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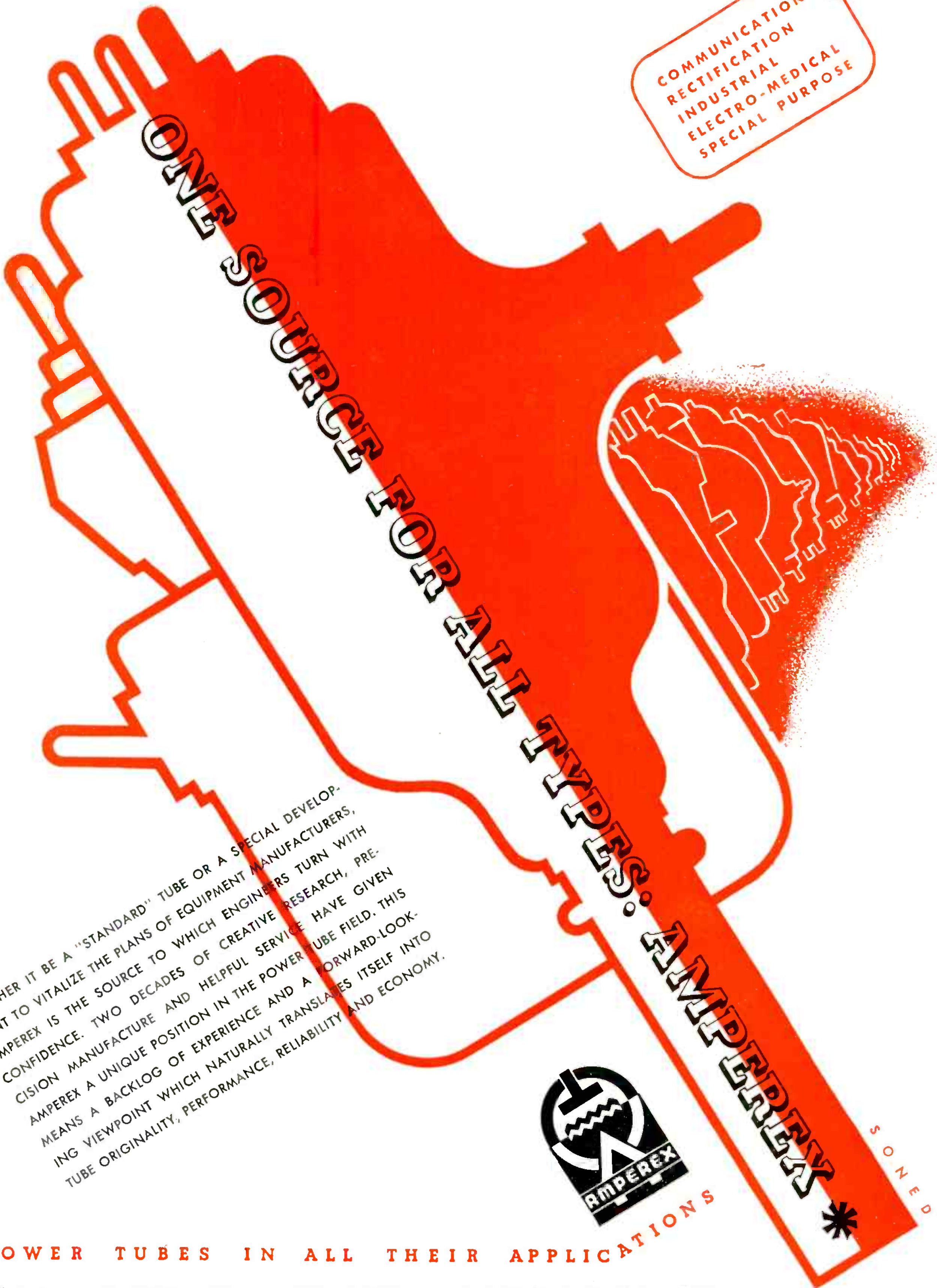

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Type	Application	Level	Pri. Imp.	D.C. in Pri.	Sec. Imp.	List Price
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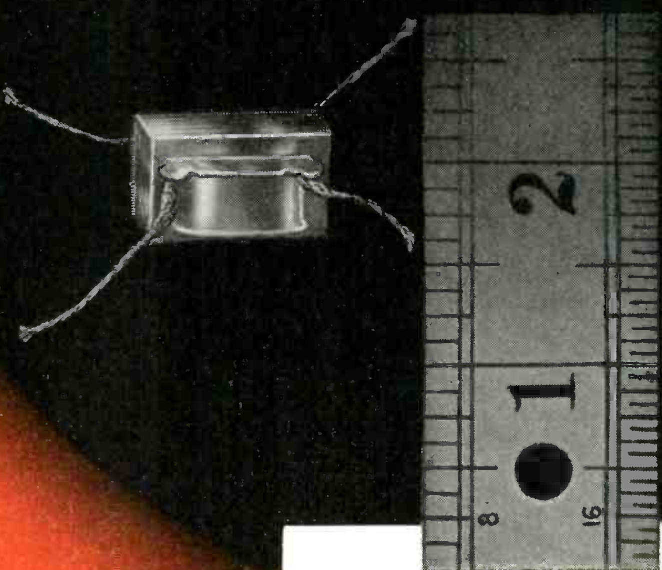
SO-3	Plate to Line	+ 23 V.U.	10,000 25,000	3/1.5 mil.	200 500	5.00
SO-4	Output	+ 20 V.U.	30,000	1.0 mil.	50	5.00
SO-5	Reactor 50 HY at 1 mil. D.C. 3000 ohms D.C. Res.					4.50



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0-1	Mike pickup or line to 1 grid	50, 200, 500	50,000	$11.60
0-4	Single plate to 1 grid	8,000 to 15,000	60,000	$ 9.25
0-5	Single plate to 1 grid, D.C. in Pri.	8,000 to 15,000	60,000	$ 9.25
0-6	Single plate to 2 grids	8,000 to 15,000	95,000	$10.45
0-8	Single plate to line	8,000 to 15,000	50, 200, 500	$11.60
0-9	Single plate to line, D.C. in Pri.	8,000 to 15,000	50, 200, 500	$11.60
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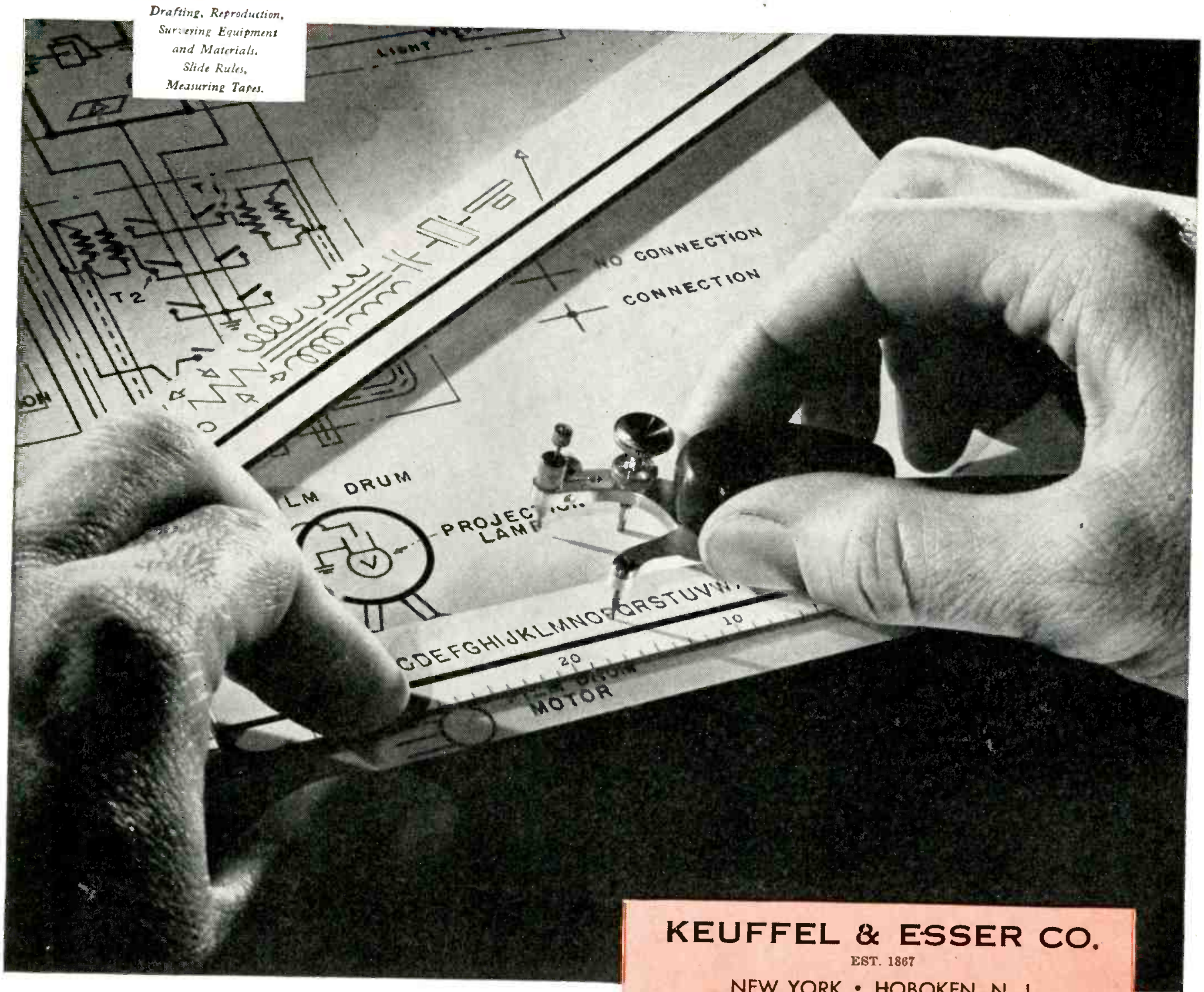

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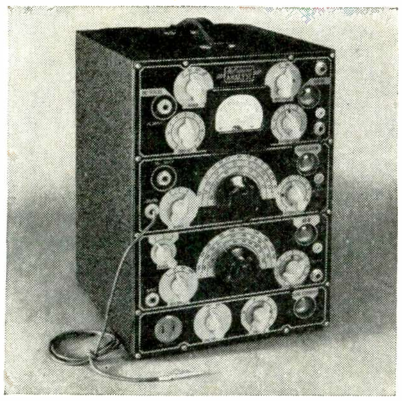

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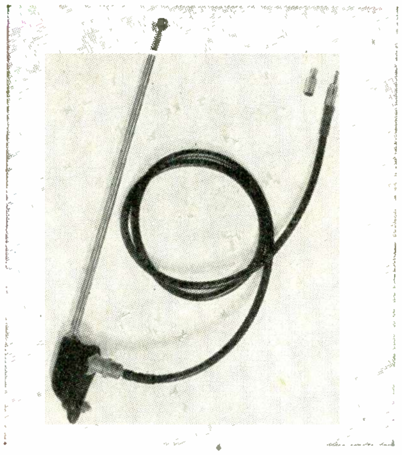

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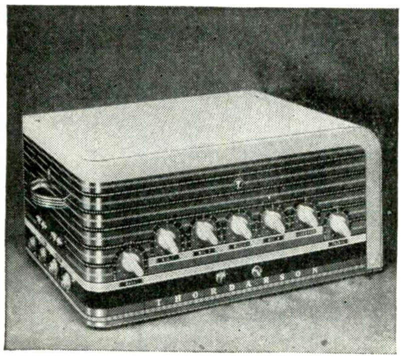

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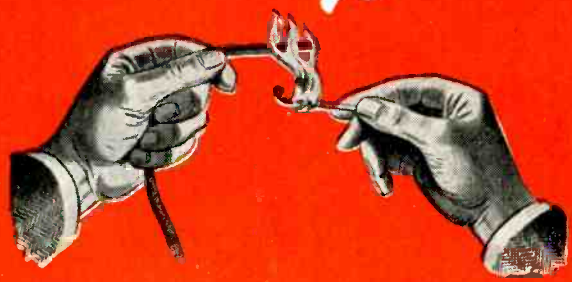

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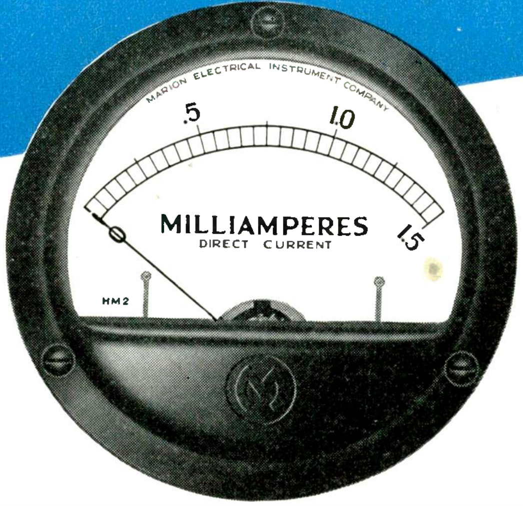

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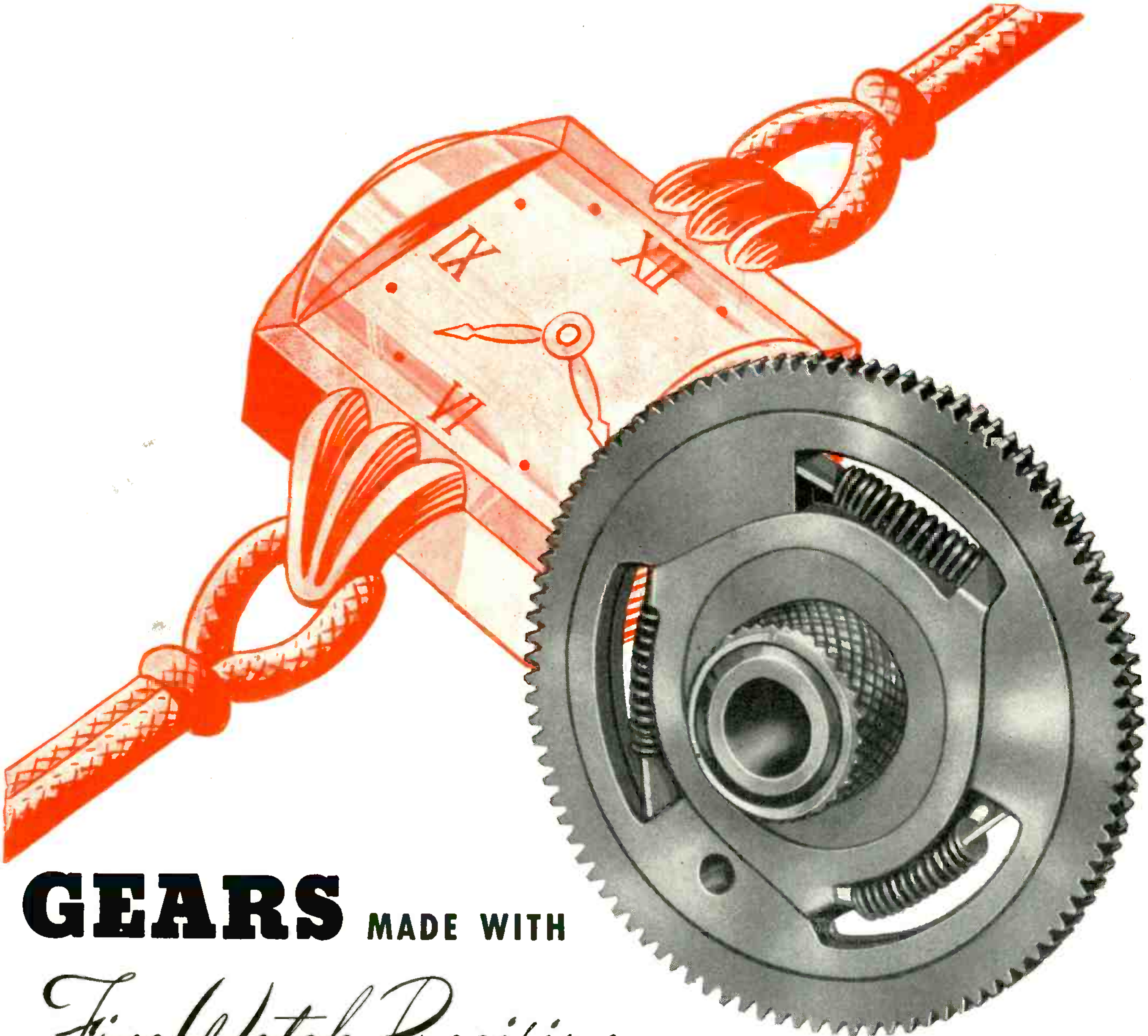

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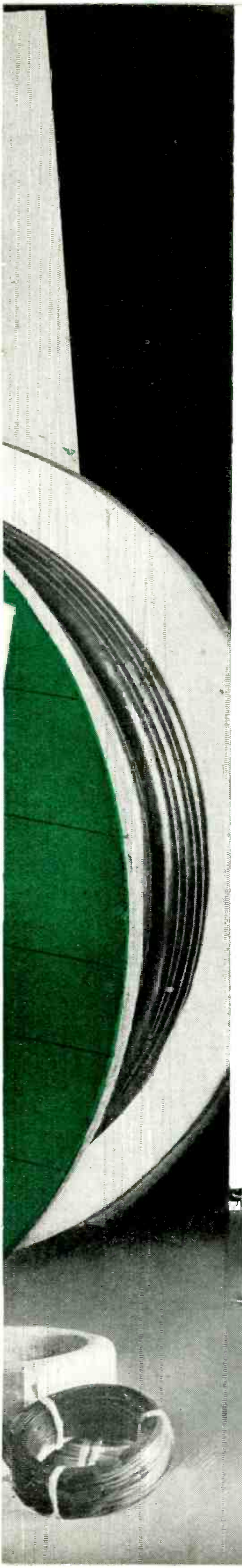

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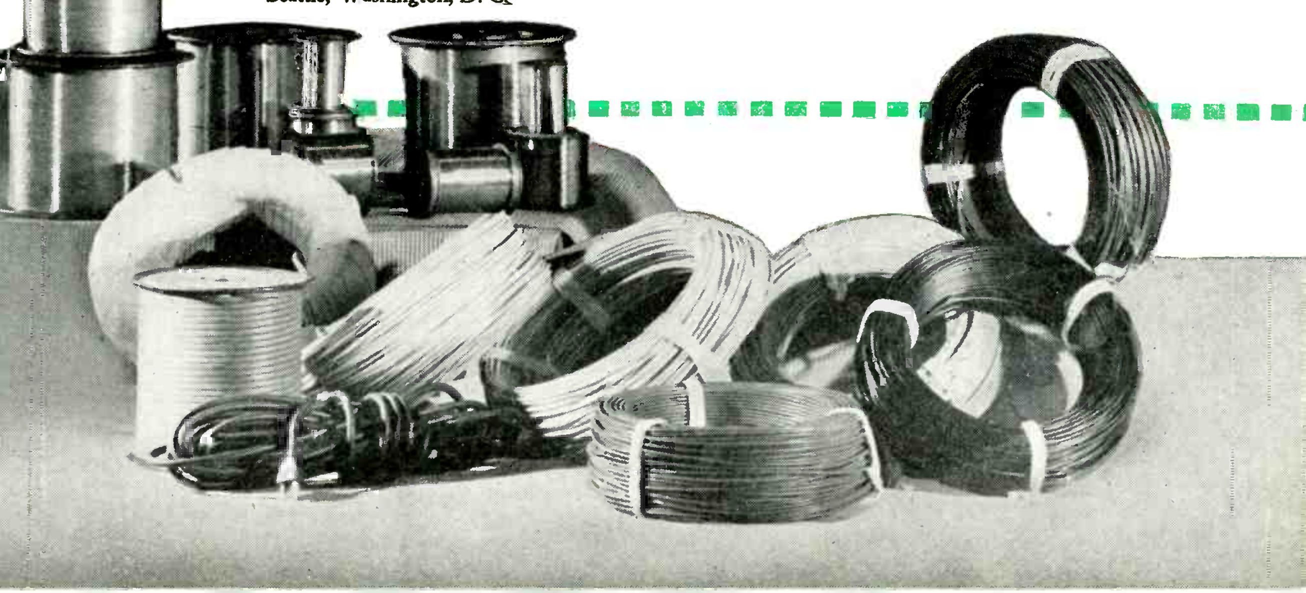

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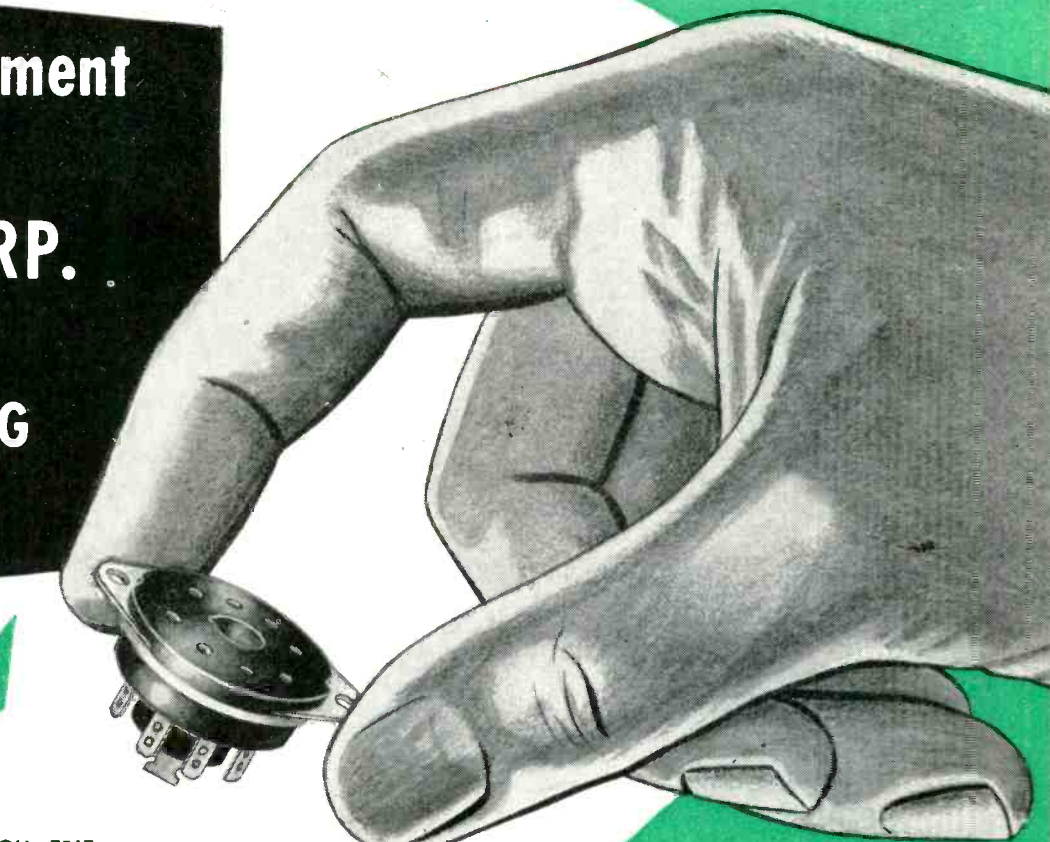

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Puts the By-Pass Condensers where they belong . . . *Around the Tube Pins*

1 *Provides shortest possible electrical path to ground.*

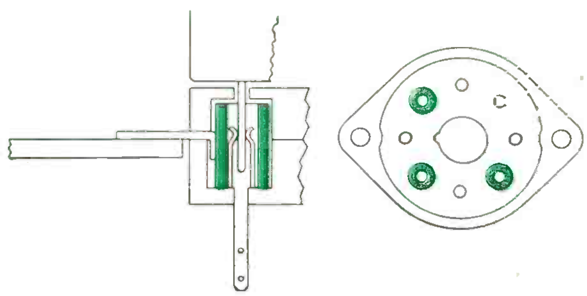
2 *Saves space—permits moving other components closer to tube socket.*

3 *Reduces set assembly costs.*

4 *Capacitive coupling effect between by-passed tube pin and adjacent pins is reduced by shielding effect of outer electrode of condenser.*

5 *Plexicon sockets are installed exactly the same as standard Cinch Lock-in, Octal, and Miniature type sockets.*

6 *Top of Cinch-Erie Plexicon Lock-in type socket matches tube base.*



The above two schematic diagrams show the basic design principles of Cinch-Erie Plexicon Tube Sockets.

In the plan view, the socket is shown with condensers for by-passing three tube pins. The silvered-ceramic condensers are shown in green.

Note in the side view that standard tube prong clips are used, and that the condenser completely surrounds the tube pin.

Mounting dimensions of the Lock-in type are: 1.312" between center line of mounting holes; chassis hole 1.125" diameter.

Electronics Division

and ERIE RESISTOR CORP.

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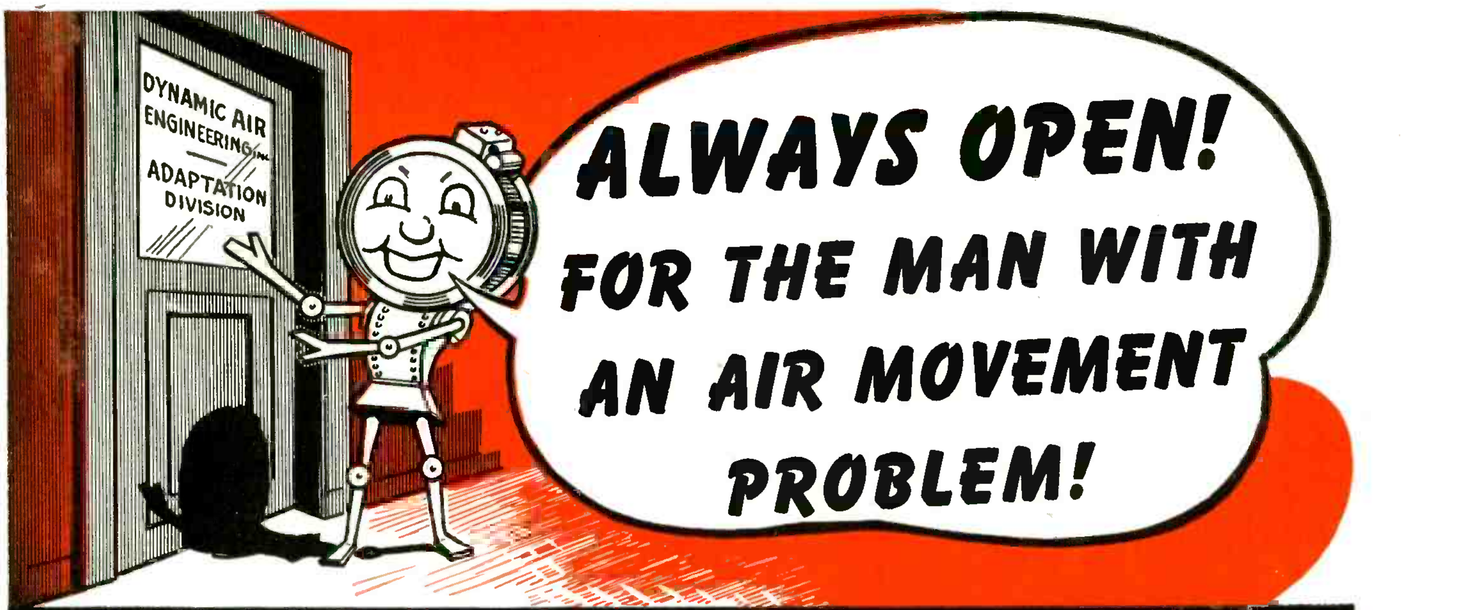

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115-V D.C. . . .	1/100 to 4 h.p.
115-V A.C. . . .	1/100 to ½ h.p.
400-cycle A.C. . .	1/500 to 1 h.p.

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LOS ANGELES, U. S. A.

DESIGNERS and BUILDERS of HIGH EFFICIENCY AXIAL FLOW EQUIPMENT

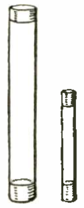
LIKE A TIN CAN . . .

THE answer to that is easy! They're like a tin can because they also form permanent hermetic seals when soldered in place. By means of the famous Corning metallizing process, metal is attached to glass so firmly it can't be removed without taking glass with it. This means that there is no possibility of leakage and assembly parts and operations are cut in half.

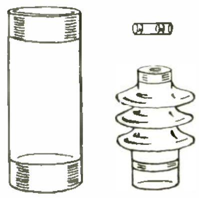
These bushings have high voltage rating, high volume and surface resistivity and high dielectric strength. They're strong, too, and being glass, resist chemical action and weathering. And the Pyrex Brand low-expansion glass makes them able to withstand great thermal shock. As you can see they come in both tubular and skirted form. Many standard items are available for immediate shipment. Or special items can be quickly made in any quantity desired.

If metallized glass can improve your product through hermetic seals or faster assembly, Corning can help you. Look at the Corning Electronic products below. If something like these is what you've been looking for, write, wire or phone The Electronic Sales Department, E-2, Technical Products Division, Corning Glass Works, Corning, New York. There'll be a Corning engineer working on your problem as soon as he can get there.

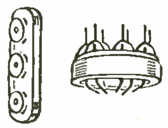
NOTE—*The metallized Tubes and Bushings, Headers and Coil Forms below are all made by the famous Corning Metallizing Process Can be soldered into place to form true and permanent hermetic seals. Impervious to dust, moisture and corrosion.*



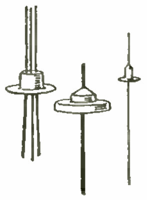
Metallized Tubes *for resistors, capacitors, etc. 20 standard sizes ½" x 2" to 1¼" x 10". Mass-produced for immediate shipment.*



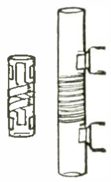
Metallized Bushings. *Tubes in 10 standard sizes, 5/16" x 25/32" to 1" x 4 7/32" in mass production for immediate shipment.*



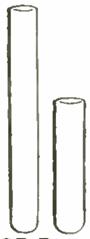
Headers — *The best way to get a large number of leads in a small space for assembly in one operation.*



Eyelet Terminals — *Single or multiple eyelets permit design flexibility. Standard items readily available in quantity.*



Coil Forms—*Grooved for ordinary frequencies—metallized for high frequencies. In various designs and mountings.*



VYCOR Brand cylinders—*very low loss characteristics. Stands thermal shock up to 900°C. Can be metallized.*

"VYCOR", "CORNING" *and* "PYREX" *are registered trade-marks and indicate maufacture by Corning Glass Works, Corning, N. Y.*

Electronic Glassware

TRADE MARK VYCOR REG. U.S. PAT. OFF.
T.M.REG. CORNING U.S. PAT. OFF.
T.M.REG. PYREX U.S. PAT. OFF.

It's a mark of quality in any equipment when the frequency source is a BLILEY CRYSTAL

Anyone familiar with radio frequency applications knows that the name Bliley on a crystal means original engineering for a specific job. True—Bliley builds crystals by the million—but Bliley craftsmanship was never gained through mass production.

Fifteen years of interpreting the needs of communications engineers, personalized attention to their individual problems, has provided the engineering background and experience that has made possible consistent quality production.

In the current line of Bliley Crystals all that proved good in wartime models has been retained, with important refinements for peacetime applications. New types have been added—more are on the way.

Make it a habit to consult Bliley engineers on all of your frequency control problems. You will benefit from this mark of quality in your equipment.

TYPE TC91—This new Temperature Stabilizer is just one of many products described in a new Bliley bulletin. Write for your copy.

Ask for bulletin E-27

Bliley CRYSTALS

BLILEY ELECTRIC COMPANY • UNION STATION BUILDING, ERIE, PENNSYLVANIA

Why this team could do

There are three reasons why the team of Bell Telephone Laboratories and Western Electric was able to handle big war jobs fast and well.

(1) It had the men — an integrated organization of scientists, engineers and shop workers, long trained to work together in designing and producing complex electronic equipment.

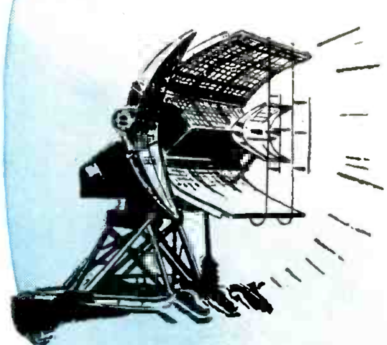
(2) It had unequalled physical facilities.

(3) Perhaps most important of all, it had a long-established and thoroughly tested method of attack on new problems.

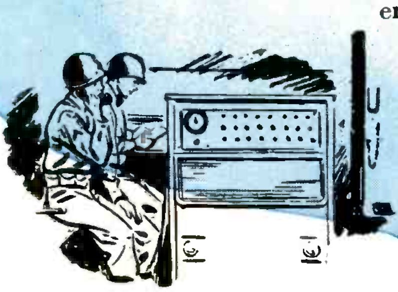
What is this method of attack?

In simple terms, it is this. Observe some phenomenon for which no explanation is known — wonder about its relationship to known phenomena—measure everything you can—fit the data together—and find in the answer how to make new and better equipment.

In the realm of *pure research,* Bell Laboratories have carried on continuing studies in all branches of science, with particular emphasis on physics, chemistry and mathematics. Often they have set out to gain new knowledge



Bell Laboratories and Western Electric teamed up to supply more than 56,000 radars of 64 types—approximately 50% of the nation's radar production on a dollar volume basis.



Bell Laboratories designed and Western Electric produced more than 1600 electronic gun directors and gun data computers which greatly increased the accuracy of anti-aircraft and coast defense guns.

More than 1,000,000 airborne radio receivers and transmitters were furnished by Western Electric to help coordinate attack and defense in the air.

Bell Laboratories designed and Western Electric furnished more than 139,000 multi-channel FM receivers and 74,000 multi-channel FM transmitters for use by the Armored Forces and Artillery.

Bell Laboratories and Western Electric furnished revolutionary carrier telephone terminal equipment in great quantities—all "packaged" for quick installation in the field.

war jobs like these

with no immediate prospect of an application in the communications field. Time after time, their discoveries have eventually brought about fundamental scientific advances.

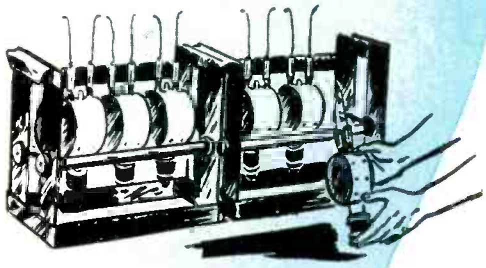
Applying new discoveries

As new discoveries have reached the stage of application, Western Electric manufacturing engineers have always worked closely with Bell Laboratories men to assure a final design suited to quantity production of highest quality equipment.

During the war, the capabilities of this unique research-production team expanded rapidly. New techniques were explored—new methods were developed—new ideas were born, rich with possibilities for the future.

What this means to YOU

Today Bell Laboratories and Western Electric are once more applying their facilities and their philosophy to the development and production of electronic and communications equipment for a world at peace. Depend on this team for continued leadership in AM, FM and Television broadcasting equipment.



Bell Laboratories and Western Electric played outstanding roles in the design and production of magnetrons and other essential vacuum tubes for use in radar and communications.

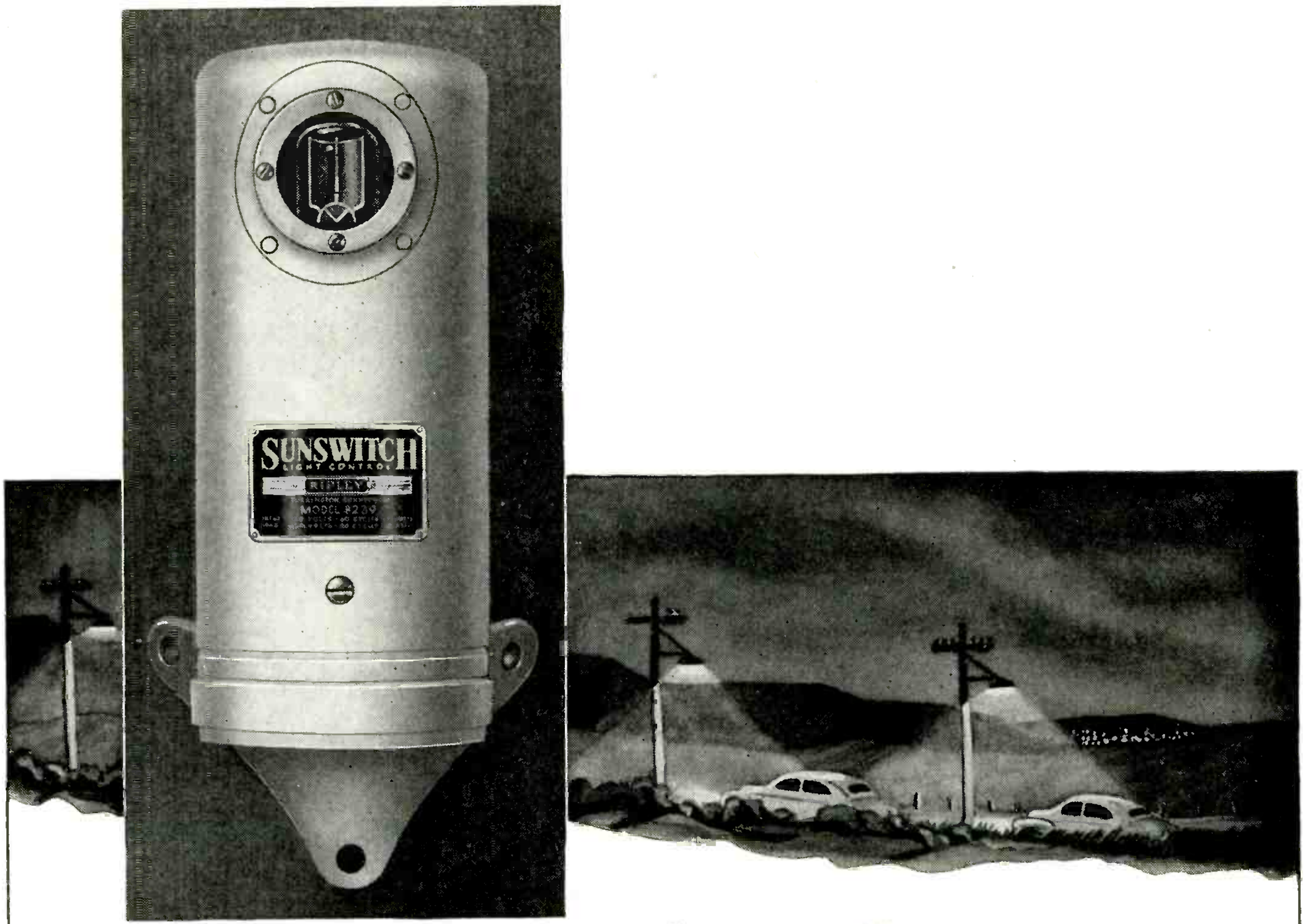
AMERICAN TELEPHONE & TELEGRAPH CO. BELL SYSTEM AND ASSOCIATED COMPANIES

BELL TELEPHONE LABORATORIES

World's largest organization devoted exclusively to research and development in all phases of electrical communication.

Western Electric

Manufacturing unit of the Bell System and nation's largest producer of communications and electronic equipment.



Tested for Four Years . . . .

Back in 1941 our engineers had completed the design of a new street-lighting control which unfailingly insures adequate illumination regardless of changes and fluctuations in weather and the twilight hour.

Wartime obligations prevented production, but for four years the engineers' prototypes have been tested under actual street-lighting conditions . . . time-proven, it is now offered as our

SUNSWITCH
LIGHT CONTROL

A practical and rugged unit with 100 percent safety factor . . . its sturdy components assure a negligible maintenance cost. Tooling up for large scale production is now completed. Write for Bulletin No. 8239.

The SUNSWITCH can also be used to control illumination of public buildings, outdoor advertising, airport beacons, radio mast running lights, and ships' running lights.

The **RIPLEY** *Company*

13 NEW LITCHFIELD STREET **TORRINGTON, CONNECTICUT**

High Safety Factor insulation

MEANS BETTER OIL AND ACID RESISTANCE •

• Want an effective means of combating high heat, dust, moisture and overloads—hazards that cause the greatest losses to users of electrical equipment? Fiberglas* Electrical Insulation Materials enable the designer and manufacturer of electrical equipment to provide protection against the damaging effects of oil and most acids. And another big plus value of Fiberglas Insulation is its merchandising feature and sales influence. It is winning widespread buyer preference because it improves quality, performance and *use economies*.

The high safety factors inherent in Fiberglas Insulations help solve most electrical insulation problems. Fiberglas, fine fibers of glass twisted into yarns and woven into textiles, provides a strong, thin, flexible base for insulating impregnants. Fiberglas Electrical Insulation Materials are sold nationally by leading distributors and are available in the form of laminates, mica combinations, insulated wire—treated or untreated tying cords, sleevings, tapes, braids, cloths and mats. Ask your Fiberglas Distributor for the complete story on the *use economies* of Fiberglas—and add the "extra" protection of Fiberglas High Safety Factor Insulation to your electrical equipment.

For performance and application data, write for the new Fiberglas Electrical Insulation Materials catalog, *Owens-Corning Fiberglas Corporation, 1860 Nicholas Building, Toledo 1, Ohio. In Canada, Fiberglas Canada Ltd., Oshawa, Ont.*

FIBERGLAS ELECTRICAL INSULATION MATERIALS

*T. M. Reg. U. S. Pat. Off.

Other Fiberglas Products: Thermal and Acoustical Insulations • Dust-Stop* Air Filters • Yarns, Cloths, Mats and Basic Fibers

ELECTRONICS DESIGNER'S

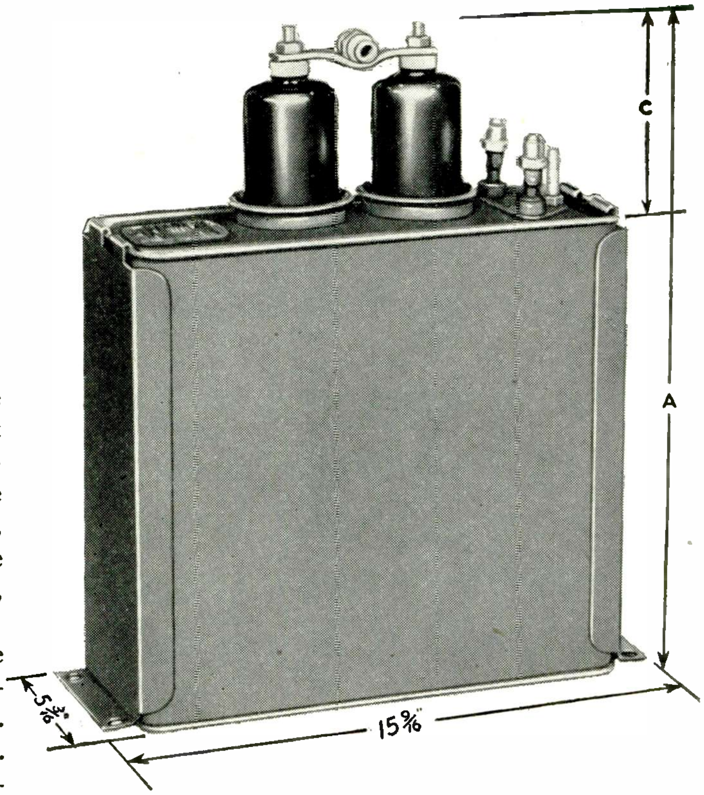
HERE 3 CAPACITORS DO TWICE THE WORK OF 25

A MANUFACTURER of induction heaters replaced 25 mica capacitors in his resonant (tank) circuit with three General Electric HFP parallel-plate, water-cooled capacitors. He saved nearly half the cost and space, and more than doubled the kva. Result: a more compact, more powerful, and more efficient heater.

Class HFP capacitors, with their two sets of heavy, sheet-aluminum plates, are specifically designed for use in resonant circuits of high-frequency oscillators, such as those employed in electronic heaters. Outstanding features of Class HFP capacitors are compact construction, and ability to operate at high voltages and to carry heavy continuous currents at frequencies from 50 kilocycles up into the megacycles. The special dielectric is a new, stable, synthetic liquid which combines the desirable characteristics of low loss, high dielectric constant, and high dielectric strength.

A coil of copper tubing, for water-cooling the capacitor, is installed inside the case in direct contact with the grounded pair of capacitor plates. Couplings are provided for connection to 3/8-in. copper tubing. The cooling feature permits a compact assembly and high current rating per unit volume.

The cases are of nonmagnetic metal, hermetically sealed, and flexible enough to take care of thermal expansion of the liquid dielectric. Capacitance tolerance is from plus 5 per cent to minus 5 per cent of the rated capacitance at 25 C; Q factor is above 2000 for full load operation at frequencies from 50 kilocycles to one megacycle. Internal inductance is low, which gives resonant frequencies from 3 to 9 megacycles, depending upon the capacitance rating. Write for Bulletin GEA-4365. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*



CLASS HFP HIGH-FREQUENCY, PARALLEL-PLATE, WATER-COOLED CAPACITORS

Maximum Permissible Rms Working Voltage	Microfarad Rating	Maximum Permissible Rms Working Current in Amp at 540 Kilocycles	Approximate Dimensions in Inches	
			A	C
2000	0.025	170	16 7/32	2 1/2
	0.030	204		
	0.034	230		
3000	0.0165	168	16 7/32	2 1/2
6000	0.0075	153	18 7/16	4 7/16
	0.01	204		
6600	0.009	202	18 7/16	4 7/16
9000	0.0029	88	18 7/16	4 7/16
	0.005	153		
	0.0056	171		

GENERAL ELECTRIC

DIGEST

Timely Highlights on G-E Components

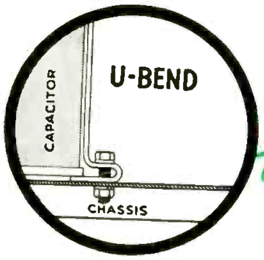
LIGHT-WEIGHT TRANSFORMERS *for tight spots*

When size and weight are important and weather resistance isn't, G-E core-and-coil transformers solve a lot of electronic-design problems. Uniform coils, automatically wound over the finest-grade core laminations, are of the same high quality and give the same reliable performance as G-E cased transformers.

Standard core and coil units include 60 types and ratings of plate transformers, 106 filament transformers, 34 plate-and-filament transformers, and 61 reactors. Ratings up to 50 kva (physical size) are wound on standard laminated cores; larger units can be built from special parts. Write for Bulletin GEA-4280.

Small ONLY IN *Size*

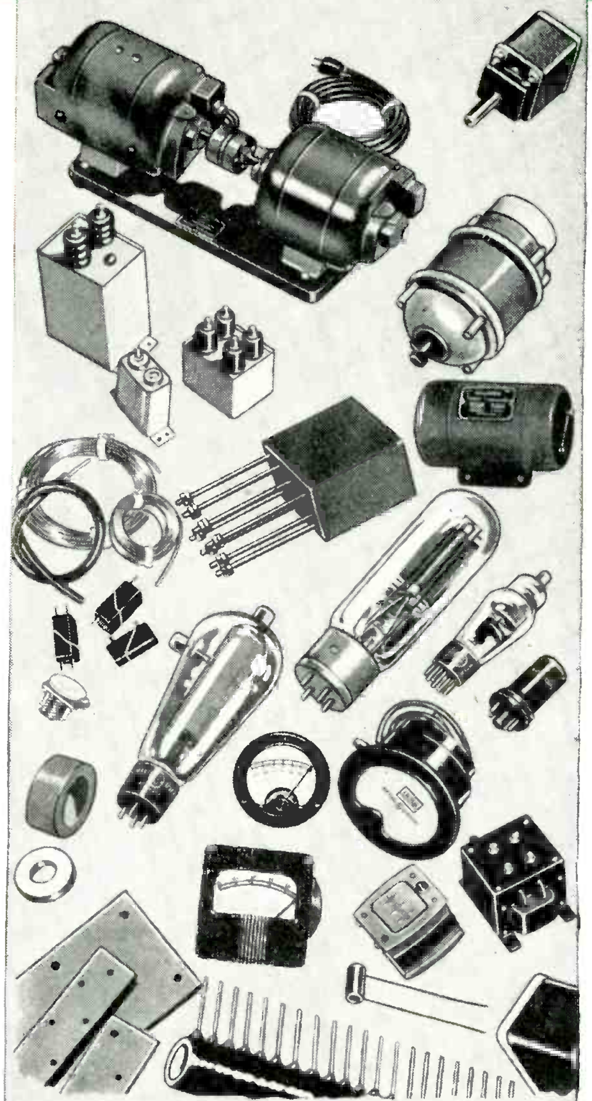
Inside these G-E small panel instruments are packed accuracy and reliability usually associated with larger G-E instruments. They have space-saving internal-pivot construction. They respond quickly. Accurate readings are easily made. The instrument weighs a mere 3 ounces and is just 1½ inches wide and less than 1 inch deep. Either watertight or conventional construction is available for direct-current, audio-frequency and radio frequency applications. Write for Bulletin GEA-4380.



BRACKETS *that hold their own*

A distinct advance in bracket design simplifies the mounting of rectangular-cased G-E capacitors. A U-bend replaces the conventional L-shape and provides a spring-washer effect for secure capacitor mounting. At the same time, it reduces strain on both capacitor and chassis, and compensates for tolerances in capacitor case heights.

For either base or inverted mounting, U-bend brackets are available for most G-E rectangular-case a-c and d-c capacitors. Write for Bulletin GEA-4357.



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***

General Electric Company
Apparatus Dept., Sec. 642-10
Schenectady 5, N. Y.

Please send me the bulletins checked:

........GEA-4365 ....GEA-4280
........GEA-4380 ....GEA-4357

NAME..

COMPANY..

ADDRESS..

CITY.. STATE..................

VARNISHED

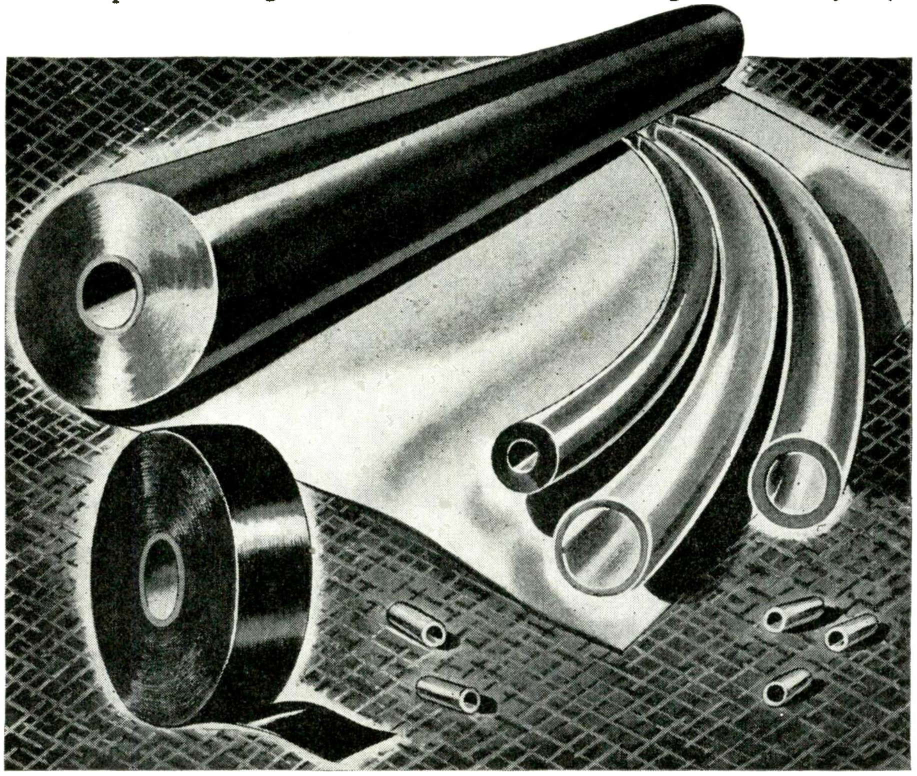
fiberglas *Insulations*

. . . that provide all the advantages of Fiberglas, *in fullest measure!*

It is the *varnish* and its proper application that endows Fiberglas insulation with that *extra* insulating protection.

To insure this *added increment* of protection, Irvington uses only carefully compounded insulating varnishes, scientifically applied to a Fiberglas base. In fact Irvington Fiberglas reflects the same exacting research and supervised production that has kept Irvington the leader in electrical insulation.

The varnished Fiberglas insulations you require in types, sizes and specifications, are all available at IRVINGTON. For samples, or full particulars, write Dept. 106, Irvington Varnish & Insulator Co., Irvington 11, New Jersey.



- CLOTH
- TUBINGS
- SLEEVINGS
- TAPE
- PUNCHINGS
- WIRE MARKERS
- SLOT

STANDARD OF THE WORLD IRVINGTON INSULATION TRADE MARK REG. U.S. PAT. OFF.

IRVINGTON VARNISH & INSULATOR COMPANY

IRVINGTON 11, NEW JERSEY

enough light for television pick-up

REVOLUTIONARY, NEW RCA "CAT'S EYE" CAMERA

- ✓ 100 times more sensitive than conventional television cameras. Provides greater depth of perception and clearer views under shifting light conditions.
- ✓ Wide sensitivity range provides unvarying transmission despite wide fluctuations of light and shadow (from the sunny to the shady end of a tennis court, for example).
- ✓ Lightweight, portable, easy to use, quickly set up. Telephoto lenses are easily applied.
- ✓ Improved stability which protects images from interference due to sudden bursts of light (such as exploding flash bulbs).

Picks up scenes in moonlight, in candlelight, and in any kind of weather

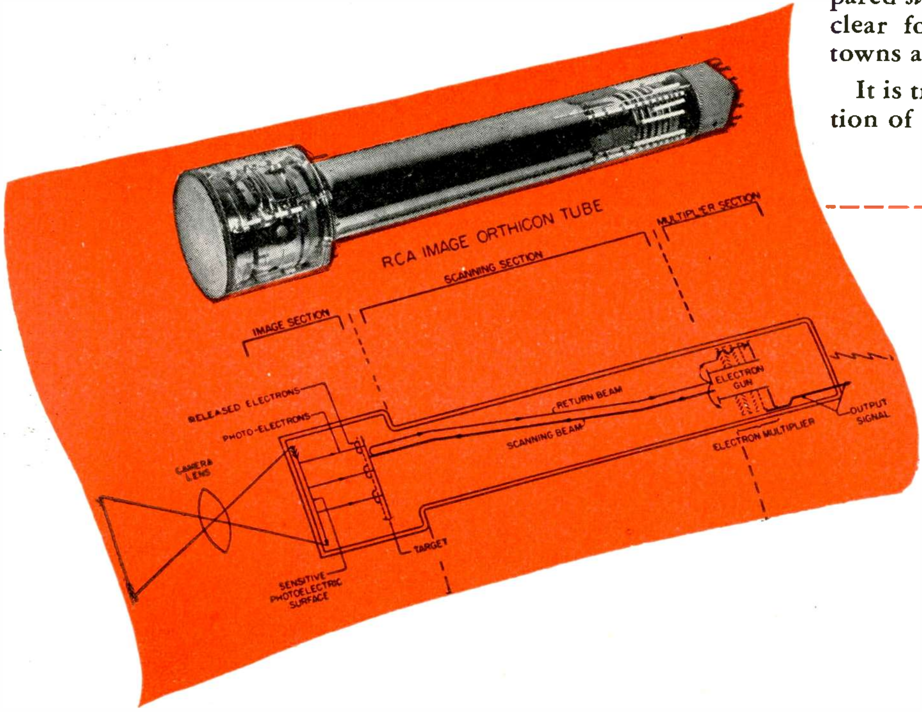
THIS television camera, utilizing RCA's amazing new electron tube—the image orthicon—opens up a wealth of new program opportunities.

Now, for the first time, round-the-clock television news coverage is possible—spot news and special events. It is now practical to televise football games, baseball games, ice hockey, boxing and other sports events, in any kind of weather, day or night. Remote indoor pick-up such as in theatres, concert halls, schools, churches, and courtrooms are other of its almost limitless application possibilities. Using infrared rays, it is even possible to pick up events in total darkness.

Equally significant are the lowered program production costs this camera makes possible. Many expensive-to-solve illumination problems are eliminated.

With such an increased source of programs, specially prepared *studio* programs can be greatly reduced. The way is now clear for practical television program production in small towns and cities.

It is truly the "Aladdin's lamp of television." Radio Corporation of America, Broadcast Equipment Section, Camden, N. J.



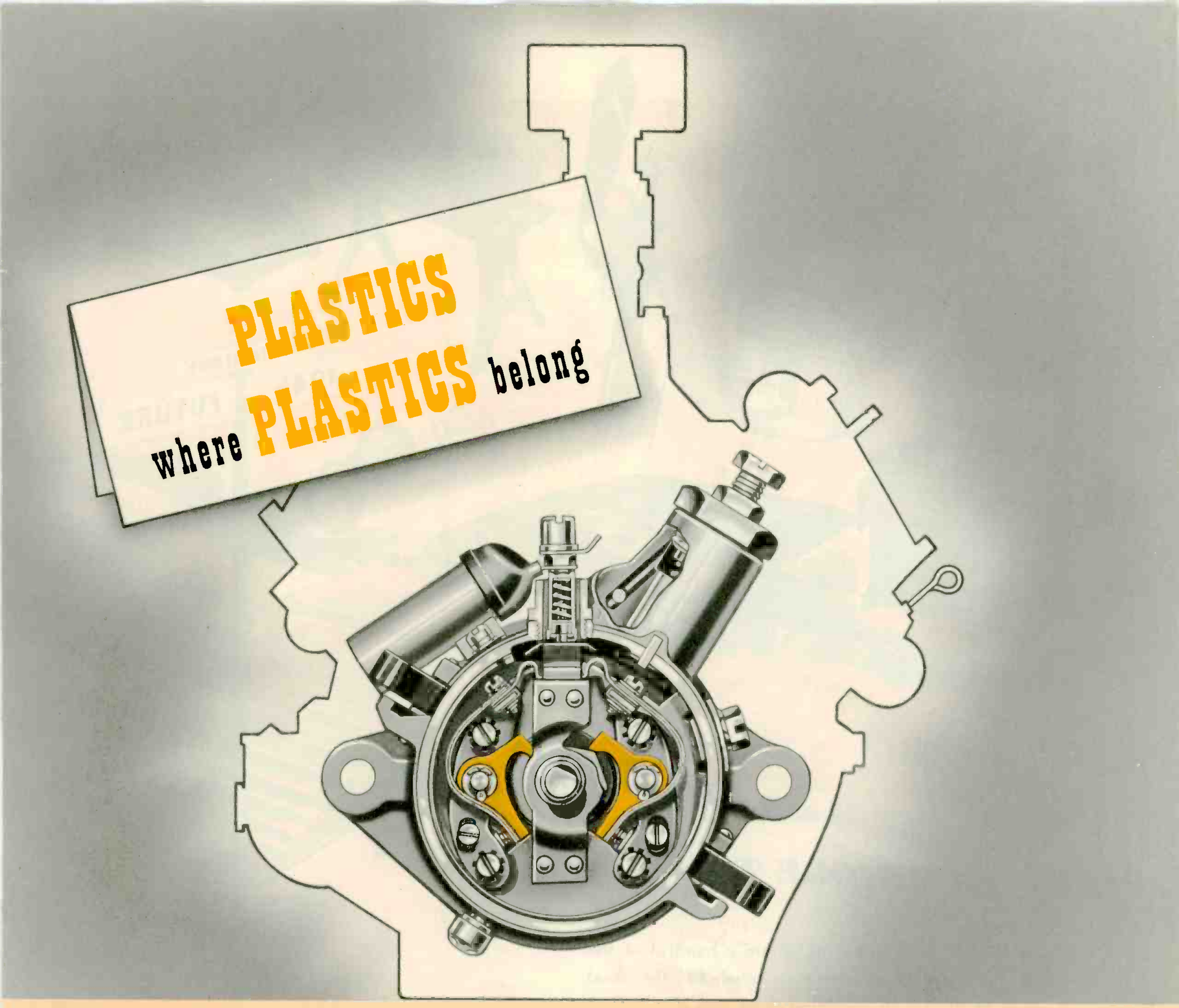
The new RCA image-orthicon tube—the "eye" of the camera. A light image from the subject (arrow at extreme left) is picked up by the camera lens and focused on the light-sensitive face of the tube, releasing electrons from each of thousands of tiny cells in proportion to the intensity of the light striking it. These electrons are directed on parallel courses from the back of the tube face to the target, from which each striking electron liberates several more, leaving a pattern of proportionate positive charges on the front of the target. When the back of the target is scanned by the beam from the electron gun in the base of the tube, enough electrons are deposited at each point to neutralize the positive charges, the rest of the beam returning, as indicated, to a series of "electron multiplier" stages or dynodes surrounding the electron gun, which multiply the signal many times. The output of the tube is further amplified in the camera pre-amplifiers and then carried to the television mixing circuits.

TELEVISION BROADCAST EQUIPMENT

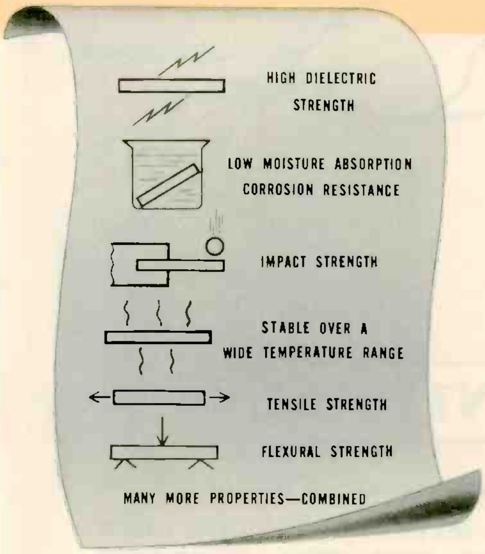
RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DIVISION, CAMDEN, N. J.

Federal 134 Transmitting Tube, 200 KW oscillator and amplifier; length, 34-3/8".



Using High Impact Fatigue Strength, Wear Resistance



THE BREAKER ARM is an important small part in any automotive ignition system. Synthane for this application is a good example of using plastics where plastics belong.

Synthane qualifies here because of its high resistance to impact fatigue, excellent wearing qualities, and insulating characteristics.

For these reasons, or possibly others, Synthane may be just what you need in your product. It's easy to find out, and almost always better to find out before you design.

Perhaps we can help you fit plastics into your job, and furnish you the necessary materials or the complete part ready to install. In any event, don't hesitate to call on us. And write for the complete Synthane catalog.

SYNTHANE CORPORATION • OAKS • PENNSYLVANIA

SYNTHANE
S

SYNTHANE TECHNICAL PLASTICS • DESIGN • MATERIALS • FABRICATION • SHEETS • RODS • TUBES • FABRICATED PARTS • MOLDED-LAMINATED • MOLDED-MACERATED

HOW TO BRIDGE THIS GAP QUICKLY

HERE, on the "banks" of '45 are a handful of the thousands of products stranded by the flood waters of the war in '41. All of them were applications making use of our type of plastics—Synthane. You are probably taking up where you left off or going into new lines of manufacture.

If you are a little rusty on the pre-war part Synthane might have played in your product, or need assistance in designing for the use of Synthane in new or improved products, send for our complete catalog, or ask for our help now.

SYNTHANE CORPORATION, OAKS, PENNA.

Gentlemen:

Please send me without obligation the complete catalog of Synthane technical plastics.

NAME ________________________

COMPANY ________________________

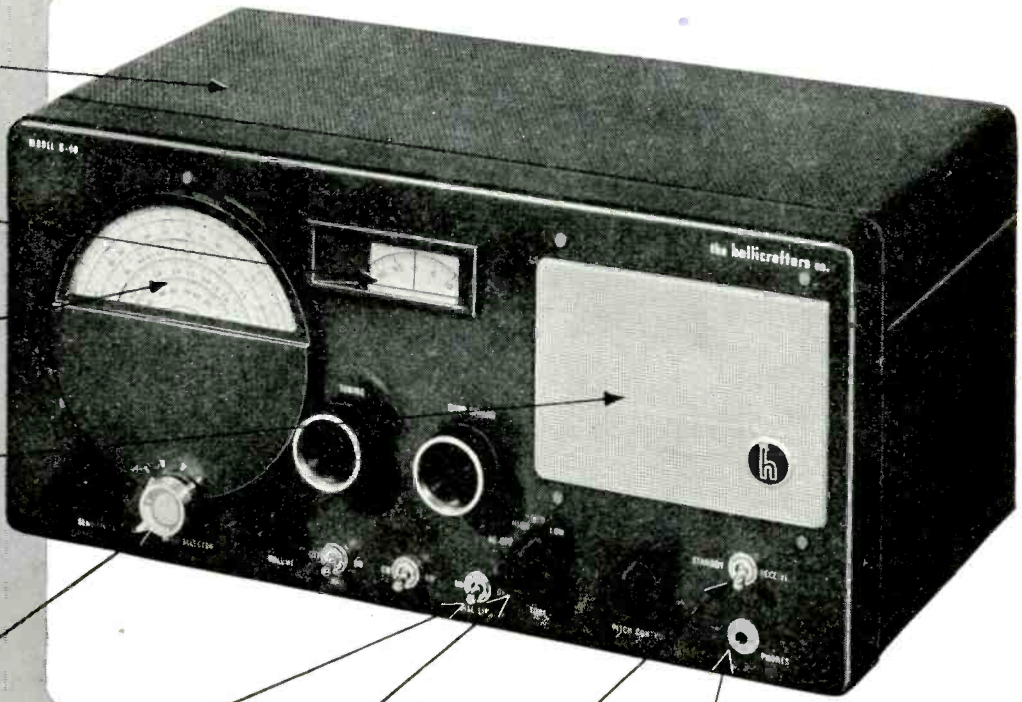
ADDRESS ________________________

CITY ____________ ZONE ______ STATE ______

Representatives in All Principal Cities

PLAN YOUR PRESENT AND FUTURE WITH SYNTHANE TECHNICAL PLASTICS • SHEETS
RODS • TUBES • FABRICATED PARTS • MOLDED-LAMINATED • MOLDED-MACERATED

hallicrafters *new Model* S-40



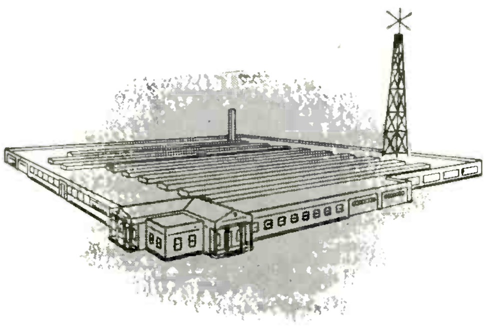
(APPROXIMATELY)

New design, *new* utility in a great *new* communications receiver . . . $79.50

Here is Hallicrafters new Model S-40. With this great communications receiver, handsomely designed, expertly engineered, Hallicrafters points the way to exciting new developments in amateur radio. Read those specifications . . . it's tailor-made for hams. Look at the sheer beauty of the S-40 . . . nothing like it to be seen in the communications field. Listen to the amazing performance . . . excels anything in its price class. See your local distributor about when you can get an S-40.

INSIDE STUFF: Beneath the sleek exterior of the S-40 is a beautifully engineered chassis. One stage of tuned radio frequency amplification, the S-40 uses a type 6SA7 tube as converter mixer for best signal to noise ratio. RF coils are of the permeability adjusted "micro-set" type identical with those used in the most expensive Hallicrafters receivers. The high frequency oscillator is temperature compensated for maximum stability.

From every angle the S-40 is an ideal receiver for all high frequency applications.

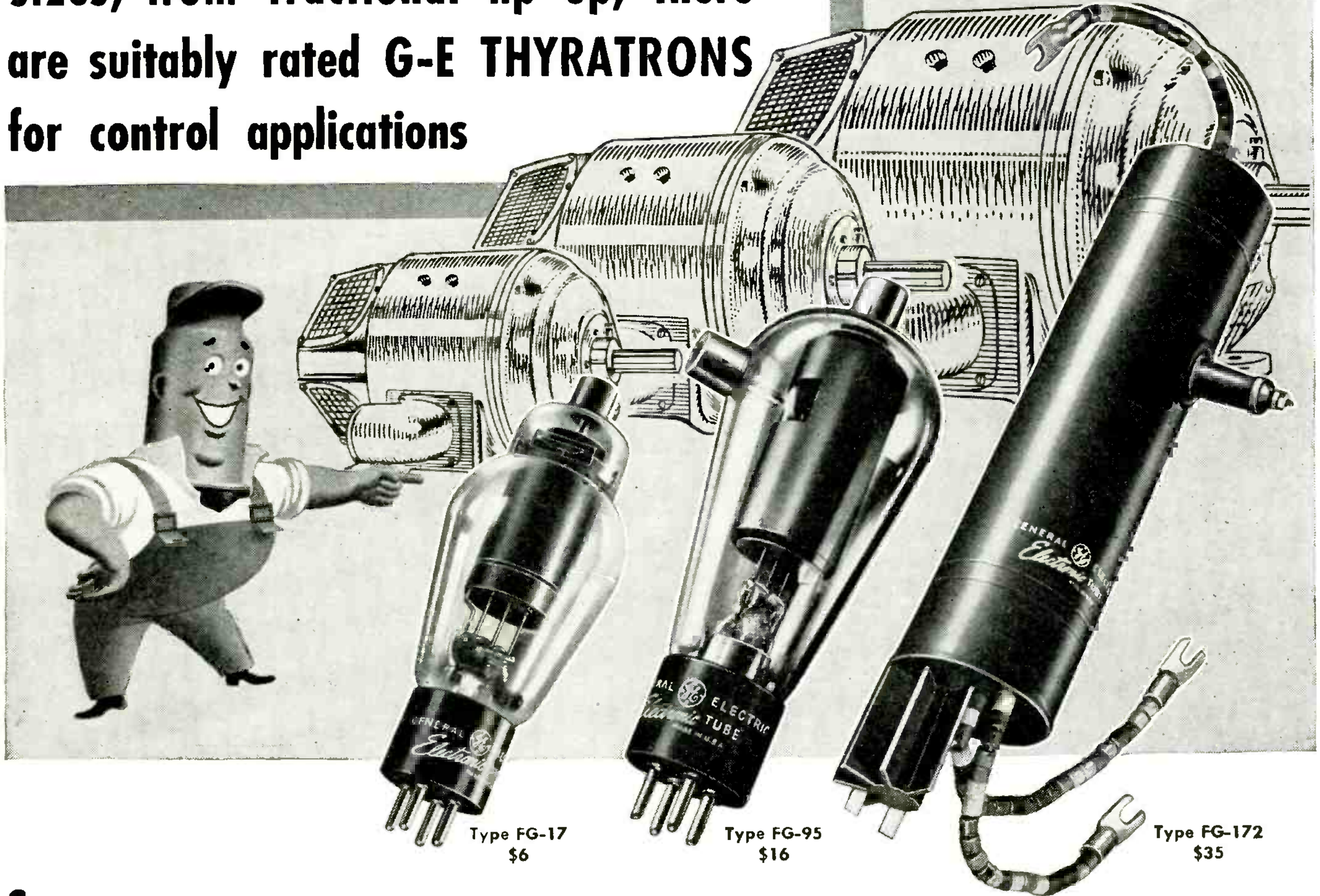


hallicrafters RADIO

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

Sole Hallicrafters Representatives in Canada: Rogers Majestic Limited, Toronto - Montreal

For motors of various sizes, from fractional hp up, there are suitably rated G-E THYRATRONS for control applications



Type FG-17
$6

Type FG-95
$16

Type FG-172
$35

Small, medium, or large, the electric motor whose control panel you may be designing, will take its orders from a G-E thyratron tube rated for precisely that size equipment.

Three of the more popular types in G.E.'s large thyratron group are shown above. Whatever your control tube need, General Electric can meet this need from its wide range of tested types developed through years of serving industry's electronic requirements.

G-E thyratrons in all sizes are available to the designer of apparatus not only for regulating motor speeds, but for controlling welders, lighting circuits, and other equipment where the fast, infallible action of electronic tubes is desired.

To help solve *your* problem of selection in this field, G-E tube engineers gladly will bring to bear a rich background of practical experience. Contact your nearest G-E office, or write:

Electronics Department
General Electric Company
Schenectady 5, N. Y.

TUBE RATINGS

RATING	FG-17	FG-95	FG-172
Cathode voltage	2.5 v	5 v	5 v
Cathode current	5 amp	4.5 amp	10 amp
Anode peak voltage, inverse	5,000 v	1,000 v	2,000 v
Anode peak current	2 amp	15 amp	40 amp
Anode avg current	0.5 amp	2.5 amp	6.4 amp
No. of electrodes	3	4	4
Envelope design	Glass	Glass	Metal

GENERAL ELECTRIC

162-E2-8850

TRANSMITTING, RECEIVING, INDUSTRIAL, SPECIAL PURPOSE TUBES • VACUUM SWITCHES AND CAPACITORS

Looms Large on the
CERAMIC Firmament

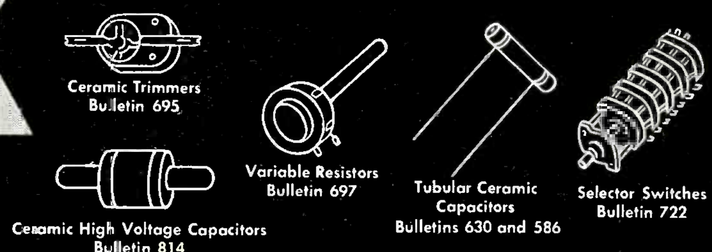
Your search for a "hard-as-diamond" versatile material ends when you discover the myriad possibilities of Steatite.

Let us tell you more about STEATITE . . . a material that may solve your production problems.

Centralab

Division of GLOBE-UNION INC., Milwaukee

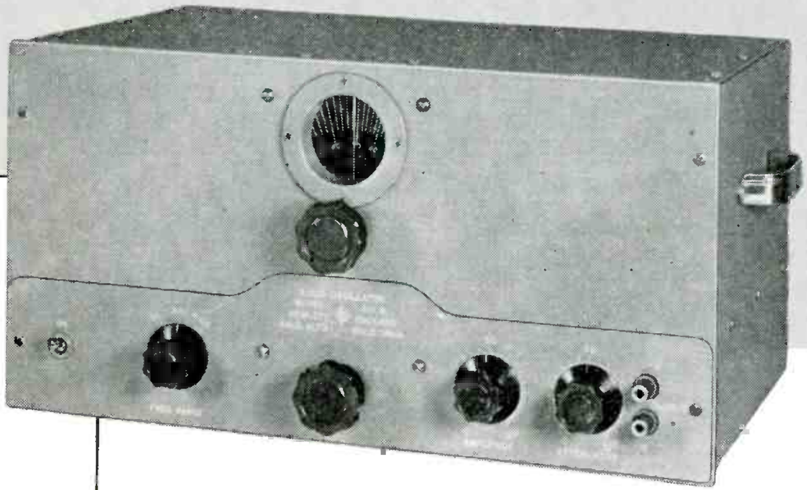
PRODUCERS OF



LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

A New -*hp*- AF Oscillator

MODEL 201B



OUTSTANDING NEW FEATURES

3 Watts Output

Distortion Less Than ½ of 1%

Low Hum Level

New Dial With Ball-Bearing Drive

Accurate Expanded Frequency Calibration

Improved Control of Output Level

In FM and other fields where high fidelity is important, this new -*hp*- Model 201B Audio Frequency Oscillator will meet every requirement for speed, ease of operation, accuracy and purity of wave form. The product of 6 years of -*hp*- oscillator development, this new oscillator has many brand new features, in addition to the revolutionary resistance-tuned circuit which has made -*hp*- a byword in engineering circles.

The 201B has an accurate, convenient method of frequency control. The 6" dial, with smooth ball-bearing action, may be tuned by a directly controlled knob, or for still greater accuracy, may be set by the vernier which has a ratio of 6 to 1 to the main dial. The illuminated main dial is designed so that parallax is eliminated. It is calibrated over 300 degrees with approximately 95 calibration points and has an effective scale length of about 47 inches. The frequency range is 20 cps to 20 kc.

The amplifier delivers up to 3 watts of power into a 600 ohm resistance load, with distortion held to 1%. Thus there is sufficient power available for driving almost any kind of laboratory or production equipment. Harmonic distortion may be kept to less than ½ of 1%, if the output of the amplifier is limited to 1 watt.

Another important feature of this oscillator is the provision which is made for standardizing each frequency range against a reliable standard, such as -*hp's*- Model 100B Secondary Frequency Standard. By standardizing the instrument regularly, frequencies can be depended upon to be better than 1% accurate.

A new departure in oscillator design is the dual method for controlling output level. A volume control which is ahead of the amplifier controls the voltage at which the amplifier operates. An output attenuator is provided to attenuate the signal delivered by the amplifier. Attenuation is approximately linear from zero to 40 DB. Both hum level and output voltage are thus attenuated together. As a result, hum level may be kept 60 DB or more below the signal level, a special advantage in cases where small test signals are used.

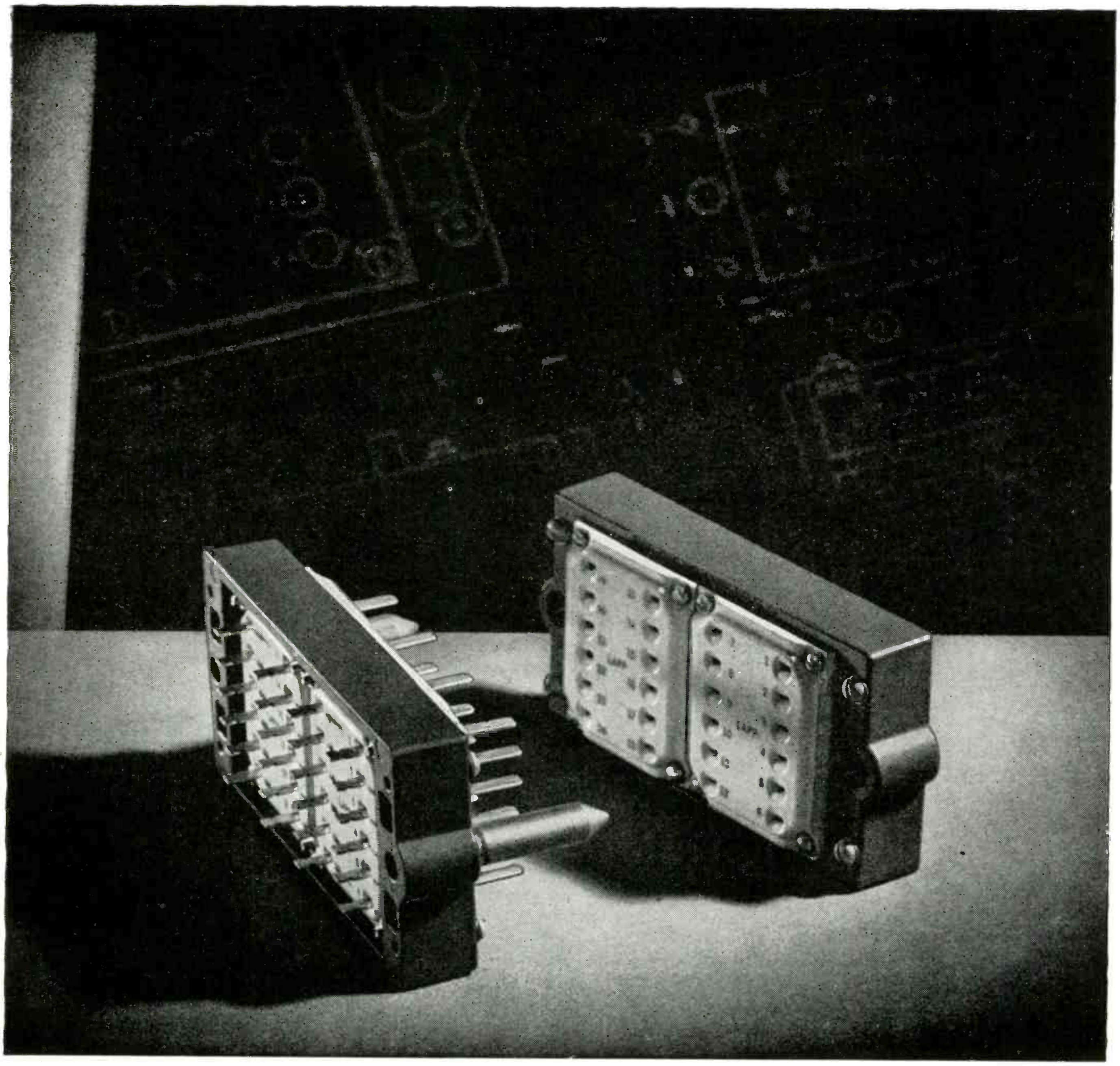
The impedance looking back into the out circuit is about 50 ohms; thus the voltage regulation for varying loads is extremely good. For measurements where it is desirable to have impedance looking back into the instrument of 600 ohms, as in transmission measurements, the attenuator may be used to give about 6 DB or more of attenuation, making the reflected impedance of the instrument about 600 ohms.

Care has been taken to perfect every detail of this new oscillator. Improved chassis layout and placement of component parts minimizes thermal drift. The voltage on the oscillator is maintained constant with an electronic voltage regulator. The entire instrument is characterized by greater mechanical rigidity; the tuning assembly is mounted on a sturdy cast aluminum frame. The chassis itself is made of aluminum; the oscillator is light in weight and easy to handle. Write today for latest data, prices and delivery information on this versatile, accurate resistance-tuned oscillator.

HEWLETT-PACKARD COMPANY

BOX 1158A · STATION A · PALO ALTO, CALIFORNIA

Audio Frequency Oscillators · *Signal Generators* · *Vacuum Tube Voltmeters* · *Noise and Distortion Analyzers* · *Wave Analyzers* · *Frequency Meters* · *Square Wave Generators* · *Frequency Standards* · *Attenuators* · *Electronic Tachometers*



An Electronic Part ... ENGINEERED TO A SPECIFIC NEED

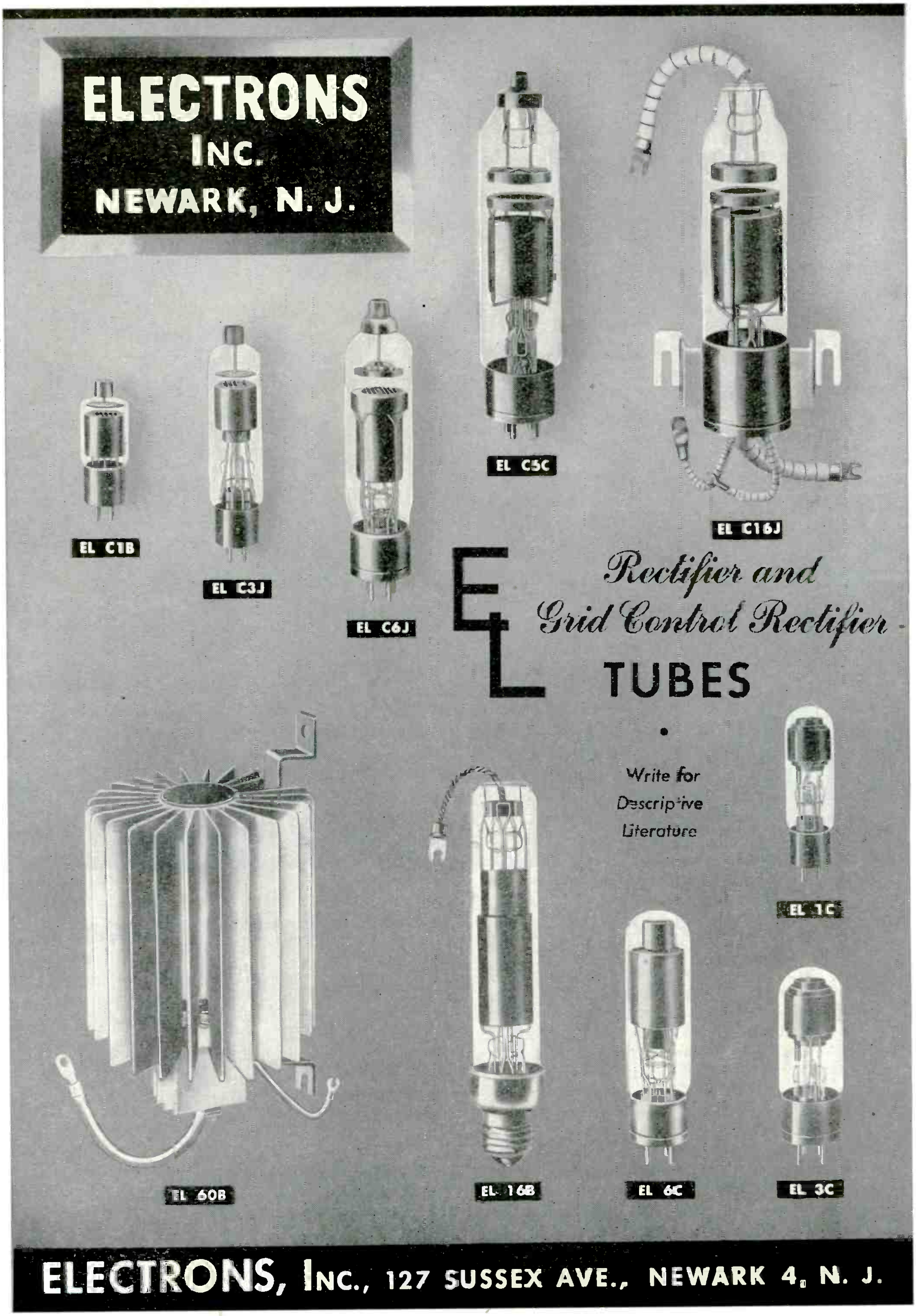
This is a special-purpose electronic part. It is a plug-receptacle assembly for use with rack-panel type of mounting. Twenty-four silver-plated phospher-bronze contacts are provided, each male and female contact full floating between steatite plates. Heavy guide pins and matching holes in the frame assure perfect alignment.

We don't know that your product has any need for such a part as this. We do know, however, that this part is most exactly suited to its special requirement just as are hundreds upon hundreds of other parts which have been created through Lapp engineering and Lapp production facilities directed to the solution of specific problems.

With a broad basic knowledge of ceramics—their capabilities and their limitations—Lapp has been able to simplify and to improve many types of electronic equipment through engineering and production of sub-assemblies that make most efficient use of porcelain or steatite and associated metal parts.

There may be a way you can improve performance, cut costs and cut production time through use of Lapp-designed and Lapp-built sub-assemblies. We'd like to discuss your specific requirements with you. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp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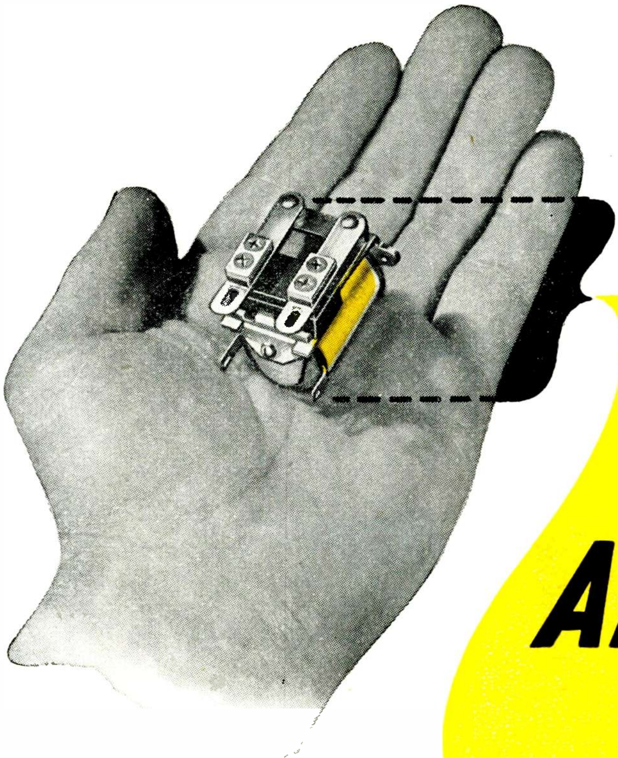


Save Space in your controls! use Allied's "CR" Relays

The "CR" relay illustrated is a single pole normally open double break arrangement. Standard insulation is molded bakelite. Contacts are silver, although alloy contacts can be supplied. Contact rating with ¼" silver is 15 amperes at 24 volts D. C. or 110 volts A. C. Non-inductive. The arrangement shown is 1 33/64" high; 1 3/32" wide and 1 25/32" long. Weight 3 ounces.

Remarkably small for a power relay the "CR" developed by Allied will enable you to materially reduce the size and weight of your electronic controls.

Having large contacts and heavy gram pressure the "CR" performs switching operations which usually require considerably larger relays. Highly adaptable the "CR" has two, three and four pole variations. Conveniently located contact and coil terminals permit speedy and simple assembly of the relay into your unit. For severe dust and dirt conditions the "CR" can be hermetically sealed with the handy plug-in base or with solder terminals.

The "CR" is but one of many types of relays produced by Allied to the high quality standards demanded by your product. Several modern, strategically located plants are available to furnish your immediate requirements. A check with Allied engineers will help you in the selection of the correct relay for your control. Write today.

Allied Relay Types

Power, Sensitive, Telephone, Differential and others.

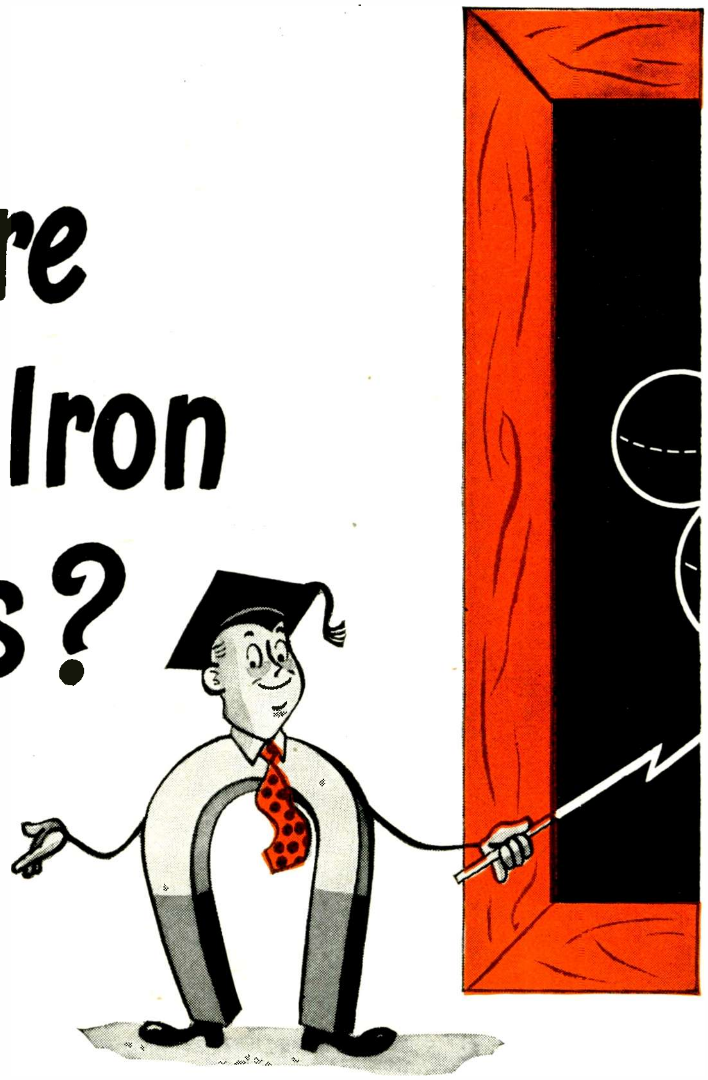
Also—Solenoids and Electro-magnetic devices.

ALLIED CONTROL COMPANY, INC.

GENERAL OFFICES: 2 East End Ave. (at 79th St.) New York 21, N. Y. *Factories:* New York City (2 East End Ave.)—Plantsville, Conn. *Chicago*—4321 N. Knox Avenue, Chicago 41, Illinois. *In California:* Allied Control Co. of California, Inc., 1633 South Hope St., Los Angeles 15, Calif.

AC-1

What are Carbonyl Iron Powders?



ABOVE you see the fundamental characteristics found only in G.A.F. Carbonyl Iron Powders. The text below outlines kinds of powders, chemical and physical analysis, including "Q" value, and suggested uses.

G.A.F. Carbonyl Iron Powders are obtained by thermal decomposition of iron penta-carbonyl. There are five different grades in production, which are designated as "L," "C," "E," "TH," and "SF" Powder.

The particles making up the powders "E," "TH," and "SF" are spherical with a characteristic structure of increasingly larger shells. The particles of "L" and "C" are made up of homogenous spheres and agglomerates.

The chemical analysis, the weight-average particle size, the "tap density," and the apparent density as determined in a Scott Volumeter are given in the following table for the five different grades:

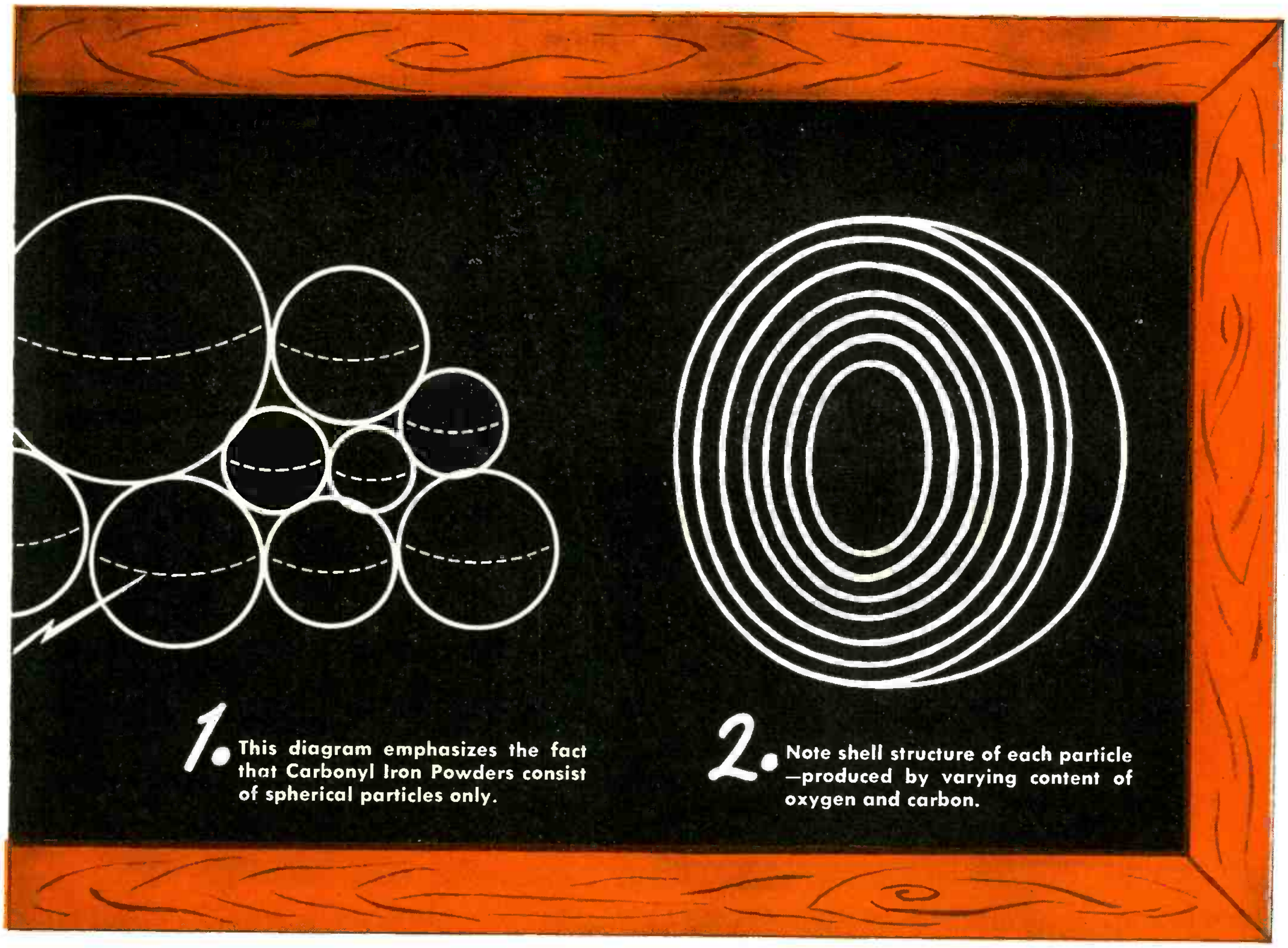
TABLE 1

Grade	Chemical Analysis % Carbon	% Oxygen	% Nitrogen	Wt. Ave. diameter microns	Tap Density g/cm3	Apparent Density g/cm3
L	0.005–0.03	0.1 –0.2	0.005–0.05	20	3.5–4.0	1.8–3.0
C	0.03 –0.12	0.1 –0.3	0.01 –0.1	10	4.4–4.7	2.5–3.0
E	0.65 –0.80	0.45–0.60	0.6 –0.7	8	4.4–4.7	2.5–3.5
TH	0.5 –0.6	0.6 –0.7	0.5 –0.6	5	4.4–4.7	2.5–3.5
SF	0.5 –0.6	0.7 –0.8	0.5 –0.6	3	4.7–4.8	2.5–3.5

With reference to the chemical analysis shown above, it should be noted that spectroscopic analysis shows the rest to be iron with other elements present in traces only.

Carbonyl Iron Powders are primarily useful as electromagnetic material over the entire communication frequency spectrum.

Table 2 at right gives relative Q values (quality factors) and effective permeabilities for the different grades



1. This diagram emphasizes the fact that Carbonyl Iron Powders consist of spherical particles only.

2. Note shell structure of each particle —produced by varying content of oxygen and carbon.

of carbonyl iron powder. The values given in the table are derived from measurements on straight cylindrical cores placed in simple solenoidal coils. Although the data were not obtained at optimum conditions, the Q values as expressed in percentage of the best core give an indication of the useful frequency ranges for the different powder grades.

TABLE 2

Carbonyl Iron Grade	Effective Permeability at 1 kc	Relative Quality Factor at 10 kc	150 kc	200 kc	1 Mc	100 Mc
L	4.16	100	96	90	43	1
C	3.65	94	100	98	72	3
E	3.09	81	94	100	97	30
TH	2.97	81	93	98	100	54
SF	2.17	62	71	78	84	100

(Note: The actually measured Q values can be obtained by multiplying the rows respectively with: 0.78, 1.09, 1.25, 2.63, and 1.62.)

"L" and "C" powders are also used as powder metallurgical material because of their low sintering temperatures, high tensile strengths, and other very desirable qualities. (Sintering begins below 500°C and tensile strengths reach 150,000 psi.)

Further information can be obtained from the Special Products Sales Dept., General Aniline and Film Corporation, 270 Park Ave., New York 17, N. Y.

G.A.F. CARBONYL IRON POWDERS

His key unlocked the door to progress

Ben Franklin found electricity in the sky by flying a key on a kite. Long before the world ever heard of Ohm, Volta and Faraday, he laid the foundation for modern electrical research. His key helped unlock the secret of electricity which later led to the science of electronics.

Today the key to better television reception has also been found in the improved face plates that the United States Navy used for Radar. These were supplied by our compact group of specialists after the two largest face plate contractors for the Navy said that the highest practical degree of accuracy had been met. We disagreed and set new, high standards which we maintained on a volume basis.

Since then we have done experimental and development work for practically every large manufacturer of television sets in this country. We have proved again and again that good reception in television depends primarily upon the quality of the face plate on the cathode ray tube.

You will find us ready to cooperate on all problems that involve precision optics. We have always worked exclusively for other manufacturers and make only optical components.

Our plant is equipped with the most modern machinery and staffed with workers who are especially trained to maintain production with precision and quality with economy. Every job we do is "custom-made".

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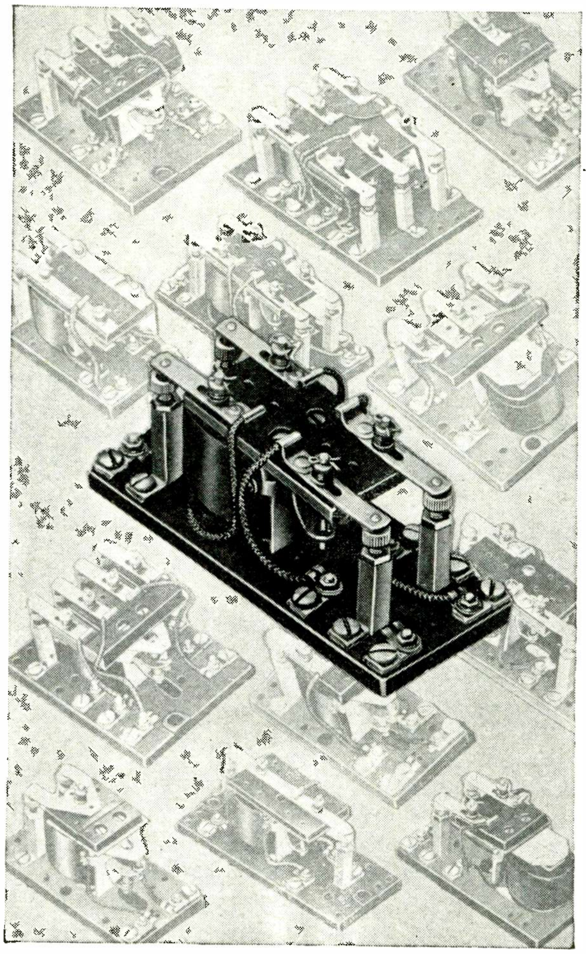


BULLETIN 130 RELAYS

To serve the Electrical and Electronic Industries Ward Leonard has developed a relay capable of service in the widest possible variety of applications.

By designing a basic relay it was possible to produce a unit employing many interchangeable parts. With interchangeable components the broadest range of requirements as to voltages, currents and contact arrangements can be met.

By employing modern production methods embodying standardization of relay parts the greatest flexibility of individual relay assemblies of highest quality is provided. This standardization system, along with quantity production, fully assures the user of a better, more economical relay, utilizing the most modern features of relay design.

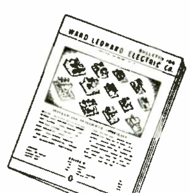
The Bulletin 130 relays offer the user the choice of one to four poles, 6 to 230 volts D. C. and 6 to 440 volts A. C. in single or double throw, normally open or closed, with or without blowout coils and a host of other options. With such flexibility of arrangement, custom requirements can be met without prohibitive cost or undue delay in delivery.

WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control devices since 1892

Send for Bulletin No. 130 giving full particulars of this line of Relays. In it you will find relays that exactly meet your requirements.



WARD LEONARD ELECTRIC COMPANY 32 SOUTH STREET • MOUNT VERNON, N. Y.

OFFICES IN PRINCIPAL CITIES

JUST by the simple expedient of putting a ruler to a recording disc, you can, in one sense, "measure" recording quality.

The disc must reflect a *true* image. Any imperfection in the reflection means that you can expect corresponding imperfection in recording characteristics. That's just A-B-C.

But a *better* recording disc must possess many other in-built qualities in addition to a flat, smooth, mirror-like surface:

For recording, it must have (a) split-hair accuracy in thickness of coating (b) easy cutting characteristics (c) positive thread-throw with no annoying static and (d) these qualities must not change — *regardless of the age of the disc.*

For playback, it must have (a) brilliant high frequency response (b) no audible background scratch, even after many playings (c) no increase in surface noise from the time of recording to playback or processing.

— *And finally,* these qualities must last as long as the recording is needed. *There must be no deterioration with the years.*

* * *

You cannot discover these qualities in a recording disc, by any yardstick we know of — except one:

Just look for the name Audiodisc — because it assures you all the qualities named above — a combination you will not find in any other recording disc.

Audiodiscs are manufactured by a patented, precision-machine process which is *uniquely* theirs, and the *Audiodisc* recording lacquer is produced from a formula developed by our research engineers. Thus, *Audiodisc* quality is consistently dependable. It is fully controlled—straight through from raw materials to finished disc.

There is an *Audiodisc* designed and priced for every recording need. No matter what the purpose, the name *Audiodisc* is, and will remain, the measure of a *better* recording disc.

AUDIO DEVICES, INC., **444 Madison Avenue, New York 22, N. Y.**

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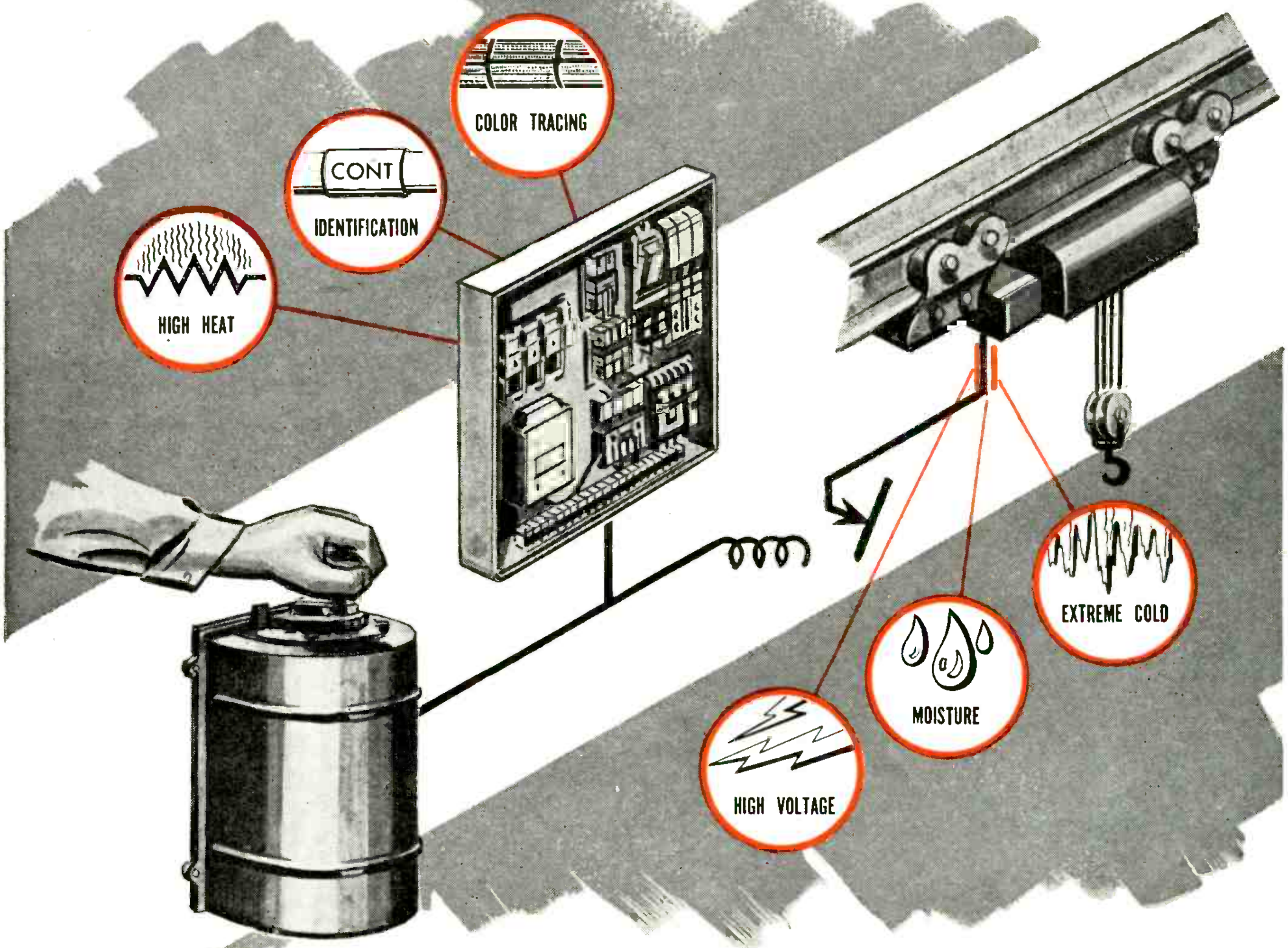
turbo INSULATIONS



..provide simple solutions to intricate problems!

Control circuits—the nerve centers of modern industrial equipment—are critical in demands on dependability. TURBO insulations—diversified in characteristics—meet these exacting requirements. In both protected or exposed locations they provide a type of insulation—safety factor engineered—to preclude operating impairment resulting from insulation breakdown. To further economy, they are supplied in a full range of vivid colors that simplify maintenance and speed repair.

FLEXIBLE VARNISHED OIL TUBING: offers immunity to corrosive fumes, acid, alkalis and most solvents. It is impervious to moisture and non-hygroscopic.

VARNISHED GLASS TUBING: capable of functioning in high ambient temperatures—enclosed motors, unventilated areas, and general heavy duty installations.

EXTRUDED TUBINGS: smooth wall, withstand extreme low temperature without embrittlement. Provide dependable insulation in sub-zero cold. Retains flexibility at all times.

WIRE IDENTIFICATION MARKERS: two types—sleeve type that slips directly over pipes, tubes, conductors; and tab type with flexible flag attached to sleeve. Both available in any marking.

Write today for free Specimen Board with samples and sizes of each.

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on your Oscillograph Screen with the

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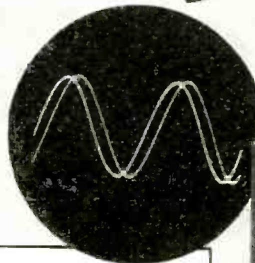
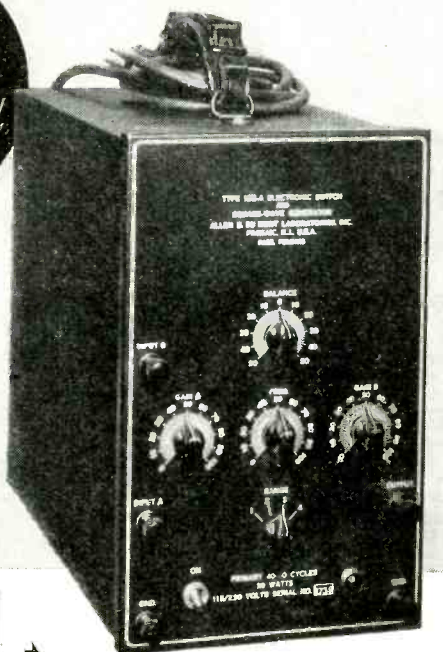
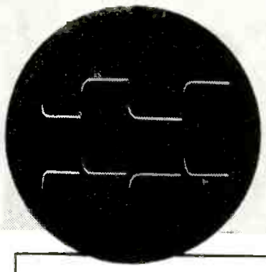


Phase shift introduced through an R-C network.



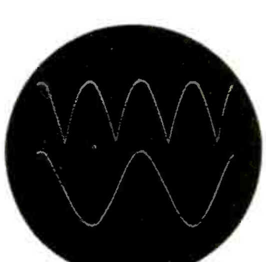


Square-wave input (top) to differentiator network, showing differentiated output (below).

The utility of any oscillograph can be greatly increased by operating it in combination with a Du Mont Type 185-A Electronic Switch!

Imagine the convenience and the time saved in being able to view simultaneously TWO or MORE related signals and readily compare them for amplitude, waveform, and frequency or phase relationship. Sound, light, heat, mechanical motion—in fact, any quantity which may be translated into an electrical function may easily be compared with a standard signal. A balance control makes it also possible to separate or superimpose the signals at will. By operating two Du Mont Type 185-A Switches in cascade, three independent channels are provided for the study of signals from three different sources . . . all THREE signals appearing AT ONE TIME on the SINGLE SCREEN of the cathode-ray oscillograph.

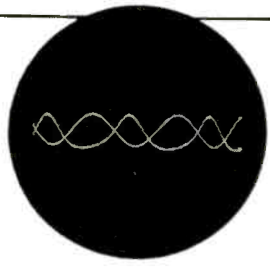
This versatile but inexpensive Du Mont instrument may also be used as a square-wave generator with an output range of from 5 to 500 cycles . . . suitable for many uses including the testing of audio amplifiers.

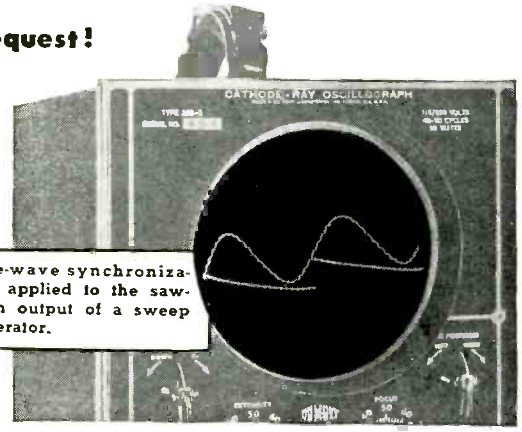


Sine-wave input (bottom) to full-wave rectifier showing rectified output (top).

Descriptive literature on request!

Comparison of input and output of phase inverter. Distortion in phase inverter is evident.





Sine-wave synchronization applied to the sawtooth output of a sweep generator.

Du MONT "Cathode-Ray Headquarters" also offers oscillographs and cathode-ray tubes in a wide range of types and sizes to meet all requirements. Ask for information.

DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

avoid damage from "in-the-package" moisture

no rust
no corrosion
in this container

The illustration shows Mr. Otto Mueller, packaging foreman, inspecting one of his Ampro Saund-On-Film Projectors sealed tightly within a representative moisture vapor-proof barrier, ready to be placed in a shipping carton. Packed within the barrier, with the Projector, are three small bags of Jay Cee Silica Gel . . . which adsorb "in-the-package" moisture and prevent damage from rust or corrosion.

(Cellophane packaging was used in this illustration as a substitute for the actual wrapping).

SHIPPERS! Your product can be seriously damaged by rust, corrosion, or mildew . . . because of "in-the-package" moisture. Avoid such damage. Include Jay Cee Silica Gel, the ideal drying agent, in the packages with your product.

Your container may be sealed "tight as a drum" against outside moisture. Yet, the vapor within can cause untold harm. Particularly, a slight drop in temperature can release dangerous moisture.

Jay Cee Silica Gel keeps the air in the package dry . . . adsorbs the vapor . . . prevents moisture damage. Jay Cee Silica Gel is a crystalline substance resembling rock salt in general appearance . . . chemically inert. Has amazing power to take up moisture without its particles changing in size or shape. Packed in 1, 2, 4, 8 oz. and 1 and 5 lb. bags. Used widely with shipments of metal parts, precision instruments, electronic equipment, dehydrated foods, fabrics, and chemicals.

JAY CEE SILICA GEL

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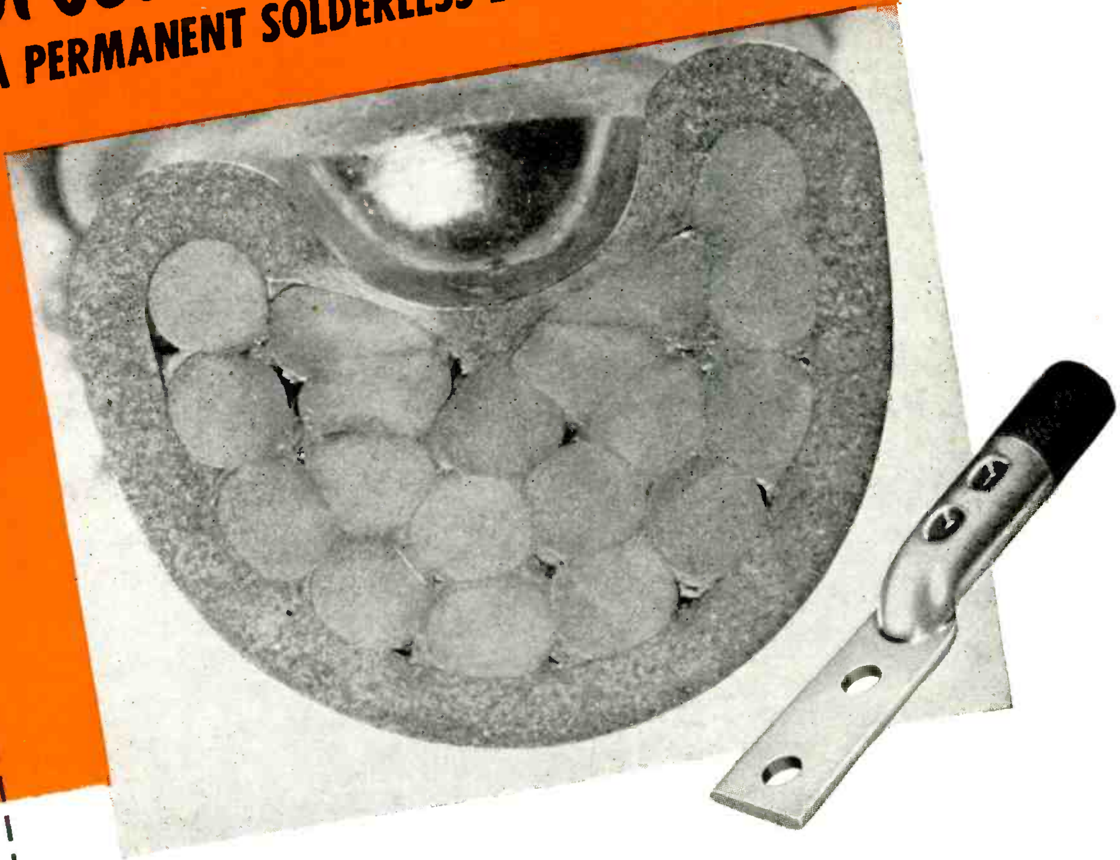
Cross Section
OF A PERMANENT SOLDERLESS ELECTRICAL CONNECTION



made the Burndy Indent way

THIS enlarged cross section clearly shows why a Burndy HYDENT connection is a *permanent* and *trouble-free* connection. The one-piece pure-copper Hylug, and the cable, have been permanently "compressed" into virtually one solid conductor by simple, quick indenting with a Burndy HYTOOL. This indent way is a big time-saver, too, for one operator can indent up to 1000 small-wire connections per hour.

HYDENT connectors are available as lugs, links, tees and taps, for conductor sizes from #22 to 2000 Mcm. HYTOOLS and HYPRESSES for indenting are available for every need. WRITE FOR THE HYDENT CATALOG. Burndy Engineering Co., Inc., 107-J Bruckner Blvd., New York 54, N. Y.

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HIGHER POWER:
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Where Mobility Must Be Considered

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1400 WATTS OUTPUT
COMPACT
RUGGED
ECONOMICAL
RELIABLE

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THE 833-A is one of the largest radiation-cooled triodes. Under CCS rating it will take an input of 1250 watts for plate modulated service at a frequency as high as 20 megacycles with forced air cooling.

The 833-A may be used at 1250 watts input for industrial heating at 30 megacycles without forced air cooling.

Note the very ample zirconium coated plate, giving long life at reduced plate temperatures.

A heavy duty 100 watt filament in the 833-A provides ample reserve emission for long life and heavy duty service. Filament shielding has been introduced to prevent bulb deterioration and reduce input circuit demands.

Large rugged post terminals on all leads through the glass envelope make the 833-A a solution for circuits where very high circulating currents are present. In our factory an electronic glass sealing machine that joins these heavy post terminals to the glass envelope is powered by two 833-A's

Catalog Sheets and Tubes are now Available

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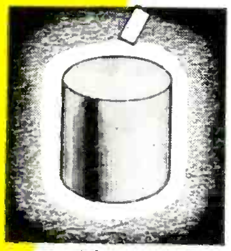
True High Fidelity, long-lasting and trouble-free, is built into the design, construction and materials of every Aireon Cinaudagraph Speaker. The result of exacting research and precision workmanship, the Aireon Cinaudagraph Speaker incorporates many electronic and acoustical developments for stamina and tone. The design of the special polyfibrous cones . . . the Acim voice-coil form, impervious to moisture or temperature variations . . . the use of Alnico 5 "the miracle metal" in the magnet structures . . . ribbon wire voice coils . . . are only a few of the plus factors which give Aireon Cinaudagraph Speakers the more efficient performance you require.



Alnico 5

All P.M. Models of Aireon Cinaudagraph Speakers use Alnico 5, the miracle metal that gives you 4 times the performance without size or weight increase.

Cinaudagraph Speakers, Inc.

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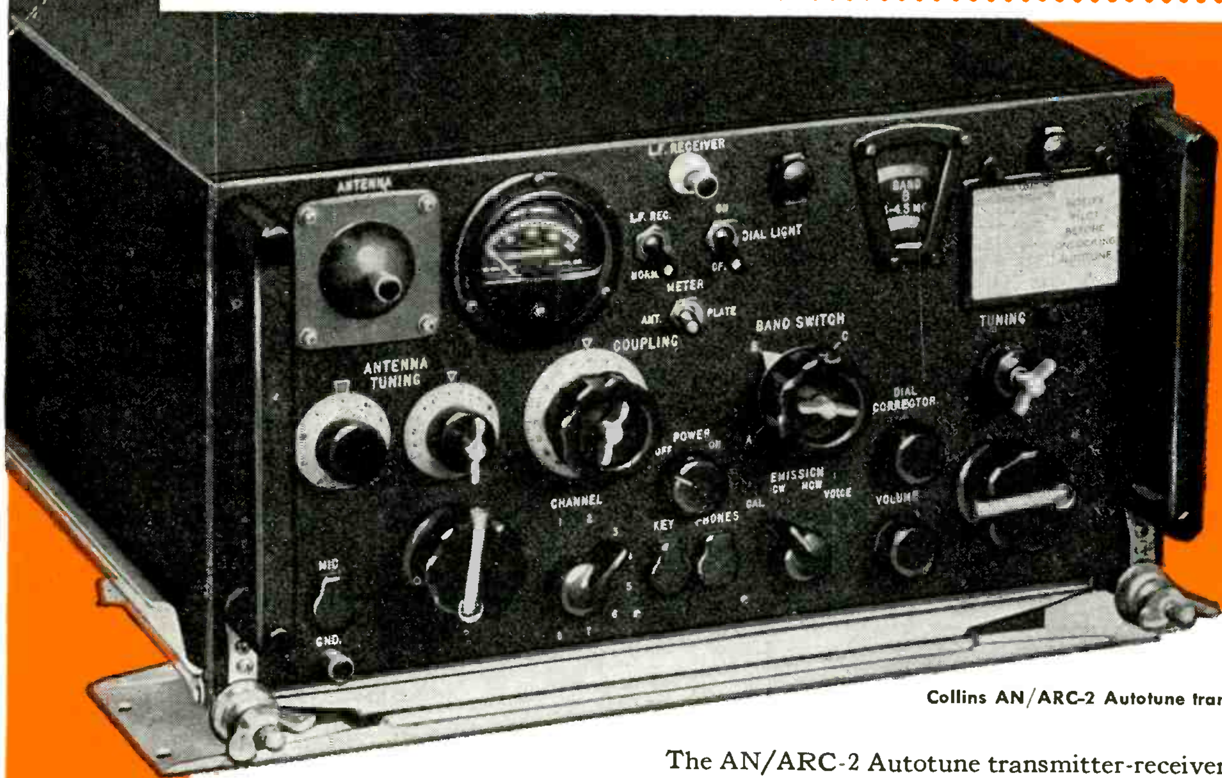
A rugged performer with a big voice and keen ear!



Collins AN/ARC-2 Autotune transmitter-receiver

Remote Control Box

The AN/ARC-2 Autotune transmitter-receiver was designed and is built by Collins for two place and larger military aircraft. It is an example of the experience, design ingenuity and manufacturing skill also available, in the Collins organization, to commercial users of communication equipment.

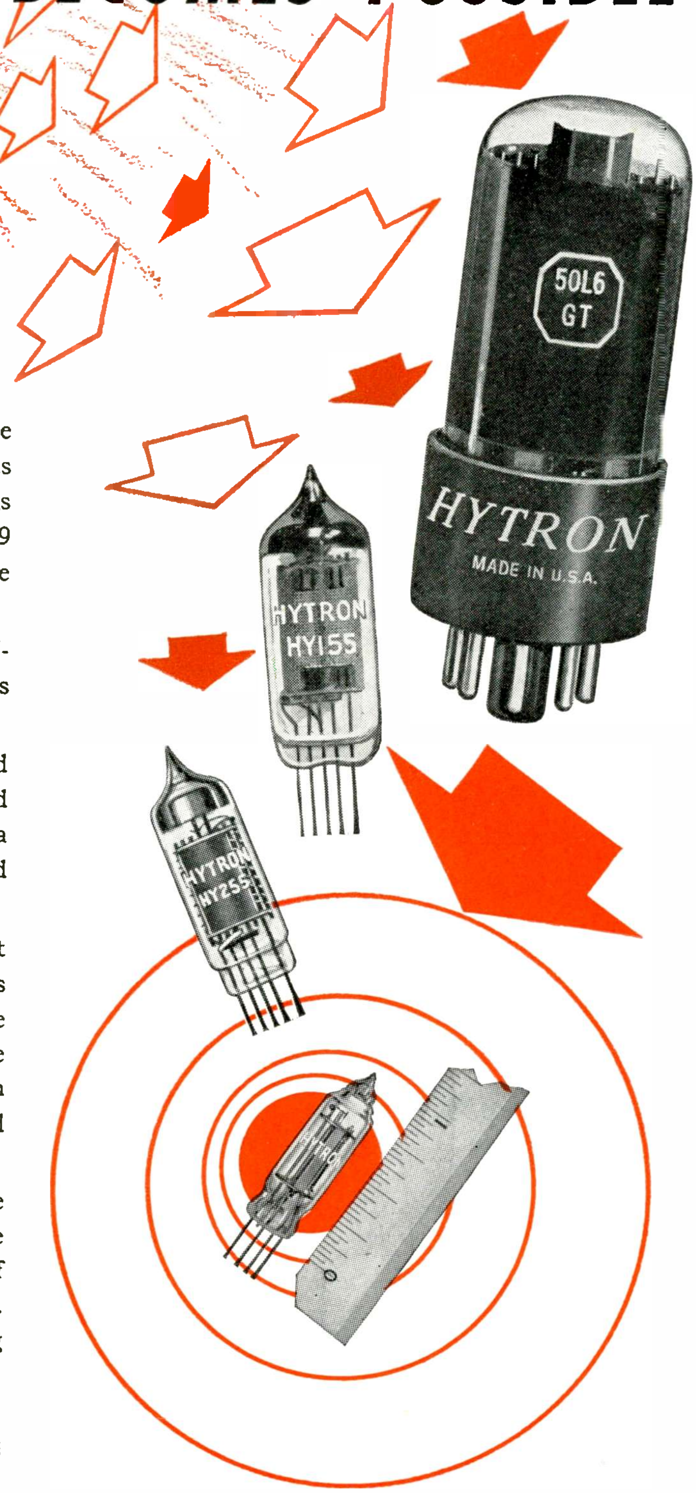
Transmitter, receiver and dynamotor are all contained in the same case. The weight and space requirement of the AN/ARC-2 is considerably less than that of the equipment it replaces. Any one of eight pretuned channels is immediately and automatically available by means of the Collins Autotune, operated either at the main panel or by remote control. The transmitter and receiver operate on the same frequency and are tuned simultaneously by a single set of controls.

This equipment, including its Autotune mechanism, functions reliably at all temperatures from $-58°$ to $+140°$ F, all altitudes from sea level to 40,000 feet, and all conditions of humidity up to saturation.

The Collins organization specializes in fulfilling exacting requirements. We will welcome an opportunity to make recommendations regarding your needs in the field of radio communication equipment. Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y.

IN RADIO COMMUNICATIONS, IT'S . . . COLLINS

OVER AND OVER AGAIN
THE IMPOSSIBLE BECOMES POSSIBLE



Over and over again, Hytron has licked the problem of making smaller and smaller radio tubes. Its BANTAM GT, which other tube engineers said was impossible, telescoped glass receiving tubes to the T-9 bulb (bantam and loktal), and has since become the most popular receiving tube.

Next Hytron sweated out development of the BANTAM JR.—the first subminiature. The HY155 was soon superseded by the even tinier HY255.

It was only natural that the Navy and OSRD should turn to Hytron in 1940, to design diminutive, rugged tubes for the VT or variable time fuse. Fired from a gun, such tubes, despite their size, must withstand 20,000 G's and 475 rps.

Months of research at Hytron resulted in the smallest tube which has ever been mass-produced. The tube's internal cubic volume is approximately half that of the smallest competitive tube. Again new horizons were explored by Hytron. New techniques and production equipment solved fabrication, assembly, glass, and exhaust problems.

The same skills which created the BANTAM GT, the BANTAM JR., and the smallest VT-fuse subminiature are now concentrated primarily on production of Hytron GT's and T-5½ miniatures for home receivers. You can count, however, on Hytron's continuing leadership in vacuum tube development.

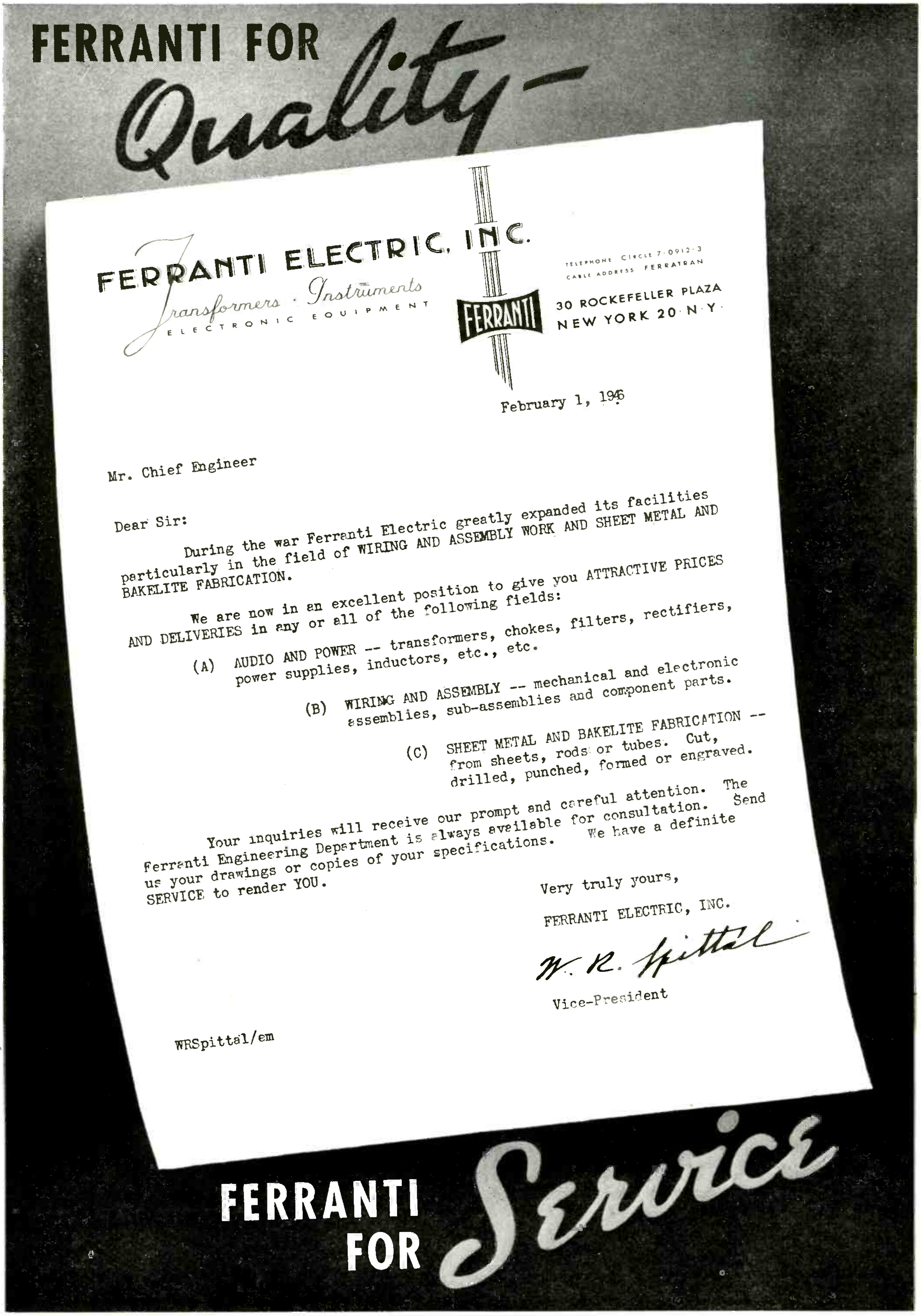
ALL TUBES ACTUAL SIZE

OLDEST MANUFACTURER SPECIALIZING IN RADIO RECEIVING TUBES

HYTRON

RADIO AND ELECTRONICS CORP.

MAIN OFFICE: SALEM, MASSACHUSETTS



February 1, 1946

Mr. Chief Engineer

Dear Sir:

During the war Ferranti Electric greatly expanded its facilities particularly in the field of WIRING AND ASSEMBLY WORK AND SHEET METAL AND BAKELITE FABRICATION.

We are now in an excellent position to give you ATTRACTIVE PRICES AND DELIVERIES in any or all of the following fields:

(A) AUDIO AND POWER -- transformers, chokes, filters, rectifiers, power supplies, inductors, etc., etc.

(B) WIRING AND ASSEMBLY -- mechanical and electronic assemblies, sub-assemblies and component parts.

(C) SHEET METAL AND BAKELITE FABRICATION -- from sheets, rods or tubes. Cut, drilled, punched, formed or engraved.

Your inquiries will receive our prompt and careful attention. The Ferranti Engineering Department is always available for consultation. Send us your drawings or copies of your specifications. We have a definite SERVICE to render YOU.

Very truly yours,

FERRANTI ELECTRIC, INC.

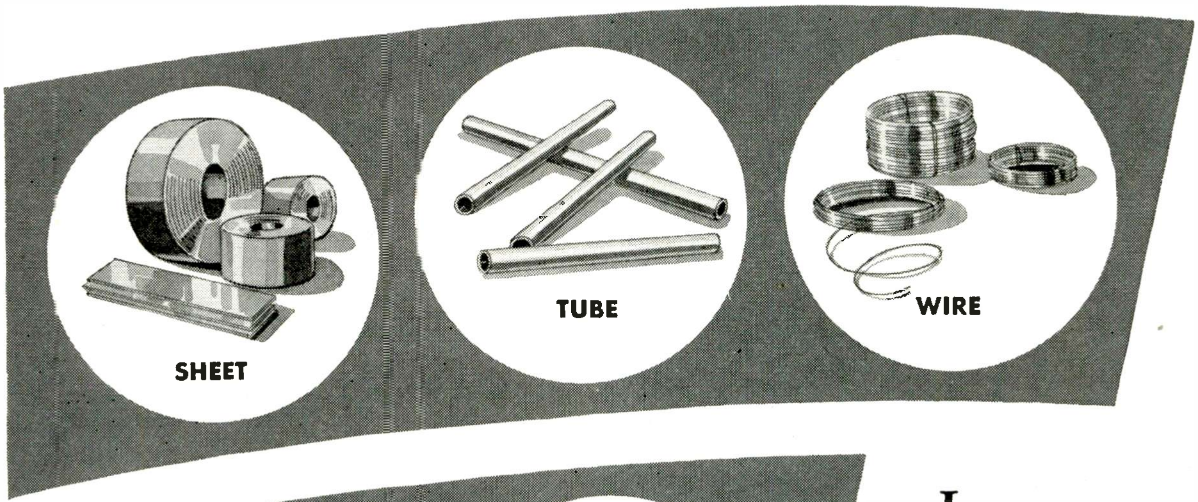
W. R. Spittal

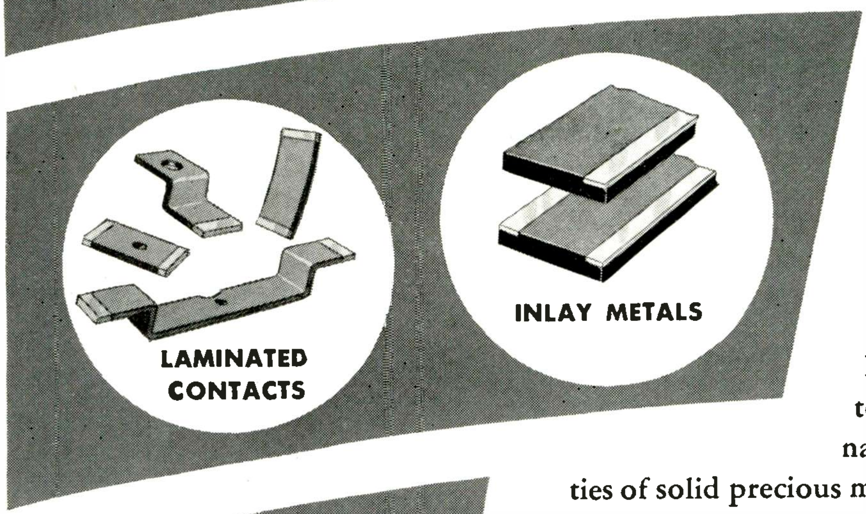
Vice-President

WRSpittal/em

GENERAL PLATE
Laminated Metals

Give Solid Precious Metal Performance at Low Cost





If you are looking for better electrical performance, corrosion resistance, ease of workability, long life . . . and exceptionally low cost, then look into the advantages provided by General Plate Laminated Metals.

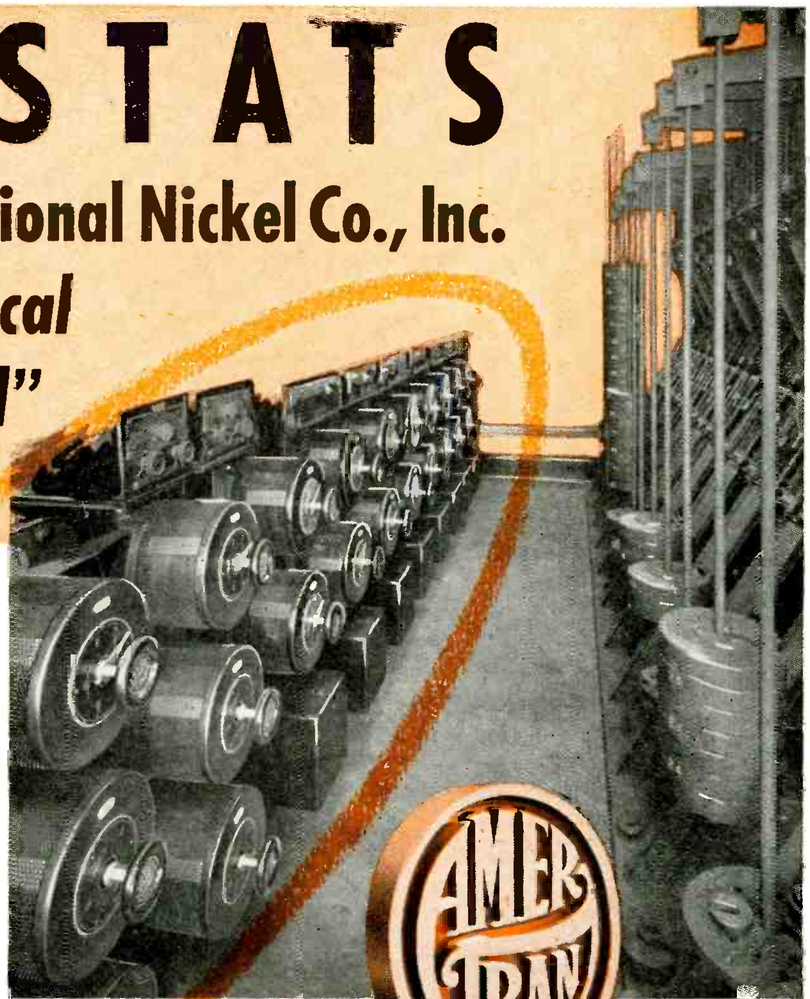
By permanently bonding base metals to precious metals, General Plate Laminated Metals give you all the properties of solid precious metals at a fraction of the cost of solid precious metals. In addition, the base metal adds strength and rigidity not usually found in precious metals. You'll find General Plate Laminated Metals ideal for use in such applications as electrical contacts, chemical apparatus, radar and radio equipment, mobile equipment and instruments. They'll help you cut costs, increase production and improve product performance.

General Plate Laminated Metals are available in sheet, tube and wire or as fabricated parts. Base to base metal combinations . . . providing physical and structural properties not found in single base metals . . . are also available. Write for information today.

GENERAL PLATE DIVISION
of Metals & Controls Corporation
50 Church St., New York, N. Y.; 205 W. Wacker Drive, Chicago, Ill.; 2635 Page Drive, Altadena, California
Grant Bldg., Rm. 603, Pittsburgh, Pa.
ATTLEBORO, MASSACHUSETTS

TRANSTATS

used by The International Nickel Co., Inc. for "... close electrical temperature control"



In this research laboratory at Bayonne, N.J., Transtats are used to control elevated temperatures in "creep testing" of alloys for high temperature applications. Since these tests are continuous over long periods, a high degree of reliability and accurate control are essential. The Transtats in conjunction with automatic controllers, connected to resistance heaters, keep the temperature at the required degree within close limits.

For a continuously adjustable voltage or a constant voltage from a fluctuating source, specify Transtats.

6 TRANSTAT "EXTRAS"

1. **Potentiometer smoothness** with transformer efficiency (93-99%)
2. **High turn-to-turn insulation** and solid insulating material between commutator bars—a combination of extra wire insulation and varnish impregnation of core and coil.
3. **Broad, Uniform Commutating Surface** ground from the evenly spaced outer wires of the coil.
4. **Smooth Commutating Surface.** Velvety action—no arcing—every turn a perfect contact.
5. **Longer Brush—more contact area,** reducing current density and providing greater area for heat dissipation.
6. **Balanced Collector Arm** maintains brush setting at any degree of mounting.

AMERICAN TRANSFORMER COMPANY
178 Emmet Street • Newark 5, New Jersey

AMERTRAN
MANUFACTURING SINCE 1901 AT NEWARK N. J.

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


10"
12"
8"
6"
5"
New Jensen
PM SPEAKERS with
ALNICO 5
Newly designed in every detail . . . magnets, housings, magnetic structures, voice coils and cones . . . and incorporating the new and powerful ALNICO 5 magnet material, this new family of PM speakers will add an imposing and important series of speakers to the JENSEN line.
These new models are now being tooled for production and, when ready, complete specifications and prices will be issued to the trade in Data Sheet TD-133. . . . Watch for other postwar innovations soon to come from the JENSEN laboratories.
JENSEN RADIO MANUFACTURING COMPANY, 6607 S. Laramie Ave., Chicago 38, Ill.
IN CANADA: Copper Wire Products, Ltd., 138 Oxford St., Guelph, Ont.
Jensen
SPEAKERS WITH
ALNICO 5
Specialists in Design and Manufacture of Fine Acoustic Equipment

LET'S FOCUS on *your* PROBLEMS!

Electrostatic Shielding

Tungsten Drawing

Positive Rectifier Contact

Ray-focusing Anodes

Corona Prevention

. . . And these are only a few—typical of the electronic industries—problems which **"dag"** colloidal graphite regularly solves.

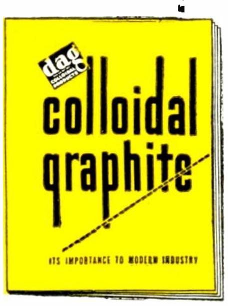
"Dag" colloidal graphite is a *unique* product with a *unique* assortment of properties—19 of them—properties which make for such wide ranges of usefulness as high and low temperature lubrication, parting, surface coating, impregnation, and conductive film deposition. All 19 properties of the material, along with characteristics and use data for its 18 dispersions (in water, oil, alcohols, volatile hydrocarbons and special carriers) are fully discussed in the new bulletins listed below.

Write for and consult this information. Evaluate colloidalized, dispersed, pure, electric furnace graphite—**"dag"** colloidal graphite—in terms of your business. Let's focus on your problems, and we might find an answer.

dag colloidal graphite

REG. U.S. PAT. OFF.

ACHESON COLLOIDS CORPORATION, Port Huron, Michigan



This new literature on **"dag"** colloidal graphite is yours for the asking:

430	A general booklet on the story of **"dag"** colloidal graphite. 12 pages profusely illustrated.	☐
440.	A complete list of **"dag"** colloidal graphite dispersions with applications.	☐
421	Facts about **"dag"** colloidal graphite for ASSEMBLING AND RUNNING-IN ENGINES AND MACHINERY.	☐
422	Facts about **"dag"** colloidal graphite as a PARTING COMPOUND.	☐
423	Facts about **"dag"** colloidal graphite as a HIGH TEMPERATURE LUBRICANT.	☐
431	Facts about **"dag"** colloidal graphite for IMPREGNATION AND SURFACE COATINGS.	☐
432	Facts about **"dag"** colloidal graphite in the FIELD OF ELECTRONICS.	☐

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

JMLCo. A-B1

Please send me without obligation, a copy of each of the bulletins checked:

NAME __________

POSITION __________

FIRM __________

ADDRESS __________

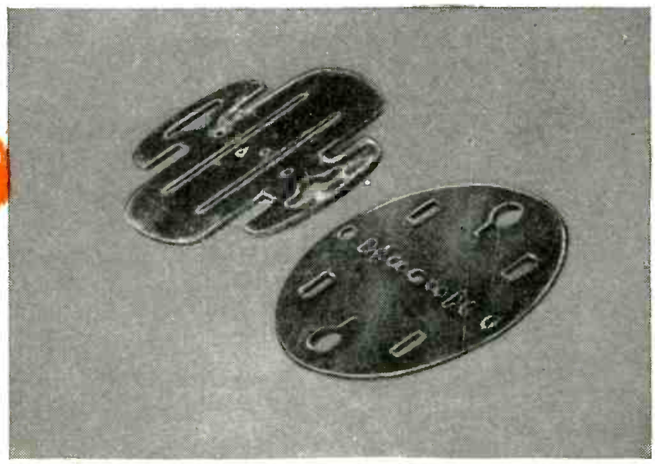
ZONE No. ______ STATE ______

OUR PRESENT OIL SUPPLIER IS __________

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

How You Can In Vacuum

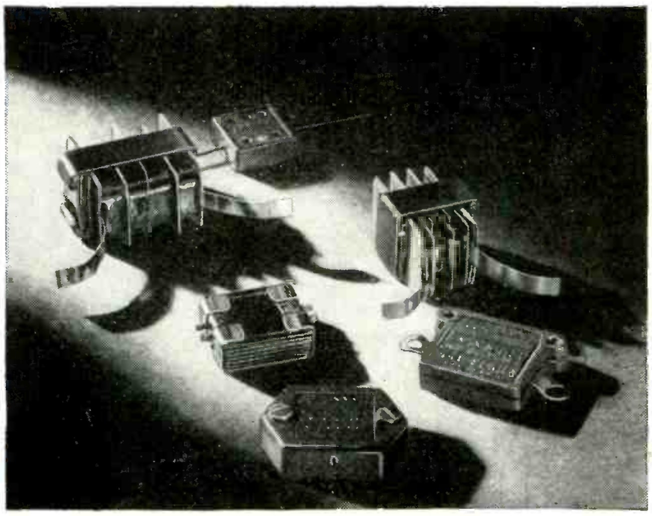
A few of the RCA tube types which utilize precision fabricated mica stampings to assist in maintaining RCA's high standard of tube performance.



Typical mica stampings for use in vacuum tubes. Accuracy in punching insures reduced rejects and contributes to a high standard of tube performance.

PROPERTIES OF SHEET MICA

	Muscocvite	Phlogophite
Specific Gravity	2.76—3.0	2.78—2.85
Hardness, Moh's scale	2.8 —3.2	2.5 —2.7
Max. temperature at which employable	1,027 F	1,832 F
Power factor at 1,000 kc	.0001—.0004	.004—.07
Dielectric constant	6.0—7.0	5.0—6.0



Capacitors made by Aerovox utilize mica because of its excellent insulating qualities. Photos show capacitors with and without plastic housings.

MUNSELL MICA | MICANITE Built-Up Mica | LAMICOID Laminated Plastics | EMPIRE Varnished Cloths and Tapes | MICO Insulating Specialties

Cut Rejects

Tube Production

WITH PRECISION FABRICATED MICA

Filament, grid, and plate supports require accurately punched mica stampings to insure correct alignment—an essential requirement for uniformity in tube characteristics and reduced rejects. Although tolerances of ±.0005 in. suffice for average requirements, we can supply stampings to ± .00025 in.

In order to make sure that measurements are being maintained during production, punchings are checked by a precision gauge at regular intervals. But, in addition to the accuracy of the punchings, the selection of the proper grade of mica requires considerable skill and experience. The mica itself must be of unvarying quality. Mica that is gaseous or has waves or buckles will make an inferior tube or cause a complete reject. Such rejects are of infinitely greater cost than the mica stampings.

There are many other electronic applications that require precision fabricated mica as well as mica's great dielectric strength, electrical resistivity, uniform dielectric constant, and capacitance stability. Add to these qualities a low dielectric loss and resistance to very high temperature, and you have an insulation material for which there is no known substitute.

Send us your blue-prints and specifications and we shall be glad to suggest the grade of mica which we feel is best suited to your applications.

EUGENE MUNSELL DIVISION OF

MICA *Insulator* COMPANY

797 Broadway, Schenectady 1, N. Y. **200 Varick St., New York 14, N. Y.**

SALES OFFICES:

Boston: 285 Columbus Avenue • Chicago: 600 West Van Buren Street • Cincinnati: 3403 Hazelwood Avenue • Cleveland: 1276 West 3rd St. • Detroit: Book Building • Houston: Bakoring, Inc., 1020 Houston Ave. • New York: 200 Varick St. • Triangle Pacific Co. at Los Angeles: 340 Azusa Street • San Francisco: 1045 Bryant Street

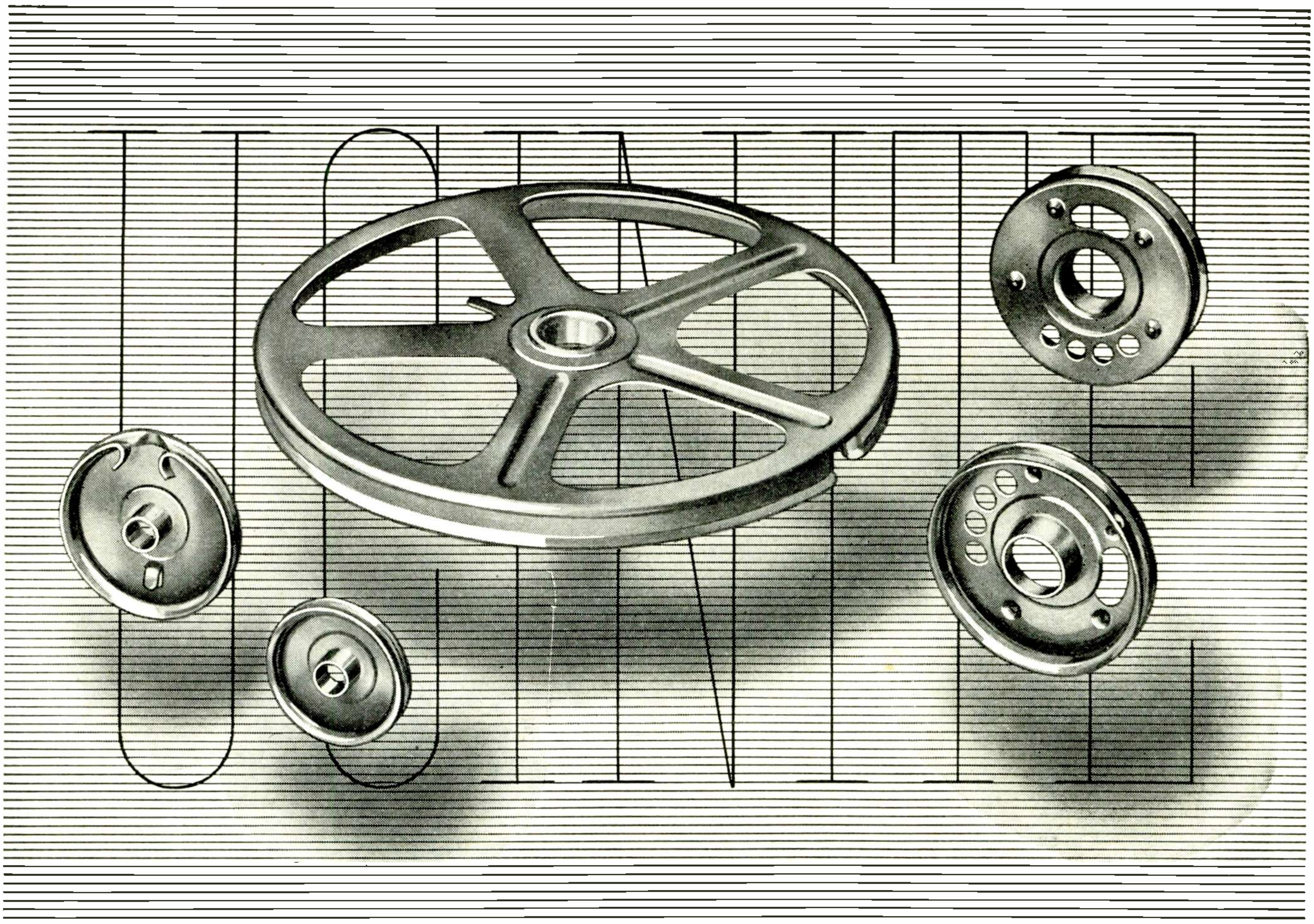
Just out

A new 4-page bulletin on mica insulation. Contains application data and characteristics for the seven different grades of mica available from us.

Mica Insulator Company
797 Broadway, Schenectady 1, N. Y.
Gentlemen:

( ) Please rush my copy of your new 4-page bulletin on electrical mica. ( ) Enclose price list.
( ) Please have your application engineer see me when in my vicinity.

Name ....
Position ....
Company ....
Address ....
City .... State ....



All kinds... all sizes... all finishes

We are completely tooled for making fixed pulleys for the electronics industries from $\frac{1}{2}''$ effective diameter to $3\frac{15}{16}''$ effective diameter for use with either $\frac{1}{4}''$ or $\frac{3}{8}''$ shafts. Small idler pulleys are designed substantially for use with $\frac{3}{16}''$ shafts.

We can supply these pulleys regularly with lancings, perforations and hooks which conform to the standards established by the R. M. A. or can, with Ucinite's usual ingenuity and adaptability, meet other requirements when necessary.

The UCINITE CO.
Newtonville 60, Mass.
Division of United-Carr Fastener Corp.

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

Save... with R/C standards

Over almost a quarter of a century of concentration on Variable Capacitors exclusively has resulted in an unsurpassed variety of standard "production line" types that are spelling real efficiency and economy for many radio-electronic manufacturers. Readily adaptable to hundreds of circuit requirements, these standard R/C types embody the same engineering care and precision workmanship that have made tailor-made R/C special units first choice for exacting, out-of-the-ordinary applications.

It should pay you to stack their broad possibilities against your next design requirement—while it is still on the drafting board stage.

RADIO CONDENSER COMPANY, CAMDEN, N. J.
RADIO CONDENSER CO., Ltd., Toronto, Canada

RADIO CONDENSER COMPANY

SUPPLIERS TO SET MANUFACTURERS ONLY

For *greater* brilliance and *greater* DEFLECTION SENSITIVITY—

DUMONT
TYPE 3JP
Cathode-ray TUBE

Here's the logical successor to the war-time Types 3BP and 3FP, combining the high deflection sensitivity of the 3BP with the higher operating voltage and brightness of the 3FP. Thus, it is the ideal tube for test equipment which is operated under high ambient light.

The new DuMont Type 3JP is designed for oscillographic and other applications requiring a small, short tube with very high light output and high deflection sensitivity. The focusing electrode current under operating conditions is negligible, thereby simplifying bleeder design. The 2" dia. neck and dihepta1 base provide adequate insulation between electrode leads for high-altitude insulation.

For applications where deflecting voltages are under suitable control, the 3JP is directly interchangeable with the 3FP. Equipment using the 3BP may be readily adapted to use the 3JP by providing for connecting the intensifier electrode of the 3JP either to the second anode potential or to a higher potential than the second anode. Due to the higher deflection sensitivity, the 3JP can be utilized with intensifier potential equal to twice the second anode potential without reduction in sensitivity, as compared with the 3BP operating with the same second anode potential.

TECHNICAL DATA ON REQUEST.

CHARACTERISTICS . . .

Deflection and Focus	Electrostatic
Screen: Choice of P1, P2, P4, P7 and P11 Screens	

RATINGS:

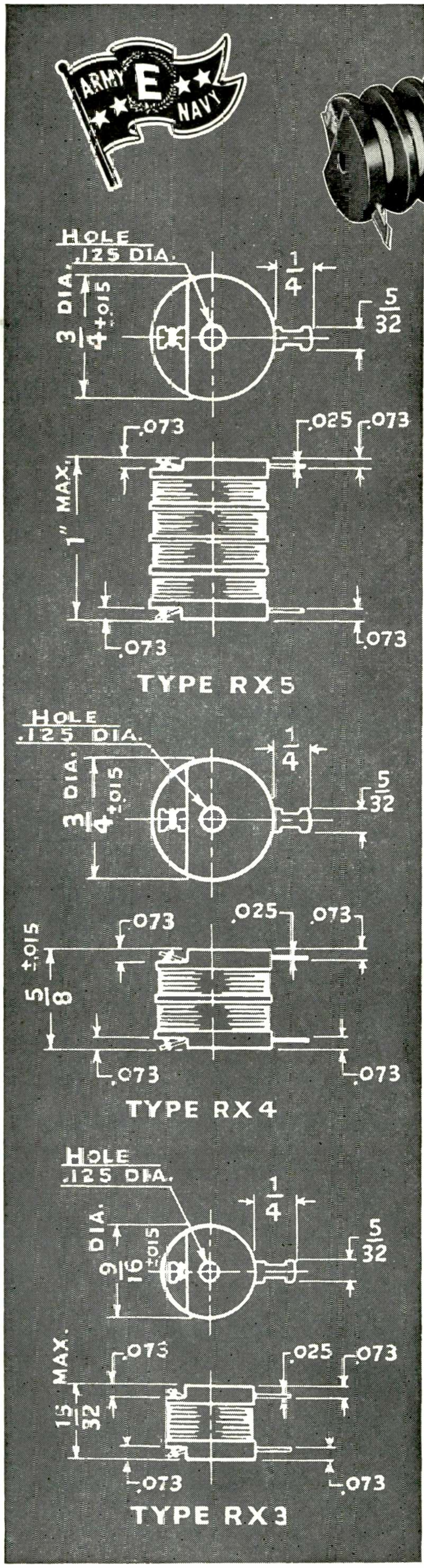
Heater Voltage	6.3 a.c. or d.c.
Current	0.6 ampere
Anode #3 (Intensifier)	4400 volts max.
Anode #2 (Accelerating)	2200 volts max.
Anode #1 (Focusing)	1100 volts max.
Grid (Control Voltage)	Never Positive
Peak Voltage between Accelerating Electrode and Any Deflecting Electrode	550 volts max.
Grid Circuit Resistance	1.5 meg. max.
Impedance of Any Deflecting Electrode Circuit at Heater Supply Frequency	1.0 meg. max.
E_b3/E_b2 Ratio	2.3 max.

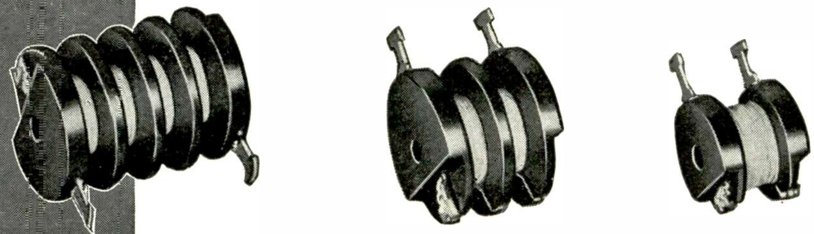
MECHANICAL CHARACTERISTICS:

Overall Length	10"
Maximum Diameter	3"
Base	Med. 12-pin diheptal

DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.





3 NEW BOBBIN TYPE RESISTORS

MAXIMUM RESISTANCE VALUES

Type RX3	Type RX4	Type RX5
100,000 ohms	300,000 ohms	500,000 ohms
(wound with 1.5 mil. dia. ceramic-insulated wire)		
25,000 ohms	75,000 ohms	125,000 ohms
(wound with 2.5 mil. dia. ceramic-insulated wire)		
MAX. POWER RATING AT 80° C. AMBIENT		
1 watt	2 watts	3 watts

MAX. TEMPERATURE—Ambient plus rise: 150° C.

RESISTANCE TOLERANCE: ±½% to ±5%, as specified. Where close tolerances are necessary, power ratings should be reduced in order to maintain stability. For example, one-third power rating is consistent with 1% tolerance.

TEMPERATURE COEFFICIENT—Standard temperature coefficient is that of nickel-chromium wire, .017%. Lower coefficients can be provided with special alloy wires, restricting the resistance range in some cases.

STABILITY—Resistors can be current- and temperature-aged after winding to provide instrument resistor stability. When operated at ratings consistent with tolerance, stability is ±0.1% or 1/10 of tolerance, whichever is larger.

CONSTRUCTION—Resistors are wound with ceramic-insulated Sprague Koolohm resistance wire on molded, high-temperature plastic forms. The lug terminals are tinned copper inserts molded in the plastic form.

HUMIDITY RESISTANCE—Resistors are impregnated to provide protection against tropical humidity conditions.

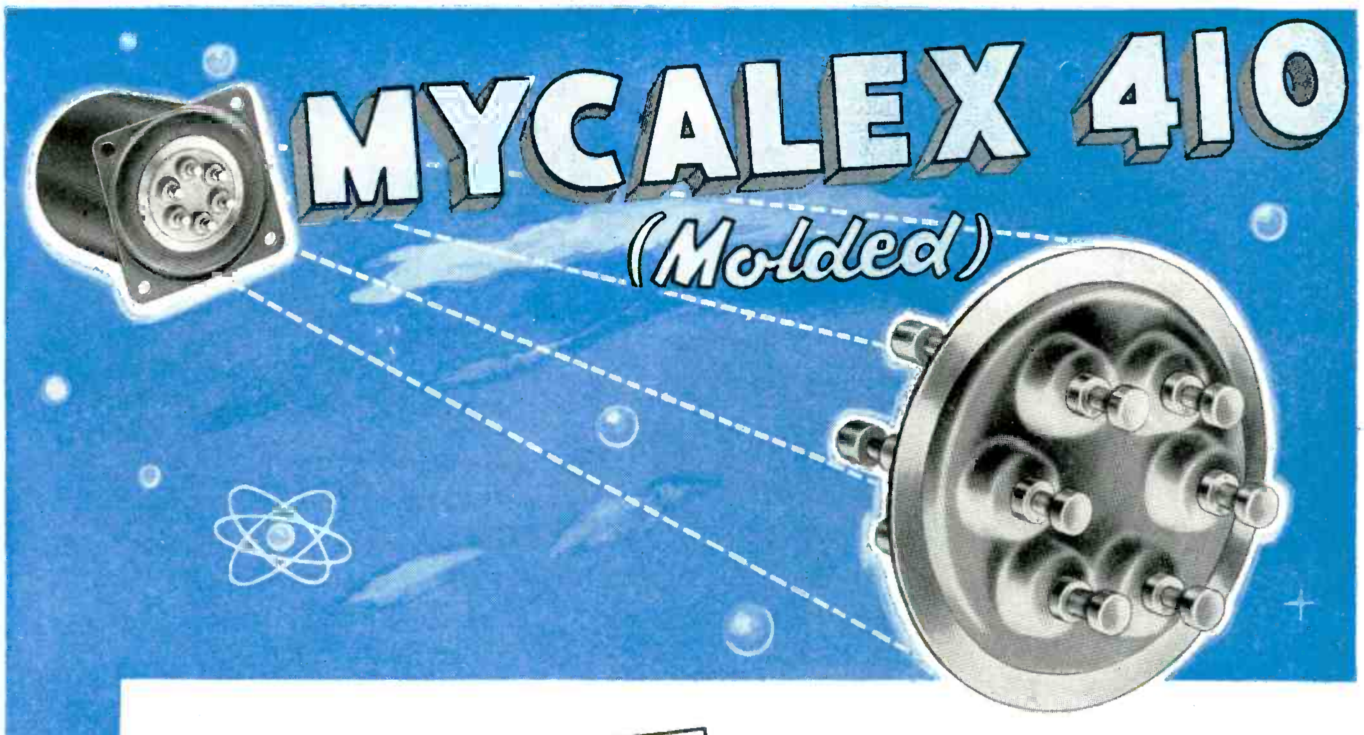
SPRAGUE KOOLOHM

Trademark Reg. U. S. Pat. Off.

WIRE-WOUND RESISTORS

FIRST with Grade 1, Class 1 Resistors; FIRST with resistors wound with ceramic-insulated wire; FIRST with glass-to-metal sealed resistors; FIRST with glazed ceramic coatings and new style end seals; FIRST with Megomax high-resistance, high-voltage resistors.

SPRAGUE ELECTRIC COMPANY, Resistor Division, NORTH ADAMS, MASS.



UNITED TRANSFORMER CORPORATION

150 VARICK STREET

NEW YORK 13, N. Y.

November 3, 1945

Mycalex Corp. of America
30 Rockefeller Plaza
New York 20, N. Y.

Attention: Mr. Jerome Taishoff

Gentlemen:

We have conducted the following test on the two-six terminal molded mycalex assemblies you submitted:

1 - Meg test - 500 megohms
2 - Place in oven at 40°C. for 8 hours
3 - Place in hot sodium chloride at 65°C for 1 hour
4 - Place in cold sodium chloride at 0°C for 1 hour
5 - Leave overnight in salt water at room temperature 20°C
6 - Meg test - infinity test

This test was repeated three times. At the end of the test the unit was tested for leakage and showed a small amount. This amount was within the limitations imposed by the Army Signal Corps. After the assemblies had dried for about 15 minutes they indicated no leakage. We consider these terminals to be extremely satisfactory for hermetic sealing purposes.

We wonder what would happen if these same 6 terminals were compressed into a smaller diameter assembly? We would greatly appreciate receiving samples of your single terminal assemblies.

Yours very truly,

S. W. Levy

S. W. Levy
Chief Production Engineer

MAKES **"EXTREMELY SATISFACTORY HERMETIC SEAL"**

REPORTS *United Transformer Corp.*

Are you seeking a hermetic seal for transformer terminals? Do you want a low loss, high frequency insulating material that will bond to metal and give positive assurance against oil leakage and the damaging effects of moisture?

Then read the United Transformer Corporation report made after tests of MOLDED MYCALEX in conjunction with Monel Metal in this application. The results speak for themselves.

For 25 years MYCALEX has been known to engineers the world over as the "most nearly perfect high frequency low loss insulation." Now, in highly perfected form, MYCALEX offers new opportunities for product improvement.

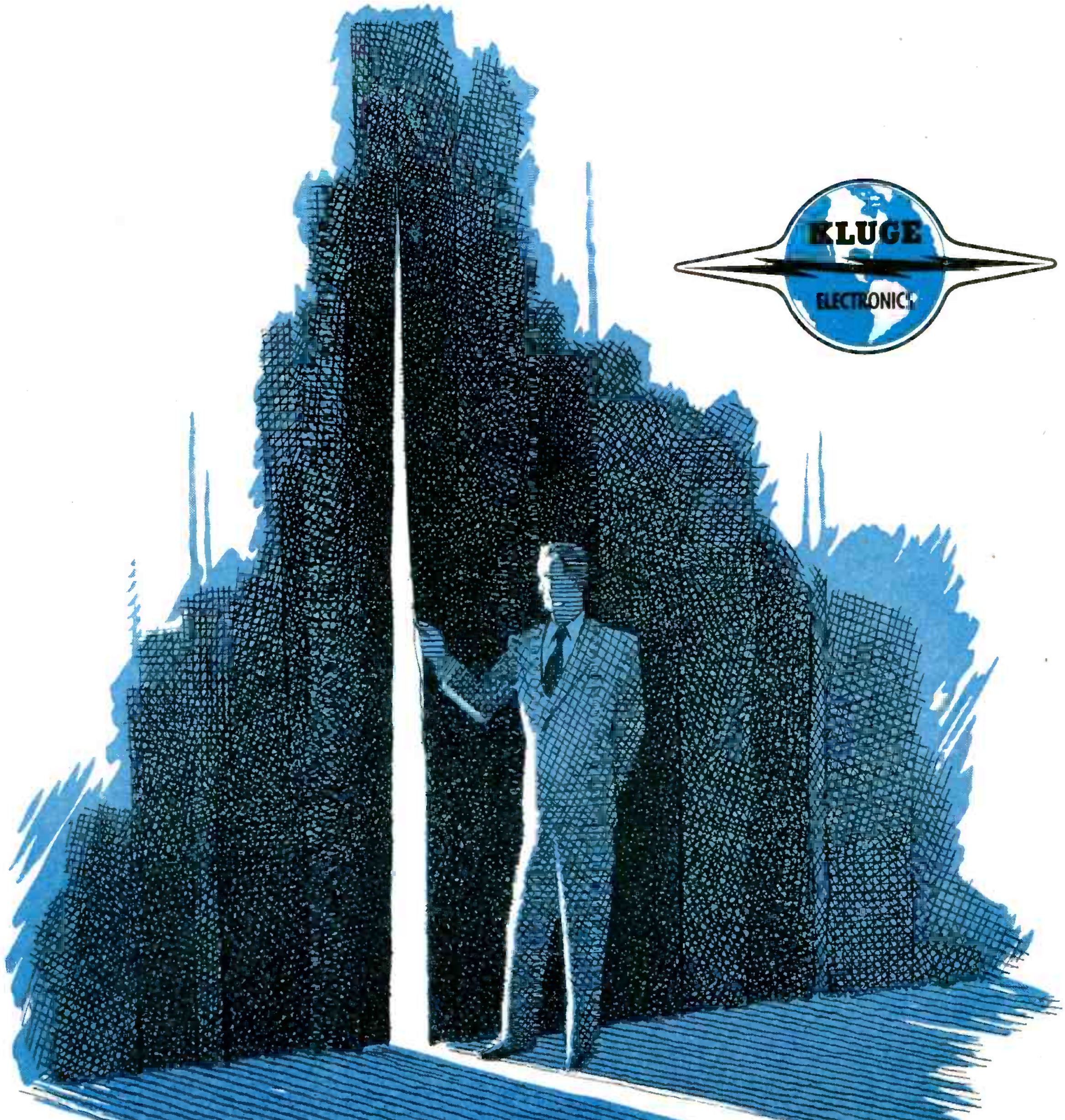
Specify MYCALEX where low loss factor and high dielectric strength are required. Our engineers are at your service.

SINCE 1919 MYCALEX THE INSULATOR
TRADE MARK REG. U. S. PAT. OFF.

MYCALEX CORPORATION OF AMERICA

"Owners of 'MYCALEX' Patents"

Plant and General Offices, CLIFTON, N. J. *Executive Offices,* 30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.



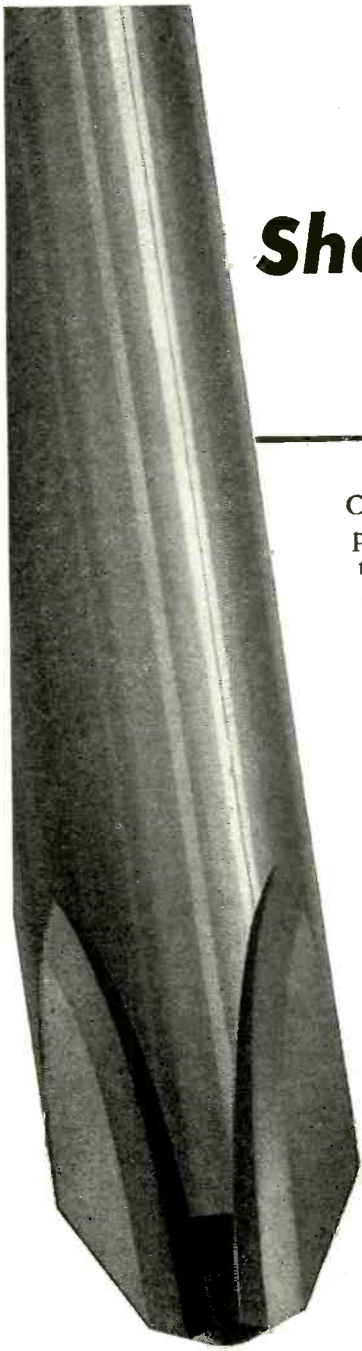
Soon . . . A New "Ham" Era

The curtain is rising on a remarkable "new era" development for the "hams" and *potential* hams of the world! It's so logical . . . so ingenious, in its use of advanced electronics and ultra-modern principles of design that we have kept the secret for showings in *all parts of the country,* at the same time. Dealers will be ready soon. Don't miss their KLUGE "Premieres" . . . It won't be long!

KLUGE
ELECTRONICS
COMPANY

1031 NORTH ALVARADO STREET • LOS ANGELES 26, CALIFORNIA


DESIGNED AND ENGINEERED AT NO. 1 PLASTICS AVENUE
PROBLEM —
MOLD TUNING BAR TO ACCURATE
DIMENSIONS—PERFORMANCE
REQUIRES RIGIDITY
AND STABILITY



"I've run tests and I Know... These are the Sharpest Cost-Cutting Tools that any shop can use!"

Comparative tests of American Phillips Screws with any other type prove: *American Phillips Screws always cost less to use.* Here are some of the reasons:

Easier Handling: 4-winged driver fits firm and straight into tapered recess in screw-head . . . can't twist out. Spiral and power drivers are safe to use on all jobs. No fumbling, false starts or dropped screws.

Fast, Straight Driving: Screw and driver align automatically into one straight driving unit. Starting is faster. Driving is easier. And screws are turned up tight and flush the *first* time, *every* time.

Cleaner Fastenings . . . Unmarred Work: No crookedly driven screws, no split or burred screw heads. And because the driver can't twist out, there are no slashes on work-surfaces, no injuries to workers.

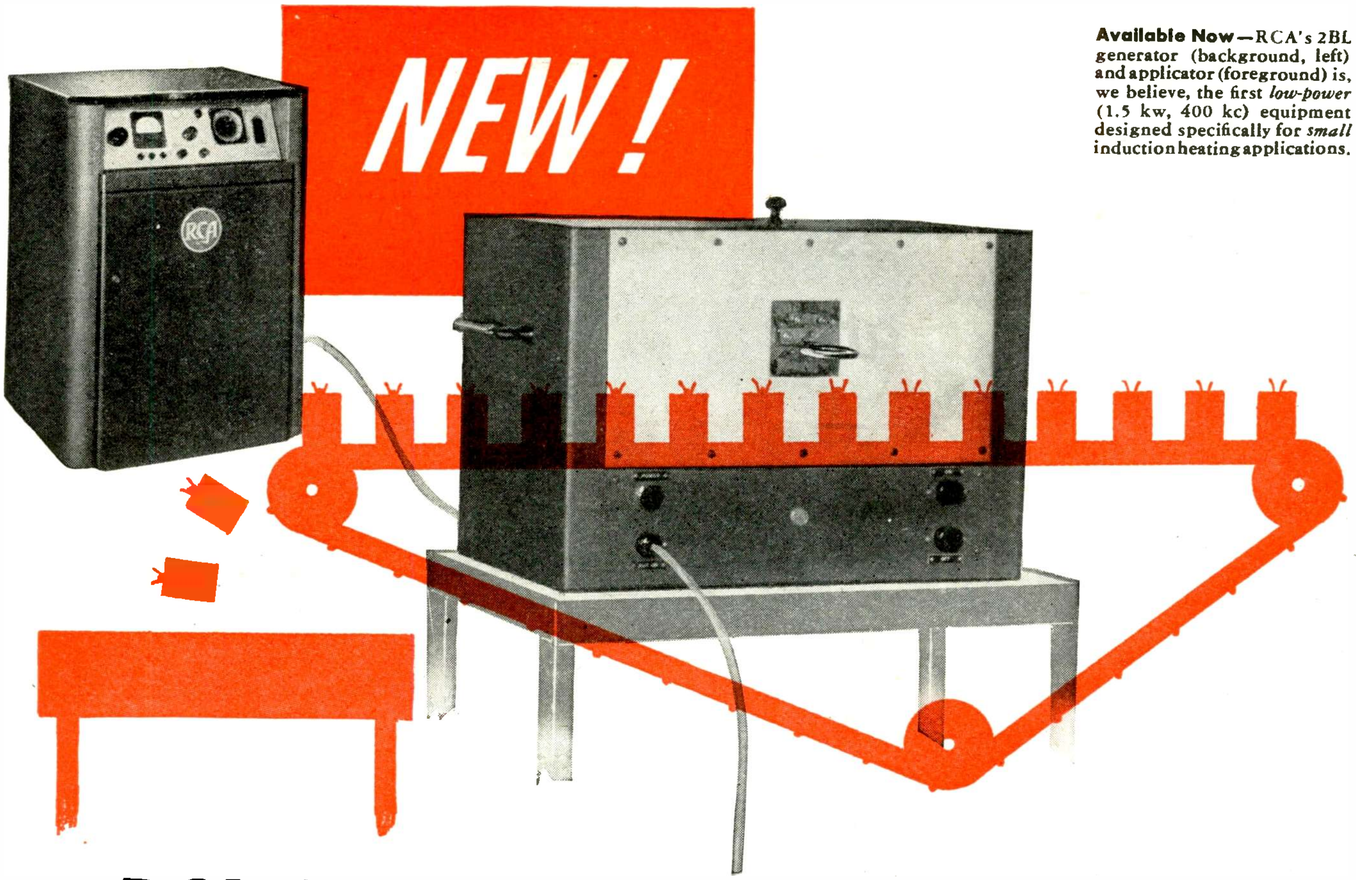
IN SUM: American Phillips Screws save an average of 50% in assembly time.

Today, with assembly costs increased and threatening to go higher, the time saved through the use of American Phillips Screws becomes doubly important. And you get a further saving, too, from American's 4-phase inspection, which gives you a higher "perfection-percentage" in every order for *American* Phillips Screws and Bolts. So start action today, to cut costs the American way.

AMERICAN SCREW COMPANY
PROVIDENCE 1, R. I.
Chicago 11: 589 E. Illinois Street
Detroit 2: 502 Stephenson Building

You've got Thousands to Gain—and Nothing to Lose
WHEN YOU CHANGE TO:

AMERICAN PHILLIPS *Screws*



Available Now—RCA's 2BL generator (background, left) and applicator (foreground) is, we believe, the first *low-power* (1.5 kw, 400 kc) equipment designed specifically for *small* induction heating applications.

RCA ELECTRONIC GENERATOR

speeds small soldering and brazing jobs

YOU will find this equipment particularly useful for soldering and brazing such items as condenser cans, terminals, radiator valves, and watch cases. It can also be used to save time on small hardening, heat-treating, and welding operations.

As the applicator (work unit) is separate from the generator, unusual working flexibility is assured—the applicator can be mounted right next to the assembly line and the generator installed as much as 25 feet away (out of the high-priority working area). The foot switch connected to the applicator allows the operator free use of hands; all other controls—such as timing and output—are preset at the generator. A "universal" output transformer assures a match for any load, and eliminates the need for readjusting the generator during the heating cycle.

Installation is easy—just plug into any 230-volt, single phase, 60-cycle outlet and connect water supply to work coil. Installation supervision and operator training is provided at no extra cost to you. Also, a contract is available for complete service and maintenance by RCA.

Use the coupon below to get complete information on the other outstanding features of this equipment which contribute to its compactness, ease of operation, accessibility, low maintenance, and safety.

★ ★ ★

SEE THE 2BL at the Chemical Exposition in New York, February 25 to March 2 or at the Metals Congress in Cleveland, February 4 to 8.

FOR QUICK FACTS, CLIP THE COUPON

Radio Corporation of America
Electronic Apparatus Section
Dept. 30-B, Camden, New Jersey

Please send me complete information on the new RCA 2BL electronic power generator for induction heating.

Name__________ Title__________

Company__________

Street Address__________

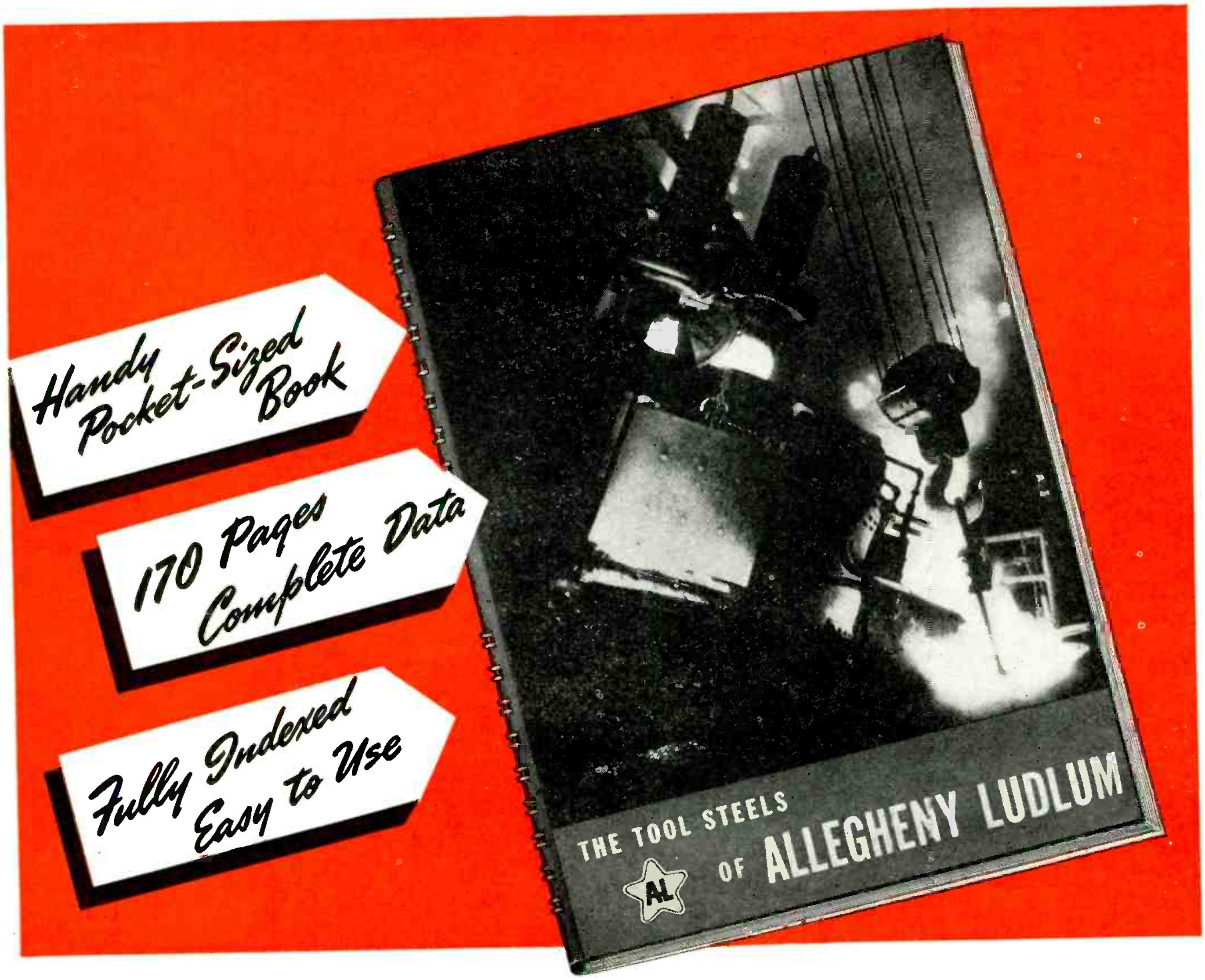
City__________ Zone____ State__________

RCA

ELECTRONIC HEATING

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DIVISION, CAMDEN, N. J.



THE ANSWERS TO <u>ALL</u> YOUR NEEDS IN

TOOL AND DIE STEELS . . .

- ★ HIGH SPEED STEELS
- ★ HOT WORK STEELS
- ★ SHOCK RESISTING STEELS
- ★ COLD WORK STEELS
- ★ CARBON STEELS
- ★ HIGH SPEED AND TOOL STEEL FORGINGS
- ★ CAST-TO-SHAPE TOOL STEELS
- ★ COMPOSITE DIE STEELS

TO MEET ANY REQUIREMENTS

TODAY—and for a long time to come—the premium on production cost-saving is greater than ever before. Match up each one of your machine operations with the tool or die steel that will do the job faster, better, or with less "down" time. This new booklet gives you complete information on the exceptionally large family of Allegheny Ludlum Tool Steels—invaluable data on properties, uses, selection and handling that every production man should have.

write for your copy. . . Address Dept. E-38

ALLEGHENY LUDLUM

STEEL CORPORATION · General Offices, Brackenridge, Pa.

Pioneer in Speciallloy Steels

THE FAILURE OF "FACT-FINDING"

THE PRESIDENT has asked Congress to grant him authority to appoint fact-finding boards to deal with nationally important labor disputes. Most citizens would like to see some reasonable and objective solution of the industrial strife that now is disrupting reconversion. Unfortunately, the record of the "fact-finding" procedure indicates that any claim of impartiality for this process is a gross misrepresentation.

The Administration bill would authorize the President to appoint such boards in cases certified to him by the Secretary of Labor. Each board would report to the President "its findings of fact and such recommendations concerning the dispute as the board deems appropriate." Its facilities and staff would be provided by the Secretary of Labor. The bill provides for an interval of not more than 30 days known as a waiting or "cooling off" period during which it would be "unlawful" (though no penalties are specified) for anyone to promote or encourage work stoppages.

Because the Administration did not wait for Congressional action upon its proposal, but appointed a number of fact-finding bodies to deal with current emergency cases, we have been afforded at least a partial preview of how the procedure may be expected to work out if laws establishing it are passed.

If the reports handed down by the fact-finding panels in the General Motors and oil disputes may be regarded as representative, it can be stated conclusively that Government-appointed "fact-finding" boards will concern themselves to only a minor degree with the establishing of facts. A far greater share of their effort will be concerned with the speculative business of forecasting future output and production efficiency and appraising the "ability to pay" of the companies involved. But the predominant emphasis will be placed upon framing recommendations for settling the disputes in line with announced Government wage-price policy.

In short, the procedure essentially will be one of registering with the public a government opinion as to how far wages may be raised in the cases at issue without raising price ceilings. Both the General Motors and the Oil Panels stated, in quite explicit terms, that this was their conception of the job assigned them.

"Fact-Finding" in Auto and Oil Disputes

As the General Motors Panel phrased it: "This board subscribes to, and has been guided by, the national wage-price policy" — which it summarizes as calling for wage increases to maintain take-home pay at wartime levels, to the degree possible without inflationary price rises.

The Oil Panel was even more forthright in the statement of what it was supposed to do. "In the judgment of the panel," it declared, "the earnings of the workers must be as high as is consistent with both the maintenance of the stability of the price structure and the provision for reasonable returns to the owners of industry." In other words, prices and the return to investors are to remain fixed, with labor entitled to an ever-increasing return up to the limit of what the traffic will bear.

Having thus outlined their respective conceptions of the job, each panel proceeded to carry out its mission.

The Automobile Panel recommended that General Motors increase its basic hourly wage rates by 19½ cents, which amounts to about a 17½ per cent increase on the company's average hourly wage of $1.12. The Oil Panel recommended an 18 per cent increase in basic hourly wage rates, or an additional 21 cents to the average wage rate of $1.20.

The General Motors recommendation was based almost exclusively upon the Panel's calculation that a 19½ cent raise would keep weekly take-home pay equal to that earned in 1944 when the work-week averaged 45.6 hours. The calculation turned on an estimate of what the effective work-week was likely to be in 1946.

The Oil Panel's recommendation appears to have been based on a more complex but no more conclusive accounting. After calculating that the maintenance of July 1945 take-home pay after 40-hour shifts were restored would require a 22 per cent increase in straight-time hourly wages, it recommended that an 18 per cent increase be made. It accounted for 9½ per cent of this by noting that this was needed to cover cost-of-living rises, and explained that the rest was justified by a combination of factors including loss of premium overtime pay, higher productivity, and settlements already negotiated. Since the Panel gave no indication of the weight given to these several factors, it may not be unfair to assume that the last-named was given preponderant importance, since 18 per cent was the increase already granted in collective bargaining by Sinclair and certain other oil companies.

Higher Pay Without Higher Prices

Both panels stated that the pay increases recommended could be met without raising price ceilings, but neither documents its case on this score with very conclusive "facts".

The Oil Panel confined its observations on this account to the statements that only one company in its group had pleaded "inability to pay" and that the industry was in a generally profitable position during 1943 and 1944.

The Automotive Panel stated that, under a number of assumptions about the 1946 operations of General Motors which it believed to be valid, the Company would have higher earnings than it had in 1941, its previous record year. It specifically stated that its findings in the case were not applicable outside the automobile industry, but it recognized that the General Motors settlement would more or less determine the settlements of other automotive companies. It stated that it had not been able to arrive at a clear conviction as to the ability of other auto makers to pay similar wage advances, but it dismissed the issue by observing that they could expect to operate at full capacity in 1946, and that this should provide savings to offset the increased wage expenditures.

From the management point of view, one of the most serious limitations in the panels' procedure was their failure to deal with any of the Company claims put forward. In ordinary collective bargaining the demands of both sides are advanced and concessions in one direction are traded for concessions in the other. Here, although the companies involved had insisted upon their need for guarantees against contract violations and wild-cat strikes, and for other union concessions, nothing but the wage issue was considered by the "fact-finding" bodies. The General Motors Panel specifically recommended that the wage increase of 19½ cents be granted, but that otherwise "the status quo prevailing before the strike be restored by the reinstatement of the 1945 contract between the parties." Handled thus, fact-finding becomes indeed a wholly one-sided exercise.

Both panels accepted, quite uncritically, the general position taken by Government spokesmen that wage increases are inflationary only if they are directly translated into price advances. It should be obvious that all wage increases add to the inflationary pressure, if made at a time like the present when consumer purchasing power far outstrips the volume of goods and services available to satisfy it.

"Fact-Finding" Dodged in Steel and Rails

It is ironic, too, that even while the Automotive and Oil Panel groups were holding the "government policy" line, the President and his Reconversion and Stabilization Directors were busily at work trying to dent it. In the steel dispute, although price rises in this industry have a particularly sharp inter-industry impact, hearings by the appointed fact-finding board were deferred while negotiations were carried forward by the President and his advisors under which the industry was offered a price increase of approximately $4.00 a ton on condition that U. S. Steel and the United Steelworkers agree upon a mutually acceptable wage boost. It is hard to avoid the cynical conclusion that wage increases constitute the major administration policy, and that the principle of not translating them into increased prices is sacred only in those cases where there can be some reasonably plausible showing that wages may be raised without price advances.

Much the same general conclusion — that the "facts" are controlling only if they support a substantial wage increase — is sustained by the history of the administration of the Railway Labor Act of 1926, often cited as a glowing example of how "fact-finding" by so-called Emergency Boards of Presidential appointees has served to prevent strikes on the railroads. It is true that reports of almost all of the 31 Emergency Boards appointed to look into threatened railway strikes in the 20 years since the act was passed have provided the basis for a settlement of the disputes in question. The fact — a real fact — remains, that in 1941 and again two years later the wage adjustments found appropriate by Emergency Boards in major railway labor disputes were revised upwards at the White House after the unions involved rejected them as unsatisfactory and threatened to strike. The second upward revision was made after government seizure of the railroads to prevent a national transportation tie-up. When the "facts" did not indicate a large enough wage increase to satisfy the union and the Administration, the "facts" went out the window.

It would be irresponsible to deny the importance of finding some tenable solution of current disputes that threaten to completely disrupt the reconversion process. But upon the evidence of experience, "fact-finding" boards cannot be expected to operate according to the common conception of their function — as agencies designed to sift out for the public an objective and significant weighing of the facts behind conflicting claims.

Without Principles Facts Mean Little

Facts, if they are assembled upon a sufficiently partisan basis, can be made to document almost any case one wishes to establish. The major difficulty in marshalling facts to resolve wage disputes is that there are no agreed-upon principles to determine the levels at which wages should be set. In the absence of such principles, it is inevitable that "fact-finding" boards, appointed by the Administration, manned largely by those who helped develop and administer Administration wage policies, and depending for technical assistance upon Administration Departments, will serve merely to implement Administration wage policy.

If Government means to reassert its wartime authority to fix wages — an objective specifically disavowed by the President and seemingly wanted by no one — it should accept the responsibility directly, rather than operate to that end through "fact-finding" boards which are independent in theory, but which cannot be so in fact.

The failure of the brand of "fact-finding" now urged upon Congress by the President is evident. Therefore, we must look for a solution along other lines.

What is needed is for labor and management to agree upon the principles that should govern the determination of wages under free collective bargaining. When such agreement is reached, then and only then, can fact-finding become an objective and useful instrument for settling wage disputes.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

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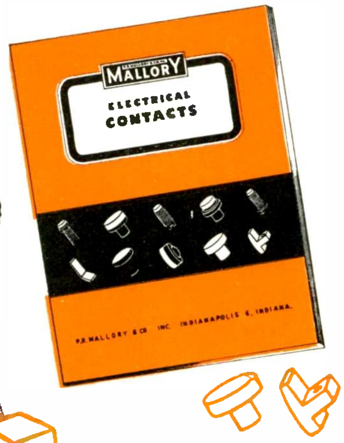

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CROSS TALK

►**TELEVISION** . . . The "progress report" on television given by RCA engineers at the Princeton laboratories in December indicated definitely that television no longer lurks around an ever-receding corner. On the contrary, the road looks wide and straight. All that is needed is something to ride in and some place to go. To delay for further, more perfect, developments will only rob us of the pleasures of looking-in while we wait for omnipotent scientists and engineers to produce new magic—which they will do whether we wait or not.

Newspaper men witnessing the demonstrations of direct-viewing and projection black-and-white receivers and a laboratory color setup seemed more concerned about the bogyman of obsolescence than with the fact that television is at last ready for the home. The positive fact is that black-and-white television sets soon to go into production exhibit pictures which are far brighter, have better contrast and seem more detailed than was possible at the beginning of the war. The pictures can be viewed with pleasure without turning out the house lights. Future progress in black-and-white must be in small degrees and probably will be confined largely to projection systems.

The question of obsolescence needs definition. For example a projection receiver makes it possible for more people to view a given receiver or for the same number to look at it from a greater distance. Psychologically, of course, a big picture is more impressive than a small picture—but technically there is the same information as exists in the smaller image, the only difference being that this information is spread over a larger area.

Projection systems with their bigger pictures will not make direct-viewing sets unworkable.

The $64 question is whether color makes black-and-white obsolete? It will do so only if black-and-white transmission is to cease when color is ready. The only possible precedent for such a drastic action is that of f-m where numerous receivers will become unworkable when the transmitters move to their newly assigned bands. But in this case there had been no continuous production of receivers and the transmissions themselves have been conducted with a left-handed enthusiasm since we got into the war.

There is no doubt about the impact of color television on those who see it for the first time. In adolescent language it is "terrific." But to make this impression, special shows are necessary. The run-of-mine productions are not worth the difference, and in fact the emotional appeal of a good drama can easily be ruined by the distraction of color. So drab is our average life that color must be sought and invented. And no matter how desirable color is, it is not necessary. The advantage of adding it is nothing compared to the difference between television in black-and-white and no television at all.

Americans are adventurous and it is a guess that the public will be quite willing to take the chance that color will make television vastly superior at some future date and that when such a happy event occurs, they will be willing to unload their existing sets for something incomparably superior. It is another guess that they would prefer this to waiting around for another year or two or five for the millenium to arrive.

►**RESOLUTIONS** . . . Mr. Petrillo's dictum that broadcasters shall no longer transmit to American listeners music originating in foreign lands leads one to wonder if he will ultimately get around to prohibiting radio set manufacturers from putting short-wave bands on their sets or if he will ask American listeners to refrain from picking up the BBC symphony or the rumba from South America or drinking or marching songs from Germany or a little bit of yodeling from Berne. If such a request were made it is remotely possible that the good old American listener will make up his New Year's resolution to listen when and where and to what he damn pleases.

THE RESNATRON

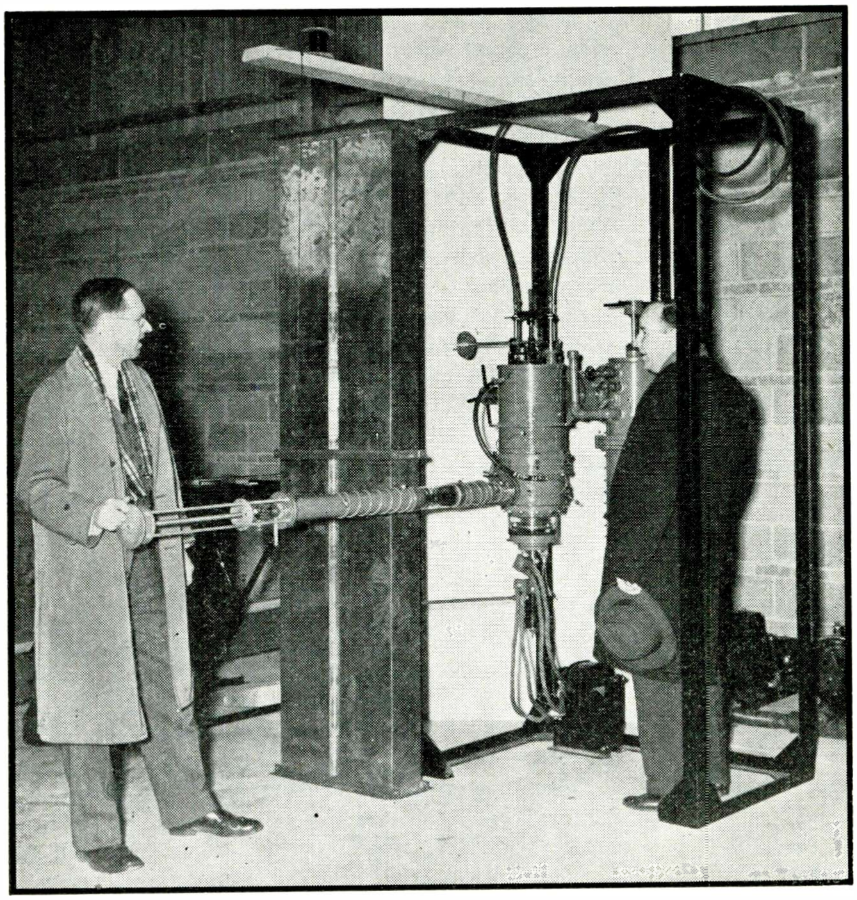
First published information on the most powerful uhf oscillator and amplifier now in existence. Used during the war to jam German radars, the resnatron can generate 50 kilowatts, continuous wave, at any frequency between 350 and 650 mc

By WINFIELD W. SALISBURY
Director of Research
Collins Radio Company, Cedar Rapids, Iowa

THE resnatron is a high-power uhf oscillator-amplifier tetrode, developed during the war as a source of continuous-wave r-f energy to jam German airborne radars operating in the neighborhood of 500 mc. The resnatron tube combines several techniques which have been used in other tubes, such as self-contained resonant cavities, electron bunching, beam-forming, and the introduction of phase shift between grid and plate oscillating circuits to compensate for transit time. Yet it remains a tetrode in basic design, with a clearly defined cathode, control grid, screen grid, and anode.

The tube can generate, on a continuous basis, 50 kilowatts of output power at an anode efficiency of 60 to 70 percent. The resonant cavities are tunable from 350 to 650 mc, and the adjustment can be performed while the tube is in operation. The tube can be modulated in frequency or amplitude, and it can operate as a power amplifier with about 10 times power gain. In one power run of eight hours duration the tube developed 85 kw, c-w, at 600 mc. Water cooling is required to carry away heat liberated throughout the structure.

In its wartime form, the tube was operated on the pumps, a great convenience in view of the vacuum seals around the tuning controls. There is no reason, however, why the tube should not be constructed in sealed-off form and still remain tunable over a smaller range.



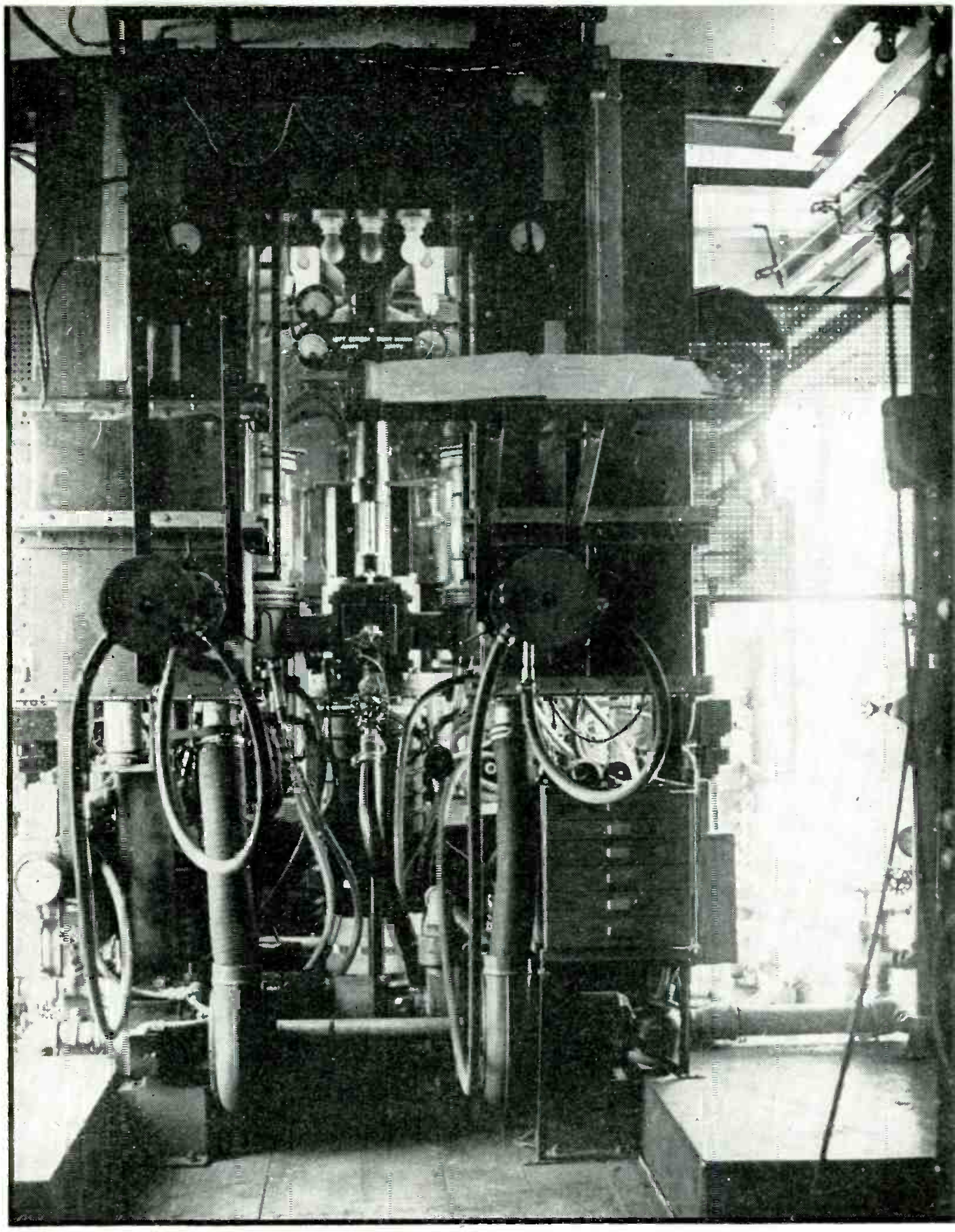
Resnatron tube, showing r-f output under adjustment by Dr. J. J. Livingood while W. W. Salisbury looks on. The vertical rectangular pipe to left of tube is a section of waveguide used with the tube

Development of the Resnatron

The research which lead to the resnatron tube started in 1938 at the University of California. The beginning of this research was the result of discussions between the author, Dr. L. C. Marshall, and Dr. David Sloan regarding the limitations to the production of high power in high-frequency oscillating circuits. The result of these discussions was the determination that an attempt could be made on a new range of frequency and power, if electron transit time could be ignored or overcome in some way, and if the electronic circuit problems could be tackled by reducing the inductance of the vacuum tube leads.

Funds for the resnatron research were first furnished by the Electrical Engineering Department of the University of California and later by the Research Corporation. Rather startling results were achieved almost immediately by using focused electron beams and by incorporating the tuned circuits in the internal structure of the vacuum tube.

High efficiencies were recorded and an average power output of



Two resnatrons mounted in a truck and used to jam German radars in July 1943. The piping is used for water cooling

eight kilowatts was finally achieved with raw a-c on the electrodes at a frequency of 860 megacycles. This indicated a peak power of the order of 60 kilowatts, which from the construction and power-dissipating capacity of the elements seemed a very likely possibility for c-w operation of the tube.

By the time the research had reached this point, it was felt that the basic principles involved were thoroughly understood, and that all that was necessary was the refinement of details to make a practical installation. By this time, war research had sprung up under the auspices of the OSRD and NDRC and it was decided that the research in producing practical tubes should be taken over by the OSRD. A contract was therefore let to the Westinghouse Research Laboratory at East Pittsburgh to continue this work. Dr. L. C. Marshall was already working at the MIT Radiation Laboratory on microwave radar, so Dr. D. H. Sloan was persuaded to continue the work on the resnatron tube.

This OSRD contract was first operated under the auspices of the MIT Radiation Laboratory but was later transferred to the Harvard Radio Research Laboratory when it became evident that the primary use of this development could be in radar countermeasures. This work was done under the able leadership of Dr. F. E. Terman. As the original work at the University of California was done on a frequency of approximately 860 megacycles with a very limited tuning range, it was necessary to modify the design for wider tuning range and for the frequencies which it was desirable to deny to the German Luftwaffe. The project in which this tube was finally used was known by the code word of Project Tuba (Radar Countermeasures, ELECTRONICS, page 92, January, 1946).

In utilizing the high power output of the tube, waveguides were used rather than transmission lines, because of the difficulty with insulators. Two sizes of waveguide were made standard—6 by 15 inches and 6 by 22 inches—depending on the part of the frequency spectrum used. Power levels of 50 kw were obtained at anode efficiencies varying from 40 percent to 70 percent, depending on the modulation bandwidth required. Noise modulation was used.

Powers upward of 50 kilowatts coming from a waveguide 6 by 15 inches produce spectacular effects. An ordinary light bulb, held in this radiation field, explodes. Fluorescent lamps light many feet away. A piece of steel wool held near the end of the waveguide explodes into arcs and will produce a good case of sunburn in a few minutes. In one case, an open waveguide was operated in the laboratory for a few minutes, and on the wall ahead of it a tool board exploded into arcs wherever the tools were near resonant length.

In early field operations, a large horn having an aperture 6 by 18 feet and made of chicken wire was used. During operation, one of the Royal Air Force sergeants standing in front of this radiator brought opposite fingers of his two hands together and pulled them apart, producing an arc. The resnatron tube was operated as a self-excited oscillator in the field operations, but in the laboratory it has been used successfully as a power amplifier, particularly of the class C type. As an

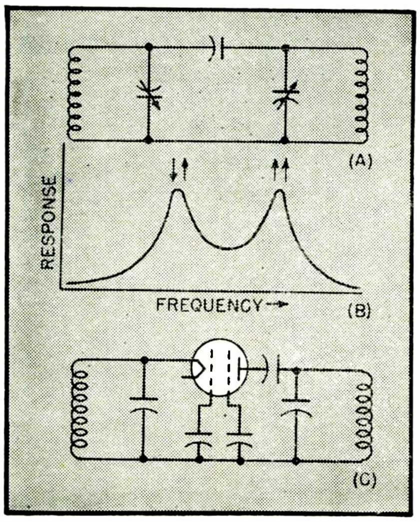


FIG. 1—Equivalent circuit (C) and resonance characteristic of the resnatron. Capacitively-coupled tuned circuit (A) displays double resonance peaks (B) representing in-phase, out-of-phase oscillations

amplifier, it offers 10 db or more of gain and the same efficiency as when operated as a self-excited oscillator.

Theory of Operation

The resnatron may best be described as operating as a grounded grid tetrode; that is, both the control grid and the screen grid are operated at radio-frequency ground with the filament oscillating with respect to the control grid and the anode oscillating with respect to the screen grid. In effect the tube consists of two excited cavities. One, the output cavity, is between the screen grid and the anode; the other, the input cavity, is between the control grid and the filament structure. Power is introduced into the filament control-grid (cathode) cavity by a coupling loop, and another coupling loop in the screen-grid-anode (anode) cavity connects to the output. The equivalent circuit (Fig. 1) is like that of a tuned-grid tuned-plate oscillator.

Self-excited operation can be obtained either by taking power from the output loop and connecting it to the input loop or by means of capacitance probes which reach through the grid spaces of the tube from the top of the cathode to the anode cavity. This latter arrangement is superior for broad-band use and for quick change in frequency. If accurate frequency control is required, as may be the case in future commercial uses, the external feedback circuit is more desirable.

To understand how the tube operates one may consider that it consists of two resonant circuits (Fig. 1A) coupled together by capacitance and appropriately connected to the electronic structure of the tube. Such a pair of circuits has two resonant frequencies (Fig. 1B) even though the circuits are individually tuned to the same frequency. On the low-frequency peak, the tube cavities operate 180 degrees out of phase, while on the high-frequency peak they operate in phase.

The time of transit of the electrons in passing from the cathode cavity to the anode cavity introduces a lag in the phase angle between the oscillations in the two cavities. To this phase lag must be added an additional lag, to bring the two cavities into the opposite phase condition required for oscillation. The additional phase lag is obtained by slightly detuning the cathode cavity. A continuous adjustment of the additional phase lag is possible because of the resistance component in the cathode cavity, due to electron loading. Moreover, this resistive component does not represent a loss of power, since the energy put into the electron stream reappears in the anode cavity and contributes to the useful power output. Thus the effect of transit time can be compensated without lowering the efficiency.

The transfer of energy from cathode to anode cavities is accomplished by electron bunching, in the manner of the class-C amplifier. The electron bunches, formed in the space

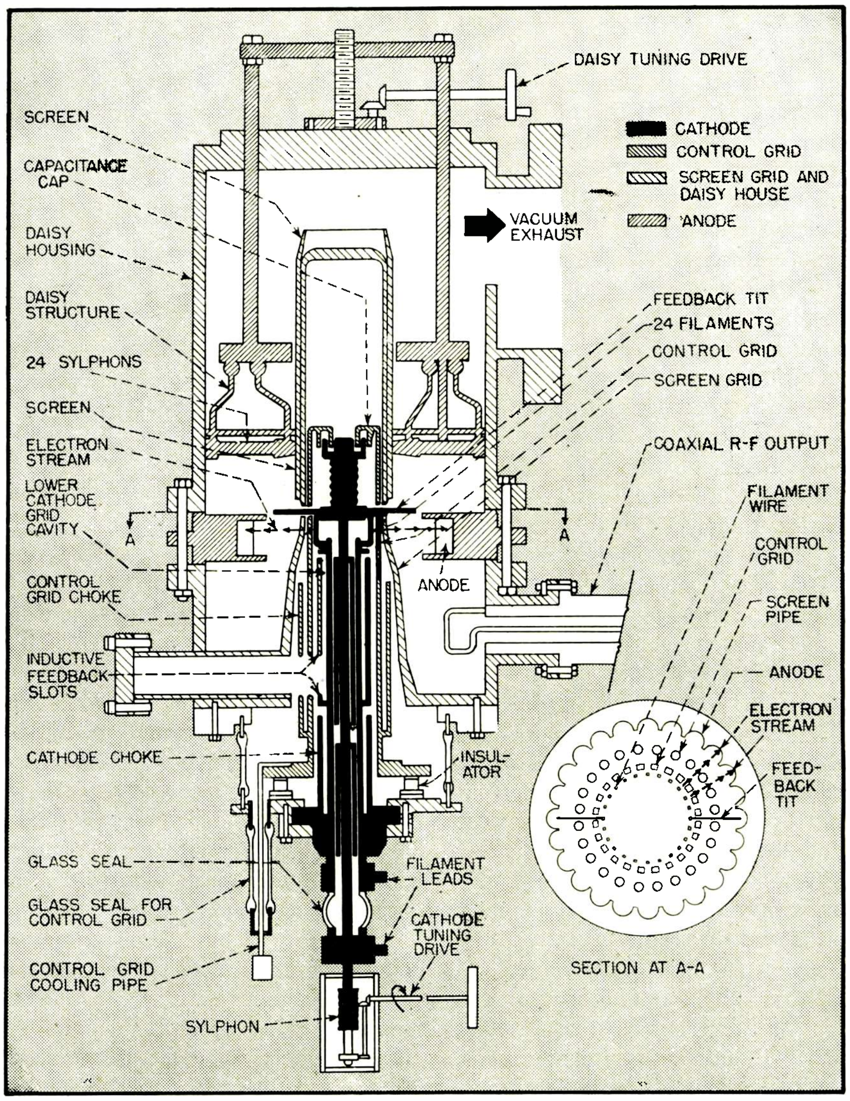


FIG. 2—Diagrammatic view of model 4 resnatron. Tuning drives adjust size of cathode and anode cavities, and permit adjustment while in operation over range from 350 to 650 mc

between the two cavities (between control grid and screen grid), preserve their shape until they deliver their energy to the anode cavity. In a triode structure, the bunches would quickly lose their shape after emerging from the cathode cavity, and the efficiency would be lowered. This effect has been noted in triode forms of the tube.

The accompanying cross-sectional view (Fig. 2) shows the internal construction. The emitter consists of 24 pure tungsten filaments about one inch long and made from 50-mil tungsten wire, ground to half-round shape so as to present a flat finished surface. These filaments are bent in the shape of a magazine staple and the ends hard-soldered in two copper rings. A filament current of 1,800 amperes at two volts is required to heat the emitter. The peak emission is in the neighborhood of 25 or 30 amperes.

The emitter is mounted on a copper water-cooled stand, which contains a resonant quarter-wave choke, at the bottom, of concentric quarter-wave cylinders. At the top is a sylphon-operated tuning structure operated by an extension line and external sylphon.

The control grid is a piece of copper tubing which fits over the assembly and is mounted on separate insulators. The quarter-wave overlap over the lower choke forms an effective by pass capacitor to prevent the leakage of power from the cathode cavity, while insulating the negative

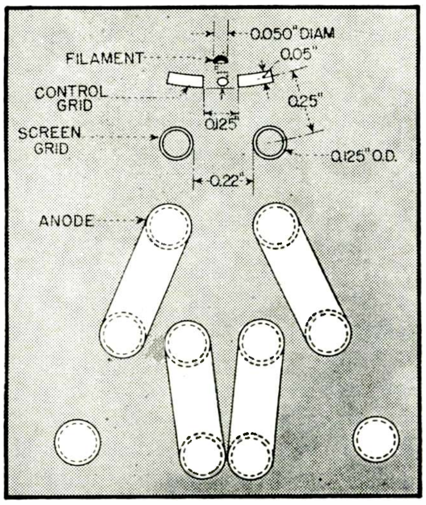


FIG. 3—Dimensions and arrangement of electrodes. Electrons are beam-formed and simultaneously bunched during passage between control grid and screen grid

grid voltage developed across the external grid leak. The grid consists of slots in the copper cylinder, opposite the filaments, so that each filament looks out through an unobstructed opening and electron control is carried on by focusing action entirely. The grid slots are somewhat longer than the filaments and about 100 mils wide and about 80 mils thick.

The screen grid is a copper tube structure which surrounds the control grid, mounted directly on the anode since the anode and screen grid are operated at the same d-c potential It is arranged to form, with the anode and its supports, a doubly-closed concentric line structure which has a resonance at approximately one half wavelength. This structure (the daisy) is tuned

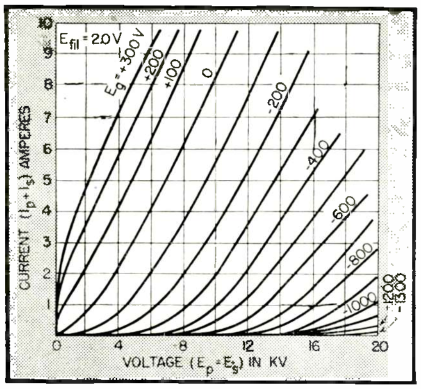


FIG. 4—Static plate characteristics of the model 4 resnatron, with screen grid and anode at same potential. Maximum continuous plate current is about 10 amperes

by a series of sylphons which extend radially around the screen grid and attach to the outer coaxial cylinder above the anode, thus forming a sliding short-circuit which can be moved by means of rods which protrude through vacuum seals at the top of the tube. A gear and screw arrangement allow the daisy to be readily moved by means of a tuning wheel from the outside of the anode structure. As the anode is operated at d-c ground potential, a metal hand wheel is satisfactory.

The output loop, at the end of a 50-ohm coaxial line of three inches outer diameter, extends to the lower part of the cavity between the screen grid and the anode. This rod leads to a glass output seal and matching plunger. The output seal consists of a cylindrical glass insert in the three-

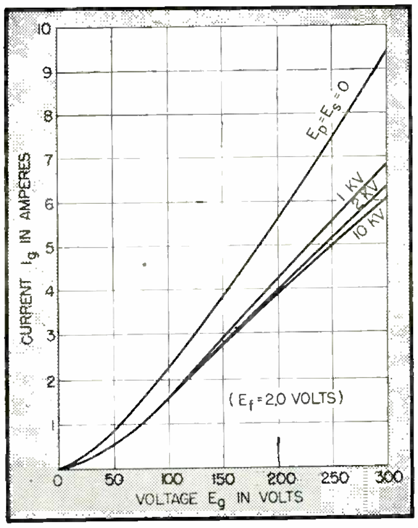


FIG. 5—Grid current characteristic of the model 4 resnatron, taken on static basis with screen grid and anode at same voltage

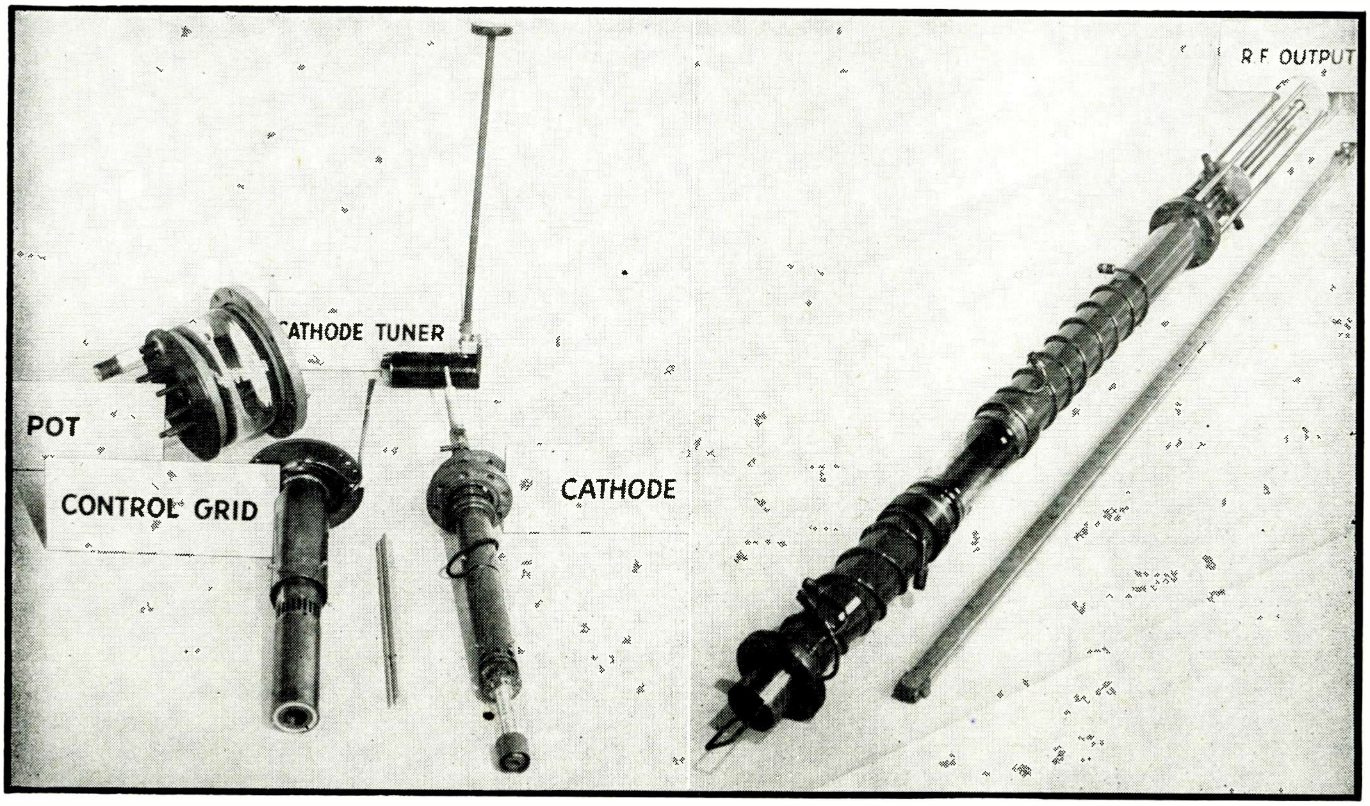
inch outer conductor of the coaxial line. This insert is made by sealing the glass to two cylindrical sections of Kovar, which are hard-soldered to copper ends and these in turn are soft-soldered to the outer conductor of the coaxial line. This is the only insulator in the r-f system and operates satisfactorily even at very high power providing an airblast cools the glass.

The glass section is inserted through the waveguide so as to reach across the small dimension, displaced an appropriate amount from the center of the guide. The arrangement provides an output impedance match from the coaxial line to the waveguide. The coaxial line is part of the vacuum system and the vacuum insulation seems necessary, as judged from earlier experiences with similar size lines.

The output seal has been very successful and has not failed in service except due to mechanical breakage. Power of the order of 80 kilowatts has been transmitted through it, even with high standing wave ratios, without any sign of failure. This is not intended to indicate that an output seal for these high powers and frequencies is an easy matter. Many attempts were made before this successful lead was perfected.

The output powers quoted were measured by means of temperature rise in measured water flows and include, in anode losses, all the losses in the resonant circuits.

An opening, similar to the output



Component structures of the cathode resonator and r-f output. Figure 2 shows the relative positions of the parts. The glass seal in the coaxial r-f output lead extends across the waveguide cross-section

opening, can be seen in the diagram (Fig. 2) which connects through the anode-screen grid cavity into the cavity between the control grid and the cathode. This is for amplifier input or for inductive feedback input. The capacitance feedback probes can be seen at the top of the cathode structure, just beneath the cathode tuning sylphon.

The filament and control grid assembly are mounted on an insulator made by sealing a glass tube about 8 inches diameter to two kovar cups about four inches apart. This insulator has only to insulate a d-c power supply to the tube. The control grid is mounted on a lavite insulator inside of this insulating cup and has its leadout and water-cooling pipes insulated by means of a small kovar glass seal about three inches long and one inch in diameter, which protrudes from the bottom of the supporting cup.

All parts of the tube are water cooled. Water pressure on the sylphons of the anode-screen grid tuning spider is largely responsible for the success of this tuning mechanism, as a steady pressure on both the inner and outer conductors of the anode resonant cavity makes this a low-loss connector. The anode water cooling was operated at 200 pounds pressure and with about 20 gallons per minute water flow. In the course of static curve tests, powers as high as 120 kilowatts have been dissipated on this small anode, which is about one inch high and about six inches diameter.

Typical operation of the tube is as follows: with an output of 85 kilowatts, 140 kilowatt input was utilized with 8 amperes of plate current at $17\frac{1}{2}$ kilovolts. The grid current is 1 to $1\frac{1}{2}$ amperes, depending on the adjustment, with a grid voltage of about 2,500 volts d-c average. The screen grid is operated at anode potential.

The whole tube structure is mounted on a large vacuum manifold which fits on the top of an eight-inch high-speed triple-jet diffusion pump. The diffusion pump is usually backed up by a large mechanical pump. This heavy-duty high-speed vacuum system is a great convenience in getting started again after changing a set of filaments or making any repairs due to mechanical damage. The anode, pumps, and output structure are at d-c ground. This necessitates that the filaments have an insulating transformer as they are the high-potential part of the circuit of the resnatron.

The tube can be easily operated for static tests by merely mistuning either the anode or cathode with respect to the other. Screen grid and anode currents were separated in static tests by means of a small insulating ring inserted between the anode and the supporting parts of the tuning structure.

The static tests taken on a typical tube are as shown in the accompanying diagram (Fig. 4, 5, and 6). It will be noted that they are all similar to any conventional tube. The inner structure of the tube operated as a triode has a maximum amplification factor of about 25.

Because of secondary emission, it is difficult to operate the resnatron at low power levels. At screen grid voltages below 2,000 volts, and especially at 400 volts, there is a strong emission of secondary electrons from the anode which gives a large dip in the characteristic curve. This electron current represents a heavy loading of the screen grid-anode cavity. Fortunately, at the high voltages used at high power levels, the secondary emission almost entirely

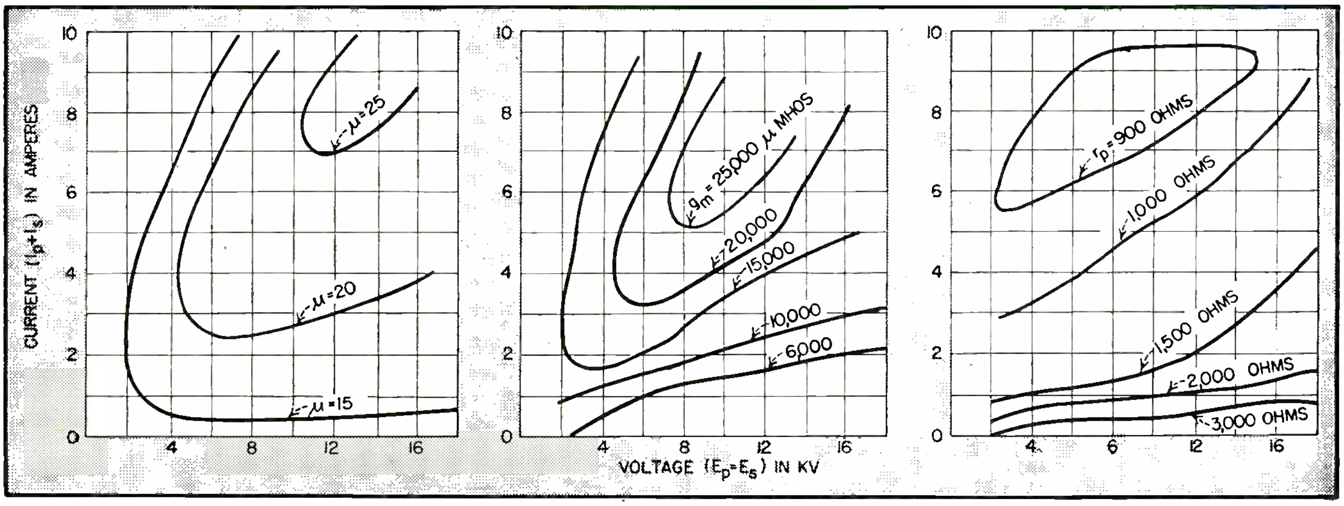


FIG. 6—Amplification factor (μ), transconductance (g_m) and dynamic plate resistance (r_p) contours plotted on plate voltage and current coordinates

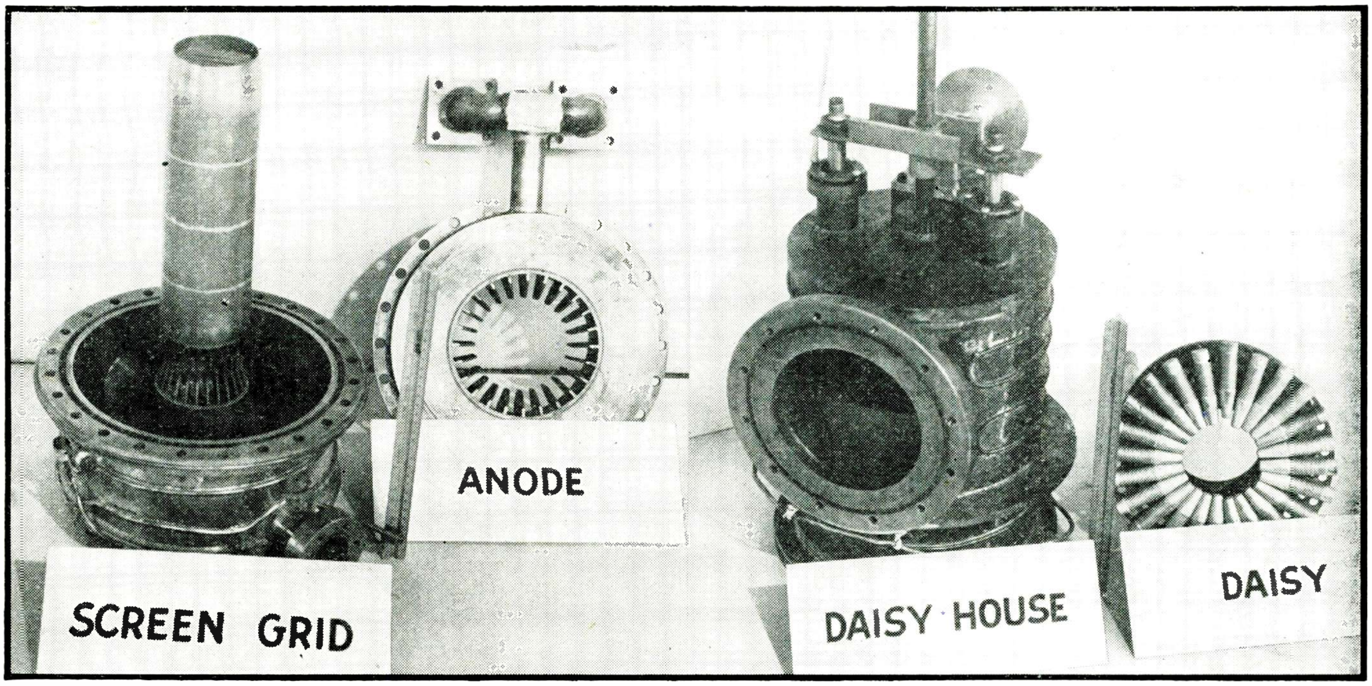
disappears and hence does not detract from the efficiency when the tube is operated at powers above about 10 kilowatts.

The resnatron will operate at reduced efficiency as a class B amplifier and could be used to amplify either amplitude-modulated signals or frequency-modulated signals. It can be modulated itself by either anode or grid modulation, although there may be some question about the linearity in case high-percentage modulation is used for grid modulation.

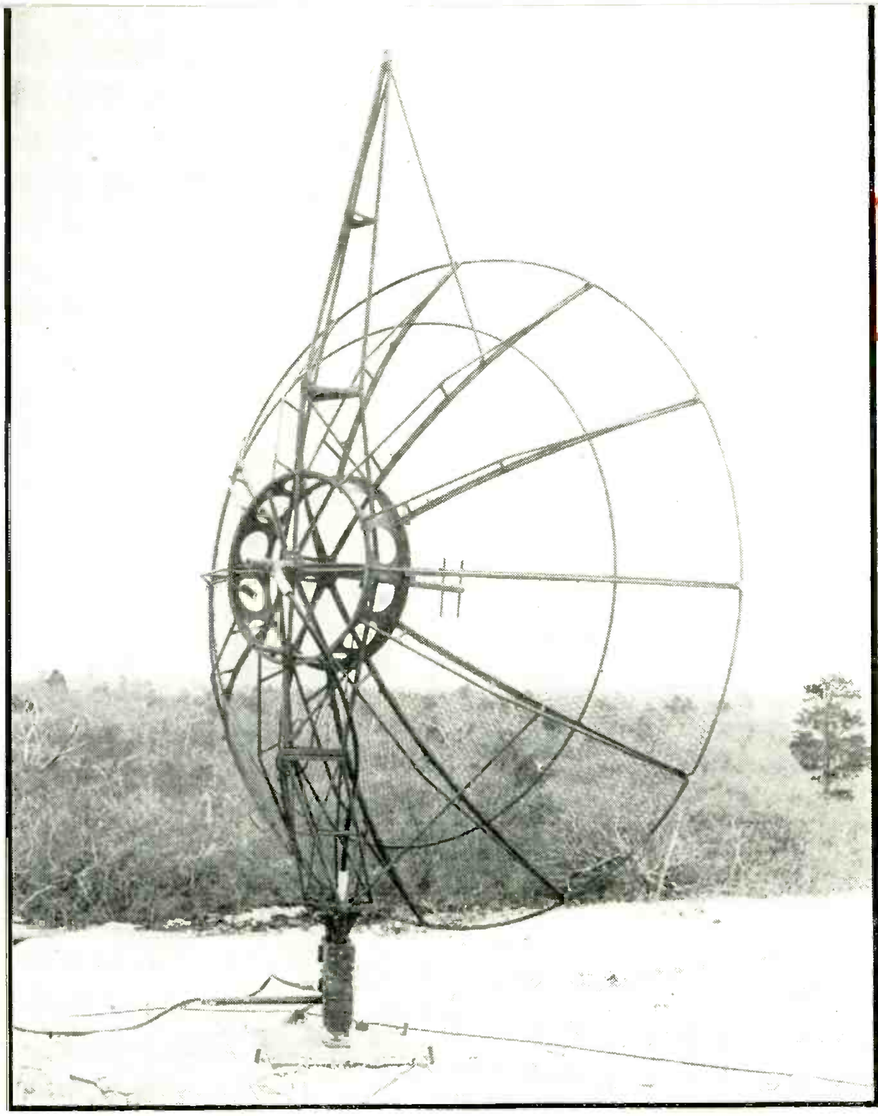
The principal limitation on frequency bandwidth is the required operating Q of the output cavity. The operating Q can vary between about 50 and 150, but if the lower figure is used, the efficiency is affected adversely. The limit of frequency possibilities for a resnatron type tube has not yet been completely explored. There seems no doubt that it would operate efficiently and successfully for powers of 50 or more kilowatts in the new f-m broadcast band. The author also feels strongly that the design could be pushed in frequency into the microwave region now used in radar, and that high c-w powers are possible in this region.

The use of the resnatron as a wartime device in the war just ended is a long subject and must be referred to the future. However, the building and operation, in the field, of a 50-kilowatt radar jamming transmitter mounted on trucks and with each outfit capable of operating two tubes simultaneously at 50 kilowatts output was a large and exciting undertaking.

It is sincerely hoped that this development, which has been so greatly stimulated by war, will continue on to be a useful and important peacetime development. It should have important applications to the f-m broadcast and television field.



Elements of the anode cavity. The daisy forms the top of the anode resonant cavity and is moved within its house in tuning the output. A similar system permits tuning the cathode cavity



RADAR

By LT. COL. HAROLD A. ZAHL
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and

MAJOR JOHN W. MARCHETTI
AAF Watson Laboratories, Red Bank, N. J.

Close-up of antenna, showing remote indicating gear at base, permitting antenna to be separated 100 feet from operating position. Since the antenna was a favorite target, separation protected crew

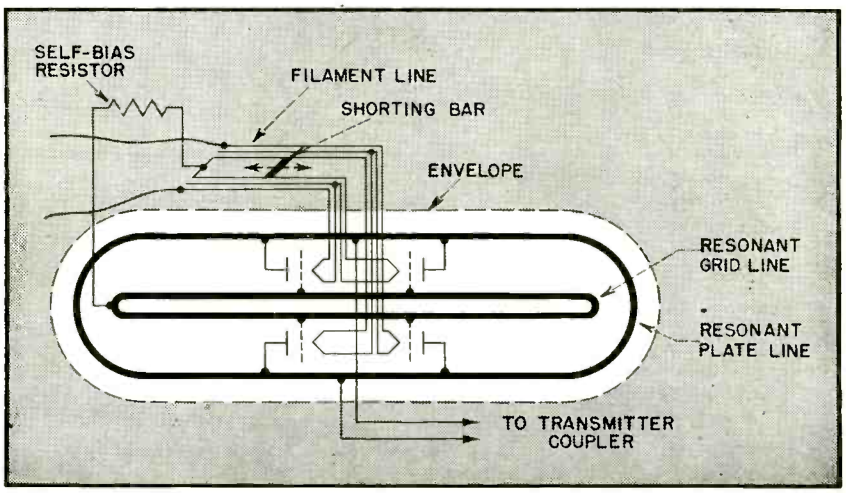


FIG. 1—Schematic of the internal-circuit triode oscillator. Four triodes are connected directly to resonant grid and plate lines within the tube

THE TRANSMITTER of the AN/TPS-3 radar is a single-tube oscillator employing a tube specially developed for this frequency by the first named author. It consists of four triode sections connected in push-pull-parallel as shown in Fig. 1. These sections are connected together by means of tuned grid and plate lines entirely contained within the glass envelope. The r-f output is brought from the tube by two leads connected to each side of the plate line at its maximum voltage point.

The grid line is situated directly below the plate line and is therefore coupled to it. A lead from each end of this line, at its zero voltage points, is brought out of the tube. Grid bias is applied to either one of these leads.

Each of the four thoriated tungsten filaments is brought out independently and they are tied together externally by another section of transmission line. By properly adjusting the length of this filament line the tube may be made to operate over a frequency band of 590 to 610 mc. Grid bias is developed by connecting a resistance of the proper value between one of the grid leads and the zero voltage point of the filament line.

The tube operates as a push-pull triode oscillator in a tuned-grid tuned-plate circuit. The most efficient means of coupling to the tube is to connect the transmission line directly to the plate leads. For safety reasons, the transmission line must be held at d-c ground potential. This requires the plates to be held at d-c ground and the keying voltage must be applied negatively to the filaments.

Although the tube has operated satisfactorily at 30 kv, the normal operating voltage in the AN/TPS-3 is 24 kv. This voltage is applied to the filaments in negative pulses of

ON 50 CENTIMETERS

Details of transmitter, receiver and indicator systems of the TPS-3 600-mc early-warning radar are presented in this concluding installment. The transmitting tube contains tuned circuits within the envelope, and is modulated by a rotary spark gap

1.5 microseconds duration, occurring at the rate of 200 per second. This means that the transmitter is operating only 0.03 percent of the time. During this operating time it produces r-f power at a rate of 200 kw, but the average power produced is only 60 watts. The high peak power requirement puts a stringent demand on filament design, since the filament must be large enough to provide sufficient emission to allow the production of 200 kw. The filaments consume 400 watts of heating power.

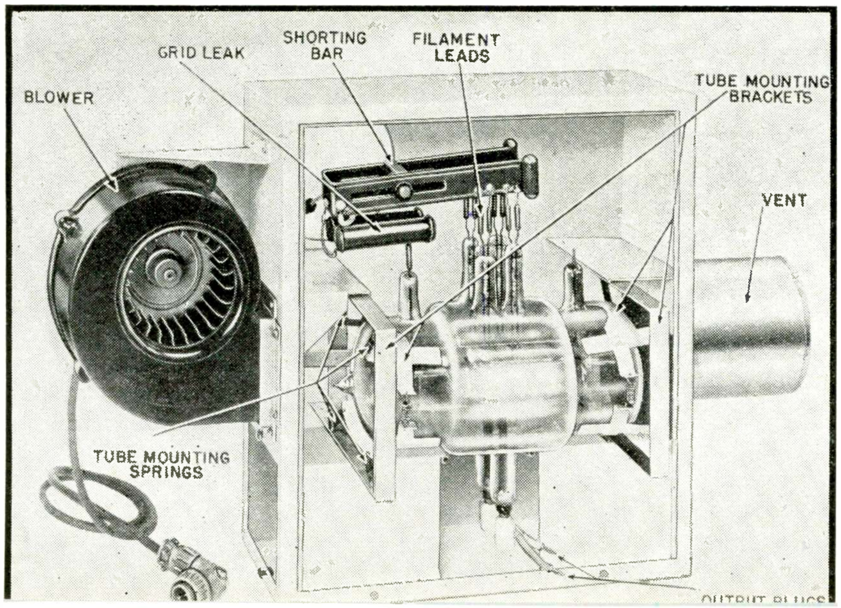
Another unusual feature is the large interelectrode spacing. If it were not for the high voltage employed, this would mean a prohibitively long transit time at 600 mc and the tube would operate very inefficiently. As a matter of fact, the tube will not oscillate until the voltage exceeds about 5000 volts. This means that the tube cannot be used as a cw oscillator since the plate dissipation would be far too high. Under the pulsed conditions the tube operates at 25 to 30 percent plate efficiency.

The modulating system consists of a modulator unit, a pulse transformer, and a rotary spark gap mounted on the shaft of the power unit. A functional schematic of these units is shown in Fig. 2. The modulator and power unit are placed 50 feet from the console of the radar and connected to it by cables. The pulse transformer is in the console, situated next to the transmitter, and is connected to the modulator by 50-ohm flexible coaxial cable.

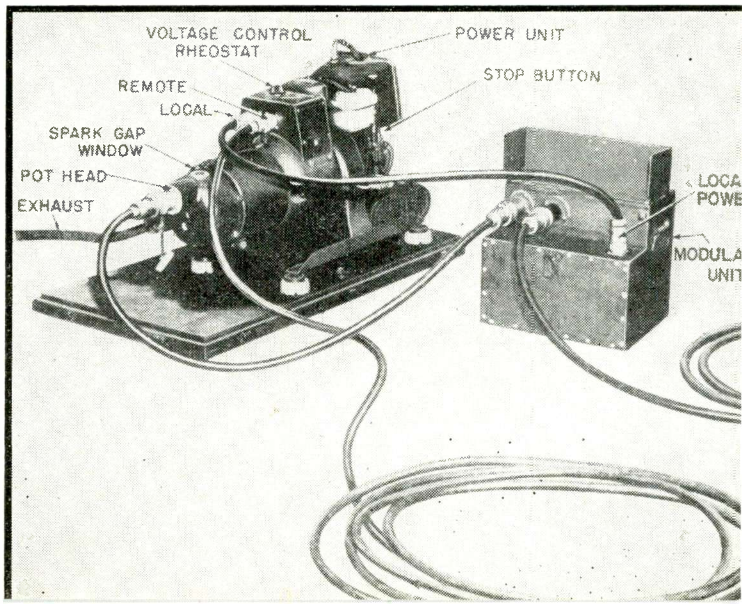
The Modulating System

The modulator proper consists of a conventional voltage doubler, a charging choke and a pulse-forming artificial transmission line. The voltage doubler produces 8000 volts, negative d-c, across the terminals of its filter capacitors and applies it through the charging choke to the five parallel capacitors of the pulse line. These form a series-resonant circuit with a half period of 5000 microseconds. When the 8000 volts is applied to this combination the voltage on the capacitors builds up slowly. In 5000 microseconds it reaches twice the applied voltage, or 16,000 volts negative. When the pulse line is shorted to ground, it discharges through the primary of the pulse transformer in a period of 1½ microseconds. The time of discharge is determined by the constants of the line, i.e., the values of the capacitances and inductances. These constants are adjusted so that the characteristic impedance of the line at the pulse frequency is 50 ohms. Since the pulse line is connected to a 50-ohm load, half of the total voltage will appear across the load and half across the pulse line.

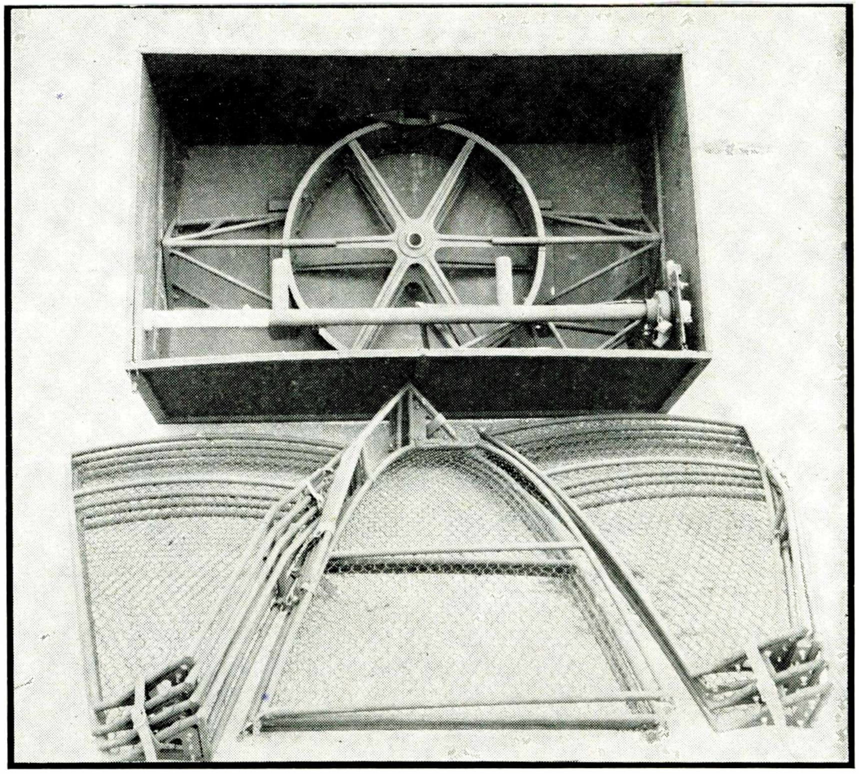
The pulse transformer has applied to its primary a rectangular pulse



Interior view of transmitter, showing VT-158 internal-circuit tube. The corresponding schematic circuit is shown in Fig. 1. The output is taken directly from the plates, at d-c ground potential. Negative modulating pulses are applied to the filament



Power unit and modulator. A three-pole rotary spark gap, mounted on the shaft of the 400-cps primary power alternator, discharges the pulse-forming circuit at 200 pulses per second



Antenna disassembled and packed for transport. All major components can be broken down into small packages, each capable of being carried by a man

of 8000 volts amplitude, 1.5 microseconds long. This transformer is designed with a very low leakage inductance and low losses so it will pass high frequencies efficiently. The ratio of primary to secondary is 1:3 so that the secondary voltage will be −24,000 volts. Figure 2 shows two windings on the secondary of the pulse transformer. These are actually two parallel windings insulated from each other, and carry the filament current for the transmitter tube. This allows the use of a filament transformer without high-voltage insulation. A separate winding of very few turns on the pulse transformer produces a 400-volt negative pulse which is used as a trigger to control the circuits in the indicator.

The switch that short-circuits the pulse line is a rotary spark gap mounted on the shaft of the power unit. The power unit is a 12-pole 400-cycle alternator operating at 4000 rpm. Since the spark gap has three segments, the pulse line will be short-circuited three times per revolution, or 200 times per second. The high voltage point of the pulse line is connected to a single stationary tungsten pin in the housing of the spark gap. A metal disc fixed to the shaft of the alternator carries three tungsten pins, spaced 120 deg. apart, past the stationary pin. A carbon brush riding on the metal disc provides a low resistance path to ground. When one of the rotating pins approaches the stationary pin, the 16,000 volts on the stationary pin breaks down the air between them and provides an ionized path through which the pulse line discharges. Between pulses the voltage doubler and charging choke again charge up the pulse line to −16,000 volts. The wave shape of the voltage on the pulse line and the wave shape of the voltage on the primary of the pulse transformer are shown in Figure 3.

It is interesting to note the magnitude of the instantaneous currents and powers flowing in some of these circuits. For instance, the transmitter tube is known to have an impedance of 450 ohms to direct current. Since the applied voltage is 24,000, the direct current flowing through the transmitter tube during the pulse is approximately 50 amperes and the plate power is approximately 1.2 megawatts. The current in the primary of the pulse transformer and the rotary spark gap is 150 amperes.

Receiving and Indicating System

The receiver is conventional, operating on the superheterodyne principle. It differs from an ordinary receiver only in the wide bandpass and in the low noise figure. The optimum bandwidth for a receiver to be used with a 1.5 microsecond pulse is the reciprocal of the pulse width, or 0.66 mc; however this optimum is not very critical and the actual bandpass of the receiver is approximately 1.25 mc.

The noise figure of a receiver can be considered as a comparison of the actual receiver with a perfect receiver. Since the radar must operate on extremely small signals, the gain of the receiving system is usually high, so that noise is always present in the output circuit. The amplitude of this noise is the limiting factor in the size of the signal that is discernible. The output circuit of a perfect receiver will have present in it only the amplified thermal noise in its input circuit. An actual receiver has, in addition other noise, such as shot noise, generated within

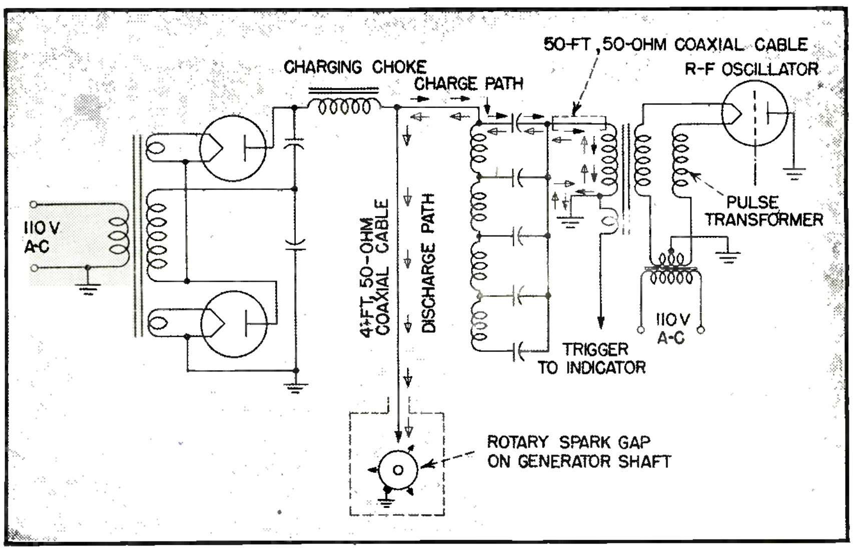


FIG. 2—The modulator circuit. The voltage doubler charges the *LC* network (pulse-forming artificial transmission line), which is discharged through the r-f oscillator by the rotary spark gap

the receiver itself. The noise figure is a method of comparing the actual noise present to the noise that would be present if the only source were the passive resistance of the input circuit. The noise figure is expressed in db and is independent of the impedance of the input circuit or bandwidth and is therefore a figure of merit of all radar receivers. The receiver of the AN/TPS-3 has a noise figure of approximately 10 db.

Figure 4 is a block diagram of the receiver. The first two stages are

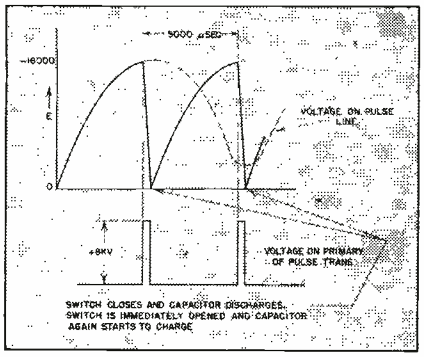


FIG. 3—Waveforms in the modulator circuit. Resonance charging is employed to reach 16,000 volts across pulse line, which is discharged at peak of cycle

radio-frequency amplifiers tuned to 600 mc, employing grounded grid triodes. The local oscillator is injected into the cathode circuit of the second r-f amplifier and the converter is a silicon crystal in the plate circuit of this stage. The converter output feeds into an i-f amplifier consisting of six stages, followed by a diode detector and a video amplifier whose output is then fed into the indicator. There are also several special circuits built into the receiver to eliminate interference caused by the enemy as countermeasures. These are known as antijamming circuits.

The indicator circuits divide themselves into four sections. These are the video circuits, the type-A indicator sweep circuits, the plan position indicator (ppi) sweep circuits and the marker circuits. The type-A presentation sweep circuit shown in Fig. 5 begins with a one-shot multivibrator that produces negative square waves. By means of a switch, the length of the square wave can be set to 200, 600, and 1200 microseconds. The square wave is applied to a sweep generator which produces a linear sawtooth wave of the same period as the square wave. The sawtooth is amplified by a pair of cascade amplifiers and applied to the horizontal plates of the A-scope.

The ppi presentation, (Fig. 6), starts with its own independent multivibrator, also adjustable over the same three ranges as the A-scope. This allows the range presentation of the A and the ppi-scope to be set independently. The ppi multivibrator is fed into another sawtooth generator and a single stage preamplifier. The preamplifier drives the primary of a rotary transformer, each of whose two secondaries are connected through amplifiers to one pair of magnetic deflection coils on the ppi tube. The rotary transformer is essentially a two-phase motor with a single-phase rotor which is rigidly connected to the antenna.

As the antenna rotates the rotor must follow. This induces sawtooth voltages of varying magnitude in each of the two secondaries on the stator. The voltages in each of the two stator windings are in time phase, but are 90 deg apart in space phase; i.e. when the voltage in one winding is a maximum, the other is a minimum. These voltages are amplified and applied to the deflection yokes of the ppi tube. The result is a radial sweep which rotates about the center of the tube in synchronism with the rotation of the antenna. By pointing the antenna toward true north and then adjusting the position of the stator until the sweep line points to 0 deg on a graduated scale around the face of the tube, the sweep line is made to indicate true antenna position.

Both the A-scope multivibrator and ppi-scope multivibrator are triggered by the pulse generated in the third winding of the pulse transformer, so that the sweep line in both tubes always begins the instant voltage is applied to the transmitter. Although the voltage on the transmitter only lasts for 1.5 microseconds, the sweep line in each tube continues for the length of time determined by the setting of the controlling resistor in its multivibrator.

Of special interest in the ppi sweep circuit are the precautions taken to have the sweep line begin every sweep exactly at the center of the tube. This is accomplished by a clamping circuit. Each of the magnetic deflection yokes of the ppi tube are driven by a pair of amplifiers in push-pull. The grid of each push-

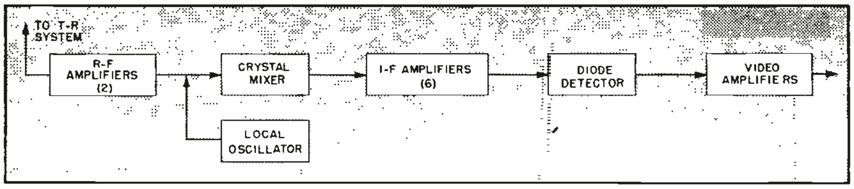


FIG. 4—Block diagram of receiver. At 600 mc, useful gain can be obtained by preamplification before the mixer. The nominal bandwidth of the i-f amplifier is 1.25 mc

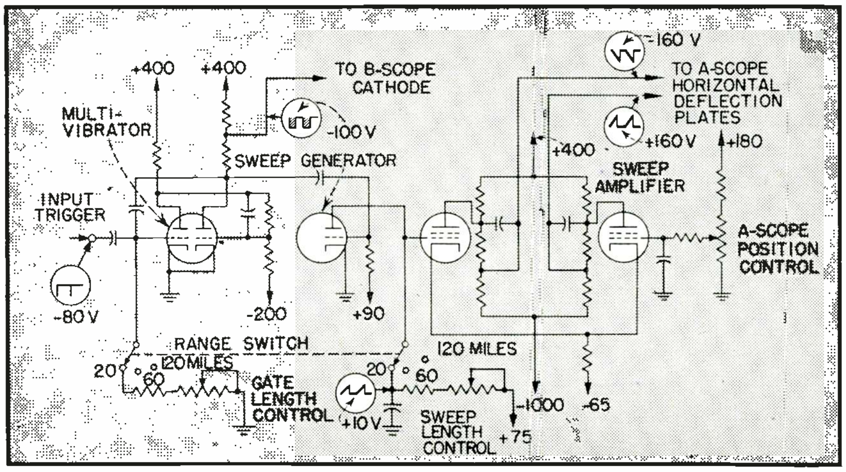


FIG. 5—Simplified schematic of sweep circuit for type-A indicator

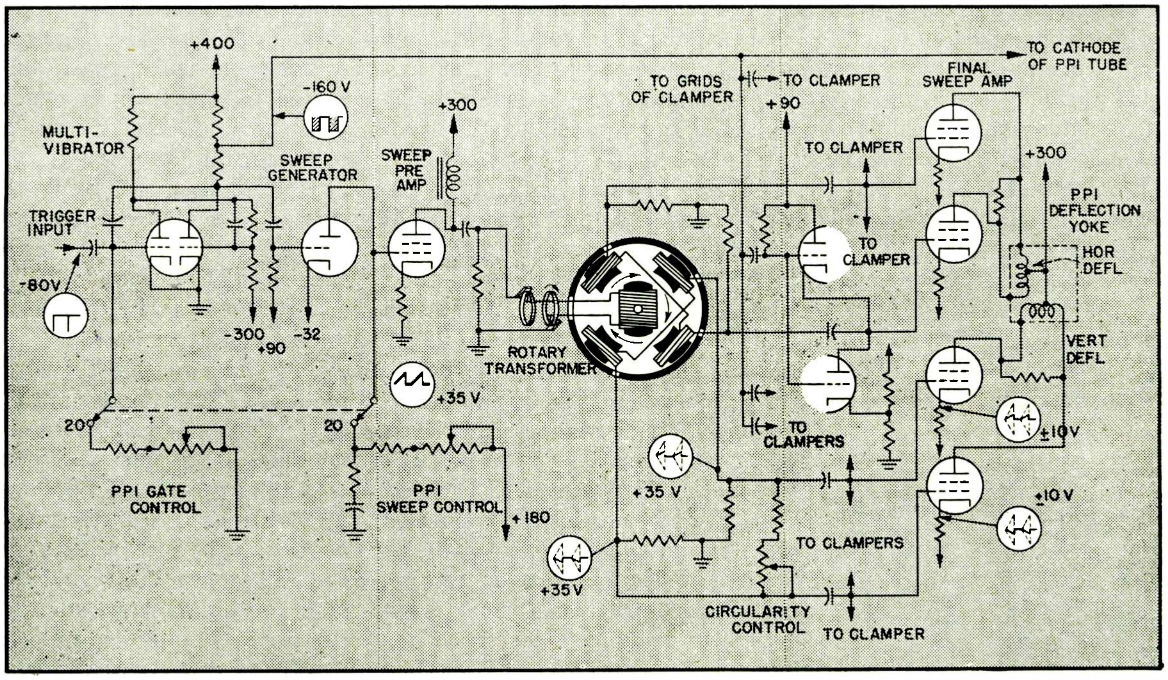


FIG. 6—Simplified schematic of sweep circuit for plan position indicator. Rotor of rotary transformer is connected to antenna drive, so direction of deflection corresponds to antenna position

pull amplifier is connected to a pair of clamping tubes as shown in the functional schematic. The grids of the clamping tubes are tied to a high positive voltage so that the clampers are normally practically short-circuited. This keeps the grid of each of the push-pull amplifiers at a fixed potential determined by the voltage drop through the clampers and the resistance from the cathode circuit of the lower clamper to ground. When the sweep voltage is applied to the grid of the amplifier a portion of the square wave from the multivibrator is also applied to the grids of the clampers. This being negative, the clampers are cut off and the grid of the amplifier is allowed to rise linearly with the sawtooth. At the end of the sawtooth the square wave also is ended and the clampers are once more short-circuited, bringing the amplifier grids back to the same fixed potential.

Separate video channels, Fig. 7, are provided for the A-scope and ppi-scope. The A-scope video is a single stage amplifier whose output is connected to one vertical plate of the A-scope. The ppi video channel is somewhat more complicated, since the signals are applied to the ppi tube as intensity modulation and their levels must be accurately controlled. The amplifier consists of two stages in cascade which act as amplifiers

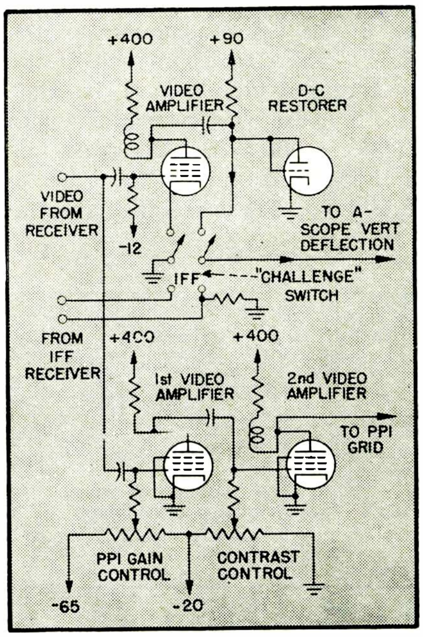


FIG. 7—Video amplifiers for A-scope and ppi. The ppi stages limit the pulses to avoid blooming and loss of contrast

and clippers. By controlling the bias on these two stages the maximum and minimum signal level can be controlled, giving control of gain and contrast. The output of this two-stage amplifier is connected to the control grid of the ppi tube.

The unoccupied deflection plate of the A-scope tube is connected to the output of the marker circuits. These circuits produce marker pulses which resemble echoes, spaced at even intervals along the A-scope and ppi-scope sweep line. The markers are spaced 107 microseconds apart, representing 10 miles. Every fifty-mile marker is somewhat longer than the others. The marker circuits begin with a multivibrator which is triggered from the same source as the sweep multivibrators and produces a square wave of fixed length equal to the maximum range of the presentations. This square wave is applied to a normally quiescent oscillator whose tank circuit is adjusted to 93 kc. The resultant oscillations have a period of 107 microseconds. These are then amplified, squared, and clipped as shown in Fig. 8. The resulting markers are then fed into one half of a mixer tube, the other half of which is fed by one-shot multivibrator flip flop circuit whose constants are adjusted to $\frac{1}{5}$ the frequency of the 10-mile markers. This circuit is driven from a point in the 10-mile marker circuit and produces a longer marker at every fifth 10-mile marker. The output of the mixer tube is fed directly to the A-scope and through a buffer amplifier to the control grid of the ppi scope. On the A-scope the markers appear as downward deflections along the sweep line, giving the impression of a marked scale. On the ppi scope they appear as bright spots along the sweep line, giving concentric circles as the sweep line rotates. The range of any target may be measured at once on either the A-scope or the ppi-scope by noting its position with respect to the markers.

Since the maximum sweep length of both tubes is only 1200 microseconds and the total time between successive r-f pulses is 5000 microseconds, some means must be provided to extinguish both tubes during the period when no sweep is present. This is accomplished by applying the square wave in each multivibrator to the cathode of its scope. The square wave turns on the c-r beam only during the time of each sweep.

FIG. 9—TPS-3 with separation kit in place. The antenna at left is the iff radiator, used to identify friendly planes

Recent Modifications

After the AN/TPS-3 had been in production for some time, field reports indicated that certain changes would be desirable. The most important of these was some means of protecting the operator, since it developed that radar antennas were a favorite target for strafing enemy planes. Accordingly, Evans Signal Laboratory designed and produced a pedestal upon which the antenna could be mounted 100 feet from the set. This pedestal contained only the antenna drive motor, the rotary transformer and a means of connecting r-f power to the antenna. It was connected to the radar set by a control cable and flexible 50-ohm cable of large enough diameter to carry the peak r-f power. This allowed the set itself and the operators to be dug into a fox hole or any other available shelter leaving the antenna unrestricted. Fig. 9 is a photograph of a test setup showing the separation kit.

Acknowledgment

The authors wish to acknowledge the cooperation of many individuals in commercial concerns who assisted in the realization of this equipment. In particular, it is desired to acknowledge Dr. Irving Wolff and Martin Richmann of RCA for their contributions on the receiver, W. Eitel and J. McCullough of Eitel-McCullough for their assistance on the VT-158 internal-circuit transmitting tube, W. Schwam and N. Aram of Zenith Radio Corporation, J. Knezo and H. Bolton of Breeze Corporation, Dr. S. Mauntner of Skydyne Corporation and A. Newman of Homelite Corporation.

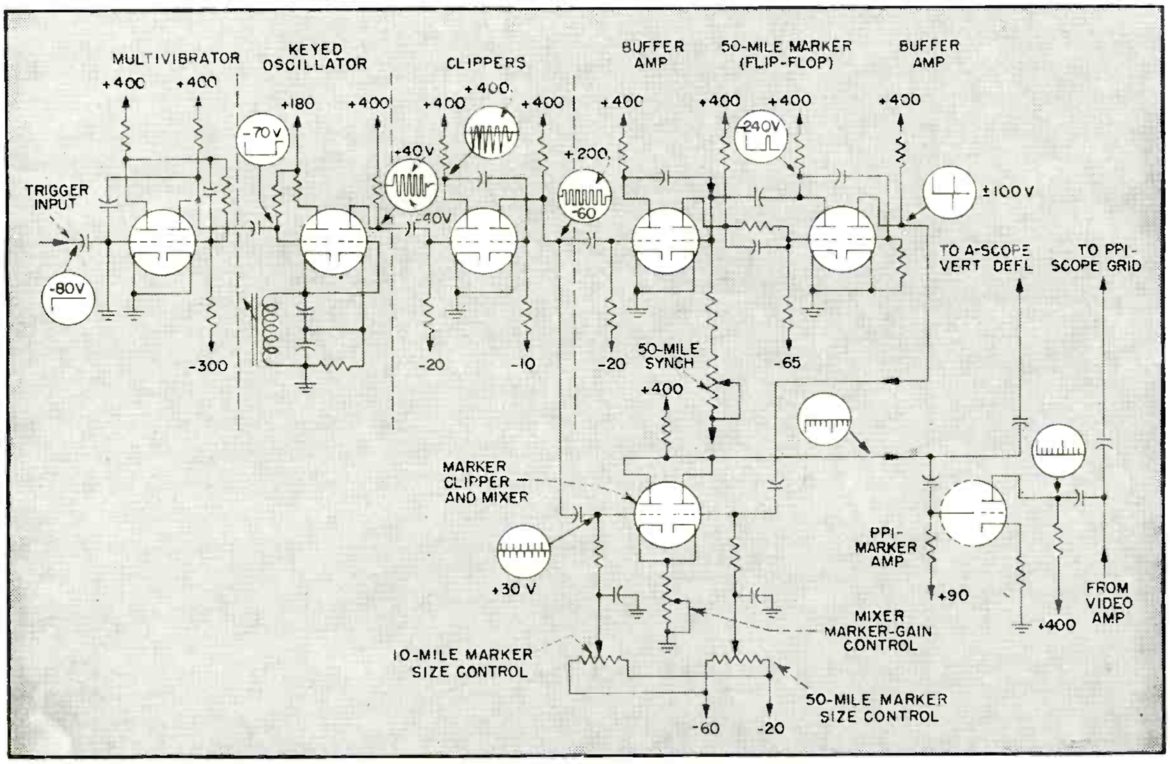


FIG. 8—Simplified schematic of marker circuits, which produce vertical calibration marks on A-scope, concentric range circles on ppi

Proximity Fuzes

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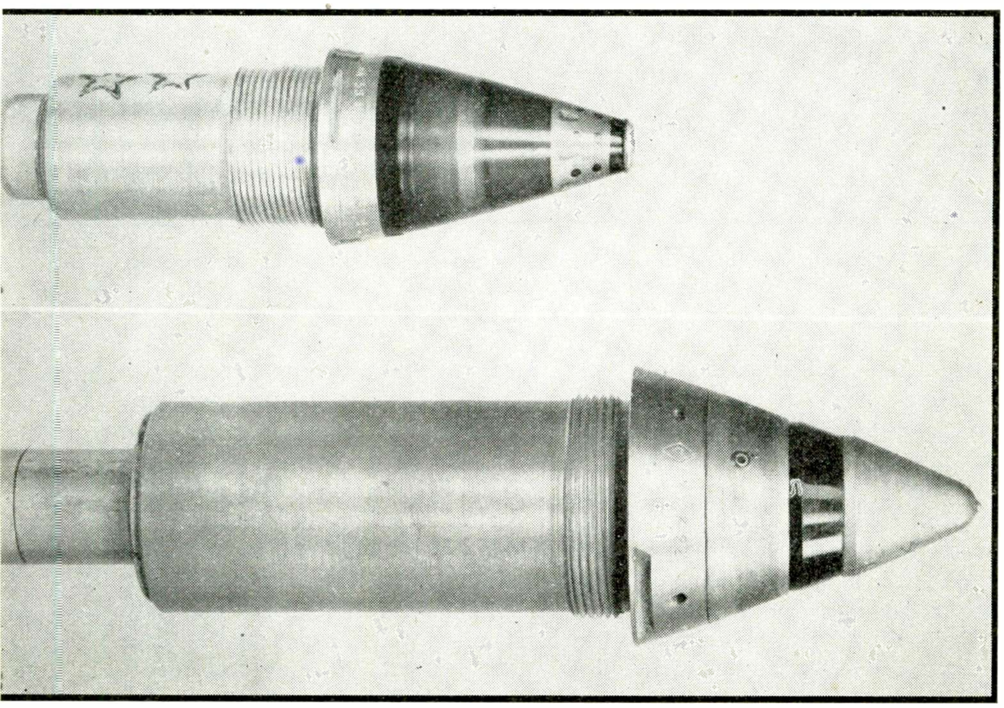


FIG. 1—Two examples of the artillery-type fuze. The antenna is the conical segment in the nose, insulated from the fuze proper by a rugged plastic

THE recent relaxation of security regulations by the Army and Navy on the VT (radio proximity) fuze now permits the presentation of the engineering problems involved in the design and production of this device which may be of interest to electronic and radio engineers.

Fundamental Circuit Problems

The design of the antenna for the proximity fuze must be very closely coordinated with oscillator and detector designs. Aside from the loading of the oscillator and detector the antenna must be such that it will radiate the energy from the oscillator in the proper direction. The requirement is that the energy from the antenna be concentrated in a beam whose shape roughly matches the fragmentation pattern of the projectile. The shape of this radiation pattern depends upon the size and placement of the antenna as well as the dimensions of the projectile and the frequency. Antenna radiation patterns for proximity fuzes were shown and discussed in some detail in a prior article.[1]

The usual arrangement was to have the nose of the fuze made of an insulating material with the antenna in the form of a conical metal piece mounted directly in the nose. Bakelite, polystyrene, methyl-methacrylate, and ethyl cellulose plastics were used as insulation in various models. The latter material was used most extensively, because its extreme toughness would better resist the rough handling given the fuzes in the ammunition hoists and loading mechanisms. This designation of the nose cap as the "antenna" is admittedly arbitrary, since currents are induced in the metal body of the projectile itself, causing it to radiate energy which combines with that from the cap to form the resulting pattern of energy in space. The first fuzes which were used against Japanese planes by the United States Navy had an external cast aluminum cap for an antenna as shown in Fig. 1B. This proved to be undesirable mechanically, and was soon superseded by a molded-in metal insert which can be seen through the transparent plastic in Fig. 1A.

electronics WAR REPORT

A simple one-tube oscillator is provided for the transmitter of the fuze. The energy radiated by the antenna strikes the target and is reflected back and picked up on the transmitting antenna. It is then detected and amplified to provide the signal for triggering the fuze. A separate detector may be used, but in the artillery fuze, space was at such a premium that the oscillator used for transmitting was also used as the detector. This is essentially a regenerative detector. If an oscillator is connected to an antenna, an object moving into the radiated field will cause a change in plate current of the oscillator tube. This change in current will cause a voltage to appear across any impedance in the plate circuit. A conventional type of Hartley oscillator, such as is used in other radio applications, is shown in Fig. 2, with an impedance Z in its plate circuit.

Operation of the fuze circuit is comparable in principle to a number of suggested alarm systems in which a standing-wave pattern is set up in the area to be protected. Movement of a person in the area changes the loading on the transmitter or a receiver, operating an alarm actuated by changes in plate current. The proximity fuze differs in that an alternating current appears at the plate circuit impedance, Z, owing to the Doppler effect, as the projectile approaches the target.

Even in the case where the projectile is approaching a good reflecting

for Artillery

The artillery fuze, unlike the bomb and rocket fuzes previously described, must withstand the acceleration of gunfire, up to 20,000 times that of gravity. Circuits and components to meet this requirement are described

surface such as the ground, or salt water, the signal developed across the oscillator plate impedance is not sufficient to operate the thyratron reliably. It is therefore necessary to amplify this signal, and this may be done in an amplifier utilizing either pentode or triode tubes depending upon the gain required. Adjustments of amplifier gain, of course, determine to a considerable extent the sensitivity of the fuze in the presence of nearby objects. Such an amplifier can be also peaked to eliminate, or minimize, tube microphonics and extraneous noise. For small size and compactness, a resistance-coupled amplifier may be used. A conventional amplifier of this type is shown in Fig. 2.

It is necessary for the incoming signal to operate an electric blasting cap which in turn sets off an auxiliary detonator which then explodes the main charge. The time for this complete series of operations is less than one millisecond. The electric detonator is fired by means of a thyratron, operating as a switch, which connects the plate-supply voltage through the detonator. The thyratron grid is normally biased several volts negative to prevent its conducting in the absence of a signal. The incoming signal from the amplifier is impressed on the thyratron grid and when its peak value has driven the thyratron grid sufficiently toward the positive region, the thyratron ionizes, passing current through the detonator and exploding it.

Figure 2 shows a typical firing circuit with a capacitor C, and a resistor R_B, in the thyratron plate circuit. This RC combination is a safety feature which keeps the fuze inoperative for a short interval at the beginning of flight. Before the projectile is fired, the capacitor has no charge, and the battery voltage is zero. Voltage is applied at the moment of shooting and the capacitor starts to charge. The thyratron cannot conduct and fire the detonator until the voltage on the capacitor has risen to a predetermined value. This can be controlled by changing the

TWO TYPES OF VT FUZE

The generator-type proximity fuze, described by Drs. Huntoon and Miller in the December issue, was designed for low-acceleration projectiles, such as rockets, and bombs, by the Ordnance Development Division of the Bureau of Standards. The battery-operated fuze, described here by Dr. Selvidge, is intended for the high-acceleration projectiles, such as howitzers and anti-aircraft shells. It was designed by Section T of the OSRD at Johns Hopkins. While the principles of operation are the same, the two fuzes represent radically different design problems.

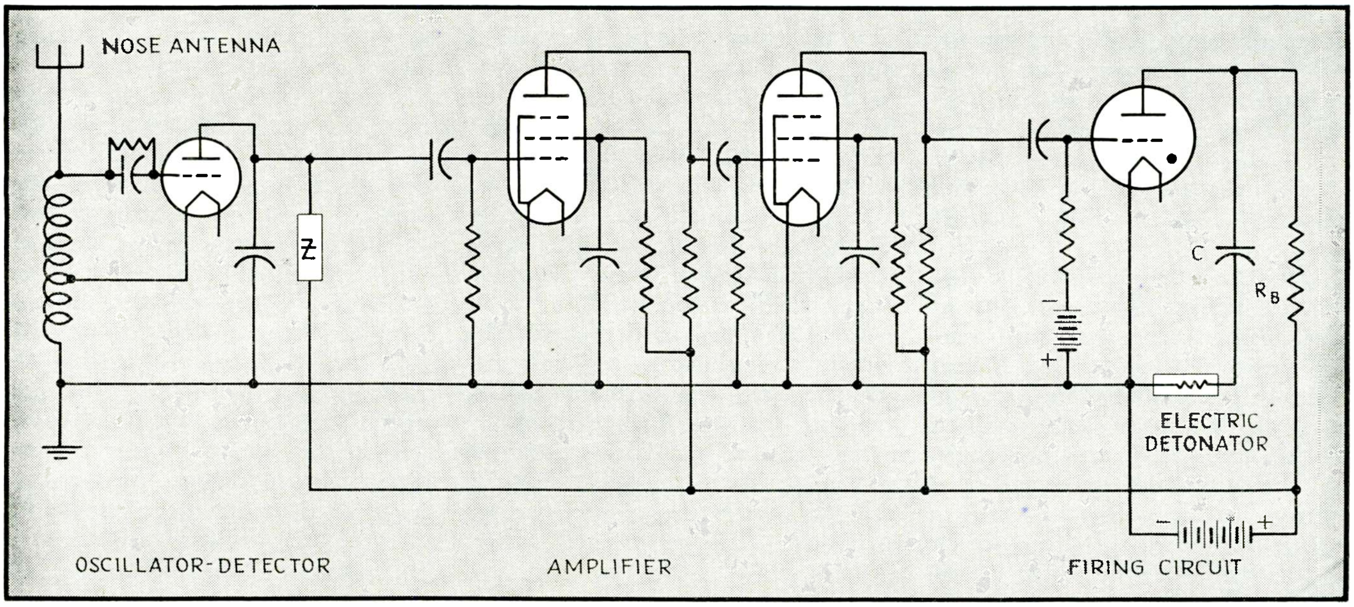


FIG. 2—Schematic of the four-tube fuze circuit, consisting of a transmitter-detector, two-stage audio amplifier and thyratron switch. Circuit values have not yet been released

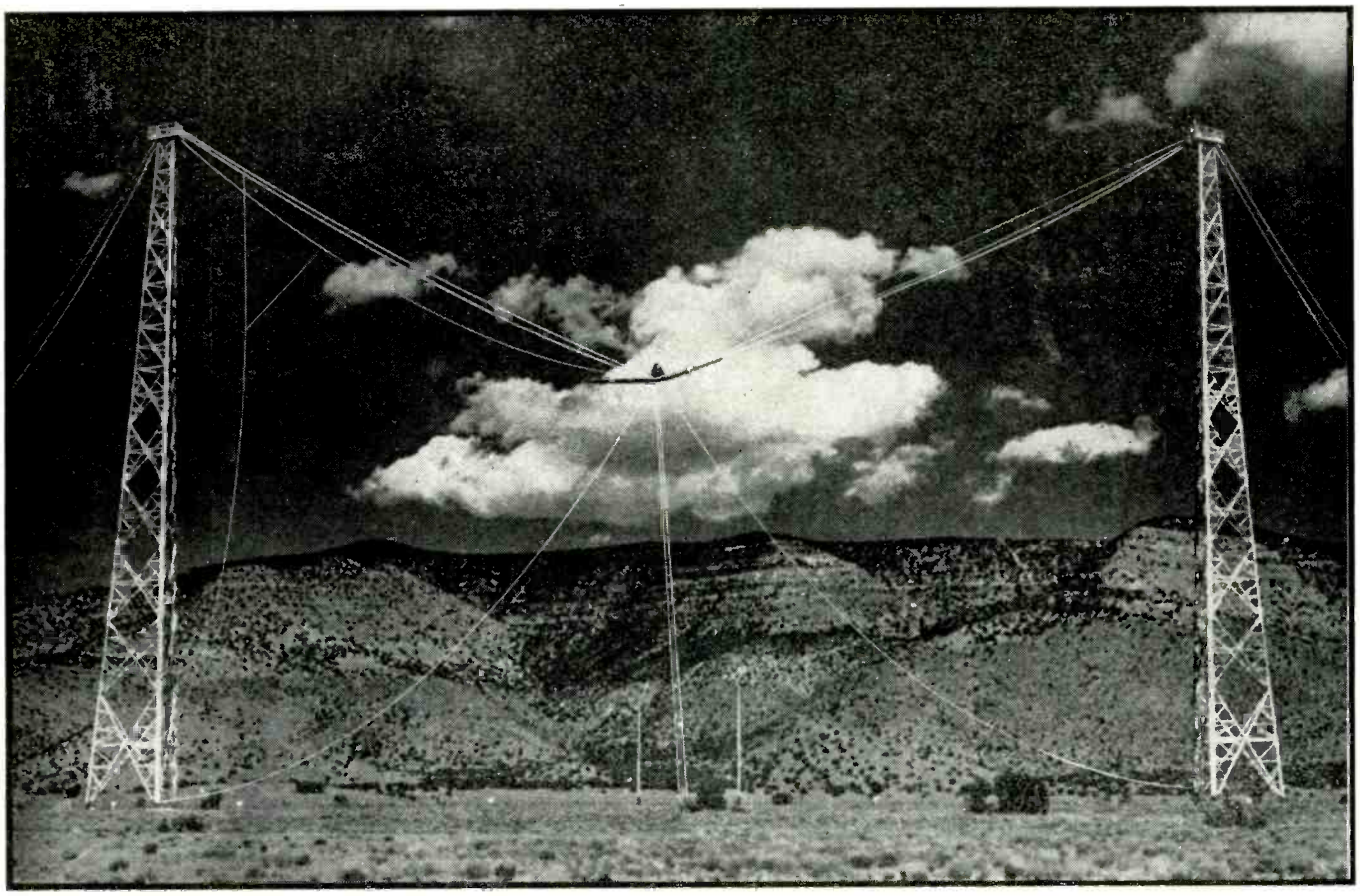


FIG. 3—Testing station near Albuquerque, N. M. showing aircraft suspended between towers for firing tests of anti-aircraft fuzes

RC time constant of the circuit and affords an electrical delay safety feature.

Fuse Testing

Quality control and engineering tests were carried on at a proving ground operated by the University of New Mexico, near Albuquerque. Actual airplanes, allied and enemy, were suspended between tall masts, as shown in Fig. 3, and shot at with proximity-fuzed ammunition. These tests showed both the sensitivity pattern in space of the fuze and vulnerability of various aircraft types.

Since laboratory tests could not exactly simulate the conditions of actual firing from a gun, fuze-operated projectiles were fired almost vertically, later falling to the ground base first. When the shells had been dug out, an autopsy was performed upon the fuze to determine causes of failure. The projectiles carried a small smoke puff which was set off by proximity of the fuze to the ground to indicate successful operation without destruction of the fuze.

In the proximity fuze for artillery use it was quickly realized that the heart of the device is the rugged tube. Such problems as packaging and power supplies seemed to be capable of easy solution when compared with the job of making radio tubes strong enough to withstand accelerations of 20,000g ($g = 32$ ft/sec/sec) when fired from a gun. It was necessary to achieve almost 100 percent tube operability if a reliable fuze were to be constructed containing four or five tubes, and it was some 14 months after the first tests were started before a satisfactory rugged tube was in production. The tubes which were finally put into large scale manufacture were designed completely from the beginning to be used in the proximity fuzes. The successful engineering of their mechanical parts was accomplished by applying the same principles of dynamic design and stress analysis which are used in the construction of bridges, skyscrapers, and other large structures. The stresses and deflections of every part in the tube, however minute, were carefully computed as well as measured.

In the barrel of the gun the fuze must withstand an axial acceleration of 3,000g to 16,000g, the lower values being encountered in howitzers and the higher in anti-aircraft projectiles. The fuzes were designed to withstand acceleration in excess of 20,000g. Since the fuze does not operate until after it leaves the gun, it is not necessary that the tubes be operative during the high accelerations experienced at the moment of shooting. The decrease in velocity after the projectile leaves the gun subjects it to a very small deceleration along its axis. However spin causes a radial acceleration of 800g to 3,000g to be experienced throughout the flight, and it is necessary for the tube to be operative while this acceleration is applied. Its effect is kept to a minimum by placing the tubes as close to the axis of the projectile as possible. Figure 4 shows some of the types of rugged tubes which were developed for artillery fuzes. In the fuzes they are mounted in close-fitting rubber cups.

The secret of making a tube with a glass envelope which will withstand 20,000g lies partly in the method of mounting in the fuze, and partly in the meticulous elimination of glass strains and careful control of glass quality during the manufacturing process.

Electrical Characteristics

With the exception of the low microphonics and the electrical characteristics of the thyratron, the electrical performance of the rugged tubes is not particularly spectacular when compared with larger types. The requirement that the fuze be capable of operation within one or two seconds after firing from the gun made it impossible to use indirectly heated cathodes. The filament was stretched very tightly to reduce microphonics to a minimum and these tubes are among the most non-microphonic filamentary types ever made.

Static characteristic curves for the pentode are shown in Fig. 5. It will be seen that this is not a particularly good pentode and much better electrical characteristics could have been built into this small envelope had this been necessary. However the general policy in the tube development was to make the tubes only good enough to perform the purpose for which they were intended and no effort was made to make them generally useful for other applications. Some advantage was taken of the fact that the tube life required was only a matter of minutes, but the pentodes, for example, are capable of several hundred hours of operation.

In order for the thyratron to fire the electric detonator it was necessary for it to pass two or three amperes peak current into a load of approximately 10 ohms. The normal battery current used in heating the filament is less than 1/10 of this peak value and is not sufficient to supply this large current surge. It is only through the formation of a hot spot on the filament surface that the emission is sustained, even for a brief period of time. This hot spot is formed as a result of bombardment by heavy positive ions. The arc does not last long enough to burn out the filament or impair its strength.

On account of the small size and

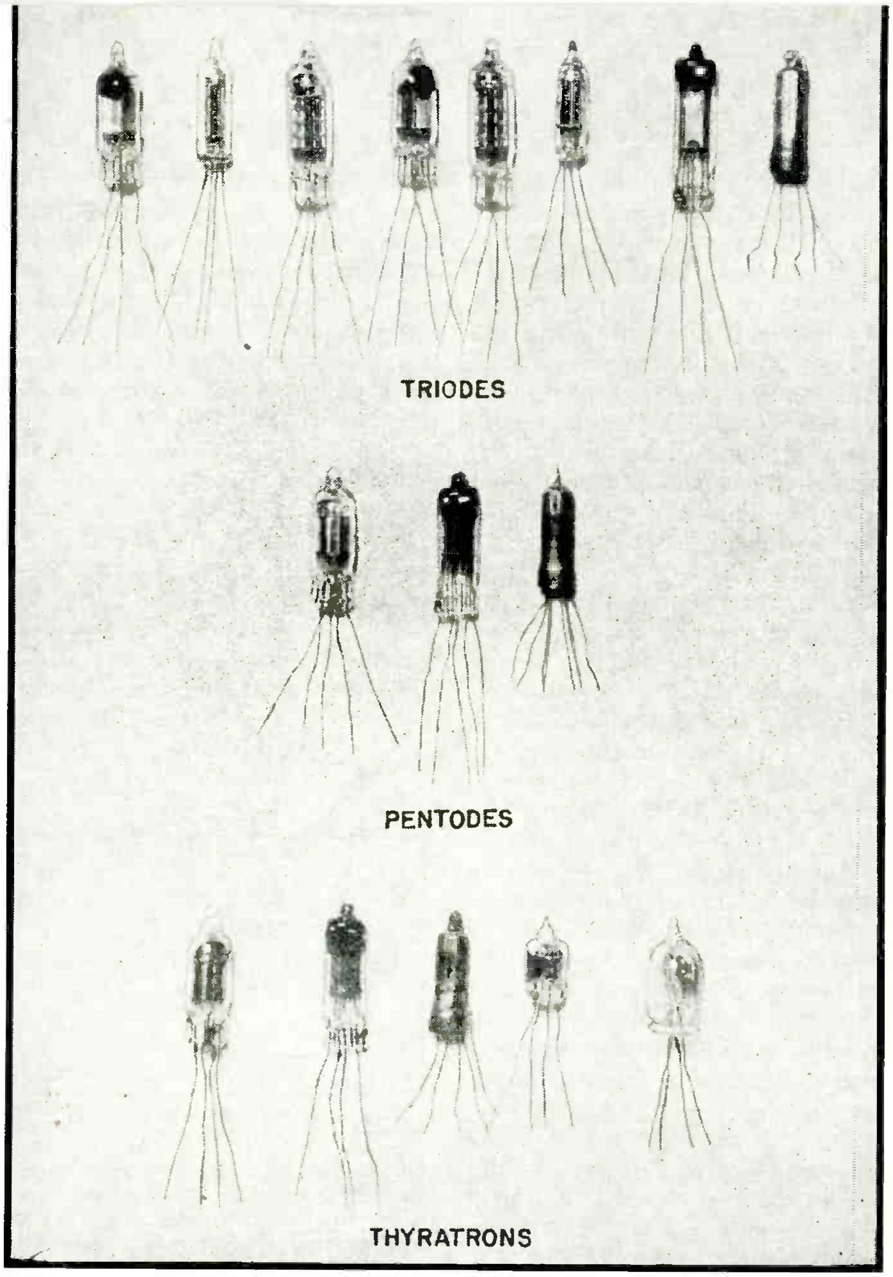


FIG. 4—Different tubes (five manufacturers are represented) used in the artillery-type fuze. In use the tubes are mounted in rubber cups. In all, 130 million of these tubes were manufactured

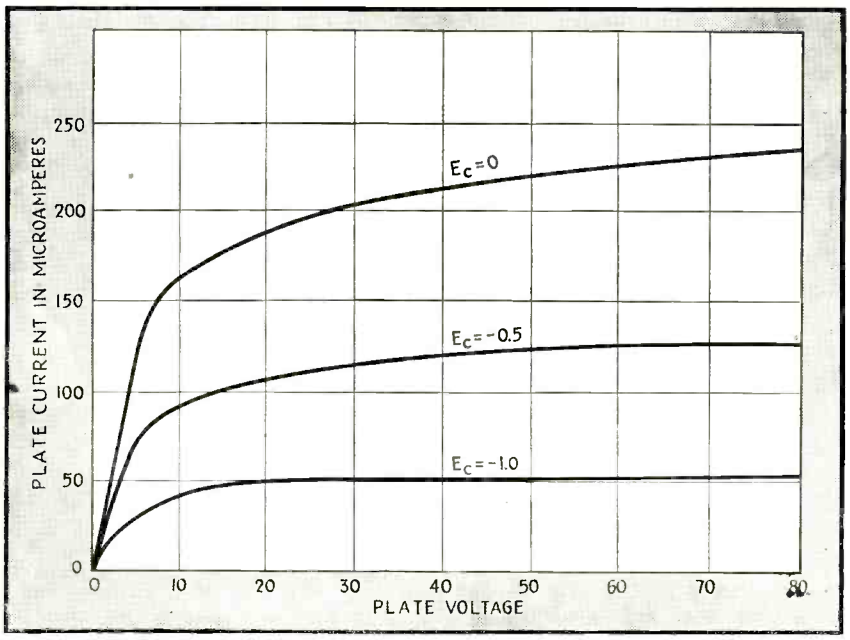


FIG. 5—Typical plate characteristic of the pentode used for audio amplification in the fuze. The operating life need only be a few minutes; actually it is several hundred hours

minute clearances in the structure of these tubes, the problem of preventing leakage between elements was of particular importance. Leakage can occur both internally along the micas, and externally along the glass, especially in the presence of corrosion or foreign material. The usual effect of such leakage in thyratrons is to change the striking voltage of the tube, making it more sensitive. The reason for this can be understood by reference to Fig. 6. Here is shown a thyratron with leakage resistance from plate to filament R_1, leakage from plate to grid R_2 and from grid to filament R_3. The circuit also includes a plate battery, bias battery, and external grid resistance R_g. The leakage resistances R_1, R_2, and R_3 may be either internal or external or a combination of both. The leakage from plate to filament R_1 being directly across the tube has no effect upon the striking voltage. However R_2 plus R_3 paralleled by R_g forms a voltage divider across the positive plate supply which will raise the grid to a more positive potential, depending upon the ratio of the plate-to-grid and grid-to-filament resistances.

If the external resistance R_g in the grid circuit is very large, the net positive voltage applied to the grid from this voltage divider action may be quite large, and very considerable negative grid bias may be required to prevent the tube from firing continuously. It will thus be seen that the total resistance permissible in the external grid circuit of the thyratron is limited by the control that can be exercised at the factory over the internal leakage between the elements of the tubes. The value of R_3 is less important than R_2, since it is always shunted by the external resistance R_g.

A negative grid bias of several volts was normally applied to the thyratron grid to prevent firing until it was overcome by a sufficiently large applied signal voltage. Figure 7 shows a characteristic curve of striking voltage for values of plate and grid bias voltage of a typical thyratron.

Tube Testing

The mechanical quality control of rugged tubes in large scale production presented problems not heretofore encountered in ordinary tube manufacture. The problem of training operators and inspectors and instituting a schedule of rigid inspection for mechanical defects during the process of manufacture was a tremendous job in itself. An overall check on mechanical quality at the tube factory was obtained by the use of centrifuges. Each of the 130,000,000 tubes manufactured was tested in a centrifuge at the factory under a force in excess of 20,000g along the axis of the tube. Electrical tests which followed this centrifuging then weeded out tubes which failed to withstand the high acceleration. Because of excellent quality control during manufacture, rejects at this point seldom were in excess of 3 percent. It was found however that the gradual acceleration obtained in the centrifuge was not the equivalent of shooting the tubes out of a gun although the numerical value of the acceleration was the same. This is a typical example of the differences often encountered between static and dynamic testing methods.

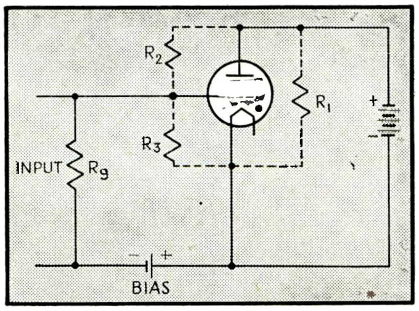


FIG. 6—Simplified schematic of the thyratron firing circuit, showing leakage paths in the grid circuit. Careful control of grid leakage was required to stabilize operation

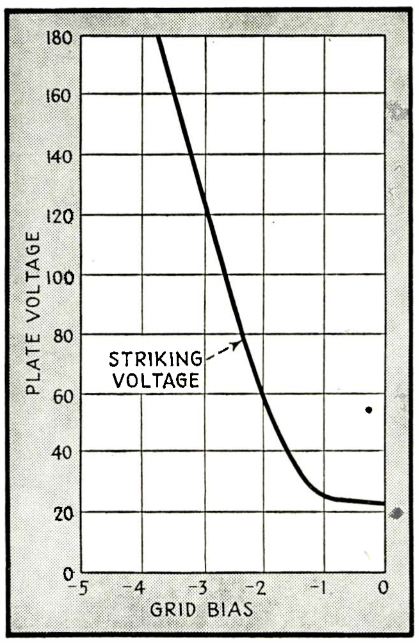


FIG. 7—Control grid characteristic of a typical filamentary thyratron. At a plate voltage of about 90 volts, the discharge is withheld by a bias of about —3 volts

To insure that the tubes would be satisfactory when fired in guns, a sample was obtained daily from each shift at each tube plant and sent to the Section T central laboratory for such a test. There the tubes were checked electrically and then shot from guns, at 20,000g acceleration, without being connected in circuits or otherwise electrically operated during flight. The inert projectiles carrying the tubes were recovered from the ground and the tubes then checked again electrically to make sure that no mechanical defects had occurred. Every tube which failed this test was examined to determine the cause of failure and a report made to the manufacturer describing the difficulty. Several hundred thousand tubes were shot for this mechanical quality control testing. However this was a very small percentage of daily production, and it was necessary to adhere strictly to principles of statistical quality control in the operation of these tests. If more than a small percentage of the tubes of a given batch showed failures, the lot was rejected.

Batteries

While wind-driven generators were used on the bomb and rocket fuzes, the artillery projectiles used battery power. The electrical requirements for these batteries were that they be capable of delivering approximately 90 volts for plate supply, 7.5 volts thyratron bias and approximately 1.3 volts for filament supply. As in the case of other circuit components the two primary requisites were ruggedness and small size. The first batteries which were successfully used were dry batteries, the B and C supply being formed of modified cell stacks from conventional small hearing-aid batteries. Pen-lite cells were the source of filament power. Some difficulties were encountered in making sufficiently rugged connections between cells in the stacks, but the principal problem in the dry battery was its relatively short shelf life, particularly when stored under the tropical conditions of the South Pacific.

The solution of the shelf life problem was found in the development of a so-called reserve battery. This is a wet battery in which the electrolyte is contained in a glass ampoule so that it is not in contact with the plates until the shock of firing breaks the ampoule. The spin of the projectile then distributes the electrolyte through the cells of the battery. The electrical advantages of this are considerable, since it gives long shelf life, and the inherent nature of the wet battery permits much heavier current drain. The internal construction of this battery is shown in cross section in Fig. 8.

As in the case of the rugged tubes, special shooting tests with post mortems were made daily on samples of batteries, as a quality control test. Testing methods for dry batteries were quite conventional but it was not possible to perform an electrical test on the reserve battery without destroying it. Here again, careful application of statistical quality control methods was necessary in order to insure adequate control of battery characteristics. An important characteristic of the reserve battery which required checking was the activation time. That is the time required after firing for the electrolyte to flow completely through the battery and cause voltage to be delivered to the fuze.

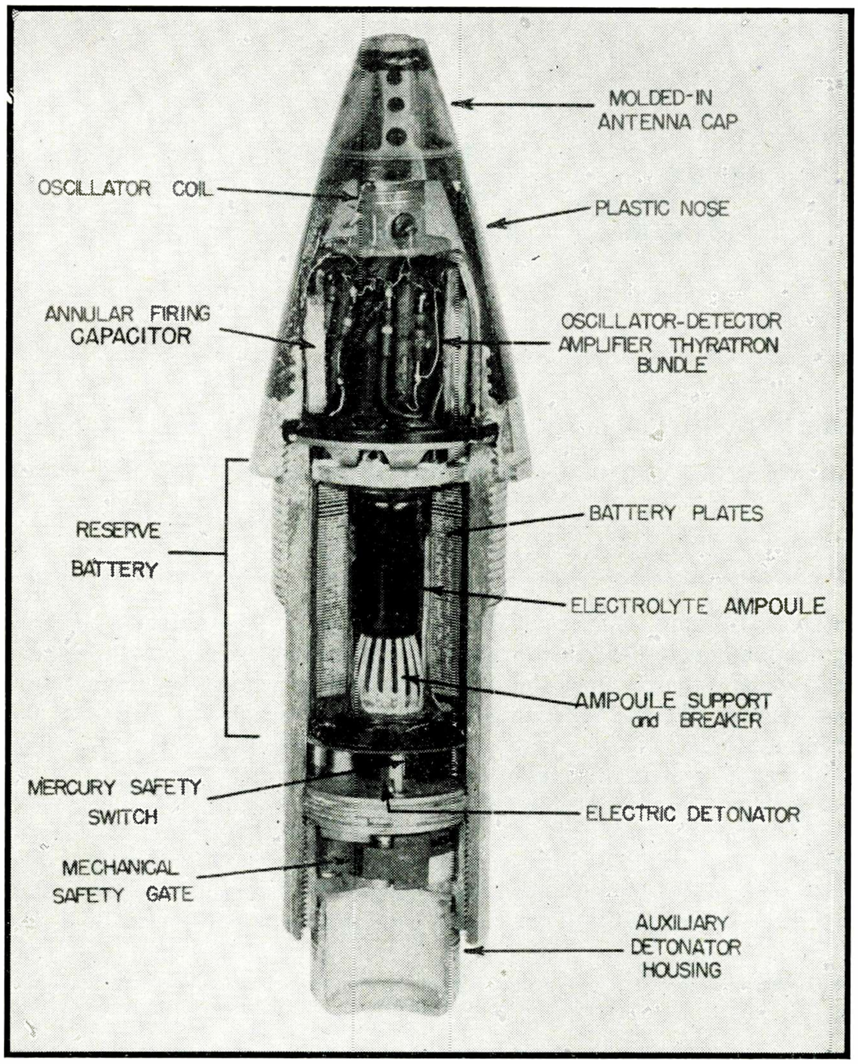


FIG. 8—Internal structure of the artillery type fuze. When the fuze is fired, the ampoule is crushed against the "breaker." Thereafter centrifugal force spreads electrolyte through the battery structure, which energizes the circuits

Packaging

The space requirements for the radio proximity fuze for artillery projectiles were very stringent. It was necessary to design fuzes for guns as small as the 75mm and every cubic inch of space required for the fuze meant that much less explosive in the projectile. This situation was particularly critical in long slender projectiles, since they already had too little explosive in the nose. In the original design shown in Fig. 1B, the oscillator and associated parts were contained in the conical nose with the amplifier and thyratron located in a separate cylindrical container beneath it, the battery on the bottom. This design was later simplified with all the electronic parts in the nose and the battery in the cylinder just beneath it. This reduced the length from about 12 to 8 inches and the size proportionately as shown in Fig. 1A.

No chassis was used in the construction of these fuzes. The tubes were mounted in close fitting rubber cups near the center of the electronic bundle. Resistors and capacitors were then wired together in sub-assemblies and wrapped around the central rubber cups containing the tubes. The resistors and capacitors were temporarily held in place by means of drops of wax or by rubber bands. After all connections were made, the electronic parts were placed in the plastic nose and all the air spaces filled by potting with wax. A terminal plate with 8 pins was provided at the bottom of the electronic assembly to afford a method of connecting with the mating socket element mounted on the top of the battery. Conventional quarter-watt resistors were used as circuit elements but it was necessary to have especially small paper capacitors made in order to fit in the available space. Since the maximum voltages encountered were very low, it was possible to make capacitors for this use that were quite small in size. A four-tube circuit similar to that shown in Fig. 2 occupies a volume of approximately 2.2 cubic inches.

The author wishes to express his appreciation to the many members of the Applied Physics Laboratory who contributed numerous suggestions and assisted in the preparation of this information.

REFERENCE

(1) "Generator-Powered Proximity Fuze", ELECTRONICS, page 98, December 1945.

The SCR-584 Radar

Details of the circuits for timing echoes to 0.01 microsecond, the deflection system for plan position indicator, and the automatic antenna-positioning gear are presented in this final installment

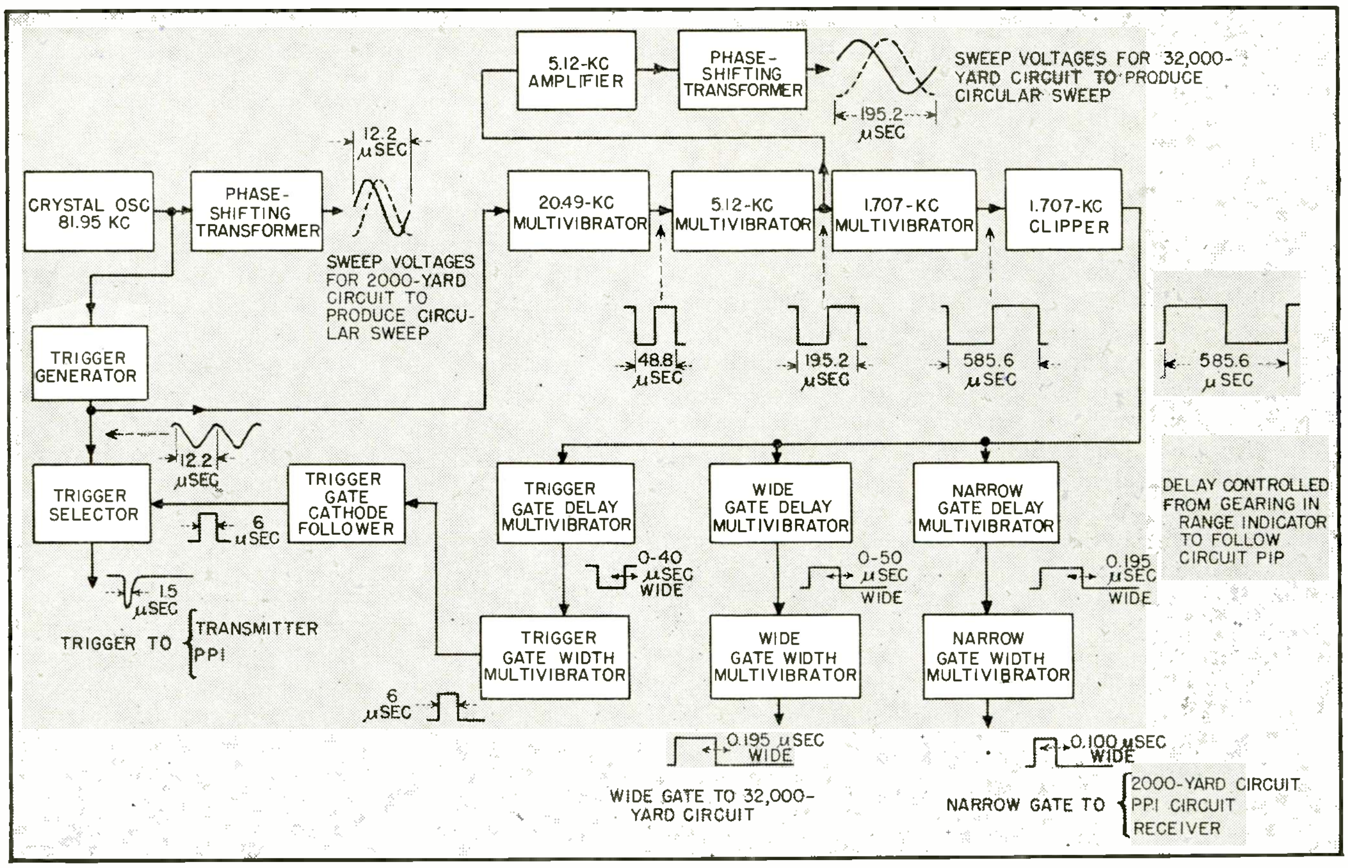
THE ELEMENTS of the SCR-584 not previously described are the range system, the plan-position indicator system and the antenna positioning system.

The range system is employed to measure the distance to the target to a dynamic accuracy of plus or minus 25 yards. The ppi presents a plan view of all targets within range during the search phase of the radar operation. The antenna positioning system employs the error signal developed in conical scanning to direct the radiator to the target to an accuracy of 0.06 degree.

Range System

The basic function of the range system, measuring the interval between transmission and reception of the pulses, is performed by a timing unit, the block diagram of which is shown in Fig. 1. The fundamental timing source is a quartz crystal, operating at 81.95 kc. One complete cycle of this frequency corresponds to the echo interval from a target at 2000 yards. Frequency dividing circuits are employed to convert the 81.95 kc frequency to 1707 cps, whose period corresponds to a range of 32,000 yards. These two range inter-

FIG. 1—Block diagram of the SCR-584 range system which measures the time interval between the transmission of pulses and reception of pulse echoes, displaying this information in terms of yards on two type-J indicator tubes



electronics WAR REPORT

SCR-784 radar, like SCR-584 electrically, but mounted on water-proof carriage which can be floated ashore on an assault landing. The operators are protected by the tent flap. Total weight 12,000 pounds

vals, 2000 and 32,000 yards, are displayed on two cathode-ray indicator tubes, the sweeps of which are generated directly by the 81.95-kc and 1707-cps waves. The 32,000-yard scope (coarse range indicator) indicates the range to the nearest 2000 yards and the 2000-yard scope (fine range indicator) is employed to interpolate within this interval.

The two indicator screens are shown in Fig. 2. The sweep trace is circular in form, being formed by applying two sinuosidal deflection voltages, displaced in phase by 90 degrees, to the horizontal and vertical deflection plates. The Lissajous figure produced by this combination of waves is a circle. The pulses are imposed on the circular trace by radial deflection, as shown in the figure. The pulse voltage is applied to an electrode which extends along the axis of the tube and terminates through a seal at the center of the screen. The coarse range scope reveals the transmitted pulse at zero yards, as well as echoes (clutter) arising near the radar. A typical target echo is shown in the figure as a radial pulse at about 13,000 yards. A hairline, manipulated by the radar operator, is set over this echo. This adjustment controls a delay circuit which selects the sweep interval on the fine range scope. In the case shown, the sweep interval is between 12,000 and 13,000 yards. The fine range scope reveals that the leading edge of the target echo is 410 yards beyond the 12,000 yard mark, that is, the actual range is 12,410 yards. The hairline pointer on the fine range scope is geared mechanically, as shown in Fig. 3, to the hairline on the coarse scope, through a 16-to-1 gearing arrangement.

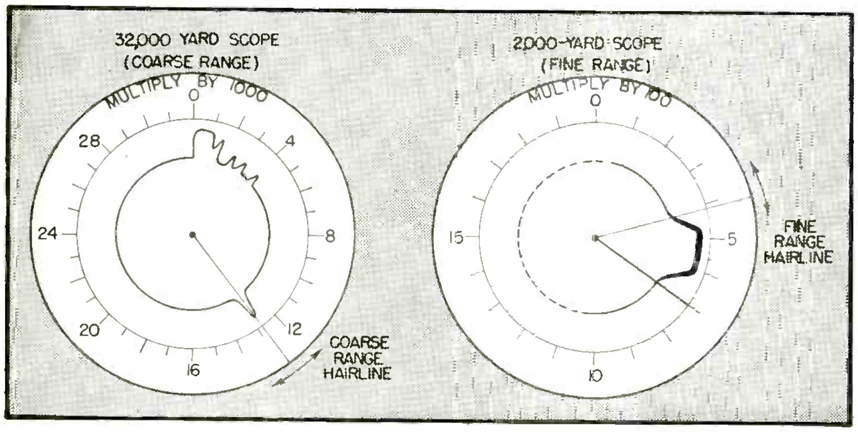


FIG. 2—The two indicator screens, for determining coarse and fine range. The coarse screen shows the transmitted pulse at zero yards, echoes caused by known objects near the radar and, in this example, a target just under 13,000 yards. The fine range scope, serving as a vernier, reveals that target range is 12,410 yards

The pulse sequence which coordinates the indicator sweeps with the transmitted pulses is shown in Fig. 4. The range unit generates the transmitter trigger pulse, shown at the

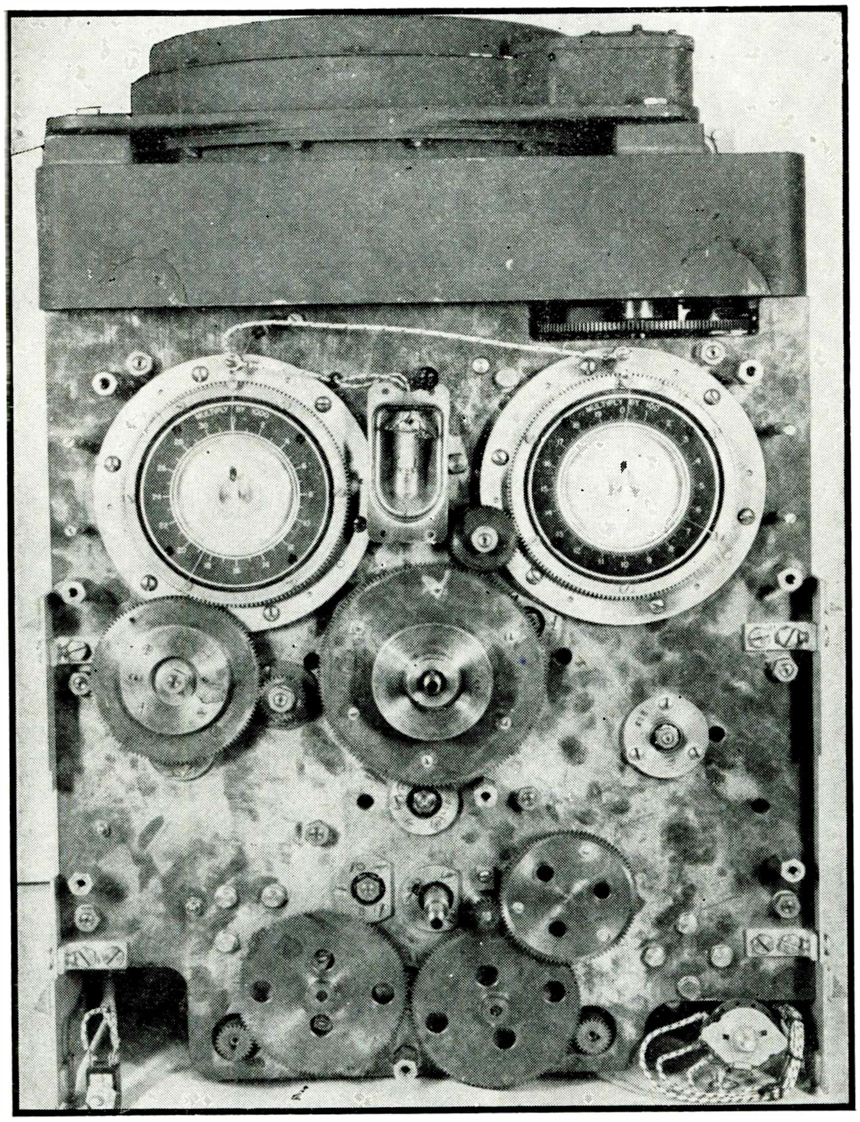


FIG. 3—The hairline pointer on the fine-range scope is geared to the hairline on the coarse scope through a 16-to-1 mechanical system

top below the time scale, which in turn controls the transmitted pulse and typical echo signal shown immediately below. The timer also generates a wide gate pulse, a rectangular wave whose leading edge occurs with the transmitted pulse and extends for 195 microseconds (equivalent to 32,000 yards). This rectangular wave, in positive polarity, is applied to the control grid of the coarse range scope, thus brightening the trace during the 32,000-yard interval. During the remaining portion of the interval between transmitted pulses, the coarse sweep is blanked out. Finally, the timing unit generates a narrow gate pulse, about 3-microseconds long (equals 500 yards range). The position of this narrow gate pulse, relative to the wide gate pulse, is adjustable by a delay circuit geared to the hairlines. The narrow gate pulse brightens a corresponding portion of the fine sweep, about one quarter of the full revolution.

The manner in which the timing unit generates these various pulses is indicated in the block diagram (Fig. 1). The crystal oscillator output is first conducted to a phase-shifting transformer which generates the two 81.95-kc sinewaves in quadrature for the fine sweep. Another output from the crystal drives the trigger generator, a cathode-coupled stage which removes the negative halves of the sinewave and accentuates the leading edge of the positive waves. These sharpened waves are passed, in one channel, to the trigger selector which blocks all but one of every 48 pulses. Thus the trigger output occurs at 81.95/48 = 1707 cps. The trigger selector also sharpens the leading edge and shortens the trigger to 1.5 microseconds width. The trigger output then passes to the transmitter system (driver and modulator, see Part I, November 1945 ELECTRONICS) and to the ppi system, as described later.

A second output of the trigger generator leads to the frequency divider chain, consisting of three cascaded multivibrators, which introduce successive divisions of 4, 4, and 3 or a total of 48. After the first two stages (division by 16) the 5.12 kc signal is conveyed to an amplifier and phase-shifting transformer which develops the quaradature sweep voltages for the coarse sweep. The 1707-cps output of the third multivibrator is clipped to produce a rectangular wave of 585.6 microseconds duration, from which the wide gate, narrow gate, and trigger selector pulses are derived.

The leading edge of this 585.6-microsecond wave initiates the action of three delay multivibrators, which react by forming rectangular waves of adjustable width. In the case of the narrow gate the width of the delay wave may be adjusted from 0 to 195 microseconds by adjusting the bias on one of the grids of the multivibrator. A potentiometer geared to the hairline of the coarse range scope provides this bias, and the width of the delay wave is thereby determined by the setting of the coarse hairline. The trailing edge of the delay wave triggers off another multivibrator (narrow gate width) which produces a rectangular wave adjustable in width from 0 to 100 microseconds. This width is set at about 3 microseconds and not thereafter changed. By this sequence of operations a narrow gate pulse of fixed width but of adjustable time of occurrence is obtained. The narrow gate is thereafter employed to brighten the fine range sweep and a corresponding portion of the ppi sweep, as well as to control the gain of the servo channel in the receiver as previously described.

A similar combination of two multivibrators produces the wide gate pulse, corresponding to an interval of 32,000 yards and adjustable in time over a range of 50 microseconds. This adjustable delay is employed to line up the wide gate with the transmitted pulse. Thus, when the wide gate is applied to brighten the coarse range scope, the visible portion of the sweep can be made to include any desired portion of the transmitted pulse.

The final portion of the range unit is another combination of delay and width multivibrators which produce the trigger gate. This is a 1707-pps rectangular wave of 6 microseconds duration, adjustable in time over a range of 40 microseconds. The trigger gate is applied through a cathode follower to the trigger selector previously mentioned. The trigger gate opens the trigger selector for a period long enough to select one in 48 of the 81.95/kc triggers, which occur every 12.2 microseconds. The 40-microsecond adjustable delay thus permits selecting any one of three successive triggers. This is equivalent to adjusting the phase of the transmitted pulses relative to the sweep voltages, wide and narrow gates.

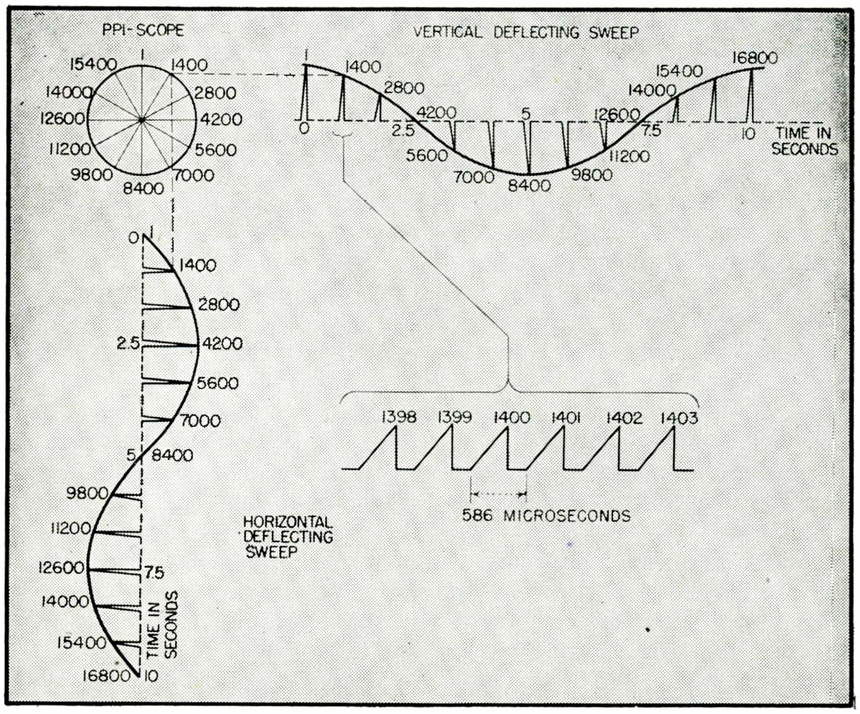


FIG. 5—Vertical and horizontal deflection voltages applied to the ppi-scope combine in the manner shown to form a continuously rotating sweep, as described in detail in the text

In tracking an aircraft target, the range operator turns the range handwheel so as to keep the hairlines on the coarse and fine sweeps centered over the target echo. To assist in accurate tracking, the tracking handwheel is motor driven at a rate which is controlled by the motion of the handwheel. In this system, known as aided tracking, motion of the handwheel is translated directly into a corresponding motion of the hairline, and simultaneously introduces a correction to the speed of the motor drive. In this way the motor drive smoothly and continuously approaches the speed of the target echo, and changes in the target speed are followed with a minimum of hunting.

Plan Position Indicator System

The remaining portion of the indicating system is the plan position indicator (ppi). As described elsewhere in this series, the ppi makes use of a radially-deflected c-r tube, the direction of radial motion corresponding with the direction of the radiated beam. The beam starts from the center of the tube coincidentally with each transmitted pulse and moves outward at constant velocity. The target echo brightens the beam, causing a spot of light to appear at a position corresponding to the range and azimuth of the target. The radiated beam rotates at 6 rpm, so the c-r screen is covered completely in 10 seconds. It is essential that the image on the screen persist for at least this length of time, if all portions of the presentation are to be simultaneously visible to the radar operator.

The necessary persistence is obtained by using the P7 phosphor. This phosphor has two layers. The layer next to the electron gun has short persistence and fluoresces with a brilliant blue light when the electron beam impinges on it. The remaining layer, next to the glass envelope, is excited by this intial blue flash and retains the image in the form of a yellow afterglow which decays exponentially at a slow rate. The yellow light is visible, in darkness, for as much as a minute after the excitation is removed, and a sub-

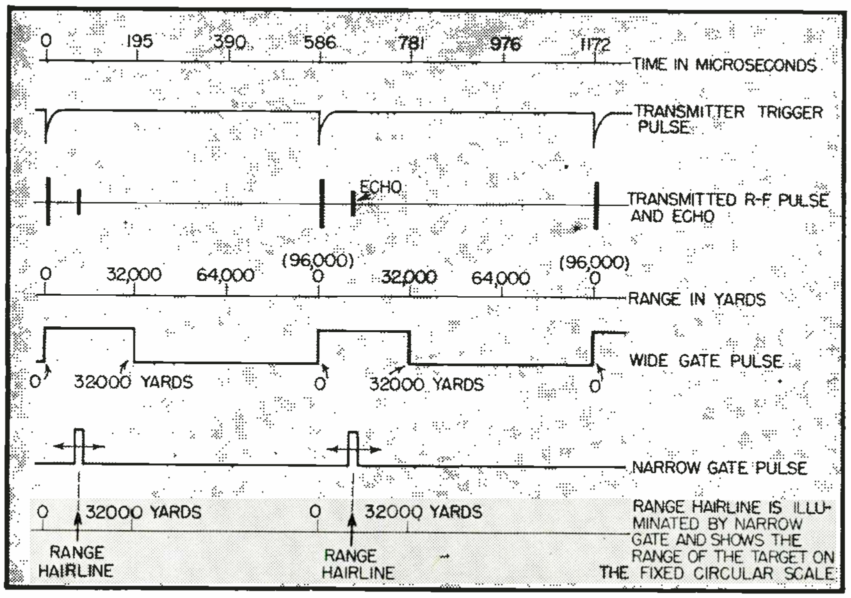


FIG. 4—Pulse sequence which coordinates the indicator sweeps with the transmitted pulses in the SCR-584 radar

stantial fraction of the light remains after the 10-second interval of each rotation. An amber plastic filter is placed over the screen to remove the initial blue flash.

The 7BP7 c-r tube is magnetically focused and deflected. The radial deflection is produced by a stationary magnetic deflection yoke fixed in position around the neck of tube. The yoke is provided with two sets of coils, one of which provides vertical deflection, the other horizontal deflection. Sawtooth waves of current are applied simultaneouly to these coils, causing the spot to deflect along a direction determined by the relative amplitudes of the vertical and horizontal component deflections.

The manner in which the vertical and horizontal deflections combine to form a continuously rotating sweep is illustrated in Fig. 5. The sawtooth waves are modulated in amplitude with sinusoidal envelopes, the vertical and horizontal enevlopes being 90 degrees out of phase. The numbers on the envelopes indicate the number of sawtooth waves which have been generated at each point; only a few of the actual sawteeth are shown, for clarity. In one complete rotation, some 16,800 radial sweeps are produced by as many sawteeth.

The generation of the modulated sawtooth waves is carried out in circuits illustrated in Fig. 6, which is a block diagram of the ppi unit. The input, shown at the upper left, is the trigger generated by the range unit (Fig. 1), which also initiates each transmitted pulse. The trigger is first amplified and then applied to a multivibrator, which produces a negative rectangular wave whose length corresponds to the length of the radial sweep.

Two values of sweep are provided, 70,000 yards and 35,000 yards, selected by a switch which adjusts the constants of the multivibrator. The rectangular wave is applied to the grid of the sawtooth generator, a triode tube across whose plate and cathode is a capacitor connected to a high voltage source. While conducting, the triode short-circuits the capacitor and no voltage appears across it. When the negative wave from the multivibrator appears, however, the triode became suddenly nonconducting, the short is removed from the capacitor, and the voltage across it increases. The charging voltage is high enough, and the length of the charging period short enough, to keep the voltage across the capacitor substantially linear during the sweep period.

The basic sweep sawtooth must then be divided into two groups and each group sinusoidally modulated in quadrature (Fig. 5). This is accomplished by passing the sawtooth wave through a power amplifier-driver

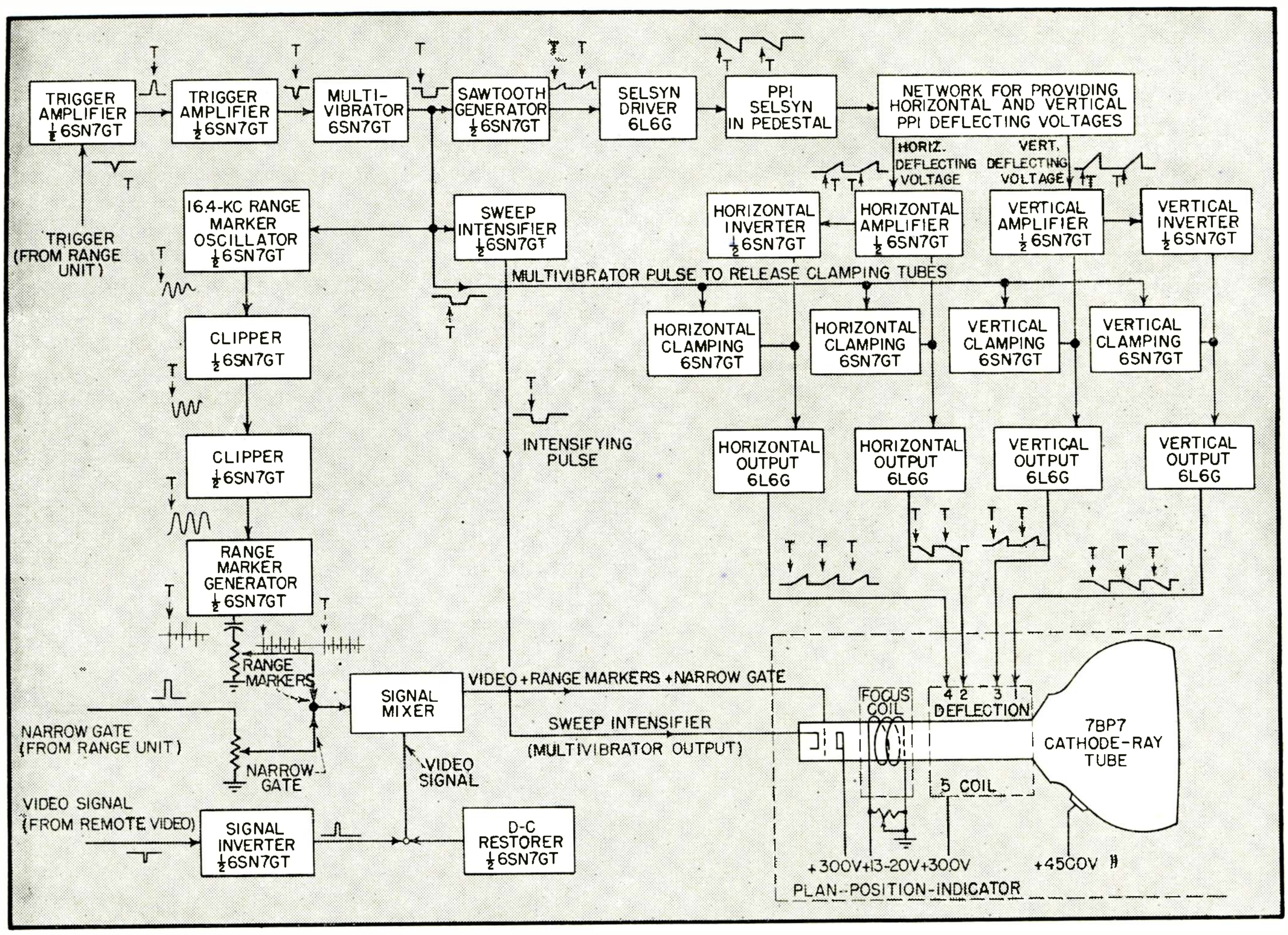


FIG. 6—Block diagram of the SCR-584 radar ppi unit. Arrowheads marked with the letter *T* indicate the instants at which the various units are operated by the trigger pulse from the range unit

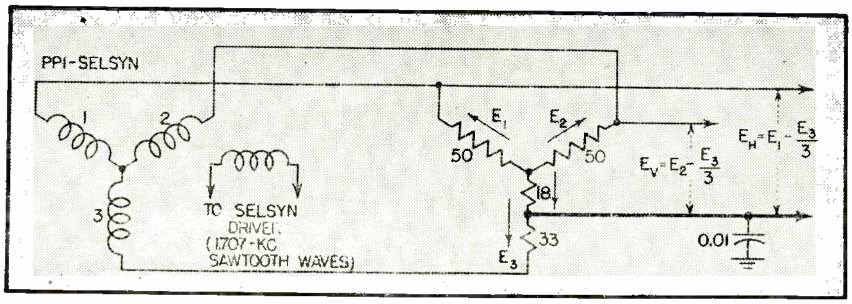


FIG. 7—A selsyn, mounted on the shaft of the radiator pedestal, develops horizontal and vertical deflecting voltages for the ppi sweep

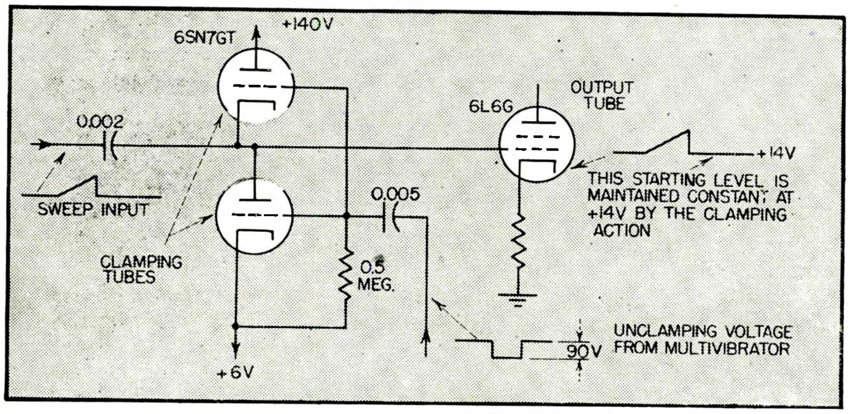


FIG. 8—Clamping circuit employed in the ppi deflection system

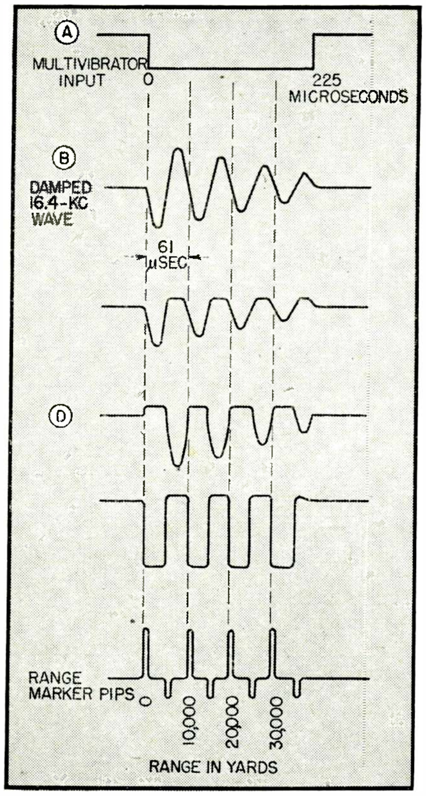


FIG. 9—Simplified waveforms present at various points in the SCR-584 radar range-marker circuit

stage and thence to the rotor coil of a selsyn (three-phase generator), mounted on the pedestal shaft of the radiator pedestal. The selsyn is capable of passing the 1707-cps sawtooth waves without distortion and, in consequence, sawtooth waves appear across each of the three stator coils, as shown in Fig. 7. The relative magnitudes of the three groups of sawtooth waves depend on the position of the rotor with respect to the stator, which in turn is determined by the direction in which the radiator is pointing.

It is then necessary to combine the sawtooth waves from the three stator coils to form sinusoidally modulated waves (Fig. 5). This is accomplished by a resistor network comprising three resistors, one of which is tapped about one third of the distance from the neutral point. This tap is taken as the common point (a-c ground) for the horizontal and vertical deflection voltages, which appear, respectively, across the two upper terminals of the Y-network as shown. In this manner, the three sets of sawtooth waves, modulated sinusoidally with envelopes 120 degrees out of phase, are converted to two sets of waves, modulated with envelopes 90 degrees out of phase. The vector summation of these two sawtooth waves is such as to produce a deflection in the direction corresponding to the selsyn rotor, that is, the direction of the radiator.

The remaining portions of the ppi deflection system (Fig. 6) modify the sawtooth waves for application to the deflection coils. First the deflections waves are amplified, and then passed through phase inverter stages to convert to push-pull operation. Push-pull deflection is required to minimize distortion of the deflection waveform, and to assure good focus and linearity at all parts of the screen. The final push-pull output amplifier stage in each case consists of a pair of 6L6 beam-power tubes.

At the grids of the output deflection amplifiers 6SN7 double triodes are connected which act as clamping circuits. The clamping circuit is used to insure that each of the four sawtooth waves (horizontal push-pull and vertical push-pull) have the same starting point, in time, regardless of the amplitude of the sweep, which is continually varying as the radiator rotates. As shown in Fig. 8, the clamping circuit consists of two triodes in series, with the grid of the output deflection amplifier connected to the common midpoint of the combination. The grids of the triodes are controlled by the rectangular wave from the multivibrator. During the sweep period, while the rectangular wave is negative, they are cut-off and essentially removed from the circuit. The grid of the deflection amplifier is thus free to follow the deflection waveform applied to it. At the conclusion of the sweep period, the rectangular wave becomes slightly positive, and the clamping tubes are driven to full conduction. The internal resistances of the clamping tubes then act as a voltage divider, and the grid of the output amplifier is rigidly clamped to a potential of +14 volts, where it remains until the next sweep period starts. Since similar clamping circuits are applied to the grids of all four output deflection amplifiers, the sawtooth waves all start from precisely the same value of potential at the same instant. This insures that the radial deflection shall start from the center of the tube.

The remaining portions of the ppi system (Fig. 6) are concerned with modulating the intensity of the c-r beam. In the first place, the negative output wave of the multivibrator is

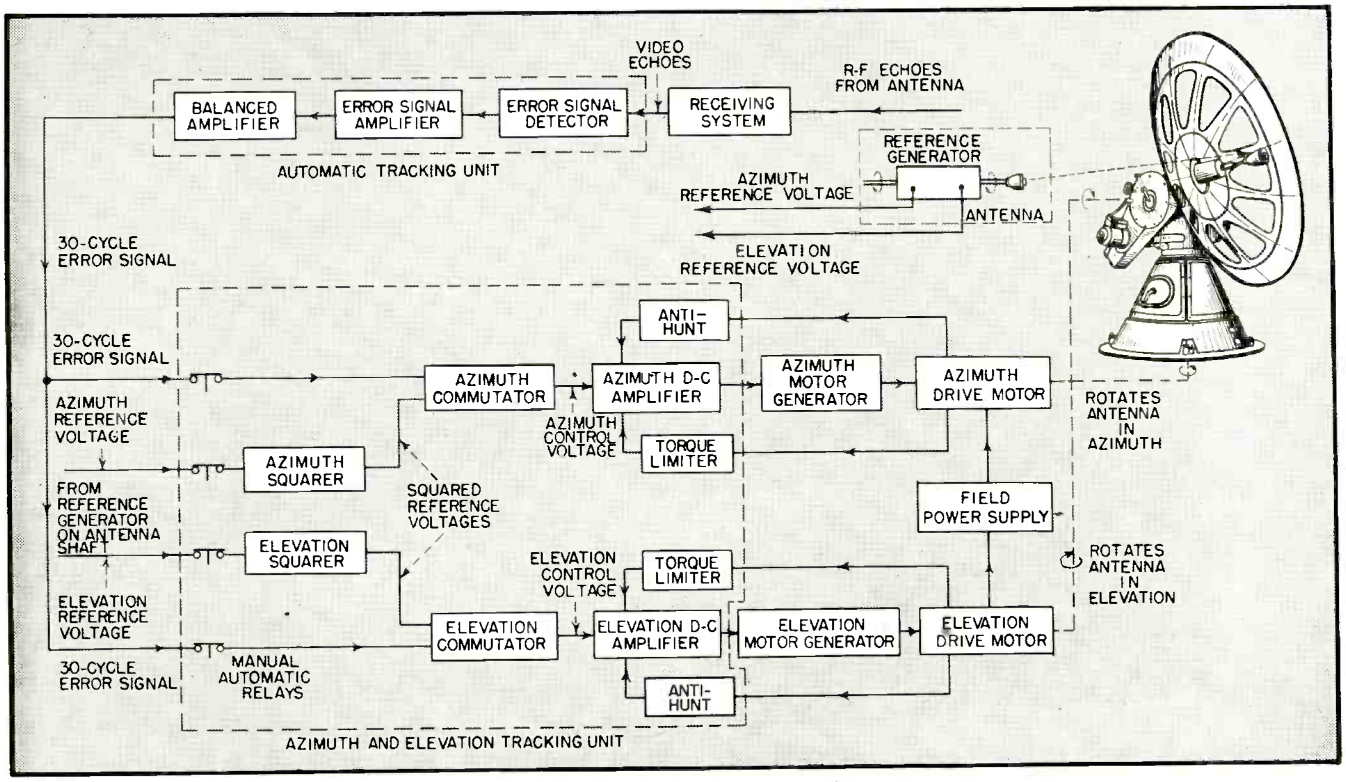
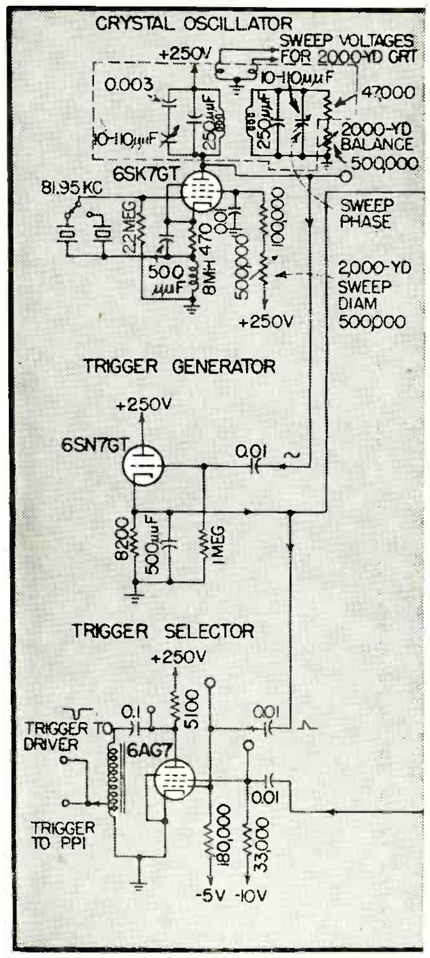


FIG. 10—Block diagram of the electro-mechanical system which positions the antenna

passed through a cathode-coupled sweep intensifier stage and applied, still in negative polarity, to the cathode of the electron gun. A negative pulse on the cathode is equivalent to a positive pulse on the grid, so the c-r beam is intensified during the sweep period. During the remainder of the interval between transmitted pulses, the beam is blanked out, so the beam is invisible during the retrace time and the rest time prior to the ensuing sweep.

Another intensity-modulating circuit provides the target echo (video signal) from the receiver. This arrives negatively polarized, is inverted and, after d-c restoration, passed to a mixer and thence to the control grid of the electron gun. The d-c restorer is a diode which maintains the base of the video waveform at a fixed bias level. If d-c restoration were not used, the bias level would fall on the average of the video signal and weak signals would be depressed below the visible level. The d-c restorer insures that such weak signals are always visible. It also brings up the noise, but the overall effect on signal-to-noise ratio is decidedly beneficial.

The final intensity modulation function is the provision of range markers. These appear as concentric circles on the ppi screen, spaced at intervals corresponding to 10,000 yards, and are used by the operator in estimating the range of the target prior to finding the target on the precision range indicator. The range circles are produced by short positive pulses applied to the control grid of the electron gun (Fig. 6) at intervals along each radial sweep. Since the 10,000-yard interval corresponds to 61 microseconds, the marker pulses are separated by this amount, and are derived from a 16.4-kc oscillator. In the interest of simplicity and accuracy this marker oscillator is not a c-w circuit, but is a damped oscillator, shock excited by the leading edge of the multivibrator rectangular wave. The oscillator consists simply of a triode with a tuned circuit in its cathode, and with the multivibrator wave applied to its grid. The damped train of oscillations produced in this circuit is passed through a succession of clipping and peaking circuits



which produce the waveforms shown in Fig. 9, culminating in sharp positive pulses separated at 61 microseconds. To these range markers are added the narrow gate signal from the range unit, which produces another range circle at a range equal to the setting of the coarse and fine hairlines. Thus when a target is discovered on the ppi, the range hairlines are adjusted until the range circle falls on the ppi target image. The echo appearing on the coarse range scope then corresponds to the selected target on the ppi.

Antenna Positioning System

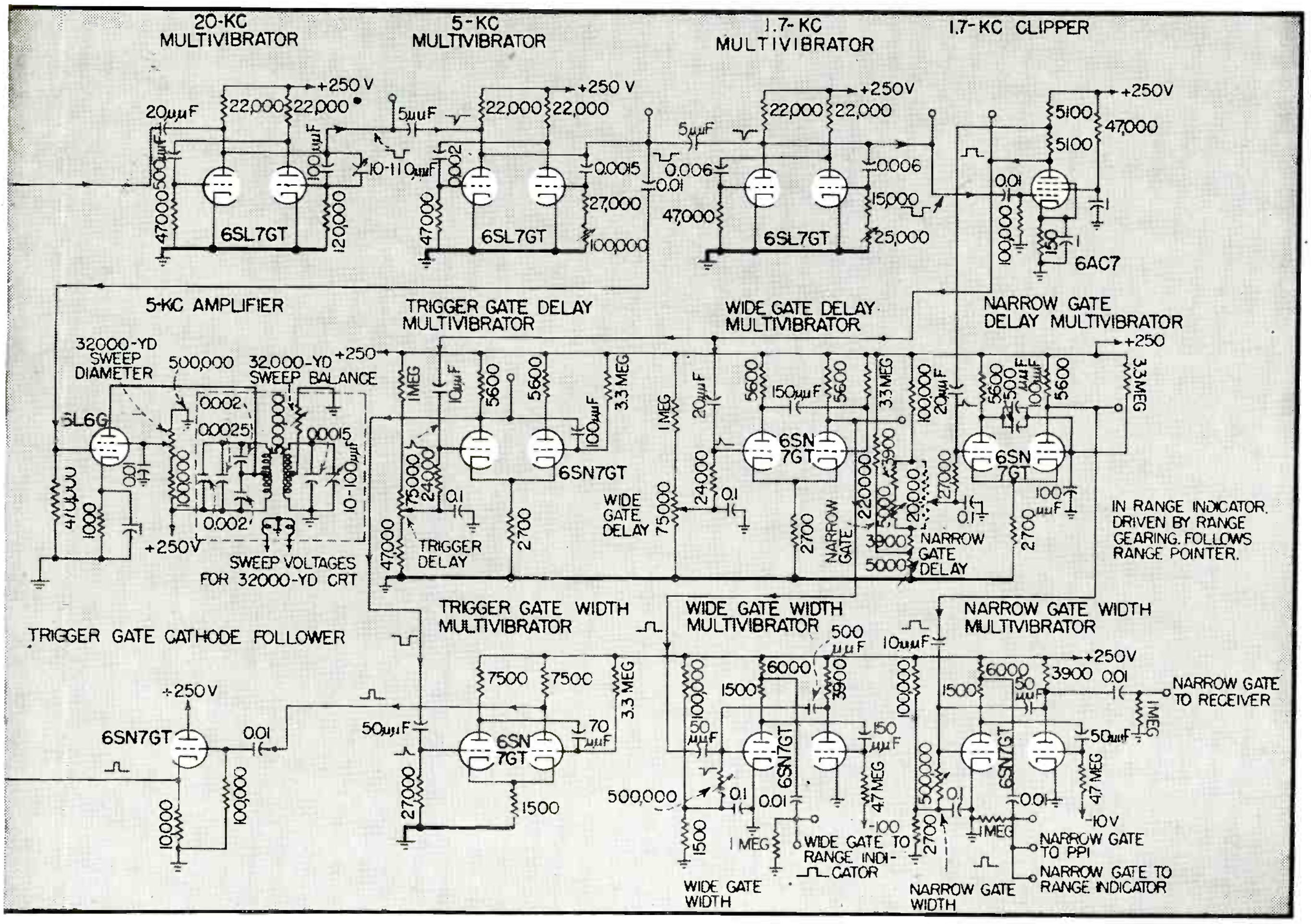
A block diagram of the electromechanical system which positions the antenna is shown in Fig. 10. As stated in Part I of this series, the echo pulses from the target are modulated sinusoidally in amplitude when the target is off the axis of the reflector. This envelope known as the error signal, occurs at 30 cps when the dipole radiator is spinning at 1800 rpm. The envelope is removed from the video signal by a third detector, amplified and converted to a balanced-push-pull output. The error signal is then compared with reference voltages derived in quadrature from a 30-cps generator mounted on the dipole spinner shaft. The reference voltages are converted to rectangular form and combined with the error signal in two commutator circuits, one for azimuth and the other for elevation.

The commutator circuit consists of two double triodes, to the grids of which the push-pull error signals are applied and to the plates of which the squared reference voltages are applied. The cathode current of each commutator tube consists of segments of the error signal waveform, which are balanced against each other. The average value of the combined output is zero when the error signal is zero, and increases negatively or positively as the phase of the error signal advances upon or falls behind the reference voltage. The average value of the combined segments is developed in a low-pass filter and applied to a d-c amplifier which in turn drives an intermediate motor generator driving the azimuth and elevation-positioning motor. Anti-hunt and torque-limiting devices are used to provide smooth operation.

In the listing the SCR-584 specifications in Part I (page 105, November issue), the dynamic range accuracy was given as plus or minus 2 yards, instead of plus or minus 25 yards as correctly stated in the text.

—D.G.F.

Simplified schematic of the range unit, discussed in detail in this final installment on the 584



GERMANIUM CRYSTAL DIODES

Theory, construction, and performance characteristics of the type 1N34 germanium crystal diode, which has many advantages over vacuum-tube diodes. Applications include detector in broadcast, f-m, and television receivers, modulator, and sine-wave or relaxation oscillator

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THE normal linear Ohm's Law relation pertaining to the current-voltage characteristic of most solids is well known. This law embraces practically all conductors and insulators. There is, however, another classification of solids, namely semiconductors, which lies between conductor and nonconductor solids.

As early as 1834, Faraday reported investigations on the highly negative temperature coefficient of resistivity exhibited by silver sulphide. Accompanying this behavior was a nonohmic current-voltage relation; that is, as the current through the solid was increased, the voltage drop across the solid did not increase in direct proportion.

Taylor (1903) reported a characteristic for a metal-metal oxide in which rising current gave a nonproportionally rising voltage drop up to a point where, with still increasing currents, the voltage drop remained constant. Eccles (1910) predicted that, under certain conditions, negative dynamic resistance characteristics would be exhibited.

Most of the aforementioned phenomena included no polarization effects. The characteristics obtained were nearly similar in both directions of current. It was found, however, that a few metal oxides, and some metals with slight impurities, exhibited highly polarized nonlinear characteristics. The metals silicon and germanium possess these properties to a very marked degree. Moreover, germanium combined with certain impurities will withstand relatively high voltages, making it extremely useful as an electrical circuit element. Such an element is now commercially available.

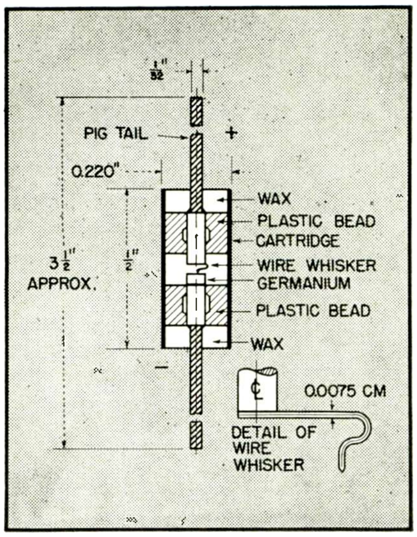


FIG. 1—Constructional details of type 1N34 germanium crystal diode

Construction Details

A cross-section of a type 1N34 germanium crystal diode and a detailed sketch of its wire whisker are shown in Fig. 1. The unit is compact and light-weight and is made with tinned-copper pigtail leads for ease of installation. The metal shell, which is not part of the electrical circuit, is marked to indicate the direction of high conductance. The cathode (germanium) is marked minus (−), while the anode (tungsten metal wire) is marked plus (+).

The necessary properties of the metal used for the whisker are manifold. The material must be a good spring in order to absorb shock. Its mass-to-strength ratio must be low. Its thermal and electric conductivity should be high. The material must lend itself to being drawn into fine wire and yet not be plastic. Most of these requirements are fulfilled by tungsten made up as a cylin-

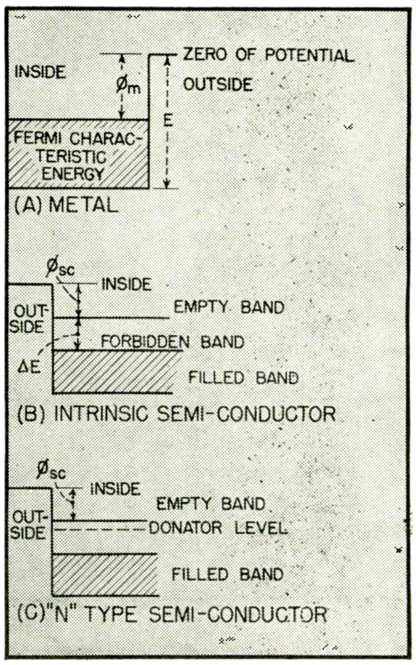
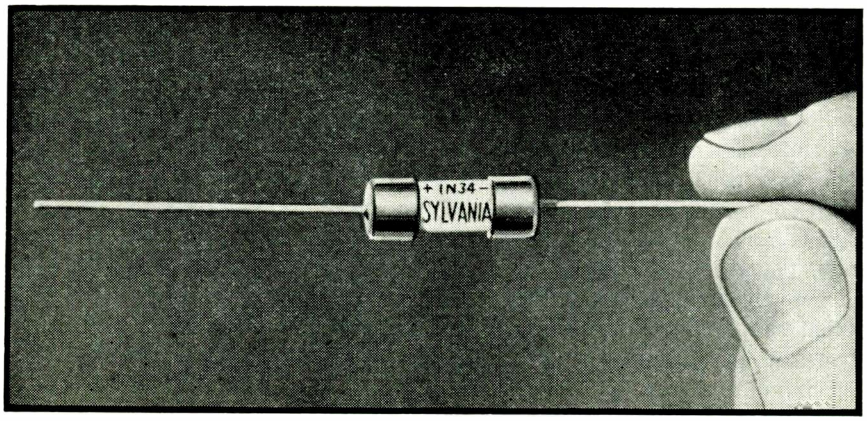


FIG. 2—Energy level diagrams of three types of solids

drical piece 75 microns in diameter and approximately 0.25 centimeter in total length. Because of tungsten's fibrous structure, the wire may be ground to a needle-sharp point which will not mushroom excessively under applied force.

The second material that is of importance in a contact rectifier is the semiconductor, and this is by far the more critical of the two. Germanium, which is used as the semiconductor in the type 1N34 crystal diode, was discovered in 1886 by Winkler. It is never found in the free state, usually occurring in the dioxide form (GeO_2). This is reduced with hydrogen, leaving the amorphous metal in a pure state. Oxidation at room temperature is slow. Upon melting and cooling, the dull gray powder forms crystals of the diamond type. The resistivity of these pure crystalline structures is high at room temperature. As will be seen later, this resistivity is also a measure of the purity. The crystallized material will take a high polish and is highly absorbent in the visible and infrared light spectrum.

In the melting process, a small amount of tin is added. The tin partially dissolves in the germanium, forming a lattice-imperfection semiconductor. The rest of the tin collects at the grain boundaries and contributes to the lowering of the resistivity of the semiconductor. The hardened ingot is cut into wafers 0.6 mm thick, polished to optical smoothness on one surface, and then cut into squares 3 mm on a side. The crystal is now ready for soldering to one of the lead wires.



Type 1N34 diode, showing self-supporting leads

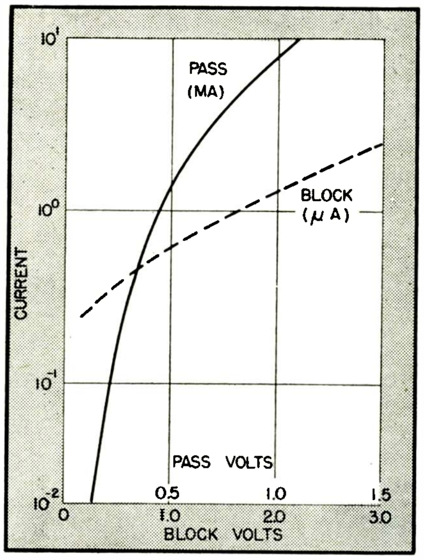


FIG. 5—Typical static characteristic of type 1N34 crystal diode

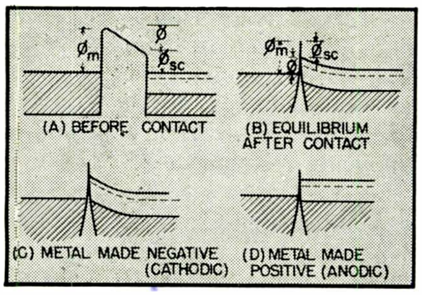


FIG. 3—Contact energy level diagrams

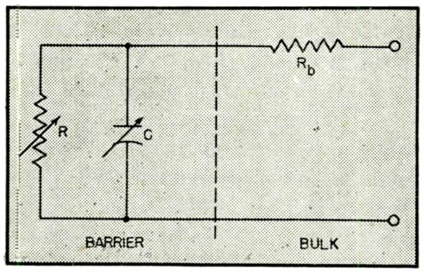


FIG. 4—Equivalent circuit of germanium crystal for frequencies below 100 mc

Atomic Structure

It is necessary to have a knowledge of the atomic structure and the energy levels of metals and semiconductors in order to discuss rectification at the contact. The atoms of these solids are bound together and form a definite pattern known as the crystal lattice. Each atom nucleus is surrounded by a number of electrons which have definite paths and energies. Some of these electrons revolve about the nucleus in very tight elliptical orbits and are called bound electrons. There is another group of electrons that are not so tightly bound. In fact, they may jump from atom to atom and, if enough energy is acquired, may even depart from the solid. These are called free electrons, and it is these in which we are most interested. Because of the complexity of the heavier atoms, it has become customary to discuss the behavior of the electrons in solids in terms of the modern theory of solids.

The well founded energy level diagram for metals is shown in Fig. 2A. Here the ordinate is energy and there exist in the metal levels of free electron energy up to and including a maximum which, at absolute zero, is called the Fermi characteristic energy. These levels are indicated by the shaded portion of the diagram. This characteristic energy maximum is only slightly dependent on temperature but very strongly dependent on the density of electrons in the particular solid. The maximum energy of the electrons is therefore a function of the specific solid under consideration. The value ϕ_m is that energy which an electron must release or acquire as it enters or leaves a metal. That is, if an electron is carried into the metal from the outside, it experiences a drop in potential energy equal to $-E$, if the potential outside is taken as zero. The quantity ϕ_m is called the work function of the metal solid. It is known that the variation in energy at the boundary is not exactly as shown, but the picture is sufficiently accurate for this discussion.

The energy diagrams of an intrinsic semiconductor and a lattice-imperfection semiconductor are shown by Fig. 2B and 2C respectively. For the intrinsic semiconductor, the energy levels of the electrons are divided into two groups, namely, a filled or occupied band and a permitted but normally empty band. Electrons added to the latter would be available for conduction. There is a spacing between these two bands, called the forbidden region, where no electrons can exist. No conduction can occur when the spacing between the uppermost level of the filled band and the bottom of the empty band is great, i.e.,ΔE is the older of several electron volts. If $KT > \Delta E$, which might be for very high temperatures, electrons that lie near the top of the filled band may become sufficiently excited to jump into the empty band, thus making conduction possible. It must be remembered that the distribution of energies at elevated temperatures allows a few electrons to have rather high energies.

It follows then that these intrinsic semiconductors are excellent insulators at low and absolute zero values of temperature, but become nearly perfect conductors at $T \rightarrow \infty$. This negative temperature coefficient of resistivity typifies all semiconductors.

The germanium semiconductor in which we are interested is of the lattice-imperfection type due to the dissolved tin. In this N type or electron-excess semiconductor, levels are introduced in the forbidden region that are of the order of KT from the unfilled or conduction band. It is the introduction of these discrete levels that is of great importance to the problem at hand. The atoms of tin in the crystal lattice cause a distortion of both the physical shape and the electrical and mechanical forces that are an integral part of such a structure. It is this distortion that gives rise to levels intermediate to the filled and unfilled bands. The electrons contained in these introduced levels are supplied by the impurity. If they are excited sufficiently, they will rise to the conduction band and the solid will become an electronic conductor provided ϕ_{sc}, the work function of the semiconductor, is overcome.

Contact Considerations

When a metal and a lattice-imperfection semiconductor are placed in contact, the changes in energy level distribution are as portrayed in Fig. 3A and 3B. It will be noted that a distinct hump appears at the contact surface and that the energy level of the semiconductor is distorted upward. In a metal-to-metal contact the hump would be much lower and the distortion would be negligible. Electrons would therefore be able to flow relatively freely from either metal to the other, resulting in complete equilibrium. In the case of the metal to semiconductor contact, however, exchange of electrons cannot freely take place.

The difference in work functions of the two materials produces a contact difference of potential $\phi = \phi_{sc} - \phi_m$. It is therefore much easier for an electron near the conduction band in the semiconductor to pass over the potential hump than for an electron near the conduction band of the metal. Because we now have a condition in which electrons can flow more easily in one direction than in the other, rectification may be effected.

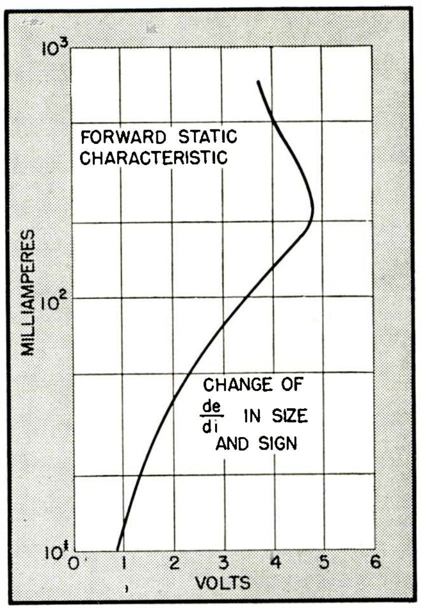


FIG. 6—Curve illustrating how dynamic resistance of a germanium crystal diode can be negative under certain conditions

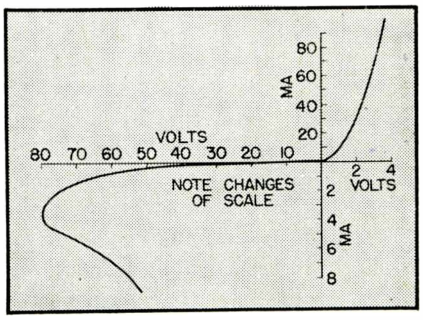


FIG. 7—Blocking characteristic of germanium diode

The process of rectification as described above is enhanced by two other factors. Certain electrons in the semiconductor may pass through the barrier (tunnel) to the metal even though they lack the requisite amount of energy to pass over the hump. This tunneling process is explainable by quantum mechanics and will not be discussed here. The other factor which increases rectification is application of an external potential of the proper polarity. By making the metal positive, the energy levels in the semiconductor will be elevated relative to those in the metal. The distortion is thus eliminated and electrons may flow freely from the semiconductor into the metal.

In this last case, with a positive potential applied to the metal, the flow of electrons is limited only by the bulk resistance of the semiconductor. This resistance, that is, its ability to supply electrons from the donator level, is given by

$$R_b = \rho/4a \qquad (1)$$

where ρ is the resistivity of the bulk material and a is the contact radius. Figures 3C and 3D illustrate the limiting case.

On the other hand, if the metal is made negative, the energy levels in the semiconductor will be depressed relative to those in the metal. The electrons in the metal repel those in the semiconductor, further distorting the energy level and producing a high back resistance.

In addition to electronic conduction just described, another mechanism takes place simultaneously, but in such a manner as to decrease the back resistance. This is called hole conduction. The impurity introduces into the forbidden region near the filled band of the semiconductor energy levels which are normally empty. These acceptor levels may receive electrons from the top of the filled band, leaving holes therein. The holes cause a distortion in the opposite sense, that is, the barrier will curve downwards at the contact. These holes pass easily from the semiconductor to the metal, the result being a transfer of positive charge in the same direction. The back resistance of the contact is limited by the amount of hole conduction. Fortunately, by proper preparation and treatment, the composition of the semiconductor can be so controlled as to minimize the density of the acceptor levels relative to the donator levels.

Current-Voltage Relationships

The equivalent circuit of the type 1N34 for frequencies less than 100 mc is shown in Fig. 4. It consists of the bulk resistance R_b in series with the barrier impedance. The latter may be represented by a resistance, which is dependent on the magnitude and polarity of the applied voltage, in parallel with the barrier capacitance. This capacitance, which is also a function of the applied voltage, is discussed more fully in the Appendix.

The pass characteristic of the germanium crystal diode closely approximates the following exponential form up to one hundredth of an ampere or so.

$$i_f = i_0(\epsilon^{aV} - 1) \qquad (2)$$

where V = voltage applied to the barrier

$= E_{applied} - i_f R_b$

$i_0 = 10^{-6}$ ampere approx.

$\alpha = 0.05$ volt^{-1} approx.

The values given above were found by plotting the currents and voltages on semilog paper, as in Fig. 5.

As one continues to increase the forward current a point is reached where the dynamic forward resistance de/di becomes negative, even though the static resistance V/I is positive. The forward resistance in these voltage and current ranges, that is, after the barrier has been overcome at approximately one volt, is given by the expression in Eq. 1. However, because ρ varies greatly with temperature for a particular sample according to

$$\log \rho = \gamma\ (1/T) \qquad (3)$$

where γ is a constant, it is possible, at some high temperature caused by excessive currents, to have a dynamic resistance equal to or less than zero. A curve showing this is given in Fig. 6.

The phenomenon is of little practical importance as it is usually masked by a load of several hundreds of ohms in series with the unit. It is, however, of academic interest.

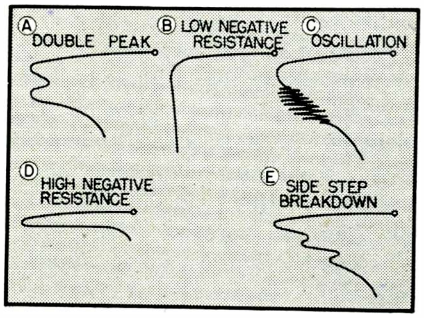


FIG. 8—Different types of breakdown, as viewed on scope, for germanium diode units

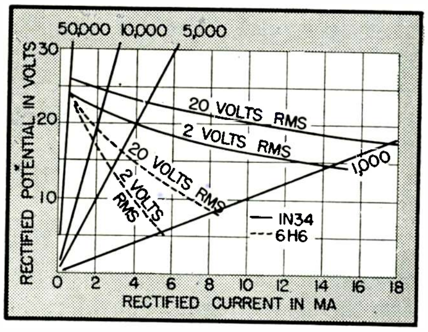


FIG. 9—Comparison of performance characteristics of 1N34 germanium diode (solid lines) with 6H6 vacuum diode (dotted lines). When reading rectified current and voltage for 2-volt signals, divide scale values by 10

Moreover, values of current necessary to produce such an effect would not be found in practical circuits, nor is it advisable to attempt them because they cause excessive temperature that will impair the desired rectifying properties.

The blocking characteristic of the germanium diode is the most interesting. From the curve of Fig. 7, it is obvious that startling effects are present.

In tracing the d-c characteristic and analyzing the results, it is found that:

(1) The resistance is extremely high up to several volts from the origin (of the order of megohms).

(2) The current is nearly ohmic at low voltages (0 to 6 volts), whence it becomes exponential, following

$$i_b = i_0' \epsilon^{\beta V} \qquad (4)$$

where the coefficients are similar to those for the forward characteristic and the approximate values are $i_0' = 2.5 \times 10^{-6}$ ampere and $\beta = 0.1$ to 0.2 volt^{-1}.

(3) At some voltage, characteristic of the particular unit, usually greater than 75 but less than 200 volts, the characteristic departs from the exponential form. The dynamic resistance becomes zero and then negative as the current is increased, so that the voltage developed across the unit decreases. This action is analogous to that in the forward direction in being temperature dependent. In fact, if one uses the proper scale multiplying factor, the two curves of forward and blocking currents will be very nearly identical.

Most units have curves similar to that of Fig. 7 but differing in voltages and currents. However, many different shapes may be obtained. Figure 8 shows some of the variations observed. Changes are noticed if ambient temperature is varied, or if current is allowed to flow through the unit for a period of time. With increased temperature or continued current, the curves tend toward the basic one of Fig. 7.

Possible explanations for this behavior in the back direction are first, that the distribution and mobility of holes may be more temperature dependent than predicted by theory, and second, that there is a possibility that hole conduction may take place through areas several orders of magnitude smaller than that for electron conduction. This would give rise to the possibility of a much higher back resistance and the probability that the smaller areas might break down to larger areas of conductivity, thus allowing the current to increase rapidly.

Temperature Dependence

The germanium crystal, or any other nonlinear device that depends upon the imperfection crystal lattice for its behavior, will be inherently very dependent upon temperature. Because the contact and the bulk material do have resistance, and this resistance is confined to a small volume, very high temperatures will be obtained at the contact if a sizable current is passed through the unit. Because of the geometry of the contact, most of the heat will be conducted from the contact through the germanium (see Appendix). The increased temperature will have the effect of decreasing the resistance. The effect will be more noticeable in the back characteristic than in the forward. Data show that the back resistance changes by a factor of ½ for a 70 C rise and by 2 for a 70 C fall from room temperature. The forward resistance is very little affected by increasing ambient temperatures up to 100 C whence it becomes quite temperature dependent. Decreasing ambient temperature has a greater effect, a drop of 70 C doubling the value of resistance at room temperature.

Rectification

An important use of germanium crystal diodes is the detection of radio and intermediate frequencies. The increasing interest in frequency modulation and television has placed new requirements on detectors. Small interelectrode capacitances and ability to work into a low resistive load with reasonable efficiency are two of the most important. These requirements are imposed by the higher frequencies used by f-m and television, and by the broad passband of intermediate and video stages.

The type 1N34 unit satisfies these demands. The cathode-to-anode capacitance is of the order of 3 $\mu\mu$f and the forward conductance is very high, thereby making an excellent unit for the above uses. In Fig. 9 a conventional 6H6 vacuum tube diode is compared with the 1N34. The superiority of the latter, especially for low values of load resistance, is readily apparent.

Because the 1N34 is soldered directly into the circuit, it is of extreme practical importance that it have long life. Preliminary tests show that no failure or deterioration has occurred for more than 1000 hours of continuous operation. These units were subjected to electrical conditions that were considered far in excess of normal practice.

For design information it is necessary to know the variation that would be encountered in production units. Numerous tests have shown that the rectified output will vary less than ±5 percent. This figure holds for the audio range. Even at frequencies in excess of 20 megacycles variations from the mean will not exceed 15 percent.

The 1N34 unit is recommended as a rectifier for frequencies not over 100 mc. As an indication of the frequency response, it might be noted that, referring again to Fig. 9, with 1000-ohm loading and 14.4 volts rms at 30 mc applied, the rectified output is 10 v d-c.

Other Uses

There are many uses other than as detectors or rectifiers that suggest themselves from consideration of the electrical characteristics. Some of these are modulators of all descriptions, voltage regulators, low-frequency oscillators, d-c restorers, and polarizing devices. Typical applications are shown in Fig. 10.

As a nonlinear device the germanium crystal diode is readily adapted to modulator and demodulator circuits. The portion of the curve in which the dynamic resistance becomes zero or negative may be used for voltage regulation. Suitable characteristics for this use are most often obtained when the peak voltage (blocking) is relatively low (20 to 50 volts). If necessary, a small positive series resistance may be added to correct the negative dynamic resistance to zero. The curve shown in Fig. 8B is the ideal blocking curve for regulator use. The advantages of this regulator over the gaseous discharge type are freedom from flicker, absence of high firing voltages, and compactness. It must be kept in mind that large changes in ambient temperature and excessive currents will affect the regulation and life of the unit. Normal currents for regulator use are 7 to 30 ma d-c.

The high negative dynamic resistance of the blocking characteristic permits the production of sinusoidal oscillations up to one megacycle in series resonant circuits. The rapid tripping action that is offered by the blocking characteristic makes possible a relaxation oscillator at frequencies up to 500 kc.

Conclusion

The type 1N34 germanium crystal diode offers many physical and electrical advantages. Diminutive weight and size are mandatory in most portable and airborne equipment, and are indicated in many control devices. Economy of space and material is furthered by the absence of heater supplies and attendant high-voltage insulation. Simplification of wiring and an overall reduction of ground capacitance result in improved circuit performance, particularly at high frequencies. At any frequency, hum and noise due to diode a-c heater supplies are completely excluded.

Only a few of the many possible applications of the 1N34 diode have been mentioned in this paper. In the near future, new and valuable uses will surely be discovered for this versatile device.

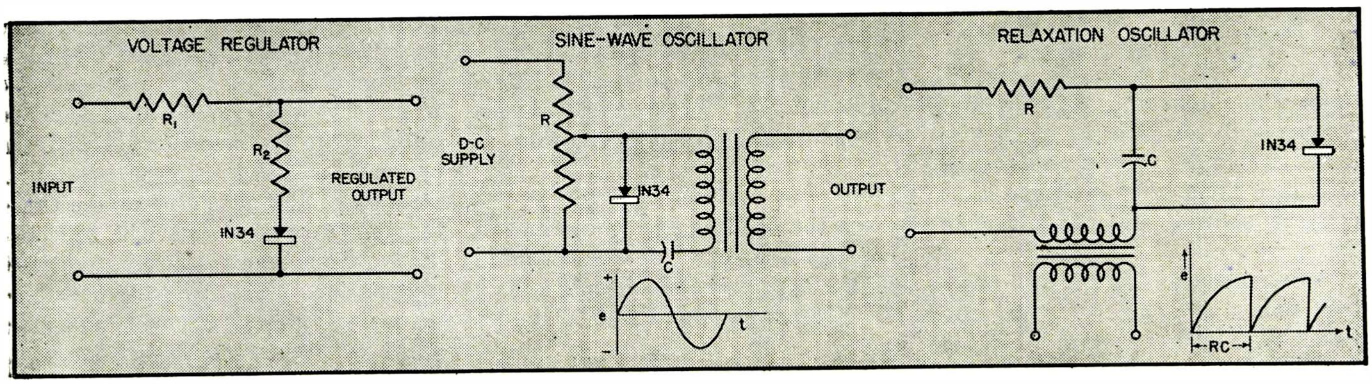


FIG. 10—Typical applications of germanium crystal diodes

Appendix

Heat Transfer from the Contact. In the thermal system of Fig. 11, the heat developed at the contact will be conducted in two directions, namely, through the semiconductor and through the metal.

The resistance to thermal flow will be a function naturally of the geometry and material. If we consider the semiconductor as a very large volume with a circular surface contact of radius a, the thermal resistance will be given by

$$R_1 = 1/(4K_1a) \qquad (5)$$

where K_1 is the thermal conductivity of the material. This has been measured and was found to be 0.14 cal/sec-deg-cm or 0.59 watt/deg-cm. This gives, for a radius of 4.5×10^{-4} cm, $R_1 = 940$ deg/watt.

Torrey has shown that the thermal resistance of the truncated metal cone is given by

$$R_2 = 1/(K_2\, a \tan \psi/2) \qquad (6)$$

where K_2 is the thermal conductivity of the material and ψ is the half angle of the tip. The above formula was reached by assuming the cone to be a hyperboloid, thus simplifying the derivation.

The conductivity for tungsten is $K_2 = 0.476$ cal/sec-deg-cm or 1.97 watts/deg-cm. For $\psi = 40°$, $R_2 = 213$ deg/watt.

The thermal resistance of the metal stem is given by

$$R_3 = L/(K_2\pi r^2) \qquad (7)$$

where L is the length and r is the radius. For a length $L = 0.25$ cm and $r = 3.8 \times 10^{-3}$ cm, $R_3 = 2800$ deg/watt.

The total thermal resistance of the tungsten wire is therefore $R_2 + R_3 = 3{,}013$ deg/watt. This compares with 940 deg/watt for R_1, the thermal resistance of the semiconductor, and indicates that most of the heat is carried away by the latter.

Low-Frequency Rectification. Consider the model shown in Fig. 12. The following conditions are known.

(1) R_b is ohmic, that is, it does not vary with applied voltage, and is small, having a value between 20 and 35 ohms.

(2) C, the barrier capacitance, is of the order of 0.5—2.5 $\mu\mu$f, and is dependent on the applied voltage.

(3) R_e varies greatly with applied voltage. For all back voltages and for small forward voltages, it is very high. When the forward voltage is approximately one volt or higher, R_e is reduced to low values.

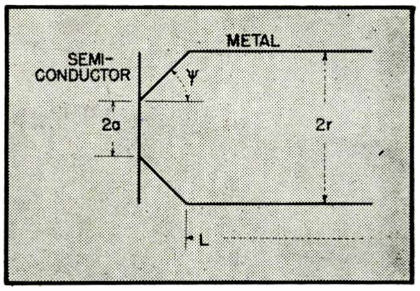


FIG. 11—Heat transfer problem

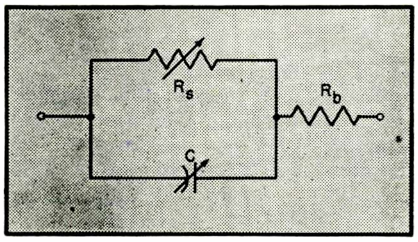


FIG. 12—Equivalent circuit

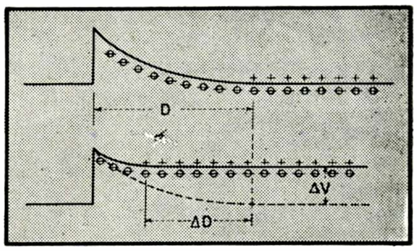


FIG. 13—Barrier capacitance conditions

The rectification efficiency is

$$R_{eff} = \alpha Z_{back}/Z_{front} \qquad (8)$$

where α is a proportionality constant.

$$i_b = i_0' e^{\beta V}$$

$$Z_{back} = R_b + Z_{barrier}$$

$$Z_{front} = R_b$$

$$R_{eff} = \delta \frac{R_b + \dfrac{1}{(1/R_c) + j\omega C}}{R_b}$$

$$= \delta\left(1 + \frac{1}{(R_b/R_c) + jR_b\omega C}\right) \qquad (9)$$

For good rectification, $(R_b/R_c) + jR_b\omega C$ must be as small as possible. Since R_b/R_c is of the order of 10^{-3} and $R_b\omega C$ is less than 1.1×10^{-3} for frequencies of one megacycle, we see that the condition is fulfilled.

High-Frequency Rectification. As ω is increased, two effects become important. Measurements show that the back impedance decreases faster than can be explained by the effect of the contact capacitance. This leads to the conclusion that R_e depends not only on voltage but also on frequency, i.e., varies inversely with both. This variation has not yet been explained so that efficiency data must be relied upon.

Barrier Capacitance. Consider the conditions at the boundary of metal and semiconductor with no applied voltage and with applied voltage ΔV, as in Fig. 13.

The barrier will in effect be lowered and a conduction current will flow, due to the raising of the electron potential by ΔV. Two other effects can be noticed: (1) a charging current ΔQ is necessary to account for the redistribution of the electrons; (2) the barrier thickness is reduced by the amount ΔD.

The total charge per unit area will be given by

$$Q = NeD \qquad (10)$$

where N is the density of donators, e is the electronic charge, and D is the thickness of the barrier, which is dependent on V.

The capacitance will be given by

$$C = A\frac{dQ}{dV} = A\,Ne\frac{\partial D}{\partial V}$$

Bethe gives for this thickness

$$D = \sqrt{\epsilon\left(\frac{V_o - V_a}{2\pi Ne}\right)} \qquad (12)$$

where ϵ is the dielectric constant, V_o is the contact potential difference, and V_a is the applied voltage. Thus,

$$\frac{\partial D}{\partial V} = \frac{1}{2}\sqrt{\frac{\epsilon}{2\pi NeV}} \qquad (13)$$

which gives

$$C = \frac{A\,Ne}{2}\sqrt{\frac{\epsilon}{2\pi NeV}}$$

$$= \frac{A\,Ne}{2}\sqrt{\frac{\epsilon}{2\pi Ne(V_o - V_a)}} \qquad (14)$$

and also $C = A\epsilon/4\pi D \qquad (15)$

This comes from the well-known capacitance formula for two parallel plates.

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The TELERAN

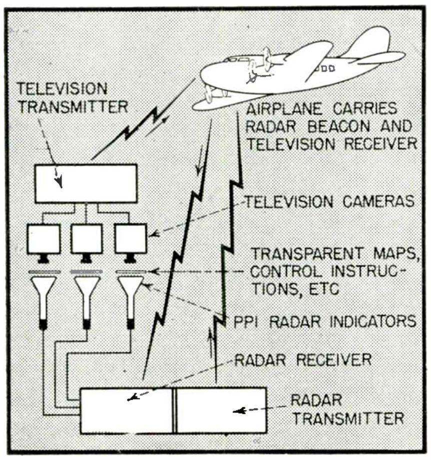
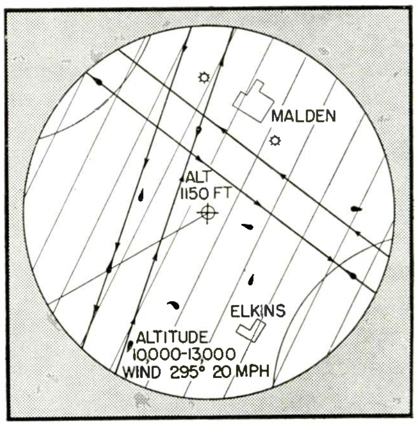


FIG. 1—(left) Elements of the Teleran system. Information on aerial activity gathered by ground-based radar is combined with map information and televised to pilots

FIG. 2—(right) Typical television image received by pilot while en route. The tear-shaped dots are radar echos from aircraft. Map, altitude and weather information are superposed during television pick-up from radar scope



Two of the most comprehensive of all electronic developments, television and radar, can be combined to fulfill the complex requirements of air navigation. It is apparent that the constantly increasing density of air traffic, both military and civil, will require the development of an improved navigation method. While improvements in present methods will suffice for the immediate future, a more comprehensive solution will be required within a very few years. Any new system must make possible, under all conditions of weather, the flying of large numbers of aircraft having many different speeds, different maneuverabilities, and different destinations, under different degrees of pilot skill.

Before describing the television and radar methods designed to accomplish the desired results, let us review some limitations of present methods. No accurate means of location of individual aircraft is employed. Excessive use of communication channels is required, with resulting overloading. Fixed paths provided by radio ranges are of little use when it is necessary to deviate from the established airways. A high degree of pilot skill is required for instrument flight. Traffic handling capacity is limited, particularly under conditions of poor visibility. Means for collision prevention are not provided. These are but a few of the problems which can be solved only temporarily by improvements in the existing methods of air navigation.

Air Navigation Requirements

Certain requirements must be met by an eventual air navigation system. The more important are:

(1) Information for navigation, traffic control, collision prevention and landing must be presented to the pilot in a simple, natural manner, a manner so obvious that little skill will be required for its use.

(2) The system must be suitable for operation in all kinds of weather.

(3) The weight and complication of the equipment carried in the aircraft must be minimized.

(4) For the control of traffic, accurate position data on all aircraft within the control area must be presented to the traffic control personnel. Resulting traffic instructions must then be made available to the pilot conveniently and well in advance.

(5) The use of voice communications must be reduced rather than increased.

(6) The system must operate in conjunction with existing navigational aids and must be flexible with regard to changes in traffic control methods. It must be capable of handling greatly increased traffic densities.

(7) The identification of individual aircraft must be automatic or, better still, unnecessary.

(8) It must provide adequate warning of impending collisions between aircraft, or between aircraft and terrain.

(9) The system must be capable

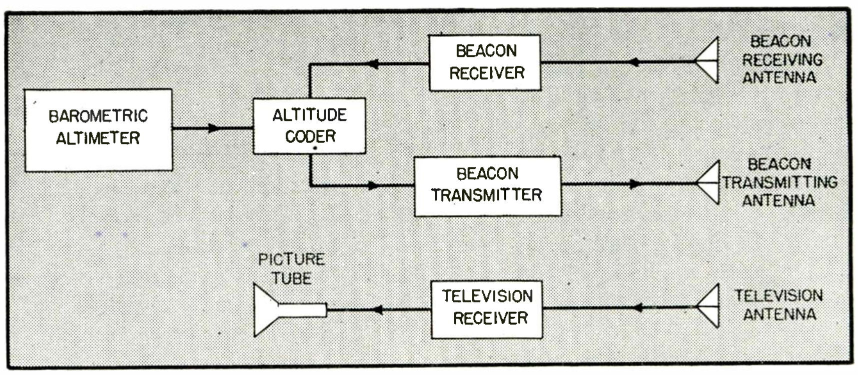


FIG. 3—Block diagram of functional elements of Teleran. Each aircraft carries a responder beacon, which replies with an altitude code when the radar beam passes by

PROPOSAL

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A system of navigation and traffic control, utilizing existing television and radar techniques to present visual information directly to the pilot, is proposed to cope with the expanding needs of commercial and military aviation

of providing needed supplementary information, such as weather data.

These are only a few of the requirements of an ideal navigation system, but they indicate the general nature of the problem.

The Teleran Solution

In using radar alone for air navigation, there are several serious limitations. For instance, if the radar is airborne, the equipment is relatively heavy and bulky, and it requires skill for operation. Because of limitations on aircraft antenna size, airborne radar does not produce information of the highest definition. Furthermore, it provides no traffic control data on the ground for the use of the traffic controller. Ground radar, on the other hand, furnishes adequate information in sufficient detail, but this information is on the ground and is not available to the pilot.

Full advantages of radar can be realized if information from a high-definition ground-search radar can be transmitted to the pilot. Voice communication channels would not be practical for this purpose. One has only to imagine the number of words required to describe the movement of a number of planes around an airport to realize the difficulty of using voice facilities.

Fortunately, television furnishes an excellent means for transmitting almost limitless amounts of information and of depicting that information in a manner requiring little effort for its perception and use. In fact, television is uniquely suited for transmission of ground radar information to aircraft. In addition, it provides a means for transmitting other data such as weather maps, ceiling, visibility and traffic instructions. Rather than being instrumental in nature, the received information is pictorial.

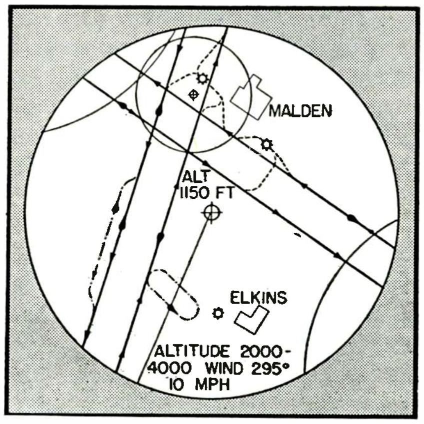

FIG. 4—Pilot presentation (television picture in cockpit) at lower altitude than Fig. 2, during approach to airport. Local information is received during this phase

In December 1941, the Teleran system (a contraction of Television-Radar Air Navigation) was devised but, due to the war, actual development was not undertaken until 1945. In Teleran, aircraft positions are determined by ground-based microwave radars, the data from which are combined with other graphic information (e.g., control instructions, maps, etc.) and transmitted aloft by television. Figure 1 is a block diagram of a simple installation. Ppi radar presentations are viewed by television cameras. Maps of the area are superposed, either optically or electrically, and the combined picture is transmitted aloft by television. The map or chart may contain many graphic data of interest, and the kinds and amount of information which can be transmitted are almost limitless. Since the position of all aircraft at all altitudes would be confusing to the pilot, the system includes a system of separating the signals received from aircraft at various altitudes, and transmitting a separate picture for each altitude level. Aircraft move rapidly horizontally and slowly vertically, so that it is logical to provide the pilot with information on the location of objects many miles from him horizontally but not to include objects more than a thousand or so feet above or below him. Thus the pilot does not have to think in three demensions.

Equipment Operation

Figure 2 is a typical example of the picture received by the pilot over Teleran. It will be observed that the radar echoes are displayed in such a way that their relative positions with respect to each other and with respect to landmarks are clearly shown. The radar echoes are elongated in the direction of each aircraft's ground track.

The parallel lines superposed on the picture are not part of the television transmission. They are ruled on a transparent disk which is connected to the aircraft's directional gyro (gyro compass) and are used to show the heading of the aircraft. Thus in a single picture the pilot sees his own position, the position of

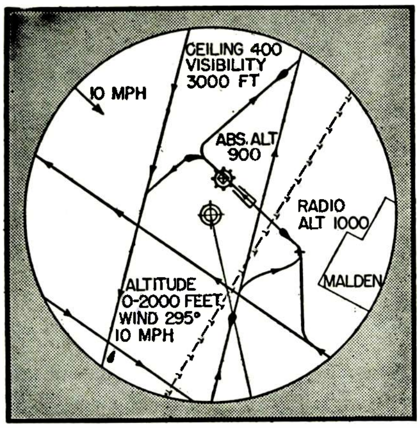

FIG. 5—Pilot's image when in immediate vicinity of airport. Scale has been enlarged to reveal details of traffic pattern

other aircraft, his own heading, the location of airways and other information. A Teleran picture constitutes his chief navigational instrument.

Each aircraft carries a transponder (beacon), in part to produce a clear image on the ground radar ppi screens, and in part to permit the altitude separation feature mentioned above. The transponder is tied into the barometric altimeter so that its transmitted signal is coded in relation to altitude. By means of this code, the altitude separation can be accomplished automatically by the ground radar. This radar will have a number of ppi indicators, each showing only the aircraft at a given altitude. Successive altitude levels will be made to overlap by 25 percent to avoid collision possibilities if aircraft change from one level to another. A block diagram of airborne components is shown in Fig. 3. It is, of course, imperative that there be means for the pilot to identify his own plane. This is done by a radial line which appears in the picture and which passes through the pilot's own aircraft.

Each pilot sees himself as a spot moving on a map, which is the way pilots naturally visualize their flight. The type of information transmitted over the television link will depend upon altitude. For instance, a pilot flying at 15,000 feet will be shown the location of cities, airways, settlements, etc. but will not be shown details such as the locations of approach paths to airports. However, approach paths, ground obstacles and other data will be transmitted to the aircraft flying at 3,000 feet.

An example of a picture for a lower altitude is shown in Fig. 4. Approach paths are shown for two of the airports in the picture. This figure also illustrates the flexibility in traffic control procedures. The aircraft in which Fig. 4 is received (the one with the radial line through it) is flying on a holding course to which it was assigned by traffic control. Another aircraft is taking a passing course around a slower aircraft. Special courses of this sort can be established by the traffic controller and can be removed as soon as the need for them ceases to exist.

For use in observing and controlling the traffic around a busy airport, it is advisable to have a separate ground radar devoted solely to this problem. This radar could have a fifteen-mile range. The picture such as would be transmitted with this radar is illustrated in Fig. 5. Ceiling and visibility data are now transmitted, as are the absolute altitude of the airport and an arrow showing the wind velocity and direction.

The basic Teleran system for navigation, therefore, includes a long-range ground-search radar, a short-range ground radar, ground selection of codes to separate the signals received from various altitude levels, television cameras for picking up the radar presentations, a television transmitter for sending the pictures aloft and a television receiver and transponder in each aircraft. The simplicity of the airborne equipment is particularly noteworthy.

Instrument Approach

When visibility is greatly restricted, some means must be provided for completing the landing by instruments. In Teleran, this is accomplished by employing a high-precision, rapid-scanning ground radar such as the radar portion of the ground-control approach (GCA) system (page 112, November 1945 issue of ELECTRONICS).

By certain modifications in the radar equipment and by other techniques too involved to describe here, it is possible to obtain a presentation which continually shows the pilot his position with respect to the glide path, his heading, his pitch attitude and the location of other aircraft ahead of him or behind him in the glide path. A typical picture received by the pilot is shown in Fig. 6. The position of the aircraft with respect to airport and imaginary extension of the runway is clearly shown in a manner similar to that of the previous pictures. In addition, there is automatically presented a horizontal line which appears above or below the spot representing the aircraft, depending on whether the aircraft is below or above the exact glide path. Thus, in Fig. 6 the plane nearer the airport is exactly on the glide path, while the plane more remote from the airport is below and to the right of the glide path. To aid the pilot in maintaining smooth descent, indications (obtained from the aircraft's gyros) are given for the plane's pitch and heading.

Figure 7 is a perspective sketch of a complete Teleran installation. If such installations are repeated about every hundred miles along an airway, Teleran can be used for long range overland navigation. This would allow aircraft a great degree of navigational flexibility, and would particularly benefit the itinerant flier. It is interesting to note that with Teleran a new airway may be established by merely drawing a line on a map or chart.

With Teleran, almost infinite variations are possible in methods of

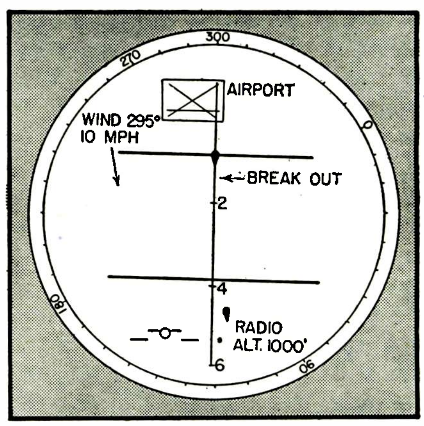

FIG. 6—Landing presentation, to which pilot switches during final descent. The information provided by ground-control-aplarged to reveal details of traffic pattern

traffic control. Methods can be worked out which will permit precise control of the position of each aircraft. As for the important subject of meteorological data, it may prove desirable to transmit weather maps over the television link at given periods.

Besides the advantages previously outlined the system has the very definite advantage of being self-calibrating and self-warning. Should anything fail in either the ground or the airborne apparatus the pilot is immediately aware of the difficulty and will not receive false or misleading indications. The scale is established on the ground and the scale in miles may be transmitted with the picture. Therefore, no change is necessary in the airborne equipment to make it suitable in all zones and for all functions. The presence of a distance scale permits ground speed to be accurately estimated and will greatly assist both the pilot and the ground controller by providing a means whereby the time of arrival of the craft into the control zone, and the progression in the various patterns, may be predicted with considerable precision.

Another feature is the possibilty of providing the controller with information as to traffic conditions beyond his particular control zone. Wherever a search radar equipment is installed for purposes of surveillance, the information may be transmitted to a remote observer by relay means. By such means the traffic controller may, at his discretion, observe the traffic approaching his control zone, or the airport tower may observe the traffic in the approach control zone.

Available Techniques

How much of the equipment and knowledge required for the construction of the system described above exists and how near are the remaining problems to solution? Ground radars having ranges in excess of 100 miles have been built and operated successfully. Beacons to work with those radars have also been designed and built in some quantity. The techniques of television, fairly well established before the war, have been improved by wartime experience, and lightweight airborne television receivers have been mass produced. Thus the basic data required for the system design is at hand.

Several problems do need further investigation and development. Among these is the problem of transforming the incoming radar signals into television video. A possible method is viewing the radar indicators with high-sensitivity television pickup tubes. Experiments have been performed on this with moderate success, and it is a virtual certainty that with a brighter indicator tube and a faster optical system, completely satisfactory results can be achieved.

Some investigation of methods of beacon coding with altitude is required in order to insure that no spurious echoes will be produced under dense traffic conditions. A number of different coding methods are available and it is reasonable to assume that at least one of them will be satisfactory. The radio frequency employed for the television transmission will be high, probably close to the microwave region. Transmitter tubes and radio-frequency components developed during the war can be used with only minor modifications.

Teleran appears to be capable of meeting requirements of a comprehensive system for air navigation, traffic control, collision prevention and instrument approach. It presents information to the pilot in a very simple manner, and in a way gives him a new and better way to fly his aircraft. It is very flexible with regard to traffic control. Any changes in traffic control or other procedures for sending information aloft do not create obsolescence of the aircraft equipment. The same apparatus in the plane is used for all operations. It provides a maximum of safety against collision both with terrain obstacles and with other aircraft.

It will be appreciated that the bandwidth necessary to transmit the television picture can be much less than that required for broadcast television, since the motions involved are relatively slow. In other words, the frame frequency can be reduced. Suitable frequencies in the region of 1000 megacycles have been assigned by the FCC to air navigational purposes. The techniques employed in Teleran are not radical departures from those already available which were employed during the war. While additional development work is required, the elements of the system are within the realm of accomplished fact.

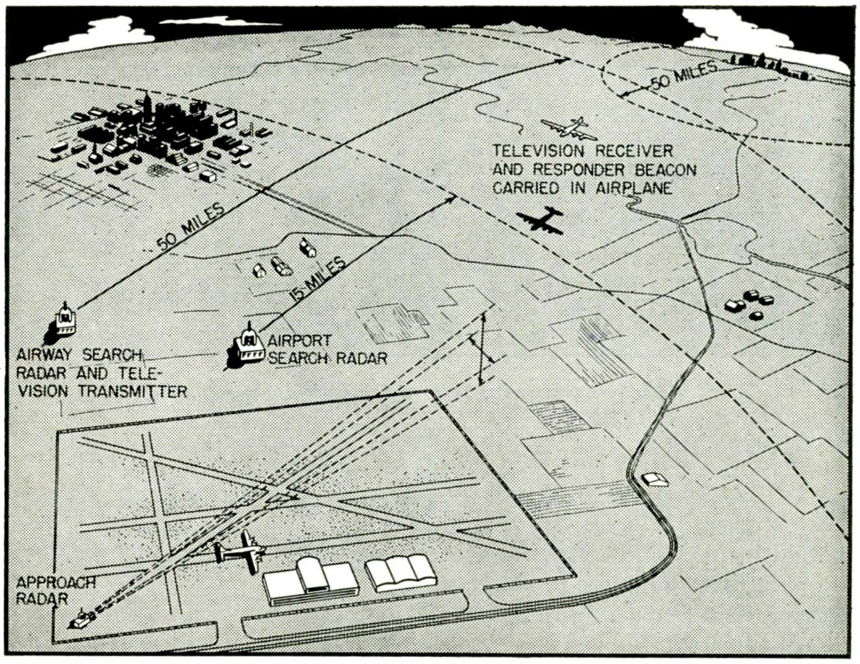

Fig. 7—Typical installation, showing location and ranges of ground radars for long-range search, airport search and landing

Electronic SHUTTER-TESTERS

Photoelectric system feeding a bank of stylii produces on Teledeltos paper a recording of camera shutter-opening area plotted against time, for testing both iris and focal-plane shutters. Direct-indicating accessory shows percent deviation from rated shutter speed

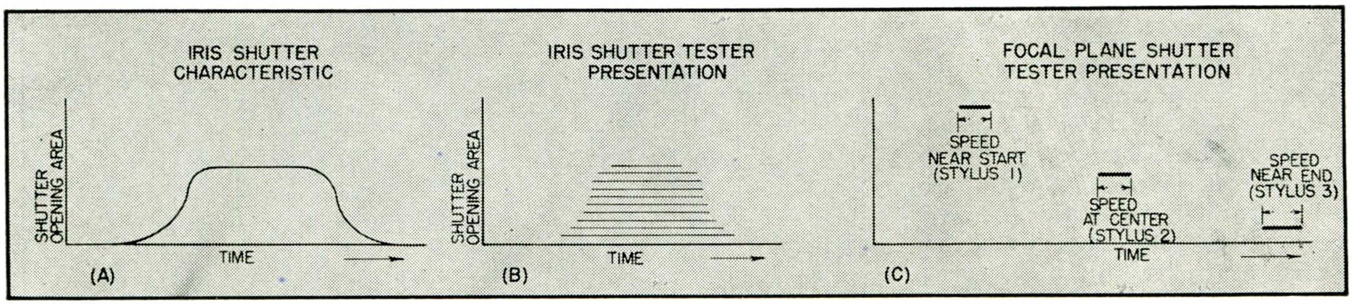

FIG. 1—Examples of records obtained with electronic shutter-tester for iris and focal-plane shutters

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MILITARY demands for large numbers of precision aerial cameras during World War II dictated an accelerated mass-production program. With this program arose the need for a shutter tester of high accuracy, applicable to production-line use. Previous shutter-testing methods, employing both photographic and electronic techniques, were well suited to laboratory use but hardly applicable to production requirements.

One requirement of the new tester was that it be capable of yielding a permanent record of shutter characteristics for both iris-type (between-the-lens) shutters and focal-plane shutters. In the case of the iris type, the record should indicate both speed and efficiency, while for the focal-plane type the record should show the shutter speed at three points: near the beginning, center, and end of the curtain travel. This instrument must also have an auxiliary time-measuring circuit for testing the K-19 night photo camera. Another requirement was a visual-indicating shutter tester for both iris and focal-plane shutters. This article describes shutter testers that evolved from this development program and outlines the factors influencing the design.

In considering the requirement that data from the recording shutter-tester be in the form of a permanent record, it was deemed impractical to use any method involving a photographic process. This conclusion was reached because the time consumed in the development, fixing, washing, and drying sequence would be prohibitive, and because a setup involving a darkroom is inconvenient. This eliminates photographic methods of shutter testing, as well as electronic methods that employ a recording string-oscillograph.

Other possible recording means were studied, and as a result of this investigation it was decided to use Teledeltos recording paper, which has the property of carbonizing and forming a dark line when a stylus energized with sufficient voltage is drawn against it.

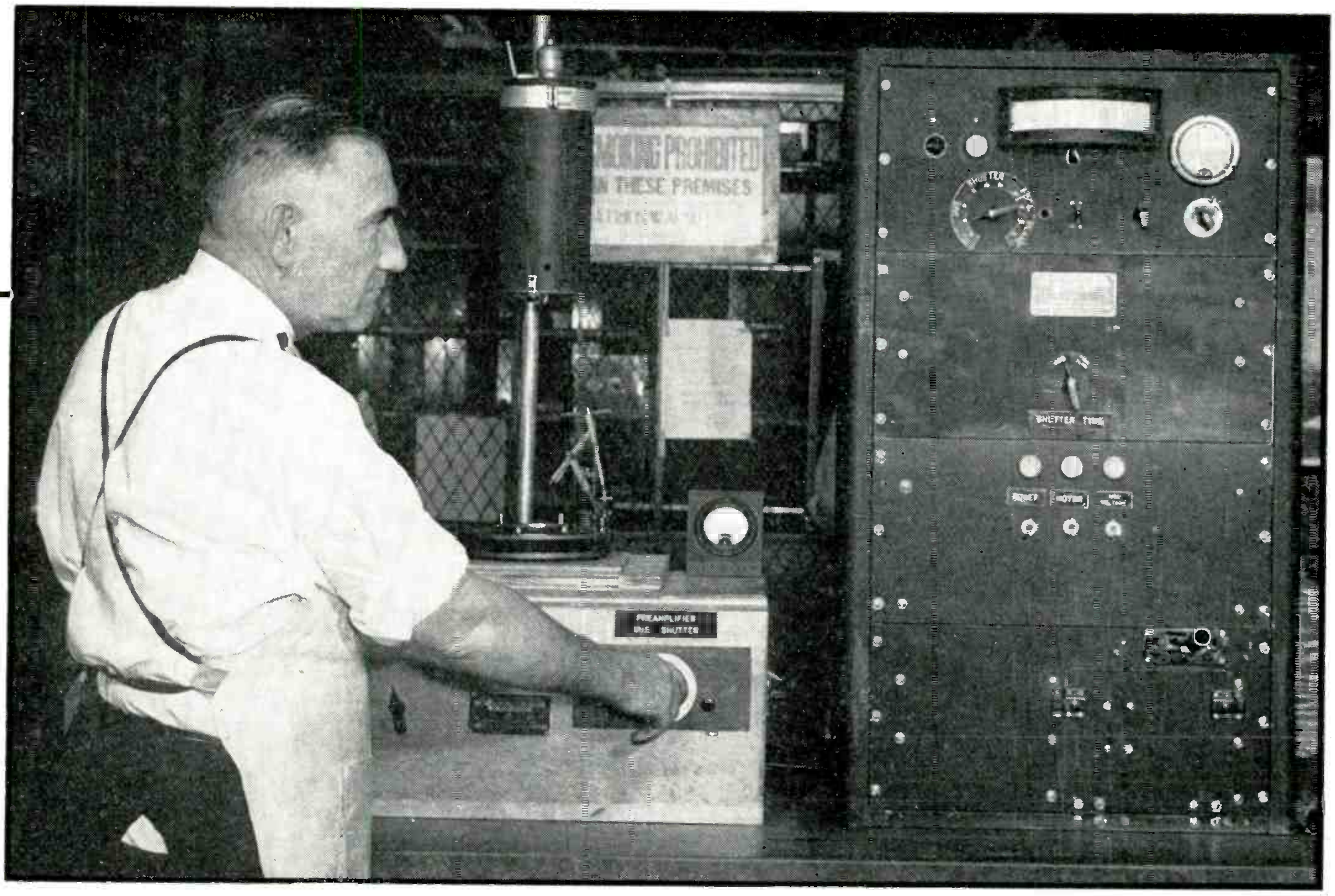
TABLE I. Relation of Shutter Speeds to Trace Lengths

Shutter Speed	Drum Speed	
	1200 rpm	2400 rpm
1/25 sec	12 inches	......
1/50 sec	6 inches	......
1/100 sec	3 inches	......
1/200 sec	......	3 inches
1/500 sec	......	1.2 inches

Recording Shutter-Tester

The best recorded data to provide speed and efficiency figures for an iris shutter is the curve of shutter opening area vs time. A typical curve is shown in Fig. 1A. The advantage of this type of presentation is that it provides sufficient data to rate shutter speed on any of the several bases. To reproduce this curve on Teledeltos paper, it was decided to move the paper under ten stylii equally spaced in a straight line and controlled individually, to give the result shown in Fig. 1B.

With this setup the focal-plane shutter tester could use three of the stylii to show the speed at three curtain positions, giving a record like

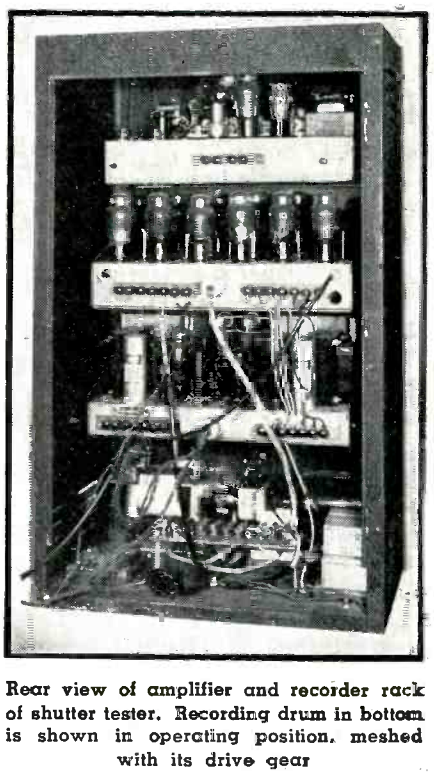


Recording shutter-tester developed by Fairchild Camera and Instrument Corp., being used to check a shutter at all speeds before it is installed in its camera. Recording drum is behind hinged doors in lowest rack

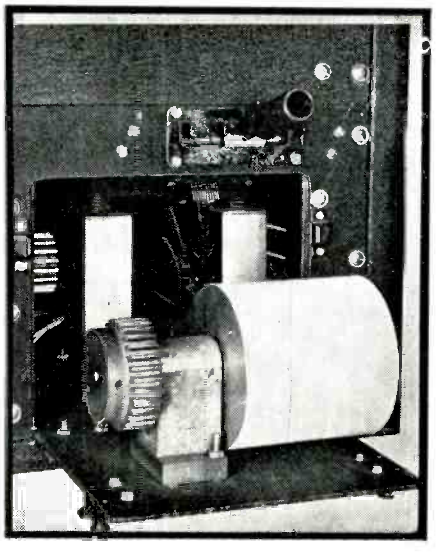
that in Fig. 1C. The recorded lines would not necessarily appear in sequence, as it is possible for the recording drum to make more than one revolution between traces.

The paper was moved beneath the stylii by mounting it on a cylindrical drum of 15-inch circumference, driven by a synchronous motor. The stylii cannot be allowed to rest too long on the paper with the drum rotating as they wear marks which can be confused with the signal traces. To avoid this trouble, the stylii arms are held off the paper by a spring system. Just before the shutter is tripped, a switch is thrown to energize a solenoid which overcomes the spring and contacts the stylii with the paper. Two drum speeds are provided. This is necessary to prevent the traces for low shutter speeds from taking up more than one revolution and overlapping, and still be able to provide a long enough trace for accurate measurement at high shutter speeds. Knowing the drum speed and circumference, the lengths of trace for various shutter speeds can be calculated. Typical values are given in Table I.

The shutter speed tolerance of $\pm$ 10% can readily be detected on this basis. The system necessary to



Rear view of amplifier and recorder rack of shutter tester. Recording drum in bottom is shown in operating position, meshed with its drive gear



Recording drum of recording shutter-tester, shown hinged outward for changing of paper. Recordings of four shutters can be obtained on a single sheet of Teledeltos paper before reloading

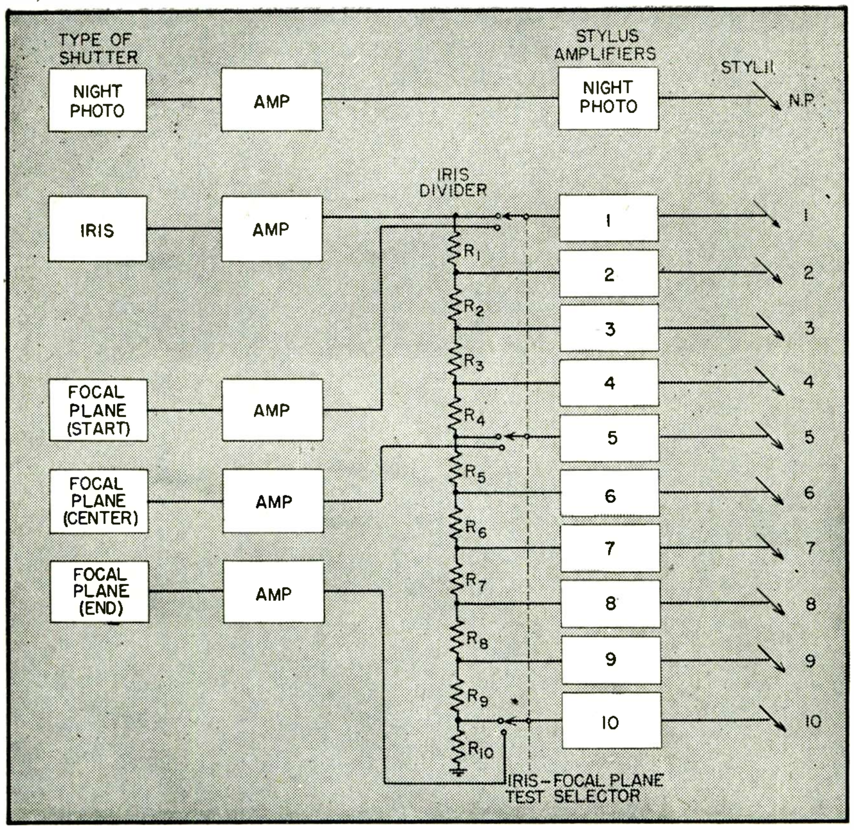


FIG. 2—Block diagram of recording shutter-tester

accomplish this presentation of data on Teledeltos is outlined in block diagram form in Fig. 2.

Iris Shutter Optic and Phototube Unit

In the case of the iris shutter, the first step necessary to achieve the end result shown in Fig. 1B is to convert the shutter opening area into a corresponding electrical voltage. This was accomplished by the photoelectric arrangement of Fig. 3. A light source consisting of a tungsten-filament bulb in a reflector is placed a considerable distance above the shutter. This applies uniform illumination with approximately parallel light rays to one side of the shutter.

It was found necessary to operate the lamp from a d-c source to avoid ripple pickup by the phototube. A lens system on the other side is adjusted to focus an image of the light source on a piece of diffusing material which in turn reflects light to the phototube. The shutter then acts as a variable iris controlling the amount of light received by the phototube. This proved to be the best way to maintain a linear relationship between shutter opening area and phototube output current. The voltage output from the phototube load resistor when the shutter is operated is therefore varying as in Fig. 1A. The system that translates this voltage pulse into lines on the Teledeltos paper must have a frequency response range such that no distortion is introduced.

To consider the frequency response requirements, refer to Fig 4. To transmit without distortion an isolated trapezoidal pulse in time a general rule is that the circuit must be flat in response up to a frequency f determined by $1/T$, where T is the time duration of the slope. The pulse obtained from the phototube approaches the shape of Fig. 4. Assuming that the highest shutter speed to be encountered would be 1/1000 sec and assuming that the slope duration might be 10 percent of this, the upper frequency limit f is 10,000 cps. Circuit constants to meet this frequency requirement are

$$f = 1/2\,\pi\,RC \qquad (1)$$

where f is the frequency where response is 3 db down, R is load resistance, and C is shunt capacitance.

In designing the photoelectric circuit, it is desirable to use the maximum permissible value of load resistance to achieve the maximum signal voltage, and thus reduce the amplifier gain requirements. However, as the phototube is built into the shutter test jig, it must be separated from the main amplifier-recorder rack by some five feet of cable. This introduces a high value of shunt capacitance that severely limits the value of phototube load resistance when Eq. 1 is considered. It was accordingly decided to use a cathode follower as an impedance changer at the phototube to reduce the shunt capacitance across the load resistor to a minimum. The circuit is shown in Fig. 5. By locating the 6SN7 very close to the 929, it was possible to use 1.3 megohms for R_L.

Focal-Plane Optic and Phototube Unit

To measure the speed of a focal-plane shutter, it is necessary to measure the time required for the shutter slit to pass a point. The arrangement in Fig. 6 was designed to do this. This setup provides a source of illumination to the top of the shutter while the shutter opening is passed over a narrow slot parallel with it and very closely under it. The light source is restricted with a slot to make the light applied to the shutter more nearly parallel. During the

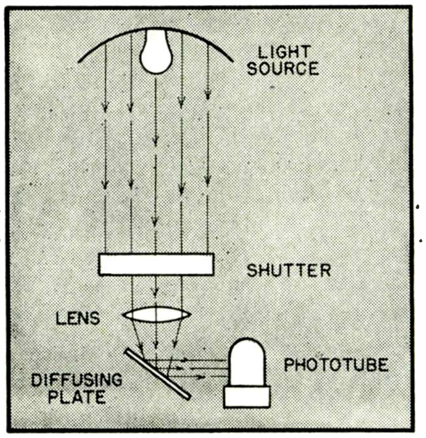


FIG. 3—Optical system of shutter-tester

coincidence of the openings, light will fall on the cathode of the phototube. The output of the phototube will then also be in the form of a trapezoidal pulse. The duration T of the slope is the time taken for the edge of the shutter opening to pass over the slot and is therefore a function of slot width.

As the width of this trapezoid near its top is the time recorded to indicate speed, it is desirable to keep the slope duration small enough to limit the error to 2 percent. It is there-

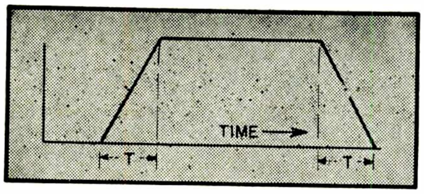


FIG. 4—Voltage output of phototube during operation of iris shutter

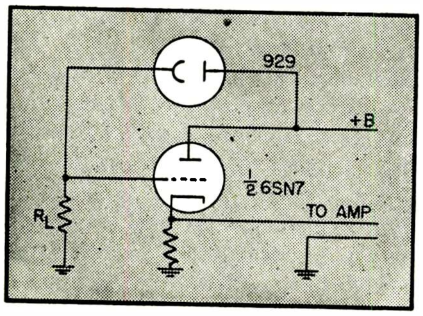


FIG. 5—Phototube and impedance-changer circuit

fore necessary that the beginning slope and ending slope each be 1 percent of the base time. This means that the slot width should be 1 percent of the curtain opening width.

The minimum curtain opening to the considered is ⅛ inch, so the slot was fixed at 0.00125 inch. For a shutter speed of 1/1000 sec and a 1 percent slot, a uniform frequency response up to 100,000 cps is required ($f = 1/T = 1/0.001 = 100,000$).

Three phototubes are built into the shutter holder jig and, as in the iris unit, require long cabling to the amplifier, necessitating cathode followers. The three phototube circuits are similar to that shown in Fig. 5, except that a 6J5 is used with R_L equal to 150,000 ohms.

Stylus Control Amplifier

For controlling the stylii, the circuit of Fig. 7 was used. It is basically a two-stage direct-coupled amplifier using Teledeltos as the output plate load resistor. The 6SF5 plate load resistor satisfies Eq. 2 for 100,000 cps. The 6SF5 is normally at zero bias and the voltage drop across its plate load resistance is sufficient to bias the 6L6 to plate current cutoff.

When a negative signal is applied to the 6SF5 grid, its plate current decreases and the negative bias is removed from the 6L6, allowing current to flow through the Teledeltos (assuming the solenoid is energized so it holds the stylii down on the recording drum). An input signal to the 6SF5 grid of one volt is sufficient to produce a trace.

It was initially planned to ground the recording drum, thus grounding the positive 250-volt plate supply of the 6L6. However, this led to hum difficulties in the 6SF5 grid circuit due to the floating power supply circuit. The drum was therefore insulated and the ground applied at the negative terminal of the 6SF5 power supply. The operator is protected by the mechanical arrangement of the drum. For changing recording paper, the drum is hinged outward, as shown, disengaging it from the drive motor and disconnecting it from the high voltage.

Eleven of these stylus amplifiers are provided, ten for iris shutter recording (three of which are used for focal plane recording) and one for night photo camera timing, as was shown in Fig. 2. All run from a common power supply.

Iris Divider System

The first consideration in designing the iris divider system is the voltage increments on which the chain of stylus amplifiers are to operate. The first amplifier in the chain goes directly to the signal source and will always operate on one volt. If the divider is designed so the succeeding channels work on one-volt increments, the situation shown in Fig. 8A will exist. This is an undesirable condition as the base line of the recording is not the true base line. To avoid this difficulty, the divider was designed to give 10-volt operating increments. This yields a recording with negligible error in the base line, as in Fig. 8B.

The divider resistance was made 100,000 ohms and was built up of precision wire-wound resistors having one-percent tolerance, for which individual values are given in Table II.

Amplifier for Iris Shutters

From the preceding discussion, it is seen that the amplifier unit for iris shutters must be capable of amplifying the phototube output sufficiently to supply the divider with a 91-volt pulse without appreciable distortion. The components were selected by using Eq. 1 on the basis of passing up to 10,000 cps. The resultant circuit is shown in Fig. 9. Gain control R_1 is necessary to compensate for the difference between maximum opening areas of the various shutter types. A position is selected for each shutter type so that the amplifier output to the divider at full shutter opening is the 91 volts required so that the last stylus amplifier just operates to form a trace.

The smallest shutter gives a 2-volt signal at full opening, so the gain is based on this figure, and all larger shutters are scaled down to this value by R_1.

Potentiometer R_2 is provided to oppose the steady direct voltage present across the cathode follower resistance, so that no d-c potential exists across the gain control. In addition, a 100-ohm potentiometer adjusts the bias on the 6SJ7.

With the phototube totally dark and the system warmed up, R_2 is adjusted until moving R_1 slowly from one end to another does not cause the plate current meter to vary. The bias is then adjusted to the correct value as indicated by zero indication

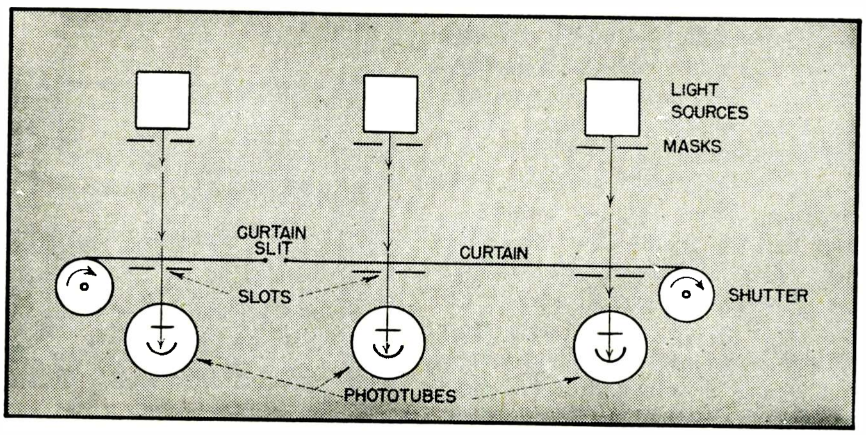


FIG. 6—Optical system of focal-plane shutter-tester

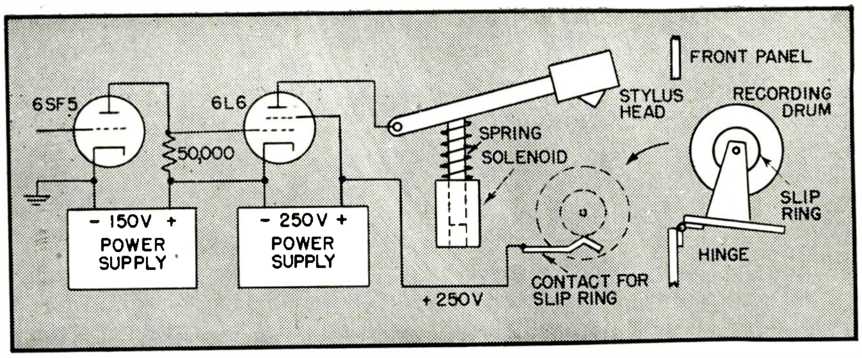


FIG. 7—Basic circuit used in each stylus-control amplifier. Plate circuit of 6L6 is completed when stylus is pulled down to recording drum by the solenoid, because the drum is 250 volts positive

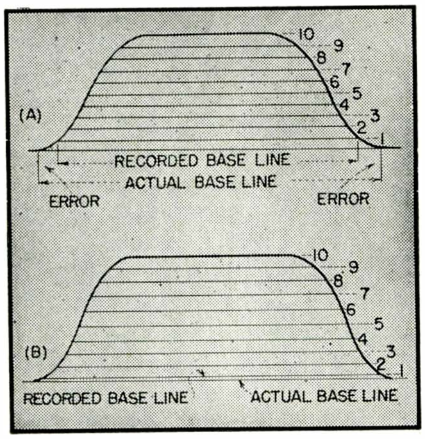


FIG. 8—Base-line recording errors for 1-volt (A) and 10-volt (B) operating increments of iris voltage-divider

of the plate milliammeter. Controls R_1 and R_2 are screwdriver adjustments and only have to be realigned occasionally as a routine check.

When the system is to be set up for a new type shutter, the shutter is opened to its wide-open position and is illuminated. This gives the maximum value of light that the phototube will receive when the shutter is operated normally. Control R_1 is adjusted to give a reading of 1.2 milliamperes on the meter, thus insuring that the top of the phototube output pulse will just be the top of the recorded pulse. The cathode follower is used as before to act as an impendance changer and minimize shunt capacitance effects.

It is theoretically desirable to keep the system a d-c amplifier throughout, to handle the d-c component that exists in trapezoidal pulse. However, the practical difficulties encountered in the system dictated the use of an isolating capacitor C. Because the capacitor will not pass direct current, there is some distortion of the pulse as in Fig. 10, but by suitable choice of RC ratio the effect can be reduced to the point where it is not serious.

Amplifier for Focal-Plane Shutters

The function of the amplifier for focal-plane shutters is to raise the level of the optical system output to the voltage necessary to excite the stylus control to form a trace. The maximum output of the phototube is 1 millivolt and the voltage required to draw a trace is 1 volt, so the requirement is an amplifier with a gain of 1,000 or more and a frequency response to 100,000 cps. The circuit of Fig. 11 is the result of designing to these figures. As the lowest shutter speed is 1/125 sec and as no steady-state light calibration is needed, the amplifier is capacitance coupled throughout. The cathode-follower output is used to provide a low-impedance line to the stylus amplifier. Three of these amplifiers are provided, one for each phototube output. It was originally planned to use type 931 photomultipliers for the focal-plane tester because of the low light level encountered, but these tubes were critical at the time of this development and could not be obtained. Their use would have eliminated the need for the high-gain amplifier.

Night Photo Timing

The K-19 night photo unit required an auxiliary circuit for adequately testing it. This camera has a magnetically actuated iris-type shutter which is controlled by a phototube-amplifier arrangement. In use, the light from a flash bomb dropped from the camera airplane reaches the phototube, actuating the shutter through an amplifier. The requirement is that the shutter shall be fully open in 10 milliseconds from the start of the flash, at which time the flash has reached peak intensity. The system must work on a light intensity change of 0.2 foot-candle.

In the testing of this camera, the shutter is tripped by a pulse of light which simultaneously actuates a phototube in the tester. The light pulse is produced by operating a shutter located in front of the light source, as shown in Fig. 12. The shutter sped is 1/500th second, which gives a light pulse wave front similar to the actual flash bomb. This is important because the K-19 camera operates on rate of change of light rather than steady-state values. This light pulse passes through the shutter and strikes an optical dividing system consisting of a piece of glass set at 45 degrees to the light path.

Most of the light passes straight

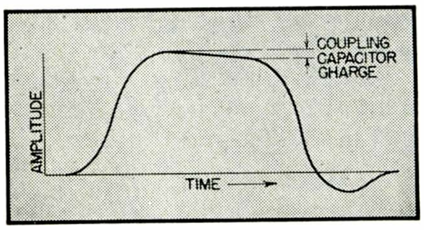


FIG. 10—Overshoot distortion caused by use of isolating capacitor C in Fig. 9

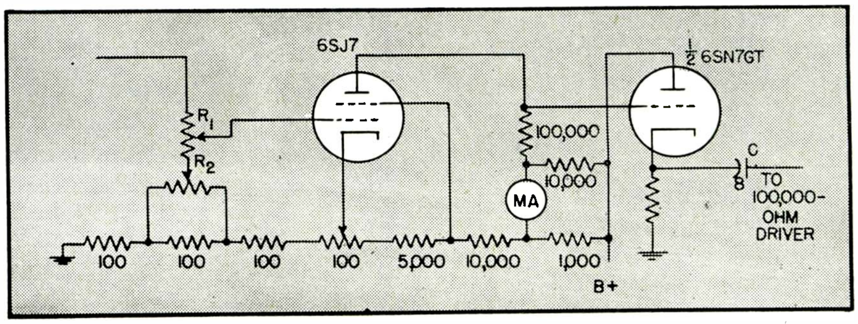


FIG. 9—Amplifier circuit used between phototube and iris voltage-divider when testing iris shutters

through and strikes the cathode of the timing phototube, while a small portion is reflected by the glass to actuate the phototube of the K-19 camera and trip its shutter. This reflected light is further attenuated by a neutral filter so the maximum light reaching the K-19 phototube is 0.2 foot-candle. The light reaching the timing-channel phototube is amplified and fed to the stylus control to form a line. The beginning of this line is the exact instant that the K-19 phototube was energized, so the distance to full open shutter can be measured to see if it is within the 10 milliseconds allowed. A typical record is shown in Fig. 13.

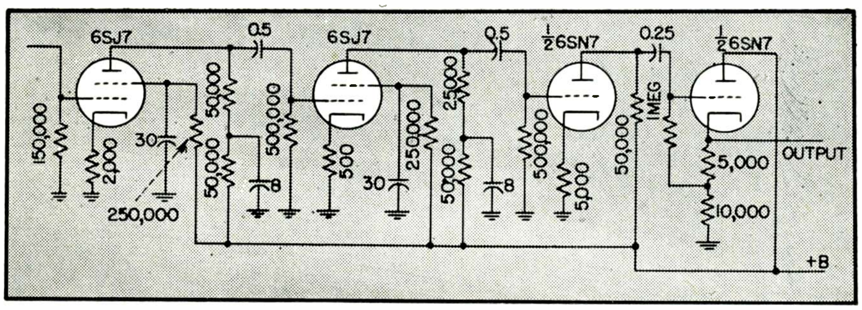


FIG. 11—Amplifier circuit used between phototube and stylus-control amplifier when testing focal-plane shutters

Direct-Indicating Shutter Tester

The direct-indicating tester was developed as a general utility instrument to be used separately or in conjunction with the recording tester. To obtain a high degree of accuracy from the indicator, the output reading is presented as percent deviation from rated shutter speed. In this instrument, iris shutter speed is defined as the total open time, which is the time duration of the base of the characteristic trapezoid.

The final design of this unit consists of a time-measuring circuit, a comparing circuit, and an indicating circuit, as in Fig. 14.

Time-Measuring Circuit

The time-measuring circuit makes use of the constant-current characteristic of a pentode to charge a capacitor to a voltage proportional to time. The input is received from the amplifier output of the iris or focal-plane recording testers previously described, or from a similar circuit when used separately.

The 6SF5 tube acts as a combination amplifier and limiter. It is run normally at some bias such that the drop through its plate load resistor keps the 6SJ7 biased beyond plate current cutoff. A small negative signal then will drive the 6SF5 to cutoff and the 6SJ7 will become conductive and start charging the capacitor in its plate circuit at constant current. This charging current flowing in the cathode circuit and in the divider causes some regeneration due to R_1 and R_2, which effectively increases the gain of the circuit but is not sufficient to cause instability. The effect is somewhat counteracted by the degeneration in R_3, which is provided to keep the 6SJ7 grid in a region of greater current linearity.

For iris shutters the arrangement is such that the 6SF5 is driven to cutoff by a shutter opening area equal to one percent of total opening, remaining in that condition until the shutter is within one percent of being closed. Thus the capacitor is being charged at constant current for the full open time of the shutter. With focal-plane shutters, the trapezoidal pulse described previously is

TABLE II. Voltage Divider Design

	% of total	Value in ohms	Gives 1v when input is
R^1	90.90	90,900	11v
R^2	4.33	4,330	21v
R^3	1.54	1,540	31v
R^4	0.79	790	41v
R^5	0.48	480	51v
R^6	0.32	320	61v
R^7	0.23	230	71v
R^8	0.17	170	81v
R^9	0.14	140	91v
R^{10}	1.10	1,100	......

of sufficient amplitude to drive the 6SF5 to cutoff and charge the capacitor for its duration.

One capacitor (C_1, C_2, or C_3) is used for each shutter speed to be covered, and a switch is provided to select the proper one. The capacitor values are so chosen that each one when charged for its indicated shutter speed will develop the same voltage.

Comparator Circuit

Switch S_1 is a telephone-type switch that connects the 6SJ7 plate circuit to the capacitor selected by the speed selector switch. When the shutter is operated and the capacitor charged, S_1 is thrown to its other

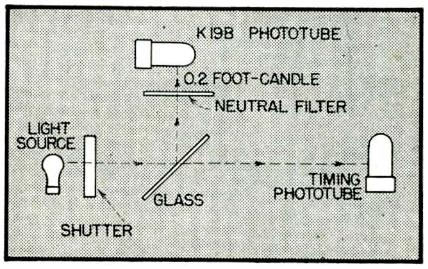


FIG. 12—Optical system of night photo shutter-tester

position. This disconnects the capacitor from the plate circuit and places it in series opposition with a standard source of voltage.

If the shutter speed is exact, the two voltages will be equal and their resultant will be zero. If the shutter is in error, the voltages will differ and the resultant will indicate the direction and amount of error.

Switch S_3 is provided to completely discharge the capacitor before repeating the charging process.

It was found impossible to conveniently select capacitor values close enough to give an exact voltage for a given charging time, so voltage trimmers R_4, R_5, and R_6 were added. One of these is selected with each capacitor value ahd is adjusted to give the proper comparison voltage. This circuit is calibrated by applying electrical pulses of known time duration from a commutator arrangement to the amplifier input.

Indicator Circuit

The resultant of the capacitor and comparison voltages is fed into an indicator circuit through a 30-meg resistor. This value is made high so the capacitor will discharge slowly enough to provide a reliable reading for conditions of shutter error.

The 6J5 circuit is essentially a vacuum-tube voltmeter with a zero-center indicator. Shutter speeds higher than rated result in an up-

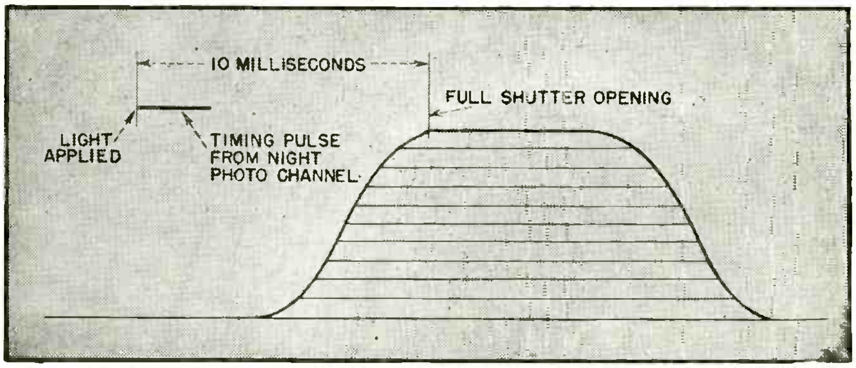


FIG. 13—Timing record obtained when checking night photo shutters

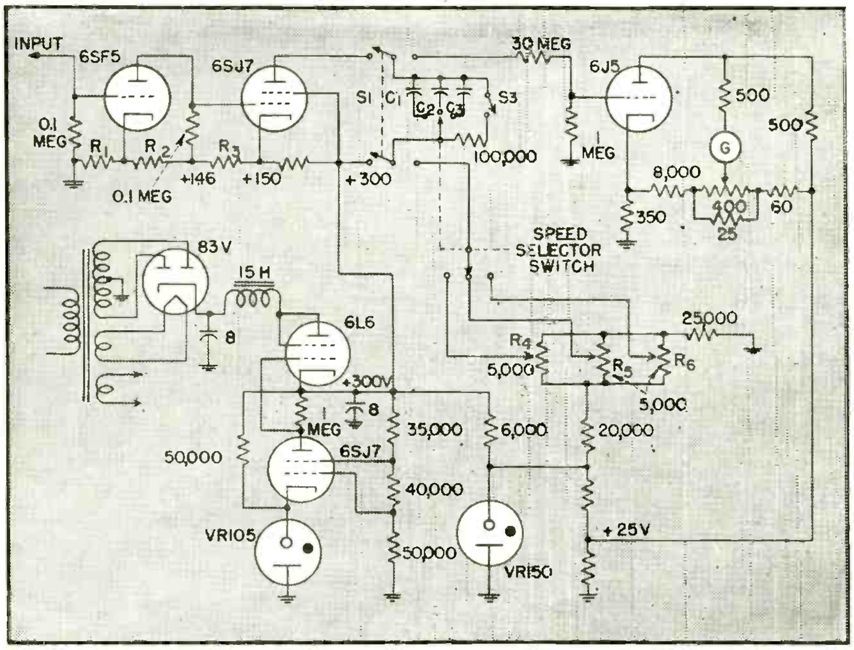


FIG. 14—Circuit of direct-indicating shutter tester

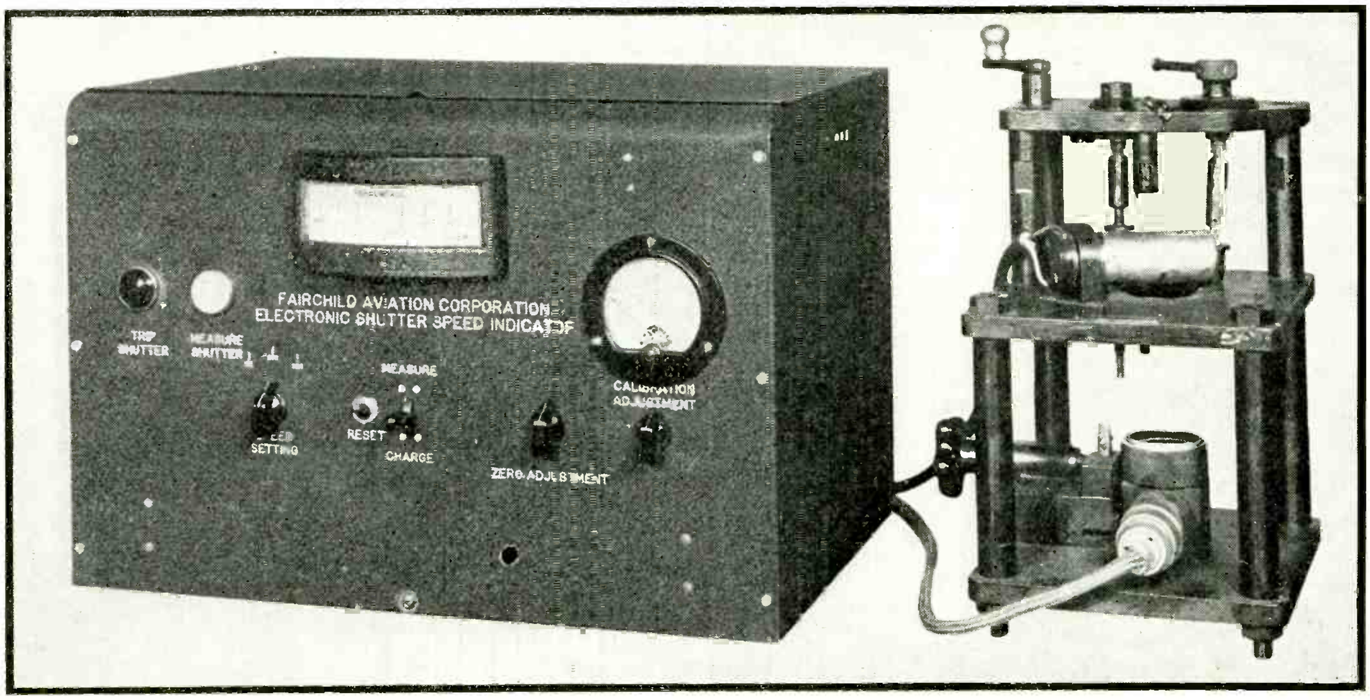
ward deflection, low speeds in a downward deflection. As the voltages being compared for any shutter speed are the same, the indicator can be calibrated in percentage deviation from rated speed. The slight variations due to R_1, R_5, and R_6 do not introduce appreciable error. The full meter scale covers ± 15 percent error.

The circuit constants are such that large inputs cannot damage the 50-0-50 microampere meter, as the 6J5 reaches saturation slightly off scale on the upper end and reaches cutoff beyond the lower end.

Several of these testers were built, for various numbers of shutter speeds. The unit shown in the circuit was arranged for shutter speeds of 1/125, 1/250, and 1/500 second.

The indicating tester proved an accurate and convenient means of measuring shutter speed. On some production runs it was used exclusively for speed tests, the recording instrument being resorted to only for occasional spot checks. It was also useful in production adjustment of shutters.

The author is indebted to Irving Doyle, Fairchild engineer, and Robert Nelson of the inspection department for substantial cooperation and many helpful ideas in connection with the development of the recording shutter tester.



Direct-indicating shutter tester, with fixture for phototube, light source, and shutter holder at the right

CAVITY Oscillator Circuits

Design of re-entrant type cavity oscillators using disk-seal tubes for uhf c-w or pulse operation takes into consideration methods of tuning and of extracting power. Dimensions and tuning characteristics of 10-cm oscillators are given

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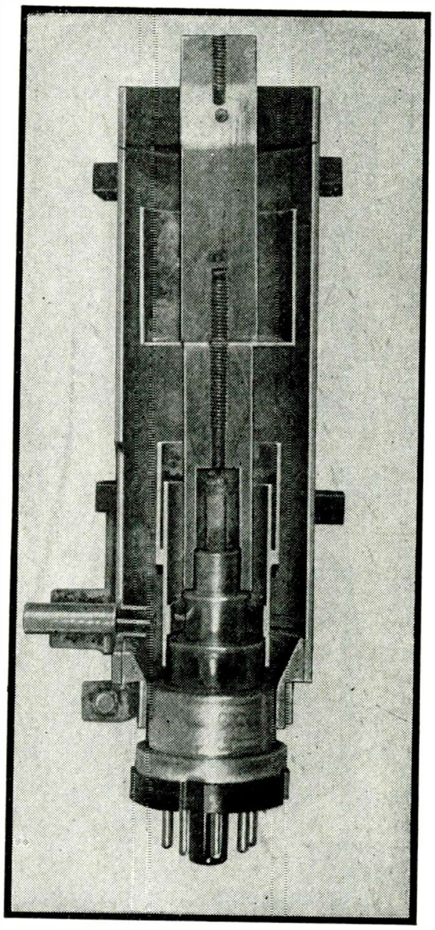
DISK-SEAL TUBES are particularly adapted to the grid-separation circuit (also designated in the literature as grounded-grid or grid-return circuit), as contrasted to the conventional circuit usually used at lower frequencies. The differences between the two circuits are illustrated in Fig. 1A and 1B. The circuit usually used at lower frequencies is shown in Fig. 1A. Here the signal is introduced between the cathode and grid and the load is placed between the plate and the cathode. At frequencies where lumped circuit elements are generally used, this circuit performs satisfactorily. However, at higher frequencies where one is forced to use cavity resonators, the conventional circuit becomes impractical. The problems of shielding between input and output and of controlling exchange of energy between input and output become of prime importance.

Grid Separation Circuit

The grid-separation circuit shown in Figure 1B represents a practical solution. This circuit can also be used at lower frequencies; that is, its usefulness is not limited to cases where cavity resonators must be used. It is readily seen that, if the resonant elements are formed by resonant cavities as in Fig. 2, the grid plane forms a separation between the two resonant spaces; namely, the cathode-grid space and the grid-plate space. The only means by which energy can be exchanged between the two resonators is through the electron stream and by means of the coupling through the grid.



Construction and parts of a re-entrant cavity oscillator of the type shown in Fig. 5. for use in the uhf range

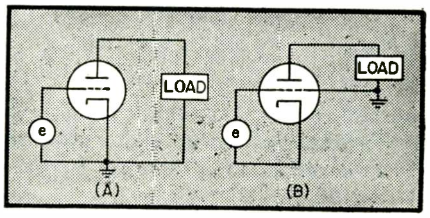
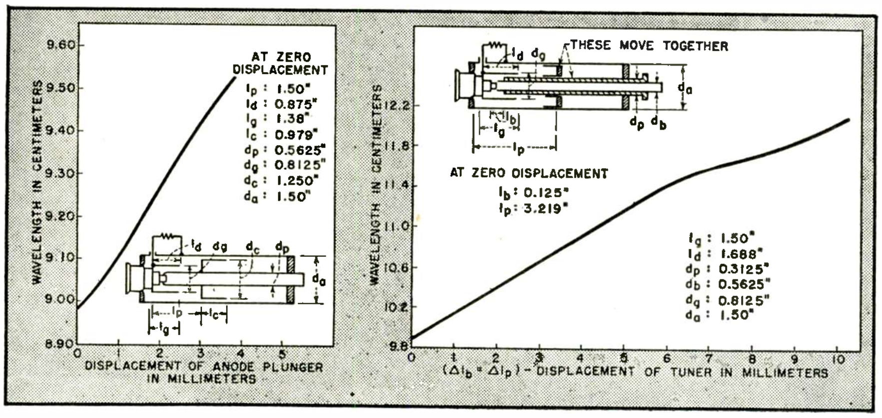


FIG. 1—(A) Grounded-cathode circuit conventionally used at low frequencies, and (B) grounded-grid circuit used at high frequencies



Left. Frequency characteristics of re-entrant oscillator of the type shown in Fig. 5. Right. Frequency characteristic of re-entrant oscillator tuned by the method illustrated in Fig. 6

Computations on a circuit like this are similar to those on conventional circuits. For example, the power gain G is given by the expression

$$G = \frac{\mu + 1}{R_1 + R_p} R_1$$

and for $R_p \gg R_1$, $\mu \gg 1$

$$G = G_m R_1$$

where G_m and μ are the transconductance and amplification factor respectively, R_p is the plate impedance of the tube at the frequency used, and R_1 is the impedance of the load.

In oscillators an external coupling (feedback) of some kind between the

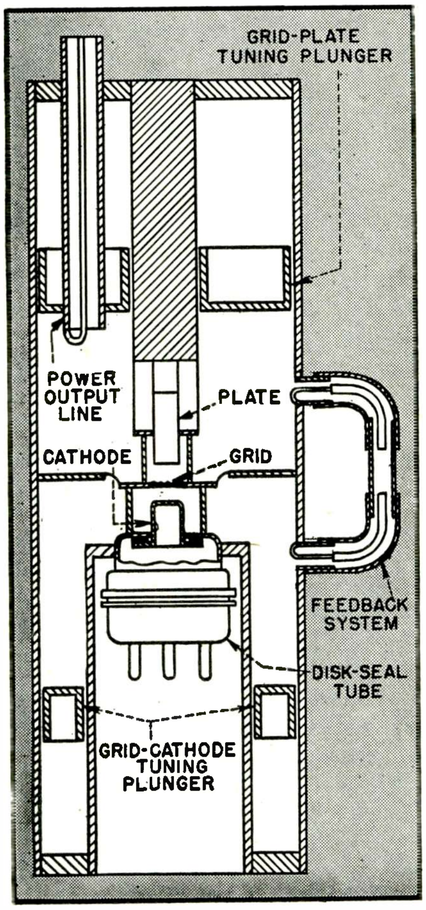


FIG. 2—In this grounded-grid cavity circuit, the grid and grid mounting ring form a separating plane between cathode and anode cavities

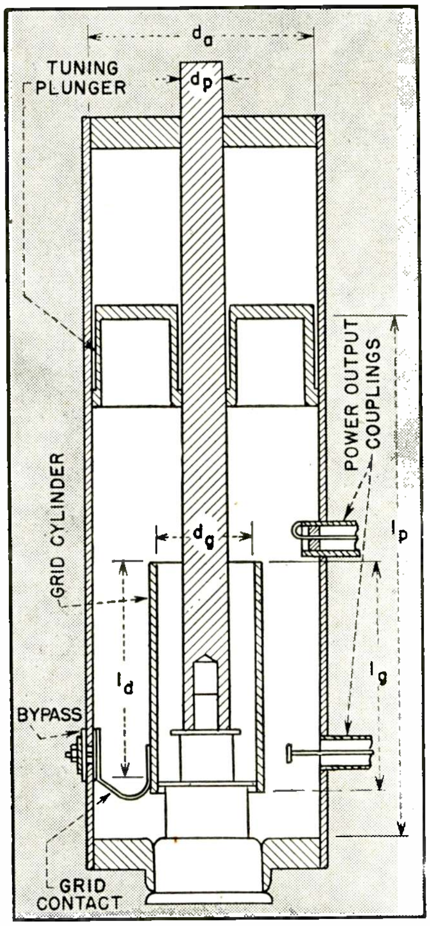


FIG. 3—Length of the grid cylinder determines the frequency of this cavity oscillator. The tuning plunger is set for optimum performance

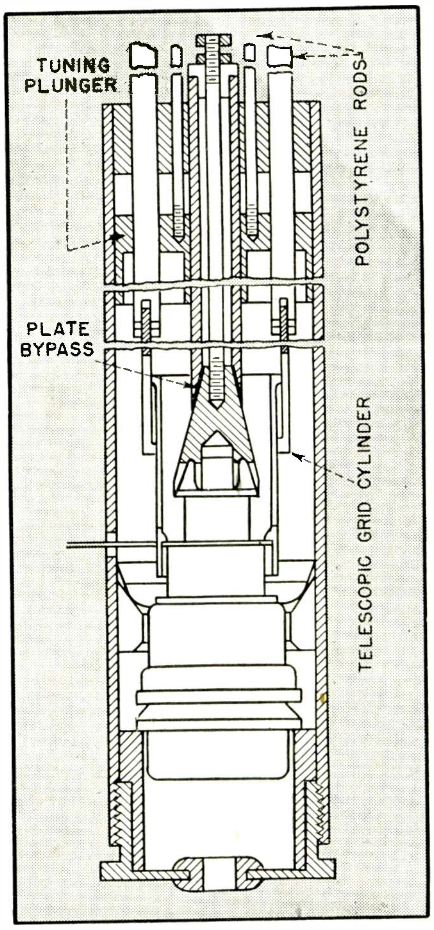


FIG. 4—As the telescoping grid cylinder tunes the cavity oscillator, the tuning plunger also moves to maintain optimum conditions

two resonators is usually necessary, as indicated in Fig. 2. For amplifiers a regenerative control must be used in some cases. This coupling, called the feedback or regeneration circuit, has the job of taking a definite amount of energy from the grid-plate resonator and delivering it at a proper phase to the grid-cathode resonator. Generally a circuit like this is frequency-sensitive and represents a design problem for tunable oscillators, particularly if a single control tuning is desired over an appreciable frequency range. Various designs of this coupling are possible.

Re-entrant Oscillator

This article deals with an oscillator of a design named the re-entrant type oscillator. This oscillator is simple mechanically. It can be tuned by a single control over a considerable range with fairly constant power output. The efficiency and reliability of this circuit, especially in the higher frequency range (around 3000 mc), became evident early in its development. It has been used successfully in a number of practical applications both as c-w and pulsed power sources. Different modifications of this circuit as applied to tubes of types 2C40 and 2C43 (see McArthur, E. D., Disk-Seal Tubes, ELECTRONICS, Feb. 1945, p. 98) are shown in Fig. 3 to 9.

As shown in Fig. 3, the oscillator consists of an outer cylinder which makes contact over the base of a disk-seal tube. An inner rod makes contact with its plate cap. A finger or capacitive type plunger closes the resonant space. The grid connection consists of a cylinder which clamps around the grid ring of the disk-seal tube. A d-c connection for the grid bias is made at the proper points on the grid cylinder. The frequency of oscillation depends primarily upon the length of the grid cylinder as shown by Table I. The plunger has to be placed at a proper position to obtain optimum performance. There are, however, other modes of operation in which plunger position is more important than grid cylinder length in setting the frequency.

For the circuit of Fig. 3, a d-c plate potential of 250 to 500 volts is recommended. A power output of 100 to 150 milliwatts can be obtained

TABLE I—C-W OPERATION OF CAVITY OSCILLATOR

f in mc	l_g	l_p	l_d
	all in inches		
3300	1.37	2.0	1.17
3000	1.75	2.4	1.55
1500	3.8	6.2	2.35
1000	5.6	9.4	1.78

See Fig. 3 for dimensions, d_p: 9/16 in., d_g: 13/16 in., d_a: 1-1/2 in.

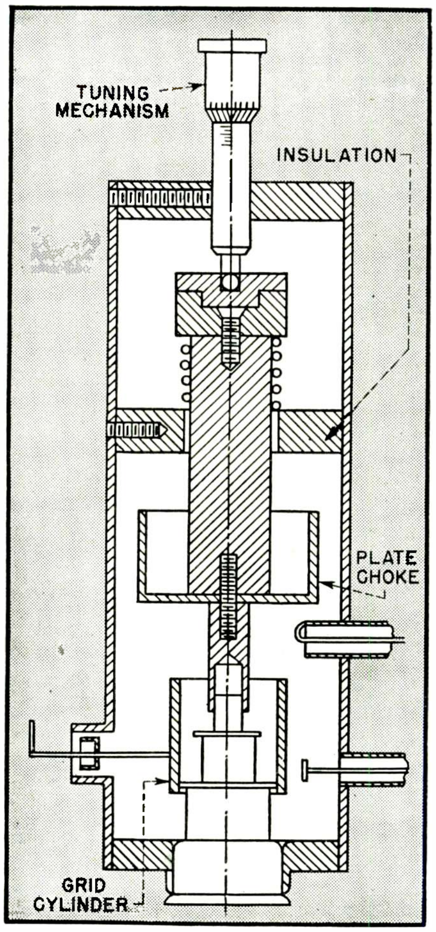


FIG. 5—This tuning method requires a sliding contact at the anode cap that must pass d-c and withstand the high anode temperature

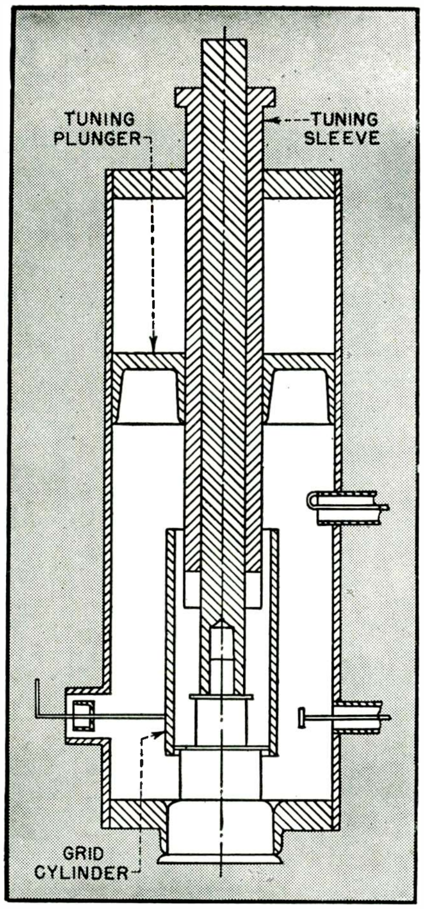


FIG. 6—To obtain a more reliable sliding contact than that of Fig. 5, the tuning plunger is mounted on a sleeve that slides on the plate rod

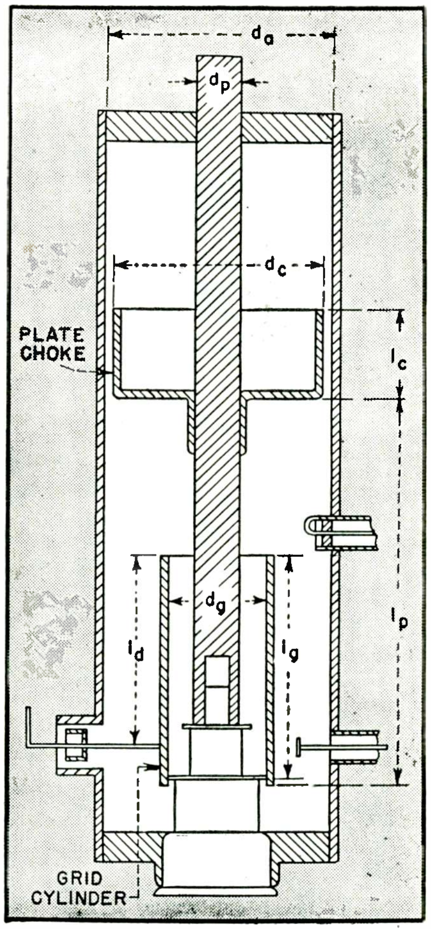


FIG. 7—Whereas tuning plungers have both inside and outside sliding contacts, plate chokes must slide only on their inside faces

from a 2C40 tube at 3000 mc with a plate voltage of 250 volts.

Tuning Methods

Tuning can be accomplished in various ways. One method is to make the grid cylinder telescopic and to move it together with the plunger as shown in Fig. 4. Tuning can also be accomplished by moving the plate contact assembly including the plunger along the anode cap as shown in Fig. 5.

Figure 6 shows an oscillator which has a movable tuner on the plate rod and a separate plunger. The tuner on the plate rod is first put as near the plate of the tube as possible and the plunger adjusted for optimum operation. Then the plate tuner and the plunger are locked rigidly together and moved simultaneously for tuning.

The problem of power extraction from such an oscillator is, of course, one of matching the desired load impedance to the impedance that the oscillator requires for optimum operation. This can be accomplished in any of the well-known ways of impedance matching over the necessary range. Preferably, points for power extraction should be chosen which are physically convenient. The adjustments of the impedance matching system will then be best accomplished experimentally. For example, the loop near the end of the grid cylinder nearest the plate side or a probe near the grid ring have been used successfully. The adjustment was accomplished by moving these probes or loops radially and axially. These different methods are illustrated in the drawings of the several types of oscillators.

For pulsed operation with the 2C43, the data for the oscillator shown in Fig. 7 is presented in Table II. A plate voltage peak of 2.5 to 3 kv was used with these circuits. A power output in the order of 1 kw can be obtained with 3 kv at the plate, 1,000 pulses per second, and 1-microsecond pulse duration.

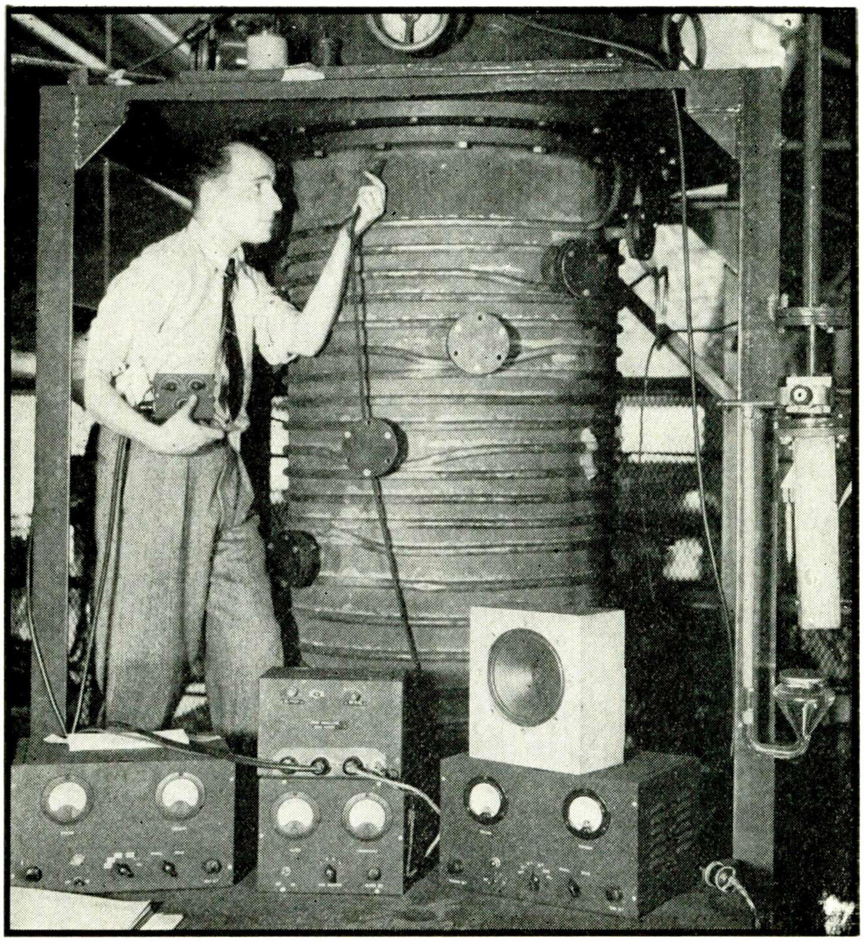
The frequencies given in this article are, of course, only approximate for the indicated dimensions. The actual frequencies will depend on which type of tube is used and will vary somewhat among individual tubes of the same type.

TABLE II—PULSED OPERATION OF CAVITY OSCILLATOR

f in mc	l_g	l_c	l_d	l_p
	all in centimeters			
3300	2.7	2.28	2.2	5.4
3000	3.5	2.5	3.0	6.2

See Fig. 7 for dimensions, d_a: 1-15/32 in., d_p: 9/16 in., d_c: 1-1/4 in., d_g: 13/16 in.

Audio Aid



The audio aid, consisting of a control box held by the operator, a loudspeaker, and the small unit, in this instance standing on top of another piece of test gear in the center foreground, permits one man to spray a vacuum chamber with telltale gas while at the same time listening for indication of leakage

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WITH THE ADVENT of industrial processes requiring vacua of less than 10^{-4} mm of mercury pressure in volumes as great as hundreds of cubic feet, the problem of leak hunting under operating conditions has become acute. Vacuum equipment may often be pressure-tested with high pressure air and soap bubbles before assembly, but after final installation this is usually impossible. Accordingly, ionization gauges, pirani gauges, filament emission gauges and, more recently, the mass spectrometer have been utilized as aids in leak hunting after the system has been evacuated.

In all leak-hunting methods employing these instruments, the output meter of the vacuum gauge is watched while a gas of some type, or a liquid (usually the former) is sprayed over the suspected portion of the vacuum system. When a leak is covered by the gas stream, the output meter reading changes, indicating a change of gas composition inside the vacuum chamber. In many cases an audio indication of change of gas composition is desirable when one is leak hunting.

Typical Vacuum Gauges

Figure 1 illustrates schematically how each of the above mentioned instruments is utilized in leak hunting. When an ionization gauge is used, the microammeter in the plate circuit is observed while a jet of gas, either illuminating gas, hydrogen, helium, oxygen, etc., is run over the suspected section. When a leak is covered by the gas jet, the composition of the atmosphere in the vacuum chambers is altered. If the foreign gas ionizes more readily than air, then more than the normal number of ions will be produced by electrons colliding with gas molecules in their motion from cathode to grid. Since the plate of the ionization gauge is negative with respect to the cathode, it collects the possitive ions generated, and the microammeter reading increases. It had been found that covering a leak with illuminating gas would cause the μa reading to increase, whereas hydrogen or helium decreased the reading.

When a filament emission gauge is used, the emission of the filament is observed as oxygen is blown over the suspected portion of the vacuum system. It has been found that filament emission is very sensitive to the concentration of oxygen in the vacuum atmosphere. In leak hunting, the milliammeter is watched as oxygen is sprayed. A diode filament emission gauge is normally used, rather than a triode, and the steady emission is balanced out on a bridge circuit.

In the pirani gauge, use is made of the fact that the cooling of a filament, and consequently its temperature and resistance, are dependent on the density and chemical composition of the surrounding atmosphere. The greater the pressure (in the micron region) the greater will be the cooling effect of the gas and the lower will be the resistance of a heated filament in a vacuum system. A bridge circuit detects changes in filament resistance. With a pirani gauge, it is generally best to use hydrogen in the gas jet as it cools the filament much more rapidly than

for Vacuum-Leak Hunting

Applicable to most instruments used to detect vacuum leaks when gas is sprayed over the outside of a system, the accessory described here produces a variation in audible tone, or ceases producing a tone, when a leak is detected. Thus only one operator is needed, instead of a man to spray gas and another to watch meters

any other gas. Also, due to its light mass, hydrogen leaks into the vacuum system more readily than most other gases, and thus produces a faster response of the gauge.

The mass spectrometer leak hunter takes advantage of the fact that the quantity of helium in the atmosphere at sea level is very low. A mass spectrometer set to detect helium will normally read currents in the order of micro-microamperes. When a helium jet is moved near a leak, the concentration of helium in the vacuum atmosphere increases many times, and the output microammeter reading increases. This method of leak hunting is very sensitive.

Audio Indicator Circuit

The necessity of watching a meter is often an annoying handicap. If one person is doing the leak hunting, he has to divide his attention between the meter and the section of the vacuum system under test. On large equipment, or on installations where it is not possible to have the meter within reading distance of the equipment under test, two people have to work together, one calling out meter readings and the other handling the gas jet. There is usually a time lag between the response of the reader and the action of the gas jet operator, and, in careful work, this slows down considerably pin-point location of leaks. Furthermore, in noisy atmospheres the necessity of talking loudly and concentrating on numbers being called becomes very tiring to both operators.

Accordingly, it was found expedient to develop a method for converting gauge output-meter readings into audio oscillations, and for having the frequency of the tone change as the vacuum-indicating meter readings changed. Thus, the leak hunting can be done by one operator, under any circumstances of noisy surroundings or inaccessibility of leaky sections.

The basic circuit for producing a frequency-modulated tone with change of input voltage is illustrated in Fig. 2. Components R_1, C_1, L_1 and the thyratron T_1 constitute a relaxation oscillator, the frequency of which may be changed by varying the control grid voltage. The T_2 circuit is an audio amplifier, for converting the voltage variations across C_1 into an audible loudspeaker sound.

The plate voltage at which the

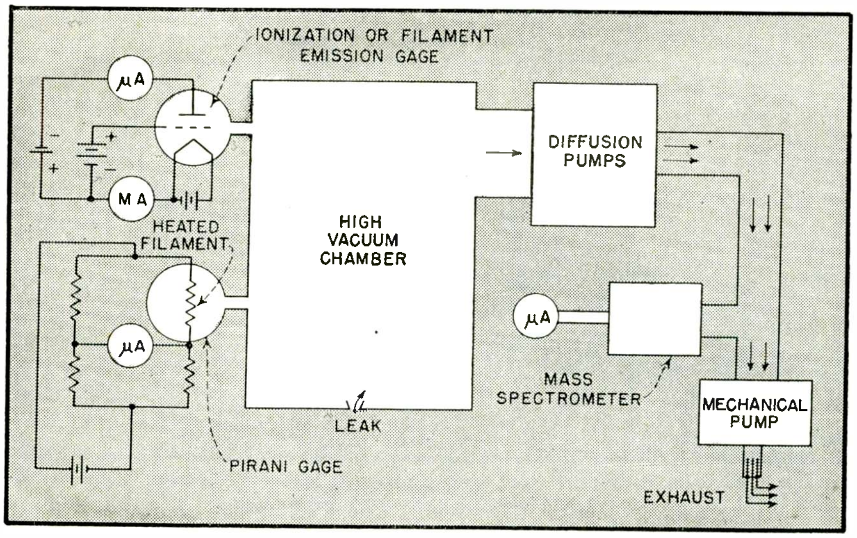


FIG. 1—Conventional methods of connecting leak-detecting apparatus to vacuum systems. The audio aid described in these pages lends itself to all of them

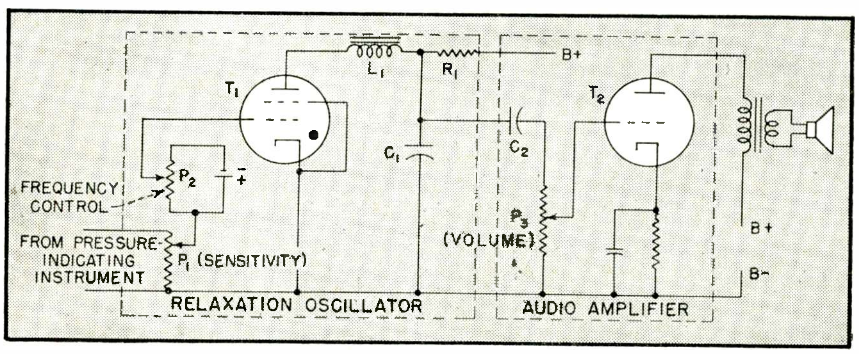


FIG. 2—Basic circuit for converting a varying d-c voltage into a frequency-modulated audio signal

thyratron breaks down is a function of the control grid voltage. With a high negative grid voltage, the plate voltage, or the voltage across C_1, must be high if T_1 is to fire. As the T_1 grid voltage is made less negative, the plate voltage required for firing decreases. Thus C_1 is charged up at a rate through R_1 determined mainly by B+, R_1 and C_1, and discharges when T_1 fires. Accordingly, the frequency with which C_1 discharges increases as the firing voltage of T_1 decreases. As the grid voltage becomes more negative, the relaxation oscillator capacitor has to charge to a higher voltage before the thyratron fires, and the resulting audio oscillation decreases in frequency. If the grid voltage is made sufficiently negative, C_1 will charge up to B+ voltage without firing T_1, and there will be no audio signal.

The voltage swing at the input to the audio amplifier grid circuit is smaller as the frequency increases, since the peak voltage across C_1 is smaller for higher frequencies. This is not objectionable, for the C_2-P_3 circuit can be designed to compensate for the high-frequency signal attenuation by cutting down the transmission of low frequencies. In addition, the ear is more sensitive to the higher frequencies than to the lower frequencies. The net result is that with volume control P_3 set at any value, the output intensity sounds quite constant as the frequency is varied from low to high-values.

The thyratron control grid voltage is the sum of the voltage tapped off the potentiometer P_2 and the part of the output voltage of the vacuum gauge (or the amplified output, for greater sensitivity) tapped off P_1. As the vacuum reading changes, because of an actual change in pressure or due to an apparent change caused by covering a leak with gas, the grid voltage will be altered, with a resulting change in oscillation frequency.

Using the Indicator

For leak hunting, the frequency-modulated audio oscillator or howler is employed as follows:

The output voltage of the vacuum gauge or mass spectrometer is fed into the thyratron grid circuit of the device and, with the vacuum system at a steady pressure, the audio oscillator is set to produce any desired frequency, preferably a low one, by means of P_2, the balance-frequency or steady-frequency control. The operator then sprays the suspected part with gas, and when a leak is encountered, the pitch of the oscillation is automatically changed, indicating that a leak has been found.

At low frequencies the ear is very sensitive to small changes of pitch, and thus the operator need not concentrate on the tone value of the oscillation. If the circuit is designed so that the frequency decreases when a leak is encountered, and the balance frequency is set at a very low value, then the howler will stop oscillating when gas hits a leak.

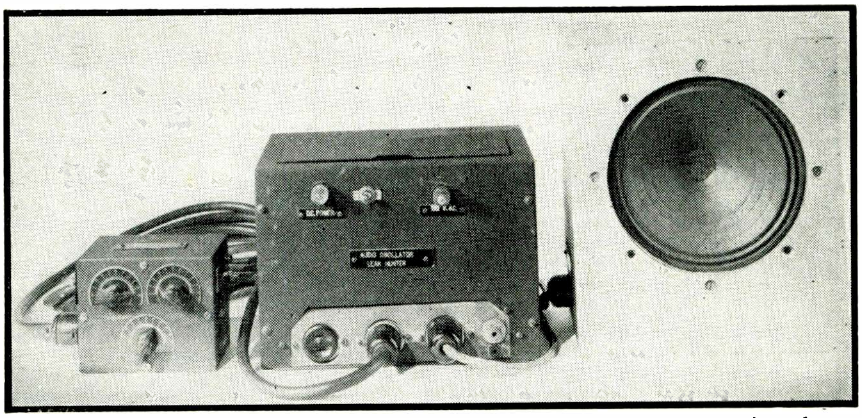
An oscillogram of the howler in operation is shown in Fig. 3. The input to the howler in this case was the voltage developed across the input resistance of the electronic microammeter circuit commonly employed in ionization gauges. This represented about two volts, and produced a steady howler frequency with a fundamental component of about 300 cps. As soon as gas began to leak into the vacuum system, the ion gauge current increased, decreasing the frequency of oscillation gradually to about 180 cps in 0.3 seconds, and then blocking oscillations completely.

Details of Design

A complete schematic wiring diagram of the apparatus is shown in Fig. 4. The 6SN7 is a d-c amplifier for increasing the output frequency change with a given ion current change. In operation, the sensitivity control potentiometer is put in parallel with the input to the ion gauge electronic microammeter (or in series with a galvanometer, in case the ion gauge plate current is read on such an instrument.) This input voltage is amplified by the 6SN7, and is fed from the plate of that tube to the control grid of the 2050 thyratron. The net control-grid voltage is the difference between the variable 6SN7 plate voltage and the relatively constant neon tube drop. As the 6SN7 plate voltage decreases, the oscillator frequency drops. A positive signal input to the grid of the 6SN7 will result in lowered oscillator frequency.

It had been found that with the circuit constants given satisfactory operation is obtained by setting the steady-state frequency control to produce a 30-cycle output. With this setting, an increase of ion gauge current corresponding to an increase in howler input voltage of 1/40 volt, stops howler oscillations. This input voltage change of 1/40 volt corresponded in one instance to a pressure change of less than 10^{-7}mm, or 10^{-4} microns on the most sensitive scale of the ion gauge. With the aid of this howler and an ionization gauge, leaks so small have been found that repairing three of them improved the vacuum by less than 10^{-7}mm. A distinct change in howler pitch can be heard before a shift in ion gauge meter reading can be seen.

The sensitivity of the circuit is so great that the sensitivity control had to be set quite low to obtain the oscillogram of Fig. 3. If full sensitivity were used, the change of input voltage needed to block 30-cycle



The three units of the audio aid for vacuum-leak hunting. A smaller loudspeaker could be used in quiet surroundings

steady oscillations would be so small that it would not show on the oscillographic record, and the ionization gauge voltage would appear as a straight line.

The circuit illustrated can be readily redesigned to produce greater sensitivity by using a higher-gain tube in the d-c amplifier, possibly a 6J7. The increased frequency drift that might result would not be objectionable, since the drift would still be slow in comparison to the sudden change in pitch resulting from a leak being encountered. A stabilized B supply will reduce drift considerably.

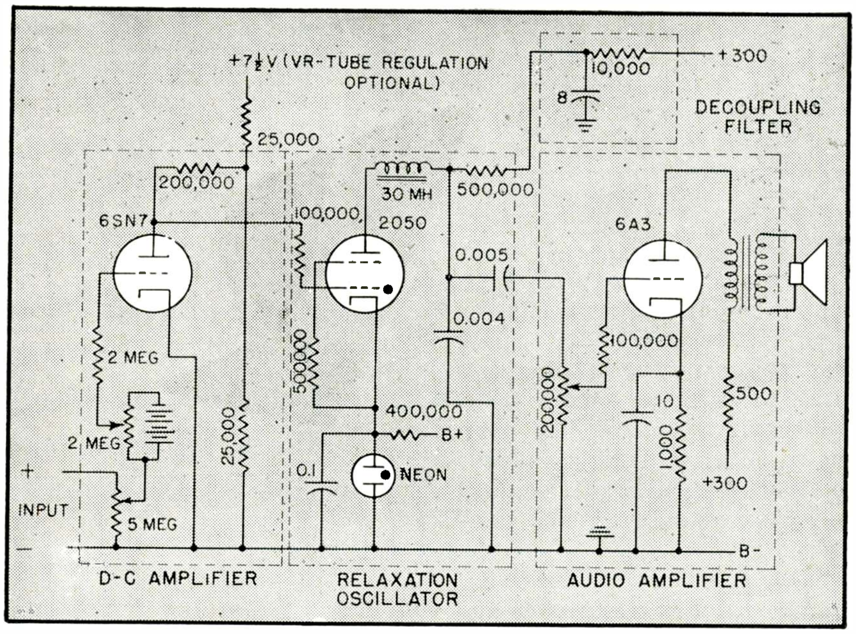


FIG. 4—Complete circuit diagram of the audio aid. A d-c amplifier is used ahead of the 2050 thyratron to increase audio output frequency change with vacuum chamber ion change

Refinements of Design and Use

The howler can be used as a rough quantitative indicator of leak magnitude. The frequency is set very low for leak hunting, to ensure maximum sensitivity due to oscillation ceasing when a leak is encountered, and the sensitivity control is set for highest sensitivity. When the leak is discovered, one may increase the steady-state frequency, and see if applying gas to the leak again reduces the oscillation frequency to zero. A large leak will result in oscillations being cut off even if the howler is set at 5000 cycles, whereas a small leak will drop the pitch noticeably at this range, but will not block the oscillator. In case the leak is so large that oscillations are cut off even with the steady-state frequency set at its upper limit, the sensitivity can be reduced and the test procedure repeated.

The type of leak can also be deduced from the behavior of the howler. If the leak is over a long, tortuous path, such as the thread of a screw joint or gauge connection, or a long seam weld blow-hole, then the frequency will drop very slowly, and there may be a delay of a few seconds between application of the gas stream to the leak and response of the howler. If the leak is directly entrant into the vacuum system, the frequency will drop very rapidly within a second of application of gas to the surface of the vacuum system at the leak.

A pair of phone jacks and a jack-loudspeaker selector switch may be provided if a loudspeaker is objectionable to others in the work area; two men may use earphones for simultaneous work on different parts of the vacuum system. Most of the space in the main cabinet is occupied by the d-c power supply. When the howler is built integral with an ion gauge or mass spectrometer, the d-c supply needed for the latter device may be utilized. In general, a 6A3 is much more powerful than the application requires, expecially if earphones are used, and a twin-triode tube can be employed for the d-c amplifier and audio amplifier. Thus, only two additional tubes are needed for a howler under these circumstances.

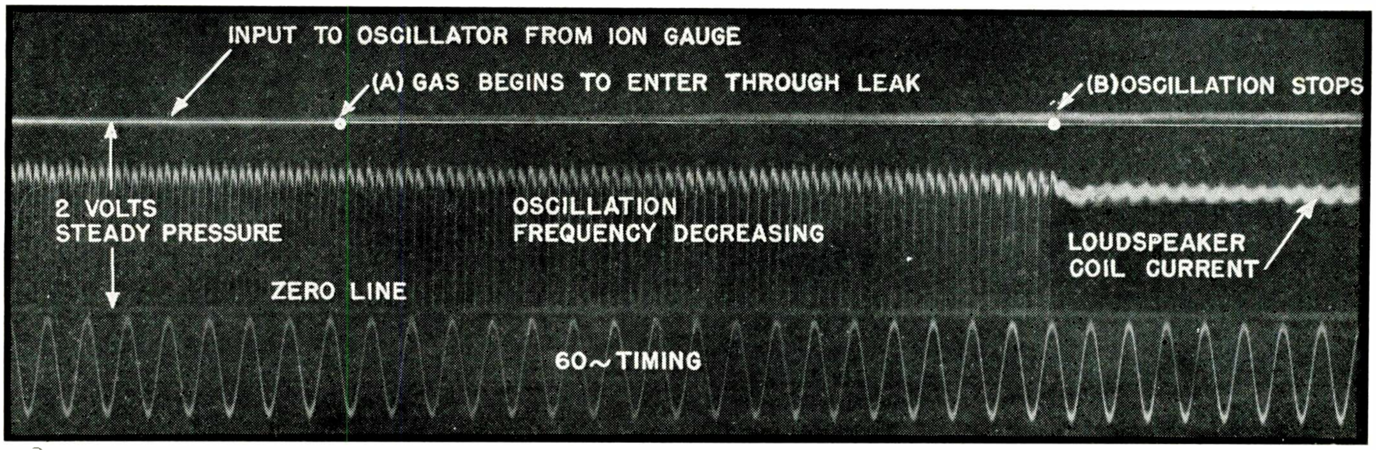


FIG. 3—Oscillogram showing how the audio aid operates. Leaks may be detected by listening for variation in audio frequency, or by cessation of audio oscillation, depending upon how the device is adjusted

Instantaneous

Circuits are pre-set to numbered switches. Throwing one switch disconnects any line in use and connects the desired one to the outgoing channel without key clicks. More exacting requirements are filled by addition of relays and indicator lamps that also provide remote switching

By JOSEPH ZELLE
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THE electronic engineer is often confronted with the problem of changing circuits with a minimum loss of time or error. While some rather foolproof systems have been devised which have served their purpose well, in general they have been complicated in nature. Also, an occasional job arises that would hardly justify such costly and elaborate set-ups.

A fairly effective yet inexpensive instantaneous switching system can be built around the basic circuit illustrated in Fig. 1. Only one switch can connect its circuit to an outgoing channel at one time. In the example shown, switch 3 connects circuit 3 to the output. At the same time switch 5, in the ON position, is all set to take over the moment switch 3 is turned off. For, as switch 3 is flipped off, first it disconnects circuit 3 from the outgoing channel, and then it connects switch 5 through switches 1 to 4 to the outgoing channel.

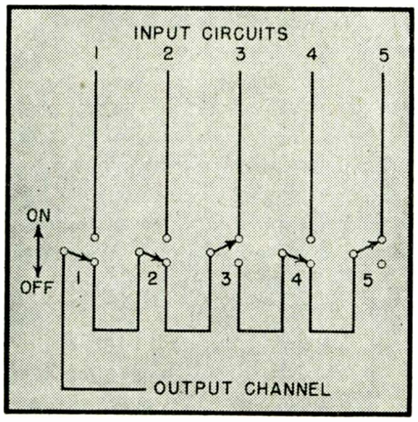


FIG. 1—Basic switching circuit that prevents more than one incoming program from feeding an output channel

The arrangement has three advantages: circuits can be pre-set in the order in which they are to be used, so that switching becomes virtually errorless and semi-automatic; secondly, the switching will be practically instantaneous since it is achieved by one flip of a switch; and thirdly, the circuits are mechanically interlocked, therefore only one circuit can be put on the outgoing channel at a time.

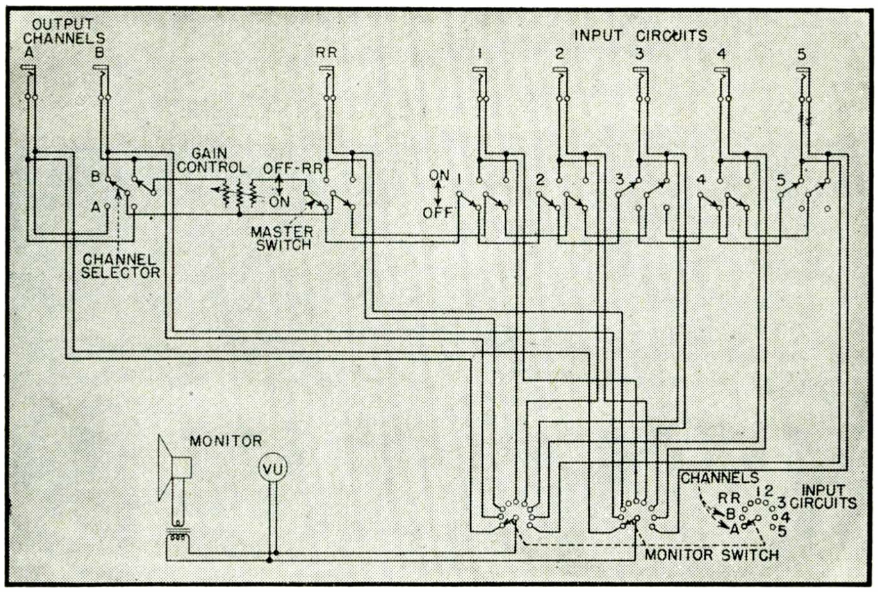


FIG. 2—Complete circuit of switching unit for feeding any one of five circuits into either of two channels

Applications

Any number of circuits can be tied in. They can be connected directly to the switches permanently, or for more flexibility, jacks can be provided as shown in Fig. 2 so that any incoming or outgoing available circuit can be patched. Again, by using a second similar system so that one selector feeds into the other, very involved switching can easily be controlled by using two hands. One selector can, for instance, choose the outgoing channel, while the other selector could choose the incoming material. Such circuits can be extended to be operated by cam and motor-driven devices for continuous instantaneous switching.

When double-pole, double-throw switches are connected in this manner, balanced or unbalanced lines can be switched directly into a particular channel. Such a unit is illustrated schematically in Fig. 2 and finds special application in monitoring work or where tolerances are not too stringent.

With the proper channel selected, and the master switch in the OFF

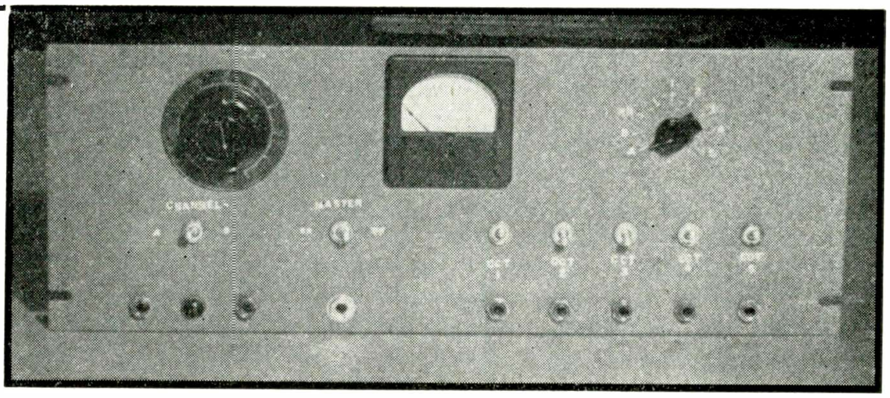
Program Switching

position, the operator patches his receivers, recorders, amplifiers, and so forth to input circuits 1 to 5 (or more) in the order in which they are to be used. The switches are all turned on but the first switch on will have control, going from left to right. If the master switch is kept off, it can be used to start the first program "on the nose." When a change is required, snapping the first switch to OFF will turn off its circuit and put the next one on whose switch is set to ON. If the operator must return to a previous circuit again, merely flipping that switch on will cut the succeeding circuit and put its own circuit back on.

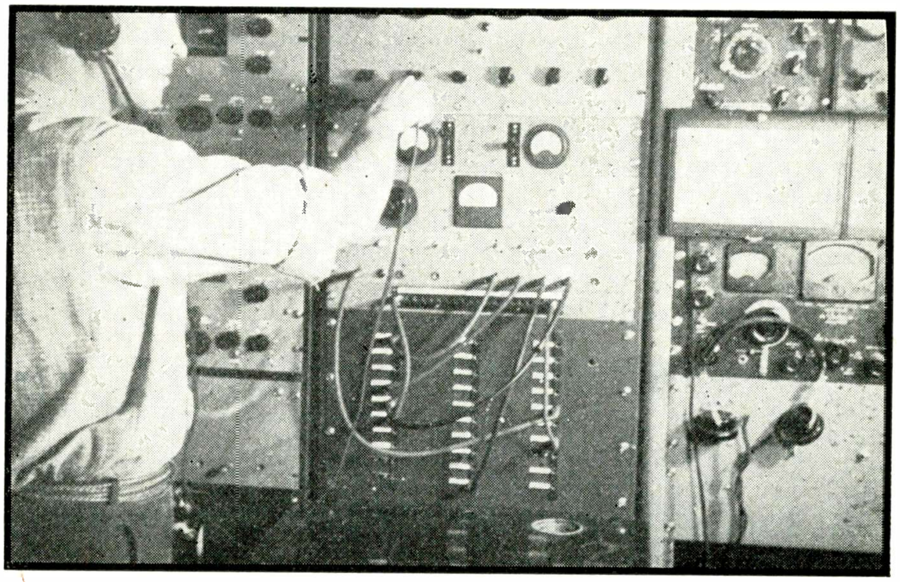
Continuous Recording

The switch that selects either channel *A* or channel *B* is an arrangement especially advantageous in switching from one recorder to another. With the first recorder cutting a program that must be continued on another blank, the operator starts his second recorder cutting a silent groove about thirty seconds before he intends to switch. Then at some convenient pause or break in the program he throws this switch. The first recorder will record no longer but will cut a silent groove, while the second recorder will cut the program material. The switch-over will be clean-cut and smooth so that not even a syllable will be lost. An operator has full control of the situation, with plenty of time for starting the second record and leisurely removing the first one.

Even more intricate switching can be as easily controlled. If two programs are to alternate over two different channels, two switches thrown simultaneously will accomplish the entire operation. The input and output are then used in reverse. Channel A is made to feed the first program, channel B feeds the succeeding program, and two re-



Panel of instantaneous switching unit



An OWI engineer prepares to switch a program feed to the monitoring room in New York

corders are patched to switches 1 and 2, both on. Channel A will feed its material to circuit 1, and when channel A and switch 1 are dropped, channel B will feed circuit 2.

The master switch in Fig. 2 allows the operator to set up all his incoming programs ready to start at the desired moment, yet the material will not appear in the outgoing channel. Disregarding the jack labeled RR for the moment, with the master switch in the OFF or RR position, nothing will be fed to the outgoing channel. When the time approaches for a feed, throwing it on will start the first circuit from the left whose switch is in the ON position. In Fig. 2, this would be circuit 3, because switch 3 is the first in the ON position.

Receiving Remotes

By connecting the jack RR into the circuit, it is possible to receive as well as send on direct lines to remote points. In broadcasting, this is a convenience to the remote control engineer who can listen to the program right up to cue time. The operator at the master control can feed cue down the line to the remote point, patching it into circuit 1, let us say. The RR jack is patched to the studio consolette remote channel. As the announcer finishes his cue, throwing the master switch to the RR position will cut cue and put the remote line on the air, putting control of the succeeding program in the hands of the remote engineer. Here again the result is smooth errorless switching without risky blind feeds from remote points. The gain control works in the same direction whether receiving or sending a program.

One objectionable flaw with the particular system of Fig. 2 is that the circuits operate unloaded except the one actually feeding the line. At the OWI radiophoto and monitoring receiving station at Slingerlands, N. Y., this has resulted in arcing and grounded secondaries of output transformers of receivers when operated wide open for long periods unloaded. This difficulty was overcome by shunting ten-watt, 1,000-ohm resistors across the outputs to partially load the amplifiers of the receivers. Only a 3-db loss by actual measurement was introduced by the mismatch with no noticeable distortion in quality.

For more exacting requirements, a circuit such as Fig. 3 might be incorporated, which has the additional feature of remote control. Here the changeover is accomplished by sensitive fast-acting relays commonly found in control rooms and studios. The four-pole, double-throw relays enable the individual circuits to be loaded constantly until actually in service. In this way gaging levels becomes easier since the load resistors will be of the same value as the line impedance.

The control voltage used to operate the relays can also be used for indicating lamps. By connecting the operating side of the switches in series and the pre-setting circuits in parallel, every switch in the ON position will operate pre-set lamps, but only the switch actually in control will operate the ON AIR lamp. The control-room engineer will know instantly which circuit is hot, and which circuits have been pre-set for operation in sequence.

Originally there was some question as to the effect of key clicks on switch-overs. In practice, though, no objectionable reaction was noticeable provided the levels of the various circuits were almost the same. Even with the receivers unloaded, when it would be expected that violent reaction would take place at the instant of loading, the switching was normal.

Monitor Circuit

Because it is so important that correct levels and equal levels be maintained, a selector switch was included to enable the operator to check each circuit for level and quality of program before it goes on the air. Without some load resistor, the readings will have to be considerably higher if correct level is to be delivered under actual operating conditions. These level settings will have to be determined experimentally, when the unit is installed. By introducing the switching unit at a level of 5 or 6 db below zero level, switching can be done right at the telephone switchboard, and cross-talk is completely absent, even though the leads are unshielded. If accomplished at lower levels, there may be danger of noises due to bad switch contacts and so forth, while higher levels may cause cross-modulation, requiring full shielding of switches and their leads.

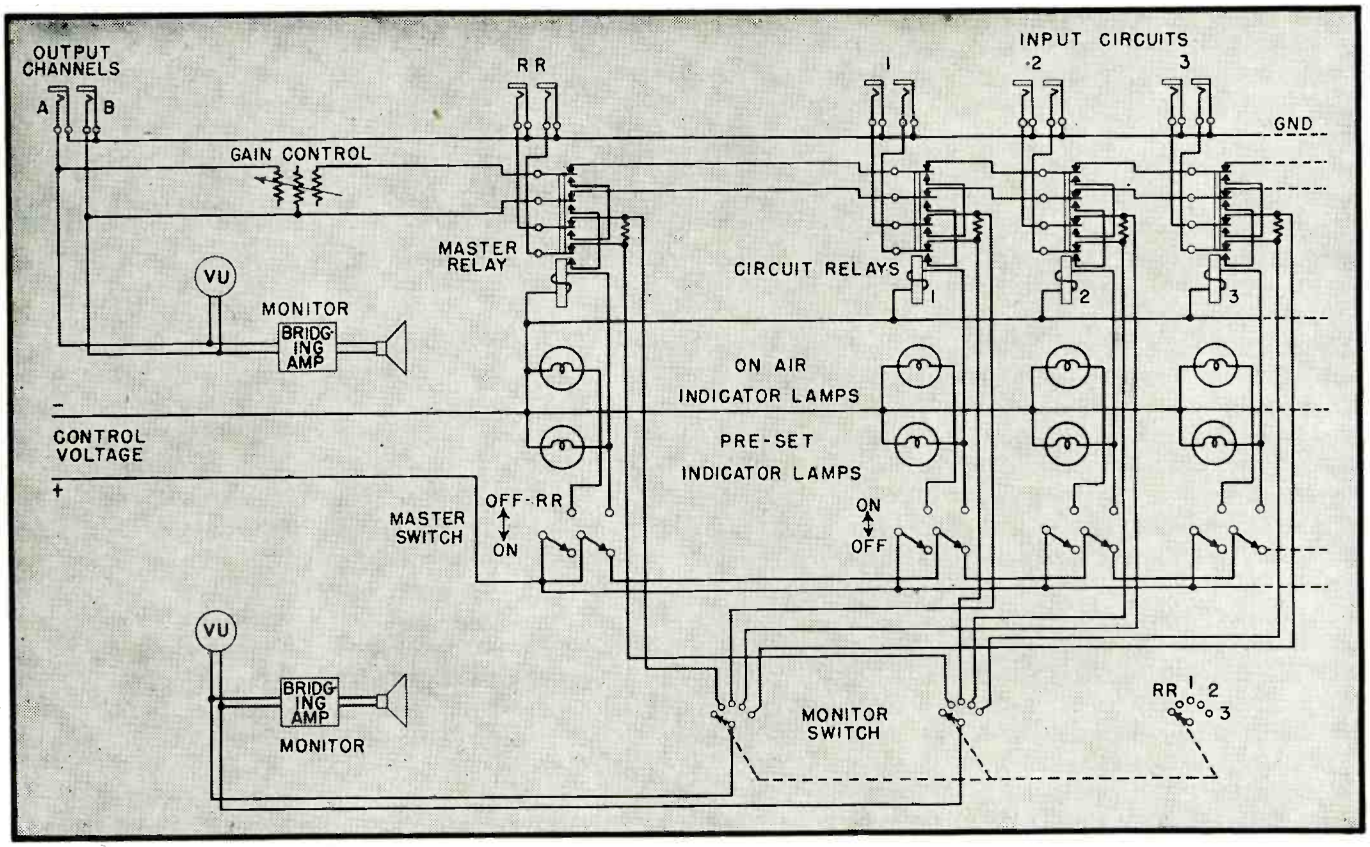
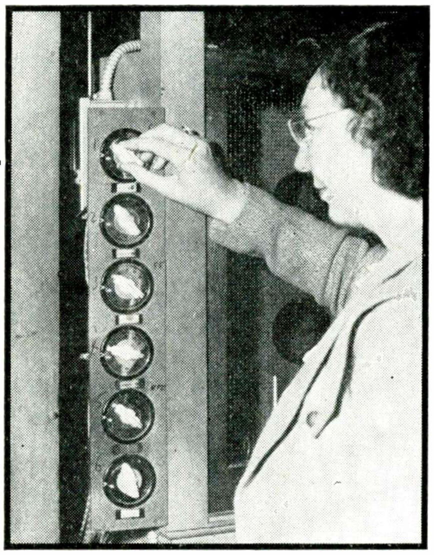


FIG. 3—Modified circuit with relays for remote control of the switching operations. When inputs are properly patched, the indicator lamps show pre-set inputs in sequence and the program on the air

TUBE-SEASONING TIMER



Six automatic time-switches are mounted on a vertical panel

Versatile unit for controlling the time schedule of cathode-ray tube seasoning racks up to 55 minutes. Various numbers of tubes can be seasoned on different runs

By M. SILVERMAN
Production Manager
Cathode Ray Tube Division
North American Philips Co., Inc.,
Dobbs Ferry, N. Y.

MANY METHODS can be evolved for controlling the time schedule on cathode-ray tube seasoning racks, depending only on the ingenuity of the design engineer. Our company developed and has used for some time a satisfactory system.

Accuracy of time periods is not extremely critical and a spring-driven timer was found quite adequate for the job. The one we used was made by Walser Automatic Timer Co. Figure 1 shows the diagram of connections.

The switching arrangement throws resistors in and out of the heater circuit to change heater voltage. Minor variation in the number of tubes on the rack for different runs is no serious problem. A complete load of 20 tubes is standard practice. However, absence of one or two tubes from the rack does not affect current drawn through R_1 and R_2 materially. Voltage drop across the resistors is practically unchanged.

Switches can be adjusted either to open or close a circuit after a predetermined time interval. To start, proper settings are applied to all timers. This leaves the rack as shown in the diagram, with the a-c line connected and, in a typical cathode-ray tube test, with 11 volts impressed across the heaters. Operation then proceeds as follows:

1 Opens after 10 minutes; Throws in R_1 and lowers heater voltage to 10 volts
2 Closes after 10 minutes; Turns on A_1, A_2, and deflection plates
3 Opens after 45 minutes; Lowers heater voltage to 9 volts
4 Opens after 45 minutes; Turns off A_1, A_2, and deflection plates
5 Closes after 45 minutes; Turns on grid
6 Opens after 55 minutes; Turns off a-c line

This type of timer is extremely versatile and permits considerable latitude in schedule changes. The longest possible time interval is 55 minutes which, in our experience, has proved ample.

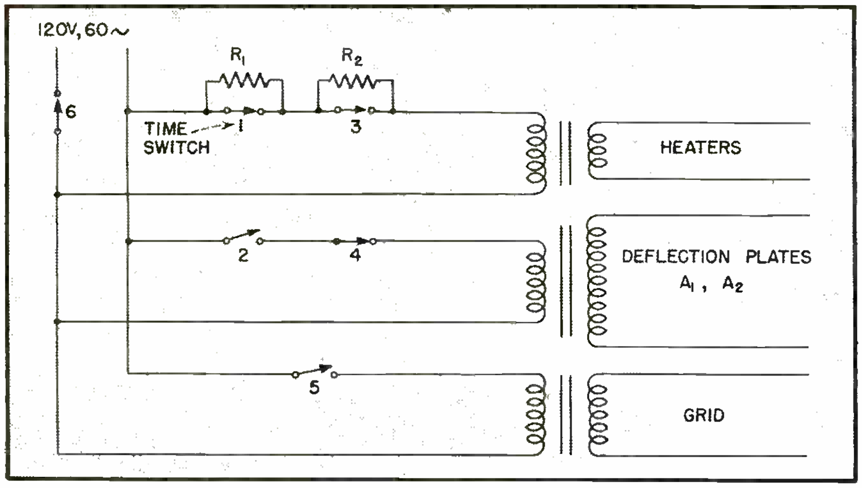
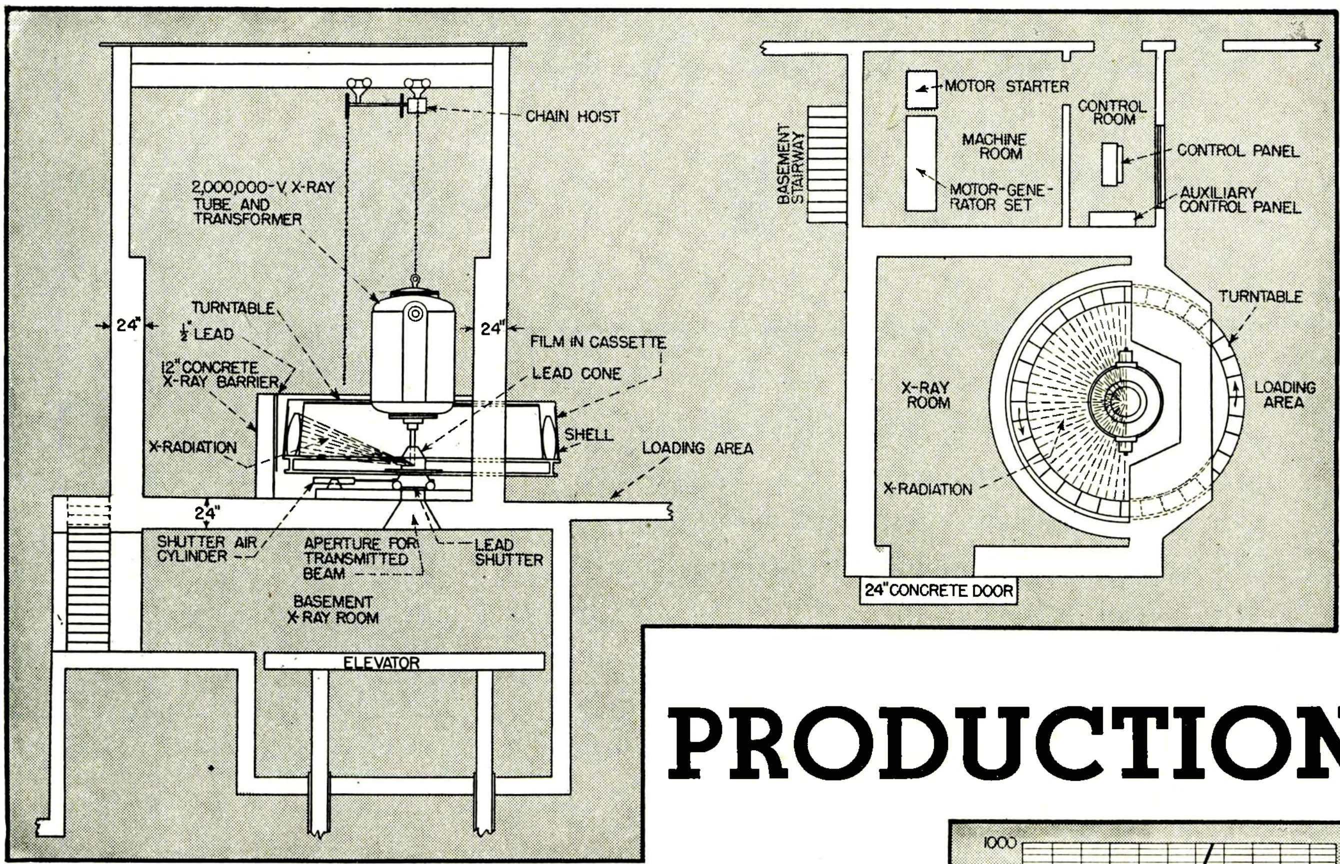
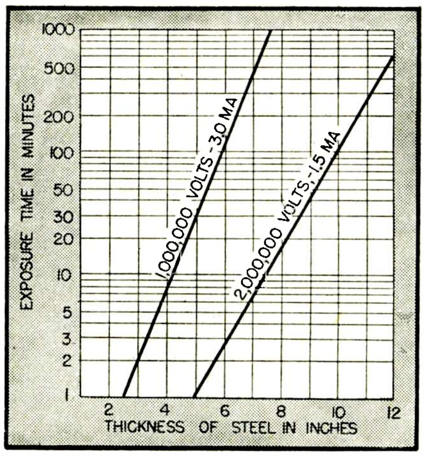


FIG. 1—Circuit showing the arrangement of switches, resistors and transformers



PRODUCTION

Plan and elevation of 2,000,000-volt x-ray installation. Rotating turntable carries bombs or shells around x-ray tube. Speed of turntable governs duration of exposure



Comparison of radiographic speeds of General Electric one- and two-million volt x-ray units, showing the higher-voltage machine to be about 100 times faster than the lower-voltage unit

THE use of supervoltage x-ray units in the examination of large shells and bombs during the last year of the war permitted saving much ordnance which might otherwise have been rejected. It is now possible to reveal details of these 2,000-kvp (kilovolt peak) installations. Although four were placed in operation, the Elwood, Illinois plant operated by Sanderson & Porter will be described because the ammunition produced here was larger and the installation is more recent than the others.

Advantages of Super-Voltage X-rays

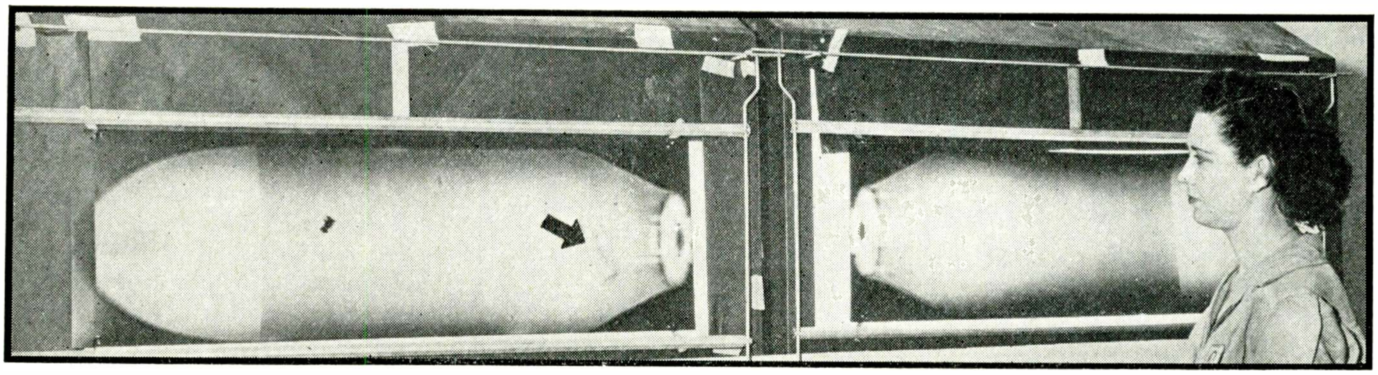
Instead of hit-or-miss destructive testing, in which hundreds of shells are rejected if a major defect is found in one unit of a sub-lot, ordnance plants can now make nondestructive tests showing flaws at any depth or thickness in the ammunition. The speed of such high-voltage x-ray equipment permits the examination of each piece of ammunition in a suspect sub-lot. It also allows re-working of all defective shells and then x-raying them again to determine whether the flaw has been remedied. When all factors are under control, this can make possible the virtual elimination of rejects due to defects in chemical charge.

The other advantages of x-rays over destructive testing are obvious: they permit inspecting the entire shell (not just the two mating surfaces of a split of cross-section), provide a permanent record of the defect, and permit re-working of the defective shell.

An advantage of higher voltages is that the work may be placed at a greater distance from the tube, thus permitting a larger area to be subjected to x-radiation while still maintaining a relatively high radiation strength. Thus, even with thinner sections, high-voltage x-rays are advantageous. It is also possible, with the more powerful radiation, to use film of less speed but greater contrast, making up to some extent for the loss in contrast from exposure of film to shorter wavelength.

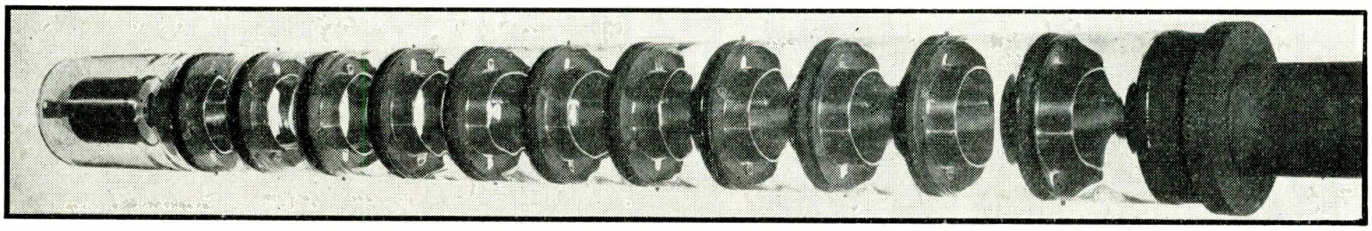
Placing the part at a greater distance from the tube also increases detail and decreases distortion of the pictures by reducing the angle at which rays strike the part.

The 2,000,000-volt unit was installed at Elwood in time to aid in the quality control of a new type shell having a much deeper booster cavity than was previously made. The resultant pouring problems were rapidly solved by means of the thorough inspection possible with x-radiation. For an 8-inch thickness of



Radiographs of 250-pound TNT-filled bombs, on viewer for examination. Arrow points to cavitation in top-off, a cause for rejection

Below—Closeup of million-volt x-ray tube having same sectional construction and intermediate electrodes as new 2,000,000-volt tube



By DAVID GOODMAN
General Electric X-ray Corporation
Chicago, Illinois

CONTROL with 2,000,000-volt X-rays

Details of super-voltage installation using conventional x-ray tube construction and resonant transformer, and description of continuous industrial radiographic setup used during war for inspection of powder charges in large loaded shells and bombs

steel, the 2,000,000-volt unit is 100 times faster than a 1,000,000-volt unit. What is lost in contrast and sensitivity through using the higher-voltage machine is more than gained by detection of defects in materials having widely varying densities and thicknesses.

Reflected and Transmitted Beams

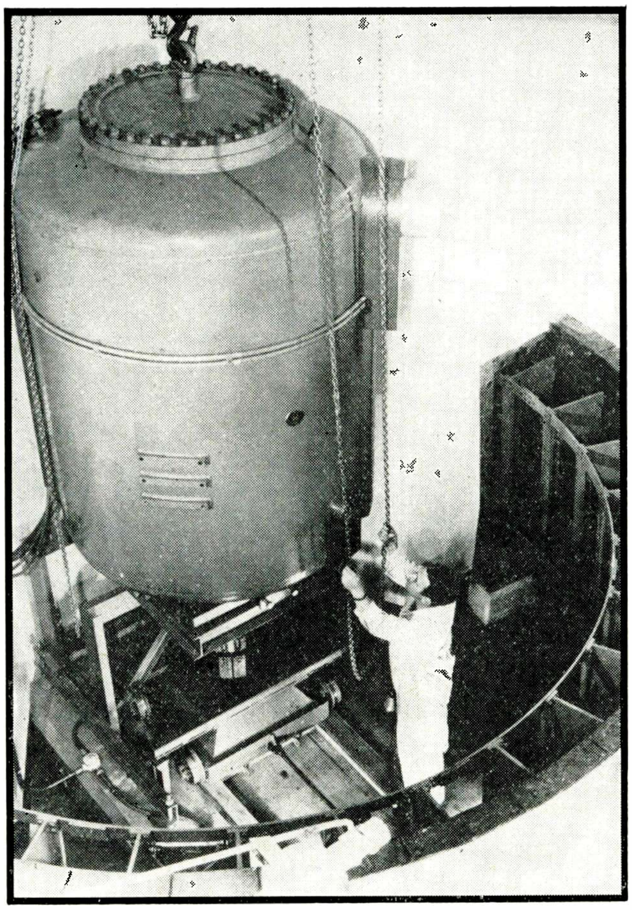
That portion of the x-ray beam which is reflected from the anode of the tube (the portion coming from the electron-stream side of the target) was used for radiography of shells and bombs carried around the machine on a continuous ring conveyor (described later), while the beam transmitted through the anode was utilized for x-raying of still larger shells and bombs in the basement. Actually, when the electrons strike the target in an x-ray tube, x-radiation is given off in all directions, like the explosion of a shell. Radiation in the half-sphere on the electron-beam side of the target is called the reflected beam, while radiation in the other half-sphere is called the transmitted beam because this goes through the target. Both beams are identical and may be used simultaneously. Lead cones are used above and below the target to limit each beam to the area desired.

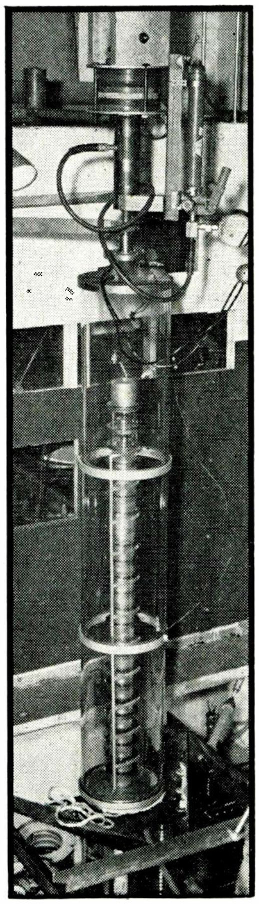
When no operations are under way in the basement, a 12-inch thick lead shutter absorbs the transmitted beam. Items handled in the basement would, as a rule, be those of extremely large size, too large or too few to handle on the ring, where size range is limited and production-line technique is demanded for economical operation. The transmitted beam is more penetrating than the reflected beam.

The use of the transmitted beam in basement operations also permits experimental and occasional radiography without interfering with the production run on the turntable ring, and permits radiography of objects much larger than those adaptable to turntable handling.

Lead Masking and Protection

In the Elwood installation, a 10-inch thick lead cone is placed on the floor around the anode, with openings to permit irradiation over a horizontal angle of 180 degrees as ammunition is carried through the exposure area by the ring. In addition, a series of lead plates called the primary curtain is placed around the





Left—Lowering freon-filled resonant transformer into operating position. X-ray tube is in center of transformer. Right—High-voltage aging of 2,000,000-volt x-ray tube inside freon-filled glass cylinder prior to installation in resonant transformer

opening of the cone to produce a uniform density on the film in spite of the varying thicknesses of the shell or bomb.

A lead filter one-eighth inch thick is placed between the object and the film to screen the longer wavelengths, thus increasing film latitude (ability to reveal a range of cross-sections on a single film) and to filter out secondary and scattered radiation resulting from the passage of x-rays into the ammunition and surrounding partitions.

Lead is also employed in the form of silhouetted diaphragms which frame each piece of ammunition, preventing fogging of film by radiation which passes between pieces of ammunition. In addition, a lead shield is placed behind the film and in front of a concrete innerwall. This shielding forms a half-circle 16 feet in diameter, 6 feet high and ½ inch thick, protecting the area outside from the primary radiation and reducing scattered radiation to a minimum.

The basic protection to personnel consists of this internal concrete wall and its lead shield, plus the 24-inch thick concrete floor and walls and the 12-inch thick lead shutter that stops the transmitted beam when no work is in progress in the basement.

Shell Loading Problems

Defects which commonly occur in shell loading fall into five classifications: (1) The annular ring around the deep booster cavity; (2) the cavitation below the guiding sleeve; (3) scattered cavitation, often due to faulty working of scrap into the poured charge; (4) cracked casts; (5) impurities of various types. In addition, there is a special flaw termed crystallization, which is attributed to hesitation in the pour. Failure to pour continuously permits some of the charge to harden on the exterior surface before additional charge is poured.

X-ray inspection makes it possible to study a larger percentage of the shells produced, thus enabling management to determine whether the methods of any particular person are resulting in defective shells. Where this is difficult to determine, individual pourings can be x-rayed in the basement until the exact cause is determined. This is of great importance in a field such as this, where high-quantity production of a few unvarying items is the rule.

The X-Ray Machine

Two principal factors made possible the construction of a machine operating on 2,000,000 volts and yet capable of being housed in a reasonably-sized room. One was the development of a large low-frequency resonant transformer which permitted insertion of the long x-ray tube in the center; the other was the tube itself, actually a further development of the 12-section fernico-ring design used on the 1,000,000-volt apparatus. Permanently vacuum-sealed, the 2,000,000-volt tube contains 24 intermediate electrodes whose function it is to make the potential gradient uniform across the tube.

The transformer—heart of the electrical system—has a low-voltage winding consisting of two flat coils of rectangular wire and a high-voltage coil with 243 thin flat sections spaced apart for cooling. The obtaining of a uniform potential gradient along the length of the coil stack is facilitated by spacing the upper coils more closely than those at the lower end. Thus, radial spring taps to the x-ray tube can be used to supply the proper voltage to each of the 24 electrodes in the tube.

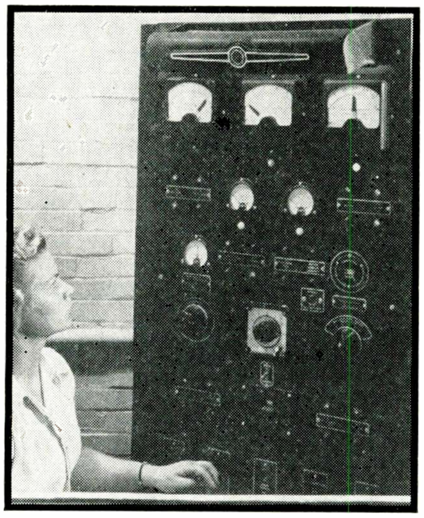
Three improvements are made possible by using a resonant-type transformer—reduced weight due to elimination of the iron core, elimination of insulation space between core and high-voltage winding, and easier tube connections. The high-voltage winding has a natural frequency of oscillation of 180 cycles per second. This is derived from the 60-cycle supply line through a synchronous motor-generator set which eliminates the effect of line voltage fluctuations. It is this step-up in frequency that permits eliminating the iron core in favor of resonance.

The tube has a filamentary cathode, a copper-backed tungsten target mounted in the lower end of an extension chamber, and cylindrical accelerating electrodes in each of the 24 intermediate sections. The chamber walls and the target are cooled by water. Sandblasting the inside glass walls of the tube eliminates dangerous field current which might otherwise result from the application of increased voltage to each tube section.

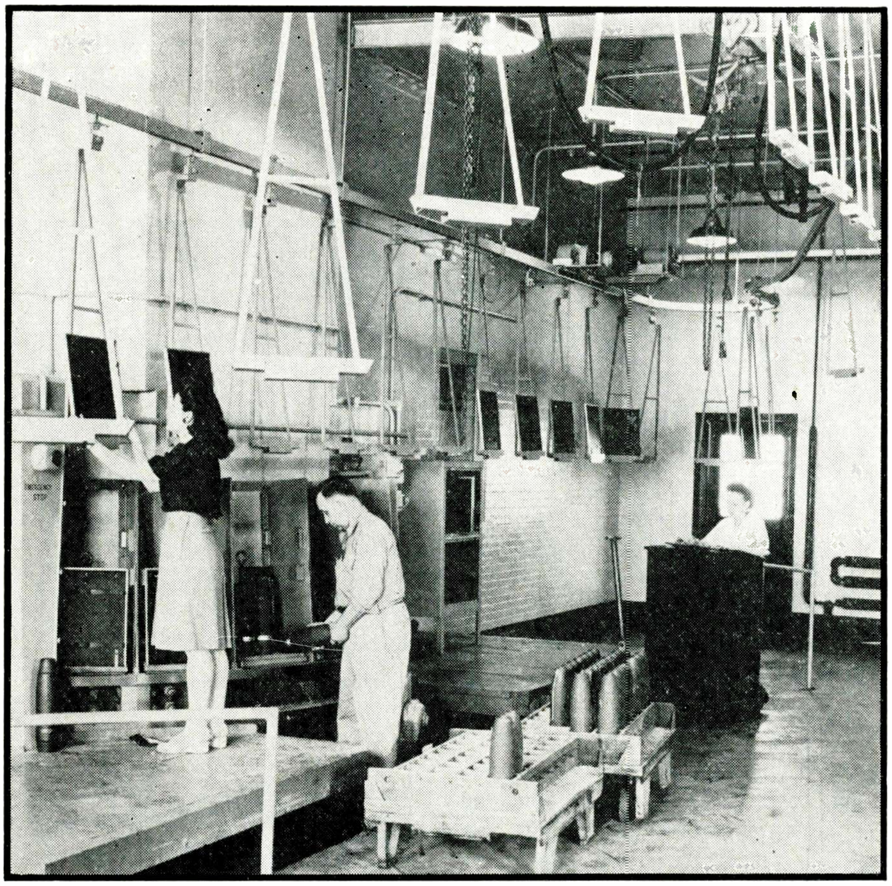
Two exciters are used on the frequency changer. One supplies the motor field, focusing coil, and electronic protective relays. The other supplies only the alternator field. The 180-cps voltage to the high-tension transformer is controlled by adjusting the field current of the d-c exciter.

Complex Safety Interlocks

The electrical system of this installation is so thoroughly interlocked with safety devices and so many systems are connected in series that it is impossible to produce x-radiation unless all factors are in order. In addition, a warning bell sounds in the x-ray room in case personnel are caught inside after the door has been closed. This is the signal that the x-ray is about to be operated. When he hears this, the person inside has merely to press a button to interrupt the circuit and sound an alarm.



Control panel for two-million-volt x-ray machine



Turntable-loading area of industrial setup for continuous radiographic inspection of loaded shells. Exposed film cassettes are carried to developing room by overhead conveyor

Conveyor-Line Techniques

The x-ray process begins when a lift-truck takes finished shells off the production line and brings them—a skid at a time—to the ring loading section behind the x-ray room. Here, on that half of the ring which is outside the x-ray room, the personnel load and unload the constantly-moving conveyor, which is driven by a 5-hp motor operating through an adjustable speed reducer, a traction cone and a second speed reducer.

The length of time required for the ring to traverse the interior of the room determines the exposure. The exposure can also be regulated by the use of lead shields to form a primary curtain that screens part of the primary beam, and by changing milliamperage.

The ring passes through the wall at the rear of the room within a lead-lined tunnel that is fitted with lead-rubber baffles around the exterior ports. The mountings on the ring are arranged with vertical lead shields between each shell. There are always at least two of these shields in the tunnel at any one time. Thus, lead protection is provided in three planes, two of them at right angles to the third.

The films in their cassettes pass through the x-ray room with the shells, then travel by conveyor from the unloading area through a light-baffled tunnel into the darkroom. Here an interruption in the production-line system is necessary to place the films on hangettes used in the completely automatic Pako film developing unit, which not only moves the films at a prescribed rate from one solution to another, but also raises and lowers the films while in each solution in order to insure positive contact of the solution with the film surface. The conveyor system on this device also lifts the developed film from the wash tank and carries it through a light-baffling tunnel into the viewing room.

Since only a small proportion of the developed films need be saved, most of them are read while wet, having been run through the wash only long enough to permit immediate viewing. This not only saves time on the viewing end but also permits shells to move out faster, because their condition is being checked more rapidly.

Measuring

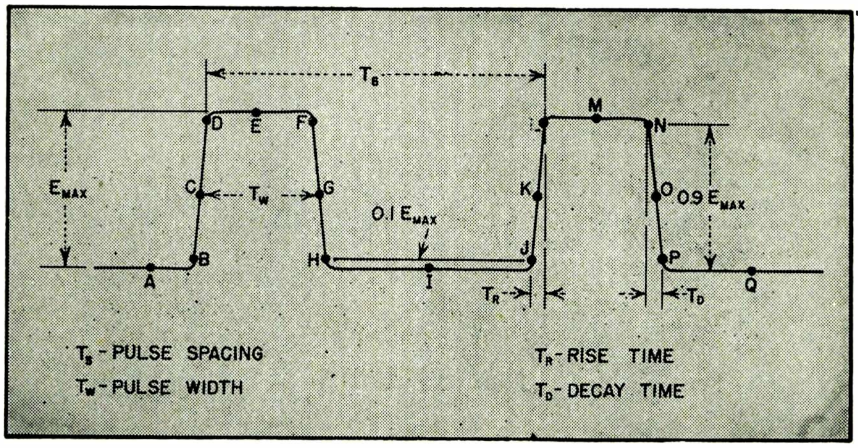


FIG. 1—Critical points from which pulse characteristics are measured

MEASUREMENT of pulse characteristics has been developed to a high degree of precision in the past few years. The relatively crude method of measurement using a linear saw-tooth sweep has been supplanted by more sophisticated means such as circular, spiral, or expanded sweeps.

By using the principle of coincidence the method described herein is capable of high accuracy without requiring great skill on the part of the operator, and therefore lends itself to production testing. In the laboratory it is valuable because of its adaptability to measurements in the 0.1- to 100-microsecond range.

Particular applications of this method of measuring pulses are in metering velocity of light, delays at discontinuities in filters and transmission lines, in television, in radar ranging, and for calibrating linear sweeps.

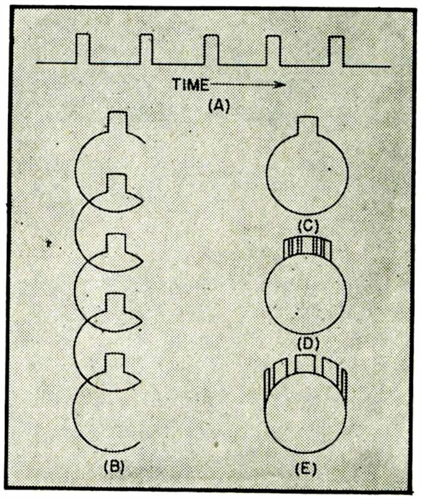


FIG. 2—To observe the pulse sequence shown at (A), a circular sweep, shown expanded at (B), can be used. At synchronism the trace appears as at (C); off synchronism it appears as at (D) or (E)

Measuring Pulse Spacing

This method of pulse measurement is intended to increase the realizable accuracy and ease of measuring (1) time intervals between two or more pulses, (2) pulse duration, and (3) pulse growth and decay times.

Pulse spacing T_S in Fig. 1 is the time interval between any two corresponding parts of two successive pulses in one trigger cycle. The duration of the pulse, T_W, is arbitrarily defined as the time difference between the 50-percent amplitude points. The rise time T_R is the time required for the pulse to increase from 10 percent to 90 percent of its full amplitude. Decay time T_D is the time required for the pulse to decrease from 90 percent to 10 percent of full amplitude. It is assumed throughout this discussion that the entire phenomenon to be measured occurs in one repetition period and is periodic in nature.

Figure 2A shows a train of pulses as they would appear on a suitable linear saw-tooth sweep. The distance between successive pulses is proportional to their time spacing. Imagine this same sweep wound like a rope so that it appears as a pile of coils as in Fig. 2B. If these traces are superimposed upon each other and if the circumference of each sweep is the same as the distance between pulses, the picture will appear as in Fig. 2C. If the length of each sweep is too short or too long the result will appear as in Fig. 2D or 2E. In other words, when the length of one circumference is just equal to the pulse spacing only one pulse will appear. When the length of the sweep is held constant corresponding to some predetermined amount of time, the pulse spacing can be varied until coincidence occurs. On the other hand, if the pulse

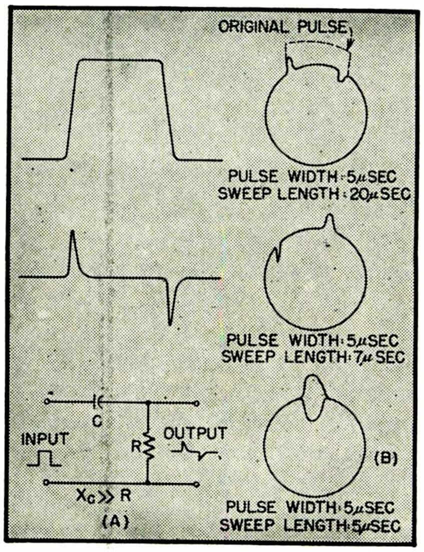


FIG. 3—(A) Left—If the pulse to be measured, as shown at the top, is differentiated by such a circuit as this, the derivative pulses, shown in the middle, are obtained. (B) Right—To measure pulse width, the derivative pulses are placed on a circular sweep and either the sweep or pulse generator adjusted until coincidence is obtained

Pulse Characteristics

Method and equipment for rapid, accurate determination of pulse characteristics have laboratory precision and production-line simplicity. Basically, circuits and techniques measure time by obtaining coincidence with a standard time interval

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spacing is held fixed, the frequency which determines the length of the circular sweep can be altered until coincidence results.

Thus this technique provides a system for either measuring or adjusting pulse spacing. The method requires a setting of frequency until coincidence is obtained. The accuracy, therefore, is dependent on frequency primarily and on the setting or resolution error in obtaining coincidence. No complicated judgments or measurements are required on the part of the operator—a desirable fact for production measuring equipment.

The pulse spacing is given by the equation

$$T_S = 1/f_C \quad (1)$$

where T_S is the pulse spacing, and f_C is the coincidence frequency.

Measuring Pulse Width

Pulse width can be measured in two ways, both of which are based on the spacing measurement just described. Referring to Fig. 3A one sees a pulse with fairly steep sides shown along with its derivative. This derivative can be obtained in several ways, one of which is shown. When the differentiated pulse is impressed on the variable-frequency sweep, patterns similar to those on Fig. 3B result. Essentially the pulse width measurement consists of measuring the spacing between the two pulses obtained by differentiating the leading and lagging edges of the original pulse.

An alternative method of determing pulse width is perhaps more suitable for many purposes. This is illustrated by Fig. 4. The figures are self-explanatory and show the effect on the pattern of increasing the sweep frequency. The method can be applied successfully with either elliptical, circular, or flat sinusoidal sweeps. This method enables determination of pulse width between points of any required percent of maximum pulse amplitude.

Measuring Growth and Decay Times

One method of measuring growth time depends upon the procedure previously described for pulse width measurements. If the pulse width is measured as described, at the 10- and 90-percent points, the rise time is determined as follows

$$T_R = T_D = \frac{(1/f_{0.1}) - (1/f_{0.9})}{2} \quad (2)$$

where T_R is the rise time from 0.1 to $0.9E_{MAX}$, T_D is the decay time from 0.9 to $0.1E_{MAX}$, $f_{0.1}$ is the frequency corresponding to the width at $0.1E_{MAX}$, $f_{0.9}$ is the frequency corresponding to the width at $0.9E_{MAX}$, and E_{MAX} is the peak value of the pulse as indicated in Fig. 1.

The accuracy of Eq. 2 depends upon the equality of T_R and T_D. Figure 5 illustrates this method used with linear sweeps.

In cases where T_R does not equal T_D, an alternative method may be superior. Refer again to Fig. 3A. The shapes of the pulses shown are proportional to the rate of change of the measured pulse (if X_C is very much greater than R). Thus the width of the pulse at the base is proportional to rise or decay time. Measuring the width of the positive and negative derivative pulses by the methods previously described will give the values of T_R and T_D.

Accuracy of Measurement

The precision of the spacing measurement depends primarily on frequency. Errors which are due to sweep irregularity and resolution are quite small. However, at the present state of the art, frequency can be measured or set to better than one part in one million. In practice, therefore, the resolution of the coincidence setting determines the maximum accuracy.

Figure 6A shows the face of a

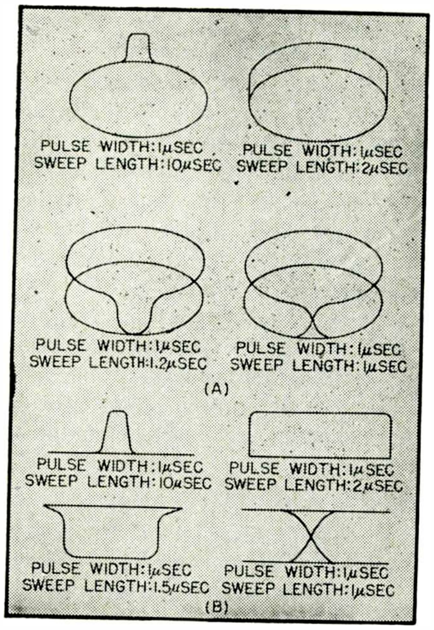

FIG. 4—Using either an elliptical (A) or a horizontal sinusoidal (B) sweep, one can determine pulse length by adjusting the sweep period relative to the pulse duration, giving the simple patterns shown at the right. Crossover is at the 50 percent point

cathode-ray tube with an eliptical pattern. An elliptical trace is used with conventional cathode-ray tubes because it insures best utilization of the screen area. Width of the trace limits the precision with which coincidence can be set. With a good cathode-ray tube, the thickness of the trace can be made less than 0.0312 inch. The length of one cycle of the elliptical trace depends upon

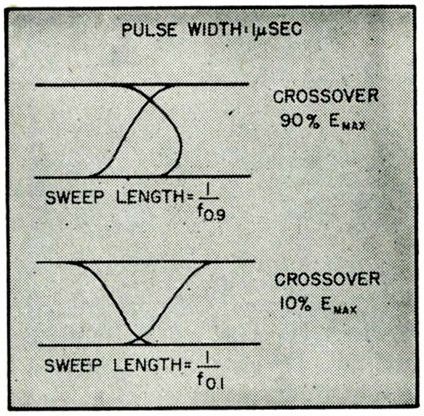

FIG. 5—When growth and decay times are approximately equal, they can be determined from measurements of pulse duration at the 10- and 90-percent amplitude points as shown here

tube diameter. A 5-inch cathode-ray tube will accommodate a trace length of approximately 12 inches.

Figure 6B shows two sine-wave cycles. The sections A and A' represent the maximum-velocity portions at the top side of the elliptical trace. It is on this part of the elliptical trace that the pulses should be set. The sections A and A' include about plus and minus 45 degrees. On the elliptical sweep 90 degrees at the maximum-velocity portion corresponds to approximately two-thirds of the horizontal deflection. If the coincident pulses are located on this maximum-velocity section, the resolution error can be computed from

$$\varepsilon = (R/\pi D)T \text{ seconds} \qquad (3)$$

where ε is the resolution error, R is the resolution in inches, D is the width of the sweep pattern in the horizontal direction, and T is the period of one sweep cycle.

Equation 3 can be used with equal accuracy whether the sweep is elliptical, circular, or flat simple harmonic in character. The only requirement is that the displayed pulses be set to the maximum-velocity portion of the sweep.

Substituting the following typical values into Eq. 3

$$R = 0.312 \text{ inch}$$
$$D = 4 \text{ inches}$$
$$T = 1 \text{ microsecond}$$

one obtains $\varepsilon = 0.0024$ microsecond error, or an error of 0.24 percent.

In many applications the spacing between trains of pulses is required. In this case the error would be divided by N-1 where N is the number of pulses in the train. It can be seen that the error in measuring the spacing of a train of eleven pulses spaced one microsecond apart would be in the order of 2.4 ten thousandths of one microsecond or 2.4×10^{-10} second.

The accuracy of the measurement can be improved if necessary by using larger cathode-ray tubes and higher accelerating potentials to obtain larger and finer traces. The limits to the size and complexity of the equipment are an economic factor which must be evaluated in each application. The accuracy figures shown above do not require skillful manipulation of the test equipment or careful judgment in reading anything but frequency.

The method described in the preceding sections has been used by the author with excellent success. Equipments of several types have been constructed and are now in use.

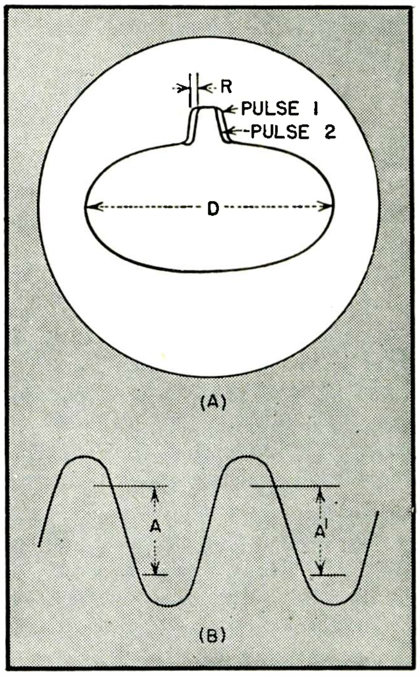

FIG. 6—For minimum error of measurement, the pulse (A) should be located on the most linear portion of the sinusoidal sweep (B)

Practical Systems

Fundamentally, there are two ways of using the outlined method. The first is to measure any of the quantities indicated, requiring variable frequency. The second is to set other equipments by means of the method, usually requiring fixed frequencies. However in either case the fundamental principles are identical.

Figure 7 shows a simplified block diagram of a typical system and a typical circuit for each of the less standard units. The requirements and characteristics of each unit follow.

STANDARD-FREQUENCY GENERATOR may supply either fixed or variable frequencies in whatever ranges are required. This unit should be capable of high precision.

FREQUENCY DIVIDERS are a necessary component in any system in which the elliptical sweep must be synchronized with the display. The sweep frequency is usually much higher than the pulse recurrence frequency, and therefore frequency dividers are utilized.

TRIGGER GENERATOR is used to sharpen the output of the frequency dividers and to privide a sharp, precise initiating pulse.

MANUAL PHASE SHIFTER is useful in rotating the display with respect to any fixed point. This enables locating the pulses on the maximum-velocity portion of the trace. In an oscilloscope which utilizes radial deflection, this circuit might be deleted.

SWEEP AMPLIFIERS are required because most standard-frequency generators do not develop sufficient voltage to deflect the beam of a cathode-ray tube directly.

PHASE SPLITTERS are used in obtaining an elliptical sweep. It is necessary to phase-shift the horizontal deflecting potential 90 degrees with respect to the vertical deflecting potential. The horizontal deflecting potential is usually fed push-pull while the vertical phase is con-

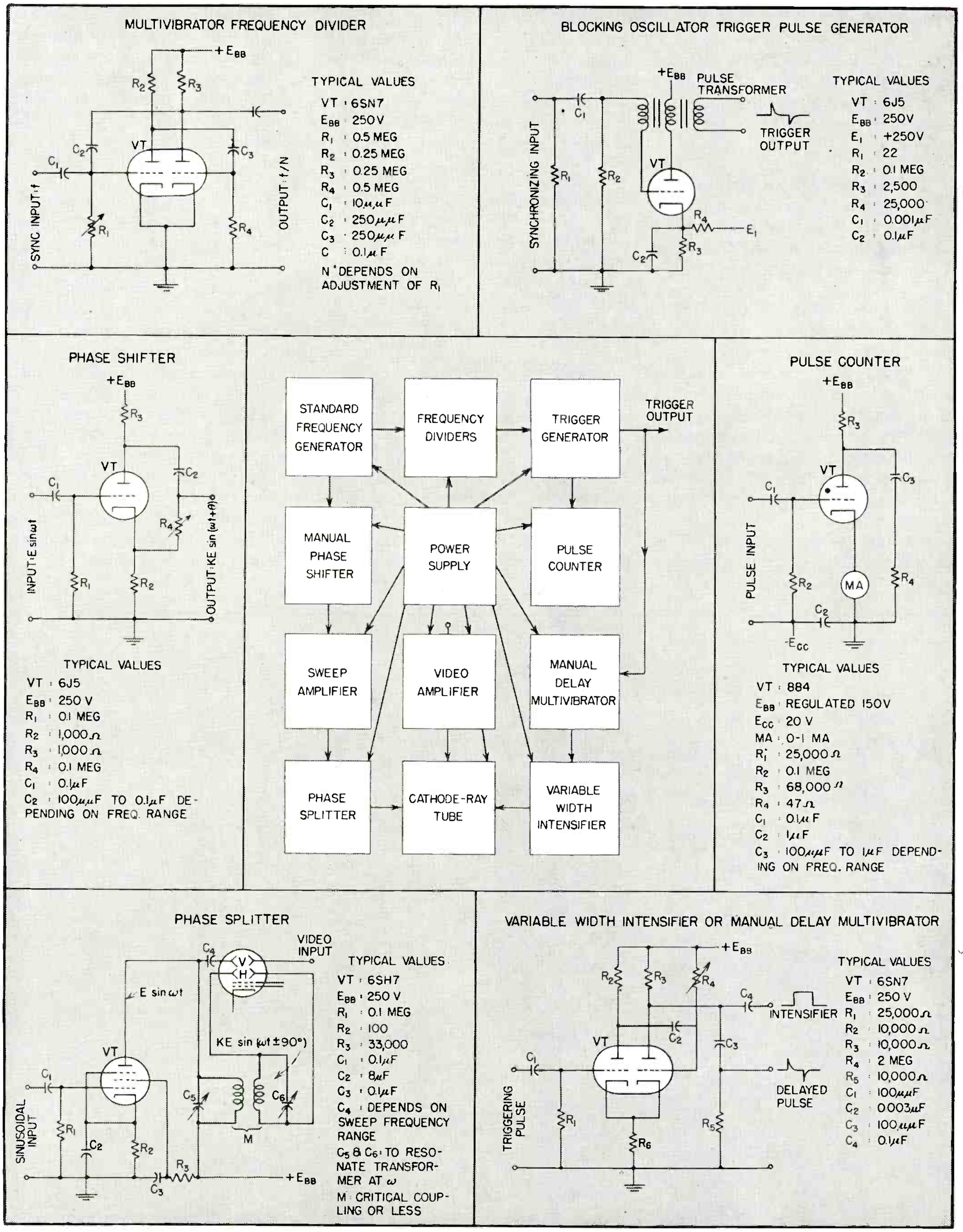

FIG. 7—The block diagram indicates the functioning of the equipment used in measuring pulses. The individual circuits are illustrative of the types of units comprising the system. Blocks for which no circuits are shown are conventional. See the bibliography for additional circuits suitable for each unit in the system

nected single-ended to one vertical deflecting plate.

CATHODE-RAY TUBE is the heart of the equipment. The size of the tube depends on the accuracy required as well as upon economic factors.

VIDEO AMPLIFIER may or may not be required, depending upon the application. It usually is connected single-ended, into one vertical plate of the cathode-ray tube.

VARIABLE WIDTH INTENSIFIER is an essential part of the system. The display to be observed may occur in only a few sweep cycles of each trigger recurrence cycle. If all the sweeps were permitted to appear, very low contrast would result. The intensifier, analogous to the blanker used in television practice, is introduced into the grid or cathode circuit of the cathode-ray tube. It is made variable in duration so that any number of sweep cycles can be viewed at will. The possible ambiguity, which can occur if the sweep length is half of the pulse spacing, is removed by use of the intensifier. Only when the correct sweep length is used can the pulse appear as in Fig. 2C, that is, with an open base line under the pulse.

MANUAL DELAY MULTIVIBRATOR is used in many applications where the phenomenon to be viewed is delayed with respect to the trigger pulse. If this is the case, it may be desirable to delay the intensifier pulse a corresponding amount so that no more sweep cycles are illuminated than are necessary.

PULSE COUNTER is incorporated if it is desirable to know the pulse recurrence frequency.

Variations of Method

It is not necessary to confine oneself to deflection methods to measure pulse characteristics. It is possible to obtain coincidence using intensity modulation as well. In this case a circular sweep is used, but the video pulses are connected to the grid circuit of the cathode ray-tube, while the intensifier pulses are impressed on the cathode. A bright spot will appear on the dimmed trace corresponding to each pulse instead of a deflection of the trace. When the bright spots merge, coincidence is obtained.

There is a limitation to the foregoing method. In those instances where the triggering pulse, which initiates the phenomenon to be measured, is derived from the sweep frequency, the pulse rate will change as the sweep length is altered to obtain coincidence. The pulse rate must be an integral submultiple of the sweep frequency, therefore at high pulse rates it may not be possible to obtain a desired value of pulse repetition frequency. For example, if the sweep frequency is 100 kc, it is not possible to obtain a pulse rate of 10.5 kc. The closest that one could approach the desired rate is 10.0 kc or 11.1 kc.

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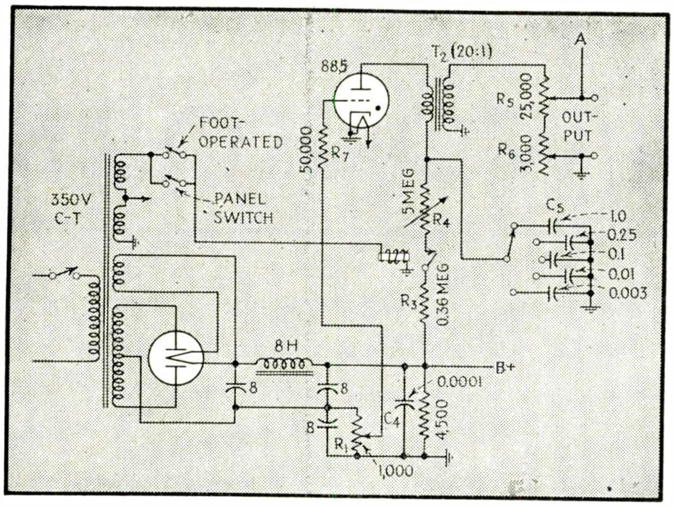
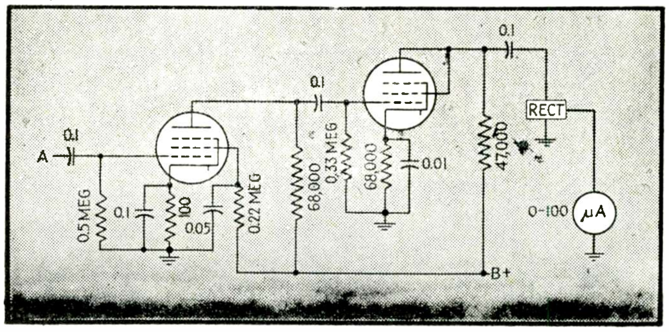


FIG. 1—Oscillator circuit, with relay for plate keying

FIG. 2—Optional pulse-amplitude metering circuit



NERVE STIMULATOR

Thyratron-type relaxation oscillator with plate-supply keying eliminates high initial pulse, provides 0.3 to 30,000-cps pulses for biological research and medical therapy

By
WALTER IRA WEISS
New York, N. Y.

IN MANY fields of biological research, clinical medicine, and surgery, a voltage of variable amplitude and frequency is used to stimulate nerve tissue or effector organs. The source of this voltage varies from the crudest induction coil and step-down transformer on up to highly complex electronic circuits.[1, 2, 3]

The thyratron-type relaxation oscillator using a high negative grid bias to key oscillations is quite popular, but since the capacitor charges up to the full plate supply voltage when the grid is held negative, the initial pulse is extremely high in respect to those that follow.

Keying the plate supply voltage eliminates this fault in the stimulator circuit shown in Fig. 1. Here a type 885 argon-filled thyratron is used as a relaxation oscillator. Capacitor C_5 charges through resistors R_3 and R_4 until the voltage across it is equal to the firing potential of the thyratron. At this point the tube breaks down and the capacitor discharges through it and through the primary winding of T_2. The secondary voltage of T_2 is not the usual sawtooth wave shape associated with thyratron relaxation oscillators, but rather is a pulsed wave made up of damped oscillations which are of such high frequency and decay so rapidly that only a single pulse appears on a cathode-ray screen, even when the time axis is expanded.

The pulse repetition rate is controlled roughly by switching of capacitors for C_5, with R_4 providing vernier control as in the standard sawtooth circuit. The range covered is from one pulse every 3 seconds to 30,000 pulses per second. The magnitude of the output voltage is controlled by R_5 (coarse) and R_6 (fine).

Grid bias control R_1 changes the grid bias and hence the firing potential of the thyratron, which in turn changes both the magnitude and the frequency of the output pulse. Thus, making the grid more negative increases the firing potential of the tube, increasing the magnitude of the output pulse and decreasing the frequency of oscillation.

Conventional damped oscillations may be obtained by shunting the secondary of T_2 with a 1-μf capacitor. A sawtooth voltage that can serve as a linear time base for an oscilloscope is available across C_5. The optional metering circuit used with this stimulator consists of a two-stage amplifier feeding into a copper-oxide rectifier meter as in Fig. 2. It permits duplicating output voltages from one day to the next.

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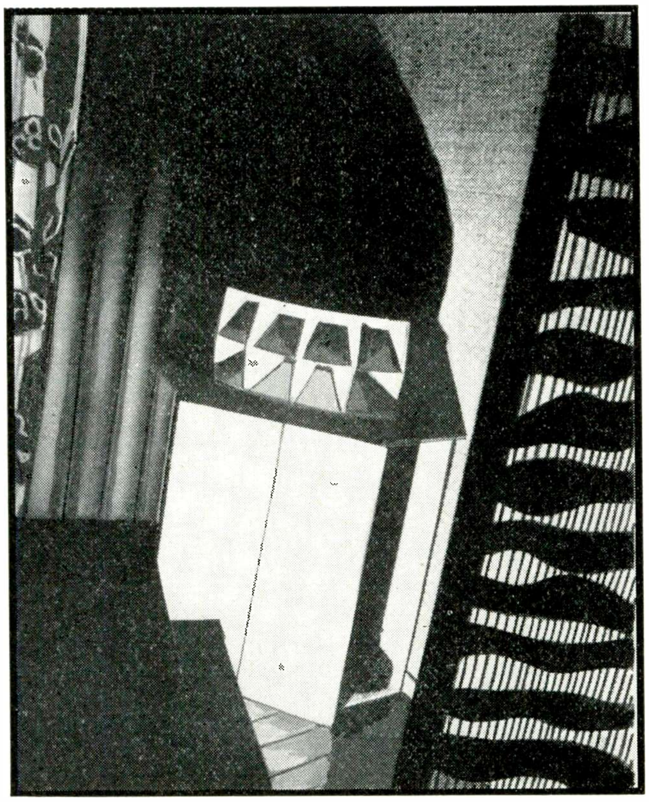
Design of COMPACT TWO-HORN

For room - corner locations, where walls can be utilized to produce reflections that multiply the mouth area of the woofer sufficiently for efficient propagation of sound waves down to 40 cps. Companion tweeter gives wide-angle radiation



Speaker unit in Sherman Fairchild's Town House, described in April 1943 *Architectural Forum*. No grilles are used, but the tall openwork screen just visible at the right is generally set across the corner of the room to hide the entire speaker. The radio receiver is elsewhere in the room

HERETOFORE high-quality horn loudspeakers have been applied only to such uses where their disadvantage due to bulk can be tolerated and where their advantages of large acoustic output capacity and high efficiency outweigh that disadvantage.

For low and moderate power, horns should not continue to be overlooked. Their high efficiency results in freedom from distortion, and recently their size disadvantage has been removed.

This paper describes a newly developed speaker, the quality and dimensions of which make it suitable for monitoring purposes where space may be limited, for use in homes, and for small theaters.[1, 2, 3]

The frequency response covers at least the range from 40 to 12,000 cycles, the efficiency is about 50 percent, and the efficacy, taking into account the ability of a variable-impedance device to absorb power from a low-impedance generator, is about 30 percent. The power-handling capacity is at least 3 acoustic watts output. The occupied volumetric space is only 20 cubic feet. Size reduction from the more familiar theater horns is accomplished by corner operation whereby wall reflections multiply the inadequate actual mouth area up to adequate effective area for propagating the long 40-cycle waves.

The low-frequency speaker is designed to take ultimate advantage of the effect of a corner on acoustic impedance. It is capable of efficient radiation of sound wavelengths 6 to 10 times the longest dimension of the speaker housing. The high-frequency horn is specially developed as a companion to the low-frequency unit and has several novel features.

The Low-Frequency Speaker

Low-frequency speakers of the horn type have involved large structures per unit of maximum wavelength transmitted because of the required large mouth area and long taper. While some workers prefer a mouth area equivalent to a circle of diameter equal to one-third wavelength, it has been possible by careful design to handle large amounts of power with negligible distortion with equivalent mouth diameters as small as 0.16 wavelength. The cubical volume of such woofers range from about 80 to over 200 cubic feet.

By refolding the woofer air column to take full advantage of a room corner, the cubical volume of the low-frequency speaker was reduced to 16 cubic feet. The actual mouth size of only about 4 square feet is increased by wall reflections to offer 16 square feet of equivalent baffled radiating area, equivalent to

LOUDSPEAKER

By PAUL W. KLIPSCH
Hope, Arkansas

a 4.5-foot diameter circle or 0.16 wavelength at 40 cycles. From voice coil impedance measurements and other tests, the response is as flat and harmonic content as low as for speakers 8 to 16 times as bulky.

Constructional details of the low-frequency unit are shown in Fig. 1. The vertical height is 38½ inches, and the front panel width is 24 inches. Dimensional errors up to 5 percent involve imperceptible

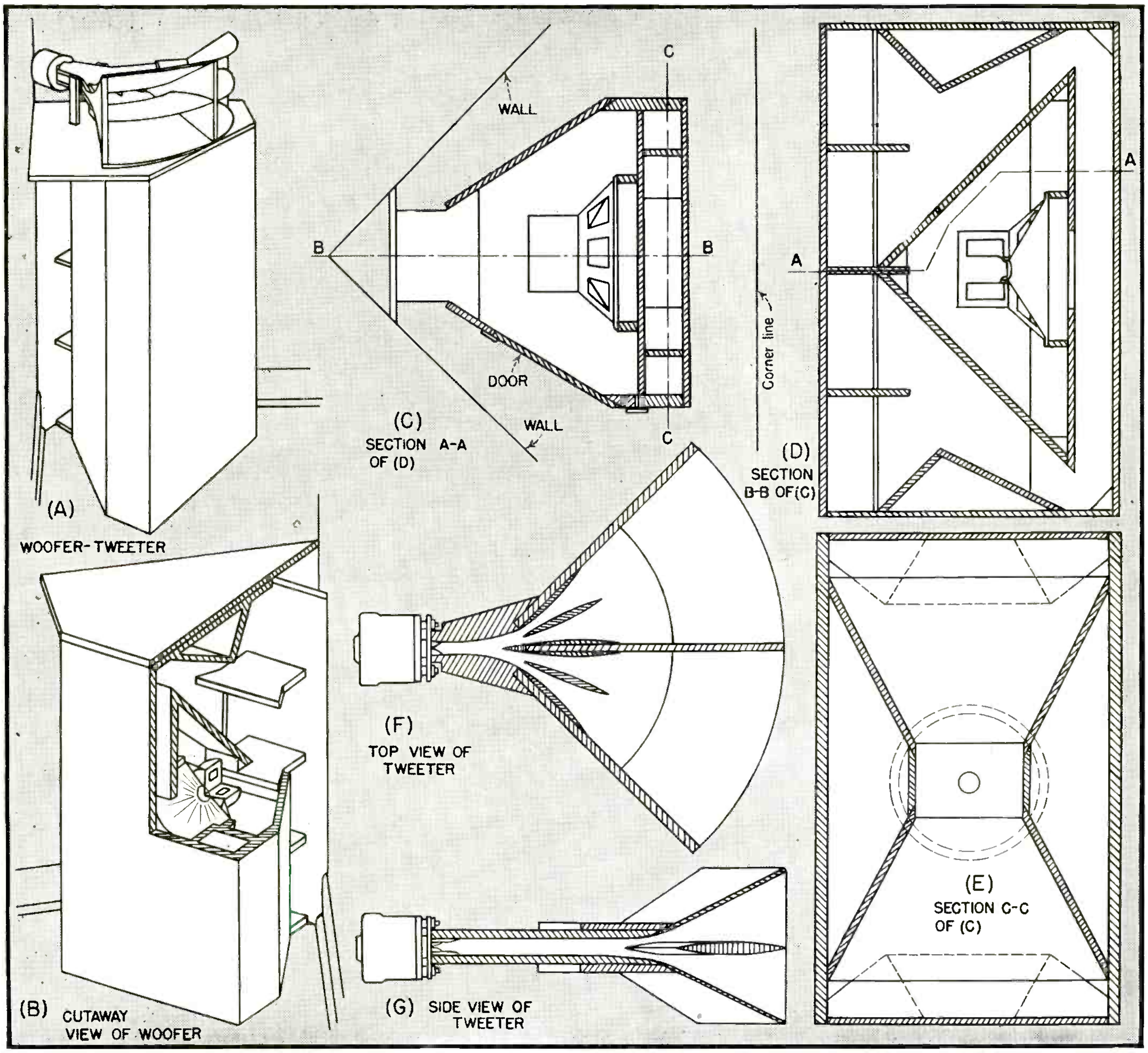


FIG. 1—Sketches and sectional views of low-frequency horn and high-frequency horn. The lower unit (woofer) utilizes wall and floor reflections to improve the impedance match at the mouth, while the upper unit (tweeter) employs cellular construction to give comparable angular distribution of sound for high-quality coverage of the entire room. The system offers a means for minimizing cross-modulation and frequency-modulation distortion while handling high acoustic power

changes in performance, so other dimensions may be obtained by scaling the diagrams. There is one important caution, however; all joints must be air tight. Even a slight leak in the air chamber will result in very poor performance over the entire frequency range for which the speaker is designed.

The original design contemplated the use of ½-inch plywood. Such thickness not being available, ¾-inch plywood was used for the first model, making it unnecessarily heavy. It is believed that the bracing as shown would permit the use of ⅜-inch material, or even ¼-inch thickness for certain parts provided all joints are well glued except for the side door. Such openings as must be provided for access to the driving unit must be air tight. Sponge rubber packing is suitable.

Air tightness and structural rigidity are important considerations. A horn is not a sounding board but a boundary for an air column. Therefore, the structure itself should not vibrate but serve as a rigid conduit. Small leaks or undue cabinet vibration will nullify the advantages attainable with this or any other horn design.

In a large-throat horn, acoustic output below the acoustic cutoff of the horn occurs, as indicated in Fig. 2. Thus the present speaker was designed with a cutoff, due to taper, of 47 cycles, but clean fundamentals can be radiated down to 40 cycles. Dotted portions represent the curves as ordinarily drawn, erroneously indicating cutoff.[4]

The driving motor for the low-frequency horn has a 12-inch paper diaphragm. A larger motor can also be used. The choice of a motor should be based on a high product of flux density times effective voice coil mass. The Jensen A-12-PM and the Lansing 415 have been used in two experimental models.

Owing to the variations in voice coil impedance with frequency, preference should be given to low-impedance triode tubes in the power stage. This could well be a general statement; a direct radiator loudspeaker will ordinarily display several times as much variation in voice coil impedance as does the described horn, so low-impedance triodes are even more important if distortion is to be minimized. Even when feedback is employed, the advantage lies with the triode.

The High-Frequency Unit

Available commercial high-frequency units and known designs did not prove entirely satisfactory as a companion unit to the corner woofer. Either the radiation angle failed to match that of the woofer, or the frequency response was faulty. Several models were constructed along conventional lines, each of which exhibited one or more defects as far as this specific application is concerned. After considerable study and design, a new approach to the problem resulted in the development of a high-frequency horn which is believed to be novel.

The exterior appearance of this new speaker is shown in Fig. 1A, along with sectional views in Fig. 1F and 1G. The design was carefully checked to insure that the wave fronts are circular arcs, so that the frequency response would be flat and the radiation angle would be 60 by 90 degrees over the frequency range transmitted.

The air column length of the high-frequency unit is 21 inches, the mouth area is 240 square inches with a 9-inch height, and the throat area is 0.38 square inch. The throat has a 0.700-inch diameter, to fit the WE 713A, the WE 555W, and other driving motors. Wedge inserts let the throat expand from a 0.700-inch circle to a 0.700-inch square in the first ⅞ inch of length. From there expansion to 0.700-inch width by 1.00-inch height takes place in the next 1⅛ inch. Thence the 1-inch height remains constant out to the outer tips of the inner deflectors, while the width increases until the horizontal angle has reached 90 degrees. Then expansion in both horizontal and vertical direction takes place until the vertical angle is 60 degrees.

The expansion rate is exponential, chosen as being the most economical of space for the desired performance. The area of the air column doubles every 2¼ inches along the horn length or along the path traversed by the wave front. This rate of expansion sets the cutoff limit at 330 cycles. The overall length is such that with most available motors the assembly will fit on top of the woofer unit.

For the hand-constructed pilot model, the top and bottom members were built from glued plywood. The curved mouth surfaces were ⅛-inch plywood material known as Tek-

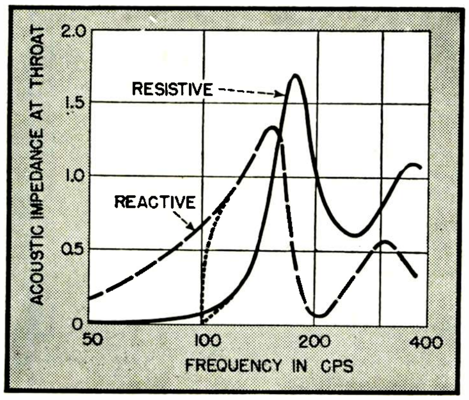


FIG. 2—Computed curves for components of throat impedance of a low-frequency horn having a cutoff frequency of 100 cps

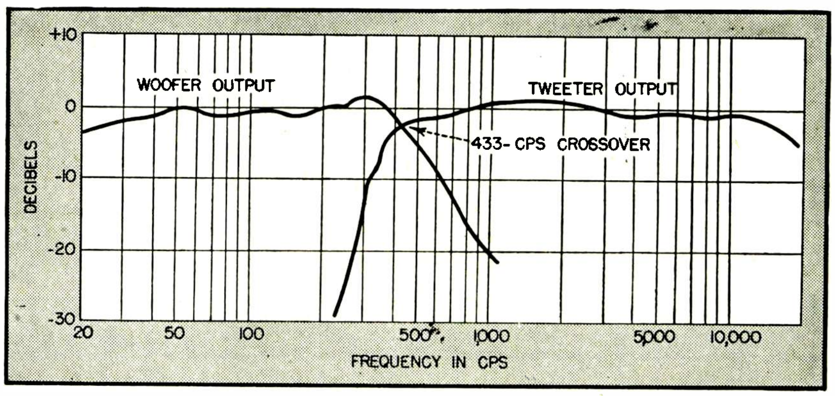


FIG. 3—Outputs of crossover network used to drive the two horns, as measured through the amplifier and input transformer with speakers acting as connected loads. These curves do not show the performance of the loudspeakers

wood. For a manufactured product, post-forming plastics or plys molded to the contour would be economically and structurally better, and would enable one-piece construction of the top and bottom members.

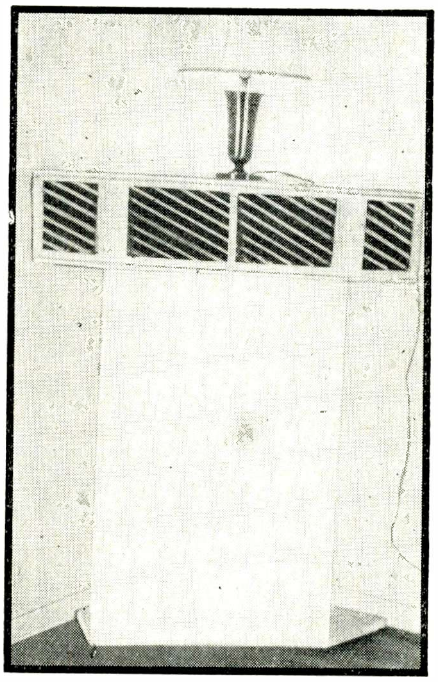
Dimensional accuracy is somewhat critical if the extreme high frequencies are to be radiated into the desired solid angle. The model was held to about 0.02-inch tolerance in the first 10 inches of expansion, and to $\frac{1}{16}$-inch tolerance beyond this. Such close tolerance may be unnecessary, but several previous attempts at constructing high-frequency units were such dismal failures that every attempt was made to design and construct this one with adequate precision.

This high-frequency horn has a mouth area much larger than necessary to avoid mouth reflection in order to give the desired angular radiation properties. It adds only 10 inches to the height of the woofer unit, bringing the total occupied space for the two speakers up to 20 cubic feet and the overall height to only 48½ inches.

The cutoff of 330 cycles seems to be low enough to use with a crossover frequency of 400 or 450 cycles, especially in view of the type of crossover network used.[5] Performance curves for this network are given in Fig. 3. The small throat precludes benefit from radiation resistance below cutoff so about 30 db per octave is built into the high-pass part of the crossover network. Such a high slope might be expected to give some transient effects, but the constant-K sections slope gradually at first and such transients as do exist appear to have no deleterious effect on actual performance. With a WE 555W driving motor, response is good to about 7000 cycles. A WE 713A extends the response to at least 12,000 cycles.

The Speaker System

This loudspeaker system[6] has been in use for over four years, with two different woofer baffles and three different high-frequency horns. Both an apartment and the living room of a larger house, neither specially treated acoustically, have been used as the environment for the experimental speakers.



Speaker unit constructed by George E. Beggs, Jr. of Warrington, Pa. for use in the living room of his home. Tweeter openings are behind the grille cloth at the top. Woofer openings along the two walls could be similarly covered if desired

In a large hangar (about 500,000 cubic feet) with very live walls, the bass was somewhat overbearing. A pad could have been advantageously placed in the low-frequency line. It is believed that in a medium-size hall with proper reverberation time, the system can be used without equalization.

The ability to convert amplifier power into acoustic power, including the ability of the variable-impedance speaker load to absorb power from the constant-impedance amplifier source, represents a usable average efficiency of 30 percent. The intrinsic efficiency of the speaker itself is about 50 percent.

Suggested Applications

The system was originally devised for home radio-phonograph applications. The large load capacity and freedom from distortion, coupled with high-fidelity performance extending the range toward both the lower and upper limits of audibility, makes the speaker ideally suited for several other applications. These include critical studio monitoring, electric organs, and little theater sound systems.

It is believed that the performance of this speaker will nearly match the best the theater has to offer, so sound tracks passing monitoring tests on this speaker should sound well in any theater installation. Monitoring of radio channels and phonograph record quality with this system insures that the producer is hearing everything being reproduced by the best speakers in the hands of the public. The wide range, both in the bass and high registers, will reveal rumble, flutter, hum, hiss, surface noise, and circuit noise so that remedial steps can be undertaken.

A duplicate of the monitor unit placed outside a broadcast studio would make high-quality reproduction of a program available to a larger visitor audience than if a single monitor unit were employed inside the studio.

For the little theater where stage space is apt to be at a premium, the small size, wide range and low distortion of this speaker offer great advantages. About the only difference in performance between this speaker and a large theater unit is the load capacity, and it is believed this will be adequate for halls up to 100,000 cubic feet or more.

When this speaker is referred to as small, it should be remembered that the physical size is augmented by the mirror-images produced by the walls forming the room corner, so that the mouth size is adequate for the intended performance. The only way to be convinced of the performance is to hear one of these units.

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NOTE: While structural details have been given that would enable the reader to construct a satisfactory model, the subject matter is covered by patents issued and pending. Construction for personal or experimental use will be encouraged by the author if permission is requested. Comments and criticisms from such experimenters are invited.

EFFECTIVENESS as R-f Shielding

By SCOTT L. SHIVE

Radio Engineer, Signal Corps Engineering Laboratories
Coles Signal Laboratory, Red Bank, New Jersey

WIDESPREAD USE is made of conduits, either flexible or rigid, for shielding conductors from stray external r-f fields or for confining r-f fields radiated from conductors which themselves are carrying r-f currents. Electrical wiring, particularly the high-tension ignition wiring of aircraft and vehicular gasoline-driven engines, may be cited as one common and timely example of conductors requiring such shielding. The radio interference set up by and radiated from these circuits would make radio communication within the immediate area difficult, if not impossible, were it not for the practice of inclosing these wires in a conduit shield.

Since different applications require varying degrees of conduit shielding effectiveness, depending upon the frequency and intensity of the field to be shielded, it becomes desirable from the standpoint of economy to study the factors in composition and construction of conduit that make for good or poor shielding, and be able to compare the relative merits of any specific types. Hence the need arises for a practical laboratory method of evaluating the r-f shielding effectiveness of any given sample. The purpose of this paper is to describe such a method and to present and discuss a number of typical measurements obtained therewith.

Principle of Operation

Figure 1 shows a block diagram of the conduit tester and associated equipment. Basically, shielding effectiveness is determined in this method by measuring the attenuation suffered by an electromagnetic field, varying sinusoidally at a radio frequency, in passing from its origin inside the conduit specimen through the walls to the outside. A localized r-f field of sufficient strength to be readily detectable after penetrating the walls is produced by a small solenoid or radiating coil, placed within the test sample and excited by r-f voltage from a standard signal generator. A pickup probe coil is oriented outside the conduit specimen in such a position as to link the field of the radiating coil.

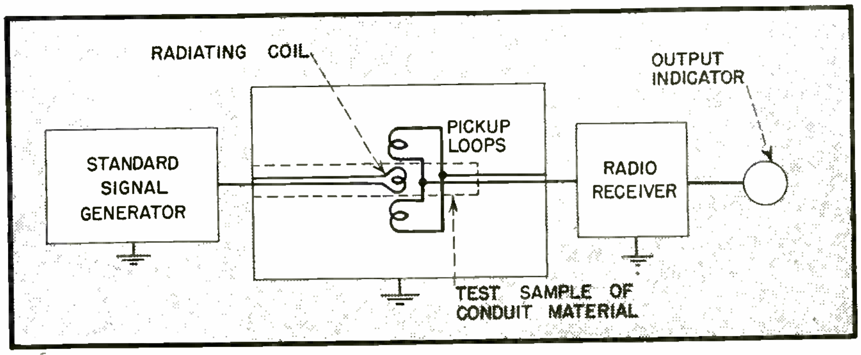


FIG. 1—Block diagram of conduit tester. Accuracy depends on calibration of r-f attenuator in output circuit of signal generator

The r-f voltage induced in the turns of the pickup coil is amplified in a radio receiver coupled to an output indicator. The ratio of signal generator voltage to produce a given receiver output when conduit is interposed between the radiating coil and the pickup coil, to that required to produce the same receiver output with the conduit absent, is equal to the ratio by which the field strength is reduced in passing through the conduit wall. This ratio may be converted into decibels of field strength attenuation (decibels $= 20 \log_{10}$ of ratio) and as such is considered a figure of merit for shielding effectiveness of the conduit.

The test cabinet itself is a sheet metal box provided with a hinged lid which when closed makes metal-to-metal contact in a continuous line around the top of the cabinet, as shown in Fig. 2. The primary purpose of such complete shielding is to exclude stray fields which might affect measurement results, and thus permit operation of the conduit tester in areas of relatively strong radio interference fields.

Radiating Coil

The radiating coil consists of a small solenoid, normally housed within a protective polystyrene sheath, and surrounded by a Faraday shield as in Fig. 3. Radio-frequency current is conducted to the radiating coil through a pair of insulated conductors inclosed in a small brass tube. The tube serves to shield the conductors from varying ground capacitance effects which might otherwise be introduced by installing and removing the conduit test specimen. It also insures that no radiation shall occur from any source other than the radiating coil, and finally, it may serve as a mechanical support for the specimen under test.

The Faraday shield surrounding the radiating coil is essential for stable, repeatable measurements

OF CONDUIT

Tester measures attenuation incurred by r-f electromagnetic field in passing from radiating loop inside conduit through walls to pickup loops on outside. Accuracy is independent of signal generator and receiver, depending only on calibration of r-f attenuator used

particularly in the frequency range above 100 mc. It provides for a relatively constant capacitance between radiating coil and ground and between turns of the radiating coil, regardless of the presence or absence of any test specimen. At or near the resonant frequency of the radiating coil, measurement accuracy is quite critical to slight changes in these capacitances. The shield consists of a number of narrow insulated strips of aluminum foil lying parallel to each other along the inside wall of the polystyrene housing for the radiating coil. Each strip is grounded at its inner end to the brass tube.

A standard signal generator supplying calibrated r-f voltage is connected through a coaxial line to the junction box on the left end of the test cabinet, where connections are made to the radiating coil conductors.

Pickup Loops

The pickup probe consists of two loops of copper tubing within each of which is an insulated conductor. The loops are spaced one on each side of the radiating coil and are soldered into a small copper junction box at the base. The purpose of the copper tubing is to provide electrostatic shielding for the insulated conductors forming the turns of the probe winding. However, to allow unimpaired electromagnetic coupling to the insulated conductor within, the shielding is split at the top of each loop and the cut ends are separated by a short air gap. In order to provide equal pickup by the two halves of the pickup probe winding, particularly at frequencies above 50 mc, it was found necessary to connect the two halves in parallel rather than in series; otherwise the shift in phase of the r-f current in traveling from one half to the other would be such that at certain frequencies the induced emf in one half would be out of phase with the current, and partial or even complete cancellation could occur. The paralleling connections are made within the junction box, and conductors connected to the two paralleling junctions are led away within a shield covering. One of the pair is connected to the receiver antenna post, and the other is grounded to the inner surface of the shielding.

The pickup coil is located in a fixed position centrally surrounding the radiating coil such that the turns of the probe link the maximum number of flux lines of the field produced by the radiating coil. Dimensions of the radiating coil and pickup probe may be varied within reasonable limits as required to accommodate various sizes of shielding test samples, inasmuch as the measured values of shielding effectiveness are independent of the physical size of these fixtures.

Testing Procedure

The sample of any tubular shielding material to be tested is first slipped over the radiating coil and secured to the connector in the cabinet wall. The other end of the sample, extending out into the cabinet, need not be grounded nor secured in any way, but the sample should be long enough to extend in a straight line beyond the radiating coil for a distance of not less than four times the diameter of the sample. The signal generator output voltage, at the particular frequency

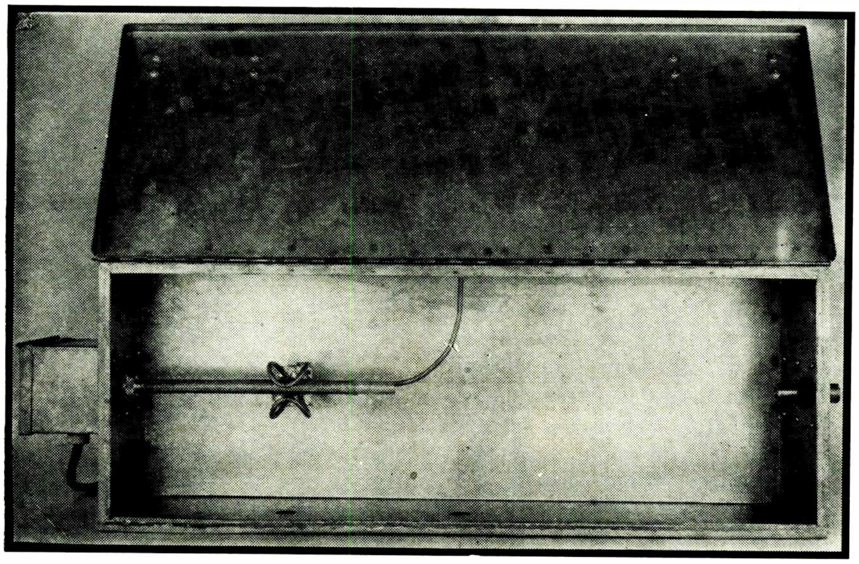


FIG. 2—Conduit tester with cover raised, showing sample of braid shielding drawn over polystyrene tube, ready for test. Junction box outside cabinet at left connects coaxial line from signal generator to leads going to small radiating coil inside the polystyrene tube

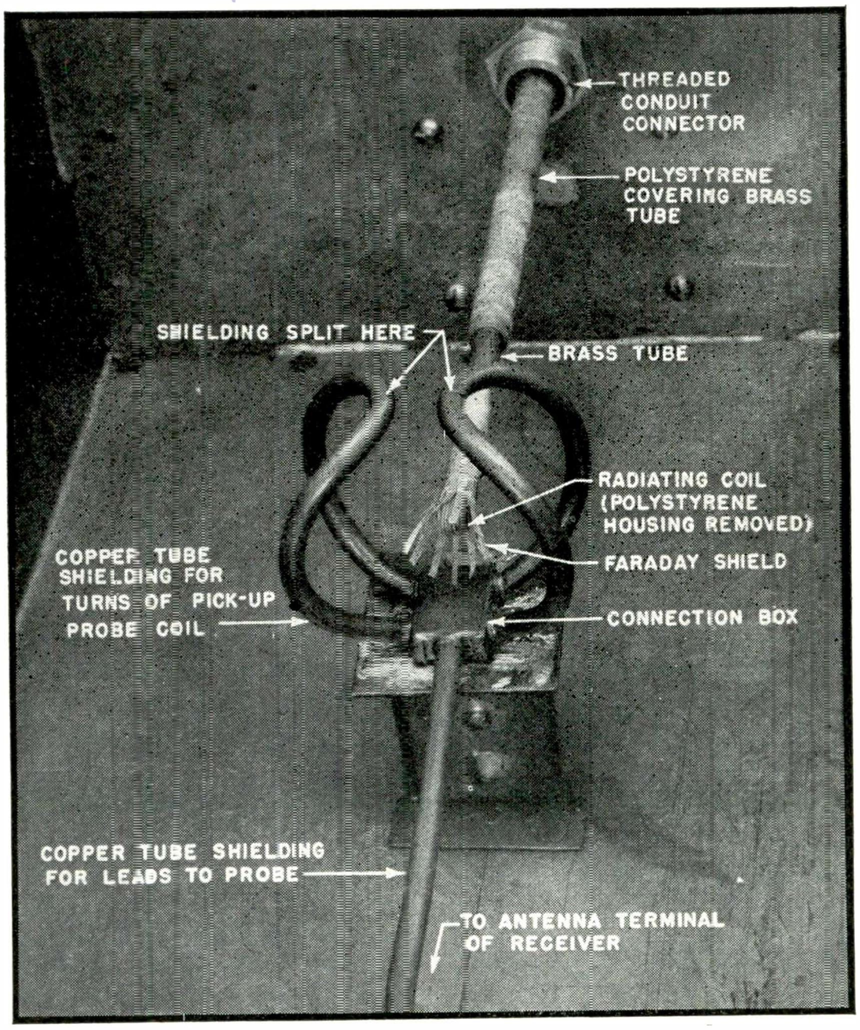


FIG. 3—Closeup of radiating coil and its Faraday shield, mounted between the two single-turn pickup loops

desired, is raised until a convenient reading is registered on an output indicator connected to the radio receiver, also tuned to the same frequency. The test sample is then removed and the signal generator output voltage is lowered until the same receiver output as before is obtained. The ratio of the two signal generator settings is a measure of the shielding effectiveness of the sample. For convenience in handling and plotting, this ratio has been converted into decibels representing electromagnetic field strength attenuation.

Design Considerations

Before presenting the results of actual measurements on various tubular shielding specimens, it will be well to examine briefly some of the major considerations involved in the design of this instrument.

The single concept which exerted the greatest influence on initial development was that shielding effectiveness be evaluated in absolute terms—standard electrical units such as decibels of attenuation, not in terms of some other arbitrarily chosen sample or in terms depending in any way upon measuring equipment characteristics which could vary from one setup to another. Thus the receiver, no two of which are exactly alike, is eliminated from any role of directly metering r-f voltages and is used merely as a fixed-point indicator. The actual metering is accomplished by the accurately calibrated r-f attenuator in conjunction with the signal generator. Furthermore, the absolute microvolts of output need not correspond to the actual attenuator settings, since only ratios are significant. Percent modulation of the r-f signal has no bearing on measurement results; in fact, completely unmodulated signals may be used, in which case the receiver beat-frequency oscillator must be employed to obtain the audio output. Within relatively wide limits investigated, the diameter, number of turns, and wire size of both pickup probe and radiating coil did not affect the measured value of shielding effectiveness for any given conduit sample.

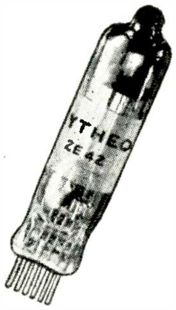
Use of Locolized R-f Field

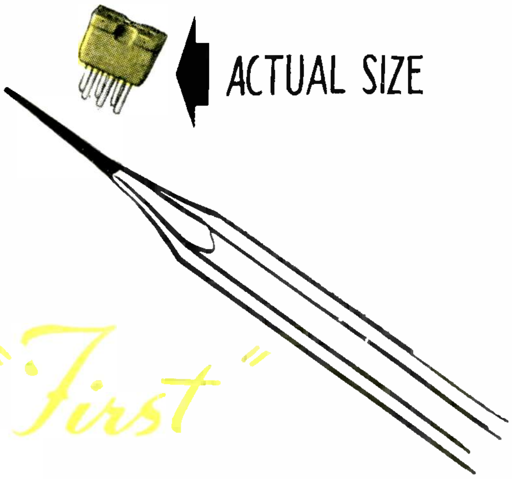
In most practical applications of conduit shielding, the conductor to be shielded lies centrally along the axis of the conduit. Hence, it would appear most reasonable to preserve this same physical relation when evaluating shielding effectiveness of the conduit. One of the preliminary experimental models of conduit tester was, in fact, designed toward that end. Radio-frequency current from a signal generator was fed into a conductor lying along the axis of the conduit sample, and a probe coil surrounding the conduit was used in conjunction with a radio receiver to detect the r-f field existing outside the conduit. However, two major disadvantages to this method were immediately apparent. First, the maximum signal strength delivered by any available signal generator was too weak to be detected readily after penetrating some of the more effective grades of conduit; second, the results were extremely critical to slight variations in contact at the end connections.

In order to obviate both these disadvantages in one step, the straight conductor was replaced by the small solenoid coil capable of generating a strong localized r-f field easily detectable through the best grades of conduit. Also, by localizing the field in this way, only that section of conduit sample in the immediate vicinity of the radiating coil was contributing to the shielding effectiveness measurement. What happened to the conduit at a short distance either side of the radiating coil, whether it terminated altogether, whether capped over, bent or twisted, all had relatively no bearing on the measurement. Thus the measurement was truly one of the shielding ma-

FOR SERVICE IN POCKET SETS

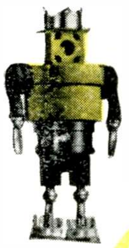
WITH RAYTHEON



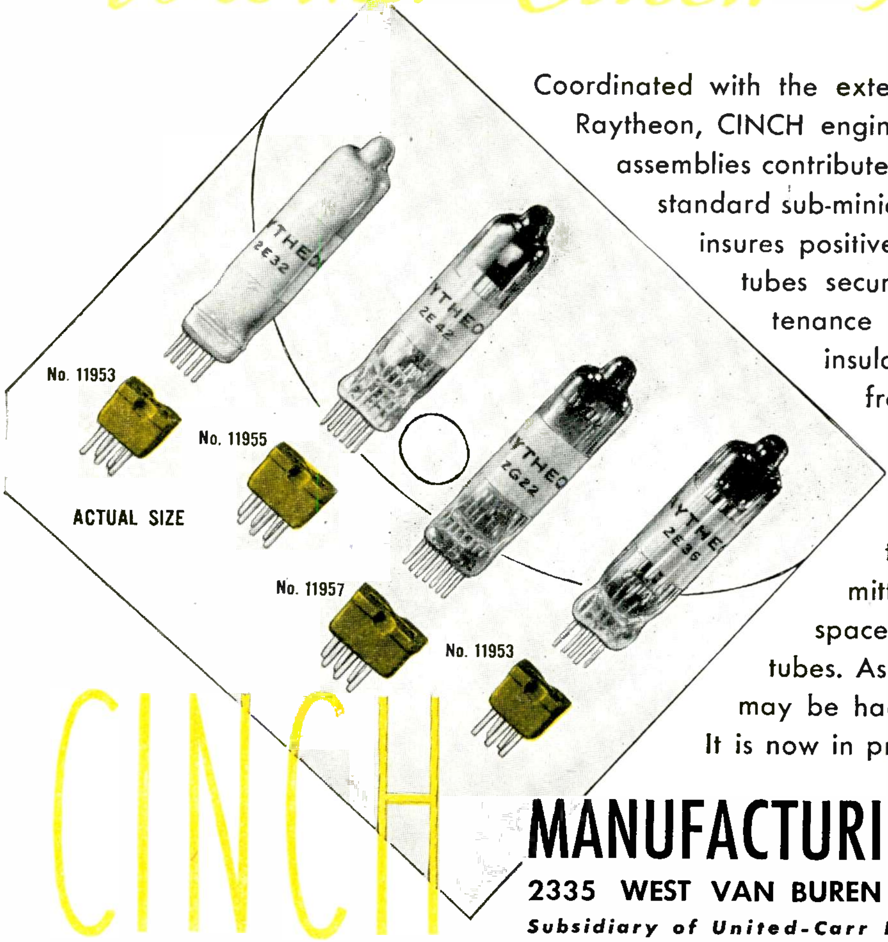


ACTUAL SIZE

IT'S A CINCH



Another Cinch "First"



Coordinated with the extensive and exhaustive research of Raytheon, CINCH engineering experience in metal-plastic assemblies contributes to industry a perfected socket for standard sub-miniature tubes. This "mite" of a socket insures positive electrical contact, holds the tiny tubes securely in place, permits easy maintenance and replacement, yields maximum insulation resistance and minimum high frequency loss, and provides manufacturers of pocket radio receivers and hearing aids a labor saving chassis installation which serves terminal board functions while permitting designers to obtain maximum space afforded by the standard flat base tubes. As illustrated, the tiny CINCH Socket may be had with five, six or seven contacts. It is now in production and available on order.

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terial itself and was not affected by end connections.

Orientation of Radiating Coil

Two possible orientations of the radiating coil in relation to the conduit specimen are shown in Fig. 4. While solid-wall conduit gave identical attenuation values under either condition, flexible conduits, with spiral seams at the joining of the spirally wound strip of metal inner-core, exhibited appreciably greater shielding effectiveness when measured with the radiating coil coaxial with the test sample than when measured with the radiating coil at right angles to this position.

The explanation for this difference may best be understood by examining the positions assumed by the r-f fields and the accompanying eddy currents in the walls of the conduit for each orientation. When the radiating coil lies coaxially with the test specimen, the eddy currents induced by the field circulate around the conduit in the manner shown, exactly as currents would be induced in a closed conducting ring located centrally around the axis of the coil. Since the path of these eddy currents is approximately parallel to the seams of spirally wound conduit, the resistance introduced by the seams is low and the shielding effectiveness is consequently high.

When the axis of the coil is at right angles to the conduit axis, the eddy currents are induced in the conduit walls around the intersection of the walls and the projected coil axis. Since this path is in part perpendicular to the spiral seams of the flexible conduit, the resistance thereby introduced into the path is relatively high, and the shielding effectiveness is correspondingly low. However, in the case of solid-wall conduits or tubes, the resistance to eddy currents is the same in any direction, hence the shielding effectiveness is unchanged regardless of the orientation of the radiating coil and its field. In light of this analysis, it appeared preferable to standardize the radiating coil position as that perpendicular to the axis of the test sample. The eddy currents so induced travel over a portion of their path in a direction lengthwise of the conduit and more nearly duplicate conditions occurring in a normal conduit installation that is being used for r-f shielding purposes.

Shielding Effectiveness of Specific Test Samples

Results for a series of six solid-wall brass tubes and two solid-wall copper tubes of varying wall thicknesses are given in Fig. 5. Although no exact mathematical formula will be evolved here for accurately calculating the shielding effectiveness of any solid-wall tube at any frequency, certain factors upon which shielding effectiveness does depend are quite evident, and within limits the actual manner of dependency may be determined by inspection of the curves.

The slope of the curves for the thinner-walled brass tubes is fairly consistent at 6 db rise for each 100-percent increase in frequency. Thus, since 6 db represents a 2 to 1 ratio, or a 100-percent change, shielding effectiveness for very thin tubes is seen to be directly proportional to frequency. However, for the heavier-walled tubes, and even for the very thin tubes at high frequencies, the shielding effectiveness increases at a rate greater than merely proportional to frequency. The resulting upward curvature becomes discernable in the region where skin depth, or depth of penetration, approaches and becomes less than the wall thickness. Shielding effectiveness then increases exponentially with frequency as the ratio of wall thickness to skin depth exceeds unity.

Shielding effectiveness varies with wall thickness at all frequencies. In fact, for the straight-line portion of the curves, the variation is seen to be one of direct proportionality, for with each doubling of wall thickness, other factors re-

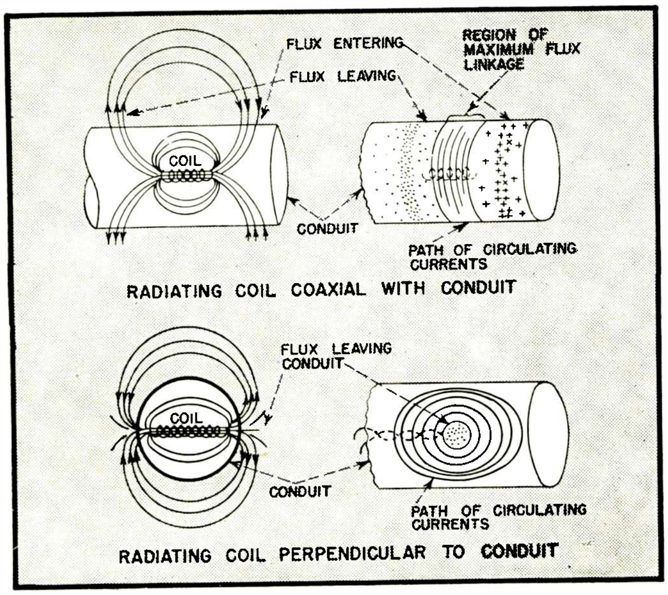

FIG. 4—Paths of flux around radiating coil and circulating currents through conduit for coaxial and perpendicular orientation of radiating coil inside test sample of conduit

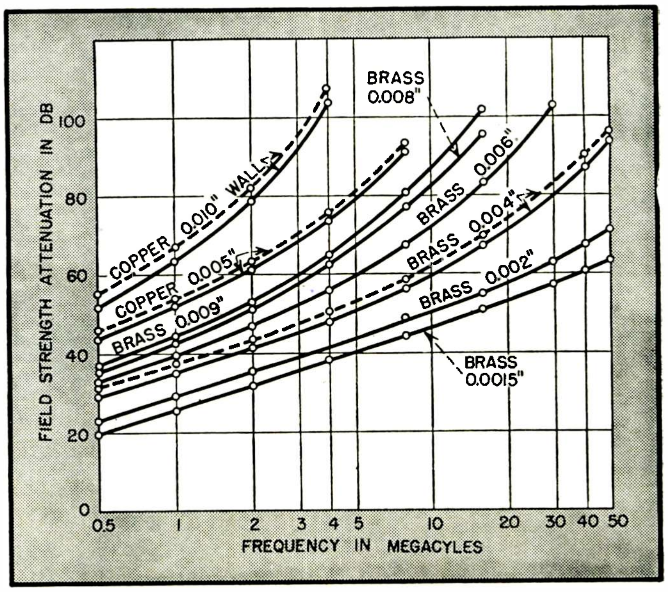

FIG. 5—Shielding effectiveness of ½-inch diameter (solid curves) and 1-inch diameter (dash-dash curves) brass and copper solid-wall tubing with various wall thicknesses

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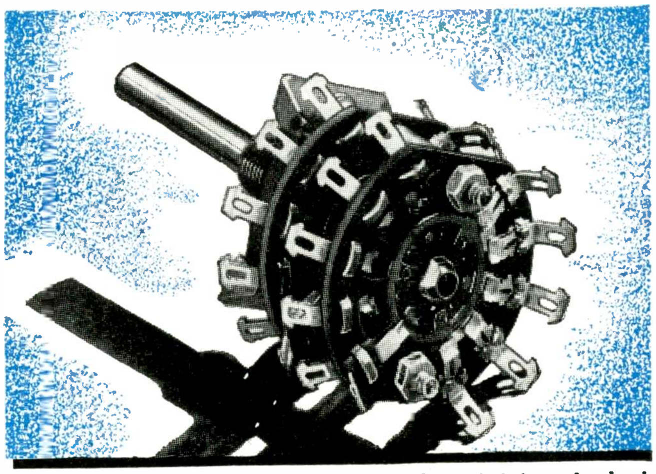
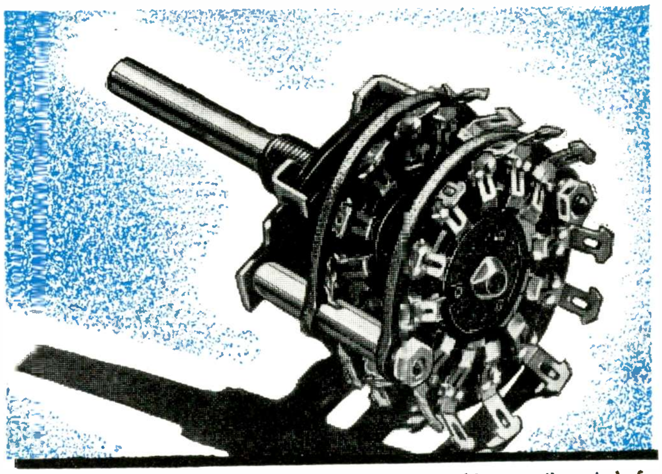
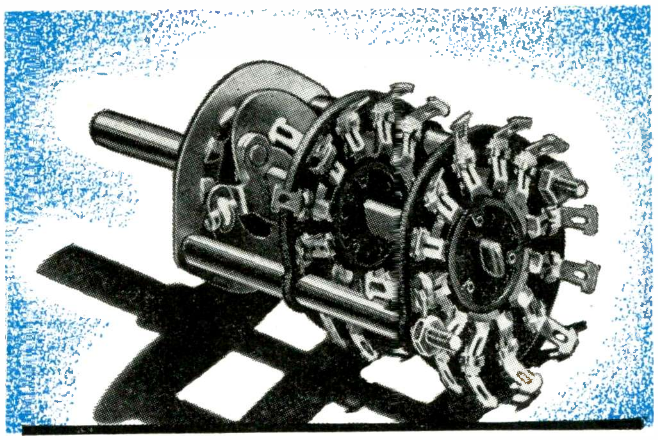


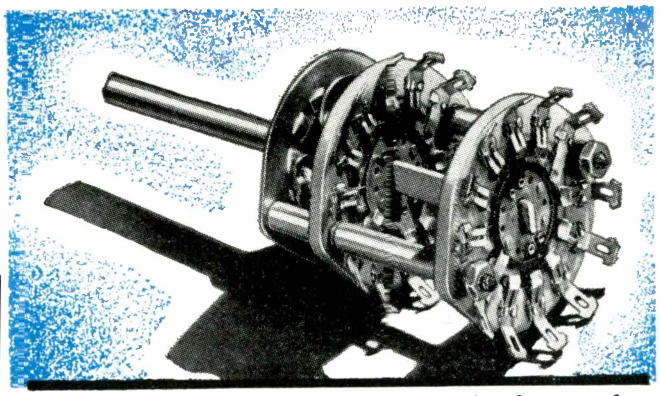
RS-60 (Above) Smallest of the RS switches—ideal for under-chassis mounting.



RS-50 (Above) Low-torque indexing features this versatile switch for radio receiver use.



RS-40 (Above) Somewhat larger than the RS-60, but still highly compact. With snap indexing.



RS-30 CERAMIC (Above) Offers all the advantages of an RS-40 switch plus maximum insulation.

maining constant, shielding effectiveness is 6 db higher.

The copper tubes are considerably more effective than brass tubes of the same diameter and wall thickness, hence conductivity is a factor. The conductivity of copper may be taken as approximately four times that of brass, and if curves of copper tubes and brass tubes of equal wall thickness are compared in the straight-line region, the copper tubes are found to be approximately 12 db higher, or four times more effective than the corresponding brass tubes. Accordingly, shielding effectiveness is directly proportional to conductivity where wall thickness is less than skin depth.

In Fig. 5, 1-inch diameter tubes are compared with ½-inch tubes of similar material and wall thickness. The larger-diameter tubes are everywhere more effective by approximately 3 db.

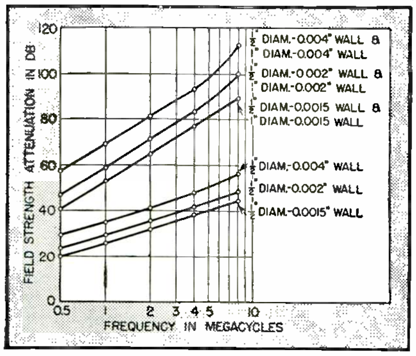


FIG. 6—Variation of shielding effectiveness with frequency for three combinations of ½-inch and 1-inch diameter solid-wall brass tubing, with curves for single ½-inch tubes shown separately for comparison

Results for Concentric Shields

Figure 6 shows the shielding effectiveness obtained by placing a ½-inch tube inside a 1-inch tube of similar material and wall thickness. The slope of the curves for the combinations is 12 db rise per each frequency octave as against 6 for each tube measured singly, and the attenuation produced by two concentric shields is approximately the sum of the attenuation readings of each tube measured separately. This is to be expected in view of the concept that the electromagnetic field undergoes a given attenuation in passing through an interposed sheet of conducting material, in much the same manner that electric waves are attenuated by a section of transmission line. Except for intersectional reflection losses, each sheet of conducting material or each section of line increases the total attenuation by the number of units contributed by itself alone.

Shielding effectiveness of a single solid-wall tube is a function of frequency to the first power, referring now only to the straight-line region of the frequency-attenuation characteristic, while effectiveness for two coaxial tubes in combination is a function of frequency squared. If there were three tubes, it would be a function of frequency cubed. This relationship suggests the possibility of constructing an extremely effective conduit by merely combining several layers of some shielding material, each layer of which by itself need not be very effective.

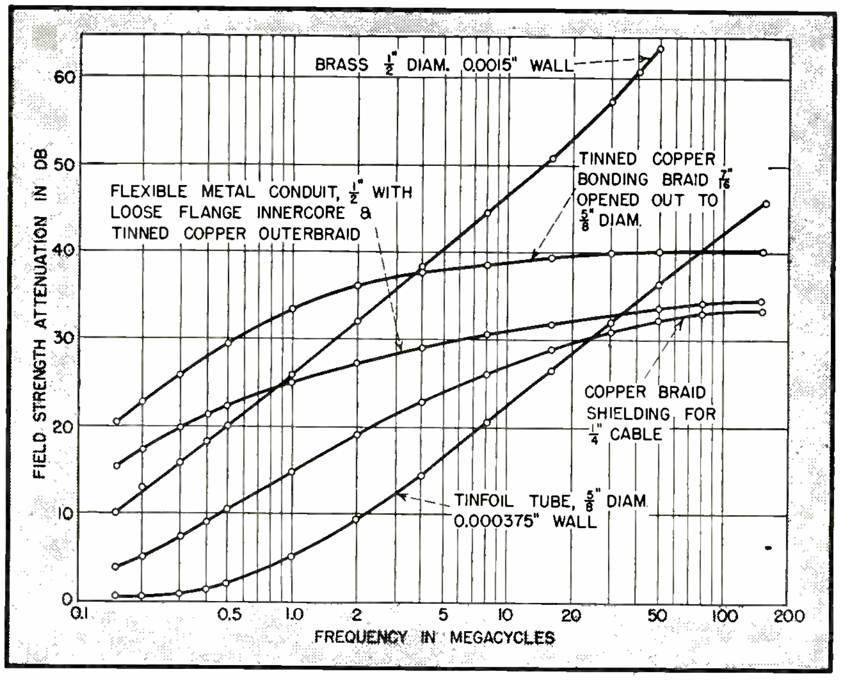


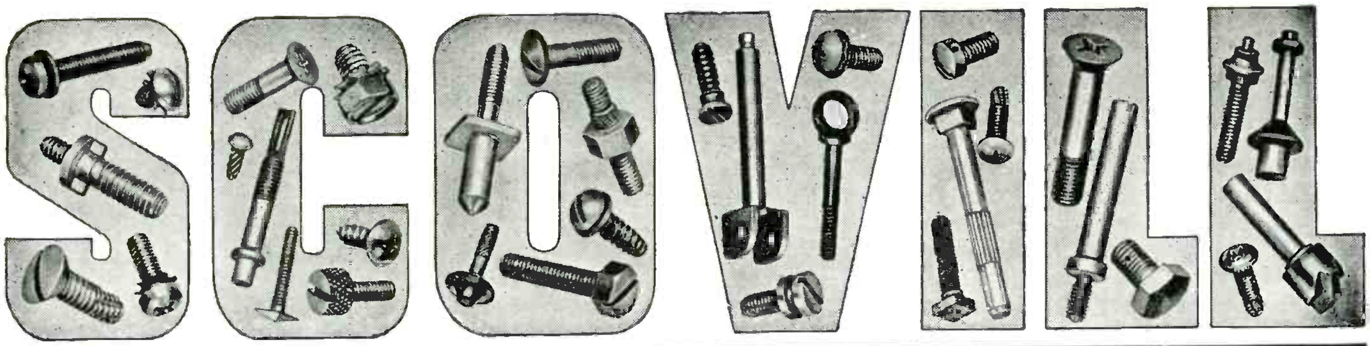
FIG. 7—Variation of shielding effectiveness with frequency for five samples of solid, flexible, and braided shielding

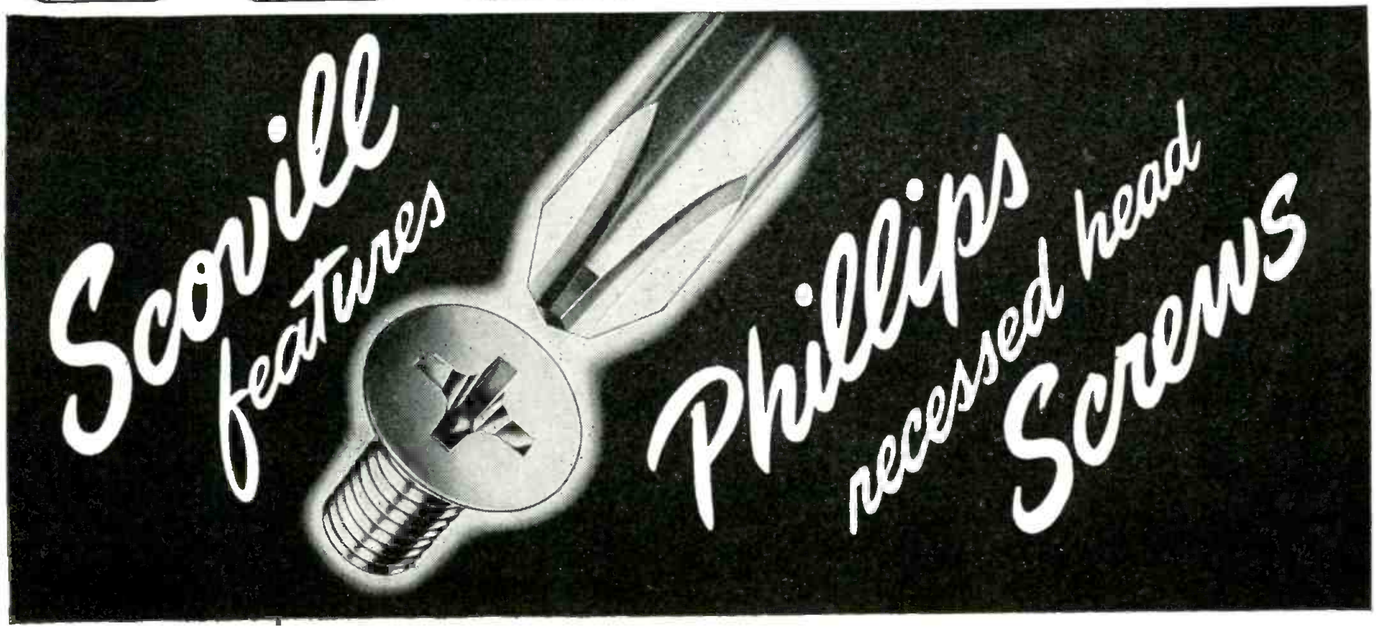
Tinfoil and Braid Samples

Figure 7 shows the shielding effectiveness characteristics for a number of miscellaneous types of shielding materials. Owing to its thinner walls and lower conductivity, the tinfoil tube is substantially less effective than the solid-wall brass tube. However, from approximately 2 mc up, the slopes are identical. It is interesting to observe that in spite of the extreme wall thinness and relatively low conductivity, the solid-wall tinfoil tube has greater shielding effectiveness above 80 mc than the heavier but porous conduit and braids. The tinfoil tube, however, is comparatively ineffective at the low end of the frequency range shown, and the slope becomes less as the zero attenuation level is approached.

The one flexible conduit consisting of a loose-crimp inner core plus a tinned copper outer braid. The two braid samples are seen to have quite similar curves in that the shielding effectiveness increases rapidly in the lower-frequency range, but flattens out until shielding effectiveness remains virtually constant with any further rise in frequency. This appears to be characteristic of shielding materials of nonsolid-wall construction, such as braids or conduits with loose (not soldered) crimp or flange innercore construction.

The method is applicable to practically any shielding material in conduit form. The testing procedure can be conducted by semiskilled operators and could be adapted readily to a spot check control of commercial production.





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INDUSTRIAL CONTROL

Pressure-Time Curves in Electronic Observation of Engines

By W. F. Brown

Electro Products Laboratories
Chicago, Illinois

Studies of internal combustion engines are facilitated by means of a new electronic tool that uses a capacitance-type pickup to provide observation and measurement of such factors as compression, peak pressures, opening and closing of valves, static pressures, etc. Adjustments such as fuel to air ratio, spark and valve timing and changes of injection timing in deisel engines, can be made and the effects viewed on an oscilloscope or photographed to provide a permanent record. Calibration is possible, providing means of determining peak pressures and other important pressure points.

Called the Pressuregraph, the instrument is basically a capacitance bridge excited by a 100 kc oscillator. Two arms of the bridge consist of fixed resistors; the other two arms are capacitors. One of the capacitance arms includes a diaphragm upon which pressure impulses impinge, the other arm is adjustable so that the bridge may be balanced.

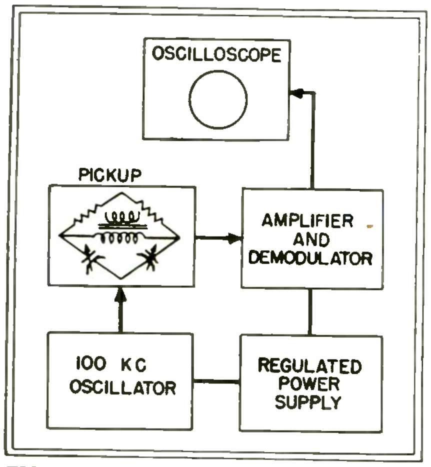

FIG. 1—Block diagram of Pressuregraph system showing connections to pickup head and oscilloscope

The output of the bridge is fed through a special impedance-matching transformer and 600-ohm line to a two-stage amplifier and demodulator. The oscillograph is fed from the amplifier and demodulator as shown in Fig. 1.

The bridge and the impedance-matching transformer are contained in the pickup shown in Fig. 2. The diaphragm end of the pickup is inserted in the engine by adaptors.

Operation

Figure 3 is the schematic diagram of the system. Variation in pressure on the diaphragm of the pickup unbalances the bridge and modulates the 100-kc signal. The pressure-modulated signal is amplified and a three-position switch permits selection of a true modulated wave, a signal having the negative modula-

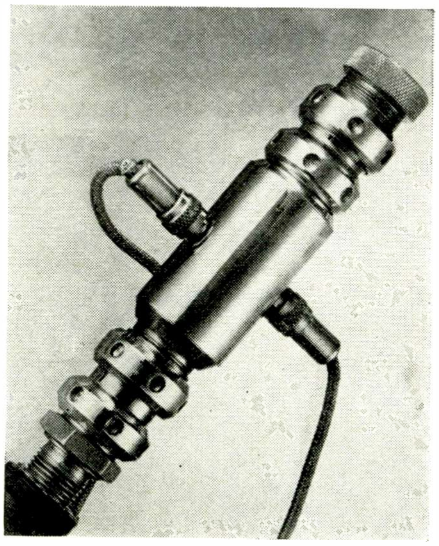

FIG. 2—The pickup head contains the elements of the bridge circuit. The knurled nut is used to adjust a variable capacitor for balance

tion suppressed, or a demodulated signal giving a single line pattern showing substantially the contour of the positive modulation. The type of pattern for each of the selector positions is shown in Fig. 4.

Switch position 1 indicates the true pressure time pattern as no demodulation or integration is employed. The next best pattern is from position 2, where a small amount of distortion is present due to the suppression of the negative modulation, however to mechanical engineers it is substantially the indicator card picture with which he is most familiar. Transient response

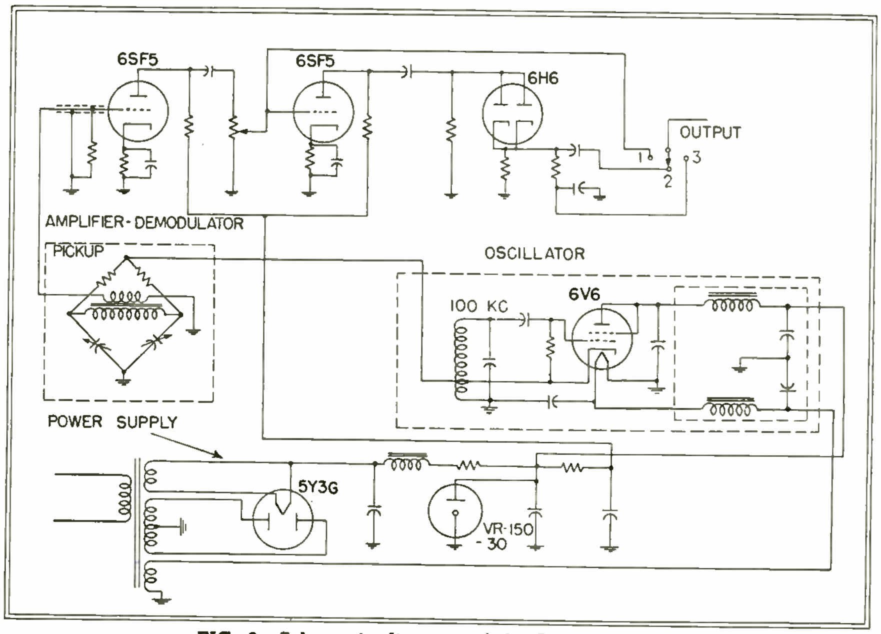

FIG. 3—Schematic diagram of the Pressuregraph

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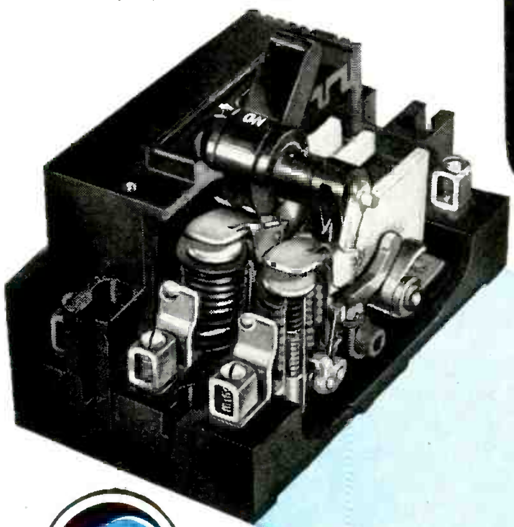

The HEINEMANN CIRCUIT BREAKER is supplied with or without a time-delay. If operated without the time-delay mechanism, it trips *instantly* on the smallest overload or short circuit, opening even before an ammeter can indicate the peak current. High speed operation is obtained by means of an armature which is attracted to a pole piece when the latter is energized by excess current, thus operating the high speed latch. The rotation of the latch releases contacts which are under heavy spring pressure.

The addition of a time-delay merely serves to keep the breaker from opening on transient overload and starting surges, but in case of short circuit it operates with the same high speed as the instantaneous type.

Magnetic blowout contacts mounted in individual arcing chambers add speed to the arc interruption. As the amount of current increases, the quenching effect becomes greater, due to the intensified magnetic blowout field.

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in these switch positions is better than one millisecond.

Position 3 produces an integrated curve so that extremely rapid pressure changes or transients are not truly recorded and is most suitable for use in conjunction with mechanical or string oscillographs.

The output of the unit is substantially linear when plotted against pressure. Temperature changes in the engine due to different operating conditions will tend to change the original balance of the bridge due to expansion of the diaphragm. Sensitivity and calibration can be restored by adjustment of the variable capacitor arm in the top of the pickup.

Calibration

Calibration of the instrument for any diaphragm and oscilloscope combination is possible using either of two methods. In one method, the piston of the engine is set at top dead center and compressed air is applied at different pressures through a tapped hole in the side or top of the cylinder. The air pressure gauge readings are tabulated against the oscilloscope deflection for each step in pressure.

In the second method, the pickup is inserted in a tank, the pressure within which can be varied and recorded on a gauge. Either compressed air or hydraulic means can be employed in the tank to effect the pressure changes, and if possible a method should be provided to main-

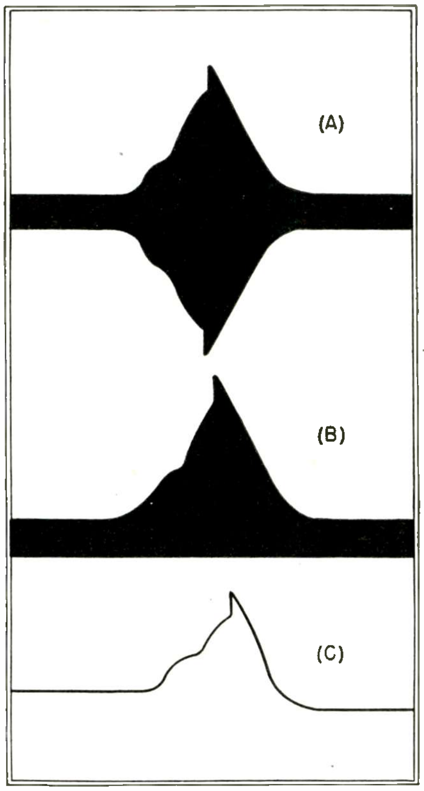


FIG. 4—Oscillograms showing rise and fall of pressure in engine cylinder during compression stroke. (A) Switch position 1, (B) Switch position 2, (C) Switch position 3

tain the pickup at the operating temperature of the engine. The same calibrating procedure is followed in this method as in the engine method.

A cathode-ray oscilloscope with a low sweep frequency is used with the Pressuregraph since the rpm of some engines when converted to revolutions per second is quite low. For instance, a 360 rpm engine is equivalent to 6 rps. To see a single pattern of the pressure time wave, sweep frequency controls of the oscillograph have to be adjusted to six cycles per second. A marker system can be used to indicate the top of the stroke, spark timing or any part of the cycle that the engine goes through. The marker can be produced by a pulse generator which in turn is triggered by mechanical means at the engine for the particular point in the engine cycle to be marked. The marker can be made to appear on the pressure time curve as a bright spot or as a blank spot in the pattern by applying the marker voltage to the Z axis.

The internal synchronizer of the oscilloscope or external synchornization from the engine shaft can be used to lock the sweep frequency in step with the pressure wave being observed. Engines with irregularities in speed and engines with a low rpm are difficult to synchronize with the internal synchronizer of the oscilloscope.

Application

Complete analysis of the operation of internal combustion engines and pressure can be made by a study of the oscilloscope patterns. Excessive instantaneous pressures, due to hydraulic momentum created by elasticity of feed pipes in diesel engines are at once apparent. Close adjustments of fuel mixtures and ignition timing are facilitated, resulting in improved designs and performance.

Production Testing of Panel Meters

By ROSCOE AMMON

Chief Engineer
Marion Electrical Instrument Co.
Manchester, N. H.

CHECKING AND CALIBRATING of d-c measuring instruments during manufacture, rechecking of accuracy in plants and laboratories during use, and demonstrating performance and accuracy on counters of retail stores

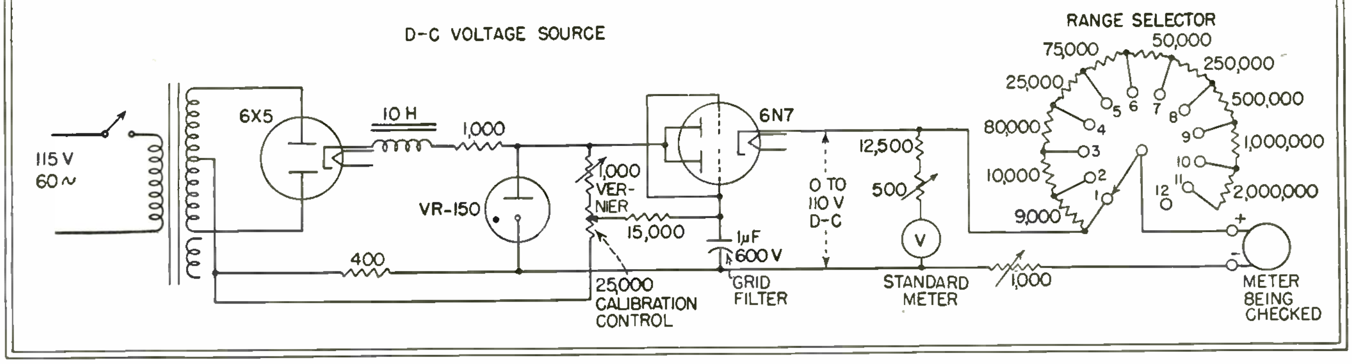
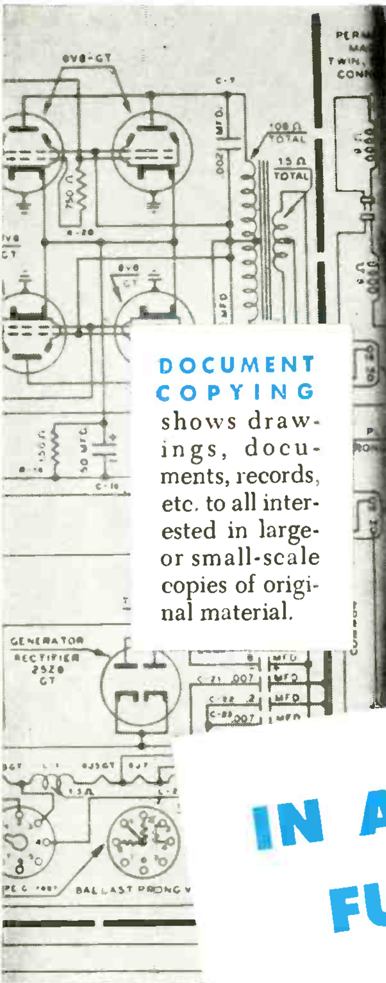
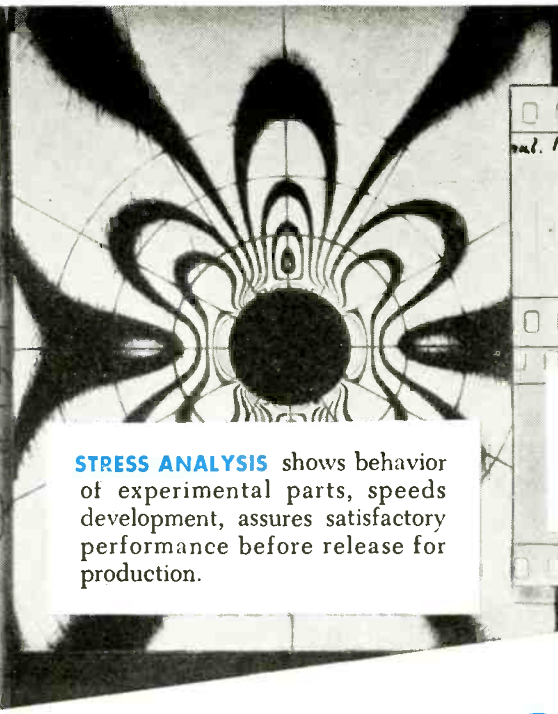
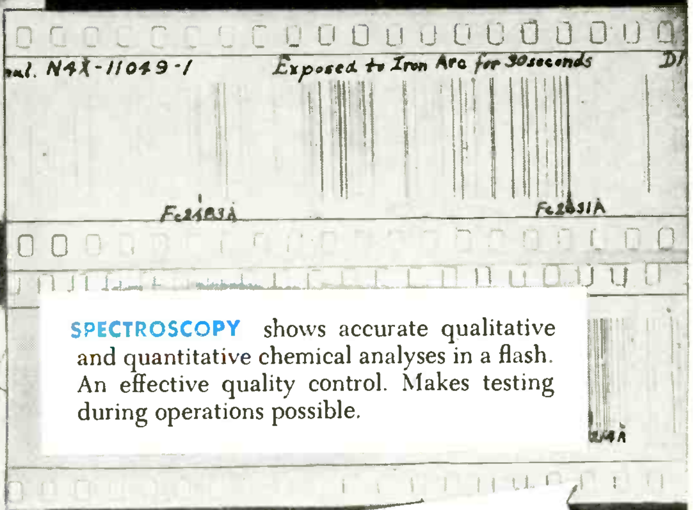


Fig. 1—Circuit diagram of type M1 meter tester manufactured by Marion Electrical Instrument Co. Range selector is set to position corresponding to range of meter being checked



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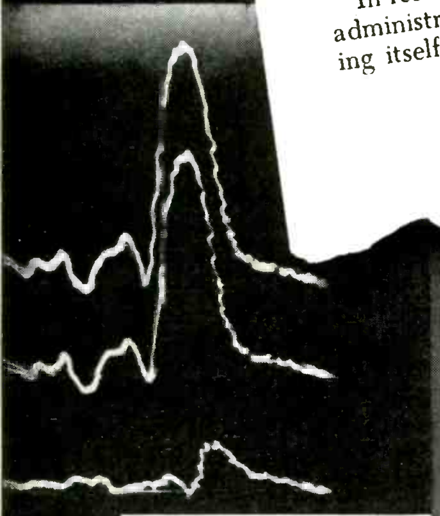

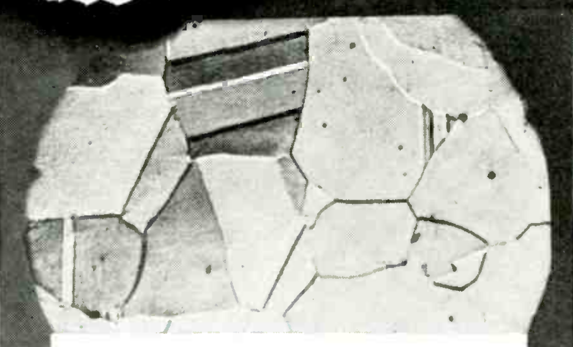

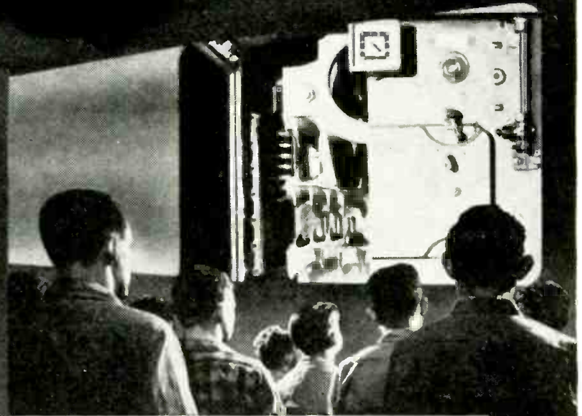

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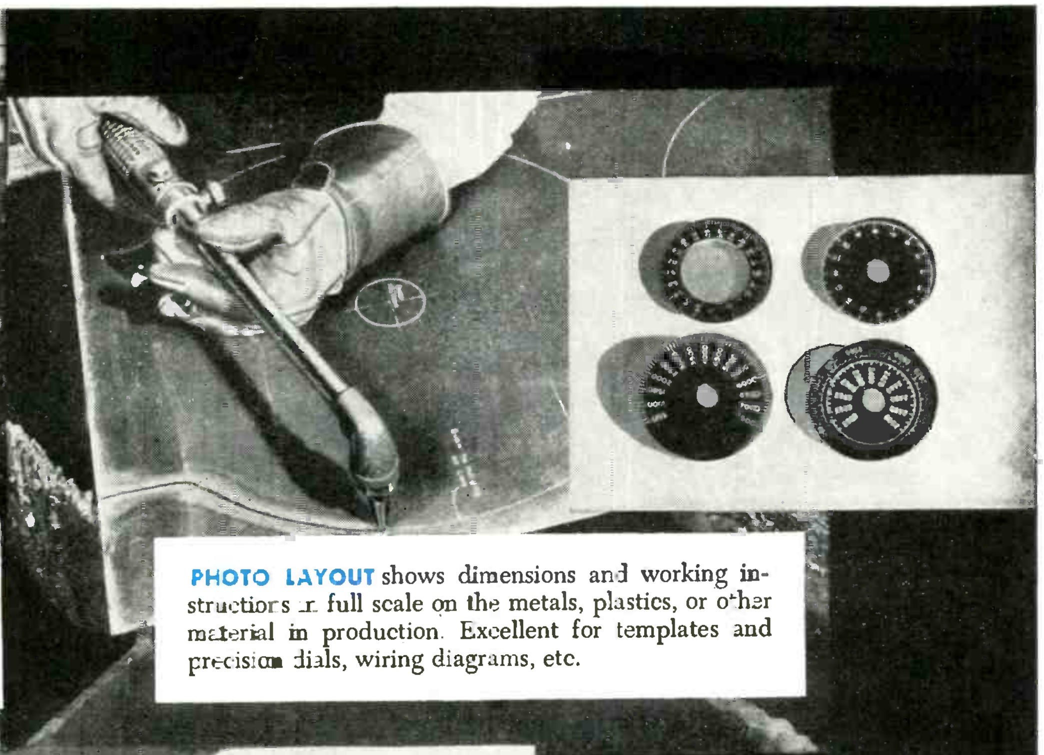

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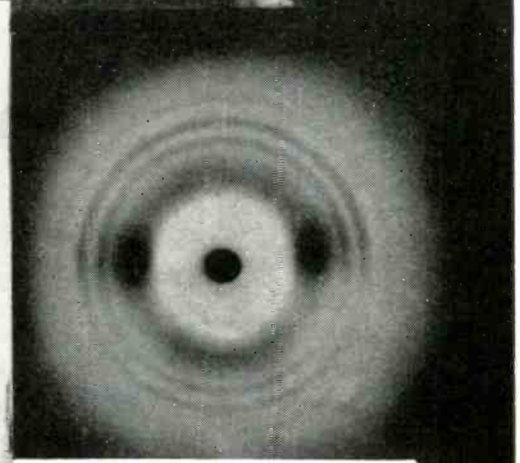

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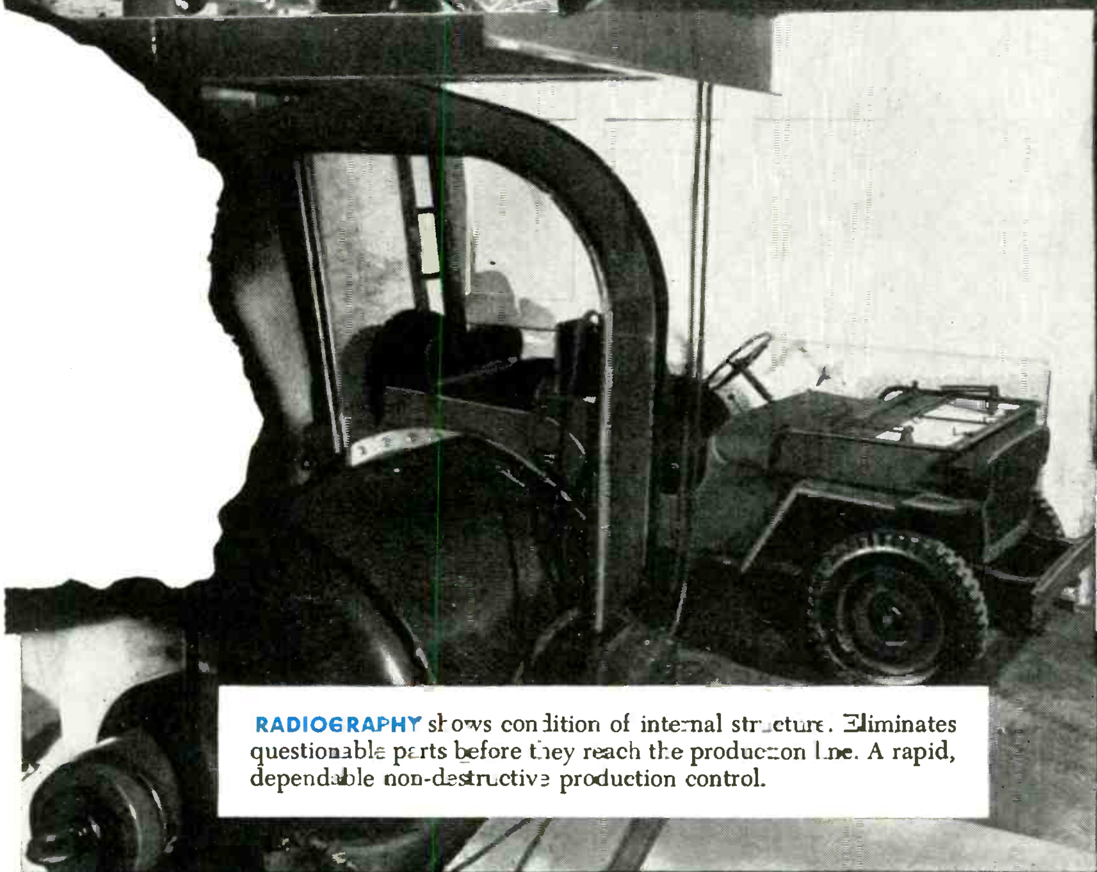

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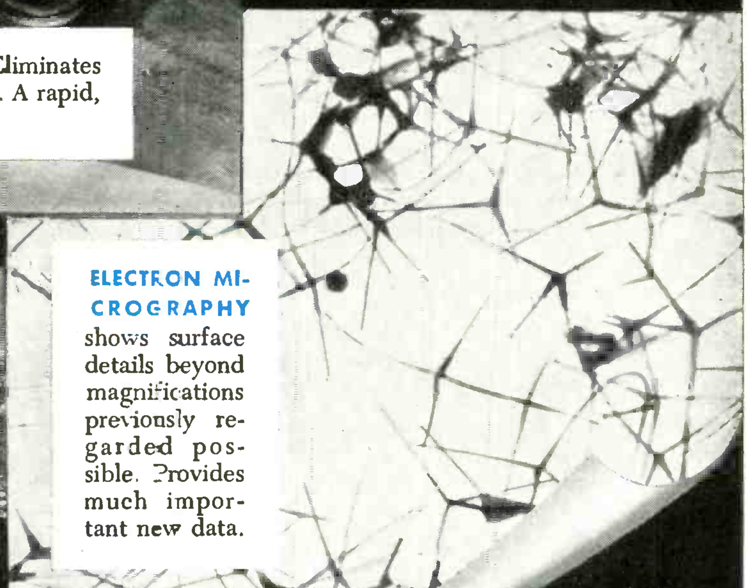

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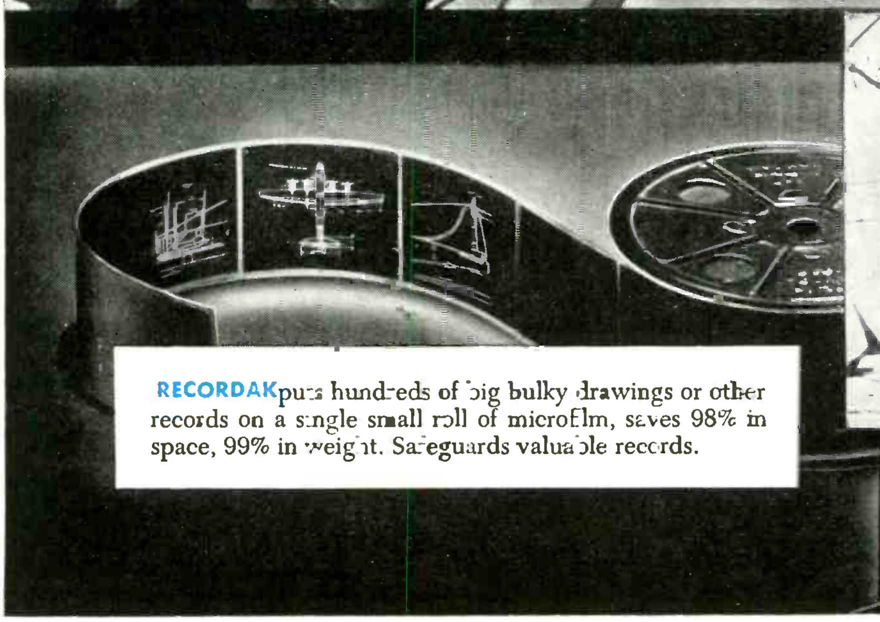

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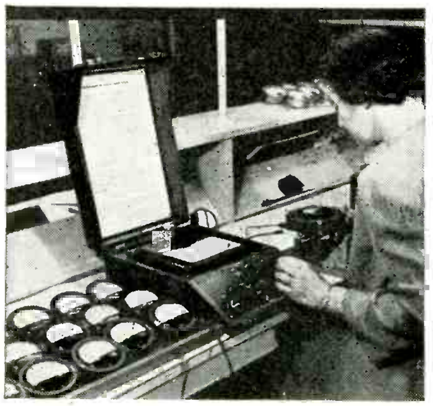
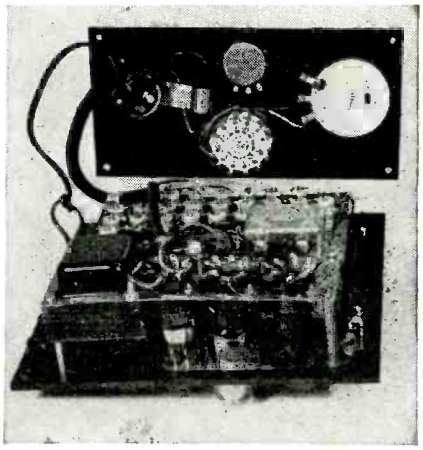
all require a d-c source of power that provides an accurately known and smoothly variable voltage. The drawbacks of carbon-type potentiometers in conventional voltage-dropping circuits for both batteries and power packs led to investigation of vacuum tubes as reheostats.

It was found that a tube having a sharp-cutoff, such as a 6N7 operated as a single triode, gave a plate-cathode resistance variation from



The meter tester in use on production line. Instructions for use are lithographed on brass plate inside the cover for permanence and convenience

about 3,000 ohms up to practically infinity when grid bias was varied over a range from a positive value of a few volts to just beyond cutoff bias. This permitted use of the v-t rheostat in series with the source for voltage-dropping purposes rather than as a voltage-dividing potentiometer. Furthermore, the 25,000-ohm potentiometer needed for bias



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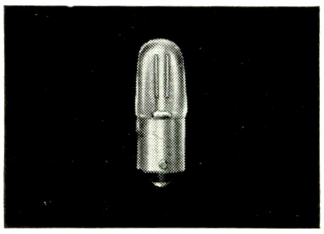
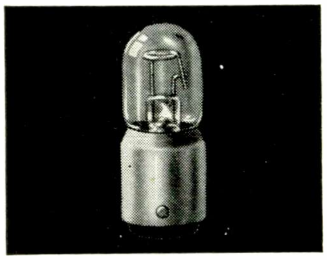
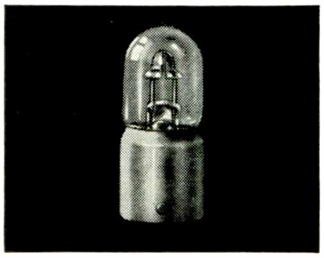


NE-51 For general indication, such as showing existence of potential across various parts of electrical circuits.



NE-17 Indicator and pilot light lamp that flashes to show condition of B-battery in portable radios. Frequency of flashes decreases as battery runs down.



NE-48 (also N-E 16). Indicator lamps. Special volt-ampere characteristics of these lamps indicate use as voltage regulators. Screw base lamp available as NE-45.*

*NE-16 meets JAN-1A specifications for 991. Special marking JCG-991 supplied for small extra charge.

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ORDER NO.	NE-2	NE-51	NE-17	NE-48	④ NE-16	NE-45	NE-30	NE-32	NE-34	NE-36	NE-40	NE-42
Watts, Nominal	1/25	1/25	③	¼	¼	¼	1	1	2	2	3	3
Volts (Circuit)	105-125	105-125	③	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Starting Voltage ① AC / DC	65 / 90	65 / 90	③	65 / 90	— / ⑤	65 / 90	60 / 85	60 / 85	60 / 85	60 / 85	60 / 85	60 / 85
Base	★Unbased (Wire Terminals)	★S. C. Bay. Min.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	Cand. Screw	Medium Screw	★D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.
Maximum Over-all Length	② 1 1/16"	1 3/16"	1½"	1½"	1½"	1⅝"	2 1/16"	2"	3 5/16"	3¾"	3 5/16"	3¾"
List Price (plus tax)	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

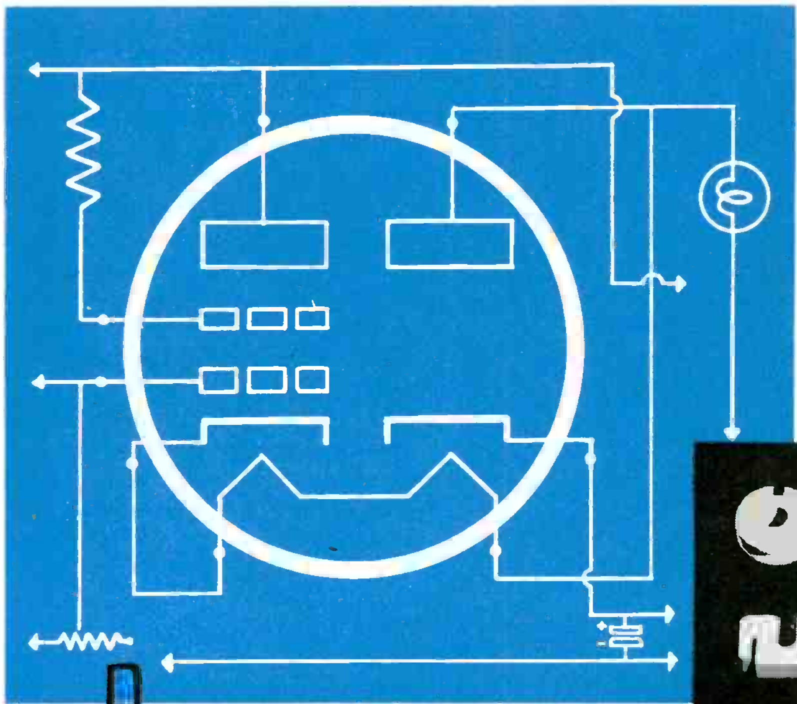
① Applies to lamp when new.
② Glass part; wire terminals extend additional 13/16".
③ Designed for DC flashing operation in RC circuit.
④ Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
⑤ Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).
★ All Bayonet Base Lamps Need External Resistance.

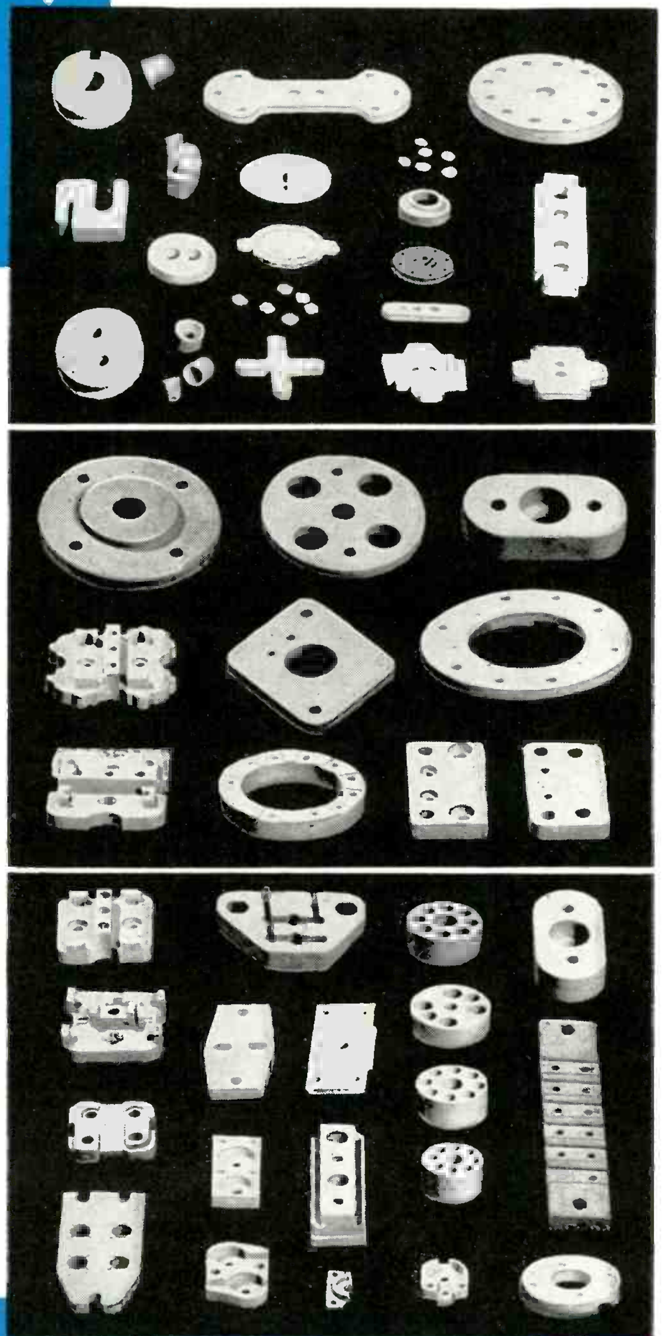
For further information, write address below for Bulletin 7100

NELA SPECIALTY DIVISION, LAMP DEPARTMENT

GENERAL ELECTRIC

1 Newark Street, Hoboken, N. J.





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STUPAKOFF CERAMICS

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Stupakoff quality control means . . .

1. Strict adherence to your specifications—
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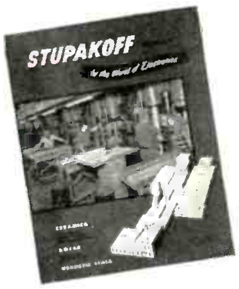
These advantages of Stupakoff Ceramics are gained through carefully selected and laboratory controlled materials . . . competent engineering, backed by years of experience and research . . . plus modern manufacturing facilities and constant inspection. For the finest ceramic insulators...specify Stupakoff.



Write for Bulletin 245 describing Stupakoff Ceramic Products and Hermetic Seals.

STUPAKOFF CERAMIC and MANUFACTURING CO.

LATROBE, PENNSYLVANIA

variation was readily obtained in a stable, smoothly-operating wire-wound unit having long life at the low grid current values encountered.

In the final circuit utilizing this feature, the meter to be checked is converted to a 100-volt d-c voltmeter by appropriate multiplier resistors in series, and connected in parallel with the precision standard 100-volt meter in the instrument. Both meters are fed by a regulated full-wave power pack through the series v-t rheostat, as shown in Fig. 1. The voltage is varied from 0 to 100 volts, by adjusting the 25,000-ohm potentiometer in the grid circuit, while the readings of the two meters are compared. Fine adjustments of voltage are obtained with a 1,000-ohm rheostat serving as vernier control in the grid circuit.

• • •

Contouring Control for Machine Tools

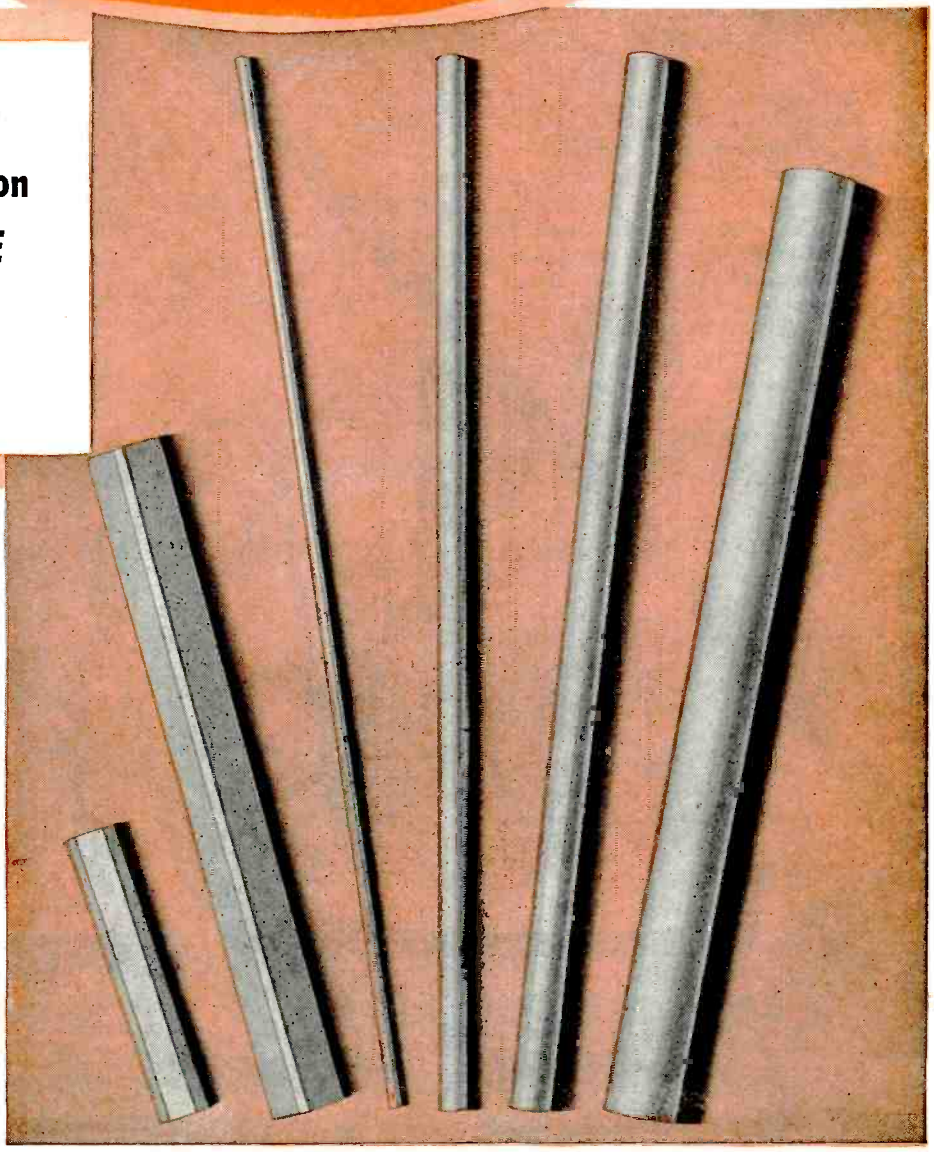
ALMOST ANYTHING that can be cut with a motor-driven tool from a pattern or template can be produced accurately and completely automatically with a machine equipped with an automatic contouring system developed by General Electric engineers. It uses an electronic finger which feels its way around the angles and curves of a pattern to control the operation of the cutting tool.

This feeler or tracing stylus comprises two magnetic bridges, each consisting of two identical magnetic circuits, one pair mounted on an axis at right angles to the other pair. The four magnetic poles are assembled on a diaphragm which is fastened to the stylus.

The very slight pressure of the feeler against the template causes a deflection of the diaphragm which in turn creates a change in voltage in the coils of the tracing head. This voltage is then conducted to electronic circuits where the signals from the bridge circuits are amplified many times and mixed into a vector signal which is related to the direction of the pressure on the stylus. This signal causes the stylus to be driven against the template and as the deflection of the stylus increases the vector signal is shifted by a bender circuit to cause the stylus to

AGALOY Tubing

You may be sure of proper surface condition ***INSIDE*** and ***OUTSIDE*** when you specify AGALOY



Small accurately drawn tubing in

- **MONEL metal**
- **INCONEL**
- **NICKEL**
- **18-8 STAINLESS**

Sizes up to and including ⅝-inch outside diameter. Welded or seamless construction.

Write for literature describing Agaloy's complete line of cold drawn Stainless, Carbon and Alloy tubing.

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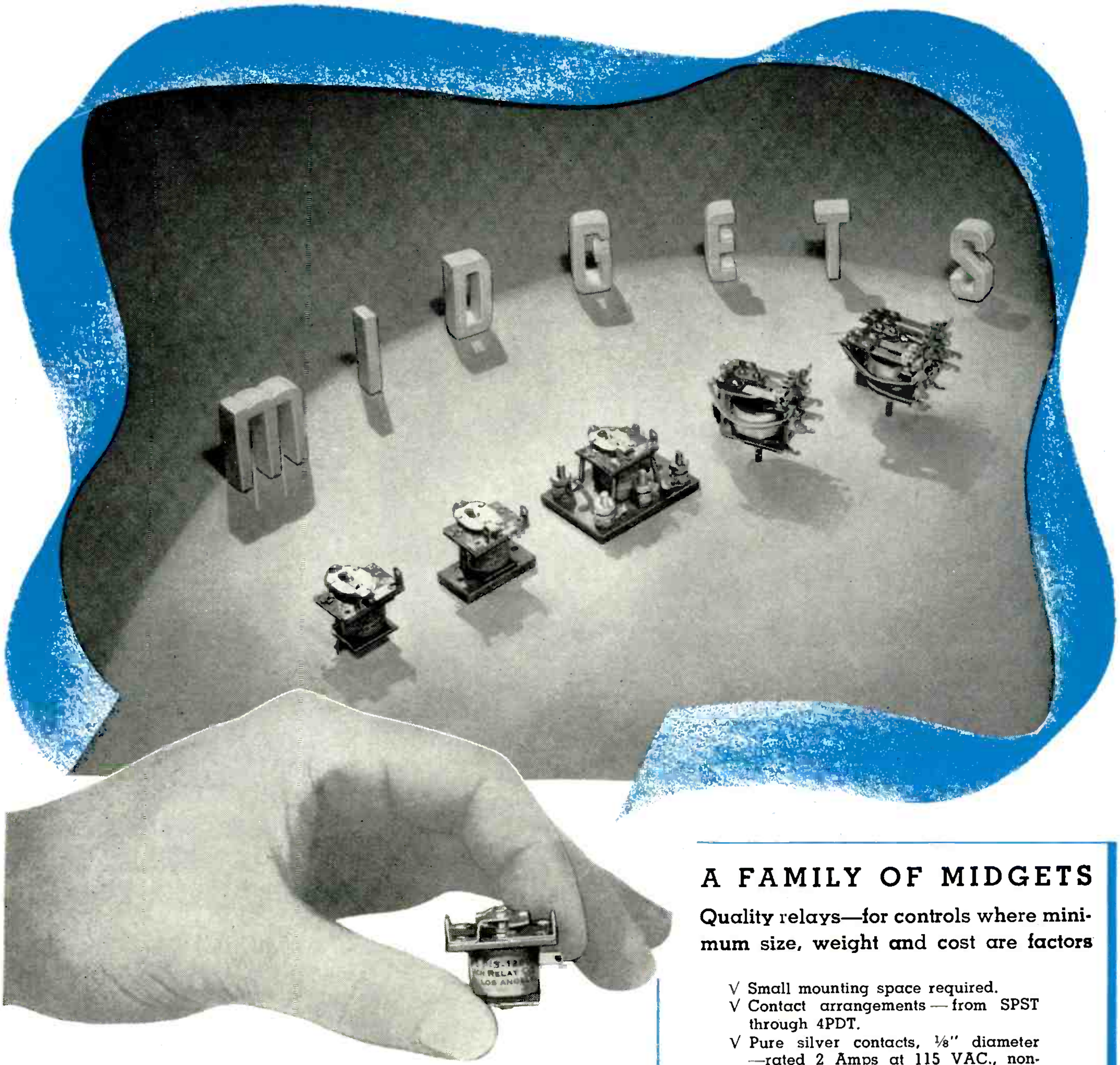
NEW YORK OFFICE: 75 WEST ST., NEW YORK 6, N. Y. • CHICAGO OFFICE: 221 NORTH LA SALLE ST., CHICAGO 1, ILLINOIS



A FAMILY OF MIDGETS

Quality relays—for controls where minimum size, weight and cost are factors

- √ Small mounting space required.
- √ Contact arrangements — from SPST through 4PDT.
- √ Pure silver contacts, 1/8" diameter —rated 2 Amps at 115 VAC., non-inductive.
- √ Available with all contacts well insulated from armature and frame.

Weighing less than two ounces—capable of handling heavy currents for their size—these miniature relays are built for long and lasting service. Thirteen different types are available now in production quantities. Standard coils consume .750 Watts, 2 to 32 VDC, or 4 V/A., 1.5 to 115 VAC. Send specifications on your planned application. Our engineers will review and recommend specific relay requirements.

LEACH RELAY CO.

5915 AVALON BOULEVARD, ★ LOS ANGELES 3, CALIF.

move along the surface of the template with a uniform deflection.

The bender circuit feeds into a translator circuit which produces two separate d-c voltages. Each voltage determines the speed of one of two feed motors. These voltages are so co-ordinated that the resultant speed of the stylus around the template is constant, regardless of the direction. When a change in contour is encountered, one motor automatically slows down or speeds up the proper amount to reproduce on the piece of work in

Graceful curves of this candlestick and aircraft supercharger were shaped by machine tools controlled by the electronic finger of the automatic contouring system developed by General Electric engineers

the machine the same contour encountered by the stylus on the pattern. If a 90-degree angle is encountered, the direction of pressure on the stylus and the direction of motion is changed by 90 degrees almost instantaneously. Both inside or outside angles can be cut.

If the stylus attempts to stray away from the template, the vector signal automatically forces the head against the pattern, insuring not only a constant degree of accuracy in pattern reproduction, but a continuous cutting operation.

Motor Control

The rapid changes in direction of machine motion are dependent on fast motor control using thyratron tubes that control motor speed and direction from the translator circuit signals almost instantaneously. Each motors can be stopped or started in less than an eighth of a second.

The speed, direction, and control

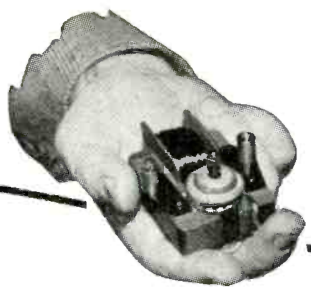
KEEP THINGS MOVING WITH alliance MOTORS

ALLIANCE MOTORS are made with centerless ground precision shafts; large, self-aligning, graphite bronze oilless-type bearings; and with adequate mounting facilities to incorporate them in any device. Shaded pole induction type motors for A.C. voltage from 24 to 250, and frequencies of 40, 50 or 60 cycles have starting torques from one-half ounce inches at 10 watts, to two ounce inches at 36 watt input. Split phase resistor type, enclosed reversible control motors for intermittent duty, with or without integral gear reduction are made for 60 cycles, 24 or 117 volts. Typical weights run from less than 13 ounces to more than two and one-half pounds.

HERE ARE JUST A FEW PLACES!

Electronic and electric controls, time, pressure, temperature, pressure and humidity controls, remote actuation controls, radio tuning and turntable drives, coin operated dispensers, fans, valves, blowers, door openers, signals, motion displays, projectors and specialized uses.

MINIATURE MOTORS THAT KEEP 'EM MOVING



With Alliance Powr-Pakt miniature electric motors you can put power right where you need it! Electronic controls and electro-mechanical devices will work faster, you cut down manual effort and increase automatic operation.

Furnished in quantity, with operating variations to meet the demands of specific jobs, Alliance Motors are built for any standard voltage or frequency. You can fit them in small places because they're small! Ratings run from less than 1-300th on up to 1-20th H.P. You can use them for continuous or intermittent duty—for starting, stopping, reversing, and for smooth, steady driving.

Remember, there's probably an Alliance motor already designed and ready to go to work for you!

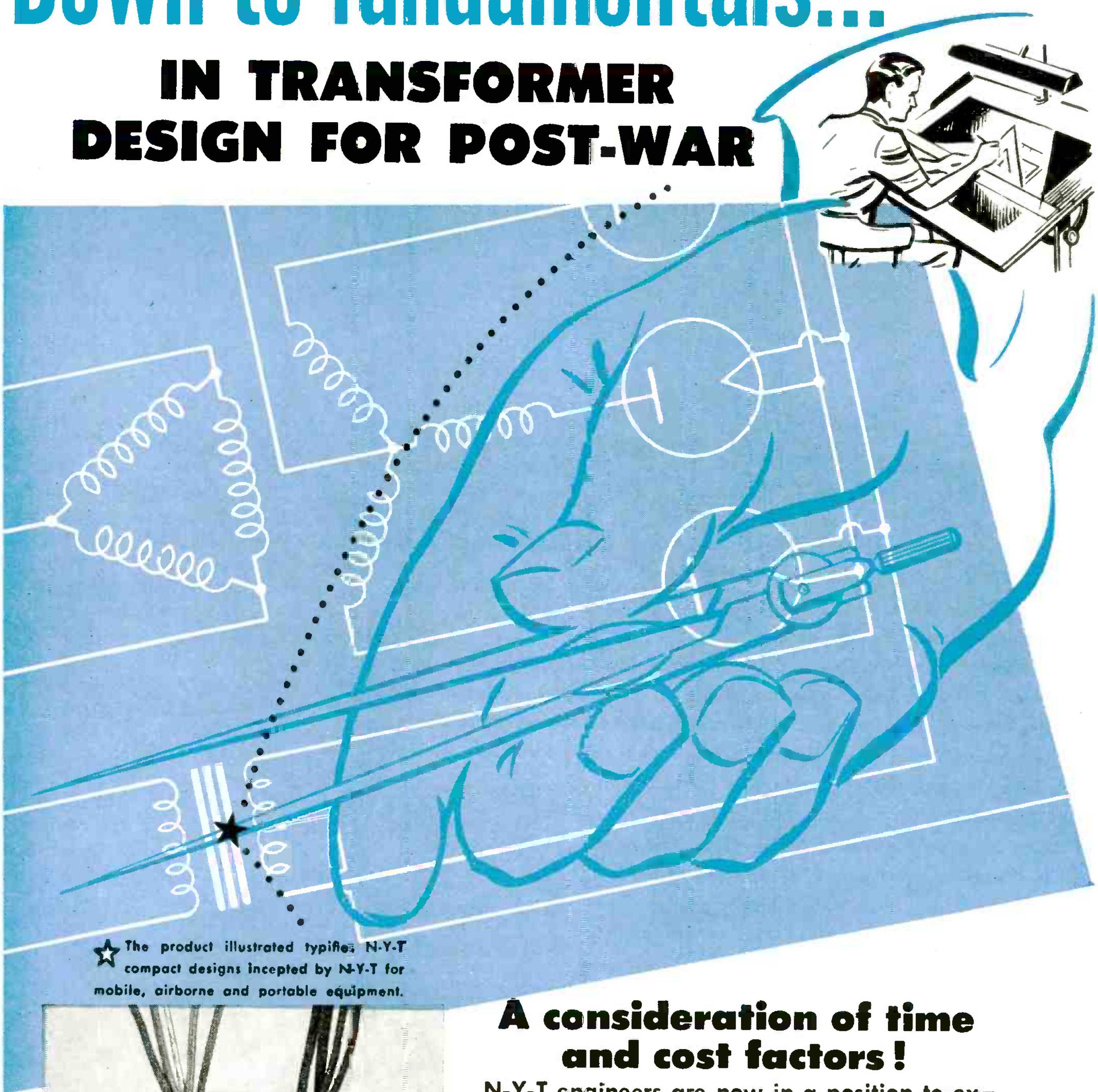
WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

ALLIANCE TOOL AND MOTOR, LTD., TORONTO 14, CANADA

Down to fundamentals...

IN TRANSFORMER DESIGN FOR POST-WAR



☆ The product illustrated typifies N-Y-T compact designs incepted by N-Y-T for mobile, airborne and portable equipment.

A consideration of time and cost factors!

N-Y-T engineers are now in a position to extend close collaboration in the solution of transformer, choke and filter problems—from blueprint to finished product. They are prepared to design special components for specific applications and produce them promptly at low unit cost. This unique service is made possible by the specialized engineering and production facilities of N-Y-T. Our engineers are available for consultation.

Address inquiries to Dept. E

NEW YORK TRANSFORMER CO
62 WILLIAMS ST., NEW YORK 5, N. Y.

of the motors is handled by the operator through a system of pushbuttons and dial controls on a master panel. There is no danger of overcutting the pattern, even manually, for when the stylus touches the pattern, the automatic control takes over and follows the template until the operator again takes control. This manual operation is particularly advantageous in following an outline pattern instead of a cutout template. The operator can then direct the tracing stylus over the drawn diagram in pencil fashion, and the motors will take care of moving the machine to follow the stylus.

The new control can be applied to many different types of metal-cutting tools and is capable of a variety of intricate cutting operations, which, if done by complete manual operation, would involve many separate directional cuts and endless gage checks.

In tests, chess men were turned from brass using the system. Five intricately contoured chess pawns were turned from the same template, each pawn with a ball at the top. Though the lathe turning of a perfect ball, alone, is considered by experienced lathe operators to be an extremely difficult operation, gage checks on the finished pawns showed less than a thousandth of an inch deviation from measurements among all five.

Machines equipped with this automatic contouring control turned out many complicated parts for jet aircraft engines and turbo-superchargers during the war.

• • •

Electronic Control of Electric Blanket

ANNOUNCED AS THE FIRST use of electronics in bed, an electrically heated and electronically controlled blanket has been introduced by the Simmons Company. The control automatically maintains the degree of warmth selected by the user and compensates for changes of body and bed temperature regardless of the room temperature.

The electronic blanket operates with a small bedside cabinet containing three electronic tubes that automatically regulate the amount of warmth in the blanket. A flexible

INSULATING MATERIALS—no matter how efficient—often are starting places for corrosion. The electrolytic action of current-carrying copper wire and moisture causes chemical decomposition, and corrosion is the result.

With LUMARITH CA (cellulose acetate) film and foil insulation such corrosion hazards are eliminated. Lumarith is inert to electrolytic action—releases no wire attacking acids.

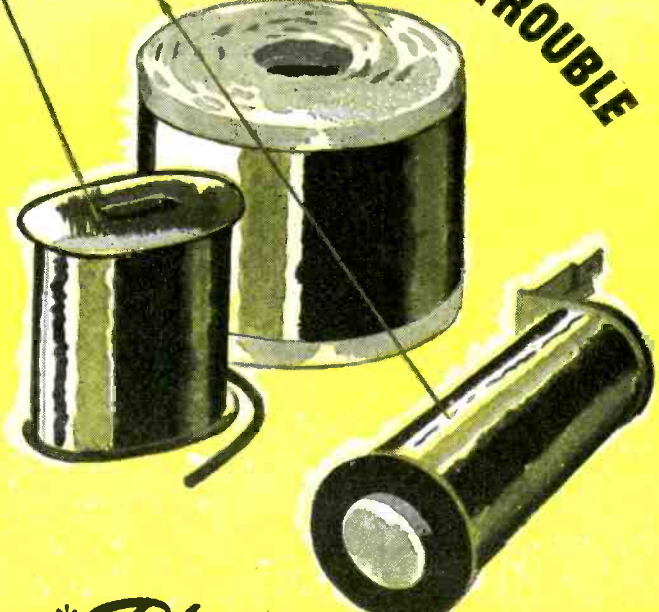
In addition, Lumarith films and foils are high in dielectric strength and arc resistance. (A.S.T.M. tests show Lumarith recovering original or greater arc resistance when conducting path is allowed to cool and arc is struck a second time.)

Lumarith CA is a Celanese plastic. It is available in sheets, rods, tubes and molding materials as well as in films and foils. Films and foils can be supplied in crystal clear transparent or with special (A-78) mat finish one side. A-78 finish increases visibility and prevents wire slippage. Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, New York.

JUST PUBLISHED

Electrical Booklet entitled "Celanese Synthetics For The Electrical Industry." Contains technical information you will need. Write for your copy today. *Reg. U. S. Pat. Off.

THE BLACK HAND IS ALWAYS LOOKING FOR TROUBLE



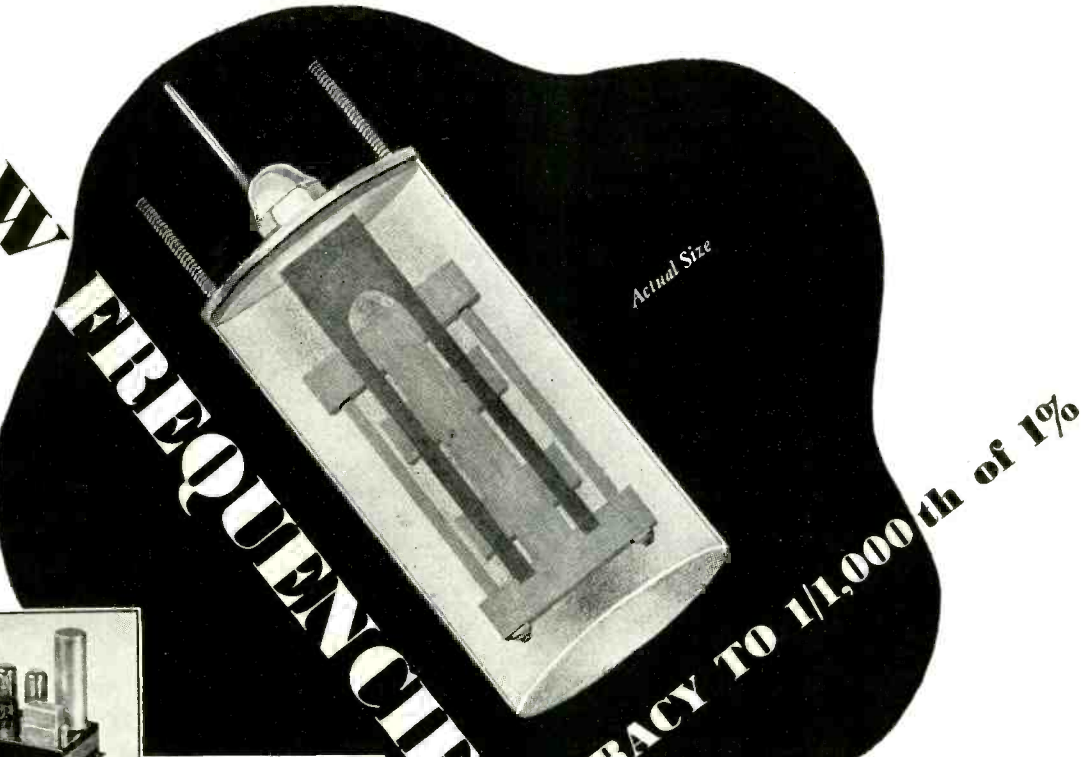
Electrical equipment Insulated with

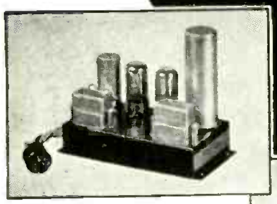
LUMARITH* CA

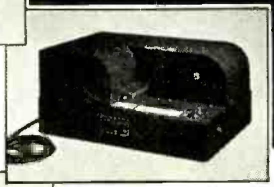
(CELLULOSE ACETATE)

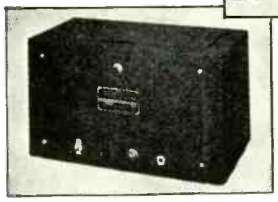
is safe against the Black Hand of electro-chemical corrosion

A Celanese* Plastic









TOP
FREQUENCY STANDARD
(60 cycle) for use with external power supply

CENTER
CHRONOGRAPH
Records time intervals with resolution to .001 second

BOTTOM
FREQUENCY STANDARD
(120 cycles) with self-contained power supply

These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.

These tuning fork assemblies are available only in single or multi-frequency instruments of our own manufacture which are designed to test, measure or control other precision equipment by mechanical, electrical accoustical or optical means.

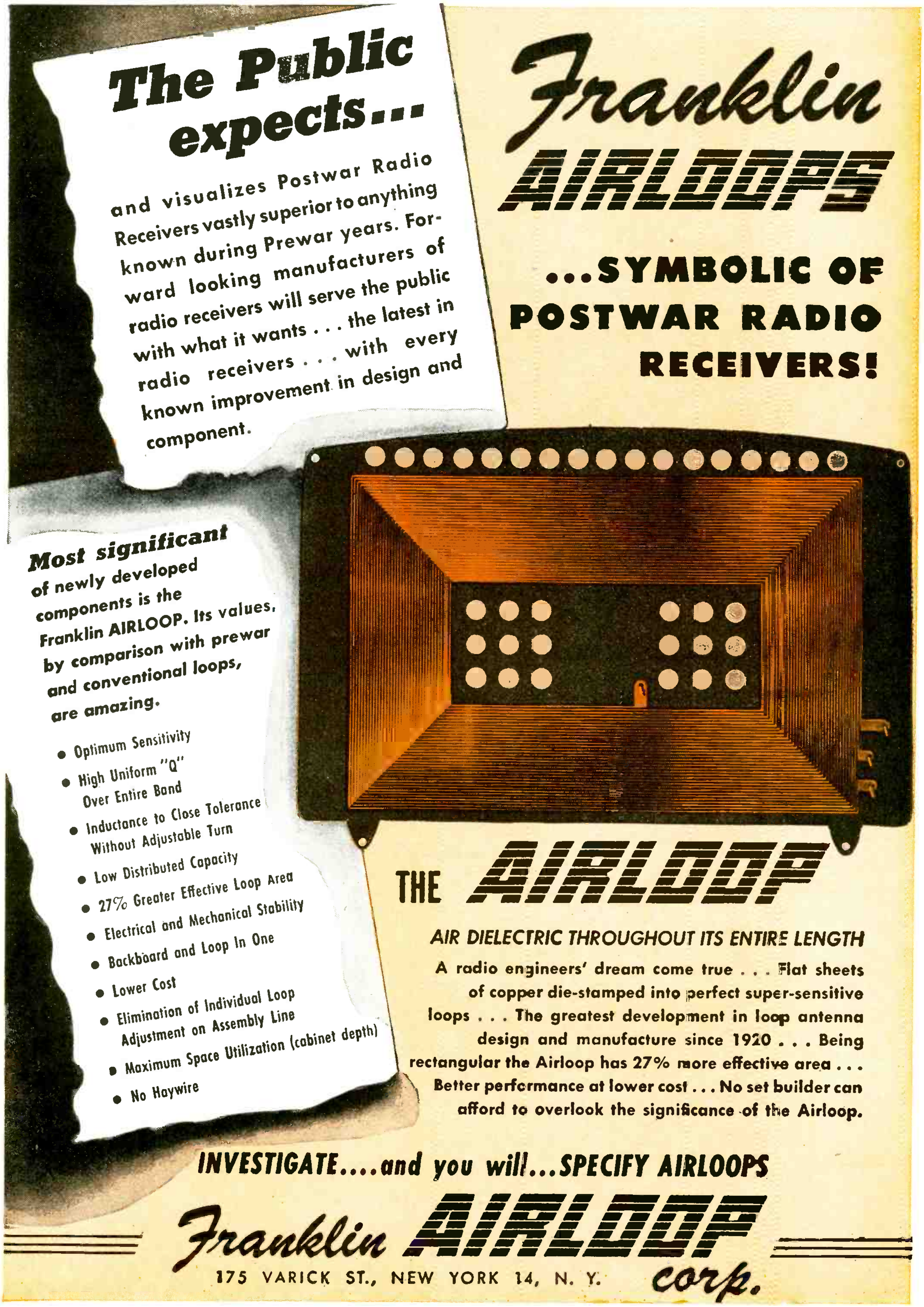
The dependability of these frequency standards is being demonstrated for myriad purposes in all climates and under all working conditions.

If you have need for low frequency standards of exceptional accuracy, your inquiries are invited.

American Time Products, Inc.

580 Fifth Ave. **New York, N. Y.**

Dist. of Western Electric & *Watch Master* Watch-rate Recorders


The Public expects...
and visualizes Postwar Radio Receivers vastly superior to anything known during Prewar years. Forward looking manufacturers of radio receivers will serve the public with what it wants . . . the latest in radio receivers . . . with every known improvement in design and component.
Franklin AIRLOOPS
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Most significant of newly developed components is the Franklin AIRLOOP. Its values, by comparison with prewar and conventional loops, are amazing.
• Optimum Sensitivity
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• Backboard and Loop In One
• Lower Cost
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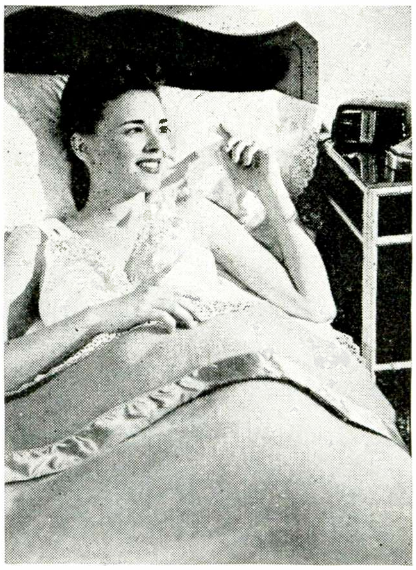
• No Haywire
THE AIRLOOP
AIR DIELECTRIC THROUGHOUT ITS ENTIRE LENGTH
A radio engineers' dream come true . . . Flat sheets of copper die-stamped into perfect super-sensitive loops . . . The greatest development in loop antenna design and manufacture since 1920 . . . Being rectangular the Airloop has 27% more effective area . . . Better performance at lower cost . . . No set builder can afford to overlook the significance of the Airloop.
INVESTIGATE....and you will...SPECIFY AIRLOOPS
Franklin AIRLOOP corp.
175 VARICK ST., NEW YORK 14, N. Y.

wire consisting of two parallel conductors runs throughout the interior of the blanket.

One of the two conductors serves as the heating element, while the other, known as a "feeler" wire of nickel alloy of high temperature coefficient, governs the degree of warmth when the blanket is in use. When the dial on the control is set at a desired temperature the feeler wire becomes



Changes in temperature of the model in bed are compensated for by electronic tubes in the plastic cabinet on the night table. A "feeler" wire, wound throughout the blanket, actuates the control and turns on and off the line current feeding the heater element in the blanket

subject to change when this temperature has been attained. The wire is conected in one arm of a Wheatstone bridge and the other arm contains the variable control used for the heat setting.

The bridge feeds one grid of a 6SL7 connected as a cascade amplifier that feeds into a 6SN7 whose sections are connected in parallel to actuate the relay controlling the heating-element circuit. A special thyratron, type 1367, provides fail-safe protection against abnormal conditions.

• • •

Electronic Bore Gage for Tubes and Pipes

CHEMICAL, PETROLEUM, metallurgical and other industries that either make or use tubes and pipes having critical requirements as to interior surface imperfections can use a

AMPLICALL

Two-Way Communication, Paging and Public Address Systems

. . . Proved during the war!

When it was necessary to save not only hours but minutes and even seconds, *AMPLICALL "came through."* Its complete day-in-and-day-out dependability, multiple uses, flexible design, trouble-free operation and tone quality make it the preferred communications system. *"AMPLICALL"* is another way of saying *"efficiency"*. . . learn how it can bring about a greater efficiency for your business.

AMPLICALL Intercommunication unit, available for two-way communication between multiple stations.

AMPLICALL Weatherproof Speaker

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AMPLICALL Audio Amplifier unit for laboratory, test equipment and general applications.

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FOR THOSE WHO SEEK

The Finest Cored Solder in the World

Ersin Multicore Solder contains 3 cores of non-corrosive Ersin Flux and provides just that extra rapidity of fluxing action which ensures a precision standard of consistently reliable solder joints. Only 3 independent cores of flux, evenly distributed across the cross-section of the solder wire, can give this extra efficiency. The cost of an individual solder joint in electronic apparatus is so little and each joint so vital that it must pay you to buy the best cored-solder—Ersin Multicore.

3 CORES OF ERSIN THE ACTIVE NON-CORROSIVE FLUX

Ersin, which is contained in the 3 cores of Multicore Solder, is a pure high grade rosin which has been subjected to a complex chemical process to increase its fluxing action to the highest degree without impairing the well known non-corrosive and protective properties of the original rosin. In effect, rosin as a flux suffices only as an agent to avoid oxidation during soldering, whereas Ersin will not only remove surface oxides, but also prevent their formation during the soldering operation. NO extra flux is required. The flux does not tend to run out of cores, so there is always a supply available for the next joint. The utmost economy of flux and solder is achieved.

ALLOYS

Five standard antimony free alloys are available. Ersin Multicore Solder is supplied in bulk quantities in any other tin-lead alloy to special order. Recently 45 tin and 55 lead alloy has been in most demand for electronic equipment. Colour coding of reels and packages makes different alloys instantly recognisable.

GAUGES

Ersin Multicore Solder is made in a wide range of gauges. Standard gauges supplied are from 10 S.W.G. - 22 S.W.G. (·128" - ·028") (3·251 - ·7109 m/ms) 13 S.W.G. (·092". 2·336 m/ms) and 16 S.W.G. (·064", 1.625 m/ms) are the most widely used sizes for the production of electronic equipment.

ERSIN MULTICORE

THE SOLDER WIRE CONTAINING *3 cores* OF NON-CORROSIVE ERSIN FLUX

MULTICORE SOLDERS LTD.

MELLIER HOUSE, ALBEMARLE STREET, LONDON, W.1, ENGLAND

Telephone: REGENT 1141 PBX 4 lines   Telegrams: DUSTICKON. WESTCENT, LONDON

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BRITISH INDUSTRIES SALES CORPORATION	SNI-DOR RADIOLECTRIC LTD.,
401 BROADWAY, NEW YORK, N.Y.13	455 CRAIG ST. WEST, MONTREAL

new electronic bore gage. Direct contact is used to measure the diameter of tube, gun and other cylindrical interiors with an accuracy of one-half of ten thousandths of an inch.

The new gage, comprising a projection rod mounted on a stabilized frame and containing a delicate, flexible point, is inserted into a bore where it checks by contact all interior surfaces. The results of the test are transmitted instantaneously to a Brown electronic precision indicator. This instrument, featuring continuous balance, picks up and indicates various imperfections, air pockets and other unwanted conditions to 0.00005 inch. The gage will be introduced by Chrome Gauge Corporation of Philadelphia.

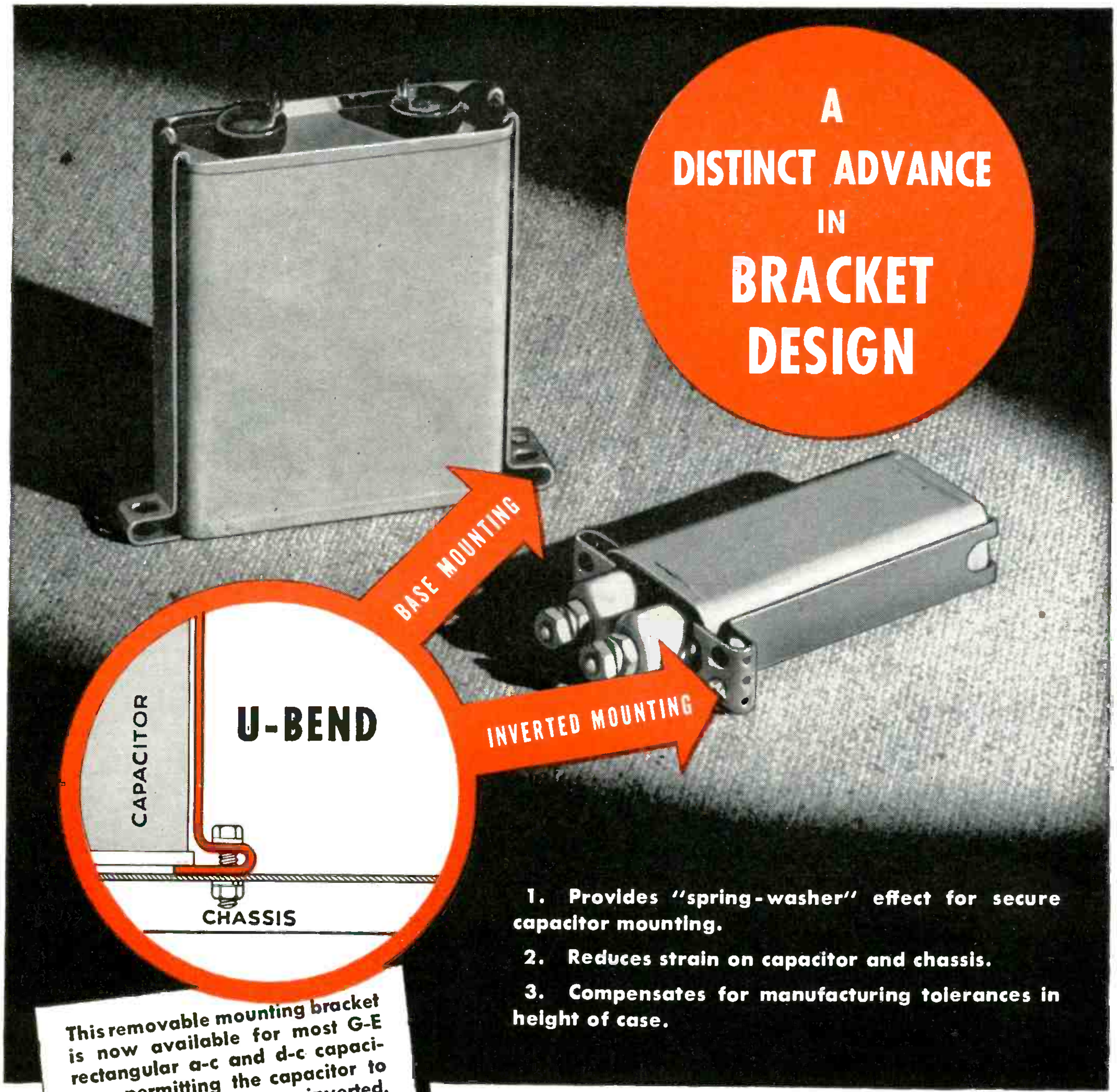
The electronic bore gage utilizes direct contact to measure cylindrical interiors with an accuracy of 0.00005 inch

• • •

Automatic Analysis of Elements in Metals

FOR USE IN METAL industries, and in any chemical process where close and constant spectroscopic control is desirable, a direct-reading spectrometer has been developed. In melting, alloying and casting of metals it will lower costs by reducing the time a melt must be kept at temperature while waiting for analytical reports. The accuracy is said to be equal or superior to that possible by spectrographic methods.

The instrument electronically measures the concentration of elements in alloys and automatically



This removable mounting bracket is now available for most G-E rectangular a-c and d-c capacitors, permitting the capacitor to be mounted upright or inverted.

In contrast with the conventional L-shaped bracket, this U-bend construction minimizes the stress on the metal chassis and prevents distortion when mounting bolts are tightened. The mounting foot is sufficiently flexible to compensate for normal tolerances in height of case, and for variations in dimensions of the bracket itself.

The brackets are sufficiently thick to provide strong, rigid support. A corrosion-resistant finish of lacquered zinc plate assures a good ground from capacitor to chassis. The brackets have either one or two mounting holes depending upon the width of the capacitor.

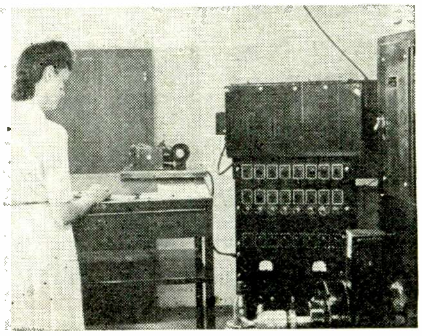
These brackets are an exclusive feature on G-E capacitors. Spade-type and L-shaped brackets can still be obtained when desired. Ask for Bulletin GEA-4357 for information on the G-E capacitors that can now be furnished with this improved feature. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

CAPACITORS

GENERAL ELECTRIC

407-96-5700

records the results. It was developed by J. L. Saunderson and coworkers at The Dow Chemical Company of Midland, Mich. and has been in use in the company's magnesium alloying plant for several months. It has been found that alloy analyses can now be made in 40 seconds, a fraction of the time required when using the standard



At Dow Chemical, girl operators use the automatically recording spectrometer to make alloy analyses in 40 seconds

spectrograph. Up to 14 elements can be determined simultaneously.

The substitution of an electronic method of measuring the intensity of spectrum lines eliminates the necessity for photographic and developing equipment and an expensive microphotometer, and avoids the errors commonly encountered due to film variation. Girl operators can be trained in one day to use the instrument efficiently since the entire operation is fully automatic from the time the metal samples are placed in the instrument until the analysis is recorded on paper.

• • •

An Electronic Bypass for Measuring Purposes

By DR. L. A. FINZI

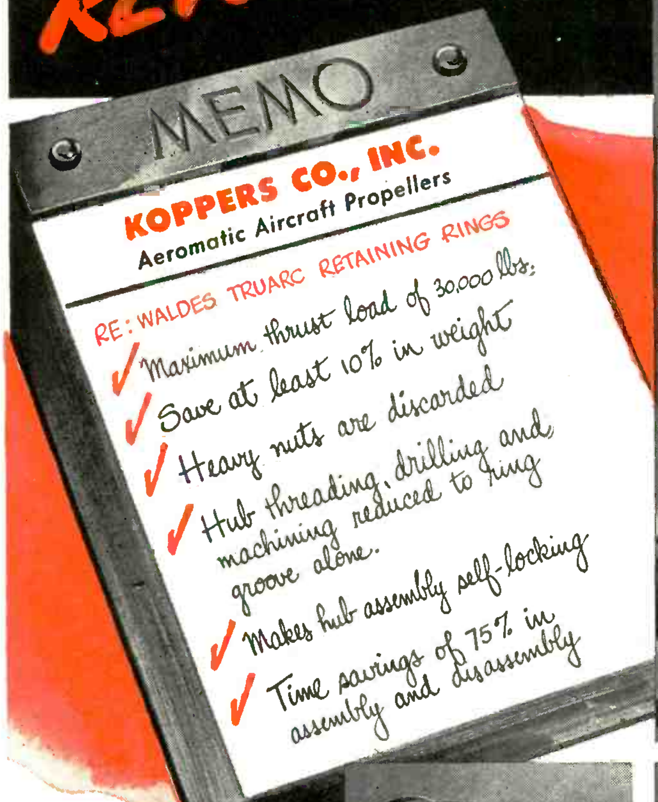
Lightning Protection Engineer
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A CIRCUIT WHICH is applicable to any measuring device in which transient overload is likely to occur during the time that measurements must be made is shown in Fig. 1.

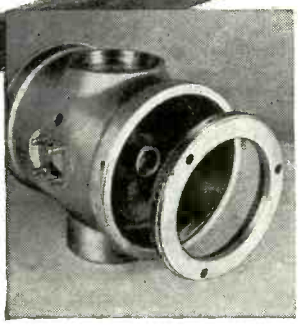
This was used in laboratory studies of lightning protective devices where it is usual practice to discharge a surge generator through test samples energized at the same

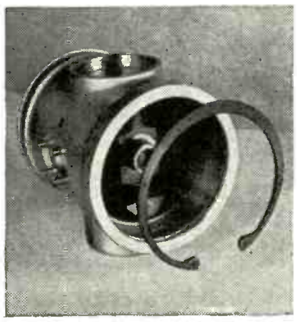
AEROMATIC AIRCRAFT

PROPELLER DESIGN REVOLUTIONIZED WITH WALDES TRUARC RETAINING RINGS



AEROMATIC AIRCRAFT PROPELLERS are standard equipment on the Rocket 185, illustrated above.





1

BEFORE TRUARC—

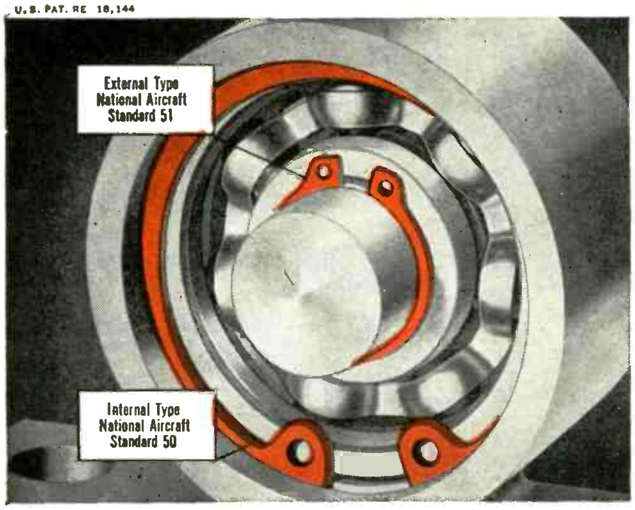
High centrifugal loads generated by whirling blades of automatic variable pitch propellers were borne by a buttress-threaded nut screwed into the hub. This meant expensive machining, extra weight.

2

AFTER TRUARC—

Elimination of conventional nut greatly reduced weight—cut machining time and cost 75%—made over all maintenance easier. Truarc retention strength against tons of centrifugal force is 3 times greater than operating load.

U. S. PAT. RE 18,144



Waldes Truarc Retaining Rings are used to save weight, space, cost and time in a wide range of products. For holding and positioning machine parts they offer definite advantages over nuts, shoulders, collars and pins. They simplify and speed up production. They can be put on and taken off again and again—and still retain the perfect circularity which gives them their never-failing grip. Test them yourself. We'll furnish samples and complete data. Write Dept. H-2.

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CANADIAN REPRESENTATIVES: PRENCO PROGRESS CORP., LTD., 72-74 STAFFORD ST., TORONTO time by a large power transformer. Such tests simulate actual field conditions and are of interest in determining whether the device is able to quench the 60-cycle current which tries to flow to ground in the path opened by lightning, and whether this quenching action is rapid enough to prevent disturbances in the power system after the stroke.

The artificial lightning current, though of very short duration, may reach many thousand amperes while the subsequent 60-cycle power currents are sometimes as low as a few amperes. This makes it difficult to adjust the sensitivity of the current element of the magnetic oscillograph, so that the loop mirror will not be knocked out by the impact of the initial stroke, and yet record appreciable deflections for the power current.

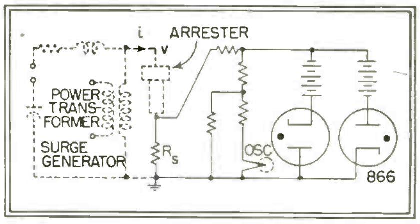


FIG. 1—Electronic by-pass circuit for protection of oscillograph. Dotted lines indicate connections to associated test apparatus

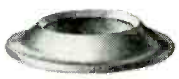
A practical solution is offered by the use of the circuit of Fig. 1. Through simple adjustments of the various resistances and of the battery voltages, either one of the 866 mercury vapor tubes—depending on the polarity of the surge stroke—becomes conducting shortly before the voltage across the measuring shunt R_s reaches any value dangerous for the oscillograph element. The voltages in the circuit are then controlled by the voltage drop of the tube. The tube discharge may be initiated in time short enough to provide sufficient protection, even if the surge current rises towards its crest in only a few microseconds. On the other hand, the tube ceases to conduct and its controlling action is removed from the measuring circuit as soon as the shunt voltage decreases again to values for which a normal recording operation is possible without damage to the instrument.

Figure 2 shows how the by-pass

NEW INSTALLATION METHOD FOR DZUS* FASTENER STUDS CUTS ASSEMBLY TIME 50%

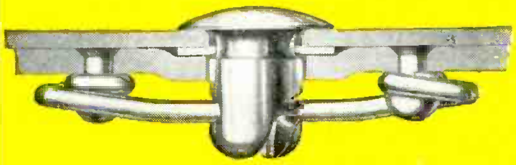
Stud

Detachable part



Grommet

Stud Assembly



Cut-away view of complete Dzus assembly

Shown above are the component parts and steps in the assembly of the Dzus spiral cam fastener, using the newly designed grommet.

A newly developed Dzus grommet slashes installation procedure about 50%. This speeds up the assembly of Dzus fasteners for mass production operations.

This is the way it works. Dzus fastener studs are placed in the holes drilled or punched in the material to be fastened. The grommet is then slipped over the end of the fastener stud and flattened with a single tool. **All types of Dzus fasteners may be installed in this manner.**

If you have a fastening problem on a hinged or removable part, let a Dzus engineer help you. There is a Dzus fastener to meet every requirement.

*The word Dzus is the registered trade mark of the Dzus Fastener Co., Inc.

DZUS FASTENER CO., INC.

BABYLON • NEW YORK

IN CANADA: RAILWAY AND POWER ENGINEERING CORP., LTD.

intervenes in a test in which power currents with a maximum value of about 32 amperes follow in the path opened by a surge reaching its crest in about seven microseconds and decaying to half of the crest value in about 20 more microseconds. It

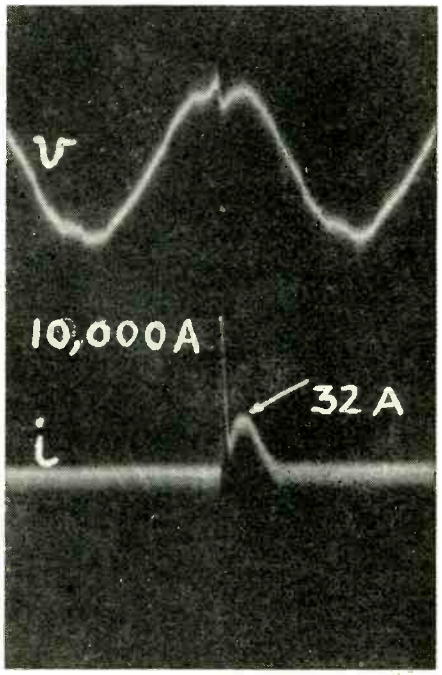
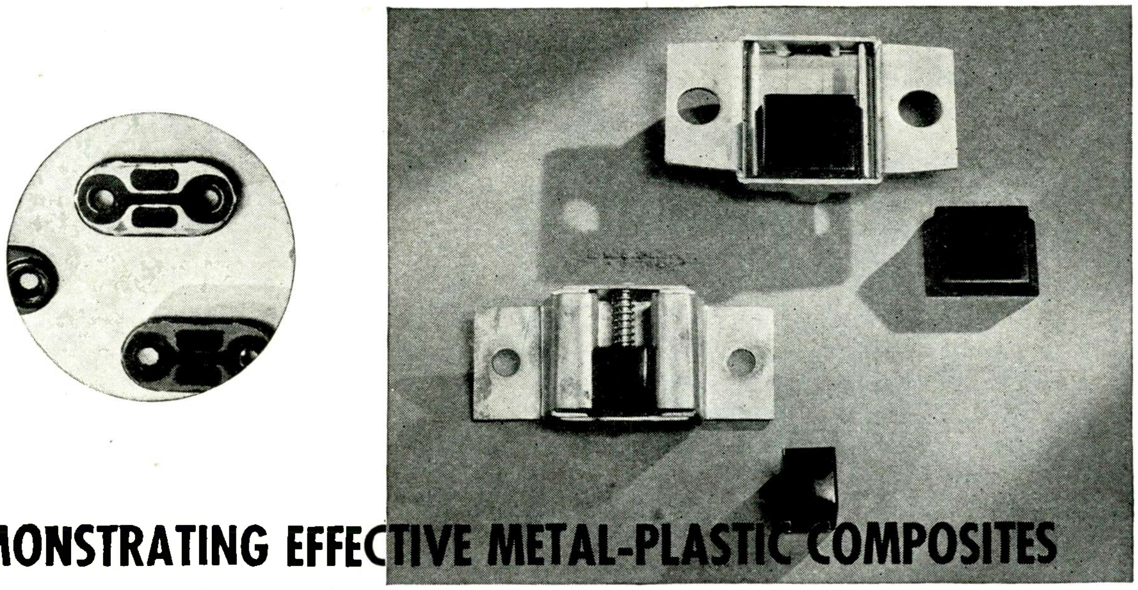


FIG. 2—Oscillogram showing operation of protective circuit during a test in which an arrester successfully interrupts power follow current

should be noticed that no significant record of the surge can be obtained by the use of the magnetic oscillograph, which is much too slow for such high speed transients; thus limitation of the initial impact, while preventing any possible damage to the oscillograph, does not actually deprive the record of any valuable indication.

In Fig. 3 the by-pass becomes useful in a different way. In this test the arrester is not able to quench the power current, which reaches many hundred amperes and flows to ground through the shunt R_S. The by-pass then intervenes once more, limiting the deflection of the oscillograph element during the time in which the power current is too high and re-establishes the normal instrument operation when the current decreases to less dangerous values.

The circuit described is simple, yet it is of interest in a number of cases in which there is need for quick-acting protection of sensitive



DEMONSTRATING EFFECTIVE METAL-PLASTIC COMPOSITES

The slamming of a door, particularly a truck door, puts a terrific strain on the materials which must stand the impact of this sharp contact. The contact wedges and take-up units illustrated are especially designed for this purpose and serve as an excellent example of the effectiveness of a metal-plastic composite.

Why Plastics?

Both the sliding wedges and the contact members were originally made from either die-cast metal or graphite-impregnated bronze. There are, however, a number of very definite advantages gained by molding the pieces of plastic. For one thing, the danger of corrosion is completely eliminated. Furthermore, wear is reduced considerably, for neither the metal nor the plastic tends to wear the other. Then there is the added feature that no finishing operations are necessary with the plastic pieces other than the removal of a slight flash or fin.

Why Phenolic Plastics?

Because of the wide range of desirable properties which are inherent characteristics of all phenolic plastics, one from this group was selected to do the job required of these take-up units. Impact strength, for example, was a prime requisite because both the sliding wedges and the contact members are subjected to terrific strain when the door is slammed. Then there is the lubrication problem. This is automatically taken care of by the inclusion of graphite as a filler material in the phenolic used. This provides self-lubrication. Noise is also reduced, for one of the unusual properties of phenolic plastics is non-reverberation.

Why Durez Phenolic Plastics?

As specialists in the development and production of phenolic plastics for the past quarter century, Durez laboratory technicians have gained the rich background necessary for maintaining the leadership of the more than 300 multi-propertied Durez phenolic molding compounds available today. Manufacturers in every field of industry are making it their practice to look to Durez phenolics for the plastics that fit their jobs.

Valuable Assistance Available

Our technicians can give you a number of examples of effective metal-plastic composites . . . examples which decisively prove that these two basic materials can be combined to make a better product . . . combined to do a job more efficiently than could either of the materials used alone.

The competent advice of experienced Durez service engineers and a wealth of proved product development data are available at all times to you and your custom molder. Durez Plastics & Chemicals, Inc., 82 Walck Road, North Tonawanda, N. Y. *Export Agents: Omni Products Corporation, 40 East 34th Street, New York 16, N. Y.*

DUREZ

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MOLDING COMPOUNDS

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PLASTICS THAT FIT THE JOB

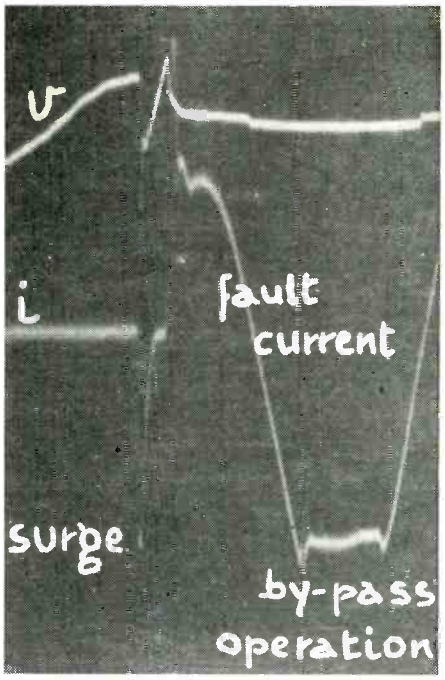
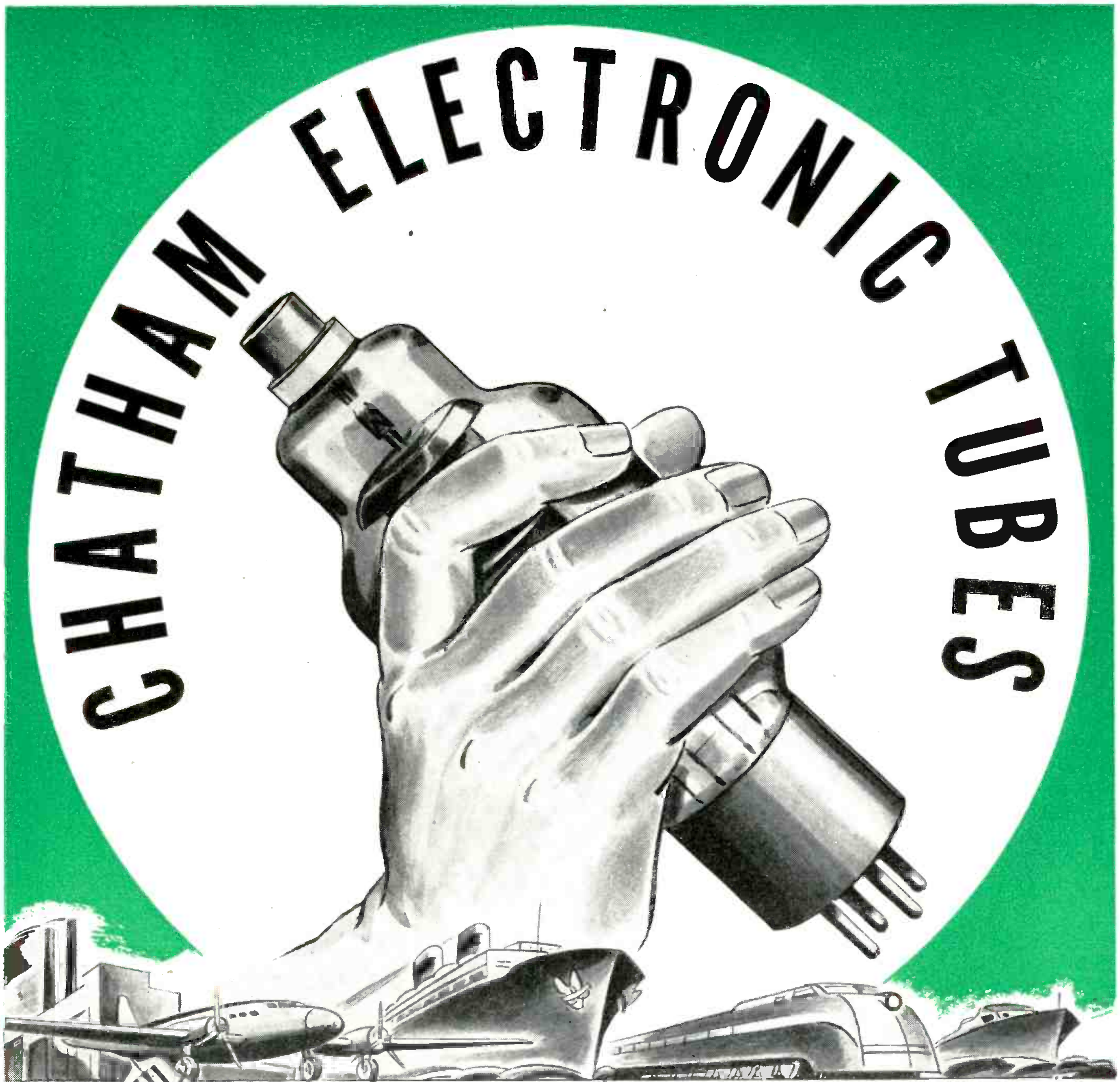


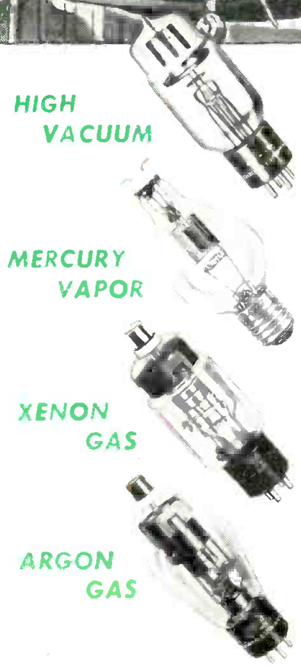
FIG. 3—Operation of circuit during test in which arrester fails to interrupt power follow current

measuring instruments against surges or overloads where it is necessary to restore the normal instrument operation as soon as the current to be measured falls back within the limits of the instrument range.

WAC IN MAN'S JOB

In this AACS control tower at an Army base, the WAC signals a plane with a light-gun suspended from the ceiling, or by radio with the microphone on the console. Night lighting controls are under her left arm, and on her right, five radio receivers standby on five frequencies. A frequency meter on top of the receiver rack permits accurate returning of the receivers after adjustment to pick up aircraft calling slightly off frequency


CHATHAM ELECTRONIC TUBES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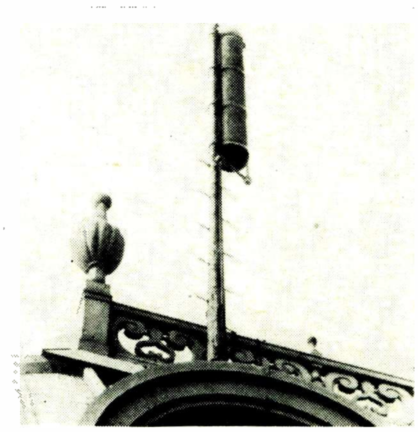
TUBES AT WORK

New Antenna Type for F-M and Facsimile

A SINGLE-UNIT antenna that has gain over a half wave has been installed atop a New York City building for f-m facsimile station WGHF, owned by Captain W. G. H. Finch. The gain is obtained by using a bent metal sheet along which the wavelength is longer than the wavelength in space so that the radiation comes from a long vertical column. This results in a concentration of radiation toward the horizon where it is desired, with less power being radiated into the sky and the area immediately adjacent to the antenna.

As the illustration shows, the new antenna resembles a skyrocket. It was designed by Dr. Andrew Alford, past chairman of the antenna committee of IRE. The tip of the mast is about 700 feet above sea level and the antenna is expected to adequately cover about 6,840 square miles of territory over a radius of 50 miles from New York. Only one seal insulator is used on the antenna because the input impedance is relatively low so that the insulation is not subjected to high voltages.



Skyrocket antenna installation for station WGHF for transmission of f-m and facsimile signals

When the station is placed in operation, both canned and live musical programs will be transmitted by f-m from studios on the top floor of the building. It is planned to transmit every hour a five-minute facsimile broadcast that will consist of five sheets of news on paper about 8½ by 11 inches in size. As the number of home models of facsimile receiving equipment in use increases, it is planned to devote longer periods of time to such broadcasts .

The installation of the station was planned before our entrance into the war but construction was delayed until Capt. Finch returned from his duties as head of Radio Counter Measures; Research and Design of the Electronics Division of the Bureau of Ships.

New Modulation Tube for Frequency Modulation

ALL NEW GENERAL ELECTRIC f-m transmitters employ a recently developed modulator tube called a Phasitron that makes possible the introduction of comparatively wide phase excursions at audio rates in a crystal-controlled r-f carrier voltage. The audio response characteristic of the circuit is such that the output of the tube is wide-swing frequency modulation.

A schematic block diagram of a typical transmitter using the new tube is shown in Fig. 1. With this circuit and tube, transmitter maintenance is said to be simplified and fewer tubes and simpler circuits are used than in prewar f-m transmitters. Direct crystal control is done using a single crystal, modulation is independent of frequency control, and better frequency stability is provided.

The structure of the Phasitron is shown in Fig. 2 and the electrodes are arranged as shown in simplified form in Fig. 3. Anodes 1 and 2 are at positive d-c potential and attract electrons from the cathode. Two focus electrodes form these electrons into a tapered, thin edge disc. This disc with the cathode for its axis lies between the neutral plane and the deflector grid structure and extends out to anode 1.

The deflector grid consists of 36 separate grid wires lettered *A*, *B*, and *C* in Fig. 3. All of the *A* wires are connected together, all of the *B* wires are connected together and all of the *C* wires are connected together. An expanded view of this grid structure and the neutral plane is shown in Fig. 4.

The output of a crystal-controlled oscillator (crystal frequency = car-

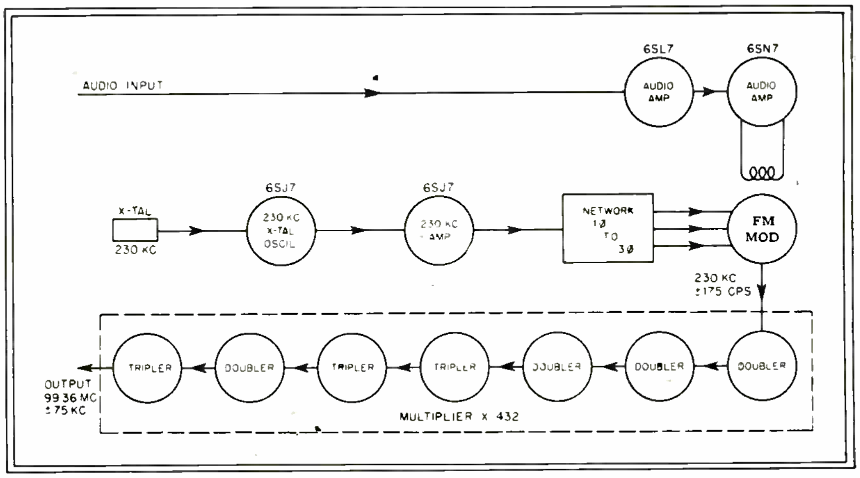
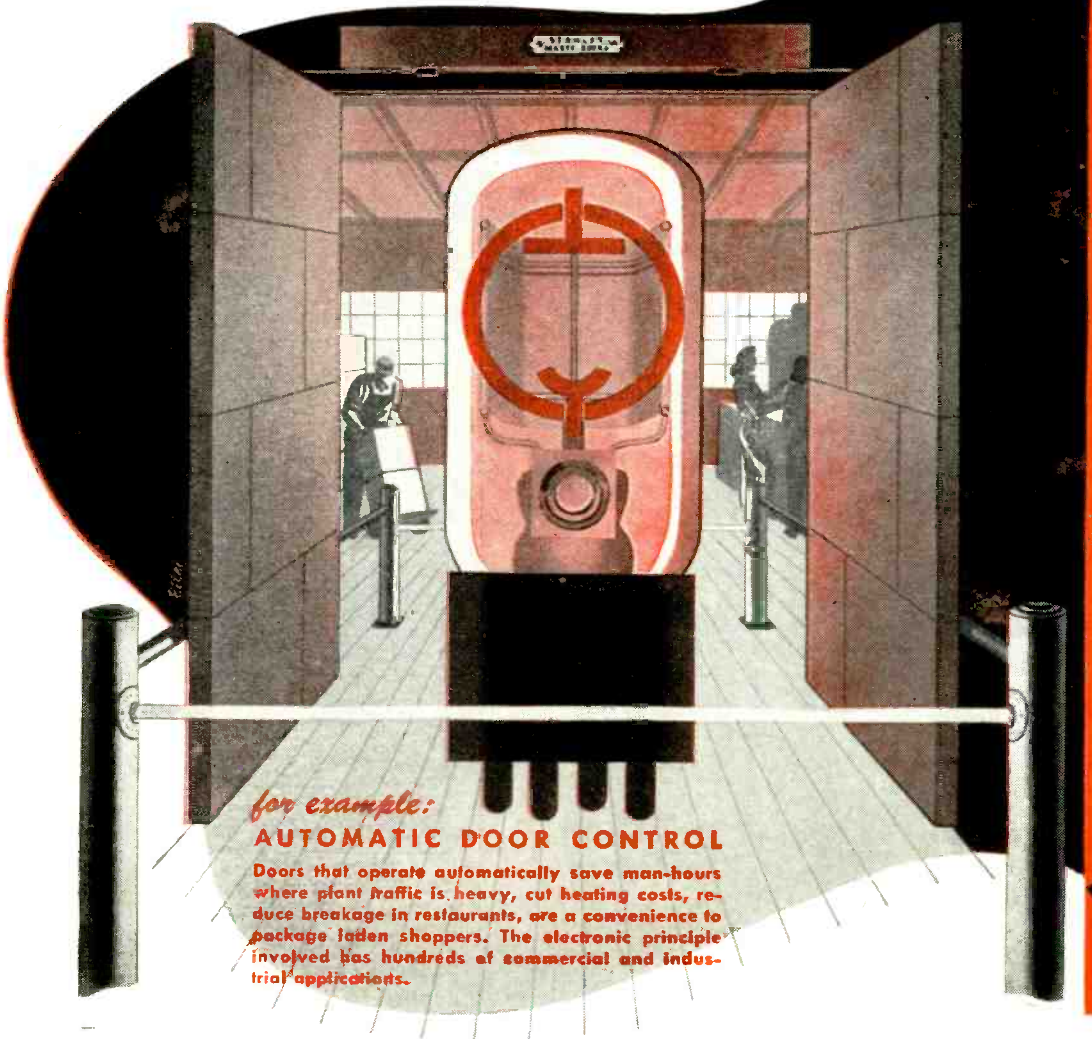


Fig. 1—Block diagram of the exciter unit of an f-m transmitter using the Phasitron tube

wherever a tube is used...



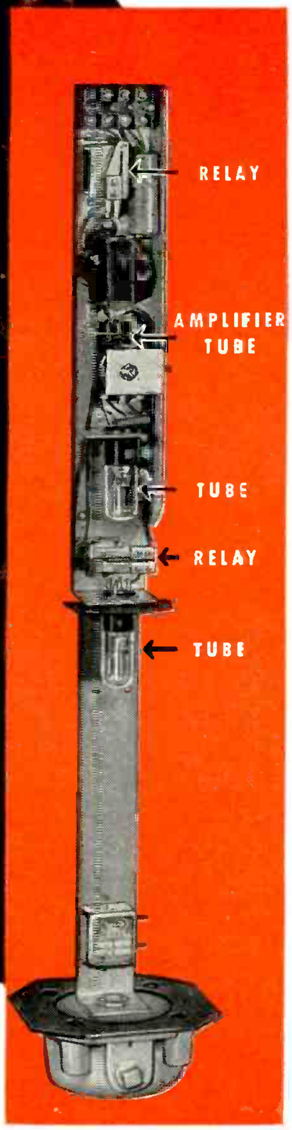


PHOTO-ELECTRIC DOOR CONTROL
Above unit manufactured by General Electric Co., is a part of STANLEY "MAGIC DOOR" CONTROLS.

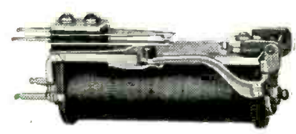
THERE'S A JOB FOR

Relays BY GUARDIAN

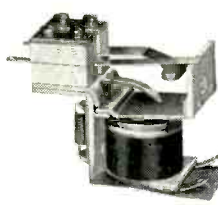
★ The "Magic Door" made by The Stanley Works of New Britain, Conn., uses a General Electric control unit which operates automatically at the approach of a pedestrian or vehicle. In this unit a beam of light focused on the cathode of a phototube causes a tiny current to flow. Enlarged through an amplifier tube this current operates a sensitive telephone type of relay such as the Guardian Series 405. Another phototube with an auxiliary relay, Guardian Series R-100, is employed to hold the doors open for anyone standing within the doorway.

The telephone type of relay is extremely sensitive and able to operate on the small current supplied through the electronic circuit. The auxiliary relay, Series R-100, is required to handle a greater current. It is a small, efficient relay having a contact capacity up to 1 KW at frequencies up to and including 28 megacycles. Contact combinations range up to double pole, double throw. Standard coils operate on 110 volts, 60 cycles, and draw approximately 7 V. A. Coils for other voltages are available. For further information write for Bulletin R-6.

Consult Guardian whenever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.



Series 405 Telephone Type Relay



Series R-100 H. F. Relay

GUARDIAN G ELECTRIC

1625-B W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY rier frequency ÷ 432) is amplified and fed into a phase-splitting network which converts the single-phase radio-frequency voltage to three

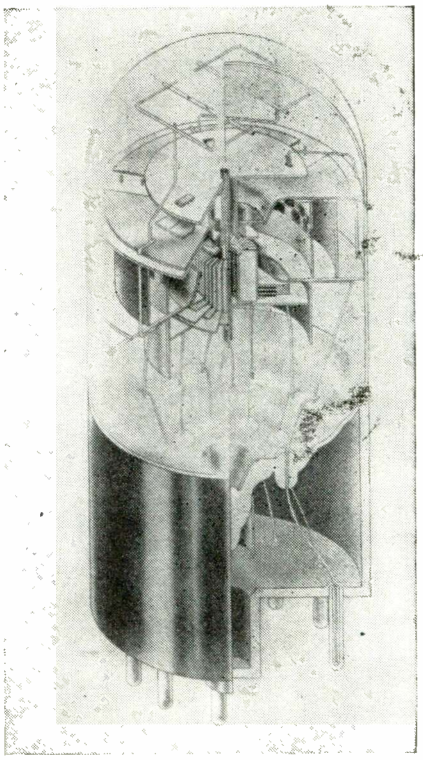


Fig. 2—Mounting of the electrodes in the phasitron

phase. This three-phase voltage is applied to the deflector grid as shown in Fig. 4. Phase A connects to the grid wires marked *A*, phase B to the *B* wires, and phase C to the *C* wires.

Theory of Operation

Figure 4 shows the deflecting action on the disc of electrons passing between the deflector grid and the neutral plane. At instant 1, grid

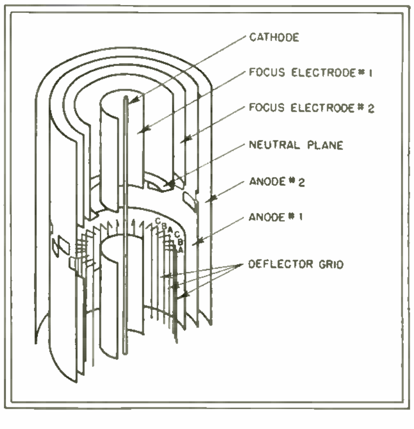
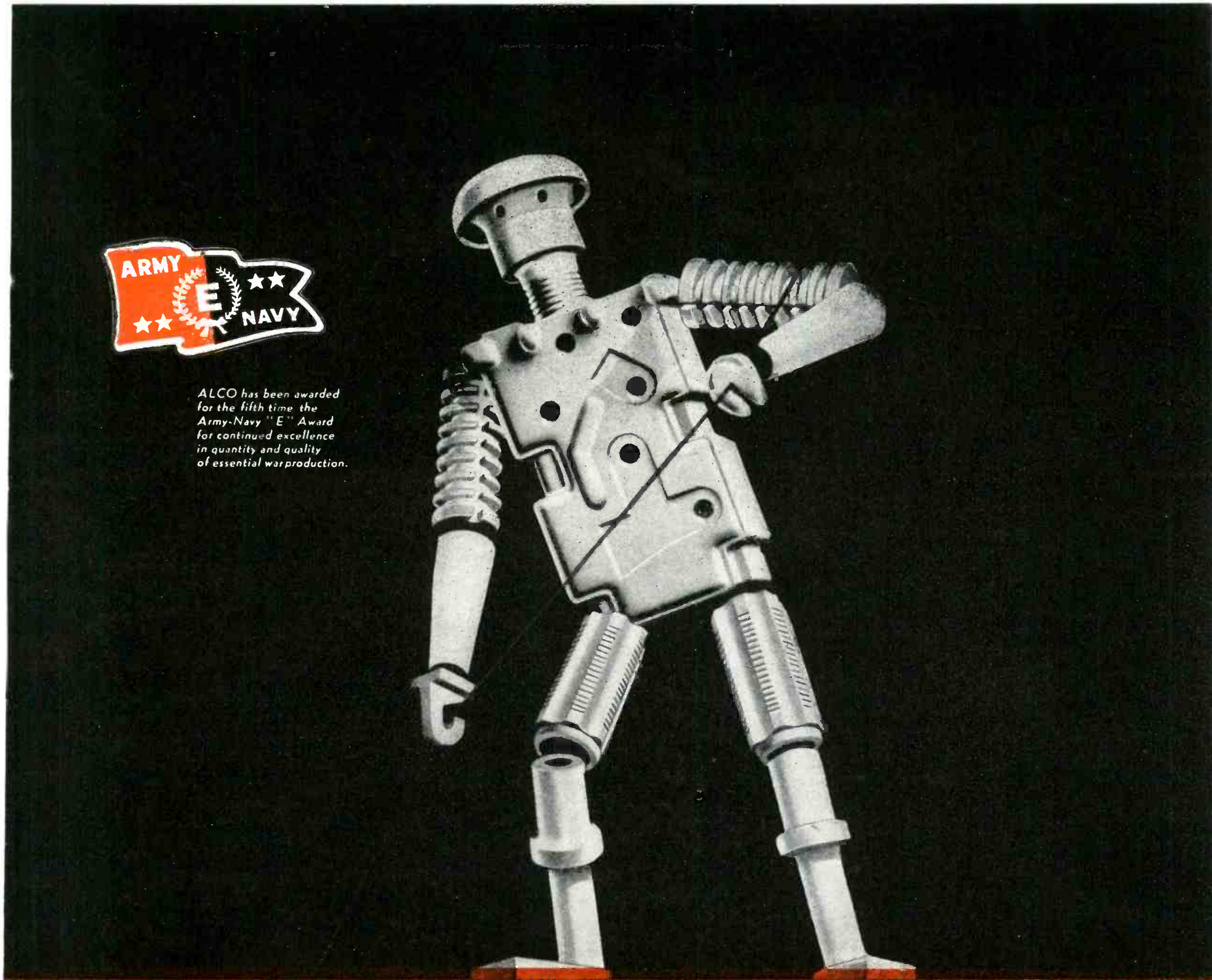


Fig. 3—Placement of electrodes. The deflector grid contains 36 separate wires



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MANY of the brilliant advances in electronics made during the war, including extensive use of ALSIMAG Steatite Ceramics in radio, radar, communications, controls and high frequency heating, will be carried forward into peace-time products of *quality.*

Of prime importance to the efficiency and stability of high frequency circuits is insulation whose composition and strength is master of both power and heat.

Permanent in their hardness, strength and rigidity, ALSIMAG Steatite Ceramic Insulators are not subject to distortion, warping or shrinking.

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CERAMICS

wires A are positive with respect to the neutral plane while grid wires B and C are negative. This results in deflection of the electron disc as shown in Fig. 4. Shown in perspec-

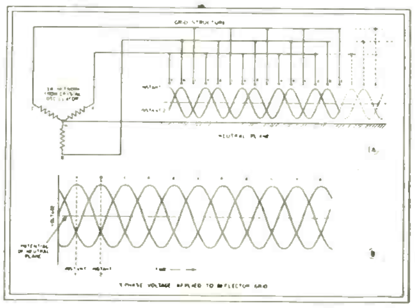

Fig. 4—Deflecting action of the grid wires on the disc of electrons

tive the disc would appear as in Fig. 5. At instant 2, one-third of a cycle later, grid wires B are positive and wires A and C are negative. The resulting deflection would be as shown at instant 2, Fig. 4. The serrated edge of the disc would appear to have moved the space of one grid wire during the time interval between instant 1 and instant 2. With the three-phase voltage applied to the deflector, the disc shown in Fig. 5 appears to be rotating.

Figure 6 shows a developed view of a portion of anode 1. This anode has 24 holes punched in it, twelve above the plane of the electron disc and twelve below. The rotating serrated edge of the electron disc impinges on this series of holes. At an instant when the disc edge is lined up as shown by the solid line in Fig. 6, most of the electrons pass on through to anode 2. Half a cycle later, the edge of the disc has moved on to the position shown by the dotted line in Fig. 5. At this instant, few, if any, electrons get through to anode 2. Thus, the current flowing to anode 2 varies sinusoidally at the crystal frequency and any variation in the angular velocity of rotation of the electron disc will result in phase and frequency variation in this output current.

Method of Modulation

A coil is placed around the tube so that its magnetic field is perpendicular to the plane of the electron disc. The electrons travelling radially out from the cathode toward the anodes through this field have a force exerted on them in a direction

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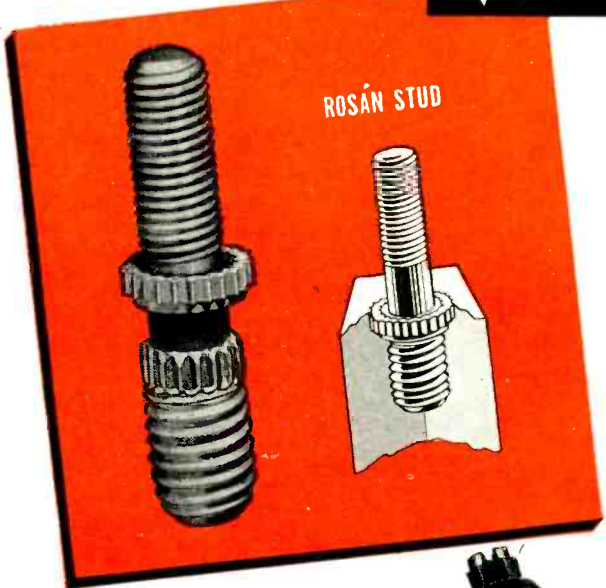

Rosán INSERTS AND STUDS STAY TIGHT

The tendency of fastenings to work loose under vibration or torque is overcome by the Rosán Locking System for inserts and studs, now made by National Screw & Mfg. Co.

Rosán Fasteners may be molded in, or easily installed in plastic parts after forming. The entire design is based on a simple serrated ring which locks either an insert or stud in position, and so prevents loosening or turning by any stresses on the connecting unit.

Securely locked in place, a Rosán Fastener gives a long wearing, high strength tapped hole or a firmly anchored projecting stud. It can be removed by drilling without disturbing the parent material.

Send for samples and full information on these revolutionary new fasteners, already adopted by leading aircraft companies and other industries.

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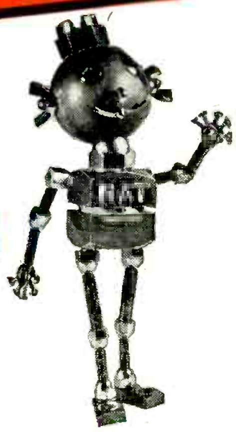

THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

perpendicular to their path and perpendicular to the direction of the magnetic field. Thus, an angular displacement is introduced in the rotation of the electron disc, causing phase shift in the output current as explained above.

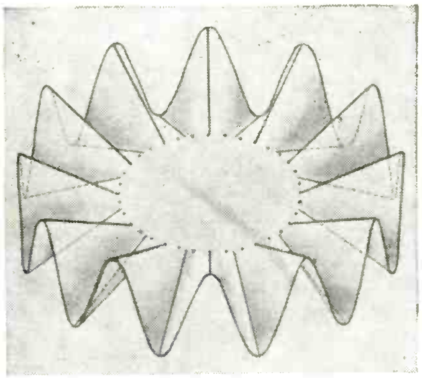

Fig. 5—Appearance of the electron disc if it were made visible

Audio-frequency current flowing in this coil causes audio-frequency angular displacements to be superimposed on the rotation of the electron disc. Thus, we obtain audio-frequency phase shifts in the output current (anode 2 current). This current flowing through a load impedance develops a phase-modulated radio-frequency voltage whose average frequency is that of the crystal.

If a d-c voltage is applied to the coil, the magnetic field set up introduces a fixed angular displacement in the rotation of the electron disc, which then continues rotating at the same rate. Therefore, we have direct crystal-controlled phase modulation.

Analogy

The modulation-induced angular phase displacement of the rotating electron disc can be compared with a similar action which is characteristic of a rotating synchronous machine. At no load, the synchronous machine rotor is aligned with the three-phase rotating magnetic field of the stationary armature winding. However, the external application of load results in a displacement of this alignment in direction and amount determined by the load. Nevertheless, for any normal load the steady-state rotor speed remains constant.

The modulation coil is driven by a push-pull voltage amplifier tube. That is, the amplitude of the audio

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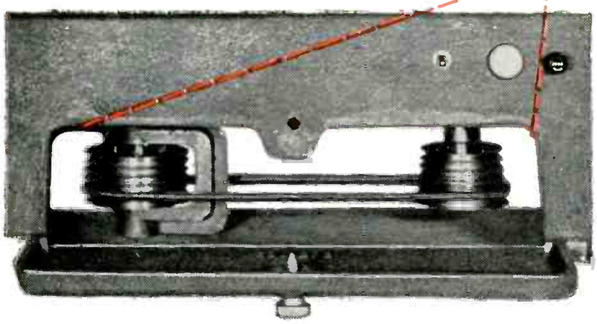

The belt on step pulleys slips instantly to any position to set cutting pitch at 96-104-112-120-128 or 136 lines per inch. Other pitches available on special order.

PRESTO'S newest *turntable* . . . for highest quality master or instantaneous recordings. The 8-D features instantaneous change of cutting pitch. An improved cutting head provides higher modulation level, more uniform frequency response and retains its calibration under all normal temperature conditions.

The heavy cast-iron turntable and mounting base insure exceptionally low background noise. Adjustable feet permit accurate leveling on bench or stand at a height to suit the operator.

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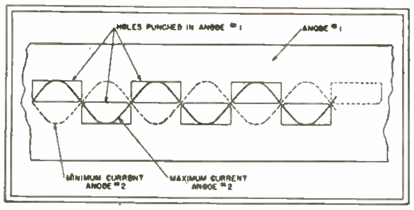

Fig. 6—Arrangement of the 24 holes punched in anode 1

voltage across the coil is constant with varying audio frequency. This means that the current flowing through the coil decreases with increasing audio frequency because the coil is almost a pure inductance over the audio range. The magnetic field strength, and thus the phase swing of the output current, therefore decreases (6 db per octave) with increasing modulation frequency, effectively providing frequency modulation.

The tube was proposed originally by Dr. Robert Adler of Zenith Radio Corporation of Chicago, Illinois. In the development of the tube and circuit, basic ideas were contributed by Dr. F. M. Bailey and Mr. H. P. Thomas of General Electric's electronics department.

• • •

Static D-F Reveals Storm Location

A DIRECTION FINDER that gives the location of distant storm centers has been announced by the War Department. Major General Harry C. Ingles, Chief Signal Officer of the Army, lifting secrecy restrictions that had limited disclosure of information on the equipment, explained that the system "has formed the basis for a new field of meteorology known as spherics, a contraction of atmospherics."

The spherics detector consists essentially of two stationary loop receiving antennas at right angles to each other; an amplifying system; and an oscilloscope. The amplified static impulses are applied to the plates of cathode-ray tube to form corresponding flashes on its screen.

The position of the flash indicates the direction of the static source, and the circumference of the face is calibrated to facilitate determination of the compass direction. When the precise direction of the static

AMPHENOL *Leads*

with a new TWIN-LEAD TRANSMISSION LINE

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Tops in Weather Resistance

ELECTRICAL DATA

Amphenol "Twin-Lead" Transmission Line is available in 300 ohm impedance value. RMA standardized on 300-ohm lead-in line for Television as the most efficient over broadband operation.

Amphenol also supplies 150 ohm twin-lead to those interested in particular applications and experimental work.

Designed especially for amateurs who operate in very narrow bands of frequency or one particular frequency. Ideal for dipoles with a nominal impedance of 72 ohms at the frequency for which they are cut.

Dielectric constant of Polyethylene—2.29. Capacities (mmf per ft.): "300"—5.8; "150"—10; "75"—19.

Velocity of propagation (approx.): "300"—82%; "150"—77%; "75"—69%

Power factor of Polyethylene—up to 1000 Mc—.0003 to .00045. Attenuation—FM and Television Band.

Megacycles	300-ohm DB per 100 Ft.	150-ohm DB per 100 Ft.	75-ohm DB per 100 Ft.
25	0.77	0.9	1.7
30	0.88	1.03	2.0
40	1.1	1.3	2.5
60	1.45	1.8	3.4
80	1.8	2.25	4.3
100	2.1	2.7	5.0
200	3.6	4.7	8.3

Amphenol's "Twin-Lead" is a solid dielectric line that transmits signals from antenna to FM and Television receivers with extremely low loss. It's tough . . . inexpensive . . . easy to install . . . repels water . . . and is unaffected by acids, alkalies and oils because the dielectric is Amphenol Polyethylene.

In temperatures as low as –70°F. Twin-Lead Transmission Line stays flexible and does not become brittle after continuous aging in sunlight. In such outstanding qualities Amphenol's "Twin-Lead" is a wire of exceptional efficiency, life and utility.

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source is known in relation to two or more such receivers, the location of the disturbance may readily be plotted on a map by means of triangulation.

A spherics network covering the western portion of the northern Atlantic Ocean has existed since June 23, 1944, and this service is credited with having contributed materially to the safety of air flights over the Atlantic. The three initial stations in this system are located at the Signal Corps laboratory near Red Bank, New Jersey; the University of Florida at Gainsville, Florida; and on the island of Bermuda. A fourth station, near St. Johns, Newfoundland, was later added.

A program of aerial reconnaissance was conducted over the North Atlantic for several months. Two B-17 bombers, fitted with weather equipment and manned by specially trained crews, made regular flights with weather observers recording all meteorological phenomena every 15 minutes during flight. In the course of 50 flights, 81 percent of all spheric data compiled by the network were verified by significant weather within 100 miles.

Additional spherics networks were later established for the Mediterranean and the Western Pacific. General Ingles reported that the spherics program is continuing as one of the Signal Corps' peacetime research and development projects.

The spherics detectors currently used are based upon a design developed by physicists at the University of Florida. They have a dependable range of 2,000 miles and are accurate to within two degrees.

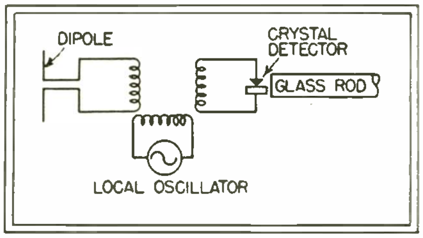
• • •

Artificial Radar Target

AN ARTIFICIAL TARGET for the German Wurzburg radar sets is shown in the illustration. A normal radar pulse is transmitted by the Wurzburg set under consideration and this pulse is picked up by a simple dipole antenna placed on a pole 20 or 30 yards from the set.

The pulse is fed from the dipole into a simple crystal detector along with the signal from a local oscillator. The intermediate frequency of 25 megacycles from this crystal

is sent down a glass rod as a mechanical vibration, and is reflected from the far end of the rod back to the crystal detector. Here it is converted upon combination with the local oscillator output to the carrier frequency of the Wurzburg and retransmitted.



Artificial target for German Wurzburg radar set. The time delay caused by the round trip of a mechanical wave along the glass rod simulates passage of a radar pulse through a much greater distance in space

On the circular range sweep of the Wurzburg there appears the echo pulse at a time delay corresponding to the total round trip time to travel to the antenna and down the glass rod as a mechanical wave and back again. Due to multiple reflection of the wave in the glass rod, there are several return pulses received on the Wurzburg. These pulses can be used to line up the Wurzburg and also calibrate the range sweep.

An interesting technical problem arose in the development of these glass rods. It was found that the circular cylindrical walls of the glass rod reflected energy, thus permitting many paths of varying time value in the glass resulting in "grass" on the range sweep. To make the walls non-reflecting, powdered glass of the same composition as the glass rod was sintered around the rod.

• • •

High-Power Military Sound Systems

DETAILS OF SOME of the high-power sound equipments designed for military purposes have been released recently. One of these is a beachmaster announcing system that is capable of creating a sound level of speech on an axis at a distance of 30 feet from the loudspeaker about 116 db above the reference level of 0.000204 dyne per square centimeter. The major part of the

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energy is radiated through a cone of 50 degrees. This has proven to be an important piece of combat communications equipment for directing landing operations.

The beachmaster's operating system was designed by Bell Telephone Laboratories and manufactured by Western Electric Co. Packaged in six watertight, portable, metal cases, the entire system may be dropped into the surf and floated ashore.

Amplifier and loudspeaker unit of the beachmaster announcing system. Made by Western Electric, it was used by the Navy during the invasions of Iwo Jima and Okinawa

The loudspeaker assembly consists of nine dynamic units and horns mounted on a common panel. During operation, the loudspeaker is attached to a metal yoke and tripod assembly so that it may be pointed up or down through an angle of 110 degrees and aimed in any horizontal direction by swiveling the yoke on the tripod. A lever-operated pin on one side of the yoke fixes the loudspeaker in any vertical position, and the height of the tripod is adjusted by means of the legs. The loudspeaker presents a load impedance of nine ohms to the amplifier and is capable of handling the full 250 watts of output.

The amplifier consists of a pre-amplifier and a power amplifier housed in a common case. The unit is ventilated during operation by a motor-driven blower. The pre-

UNDER NORMAL CONDITIONS line voltage remains fairly stable, fluctuating only slightly above or below rated value.

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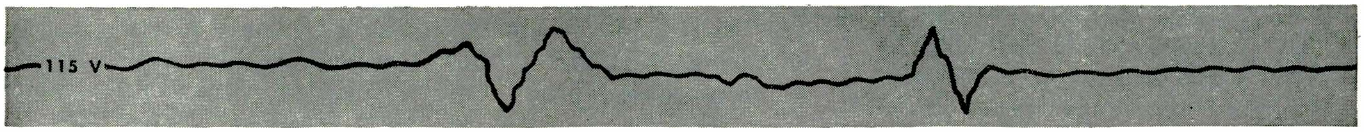

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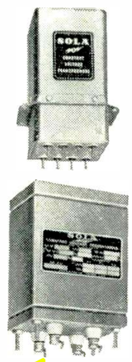

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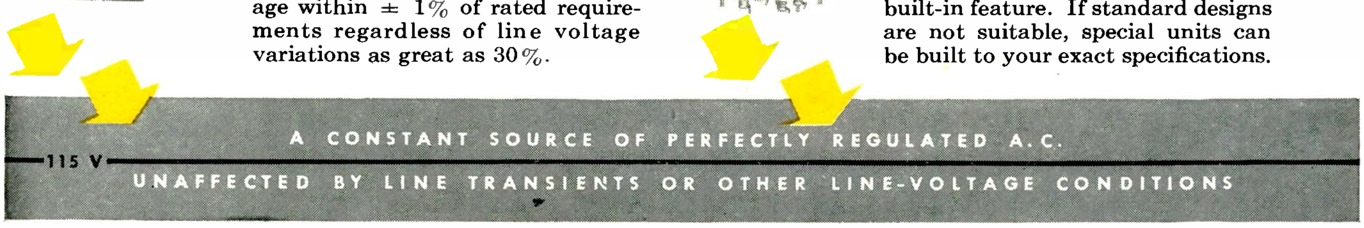

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amplifier consists of two resistance-coupled stages plus two resistance-coupled push-pull stages with transformer coupling between the second and third stage, and is transformer-coupled to the power amplifier. The latter is a single push-pull stage and includes a self-contained power pack. The microphone is of the magnetic type equipped with a feedback reduction attachment.

Power is supplied to the system by a gas-engine alternator set that will run approximately 1½ hours on a gallon of fuel and may be either manually or electrically started. It supplies 115-volt, 60-cycle, single-phase a-c and is rated at 1.67 kva with a 0.9 power factor. The system is designed to give satisfactory performance within a temperature range from −40 degrees to +130 degrees Fahrenheit in rain, mud or snow.

The overall frequency response rises from about 250 to 500 cycles, is reasonably flat to 6,000 cycles and decreases beyond that point. The amplifier has sufficient gain so that when the microphone is talked into in a normal voice, the amplifier will deliver 250 watts to the nine-ohm load.

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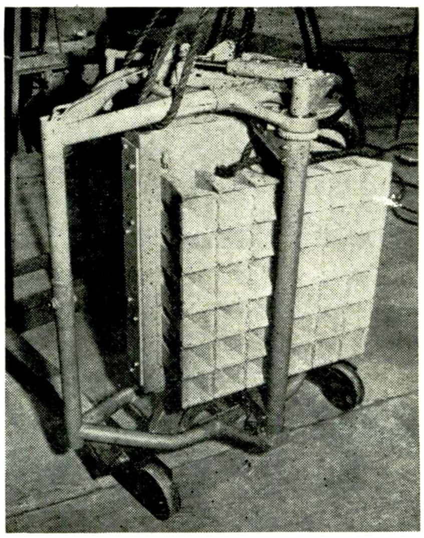

The 500-pound loudspeaker unit ready for mounting in a Navy PBY42

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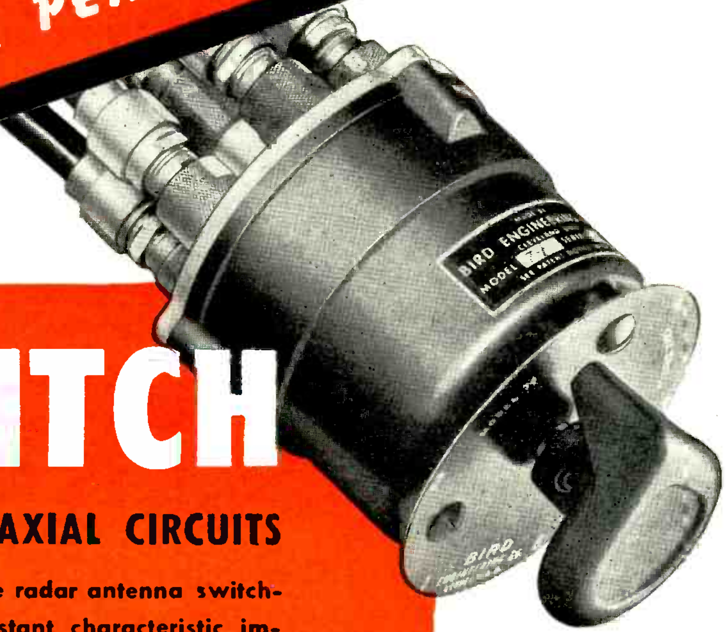

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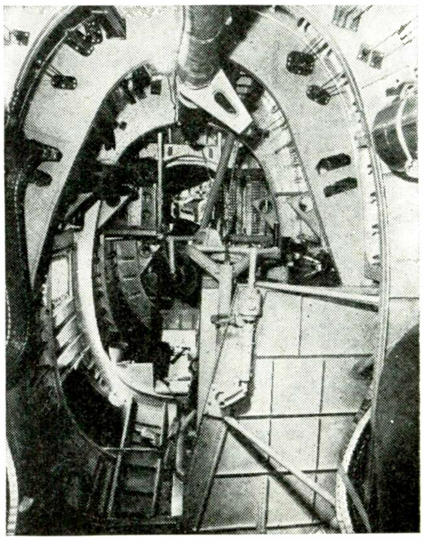


Mounting assembly of the loudspeaker unit in the plane. Part of the fuselage had to be cut away and reinforced

general information from General MacArthur in Japan directly to the Japanese people. These units produce sufficient volume to allow the human voice to be heard over an entire city from a height of 10,000 feet and were developed by Naval aeronautical engineers and the Bell Telephone Laboratories. They were installed in three PB4Y2's by the Aircraft Modification Unit of the Naval Air Material Center at Johnsville, Pa.

The task of installing the three 500-pound loudspeakers in three planes was known as Project Polly and was started last May 15. By September 1, the first Privateer was on its way to Japan, followed a few days later by the other two. In each plane, the loudspeaker installation consisted of four blocks of nine speakers each. Three shifts of men worked 24 hours a day to insert this equipment into the fuselages of the planes. They rearranged other equipment, strengthened the sections that held the added weight, and reinforced the center of the fuselage where the bending moment was greatest.

In earlier experiments conducted last December, a PV1 Ventura was equipped with a loudspeaker unit and after numerous tests had been completed was used successfully in battering down the Jap will to resist on Wotje, Saipan, Iwo Jima and Okinawa during the last stages of the war.

THE ELECTRON ART

Oscillatorless Superheterodyne

By ROBERT W. WOODS
Academic Dean of Union College
Lincoln, Nebraska

THE PROBLEM OF RERADIATION from a superheterodyne receiver, with consequent local interference and breaking of radio silence, has usually been attacked by carefully shielding and isolating the high-frequency oscillator. The possibility of radiation is still present in that there are oscillations whenever the receiver is on. The receiver described in this article is an approach to the problem from a different angle, frequency conversion without the use of a self-excited local oscillator.

Basic Circuit

The receiver is conventional except for the frequency converter and a similar type of c-w detector. In both circuits signal is fed into each of two mixers as shown in Fig. 1, and the output of each mixer is fed into the other mixer to mix with the original signal. The output circuit of one mixer is tuned to the conversion frequency (the intermediate frequency in the case of the converter; the desired audio frequency in the case of the detector). The output circuit of the other mixer is tuned to the difference (or sum) of the signal frequency and the conversion frequency, corresponding to the oscillator frequency of conventional circuits.

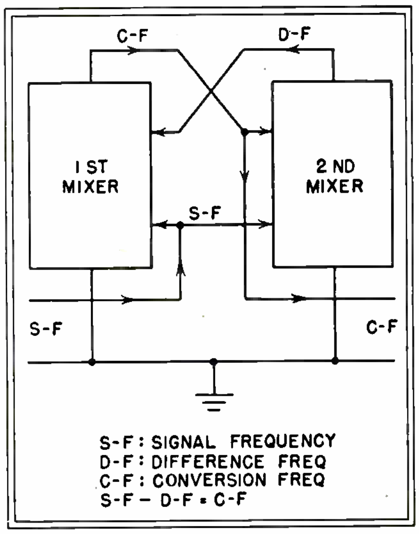


Fig. 1—Basic circuit consists of two mixers feeding each other

Thus we have a chain of feedback links from one mixer to the other and back again, which at first sight might seem to be capable of causing an oscillation. However, the links are tuned to different frequencies and the feedback is without effect unless a signal is supplied from outside the system to both mixers, which exciting signal must have a frequency that is related mathematically as indicated in Fig. 1 to the resonant frequencies of the feedback links, and must have an amplitude great enough to exceed the threshold of excitation required by the system.

Though these two circuits are quite similar in general, the converter circuit shown in Fig. 2, differs from the detector circuit of Fig. 4 in certain design features, in the mathematical theory of operation, and in the nature of the conversion signal. In the converter, the mixers are of the single input type, Fig. 2, with the signals fed in series to a single grid. With this circuit, as will appear in the analysis which follows, the amplitude of the i-f signal is proportional to the amplitude of the r-f signal. In the detector, Fig. 4, the mixers are of the double input type with a separate grid for each input frequency, that is they are multiplicative mixers. In this circuit regeneration increases the output signal to a maximum value which is independent of the amplitude of the exciting signal. If the exciting signal has an amplitude below the threshold, degeneration is present. This behavior automatically makes the detector nonresponsive to weak signals, and eliminates considerable background interference in c-w reception.

Converter Theory

The theory of operation of the converter, Fig. 2, is as follows. Assume that the r-f signal to both mixers is $A_1 \sin \omega_1 t$, the i-f signal to the 2nd mixer is $A_2 \sin \omega_2 t$, and the d-f signal to the 1st mixer is $A_3 \sin \omega_3 t$, where d-f signifies difference frequency. Then $\omega_3 = \omega_1 - \omega_2$.

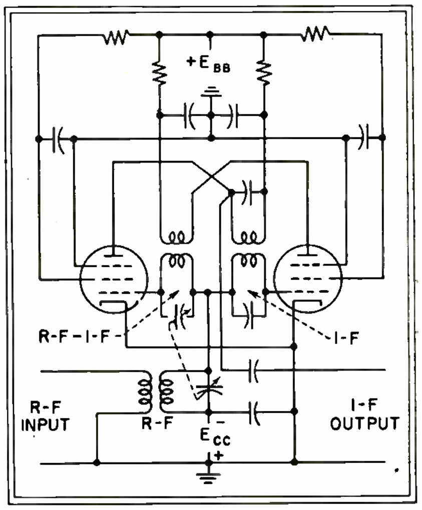


Fig. 2—Regeneration in the converter takes place only when a signal is present

The voltage applied to the grid of the 1st mixer is therefore $A_1 \sin \omega_1 t + A_3 \sin \omega_3 t$ which has a maximum amplitude $A_1 + A_3$ and a minimum amplitude $A_1 - A_3$ if $A_1 > A_3$ or $A_3 - A_1$ if $A_3 > A_1$. The amplitude of variation of this interference envelope is therefore $[(A_1 + A_3) - (A_1 - A_3)]/2 = A_3$ if $A_1 > A_3$ and $[(A_1 + A_3) - (A_3 - A_1)]/2 = A_1$ if $A_3 > A_1$.

The amplitude of this variation in the envelope of grid voltage is a sort of theoretical input amplitude of the difference frequency given in $\omega_2 = \omega_1 - \omega_3$. If, due to the gain of the mixer, the amplitude of this difference frequency in the output is K_1 times as great, then $A_2 = K_1 A_3$ if $A_1 > A_3$ and $A_2 = K_1 A_1$ if $A_3 > A_1$.

This same analysis may be applied to the 2nd mixer, giving $A_3 = K_2 A_2$

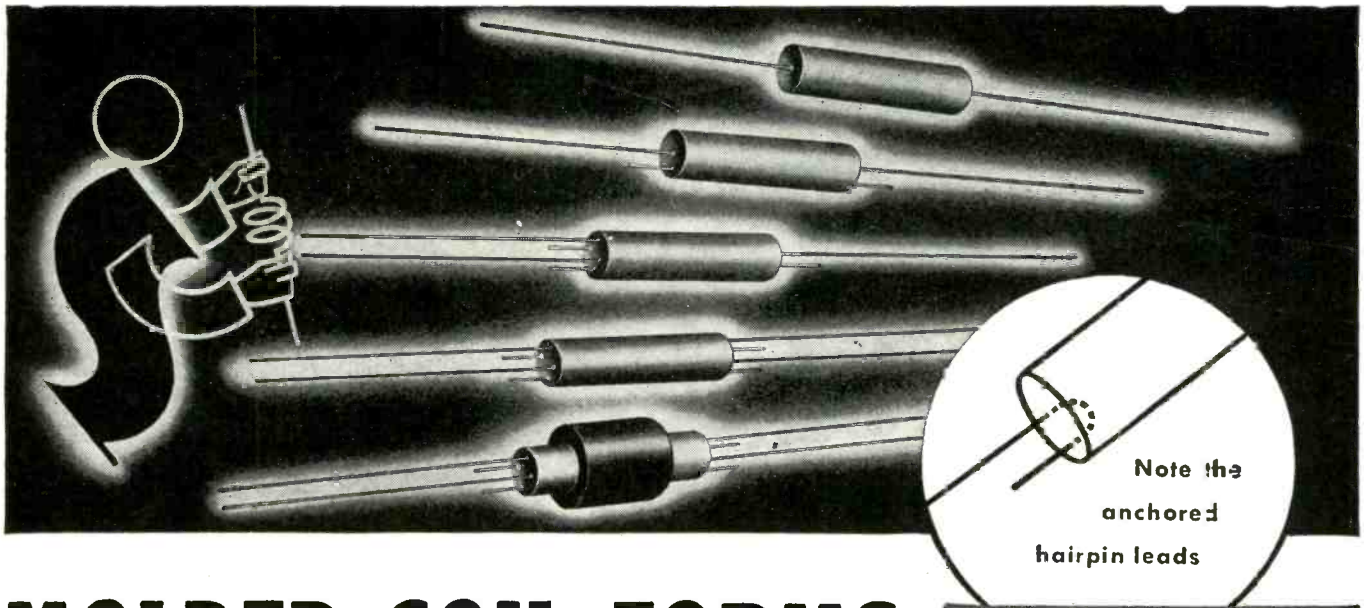
if $A_1 > A_2$ and $A_3 = K_2A_1$ if $A_2 > A_1$, where K_2 can differ from K_1.

Under starting conditions $A_3 = A_2 = 0$, except for the effect of small circulating currents in the tuned circuits caused by such statistical variations as d-c plate currents and ambient fields. It would be more accurate to say that A_2 and A_3 are very small. Thus when A_1 is applied, the condition exists that $A_1 > A_2$ and $A_1 > A_3$, and consequently $A_2 = K_1A_3$ and $A_3 = K_2A_2$. Multiplying these two equations gives $A_2A_3 = K_1K_2A_2A_3$ or $K_1K_2 = 1$. This result is interpreted to mean that if $K_1K_2 < 1$ we have degeneration, and if $K_1K_2 > 1$ we have regeneration and A_2 and A_3 build up until the conditions change to $A_2 > A_1$ and $A_3 > A_1$ when $A_2 = K_1A_1$ and $A_3 = K_2A_1$.

Converter Characteristics

From this analysis we see that the amplitude of the i-f produced by this method is dependent upon the amplitude of the r-f signal. It would be profitable at this point to observe that the conversion gain of a single input mixer is essentially constant over a wide range of amplitude of input signal, but depends on the amplitude of the input signal for very small amplitudes, becoming very small as the amplitude approaches zero.

This nonlinearity of conversion gain may be used to advantage because, by adjusting the conversion gain of the mixer so that the desired signal is strong enough to excite the conversion frequency, undesired signals of relatively smaller strength may be below the threshold required to excite the converter and will therefore not come through the receiver, thus partially eliminating the undesired background noise in c-w reception. During spaces in c-w reception, the r-f signal being absent, A_2 and A_3 drop to zero and consequently the receiver does not radiate. Even during the dots and dashes, because K_2 may be adjusted to a value only a little greater than unity, the radiation from this "oscillator" section may be minimized. There is, of course, an advantage in making K_1 quite large, in fact, there is nothing which would prevent using amplifiers in the feedback circuits of the converter as, for example, feeding back



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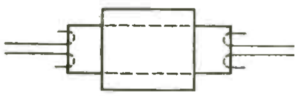

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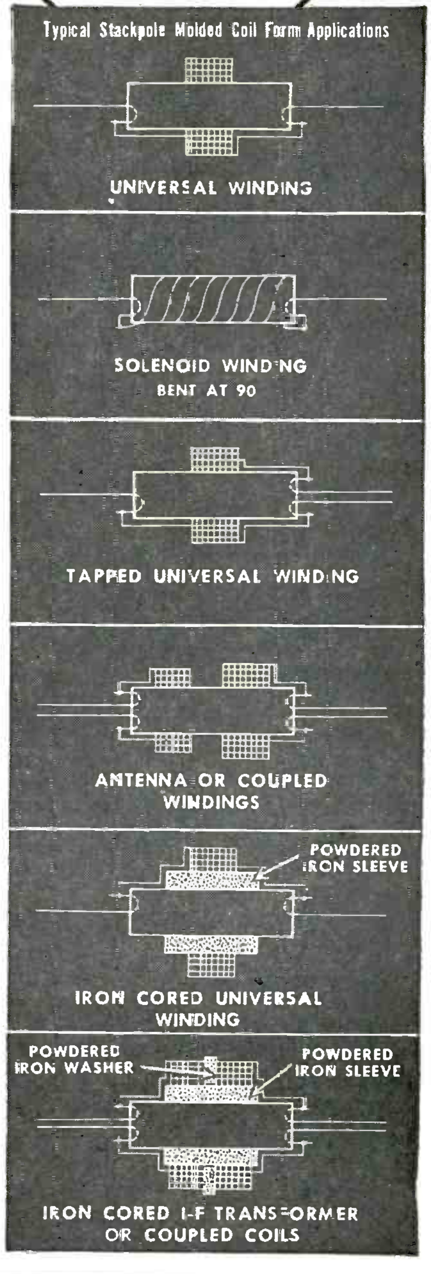

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the i-f signal from the output of the i-f amplifier instead of from the output of the 1st mixer.

Another point of importance is that the conversion frequency will be determined by the i-f tuning, provided that the Q of the i-f circuit is higher than the Q of the d-f circuit, thus providing a sort of automatic frequency control.

Because the i-f signal amplitude is a linear function of the r-f amplitude, this frequency converter may be used to receive an amplitude modulated signal as well as c-w signals.

Experimental behavior of the converter is shown in Fig. 3. The conversion gain of the single-input mixers employed in the experimental model of the converter, as determined by measurements of the i-f

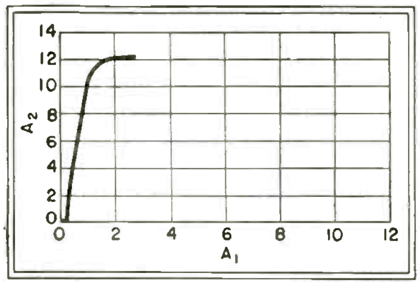


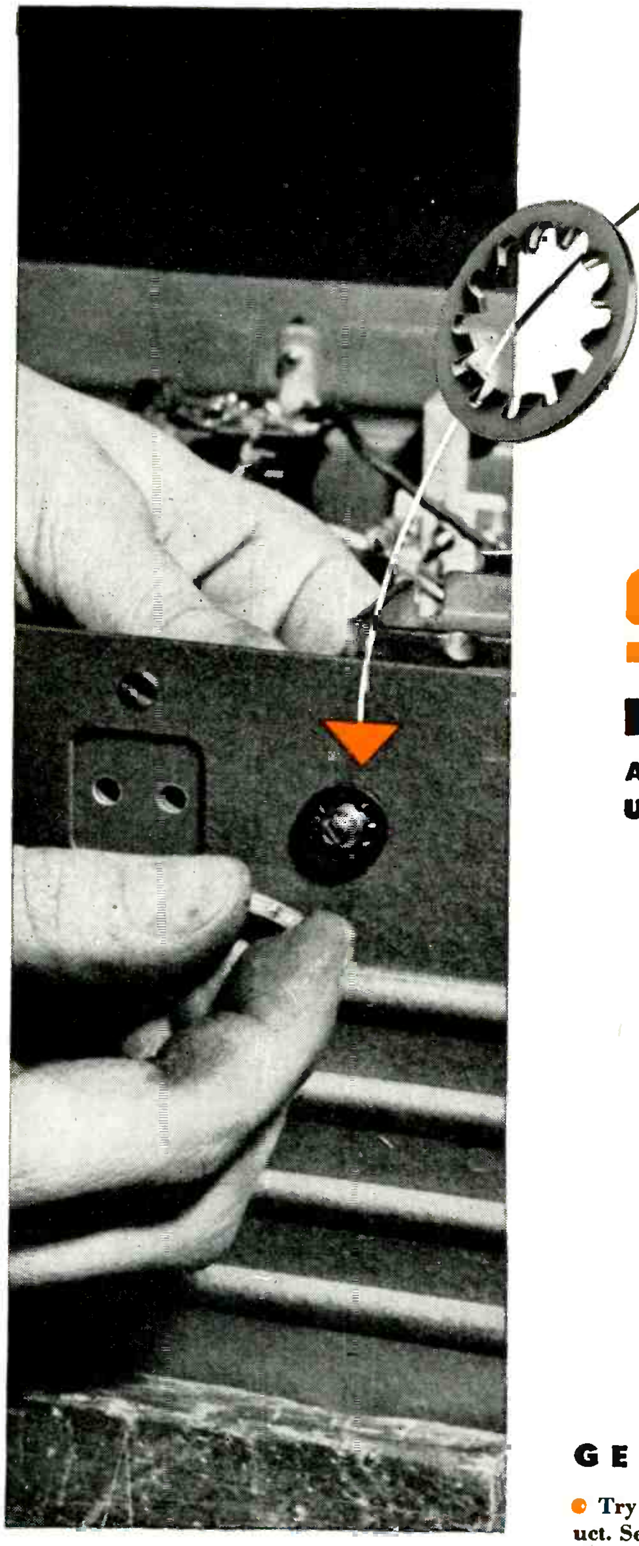
Fig. 3—Experimental measurements indicate the linear dependence of i-f amplitude on r-f amplitude up to tube saturation

and r-f amplitudes, was approximately ten. This low value of conversion gain was fortunate in that the variation of i-f amplitude with r-f amplitude was easily observed.

C-w Detector Theory

The theory of operation of the detector circuit, Fig. 4, is as follows. We shall assume for this circuit the notation i-f signal to both mixers is $B_1 \sin \omega_1 t$, a-f signal to 2nd mixer is $B_2 \sin \omega_2 t$, and s-f signal to 1st mixer is $B_3 \sin \omega_3 t$, where s-f signifies sum frequency. Then $\omega_3 = \omega_1 + \omega_2$.

In the double input mixer, to a first approximation, the g_m of the tube may be considered to be a linear function of the voltage on the #3 grid. This simplification is approximately true in the range of negative, grid voltages. Thus $g_m = g_{m0}(1 + ke_{g3})$. In the same operating region the plate current may be considered to be a linear function of the voltage on the #1 grid so that $i_b = g_m(E + e_{g1})$



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where E is a constant. Combining these two equations gives $i_b = g_{m0} \times (1 + ke_{g3})\ (E + e_{g1})$. The last term of the expansion of this equation will contain the sum and difference frequencies, for as in the 1st mixer $e_{g1} = B_1 \sin \omega_1 t$ and $e_{g3} = B_3 \sin \omega_3 t$. This last term gives the conversion-frequency, plate current

$$i_p = g_{m0}\ k\ B_1 B_3 \sin \omega_1 t \sin \omega_3 t$$
$$= \frac{g_{m0}\ k\ B_1 B_3}{2}$$
$$[\cos\ (\omega_1 - \omega_3)\ t - \cos\ (\omega_1 + \omega_3)\ t]$$

The voltage amplitude of the output signal of the mixer depends on the effective resistance R_1 of the plate load device, and would be $B_2 = R_1 (g_{m0}\ k\ B_1\ B_3)/2$. In similar manner considering the 2nd mixer $B_3 = R_2 \times (g_{m0}\ k\ B_1\ B_2)\ R_2$. Multiplying these two expressions and dividing by $B_2 B_3$ gives $1 = R_1 R_2\ (g_{m0}\ k\ B_1)^2/4$ or $B_1 = 2/g_{m0}\ k \sqrt{R_1 R_2}$.

This analytical result is interpreted to mean that there is a minimum value of the amplitude of the excitation voltage below which degeneration occurs and above which there is regeneration. The threshold value of this excitation voltage is given by the above equation. The composite quantity $g_{m0}\ k$ is the slope of the g_m vs e_{g3} curve at the operating point; for the 6L7 tube it is approximately 90 μ microohms per volt.

Note that in the converter circuit this dividing point between degeneration and regeneration was determined by the conversion gain and depends on the signal strength only

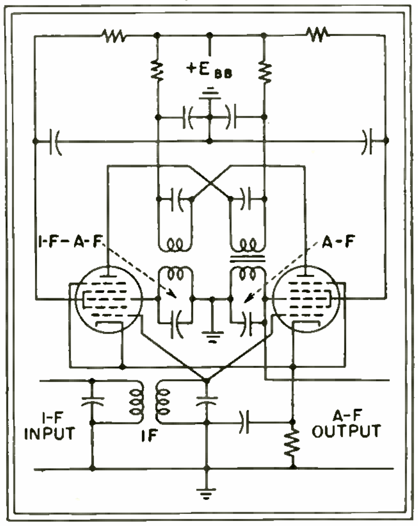


Fig. 4—The c-w detector, using double input, generates audio tone from i-f carrier

as the gain is affected thereby; in the detector the dividing point is dependent on the signal strength. In the converter, the conversion-frequency signal is modulated in the same way as the r-f signal; in the detector the amplitude B_2 of the conversion frequency signal depends not only on B_1 but also on B_3. The result is that B_2 is increased by regeneration to a maximum value determined by the circuit constants, and B_1 merely triggers the "oscillation". In the absence of B_1 both B_2 and B_3 drop to zero and the circuit become inoperative.

Even if B_1 is modulated somewhat, B_2 is constant in amplitude. However, if B_1 has a high percentage of modulation, during a part of the modulation cycle its amplitude may be below the critical value and degeneration will be present in the circuit, causing an interruption of the B_2 signal, a sort of externally blocked blocking oscillator behavior. Of course for c-w reception this consideration of the behavior of the circuit with a modulated signal is extraneous. It is presented merely as an exploration of the properties of this circuit. Some of the peculiarities of this circuit are such as to recommend it as a c-w detector. Of course it is not satisfactory as a detector for a-m signals.

Experimental behavior of the detector circuit is shown in Fig. 5. The effective resistance R_2 of the plate load on the 2nd mixer of Fig. 4, calculated from an assumed value of effective Q of the coil, was found to be approximately 10,000 ohms. The effective resistance R_1 of the plate load of the 1st mixer, calculated from low-frequency measurements of the coil constants, was found to be nearly 50,000 ohms. Using these values, the

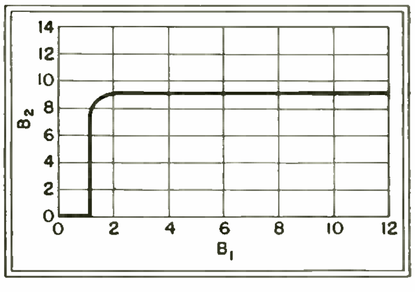


Fig. 5—Detector gain characteristic indicates that above the threshold the a-f amplitude is independent of the i-f amplitude

threshold amplitude was calculated to be one volt. The measured value of threshold was about 1.1 volt, which agrees almost too well with the theory considering the probable error in the determinations of R_1 and R_2.

Behavior such as is exhibited by these circuits, particularly by the detector, should find other applications in design of electronic apparatus. Some suggestions are as an audio oscillator excited or triggered by the presence of an unmodulated r-f signal or an oscillatorless c-w detector. A variable-frequency, crystal-controlled, r-f signal can be obtained using this circuit by feeding a crystal controlled signal to the circuit, incorporating a variable-frequency, tuned, audio unit in the plate circuit of one of the mixers and using the sum frequency from the plate circuit of the other mixer as the desired output. The circuit can be used for generation of an electronically triggered control voltage for the operation of relays. Because the triggering is dependent upon the amplitude of the signal, a series of relays operating

• • •

IFF ANTENNA

Antenna of an IFF, Identification Friend or Foe, set as installed on Okinawa for part of the radar warning system

from detectors having thresholds at different levels might be operated from the same signal. It can also be used intentionally as an intermittent oscillator to produce bursts of oscillation when triggered by a 100 percent modulated signal, that is as a sort of externally blocked blocking oscillator.

The detector circuit can also be used in an f-m receiver. By making the Q of the sum frequency, resonant circuit considerably higher than the Q of the i-f circuit, the sum frequency will remain practically constant during operation; the i-f will vary in frequency following the signal frequency. Note that in this application the detector circuit is being used as a converter. Inasmuch as the amplitude of the i-f is independent of the amplitude of the r-f, the use of this type of conversion detector eliminates the necessity for a limiter stage. Because the circuit requires an input well in excess of its threshold, it should be used as one of the later detectors in a multiple i-f type of receiver.

• • •

London News Letter

By JOHN H. JUPE
Enfield, England

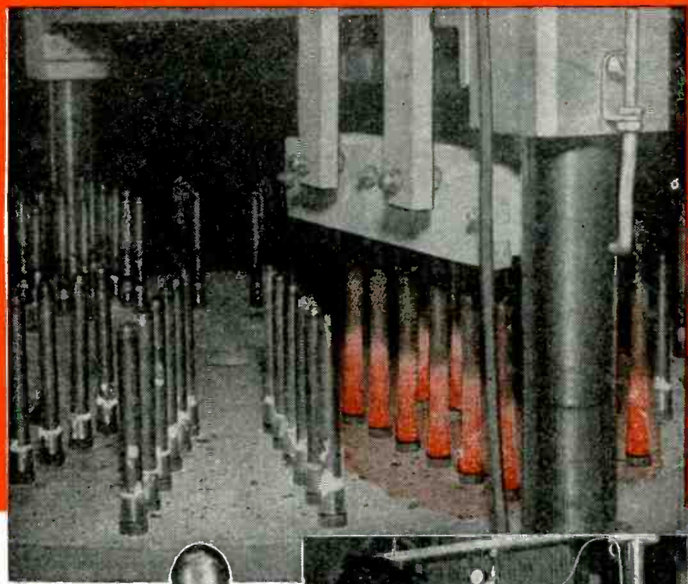
Response-Curve Marker. Usual methods of exhibiting the response curves of i-f stages on a cathode-ray tube do not afford coordination between the response curve and the quantities of frequency and amplitude. An instrument which overcomes this and permits continuous observation of the response curve together with a coordinate system indicating frequency and amplitude as derived from a standard signal generator is shown in the accompanying diagram.

The wobbulator produces the carrier sweep and is fitted with a limiter stage to secure constant output. Either mechanical or electronic sweep can be used. Coupled to the sweep system is a circuit which produces a synchronising signal.

The calibrator unit produces a gap in the response to indicate the frequency to which the signal generator is tuned. Tuning the signal

INSIST ON PROOF BY TRIAL

before you buy an Electronic Heater

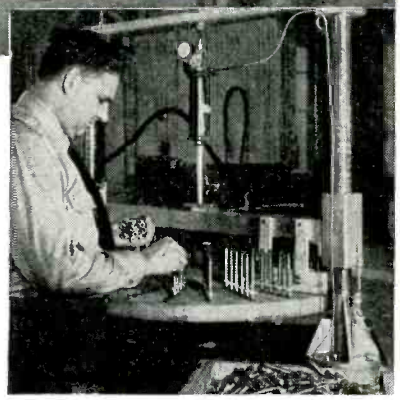


This is how Scientific Electric proved the value of electronic heating to the Progressive Welding Company of Norwalk, Connecticut . . .

GREAT improvements in product quality and remarkable savings in time and money are being achieved by means of electronic heating. Industrialists everywhere are now acclaiming its many advantages. But don't let your enthusiasm lead you to invest in an electronic heater before you have seen it perform the work you expect of it.

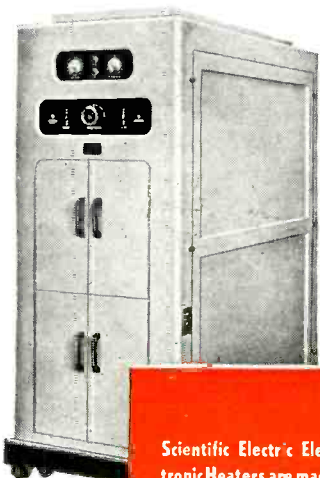
Another important point is this . . . in order to work at maximum efficiency and live up to its reputation for doing things better, faster and cheaper . . . electronic heating must be "tailored" to the job. That is why we never sell a Scientific Electric unit until it has been satisfactorily demonstrated. Regardless of the amount of time and effort required, our engineers will not release a single machine for sale until it has fulfilled every claim we make for it.

So here is a word of counsel . . . get plenty of advice before you buy. Consult with our recognized engineers who have pioneered in electronic heating since 1921 and, without obligation, they will demonstrate what electronic heating can do for you.



Above: This practical, automatic brazing turntable powered by a 40 KW. Scientific Electric heater speeded up production 700%—cut costs 87% and reduced rejects by 90%.

Left: Close-up of the finished two-piece tube assembly after being brazed by induction heating. Three complete brazing installations have been built for Progressive.



Write for a free copy of our handbook . . . *The ABC of Electronic Heating* which contains an easily understood explanation of this new heating method.

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Scientific Electric Electronic Heaters are made in these power sizes . . . and a range of frequencies up to 300 Megacycles depending upon power requirements.

3 KW	18 KW
5 KW	25 KW
7½ KW	40 KW
8 KW	60 KW
10 KW	80 KW
12½ KW	100 KW
15 KW	250 KW

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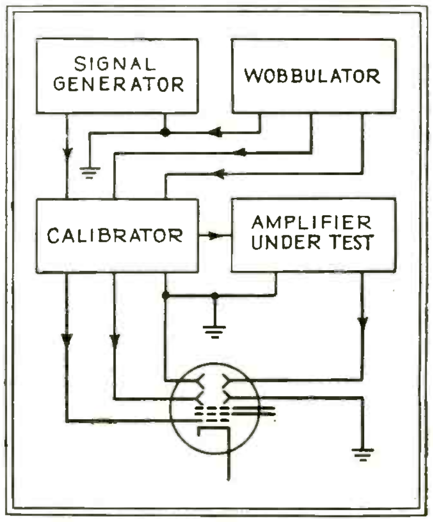
Manufacturers of

Vacuum Tube and Spark Gap Converters Since 1921 generator shifts the gap along the curve as traced on the cathode-ray tube.

Amplitude is indicated by a horizontal line which can be shifted up or down by operating the attenuator of the signal generator. In this way the db difference between



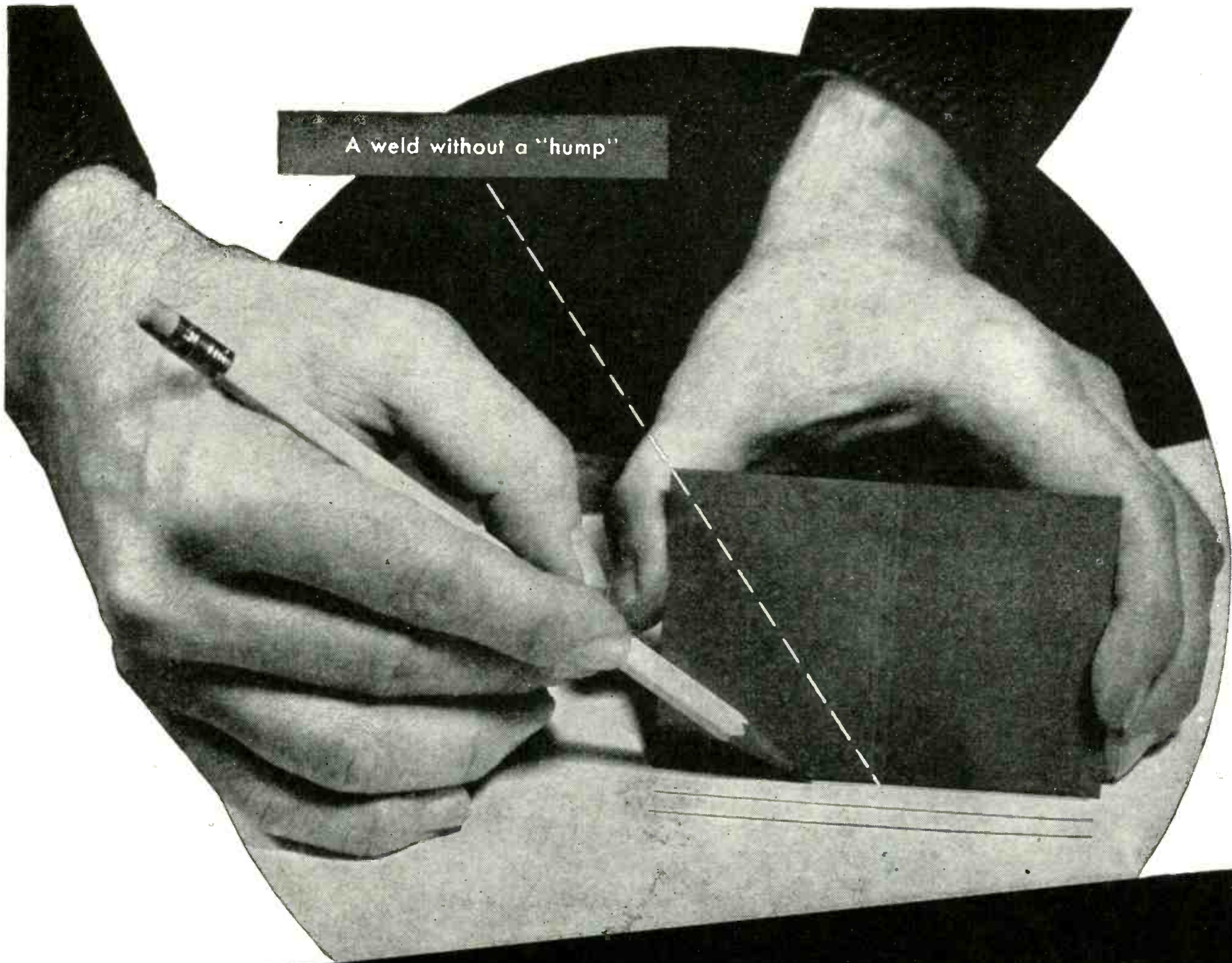
Calibrator introduces marker on time base at point corresponding to frequency set by signal generator and also provides a controllable amplitude line

any two points on the response curve can be reproduced on the attenuator scale of the signal generator.

Any point on the filter or transformer characteristic curve can be located in frequency and amplitude by this arrangement.

Electrostatic Generator. In the *Jour. I. E. E.*, 91, No. 47, F. J. Smee describes an electrostatic generator of the Van de Graaff type designed for an output of 1 ma at 700 kv, and having minimum overall height and floor space requirement, and low cost.

Four belts of 3-ply rubberized cotton, 1.4 millimeters thick, running side by side were used. The outer ones were 26 inches wide and the inner ones, 18 inches. From the total width of 88 inches a short-circuit current of 1.4 ma was expected and when tested, the machine delivered 1.7 to 1.8 ma with the belts tight, and 2.3 ma with them slack enough to touch. The linear speed of the belts is 4,600 feet per minute and they are



Here's A Guaranteed Weld Thickness in coils made from electrical sheets!

This photograph illustrates the hair-smooth butt-weld on ARMCO Electrical Steel coils made from hot rolled sheets. The pencil line drawn with the welded steel held vertically shows there is no extra metal at the weld.

The weld is *guaranteed to be within the thickness tolerance of the steel.*

Armco has perfected a unique welding method to give you Electrical Steel coils in grades where cold rolled practice has not yet been developed to assure coils of highest magnetic quality. They are supplied as narrow as one inch.

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This gives you the fabricating advantages of continuous operations for *all grades of silicon steel.* You can save time, labor and steel, because coils help step up production by eliminating all "hand-feeding" to presses. And besides being easier on dies, coils have relatively no end-of-strip scrap losses.

ARMCO Electrical grades give you steel of top magnetic quality with low core loss and exceptional permeability; steel that is ductile, flat and clean-surfaced. The American Rolling Mill Company, 401 Curtis Street, Middletown, Ohio.

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SPECIAL-PURPOSE SHEET STEELS

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driven by pulleys 4 inches in diameter, revolving at 4,400 rpm.

The circuit used to test the machine was a stack of wire-wound, oil-immersed resistors totaling 734.5 megohms. Output voltage under load was measured by short circuiting the resistors of the series stack one by one, the voltage falling with increase of load. A milliammeter placed at the earthed end of the stack measured the load current. From this reading and the resistance of the load, the output voltage was determined.

On test, the generator was found to have an almost constant current characteristic which is valuable for work on cyclotrons and other acceleration tubes because damage cannot be caused by flashover or vacuum failure.

The highest voltages obtained from the machine, measured by the spark gap method, were, with positive excitation, 910 kv., with negative excitation, 1,020 kv. These voltages taken in conjunctinon with current output, represent an excellent performance from apparatus 9 feet, 4 inches high and only 4 feet, 9 inches in diameter.

A typical example of the application of this type of machine to a high voltage, medium current x-ray plant is the installation at the Huntingdon Memorial Hospital, Boston, Mass. This plant operates at 1,000 kv. and can supply 3 ma at the target. The room housing the generator and tube is approximately 15 feet by 13 feet by 15 feet high. Target and treatment room are on the floor below.

Ultraviolet Death Test. In modern warfare a surgeon in the field or in a civilian area being subjected to aerial bombing often has to make rapid decisions as to whether a person is dead or alive. The patient's life may depend on the rapidity of the decision quite apart from whether there are others on the waiting list or not. The problem is complicated by the fact that usual signs of death may not yet be present. However, by an ultraviolet light a definite answer can now be obtained within a few seconds.

The technique consists of in-

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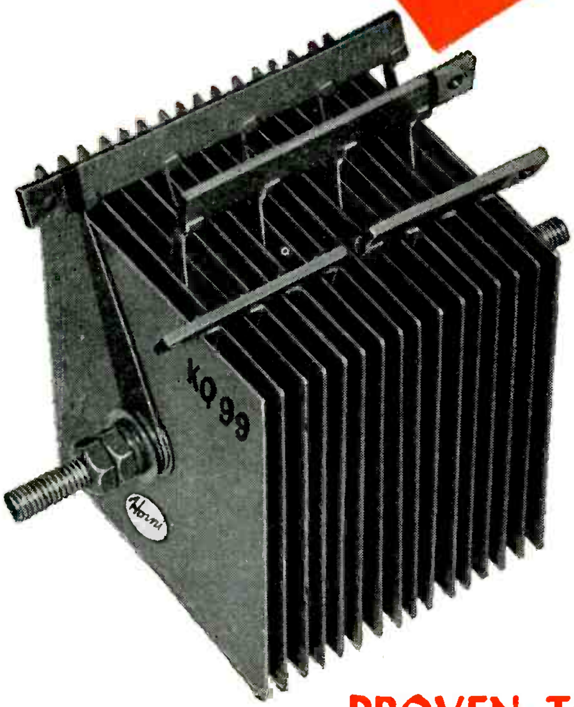

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travenously injecting a solution of uramin (a sodium or potassium salt of fluorescein). If the subject is alive, the salt passes to the eyes within 12 to 18 seconds and fluorescence under ultraviolet light is obtained, whereas if the subject is dead the test is negative.

• • •

Bimodal Oscillator

By SAMUEL LUBKIN,

Civilian Director Inspection Laboratory, Army Signal Corps, Philadelphia, Pa.

IN BEAT-FREQUENCY OSCILLATORS where two independent oscillators are used, slight frequency changes in one oscillator cause large changes in the heterodyne frequency. To counteract this instability, both frequencies for heterodyning can be obtained from the same circuit. Thus changes in most circuit elements will affect both beating frequencies equally and the beat frequency will be but little changed.

Dual-Frequency Circuits

Of the circuits having two, controllable modes of oscillation, the one consisting of two identically tuned, coupled circuits is well known. In such a circuit, illustrated in Fig. 1, the beat frequency can be controlled by varying the coupling. The two frequencies of oscillation of such a circuit are

$$f_1 = \tfrac{1}{2}\pi\sqrt{(L-M)C}$$
$$f_2 = \tfrac{1}{2}\pi\sqrt{(L+M)C}$$

Where M is small compared to L,

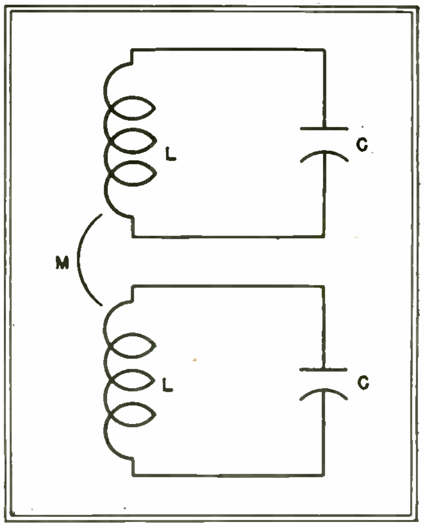
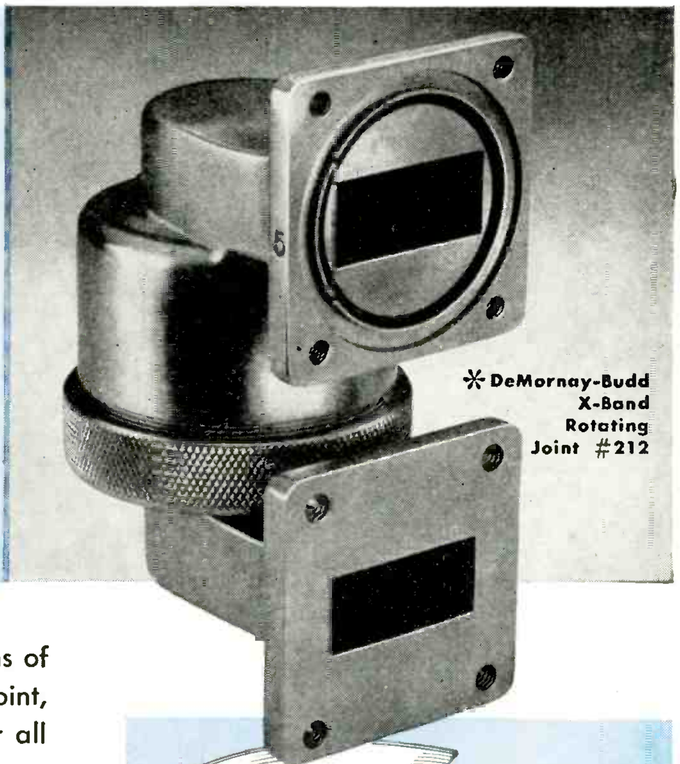


Fig. 1—Identical circuits coupled to each other have two resonant frequencies

ASSURES CONSTANT IMPEDANCE

for all positions of rotating element



✲ DeMornay-Budd X-Band Rotating Joint #212

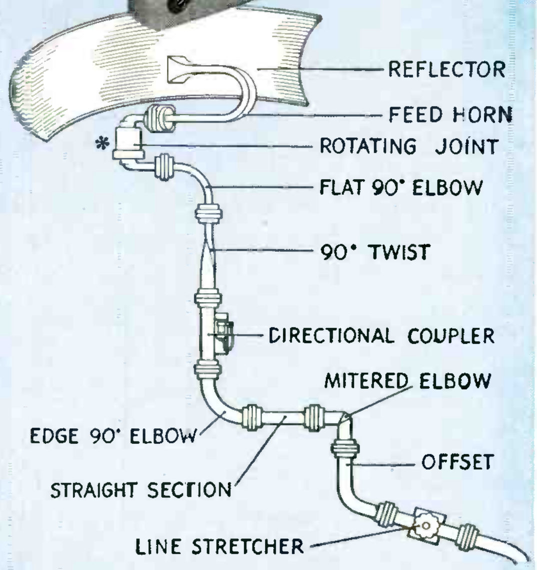
When two transmission lines, the relative positions of which are variable, are coupled by a rotating joint, it is essential that the impedance be constant for all positions of the rotating element.

Varying impedance will have a pulling effect on the R. F. oscillator and produce a variation of frequency and power output due to a changing load. The reflection coefficient of the transmission line will also vary.

The Voltage Standing Wave Ratio of the DeMornay-Budd Rotating Joint is the same for either direction of power transfer, providing balanced energy transfer for both directions. Careful engineering and precision finishing eliminate sharp corners or small radii projections which would cause arcing and breakdown.

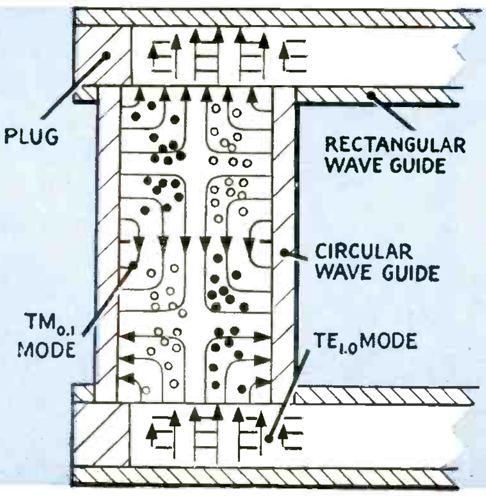
★ ★ ★

Our extensive engineering and manufacturing experience with wartime radar is at your disposal. Consult us on any of your transmission line problems, without obligation.



Asterisk indicates position of #212 Rotating Joint in above plumbing arrangement. In broad band joints it is necessary to include impedance matching devices such as tuning plugs or irises to keep the Voltage Standing Wave Ratio to a minimum and the mode constant.

DeMornay-Budd Rotating Joints are available with either choke or plain flange coupling or any combination.



Sketch illustrates a method employed by DeMornay-Budd in designing a rotating joint. The $TE_{1,0}$ mode in the rectangular wave guide is changed to a $TM_{0,1}$ mode in the circular wave guide and, as a result, a 360° rotation can be obtained without any theoretical variation in V.S.W.R.

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the difference frequency is $f = (M/L)f_0$ where $f_0 = 1/2\pi\sqrt{LC}$ is the independent resonant frequency of each circuit.

A more complete analysis shows that if the circuit constants drift with respect to each other either up or down the beat frequency increases, thus the calibration can be deliberately offset in anticipation of possible drifts. In beat-frequency oscillators where the two oscillator circuits are independent, the output frequency can drift either up or down depending on the relative direction of drift of the two oscillators. Furthermore, the output frequency of the bimodal oscillator will change but little if one circuit mode drifts with respect to the other.

Variable-Frequency Oscillators

In Fig. 1 it is preferable to vary the coupling. Varying the coupling leaves the mean high frequency the same, thus simplifying tuned-circuit and filter design, and produces a wider range of output frequency. If the two inductors or capacitors are varied, besides tracking difficulties, all frequencies will change in the same proportion.

The circuit shown in Fig. 2 uses a variable capacitor instead of variable coupling. L_0 cancels the effect of the minimum capacitance of C_0 permitting control by the latter at small difference frequencies.

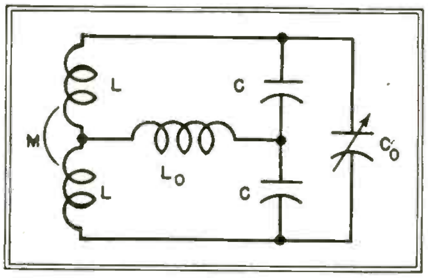

Fig. 2—Addition of capacitance and inductance in common paths provides finer frequency control

Suitable Oscillator Circuits

In addition to the two foregoing circuits there are other combinations which have two modes of oscillation. Figure 3A shows a transmission line used for this purpose. The difference between the frequencies of the two lowest modes is closely $f = 1/4\pi^2 CZ_0$ where Z_0 is the

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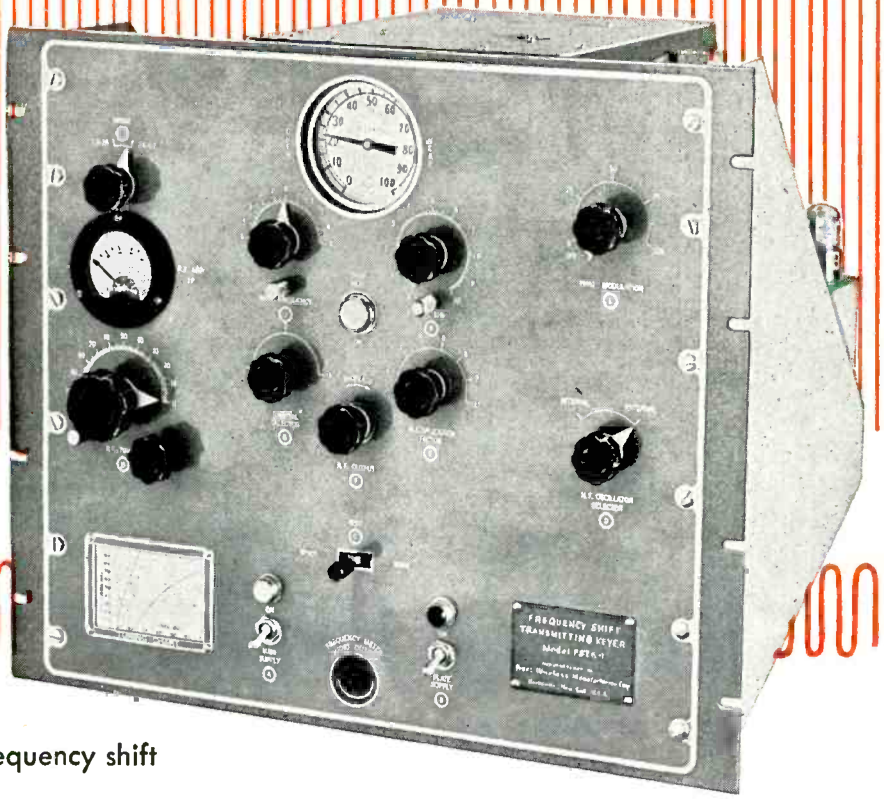
Model FSTK-1



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This precision unit provides the basic oscillatory circuit shifted by the signal intelligence whether it be Morse code, teleprinter, pictures, or facsimile. With frequency shift emission it is possible to transmit voice as an AM component simultaneously with the FS signal thereby affording two independent service channels on a single r-f carrier.

FSTK-1 is universally adaptable to any transmitter and will increase the effective radiated power more than ten to fifteen decibels by greatly improving the signal-to-noise ratio of the received signal.

Engineering Bulletin 3004 describing Frequency Shift Operation and its advantages together with a bulletin on FSTK-1 will be forwarded at your request.

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characteristic resistance of the line. In other circuits containing distributed parameters, one mode and a harmonic of another can be used to produce a heterodyne frequency.

Two crystals ground to identical frequencies can be mechanically coupled as at Fig. 3B giving the mechanical equivalent of Fig. 1, or the crystals could be electrically

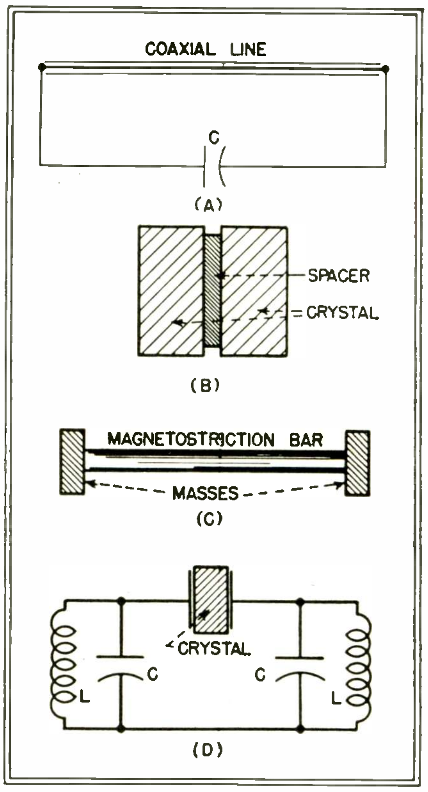

Fig. 3—Bimodal circuits can be obtained from (A) capacitance shunted transmission line, (B) mechanically coupled crystals, (C) loaded mechanical system, or (D) mechanically coupled electrical circuits

coupled. Figure 3C shows a mechanical analogy to a circuit containing distributed parameters. Two electrical circuits can be mechanically coupled as at Fig. 3D.

Circuit Coupling

Several methods can be used to sustain the two oscillating modes and to couple out from the circuit. Where the two modes differ appreciably in frequency, a single regenerative circuit, or two regenerative paths each tuned to operate at one of the modes can be used.

If the two modes are nearly equal in frequency, there may be circuit elements which operate

wholly or predominately in one of the two modes. These elements can then be connected to oscillating circuits as illustrated in Fig. 4. In some circuits the sum of two properly chosen voltages will give one mode and the difference will give the other mode. Thus by properly

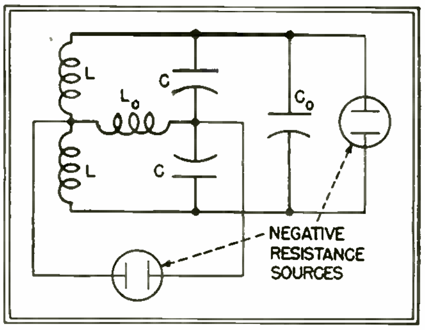

Fig. 4—Feedback networks for sustaining oscillations can be connected across the parts of the bimodal circuit that carry but one mode

combining these voltages the two frequencies can be obtained for regeneration.

It is also possible to shock excite the bimodal circuit. It will then oscillate in both modes, which can be picked off and used both to produce the desired beat frequency and to synchronize the pulse exciter.

• • •

Reduced Harmonic Voltage Across Rectifiers

By MENDEL OSNOS

Telefunken Gesellschaft fur Drahtose Telegraphie m. b. H.
Patented Oct. 2, 1934, No. 1,975,647

FILTERS CONVENTIONALLY consist of a smoothing capacitor C shunting the load R of Fig. 1. In addition they may contain a series inductor L_2, which can be shunted by an additional capacitor C_2 and the combination tuned to the most objectionable harmonic in the rectifier output. The result of this latter circuit, whether it be resonated or not, is to develop undesirably large harmonic voltages across the rectifier tubes. The purpose of the circuit of this invention is to reduce this harmonic potential appearing across the tubes.

Shunt capacitors C_1 are placed across each tube. Experiments have shown that, in addition to relieving the harmonic potential across the tubes, these capacitors reduce to 20 to 25 percent of its original ampli-

how to braze 18 pieces into 6 units

in 7 Seconds

Cutting costs by reducing assembly time is a neat trick . . . and here's how you can do it with induction heating.

The normal method of flame brazing this three-piece, steel tube assembly did as well as any other technique then available. But production was pitifully slow. It took minutes to complete one entire unit.

By designing a jig like the one shown above, a simplified, efficient system was found to do the job. The fixture held 6 complete units (18 separate pieces) in place firmly while a standard Westinghouse 20-kw generator brazed all six uniformly in 7 seconds! Final operation was so simple a girl could easily handle the assembly and brazing.

The beauty of electronic heating is its unmatched ability to do all types of heat-treating jobs quickly . . . annealing, hardening, sintering, soldering, curing, bonding and molding. Ask your Westinghouse office today for all the facts on induction heating and where it fits your operations. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30 Penna.

J-08143

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Electronics at Work

tude the alternating current flowing in load R, indicating that the capacitances substantially absorb these current variations.

Capacitors C_1 also can be proportioned so that at the same time they improve the power factor of the rectifier input. In large rectifier installations where reactors are provided in the alternating-current circuit as protection in case of flash-

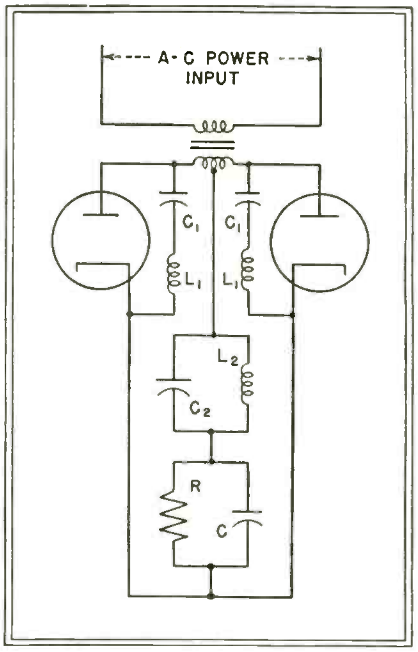

Fig. 1—Two wave rectifier to which the circuit is applied illustrates the action in relieving harmonic potentials. The circuit can be used in three phase rectifiers as well

overs, these tube shunt capacitors can be used to offset their deleterious effect on the power factor.

Because of the large current that one of the capacitors C_1 can deliver to its tube should it flash over, inductors L_1 are added in series with capacitors C_1. The series circuit L_1C_1 is tuned to resonate at the harmonic most prominent in the circuit. The series circuit is thus still predominantly capacitive at the power fundamental, and thus power factor improvement is still possible.

HOTEL PATRONS want television sets in their rooms as soon as full scale production is under way. In surveys recently taken, a majority recorded a preference for a central system.

ENGINEERS acclaim the new, small

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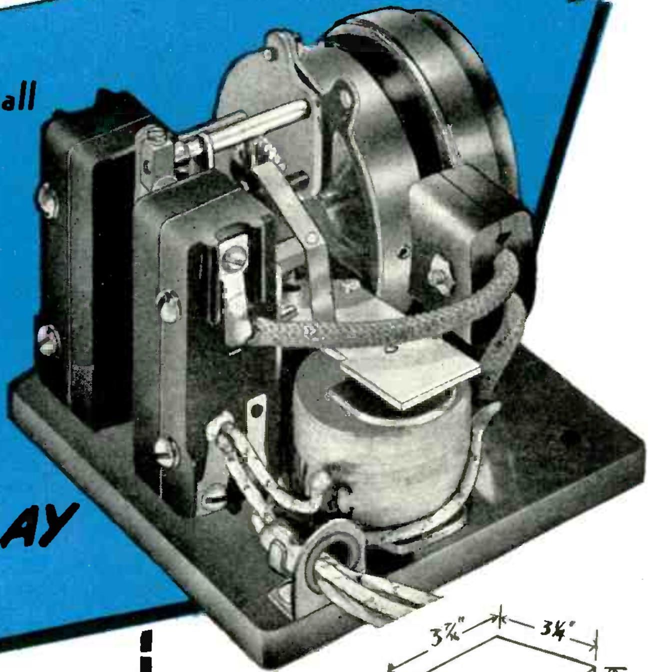

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Characteristic rugged construction insures complete dependability.

Available in Single Pole Normally Open, Single Pole Normally Closed, Single Pole Double Throw, with delay period of from one to ten minutes. Phenolic insulation. Available for front or back connection.

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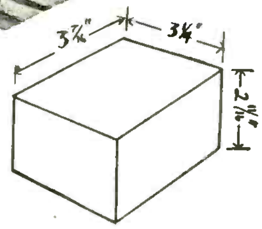

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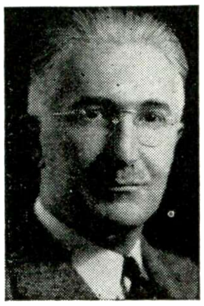
NEWS OF THE INDUSTRY

Radiation Lab book series; radio-controlled aircraft; FCC allocation changes; report on German electronic equipment industry; more engineers change jobs

IRE Awards for 1945

WAR CONTRIBUTIONS subsequent to January 1, 1940 were not considered in the selection of recipients for the January 1946 awards made by the Institute of Radio Engineers, because too short a time had elapsed since the end of the war to appraise properly the work of the many individual contributors. The two main awards and their official citations are:

MEDAL OF HONOR—to Ralph Vinton Hartley, Engineer, Bell Telephone Laboratories, New York, N. Y.—For his early work on oscillating circuits employing triode tubes and likewise for his early recognition and clear exposition of the fundamental relationship between the total amount of information which may be transmitted over a transmission system of limited bandwidth and the time required.



R. V. L. Hartley

P. C. Goldmark

MORRIS LIEBMANN MEMORIAL PRIZE—to Peter C. Goldmark, Engineer, Columbia Broadcasting System, New York, N. Y.—For his contributions to the development of television systems, particularly in the field of color

Television Progress Report

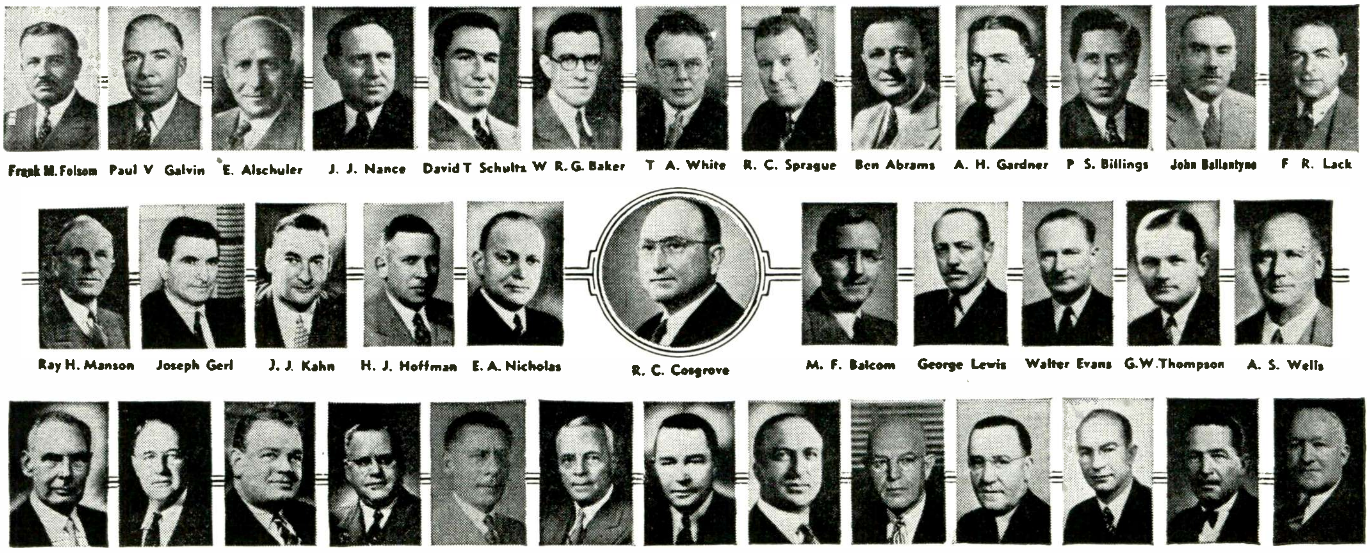
TO BRING THE PUBLIC up to date on television progress, RCA took reporters and editors through their television laboratories at Princeton on December 13, demonstrating for them the best black and white pictures attainable when the war snuffed out television research and the best present-day pictures. These demonstrations originated in the NBC television studios in New York City and were picked up in Princeton from the Empire State transmitter some 47 miles away. In addition, RCA picked up live talent in the Princeton laboratory studio, and delivered a full-color picture to the guests at the Princeton Inn, 2½ miles away.

Side by side the pre-war direct viewing picture could be compared with what is now possible. The improvement in overall brightness and contrast was clearly visible to all. With house lights on, the pre-war picture faded out, swamped by the ambient illumination, while the newer instrument seemed to suffer very little under increased room illumination.

The audience could compare projection pictures now ready for the market and the bigger and brighter pictures now attainable only in the laboratory. The sets demonstrated showed that those not bothered by the obsolescence bugaboo can have home television that is bright and full of detail as soon as manufacturers are able to put the sets on the market. Those who wish to wait for the millenium of color television will, according to RCA engineers and Mr. Sarnoff, miss about five years of the fun of having television at home.

The brighter and more contrasty black and white pictures give the illustion of having much more detail than the pre-war images. Major research will probably aim at improv-

1945-46 RMA BOARD OF DIRECTORS



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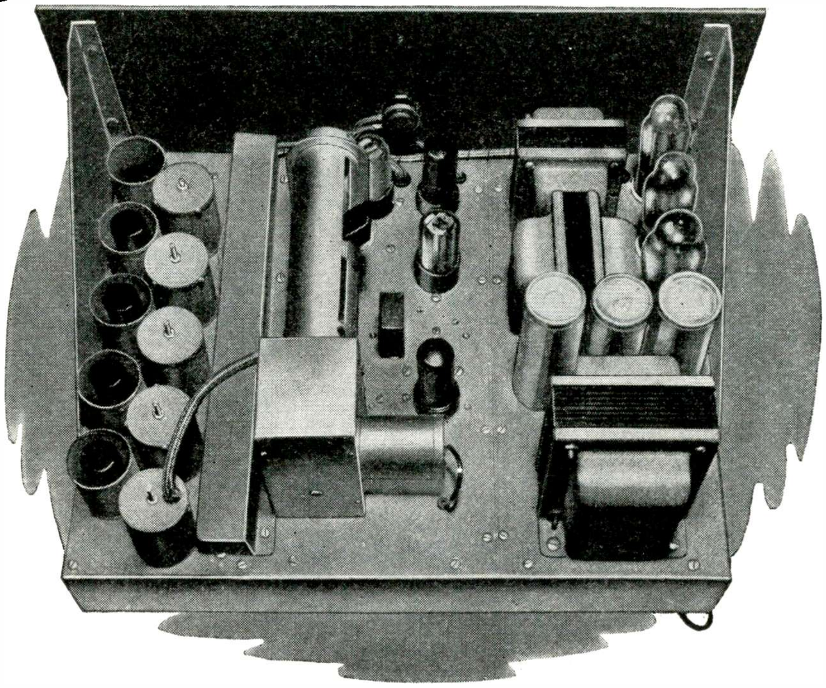
AM or FM



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LAVOIE NEW COMPLETE COMMUNICATIONS SYSTEMS for any application operating on any frequency between 100 and 3000 megacycles, provide all necessary equipment for consistent, efficient, economical performance. Engineered surveys of terrain assure adequate power for attenuation, correct antenna type and other factors necessary to good transmission and reception. LAVOIE Svstems are custom-built for single or multiple fixed frequencies, as desired.

QUICK FACTS: Crystal-controlled oscillator circuits embody new, high-efficiency harmonic generators. Receiver characteristics include a sensitivity of 3 microvolts at antenna terminals with a signal-to-noise ratio of 3 to 1, and 30% modulation for AM. Audio output power — 5 watts.

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RADIO ENGINEERS AND MANUFACTURERS

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ing the large-screen projection systems for home television receivers.

10,000-Mc Color Circuit

The color pickup from live talent employed the method of splitting the scene into its three constituent colors—red, green and blue—by mechanical filters, transmitting the three portions on a common carrier, and putting the components back together at the receiver. According to Mr. Sarnoff, no all-electronic method of color transmission is yet available and in his opinion color is not ready for the home until the mechanical filter arrangement can be done away with in favor of electronics.

In a method similar to variable-area sound recording on film, the sound in the color demonstration was put on the "edge" of the picture, the serrated border showing up in its characteristic form when proper adjustments were made to bring the edge of the picture to the center of the screen. Actually, the sound was transmitted on the same channel as the visual images, going on the air in the periods between synchronizing pulses.

The transmitter at the laboratories supplied an output of approximately 1/20 watt on a carrier frequency of 10,000 mc to a directional antenna. A velocity modulation tube furnished the output power at the transmitter. A channel approximately 12 mc wide was required.

The images at the receiver were exceedingly colorful and of good contrast. A slight flicker was visible, due to the fact that the number of frames had been reduced by a factor of three compared to black and white systems. The line detail was the same as black and white images, 525 lines.

Included in the demonstration was a system of stereo or three-dimensional color transmission in which the pickup scene and the received images were split into two halves, right and left, by means of Polaroid. Lookers-in used Polaroid glasses over the eyes to bring out the three-dimensional effect.

Radiation Lab Book Series

Publication of the Radiation Laboratory Technical Series, comprising twenty-eight books and a general index, will be undertaken by the McGraw-Hill Book Co. under an

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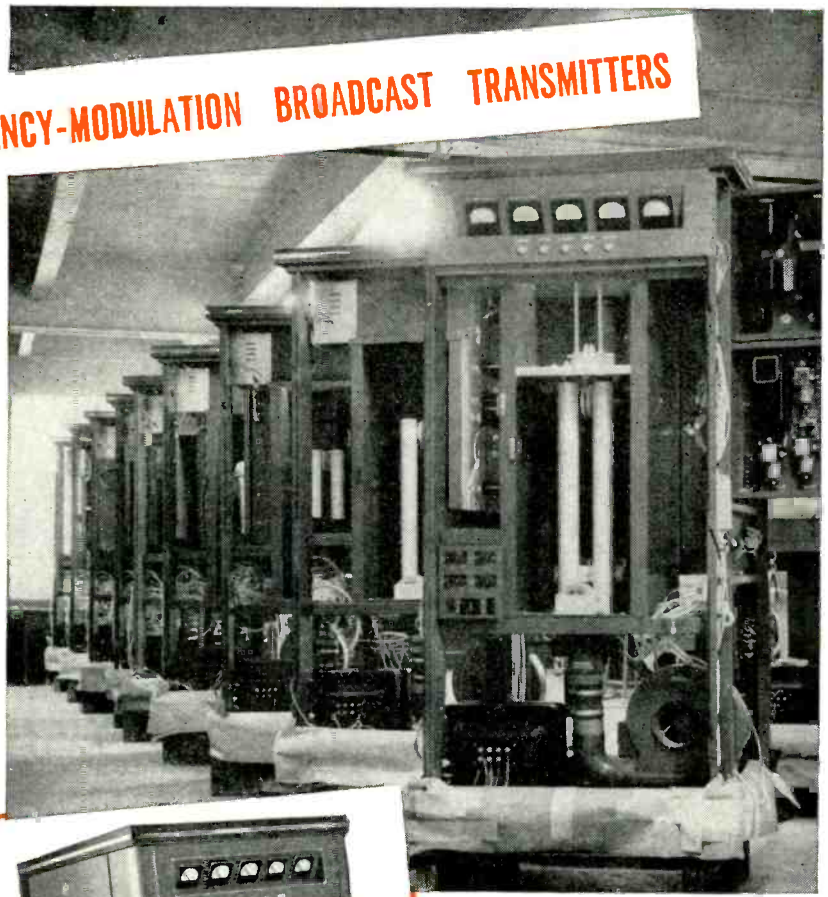
THE NEW 1000 WATT FREQUENCY-MODULATION BROADCAST TRANSMITTERS



Using the Armstrong Dual Channel Direct Crystal Controlled Modulator

Wire for Bulletin # 5006 for Complete Engineering Information on this transmitter

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RADIO ENGINEERING LABS., INC.
Long Island City, N.Y.

arrangement with the Massachusetts Institute of Technology, acting for the Office of Scientific Research and Development. The purpose of the series is to make available to science, industry, and the public generally the results of the immense developments in electronics and in microwave theory and technique during the war years, thereby providing the engineering foundation for postwar industrial developments in television, communications, and electronics.

For the first time, the technical literature of a large subject is being created all at once, on a uniform basis. Emphasis in the series will not be on radar itself, but rather on the basic techniques which underlie many phases of electronics in addition to radar. Royalties on the sale of the books will be paid to the U. S. Treasury.

Books of the series are being written chiefly by staff members of the Radiation Laboratory, but will include the results of work on radar done in British development establishments and in industrial laboratories both here and in England. Several British scientists have come to M.I.T. to cooperate in the preparation of the series.

The books cover many fields having great scientific and engineering importance, including precise timing techniques, new methods of cathode-ray tube display, generation, transmission, and radiation of high-power microwaves, and broadband amplifier techniques. Twenty-four of the titles planned for the series follow.

VHF Generators

The generation of high power microwaves is dealt with in a book on "Microwave Magnetrons" which presents the theory of operation of these oscillators as well as practical design considerations and operating techniques.

"Low Power Microwave Tubes" deals principally with the properties of reflex klystrons and lighthouse tubes when used as oscillators, amplifiers, rectifiers, and mixers.

Production of accurately timed pulses having various waveforms at high and very high peak powers is treated in "Pulse Generators."

Waveguides

Transmission line and waveguide techniques are discussed exhaus-

tively. "The Theory of Guided Waves" develops a basic theory of electromagnetic waves in waveguides. This draws from conventional field theory, circuit theory, and transmission line theory, but is directed to the solution of problems of importance in the microwave region. Maximum use of engineering concepts is made.

A "Waveguide Handbook" collects the analytical results given by the theory and presents all available numerical and experimental results in graphic form, chosen to be most convenient for practical circuit design.

"The Principles of Microwave Circuits" develops a generalization of low-frequency network theory and of the impedance concept. The properties of waveguide circuit elements and devices are developed and discussed in terms of this generalization.

"Microwave Transmission Circuits" treats from a practical point of view the same general matters. Design principles for connectors, rotary joints, and other waveguide and transmission line devices will be discussed, and examples of successful designs given.

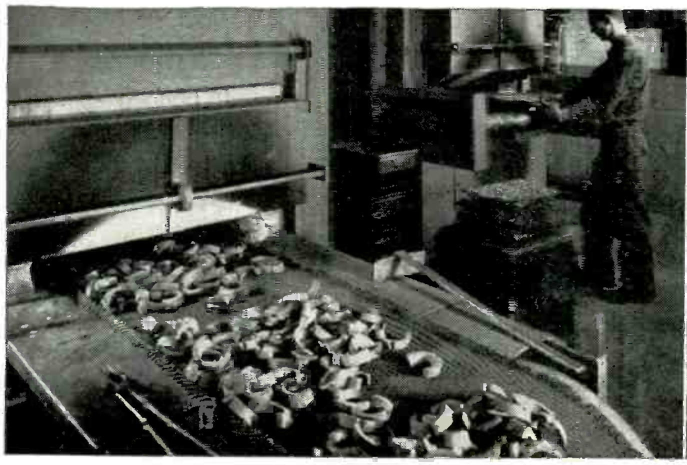
"The Techniques of Microwave Measurements" describes in detail the methods for measuring power and attenuation at high and low level, standing wave measurements, means for accurate determination of wavelength and frequency, r-f spectrum and pulse shape, and other means of measurement peculiar to the microwave field.

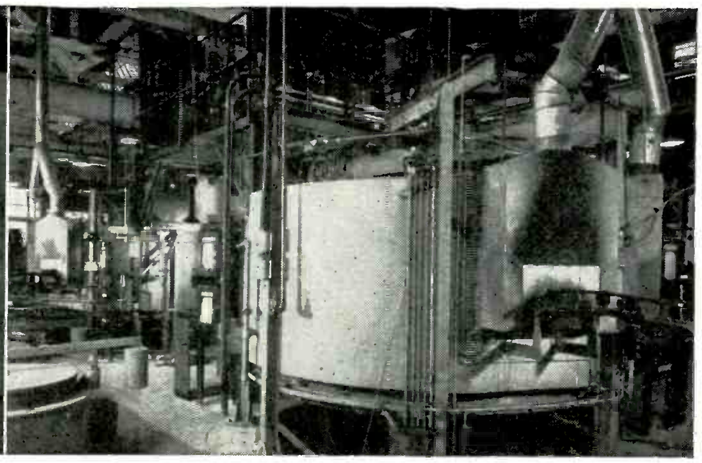
Antennas and Propagation

"Microwave Antenna Theory and Design" provides a survey of theory and design techniques for microwave antennas, a discussion of antenna measurement methods, and an indication of special methods used in antenna production.

"Propagation of Short Radio Waves in the Troposphere" summarizes the extensive wartime investigations of the propagation characteristics of radiation at frequencies too high to be affected by the ionosphere. The theory of atmospheric refraction, the meteorology of the refraction problem, and the experimental approach to the refraction problem will be followed by a treatment of matters which include target properties,

PERMANENT MAGNETS MAY DO IT BETTER





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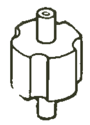
Proper techniques of heat treatment and cooling must be applied to produce the highest magnetic qualities in the various permanent magnet materials. The Alnico alloys, for instance, require extremely high temperatures and must be cooled at a carefully controlled rate, Alnico V being placed in a strong magnetic field during cooling, after which they must be drawn at precisely controlled temperatures. Exactness is imperative in these operations.

To provide the proper temperature cycles, continuous electric furnaces are utilized at The Indiana Steel Products Company. These furnaces were especially designed to provide the necessary temperature zones to produce highest magnetic quality, each one being controlled separately by an automatic pyrometer.

Our engineers will be glad to consult with you on any problems on the use and application of permanent magnets. For information on permanent magnet application, design and materials, write for the new technical "Permanent Magnet Manual." *The Indiana Steel Products Company*, 6 North Michigan Avenue, Chicago 2, Illinois.

Permanent Magnets May Do It Better



An Alnico Tachometer Magnet

ground and sea clutter, and molecular absorption.

Components

"Crystal Rectifiers" discusses the theory, properties, manufacture, and use of the silicon and germanium point contact rectifiers which have been developed for use as microwave converters and other circuit applications.

"Microwave Receiving Circuits" deals with the problem of frequency conversion and duplexing. Means of afc for a local oscillator are discussed, as are designs of mixers and duplexing assemblies.

A series of works on the design and application of vacuum-tube circuits is opened with the "Components Handbook" in which emphasis is placed on the specifications which components meet and on features of performance which are not usually given in other publications. It includes results of independent measurements of important properties of commercial components.

"Cathode Ray Tubes" describes methods for using such tubes, and includes discussions of focusing and deflection magnets and coils, the properties of fluorescent screens, and methods of constructing auxiliary apparatus such as projectors, magnetic shields, light filters, and the like.

Amplifier Circuits

"Vacuum Tube Amplifiers" deals with circuits which can be treated theoretically by linear circuit analysis. This book seeks to analyze completely many types of amplifiers, especially those of high gain, wide band pass, or large dynamic range.

"Waveforms" discusses basic circuits which include a non-linear element. These and other circuits for the generation and shaping of the form of current and voltage waves are analyzed. A treatment of their generation is followed by discussions of their manipulations, such as modulation, analysis, and frequency division.

Circuit Synthesis

"Electronic Instruments" deals with devices for the purpose of precision time measurement, data transmission, and mathematical computation. It emphasizes instrument function, gives details of engineered

circuit designs, and recommends preferred equipment types.

"Cathode Ray Tube Display Circuits" shows how c-r tubes may be combined with electronic circuits to provide a wide variety of measuring and precision data display devices.

The use of electrical and other time-variable indications in automatic control devices is discussed in "Automatic Control Systems." Basic principles for the design of electrical and mechanical feedback control systems are developed in detail, and application is then made to a series of automatic control problems such as automatic radar range and angle tracking.

"Microwave Receivers" describes many different types of complete receiving systems, suitable for radar, television, relay telephony, and repeat-back devices.

"Signal Thresholds in Interference" offers an analysis, both theoretical and experimental, of the factors affecting the perception of desired signals in the presence of various types of interference, principally receiver noise.

Radar and Loran Systems

"Radar Systems Engineering" is intended as a basic treatise and reference book for anyone interested in making any application of radar.

Applications of radar to problems of air and sea navigation are discussed in a volume entitled, "Radar Aids to Navigation."

In the book entitled, "Loran," a comprehensive treatment is made of the principles and engineering design of this war-born long-range navigational aid.

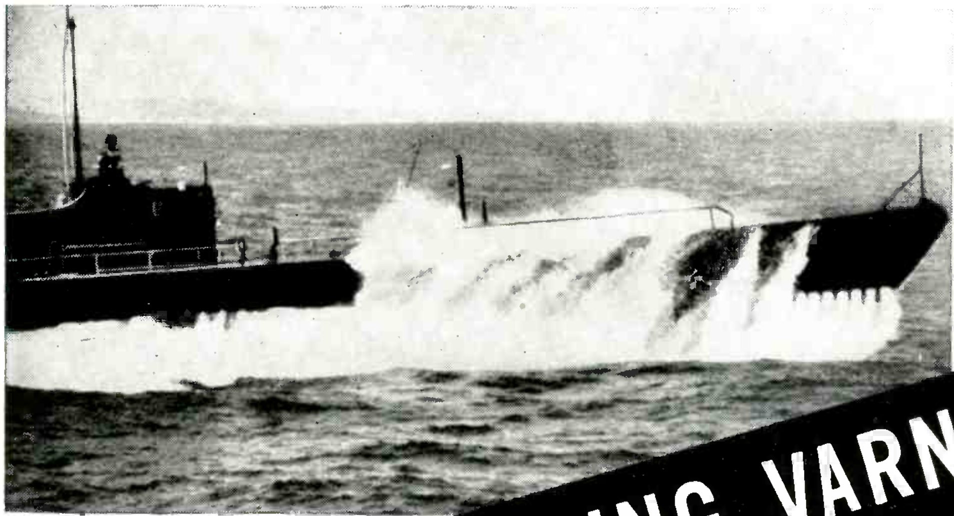
The final book is a general index providing cross-references among the various books.

Navy Demonstrates Pilotless Aircraft

FIVE RADIO-CONTROLLED pilotless drones were put through intricate air maneuvers at a recent Navy press show in Atlantic City, N. J. Combined with such things as television, influence fuses and atomic power, the pilotless aircraft or guided missile is a weapon which might well revolutionize techniques of national defense and methods of preserving the peace.

According to Rear Admiral H. B.

No electrical equipment can be any better than its insulation



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Sallada, Chief of the Bureau of Aeronautics, the extent to which we shall be able to conduct further research into the still relatively new field of pilotless aircraft depends on the money which is made available for that research. And on our ability to conduct that research depends, to large degree, our ability to defend ourselves and to preserve the peace.

Ghost Hellcat

As an example of completeness of radio control over an aircraft, the Ghost Hellcat is unique today. It is an outgrowth of Navy research which has emphasized remote control over standard aircraft rather than over the smaller target drones. The immediate application of the Ghost Hellcat is as a target for the heavy anti-aircraft guns of the Fleet.

The engineering staff at the Naval Aircraft Modification Unit, Johnsville, Pennsylvania, designed and installed the radio equipment which moves ailerons, flippers and rudder, controls the throttle and power setting, retracts and extends the landing gear, sets the flaps, steers the tail wheel, works the wheel brakes individually, makes automatic fuel tank selection and operates a smoke recognition device and fighting lights for night patrol.

The Ghost Hellcat is capable of operating consistently from a runway 150 feet wide by 2,000 feet long, with a 50-foot obstruction at the end and a 20-knot wind 50 degrees on either side of the runway. The Navy plans to convert 100 F6F-3s into Ghost Hellcats.

Original Drone

The TDD-3 is a primitive drone, an outgrowth of a gas-driven model airplane designed by Reginald Denny which incorporated a semblance of radio control. This small drone was extremely useful in training gun crews for light automatic anti-aircraft weapons. By war's end, a total of 18,856 TDD-3s had been used to train Fleet gunnery crews or were on order for further training.

The TDD-3 is launched by catapult and recovered by parachute. From the original model having a speed of approximately 50 miles an hour, a nine-foot wing span and conventional landing gear, the TDD has progressed to the present model with a speed of 140 miles an hour, a 137-

inch wing span and no landing gear. Gross weight has been held to within 150 pounds.

Dog-Fighting Drone

The fast KDR-1 standard drone is still considered experimental by the Navy, but is believed to have important possibilities as air-to-air opponent in training fighter pilots. Detailed attention to stream-lining by the Radioplane Company of Van Nuys, California, which developed the KDR-1, has made it possible for the 35-horsepower engine to develop a top speed of about 190 miles an hour. It carries enough fuel for an hour's flight over the firing line and may be recovered by parachute.

Kamikaze Drome

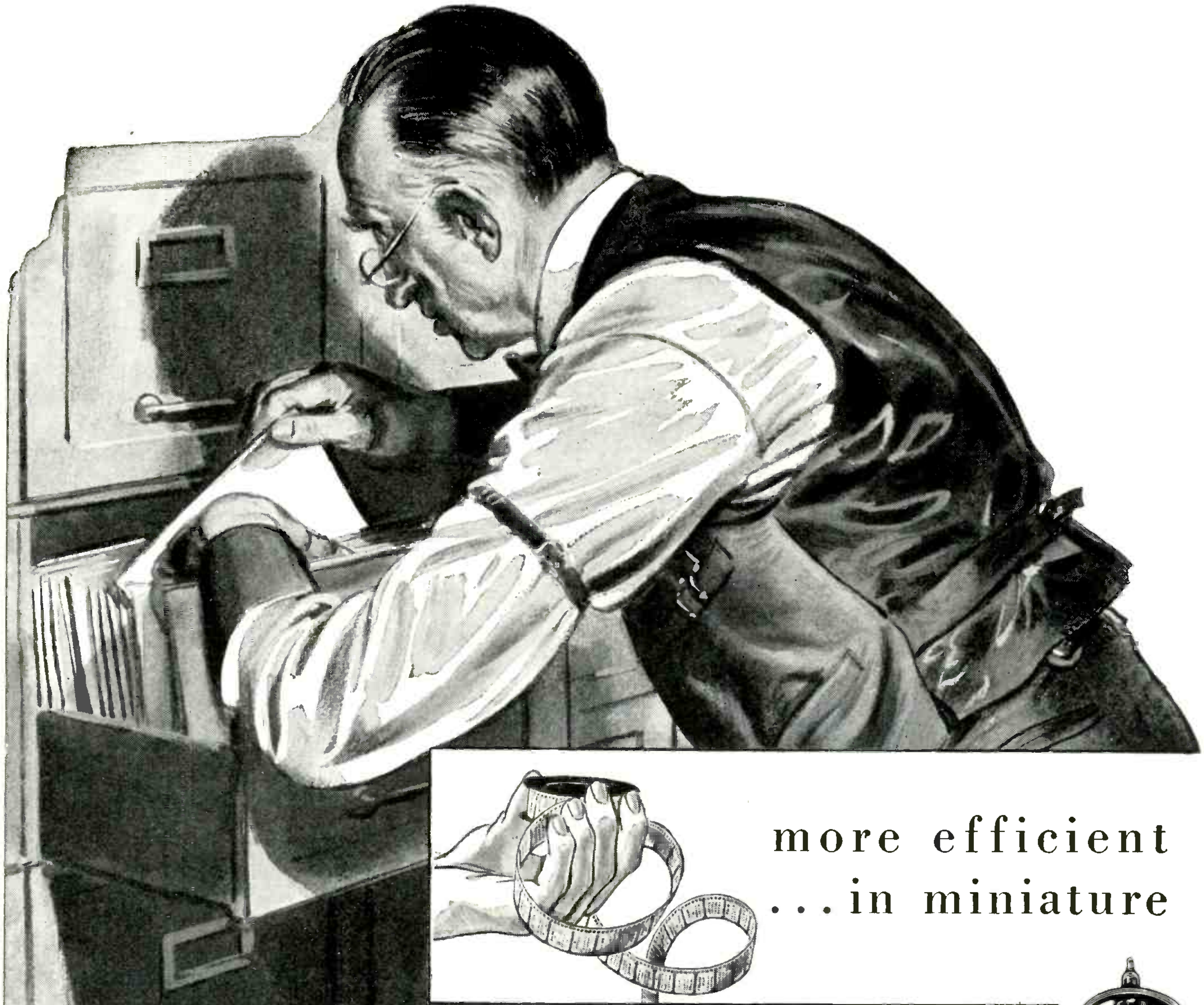
Considered the standard target aircraft, the TD2C-1 is capable of simulating high-altitude bombing runs, dive-bombing tactics, torpedo attacks and Kamikaze attacks. Speeds in excess of 300 miles per hour have been obtained during simulated suicide dive attacks designed to furnish fleet anti-aircraft gunners with a target comparable to that provided by the Japanese.

400-Mph Jet Drone

The jet drone is regarded as a formidable sparring partner for fighter pilots and anti-aircraft gunners. Powered by a Westinghouse 9 5-inch turbo-jet motor, the KDN-1 can provide simulated attacks at speeds greater than 400 miles an hour in level flight. It is launched from a patrol plane.

MIT Acoustics Laboratory

A NEW ACOUSTICS LABORATORY providing facilities for basic research and fundamental training in several fields of acoustics has been established by the Massachusetts Institute of Technology. The Director of the laboratory is Professor Richard H. Bolt of the Department of Physics. The over-all program of teaching and research is coordinated by a supervisory committee consisting of Philip M. Morse (Chairman), Professor of Physics; Richard D. Fay, Associate Professor of Electrical Communications; Lawrence B. Anderson, Professor of Architectural Design; and Julius A. Stratton, Professor of Physics, Director



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ACTUAL SIZE

A roll of microfilm about the size of a typewriter ribbon is the equivalent of the many cubic feet of filing space necessary to store records in the original paper form. Filing for record in miniature is the same trend toward efficiency as the controlling of electronic circuits with miniature tubes.

Tung-Sol Miniature Tubes and smaller component radio parts mean a reduction in the over-all size of radio equipment. Miniature Tubes are characterized by short leads, making for low lead inductance; low inter-element capacities and high mutual conductance. These factors make Tung-Sol Miniature Tubes distinctly superior in performance when used in high frequency circuits. Miniatures are constructed with smaller and lighter parts. This makes possible a more rigid construction that is more impervious to the effects of vibration and shock.

The experience of Tung-Sol engineers in designing circuits and selecting tubes is offered to manufacturers wishing to improve their present electronic equipment or to create new. All plans disclosed in consultation will, of course, be held in strictest confidence.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

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Sales Offices: Atlanta • Chicago • Dallas • Denver • Detroit • Los Angeles • New York

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors of the Research Laboratory of Electronics.

Some of the fields of investigation in the present five-year program are (1) physical properties of acoustic materials and structures, (2) functional acoustic design in architecture, (3) noise generation in high speed air flow, (4) electroacoustic instrumentation, and (5) supersonic investigations in solids, liquids, and gases.

Some of the supersonic studies in basic physics are being extended to very high frequencies through applications of microwave techniques. This part of the program is being done in collaboration with the recently established Research Laboratory of Electronics.

Previously established acoustics facilities at MIT include a microphone calibration system installed in a sound-deadened room; a sound and vibration-isolated room adaptable for reverberation and other acoustic studies; special equipment and small chambers for investigation of sonic and supersonic problems, filters, transmission lines and acoustic impedance-measuring equipment.

Special apparatus has been constructed for measuring supersonic absorption and reflection from materials under water. This equipment is currently being used for investigations in the range from 10 to 100 kc. Supersonic generating and pulsing equipment is being applied to basic research in the 10 to 100-mc region.

Radar-Guided Bombs Launched by Navy Planes

FULLY AUTOMATIC guided missiles launched from Navy planes and accurately guided by radar to targets miles away destroyed many tons of Japanese combatant and merchant shipping during the last year of the war, the Navy Department has revealed. This guided missile, having the code name Bat, was directed by the radar echoes from its target. Its radar robot pilot could sense the target under any conditions of visibility, required less space than a human pilot, and reacted much faster.

Launched from Navy Privateer patrol bombers flying outside the range of the intended victim's guns, the Bat became completely automatic when released. Any evasive maneu-

vers of the target ship were promptly followed by the weapon, while its small size and high speed made it almost immune to Japanese antiaircraft fire. The Privateers were equipped to carry a Bat under each wing.

In using the Bat, the crew of the mother plane locates the target, tells the bomb which ship to hit and pushes the release button. The released bomb flies straight to the ship selected, even when it is one of a large convoy, while the launching plane is free to proceed as its pilot wishes. The target has to be positively identified, however, for the robot pilot cannot distinguish between friend and foe.

The radar-guided bomb is approximately 12 feet long, has a 10-foot wing span, and carries a heavy explosive load. Its speed is comparable to that of a plane and its range great enough to allow the mother plane to operate well out of the enemy's longest-range antiaircraft fire.

Conventional bombing of ship targets from outside the range of antiaircraft fire yields a very small percentage of hits. The Bat's great accuracy is not affected by the distance to the target. In revealing the use of this heretofore secret weapon, Rear Admiral George F. Hussey, Jr., U.S.N., Chief of the Bureau of Ordnance, stated that it is now considered obsolescent, although some of its principles may be applicable to weapons of the future.

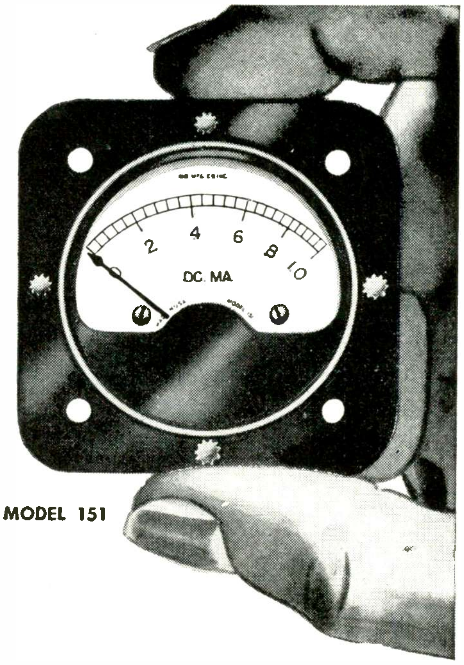
Development of the radar robot pilot was the work of scientists of the Massachusetts Institute of Technology, Cambridge, Mass., headed by Ralph Lamm and Dr. Perry Stout, and of the Bell Telephone Laboratories, where Russell C. Newhouse was in charge.

Ferry Radar Authorized

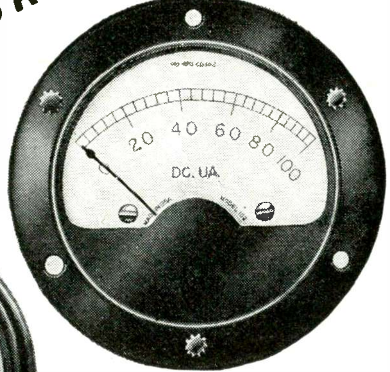
SPECIAL TEMPORARY authority to install and operate experimental radar equipment on the stream-lined ferry *SS Kalakala*, operated by the Puget Sound Navigation Co. between Seattle and Bremerton, Washington has been granted Raytheon Mfg. Co. by the FCC. The system will be used to determine operating requirements for similar ship installations all over the world.

The location and ship run was

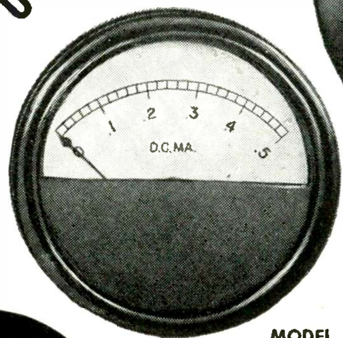
ROUNDING OUT THIS QUALITY LINE



MODEL 151



MODEL 152



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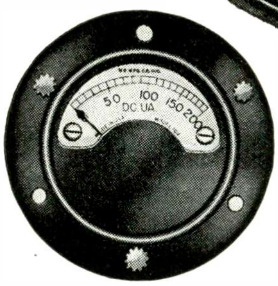
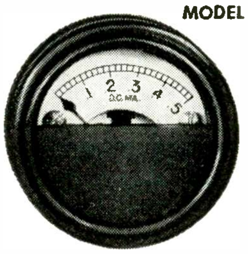


MODEL 102



MODEL 100

...A SQUARE MB 1½" METER

HERE'S THE MODEL squared to your plans. But you'll find this new miniature meter gives you more than just symmetry. There's *performance*, comparable to that of larger meters, in its responsive and sensitive movement.

This movement is the same as you'll find in the MB round models . . . carefully calibrated—and accurate to within the 2% AWS specification. Expertly designed and soundly manufactured, it assures you meters well able to stand up in long, hard service. From jewel bearings to ultra-fine wire, materials are of highest quality . . . skillfully assembled into one of the smallest elements available. It saves valuable space and important weight.

The anodized case mounts through a round panel opening and is screw-fastened. It has been economically produced . . . to make this model *economically priced!*

Model 151 is produced in all standard DC ranges, rectifier AC voltmeters and milliammeters, and thermocouple-type instruments. Write for further information on both this model and the round series . . . or for any special adaptations.

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MB
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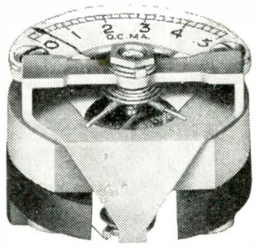
Instrument Division
331 East St., New Haven 11, Conn.



Here's the high-precision element in MB ammeters, milliammeters, microammeters, voltmeters, millivoltmeters. It's also available uncased for direct incorporation with your product.

INSTRUMENT DIVISION

ELECTRICAL METERS FOR AIRCRAFT AND PORTABLE EQUIPMENT

chosen because of the particularly difficult navigational problems. On a large percentage of days the fog obscures the run and the *Kalakala* must thread its way through the tremendous quantity of shipping in the busy Puget Sound area, where the narrow passages will afford an unusual opportunity to test the value of radar.

Frequency Allocation Changes

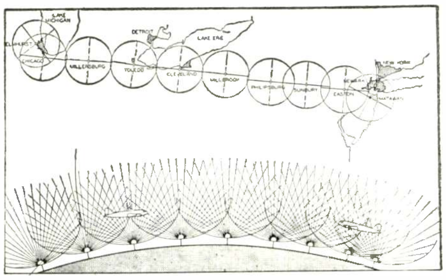
DEVELOPMENTS in various types of equipment used as aids to air and marine navigation have necessitated a number of minor modifications in FCC frequency allocations (p 92, July 1945 ELECTRONICS). The new allocations are as follows:

BAND (MC)	U. S. ALLOCATION
960-1215	Navigation Aids
1215-1295	Amateur
1295-1375	Non-Govt. (Television Relay)
1375-1425	Non-Govt.
1425-1600	Govt.
2900-3700	Navigation Aids
3700-4000	Non-Govt.
4000-4200	Air Navigation Aids (Altimeters)
4200-4400	Non-Govt.
8500-9300	Govt.
9300-9600	Navigation Aids
9600-10000	Govt.

The changes between 960 and 1600 mc are designed to provide additional spectrum space for navigation aids. Recent developments in altimeters have indicated the desirability of moving the air navigation aid band from 3700-3900 mc to 4000-4200 mc. The changes between 8500 and 10000 mc were made to permit the licensing of radar installations between 9300 and 9600 mc for use by the merchant marine. Racons are placed on 3256±3 mc with guard band 3246-3266 mc and on 9310±3 mc with guard band 9300-9320 mc.

VHF Radio Ranges

VERY HIGH-FREQUENCY radio equipment, to operate between 108 and 132 mc, is being installed in all United Air Lines planes. The new



New York-Chicago radio skyway, showing locations of new CAA vhf radio range transmitters

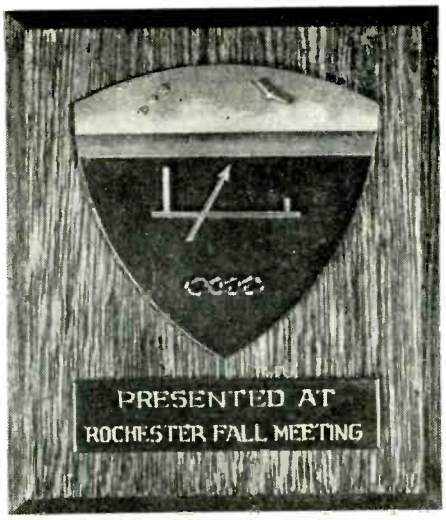
equipment will operate in conjunction with the vhf radio ranges installed by the Civil Aeronautics Administration and with glide-path receivers for instrument landings, as well as provide two-way communication between planes and ground stations. The ranges will be of the visual type, actuating a left-right indicator on the plane's instrument panel.

4,000-mc Television Relay

A CHAIN OF MICROWAVE relay stations between Milwaukee and Chicago, costing about $500,000 and using initially a frequency in the 4,000-mc range, is scheduled for completion in the spring of 1947. The application is now on file with the FCC. Three intermediate stations about 25 miles apart will be employed, near Barrington, Illinois, Wilmot, Wisconsin, and Prospect, Wisconsin. The towers will be 120

RADAR ACHIEVEMENT PLAQUE

Dr. Lee DuBridge, with plaque he received at 1945 Rochester Fall Meeting for his contributions to the development of radar apparatus. Among the symbols are the pips of an A-scope radar presentation, on which is superimposed an arrow representing the direction vector for radar spotting of a plane



Electro-Voice ANNOUNCES THE CARDAX

A NEW Cardioid Crystal Microphone

with Revolutionary New MECHANOPHASE* Principle of Unidirectivity . . . Dual Frequency Response . . . High Output . . . and other big features!

Here, for the first time, you get *all* these features in *one* microphone! With amazing flexibility, new CARDAX efficiently serves many applications . . . easily solves everyday problems of sound pick-up and reproduction!

★ **TRUE CARDIOID POLAR PATTERN** New E-V Mechanophase* principle gives wide-angle front pick-up in true cardioid pattern over wide frequency range. Sound at rear *dead* zone cancels out and is not reproduced.

★ **STOPS FEEDBACK—CUTS BACKGROUND NOISE AND REVERBERATION PICK-UP** Permits nearly double usable loud speaker volume. Simplifies microphone and speaker placement. Assures finer reproduction of just the sound wanted.

★ **DUAL FREQUENCY RESPONSE** Screw control on back gives (a) Wide range flat response for high fidelity sound pick-up or (b) Wide range with rising characteristic for extra crispness of speech or high frequency emphasis.

★ **HIGH OUTPUT LEVEL** —57 db for flat frequency response. —48 db for rising frequency response.

★ **VOICE AND MUSIC PICK-UP EXACTLY AS DESIRED** Ideal for public address, recording, remote broadcast, communications . . . indoors and outdoors.

★ **FULLY EQUIPPED FOR CONVENIENT OPERATION** Tilting head. Built-in "On-Off" switch. Dual frequency range selector switch. Cable connector. 20 ft. cable. Bimorph crystal. 5/8"-27 thread. New modern functional design. Satin chrome finish. **CARDAX Model 950, List Price........$37.00**

Licensed under Brush Patents. Electro-Voice Patents Pending.

EXCLUSIVE NEW MECHANOPHASE* PRINCIPLE DEVELOPED BY Electro-Voice

Utilizes a phase shifting diaphragm to produce a high degree of unidirectivity at all frequencies. Gives true cardioid characteristic by nullifying back pick-up. Unlike any previous method of obtaining unidirectivity and has many important advantages.

*Patents Pending

SEND FOR BULLETIN NOW

Get full facts about amazing new CARDAX! Describes Mechanophase. Shows how dual frequency response selector works. Includes diagrams and response curves.

No Finer Choice Than **Electro-Voice MICROPHONES**

ELECTRO-VOICE, INC., 1239 South Bend Ave., South Bend 24, Indiana
Export Division: 13 East 40th St., New York 16, N. Y., U.S.A.—Cables: Arlab

feet high, so that the line-of-sight beam will clear the 104-foot curvature of the earth at the midpoint between towers. The link is to be park of the nationwide network of interconnected coaxial cables and radio relay channels now under construction by American Telephone and Telegraph Co. It will be employed for television transmission in cooperation with the Milwaukee Journal television station WMJT, as well as for communication purposes.

Radio for Irrigation

AUTHORITY TO CONSTRUCT a radio system to be used in the operation of irrigation networks serving 100,000 acres of rice and other crops has been granted the Garwood Irrigation Company of Garwood, Texas, by the FCC. This radio system will substitute for present communication by messengers traveling horseback or by automobile.

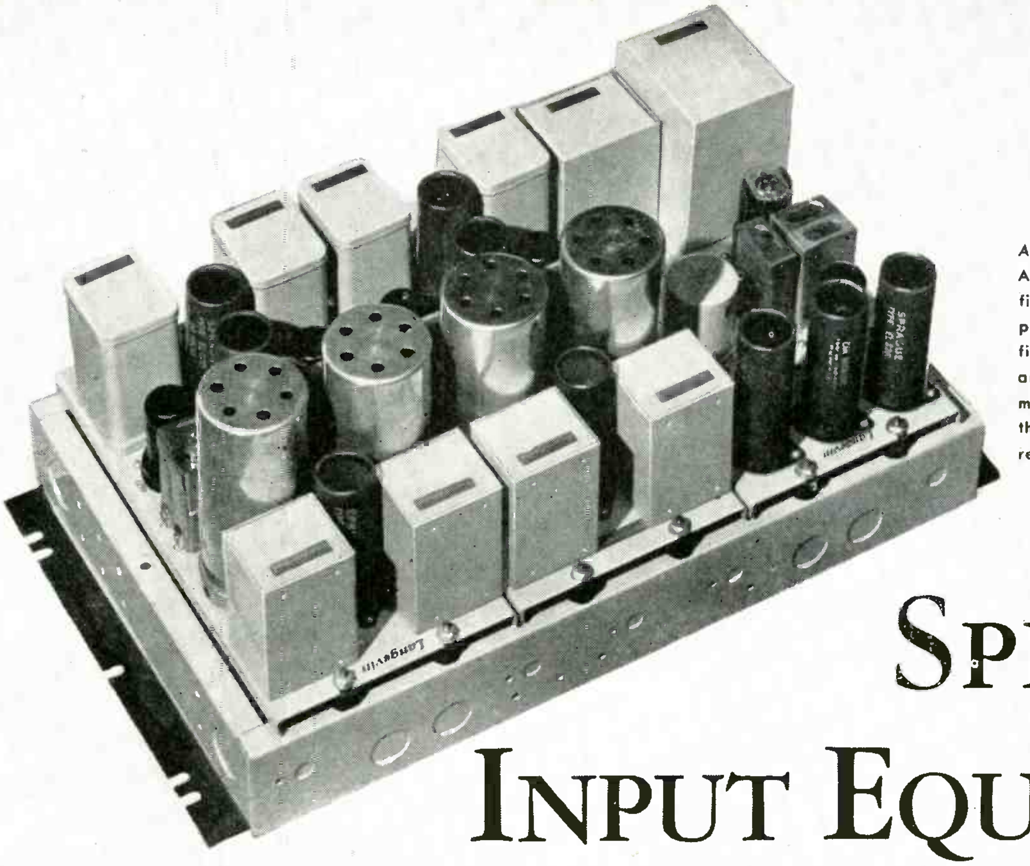
The frequency assigned is 35.46 mc. Frequency-modulation telephony will be used, with one land station, two 50-watt portable and mobile units, and four 35-watt mobile units.

Disposition of German Electronic Equipment Industry

A FORMAL REPORT, "Treatment of the German Electronic Equipment Industry from the Standpoint of International Security" has been issued by a subcommittee headed by Ray C. Ellis, FEA consultant and formerly director of the WPB Radio and Radar Division, now with the Applied Physics Laboratory of The John Hopkins University, Silver Spring, Md. While the recommendations therein do not represent the adopted policy or program of the United States, they are regarded as likely to play an important part in forthcoming international conferences.

As used in this report, electronic eqquipment is defined as any type of equipment, including components thereof, making use of the control features of a vacuum or gaseous tube containing two or more elements.

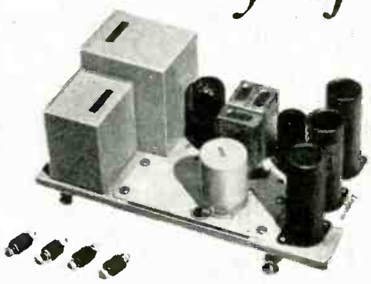
The report emphasizes that electronics has emerged as one of the leading factors in successful modern warfare. A perpetual program for regulation of production of electronic equipment is therefore essen-



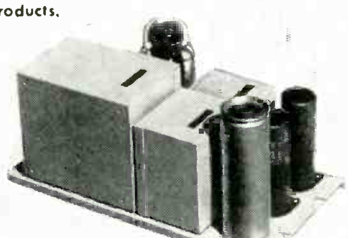
AT LEFT. Two Langevin Type 111-A Dual Pre-Amplifiers and one Langevin 102-A Line-Amplifier mounted on a 3-A Mounting Frame. This unit provides four pre-amplifiers and one line-amplifier, or three pre-amplifiers, one booster-amplifier and one line-amplifier, all in 10½" of rack mounting space. External power supply such as the Langevin 201-B Rectifier, as shown below, is required.

Speech Input Equipment

Worthy of an Engineer's Careful Consideration



TYPE 102A Amplifier is one of the 102 Series Line Amplifiers of which four different types are available. The "A" is mostly used to drive the line after the master gain control. It is quiet, has excellent frequency characteristic and ample power output with low distortion products.



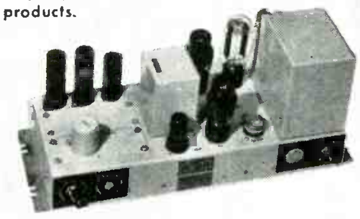
The 201-B Rectifier is one of the 201 Series Rectifiers, of which two types are available, the "B" having additional filtering, thereby giving a slightly lower ripple content than the "A." This unit is capable of supplying power for one 102 Series Line Amplifier and three 111 Pre-Amplifiers (six pre-amplifiers).

Every unit of Langevin speech input equipment is held to a rigid standard of performance. These units may be cascaded in accordance with good engineering practices and still be well within the allowable limits of FM requirements as to frequency response, noise and distortion products.

All Langevin speech input equipment units are mounted on standard 5¼" x 10¼" chassis. Three of these units can be mounted on a Langevin 3-A Mounting Frame, which occupies 10½" of space on any standard rack. Wall mounting steel cabinets for housing these units are also available.

We are proud of the products which bear the name ***Langevin.*** It will only appear on good apparatus.

The 111-A Amplifier consists of two individual pre-amplifiers on a single chassis for use in high quality speech input equipment. Its compact unitized construction saves rack space. Input impedances of 30, 250 and 600 ohms; output impedance 600 ohms. It is quiet and has excellent frequency characteristics and ample power output with low distortion products.



The 108-A Amplifier is one of the 108 Series Monitor Amplifiers, of which four different types are available. The "A" is ordinarily used to drive a monitor system from a 600 ohm or bridging source. Its distortion is low for this type of service. It is quiet and has ample power output with excellent frequency characteristics.

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK	SAN FRANCISCO	LOS ANGELES
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tial to prevent redevelopment of a war potential in Germany, yet absolute prohibition of electronic research and production is neither sufficient nor feasible. Oppressive measures might only temporarily remove war potential, driving the German people to smuggling and clandestine production and leaving a supply of electronic technicians free to band together in some other country to develop and produce war weapons. Certain electronic equipments having uses only as war weapons should be prohibited from both production and importation, according to the recommendations, with the list of banned items being reviewed constantly in the light of new developments.

Status of Broadcasting

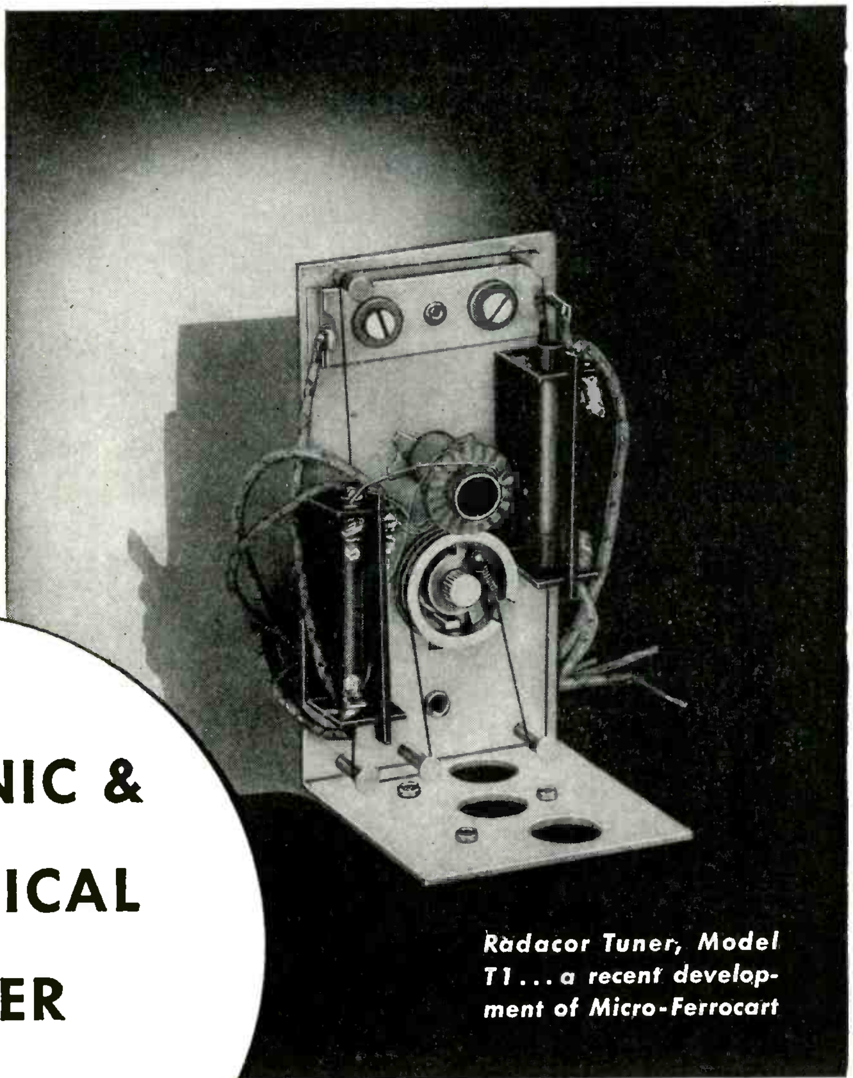
Continuance of domestic radio production is urged, with no listeners' registration or license fee, and with perhaps a doubling of the number of entertainment receivers in homes and inclusion of short-wave bands in new sets to permit reception of stations outside of Germany. Production and assembly facilities for tubes, transformers, capacitors, resistors, and end equipment in the domestic radio field should be permitted but restricted to one city or district so as to permit inspection. Exports of radio and electronic equipment or parts would be prohibited to help insure keeping of productive capacity within the limits of domestic requirements and to prevent other countries from developing a dependence on German equipment. Electronic research should be permitted and encouraged but kept under close observation.

Prohibited Items

Production of all items in the following list would be banned, and existing facilities for production would be confiscated along with existing stocks of equipments:

Television. Many special items, such as special cathode-ray tubes, Iconoscopes and certain other special devices can be clearly identified as part of television equipments. These, as individual items, should be prohibited together with completed transmitters and receivers, including the building or manufacture of the special circuits necessary.

Pulse Circuits (Radar). Up to



Radacor Tuner, Model T1 . . . a recent development of Micro-Ferrocart

ELECTRONIC & MECHANICAL POWDER METALLURGY

MICRO-FERROCART's

Electronic & Mechanical Powder Metallurgy provides a faster, more efficient method of production with no decrease in the quality, appearance, and durability of the finished product . . . a definite step toward that economy in manufacture demanded by post-war competition.

Our engineering staff and complete laboratory facilities are available to help you in determining how these methods may be turned to profitable use in your plant.

Write us today for complete information.

ELECTRONIC & MECHANICAL POWDER METALLURGY

MICRO-FERROCART PRODUCTS DIVISION

MAGUIRE INDUSTRIES, *INCORPORATED* 375 FAIRFIELD AVENUE, STAMFORD, CONN.

the present time, pulse circuits have not been used in any peace-time pursuits. Although those circuits hold forth great possibilities in airways control and navigation identification, there will be a large excess of such materials at the end of the war. It is considered unnecessary that any of this equipment be built in Germany; there will be ample supply for importation in case German airways (under the control of the Allied Nations) need such equipment. A careful screening of components manufactured for ostensibly simple circuits will be necessary in the component field to assure the control group that such components could not be used in pulse work.

Specialized Military Equipment. No circuit designs should be allowed and no equipment built, such as radio link sets, receivers and transmitters capable of withstanding the rigors of permanent moving and heavy handling. Components capable of being used in these circuits should be prohibited unless needed by other activities.

Under-Water Sound (Sonar). This equipment is highly specialized and most of the components can be readily recognized. It should be prohibited in toto.

Facsimile and Picture Transmission. It is possible that other industries, such as telephone and telegraph and broadcasting facilities may need some of this equipment. However, it is recommended that it be imported during the first period of rehabilitation and that its manufacture be prohibited.

Marine Radio Equipment. The special rigors and hardships to which this equipment is subject should be easily recognized. This equipment should be prohibited and its components carefully screened before any are allowed to be manufactured.

Amateur Equipment. It is the recommendation of this committee that amateurs not be allowed to carry on any activity within Germany for an interim period. Therefore, there would be no necessity for the building of amateur transmitters and receivers. This activity requires a different control in that individuals purchase parts and assemble their own equipment. This type of control should be put on and the work of such amateurs prohibited.

Test Equipment. Test equipment

★

CONTRACT MANUFACTURING

...as an Industry Policy

Industry has always purchased functional parts such as carburetors, fractional motors and such from other makers. But it took the war to spread the practice of contracting the manufacture of special assemblies.

Speed was the emphasis then, and cost was secondary. But with reconversion, cost reassumes its normal importance.

Speed and Economy Can Team Up!

Like hundreds of others we did our share of manufacture for others during the war—perhaps we got more than our share. In looking for the reason, perhaps there's something to the idea that we've been at this contract manufacturing business for more than 50 years. Just by the law of averages, we ought to know the business.

And since ours was not a war baby fed on the easy cost-plus formula, we should also be able to cut a few corners on costs too. For we were brought up with a stop-watch in one hand, a finely sharpened pencil in the other—and a group of hard-boiled cost-minded peace-time primes looking over our shoulder.

Why not "Call our Bluff" (?)

Maybe we can show *you* something on costs that will cause you to contract some of those assemblies you were planning to make yourself. Maybe we can do it just as fast (maybe faster) and save you a lot of headaches, labor and equipment problems.

Why not check us on the possibilities in this suggestion? It won't cost you anything to look into it with us—and it may save you both time and money.

★ ★ ★

Write on your business stationery for 48-page book, "Let Lewyt Do It"—the story of the Lewyt organization in pictures. Lewyt Corporation, 62 Broadway, Brooklyn 11, N. Y.

Lewyt

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BONDS

FOR MORE THAN 50 YEARS A CONTRACT MANUFACTURER ... EXPERTLY STAFFED TO PRODUCE COMPLETE ELECTRONIC AND MECHANICAL ASSEMBLIES, COMPONENT PARTS, SUB-ASSEMBLIES AND METAL PRODUCTS TO THE MOST EXACTING REQUIREMENTS

applicable to all of the above may be difficult to recognize in many cases where the equipment is used in common with regular industrial activities and still may be used in the specialized equipment. A very close check on the quantity manufactured and the location of the equipment should be kept. Items of test equipment designed and used especially with the above items of equipment should be prohibited.

Vacuum Tubes. In order to control the production of vacuum tubes it will be necessary to index all types of German tubes with their characteristics and then determine what tubes are necessary for a peace-time economy. It is not believed that a generalized limiting specification on vacuum tubes is feasible. For example, the services have approximately 8,000 different tube types and an examination of this list reveals no general specification which would separate those necessary for peace-time use and those of military value only.

German Companies

Electronic equipment in Germany has been manufactured by about 50 companies with approximately 160 plants located throughout the country. Five companies—C. Lorenz, Osram, Siemens & Halske, Telefunken, and A. E. G.—have dominated the field. Electronic tube manufacture has been controlled almost exclusively by Telefunken. Although the major part of the research in this field has been conducted by the larger firms such as Telefunken and Siemens & Halske, the Government has kept in close contact with such developments through the Reichpost Ministry. This agency is the civilian communications organization of Germany. It carries on its own research, finances numerous development projects through its Institute of Research and Experiment, and keeps records on new inventions in the field of communications.

From 1930 to 1938 there was a program of standardization which in general reduced the number of types of electronic parts by from 65 to 98 percent. Together with her program of standardization, Germany kept the specifications for commercial components to such strict standards that they would serve equally well in military equipment. Prices of finished sets reflected these

LORD
SHEAR TYPE
Bonded Rubber
MOUNTINGS

FOR a generation Lord has been answering one question: How can vibration be controlled? The question has come from a hundred industries, in a hundred different forms. As speed has been multiplied and power added to power; as advancing science has created new devices, requiring greater precision and more complete isolation from outside disturbance, the solution has become more complicated.

In finding the answer to such difficult problems, Lord has frankly had three advantages over the field. Through years of laboratory testing and field applications, Lord has gained an undisputed leadership in its scientific knowledge of vibration forces. In its exclusive method of using Bonded Rubber *Stressed in Free Shear,* it has the best known agency for meeting them. Through unbiased specialization, it has developed the most effective application of that agency for each individual problem.

Every genuine Lord Mounting carries the name "LORD" embossed in the rubber or in raised letters on the forgings.

IT TAKES BONDED RUBBER *In Shear* TO ABSORB VIBRATION

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★
BUY VICTORY BONDS
★

Originators of Shear Type Bonded Rubber Mountings high standards. In 1938 the cheapest superheterodyne sold for $74, an average large table model cost from $215 to $260, and consoles ran as high as $600. These prices of finished sets coupled with government encouragement stimulated amateurs and laymen throughout the Reich to purchase components and assemble their own sets. Industry was placed in a position to build the finest types of components which could be either sold to the public or used for military assemblies. There was thus no problem of conversion for war; it was simply a matter of accelerating and diverting production to military equipment.

H-F Heating Conference

APPLICATION OF electronic heating in the Los Angeles area was stimulated by a series of practical papers presented at a recent conference held in that city under the auspices of the Pacific Coast Electrical Association. Cooperating societies included AIEE, American Society for Metals, American Welding Society, American Society of Industrial Engineers, American Society of Mechanical Engineers, Society of Automotive Engineers, Electrical Maintenance Engineers Association, and the Society of the Plastics Industry.

Stressed by most of the speakers was the fact that high-frequency techniques will be required by industries which desire to maintain a competitive position. Topics covered include heat treating, melting, heating for forming, and heating for joining of metals; sterilizing and otherwise treating foods and pharmaceuticals; and processing lumber for furniture and construction. Each session ended with demonstrations of full-scale equipment.

Following is a list of the papers and their authors:

Frequency Effects in Induction and Dielectric Heating, by R. A. Nielson, Westinghouse Electric Corp.

Electronic Equipment Application for Induction Heating, by W. S. Williams, Allis-Chalmers Mfg. Co.

Sources of High-Frequency Current and their Characteristics for Induction Heating, by Harlan A. Messner, Ohio Crankshaft Co.

Application of High Frequency to Production Heat Treating and Annealing, by Fred M. Arnold, Norris Stamping and Mfg. Co.

Melting and Forging of Metals with Induction Heating, by J. Max Lee, Ajax Electrothermic Corp.

The Electronic World of Today and Tomorrow, by Kenneth A. Smith, Electronic Chemical Engineering Co.

Heat Treatment of Metals, by R. W. Steenrod, General Electric Co.

Pre-Heating and Stress Relieving with Induc-

Night aerial photo of St. Lo in Normandy on D-Day. Taken with the new "super" flash tube.

During the closing stages of the war, many a lone plane, traveling fast at medium altitudes, would roar over enemy territory in the dead of night.

As it winged over certain areas, an intermittent series of blindingly brilliant flashes would dart like lightning from its belly.

Then, the plane would speed away.

Such planes were on photo reconnaissance. Each was equipped with a "super" flash tube a thousandfold brighter than a news photographer's strongest flash bulb. In its split-second bursts of dazzling light, nocturnal troop movements were easily filmed from altitudes as high as 10,000 feet.

How the "Super" Flash Tube Works

The source of light is a 4,000-volt discharge between two electrodes in a coiled quartz tube filled with a rare gas. The outer container is a cylinder of Pyrex.

A single discharge gives plenty of light *...and plenty of heat.* It is this intense heat that has made Inconel the choice for the springs, clips and wire used to support the quartz coil within the Pyrex cylinder.

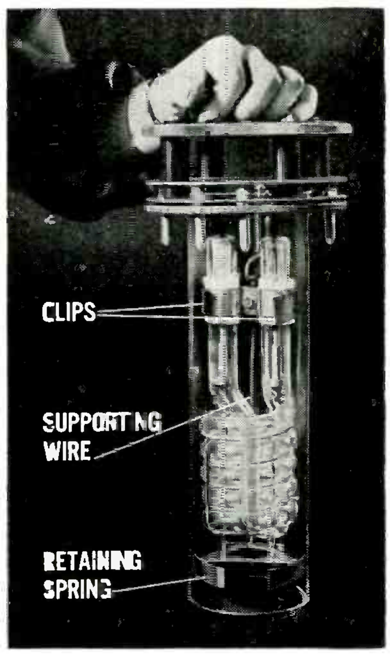
No other metal could stand up under such extreme temperatures. Before Inconel was used, previous supporting metals either lost their springiness or became distorted.

With Inconel on the job, there has been no trouble. This high-Nickel alloy retains its properties at elevated temperatures... doesn't scale away... never rusts.

Thermally durable Inconel is used on many jobs where high heat is a problem. Perhaps in your product, too, you can use Inconel in some form *"to build-in the performance you plan."*

Detailed information on this INCO Nickel Alloy is given in Technical Bulletin T-7, "Engineering Properties of Inconel." For your copy, write:

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.



The "super" repeating flash tube built by General Electric's Lamp Department, Nela Park, Cleveland, Ohio. Arrows indicate the metal supporting parts.

Possible peacetime uses for the flash tube's sudden bolts of sun-like radiance include aerial beacons, marine lighthouses, and scientific photography.

NICKEL INCO ALLOYS

TRADE MARK

MONEL* • "K" MONEL* • "R" MONEL* • "KR" MONEL* • "S" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL* • *Sheet... Strip... Rod... Tubing... Wire... Castings... Welding Rods (Gas and Electric)*

*Reg. U. S. Pat. Off.

tion Heating, by Lombard Smith, Lombard Smith Co.

Application of High Frequency Heating to Silver Brazing and Soldering, by John Ross, Handy and Harmon.

Recent Developments in Design of Dielectric Heating Equipment, by V. Elconin, Airtronics Mfg. Co.

Use of Dielectric Heating for Sterilization, Pasteurization, and Enzyme Control in Foods and Drugs, by Kenneth A. Smith, Electronic Chemical Engineering Co.

Furniture, Housing, and Lumber Industries—Application of High-Frequency Heating, by E. S. Winlund, Radio Corp. of America.

Function of the Electric Utility in High-Frequency Application, by H. H. Douglas, Southern California Edison Co.

MEETINGS TO COME

JAN. 23-26, INSTITUTE OF RADIO ENGINEERS, 33d Annual Winter Technical Meeting; Astor Hotel, New York, N. Y.; E. J. Content, chairman of meeting committee, WOR, 1440 Broadway, New York 18, N. Y.

FEB. 6-8; AMERICAN INDUSTRIAL RADIUM & X-RAY SOCIETY, Annual Convention; Hollenden Hotel, Cleveland, Ohio.

FEB. 9; INSTITUTE OF RADIO ENGINEERS, Chicago Section; Chicago Engineering Conference and Banquet; Merchants and Manufacturers Club, Merchandise Mart, Chicago.

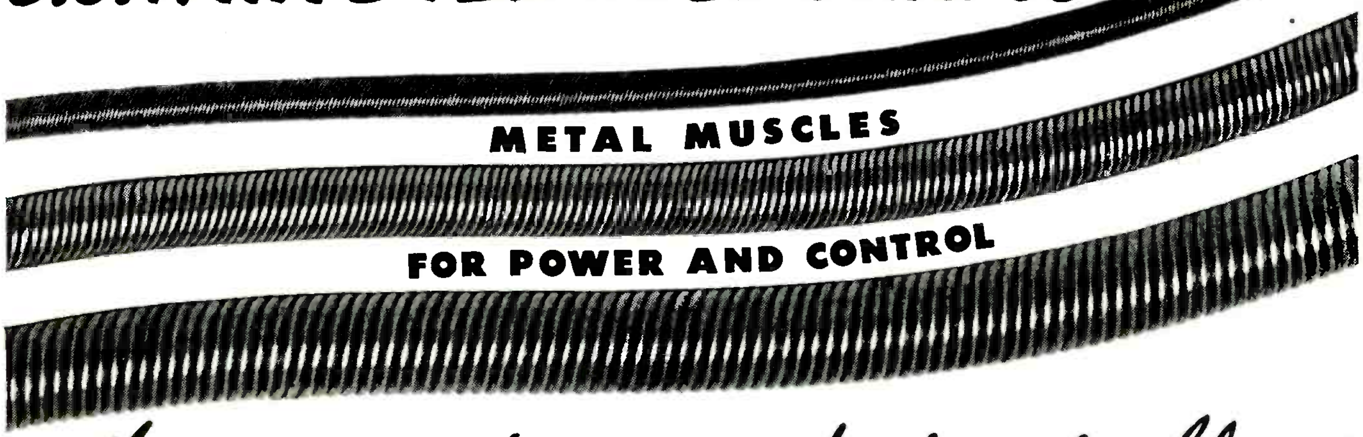
FEB. 13; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Frequency Spectrum Theory Applied to Servomechanisms, by E. B. Ferrel, Bell Telephone Laboratories; Room 301, Pupin Hall, Columbia University, 7 p.m.; H. E. Farrer, AIEE Headquarters, 33 West 39 St., New York 18, N. Y.

MARCH 7-9; OPTICAL SOCIETY OF AMERICA; Winter Meeting; Hotel Statler, Cleveland, Ohio. For Program, write A. C. Hardy, Sec., Optical Society of America, Mass. Inst. of Technology, Cambridge 39, Mass.

MARCH 13; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Non-Linearity in Servomechanisms, by Dr. L. A. MacColl, Bell Telephone Laboratories; same place as Feb. 13 meeting.

MARCH 18-23; BROADCAST ENGINEERING CONFERENCE; developments since 1942 in broadcasting engineering, including f-m and television; directed by Dr. W. L. Everitt, head, Department of Electrical Engineering, University of Illinois, Urbana, Ill., who requests addresses of those interested so they can be kept in-

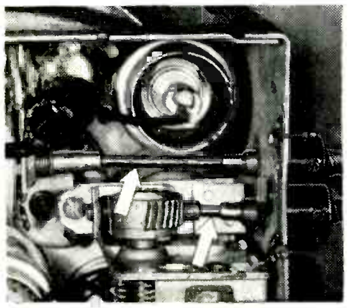
S.S.WHITE FLEXIBLE SHAFTS



METAL MUSCLES

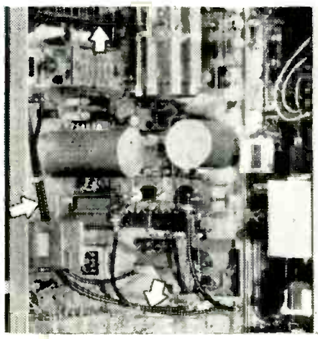
FOR POWER AND CONTROL

–the answer to many design problems

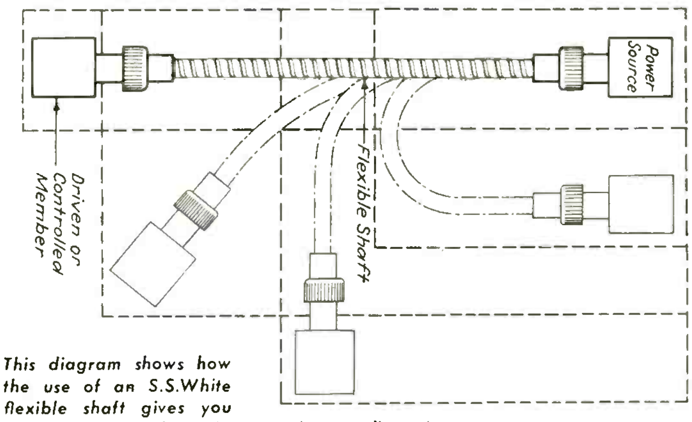


Use of S.S.White flexible shafting for coupling external control shafts or dials to variable elements — as in this radio receiver — damps vibration, eliminates need for precise mounting and alignment — gives complete freedom in locating the controlled elements.

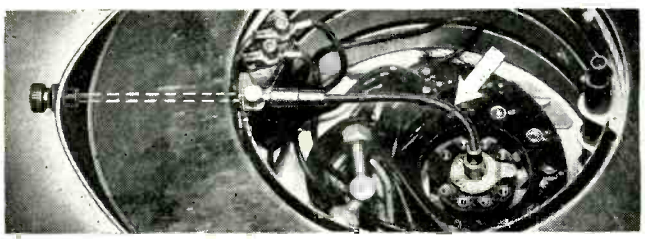
S.S.White flexible shafts are more than just basic mechanical elements for transmitting rotational power in paths other than straight lines, and for mechanical remote control. Through their use, instruments and other types of equipment can be simplified and improved and their manufacture made easier and less costly. A few examples are illustrated.



Use of S.S.White flexible shafts for coupling variable elements to control dials — as in this broadcast transmitter — permits location of elements to simplify wiring, facilitate assembly and servicing, save space, and centralize controls for convenient operation.



This diagram shows how the use of an S.S.White flexible shaft gives you wide latitude in determining equipment dimensions.



This unit (cover removed) shows how an S.S.White flexible shaft solves the problem of operating a rotary switch or other variable element from a conveniently located outside point.

GET THIS FLEXIBLE SHAFT HANDBOOK—FREE

This 256-page standard handbook size volume completely covers the subject of flexible shafts. It gives all essential technical data and explains how to select and apply shafts for specific requirements. A copy will be mailed free, if you write for it on your business letterhead.

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

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ARMY E NAVY

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

One of America's AAAA Industrial Enterprises formed on the program details.

MARCH 27-30; AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE; Annual Meeting; St. Louis, Missouri. H. A. Meyerhoff, Exec. Secretary, Smithsonian Institution Bldg., Washington 25, D. C.

APRIL 10; AIEE; Applications of Servomechanisms, by S. J. Mikina, Westinghouse Electric Corp. Research Laboratories; 7 p.m. same place as Feb. 13 meeting.

PERSONNEL

WINFIELD W. SALISBURY has joined Collins Radio Co., Cedar Rapids, Iowa, as director of their Research Division. He was formerly engaged in wartime development of radar and the resnatron radar-jamming tube at Harvard Radio Research Laboratories.

W. W. Salisbury

W. W. Farley

WILLIAM W. FARLEY, now assistant director of the Research Division at Collins, has for the past four years worked on radar at Harvard RRL and at MIT Radiation Laboratory.

CLAUDE T. EVERSON will carry on microwave design and research in the Research Division of Collins. His work with the U. S. Army Air Corps involved similar equipment.

C. T. Everson

F. L. Moseley

FRANCIS L. MOSELEY, formerly an AAF Colonel and Chief of the Communications and Navigation Laboratory of the Radio and Radar Section at Wright Field, has joined the

DEPENDABLE OPERATION—BECAUSE THEY HAVE FEWER MOVING PARTS

Everything You Want In Record Changers

MINIMUM FRICTION . . . SILENT . . .
LONG LIFE . . . CONSTANT SPEED . . .
TROUBLE-FREE OPERATION

SEEBURG
Record Changers

The dependability of SEEBURG RECORD CHANGERS has been proven by the many years of actual use. While new and more efficient features have been included . . . the simplicity of the operating mechanism has been retained to render the same reliable, trouble-free operation that characterizes SEEBURG RECORD CHANGERS.

SEEBURG *Wire* RECORDER

The scientific and commercial development of Wire Recording is a triumph of electronic engineering! SEEBURG engineering and research has played a major role in this new recording and reproducing instrument. One simple control knob operates the SEEBURG WIRE RECORDER to record and reproduce speeches, plays, meetings, music, radio programs, etc. There are no needles or discs used.

IT WILL BE NECESSARY... for radio manufacturers to make provisions in their circuits to accommodate the SEEBURG WIRE RECORDER. We therefore invite prompt inquiries from interested radio manufacturers.

Seeburg

1902 DEPENDABLE MECHANISMS 1946

J. P. SEEBURG CORP. • CHICAGO

engineering department of Collins. He was responsible for development of the AAF instrument approach system for blind landing, and developed the first commercially used automatic radio compass for aircraft while with Sperry Gyroscope Co. prior to 1941.

PAUL H. THOMSEN became chief radio engineer for the Los Angeles branch of Air Associates, Inc., and will direct the activities of their engineering department in fulfilling CAA, Army and civilian contracts for aircraft and ground radio communication and navigation equipment.

WILLIAM F. FRANKART will be in charge of engineering for a newly formed radio-electronic section at Precision Specialties, Los Angeles, Calif.

ALLAN R. OGILVIE has been named a vice president of Maguire Industries, Inc., and placed in charge of its Brigeport, Conn. plant. He was formerly chief engineer of the company's electronics division, a post to which Carlton Wasmansdorff succeeds. The Bridgeport plant is being retooled for the manufacture of railroad, aviation, and marine communication equipment, radio receivers, and automatic record changers.

A. R. Ogilvie

N. S. Kornetz

NORMAN S. KORNETZ becomes project engineer in charge of Westinghouse television receiver development, and will devote particular attention to receiving units to be used in flight tests of Stratovision. He recently served with the U. S. Signal Corps in India, where he was in charge of all administrative radio communications in the Calcutta area.

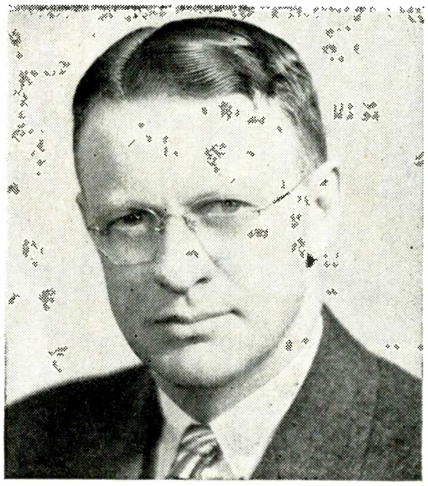
N. A. MOERMAN, formerly at Aberdeen Proving Grounds, Maryland, where he was responsible for design and maintenance of various electronic measuring equipment,

A MILESTONE IN RAILROAD RADIO!

"Modern railroad transportation systems cannot function to their maximum efficiencies without the use of modern communications networks. That is why the Santa Fe System maintains complete telephone and teletype, as well as telegraph systems along its entire thirteen-thousand-mile right-of-way. It is also the reason for Santa Fe's immediate and careful exploration of all new communications techniques, such as railroad radio, and accounts for the many 'firsts' contributed by the Santa Fe to the railroad communications art."

President

Atchison, Topeka and Santa Fe Railway



AM or FM? Which to use on railroad radio? This question has long troubled engineers in both the railroad and the radio fields.

To determine the comparative operating characteristics of AM and FM radio equipment, The Atchison, Topeka and Santa Fe Railway, in conjunction with the Farnsworth Television & Radio Corporation, recently conducted an exhaustive series of tests.

As a result, railway men the nation over have for the first time a thorough evaluation of both types of modulation for railroad service. Of equal importance is the fact that the information derived now enables Farnsworth to design better railroad radio equipment. Efficiency will be increased; the way has been opened to reductions in purchase price and maintenance cost.

Such tests add one more milestone to the development of railroad communications. The engineers of Farnsworth's Mobile Communications Division have pioneered many other important achievements. Backed by Farnsworth's ample production facilities, these engineers are now prepared to offer practical radio assistance to all the railroads of America.

The Farnsworth Television & Radio Corporation, Dept. E-2, Ft. Wayne 1, Indiana.

FARNSWORTH **TELEVISION & RADIO CORPORATION**

Farnsworth Radio and Television Receivers and Transmitters • Aircraft Radio Equipment • Farnsworth Television Tubes • Halstead Mobile Communications and Traffic Control Systems for Rail and Highway • the Farnsworth Phonograph-Radio • the Capehart • the Panamuse by Capehart

joins Potter Instrument Co. of Flushing, N. Y. as sales engineer.

STANLEY CUTLER joins the technical staff of Hoffman Radio Corp., Los Angeles, as a radio project engineer.

RICHARD E. MATHES has been made chief engineer and plant manager of Finch Telecommunications, Inc. of Passaic, N. J., having been recently released from active duty in

Commdr. R. E. Mathes

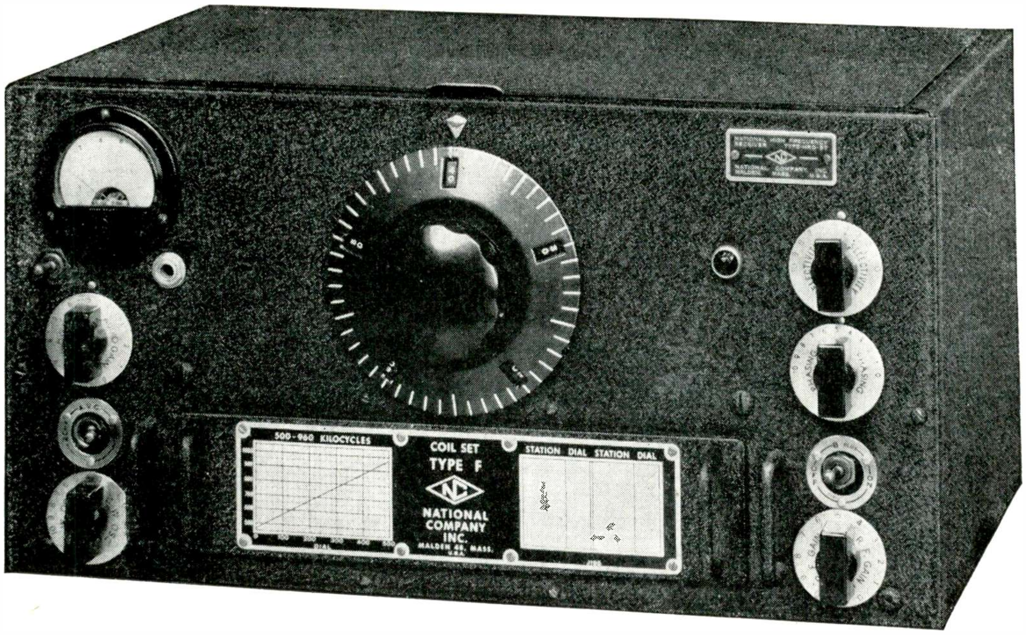
the Navy's Bureau of Ships, where he assisted Capt. Finch in development and design of special electronic equipment for ships and aircraft.

BEVERLY F. FREDENDALL is now associated with Frederick Hart & Co., Inc. of New York, a subsidiary of American Type Founders, in design and manufacture of Recordgraph and Hartron recording equipment. He was previously with National Broadcasting Co. for 16 years, handling operation and design of audio and video broadcasting systems and recording systems.

W. P. SHORT has been named chief engineer of the newly created home radio receiver department at Federal Telephone and Radio Corp., Newark, N. J. He has had radar experience with the Navy and radar development work at Radiation Laboratory, MIT, and for a time was chief engineer of Research Construction Co.

H. A. SNOW becomes senior engineer of Federal's new radio receiver department. He developed the variable mu tube while with Boonton Research Corp., and an electronic gage while working on production of aircraft transmitters at Foote, Pierson and Co. of Newark during the war.

S. J. REISMAN, formerly chief of the technical publications section of Bendix Radio Division, Balti-



THE HRO-5TA

Your old friend, the HRO, has seen active service all over the world with the armed forces of the United States and our allies. Much has been learned, and the HRO has emerged from its trial by fire an even better receiver than the superb receiver you knew before the War.

The HRO-5TA (table model) and the HRO-5RA (rack mounting) are new receivers incorporating design improvements based on field reports from all over the world. They are superb performers of extreme reliability.

The new National catalogue lists the new HRO-5A receivers and their accessories together with a versatile group of parts you will need in your new rig. Ask your dealer for a copy.

NATIONAL COMPANY, INC.
MALDEN, MASSACHUSETTS, U.S.A.

MALDEN
MELROSE
★ ★ ★ ★

more, Md., is now president of Techlit Consultants, Inc., 220 E. 42nd St., New York, N. Y.

E. A. LEACH recently joined Hammarlund Mfg. Co., Inc., New York, N. Y., as executive engineer to direct all engineering activities. He comes from General Electric Co., having joined them in 1928 after getting his master's degree from MIT.


Ted Leach


Paul D. Zottu

PAUL D. ZOTTU, formerly chief engineer, Thermex Division, Girdler Corp., Louisville, Ky., has announced his entrance into the field of consulting industrial electronic engineering, specializing in applications, equipment and component design, and equipment selection for high-frequency induction and dielectric heating. His new address is 95 Country Club Road, Newton Centre, Mass.

MARVIN HOBBS is now principally responsible for engineering activities at Scott Radio Laboratories, Chicago. He returned recently from a tour of the Pacific Theater as an Operations Analyst for the Far East Air Forces, and during the war worked chiefly on aircraft control and warning systems using radio and radar equipment.


M. Hobbs

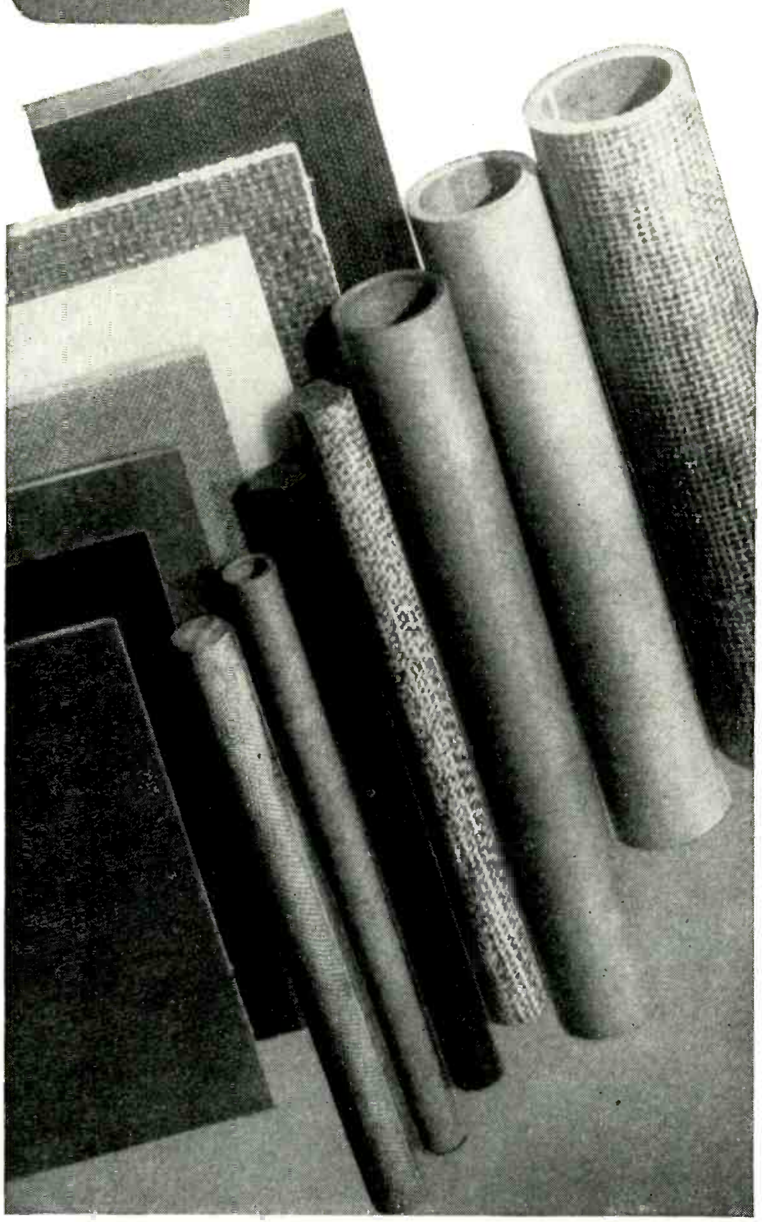

R. H. De Pasquale

RAY H. DE PASQUALE has been made vice-president and general manager of the newly formed Press Wireless

OVER 50 GRADES OF

G-E TEXTOLITE SHEETS, TUBES, RODS

for NEW JOBS
MANY JOBS
GOOD JOBS



G-E Textolite sheets, tubes and rods are manufactured in over fifty grades; consequently their versatility as a laminated plastics material is broad. This versatility leads to many new applications . . . applications where G-E Textolite fills the bill better than other types of materials. And also since each grade has an individual combination of properties, a wide range of applications is covered . . . Textolite is used for many purposes, and every grade is formulated to do a specific job well.

If you are looking for a laminated plastics material—one that must have a special set of properties for your needs . . . electrical, chemical, mechanical, thermal—investigate the many grades of G-E Textolite; if one of these grades won't meet your requirements, we'll do our best to engineer one that will.

For further information write to Section S-1, Plastics Divisions, General Electric Company, One Plastics Avenue, Pittsfield, Mass.

EVERYTHING IN *Plastics*

G-E TEXTOLITE
IS SUPPLIED IN THE FOLLOWING FORMS:

Sheets, Tubes, and Rods — **Molded-Laminated Parts**
Fabricated Parts — **Post-Formed Laminates**
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Low-Pressure Molded Parts

GENERAL ELECTRIC

CD46-E1

Mfg. Corp., created to meet increasing civilian demands for communications equipment. He was formerly director of manufacturing for Press Wireless, Inc.

BUSINESS NEWS

G. C. WILSON & CO., Chatham, N. J., was organized recently by G. C. Wilson, its president, to develop electronic controls for industrial applications, with emphasis on servomechanisms and remote controls.

COLE, HOLDAM & MCGRATH, a partnership of three former members of the MIT Radiation Laboratory, has been established at 107 Massachusetts Ave., Boston 15, Mass. to provide consulting service in the fields of radar and industrial electronics.

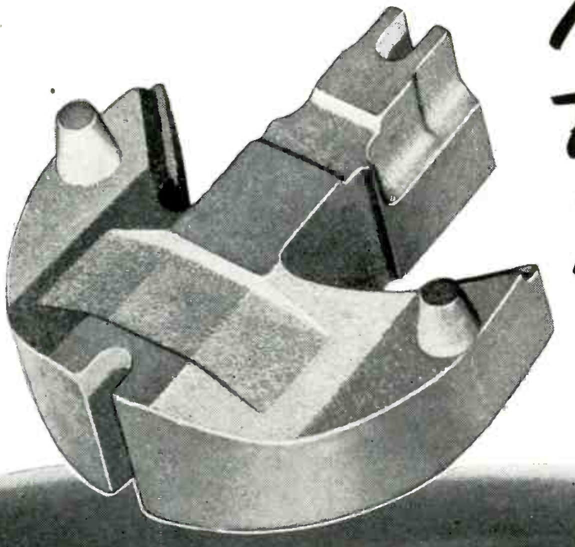
SHERMAN INDUSTRIAL ELECTRONICS CO., Belleville, N. J., has been organized as an engineering, manufacturing, and service organization specializing in electronic heating. It is headed by Vernon W. Sherman, formerly manager of Industrial Electronics Division of Federal Telephone and Radio Corp.

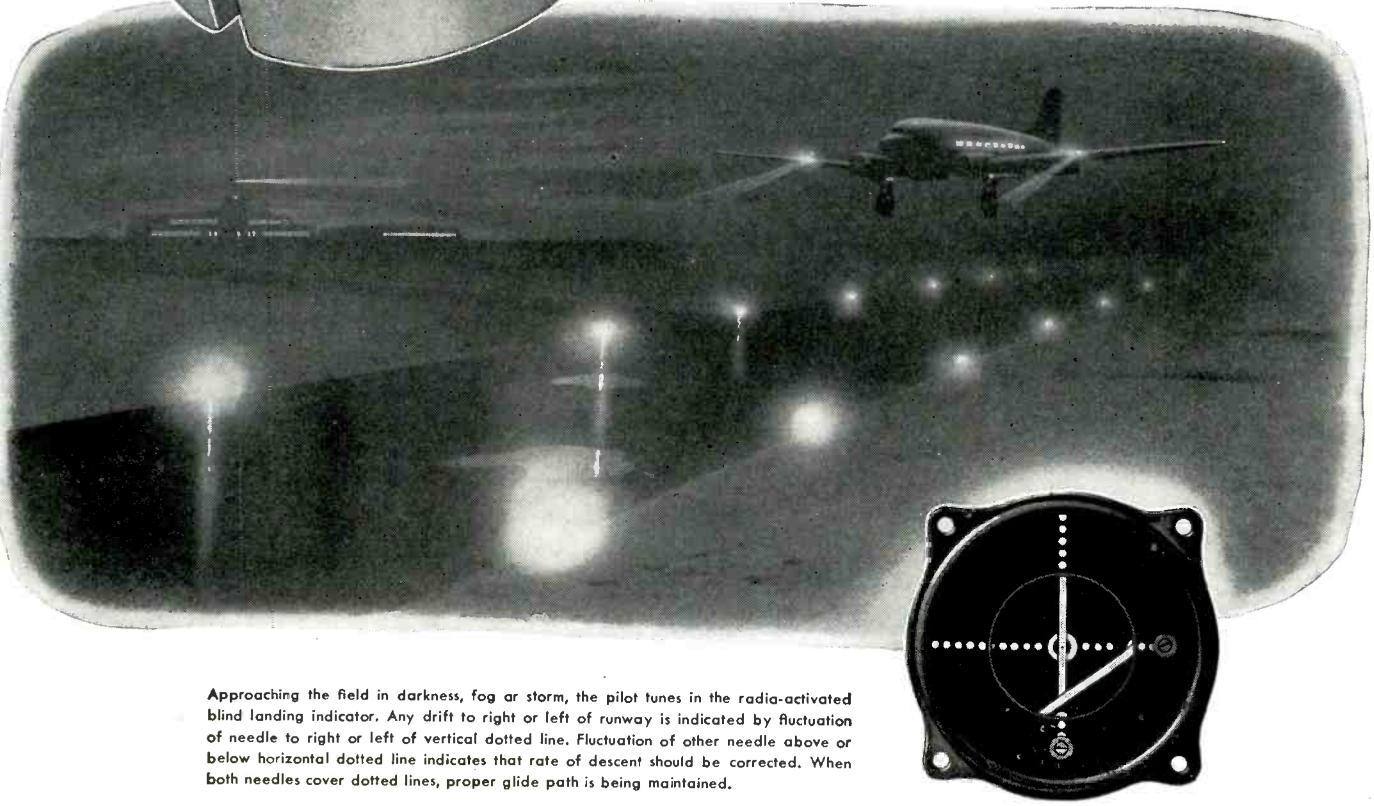
BENDIX RADIO DIVISION announces completion of plans to purchase its Towson plant from the Defense Plant Corp. for approximately $1,700,000 and has started additions and improvements that will cost another $500,000.

ELECTRO MANUFACTURING CO., Chicago, has purchased the General Electric Lamp Department's business in rectified fluorescent and Cooper Hewitt fixtures.

TELEVISION BROADCASTERS ASSOCIATION, INC., New York City, has elected to its board of directors Ernest H. Vogel, vice-president in charge of sales for Farnsworth Television & Radio Corp., J. R. Poppele of Bamberger Broadcasting Service, and G. Emerson Markham of General Electric Co. Other directors of TBA include O. B. Hanson of National Broadcasting Co., Paul Raibourn of Television Productions, Inc., Allen B. DuMont of Allen B. DuMont Laboratories, Curtis W. Mason of Earle C. Anthony, Inc., F. J. Bingley of Philco Radio & Television Corp., and E. A. Hayes of Hughes Productions. At their recent annual meeting, the board of directors reelected all its officers for 1946.

This Magnet is the heart of the Blind Landing Indicator!





Approaching the field in darkness, fog or storm, the pilot tunes in the radio-activated blind landing indicator. Any drift to right or left of runway is indicated by fluctuation of needle to right or left of vertical dotted line. Fluctuation of other needle above or below horizontal dotted line indicates that rate of descent should be corrected. When both needles cover dotted lines, proper glide path is being maintained.

Perfecting the blind landing indicator involved a difficult problem in magnetics.

Thomas & Skinner, specialists for 44 years in designing and manufacturing all sizes and shapes of permanent magnets, provides an unusual magnet containing *two* magnetic circuits and having maximum flux and stability.

For solution of *any* of your problems in magnetics, consult Thomas & Skinner engineers. Write us today.

THOMAS & SKINNER STEEL PRODUCTS CO.
1116 East 23rd Street **Indianapolis 5, Indiana**

Thomas & Skinner

Permanent Magnets

NEW PRODUCTS

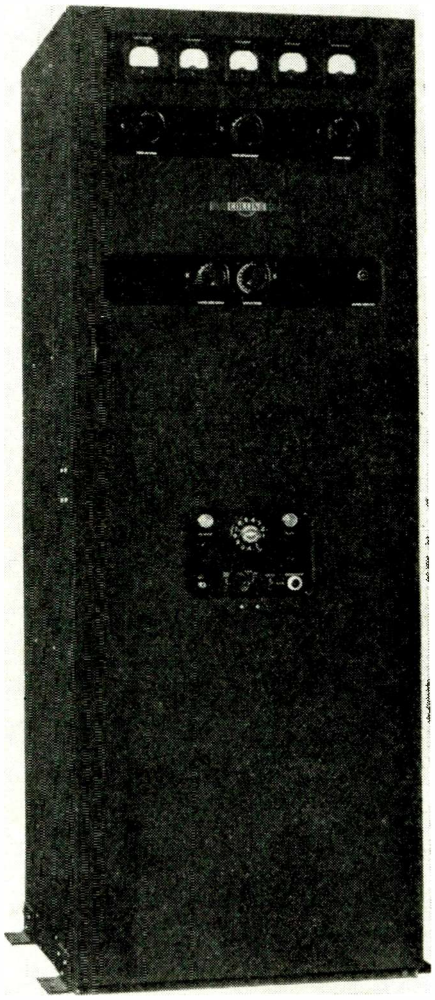
New materials, new components, new assemblies; new measuring equipment; new technical bulletins, and new catalogs

1

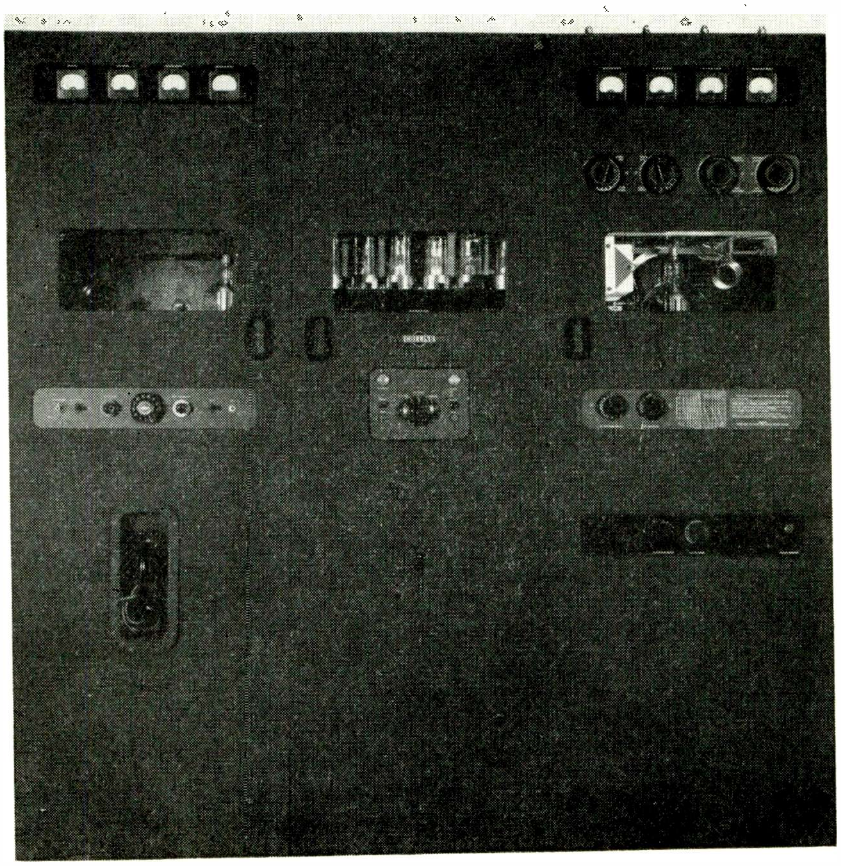
Communication Transmitters

NOW IN PRODUCTION by Collins Radio Co., Cedar Rapids, Iowa, are three communications transmitters described in detail below.

The 231D is a ten-channel, 2-18.1-mc, 5-kw communication transmitter, designed for point-to-point, shore-to-ship, or ground-to-plane communications. It embodies the Collins Autotune system, by means of which the carrier can be quickly and automatically shifted to any of ten preselected frequencies with all circuits precisely tuned. The maximum power output is 3 kw on phone or mcw, or 5 kw on c-w. Only one set of tuning elements is used for the entire frequency range, and will match a wide range of antenna impedances without the necessity for auxiliary tuning units. Keying speeds of up to 200 words per minute can be used. The frequency response is flat within 3 db from 150 cps to 3,500 cps. A compression circuit is incorporated to raise the average modulation level. Harmonic distortion is less than 10 percent up to 100 percent modulation at 1,000 cps. Crystal or sealed master-oscillator frequency control is available. Operation of the transmitter can be controlled from a position as far as 25 miles away. A 230-v, 50/60-cps, three-phase, and a 115-v, 50/60-cps, single-phase power source are required.



500-watt transmitter



Collins 231D transmitter

The 16F is a 2-20 mc, 10-channel, 500-watt communication transmitter, provided with quick, automatic frequency shift. The maximum power output is 300 watts on phone or mcw, and 500 watts on c-w. Keying speeds reaching 200 words per minute are made possible through electronic control. Noise level is at least 40 db below 100 percent modulation. Frequency response varies less than 3 db from 150 to 3,500 cps. A compression circuit is incorporated to raise the average modulation level. Harmonic distortion is less than 10 percent up to 95 percent modulation and 15 db of compression. Crystal or master oscillator frequency control is available. Operation can be controlled from a point as far as 25 miles away from the transmitter. The power source required is 115 v, 50/60 cps, single phase.

The 32RA is a four-channel, 75-

JUST OFF THE PRESS!

TWO NEW BULLETINS
YOU SHOULD HAVE IN YOUR FILES

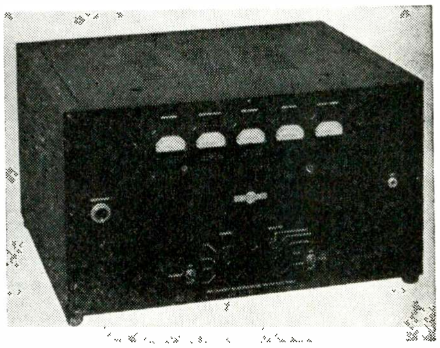
They contain complete specifications and other informative data about the finest Emergency Communications Equipment ever to bear the HARVEY name.

These new HAR-CAM FM Transmitters and FM-AM Receivers now ready for release offer the last word in operating efficiency, ease of installation, and dependable, economical transmission and detection. HARVEY of CAMBRIDGE'S pre-war specialization in this field, plus the skill, experience and "know-how" gained through war work, particularly in the development of Loran and Radar Transmitters and other vital military equipment, are your guarantee of quality and performance to meet your most exacting specifications.

Now is the time to get the story on HAR-CAM Emergency Communications Equipment. Write for Bulletins H-35 and H-36 today. No obligation, of course.

HARVEY RADIO LABORATORIES, INC.

439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS



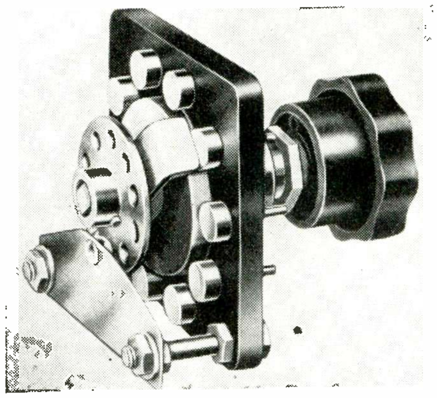
Four-channel transmitter

watt, 1.5-to-15 mc transmitter with a panel control for changing frequency. The unit has adequate audio characteristics for communications use. Operating from a 115-v, 50/60-cps, single-phase line, the transmitter weighs 120 lb and measures 12½ x 22 x 18 in. The type 32RB is similar except for substitution of a dynamotor to operate on d-c at 12, 24, 32 or 110 v.

2

Rotary Selector Switch

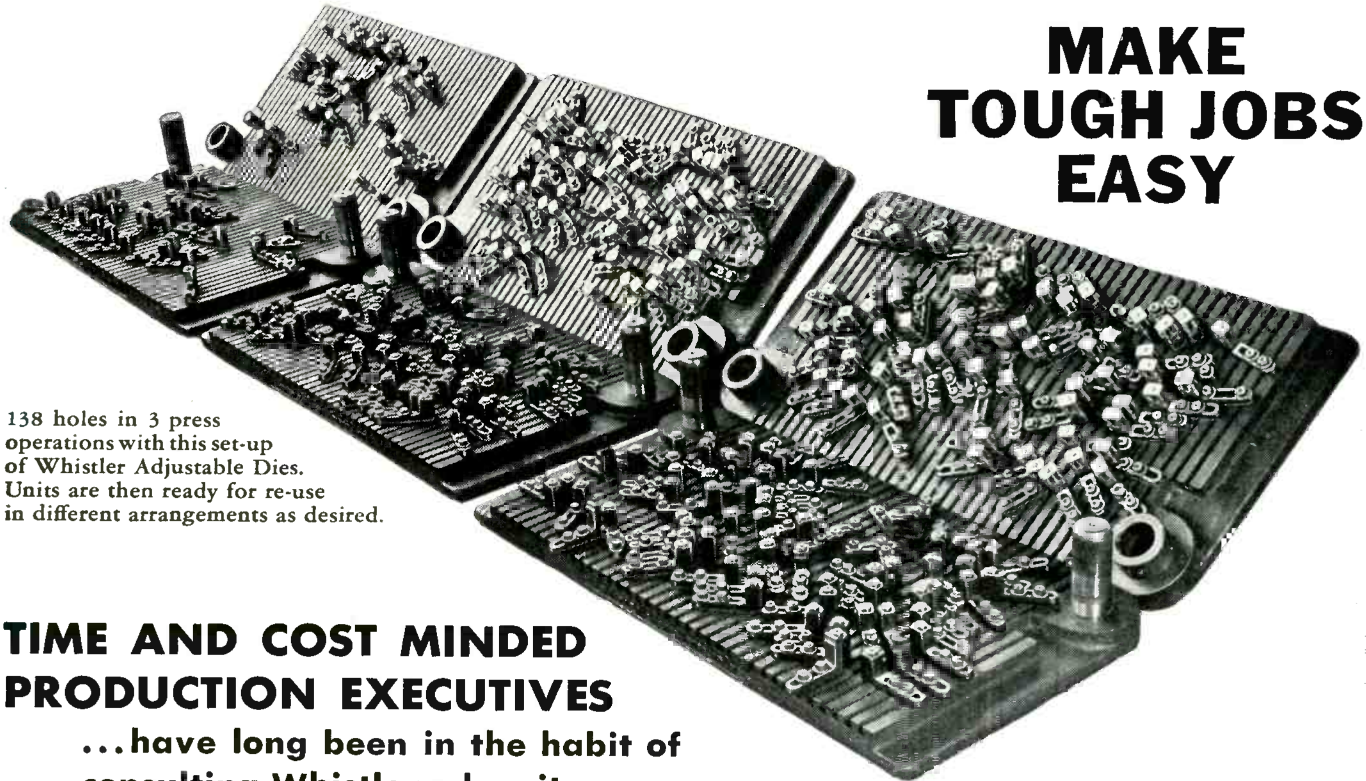
THE EASTERN ELECTRONICS Corp., 41 Chestnut St., New Haven, Conn., announces a rotary selector switch designed for use where low contact resistance and mechanical sturdiness are required. The switch contact studs are forced into a laminated bakelite disc which also carries the central bearing and return contact.



A laminated phosphor-bronze brush is secured to the shaft, and arranged to complete the circuit between the switch studs and the central bearing. A detent disc is also carried by the shaft and secured in fixed relation to the laminated brush. A phosphor-bronze detent spring is

WHISTLER PERFORATING—NOTCHING SLOTTING—ROUNDING DIES

MAKE TOUGH JOBS EASY



138 holes in 3 press operations with this set-up of Whistler Adjustable Dies. Units are then ready for re-use in different arrangements as desired.

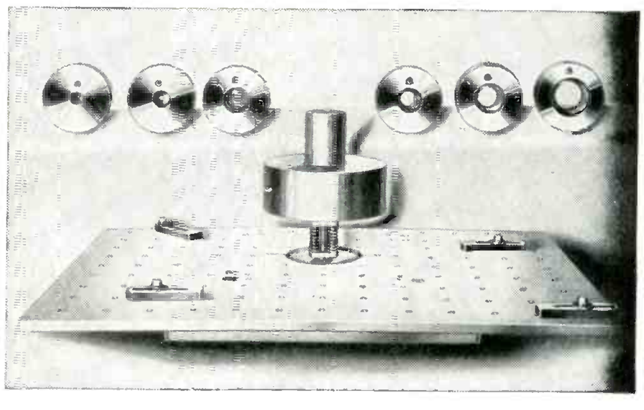
TIME AND COST MINDED PRODUCTION EXECUTIVES

...have long been in the habit of consulting Whistler when it comes to dies for work on sheet metals.

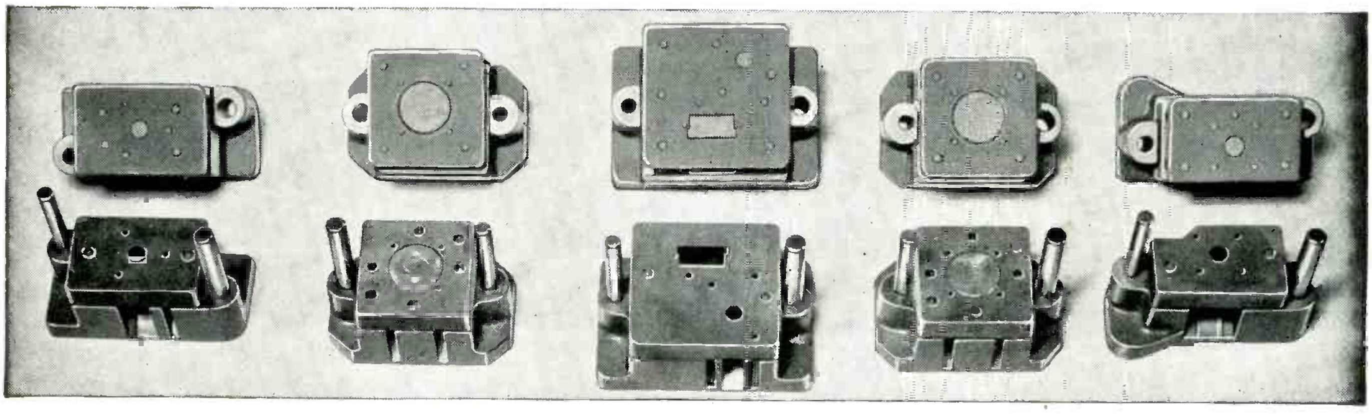
A leading Whistler achievement in reducing die-making and production costs is the multi-use Adjustable Perforating Dies which enable most set-ups to be made from stock units. The Single Hole Perforator, another Whistler development, presents new advantages in quick changes and a wide range of hole sizes. In fact Whistler adjustable dies, group dies, and single purpose dies have contributed greatly to the production achievements of the nation's leaders in practically every line of manufacture. Write for the Whistler catalogs and get the entire story of how to reduce manufacturing costs and get into production faster.

S. B. WHISTLER & SON, INC.
752-756 MILITARY ROAD, BUFFALO 17, NEW YORK

Illustrated below, ready for production, is the Whistler Single Hole Perforator set with punch and die adaptor rings for perforating $\frac{1}{32}''$ to $1\frac{1}{2}''$ in mild steel to and including $\frac{1}{4}''$ thickness when used with Whistler Punches, dies and strippers.



Group dies and special shapes to order. Often used on the press in combination set-ups with Whistler Adjustable Dies.



rigidly fastened to the Bakelite disc, by means of two posts and is arranged to hold a steel ball in contact with the detent disc.

The advantage of this arrangement is that the detent spring maintains a predetermined fixed frictional contact between the laminated brush and switch studs. This type of construction insures long wear with a constant low contact resistance less than 0.001 ohm.

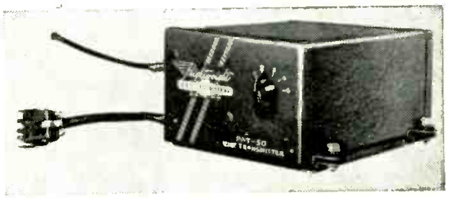
In applications where the switch is subjected to an oxidizing atmosphere, silver contact studs can be supplied. Several sections can be added to obtain multi-polar switching.

The switch is well suited for such uses as precision test instruments, or where extremely low and constant contact resistance must be maintained, as in shunt ammeters, thermocouple type measuring equipment, and Wheatstone Bridges.

3

VHF Aircraft Transmitter

BENDIX RADIO, Baltimore 4, Md., has designed a very high frequency transmitter for private flyers desirous of communicating with the



ground on the new CAA frequencies, 131.9 and 131.7 mc. Light in weight and crystal-controlled, it is the first item in a series of personal plane equipment.

4

Low-Wattage Bobbin-Type Resistors

THREE COMPACT new units rated at 1, 2 and 3 watts at 80 C ambient have just been added to the Sprague Koolohm line of wire-wound bobbin-type resistors manufactured by Sprague Electric Co., Resistor Division, North Adams, Mass. They are wound with ceramic-insulated resistance wire on molded, high-temperature plastic forms and are impregnated for protection against

POWERSTAT

Variable Voltage Transformers now available with fuse protection.

All investments should be protected — not only for the monetary but for convenience and time considerations. This is especially true in these days of trying to be the first on the market with new products. The failure of equipment may mean loss of time, money, and prestige. An example might be the burning-out from overloading of a POWERSTAT Variable Transformer used in production or laboratory testing. Although delivery of POWERSTATS is prompt it takes valuable time for shipment. SECO engineers in realizing these facts have provided the popular type 116, and when desired in the 1126 and 1226 models, with fuse protection.

Why fuse protection versus heat actuated devices? A fuse gives positive and instantaneous action — opening the circuit immediately when a short circuit occurs. There is no danger of recycling — that is, the circuit closing after a period of time. Such action might injure certain apparatus or the operator who assumed the circuit to be dead.

We at SECO would appreciate your comments.

Send for Bulletin LE

SUPERIOR ELECTRIC COMPANY

702 LAUREL STREET, • • • BRISTOL, CONNECTICUT

STOCKED BY LEADING DISTRIBUTORS IN THE UNITED STATES AND CANADA

tropical humidity conditions. Resistance tolerance is available from $\pm\frac{1}{2}$ percent to ± 5 percent. Standard temperature coefficient wound with nickel-chromium wire is 0.017 percent. Lower coefficients can be provided by use of special alloy wires. Maximum permissible temperature is 150 C.

Type RX3, $\frac{9}{16}$ in. diam x $\frac{15}{32}$ in. long carries a maximum resistance value of 100,000 ohms when wound with 1.5-mil ceramic-insulated wire or 25,000 ohms with 2.5-mil wire. Type RX4, $\frac{3}{4}$ in. diam x $\frac{3}{4}$ in. long, has a maximum value of 300,000 ohms with 1.5-mil wire and 75,000 ohms with 2.5 mil wire. Type RX5, $\frac{3}{4}$ in. diam x 1 in. long has 500,000 ohms with 1.5-mil wire, or a maximum of 125,000 ohms with 2.5 mil wire.

5

Unbreakable Test Record

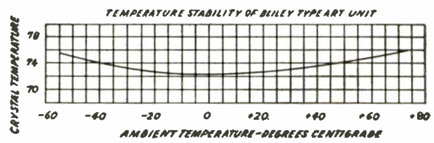
UNIVERSAL MICROPHONE Co., Inglewood, Cal., is now distributing its type D61 constant-velocity frequency record for use in checking frequency response of phonograph pickups and recording components. Pressed from new unbreakable material, it is useful for determining overall response of recording and reproducing systems.

The record is a 12-inch lateral-recorded, high-grade pressing for use on 78 rpm turntable and covers the following ranges at constant velocity: 50 to 100 cps at plus 7 db; 200 to 500 cps at plus 14 db; 500 to 10,000 cps at plus 21 db; 1000 cps in 2 db steps from plus 8 to plus 18 db; and 40 cps at plus 18 db.

6

VHF Crystal with Heater

A NEW CRYSTAL UNIT, type ART, is available from Bliley Electric Company, Erie, Pennsylvania. Designed for services such as police and radio communications where frequency stability must be maintained for temperatures ranges of



electronics READER SERVICE...

TO BRING YOUR LIBRARY UP TO DATE ON LITERATURE AND NEW PRODUCTS

Manufacturers' Literature as well as further information on New Products described in this issue are important "working tools" for design and production departments. To make it easy to keep up to date, ELECTRONICS will request manufacturers to send readers the literature in which they are interested. Just fill out card—we do the rest.

HOW TO ORDER

Fill out, *completely*, one coupon for each piece of literature or new product information you order. This gives your request authority and allows the manufacturer to address your copy correctly, thus assuring prompt delivery.

PLEASE NOTE...

In the event this copy of ELECTRONICS is passed along to other members of your company, **please** leave this sheet in for their convenience. This assures everyone in your plant the opportunity to fill in their requests. When the round is completed, cards can then be detached along perforated lines and dropped in the mail. Each individual request will be mailed by us to the company offering the information.

Write in circle number of item describing one catalog wanted →

Your Company Name JonesMfg-Co
Address 3217 Lewis Ave.
Chicago, Illinois
Your Name John Smith
Your Title Chief Engineer
ELECTRONICS, 330 W. 42nd St., New York 18

CARDS NOT GOOD AFTER MAY 1, 1946

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An electronics service designed for READERS and MANUFACTURERS

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For the Reader . . .

ELECTRONICS' fundamental policy has always been to supply its readers with all the pertinent and timely industry news. The ELECTRONICS' Reader Service supplements this policy by offering the reader an easy and effective means of obtaining complete, up to the minute data on new products and of maintaining at his fingertips comprehensive, practicable information on "who's doing what" in the industry.

There's complete coverage in every issue of ELECTRONICS of the month by month development by manufacturers of new materials, components and equipment, as well as brief mention of all the important, new, manufacturers' technical pamphlets and catalogs. Some of these items will be of particular interest to specific design and plant engineers, buyers, executives and others of our readers. They will want to make further inquiry concerning the new products described, or they will want to read and make a permanent part of their industrial library some of the manufacturers' literature and catalogs. ELECTRONICS' Reader Service makes it easy for them to obtain in readily accessible and usable form the information they desire.

For the Manufacturer . . .

ELECTRONICS' Reader Service will also be welcomed by manufacturers who are desirous of placing the complete news of their product developments as well as their technical bulletins and catalogs in the hand of those members of the electronic industry . . . including design, electrical, and production engineers, researchers, physicists, executives, and buyers — who have a particular interest in, or represent a potential buying power, for their products.

•

SUGGESTIONS FOR THE IMPROVEMENT OF OUR READERS' SERVICE ARE INVITED

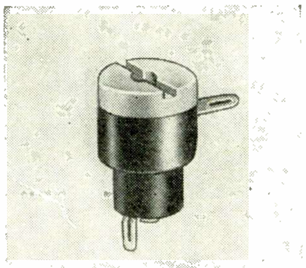
ELECTRONICS is constantly seeking new and improved ways of providing its readers with the news and information they want and need, and of assisting the manufacturer in effectively delivering his message to electronic markets. If you have any ideas for us, send them along. They'll receive prompt and grateful consideration.

− 55C to + 75C, the unit plugs into a standard 5-prong tube socket. A built-in heater operating on 6.3 v at 1 amp provides temperature control within ± 2C. This permits an over-all frequency tolerance of ± .005 percent or better including variations due to temperature change as well as tolerances required for crystal production. The unit is available for any frequency between 3,500 kc and 11,000 kc.

7

Ceramic Trimmers

DESIGNED BY Erie Resistor Corp., Erie, Pa., the overall dimensions, of these new trimmers (types TS-IF) are ½-in. diameter x 45/64-in. high, and they are for use in a wide range of applications in broadcasting and high frequency bands. Ceramic dielectric is used in the units. Capacitance change is essentially constant per degree of rotation, and full range is covered in 180-degree rotation. Voltage rating is 350 v d-c; flash test 700 v d-c for 15 sec; initial Q factor at 1 mc, 500 min; and initial leakage resistance 10,000 meg min. Noise level is kept to a minimum at high frequencies.



ACTUAL SIZE

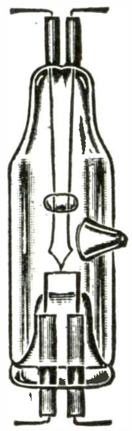
8

Vacuum Thermocouples

MEASUREMENTS OF CURRENTS and voltages at uhf are now possible with the Type U vacuum thermocouples designed specifically for this purpose, by the Field Electrical Instrument Co., 109 East 184th St., N. Y. 53, N. Y.

Constructional features giving maximum accuracy at uhf include, use of very small diameter, non-

magnetic heater wires to minimize inductance and skin effect; heater and couple leads are at opposite ends of the glass bulb with the couple at right angles to the heater to minimize both capacitive and mutual inductive coupling between the heater and couple; use of an insulating bead between the heater and the couple so that except for an extremely small capacitance through the bead, the couple circuit



is electrically isolated from the heater circuit; reduction of the length of heater and lead-in wires so the length of the loop forming this circuit is only 1¼ inch, giving it an extremely low residual inductance and capacitance.

The electrical efficiency of these thermocouples is such that inexpensive millivoltmeters may be used. Such millivoltmeters are in the ten to fifteen dollar class and are sufficiently accurate for ultra-high frequency work.

9

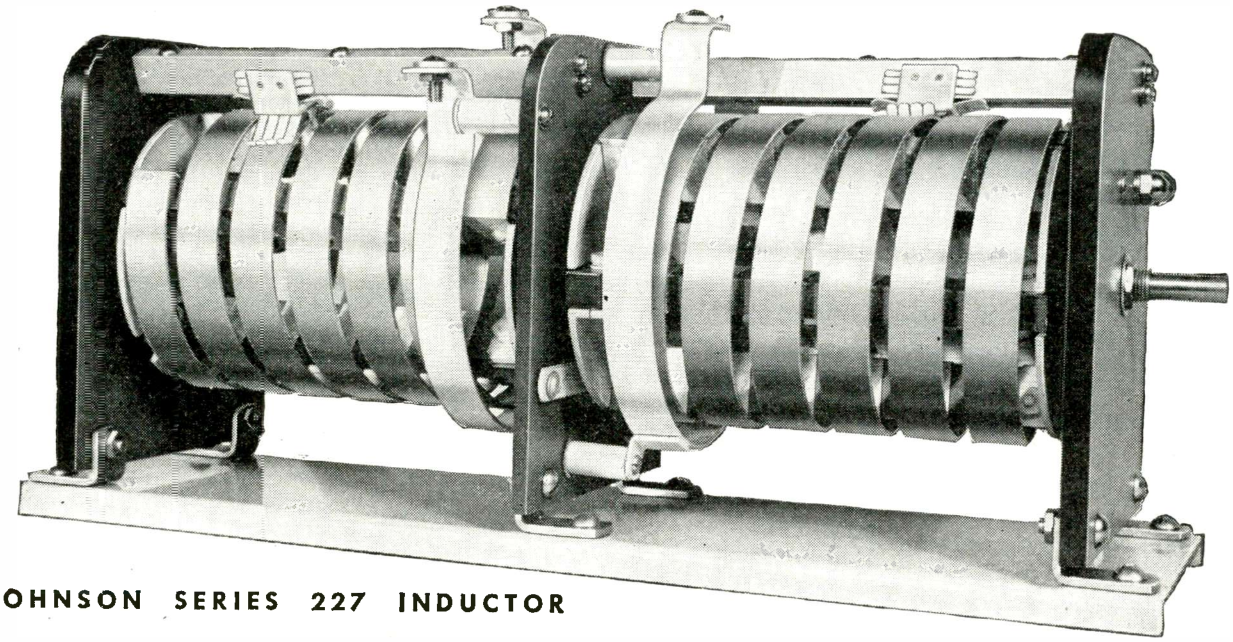
Cold Cathode Recorder Tube

A MODULATOR GLOW tube of the crater type that is rugged and dependable for all photoelectric uses is designated type R-1130 by the makers, Industrial Electronics Division of Sylvania Electric Products Inc., Boston, Mass.

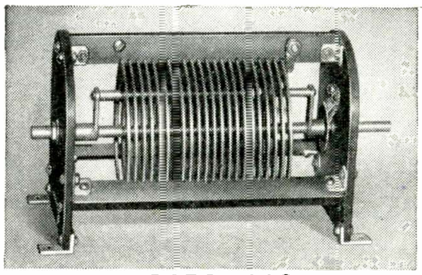
The tube, usually operated by the single-ended output stage of a push-pull amplifier, provides a modulated, high-intensity point-of-light source by means of a hollow cathode producing high ionization density which may be viewed in depth.

Current through the tube varies linearly with the signal voltage

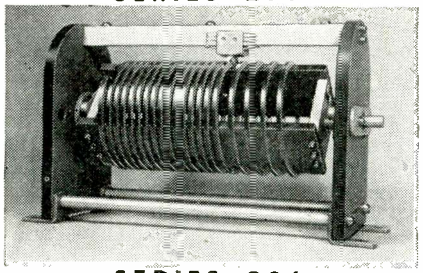
VARIABLE INDUCTORS



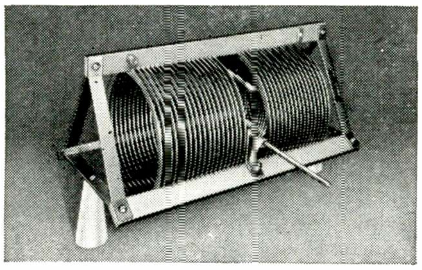
JOHNSON SERIES 227 INDUCTOR



SERIES 212



SERIES 226



SERIES 204

ELECTRONIC HEATING—Designed for high current, the variable inductor shown above is especially adaptable for electronic heating installations. Available in single and dual models, with or without coupling links, the series 227 inductors are engineered to meet the rigid requirements of electronic heating circuits. Wound with heavy copper ribbon, conductor and contact surfaces may be heavily silver plated for minimum R.F. resistance. The dual model features counter-rotating coils, providing automatic balancing for push-pull circuits. Machined Mycalex is used for end frames and supporting bars. For lower power electronic heating applications the Johnson series 212 variable inductor, shown at left, is designed to give maximum efficiency. Conductor surfaces are of edge-wound copper strip, frames and supporting bars are of machined Mycalex.

TRANSMITTERS—The series 227 variable inductor shown above, is also engineered to meet demands of high-power transmitter tank designs, while the series 212 is recommended for applications at lower frequencies in medium power transmitters. The Johnson series 226 variable inductor is applicable for high-frequencies and for a wide frequency range by means of its variable pitch design. The Johnson series 204 inductor is widely used for tank coupling and other transmitter applications and can be supplied with either a variable coupling rotor or as a variometer.

VARIABLE INDUCTORS—Offer many important advantages to the electronic engineer and manufacturer. They provide close control and adjustment of fixed and limited frequency range circuits and allow the use of smaller, lower-cost, fixed capacitors. In series filters or networks where it is desired to simulate high-capacity, low-impedance conditions variable inductors again serve as desirable means of control.

Whether you need inductors for electronic heating equipment or transmitters, you will find Johnson's engineering and production facilities ready to meet your needs. Johnson fixed and variable inductors range in size from small, wire-wound units for oscillator and low-power stages to the large, high-power models where copper tubing acts as the conductor for both radio-frequency current and liquid for cooling.

TUBE SOCKETS • VARIABLE CAPACITORS • INSULATORS • BROADCAST COMPONENTS

Write for Specific Information

JOHNSON
a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA regardless of changes in tube impedance. Light output-current characteristics produce good average light response. Bulbs are selected to minimize distortion in the optical path. Useful life is extended through the use of mica baffles to reduce bulb blackening.

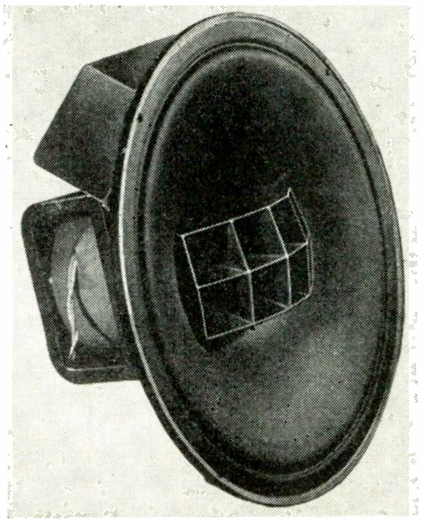
Use in a typical facsimile receiver the light output of the tube is focused through a baffle with a sharp rectangular opening to produce a spot of light 0.0072 in. high and 0.0104 in. wide on a drum rotating at 90 rpm. Scanning movement is 0.0104 in. per revolution.

The tube is supplied in a T-9 bulb with intermediate shell octal base and may be operated in any position. Providing a useful light range between 3500 and 6500 angstroms it will respond to frequencies between 15 and 15,000 cps. Rated at 135 v d-c with currents ranging from 5 to 35 ma, it requires a starting voltage of 170 d-c, maximum.

10

Small Coaxial Speaker

THE STEPHENS Mfg. Co., of 10416 National Boulevard, Los Angeles 34, California, has developed the Tru-Sonic Co-axial Speaker to meet the demand for a small, low cost, two-way sound reproducing assembly that would give comparable performance to that provided



in larger, separate two-way sound systems. The assembly consists of a low-frequency paper cone, a high-frequency diaphragm operating into a multicellular horn and a divid-

ing network, all mounted on a rugged cast aluminum frame, 15⅛ in. in diam. and 9½ in. in depth. The multicellular horn allows a vertical sound distribution of 40 deg. and a horizontal distribution of 80 deg.

11

Lightweight Precision Motor

A NEW A-C/D-C ELECTRIC MOTOR, Model DS-105, weighing only 11 oz and developing 1 inch-oz torque at 8000 rpm and 4 inch-oz locked torque (8000 rpm) is now offered by Electro Engineering Industries, 800 N. Clark Street, Chicago, Illinois. Body dimensions are 1.687 in. diam by 2 9/16 in. long, with ¼ in diam shaft.

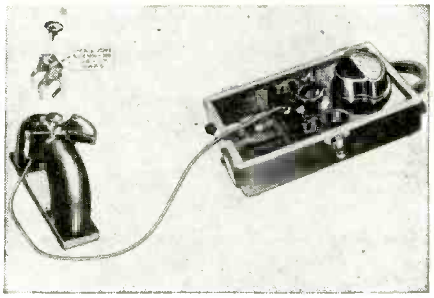
A special governor makes possible new refinements in speed control with accuracy to within 0.25 percent. For electronic applications requiring complete freedom from radio-frequency interference, a capacitor type motor is offered, with the capacitor built permanently in circuit. Small, permanent-magnet motors are also available. All motors may be obtained with Torrington lightweight blowers attached at one or both ends.

Motors are wound for 6 to 115 volts, and have sealed ball bearings, die-cast housings, ground cores, and laminated fields.

12

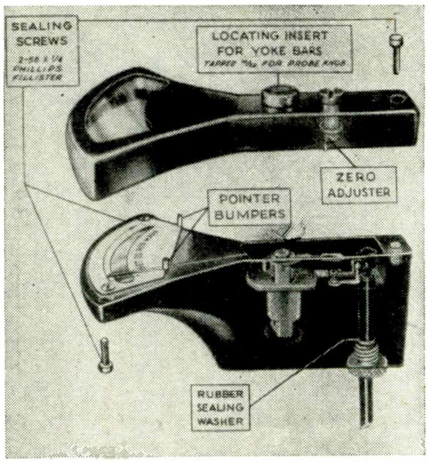
Direct-reading Fluxmeter

THE DIRECT-READING fluxmeter was primarily developed by the Marion Electrical Instrument Co., Manchester, N. H., for the very precise measurement of the field strengths of magnets used with magnetron assemblies. It is, however, a very versatile instrument. It can be used to measure magnetic fields and gaps ½ in. or greater, within



the range of 1200 to 9600 gauss. The fluxmeter consists essentially, of two special D'arsonval instruments connected in series, provided with suitable shunts, current and range selection controls. The overall accuracy of the instrument in all fields, and at all points on the scale is considerably better than 1 percent.

The unit weighs 6½ lb. in its carrying case of hand-rubbed oak, 5 x 6 x 10½ in. It is operated from a single Type D flashlight cell. The cable on the probe element is 4½



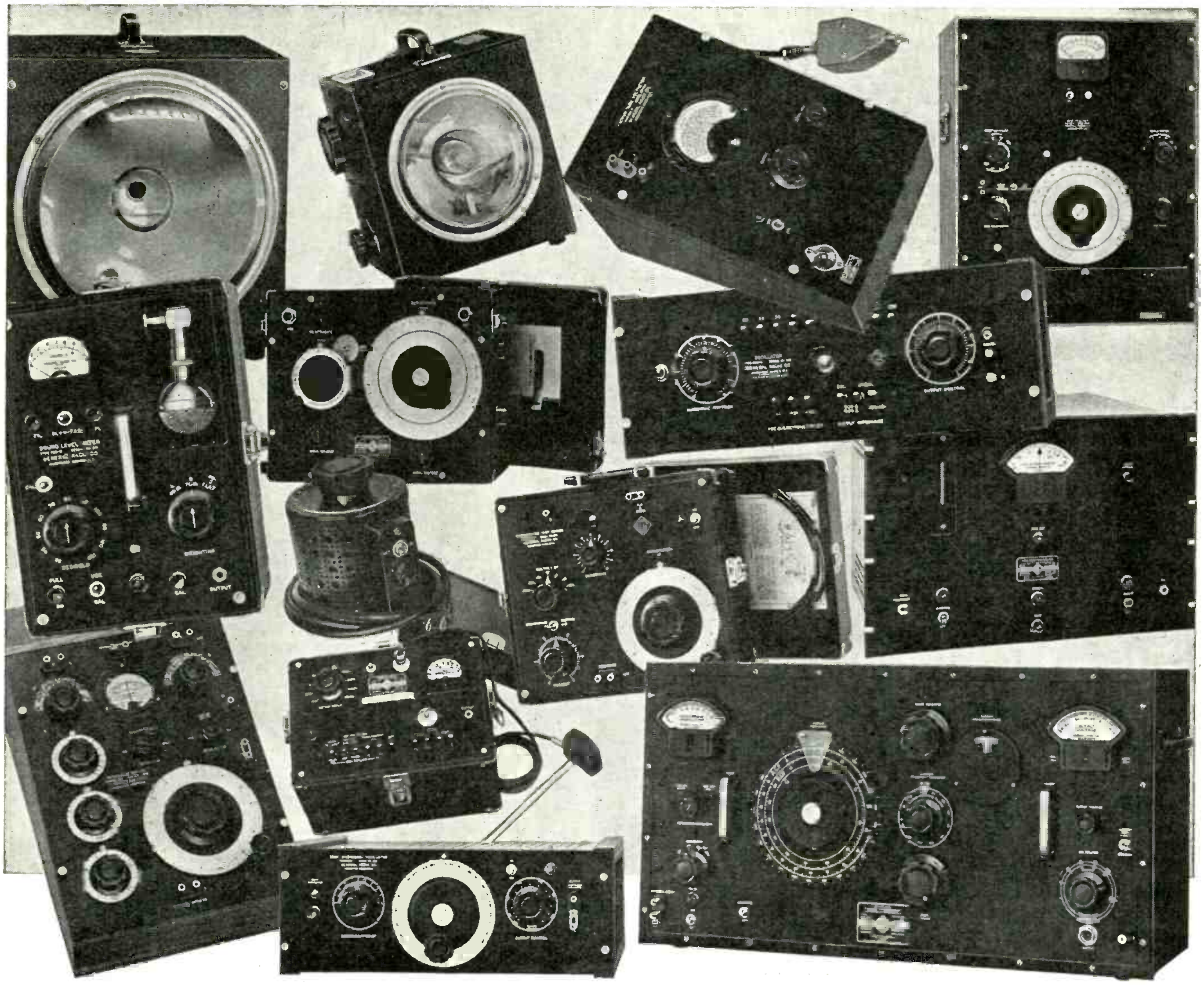
feet in length. The unit is provided with adapters for use with magnetron magnet assemblies having gaps of 0.550 to 0.750 in., with pole diameters of ⅞ in. and with adapters for gaps of 1.3 to 1.5 in. with pole faces of 1⅝ and 2 in. in diameter. For magnetic measurements in fields of non-standard magnets, and other sources, the probe element is marked with centering lines and provided with a handle so that it may be inserted into any field.

13

UHF Triode

THE NEW TYPE TUF-20 transmitting or receiving triode rated for 250 mc designed for uhf service has just been released by Taylor Tubes, Inc., 2312 Wabansia Avenue, Chicago, Illinois. Constructed with a Nonex glass envelope and a tantalum plate, it will operate at full ratings up to 250 mc and at reduced ratings for higher frequencies.

The tube is designed primarily for mobile application and its internal structure has been engi-



IN *ANY* LABORATORY . . . .

It is difficult to picture any modern scientific or industrial laboratory that does not have need for *some* G-R instrument. The considerable impetus given to electronic research during the war has greatly expanded the need for G-R equipment.

Since it was founded in 1915, General Radio has developed, manufactured and supplied industry with an increasingly large number of instruments for audio- and radio-frequency measurements, until at the present time the complete line of G-R equipment and accessories is numbered in the hundreds of models.

General Radio instruments include:

INDUSTRIAL INSTRUMENTS: Stroboscopes, Sound and Vibration Meters and Analyzers, D-C Amplifier, Variac Continuously-Adjustable Transformers

WAVEFORM INSTRUMENTS: Wave Analyzer, Modulation Meter, Distortion Meter, Wave Filters, Oscillograph Recorder.

FREQUENCY MEASURING EQUIPMENT: Primary and Secondary Standards of Frequency, Interpolation Equipment, Heterodyne Frequency Meters, Frequency Monitors, Wavemeters

BRIDGES for measuring: Capacitance, Power Factor, Inductance, Resistance, Vacuum-Tube Characteristics

RESISTANCE: Standards, Decade Resistors, Resistance Units, Attenuators, Rheostat-Potentiometers

CAPACITANCE: Air and Mica Standards, General-Purpose Fixed and Variable Condensers

INDUCTANCE: Standards and Variable Inductors

STANDARD—SIGNAL GENERATORS

OSCILLATORS: Electronic Audio- and Radio-Frequency, Pulse Generator, Tuning Forks

METERS: Vacuum-Tube and Rectifier-Type Voltmeters, Microvolter, Megohmmeters, Oxide Rectifiers

PARTS AND ACCESSORIES: Switches, Dials and Knobs, Plugs and Jacks, R-F Chokes

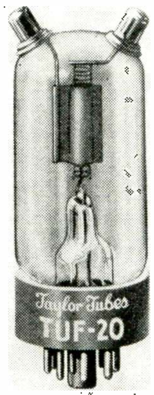
Before you buy any electronic laboratory measuring equipment, it will pay you to investigate the G-R line.

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 1000 N. Seward St., Los Angeles 38

neered to withstand hard usage. Its instant-lighting, thoriated filament permits power conservation during standby periods, a valuable consideration in single-battery operated auto or airplane radio transmitters.

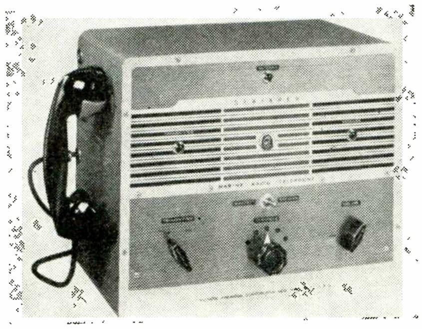
Tube characteristics are: size, 3¾ in. overall height by 1½ in. maximum diameter; Micalex octal base, with grid and plate connections brought out through the top of the tube; grid to plate capacitance, 3.6 $\mu\mu$f; grid to filament capacitance, 1.8 $\mu\mu$f; plate to filament capacitance, 0.095 $\mu\mu$f; amplification factor, 10; filament 6.3 v a-c or d-c at 2.75 amp; maximum plate power, 750 v at 0.075 amp; plate dissipation, 20 watts. Typical operation: Plate volts, 750; plate current, 75 ma; grid voltage, − 150 v; maximum d-c grid current, 20 ma approximate driving power, 1.5 to 2.5 watts; approximate carrier output, 40 w (at 115 mc). The price is $4.95 net.



14

Marine Radio Telephone

A SIMPLE, crystal-controlled radio telephone suitable for installation on medium and small yachts and commercial boats is offered by Hudson American Corp., 25 West

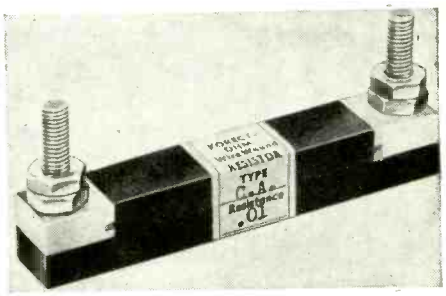


43rd St., New York 18, N. Y. One model, the Seafarer, is 13 in. high, 16 in. wide and 9 in. deep, rustproofed and tropicalized, with five frequency channels available. Crystal kits are available for all frequencies assigned for this type of communication. It operates on 6 or 12 v d-c, and output power is about 15 w.

15

Shunt-Type Resistor

EASTERN ELECTRONICS Corp., 41 Chestnut St., New Haven, Conn., has recently developed the type XM shunt-type resistor for use as a shunt and series resistor in measuring circuits where a power rating up to 25 watts is required. The resistor is so designed that the resistance element is completely enclosed and protected



from mechanical injury, and the enclosure, with its impregnation, forms a substantially fume- and moisture-proof protection. The element is manganin wire or ribbon, and can be adjusted to an accuracy of 0.1 percent. This type of resistor can be supplied in resistance values of 0.01 to 10 ohms.

16

Variable-Speed Drive

A NEW ELECTRONIC SPEED control is being marketed under the name Servotron by the Submarine Signal Co., 160 State St., Boston 9, Mass. Although similar to variable speed drives supplied for some time to the machine-tool industry, the new model embodies a number of new principles and features which are expected to create new industrial techniques.

The a-c operated electronic controller runs a d-c motor at speeds which are infinitely variable within the motor's speed and load

Permanently Insulated Rockbestos Wires, Cables and Cords

TURN THUMBS DOWN

ON WIRE FAILURES...

A few of the 125 different wires, cables and cords designed for severe or unusual operating conditions by Rockbestos.

ROCKBESTOS FIREWALL HOOKUP WIRE

Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt insulated with high dielectric synthetic tape, impregnated felted asbestos and covered with color coded lacquered glass braid.

Ideal for small motor, coil, transformer and dynamotor leads and bunched wiring in compact apparatus. The first small diameter heat and flame resistant high-dielectric hookup wire, designed in 1937 and approved by the C.A.A. for use in airborne radio equipment. Widely used since in automotive and ground communications systems, electronic devices and apparatus. Operating temperature range 125° C. to minus 50° C. Also in twisted pair, tripled, shielded and multiple constructions.

ROCKBESTOS THERMOSTAT CONTROL WIRE

Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125", or .025" or (for 115 volt service) .031" of impregnated felted asbestos insulation and steel armor.

This multi-conductor control wire is widely used for low voltage inter-communicating, signal and temperature control systems. Its heat, flame and moisture resisting asbestos insulation assures troubleproof circuits and the rugged steel armor protects against damage and abrasion during installation.

ROCKBESTOS A.V.C. 600 VOLT SWITCHBOARD WIRE
Nat. Elec. Code Type AVB—max. operating temp. 194°F.

Sizes No. 18 to No. 4/0 AWG with varnished cambric and impregnated asbestos insulation and gray, black, white or colored flameproof braid.

Combine fire insurance and fine appearance in your switchboards and control panels with Rockbestos Switchboard Wire. It is fireproof and will not dry out under heat. Sharp, clean bends can be made without cracking as the asbestos wall acts as a cushion under the braid. Rockbestos A.V.C. Hinge Cable and Switchboard Bus Cable have the same fireproof and heatproof characteristics.

Another New Rockbestos Firewall Construction

Rockbestos High Temperature Wire—*with a maximum operating temperature* of 400°F.—designed for jet-propelled plane applications, circuits to hot-wing de-icers, fire detectors and extinguishers, and air heating units where baking temperatures destroy ordinary insulation. Under continuous operation at rated temperature it retains its original dielectric strength and resistance to flame, *and progressively improves* in its resistance to moisture and abrasion. Now available for other severe applications. Write for information and samples.

When dependable performance calls for a wire, cable or cord that must withstand high ambient temperatures, conductor-heating overloads or heating and cooling cycles . . . oil, grease, corrosive fumes, moisture, and even flame . . . it will pay you to look over the *permanently insulated* wires Rockbestos has developed in specializing on constructions for severe or unusual operating conditions.

You'll probably find the wire you need for improved performance in our line of 125 standard heat and flame resistant constructions. To mention a few, there are tiny, space saving control cables with 3 to 6 conductors in sizes 20 to 26 AWG, and other larger multi-conductor constructions . . . 600 volt motor lead cable and power cables rated at 600 to 5000 volts from 18 AWG up . . . asbestos insulated magnet wire . . . and then there's Firewall Hookup Wire, a thin-walled high-dielectric construction in braided, shielded and multiples, so resistant to heat and flame that even though the conductor gets red hot the insulation still maintains coverage.

And for those applications where a standard won't do Rockbestos Research will gladly tackle the problem and develop a wire that will meet your mechanical and performance requirements . . . just as it has for many manufacturers of electrical products. For recommendations, samples or engineering assistance write the nearest district office or:

ROCKBESTOS PRODUCTS CORPORATION
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Solve. Wiring Problems

DO YOUR SHARE WITH VICTORY BONDS

NEW YORK BUFFALO CLEVELAND CHICAGO PITTSBURGH ST. LOUIS LOS ANGELES SAN FRANCISCO SEATTLE PORTLAND, ORE.

capacity. It maintains uniform torque over the entire speed range. The drive eliminates changing of gears encountered in mechanical drive systems.

The Servotron has instantaneous dynamic braking and instant reversal without speed overrun. Within the coming year it is expected that a complete line of drives from 1/50 hp to 5 hp will be available. Larger units are also being developed.

17

Railroad Loudspeaker

OPERADIO MANUFACTURING Co., St. Charles, Illinois, announces development of a loudspeaker for outdoor use. The unit, completely sealed and weatherproofed, can be mounted in-

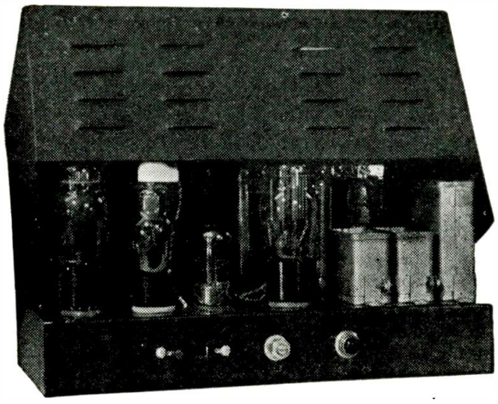
side or outside locomotive cabs and on stationary equipment. Its connection to standard railroad conduits can be made without exposing the interior of the unit. Air pressure on the diaphragm is minimized by a new method of construction.

18

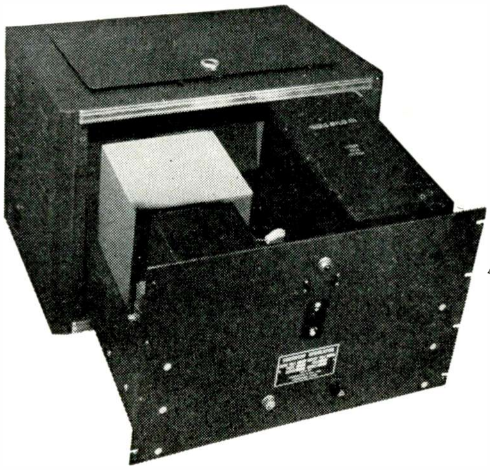
Servo-Generator and Sine-Wave Power Generator

WESTINGHOUSE ELECTRIC Corp., Pittsburgh 30, Pa., reveals details of an a-c driven exciter and d-c generator used in tracking-type radar. Linear response, extremely low generator residual voltage and quick response have been engineered into the so-called mechanical amplifier. Also

ELECTRONIC
A. C. VOLTAGE REGULATORS
by Sorensen



Model 250



Model 1750

AVAILABLE FOR IMMEDIATE DELIVERY:

Model No.	Load Range
250	25 to 250 V.A.
1000	200 to 1000 V.A.
1750	800 to 2000 V.A.
5000	1000 to 5000 V.A.

NOTE THESE FEATURES:

- Output voltage maintained to within ± .2% (adjustable 110-120 volts) with input fluctuations 95 to 130
- Output voltage constant to .2% despite variations in load over entire rated range of unit
- Minimum wave form distortion—about 5% average
- Independent of load power factor
- Independent of frequency variations ± 15%
- Quick response time—output voltage stabilized in SIX cycles maximum
- Built for long, trouble free service. Component parts conservatively rated—transformers, etc. hermetically sealed

For additional information and prices, write the factory or our Sales Representative nearest to you.

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N. B. NEELEY ENTERPRISES
7422 MELROSE AVE.
HOLLYWOOD, CALIF.

NEW ENGLAND: IRVING I. KAHN CO., 3324 Main St., Hartford, Conn.

SORENSEN & COMPANY, INC.

AIRBORNE ELECTRONICS

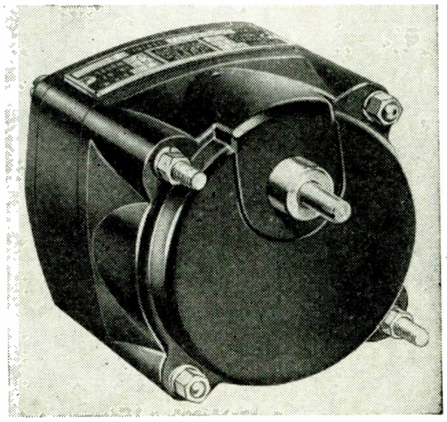
STAMFORD, CONN.

available is an engine-driven 400-cps, 8-kva generator which has seen aircraft service in supplying sine-wave power to a radar load. The generator has an outside diameter of 6 in.

19

Small Gearmotor

JOHN OSTER Manufacturing Co., Racine, Wis. has added two new types to its line of fractional-hp motors, with outputs in the range 1/1000 to

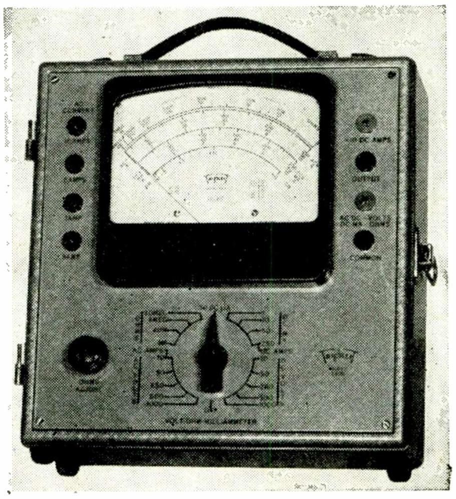


1/2000 hp. Available in 4-pole or 2-pole types, with or without gear reduction, these precision capacitor synchronous and induction motors are suitable for instrument and control applications.

20

Volt-Ohm-Milliammeter

THE TRIPLETT Electrical Instrument Co., Bluffton, Ohio now has available the model 2405 multi-range meter with the following scales: d-c volts, 0-50-250-500-1,000 at 25,000 ohms per volt; a-c volts, 0-50-250-500-1,000 at 1,000 ohms per volt; d-c amp, 0-10



a-c amp, 0-0.5-1-5-10; d-c ma, 0-1-10-50-250; d-c μa, 0-50; ohms, 0-4,000-40,000; megohms, 4-40. As an output meter, the instrument is used with a capacitor in series with the a-c volt scale.

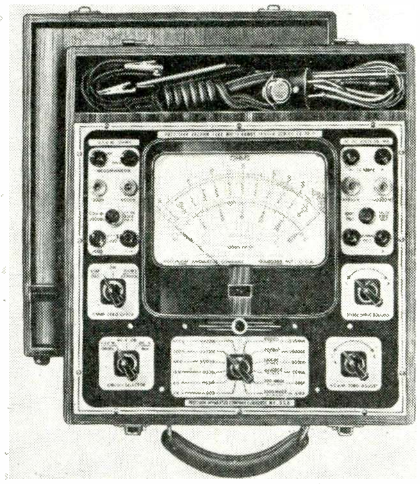
The 6-in. microammeter has a 5.6-in. scale for easy reading. Batteries are self-contained in a metal case 10 x 10 x 5¾ in. which has a hinged cover and handle. Leads are furnished. The meter weighs approximately 11 lb.

21

Vacuum-Tube Voltmeter

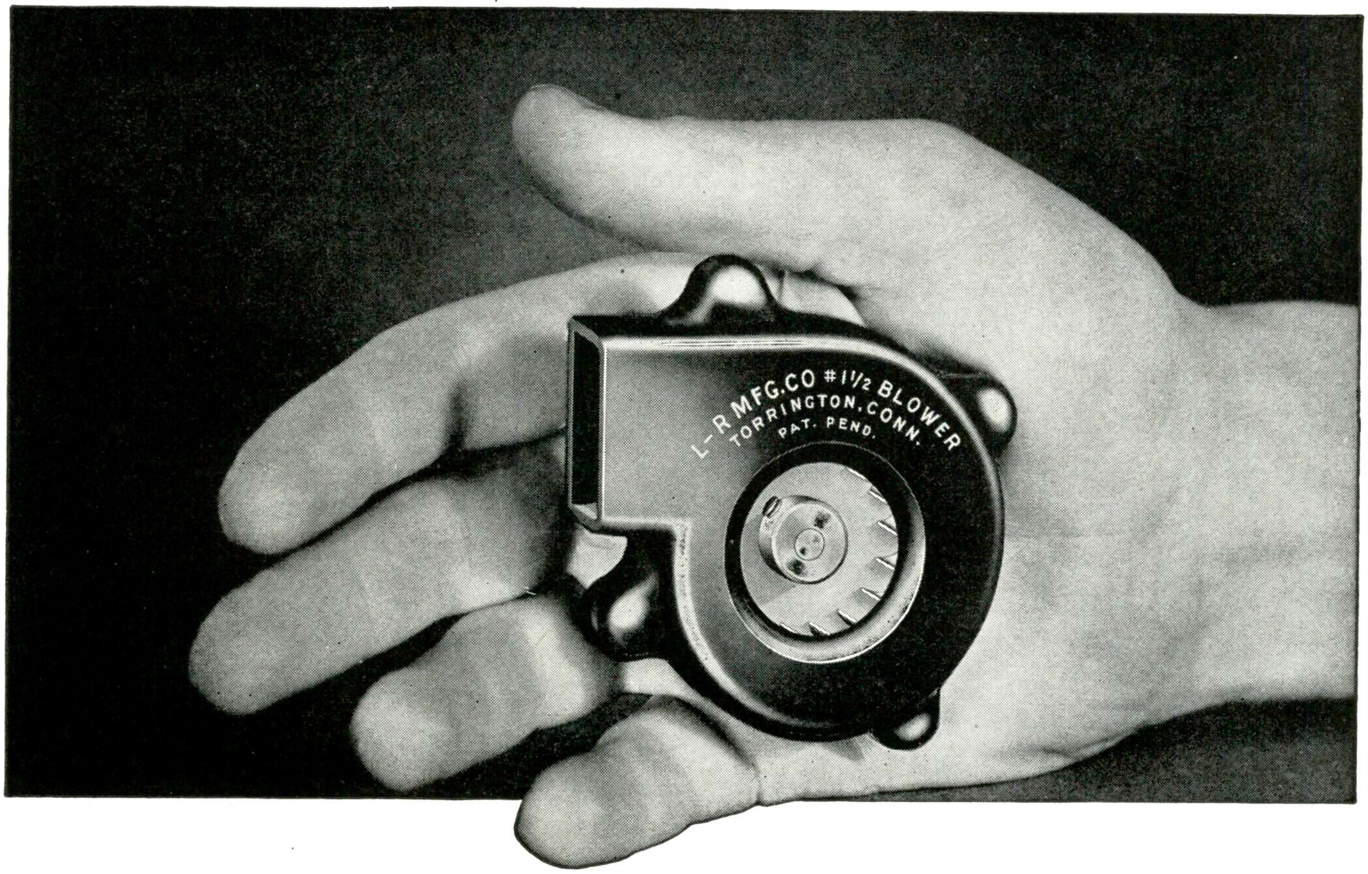
THE PRECISION APPARATUS Company, 92-27 Horace Harding Blvd., Elmhurst, N. Y., is manufacturing the EV-10-P portable vacuum-tube multirange tester with all zero-center vacuum-tube voltmeter ranges. It includes direct reading megohmmeter, milliammeter, ammeter, output and decibel meter. Sensitivity is 1,000 ohms per volt for a-c and d-c voltmeter ranges.

Incorporating a full 7-in. rectangular meter, the instrument employs a stabilized bridge circuit using only



three tubes, a 6C5, 6X5, and VR150. The power-supply plate-voltage output remains constant over severe line voltage variations, eliminating annoying meter vs line voltage shift. The meter is zero-center on all ranges when used in the vtvm circuit, indicating both polarity and magnitude without reversing the prods or use of a polarity switch.

The tester is designed to permit rapid checking of voltages, currents and resistances encountered in tele-



MOVING AIR...

15 CUBIC FEET A MINUTE
ONLY 2½" OF SPACE NEEDED

The blower illustrated, No. 1½*, is one of many blower models manufactured by the L-R Mfg. Div. with C.F.M.'s at 8000 R.P.M. ranging from 15 to 270. These blowers will outperform many larger and heavier types formerly in use and where size and weight are factors, they are the answer to cooling problems presented by electronic tubes or circuit components in airborne communication units as well as in many industrial applications.

*WEIGHT: 2 oz.; CAPACITY: 15 C. F. M. at 8000 R. P. M.; CONSTRUCTION: Housing of high impact phenolic plastic. Wheel is turbo-type cadmium-plated steel; SIZE: 2⅝" long x 61/64" wide x 2½" high.

BLOWER DIVISION

The RIPLEY Company

13 NEW LITCHFIELD STREET — TORRINGTON, CONNECTICUT

vision, photoelectric, f-m, a-m or any high-sensitivity circuits without disturbing the operation of the circuits under analysis. A single master range selector provides rapid, positive shift from one range to another.

The functions are as follows: eight zero-center vtvm ranges from ± 3 v d-c to $\pm 6{,}000$ v d-c full scale; six resistance ranges from 0-2,000 ohms to 0-2,000 megohms; eight a-c and eight d-c ranges from 600 μa to 12 amp; eight output ranges from 3 to 6,000 v and eight decibel ranges from -26 to $+70$ db. A vacuum-tube probe for supersonic, r-f and uhf voltages is available as an optional accessory, known as Series RF-10 probe and incorporating a peak-rectifier circuit around a 9002 miniature tube.

The instrument is furnished in a hardwood case with removable cover and tool compartment, complete with tubes, ohmmeter battery and testing probes. Overall dimensions are about 12 x 13 x 6 in.

22

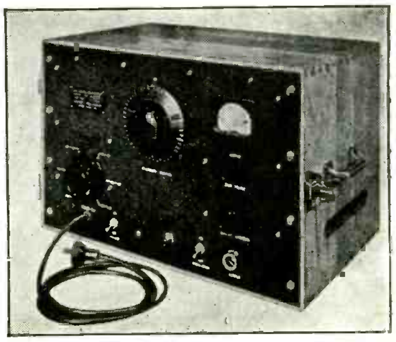
Midget Quartz Crystal

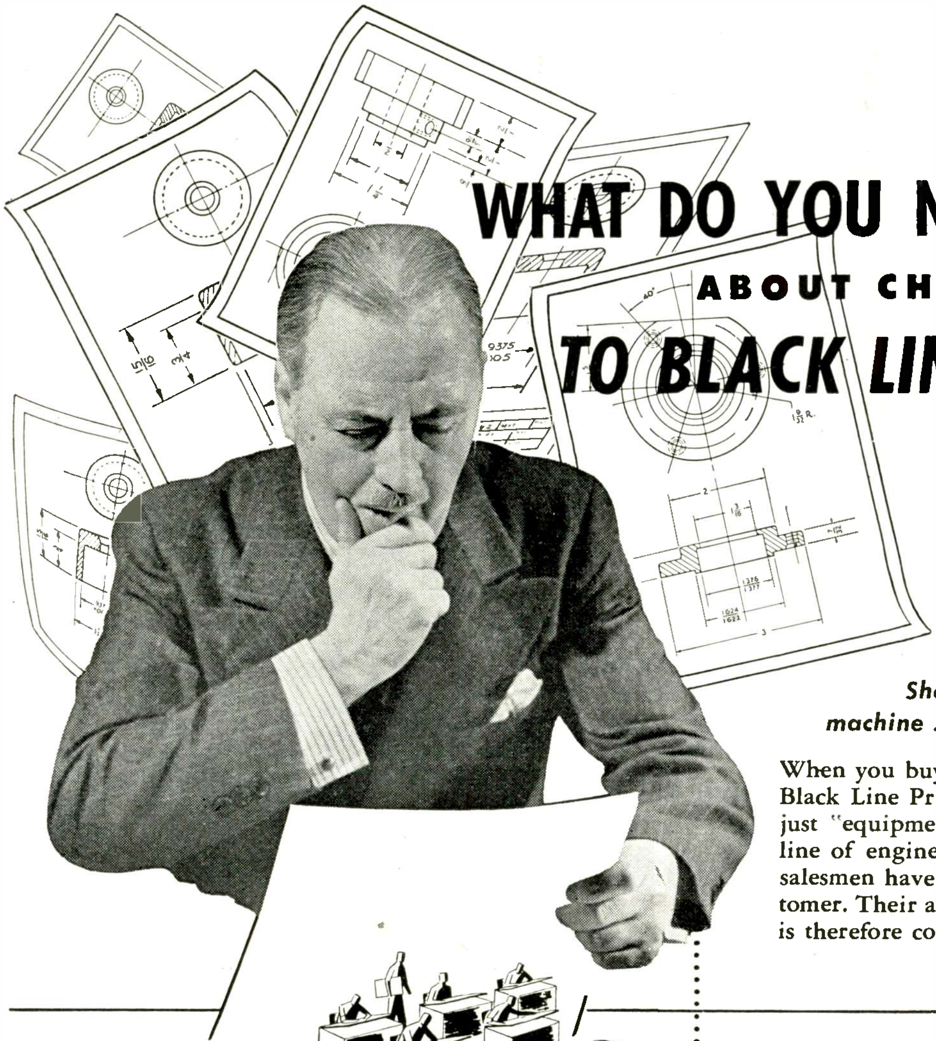
THE JAMES KNIGHTS Company of Sandwich, Illinois announces the development of a new midget-size type HI5 shock-proof quartz crystal with tinned pig-tail connections which may be readily soldered into the circuit. The new crystal, complete with phenolic holder, weighs less than ⅛ oz. Actual size of the unit is 0.600 by 0.725 by 0.350 in. It is dustproof and moisture resistant. Available frequency range is from 3,000 to 15,000 kc. Frequency tolerance is 0.01 percent over a temperature range of 0C to 70C. The crystal is processed to eliminate aging.

23

R-f Signal Generator

BARKER & WILLIAMSON, 235 Fairfield Ave., Upper Darby, Pa. are bringing out a new precision-built, high-level





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Should I buy just a machine . . . or a service?

When you buy a BW machine for making Bruning Black Line Prints, you are buying much more than just "equipment." Because Bruning sells a *complete* line of engineering and drafting supplies, Bruning salesmen have a continuing interest in you as a customer. Their advice on making and using BW Prints is therefore constantly available.

What's the ratio between draftsmen and print needs?

Do you know the exact relationship between the number of draftsmen you employ and the volume of black line prints you need? The Bruning BW System provides careful analysis of your print needs—based on 17 years of experience by Bruning field engineers. You are sure of a *careful* preliminary survey.

How can I provide for peak loads without over-buying on equipment?

The Bruning BW System provides a line of printing and developing equipment so complete that you are sure of getting the right machine for your needs. This Bruning Model 41 BW Printer-Developer, for example, is especially designed to provide ample volume for medium print users—but costs much less than a high-volume machine.

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1. A versatile, simple method for making black line prints directly from tracings.
2. 17 years' experience in analyzing printmaking needs.
3. A complete line of materials, including white and green-tinted stock, thin and heavyweight stock, black, red or brown line prints, BW Transparents to supplement original tracings and BW Film for intensifying pencil lines on tracings.
4. A complete line of printing and developing machines to fit every requirement.
5. A continuing service . . . because Bruning sells everything for the engineer and draftsman, not just BW equipment. Buying a BW machine is, therefore, not a "one time sale."
6. Continuing research and development in the customer's interest.

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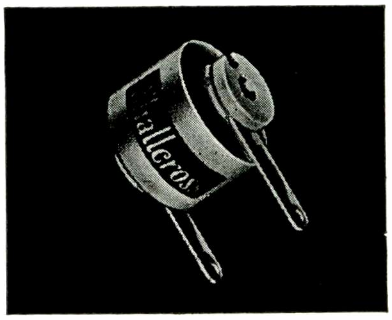
r-f signal generator covering the range from 400 kc to 60 mc in six steps. Modulation of 30 percent at 1,000 cps is optional by means of a panel switch. Output is 3 v (rms) at all frequencies and is read directly from a panel voltmeter. Output is through an output jack and coaxial cable terminated in a 75-ohm resistive load. Calibration is accurate to better than 0.5 percent and is read from a large individually calibrated chart mounted on the lid of each cabinet. The six ranges are: 400-1,000 kc, 1,000-2,500 kc, 2500 kc-6 mc, 6-13 mc, 13-28 mc, 28-60 mc.

24

Half-Watt Resistor

SHALLCROSS MFG. Co., Jackson and Pusey Avenues, Collingdale, Pa. has added a new unit, type 1101, rated at 0.5 watt and only $\frac{7}{8}$ in. long x $\frac{7}{8}$ in. in diameter, to the line of hermetically sealed Shallcross fixed accurate wire-wound resistors. The new resistor is designed for style RB12A under JAN Specification R93. Maximum



resistance value when wound with nickel chromium wire is 350,000 ohms, maximum voltage 420 v.

Resistance element, winding form and protective ceramic shell form a rigid, integral unit. No internal leads or floating wires are used, and hermetic-sealing is obtained without use of ferrule caps or glass drawing by a special solder process. Other units are rated at 0.75, 1.5 and 2.0 watts.

25

Small Motors

EASTERN AIR DEVICES, Inc., 585 Dean St., Brooklyn 17, N. Y., has in production a new line of fractional-hp motors of various types with frame diameters ranging from $1\frac{3}{4}$ to $3\frac{5}{16}$ in. These motors can be used in original

equipment of all types, including recorders, business machines, automatic devices, record players, air circulators, driving fans and blowers. End covers are die cast, providing mechanical rigidity. Mounting faces are precision machined so that gear trains may be run directly from the motor shaft with perfect alignment.

26

Wire-Wound Resistors

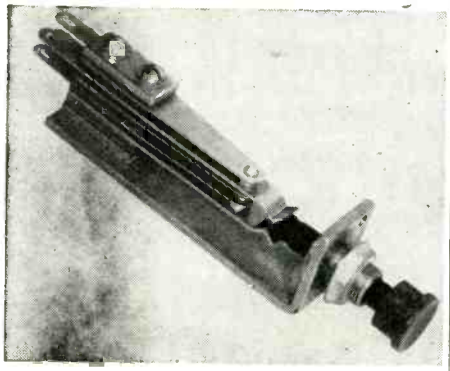
INSTRUMENT RESISTORS Co., 25 Amity St., Little Falls, N. J., offers four new types of resistors—ALA, ACA, BLA, and BCA, which provide close tolerance at low cost. Wound with either nichrome or manganin, they are rated according to type at 3, 6, 5, and 10 watts respectively. Maximum

resistance for the first two is 25,000 ohms for a body size 1⅛ in. long x ⅜ in. diam. The 5- and 10-w types have a maximum resistance of 50,000 ohms with a length of 1⅝ in. Standard tolerances are 3 percent although they can be supplied for 1 percent and also non-inductive windings.

27

Heavy Duty Push Switch

DONALD P. MOSSMAN, Inc., 612 N. Michigan Ave., Chicago, Ill., announces a new standard-duty 5-amp and extra-heavy-duty 10-amp push switch, designed for circuits carrying heavier currents than are usually found in communication and signal systems. Designated as Series 5300 and 5300X, respectively, the new development can handle heavier currents, and require less panel space



than the Series 4300 and 4400 push and jack switches.

The standard duty switch is available for 5 amp, 115 v, a-c (non-inductive), and the extra heavy duty for 10 amp. The switch illustrated is built with both make-break, and break, locking. It is also available in a non-locking position. Both are heavily nickel plated, have phosphor bronze springs with fine silver contacts, plungers of hard rubber, and red or black plastic knobs. Overall dimensions of the switch illustrated are $\frac{3}{4}$ x 1 x $4\frac{1}{4}$ in.

Units are also available as a heavy duty plug jack, used in conjunction with a standard PL-55 phone plug. The Series 5300X requires a special plug to handle 10 amp.

28

Power Resistor

P. R. MALLORY & Co., Inc., 3029 East Washington St., Indianapolis, Ind. announces development of the RN resistor, a new vitreous enamel tab-type unit which meets joint Army and Navy Grade 1 Class 1 specifications (JAN R26). It can withstand thermal shock from 275 C to 0 C, operate safely at 275 C and is capable of withstanding momentary voltage overloads up to ten times its rated wattage. Its characteristics are derived chiefly through the use of improved materials and new manufacturing techniques.

29

Non-Linear Potentiometer

FAIRCHILD CAMERA and Instrument Corp., 88-06 Van Wyck Boulevard, Jamaica 1, N. Y., have one type of non-linear potentiometer in production and can design others to meet specifications. Used during the war in military equipment such as radar navigational and tracking equipment, computing gunsights and bombsights, these potentiometers should find use in providing electronic substitutes for cams, eccentric gears and other mechanical

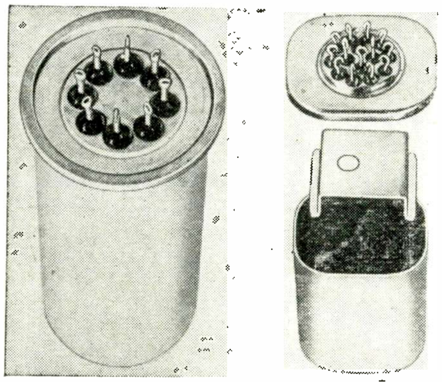
methods of non-linear compensation.

Maximum resistance is limited to 100,000 ohms (linear winding) and a maximum rate of resistance change of 330 ohms per degree rotation. Error is limited to a total of 1 percent or less, power to 2.5 w. Each unit is 25/32 in. thick and has a diameter of 1⅝ in. shaft diameter is optional. Mechanical rotation can be limited or continuous, although the electrical angle covers 310 deg.

30

Component Enclosures

ELECTRICAL INDUSTRIES, Inc., 42 Summer Ave., Newark 4, New Jersey, offers a new line of enclosures for electrical components, such as relays, coils, and transformers. Round or square cans are available with or without equipment-mounting bridges attached to the can interior. Can



lengths to 6 in. are supplied. Terminals are brought out through sealed headers in the base. The headers can be supplied for plug-in use.

Round cans have a maximum of eight contacts; square cans a maximum of fourteen. These new enclosures offer complete protection from dirt, moisture and mechanical damage.

31

Portable Multimeter

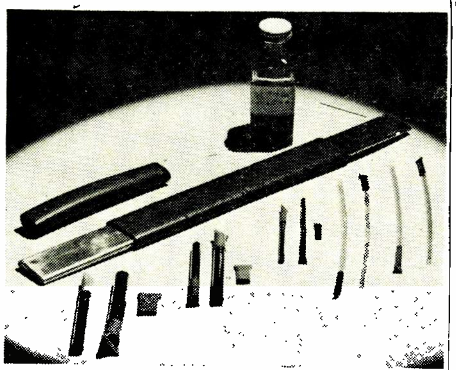
RADIO CITY PRODUCTS Co., 127 West 26th St., New York, offers the Model 448 meter consisting of a 3-in. square meter with a movement of 200 μa and a sensitivity of 5000 ohms per volt. Ranges of multitester are: d-c 0-5-50-250-1,000 v; a-c 0-5-50-250-1,000 v; output voltmeter, 0-5-50-250-1,000 v; d-c 0.5-10-100-1,000 ma; ohmmeter 0-1,000, 0-10,000, 0-0.1 meg 0-1 meg;

decibel meter, -6 to $+10$, -14 to $+26$, -28 to $+40$, -40 to $+52$ db. The db range is calibrated for a 500-ohm line. For lines of other impedance, correction charts are supplied. The Model 448 is $5\frac{7}{8} \times 3\frac{1}{16} \times 2\frac{1}{8}$ in. It weighs only $1\frac{3}{4}$ lb, complete with self-contained batteries in snap spring contact holders.

32

Plastic Caps and Sleeves

THE PLASTICS DIVISION, General Electric Co., Pittsfield, Mass., has developed a new type of compound used in making air- and water-tight seals. This new material has been used to seal the ends of metal tubing to keep the interior free of dust and moisture in shipping and storage. New uses are being discovered, the most recent one being lead markers on wires and cables. These caps and



sleeves are available in red, blue, green, orange, yellow, white, and transparent. Their good electrical properties make them useful also as insulation covering for bus bars selsyn motors, and wire cleats. They can be produced to specified diameters and thickness and shipped dry.

Previous to use these caps and sleeves must be soaked in a solution, and can then be expanded as much as 50 percent of their normal size. They are placed in position while dilated and allowed to dry. When thoroughly dry, they shrink to smaller than their normal size to form a tight fit. They can be crimped any length with a trade mark added if desirable.

33

Lighthouse Tube

EITEL-MCCULLOUGH, Inc., San Bruno, California, announces the 3X100A11/2C39 transmitting tube. The tube is a miniature external-anode triode, of the lighthouse variety, and offers exceptional performance in applications requiring up to 25 watts of power at frequencies to above 500 mc. Its rugged construction, unusually high transconductance and 100 watts plate dissipation make it useful over a very wide range of frequencies, either in fixed or mobile equipment. It has an indirectly heated cathode with a 6.3-v heater. The overall height is 2¾ in. and the diameter is 1¼ in.

34

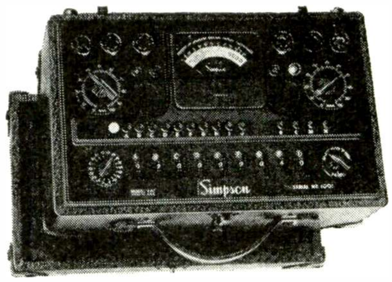
PA Amplifier

CLARK RADIO Equipment Corp., 4313 Lincoln Ave., Chicago 18, Ill., presents the first in a series of public address amplifiers having adequate frequency response for broadcast speech input systems. Its salient characteristics are summarized: power output, 30 w at less than 4 percent harmonic distortion, three high-impedance inputs, four low-impedance output values, two equalizers, hum level 55 db below maximum output and frequency response within ±2 db from 50 to 10,000 cps. Power: 150 w at 117 v, 60 cps; 10 in. high x 20 in. wide (including handles) x 11⅜ in. deep; 38 lb net.

35

Dynamic Tube Tester

SIMPSON ELECTRIC Co., 5218 W. Kinzie St., Chicago 44, Ill., promises early delivery on a new mutual conductance tube tester. A tube under test by the instrument is compared with the standard rated micromho value for that tube. Colored zones on the dial coincide with the micromho rating or percent of mutual conductance, indicating that the tube is



good, fair, doubtful or definitely bad.

Ten pushbutton switches and nine rotating switches of six positions each provide a multitude of combinations in tube element and circuit se-

lection. Very complicated tubes require only a few settings. A tube chart is provided for quickly identifying the tube and setting the controls. The case is plywood with heavy fabricoid covering.

36

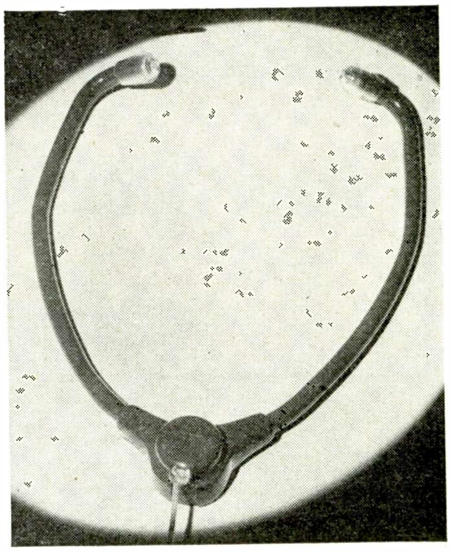
Plug-in Meter Assembly

ANDREW CO., 363 East 75th St., Chicago 19, Ill., facilitates tuning and maintaining r-f networks by use of type 821-A plug-in assemblies at all points where radio-frequency currents are to be measured. Meters of various ranges, attached to type 821-B brackets, can then be plugged in after removal of a shorting bar. The 821-A assembly with shorting bar costs $4.50; the 821-B meter bracket is $2.50.

37

Chinphones

TELEX PRODUCTS CO., Telex Park, Minneapolis 1, Minn., attempts to minimize headphone fatigue by suspending the reproducing unit under

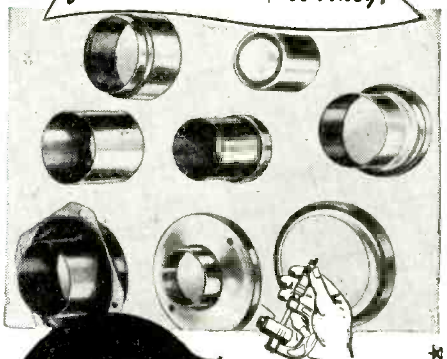


the chin rather than against the ears. Called a Monoset and constructed of tenite, the unit weighs only 1.2 oz. Its impedance is 128 ohms and it has a sensitivity of 18 dynes per sq cm. for a 10 microwatt input.

38

Acorn Socket

THE NATIONAL CO., 61 Sherman St., Malden 48, Mass. is now releasing the XLA socket for civilian use. Insertion of an acorn tube is accomplished by a rotary motion which *for dimensional accuracy!*



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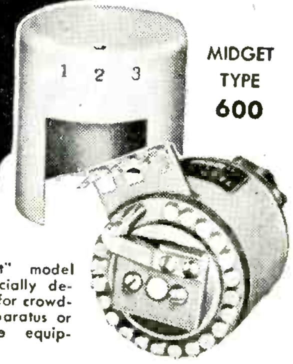

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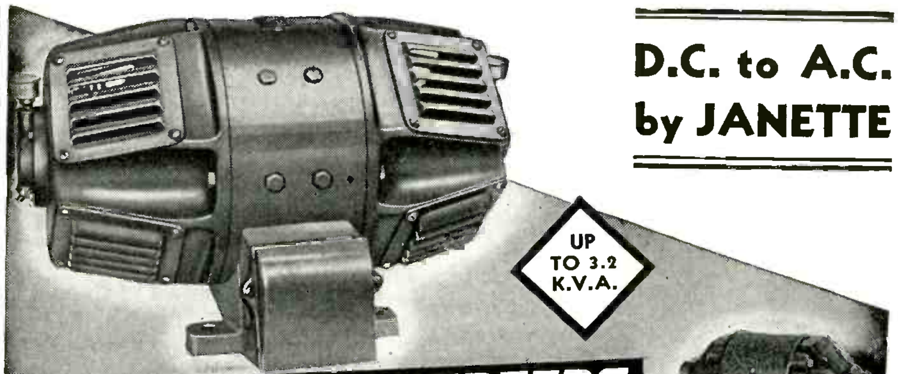

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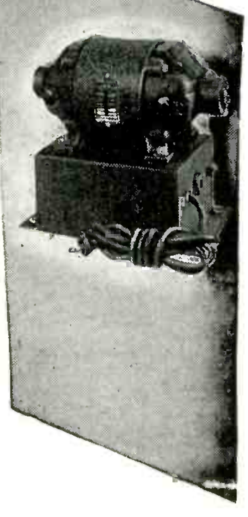

Electronic and Gaseous Tube Devices can be operated from direct current power by means of a rugged Janette converter. When used with sound devices, specially designed filters discriminating enough to filter out unwanted noises and to minimize conducted radio noise voltage, can be furnished.

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If you have a **D.C. to A.C. requirement and want a reliable, high quality converter you can safely specify a Janette.**

Janette

Ask for Bulletin 13-25

Janette Manufacturing Co. 556 W. Monroe St. Chicago 6, Ill.

subjects the glass press to a minimum strain from the contact prongs. The socket can be supplied with the XLA-S silver-plated shield for pentodes and the XLA-C ceramic capacitor which may be mounted inside the socket in place of the contact screw. These capacitors are available in sizes of 100, 50, 25 and 7 $\mu\mu$f.

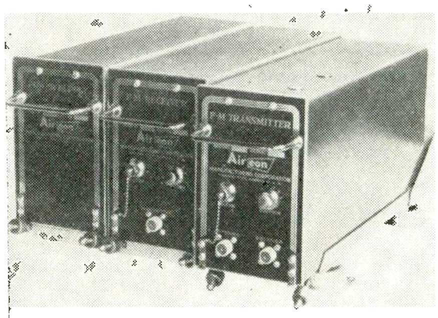
Seven contacts are provided so that the new 6F4 tube can be inserted as well as the five-prong 950 series.

39

Mobile Communication

AIREON MANUFACTURING CORPORATION OF KANSAS CITY, KANSAS, announces mobile vhf station equipment which operates in the 30 to 42 mc band and is intended for police, fire department, taxi and delivery truck use.

The transmitter-receiver combination shown in the illustration may be operated on either 6 v d-c or 110 v a-c by interchanging power supplies. Control of the transmitter



and receiver is gained by a push-to-talk button on the single-button carbon microphone provided with the station.

Three speaker consoles, two for fixed installations and one for mobile installations, are available. All three are equipped with volume control, noise squelch control and pilot lights for transmit-receive warning.

The mobile station is 60-watt crystal-controlled, phase-modulated with type 807 power amplifiers feeding a quarter-wave whip antenna for mobile operation and a half-wave coaxial antenna for central station operation. The transmitter consists of a crystal oscillator, balanced modulator, multiplier, multiplier-driver and power amplifier stages. Modulation is type A3 with a fre-

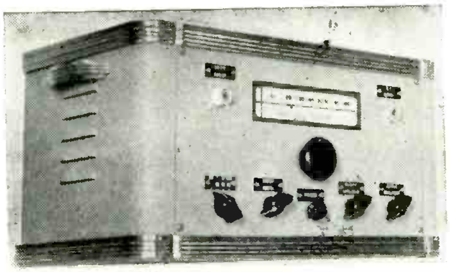
quency deviation of 12 kc. A relay system permits local or remote operation of any installation. By use of a plug-in meter and a six-position metering switch, grid current in all stages and power output may be measured.

The receiver is a thirteen-tube double superheterodyne, entirely permeability tuned, with both i-f stages crystal controlled. Sensitivity is one-half microvolt and the audio power output is one and one-half watts. Alignment of the receiver can be accomplished by use of a 250 μa d-c meter plugged into the receiver meter jack.

40

Television and F-M Products

United States Television Mfg. Corp., 106 7th Ave., New York 11, N. Y., has a number of items available for wide-band services such as f-m, radar and television. The sweep generator (TVFM) covers a continuous range from 500 kc to 110 mc and is adjustable from 10 mc down to 5,000 cps at any frequency within the above range for alignment of narrow-band receivers or amplifiers. Self-contained power supply; input 110 v, 50/60 cps, 60 watts. Two internal markers are provided, one at intervals of 10 mc, the other at intervals of 1 mc for bandwidth measurement. The amplitude of these markers is adjustable from the panel. The main dial is marked in megacycles per sec. and when set at any frequency the sweep is plus and minus 5 mc from this setting.



Sweep Generator

An attenuator is provided which reduces the output signal of 0.1 v to about 30 μv, which is well below the gain control region of most receiver or amplifier systems. The unit measures 14½ x 8 x 8 in., weighs 16 lb, and costs $395.

Two high-voltage power supplies furnish up to 12 or up to 30 kv and

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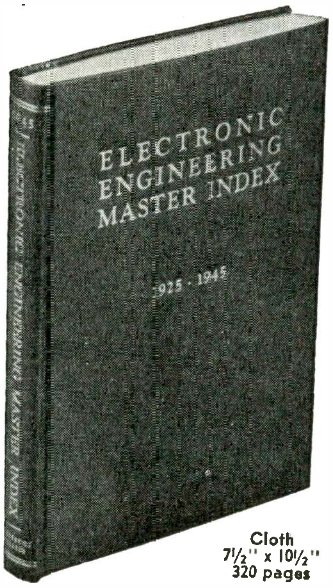

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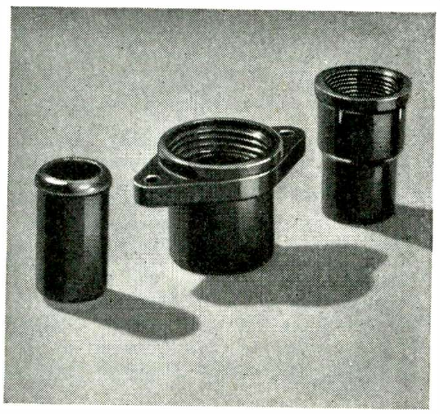

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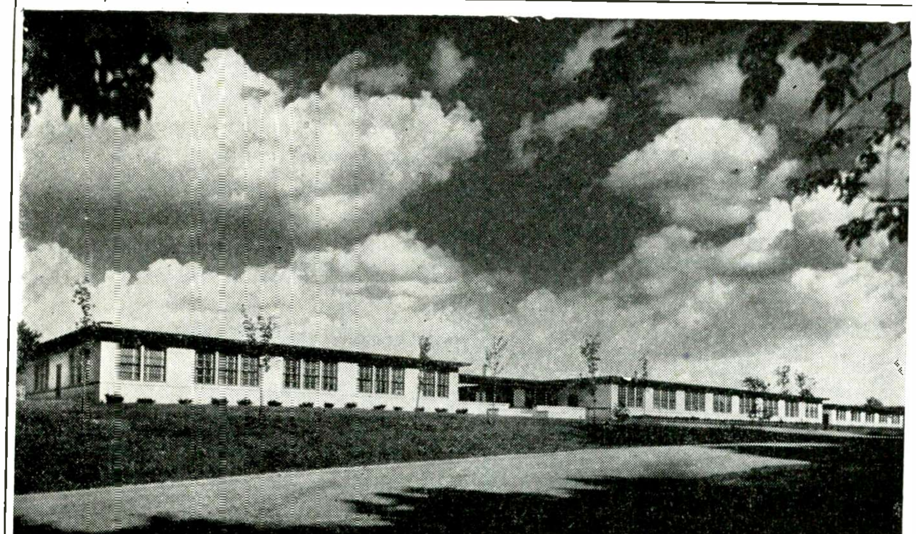

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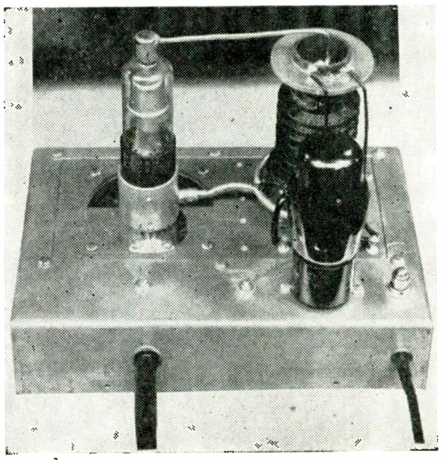
VOKAR *Corporation*

7300 HURON RIVER DRIVE • DEXTER, MICHIGAN

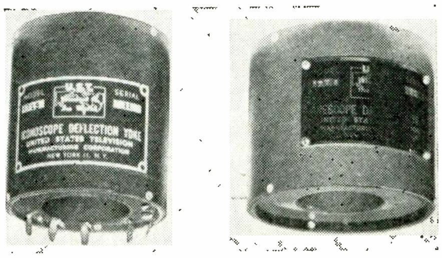
are suitable for 7, 10, 12, or 14-in. direct-viewing Kinescopes. The smaller unit has an output voltage adjustable from 6 to 12 kv d-c, obtained from rectified r-f. Regulation of 10 percent for from 0 to 800 μamp is obtainable. The r-f rectification principle allows lighter components



High-Voltage Power Supply

and a filter-input capacitor of only 500 $\mu\mu$f, thereby reducing shock hazard. Price for a single unit is \$65, and about \$20 per unit in lots of 1,000. Iconoscope yokes (ITY5) with overall length of 3 in., 2¾ in. outside diam, 2 mh vertical inductance, 100 μh horizontal inductance (at 1,000 cps) and low crosstalk will, in general, require newly designed output transformers. Unit price is \$100, \$88.20 for small lots.

Deflection yokes for direct-viewing or projection television c-r tubes are also available. The model RTY5 for 50 and 55 deg deflection has the following characteristics; Q, 15; L, 5 mh; R, 20 ohms for horizontal coils and L, 20 mh; R, 30 ohms for vertical. Deviation from true rectangularity of the scanning raster is less than 0.3 percent of any edge dimension. Overall length, 3 in., outside dimension 3¼ in. plus terminal lugs. The inside dimension is 1½ in. Model PTY5 for 40-deg deflection angle has, for horizontal coils, Q, 15; L,



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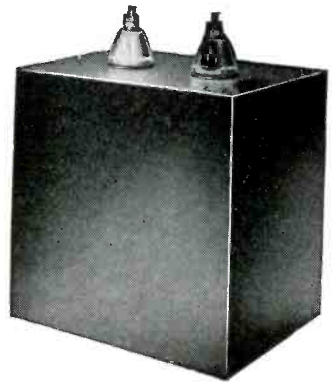

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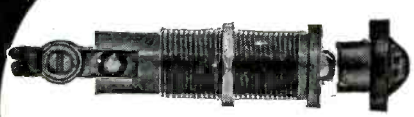

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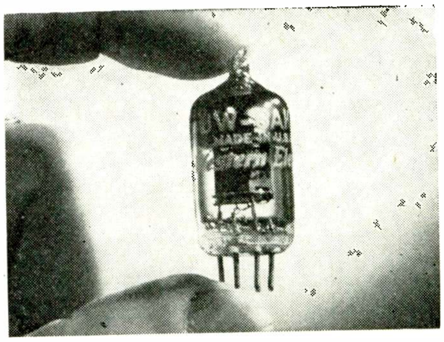
41

Miniature Pentode

WESTERN ELECTRIC Co., Inc., 195 Broadway, New York 7, N. Y., has adapted the type 6AK5 miniature pentode from tubes designed for broad-band coaxial cable systems. Operating up to 350 mc, it should play an important role in f-m and television. With a diameter of ¾ in.



and a seated height of 1½ in., the tube has an indirectly heated cathode operating at 6.3 v and 0.175 amp. Plate and screen operate at 120 v, the grid at 2 v. Plate current is 7.5 ma and screen, 2.5 ma. Transconductance is 5,000 μmhos; input capacitance 4 $\mu\mu$f; output, 2 $\mu\mu$f. Plate-grid capacitance is 0.01 $\mu\mu$f.

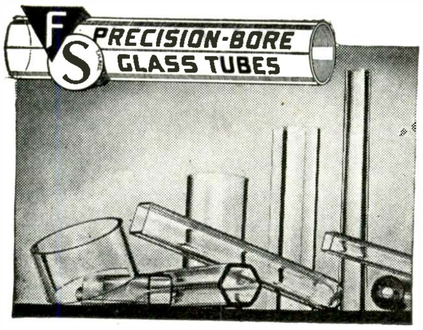
Literature

42

Crystals. Aireon Mfg. Corp., Kansas City, Kansas. A new catalog describing all types of crystals, mounted and unmounted, featuring a compact transmitter unit to be soldered into the circuit like a resistor or capacitor. Another for use as an i-f filter is similarly supplied with soldering lugs.

43

Airplane Radio. Bendix Aviation Corp., Towson 4, Md. A 24-page pamphlet entitled "For Wider Horizons" describes simple radio equipment and navigational techniques



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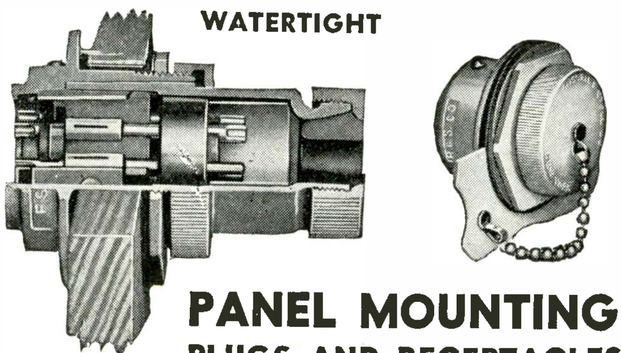

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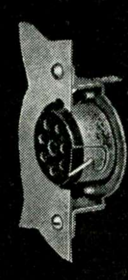

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for the personal plane pilot. Illustrated with cartoons and drawings.

44

Diversity Receiver. Schuttig and Co., Washington 17, D. C. Block diagrams, specifications and photographs of diversity reception components for radio telephone and telegraph. A necessity for high-speed printer or other signalling circuits, the diversity system of receiving fading signals insures communication otherwise impossible.

45

Capacitors. Electrical Reactance Corp., Franklinville, N. Y. Illustrated bulletin covering silver-electrode, ceramic capacitors with complete specifications and JAN type designations.

46

Batteries. National Carbon Co., Inc., 30 East 42nd St., New York 17, N. Y. Battery Engineering Bulletin which shows batteries according to usage and suggested current range. With this information a table will show a choice of several suitable to the purpose. Weight, size and operating cost will then determine the final choice. Sketches of size and location of terminals are given.

47

Insulation. William Brand & Co., 276 4th Ave., New York 10, N. Y. Theory and Behavior of Dielectrics, Mica and Mica Plate, Natural Oils as Dielectrics, Varnishes for Electrical Insulation, Inorganic Insulations, Table of Mechanical and Electrical Properties of Plastic Materials are some of the headings given in this 32-page bulletin.

48

H-F Heating. Radio Corporation of America, Camden, N. J. Mechanical and electrical specifications, illustrations, suggestions for use of Model 2-B and Type 15-B power generators for high-frequency heating.

49

Dry Rectifiers. Radio Receptor Co., Inc., 251 West 19th St., New York 11, N. Y. Ratings of Seletron selenium rectifiers and typical circuit connections. Graphs of voltage variation with load and derating table for high ambient temperatures.

50

Meters. Marion Electrical Instru-

ment Co., Manchester, N. H. A 28-page book describing the line of standard and hermetically sealed electrical indicating instruments. A buyer's guide to help the prospective user choose the instrument to fit his need, and a story of production procedures and tests.

51

Tubes. Sylvania Electric Products Inc., Emporium, Penna. This manufacturer has summed up descriptions and specifications on a number of new tube types. Three of these are for stroboscopic work, designated strobotron, gas discharge, and strobolux. The glow modulator tube is suitable for facsimile recording. Complete ratings are available for the type 7AG7 sharp-cutoff pentode and the 6K4 general purpose triode. A crystal diode for use at high frequencies is described. For measuring low gas pressures there are available two other tubes, the pirani and thermocouple types. Other separate sheets list lock-in tube classifications, tentative miniature tube characteristics, and tentative proximity fuse style characteristics.

52

Test Clips. Frankel Connector Co., Inc., 177 Hudson St., New York, N. Y. In Catalog No. 4-C, the bulk of the 48 pages is devoted to heavy duty connectors. One page describes an excellent line of small test clips widely used in telephone and radio service. Some of these are characterized by a pin point attached to one jaw so that an insulated wire may be pierced for contact without appreciably breaking the protective rubber insulation.

53

Plastics. The Society of the Plastics Industry, Inc., 295 Madison Ave., New York 17, N. Y. To combat extravagant claims and delirious hopes for the future of plastics, the Society has published a history of the subject, together with an estimate of employment opportunities. A list of schools and colleges giving courses in plastics and a bibliography of trade papers and texts concludes the 36-page booklet. The returning service man or woman would do well to study this information.

54

Cables and Harness. Alden Prod-

ucts Co., 117 North Main St., Brockton 64, Mass. Among the various products and services available, cable assemblies are described in Section E of the company's Blue Book. Types of wire and typical cables are described.

55

Transmitters. Federal Telephone and Radio Corp., 591 Broad St., Newark 1, N. J. A brochure on a complete f-m radio telephone system for police, fire and all emergency services.

56

Power Tubes. Federal Telephone and Radio Corp., 591 Broad St., Newark 1, N. J. Types and ratings of air- and water-cooled power tubes for industrial or radio communication service. Mercury vapor and high-vacuum, water-cooled rectifiers are included.

57

X-Ray Equipment. North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y. A 12-page booklet entitled "Norelco Industrial X-ray Equipment" describes equipment suitable for quality control in manufacturing.

NEW BOOKS

Luminous Tube Lighting

By HENRY A. MILLER. *George Newnes Ltd., Tower House, Southampton Street, Strand, London, W.C.2. 143 pages. Price 10/6.*

BEGINNING with a brief resumé of the elementary experiments in which were observed the several forms of discharge between metallic electrodes sealed into glass containers when connected to a source of current, the author explains the actions of excitation ionization, and radiation in the discharge tube, the theoretical considerations related to the initiation of the discharge, the mechanism of the positive column, and the optical factors.

In the chapters dealing with low-pressure tubes and higher-pressure tubes, the subjects treated are: Neon tubes, neon test tubes, discharge tube stroboscope, sodium discharge lamps, ultraviolet lamps, mercury-arc violet lamps, medium-pressure hot-cathode tube, high-pressure hot-cathode tube, and the Sieray-Dual lamp.

The construction and characteristics of the fluorescent lamp are closely examined under headings that include: principle of operation, auxiliary apparatus, replaceable starters, ballasts, supply voltage, sensitivity of fluorescent powder, and radiant heating effects.

In the chapter on neon signs again there is much useful information. Here the author describes and discusses step-up transformers, avoidance of over-loading, current outputs, required voltage, power factor correction, rotary converters, inverters, "Uneon" system, Tesla coils, maintenance of neon signs, animating neon signs, photoelectric control, and data for installations.—J.K.

• • •

Principles of Industrial Process Control

By DONALD P. ECKMAN, *John Wiley & Sons, Inc., New York, N. Y.*, $3.50.

THE THEORY DEVELOPED in this book is based entirely on the principles of regular oscillations. Applied to problems of temperature, level, or other controls in process plants, this can only be approximate.

Let us consider, for instance, the conditions controlling the function of a pH regulator which simply proportions two streams in such a fashion that the acidity or alkalinity in a tank is kept constant. To submit such a process to the treatment developed in this book would be quite far fetched. There are many other control problems into which an energy balance does not enter and others where energy balance is an accessory effect.

The value of this book would have been considerably enhanced if some detailed example application of this theory to a particular case had been given, including a comparison of the figures theoretically arrived at and the results observed.

As it is, one almost wonders how much of this mathematical treatment can be of genuine assistance in the solution of actual industrial control problems and how much should be considered purely mental gymnastics.—PAUL G. WEILLER

• • •

Principles of Radio for Operators

By RALPH ATHERTON, *Assistant Professor of Mathematics, Miami University. The Macmillan Company, New York*, 1945, 345 *pages*, $3.75.

THIS BOOK IS an excellent text for the beginner who desires a good working knowledge of the fundamentals underlying radio communication without an extensive mathematical treatment. It is well illustrated and written in a simple, straightforward style adaptable to either classroom or self instruction. An outstanding feature of the book is the list of sound motion picture and slide films currently available for group instruction.

A concise statement of the more important facts to be discussed appears at the beginning of each chapter, and appropriate subtitles are generously used throughout the text. Wherever practicable, photographs and good line drawings of actual radio parts and assemblies are used to supplement the many basic circuit diagrams. Test questions and practical experiments are given at the end of each chapter.

The first part of the book is devoted to such basic subjects as the nature of electric currents, batteries, simple circuits and the properties of electrical resistance, inductance and

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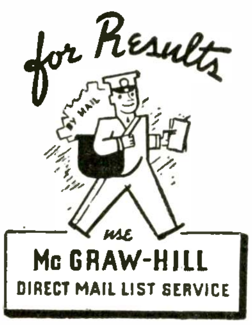

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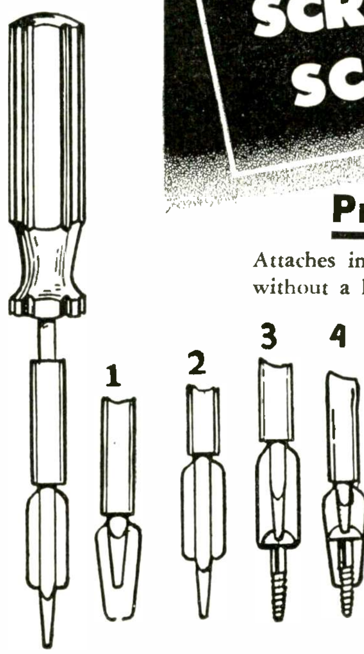

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XCELITE QUALITY TOOLS PREFERRED BY THE EXPERTS capacitance. The application of these fundamentals to radio is pointed out as they are introduced. The remainder of the book deals directly with vacuum tubes, power supplies, receivers, transmitters, and antennas.

The book was intended to serve as a training manual and handbook for operators, maintenance men, and those interested in the construction of sending, receiving and test equipment, but falls short of this goal. The value of the book to an operator preparing for a higher grade of license, or the beginner trying for an amateur operators' permit would be increased tremendously if the test questions at the close of each chapter had been selected from the various Study Guides of the FCC. Even so, some persons might require a more extensive treatment of the subject.

The section on trouble shooting, consisting of four pages most of which are given over to diagrams of elementary test equipment, is quite inadequate. Layout plans and assembly details which would be of value to anyone desiring to build radio equipment are not given. The appendix of the book does, however, include a section devoted to safety suggestions, artificial respiration, emergency treatment of burns and the standard RMA color codes for resistors, capacitors, and transformers, and a table of receiving and transmitting vacuum-tube characteristics with socket connections.—RAYMOND SCHAAF

• • •

Electronics Laboratory Manual

By RALPH R. WRIGHT, *Virginia Polytechnic Institute. McGraw-Hill Book Co., Inc., New York, N. Y., 1945, 77 pages, $1.00.*

THIS IS A LABORATORY textbook for engineering students who are taking their first course in electronics. There are 12 basic experiments to acquaint the student with the characteristics, principles of operation, and applications of electron tubes. These experiments include static characteristics of diodes, triodes, tetrodes, pentodes and beam power tubes; gas diodes and triodes and their applications; power supply systems, audio-frequency voltage and power amplifiers; cathode-ray oscillograph and phototubes.

The experiments are well arranged, with sufficient theory and diagrams to prepare the student for the observations and conclusions. There is a very complete list of references at the end of each experiment, which are useful in any discussion generally included in the laboratory report.

The author has omitted any experiment on radio-frequency power amplifiers or oscillators, possibly because they are often included in second semester courses on electronics.

In discussing types of cathode-ray tubes at the beginning of Experiment Seven, there is no mention of the combination of electrostatic focussing and magnetic deflection, and the student draws the conclusion that cathode-ray tubes are either electrostatic in both focussing and deflection, or electromagnetic in both functions. The third combination is very basic, its most common application being in television equipment.

There are two comments to be made about the experiment on phototubes and photocells. While the theory of the barrier type cell is briefly discussed it is not included in the experiment. Although the copper-oxide type of cell is no longer used, the iron-selenium cell is found in many applications. In taking observations on this type of cell and then plotting results first as current-vs-light and then as volts-vs-light, the student readily sees that this cell is high in current output compared to the vacuum and gas phototube, making it desirable for current-operated devices, but very poor in voltage output, making it undesirable for voltage-operated devices such as the usual vacuum or gas amplifier or relay tube which usually follows the phototube.

The other point which would be debatable is the use of protective resistors one megohm or greater in series with gas and vacuum phototubes for the measurement of static characteristics, because this practice makes some change in the shape of the curves. The vacuum phototube would not need protection against high current with maximum light values of 0.5 lumen and in the case of the gas tube some care will have to be shown by the experimenter that light and voltage values do not allow visible ionization.

A technique that could have been included in the phototube measurements is the use of a standard d-c vacuum-tube voltmeter to measure the drop across about 100,000 ohms to obtain current values, since the low-reading microammeters required may not always be available.

The manual fills a distinct need either for those institutions that are just adding an electronics course to their engineering curriculum, or to replace the mimeographed copies of experiments used in present courses. — HOLLIS S. BAIRD.

• • •

Radio Sound Effects

By JOSEPH CRAMER, *Director of Promotion and Research, and* WILLIAM B. HOFFMAN, *Sound Effects Dept., Radio Station WOR. Ziff-Davis Publishing Co., New York, N. Y.*, 1945, 71 *pages*, $1.50.

TWO EXPERTS in the field of commercial radio broadcasting describe how the technique of making sounds can be so timed as to create an illusion of reality in the listener's mind. Not a text, but a syllabus of study for broadcasters, sound technicians, and students of radio drama, the volume makes no pretense of teaching its reader in one easy lesson. The casual reader is brought up smartly at the end of each chapter by a list of assignments which point up the important ideas.

The techniques of sound making are broken down into Mechanics of Sound Effects; Manual, Recorded (special emphasis on use of the turntable), Trick, and Supplementary Sound Effects; the whole introduced and interlarded with practical talk about the psychology of the subject. The book ends with a glossary of studio terminology and a soundsman's book of etiquette.

Steering a broad middle course between the esoteric trade talk of the technician and the jargon of the production man, the authors still make their audience aware of the difference between an eight ball and a fluff and why a director touches his nose.—A. A. McK.

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Textile World

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.

Camera Focusing By Radar?

Dear Mr. Henney:

ALTHOUGH PRESENT DAY radar measures distances in terms of thousands of yards, future developments in the art may make it possible to measure distances in terms of feet. The use of radar, or its principle, in the automatic control of optical focusing systems could ease considerably the strain of constant attention to focusing, which is the lot of most cameramen.

One difficulty in such an arrangement might be that, if the radar focusing beam should inadvertently wander off the principal subject, such as an actor, and strike a background fifteen feet away, the cameraman might be embarrassed to find his subject completely out of focus in a split second.

Perhaps an adjustable time-delay circuit could be incorporated to permit such accidental misdirection of the electronic focusing beam to occur, for a brief moment, without putting the optical system out of focus. Thus time would be allowed to reframe the subject without defocusing.

Also, the change-of-focus mechanism could be designed with a suitable lag to accommodate shifts to various focal planes at normal rates of change.

W. S. STEWART
Los Angeles, Calif.

• • •

More on Hartley Law

Dear Mr. Henney:

I HAVE NOTED Mr. Unger's comments in "Backtalk" of the December issue of ELECTRONICS.

Mr. Unger has made no effort to obtain full data on this subject before making his comments and is

CONTACTS

FOR THE FIELD OF ELECTRONICS

A Good Habit

This "Where to Buy" Section supplements other advertising in this magazine.

It's a good habit to check this page—every issue.

therefore entirely unaware of what we have been trying to do. As I have been careful to point out in all verbal presentations of Craig television, we employ very special means both for exciting and damping the crystal filter and have made marked progress thereon. Details thereof will be published as soon as the work has been completed and the patent applications have cleared the patent office. Meanwhile, I intend to take no further part in this discussion.

One simple way to promulgate the proposed "Hartley Law" would be to state that it applies to scanning of the transmitted image, wherein the question of any exception does not arise . . .

PALMER H. CRAIG
Head of Department of Electrical Engineering University of Florida Gainesville, Fla.

• • •

Against Talk

Dear Mr. Henney:

AFTER LISTENING to the radio for several hours a day in a hospital room, I am convinced the whole world is moronic except me and thee. And I think even thee is a little queer because thee has the courage to speak out against TALK, TALK, TALK.

If we must have TALK, I wish someone would start an "Association for the Improvement of the Speech of Broadcasters". I do admire them for their ingenious and unexpected mispronunciations and for their artful way of chopping up a sentence into unrelated fragments.

Gentlemen, if you must TALK, TALK, TALK, please speak English. The radio doth murder speech.

Mr. Henney, here is my hand, a little feeble now, but growing stronger, in hearty support of your crusade against TALK, TALK, TALK.

NICHOLAS B. COOK
Barnert Memorial Hospital Paterson, N. J.

—◆—

AMONG THE adaptions of wartime radio and radar equipment to peacetime use made by the industry and the RFC are garden umbrella holders and flagpoles from antenna masts, treasure finders from mine detectors, and curtain rods from ground rods.

(Continued on page 365)

POSITIONS WANTED

(Continued from page 364)

INDUSTRIAL ELECTRONIC Development Engineer, graduate electrical engineer, with 6 years experience on development, design, and application of photoelectric, motor, welding and other special electronic control and follow-up systems. Age 30. Desires permanent development or application position with progressive company, either large or small. PW-102, Electronics, 330 W. 42nd St., New York 18, N. Y.

SALES ENGINEER: B. S. in E. E. with 20 years sales experience in selling electrical and mechanical equipment. Dealings with southern utilities, industrial plants, architects and designing engineers. Field officer being released from the Army Air Forces and desires position. Married—one child. Will go anywhere in states. PW-104, Electronics, 330 W. 42nd St., New York 18, N. Y.

RADIO ENGINEER—Physicist—Desires chief engineer position in small progressive organization or supervisory position in larger organization. Can direct mechanical design, appreciate cost and understand production methods. Twelve years research and developmental engineering experience in radio, electronics, magnetic devices, industrial control, acoustics, and fields of applied physics. Have creative ability and can apply mathematics. Have patents and technical papers. Location Chicago or west to Rockies. PW-105, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

ELECTRONICS INSTALLATION Engineer. Release from Navy in February. 19 years experience various phases electrical and electronics field, of which 6½ years was aircraft (2 years television) and associated equipment. Desire permanent position. Record and references available. PW-106, Electronics, 330 W. 42nd St., New York 18, N. Y.

SUPERVISING ENGINEER with prime interest and experience in the communications and electrical control field desires to present his qualifications to progressive manufacturer for consideration for position offering enough latitude for authority for full exercise of initiative, mature judgement and natural aptitude for getting things done. Experience covers 25 years design, development quality control, inspection and application of radio, telephone and electronic equipment. Engineering education include recent refresher course in microwave techniques, electronics and management. PW-107, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

CHEMIST-CHEMICAL Engineer. Two degrees. Five years' industrial experience in research, development, sales-service on materials for electrical and electronic application—dielectrics, resistors, capacitors, ceramics, etc. Broad electrical training, proven ability, excellent references. Desires responsible position in research and development or technical sales. PW-111, Electronics, 330 W. 42nd St., New York 18, N. Y.

RADIO ENGINEER, age 30, seven years experience design, development and research auto radios, FM, radar countermeasures, VHE DF systems desires responsible position development and research UHF VHF equipment or television. At present project engineer with large concern. Prefer location Long Island, West or Southwest. PW-108, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRONIC ENGINEER, Cal Tech graduate. Development, test, installation, administrative experience on instrument landing equipment, radio, radar consisting of 1 year industry, 2½ years Signal Corps offices, desires position with future. PW-109, Electronics, 330 W. 42nd St., New York 18, N. Y.

CHIEF RADIO Technician being discharged in January wishes to contact east coast organization. Young, resourceful, some college and a great deal of experience. Will appear at any place for interview upon receipt of slightest encouragement. W. G. Palmer, 505 N. Main St., Farmville, North Carolina.

SELLING OPPORTUNITY WANTED

SALES ENGINEERING position desired by engineer, B.S. in E.E., having 15 years radio receiver design experience in U.S. and Europe. Neat appearance, some supervisory and technical contact experience. Desires connection with reputable firm or sales representative office. Will consider various locations. In reply please give details. SA-988, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

FIELD REPRESENTATIVE and Service Engineer, 16 years experience electronic equipment, including sales, contact and labor relations. Desires position where this experience would be of more value to a company, than pure engineering work. RA-110, Electronics, 330 W. 42nd St., New York 18, N. Y.

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ELECTRONIC DEVELOPMENT ENGINEERS

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P-670, Electronics
330 West 42nd St., New York 18, N. Y.

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Preferably with training in physics for interesting work in magnetron development. Tube experience not essential. Personnel Division, RCA Victor Division, Camden, New Jersey.

SALES ENGINEERS

wanted by large manufacturer of radio components

Will be trained for territorial office management. Should have background of broadcast receiver design engineering experience, pleasing personality and desire to learn overall sales and business management. The position will be remunerated by salary plus bonus. In reply give background, nationality and minimum acceptable income to start.

SW-998, Electronics
330 W. 42nd St., New York 18, N. Y.

ELECTRONIC SALES

If you can use a young man with 3½ years high grade research experience, 5 years college electronics physics, and college training in selling, write

SA-996, Electronics
330 West 42nd St., New York 18, N. Y.

Attention

RADIO MANUFACTURERS

A Senior Naval Officer about to be released who has had extensive experience both as a civilian and officer with the top executive and procurement personnel of the leading radio manufacturers and military procurement offices is desirous of effecting sales representation in eastern Pa, southern N. J, Del, Md, and D.C. Background of 15 years of successful sales and merchandising experience. Organization to represent component and set manufacturer will be established by January 15th. Correspondence invited.

RA-994, Electronics
330 West 42nd St., New York 18, N. Y.

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Westinghouse A.C. Voltmeter — Type NA-35—3½" Round—0 to 150 Volts........$2.95 ea.

Westinghouse A.C. Ammeter—Type NA-35—3½" Round—0 to 50 Amps ....$2.95 ea.

Battery Charging Ammeter — 2" Round—30-0-30 Amps. . $.30 ea.

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Heavy Duty Cutler-Hammer Toggle Switch — Single Pole Single Throw—20 Amps......$.16 ea.

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Magnet Wire—#11 Single Cotton —Heavy Formvar—12" or 24" Reels ....$.18 lb.

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PIONEER ELECTRIC COMPANY

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Los Angeles 23, California

(See Following Page For Additional Representative Available Advertisement)

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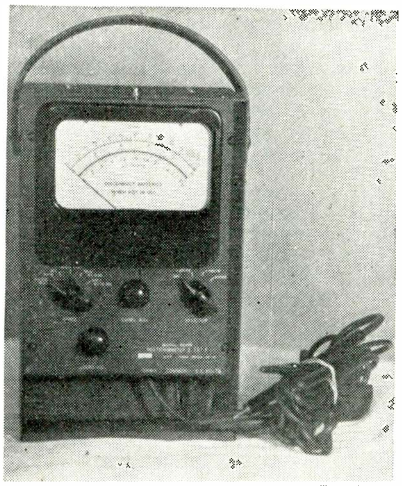
NEW SURPLUS Vacuum Tube Voltmeters



SIGNAL CORP TYPE I-107-F

RANGES

DC volts, 0-3-10-30-100-300 volts F.S.

Ohms.	Mid Scale	Full Scale
Rx 1	10	1000
Rx 10	100	10,000
Rx 100	1000	100,000
Rx 1,000	10,000	1,000,000
Rx 10,000	100,000	10,000,000

Input resistance on 3 volt range is 8 megohms.

Uses a Simpson 400 microamper 4½ square 2% D.C. meter.

Made by Precision Apparatus for the signal corp.

Comes complete in metal carrying case with leather handle and detachable cover.

Uses two flashlight batteries internal, and a 1½ & 90 volt external battery.

Comes complete ready to use with batteries and test leads with a spare tube, type ILE3.

Price FOB **$22.50**

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Materials and parts for manufacturing and assembly or electrical, mechanical and radio products.

Insulation products (sheet, molded, extruded, paper, paper tubes, ceramics, standard and custom molding), insulated wire, resistance wire, stampings, washers, screw machine products, drawn and extruded cans and containers, wire forms, springs, headed products, etc.

Thorough experience will properly represent you.

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Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

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NEW METERS in Quantity

4" Westgh Type DY Surface Mtg.
- 0-150 Volts A.C. $9.00
- 0-2½ Amperes A.C. $8.00
- 0-15 Amperes A.C. $8.00
- 50 Amperes A.C. $9.00
- 60 Amperes A.C. $9.00
- Some Black and Some White Scales

4" Weston Type 642-3 Surface Mtg.
- 0-150 Volt A.C. $9.00
- 0-15 Amperes A.C. $8.00

3½" Weston Type 301
- 0-150 Volts D.C. $4.00

4½ Westgh DY Frequency Meter
- 50-70 Cycles, 115 volts $31.00

2000 lbs. Mitchel Rand #589 Ex Transformer pitch.
125 Field Rheostats, Ward Leonard, 50 ohms, 6.3-3.15 Amperes, 13½" Round with handle.
225 Field Rheostats, Ward Leonard, 70 ohms, 3.6-1.8 ampere, Each plate, 8" Round without handle, 3 plates to a unit.

RELAYS

300 Leach 48 Volts D. C. Type #1257, coil # 359, 1550 ohms S. P. Double Throw
250 Ward Leonard, 8 volts D.C. S.P. D.T.
125 Struters Dunn, 2 Pole D.T. 115 volts, 60 cy.
300 Leach 4 Pole D.T. 115 volts, 60 cycle

VARIABLE OHMITE RESISTORS

175 25 Watt 75 ohm 1½" Round
138 25 Watt 250 ohm 1½" Round
115 50 Watt 5 ohm 2" Round
80 50 Watt 1600 ohm, 2" Round
984 100 Watt 100 ohm, 3" Round
99 400 Watt 490 ohm, Double Plate 4" Round

ELECTROLYTIC

580 .5 Mfd, .5 Mfd, 1.0 Mfd, 115 volts, 60 cycles.
300 .25 Mfd, .25 Mfd, 1 Mfd
450 1 Mfd, 1 Mfd.

WARD LEONARD VITREOUS ENAMELED RESISTORS

Qt	Ohms	Watts	Taps
50	125	115	
25	65	110	
650	550	90	
550	40	75	
30	125	40	
71	30	75	
1240	10	60	
1070	125	40	
200	8000	32	
200	250	20	
400	60	20	
344	1200	20	
550	600	50	
313	7½	60	
450	125	40	
179	60	75	
74	600	75	
1463	10	300	
3400	9.4*	4	
100	500	115	4
514	120	75	3
78	1000	90	1
163	45	75	2
300	20	75	2
759	6500	35	1
62	100	25	3
105	120	45	3
65	480	70	5
86	100	50	4
5850*	20.5	10	1

ADJUSTABLE SLIDE TYPE

1550	500	40	1 slide
100	250	90	1 slide
180	25	55	2 slides
104	11	55	6 slides
46	13	55	2 slides

TUBLAR OIL FILLED CONDENSERS

	MFD	Volts D.C.	
150	.05	200	TVC 2S 5-8
6600	.07	200	84
100	.075	200	VC 6A 58
650	.1	200	VC 1A665
50	.005	450	
1300	.165	200	TBC 103

50	.02	200	289X
100	.25	200	289X
50	.005	200	289
50	.5	400	489
50	.02		Mica
1000	.05	200	284
130	.15	200	VC 1A668
50	.002		Mica
25	.025	200	289X
125	.03	200	284
1700	.1	200	289X
50	.0005		Mica
1500	.1	600	689
2200	.05	200	289
30	.025	200	284
5400	.1	200	284
30	.015	200	289X
250	.5	200	VC 6A59
50	.5	200	284
30	.02	200	284

BATHTUB & MISC. CONDENSERS

	Mfd	VDC	Type
700	2.	200	LU
270	1.	200	R06
20	.25	200	R11
25	.025	600	P01
45	.65	200	R05
10	1.	200	R11
600	2.	200	UC
30	.5	200	HC 4066
140	.2	600	TDF 6020
10	.2	200	C 2205
40	.2	400	418
70	.165	200	R 06c
75	1.	400	R 09
30	.13	200	N 11
110	1.	200	R 01
50	1.	400	R 12
50	.5	400	R 10
125	.5	200	R 04
10	.5	200	R 11
75	.65	200	P 03
110	4.	115V 60cy	8990-5XR
12	1.	600	HC 3083
180	4.	115V 60cy	8990-5
6	4.	200	C 2400
10	3.	120 VAC	R 04
75	.25	200	P 07
200	.5	200	230
10	1.	200	P 05
240	.5	200	R 08c
25	.08	200	R 08c

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Each issue is only part of the complete service we are organized and glad to render to reader and advertiser, alike. We want you to consider Electronics your primary source of information in this field.

Departmental Staff,

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AMMETERS	MEGOHMMETERS
MICRO AMMETERS	RHEOSTATS
OHMMETERS	VARIABLE TRANSFORMERS
FREQ. METERS	RELAYS

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Your Business
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40 years' experience
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INDEX TO ADVERTISERS

INDEX TO ADVERTISERS

Continued

SEARCHLIGHT SECTION

(Classified Advertising)

Insulation from Geon latex offers added advantages

★ In radio hookup and switchboard wire.

★ In impregnated glass insulating tapes.

★ In semi-conducting coatings.

Along with all the advantages GEON has in domestic, industrial, and utility wiring.

THE properties of extruded wire and cable insulation made from GEON are well known in the electrical field—excellent electrical properties, resistance to most normally destructive elements, ease of handling, and many others.

All these advantages—*plus important additional ones for particular applications*—can be had through the use of GEON latex which coats wire and tape by a dipping process rather than by extrusion.

Thinner coatings

Of great importance in radio and switchboard wiring is the fact that insulation from GEON latex can be applied in much thinner coatings than can normally be obtained from extrusion. That means easier handling, lighter weight, and more conductors in a given space.

Used with glass insulating tapes, GEON serves two purposes—as a thin coating of insulation with good heat and chemical resistance; as a binder for the glass fibres to give them high flexibility and long life.

Semi-conducting coatings

Thanks to special compounding made possible with GEON latex, semi-conducting coatings of this material provide much greater conductivity than can be had with extrusion compounds.

More improvements to come?

These are some of the advantages of GEON latex that are already apparent. It is likely that additional ones will be uncovered as the material is used more and more broadly.

We suggest that you consult with your supplier of wire and cable regularly to keep abreast of the steady improvements in insulation that are being made possible by GEON polyvinyl materials. Or for help with special problems or applications please write Department F-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

Geon Polyvinyl Materials

B. F. Goodrich Chemical Company A DIVISION OF THE B. F. GOODRICH COMPANY

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Series 690

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- **2 MOUNTINGS:** Portable and Rack Type
- **3 BASE IMPEDANCES:** 500, 600 and 135 ohms
- **2 CIRCUITS:** "T" and Balanced "H"*
- **2 RANGES:** 0-110DB, steps of 1DB (2 dials)
  0-111DB, steps of 0.1DB (3 dials)

*Balanced "H" type may be used as an unbalanced network of one-half the base impedance.

PORTABLE TYPES

"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

OTHER SPECIFICATIONS

ACCURACY: Resistors calibrated within ±1%

PLUG-IN PADS: Octal tube base, panel mounting, in wide range of impedances and losses.

FREQUENCY RANGE: 0-17,000 c.p.s.; at higher frequencies, slight reduction in accuracy.

OPERATION LEVEL: +20DB (0.6w) maximum input.

SIZE: 2 dial portable: 5"x10"x5"; 3 dial portable 6"x11½"x5"; rack: 3½"x19".

Daven Attenuation Standards, types 740 and 742 (resistor accuracy ±½%), are designed for applications requiring greater accuracy. See your DAVEN Catalog or write for details.

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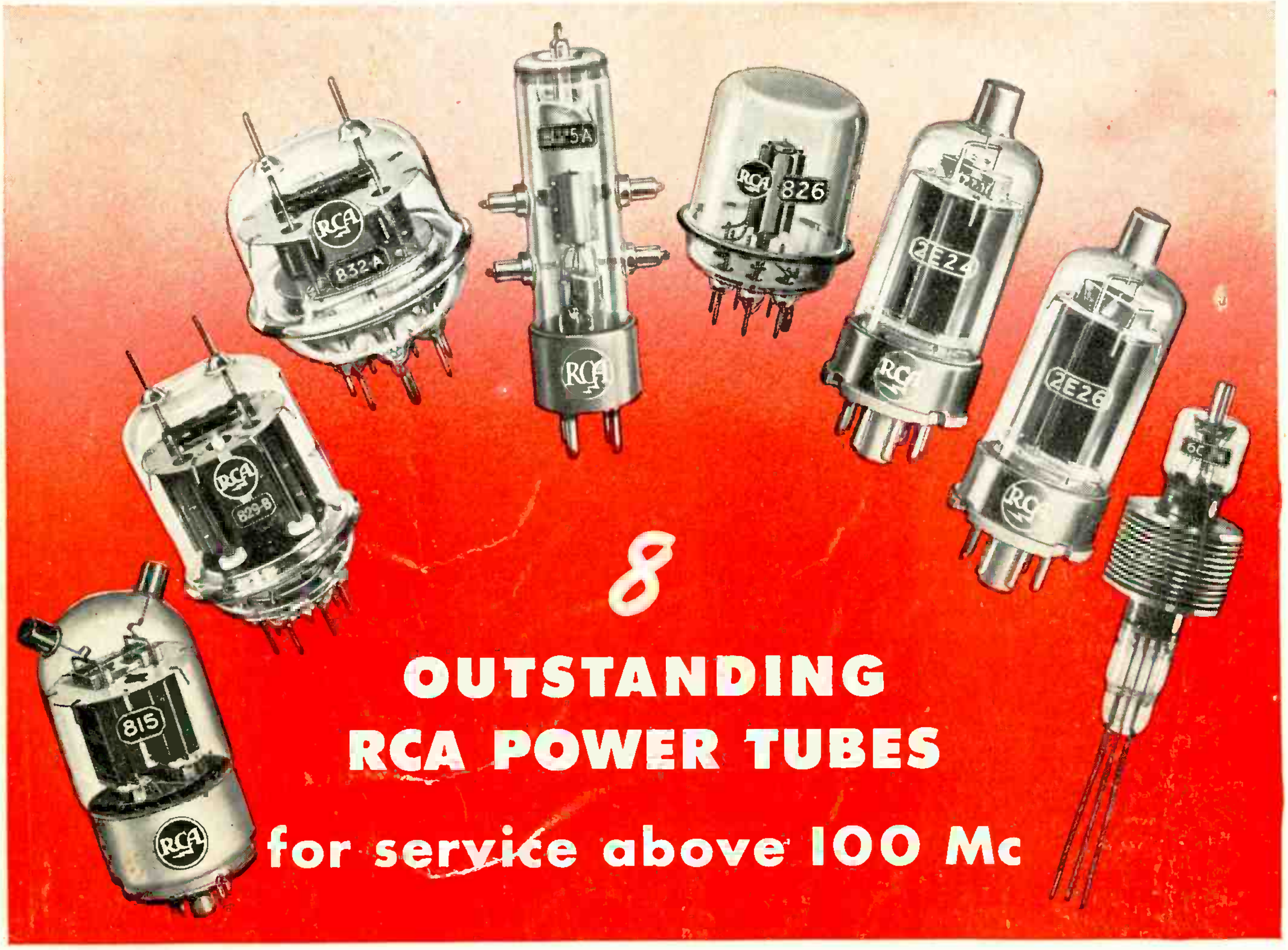
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

Daven manufactures the most complete line of precision attenuators in the world, plus more than 80 models of specialized and laboratory test equipment.



Ideally suited to compact transmitter designs for emergency, aeronautical, and other upper-frequency applications

TWIN BEAM-POWER TYPES: The RCA 815, 829-B and 832-A push-pull beam-power tubes offer unusual compactness, combining high-power sensitivity with low plate-voltage requirements. Neutralization is seldom necessary.

SINGLE BEAM-POWER TYPES: The new RCA 2E24 is a quick-heating type for emergency stand-by service. Its sturdy *coated-type* filament reaches operating temperature in less than two seconds. The new RCA 2E26 is a slow-heating type particularly adaptable to FM transmitter designs.

POWER TRIODES: The RCA 826 and 8025-A triodes can be operated with unusual plate efficiency at frequencies as high as 250 and 500 Mc, respectively. Both tubes have a double-helical, center-tapped filament to minimize the effect of filament-lead inductance. The 8025-A has double grid and plate connections that can be paralleled to reduce lead inductance. The new RCA-6C24 high-power triode employs forced-air cooling. Its relatively small size, center-tapped filament, and low inter-electrode capacitances account for its exceptional high-frequency performance.

RCA tube application engineers are ready to consult with you on any design problems you may have involving these or other RCA Electron Tubes. If you wish their services, or additional technical data on these tube types, write to RCA, Commercial Engineering Department, Section D-6B, Harrison, N. J.

COMPARATIVE TECHNICAL DATA
(Plate-Modulated Class C Telephony)

Tube Type No.	Plate Input Watts	Driving Power at Tube	Max. Rating Freq. Mc	Plate Volts	List Price
2E24	ICAS 27	0.2	125	500	$3.50
2E26	ICAS 27	0.2	125	500	3.20
6C24	CCS 1000	75.0	160	2500	45.00
815	ICAS 60	0.2	125	400	4.50
826	CCS 75	6.5	250	800	12.00
829-B	CCS 90	1.0	200	425	17.00
832-A	CCS 22	0.2	200	425	13.00
8025-A	ICAS 33	1.5	500	800	11.00

The Fountainhead of Modern Tube Development is RCA

TUBE DIVISION

RADIO CORPORATION of AMERICA

HARRISON, N. J.