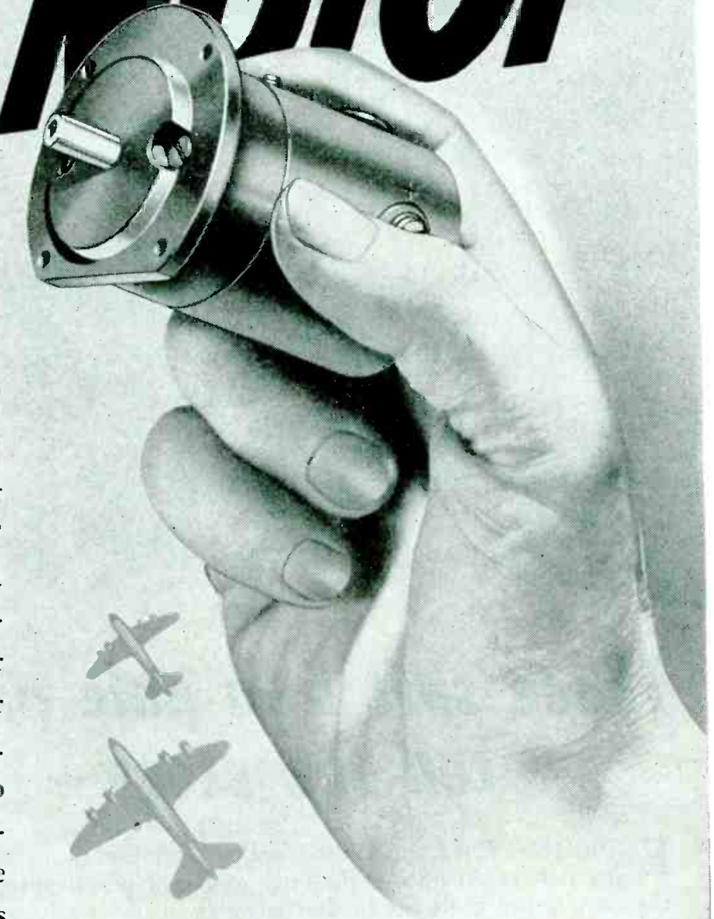
INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory



This *Oster* Motor

REG. U. S. PAT. OFF.



gives you smooth performance on many aircraft and blower installations . . . saves weight, too!

Here is a dependable fractional horsepower motor with features that result from over fifteen years' experience in building this type of quality motor. Its light weight, space-conserving size, and dependability make it ideal for aircraft and blower installations. It may suggest itself as the answer to the motor problem in your peacetime product. You can depend on Oster motors to live up to the world-wide reputation of pre-war Oster appliances, and to deliver results that add to the prestige of your product. Let us help you fit this or other Oster motors to your requirements.

FEATURES OF TYPE B-6A MOTOR

Housing: Die cast aluminum, totally enclosed.

Finish: Black anodized.

Weight: 10 oz.

Bearings: Single shielded ball bearings lubricated with grease suited for any specific application. Bearing housings fitted with steel inserts to assure permanent bearing alignment and proper bearing fits.

Mounting: Flange or standard 3/4" dia. air corps rabbet.

Brushes: Metal graphite of ample size to assure unusually long brush life.

Windings: Available in shunt, series, and split series reversible, 12 and 24 volt, intermittent and continuous duty.

Temperature Rise: 55°C max. frame temp. rise at rated load.

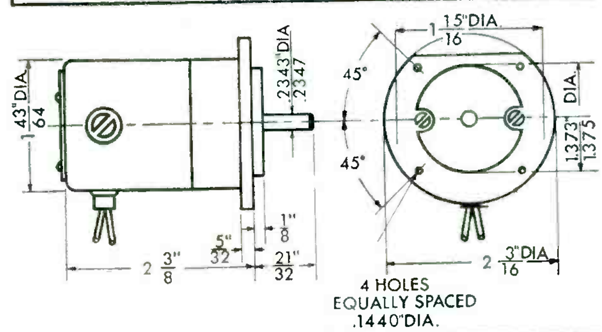
Modifications: Special shaft extensions, mounting arrangements, leads etc. also furnished for operation in high ambient temperatures and high altitudes.

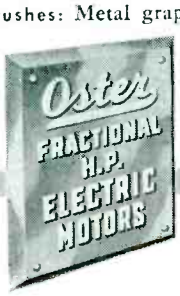
Applications: Suitable for operation of blowers, switching arrangements and other similar aircraft applications.

All data and ratings are approximate

TYPICAL RATINGS OF B-6A MOTOR, CONTINUOUS DUTY

Maximum H.P.	1/100	1/150	1/200
R.P.M.	7500	5800	3800
Full load amps. at 24 volts	1.00	.70	.55
Starting torque in % of full load torque	200 min.	200 min.	200 min.

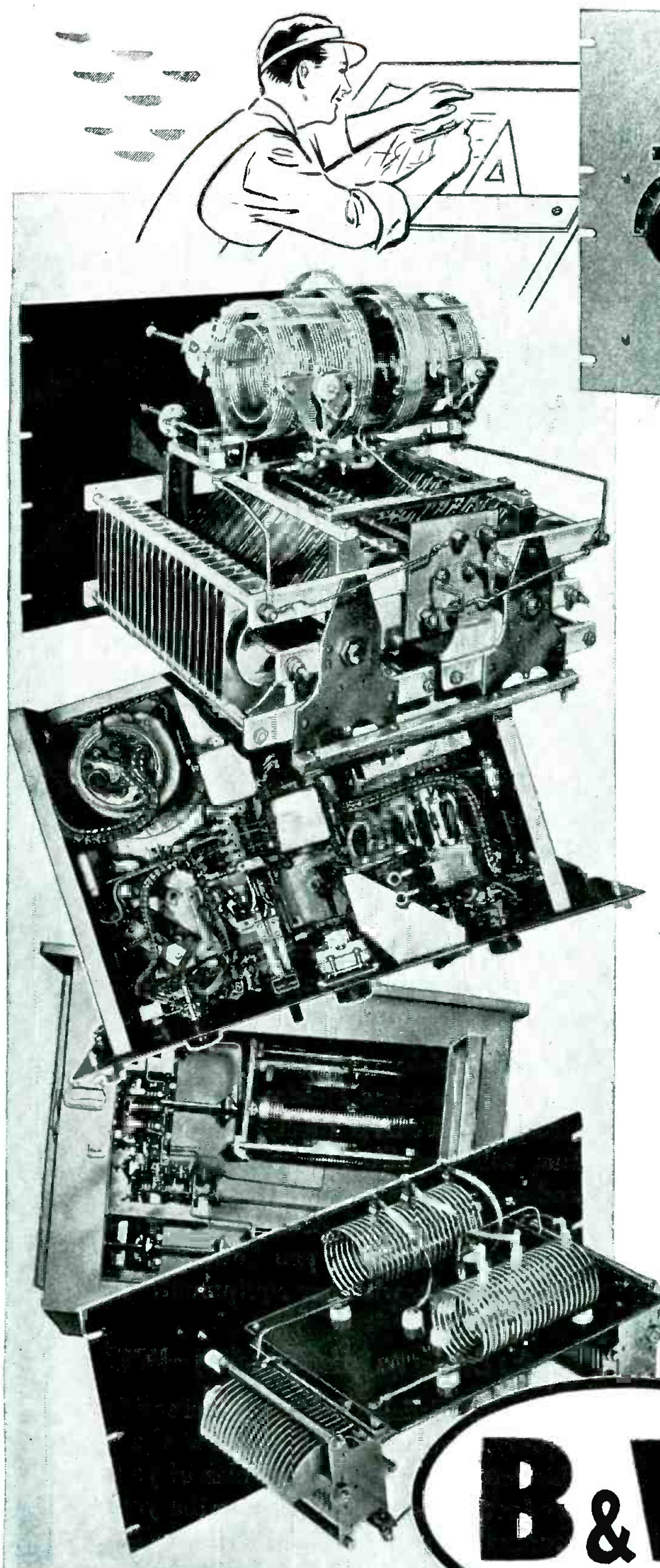


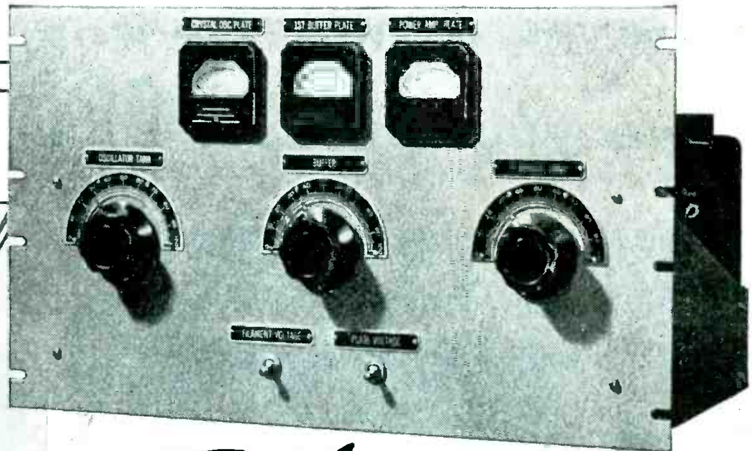


John Oster Manufacturing Company

DEPARTMENT L-20

RACINE, WISCONSIN





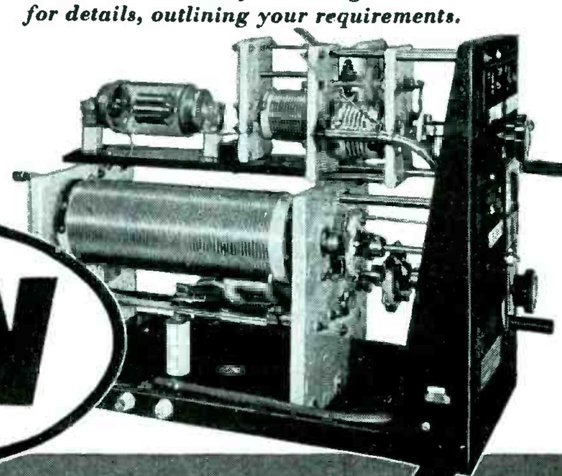
"Tailor-made" ELECTRONIC EQUIPMENT

ASSEMBLIES

Designed and produced from stem to stern by recognized experts to match your needs *exactly*.

DIELECTRIC AND INDUCTION HEATING EQUIPMENT • TUNING UNITS • TEST EQUIPMENT • RADIO TRANSMITTERS • HIGH AND ULTRA-HIGH FREQUENCY EQUIPMENT

B & W is neither too large for the smallest job nor too small for the largest. Write for details, outlining your requirements.



B&W

BARKER & WILLIAMSON

AIR INDUCTORS • VARIABLE CONDENSERS • ELECTRONIC EQUIPMENT ASSEMBLIES

DEPT. E-114 235 FAIRFIELD ROAD, UPPER DARBY, PA.

Export: LINDETEVES, INC., 10 Rockefeller Plaza, New York, N. Y., U. S. A.

THE NEW MULTIRANGE FLUXMETER

MODEL F

FOR THE
MEASUREMENT OF
MAGNETIC CIRCUIT
CONDITIONS
AND
ASSOCIATED TESTS

ACCURACY ½%

RANGE
5 LINES PER SQ. CM.
TO
30,000,000 LINES PER SQ. CM.

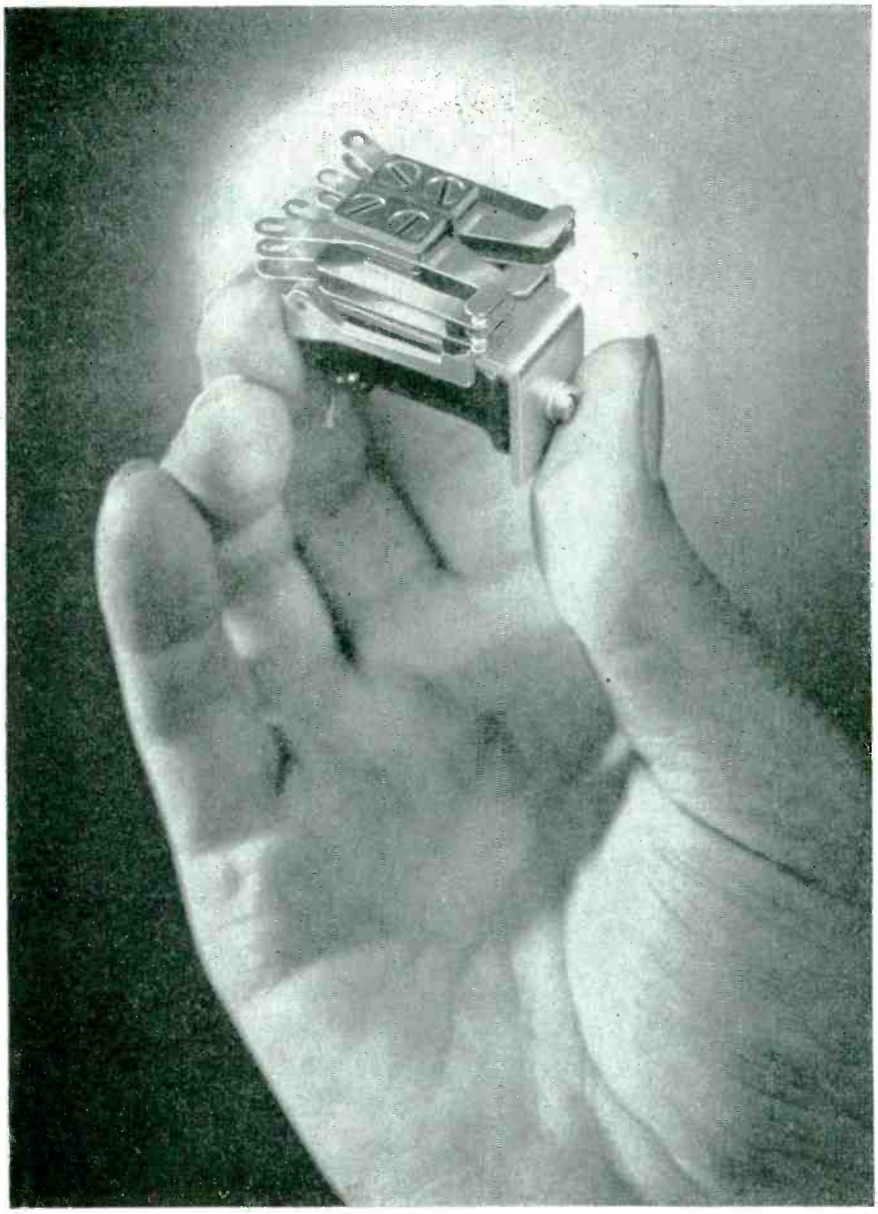
SEARCH COIL RESISTANCE
INCREASED TO 15 OHMS.

THIS NEW DESIGN REPRESENTS THE FIRST MAJOR IMPROVEMENT IN THIS TYPE OF INSTRUMENT IN THE PAST 25 YEARS. A COMPLETE TECHNICAL BULLETIN WILL BE GLADLY SENT ON REQUEST.

SENSITIVE RESEARCH
INSTRUMENT COMPANY

9-11 ELM AVE. MOUNT VERNON N.Y.

Electrical Instruments of Precision since 1927



Small, but OH, MIGHTY!

Yes, here is a mighty important little unit designed and developed by Cook engineers. Here is a small relay, one of the "400" series of Cook relays (illustration above is actual size) that will meet the most exacting requirements of all engineers and manufacturers. Here is a space-saver that makes no sacrifice of sturdiness, accessibility, life of service or all 'round quality in comparison with larger standard type relays. Like all Cook relays, the "400" is built of the finest materials. Stainless steel bearing pins for long life and permanent adjustment, new coil terminal design to prevent coil losses due to breakage of lead wires, wide spacing of spring terminals, and elongated holes to facilitate wiring, high permeable magnetic materials annealed in controlled atmosphere, coils wrapped in serving and bakelite impregnated against moisture to Air Corps specifications with single or twin contacts and single or double spring pile-ups.

Production of all types of these relays is still limited to high priority Government contracts; however, our home and field engineers will be pleased to consult with you on your post-war requirements, on this as well as all Cook products.

COOK ELECTRIC Company

2700 SOUTHPORT AVENUE • CHICAGO 14, ILLINOIS

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MEASURES QUANTITIES

with greater sensitivity & range than ever before accomplished

PATS. APP. FOR

TECH LAB MICROHMMETER

. . . *gives direct and instantaneous readings of resistance values* down to 5 microhms and up to 1,000,000 megohms. Accuracy in all measurements to better than 2%. Output is sufficient to drive recorder. Entirely AC operated. Furnished in two models. Reasonably prompt deliveries. For complete data regarding other applications write for Bulletin No. 432.

Quality manufacturers of attenuators and other electrical resistance instruments. For complete data write for Bulletin No. 431.

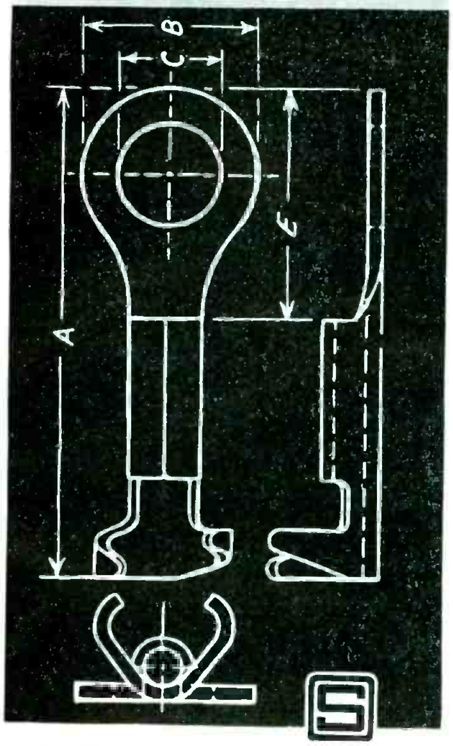
TECH LABORATORIES

7 LINCOLN STREET
JERSEY CITY 7, N. J.

Get the Specifications On This Improved

One-Piece

Solderless Terminal



You'll be amazed to see how production can be increased and performance improved, with the Sherman UNI-CRIMP One-Piece Solderless Terminal.

Here's a terminal that insures highest conductivity. It is made of fine grain, specially rolled, pure electrolytic copper, rated at 100% conductivity. And — the entire inside of the barrel is serrated, which provides a strong grip on the entire circumference of the wire, and *greatly increases the contact area.*

Write for Bulletin UC-2, giving full specifications. See for yourself why the UNI-CRIMP is stronger mechanically, more efficient electrically, easier to install, and more economical.

Find out how you can switch over to the UNI-CRIMP and speed up production, without any change in your present set-up.

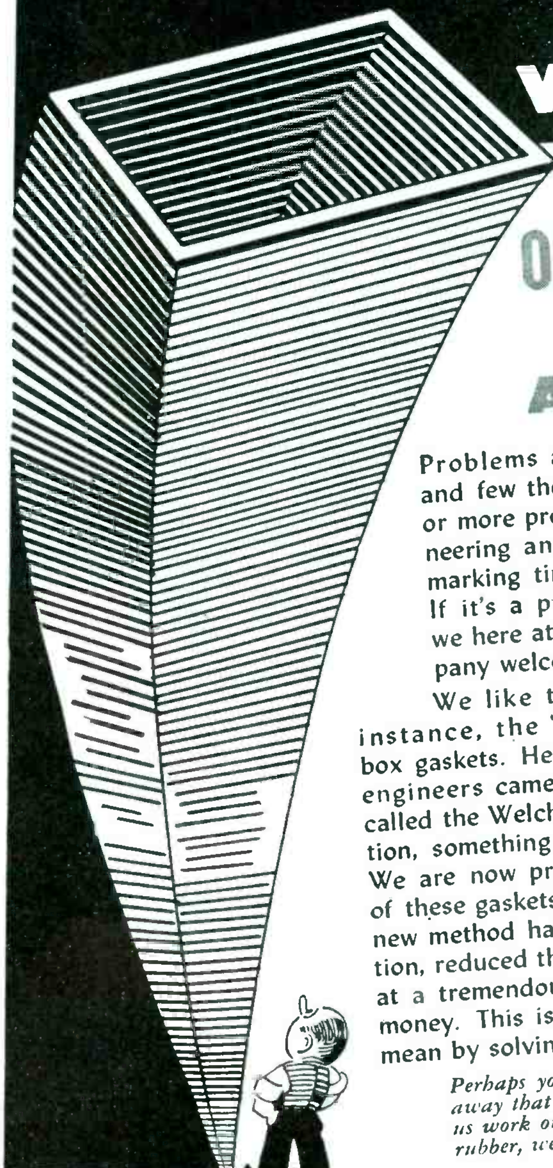
H. B. Sherman Mfg. Co., Battle Creek, Mich.

The Sherman

UNI-CRIMP

Solderless Terminal

A *Tough* PROBLEM DEVELOPED INTO BIG VOLUME!



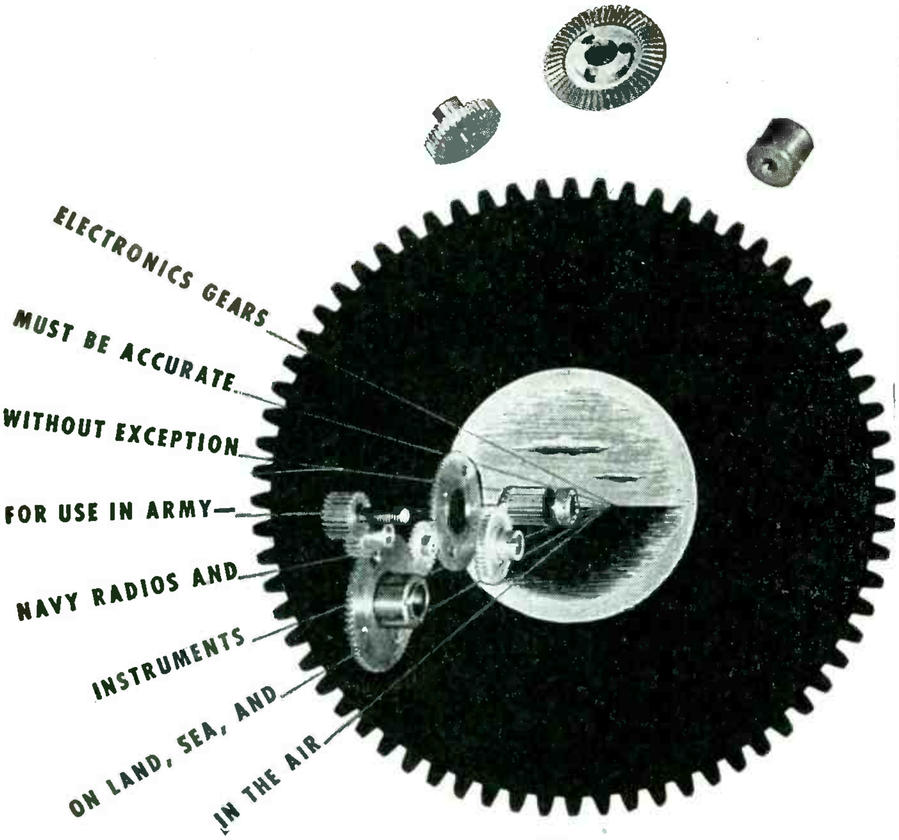
OVER ONE MILLION GASKETS A MONTH

Problems are the order of the day and few there be who have not one or more problems in designing, engineering and manufacturing that are marking time, waiting to be solved. If it's a problem involving rubber, we here at the Johnson Rubber Company welcome it.

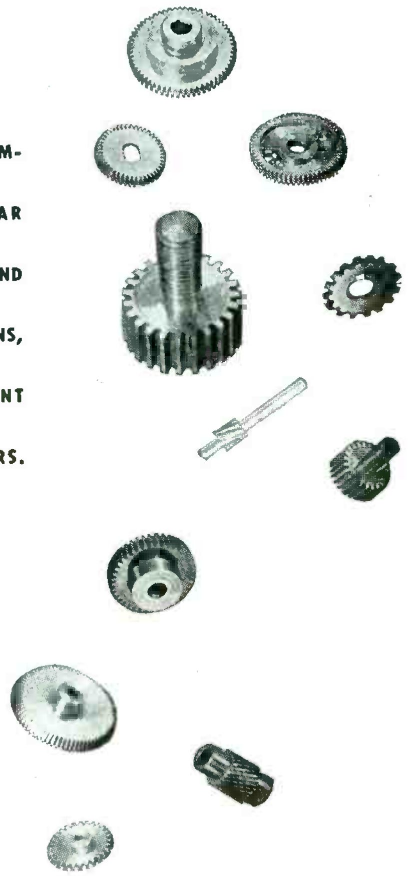
We like the tough ones, take, for instance, the "one piece" ammunition box gaskets. Here was a "toughy" and our engineers came through with what is now called the Welch gasket method of production, something new and entirely different. We are now producing the largest volume of these gaskets in the country today. This new method has greatly increased production, reduced the time element — all of this at a tremendous savings in material and money. This is an illustration of what we mean by solving problems in rubber.

Perhaps you have a good idea tucked away that "couldn't be done"; if so, let us work on it. If it can be done with rubber, we will have the answer for you.

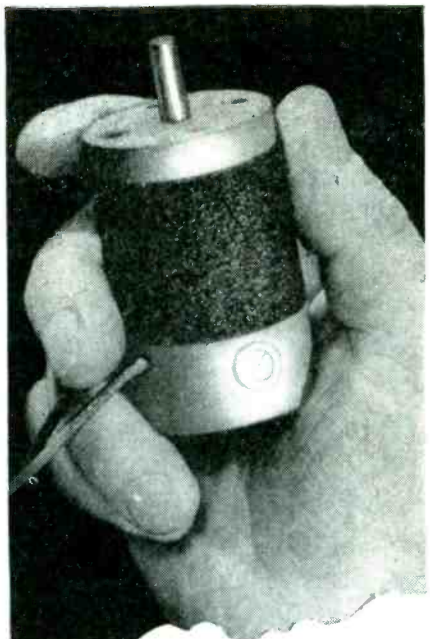
JOHNSON RUBBER CO.



ACCURACY CANNOT BE COMPROMISED WITH IN THESE WAR DAYS OF LIGHTNING SPEEDS AND WORLD WIDE COMMUNICATIONS, ALL TUNED INTO OUR PRESENT TEMPO BY PRECISION GEARS.



Quaker City Gear Works
INCORPORATED
1910-32 North Front Street, Philadelphia, Pennsylvania



IT PACKS A
BIG PUNCH

It's small but lusty—concentrated power for dependable performance on many types of jobs requiring maximum power per ounce of weight. 1/20th to 1/200th H. P. From 3000 to 20,000 R. P. M. 6 to 115 volts AC-DC. It's engineered and precision-built to your exact specifications. What type of small fractional H.P. motor do you need? Send specifications and quantity wanted. Write today.

Small Motors, Inc.
1318 ELSTON AVE., CHICAGO 22, ILLINOIS

Manufacturers of special small universal, fractional H. P. motors, dynamotors, shaded pole motors, heater motors, generators.

Design · Engineering · Production

THEY INCREASE TUBE EFFICIENCY

TUBE efficiency depends largely upon the ability of the Anode to withstand the rapidity of bombarding electrons under high frequencies and increased power.

Speer Graphite Anodes are manufactured by a method which insures greater plate dissemination—not only of heat but also of power. This process eliminates warping and shrinkage generally brought about by high operating power as well as completely expelling all gases from the anodes.

The uniform operating characteristics of Speer Graphite Anodes remain constant. This permits closely matching of tubes for transmitting and rectifying and achieves efficient performance throughout the life of the tube. Speer Graphite Anodes are available in various designs to conform carefully with standard tube construction. Then too, special anodes can be made to meet special requirements. For high tube efficiency, plus other advantages listed at the right, specify Speer Graphite Anodes.

SPEER GRAPHITE ANODES

- Increase allowable plate power dissipation.
- Lower temperatures of associated tube parts.
- Withstand severe overloads.
- Defy warping.
- Prevent hot spots or fused holes.
- Minimize bulb darkening and insulator leakage.
- Improve degassing qualities.
- Decrease gas troubles.
- Enhance tube appearance.
- Provide precise anode dimensions.
- Produce uniform tube characteristics.
- Retain original dimensions in service.
- Maintain normal tube characteristics.
- Allow wide latitude of anode design.

SEC

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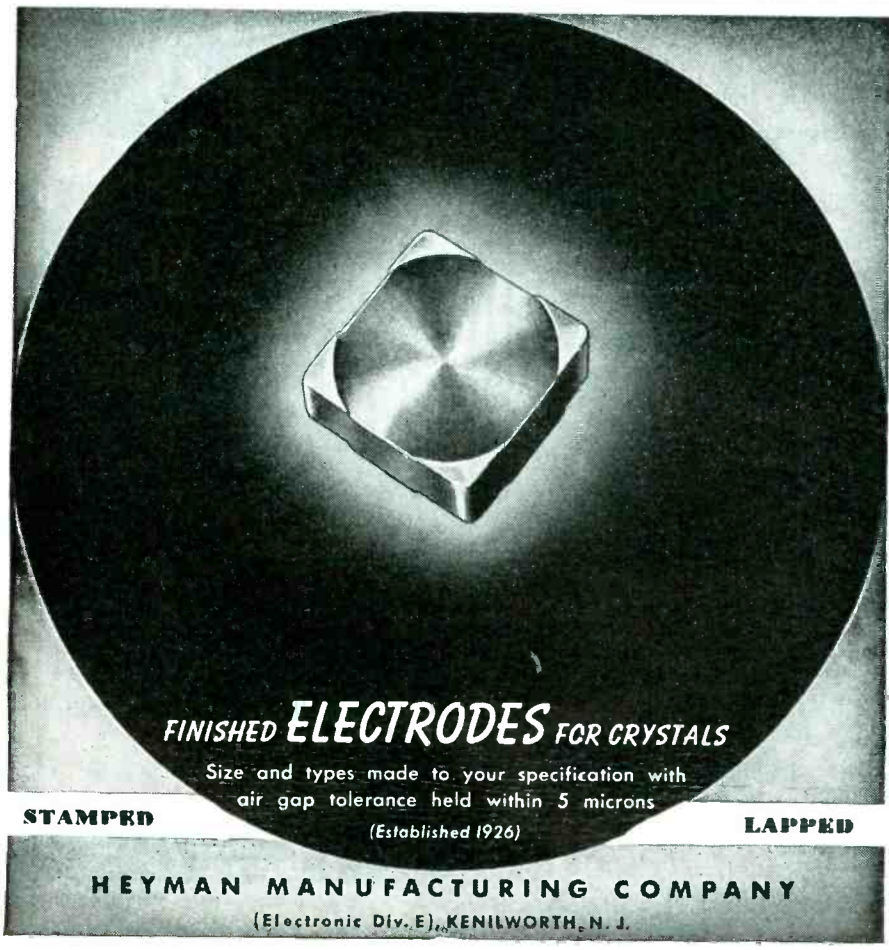

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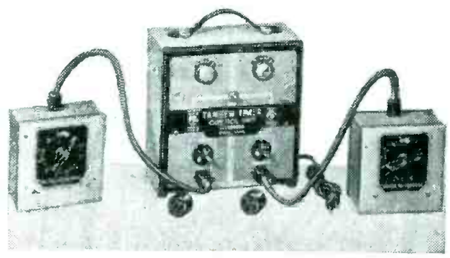
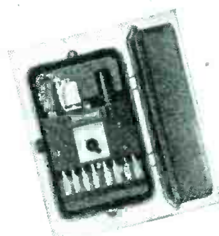
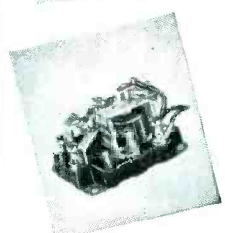
READY FOR EMERGENCY SHIPMENT



Here's a FASTER Coast-to Coast Service That Helps You Maintain Rush Schedules!





Industrial demand for good Relays, Photo - electric Equipment and Timers grows greater month by month. Newly discovered applications for these vital units are constantly raising production to new heights of speed and efficiency. These modern electronic units control combustion, count and sort products, act as burglar alarms, time life tests . . in fact find application in countless industrial processes.

We picture a few of many makes and sizes of Relays and Timers speedily available to industry everywhere by our unique Emergency Service. Our specially organized Industrial Department is streamlined, stocked and manned to give you an entirely new type of service. Whether you need expert technical advice or a demonstration of what we mean by "Emergency Service", phone or write today!

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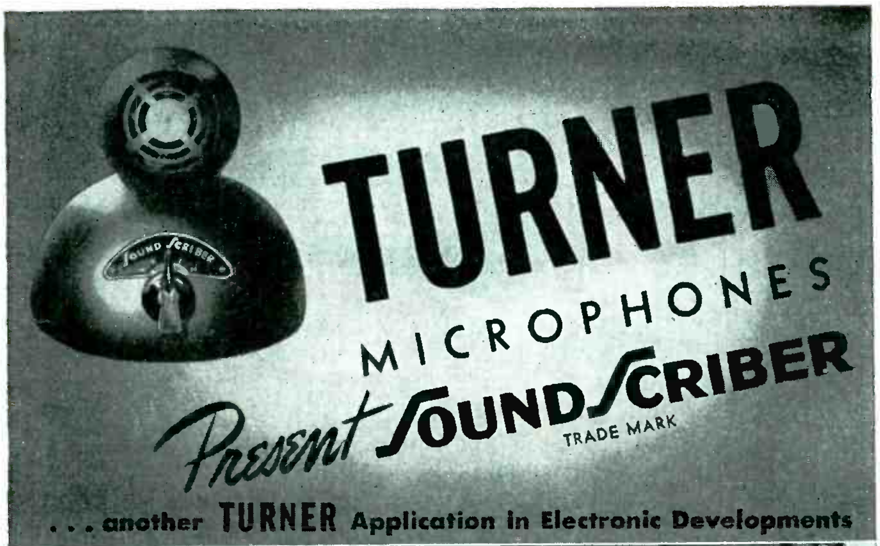
Radio and Electronic Supplies

WALKER-JIMIESON, INC.

311 S. WESTERN AVE., CHICAGO 12

PHONE: CANAL 2525



Confidentially Yours!

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SoundScriber is creating new standards in business life.

Whether you are discussing important matters with associates or others, giving instructions to employees, interviewing or writing letters, your voice is registered Electronically while you talk — giving you an immediate SoundScript on a featherweight plastic disc.

TURNER Microphones are standard equipment with SoundScriber.

Today — TURNER microphones serve every branch of the armed forces in addition to business, education, the professions and science. Tomorrow will open even wider use for Turner applications in electronic communications.

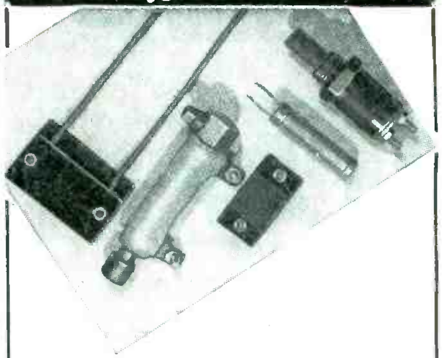
Crystals Licensed under Patents of the Brush Development Co.

TURNER — Pioneers in the communications field

The TURNER Company

CEDAR RAPIDS, IOWA

Let Us Help You Build a *Better* Product



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—65 Skilled Workers
—Modern Equipment
—Trained Supervision

ready to go to work for you. Keep your costs in line.

TRY TUTTLE FIRST

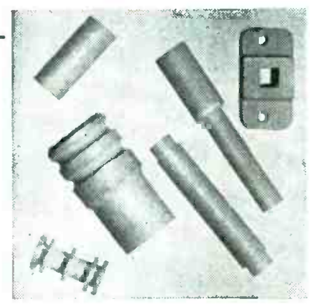
for Strip Resistors — Porcelain Heating Elements — Standard and Special Heating Elements

Write for Bulletin S101C

H. W. TUTTLE & CO.

ADRIAN, MICHIGAN

Lavite STEATITE CERAMIC



CHARACTERISTICS

Specific gravity of only 2.5 to 2.6 cent. Per cent power factor.

Water absorption S. 1.5-0.001 per S. 1.5 to 60 cycles was only 0.0165.

Dielectric constant at 60 cycles was 5.9-1000 KC 5.4.

Makers of electrical and radio apparatus destined for war service are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

D. M. STEWARD MFG. COMPANY

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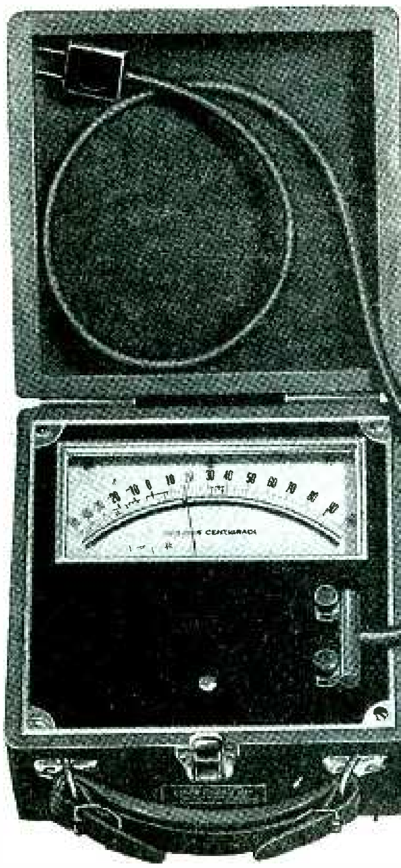
For Accurate Checking of Crystals In Sub-Zero Range!

ELEMATIC

HIGH RESISTANCE

PYROMETER

Here is a precision laboratory instrument, developed by our engineers at the request of radio manufacturers, for the specific purpose of checking crystals under sub-zero conditions. Produced only after exhaustive tests, this Elematic Pyrometer is guaranteed to be accurate within 2% of the full scale.



MODEL 40

Standard model illustrated equipped with Minus 50° C. to Plus 100° C. but is also available in scale range of 0—150° C.—Minus 40° to Plus 50° C.—Minus 85° to Plus 85° C. and Minus 60° to Plus 100° C.

The Elematic Model 40 is housed in a finely finished walnut case, with hinged removable cover and leather carrying handle. It has a high resistance movement. Mirror on scale to avoid parallax errors, 5¾″ scale, 6″ knife edge pointer, automatic compensation, two sapphire jewels and lapped pivots. Adaptable for all types of crystal holders and available in all standard ranges and thermocouple accessories.

Write for full information on the Model 40 High Resistance Pyrometer and other Elematic Instruments and Accessories.

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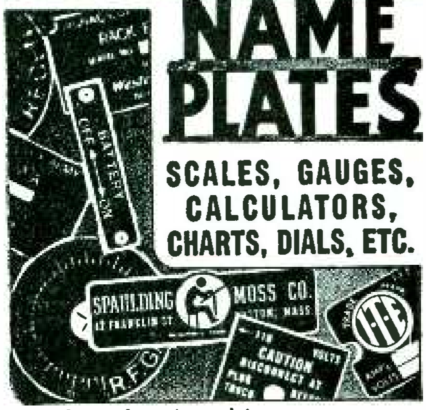

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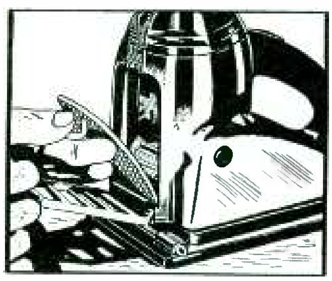

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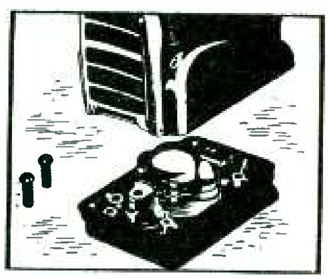

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D.C. MILLIAMMETER:
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0-1.4-14 amperes

D.C. VOLTS, 25,000 OHMS PER VOLT:
0-3.5-7-35-140-350-700-1400 volts

D.C. VOLTS, 1000 OHMS PER VOLT:
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A.C. VOLTS, 1000 OHMS PER VOLT:
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OUTPUT VOLTMETER:
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DECIBEL METER:
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OHMMETER:
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0-5-50 MEGOHMS

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Battery Operated

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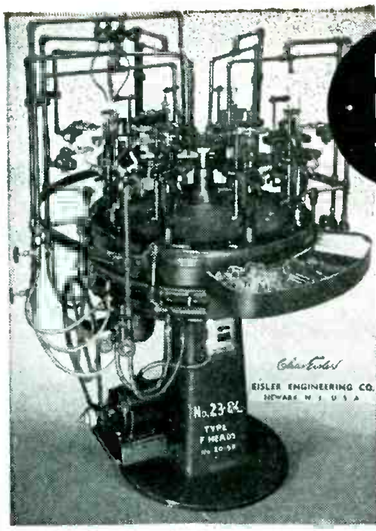

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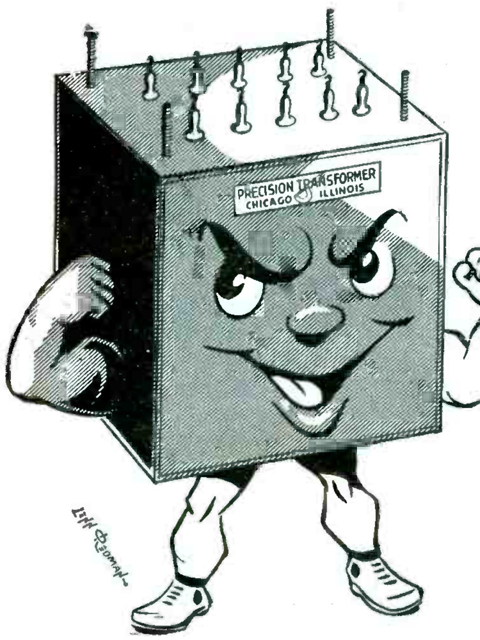

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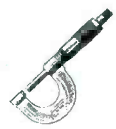

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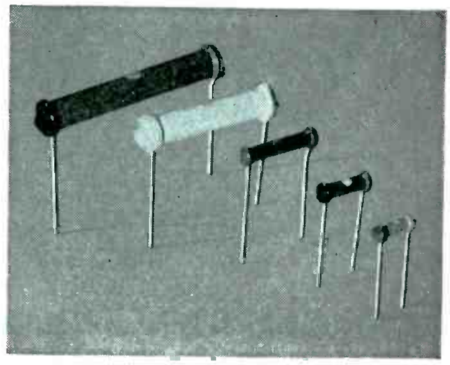

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997-A	1/5	150 Ohms to 4.7 Megohms	21/64"	7/64"
763-A	1/4	47 Ohms to 15 Megohms	5/8"	7/32"
759-A	1/2	33 Ohms to 15 Megohms	3/4"	1/4"
766-A	1	47 Ohms to 15 Megohms	1 1/8"	1/4"
792-A	3	22 Ohms to 150,000 Ohms	1 7/8"	15/32"
774-A	5	33 Ohms to 220,000 Ohms	2 5/8"	15/32"

TYPE "CX" RESISTORS

997-CX	1/4	1 to 150 Ohms	21/64"	7/64"
763-CX	1/2	1 to 47 Ohms	5/8"	7/32"
759-CX	1	1 to 33 Ohms	3/4"	1/4"
766-CX	2	1 to 47 Ohms	1 1/8"	1/4"
792-CX	4	1 to 22 Ohms	1 7/8"	15/32"
774-CX	6	1 to 33 Ohms	2 5/8"	15/32"

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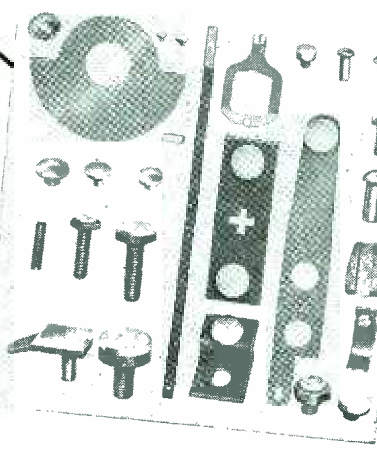

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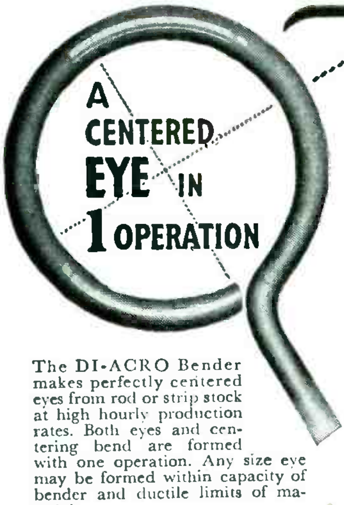

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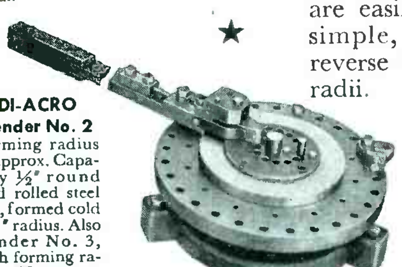

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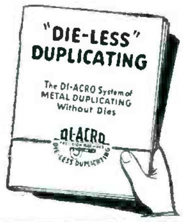

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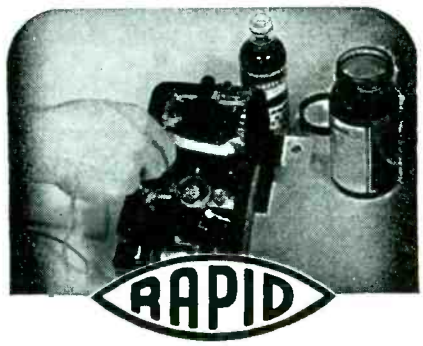

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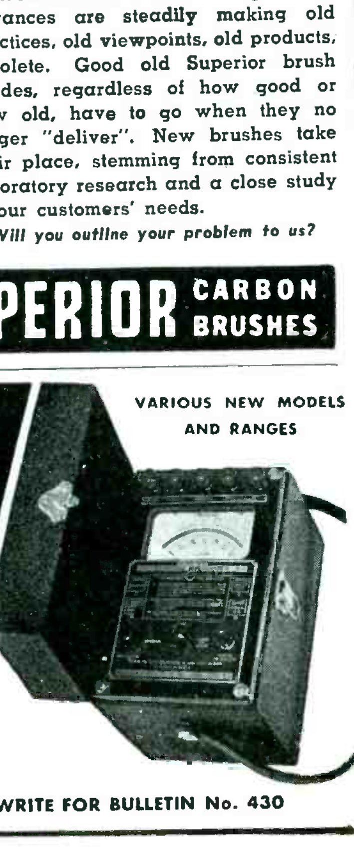

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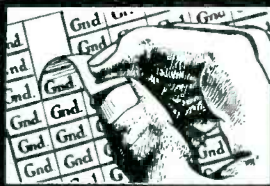

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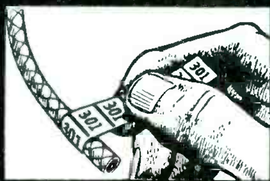

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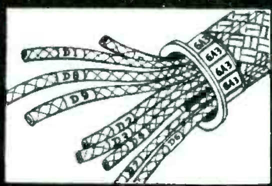

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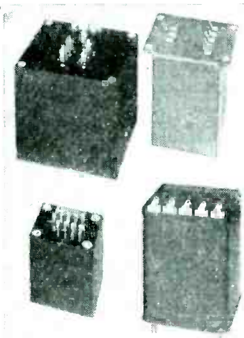

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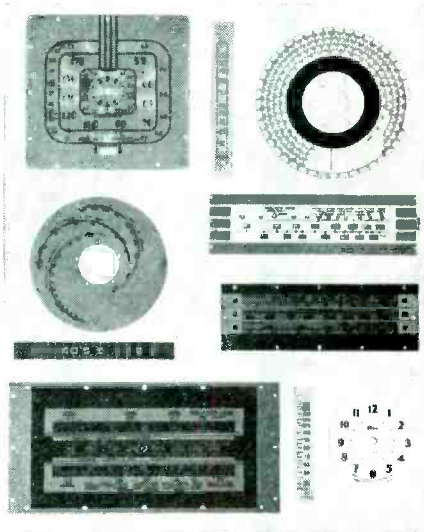

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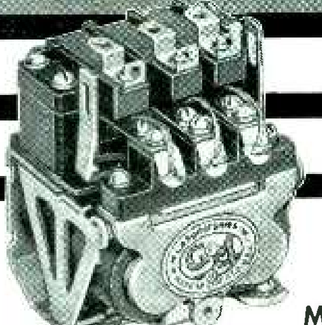

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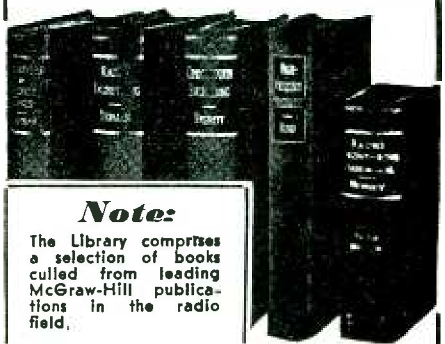

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(Additional Position Vacant ads on pages 360, 371, 375 & 376)

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Wanted, also, a graduate engineer experienced in design of phonograph pickups and similar electro-magnetic devices.

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A Central New England manufacturer employing over 1000 people needs Draftsman-Designer on telephone and signaling (mechanical) apparatus.

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WMC Regulations Prevail

P-724, Electronics
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Project development engineering positions open with excellent postwar future assured. Salaries open. Confidential inquiries respected. International Detrola Corporation.

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experienced in mechanical, electrical or acoustical field. Openings offer good postwar opportunity with aggressive company in a midwestern city of 35,000, in continuous operation for 70 years, leader in its field, highest possible financial rating of AA-A1. State age, experience, education. Address

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with adequate facilities to take on the design of R.F. precision measuring instruments on a contract basis.

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Our staff knows of this advertisement.

P-739, Electronics

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WANTED

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P-742, Electronics

330 West 42nd St., New York 18, N. Y.

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P-739, Electronics

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WANTED

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Statement of Availability Required.

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Backlog of military electronic and electrical postwar projects. Large engineering firm. Location Manhattan. Write detailing experience, salary and availability or call:

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IN an Eastern rayon mill, increased production demands returned to service a number of old and outmoded spinning machines. In this old equipment the electric motor leads are constantly exposed to 10% sulphuric acid fumes as well as oil and grease. The photograph gives some idea of the conditions. And just to make it harder, spare leads are stored in an unheated warehouse where winter temperatures go well below zero. Ordinary wire insulation material might do the job. But frequent shutdowns would be necessary to change the leads as they deteriorated. And shutdowns had to be avoided if production were to stay up.

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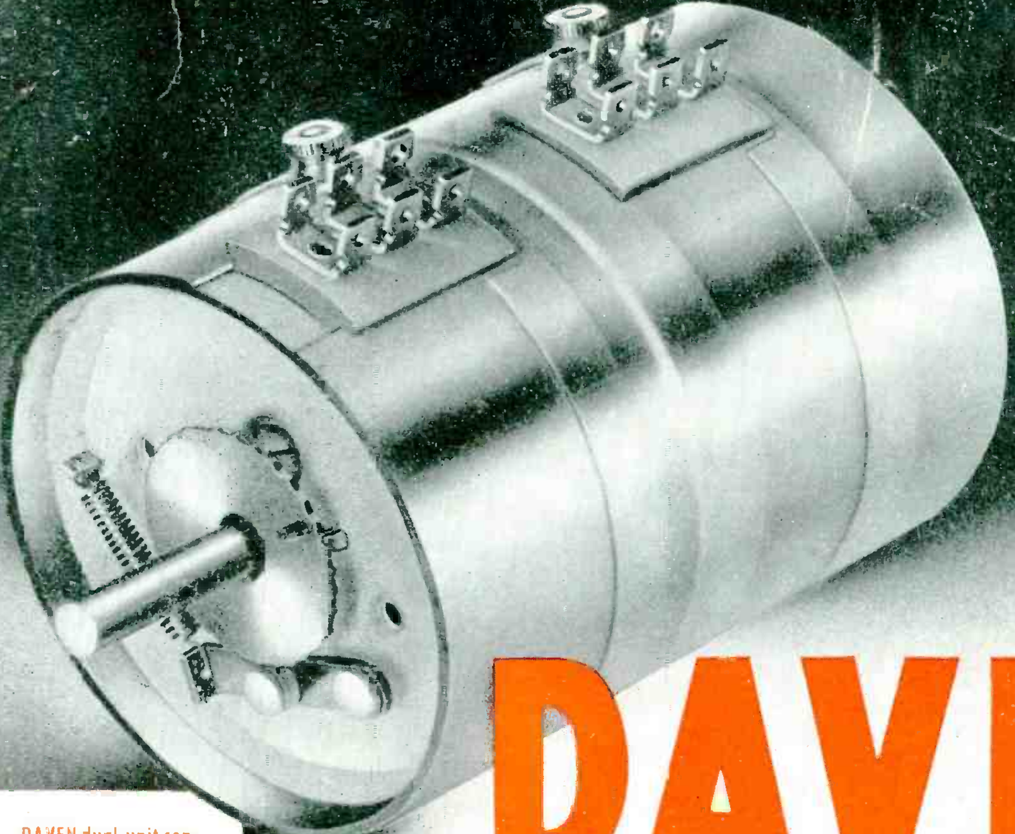


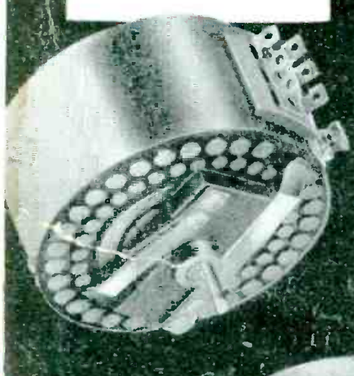
DAVEN dual-unit construction finds most important application in Balanced "H" attenuators, as well as in special multiple-circuit controls of the Potentiometer, "T", Ladder, "L" and Rheostat types.

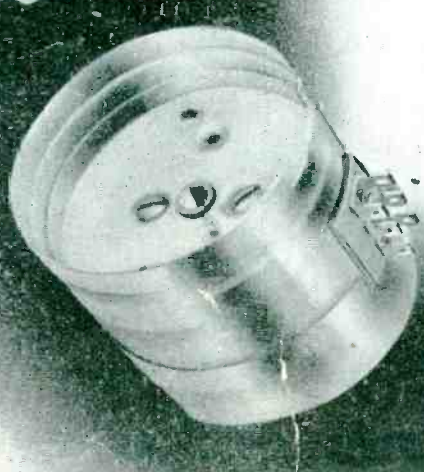
DAVEN

ANNOUNCES A NEWLY-IMPROVED MODEL for DUAL-UNIT* ATTENUATORS

DAVEN engineers have incorporated into the improved dual-unit all the important new features recently announced for DAVEN standard single-unit attenuators. A noteworthy addition in the dual-unit is the improved method of coupling front and rear attenuators. The respective shafts of each meet in a lap joint within a long, snug collar, providing quick and complete access to either unit. By loosening a knurled nut and releasing a snap-on fitting, the front or rear switch may be reached without dismounting the front unit from the instrument panel.

*Patent Pending





Features of DAVEN Dual-Unit Attenuators

SEPARABLE COUPLING—Front and rear units now easily separated: gives quick access to either unit. Simple, durable, foolproof construction illustrated at left.

IMPROVED SHIELDING—Sturdy, snug fitting, 3 piece steel cover affords superb electrical and dust shielding, as well as greater all around ruggedness.

NEW DETENT DEVICE—Large gear and roller mounted in recessed front end of front unit, separate from resistive network, gives accurate indexing. (Illustrated.)

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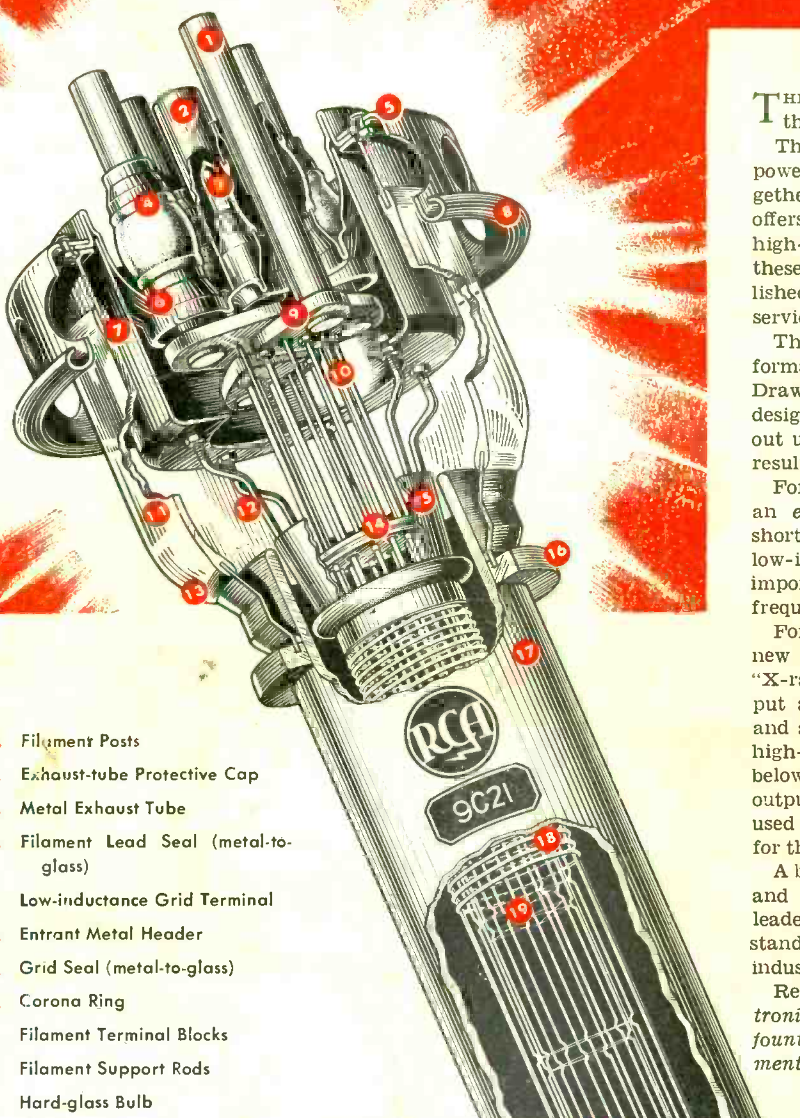

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RCA 9C22, air-cooled twin of 9C21, also offers high performance in industrial and radio broadcast service

THIS IS the story of a new tube design that "rewrites the rule book."

The tube is the new RCA 9C21, a high-power, water-cooled triode . . . which, together with its air-cooled twin, the 9C22, offers important advantages in high-power, high-frequency equipment. In designing these tubes, RCA engineers have established new concepts of tube design for such service.

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A better tube, for better performance . . . and another example of the engineering leadership that makes RCA tubes the standard of comparison in the electronic industry.

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