FEBRUARY · 1945

electronics

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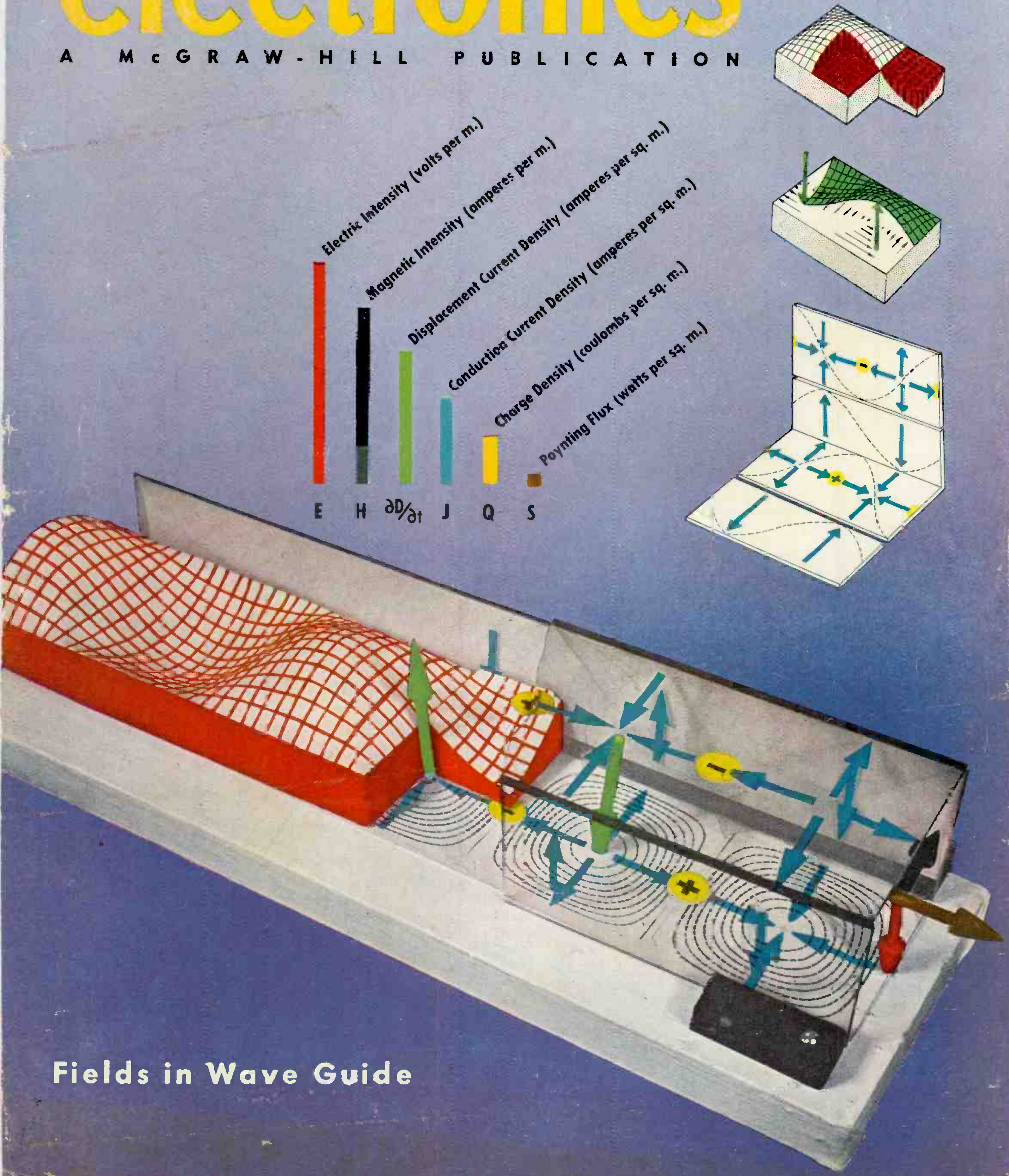
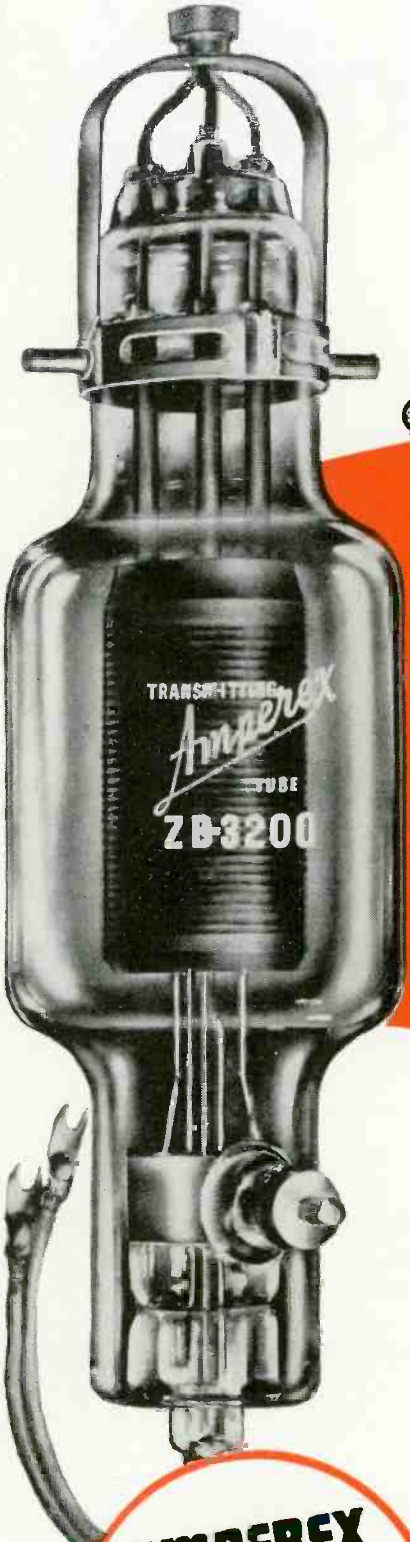


Fields in Wave Guide



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electronics

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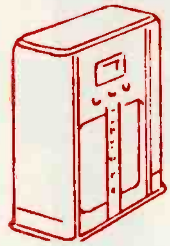


CONSOLE CABINETS
Thalid impression molding

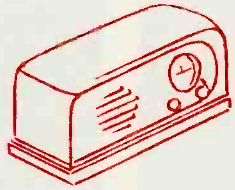
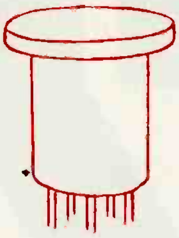
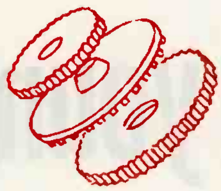


TABLE MODELS
Cerex • Resinox

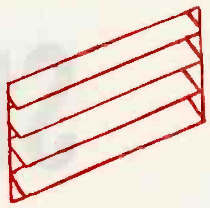


COIL FORMS
Cerex • Lustron • Resinox
Styramic HT

ESCUTCHEONS
Thalid impression molding
Fibestos • Lustron • Resinox

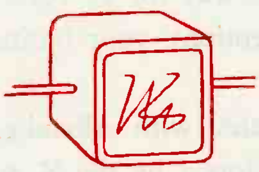


GEARS
Laminates of Resinox

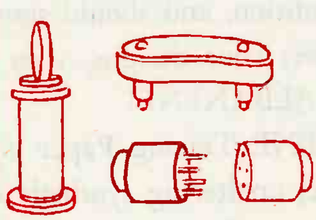


GRILLS
Fibestos • Lustron

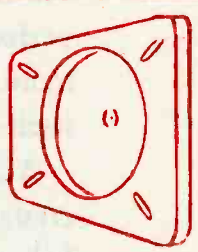
HEAD SETS
Resinox



MOLDED CAPACITORS
Cerex • Resimene • Resinox



POWER PLUGS, JACKS, CONNECTORS
Resimene • Resinox • Cerex



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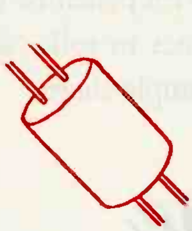
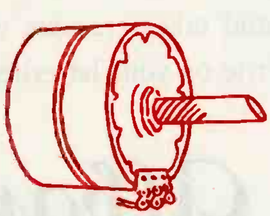
Resinox bonded pulp and paper
Thalid impression moldings

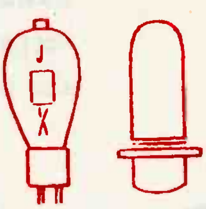
STAND-OFF INSULATORS
Cerex • Lustron
Styramic HT



STATIC ELIMINATOR HOUSINGS
Resinox



SWITCH AND CONTROL PARTS
Resinox molded • Resimene



TUBE BASES
Resinox molded bases
Resinox cements

TUBE SOCKETS
Cerex • Lustron
Laminates of Resinox

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.05 mfd. to 1.0 mfd. 1,000 V.D.C.
STANDARD CAPACITANCE TOLERANCE 20%**
TEST VOLTAGE . . . . Twice D. C. rating
GROUND TEST . . . . 2,500 Volts D. C.
OPERATING TEMPERATURE . . . . -55° F to 185° F
SHUNT RESISTANCE
.05 to 0.1 mfd. 20,000 megohms
.25 to 0.5 mfd. 12,000 megohms
1.0 mfd. 10,000 megohms
2.0 mfd. 5,000 megohms
POWER FACTOR . . . 1,000 cycles—.002 to .005
CONTAINER SIZE
Width 5/8", length 1-5/16", height 2¼"
MOUNTING HOLE CENTERS . . . . 1½"

MIDGET SPG-CAPACITORS

TYPE SPGM*
RATINGS . . . . . .05, .1 and
2 x .05 600 V.D.C.
-.05 and .1 1,000 V.D.C.
STANDARD CAPACITANCE TOLERANCE 20%**
GROUND TEST . . . . 2,500 V.D.C.
OPERATING TEMPERATURES . . . . -55° F to 185° F
SHUNT RESISTANCE . . . . 20,000 megohms
POWER FACTOR . . . . . At 1,000 cycles—.0075
CONTAINER SIZE
Width 5/8", length 1-5/16", height 1-11/64"
MOUNTING HOLE CENTERS . . . . 1½"

*Data sheets showing complete code number for units having a specific capacitance value and voltage rating available on request. **Other tolerances available.

Illustrations show capacitors with terminals on bottoms.
Capacitors also available with terminals on top.

MIDGET SPG CAPACITOR

SPG CAPACITOR

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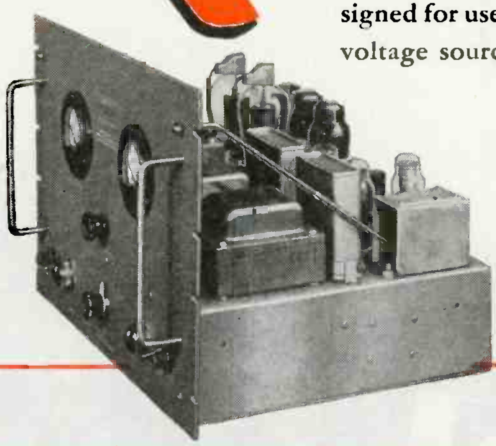
for use with CONSTANT FREQUENCY OSCILLATORS

AMPLIFIERS • PULSE GENERATORS • MEASUREMENT EQUIPMENT

500 to 1000 VOLTS

The HARVEY Regulated Power Supply 206 PA



This new HARVEY OF CAMBRIDGE development is designed for use with equipment requiring a constant D.C. voltage source in the 500-1000 volt range. It operates in two ranges—500 to 700 *at ¼ of an ampere;* 700 to 1000 volts at .2 of an ampere. The voltage change caused by current change *is less than one per cent* in both ranges. Write for complete specifications.

200 to 300 VOLTS

The HARVEY Regulated Power Supply 106 PA

performs smoothly and dependably in the lower voltages. It has a D.C. output variable from between 200 to 300 volts that is regulated *to within one per cent.* It operates on 115 volts, 50-60 cycles A.C., introduced by a convenient two-prong male plug. For complete information, write for bulletin.

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HARVEY RADIO LABORATORIES, INC.

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Many thousands of Hammarlund
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MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

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Good news for designers of welding and motor controls, timing circuits, and voltage regulating devices:

This stream-lined Westinghouse Thyratron WL-672 has everything you need in a grid-controlled mercury vapor rectifier. Look at its sturdy industrial size base, slotted to give greater creepage distance . . . oversize anode-support and dome-type construction hold every part rigidly in its exact position, for unwavering performance . . . extra large high-current-capacity pins and cap that won't get hot and burn off . . . totally enclosed arc stream for better control.

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Quality Controlled Electronic Tubes

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

There can be no question that both AM and FM are slated for important jobs in the world of tomorrow—in broadcasting, aviation, mobile and marine radio. And Western Electric will offer you the finest equipment of each type—backed by 76 years of leadership in making communications apparatus for almost every purpose.


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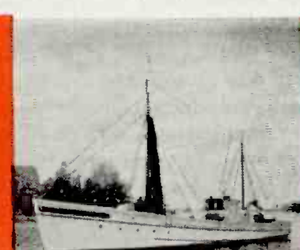
MOBILE RADIO


MARINE RADIO

Western Electric has specialized

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IN TURNTABLE EQUIPMENT

Elections come and go, but the broadcasters' favorite is always...RCA Turntable Equipment. Here is sturdy, dependable construction; equipment particularly designed for broadcast station needs.

In the RCA 70-C1 Turntable with its combination head, the broadcaster will find equipment of great flexibility. These turntables will be available for delivery on rated orders early in 1945. Inquire now!

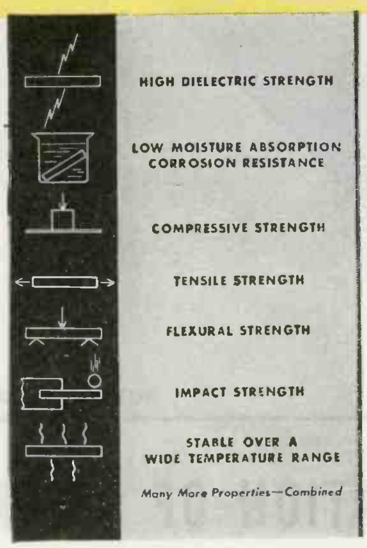
For broadcasters interested in postwar reservations of turntables, new AM, FM or Television equipment, speech input equipment, etc.—write the Broadcast Equipment Section for information on the RCA Broadcast Equipment Priority Plan.

FEATURES OF THE RCA 70-C1 TRANSCRIPTION TURNTABLE

- ★ Combination pickup for vertical and lateral transcriptions.
- ★ Counter balanced tone arm, free of noise and vibration. Six-position switch for control of compensation.
- ★ Excellent speed regulation. High torque for quick starting.
- ★ Turntable operation within proximity of microphone possible. (Silent type power switch; low motor noise.)
- ★ Isolation of motor noise from cabinet. Filters securely mounted and arranged for minimum hum pickup.
- ★ Modern cabinet design, attractive trim. Umber gray cabinet finish.

A Scene From the Metro-Goldwyn-Mayer Picture—EDISON, THE MAN

The Birth of the "Little Sun" Every Home Welcomed



OF ALL man's inventions, one of the greatest, universally, was Edison's incandescent filament . . . a fine thread from which a new pattern of life was woven.

Edison simply experimented with known substances until he found one that met his singular requirements. You may have material problems, too. However, knowing your requirements, you may find your special answer in technical plastics.

If excellent electrical properties, resistance to corrosion, mechanical strength, easy machineability and many other combined characteristics are desirable, our type of technical plastics—Synthane—can be very helpful to you.

You are invited to send for the complete Synthane catalog and compare your needs with Synthane's advantages. Synthane Corporation, Oaks, Pa.

SYNTHANE TECHNICAL PLASTIC

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

Plan your present and future products with Synthane Technical Plastics

A comparison of SYNTHANE TECHNICAL PLASTICS with certain metals, debunking a popular notion that plastics being "magic" can be used indiscriminately

IT IS CHARACTERISTICALLY HUMAN to back a winner . . . to ascribe precipitately to vitamins or sulfa drugs or plastics more powers and claims than sober research can keep up with. Plastics have their possibilities . . . and their limitations. Good design is the reward of knowing both.

Plastics are doing many jobs that metals used to do, especially since certain critical metal shortages have cropped up. But, basically, plastics are not substitute materials. Correctly applied, they should and do stand solely on their own merits.

INTERESTING COMPARISONS TO PROVE the point can be made between our type of plastics—Synthane—and certain metals. Synthane is made by applying heat and pressure to paper or fabric impregnated with thermosetting resins. It is non-metallic, a fact which should at once suggest uses fundamentally different from those of metals. Actually, Synthane is an excellent electrical insulator, and so you find it in hundreds of radio and electrical products and applications, not in place of metal, but to insulate metal. That does not imply Synthane cannot replace metal. As a matter of fact, Synthane has taken over for metals in pulleys, bearings, panels, structural members, scales, dials. The reasons can usually be traced to one or a combination of the many properties of Synthane technical plastics.

ONE OF THE PRINCIPAL REASONS at present is light weight. Synthane has a specific gravity ranging from 1.20 to 1.70, about half that of aluminum, less than magnesium. So in many unstressed parts for aircraft Synthane is a logical consideration.

SYNTHANE LAMINATED PLASTICS GENERALLY have lower mechanical strength than metals for a given cross section. For example, an approximate comparison might read like this:

	Tensile Strength (p.s.i.) ultimate	Compressive Strength (p.s.i.)
Alloyed Aluminum	16,000–60,000	9,000– 47,000 (y)
Brass	40,000–80,000	28,000–126,000 (u)
Cast Iron	16,000–45,000	80,000–200,000 (u)
Synthane	8,000–12,000	30,000– 50,000 (u)

(y—yield strength
u—ultimate strength)

IT IS IMPORTANT, HOWEVER, TO REMEMBER that on a weight basis, Synthane may be stronger though redesign of a part for plastics may be necessary.

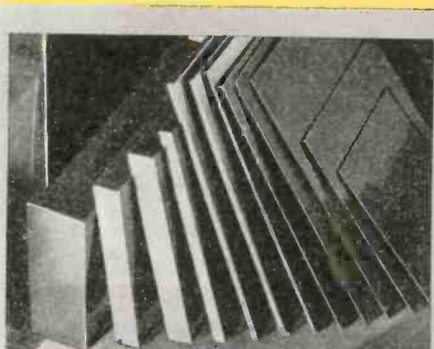
HARDNESS IS A PROPERTY in which another interesting comparison of Synthane with metals can be made. Brinell hardness, tested with 500 Kg. load, 10 mm ball, shows approximately these values: Alloyed aluminum 45-110, Brass 95-150, magnesium (drawn annealed) 29, annealed cast iron 77, Synthane 24-40.

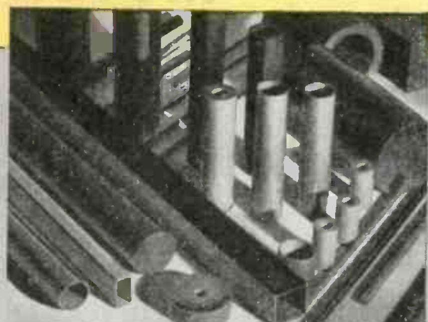
BEHAVIOR UNDER TEMPERATURE CONDITIONS is characteristic of Synthane's non-metallic composition. For instance, whereas the thermal conductivity of aluminum alloys may range from .20 to .54 calories per second per square centimeter per centimeter of thickness per degree C., Synthane's thermal conductivity is about .0005 to .0008. The coefficient of thermal expansion of Synthane is about .0000140 inches per inch per degree F., approximately the same as alloyed aluminum, slightly more than pure aluminum, copper, brass.

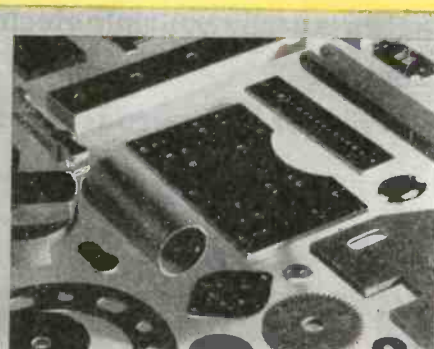
CORROSION RESISTANCE IS A SUBJECT of such complications as to temperature, degree of concentration, and type of agent that any comparison with metals would necessarily be lengthy. Synthane does resist corrosion from water, many acids, oils, and salts, and to a greater or lesser extent than metals depending on the metal with which it is compared and the corrosion conditions. Synthane is extensively used as a corrosion resistant material.

APART FROM ITS PHYSICAL, CHEMICAL, electrical and chemical properties, Synthane may be easily and quickly machined by ordinary shop methods, a point which may occasionally influence selection when other factors are the same. And, just as metals are cast for economy in large quantities, so Synthane is available in two molded forms, molded-laminated and molded-macerated, for economy of duplication.

OBVIOUSLY, IN CERTAIN CASES there can be no question of whether to use Synthane plastics or a metal such as when the material must be an electrical conductor or an electrical insulator, in other cases, weight or strength may decide, or corrosion resistance, resilience, hardness, machinability. Or as often happens, the decision may rest upon the extent to which the material required meets many combined specifications. Synthane technical plastics are usually more desired for their combination of properties than for any one specific property for which another specific material or metal may be the only logical answer.





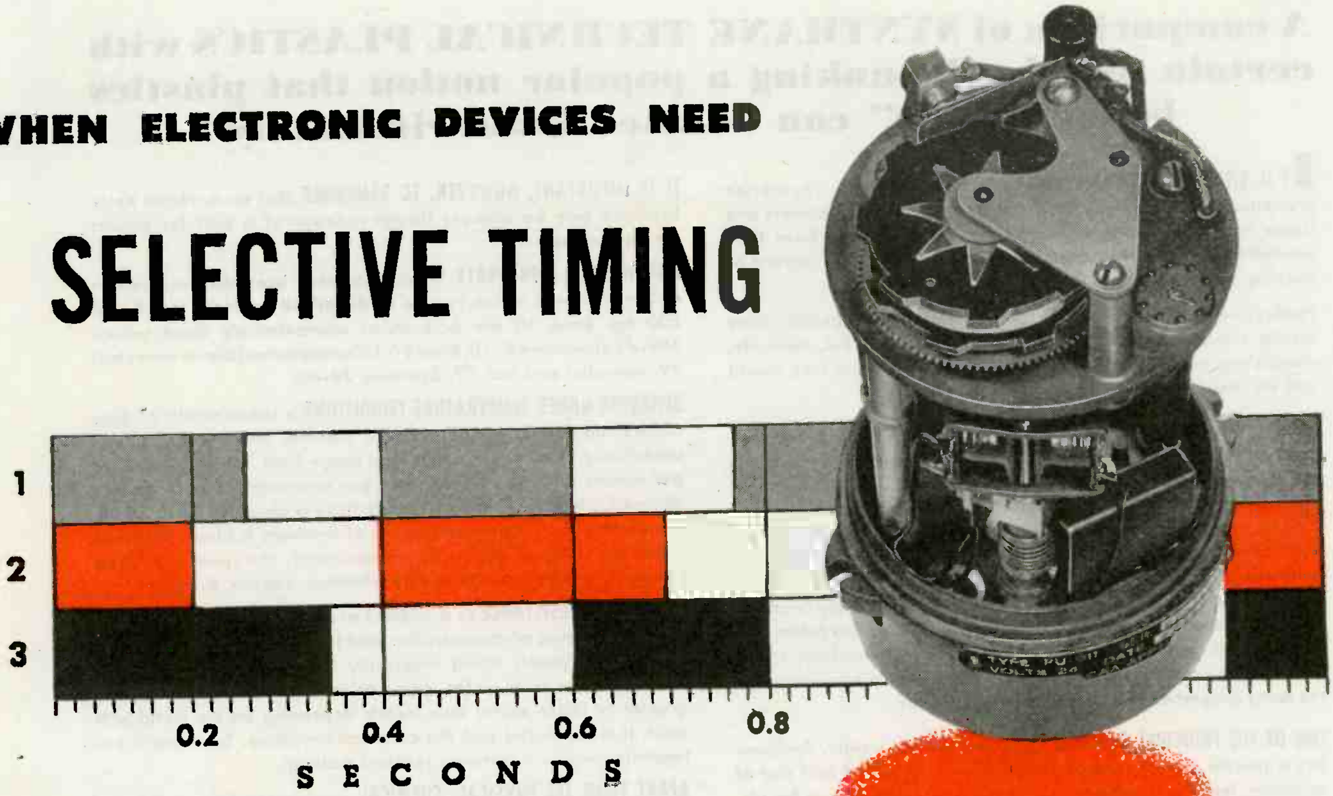


SYNTHANE CORPORATION, OAKS, PENNA.

REPRESENTATIVES IN ALL PRINCIPAL CITIES

WHEN ELECTRONIC DEVICES NEED

SELECTIVE TIMING



Selective timing of two or more circuits to hundredths of a second is dependably accomplished with the W&T Constant Speed Motor Mechanism.

With a current input of only 0.003 milliamperes, the motor delivers 1800 gram inches per minute (a feature of especial importance in battery powered systems). It operates at a constant speed, regardless of voltage changes as great as ±20%.

Compact and self-contained, the mechanism is easily built into electronic control devices.

Write for illustrated technical bulletin

THE W&T CONSTANT SPEED MOTOR MECHANISM

A-37

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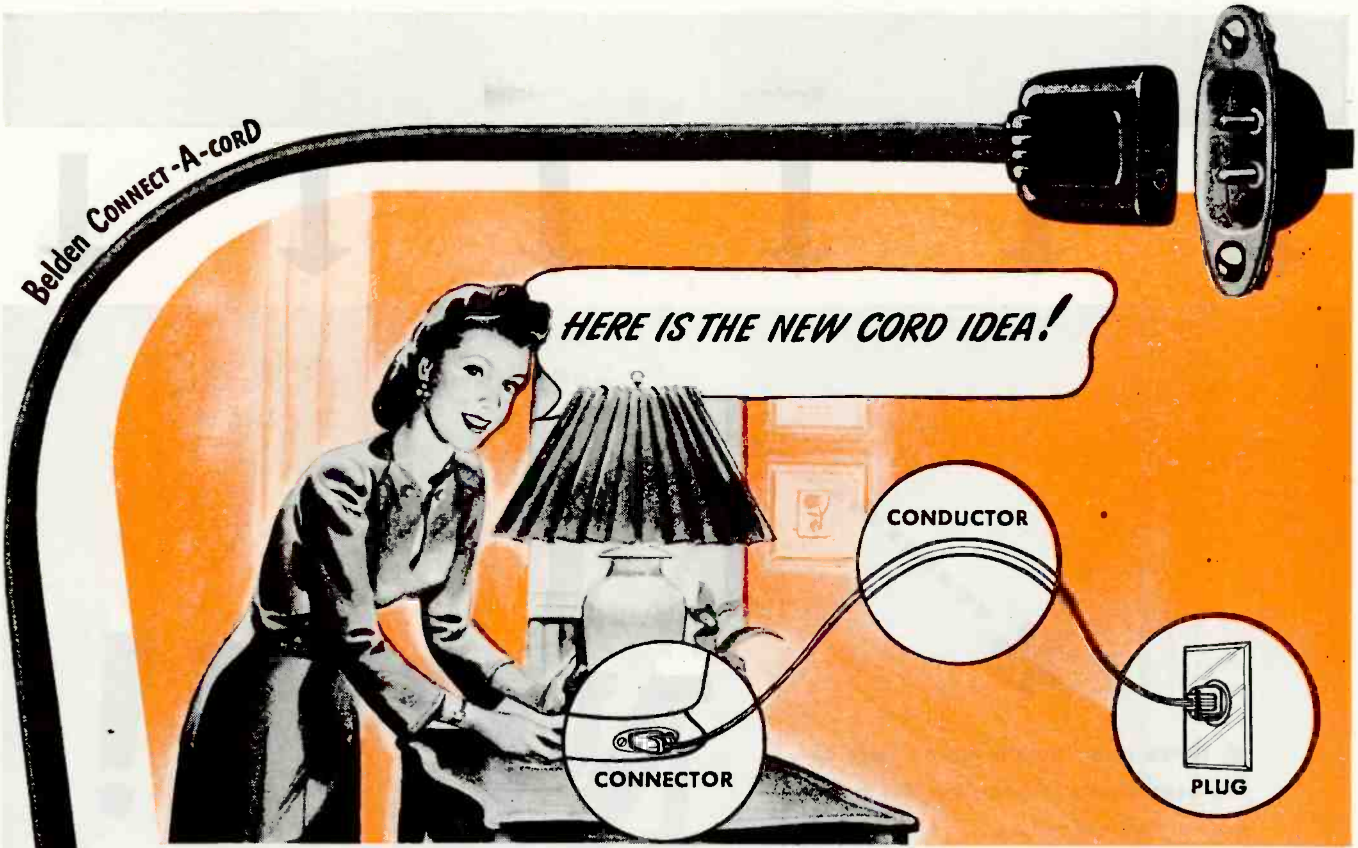
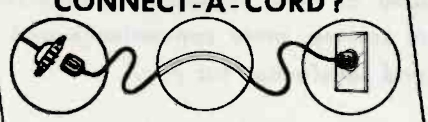


the Belden CONNECT-A-CORD

what is the Belden CONNECT-A-CORD?



CONNECTOR + CONDUCTOR + PLUG

Users want this new advantage—

It's a new idea—still, as a result of a recent survey, 24% of the lamp users were already found to be in favor of the advantages of the Belden Connect-A-corD.

This new Belden product is no "postwar dream." It is already engineered—and only offered after a thorough check which has shown conclusively that your customers want the Belden Connect-A-corD on their better electrical equipment.

FOR ALL YOUR NEWLY DESIGNED APPLIANCES—*Belden Connect-A-corD*

1. Provides a cord for every appliance or tool—detachable at the appliance end as well as the plug end.
2. Available in various lengths and colors to fit any installation.
3. Easy to replace—eliminates dealer cord repair service.
4. Simplifies line assembly operation. Simplifies packing and display.
5. Provides a NEW SALES FEATURE.

There is something new in cords! Belden-developed connectors and appliance outlets make possible the new Belden "Connect-A-corD." Styled to your particular requirements, the Connect-A-corD simplifies cord assembly problems—eliminates dealer complaints due to costly cord service—gives customers new satisfaction in your products.

A worth-while sales feature—promoted by consistent national advertising. Get information on the new Corditis-free Connect-A-corD today.

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

Belden

Corditis-free CORDS

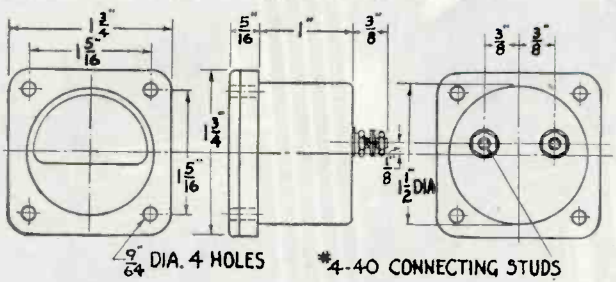
SMALL BUT *STURDY*...

The New Line of ROLLER-SMITH 1½" Panel Instruments

Design and development of this line of 1½" instruments were based on rigid U. S. Army Air Force specifications. They are built to withstand extreme conditions of temperature, humidity, vibration and shock, and immersion tests have demonstrated their ability to withstand a hydrostatic pressure of 14.7 psi.

Roller-Smith 1½" instruments are now available in d-c voltmeters, 1000 ohms per volt, in all practical ranges above 50 millivolts; d-c ammeters in all practical ranges above 500 microamperes. For certain applications instruments can be supplied with ranges below those specified. Correspondence is invited.

When desired, solder lugs can be furnished instead of the connecting studs shown.



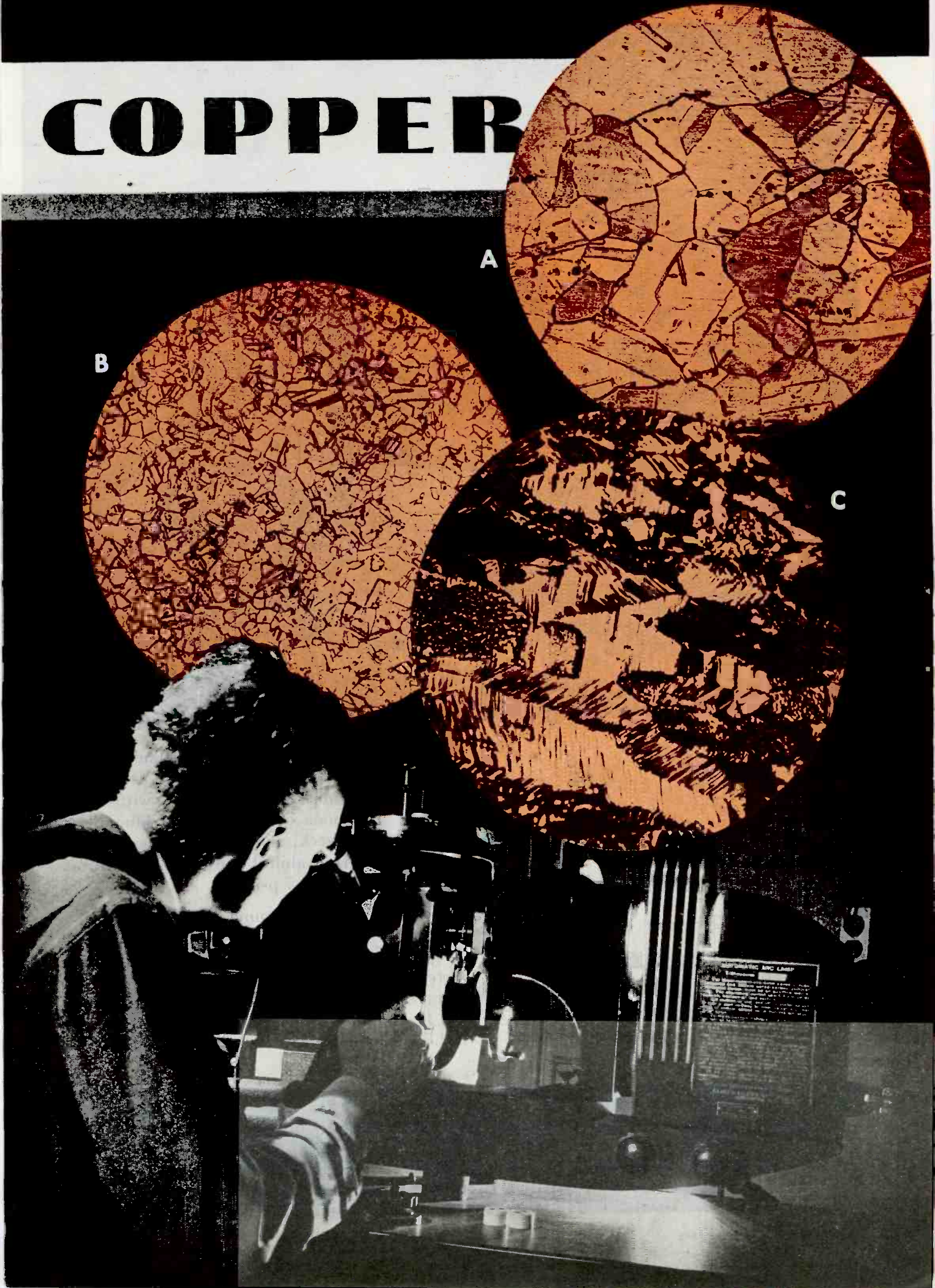
ROLLER-SMITH BETHLEHEM, PENNA.

Canadian Plant: ROLLER-SMITH MARSLAND LTD., Kitchener, Ontario

Sales Representatives in all Principal Cities

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS • AIRCRAFT INSTRUMENTS • PRECISION BALANCES • AIR AND OIL CIRCUIT BREAKERS • ROTARY SWITCHES • SWITCHGEAR • RELAYS

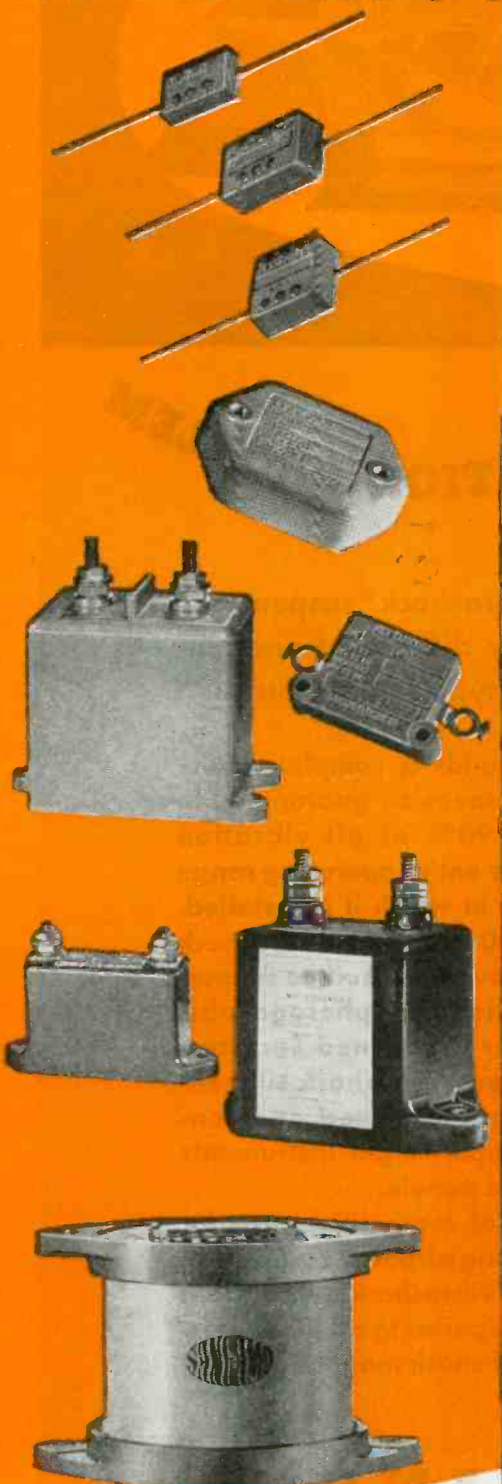
COPPER



BUILT INTO . . . .

Sangamo

MICA CAPACITORS



Mica Punching

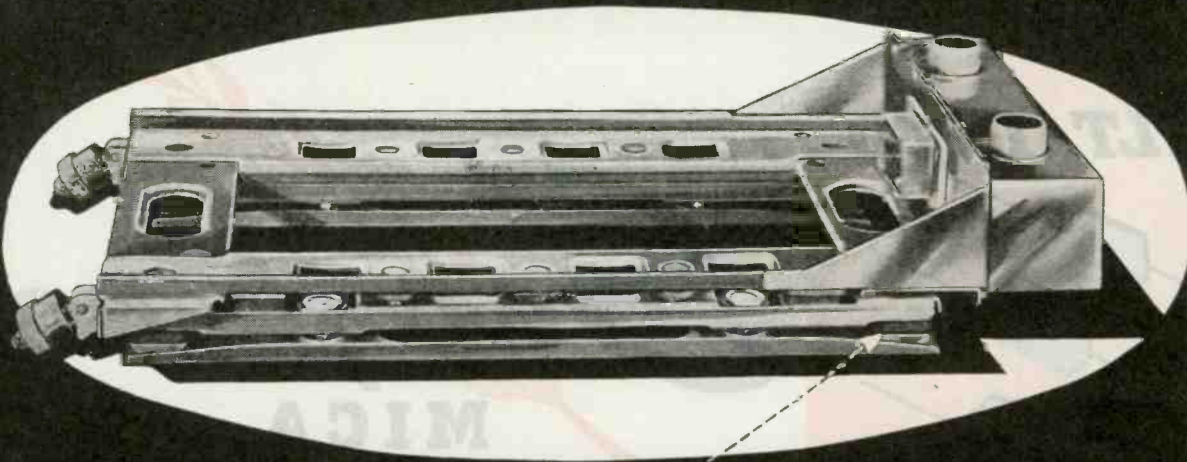
The great number of case sizes in which Sangamo Mica Capacitors are manufactured necessitates a large variety of sizes and shapes of mica films. Mica, as produced in nature, has no semblance of uniformity, consequently it must be fabricated to the desired size and shape. Mica is a hard brittle material requiring the use of specially designed dies to insure a finished film with sharp, clean edges and free from fractures.

Thus, only by maintaining constant vigilance in each of the manufacturing processes, is it possible to produce a capacitor capable of giving long and dependable service under the severe operating conditions encountered by modern electronic equipments.

ARMY E NAVY

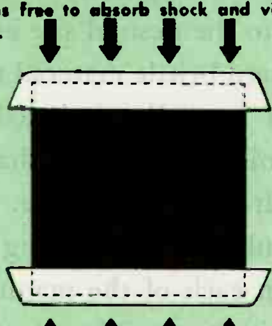
COMPANY SPRINGFIELD ILLINOIS

. . . WATT HOUR METERS . . . TIME SWITCHES . . .

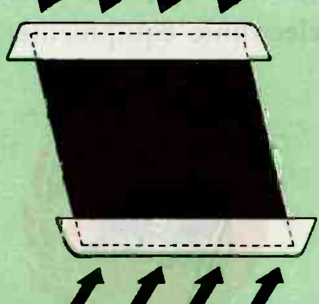


NEW WAY TO LICK YOUR VIBRATION PROBLEM

EIGHT SPECIAL CUSHION BLOCKS of controlled density rubber are arranged for multiple absorption of vibration impulses in *all* directions. Note the curvature at top and bottom of rubber blocks. This curvature disappears under load (see below). This design assures central loading and an even distribution of stress for best absorption results. The cushion is free to absorb shock and vibration from any direction.



VERTICAL DEFLECTION — The uniform distribution of loading over the entire surface of the rubber block eliminates concentrated tensile or shearing stresses. Long service life is thereby assured.



HORIZONTAL DEFLECTION — Because the blocks are free to deflect laterally, vibration and impact loads are easily absorbed. The conventional method of bonding a rubber disc to a metal ring does not provide this horizontal freedom.

Robinson Vibrashock* suspensions are radically different from conventional type shock mounts

Robinson builds a *complete, fully engineered suspension* guaranteed to absorb over 90% of all vibration throughout the entire operating range of the aircraft in which it is installed.

Over 75,000 Robinson Vibrashock suspensions have been built to support airborne radio and photographic equipment for the Armed Services. Other Robinson Vibrashock suspensions are being designed and constructed to support flight instruments and instrument panels.

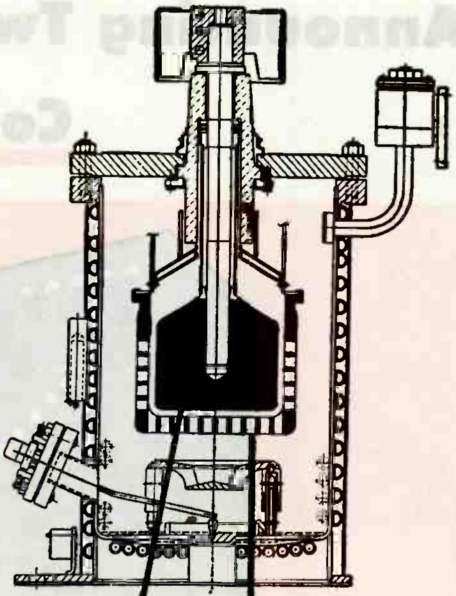
As a result of competitive tests for use in supporting airborne equipment, the Robinson Vibrashock suspensions have proven superior to all other present methods of shock mounting.

*Trade Mark

ROBINSON AVIATION, INC.

730 FIFTH AVENUE, NEW YORK 19, N. Y.
FIRST NATIONAL BUILDING, HOLLYWOOD 28, CALIF.

"Unless you can express it as a *Number* you have no information"



THAT'S AN UNWRITTEN LAW in many laboratories today. Because "National" graphite's purity—*99.979%*—could be expressed as a number, the manufacturer's engineers knew what its performance characteristics would be when used as the anode and anode shield material in this Ignitron Rectifier.

Across the nation, banks of these rectifiers are serving war plants, traction companies, shipyards and mills efficiently and dependably.

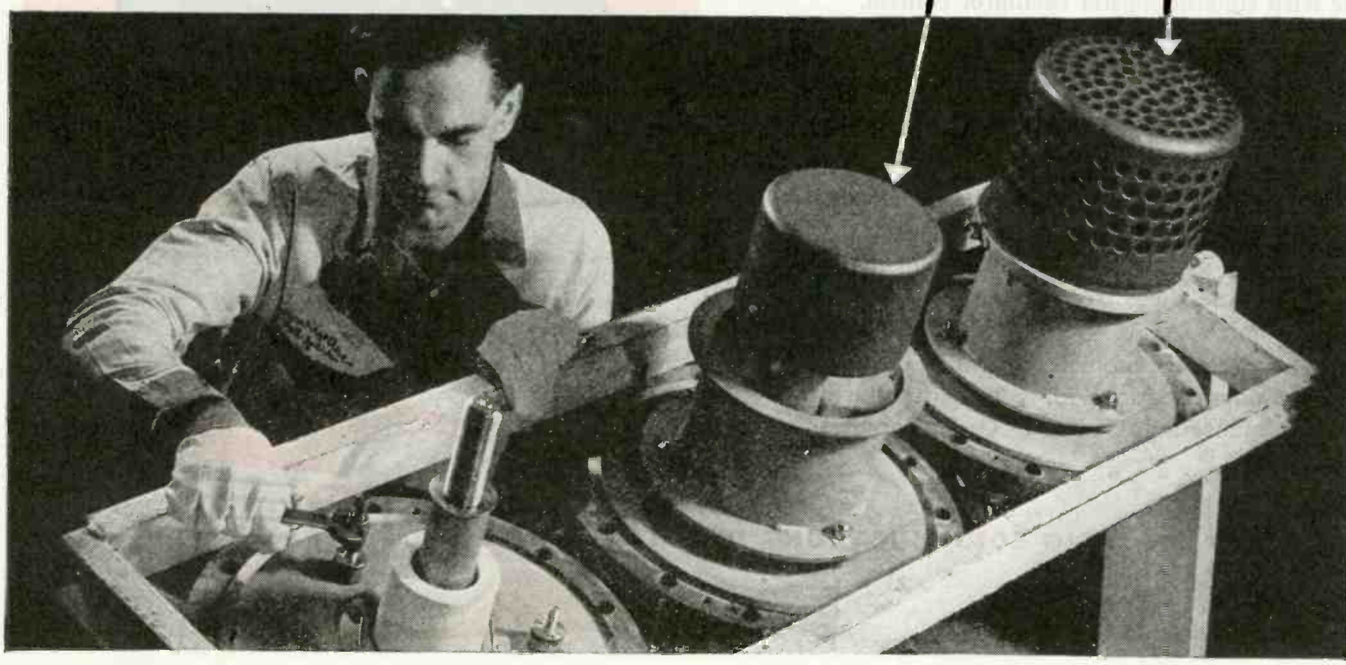
Engineers have long known that graphite does not fuse, soften or warp, and has nearly perfect heat radiation properties. Thus, in many types of both vacuum and gas-filled industrial and radio tubes where great heat must be dissipated, or where warpage of multiple tube components must be prevented, graphite is the ideal material.

As pioneers in the carbon and graphite manufacturing business in America, National Carbon Company has brought to highest perfection the art of making high-purity graphite. That is why "National" High-Purity Graphite is most frequently specified for vital industrial and radio tube components. Graphite of even higher purity is supplied for some applications. We welcome the opportunity to discuss the advantages of this "National" electronic graphite.

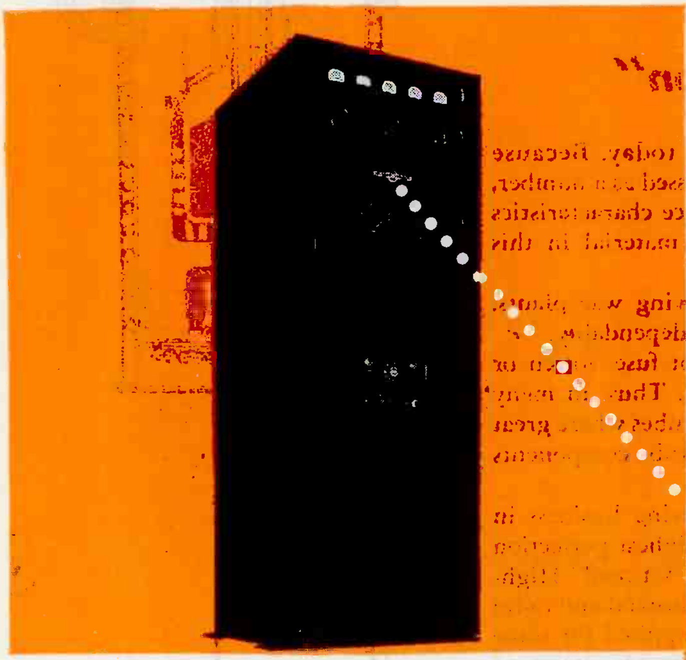
NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC
General Offices: 30 East 42nd Street, New York 17, N. Y.
Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

The registered trade-mark "National" distinguishes products of National Carbon Company, Inc.

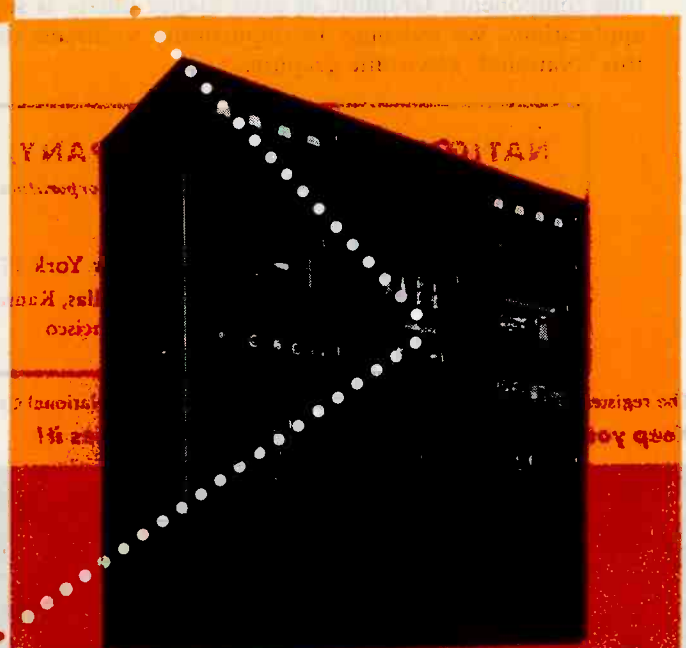
Keep your eye on the infantry . . . the Doughboy does it!



Announcing Two Highly Developed Collins Autotune* Transmitters



Collins 16F-9—Nominal power output: 300 watts phone: 500 watts CW. Frequency range: 2 to 18 mc. Ten quick-shift frequencies.



Collins 231D-13—Nominal power output: 3000 watts phone; 5000 watts CW. Frequency range: 2 to 18 mc. Ten quick-shift frequencies.

IN DESIGN and construction, these transmitters reflect intense engineering endeavor and hard won experience in meeting the requirements of war. The most advanced laboratory refinements are combined with military ruggedness on a production line basis!

The lessons learned since Pearl Harbor have increased the already high reset accuracy and dependability of the Collins Autotune. Any one of ten frequencies is reliably, precisely available at the flip of a dial, from a remote point. The standard models are crystal controlled, and special models are available with tunable master oscillator control.

The physical size of these transmitters has been increased, and components specially Collins re-designed, to increase safety factors throughout.

The renowned Collins pi network matches into a wide variety of single wire or vertical antennas. The 231D-13 also matches into a 600 ohm balanced transmission line from 4 to 18 mc.

Frequency-shift keying is available, making it possible to use these transmitters in printing telegraph circuits.

We will welcome inquiries and an opportunity to make recommendations for your particular application. Collins Radio Company, Cedar Rapids, Iowa.

*The Collins Autotune is a repositioning mechanism which quick-shifts all tuning controls simultaneously and with extreme precision to any one of a number of pre-selected frequencies. Patents issued and pending in the U. S. A. and other countries.

IN RADIO COMMUNICATIONS, IT'S . . . COLLINS

ARMY E NAVY

Endorsed from coast to coast

FOR AM COMMUNICATION AND POLICE RADIO WORK

Types GL-159 and GL-169. Price $60 each. Medium power high-vacuum triodes for Class B and C service.

These G-E tubes are strong links in your chain of equipment for dependable transmission

Tantalum anodes used in the GL-159 and GL-169—three-electrode tubes with medium frequency and power ratings—are more durable than other types at high temperatures, and permit greater dissipation per unit of area. This feature is one of many advancements in the design and construction of these popular amplifiers, enabling them to render the kind of efficient service on which you can bank under all conditions.

Types GL-159 and GL-169 are exceptionally easy to mount. Another advantage is their medium size and ratings, the two tubes being similar in characteristics except for the amplification factor, which is 20 for the GL-159, 85 for the GL-169. Filament voltage and current are 10 v and 9.60 amp. The GL-159 is principally employed in Class C service, with maximum plate ratings of 2,000 v and 0.4 amp—plate input 800 w, dissipation 250 w. Highest frequency at maximum plate input is 15 megacycles; at 50 percent plate input, 35 megacycles.

The GL-169 is designed primarily for Class B audio-frequency service, with an output for two tubes up to 900 w. For such service the maximum ratings per tube are: d-c plate voltage 2,000 v, signal current 0.4 amp; d-c signal plate input 750 w, dissipation 250 w.

Thus these tubes meet ideally the needs of communication, police radio, or other work which employs AM equipment. A price of $60, made possible by large-scale production in the world's most modern tube factory, spells high dollar-value. Check with your nearest G-E office or distributor for detailed information on these or other transmitting tubes in the G-E complete line. Or write *Electronics Department, General Electric, Schenectady 5, New York.*

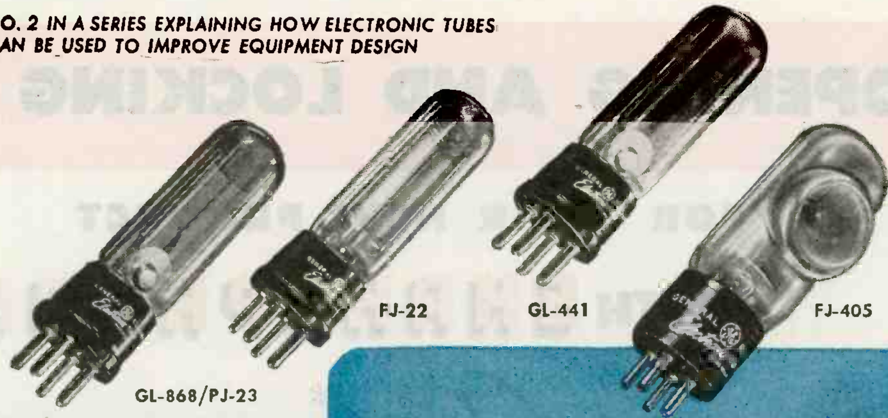
Hear the G-E radio programs: "The World Today" news, Monday through Friday, 6:45 p. m., EWT, CBS. "The G-E All-Girl Orchestra," Sunday 10 p. m., EWT, NBC. "The G-E Houseparty," Monday through Friday, 4 p. m., EWT, CBS.

GENERAL ELECTRIC

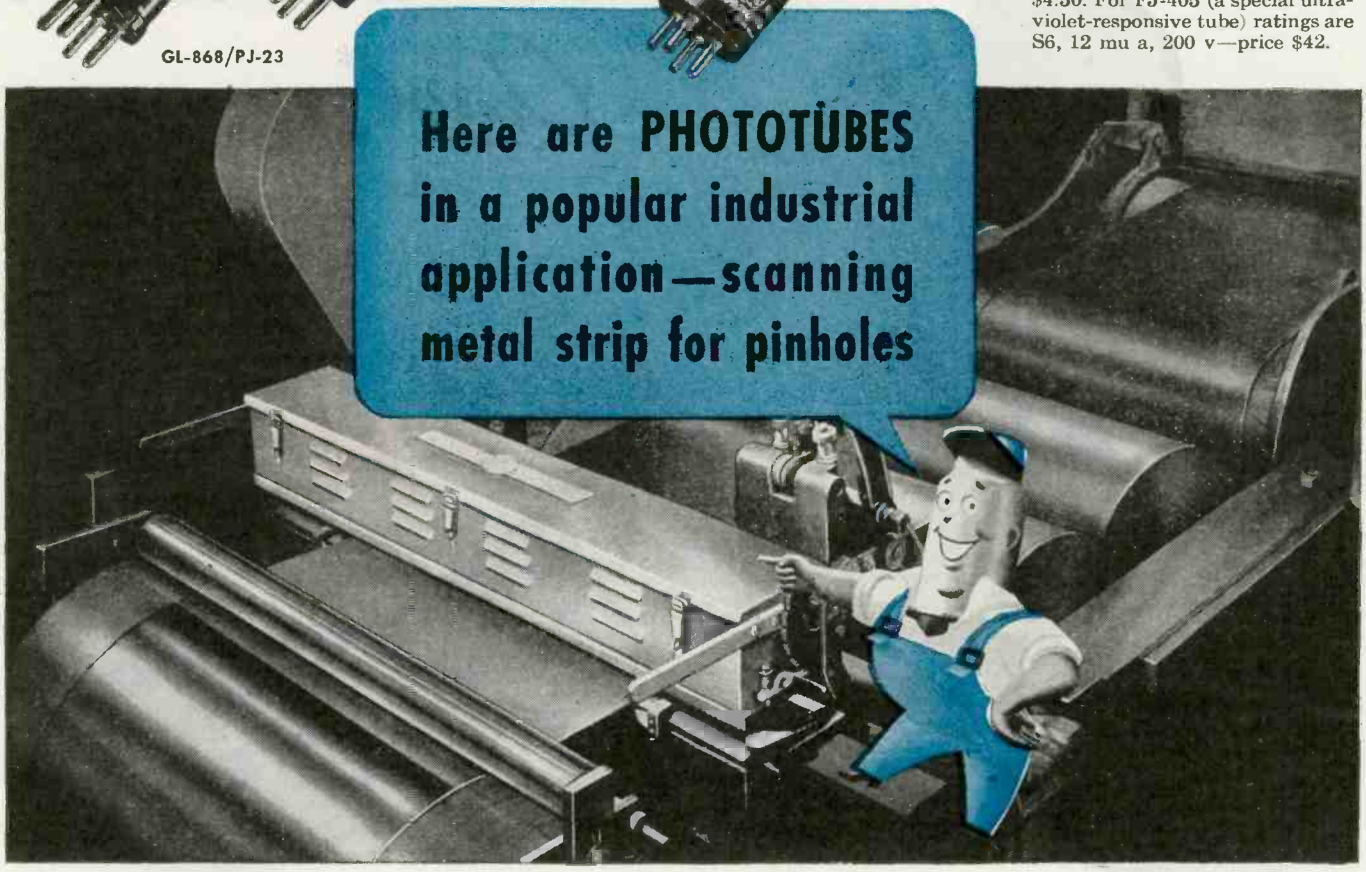
161-02-8850


The TINYMITE
SMALLEST PAPER CAPACITOR - - -
yet 100%
MOISTUREPROOF
TYPE P5N
TYPE P4N
FEATURES
1. Bakelite Resinoid Ends. Lead wire cannot pull out, even under hot conditions.
2. Non-Inductive.
3. Excellent Temperature Coefficient.
4. Very high leakage Resistance.
5. Fine Power-Factor.
6. Range from 20 MMFD to .25 MFD. From 150 volts to 600 volts.
7. Types P4N, P5N for 100% humidity operation.
8. Types P4, P5 for 95% humidity operation.
Samples and price list on Request
BUY EXTRA WAR BONDS . . .
. . . 'TIL THE WAR IS OVER
Pat. Pend.
DUMONT
ELECTRIC CO.
MFR'S OF
CAPACITORS FOR EVERY REQUIREMENT
34 HUBERT STREET NEW YORK, N. Y.

NO. 2 IN A SERIES EXPLAINING HOW ELECTRONIC TUBES CAN BE USED TO IMPROVE EQUIPMENT DESIGN



GL-868/PJ-23 is gas-filled and the others vacuum types. Spectral response of GL-868/PJ-23 (R. M. A. standard) is S1, sensitivity to light 90 microamperes per lumen, anode voltage 100—price $2.60. For PJ-22 the same ratings in order are S1, 20 mu a, 500 v—price $2.60. For GL-441 ratings are S4, 45 mu a, 250 v—price $4.50. For FJ-405 (a special ultra-violet-responsive tube) ratings are S6, 12 mu a, 200 v—price $42.



These G-E tubes that "see" will do scores of automatic jobs faster — more accurately — more reliably — at lower cost

When your designing staff is faced with a problem that involves grading product for size, counting or sorting manufactured articles coming off the line, positioning material being fed into machines, or doing rapidly and infallibly other work which calls for properties of visual selection, then it is time to check into phototubes as the best and most practical method of handling the job.

Wherever the interruption of a beam of visible or invisible light can be made to have functional meaning, phototubes may be used to initiate the operation of control apparatus. Jobs such as aligning paper on presses for accurate register, signaling content-levels in bins or tanks, sounding alarms when moving equipment exceeds safe limits of travel—these call for phototubes as the fastest-operating, most practical and reliable method of doing the work.

Consult General Electric on phototube applications and circuits for greater efficiency and economy in the operation of your equipment. Your nearest G-E office or distributor will supply information on phototubes or other industrial electronic tubes. Also ask for "How Electronic Tubes Work," a non-technical booklet on industrial tubes and their applications. *Electronics Department, General Electric, Schenectady 5, N. Y.*

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

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

GENERAL ELECTRIC

162-D4-8850

Illustrated about 3 times larger than actual size

Santay's Precision Craftsmanship Scores Again!.. The maximum wall thickness of this little coil form is only .008 inch! Just imagine! Only twice as thick as the paper this ad is printed on!

Santay's Precision Craftsmanship has scored again in producing this delicate coil form for the Zenith Radio Corporation. It is used in making their Hearing Aid. The ability to build molds is one of the most important factors in producing such intricate thermoplastic parts successfully. Santay engineers design and build all their own molds.

Santay could possibly do something equally fine for you—not right now of course. because all of Santay's facilities are being devoted to the war effort. However, we would like to honor your post-war problem or inquiry now.

INJECTION MOLDING • METAL STAMPING • ELECTRO-MECHANICAL ASSEMBLIES

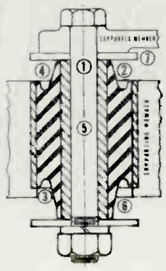
SANTAY CORPORATION 351-359 N. CRAWFORD AVE., CHICAGO 24, ILLINOIS

FORMERLY SINKO TOOL & MANUFACTURING CO.

REPRESENTATIVES: POTTER & DUGAN, INC., 29 WILKESON STREET, BUFFALO 2, NEW YORK • PAUL SEILER, 7775 CORTLAND AVENUE, DETROIT 4, MICHIGAN • QUEISSER BROS., 108 E. NINTH STREET, INDIANAPOLIS 2, INDIANA

For Better Control of Vibration

LORD
SHEAR TYPE
Bonded Rubber
MOUNTINGS



TUBE FORM

1. **End Extensions**—Provide clearance between the metal members for free movement in shear.
2. **End Shape**—Throws flexing action away from the metal parts into the rubber body, preventing stress concentration at the edge of the bond.
3. **Rubber-to-Metal Bond**—Lord Methods produce a high ratio of bond strength to working stress, resulting in a large factor of safety.
4. **Rubber Compounds**—Developed particularly for shear type mountings and may be changed in properties to suit a wide range of conditions.
5. **Center Sleeve**—Dimensions may be changed to meet any unique installation conditions.
6. **Sound**—Use of Lord mountings eliminates noise normally transmitted through solid metallic paths.
7. **Safety**—Metal washers, installed as shown, limit movement under ordinary overload or shock. If excessive overloads cause the rubber to fail, the suspended member will not be released without breaking one of the metal parts.

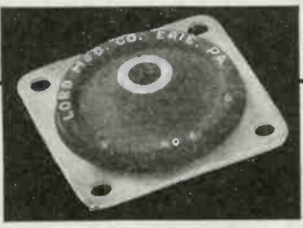
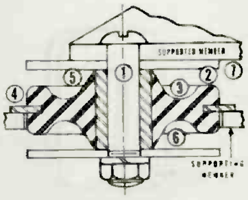


PLATE FORM



1. **End Extensions**—Provide clearance between center metal member and rubber Snubbing Shoulders for free movement in shear.
2. **Snubbing Shoulders**—Arrest shock movement and supply a cushioned stop on contact with metal washers.
3. **End Shape**—Throws flexing action away from metal parts into the rubber body, preventing stress concentration at the bond.
4. **Rubber-to-Metal Bond**—Lord Methods produce a high ratio of bond strength to working stress, resulting in an ample factor of safety.
5. **Rubber Compounds**—Developed particularly for shear type mountings may be changed in thickness of body and in properties to suit a wide range of conditions.
6. **Sound**—Use of Lord mountings eliminates noise normally transmitted through solid metallic paths.
7. **Safety**—Metal washers, installed as shown, make up an inter-locking system of metal parts, which limit and cushion excessive movement under conditions of overload or shock.

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

Lord's *Bonded Rubber* Shear Type Mountings embody many exclusive patented features available only in Lord Mountings. Typical methods of installation and design features are shown above. Lord's special bonding process insures a bond between rubber and metal that is as strong or stronger than the rubber itself. The contour of the rubber element is designed to throw flexing action away from the metal parts into the rubber body, preventing concentration of stress at the edge of the bond. Countless formulae developed through years of experience and scientific control of compounding methods enable Lord to produce a rubber body with the exact degree of stiffness and other qualities needed for the job the mounting is required to perform. Lord's bonding process leaves the rubber body in a natural state of rest, with no "built-in" stresses of tension, compression or torque, to detract from its full potential in combatting the forces of vibration over a long service life.

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

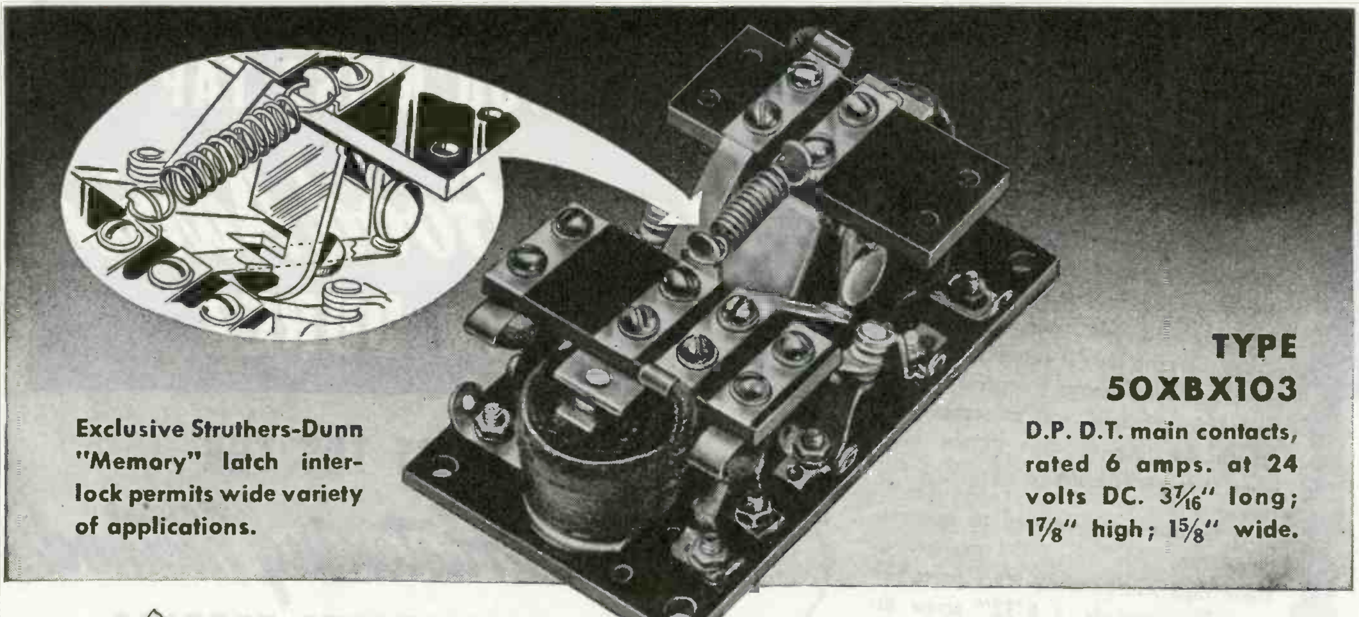
BUY EXTRA WAR BONDS

IT TAKES BONDED 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



A New Struthers-Dunn
"MEMORY" RELAY SERIES

Simplified Interlock—Symmetrical Design

Sturdily constructed to aviation specifications, and of immensely simplified design, Series 50XBX 2-coil Relays are an important addition to the well-known line of Struthers-Dunn "Memory" types. A new style positive interlock between the two symmetrical operating elements represents latch-in relay construction in its simplest, most dependable form. This latch requires no extraneous parts other than integral extensions of the sturdy coil "armatures" themselves. It operates positively from a momentary impulse and a minimum of power. Application of power to one coil latches the contacts into one position. Power then applied to the other coil throws the contacts into a latched-in second position.

A third "unlatched" position, valuable for certain applications, can be obtained by energizing both coils simultaneously.

The 50XBX design makes it easy to obtain make-before-break, or break-before-make contact combinations. Contacts do not interrupt the coil circuit until the "throw" is entirely completed and contacts are locked in the new position.

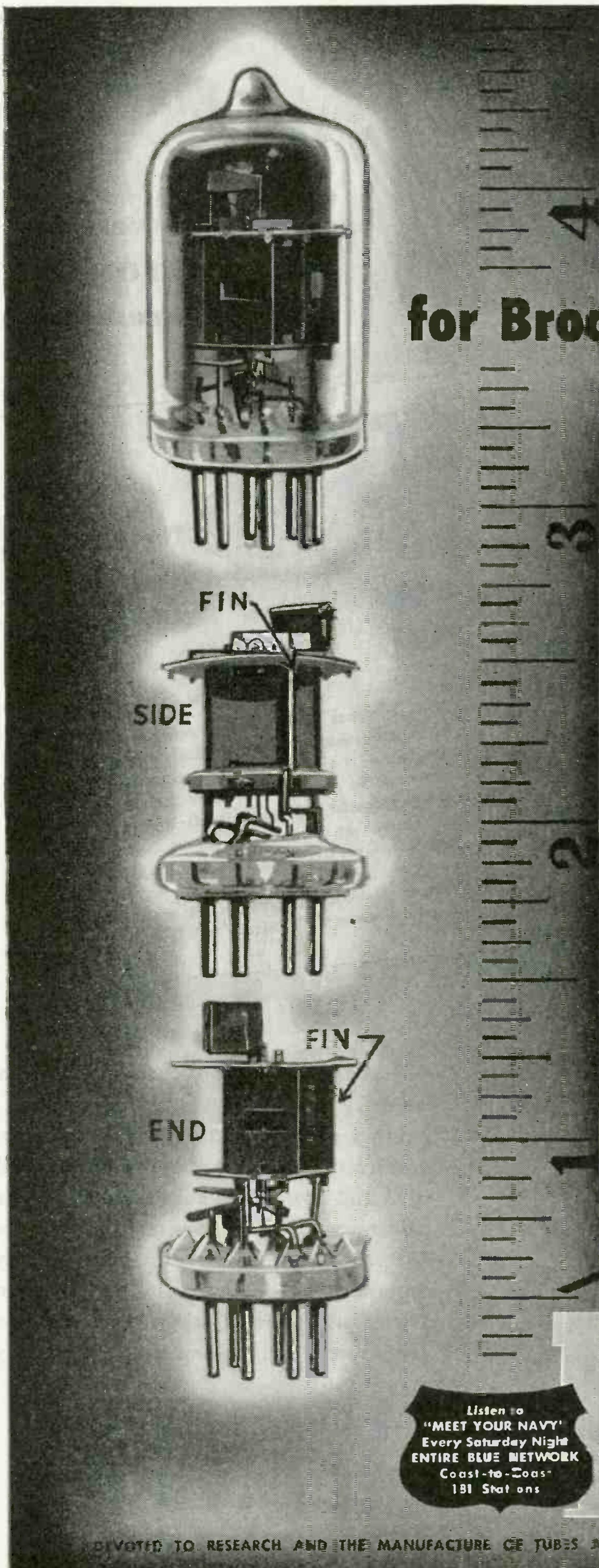
Struthers-Dunn Memory Relays of this general type are produced in ratings from 6 to 200 amperes or more, and with practically any desired contact arrangement. Standard types provide for two auxiliary contacts, one in each coil circuit. The use of auxiliary contacts makes it possible to obtain operation over an extremely wide range of voltages, a-c or d-c.

STRUTHERS-DUNN, INC., 1321 Arch Street, Philadelphia 7, Pa.

STRUTHERS-DUNN

5,288 RELAY TYPES

DISTRICT ENGINEERING OFFICES: ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DENVER • DETROIT • HARTFORD INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL • NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO • WASHINGTON



RAYTHEON 6AK5

for Broad-Band Amplifiers

in the high and ultra-high frequency regions

For several years Raytheon has been producing for the government a miniature pentode tube so compact and so outstanding in performance that it should be carefully considered by engineers designing future FM, television and amateur equipment.

Interelectrode spacings and element size have been so greatly reduced that the 6AK5 combines the desirable features of low input and output capacitance with high transconductance, reduced lead inductances and lower transit time losses.

It is obvious that "split-hair precision" is required to manufacture the 6AK5, for the distance between the control grid and the cathode is .0035 in.—and the grid is wound with tungsten wire whose diameter is *a fraction of that of a human hair.*

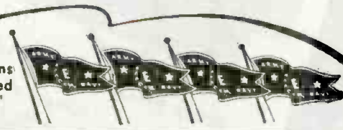
The 6AK5 is just one example of Raytheon's outstanding ability to build fine tubes for important military use—ability that will be equally evident in the postwar products of the radio and electronics industry.

Specifications of 6AK5

Maximum Diameter		¾	inches
Maximum Seated Height		1¾	inches
Filament Voltage	6.3	6.3	volts
Filament Current	0.175	0.175	amperes
Plate Voltage	180	120	volts
Screen Voltage	120	120	volts
Control Grid Bias	—2	—2	volts
Plate Current	7.7	7.5	ma
Screen Current	2.4	2.5	ma
Transconductance	5100	5000	umhos
Control Grid to Plate Capacitance*		0.01	μμf
Input Capacitance*		4.0	μμf
Output Capacitance*		2.8	μμf

**Using RMA Miniature Shield*

All Four Divisions Have Been Awarded Army-Navy "E" with Stars



RAYTHEON

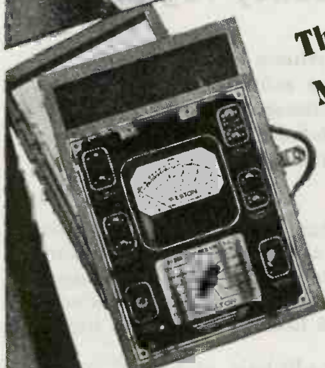
RADIO RECEIVING TUBE DIVISION

Newton, Mass. · Los Angeles · New York · Chicago · Atlanta

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

Simplify TEST PROCEDURE

with these versatile WESTON Test Instruments.



The Multi-Purpose, Super-Sensitive Analyzer
(MODEL 772)

A compact and practical wide-purpose instrument with sensitivity of 20,000 ohms per volt, on dc ranges.

• volt, or 1000 ohms per

Ranges – all self-contained

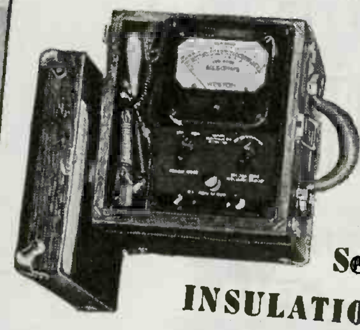
Voltage, a-c and d-c – 0-1000/250/50/10/2.5.

Current, d-c – 0-10/1 amps. – 0-250/50/10/1 milliamps. and 100 microamps.

Ohms – Full Scale – 30/3 megohms – 30,000/3000 ohms. Center Scale – 250,000/25,000/250/25 ohms.

Decibels – –14 to +2, –2 to +14, +12 to +28, +26 to +42, +38 to +54.

(Voltages up to 5000 dc available through use of external WESTON Televerter, Model 766.)



The Direct-Reading, Self-Contained INSULATION TESTER
(MODEL 796)

This compact direct-reading resistance tester eliminates hand cranking and thus makes leakage testing a simple one-man job especially in unaccessable places. Tests up to 200 megohms at test potential of 350 to 500 volts d-c; although, the current at terminals is only a few microamperes. Operates from long life, light-weight batteries. There are no vibrators to replace. Ranges: 0-20-300 megohms full scale; 0-.5-5 megohms center scale. Size 8" x 9⅛" x 8".

The Industrial Circuit Tester
(MODEL 785)

Recognized as the most complete unit for routine maintenance tests, and for testing needs which require an ultra-sensitive instrument.

Ranges all self-contained

D-C VOLTAGE . . . Six Full Scale Ranges of: 1/10/50/200/500/1000 volts (20,000 Ohms per volt).

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D-C CURRENT . . . Six Full Scale Ranges of: 50 Microamps . . . 1/10/100 Milliamps. . . . 1/10 Amps. (Higher ranges, at half scale reading, with 100 mv. external shunts).

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RESISTANCE . . . Five Full Scale Ranges of: 3,000/30,000/300,000 Ohms . . . 3/30 Megohms. Center Scale Values . . . 25/250/2,500/25,000/250,000 Ohms. (Self-Contained Batteries)

With production currently running slightly ahead of war requirements, a limited number of the popular WESTON test instruments shown herewith are available and are offered subject to prior sale. Orders can be placed direct, or with the WESTON representative in your vicinity. Literature available from... WESTON Electrical Instrument Corporation, 578 Frelinghuysen Avenue, Newark 5, New Jersey.

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INSTRUMENTS

LOOK to G.E. for help in meeting those urgent production schedules. Right now our expanded facilities for fabricating G-E mycalex parts are ready to take on the job of assisting you. We can supply G-E mycalex parts more quickly, supply them in large or small quantities and, most important, make them exactly to your specifications.

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Act now to step up production speed. Your inquiry on G-E mycalex parts and fabrication facilities will receive prompt attention. We will be glad to quote prices and delivery dates on the parts you need.

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FREE—
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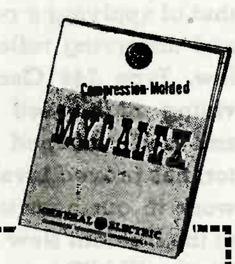

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GENERAL ELECTRIC
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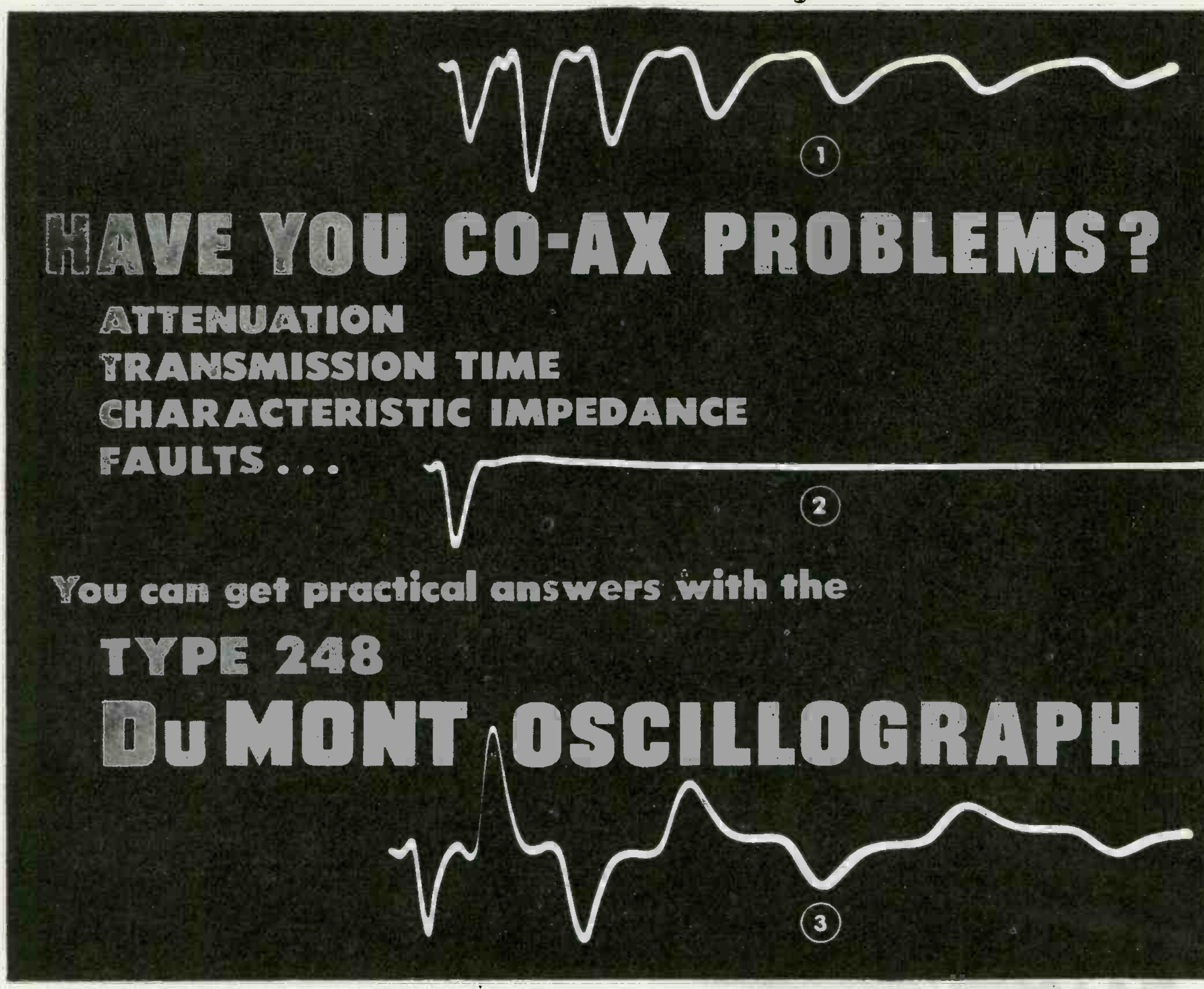
Over 21 Years of MYCALEX Experience—Your Assurance of Quality!

GENERAL ELECTRIC

168-D1



➧ The quickest method for determining co-ax line characteristics is that of applying a pulse to one end and observing reflections that follow. Type 248 Oscillograph, providing high-speed driven sweep and self-contained pulse generator, has proved invaluable for such work in our own laboratories and at the DuMont New York Television Station WABD.

Oscillograms herewith are typical of those obtained when testing a 200- or 300-foot 75-ohm cable, indicating respectively: (1) Reflections from an open-circuited far end; (2) The absence of reflections following the initial negative pulse, when line is correctly terminated; and (3) Reflections of reversed polarity from a shorted far end. (In each case the pulses are viewed at sending end, which is terminated in a resistance much greater than 75 ohms.)

Transmission time can of course be immediately determined from interval between reflections, using 1 or 10 microsecond markers available from oscillograph's timing circuit. Reflections illustrated are approximately 1 microsecond apart. Attenuation can be calculated from difference in height of successive peaks.

Proper terminating impedance can be found by varying resistance across receiving end until no reflections are visible. This resistance when measured gives characteristic impedance of cable very accurately. Any discontinuities along line give reflections indicating locations and natures of faults by their spacing and polarities.

➧ **Write for literature . . .**

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Versatile **dag** dispersions of colloidal graphite can help you cure headaches like these:

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In shops and laboratories, by experimenters and by manufacturers these Centralab switches are becoming increasingly popular.
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These Centralab switches are available in ten different combinations including positive and spring return action types with either shorting or non-shorting contacts.
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Division of GLOBE-UNION INC., Milwaukee
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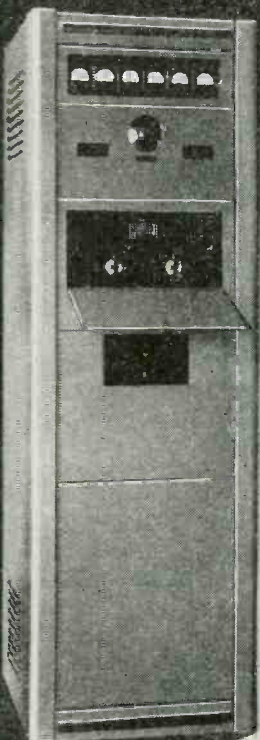

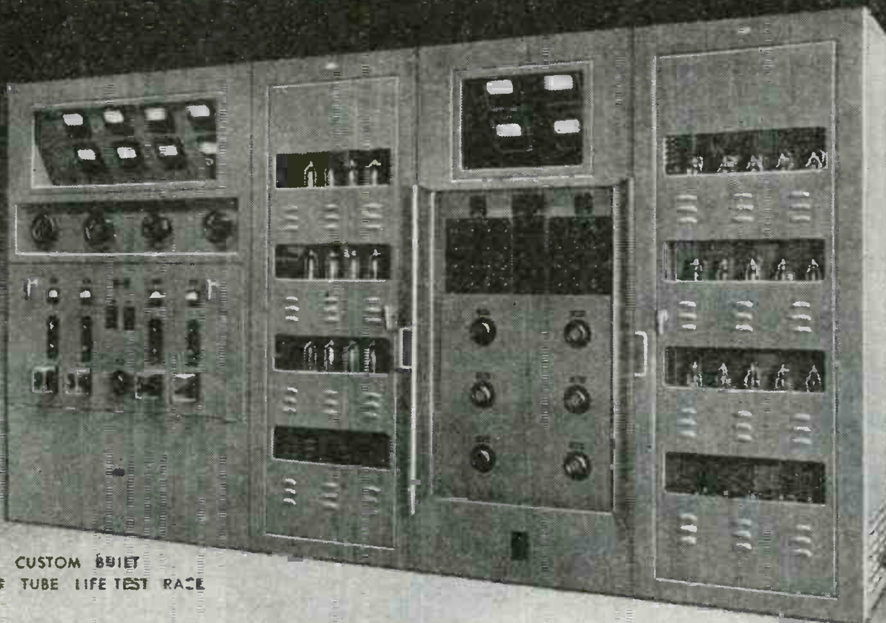

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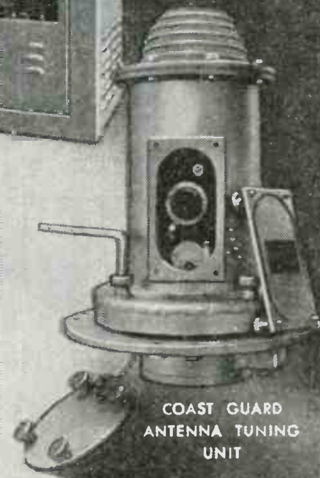

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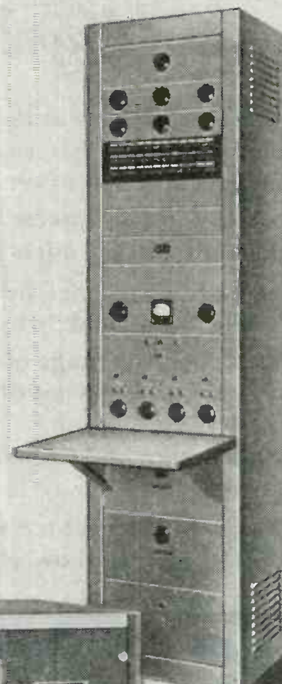

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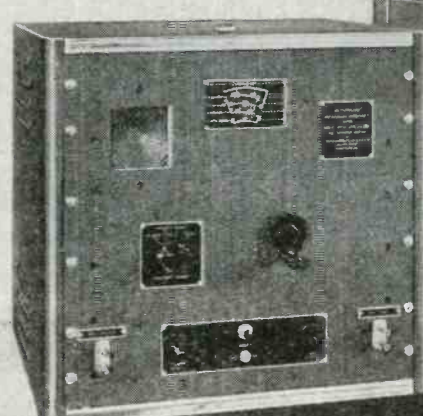

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Send for this free sample card containing 8 standard sizes of grommets

SEVEN SPECIAL ADVANTAGES

1. All edges are chamfered.
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6. All threads are clean and lubricated.
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The new larger sizes range up to ½" inside diameter. Like the smaller sizes, they are 100% phenolic plastic, and will not "pop out" when you pack wires through them snugly. This sure, speedy assembly is why they cost less in the long run.

CREATIVE GROMMETS ARE IN STOCK AT:

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For special size Grommets in quantity or Creative's custom work without molds, contact factory or the following direct factory representatives:

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"As manufacturers of transportation equipment we are constantly alert for the new developments that mean advancement and progress. We look for factors of efficiency, safety and comfort, and any development that provides these factors is a definite step forward. It would seem that..."

"VIBRATOR POWER SUPPLIES MAKE A VITAL CONTRIBUTION TO PROGRESS"

Mr. MacEnulty, Vibrator Power Supplies are truly contributing not only to the transportation industry but to many other industries as well. Wherever direct current must be changed in voltage, or to alternating current, for fluorescent lighting or other applications they have proved their advantages. They offer efficiency, versatility and economy in current conversion; and as they are now serving the armed forces with dependability, so in the electronic and electrical era of tomorrow, they will benefit many fields: Transit, railroad, aviation, marine, radio, electronic and electrical, and will have many individual applications within those fields for power outputs of up to 1000 watts.

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Model S-1050 is a typical military model Vibrator Power Supply which may easily be adapted for peacetime mobile radio transmitters. Input voltage: 12 or 24 volts DC. Output voltage: 475 volts DC at 200 MA, 8 volts DC at 4.5 MA. Dimensions: 9½ x 8⅜ x 13 13/16 inches. Weight: 52 pounds.

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...matching the skill of fine watchmaking

Each step in producing Western brass or other copper base alloys requires the pains-taking precision that is used in making time-pieces of finest accuracy.

The temper you specify, the tolerances, the finish, will be supplied *as ordered*—in sheet, strip, long coils or stamped parts. Western mills at East Alton, Ill., and New Haven, Conn., *produce* that way.

We have the facilities, the experience, the skill, and most important, the *desire*. Those four factors comprise a valuable combination. That combination is faithfully serving America at war, but the capacity of Western mills is such that we may be able to serve you, too, now or later. Specify Western on your next order for copper-alloy metals.

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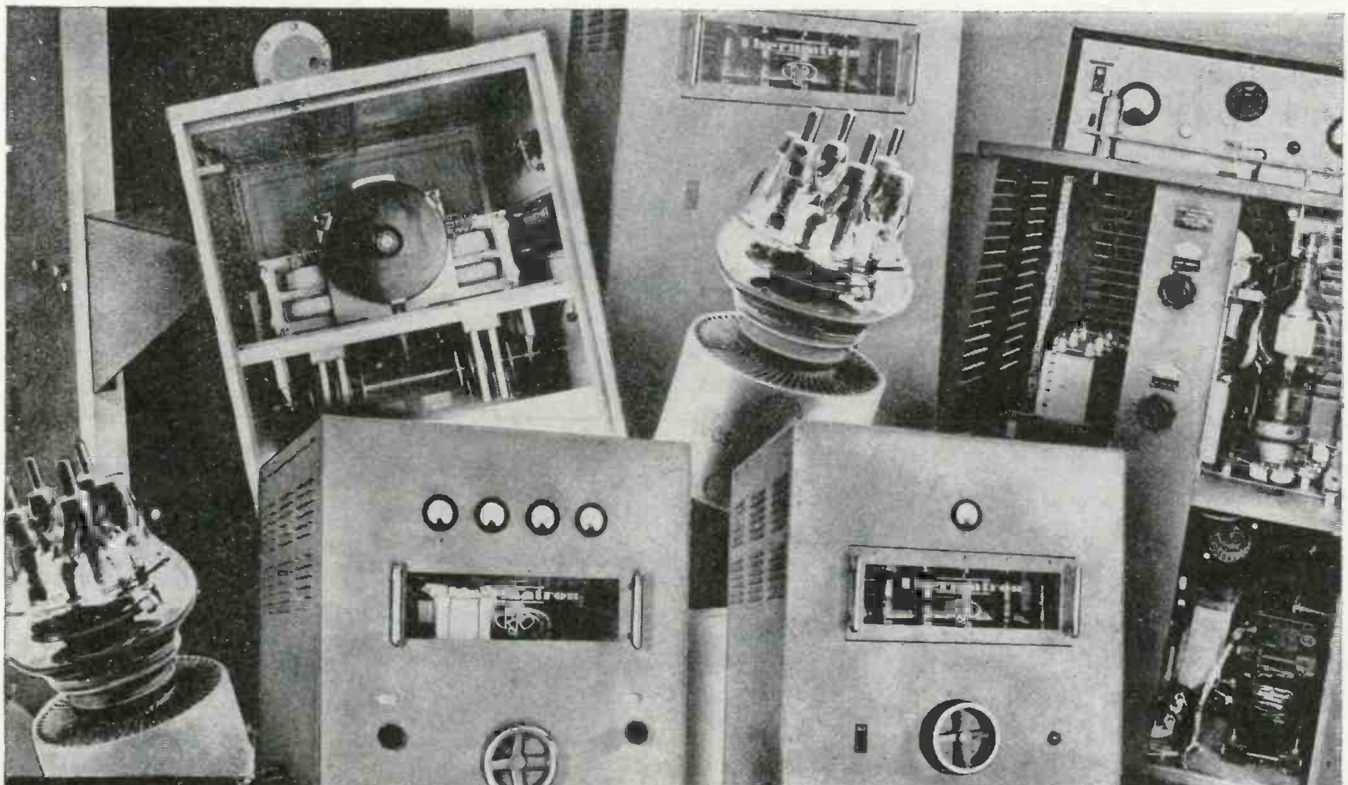

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ELECTRONIC HIGH FREQUENCY HEATERS

THERMATRON internal heat generation, designed and perfected by *Radio Receptor* engineers, opens up new vistas for the processing of many diversified types of materials, including . . .

Plastics
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Radio Receptor engineers supervise THERMATRON installation without charge. Field engineers make periodic check-ups, and emergency service is available on a nation-wide basis. Advice and consultation on present or projected applications freely available.

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Thermatron Division

RADIO RECEPTOR COMPANY, Inc.
251 WEST 19th STREET **NEW YORK 11, N.Y.**

SINCE 1922 IN RADIO AND ELECTRONICS

they said

it couldn't

be done . . .

and again . . .

THEY SAID

IT COULDN'T

BE DONE . . .

Hytron's telescoping of receiving tubes to BANTAM GT size was at first considered impracticable. Development of the BANTAM JR. was another impossibility to be proved possible. This first sub-miniature was a tiny tube whose diameter was about that of your little finger — and it was a pentode at that! As a production tube it just didn't seem to make sense.

Encouraged by hearing-aid manufacturers eager to gain the additional sensitivity of the vacuum tube, Hytron sweated it out for two long years. Operators were trained to assemble the minute parts under magnifying glasses. A simple reversal of the conventional stem made baseless tubes possible. Problems of obtaining suitable vacuum with such small bulbs, were licked.

Finally in 1938, Hytron introduced the first successful sub-miniature. Tiny but rugged despite a hair-like filament and a diminutive mount structure, its low current drain and compactness made the BANTAM JR. a natural for all kinds of portable equipment, hearing aids, and military electronic devices. After the war, watch for even smaller and better Hytron sub-miniatures.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

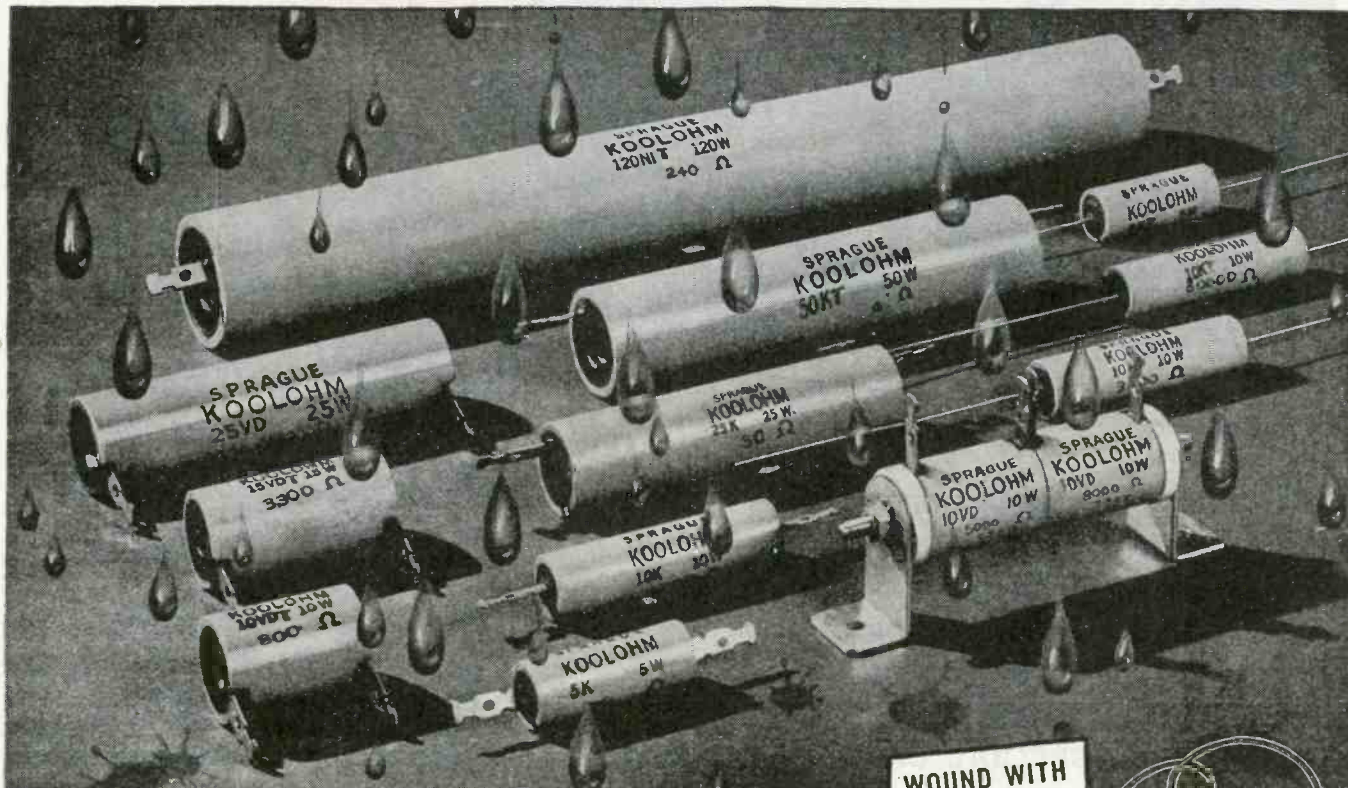
SALEM AND NEWBURYPORT, MASS.

HYTRON RADIO TUBES

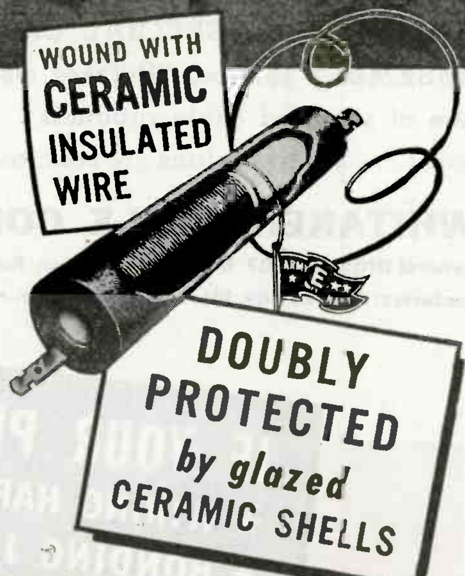
ARMY E NAVY

BUY ANOTHER WAR BOND

Now! EXTRA HUMIDITY PROTECTION IS STANDARD



. . . designed for tropical conditions
. . . unbeatable on ANY job



Standard Sprague Koolohm Wire Wound Resistors now offer the same high degree of humidity protection formerly obtainable only on special order to match exacting military specifications. This construction, newly adopted as standard, includes a glazed ceramic outer shell and a new type of end seal. These features give maximum protection against even the most severe tropical humidity conditions. Type numbers remain the same except for the fact that the letter "T" has been added to designate the new standard construction.

Thus, again, Sprague leads the way in practical, truly modern wire wound resistor construction. Your job of resistor selection is greatly simplified. No need to study and choose between types or coatings. One type of Koolohms, the *standard* type, does the job—under any climatic condition, anywhere in the world!

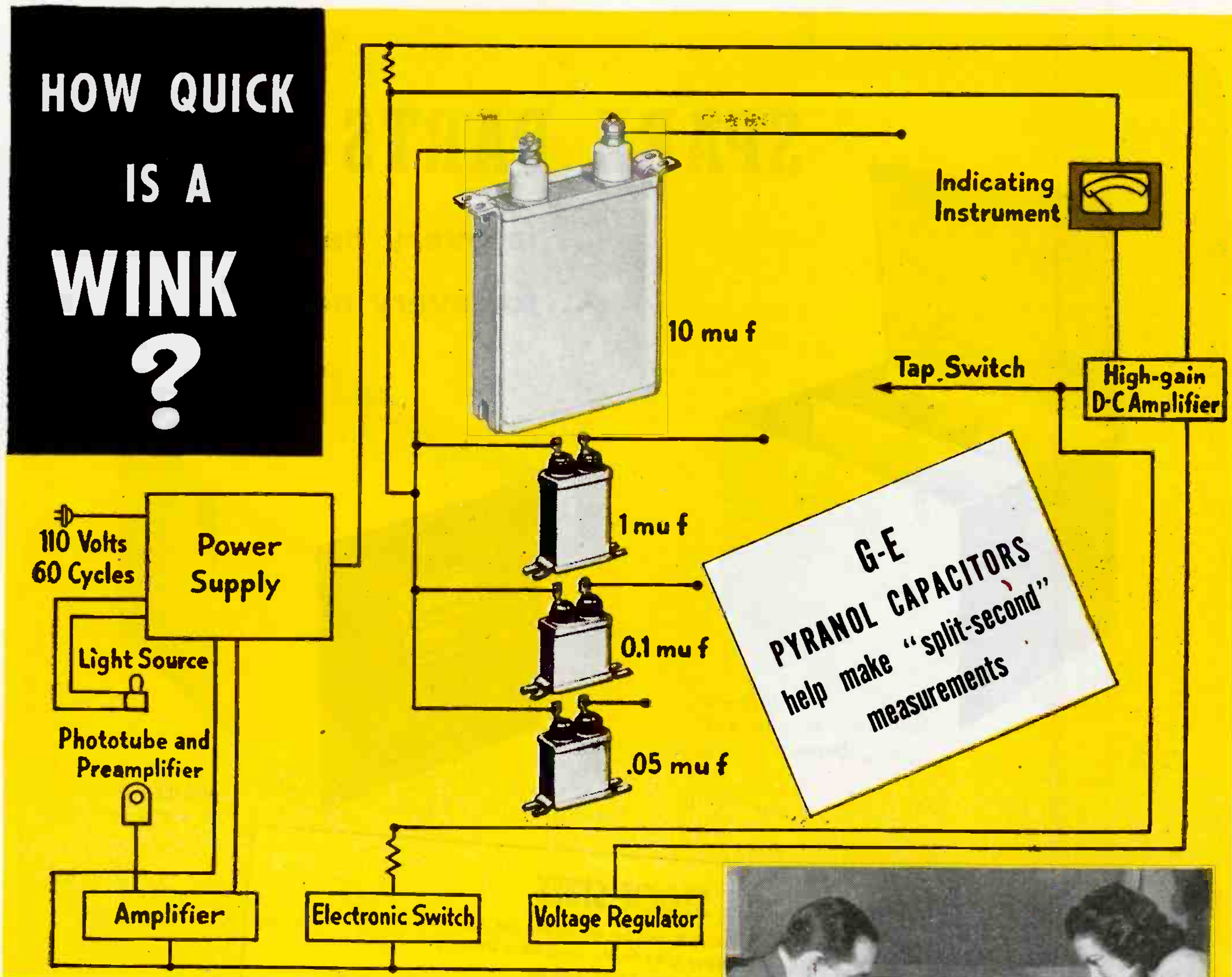
SPRAGUE ELECTRIC COMPANY, North Adams, Mass.
(formerly Sprague Specialties Co.)

SPRAGUE KOOLOHM RESISTORS

TRADEMARK REGISTERED U.S. PAT. OFF.

The Greatest Wire-Wound Resistor Development in 20 Years

HOW QUICK IS A WINK?



Another new job for capacitors

WHILE we have not yet measured the quickness of a wink with the time-interval meter, we know that it will do more practical jobs like measuring the time required for a camera shutter to open, or the time that it remains open. This meter is also being used to synchronize flash-bulb contacts on camera shutters, test relay performance, and measure the velocity of moving bodies.

Here's how Pyranol* capacitors are used in its circuit: An external contact or a phototube, working through the amplifier, causes the electronic switch to close during the time period to be measured. While the electronic switch is closed, one of the Pyranol capacitors is charged at a constant rate through a precision resistor. Thus, the voltage developed across the Pyranol capacitor is a direct measure of the required time interval.

Four Pyranol capacitors and several charging resistors are used to obtain eight full-scale ranges (0.001, 0.003, 0.01, 0.03, 0.1, 0.3, 1, and 3 seconds). A tap switch on the instrument panel is used to select the correct Pyranol capacitor and resistor for the desired scale range.

An inverse feed-back arrangement holds the charging rate constant while the Pyranol capacitor is charging, and also corrects for leakage in several elements. The feedback principle also enables the use of a direct indicating instrument to measure the capacitor charge, without discharging the capacitor.

The way Pyranol capacitors are used in this circuit may suggest a better way to do some job in one of your circuits. Remember that the high capacitance per cubic inch of Pyranol capacitors, their compact, space-saving shapes, and long life make them ideal for a wide variety of built-in applications.

This sensitive electronic instrument accurately measures time intervals as short as 1/10,000 second. It is being used here to measure the time the man takes to react and turn off the lamp after it has been turned on by the girl. (Reaction time on this test: 175–200 milliseconds.)

Booklets on our various lines—h-f paper dielectric, h-f parallel plate, Lectrofilm, as well as Pyranol units—are yours for the asking. General Electric, Schenectady 5, N. Y.

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GENERAL ELECTRIC

407-85-5700

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

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

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

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

MECHANICAL PROPERTIES*

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

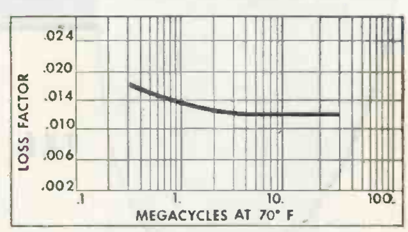
ELECTRICAL PROPERTIES*

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

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

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

Special formulas compounded for special requirements.



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

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WITH LEXEL INSULATED WIRE

If you are worried about copper wire corrosion, there's good news in recent tests made by a well-known laboratory. They placed cellulose acetate butyrate film in contact with copper wires in electrical use, under maximum water absorption conditions. *No evidence of corrosion was found on either the wire or the film.* (Copy of report on request.)

Lexel insulating tape is cellulose acetate butyrate. These tests confirm our own laboratory findings and the long experience of Lexel users. They prove not only its noncorrosive qualities, but also its low moisture absorption characteristics.

Lexel has other advantages, too. Small bulk and weight save space in tight places. The conductor is always center-sealed by heat in a continuous helical tube. Lexel has high dielectric strength and insulation resistance.

Test Lexel insulation tape for instruments, controls, lead-in and hook-up wires and other low-tension applications. We'll send you samples and names of manufacturers that can supply Lexel insulated wire and cable.

CUSTOM-MADE INSULATION

As a regular service, Dobeckmun engineers also develop laminated insulation products, custom-made to special purpose specifications, such as *slot cell and phase insulation for motors, insulation for shipboard cables and other uses. If your requirements are unusual, call on us.

"LEXEL" is a registered trade-mark of The Dobeckmun Company.

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INDUSTRIAL PRODUCTS DIVISION • CLEVELAND 13, OHIO
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*Made by the makers of DOBAR Insulation

War Babies are Children of Destiny!

E-E Engineering nurtures them—

Disparaging connotations to the contrary new inventions—the war-babies of today—are destined to be the production giants of tomorrow! New processes born of adversity—electronically controlled resistance welding and electronic induction heating, typify this trend. The growth of these industrial embryos depends, in the last analysis, on the development of efficient applicable components essential to the particular job in hand. E-E Grid controlled Rectifiers are such components.

Specifically designed to supply constant voltage under widely varying load conditions, these tubes meet, completely, the rigorous requirements of industrial applications. By a simple, inexpensive circuit adaption they also provide a continuously variable source of power of unusual flexibility, ideally suited to electronic heating. Further—the use of these tubes, in appropriate circuits, effects considerable reduction in hum with accompanying lower filter cost.

For complete technical information, write for the new E-E Data Book today. No obligation is incurred.

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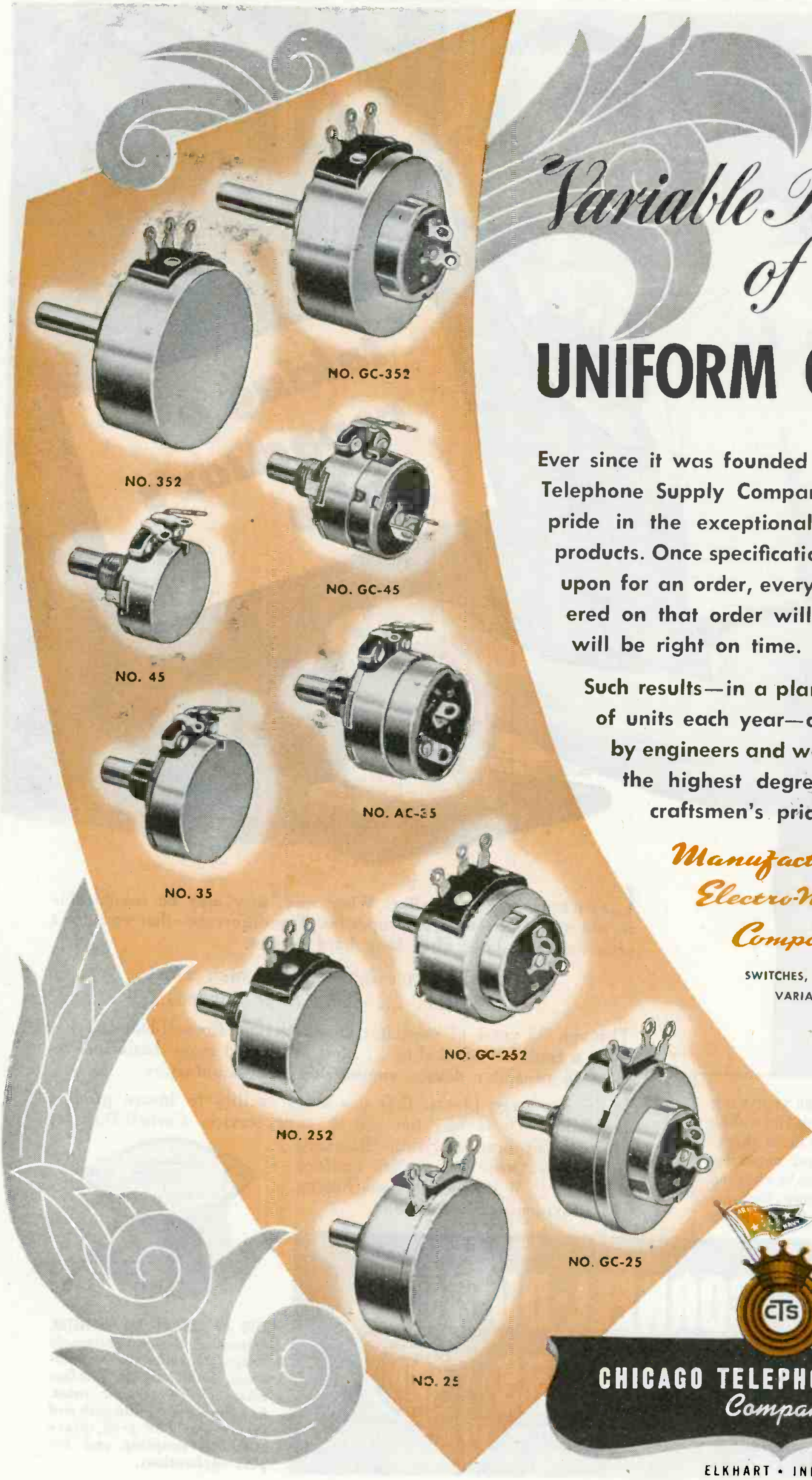
EXPORT DIVISION: 25 WARREN STREET, NEW YORK, 7, NEW YORK
CABLE ADDRESS: SIMONTRICE NEWYORK



Variable Resistors of UNIFORM QUALITY

Ever since it was founded in 1896, the Chicago Telephone Supply Company has taken special pride in the exceptional uniformity of their products. Once specifications have been agreed upon for an order, every C.T.S. resistor delivered on that order will be right—and they will be right on time.

Such results—in a plant producing millions of units each year—can be achieved only by engineers and workmen who combine the highest degree of skill with true craftsmen's pride in their work.

Manufacturers of Quality Electro-Mechanical Components Since 1896

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ELKHART • INDIANA

Capacitors may look alike. When new, they may be comparable in physical and electrical properties. The difference—that you don't see—shows up later after long hard service.

The difference is due to the men who make them . . . and their methods.

Through 35 years of capacitor specialization, Cornell-Dubilier has built a tradition of quality . . . has originated many basic innovations in capacitor design, engineering and manufacture.

In its six large plants, C-D has every facility to insure product perfection. These facilities are at your service. Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey. Other Plants: New Bedford, Brookline, Worcester, Massachusetts, and Providence, Rhode Island.

This specialist is giving our Type 59 a thorough physical. Here he is checking voltage and capacity. Type 59 will also be checked for current rating, temperature rise and insulation resistance.

TYPE 59 TRANSMITTING CAPACITOR. *Improved design, extremely adaptable under severe operating conditions. In low-loss white glazed ceramic cases. Low-resistance, wide-path end terminals. For grid, plate blocking, coupling and by-pass applications.*

CORNELL-DUBILIER CAPACITORS

1910 · 1945

MICA · DYKANOL · PAPER · WET AND DRY ELECTROLYTICS

LET US DEMONSTRATE WHAT ELECTRONIC HEATING can do for YOU

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

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

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

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

Write for free copy of
The ABC of Electronic Heating

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

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

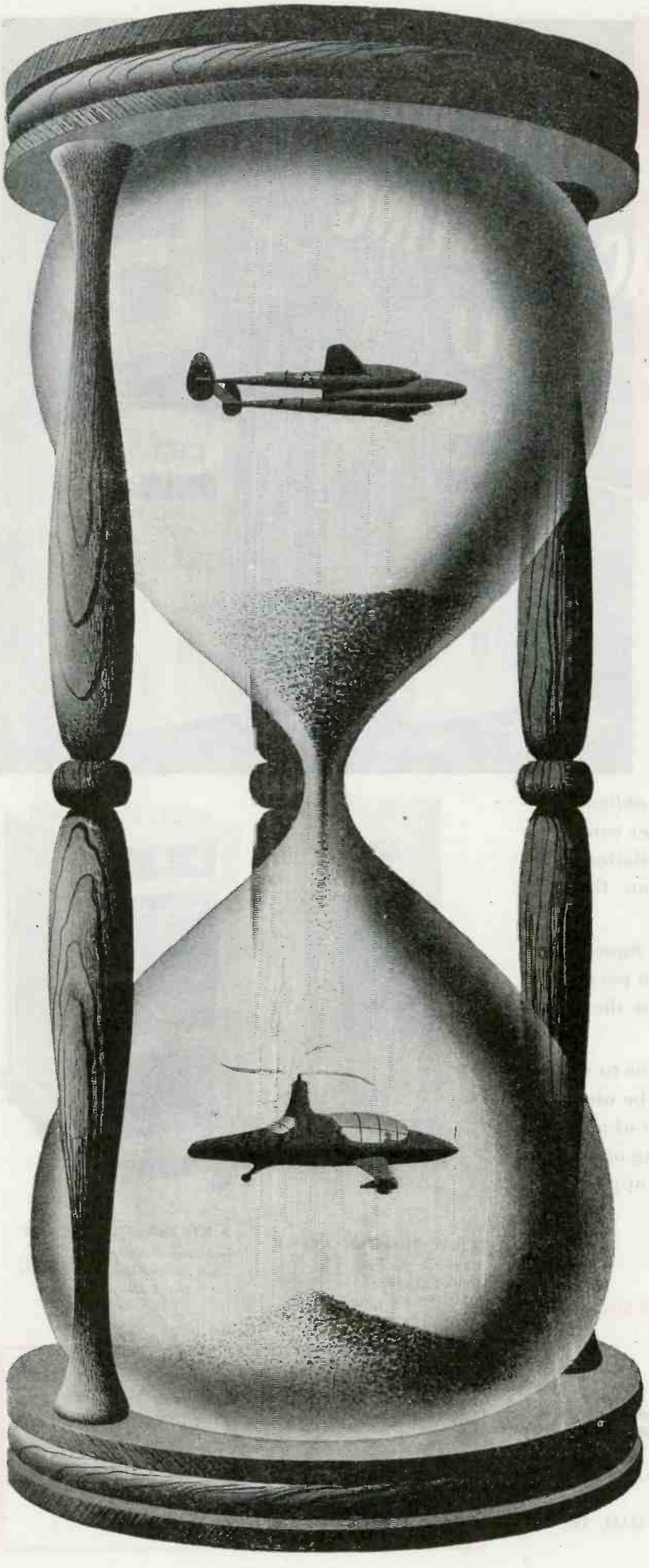
Manufacturers of
Vacuum Tube and Spark Gap Converters Since 1921

Scientific Electric

DIVISION OF "S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE ST. GARFIELD, N. J.

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



WILCO facilities Expanded to Meet Wartime Needs!

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

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

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

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

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

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

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

WILCO

Thermometals—Electrical Contacts
Precious Metal Bimetallic Products

ELECTRONICS **DESIGNER'S**

How G.E.'s High-sensitivity Tests *Lowered the Losses* IN UHF CABLE

Early in 1940, G-E engineers began completely new investigations into the production of urgently needed UHF cable, with a view to producing better cable faster.

They knew, from experience, that slight changes in braid pattern made large variations in losses, and they were determined to find the one best pattern for each type of UHF cable. Using high-sensitivity instruments and other laboratory facilities that were unmatched at that time by any other manufacturer, they studied the effects of width of strand, the weaving angle, and the spacing between strands. After hundreds of tests, concentric-braid patterns which gave the lowest losses were devised.

But braid pattern was just one of the problems. There was also the influence of the dielectric material. Our engineers found that the presence of the slightest impurity, or even minor physical variations in the extrusion process, boosted the losses. Here again, it was G-E experience—gained in the extrusion of similar compounds—that lead to the solution of the problem.

Similarly, the remaining problems involved in both design and production were solved. Today, G.E. offers a complete line of UHF cable to meet numerous exacting requirements. Details are available from our nearest office.

Whether you are designing new electronic equipment for television or for war weapons, you can't find a better starting point than G-E ultra-high-frequency cable. *General Electric, Schenectady*, N. Y.

General Electric Company, Sec. A642-5,
Schenectady 5, N. Y.

Yes, please send me

..........GEA-3911 (on Formex wire)

..........GEA-36344 (on voltage stabilizers)

NAME..........

COMPANY..........

ADDRESS..........

....

642-6

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

GENERAL ELECTRIC

DIGEST

TIMELY HIGHLIGHTS ON G-E COMPONENTS

FORMEX MAGNET WIRE

Round or Ribbon—

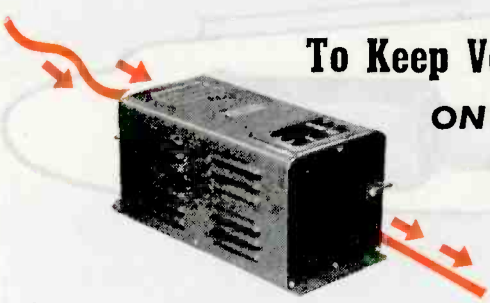
Ultra Thin

Where your new product designs put a premium on space, you'll find the ideal magnet wire for your difficult coil-winding jobs in G-E Formex.* In "ribbon thin" rectangular shape, or in round cross sections "mikeing" less than a strand of human hair, this tough, strongly insulated wire enables you to wind more compact, more rigid coils.

G-E Formex ribbon-rectangular magnet wire is available from four mils up to nine and one-half mils in thickness.

Round Formex is available in standard sizes from 8 Awg to 40 Awg, and in ultrafine sizes from 41 Awg down to one circular mil in copper area.

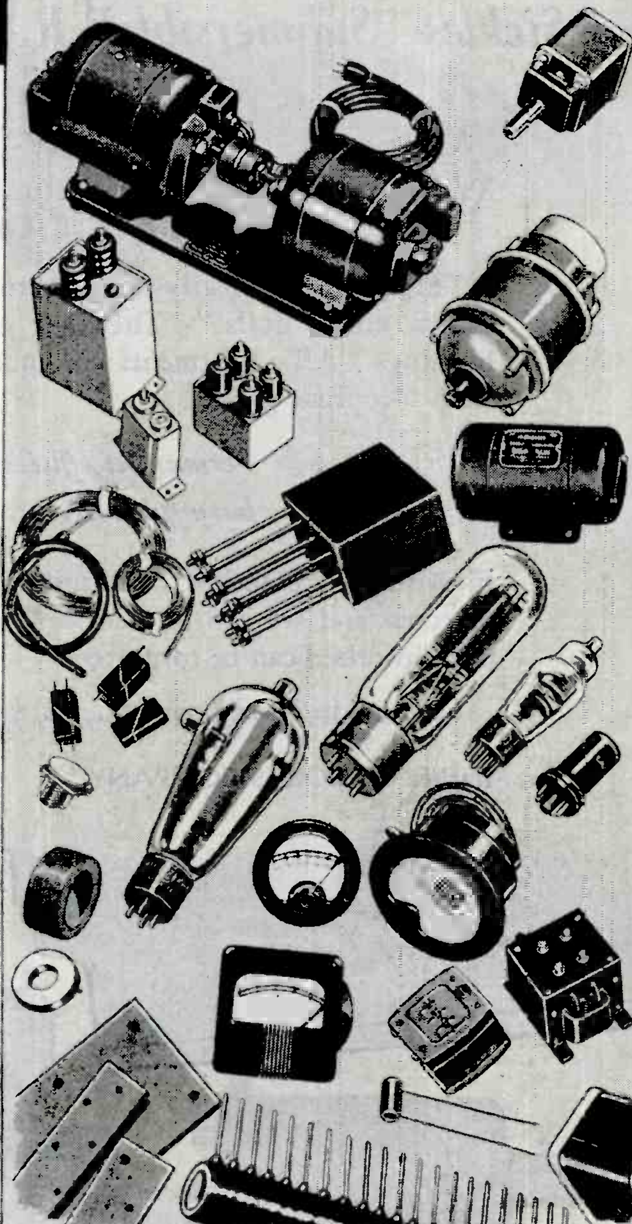
Write now for full information on sizes, shapes, and recommendations for baking procedure and bonding agents. Ask for Bulletin GEA-3911.



To Keep Voltage *ON THE* BEAM

This G-E automatic voltage stabilizer is used with equipment that requires closely regulated input voltage. Changes of input potential or the effects of uneven load are corrected immediately. There are no moving parts—no adjustments are required. Ask for Bulletin GEA-3634A.

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



Capacitors • Sensitive control and time-delay relays • Limit switches • Motors, dynamotors, amplidynes • Motor-generator sets • Alnico magnets • Small panel instruments • Formex magnet wire • Radio transformers • Switchettes • Selsyns • Chokes • *also tubes, crystals, plastics products, insulation materials, and many others*

"TAKE 'ER DOWN"

and Sickles "Submersible" R. F. Components are unharmed

WATER, corrosive chemicals and gases, even fungi are harmless to Sickles "Submersible" R. F. Components.

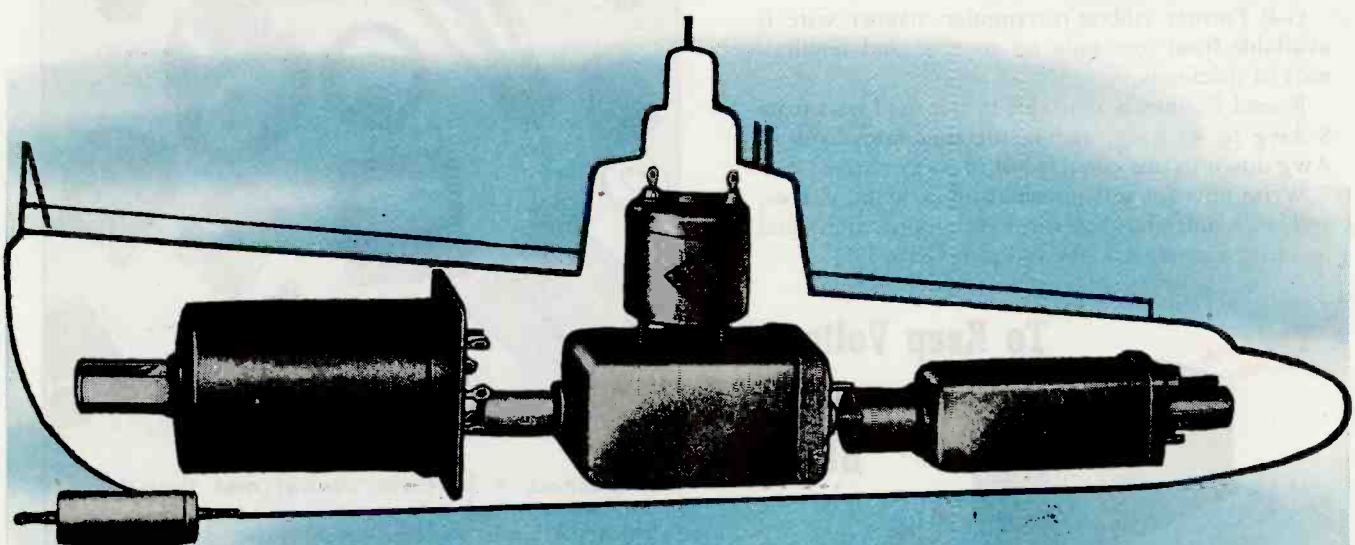
They are hermetically-sealed with wide soldered joints in sturdy deep-drawn zinc "hulls." They are equipped with fused metal-to-glass bushings. All adjustments are under rugged "hatches" that are sealed with Neoprene gaskets.

Permanent efficiency is sealed IN —
harmful elements are sealed OUT

Flexibility is practically unlimited. Tell us your needs, give us plenty of room and we can produce a "Submersible" R. F. Component that once installed can be forgotten.

For best in circuit components, specify Sickles.

THE F. W. SICKLES COMPANY • CHICOPEE, MASSACHUSETTS



SICKLES

Radio and Electronic Specialties for Today and Tomorrow

WORTH GETTING "STEAMED-UP" ABOUT

Designed by Brooks Stevens, molded by Raymond Laboratories for The Spartan Co., Minneapolis

The Spartan vaporizer illustrated above is a brand new development in humidifying equipment. Entirely automatic, this vaporizer holds a full half-gallon of water and gives off steam immediately even though the water is ice cold. The unusual design and ingenious mechanical principle of this unit typify the progressiveness of American industry in developing new products and improving old ones with plastics.

The ever-increasing usage of Durez phenolic molding compounds by manufacturers throughout industry is due directly to two reasons.

First is the unusual versatility of the phenolics. These most versatile of all plastics possess such desirable properties as excellent moldability, highest dimensional stability, diversity of finishes, dielectric strength, and resistance to heat, moisture, acids and alkalies.

Second is the rich background which Durez technicians have acquired through *specializing* in the production of phenolics during the past quarter century. They have participated in the successful development of thousands of different products, supplying in each case a plastic that fitted the job. In many instances, the finished product was not all-plastic but consisted of a combination of plastic and metal. A good example of this is the above illustrated Spartan vaporizer. The lower container, inner elements, knobs and handles were molded from a Durez phenolic compound. The cover is a satin-finish aluminum stamping.

Undoubtedly you are working out the development plans for a product which is scheduled for post-victory marketing. Naturally you are considering the use of plastics in this connection. The benefits of our broad experience plus the wealth of data collected in our files are at your disposal at all times. Durez Plastics & Chemicals, Inc., 322 Walck Road, North Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

MOLDING COMPOUNDS

INDUSTRIAL RESINS

OIL SOLUBLE RESINS

PLASTICS THAT FIT THE JOB

ELECTRONICS DESIGNER'S

How G.E.'s High-sensitivity Tests *Lowered the Losses* IN UHF CABLE

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General Electric Company, Sec. A642-5,
Schenectady 5, N. Y.

Yes, please send me

........GEA-3911 (on Formex wire)

........GEA-36344 (on voltage stabilizers)

NAME..

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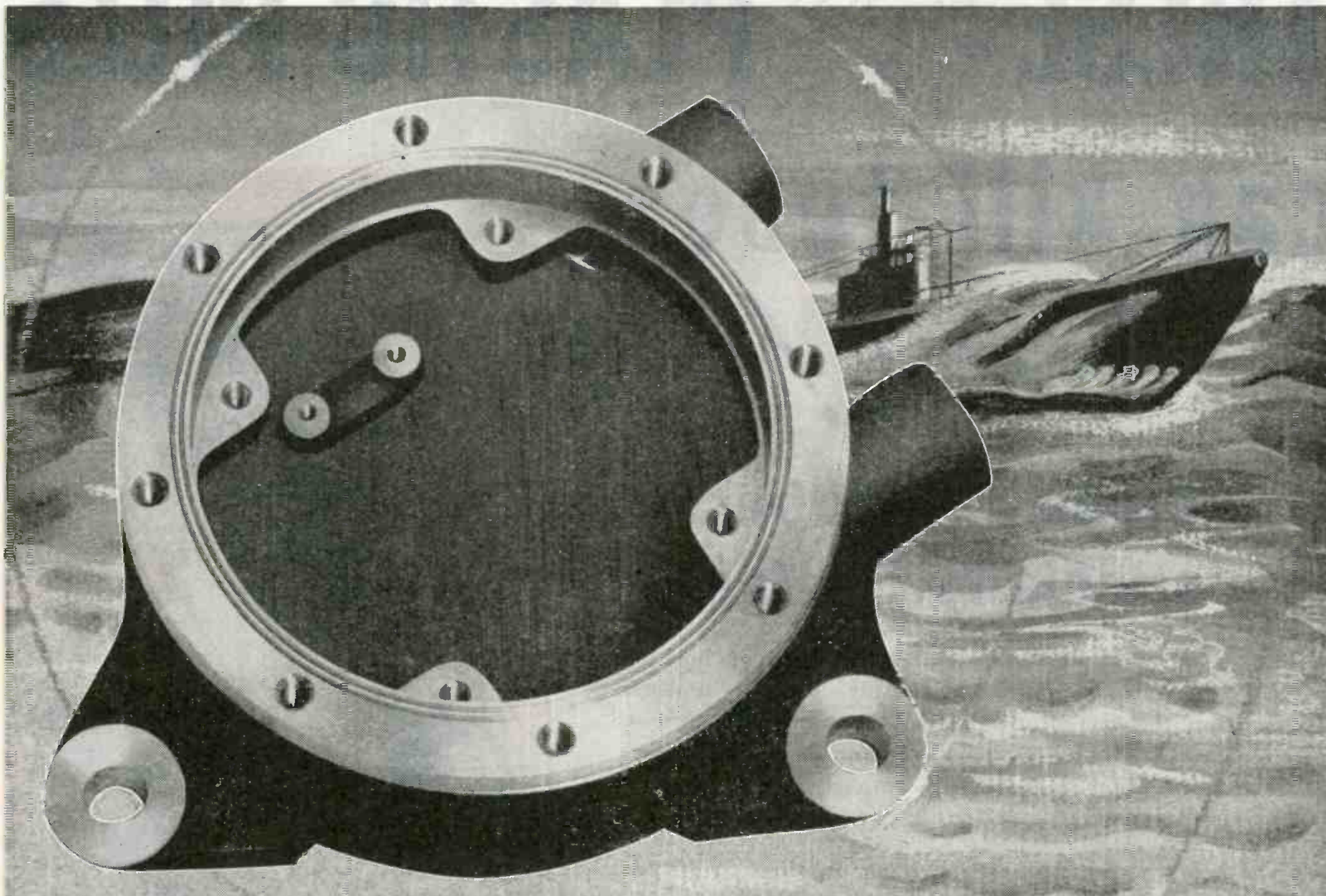
Buy all the BONDS you can
—*and keep all you buy*

GENERAL ELECTRIC



A POSTWAR LOUD SPEAKER?

Yes, if you are going to use it on a submarine. But don't expect all Jensen postwar loud speakers to look like this. This one was designed especially to be used on submarines and to withstand the terrific pressure of fathoms of deep sea water and the explosive concussion of depth charges.

Just the same, Jensen Engineers and factory have learned plenty in the process of designing this and many other specialized speakers for front line operations. Jensen postwar speakers will reflect this experience in the most extensive and improved line of loud speakers ever known. More than ever before, every buyer and user of a loud speaker will find positive assurance of the most advanced art in Jensen products. Intensive specialization for more than 15 years is one good reason for that . . . Jensen alone can claim that distinction.

Jensen

RADIO MANUFACTURING COMPANY
6601 S. Laramie Ave., Chicago 38, U.S.A.

Manufacturers and Designers of Fine Acoustic Equipment

THESE PLASTIC PILLS can kill tubes *Fast!*

...unless the tubes are specially designed

Faster and more uniform heating of preforms is now being achieved with electronic heating. For this unusual function the Scientific Electric Company of Garfield, N. J. builds High Frequency Vacuum Tube Generators distinguished for their rugged, compact construction and advanced engineering design.

The heart of these units is a tough proving ground for tube stamina. Every plastic preform requires a specific power and frequency combination. The resulting variations of load and frequency encountered greatly shortens the life of the *average* tubes built to *ordinary* standards. Only specially designed tubes can stand the "gaff."

Scientific Electric Engineers approve the installation of United Mercury Power Rectifiers and Heavy Duty Oscillators in all S.E. Dielectric Heaters. Underlying this preference for United Tubes is their sterling workmanship—unusual physical ruggedness and inherent stability under changing loads and frequencies.

Be guided by Engineers who have pioneered in Electronic Heating since 1921. Standardize on tubes by UNITED. Get the facts about these better rectifiers and oscillators today. Write for technical data and tube interchange information.

For sustained efficiency and economical operation Scientific Electric High Frequency Heaters depend on Tubes by UNITED

UNITED

ELECTRONICS COMPANY

NEWARK, 2 New Jersey

Transmitting Tubes EXCLUSIVELY Since 1934

ELECTRONIC FINGERS *feel* THE WAY - - -

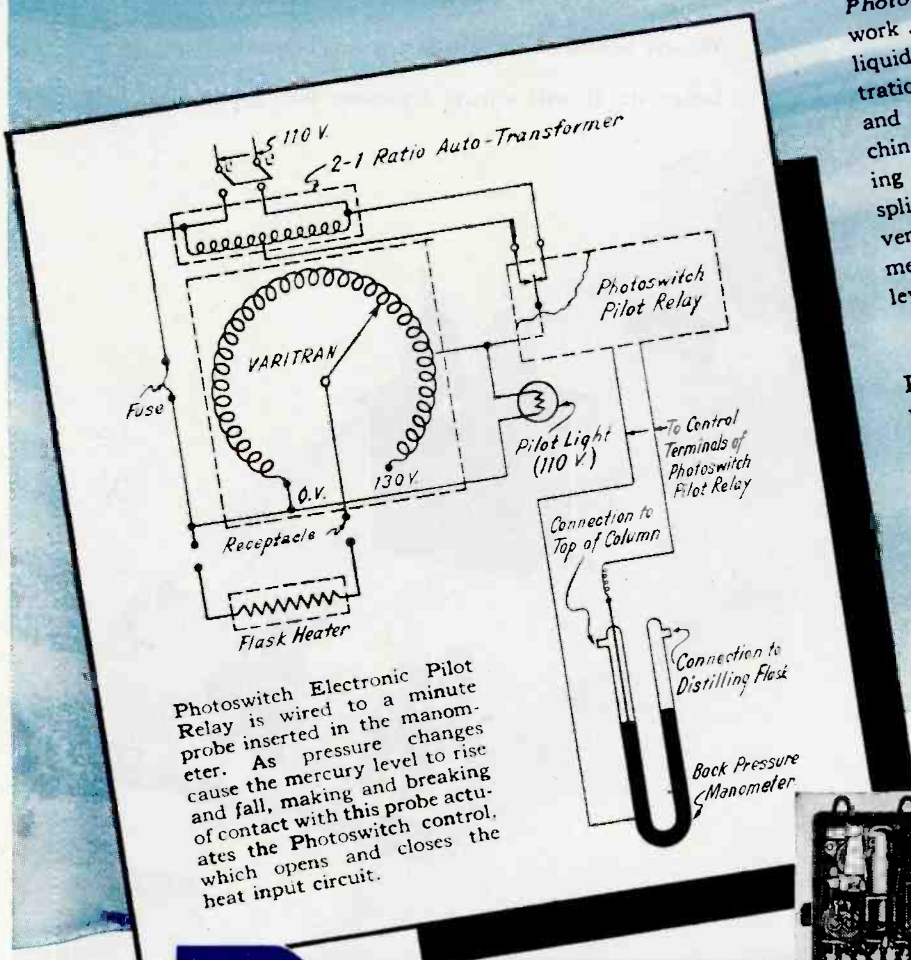
to Maintain Constant Vapor Velocity

With the aid of Photoswitch Pilot Relay, Podbielniak Centrifugal Company, manufacturer of laboratory equipment, puts electrons to work to maintain a constant vapor velocity in the distilling column of their high-temperature fractional distillation apparatus. As only microamperes are passed through the manometer fluid there is no danger of electrolysis, oxidation or explosion from sparking contacts in the presence of inflammable vapors.

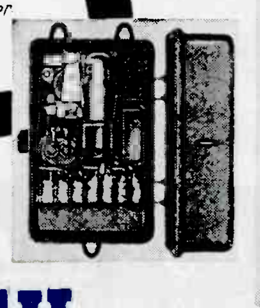
Photoswitch is putting electronics to work . . . today . . . controlling levels of liquids and powders; detecting concentration, contamination, turbidity, smoke and vapor density; safeguarding machines and property; counting, inspecting and routing production; timing for split-second repeat-cycle accuracy; preventing explosions in heating equipment, and maintaining boiler water levels automatically.

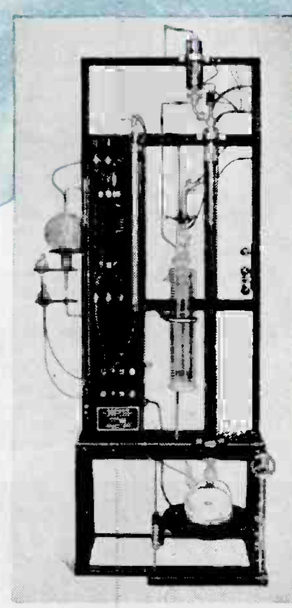
★ ★ ★

Photoswitch engineers are ready to work with you *now*. . . . Write to Photoswitch Incorporated at Cambridge 42, Massachusetts.



Photoswitch Electronic Pilot Relay is wired to a minute probe inserted in the manometer. As pressure changes cause the mercury level to rise and fall, making and breaking of contact with this probe actuates the Photoswitch control, which opens and closes the heat input circuit.





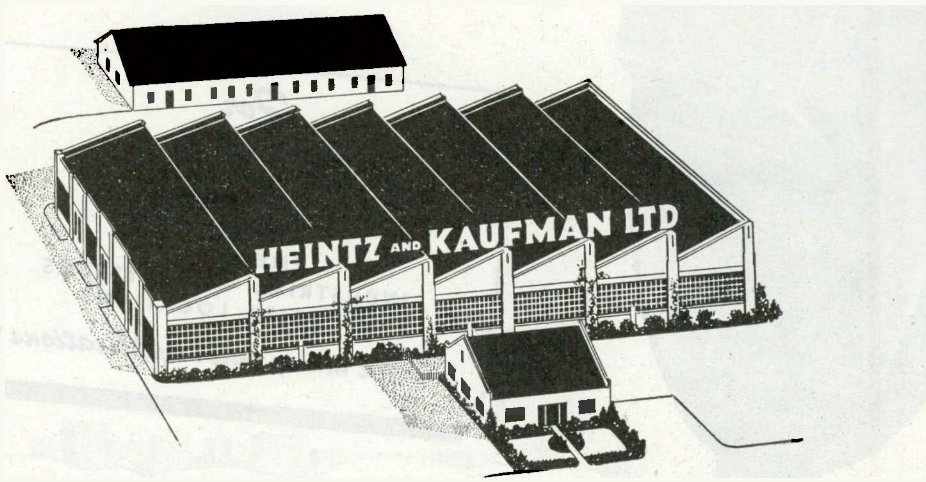
Field-proven for accuracy and reliability. Photoswitch Pilot Relay is an integral part of this precision laboratory equipment.

PHOTOSWITCH INCORPORATED

L-3

PHOTOELECTRIC AND ELECTRONIC CONTROLS FOR EVERY INDUSTRIAL PURPOSE

Fine Apparatus
These are a few of the many high quality units manufactured by this Company. They are representative of skillful engineering, rigid control in manufacture plus careful selection of component parts and raw materials properly finished.
We are proud of the product which bears the name Langevin. It will *always* represent fine apparatus.
C
D
E
F
A. Type 300A Output Transformer. Designed from 4 6L6's PP PLL to nominal secondary 2/18/32/150/600 ohms. Rated at 50 watts. Wide frequency response. Wt. 16 lbs.
B. Type 24A Loudspeaker for outdoor application. Rated for power input up to 100 watts. With proper drive units frequency response 110/6500 C.P.S. Bell diameter 25". Length 38".
C. Type 108B Amplifier. Delivers 20 watts with less than 5% RMS harmonic content. Frequency response ±1 db. 30/16000 C.P.S. 30/250 ohms input. 8/500 ohms output.
D. Special transformer to exacting requirements. Primary 110 v. 400 cycle. Secondary 10 v. at 10 amps. Test voltage 50000 RMS.
E. Type 101A Power Amplifier. Rated at 50 watts with less than 3% RMS harmonic content. Frequency response ±1 db. 30/16000 C.P.S. 600 ohm or bridging input. Output adjustable 1/1000 ohms.
F. Type 400C Input Transformer. Primary 600-15000 ohms. Secondary 60000 ohms. Level +10 V.U. at .001 milliwatt reference level. Fully shielded and rotatable.
The Langevin Company
INCORPORATED
SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING
NEW YORK
37 W. 65 St., 23
SAN FRANCISCO
1050 Howard St., 3
LOS ANGELES
1000 N. Seward St., 38



A STATEMENT OF POLICY TO THE EQUIPMENT MANUFACTURER CONCERNING *Gammatron Tubes*

WE at Heintz and Kaufman Ltd. believe that equipment manufacturers, many of whom are making their long-range plans now, will be interested in the policies for the standardization and stabilization of tube types which have been established for Gammatrons. These policies merit consideration when designing equipment either for military or civilian use.

Practically all tubes now sold to the Government must conform to specifications covering electrical standards and physical dimensions.

We are heartily in favor of the Signal Corps and Bureau of Ships joint standardization of electronic component parts. The good work of the Radio Manufacturers Association likewise deserves the highest commendation. We believe that the Joint Army and Navy Specifications for Vacuum Tubes ("JAN specs") will be accepted voluntarily by tube manufacturers as post-war commercial standards, since they offer many advantages to the equipment manufacturer.

All H&K Gammatrons when again manufactured for commercial use will conform to the rigid physical and electrical specifications now required by "JAN specs."

Thus when you design equipment around Gammatron tubes you can be sure that neither electrical nor physical changes in these tubes will make redesign of equipment necessary, or replacement difficult.

We plan to tell you more about our standardization and development policies in future advertisements. So please be on the watch for them each month.

BUY WAR BONDS

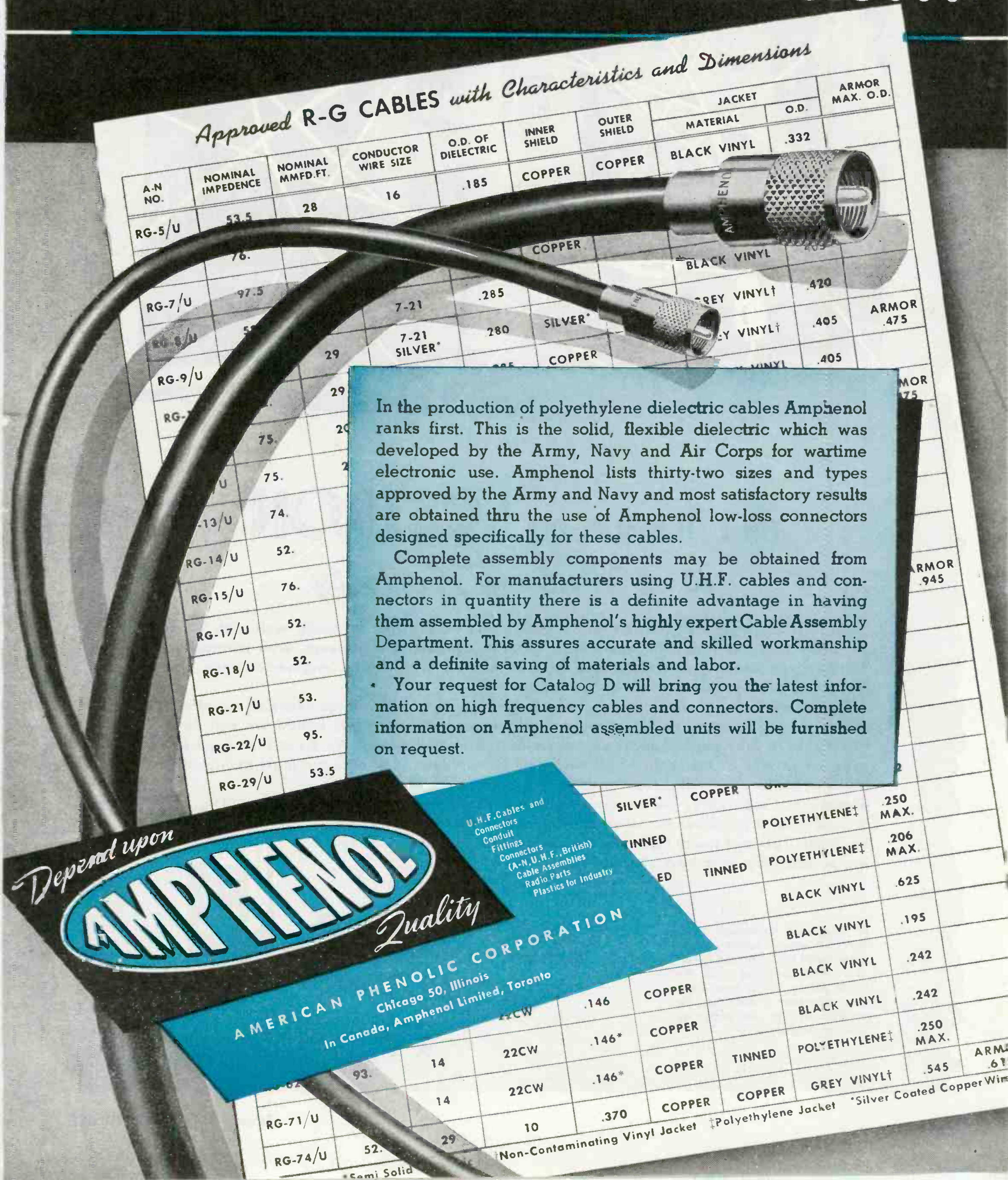
HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA

Gammatron Tubes

AMPHENOL *Offers*

The Most Complete Line of U. H. F. Cables and Connectors . . .



In the production of polyethylene dielectric cables Amphenol ranks first. This is the solid, flexible dielectric which was developed by the Army, Navy and Air Corps for wartime electronic use. Amphenol lists thirty-two sizes and types approved by the Army and Navy and most satisfactory results are obtained thru the use of Amphenol low-loss connectors designed specifically for these cables.

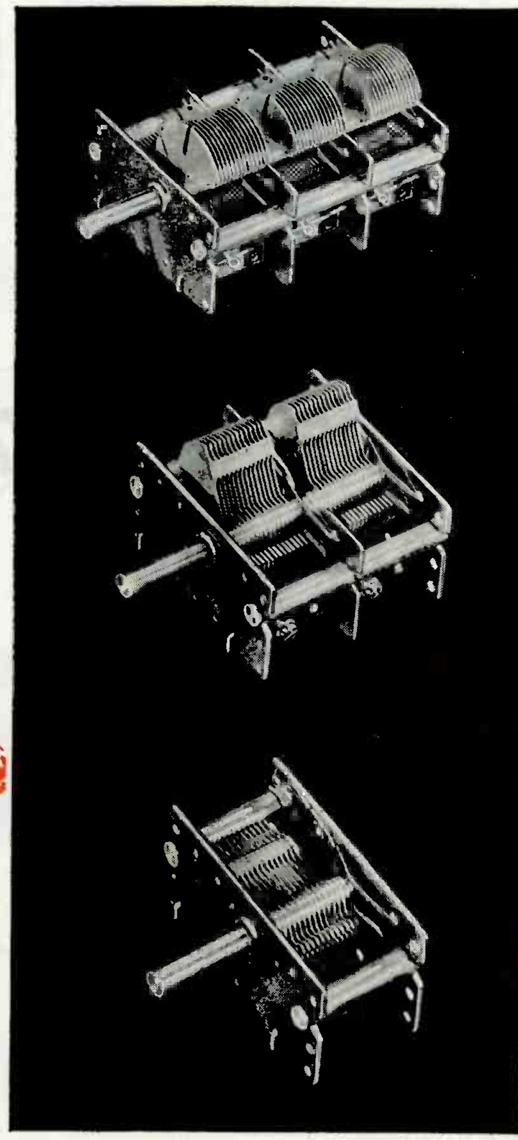
Complete assembly components may be obtained from Amphenol. For manufacturers using U.H.F. cables and connectors in quantity there is a definite advantage in having them assembled by Amphenol's highly expert Cable Assembly Department. This assures accurate and skilled workmanship and a definite saving of materials and labor.

Your request for Catalog D will bring you the latest information on high frequency cables and connectors. Complete information on Amphenol assembled units will be furnished on request.

Depend upon **AMPHENOL** *Quality*

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

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



23 YEARS

of Variable Capacitor KNOW HOW

ONE after another throughout the long history of Radio, Capacitors have been designed, perfected and mass-produced by R/C.

This is the normal result of over 23 years of undivided attention to the proper design, construction and application of this one highly critical, amazingly adaptable component.

And it is further, the result of the natural development of a group of experts—men who know more about variable capacitor problems and how to solve them than can be found anywhere else in the world.

RADIO CONDENSER CO.

CAMDEN, N. J.

RADIO CONDENSER COMPANY, LTD., TORONTO, CANADA

BAKELITE

TRADE-MARK

TOWER OF *Dielectric* STRENGTH 4" HIGH

JUST 4 INCHES HIGH—this housing for a Millen coil! But it gives peak performance in high-frequency circuits where low-loss insulation is a topmost requirement. It's made of BAKELITE polystyrene, noted for its exceptional dielectric qualities, dimensional stability, low water absorption, and remarkable resistance to most chemicals.

Designers and manufacturers of electrical and electronic equipment will be interested in the many outstanding properties of BAKELITE polystyrene. It has a high index of refraction. Its specific gravity is low—1.05. It is produced in various forms that are adaptable to several methods of fabrication. Bakelite Corporation supplies BAKELITE polystyrene plastics in the form of molding materials and insulating films. Fabricators supply BAKELITE polystyrene plastics in such forms as rigid sheets, tubes, and rods; flexible film that can be punched and stamped; filaments in continuous rolls; and electrical insulating coatings.

Our Engineering Staff and Development Laboratories will be glad to work with you in applying BAKELITE polystyrene plastics to essential applications. Write Department 7 for names of fabricators.

TRADE MARK

BAKELITE CORPORATION

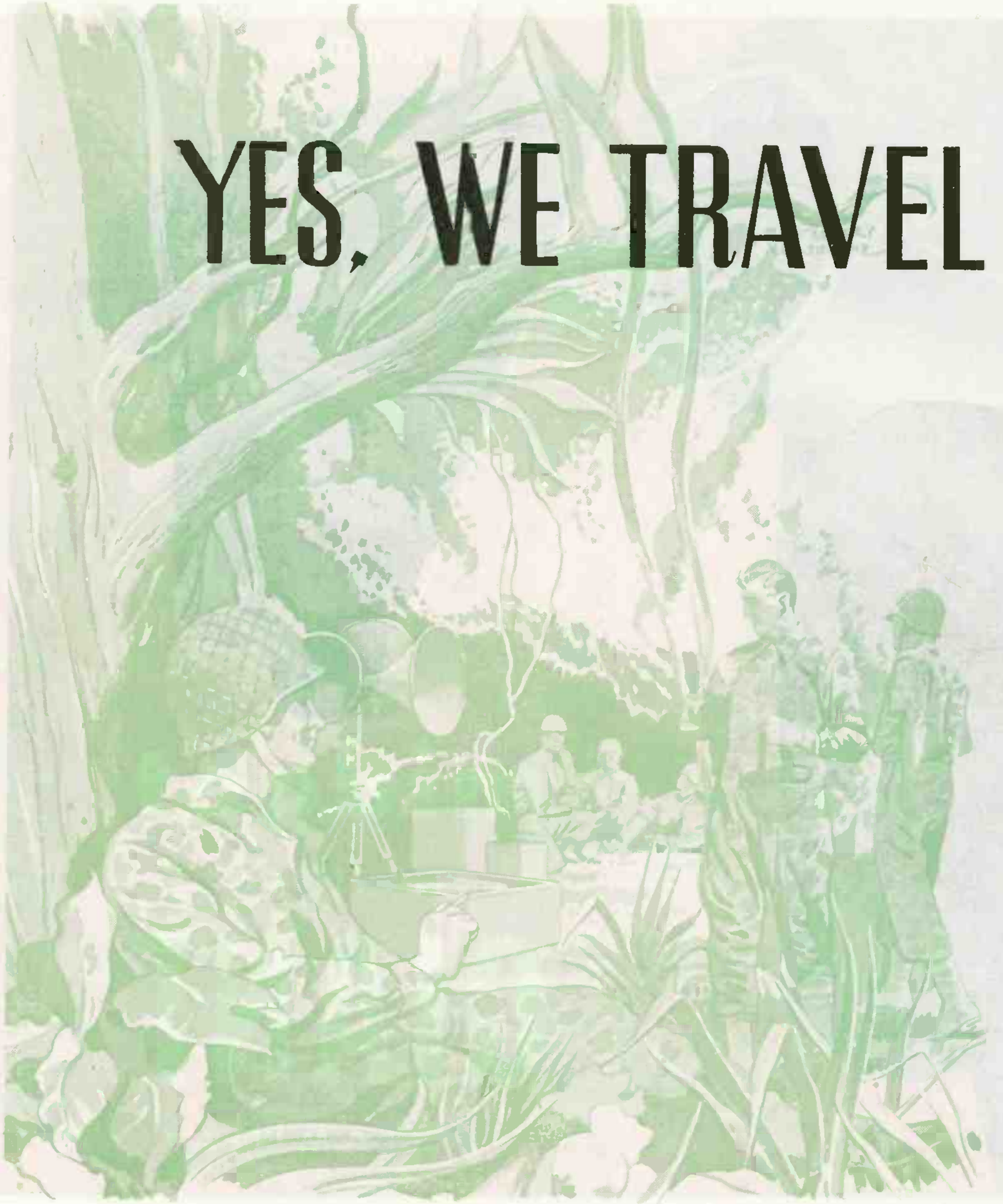
Unit of Union Carbide and Carbon Corporation

30 EAST 42ND STREET, NEW YORK 17, N.Y.

UCC

Polystyrene Plastics

YES, WE TRAVEL FAR



That compelling force—the demand for quality—has spurred Audiodiscs to ever greater production. Each month we manufacture a larger number of these superior recording blanks, but most of this increase must be devoted to radio programs for the armed forces. Yes, we travel far to aid the war effort—and we have traveled far in quality that means better recordings both now and in the years to come.

AUDIO DEVICES, INC., 444 Madison Ave., New York

. . . they speak for themselves **audiodiscs**

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

As radio development moves onward and upward, Hallicrafters engineers are setting the pace, pushing back the horizons in the exciting fields of very high frequency, ultra high frequency, and super high frequency development work. The range of the Model S-37 illustrated here covers higher frequencies than any other continuous tuning commercial type receiver. It is becoming a prime instrument of experiment and research in marking out the new directions that all radio will take.

New directions in radio will be charted by Hallicrafters

hallicrafters RADIO

Buy a War Bond Today!

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

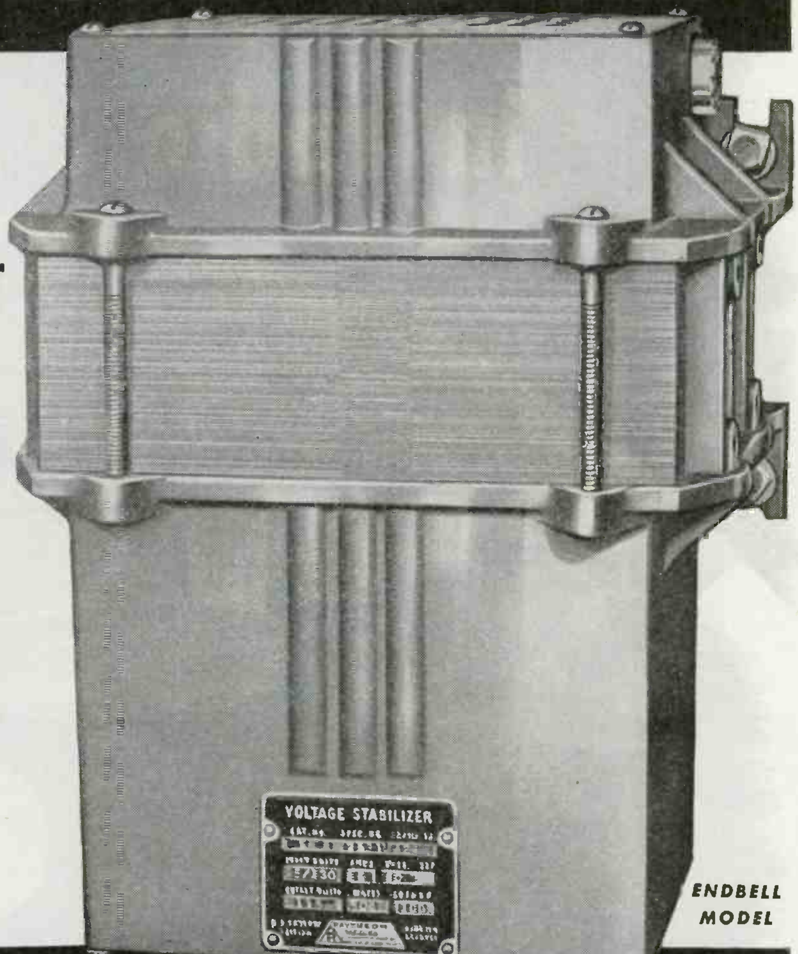
RAYTHEON VOLTAGE STABILIZERS

INSURE ACCURATE OPERATION of ELECTRICAL EQUIPMENT

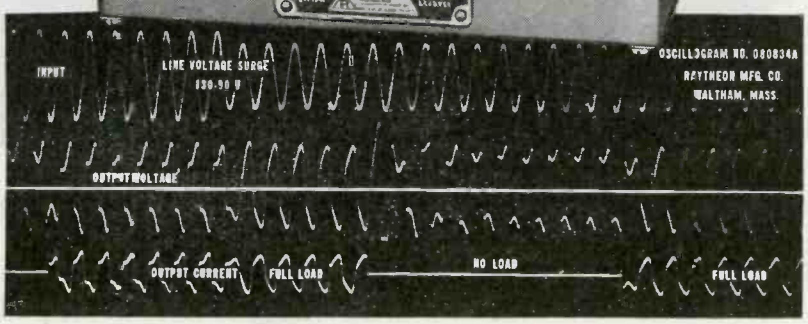
Stabilize Varying Input Voltage Within 2 Cycles to Constant Output Voltage at $\pm\frac{1}{2}$ of 1%

Raytheon Voltage Stabilizers, incorporated into electrical equipment, insure accurate, dependable operation by providing stabilized A. C. voltage to $\pm\frac{1}{2}$ of 1%. They are available in three designs . . . uncased, cased and endbell . . . to meet every installation requirement whether it is to be built into new equipment or products already in use. Entirely automatic in operation, it is ideal for equipment in unattended locations.

Write for Bulletin DL 48-537. It gives the complete story.



ENDBELL MODEL



TIME CONSTANT

Transient changes in output voltage result from variations in line voltage. These transients disappear entirely in 6 cycles. The major effect of the transient recovery is practically complete in 2 cycles. These changes are not evidenced on a volt meter of normal characteristics and their behavior is usually unimportant. Transients resulting from connecting or disconnecting the load require somewhat longer time for recovery. Smaller changes in load cause proportionately smaller transient disturbances in output voltage. This characteristic is shown above.

Tune in the Raytheon radio program: "MEET YOUR NAVY", every Saturday night on the Blue Network. Consult your local newspaper for time and station.

RAYTHEON MANUFACTURING COMPANY
Electrical Equipment Division
190 WILLOW STREET, WALTHAM, MASS.

The coveted Army-Navy "E", for Excellence in the manufacture of war equipment and tubes, flies over all four Raytheon Plants where over 16,000 men and women are producing for VICTORY.

Devoted to research and manufacture of complete electronic equipment; receiving, transmitting and hearing aid tubes; transformers; and voltage stabilizers.


G.I.
IS STILL ON
THE MAIN LINE
The first in our industry to be so honored
ARMY E NAVY
POST WAR VARIABLE CONDENSERS
POST WAR RECORD CHANGERS
POST WAR SPEAKERS
G.I. WAR PRODUCTION
G. I.'s main line is still Radio Components—but just now civilian items are sidetracked. We must keep the road clear for all-out war production, which has right of way till that last stop—Victory—is reached. But with that destination reached we're ready to switch right back to mass output of condensers, tuning units, actuators and record changers for home radio sets. Yes, and there's a new "branch" added to our main line—*Speakers,* which we plan to route through in a big way after victory. Meanwhile:
WE STILL HAVE CAPACITY FOR URGENT WAR ASSIGNMENTS!
GENERAL INSTRUMENT
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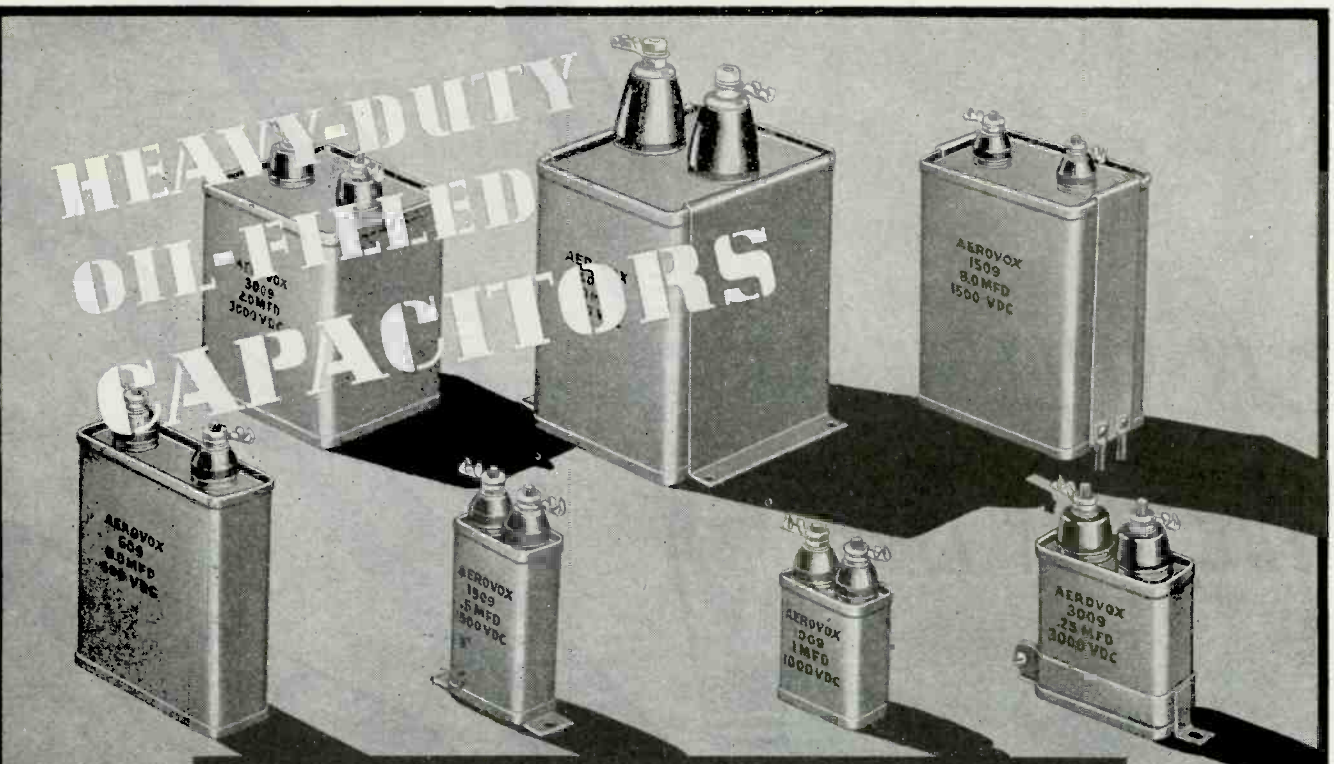

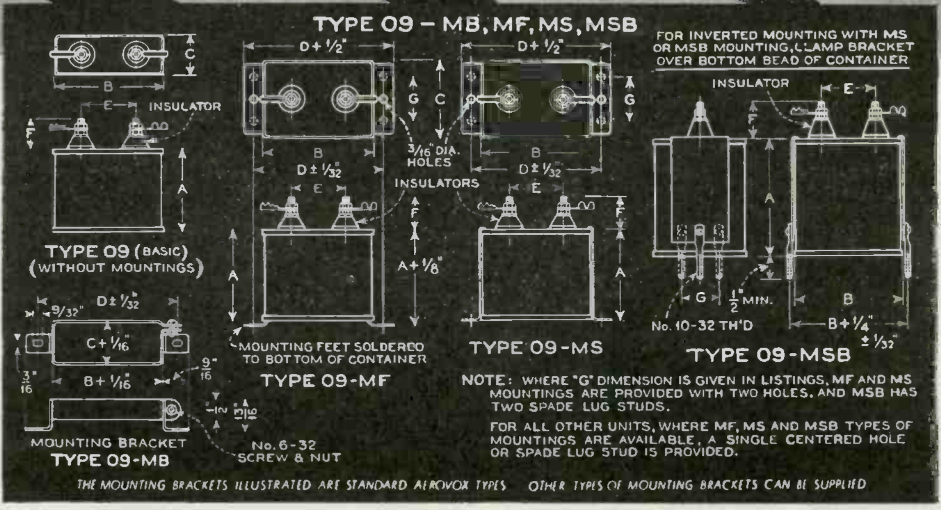

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The Little GIANT

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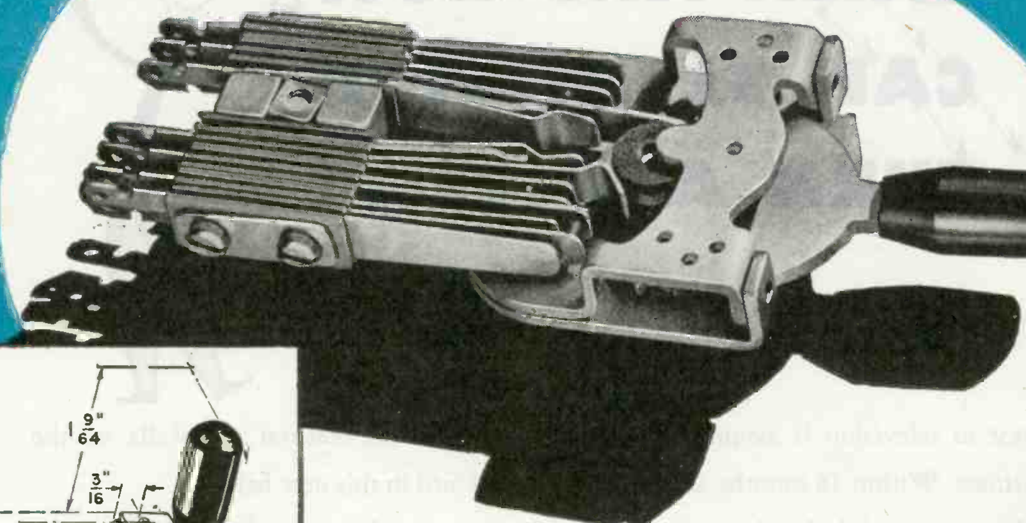

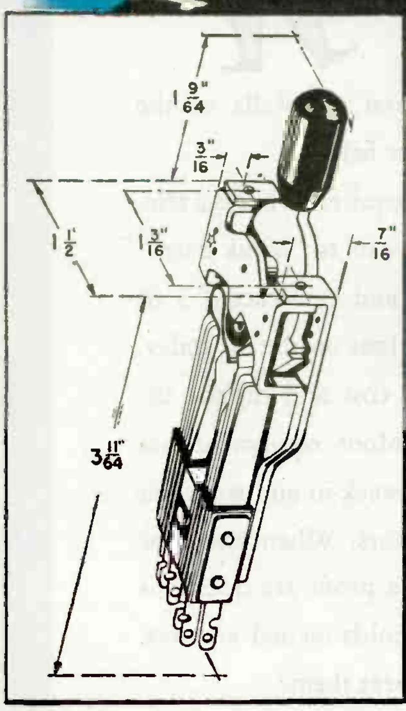

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Interest in television is assuming flood proportions. Within 18 months after Victory there is every indication that television service will be available to 30,000,000 people . . . and enjoyment limited only by plant capacity of set manufacturers.

Prospective television station operators who reserve DuMont telecasting equipment *now* will be prepared to ride a wave of unprecedented popular enthusiasm . . . to ride the swift and inevitable commercial expansion of the greatest scientific advance of our time. Valuable prestige and good-will are natural windfalls of the early bird in this new field.

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REDEDICATION

An Obligation to Our Fighting Men

DURING the last few weeks we have been forcibly reminded that so long as we still are fighting either of our major foes, first claim upon the productive resources of the United States—its manpower, materials, utilities, and industrial facilities—must be the production and delivery of munitions and war supplies. All other claims are secondary. No responsible citizen would have it otherwise. For in this war even more is at stake than our existence as a Nation. We dare not forget that we are engaged in a struggle that challenges the fundamental values upon which our civilization has been built.

It is not easy to list the values that we are fighting to uphold. They have been clothed in a variety of shapes over the centuries. They will assume new forms in the years ahead. But they have an inner consistency that free men the world over can feel and recognize: the right of the commoner against the noble, the right of the individual against the state, the right of trial by jury, the right to vote, the right to an education, the right to freedom of speech and worship, the right to work in a sphere of one's own choosing, the dignity and the equality of the individual under the law—these are our cultural heritage, painfully won and often precariously held over the ages, always to be rewon, redefined and buttressed by each succeeding generation of men.

The preservation of this vital core of value, and its transmission to our sons and daughters depends upon our victory in this struggle. So those things which are essential to victory must come first. And since the production of war munitions in overwhelming volume and quality can hasten that victory and save countless lives of our fighting men, no effort that will contribute to this end should be regarded by us as a sacrifice.

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The present is no time for self-congratulation upon our achievements either in the theatres of battle or of production. The mounting casualty lists should suffice to curdle the savor of any such indulgence. The most that can be said in reasonable taste and good conscience is that performance in both fields is such as to warrant our firm confidence that we can carry to successful completion the tasks that remain to be done.

Nor is there profit in even observing, much less deploring, that the tasks ahead are more formidable than those which were defined for us a few short months ago. Then, all of us—military leaders, government officials, workers, and business men—were riding a crest of optimism as to an early end of the war in Europe and as to the character and dimension of the war against Japan. Already we had begun to turn anxiously toward the problems of reconversion which then seemed so near at hand. Schedules for war production, based upon the best available estimates of need, called for a 5 billion dollar reduction from 1944 performance, even though we might have to continue a two-theatre war, and for a 40 percent reduction in the event of an early victory in Europe.

Today, those forward estimates have been revised sharply upward. That is true both of the 1945 requirements to meet the needs of a two-theatre war, and of requirements for the Pacific war once the European phase is ended. For this upward revision four chief reasons are responsible:

1. European battle experience has shown markedly greater use of expendable munitions than was provided in the formulae upon which our original production schedules were calculated: the result has been a depletion of inventories on a scale that would become dangerous if allowed to continue.
2. Experience has also demonstrated the need for new types of weapons or increased complements of some existing types to match new enemy equipment or tactics.
3. A less easy optimism as to the early ending of the European war has given rise to a growing disinclination to gamble on the approximate date.
4. An increasing conviction prevails that the war against Japan may require ground-army operations on the Asiatic mainland on a scale greater than originally premised.

But if these changes in the fortunes and outlook of war have raised our estimates of military requirements, may not subsequent favorable changes in the military situation cause them again to be revised downward? It is entirely possible. But our military men have learned that they cannot safely discount what *might desirably happen* as something that *will happen*. Those working on the production front also must learn that lesson. Fortunately, the record shows that we have been able to maintain a war production almost equal to that of the rest of the world combined, even while we produced for civilian use on a scale that has been large even by our own pre-war standards. So we have ample margin to whip whatever war job may be required of us. As now defined, the task will not be easy. But it *can* and *will* be done.

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What, then, is the production task with which we are charged? Our 1945 production for the two-theatre war now calls for the substantial maintenance of the over-all levels reached in the latter months of 1944. But there is a shift of emphasis. Almost half of the programs for specific equipment items are declining. A few are scheduled to hold level. About 45 percent are scheduled to rise sharply. That means that workers and facilities must be shifted to man the expanding programs. At the same time the armed services are calling for many more men than can be supplied from those who become newly eligible to the 18 year old age group. That means further drafts upon war workers. It means also replacements for them when they are taken from the expanding programs. Finally, events demand that we produce as much as possible of many items during the first half of 1945.

Our task, then, is one of intensified effort for the immediate future, with multiple readjustments at a stage when adjustments are hard to make. Materials for which demand was easing as pipe-lines were being drained in anticipation of falling schedules again are tight as the pipe-lines are being refilled to meet augmented requirements. Men, women, and facilities must be shifted from less essential to more essential tasks. What must be done will be done. But unless there is much voluntary accommodation, it will be necessary for us to suffer a formidable amount of governmental direction which none of us likes, many of us deeply resent, and all of us, when personally affected, volubly protest. The more we police ourselves, the less we shall be policed.

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Even after Germany has been defeated, we shall still face a far from light production requirement to continue the war against Japan. As currently defined this phase might require war expenditures at something like $70 billions a year, an over-all reduction of approximately 20 percent from the $89 billions spent in 1944. Reduction in munitions output would be somewhat greater, probably from 25 percent to 30 percent below 1944 levels. But it is important for us to acknowledge that the reduction is going to be substantially less than the 40 percent previously estimated.

Only a few months ago there were those who questioned sharply the possibility that we might need 60 percent of current munitions output to win the Japanese war. Now the judgment of the military is that 70 percent will be none too high.

Actually the latter level would represent an increase of little more than 50 percent above what now is being produced for the Pacific area. This, certainly, is a modest estimate when we reflect that we shall inevitably more than triple the Army forces assigned to that theatre.

Such a program probably would give us a current munitions supply from three to four times that produced by Japan, but it is believed that we shall need that much to compensate for the advantages derived by Japan from the fact that she will be fighting a defensive war, from the volume of her accumulated stores, from her prepared positions, her shorter lines of supply and transport, and from her large troop reserves, the bulk of which we have yet to meet in battle. Certainly our present 3 to 1 production edge over Germany does not appear to be excessive.

The more modest V-E Day cuts contemplated by the present plan will mean a less acute reconversion problem when they are made, but will leave a greater one to be met at the end of the war. They will mean probably a net increase of not more than 4 million workers available for civilian work during the transition period. Their orderly absorption should present no embarrassing problem. Indeed, we now are warned by Washington that war production following V-E Day may require the protection of considerably closer control than was contemplated under the 40 percent cuts previously expected.

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In short, we face for the immediate future a more difficult production job. It is made the more formidable by the fact that we had dulled the keen edge of our will to produce by our premature expectation of a reduction in requirements. Now we are told that the trend of war production for the immediate future is up, that it is unsafe to discount the date of victory in Europe, and that the amount of leeway for reconversion after the defeat of Germany is less than had been anticipated.

Accordingly, we must rededicate ourselves to the task of driving war production up. We must do without some of the things that we have enjoyed on the civilian front rather than demand more of those things; we have still to devote our abilities and energies first and foremost to the demands of war.

Whatever will assure and hasten victory must have first place in any statement of American policy.

Without victory, our aims, and the underlying values upon which they are based, will be extinguished, blotted out by the opposing aims and values proclaimed by our enemies.

The needs of our fighting men must be put first. For, unless we win the war, the National aims and policies of the United States will cease to have meaning in the world.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

THIS IS THE 32ND OF A SERIES

Of course it uses Eimac tubes

This compact Thermex unit measures 28 inches by 28 inches, stands 47 inches high, and weighs only 614 pounds. It is a practical and flexible piece of equipment with built-in heating cabinet and removable 12 inch by 15 inch drawer-electrode.

Being completely automatic, there is nothing to do but plug this Thermex in and load and unload the preform drawer. No dials, no tuning, not even a button to push. Closing the preform drawer all the way in, turns on the high frequency power and timer. At the end of the prescribed time, which may be anywhere from 5 to 10 seconds up to 2 minutes, the red indicating light goes out, the operator removes the tray and unloads the preforms into the mold cavities.

The Thermex Model No. 2-P, which is illustrated, operates at a frequency of 25 to 30 megacycles using 230 volt 60 cycle single phase current. It has an output in excess of 3400 BTUs per hour, and it uses a pair of Eimac 450-TH tubes. The use of electronic heating has increased production for many plastic manufacturers who have been leaders in utilizing the science of electronics.

The Thermex Division of the Girdler Corporation of Louisville, Ky., is a leader in supplying equipment for this and other industrial applications. It's natural that Eimac tubes are used, since these tubes are first choice of leading electronic engineers throughout the world.

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ELECTRONICS....KEITH HENNEY....Editor....FEBRUARY, 1945

CROSS TALK

▶ **ECHOES** . . . Something new has been added to the repertoire of tricks used by electronic engineers. This is the echo technique. Shoot a radio wave into the air and it will be reflected by any conducting surface, sending back to the transmitter echoes of the original signal. A partially ionized layer of gas, an airplane or a ship at sea will do it. Since the directivity at the transmitter may be very great, the location of the reflector in elevation and azimuth can be determined.

Furthermore, since radio waves travel at a finite velocity (186,000 miles per second or about 327 yards per microsecond) the distance of the reflector can be determined.

Sound waves travel through sea water at a finite rate—about 5000 feet per second—and since a fairly narrow beam of sound waves can be produced in the supersonic region, nature and electronics have provided us with a pretty good submarine detector. It is also good for sunken ships, reefs or a school of fish, all of which will produce echoes. Sound waves travel through the earth with known characteristics as the seismologists and the geophysicists have discovered and utilized.

Now comes Professor Firestone of the University of Michigan. He holds a vibrating piezoelectric plate up against a block of metal. Sound waves in the supersonic region travel through the plate and return to the front surface as echoes produced by the rear surface, or by flaws within the block. So, electronics has provided industrial engineers with a new, sensitive, nondestructive test, a method of measuring the thickness of a metal plate whose rear surface may be inaccessible, or for exploring the interior for hidden flaws.

The wonder is that all of this wasn't done long ago!

▶ **SYMBOLS** . . . Some time ago, October issue to be explicit, ELECTRONICS offered a free lunch to the author of the first paper to arrive here for publication using the compromise symbols for electronic components adopted by the American Standards Association. Dr. Harrison's paper on Klystron oscillators won the free lunch, and a very pleasant time was had by all.

The symbols problem is serious. For years there were two sets of symbols for certain widely-used components and great was the confusion compounded thereby. Now that there has been agreement, it behooves everyone —engineers, students, professors, authors, publishers—to stick together and to wipe out and forget the old confusion.

As a matter of cold hard fact, too much of our time and effort is spent fixing up the diagrams of authors who are still acting as if no standardization had ever been accomplished. This indecent use of time and energy must be better employed.

The correct symbols to use can be ascertained by looking at ASA Bulletin Z32.5-1944.

▶ **FREQUENCIES** . . . On January 16 the FCC announced new allocations for services operating above 25 Mc. Frequencies assigned various communications and industrial services are listed in the "News of the Industry" department pages of this issue. Next month ELECTRONICS will present a detailed analysis and interpretation of what the allocations mean to the future of the industry.

▶ **BJ** . . . In spite of the fact that many knew that B. J. Thompson, outstanding electronic engineer, had been missing after a Mediterranean flight, the final announcement of his death was a distinct shock. On a special mission for the Secretary of War, Mr. Thompson's plane disappeared on the night of July 4, last year.

"BJ", as Mr. Thompson was affectionately known by a very large number of radio and electronic engineers, was one of the most promising young men in our field. His contributions already made were of the first rank; the development of the acorn type tubes being best known. In addition, the high esteem in which he was held by his associates and the men who worked under him and his fellow engineers throughout the industry makes his loss very great.

Planning an F-M Station

A practical discussion of the problems confronting a-m stations contemplating the new service. Notes on the selection of sites, estimation of coverage, determination of required transmitter power, choice of antennas, and building layouts

By P. B. LAESER
FM-Television Engineering Supervisor
WMFM-WTMJ
The Milwaukee Journal Radio Stations
Milwaukee, Wisc.

AFTER THE DECISION is made to enter the f-m field, the broadcast station engineer is confronted with the job of satisfying management as to the cost of serving the proposed market area. Can he use any of his present a-m facilities? What are the possible sites for the transmitter and antenna? Are suitable wire lines available or does he have to resort to a studio-to-transmitter (STL) link?

Basically, the problem settles down to taking inventory of the present transmitter site, determining whether a signal can be propagated from there over the territory specified, and deciding what will be necessary to feed a high-quality program service from the studio to the transmitter.

Determination of Coverage Area

In the majority of cases an entirely new transmitter location will be chosen for the f-m installation because good locations for broadcast band antenna systems are not often satisfactory for f-m.

Many a-m stations are located in lowland or swamp areas to provide a ground system with good conductivity. This particular consideration is not an important factor in the f-m band. More important is the elevation of the terrain with reference to the area to be served, and a site overlooking as much area as possible is needed.

Signal propagation over the broadcast band shows a wide variation between extreme frequencies for a given power and antenna system. This is in direct contrast to the f-m band, where substantially the same results are had on any frequency within the band. Very-high-frequency signal propagation results in coverage more definitely related to specific areas than standard broadcasting. Recognizing this, the FCC is authorizing applicants to apply for specific trading areas and has set up the following four classifications of coverage:

Class A. An area comprising a limited trade area and a city, usually composed of one small city and adjacent area.

Class B. An area comprising a basic trade area and a principal city, usually composed of a principal city, one or more smaller cities and the areas adjacent to these cities.

Class C. An area of at least 15,000 square miles, comprising primarily a large rural area and that part of basic trade areas which cannot be served by stations assigned basic trade areas due to economic and technical limitations.

Class D. An area having substantially different characteristics (social, cultural and economic) from those specified in classifications A, B and C, where the establishment of a special program and technical service is in the public interest.

Five channels are at present set up for non-commercial educational stations. Since a request for other frequencies and additional channels has been made by the RTPB, the present allocations for the various

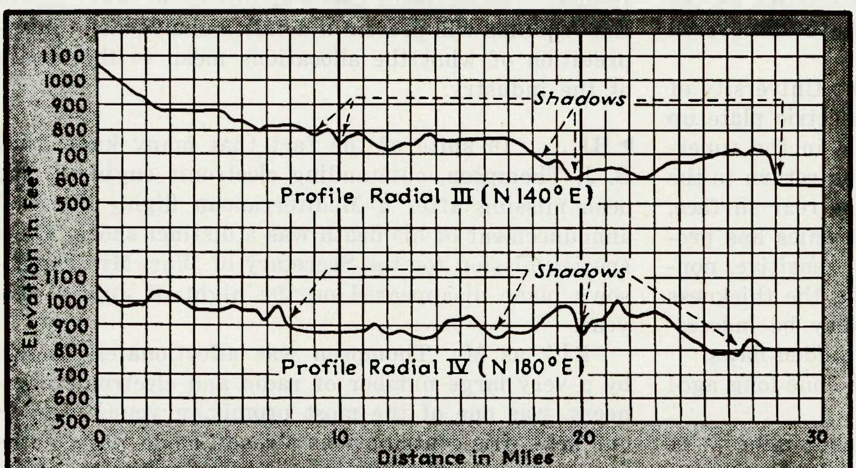
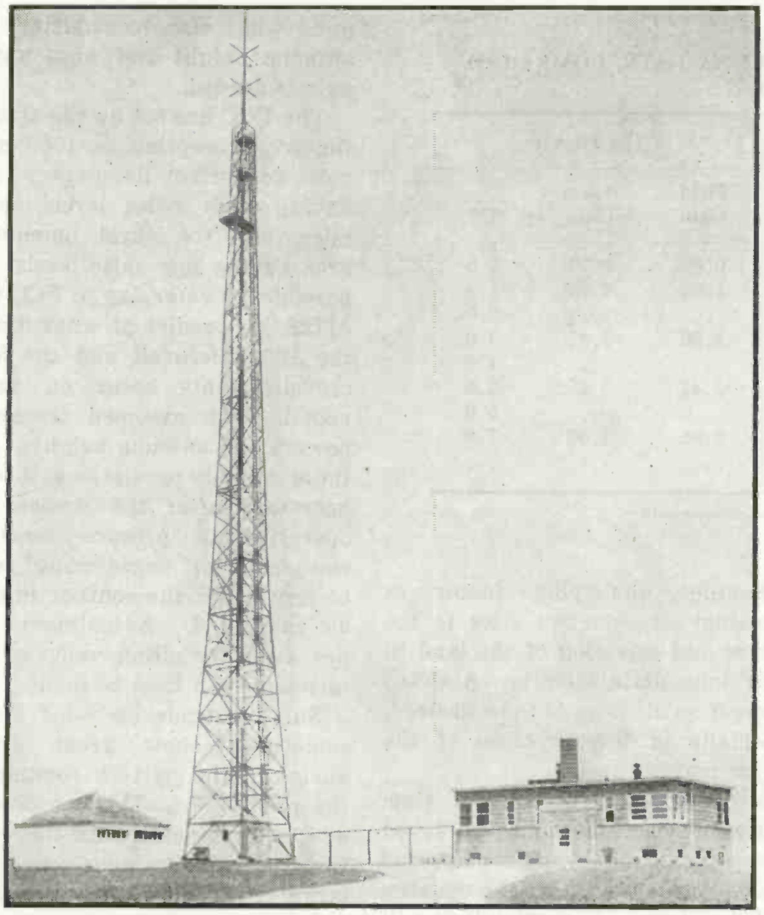


FIG. 1—Profile of the land elevation above sea-level along each of two radials centered on Richfield, Wisc. Note that a number of points, even within the primary service area, are in shadow



WMFM transmitter building and antenna at Richfield, Wisc. The tower is 200 ft high, and on top of it is a two-bay turnstile. The platform at the 175-ft level supports a studio-to-station link receiving antenna. The elevated trough carrying two coaxial transmission lines between transmitter house and tower may be seen

classifications may be modified in the near future.[1]

Complete data on trade areas can be obtained by referring to available maps.[2]

Transmitter Sites and Shadow Effect

Many cities have unusually tall buildings which are well suited for f-m installations. However, the location of such buildings in relation to the service area should be considered, especially if a circular pattern is contemplated. As an illustration, cities on the seaboards and on the Great Lakes in some instances are adjacent to large water areas.

If the initial outlay is for a class A station and plans are not for a large rural coverage, the transmitter should be placed at a point where the noise level is highest and population most dense. At the outskirts of the area, probably, the population will be sparse and noise levels low. Lower signal intensities will therefore be tolerable. Adequate lines between the studio and transmitter generally are available for a 50 to 15,000-cps circuit when the transmitter is located in a city.

There will be installation difficulties but these are not insurmountable. For example, it may be necessary to hoist material outside a building in a busy area or dismantle large units to fit the elevators. Steel beams may have to be cut in two, transported to the roof and welded together again. Such work is generally best carried out on a Sunday, roping off the street below to minimize danger to the populace. In negotiating for building space, the lease should clearly specify the extent of the roof rights for the antenna system.

To cover a large metropolitan area and large rural areas or large rural areas plus several metropolitan areas (class B or C) it is necessary in most cases to locate the transmitter at a point quite remote from the studio. Fortunate is the station that is located on high ground overlooking its principal city and trade areas. In choosing this site several factors must be considered, elevation being the prime requisite.

Obstructions such as hills, cliffs,

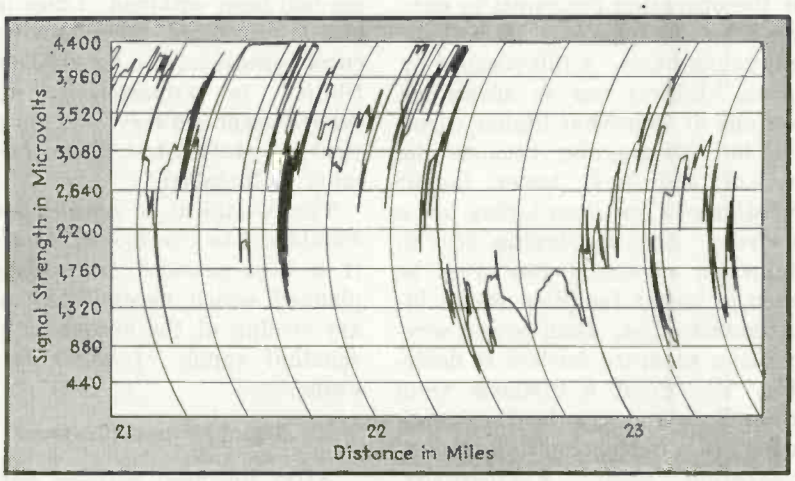


FIG. 2—Shadows such as those shown in Fig. 1 produce marked variations in signal strength, as shown on this graph obtained by continuous recording while driving through a hilly area

TABLE 1—MULTI-ELEMENT ANTENNA GAIN, COMPARED WITH DIPOLE

	TURNSTILE			CIRCULAR		
Layers	Field Gain	Power Gain	D*	Field Gain	Power Gain	D*
1	0.707	0.50	0.0	0.89	0.79	0.0
2	1.12	1.25	0.5	1.28	1.66	1.0
3	1.41	2.00	1.0	....	....	2.0
4	1.66	2.75	1.5	1.86	3.47	3.0
5	1.87	3.50	2.0	....	....	4.0
6	2.06	4.24	2.5	2.45	5.25	5.0
7	2.26	5.05	3.0	....	....	6.0
8	2.40	5.76	3.5	2.66	7.08	7.0
10	2.69	7.24	4.5	....	....	...

* Distance in wavelengths between top and bottom elements.

or buildings, when present in the transmission path, introduce attenuation and these zones are known as shadow zones. The area encompassed in a shadow will receive only a fraction of the signal intensity available at other equidistant points, the actual signal strength depending on the degree of shielding. Examination of the elevation along sample radials shown in Fig. 1 will reveal cases where line-of-sight transmission is not obtained. It is not unusual to find shadows such as these in the primary area of existing f-m stations. Figure 2 shows a sample recording of signal strength made while driving through such a shadow.

If the station is planned for the northern states or mountainous country, a location on a main highway or at least a good secondary road maintained in the winter is advantageous, making it possible for the operating personnel to gain access to the property on an all-year-round basis. A hill reached by a good highway has an advantage over one of somewhat higher elevation but inaccessible, because the cost of additional tower height sometimes is less than laying out a new road. Also, by staying close to highways, advantage can often be taken of power facilities which interconnect cities. Dual power service from separate feeders is desirable. Too great a distance from power lines may require the installation of an independent emergency generating plant. Furthermore, complete dependence on local power facilities may not be advisable in all cases.

Another qualifying factor in choosing between two sites is the nature and elevation of the land in their immediate vicinity. A sharp drop-off on all sides is to be desired, especially in the direction of the major market area.

A considerable amount of time and effort can sometimes be saved by procuring quadrangle maps for the various sections of the country under scrutiny. Immediately it will become apparent which of several likely spots has greater elevation above sea level and sites can be evaluated accordingly. If there is any doubt, an altimeter should be obtained and checks made to verify.

Telephone service may be obtained in some locations not too far from inter-city trunk systems by branching off with underground circuits. In one instance a line was laid underground for four miles after easements from property owners had been obtained. Lines in cables are preferred to open-wire circuits because of the latter's susceptibility to atmospheric noises. Where telephone service is not practical a station-to-transmitter-link must be installed.

The possibility of a water system should not be overlooked, especially if a high-powered transmitter is planned which necessitates auxiliary cooling of the air plasts and a constant supply of water for the evaporator.

Signal-Strength Contours

After the most suitable site has been chosen and all the factors related to the site are set down and evaluated, the next step is to determine what size transmitter, what antenna height and what antenna gain is needed.

The FCC has set up the standard for good reception as 1000 microvolts for urban listeners in areas having high noise levels and 50 microvolts for rural listeners in area having low noise levels. It is possible, by referring to FCC Chart 41722,[3] to predict at what distance the 1000-microvolt and the 50-microvolt points occur on various radials with assumed transmitter powers and antenna heights. Since these are only predictions, it will be necessary after the station is in operation to procure measuring equipment or engineering service to prove that the contour lines are as calculated. Adjustments compensating for either under or over-estimates can then be made.

Surveys made on v-h-f stations sometimes show great discrepancies in the pattern compared to the predictions. This, no doubt, is due to irregularities in the terrain involved. Mountainous country and large cities show great deviations compared to the surveys made in country more level and less densly populated. Figure 3 is an illustration of the predicted contours of WMFM, Milwaukee (formerly W55M).

After establishing the two contours, the area in square miles can

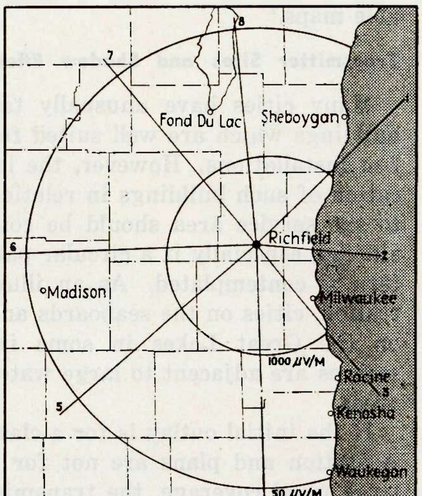


FIG. 3—Map showing predicted 1000 and 50-microvolt contours around WMFM. Radials on which signal-strength measurements were later taken are numbered

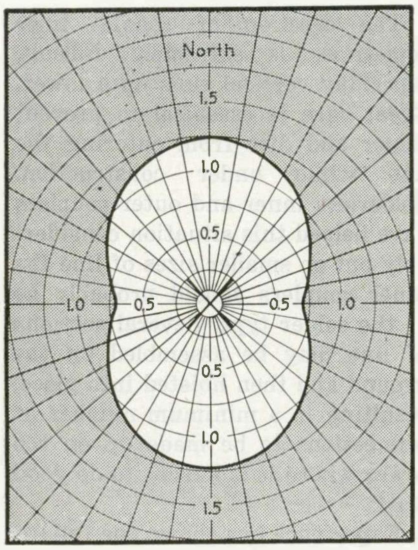


FIG. 4—(Left) Radiation pattern of a 60-deg phased turnstile called a "dumbell", having equal currents in all elements, showing north-south directional gain over a 90-deg turnstile

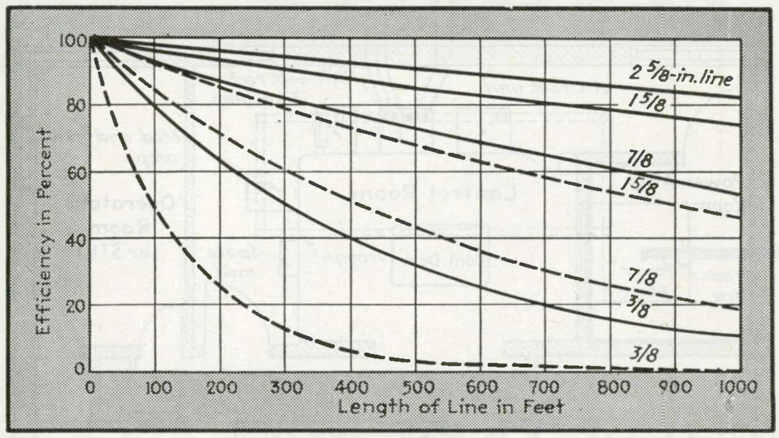


FIG. 5—Graph illustrating the percent efficiency of various sizes of coaxial transmission line using Isolantite insulation. Solid lines show efficiency at 50 Mc. Dashed lines show efficiency at 300 Mc (General Electric)

be measured by the use of a planimeter. Population analysis of the service area can then be carried out.

In the majority of cases it is probable that the f-m transmitting antenna will be independent of other antennas and on its own supporting structure. However, a question arises and will come up again and again in the future regarding the possibility of mounting an f-m antenna on the tower of an active a-m station. Where this is contemplated each tower will present its own structural problems and these will have to be analyzed by the manufacturer. The effect of loading the a-m tower with a heavy f-m array will, particularly, have to be carefully calculated. There is also the possibility that adding an f-m radiating structure might change the a-m antenna current distribution, and the phase angle in the case of a directional array.

Antennas

Horizontal polarization of the f-m antenna is recommended because of the high power-gain attainable while maintaining a structure rugged enough to combat the elements. Vertically-polarized antennas giving high power-gain are comparatively difficult to construct, whereas stacked horizontal units giving appreciable gain are readily obtained.

There are several ways of accomplishing antenna power-gain, namely, by stacked circular antennas commonly known as "donuts", by "turnstiles" using successive layers of arms radiating from the mast, or by square loops stacked one above the other and known as Alford loops. There are also several other suggested methods of securing horizontal directivity, such as corner reflectors and spiral antennas. Such antennas effectively increase the power by reducing the signal radiated vertically and concentrating it in the horizontal plane, i.e., along the earth's surface.

The effective signal radiated (ESR) is the all-important factor in evaluating an f-m system and, therefore, it should be determined whether a high-gain antenna system and a low-powered transmitter or a low-gain antenna and a high-powered transmitter are to be used. For example, for one typical transmitter site a calculated 4000 watts of effective signal is needed to assure a 1000-microvolt contour at 20 miles. This can be accomplished with 4000 watts of generated power using an antenna with a power gain of 1, or by using a more complex antenna system giving a gain of 4 and reducing the generated power to 1000 watts. The results in either case are theoretically identical. By referring to the following table of more or less standardized transmitter sizes it will be noted that 4000 watts falls between 3 and 10,000 watts, making it necessary to install a 10-kw transmitter.

250 watts
1,000 watts
3,000 watts
10,000 watts
25,000 watts
50,000 watts
100,000 watts

It is obvious that the most economical approach in this case would be to use a 1-kw transmitter with an antenna having a gain of 4 since the cost of the antenna would not approach the cost of a 10-kw transmitter. In addition, the maintenance and upkeep would be very much in favor of the smaller transmitter and the more complex antenna system.

Table I gives a comparison between two popular high-gain antenna types and a dipole having a gain of one. Comparative values of antenna gain for equal mast height are in favor of the turnstile, as the

TABLE 2—TURNSTILES VS DIPOLE

90-DEGREE		60-DEGREE	
		Field Gain	
Layers	Field Gain	North-South	East-West
2	1.12	1.36	0.79
4	1.66	2.02	1.19
6	2.06	2.51	1.44
8	2.40	2.93	1.68

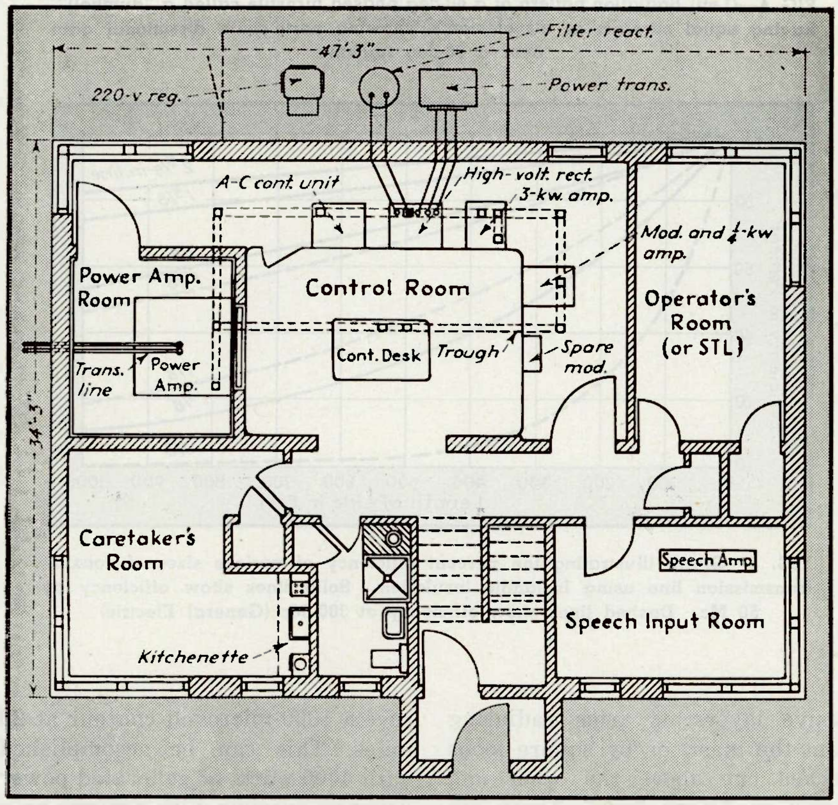


FIG. 6—First-floor plan of the WMFM transmitter building at Richfield, Wisc.

distance between layers of the turnstile antenna is ½ wavelength and of the circular antenna one wavelength. This corresponds to approximately 10 and 20 feet respectively, depending on the exact frequency used. In the event of CAA restrictions on height of the tower structure this represents an important factor.

Some modification of pattern can be obtained with a turnstile by either phasing or varying the current relationship of the elements in quadrature to obtain an elliptical pattern if it is desired to cover an elongated market area. Using a 60-deg phased turnstile, with equal currents, an increase of about 22 percent in one direction can be obtained with a loss of approximately 30 percent in the other direction. Figure 4 shows the pattern of a 60-deg turnstile that has been dubbed the "dumbbell." Table II shows the relative increase in field gain over a 90-deg turnstile for various numbers of layers. Note that the desired north-south field gain of a four-layer turnstile 60-deg phased is 2.02 compared to a standard 90-deg turnstile of six layers giving a gain of 2.06. Thus the 60-deg turnstile will provide a solution to some of the cases where an irregular trade area cannot be served adequately with a circular pattern.

Transmission Lines

Considerable trouble has been experienced in the past with transmission lines. Open-wire and coaxial lines are in use and both require careful matching to obtain a reasonably low standing-wave ratio. Ratios of 1 to 1.25 have proven satisfactory for coaxial lines. A somewhat higher value can be tolerated on open lines.

Sleet and ice formation has been the most troublesome condition, resulting in flashover and occasional burn-out of the feeder system, a situation not too easy to repair under adverse conditions. De-icers have been built into some antenna installations and are especially valuable in zones subject to sleet formation. They are controlled from the power panel inside the building or can be made to operate automatically within the temperature range of sleet formation, and in no way affect the operation of the antenna. Without such protection it would be necessary to reduce the input power for transmission line protection.

The erection of coaxial lines sometimes is extremely difficult, especially vertical runs up a tower. Great care is essential to prevent solder and dirt from entering the line while under construction. Solderless inner and outer couplers have helped this situation considerably but on smaller sizes of line the inner couplers should probably be of the solder type. Several sections of line may be assembled on the ground and then hoisted into place, resulting in a minimum number of connections to be made up on the tower where it is harder to do good work.

Experience has shown the following transmission line sizes to be adequate for transmitter power outputs as listed below, assuming that the line is correctly terminated to eliminate standing waves:

250 watts or less	70 ohms 3/8 in. OD
250 watts to 1 kw	70 ohms 7/8 in. OD
1 kw to 3 kw	70 ohms 1-3/8 in. OD
3 kw to 10 kw	70 ohms 1-5/8 in. OD
10 kw to 25 kw	70 ohms 3-1/8 in. OD
25 kw to 50 kw	35 ohms 2-3-1/8 in. OD

Lines somewhat larger than are strictly necessary are suggested, giving additional safety factor. Larger lines also result in lower losses and may be advisable if the length of line is unusually long. For the STL transmission line sizes should be especially generous because at the higher frequencies involved losses increase appreciably and power is more difficult to generate. Figure 5 shows relative line loss at 50 Mc and 300 Mc for various sizes and lengths of typical coaxial line.

Transmitter Building

An f-m installation does not require as large a space as its a-m counterpart. A typical 1-kw f-m transmitter is a completely self-contained unit including blower and power supplies, occupying a space approximately 72 by 30 by 72 in. over all. A floor space as small as 350 square feet would be sufficient to accommodate the transmitter, and a room adjacent to the transmitter suitable for audio console, turntables, line amplifier, frequency and modulation monitor, and monitoring receiver. A typical 50-kw transmitter occupies space comparable to the average 5 and 10-

kw a-m stations now in service.

A typical 50-kw installation is the Milwaukee Journal f-m station WMFM, which houses its transmitter in a two-story building 47 by 34 ft in size. On the first floor shown in Fig. 6, is the transmitter, speech and test room, STL receiving room, caretaker's quarters and toilet. The basement, shown in Fig. 7, is devoted to the cooling and pump room, heating plant, work shop, tube storage and building utility. Rectangular steel ducts 4 by 6 in. are placed along the ceiling of the basement to house the inter-connect wiring between the various transmitter units directly above. All motor-generators, blowers, water pumps, etc. are mounted on rubber rails to minimize the noise transmitted through the building foundations.

The 50-kw transmitter comprises five units. The modulator is incorporated in the 250-watt unit, and followed by a 3-kw amplifier in a cabinet directly alongside, with its associated rectifiers and blowers. Following this is the high-voltage rectifier and power-control units mounted in racks somewhat larger. The plate transformer for the 100-kw rectifier, with its voltage regulator and reactor, is mounted directly outside the building on a raised concrete block platform for protection against snow. The 50-kw power amplifier is installed in a separate room which is completely shielded by 0.006-in. thick copper, including the floor and door.

A balanced concentric line consisting of two 3⅛-in. lines is inductively coupled to the power amplifier. These lines are mounted on an elevated trough spanning the distance between the tower and transmitter building. To minimize sudden differential changes between the inner and outer conductors, the trough is covered with a sectionalized, removable shield. Mounted directly at the transmission-line end-seals are two diodes which act as a vacuum-tube voltmeter reading the relative voltage for daily comparison and reference purposes. For the present, indirect measurement of power output is used and calculated at 60 percent of the plate input of the final stage.

The ground system deviates greatly from a-m band practice insofar as radial wires were not buried as a part of the radiating system and only sufficient copper was laid for equipment grounds and protection against lightning. The ground system consists of sheets of expanded copper screening each 6 by 10 ft in size, laid around the entire building and covered with eight inches of soil. The tower ground is made up of similar pieces forming a mat 30 by 30 ft overall and tied to the building ground by several two-inch copper straps.

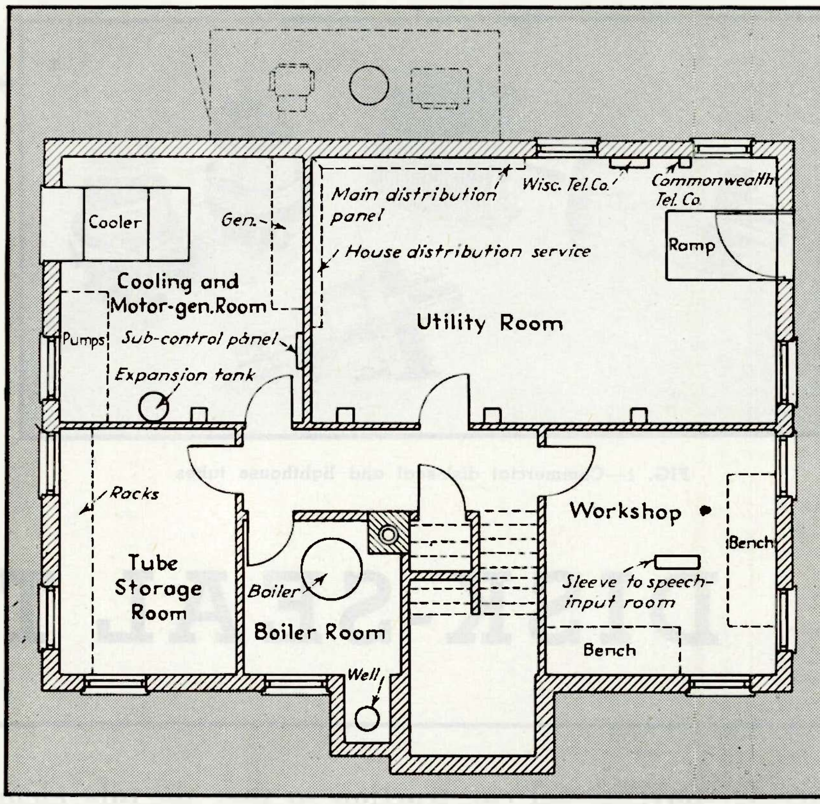


FIG. 7—Basement floor plan of the WMFM transmitter building

During the period of construction, the entire building metalwork, such as conduit, water pipes, reinforcing steel, metal lathe, was bonded together and spot-welded. Every 10 feet, four-inch copper straps were brought out of the masonry slightly below ground level and joined to the screening.

Power

The WMFM a-c power requirement for the transmitter itself is about 102 kva with the transmitter operating at its licensed power input of 60.5 kw. When the amplifier is running at full 50-kw r-f output, the a-c power demand rises to 135 kva. Power requirements given here do not include equipment such as the electric stove, building heating, water pump, tower and building lighting.

The local utility supplies service from either of two 26,400-volt lines, each line coming from a different direction on separate feeders. Three 50-kva transformers feed 240-volt, 3-phase power into the building through an underground duct.

Transmitters of various sizes will use approximately the following a-c power:

250 watts	1.2 kw
1,000 wt	3.5 kw
3,000 watts	7.5 kw
10,000 watts	24.0 kw
50,000 watts	135.0 kw

The power used by associated equipment such as speech input, monitoring, and lighting, should be added to the above estimated power requirements.

References

(1) A Report on the FCC Frequency Allocation Hearing, ELECTRONICS, p. 92, Dec. 1944.

(2) "Retail Shopping Areas," J. Walter Thompson Co., New York; "Four-Color Retail Trading Areas," Hagstrom Map Co., New York; "Trading Areas," Rand McNally & Co., Chicago; "Consumer Trading Areas," Hearst Magazines, Inc., New York.

(3) "Standards of Good Engineering Practice for High-Frequency Stations," Federal Communications Commission, Washington, D. C.

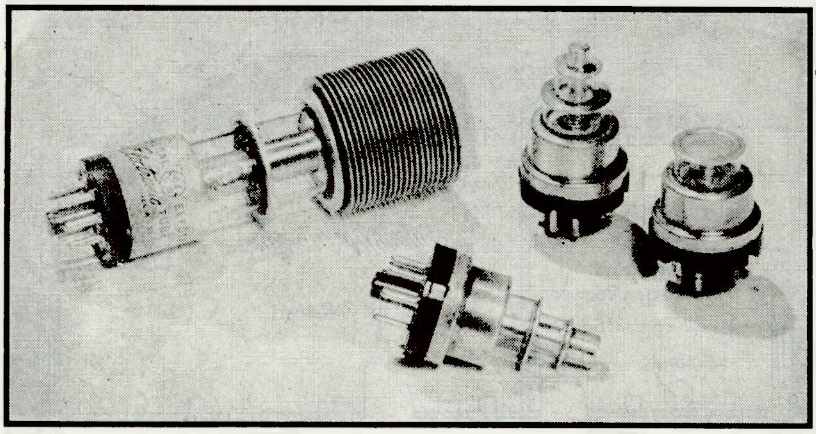


FIG. 1—Commercial disk-seal and lighthouse tubes

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DISK-SEAL TUBES

Altering conventional construction so that the tube elements become part of the electromagnetic circuit improves high-frequency operation. Disk-seal tube design places the electron stream in the high-impedance region of a cavity resonator

THE DEMAND for higher frequency and more power for new services and industries has grown as rapidly as research and development could push back the frontier. One of these outgrowths of research is the disk-seal tube. This new type tube, which includes that group known as lighthouse tubes, is a development that has greatly extended the usable frequency spectrum and introduced a new concept of the relation between the electron tube and its associated circuit.

The Basic Idea

Electronically, the disk-seal tube, or more simply the disk tube, is a multi-electrode tube using the same space-charge control principle as conventional triodes, tetrodes and pentodes.

Geometrically, it is a tube built from simple, smooth-surfaced disks and cylinders into a structure which usually, but not necessarily, has circular symmetry. As we shall see, the ultrahigh-frequency property of any such metal shape is a design factor whose significance is just becoming evident.

Philosophically, the disk tube is an embodiment of the principle that in the microwave field we can no longer speak of tubes and circuits as two distinct entities. It is necessary to think of a microwave oscillator, for example, not as an electron tube with an attached circuit but rather as a single electrical system having one section walled off and evacuated to house the electronic activity.

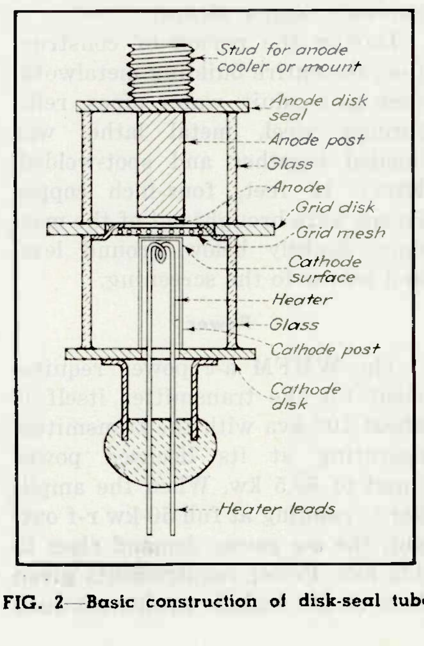


FIG. 2—Basic construction of disk-seal tube

A group of commercial disk tubes is shown in Fig. 1. Figure 2 is a cross-sectional view showing the basic mechanical features common to disk tubes. Figure 3 shows the constructional details of the 2C40 lighthouse tube.

Frequency Limitations of Conventional Tubes

In trying to reach the highest possible oscillation frequency with a given tube one usually starts at a low frequency, using some standard oscillator circuit such as the one in Fig. 4(a). The frequency is raised by decreasing L and C until the circuit looks like that in Fig. 4(b). A point is finally reached where the circuit has been made as small as possible and the tube is being operated at the maximum allowable plate power dissipation and voltage. The tube has reached its apparent maximum frequency.

Let us study the circuit arrangement in Fig. 4(c), which is the same as that in Fig. 4(b) but with the interelectrode capacitances and the lead inductances shown. If the cathode is sufficiently isolated by the chokes, the radio-frequency potential of the cathode will be fixed with respect to the anode and grid by the two interelectrode capacitors C_{gk} and C_{pk}. Thus, the excitation or feedback voltage appears across C_{gk} and is not adjustable. When we include these two capacitors, it becomes clear that Fig. 4(b) is the familiar Colpitts oscillator circuit which we might expect to operate in the usual way if it were not for a number of new factors which creep in as we try to drive the frequency higher.

One reason why the frequency cannot be made higher lies in the indicated lead inductances and distributed capacitance of the electrode structures. In many cases, the main oscillating circuit is a two-wire transmission line connected to the grid and anode; a line which, in addition to its desirable features, has several serious drawbacks. One is that, although a quarter-wave line in itself is physically large even at very short wavelengths, the line is shortened by the interelectrode and stray capacitance of the tube elements until at some high frequency the part external to the tube vanishes.

Another factor is the increased energy losses due to the electromagnetic radiation from every part of the circuit. This becomes more severe as the tube electrodes and circuit elements become more comparable in size to the wavelength. Usually this tube radiation becomes so large that little or no useful output can be obtained, or it may even prevent oscillations from starting. This radiation is always a major limitation on the impedance which can be developed with an unshielded system.

Electron-Stream Transit Time

Still other difficulties arise from the electron transit time. When the electron transit time becomes comparable with the oscillation period, some properties of the electron stream which were negligible at low frequency become important. This does not mean that an insuperable barrier has been raised. It does mean that the system must be looked at in a far broader sense.

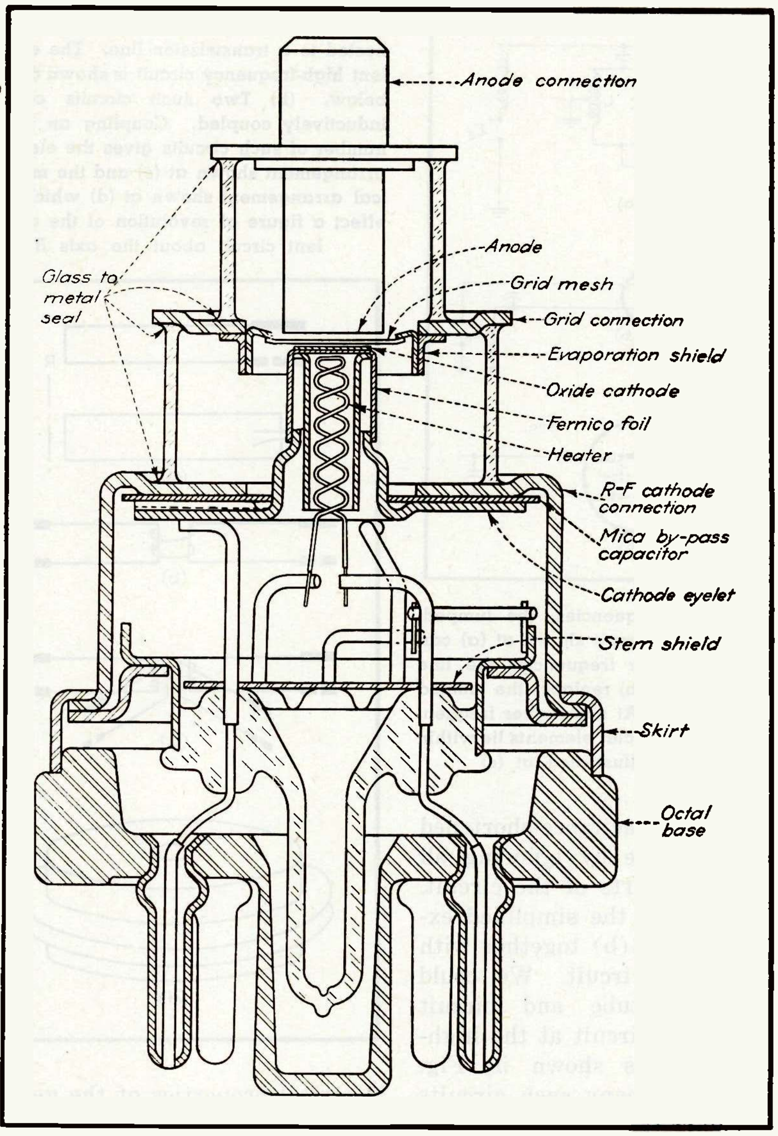


FIG. 3—Mechanical details of the 2C40 lighthouse tube

Because of transit time of the electron stream, there will be a dissipative load introduced at the excitation or input terminals of the circuit. There will also be a phase angle between the excitation voltage and the fundamental component of anode current such that the tube input and output voltages will almost never have the 180-degree phase relation common at low frequency. Phase angle as such need not be harmful provided we recognize and meet the added circuit requirements which it imposes. On the other hand, characteristics such as transconductance are adversely affected in comparison with d-c values so that there is an even greater need for efficient circuits than at low frequency.

The feedback circuit in the oscillator must be capable of providing the necessary excitation voltage in spite of the extra driving power, as well as almost any phase angle between its input and output voltages. But, with the arrangement shown in Fig. 4(c) the feedback voltage is almost entirely fixed both in amplitude and phase by the self and mutual reactances of the tube parts. None of these circuit elements can be adjusted and so above the frequency at which the phase relation between input and output becomes appreciably different than 180 degrees, the feedback conditions for sustaining oscillation cannot be met.

Use of Cavity Resonators

The frequency-determining circuit connected between grid and anode of Fig. 4(b) can be reduced

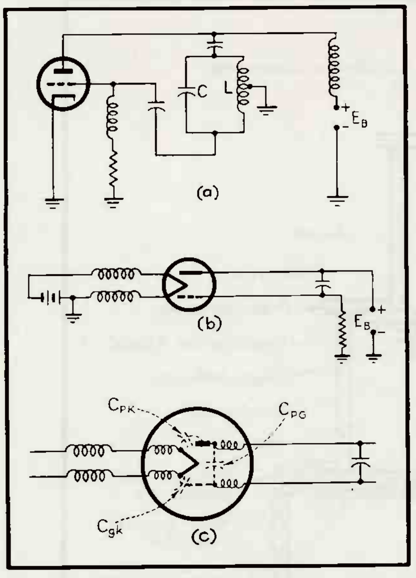
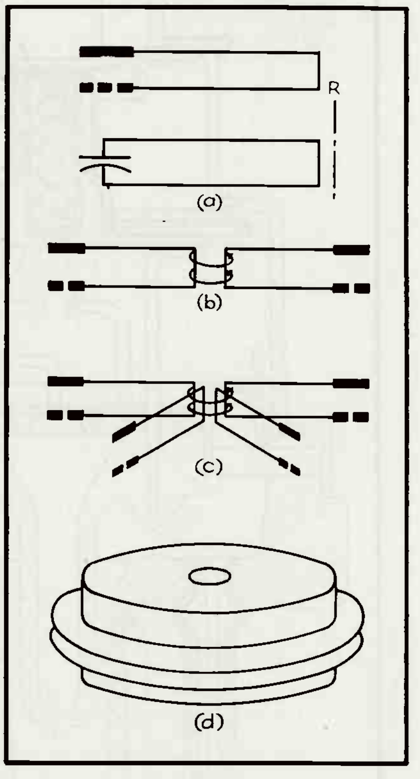


FIG. 4—At low frequencies, the lumped-constant oscillator circuit shown at (a) can be used. At higher frequencies the line oscillator shown at (b) replaces the lumped constant oscillator. At still higher frequencies the important circuit elements lie within the tube as illustrated at (c)

FIG. 5—At (a) the grid and plate are connected to a transmission line. The equivalent high-frequency circuit is shown directly below. (b) Two such circuits can be inductively coupled. Coupling an infinite number of such circuits gives the electrical arrangement shown at (c) and the mechanical arrangement shown at (d) which is in effect a figure of revolution of the equivalent circuit about the axis *R*



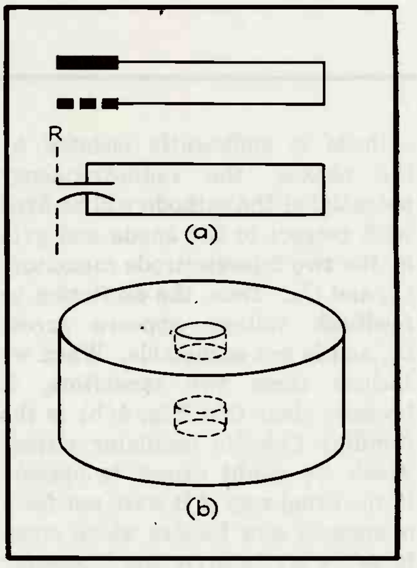


FIG. 6—Choosing a different axis of revolution from that of Fig. 5 for the equivalent circuit at (a) gives the mechanical arrangement at (b) which readily lends itself to use as the electromagnetic basis of the disk-seal tube; the electrodes for the electronic system go at the center

to a simple capacitance-shortened quarter-wave line by ignoring all direct-current parts of the circuit. Fig. 5(a) shows the simplified extract from Fig. 4(b) together with the equivalent circuit. We could have another tube and circuit coupled to this circuit at the high-current point as shown in Fig. 5(b). In fact, many such circuits could be added as at Fig. 5(c), the ultimate being equivalent to the rotation of the circuit at Fig. 5(a) about an axis *R* to give the structure shown in Fig. 5(d). The shortened quarter-wave line in Fig. 5(a) has, by rotation, generated a closed metal structure made of two parallel flat metal disks joined by a cylindrical hub at the center and terminated at the periphery by an annular ring capacitor.

Continuing the same line of thought gives rise to other structures such as that in Fig. 6. Such totally enclosed circuits or cavity resonators are ideally suited to ultrahigh-frequency needs. The one shown in Fig. 6, for example, would be expected to have much the same current and voltage distribution as do the quarter-wave line sections from which it was developed and which make up its radii.

This is a sound physical picture but inaccurate numerically. A more exact analysis must be based on the electrical properties of the geometrical shape. A simple radial resonator and a quarter-wave open line are shown in Fig. 7, together with the current and voltage distribution for each. In the uniform open line, the resonant line length is 0.25 λ, whereas in the resonator the radius is 0.38 λ.

The most important distinction between line and cavity is that the hollow resonator of Fig. 7 is self shielding. The electric and magnetic fields exist wholly within the resonator. If the metal walls of the resonator are made a few times thicker than the skin thickness or depth of field penetration, there will be no appreciable coupling between the space inside and that outside the resonator and, therefore, there will be no energy lost by radiation.

Union of Tube and Tank

If cavities are to be used to their fullest advantage, the electronic part and the electromagnetic part of the circuit must be considered as a unit. The disk tube brings about this union in a way illustrated by Fig. 8. Fig. 8(a) shows a vertical cross section of a simple radial resonator similar to that developed in Fig. 6. The point of maximum impedance occurs internally between the two surfaces, *S*. It is here that the grid and anode connections would be made if the cavity were to be used in place of the open wire line of Fig. 4(b).

The genesis of the disk tube is obvious from here on, for, if the surfaces *S* are proper for grid and anode connections, it would be even better if they became the actual grid and anode electrodes. Fig. 8(b) shows the development of such electrodes and Fig. 8(c) shows a section of a resonator containing the electrodes walled off and evacuated to form the upper part of the disk tube illustrated in Fig. 2. The electronic circuit element has been coupled directly to the electromagnetic circuit element with very little geometric disturbance to either component. There is no anode- or grid-lead inductance in the ordinary sense. Neither is there unwanted capacitance except that due to the active part of the electrodes. All of these metal surfaces help to shape and contain the electromagnetic field. By maintaining substantial continuity of the metal surfaces, the tube elements become an integrated part of the circuit.

Controllable Feedback

The use of a cavity resonator goes a long way toward solving the problems posed by the output circuit of our sample oscillator but some other problems—feedback for example—have not yet been touched.

It was pointed out that one reason why the circuit of Fig. 4(c) fails is that it allows no adjustment of either the amplitude or phase of the feedback voltage. The essentials of this circuit are redrawn in Fig. 9(a) using lumped circuits and showing the interelectrode capacitances which fix the feedback voltage.

A considerable amount of control can be gained by including C_{pk} in a tuned circuit as shown in Fig. 9(b). This tuned input circuit should be a cavity resonator for the same reasons which prescribe a resonator for the output circuit. Frequently C_{pk} is not large enough to provide adequate feedback and, in that case, it is supplemented by an added adjustable link.

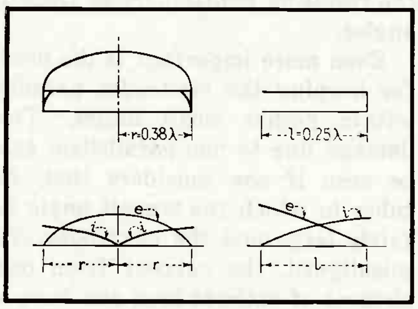


FIG. 7—Resonant dimensions of a cylindrical cavity and a transmission line, and the current and potential distribution of each

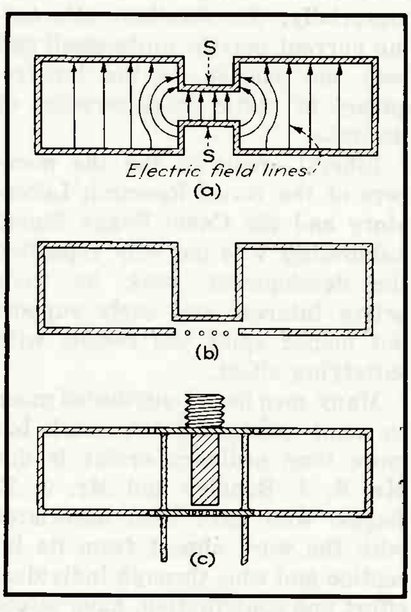


FIG. 8—The evolution of the disk-seal tube from a cavity resonator

Figure 10, which shows two resonators having a common central wall, illustrates the general mechanical combination of a disk tube and a double resonator which has come to be known as the grid-return, grounded-grid or, more properly, the grid-separation circuit.

An important attribute of the disk tube is the physical separation of the input and output circuits which it permits. This is important because physical separation means electrical separation since, even though the central cavity-dividing wall and the grid disk are common to both resonators, the small depth of field penetration into this wall effectively keeps the electromagnetic fields within their own cavities. In other words, C_{pk} is the only coupling reactance left; the dozens of small coupling capacitances and mutual inductances between electrode parts and leads in conventional tube designs are eliminated.

If it is desirable—and it is in some cases—C_{pk} may be made inconsequential by adding a screen grid.

Through these features, the disk tube permits the use of distinct input and output circuits; the feedback circuit between the two is reduced to a known impedance and the various circuit parameters brought under individual control. These circuits have been the subject of much intensive study, both theoretical and physical, and several basic forms have been evolved.

Electromagnetic Shielding Provides Heat Radiation

Figure 11 shows a cavity oscillator circuit. The mechanical layout of this circuit illustrates another very important property of the disk tubes. At very high frequencies, the electric field within the resonator and between electrodes penetrates the metal surfaces a distance in the order of only about one thousandth of an inch and therefore the current conduction is entirely confined to those surfaces which are exposed

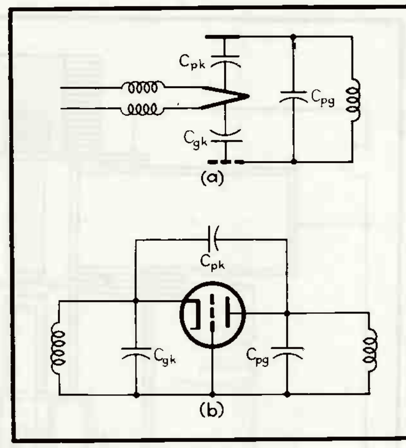


FIG. 9—The circuits used with the disk-seal tube take advantage of the interelectrode capacitances shown in drawing (a) by placing them in the resonant circuits as at (b)

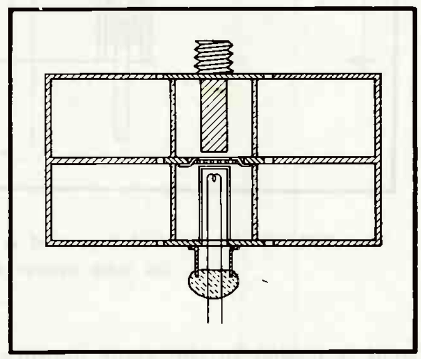


FIG. 10—The disk-seal tube and resonator equivalent of the lumped-constant circuit shown at Fig. 9 (b)

to the electric field. Thus, there will be high frequency electric currents flowing on the inner surfaces of the resonators and none on their outer surfaces. One might say that the inner and outer surfaces are insulated. Heat, on the other hand, does penetrate the resonator walls and is conducted throughout the metallic circuit. These differing laws of behavior are the source of a most advantageous function which occurs automatically in the disk tubes.

In the disk tube, high-frequency energy flows from its point of origin on the anode surface into the resonator. On the other hand, heat generated at the anode flows through the solid anode rod to the outside of the resonator. This automatic filtering permits anode cooling to be carried out by any appropriate method outside the cavity without interfering in any way with the high-frequency part of the system inside the cavity. The

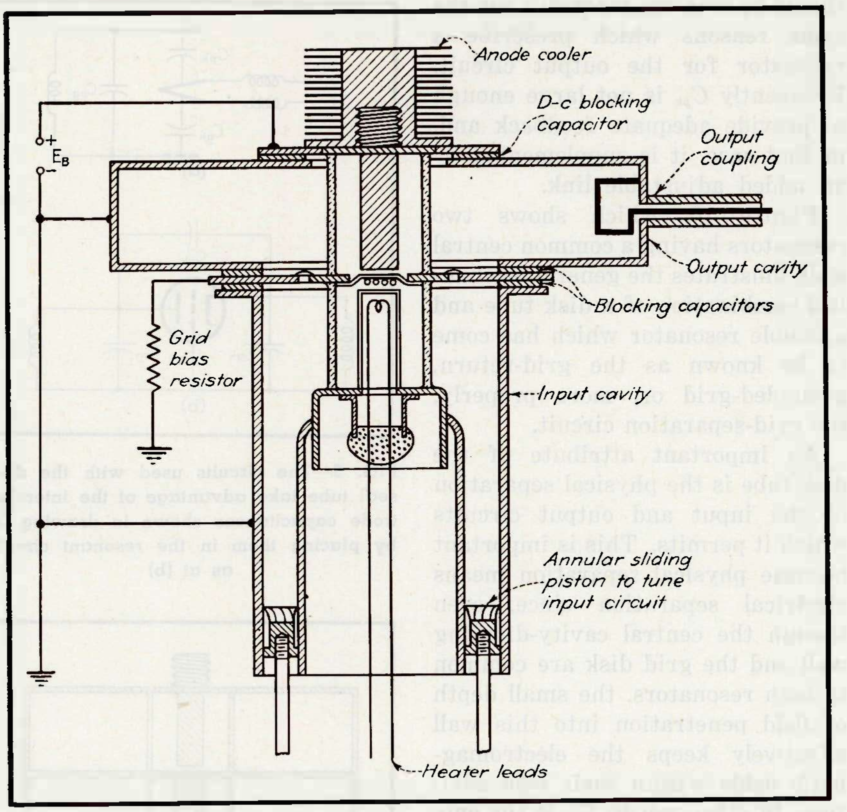


FIG. 11—Mechanical layout of a disk-seal tube circuit shows unity of the tube proper with the wave circuit

grid is cooled in the same manner so that troubles arising from primary grid emission are greatly reduced.

Since the same reasoning applies in reverse, it is possible to locate the cathode heater together with all its power supply wiring wholly outside the cavities and free of ultrahigh-frequency field.

The same filtering occurs with direct current or low-frequency alternating current and therefore power connections can be made to the cavity system without the use of elaborate isolating chokes.

Design Requirements

Mechanically the disk seals in many of these tubes are made of a metal suitable for sealing to glass. High electrical conductivity is preserved by a thin coating of copper or silver which, since it need be only a few thousandths of an inch thick, will not cause dangerous stresses in the vacuum seals. Again we take advantage of the small field penetration to fabricate a composite structure having good electrical conductivity as well as suitable mechanical properties.

The parallel-plane electrodes offer an opportunity as well as pose a problem. To make efficient microwave tubes it is important to use the electron stream efficiently. The degree to which desirable electronic properties are achieved may be judged by one or more of several criteria depending on the type of service considered. For instance, we are always interested in low interelectrode capacitance and yet for a power amplifier we must not sacrifice current-carrying ability. For this application we might use the ratio C/i_p as a figure of merit. For low level amplifiers, where power gain and electron noise are important, we want the highest transconductance possible for a given current. Here we are interested in a large ratio of G_m/i_p. For some jobs, interest will center on power gain and bandwidth. In almost every case, it is desirable that the transit angle be kept small.

Manufacturing Tolerances

When we examine the various criteria, we find generally that they are all improved by decreasing the interelectrode spacing, particularly the grid-cathode spacing. The end-on presentation of plane electrodes is an arrangement uniquely suited to this need. The electrodes require accurate positioning in only one major dimension rather than two as would be the case for cylindrical electrodes. Tube construction and assembly methods enable a tube like the 2C40 to be built with a cathode-grid spacing of 4.0 mils. Developmental tubes have been built with only 1.0 mil cathode-to-grid clearance.

If space-charge control of the usual type is to be retained, the grid-wire size and pitch must be reduced in proportion otherwise it will become so coarse relative to the reduced interelectrode spacing that the electric field will become non-uniform between the grid and cathode. Under this condition, the low-frequency characteristics are poor and the high-frequency characteristics suffer even more severely from the resulting multiplicity of transit angles.

Even more important is the need for keeping the electrodes parallel within rather small limits. The damage due to non-parallelism can be seen if one considers that, in tubes in which the transit angle is fairly large and the electrodes are misaligned, the current from one element of cathode area can have a quite different phase angle from that of neighboring areas. Since the high-frequency components of current from these elements add vectorially, the resultant alternating current may be quite small and bear no relation to the low-frequency or static characteristics of the tube.

Liberal credit is due the members of the Naval Research Laboratory and the Camp Evans Signal Laboratory who not only expedited the development work by their active interest and early support but helped apply the results with satisfying effect.

Many men have contributed much to many phases of this work but more than ordinary credit is due Mr. R. J. Bondley and Mr. J. E. Beggs, who have been associated with the work almost from its inception and who, through individual effort and contribution, have solved many of the basic design problems in these tubes.

Measuring the Elasticity of SYNTHETIC YARNS

Young's modulus is determined with a minimum of error due to plastic deformation. Fiber under test is excited at 10 kc per second, producing high-loading under short-period conditions. Method also lends itself to testing of plastic films and other materials

By SHIRLEIGH SILVERMAN* and J. W. BALLOU**

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As the synthetic textile industry has grown from its early days when rayon was considered merely artificial silk, to the status of a widespread, self-sufficient industry, it has become more and more important to understand and to measure inherent physical properties of new man-made yarns. This is particularly true of yarns intended for such things as tire-cords, where physical properties are involved which never before were of much importance.

At the present time, empirical testing is usually resorted to in the end, for lack of ability of the usual stress-strain curve to impart information which closely correlates with observed practical performance. However, since it was felt that the elastic properties of a string under tension are fundamental characteristics of the system, it was decided to develop a technique for measuring the elastic modulus in an unambiguous manner. The modulus likely to be of primary interest is Young's modulus, defined as

$$E = \frac{\text{force per unit cross section}}{\text{elongation per unit length}}$$

In dealing with systems that exhibit both plasticity and elasticity, such as fibers and films, the usual methods of measuring Young's modulus are apt to give results highly influenced by the presence of the plastic component since, in general, a low rate of loading is employed. When a load is applied slowly to such a medium, plastic deformation is observed. i.e., complete recovery is not present after the release of the stress.

Young's modulus may be determined from the slope of the ordinary strain curve. But in a good many cases the resultant stretching produces a change of structure, e.g., by increasing the orientation; and it is for these reasons that the usual mechanical methods are not

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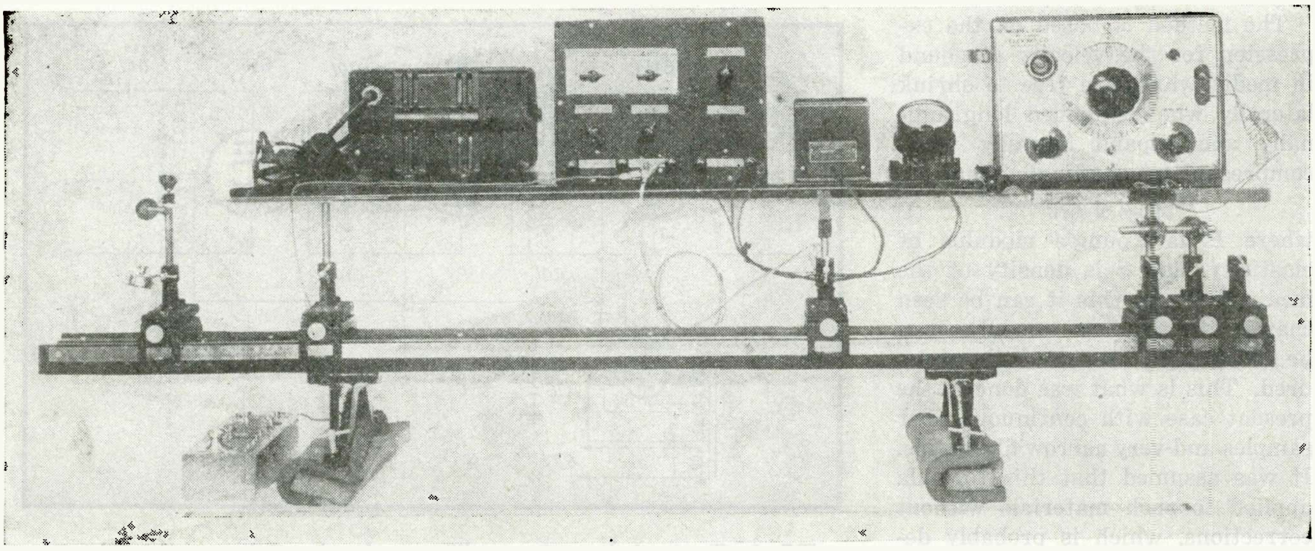

Photograph of the test setup used by the authors. The various component parts of the system are identified in the schematic of Fig. 1, appearing on the next page

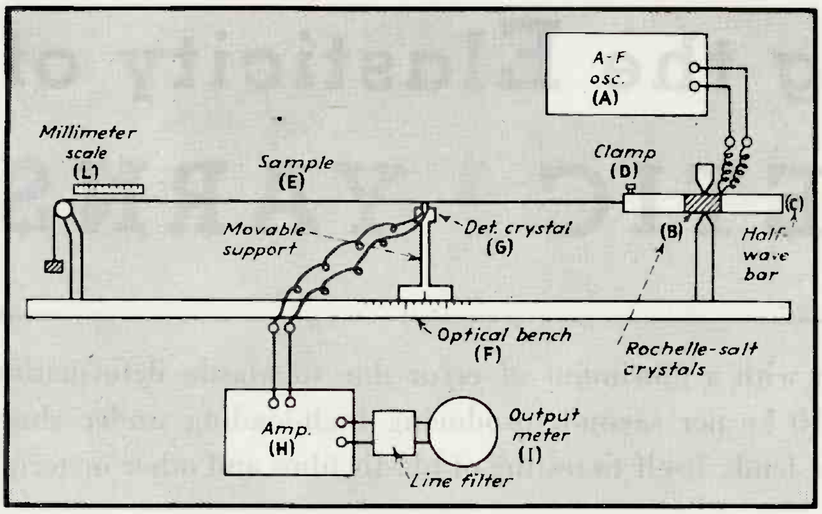

FIG. 1—Schematic of the setup used to measure the elasticity of synthetic yarns and plastic films by a method described in the text. A photograph of the equipment appears on the preceding page

adapted to a study of the truly elastic characteristics of fibers and films. Also, it is difficult to apply some of the methods, such as those based on compression, impact and photo-elastic effects.

To study the elastic component alone requires a high rate of loading so that the deformation is executed very rapidly, thereby minimizing the relaxation and plastic processes. The problem of obtaining this high rate of loading for such measurements was solved by the use of longitudinal vibrations of relatively high frequency, around 10 kc, an application of sound waves used previously by Meyer and Lotmar[1] but in a less versatile form than that described in this paper.

Method

The method is based on the expression for the velocity of sound in media which are free to shrink laterally when extended longitudinally and expand laterally when compressed longitudinally, that is:

$$V = \sqrt{E/d} \qquad (1)$$

where E is Young's modulus of elasticity, and d is density of the medium. From this it can be seen that E, the adiabatic modulus, can be calculated if V and d are measured. This is what was done in the present case with continuous fiber samples and very narrow film strips. It was assumed that this formula applied to such materials without corrections, which is probably defensible particularly in the case of the fibers which were usually made up of filaments of very small cross section.

It is a fortunate thing that V is independent of the fiber cross sectional area, thereby making it unnecessary to measure cross section accurately. This is a distinct advantage not found in the usual methods for measuring Young's modulus. It was necessary to know the density of the fibers and films tested, but the literature provided reliable values in most cases.

Standing waves of a definite frequency were set up in the sample and the half-wavelengths measured. Knowing the frequency, the velocity was then calculated.

Remembering the usual relation for wave motion: $V = n\lambda$, where V is velocity of sound, n is frequency of vibration, and λ is wavelength, we get, by substituting in Eq. (1).

$$E = n^2 \lambda^2 d = 4 n^2 d (\lambda/2)^2 \qquad (2)$$

Equipment

In the equipment illustrated in the photo and shown schematically in Fig. 1 the source of the longitudinal vibrations is a halfwave bar of steel (C) cut to resonate at 10 kc. Two Brush rochelle-salt crystals (B) cut to respond at the same frequency are cemented to opposite sides of the bar. The whole system is excited to resonance by a Televiso VG-1 audio oscillator (A). The particular bar and crystal combination used gave a not-too-broad resonance at 9.4 kc with sufficient amplitude for measurements with only a few volts oscillator output.

The sample of film or fiber (E) was clamped at (D) and its elongation read from the millimeter scale (L). The sound source, along with the pulley and clamp at the other end, was mounted on an optical bench (F) and the sample was run over the pulley and loaded by a weight to give the desired tension or clamped at the desired elongation.

A rochelle-salt crystal (G) of the type commonly used in high-fidelity phonograph pickups was mounted in a support which could move along the optical bench; the crystal wafer had a small steel wire imbedded in its waxed edge to serve as a bearing surface for the yarn or film sample.

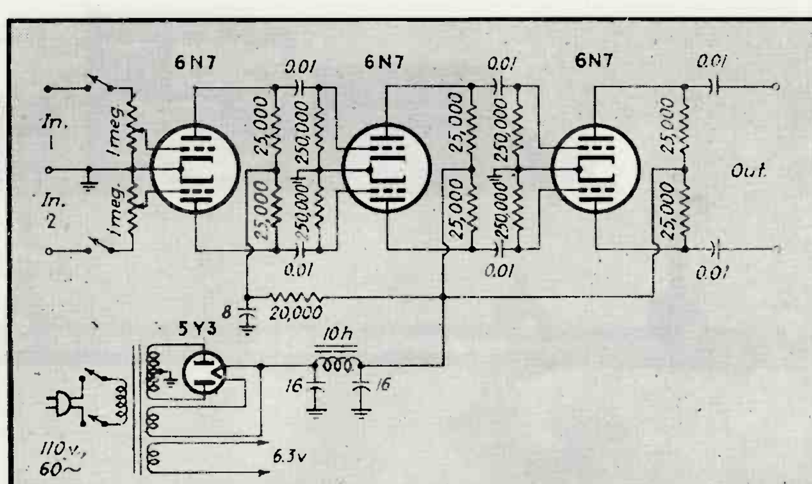

FIG. 2—Circuit of the audio amplifier employed. Only one channel was used in the experiments described. The second channel was provided to facilitate a proposed direct-reading scheme utilizing a phase-meter

The pickup crystal acts both as a reflecting fret and detector of the amplitude of standing waves when these are set up. The crystal pickup feeds into one channel of an amplifier (H) whose circuit is shown in Fig. 2. The amplifier output is filtered through a General Radio 614-P3 60-cycle line filter to a Triplett output meter (1).

The crystal pickup offers a sufficient discontinuity so that some of the energy in the sample is returned of the source. When this returned energy is in phase, standing waves are formed and an intensity increase, as shown by the output meter, occurs. To determine the half-wavelength, the position of the movable crystal support on the optical bench is noted for two successive maxima, the difference then being the required value. This scheme is preferable because end effects cancel out.

Operation

In operating the setup, the sample is put in under a definite load or elongation. The detecting crystal is adjusted for height so that good contact with the sample is insured. This adjustment is very important and some practice is required in finding the optimum condition.

The position of the detecting crystal, the amplifier gain and the oscillator output are next adjusted so that a signal of a volt or so appears on the meter. The oscillator frequency is then adjusted for resonance as indicated by a peak in the meter reading at this arbitrary setting of the pickup.

Next the detecting crystal is moved along the optical bench until an absolute peak is found, meter readings every 1 mm are taken and the peak is accurately located. The detecting crystal is then moved on to the next peak and a similar bracketing measurement made.

The small millimeter scale was used for measuring sample elongation under various loads, using a fiducial mark on the sample.

In working with fibers, any twist above three turns per inch was removed before measurements were made. It was found necessary to load all samples initially by a small amount to get good maxima readings. This was done in all cases and the elongation was calculated using the length at this loading as the original length. In general, cords twisted from strands could not be tested as the surface was too irregular.

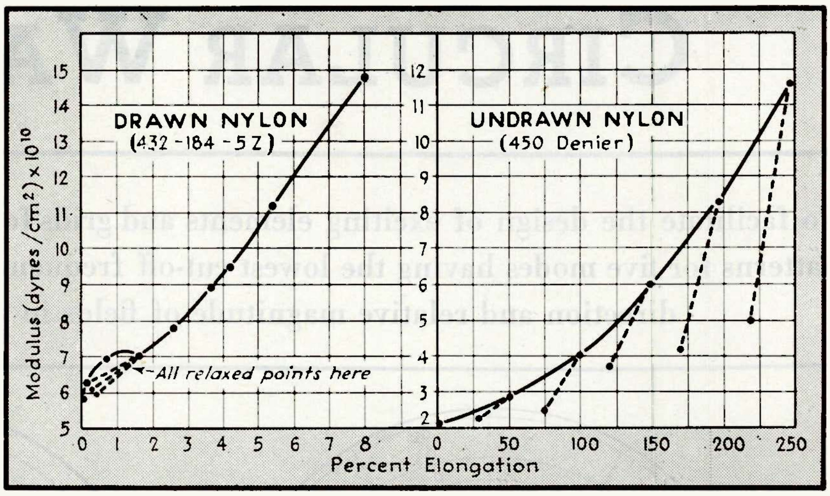

FIG. 3—Graphs showing characteristic behavior of a Nylon polymer yarn, depicting the change in modulus introduced by a drawing operation which orients the yarn and forms it into a tough resilient material

In working with films such as cellophane, a strip a few mm wide was cut in the desired direction and put in under a load of 100 g. As before, if the sample was stretched, the length at this load was taken as the original length.

To facilitate routine use of this method, graphs were prepared for each common density used, the modulus being plotted vs the half-wavelength at the operating frequency. The half-wavelength encountered in the tests ranged from 5 to 30 cm. It was found practical to train an operator to use the setup for routine testing, and it is hoped in the future to be able to adapt the arrangement to a direct-reading scheme—perhaps by use of a suitable phase-meter. For this future eventuality, the amplifier was built with two matched channels, although only one channel was used in work covered in this report.

Results

The apparatus was first proved-in with steel and copper wires. For such materials, sound velocities checked with International Critical Table values to ±1 percent. No trace of transverse vibrations was found; this was gratifying but expected, since the range of transverse vibrations for the tensions, lengths and linear mass densities encountered is more than an order of magnitude below 10 kc.

Of the materials investigated (a more complete summary is to be found in the reference) the following values were found:

Materials	dynes/cm²
Copper—annealed wire	12×10^{11}
Steel piano wire	20×10^{11}
Linen	36×10^{10}
Rayon tire cord	21×10^{10}
Human hair	$6–7 \times 10^{10}$
Silk	19×10^{10}
Cellophane film	$5–12 \times 10^{10}$

The characteristic behavior of a Nylon polymer yarn is shown in Fig. 3. This depicts the change in modulus introduced by the drawing operation which orients the yarn and forms it into the tough resilient material so well-known to the textile trade. The dotted lines show the behavior when the tension is relaxed.

Conclusion

This method for modulus measurements has much to recommend it. It is simple, direct and rapid. The sample is not damaged and its behavior may be observed through a predetermined cycle. Its applications to the study of elastomers in the synthetic rubber industry, as well as to wire and many other phases of metallurgy are indicated, in addition to its potential usefulness in the textile field itself.

Reference

(1) Meyer, K. H., and Lotmar, W., The Elasticity of Cellulose, *Helvetica Chimica Acta*, 19, 68-86, 1936.

CIRCULAR WAVE GUIDE

To facilitate the design of exciting elements and grids for filtering particular modes, field patterns for five modes having the lowest cut-off frequencies are plotted. Diagrams show direction and relative magnitude of fields in the transverse plane

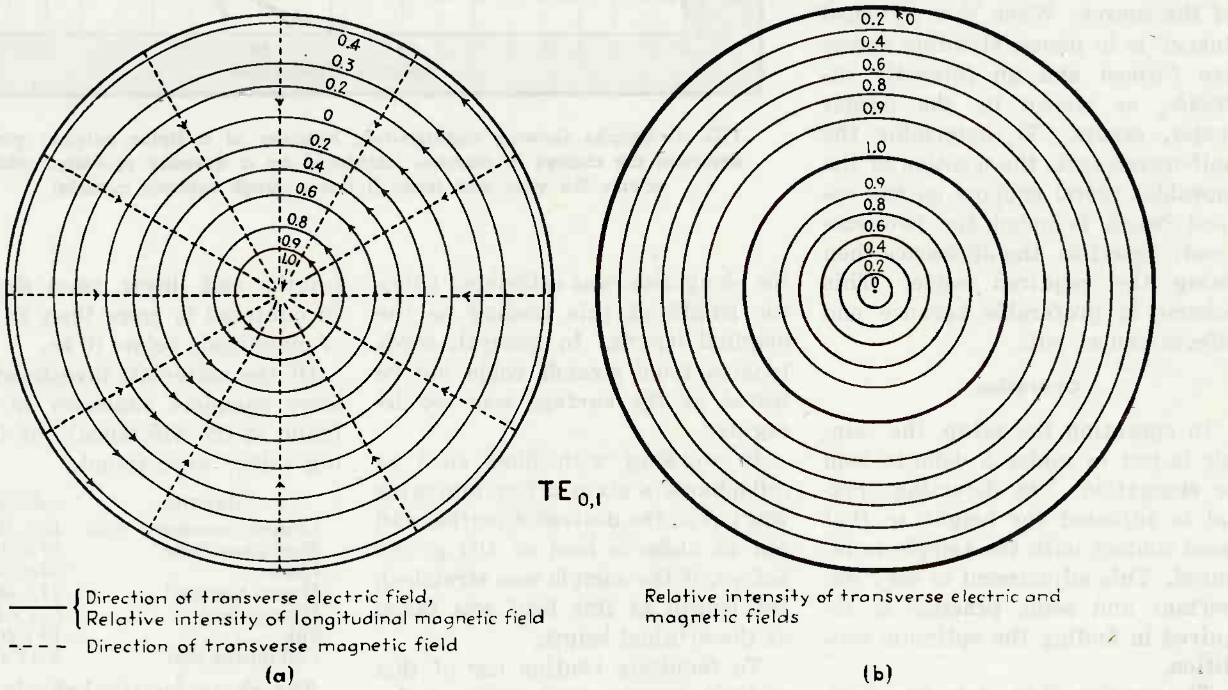

FIG. 1—The wave guide field pattern of the simplest transverse electric wave

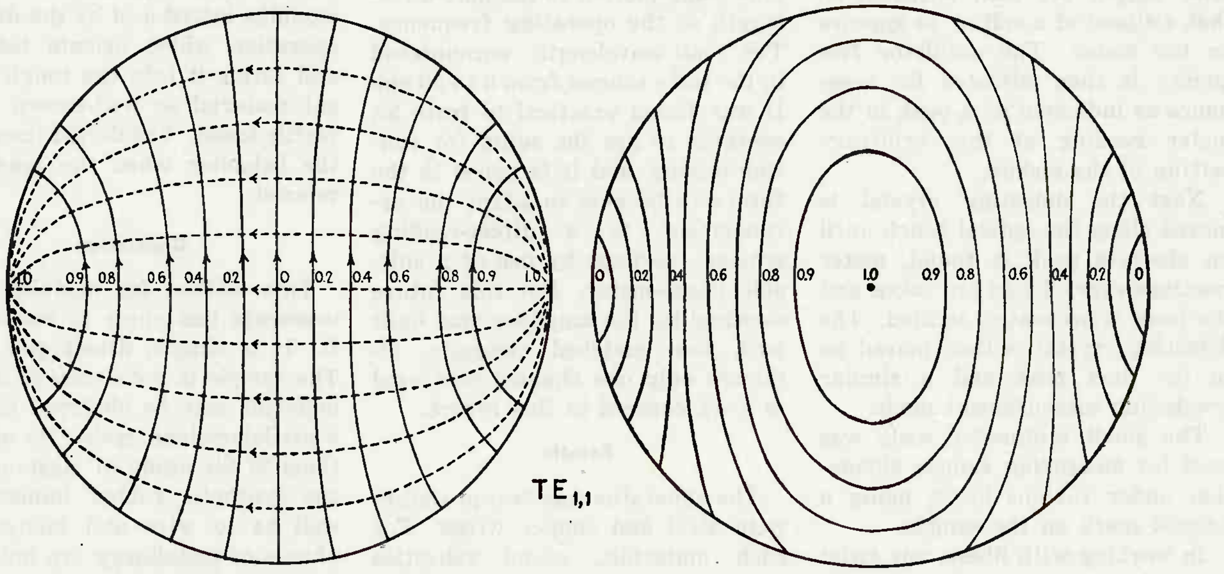

FIG. 2—For a given wave guide radius, this mode will transmit the lowest frequency

FIELDS

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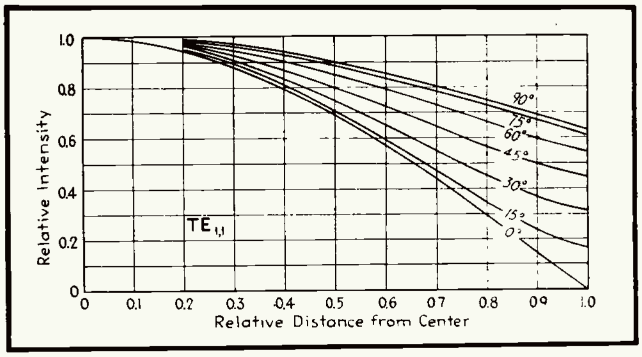


FIG. 3—As an aid to plotting relative transverse field intensity, this intermediate graph is used

THE diagrams presented in this paper describe the electric and magnetic fields inside circular wave guides for certain modes of transmission.

For each mode considered there are curves showing the direction and relative intensity of the transverse fields and the relative intensity of the longitudinal field. The direction of the longitudinal field is, of course, always along the axis of the guide.

The five modes of transmission presented here are those which have the lowest cut-off frequencies.

Applications of Field Patterns

These curves find practical application in designing many types of wave guide equipment. For example, the design of devices for initiating and receiving the various modes, either independently or simultaneously in a single guide, is aided by a knowledge of the locations of regions of maximum field strengths and their associated directions.

Likewise, the design of filters for passing a desired mode or modes and attenuating undesired modes is materially aided by this information. A further use might be the design of coupling units of all sorts. One application in which these curves have been of considerable benefit is the design of a transducer for changing from one mode of transmission to another.

The curves are of considerable theoretical interest and it is hoped that they will add to the existing knowledge of wave guide transmission.

TE Field Equations

In a circular, air-filled guide of perfect wall-conductivity at a frequency well above the cut-off frequency, the transverse electric waves ($TE_{n,m}$) are defined by the following equations:

$$E_x = 0 \quad (1)$$

$$H_x = AJ_n\,(K_m'\,r/a)\cos(n\theta)\cos(\omega t - \beta x) \quad (2)$$

$$E_\theta = (377A)\,(f/f_0)\,[J_n'\,(K_m'\,r/a)\cos(n\theta)\sin(\omega t - \beta x)] \quad (3)$$

$$H_r = -A\sqrt{(f/f_0)^2 - 1}\,[J_n'\,(K_m'\,r/a)\cos(n\theta)\sin(\omega t - \beta x)] \quad (4)$$

$$E_r = (377A)\,(n/K_m')\,(a/r)\,(f/f_0)\,[J_n\,(K_m'\,r/a)\sin(n\theta)\sin(\omega t - \beta x)] \quad (5)$$

$$H_\theta = A\,(n/K_m')\,(a/r)\sqrt{(f/f_0)^2 - 1}\,[J_n\,(K_m'\,r/a)\sin(n\theta)\sin(\omega t - \beta x)] \quad (6)$$

where

E = the electric field intensity in volts per meter along the axis indicated by the subscript
H = the magnetic field intensity in ampere-turns per meter along the axis indicated by the subscript
A = a constant determining the maximum amplitude of the field
a = the diameter of the guide
r/a = the relative radial distance from the center of the guide
x = the distance along the axis of the guide
θ = the angle in the transverse plane
$J_n(\ )$ = the Bessel function of the first kind of order n
$J_n'(\ )$ = the first derivative of $J_n(\ )$ with respect to its argument
K_m' = the mth root of $J_n'(K) = 0$
f_o = the cut-off frequency
f = the frequency of transmission
$\omega = 2\pi f$
β = the phase shift in the guide in radians per meter

In these equations the factors which determine the phase of the components are of no importance in calculating the field direction and relative intensity beyond indicating that all transverse components are in phase. For that reason these factors are omitted throughout the following discussion.

The direction of the transverse electric field is given at every point inside the guide by the differential equation

$$r\,d\theta/dr = E_\theta/E_r \quad (7)$$

If the expressions for E_θ and E_r from Eq. (3) and (5) are substituted in Eq. (7) and the integration carried out the resulting equation is

$$J_n\,(K_m'\,r/a)\cos(n\theta) = C \quad (8)$$

where C is an arbitrary constant. Except for a constant multiplier, the left side of this equation is also the expression for H_x. Therefore, Eq. (8) defines a family of curves which at every point determines the direction of the transverse electric field and also, with appropriate choices of C, give the contours of relative intensity for the longitudinal magnetic field, H_x.

The results of evaluating Eq. (8) for the $TE_{0,1}$, $TE_{1,1}$, and $TE_{2,1}$ modes are shown by the solid lines in Fig. 1(a), Fig. 2 (a), and Fig. 4(a) respectively. The number near each line is the relative intensity of H_x for that particular contour. The tangent to the line at any point is the direction of the transverse electric field at that point.

The same figures also show with dotted lines the direction of the transverse magnetic field. These curves are not calculated but are simply sketched in as the orthogonal trajectories of the first set. In fact, calculated curves for the $TE_{1,1}$ and $TE_{2,1}$ modes would be difficult to obtain as the family is represented mathematically by a slowly convergent infinite series.

Determination of Relative Transverse Field Intensity

The next items of interest are the contours of relative intensity for the transverse electric and magnetic fields. In the case of the $TE_{0,1}$ mode where E_r is zero, these curves are easily obtained by setting the expression for E_θ equal to an ap-

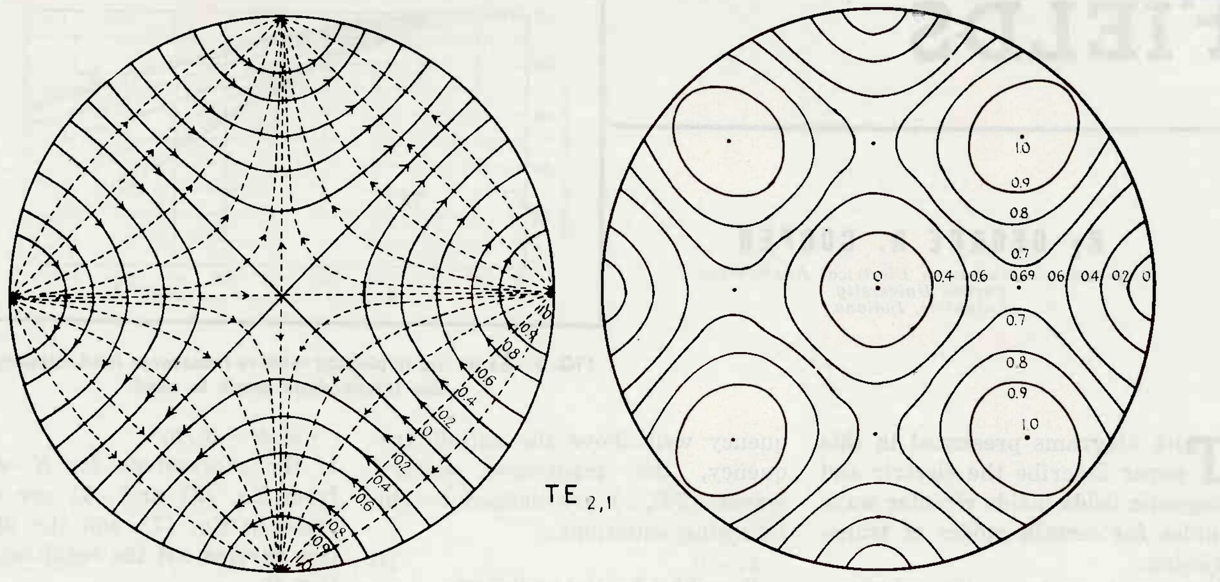


FIG. 4—To excite guides, probes can be aligned with the electric field at points of maximum intensity

propriate set of constants. The results are shown in Fig. 1(b).

For the $TE_{1,1}$ and $TE_{2,1}$ modes the problem is more difficult as there are two components to consider and the total transverse field is the resultant of these two. The first step is to evaluate E_θ and E_r for a number of values of r/a and θ and to find the resultant field by taking the square root of the sums of the squares of these two components. The resultant values, expressed as relative intensity, are then plotted as a function of r/a with θ as a parameter. These intermediate curves are shown in Fig. 3 and Fig. 5. From these curves it is possible to read the values of r/a and θ needed to plot the contours of relative intensity. These contours are shown in Fig. 2(b) and Fig. 4(b).

Although the contour intensity curves were calculated from the electric field equations, they apply equally well to the transverse magnetic field because of the constant

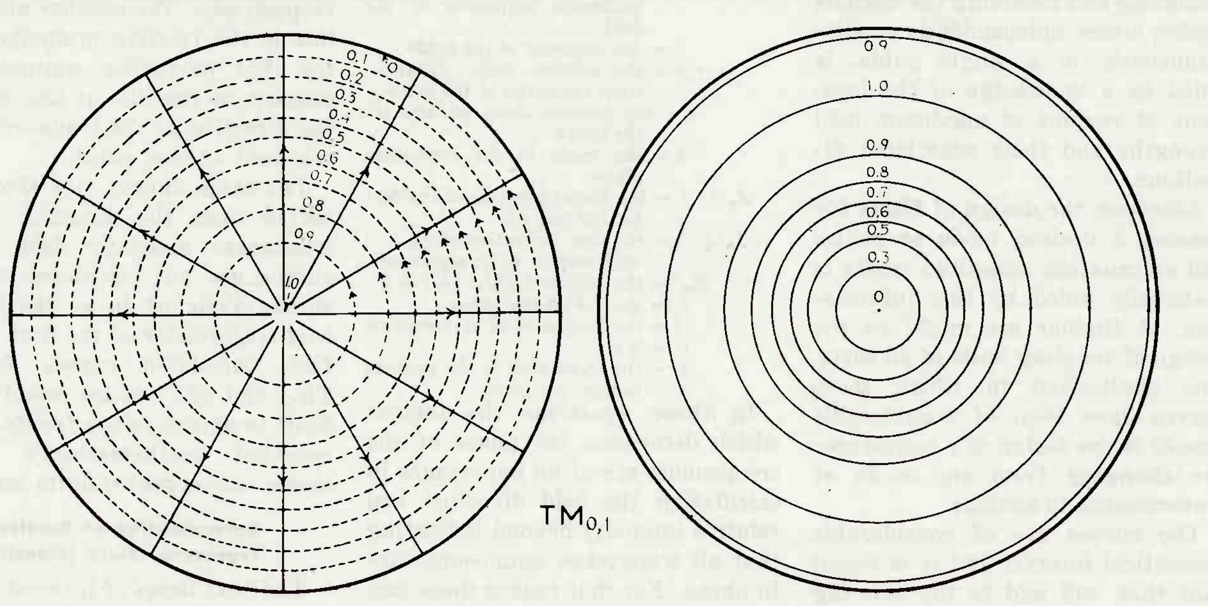


FIG. 6—Of the *TM* modes, this one transmits the longest wavelength in a given guide

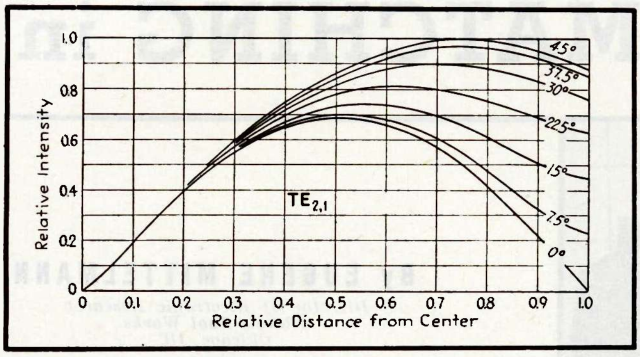


FIG. 5—This intermediate graph gives relative intensity, but not direction, of the transverse field

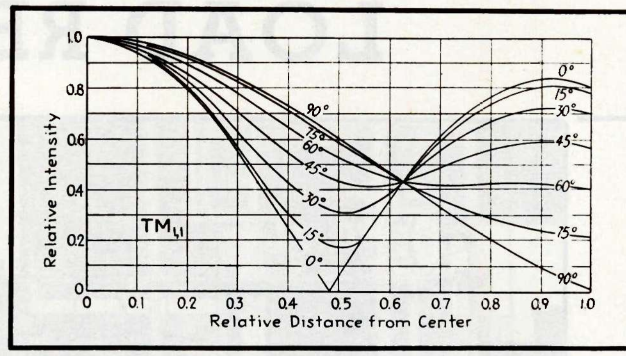


FIG. 8—Replotting these curves on polar coordinates as in Fig. 7(b) gives intensity contours

ratio between orthogonal field components. It is obviously impossible to represent the intensity or direction of the total magnetic field with a single set of curves as the longitudinal and transverse components are ninety degrees out of time phase.

TM Field Equations

The transverse magnetic waves ($TM_{n,m}$) may be represented by the following equations:

$$H_x = 0 \tag{9}$$

$$E_x = A\, J_n\,(K_m\, r/a) \cos(n\theta) \cos(\omega t - \beta x) \tag{10}$$

$$H_\theta = -(A/377)\,(f/f_0)\,[J_n'\,(K_m\, r/a) \cos(n\theta) \sin(\omega t - \beta x)] \tag{11}$$

$$E_r = -A \sqrt{(f/f_0)^2 - 1}\,[J_n'\,(K_m\, r/a) \cos(n\theta) \sin(\omega t - \beta x)] \tag{12}$$

$$H_r = -(A/377)\,(n/K_m)\,(a/r)\,(f/f_0)\,[J_n\,(K_m\, r/a) \sin(n\theta) \sin(\omega t - \beta x)] \tag{13}$$

$$E_\theta = A\,(n/K_m)\,(a/r) \sqrt{(f/f_0)^2 - 1}\,[J_n\,(K_m\, r/a) \sin(n\,\theta) \sin(\omega t - \beta x)] \tag{14}$$

where

K_m is the mth root of $J_n\,(K) = 0$

By a method similar to that used previously it is possible to show that the equation

$$J_n\,(K_m\, r/a) \cos(n\theta) = C \tag{15}$$

defines a family of curves which gives the direction of the transverse magnetic field and, also, contours of relative intensity for the longitudinal electric field. These curves for the $TM_{0,1}$ and $TM_{1,1}$ modes are shown by the dotted lines in Fig. 6(a) and Fig. 7(a) respectively. The directions of the transverse electric field are shown by the solid lines drawn in the same figures.

The contours of relative intensity for the transverse electric field are determined by the same general method as was used for the *TE* waves. Since no intermediate curves are needed for the $TM_{0,1}$ mode, the final result is plotted immediately in Fig. 6(b). For the $TM_{1,1}$ mode intermediate curves are necessary and these are shown in Fig. 8. The contours of relative intensity for this mode are then plotted in Fig. 7(b). As in the case of the *TE* waves, these curves apply equally well to the magnetic field.

The author gratefully acknowledges the encouragement and assistance given by Professor R. P. Siskind of the School of Electrical Engineering, Purdue University.

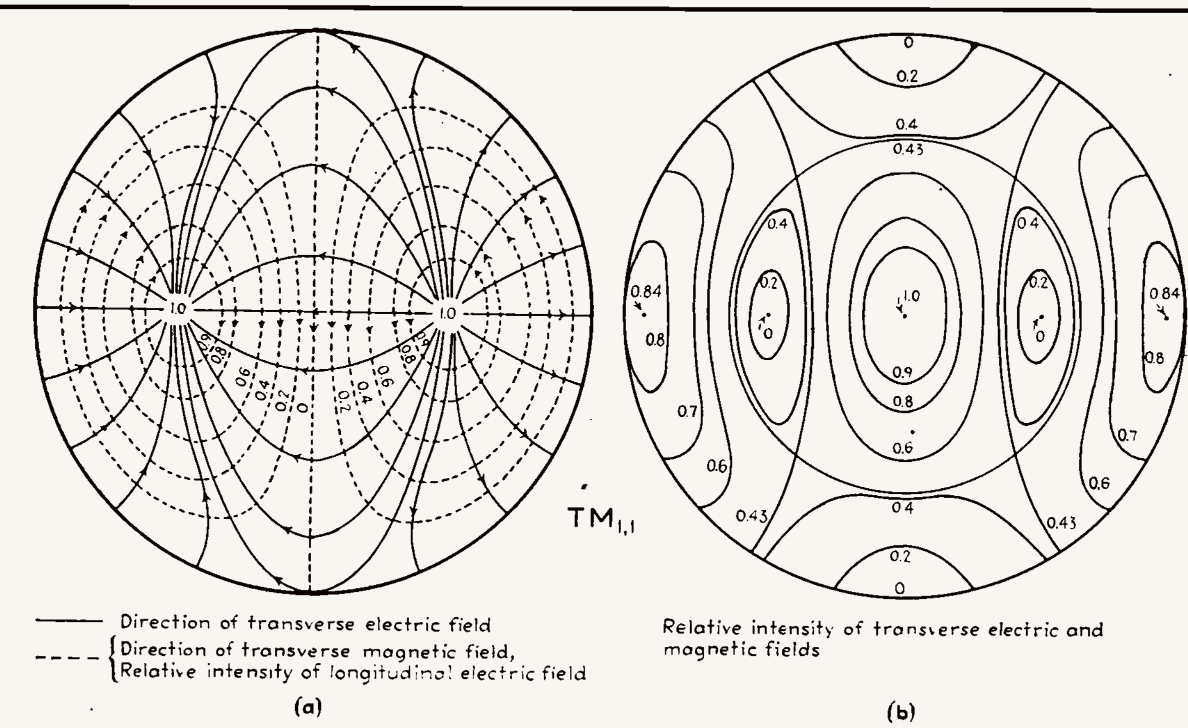
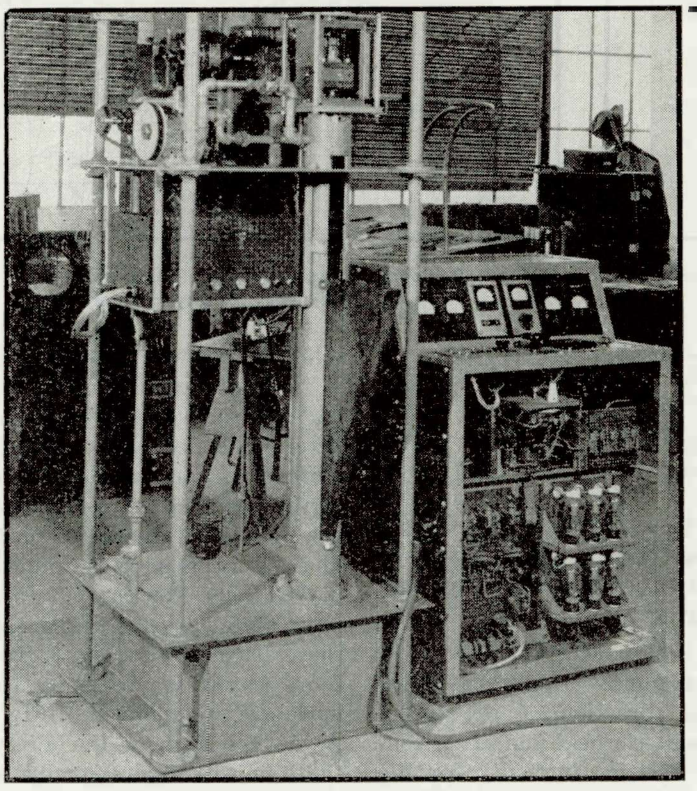


FIG. 7—This $TM_{1,1}$ mode has the same cut-off frequency as the $TE_{0,1}$ mode shown in Fig. 1

LOAD REMATCHING in



Continuous rematching equipment developed for heating a moving charge having a non-uniform cross-section, such as rifling broaches

By EUGENE MITTELMANN

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Illinois Tool Works
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THE problems confronting the radio engineer designing high-frequency generators for industrial purposes are in many respects different from those encountered in the field of communications. This will perhaps be most evident when one considers the different natures of the load impedances to be dealt with in both fields.

Usually the oscillator or the final amplifier of the communications generator delivers power into a load of constant impedance. Maximum power delivery is obtained by proper matching of the load to the generator impedance.

In the field of high-frequency heating generators for industrial purposes, conditions are more complicated, due to the fact that the generator must be able to deliver power to a wide variety of load impedances, and the value of the load impedance itself in any particular application seldom remains constant; rather, it changes within wide limits during the heating cycle. The above conditions will hold true for both induction and dielectric heating.

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

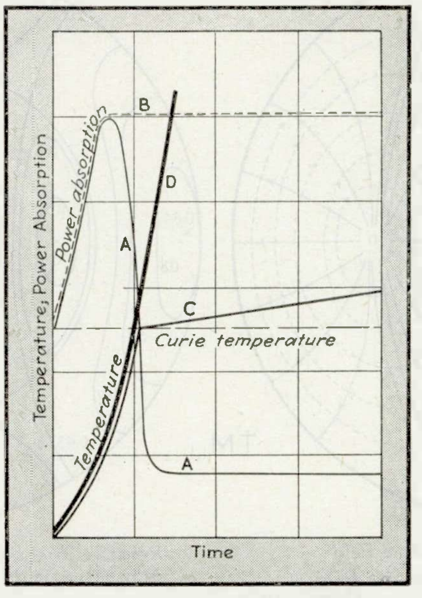


FIG. 1—Variation of power absorption and temperature of a ferromagnetic charge with time during the heating cycle, assuming constant current through heater coil

In the high-temperature heat treatment of ferrous metals by high-frequency induction, the heating cycle is divided into two distinct regions. The dividing point is around 1450 deg F, at which temperature the metal loses its magnetic properties and becomes paramagnetic. The amount of power which is absorbed by the charge and converted into heat is determined by the density of the high-frequency magnetic field. This in turn is a direct function of the magnetic permeability of the material.

In the beginning of the heating cycle the permeability, and with it the power absorption, increases and hence the temperature is raised at an accelerated rate. This corresponds to the first part of curve A in Fig. 1, which shows the power absorption for constant current through the heater coil as a function of the heating time. At the Curie point of magnetic transformation the power absorption drops rapidly below the original value at the beginning of the heating cycle, due to the loss of permeability. Correspondingly, the temperature curve C, which was rising steeply up to the critical or Curie temperature, will now increase more slowly.

The peak of curve A corresponds to the maximum value of permeability of the charge, and hence maximum power absorption. Curve B indicates the power level which it is desirable to maintain should the unit be utilized during the entire heating cycle at its full power rating. The corresponding ideal behavior of the temperature curve is represented by curve D.

From an electrical point of view the behavior of the material within the heater coil corresponds to a

ELECTRONIC HEATING

Load rematching permits using peak power output for a greater portion of the heating cycle, despite permeability changes at the Curie point in induction heating and power factor changes in dielectric heating. Circuits are given for one-step rematching with relays and for continuous rematching with a thyratron-driven motor arrangement

condition where the generator feeding the heater coil first has to supply power to a low-impedance load, then to a high-impedance load after the Curie point of magnetic transformation is reached.

Somewhat similar conditions prevail in the dielectric type of high-frequency heating. For instance, in all drying processes where moisture is given up by the material during the heating cycle, both the power factor and the dielectric constant of the material decrease with heating time. The originally low-impedance load is again changed into a high-impedance load.

Contrary behavior is observed in the heat treatment of plastic materials. For most plastics the power factor increases with increasing temperature, giving increased power absorption toward the end of the heating cycle.

Advantage of Continuous Matching

In both induction and dielectric electronic heating, there is thus a certain peak load which is considerably higher than the mean value of the power averaged over the entire heating cycle. This means that the high-frequency generator cannot be set at the beginning of the heating period for full power output without running the risk of overloading the tubes at some time during the heating cycle. Furthermore, the generator must be designed for a higher peak rating than the total amount of Btu required for a certain heating job might appear to warrant.

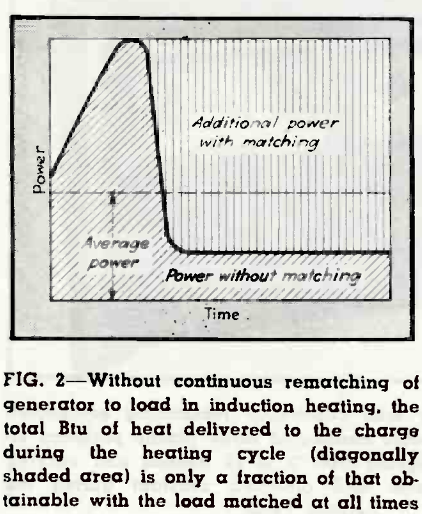


FIG. 2—Without continuous rematching of generator to load in induction heating, the total Btu of heat delivered to the charge during the heating cycle (diagonally shaded area) is only a fraction of that obtainable with the load matched at all times

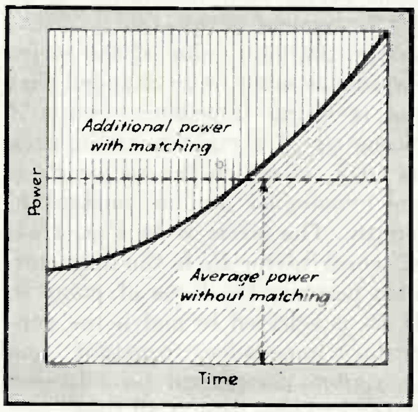


FIG. 3—In dielectric heating of thermosetting materials, power absorption increases with time because power factor increases with temperature. Continuous rematching would permit using peak power output throughout the heating cycle

Both from an engineering and an economic point of view it would, of course, be desirable to have generators available for high-frequency heating purposes which will deliver constant power to the load, irrespective of changes in impedance within reasonable limits.

In spite of the high peak power in induction heating, the average value of power absorption is relatively low, as indicated in Fig. 2. The total amount of heat energy supplied to the load is proportional to the product of time and power, and hence to the diagonally shaded area under the curve.

If conditions could be changed in such a manner as to insure continuous matching between load and generator at all times during the entire heating cycle, then the full power rating of the generator could be utilized continuously once peak power is reached. The vertically shaded area in Fig. 2 represents the additional energy that would then become available for heating.

Conditions encountered in dielectric heating of plastic materials are shown in Fig. 3. Only the diagonal shaded area of watt-seconds is available in conventional set-ups because the peak power absorption at the end of the heating cycle governs the entire cycle. However, with proper matching at the beginning of the heating cycle and continuous rematching until the end, full power could be applied at the start without running the risk of overloading the tubes toward the end.

The Problem of Rematching

In practically all applications of high-frequency heating the load impedance coupled to the generator has both reactive and resistive com-

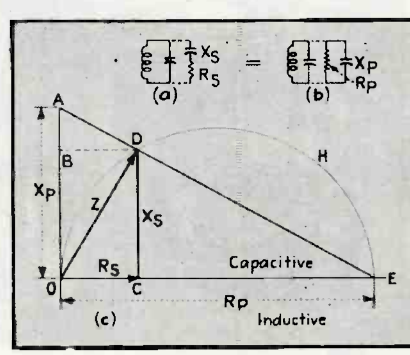


FIG. 4—Vector diagram for transformation of a series load circuit into an equivalent parallel circuit having identical power dissipation. Peak power output is delivered to the load Z as long as the loci of this vector is the circle indicated here

ponents. The load can always be represented as the series combination of a loss resistance and a reactive element, which in turn can be either inductive or capacitive.

In the load circuit of Fig. 4(a), X_S represents the total variable series reactance (the equivalent series reactance of the load plus the reactance of the variable coupling element) and R_S represents the total series resistance of the load. In the equivalent circuit of Fig. 4(b), R_P represents the equivalent parallel loss resistance and X_P the equivalent parallel reactance. The two circuits are fully equivalent if the impedance elements are related according to the impedance triangles in Fig. 4(c). When angle ODE is a right angle, triangles OCD and DCE are similar and DC/OC = CE/CD. Since CE = OE − OC = $R_P - R_S$, it follows from the laws of geometry that

$$\frac{R_P - R_S}{X_S} = \frac{X_S}{R_S} \quad (1)$$

Triangles ABD and OCD are also similar, so that AB:OC = BD:CD, and

$$\frac{X_P - X_S}{R_S} = \frac{R_S}{X_S} \quad (2)$$

By transformation and substitution of $|Z|^2$ for $R_S^2 + X_S^2$, the above equations become

$$R_P = |Z|^2/R_S \quad (3)$$

$$X_P = |Z|^2/X_S \quad (4)$$

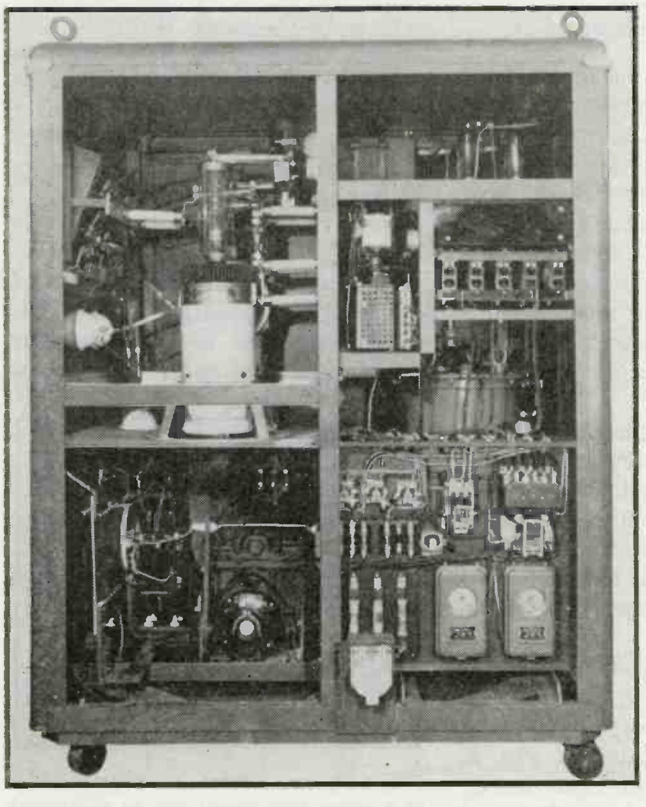
The condition that constant power shall be absorbed by the load demands that the value of the equivalent parallel loss resistance R_P referred back to the generator terminals shall remain constant. To maintain R_P constant as the equivalent series load resistance R_S or the equivalent series reactance X_S varies, the total value of the series impedance must be so changed that the resulting impedance vector Z is one leg of a right triangle, such as ODE, of which the vector R_P is the hypotenuse and is constant in length. The circle H in Fig. 4(c), of which vector R_P is the diameter, then becomes the locus of point D. If R_P is selected to match the generator impedance, constant and maximum power will be delivered to the external load at all times.

The above principle can be used to obtain constant matching between a generator and a variable load both in induction and dielectric heating.

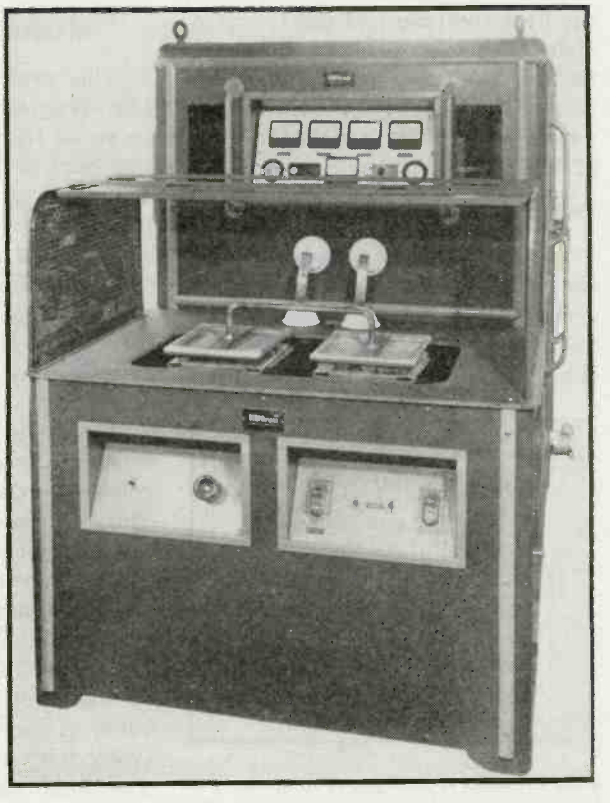
Description of Equipment

The selection of the proper rematching mechanism will necessarily be governed by the length of the heating cycle. In induction heating the cycles are usually of the order of a few seconds or even fractions of a second. In most applications of dielectric heating longer times are required, ranging from seconds up to minutes. Accordingly, two different systems of rematching will be discussed.

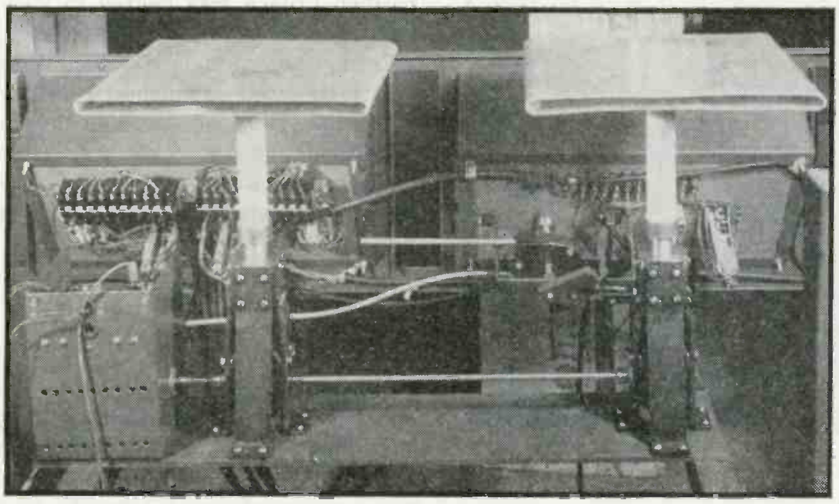
The circuit shown in Fig. 5 is used for rematching the generator to the changed load in high-frequency induction heating, especially in the high-temperature heat-treating of ferrous metals. The generator is of the self-excited push-pull class C type. The heater coil, with its charge, is connected to a part of the tank circuit through a double-pole, double-throw rematching relay. The heater coil forms part of an auto-transformer circuit. The tank coil center tap



Rear view of generator. Oscillator compartment, with two air-cooled transmitting tubes, is at upper left, with blower just below. Motor-driven Variac transformer for adjusting filament voltage is in approximate center of unit. Peak output of this unit is 20 kw



Electronic generator with continuous rematching equipment, developed for dielectric heating of large plastic preforms involving a load weighing from 3 to 12 pounds and varying in both power factor and dielectric constant during the heating cycle



Details of rematching mechanism for 20-kw plastic preheating unit. A thyratron-controlled motor moves the two capacitor plates towards or away from the electrodes supporting the plastic preforms

and the B+ terminal of the power supply are at ground potential.

A relay shunted by an adjustable resistance is in series with the plate power supply circuit and is so adjusted that it will respond to a predetermined peak value of the plate current. At the instant this peak value is reached, the plate circuit relay closes and preconditions an auxiliary relay, which will respond after the plate current changes by a few percent of its peak value toward lower current ratings. This corresponds to the descending part of the power absorption curve in Fig. 1. At this point a plunger-type time-delay relay applies full cut-off bias to the grids of both oscillator tubes and throws a rematching relay over to the high-impedance connection required after the Curie point. Additional contacts on the rematching relay then open the circuit of the time-delay relay, so the cut-off bias is removed after a time delay of a few milliseconds; this is just sufficient to allow the rematching relay to be actuated under no-load conditions. Holding contacts keep the rematching relay energized until a timer circuit terminates the heating cycle and resets all relay circuits for a new cycle.

The results obtained by this arrangement are remarkable for two reasons:

(1) Smaller power rating generators can be used on jobs for which far larger units were deemed necessary.

(2) High-frequency generators can be used economically for high-temperature jobs.

Figure 6 gives a performance comparison of a conventional high-frequency generator (A) and one having half the rated power output but equipped with the rematching mechanism (B). Generator A reaches the critical temperature of magnetic transformation somewhat sooner, but after the Curie temperature is passed the smaller unit delivers heat to the charge at a higher rate and thus arrives at higher temperatures in a shorter time.

The temperature rise before the Curie point is closely approximated by a square-law function, and for this reason the time difference between the two points at which Curie temperature is reached is relatively small. The higher the required temperatures, the greater are the differences in efficiency and required heating time.

Surface hardening of $\frac{3}{4}$-inch diameter steel rings to various depths has been achieved in 3.5 seconds with a 2-Mc generator of only 2.5 kw output, by using a rematching unit. This is interesting because up to now it was not considered possible to obtain case hardening with power inputs less than about 10 kw per square inch. The heating time for surface hardening to $\frac{1}{32}$-inch depth was 3 seconds. The temperature of magnetic transformation was reached within the first 2 seconds. During the change-over

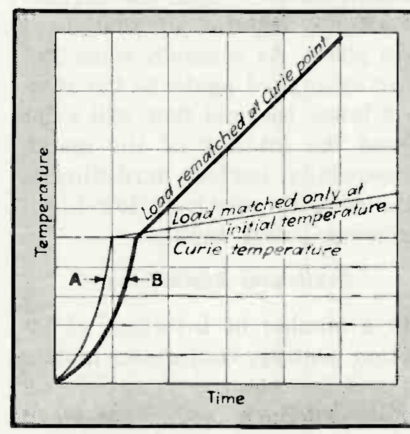


FIG. 6—Time-temperature curves for two high-frequency generators used for induction heating. The smaller unit with rematching (B) reaches temperatures above the Curie point much faster than generator A which has twice the output rating of B

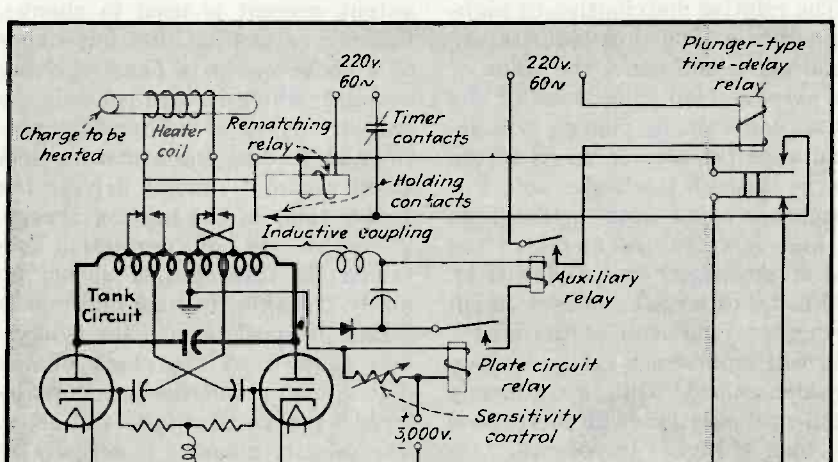
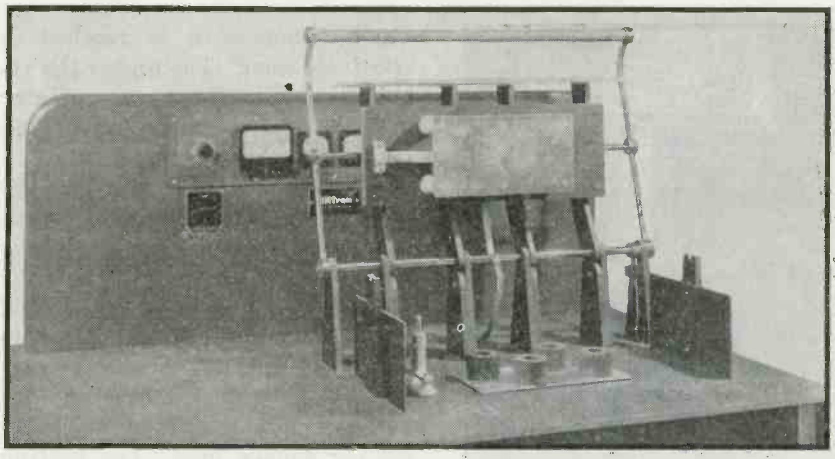


FIG. 5—Simplified schematic diagram of induction heating unit providing one step automatic rematching of tank circuit to load. The timer contacts open momentarily at the end of the heating cycle to release the rematching relay in preparation for a new cycle



Details of working table of 5-kw unit, with four preforms in position and top electrode raised

time, a few milliseconds, a certain equalization of the temperature gradient existing from the surface toward the interior of the metal takes place. As a result, when full power is applied again to the sample a lower thermal flow will exist toward the interior of the metal. Consequently, surface hardening is obtained with relatively low high-frequency power input.

Continuous Rematching

In a number of instances of induction heating, continuous matching will be required to satisfy all conditions. Such is the case when dealing with a charge fed continuously through the heater coil but of variable cross-section. An example is shown in Fig. 7, involving high-frequency heat treatment of a rifling broach.

The relative distribution of high-temperature and low-temperature metal mass, and hence the value of the average load impedance of the heater coil with its charge, will depend upon the rate of travel of the charge through the heater coil. For instance, a small cross-section piece of high-temperature metal at the end of the heater coil, followed by cold metal of large cross-section entering the front end of the heater coil, will represent a relatively low-impedance load, while a uniformly small cross-section will correspond to a load of higher impedance.

To provide uniform heating of all outer surfaces to the same temperature, the heater coil is designed to match the load to the generator at an average mass of metal within the heater coil traveling at an average speed. Every deviation from these predetermined averages will correspond to a change in load impedance and will be accordingly reflected back into the plate circuit of the oscillator.

A schematic diagram of the equipment is also shown in Fig. 7. Variation of oscillator plate current from a predetermined optimum value is used to provide a system of continuous rematching. A variable control rheostat in series with the plate current circuit converts the plate current variations into voltage variations and drives the input of a bridge-type amplifier having one control and one compensating tube. The bias of the compensating tube is so set that for the desired plate current of the oscillator a certain output current is obtained from the amplifier. This output current is used to change, through saturation, the impedance of a choke coil in a phase-shifting network, which in turn controls the output current of a thyratron rectifier in feeding the armature of a shunt-wound d-c motor driving the feeder cable of the moving charge.

The degree of regulation obtained by this method shows up nicely if a velocity-time diagram is taken. A small tachometer dynamo was coupled to the shaft of the driver motor and the speed registered by a vacuum-tube voltmeter. The velocity diagram is actually an inverted image of the broach.

The generator used in the experiment, shown elsewhere in this article along with its associated quenching device, pumps, etc., was a 2-megacycle, 2.5-kw unit. The entire 64-inch broach was heated to 2350 deg F in 92 seconds. Incidentally, this equipment demonstrates that relatively good frequency stability could be obtained without much additional effort. The frequency variation between no-load and full-load conditions at any instant was not over 75 kc total band width.

Rematching in Plastic Heating

The problem of heating plastic preforms demands equipment where the continuous adjustment of matching can be obtained between load and generator to secure maximum power absorption by the load during the entire heating cycle.

The solution is perhaps best illustrated by describing a commercially built equipment of 20-kw high-frequency output, used in the preheating of large plastic preforms. The load may vary between three to twelve pounds weight, and it was demanded that the generator shall adjust itself automatically to any new load conditions without any necessity for the operator to make adjustments.

The electronic generator used in this arrangement is of the self-excited push-pull type, with the center of the tank circuit grounded and connected to the positive terminal of the high-voltage power supply as shown in Fig. 8. The load is placed between two capacitor plates, which in turn are coupled to the tank circut by means of a variable capacitance. The spacing between the capacitor plates containing the load and the coupling plate can be changed by a reversible motor.

The feedback and initial coupling are so adjusted that for the rated maximum plate current of the oscillator tubes, matching is obtained and maximum power is delivered to the load. Any variation of the load impedance will be reflected into the plate circuit. The changing voltage drop across variable resistor R, due to plate current variations, drives the balanced-tube bridge amplifier. Two relays are connected across the output of the balanced bridge, each in series with a rectifier which allows current to pass through only one of the relays for either unbalanced condition. Thus, for increasing load impedance one of the relays will respond, closing contacts 1 of the reversible 220-volt, 60-cps motor; this moves the coupling reactance in a direction increasing the spacing, thus increasing the coupling reactance between load and generator to correct the matching. For a decrease in load, relay 2 will respond, closing contacts and reversing the motor so as to move the coupling plates in the opposite direction.

Operation During Heating Cycle

During the heating cycle of plastic preforms, the power factor of the material increases with increasing temperature. The coupling at the beginning, being adjusted for maximum power absorption, matches a relatively high-impedance load. In the course of the heating cycle the power factor will increase and the load impedance decrease accordingly. The balanced amplifier will try to correct for the lower impedance and therefore the control motor will adjust the coupling in the direction of a larger coupling reactance by increasing the spacing between the coupling plate and the electrodes. This means that at the end of the completed heating cycle both coupling plates will be in a position of maximum distance from the electrodes, and hence provide minimum coupling between load and generator. The next cycle will start at this minimum-coupling position, excluding the possibility of an overloaded plate circuit. Once the next cycle is started the rematching mechanism will automatically seek its own position of optimum coupling, corresponding to matched conditions between load and generator.

After the filament voltage is brought up to its nominal value the unit is made ready to operate by pushing a starter button on the front panel. This turns on the high-voltage power supply and simultaneously connects the armature of the reversible rematching motor across the 60-cycle, 220-volt line.

A high-frequency wattmeter indicates the amount of high-frequency power converted into heat within the load. The load electrodes are accessible after opening the screen gate in front of the unit, which automatically shuts off the high-voltage circuit. Proper recycling is obtained by a timer circuit.

The fact that the generator automatically adjusts itself to maximum power output at any present level makes it possible that a number of molding presses calling for various amounts of preform material can be supplied alternately without making any changes on the generator or its associated circuits. Such operations were performed successfully by unskilled labor.

A 5-kw generator using the same principles of automatic rematching was developed primarily for multicavity molding. The preforms are placed on the bottom electrode. The top electrode, which can be lifted by a lever mechanism, will adjust itself to any spacing corresponding to the thickness of the preform. Correspondingly, the matching capacitors will seek automatically their position of maximum power output. Power is applied to the high-voltage circuits of the d-c plate supply only when the top electrode reaches its final position, and power is disconnected when the top electrode is lifted. A timer circuit starts and ends the period during which power is applied.

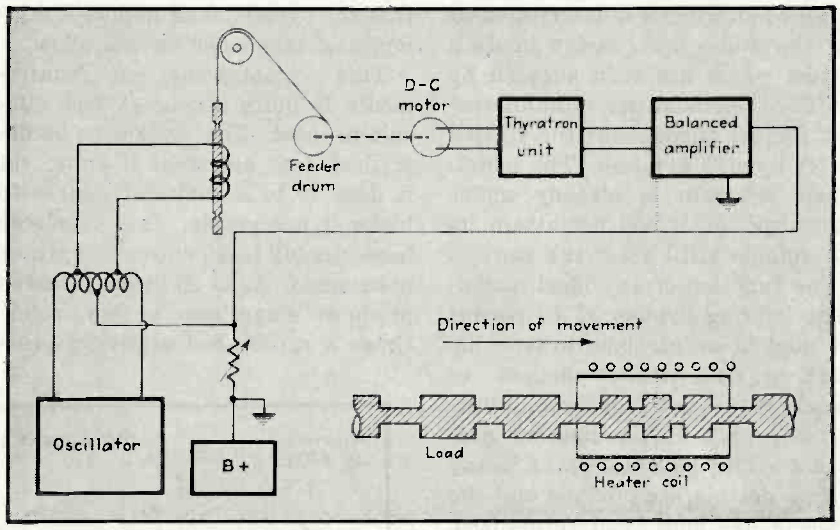


FIG. 7—Schematic diagram of electronic heating unit provided with continuous rematching equipment for heating to a constant surface temperature a moving charge of non-uniform cross-section as shown at the lower right

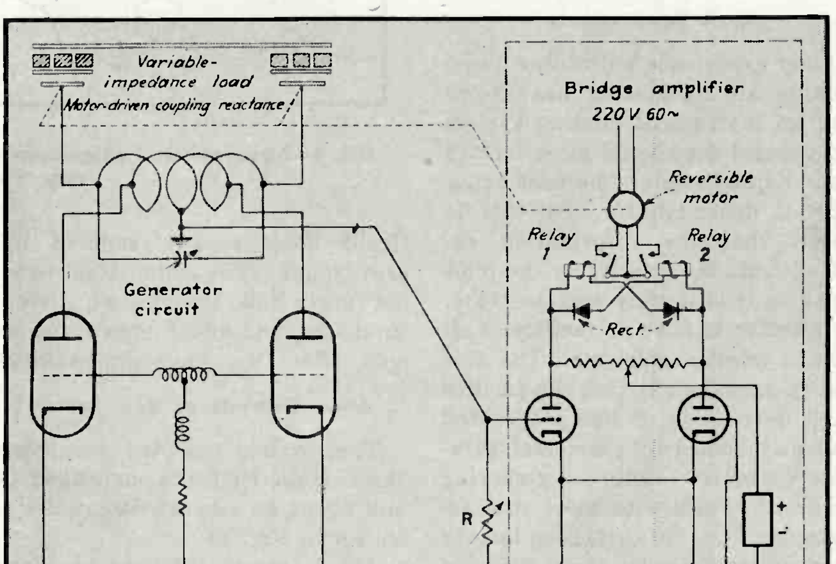


FIG. 8—Simplified schematic diagram of dielectric heating generator provided with automatic and continuous readjustment of matching between the load and the generator tank circuit

The CAA Instrument Landing System . . .

First complete technical details of blind landing system officially adopted for civil aviation in U. S. Installation program is under way and will be accelerated after the war. Part I covers theoretical aspects and runway localizer circuits

THE following is a description of the radio instrument landing system which has been adopted by the Civil Aeronautics Administration for use throughout the United States by civil aviation. The installation program is already under way, although it will not attain its full volume until after the war.

The function of any ideal instrument landing system is to permit the pilot of an airplane to land his craft safely without benefit of visual contact with the ground during any part of the landing procedure. The advantages of being able to do this are obvious and the problem has long been recognized. Many and varied solutions have been proposed but all are based on the use of radio in some form.

Basic Requirements

Long experience with other radio aids to air navigation has shown that an instrument landing system for general use should meet certain basic requirements—the first being that of dependability. By this is meant that the information received from the facility by the pilot must be trustworthy and accurate. It is better to have no facility at all than a questionable one. The second requirement is that the facility shall be capable of being operated and maintained by personnel without extensive radio engineering training. Failure to meet this requirement has, in fact, been largely responsible for delay in adoption of instrument landing by this agency. Another requirement is that the equipment shall comprise few, if any, parts not easily available or manufacturable. The fourth, and by no means the least important, is that the system shall impose a minimum of new work on the pilot.

This combination of requirements is quite stringent and difficult to meet. The system to be described does not meet it fully, yet it does so to a sufficient degree to make it acceptable. Improvements have already been, and will continue to be made. As in all fields, research produces sometimes a slow, sometimes a rapid—but always a practically continuous stream of improvements. The commercial product must follow research discontinuously, and adopt improvements only after they have accumulated.

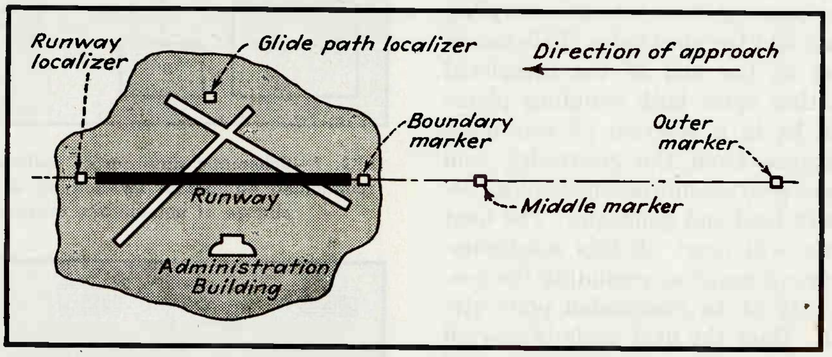


FIG. 1—Arrangement of components of CAA instrument landing system on and near a typical airport

Main Elements of New System

The system adopted comprises three main elements, arranged on and about an airport essentially as shown in Fig. 1:

(1) Runway localizer—to provide information relative to the heading of the aircraft.
(2) Markers—to indicate distance from point of contact.
(3) Glide path localizer—to provide indication of altitude.

The first of these radiates signals which overlap and produce an equi-signal zone (or course) aligned with the axis of the runway. A zero-center differential indicating instrument in the cockpit will indicate zero as long as the airplane is in this zone, and will have deflections to the right or left as the craft departs from on-course. The runway localizer operates in the frequency band from 108 Mc to 111 Mc.

The second element comprises two (sometimes three) low-powered transmitters located at specified distances from the point of contact, along the extended axis of the runway, and radiating sharply vertical patterns. Each of these transmitters operates a different colored light in the airplane to permit the pilot to identify the marker being received. All markers operate at 75 Mc.

Equi-Signal Glide Path

The third element has only recently been developed to a satisfactory stage and is not yet being installed. It will therefore not be de-

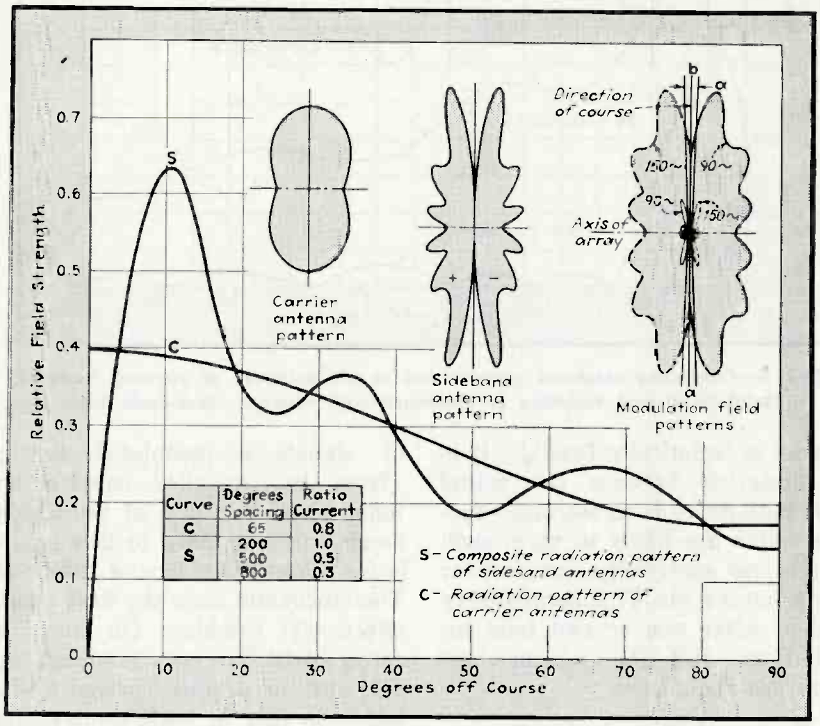
. . . Part I

By PETER CAPORALE
Chief, Radio Engineering Section
Civil Aeronautics Administration
Washington, D. C.

scribed in this paper, except by stating that it, too, radiates two overlapping signals to produce an equi-signal zone or on-course. The equi-signal surface is a vertical circular cone with the apex on the antenna. The station is located to one side of the runway so that the vertical plane through the localizer course cuts the cone parallel to but not through the axis. The intersection of the plane and the cone is thus a hyperbola. If the pilot were to follow both the glide path course and the localizer course, he would actually be traveling along a portion of this hyperbola. His position in space would thus be absolutely determined at all times during his descent, and by properly controlling the position and shape of the hyperbola, the aircraft could be brought to a complete landing without necessity of seeing the ground. Actually, the radiated patterns can be modified so that the surface of intersection is not exactly a right circular cone, but is such as to result in a more or less straight line glide path. It is anticipated that this equipment will operate at a frequency in the vicinity of 300 Mc.

An equi-signal glide path of this type was experimentally set up by Messrs. D. M. Stuart and J. C. Hromada at the Indianapolis Experimental Station of the CAA in 1938. The results were completely successful and tests, including flight tests, showed the system to be a practical one. For a number of reasons, not all technical, it was necessary to abandon this project, and constant-intensity glide path was then evolved which required the aircraft to follow a path of constant signal intensity. While the

Checking adjustment of loop antenna system for runway localizer of newly-adopted CAA radio instrument landing system



Curve	Degrees Spacing	Ratio Current
C	65	0.8
S	200	1.0
	500	0.5
	800	0.3

FIG. 2—Radiation patterns of the sideband and carrier antennas, plotted in both rectangular and polar coordinates

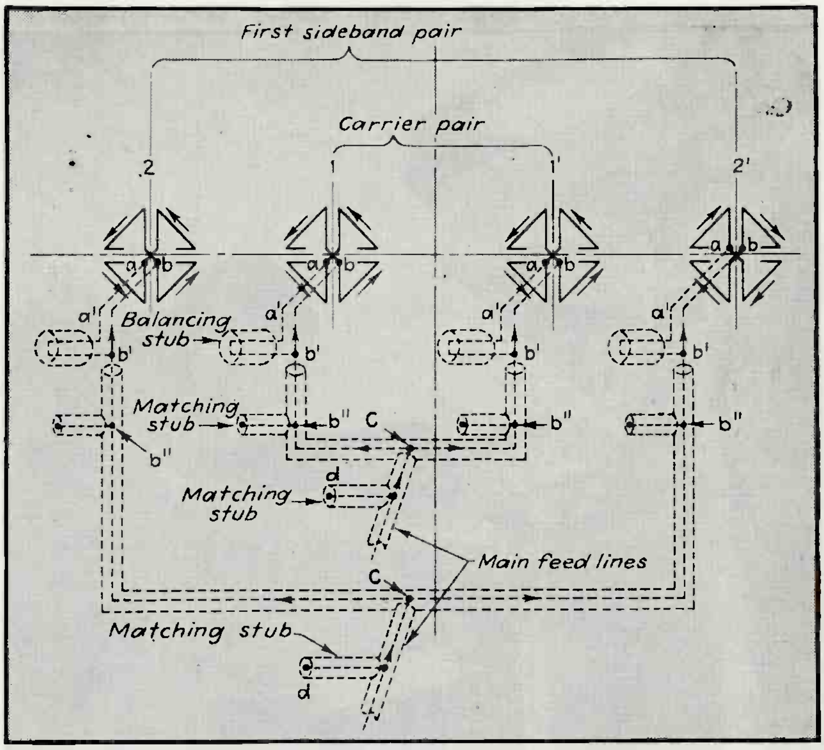


FIG. 3—Schematic diagram showing general arrangement of the first two pairs of antenna circuits associated with the runway localizer

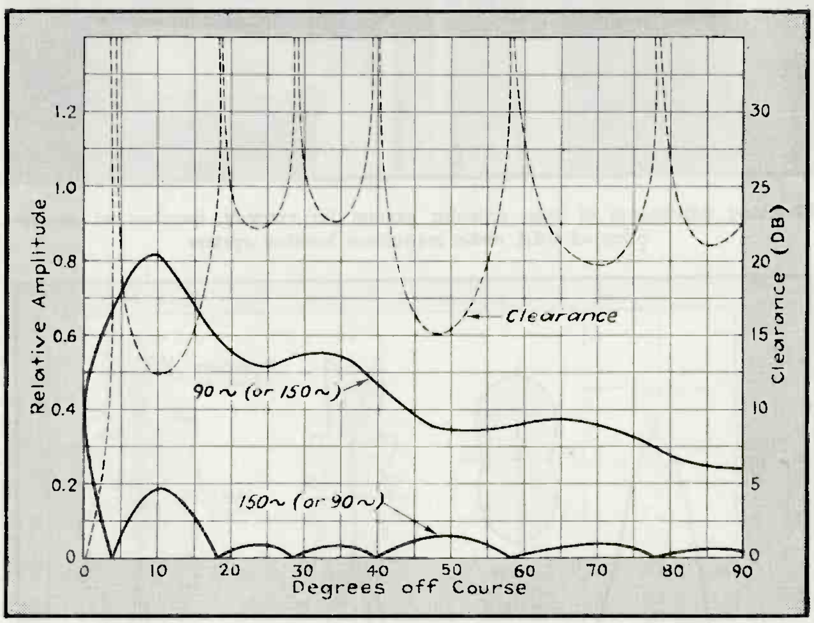


FIG. 4—Composite sideband pattern due to all radiators of runway localizer (solid lines) and variation of clearance with azimuth (dash-dash lines)

scheme is technically feasible, it is not practical because the actual glide path depends on too many factors which are likely to vary, such as receiver sensitivity, transmitter power output, etc. This became very evident after one or two trial installations and the scheme was therefore abandoned.

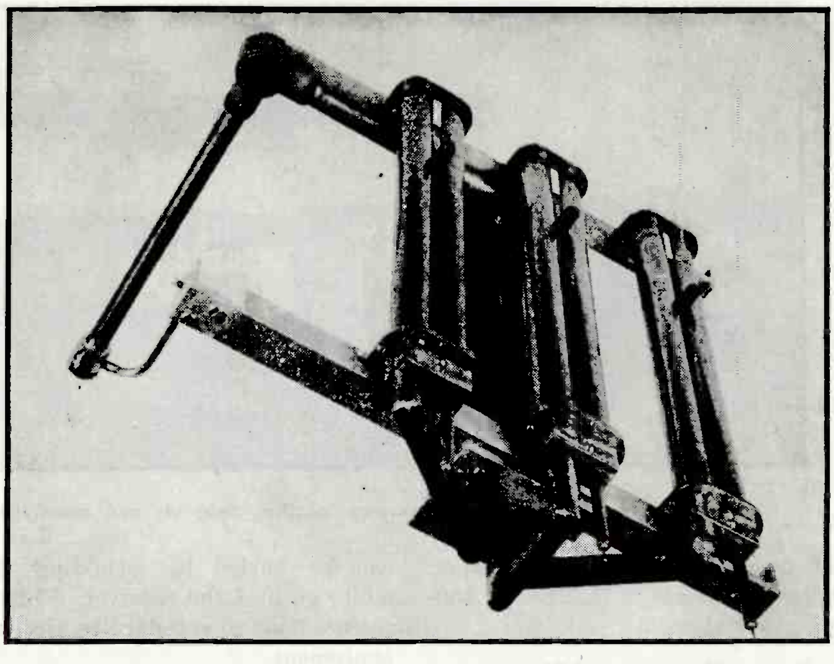
Theory of Runway Localizer

The localizer radiates two types of signals—a modulated carrier (from the so-called carrier antenna) and a group of pure sidebands corresponding to this modulation (from the sideband antenna). The sidebands from the first signal effectively combine (in the receiver) with the pure sideband signals and the overall received modulation is due to both components. The space pattern of the modulation can be controlled by means of both antennas, and this is done so as to produce two different patterns for the 90-cps and 150-cps modulation frequencies.

The radiation patterns are made highly directive, with the maximum approximately ten degrees from the course as shown in Fig. 2. The purpose of this is to maintain as much signal near the course as possible and at the same time minimize the off-course signal that might reach buildings or other structures and be reflected therefrom. Such reflections often are strong enough to affect the patterns and cause so-called multiple-course indications, and course-bends. The pattern of the carrier (about 110 Mc) is in fact much less directional, as it should be, since it is desired that the avc in the aircraft receiver be operative regardless of bearing with respect to the transmitter.

To obtain the desired radiation pattern, a linear array of radiators is arranged with the axis perpendicular to, and the center on the axis of the runway. The array is arranged in pairs, each symmetrical about the center. The radiators are vertical magnetic doublets (horizontal current loops) with patterns circular in the horizontal plane. The center pair, henceforth called carrier pair, is operated in phase with each other and fed with normally modulated carrier. The resulting radiation then contains the carrier frequency and all of the associated sidebands. Each of these sidebands will, of course, have the same space pattern as the carrier (due to the negligible difference in frequency between carrier pairs and sideband pairs).

As is well known, the electric field resulting from such a doublet has no components except in a plane at right angles to the axis of the doublet. In this case, the field is therefore purely horizontal which is of some practical advantage. For example, vertical metallic supports, lines, conduits, etc., inevitable in an actual installation, do not absorb any energy and therefore do not observably distort the radiated pattern. Furthermore, the coefficient of reflection from large surfaces is slightly less for horizontally polarized waves—particularly if the angle of incidence approaches the value of Brewster's angle (which



Quarter-wave transmission line transformers used as phasing controls to place all sideband antenna pairs in phase with each other and in quadrature with the carrier antenna pair of the runway localizer system

in this case is of the order of 6.5°). On the other hand, a number of comparative tests of vertical as well as horizontal arrays has failed to demonstrate unequivocally the superiority of one or the other type of polarization. In view of this and of the definite advantages of vertical arrays in simplicity and economy, the latter have not been summarily dismissed from future consideration.

The elements of each of the other pairs (hereafter called sideband pairs) are operated 180 degrees out of phase and all elements on one side of the center are in phase with each other. All the sideband pairs are, furthermore, fed in quadrature with the carrier pair. Feed arrangements for the carrier pair and the first sideband pair are shown in Fig. 3.

Since a further rotation of 90 degrees is inherent in the radiation from the sideband pairs (see Appendix I), the resultant pattern will be in phase (or 180 degrees out of phase) with that radiated by the carrier pair. The pattern for three sideband pairs (the usual number in a typical installation) is shown in Fig. 2. There are only two lobes, of opposite phase, and with nulls along the direction of the course. It is to be noted that the phase in the pattern is independent of azimuth except for the two reversals at the nulls.

The pattern from the carrier pair is likewise of constant phase. The resultant pattern due to a combination of the two therefore is merely the algebraic sum. With the proper choice of current ratios, the resultant can be placed almost wholly on one side of the course line with little or no radiation on the other side, and the side of maximum radiation is that in which the sideband lobe is in phase with the pattern from the carrier pair. To produce the modulation field patterns of Fig. 2, the right-hand sideband lobe is arranged to be in phase with the carrier pattern in

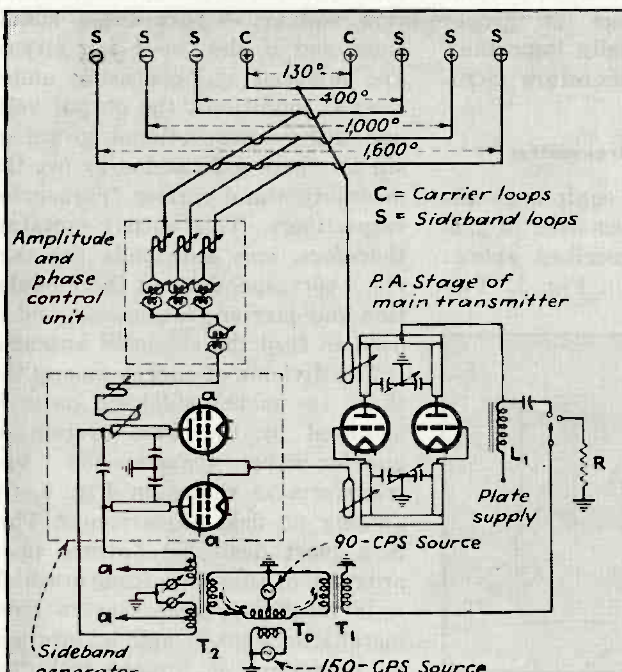


FIG. 5—Output and antenna circuits of runway localizer. Main transmitter feeds only carrier loop, with other loops being fed by the sideband generator

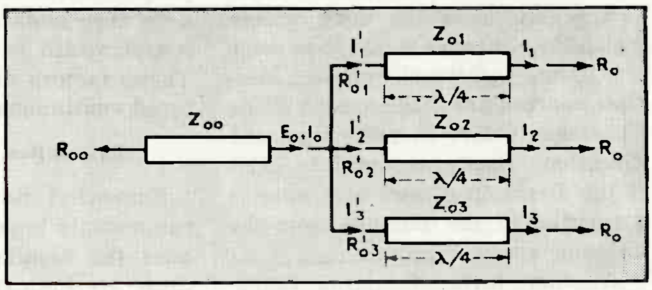


FIG. 6 (above)—Phase control unit serving the antenna system

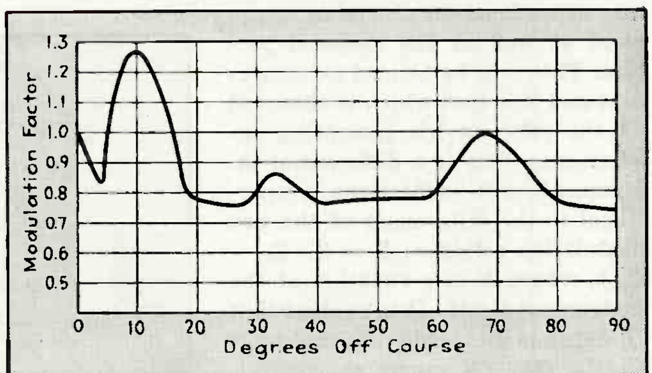
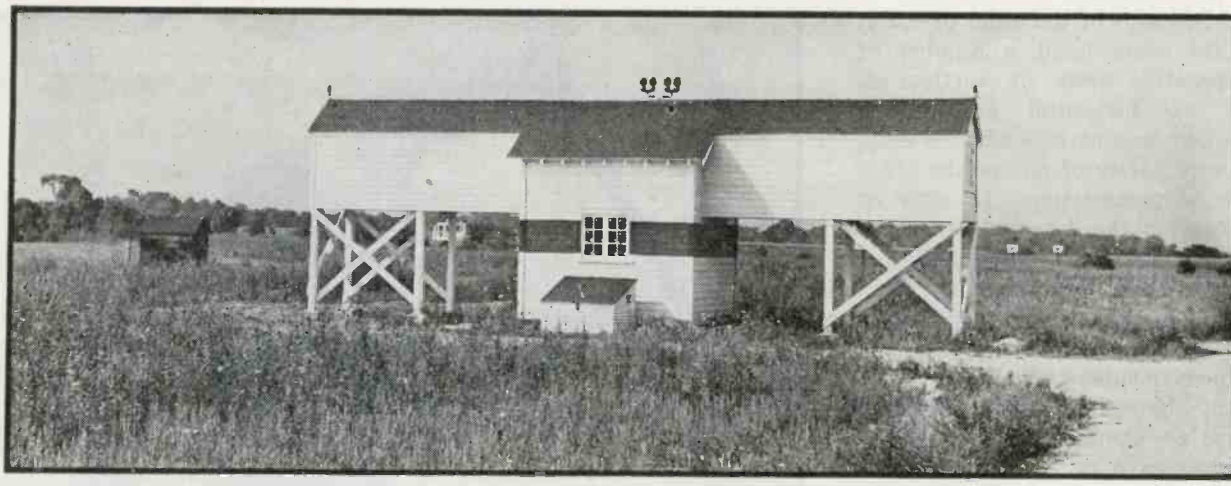


FIG. 7—Variation of modulation factor of runway localizer



Building housing runway localizer antennas and associated transmitter equipment

the case of the 90-cps modulation, and out of phase in the case of 150-cps modulation.

Course Clearance and Sharpness

There are several characteristics of these patterns which are important in the operation of the localizer. Figure 4 represents, in rectangular coordinates, one quadrant of the modulation field patterns shown in polar form in Fig. 2. The ratio of amplitudes of the two modulation frequencies in any direction (in decibels) is defined as clearance. The clearance in a direction 1½ degrees off course is defined as r-f course sharpness. Along the course, the clearance is obviously zero. Course width is the zone within which the clearance is less than some maximum—arbitrarily chosen. Multiple courses are said to exist if the clearance is zero in more than one direction. Bends are said to exist if the direction of zero clearance is a function of the distance from the antenna array.

Another form of course sharpness depends on the receiving equipment as well as the radiated pattern. This may be termed a-f sharpness and it is that which is observed by the pilot on his indicating instrument. This is a differential instrument with deflections proportional to the differences of the two modulation voltages: $D = K\ (C_{90} - C_{150})$, where K is a function of the instrument itself. It is evident that D depends not only on the ratio C_{90}/C_{150} (the r-f course sharpness), but also on the absolute values of these voltages, so that the deflection for a given value of C_{90}/C_{150} can be varied by adjusting the audio gain of the receiver. This is in fact done to standardize aircraft equipment.

The discussion is devoted mainly to clearance since this is a characteristic of the transmitting system only, and not of the receiving system also, as a-f sharpness is. (Actually, the observed clearance is also a function of the surrounding terrain.)

In operation, it is important that the clearance in all directions (except on course) be adequate so as to produce no multiples nor even the impression that a course is being approached. The importance of proper course alignment is obvious and the maintenance of proper course width is equally important. These factors are therefore monitored continuously.

Description of Transmitter

Somewhat novel equipment arrangements have been used to produce the results described above; these are indicated in Fig. 5. Two main sources of r-f power feed the antenna array, one supplying modulated carrier to the carrier pair of loops (c) and one supplying pure sideband energy to the sideband pairs (s).

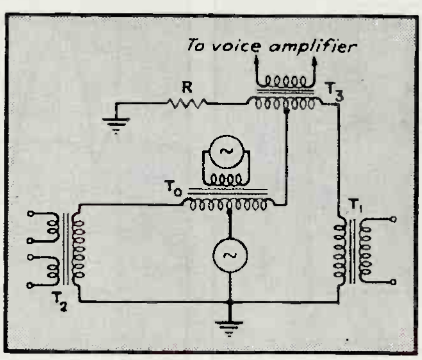


FIG. 8—Hybrid unit used with voice channel to give verbal instructions to incoming pilots over runway localizer radio system

Modulated carrier power is obtained from the output tank of a 200-watt transmitter and carried directly to the antenna by means of 70-ohm coaxial line. The transmitter is crystal-controlled and the power amplifier stage is plate-modulated by the 90-cps and 150-cps signals from the motor-alternator unit. Pure carrier from the grid circuit of this amplifier is used to excite a sideband generator, the plate circuit of which is fed by the modulation voltage. Under these conditions and if the tubes and circuit are balanced and operating under class C conditions, the output voltage will be proportional to sin qt sin ωt where $q/2\pi$ and $\omega/2\pi$ are the modulation and carrier frequencies respectively. This output contains, therefore, only sidebands (no carrier) corresponding to the modulation and carrier frequencies, and is used to feed the sideband antenna.

The division of energy among the three (or more) sideband pairs is achieved by the fixed system of quarter-wave transmission line transformers shown in Fig. 6, requiring no field adjustments. This is a most desirable feature in a program of this magnitude in which it is frequently necessary to have installations made and maintained by personnel of limited technical qualifications. The loads (R_0) are all equal to each other and are essentially 70 ohms resistive.

The desired current ratio is $I_1:I_2:I_3 = 1:0.5:0.3$, hence the desired power ratio is $P_1:P_2:P_3 = 1:0.25:0.09$. The power input to each transformer section being E_0^2/R_0', it follows that $(1/R_{01}'):(1/R_{02}'):(1/R_{03}') = 1:0.25:0.09$, and since $Z_{01}^2 = R_0R_{01}'$, etc., the characteristic admittances have the same relative values as the currents. The impedance Z_{00} is selected to match the parallel impedances of the three sections to the source R_{00}. The value of Z_{01} is chosen to result in practical dimensions for the various conductors and for this reason is different from R_0.

Audio Hybrid Circuit

The phasing, which determines on which side of the course the main lobe of each modulation pattern occurs, is accomplished in a special audio hybrid circuit. Referring to Fig. 5, the 90-cps source and the 150-cps source are connected into a balanced center-tapped transformer. The center-tapped winding is loaded symmetrically by the sideband generator plate circuit and the main transmitter p.a. plate circuit. Under these conditions, the 90-cps components in these loads are in phase with each other, and the 150-cps components are out of phase.

This same relationship (or the reverse, depending on the polarities of the coupling transformers) persists up to and including the antenna array, thus producing modulation field patterns similar to that in Fig. 2. In order that these phase relationships be obtained, it is necessary that the loads presented by the two coupling transformers, T_1 and T_2, be purely resistive and equal. If they are not purely resistive, it is likely that they will not have the same phase angle and usually their reactance will differ for the two modulation frequencies. This disturbs the desired phase relations and results in interaction between the two audio-frequency sources by virtue of the unbalance in transformer T_0.

In the actual equipment, the phase angles of the loads presented by T_1 and T_2 are of the order of two or three degrees. The value of this phase angle is affected chiefly by the self inductances of the various transformer windings (and the inductor L_1), which are several hundred henrys or more (although, due to the magnitudes involved, the leakage reactance may become important without the necessary precautions)*.

Modulation Percentage

The 200-watt carrier is modulated 100 percent on course, assuming no voice channel; with voice on the same carrier, the 90 and 150-cps modulation would be correspondingly less. With peak modulation by both 90 cps and 150 cps, each of these frequencies modulates the carrier only 50 percent. A useful modulating power of 25 watts at each frequency is, therefore, required. With a plate efficiency of the order of 50 percent in the p.a., the actual power required is more nearly 50 watts, and considering further that a like amount is required by the sideband generator (actually somewhat more due to the lower efficiency of the latter), it can be seen that each modulation generator must furnish about 100 watts.

With 100 percent modulation on course (where the contribution from the side-band loops is zero), the modulation off course will in general differ from 100 percent and will vary with azimuth due to the radiation pattern of the array. It might offhand appear that if the carrier is itself modulated 100 percent, the superposition of radiation from the sideband loops would result in overmodulation everywhere except on course. This is not the case. Radiation from the sideband loops adds to the carrier modulation for one of the modulation frequencies, but subtracts for the other, so that the net result can be, and for most values of azimuth is less than 100 percent modulation (see Fig. 7). It is evident that overmodulation does not occur except between 5 deg and 15 deg off-course, and the maximum is only 128 percent.

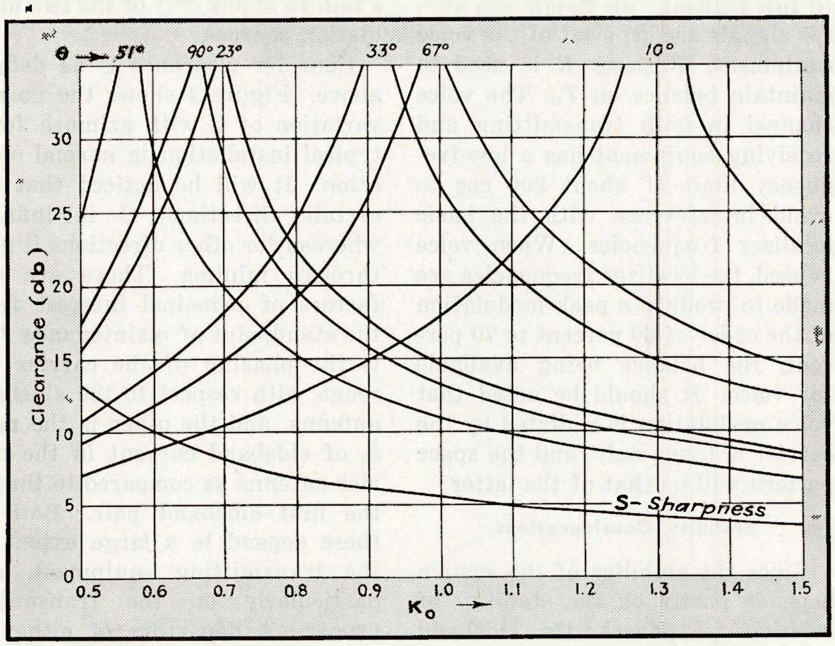


FIG. 9—Variation of clearance with sideband current in carrier loops

Insertion of Voice Channel

It is sometimes desirable to be able to operate a voice channel on the localizer to permit phone contacts with a pilot prior to or during an actual approach. This is easily done, the insertion of the voice modulation being made in the hybrid circuit consisting of transformers T_0, T_1 and T_2 (Fig. 5). Voice signals are introduced by a third

*It is easy to show that if the secondary of a transformer is loaded by a resistive load R, and if the self-reactance of the secondary winding is $X = kR$, then the impedance looking into the primary will have a phase angle equal to $\tan^{-1}(1/k)$, assuming no leakage reactance. For this angle to be three degrees for $R = 10{,}000$ ohms, X must be at least 190,000 ohms, which requires the self-inductance (at 90 cps) to be 340 henrys. On the other hand, such large inductances introduce the problem of leakage reactance. If the reflected impedance is of the order of 1,000 ohms, then the leakage reactance cannot exceed about 50 ohms (or roughly 0.1 henry).

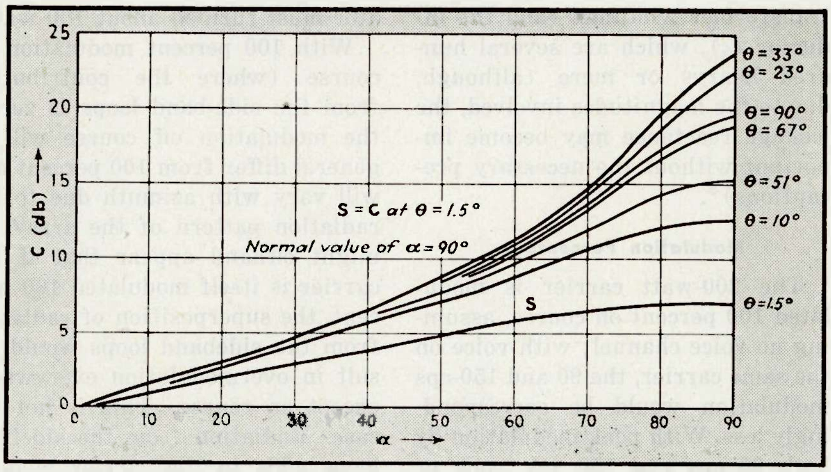


FIG. 10—Variation of clearance with phase of carrier loop current

transformer (T_3 in Fig. 8) also having a center-tapped secondary forming a second balanced circuit. In this manner, the 90-cps and 150-cps signals are kept out of the voice equipment. Resistor R is used to maintain balance on T_3. The voice channel in both transmitting and receiving equipment has a low-frequency limit of about 200 cps to avoid interference with the basic localizer frequencies. When voice is used, the localizer frequencies are made to produce a peak modulation of the order of 60 percent to 70 percent, the balance being available for voice. It should be noted that voice modulation is radiated by the carrier antenna only, and the space pattern will be that of the latter.

Stability Considerations

Since the stability of the system depends partly on the stability of relative r-f phases, the sideband generator is driven, as stated, directly from the unmodulated grid tank of the transmitter power amplifier. All r-f energy is carried over coaxial copper lines with air dielectric, and the lines to the antenna array are filled with dry air under low pressure to prevent breathing of moisture. An experimental installation utilizing solid-dielectric cables throughout has been made. If satisfactory, these cables would evidently be preferable to air dielectric lines.

The system is inherently quite stable for any reasonable variation in the several parameters. The alignment of the course is not affected by any change except one which in some way modifies the symmetry of the patterns about the direction of the course. This might result from mechanical injury to one side of the array, or to a failure of one only of the two modulation sources.

Consider clearance C as defined above. Figure 4 shows the normal variation of C with azimuth for a typical installation in normal operation. It will be noticed that for certain directions C is infinite, whereas for other directions it goes through minima. There are two factors of principal interest from the standpoint of maintenance. One is the phasing of the carrier antenna with respect to the sideband antenna, and the other is the ratio k_0 of sideband current in the carrier antenna as compared to that in the first sideband pair. Both of these depend to a large extent on the transmitting equipment, and particularly on the transmitter proper. A departure of either of these factors (but not both) from normal will affect the values of minimum clearance, but not the position of these minima relative to the course (see Appendix I).

Figure 9 shows the variation of minimum clearance values with variation of k_0 for $\alpha = \pi/2$, and Fig. 10 shows the corresponding variation with α for the normal value of k_0. (The curves marked S represent course sharpness. or clearance at $\theta = 1.52$.) A departure of either α or k_0 from normal reduces the value of one or more of the clearance minima, yet a change in k_0 by 40 percent or a change in α of 45 degrees results in clearances not smaller than 6 db. Both of these minima are adequate for proper operation provided the aircraft receiver has sufficient audio gain. Figure 11 shows corresponding effects for changes in the current of the third (outermost) sideband pair.

A pertinent question commonly raised concerns the effect of unbalance in the sideband generator, resulting for example from the failure of one of the tubes. The most evident effect is to introduce carrier into the sideband loops, and the consequent radiation will merely distort somewhat the overall carrier space pattern. Another effect is to reduce the sideband output, which amounts to increasing the value of k_0 in Fig. 9. However, even if one of the tubes fails completely, this effectively increases k_0 by a factor of about 2; Fig. 9 shows the relatively small effect of this on clearance and sharpness. There is no need for using matched tubes.

To insure the maximum possible stability of the system, the equipment is itself designed to be stable within very close tolerances over a wide range of ambient and service conditions, as is done with all equipment used in CAA facilities.

Monitoring the Runway Localizer

The above study of the operational changes to be expected when different parameters vary has pointed the way to the method of monitoring the localizer. The question of monitoring the localizer (as well as the other parts of the system) is naturally important since the equipment is unattended in all installations.

The first and obvious concern is with the proper alignment of the course. In the first installations a field detector was placed 150 feet from the antenna, directly on either the front or back course. The position of the course is, however, relatively stable and independent of some of the more likely malfunctionings of equipment such as detuning of transmitter p.a. or sideband generator. On the other hand, such variables do affect the clearance off course, and a receiver located on course would not reveal these changes.

It is important to have ample clearance off-course to avoid serious confusion to a pilot. A receiver is therefore located about 50 degrees off course to permit monitoring this clearance, the one on course being used to monitor course alignment and signal level. The signal from the clearance monitor is fed through a transmission line (Fig. 12) to the control tower where it operates a visual indicator as well as alarm and recording circuits. The course monitor is arranged so that if the course moved beyond a predetermined limit, or if the level changes more than a preset amount, its output operates to open the line carrying the clearance signal and thereby causes various alarm and other circuits to function at the control tower. Lines from the marker stations carry corresponding signals which also operate the recorder and alarm functions as well as visual indicators. Since these signals are all at different audio frequencies they are easily separated, where necessary, by appropriate filters.

Tune-Up Procedure

The system has been designed with consideration for the limited technical training of installation and maintenance personnel. One feature which contributes materially to simplifying the tune-up process is the possibility of radiating simultaneously unmodulated carrier from the carrier pair and sidebands from the sideband pairs. This can be done as shown in Fig. 5 by loading the modulation transformer in the transmitter with a dummy load in lieu of the p.a. plate circuit. The only modulation on the carrier is then that due to radiation from the sideband loops. The latter can be phased correctly by adjusting the phaser to each sideband pair until the audio signal on the output of the clearance monitor is a maximum (see Appendix I). This process is a matter of a few minutes. In earlier systems making use of mechanical modulation it was impossible to radiate pure carrier simultaneously with pure sidebands, and the phasing process involved lengthy field observations of patterns, requiring from a few days to a few weeks.

Likewise, the ratio of sideband current in the carrier loops, to the sideband current in the sideband loops (the quantity k_0) is readily adjusted by comparing (by field measurements at one position) the modulation due to radiation from the sideband loops with the modulation from the transmitter. The latter reading is obtained with no radiation from the sideband loops.

The remainder of this two-part article, to appear in the next issue, describes the runway localizer equipment in considerable detail and takes up the various topographical factors affecting the location of the equipment at an airport.

APPENDIX I

For the array used, and if the loop currents are $k_n \cos \omega t$, the space pattern for the sidebands of one modulation frequency is given by

$$p = K\,(p_1^2 + p_2^2)^{1/2} \cos(\omega t + \psi) \qquad (1)$$

where

$p_1 \equiv k_0 \cos\alpha \cos\beta_0$

$p_2 \equiv k_0 \sin\alpha \cos\beta_0 + a$

$a \equiv \sin\beta_1 + k_2 \sin\beta_2 + k_3 \sin\beta_3$

$\beta_0 \equiv \delta_0 \sin\theta,\ \beta_1 \equiv \delta_1 \sin\theta$, etc.

$\delta_0, \delta_1, \ldots \equiv$ electrical spacing of loops from center of array

$\theta \equiv$ azimuth measured from perpendicular bisector of array.

$k_0, k_2, \ldots \equiv$ relative amplitudes of radiator currents referred to the current in the first sideband pair.

$\psi \equiv \tan^{-1}(p_2/p_1)$

$\alpha \equiv$ phase of carrier loops relative to sideband loops.

It follows from Eq. (1) that the radiation from the sideband loops is in quadrature with the loop currents. This may be seen by eliminating the terms due to the carrier pair (i.e., $p_1 = 0$, $p_2 = a$). This im-

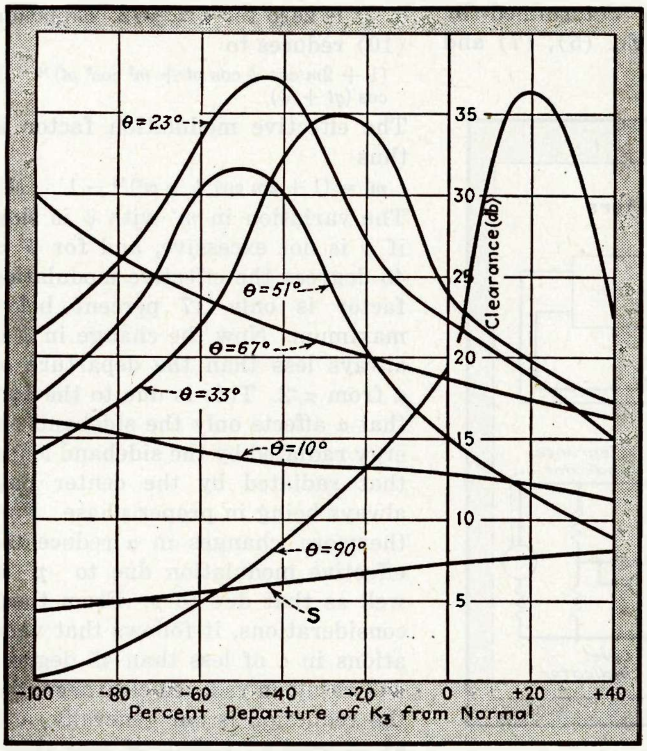
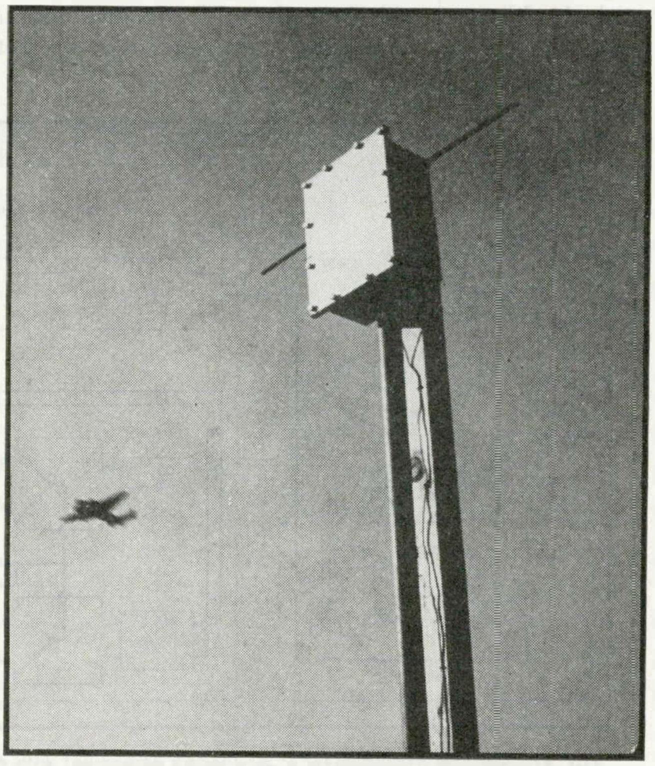


FIG. 11—Variation of clearance with current in outer pair



Localizer field monitor used to detect failure of on-course pattern mediately results in $\psi = \tan^{-1}\infty = \pi/2$. On the other hand, the radiation from the carrier pair is in phase with the loop current since if $a = 0$, then ψ is equal to α, the original phase of the carrier loop currents. For optimum addition of radiation from these two portions of the array the sideband loops must be fed in quadrature with respect to the carrier loops, i.e., $\alpha = \pi/2$. This optimum phasing may also be deduced by considering the magnitude of p from Eq. (1). This may be written $|p| = K (k_0^2 \cos^2 \beta_0 + a^2 + 2ak_0 \sin \alpha \cos \beta_0)^{\frac{1}{2}}$ which is obviously maximum when $\alpha = \pi/2$ (a, k_0 and $\cos \beta_0$ being positive).

In any direction θ, the sideband signal due to one modulation frequency will be as given above by Eq. (1), while that due to the other modulation frequency will be

$$p' = K (p_1^2 + p_3^2)^{1/2} \cos (\omega t + \psi') \qquad (3)$$

where

$$p_3 \equiv k_0 \sin \alpha \cos \beta_0 - a$$

and

$$\psi' \equiv \tan^{-1} (p_3/p_1) \qquad (4)$$

The clearance, as defined previously, will then be

$$C = 20 \log (p/p') \qquad (5)$$

and the sharpness S will be the value of C at $\theta = 1.5°$. On course ($\theta = 0$), $p = p'$ and $C = 0$. As θ departs from 0, C increases rapidly and should, preferably, remain as large as possible. Actually, it increases and decreases for different values of θ, and there will be some direction, or directions, in which it will have a minimum value (not less than 10 db, however). If, for any reason, the values of k or α vary, this minimum value of C will vary also, though not the positions at which the minima occur. This may be seen by considering the ratio p/p' on which C depends:

$$R \equiv (p/p')^2 = \frac{k_0^2 \cos^2 \beta_0 + a^2 + 2\, ak_0 \sin \alpha \cos \beta_0}{k_0^2 \cos^2 \beta_0 + a^2 - 2\, ak_0 \sin \alpha \cos \beta_0} \qquad (6)$$

Without further manipulation, it is evident from Eq. (6) that for any value of θ, R approaches unity (and hence the clearance C approaches zero) as α departs from the value $\pi/2$. At the extreme value $\alpha = 0$, the clearance is zero in all directions. Evidently, also, if $C > 0$ for $\alpha = \pi/2$, it will remain greater than zero for all values of α except $\alpha = 0$.

It may also be seen from Eq. (6) that the values of θ where C has minima remain unchanged though the values of the minima decrease as α departs from $\pi/2$. By rewriting R as

$$R = \frac{g^2 + 2\, g \sin \alpha + 1}{g^2 - 2\, g \sin \alpha + 1} \qquad (7)$$

it follows that

$$\frac{\partial R}{\partial \theta} = \frac{4 \sin \alpha\, (1 - 2\, g^2)}{(g^2 - 2\, g \sin \alpha + 1)^2} \frac{\partial g}{\partial \theta} \qquad (8)$$

The values of θ where C has minima (or maxima) are determined by $\partial C/\partial \theta = 0$; from Eq. (5), (7) and (9) this reduces to $(1 - 2g^2)\partial g/\partial \theta = 0$, which is independent of α.

It is likewise easy to show from Eq. (6) that the positions (but not the values) of minima for C are independent of k_0 provided $\alpha = \pi/2$. This is not true for other values of α. Figure 9 shows the variation of the values of these minima with k_0, for $\alpha = \pi/2$. Figure 10 shows the variation of these same minima with α, for $k_0 = 0.8$ (its normal value).

In considering Fig. 9 and 10, it should be remembered that they refer to the clearance C as defined by Eq. (5). This clearance so defined depends only on the ratio p/p' and these are merely the amplitudes of the resultant radiated sidebands. The modulation factors at the two audio frequencies do not necessarily have this same ratio except for $\alpha = \pi/2$, in which case the sidebands are in the proper phase with respect to the carrier for all values of θ. When $\alpha \neq \pi/2$ this is no longer the case.

For $\alpha = \pi/2$, the radiated carrier and sidebands are

$$\cos qt + m \cos pt \cos qt \qquad (9)$$

When $\alpha \neq \pi/2$, the sidebands are no longer in phase with the carrier, so to speak, and the expression may be written

$$\cos (qt + \psi) + m\, (\theta) \cos pt \cos qt \qquad (10)$$

where ψ is the phase shift due to α. It is zero for $\alpha = \pi/2$. Equation (10) reduces to

$$(1 + 2m \cos \psi \cos pt + m^2 \cos^2 pt)^{1/2} \cos (qt + \psi)$$

The effective modulation factor is thus

$$m' = (1 + 2m \cos \psi + m^2)^{1/2} - 1 \qquad (11)$$

The variation in m' with ψ is slow if ψ is not excessive, and for $\psi = 45$ degrees the effective modulation factor is only 17 percent below maximum. Now the change in ψ is always less than the departure of α from $\pi/2$. This is due to the fact that α affects only the sideband energy radiated by the sideband loops, that radiated by the center pair always being in proper phase. Furthermore, changes in α reduce the effective modulation due to p' as well as that due to p. From these considerations, it follows that variations in α of less than 45 degrees will result in reduced clearance, but the reduction is not generally such as to produce points of zero clearance, or apparent spurious courses.

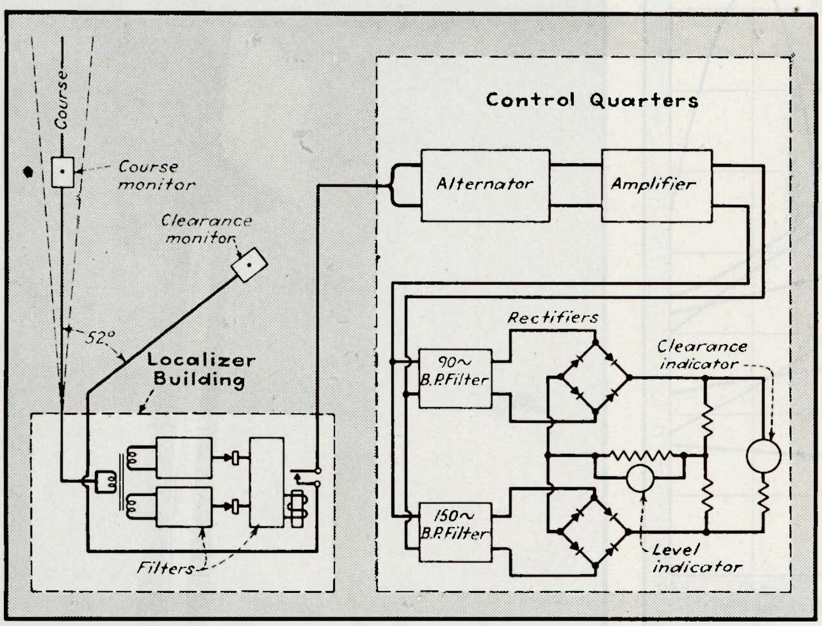


FIG. 12—General arrangement of monitoring equipment with respect to the runway localizer field

Tubeless Probe for VTVM

R-F circuit loading due to the input admittance of the measuring instrument is reduced by employing a cathode follower in the input circuit of a vacuum-tube voltmeter

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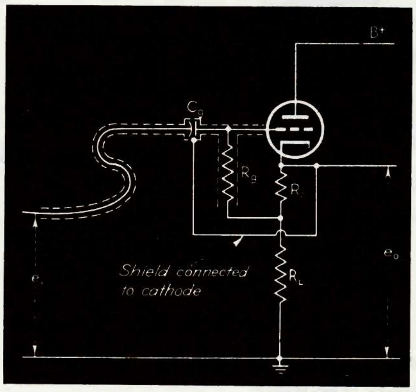
Washington, D. C.

USERS of vacuum-tube voltmeters who have struggled with necessarily bulky vacuum-tube probes in confined spaces will appreciate the value of the arrangement to be described. The circuit is practically as effective as a vacuum-tube probe and has the advantage of permitting the tube to be located some distance away from the circuit under test.

A cathode follower is employed, and is fed through a shielded conductor. The shield is not grounded but is connected directly to the cathode of the tube. The capacitance of the shielded conductor thus is added to the grid-cathode capacitance of the cathode follower, but because of the cathode-follower characteristics this total capacitance does not appear as such at the input terminals. The effective input capacitance at the probe terminals is the total capacitance between grid and cathode multiplied by a reduction factor which by proper design may be 0.01.



Cathode-follower circuit for use in vtvm to eliminate the tube in the test probe

Circuit Theory

The chief characteristics of the cathode follower are low input capacitance, high input resistance, and low output impedance. These are given as $C_i = \alpha\, C_g$, $R_i = R_g/\alpha$, $Z_o = A/G_m$ where C_g = total effective capacitance between grid and cathode of the tube, R_g = effective grid-cathode resistance, A = gain of the circuit, and $\alpha = 1 - A = \frac{e_i - e_o}{e_i}$, a number less than unity.

An analysis of the circuit will show that the gain

$$A = e_o/e_i = \frac{1}{1 + 1/\mu + 1/G_mZ_L}$$

and the reduction factor $\alpha = 1 - A = 1/\mu + 1/G_mZ_L$ approximately, if μ and G_mZ_L are large. Large values of μ and G_m thus are desirable in order that α may be small.

The output impedance of the cathode follower is its cathode-to-ground impedance, and its value from the equivalent circuit is A/G_m, assuming the source impedance to be small as compared with the actual grid-cathode impedance. This also is the impedance of the shield to ground. The larger the G_m, therefore, the smaller is this value. Although the shield is not directly grounded, its impedance to ground nevertheless will be low. The effective input resistance, at the probe terminals, is the actual grid-cathode resistance multiplied by the reduction factor $1/\alpha$.

Operating Values

A circuit of this type, which the writer has found useful at frequencies up to several hundred kilocycles, employs a type 6SF5 high-mu triode operating under the conditions: $E_p = 100$ v; $I_p = 0.4$ ma; $E_g = -1$v. With circuit constants as follows: $E_b = 200$ v; $C_g = 1000$ $\mu\mu$f; $R_g = 10$ megohms; $R_c = 2500$ ohms; $R_L = 250{,}000$ ohms.

The published values of μ and G_m for these conditions are respectively 100, and 1150 micromhos, giving a value of $\alpha = 0.013$. Hence the two-foot length of 60-$\mu\mu$f-per-foot shielded cable used as an input lead should appear as a shunt capacitance of only $2 \times 60 \times 0.013 = 1.6$ $\mu\mu$f. With total grid-cathode resistance of 5 megohms, the apparent shunt input resistance is $5/0.013 = 380$ megohms.

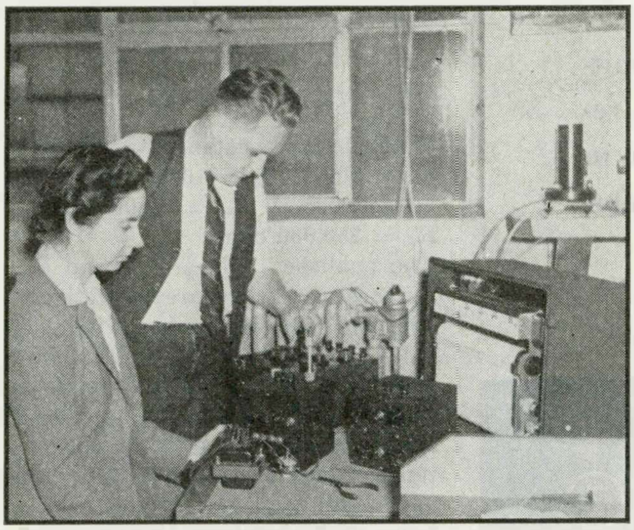
The measured input impedance of this circuit was found to be approximately 5 $\mu\mu$f in parallel with 300 megohms at frequencies from 1 cps to 500,000 cps, the difference between 5 $\mu\mu$f and 1.6 $\mu\mu$f being accounted for as the grid-to-ground capacitance within the tube. The voltage gain is about 0.98.

Limitations

The chief limitation of the high frequency operation of this circuit is the cathode-ground capacitance, since this must be considered as shunting the cathode resistor for the purpose of evaluating Z_L. The high frequency limit evidently may be extended by using a tube having a higher transconductance and requiring a lower value of cathode resistor. The low frequency limit may be extended by increasing the value of C_g.

The cathode-to-ground impedance of the tube appears relatively low even for a source impedance as high as several megohms, and hum pickup is much reduced as compared with an unshielded lead. For low-level measurements, a double-shielded cable may be used, the inner shield being connected to the cathode and the outer one to ground. With the double shield, the cutoff value will be constant and independent of location but it will be lower because of the increased cathode-to-ground capacitance.

A Photoelectric



Calibrating the phototube amplifier

Optical system of sensitive galvanometer operates amplifier which has sufficient output to operate a recording meter. Feedback from amplifier to galvanometer eliminates necessity for damping resistor and reduces galvanometer deflection by mechanical vibration

By GABRIELLE ASSET

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To measure voltages as low as one microvolt a phototube amplifier has been developed for use with a sensitive galvanometer and an electronic recorder. The galvanometer deflection acts optically on a twin phototube to produce an unbalance which is amplified so that it is measurable by means of the recorder. A feedback circuit to the galvanometer reduces the effect of vibration. Under good conditions readings on the one-microvolt range can be duplicated within ±0.75 percent.

As an example of the application of this instrument, in the petroleum and rubber industries infrared radiant energy is used for spectroscopic analysis of hydrocarbons. In the majority of such analytical equipment, transmitted radiation falls upon a thermocouple or thermopile setting up an electromotive force of the order of 10 microvolts or less.

Measuring such a small emf under industrial conditions requires a detecting device which is sensitive yet sturdy. The recorder used with the detecting device should also be sturdy and have a wide, easily read scale which is linear with the thermocouple emf. A sufficiently sensitive detecting device cannot directly operate a reliably sturdy recorder.

Galvanometer and Recorder

The galvanometer with which the amplifier is designed to be used is a Leeds and Northrup type 2500 which has a sensitivity of 0.32 microvolts per mm at one meter, a coil resistance of 11.5 ohms and a period of 5 seconds. Although the critical damping resistance is 52 ohms, none was necessary because of the damping of negative feedback from the amplifier. This galvanometer represents a compromise between sensitivity and ease of adjustment. A more sensitive galvanometer can be used to greater advantage in some instances, employing a larger negative feedback for the microvolt scale for the same galvanometer deflection. However, more time is required for the adjustment of the more sensitive instrument.

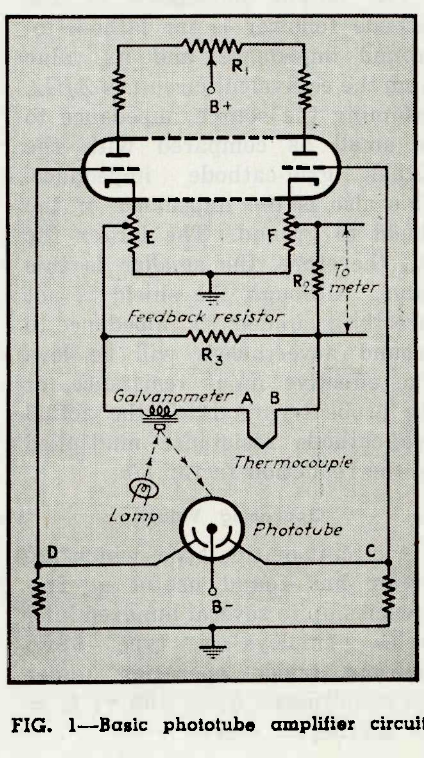


FIG. 1—Basic phototube amplifier circuit

The lamp used with the galvanometer has a straight vertical coiled filament. The beam of light from this filament is focused, by means of a lens in the lamp housing, on the cathodes of the twin phototube of the amplifier, the beam having been first reflected at the mirror of the galvanometer. The two cathodes of the phototube are separated by a space of 1/32 inch. The image of the filament is wide enough to straddle this space and to cover a strip on each cathode about 1/16 inch wide.

The meter used as an indicator of emf is a Brown Electronic strip chart potentiometer recorder, which

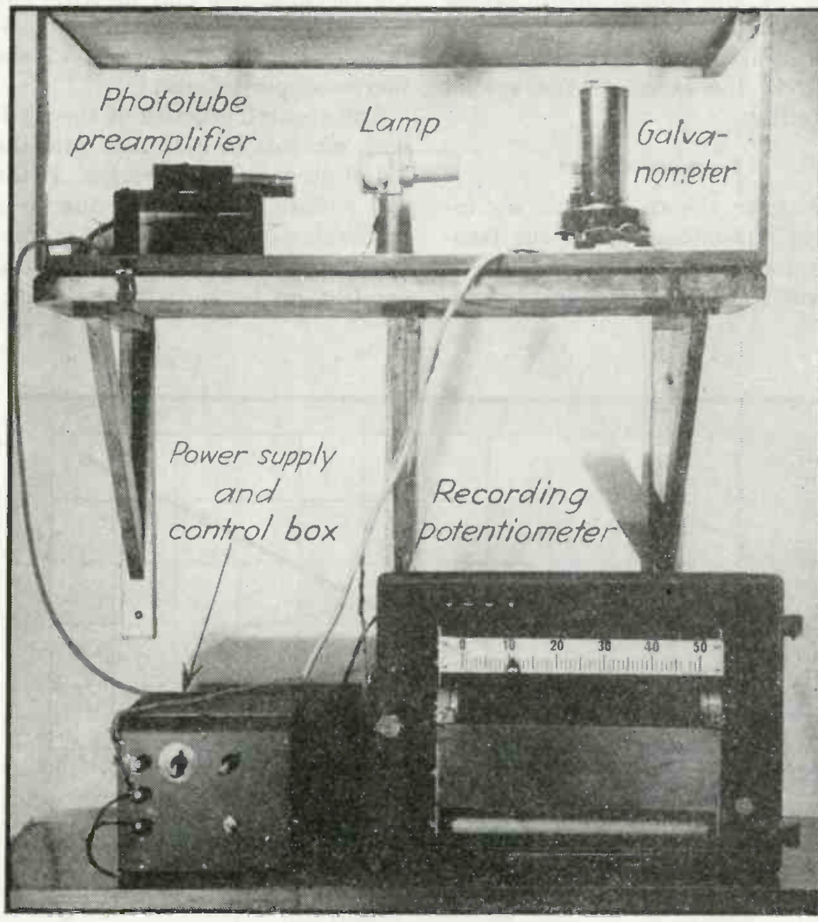
Galvanometer Amplifier

has proved to be highly satisfactory for use with the phototube amplifier. No noticeable zero drift exists and its readings are reliable within ±0.25 percent of full scale deflection. The model used has a span of 4 millivolts. The time required for full scale travel of the pointer is 11 seconds, but this can be reduced by changing the gear reduction of the balancing motor.

Phototube Amplifier

The amplifier is built in two units. A control box contains the control knobs, selector switch, all the resistors in the measuring and amplifier circuits and the power pack.

In the vacuum-tube unit are mounted the triodes of the amplifier and the twin phototube. A projecting light shield prevents scattered light from affecting the phototube. When the system is in operation, the galvanometer, vacuum tube unit and lamp are enclosed in a box to keep the temperature uniform and to reduce further the effects of stray light on the phototube.



The phototube amplifier is the connecting link between a sensitive galvanometer and an electronic recorder. The optical system comprising the lamp, galvanometer mirror and phototube of the amplifier is best enclosed to eliminate stray light and temperature variations

The operation of the phototube amplifier is illustrated by Fig. 1, a simplified diagram of the circuit. When there is no emf across the thermocouple terminals AB, the galvanometer coil is undeflected. Light from the lamp strikes the galvanometer mirror and is reflected to the twin phototube. The optical alignment of the lamp, galvanometer and phototube is adjusted so that the same amount of light falls on each cathode of the twin phototube.

The phototube load resistors are equal, and therefore the potential at points C and D are equal. To make points E and F equal in potential the two sections of the duotriode are balanced by R_1.

The measuring circuit is across points E and F. Whenever these two points are at the same potential, no current flows around this loop. The meter, which records the voltage drop across R_2, consequently reads zero.

When the equipment is in use in spectroscopic analysis, radiation falls on the thermocouple, raising its temperature and producing a small emf. This emf causes the galvanometer coil to deflect through a small angle. The resultant deflection of the light beam reflected from the galvanometer mirror then illuminates a greater area of one cathode of the phototube than of the other. The resulting unbalance in potentials at C and D is proportional to the thermocouple emf if the light beam is not deflected beyond that position where its edge just fails to strike one of the cathodes.

This difference in potential results in a like difference in potential at the grids of the duotriode. These changes in grid voltages, being amplified without distortion, produce a difference of potential between E and F which is proportional to the thermocouple emf. The potential difference between E and F is large enough to produce a drop across R_2 sufficient to actuate an electronic potentiometer recorder.

A sensitive galvanometer such as the one used here ordinarily responds to every type of mechanical disturbance unless a vibration-absorbing mounting is provided. In this circuit feedback is used to keep the galvanometer coil steady in spite of mechanical disturbances and changes in line voltage which exist in practically all locations and to avoid the necessity for special mountings.

Feedback Circuit

Thus far, the analysis has not included a consideration of the feedback used. Current flowing between E and F through the small feedback resistor R_3 introduces a small potential drop into the galvanometer circuit. This small potential is so directed that it is opposite to the thermocouple emf at AB. The circuit is so designed that this feedback voltage is 90 percent of the thermocouple voltage.

The steadying action of the feedback can best be described with the aid of an assumed vibration. If the coil suffers a deflection due to a mechanical disturbance, the deflection upsets the optical-electrical equilibrium between the two cathodes of the photoelectric cell. The difference of potential between points C and D is amplified, causing a current to flow through the measuring circuit which includes the feedback resistor R_3. The feedback voltage is of a polarity that opposed the assumed coil deflection and is within 10 percent of the voltage-equivalent of that deflection, and therefore prevents excessive deflection and holds the coil near its null position.

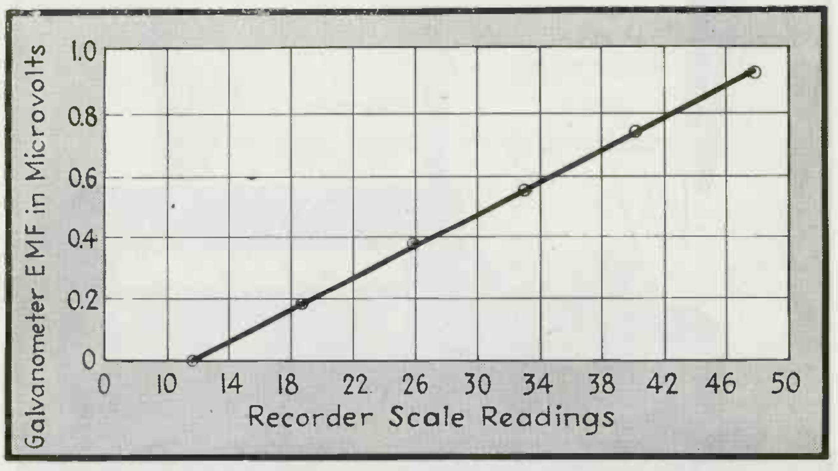


FIG. 3—Comparison of calibration over a period of four days illustrates instrument stability

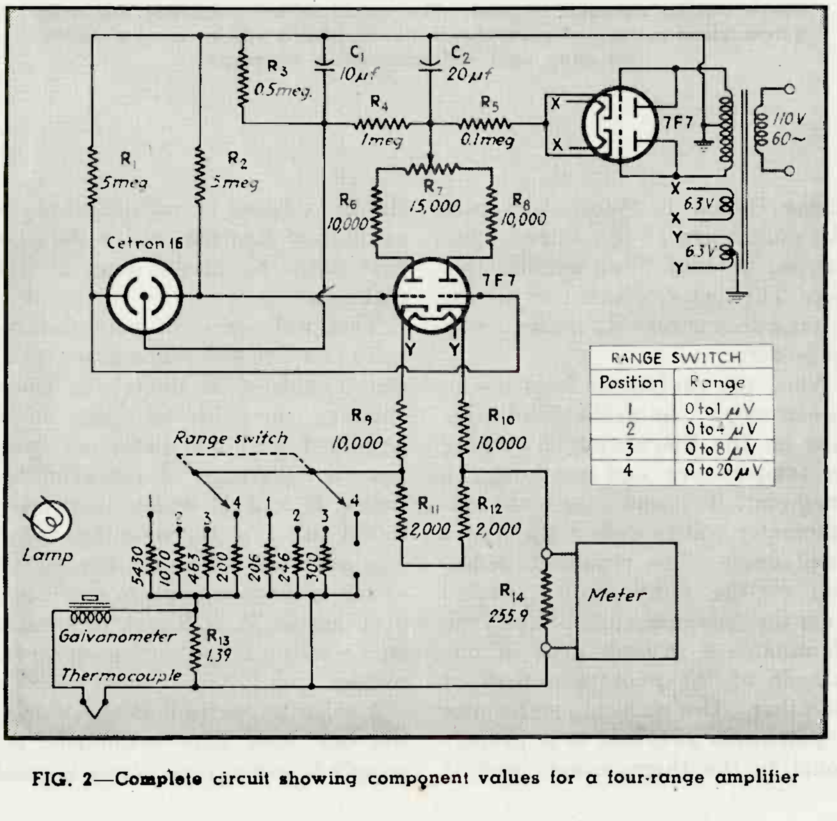


FIG. 2—Complete circuit showing component values for a four-range amplifier

Complete Circuit

In reducing the theoretical design of the phototube amplifier to a practical unit it was necessary to adapt the basic circuit to a multiple range circuit, reduce zero drift to a minimum, obtain maximum sensitivity and to secure constant calibration.

The basic circuit was changed to measure thermocouple emf in 4 ranges: 0-20 microvolts, 0-8 microvolts, 0-4 microvolts and 0-1 microvolt. A schematic wiring diagram, Fig. 2, shows the final circuit. Eight resistors were inserted in the measuring circuit to provide the required ranges. Each range is determined by a pair of resistors, one in series with the feedback resistor, and the other shunting the two in series as shown. The computation of the values of the resistors which determine the ranges was based on the following considerations:

(1) Output voltage regardless of the range is proportional to angular deflection of the galvanometer coil.

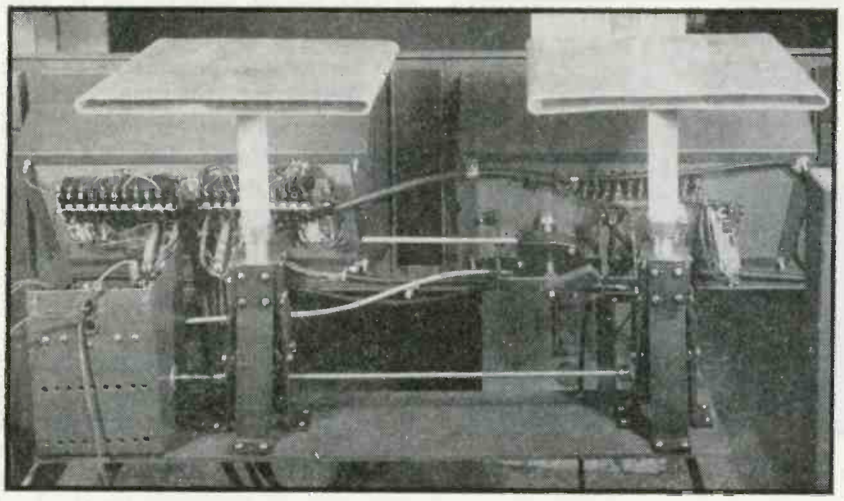
(2) The reflected light has just reached the position where it illuminates only one cathode of the phototube when the output meter to be used with this unit has reached full scale.

(3) The feedback voltage is at least 90 percent of the thermocouple emf.

Condition 2 means that the photoelectric unbalance is a maximum within its linear limits, and that at this unbalance four millivolts is obtained across R_{14}.

Precautions to Assure Stability

Reduction of zero drift was effected by eliminating as far as possible the sources of stray thermal emf in the measuring and galvanometer circuits. Spurious emf is



Details of rematching mechanism for 20-kw plastic preheating unit. A thyratron-controlled motor moves the two capacitor plates towards or away from the electrodes supporting the plastic preforms

and the B+ terminal of the power supply are at ground potential.

A relay shunted by an adjustable resistance is in series with the plate power supply circuit and is so adjusted that it will respond to a predetermined peak value of the plate current. At the instant this peak value is reached, the plate circuit relay closes and preconditions an auxiliary relay, which will respond after the plate current changes by a few percent of its peak value toward lower current ratings. This corresponds to the descending part of the power absorption curve in Fig. 1. At this point a plunger-type time-delay relay applies full cut-off bias to the grids of both oscillator tubes and throws a rematching relay over to the high-impedance connection required after the Curie point. Additional contacts on the rematching relay then open the circuit of the time-delay relay, so the cut-off bias is removed after a time delay of a few milliseconds; this is just sufficient to allow the rematching relay to be actuated under no-load conditions. Holding contacts keep the rematching relay energized until a timer circuit terminates the heating cycle and resets all relay circuits for a new cycle.

The results obtained by this arrangement are remarkable for two reasons:

(1) Smaller power rating generators can be used on jobs for which far larger units were deemed necessary.

(2) High-frequency generators can be used economically for high-temperature jobs.

Figure 6 gives a performance comparison of a conventional high-frequency generator (A) and one having half the rated power output but equipped with the rematching mechanism (B). Generator A reaches the critical temperature of magnetic transformation somewhat sooner, but after the Curie temperature is passed the smaller unit delivers heat to the charge at a higher rate and thus arrives at higher temperatures in a shorter time.

The temperature rise before the Curie point is closely approximated by a square-law function, and for this reason the time difference between the two points at which Curie temperature is reached is relatively small. The higher the required temperatures, the greater are the differences in efficiency and required heating time.

Surface hardening of ¾-inch diameter steel rings to various depths has been achieved in 3.5 seconds with a 2-Mc generator of only 2.5 kw output, by using a rematching unit. This is interesting because up to now it was not considered possible to obtain case hardening with power inputs less than about 10 kw per square inch. The heating time for surface hardening to $\frac{1}{32}$-inch depth was 3 seconds. The temperature of magnetic transformation was reached within the first 2 seconds. During the change-over

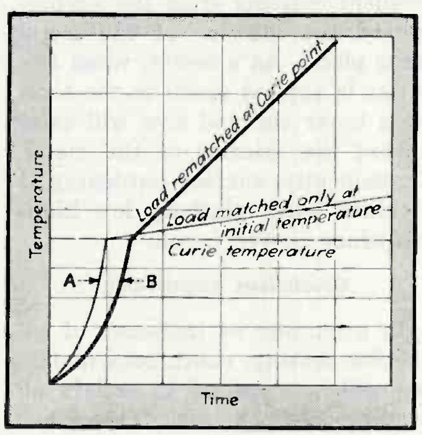


FIG. 6—Time-temperature curves for two high-frequency generators used for induction heating. The smaller unit with rematching (B) reaches temperatures above the Curie point much faster than generator A which has twice the output rating of B

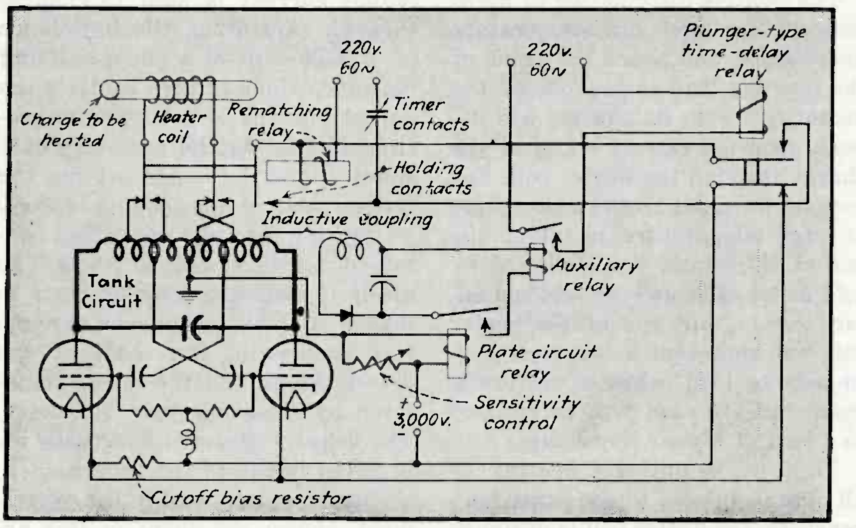
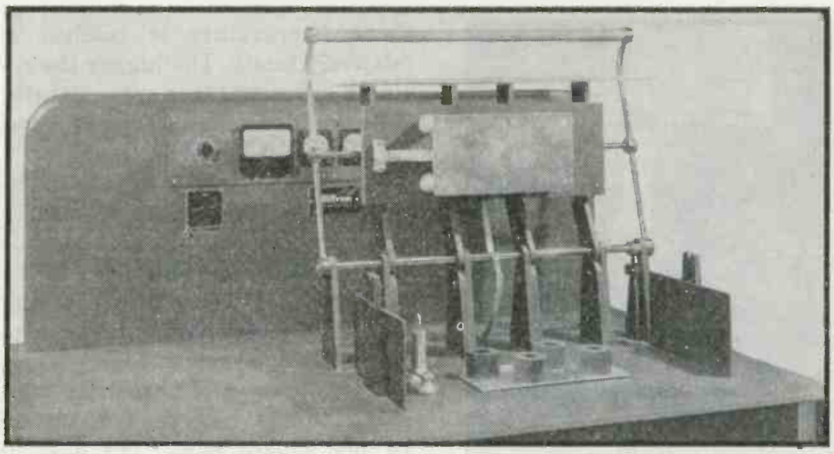


FIG. 5—Simplified schematic diagram of induction heating unit providing one step automatic rematching of tank circuit to load. The timer contacts open momentarily at the end of the heating cycle to release the rematching relay in preparation for a new cycle



Details of working table of 5-kw unit, with four preforms in position and top electrode raised

time, a few milliseconds, a certain equalization of the temperature gradient existing from the surface toward the interior of the metal takes place. As a result, when full power is applied again to the sample a lower thermal flow will exist toward the interior of the metal. Consequently, surface hardening is obtained with relatively low high-frequency power input.

Continuous Rematching

In a number of instances of induction heating, continuous matching will be required to satisfy all conditions. Such is the case when dealing with a charge fed continuously through the heater coil but of variable cross-section. An example is shown in Fig. 7, involving high-frequency heat treatment of a rifling broach.

The relative distribution of high-temperature and low-temperature metal mass, and hence the value of the average load impedance of the heater coil with its charge, will depend upon the rate of travel of the charge through the heater coil. For instance, a small cross-section piece of high-temperature metal at the end of the heater coil, followed by cold metal of large cross-section entering the front end of the heater coil, will represent a relatively low-impedance load, while a uniformly small cross-section will correspond to a load of higher impedance.

To provide uniform heating of all outer surfaces to the same temperature, the heater coil is designed to match the load to the generator at an average mass of metal within the heater coil traveling at an average speed. Every deviation from these predetermined averages will correspond to a change in load impedance and will be accordingly reflected back into the plate circuit of the oscillator.

A schematic diagram of the equipment is also shown in Fig. 7. Variation of oscillator plate current from a predetermined optimum value is used to provide a system of continuous rematching. A variable control rheostat in series with the plate current circuit converts the plate current variations into voltage variations and drives the input of a bridge-type amplifier having one control and one compensating tube. The bias of the compensating tube is so set that for the desired plate current of the oscillator a certain output current is obtained from the amplifier. This output current is used to change, through saturation, the impedance of a choke coil in a phase-shifting network, which in turn controls the output current of a thyratron rectifier in feeding the armature of a shunt-wound d-c motor driving the feeder cable of the moving charge.

The degree of regulation obtained by this method shows up nicely if a velocity-time diagram is taken. A small tachometer dynamo was coupled to the shaft of the driver motor and the speed registered by a vacuum-tube voltmeter. The velocity diagram is actually an inverted image of the broach.

The generator used in the experiment, shown elsewhere in this article along with its associated quenching device, pumps, etc., was a 2-megacycle, 2.5-kw unit. The entire 64-inch broach was heated to 2350 deg F in 92 seconds. Incidentally, this equipment demonstrates that relatively good frequency stability could be obtained without much additional effort. The frequency variation between no-load and full-load conditions at any instant was not over 75 kc total band width.

Rematching in Plastic Heating

The problem of heating plastic preforms demands equipment where the continuous adjustment of matching can be obtained between load and generator to secure maximum power absorption by the load during the entire heating cycle.

The solution is perhaps best illustrated by describing a commercially built equipment of 20-kw high-frequency output, used in the preheating of large plastic preforms. The load may vary between three to twelve pounds weight, and it was demanded that the generator shall adjust itself automatically to any new load conditions without any necessity for the operator to make adjustments.

The electronic generator used in this arrangement is of the self-excited push-pull type, with the center of the tank circuit grounded and connected to the positive terminal of the high-voltage power supply as shown in Fig. 8. The load is placed between two capacitor plates, which in turn are coupled to the tank circut by means of a variable capacitance. The spacing between the capacitor plates containing the load and the coupling plate can be changed by a reversible motor.

The feedback and initial coupling are so adjusted that for the rated maximum plate current of the oscillator tubes, matching is obtained and maximum power is delivered to the load. Any variation of the load impedance will be reflected into the plate circuit. The changing voltage drop across variable resistor R, due to plate current variations, drives the balanced-tube bridge amplifier. Two relays are connected across the output of the balanced bridge, each in series with a rectifier which allows current to pass through only one of the relays for either unbalanced condition. Thus, for increasing load impedance one of the relays will respond, closing contacts 1 of the reversible 220-volt, 60-cps motor; this moves the coupling reactance in a direction increasing the spacing, thus increasing the coupling reactance between load and generator to correct the matching. For a decrease in load, relay 2 will respond, closing contacts and reversing the motor so as to move the coupling plates in the opposite direction.

Operation During Heating Cycle

During the heating cycle of plastic preforms, the power factor of the material increases with increasing temperature. The coupling at the beginning, being adjusted for maximum power absorption, matches a relatively high-impedance load. In the course of the heating cycle the power factor will increase and the load impedance decrease accordingly. The balanced amplifier will try to correct for the lower impedance and therefore the control motor will adjust the coupling in the direction of a larger coupling reactance by increasing the spacing between the coupling plate and the electrodes. This means that at the end of the completed heating cycle both coupling plates will be in a position of maximum distance from the electrodes, and hence provide minimum coupling between load and generator. The next cycle will start at this minimum-coupling position, excluding the possibility of an overloaded plate circuit. Once the next cycle is started the rematching mechanism will automatically seek its own position of optimum coupling, corresponding to matched conditions between load and generator.

After the filament voltage is brought up to its nominal value the unit is made ready to operate by pushing a starter button on the front panel. This turns on the high-voltage power supply and simultaneously connects the armature of the reversible rematching motor across the 60-cycle, 220-volt line.

A high-frequency wattmeter indicates the amount of high-frequency power converted into heat within the load. The load electrodes are accessible after opening the screen gate in front of the unit, which automatically shuts off the high-voltage circuit. Proper recycling is obtained by a timer circuit.

The fact that the generator automatically adjusts itself to maximum power output at any present level makes it possible that a number of molding presses calling for various amounts of preform material can be supplied alternately without making any changes on the generator or its associated circuits. Such operations were performed successfully by unskilled labor.

A 5-kw generator using the same principles of automatic rematching was developed primarily for multicavity molding. The preforms are placed on the bottom electrode. The top electrode, which can be lifted by a lever mechanism, will adjust itself to any spacing corresponding to the thickness of the preform. Correspondingly, the matching capacitors will seek automatically their position of maximum power output. Power is applied to the high-voltage circuits of the d-c plate supply only when the top electrode reaches its final position, and power is disconnected when the top electrode is lifted. A timer circuit starts and ends the period during which power is applied.

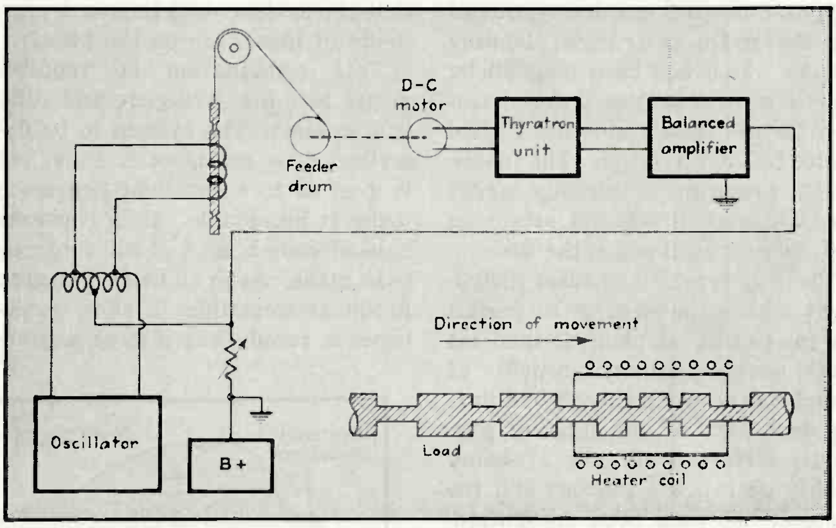


FIG. 7—Schematic diagram of electronic heating unit provided with continuous rematching equipment for heating to a constant surface temperature a moving charge of non-uniform cross-section as shown at the lower right

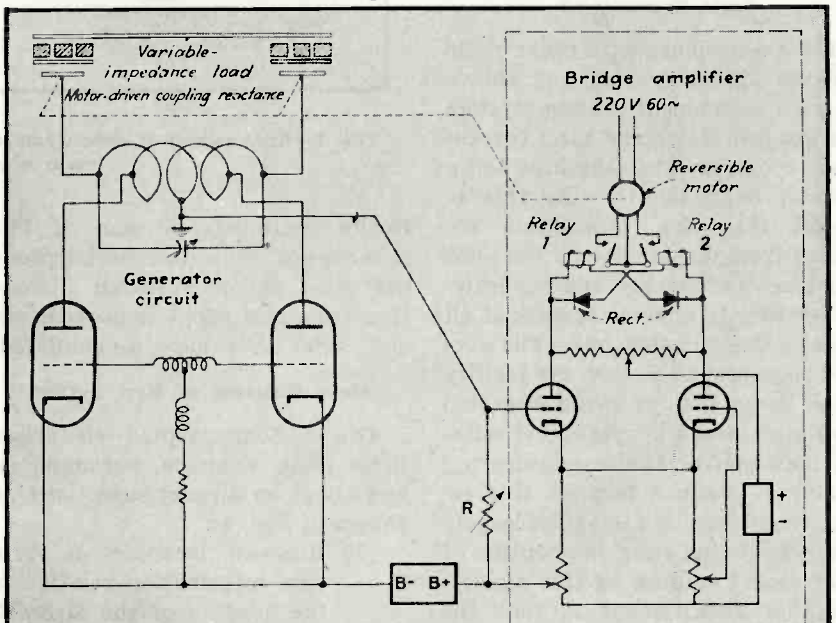


FIG. 8—Simplified schematic diagram of dielectric heating generator provided with automatic and continuous readjustment of matching between the load and the generator tank circuit

The CAA Instrument Landing System . . .

First complete technical details of blind landing system officially adopted for civil aviation in U. S. Installation program is under way and will be accelerated after the war. Part I covers theoretical aspects and runway localizer circuits

THE following is a description of the radio instrument landing system which has been adopted by the Civil Aeronautics Administration for use throughout the United States by civil aviation. The installation program is already under way, although it will not attain its full volume until after the war.

The function of any ideal instrument landing system is to permit the pilot of an airplane to land his craft safely without benefit of visual contact with the ground during any part of the landing procedure. The advantages of being able to do this are obvious and the problem has long been recognized. Many and varied solutions have been proposed but all are based on the use of radio in some form.

Basic Requirements

Long experience with other radio aids to air navigation has shown that an instrument landing system for general use should meet certain basic requirements—the first being that of dependability. By this is meant that the information received from the facility by the pilot must be trustworthy and accurate. It is better to have no facility at all than a questionable one. The second requirement is that the facility shall be capable of being operated and maintained by personnel without extensive radio engineering training. Failure to meet this requirement has, in fact, been largely responsible for delay in adoption of instrument landing by this agency. Another requirement is that the equipment shall comprise few, if any, parts not easily available or manufacturable. The fourth, and by no means the least important, is that the system shall impose a minimum of new work on the pilot.

This combination of requirements is quite stringent and difficult to meet. The system to be described does not meet it fully, yet it does so to a sufficient degree to make it acceptable. Improvements have already been, and will continue to be made. As in all fields, research produces sometimes a slow, sometimes a rapid—but always a practically continuous stream of improvements. The commercial product must follow research discontinuously, and adopt improvements only after they have accumulated.

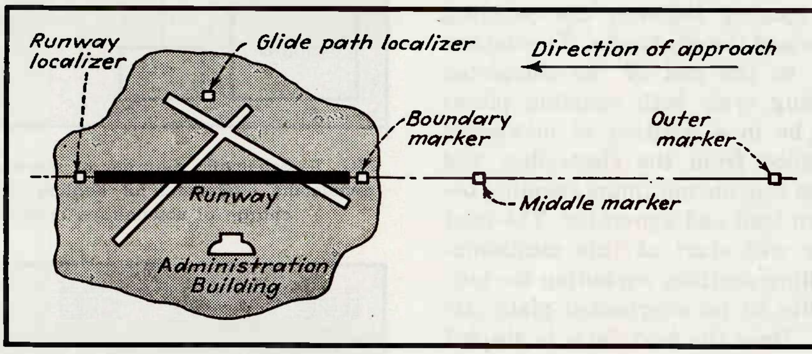


FIG. 1—Arrangement of components of CAA instrument landing system on and near a typical airport

Main Elements of New System

The system adopted comprises three main elements, arranged on and about an airport essentially as shown in Fig. 1:

(1) Runway localizer—to provide information relative to the heading of the aircraft.
(2) Markers—to indicate distance from point of contact.
(3) Glide path localizer—to provide indication of altitude.

The first of these radiates signals which overlap and produce an equisignal zone (or course) aligned with the axis of the runway. A zero-center differential indicating instrument in the cockpit will indicate zero as long as the airplane is in this zone, and will have deflections to the right or left as the craft departs from on-course. The runway localizer operates in the frequency band from 108 Mc to 111 Mc.

The second element comprises two (sometimes three) low-powered transmitters located at specified distances from the point of contact, along the extended axis of the runway, and radiating sharply vertical patterns. Each of these transmitters operates a different colored light in the airplane to permit the pilot to identify the marker being received. All markers operate at 75 Mc.

Equi-Signal Glide Path

The third element has only recently been developed to a satisfactory stage and is not yet being installed. It will therefore not be de-

. . . Part I

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Chief, Radio Engineering Section
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scribed in this paper, except by stating that it, too, radiates two overlapping signals to produce an equi-signal zone or on-course. The equi-signal surface is a vertical circular cone with the apex on the antenna. The station is located to one side of the runway so that the vertical plane through the localizer course cuts the cone parallel to but not through the axis. The intersection of the plane and the cone is thus a hyperbola. If the pilot were to follow both the glide path course and the localizer course, he would actually be traveling along a portion of this hyperbola. His position in space would thus be absolutely determined at all times during his descent, and by properly controlling the position and shape of the hyperbola, the aircraft could be brought to a complete landing without necessity of seeing the ground. Actually, the radiated patterns can be modified so that the surface of intersection is not exactly a right circular cone, but is such as to result in a more or less straight line glide path. It is anticipated that this equipment will operate at a frequency in the vicinity of 300 Mc.

An equi-signal glide path of this type was experimentally set up by Messrs. D. M. Stuart and J. C. Hromada at the Indianapolis Experimental Station of the CAA in 1938. The results were completely successful and tests, including flight tests, showed the system to be a practical one. For a number of reasons, not all technical, it was necessary to abandon this project, and constant-intensity glide path was then evolved which required the aircraft to follow a path of constant signal intensity. While the

Checking adjustment of loop antenna system for runway localizer of newly-adopted CAA radio instrument landing system

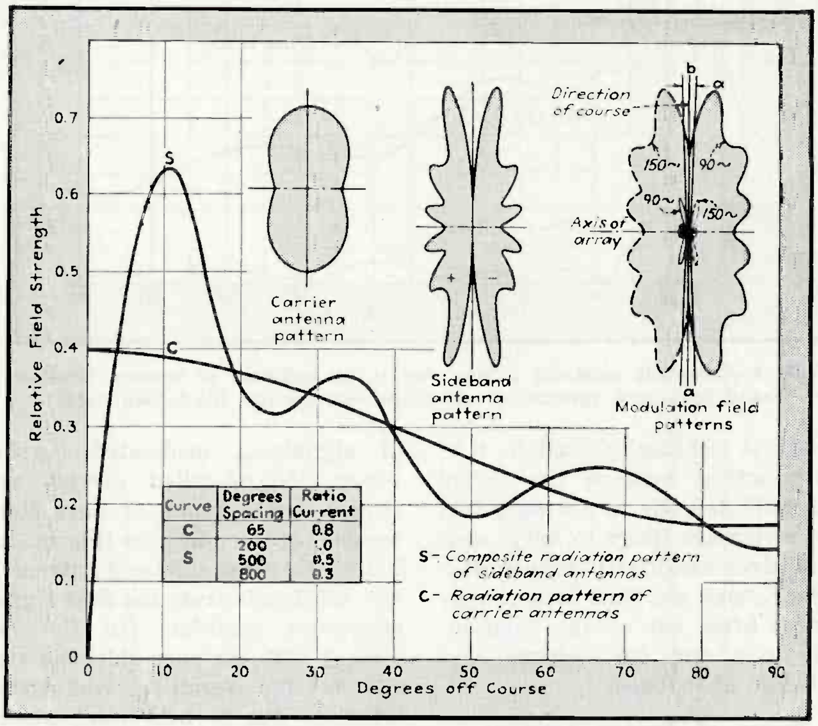


FIG. 2—Radiation patterns of the sideband and carrier antennas, plotted in both rectangular and polar coordinates

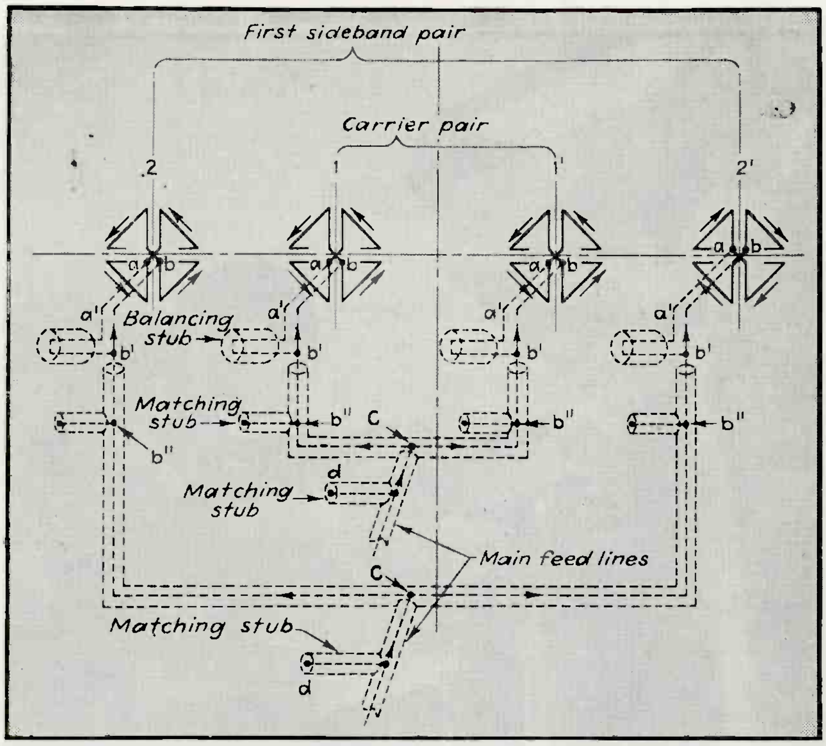


FIG. 3—Schematic diagram showing general arrangement of the first two pairs of antenna circuits associated with the runway localizer

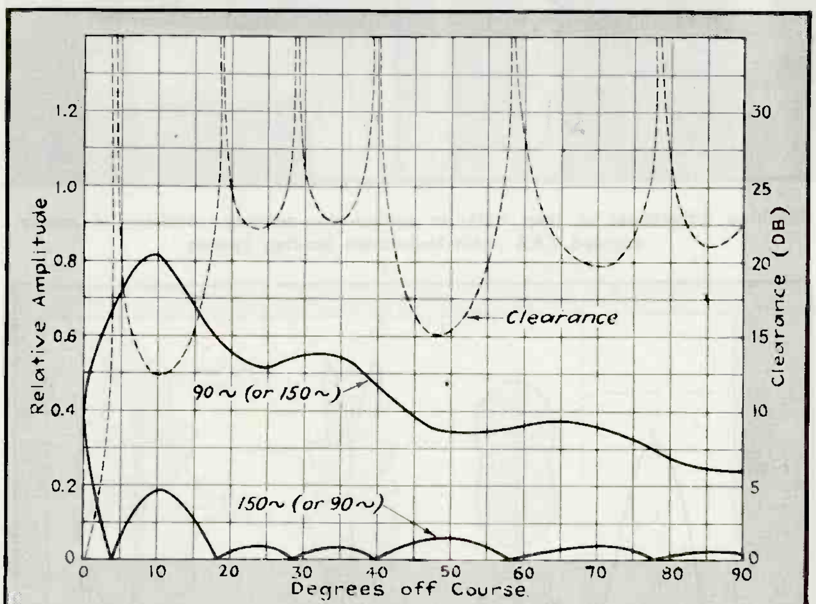


FIG. 4—Composite sideband pattern due to all radiators of runway localizer (solid lines) and variation of clearance with azimuth (dash-dash lines)

scheme is technically feasible, it is not practical because the actual glide path depends on too many factors which are likely to vary, such as receiver sensitivity, transmitter power output, etc. This became very evident after one or two trial installations and the scheme was therefore abandoned.

Theory of Runway Localizer

The localizer radiates two types of signals—a modulated carrier (from the so-called carrier antenna) and a group of pure sidebands corresponding to this modulation (from the sideband antenna). The sidebands from the first signal effectively combine (in the receiver) with the pure sideband signals and the overall received modulation is due to both components. The space pattern of the modulation can be controlled by means of both antennas, and this is done so as to produce two different patterns for the 90-cps and 150-cps modulation frequencies.

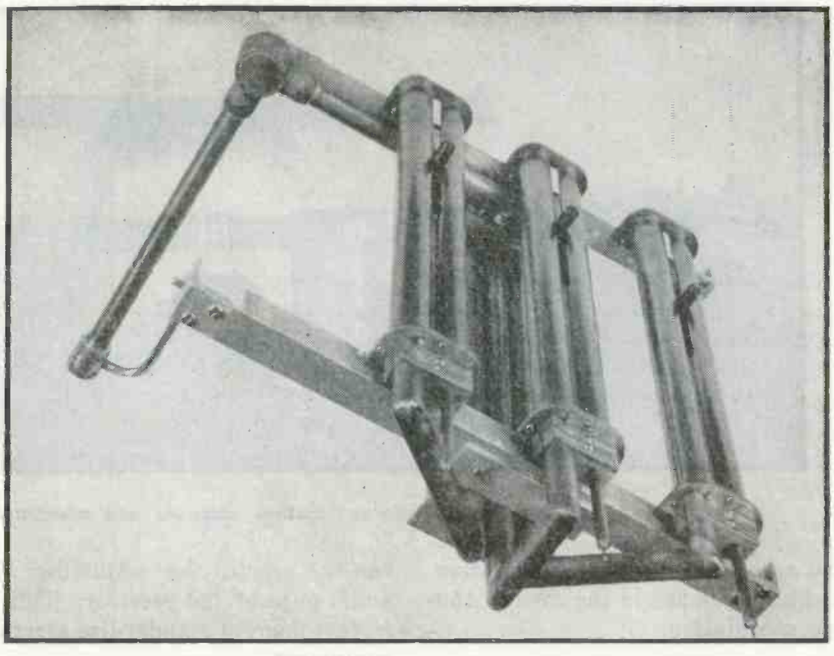
The radiation patterns are made highly directive, with the maximum approximately ten degrees from the course as shown in Fig. 2. The purpose of this is to maintain as much signal near the course as possible and at the same time minimize the off-course signal that might reach buildings or other structures and be reflected therefrom. Such reflections often are strong enough to affect the patterns and cause so-called multiple-course indications, and course-bends. The pattern of the carrier (about 110 Mc) is in fact much less directional, as it should be, since it is desired that the avc in the aircraft receiver be operative regardless of bearing with respect to the transmitter.

To obtain the desired radiation pattern, a linear array of radiators is arranged with the axis perpendicular to, and the center on the axis of the runway. The array is arranged in pairs, each symmetrical about the center. The radiators are vertical magnetic doublets (horizontal current loops) with patterns circular in the horizontal plane. The center pair, henceforth called carrier pair, is operated in phase with each other and fed with normally modulated carrier. The resulting radiation then contains the carrier frequency and all of the associated sidebands. Each of these sidebands will, of course, have the same space pattern as the carrier (due to the negligible difference in frequency between carrier pairs and sideband pairs).

As is well known, the electric field resulting from such a doublet has no components except in a plane at right angles to the axis of the doublet. In this case, the field is therefore purely horizontal which is of some practical advantage. For example, vertical metallic supports, lines, conduits, etc., inevitable in an actual installation, do not absorb any energy and therefore do not observably distort the radiated pattern. Furthermore, the coefficient of reflection from large surfaces is slightly less for horizontally polarized waves—particularly if the angle of incidence approaches the value of Brewster's angle (which in this case is of the order of 6.5°). On the other hand, a number of comparative tests of vertical as well as horizontal arrays has failed to demonstrate unequivocally the superiority of one or the other type of polarization. In view of this and of the definite advantages of vertical arrays in simplicity and economy, the latter have not been summarily dismissed from future consideration.

The elements of each of the other pairs (hereafter called sideband pairs) are operated 180 degrees out of phase and all elements on one side of the center are in phase with each other. All the sideband pairs are, furthermore, fed in quadrature with the carrier pair. Feed arrangements for the carrier pair and the first sideband pair are shown in Fig. 3.

Since a further rotation of 90 degrees is inherent in the radiation from the sideband pairs (see Appendix I), the resultant pattern will be in phase (or 180 degrees out of phase) with that radiated by the carrier pair. The pattern for three sideband pairs (the usual number in a typical installation) is shown in Fig. 2. There are only two lobes, of opposite phase, and with nulls along the direction of the course. It is to be noted that the phase in



Quarter-wave transmission line transformers used as phasing controls to place all sideband antenna pairs in phase with each other and in quadrature with the carrier antenna pair of the runway localizer system

the pattern is independent of azimuth except for the two reversals at the nulls.

The pattern from the carrier pair is likewise of constant phase. The resultant pattern due to a combination of the two therefore is merely the algebraic sum. With the proper choice of current ratios, the resultant can be placed almost wholly on one side of the course line with little or no radiation on the other side, and the side of maximum radiation is that in which the sideband lobe is in phase with the pattern from the carrier pair. To produce the modulation field patterns of Fig. 2, the right-hand sideband lobe is arranged to be in phase with the carrier pattern in

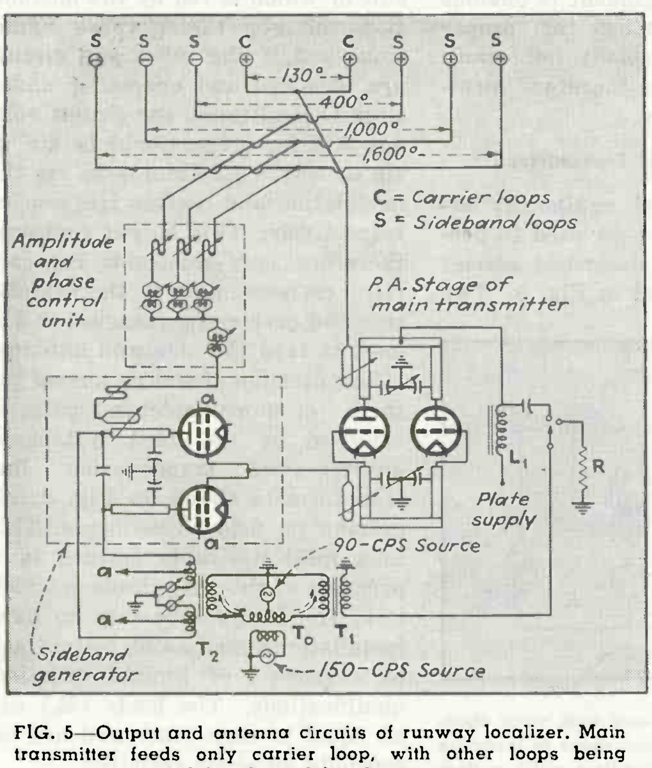


FIG. 5—Output and antenna circuits of runway localizer. Main transmitter feeds only carrier loop, with other loops being fed by the sideband generator

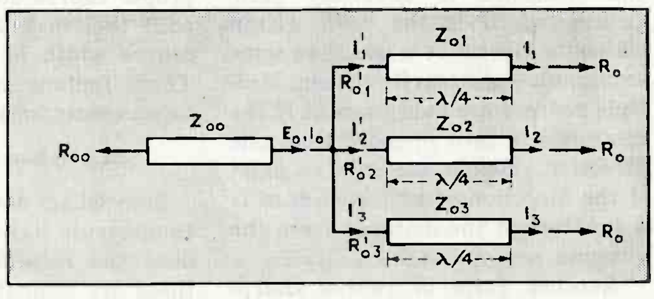


FIG. 6 (above)—Phase control unit serving the antenna system

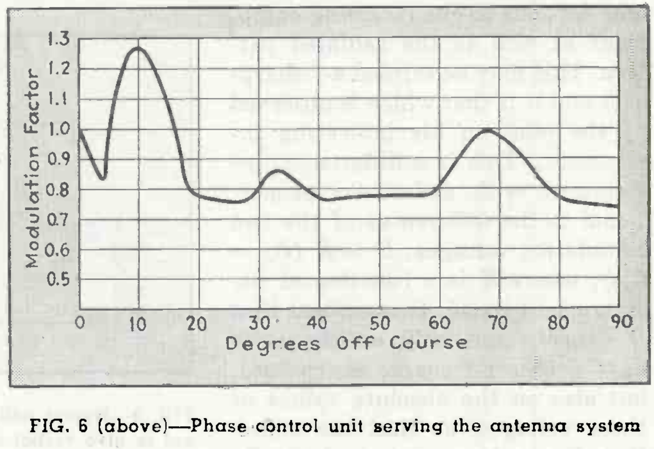
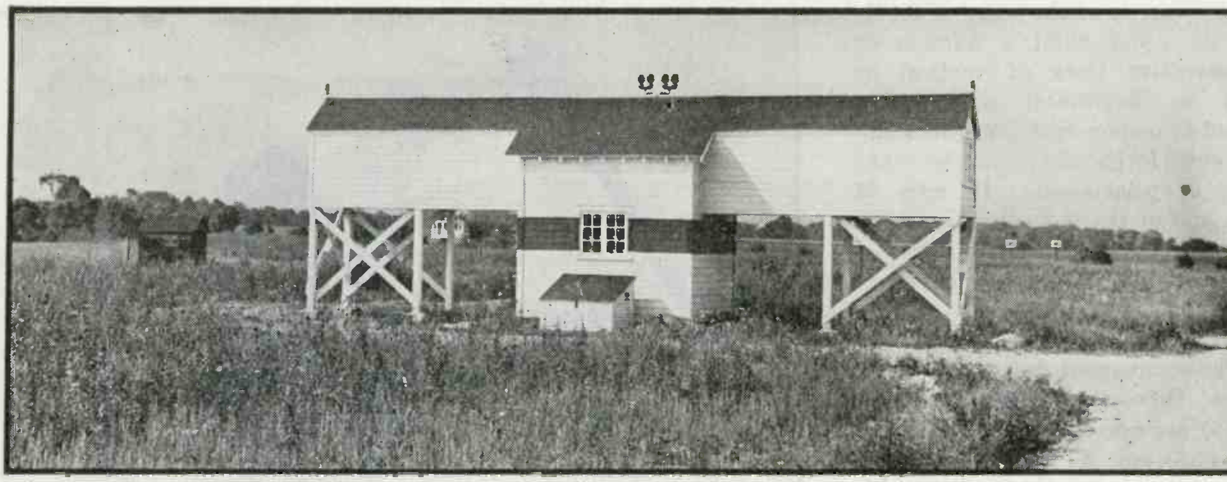


FIG. 7—Variation of modulation factor of runway localizer



Building housing runway localizer antennas and associated transmitter equipment

the case of the 90-cps modulation, and out of phase in the case of 150-cps modulation.

Course Clearance and Sharpness

There are several characteristics of these patterns which are important in the operation of the localizer. Figure 4 represents, in rectangular coordinates, one quadrant of the modulation field patterns shown in polar form in Fig. 2. The ratio of amplitudes of the two modulation frequencies in any direction (in decibels) is defined as clearance. The clearance in a direction 1½ degrees off course is defined as r-f course sharpness. Along the course, the clearance is obviously zero. Course width is the zone within which the clearance is less than some maximum—arbitrarily chosen. Multiple courses are said to exist if the clearance is zero in more than one direction. Bends are said to exist if the direction of zero clearance is a function of the distance from the antenna array.

Another form of course sharpness depends on the receiving equipment as well as the radiated pattern. This may be termed a-f sharpness and it is that which is observed by the pilot on his indicating instrument. This is a differential instrument with deflections proportional to the differences of the two modulation voltages: $D = K\ (C_{90} - C_{150})$, where K is a function of the instrument itself. It is evident that D depends not only on the ratio C_{90}/C_{150} (the r-f course sharpness), but also on the absolute values of these voltages, so that the deflection for a given value of C_{90}/C_{150} can be varied by adjusting the audio gain of the receiver. This is in fact done to standardize aircraft equipment.

The discussion is devoted mainly to clearance since this is a characteristic of the transmitting system only, and not of the receiving system also, as a-f sharpness is. (Actually, the observed clearance is also a function of the surrounding terrain.)

In operation, it is important that the clearance in all directions (except on course) be adequate so as to produce no multiples nor even the impression that a course is being approached. The importance of proper course alignment is obvious and the maintenance of proper course width is equally important. These factors are therefore monitored continuously.

Description of Transmitter

Somewhat novel equipment arrangements have been used to produce the results described above; these are indicated in Fig. 5. Two main sources of r-f power feed the antenna array, one supplying modulated carrier to the carrier pair of loops (c) and one supplying pure sideband energy to the sideband pairs (s).

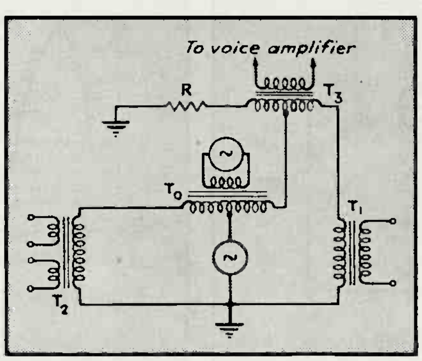


FIG. 8—Hybrid unit used with voice channel to give verbal instructions to incoming pilots over runway localizer radio system

Modulated carrier power is obtained from the output tank of a 200-watt transmitter and carried directly to the antenna by means of 70-ohm coaxial line. The transmitter is crystal-controlled and the power amplifier stage is plate-modulated by the 90-cps and 150-cps signals from the motor-alternator unit. Pure carrier from the grid circuit of this amplifier is used to excite a sideband generator, the plate circuit of which is fed by the modulation voltage. Under these conditions and if the tubes and circuit are balanced and operating under class C conditions, the output voltage will be proportional to sin qt sin ωt where $q/2\pi$ and $\omega/2\pi$ are the modulation and carrier frequencies respectively. This output contains, therefore, only sidebands (no carrier) corresponding to the modulation and carrier frequencies, and is used to feed the sideband antenna.

The division of energy among the three (or more) sideband pairs is achieved by the fixed system of quarter-wave transmission line transformers shown in Fig. 6, requiring no field adjustments. This is a most desirable feature in a program of this magnitude in which it is frequently necessary to have installations made and maintained by personnel of limited technical qualifications. The loads (R_0) are all equal to each other and are essentially 70 ohms resistive.

The desired current ratio is $I_1:I_2:I_3 = 1:0.5:0.3$, hence the desired power ratio is $P_1:P_2:P_3 = 1:0.25:0.09$. The power input to each transformer section being E_0^2/R_0', it follows that $(1/R_0'{}_1):(1/R_0'{}_2):(1/R_0'{}_3) = 1:0.25:0.09$, and since $Z_0{}^2_1 = R_0 R_0'{}_1$, etc., the characteristic admittances have the same relative values as the currents. The impedance Z_{00} is selected to match the parallel impedances of the three sections to the source R_{00}. The value of Z_{01} is chosen to result in practical dimensions for the various conductors and for this reason is different from R_0.

Audio Hybrid Circuit

The phasing, which determines on which side of the course the main lobe of each modulation pattern occurs, is accomplished in a special audio hybrid circuit. Referring to Fig. 5, the 90-cps source and the 150-cps source are connected into a balanced center-tapped transformer. The center-tapped winding is loaded symmetrically by the sideband generator plate circuit and the main transmitter p.a. plate circuit. Under these conditions, the 90-cps components in these loads are in phase with each other, and the 150-cps components are out of phase.

This same relationship (or the reverse, depending on the polarities of the coupling transformers) persists up to and including the antenna array, thus producing modulation field patterns similar to that in Fig. 2. In order that these phase relationships be obtained, it is necessary that the loads presented by the two coupling transformers, T_1 and T_2, be purely resistive and equal. If they are not purely resistive, it is likely that they will not have the same phase angle and usually their reactance will differ for the two modulation frequencies. This disturbs the desired phase relations and results in interaction between the two audio-frequency sources by virtue of the unbalance in transformer T_0.

In the actual equipment, the phase angles of the loads presented by T_1 and T_2 are of the order of two or three degrees. The value of this phase angle is affected chiefly by the self inductances of the various transformer windings (and the inductor L_1), which are several hundred henrys or more (although, due to the magnitudes involved, the leakage reactance may become important without the necessary precautions)*.

Modulation Percentage

The 200-watt carrier is modulated 100 percent on course, assuming no voice channel; with voice on the same carrier, the 90 and 150-cps modulation would be correspondingly less. With peak modulation by both 90 cps and 150 cps, each of these frequencies modulates the carrier only 50 percent. A useful modulating power of 25 watts at each frequency is, therefore, required. With a plate efficiency of the order of 50 percent in the p.a., the actual power required is more nearly 50 watts, and considering further that a like amount is required by the sideband generator (actually somewhat more due to the lower efficiency of the latter), it can be seen that each modulation generator must furnish about 100 watts.

With 100 percent modulation on course (where the contribution from the side-band loops is zero), the modulation off course will in general differ from 100 percent and will vary with azimuth due to the radiation pattern of the array. It might offhand appear that if the carrier is itself modulated 100 percent, the superposition of radiation from the sideband loops would result in overmodulation everywhere except on course. This is not the case. Radiation from the sideband loops adds to the carrier modulation for one of the modulation frequencies, but subtracts for the other, so that the net result can be, and for most values of azimuth is less than 100 percent modulation (see Fig. 7). It is evident that overmodulation does not occur except between 5 deg and 15 deg off-course, and the maximum is only 128 percent.

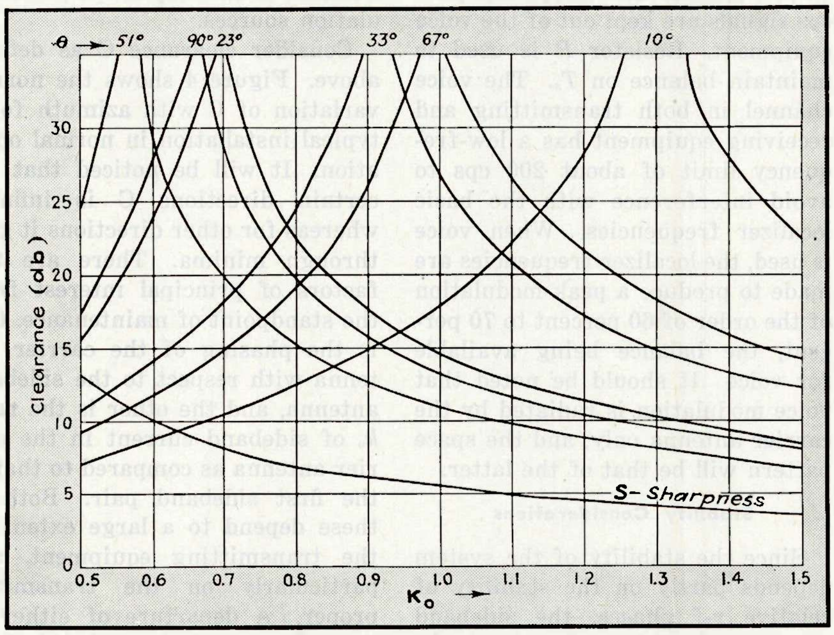


FIG. 9—Variation of clearance with sideband current in carrier loops

Insertion of Voice Channel

It is sometimes desirable to be able to operate a voice channel on the localizer to permit phone contacts with a pilot prior to or during an actual approach. This is easily done, the insertion of the voice modulation being made in the hybrid circuit consisting of transformers T_0, T_1 and T_2 (Fig. 5). Voice signals are introduced by a third

*It is easy to show that if the secondary of a transformer is loaded by a resistive load R, and if the self-reactance of the secondary winding is $X = kR$, then the impedance looking into the primary will have a phase angle equal to $\tan^{-1}(1/k)$, assuming no leakage reactance. For this angle to be three degrees for $R = 10{,}000$ ohms, X must be at least 190,000 ohms, which requires the self-inductance (at 90 cps) to be 340 henrys. On the other hand, such large inductances introduce the problem of leakage reactance. If the reflected impedance is of the order of 1,000 ohms, then the leakage reactance cannot exceed about 50 ohms (or roughly 0.1 henry).

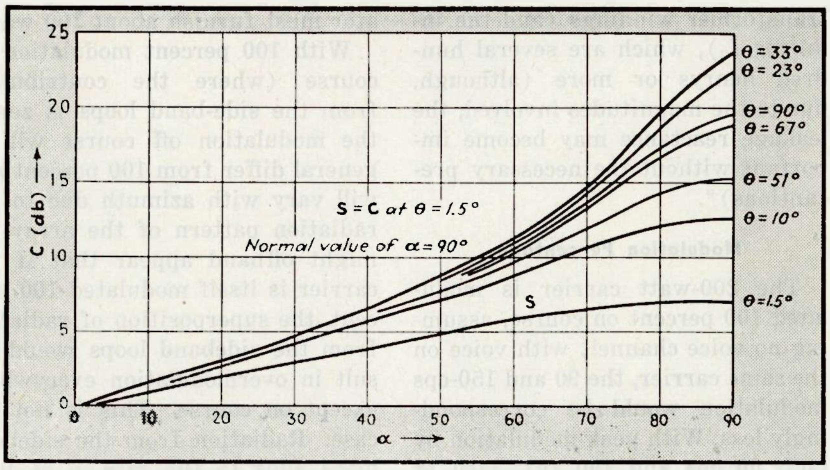


FIG. 10—Variation of clearance with phase of carrier loop current

transformer (T_3 in Fig. 8) also having a center-tapped secondary forming a second balanced circuit. In this manner, the 90-cps and 150-cps signals are kept out of the voice equipment. Resistor R is used to maintain balance on T_3. The voice channel in both transmitting and receiving equipment has a low-frequency limit of about 200 cps to avoid interference with the basic localizer frequencies. When voice is used, the localizer frequencies are made to produce a peak modulation of the order of 60 percent to 70 percent, the balance being available for voice. It should be noted that voice modulation is radiated by the carrier antenna only, and the space pattern will be that of the latter.

Stability Considerations

Since the stability of the system depends partly on the stability of relative r-f phases, the sideband generator is driven, as stated, directly from the unmodulated grid tank of the transmitter power amplifier. All r-f energy is carried over coaxial copper lines with air dielectric, and the lines to the antenna array are filled with dry air under low pressure to prevent breathing of moisture. An experimental installation utilizing solid-dielectric cables throughout has been made. If satisfactory, these cables would evidently be preferable to air dielectric lines.

The system is inherently quite stable for any reasonable variation in the several parameters. The alignment of the course is not affected by any change except one which in some way modifies the symmetry of the patterns about the direction of the course. This might result from mechanical injury to one side of the array, or to a failure of one only of the two modulation sources.

Consider clearance C as defined above. Figure 4 shows the normal variation of C with azimuth for a typical installation in normal operation. It will be noticed that for certain directions C is infinite, whereas for other directions it goes through minima. There are two factors of principal interest from the standpoint of maintenance. One is the phasing of the carrier antenna with respect to the sideband antenna, and the other is the ratio k_0 of sideband current in the carrier antenna as compared to that in the first sideband pair. Both of these depend to a large extent on the transmitting equipment, and particularly on the transmitter proper. A departure of either of these factors (but not both) from normal will affect the values of minimum clearance, but not the position of these minima relative to the course (see Appendix I).

Figure 9 shows the variation of minimum clearance values with variation of k_0 for $\alpha = \pi/2$, and Fig. 10 shows the corresponding variation with α for the normal value of k_0. (The curves marked S represent course sharpness. or clearance at $\theta = 1.52$.) A departure of either α or k_0 from normal reduces the value of one or more of the clearance minima, yet a change in k_0 by 40 percent or a change in α of 45 degrees results in clearances not smaller than 6 db. Both of these minima are adequate for proper operation provided the aircraft receiver has sufficient audio gain. Figure 11 shows corresponding effects for changes in the current of the third (outermost) sideband pair.

A pertinent question commonly raised concerns the effect of unbalance in the sideband generator, resulting for example from the failure of one of the tubes. The most evident effect is to introduce carrier into the sideband loops, and the consequent radiation will merely distort somewhat the overall carrier space pattern. Another effect is to reduce the sideband output, which amounts to increasing the value of k_0 in Fig. 9. However, even if one of the tubes fails completely, this effectively increases k_0 by a factor of about 2; Fig. 9 shows the relatively small effect of this on clearance and sharpness. There is no need for using matched tubes.

To insure the maximum possible stability of the system, the equipment is itself designed to be stable within very close tolerances over a wide range of ambient and service conditions, as is done with all equipment used in CAA facilities.

Monitoring the Runway Localizer

The above study of the operational changes to be expected when different parameters vary has pointed the way to the method of monitoring the localizer. The question of monitoring the localizer (as well as the other parts of the system) is naturally important since the equipment is unattended in all installations.

The first and obvious concern is with the proper alignment of the course. In the first installations a field detector was placed 150 feet from the antenna, directly on either the front or back course. The position of the course is, however, relatively stable and independent of some of the more likely malfunctionings of equipment such as detuning of transmitter p.a. or sideband generator. On the other hand, such variables do affect the clearance off course, and a receiver located on course would not reveal these changes.

It is important to have ample clearance off-course to avoid serious confusion to a pilot. A receiver is therefore located about 50 degrees off course to permit monitoring this clearance, the one on course being used to monitor course alignment and signal level. The signal from the clearance monitor is fed through a transmission line (Fig. 12) to the control tower where it operates a visual indicator as well as alarm and recording circuits. The course monitor is arranged so that if the course moved beyond a predetermined limit, or if the level changes more than a preset amount, its output operates to open the line carrying the clearance signal and thereby causes various alarm and other circuits to function at the control tower. Lines from the marker stations carry corresponding signals which also operate the recorder and alarm functions as well as visual indicators. Since these signals are all at different audio frequencies they are easily separated, where necessary, by appropriate filters.

Tune-Up Procedure

The system has been designed with consideration for the limited technical training of installation and maintenance personnel. One feature which contributes materially to simplifying the tune-up process is the possibility of radiating simultaneously unmodulated carrier from the carrier pair and sidebands from the sideband pairs. This can be done as shown in Fig. 5 by loading the modulation transformer in the transmitter with a dummy load in lieu of the p.a. plate circuit. The only modulation on the carrier is then that due to radiation from the sideband loops. The latter can be phased correctly by adjusting the phaser to each sideband pair until the audio signal on the output of the clearance monitor is a maximum (see Appendix I). This process is a matter of a few minutes. In earlier systems making use of mechanical modulation it was impossible to radiate pure carrier simultaneously with pure sidebands, and the phasing process involved lengthy field observations of patterns, requiring from a few days to a few weeks.

Likewise, the ratio of sideband current in the carrier loops, to the sideband current in the sideband loops (the quantity k_0) is readily adjusted by comparing (by field measurements at one position) the modulation due to radiation from the sideband loops with the modulation from the transmitter. The latter reading is obtained with no radiation from the sideband loops.

The remainder of this two-part article, to appear in the next issue, describes the runway localizer equipment in considerable detail and takes up the various topographical factors affecting the location of the equipment at an airport.

APPENDIX I

For the array used, and if the loop currents are $k_n \cos \omega t$, the space pattern for the sidebands of one modulation frequency is given by

$$p = K\,(p_1^2 + p_2^2)^{1/2} \cos(\omega t + \psi) \qquad (1)$$

where

$p_1 \equiv k_0 \cos\alpha \cos\beta_0$

$p_2 \equiv k_0 \sin\alpha \cos\beta_0 + a$

$a \equiv \sin\beta_1 + k_2 \sin\beta_2 + k_3 \sin\beta_3$

$\beta_0 \equiv \delta_0 \sin\theta,\ \beta_1 \equiv \delta_1 \sin\theta$, etc.

$\delta_0, \delta_1, \ldots \equiv$ electrical spacing of loops from center of array

$\theta \equiv$ azimuth measured from perpendicular bisector of array.

$k_0, k_2, \ldots \equiv$ relative amplitudes of radiator currents referred to the current in the first sideband pair.

$\psi \equiv \tan^{-1}(p_2/p_1)$

$\alpha \equiv$ phase of carrier loops relative to sideband loops.

It follows from Eq. (1) that the radiation from the sideband loops is in quadrature with the loop currents. This may be seen by eliminating the terms due to the carrier pair (i.e., $p_1 = 0$, $p_2 = a$). This im-

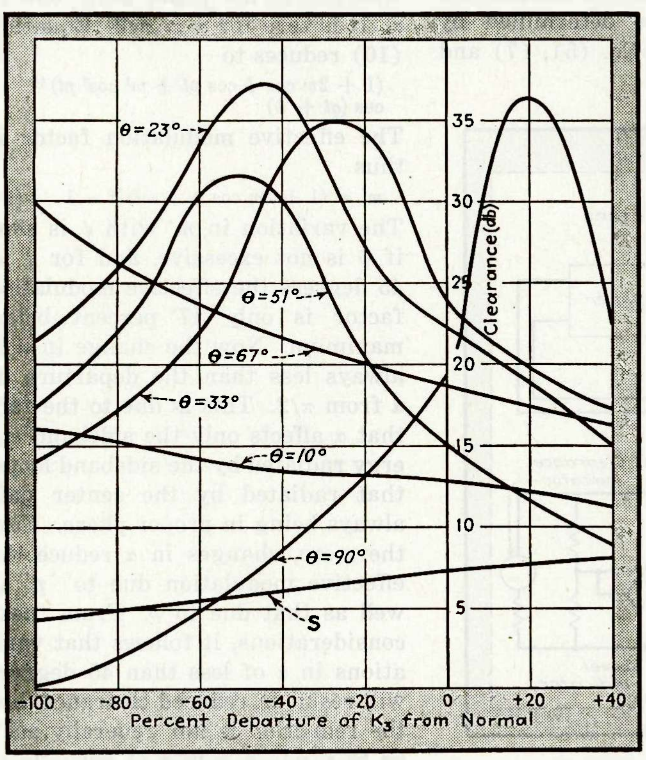
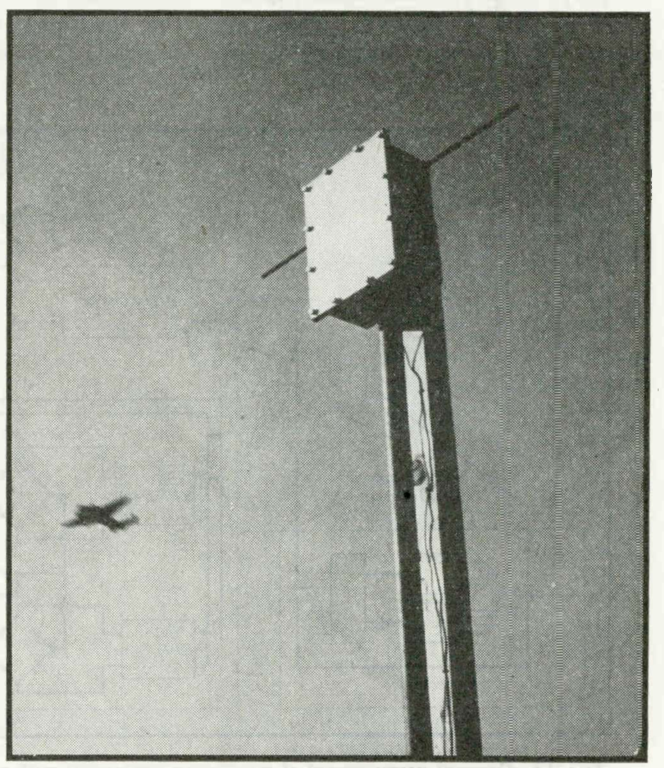


FIG. 11—Variation of clearance with current in outer pair



Localizer field monitor used to detect failure of on-course pattern

mediately results in $\psi = \tan^{-1}\infty = \pi/2$. On the other hand, the radiation from the carrier pair is in phase with the loop current since if $a = 0$, then ψ is equal to α, the original phase of the carrier loop currents. For optimum addition of radiation from these two portions of the array the sideband loops must be fed in quadrature with respect to the carrier loops, i.e., $\alpha = \pi/2$. This optimum phasing may also be deduced by considering the magnitude of p from Eq. (1). This may be written $|p| = K(k_0^2\cos^2\beta_0 + a^2 + 2ak_0\sin\alpha\cos\beta_0)^{1/2}$ which is obviously maximum when $\alpha = \pi/2$ (a, k_0 and $\cos\beta_0$ being positive).

In any direction θ, the sideband signal due to one modulation frequency will be as given above by Eq. (1), while that due to the other modulation frequency will be

$$p' = K(p_1^2 + p_3^2)^{1/2}\cos(\omega t + \psi') \quad (3)$$

where

$$p_3 \equiv k_0\sin\alpha\cos\beta_0 - a$$

and

$$\psi' \equiv \tan^{-1}(p_3/p_1) \quad (4)$$

The clearance, as defined previously, will then be

$$C = 20\log(p/p') \quad (5)$$

and the sharpness S will be the value of C at $\theta = 1.5°$. On course ($\theta = 0$), $p = p'$ and $C = 0$. As θ departs from 0, C increases rapidly and should, preferably, remain as large as possible. Actually, it increases and decreases for different values of θ, and there will be some direction, or directions, in which it will have a minimum value (not less than 10 db, however). If, for any reason, the values of k or α vary, this minimum value of C will vary also, though not the positions at which the minima occur. This may be seen by considering the ratio p/p' on which C depends:

$$R \equiv (p/p')^2 = \frac{k_0^2\cos^2\beta_0 + a^2 + 2ak_0\sin\alpha\cos\beta_0}{k_0^2\cos^2\beta_0 + a^2 - 2ak_0\sin\alpha\cos\beta_0} \quad (6)$$

Without further manipulation, it is evident from Eq. (6) that for any value of θ, R approaches unity (and hence the clearance C approaches zero) as α departs from the value $\pi/2$. At the extreme value $\alpha = 0$, the clearance is zero in all directions. Evidently, also, if $C > 0$ for $\alpha = \pi/2$, it will remain greater than zero for all values of α except $\alpha = 0$.

It may also be seen from Eq. (6) that the values of θ where C has minima remain unchanged though the values of the minima decrease as α departs from $\pi/2$. By rewriting R as

$$R = \frac{g^2 + 2g\sin\alpha + 1}{g^2 - 2g\sin\alpha + 1} \quad (7)$$

it follows that

$$\frac{\partial R}{\partial\theta} = \frac{4\sin\alpha\,(1 - 2g^2)}{(g^2 - 2g\sin\alpha + 1)^2}\,\frac{\partial g}{\partial\theta} \quad (8)$$

The values of θ where C has minima (or maxima) are determined by $\partial C/\partial\theta = 0$; from Eq. (5), (7) and (9) this reduces to $(1 - 2g^2)\partial g/\partial\theta = 0$, which is independent of α.

It is likewise easy to show from Eq. (6) that the positions (but not the values) of minima for C are independent of k_0 provided $\alpha = \pi/2$. This is not true for other values of α. Figure 9 shows the variation of the values of these minima with k_0, for $\alpha = \pi/2$. Figure 10 shows the variation of these same minima with α, for $k_0 = 0.8$ (its normal value).

In considering Fig. 9 and 10, it should be remembered that they refer to the clearance C as defined by Eq. (5). This clearance so defined depends only on the ratio p/p' and these are merely the amplitudes of the resultant radiated sidebands. The modulation factors at the two audio frequencies do not necessarily have this same ratio except for $\alpha = \pi/2$, in which case the sidebands are in the proper phase with respect to the carrier for all values of θ. When $\alpha \neq \pi/2$ this is no longer the case.

For $\alpha = \pi/2$, the radiated carrier and sidebands are

$$\cos qt + m\cos pt\cos qt \quad (9)$$

When $\alpha \neq \pi/2$, the sidebands are no longer in phase with the carrier, so to speak, and the expression may be written

$$\cos(qt + \psi) + m(\theta)\cos pt\cos qt \quad (10)$$

where ψ is the phase shift due to α. It is zero for $\alpha = \pi/2$. Equation (10) reduces to

$$(1 + 2m\cos\psi\cos pt + m^2\cos^2 pt)^{1/2}\cos(qt + \psi)$$

The effective modulation factor is thus

$$m' = (1 + 2m\cos\psi + m^2)^{1/2} - 1 \quad (11)$$

The variation in m' with ψ is slow if ψ is not excessive, and for $\psi = 45$ degrees the effective modulation factor is only 17 percent below maximum. Now the change in ψ is always less than the departure of α from $\pi/2$. This is due to the fact that α affects only the sideband energy radiated by the sideband loops, that radiated by the center pair always being in proper phase. Furthermore, changes in α reduce the effective modulation due to p' as well as that due to p. From these considerations, it follows that variations in α of less than 45 degrees will result in reduced clearance, but the reduction is not generally such as to produce points of zero clearance, or apparent spurious courses.

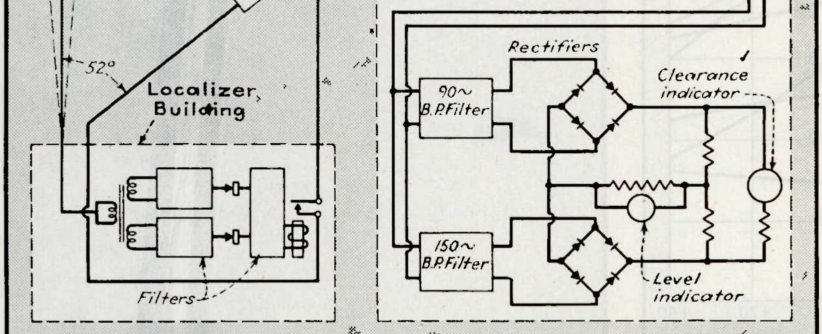


FIG. 12—General arrangement of monitoring equipment with respect to the runway localizer field

Tubeless Probe for VTVM

R-F circuit loading due to the input admittance of the measuring instrument is reduced by employing a cathode follower in the input circuit of a vacuum-tube voltmeter

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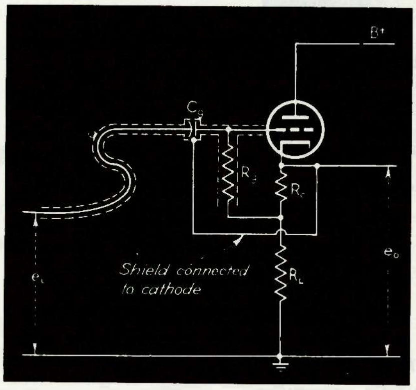
Washington, D. C.

USERS of vacuum-tube voltmeters who have struggled with necessarily bulky vacuum-tube probes in confined spaces will appreciate the value of the arrangement to be described. The circuit is practically as effective as a vacuum-tube probe and has the advantage of permitting the tube to be located some distance away from the circuit under test.

A cathode follower is employed, and is fed through a shielded conductor. The shield is not grounded but is connected directly to the cathode of the tube. The capacitance of the shielded conductor thus is added to the grid-cathode capacitance of the cathode follower, but because of the cathode-follower characteristics this total capacitance does not appear as such at the input terminals. The effective input capacitance at the probe terminals is the total capacitance between grid and cathode multiplied by a reduction factor which by proper design may be 0.01.



Cathode-follower circuit for use in vtvm to eliminate the tube in the test probe

Circuit Theory

The chief characteristics of the cathode follower are low input capacitance, high input resistance, and low output impedance. These are given as $C_i = \alpha C_g$, $R_i = R_g/\alpha$, $Z_o = A/G_m$ where C_g = total effective capacitance between grid and cathode of the tube, R_g = effective grid-cathode resistance, A = gain of the circuit, and $\alpha = 1 - A = \frac{e_i - e_o}{e_i}$, a number less than unity.

An analysis of the circuit will show that the gain

$$A = e_o/e_i = \frac{1}{1 + 1/\mu + 1/G_m Z_L}$$

and the reduction factor $\alpha = 1 - A = 1/\mu + 1/G_m Z_L$ approximately, if μ and $G_m Z_L$ are large. Large values of μ and G_m thus are desirable in order that α may be small.

The output impedance of the cathode follower is its cathode-to-ground impedance, and its value from the equivalent circuit is A/G_m, assuming the source impedance to be small as compared with the actual grid-cathode impedance. This also is the impedance of the shield to ground. The larger the G_m, therefore, the smaller is this value. Although the shield is not directly grounded, its impedance to ground nevertheless will be low. The effective input resistance, at the probe terminals, is the actual grid-cathode resistance multiplied by the reduction factor $1/\alpha$.

Operating Values

A circuit of this type, which the writer has found useful at frequencies up to several hundred kilocycles, employs a type 6SF5 high-mu triode operating under the conditions: $E_p = 100$ v; $I_p = 0.4$ ma; $E_g = -1$v. With circuit constants as follows: $E_b = 200$ v; $C_g = 1000$ $\mu\mu$f; $R_g = 10$ megohms; $R_c = 2500$ ohms; $R_L = 250{,}000$ ohms.

The published values of μ and G_m for these conditions are respectively 100, and 1150 micromhos, giving a value of $\alpha = 0.013$. Hence the two-foot length of 60-$\mu\mu$f-per-foot shielded cable used as an input lead should appear as a shunt capacitance of only $2 \times 60 \times 0.013 = 1.6$ $\mu\mu$f. With total grid-cathode resistance of 5 megohms, the apparent shunt input resistance is $5/0.013 = 380$ megohms.

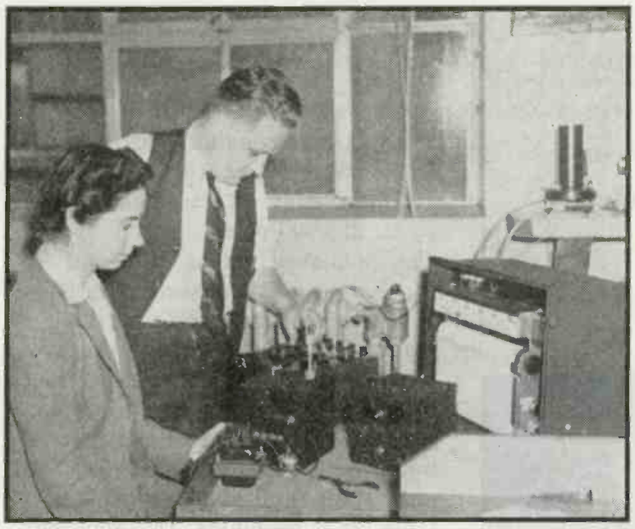
The measured input impedance of this circuit was found to be approximately 5 $\mu\mu$f in parallel with 300 megohms at frequencies from 1 cps to 500,000 cps, the difference between 5 $\mu\mu$f and 1.6 $\mu\mu$f being accounted for as the grid-to-ground capacitance within the tube. The voltage gain is about 0.98.

Limitations

The chief limitation of the high frequency operation of this circuit is the cathode-ground capacitance, since this must be considered as shunting the cathode resistor for the purpose of evaluating Z_L. The high frequency limit evidently may be extended by using a tube having a higher transconductance and requiring a lower value of cathode resistor. The low frequency limit may be extended by increasing the value of C_g.

The cathode-to-ground impedance of the tube appears relatively low even for a source impedance as high as several megohms, and hum pickup is much reduced as compared with an unshielded lead. For low-level measurements, a double-shielded cable may be used, the inner shield being connected to the cathode and the outer one to ground. With the double shield, the cutoff value will be constant and independent of location but it will be lower because of the increased cathode-to-ground capacitance.

A Photoelectric



Calibrating the phototube amplifier

Optical system of sensitive galvanometer operates amplifier which has sufficient output to operate a recording meter. Feedback from amplifier to galvanometer eliminates necessity for damping resistor and reduces galvanometer deflection by mechanical vibration

By GABRIELLE ASSET

Research Engineer
The Brown Instrument Company
Division of Minneapolis-Honeywell
Regulator Co., Philadelphia, Pa.

TO MEASURE voltages as low as one microvolt a phototube amplifier has been developed for use with a sensitive galvanometer and an electronic recorder. The galvanometer deflection acts optically on a twin phototube to produce an unbalance which is amplified so that it is measurable by means of the recorder. A feedback circuit to the galvanometer reduces the effect of vibration. Under good conditions readings on the one-microvolt range can be duplicated within ± 0.75 percent.

As an example of the application of this instrument, in the petroleum and rubber industries infrared radiant energy is used for spectroscopic analysis of hydrocarbons. In the majority of such analytical equipment, transmitted radiation falls upon a thermocouple or thermopile setting up an electromotive force of the order of 10 microvolts or less.

Measuring such a small emf under industrial conditions requires a detecting device which is sensitive yet sturdy. The recorder used with the detecting device should also be sturdy and have a wide, easily read scale which is linear with the thermocouple emf. A sufficiently sensitive detecting device cannot directly operate a reliably sturdy recorder.

Galvanometer and Recorder

The galvanometer with which the amplifier is designed to be used is a Leeds and Northrup type 2500 which has a sensitivity of 0.32 microvolts per mm at one meter, a coil resistance of 11.5 ohms and a period of 5 seconds. Although the critical damping resistance is 52 ohms, none was necessary because of the damping of negative feedback from the amplifier. This galvanometer represents a compromise between sensitivity and ease of adjustment. A more sensitive galvanometer can be used to greater advantage in some instances, employing a larger negative feedback for the microvolt scale for the same galvanometer deflection. However, more time is required for the adjustment of the more sensitive instrument.

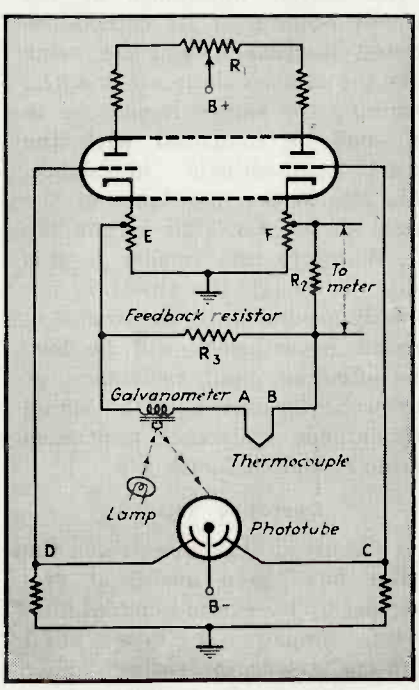


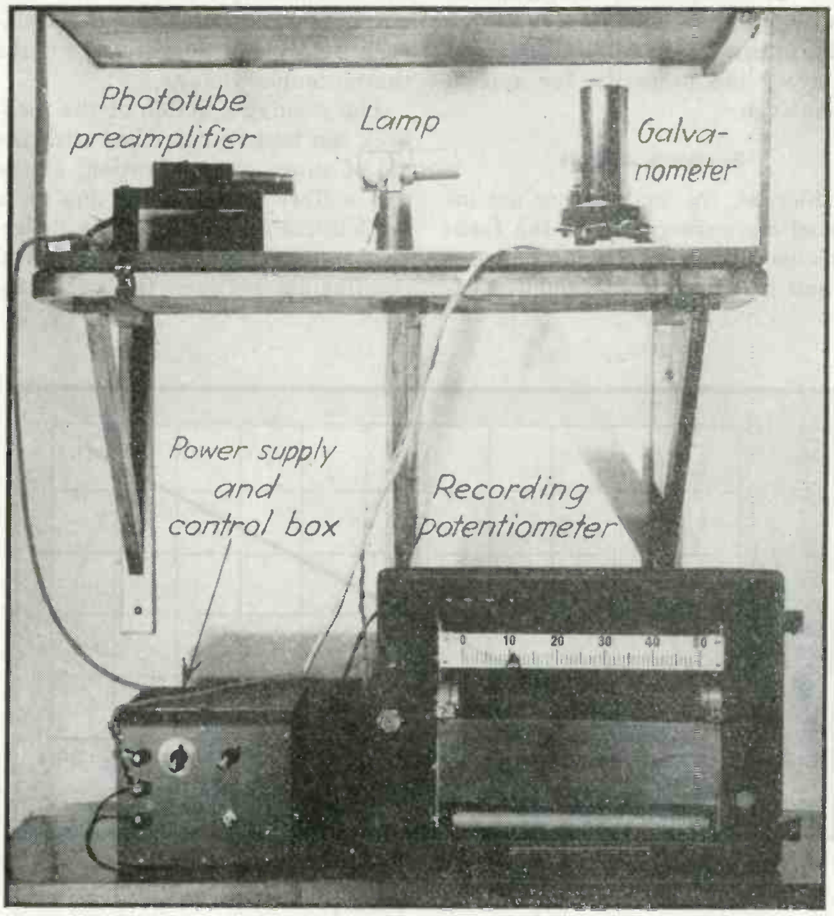
FIG. 1—Basic phototube amplifier circuit

The lamp used with the galvanometer has a straight vertical coiled filament. The beam of light from this filament is focused, by means of a lens in the lamp housing, on the cathodes of the twin phototube of the amplifier, the beam having been first reflected at the mirror of the galvanometer. The two cathodes of the phototube are separated by a space of 1/32 inch. The image of the filament is wide enough to straddle this space and to cover a strip on each cathode about 1/16 inch wide.

The meter used as an indicator of emf is a Brown Electronic strip chart potentiometer recorder, which

Galvanometer Amplifier

has proved to be highly satisfactory for use with the phototube amplifier. No noticeable zero drift exists and its readings are reliable within ±0.25 percent of full scale deflection. The model used has a span of 4 millivolts. The time required for full scale travel of the pointer is 11 seconds, but this can be reduced by changing the gear reduction of the balancing motor.



The phototube amplifier is the connecting link between a sensitive galvanometer and an electronic recorder. The optical system comprising the lamp, galvanometer mirror and phototube of the amplifier is best enclosed to eliminate stray light and temperature variations

Phototube Amplifier

The amplifier is built in two units. A control box contains the control knobs, selector switch, all the resistors in the measuring and amplifier circuits and the power pack.

In the vacuum-tube unit are mounted the triodes of the amplifier and the twin phototube. A projecting light shield prevents scattered light from affecting the phototube. When the system is in operation, the galvanometer, vacuum tube unit and lamp are enclosed in a box to keep the temperature uniform and to reduce further the effects of stray light on the phototube.

The operation of the phototube amplifier is illustrated by Fig. 1, a simplified diagram of the circuit. When there is no emf across the thermocouple terminals AB, the galvanometer coil is undeflected. Light from the lamp strikes the galvanometer mirror and is reflected to the twin phototube. The optical alignment of the lamp, galvanometer and phototube is adjusted so that the same amount of light falls on each cathode of the twin phototube.

The phototube load resistors are equal, and therefore the potential at points C and D are equal. To make points E and F equal in potential the two sections of the duotriode are balanced by R_1.

The measuring circuit is across points E and F. Whenever these two points are at the same potential, no current flows around this loop. The meter, which records the voltage drop across R_2, consequently reads zero.

When the equipment is in use in spectroscopic analysis, radiation falls on the thermocouple, raising its temperature and producing a small emf. This emf causes the galvanometer coil to deflect through a small angle. The resultant deflection of the light beam reflected from the galvanometer mirror then illuminates a greater area of one cathode of the phototube than of the other. The resulting unbalance in potentials at C and D is proportional to the thermocouple emf if the light beam is not deflected beyond that position where its edge just fails to strike one of the cathodes.

This difference in potential results in a like difference in potential at the grids of the duotriode. These changes in grid voltages, being amplified without distortion, produce a difference of potential between E and F which is proportional to the thermocouple emf. The potential difference between E and F is large enough to produce a drop across R_2 sufficient to actuate an electronic potentiometer recorder.

A sensitive galvanometer such as the one used here ordinarily responds to every type of mechanical disturbance unless a vibration-absorbing mounting is provided. In this circuit feedback is used to keep the galvanometer coil steady in spite of mechanical disturbances and changes in line voltage which exist in practically all locations and to avoid the necessity for special mountings.

Feedback Circuit

Thus far, the analysis has not included a consideration of the feedback used. Current flowing between E and F through the small feedback resistor R_3 introduces a small potential drop into the galvanometer circuit. This small potential is so directed that it is opposite to the thermocouple emf at AB. The circuit is so designed that this feedback voltage is 90 percent of the thermocouple voltage.

The steadying action of the feedback can best be described with the aid of an assumed vibration. If the coil suffers a deflection due to a mechanical disturbance, the deflection upsets the optical-electrical equilibrium between the two cathodes of the photoelectric cell. The difference of potential between points C and D is amplified, causing a current to flow through the measuring circuit which includes the feedback resistor R_3. The feedback voltage is of a polarity that opposed the assumed coil deflection and is within 10 percent of the voltage-equivalent of that deflection, and therefore prevents excessive deflection and holds the coil near its null position.

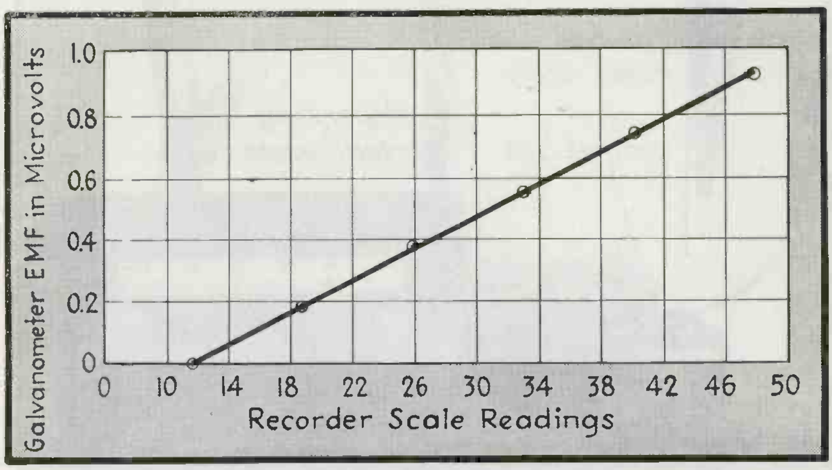


FIG. 3—Comparison of calibration over a period of four days illustrates instrument stability

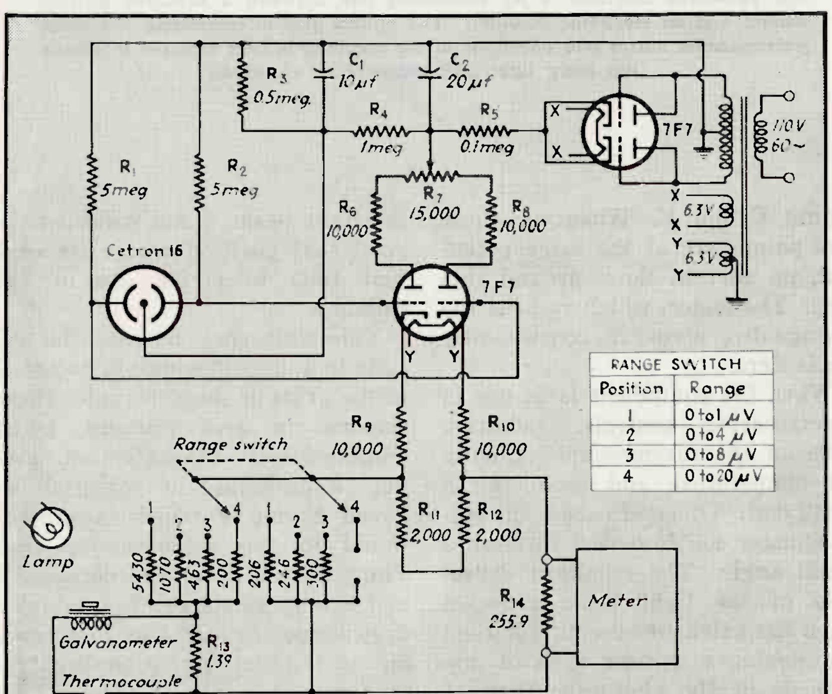


FIG. 2—Complete circuit showing component values for a four-range amplifier

Complete Circuit

In reducing the theoretical design of the phototube amplifier to a practical unit it was necessary to adapt the basic circuit to a multiple range circuit, reduce zero drift to a minimum, obtain maximum sensitivity and to secure constant calibration.

The basic circuit was changed to measure thermocouple emf in 4 ranges: 0-20 microvolts, 0-8 microvolts, 0-4 microvolts and 0-1 microvolt. A schematic wiring diagram, Fig. 2, shows the final circuit. Eight resistors were inserted in the measuring circuit to provide the required ranges. Each range is determined by a pair of resistors, one in series with the feedback resistor, and the other shunting the two in series as shown. The computation of the values of the resistors which determine the ranges was based on the following considerations:

(1) Output voltage regardless of the range is proportional to angular deflection of the galvanometer coil.

(2) The reflected light has just reached the position where it illuminates only one cathode of the phototube when the output meter to be used with this unit has reached full scale.

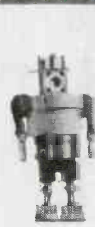
(3) The feedback voltage is at least 90 percent of the thermocouple emf.

Condition 2 means that the photoelectric unbalance is a maximum within its linear limits, and that at this unbalance four millivolts is obtained across R_{14}.

Precautions to Assure Stability

Reduction of zero drift was effected by eliminating as far as possible the sources of stray thermal emf in the measuring and galvanometer circuits. Spurious emf is

More often than not the socket in service is a "CINCH"



IT'S "KNOW HOW"

For reliable Communication all factors must be coordinated. So the CINCH contribution to the electronics program, the radio tube socket is a record of achievement. From the first socket manufactured sixteen years ago to the complete line now in service everywhere . . . a volume of increase that always exceeded the pace of the industry. Such a record signifies "KNOW HOW". As evidence of intensive research and resourceful engineering, CINCH was the first in the field with a complete line of miniature socket assemblies, together with nut straps, shield and associated items.

CINCH *Fasteners ★ Miniature Sockets*
Filler Necks ★ Octal Sockets ★ Lugs
Terminal Strips ★ Metal Stampings

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MANUFACTURING CORPORATION
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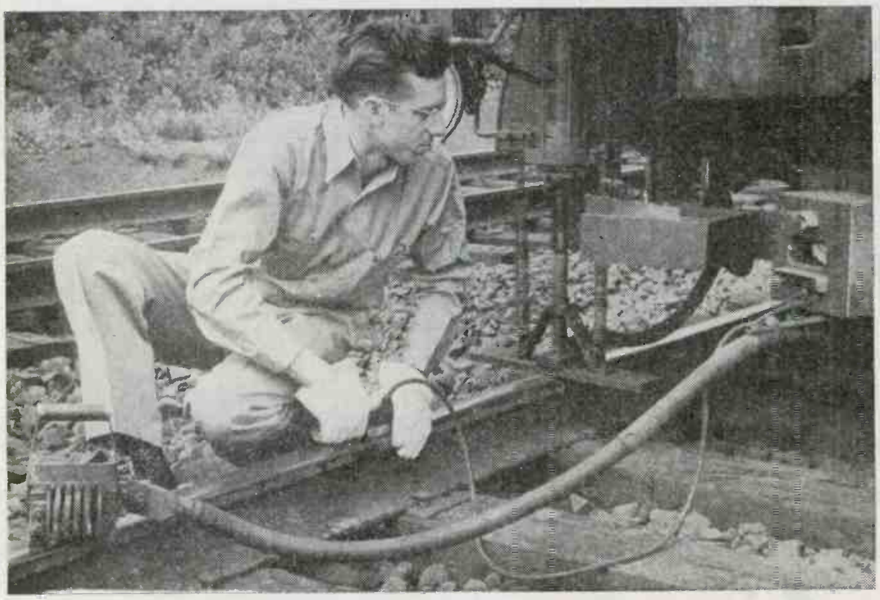
Subsidiary of UNITED-CARR FASTENER CORPORATION, Cambridge, Mass.

INDUSTRIAL CONTROL

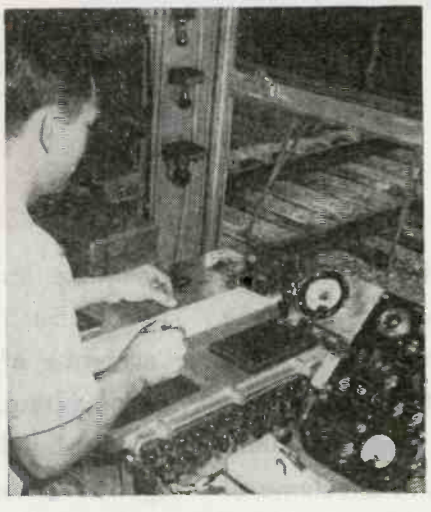
Mobile Testing of Railroad Rails



When a rail is suspected of having a defect, white paint is sprayed from the moving car on the tracks. As shown above, an additional test probe of the electronic equipment is then used to find the exact location

TRACKAGE OF AMERICAN and Canadian railroads is tested with electronic equipment operated by Sperry Rail Service. These rail-fissure detector cars checked about 165,000 miles of rail in 1943 and their findings resulted in replacement of nearly 100,000 defective rails.

In testing, the cars move over the tracks at a speed of from six to nine miles an hour, stopping each time a defect is found. They average about 30 miles in a 12-hour day. The detector cars are self-propelled by gas-electric drive and contain electronic detecting and recording apparatus. As the car moves, an operator checks tape on which a continuous record of the condition of both rails is revealed. The rails are pre-energized, and defects, their extent



Tape in the recording unit of the rail fissure detector is watched by a technician as the special electronically equipped car moves along the railroad tracks

and location, are clearly indicated by distinctive marks caused by breaks in electrical current passing through the rail and picked up by the search unit which is attached to the underside of the car.

A fleet of 17 detector cars works from dawn to dusk on a seven-day schedule. Each car is a self-contained unit carrying a crew of five men, and has complete living facilities, including cook's galley, shower bath and sleeping quarters. They travel from coast to coast, as far north as Hudson Bay, Canada, and as far south as Bakersfield, Calif.

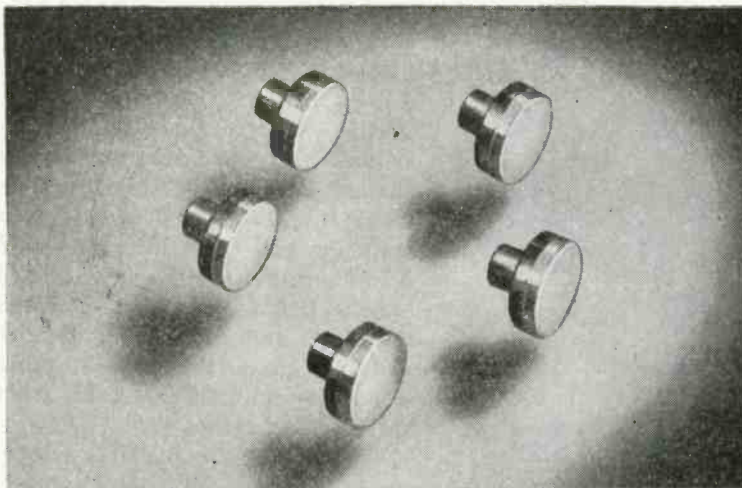
Hopper Control for Ore Crusher

AUTOMATIC CONTROL of ore crushers, to keep the machines operating continually at the peak load corresponding to maximum efficiency, is being done in the mining industry by two distinctly different types of electronic control units. In one installation, a microphone is positioned alongside the crusher, and connected to an amplifier and relay combination that controls the conveyor feeding ore into the machine. When the noise level drops to a point indicating that the crusher is running almost empty, the electronic ear detects the condition and calls for ore to be fed into the hopper.

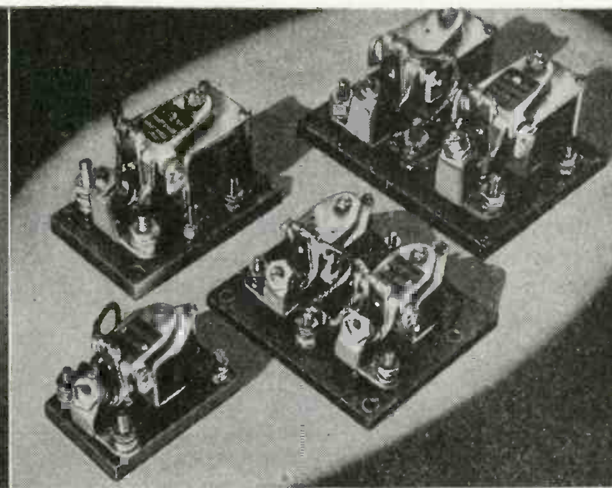
A second company uses a phototube arrangement to monitor the amount of electric power drawn by the electric motor which drives the crusher. This power consumption is high when the crusher is fully loaded, and drops as the machine empties. A light source and phototube are mounted over a wattmeter in such a way that the meter pointer interrupts the light beam when the power drops. The phototube feeds an amplifier-relay combination controlling the ore feed mechanism.

Temperature Control in Aircraft

ELECTRONIC ANTICIPATION of temperature requirements by automatic electronic cabin temperature control system has been in test service on several airlines and combat use on Army transport ships for some time. The complete sys-



Mallory Elkonite G-13 Contacts.



"Nut cracker" relays—photograph courtesy Struthers-Dunn Inc.

Small . . . But They Carry High Inrush Loads . . .

MALLORY ELECTRICAL CONTACTS

ELECTRICAL contacts for these "nut cracker" relays must be *small*—space is at a premium. They must be *tough*—to stand shock and vibration. Contacts must be *electrically rugged*—to carry as much as 1000 amperes inrush current at 24 volts DC.

Mallory metallurgists and contact engineers have helped the relay manufacturer to find exactly the right contact material to meet these rigorous requirements. Elkonite* G-13, developed by Mallory, efficiently carries the high current load with no welding or arcing.

Its toughness meets physical "specs" not only for impact strength but also for wear resistance—assuring long life.

Elkonite compound metals may be the answer if you're seeking materials for contacts or contact assemblies with unusual electrical and physical properties. With Elkonite G-13 and the related G-12 and G-14 materials, there is a sufficient range of properties to cover applications from relatively low current switches and relays up to heavy-duty circuit breakers.

Consult experienced Mallory engineers on your contact and contact assembly problems. Often they can suggest complete assemblies that simplify your designs, save you fabricating time, and assure a more efficient product.

TYPICAL PHYSICAL PROPERTIES OF ELKONITE G-13

Grams per cc.	12.3
Lbs. per cu. in.	0.45
Conductivity % I.A.C.S.	55-60
Rockwell Hardness	70-80B
Tensile Strength psi	40,000
Cross Breaking Strength psi	115,000

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

**Elkonite: trademark registered by P. R. Mallory & Co., Inc., for electric contacting elements.*

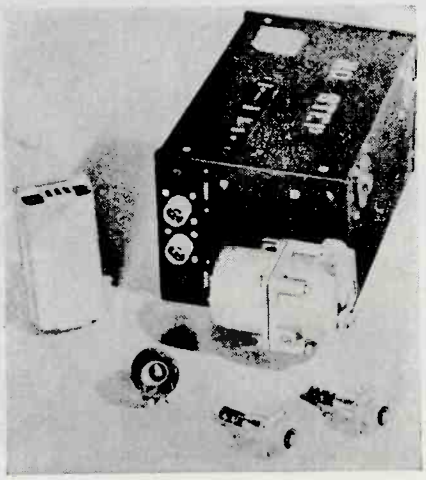
ELECTRICAL CONTACTS AND CONTACT ASSEMBLIES

tem is shown in the drawing as developed by Minneapolis-Honeywell Regulator Company for the C-54.

Numbers (1) and (5) in the drawing are safety switches and valves which automatically cut off the flow of gasoline to the heaters if the fuel line breaks. At (2) is an air ram switch which automatically guards against operation of the heaters until sufficient forward speed is obtained to drive enough air over the heaters for adequate combustion. Numbers (3) and (8) are outside air compensators which actually turn the aircraft heaters on before a need for heat is detected within the cabin. At (4) is a control switch, installed in the cockpit, which selects the temperatures desired. Number (6) is an amplifier, which can be installed anywhere in the plane, and (7) is a cabinstat, installed in the space to be heated.

The new control system is a package unit weighing slightly under eight pounds, and is designed to hold automatically any cabin temperature selected by the pilot. To passengers, this means comfortable conditions under all kinds of flying weather, and to pilots and stewards it means an end to passenger complaints and the nuisance of constantly making adjustments of manual controls.

The new control system is connected to the master control switch in the cockpit and is automatically turned on when the pilot starts the engines. Unless heat is required immediately, the heating system remains inoperative until outside temperatures fall to a point requiring the addition of heat for passenger comfort. At this point, the heating system starts delivering heat to the cabin in the exact amounts needed to maintain the pre-selected temperature — usually 70 degrees.

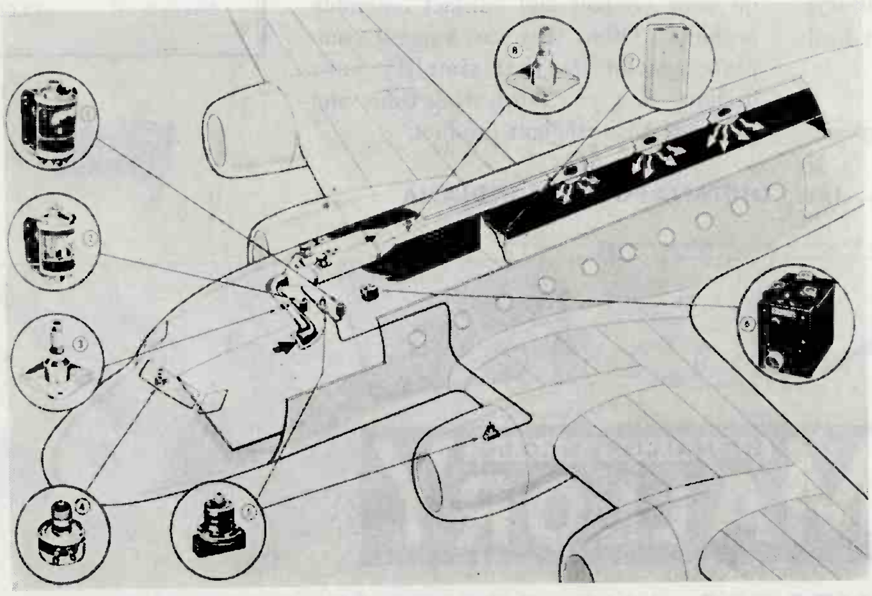


Units of the temperature control system. The electronic amplifier and infinite position motor which connects to the dampers of the plane's heaters are in the large cabinet. At left is the cabinstat, and at lower right are the outside air compensators which sense temperature changes and signal the amplifier that controls the motor delivering heat into the cabin

The system includes an outside air compensator, which is a small coil of wire installed in the duct bringing outside air into the plane's heaters. Temperature fluctuations change the electrical resistance of the wire and this change is measured through electronic tubes. When the tubes learn from the coil that the outside air is colder or warmer, as the case may be, they actuate a motor which opens or closes a mixing damper and thus proportions the amounts of outside air with heated air from the plane's heaters.

The system also includes a thermostat in the cabin which interprets temperatures and notifies the tubes which, getting signals from both coils, position the mixing damper to maintain the selected inside temperature. The latter is determined by a small dial mounted in the cockpit.

If a plane takes off while ground temperatures are at 70 degrees, no cabin heat is required, but as it climbs, outside temperatures usually drop. The outside compensator notices this drop immediately and tells the tubes which, in turn, start delivery of heat to the cabin. Passengers are not conscious of the outside change, however, because of the reservoir of heat in the cabin. Before this heat is lost to the outside, making the passengers uncomfortable, heat comes into the cabin in the exact proportion needed to maintain a constant and comfortable temperature. The reverse is true when the plane moves into warmer temperatures, because while the inside cabinstat calls for heat, the outside coil knows that less heat will be required and so less heat is delivered.



Illustrating the location of units of the Minneapolis-Honeywell electronic cabin temperature control system for planes, as installed on a C-54

Smoke Density Indicator and Recorder for Industrial Plants

Old time factory men responsible for control of kilns, boilers and other industrial furnaces watched the stack to get efficient results. Nowadays, the same old rule still applies but with electronic equipment doing the watching and providing continuous monitoring of the product of combustion.

The figure shows a wiring diagram of a smoke-density indicator and recorder made by Brooke En-

GRADE 1 — CLASS 1 RESISTORS

Exhaustively tested for dependable performance and sound construction, IRC's Type GRW *GRADE 1—CLASS 1 RESISTORS* are now available. Only after every requirement of Army-Navy specification Jan-R-26 had been met or surpassed would our Engineering Department approve this product for the applications for which it is designed.

Resistant to salt water immersion following thermal shock, they are capable of continuous efficient operation at a total temperature of 275° C. (ambient plus rise).

Made in 7 standard sizes with power ratings from 15 to 140 watts and resistance ranges of from 0.1 to 46000 ohms, the GRW's are enclosed in special heat-treated glass for optimum strength. Non-corrosive ferrules are hermetically sealed to the tube with pure lead. Nickel alloy leads pass through the centering devices and are welded to the outer ferrule cups. All resistors are *space wound.*

These IRC GRADE 1—CLASS 1's are engineered to "take it" far beyond normal requirements and can stand transverse loads as high as 100 pounds without failure or damage of any kind.

PREFERRED FOR PERFORMANCE * IRC * FIXED & VARIABLE RESISTORS

Write today for special Engineering Bulletin containing dimension drawings, temperature rise and de-rating curves as well as other technical data.

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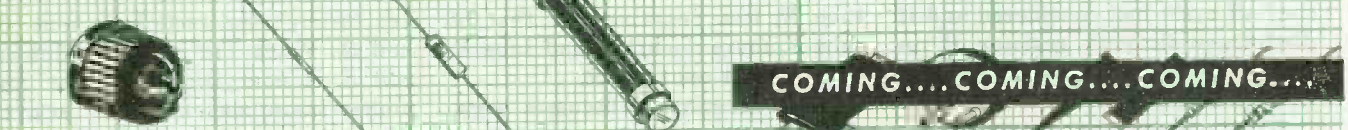
Dept. 1-B

401 NORTH BROAD STREET, PHILADELPHIA 8, PA.

IRC makes more types of resistance units, in more shapes, for more applications than any other manufacturer in the world.



gineering Co. of Philadelphia. In this equipment, the eye box is installed at the point of observation in the stack and contains a double diode tube E, a double triode E_1 and a phototube P. In the control panel unit there are two thyratron tubes E_2 and E_3, a double diode E_4, and two signal lights, a red one R and an amber one A.

Control of the equipment centers in two switches, one for the light source and one for the electric eye. Assume both the light and the eye switches closed. Transformer T_1 supplies about 5 amp at 6-v to the lamp for the light beam across the gas stream to the phototube. Resistor R_1 permits adjusting the light beam to suit the gas density where the equipment is installed.

Operation

A tap taken between resistors R_4 and R_5 puts a negative potential on grid G_1 of tube E_1. With normal conditions in the stack, potentials on grids G and G_1 are equal. Tube E also charges capacitors C and C_1 to the polarity shown.

Assume that polarity of the line reverses to that indicated. With this line polarity, rectifying tube E becomes inactive because its anodes are now negative. However, capacitors C and C_1 were charged on the previous half cycle. Capacitor C discharges through tube P and resistor R_2 to maintain grid G negative. Capacitor C_1 discharges through resistors R_4 and R_6 to maintain a negative potential on grid G_1 of tube E_1.

A voltage drop across resistor R_7 puts a negative potential on grid G_2 of tube E_2, through part of resistor R_8 and resistor R_{10} and also through the left-hand half of T_3 transformer secondary, resistors R_{11} and R_{10}. A negative potential is applied in the same way to tube E_4 through a similar circuit. Tubes E_2 and E_3 are inactive during this half of the cycle because their anodes are made negative through lamps R and A. For the same reason, tube E_4 is inactive during the next half of the cycle, but capacitor C_2 was charged on the half cycle just considered and it discharges through resistor R_8 to maintain the grids of tubes E_2 and E_3 negative.

With normal gas conditions in the stack, the pointer of the indicating-meter M takes a vertical position. Currents flowing in the two halves of transformer T_3 are in opposite directions and when these currents are equal, as with normal gas conditions, they neutralize each other so that they do not produce a flux to energize the secondary winding. Under these conditions, tube E_4 impresses a negative potential on the grids of tubes E_2 and E_3 of a value that just prevents them firing.

Heavy Smoke

Assume that the stack gases darken, then less light will reach photoelectric tube P and less current will pass through resistor R_2, causing a reduction in negative potential on grid G. This lets more current flow to the left-hand anode than to the right-hand one, which in turn permits more current to flow in the right-hand side of transformer T_3 primary than in its left-hand side. As a result, a voltage is induced in the secondary of this transformer that makes the grid of tube E_2 less negative and that of tube E_4 more negative, and tube E_2 fires to light red lamp R.

When terminal G becomes negative, more current also flows through indicator M to deflect its needle to the left of midposition and show the amount stack gases have darkened.

If the stack gases become more clear than normal, showing the presence of too much excess air, then current flow through the phototube increases. This increases the potential on grid G and reduces current flow through the right-hand part of transformer T_3 primary. This permits the left-hand end of the primary to establish the secondary potential which is opposite to that for gas more dense than normal. Now the grid of tube E_4 is made less negative and it fires to light amber lamp, A. Less current also flows through meter M and its pointer swings proportionally to the right to show the amount the stack gas is under color.

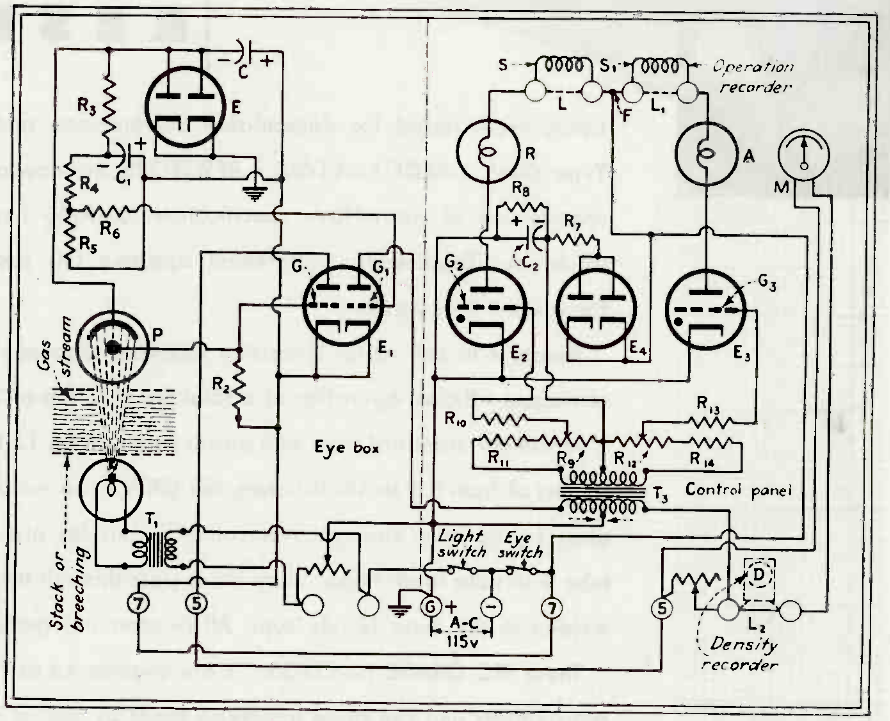
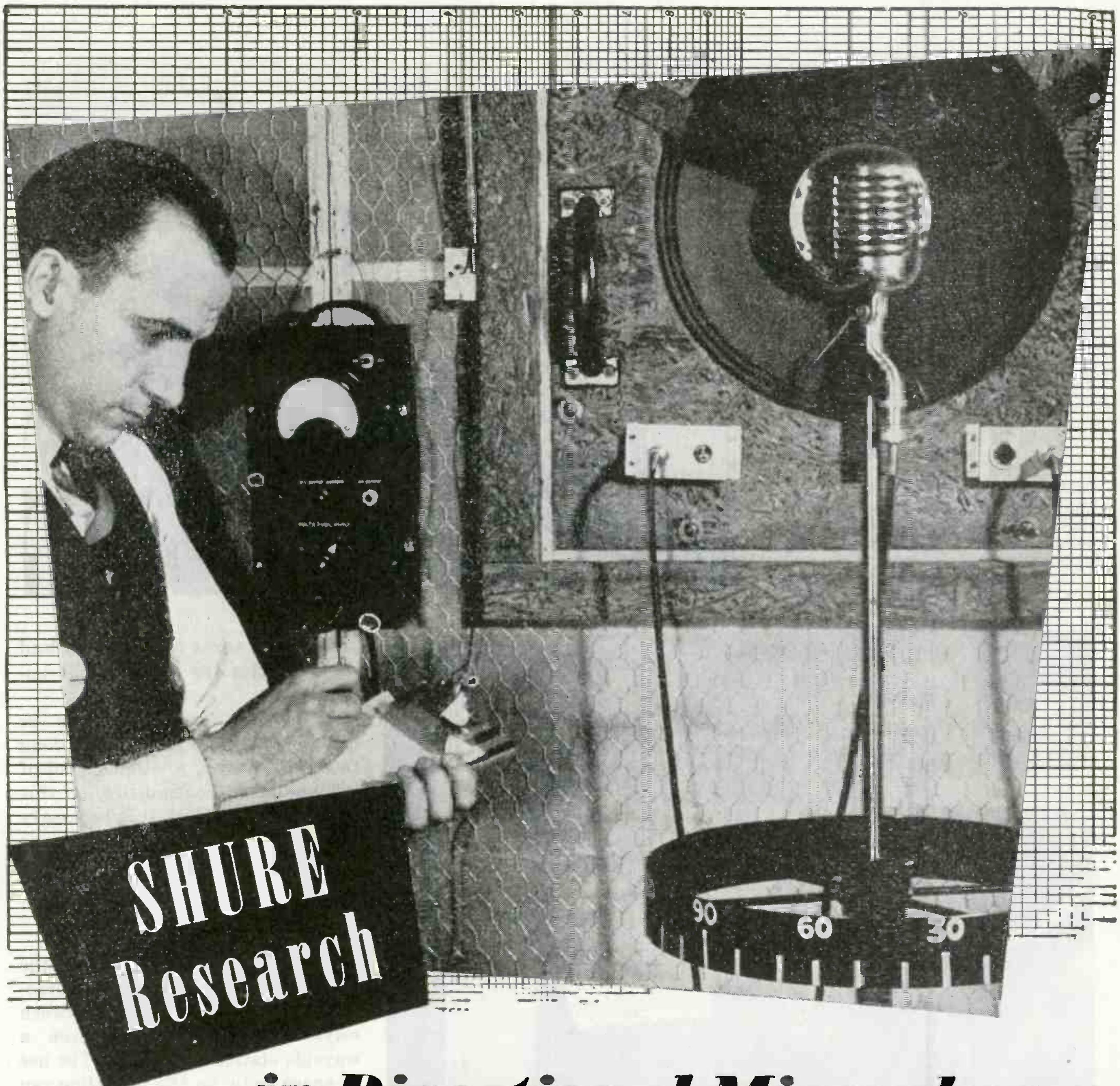


FIG. 1—Complete electronic circuit of a smoke density indicator. Recording equipment may be used with the unit to show the length of time the smoke is off-color or the density of the gases

Recording

Either one of two recorders may be used. When an operation recorder is used, links L and L_1 are removed, and then the lamp circuits are through the recorder's coils, S and S_1. When the red lamp lights, coil S is energized. Lighting the amber lamp makes coil S_1 active. This recorder shows only that the stack gas is off color and for how


SHURE
Research
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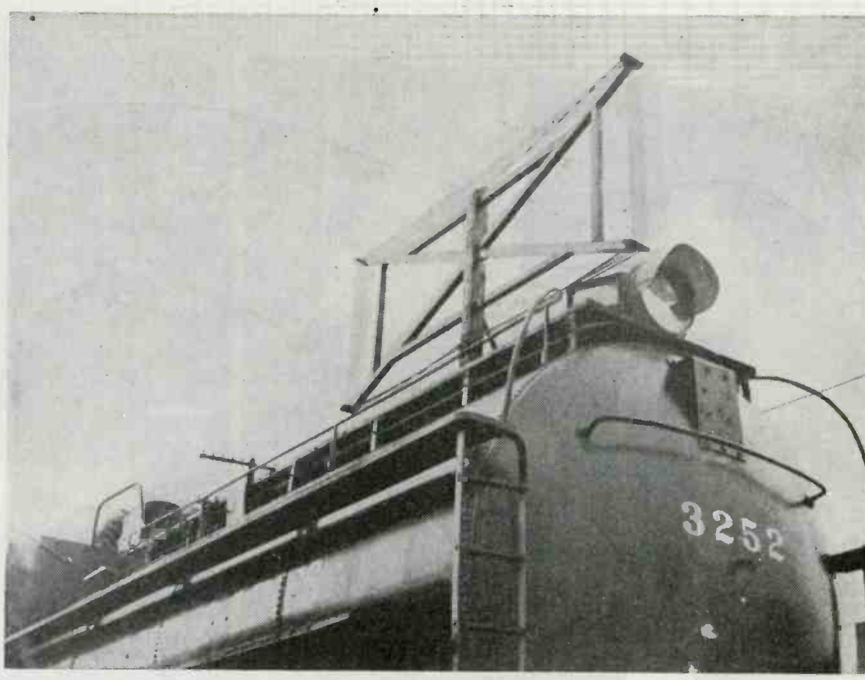
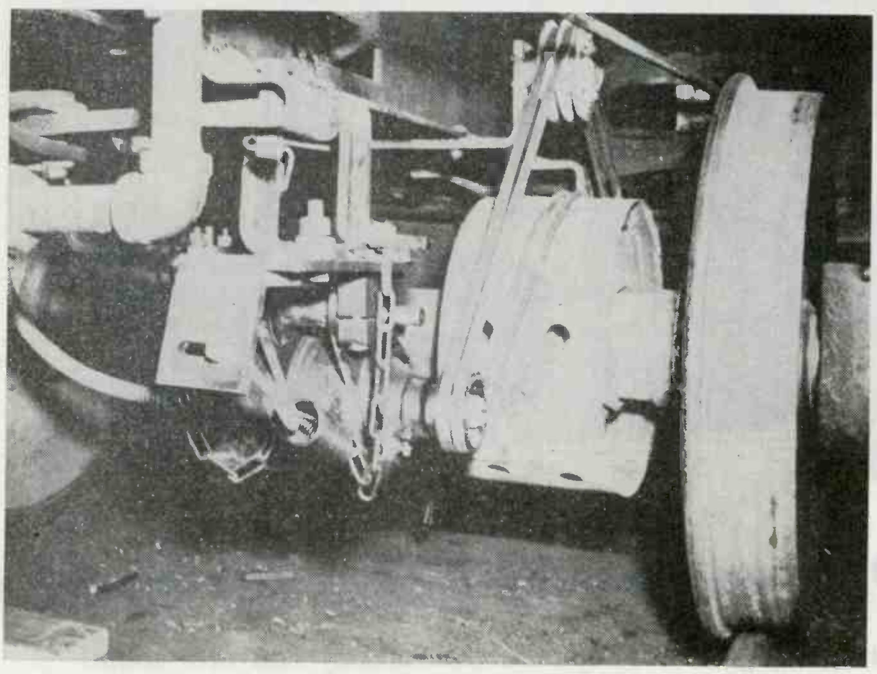
long it is off color, but does not record the density of the gas. To use a density recorder, D, remove link L_2 to put D and M in series. D records the amount the stack gas is off color and in what direction, that is, it records the amount needle of meter M is deflected, and the direction of its movement.

RIGHT—The loop antenna for induction to the wayside wires is mounted on the locomotive



BELOW—Power for the electronic equipment used by Aireon in caboose installations is supplied by a 24-volt battery. Charging is accomplished by a generator belt-driven from the caboose wheel



Carrier Current versus Space Radio for Railroads

As a result of a survey of electronic equipment used by various railroads, engineers of Aireon Manufacturing Company have found that the induction type of carrier current communication may not always be applicable for all aspects of railroad radio. The sole limitation, when one exists, is in the head to rear end circuit. This is due to the fact that two magnetic coupling links are involved, i.e., rear end to wayside wires and wayside wires to head end. A loss factor of about 20 db is involved in each of these magnetic jumps.

Failure of the head to rear end circuit to operate at full efficiency is due to one of the following reasons:

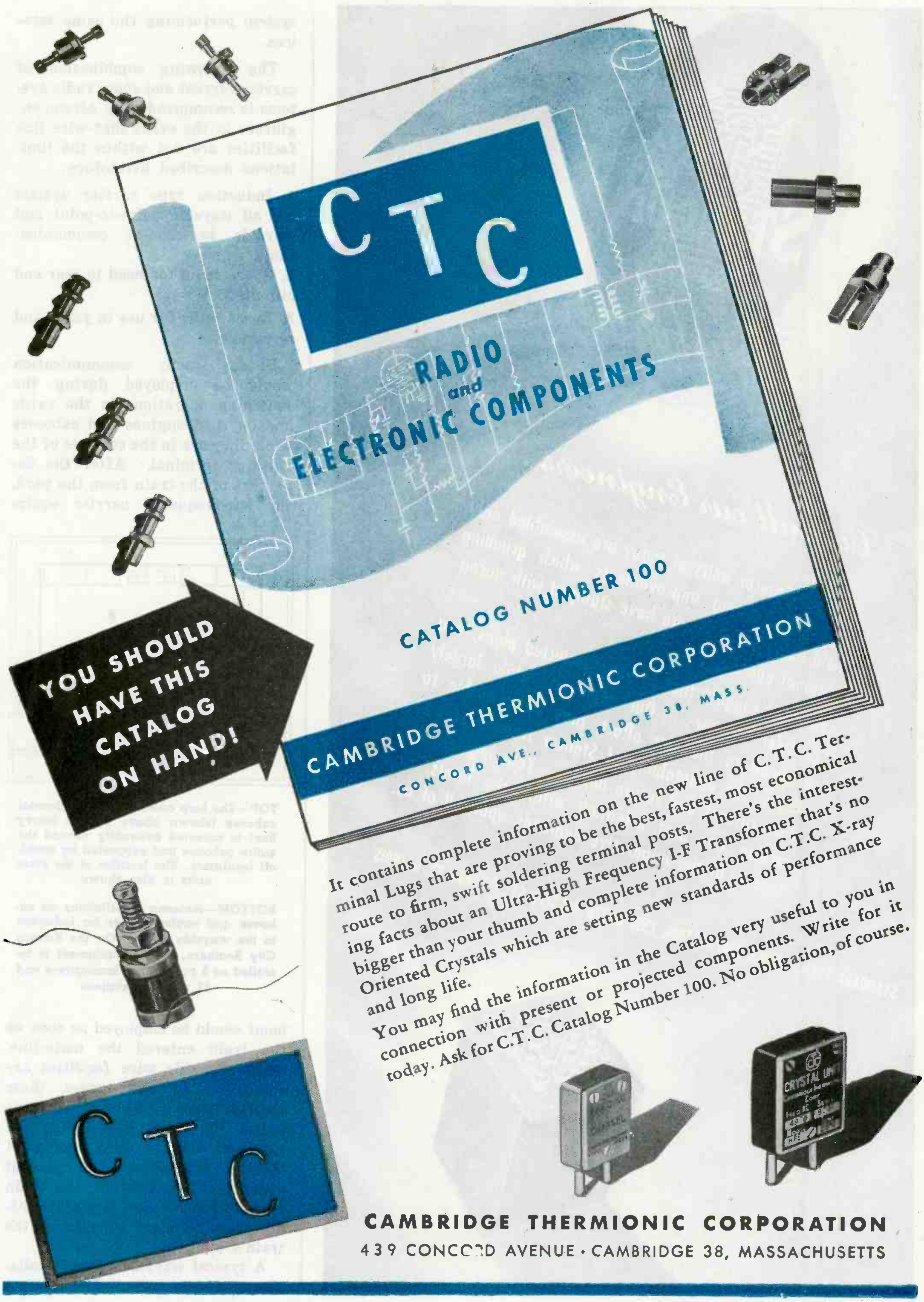
1. The non-existence of wayside wires, and inability to provide such facilities due to physical limitations.
2. Spacing between wayside wires and track too great for practical induction communication, i.e., spacing in excess of 200 feet.
3. Wayside wires contained in lead sheath cables for considerable distances.

In general, corrections can be made by adding a single wire along the right-of-way, to augment all of the possible discontinuities. If this is found impractical, it is necessary to consider the use of 100 percent space radio or a combination of induction type and radio.

Use for Each

It is generally agreed that the induction system is the most practical for communication between wayside stations and between a wayside station and train. The use of space radio on the main-line can be confined to end-to-end communication, except the possibility of using space radio for wayside contacts about certain sections of track where wire facilities are not suitable. The only possible alternative to the induction system for wayside operation is a vhf relay link. This has serious disadvantages, as follows:

1. The frequencies which will probably be allotted to this service are so high as to require relatively new engineering approaches.
2. Because of the line of sight limitation of transmission range, expensive towers, power lines, etc., will be required.
3. The cost per mile is many times in excess of the cost of an induction



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You may find the information in the Catalog very useful to you in connection with present or projected components. Write for it today. Ask for C.T.C. Catalog Number 100. No obligation, of course.
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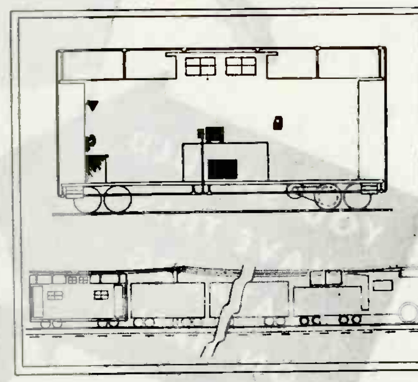
system performing the same services.

The following combination of carrier current and space radio systems is recommended by Aireon engineers in the event that wire line facilities are not within the limitations described heretofore:

1. Induction type carrier system for all wayside point-to-point and wayside to caboose communications.
2. Space radio for head to rear end circuits.
3. Space radio for use in yards and terminals.

Space radio communication would be employed during the switching operations in the yards and on road engines and cabooses while they are in the confines of the yard or terminal. After the departure of the train from the yard, the low-frequency carrier equip-



TOP—The loop antenna for an all-metal caboose (shown above by the heavy line) is mounted externally around the entire caboose and supported by stand-off insulators. The location of the other units is also shown

BOTTOM—Antenna installations on caboose and engine tender for induction to the wayside wires. On the Kansas City Southern, Aireon equipment is installed on 5 cabooses, 5 locomotives and 22 wayside stations

ment would be employed as soon as the train entered the main-line, where wayside wire facilities are available. In most cases, these wayside wires would be at trackside before the train was out of the range of the vhf yard equipment thereby permitting 100 percent communication between the train crew with some yard or wayside office from terminal to train of the train's run.

A typical wayside office installation of Aireon induction equipment

The attractive Ls housing of the Recordagage leaves all parts of the complex instrument readily accessible.

Beauty THAT'S MORE THAN SKIN DEEP

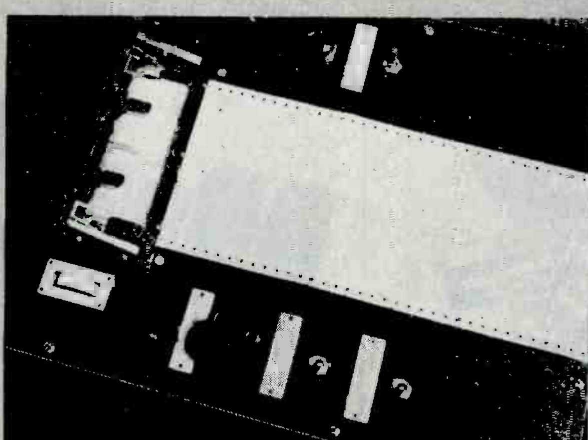
Electronically operated Recordagage is supported, protected, and attractively housed by its sturdy Ls cabinet

The Physicists Research Company, builders of the electronic displacement charting device called the Recordagage, chose Lindsay Structure for the housing for other advantages as well as for its attractiveness.

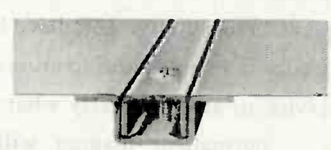
Equipment housed in sturdy Lindsay Structure is protected against dirt, moisture, and mechanical damage. The die-formed parts for Ls fit snugly together; Ls units, utilizing the principle of uniform tensioning, are rigid and vibration-proof.

The unique high strength-weight ratio of Lindsay Structure saves space and weight in any of its thousands of applications. No heavy, bulky diagonals, gussets, or struts are necessary. Quickly and easily assembled, this modern method of light metal construction requires no retooling, trimming, fitting, welding, or riveting for its erection.

Investigate the advantages of Ls when applied to your product. Write to **Lindsay and Lindsay, 222-D W. Adams St., Chicago 6, Ill.; to 60 E. 42nd St., New York 17, N. Y.; or to Lindsay Structure (Canada) Ltd., Dominion Square Bldg., Montreal.**



Top panel of the Recordagage. Panel is of black bakelite and is mounted directly to the Ls.



Easy to assemble

Ls

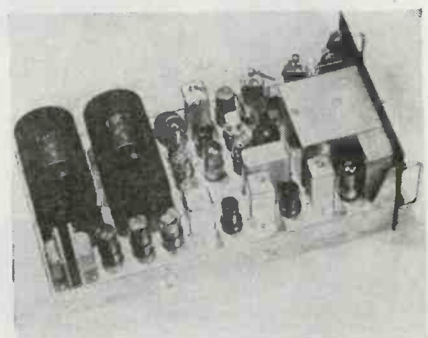
LINDSAY STRUCTURE

U. S. Patents 2017629, 2263510, 2263511
U. S. and Foreign Patents and Patents Pending

consists of a frequency-modulation transmitter and receiver combination designed to operate in the low-frequency portion of the spectrum (approximately 70 to 200 kc). The transmitter section comprises a stabilized oscillator, an audio amplifier and reactance tube, and a class-C power amplifier, whose output power may be coupled between one of the wayside telephone wires (and ground)—or between two wayside wires and ground in simplex fashion, through appropriate tuned filters. The power output of the transmitter as delivered to an average simplex line circuit is adjustable in six steps from approximately 0.1 to 5.0 watts. This adjustable feature provides a means of setting the power output to conform to a particular local circuit requirement.

Receiver

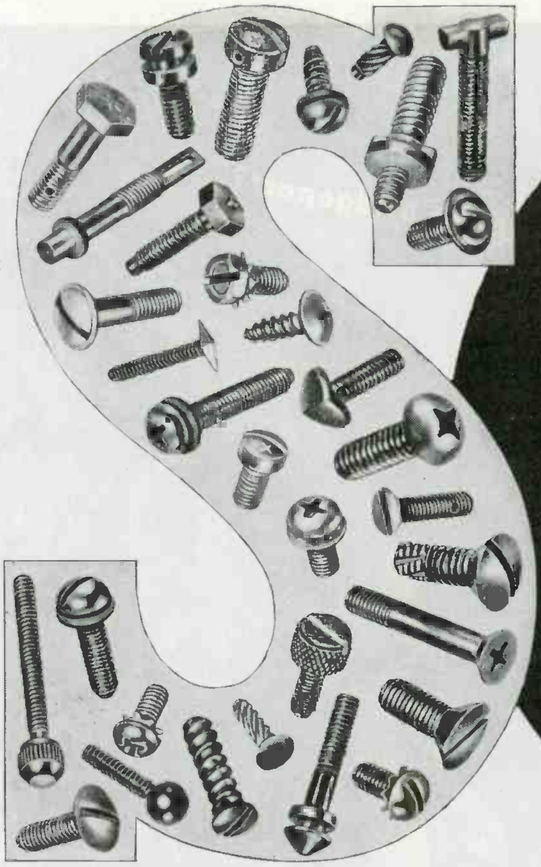
The f-m receiver contains two pretuned r-f amplifiers, a limiter and discriminator circuit, and an audio amplifier. To minimize interference from noise, special circuits have been incorporated to provide automatic noise squelch action without manual adjustment. This



Complete chassis, including dynamotors, of the f-m transmitter and receiver designed for operation on frequencies between 70 and 200 kc

squelch circuit provides practically complete noise-free reception for all anticipated values of received signal to noise ratio. Either the receiver or transmitter is in operation at one time, but not both. However, no common operating components or tubes are employed in the transmitter or receiver.

To facilitate remote control operation of the equipment (as for example, control over a considerable distance by means of a dispatcher's telephone circuit), a



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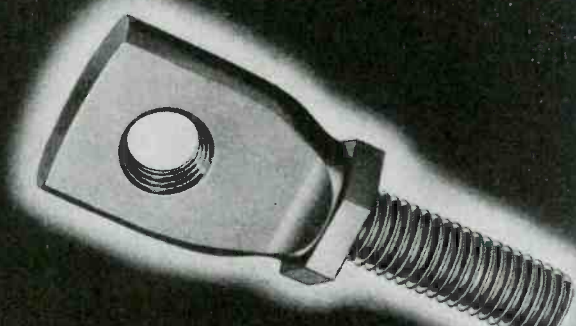

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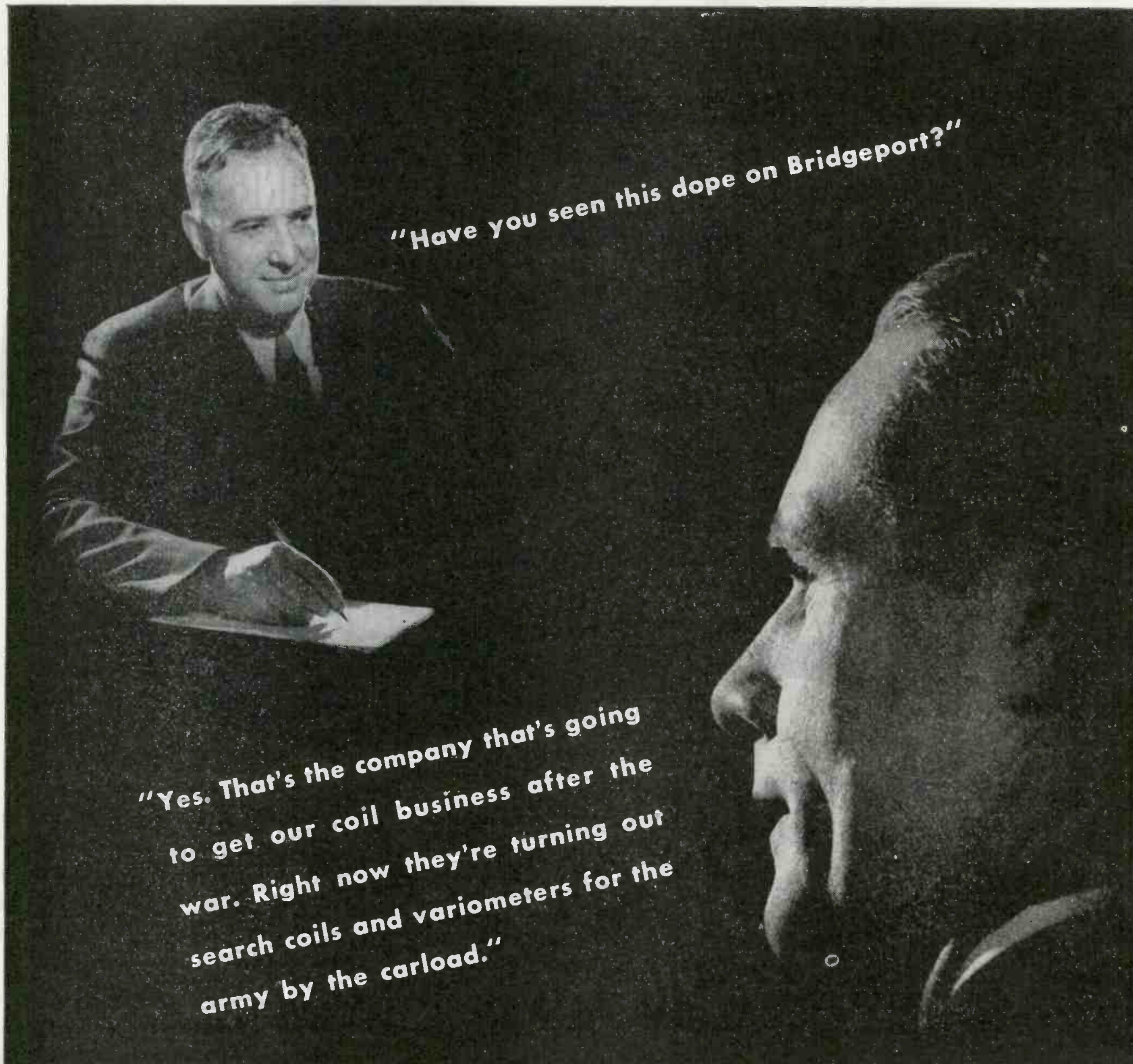

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Bridgeport's central location, right near the center of population, gives you fast, trunk line service to any point in America. Write to us TODAY to insure early postwar delivery of R. F. coils and chokes, I. F. transformers and transmitting coils and chokes.

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Transmitting Coils • Transmitting Chokes

voice-operated "vodas" is provided. This requires that the receiver and transmitter be interlocked electronically to permit operation on a talk-to-talk basis. No relays or mechanical switching devices are employed, all switching being done electronically.

Mobile Equipment

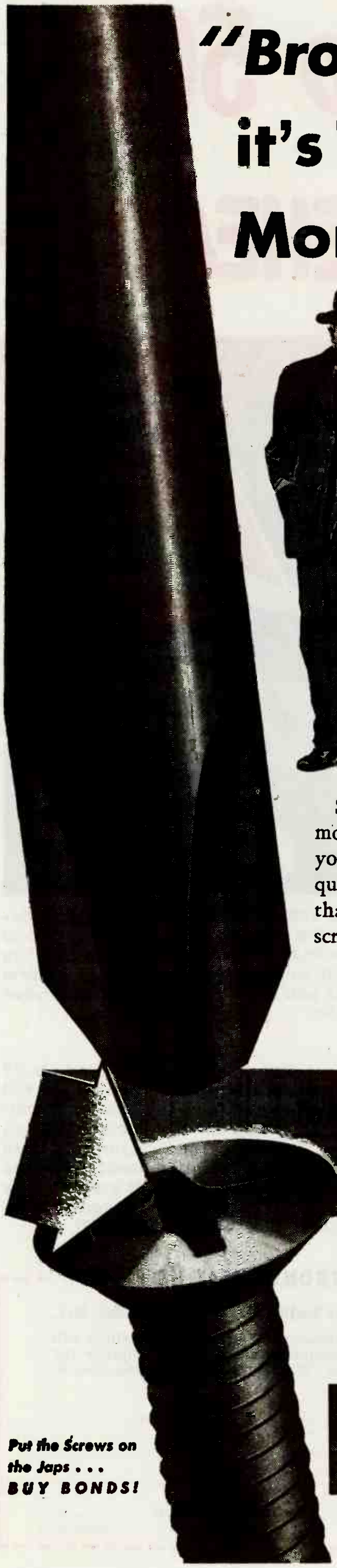
The equipment for use in either caboose or locomotive operates from a 24-volt d-c source, and requires 400 watts for periods of transmission, and 100 watts standby power for continuous operation of the receiver. The receiver circuit is similar to that in the wayside station.

The transmitter section employs a stabilized oscillator, an audio amplifier and reactance tube, and a class-C amplifier output stage which feeds 50 watts of carrier power to the loop antenna. The mobile equipment operates on a push-to-talk basis. While the handset is on the hook switch, all calls are received on the loudspeaker. During conversations, the earphone of the handset operates.

For locomotive installations, the unit is mounted either in the cab or in a weather-proof box on the deck of the tender. If mounted on the tender, it is remotely controlled from the cab. The remote control unit contains the hook switch for holding the handset, the audio volume control and the signal indicating lights, and is designed for mounting either in the locomotive or in the caboose.

Pickup Loop

In general, the loop antenna for the caboose varies with the type of car on which the equipment is to be used. For a wooden caboose with canvas roof, the loop can be installed inside the car. Such a loop, as operated at 175-kc carrier frequency, consists of 4 turns of wire wound in a vertical plane with dimensions equal to the inside height and length of the car. For cabooses employing wooden construction with steel reinforcing beams and a metal roof (or for all-steel cabooses), the loop antenna is installed externally and consists of approximately 4 turns of wire wound in a vertical plane completely surrounding the car and supported on top and bottom of the



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Workers on screw assemblies feel as though they had been freed from a chain gang, when their production chiefs liberate them from slow, exhausting, ***high-cost*** slotted screw driving . . . up to speedy, easy, *low-cost* American Phillips Screws and 4-winged Phillips power drivers.

For then they find that they can make their jobs amount to something . . . that it's actually far easier to do better work and more of it . . . yet still end their shifts without undue fatigue. Simply because American Phillips Screws drive automatically straight—and because the 4-winged driver can't jump out of the recess.

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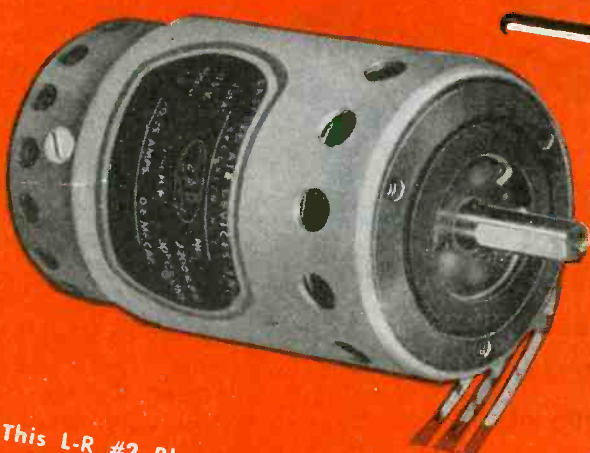

115 VOLT 400 CYCLE BLOWER

This L-R #2 Blower, powered with our J31A $\frac{1}{100}$ H.P. single phase Capacitor motor measures $4\frac{7}{32}$" overall length, $3\frac{3}{4}$" overall blower diameter, $1\frac{15}{16}$" overall motor diameter and weighs $19\frac{1}{2}$ ozs. Running at 7200 R.P.M., it circulates 22 cu. ft. per min. continuously. It is designed for use in ambient temperatures up to 80° C. Production facilities enable us to offer prompt deliveries on this equipment, which is outstanding in efficiency and air delivery for its small size and light weight.

NOTE: Type J31A and J49 motors are available for use in other applications. Write for information and performance data.

115 VOLT—60 CYCLE BLOWER

For same application as above but for operation on 60 cycles supplied at 3300 R.P.M. L-R No. 2 Blower, powered with our J49 capacitor motor, circulates 10 cu. ft. per min., continuous duty, with 9 watts input to motor.

J49 Dimensions:
Overall Length......$2\frac{1}{8}$"
Overall Diameter....$1\frac{3}{4}$"
Weight..........16 ozs.

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car by suitable masts or brackets. In the case of locomotives, the loop antenna varies with the engine model. Most suitable positions are on the deck of the tender or in front of the smoke-box.

Optimum Performance

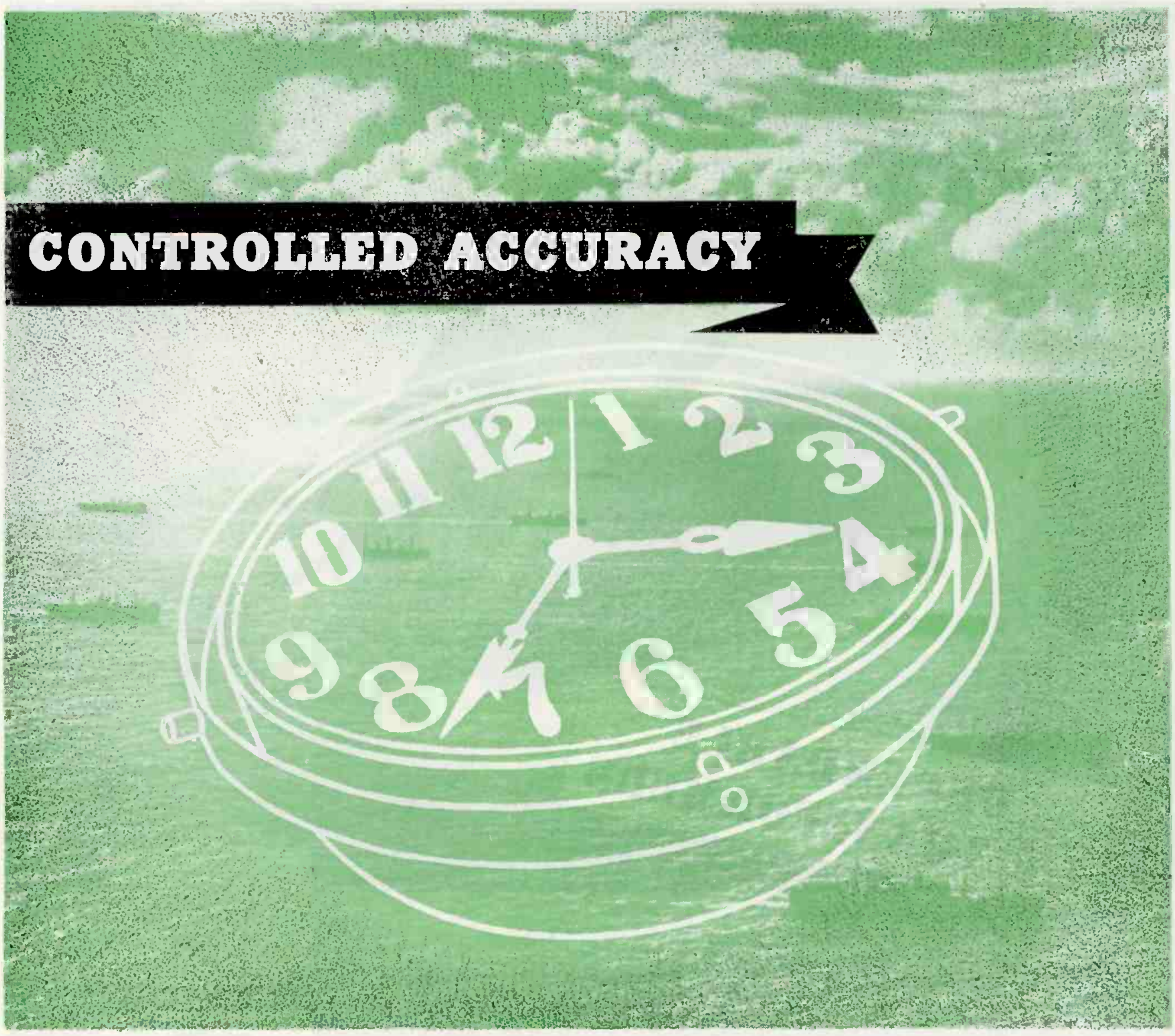
The only important limiting factor to the complete successful operation of this system is the distance between the track and the wayside wires. For frequencies between 150-200 kc. the equipment performs satisfactorily when the track to wayside wire separation does not exceed 150 feet as measured horizontally. Operating conditions are retained for this horizontal distance and for road conditions wherein the wayside wires are not more than 75 feet above or below the track level. Up to 100 percent in excess of these figures, the system will still perform creditably with satisfactory signal-to-noise ratio in the receiver. No modifications of wayside wires are required except in certain rare instances where telephone drops may have to be isolated for that particular carrier frequency. This is accomplished by insertion of a tuned circuit at a junction point.

Where no wayside wires are sufficiently close, a simple single wire line can be mounted on fence posts or on light construction poles for transmission of the carrier frequency. Although the carrier-frequency signal may be applied by the wayside station to only one pair of a number of overhead wires, the signal is carried by all the wires due to capacitive and inductive coupling among them. Consequently, if wires are broken, even though they be the wires to which the signal was originally applied, it is necessary only to have one wire available for continuation of the communication system. Wires can be down for several pole lengths before the influence of the break is noticed.

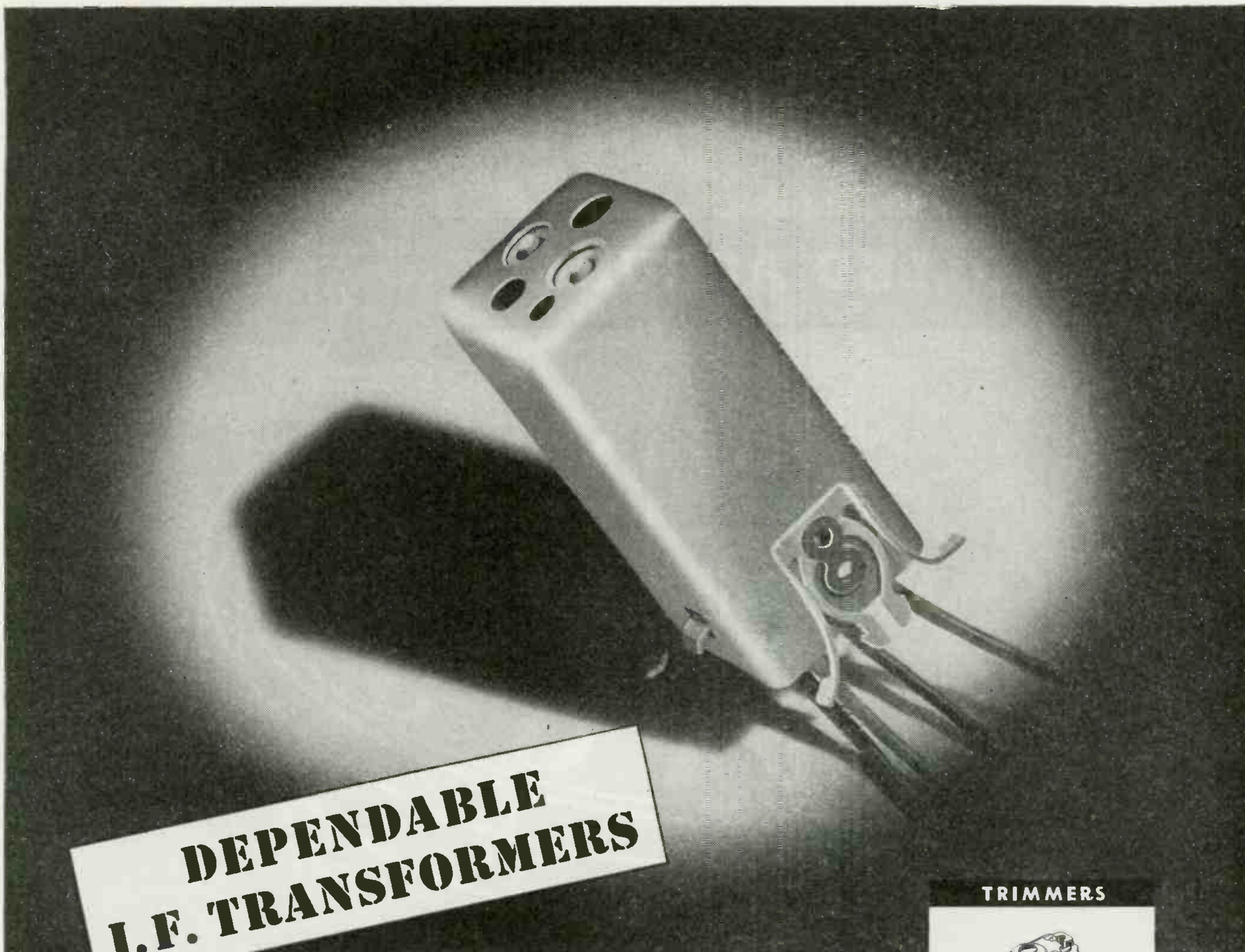
• • •

Electronic Inspection of Magnetic Materials

TESTING OF RAILROAD rails has been done in the U.S.S.R. by a defectoscope, an electromagnetic device that contains ferro-magnetic plates. These plates close a transmitter



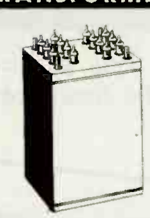
Tiny precision wire for springs gives Chronometer-timed convoys split-second timing.



DEPENDABLE I.F. TRANSFORMERS

TRIMMERS

TRANSFORMERS



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R. F. COILS

The performance of a Radio Receiver has three basic criteria—Sensitivity, Selectivity and Quality of Reproduction.

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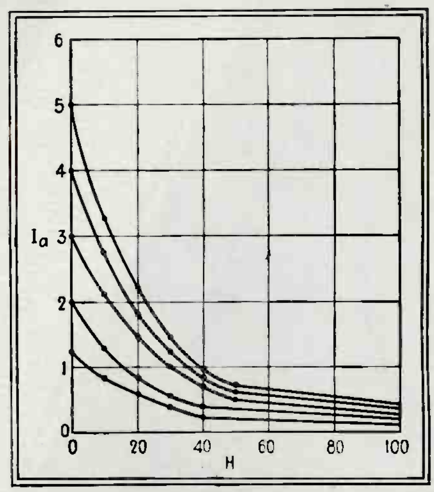
circuit when acted upon by the magnetic dispersion field over the flaw. Operating speed of this arrangement was low, however, and a faster detector was sought that would shorten the time that a section of track was out of use and allow testing at working speeds so as to simulate operating conditions of stress, etc.

An electronic detector has been developed that permits testing at speeds of 10-25 kilometers per hour, depending on the profile of the track.

This new inertialess detector is a thermionic tube with a specially shaped anode. This is in the form of a cylinder with its concave surface pointing downward to the bottom of the tube, and with the filament in the center of the semicylinder. The usual top of the tube



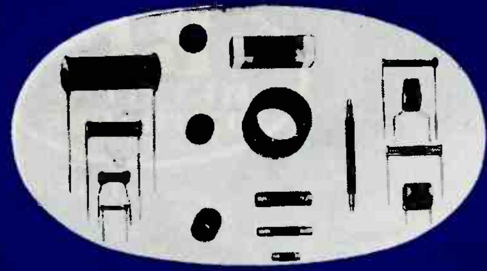
Four curves plotted at different anode voltages for anode current versus H, the magnetic intensity

is thus the bottom and is made flat to allow the heating wire to approach as closely as possible to the glass without causing injury. To increase sensitivity, the tube is connected to an electronic amplifier.

In the testing technique, the rail is subjected to a permanent magnet, an electro-magnet, or a powerful current. The tube, enclosed in a special protective frame, is placed on the part to be tested perpendicular to the filament.

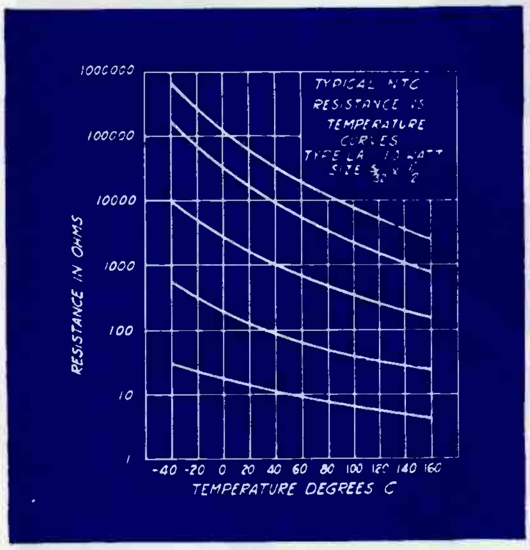
Theory of Operation

Before the tube is placed on the test piece, the electrons emitted by the cathode are distributed uniformly over the whole interior surface of the anode but the presence



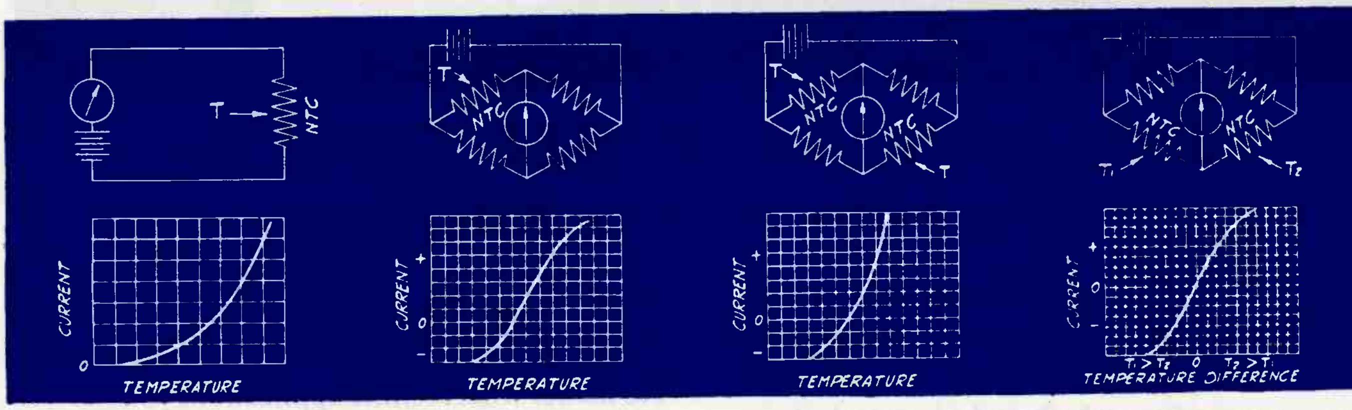
Do you have a

TEMPERATURE MEASUREMENT OR CONTROL PROBLEM ?



CHECK THESE ADVANTAGES OF KEYSTONE NTC UNITS FOR YOUR APPLICATION

Keystone NTC units are electrical resistors especially developed to have an unusually high negative temperature coefficient of resistivity. The slopes are much greater than those observed with pure metals or their alloys. The result is an element with very high thermal sensitivity, useful on AC or DC, inherently suitable for remote indication, which has gained wide acceptance for temperature measurement and control purposes. NTC units are made in wide range of shapes, resistance values, temperature coefficients and wattage ratings, of which the characteristics at the left are typical. The circuits below suggest basic means for translating resistance changes into current or voltage variations. Modifications and extensions of these principles are many, especially in conjunction with electronic apparatus.



This simple series circuit of voltage source, instrument and NTC unit has been utilized to indicate engine coolant temperature, etc. It provides sufficient accuracy for many applications despite scale crowding at the bottom.

Basic bridge circuit straightens and steepens the characteristic. Zero-center meter may be used or balance point may be placed near the lowest temperature. Electronic balance indication provides enhanced sensitivity.

Adding a second NTC unit, and exposing both to the temperature to be indicated, gives a double unbalancing effect and increases sensitivity under certain conditions over part of the temperature range.

Two NTC units in adjacent arms is a method of indicating equality of two temperatures, or temperature difference or rise. Temperature of either source can be obtained by substitution of standard resistance for other NTC unit.

Keystone NTC resistors are also valuable for neutralizing the change in resistance with temperature of electrical indicating instruments and control devices, for introducing time delays and many other applications. Write and tell us about your problem—we'll be glad to analyze it for the applicability of NTC units.

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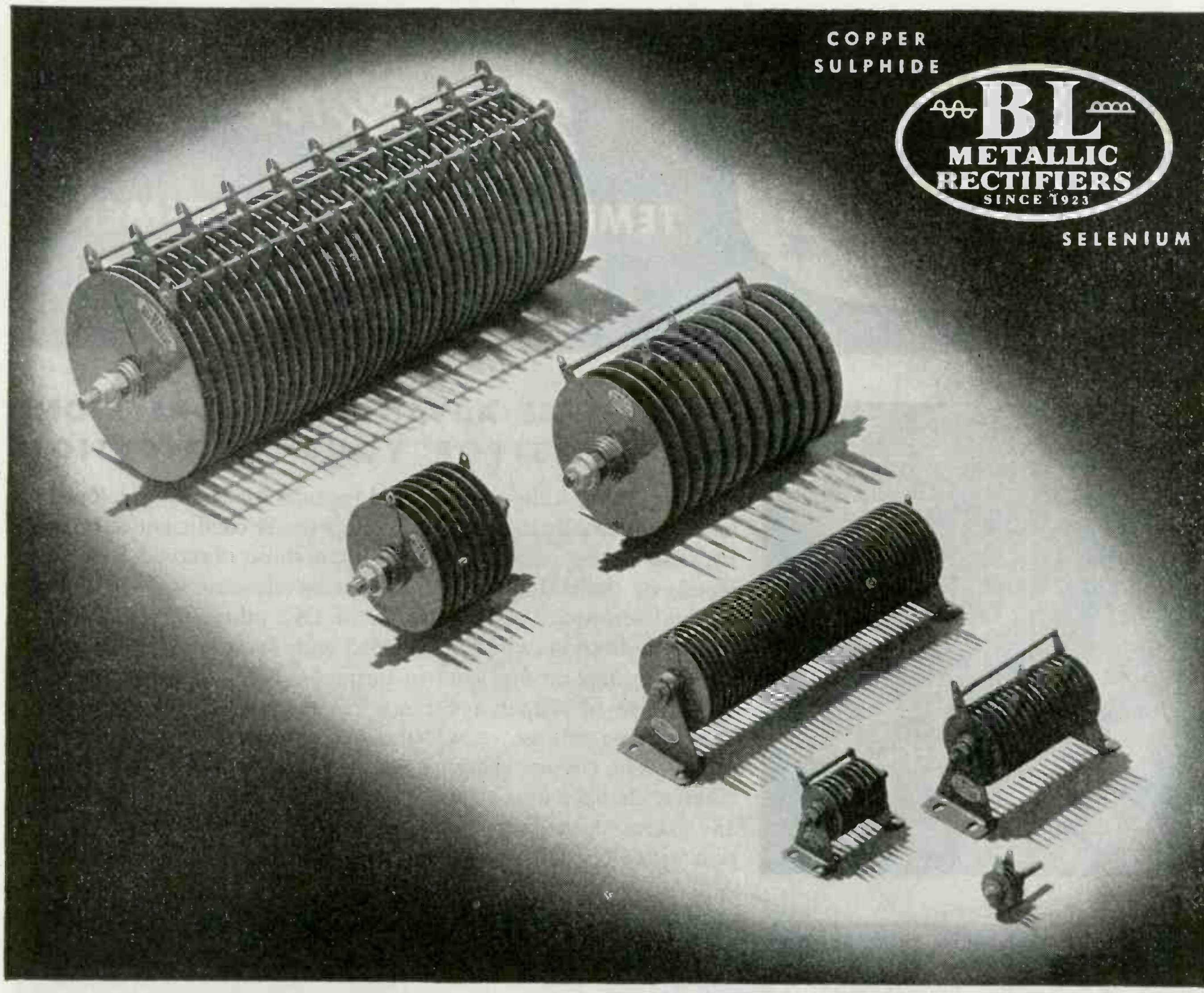

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Intricate problems in electronic munitions making, requiring advanced radio engineering, find ready solution at International Detrola, where the quick questions are: how well?—how exacting?—how swiftly can we build it? Trainloads of first-quality equipment sent to our troops afield echo the answers. The day is coming when these war-tested talents will provide the very finest in Detrola-built Radio Receivers . . Television Receivers . . Automatic Record Changers, and other electronic instruments.

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BUY MORE WAR BONDS

of a general field of dispersion will cause a redistribution of the electron flow towards the lines of force of the magnetic field. This brings about an increase in the internal resistance of the tube and a change in the anode current. By selecting suitable loading resistance it is possible to give the first tube in the amplifier a standard grid bias which will compensate the disturbance and restore the original anode current. It is therefore possible to adjust the detector so that it will not react when it passes over sound parts.

If the tube passes over a flaw, a local field of dispersion is created which sharply deflects the electron flow by shortening the path from the cathode to the anode. This produces a drop in the grid voltage of the first amplifier tube and so alters its anode current. These variations are either used to operate a relay and an alarm system, or are presented on a cathode-ray oscilloscope. The curves show the dependence of the anode current on the intensity field H at different anode voltages.

Results

Tests made on rails with various types of flaws have shown that those with a cross section of the order of 0.1 percent of the total cross-section may easily be detected and it was found that the indications do not depend on the speed of the tube over the rail, a

• • •

RADIO IN BLIMP

Communications equipment in Navy blimp is operated by John H. Scott, Aviation Radioman 3C, to contact other members of an air-sea rescue task unit

depend on **STEDMAN PRECISION TOOLS**

for Precision Mass Production

Stedman equipment has become standard among radio manufacturers because it is especially designed to speed assembly-line production, lower costs and insure a better finished product.

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3. Adjustable to any size within base limits of the Jig. Comes in 4 standard sizes (6", 9", 12", 15" swing) or we will make Jigs to your specifications.
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High precision machined (not die cast). Stainless steel pins. Used to hold socket clips in correct alignment during wiring.

TUBE PIN STRAIGHTENERS (LOCK-IN AND MINIATURE*)

Stainless steel inserts are standard for corrosion resistance. Inserts are replaceable. Hardened tool steel inserts available for factory production use. Body and posts are cadmium plated.

PRECISION GAGES

High precision gages for all types of tube bases. *Adherence to standards eliminates rejections! Increases profits!*

TEST AND ADAPTER PLUGS

Made to fit any type socket. Silver plated brass pins. Handsome plastic grip. Good dielectric characteristics.

SOCKET MOUNTING TOOL

Installs snap ring *in a jiffy!* Speeds up socket mounting in chassis. Just drop snap ring over expander tube, place handle on tube and press snap ring down on to socket. *Simple, quick, economical!*

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Write or wire us of your requirements

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CONTROL FOR *Giants*

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great advantage over the existing methods using ferro-magnetic plates or powders.

This defectoscope is capable of wide variations in sensitivity. Increasing the anode voltage decreases the sensitivity because weak dispersion fields of abnormal shape will not have time to affect the electron flow. On the other hand, reducing the anode voltage and increasing the filament temperature results in an increase of sensitivity.

For the lower testing speeds, it was found that a sensitive relay and a paper-tape type of recorder gave good results, but for the highest speeds a c-r oscilloscope working in conjunction with photographic paper was found to be better.

• • •

Power Supplies for Photoelectric Controls

By Daniel Schulman

In many industrial applications of phototubes and photocells, some consideration must be given to undesirable modulation of the light source by the lamp current. To eliminate this condition, one method is to excite the lamp used as the light source by means of power from an a-f or r-f oscillator instead of from the usual 60-cycle supply line. In certain industrial control applications, this is done so that response is had by the control equipment to only one lamp in a group, the proper frequency being selected by a band-pass filter in the phototube amplifier.

These problems are similar to those that exist in facsimile transmission and sound motion pictures. In these fields, self-excited oscillators or master-oscillator power-amplifiers are commonly used to supply the lamp with current. The frequency of excitation may range from 300 cycles per second up into the radio-frequency region. The particular frequency selected will be dependent upon the inertia characteristics of the filament. As a rule, the higher the power of the exciter lamp, the greater is the inertia of the filament, and the lower is the frequency required for minimum modulation.

In Fig. 1 is shown the circuit of a self-excited oscillator that has

INCREDIBLE SALVAGE

The Case of the Flying Gull . . .

During the storm season of 1942, *The Flying Gull* ran into heavy seas in the Gulf of Mexico.* Running before a terrific wind, she all but made port. Then, just as she was putting about near Hunter's Point, she shipped a gigantic wave and foundered. All hands were saved. But *The Flying Gull* rested in eight fathoms of Gulf water.

Salvage operations were started. Later in 1942, when The Flying Gull was in the dock and her electrical equipment ripped out, an amazing thing occurred. George Long, of The Harris Salvage and Drydock Company of Galveston, put the Thermador transformer equipment on a shelf in the sunshine—mentally assigning it to the scrap metal drive. Three days later, out of curiosity, he hooked the transformers onto a testing bench and flipped on the current. To his amazement, they still showed signs of life. He then ran standard tests. To his further astonishment, all twelve of the transformers were not only working—they were working perfectly.

Harvy Stark, owner of the boat, had already ordered a complete new set of transformers from Thermador. He cancelled the re-order. And today The Flying Gull sails with her original Thermador transformers. Not designed for the briny deep—but they could take it!

Such stories of plus performance are not accidents, for Thermador transformers are built to perform beyond normal expectations. They are completely manufactured—not just assembled—under one roof on a vast array of modern precision equipment. They are made *only* from the finest materials, engineered by men of broad experience. The result is not alone quality but *quality in quantity.* If that meets your specifications, better discuss transformers with Thermador.

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DEFEAT HEAT • COLD • HUMIDITY

An actual case history from Thermador files; however names, dates, and location have been altered.* **Buy MORE War Bonds.

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THERMADOR ELECTRICAL MANUFACTURING COMPANY
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been used to excite a 6-watt lamp in a 16-mm sound projector. This circuit is designed to operate in the supersonic frequencies, desirable for two reasons. Lower audio frequencies would have a tendency to be picked up by induction into the high-impedance input of the first audio stage in the high gain amplifier. Radio frequencies of a higher order would have a tendency to radiate, and also reduce the efficiency of the oscillator. Efficiency

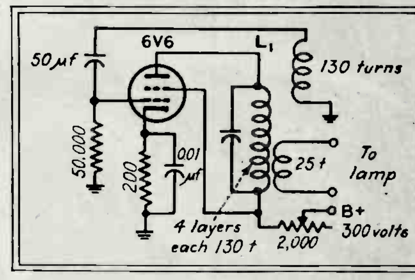


Fig. 1—Circuit of self-excited oscillator for supplying current to a 6-watt exciter lamp

is quite important since excessive plate current would call for a larger and more expensive power transformer.

In addition to the grid leak bias there is shown a self-biasing resistor. Should the exciter lamp burn out, the tube might cease to oscillate and the cathode resistor would bias the grid and hold the plate current down to a normal value. This is necessary so that the tube will not be damaged. The 0.01-μf capacitor places the cathode effectively at ground potential. The variable rheostat in the plate circuit will vary the brilliance of the lamp.

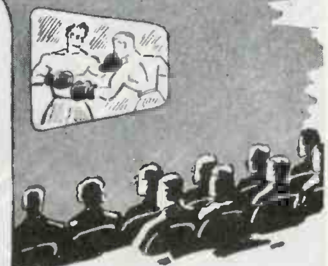
Coil Data

Inductor L_1 is of the air-core type wound on three-inch tubing with ⅜-in. inner diameter. There are three windings, a primary coil of four layers, 130 turns each of No. 28 wire; a feedback coil of 130 turns of No. 28 wire, and, a lamp winding of 25 turns of No. 18 enamel wire. One side of the lamp winding may be grounded. There is no heat generated in this coil.

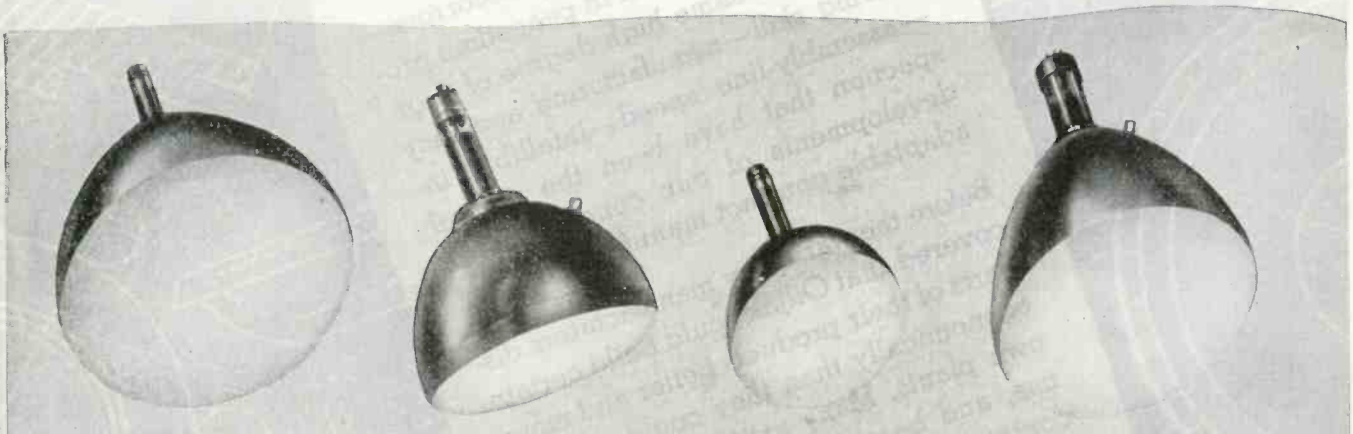
With this type of oscillator, a high-quality sound amplifier may be employed, since no attenuation of the low-frequency response is necessary. An objectionable feature of this circuit is that the brilliance

PREPARED...

Engineers now planning commercial Television will find that RAULAND has anticipated all of the present day tube applications for direct-viewing for the home and projection for home and theatre, using either reflective or refractive optics. Invitation is extended to confer with RAULAND engineers concerning plans now being formulated.



One of the important qualities which determines the usefulness of the tube in a given application is its light flux density (measured in candlepower) per microampere beam current. The range for tubes shown runs from .05 to .5 candlepower per microampere, while the useful beam current ranges up to 3000 microamperes.



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Short 15" tube, showing a 13"x 10" picture

Short 12" tube, showing a 9½"x 7½" picture

9" tube, showing a 7⅜" x 5½" picture

Electrostatically focused and deflected 12" tube, showing a 9½"x 7½" picture

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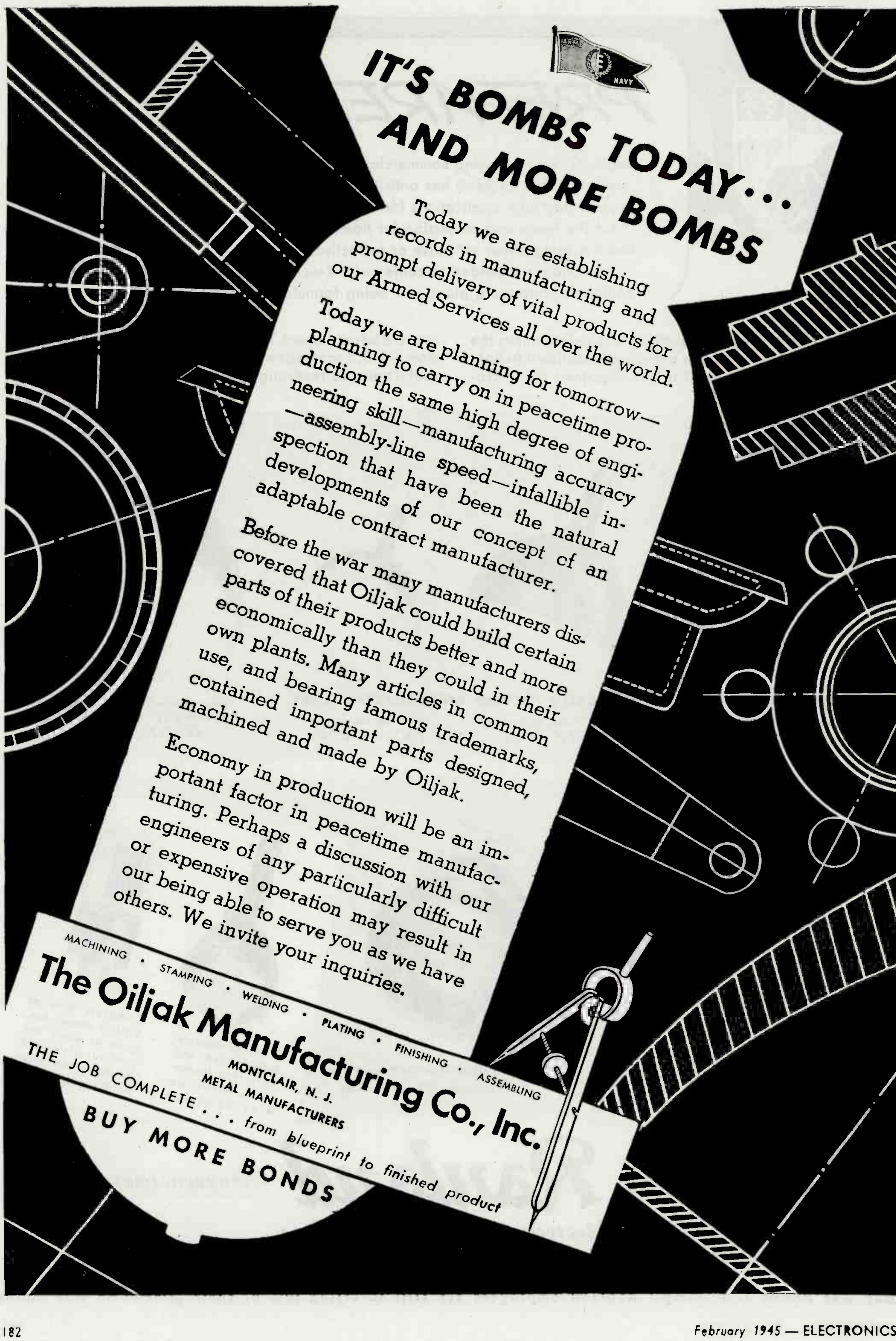
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Before the war many manufacturers discovered that Oiljak could build certain parts of their products better and more economically than they could in their own plants. Many articles in common use, and bearing famous trademarks, contained important parts designed, machined and made by Oiljak.
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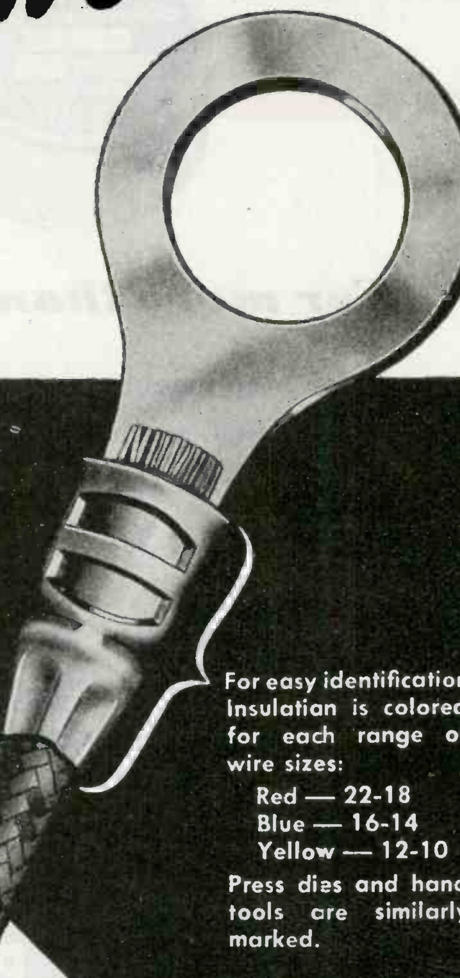

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For easy identification Insulation is colored for each range of wire sizes:

Red — 22-18
Blue — 16-14
Yellow — 12-10

Press dies and hand tools are similarly marked.

THE FACTS

1. The insulation is permanently bonded to the barrel of the terminal — will not distort, slip, crack or peel off — its dielectric qualities are equal to or exceed any conventional crimped terminal with loose sleeving.

2. The production cost of applying separate tubing to the terminal is approximately the same as the cost of applying the terminal itself to the wire. By using the Pre-insulated Terminal you eliminate such costly operations as buying, expediting, stocking, cutting and installing insulation sleeving of the proper size.

3. The AMP Pre-insulated Terminal is delivered to you ready to install with AMP precision hand, foot or power installation tools.

4. In addition to Pre-insulation, you get all of the features of the famous AMP "Diamond Grip" Insulation Support terminal — two crimps on the barrel and one on the insulation sleeve — all performed in one operation.

TEST DATA

on insulation used in AMP Pre-insulated solderless terminals:

- The pre-insulation takes the exact contour of the crimp without distortion or cracking. It will not dry out or come loose.
- Dry dielectric strength 750 VPM.
- Wet dielectric strength 350 VPM.
- Tensile strength pounds per square inch 2150.
- Life at 220° F. over 400 hours.
- Does not shatter when pinched with pliers at minus 40° F.
- Does not support combustion when tested in accordance with ASTM D350-40T.

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1521-53 N. 4th ST. HARRISBURG, PENNA. • TELEPHONE: HARRISBURG 4-0101 of the lamp changes with line voltage variations.

Figure 2 shows a phase neutralization method that may be used when 60-cycle modulation is encountered. Resistor network R_1 and R_2 impress a 60-cycle voltage equal in amplitude and 180 deg out of phase with the signal voltage, so that the effective potential measured from point *A* to ground will equal zero. The alternating poten-

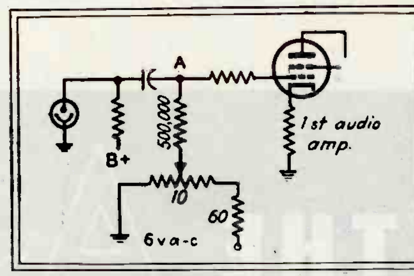


Fig. 2—Balancing arrangement for overcoming the effect of 60-cycle modulation of a light beam

tial must be properly phased in the R_1 and R_2 network to give proper cancelation. Reversing the secondary or primary leads of the power transformer will give the proper phase. This system has the advantage of being economical but requires frequent adjustment and also affects the frequency response.

Filter Circuit

Figure 3 shows a high-pass filter arrangement that is commonly used. Attenuation of the low frequencies will start at 350 cycles with the values indicated, and at 60 cycles the hum modulation is at an acceptable level. It is desirable to have the hum level 45 decibels

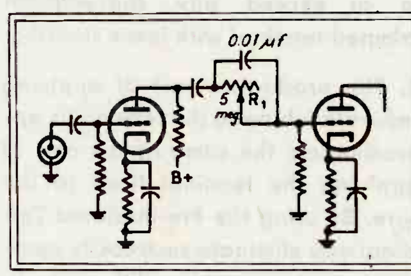
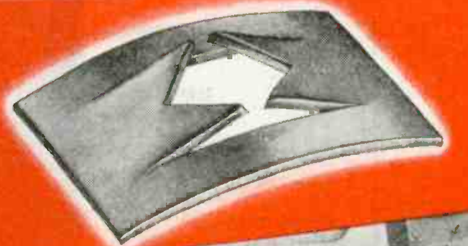


Fig. 3—This high-pass filter circuit satisfactorily attenuates frequencies below 350 cycles

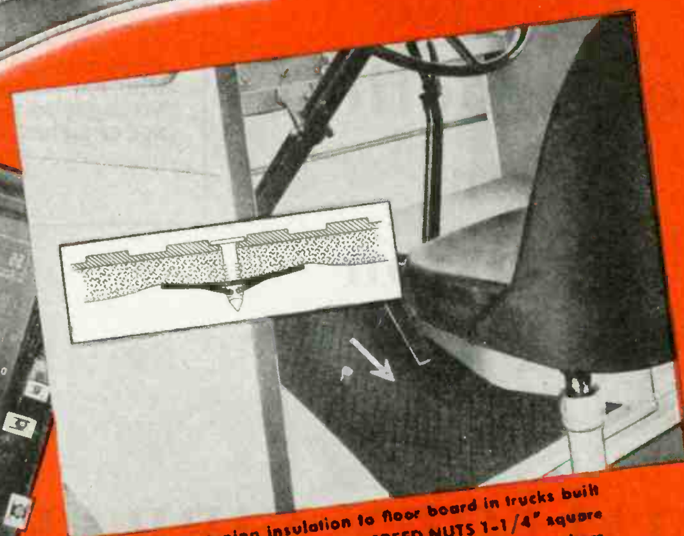
below the signal level in 16-mm sound projectors.

In facsimile transmission, special problems are involved. Normally, the picture is placed on a revolving

THE NUT THAT *Locks* ON UNTHREADED STUDS!



Thirty-eight SPEED NUTS are pushed over integrally molded plastic studs in this radio panel assembly, eliminating threaded inserts, reducing mold costs and assembly time.



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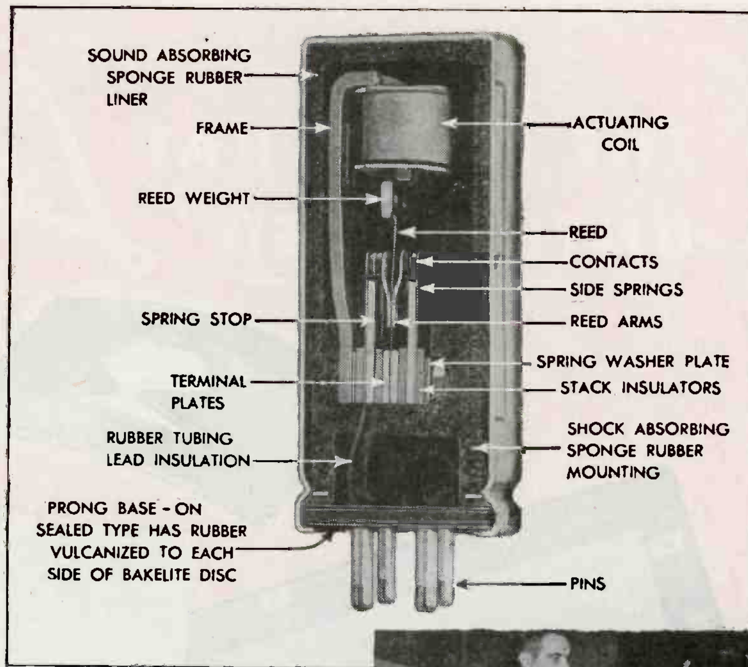

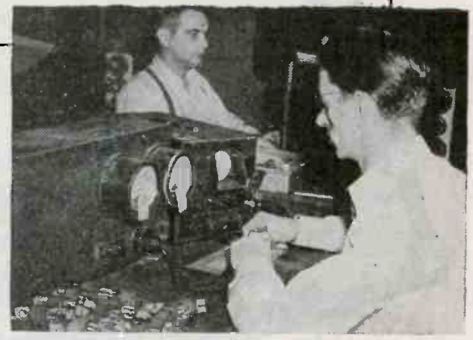

Each Mallory Vibrator is tested on the oscilloscope for wave form under all operating conditions to insure precise performance.

Behind each of the construction features you see in this cross-section of a Mallory Vibrator are three important factors:

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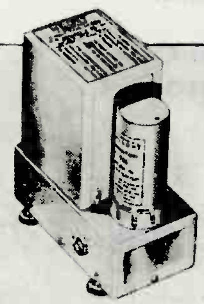

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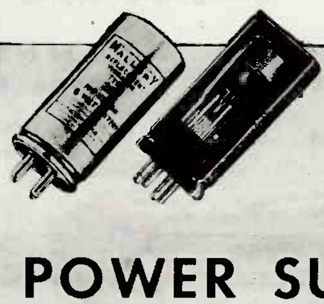

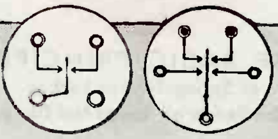

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The illustrated unit typifies the many compact designs incepted by N-Y-T for mobile, airborne and portable equipment. Resourceful N-Y-T engineering, new materials and advanced techniques make possible full retention of desirable characteristics where such drastic paring of size and weight is imperative for efficient functioning.

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drum and the small area that is illuminated by the exciter lamp is focused by an optical arrangement to the sensitized medium of a phototube. Variable intensities of light are reflected from the exposed area depending upon the degree of white in the picture. Voltage peaks of 60 cycles would correspond to greater lamp voltages at certain phases of the cycle. These peaks of voltage cause corresponding peaks of illumination which show up as definite patterns of wavy lines. This objection can be removed by having a controlled high audio-frequency voltage feeding the exciter lamp.

Use of Class B Amplifier

Figure 4 shows a satisfactory circuit that overcomes these difficulties. The lamp is excited from a low-voltage secondary winding of the output transformer T_1. An

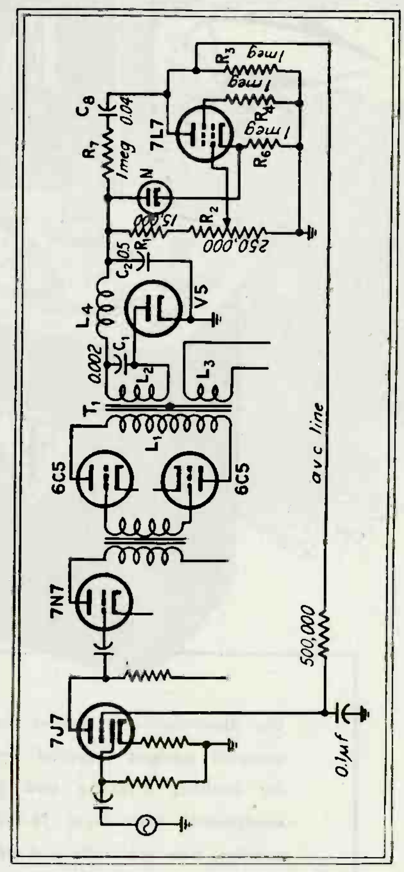

Fig. 4—Circuit of controlled amplifier for supplying current to an exciter lamp in a photoelectric control system. Both input voltage and line voltage variations are corrected by the avc arrangement to maintain a constant output

audio signal is fed into the input of the first audio amplifier tube. This is resistance coupled into a driver tube. Since efficiency is desirable and only a single frequency is

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EXPERIENCE spot-lighted the necessity for gaging *at the machine* by which the operators themselves could quickly detect any tendency towards "out-of-control" running.

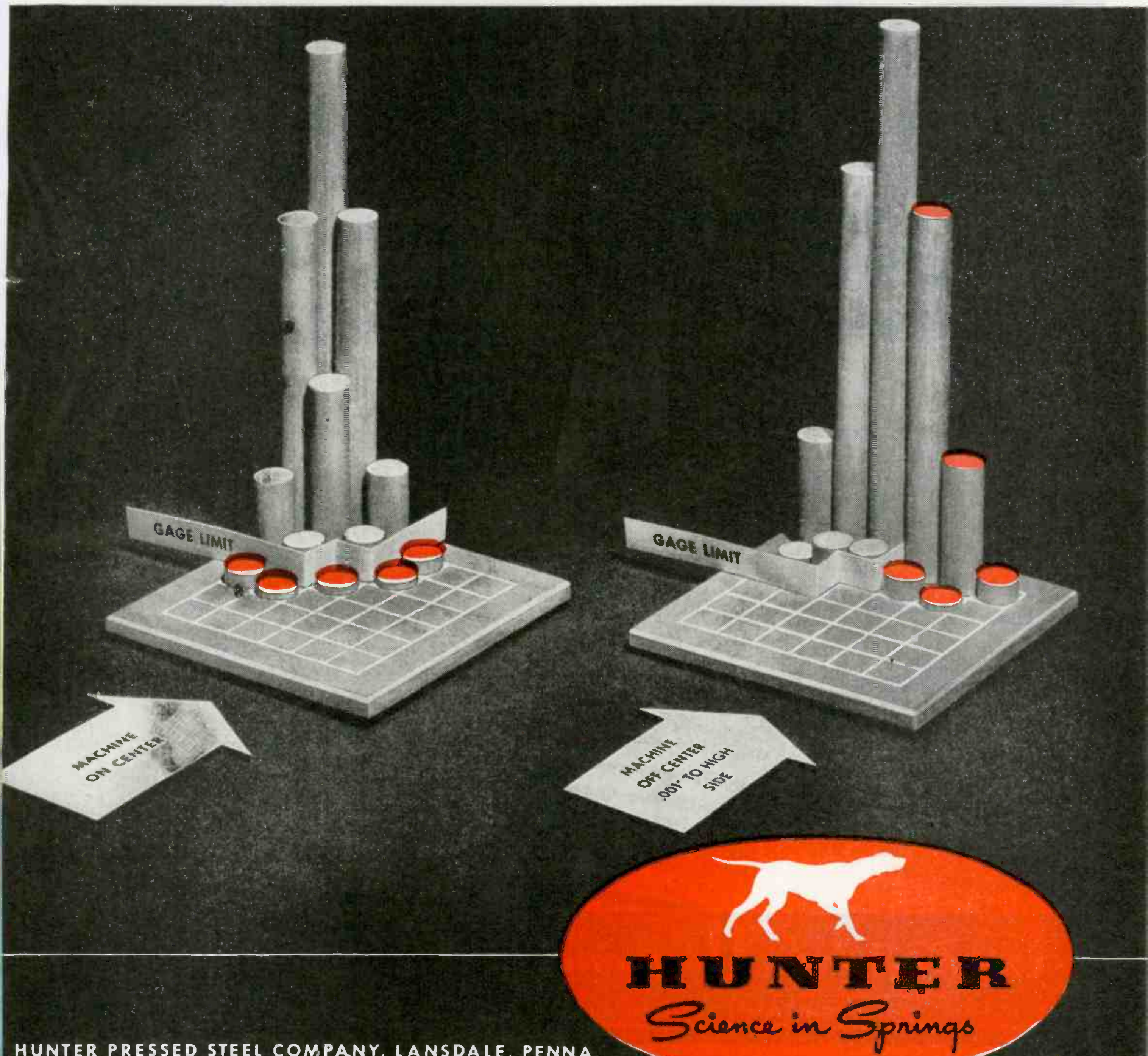
Setting go-no-go gages at the specified tolerance was ineffective. Studies resulted in development of a simple technique which we have called "control gaging."

This new technique, now used by Hunter on all control-charted operations, has proved very efficient. On short-run, close-tolerance jobs, where control charting cannot be effectively applied, control gaging obtains a degree of control comparable with long-run control-charted jobs.

In control gaging, the setting of the gages is determined by a simple mathematical analysis of samples from the machine. While running, the operator draws 5 pieces *produced in succession*, passes them through the control gage, and notes the number of failures at both limits. If, for example, *over* 2 pieces fail at the high limit the machine is running to the high side. A combination of low and high failures exceeding 3 pieces indicates the range has increased.

Suppose a machine is producing parts with a tolerance of ± .003". Now assume the machine setting shifts so that production is running + .004" — .002". The machine operator has only one chance in 44 of detecting the shift using conventional gage limits. Control gages, however, would definitely show the machine was off center through an increase in number of gage failures (beyond the 2 high max.) to 26% of the lots checked. The ratio of efficiency is at least 10/1 in favor of the control gage method.

THIS PROBLEM *posed in the last paragraph above is illustrated by the models below. The heights of the bars show the relative frequencies with which control gage limits are exceeded. Note the strong positive shift in these frequencies with off-center running. Control gage setting for sample size* $5 = \bar{X}' \pm .577\,\bar{R}$*. If you are not already acquainted with statistical methods for quality control we recommend that you promptly obtain copies of ASA Bulletins Z1.1-1941, Z1.2-1942 and Z1.3-1942 from the American Standards Association, 29 West 39th Street, New York, N. Y.*



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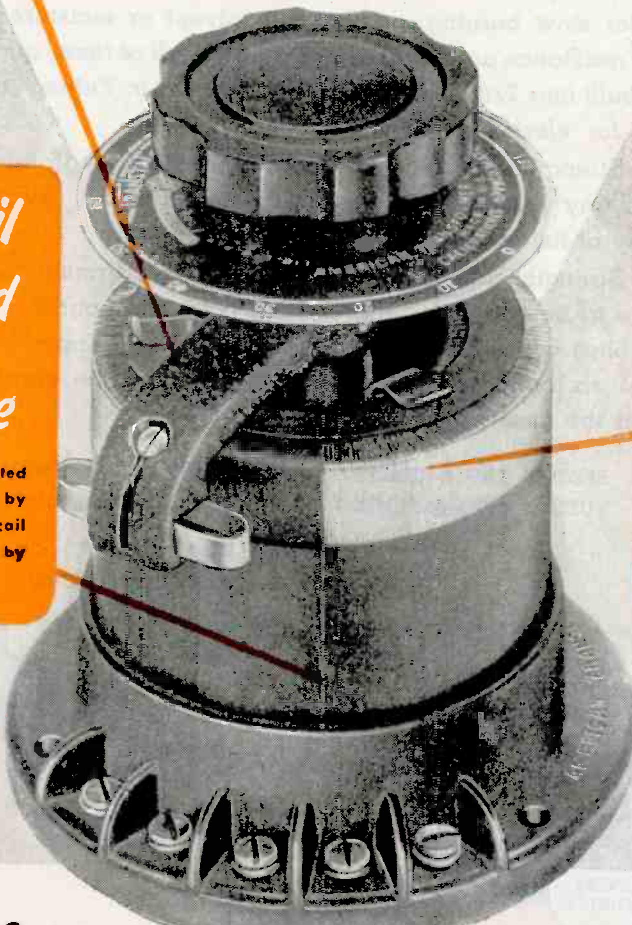

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Ground from parallel wires on outer periphery of coil, forms long even segments with solid insulation necessary to avoid shorted turns. Greater contact area results in a lower operating temperature. Smooth, mirror-like finish provides a practically frictionless brush track.

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Triple-Strength combines in one tubing the most significant values and properties required of electrical insulation, today.

No longer is it necessary to specify one brand of tubing for dielectric up to 3500 volts, another for non-fraying ends, another for slow burning, another for solvent or moisture or humidity resistance or for extreme flexibility—*all of these qualities are built-into Triple Strength, the optimum in Tubing and Sleeving for electrical insulation.*

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- Extruded Plastic Tubing
- Varnished Cambric Cloth and Tape
- Mica Plate, Tape, Paper, Cloth and Tubing

amplified, class B amplification is employed in the following stage. The circuit constants are designed for amplification and peak band-pass at the one frequency.

It is necessary to control the output of this amplifier and regulate the voltage at the lamp. Line voltage variations affect the plate voltage and hence the power output. Signal voltage variations would affect the gain and also illumination. Changes and audio signal variations would cause streaks in the picture transmission that would not correspond to the original.

Audio AVC

Regulation is accomplished by a revised automatic volume control circuit that provides bias to the third grid of the input 7J7. This arrangement seeks the correct output by a differentiating means and amplifies the resultant by the 7L7 d-c amplifier tube. The reference voltage is the drop across a ¼-watt neon bulb, *N*. Voltage from the output transformer is properly matched to an exciter lamp and the differentiating circuit. For an 18-watt lamp, a 4-ohm secondary will properly match the impedance and is shown as L_3. Winding L_2 is a high-voltage secondary that supplies 300 volts to the output rectifier tube V_6. Inductor L_4 with C_1 and C_2 filter the d-c potential that appears across R_1 and R_2. A negative potential is placed on the cathode of the 7L7 tube through the ¼-watt neon bulb *N*. Any change in plate current of the 7L7 appears as a voltage of negative polarity across R_6. This potential is applied through an RC filter with a time constant of 0.1 second to bias the third grid of the input 6J7 to maintain a regulated output. The voltage at which the circuit will hunt is dependent upon the setting of R_2. If there is 300 volts of negative polarity across R_1 and R_2, then across R_6 there will be 240 volts, since the neon bulb drops approximately 60 volts and maintains that fixed drop. If R_2 is set at negative 250 volts to ground, there will then exist tube potentials of 240 volts plate and screen supply and negative 10 volts on the control grid.

Theory of Operation

When a rise in line voltage or signal voltage occurs, there is more


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power output. Suppose a 310-volt potential instead of 300 exists across R_1 and R_2. Since the drop across the neon bulb is constant at 60 volts, there will exist 250 volts between cathode and ground. The setting of R_2 places the divider network in a 5-to-1 ratio of resistance since it was set in a voltage ratio of 250 to 50 volts. The potential existing from grid to ground will equal 5/6 of 310 or 258.3 volts. This is 1.7 volts more positive on the grid than the original circuit potential. The 7L7 will then draw more current and cause a greater voltage drop across R_3, which will in turn place a more negative bias on the 7J7. Reduction and stabilization of the amplifier output is then accomplished and the output is restored to 300 volts across R_1 and R_2. Maintaining this output constant will regulate the exciter lamp voltage since the two circuits are coupled to the same primary.

Instead of 310 volts appearing across R_1 and R_2, an instantaneous rise to 400 volts may develop. Then the circuit potentials will equal negative 340 from cathode to ground, 340 volts plate and screen supply, and 5/6 of 400 or negative 333 volts to ground at the grid. A positive potential of 7 volts will then exist on the grid of the 7L7. This is 17 volts more than the original setting. The circuit will then have a tendency to hunt, with a consequential time delay that may burn out the exciter lamp before regulation takes hold. To prevent this, R_7 and C_8 are incorporated. Resistor R_7 is selected to give optimum phase angle to prevent regeneration.

This circuit will regulate within 1/20 of a volt on signal variations of 3 to 10 volts, and line voltage variations between 90 and 130 volts. The frequency may range from 300 to 3000 cycles per second on the signal grid.

• • •

Electronic Width-Gage for Strip Materials

THE CIRCUIT of a vacuum-tube gage for measuring the width of movie film is shown in the illustration. With minor changes, the unit can be adopted to give width or thickness measurements for many other

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A WIDE RANGE OF TUBES — OF WIDE APPLICATION

THE enviable engineering tradition on which the foundation of the North American Philips Company, Inc., rests, is reflected in the superior quality and performance of electronic tubes bearing the NORELCO stamp. Contributing to the long life and uniform characteristics of these tubes are many exclusive manufacturing techniques and inspection methods developed over a long period.

Among the types we now manufacture — some of which are illustrated — are a number of special-purpose, cathode-ray and transmitting tubes for high and ultra-high frequency applications, r-f and a-f power amplifier tubes, and low- and high-power rectifiers. Although all the tubes we produce now go to the armed forces, we invite inquiries from prospective users. A list of the tube types we are especially equipped to produce will be sent on request.

In the North American Philips Company, there is gathered together a team of outstanding electronic engineers, coached by a group with world-wide experience resulting from fifty years of research and development in the electrical field. This new combination of technical talent has at its command many exclusive processes that insure electronic devices of the highest precision and quality. Today, North American Philips works for a United Nations Victory; tomorrow, its aim will be to serve industry.

OTHER PRODUCTS: In addition to the electronic tubes mentioned above we make Quartz Oscillator Plates; Searchray (X-ray) Apparatus, X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Tungsten and Molybdenum products; Fine Wire; Diamond Dies.

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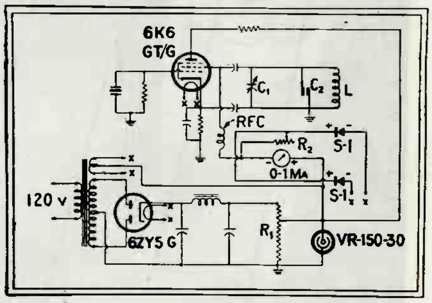
Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Division); Lewiston, Maine (Elmet Division) applications. The measurements provided are in agreement with test-blocks and stereo comparators and readings are reproducible within 0.002 mm, a degree of accuracy somewhat beyond that attained by operators using the optical equipment.

The essential element of the unit is a small lever, about 2 inches long, swinging on a bearing about one-third the distance below the upper end. At the upper end of the lever, a rounded surface presses lightly against one edge of the film as it passes through the gage. If the film becomes wider, the upper end of the lever is pushed outward, and since this is above the fulcrum, the lower end of the lever swings inward. As the lever swings, a metal disk at the lower end moves nearer to, or farther from, a similar disk which is fixed and immovable. These two metal plates never actually touch one another, but as the distance between them varies with variation of film width, they actually constitute a variable capacitor.



Circuit of electronic gage for measuring width of a continuous strip such as movie film

With change of film width, there is a change in capacitance of the variable capacitor and this change is amplified electronically, giving a direct reading or recording of film width in millimeters. Thus, with but one moving part in the actual measuring mechanism, variations of film width are measured in a fraction of a second, and the most minute changes are amplified to a degree allowing clear and easy reading, without injury to film from pressure.

Mechanical Arrangement

In the unit, the film passes from the feed roll, under a guide-roller, through the measuring head, under a second guide-roller and to a take-

Special Round Head Shoulder Pin

Special Hex Head Shoulder Bolt

Special Pronged Pin

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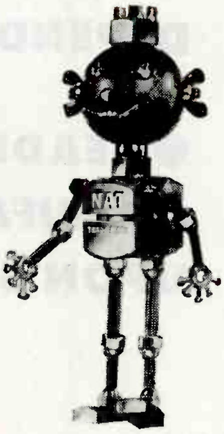
Send for a copy of this case history booklet describing briefly, with diagrams, 15 typical instances of time, materials and money saved. Ask for the "Savings" booklet.



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ARMY E NAVY

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In our molded plastics division, we have the know-how to do large or small jobs, simple or intricate, in any quantities. While we don't attempt to design or redesign your parts, our skilled and co-operative team of engineers, mold makers and machine operators frequently make suggestions for better, faster or lower cost moldings that will meet or beat your specifications.

You'll find similar ability in our small motors division. For years, we've built *Smooth Power* drives for our own lines of recorders, record-changers and turntables, and for electric and electronic products of leading manufacturers. If one of our many standard motors or drive assemblies won't meet your specifications, we'll design and build one that will, exactly.

So, if you're specifying molded plastics or small motors, we'd like to work with you. Definite commitments must wait until the end of our military work is in sight, but a start now may help you get to the markets quicker with your postwar products. It will be appreciated if you will address the specific division . . . *molded plastics* or *small motors*.

THE GENERAL INDUSTRIES COMPANY
ELYRIA, OHIO

ARMY E NAVY

up roll which is driven by a motor. Guide rollers, measuring head, and spindles for the film rolls are all constructed so that 8-mm, 16-mm, or 35-mm films can be measured interchangeably.

The measuring head consists of a fixed lateral film guide which is adjustable for any standard width of film, a ballbearing film-supporting roller and a movable lateral film guide which is attached to the swinging lever, with a movable capacitor plate attached to the lower end.

As the film passes through the measuring head, it is curved over a ballbearing film-supporting roller. The path described by the film in passing over this roller forces it into a partially cylindrical contour at the point of measurement, thereby inducing lateral rigidity and assuring that the true width of the film will be measured. This simple method of film-guidance is one of the prime factors insuring accuracy and reproducibility of readings with the instrument.

Use of Oscillator

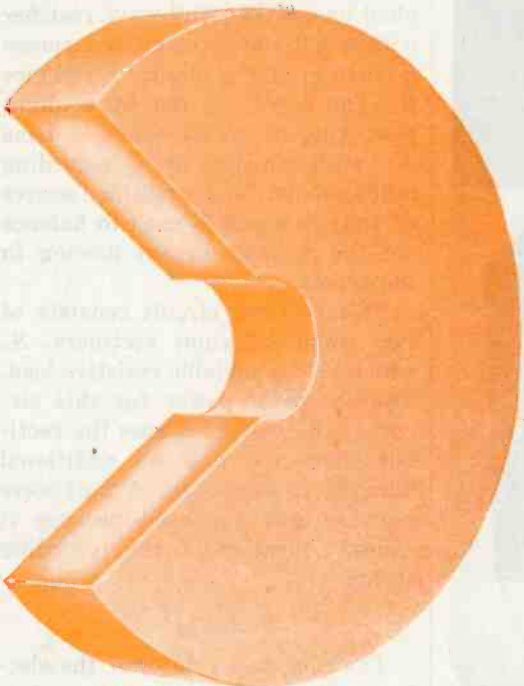
Small variations of capacitance can be measured conveniently by their effect upon the frequency of an oscillator circuit or by their effect upon the amplitude of current in a parallel resonant circuit and this principle is used in the electronic width-gage. Essentially it is a fixed vacuum-tube oscillator loaded by a variable tuned circuit, the impedance of which varies with the capacitance fluctuation of the mechanical capacitor C_2. As a result, the direct current flowing through the vacuum tube varies, and these variations are directly proportional to variations in width of the film or other object being measured.

Capacitor C_1 is a fine control to compensate for minor fluctuations in frequency. If reproducible results are desired, it is extremely important that the resonance at which the circuit operates be confined to one point on the resonance curve. Assuming that the overall capacitance is changed by a very small amount to some value less than that required, the change of current for a given change of capacitance will be less because of the nonlinearity of the resonance curve.

The source of oscillation is a

History of Communications. Number Thirteen of a Series

two-day curing job... Cut to 7½ minutes



Cross section of grinding wheel . . . formerly oven baked . . . heat soaks in slowly from surface.

Same section . . . now cured by radio-frequency heating . . . heat builds up speedily, evenly throughout.

The old, slow oven cure took 48 hours—just to heat the resin bond of a grinding wheel 8½″ in diameter by 1¼″ thick.

Now 7½ minutes are plenty . . . heat mounts at 20°C per minute . . . and splitting due to uneven heating is no longer a major hazard. Now it's done by radio frequency which heats dielectrics uniformly from center to skin.

This speedy heating is often applicable to processes in wood, chemicals, plastics, rubber, textiles and dozens of other products—with no waiting for heat to "soak in" and no rejects due to overheated surfaces.

This accurate, uniform heating is simplified into a "push button" job for unskilled help, with all equipment and controls in one safe, spacesaving cabinet. The cabinet is shielded to minimize interference with radio communications.

Single standard units are available in output capacities ranging up to 200 kw. The range of frequencies is wide enough for almost every dielectric and induction heating need. For more information, write for Descriptive Data 85-800. Or, for suggestions on a specific application, ask a Westinghouse engineer to call. Westinghouse Electric & Manufacturing Co., P.O. Box 868, Pittsburgh 30, Pa.

J-08097

2 KW RADIO-FREQUENCY GENERATOR

This unit has a nominal output of 2 kw. Controls and meters are all conveniently located on front panel. Circuit breaker and relays are readily accessible through the lower door on left side of cubicle.

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Electronics at Work

quartz crystal connected to the grid of a 6K6GT/G vacuum tube. The parallel resonant circuit is connected to the screen grid, a feature of design leading to increased stability of operation. The plate and screen grid are operated at half their rated voltages. Power is supplied by a 6ZY5G full-wave rectifier with a VR-150-30 connected across a fraction of the bleeder resistance R_1. The screen is fed by a shunt consisting of an r-f choke, a 1-ma d-c milliammeter or a recording milliammeter, and a rectified source of voltage which is used to balance out the normal current flowing in the screen.

This rectifier circuit consists of two small selenium rectifiers, S_1, which feed a variable resistive load. The source of power for this circuit is the voltage across the rectifier filaments, and no additional filtering is necessary. A half-wave rectifier was not used because it caused vibration of the recording stylus.

Stability

The component units of the electronic circuit were selected to minimize the generation of heat, since the impedance of a tuned circuit and of the tube elements are functions of the surrounding temperature. Accordingly, the screen-grid current will fluctuate if the necessary precautions are not observed to prevent fluctuations of temperature. With the present circuit, after approximately five minutes for heating, no drift in screen-grid current was noticed during continuous operation for 48 hours. The stability of the circuit is excellent.

Operation of the circuit is illustrated by the graph, which shows the relation between screen-grid current and capacitance of the resonant circuit. In a crystal oscillator circuit, the resonance curve is not symmetrical, one side of the curve having a slope much greater than the other. This effect is caused by the influence of the tuned circuit upon the crystal impedance. When film is held between the fingers, as in threading the width-gage, the capacitance is varied so the circuit is no longer in resonance, as indicated by a or some other point on the curve. The direct current I corresponding to a point a is balanced until the meter reading cor-

It is no longer a military secret that the successful operation of high frequency electronic apparatus depends upon precision-built, gold-plated "plumbing". And it is no secret that DICO is a foremost producer of this electronic plumbing — machined to strict specifications, silver-soldered with meticulous accuracy, and precision plated to a tolerance of 5/100,000 of an inch.

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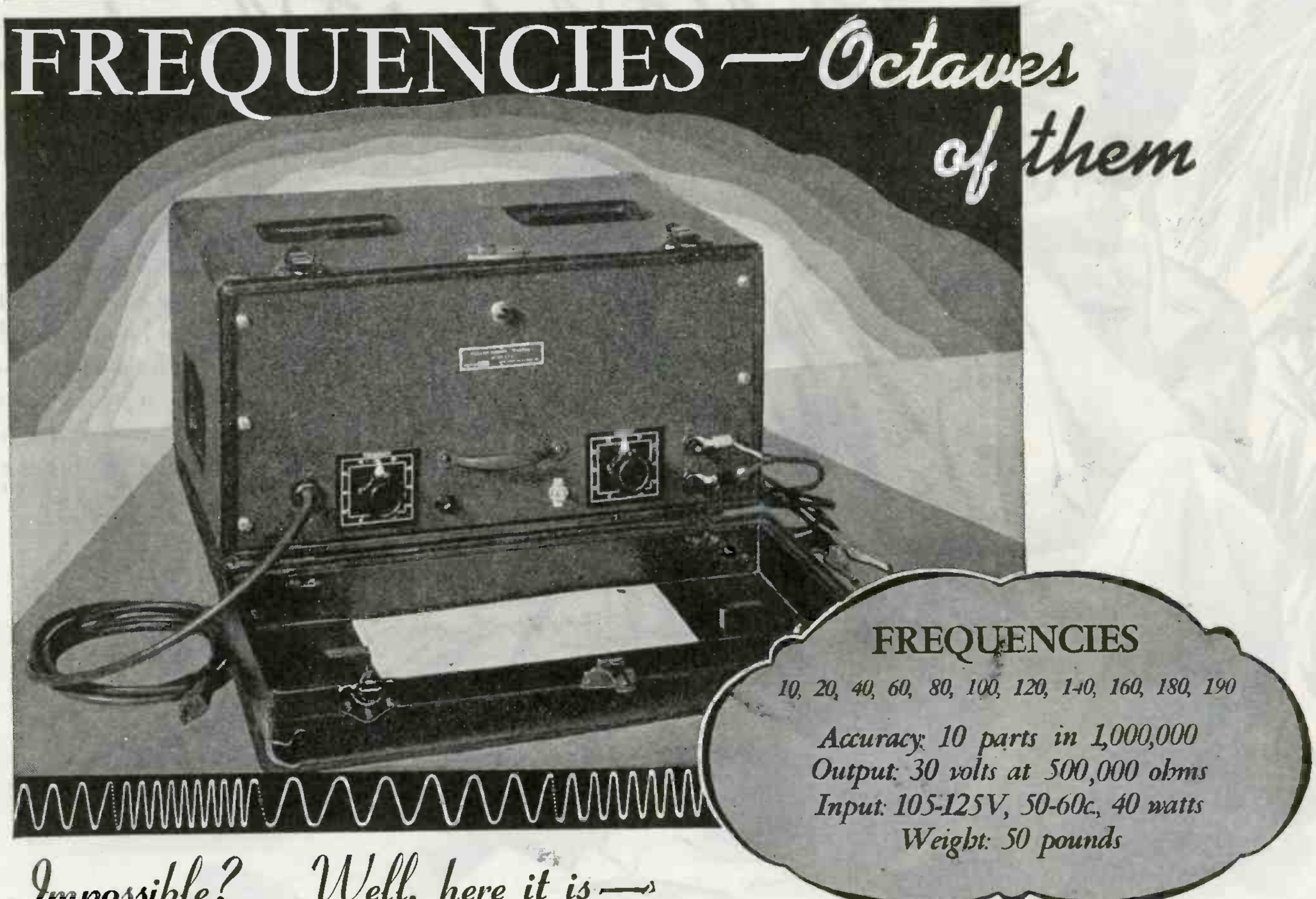

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This Multi-frequency generator furnishes the frequencies shown above at the turn of a switch. All frequencies are obtained from a temperature-compensated tuning fork and voltage-stabilized circuit.

With this unit it is possible to calibrate oscillators at many selected points without encountering complex oscilloscope patterns. One of the uncertainties involved in development work on tuned circuits, filters, reeds—and in time measurement can be minimized with the aid of this instrument.

Developed primarily to check frequency meters for precision war work, this Multi-frequency generator possesses a rugged durability and dependability in service that will prove an extra value to many laboratories.

Additional information available on request.

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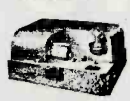
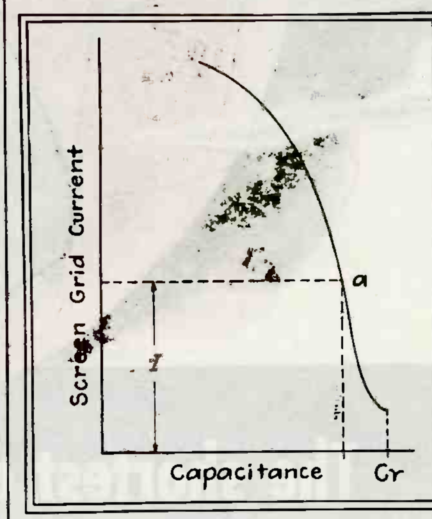


and distributor of Western Electric Watch-rate Recorders

American Time Products, INC.
580 Fifth Avenue New York 19, N. Y.

responds to the desired reading on the scale. As the width of the film becomes greater or less than the width corresponding to a zero setting of the width-gage, the meter indicates a flow of current greater or less than the value represented by the point *a* on the curve. Once this point for correct operation has been determined, calibration of the instrument becomes simple.

The difference in current can be materially amplified by increasing the Q value of the resonant circuit. The sensitivity to small changes of



Graph of change in screen-grid current plotted against change in capacitance of a resonant circuit in an oscillator

capacitance can be increased also by increasing the frequency of the generator.

For linear differences of current with changes of capacitance, the circuit should be operated on the part of the resonance curve where the change of slope is zero. With only small changes of capacitance, such a portion of the curve does exist for practical purposes. In this instrument, described by S. C. Coroniti and H. Scott Baldwin in the *Journal of the Society Motion Picture Engineers* for November, 1943, this portion of the curve corresponds to a linear response for changes of capacitance effected by variations of film width not exceeding 0.25 mm.

By replacing the d-c meter by a recording milliammeter, continuous automatic recording of variations in width can be achieved. The speed of the recording chart and of the film can be adjusted to suit the convenience of the operator.

TUBES AT WORK

An intermediate-frequency transmitter is tuned by the radioman in the training mock-up of the forward section of a PBM-3 Mariner. All equipment operates normally, as does intercom system

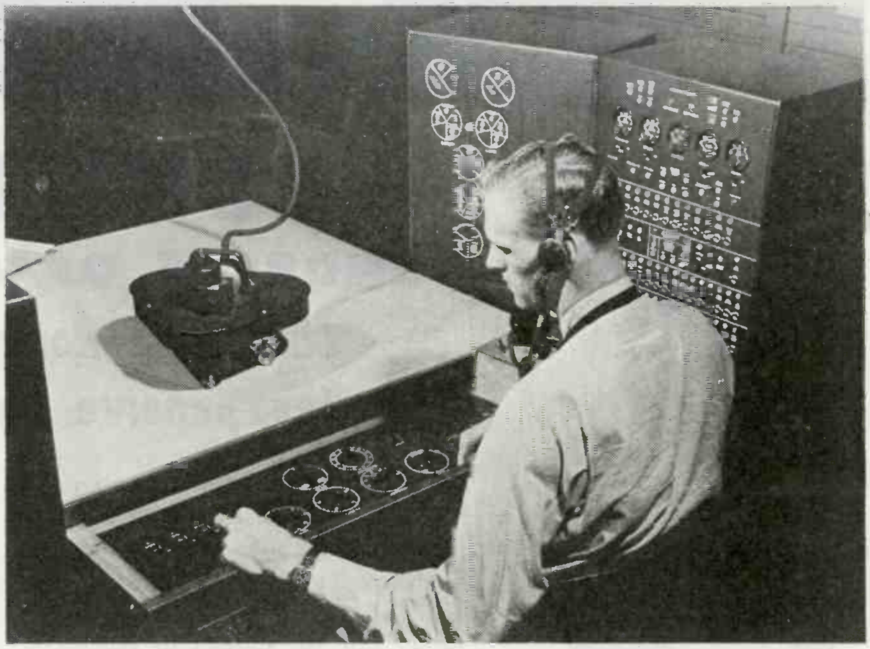
Operational Flight Trainer Uses 200 Tubes

BUILT TO RESEMBLE the interior of an actual plane, a stationary operational trainer used by the Navy uses over 200 electronic tubes and about sixty electric motors to simulate flying conditions on a PBM-3 Mariner. In addition to the normal electronic equipment used for navigation and communication, electronic units are used in computing circuits that enable an instructor to tell whether the pilot, co-pilot, radioman, navigator and flight engineer are doing what they should under various conditions in flight.

Features of the new crew-trainer are shown in the photographs. These include a mock-up of the forward portion of the plane which contains all of the regular operating controls. Steps lead through narrow passageways to the upper deck, where are located all the flight engineers' panels with their instruments, switches and knobs, primarily for engine control. On the port side is the chart table and navigator's seat and on the starboard are the radio units with a desk and chair for the radioman. In the cockpit are positions for pilot and co-pilot, with duplicate flying controls and instruments, and a bank of indicators and switches in the center.

Electronic circuits also operate loudspeakers to simulate engine noise and vibration. Starting and stopping the engines, taking off, flight, and landing operations are tied into the intricate system, and provide the proper instrument indications.

In an adjacent room, an instructor's desk contains instruments that duplicate those in the plane, at the pilot's, engineer's and radioman's positions. By watching these instruments, the instructor can see just what is going on in the plane at all times. He can also listen in on the crew's intercom conversations and hears all radio messages passing between the plane and a simulated control tower. He follows the actions taken by the crew, gives instructions when necessary, monitors the actual course that would be flown as a result of the actions of the crew, and is also able to adjust conditions so as to find out how the crew responds to emergencies or to changed conditions of flight.



Flight problems for the crew in the electronically-equipped trainer are set up by the instructor. Values of wind velocity, direction, rough air, wing ice, etc., are determined by the knobs. Monitoring of the crew's actions is done with the aid of the indicator panel at the right and the flight recorder (called the "crab") on the desk that automatically follows the course flown

The instructor causes changed conditions such as velocity and direction of wind, icing of the wings, rough air, changes in weight and center of gravity, and he can disable either or both of the engines.

At the instance of Captain Luis de Florez, USNR, head of the Bu-

Offner Electric Shock Therapy apparatus has been widely prescribed for treatment of psychiatric patients for more than five years. From the very first experimental model to present-day production units, Guardian Overload Relays have been used exclusively to protect the patient from dangerous current surges.

Relays BY GUARDIAN

In certain types of mental disorders it is possible to shock patients back to normal by passing an electric current through brain tissues. Naturally the patient must be protected against the possibility of excessive current surges. Such protection must be positive—dependable. In providing this protection, Guardian Series L Overload Relays have established a perfect record for safe, dependable performance in hundreds of thousands of known treatments.

The Series L Overload Relay provides accurate protection against surges and overloads. Standard coils attract on 150, 250, 500, or 750 milliamperes; coils for operation on other current values are available on specification.

The large, oversize contacts used on this relay can take severe overloads without damage. They are rated for 1500 watts on 110 volt non-inductive A.C. and in A.C. primary circuits of any inductive power supply delivering up to and including 1 kilowatt. Contacts lock open and cannot be reset until overload is removed. For further information, write for Series L bulletin.

Consult Guardian whenever a tube is used—however—Relays by Guardian are NOT limited to tube applications, but may be used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

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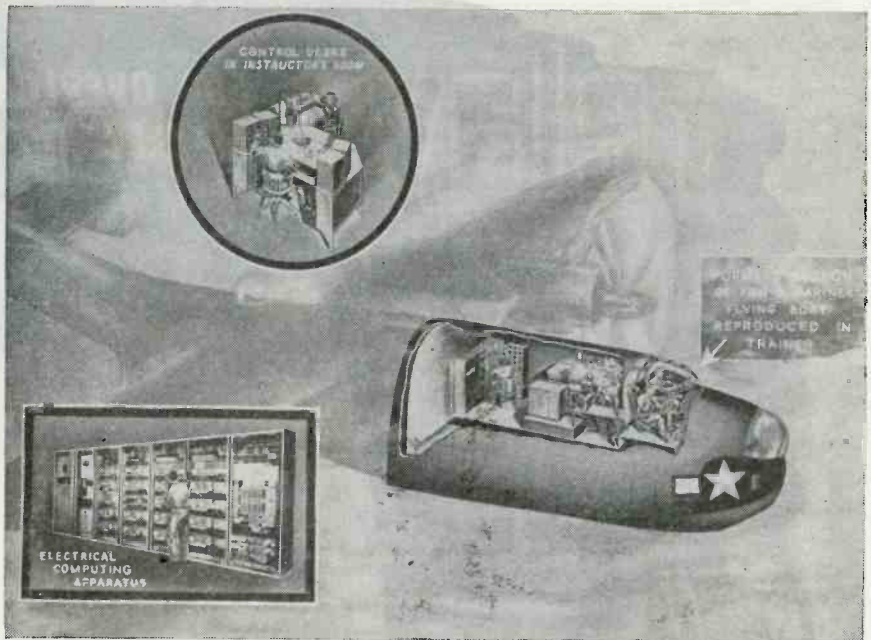


Important sections of the operational flight crew trainer used for instructing Navy airmen under operating conditions without leaving the ground. More than 200 electronic tubes and 60 electric motors are in the equipment

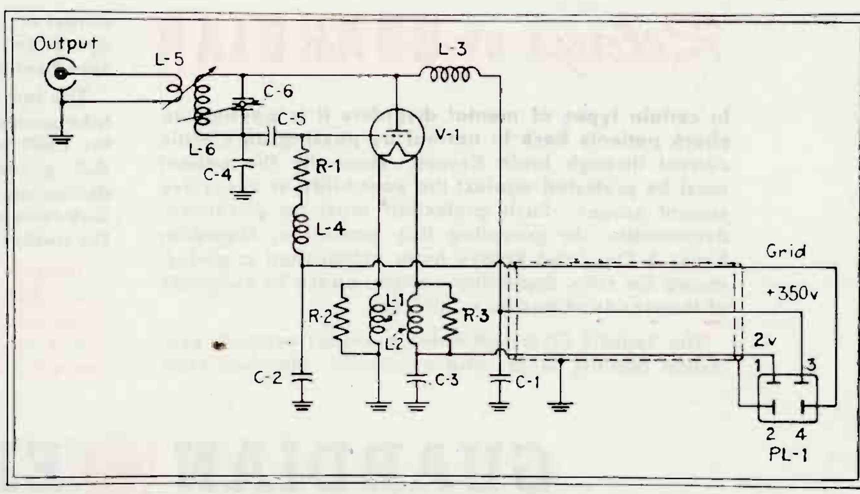
reau of Aeronautics' Special Devices Division, the first crew trainer of this type, designed and built by Bell Telephone Laboratories in 1943, was installed by the Navy at its training center at Banana River, Florida, where it is now in use daily. Subsequent trainers were built by Western Electric Company.

One of the trainers is now in use at Patuxent River, Maryland, where it is used by Naval Air Transport Service in training oceanic flight crews. This unit was shown to the press in January.

Butterfly Circuit in V-H-F Oscillator

A NEW WIDE RANGE oscillator that covers frequencies from 100 to 500 megacycles is shown schematically in the illustration. By use of the new butterfly circuit as the frequency-determining element, all sliding contacts have been eliminated.

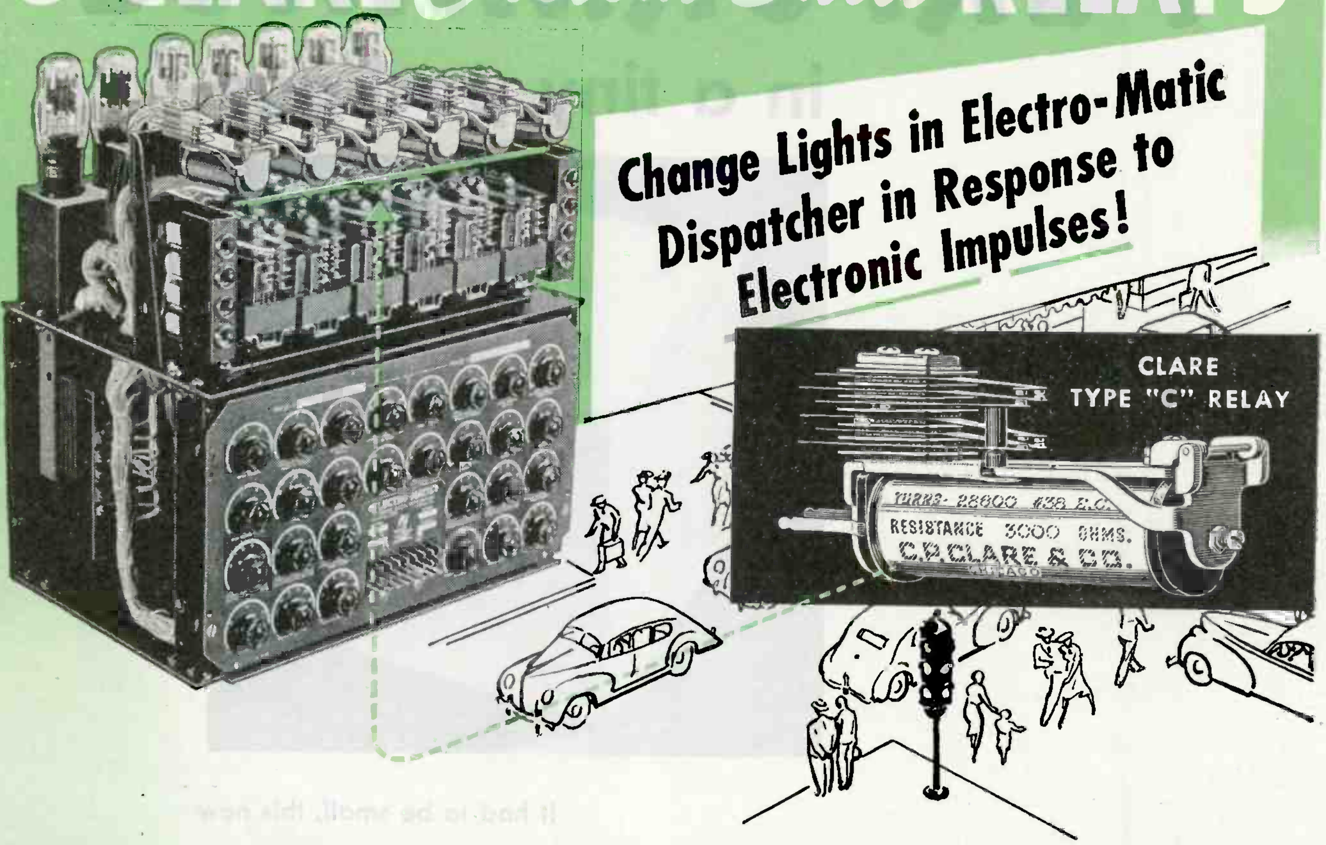
For a 120-deg rotation of the capacitor rotor, the effective capacitance of this circuit varies by a factor of 10.6 from 94 $\mu\mu$f to 8.8 $\mu\mu$f, and the effective inductance by a factor of 2.9 from 30 cm to 10.3 cm, giving a frequency range of 95 Mc to 525 Mc. The capacitance variation of the tuning circuit alone is considerably better than these



Schematic of v-h-f oscillator that contains the butterfly circuit for tuning from 100 to 500 Mc without sliding contacts

6 CLARE "Custom Built" RELAYS

Change Lights in Electro-Matic Dispatcher in Response to Electronic Impulses!



The Electro-Matic Two-Phase Dispatcher, manufactured by the Automatic Signal Corporation of East Norwalk, Conn., is a distinct advance in modern traffic control. It literally counts and times the cars in heavy traffic.

Six Clare Type "C" Relays open and close the contacts . . . cause the lights to change at the proper time . . . on actuation by electronic impulses.

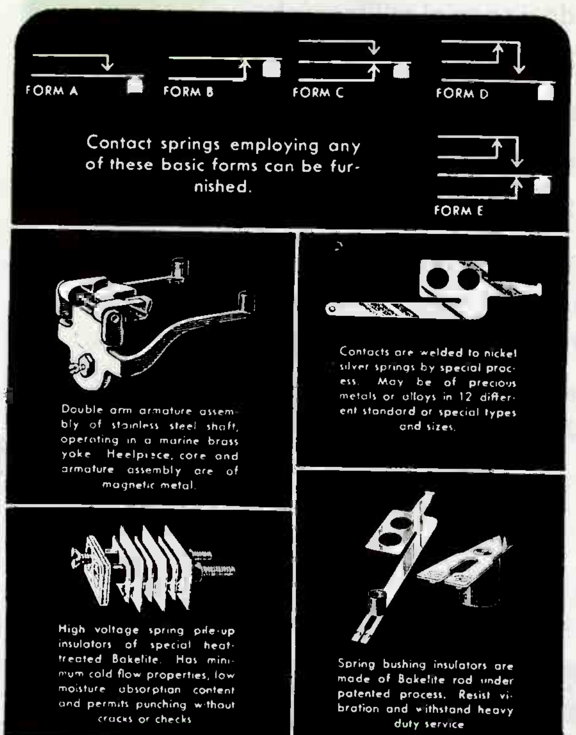
These Clare "Custom-Built" Relays were selected by the Automatic Signal Corporation for this "super traffic cop" because of their accurate and precise operation, their ability to open and close circuits quickly and their rugged construction of the finest materials.

The Clare Type "C" d.c. Relay, like all Clare "Custom-Built" Relays, has that unusual flexibility which permits design and production engineers to have just the relay for the specific function required.

By "custom-building" to exact specifications, Clare Relays assure exceptional service in spots where hard usage, long life and absolute dependability are prime factors. Special features of Clare construction adequately meet severe conditions of temperature, humidity, atmospheric pressure, voltage and vibration.

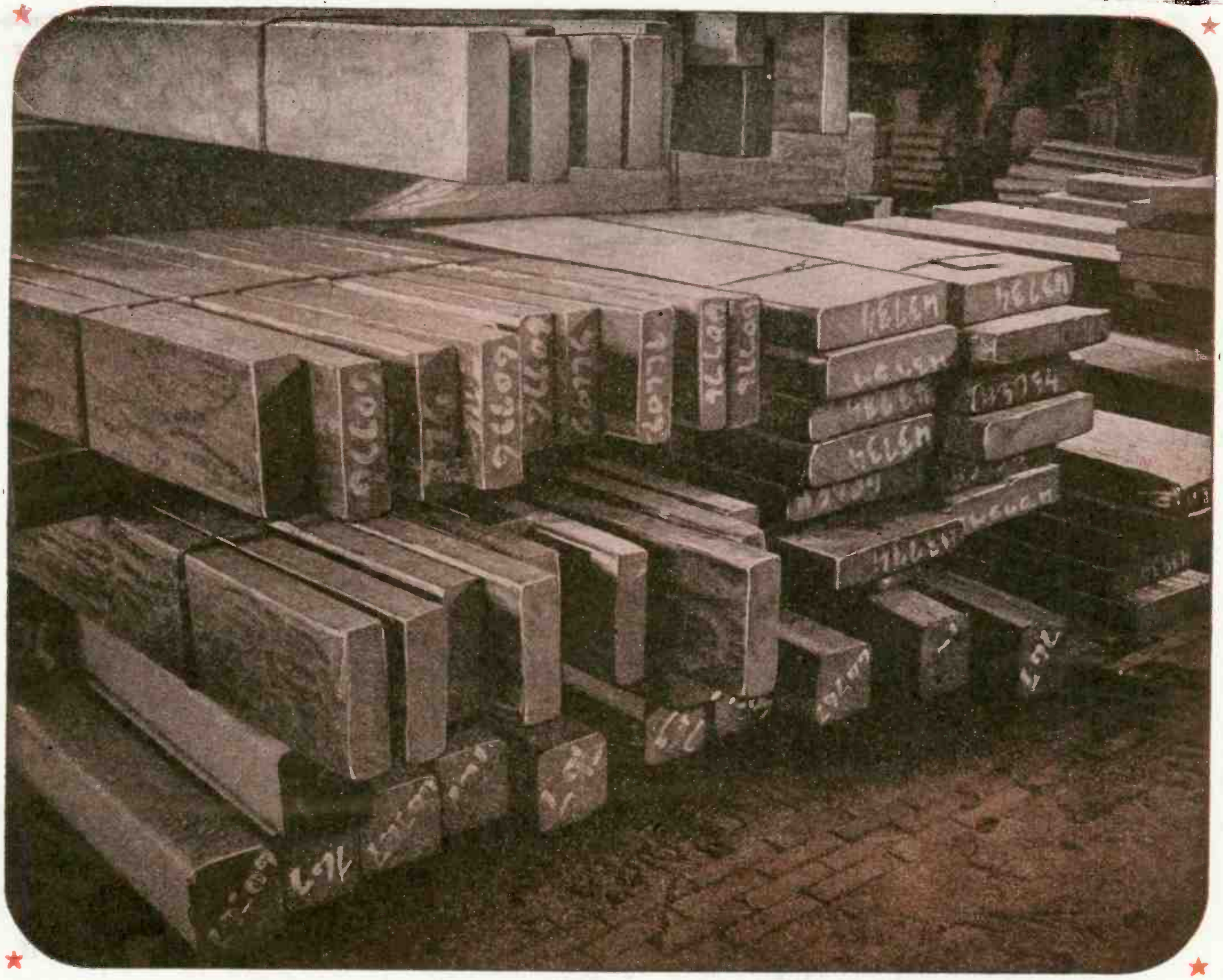
Pictured and described here are a few of these Clare "Custom-Built" Relay features that make it possible for Clare Relays to reduce overall relay cost, simplify installation and insure more dependable performance in such applications as sequence control of machine tools, radio, radar or other electronic controls, electric eye controls, counting equipment and alarm systems.

Whatever your design problem, there is a Clare "Custom-Built" Relay to meet it. Clare engineers are ready at all times to assist in developing a relay "custom-built" to your exact requirements. Send for the Clare catalog and data book. Address: C. P. CLARE & CO., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Sales engineers in all principal cities. Cable Address: CLARELAY.



CLARE RELAYS

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



OWI Photo by Palmer in an Allegheny Ludlum plant

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ADDRESS DEPT. E-31

THOSE slabs and billets of special high-alloy steels, awaiting further processing in Allegheny Ludlum plants, are raw materials for the world's finest mechanical equipment. They're also the main reason *why* it's the finest. Special steels give the extra performance—the superior electrical properties, or strength and toughness, or resistance to heat, wear and corrosion, as the case may be—that gives one product the edge over another.

That is true for combat equipment, and it's true for commercial products. Our principal high-alloy products are corrosion and heat-resisting, tool and die, electrical, valve and nitriding steels. Many of them we originated. Let us help you to fit them into your products and plans, and to handle them economically.

STEEL FOR THE NATION'S WELFARE

Allegheny Ludlum

STEEL CORPORATION

BRACKENRIDGE, PENNSYLVANIA

W&D . . . B-9338

figures indicate since the grid-to-plate capacitance of the oscillator tube and a trimmer capacitor are added to the minimum capacitance.

Grid and plate of the oscillator tube are connected directly across the tuned circuit as shown in the diagram. The filament of the tube is fed by chokes, allowing it to assume a potential determined by the electrode capacitance of the tube and by the capacitance of the tuned circuit to ground. This latter capacitance is adjusted to optimum value by a small grounding capacitor. To compensate for variations in tube electrode capacitance, a trimmer capacitor is provided.

The main dial is calibrated directly in megacycles. The vernier dial carries 100 uniform divisions and covers the tuning range in approximately 10 revolutions. An auxiliary scale on the main dial indicates revolutions of the vernier.

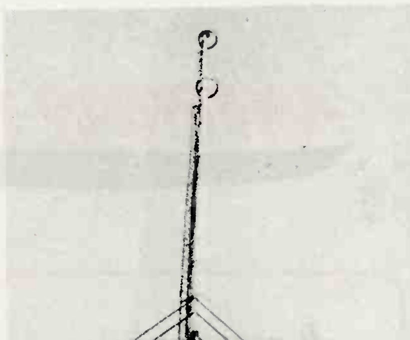
Power Supply Indicator

A type 316-A vacuum tube is used in the oscillator circuit. Connections to a separate power supply are made through a 4-conductor shielded cable permanently attached to the oscillator.

The plate voltage supplied is 350

• • •

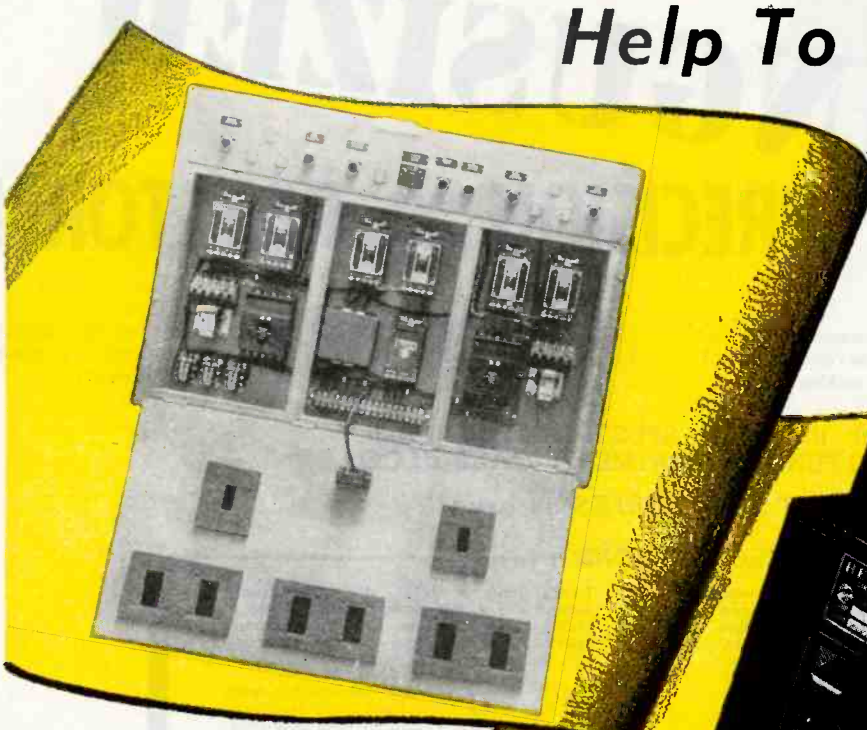
F-M ANTENNA ON HIGH



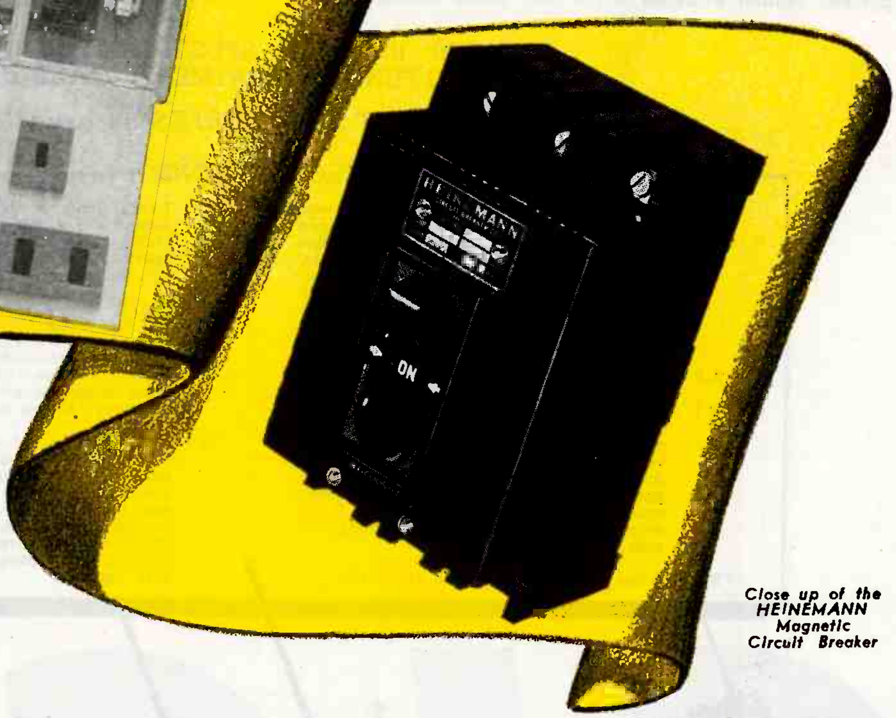
A new two-bay General Electric circular antenna was recently installed by Columbia Broadcasting System engineers atop the 700-ft building at 500 Fifth Avenue, New York City for use by station WABC-FM. Provision has been made for adding two more bays to this 14-ton structure, the height of which is 100 ft above the roof. When the antenna is put into use, CBS will have the first f-m station in New York City to cover its assigned area

How Can a HEINEMANN MAGNETIC CIRCUIT BREAKER Help To Melt Glass?

Ask atc They Know!



Open view of
ATC Automatic Time Control Panel
Showing HEINEMANN Circuit Breakers in Place



Close up of the
HEINEMANN
Magnetic
Circuit Breaker

"FULLY MAGNETIC"

describes the most important feature of the HEINEMANN Circuit Breaker. This means that these breakers have a fully electro-magnetic trip unit that acts instantaneously on short circuits or dangerous overloads. They also have a true inverse time delay in a hermetically sealed unit which allows passage of inrush current. Continued overload, however, opens the breaker in time inverse to the ratio of the current. Breakers are manufactured with time delays closely matched to customer's specification. Magnetic Blowout Contacts mounted in individual arcing chambers add speed to the arc interruption.

When Automatic Temperature Control Co., Inc. wanted dependable equipment to be used as component parts in conjunction with the A T C complete line of automatic time controls, they turned to HEINEMANN for the protective device. And when the Hartford-Empire Co. developed its revolutionary new method of glass melting, the HEINEMANN Magnetic Circuit Breakers on the time control panels supplied by A T C bore the responsibility of protecting many thousands of dollars worth of vital equipment. It may be that HEINEMANN Magnetic Circuit Breakers can perform an equally important service for you.

Send For Catalog Showing Complete Line and Engineering Data

HEINEMANN CIRCUIT BREAKER CO.

Subsidiary of Heinemann Electric Co., Established 1888

97 PLUM STREET, TRENTON, N. J.

ELCO meets the challenge of the Jungle with

FUNGUSIZED*

PRECISION *wire-wound* RESISTORS!

ELCO engineers not only met the new requirements of the U. S. Signal Corps, but exceeded them by several hundred percent. Further evidence of the way ELCO tackles a job.

ELCO *FUNGUSIZED RESISTORS are so treated to combat the destruction powers of parasitic organisms. They are made to stand up in stifling jungle heat and humidity.

IF YOUR RESISTOR SPECIFICATIONS CALL FOR ANTI-FUNGUS TREATMENT—*CALL ELCO*

***PROMPT DELIVERIES** as usual!*

SPECIFICATIONS:

"A-1"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—½% standard accuracy—non inductive pie wound—½ watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A-R"—Same as A-1, with leads reversed.

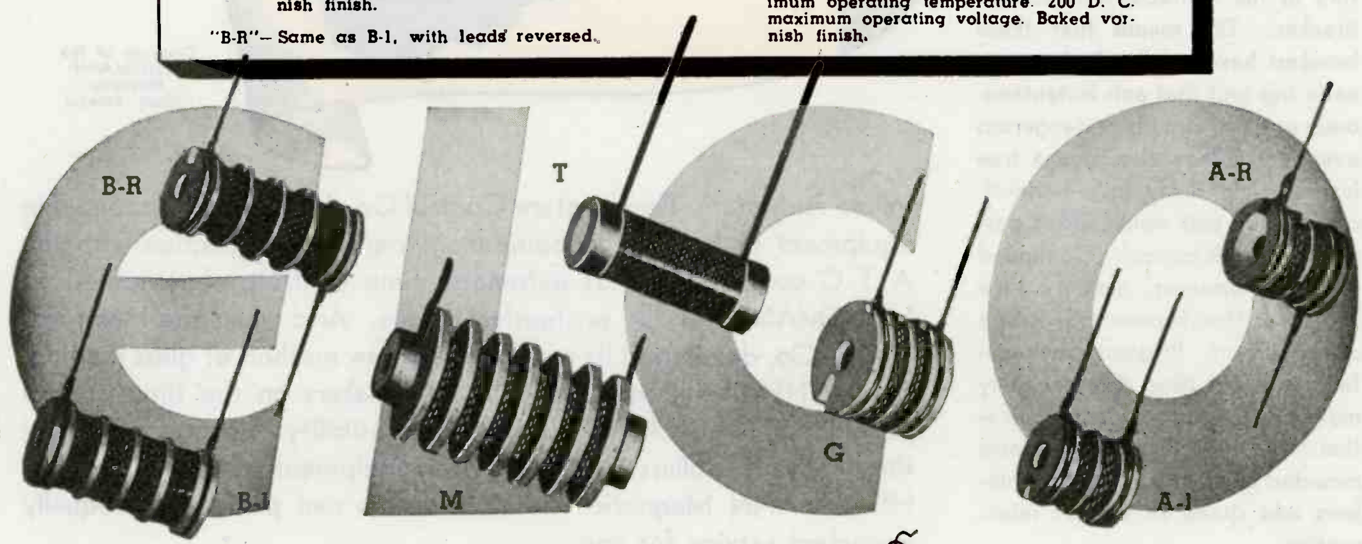
"B-1"—15/16 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—½% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—⅛ x .015 strap terminals—35 to 35,000 ohms—2 watts. 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

"M"—1-13/32 long x ¼" dia.—Mountable with 6-32 screw—⅛ x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy Baked varnish finish.

"G"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. ½% standard accuracy—non inductive pie wound .8 watts, 30° C. 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

BH NON-FRAYING FIBERGLAS SLEEVING

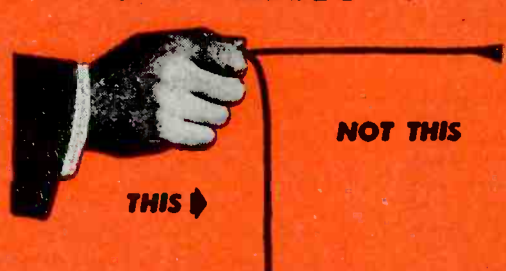
ENDS "WIRE THREADING" WORRIES

BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

2 WAYS BETTER

THIS NOT THIS

NON-FRAYING



NOT THIS

THIS

NON-STIFFENING

INSERTING bare wire in rough sleeving that frays out on the ends is time- and patience-consuming. The job is much simpler and less irksome when you use BH *Extra Flexible* Fiberglas Sleeving, the non-fraying, smooth bore insulation that takes fine-stranded wires without a hitch.

Special-processed BH Sleeving is *permanently* flexible and non-fraying. It won't harden and crack with age, and it won't burn. In addition, it has all the other desirable electrical and physical features of inorganic Fiberglas.

If you're looking for an easy-working, long-lasting insulation, why not try BH *Extra Flexible* Fiberglas Sleeving? It's available in all standard colors and sizes from No. 20 to ⅝", inclusive. Write for samples today!

BH SPECIAL TREATED FIBERGLAS SLEEVING CUTS CLEAN, DEFIES HEAT

Here's another high quality BH Fiberglas Sleeving. No saturant is used in the exclusive BH process, yet the sleeving will not fray when cut and withstands heat up to 1200° F. Made in natural color only—all standard sizes. Try it!

BH PRODUCTS

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

BENTLEY, HARRIS MANUFACTURING CO.

Dept. E Conshohocken, Penna.

volts, which is the highest voltage that can be used unless precautions are taken to prevent destruction of the oscillator tube if oscillations are stopped by overcoupling to the load. In addition to filament and plate supply circuits, the power supply contains an electron-ray tube connected to indicate the grid current of the oscillator. The eye of the indicator tube is closed in operation and opens when grid current is interrupted.

Coupling to the load is inductive and is varied by turning the shield of the output jack between two positions marked maximum and minimum, and further variation of the coupling is obtained by moving the output jack in and out through the metal housing.

The maximum power output obtainable from the oscillator is approximately 1 watt at 500 Mc and is greater at lower frequencies.

Made by General Radio Company, the unit replaces the type 757-A v-h-f oscillator announced in 141. Both use the same tube but the new unit is half the size and weight.

• • •

Enemy Radiosondes Compared to Ours

CAPTURED ENEMY RADIOSONDES give fewer readings than ours and therefore are less accurate. They are well built and well designed, and are smaller in size and lighter in weight than American instruments. Their mercury thermometers and manometers are not suited for mass production since certain component parts can be made only by hand, and at least two precalibrations are necessary. The foreign instruments use vibrators and transformers to obtain desired voltages and alternating currents.

The Germans have two types of radiosondes in general use. One type employs wet and dry bulb mercury in glass thermometers for measuring temperature and relative humidity, and a mercury-filled glass manometer for determination of pressure. The glass tubes have metal coils on the outside distributed through the operating length of the mercury columns within the glass tubes. Two transmitters are used, and two radio frequencies and two antennas are required. Constant tracking of the signals at


SAVE TIME!
..the insulation that clips hours off assembling production time—
TURBO
★ FLEXIBLE VARNISHED TUBING
★ SATURATED SLEEVING
★ VARNISHED GLASS TUBING
★ EXTRUDED TUBING
★ WIRE IDENTIFICATION MARKERS
...new efficiencies!
TURBO insulation sleevings offer multiple installation and maintenance advantages. All encompass a full range of vivid colors for rapid identification, and perfect concentricity for easy application. The extra flexibility of these quality products permits flexing over sharply bent conductors. The exclusive inside impregnation of TURBO assures an extra installation factor, and rapid snaking and fishing operations.
There is a TURBO insulation available to meet any particular requirement—low moisture absorption, abrasion resistance, high dielectric strength, immunity to heat, cold, acid and alkalis. For rapid identification of conductors, tubes, pipes and rods, TURBO Wire Markers provide clear, permanent marking. Any characters or inscription can be provided. Installation of markers is rapid, simple —color to specification. A letter on company letterhead will bring you the TURBO Sample Board showing sizes and types of each.
WILLIAM BRAND & CO
IF IT'S TURBO IT SAFE-GUARDS
276 FOURTH AVE., NEW YORK, N. Y.
325 W. HURON ST., CHICAGO, ILL.

the ground station is apparently required to operate this set.

Chronometric radiosondes that employ bimetallic elements to measure temperature, and hair hygrometers to measure humidity are also used by the Germans. Temperature contacts are made twice a minute, humidity contacts once a minute.

In Japanese radiosondes, pressure is determined in much the same way as in the chronometric instrument of the Germans; however, there are only seven contacts. These also must operate on two radio frequencies.

Our radiosonde operates with one transmitter whose carrier is audio modulated. Variation in audio modulation can be translated into meteorological data. The signal is received and graphically recorded on a chart. The number of contacts can be counted and the pressure read. Then the elevation is determined. Some American radiosondes have 80 contacts; others 95.

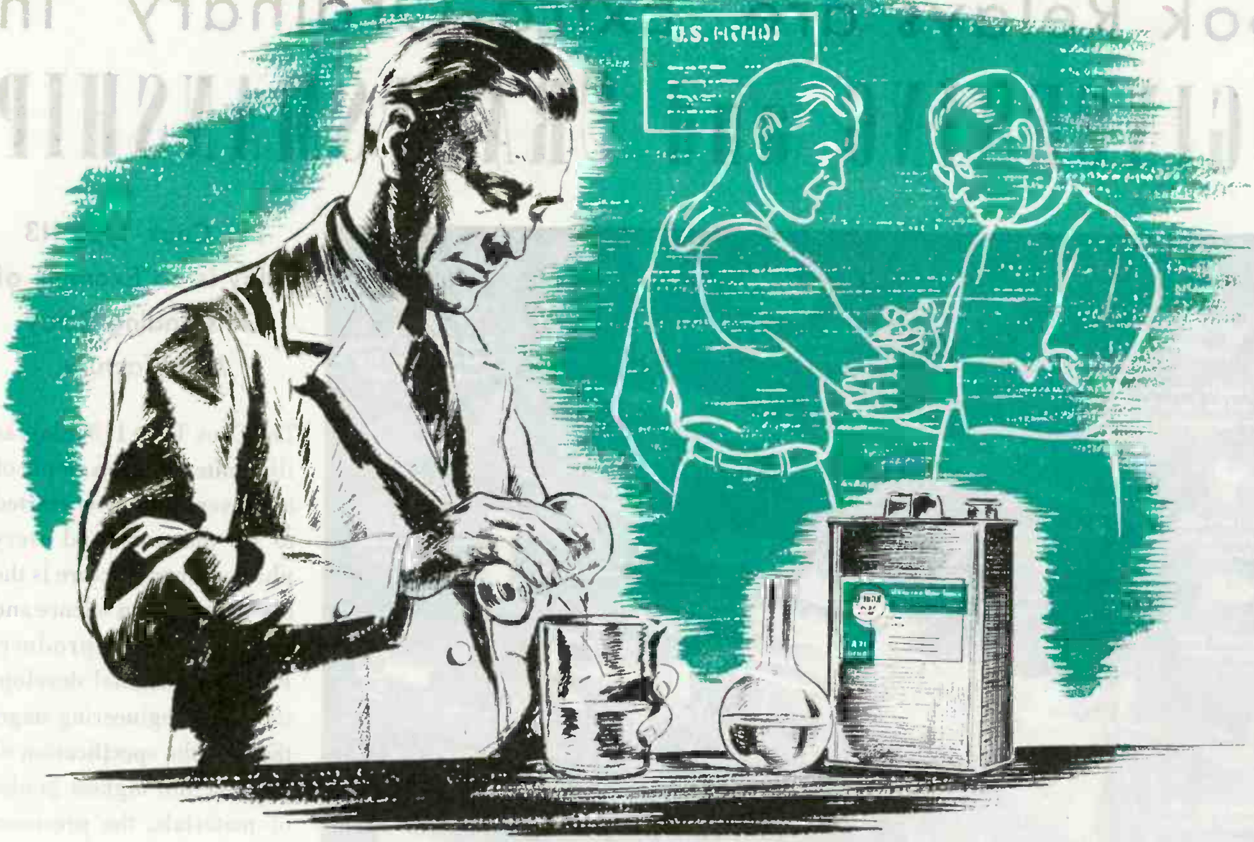
• • •

Sound Equipment Spots German Guns

WITH THE BRITISH Fifth Army, electronic sound equipment in listening posts is used for plotting the location of enemy gun positions.

When the report of an enemy gun reaches a listening post in the forward area, a man on duty presses a button which starts the recording machine of a sound ranging unit at headquarters. As the sound wave reaches each of several microphones or resonator, spaced out along the hill, it is converted into an electrical impulse and passed along a telephone cable to the recording machine. At the recording machine, the electrical impulse causes a wire to vibrate. There is a wire for each microphone, and an image of each wire is thrown onto a moving strip of sensitised paper. When one wire vibrates, the vibration is recorded as a sharp zig-zag which breaks an otherwise straight line. The distance between zig-zags on adjacent microphone recordings represents a time difference.

There is an infinite number of places, at increasing distances away from the microphones, which will give the same time difference for a sound wave reaching the two



TROPICALIZED . . .

BOTH MEN AND COMMUNICATION EQUIPMENT NEED PROTECTION AGAINST THE TROPICS

Just as G. I. Joe is innoculated to protect him against germs before he sails for the tropics, so today are many delicate parts of communication equipment dipped and brushed with Tropicalized Q-Max A-27 H.F. Lacquer before it reaches the tropics and its performance enemy, fungi and mold.

To Q-Max research chemists, must go credit for finding the right fungicide-and-lacquer combination. Many effective fungicides were discarded because they were incompatible with the lacquer, or interfered with its good electrical characteristics, or its fine corrosion resistance.

But Q-Max "know how" found the correct fungicide and the Tropicalized lacquer is so effective that it not only fungus-proofs the coated area, but the untreated surfaces adjacent to the treated part as well.

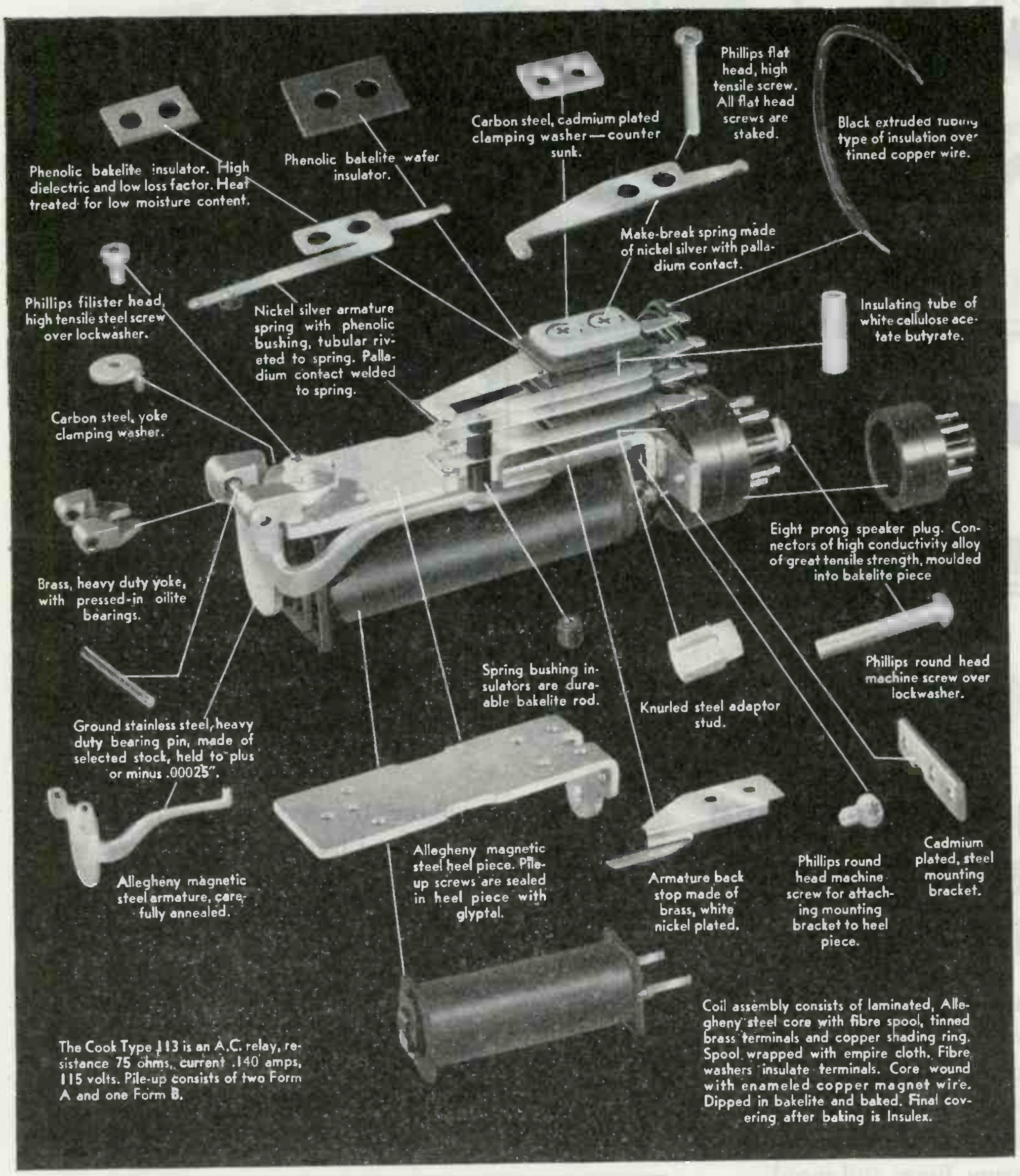
In war or peace, it's always worthwhile to play safe and use Tropicalized Q-Max A-27 H.F. Lacquer to fungus-proof components of your electrical and communication apparatus. Specify "Tropicalized"—it's on the Q-Max label.

COAXIAL TRANSMISSION LINE & FITTINGS
STERLING SWITCHES
AUTO-DRYAIRE
ANTENNA & RADIATING SYSTEMS
TROPICALIZED Q-MAX A-27 H. F. LACQUER

Communication PRODUCTS COMPANY, INC.

Q-MAX CHEMICAL DIVISION: 346 BERGEN AVENUE, JERSEY CITY 5, N. J.

Cook Relays are "Extra-Ordinary" in
ENGINEERING and CRAFTSMANSHIP



The Cook Type 113 Relay Is an Example of Outstanding Relay Manufacture

The Cook Type 113 relay, as illustrated, is an example of how every energy is exerted to see that each and every phase of manufacture is the best that modern science and engineering can produce. From the original development and engineering stage, through the specification of the best and highest grades of materials, the precision manufacture of all parts, the careful assembly, the rigid testing of the completed relay, every step along the way is an operation in which Cook craftsmen take pride, with the knowledge that on their efforts depend the continuance of the Cook reputation for the production of "extra-ordinary" relays.

Nothing is left to chance with a Cook relay, each part is a carefully engineered item, all materials must pass the inspection of our metallurgical laboratory, there is no "wishful thinking" that some stock-bin part is "good enough". . . It's this close attention to detail that makes Cook relays "extra-ordinary."

Whether your requirements are for a standard type relay or a special type relay for an unusual application, you can rely on Cook engineering and craftsmanship to give you those "plus features" of performance and dependability. Cook's engineering staff is at your service to assist you with your relay problems. A staff of field engineers, located in various key cities through the United States and Canada is also available to you. Why not call on one of these experts when you desire a better relay for your finest equipment?

2700 SOUTHPORT AVENUE
CHICAGO 14, ILLINOIS

COOK ELECTRIC Company

14 MICRO SWITCHES

Control 12 Accurate Operations of this Stokes Molding Press Every 33 Seconds

Timing, limiting and safety operations of this Stokes Automatic molding press, which can perform a complete cycle in as little as 33 seconds, are accurately controlled by 14 Micro Switches:

The F. J. Stokes Machine Company of Philadelphia, Pa., turned to Micro Switch as the control components of this accurate molding machine because their small size, precise operating characteristics, long life and dependability most exactly met their requirements.

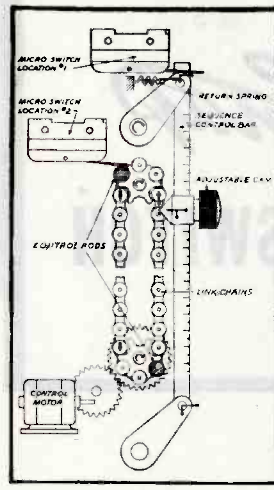
Experience of the F. J. Stokes Machine Company with Micro Switches is typical of the many uses design engineers are finding for this small, sensitive, durable, snap-action switch.

Design engineers who are planning products for the highly competitive post-war markets should be thoroughly familiar with Micro Switches and the many advantages they have to offer. We will be glad to send you as many Micro Switch Handbook-Catalogs as you may be able to use. Write for them today.

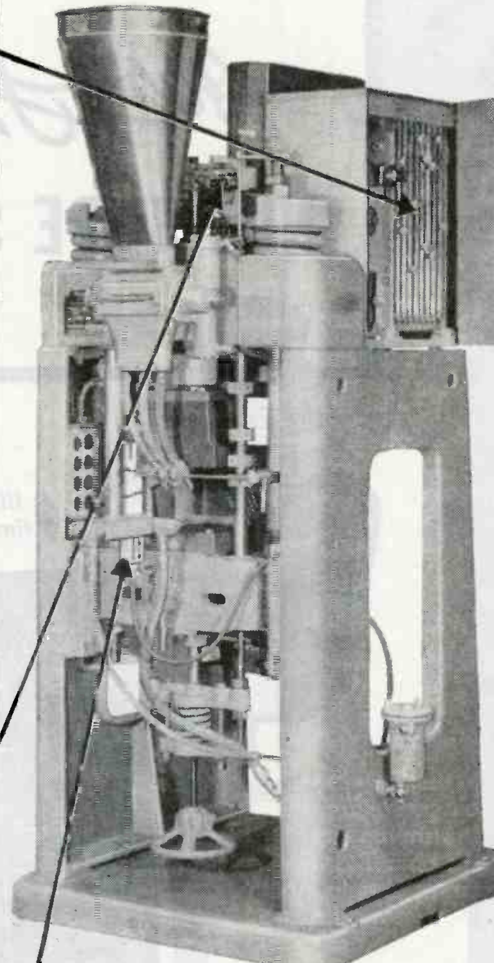
Handbook-Catalog No. 71 gives complete information on Micro Switch for use in aircraft equipment.

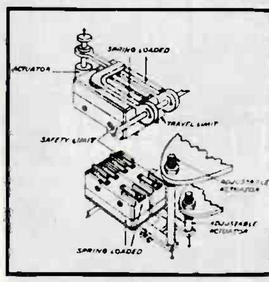
Handbook-Catalog No. 60 gives complete details on electrical characteristics, housings, and actuators.

Two stars have been added to our "E" Flag as further recognition to the men and women of Micro Switch for maintaining our war production standards.

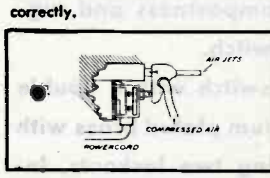


Nine Plastic Enclosed Micro Switches are used in the sequence and timer control. Eight of them are actuated by adjustable cams set along the sequence control bars. The ninth shuts off the control motor and starts the timer which determines the curing operation of the mold.





Four Plastic Enclosed Micro Switches are used—two as travel limits and two as safety limits for the press ram. The travel limits are operated by adjustable push rod actuators to stop the press ram at the correct extremes of movement. The safety limits operate only to stop the press if the others should not be set correctly.



One Die Cast Enclosed Micro Switch is used on the air and mechanical mold cleaner. It is actuated by a push rod and operates the six air jets which blow a sheet of air through the mold to blow off the molded part.

The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision, snap-acting switch. Underwriters' listed and rated at 1200 V.A. at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate reproducibility of performance is maintained over millions of operations. Basic switches of different characteristics are combined with various actuators and metal housings to meet a wide range of requirements.

MICRO SWITCH TRADE MARK

A DIVISION OF FIRST INDUSTRIAL CORPORATION

FREEPORT, ILL., U.S.A., Sales Offices in New York, Chicago, Cleveland, Los Angeles, Boston, Dallas, Portland, (Ore.)

Let's all back the attack—Buy extra War Bonds microphones. If a line is drawn from a point midway between the two microphones through all the successive positions from which the sound could have originated, the result is a curve. In practice, the curve is not employed but a straight line which gives an average is used instead.

From the difference in time the sound waves takes to strike two adjacent microphones, a bearing line is obtained. Somewhere along this line lies the enemy gun. The use of a number of microphones gives a

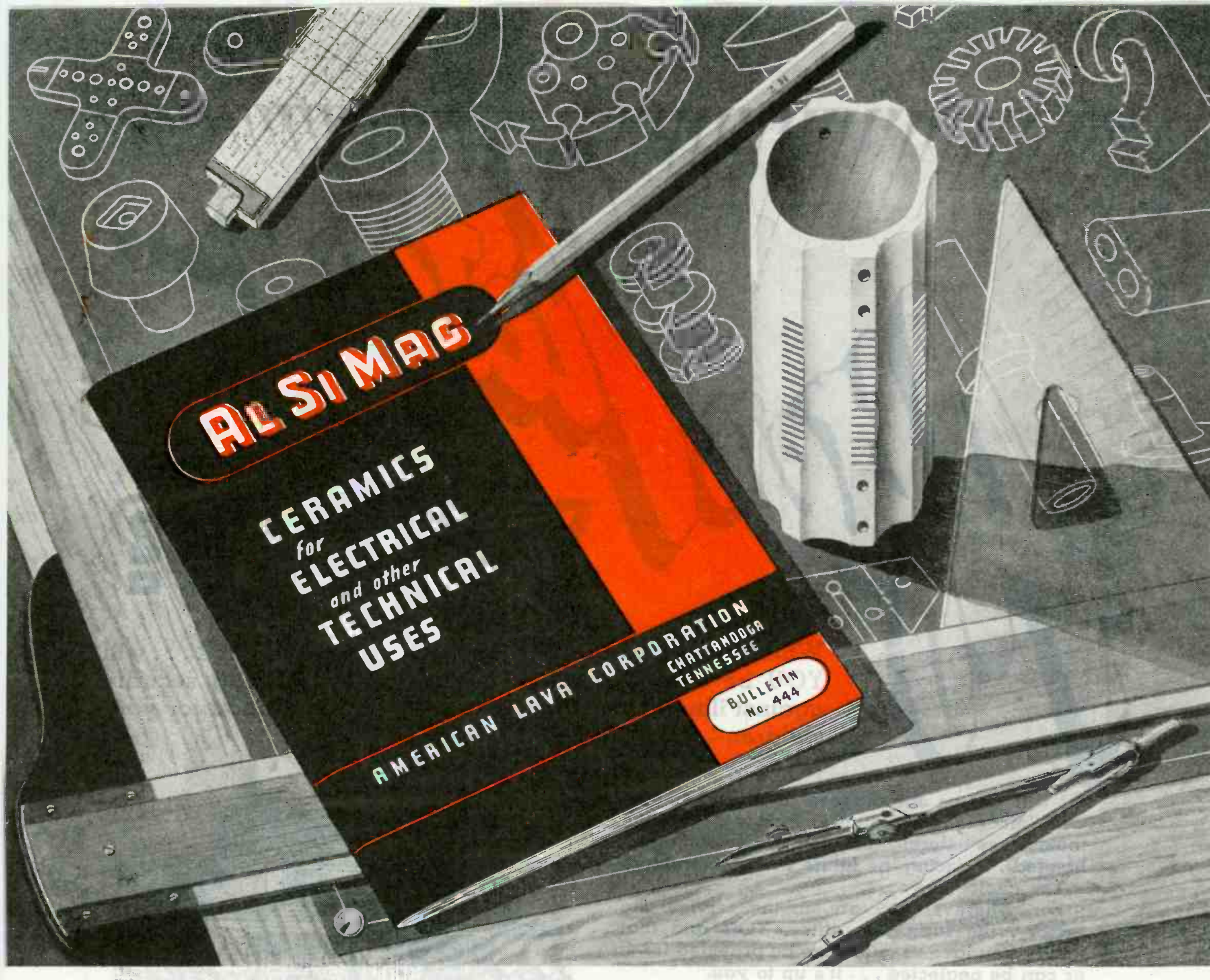
Gunfire from enemy artillery is picked up by microphones and electronically amplified to actuate recording equipment at this gun-plotting center of the British Fifth Army

number of bearing lines, and where they intersect on the map is the position of the enemy gun. Air temperature, wind speed and direction affect the accuracy of the results, and so an RAF meteorological unit is attached to the sound-ranging troops to provide meteorological information. If enemy shellfire cuts the telephone cable, the listening post immediately switches over to radio equipment and gives the order to the recording center for the recording machine to be started. As soon as the shell has landed, the machine is switched off so as not to waste paper. In this manner, enemy gun positions which are out of sight can be pin-pointed on the map.

• • •

Single-Side-Band Transmission

A PRACTICAL SYSTEM of transmitting the components of only one side band of the two side bands produced by the usual amplitude-mod-



ANNOUNCING BULLETIN NO. 444

... JUST OFF THE PRESS

BULLETIN No. 444 will prove a valuable tool in the hands of Engineers, Designers and Research Men. It is also a helpful, informative guide for Purchasing Agents.

AlSiMag Ceramic Insulator bodies, each with its particular physical and electrical characteristics, are concisely described and the uses indicated.

Typical designs taken from a roster of more than 25,000 distinct items are splendidly illustrated—in groups of applications covering electrical, electronic, industrial heating, chemical, automotive and other fields. Property charts and other technical data, together with practical information on manufacturing processes, are included.

Here is valuable, authentic information... the latest work on Ceramic insulators ... in concise, easy-to-use form. If you have not received your complimentary copy of Bulletin No. 444, please write for it today.

ALCO has been awarded for the fifth time the Army-Navy "E" Award for "continued excellence in quantity and quality of essential war production."

AMERICAN LAVA CORPORATION
CHATTANOOGA 5, TENNESSEE

a NEW *Industrial* POWER TUBE *by Federal*

Federal presents a new and rugged power tube that fills an immediate demand — a power tube that has been *specially* designed for industrial use in high-frequency heating equipment, both dielectric and induction.

Really built to withstand the constant jars, shocks, and vibration commonly encountered in manufacturing operations, this heavy-duty vacuum tube is very conservatively rated, and will stand up under extremely hard usage.

Widely spaced, unusually sturdy filament and grid elements, without internal ceramic insulation, give this tube a ruggedness that makes it the logical choice for dependability in the design of industrial heating equipment.

For industrial power tubes, and also for rectifier and transmitting tubes, see Federal first... because "Federal always *has* made better tubes."

TECHNICAL DATA FOR TYPE F-5303

Filament Voltage	11.0 volts
Filament Current	27.5 amps.
Maximum Ratings for Maximum Frequency of 50 Mcs.	
DC Plate Voltage	3500. volts
DC Plate Current	1.0 amp.
Plate Dissipation	1200 watts
Overall Height	app. 7"
Maximum Diameter	3⅛"
Supplied with 6" flexible copper leads, 2 on each terminal.	
Type of Cooling	Forced-air
(Also supplied for water-cooling, type F-5302.)	

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

Newark 1, New Jersey

ulation system has been developed by Westinghouse engineers to increase the effectiveness of the available frequency band by decreasing the width of the channels required for transmission. The new system increases the ratio of signal to noise by as much as 8 to 1, the highest of any known transmission method occupying comparable space in the frequency band.

Single-side-band signals have been generated as double-side-band signals and passed through filters to eliminate the unwanted side band. At power-line carrier frequencies it is difficult to build filters with sufficiently sharp cut-off characteristics for this purpose. Recently, circuits that permit the use of a much simpler system of single-side-band generation requiring no filters or double modulation schemes, have been developed.

In the single-side-band system, instead of continuously transmitting a base or carrier frequency and superimposing on its amplitude the voice or signal frequencies to be transmitted, only the band of frequencies representing the carrier plus (or minus, but not both) the signal frequencies are transmitted over the power line. The carrier wave itself is not transmitted; thus, the full power available is concentrated in side-band frequencies. At the receiver end, the carrier frequency is recreated and mixed with the received side band. Demodulation is effected in the regular manner. The apparatus consists of a new unit to be added to standard amplitude-modulated equipment.

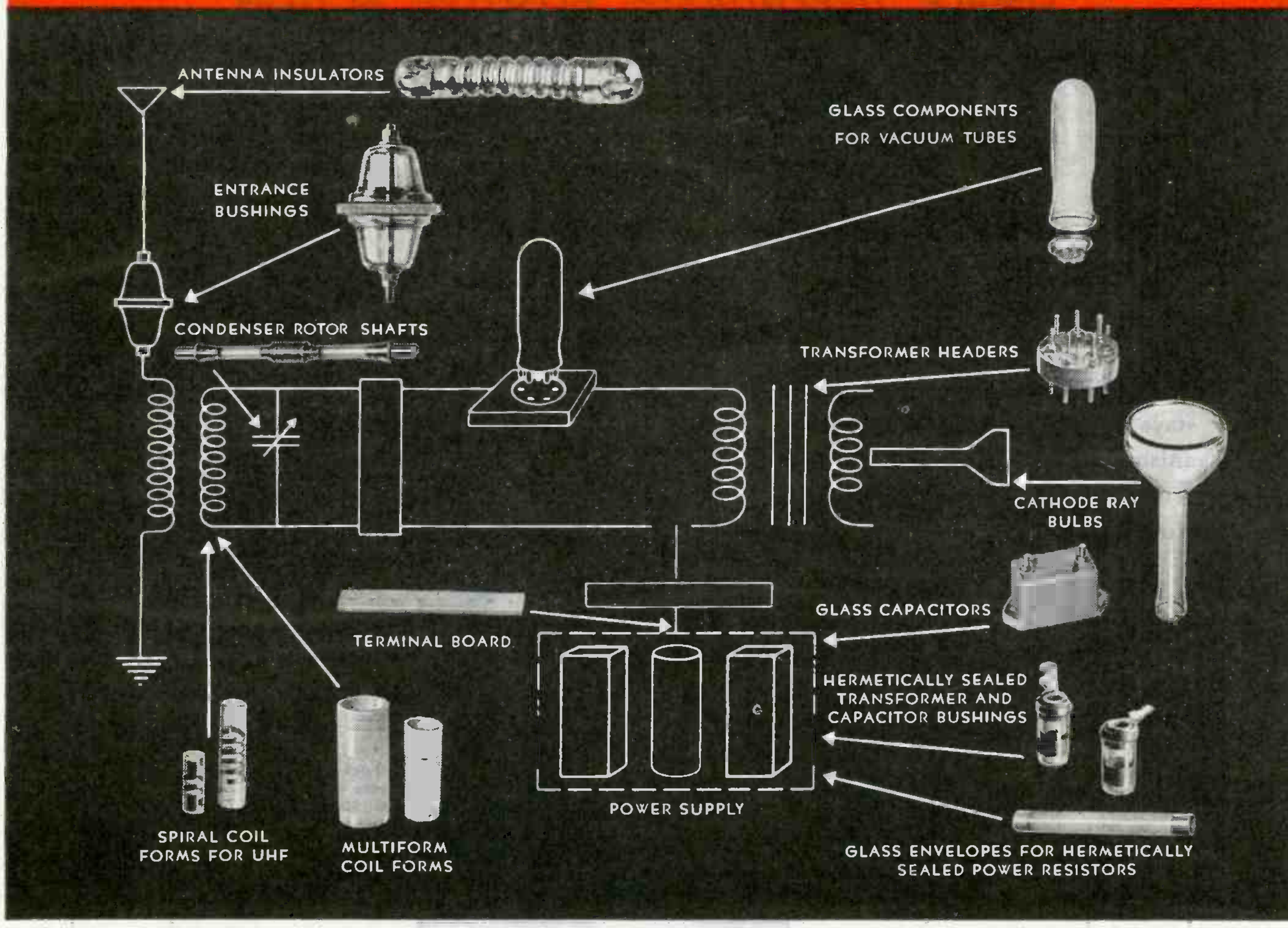
• • •

Specimen Stage for the Electron Microscope

By Perry C. Smith, Robert G. Picard and Frank E. Runge
Radio Corporation of America

One of the least discussed parts of an electron miscroscope, yet one of the most important, is the specimen stage. When it is realized that the specimen stage supports materials which are subject to tremendous magnifications, and that these materials must remain at absolute rest while photographic exposures are being made, some conception of the mechanical prob-

ARE YOU LETTING GLASS HELP YOU ALL IT CAN?



IT wouldn't be surprising if you aren't familiar with everything glass is doing in electronic equipment today. Progress has been rapid. In the above *"circuit"*, for example, you'll find it on the job in (twelve) vital places. At Corning right now we're making a lot of other electronic glassware that we can't show. After the war we'll tell you all about it.

It's no accident that a major part of the electronic glassware in use got its start at Corning. We've dug in on some tough ones and ferreted out solutions. They told us we couldn't solder metal to glass — they needed glasses with a coefficient of expansion practically equal to that of fused quartz —they needed something to take the place of mica in capacitors — Corning Research found the answers to these and many other electronic problems.

Our 250 glass experts—the men behind "Corning Research"— our facilities and all our knowledge of glass are at your service. Write for a copy of an informative new booklet "There Will Be More Glass Parts in Postwar Electrical Products." Address Electronic Sales Dept. E-2, Bulb and Tubing Division, Corning Glass Works, Corning, N. Y.

CORNING means Research in Glass

Electronic Glassware

T.M.REG. CORNING U.S. PAT. OFF. — T.M.REG. PYREX U.S. PAT. OFF.

"PYREX" and "CORNING" are registered trade-marks of Corning Glass Works

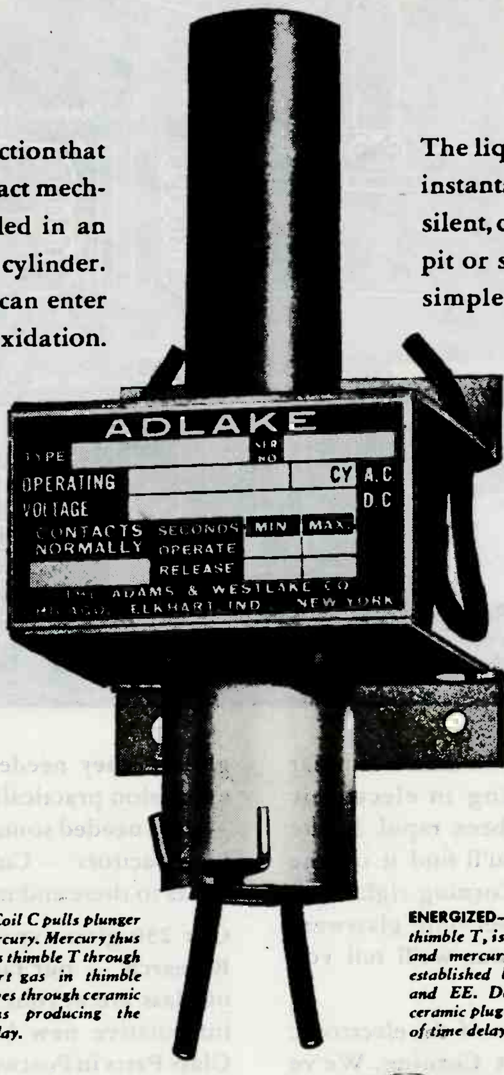
RELAYS THAT "Click" ON THE JOB!

SIMPLE, DEPENDABLE, POSITIVE ACTION

You can depend on silent Adlake plunger-type Relays to "make good" on every kind of equipment into which you design these modern, hermetically sealed mercury relays for timing, load and control circuits. May we co-operate with your designers by suggesting the type of Adlake Relays best adapted to your product?

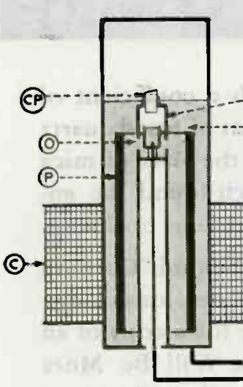
Adlake Relays have snap action that stays "snappy." The contact mechanism is hermetically sealed in an armored glass or metal cylinder. No dirt, dust, or moisture can enter . . . there is no danger of oxidation.

The liquid metal mercury contact is instantaneous, positive in action, silent, chatter-free, and cannot burn, pit or stick. No other relays are as simple, rugged and dependable. Write for bulletin.



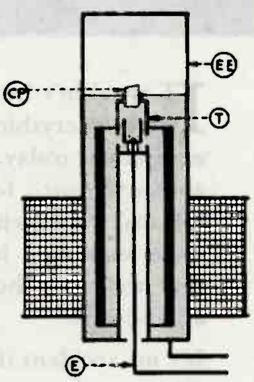
Adlake Model 1040 . . . for panel mounting . . . available with either quick or time delay action, normally open or closed.

Quick acting relays are available with contact ratings up to 50 amperes A.C. with proportional D.C. ratings.



ENERGIZED—*Coil C pulls plunger P down into mercury. Mercury thus displaced enters thimble T through orifice O. Inert gas in thimble gradually escapes through ceramic plug CP—thus producing the desired time delay.*

ENERGIZED—*Mercury now fills thimble T, is completely leveled off and mercury-to-mercury contact established between electrodes E and EE. Degree of porosity of ceramic plug CP determines length of time delay.*



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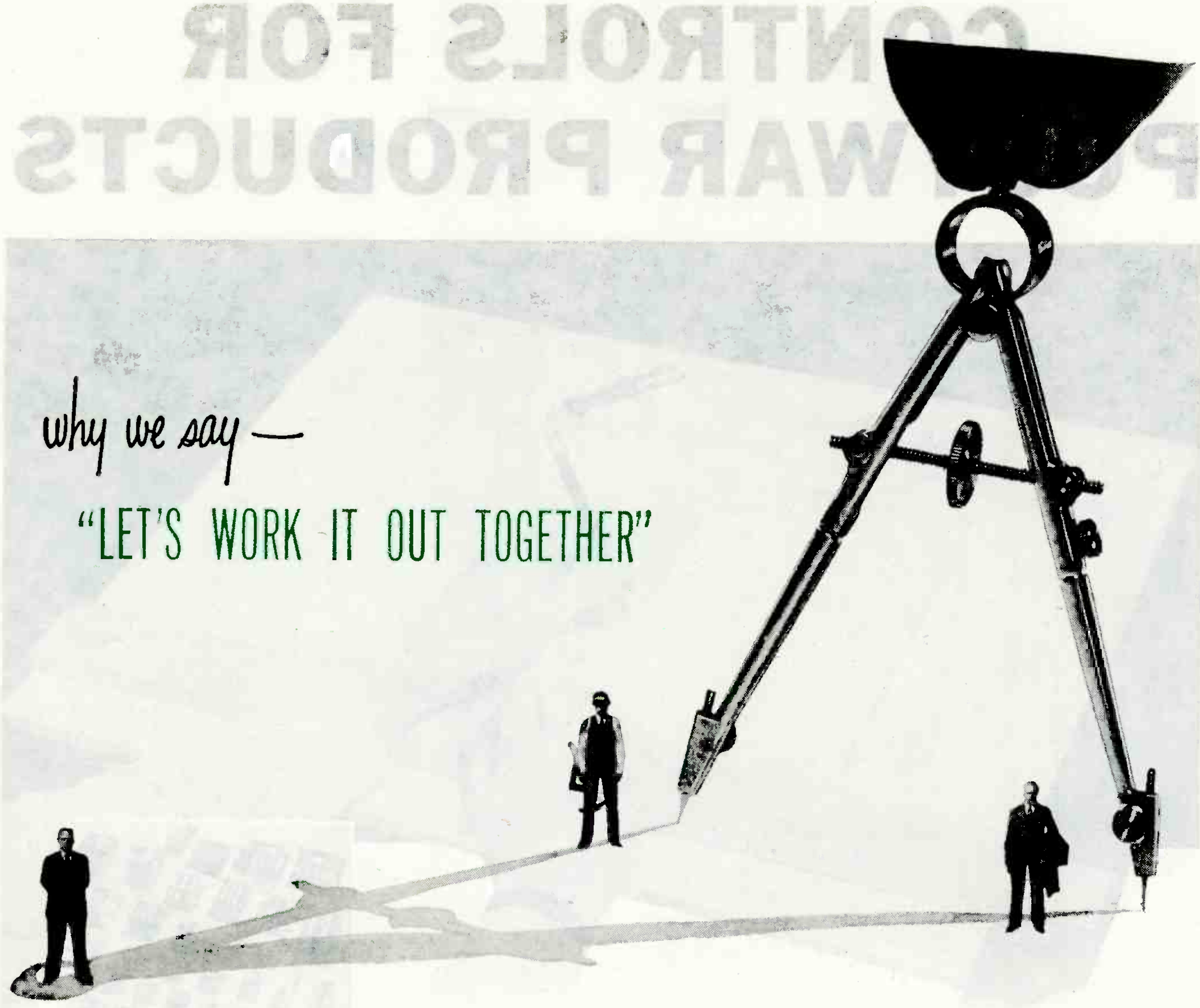
lems involved may be reached. Coupled with the above, is the problem of controlling the specimen from the exterior of a highly evacuated microscope column while at the same time not raising the pressure within the column. Design consideration must also be given to convenience of control and mechanical simplicity.

Electron microscope specimens are generally mounted on a thin film or supporting membrane, as the usual microscope slide is much too thick to be penetrated by the electron beam. Suitable films are made by casting a 2 percent solution of collodion on distilled water. As a result of low surface tension, the film material and its solvent spread out over a large area on the surface of the water. After the solvent has evaporated, the specimen is affixed to a film and supporting screen by one of several simple techniques. The film itself varies in thickness from approximately 0.0000004 inch to 0.000001 inch depending on the percent solution and solvent used. Films of these dimensions are strong enough to retain most types of specimens, are transparent to the electron beam, and show no structure of their own in the photographic image.

Use of Screen

To provide a rigid yet electron-transparent support for the rather delicate film and its included specimen, another prop is required. Generally, this is a 200-mesh screen about ⅛ inch in diameter which provides the equivalent of the glass slide common to light microscopy. Thus, a typical specimen ready for examination by electron microscopy can be imagined as a three-layer assembly consisting of a 200-mesh metal screen, a thin collodion membrane and a dispersed assortment of specimen material.

Since the penetrating action of high-speed electrons is limited to distances of about 0.00004 inch, the metal portions of the 200-mesh screens are opaque to the electron beam. A screen of 200 mesh provides an optimum number of supporting points for the collodion films, and allows a sufficient and convenient window area for specimen observation and photography. The requisites of a good screen are: 25 percent or greater total window



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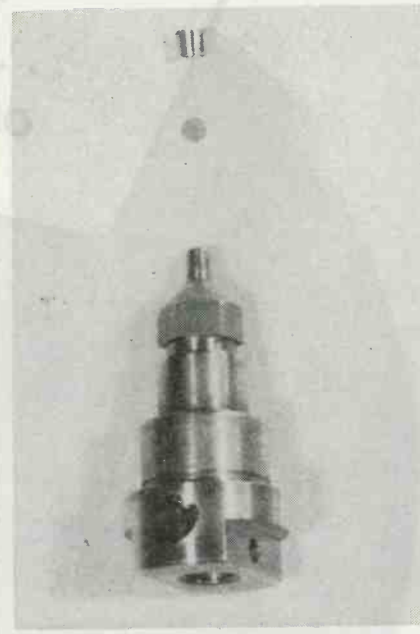
area and a clean, smooth-sided mesh made of a chemically inert material. Woven stainless steel screen which has been rolled flat until the warp and woof present practically a plane surface fulfills the requirements.

Other techniques omit the collodion film. For example, metallic oxides will cling readily to the metal screen surfaces and inner edges of the mesh. The screen is



Adjustable high-magnification specimen holder. Above it are the specimen screen and screen holder cap

coated by simply holding it in the smoke of the burning metal. Thus, it is obvious that clean smooth-mesh screens are a necessity to avoid misinterpretations of results.

Cartridge Types

Prepared specimen screens are loaded into small specially designed brass cartridges to facilitate handling and insertion of the specimen into the microscope column. Cartridges may be of various designs to accommodate varying problems and techniques. An adjustable length cartridge provides control of specimen-objective lens spacing, thereby adding to the magnification ranges obtainable through varying the focal lengths of the objective and projector lenses only. Through means external to the microscope, another design of cartridge can be made to tilt the specimen at an angle, first to one side of the electron optical axis and then to the opposite side an equal amount. The

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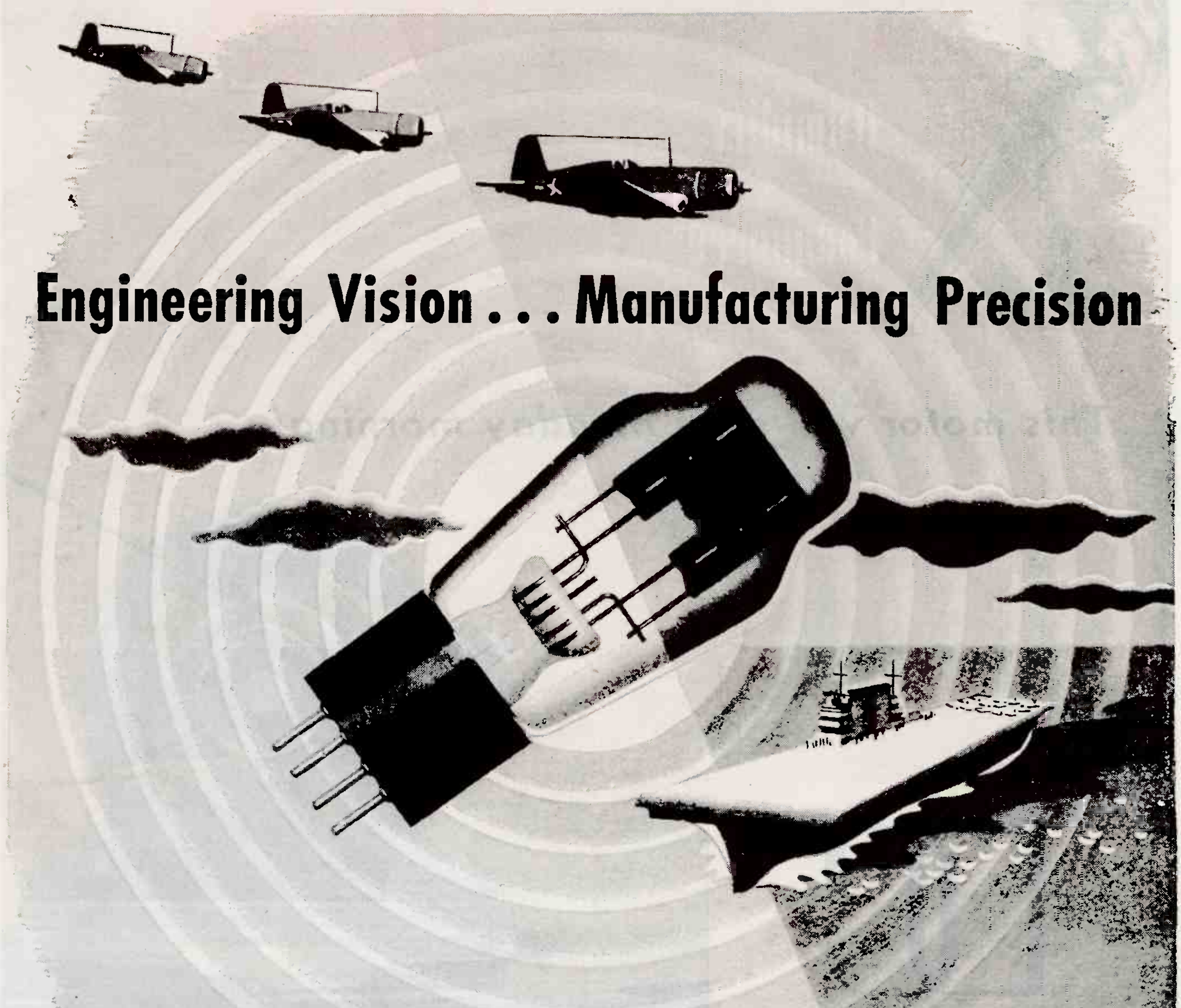

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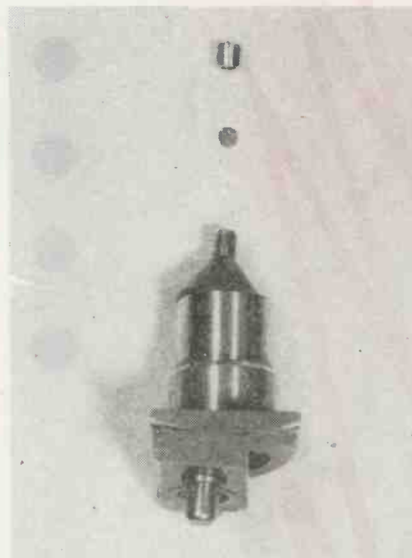
pair of negatives produced by this process, when viewed with a stereoscopic lens system, produces three-dimensional or stereoscopic images.

A $\frac{1}{8}$-inch diameter, 200-mesh screen contains about 500 holes, each hole being about 0.0025 in. square. Only 25 to 30 holes, roughly 5 percent, are scanned for specimen material and are more than sufficient for practically all studies. To scan an area 5 holes on a side, requires a specimen stage movement in one direction of 0.025 in. and another movement, at 90 deg to the first, of an equal amount.

Since direct electronic magnification may range from 100 to 20,000 times, the image of the boundary of a specimen screen hole may be $\frac{1}{4}$-in. square or it may expand to



Stereo specimen holder tilted to one side for making one of a pair of stereo negatives

slightly over four feet on a side. Considering that micrograph negatives can be photographically enlarged up to more than 10 times before the grain of the emulsion becomes a limiting factor in the quality of the details of the enlargement, it is interesting to speculate on the possible theoretical area of an enlargement of a screen window —it could embrace more than 1600 square feet!

Stage Movement

Since movement of the specimen within the microscope column is accomplished by means of a rotatable control which is coupled to the specimen stage through mechanical linkages and gear reducers, and

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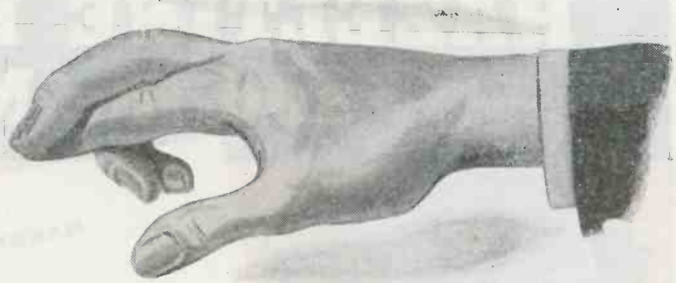

There's no substitute for Accurate Wire-Planning while Your Product is in the design stage . . .

Don't use rule of thumb methods or guess-work in selecting wire if you want to avoid the risk of putting an improperly wired product on the market. Check and correct all possible trouble-spots in your design . . . make tests under every possible service condition you can imagine . . . then specify the wire that guarantees the most dependable performance.

The chart below lists some of the major factors you'll have to consider if you want your product to be right and stay *right* under the use and abuse of service. Check it against the possibility of eliminating hot-spots and abrasion and vibration points in your design . . . also for wire requirements that will meet the anticipated conditions under which your product will operate.

The Rockbestos line of 122 standard wires, cables and cords, developed in solving the wiring problems of other manufacturers, should answer most of your needs . . . but Rockbestos Research will be glad to develop a new construction for you if required. For recommendations or engineering advice write to the nearest district office or:

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BUSHING DIAMETERS	☐	POSSIBLE OVERLOADS	☐
OPERATING VOLTAGE	☐	INSULATION RESISTANCE	☐
DIELECTRIC STRENGTH	☐	UNDERWRITERS' APPROVAL	☐
RESISTANCE TO CORROSIVE FUMES	☐	CURRENT CARRYING CAPACITY	☐
OPERATING TEMPERATURES	☐	RESISTANCE TO OIL	☐
RESISTANCE TO HEAT	☐	RESISTANCE TO COLD	☐
RESISTANCE TO FLAME	☐	RESISTANCE TO GREASE	☐
RESISTANCE TO ABRASION	☐	RESISTANCE TO MOISTURE	☐
RESISTANCE TO VIBRATION	☐	AMBIENT TEMPERATURES	☐

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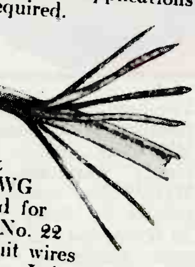

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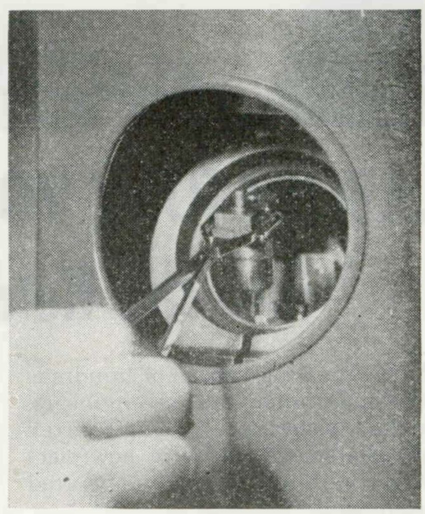
since a wide range of direct magnification is involved, an optimum of linear movement of specimen with respect to rotation of the manual controls must be chosen. For a direct magnification range up to 20,000 times, a 30-deg rotation of a able with the RCA universal microscope, a stage displacement of 0.001 inch for each rotation of a control knob was found to be most satisfactory. Thus, considering a fluorescent viewing field 3 in. square at 20,000 times, a 30-deg rotation of a control knob will produce an entirely new field provided the frame of the viewing screen is in correspondence with the frame of the window of the specimen screen. Lack of correspondence is caused by the spiral path imparted to the electron beam when acted upon by electro-magnetic fields. The stronger the magnetic field, the finer is the pitch of the spiral. Although the specimen stage movement and specimen may be in exact correspondence with the viewing



Tongs are used to insert the stereo holder into the object chamber and stage

screen mechanically, the image of the specimen may be circularly out of correspondence by anything less than one revolution for any given set of electron optical conditions.

Scanning Fields

As magnification is decreased, proportionately greater rotary movement of the control knobs is required to exchange one field for another. In any event, twenty-five rotations of each control knob must be made to move the specimen stage its permitted freedom of 0.025

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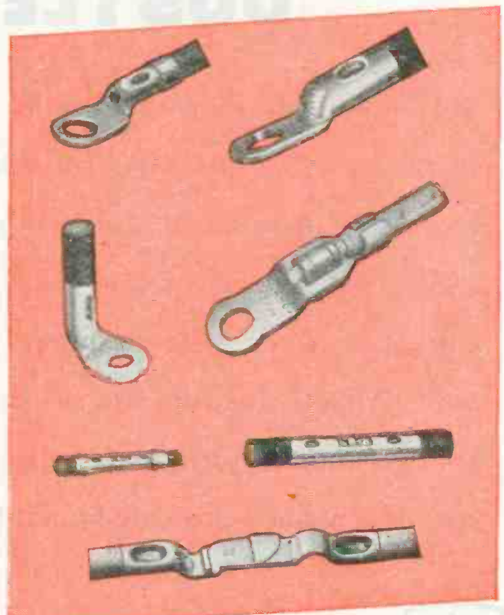

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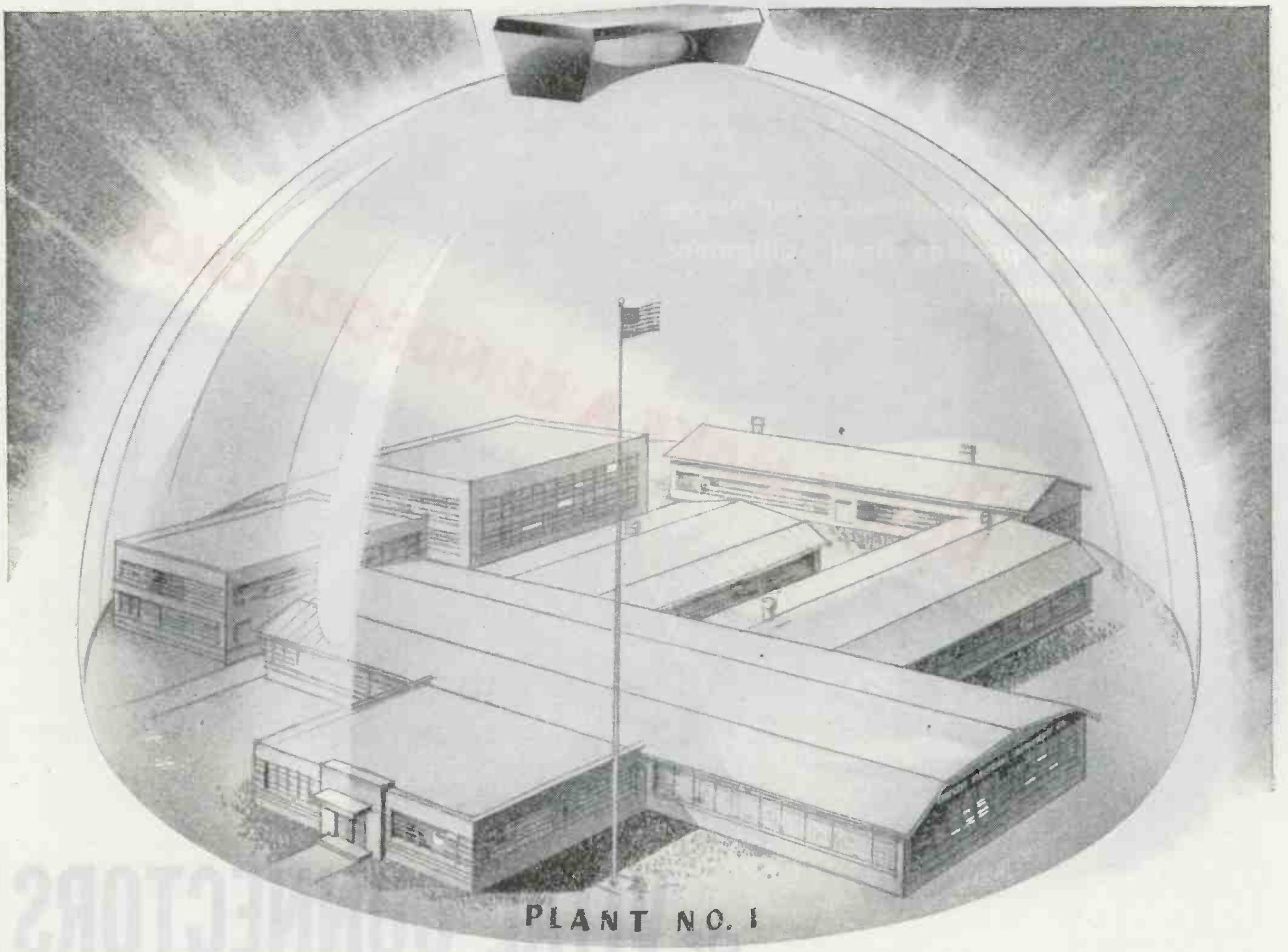

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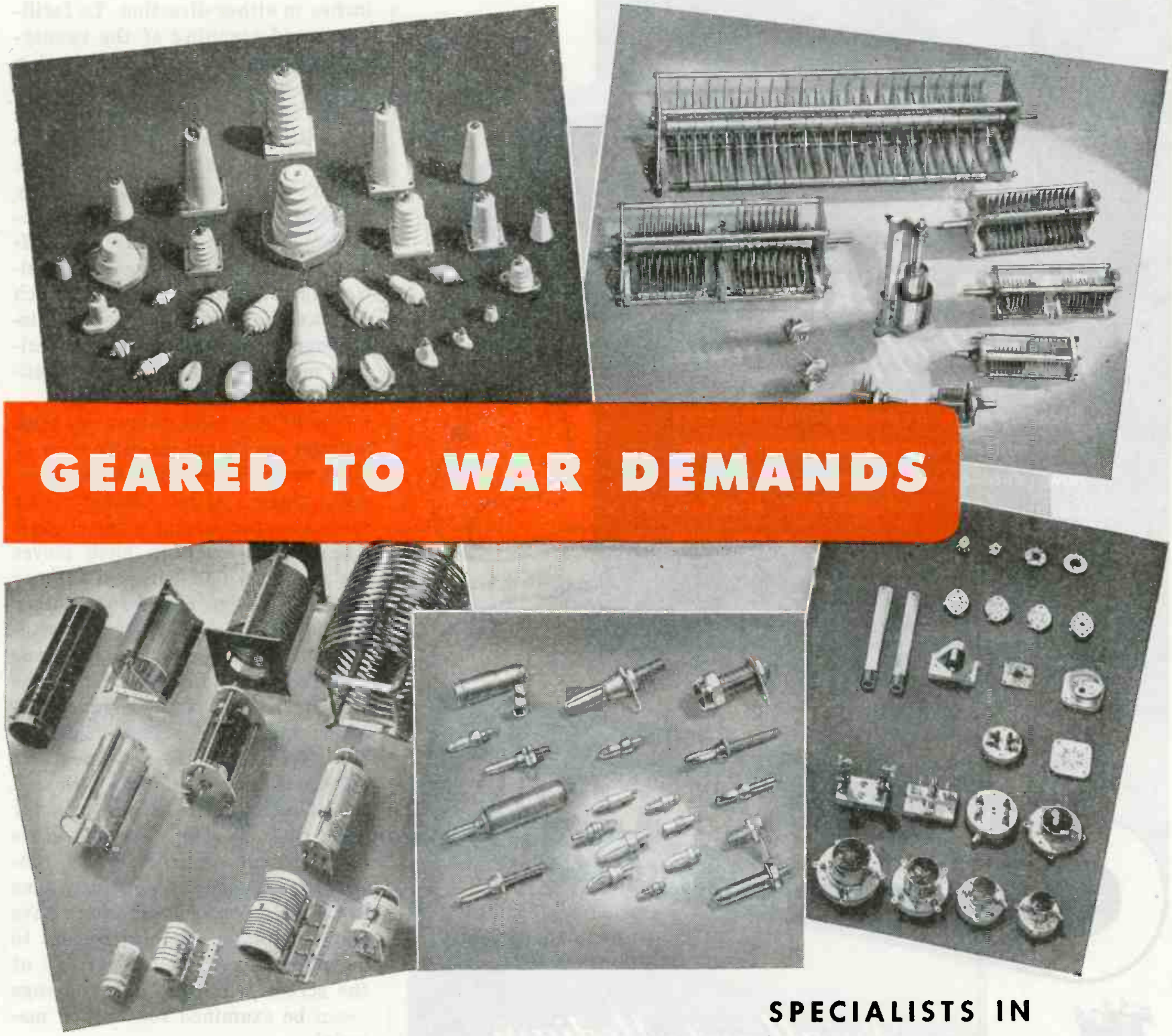

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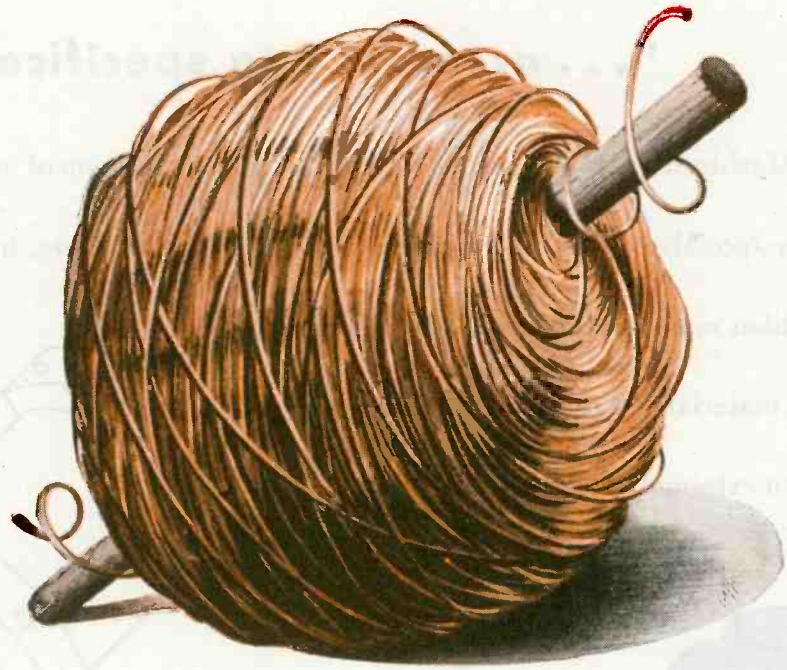
E. F. JOHNSON COMPANY • WASECA • MINNESOTA inches in either direction. To facilitate rapid scanning of the twenty-five selected holes of the viewing screen, each control knob is provided with a small stem handle near its periphery. These handles permit the control knobs to be "spun" and image fields rapidly checked for items of major interest; yet the controls are sufficiently accurate to permit positioning the image to within $\frac{1}{16}$ inch at maximum magnification, a displacement corresponding to a specimen movement of less than *3 millionths of an inch.*

The RCA console microscope with a direct maximum magnification of 5000 times is designed with specimen stage control knobs which move the specimen at a faster rate. Each revolution of a knob moves the specimen 0.010 inch. Thus one field may be exchanged for another on the 3-in. diameter viewing window by rotating a control knob approximately 25 deg. Since the viewing field is circular, image rotation and frame correspondence do not affect the total movement required to exchange fields although the direction in which the transfer takes place is still a random route for different electron optical conditions. Mechanical considerations in the RCA console microscope have allowed greater stage movement to be obtained. About 10 percent of the screen windows—100 openings—can be examined for wanted materials.

Vibration

An important factor in specimen stage design is the filtering of mechanical vibrations. It is generally sufficient to shock mount the microscope column from the cabinet to overcome average building vibration. Under extreme conditions, the whole microscope cabinet is also shock mounted. Vibrating parts within the cabinet are individually shock mounted. Since the effects of mechanical disturbances become more deleterious as magnification is increased, filtering must be adequately designed to protect the specimen stage at the highest magnification of the instrument. Specimen stages are equipped with tiny clamping springs which prevent the specimen cartridges from vibrating independently of



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View of a modern coil winding department at one of the Anaconda plants.

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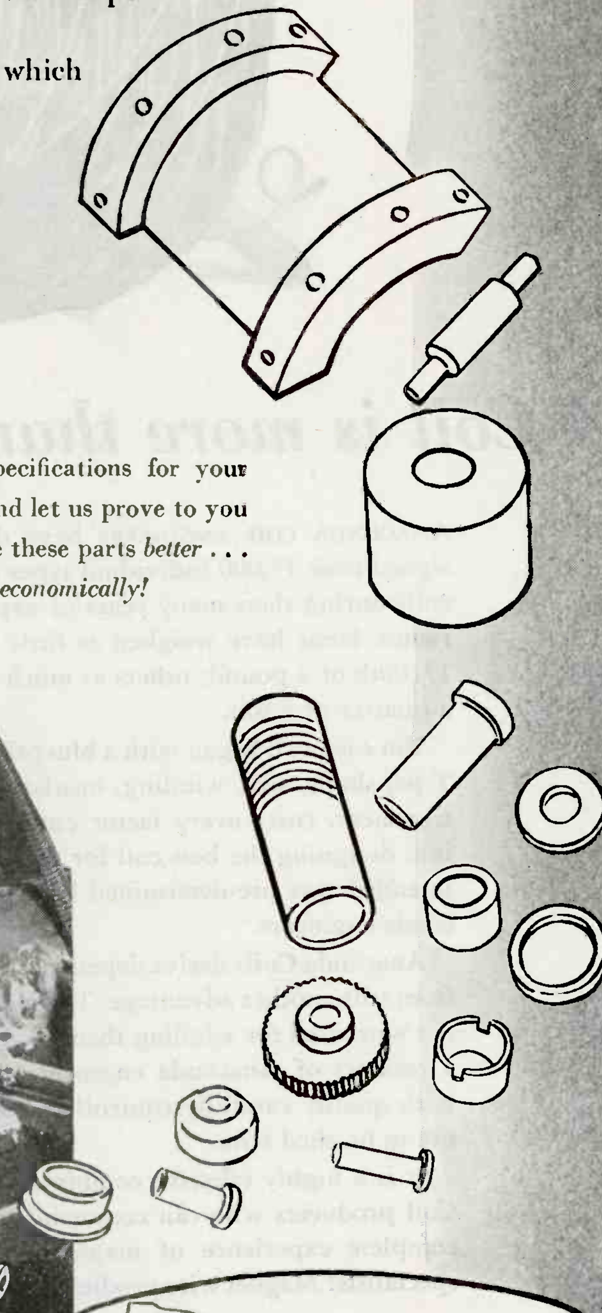

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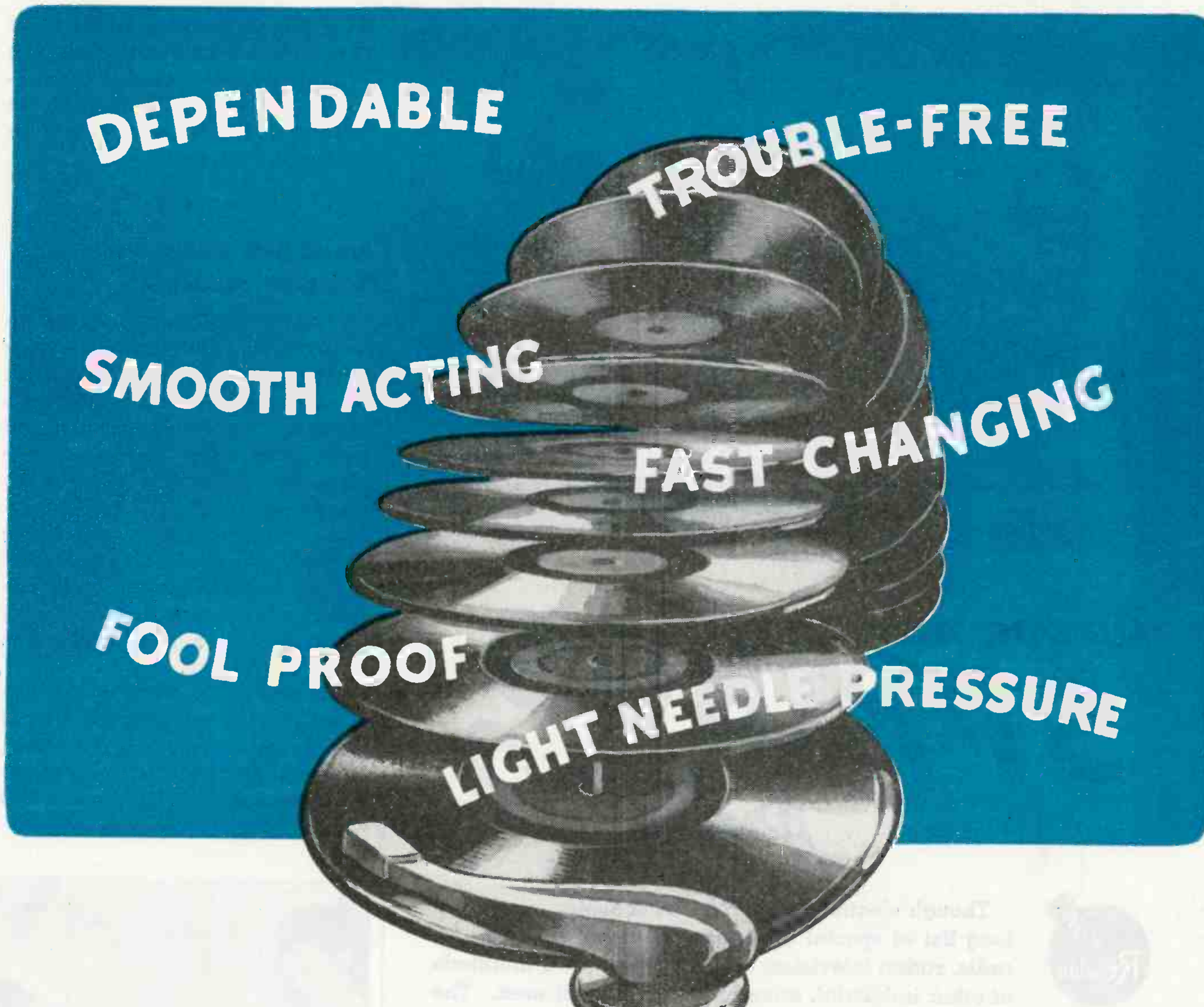

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3825 W. ARMITAGE AVE. CHICAGO 47, ILLINOIS the stage. A spurious vibration of as little as one-millionth of an inch at the specimen stage can completely destroy the identity of the smaller particles encountered in electron microscopy.

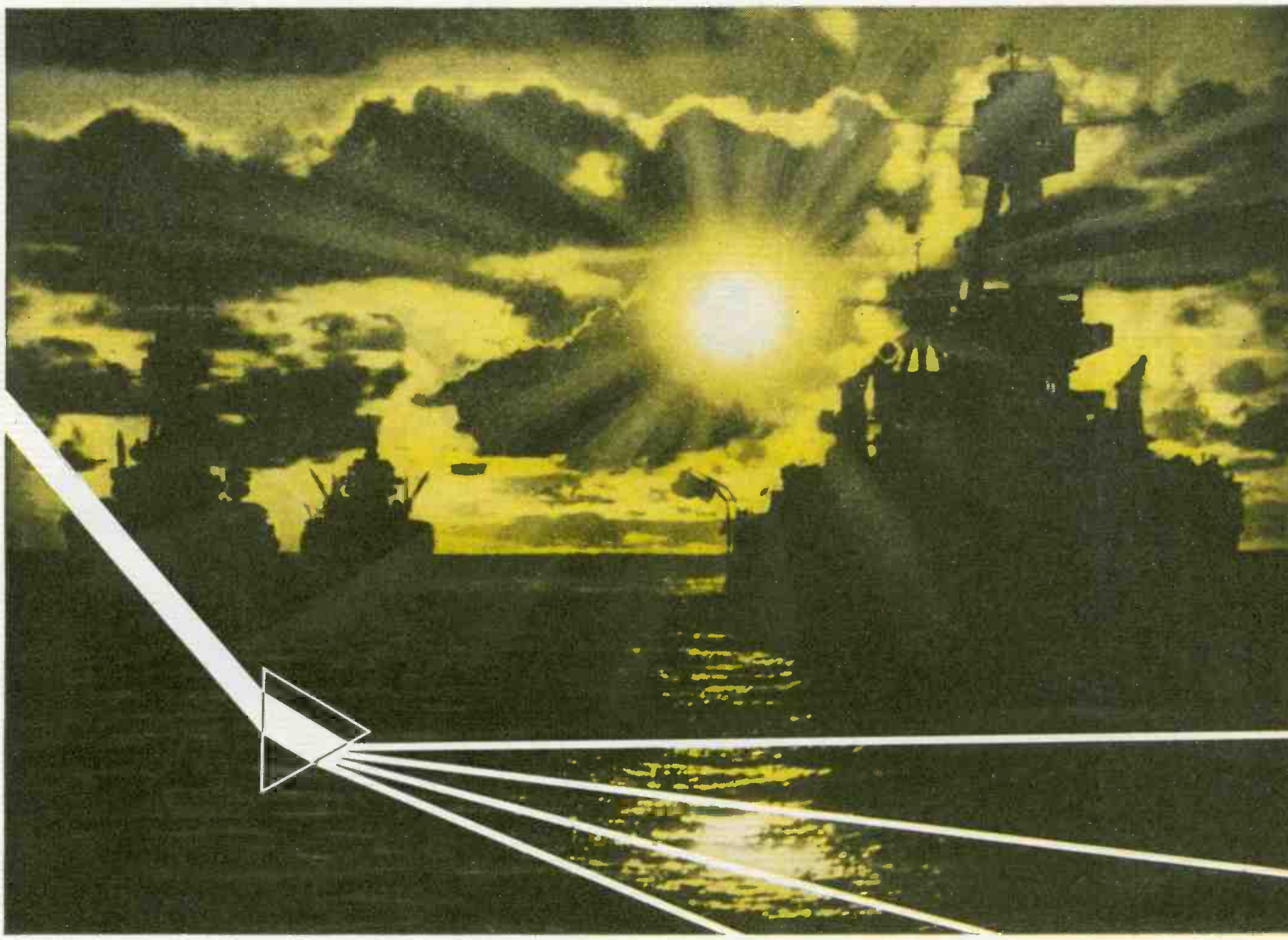
• • •

Music Sets Speed for Teletype Students

AT UNITED AIR LINES' communications school at Chicago, music from a record player is a new wrinkle in training communications fledglings to master the rhythm, accuracy and speed necessary to operate teletype machines. Daily practice sessions are accompanied by amplified recorded music, and instructors of the company's educational department say the plan has increased average speed on time tests as much as 10 to 15 words a minute after three weeks of training.

An average of 20 girls are enrolled in each seven-weeks' United Air Lines communications class, studying company policy, meteorology, weather reporting, radio and leased wire procedures. As explained by D. I. Peterson, supervisor of the training program, anyone familiar with typing can operate a teletype machine with practice, but the teletype requires a different touch than a typewriter and is geared for a set speed—usually 65 words a minute. It must be operated in rhythm to attain speed

An instructor checks the speed of a teletype student who listens to music from a record player to establish rhythm and speed



Some of the smaller things on a battlewagon

When enemy planes are in the skies, the survival of our great battleships often depends upon the accuracy of a handful of tiny pieces of glass. These are the optical components of the anti-aircraft fire control instruments. They must be as nearly perfect as the most advanced techniques can make them.

No wonder the Bureau of Ordnance of the United States Navy is so particular in the selection of these optics upon which the safety of our ships and men depends. Very few manufacturers have been able to meet the rigid naval specifications for parts like these.

Our technicians and craftsmen are justly proud that they can grind and polish glass to the exacting naval requirements. This compact group of precision lens specialists has been busy all through the war supplying our armed forces. They are looking forward to the time when they can apply their war-improved skills to the production of equally fine products for peace.

The plant in which they work has always been solely devoted to producing precision optics for other manufacturers. No other products are made here. If you have a post-war problem in optics you will find the kind of help you need in this modern, well-equipped plant.

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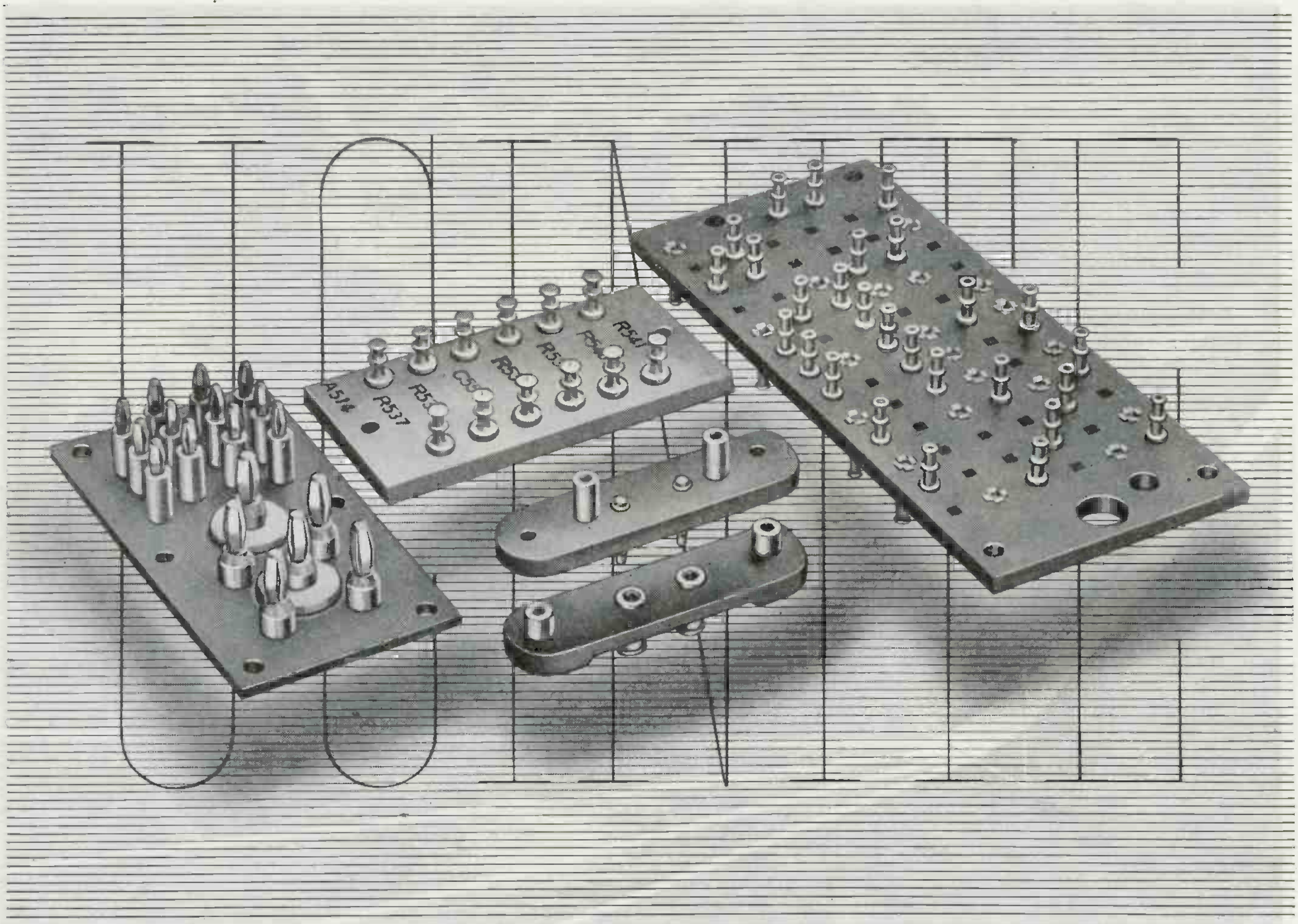

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We take them as they come. Assemblies like these are run-of-the-mill jobs at Ucinite in ceramic, bakelite or the new moulded panels which are being ordered to eliminate the deteriorating fungus growths of tropical climates.

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and accuracy, and that takes practice.

March tunes have been found best for improving speed, although records such as Frankie Carle's "Sweet Lorraine" provide an appropriate tempo for beginners. A pronounced jump in speed resulted following the introduction of music in practice sessions.

• • •

Deficiencies of Group Hearing Aids

By Arthur G. Norris

The first commercially produced group hearing aids were rather terrifying contraptions, full of knobs, wires and mystery, to say nothing of a frequency response which would not be tolerated in the cheapest radio today. The many wired appendages, complicated switching and volume control arrangements, and frequent failure of parts did nothing to alleviate the mystery and terror.

Refinement has been most apparent in the construction of parts for the sets and in their combination, but little attention has been paid to classroom utility. The present-day group hearing aids parallel closely the pattern set by the experimental sets built in the late 20's. Probably the reason for this has been that the makers of the group aids have never had to use them in a classroom full of squirming deaf youngsters. To the manufacturer, it has been a problem of high-fidelity amplification and there interest seemed to stop.

List of Defects

Most group hearing aids manufactured for classroom or auditorium use have one or more of the following defects which seriously interfere with optimum use of the equipment:

1. Over-simplification of amplifier design. Apparatus of this type is not a highly competitive product and is largely custom-built, hence there is little reason for taking the short-cuts which save pennies at the expense of precision and distortion-free output.
2. Inadequate tone control.
3. No arrangement to fit the amplifier output to the individual hearing pattern. In the present-day apparatus what is good for one

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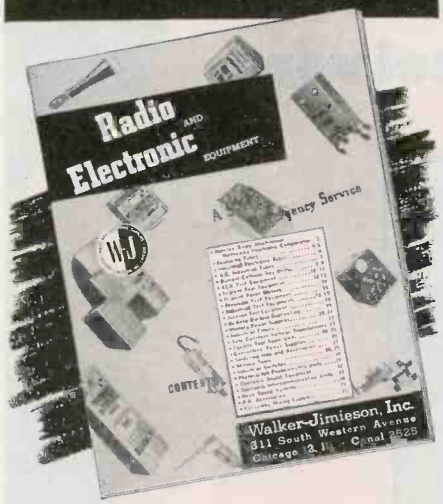

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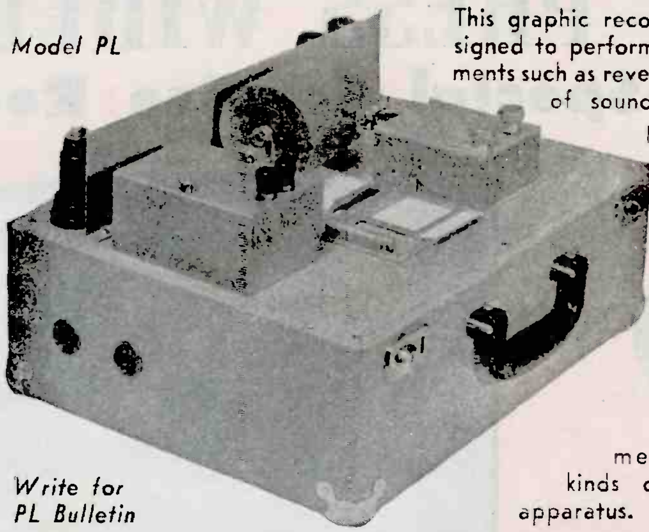

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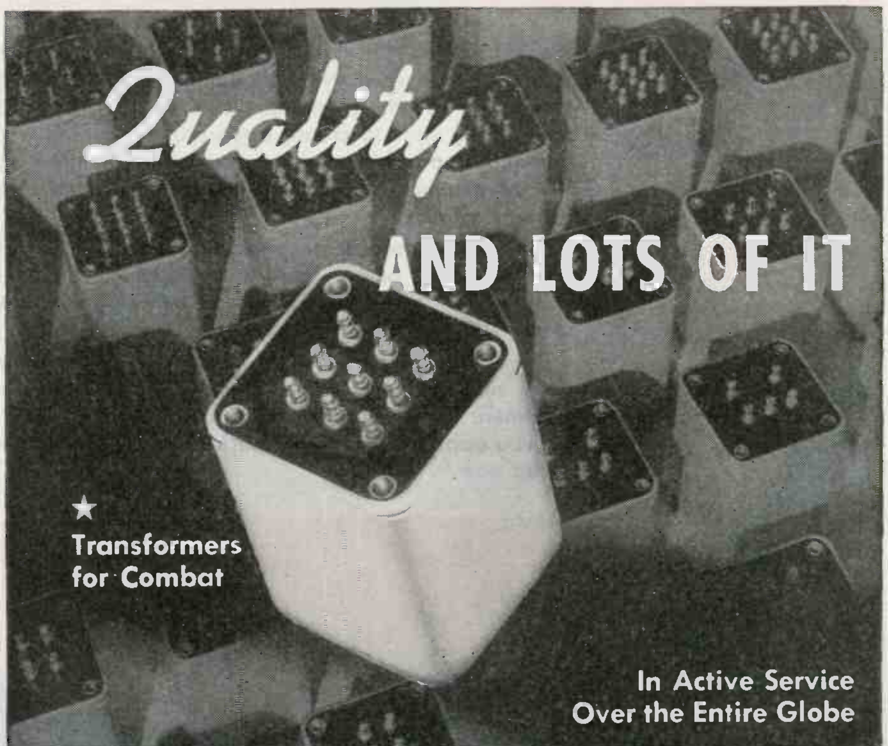

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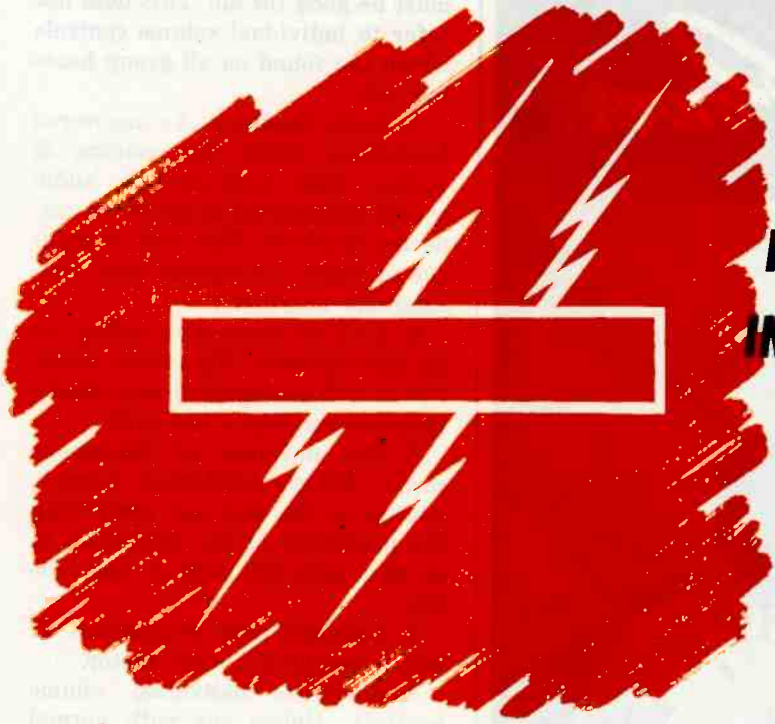

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must be good for all. This does not refer to individual volume controls which are found on all group hearing aids.

4. Audio feedback. An uncovered headphone when the volume is turned high produces an audio squeal, reproduced in the other connected headsets. This can be painful to those individuals with considerable hearing.

5. Lack of room-wide pickup by the microphones. Here room acoustics as well as improved microphone installations play a big part.

6. The nuisance of headphone cords. Always developing "opens". Always in the way and restricting the movement of the individual to an area near the desk or seat outlet.

7. Uncomfortable headphones, in which weight is a large factor.

8. Short-life individual volume controls. Unless one with normal hearing checks these at frequent intervals, the deafened person is apt to interpret the scratchiness of a deteriorating control as a part of the sound picture.

9. The installation difficulties of the wiring system for carrying the amplifier output to the individual outlets, and also the nuisance of the wiring system for the microphone input—cords all over the place.

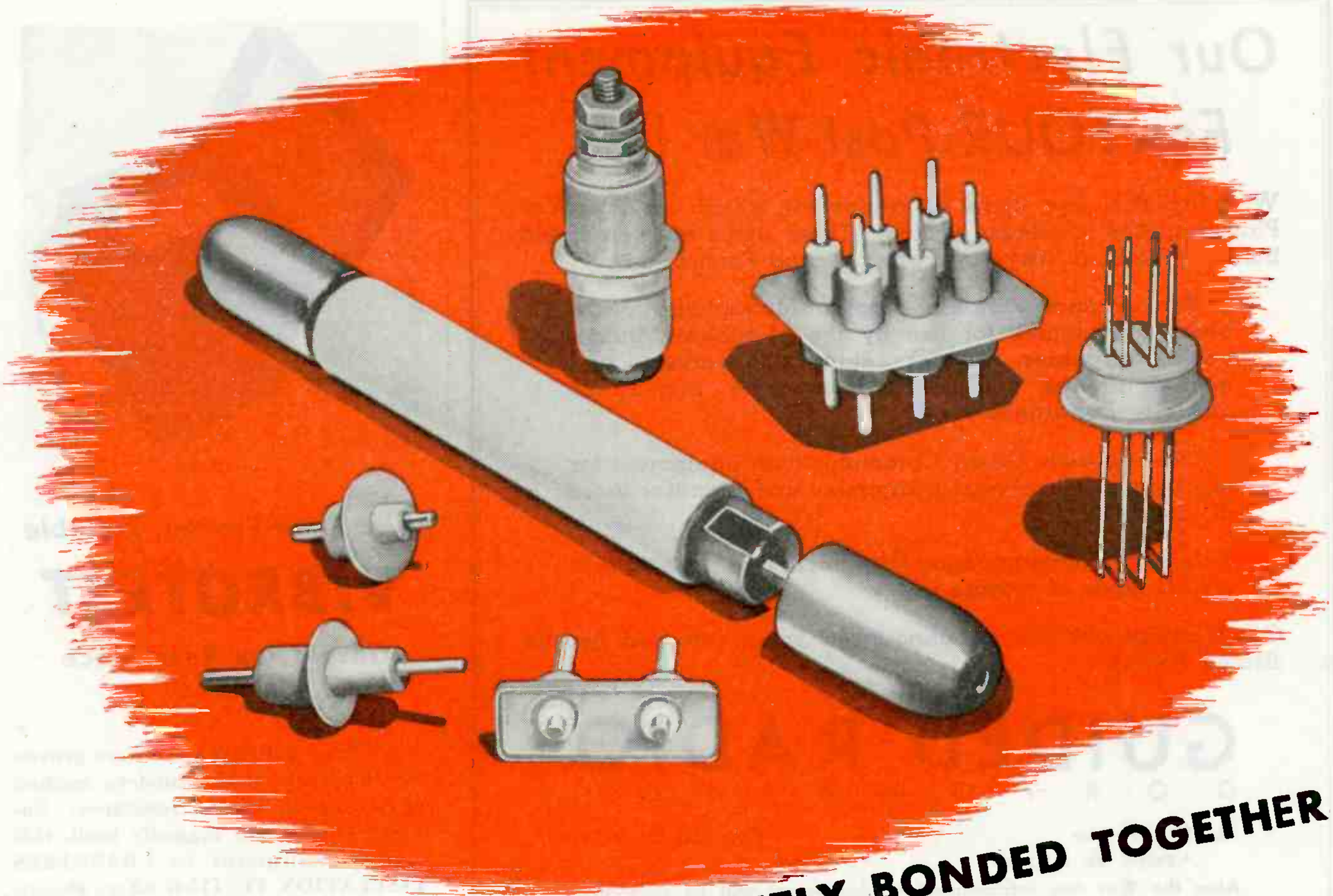
10. Only a few commercial group aids designed for schoolroom use have provision for radio or phonograph input. This would be a desirable feature.

Some of the suggestions advanced will be considered impractical, but we believe they point a direction for future investigation. All of these defects cannot be brushed aside with one sweep of the pen. By calling attention to these shortcomings, and at the same time pointing a direction in which possible solution lies, we will have accomplished our aim.

Amplifier Design

The first objection, that of over-simplification of amplifier design, requires for correction greater study of amplifier components, better selection of parts, and a breaking away from the tendency to make one tube do the work of two. A few dollars added to the cost will make little difference.

The practice to date has been to cram the bass and treble control



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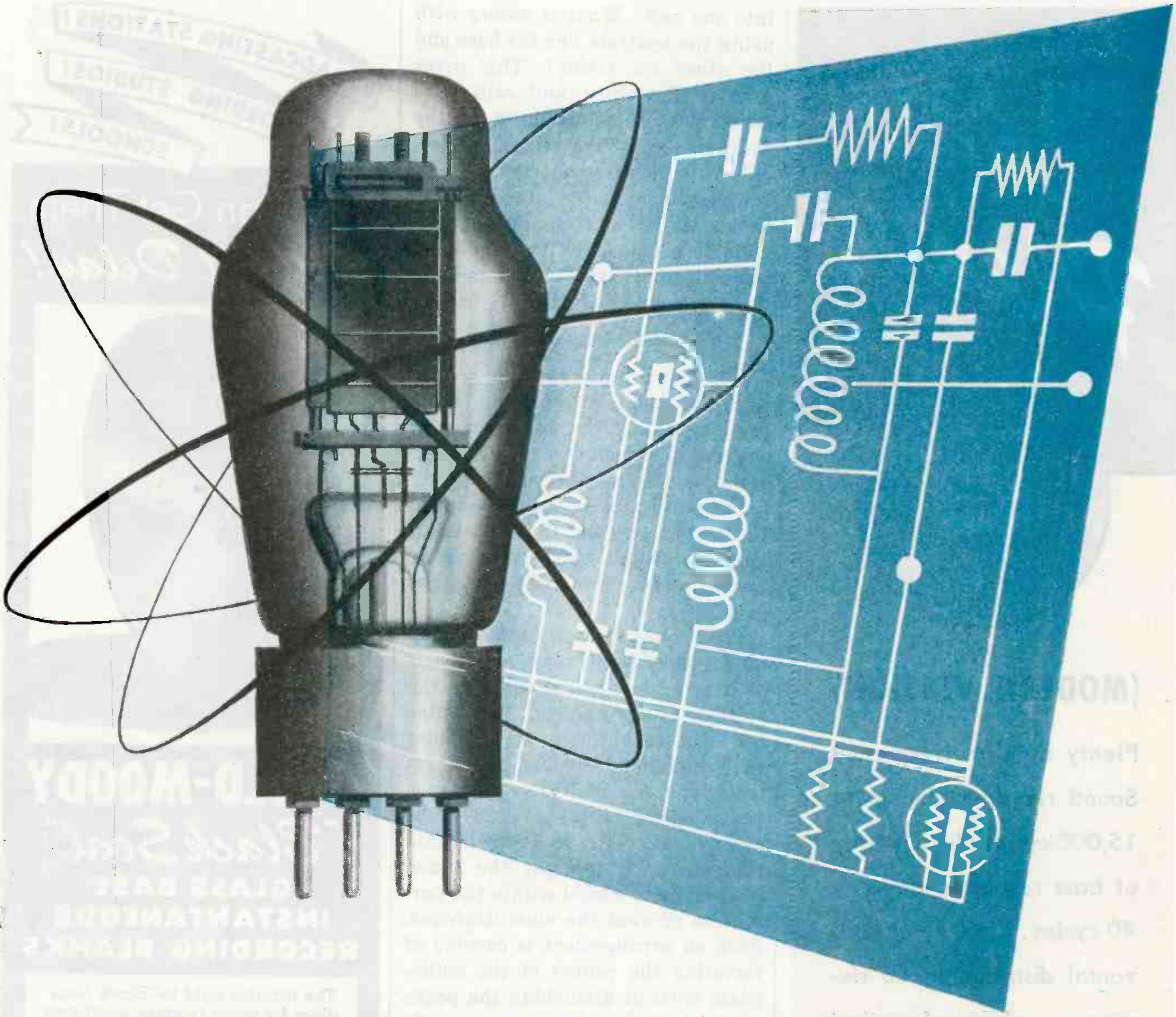

into one unit. What is wrong with using two controls, one for bass and the other for treble? This gives greater flexibility and will give some measure of striking at the average need of the group.

No attempt is made today to fit the amplifier to the needs of the group as a whole. Present-day amplifiers just amplify within certain limits. If what comes out fits the listener, he is lucky.

Octave Control

Why not average the audiograms (graphic representations of hearing losses) of the individuals in the group in octave or half-octave steps over the speech range, setting a group of knobs on the amplifier to these averages, and thus obtain an amplifier output which more nearly approximates the needs of the group?

Some classification of the group of deafened individuals on a basis of hearing loss would assist in the solution of the problem. The writer has had constructed an amplifier with individual channel gain controls, one for each octave over a range of six octaves (128—4096 cycles) and with an overall gain control which brought the tuned pattern up to a level within the perception of even the most deafened. Such an arrangement is capable of elevating the valleys of the audiogram without disturbing the peaks at which the hearing is more nearly normal.

This problem could probably be solved more effectively, if instead of one master amplifier for the group, smaller, individually adjusted amplifiers were constructed. This might be worked out on a basis of secondary stage amplification after overall pre-amplification, thereby making the individual amplifiers smaller.

Feedback Problem

Audio feedback in the classroom amplifier is one of the most discouraging elements in the use of the group hearing aid. With a sensitive microphone and the amplifier volume turned up high, an uncovered or poorly fitted earpiece will produce very objectionable audio feedback. The elimination of this deterrent to a full use of the group hearing aid should not be too difficult or too expensive. Audio


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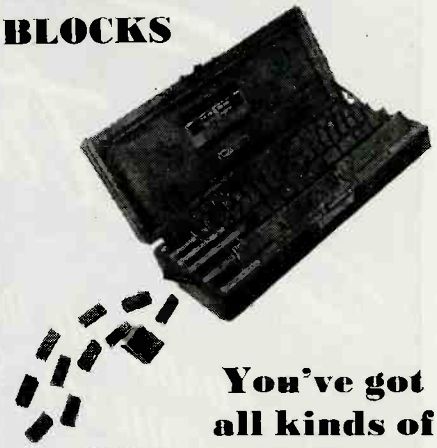

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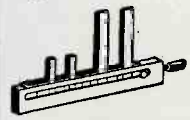

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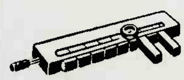
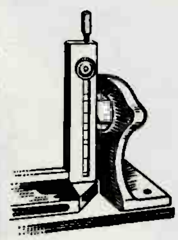
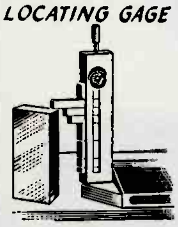


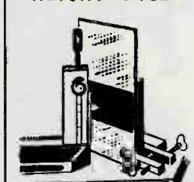
SNAP GAGE



LOCATING GAGE



HEIGHT GAGE



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feedback, being a function of circuit dimensions and room acoustics and occurring at a frequency usually well above the speech range, might readily be controlled by a tuned crystal circuit responsive only to the frequency band of the feedback. Other circuit refinements, such as separate high-voltage power supplies for each stage of amplification, would assist in reduction of this trouble.

Most commercially made group hearing aids in use today have microphones which are highly sensitive, but they still leave much to be desired in the matter of picking up faint voices in the back of the room. Schoolroom use of the hearing aid requires that the children be able to hear their own voices as well as that of the teacher. To do this the microphone must be of high quality and must be nondirectional. Placement of the microphone in the room has considerable bearing on the problem. In general, the greater the microphone sensitivity, the greater the trouble with audio feedback, but with the elimination of the feedback or the boosting of it to inaudible frequencies, better microphones could be used.

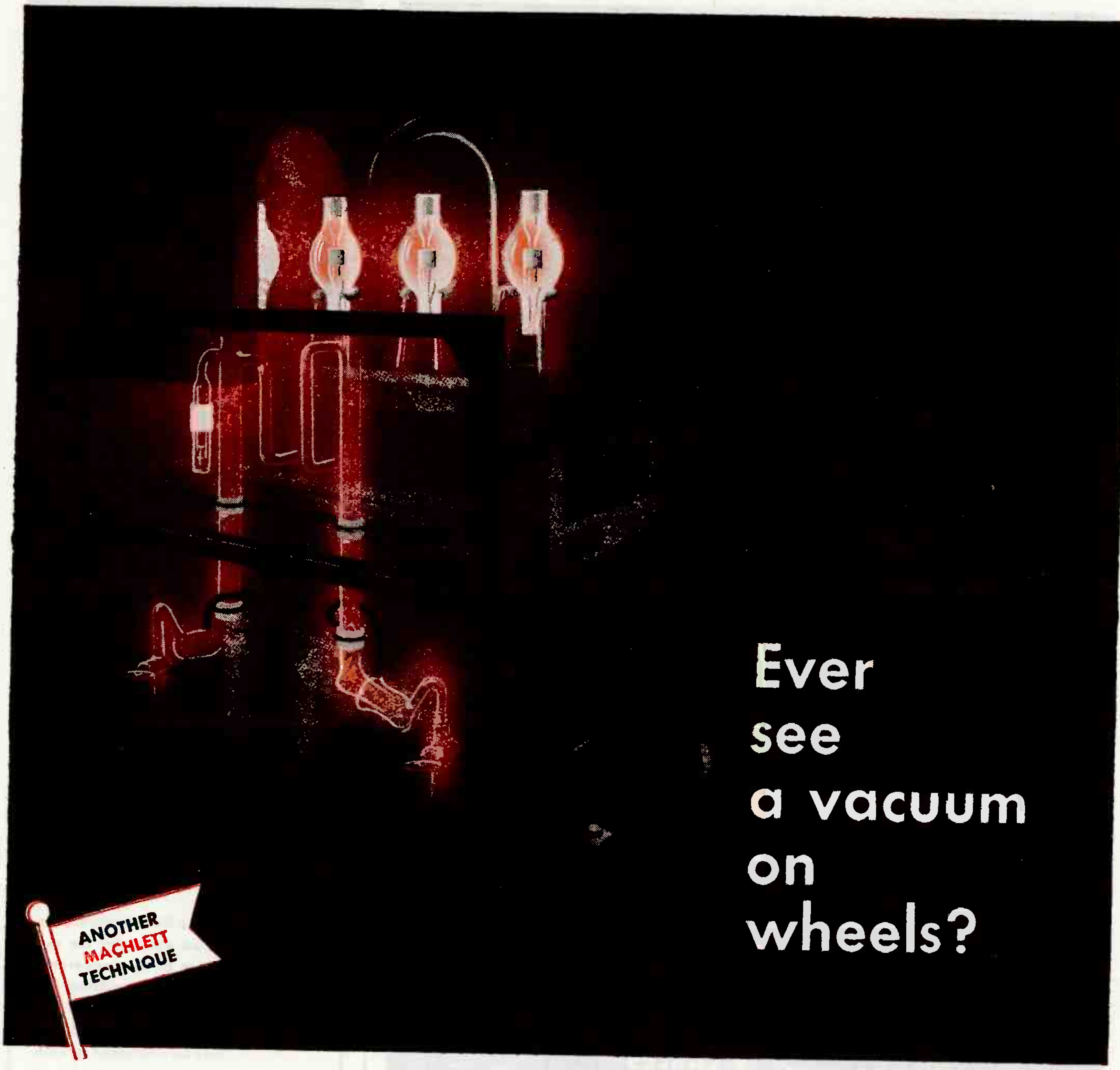
Cords

Until it is possible to produce non-twistable, non-kinkable cords,

• • •

RADIO SEA CADETS

Sea Cadets join the British Royal Navy at the age of 17 to be trained as signalmen and telegraphists. In the photo above, cadets are receiving instruction on a high-power transmitter at H.M. Signal School



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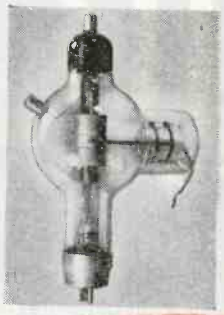

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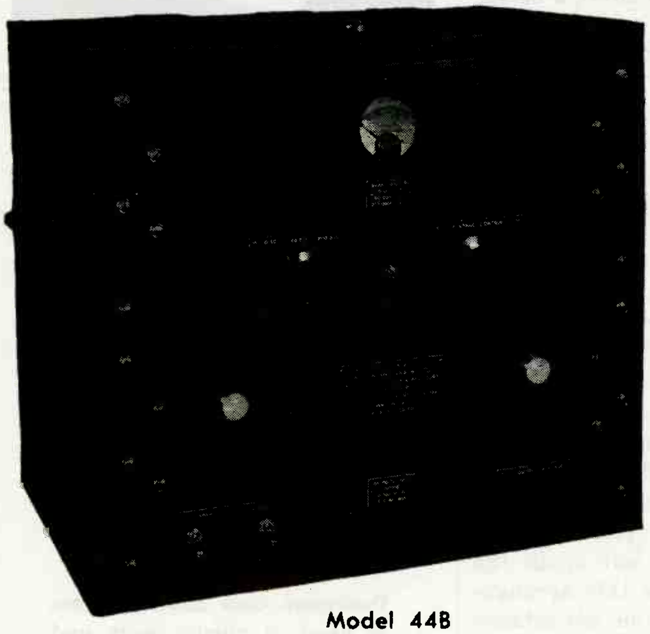

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OUTPUT CURRENT – 250 MA Max
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this part of the equipment is going to cause more than its proportionate share of trouble. Perhaps some sort of a double swivel tip would do the work—one at each end of the cord. Or, instead of the somewhat rigid cord of today, something completely "soft" might be used. A very soft cord might not kink so badly—perhaps something like a soft braided silk rope.

Headphones are too heavy. The crystal type of phone is an advance over the magnetic type as far as weight is concerned, but it is still unwieldy. Individual hearing aids show considerable progress made in the direction of weight and size reduction of the earpiece. It should not be too difficult to effect a better seal at the ear and thus make it possible to reduce the diaphragm size without loss of efficiency.

Any scheme of room wiring developed up to now has been cumbersome. It is necessary to wire power to the amplifier, wire the microphone input to the amplifier, and wire the output of the amplifier to the various headsets. There might be substituted a system of radio transmission. Would it be feasible to use a vhf transmitter and equip each desk with a battery-powered receiver with adequate gain and tuned to the individual user? Instead of batteries as a source of power an inductive power pickup might be arranged, but again the wiring necessary for this arrangement might offset the advantages gained.

Ideal System

These suggestions are not so fanciful as they may seem. Preliminary experiments have given rise to the belief that many of the troubles enumerated can be eliminated when it again becomes possible to produce instruments of this type.

The ideal post-war group hearing aid should have most, if not all of the following characteristics:

1. High, distortionless gain to amplify even the faintest sounds.
2. Ultra-sensitive, nondirectional microphones capable of covering the entire room area.
3. Freedom from audio feedback.
4. Adjustability to individual hearing patterns.
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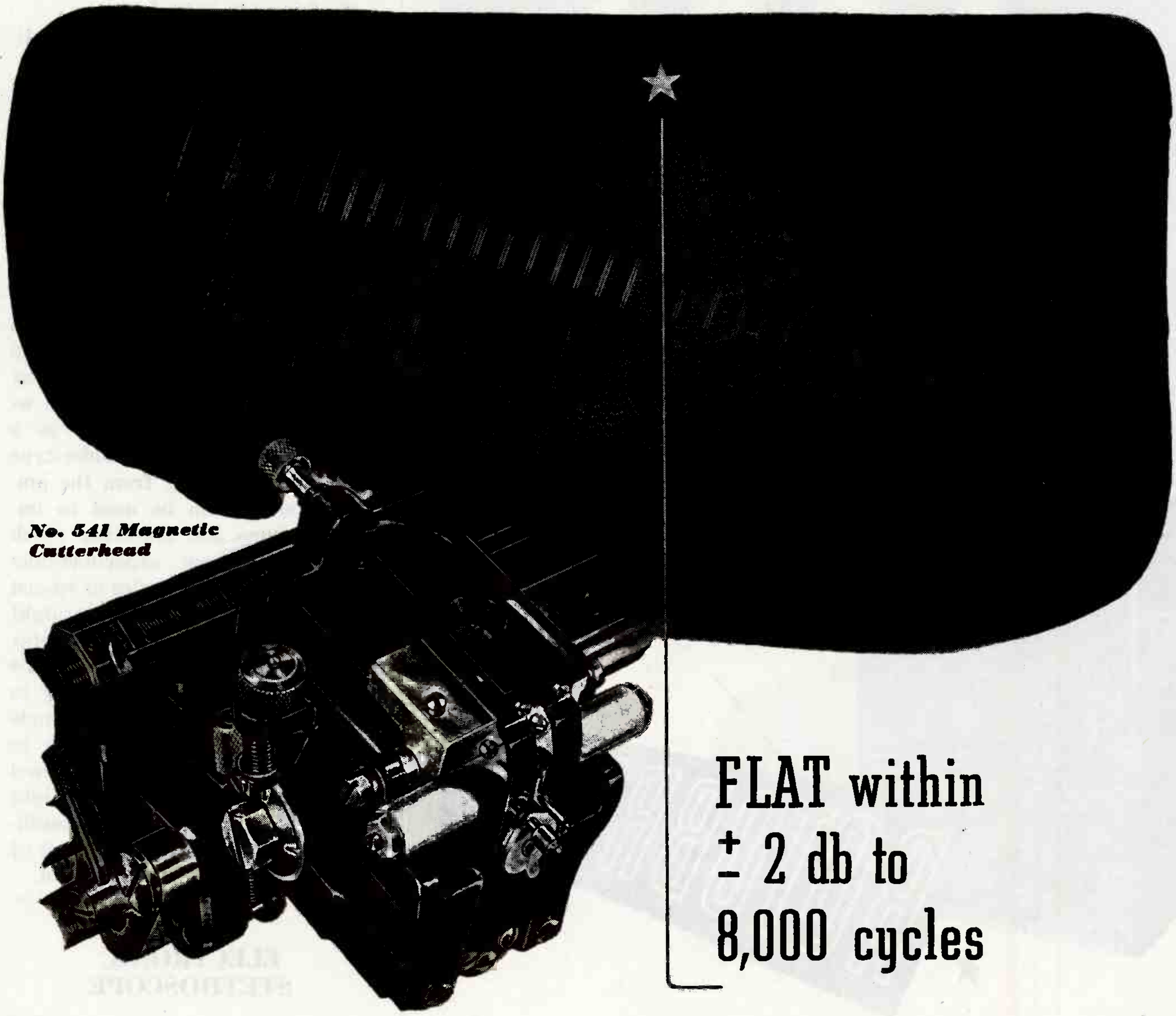

Reproduced above is an actual photograph of a "light" method frequency pattern. The inside, the wide midway and the outside band are 1,000 cycle reference bands. Starting at 1,500 cycles, at the midway reference band, the succeeding outward bands increase by 500 cycle increments to 8,000 cycles.

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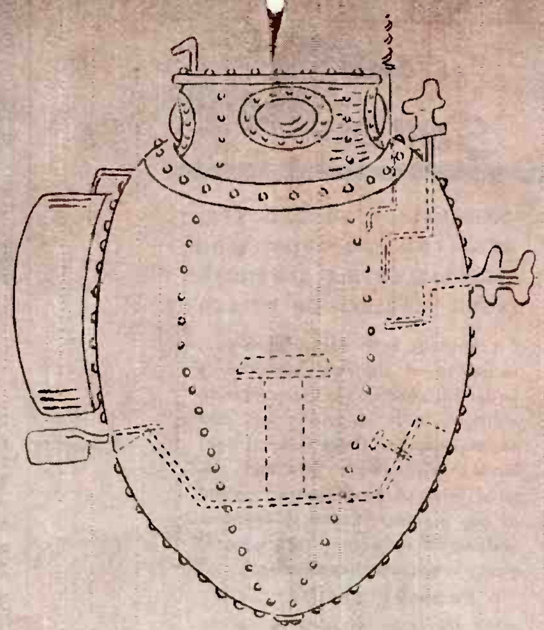
Speech improvement of deaf children goes hand in hand with utilization of partial hearing via the hearing aid. Here the group hearing aid can be augmented by the use of a visual aid as well as the use of amplified speech as a teaching medium. A ladder-type neon tube operating from the amplifier output can be used to improve volume and inflection. Such a tube has been experimentally constructed using a series of spaced electrodes inserted into a straight length of tubing. Using a resistor network, the light column can be made to rise and fall according to the speech inflection. Vowel sounds can be calibrated on the tube in terms of levels—each pure vowel sound to produce a column of light of a different length. This speech-teaching device should be a part of each post-war group hearing aid.

• • •

ELECTRONIC STETHOSCOPE

High-pitched body tones are accentuated and tones of lower pitch are subdued by the Stethetron, an electronic stethoscope. Lieutenant Rafael Morales, physician at the Military Hospital in Havana, Cuba, tries the instrument on Evelyn Dobson, model



Experience Counts

The unusual craft shown above was the first submarine of the American Navy. Built in 1776 by David Bushnell, it was used against the British warship, "The Eagle" which was lying off New York. Now, "The American Turtle"—that's what it was called—acted like a submarine all right, but that was about all. It didn't sink or damage any ships. Bushnell had a good idea but he simply did not have enough knowledge or experience to make his idea practical.

The moral of this story is: *In the development of the first submarine as in the development and manufacture of all products, Experience Counts.*

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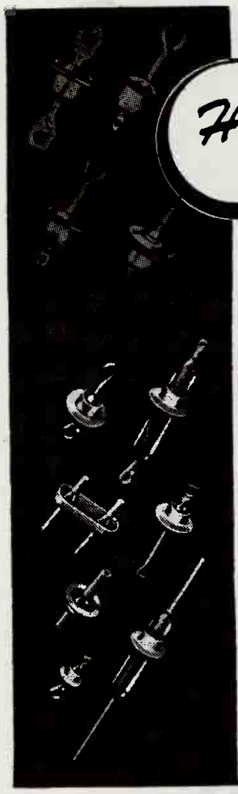

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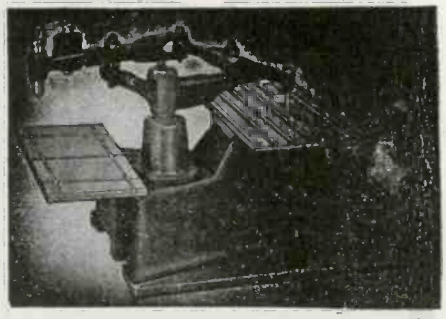

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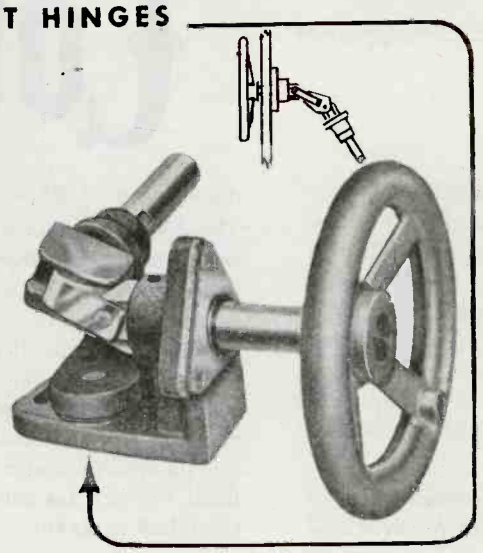

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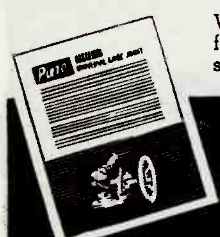

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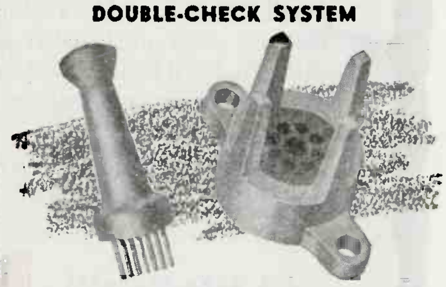

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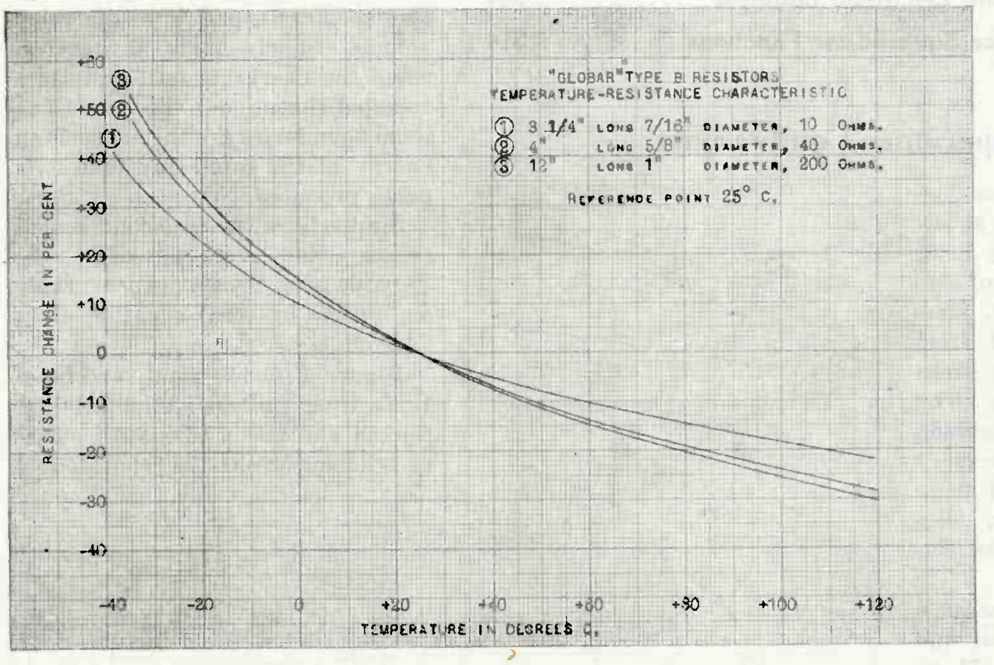

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Resistors like those illustrated are not to be found in catalogs, as they are made to cover special problems. It is essential that complete information such as:

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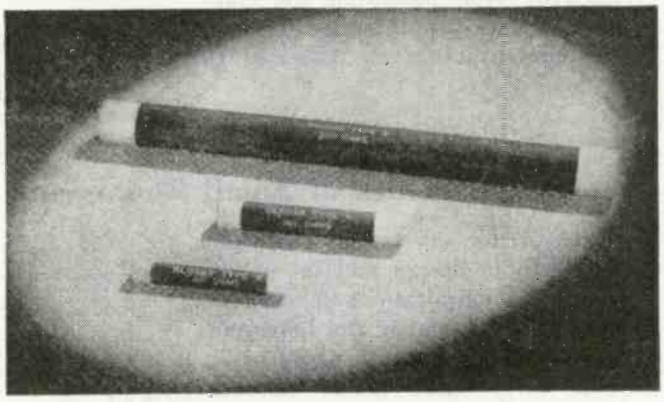

Resistors for applications requiring more pronounced characteristics are also available. Working samples for engineering tests will be furnished if required. The Carborundum Company, Niagara Falls, N. Y.

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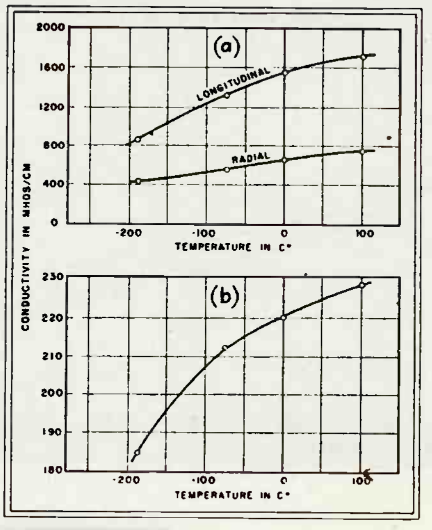
THE ELECTRON ART

Low-Temperature Conductivity

THERMAL AND ELECTRICAL conductivity of graphite and carbon at low temperatures are discussed by R. A. Buerschaper in the *Journal of Applied Physics* for May, 1944. Electrical conductivity obtained from laboratory measurements is given in the accompanying graphs. The tests were conducted on Acheson graphite electrodes cut into rods along the electrode axis, and along the radius, and on carbon electrodes, both supplied by the National Carbon Co.

These measurements agree at 0 deg C with those of Powell and Schofield (*Proc. Phys. Soc.*, 51, p. 153-172) who measured the conductivity of graphite and carbon at temperatures from 100 deg C to 2500 deg C.



(a) Electrical conductivity of graphite vs temperature. (b) Electrical conductivity of carbon vs temperature

Acoustics of Small Rooms and Studios

INFORMATION OF VALUE, both for small studio design and in understanding the limitations imposed on final reproduction by the listener's room, is contained in a paper by J. Moir in *Wireless World* (Dorset House, Stamford St., London, S.E.I., England) for November, 1944.

Small-room reproduction, to be comparable to concert-hall performance, must produce the same instantaneous and spatial acoustic pattern. To determine how closely this goal could be reached, theoretical analyses of other investigators were compared with data taken in the room shown in Fig. 1.

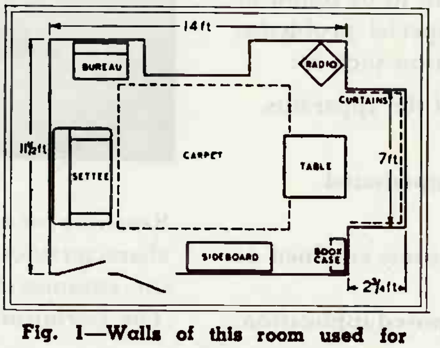


Fig. 1—Walls of this room used for acoustic measurements were distempered and the floor was covered with linoleum

Reverberation Time

Sabine concluded from investigation of acoustics of rooms that the primary factor was the time taken for room boundaries to absorb the sound energy after cessation of the initial sound. He defined reverberation time as that period taken for the average sound energy to decay to −60 db below its initial value, and developed empirical equations from which reverberation time of a room could be calculated.

Average sound energy in a room grows exponentially, from the instant the sound source commences, in accordance with the equation $P = (4E/cS\alpha)(1-\epsilon^{-cS\alpha t/4V})$ where P is the sound energy density, E is the rate of emission of the source, c the velocity of sound, S the total surface area, α the average absorption coefficient, and V is the room volume. Steady state is reached when the energy is uniformly distributed throughout the room. The room boundaries are then absorbing energy at the same rate that it is being produced.

Similarly, when the sound source ceases, the average sound energy density decays exponentially as given by the equation $P = (4E/cS\alpha)\epsilon^{-cS\alpha t/4V}$.

Figure 2 shows how reverberation time affects intelligibility. Speech and music consist of series of syllables or phrases separated by well defined intervals of silence. If the decay rate of the room is so slow that energy from successive syllables overlaps, lack of intelligibility results. If reverberation time is short, each syllable stands alone and is readily understood.

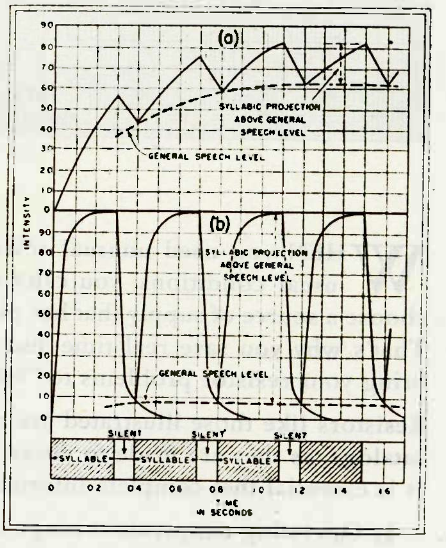


Fig. 2—Growth and decay of sound in a room (a) of 5 sec reverberation time, and (b) of 0.5 sec reverberation time show the general speech level and the syllabic projection above that level

Optimum Reverberation Time

Subjective tests show that very short reverberation times give a dull, lifeless effect to sounds, probably as a result of our long experience listening in rooms having ap-

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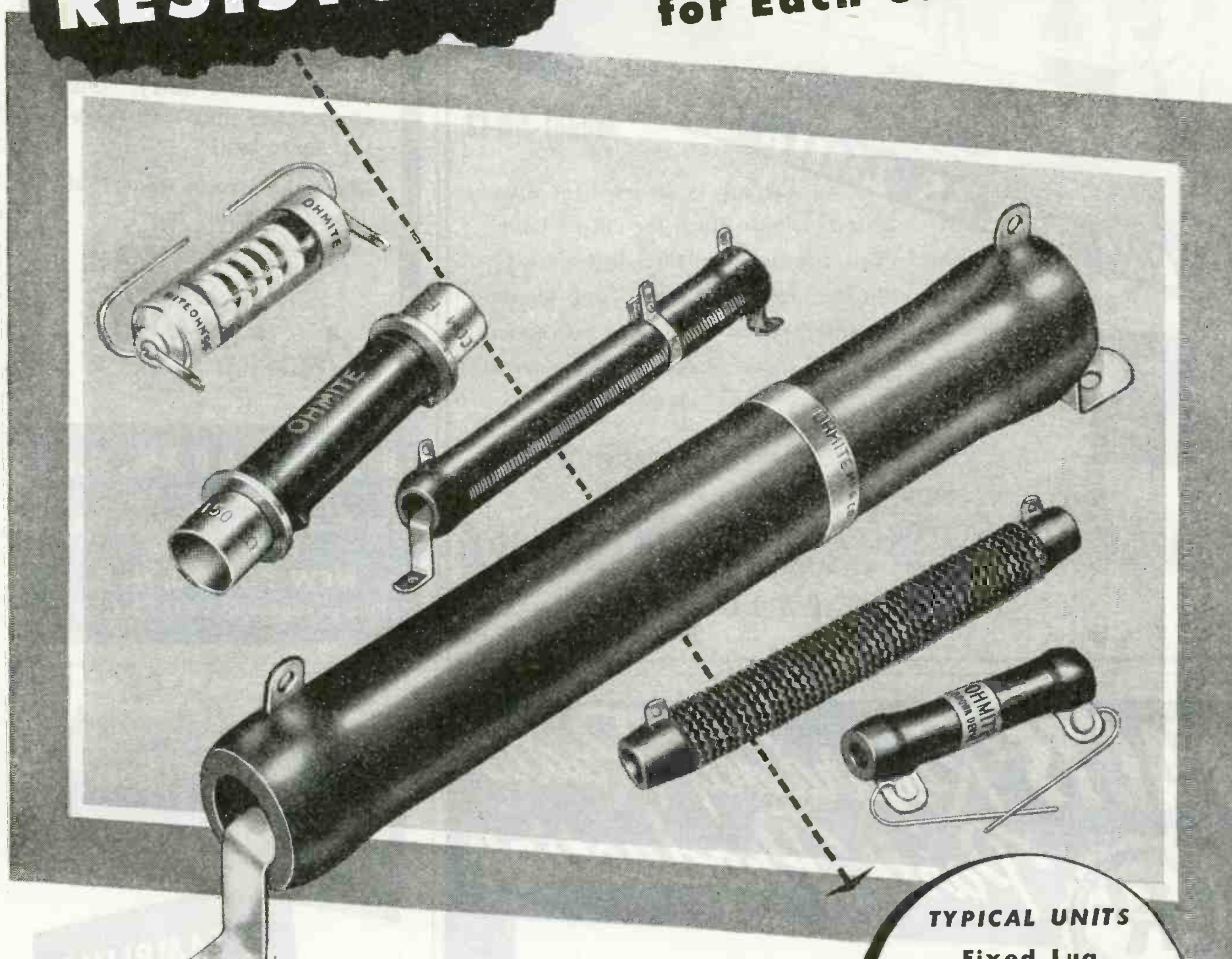

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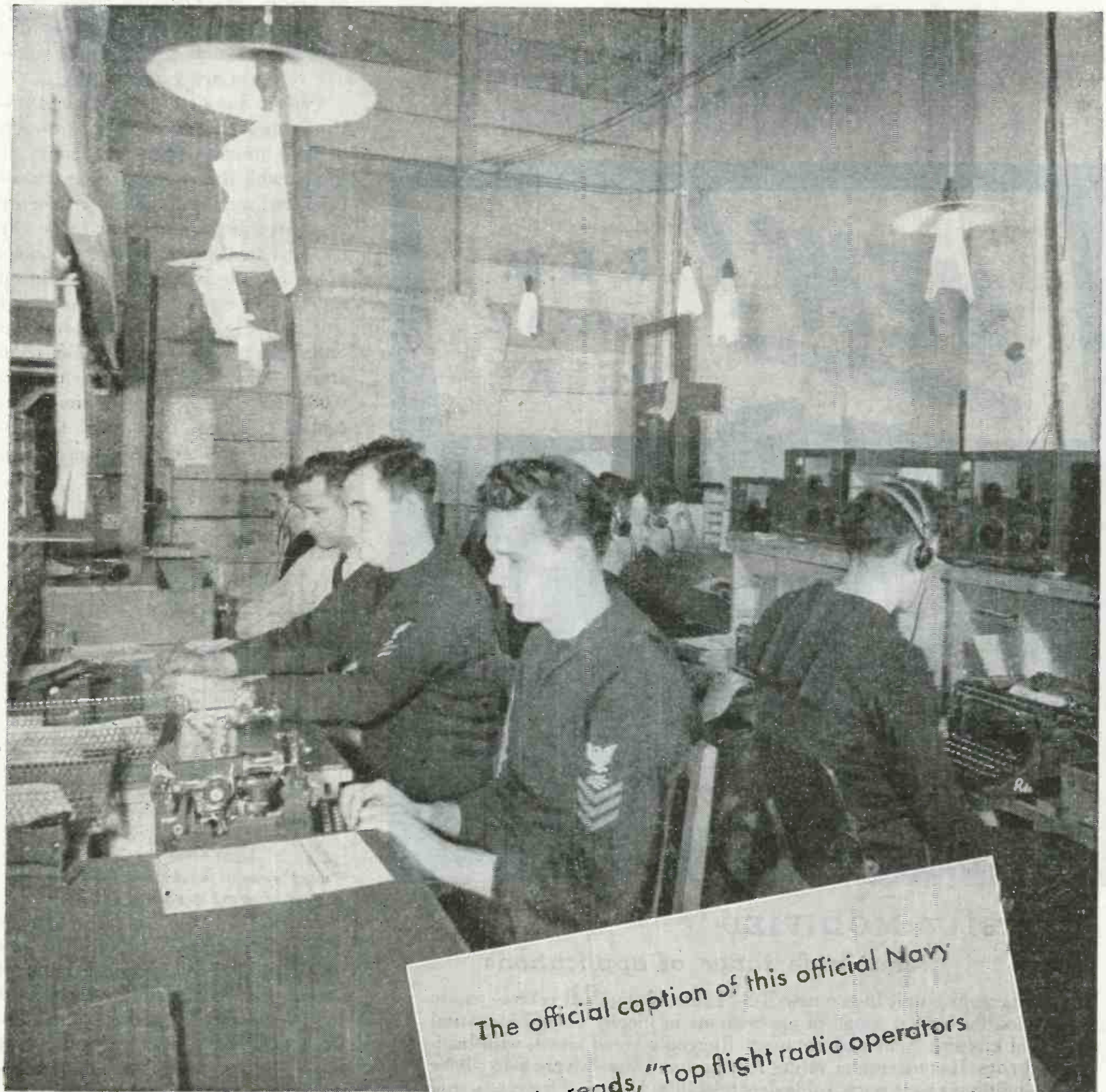


The official caption of this official Navy Photo reads, "Top flight radio operators plus top flight equipment equals top flight performance at an African clearing base for the Italian Front."

NATIONAL COMPANY

MALDEN MASS, U. S. A.

NATIONAL RECEIVERS ARE IN SERVICE THROUGHOUT THE WORLD preciable reverberation times. Subjectively determined optimum reverberation time for rooms of various volumes are given in Fig. 3.

Theory has little to say about optimum reverberation time, although it does predict that for rooms of comparable dimensions those for reproduced music should have shorter reverberation times than those for live production of the same class of music because the reproduced music will contain the reverberant sound of the production studio.

Sabine gives for reverberation time the empirical equation $T = 0.05V/S\alpha$. The most convenient control of this time is through the absorption coefficient. Absorption co-

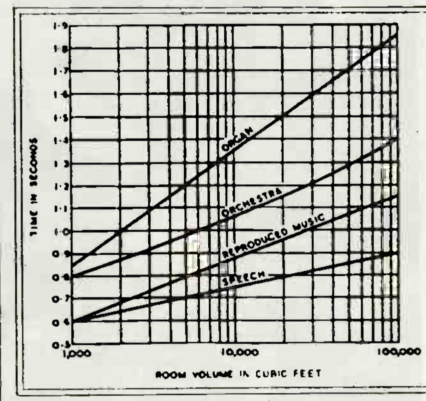
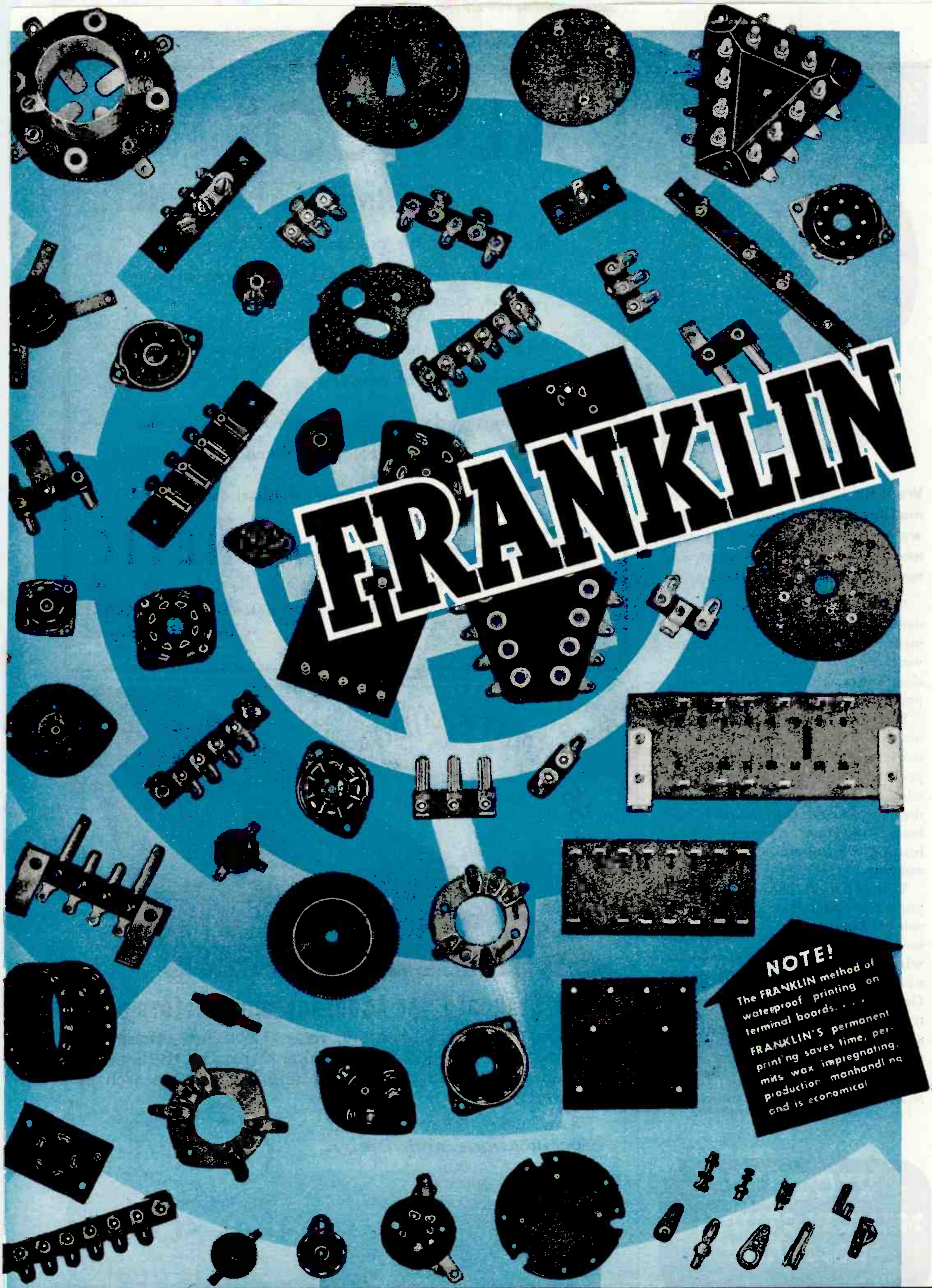


Fig. 3—Subjectively determined optimum reverberation times for different types of sound in various sizes of rooms

efficient expresses the effectiveness of a material in absorbing incident sound. For hard rigid material, α is low; for soft porous material, it approaches unity. Figure 4 presents some of the available data on absorption coefficients of material common in domestic architecture. It will be seen that sound absorption varies with frequency.

Theoretical work of Knudson and McNair suggests that optimum reverberation time should change with frequency as shown in Fig. 5. Experience substantiates this theory, except above 3 kc where a gradual fall with increasing frequency of reverberation time appears more acceptable.

Measurements in the room of Fig. 1 show the reverberation time vs frequency of the measured curve in Fig. 5. It will be seen that the observed reverbation time is below the optimum time. Some of the absorbent material such as chairs and carpet was removed but this did not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Output current . . .	7.5 amperes available over entire output voltage range.	3.0 amperes available over entire output voltage range.
Output watts	1000 va	810 va
No-load power loss . .	3.5 watts	3.5 watts
Dimensions	Over-all —— 5 1/16 x 6 7/8 x 6 3/8 inches high 3 mounting holes — 120 degrees apart on 2½ inch radius.	

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increase the reverberation time to the optimum.

Wall Vibration

The absorption curve of Fig. 4 indicates that the reverberation time should measure longer at low frequencies than at high. This was not the case, as is shown in Fig. 5, because of absorption by vibration of the room structure.

The physical properties of floors, walls and ceilings absorb the sound energy required to produce and maintain their vibration, the energy being dissipated in internal friction. In addition, building elements have resonant frequencies, especially at low frequencies. At these frequencies, they absorb and dissipate many times the energy they absorb well off resonance. Thus non-porous surfaces which would have low absorption if rigid, have high absorption at some low frequency where they are resonant. Increasing the mass of the surface will place this frequency below the audible range, although, the usual domestic construction is such as to provide excellent vibrating absorbers in the lower audible register. The result is the bass-deficient measured characteristic rather than the optimum reverberation time vs frequency characteristic of Fig. 5.

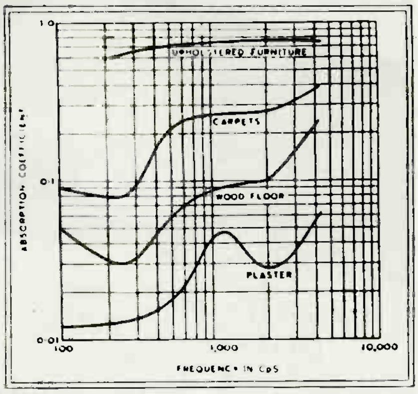

Fig. 4—Absorption coefficients of typical domestic surface materials

The direct effect of this deficiency is an obvious lack of bass because sound intensity in an enclosure is almost directly proportional to reverberation time. This lack of bass cannot be completely corrected by increasing the bass output of the loudspeaker, although it may be partially corrected in this manner. The subtle difference is that reverberation adds coloration to the di-

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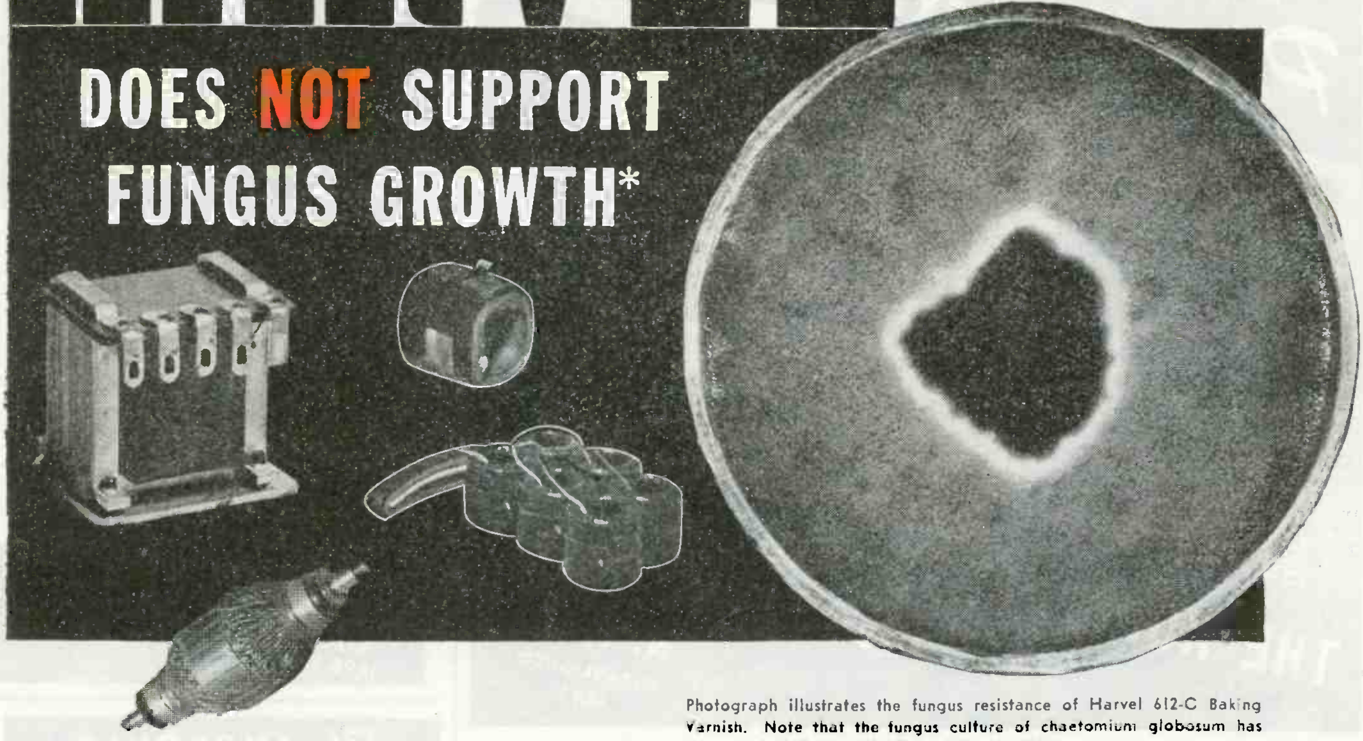

Photograph illustrates the fungus resistance of Harvel 612-C Baking Varnish. Note that the fungus culture of chaetomium globosum has not attacked the sample film of Harvel 612-C.

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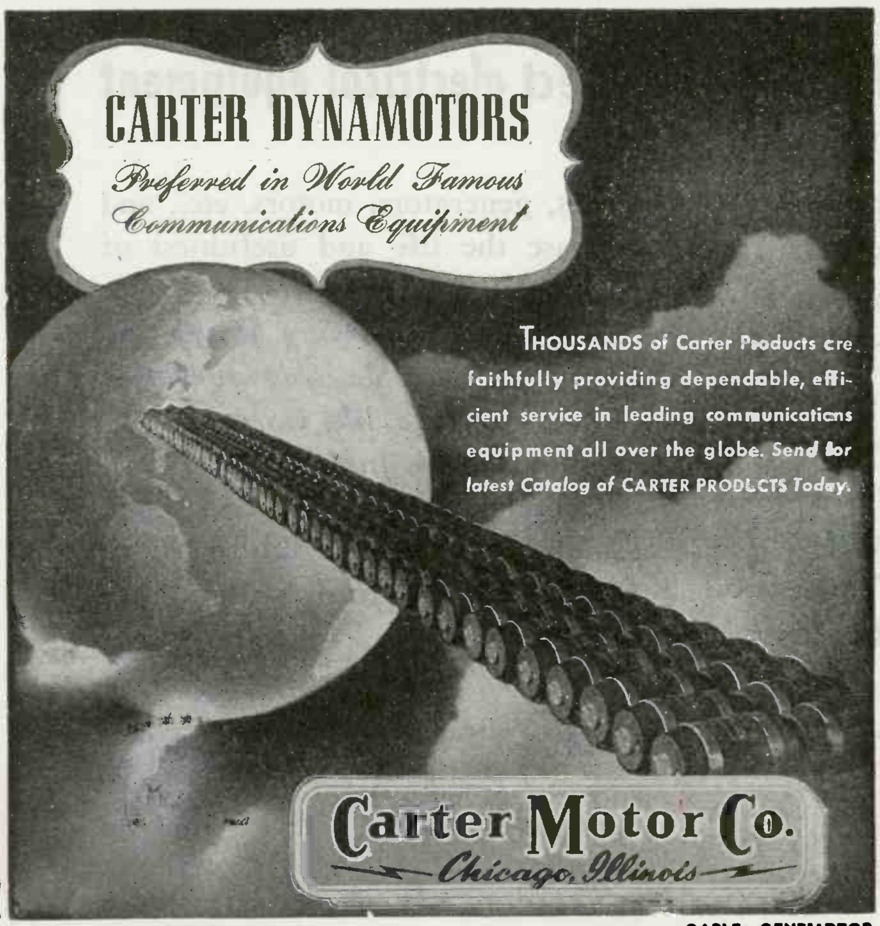

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rect sound by adding components which persist after the original has ceased, while an increase in bass loudspeaker output merely increases the direct sound intensity. Listening experience in comparable rooms having reverberation characteristics similar to the two curves of Fig. 5 suggests that this point is of more than academic interest.

Wall and Room Resonance

Vibrating surfaces may reinforce the reproduced sound at the resonant frequency of the partition. For example, mechanical coupling through the cabinet from loudspeaker to floor can greatly increase radiating efficiency at the resonant frequency of the immediate section of flooring. If the effect is objectionable, it can be reduced by placing loaded isolating pads beneath the cabinet.

The reverberation time at a particular frequency may be effectively increased if the vibrating partition

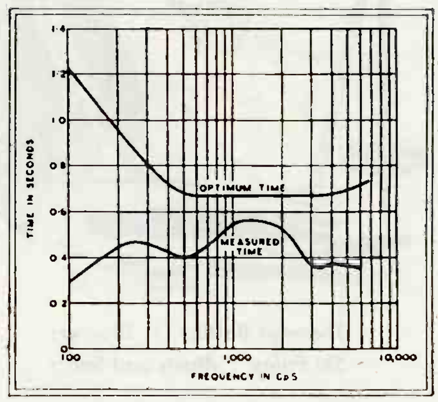

Fig. 5—Optimum and measured reverberation times for the room of Fig. 1 as a function of frequency

has a slower rate of decay than the room, with the result that the partition returns energy at its resonant frequency to the room after normal room vibration has ceased. If the returned energy was at the frequency of the incident energy, the effect would only be to increase the decay time, but transient sound having frequency components near partition resonance or harmonically related frequencies will produce reverberation at the resonant frequency of the partition. This reradiated energy, having been translated in frequency by the partition, may be discordant unless of very low intensity compared to the fun-

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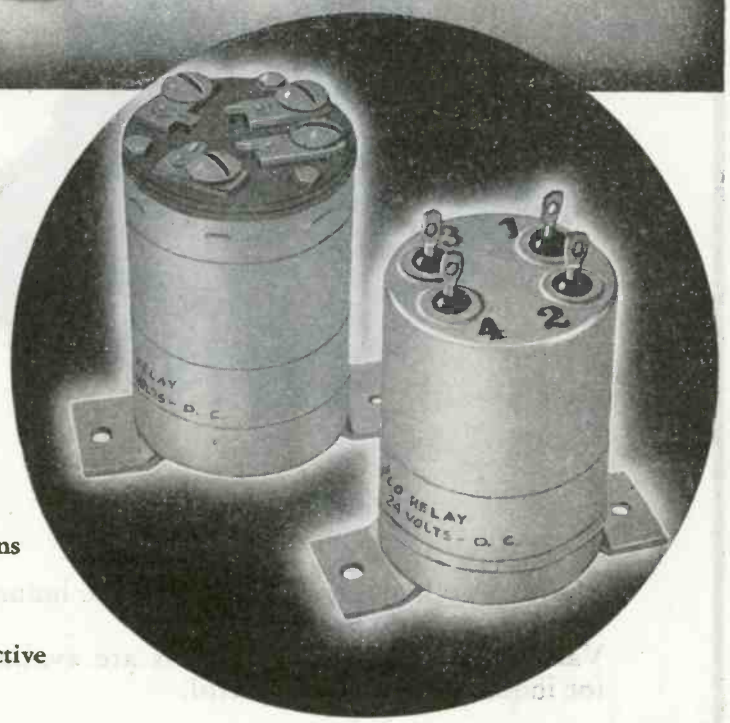

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damental of the original sound.

A small room, having dimensions comparable to a wavelength at the bass frequencies, also has resonances similar to those of a stopped organ pipe. Lord Rayleigh derived the expression for these frequencies for three-dimensional space as $f = (c/2)\sqrt{(A/L)^2 + (B/W)^2 + (D/H)^2}$, where L is length, W width, H is height, and A, B, D are integers 0, 1, 2, 3, etc. From this equation it is seen that a small room can have an anharmonically related series of peaks in its frequency characteristic. The effect of these partition and room resonances may be such as to increase a 5-percent harmonic in the electrical system to a 50-percent harmonic in the final reproduced sound.

Mean Free Path

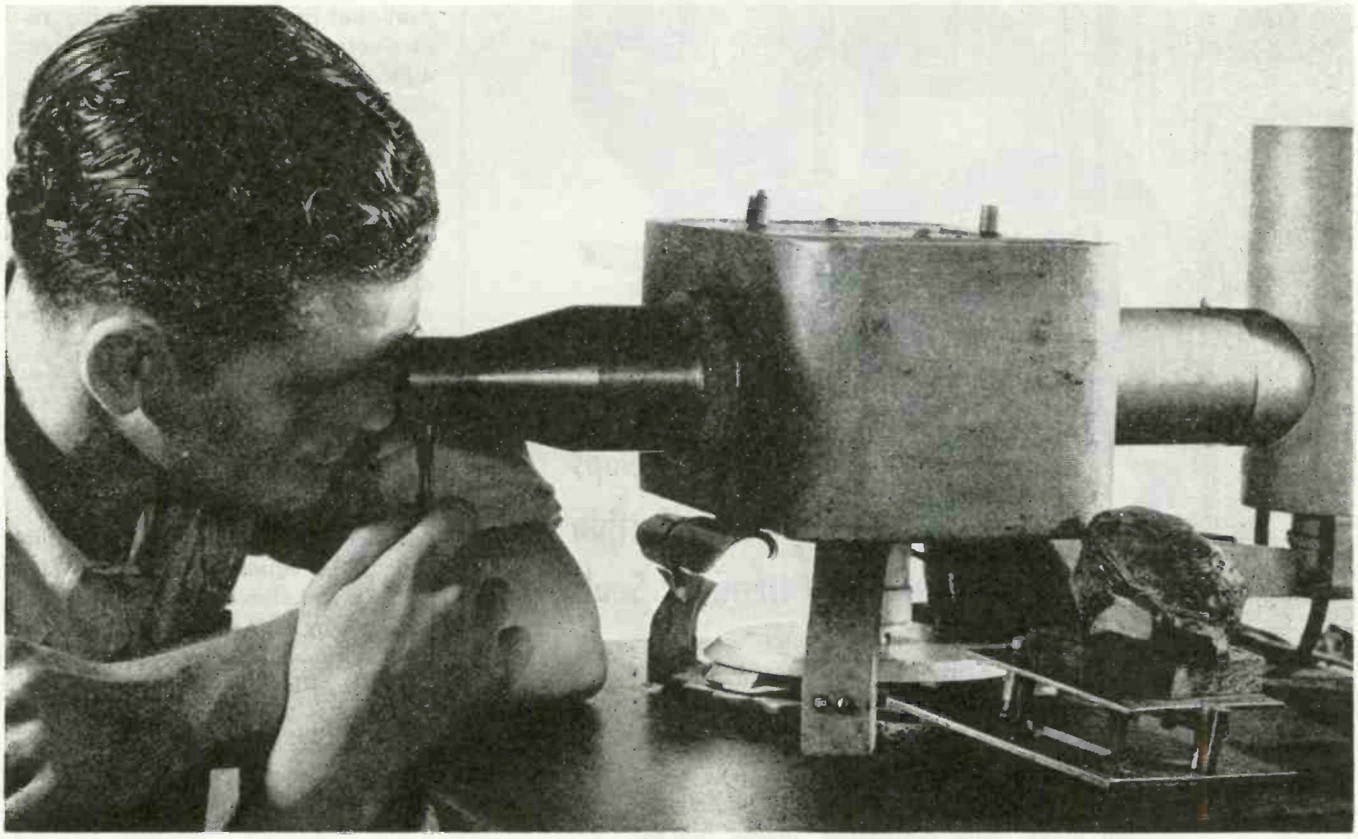
Because of the change of reverberation time with frequency, the concept of an optimum reverberation time is of dubious value when applied to small rooms. If the mean free path ($4V/S$) of the room is considered, it will be realized that in a small room there are more reflections with their attendent modification of the intensity and relative frequency component of the sound per second than in a large room or auditorium.

Our main impression of quality is probably formed in the first 250 milliseconds. Thus in a smaller room, where a larger number of reflections takes place during this impression-forming period, there is far greater opportunity for the room to impose its characteristics upon the sound than in a larger room.

A comparison of the same program reproduced in the room of Fig. 1 and in a motion-picture theater indicates that the reproduction in the theater was preferable, although the electrical characteristics of the domestic installation were superior.

From these observations it is evi-

RADIO RECEPTION is best immediately before and at the time of a full moon and varies with the phases of the moon, according to Dr. Harlan T. Stetson, director of the laboratory for cosmic terrestial research of MIT.

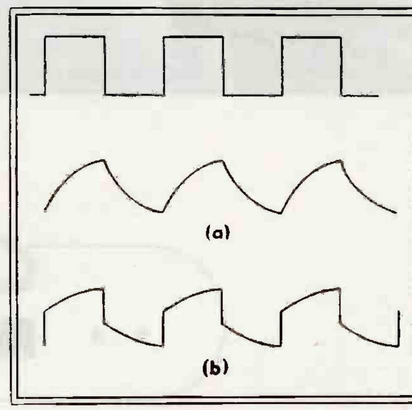


dent that in small rooms quality reproduction of low notes is the most difficult, and that—because of accumulated experience listening in large halls—small-room reproduction does not fit our concept of quality. However, the position is rapidly changing to one in which a high percentage of our listening is done in small rooms and our standards of good quality may undergo a gradual change.

• • •

Resonant Circuit Response to F-M Signal

TRANSIENT RESPONSE of an RLC parallel resonant circuit to amplitude and frequency-modulation signals is analyzed by operational methods by D. A. Bell in the March, 1944 *Philosophical Magazine* (Red Lion Ct., Fleet St., E.C. 4, London, England). For a modulation bandwidth which is large compared with the circuit bandwidth, the response of a system in which all elements but the parallel resonant circuit are linear is shown in the accompanying illustration. Similar results are obtained for wideband sinusoidal modulation.



Square-wave modulation signal is reproduced by an a-m system involving a resonant circuit as at (a), and by an f-m system containing the same resonant circuit as at (b)

• • •

Laplace Transforms for the Electronic Engineer

BY GERSHON J. WHEELER

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sical method of solving these equations, but rather an additional tool for the engineer. Briefly, it is a means of transforming a differential equation into what might be called an equivalent algebraic equation which can be solved in a straightforward manner.

This article will discuss how this transformation may be used, but will make no attempt to explain why it works. This approach is contrary to sound mathematical procedure, but it is practical.

Before tackling a differential equation by this method, it is necessary for one to know the algebraic equivalent of each function in the equation. This algebraic equivalent is known as the Laplace transform of the function. The more common Laplace transform pairs, the function and its transform, and some elementary properties are included in the table below. In each case t is the independent variable.

Referring to the table of transforms, from (4) it is plain that the transform of t is $1/p^2$ and of $t^2/2$ is $1/p^3$. From (13) one can see that $7t^2/2$ will have a transform 7 times that of $t^2/2$, namely $7/p^3$. From (14), the transform of $t-a$ is the same as the transform to t multiplied by ϵ^{-ap}, or $(1/p)\epsilon^{-ap}$. Since $\omega/(p^2+\omega^2)$ is the transform of sin ωt, then from (15) $\omega/[(p-a)^2+\omega^2]$ is the transform of ϵ^{at} sin ωt.

SHORT TABLE OF LAPLACE TRANSFORMS

	Function	Transform
1	1 (unity)	$1/p$
2	x	$\bar{x}$
3	K	K/p
4	$\frac{t^{n-1}}{n-1}$	$1/p^n$
5	ϵ^{at}	$1/(p-a)$
6	dx/dt	$p\bar{x} - x_0$
7	d^2x/dt^2	$p^2\bar{x} - px_0 - x_1$
8	$\sin \omega t$	$\omega/(p^2+\omega^2)$
9	$\cos \omega t$	$p/(p^2+\omega^2)$
10	$\text{Sinh } \omega t$	$\omega/(p^2-\omega^2)$
11	$\cosh \omega t$	$p/(p^2-\omega^2)$
12	$\frac{1}{(p+a)(p-b)}$	$\frac{\epsilon^{-at}-\epsilon^{-bt}}{b-a}$
13	$Kf(x)$	$K\bar{f}(x)$
14	$f(t-T)$	$\bar{f}(p)\,\epsilon^{-pT}$
15	$f(t)\,\epsilon^{Kt}$	$\bar{f}(p-K)$

where
x = any variable dependent upon t
K = a constant
x_0 = initial value of x
x_1 = initial value of dx/dt
T = initial value of t

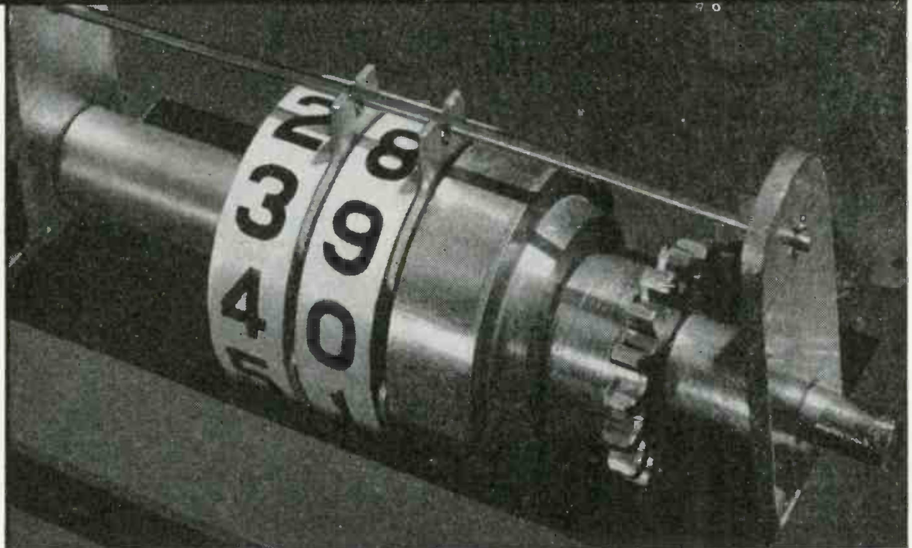
If a fixed voltage E is applied to a series circuit comprising an inductance L and a resistance R, what is the current as a function of time? The differential equation for the circuit is

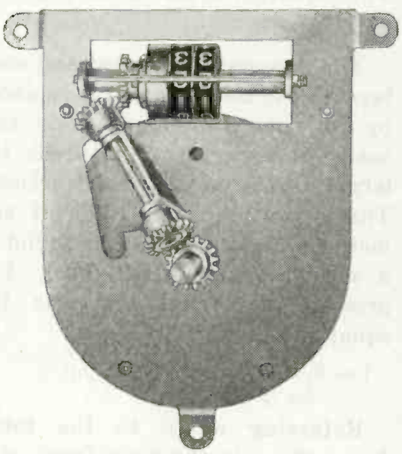
$$E = L\,(di/dt) + Ri$$

or

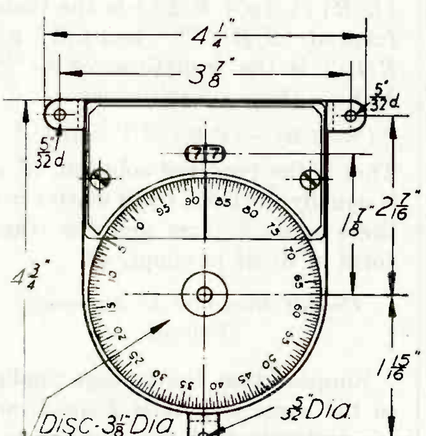
TECHRAD

INTERPOLATING COUNTERDIAL

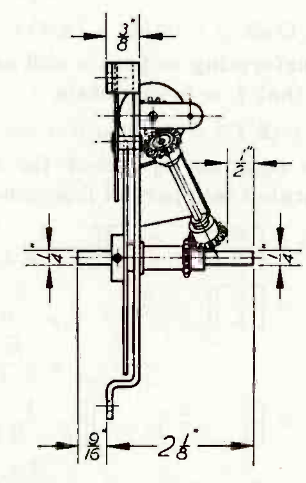




Rear view construction of Techrad Interpolating Counterdial



Front and side dimensions of Techrad Interpolating Counterdial



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$$(E/L) = (di/dt) + (R/L)\,i$$

To solve this equation by Laplace transformation the first step is to replace each term by its transform.

From the table, the transform of di/dt by (6) is $p\bar{\imath} - i_0$ of $(R/L)i$ by (2) and (13) is $(R/L)\bar{\imath}$, and of E/L by (3) is E/pL. Thus the new algebraic equation is

$$(E/pL) = pi_0 + (R/L)\,\bar{\imath}$$

This equation is solved for $\bar{\imath}$, giving

$$\bar{\imath} = [E/pL\,(p + R/L)] + [i_0/(p + R/L)]$$

The process is reversed and each term in the last equation is replaced by its time function. To do this easily, it is necessary to break the larger terms into partial fractions. This operation is not difficult and methods of doing it can be found in a second year algebra book. Expressed in partial fractions the equation is

$$\bar{\imath} = E/R\,[(1/p) - 1/(p + R/L)] + [i_0/(p + R/L)]$$

Referring again to the table, from (2) $\bar{\imath}$ is the transform of i, from (3) E/Rp is the transform of E/R, and from (3) and (15) $[E/R]\,[1/(p + R/L)]$ is the transform of $(E/R)\epsilon^{-Rt/L}$, and $i_0[1/(p + R/L)]$ is the transform of $i_0\epsilon^{-Rt/L}$. Making these substitutions

$$i = (E/R) - (E/R)\epsilon^{-Rt/L} + i_0\epsilon^{-Rt/L}$$

This is the required solution. If, as is usually the case, $i = 0$ when $t = 0$, there is no i_0 term and the transform of di/dt is simply pi.

Circuit Response to Sinusoidal Voltage

Suppose that the voltage applied to the same circuit is $E\sin\omega t$, and we desire to find the current as a function of time. The equation is

$$E\sin\omega t = L\,(di/dt) + Ri$$

or

$$(E/L)\sin\omega t = (di/dt) + (R/L)\,i$$

Transforming as before and assuming that $i_0 = 0$ we obtain

$$p\bar{\imath} + (R/L)\bar{\imath} = (E/L)\,(\omega/p^2 + \omega^2)$$

This equation is solved for $\bar{\imath}$ and separated into partial fractions.

$$\bar{\imath} = \left[\frac{E}{L}\right]\left[\frac{\omega}{p^2 + \omega^2}\right]\left[\frac{1}{p + R/L}\right]$$

$$= \left[\frac{E}{L}\right]\left[\frac{\omega}{\omega^2 + R^2/L^2}\right]\left[\frac{1}{p + R/L} - \frac{p}{p^2 + \omega^2} + \frac{R/L}{p^2 + \omega^2}\right]$$

$$= \left[\frac{E\omega}{L\,(\omega^2 + R^2/L^2)}\right]\left[\frac{1}{p + R/L} - \frac{p}{p^2 + \omega^2} + \frac{R\,\omega}{L\omega\,(p^2 + \omega^2)}\right]$$

Replacing the transformations by their time functions

$$i = \left[\frac{E\omega}{L(\omega^2 + R^2/L^2)} \right] \times$$
$$[\epsilon^{-Rt/L} - \cos \omega t + (R/\omega L) \sin \omega t]$$

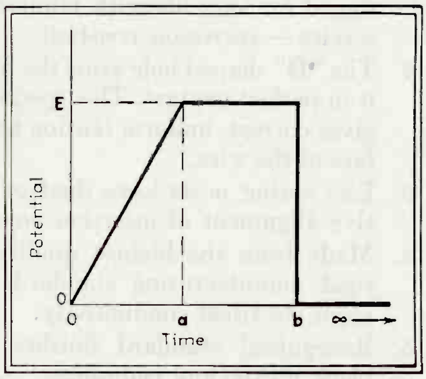
Circuit Response to Complex Voltage

If the voltage applied to the same circuit were a discontinuous function such that from $t = 0$ to $t = a$ it were Et/a, and from $t = a$ to $t = b$ it were E, and from $t = b$ to $t = \infty$ it were zero, what would be the current vs time? In this type of problem, we must assume that the voltage is composed of three separate applied voltages, v_1, v_2, v_3.

$v_1 = Et/a$, and starts at $t = 0$
$v_2 = -E(t-a)/a$, and starts at $t = a$
$v_3 = -E$, and starts at $t = b$

All three voltages continue to ∞. The accompanying sketch shows the resultant applied voltage.

From $t = 0$ to $t = a$ the voltage is only v_1, which is Et/a. From $t = a$ to $t = b$ the voltage is $v_1 + v_2$, which is $[Et/a] - [E(t-a)/a] = E$. From



Applied voltage versus time for third illustrative example of Laplace transform

$t = b$ to $t = \infty$, the voltage is $v_1 + v_2 + v_3$ which is zero. The initial requirements are thus satisfied.

The differential circuit equation is

$$L\,(di/dt) + Ri = \underset{\text{from } t=0}{Et/a} - \underset{\text{from } t=a}{E(t-a)/a} - \underset{\text{from } t=b}{E}$$

As before, the transform of $L(di/dt) + Ri$ is $Lp\bar{\imath} + R\bar{\imath}$. The transform of Et/a is E/ap^2. From (14), the transform of $E(t-a)/a$ is $(E/ap^2)\epsilon^{-ap}$. The exponential factor of the transform indicates that it starts at $t = a$. This time correction appears automatically here because the original function involved $t-a$. However, the transform of E,

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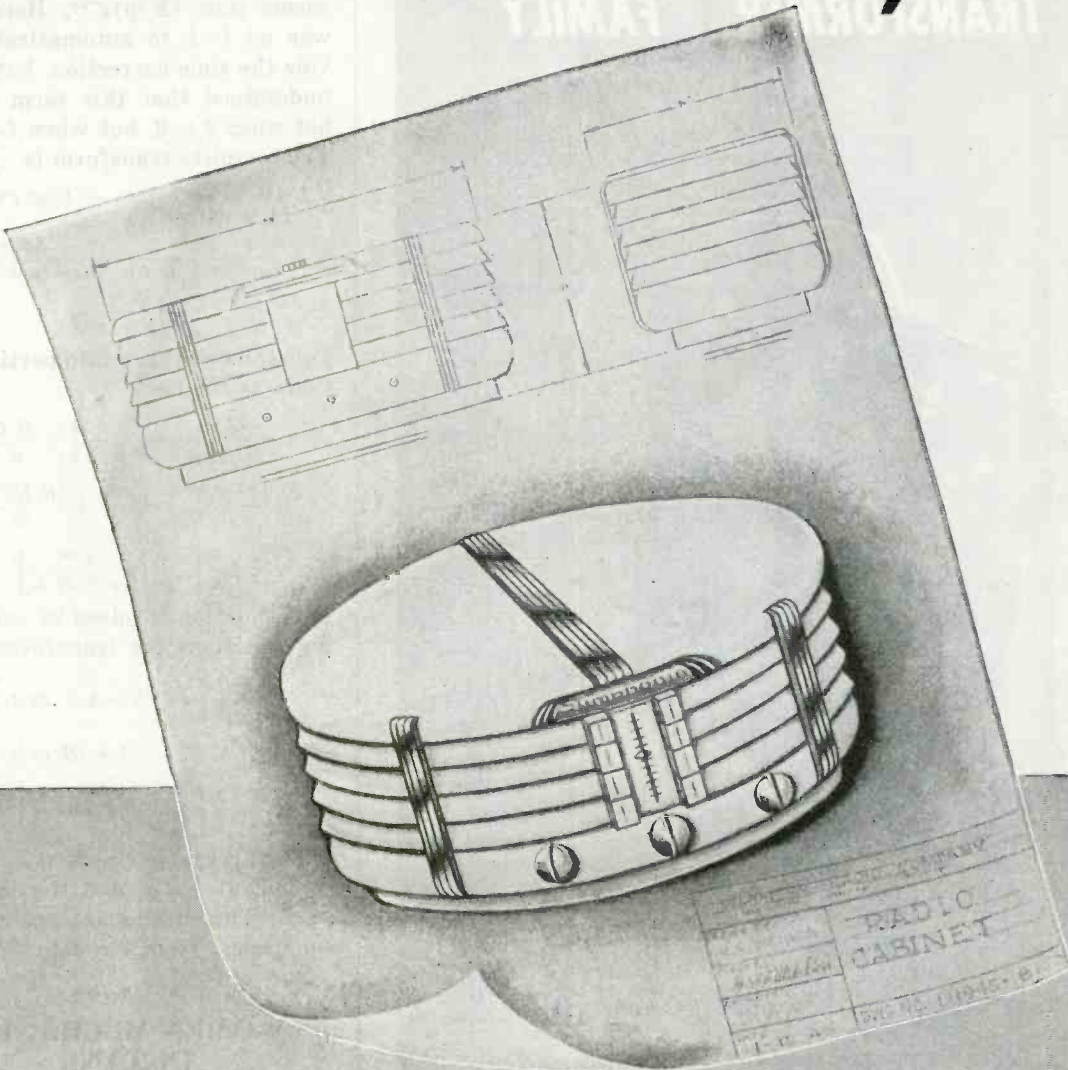

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which is normally E/p, must be multiplied by ϵ^{-bp} since it starts at $t = b$; thus the last term of the differential circuit equation transforms into $(E/p)\epsilon^{-bp}$. Here there was no $t-b$ to automatically provide the time correction, but it was understood that this term begins, not when $t = 0$, but when $t-b = 0$. The complete transform is

$$Lp\bar{\imath} + R\bar{\imath} = (E/ap^2) - (Eap^2)\epsilon^{-ap} - (E/p)\epsilon^{-bp}$$

$$\bar{\imath} = \frac{E}{Lap^2\,(p + R/L)} - \frac{E\epsilon^{-ap}}{Lap^2\,(p + R/L)} - \frac{E\epsilon^{-bp}}{pL\,(p + R/L)}$$

This can be broken into partial fractions as follows

$$\bar{\imath} = \frac{EL}{aR^2}\left[\frac{1}{p + R/L} - \frac{1}{p} + \frac{R/L}{p^2}\right] - \frac{EL}{aR^2}\left[\frac{\epsilon^{-ap}}{p + R/L} - \frac{\epsilon^{-ap}}{p} + \frac{(R/L)\epsilon^{-ap}}{p^2}\right] - \frac{E}{R}\left[\frac{\epsilon^{-bp}}{p} - \frac{\epsilon^{-bp}}{p + R/L}\right]$$

This equation is solved by substituting functions for transforms.

$$i = \frac{EL}{aR^2}\left[\epsilon^{-Rt/L} - 1 + Rt/L\right] - \frac{EL}{aR^2}\left[\epsilon^{-(R/L)\,(t-a)} - 1 + (R/L)\,(t - a)\right] - \frac{E}{R}\left[1 - \epsilon^{-(R/L)\,(t-b)}\right]$$

The first term starts at $t = 0$, the second, at $t = a$, and the third, at $t = b$. Thus there are really three equations: from $t = 0$ to $t = a$ the

• • •

WOMEN MECHANICS IN TANK

In England, ATS girls repair army radio equipment. Corporal Harris was formerly a children's nurse, PTE Joan Fipping was a shop assistant (store clerk to us)

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55	63	77	120	160
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58	65	108	125	354
59	67	109	127	
60	68	112	149	

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

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value of i is given by the first term, from $t = a$ to $t = b$, by the first and second terms, and from $t = b$ *to* $t = \infty$ the whole equation gives the value of i. Note that at $t = a$ and $t = b$ there are two values of i, but that the function is continuous.

It is to be noted that in the second and third examples the Laplace transformation gives a quicker solution than the classical method. In the latter, it is necessary to guess at the answer and then check the accuracy of the guess. An experienced mathematician, that is, a good guesser, may attain a high degree of skill using the classical method, but when he is stumped he will find the Laplace transformation a useful method to know.

• • •

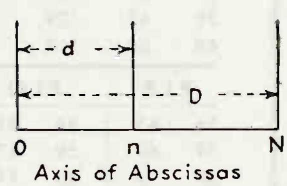
Parabolic Graph Paper for Square-Law Functions

By Albert Leen

It is often convenient to plot square-law functions such as $y = kx^2$ or $y = K\sqrt{x}$ as straight lines. One application is plotting the current indicated by a thermocouple galvanometer versus the deflection. Many such instruments have a scale calibrated in millimeters, with a known full-scale current of 110 milliamperes.

Parabolic graph paper can be ruled by scaling the axis of ordinates so that the length of an ordinate is proportional to its numeric value, that is—linearly, and scaling the axis of abscissas so that the length of an abscissa is proportional to the square of its numeric value. The axis of abscissas is scaled exactly according to the following relation:

$$d = D\frac{n^2}{N^2}$$



where d is the horizontal distance from the origin to the number n, n is the number associated with the ordinate at the distance d from the origin, D is the total length of the axis of abscissas, and N is the number represented by the distance D.

Another application is given in the accompanying power-current

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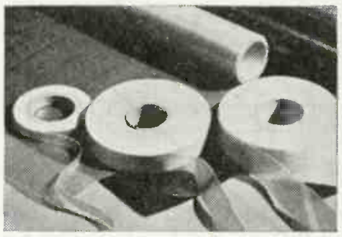

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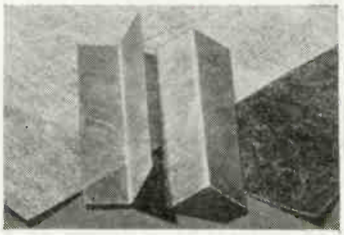

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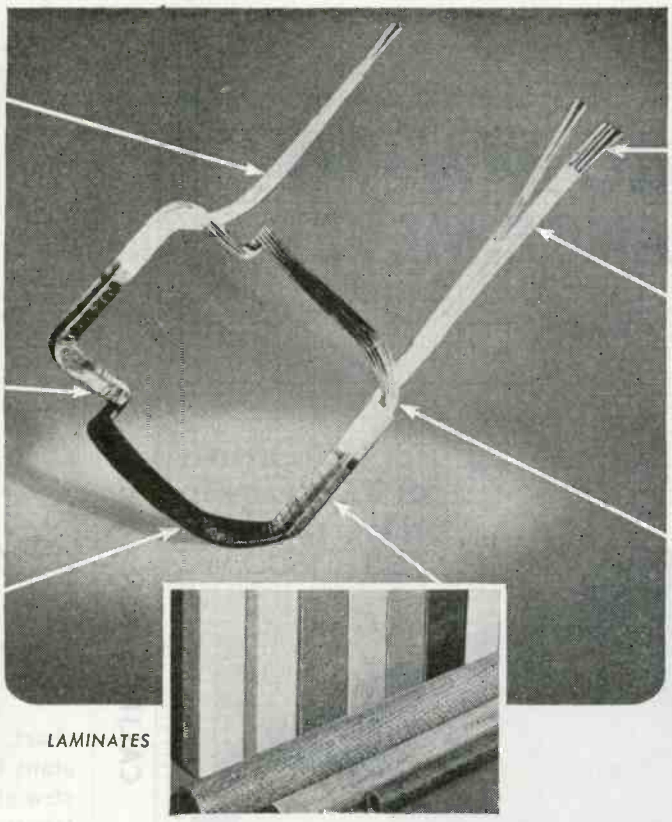

LAMINATES

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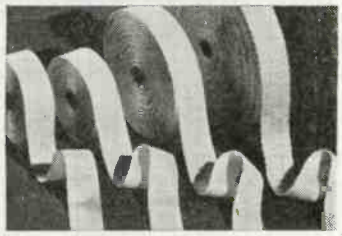

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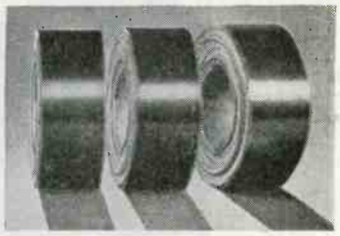

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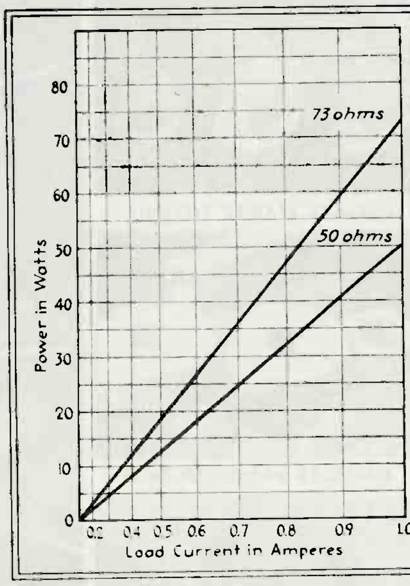

Power-current chart drawn on parabolic graph paper to provide straight lines

chart, where the power in a constant load resistance is drawn as a straight line, although the natural law is a parabola. Multiplying factors can be applied to the scales; if the current scale is multiplied by *a*, the power scale must be multiplied by a^2.

To plot power for a new value of resistance, calculate any convenient point and draw a straight line through the origin and that point. The abscissas can also be plotted as load voltage instead of load current.

• • •

TANK RADIO

With the British Eight Army, damaged radio equipment is sent from forward workshops to the REME Wireless Department for repairs by a skilled craftsman. In the photo above a repaired No. 19 set is handed up to Craftsman Jones of London for reinstallation in a Sherman tank

NEWS OF THE INDUSTRY

First FCC frequency allocations; battlefront radio; radar bombsight; conferences past; microwaves demonstrated; Conventions to Come; Washington News about Victory-First production and component availability; London Letter; Business News; Personnel

FCC Announces Allocations from 25 to 30,000 Mc

FEDERAL Communications Commission proposals for post-war allocations above 25 Mc were announced January 16th, based on the Allocations Hearings held last October. The findings, which are subject to review in hearings scheduled to start February 14th, are summarized in the accompanying table. A detailed analysis and interpretation will appear in the next issue.

Type of Service	Number of Channels	Channel Width	Location in Spectrum (Mc)
Frequency Modulation (Commercial)	70	200 kc	88–102
Frequency Modulation (Educational)	20	200 kc	84–88
Television (Commercial)	12	6 Mc	44–50, 54–84, 180–216
Television (Experimental)	——	——	480–920
Television (Relay)	——	——	1225–1325
Aviation (Instrument Landing and Radio Ranges)	70	200 kc	108–118
Aviation (Traffic Control)	20	200 kc	118–122
Aviation (Air-Ground)	50	200 kc	122–132
Aviation (Experimental)	——	——	1550–1650
Aviation (Navigation Aids)	——	——	170–180, 420–460, 508–524, 960–1125, 1450–1550, 2300–2500, 2700–3900
Amateur	——	——	28–30, 50–54, 144–148, 220–225, 420–450, 1125–1225, 2500–2700, 5200–5750, 10,000–10,500, 21,000–22,000
Police	47	40 kc 60 kc	30–44 152–156
Police (Exp. facsimile)	——	——	940–960
Fire Service	15 20	40 kc 60 kc	30–40 156–162
Forestry	33 27	40 kc 60 kc	30–40 156–162
Electric, Gas, Water, Steam (Utilities)	15 5	40 kc 60 kc	25–44 156–162
Transit Utilities	10	40 kc	25–44
Special Emergency	4 6	40 kc 60 kc	30–40 156–162
Provisional	27	40 kc	25–28
(Petroleum)	10 9	40 kc 60 kc	30–40 156–162
Geophysics	22	40 kc	25–28
(Motion Picture)	4	60 kc	156–162
(Relay Press)			
Facsimile (Commercial)	Any FM Channel (simplex)	200 kc	84–102
Facsimile (Experimental)	——	——	470–480
*Railroad	33 20	60 kc	156–162 44–50, 54–78, 192–216
*General Mobile (Taxicabs, etc.)	12 12 7	40 kc 40 kc 60 kc	30–40 42–44 156–162
*Citizens Radio-Communication (Walkie-talkie)	——	——	460–470
*Rural Telephone	——	——	44–50, 54–78; 192–216
*Rural telephone (Experimental)	——	——	1900–2300, 3900–4550, 5750–7050, 10,500–13,000, 16,000–18,000, 26,000–30,000
*Industrial, Medical (Scientific)	——	0.05 %	13.66, 27.32, 40.98
Relay Systems	——	——	1225–1325, 1900–2300, 3900–4550, 5750–7050, 10,500–13,000, 16,000–18,000, 26,000–30,000
Fixed Public Services	——	——	44–50, 54–78; 192–216, 940–960, 1900–2300, 3900–4550, 5750–7050, 10,500–13,000, 16,000–18,000, 26,000–30,000
Coastal Ship	33 7	40 kc 60 kc	30–44 156–162
Relay Broadcast	22 4	40 kc 60 kc	25–28 156–162
Studio-Transmitter	——	——	940–960 192–216
Development Broadcast	——	——	920–960

* New class of service.

Lunar Television Described at TBA Conference

REMOTE TELEVISION pickups from the moon are coming along one of these days, according to Vladimir K. Zworykin of RCA Laboratories, speaking at the banquet of the first annual conference of Television Broadcasters Association in New York recently.

Each recipient of a technical award (Zworykin, Bingley, DuMont, Espenscheid, Farnsworth, and Goldmark, as reported in ELEC-

Standing at right, O. B. Hanson, NBC, answers a question during the technical round-table session of Television Broadcasters Association's first annual conference in New York. Dr. Alfred N. Goldsmith, at the lectern, center, was the moderator. Seated participants are, l to r, F. J. Bingley, Philco; J. E. Keister, GE; Klaus Landsberg, Television Productions; A. H. Brolly, Balaban & Katz; Curtis W. Mason, KFI; A. B. DuMont; and C. B. Jolliffe, RCA

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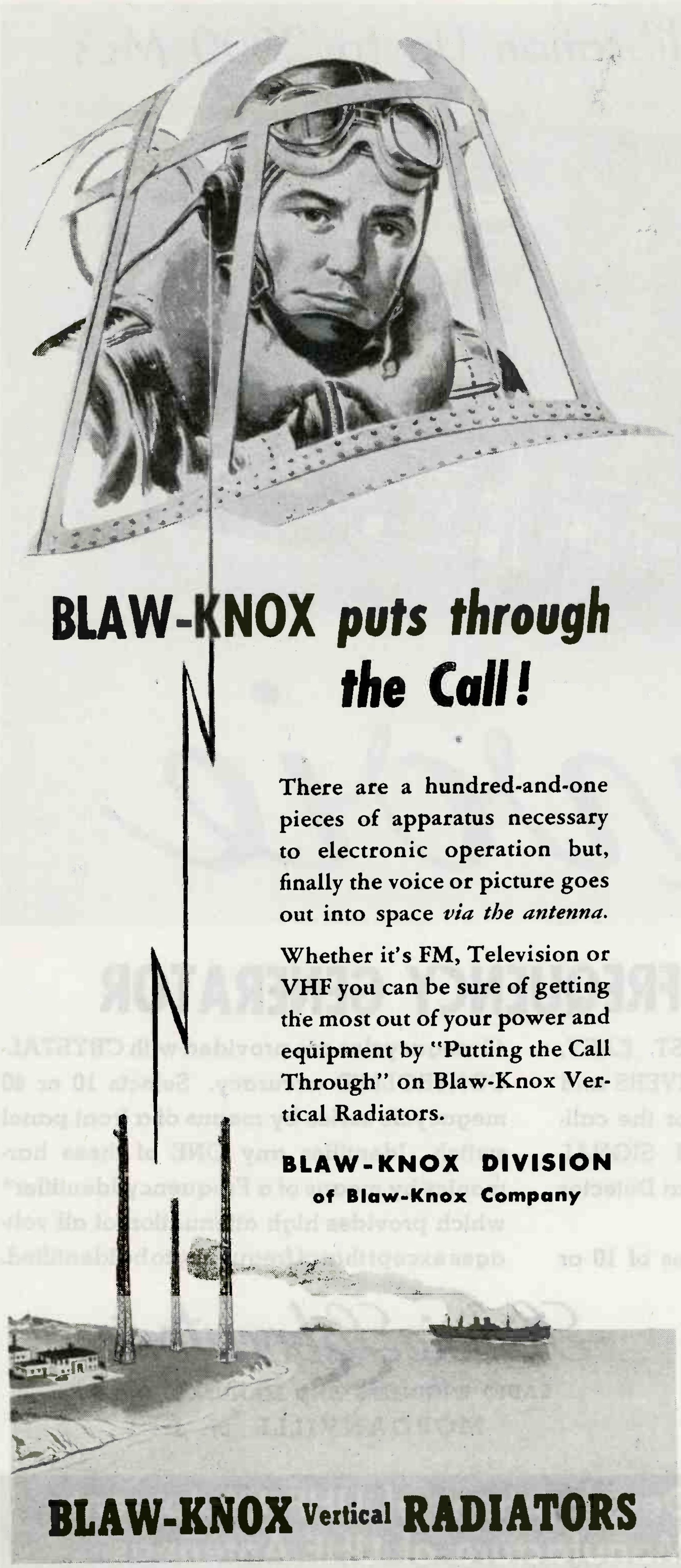
MORGANVILLE, N. J.

Specialists in The Development of UHF Equipment *and in* The Manufacture of UHF Antennas



TRONICS for January) was asked to say a few words about the things he saw in the future of television. Tongue in cheek, Mr. Zworykin pointed out that with the trend as it is toward smaller and lighter equipment, it probably wouldn't be long before a teletransmitter could be pared down to the present size of a walkie-talkie—sort of a walkie-lookie.

The next step he visualized was the installation of one of these units in a rocket which could be sent to the moon, televising as it went. This prognostication to outprognosticate all prognosticators got a large hand from the group of more than a thousand who attended the dinner. Registration for all activities was in the neighborhood of 800.

Sixteen Medals Presented

Additional awards for general contributions to television were made to: Brig. General David Sarnoff, Radio Corp. of America, for his initial vision of television as a social force and for the steadfastness of his leadership in the face of obstacles to television; W. R. G. Baker, General Electric Co., for his leadership in standardizing television through the National Television Systems Committee and supporting it through RTPB; David B. Smith, Philco Corp. for his work on NTSC and RTPB; and Dr. A. N. Goldsmith for his work on NTSC and RTPB and his vision in the relationship of motion picture and television.

Program awards were made to Sam Cuff, WABD; John Williams, WNBT; Robert Gibson, WRGB; Paul Knight, WPTZ; Worthington Miner, WCBW; and Klaus Landsberg, W6XYZ.

Some of the other activities of technical interest included discussions of network television by Harold S. Osborne, AT&T; Naval electronic training, by Commander Bill Eddy, Balaban & Katz; color, by Peter Goldmark, CBS; automatic radio relay systems, by W. S. Lemmon, International Business Machines Corp.; multiple-spectrum use, by D. B. Smith, Philco Corp.; tubes, by Merrill A. Trainer, RCA; and satellite transmitters, by J. E. Keister, GE. Proceedings are being published by the Association.

At the business meeting which

OLDEST IN NAME—
NEWEST IN IDEAS
MAGNAVOX

TYPE FP

Improved processing technique insures fine performance, long life, economy, speedy delivery.

"LOOK TO THE PAST for the future" in the case of Magnavox. This company, with radio's oldest name, is still pioneering . . . blazing new trails in design and advanced engineering. And its pioneering is made practical by 33 years of doing. *There is no substitute for experience!*

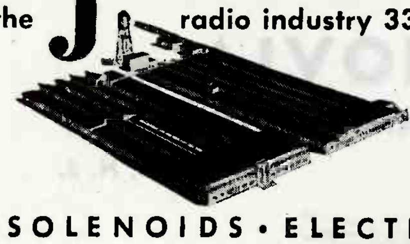
Specializing in FP (fabricated plate) Electrolytic Capacitors, with millions of them now in service, Magnavox is able to effect a full standardization program with all the advantages to you that this provides. Our technical department is available for consultation regarding capacitors for special applications.

After Victory, we shall again serve the radio industry in the traditional Magnavox manner, with the added advantages of our new developments and the superb equipment of our new modern six-acre plant.

The Magnavox Company, Components Division, Fort Wayne 4, Ind.

Magnavox

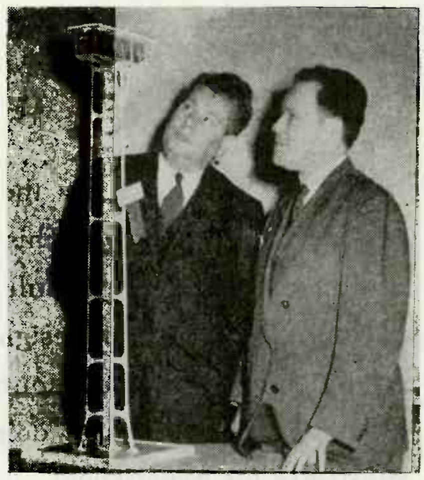
has served the radio industry 33 years



SPEAKERS • CAPACITORS • SOLENOIDS • ELECTRONIC EQUIPMENT

ended the conference, J. R. Poppele, chief engineer of Bamberger Broadcasting Service, was elected president to succeed Allen B. DuMont and O. B. Hanson of NBC was made assistant secretary-treasurer. Eight new members were accepted, bringing the full roster to 37.

Included in the conference itself was at least one technical achievement. Twenty-eight video receivers were installed in the conference hall under the supervision of F. J. Bingley, Philco Corp., and arranged to work from common antennas through a special amplifier having a separate output tube for each receiver. Interference between channels was eliminated and tuning was entirely satisfactory. This development is heralded as a solution to apartment-house and other large-building installations.



Paul L. Chamberlain, manager of sales for GE's transmitter division and Walter S. Lemmon, general manager of the Radiotype Division, International Business Machines Corp., examine a model of the automatic relay tower the two companies propose to use in networking radiotype, facsimile, fm, and television. This is a six-channel unit

IRE Award Citations

THE AWARDS COMMITTEE of the Institute of Radio Engineers has reported the following individuals for various honors as indicated:

H. H. Beverage, Radio Corp. of America, for the Medal of Honor in recognition of radio research toward efficiency in communications and devotion to affairs of IRE.

W. W. Hansen, Sperry Gyroscope Co., the Morris Liebmann Memorial Prize for application of electro-

magnetic theory to radiation, antennas, resonators, and electron bunching; and for development of practical microwave equipment and techniques.

H. H. Buttner, International Telephone & Radio Mfg. Co., fellowship in recognition of radio communication activities in the international field.

O. H. Caldwell, Caldwell-Clements Inc., fellowship for contribution in broadening the horizon of the engineer by efforts to increase the use of electronic principles in industry.

W. H. Doherty, Bell Telephone Laboratories, fellowship for contribution to the development of radio transmitting equipment.

A. W. Hull, General Electric Co., fellowship in recognition of contribution to the design of radio and industrial electron tubes.

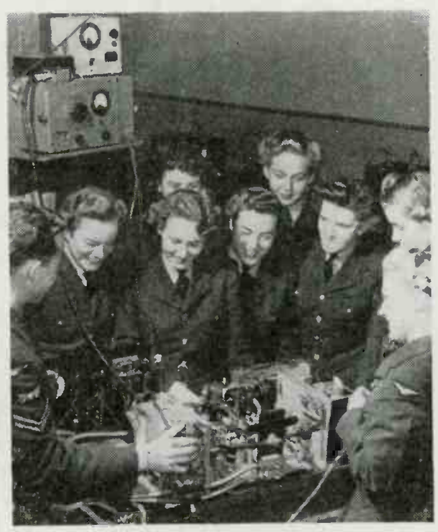
A. L. Loomis, Loomis Institute for Scientific Research, fellowship for work in the application of electronic techniques to medical research and for contribution to microwave development.

A. V. Loughren, Hazeltine Service Corp., fellowship for contribution to broadcast and television engineering.

F. X. Rettenmeyer, Radio Corp. of America, fellowship in recognition of development of broadcast,

• • •

CANADIAN YL SCHOOL



Members of the RCAF Women's Division take up the intricacies of an English model aircraft transmitter and receiver as part of their training as radiotelephone operators

more efficient ...in miniature

Compared to the light, accurate, hard hitting guns of today, the blunderbuss of our forefathers was a clumsy, uncertain weapon. Engineering has gone a long way in the development of more efficient firearms. And the modern miniature electronic tube is just as revolutionary. A little glass enclosed TUNG-SOL Tube, not much bigger than an acorn, will do the work of a large old type tube and generally do it better.

To set builders, compactness of tubes is so important that TUNG-SOL is making new type tubes and redesigning many of the old types in miniature. Old types are continued in production, however, for replacement in existing equipment.

Manufacturers of radio sets and other electronic devices are invited to work with TUNG-SOL engineers in the development of more compact and more efficient electronic equipment through the use of miniature tubes. Of course, consultation work of this nature is strictly confidential.

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 automobile and aviation receivers.

S. A. Schelkunoff, Bell Telephone Laboratories, fellowship for mathematical contributions to electromagnetic theory.

R. L. Smith-Rose, Chicago Telephone Supply Co., fellowship for pioneer work in direction finding and radio propagation allied to leadership of an outstanding radio research group.

K. S. Van Dyke, Wesleyan University, fellowship for research on characteristics of piezo-electric crystals and their application to frequency control.

E. M. Webster, Federal Communications Commission, fellowship for contribution to maritime mobile radio services and promotion of safety at sea.

P. D. Zottu, Girdler Corp., fellowship for activities in high frequency dielectric heating.

Phones for Autos

RADIO-TELEPHONE SERVICE is planned for Philadelphia and Pittsburgh by Bell Telephone Co. of Pennsylvania. Available for trucks, buses, commercial vehicles, and private automobiles, the service will be charged on a fixed-fee basis similar to existing telephone billings.

Shortwave transmitters are planned for both cities and switchboards will be used to link vehicles with existing telephone service. It will be possible to call equipped vehicles within a radius of 15 miles from fixed telephone installations or to call fixed telephones from cars.

NAB Committee Appointments

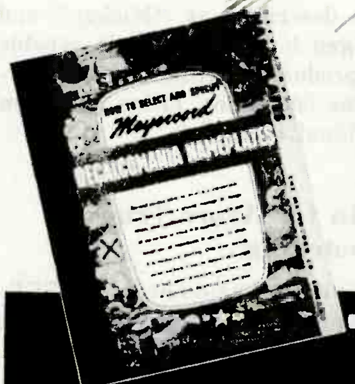
RECENTLY ANNOUNCED by National Association of Broadcasters is the following list of individuals who have been selected to serve on the standing engineering committee for next year. Those listed have already indicated their acceptance of the appointments: Italo Martino, WDRC; Earle Godfrey, WBAB; T. C. Kenney, KDKA; Philip F. Hedrick, WSJS; J. B. Fuqua, WGAC; J. D. Bloom, WWL; Frank A. Dieringer, WFMJ; Stokes Gresham,

the *RIGHT* oil IDENTIFIED for the *RIGHT* Job...

with MEYERCORD DECALS

Oil Company Uses Meyercord Decals for New Coded Lubrication System

By the use of matching numerals applied with decalcomania, an ingenious "Coded Lubrication System", developed by a nationally known oil company, now provides positive identification between all lubrication points . . . grease guns . . . oil cans . . . storage containers. Meyercord Decals are used throughout because of their brilliant, lasting visibility, ease of application, and resistance to oil, grease, vibration, acid, abrasion and temperature extremes. Meyercord Decals are the modern method for all nameplate identification. Investigate their flexible, low-cost use for your plant or product . . . for trademarks, operating instructions, wiring diagrams, factory charts, color codes, etc. They're washable and durable. Any size, design or colors can be produced for application to any commercial surface. Free designing and technical service is at your disposal. Write for literature. Please address all inquiries to Department 9-2.



FREE!
DECAL CHECK CHART

Tells how to select and apply the correct Decal to 16 different surfaces. Conveniently arranged in file folder form. Write for free Check Chart today.

Buy War Bonds—and Keep Them

THE MEYERCORD CO.

World's Largest Manufacturers of Decals

CHICAGO 44, U. S. A. · SALES OFFICES IN PRINCIPAL CITIES

Jr., WISH; Oscar C. Hirsch, WKRO; Mark W. Bullock, KFAB; William G. Egerton, KTSA; Robert H. Owen, KOA; George Greaves, KPO; Lester H. Bowman, KNX; and J. D. Kolesar, KMO.

The Engineering Executive Committee consists of Porter Houston, WCBM, chairman; O. B. Hanson, NBC; Karl B. Hoffman, WGR; William B. Lodge, CBS; and J. B. Fuqua, WGAC.

Increasing Scope of Radio

IN THE FEDERAL Communications Commission's latest Master Frequency List, supplemented to September 1, 1944, there are 2022 numbers used as designations for frequency assignees. Uses are keyed to aircraft, agriculture, amateur, airport, aviation, broadcast, coastal harbor, coastal phone, coastal telegraph, direction finding, experimental, forestry, fixed, government, general communication, geophysical, guard band, international broadcast, intership phone, intership, mobile press, maritime calling, marine fire, motion picture, police, relay broadcast, relay press, ship harbor, ship telephone, state police, ship telegraph, special emergency, special services, and television broadcast—34 in all.

R-F Eyesight for Postwar?

ALLIED MILITARY LEADERS have officially disclosed the existence of the radar bombsight which makes it possible to find bombing objectives otherwise hidden by dust, clouds and smoke screens.

The first such unit was developed by British inventors during the Battle of Britain in 1940. Variously described as "Mickey" and the "gen box", the unit is capable of reproducing outlines of such targets as coastlines, cities and even individual buildings.

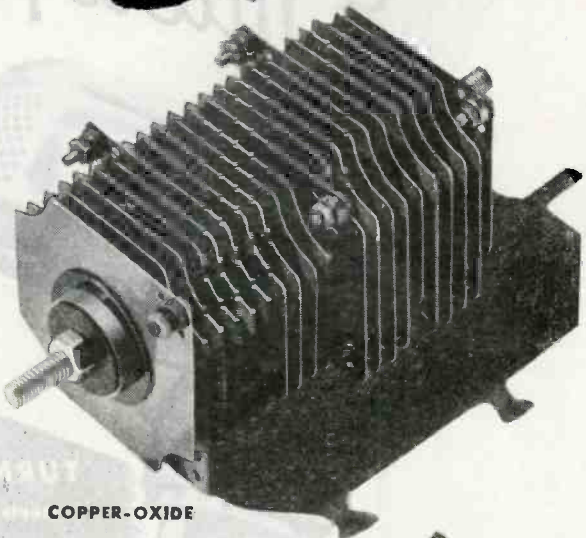
Radio for Army Truck Dispatching

A SIX-STATION RADIO net using SCR-399 radio sets in 2½-ton trucks is given credit for much of the efficiency of the express truck highway between the Normandy beachheads and our western front armies. This road, which was re-

THAT TRAIN WHISTLE STARTED ME THINKING

APPLICATIONS FOR D-C RECTIFIERS ARE LIMITLESS

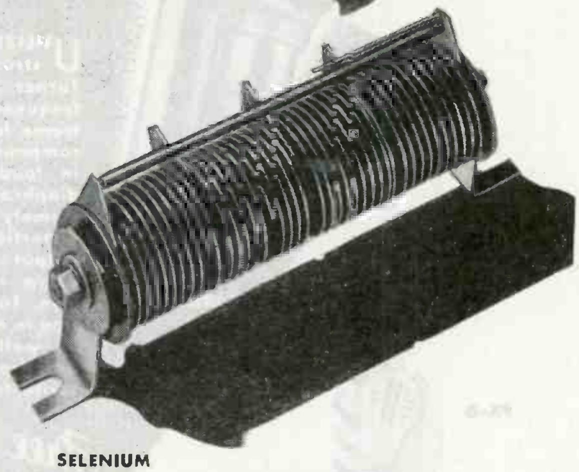
Oftentimes the possibilities for a product are overlooked. Think for a few minutes about rectifiers. A small copper-oxide rectifier supplies the d-c power to make a toy train whistle—in steel mills, large rectifiers deliver output of 60,000 amperes to supply power for tin plating. From the smallest to the largest application for direct current, there are copper-oxide or selenium or Tungar rectifiers to fit the need.



COPPER-OXIDE

ONLY G. E. OFFERS ALL THREE

Where other manufacturers offer one or two of these low cost, low voltage rectifiers, General Electric offers all three. Naturally, each type differs in characteristics, basic materials and construction. The most efficient rectifier for one application may be least efficient on the very next. It is in determining which type to use for each application that G.E. can help most—so look to G.E. for an impartial answer to all rectifier problems. For further information write to Section A255-119, Appliance and Merchandise Dept., General Electric Co., Bridgeport, Connecticut.



SELENIUM

BUY WAR BONDS AND KEEP THEM

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news every weekday 6:45 P.M. EWT, CBS.

TUNGAR

GENERAL ELECTRIC

ferred to as the Red Ball Express, existed only 81 days but carried more than half a million tons of supplies a distance of 700 miles before being discontinued in favor of the repaired French railways.

When truck convoys were formed up at the western end of the highway, a message was forwarded to all stations along the route, describing the contents and destination and giving full instructions as to its handling. Peak traffic handled in a single day was 93 messages averaging approximately 60 words per message.

Scavenged Fifty-Watter

RADIO KWAJALEIN is located on Kwajalein atoll in the Marshall Islands. It occupies a space 12 ft. by 5 ft. and puts out 50 watts of power from salvaged Army, Navy, and Marine Corps equipment, combined with a scattering of captured Japanese and personally donated items.

Conceived by Major Leland W. Smith, of Winston-Salem, N. C., previously an active ham, the equipment is manned by Marine Corps personnel. Because of the lack of tools, almost two months time was devoted to assembling such items

Marine Technical Sergeant Charles T. Haas, Tucumcari, New Mexico, cues in the news commentator at Radio Kwajalein, Kwajalein Atoll, Marshall Islands

as an aluminum panel from a damaged Liberator, power plant and turntables which had been discarded as unserviceable by the Navy; quartz frequency-control crystals ground on the spot; and coils and transformers made up by the builders.

The daily schedule includes transmission from 6 to 7:30 a.m., from noon to 2 p.m., and from 5 to 9 p. m. Most of the construction work was done by Marine Technical Sergeant Charles T. Haas of Tucumcari, New

"The following is electrically transcribed..."

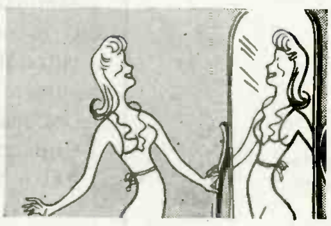
on PRESTO discs!

Pepsi-Cola's bouncy little ditty seems likely to become an American folksong. It has been played on the air more than a million times since 1939. You've heard it in swing-time and in "classical" versions for the intelligentsia. It has made Pepsi-Cola a buy-word in homes throughout the nation.

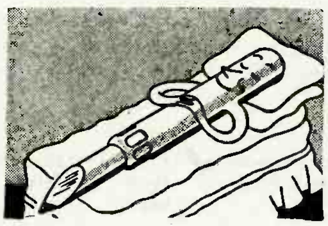
Pepsi-Cola "spots" are cut on PRESTO discs. *Most important transcriptions are.* For recording engineers know that PRESTO discs give finer results with less margin for error—*actually perform better than most of the recording equipment on which they are used.* That's why you'll find, in most large broadcasting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

WHY BROADCASTING STUDIOS USE MORE PRESTO DISCS THAN ANY OTHER BRAND

Less Surface Noise



No Distortion



Easier on Cutting Needle

No Fussy Needle Adjustments

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

PRESTO

RECORDING CORPORATION

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

Walter P. Downs Ltd., in Canada

Mexico. Modern circuits were used throughout and modified only where absolutely necessary because of material shortages.

Parts and Equipment Conference

DURING OCTOBER a registration of nearly 1,500 attended the Electronic Parts and Equipment Industry Conference at the Hotel Stevens in Chicago. Sponsored by the Electronic Parts and Equipment Manufacturers; Eastern Div., Sales Managers Club; RMA; and National Electronic Distributors Association, the meeting featured 150 manufacturers who maintained conference booths as well as a large participation by distributors and manufacturers' representatives.

Signal Corps Afloat

AS THE PHILIPPINE invasion materialized, facilities for broadcast and press coverage were provided by Army Communications Service of the Signal Corps. A special Signal Corps radio ship was utilized as part of the fleet which landed the invasion forces. Involved was the largest network in history. It provided at least two alternate circuits for transmission of broadcast and press material including radiophotos.

Additional RMA Members

AT A RECENT MEETING of the Radio Manufacturers Association executive committee, nine concerns were voted into active membership. These were: Ensign Coil Co., Chicago; General Television & Radio Corp., Chicago; Lear Inc., Chicago; Maguire Industries Inc., Greenwich, Conn.; Permoflux Corp., Chicago; Radio and Television Inc., New York; Rek-O-Kut Co., New York; Screenmakers, New York, and Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.

Microwave Demonstration

FOR THE FIRST TIME, NDRC has authorized discussion and demonstration of a complete microwave system for communication purposes. It was presented at the 597th meeting of the New York Electrical Society recently by Dr. George B.

CAPACITOR SELECTION *Simplified*

Probably no type of Electrical-Electronic component affords a greater variety of selection for a given application than capacitors. Probably no component is more susceptible to design changes to accommodate given conditions. Moreover, nowhere has engineering been moving faster in developing new types, improving old types and, in general, changing past conceptions of Capacitor usage.

That's why proper Capacitor selection is no casual matter—and this, in turn, is why we make the following recommendation to Capacitor users:

Write today for a supply of Sprague Capacitor Sample Request Forms. Then, as Capacitor applications arise, send full data to Sprague engineers on these forms. Let Sprague consider all factors involved—both in the light of long, specialized experience, and of the latest Capacitor developments or adaptations which Sprague engineering may have to offer.

It takes no longer to buy Capacitors on this basis. Such service makes them cost no more—and it frequently means important savings, increased efficiency on your production line, and greater dependability for your product.

SPRAGUE ELECTRIC COMPANY, North Adams, Mass.
(Formerly Sprague Specialties Co.)

SPRAGUE CAPACITOR TYPES

Dry Electrolytics — Paper—Mica
Power Factor Correction
High Voltage Networks
*Vitamin Q Capacitors
Radio Noise Suppression
Filters, etc., etc.

SPRAGUE RESISTOR TYPES

*Koolohm Wire-Wound Power
Hermetically-sealed Wire Wounds
Bobbin Types
Voltage Divider Sections
Precision Meter Multipliers, etc.

*T. Ms. Reg. U. S. Pat. Off.

ARMY E NAVY

SPRAGUE

CAPACITORS — *KOOLOHM RESISTORS

Hoadley who is in charge of the instructional microwave laboratory at the Polytechnic Institute of Brooklyn.

Pointing out that the impetus of the war has been such as to make networks of microwave booster stations actually practical, Dr. Hoadley demonstrated the use of plain sections of galvanized iron drainpipe as wave guides and showed by analogy the reflection of microwave beams from topographic objects.

The lecture included a discussion of protective equipment for ships and planes to utilize radar principles in movements through fog. He also displayed a horn-type radiator which is analogous to the horn on a loudspeaker, a parabolic reflector analogous to a searchlight, and a Klystron oscillator.

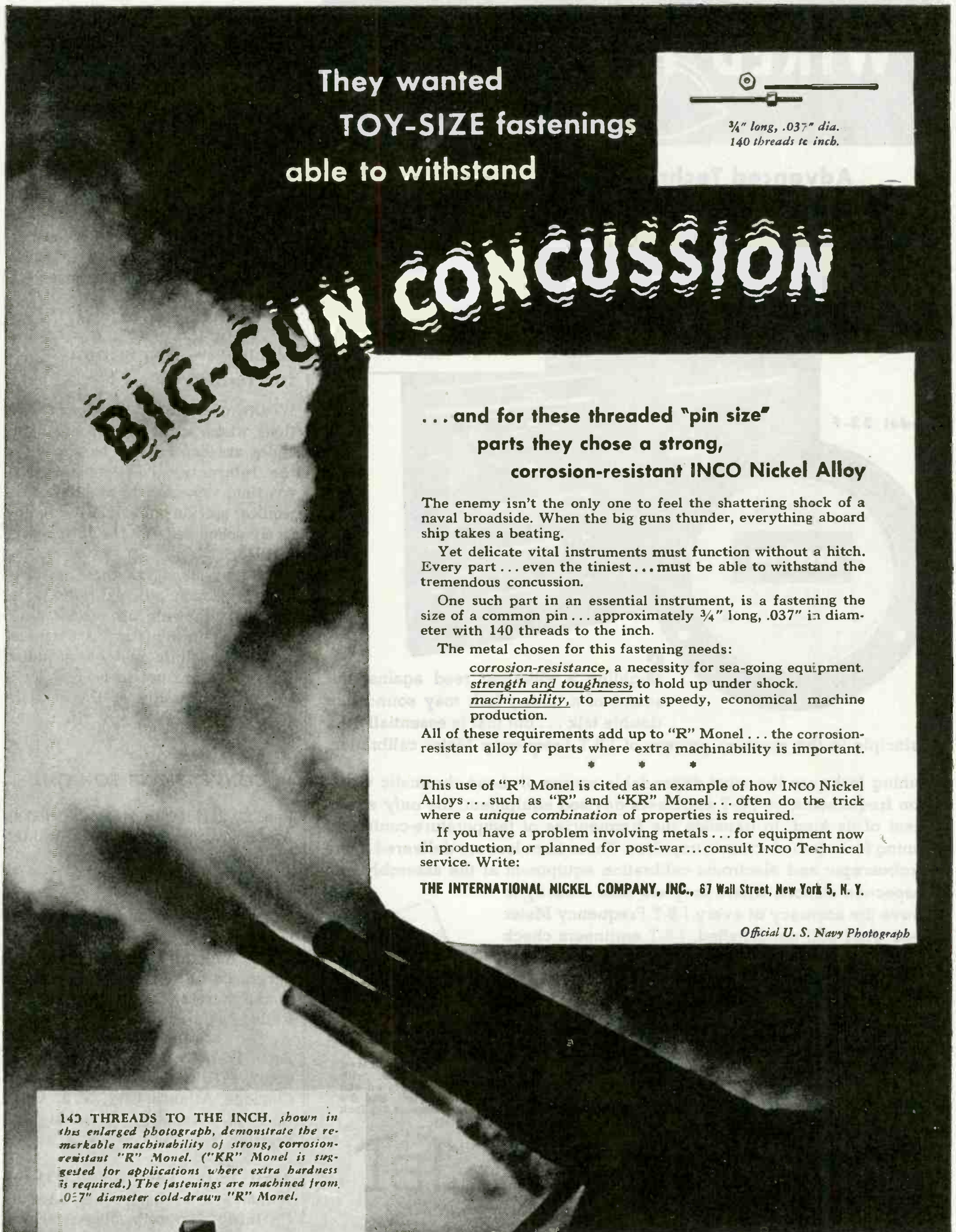
New IRE Section

Members of the newly approved Cedar Rapids Chapter of IRE discuss a presentation of Centralab products. Left to right are: R. V. Guettler, G. Milton Ehlers, and W. S. Parsons of Centralab, standing, and T. A. Hunter, Collins Radio Corp., temporary chairman of the section.

THIRTY COUNTIES in Iowa and two in Illinois are included in the scope of a new institute of Radio Engineers Chapter with headquarters at Cedar Rapids, Iowa. Membership is expected to run to about 100, 64 having been in attendance at the organizational meeting held recently. Temporary chairman is T. A. Hunter of Collins Radio Corp.

Post-War Radio Services

NOW IS THE TIME to start assembling the additional "know how" radio service men will need to keep pace with post-war developments in the radio field, thinks Leonard C.



They wanted
TOY-SIZE fastenings
able to withstand

¾" long, .037" dia.
140 threads tc inch.

BIG-GUN CONCUSSION

. . . and for these threaded "pin size" parts they chose a strong, corrosion-resistant INCO Nickel Alloy

The enemy isn't the only one to feel the shattering shock of a naval broadside. When the big guns thunder, everything aboard ship takes a beating.

Yet delicate vital instruments must function without a hitch. Every part . . . even the tiniest . . . must be able to withstand the tremendous concussion.

One such part in an essential instrument, is a fastening the size of a common pin . . . approximately ¾" long, .037" in diameter with 140 threads to the inch.

The metal chosen for this fastening needs:

- corrosion-resistance, a necessity for sea-going equipment.
- strength and toughness, to hold up under shock.
- machinability, to permit speedy, economical machine production.

All of these requirements add up to "R" Monel . . . the corrosion-resistant alloy for parts where extra machinability is important.

* * *

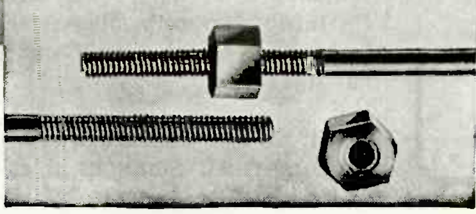
This use of "R" Monel is cited as an example of how INCO Nickel Alloys . . . such as "R" and "KR" Monel . . . often do the trick where a *unique combination* of properties is required.

If you have a problem involving metals . . . for equipment now in production, or planned for post-war . . . consult INCO Technical service. Write:

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N. Y.

Official U. S. Navy Photograph

140 THREADS TO THE INCH, *shown in this enlarged photograph, demonstrate the remarkable machinability of strong, corrosion-resistant "R" Monel. ("KR" Monel is suggested for applications where extra hardness is required.) The fastenings are machined from .037" diameter cold-drawn "R" Monel.*



INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • "Z" NICKEL • NICKEL
Sheet... Strip... Rod... Tubing... Wire... Castings

Truesdell of the Radio Division of the Bendix Aviation Corp., Baltimore, Md. Speaking at a meeting of Philadelphia radio servicemen, Truesdell predicted the appearance of new opportunities with fm and television.

Besides acquiring information, the service man should work on the assembly of modern facilities and equipment. A second phase can be the absorption of ex-servicemen whose advanced training in radio will make them particularly useful.

Electronics Exposition for Industry

WORKING EXHIBITS or demonstrations which utilize electronic principles are expected to be shown at the International Electronics Exposition, sponsored by the electronics section of NEMA, tentatively scheduled for the latter part of 1945.

Present plans are that the electronics section will exhibit statistical data showing use of electronic equipment in industry. A technical session or clinic will be included. Exhibitors are not to be restricted to the membership of the association.

CONVENTIONS TO COME

Feb. 20-21. RADIO MANUFACTURERS ASSOCIATION, Annual Mid-Winter Conference . . . Cancelled.

Feb. 26-March 2. AMERICAN SOCIETY FOR TESTING MATERIALS, Committee Week and Spring Meeting (28), William Penn Hotel, Pittsburgh, Pa. R. J. Painter, assistant to the secretary, 260 S. Broad St., Philadelphia 2, Pa.

April 12-14. ELECTROCHEMICAL SOCIETY, 87th General Meeting, Hotel Claridge, Atlantic City, N. J. Colin G. Fink, secretary, Columbia University, New York 27, N. Y.

April 12-14. OPTICAL SOCIETY OF AMERICA, Cleveland, Ohio. Arthur C. Hardy, secretary, Massachusetts Institute of Technology, Cambridge 39, Mass.

April 26-27. INSTITUTE OF THE AERONAUTICAL SCIENCES, National

Light Aircraft Meeting, Detroit, Mich. Meetings Committee, 1505 RCA Building West, 30 Rockfeller Plaza, New York 20, N. Y.

WASHINGTON NEWS

VICTORY-FIRST PRODUCTION. "Reconversion" and "cutbacks" were described by Director Louis J. Chatten of the Radio and Radar Division, WPB, as two bugaboo words standing in the way of increased Victory-First production of electronics in industry, when he spoke before a recent RMA export committee meeting. As he pointed out, publicity has made the two subjects more interesting reading than the war news.

Production reports for October show communication and electronic equipment up 5 percent over September, but still 6 percent short of schedule. Radio equipment output equaled September production but was 7 percent under schedule, while airborne radio production for the Army was up 12 percent and only 3 percent short of schedule. Radar equipment production was up 4 percent but still lagged 8 percent behind schedule.

The new Victory-First production program faced by the radio and radar industry calls for maximum peak production of over-all products and equipment at the rate of $250,000,000 a month by March 1, 1945. WPB announces plans to undertake immediately a survey of the industry aimed at establishing a factual background covering production, labor, and other elements related to the industry's ability to get increased production.

Shortages of radio receiving tubes for the maintenance of Army and Navy combat equipment and replacement of increasing battle losses must be made up at the expense of civilian radio tube supplies, it was announced, and therefore the number of civilian tubes available in the first quarter of 1945 will be much smaller than the hoped-for 2,000,000 tubes a month.

NON-CRITICAL COMPONENTS. Regulations of WPB have been relaxed to make it possible to buy a number of types of parts and components out of idle and excess stocks of war contractors. Items no longer con-

STRAIGHT TO THE MARK!

Our Navy's PT Boats are driving the war home to the enemy at high speed. They're shooting straight to the mark! They're demonstrating the power of American ingenuity and industry to the Jap war lords!

Eastern is serving on board these scrappy, hard-hitting PT Boats. Eastern equipment helps them carry out each assignment—swiftly and surely. Amplifiers, only a few short years ago, were thought of mainly in connection with sound systems. Today, they are an important part of many essential war instruments.

Eastern is proud to utilize its engineering and production facilities in the war effort . . . certain that its war-time experience will result in better-than-ever post-war sound and electronic equipment. Until the victory is won, Eastern will continue to devote all its resources to the design and manufacture of war equipment. To aid the war effort, our engineers are available for consultation on any amplification problem you may have.

On request, we shall be glad to forward brochure containing the first of a series of articles covering technical phases of interest on sound amplification prepared by our engineering staff. Ask for Brochure 2-F.

Buy MORE War Bonds

EASTERN AMPLIFIER CORPORATION

794 East 140th Street, New York 54, N. Y.

EASTERN AMPLIFIERS

sidered critical include certain capacitors, some types of resistors, crystal assemblies, insulators, microphones, sockets and loudspeakers.

AIRPORTS PLANNED. Prepared by the Civil Aeronautics Administration, a national airport plan has recently been sent to Congress by the Secretary of Commerce. The report recommends construction of 3,050 airports and improvement of 1,625 existing fields. Construction is to be financed over a period of five to ten years by federal aid with matching of funds by the state. Radio facilities will be included with other items to a total of $1,021,567,945.

RECEIVING-TUBE SCHEDULING. Headed by Milton Lauer of the Radio and Radar Division, WPB, as government presiding officer, the following individuals constitute the newly-appointed receiving-tube-scheduling industry advisory committee: William Hieatt, Ken-Rad Tube and Lamp Corp.; G. C. Brewster and L. F. Holleran, RCA; Ray Paret, National Union Radio Corp.; K. Johnson and F. E. Anderson, Raytheon Mfg. Co.; John Q. Adams, Hytron Corp.; K. Morehead and H. W. Van Twistern, Tung-Sol Lamp Works; H. J. Klein and A. L. Milk, Sylvania Electric Products.

LONDON LETTER

By JOHN H. JUPE

ELECTRONIC OPPORTUNITIES FOR EX-SERVICEMEN. Many men leaving the technical branches of the fighting services will want to use their newly acquired technical knowledge as a means to earn a living and some opportunities for development in the science of cinematography were mentioned by Mr. A. G. D. West in his presidential address to the British Kinematograph Society recently. All were electronic and they included problems of theatre acoustics, uniformity of sound reproduction, uniform screen brightness, maintenance of quality in recording, and improvements in 16-mm sound film.

Another field in which electronic research is badly needed involves the quality of sound in the various types of office dictation recorders used by business men. Without ex-

ception, the a-f response is very bad (apart from other faults) and it is high time that something was done in the matter, because here is the ideal way of showing the business man exactly what electronics can do.

BUSINESS NEWS

UTAH RADIO PRODUCTS COMPANY'S subsidiary, Caswell-Runyan Co., Huntington, Ind., has purchased property and equipment formerly owned by the Goshen Veneer Co. for the production of panels and related items to go into radio receivers.

KEN-RAD CORP. has sold its tube facilities at Owensboro, Ky., and Huntington and Rock Port, Ind., to General Electric Co.

ST. JOHN X-RAY SERVICE INC., Long Island City, N. Y., marks its 20th anniversary of operation.

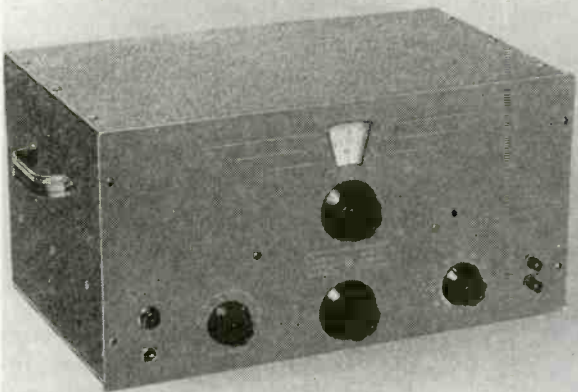
PRESS WIRELESS forms a new division to be known as Press Wireless Institute. Previously operating as a Signal Corps radio school, the facilities are now being used for instruction of seamen from the U. S. Navy. The curriculum places special emphasis on high-power transmitter work, antenna technique, and trouble shooting.

ELECTRONIC CORP. OF AMERICA, United Transformer Co., and Emerson Radio and Phonograph Co., New York, N. Y., participated through joint labor-management activities in a special program for distribution of Christmas gifts to Russian children.

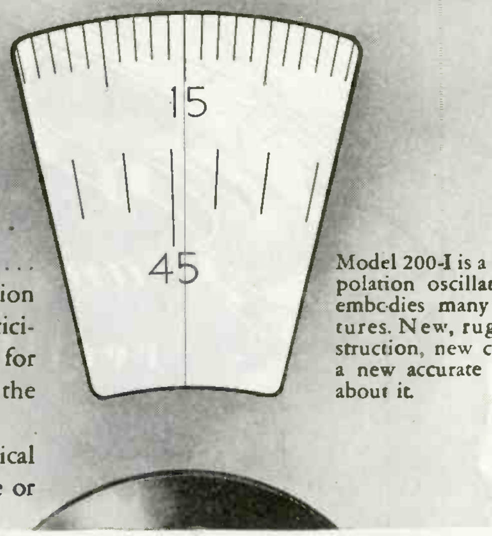
GENERAL ELECTRIC X-RAY CORP. enlarges its Chicago facilities by the addition of 12,000 square feet of floor space at 1417 West Jackson Blvd. Tube laboratories which had previously been scattered throughout the company's main plant, will be housed here as a centralized experimental section.

WAR PRODUCTION BOARD statistics compiled from about 10,000 reports from private and government-owned manufacturing plants indicate that the first quarter of 1944 saw communication and electron equipment shipped to the extent of

A LIFETIME of SPLIT-HAIR ACCURACY
is Standard Equipment
with Every -hp- Instrument



MODEL
200-I



"Guess-testing" belongs to the era of crystal sets and silent pictures . . . Radio and electronics of today *and tomorrow* demand the use of precision testing and measuring instruments. Hewlett-Packard engineers anticipated this demand. There is a standard *-hp-* instrument available for making every important test and measurement *with insured accuracy* in the audio frequency field.

A few of these instruments are illustrated below . . . complete technical information will be sent on request. For special applications, a note or sketch outlining your problem will receive prompt attention.

Model 200-I is a new interpolation oscillator which embodies many new features. New, rugged construction, new circuit and a new accurate dial. **Ask about it.**

RESISTANCE-TUNED AUDIO OSCILLATORS

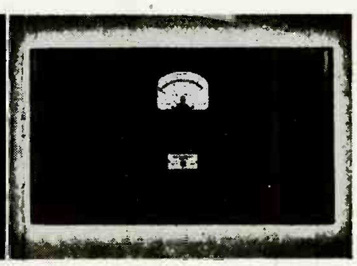
Require no zero setting...several models available to cover frequency ranges from 2 cps to 200 kc.

AUDIO SIGNAL GENERATORS

Three models—205-A, 205-AG, 205-AH —provide frequency ranges from 20 cps to 100 kc.

VACUUM TUBE VOLTMETERS

Make accurate voltage measurements from 1 cycle to 1 megacycle, cover nine ranges, (.03 volts to 300 volts) with full scale sensitivity.

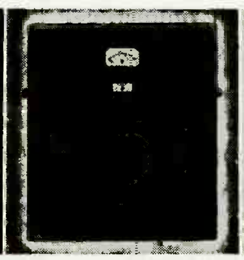


DISTORTION ANALYZERS

Three models available—320-A, 320-B and 325-B—to provide frequency coverage from 30 cps to 15 kc. Model 325-B incorporates a vacuum tube voltmeter.

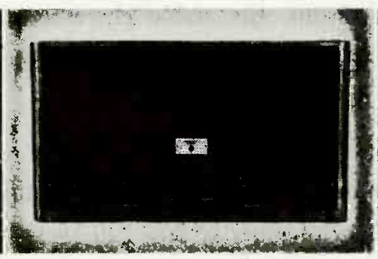
ELECTRONIC FREQUENCY METER

The Model 500-A is designed to measure the frequency of an alternating voltage from 10 cps to 50 kc. Overall accuracy is ± 2% of full scale value.



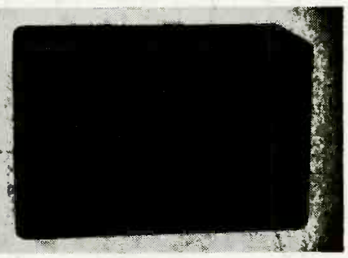
HARMONIC WAVE ANALYZER

Measures individual components of a complex wave over a frequency range of 30 to 16,000 cps. The selectivity can be varied continuously, making the analyzer adaptable to a wide variety of measurements.



FREQUENCY STANDARDS

The Model 100-B supplies standard frequencies of 100, 1,000, 10,000 and 100,000 cps. all of which are available simultaneously.



ATTENUATOR AND VOLTAGE DIVIDERS

The Model 350-A consists of a 10 db and a 100 db bridged-T attenuator, providing a total of 110 db attenuation, variable in 1 db steps. Other attenuators and voltage dividers can be quickly supplied.

HEWLETT-PACKARD COMPANY

BOX 990A, STATION A **PALO ALTO, CALIFORNIA**

CANADIAN OFFICE:
560 KING STREET WEST
TORONTO 2, CANADA

990

$1,049,298,000 involving 34,475 short tons of carbon steel, 10,614 short tons of alloy steel, 28,941,000 lb of copper and copper-base alloys; and 11,166,000 lb of aluminum.

PERMOFLUX CORP. consolidates its engineering and manufacturing facilities at 4900 West Grand Ave., Chicago 39, Ill.

WESTERN ELECTRIC CO., New York, N. Y., plans to manufacture television transmitting equipment post war.

PEERLESS ELECTRICAL PRODUCTS CO., Los Angeles, Calif., has installed the first complete hydrogen annealing plant in the West for treatment of high permeability materials going into wide-range audio transformers.

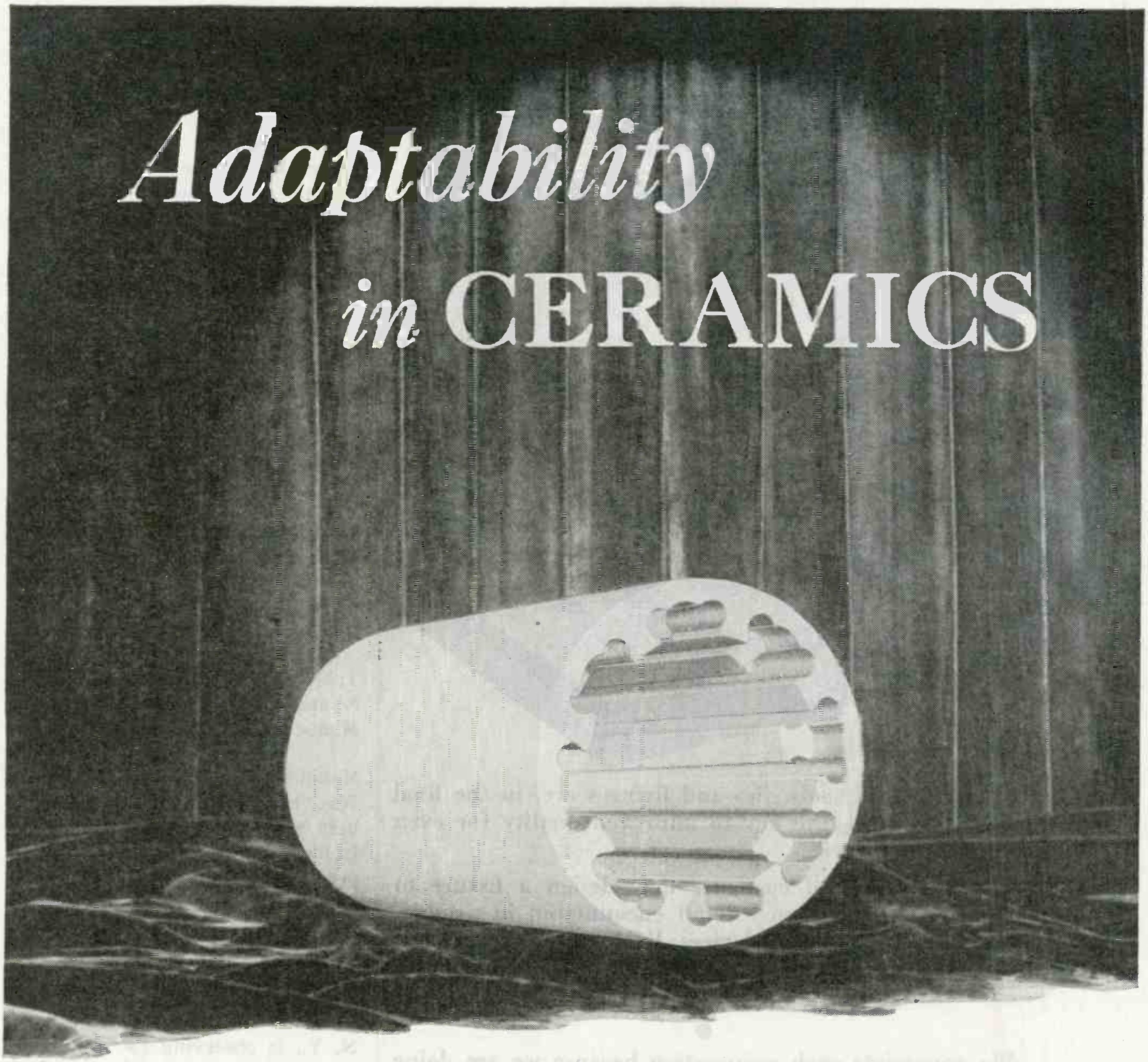
HARVEY MACHINE CO. INC., Los Angeles, Calif., has developed a miniature six-tube receiver for post-war distribution. It is described as about the size of three packages of cigarettes—neither being currently available.

PHILCO CORP., Philadelphia, Pa., is cooperating with the Massachusetts Institute of Technology on plans for a professional course in electronics. The new cooperative course, which leads to a master of science degree, will emphasize the advancement of television and highly developed production methods in applying wartime techniques to the arts of peace.

ASSOCIATION OF AMERICAN RAILROADS is forming a central radio- and communications-engineering and technical committee to coordinate frequency needs. The committee will maintain liaison for all member roads with FCC.

INDUSTRIAL ELECTRONICS, Detroit, Mich., and Visual Training Corp. are forming a combined school to give instructions in electricity and electronics. Students will be offered two-year engineering courses or short specialized training periods for specific industrial positions.

ATLAS CORP. acquires an interest in the Societe de Gerance de Radio Imperial of Tangiers. The plan is



COIL FORM FOR INTERNAL WINDING
by STUPAKOFF

Permanently strong and stable both mechanically and electrically, ceramics are versatile materials capable of intricate design. Competent engineering enables dimensional tolerances to be held to a minimum.

The internally wound coil form illustrated is engineered and produced by Stupakoff for a specific application. Resistance to thermal shock and mechanical strength are specifications embodied in this one-piece extruded insulator. Slotted, longitudinal winding holes expose the heating element and allow heat to be directed instantaneously to the center of the coil.

Specialists in the field of electrical insulation, Stupakoff engineers are trained to find *specific* solutions for *your* insulation problems. Contact Stupakoff today—two generations of dependability in the ceramic field justify this choice.

"FOR GREAT ACHIEVEMENT"

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Ceramics for the World of Electronics

to build and operate broadcasting, television, wireless-communication, and facsimile-transmission facilities in such French points as Martinique, French Guiana, Guadeloupe, territories in India, Madagascar, la Reunion, New Caledonia, Oceanic Settlements, Clipperton Island, and St. Pierre et Miquelon.

RCA PHOTOPHONE EQUIPMENTS LTD., Bombay, India, has a far-reaching postwar program for expansion of India's film industry. Opportunities are spotlighted by the fact that India's 390 million inhabitants are served by only 1700 film houses as compared with 17,000 in this country of 130-million population.

THE 1350 SIXTH AVE. CORP., New York, N. Y., is planning what it believes to be the first theater in the U. S. to be built and equipped for projection television.

TELICON CORP. has opened a second crystal-finishing plant at 70th and Madison Ave., New York, N. Y.

MARQUETTE UNIVERSITY, Milwaukee, Wis., has 80 electrical union members studying in the special electronics course they are giving to produce better electricians. Instruction is to be given to 500 similar students who will carry their enlightenment back to the local organizations.

WESTERN ELECTRIC CO., New York, N. Y., is observing its 75th anniversary. It currently employs nearly 100,000 men and women and is the Nation's largest producer of communications and electronic equipment for the armed forces.

EMERSON RADIO AND PHONOGRAPH CORP., New York, N. Y., disbursed approximately $149,000 to workers as a year-end bonus.

HOLTZER-CABOT ELECTRIC CO., Boston, Mass., has sold its signal systems department to Faraday Electric Corp., Chicago, Ill. Holtzer-Cabot is a wholly-owned subsidiary of Commercial Investment Trust Corp.

PHILCO CORP., Philadelphia, Pa., has made 52 percent more radar and other electronic equipment in the first nine months of 1944

than in the same fraction of last year. Earnings are up over the same period from $1.78 to $2.11 per share.

PERSONNEL

HOWARD THOMAS, of Packard Bell Co., is elected president of West Coast Electronics Manufacturers Association. He succeeds H. Leslie Hoffman. Lew Howard of Peerless Electrical Products Co. becomes vice-president and James L. Fouch of Universal Microphone Co., treasurer.

H. B. MARVIN has been made available for special assignments in the tube division of General Electric Co., Schenectady, N. Y. He was formerly assistant engineer in the general engineering laboratory.

W. E. FULLERTON has been made vice-president in charge of production at Zenith Radio Corp., Chicago, Ill.

WINFIELD G. WAGENER is appointed chief engineer of the Vacuum Tube Division, Litton Engineering Lab-

oratories, Redwood City, Calif. He was previously chief engineer for Heintz & Kaufman, Ltd., San Francisco, Calif.

ALVA VAN ALYSTYNE has been made chief transmitter engineer at WMFM, Milwaukee, Wis. He was formerly a transmitter engineer.

STANLEY A. DUVALL has been made chief engineer at Runzel Cord & Wire Co., Chicago, Ill. He was formerly in electronic consultation work.

E. A. HERTZLER has been made director of war research at United Electronics Co., Newark, N. J. He was formerly at Pratt Institute.

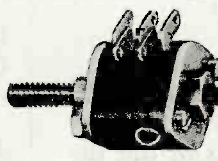
HAROLD W. SCHAEFER has been made assistant manager of the ra-

NEW RECTIFIERS FOR SIMPLIFICATION OF CIRCUIT DESIGN PROBLEMS

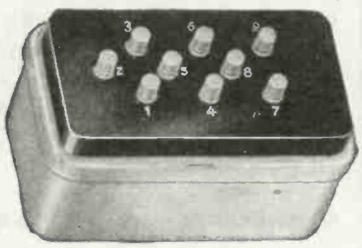
STANDARD MODELS OF COPROX RECTIFIERS

Coprox Model CX-2E4-A9, ring-connected and mounted in tube base, detects phase differentials in A.C. currents and small D.C. potentials applied to balanced A.C. circuits. Maximum 4.5 volts continuous. Shown here in actual size.

Coprox Model CX-1C2B1, a center tap, full wave rectifier. Completely enclosed in Bakelite. Low capacitance. Rectifies high frequency current. Conservatively rated up to 4.5 volts A.C., 3.0 volts D.C., 500 microamperes D.C. Other models and capacities to meet all needs.

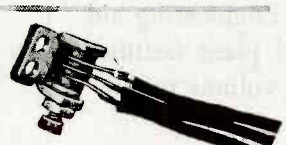


Coprox Model CX-4D4F23, a full wave rectifier with high conversion efficiency, for electronic control work. Rated at 5 volts A.C., 40 milliamperes D.C. continuous. Fully enclosed. Mounts on a single screw.



Coprox CX-3E8C3 double bridge rectifier with current and temperature current characteristics balanced to better than 1% over a range of —40°C to +70°C. Rated up to 4.5 volts A.C., 3 volts D.C. 5 milliamperes D.C. Other models and capacities to meet all needs

Coprox CX-2E1H5 (Not illustrated) Single half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.



Coprox CX-2E4F2 (Not illustrated) Full wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 5 milliamperes D.C.

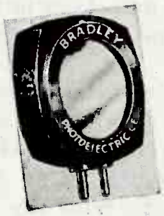
Coprox CX-2E2D4 (Above) Double half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.

Many variations are possible with the basic Coprox Rectifier models described at the left. Bradley's application experience can help you, not only in the use of these units but also in the development and production of special rectifiers for special jobs. Here are the special features of all Bradley Coprox Rectifiers:

- *Gold coating of "pellets" to combat aging.*
- *Pre-soldered lead wires, or special terminals, to prevent overheating during assembly.*
- *High leakage, low forward resistance, for efficient operation.*
- *Waterproof lacquering or wax potting, for perfect sealing.*
- *Highly adaptable mountings.*
- *Ratings are very conservative.*

For samples and special data which will help you design more efficient circuits that will stand up longer than others, write Bradley. Ask any questions you have in mind.

LUXTRON PHOTOCELLS



A Bradley booklet is available, to suggest the many ways in which Luxtron* photocells can be used for control and testing purposes. These cells generate sufficient current to operate instruments and instrument relays without amplification. They, too, are built for long life and have varied mountings and a wide range of sizes. (*Trade Mark Reg. U. S. Pat. Off.)

BRADLEY LABORATORIES, INC.

82 MEADOW ST., NEW HAVEN 10, CONN.

dio receiver division at Westinghouse Electric & Mfg. Co. He was formerly in charge of radio and television manufacture at Radio Corp. of America.

PHILIP LAESER has made f-m-television engineering supervisor at WMFM, Milwaukee, Wis. He was formerly transmitter supervisor.

DR. DONALD B. SINCLAIR becomes assistant chief engineer in charge of circuit development at General

Radio Co., Cambridge, Mass. Before joining GR in 1936, he was a research associate at MIT.

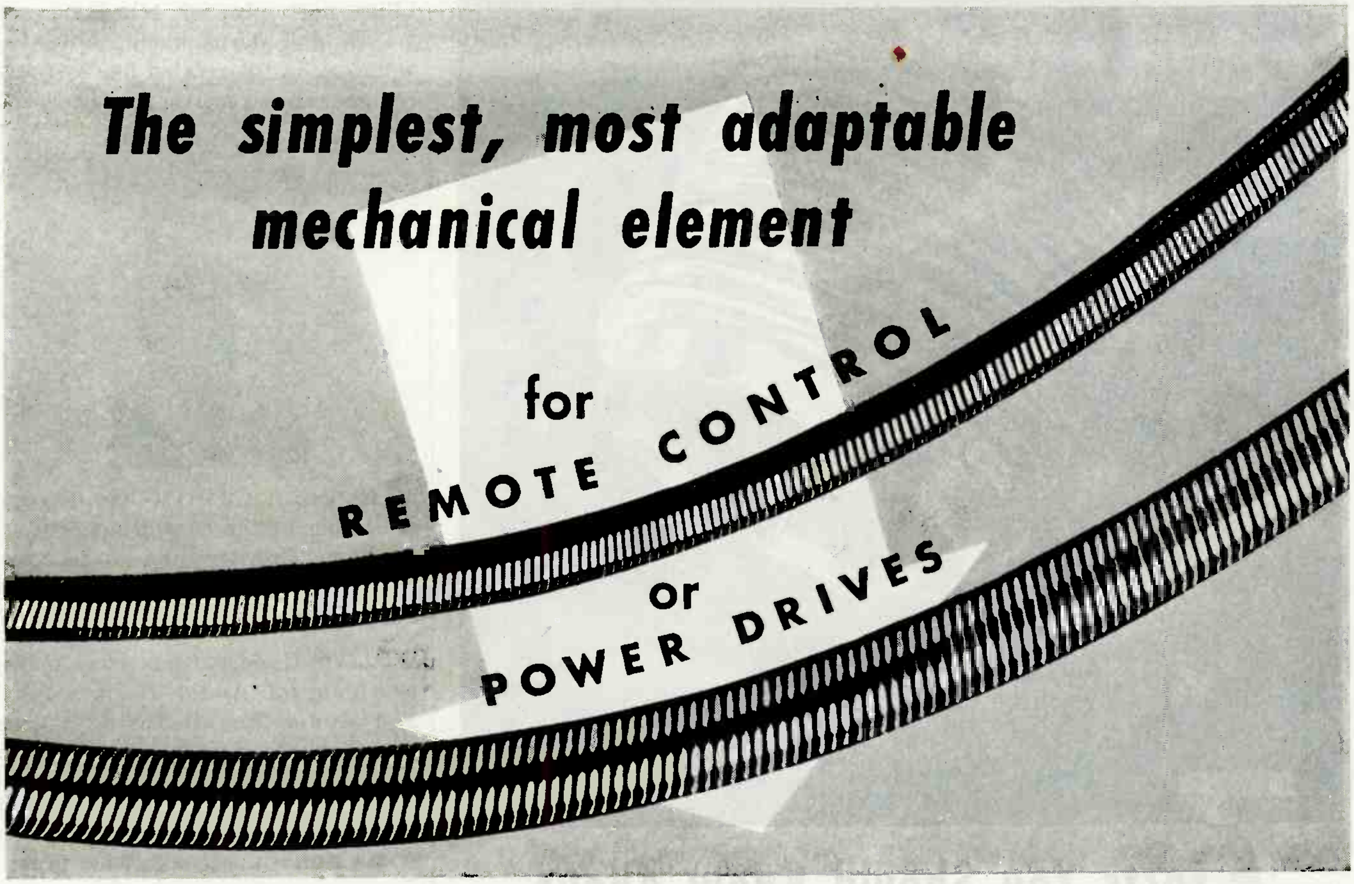
J. R. DUNCAN has been made chief television engineer at WLW, Cincinnati, Ohio. He was formerly active in the building of WLW's present television studios.

E. G. SHALKHAUSER has been made chairman of the Electronic Products and Equipment Manufacturers Association, Chicago, Ill. He is connected with Radio Manufacturing Engineers, Inc., Peoria, Ill.

C. A. CROWLEY has become a mem-

ber of the consulting firm of Graham, Crowley and Associates Inc., Chicago, Ill., and Jenkintown, Pa.

DR. PETER C. GOLDMARK heads the newly created department of engineering research and development at Columbia Broadcasting System, New York, N. Y. With the title of director, he will have the responsi-



S.S.WHITE FLEXIBLE SHAFTS

Regardless of the relative locations of driving and driven or controlled members or of the distance between them, a *single*, S. S. White flexible shaft is all you need to transmit power or remote control from one to the other. This "one-part" simplicity obviously means reduced manufacturing operations and costs.

And because S. S. White flexible shafts will transmit power or remote control between practically any two points, they give you a free hand in placing driving and driven or controlled elements wherever desirable to save space, to facilitate assembly, to increase equipment efficiency and to make equipment convenient to operate and service.

You will find S. S. White flexible shafts suited to a wide range of power drive and remote control requirements because they're made in a wide range of sizes and physical characteristics for each class of duty. Applications are numerous, notably in radio and electronic equipment, aircraft, motor vehicles, machine and portable tools. Industry uses millions of feet annually.

FLEXIBLE SHAFT HANDBOOK FREE TO ENGINEERS

This 256-page handbook completely covers the subject of flexible shafts and how to select and apply them for specific requirements. A copy will be sent free to any engineer who writes for it on his business letterhead and indicates his position or title.

ARMY E NAVY

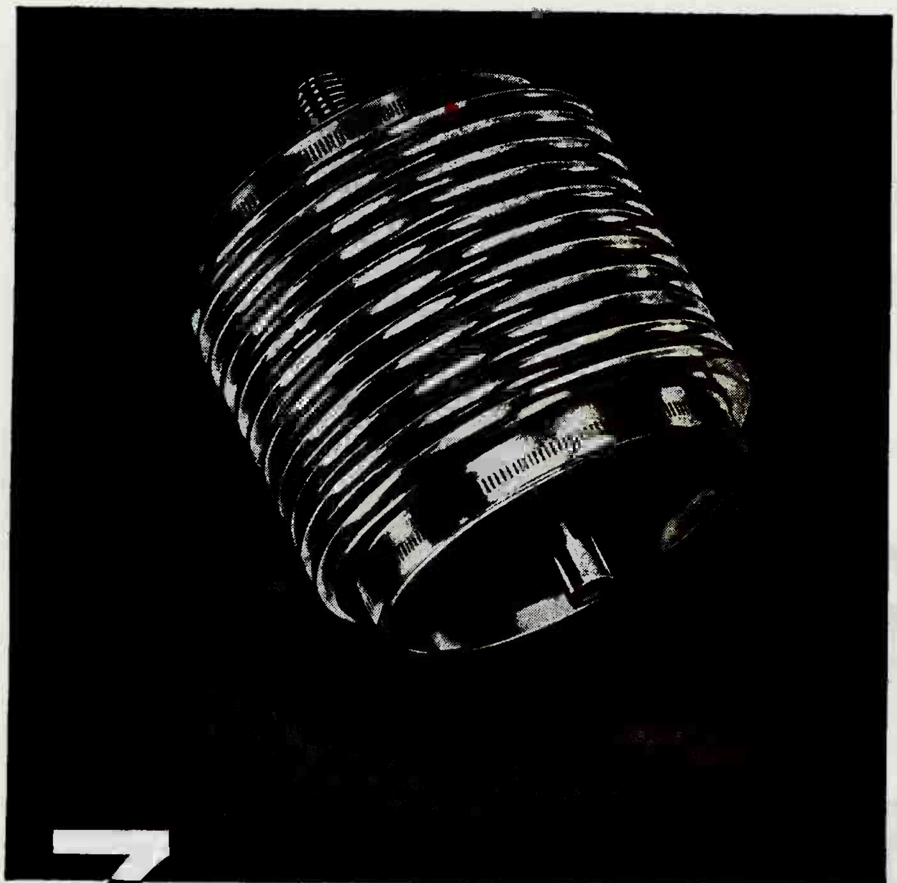
S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. B, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS · AIRCRAFT ACCESSORIES · MOLDED PLASTICS · MOLDED RESISTORS · FLEXIBLE SHAFT TOOLS

One of America's AAAA Industrial Enterprises



bility not only for television research and development, but also for work in the related fields of antennas, tubes, receivers, and recordings.

A. KENNETH GRAHAM has become a member of the consulting firm of Graham, Crowley and Associates Inc., Chicago, Ill., and Jenkintown, Pa.

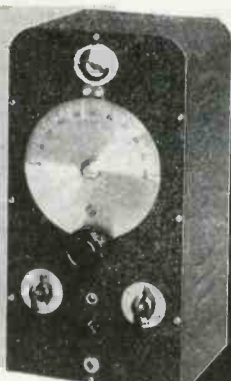
WILLIAM C. SPEED has been made president of Audio Devices Inc., and Audio Manufacturing Corp., New York, N. Y. to succeed Hazard E. Reeves. Mr. Speed was formerly vice-president.

A. J. MONACK becomes vice president in charge of engineering at Mycalex Corp. of America, New York, N. Y. He was formerly chief engineer.

MAX E. MARKELL, for the past four years chief of the vacuum tube section of the U. S. Signal Corps at Camp Evans, joins RCA at Harrison, N. J., as a specialist on industrial tube applications.

DR. ERNST FREDRICK WERNER ALEXANDERSON, consulting engineer of General Electric Co., gets the Edi-

You Are Going to Want
BROWNING FREQUENCY METERS



How will you have them?

Take this opportunity to name your specific desires . . . to have your own wishes incorporated into equipment you will want to make standard for mobile radio installations.

You will want Browning Frequency Meters because they do what you will want them to do, at a price that will let you use them generously.

Ever since their rapid acceptance several years ago, Browning Frequency Meters have been standard equipment in police and other emergency systems all over the United States.

HERE IS WHAT BROWNING FREQUENCY METERS ALREADY HAVE AND DO:

- Check, with better than .005% accuracy, any five frequencies from 1.5 to 120 Mc.
- Less than a minute required to check any one frequency.
- Pre-calibrated for specific frequencies.
- 100 Kc. crystal oscillator provides at least two check points in any band.
- High dial-reading accuracy achieved by narrow frequency range.
- Cathode ray indicator permits visual check against crystal standard and transmitter.
- Complete voltage stabilization.
- Portable, light-weight, A.C.-D.C. operation.

What More Do You Want?

Certain interesting improvements are already in store for this product of Browning Laboratories research. Whole-hearted devotion of all our energies to war production keeps them in the planning stage. But our postwar thinking, as it takes shape in rough sketches, turns to you — the future owner of future Browning Frequency Meters. We want you to have what you want.

Your letter about what you want in Browning Frequency Meters will receive a cordial welcome. And will, if possible, be reflected in the model delivered to you when we can deliver. Write soon, won't you?

BROWNING
LABORATORIES, INCORPORATED
WINCHESTER, MASSACHUSETTS

Browning Laboratories, Inc.
750 Main Street
Winchester, Mass.

Gentlemen:

Here are the new features I'd like to see in Browning Frequency Meters:

____

NAME ____________________

TITLE ____________________

COMPANY ____________________

ADDRESS ____________________

HERE ARE MY ROUGH SKETCHES

son Medal for 1944 from American Institute of Electrical Engineers for his outstanding inventions and developments in the radio, transportation, marine, and power fields.

A. M. WIGGINS is appointed chief research engineer for Electro-Voice

Corp., South Bend, Ind. He goes there from RCA Laboratories, Princeton, N. J.

MYLES V. BARASCH becomes chief engineer of Sherron Electronics Co., New York, N. Y. He has been with Western Electric Co. in charge of cathode-ray and electron-tube equipment design.

KENNETH MCLEOD takes charge of electronic quality control on the engineering staff of National Union Radio Corp. He has been working on war research at Columbia University, New York.

ROY C. SYLVANDER becomes director of engineering at Bendix Aviation

Corp.'s Eclipse-Pioneer Division, Teterboro, N. J. He has been chief engineer.

V. J. HALL joins the staff of Industrial and Commercial Electronics, Belmont, Calif., as assistant to the chief engineer. He specialized in the development of electronic equipment at Sperry Gyroscope Co.

JOHN M. MILLER JR. becomes chief engineer of United Cinephone Corp., Torrington, Conn. Formerly active in design and development

This Governor-Controlled Oster Motor

Gives You the New Design and Operating Advantages of CONSTANT SPEED

Here is a new Oster development in a constant speed, governor-controlled motor that backs up your good judgment when you specify it for applications where constant speed is a necessity. This motor is now in production and deliveries can be made in the very near future. Here are the features that assure you of satisfaction:

Housing: Die cast aluminum end brackets. Mild steel field housing. Totally enclosed.

Finish: Black anodized end brackets. Cadmium plated field housing.

Weight: 15 Oz.

Bearings: Single shielded ball bearings, lubricated with a grease suitable for any specific application. Bearing housings fitted with steel inserts.

Windings & Insulation: Field coils and armature wound with a select grade of insulated copper wire and impregnated with a high quality heat and moisture resisting insulating varnish.

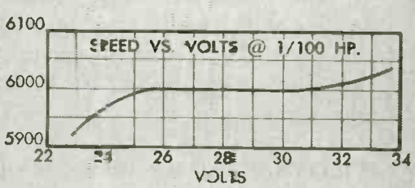
Brushes: Equipped with high grade metal graphite brushes. Beryllium copper brush springs.

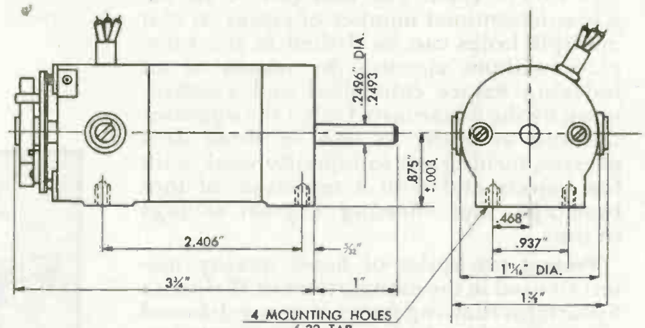
Governor: Furnished with a centrifugal governor to maintain constant speed over a voltage range of 25 to 30 volts.

Temperature Rise: Maximum frame temperature rise at rated output will not exceed 55° C.

Modifications: Motors can be furnished with special shaft extensions, mounting arrangements, finishes, leads, etc. All modified units are considered special.

When designing your post-war product, consider this new Oster development in applications where constant speed is a nesessity...





Rating of Motor Type BSTG-1A-2

Horsepower—1/100 continuous duty
Speed—6000 R.P.M. ± 1%
Voltage—25-30 volts D.C.
Amps. input—.95
Starting Torque—300% of full load torque

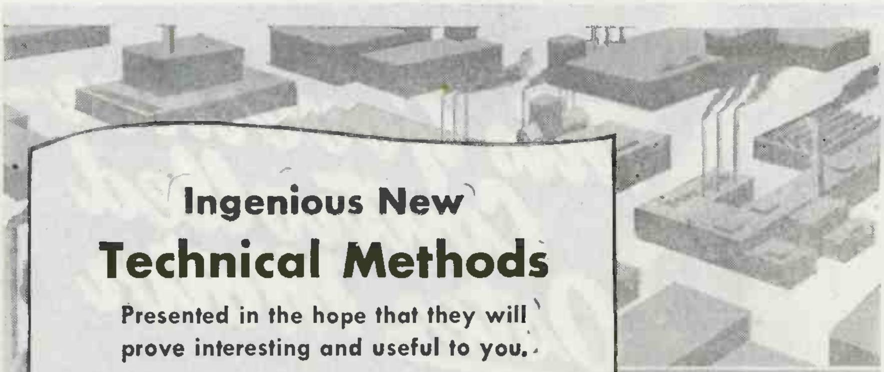
• • •

Let us help you fit this and other Oster Motors to your requirements.

M-22

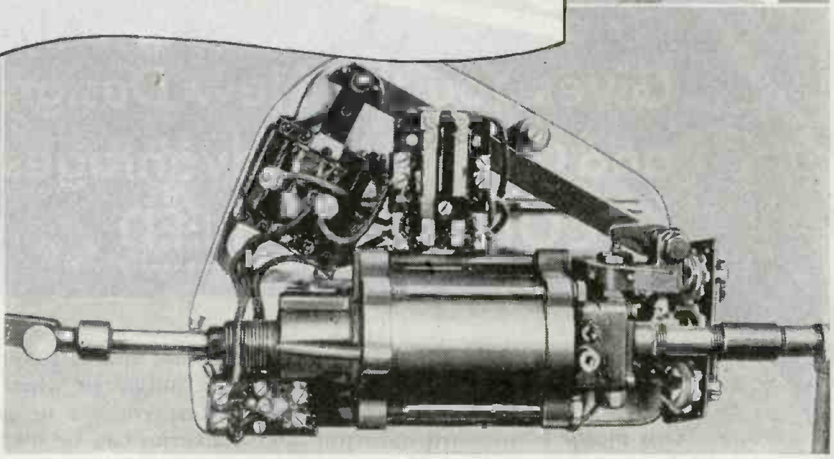
John Oster Manufacturing Co.

DEPARTMENT L-22 • RACINE, WISCONSIN



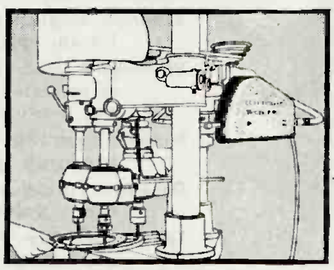
Ingenious New
Technical Methods

Presented in the hope that they will prove interesting and useful to you.



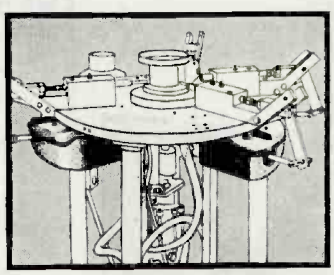
New Electroaire Power Unit Converts Standard Drill Press to Automatic

This exact control over feed and retraction speeds permits ready conversion of a standard drill press with tapping head into an automatic tapping machine, capable of producing Class III threads, even with comparatively unskilled operators. By adjusting speed to conform to the lead pitch of the threads being tapped, the tap will cut without forcing threads, and on the reverse the tap will actually "float" out of the part with no strain against the thread angle.



Set up to punch 3 holes simultaneously

Air-powered jigs and fixtures can be opened, closed, and indexed by the Electroaire Power Feed. The unit can be set for a pre-determined number of cycles so that multiple holes can be drilled in the same piece without ejection, by means of an indexing fixture controlled and synchronized by the Electroaire Unit. One operator can run as many as two or three drill presses, turning out top-quality work with few rejects and with a minimum of tool breakage, thus effecting a great savings in time.



Shows holes being drilled automatically

Present stockpiles of finest quality materials used in the manufacture of Wrigley's Spearmint chewing gum are now exhausted—necessitating discontinuance of production. When a supply of proven materials—known to be up to the finest standards of quality—is again available, Wrigley's will resume production—And Wrigley's Spearmint will be back to again help you on your job. In the meantime they are manufacturing a war brand. Wholesome but not excellent enough for the Wrigley brand name.

You can get complete information from Electroline Manufacturing Company, 1975 East 61st Street, Cleveland 3, Ohio

Z-57

work with Philco, the Navy Department, and RCA Victor; Mr. Miller is in full charge of design and development at United.

ELLIOTT R. VINSON, formerly electronic specialist at the U. S. Naval Air Station, Alameda, Calif., is appointed electronic tube specialist for the Pacific Coast District of Westinghouse Electric & Mfg. Co.

ROBERT H. STREETER, newly appointed design engineer at Supreme Instruments Corp., Greenwood,

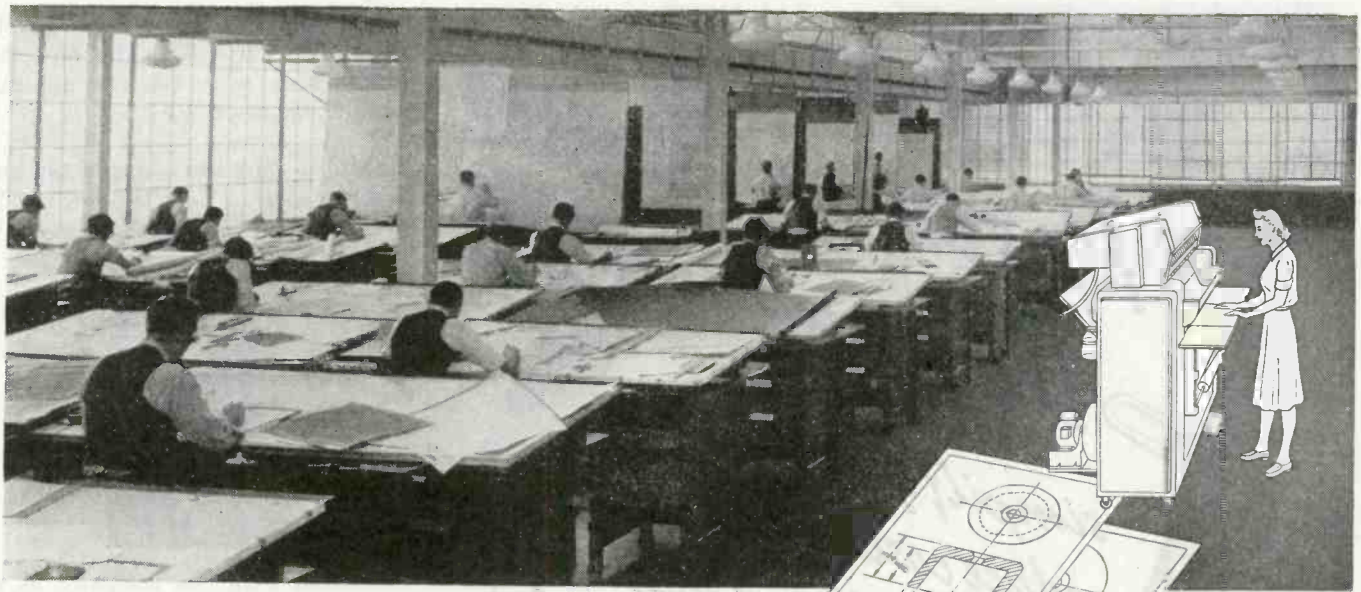
Miss., has recently gone there from Sparks-Withington Co. where he was a development engineer on automatic direction-finding equipment.

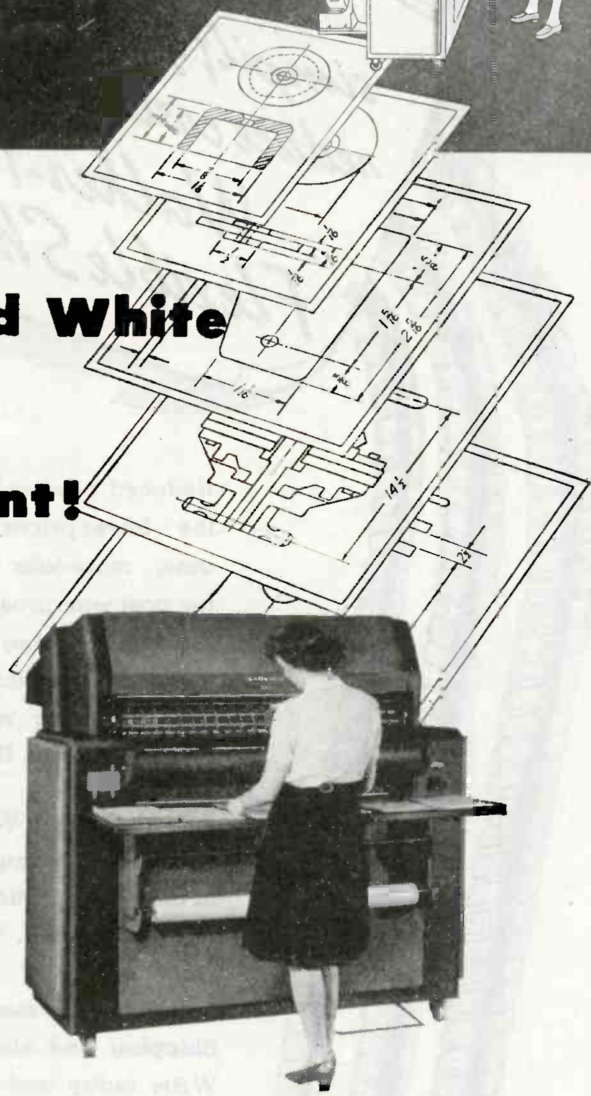
M. E. KARNS, formerly of Radio Corp. of America, becomes chief of the products and facilities branch of the radio and radar division of WPB. He takes over the duties performed by L. J. Chatten, now director.

WILLIAM F. SLOAN leaves his post as chief of equipment production section of WPB's communications division to resume consulting engineering in Chicago, Ill.

DR. JESSE E. HOBSON becomes director of Armour Research Foundation to replace Harold Vagtborg. Dr. Hobson was formerly head of the Electrical Engineering Department at Illinois Institute of Technology.

ALFRED W. PETERSON joins Automatic Electric Co., Chicago, Ill. Formerly chief engineer for the In-





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ternational Telephone & Telegraph Corp. in Puerto Rico, he had recently been with the communications division of WPB.

RAYMOND SOWARD joins Supreme Instruments Corp., Greenwood, Miss., as chief engineer. Formerly

connected with the company as a design engineer, Mr. Soward has recently served with the Signal Corps in Atlanta, Ga.

WILLIAM B. LODGE has been named director of general engineering at Columbia Broadcasting System, New York, N. Y. General engineering activities will include standard broadcasting; f-m and short-wave broadcasting; audio, studio, transmitter, and master control design; and frequency allocations.

DR. W. D. COOLIDGE retires from his post as vice president and director of the research laboratory at General Electric Co., Schenectady, N. Y. Dr. C. G. Suits, formerly assistant to the director, takes charge of the laboratory as a vice president.

AWARDS

Workers of the following concerns in the electronic field have been awarded Army-Navy E burgees for excellence in production:

Automatic Radio Mfg. Co., Inc.
Boston, Mass.
Commercial Radio-Sound Corp.
New York, N. Y.
Noblitt Sparks Industries, Inc.
Franklin, Ind.
Greenwood, Ind.
Regal Electronics Corp.
New York, N. Y.
Times Telephoto Equipment, Inc.
New York, N. Y.
United Electronics Co.
Newark, N. J.

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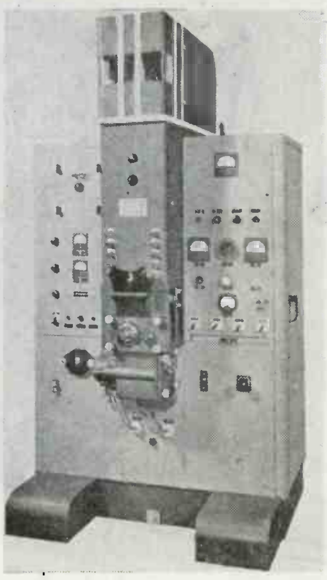
Electronic Equipment

For aircraft manufacturers, electric power companies and research laboratories, there is available a new self-contained industrial electronic oscillograph which records characteristics of electrical phe-



nomena lasting as little as a fraction of a millionth of a second. The unit consists of the oscillograph proper and a cabinet which houses all energizing and control circuits. An instrument of the cold cathode type, the oscillograph is capable of recording single electrical transients with respect to time, or two electrical phenomena with respect to each other, such as voltage versus current, in the form of diagrams produced by two pairs of electrostatic deflecting plates disposed at right angles to one another. The cathode of the tubes is energized from a 50 kv d-c rectifier with a control to correct for line voltage variation. The beam is normally blocked by a target. An impulse synchronized with the phenomena will trip the relay which bends the beam around the target so that it will strike the fluorescent screen or film below.

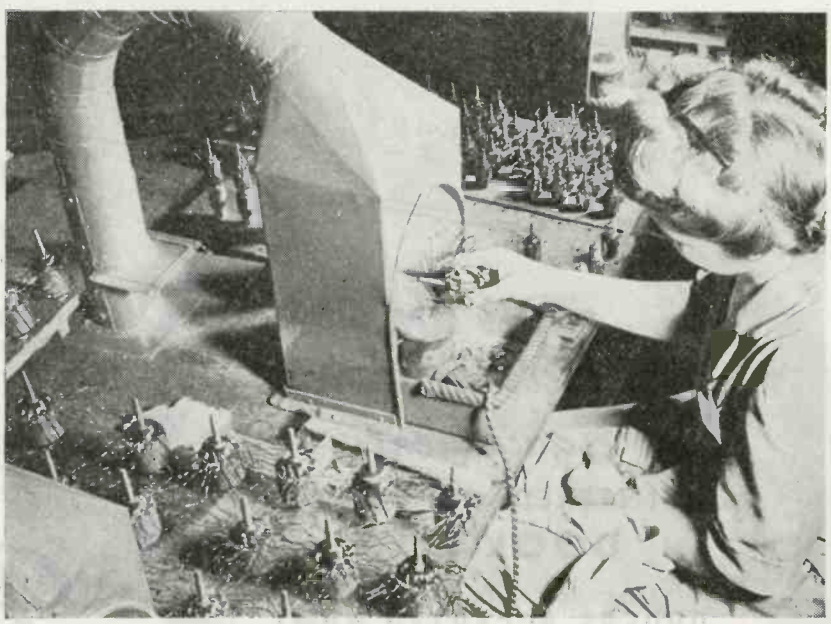
Concentrating coils, beam current meter, and leak valve, control the intensity and size of the trace on the film. Deflecting coils move the zero position of the beam so as to use the whole area of the exposed film for the record. Included with the unit are a fluorescent screen for direct observation, and a stationary film holder which takes a standard film for recording electrical phenomena lasting 1/1000 of a second or less and can be operated with a rotating film drum for phenomena lasting from 1/1000 to 1/10 of a second. A photo-electric control makes it possible to take an oscillogram in one revolution of the drum, regardless of speed. A photoelectric control eliminates the possibility of superimposed waves.

Another product announced by Westinghouse includes a new type of ceramic insulation which is called Zircon porcelain and which is for use in u-h-f equipment. The new material has very low loss at ultra-high frequencies.

Also announced is a new hot-forming molded laminate, known as Micarta 444, which combines the desirable molding properties of thermoplastic materials and the good physical characteristics of thermosetting materials. This new plastic can be heated and pressed into deep-drawn and complicated shapes. Other features of Micarta are good insulating qualities, high impact strength, and good thermal stability.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

WAR SOLDER SPEEDS PRODUCTION

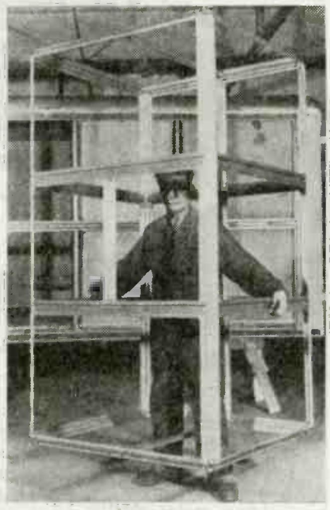


Wire loops on small armatures having their Formex insulation burned off at the same time they are tinned in one Fairchild plant. This is accomplished by heating 60-40 solder to 1,000 deg. F in an electrically-heated pot. The operation formerly required burning off the insulation in an alcohol-lamp flame and wire-brushing before soldering. This took three times as long as the present technique using the war solder

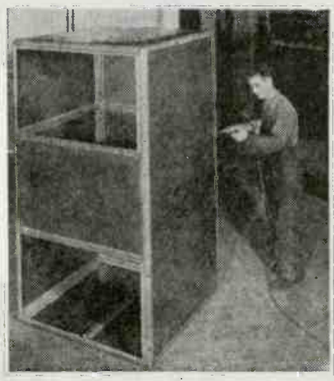
Aluminum Structure

LINDSAY STRUCTURES are now available in aluminum as well as in steel. The aluminum structures give a 50 to 60-percent saving in weight over the light steel structures, yet possess the same strength-weight ratio and ease of assembly features. These structures may be used as cabinets for electronic equipment and provide an all-metal shield that is rigid and free from vibration. The manufacturer states that because of its strength-weight ratio, the light-weight structure has adequate strength to support equipment installations. All parts for structure are accurately die-formed and can be quickly assembled with standard tools.

Lindsay & Lindsay, 222 West Adams St., Chicago, Ill.



The framework for this aluminum Lindsay structure cabinet is light enough to be easily handled by one man

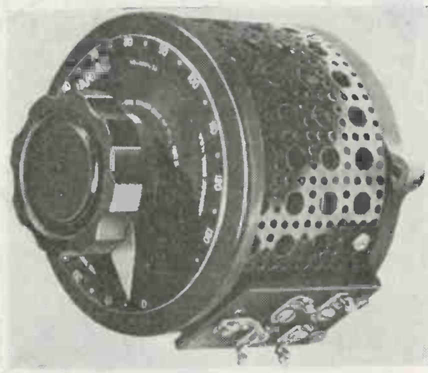


Lindsay structure shell, approximately 76 x 42 x 39 in., weighs 128½ lb.

General Radio Devices

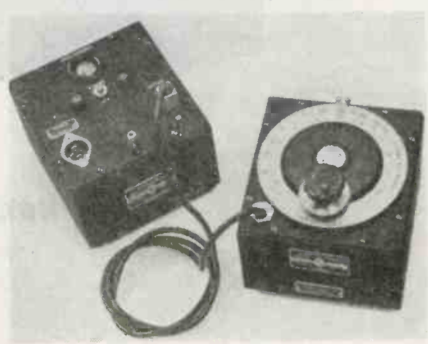
A VARIAC AND AN oscillator are two new instruments announced by General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Type 60-A is a 400-cycle Variac, 5-amp model for 115-v use. Rated nominally at 400 cycles, this variac can be used at any frequency between 400 and 2600 cycles. The rating is 860 v-amp. Output voltages



up to 135 v are obtainable with 115-v input. A new type of brush and radiator construction is used so that brushes can be changed in a few seconds. Type 60 Variac is available with or without a case. Overall height is 4⅝ in., overall diameter is 5½ in. Cased, the unit weighs 3½ lbs, and uncased 3 lbs, 2 oz.

Type 857-A u-h-f oscillator replaces the manufacturer's type 757-A. It is smaller and lighter



than the older type, covers a frequency range of 100 to 500 Mc, and is designed for use as a power source for laboratory measurements. Maximum output is ½ w or better over the entire frequency range. The frequency-determining element is a new type butterfly h-f tuned circuit in which the inductance and capacitance are varied simultaneously with a single control and no electrical contact to the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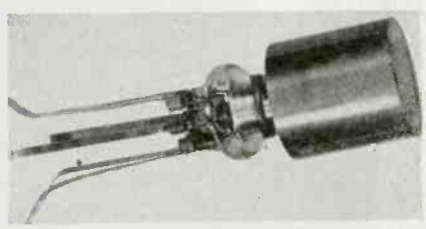
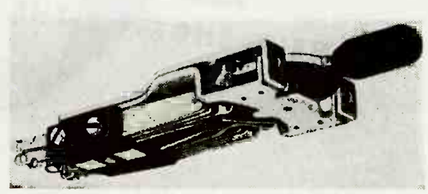
moving elements is necessary. Dial reads directly in frequency with an accuracy of ± 1 percent. Output is obtained at a coaxial jack at the side of the cabinet. Output coupling is inductive and can be varied continuously from maximum to practically zero. Supplied with the oscillator is Type 857-Pl power supply which furnishes filament and plate power and operates from a 115′ or 230-v a-c line, 42 to 60 cycles. A tube is used to indicate oscillation. Overall measurements of the oscillator are 6⅛ x 7⅜ x 7¼ in. and it weighs 6¼ lb. The power supply unit measures 5½ x 6⅜ x 7⅜ in. and weighs 9½ lb.

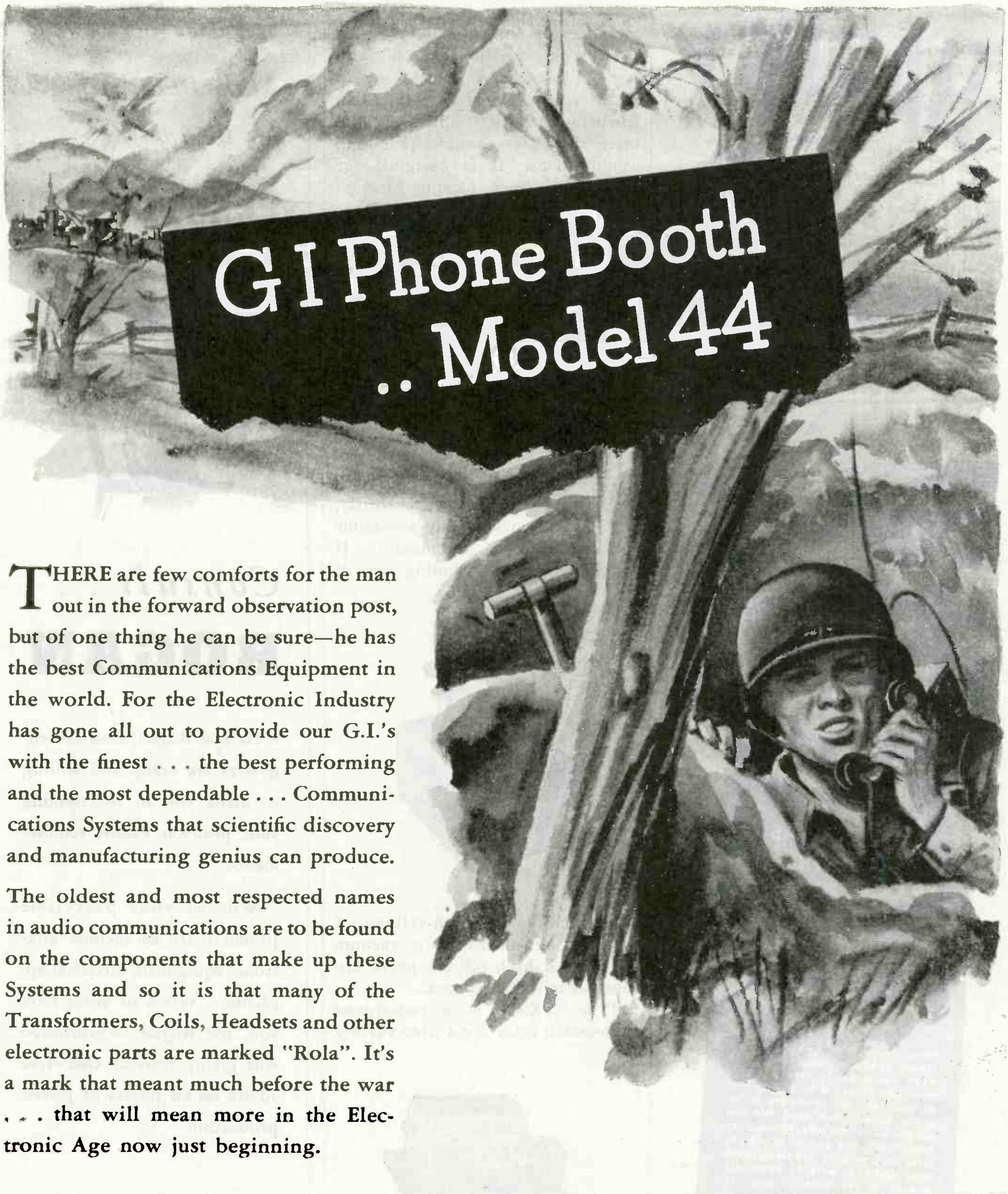
Federal Telephone & Radio Products

TYPE F-5303 IS an industrial power tube rated at 3.5 kw. Especially developed for industrial use in electronic heating, it is sturdy and compact and its six-inch flexible copper leads are permanently secured to the tube terminals. Filament and grid elements are conservatively spaced. No ceramic insulation is used. It is rated at 3500 w input and operates at full ratings at frequencies up to 50 Mc. Maximum ratings are: D-C plate voltage 3500 v, d-c plate current 1.0 amp, plate dissipation 1200 w. The filament current is 27.5 amp at 11 v. Overall height of the tube is approximately 7 in. and it has a maximum diameter of 3½ in. The tube is designed for forced-air cooling, but can be supplied for water cooling in Model No. F-5302.



The second new product announced by Federal is a narrow lever key (Series FTR-810) which





THERE are few comforts for the man out in the forward observation post, but of one thing he can be sure—he has the best Communications Equipment in the world. For the Electronic Industry has gone all out to provide our G.I.'s with the finest . . . the best performing and the most dependable . . . Communications Systems that scientific discovery and manufacturing genius can produce.

The oldest and most respected names in audio communications are to be found on the components that make up these Systems and so it is that many of the Transformers, Coils, Headsets and other electronic parts are marked "Rola". It's a mark that meant much before the war . . . that will mean more in the Electronic Age now just beginning.

ROLA

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

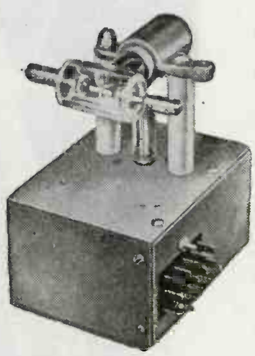
MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT measures $\frac{7}{16}$ in. wide, and is for control purposes in electronic and communications equipment where small size is important. It has an 18-spring capacity which permits more than 500 possible switching combinations. It is designed for one or two way, locking or non-locking operation with a positive, snappy action. The key assembly is held together by a single screw.

Federal Telephone & Radio Corp. Newark 1, N. J.

Relays

STRUTHERS-DUNN INC., (1321 Arch St., Philadelphia 7, Pa.) announce two products.

Type 78CCA100 vacuum switch keying relay weighs little, is sturdy, and has all parts readily accessible for inspection or adjustment. It has seven poles, including one dt



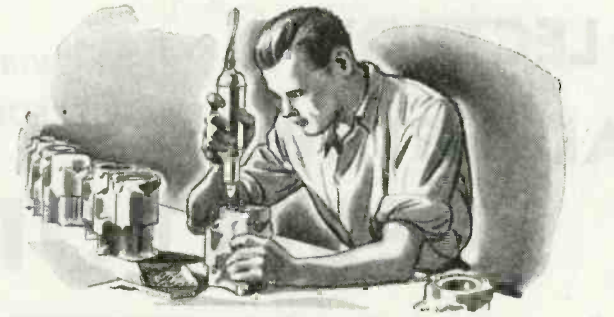
pole which handles high-voltage r-f currents by means of a vacuum switch. All high-voltage parts are rounded to reduce corona.

Type 79XAX is a redesigned snap-action relay for a wide variety

of applications. All parts are readily accessible and sensitivity adjustments can be made easily and quickly. Erratic operation due to slowly-changing coil-flux balancing the armature spring tension is eliminated. The armature of the

IT'S A PRODUCTION PLUSSER!

Time was when this manufacturer of magneto housings used slotted screws *and* helical inserts to fasten heads to withstand flight vibrations. Though expensive, this laborious, 2-step hand operation never produced completely vibrationless fastenings.



IT'S A COST REDUCER!

By switching to Phillips Recessed Head Screws, this manufacturer turned a slow-motion process into a fast, 1-step power operation, got a truly vibration-proof fastening. He also sliced fastening material costs about 71%, assembly costs correspondingly!

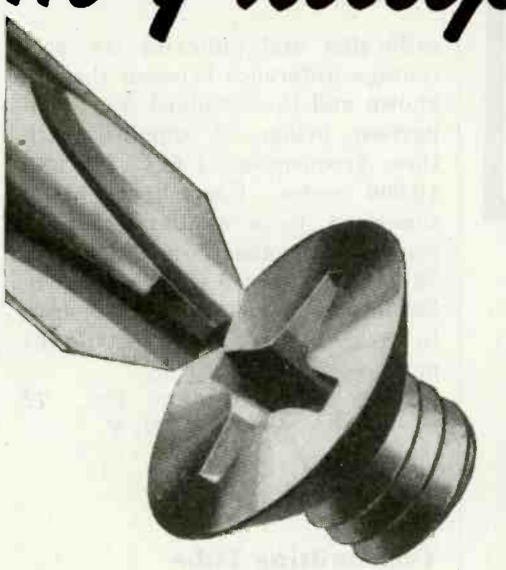
IT'S A STRENGTH BUILDER!

Besides being more efficient from assembly and cost angles, Phillips Screws are better from the design angle. Engineered to stand heaviest driving pressures, they take *any* load you need to impart product strength and rigidity.

IT'S AN ORDER GETTER!

From the sales angle, too, Phillips Screws are in a class by themselves. They snap up appearance of any product . . . make it stronger . . . and banish the burred screw heads that mar smooth surfaces, snag clothing, sabotage sales.

It's Phillips . . . the engineered recess!



In the Phillips Recess, mechanical principles are so correctly applied that every angle, plane, and dimension contributes fully to screw-driving efficiency.

. . . It's the exact pitch of the angles that eliminates driver skids.

. . . It's the engineered design of the 16 planes that makes it easy to apply full turning power – without reaming.

. . . It's the "just-right" depth of recess that enables Phillips Screw Heads to take heaviest driving pressures.

With such precise engineering, is it any wonder that Phillips Screws speed driving as much as 50% – cut costs correspondingly?

To give workers a chance to do their best, give them faster, easier-driving Phillips Recessed Head Screws. Plan Phillips Screws into your product now.

PHILLIPS *Recessed Head* SCREWS

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Made in all sizes, types and head styles

24 SOURCES

American Screw Co., Providence, R. I.
Atlantic Screw Works, Hartford, Conn.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
General Screw Mfg. Co., Chicago, Ill.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
Manufacturers Screw Products, Chicago, Ill.
Milford Rivet and Machine Co., Milford, Conn.
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Wolverine Bolt Co., Detroit, Mich.

relay almost completes its travel in either direction before the contacts snap into the new position. A bulletin describing this relay more thoroughly is available.

Comparison Bridge

THIS COMPARISON bridge measures resistors, capacitors and inductors by comparison with a standard. Components can be measured with a precision ranging from 0.5 percent to 10 percent. This range can be extended to 20 percent. This unit is self-contained, and is a-c operated on 105 to 125 v, 50 to 60 cps. The instrument consists of one a-c bridge phase shift oscillator and a vacuum-type voltmeter. A null indicator in conjunction with a

calibrated dial indicates the percentage difference between the unknown and the standard. The comparison bridge is supplied with three frequencies of 60, 1,000 and 10,000 cycles. Components being compared to a similar standard range are: capacitors 25 $\mu\mu$f to 20 μf; inductors 5 microhenries to 500 henries, resistors from 10 ohms to 5 megohms. The instrument measures 10 x 7½ x 8¼ in.

Freed Transformer Co., 72 Spring St., New York, N. Y.

Transmitting Tube

TYPE 813 BEAM POWER transmitting tubes of high sensitivity are being manufactured by Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill., under an RCA license. The tube has a maximum plate dissipation of 110 w. Maximum CW output is 360

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Right now, United States Rubber Company technicians are completely occupied with demands from the Army, Navy and Air Forces. New weapons—as well as new implements for communication and control—call for scientific protection against vibration and shock. And the proving-ground of mechanized warfare has shown that such protection is best provided by the use of rubber insulators.

Moreover, in plants directly concerned with turning out this materiel, engineered rubber mountings are no less essential. They help speed production; lengthen the life of critical machines.

You will find, however, when we are again free to serve you that "the new science of smoothness" has progressed enormously in recent years and months. War has taught our engineers and chemists much about rubber—the greatest and most useful of all the plastics.

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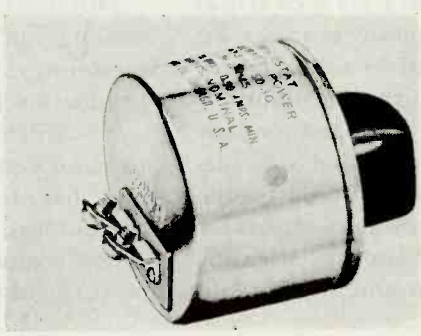
w and plate modulated output is 240 w, when operated in Class C. Mounting is either vertical or horizontal (although when mounted horizontally the filament must be kept in a vertical plane.) Filament voltage is rated 10-v a-c, or d-c at 5 amp; transconductance for plate current of 50 milliamp is approximately 3750 μmhos; interelectrode capacitances, grid to plate (with external shield) 0.2 μmf maximum; input 16.2 μmf; output 14 μmf. The tube is available for military and government orders on priority basis for war contracts.

Aircraft Power Rheostats

THESE NEW UNITS, made in accordance with latest Army-Navy Aeronautical Specification AN-R14a, are light in weight, meet various critical tests, and operate satisfactorily in temperatures from —55 deg C to +70 deg C. The two types available include Model J which is



rated 50 w, and Model H rated at 25 w. They are supplied with either linear or tapered windings in various resistances, with "off" position, as required. The units are enclosed in compact, corrosion-resisting metal containers and come supplied with a knob as illustrated.

Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.

WHY WE LIKE TO "ROLL OUR OWN"

THE production of high-efficiency electrical and electronic equipment demands close control over the manufacture of most of the parts which go into it.

To be certain of accurate control over component parts, Connecticut Telephone and Electric Division manufactures an unusually high percentage of them in its own plant. For instance, we produce our own magnets, wind our own coils. Stampings and screw machine products are turned out to our own standards, in our own shops.

These facilities for complete fabrication of the more essential elements of a piece of electrical or electronic equipment are as important to our customers as to us—they result in a better product at a "better" price . . . also assurance of our ability to keep delivery promises.

MAGNETS have a great deal to do with the efficiency of many types of electrical apparatus. Specially developed alloys treated in our own electric furnaces permit close control over the performance of C. T. & E. products.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES, INC. • MERIDEN, CONN.

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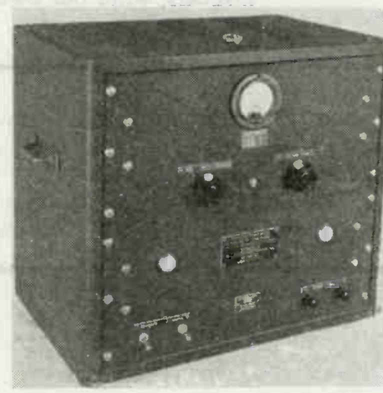
HOSPITAL AND SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS • IGNITION SYSTEMS

Regulated Power Supplies

IN APRIL ELECTRONICS Model 44 power supply unit is described. The manufacturer now has available Model 44-B (illustrated) which is similar to Model 44, but provides higher load current. Output current is rated 250 milliamp maximum (Model 44 is rated 100 milliamp maximum). Other characteristics for both models are: input 105-125-v a-c; output voltage 0-300 v d-c in three ranges; regulation (maximum voltage change with load) ±0.2 v at 300 v; ±0.1 v on 0-10-v range. Line stability (maxi-

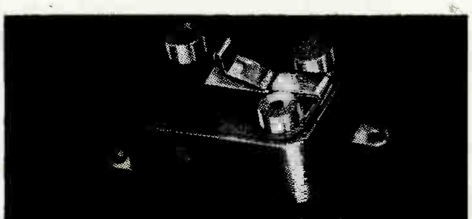


mum voltage variation with line changes) ±0.5 v at 300 v; ±0.15 v on 0-10-v range. Both instruments are intended as general laboratory instruments, or wherever a source of voltage of a variable nature is desired. A 4-page bulletin describing these units, as well as Model 42-A (described in May ELECTRONICS) is available from the manufacturer, Radio-Television Institute, Inc., 480 Lexington Ave., New York 17, N. Y.

Insulated Carbon Resistors

TWO NEW LINES, consisting of five different types of insulated carbon resistors (which cover six different AWS ratings: RC10, 20, 21, 30, 31 and 40) are in production by Erie Resistor Corp., Erie, Pa.

The first line consists of Erie type 504B (RC21) which measures 9/16 in. in length, and 7/32 in. in diameter, and which replaces the manufacturer's type 504. Type 518B (RC31) replaces type 518. It measures 29/32 in. in length and 13/64 in. in diameter. The newer types have one-piece molded phenolic cases in-

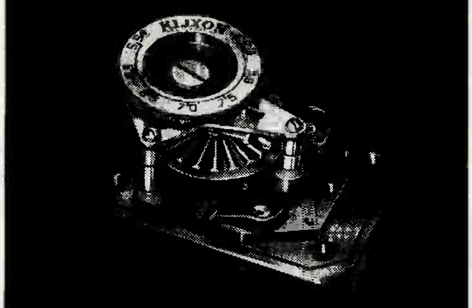


Type C-7220 Precision Snap Switch 12 amps. 30 Volts D. C., 125 Volts A. C.

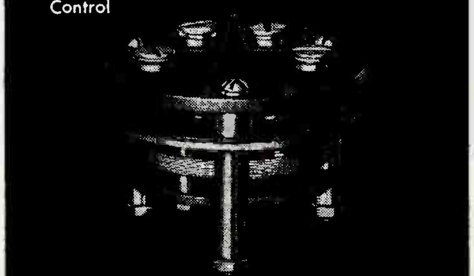
Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens

Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

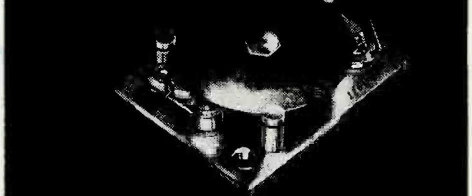
Type PM (NAF-1131) Circuit Breaker



Type RT Thermostat. Adjustable Temperature Control



Type ER Series. Ambient Compensated Time Delayed Relays



Type B-3120 Thermostat and Heater, Crystal Dew Point Control

P'S AND Q'S

of Reliable Control or Protection . . .

KLIXON DISC-OPERATED CONTROLS

Simplicity of operation is the reason for the accurate operation of Klixon Controls. These compact, light-weight controls are actuated by a simple scientifically calibrated Spencer thermostatic disc. This foolproof actuating element does away with complicated relays, toggles, magnets and other fussy parts that tend to wear and get out of adjustment. It provides sure operation by snapping to a quick clean break or a solid make . . . no matter how often it operates. And because there's nothing to get out of order, its accurate performance is unaffected by motion, altitude, vibration or shock regardless of the position of mounting.

Klixon Controls are available in a wide range of types and sizes for such applications as motor and transformer overheat protection, electric circuit overload protection, thermal time delays or temperature control for radio equipment. Investigate Klixon Controls for reliable control or protection applications. Complete information sent on request.

KLIXON

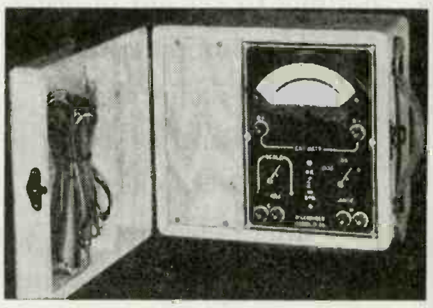
SPENCER THERMOSTAT COMPANY, Attleboro, Mass.

stead of ceramic insulation, and are available in resistance values from 0.5 ohm to 100 megohms.

Other units announced include a new line of compact, hot molded, insulated resistors in ¼-, ½-, 1- and 2-w ratings in the following types: Type 524 (RC10 and RC20) measures ⅜ in. in length, 0.135 in. diameter; Type 525 (RC30) measures 9/16 in. in length and 7/32 in. diameter; and Type 526 (RC40) measures 1⅜ in. in length, and ⅜ in. diameter. The resistance mix and insulation material of these types are molded simultaneously as an integral unit. The resistors are manufactured only in RMA preferred values from 220 ohms up to and including 4.7 megohms. Wire leads are 1½ in. maximum, No. 20 wire on types 524, 504B and 518B; No. 18 wire is used on types 525 and 526.

Resistance Meter

MODEL P-25 Milliohmer may be used in bond testing, or to measure switch or contact resistance, or fractional ohm standards, or in quantitative analysis (by the resistance check method). The circuit of the instrument is an adaptation of the potentiometric method of low resistance measurement. Accuracy is rated 1 percent or better. The meter has three ranges—from zero



to 0.005, 0.05 and 5 ohms. The scale is a direct-reading linear type. It is mirrored to eliminate parallax and facilitate extremely accurate readings. Built-in standard resistors are all of the 4-terminal type and are individually adjusted to an accuracy of ½ of 1 per cent. The unit operates on self-contained batteries. Available on priority of AA3 or better.

Superior Instruments Co., Dept. U, 227 Fulton St., New York 7, N. Y.

UNTIL the armed forces of the United Nations get all of the FERRANTI Products they need, civilian requirements must rate second place!

But our capacity is now more than ten times what it was a few years ago—and is still increasing.

We are therefore in a position to offer prompt delivery schedules on most products—exceptionally prompt delivery on many items—plus many worthwhile improvements growing out of our own wartime engineering program.

● WE THEREFORE SUGGEST:

Before making your commitments—find out what FERRANTI can do.
Full Facilities for Wiring and Assembly of Complete Equipments

FERRANTI ELECTRIC, INC., R. C. A. BLDG., NEW YORK 20, N. Y.

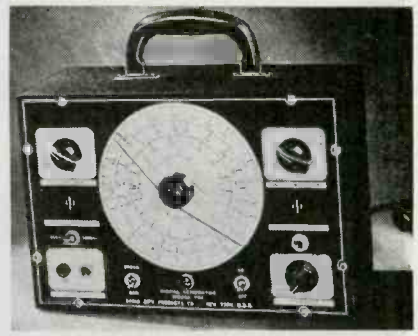
TRANSFORMERS • REACTORS • FILTERS • EQUALIZERS • ATTENUATORS • RECTIFIERS • PLATE-FILAMENT • ELECTROSTATIC VOLTMETERS • WIRING AND ASSEMBLY • MODULATION SETS • AERO TRANSFORMERS

PROMPT—SERVICE—DELIVERY

FERRANTI

Signal Generator

SIGNAL GENERATOR, Model No. 704, is a complete wide-range testing instrument with a range from 95 kc to 100 Mc. Fundamental frequencies are continuously variable from 95 kc to 25 Mc in 5 bands. Calibration is accurate to 2 percent per band up to the broadcast band, and within 3 percent for high frequency bands. A planetary drive capacitor with direct-reading calibration is used. Output can be modulated or unmodulated. Self-contained carrier-modulation is



either 400 cycles or 1,000 cycles, sine wave. Either is available for external use. Protective features of the instrument include automatic shorting of all coils not in use; individual shielding of r-f circuits, coil assembly and attenuator; and an overall steel case, chassis and panel. A 5-step attenuator is used for controlling the output. The instrument is supplied with a pilot-light "on-off" indicator and a double-fused cord.

Radio City Products Co., 127 West 26th St., New York 1, N. Y.

Current-Measuring Instruments

THESE CURRENT-MEASURING instruments feature linear scales, unit construction and dust-proof cases. Unit construction means that the jewel bearings, armature and core are all assembled as a unit and that the Alnico magnet and pole pieces are brazed together as a unit. Brazing is done in an induction furnace to insure a uniform joint and to prevent spreading or loosening under vibration. Standard meters come in a wide range of models. The manufacturer will design meters to

SYLVANIA NEWS

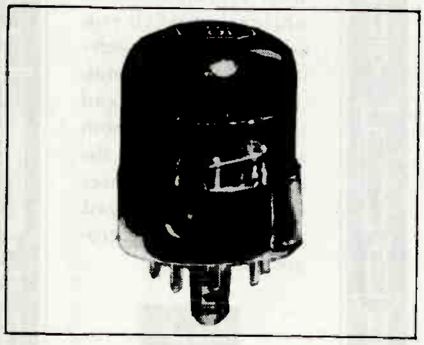
ELECTRONIC EQUIPMENT EDITION

FEBRUARY *Published in the Interests of Better Sight and Sound* 1945

Type 1AB5 Used as Mixer, RF Amplifier At 50Mc. and Above

Sylvania Electric's 1AB5 tube is a filament type pentode for use as a mixer or RF amplifier in circuits requiring a tube of greater mutual conductance than the 1LN5.

The 1AB5 is especially designed for operation at frequencies of 50Mc. and higher. Its combination of characteristics results in higher effective input resistance at these frequencies.



The tube has an 8-pin base of the Lock-In type, and a Short T-9 bulb. It is designed to operate on a filament voltage of 1.2. Full technical data are available from Sylvania Electric.

DID YOU KNOW...

That new long, small diameter fluorescent lamps soon to be placed in production at Sylvania Electric will be of the instant starting type? Using no starters, they will need less maintenance.

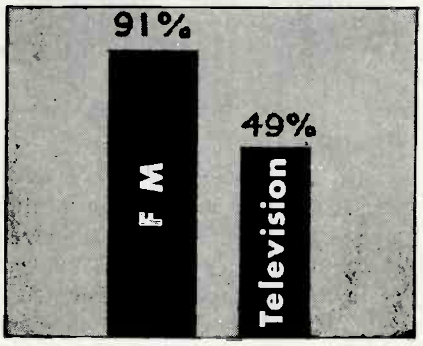
★ ★ ★

That the taking of tube characteristics by photographing an oscilloscopic trace permits the measurement of tube performance which could not otherwise be obtained? This is the method used in the Sylvania Laboratories.

Set-Owners Place FM First in Sylvania Survey of Radio Sets

91% of Consumers Interviewed Say They Want This Feature in Postwar Receivers

Preliminary reports of the nationwide survey being conducted by Sylvania Electric indicate a high degree of interest in frequency modulation. Of the thousands of set-owners who have been personally interviewed, 91% have indicated their desire to have FM incorporated in their postwar receivers.



Graph shows percentages of set-owners stating that they want FM and television in their postwar sets.

SYLVESTER SURVEY

"Would you be willing to go as high as $300 to have FM and television included in your radio set?"

70% said that they were willing to pay an additional sum in order to get this feature.

Television, while also a subject of considerable interest, ranked behind FM in the tabulation of survey results. 49% of those interviewed stated that they wanted television reception after the war. The same percentage indicated their willingness to pay extra for it.

INFLUENCE OF COST

As a guide to set manufacturers in their postwar planning, the Sylvania survey is also eliciting information on the amounts which consumers would be willing to pay in order to have FM and television. The results of this phase of the survey will be published in subsequent issues of SYLVANIA NEWS.

SURVEY CONTINUES

While the analysis of the results of personal interviews is going on, Sylvania Electric is continuing its survey, and broadening its scope, through the medium of a series of questionnaire-type advertisements appearing in leading national magazines.

The purpose of these advertisements is to gather additional information on consumer preferences and interest, not only in various types of radio and television receivers, but also in the possibility of using electronic devices in their homes.

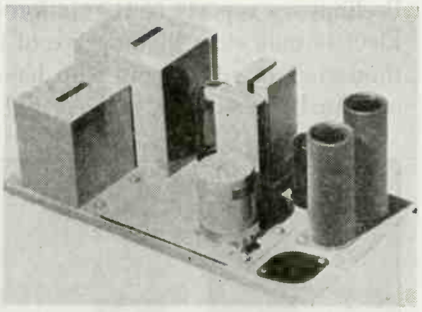
SYLVANIA ELECTRIC

SYLVANIA ELECTRIC PRODUCTS INC., *Radio Division*, Emporium, Pa.

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, ACCESSORIES; INCANDESCENT LAMPS fit individual needs, if desired. A catalog sheet, No. 101, explains the functions, adaptability and construction of these meters which are available from General Electronics Mfg. Co., Culver City, Calif.

Amplifiers

FOR F-M APPLICATIONS Series 102 amplifiers with mounting accessories are available. The series consists of the following four types of amplifiers: Type 102-A which has input impedances of 30/250 ohms and output impedance of 600 ohms; frequency response of 30-16000 cps, ±0.5 db. Type 102-B is a three-stage amplifier with a gain of 95



db. It employs input stage mixing, and is intended for public address installations. Type 102-C consists of a three-stage amplifier, fixed gain, adjustable, 75/85/95 db. Type 102-D is a two-stage amplifier with fixed gain of 61 db with 600 ohms input impedance, and 45 db bridging also with 600 ohms input impedance.

The Langevin Co., Inc., 37 West 65th St., New York 23, N. Y.

Electronic Control

DESIGNATED AS Type P25N is an electronic concentrate control for detecting and controlling, through operation of signals, valves or pumps, changes in liquid concentrations. It is intended for all applications in which changes in concentration are accompanied by a corresponding change in electrical conductivity. The instrument has a sensitivity range of 100 to 5,000 ohms and operates on a 5 percent change in probe-circuit resistance. The predetermined resistance value for which the control is set remains fixed regardless of va-

To reduce drain on batteries specify KAAR *Instant-Heating* RADIOTELEPHONES

One of the special features of Kaar mobile transmitters is their instant heating tubes. When the "push-to-talk" button on the microphone is pressed, the transmitter immediately goes on the air... but between transmissions standby current is zero. By eliminating battery drain during standby periods, this 22-watt transmitter can be operated from a vehicle's 6-volt ignition battery without requiring frequent re-charging.

The PTS-22X shown above operates on frequencies between 30 and 40 megacycles. (Available up to 62-MC on special order.) Two other Kaar transmitters, the PTL-10X and PTL-22X, for operation in the 1600-2900 KC band, are likewise equipped throughout with instant heating tubes.

Notice also how the dust cover can be removed by releasing two luggage type catches. Likewise the entire chassis can be removed for checking or servicing by releasing four additional catches.

These are but two of the features which make Kaar Radiotelephones so popular for military, civil and commercial communication between mobile units and a central station.

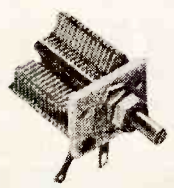
KAAR
ENGINEERING CO.
PALO ALTO, CALIFORNIA

Export Agents: FRAZAR & HANSEN
301 Clay St., San Francisco 11, Calif., U. S. A.

MOBILE RECEIVERS—Crystal controlled superheterodynes for medium and high frequencies. Easy to service.

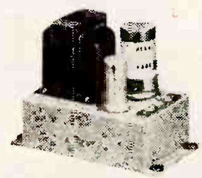
CRYSTALS—Low-drift quartz plates. Fundamental and harmonic types available in various holders.

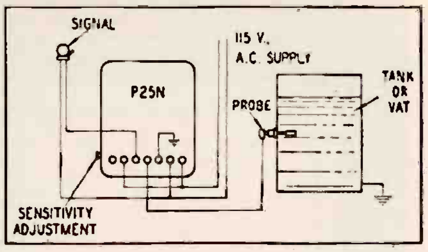
CONDENSERS—Many types of small variable air condensers available for tank circuit and antenna tuning.



MICROPHONES—Type 4-C single button carbon. Superb voice quality, high output, moisture proof.

POWER PACKS—Heavy duty vibrators and power supplies for transmitters, receivers. 6, 12, 32, volt DC.





riations in line voltage or tube characteristics. The voltage applied to the probe does not exceed 25 v, which eliminates the possibility of electric shock or explosion hazard. The unit incorporates a sp, dt relay, rated at 10 amp a-c, 5 amp d-c, for normally closed and normally open operation, and requires a power supply of 115-v a-c 60 cycles.

Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

Plugs and Jacks

FOR MANUFACTURERS of radio and radar parts and components, plugs and jacks (made to Signal Corps specifications) are available in the following types: JK-48, JK-26, JK-55 jacks, and PL-54, PL-55, PL-204, PL-291 and PL-291A plugs. These are manufactured by Amalgamated Radio Television Corporation located at 476 Broadway, New York, N. Y.

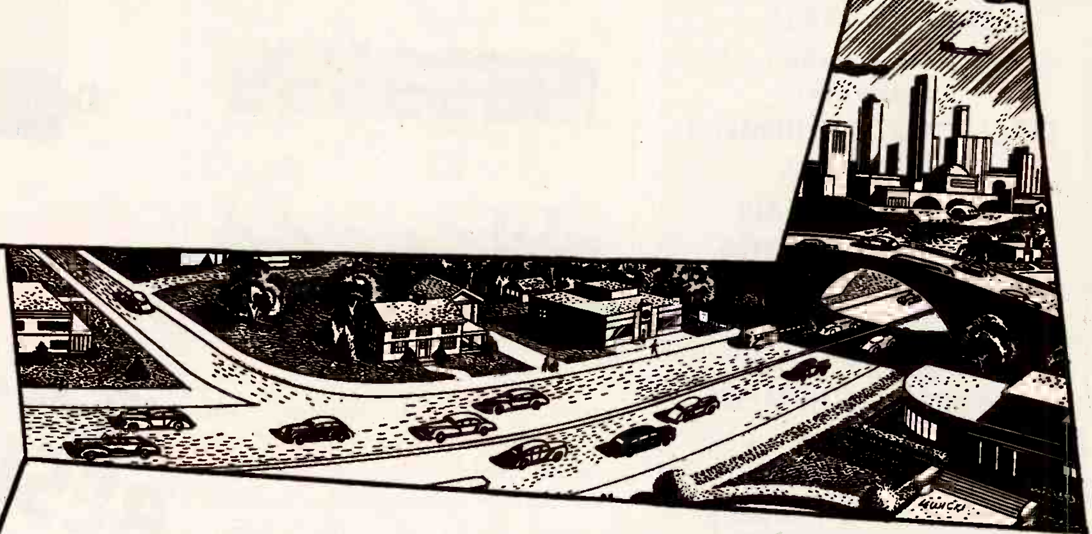
Capacitor Mounting

M TYPE BRACKETS (illustrated) have been specially developed to withstand severe vibrations, and meet all Army, Navy and Aircraft specifications. Although designed pri-

marily to permit mounting of oil capacitors in either vertical or inverted position, they are suitable for other industrial applications.

Industrial Condenser Corp., 3243 North California Ave., Chicago 18, Ill.

What's Back of
LEAR RADIO



THE NAME "LEAR" on home radios is something new. But Lear has a long history of success in radio development.

This history dates back to 1930.

Lear thinking helped to make automobile radios possible. It was Lear inventive foresight that contributed to the success of many of the most famous radios on the prewar market.

But before the war, Lear preferred to produce aircraft radios—instruments for a service that was tough and exacting.

All through the war, Lear continued radio development.

Now this ability to foresee and create is being directed into fine radios for America's homes. They will be radios such as you and your customers have never known before.

This will make the Lear distributor franchise a particularly valuable one. But there is even more! Lear policy is aimed to protect Lear distributors and dealers.

Stable discounts on stable prices on stable models will provide the sound basis for a long, steady, successful business.

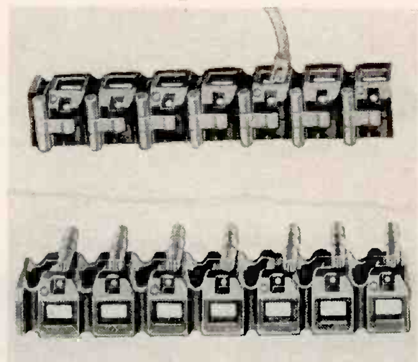
You'll be interested in knowing more about selling Lear home radios. We'll be glad to tell you about it. Address LEAR, Incorporated, Home Radio Division, Sales, 230 East Ohio Street, Chicago 11, Illinois.

LEAR RADIO

Lear INCORPORATED

Terminal Blocks

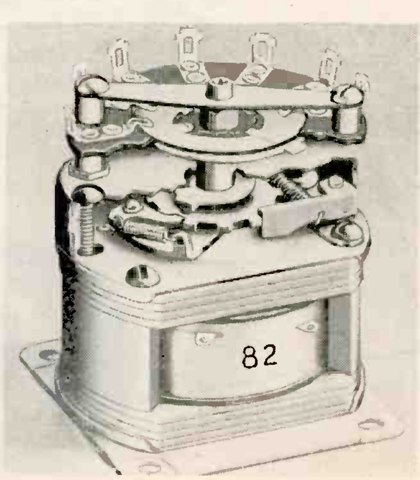
INTERCHANGEABLE WITH many standard types of AN terminal panels employing screw-type fastenings for the lugs in connecting the desired wires, a new plastic, patented terminal block is available which is capable of withstanding a 3000-v a-c insulation breakdown test. A cam-action bridge element bears against the lugs or terminals to be interconnected, and no screw-fastening device is necessary. The block may be used in place of disconnect plugs. A quick self-locking feature provides for snap-in contacts, holds the contacts firmly in position, and requires manual release by means of levers. Identification markers are clearly visible when the lever is in the locked position.



The Paul Henry Co., 2037 S. La Cienga Blvd., Los Angeles 4, Calif.

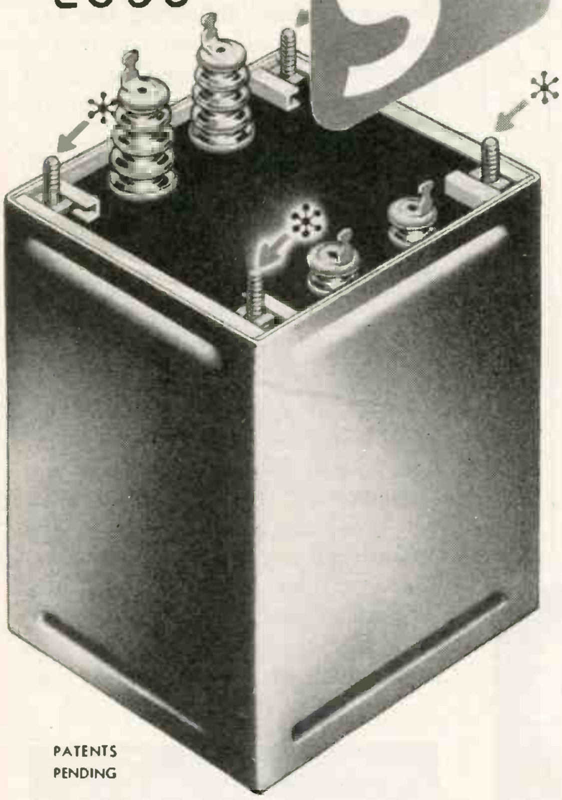
Rotary Relay

THE TYPE 82 ROTARY RELAY stepping unit is a compact twelve-position driving mechanism which operates a shaft extension through 360 deg



AN AGE OLD PROBLEM SOLVED

ANOTHER FIRST FOR ECCO



TRANSFORMERS with Self-Aligning Detachable Mounting Studs!

Actual tolerance in mounting dimension can exceed ± ¼ inch. Eliminates rejects due to bad threads, leaks around studs, bent or broken studs or changes in length specifications.

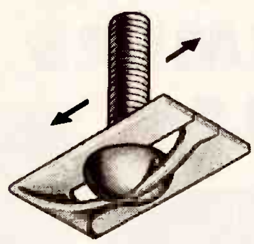
ECCO Transformers, with this new mounting feature, are available in 15 standard case sizes . . either hermetically or non-hermetically sealed.

* REPLACEABLE, IN THE FIELD, WITH ANY ROUND HEAD MACHINE SCREW AVAILABLE.

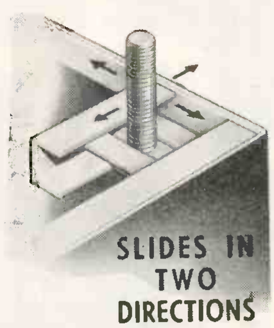
Permits "on the job" changes of stud sizes and lengths. ECCO Transformers are now shipped with studs removed and in a separate container.

WRITE FOR DATA SHEET

ADDRESS REQUEST TO DEPT. E



Detail shows the simple arrangement that prevents stud from turning while it permits centering in two directions. Clip is stamped from heavy gauge, cadmium plated steel.



In position for mounting, the stud can be moved (NOT BENT) in FOUR directions to align with poorly spaced holes. Strains applied to stud through excessive tightening are absorbed by mount.

ELECTRONIC COMPONENTS COMPANY

423 North Western Avenue, Los Angeles 4, California

in twelve progressive steps. The unit illustrated provides a twelve-position selector switch, which indexes one position for each momentary current impulse and will drive up to three wafer switches, or any other load not in excess of twelve ounce-inches torque. It can be made to operate clockwise or counter clockwise. Actuators can be furnished either as direct drives (indexing the load with the current impulse), or as spring drives (indexing the load following the current impulse). Current required to operate the relay depends upon the torque required for a particular application.

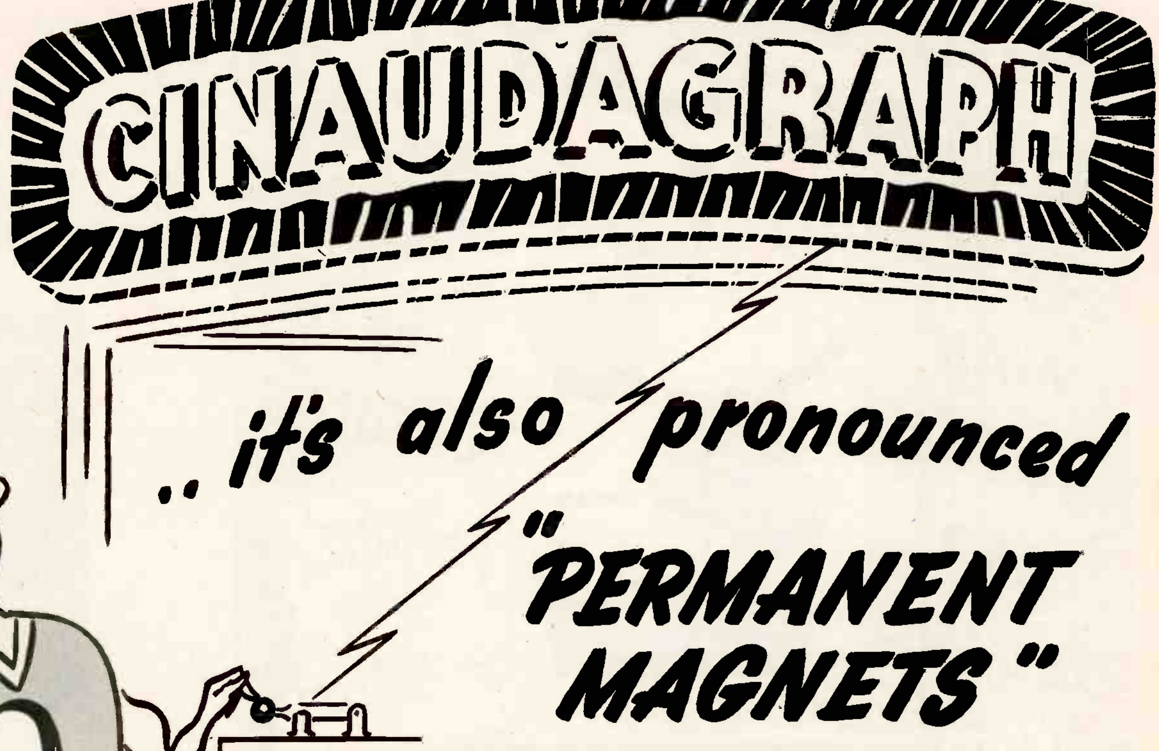
Price Brothers Co., Frederick, Md.

Magnetic Wire Recorder

BROADCAST STATIONS can now purchase Model 51 portable multi-purpose magnetic wire recorders for the first time since the war began. Speech can be recorded and reproduced with fidelity, but it is not recommended for recording music for broadcast purposes. The unit has a number of improvements, including a new recording head, new belt drive, and new level-winding wire guides. The steel case has been changed to aluminum, de-

creasing the over-all weight from 47 to 35 lb. The unit operates directly from any 105-120-v a-c line. It is supplied with a high-fidelity microphone, microphone stand and cable, power cord, one 12,000-ft spool of recording wire and one empty spool. Recordings may be kept as a permanent record or be erased magnetically and the wire used again for other recordings. Recordings or play-back are accomplished at the flip of a switch.

Electronics Dept., General Electric Co., Schenectady, N. Y.



Many have asked us, particularly in recent years, "Where's the connection between 'CINAUDAGRAPH' and 'PERMANENT MAGNETS'?" There's a clue . . . in fact, two clues . . . as to the connection. Analyze our company name carefully and you'll get it.

Yes, our interest in permanent magnets goes back many years . . . back to a period when we manufactured electronics equipment and designed and made our own magnets. Thus, our knowledge of permanent magnets encompasses not only their design and manufacture but their application.

Today, as for some years past, our business is exclusively "PERMANENT MAGNETS". And much of the knowledge stored up has been set down in writing in the pamphlet illustrated at the left. If you are working on the design of magnets or are using them, you should have this information in your files. Send for your copy.

Send for our pamphlet
PERMANENT MAGNETS

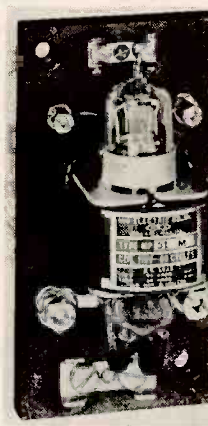
CINAUDAGRAPH CORPORATION

2 Selleck Street **Stamford, Connecticut**

CINAUDAGRAPH
CORPORATION

Newly Designed Relays

A NEW CROWN-SHAPED wire guide, forming a part of the plunger, has been incorporated in H-B mercury-plunger relays to keep the plunger upright and friction-free. These relays are of the normally open series, available up to 440 v for a-c and up to 250 v for d-c, with contact



capacities as high as 30 amp. The mercury-to-mercury hermetically-sealed contacts are positive, chatterless, noiseless, with no exposed arc. Type MP-51-M relay is illustrated.

H-B Electric Co., 6109 North 21st St., Philadelphia 38, Pa.

Metal-Testing Instrument

SIMPLE COMPARISONS of ferrous materials as to analysis and heat-treatment are provided by the Ferrograph, a new metal-testing instrument which can be used to obtain information about iron and steel very rapidly just as its larger and more elaborate counterpart, the Cyclograph, does. The Ferrograph utilizes the transformer principle of operation. About 80 percent of the mixtures of two types of iron or steel that can occur, can successively be sorted by the Ferrograph. A calibrated scale provides ten division per inch, with the tenth division accentuated. The instrument operates on 115 v, 40-60 cycles. It measures $12\frac{1}{2}$ in. wide, $17\frac{1}{4}$ in. high, and $23\frac{3}{4}$ in. deep, and weighs 100 lb. It is fully portable, and is designed to withstand rough usage in the laboratory or shop, or out in the field.

Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J.

Literature

H-F Iron Cores. These cores are designated as Crolite Magicore high-frequency cores and are described in a catalog by that name. The catalog contains thirty-three pages of descriptive matter and graphs, and gives all the information one needs to know about these powered iron cores. Henry L. Crowley & Co., Inc., West Orange, N. J.

Facsimile Communication. Elements of Facsimile Communication is the title of an 18-page book aimed at persons who are just becoming acquainted with facsimile communication. The booklet contains diagrams of the various parts of facsimile equipment and describes their individual functions. Times Telephoto Equipment Inc., 229 West 43rd St., New York 18, N. Y.

Electrical Insulating Materials. Engineering Bulletin No. ED-44 contains testing data, properties, forms, graphs, fabrication, design and uses of electrical insulating materials available from Continental-Diamond Fibre Co., Newark, Del.

Raytheon Tubes. A 44-page catalog entitled Radio Tube Data and Substitution Chart incorporates the latest technical information not previously available on this manufacturer's radio tubes. Electrical characteristics with outline drawings and diagrams of radio receiving tube types, as well as information on hearing aid tubes, special purpose tubes and radio panel lamps are included. Over 1600 substitutions are listed. Radio Receiving Tube Div., Raytheon Mfg. Co., Chapel St., Newton 58, Mass.

RCA Radio History. Twenty-five Years of Radio Progress With RCA is the title of an 88-page book published as a token of the 25th anniversary of Radio Corporation of America. It is the history of quarter of a century in radio and electronics. Department of Information, Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.

Fiberglas Insulating Materials. Catalog No. EL44-7 entitled Electrical Insulation Materials illustrates and describes the many types of insulation available and gives characteristics. It is a 24-page booklet. Owens-Corning Fiberglas Corp., Toledo 1, Ohio.

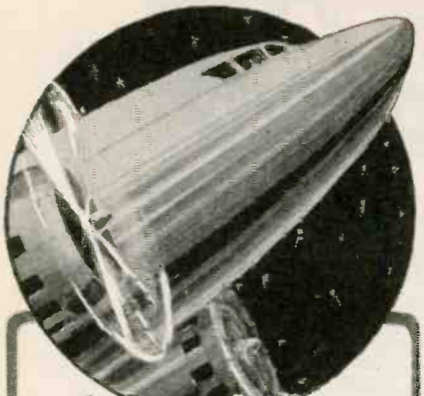
Cable Assemblies. For manufacturers of aircraft, marine, radio and electrical equipment and parts there is available a 28-page catalog which describes and illustrates engineered cable assemblies available from Whitaker Cable Corp., North Kansas City 16, Mo.

Micro Switch Catalog. This new handbook consists of 100 pages, is handsomely illustrated and describes over 500 heavy-duty type micro switches and auxiliary devices for electrical control in aircraft, marine, railway, automotive and heavy machinery. It is designated as Handbook Catalog No. 71, and is cross indexed for easy reference. Micro Switch Division, Freeport, Ill.

AN Insert Chart. This chart contains complete and practical data of molded AN insert arrangements for electrical connectors. Standard inserts from one contact to one hundred contacts are shown in full size. Inclosed with the chart is data about An and Amphenol 97 shell types and styles. American Phenolic Corp., 1830 South 54th Ave., Chicago 50, Ill.

Electronic Precision Instruments. Background data is included in a 12-page booklet which illustrates and describes such units as housing for radio antennas, central-office traffic control, cathode-ray radio direction finder, under-water radio sound equipment, capacity goniometer, wave meter, 10-channel h-f receiver, and precision mechanical devices. Airplane & Marine Instruments, Inc., 52 William St., New York, N. Y. and Clearfield, Pa.

Radio Components. Hard-to-find parts and electronic and radio components are listed in a new Special Supplement No. 97 available from Concord Radio Corp. (formerly Lafayette Radio Corp), 901 W. Jackson Blvd., Chicago 7, Ill.

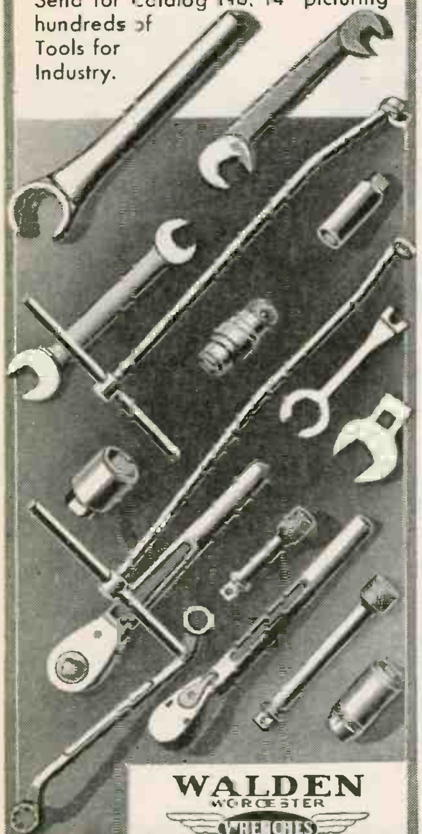


Up Up

into the night with a precious load ... every bolt and nut has been tightened with a special WRENCH.

WALDEN WORCESTER AIRPLANE TOOLS are designed to quickly reach these vital parts.

Send for Catalog No. 14* picturing hundreds of Tools for Industry.

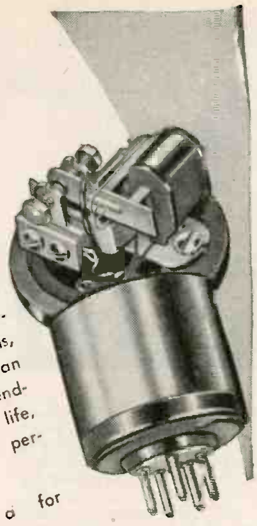


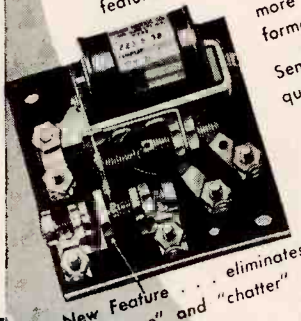
STEVENS WALDEN, INC.
468 SHREWSBURY STREET
WORCESTER, MASSACHUSETTS

RELAYS by KURMAN

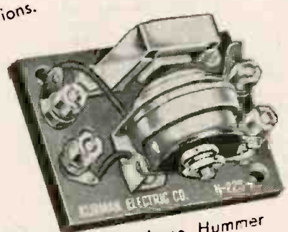
Twenty-five years' experience in solving all types of Relay Problems. Complete facilities for Designing, Engineering, Manufacturing. Specialists in producing Relays of exceptional power and sensitivity for Aircraft, Intercommunications Systems, Electronic Devices. Exclusive Kurman features provide greater dependability, longer life, more precise performance.

Send data for quotations.





New Feature . . . eliminates "bounce" and "chatter"



Microphone Hummer

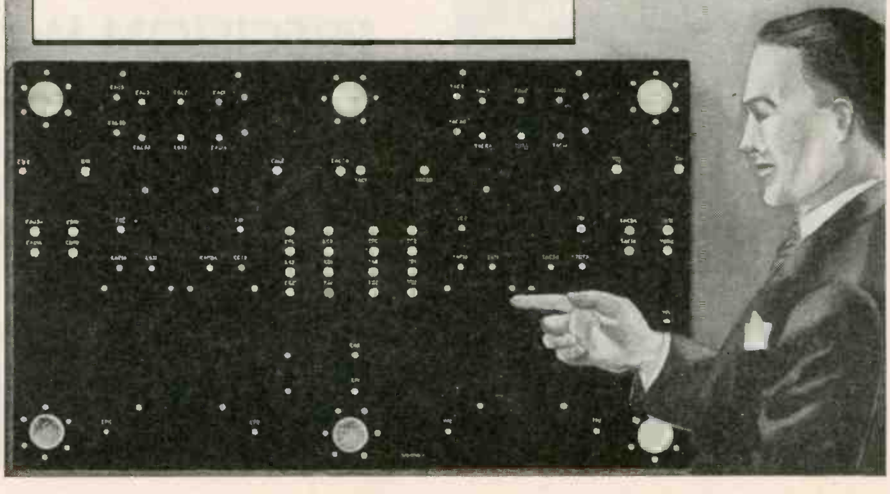
KURMAN ELECTRIC CO.
35-18 37th STREET • LONG ISLAND CITY 1, N. Y.

ACCURACY and STAMINA

. . . are demanded in this fire control panel. Our 20 years of experience in plastics fabrication assures that these exacting requirements will be fully met.

ELECTRICAL INSULATION CO.
INCORPORATED
12 VESTRY ST., NEW YORK 13, N. Y.

BAKELITE SHEETS, RODS AND TUBES
•
FABRICATED PARTS



Vibration Insulators. Duflex, Series No. 1022, vibration insulators are described and illustrated in an 8-page catalog. Harris Products Co., Cleveland 4, Ohio.

Test Set Assemblies. Manufacturers of electrical equipment (wire, cable, instruments, motors, appliances and insulating materials) who need to measure, accurately and easily, the insulation resistance of their products will be interested in an 8-page catalog entitled To Measure Insulation Resistance—L&N Test Set Assemblies. Two assemblies (one for routine plant use and the other for laboratory measurements) are described. This catalog (No. EO54-460(1) is available from Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Directory Listing. A new 1944-45 Directory listing 440 member plastics concerns in the United States and Canada is available at $2.50 from the Society of the Plastics Industry, Inc., 295 Madison Ave., New York 17, N. Y. More than 700 different plastics products are alphabetically listed together with the manufacturers of each. Also contained is a section on who's who in the plastics industry. The book contains 247 pages.

Post-War Personnel Problems. A book entitled Personnel Problems of the Postwar Transition Period was written by Charles A. Myers of the Industrial Relations Section of MIT for the Committee for Economic Development. The study was based on the experience of 32 manufacturing and non-manufacturing companies. The purpose of the book is to make known what a few outstanding companies are already doing in the belief that the scope of experience covered in the book will be valuable to other companies facing these questions. It is an interesting book.

Varnished Tubing Standards. The second edition of standards for varnished tubing and saturated sleeving used for electrical insulation is available. Standards contained in the 8-page booklet are standards adopted by the Varnished Tubing Association, Inc., 420 Lexington Ave., New York 17, N. Y.

Production Inspection Equipment. Bulletin No. 3544 is a 16-page booklet of illustrations and descriptive matter on a new inspection cabinet for continuous x-ray examinations of parts on a production schedule. Picker X-Ray Corp., 300 Fourth Ave., New York, N. Y.

Electronics Book. Can Electronics Improve Your Products is the title of a 32-page, illustrated booklet designed to provide practical information regarding this manufacturer's facilities and capacity for the production of electronic sub-assemblies and parts. Several pages are devoted to a non-technical discussion on what electronics is and what it does. Operadio Mfg. Co., St. Charles, Ill.

X-Ray Diffraction Apparatus. Bulletin No. 1XD11-44-10 describes and illustrates x-ray diffraction techniques and applications. Diagrams, typical diffraction films, and several tabulations are given to show how Norelco equipment is used for identification, research and production. North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y.

Capacitor Catalog. This catalog provides practical working data on ceramic capacitors. It contains 81 standard rating ceramic capacitor samples and some working samples. Plant illustrations, which show the manufacturing processes and testing methods including the application of solid silver for condenser plates, are included. An ASA color code makes the catalog useful as a reference source. Electrical Reactance Corp., Franklinville, N. Y.

Bendix Radio Bulletins. Units such as 2500-w ground station equipment (Model TG-14), u-h-f signal generator, video signal generator, expressor amplifier, power supplies and marker receiver are all described in separate pieces of literature available from Bendix Radio, Div. of Bendix Aviation Corp., Baltimore 4, Md. The literature on ground station equipment is a 20-page bound catalog which contains descriptive matter and illustration on the TG-14 series.

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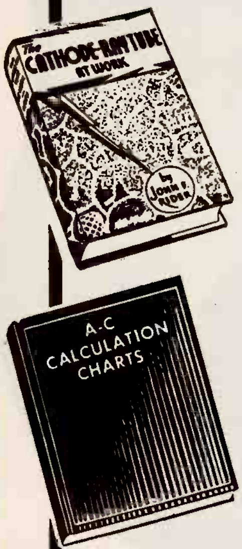
THE CATHODE-RAY TUBE AT WORK *by* John F. Rider



The cathode-ray tube is the most universally used device for research, engineering and maintenance in the radio and electrical fields.

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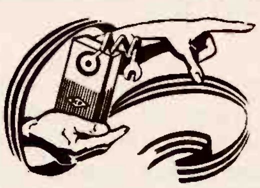

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Termination Financing for War Contractors. This 36-page booklet contains information, as released by the Office of Contract Settlement of the U. S. Government, for war contractors on how to settle contracts. It is for sale at 10 cents per copy from the Superintendent of Documents, Washington, D. C. Most of the booklet tells about how to get partial payments and how to get a termination loan.

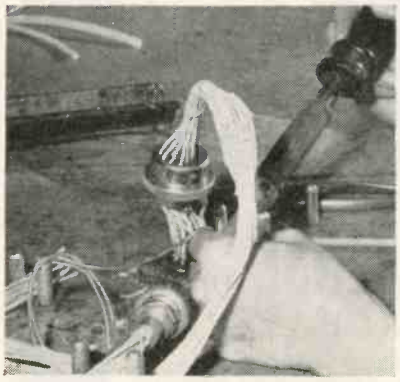
Communications History. Tom Tom to Electron is the title of an interesting 42-page catalog which is designed to be a story of communications. With this thought in mind this manufacturer has made an attempt to chronologically portray in picture and fact the history of communications. The booklet contains background data as well as descriptions of the products of Link Radio Corp., 125 West 17th St., New York 11, N. Y.

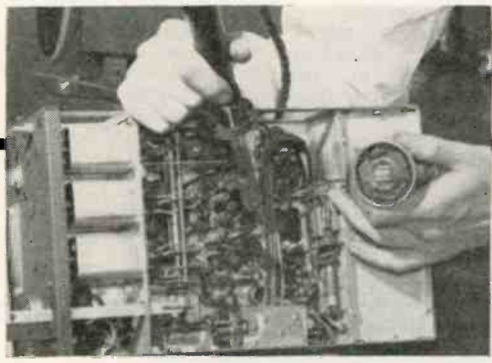
Electrically - Operated Switches. Circular No. 600 describes such electrically-operated switches as automatic transfer switches, remote control switches, and contactors and relays. Automatic Switch Co., 41 East 11th St., New York, N. Y.

• • •

SEALING C-R TUBE BUTTONS

Metallic buttons are sealed-in on cathode-ray tubes at the Dobbs Ferry plant of North American Philips. The operator controls the air pressure in the tube with her mouth while the gas burner is rotated around the button





Glass-Bonded Mica Insulation. New and larger-size sheets of glass bonded mica ceramic insulation, designated as Mykroy, are described in Bulletin No. 102. Electrical, mechanical and physical properties of Mykroy are given. Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.

Transformers. Bulletin No. 431 contains photographs and illustrations, diagrams, full construction details, and prices on the complete line of transformers, windings and reactors available from Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles 1, Calif.

Theater Television Handbook. A comprehensive handbook on the what, how and why of theater television is profusely illustrated. It is primarily devoted to technical discussion of the reception and large-screen projection of television programs. Several chapters deal with such non-technical subjects as television commercial possibilities, the handling of programs, and audience response. The book, aimed primarily at projectionists, is called Theatre Television Handbook for Projectionists. RCA Service Co., Inc., Camden, N. J.

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DYNAMIC REGULATOR

Timing of shell fuses is compared electronically to the ticking of a master electric clock at the Eclipse-Machine division of Bendix Aviation Corp. Called a dynamic regulator, the device plays an important part in production of anti-aircraft shells

NEW BOOKS

Alignment Charts, Construction and Use

By MAURICE KRAITCHIK, *Professor of Mathematics, New School for Social Research, New York. D. Van Nostrand Co., Inc., New York,* 1944, 94 *pages,* $2.50.

GENERAL PRINCIPLES of choice and graduation of scales and methods of representation for nomographs are illustrated by conversion and alignment charts of up to five variables. Although none of the charts deal specifically with electronics, the method of their construction is applicable to nomographs in electronic and allied fields. The presentation assumes a working knowledge of geometry and algebra.—F.R.

• • •

Marine Radio Manual

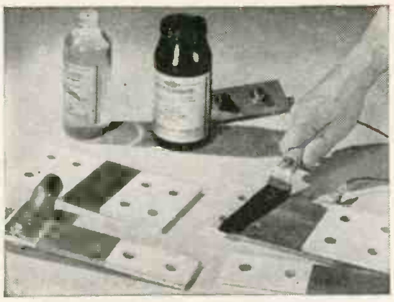
EDITED BY M. H. STRICHARTZ. *Cornell Maritime Press, 241 W. 23rd St., New York 11, N. Y., 518 pages, $4.00.*

IN NOT MANY INSTANCES can the "tricks of a trade" be bundled into a single volume that can be used as a bible by both learners and masters, but Mr. Strichartz is one person who has accomplished this admirably in "Marine Radio Manual." The book was written—assembled would be a better word because many sources were used—to serve as a guide for students who are learning to become radio officers on ships and as a refresher and manual for experienced operators.

That the purpose of the editor has been achieved is clearly evidenced by the comments of the Hon. Schuyler Otis Bland, chairman, Committee on Merchant Marine and Fisheries of the House of Representatives, in the foreword. He says:

"This manual deals with all phases of radio at sea and has been prepared as a textbook for schools training young men for radio service. It gathers between the covers of one volume all of the data needed for performing the duties of the radio operator on merchant ships.

"It has the tang of the sea on every page, for the manuscript was written in waters both safe and



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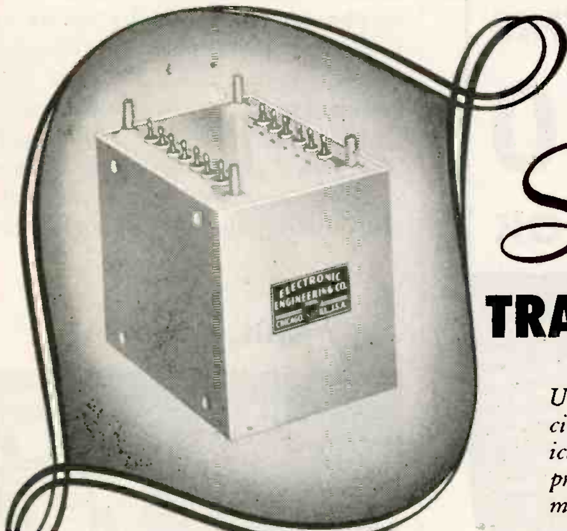

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Transformer Engineers for Specialized Applications dangerous and on ships carrying cargo as different as coal and block-busters. The editor's main fear during those dangerous days was lest he should lose his manuscript and small library. So precious were they, that when his ship ran on the rocks, after the editor had sent the SOS signal his chief concern was the preservation of the manuscript. One of his comrades found him consuming valuable time wrapping the manuscript and material in his life jacket and immediately reached the conclusion that he had gone crazy."

A radio officer's duties on a ship cover not only operation and maintenance of the equipment but actual business transactions and bookkeeping connected with sending and receiving messages. In this work he is governed by a mass of laws, rules and regulations laid down by several government agencies, the steamship company that employs him, the radio service company that owns and installs the equipment and the traditions of the sea and of his particular branch of the service. To explain all of the duties Mr. Strichartz begins with a short sketch of maritime radio history. He then delves right into all phases of the work by taking up each one in a separate chapter. Headings of these chapters are self-explanatory—the ship's radio station, the maritime radio operator, laws affecting radio officers, work in port, work at sea, radio operating, the "business" of radio tele-

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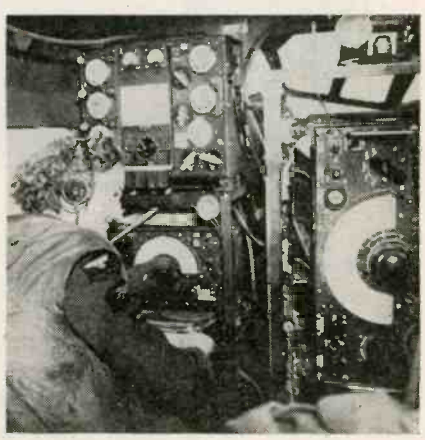
GIRL OPS FLY



British WAAFS take a one-week flying course to study RAF techniques in the air as part of their training as aircraft signal officers. In their previous radio course, they learn communications procedure and code

communications, types of telecommunications service, distress and emergency communications, radio station bookkeeping, radio navigation aids, frequency, a guide to the guidebooks, tools, maintenance, trouble-shooting, direction-finders, auto-alarms, transmitters, receivers, safety and first aid, radio medical aid and the International Morse Code. A final chapter called "General Information" might well have been listed in the table of contents as a series of appendices. A wealth of practical data is stored in this section.

One of the commendable points about this book is that the author has not gone into detailed "why's and wherefore's." Thus, it is not loaded down with lengthy explanations, which makes it interesting reading whether or not one intends to become a maritime radioman. It is crammed with details, however, about duties and equipment and therein lies its greatest general interest to the electronics field. As one browses over the descriptions of the equipment and what functions it performs there arises a feeling of pride and, possibly, pleasant surprise at what has been accomplished by electronic engineers.

The highest praise a layman could give this book is contained in the statement made by Representative Bland in the foreword when he says, "Personally, it would have been one of my greatest pleasures to have had such a volume on April 18, 1921 when I began my service on the Committee on Merchant Marine and Fisheries."—K.S.P.

• • •

Meet the Electron

By DAVID GRIMES, *Pitman Publishing Corp., New York 19, N. Y., 1944, 120 pages, $2.00.*

THIS BOOK is a brief, lucid exposition of the nature and characteristics of the electron and the many technical developments which are based upon modern knowledge of its behavior. The stories in it have been told and retold by the author over a period of twenty years to many thousands of fascinated listeners in auditoriums, schools and lecture halls, and preparation of the manuscript for this book had been almost completed at the time of his fatal airplane crash in Ireland.

Commonplace observations and

their scientific explanations are reviewed in story fashion with unusual simplicity and clarity. Essential facts are narrated so sketchily yet interestingly that readers with a little more than an elementary knowledge of electronics are likely to be disappointed because more details are not included. But to readers who are not students of science this book should make clear any mystery which may surround electronics and its applications.

An overall pattern is depicted which portrays the universal existence of electrons in nature, their actions in conductors carrying current, and their relation to magnetism. On this groundwork an explanation follows of how electronic activity is put to work in vacuum tubes and in radio reception and transmission systems. To complete the picture, related subjects are included such as sun spots, electron chemistry, electron sources, wave bands, inventions of Alexander Graham Bell, music on light waves, and television.

Pen and ink sketches by J. Riegel, Jr., are a notable feature of the book.—J.K.

• • •

Seeing the Invisible

By GESSNER G. HAWLEY, *Alfred A. Knopf, Inc., New York, 1945, 200 p., $2.50.*

THE ELECTRON MICROSCOPE, how it works, how it was developed, and its possibilities in research in many fields are described in language for the layman. The author admits that he may not secure unqualified approval of experts because of the lack of details of construction and operation. Even a student would need some of these, but he could not help but become a more interested student for having been made familiar with the vastly widened possibilities open to him in research.

The nine chapters in the book begin with a word picture background telling of "the search for the small", comparing the principles of the optical and electron microscopes. It is shown that light, on which the former depends, is too coarse a tool to distinguish particles less than 0.000008 in. in any dimension. The electron microscope distinguishes particles one hundredth that size. Particles are not only

made larger but more distinct as well.

The "why" of invisibility is explained in Chapter 2 by the length of visible light waves which, ranging from 0.000025 to 0.00005 in., are much longer than the particles that they have been called upon to make visible. How electrons are controlled to produce larger and better images is described in Chapter 3.

Two major limitations of the electron microscope, which are pointed out in Chapter 4, are that specimens to be examined must be subjected to high vacuum and its excessive drying action as well as to the heat produced by the electron stream. These are particularly serious in studying biological organisms. Examination of dense materials such as metals requires an indirect procedure, recently developed.

The history of the electron microscope is also an interesting story as told in Chapter 5. Some of the things already accomplished with the electron microscope are described in Chapter 6, the studies of carbon black as related to rubber and synthetic rubber being particularly interesting. Further accomplishments and reports on what is being attempted with the microscope are dealt with in the next chapter.

The possibilities in medical research, discussed in Chapter 8, are shown to be great in spite of previously mentioned limitations of the instrument. Pictures have been made of numerous bacteria, bacteriophages, blood corpuscles, the anatomy of insects, and related subjects.

"What lies beyond?" is a brief concluding chapter. It probes the further development of the instrument and technique of using it, perhaps for "seeing" even smaller particles such as molecules and even atoms.

The book is illustrated with more than 70 reproduced photographs and line drawings, many of which show magnifications up to 50,000 times.—M. G. V.

—◆—

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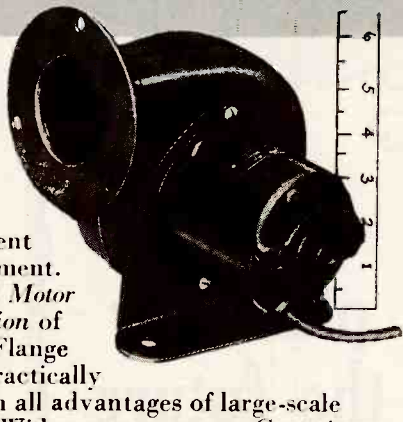

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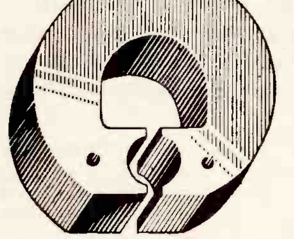

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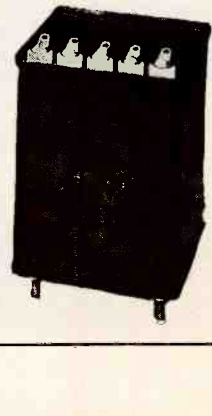

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published

Semper Fidelis!

Dear Mr. Henney:

MAY I BE permitted to convey my hearty and unqualified concurrence with the views expressed in "Cross Talk" in the December issue of ELECTRONICS. . .

It would be a gross understatement to say that I have been disturbed by some of the literature recently released purporting to show preference for degraded reproduction and the quasi theory to substantiate the findings.

You succinctly call attention to the fallacies and weak points in current studio practices—which in themselves defeat dispassionate findings in "high fidelity" tests.

I feel that you are personally acquainted with our efforts to honestly find the answers to faithful reproduction in experiments which go back many years—with no axe to grind except to learn the truth—and it is a comforting reassurance to find a friend at court with the influence obviously enjoyed by ELECTRONICS.

L. B. ROBINSON
Technical Director
The Yankee Network
Boston, Mass.

At the risk of being called idealistic, ELECTRONICS will continue to be against hamstringing high fidelity at the start and then waiting ten years to wish there had been more vision.—(Ed.)

• • •

Mathematics by the Ten Millions

Dear Sirs:

MY PAPER, "Secondary Electron Radiation," (in the September issue) seems to have attracted a certain amount of attention in this country, because three misprints in it have been pointed out to me. I thought perhaps you might like to put a correction in the next issue of ELEC-

TRONICS. The misprints are as follows:

(1) In the first column of the text on p. 100, the formula for v should read:

$$v = 5.95 \times 10^7 \sqrt{V}$$

(2) Figure 14: The numerals along the abcissa should commence with 1 and not with 0, since this is a logarithmic scale of frequency.

(3) In the Bibliography, item 82, my name "Harris" should, of course, be spelled

J. H. OWEN HARRIES
Rediffusion Ltd.
London, England

• • •

Repairmen and Hams

I AM IN one-hundred-percent agreement with Mr. B. P. Schroeder as to the disposition of surplus materials.

It would be very easy for the War Dept. to limit the sale of such materials so that large buyers could not grab all available surplus, store it a few years, then black market it to buyers.

Any gear in need of repairs usually can be serviced by the individual who uses it, sometimes with the help of the manufacturer regarding parts of special nature and diagrams.

I feel this can be done not only with electronic testing equipment, but also with surplus tubes, transformers, etc.

There are many servicemen of electronic equipment who, as Mr. Schroeder suggests, cannot afford refined equipment and possibly never will be able to. Take for example the serviceman who aligns a radio receiver with signal generator and output meter. His customers would certainly be more willing to recommend him after hearing the better quality and performance from an alignment job with a frequency-modulated oscillator and 'scope—which most servicemen cannot afford, and others who can afford don't know how to use.

This obviously puts a different light on the subject—the less wealthy serviceman who has knowledge but not money would be well able to pit his knowledge against the other fellow's money since he will be able to get the necessary

equipment, and knows how to use it.

As for the manufacturer—the surplus material would eventually enable the above-mentioned serviceman to get new products, and the manufacturer would gain in the long run.

Of course we can also mention the electronic home inventor and his experiments, the radio amateur—usually making a living at some other endeavor—and so forth. All these persons would be able to get equipment to enable them to perform their experiments with more accuracy, guess work would be minimized, and their help to the technical world would be improved.

Codeless Hams?

While many organizations such as the RTPB, ARRL, etc. are interested in frequency allocation and other technical matters, it seems to me that they might give some thought to the idea of refining the laws governing radio amateur communication. For example, I can see no logical reason why an amateur must know the Morse code in order to operate a station.

This seems absurd because there are many persons who would like to put stations on the air for purely scientific purposes (Kennelly-Heaviside measurements, and the like). These scientific-minded persons (some of them college professors) find their time fully taken up with responsibilities which limit and usually crowd out the time necessary to learn code in operable manner.

Almost anyone can recognize an SOS and knows, if he cannot respond, at least to get out the way and help by a telephone call to the Coast Guard.

It seems more logical that the technical examinations and law be given priority and amateur licensees be split into the radio telephone and radio telegraph groups as the commercial licensees are.

C. R. MADUELL JR.
Belmar, N. J.

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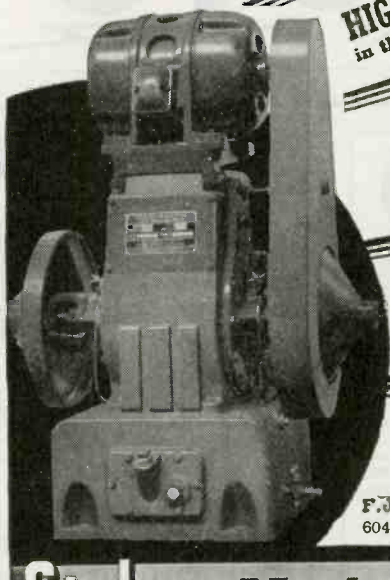

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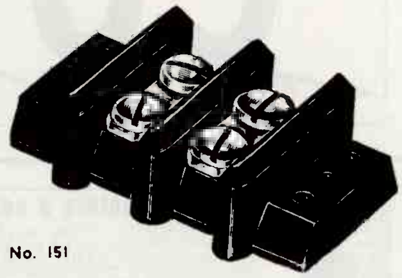

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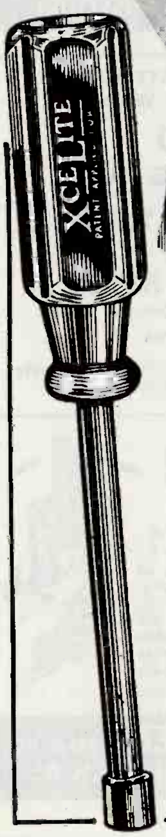

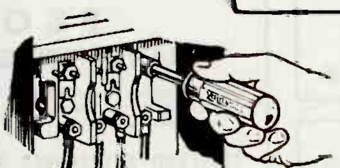

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  0-111DB, steps of 0.1DB (3 dials)

*Balanced "H" type may be used as an unbalanced network of one-half the base impedance.

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"T"	BAL "H"	DB RANGE	BASE Z
T-690-A	H-690-B	0-110	500
T-690-C	H-690-D	0-110	600
T-692	H-692	0-111	500
T-693	H-693	0-111	600
T-694	H-694	0-111	135

RACK TYPES

"T"	BAL "H"	DB RANGE	BASE Z
T-690-AR	H-690-BR	0-110	500
T-690-CR	H-690-DR	0-110	600
T-692-R	H-692-R	0-111	500
T-693-R	H-693-R	0-111	600
T-694-R	H-694-R	0-111	135

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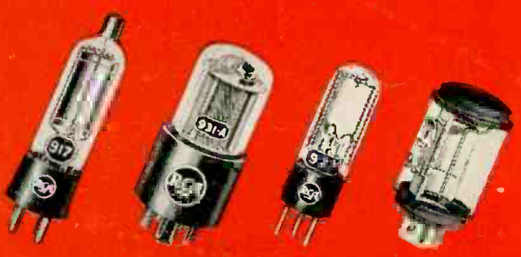
HOW TO SELECT PHOTOTUBES



PHOTOTUBES have found such a wide variety of applications that many types have been developed to meet special needs. The complete RCA line includes both gas-filled and high-vacuum phototubes, with various spectral responses and a variety of sizes and shapes. And for applications requiring extreme sensitivity, RCA supplies multiplier phototubes.

A phototube acts as a light-actuated electric valve. (It does *not* convert light energy to electrical energy, but acts only as a control device.) The current passed is in proportion to incident light. Some phototubes are "high-vacuum" types; some are filled with an inert gas (such as argon) to increase current-carrying capacity.

A multiplier phototube contains additional electrodes (dynodes) which emit secondary electrons and thus greatly increase sensitivity and output current as compared to 2-electrode phototubes.

Color Sensitivity: The cathode coating material and the envelope glass determine color sensitivity. RCA phototubes fall into five "color groups":

Use	Tube Types	Maximum Color Sensitivity
With incandescent lamps	High vacuum: 925. Gas-filled: 868, 920, 924, 927*, 928	Red and infra-red
With incandescent lamps—and for infra-red application	High vacuum: 917, 919, 922*. Gas-filled: 918, 921*, 923, 930*	Similar to above, but sensitivity extended further into infra-red
With light source for colorimetry application	High-vacuum: 926	Blue light. Approximates the human eye
With daylight, carbon-arc, or mercury-vapor light source	High-vacuum: 929*, 934. Multipliers: 931-A*, 1P21	Blue light. Very sensitive to incandescent light at a color temperature above 2700° K.
For ultra-violet measurement	High-vacuum: 935, 1P28	Same as above, but special glass envelope permits high ultra-violet sensitivity

*An RCA Preferred Type Tube

Color response curves are available on all RCA phototubes.

Vacuum- or Gas- or Multiplier-Type? Several important factors to be considered in selecting the general type of phototube for a service are given in the following table. Specific values should be considered in selecting the actual tube type.

Characteristic	High-Vacuum type	Gas-filled type	Multiplier type
Sensitivity	Low	Medium	Very high
Current Output	Low	Medium	Very high
Amplification factor	1	Up to 10	Up to 1,000,000
Relative signal-to-noise ratio (including amplifier stage)	Low	Intermediate	High
Anode Volts	Up to 500	Not over 90	Up to 1250
Distortion (audio)	Negligible	Appreciable in some cases	Negligible
Frequency Range	Limited largely by circuit	Limited by tube performance	Limited largely by circuit

Gas-filled phototubes are, at present, extensively used for sound-on-film reproduction and for relay work. Vacuum-types are widely used where high sensitivity is needed; for precision measurement where stability of calibration is essential; and for high-speed work.

Sensitivity: The sensitivity of a phototube may vary according to whether the light change is abrupt or continuous. *Static sensitivity* is the ratio of anode direct current to constant light flux. *Dynamic sensitivity* is the ratio of the variation of anode current to the variation of light input. The sensitivity of gas-filled phototubes drops off as light-source frequency increases.

Optical Systems: The use of phototubes usually involves some sort of optical system. The fundamentals of optics must be carefully considered in the successful application of phototubes.

Mechanical Features: As illustrated at left, several types of tubes are available. Size, vibration, directional requirements, etc., all may influence the choice of one of the many RCA phototubes.

Phototube Life: Phototubes are inherently sturdy, long-lived tubes and when operated under recommended conditions, give extended reliable service.

Application Hints: Here are a few general suggestions on applying phototubes:

1. In relay and measurement circuits where tubes must respond to very small amounts of light, avoid leakage currents outside tube. Keep tube terminals and sockets clean. Erratic leakage currents will affect results.
2. In amplifiers where low leakage is important, select top cap types such 917, 919, or 935.
3. Shield phototube and leads to amplifier or relay tubes when amplifier gain or phototube load resistance is high.
4. Where high-frequency response is important keep phototube leads short to minimize capacitance shunting of output.
5. For constant calibration of high-precision vacuum phototube devices, keep anode voltage at or below 20 volts. Keep incident light spread over wide cathode area.
6. Design or circuit constants should be based on tests with the equipment operating over the expected range of line-voltage variation.
7. RCA voltage-regulator tubes can improve phototube circuit performance.
8. Anode characteristic curves on phototubes can be used to predict performance under given operating conditions.

Send for this valuable data

Free to electronics engineers: "RCA Phototube Booklet," complete with 11 typical circuit diagrams, curves, tables, and clearly written text. Address: RCA, Commercial Engineering Section, Dept. 62-27E, Harrison, N. J.

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What Phototube Do You Need?

Due to space limitations, the suggestions presented here are brief and in a condensed, summary form. If you have a specific application problem or wish to discuss your phototube requirements with us, write to RCA, Commercial Engineering Section, Dept. 62-27E, Harrison, N. J. For further published information on RCA Phototubes and how to use them, send the coupon at left.

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