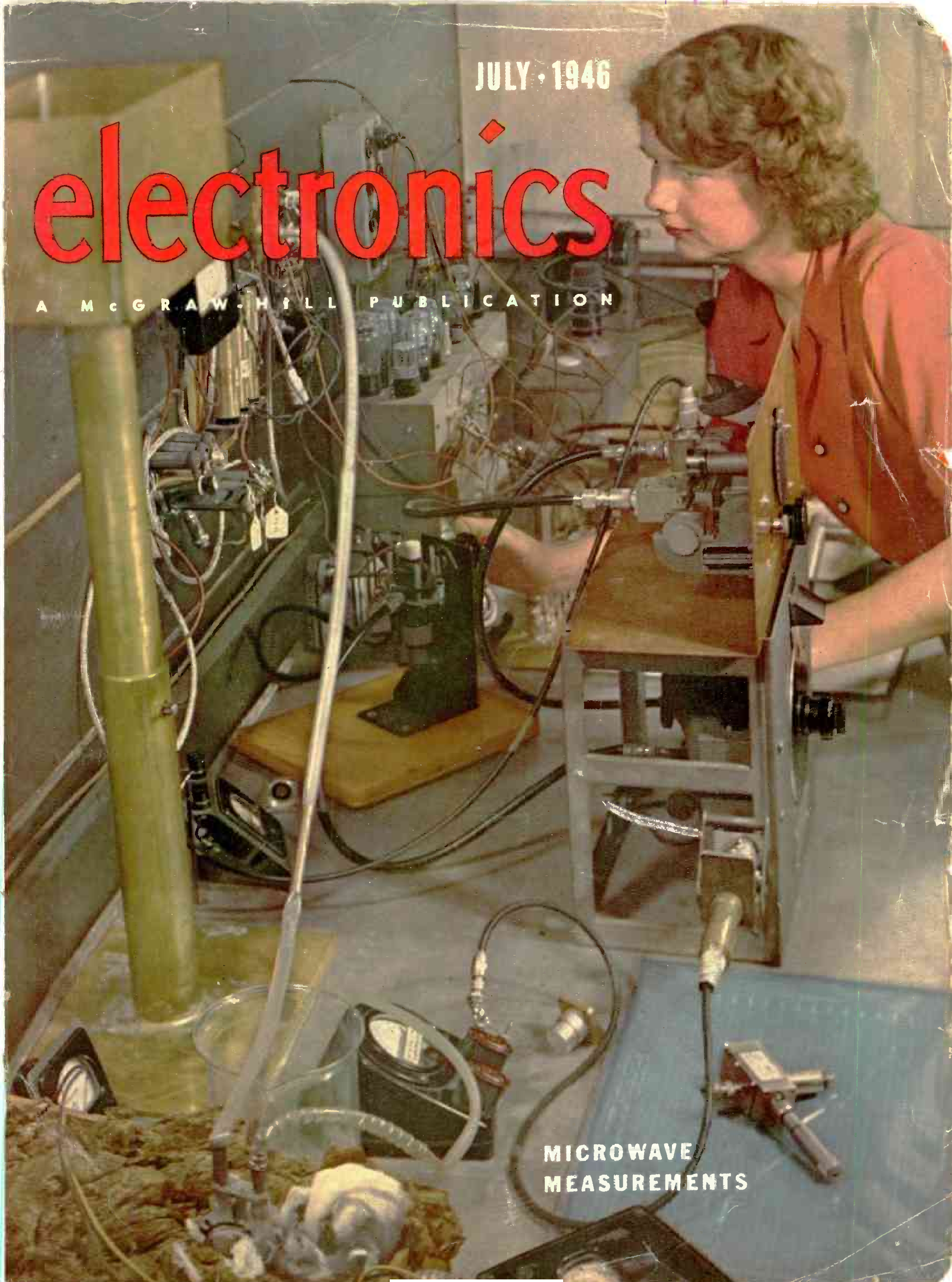
JULY · 1946

electronics

A McGRAW-HILL PUBLICATION



MICROWAVE MEASUREMENTS

electronics

A McGRAW-HILL PUBLICATION

JULY • 1946

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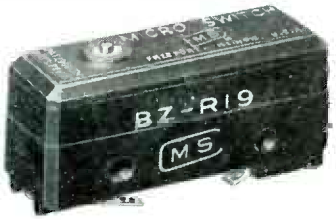
±0.0001" Look

(REPEAT ACCURACY OF OPERATING POINT)

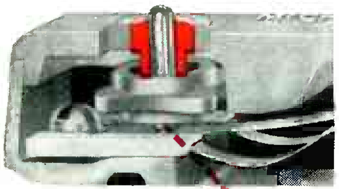
Although Micro Switch products are favorably known and widely used throughout industry, not all engineers are familiar with these three basic facts: (1) That switches bearing the familiar trademark "Micro Switch" lead the snap-action field in the precise accuracy of their performance; (2) that Micro Switch products are available in types of construction not ordinarily associated with the conventional small, plastic enclosed type of snap-action switch; (3) that Micro Switch possesses a degree of know-how which has established its leadership in the field.

The new, super-precise switch—Catalog No. BZ-R19—as described below, is the most recent example of Micro Switch precision construction and performance.

Only those who have need for superlative Snap-Action will want this *NEW* Super-Precise Switch

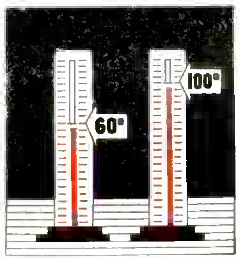


This new switch, while similar in appearance with the familiar basic Micro Switch, involves new features of construction and possesses certain operating characteristics which make it the most precise snap-action switch ever offered for use where extremely precise operation is essential. *It operates repeatedly at precisely the same point with a maximum variation of ±0.0001" over 100,000 operations!*

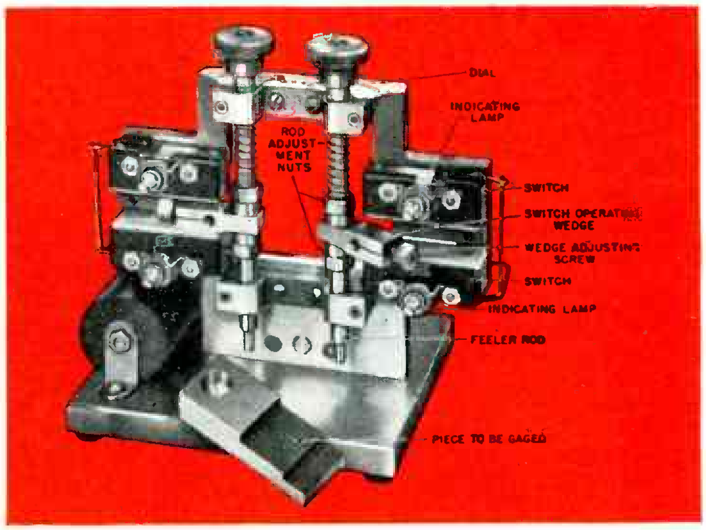


This accurate repeatability of operation at a precise point is due to special construction which involves three specific features. The stainless steel plunger pin, instead of being guided by a hole in the plastic cover, moves in a carefully fitted bronze guide imbedded in the cover. The pin and the guide are carefully ground to close tolerances assuring absolutely straight travel of the actuating plunger. Note illustration.

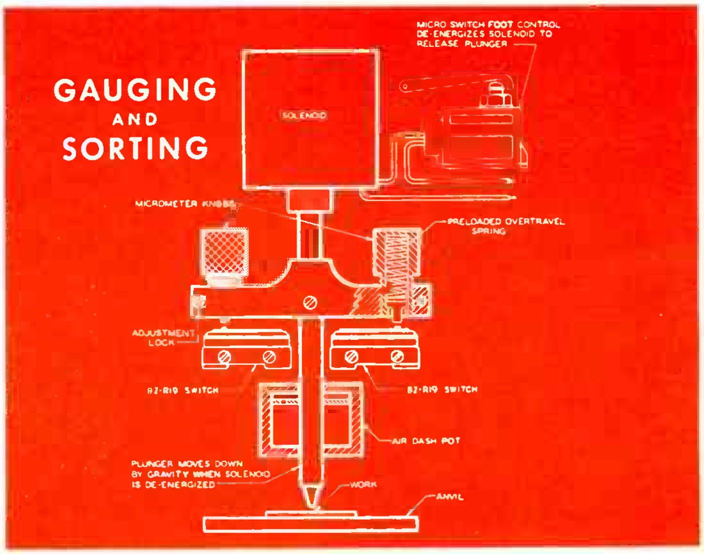
The second factor in its precise operation is the specially hardened surface of the plunger pin which exerts pressure only on the raised "pimple" in the tension member of the Micro Switch spring. With this combination, no deviation at the point of pressure is possible.



The third factor in the superlative performance of this new switch is the special construction which eliminates effect of temperatures within a normal range of 60° to 100° F.



While you can employ this switch in building your own gages, we wish to point out that accurate gaging will be attained only as the other parts of the gage embody the same precision as the switch itself. The above illustration shows how four of these new switches are used in a specially built gage used by Micro Switch to insure close tolerances in the manufacture of this new switch, as well as other Micro Switch products.



This is an example of how two of these new switches and one die cast enclosed type switch, in combination with a solenoid and micrometer knob, are used by one manufacturer in the gaging and sorting of mica. Micro Switch products, plus the extreme care used by the manufacturer in building the other parts, resulted in a reliable time and money saving tool.

To MICRO SWITCH for this *Super-Precision*

The Micro Switch snap-action principle lends itself to so many types of construction, such varied means of actuation, and so many different applications that space permits neither a description nor illustration of all of them. However, on this page, we show a few which may suggest a solution of some problem now confronting you . . . The few examples shown on this page are typical of how some engineers have utilized the Micro Switch snap-action principle of precision switching by the use of special constructions suggested and designed by Micro Switch engineers to solve a specific problem. Study these examples; compare them with your own problems, and ask for Micro Switch cooperation.

MICRO SWITCH Snap-Action can be furnished in many types of construction and with varied means of actuation

Micro Switch snap-action can be worked into so many versatile constructions and actuations that it can be used for a-thousand-and-one uses. It is not limited by shape, size, or actuation; as a result, engineering ingenuity has already adapted it to meet a wide range of mechanical and electrical problems.

Listed are a few uses where Micro Switch snap-action controls the mechanics of the following operations:

- packaging products
- bottling fluids
- recording aircraft flights
- money changing
- dispensing drinks
- heating water
- steering ships
- controlling electronic tubes
- electrical control for gages
- position indicator
- float alarms
- temperature controls
- counting mechanisms
- automatic weighing

If you have similar operations or are interested in how the above operations were accomplished, feel free to write Micro Switch, Freeport, Illinois, for complete information.

This Trade Mark MS is a sign of genuine precision Snap-Action Switches made by . . .

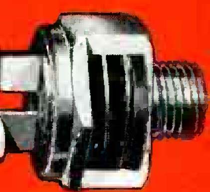
MICRO SWITCH
TRADE MS MARK
A DIVISION OF FIRST INDUSTRIAL CORPORATION
FREEPORT, ILLINOIS, U. S. A.
Sales Offices in Principal Cities

Switches shown here were specially made to meet specific problems for volume applications

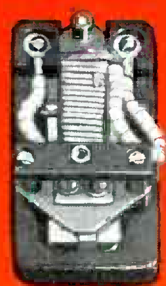
Incorporated in this construction is the Micro Switch snap-action principle with a push button actuator for panel mounting.

Here is an example of what Micro Switch engineers can accomplish by adopting the Micro Switch snap-action principle to a thermostatic switch.

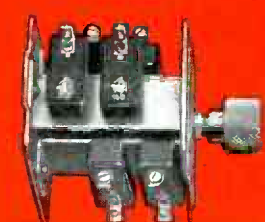
This Dual Switch Assembly incorporates the Micro Switch snap-action principle, and has been used for valve positioning indicators in marine work.



Micro Switch engineers in incorporating the Micro Switch principle into this housing call it the "nut" switch because of its construction.

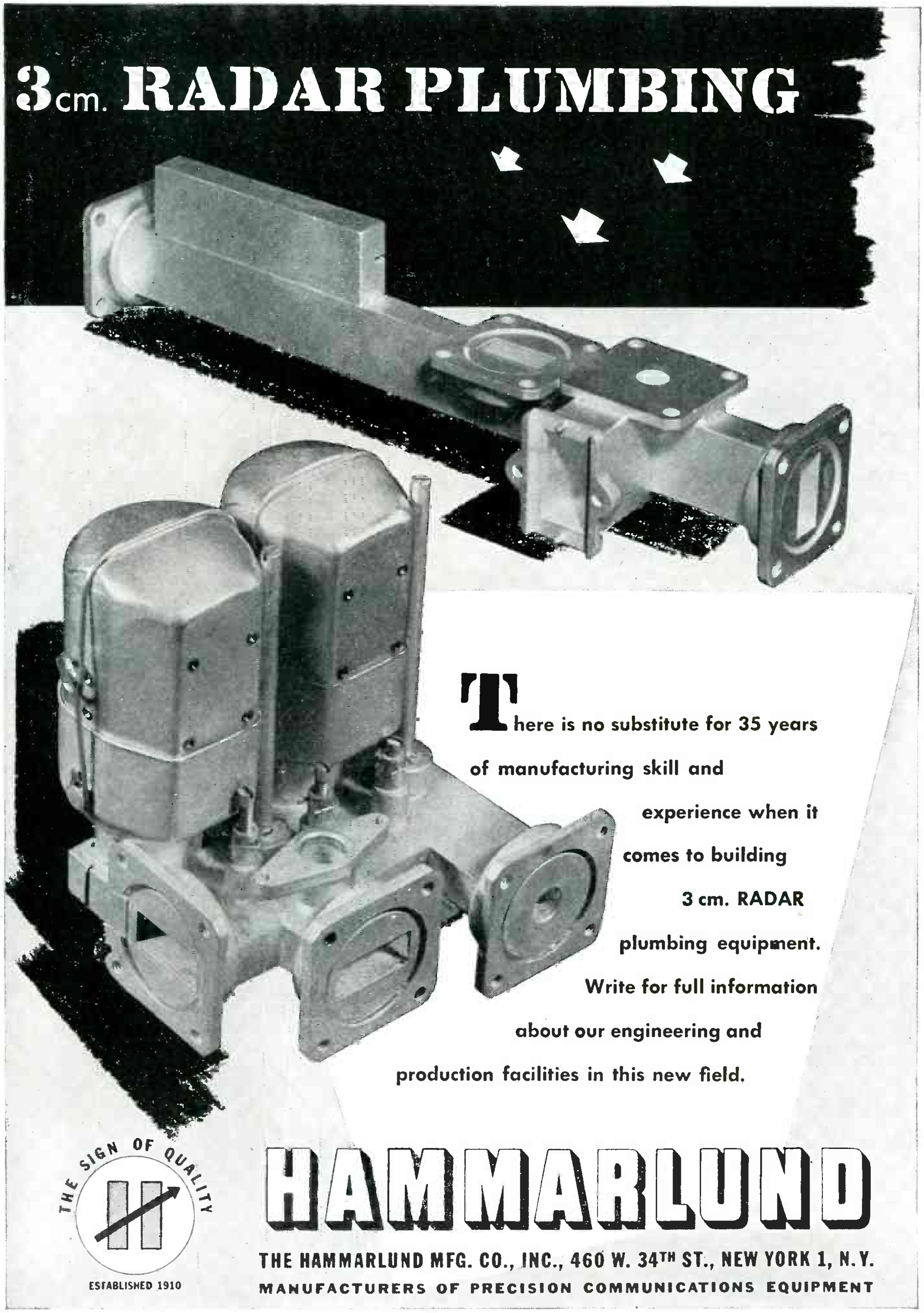


Micro Switch engineers have taken the Micro Switch snap-action principle and incorporated it into a thermal disconnect.



Here Micro Switch snap-action principle was used in a group of small switches around a rotating cam to control movements necessary to change from one aircraft gasoline tank to another.

WHY NOT DISCUSS YOUR SWITCH PROBLEMS WITH MICRO SWITCH?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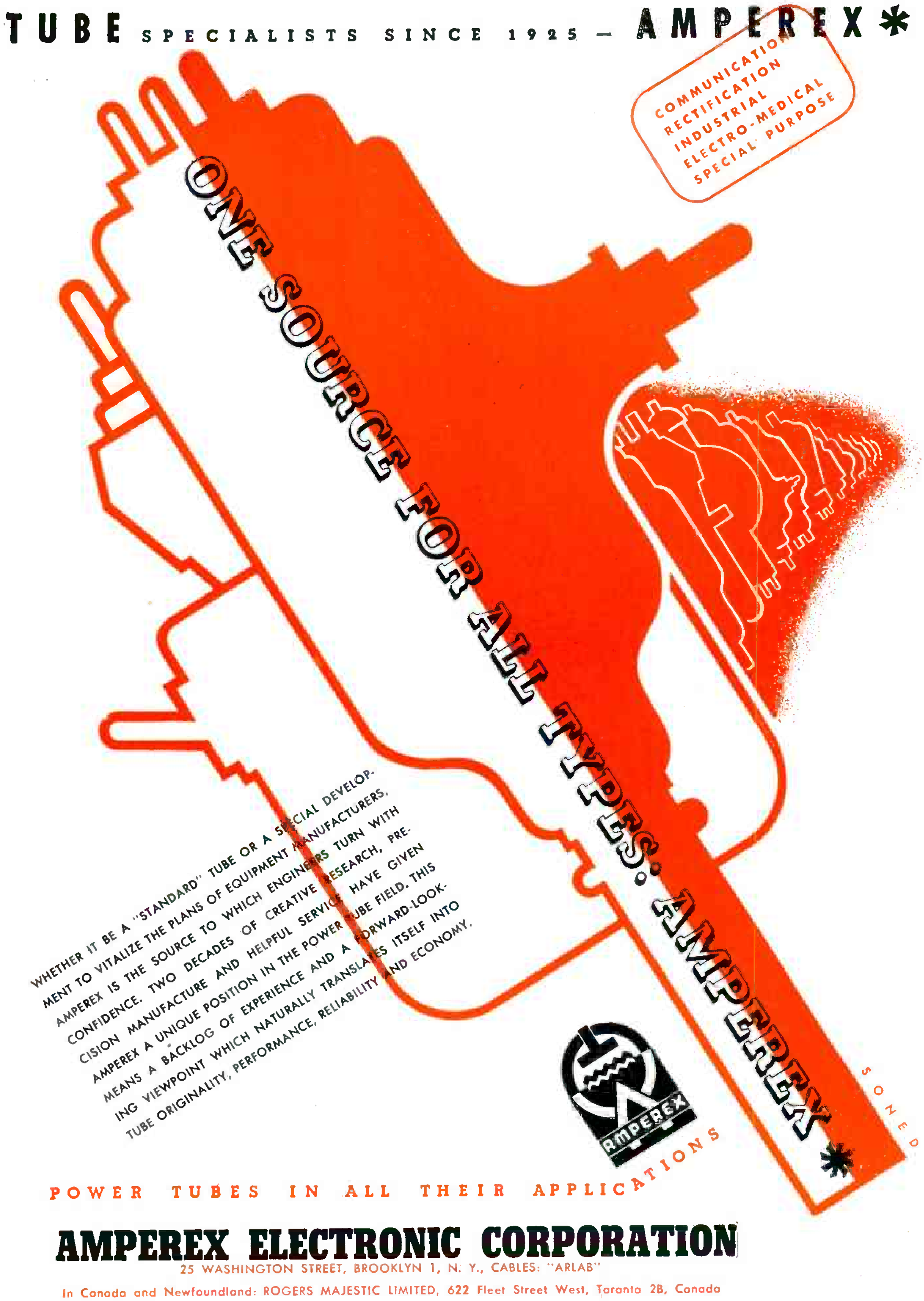
THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., NEW YORK 1, N.Y.
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT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ONE SOURCE FOR ALL TYPES: AMPEREX
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AMPEREX ELECTRONIC CORPORATION
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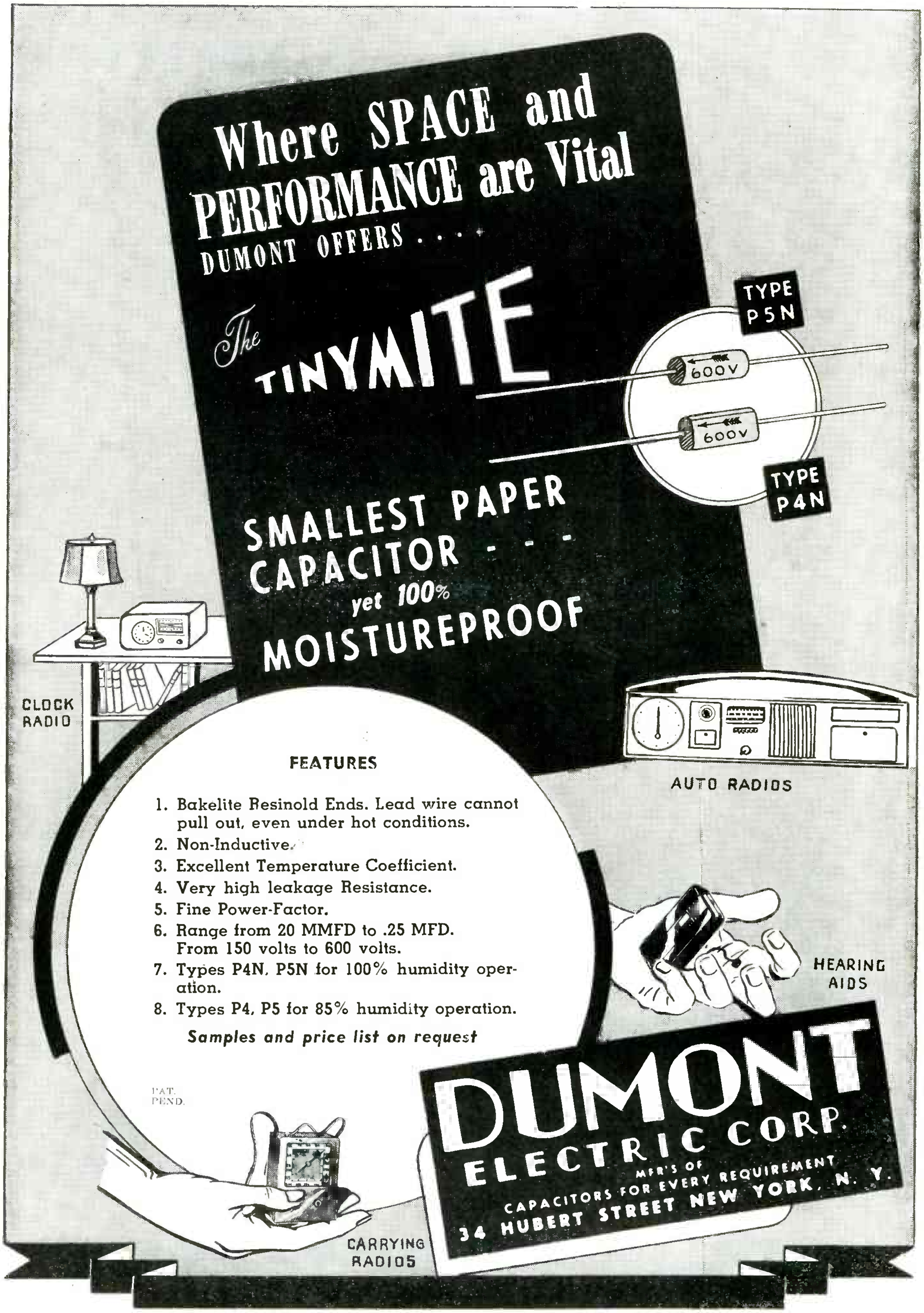
In Canada and Newfoundland: ROGERS MAJESTIC LIMITED, 622 Fleet Street West, Toronto 2B, Canada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DUMONT OFFERS . . . .
The TINYMITE
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MFR'S OF
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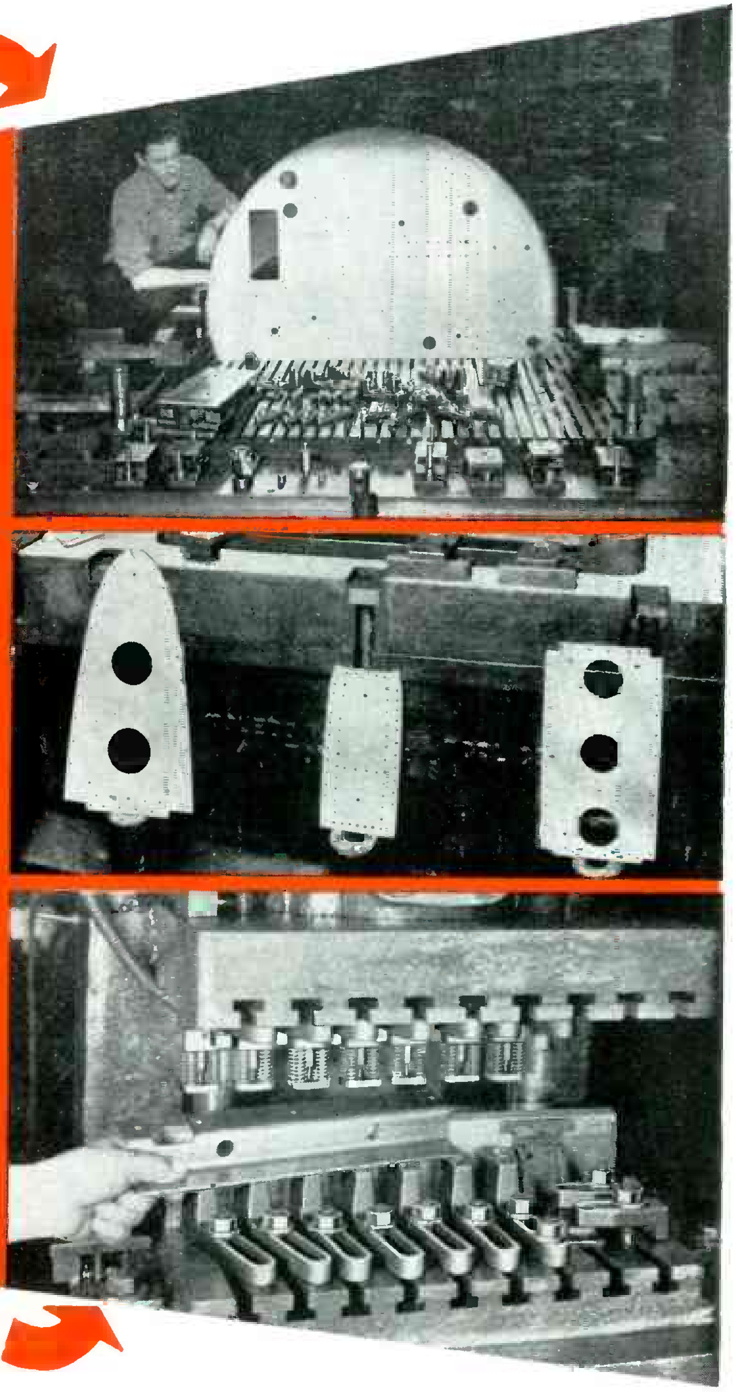
34 HUBERT STREET NEW YORK, N. Y.
CARRYING RADIOS

Some examples of what can be done with Whistler Adjustable Dies. Work in practically any type press.



Re-use same WHISTLER ADJUSTABLE DIES in unlimited combinations

1 To Pierce Holes of any diameter from 1/32″ up.

2 To Perforate Special Shapes.

3 To Notch Corners.

Make up your die sets from Whistler units taken from stock. Save production time and reduce product costs.

Whistler notching dies, group dies and standard units are especially adaptable to combined use in the same set-up. Continued re-use in a variety of arrangements quickly writes off original investment. Reason enough for their expanding popularity with hundreds of America's best known manufacturers.

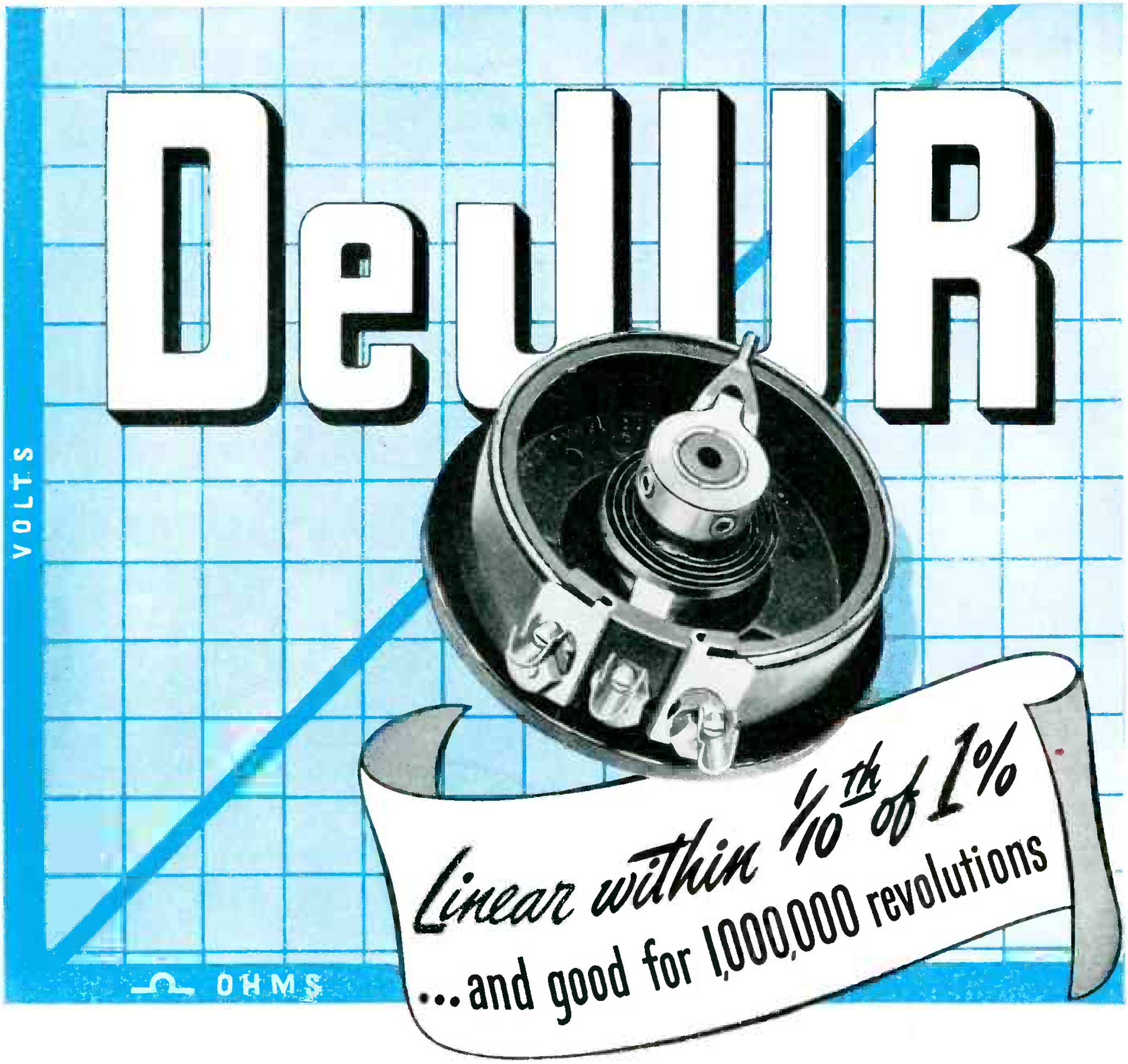
Now available from stock in a range of diameters up to 3″, shipment can be made the same day your order is received. Special sizes, shapes, notching and group dies are made to order in a few days.

You get production economy plus precision perforating in practically any press with these Whistler dies. Set-ups are easy and fast. No special tools required. Heavy duty series easily pierces 1/4″ steel. All parts interchangeable. Tolerances maintained to .0002″. There are many other advantages. Get in touch with Whistler.

WRITE FOR YOUR WHISTLER CATALOGS. Know the production advantages of Whistler Adjustable Dies.

S. B. WHISTLER & SONS, INC.

752-756 MILITARY ROAD BUFFALO 17, NEW YORK



• DEJUR Precision Potentiometers give you the combination of accuracy and ruggedness that assures long-life dependability.

These instruments . . . which are used in large quantities for radar work... are manufactured to tolerances as close as .1% in linearity. Regular production runs guaranteed to within .3%. Special "Paliney" contacts can demonstrate ability to take over one million revolutions without physical or electrical deterioration.

Join some of the greatest electrical and electronic equipment manufacturers in the world by ordering DEJUR Potentiometers from the nearby table. Prompt delivery.

DeJur-Amsco Corporation, 45-12 Northern Boulevard, Long Island City 1, N. Y.

CHART

MODEL NO.	WATTS	RANGE-OHMS MINIMUM-MAXIMUM	ROTATION MECHANICAL	ROTATION ELECTRICAL
241	50	1 — 20,000	300°	270°
245	25	1 — 20,000	300°	270°
260	6	20 — 100,000	324°	300°
260T	6	20 — 50,000	324°	300°
261	6	20 — 100,000	320°	300°
271	11	100 — 200,000	324°	300°
275	11	100 — 200,000	324°	300°
275T	11	200 — 100,000	324°	300°
281	4	1 — 100,000	320°	300°
291	6	1 — 50,000	258°	258°
292	6	1 — 50,000	258°	258°
296	8	5 — 50,000	248°	248°
501	25	100 — 500,000	326°	316°

DeJUR DeJUR U.S.A. **Products**

Their Mechanical Perfection Protects Their Electrical Performance

ANOTHER NEW

Jensen Coaxial

The most significant postwar loud speaker development yet announced is the new Jensen family of Type H *Articulated* Coaxial Speakers. The latest member is Model HNP-51, an all *ALNICO 5* design – in which low-frequency and high-frequency speakers are employed coaxially in an articulated assembly. The 15-inch l-f cone acts as an extension of the h-f speaker horn. The two loud speakers are electrically and acoustically coordinated into a system achieving brilliant and natural response through the entire useful frequency range (l-f performance depends upon the baffle or enclosure used). Frequency-dividing network has variable control in range above 4,000 cycles.

HNP-51 is recommended for FM receivers, high quality phonograph reproduction, television, review rooms, monitoring and home and public entertainment generally.

Coaxial Models HNP-50 and HNF-50 (for manufacturers) and HNP-51 (for general use), are now nearing quantity production. All Type J Jensen Coaxials (3 models) are now in production. Write for complete information.

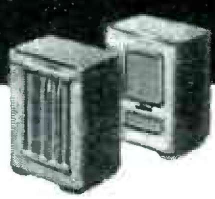
TYPE H SPECIFICATIONS

MODEL HNP-51 (15-inch) with *ALNICO 5* in both l-f and h-f units. Power rating, 25 watts maximum in speech and music systems. Input impedance, 500 ohms. List price approximately $125.

MODEL HNF-50 (15-inch) *ALNICO 5* design h-f unit; field coil in l-f unit; otherwise same as HNP-51. List price approximately $115.

COMPLETE REPRODUCERS. Model HNP-51 Speaker is offered in 2 cabinet models to form complete reproducers. Model "CR" Reproducer employs beautiful Jensen Imperial Walnut cabinet. Model "RA" Reproducer employs attractively finished general utility cabinet.

Jensen SPEAKERS WITH ALNICO 5

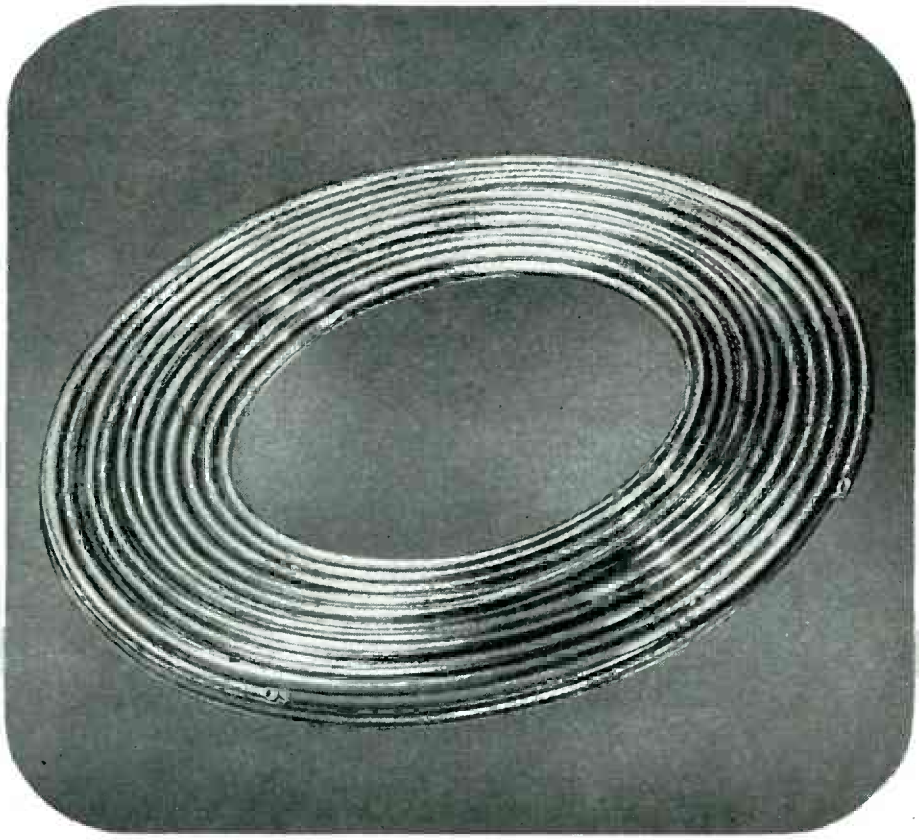


JENSEN RADIO MANUFACTURING CO., 6625 S. Laramie Ave., Chicago 38, Ill.
In Canada: Copper Wire Products, Ltd., 137 Oxford Street, Guelph, Ontario

Specialists in Design and Manufacture of Fine Acoustic Equipment

FOR INDUCTION HEATING COILS

REVERE DRYSEAL TUBE



Revere Dryseal Copper Tube is ideal for fabricating coils for induction heating applications. It is pure copper, seamless, high in both electrical and heat conductivity. Temper, dead soft, so it can be easily formed into a coil by hand or machine. Sizes from 1/8″ to 3/4″, with .035″ wall. Supplied in standard 50-foot coils, dehydrated and sealed at both ends. Sold by Revere Distributors in all parts of the country.

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COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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Mills: Baltimore, Md., Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.
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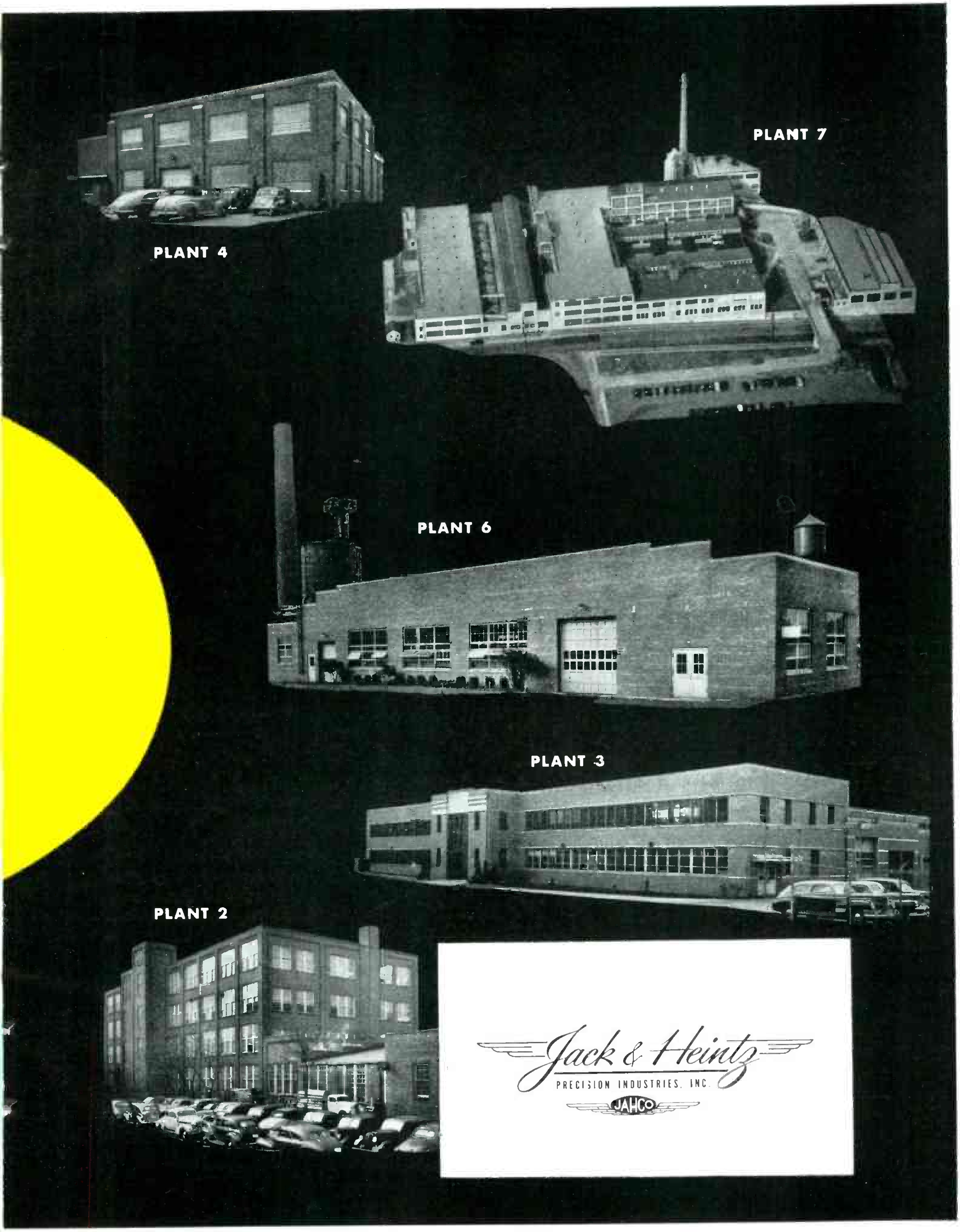
...FOR SHORT-RANGE

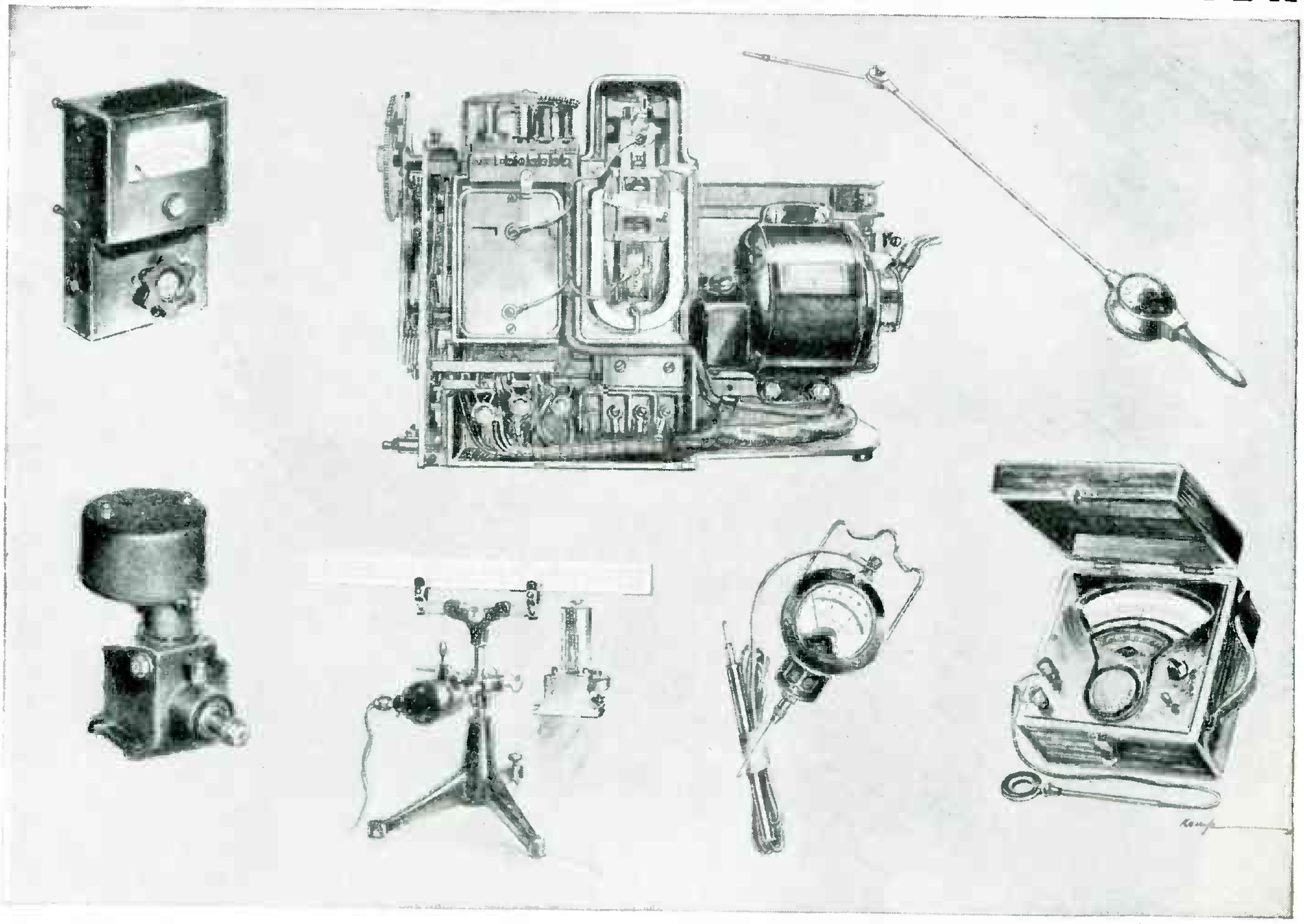
Brilliant Reproduction... Low Cost... Quickly Set Up

ON LOCATION—The microwave transmitter relays the signals picked up by field cameras to the studio—recently used with excellent results to transmit scenes of the U.N. Conference at Hunter College to Radio City.

THE RELAY TRANSMITTER consists of a parabolic antenna with hook-shaped wave guide, an easily removed transmitter built into the waterproof cylindrical housing at the back of the reflector, and the small, suitcase-type transmitter control.


PLANT 7
PLANT 4
PLANT 6
PLANT 3
PLANT 2
Jack & Heintz
PRECISION INDUSTRIES, INC.
JAHCO

PERMANENT MAGNETS MAY DO IT BETTER



Permanent Magnets Help Guide Science and Industry

Permanent magnets play a vital role in modern manufacturing methods, scientific research, testing and measurements, industrial and domestic controls, signals and alarms.

Ammeters, Wattmeters, Voltmeters, Magnetic Gauges, Thermostats, Pressure Controls, Polarized Relays and Fluxmeters—these are but a few of the many—all of which rely upon the "Packaged Energy" of the magnet in their function.

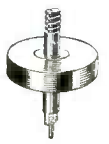
Permanent Magnets aid physicists, chemists and engineers in the laboratory, plant and field. They aid the *Pyrometer* in measuring extreme temperatures of molten metal; in recording the intense heat in ovens, linotypes, die castings; and in the exacting heat controls in electrical, rubber, paper and plastic manufacturing. The *Galvanometer* using permanent magnets is a basic tool in the measurement of electricity. It is used in connection with other devices such as the *Potentiometer.*

Permanent Magnets also serve in measuring mechanical conditions such as the measurement of speed in *Tachometers* and *Speedometers,* and to indicate relative positions, as in *Gauges.*

Permanent Magnets help guide men, methods and machines employed by modern science and industry, with split-second charting, controlling, and recording of speed, accuracy, precision and efficiency.

Actually millions of magnets serve you daily, each doing some job or process better. They range in size from the tiny, feather-weight magnet in the hearing aid to the powerful, heavy radar magnet. Perhaps permanent magnets can do some job or process better for you in your industry. You are invited to consult our engineers on any problem of magnet application.

The Indiana Steel Products Company has made magnets for more than 24,000 applications. It is the world's largest sole producer of "Packaged Energy". For complete information, please write for free "Permanent Magnet Manual".



This Alnico Magnet is the generator rotor which supplies the operating power for the proximity fuse.

Producers of "PACKAGED ENERGY"

★ ★ ★ THE INDIANA STEEL PRODUCTS COMPANY ★ ★ ★

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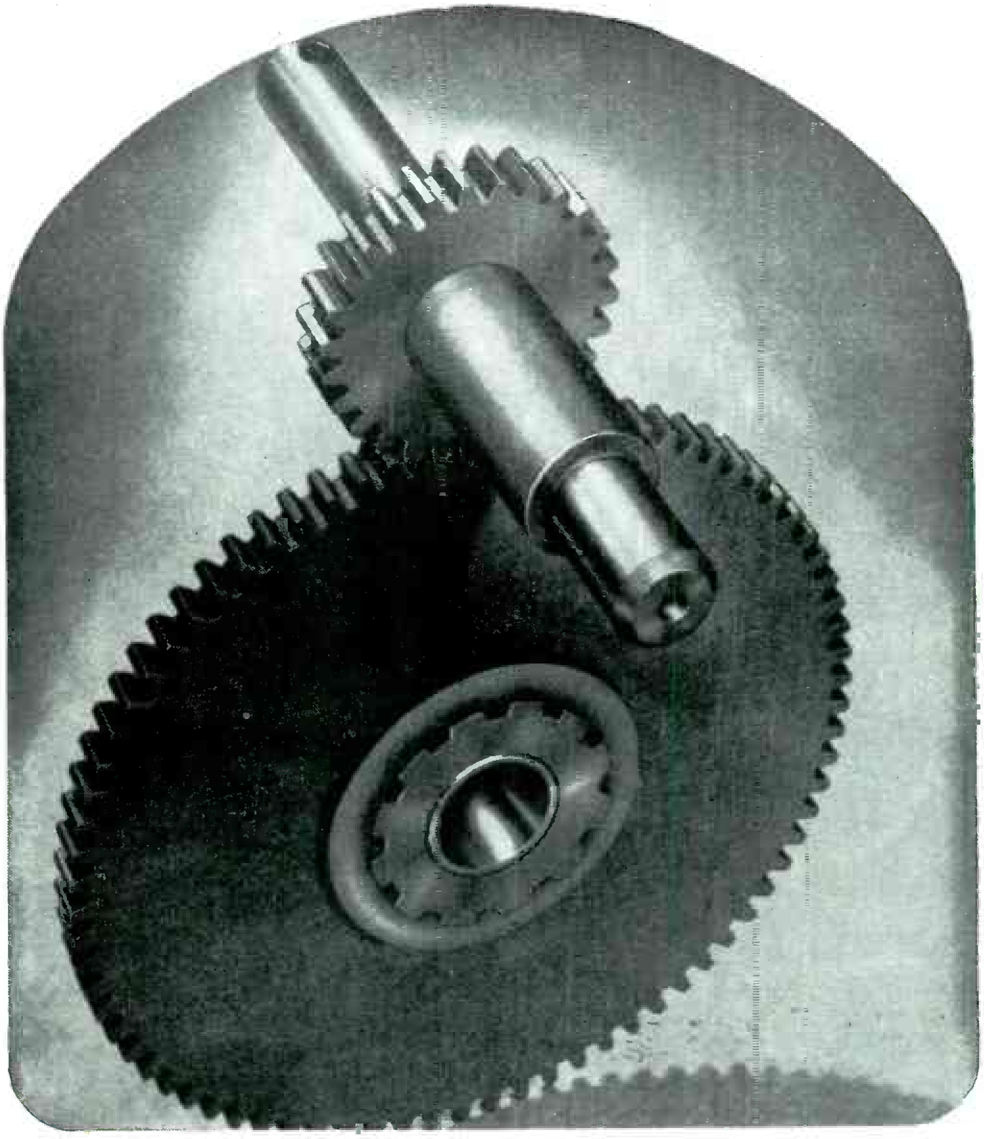
SPECIALISTS IN PERMANENT MAGNETS SINCE 1910



LOOK for the Stackpole Minute Man . . . your guarantee of expertly engineered molded materials.
Specialists for over a third of a century in MOLDED CARBON, GRAPHITE, METAL POWDERS, and MOLDED COMPOSITION MATERIALS.
STACKPOLE CARBON CO., ST. MARYS, PA.
STACKPOLE
BRUSHES AND CONTACTS
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FIXED & VARIABLE RESISTORS, etc., etc.
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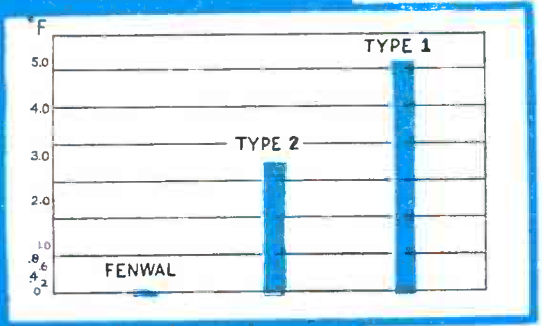
SMALL TEMPERATURE DIFFERENTIAL*

You can't have close control of temperature if the controlling thermostat has a large operating temperature differential. Fenwal THERMOSWITCH Controls have an inherent minimal temperature differential which reduces temperature overshoot and undershoot effects. This small temperature differential can be increased to suit your requirements by proper THERMOSWITCH Control application.

Chart shows the small operating temperature differential of the Fenwal THERMOSWITCH Control compared to Type 1 and Type 2 thermostats. The force exerted by the expansion and contraction of the temperature sensitive brass shell is transmitted directly through the two anchored ends of the contact support members causing a positive make or break of the electrical contacts resulting in accurate temperature control.



THERMOSTAT OPERATING DIFFERENTIAL — °F

Compact and easily installed, Fenwal THERMOSWITCH Controls have proven themselves in thousands of applications under all conditions. Investigate the advantages of THERMOSWITCH Controls as applied to your heat control problem. Send for your copy of the Thermotechnics Booklet which includes the "Fourteen Facts in Fenwal's Favor."

FLANGE HEAD THERMOSWITCH CONTROL

FOURTEEN FACTS IN FENWAL'S FAVOR

1.—Fast reaction time
2.—Large heat sensitive area, small heat storage
3.—Short heat transfer path
4.—Small temperature differential
5.—Built-in temperature anticipation
6.—Enclosed assembly
7.—Minimal vibration effects
8.—Directly responsive to radiant heat
9.—Rugged construction
10.—Adjustable over wide temperature range
11.—Minimum size
12.—Tamper-proof and sealed
13.—Uniform sensitivity over adjustable temperature range
14.—Readily installed

*#4 of the "Fourteen Facts in Fenwal's Favor".

Fenwal

FENWAL INCORPORATED
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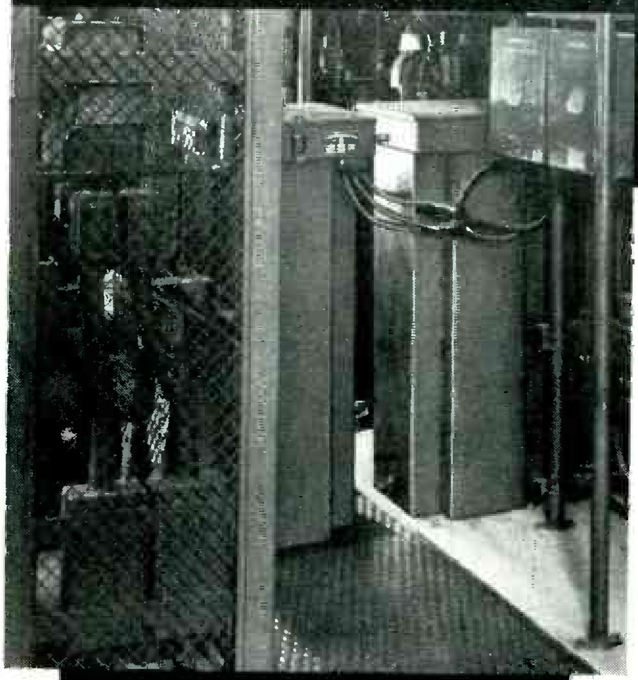
ASHLAND MASSACHUSETTS

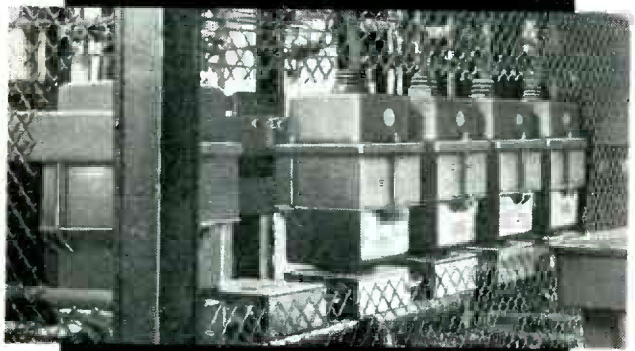
THERMOTECHNICS FOR COMPLETE TEMPERATURE REGULATION

BRENTWOOD, N. Y.

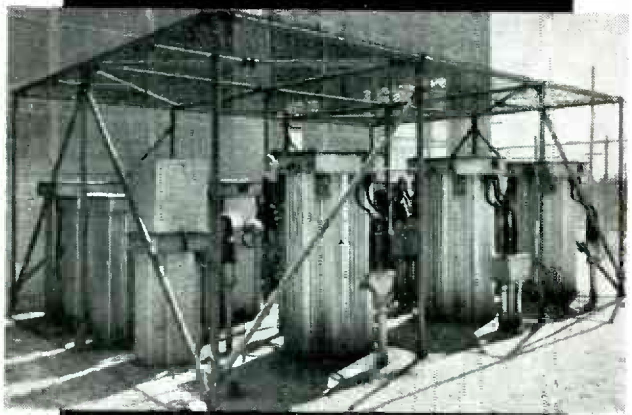
Key Station of MACKAY RADIO & TEL. CO., INC.



AmerTran voltage-regulating transformers—132 KW mercury vapor rectifier. Filament Transformers visible at left.



Closeup view of AmerTran Dry Type Filament Transformers. Rated 1.64 KW, 460—32/16 V.



Group of AmerTran Plate Transformers, outdoor installation. Supply 132 KW Transmitter. 18,600 V. secondaries.

is "alive" with

AMERTRAN TRANSFORMERS

ALIVE in every respect! Brentwood, one of the busiest of commercial radio stations, handles large volumes of traffic over a complex array of transmitters and frequencies. Station equipment is kept excited for long periods of continuous duty.

There are literally dozens of AmerTran Transformers, Retard Coils, and Reactors, indoors and out, feeding controlled voltages to various transmitter units in this station. Some of these, in the rectifier circuits of a 132 KW transmitter, are shown here.

The 1.64 KW Filament Transformers, at left, have been on the job for 15 consecutive years. This is the kind of consistent performance engineered into every AmerTran.

AmerTran Transformers are "built-in" components in the best-known communications and industrial-electronic assemblies now in operation. They are designed by authorities in electronic energy transformation, and are built in a plant devoted exclusively to the production of transformers and allied products. You may feel free to use the entire facilities of the AmerTran organization.

AMERICAN TRANSFORMER COMPANY

178 EMMET ST. NEWARK 5, N. J.

We'll be glad to send you a copy of the new Bulletin "G", showing the wide scope of AmerTran Products.

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

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REG. U. S. PAT. OFF.

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

PREPARE TODAY FOR THE *Buyer's* MARKET OF *Tomorrow*

The present "field day" for salesmen will not long last. When production comes nearer to catching up with demand, critical Buyers will sit in the driver's seat. Scarcity over, Quality and Price will be the determining factors. Then, the movement of your product to market will be controlled, not so much by salesmen as by your design and engineering staffs.

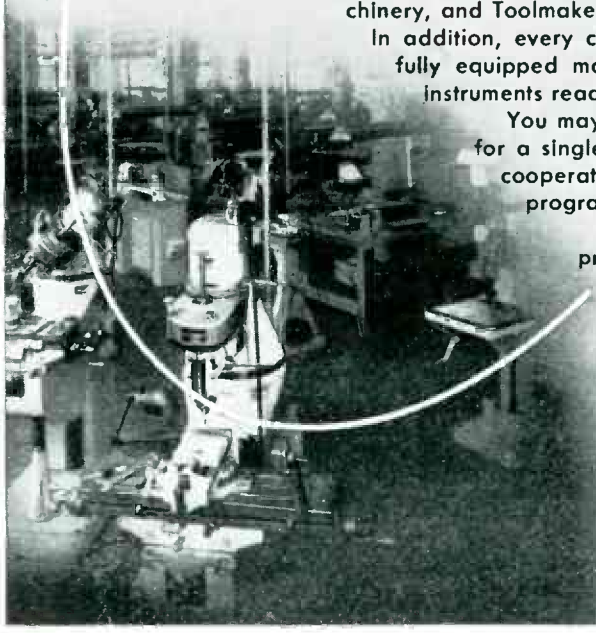
But . . . you say . . . "we're short-handed . . . they have more work than they can do now".

So, we offer, for your use, the Atlas staff of 400 skilled Engineers, Designers of Products, of Special Automatic Machinery, and Toolmakers unsurpassed in their specialized fields.

In addition, every conceivable operation is handled in Atlas' fully equipped machine sections . . . with precise inspection instruments ready to prove all required qualities and accuracies.

You may obtain these services, partially or completely . . . for a single tooling job or an entire production line . . . in full cooperation with your own staff . . . or as our own independent program.

Write or telegraph for immediate action . . . or, if you prefer, send for the Atlas brochure "A Load Off Your Shoulders onto Ours".



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Here is merchandise you need. Electronic merchandise you can sell at a profit, with or without further processing. And there's plenty of it! Enough to "plug the gap" until your normal sources of supply can replenish your shelves and stockrooms.

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● A compact, one-hand operated insulation tester . . . range .1 to 10,000 megohms . . . easily read scale . . . test potential less than 50 volts d-c. Ideal for testing electrical components, devices, materials, and new and existing installations. Details from the WESTON representative near you, or write for bulletin.

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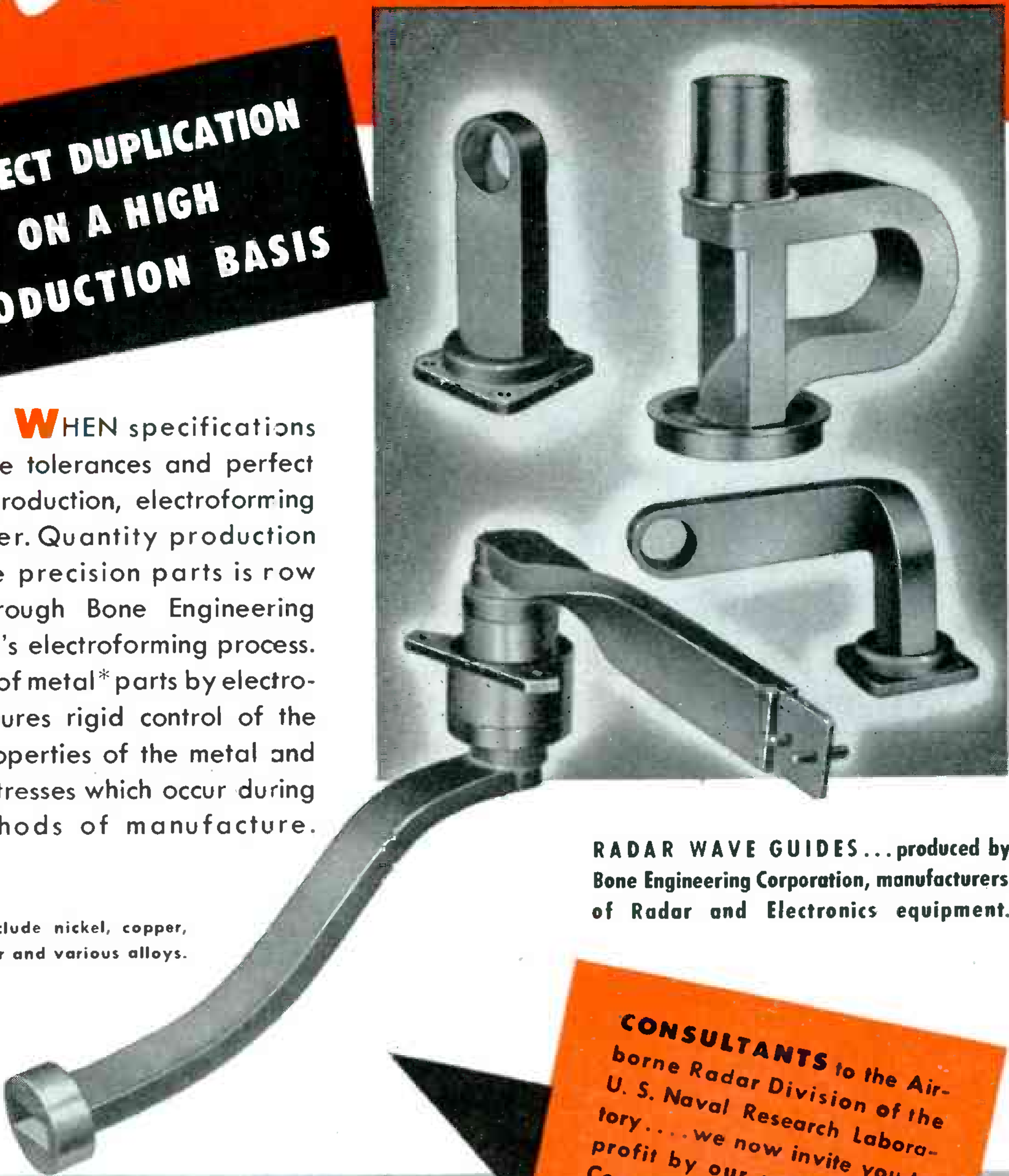

RADAR WAVE GUIDES...produced by Bone Engineering Corporation, manufacturers of Radar and Electronics equipment.

CONSULTANTS to the Airborne Radar Division of the U. S. Naval Research Laboratory....we now invite you to profit by our experience as Consultants on Electroforming.

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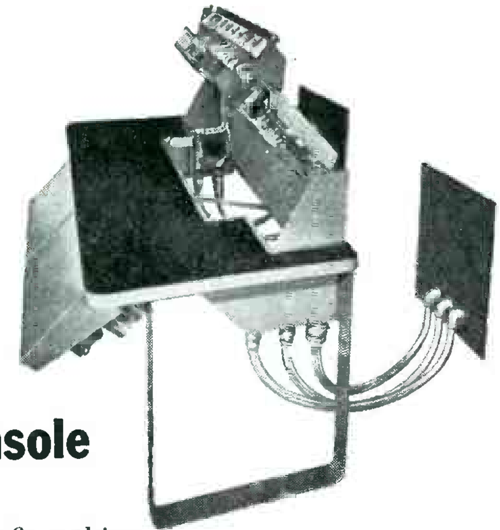
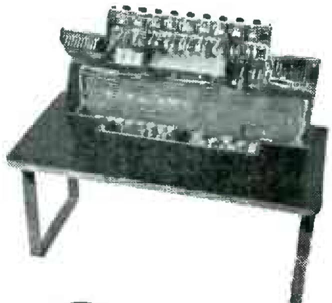
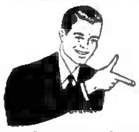
from every angle... IT'S A HONEY!



Western Electric
25B speech input console

It's got sparkling eye-appeal—that's the first thing you'll like about this new audio unit designed by Bell Laboratories. When you see how completely it opens up for inspection and maintenance—almost as easily as turning the pages of a book—you'll like that too. And when you study the list of operating advantages it gives you at moderate cost, you'll agree *it really is a honey!* Ask your nearest Graybar Broadcast Equipment Representative for *all* the the facts about this pacesetting 25B.





Look at these features:

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Complete unit design—including table and NEW plug-in cables.

Uniform, noise-free, distortionless operation over a 15,000 cycle range.

8 low level microphone channels and 3 line level channels. Any 4 microphone channels and three line level channels—7 in all—can be used simultaneously.

2 high quality main amplifier channels that handle 2 programs simultaneously—plus separate monitor and cueing channel.

7 remote line input circuits—3 normalled through for program transmission or sending or receiving cue.

All controls arranged and coordinated for maximum operating flexibility and convenience.

Compact—only 36" high, 55¼" wide, 28¼" deep.

Designed for maximum ease of installation—junction boxes supplied.

Completely wired for easy plug-in connection.

All parts readily accessible for inspection and maintenance.

Western Electric

Distributed by Graybar

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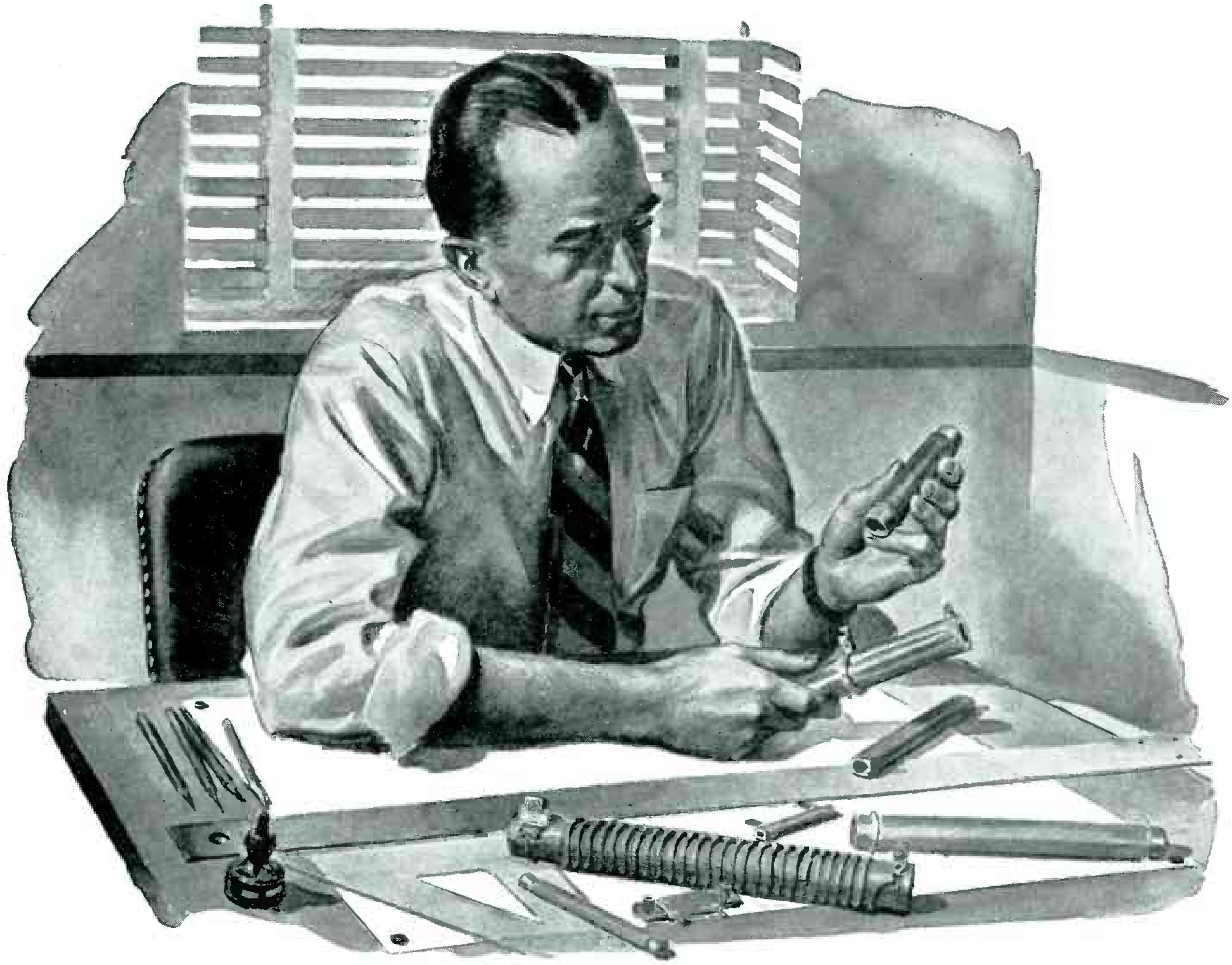

Plans for new products and the modernization of existing ones are on every drafting board. In the electrical and electronic industries manufacturers are indeed entering a competition of design. You and every other manufacturer are studying available components. When selecting resistors, give consideration to the developments that have been made to meet the severe conditions of the past several years. A resistor that better meets your requirements will add to the utility of your product.

The new Ward Leonard Hand Book "RESISTORS" gives a complete resume of available types. It discusses the advantages of each, gives resistance values, and shows terminals, mountings and enclosures. Send for a copy today.

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RELAYS • RESISTORS • RHEOSTATS

Electric control devices since 1892

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HIGH speed machine-winding of electric motor armatures necessarily exposes magnet wire to some rugged treatment. Insulating film must be *tough,* yet *pliable.* Copper must have the proper degree of anneal to "stay put" and insure uniformly filled slots and compact end-loops.

The all-around (in the groove and out) "windability" of ESSEX EXTRA TEST MAGNET WIRE in this and other exacting applications cannot be excelled.

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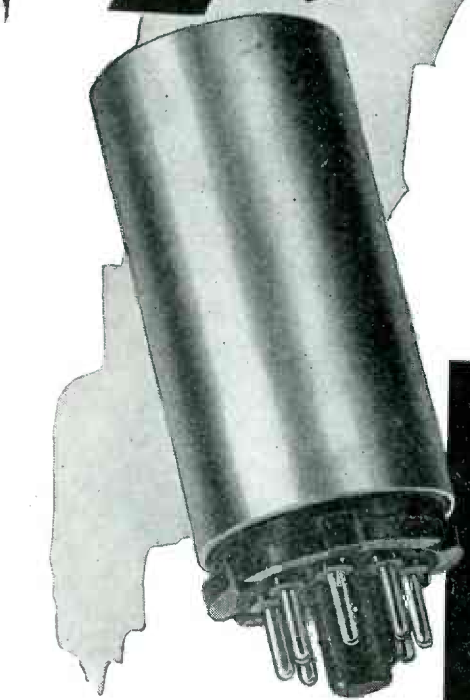
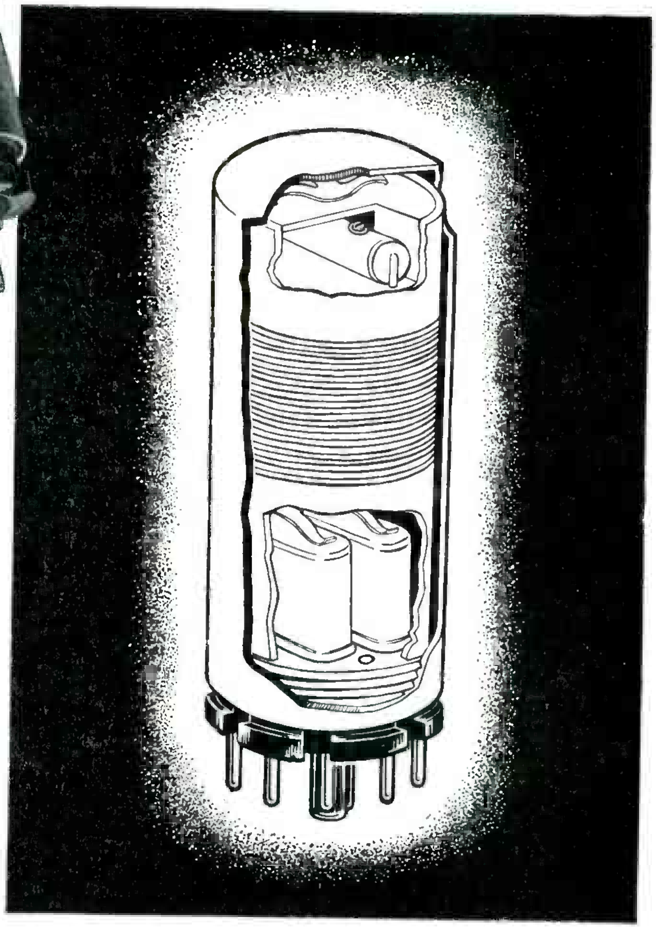
Keeps Frequency Stable and Dependable..under all Temperature Conditions

Applicable to fixed, mobile or airborne equipment requiring close frequency tolerance. Light weight and small dimensions . . . X-Thermotrol is especially desirable for aviation, police, railway and marine communications.

Constant temperature maintains exact tolerances resulting in stabilized frequency . . . Crystal holders are held steady against extreme vibrations.





X-THERMOTROL operates on A.C. or D.C. . . . 6.3, 12, 24 and 32 volts, at 12 watts.

Crystal holder cavity temperature . . . adjustable to your requirements . . . is normally set to 75 degrees Centigrade, at our factory.

X-Thermotrol is made almost entirely of aluminum and weighs only 4 ounces. Case has lustrous finish. Over-all dimensions: O.D. 1.301", height above chassis 2¾", over-all height 3¼".

Oven houses two type CR-7 hermetically sealed crystals which may be pressure, or plated mount. Plug-in construction permits instant change of either heater element or crystal units. Entire unit is mounted on octal base.

Write for complete details about this new, unusually efficient unit.

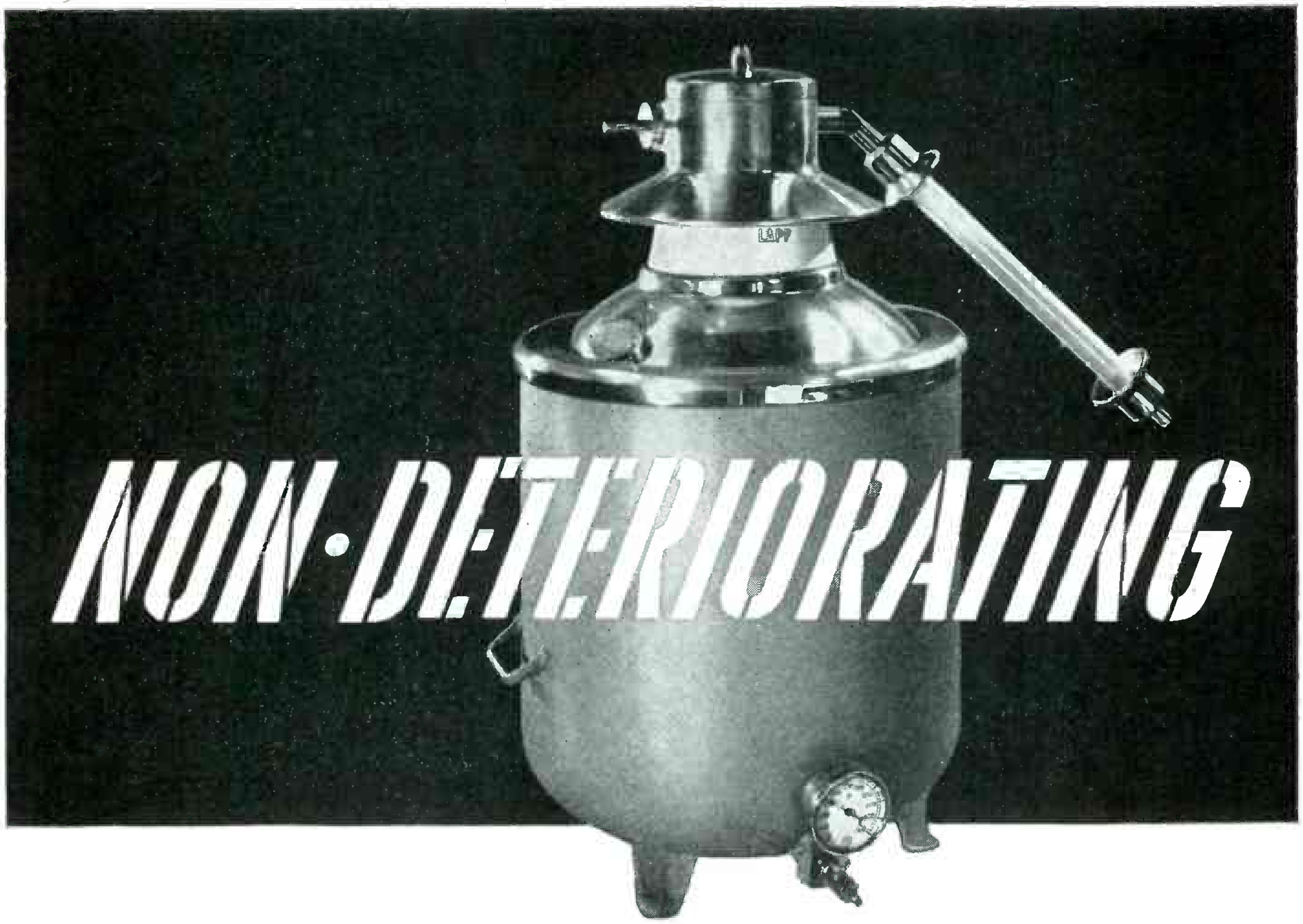
4 m.c. to 8 m.c. crystals can be placed in these holders.

We also develop laboratory models for special type equipment. Consult us about your needs.

GASKET ENGINEERING CO., INC.

Manufacturers of Crystal Holders for the Radio Industry

2444 Charlotte St. **Kansas City 8, Mo.**



....PUNCTURE-PROOF, FOR LONG, UNIFORM PERFORMANCE.

"Fail-proof" is a reasonable and honest description of the Lapp Gas-filled Condenser. It has no fixed or solid dielectric to deteriorate or puncture, and should out-last any electronic circuit of which it is a part. Also, it offers correspondingly lower loss and economy of power. Not needing to "warm up," it provides constant capacitance under temperature variation. Variable, adjustable, and fixed capacitance units are available. Fixed condensers have been made with capacitance up to 60,000 mmf., variable and adjustable units up to 16,000 mmf. Current ratings range up to 500 amperes R. M. S., and voltage ratings up to 60 Kv peak. *Above, Unit No. 25,934, rated at 200 amperes, 6500 volts, capacitance continuously variable from 4300 mmf. to 1100 mmf.* Lapp Insulator Co., Inc., Le Roy, N. Y.

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

● Aerovox silvered-mica capacitors are designed for the most critical applications requiring precise capacitance values and extreme stability. Although otherwise similar in external construction and dimensions to the smaller molded bakelite units, they are encased in molded XM low-loss *red bakelite* for immediate *silvered-mica* identification.

A silver coating is applied to the mica and fired at elevated temperatures. This insures not only a positive bond but permanent stability of the capacitance with respect to time, temperature and humidity. Units are heat-treated and wax-impregnated externally for ultimate protection against moisture penetration.

Ideal for use in circuits where capacitance must remain constant under all operating conditions. These capacitors are specifically designed for use in push-button tuning, oscillator padding circuits, fixed tuned circuits, and as capacitance standards, etc., where accuracy and stability are prime considerations.

● Write for literature . . .

Average positive temperature coefficient of only .003% per degree C.—a remarkably low value.

Excellent retrace characteristics; practically no capacitance drift with time; exceptionally high Q.

Available in three types, 1000 v.D.C. test: Type 1469, .000005 to .0005 mfd.; Type 1479 (illustrated), .0001 to .001 mfd.; Type 1464, .00075 to .0025 mfd., and .001 mfd. in 600 v. D.C. test.

Standard tolerance plus minus 5%. Also available with tolerances of plus/minus 3%, 2% and 1%.

Minimum tolerance for capacitances up to and including 10 mmf. (.00001 mfd.) plus/minus ½ mmf. Minimum tolerance available for all other capacitances, plus/minus 1% or plus/minus 1 mmf., whichever is greater.

• • •

Literature on request . . .

AEROVOX capacitors

FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

AEROVOX CORPORATION, NEW BEDFORD, MASS., U.S.A.

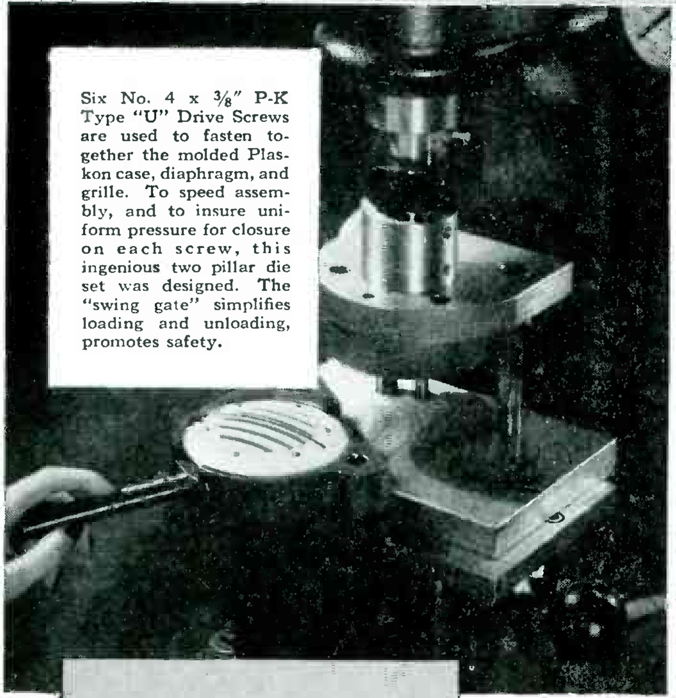
SALES OFFICES IN ALL PRINCIPAL CITIES • Export: 13 E. 40th St., New York 16, N. Y.

Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.

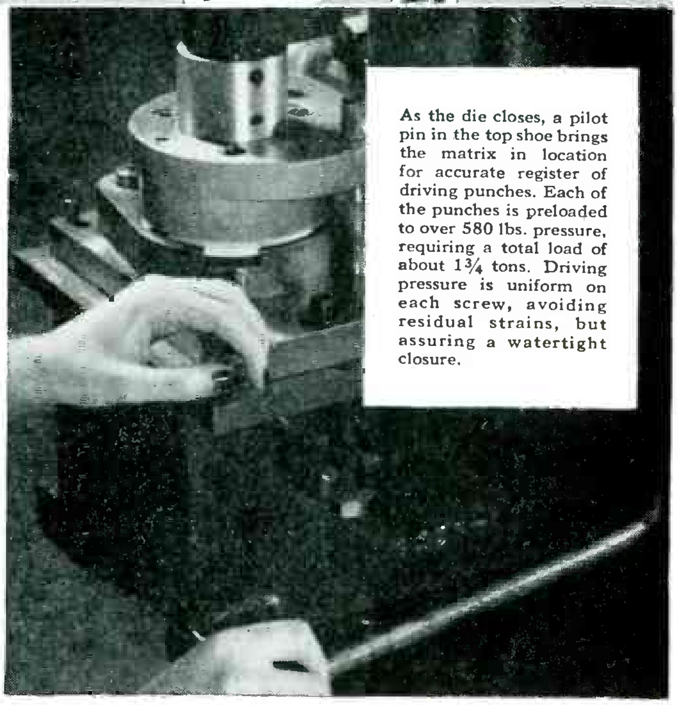

OUTSTANDING
Connectors

6 P-K SCREWS DRIVEN simultaneously to assemble case IN ONE OPERATION

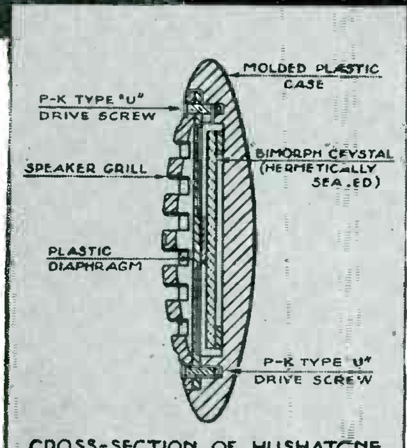
The Brush Development Company avoids expense of brass inserts and troublesome tapping in blind holes — speeds assembly of Hushatone miniature speakers for hospital use.



Six No. 4 x 3/8" P-K Type "U" Drive Screws are used to fasten together the molded Plaskon case, diaphragm, and grille. To speed assembly, and to insure uniform pressure for closure on each screw, this ingenious two pillar die set was designed. The "swing gate" simplifies loading and unloading, promotes safety.



As the die closes, a pilot pin in the top shoe brings the matrix in location for accurate register of driving punches. Each of the punches is preloaded to over 580 lbs. pressure, requiring a total load of about 1¾ tons. Driving pressure is uniform on each screw, avoiding residual strains, but assuring a watertight closure.



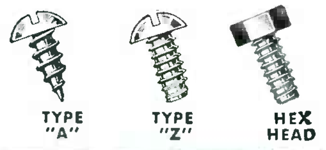
CROSS-SECTION OF HUSHATONE

Recognizing the obvious cost advantages of P-K Type "U" Drive Screws over inserts or tapping for machine screws, The Brush Development Co. engineers came up with an idea for simultaneous driving that multiplied time saving. It also met tricky requirements for uniform holding pressure to insure a lasting, liquid-proof seal that would permit sterilization. They report "no failures due to leakage or loose screws".

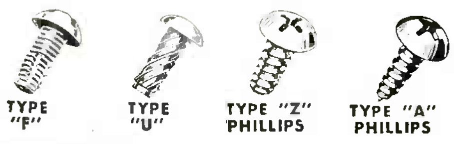
This application is one of thousands in which America's best assembly engineers have used the P-K "short cut" fastening method to save up to 50% in fastening time and labor, and reduce spoilage. It's plain *common sense* to find out if your assembly is one of the 7 out of 10 in which P-K Screws can be used to similar advantage.

A P-K Assembly Engineer will call at your request. Or, mail assembly details for recommendations. It's a sensible first step toward making the savings you've been missing. Parker-Kalon Corp., 200 Varick St., New York 14.

Sold Only Through Accredited Distributors



P-K



PARKER-KALON SELF-TAPPING SCREWS

A FASTENING FOR EVERY METAL AND PLASTIC ASSEMBLY

an open and shut case of finer craftsmanship

When you bring us your sheet metal fabrication problems, you hire 20 years of *specialized* experience in serving the highly individual needs of manufacturers of electrical, radio, electronic and mechanical apparatus. Our long history in this exacting specialty is one of intimate knowledge, and assures post-war permanence.

At your service are our 65,000 square feet of floor space . . . hundreds of skilled craftsmen . . . large stores of stock dies to save you money. Try us for chassis, panels, cabinets, racks, housings.

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Custom Craftsmen in Sheet Metal

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For Quality Electronic Products

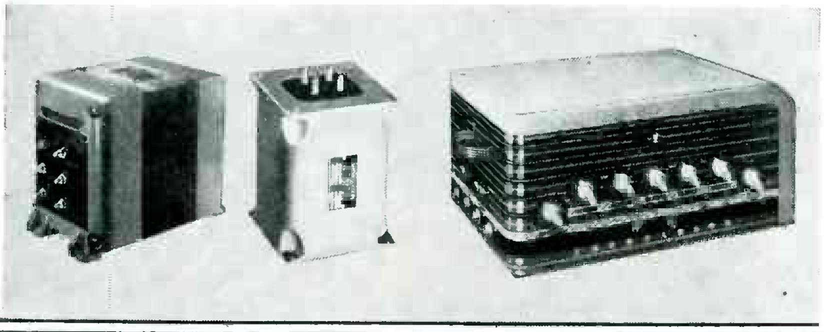
THORDARSON

TRANSFORMERS

● For all requirements . . . communications, sound amplifier, industrial, experimental and amateur.

TRU-FIDELITY AMPLIFIERS

● Advanced tone compensation, conservative ratings, multiple input channels, low hum level, etc.



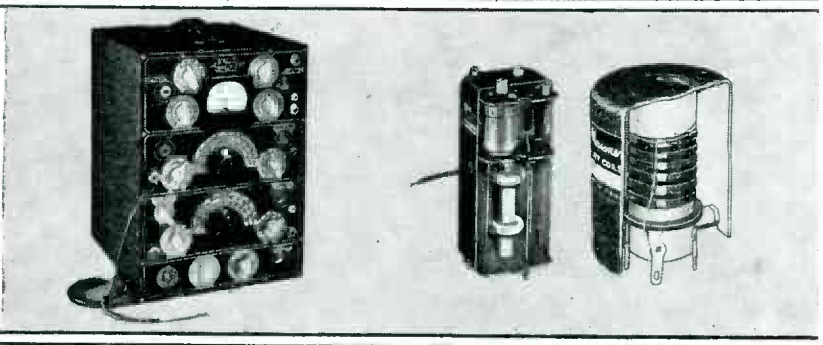
MEISSNER

COMPONENTS

● Standard, plastic and Ferrocart transformers; antenna, R. F. and oscillator coils; accessories.

SERVICE INSTRUMENTS

● Meissner Analyst...a complete servicing instrument; Signal Calibrator... self-contained and portable.



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● Exact duplicate vibrators, individually engineered, ... long life, low noise level, minimum interference.

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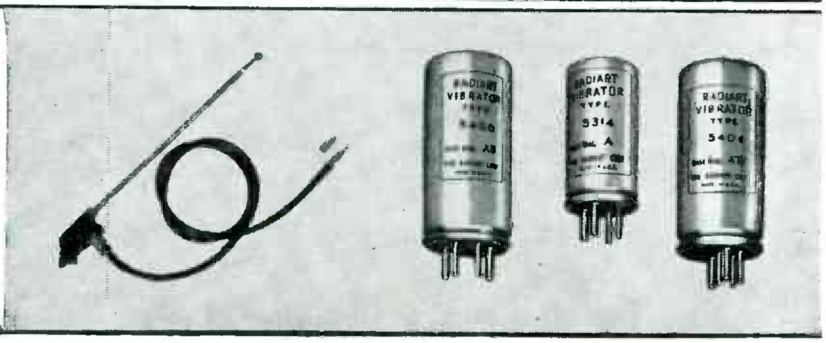
● A complete line, newly designed to fit all cars... cowl, hood and under hood types. Many exclusive features.



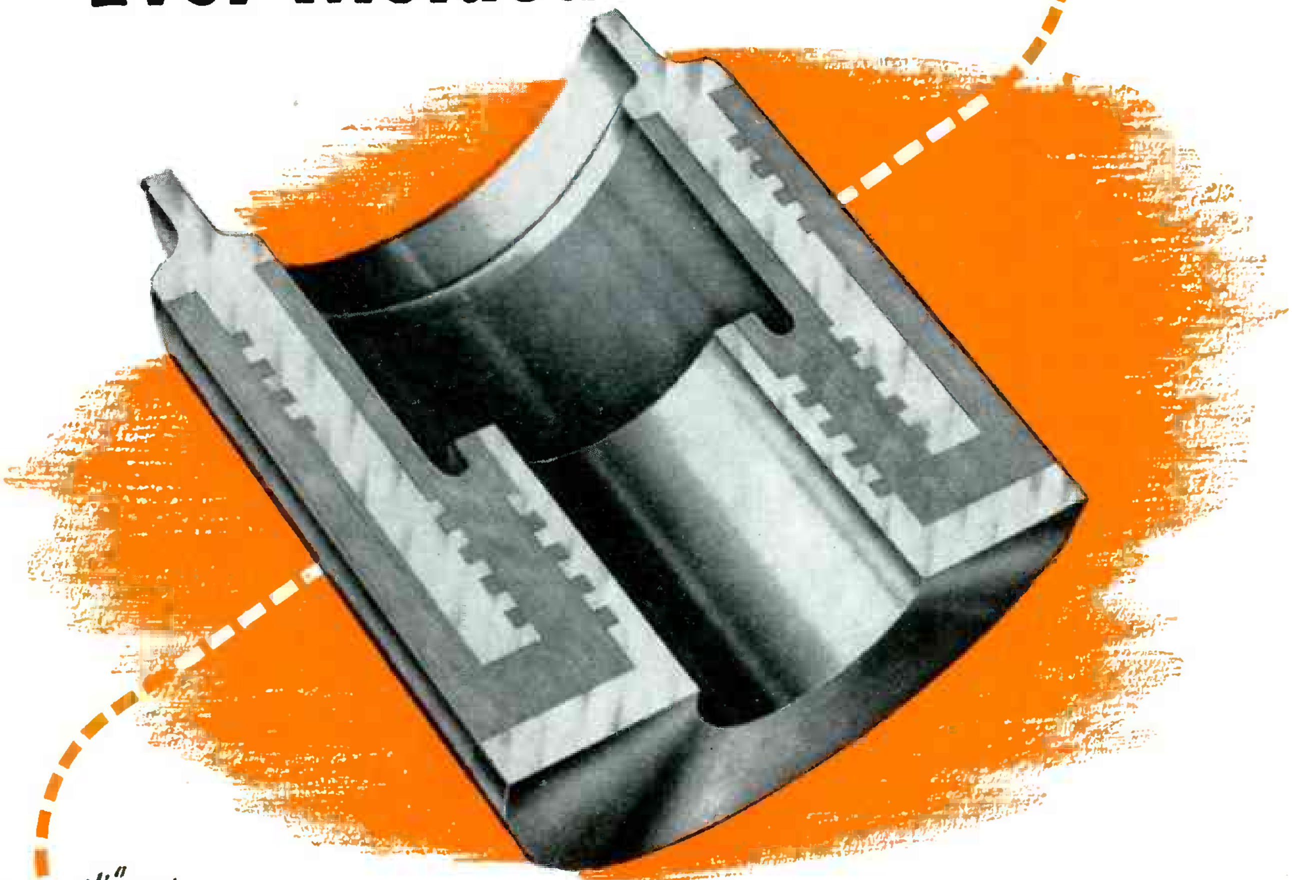
ELECTRONIC DISTRIBUTOR AND INDUSTRIAL SALES DEPARTMENT OF

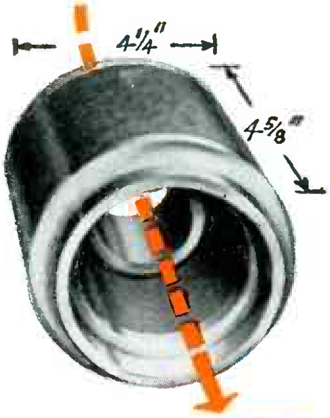
MAGUIRE INDUSTRIES, INCORPORATED

936 NORTH MICHIGAN AVENUE, CHICAGO 11, ILLINOIS

CABLE ADDRESS "MAGINDUS"

Largest MYCALEX Part Ever Molded





This cross section of a MYCALEX-to-metal molded component part was made for one of the country's leading manufacturers, and is the result of close cooperation between the customer's and our own engineering staffs. It exemplifies a new development in the molding of MYCALEX 410 with metal to form a hermetic seal.

The objective was to take advantage of the low loss factor and other desirable properties of MYCALEX 410 to produce a rugged bushing assembly in a single molding operation.

A difficulty was presented by the extremely long and branched path which the MYCALEX 410 had to follow. Total charge of MYCALEX 410 was 7 pounds, while the metal weighed 6 pounds to make a total weight of 13 pounds.

The MYCALEX and metal were sealed into one closely-bonded integral part, held to extremely close dimensional tolerances.

For more than 27 years MYCALEX has met and surpassed the most exacting needs engineers have been able to devise from year to year. MYCALEX 410, together with our highly perfected methods of molding it, is the greatest advancement in this high frequency low loss insulation to date.

Our technical staff is at your service. What is your problem in low loss insulation?

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

MYCALEX CORPORATION OF AMERICA

"Owners of 'MYCALEX' Patents"

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ANSWERING THE DEMAND FOR **"Something Better"**

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MODEL "L"

A *better* portable playback—compact, easy to carry, simple to set up. The remarkably clear, wide range of reproduction—far superior to what is ordinarily expected of a portable playback—makes it a favorite with broadcasting stations and advertising agencies who demand top performance in demonstrating recorded programs to prospective clients.

Model L plays 6 to 16″ records, 78 or 33⅓ R.P.M., on a 12″ rim-driven turntable. Standard equipment includes high quality 16″ pickup on a swivel mounting which folds into a case when not in use, four stage amplifier, 8″ loudspeaker with 20′ extension cable, and a Presto Transcriptone semi-permanent playing needle. For use on 110 volts AC only.

The complete equipment, in an attractive grey carrying case, weighs only 46 lbs.

PRESTO

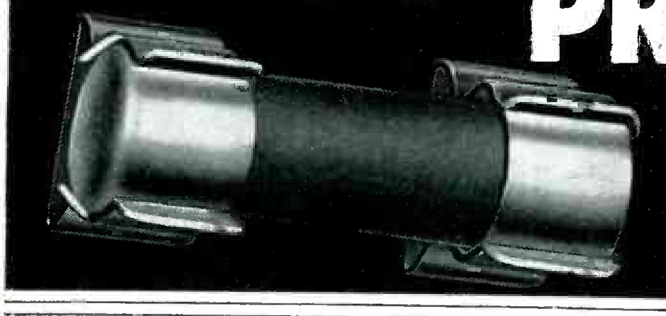
RECORDING CORPORATION

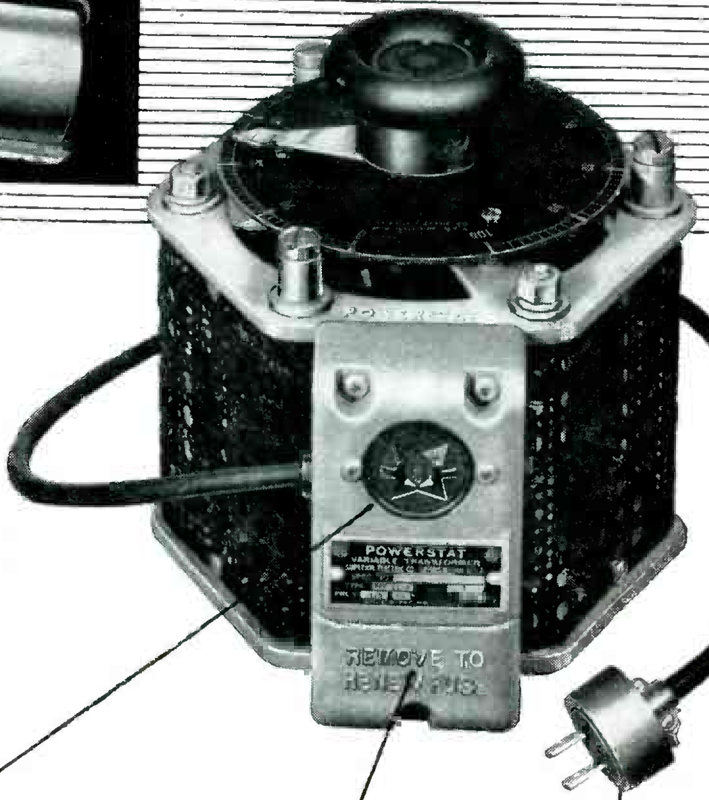
242 West 55th Street, New York 19, N. Y.

WALTER P. DOWNS, LTD., in Canada

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT

FUSE PROTECTION





As a built-in component of the newly designed 2 KVA POWERSTAT variable transformers*, the fuse in the output brush contact lead offers economies in set-up time and replacement costs. Needless to say — replacing fuses is decidedly less expensive than replacing POWERSTATS. But . . instrument protection is not the only new feature of the fused POWERSTATS. User protection is also incorporated. A totally enclosed aluminum terminal box houses all "hot" connections. With the input cord-plug and output receptacle combination, anyone can operate a POWERSTAT without danger of personal injury.

OUTPUT RECEPTACLE

To suit each requirement, the output receptacle is available in a variety of types. It can be supplied to accommodate a two or three wire — straight blade or twist-lock type plug. Connection of the load is a simple matter. There is no bother of clip-leads or direct wiring.

FUSE PROTECTION

Although the fuse has been so selected that the maximum rated current can be drawn at any dial position, it opens the circuit immediately when this value is exceeded. Burned-out coils and ruined brush contacts from overloading are a virtual impossibility. Situated in the recessed bottom portion of the durable cast-aluminum terminal box, the cartridge type fuse can be removed with very little effort. It is protected by a cast-aluminum section which is held in place by screw-connection.

INPUT CORD AND PLUG

Logically, the input cord and plug is a duplication of the output receptacle 2 or 3 wire — straight blade or twist-lock arrangement. In the 3 wire system the 3rd wire is solidly grounded to the POWERSTAT frame. By plugging the cord into a convenient outlet, the POWERSTAT is ready for use.

* Write factory for further details on either terminal stud or fused type POWERSTATS.

Send for Bulletins LE

THE SUPERIOR ELECTRIC COMPANY

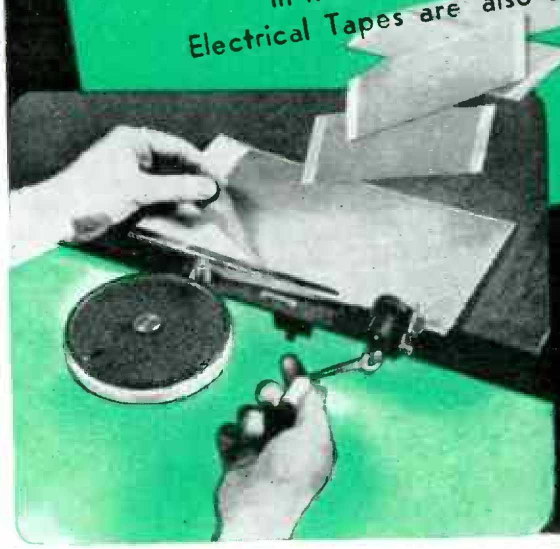
707 LAUREL STREET, • • • BRISTOL, CONNECTICUT

Put a Tear-Proof Edge On Your Slot Insulation

With THE "SCOTCH" EDGER *and* "SCOTCH" ELECTRICAL TAPE

"SCOTCH" Electrical Tape, applied smoothly — speedily — economically, to the edges of slot insulation with the "SCOTCH" Edger, provides a tear-proof reinforcement; permits the use of papers with a lower tear strength. Paper and varnished cambric can be laminated together and edged with "SCOTCH" Electrical Tape in one operation.

In the manufacture of electric motors and generators "SCOTCH" Electrical Tapes are also used for holding coil windings in place, for insulating at pole positions, for anchoring and insulating leads etc. They absorb varnish and take baking treatment without deteriorating.



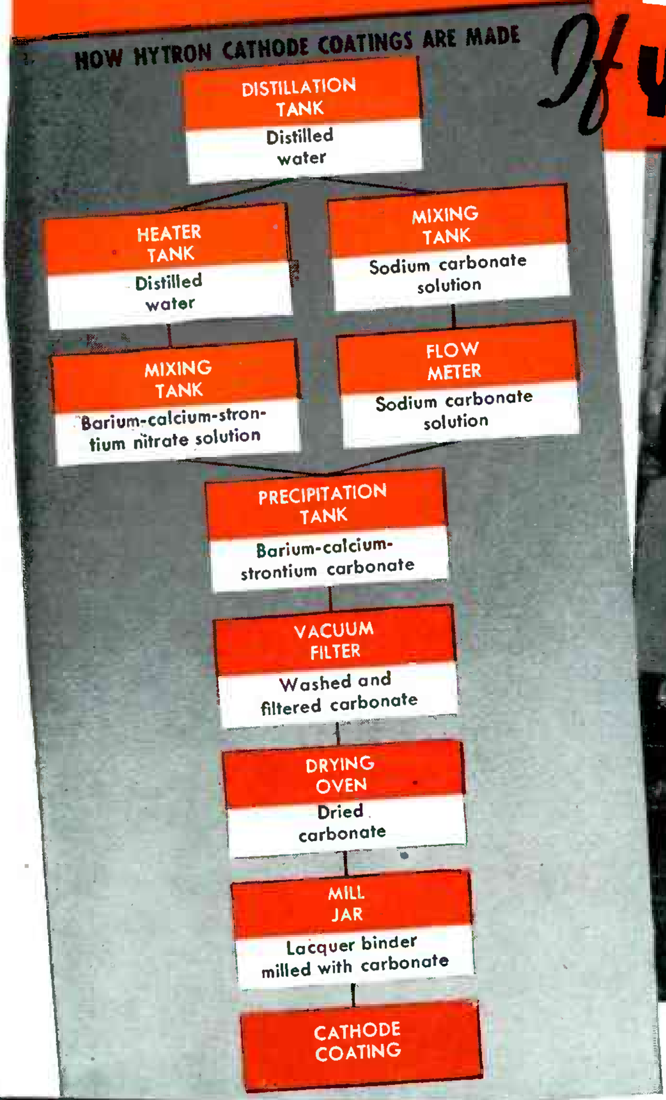
Write today, to department E5, Minnesota Mining and Manufacturing Company, for a copy of our newly revised free book on "SCOTCH" Electrical Tapes.

SCOTCH *Electrical* **TAPES**
BRAND

Made in U.S.A. by MINNESOTA MINING & MFG. CO. St. Paul 6, Minn.
THE 3M COMPANY

MAKING TUBES IS EASY...
If YOU KNOW HOW!

HOW HYTRON CATHODE COATINGS ARE MADE



First floor of Hytron chemical precipitation system. Note the flow meter, precipitation tanks, and ceramic vacuum filters. Spotless cleanliness is vital to avoid contamination of carbonates precipitated for cathode coatings.

AGAIN HYTRON KNOW-HOW WORKS FOR YOU . . .

THIS photograph and flow chart may look strange in an advertisement on radio tubes. Chemistry and metallurgy, however, are a vital part of Hytron engineering. The picture illustrates the first of three floors used by Hytron's chemical system which precipitates the carbonates for cathode coatings.

Prewar, Hytron purchased such carbonates—as did most other tube manufacturers. Wartime mass production demanded much better quality control than suppliers offered. By doing the job itself, Hytron gained extra know-how which serves you in peacetime.

For these carbonates, absolute control is required of formulation, crystal size and shape, density, purity, and viscosity. Most cathode coatings are prepared from carbonates compounded of barium, calcium, and strontium. The percentage of each of these elements affects the performance of different types of tubes. Crystal size and shape, density, freedom from impurities, all determine the degree of electronic emission. Variations in viscosity must be minimized to assure uniform application of coating on the cathode.

There is still much "black magic" in obtaining proper cathode emission. But Hytron makes easier the problems involved by accurate chemical and metallurgical controls. No research is too tough or too unrelated, if it leads to know-how which will give better performance of the Hytron tubes you buy.

OLDEST MANUFACTURER SPECIALIZING IN RADIO RECEIVING TUBES

HYTRON

RADIO AND ELECTRONICS CORP.

MAIN OFFICE: SALEM, MASSACHUSETTS

For Better Remote Broadcasts . . .

Construction is compact and clean

. . . Complete in One Package!

The light weight, small size, a-c or battery operated Collins 12Z remote amplifier is a modern contribution to the furtherance of high quality remote broadcasts. Its frequency response of 30-12,000 cps ± 1.0 db and noise level of more than 55 db below program level are in keeping with high fidelity AM and FM standards.

The 12Z features excellent performance, program protection, and convenience. Stabilized feedback maintains program quality over a wide variation of operating conditions. The self-contained batteries are connected automatically should the a-c power source fail. If the program line should fail, a twist of a knob connects a second line. The four microphone input channels have individual attenuator controls, in addition to the master control. The large, illuminated VU meter reads output level or operating voltages.

Complete in one package, the equipment weighs only 40 pounds and can be carried readily by one person. Transportation and set-up problems are reduced to a minimum. Maintenance is greatly simplified through advanced chassis design. Write us for full information.

Collins Radio Company, Cedar Rapids, Iowa

11 W. 42nd St., New York 18, N. Y. • 458 S. Spring St., Los Angeles 13, Cal.

Specifications:

Mixing channels: four
Gain: approximately 90 db
Frequency response: 30-12,000 cps ± 1.0 db
Noise level: more than 55 db below program level
Distortion: less than 1% from 50-7500 cps
Input impedance: 30/50 ohms. 200/250 ohms on special order
Output impedance: 600 ohms (150 ohms available)
Power output: 50 milliwatts (+17 dbm)
Power source: 115 volts a-c, or self-contained batteries
Batteries: standard types, easily obtained
Weight: 40 lbs. complete
Size: 14½" w, 11½" h, 8¼" d

FOR BROADCAST QUALITY, IT'S . . . COLLINS

You're the fellow in the gold fish bowl . . .

IF YOU'RE THE MAN who specifies components, you're in the public eye. Even the tiniest part you buy has "big things" to say in the quality of your product. You can't boast about cutting costs . . . if it means cutting quality. And still you've got to get the "most" for the "least."

That's why, when it comes to capacitors, you do better at Cornell-Dubilier. Others can offer capacitors that look like C-D's. But no one else can offer the wealth of experience, the engineering flexibility, the tremendous production facilities that C-D can. These are things that can't be imitated or copied. These are things that don't show up on cost sheets at all, but add up big in product dependability. They are available to any manufacturer who brings his capacitor problems to Cornell-Dubilier.

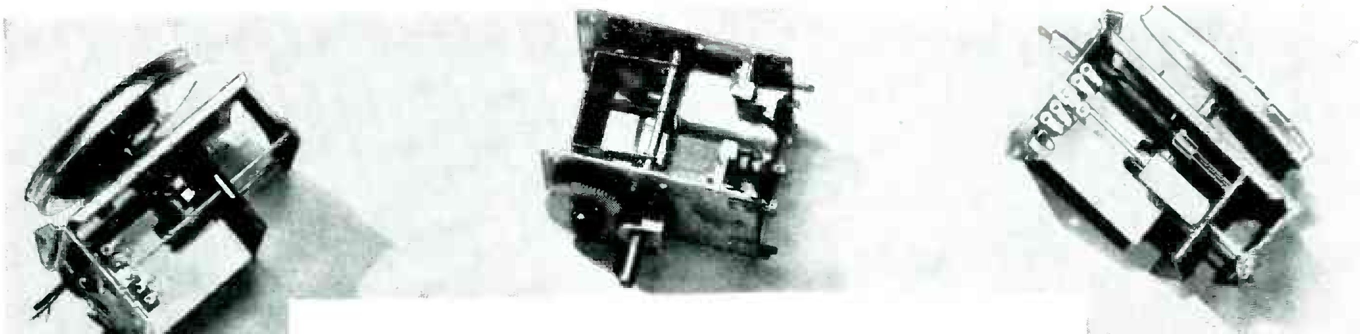
Your inquiries are invited. Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey. Other plants in New Bedford, Providence, Worcester and Brookline.

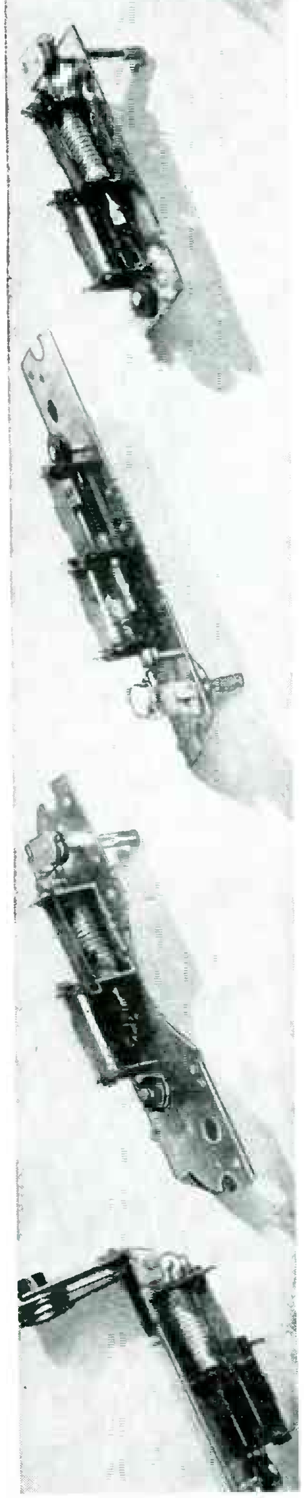
CORNELL-DUBILIER

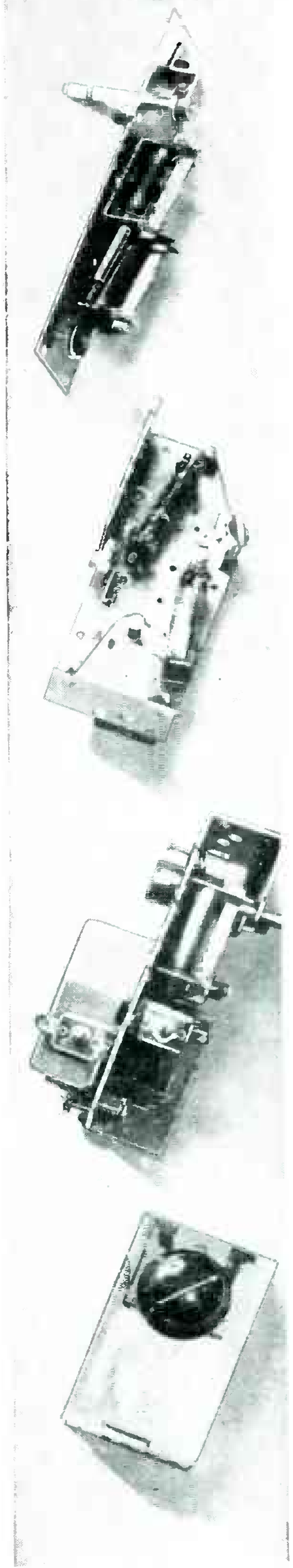
world's largest manufacturer of

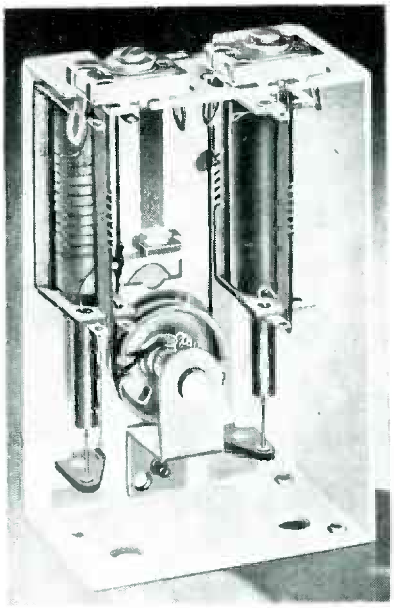
CAPACITORS

MICA • DYKANOL • PAPER • ELECTROLYTICS









DuMont proudly presents the

NEW Type 274

CATHODE-RAY OSCILLOGRAPH

SPECIFICATIONS

INPUT IMPEDANCE: Vertical-direct 5 meg. 60 µµf; amp. 1 meg. 70 µµf: Horizontal-direct 5 meg. 80 µµf, amp. 5 meg 30 µµf.

FREQUENCY RANGE: Sine wave response (at full gain) uniform within ±20% from 20 to 50,000 c.p.s., down less than 50% 100,000 c.p.s.

DEFLECTION SENSITIVITY: Amplifiers at full gain 0.65 r.m.s. volt/in., direct ±18 r.m.s. volts/in.

LINEAR TIME BASE: Variable from 8 to 30,000 c.p.s. Synchronization from vertical amplifier or external signal.

POWER SUPPLY: 115 volts, 50 to 60 cycles a.c. Power consumption app. 50 watts.

TUBES: All tubes, including 5BP1-A CRT, included.

PHYSICAL: Green wrinkle-finish steel cabinet with plastic carrying handle. Modern design green front panel, white characters, black knobs. Height 14"; width 8⅝"; depth 19⅜". Weight 35 lbs.

★ 5-inch cathode-ray tube.

★ linear time-base, 8 to 30,000 c.p.s.

★ identical vertical and horizontal amplifiers—20 to 50,000 c.p.s.

★ provision for intensity modulation.

★ modern design cabinet and panel.

Everything you want in a general-purpose oscillograph

It's here—Du Mont's new Type 274 Oscillograph—our post-war answer to a long-standing need for a good instrument for routine laboratory and production testing, and for radio servicing—at a low price of only $99.50

Send for descriptive literature!

DUMONT *Precision Electronics & Television*

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

SOUND EQUIPMENT—*precisionized*—**mechanically and electronically**—*for finer performance*

Solidly Built

Unit 524
Transcription
Turntable

To keep the original sound alive!

Today, the human ear should not be able to distinguish a recorded program from an original 'live' studio performance.

Why? Because all tell-tale rumble, noise and 'WOWS' have been eliminated from transcription turntable performance.

How? By the advanced design and solid construction of the *new* Unit 524 Fairchild Transcription Turntable.

We've removed its attractive access panel so that you can study it carefully. Let's start with its construction: The synchronous motor and drive are spring-mounted and precision-aligned in a single heavy casting at the bottom of the cabinet to reduce rumble. The hollow vertical drive shaft is equipped with mechanical filters and a special rubber coupling to reduce the transmission of vibration. And the turntable, with its sturdy shaft, is mounted in a heavily-webbed aluminum panel at the top of the cabinet to further reduce vertical vibration.

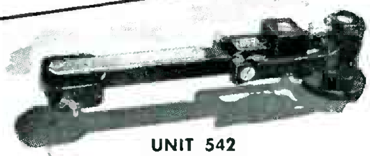
What about 'WOW'? That's reduced to a minimum at either 33.3 or 78 rpm by the famed Fairchild direct-from-the-center, two-speed drive. Evenness of speed is assured by a carefully calculated loading of the drive mechanism that keeps the motor pulling constantly, by precision control of all alignments that might cause intermittent grab and release.

The Unit 524 Fairchild Transcription Turntable is of broadcast height. It is available with or without the Unit 542 Fairchild Lateral Dynamic Pickup, illustrated below. Arrange to hear it. Listen to it critically. Then let it keep your original sound alive! Address: 88-06 Van Wyck Boulevard, Jamaica 1, New York.

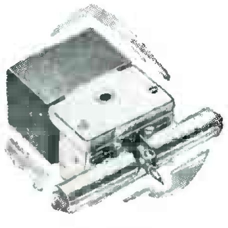
SOUND EQUIPMENT

FCI Fairchild CAMERA AND INSTRUMENT CORPORATION

FOR IMPROVED PERFORMANCE



UNIT 542
LATERAL DYNAMIC PICKUP



UNIT 541
MAGNETIC CUTTERHEAD

Earlier FAIRCHILD portable models and many other types of recorder-playbacks will give vastly improved performance if equipped with an adapter and an improved Fairchild Pickup and Cutterhead.

Write for complete information.

TWO GREAT NEW LABORATORY INSTRUMENTS

BROWNING MODEL RH-10 STANDARD FREQUENCY CALIBRATOR

Full, accurate use of station WWV, the world's finest primary frequency and time standard, is obtained from the Browning Model RH-10 Standard Frequency Calibrator. The standard Browning RH-10 is pre-tuned for 5 and 10 megacycles per second reception, at sensitivities better than ½ microvolt on either band. A dual filter system provides selection of either the 440 or 4000 cycle modulation of WWV for use as a primary frequency standard.

Checking equipment against station WWV, at accuracies up to one part in five million, the Browning Frequency Calibrator enables comparisons to be made in three general categories:

1. Precision radio frequency standards measurements.
2. Precision audio frequency standards measurements.
3. Precision time and pulse standards for physical measurements.

The Browning RH-10 consists of a high Q antenna transformer, a sharply tuned R-F amplifier, converter, oscillator, two IF stages, detector, selective amplifier output stages and a cathode ray zero beat indicator. Although normally supplied for 5 and 10 megacycles per second operation, any two combinations of 2.5, 5, 10, or 15 megacycles may be had on special order.

WRITE FOR DESCRIPTIVE LITERATURE

BROWNING MODEL OL-15 OSCILLOSCOPE

Designed for observing phenomena requiring extended range amplifiers and a wide variety of time bases, the Browning Model OL-15 Oscilloscope incorporates improvements that make it useful in numerous applications where ordinary oscilloscopes are inadequate.

For instance, the Browning OL-15 is particularly adaptable to television, radar and facsimile work, as well as with radio-frequency equipment where it is desirable to know actual r.f. waveform composition. The low repetition sweep gives visual observation when recurring phenomena of a few sweeps per second are encountered.

Suitable time base facilities for studying signals with a constant time difference, or those with an inconstant time separation between consecutive phenomena, are provided by the Browning OL-15. In general, the improved design and superior construction of the Browning OL-15 make it a highly flexible instrument for use in all laboratory work, production testing, or research applications.

WRITE FOR DESCRIPTIVE LITERATURE

BROWNING S-4 FREQUENCY METER

Especially designed for testing transmitters of marine, police, fire and other special service radio operators, the completely new Browning S-4 Frequency Meter includes many refinements perfected during our war experience building high-precision radar test equipment.

A vernier, added to the laboratory-type dial, permits reading accuracy to one part in one thousand. The telescoping whip antenna forms a convenient carrying handle, while big, easy-to-grasp knobs allow cold weather adjustment while wearing gloves.

Using 110-115 volt A.C. or D.C. current, the crystal-controlled Browning Frequency Meter checks both AM and FM equipment. The S-4 is custom built and hand calibrated for checking frequencies in any five bands from 1.5 to 100 Mc., with an accuracy of ± .0025% which exceeds the FCC requirements.

WRITE FOR DESCRIPTIVE LITERATURE

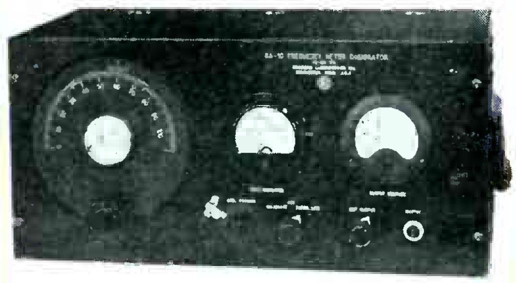
BROWNING MODEL GA-10 FREQUENCY METER CALIBRATOR and BROWNING MODEL PF-10 POWER SUPPLY

Precise checking of switchboard-type, direct-reading and 60 cycle frequency meters, and the measuring of line voltage frequency from 56 to 64 cycles, is readily accomplished with the Browning GA-10 Frequency Meter Calibrator. It is also especially useful in setting filters requiring accurate adjustment.

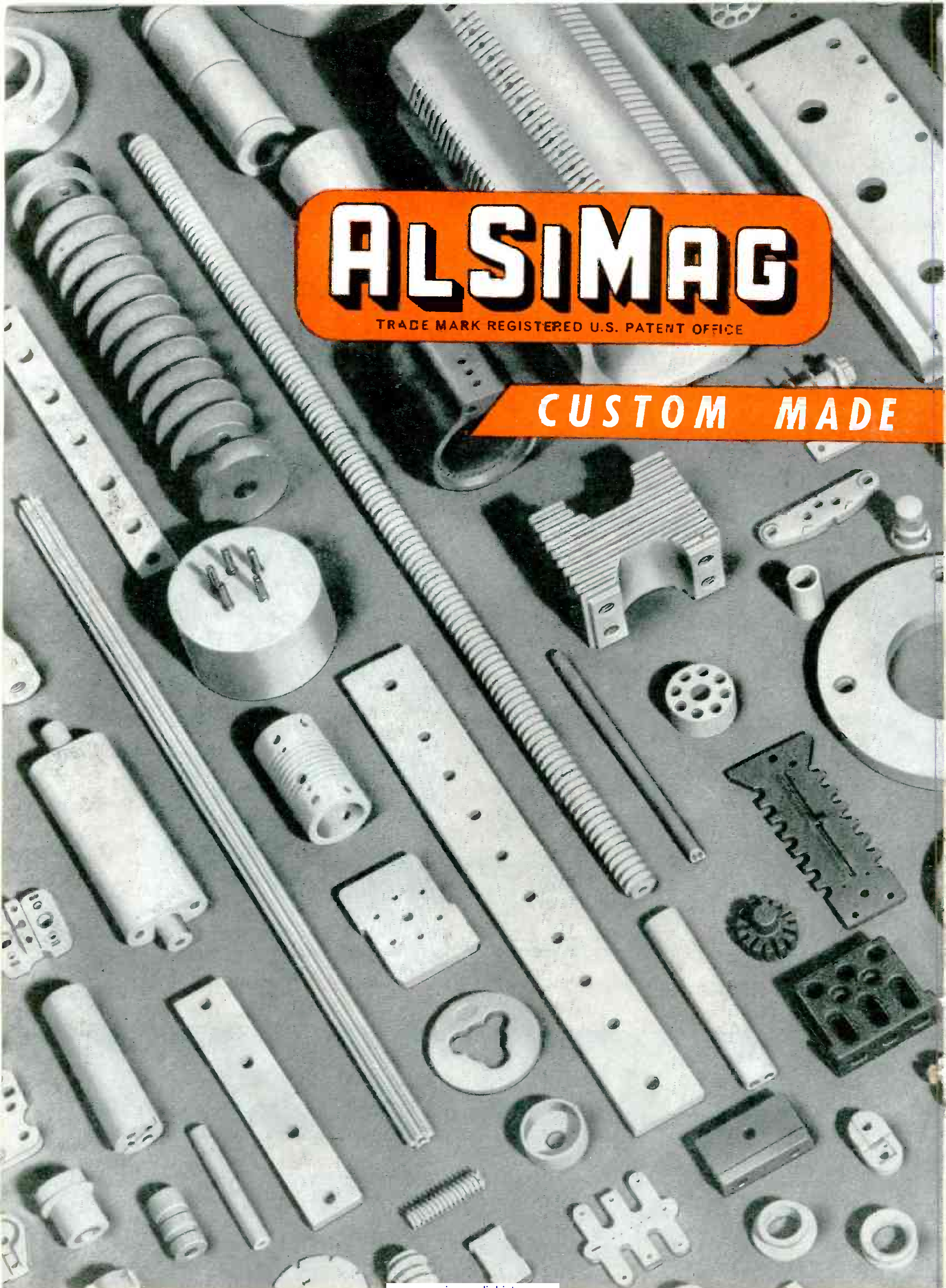
Featuring complete electronic voltage regulation, and built-in crystal standard for checking various points of the calibration, the Browning GA-10 has an accuracy of ± .05% over its entire range. The Calibrator and Power Supply are packaged in separate steel carrying cases for ease of portability.

For adjusting or checking equipment with different frequencies, such as sharply peaked filters, the Browning GA-10 is available on special order to cover a narrow range of any audio frequencies.

WRITE FOR DESCRIPTIVE LITERATURE



BROWNING LABORATORIES, INC. WINCHESTER, MASS.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TRADE MARK REGISTERED U.S. PATENT OFFICE
CUSTOM MADE

TECHNICAL CERAMICS
• PRECISION MADE TO YOUR BLUE PRINT FROM THE ALSIMAG COMPOSITION HAVING EXACTLY THE PHYSICAL CHARACTERISTICS REQUIRED FOR YOUR APPLICATION
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LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

Sensational New

VACUUM TUBE VOLTMETER

20 cps to 700 Mc

1.3 mmfd input capacity

...the instrument you have been waiting for!

-hp- Model 410A

Far surpassing any comparable instrument, this new *-hp-* Model 410A High Frequency Vacuum Tube Voltmeter measures voltage over a wider frequency range, and at a higher input impedance than any previously available instrument.

The extremely high input impedance for ac measurements makes possible the testing of video and VHF amplifier circuits without disturbing the circuit under test. The 410A for the first time provides an instrument which will give accurate voltage measurement from audio frequency up through the micro wave regions.

The *-hp-* Model 410A is the instrument the whole electronic industry has been looking for. Your early inquiry will be best assurance of prompt delivery. Write today for more complete information — prices — delivery dates.

SPECIFICATIONS

ac Measurements

Six ranges, full scale readings 1, 3, 10, 30, 100, and 300 volts.

Input impedance, 6 megohms in parallel with 1.3 uuf.

Frequency response, 20 cps to 700 mc $\pm$ 1 db.

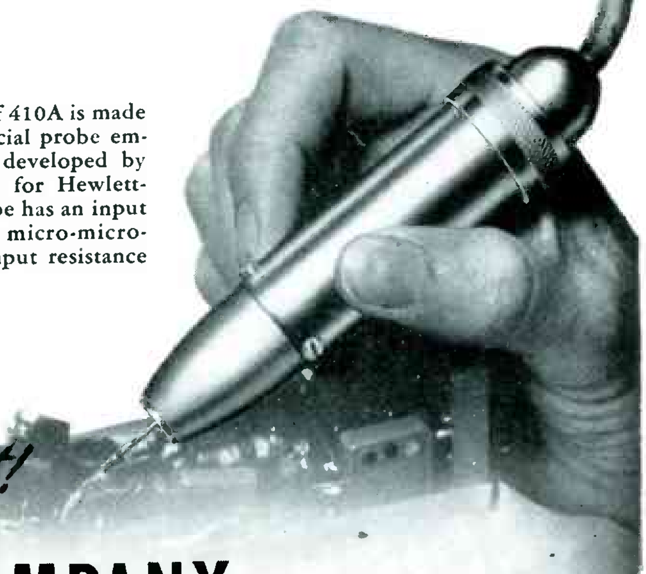
dc Measurements

Seven ranges, full scale readings 1, 3, 10, 30, 100, 300, and 1000 volts.

Input impedance, 100 megohms, all ranges.

Resistance Measurements

Seven ranges, mid scale readings 10, 100, 1000, 10,000, 100,000 ohms, 1 megohm and 10 megohms. Accuracy: $\pm$ 3%

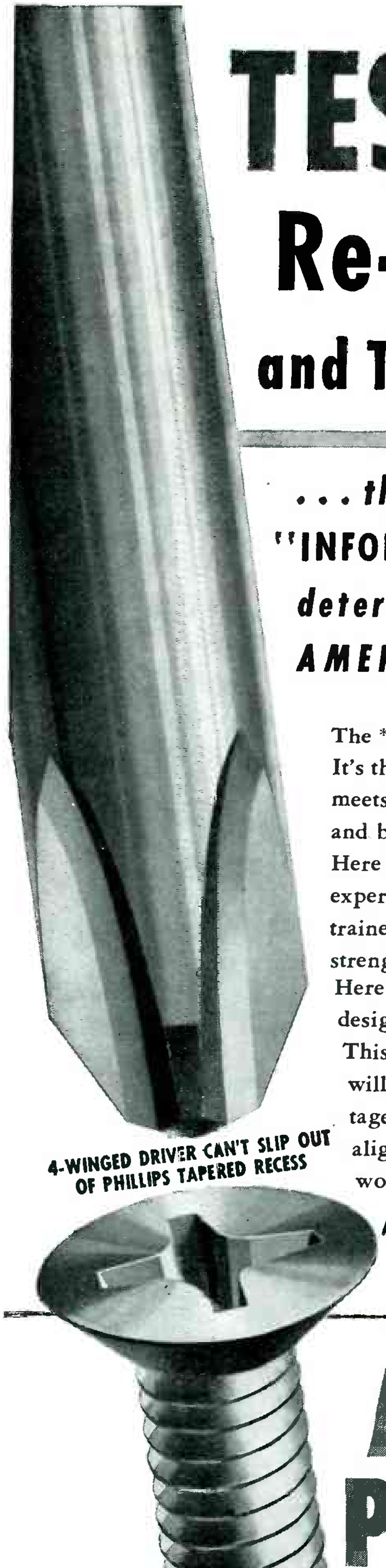


The wide range of 410A is made possible by a special probe employing a diode developed by Eimac specifically for Hewlett-Packard. The probe has an input capacity of 1.3 micro-micro-farads, and the input resistance is 6 megohms.

..another hp achievement!

HEWLETT-PACKARD COMPANY

BOX 1159A STATION A, PALO ALTO, CALIFORNIA, U.S.A.



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Re-Testing...

and Testing again

Technician testing tensile strength of American Phillips Screws.

...that's how the "INFORMATION CENTER" determines the *right AMERICAN PHILLIPS SCREW for your job

The *right American Phillips Screw for your job is more than just a *type* of screw. It's the *predetermined combination* of type, size, metal, head, and finish which best meets tests approximating the requirements dictated by your assembly methods, and by the service conditions your product has to meet.

Here in American's Engineering Research Laboratory is all the equipment and experience to pre-design any screws you need for any job. Here engineers and trained technicians work with the most modern machines for testing physical strengths, and resistance to heat, corrosion, electrolysis, wear and vibration. Here are optical comparators, measuring machines, and also special equipment designed and developed right in the laboratory.

This is the "Information Center" on any fastening problem. And from it you will get engineered, metallurgical advantages *over and above* the basic advantages of American Phillips Screws . . . ease and speed of handling . . . self-aligned power driving . . . protection against burred heads and slashed work-surfaces. So write today, free of obligation, to:

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

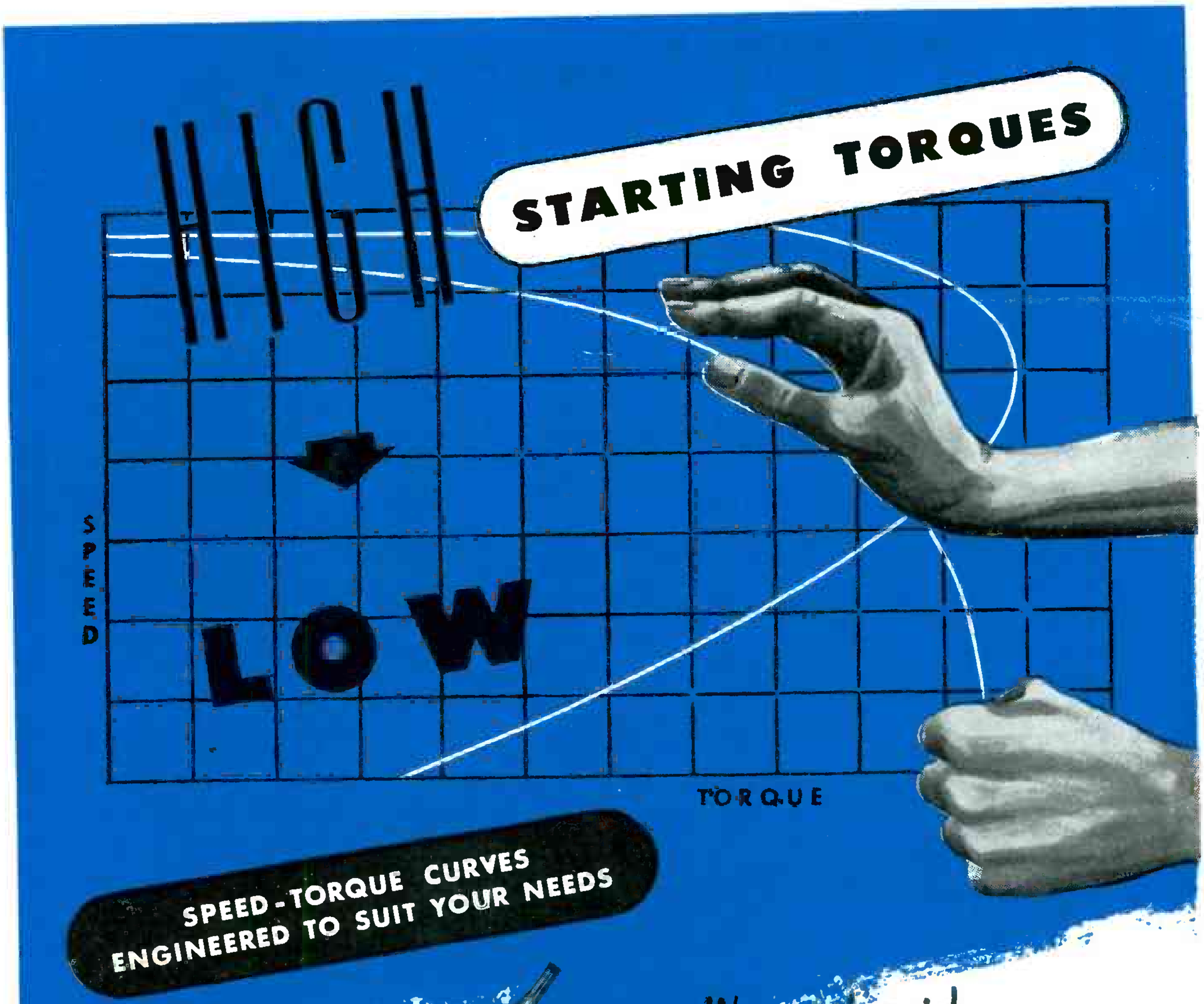
Chicago 11: **589 E. Illinois St.** *Detroit 2:* **502 Stephenson Bldg.**

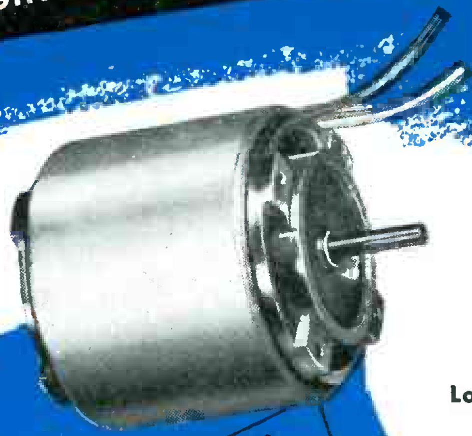
AMERICAN PHILLIPS *Screws*

SOLD THROUGH INDUSTRIAL SUPPLY DISTRIBUTORS

ALL TYPES

ALL METALS: Steel, Brass, Commercial Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)





We can furnish...

All the advantages of high starting torque without unduly high starting currents — and no brushes or commutators. Amazing breakaway power for short duty cycles.

OR

Lower starting torques and consequent high-efficiency full load performance for continuous duty operation.

Submit your equipment requirements to us.

Maximum Starting Torque Intermittent Duty

FRAME	NO. OF POLES	STARTING TORQUE
73	2	0.75 lb. in.
	4	1.50 lb. in.
731	2	1.25 lb. in.
	4	2.50 lb. in.
732	2	1.50 lb. in.
	4	3.25 lb. in.

EAD

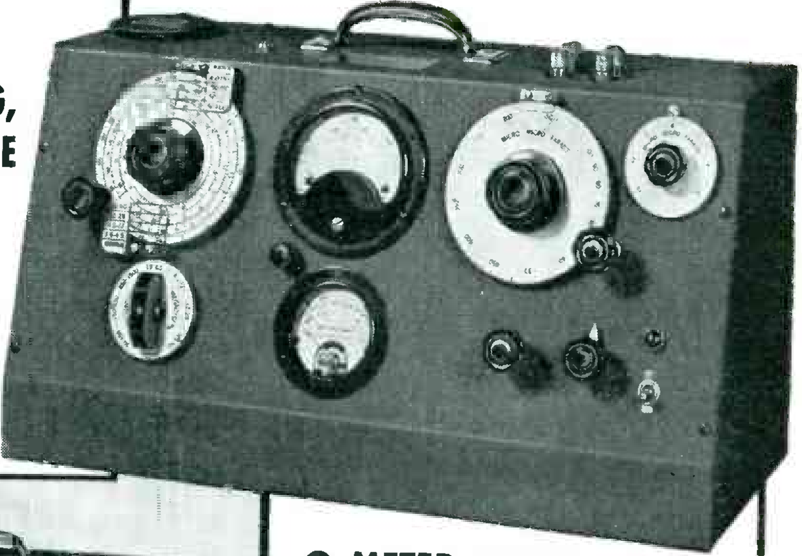
EASTERN AIR DEVICES, INC.

585 DEAN STREET • BROOKLYN 17, N. Y.

An Affiliate of THE FRED GOAT CO., INC., *Est. 1893*

PRECISION MEASURING INSTRUMENTS FOR DEVELOPMENT, ENGINEERING, AND PRODUCTION LINE USE

Since 1934 Boonton Radio Corporation has been designing and manufacturing essential measuring instruments for the engineer. Constructed of finest quality parts, assembled, and tested to exacting standards by skilled craftsmen, these instruments have become indispensable to manufacturers, research laboratories, educational institutions, and to the whole radio and electronics industry.



Q-METER *TYPE 160-A*

FREQUENCY RANGE: 50 kc to 75 mc (±1%, 50 kc—50 mc; ±3%, 50 mc—75 mc). May be extended down to 1 kc with external accessory oscillator.
RANGE OF Q MEASUREMENTS, COILS: 50—625.
ACCURACY OF Q MEASUREMENT: In general, ±5%.
RANGE OF Q TUNING CAPACITOR: Main Section, 30—450 mmf. (±1% or ±1 mmf., whichever is greater). Vernier Section, plus 3, zero, minus 3 mmf. (±0.1 mmf).

Q-METER *TYPE 170-A*

FREQUENCY RANGE: 30 mc to 200 mc (±1%).
RANGE OF Q MEASUREMENT: 80—1200.
ACCURACY OF Q MEASUREMENT: In general, ±10%.
RANGE OF Q TUNING CAPACITOR: 11—60 mmf. (±1% or ±0.5 mmf., whichever is greater).

Write for catalog C-1 and supplement

QX-CHECKER *TYPE 110-A*

FREQUENCY RANGE: 100 kc to 25 mc using accessory plug-in inductors. A calibration sheet is supplied with each inductor, accurate to within ±3%.
RANGE OF COIL CHECKS: Inductors having values between 10 microhenries and 10 millihenries may be checked against a standard to an accuracy of about ±0.2% provided the Q of the inductor is 100 or greater.
CAPACITANCE RANGE: Capacitance values between about 2—1000 mmf. may be checked against standard by direct substitution, with an accuracy of a few tenths of one mmf., provided Q of capacitors is high.

BEAT FREQUENCY GENERATOR *TYPE 140-A*

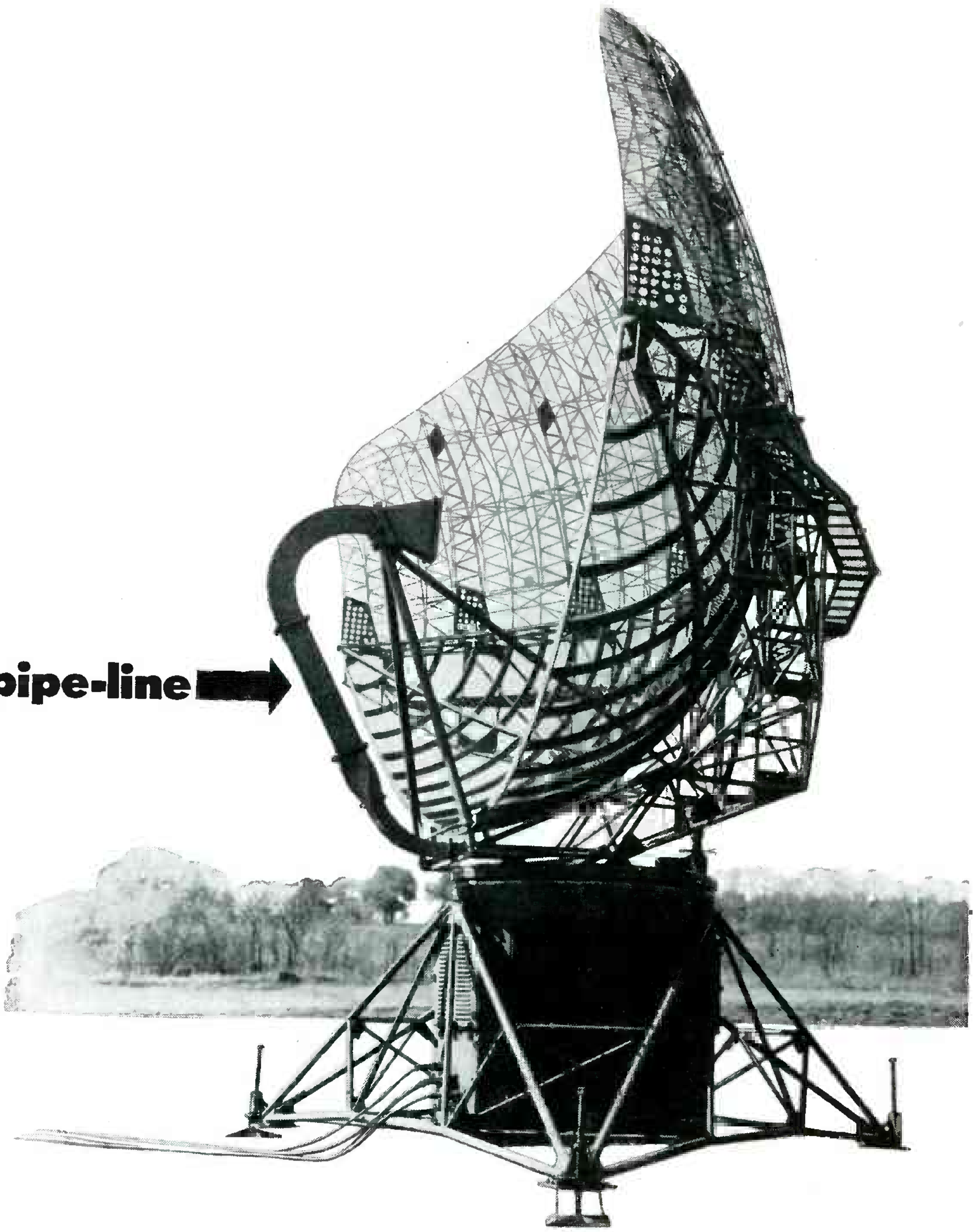
FREQUENCY RANGE: 20 cycles to 5 megacycles in two ranges: LOW RANGE: 20 to 30,000 cycles. HIGH RANGE: 30 kilocycles to 5 megacycles. Accuracy ±2 cycles up to 100 cycles, ±2% above 100 cycles.
OUTPUT POWER: One watt, available from a variety of output impedances.
ATTENUATOR: 5 steps; X1.0, X0.1, X.01, X.001, X.0001.
DISTORTION: 5% or less.

DESIGNERS AND MANUFACTURERS OF
THE "Q" METER . . . QX-CHECKER
FREQUENCY MODULATED SIGNAL GENERATOR
BEAT FREQUENCY GENERATOR
AND OTHER DIRECT READING TEST INSTRUMENTS

ARMY NAVY

BOONTON RADIO *Corporation*
BOONTON, NEW JERSEY, U.S.A.

electrical pipe-line



Microwaves make their journey from apparatus to antenna not by wire, cable, or coaxial — but by *waveguide*.

Long before the war, Bell Laboratories by theory and experiment had proved that a metal tube could serve as a pipe-line for the transmission of electric waves, even over great distances.

War came, and with it the sudden need for a conveyor of the powerful microwave pulses of radar. The metal waveguide was the answer. Simple, rugged, containing no insulation, it would operate unchanged in heat or cold. In the radar shown above, which kept track of enemy and friendly planes, a waveguide conveyed microwave pulses between reflector and the radar apparatus in the pedestal. Bell Laboratories' engineers freely shared their waveguide discoveries with war industry.

Now, by the use of special shapes and strategic angles, by putting rods across the inside and varying the diameter, waveguides can be made to separate waves of different lengths. They can slow up waves, hurry them along, reflect them, or send them into space and funnel them back. Bell Laboratories are now developing waveguides to conduct microwave energy in new radio relay systems, capable of carrying hundreds of telephone conversations simultaneously with television and music programs.

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

BELL TELEPHONE LABORATORIES

Washington, D. C., June 6, 1946. Rear Admiral Malcolm F. Schoeffel, U.S.N., Deputy Chief of Bureau of Ordnance, conferring Naval Ordnance Development Award upon Raymond M. Wilmotte, President of Wilmotte Manufacturing Company. Eighty-eight members of the organization received the Award.

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In appreciation of Distinguished Service to Naval Ordnance Development

"The congratulations of the Bureau of Ordnance are extended to every man and woman of Wilmotte Manufacturing Company for outstanding performance in connection with the research and development of Fire Control Radar Mark 29." *(Excerpt from letter of citation.)*

☆

In the rapidly developing field of electronics, the Wilmotte organization offers to industry a complete engineering service, including consultation, design, and construction.

We are prepared to engineer the application of electronic devices to manufacturing processes and inspection operations of all types.

We will design and construct integrated machines to carry out a complete manufacturing process, using electronics for increasing the speed and accuracy of production.

We are prepared to manufacture electronic equipment in accordance with your designs.

The resources of the organization include a complete laboratory; electrical and mechanical drafting department; machine shop with skilled personnel; a staff of thirty-five electronic and mechanical engineers.

We will welcome inquiries and will gladly furnish further details upon request.

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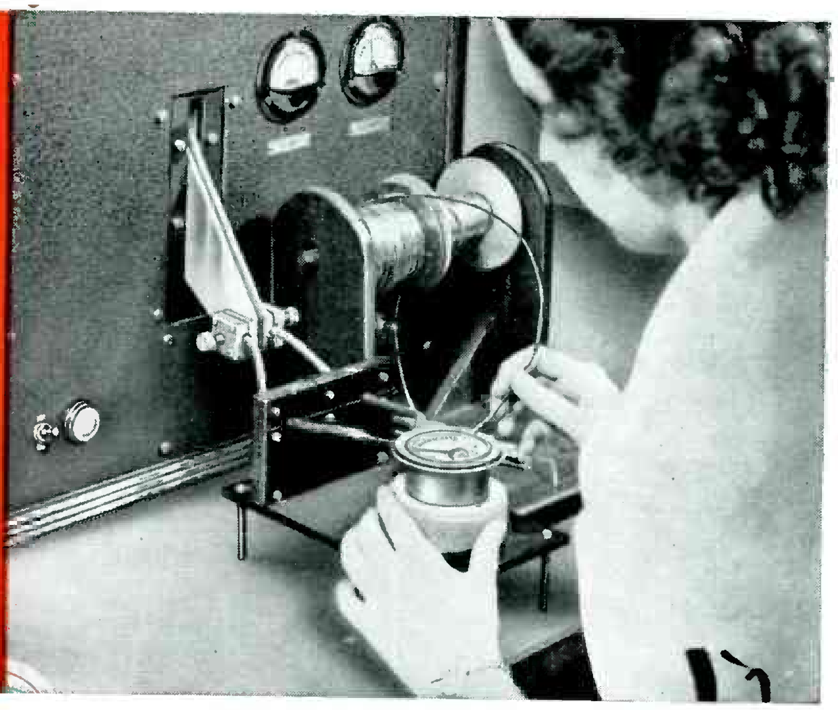
THIS GIRL IS SOLDERING GLASS TO METAL!

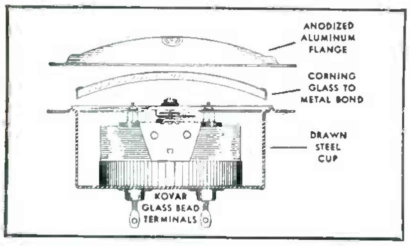


(*Photograph courtesy Marion Electrical Instrument Co.*)

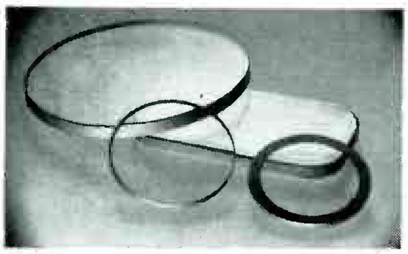
ACTUALLY she's making a better product for the same money or less. For Marion electrical products are standardizing on Corning metallized instrument windows, soldered in place to form a permanent hermetic seal. Today Marion instruments give longer-lasting, trouble-free service because neither dust nor moisture can get at them.

Corning metallizing is like no other method of joining metal to glass. It resists a pull up to 2000 P.S.I. Glass parts can be soldered into place for quicker assembly. Frequently other parts can be eliminated.

Investigate Corning metallizing. It is doing a real job in a dozen different industries. Write for Bulletin. EL-Z-10 for complete information. Or if you have a problem you think Corning metallizing might solve, one of our engineers will call at your convenience. Electronic Sales Dept. E-7, Technical Products Division, Corning Glass Works, Corning, N. Y.

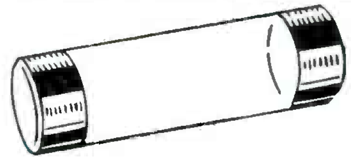


Exploded view of Marion instrument, showing how it is sealed like a vacuum tube with Corning metallized window, soldered into place.



• • •

Corning metallized windows are available in almost any shape, size or glass formula. Metallized tubes, bushings, coil forms and headers also standard.



HOW MUCH DOES IT COST?

Without knowing exactly what you want, that's hard to say. But this glass tube ½" in diameter by 1½" long with ¼" metallized bands on each end, in lots of 100,000 to 1,000,000, costs from 2c to 5c each, depending on the glass and tolerances required.

Sales Offices in Corning, New York, Chicago and San Francisco.

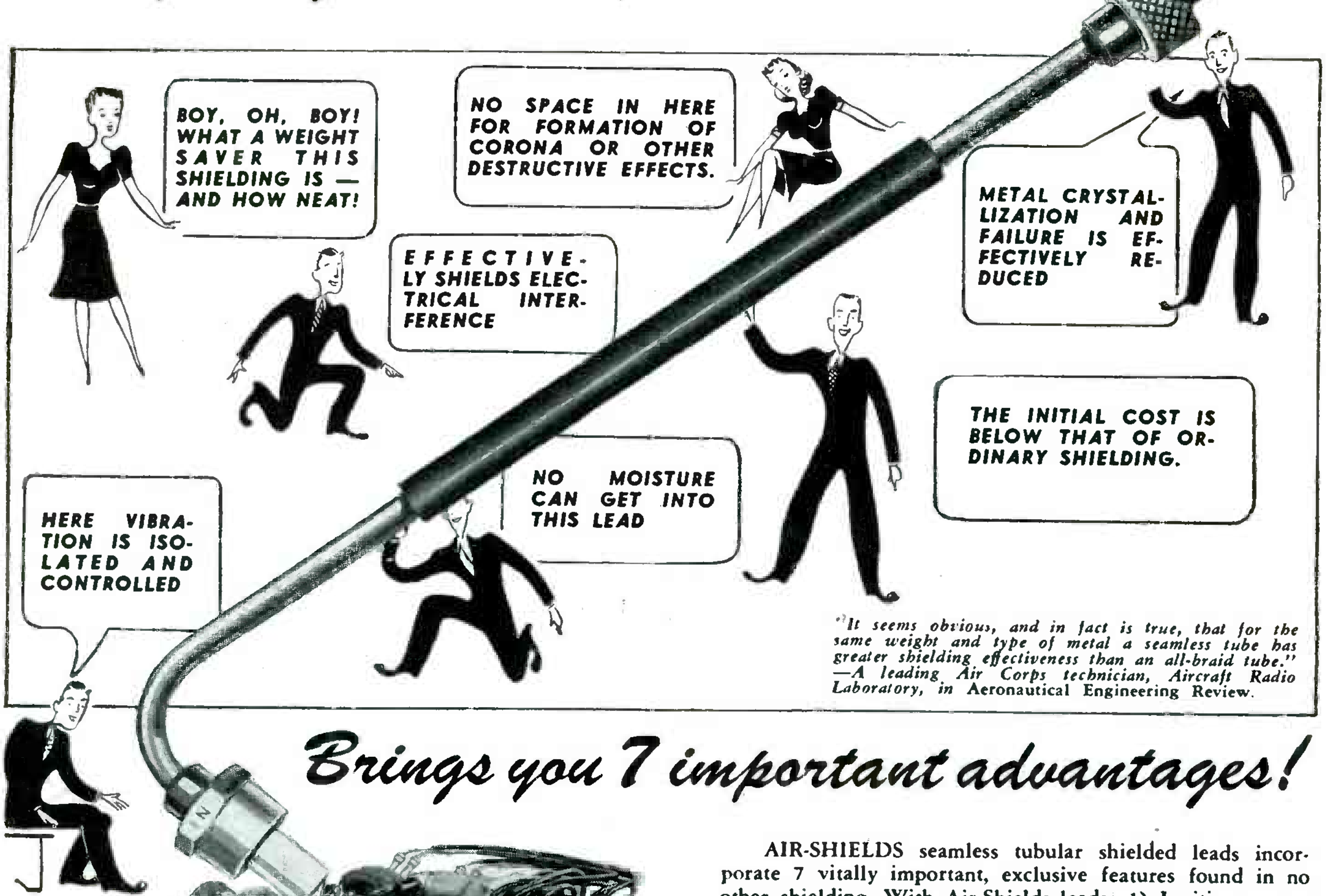
CORNING *means* Research in Glass

Electronic Glassware

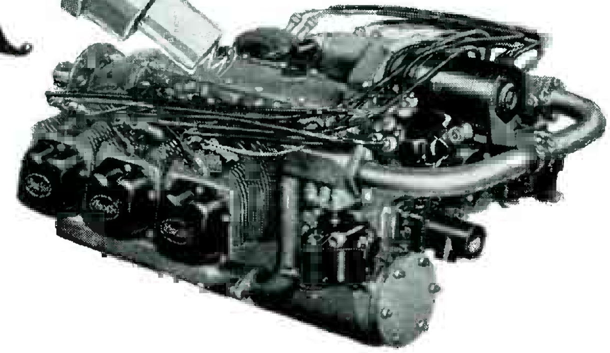
VYCOR CORNING PYREX

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

This great forward step in SHIELDING



Brings you 7 important advantages!

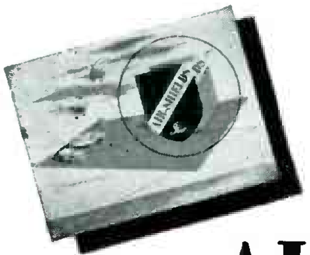


Typical Air-Shields installation on a light aircraft engine.

AIR-SHIELDS seamless tubular shielded leads incorporate 7 vitally important, exclusive features found in no other shielding. With Air-Shields leads: 1) Ignition system emanations are prevented from interfering with radio communications and other electronic devices; 2) Moisture cannot enter from outside or condensation occur within; 3) An Air-Shields installation weighs from 50 to 70 percent *less* than flexible hose-type shielding, yet will stand up to 60 pounds of air pressure at the joints. This combination of light weight and great fatigue strength saves hundreds of dollars per pound *every month* in airplanes; 4) There is no space for formation of corona and its destructive effects on insulation of cable; 5) Vibration is isolated and controlled; 6) Possibility of metal crystallization and failure is effectively reduced; 7) In most cases the initial cost of Air-Shields leads is below ordinary shielding.

New and improved construction methods, coupled with highly specialized engineering techniques, make Air-Shields shielded leads far superior to ordinary type shielding on every point where weight and efficiency are of paramount importance, while their neat appearance cannot be duplicated by all-braid leads.

Air-Shields seamless tubular shielded leads meet the need for truly effective lightweight shielding in airplane, automobile, marine and stationary gas engines. If you have a shielding problem, call on Air-Shields engineers for expert help.



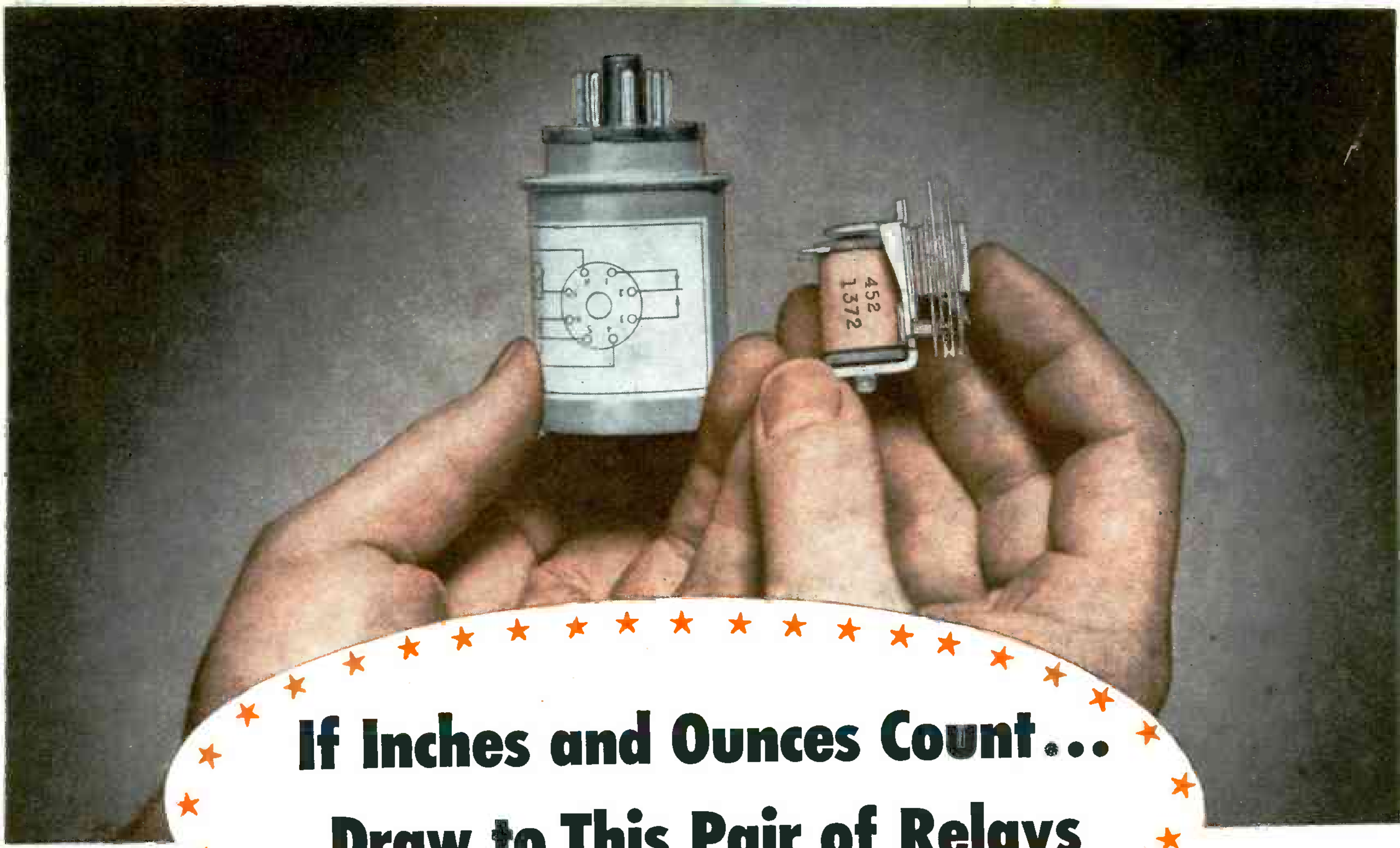
Send for this book. It tells you why Air-Shields seamless tubular shielded leads are clearly superior to ordinary shielding.

AIR-SHIELDS *Inc...*

Manufacturers of seamless tubular shielded leads, shielded spark plugs, ceramic terminal contacts and components

Hatboro, Pennsylvania

Fitting Patent Pending



If Inches and Ounces Count . . .
Draw to This Pair of Relays

● There's no room for an oversize relay in many modern streamlined designs.

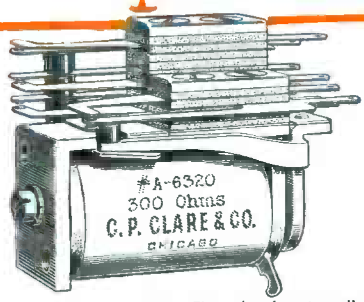
These Clare "Custom-Built" Type "K" d.c. Relays, one in a hermetically sealed cover, are typical of the forward-looking design to provide just the relay you need for new applications, new products and new designs.

Packed into this tiny Type "K" are characteristics which permit unusual speed of operation and resistance to vibration. In the sealed cover it defies the most extreme conditions of dust, moisture, air pressure, and combustible gasses.

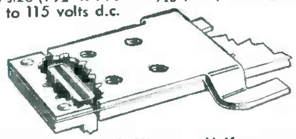
These Type "K" Relays are built for applications where precise performance, long life and dependability are prime requisites. Like all Clare "Custom-Built" Relays they give the user choice of a wide range of contact ratings . . . five different contact forms or any combination of them . . . either flat or hemispherical contacts which may be of rare metals or special alloys . . . coil windings to match the circuit and application.

Clare Sales Engineers are located in principal cities to show how Clare "custom-building" makes it possible . . . with the utmost economy . . . to secure just the relay you need. Look for them in your classified telephone directory.

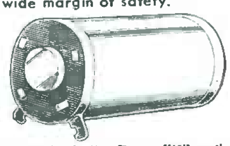
Send for the informative new Clare Engineering Data Book today. Address: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable address: CLARELAY.



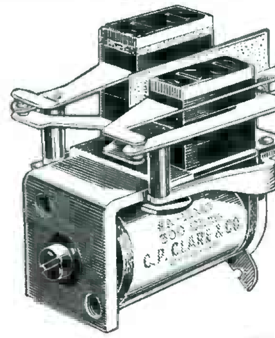
Type "K" d.c. Relay. This relay is outstanding for its speed of operation as well as for extremely small size ($1\frac{1}{2}$" x $1\frac{1}{4}$" x $\frac{13}{16}$"). Operating voltage is up to 115 volts d.c.



Special Type "K" Hinge. Uniform armature movement is assured by a hinge of "fatigueless" beryllium copper, heat treated and designed to provide a wide margin of safety.



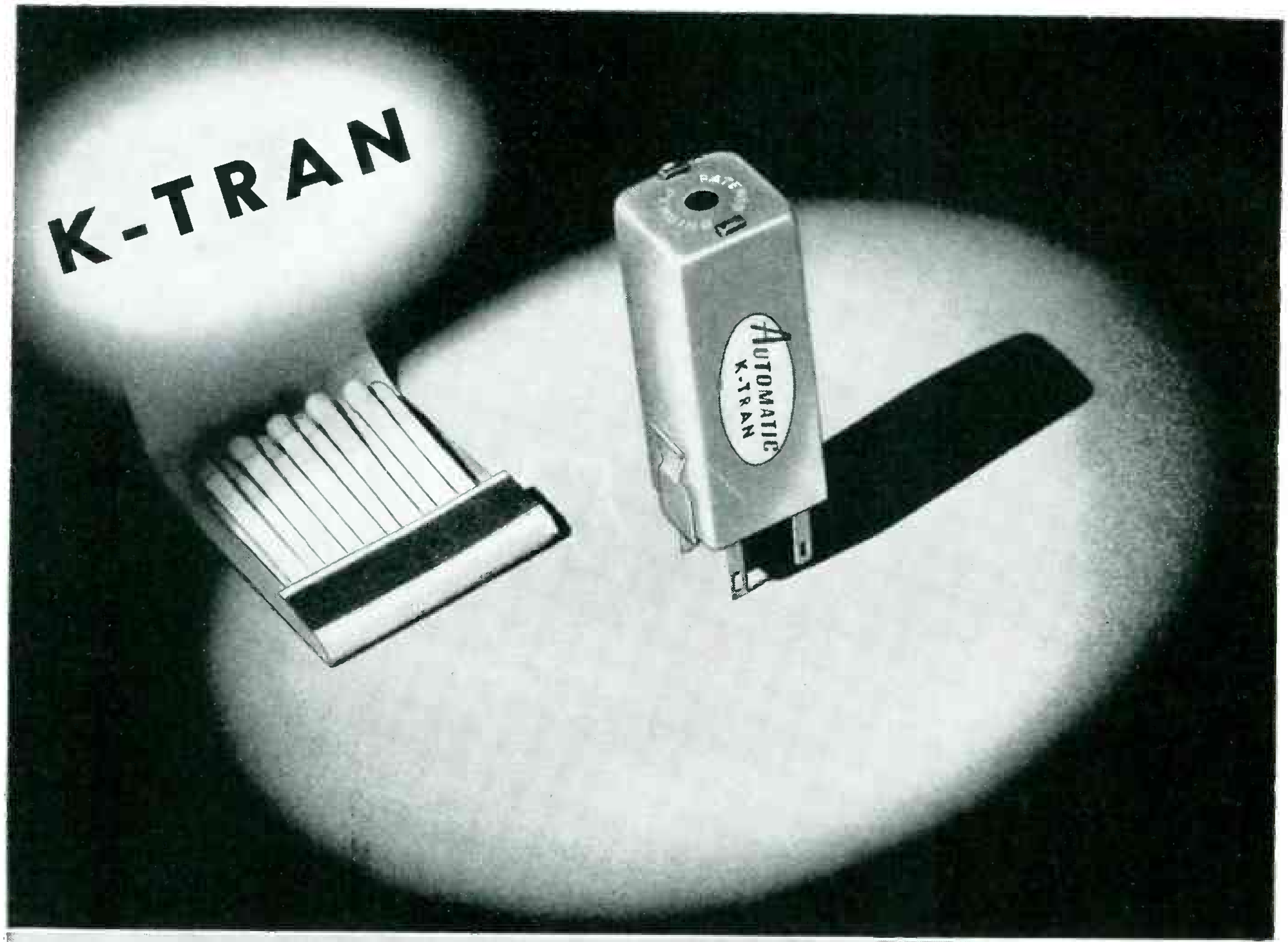
Small Type "K" Coil. Type "K" coils may be single or double wound. Screw holding coil in heelpiece is equipped with split-type lock washer. Coils may be supplied impregnated.



With Mycalex Insulators. Type "K" Relays are available with spring insulators of $\frac{1}{8}$" Mycalex for high frequency circuits. Each relay is given a 1000 volt a.c. insulation breakdown test.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical and Industrial Use



The post-war K-TRAN is an outstanding development in the standardization of I. F. transformer design.

Its ability to reproduce large transformer performance in a small space eliminates the need for large and expensive stocks of many different numbers.

Data sheets on initial types will be ready shortly.

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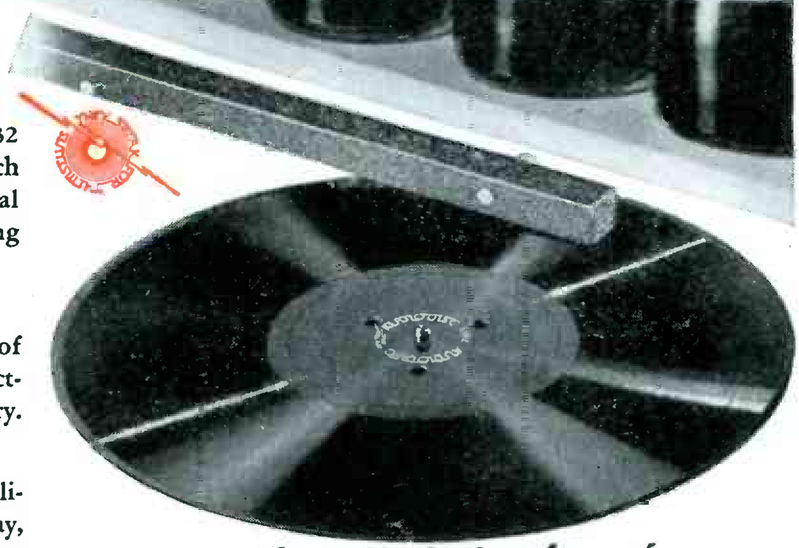

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For the leadership of Audiodiscs is the result of exhaustive experimental work, plus the most exacting quality controls known to the recording industry.

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Recently, to add still further to our research facilities, we greatly expanded our laboratory. Today, our research engineers are constantly exploring new materials and methods, in order to further improve recording fidelity and broaden the field of sound reproduction.

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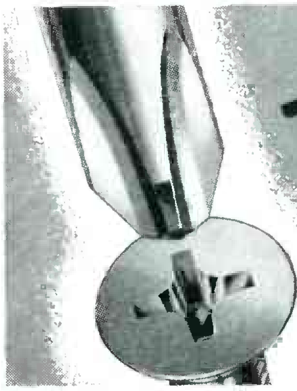


INDEPENDENT INVESTIGATOR'S STUDY SHOWS

Phillips Screws give each assembler a needed "extra hand"...end costly driver skids at SERVEL

"WE couldn't possibly use slotted screws in these door panels," the chief cabinet engineer at Servel, Inc. told the investigator. "We know, from actual tests. In many places it would be impossible to guide a slotted screw with the driver except at a snail's pace, and our driver skid damage would be terrific."

TO GET THE COMPLETE FACTS on how this leading refrigerator manufacturer enlists the many advantages of Phillips Screws, the investigator asked the same questions you would ask – learned how they make big savings day after day – the kind of savings *you* can't afford to miss with today's squeeze on profits.

THIS REPORT, with others now ready, and more to come – comprise a practical manual of modern assembly methods, never-before-printed information, inside facts you'd pay good money to get, and you can have them now, FREE!

This investigator from James O. Peck Co., industrial research authorities, is visiting representative plants to get authentic facts for you on assembly savings.

HIGHLIGHTS FROM THE SERVEL REPORT

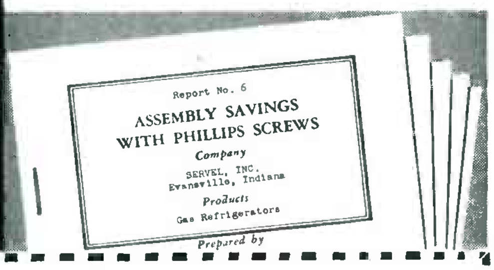
"AN ASSEMBLER WOULD NEED THREE HANDS to drive slotted screws under the rubber gasket in fastening inner door panels and even then, driver skid damage would be prohibitive. The Phillips driver is self-centering – makes it easy to guide the screw with one hand.

"IT COSTS MONEY to replace door panels punctured by skidding drivers, figuring the cost of a new panel, and time for taking out and replacing up to 43 screws. Slips are no problem with Phillips Screws. This advantage alone saves *plenty* in our big production.

"WE RAN A TEST six years ago on door assembly to prove that Phillips Screws cost much less to use than slotted. It was so convincing, no one ever suggested using slotted screws again in this application."

GET THESE REPORTS . . . READ THE COMPLETE FACTS . . . LEARN HOW YOU, TOO, CAN CUT ASSEMBLY COSTS!

All types of products are covered – metal, plastic, wood. The coupon will bring the reports ready now and the rest as they are issued. Fill it in and mail it, TODAY!



PHILLIPS *Recessed Head* SCREWS

Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

26 SOURCES

American Screw Co.
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Please put me on the list to receive all reports on Assembly Savings with Phillips Screws

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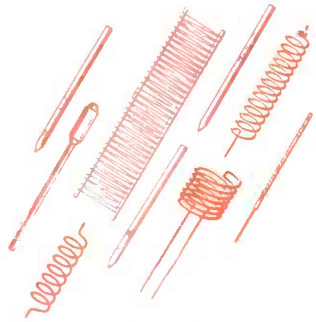
Callite tube parts



make General Electronics' power tubes extra rugged . . .

The DR575A is a heavy-duty, half-wave, mercury vapor rectifier manufactured by General Electronics, Inc. for use in induction heating apparatus. Here these tubes have proved their capacity to stand up under gruelling conditions for thousands of hours. Though rated at 15,000 volts inverse peak, they are tested at 25,000 volts—providing an overload factor in excess of 50%.

The rugged strength of the DR575A is built-in with Callite thoriated tungsten filament, "Kulgrid" leads and molybdenum rods. These Callite components permit higher operating temperatures with increased emission efficiencies.

Callite thoriated tungsten filaments contain the right proportions of tungsten and thoria to give the required electronic emission, plus the strength to withstand severe thermal shock and vibration. Callite's "Kulgrid"* is a stranded composite wire, having an inner core of copper bonded to a nickel sleeve, which does not oxidize nor become brittle at high temperatures. Callite's high purity molybdenum rod is known for its excellent working properties and complete freedom from oxidation.

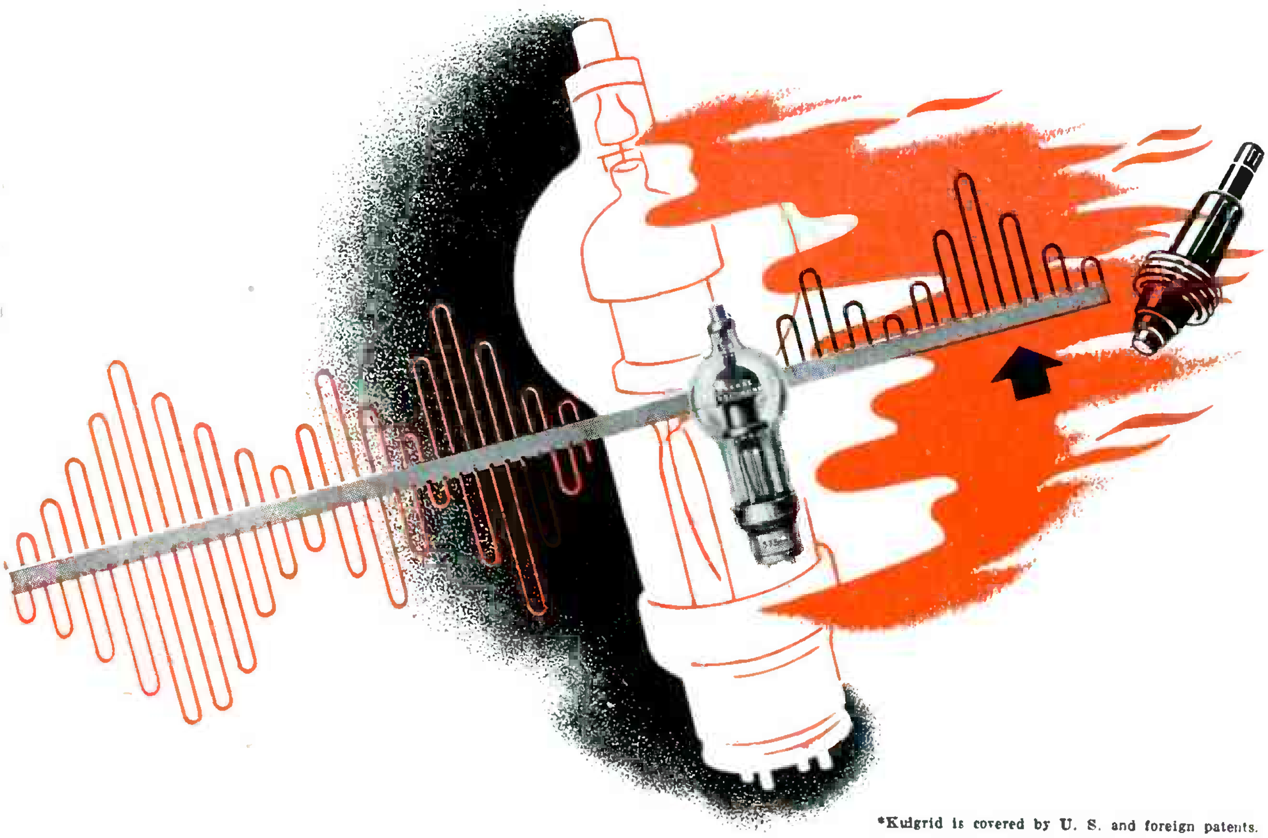
If you are striving for new highs in tube performance, investigate our specialized abilities and complete facilities for all kinds of metallurgical components. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, New Jersey. Branch Offices: Chicago, Cleveland.

Callite *Tube components*

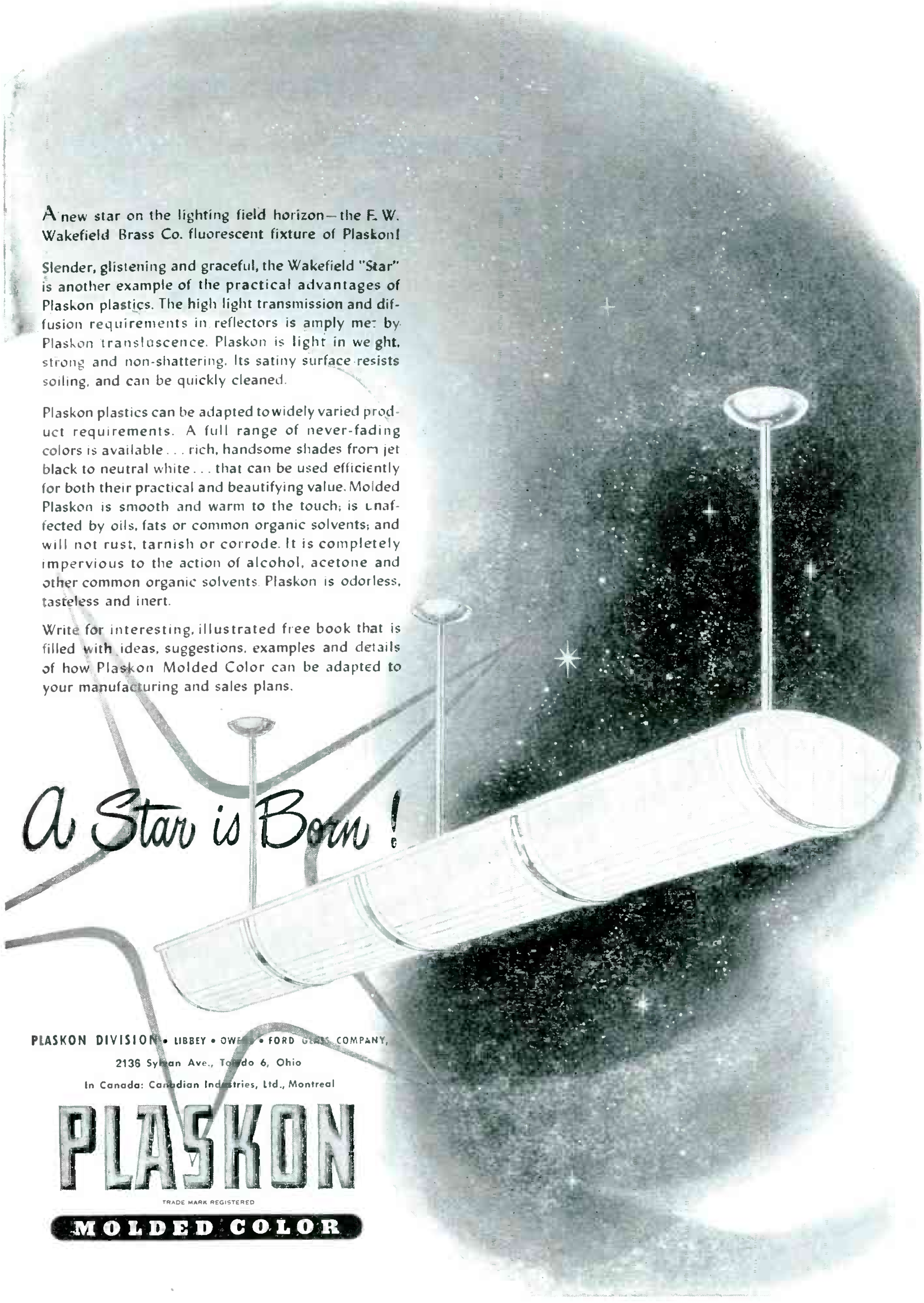
CALLITE TUNGSTEN CT

Hard glass leads, welds, tungsten and molybdenum wire, rod and sheet, formed parts and other components for electron tubes and incandescent lamps.

OVER 25 YEARS PIONEERS IN TUNGSTEN METALLURGY.



*Kulgrid is covered by U. S. and foreign patents.


A new star on the lighting field horizon—the F. W. Wakefield Brass Co. fluorescent fixture of Plaskon!
Slender, glistening and graceful, the Wakefield "Star" is another example of the practical advantages of Plaskon plastics. The high light transmission and diffusion requirements in reflectors is amply met by Plaskon translucence. Plaskon is light in weight, strong and non-shattering. Its satiny surface resists soiling, and can be quickly cleaned.
Plaskon plastics can be adapted to widely varied product requirements. A full range of never-fading colors is available . . . rich, handsome shades from jet black to neutral white . . . that can be used efficiently for both their practical and beautifying value. Molded Plaskon is smooth and warm to the touch; is unaffected by oils, fats or common organic solvents; and will not rust, tarnish or corrode. It is completely impervious to the action of alcohol, acetone and other common organic solvents. Plaskon is odorless, tasteless and inert.
Write for interesting, illustrated free book that is filled with ideas, suggestions, examples and details of how Plaskon Molded Color can be adapted to your manufacturing and sales plans.
A Star is Born!
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"and we'll safeguard the Electrical Circuits with Permanently Insulated **ROCKBESTOS** because it withstands tough service conditions"

More and more product designers are insuring the dependable operation of electronic devices and other electrical equipment with Rockbestos wires, cables and cords . . . because their *impregnated asbestos insulation* withstands wire-destroying conditions and greatly reduces the possibility of wire-failure.

Inherently heatproof and fireproof, *permanently insulated* age-resistant Rockbestos wires won't bake brittle, crack or flow under high operating or ambient temperatures . . . and won't support destructive wire-fires. They are also highly resistant to oxidation, oil, grease and corrosive fumes . . . remain flexible under extremes of heat and cold . . . and size for size they give greater carrying capacity than wires having other types of insulation.

Give your product the edge of performance protection by selecting your wire requirements from 125 standard Rockbestos constructions . . . everything from tiny multi-conductor cables to motor lead or power cables . . . and all of them are *permanently insulated* against failure. Write for recommendations or engineering assistance.

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125 different wires, cables and cords developed for enduring service by Rockbestos.

ROCKBESTOS FIREWALL HOOKUP WIRE

For electronic apparatus, airborne and ground communications equipment—also for small motor, coil, transformer and dyna-motor leads. Operating temperature range 125°C to minus 50°C. No. 22 to 4 AWG in 1000 volt rating and 12 to 16 AWG in 3000 volt insulated with high dielectric tape and impregnated felted asbestos and covered with color-coded lacquered glass braid. Also in twisted pair, tripled, shielded and multi-conductor constructions.

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For low voltage communications, signal and temperature control systems. Impregnated asbestos insulation assures trouble-free circuits and steel armor protects against abrasion during installation. Sizes No. 14 to 18 AWG in two to six conductors with .0125", .025" or (for 115 volt service) .031" of insulation.

Due to the high operating frequencies of FM, many electrical and mechanical characteristics not ordinarily considered in condensers, become of paramount importance. The most important of these is low inductance, both in leads and in the basic construction of the condensers themselves.

The condensers illustrated on this page fulfill this requirement through simplicity of design and low internal inductance. For by-pass applications, Erie Stand-Off Ceramicons and Erie Feed-Thru Ceramicons are most efficient for carrying off R.F. current to ground. Heavy terminals, with direct connection to ground, reduce external and internal inductance to a minimum. Available capacities, up to 1,000 MMF, are usually sufficient to efficiently by-pass frequencies of 80 MC or higher. Tubular Ceramicons, shown at the top right, have the same internal advantages as the Stand-Off and Feed-Thru type Ceramicons, because of their simplicity of construction, but are provided with regular pigtail leads necessary for many installations where some moderate lead inductance can be tolerated.

The Cinch-Erie Plexicon Tube Socket, shown in the center photogragh, with built-in by-pass Ceramicons, puts the condensers around the tube pins—where they belong. Leads are practically eliminated, and other components can be installed closer to the socket, further increasing efficiency. Any tube pin or groups of pins can be by-passed with condensers having up to 1,000 MMF capacity.

Erie Button Mica Condensers were designed specifically for high frequency work. Ribbon type leads, plus circular design, gives extremely short electrical path-to-ground through the entire area of the condenser. These compact units are available in a number of different mounting styles and in capacity ranges up to .006 mfd.

You can stake your reputation on these condensers for dependable use in tuned circuits, for by-pass applications, or as coupling condensers, in all FM applications. Write for complete details, giving desired operating characteristics.

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND . . . TORONTO, CANADA

Surer even than a pilot's eyes

... the high-frequency cable that makes **RADAR** *possible*

is insulated with

Du Pont POLYTHENE

CUT-BACK SECTION of a modern twin coaxial cable for use in direction-finding equipment at ultra-high frequencies (400 to 10,000 megacycles). JAN-C-17 designation RG-23/U; made by Anaconda Wire & Cable Co. The insulation, about 140-150 mils thick, is Du Pont polythene.

Radar and associated electronic developments, born in stress of war, have important peacetime uses immediately ahead. Ships and planes which, without radar, might be hopelessly lost in foul weather or fog, may now soon be located ... come safely to harbor or airport ... thanks to one or several of the four main types of radar.

In this important work Du Pont polythene plays an indispensable part. For radar depends on ultra-high frequencies—anywhere from 2 to 10,000 megacycles! The cables that carry these currents must have an insulating material of low electrical losses—which at the same time is flexible at low temperatures. *Du Pont polythene meets both these requirements.*

Other properties of Du Pont polythene: outstanding chemical inertness, light weight (specific gravity 0.92), low moisture permeability, flexibility in thin sections, rigidity in thick. For complete data sheet, write to E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Room 157, Arlington, N. J.

Du Pont manufactures polythene molding powder.

Commercial extruders convert polythene into the forms of

SHEETS **TUBES** **RODS** **FILAMENTS**

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Plastics
BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

Now...

ACCURACY within ±1/5%

Plus...

CONTINUOUS AUTOMATIC RECORDING of EXPANSION and CONTRACTION MEASUREMENTS

with the new

SYLVANIA DILATOMETER

THE SYLVANIA DILATOMETER measures expansion and contraction by the concentric quartz tube principle... providing the extreme accuracy characteristic of this method.

Simultaneously it automatically *records* the measurements . . . plotting them in the form of a complete elongation-temperature curve for an entire 8-hour cycle.

No special attention is needed to operate this new instrument. Simply insert the specimen and start the equipment. No laborious, time-consuming plotting of curves. The record is continuous. With indicating-type instruments, it is often difficult to take readings fast enough to follow true changes in length at critical points. The recording instrument overcomes this difficulty.

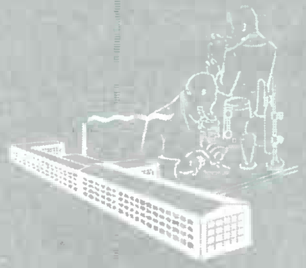
This Dilatometer is one of many electronic devices pioneered by Sylvania Electric. Inquiries are invited.

SYLVANIA ELECTRIC

Electronics Division . . . 500 Fifth Avenue, New York 18, N. Y.

MAKERS OF ELECTRONIC DEVICES; RADIO TUBES; CATHODE RAY TUBES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS

• PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS •



THE MAJOR CAPACITOR AND WIRE-WOUND RESISTOR DEVELOPMENTS OF THE PAST 5 YEARS HAVE BEEN ENGINEERED

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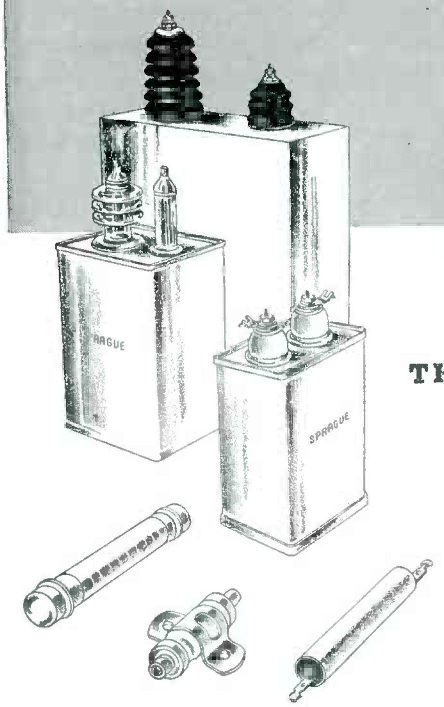

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SPRAGUE *KOOLOHM RESISTORS with glazed ceramic coating and new type end seals in one standard type for use under any climatic condition.

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Here are its characteristics. How can it fit your needs?

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AC/DC Operation, both heater and contacts operate on AC or DC interchangeably . . .

In a thermal relay, an electrical heater, rather than magnetic coil, is used to operate the contacts. This results in certain useful characteristics—inbuilt delay timing, insensitivity to transients, a non-inductive device that operates from AC or DC or interchangeably, and simple construction.

The design of the EDISON Model 501 Thermal Relay adds certain important features to these general advantages. Hermetic sealing in glass protects all parts, guarantees consistent long life, and makes operation independent of altitude. Contacts operate noiselessly in an arc-quenching atmosphere with consequent equal current ratings on AC or DC. A compensating bi-metal assures uniform response time at all ambient temperatures. The relay will operate in any position. A convenient tube-base mounting is available. Sound thermodynamic design assures consistent operation and permits a wide range of characteristics.

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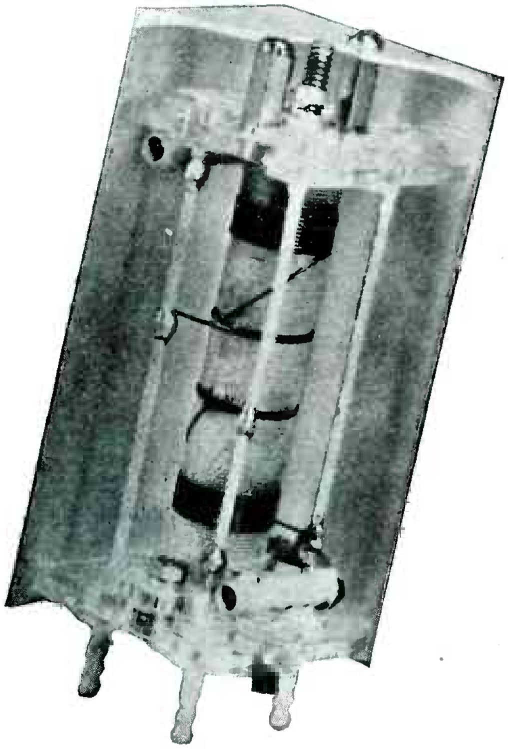

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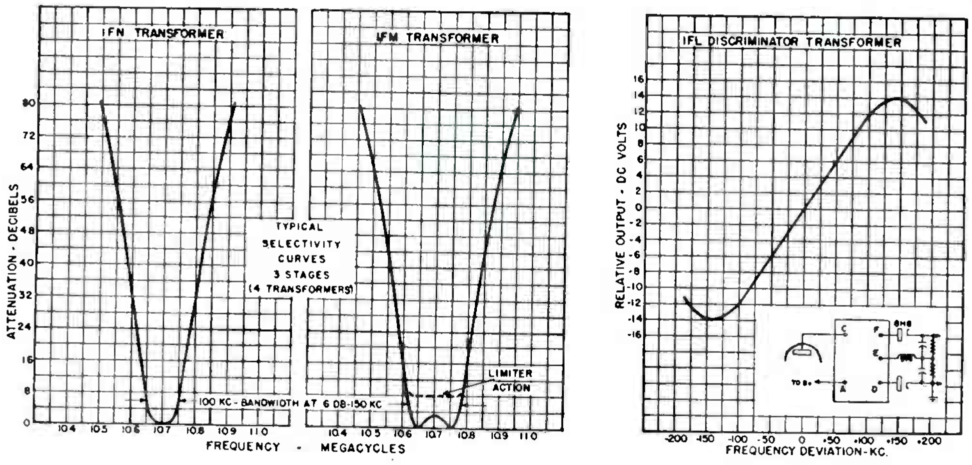
NATIONAL COMPANY, INC., MALDEN, MASS.



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Yep — they're just one more important addition to a long line of 1946 "make-life-easiers" . . . like home freezers and sun-heated homes and jet airplanes that make it possible to breakfast in New York and lunch in San Francisco . . .

Of course, the "Hallowell" Speed Tool Kits may not be on a par with sun-heated rooms or jet planes . . . but they will play an important role in the life of busy people; and, they'll mean a lot, to those who aren't so busy, but who prefer things *neat, tidy, compact . . . and convenient.*

There are seven different Kits: 2 sizes of the "Auto" Kit; 2 of the "Socket Wrench" Kit and 2 of the "Socket Screw" Kit . . . for a greater range of tool sizes; and there is a "Home" Kit. All the Kits, each one of which will fit in the palm of your hand, contain a total of 50 tools . . . Phillips, flat and hex screw drivers; clutch head bits; hex socket wrenches; a gimlet, a reamer, a tack-lifter, and even a bottle opener.

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OPA IS DYING—
. . . *what next?*

IT IS NOW clear that direct price control of the OPA type is on the way out, if not by legislative limitation then by administrative collapse.

It is equally clear that we are by no means past the danger of a swirling upsurge of prices.

Then does it follow that the passing of OPA need be tantamount to a decision to let 'em rip?

It does not.

While the OPA machinery is grinding to a stop, we can bring into play more fundamental measures to keep prices within safe limits—and to allow private management a wider area of freedom. What this article proposes is a framework of control within which private business judgment can operate. Therefore, this preamble speaks directly to our friends in the business community.

Now is a time for unrelenting self-restraint by business management. As price control disintegrates, business must scrupulously hold to prices which, after covering costs, yield *normal* profit margins. Business has everything to lose and nothing to gain if its price policies emulate the excessive wage demands made by some unions.

True leaders of business sense the danger. They do not want to price themselves out of their markets. They do not want the tag of price hogs. They do not want a buyers' strike. All management must practice the self-restraint which characterizes the wisest leaders among us.

What Wasn't Done

Virtually all responsible economic analysts agree that if direct price control is eliminated and nothing else is done, prices will move upward. The only serious disagreements are: How far? And for how long?

Some careful and competent forecasters believe that, if all price control is lifted, the official cost of living index will shoot up at least 25 per cent within a year. Some of them think that wage rates will chase right after prices, forcing new price increases until the whole operation ends in a dizzy crash.

Others agree that prices will go up all right, but they think that increased production, made possible by disentanglement from OPA red tape, will bring them down again fairly soon.

Recent developments seem to support those forecasters who think that wage increases would chase right after price increases and thus keep "the inflationary spiral" spinning toward a ghastly fall. Unions already agitate for a new round of wage increases to offset price increases which have occurred in the few months since the last round of wage increases.

Therefore, the prudent course would have been to clean up the OPA price control system, to keep it in place for a limited period as a stop-gap, and, meanwhile, to arrange to replace it with more fundamental controls, PROVIDED the federal government itself stopped promoting excessive wage increases. *The greatest single contribution to the wrecking of the OPA has been the holes driven in price ceilings by government-promoted wage increases.*

But now the stop-gap is being eliminated, and the fundamental controls are not in place. Their erection becomes urgent.

The Basic Task Now

The danger that prices and wages will get to chasing each other around a ruinous spiral arises, of course, from the accumulation during the war of an enormous sum of money that could not be spent because about 40 per cent of the nation's production was being devoted to war. Men were paid wages and profits for making artillery shells. The shells were exploded. The money remains. It has piled up until the people's backlog of cash spending power, in one form or another, exceeds $225 billions—three times the total in 1939.

More than that, banks hold $115 billions of government securities—a sixfold increase since 1939. These securities can serve as the basis for an expansion of bank credit of many times their volume. A dollar of bank credit will, of course, buy as much as a dollar of cash.

The first and basic task of preventing runaway prices is: *Get this huge accumulation of purchasing power, actual and potential, under some kind of effective control.*

A second task is to see that no unnecessary additions are made to the flood of purchasing power overhanging the market. A third task is to get the productive machinery of the country running at top speed so that it can take up the accumulation in an orderly way, not in a boom-bust sequence. We shall talk here only about the first two of these tasks.

Are there ways of getting at the root cause of a disastrous wage-price spiral which are being neglected? There are many of them. Attention has been distracted from them by building up the battle over OPA as the Armageddon of price stabilization. It is important. But it is not Armageddon. If everything that Mr. Bowles and his associates want done by way of price control legislation were done, the problem of price stabilization would still remain unsolved in the continued absence of a program to deal effectively with root causes.

Basic Remedies

Here is a rough outline of the key elements of a basic program.

1. Cut public expenditures to the bone and let tax revenues accumulate as business volume increases—perhaps broadening the tax base at the same time.

Now, if ever, is the time to run a surplus and to use it to retire debt. Immediate upward pressure on prices would thus be removed and the burden of carrying debt when the going gets tougher later on would be relieved. A $10 billion surplus of federal, state and local revenues during the next year might not be too much.

An increase in social security taxes, as the House Ways and Means Committee proposes, offers one of a number of good ways to increase revenues. Deferring public works not immediately needed affords one of numerous ways by which substantial cuts in expenditures can be made.

2. Tighten the terms on which installment credit is available for the purchase of houses, automobiles, and other consumers' goods.

Allowed to run a free course, expansion of credit to buy houses and durable consumers' goods might easily add $15 billion to consumer purchasing power next year. No such injection of credit is needed now. The more a man buys "on time" the more cash he keeps to spend on something else. For most products the cash market alone is more than big enough to keep producers busy and customers healthy.

3. Restore to the Federal Reserve system its lost control over the supply of credit by limiting the opportunities for credit expansion now afforded by huge bank holdings of government securities.

The specific measures needed are highly technical, but are agreed upon by banking experts as both feasible and fair. The important thing for the public at large to do is to recognize that we are, in effect, sitting on a powder keg with lighted match in hand until the measures are taken.

4. Revive a vigorous campaign to sell government savings bonds and other government securities to the public.

Sale of government savings bonds cuts down current consumer spending. It also allows the Treasury, if government spending is held down, to retire government bonds which the banks hold. Thus, it simplifies the problem of keeping bank credit within safe bounds.

5. Prevent a speculative inventory boom of the sort which preceded the post-World War I business collapse in 1920-21.

This involves a continuation of the loose controls of inventories now exercised by the government. In more important degree it involves well informed cooperation by bankers and business men to keep inventories from being expanded unnecessarily.

6. Maintain controls on exports in order to keep within reasonable limits the impact on our market of huge foreign demand.

Emergency foreign relief requirements must be met. But foreign demand which is enormous apart from relief requirements must be kept under control until the danger of having it send prices of export products soaring is past.

Breathing Space for Business

This program would deal with causes, not symptoms. Hence, if promptly and efficiently installed, it would do a far better job of keeping the general level of prices and wages within tolerable limits than the OPA type of price control ever could have done—even if OPA had not been so often and so badly mismanaged. The program would also do this without tying up American business in a myriad of irritating and discouraging individual regulations. It would establish broad bounds within which business enterprise would be free to be itself, not a branch of bureaucratic enterprise.

The program proposed here also has the major virtue of flexibility. If prices start to reverse their present upward course within another year, the major parts of the program can be adjusted or removed quickly.

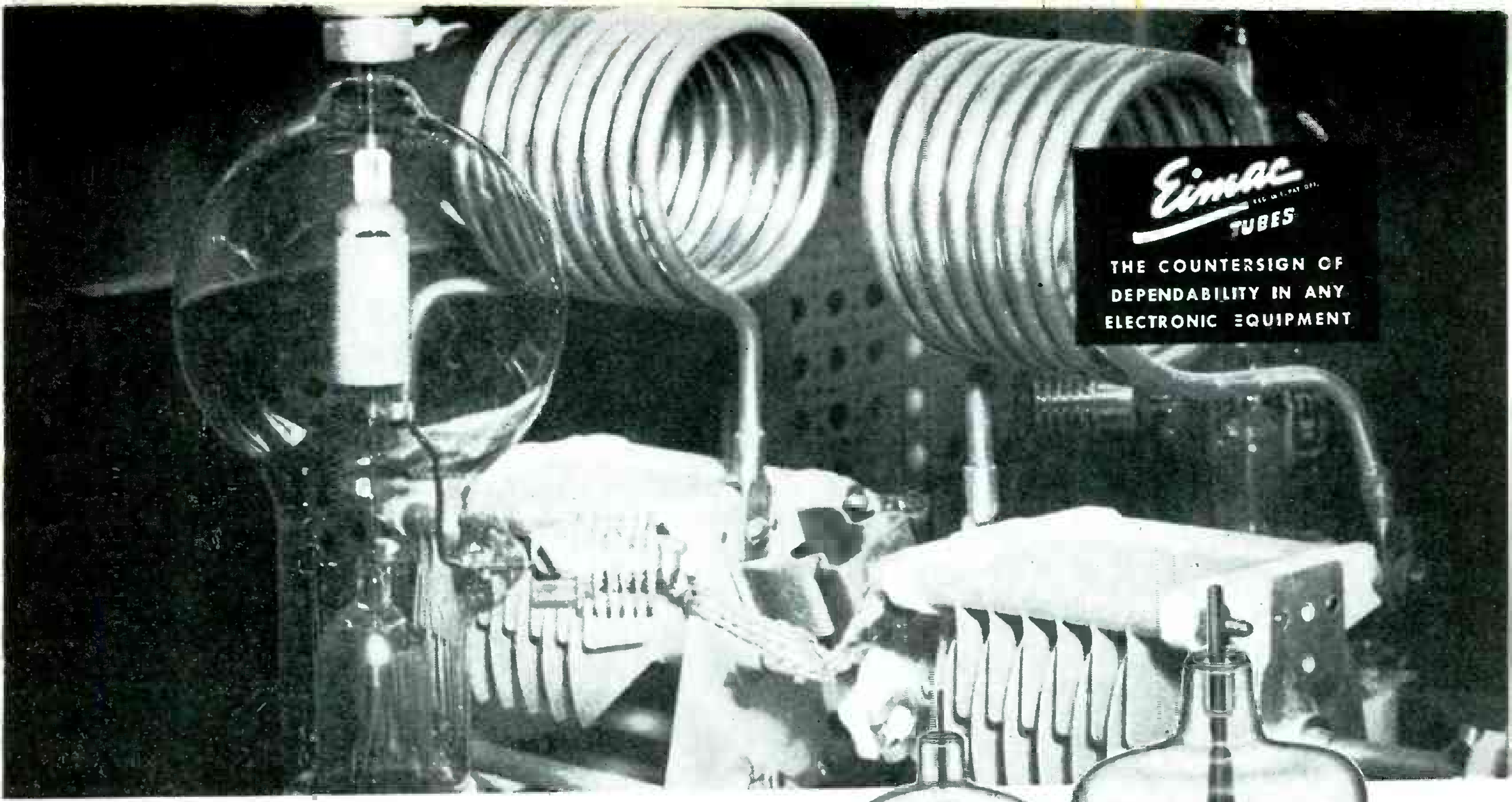
It would be gratifying to suggest junking at once all arrangements designed to place limits on price movements, even broad limits of the sort here suggested. But to do nothing while OPA falls apart, would be to run the grave risk of a runaway of prices and wages which, in the inevitable collapse, would do irretrievable damage to the business community and to the whole nation.

The risk is not worth taking.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

THIS IS THE 49TH OF A SERIES



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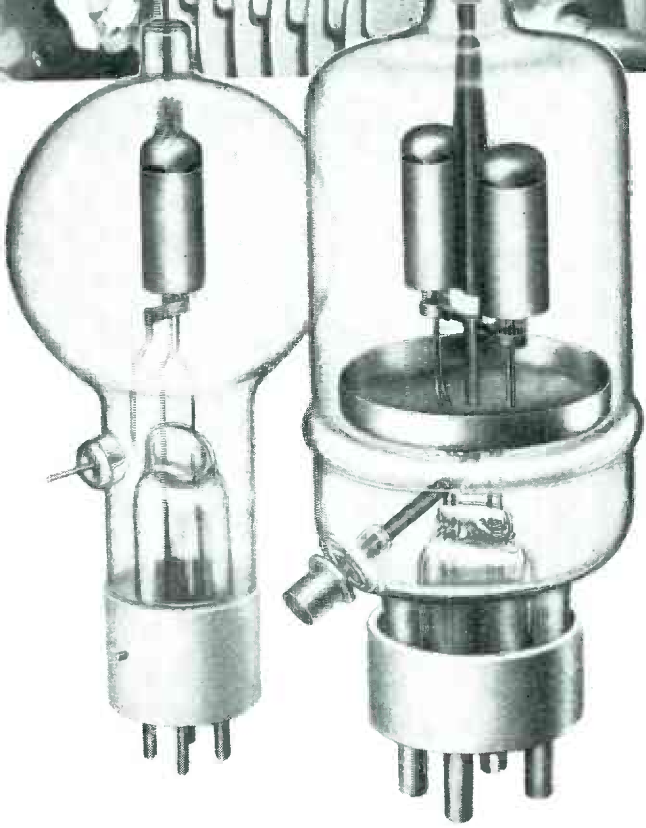
The famous Eimac 75T is now available in both high and low amplification factor types (75TH-75TL). These exceptionally flexible triodes provide a high power output at low plate voltage, and require a minimum of driving power. These Eimac 75T's are suitable for use as oscillators, amplifiers, or modulators. For example: a pair of 75TL's in a class-C amplifier can easily be operated at 500 watts input with only 1500 volts on the plate. The required grid driving power for the two tubes would be only 12 watts. In a class-B modulator, two 75TL's operated within 1500 plate volts will deliver 280 watts of audio power, sufficient to more than 100% modulate the above mentioned RF amplifier.

The Eimac 152T has twice the power handling capacity and twice the transconductance of the 75T, but *less* than twice the already low grid-plate capacity. At 1500 plate volts, 500 watts input can be run to a single 152TL, or a full kilowatt can be run to a pair of 152TL's in a class-C amplifier. For class-B audio, a pair of 152TL's will deliver 560 watts with 1500 plate volts. Eimac 152T's are also available in high and low amplification factor versions. Literature giving full technical information on these triodes available now. Write today, or contact your nearest Eimac representative.



EIMAC 75T POWER TRIODE

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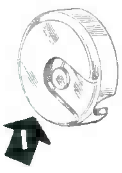

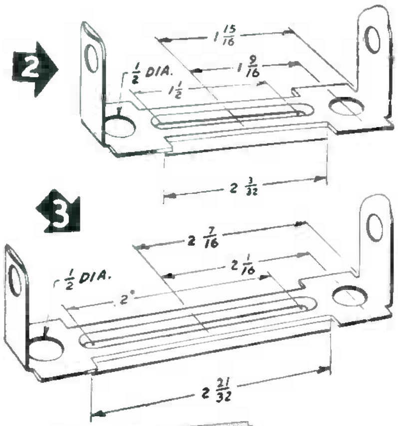

Want more details? Write for engineering data and specification folder #746-C.

Moisture-Proof ...and That's Not All!

FEW Mallory products in recent times have met with more whole-hearted enthusiasm than the Type "P" AC Motor Starting Capacitor.

To begin with, the capacitor is enclosed in a plastic case—a positive preventive of moisture absorption, the bane of the old-style cardboard insulated unit.

Next, it's equipped with splash-proof end cap and with an ingenious new type of mounting bracket. Together, these two features eliminate many extra parts and greatly simplify installation.

Finally, this Mallory Type "P" Capacitor is available in four case sizes . . . is interchangeable with former aluminum units . . . will fit any mounting hardware used for previous capacitors of comparable size.

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CROSS TALK

► **WRECK . . .** Another disastrous train wreck brings home the fact that our railroads are operating on 90 mile per hour schedules with 40 mile per hour communications.

During the war the Congressional Limited between Washington and New York was wrecked because a station agent could not tell the engineer that he had a dangerous hot box on one of the flyer's cars. Communication between station and train could have averted loss of life and equipment. In the newest smashup one train stopped to investigate possible trouble and was rammed because another speedster following closely behind could not stop soon enough. Here, again, communication could have avoided the inevitable crash.

Radio has demonstrated that it can furnish successful train-to-station and train-to-train communications. There seems to be no logical reason why rolling stock, passengers, cargo and train crews should not have the benefit of the protection that radio now has to offer.

► **INFORMATION PLEASE . . .** Anyone who cares to answer these questions for possible publication has the floor. A young engineer posed them to the editorial staff of ELECTRONICS recently and, like all engineers, he thought that there should be yes-or-no answers.

1. Should an engineer work more than 40 hours per week?

2. Should he take an interest in and express his opinions of the management and sales policies of the company he works for?

3. Would he be "stuck" if he went to work for a company in a small town?

4. Are present salaries inflated?

Possible answers are as follows:

1. If an engineer really works for 40 hours a week, he will not be much good for anything but shooting snipe the rest of the week. Under the word "working" is included the necessary study to keep up with his profession, not only to solve the particular problem of the moment but to have a smattering of the vast and constantly increasing techniques allied with electronics. If his management frowns on reading technical books or magazines on the company's time he has to do his reading at home—but this reading must be done or he will pay the penalty of having younger and better educated men push him out of his job.

2. He should certainly have an interest in such matters but he must remember that radio engineers have not risen much higher in some management's opinions than such items as typewriters and comptometers. Therefore he should go slow in expressing his opinions. He should probably wait for an invitation, which probably will never come.

3. There is an undeniable feeling that work in a small city gives one the feeling of being out of touch; but it is also a fact that a lively discussion group of fellow engineers, endeavoring collectively to understand the current technical literature, can be much more effective than mere listening to formal papers delivered before technical societies. In other words, an engineer can keep up to date no matter where he is.

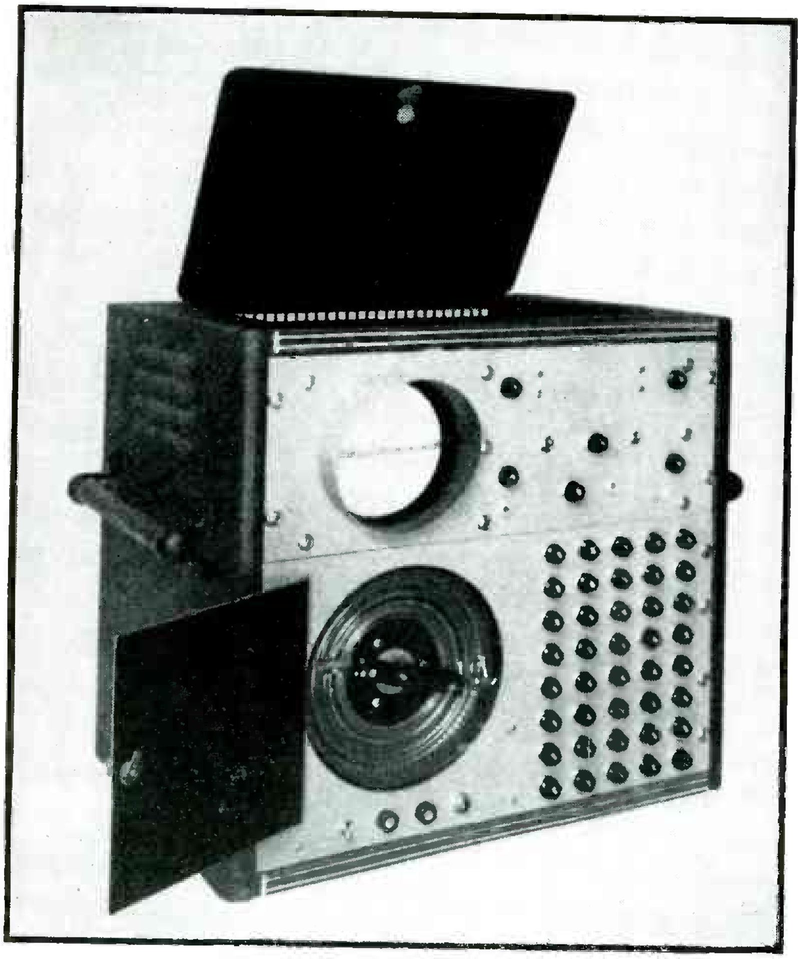
4. Engineers are subject to the laws of supply and demand. There are no protections to salaries as there are to wages. Right now there is a dearth of good engineers and salaries are high. No engineers were made during the war; many good engineers were lost; it will take the colleges quite some time to fill the void occasioned by our wartime policies of drafting technical men. Furthermore everything is inflated now; and there is also a better appreciation of the value of engineers and scientists among companies which employ them. In industries associated with electronics, management is becoming conscious of the fact that the entire structure is built upon technical knowledge.

But to continue to draw high salaries, the engineer must be good!

ALARM

By W. A. ANDERSON
Engineer, Broad Street Laboratories
RCA Laboratories
New York, N. Y.

Signal pips on a panoramic by a 40-control complex wave new signal or a shift in the fre- signals triggers a thyratron



Final model of the wave generator, alarm system, and scope built as a single unit, ready for connecting to the output of any panoramic receiver. By adjusting the 40 control knobs while watching the resultant pattern on the cathode-ray tube screen, the output of the complex wave generator can be shaped to cancel exactly any pattern appearing on the screen

When a band of frequencies in the radio spectrum is to be monitored with a panoramic receiver, it is often desirable to cancel some or all of the signal pips appearing on the cathode-ray tube screen after they have been recognized, reducing the trace on the screen to a horizontal line so that arrival of a new signal or a shift in the carrier frequency of one of the original signals will be instantly noted. A further goal is means for setting off an alarm automatically when a frequency shift occurs or a new frequency arrives, to arouse the operator or call him from other duties.

Such requirements exist in commercial radio communications stations, where one operator may have to watch several panoramic receivers and be ready to open communication with any of dozens of different stations that may call on as many different frequencies. Similar requirements exist in both military and commercial radar and sonar applications, where it is often desirable to cancel on the scope a known signal pattern and the fixed reflections occurring therefrom so that significant patterns due to target objects can be more readily observed.

All these requirements are met in the complex-wave generator and electronic alarm to be described. The radar, sonar, or panoramic receiver output is mixed with the output of the complex-wave generator and the resultant voltage fed to the deflection plates of a cathode-ray tube for visual observation of the cancelling process, as indicated by the block diagram in Fig. 1. The 40 individual controls of the wave generator are adjusted in sequence to make the pattern on the c-r tube screen drop down to zero step by step, as pulses of opposite polarity are introduced to cancel each portion of the original observed pattern. The resultant trace is for all practical purposes a horizontal line, so that new signals or frequency shifts produce instantly recognizable deviations. The alarm indication is obtained by connecting the grid of a thyratron to each vertical deflecting plate of the c-r tube, so that a new or altered signal on either plate triggers a thyratron and operates a relay in its cathode circuit.

Method of Wave Synthesis Employed

In order for a scope pattern to be cancelled, its corresponding voltage (acting on the vertical deflecting plates) must first be duplicated or synthesized by a local generator. The locally-generated voltage can then be inverted in polarity and combined with the original voltage in a linear mixer whose output is proportional to the difference between the two.

The voltage that produces a pattern on a scope can be considered as a repetitive complex wave because it repeats its wave form at a rate equal to the horizontal sweep rate. Such a complex wave, no matter what its shape, can be approximately duplicated with a large number of rectangular pulses whose individual amplitudes can be controlled. The more pulses employed, the closer becomes the approximation to the original wave.

Using a Fourier schedule as a guide, it was decided to utilize 40 rectangular pulses in the complex wave generator, making the width

SYSTEM for Panoramic Receivers

receiver screen are cancelled generator, so that arrival of a quency of one of the known circuit that operates an alarm

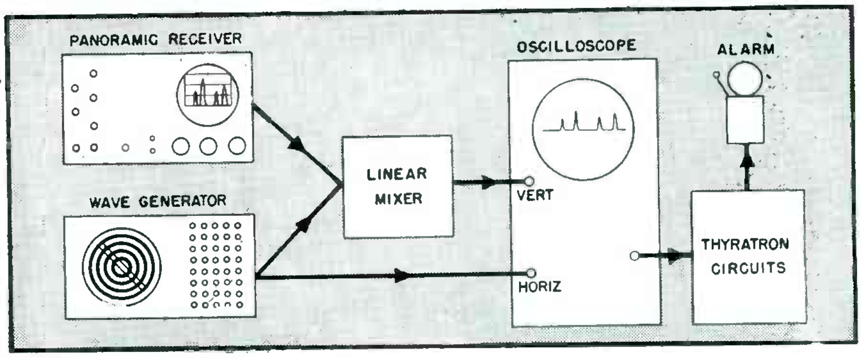


FIG. 1—Block diagram of system. When properly adjusted, arrival of a new signal at the panoramic receiver makes the alarm bell ring

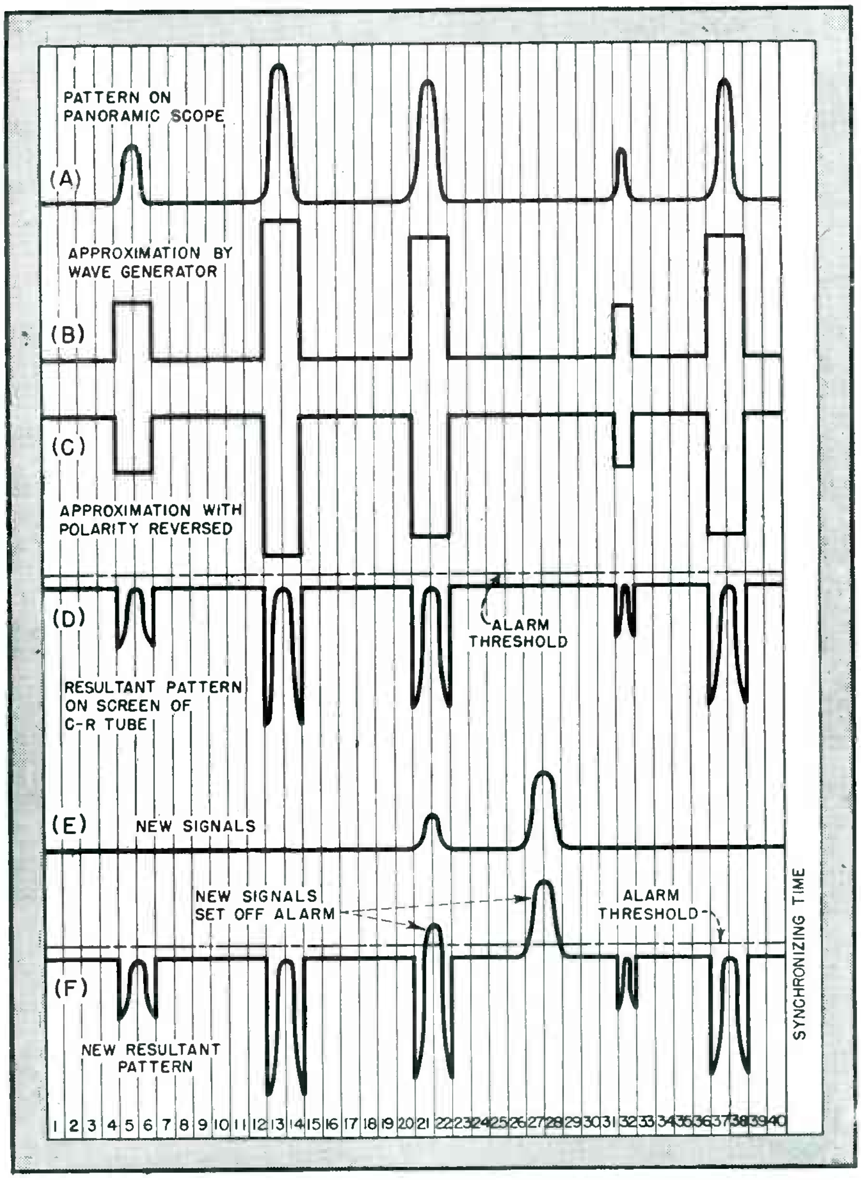


FIG. 2—Step-by-step illustration of how a panoramic receiver pattern is cancelled by the 40-control wave generator. Note that a new signal triggers the alarm even though it is directly on the frequency of a cancelled signal

of each equal to one-fortieth the total width of the pattern on the scope. This relatively small number of pulses leaves an appreciable triangular residual wherever the pattern slopes steeply, but these irregularities can be smoothed to some extent by shunting the synthesized electrical wave with an appropriate capacitance.

An example of how the system works in the case of a panoramic receiver pattern is shown in Fig. 2. The original pattern that appears on the panoramic receiver screen and initially also on the c-r tube screen of the alarm system is at A, representing pips corresponding to five different carrier frequencies in the spectrum portion being monitored. Neglecting capacitance smoothing, the approximation secured with the 40-control complex wave generator is shown at B. The synthesized wave is reversed in polarity as at C, then combined with the original wave of A to give on the c-r tube screen the resultant pattern at D, in which all parts of the original signal are below the zero axis. It is now possible to establish an alarm threshold for the thyratrons, as represented by the dot-dash horizontal line in D. If two new signals come in, as represented by pattern E, these will combine with the pattern of D to give on the c-r tube screen the new pattern shown at F, in which both signals trip off the alarm.

The approximation obtained in Fig. 2 achieves the desired results of showing new signals clearly above the zero axis and triggering the

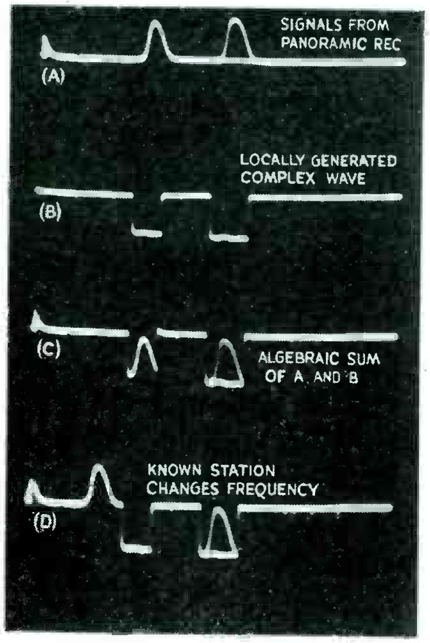


FIG. 3—Reproduction of patterns on screen of c-r tube, illustrating how a shift in the frequency of a signal is readily recognized

alarm, even though the synthesized wave is so crude that patterns are obtained below the zero axis.

Advantages of the System

On and off keying of the original signals does not interfere with cancellation or set off the alarm if the alarm threshold is properly set while all carriers are on. There is only a downward displacement in the pattern when a carrier goes off the air. Similarly, fading of the original signals does not actuate the alarm.

A further advantage is that no portion of the received frequency spectrum is blocked off. For example, if a known carrier is displaced downward and an unknown carrier of the same frequency starts up as illustrated by the first new signal in Fig. 2E, the two will add together and give a received signal of amplitude equal to the sum of the two signals. This peak amplitude will exceed the alarm threshold with respect to the normal horizontal axis.

It is thus seen that the cancellation and indicating system, when used in conjunction with a panoramic receiver or when constructed as an integral part of a panoramic receiver, provides completely automatic operation after the existing known signals have been cancelled out. Several such receiver systems could be monitored by one observer without severe optical strain since he would use the oscilloscope only during the initial setting-up procedure and during those times when the alarm indicated the appearance of a new signal.

The frequencies of several transmitters may be monitored simultaneously. If the frequency of one carrier varied it would be displaced on the time axis of the panoramic scope and rise out of its declivity, ringing the alarm. This is illustrated by the reproduction of actual patterns in Fig. 3.

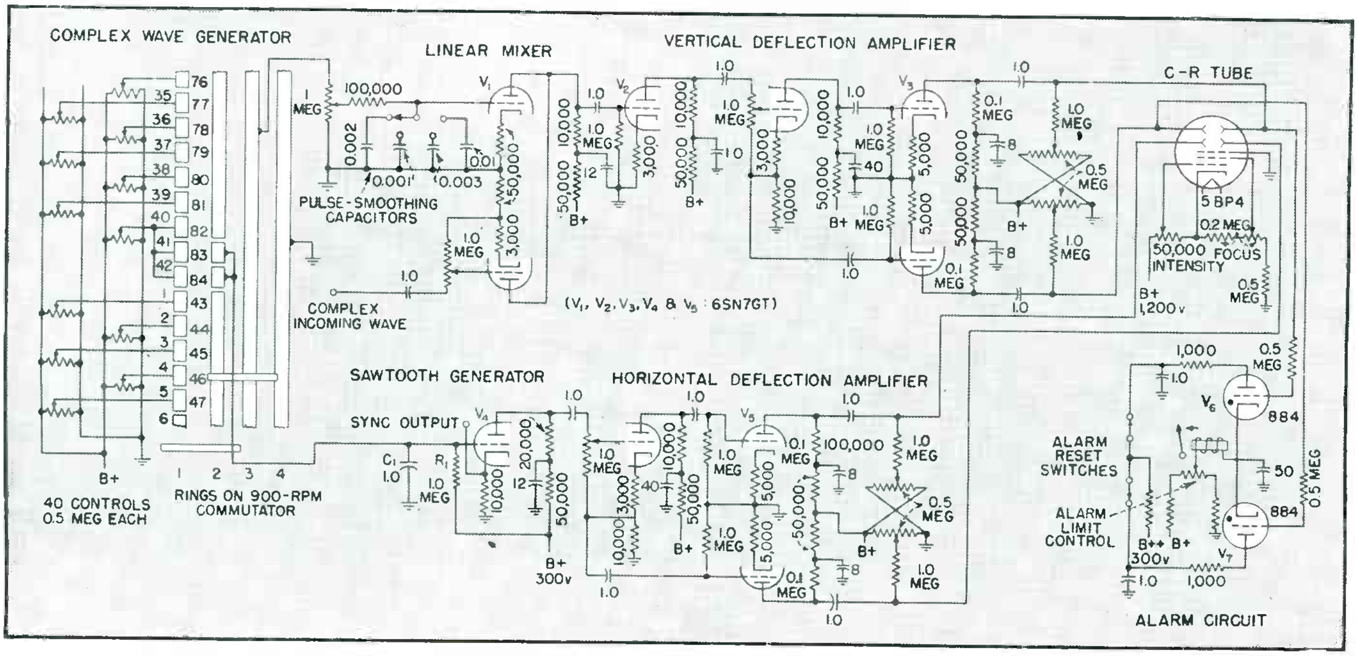
Pulse Generation

One pulse-generating proposal involved using 40 trigger circuits so arranged that each would trip immediately following the preceding one. The number of tube circuits involved was considerable, however, so this method was discarded in favor of a commutator and brush assembly.

Preliminary tests of the commutator brush-arm assembly as a complex-wave generator were carried out using a 42-segment faceplate originally built for telegraph work. In the initial setup, each of 40 of these segments was connected to the movable arm of one of 40 potentiometers. The potentiometers in turn had their respective high-impedance terminals connected in parallel. The remaining two segments were used to provide external synchronizing pulses for a standard oscilloscope. The angular velocity of the rotating brush arm in this case was approximately 15 rps, thus requiring very good low-frequency response in the succeeding amplifiers. This angular speed could not be increased materially without causing noticeable splits between the rectangular pulses unless great care was taken in the adjustment of the brush position.

In its final design, the multi-segment commutator has two solid and

FIG. 4—Circuit diagram of cancellation and alarm system. Power packs (not shown) are of conventional design except for inclusion of an electronic voltage-regulator in the low-voltage supply system. Values of components are in ohms and microfarads unless otherwise indicated



two segmented concentric rings, the outside ring being divided into 84 equal segments. The first 80 are paired by interconnecting diametrically opposite segments to double the fundamental output frequency. Thus, the complex wave output made up of 40 successive rectangular pulses has a fundamental frequency of 30 cps even though the brush actually rotates at 15 rps. The angular speed of the brush is derived from an 1,800-rpm synchronous motor operating through a 2-to-1 step-down gear train. The remaining four segments are used for periodically discharging a capacitor that produces the sawtooth voltage used for horizontal sweep of the cathode-ray tube and for synchronizing purposes.

Monitor Oscilloscope

The circuit diagram of the complete cancellation and alarm system is given in Fig. 4. The monitor oscilloscope follows conventional television technique. All amplifiers have been carefully compensated for low frequencies to insure accurate reproduction of the complex wave. Tubes permitting maximum circuit linearity were selected and their characteristics were further improved by adequate use of degeneration.

The sawtooth voltage used for horizontal oscilloscope deflection and for sweeping the heterodyne oscillator frequency of the panoramic receiver or other external equipment is generated in a simple manner. Capacitor C_1 is charged from the 300-volt supply through resistance R_1 and periodically discharged through commutator rings 2 and 4. The time during which the brush is passing over segments 41 and 42 is used for synchronizing purposes, and appropriate segments are located on commutator ring 2 to achieve discharge in the allotted time. Capacitor C_1 cannot recharge until the start of the first rectangular pulse. This is necessary since if the capacitor were permitted to recharge immediately, a part of the synchronizing time would appear on the oscilloscope screen.

In a push-pull oscilloscope deflection arrangement, one of the deflection plates must go positive with respect to the centering potential for either an upward or a downward motion of the oscilloscope trace. Consequently, by coupling the grids of a pair of thyratrons directly to the vertical plates of the oscilloscope, one thyratron can be biased to ignite on an upward deflection of the electron beam and the other on a downward deflection. The manual setting of the alarm threshold or limit control determines the amount of deflection required to operate the alarm.

The flow of cathode current that is initiated when either one or both of thyratrons V_6 and V_7 are ignited energizes the relay. This relay can be used to operate any type of alarm desired. Since the grid of a thyratron loses control after the tube is conducting, the relay will remain in its alarm position until an attendant opens the alarm switch that interrupts the flow of plate current through that thyratron.

Two power supplies are used, a 300-volt regulated supply for the amplifier circuits and a low-current 1,200-volt supply for the cathode-ray tube.

Coding-Signal Generator

The complex wave generator can approximately duplicate any wave shape having a fixed repetition period. It is therefore an ideal coding-signal generator. In a practical application, the 40 amplitude-control potentiometers might be ten-step voltage dividers numbered 1 to 10. The code designation for a particular wave would then consist of forty consecutive numbers indicating the individual settings of the 40 voltage dividers. The total number of possible combinations is approximately 10^{14}. The modulation signal superimposed on the coding signal would be intelligible only to receiving stations having the same wave generator, with its 40 controls set to cancel exactly the transmitted coding signal.

Electrical Network Analysis

A modification of the complex-wave generator can serve as a teaching aid for both steady-state and transient analysis of electrical networks. Such a unit would include a complex-wave generator, two oscilloscopes, and an assortment of ladder networks. The wave generator can furnish a large variety of wave forms to the inputs of the several networks. The input wave form can be observed on one of the oscilloscopes, and the output response of the networks can be studied individually on the second oscilloscope by appropriate switching.

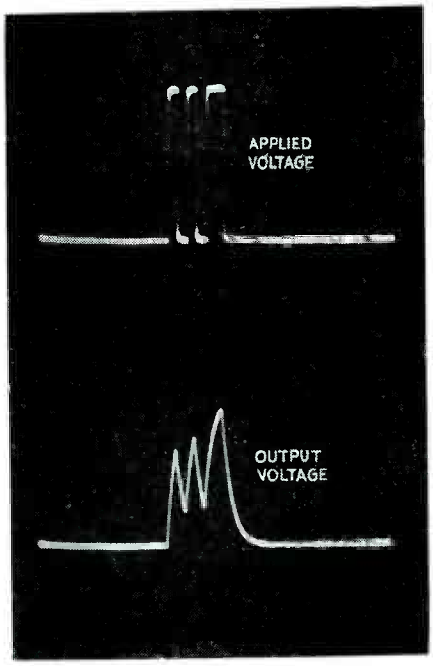


FIG. 5—Reproductions of patterns seen on c-r tube screen when using the system to determine the transient response of an RC network to an applied voltage consisting of three rectangular pulses

Consider a transient problem in which we let the applied voltage consist of three pulses, the last being twice as long as the other two. Mathematically, this problem is quite involved, but the complex-wave generator quickly gives the solution as in Fig. 5. The accuracy here is more than adequate for demonstration purposes.

Other applications include verifying existing mathematical solutions of network responses and deriving approximate responses of complex networks for which no exact solutions have been obtained. The complete system should prove particularly useful for classroom instruction especially when it is necessary to reduce instruction time to an absolute minimum.

Work on this system was carried out in RCA Laboratories, New York City, as National Defense Research Committee Project PDRC-713 under the direction of Dr. H. H. Beverage, Associate Research Director of the Laboratories, with Navy interest and consultation. Insofar as is known, the equipment described was not used in any specific military application.

HYDROGEN THYRATRONS

New fast-deionizing 4C35 and 5C22 thyratrons permit switching rates up to 5,000 per second for line modulator circuit used in keying magnetrons, for pulsed communication systems, for replacing gaps in spark-type electronic heating units, and for high-speed welding

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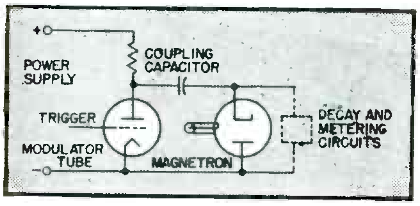


FIG. 1—Simplified circuit of a hard-tube modulator. The low-level trigger pulse is amplified by the modulator tube, normally biased below cutoff and either nonconducting or at voltage saturation to help square up the pulse, then fed to the magnetron through the coupling capacitor

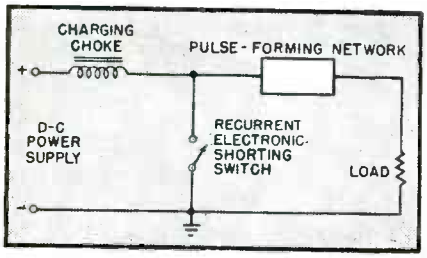


FIG. 2—Simplified circuit of a line modulator. The hydrogen thyratron serves as a shorting switch, closing for the duration of each pulse

AMONG THE MANY new techniques and devices developed as a result of the war effort have appeared hydrogen thyratrons of special design for service in modulators, particularly the pulse modulators of microwave radar systems. In this application these tubes attained a position of considerable importance and by the end of the war were being specified for a majority of the projected radar system designs. The purpose of this paper is to outline briefly the development of two of the most successful of these tubes, their construction and characteristics, and their application to line-type modulators.

It is now well-known that radar utilizes a repetitive series of very short pulses of uhf or microwave radiation to scan the target area. Modulators are used to pulse or key the transmitting oscillators to produce these bursts of r-f power. The briefness of each pulse—with durations of the order of one microsecond—poses special problems in the design of these modulators.

Hard-Tube Modulator

Before the line modulator, particularly as adapted to utilize hydrogen thyratrons, achieved its prominence in radar design, these problems were met by the so-called hard-tube modulator which employed vacuum tubes. In this type of modulator, a basic design of which is shown in Fig. 1, the pulse is formed at low levels to the approximate shape desired and fed to the keyer tube. The resulting amplified and flat-topped high-level pulse is then fed to the magnetron through a capacitor.

Although the hard-tube modulator is capable of producing excellent pulses—indeed, is the only type of modulator which can be used for producing the closely-spaced coded pulses of radar beacon systems—for general search radar it has several disadvantages: (1) The magnetron coupling capacitor is heavy and bulky (since it must have a large value of capacitance to keep the top of the pulse sufficiently flat); (2) The high voltage and current ratings impose harsh requirements on the keyer tubes; (3) Considerable voltage amplification is required to form the low-level trigger pulses.

Line Modulator

The other general type of modulator is the so-called line modulator, to which the hydrogen thyratron is adapted so well. In this type, the pulse is formed directly at high voltage levels as in Fig. 2. A small artificial transmission line, formed of recurrent *LC* networks, charges up between pulses to a very high voltage. Each time the recurrent electronic switch closes, the line releases the stored charge in a surge through the load.

The special design of this line, or pulse-forming network as it is called, is such that this discharge occurs in the desired rectangular pulse shape. The pulse shape and duration are determined entirely by the network;

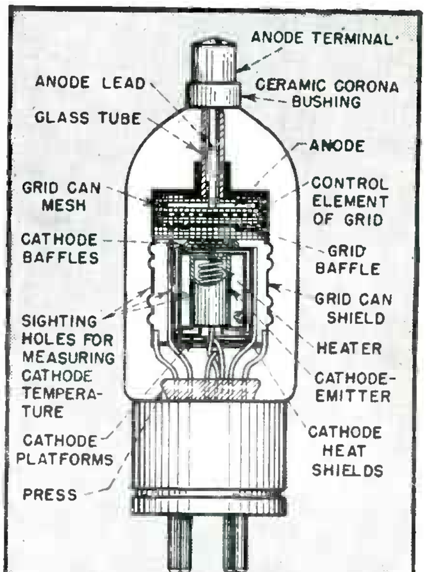


FIG. 3—Construction of type 4C35 hydrogen thyratron

Two typical hydrogen thyratrons

the switch merely initiates the discharge. The switch must close almost instantaneously to achieve a sharp leading edge on the pulse. Although the switch (unlike the keyer tube of a hard-tube modulator) does not have to open as rapidly, since the pulse-forming network controls the pulse behavior once the discharge is started, it must open quickly enough to have no detrimental influence on the charging characteristic or the start of the next pulse.

At the relatively high pulse recurrence frequencies in use (up to 4,000 pps), a rapid deionization time is essential if the switch is to be some sort of gas discharge tube. This type of modulator offers many advantages in regard to simplicity, compactness, and reduction in weight.

Switches for Line Modulators

One of the first switches extensively used in line modulators was the modified rotary spark gap, resuscitated from the early days of wireless. It was noisy and heavy, however, and troublesome as far as life and mechanical maintenance problems were concerned. In addition, it had to be precision-built, and evidenced much time jitter (erratic time variation between successive pulses).

Another form of switch employed was the enclosed fixed spark-gap. These gaps were actually gaseous diodes, being filled with gas at high pressures. Several of these tubes were connected in series to form the switch. Unfortunately, they were characterized by rather low efficiencies owing to their high voltage drops, by excessive trigger requirements, and by restricted voltage operating ranges.

The disadvantages of these early switches led Dr. Germeshausen of MIT Radiation Laboratory to propose in 1942 the use of thyratrons of special design, and to initiate a development program on this project at the Laboratory. Among the advantages which a suitable thyratron would offer were light weight, compactness, ruggedness, simplicity of construction and servicing, stability, flexibility of operation, low tube drop and attendant high efficiency, low grid driving power, low time jitter, and successful operation over a wide range of ambient temperatures (with proper gas fill).

Hydrogen Tube Chosen

The first four advantages are obtained by the choice of a line modulator, but are greatly enhanced by the utilization of a thyratron. Preliminary tests indicated that the above list of advantages could be attained with thyratrons containing hydrogen, and several tube manufacturers were called upon to help complete the development work. The early designs finally crystallized into the type 4C35, later standardized as a JAN type, which operates at peak currents up to 90 amperes with a peak voltage rating of 8 kilovolts.

Shortly after this tube was in production, Sylvania was given a contract to develop a higher-power tube, eventually standardized as the type 5C22. This tube is rated at a peak voltage of 16 kilovolts, and at peak currents up to 325 amperes.

Hydrogen was chosen for the gas fill because of its high ion mobility resulting from its light weight. This factor furnishes the desirable feature of low deionization time, which permits the rapid switching rates that characterize these tubes. Mercury, of course, was automatically ruled out because of its low ion mobility and temperature dependence. In the beginning, helium was also under consideration, for its long mean-free-path would be conducive to high plate voltage ratings. Tubes made with it, however, tended to exhibit cathode deterioration from ion bombardment.

Characteristics of Tubes

The structure of the type 4C35 hydrogen thyratron is illustrated in Fig. 3. The 5C22 is constructed in a similar manner. The anode consists of a circular metal disc fastened to a metal rod, ending in the anode cap at the top of the tube. The grid consists of a cylindrical can which completely surrounds both anode and

Table I — Electrical Ratings of 4C35 and 5C22 Hydrogen Thyratrons

Rating	4C35	5C22
Heater voltage, v	6.3	6.3
Heater current, amp	5.5–6.7	9.6–11.6
Heating time, sec	180	300
Peak anode voltage, kv	8.0	16.0
Peak anode current, amp	90	325
Peak inverse anode voltage, kv*	8.0	16.0
Average anode current, ma	100	200
Pulse duration (measured at 1/2 amplitude), μ sec	6.0	6.0
Pulse repetition frequency, pps**	4,000	
Duty cycle	0.001	0.001
Peak inverse grid voltage, v	200	200
Ambient temperature	− 50 to + 90C	− 50 to + 90C

* In pulsed operation, the peak inverse anode voltage during the first 25 microseconds after the pulse shall not exceed 2.5 kv for the 4C35 or 5 kv for the 5C22.

** The maximum pulse repetition frequency (f_{pr} in pulses per second) will depend on the peak forward anode voltage (e_{py} in volts) according to $(e_{py}^2) \times (f_{pr}) = 2.6 \times 10^{11}$ maximum. Tube may be operated in any position but should be clamped by base only. No cooling stream of air should be directly applied to the tube envelope. Tube should be kept away from strong fields which could ionize gas.

cathode. The latter is a cylindrical structure concentric with the grid can. It consists of an indirectly-heated emitting surface, or cathode proper, surrounded by cylindrical heat shields.

It will be noted that the anode is made closely-spaced from the grid. The spacing is considerably less than the mean-free-path of the hydrogen at the operating temperature. This feature is responsible for the high operating and hold-off voltages. Particular attention was given to the detailed design of the anode seal, since combined temperature and voltage effects could cause cracks in the seal. This would permit a discharge directly from the anode to the grid structure, with consequent loss of control of the tube.

The actual control element of the grid structure is the perforated disc below the anode. A baffle is mounted beneath this disc. For the final design an equipotential cathode with radiation baffles was adopted in order to avoid the difficulty with hot spots which occurred in the original directly-heated cathodes. A considerable increase in heating time results with this type of cathode, but many advantages accrue which overbalance the slight disadvantage of a longer heating time.

The mechanism of firing seems to be as follows: When the trigger pulse is applied, grid current begins to flow as a trigger voltage builds up. When this current has reached the required value, a plasma is established in the grid-cathode region. The electric field from the anode, being so intense, then causes a diffusion of electrons over to the grid-anode region. Almost immediately a plasma is established in this region, followed by an arc from anode to cathode.

A summary of the ratings on the type 4C35 and 5C22 hydrogen thyratrons is given in Table I. Recent tests indicate a life of nearly 2,000 hours for these tubes, and research now under way on cathode techniques may result in even better life figures. The 5C22 has been operated at repetition rates of 1,000 to 5,000 per second using 8 kilovolts and 75 amperes peak current, and the 4C35 has operated at frequencies over 100,000 cps at fairly low voltages and currents. For comparison, radar systems employ pulse recurrence frequencies from 100 to 4,000 pulses per second, pulse widths from 0.1 to 6.0 microseconds, peak thyratron anode voltages from 1 to 30 kilovolts, and peak powers from 5 to 3,000 kilowatts.

Hydrogen Thyratron Circuit

A practical circuit utilizing a hydrogen thyratron is shown in Fig. 4. The load in this case happens to be a pulse transformer and magnetron oscillator. The step-up pulse transformer permits magnetrons to be operated at higher voltages than the maximum thyratron voltage ratings, a fact that is aided by the high peak current capabilities of the tubes, and matches the magnetron impedance to that of the pulse-forming network. The pulse cable permits the oscillator to be located in a position remote from the modulator.

Since the anode of most magnetrons must be integrally connected to the coaxial or waveguide output transmission line, for safety reasons the anode is maintained at ground potential. This would require a filament transformer insulated for full peak voltage. By utilizing a pulse transformer with a bifilar secondary winding, a magnetron filament transformer with low insulation requirements can be used.

The pulse-forming network consists of a series of small LC sections connected in tandem to form a recurrent-network artificial transmission line open-circuited at the far end. Although many networks may be used to produce a wide variety of pulse shapes, for radar purposes from three to seven similar sections are generally used. This network charges up between pulses when the thyratron is off, and discharges in a rectangular pulse when it fires.

Network Discharging Action

If the network is charged to a voltage E, the short-circuit set up by the firing of the thyratron suddenly causes the voltage across the network terminals to drop from E to $+E/2$ and causes a voltage $-E/2$ to appear across the load. This sudden voltage change at the network terminals surges down the transmission line, is reversed and reflected at the end, and travels back to neutralize the voltage at the network terminals, as shown in the voltage profile along the pulse-

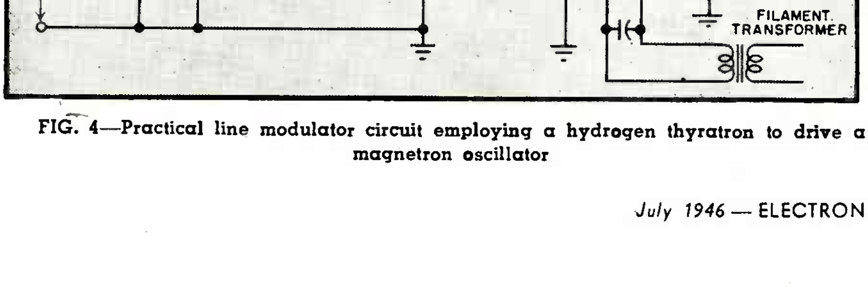


FIG. 4—Practical line modulator circuit employing a hydrogen thyratron to drive a magnetron oscillator

forming network at various instants of time (Fig. 5A). The terminal voltage stays at $E/2$ while the voltage surge is traveling along the line, as in Fig. 5B. Thus, there is produced the rectangular current pulse of Fig. 5C, with a duration depending on the length of time it takes the surge to travel down the line and back. By varying the number of sections or by changing the values of L and C in a manner consistent with other requirements, the pulse width may be varied as desired.

The cancellation of voltage at the terminals when the surge returns is perfect if the load impedance is equal to the characteristic impedance of the line. If the match is not perfect, there will be multiple reflections and re-reflections in the line until the surge energy has been completely dissipated. The load voltages for such cases are shown in Fig. 5D and 5E.

Network Charging Action

For the charging phase of the operation of the line modulator, the network inductances are so small compared to the charging choke, which is measured in henrys, that we may neglect them. The equivalent circuit is then as in Fig. 6A. In such a circuit, if we open switch S (no initial inductance current), the voltage across the switch will follow the well-known behavior of Fig. 6B.

In the so-called resonance charging, the inductance is chosen to resonate with the network capacitance at a frequency one-half that of the pulse recurrence frequency in use. The voltage waveform across the thyratron or switch S is then as in Fig. 6C, a repetition of the portion AB of the transient in Fig. 6B. This portion is essentially one-half a period of a sine wave.

In the so-called linear charging, the inductance is greater than that required for resonance at the frequency in use, and the thyratron voltage waveform approaches the saw-tooth pattern of Fig. 6D as the inductance is increased.

A third method of charging, the so-called diode charging, utilizes a small hold-off diode in conjunction with an inductance less than that required for charging at the frequency in use, as in Fig. 6E. The diode keeps the voltage from dropping off after the peak has been reached, giving the output voltage waveform of Fig. 6F.

Design of Charging Choke

Since in practice a modulator is frequently designed to operate at several combinations of pulse repetition frequencies and pulse lengths, a common arrangement is to employ a choke which is resonant at the lowest repetition frequency desired. This will then provide linear charging at the higher frequencies. The current through the charging choke periodically reaches zero with resonance and diode charging, but does not with linear charging, where constant current is approached. It should be pointed out that the current passing through chokes for resonant and diode charging has very high a-c components, so that these chokes differ markedly in design from the usual filter chokes, which are designed for currents having small a-c components superimposed on a large direct current.

Because of the electrical inertia of the inductance, the thyratron anode voltage swings up above the power supply voltage in the periodic transients described. The peak voltage reached by the thyratron is approximately twice that of the power supply voltage. The actual voltage across the load (into the pulse transformer, if employed) is about one-half that of the network peak voltage, and about equal to that of the supply.

Magnetron Sparking

The information in Table II may be of help in designing a radar line modulator using a hydrogen thyratron to drive a magnetron. When the magnetron oscillator is employed as the modulator load, the phenomenon of magnetron sparking must be carefully considered. This sparking consists of intermittent transient gaseous discharges due to gas liberated in the tube from such sources as the cathode or by field emission from the metal parts. Most magnetrons spark when first operated after an appreciable time of inoperation. This type of sparking usually cleans up after the first few minutes of operation. In the case of high-powered magnetrons, it occurs throughout life and, if the sparking rate is not excessive, does not cause any harm in the system performance.

When a magnetron sparks, the impedance match of the network and load is destroyed, since the magnetron is practically a short circuit. The network is left with a negative charge, so that, depending on the degree of mismatch, the succeeding pulse can recharge the network to 3 or 4 times the normal peak thyratron voltage. Thus, with high-power magnetrons, and particularly with long pulse widths (where the network capacitance energy storage is high), the modulator circuit components must be protected. This protection is usually provided by a shunt diode connected across the network or across the thyratron, as in Fig. 7A and 7B. With a suitable diode, the inverse voltage developed across the network is rapidly discharged and the peak network voltage held substantially constant on the succeeding recharge cycle.

Deionization Time

At high repetition rates at or near maximum peak currents, considera-

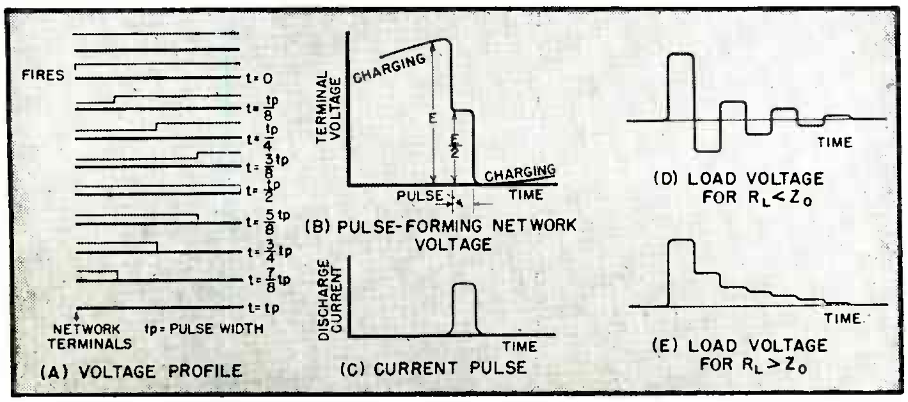


FIG. 5—Voltage and current waveforms in a line modulator circuit

tion must be given to the deionization time when the tube shuts off. If the anode voltage increases too rapidly, the cathode-grid region may not be sufficiently deionized before the anode voltage attains a value capable of reigniting the discharge. Under extreme conditions, the tube may fire itself at a rate sufficiently high to overload the average current capabilities of the power supply and kick out the overload relay. Without any additional techniques, resonance charging would be the preferred type of charging where rapid deionization is a factor, because its waveform is such as to keep the anode voltage low immediately after the pulse.

Where deionization must be considered, however, it is customary to introduce deliberately a slight mismatch to the network to provide an inverse anode voltage. By the time that the anode voltage has then reached the level where it might reignite the discharge, deionization is sufficiently complete to prevent reignition. The inverse voltage may also be produced by inserting an inductance of the order of a few microhenrys in the anode lead of the thyratron. The use of a negative grid bias, by sweeping out the positive ions remaining in the cathode-grid space immediately after a pulse (either alone or together with the aid of inverse voltage), is advantageous at high repetition rates.

Trigger Voltage Requirements

Although most tubes will fire with trigger voltage amplitudes and durations considerably lower than the minimum specified, the specifications were set conservatively to insure satisfactory triggering under all conditions. The specified JAN trigger is shown in Fig. 8. Practically all tubes will fire with a 100-volt, 2-microsecond trigger. Some tubes, however, require a trigger with a moderate amplitude and length for initial starting; after firing, the trigger can be reduced to 50 volts amplitude with satisfactory operation on most tubes.

With the specified trigger the time delay will vary from 0.5 to 0.9 microsecond for all tubes on both the 4C35 and the 5C22. Time delay here is the time from the start of the trigger pulse to the firing of the anode. It will vary greatly with changes in trigger voltage amplitude and rate of rise, whereas it is only slightly affected by changes in anode voltage or trigger output impedance. Where time delay is important, it is then possible by using a stiffer trigger pulse to reduce both the time delay and the spread in time delay from tube to tube.

As an example, a trigger with an amplitude of 200 volts, a rate of rise of 800 volts per microsecond, and an output impedance condition of 500 ohms will reduce the time delay to 0.2 to 0.6 microsecond. This stiffer trigger will also reduce the time jitter (variation of time delay from pulse to pulse for a single tube under given conditions). The maximum time jitter with the minimum specified trigger is 0.04 microsecond, a value that will be reduced to about one-half as much with the recommended stiffer trigger.

It has been found that using d-c power on the heater will reduce the jitter to a negligible amount regardless of the trigger pulse shape. This indicates that the jitter is caused by the effect of the magnetic field of the heater coil on the grid current. The time jitter in these tubes is so low as to be negligible for ordinary purposes, but it seems likely that a reverse coil type of heater, in which the magnetic field is greatly neutralized, would provide a jitter-free tube for an a-c filament source if desired. A comparison of a trigger pulse shape meeting specifications and one recommended for minimizing time delay and jitter is shown in Fig. 8.

A capacitance is usually employed for feeding the trigger to the grid, with a resistance or inductance as the grid-leak impedance element. Under certain conditions, the anode voltage may cause the grid to become positive during some part of the charging cycle, through the coupling of the anode and grid circuits by the grid-anode tube capacitance. Premature firing could occur. For this reason, when a resistance is used it should not exceed 20,000 ohms, and the coupling capacitor should not be less than 0.05 microfarad. It is generally desirable to use an inductance since this will prevent the grid voltage from rising during the charging cycle. A value of 5 to 25 millihenrys will be found satisfactory. An inductance is particularly preferable when grid bias is used to aid deionization, and it should be kept as low as possible consistent with maintaining the trigger pulse shape dictated by the minimum specifications or by time delay considerations.

Trigger Generator Circuit

A simple and compact two-tube trigger generator designed by R. Fricks which meets all the requirements of the trigger specifications is presented in Fig. 9. It was developed for a short-range navigational radar set and has proven to be quite stable during power supply variations. Frequency control may be obtained by

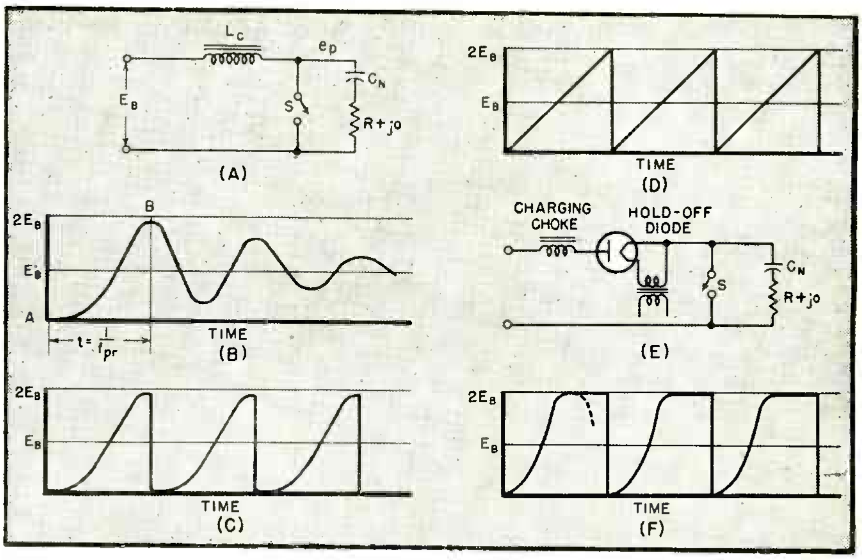
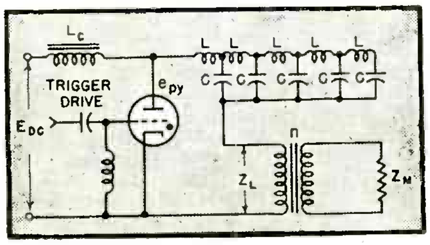


FIG. 6—Equivalent circuit of line modulator in charging phase (A), voltage waveform across switch after closing (B), resonance charging voltage waveform across thyratron (C), linear charging voltage waveform across thyratron (D), circuit for diode charging (E), and diode charging voltage waveform across thyratron (F)

Table II—Line Modulator Design



f_{pr} Pulse repetition rate
t_p Pulse width
e_{py} Peak thyratron forward anode voltage
e_{pz} Peak thyratron inverse anode voltage
I Average thyratron anode current
i_b Peak thyratron anode current
I_M Average oscillator anode current
i_M Peak oscillator anode current
C Network section capacitance
N Number of network sections
C_N Total network capacitance
L Network section inductance
P_p Peak load power
P_A Average load power
Z_L Transformed load impedance
Z_M Oscillator impedance
Z_N Network characteristic impedance
e_m Oscillator efficiency
E_L Peak load voltage
E_M Peak oscillator voltage
P_{op} Oscillator peak r-f power
P_{oa} Oscillator average r-f power
$E_{d\text{-}c}$ D-C power supply voltage
L_C Charging choke inductance
n Pulse transformer turns ratio

$$Z_N = (L/C)^{1/2}$$
$$t_p = 2\,N\,(LC)^{1/2}$$
$$i_b = \frac{e_{py}}{Z_N + Z_L} = \frac{e_{py}}{2Z_L} \text{ for load matched to network}$$
$$P_p = \left(\frac{e_{py}}{Z_N + Z_L}\right)^2 Z_L = \frac{e_{py}^2}{4Z_L} \text{ for load matched to network}$$
$$P_A = \frac{e_{py}^2}{4Z_L} f_{pr}\, t_p \text{ for match}$$
$$P_{op} = P_p e_m \qquad I = i_b f_{pr}\, t_p$$
$$P_{oa} = P_A\, e_m$$
$$E_L = \frac{e_{py}}{Z_N + Z_L} Z_L = \frac{e_{py}}{2} \text{ for load matched to network}$$
$$E_M = n^2 E_L$$
$$n^2 i_M = i_b$$
$$e_{py} \leqq 2\,E_{d\text{-}c}$$
$$f_{pr} = \frac{1}{\pi\,(L_C\,C_N)^{1/2}} \text{ for resonance charging}$$
$$L_C > \frac{1}{\pi^2 f_{pr}^2\, C_N} \text{ for linear charging}$$

varying the time constants of the multivibrator coupling circuits.

During the establishment of a plasma in the grid-anode region when the tube starts to fire, the grid potential is raised to a very high voltage for a few hundredths of a microsecond. The so-called grid spike of Fig. 10A results. It does not have much energy, but can radiate noise and also interfere with the operation of certain types of trigger circuits.

In some cases, it may be desirable to attenuate the action of the spike voltage on the trigger circuit. A low-pass filter can be readily designed to pass the grid voltage into the thyratron to prevent the spike from getting back into the generator. When such a filter is used, components rated at high voltage should be specified because of the high transient voltages involved. A t-r gas switching tube can also be used, although a gas diode with an ignition potential of the order of 300 to 400 volts may be connected across the thyratron grid and cathode. Typical grid potential curves appear in Fig. 10A and 10B.

Tube Life

During the early period of the development of the 4C35, the life was found to decrease markedly with increase in the rate of rise of the anode current. It was found that this could be overcome by improved processing techniques, and it was then thought that no limit on the rate of rise of anode current was required. Subsequently, it became apparent on the 5C22, however, that the rate of rise was important in connection with tube dissipation.

During the ionizing time of the tube, the anode potential is decreasing at an extremely rapid yet finite rate. If the anode current is permitted to rise at a high rate during this time, then the tube dissipation will be increased. It has been confirmed that, at a constant duty cycle (pulse recurrence frequency multiplied by pulse width), the average dissipation is almost a linear function of the repetition rate; this is the reason for the maximum rating of $e_{py}^2 \times f_{pr}$.

In many cases, the ceiling on the rate of rise may be set by the requirement of satisfactory operation of the oscillator, but in any event it is wise to limit it to a value consistent with satisfactory overall system performance. At low repetition rates, the tube dissipation will be low and, since a portion of the dissipation causes cathode heating, the pulse cathode temperature may be lower than normal. Under these conditions (particularly at high peak currents), a fast rate of rise may result in cathode sparking in the thyratron. This condition can be considerably aggravated by the stray capacitance to ground of any of the circuit components connected to the anode. This capacitance is charged to full peak anode voltage. When the tube fires, this stray capacitance may discharge through the thyratron and not through the network load circuit. The resultant spike on the leading edge of the pulse causes the sparking. An inductance of a few microhenrys in the anode lead will be useful in limiting the rate of rise, and

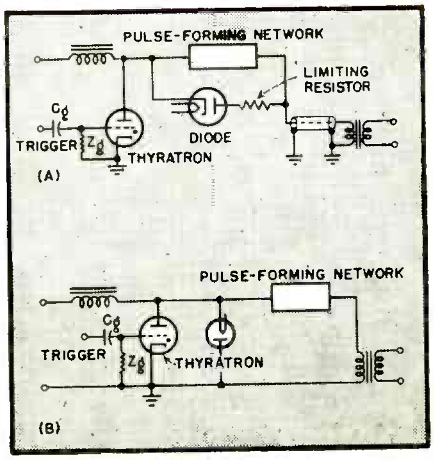


FIG. 7—Two circuits for protecting a line modulator against magnetron sparking

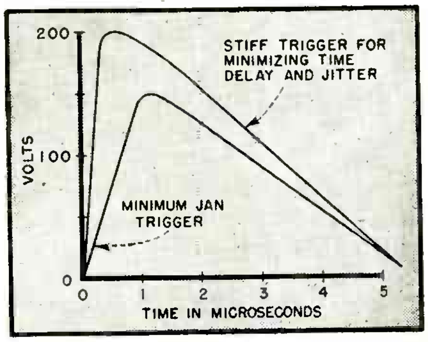


FIG. 8—Recommended open-circuit trigger voltage shapes

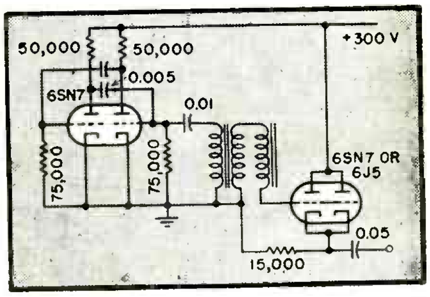


FIG. 9—Compact trigger generator circuit recommended for use with 4C35 and 5C22 hydrogen thyratrons

will not seriously distort the pulse unless it is extremely short.

The heating time of the 4C35 and 5C22 are three and five minutes, respectively, but the heating time may be reduced by increasing the applied heater voltage during the warm-up period. After the heating period the full anode voltage may be applied abruptly.

Frequency Considerations

Because of the pulsing of the magnetron, it does not furnish r-f power output at a single frequency, but over a continuous spread of frequencies closely spaced about a center value as shown in Fig. 11. If this spread is too great, much of the r-f output energy radiated may be useless, because the narrow bandwidth of the receiver limits the frequencies it can detect.

One factor which can contribute to such excessive broadening of the spectrum is a poor voltage pulse shape applied to the magnetron. This results in both frequency and amplitude modulation. The high pushing figures (instantaneous rates of change of radio frequency with respect to magnetron plate current) of some magnetrons place stringent requirements on how uniform and constant the top of the voltage pulse should be throughout the duration of the pulse. Although the static magnetron impedance is about 1,000 ohms, the low dynamic impedance (50 to 100 ohms in some cases) emphasizes any variation in this voltage, as illustrated in Fig. 12, and greatly deteriorated spectra result.

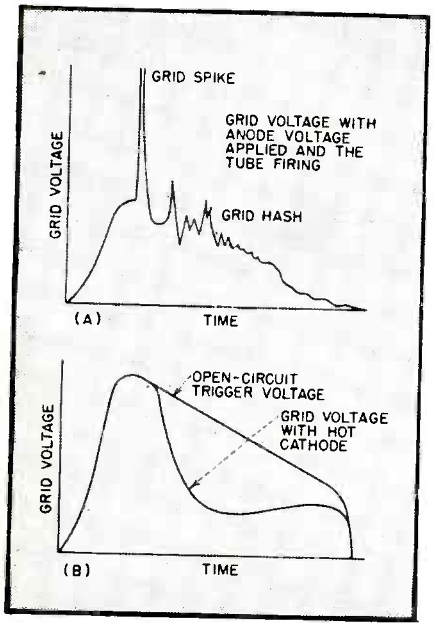


FIG. 10—Typical grid potential waveforms in trigger generator circuit

Hydrogen thyratrons may be operated successfully in parallel and series to increase the peak network voltage or peak current.

Industrial Applications

In addition to the radar applications for which the hydrogen thyratron was originally designed, there are many places where the light weight, simplicity, flexibility and ease of operation, high voltage and current capabilities, and the rapid switching performance of tubes of this type will be of value. In pulsed communication systems, in microwave local heating of glass or plastic, and in dielectric heating it has excellent possibilities. The replacement of rotary spark gaps in radar by thyratrons logically suggests the adaptation of these tubes to spark-gap induction heaters. A small 500-watt induction heater using a single thyratron has been constructed. It gave high efficiency, with an output readily controlled by adjusting the drive frequency. This suggests possible special applications for diathermy and electrosurgical equipment.

The accurately spaced pulses obtained by using pulse techniques suggest use in high-speed welding. The fact that the tube is off between pulses would permit recovery time to avoid depolarization effects in electroplating in a properly-designed system.

The rapid deionization time lends itself to employment in high-speed oscilloscope sweep circuits and to servomechanisms and motor controls where rapid switching is a factor of importance.

In a light-modulator circuit with a pulser similar to that described, a hydrogen thyratron was used to flash a gas discharge tube at frequencies between 5,000 and 6,000 times per second. Intense short-duration light flashes obtained in this way can be utilized with a uniform film motion for study of high-speed motion.

Acknowledgments

This article is based in part upon work performed for OSRD under Contract OEMar-999. Throughout the entire hydrogen thyratron program, the MIT Radiation Laboratory worked closely and cooperatively with Sylvania. Thanks are due particularly to Dr. K. J. Germeshausen for assistance in tube problems and to Mr. S. J. Krulikowski for considerable aid in connection with development of the rather intricate testing techniques involved. Appreciation is also expressed to the Evans Signal Laboratory for their cooperation in the development of the 5C22, especially to Dr. G. G. Kretschmar of the Thermionics Branch.

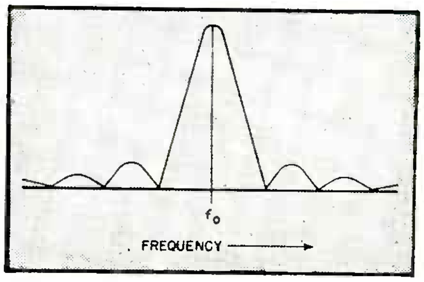


FIG. 11—Radio-frequency output spectrum of an oscillator pulsed by a rectangular pulse, as computed by Fourier analysis. At 10,000 mc the spread of the central lobe is of the order of a few megacycles

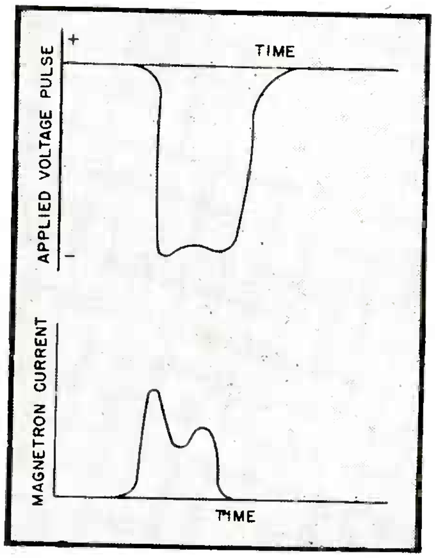


FIG. 12—Effect of a poor voltage pulse on magnetron current pulse shape, showing how a slight irregularity in the bottom of a voltage pulse is magnified in the current pulse

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Front panel of commercial single-channel cathode-ray oscilloscope as modified for the new 5SP double-beam tube by addition of five controls, a switch and an extra pair of X and Y binding posts alongside the tube. The tube projects forward from the panel due to its own length, use of an adapter socket, and a one-inch halo-eliminating plate glass in front of the tube face

Double-Beam C-R TUBE In Biological Research

New cathode-ray tube offers many advantages for simultaneous observation and recording of two or more fast transient phenomena such as nerve potentials. Simple method of modifying a DuMont type 247 oscilloscope to use the type 5SP double-beam tube is given

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ALTHOUGH recording by moving-element oscillographs (mirror and pen) has commonly been multichannel, cathode-ray oscillography in physiological laboratories has rarely involved more than a single channel, effectively limiting observation in most cases to a single event or locus of activity in the system under study at one time. This is accountable on the basis of the inconvenience of observing and photographing from several separate cathode-ray tubes.

The limitation is especially regretable because the cathode-ray tube is the most faithful recording medium available to the physiologist. This has meant that in many laboratories problems in low-frequency phenomena (below 100 cps) could be easily attacked with the advantage of multiple simultaneous observations by using ink-writers, while problems involving faster transients could not.

In general, the limitation has been taken for granted, but in retrospect it can be seen that many demonstrations would have been easier, better controlled, or more revealing if simultaneous recording at more than one point had been possible.

These considerations apply especially to the field of neurophysiology, which deals with potentials in nervous tissue involving frequency components up to and above 10,000 cps. For muscle potentials and brain and heart waves the electronic switch has been used, but commercially available types do not raise greatly the useful frequency limit over that of good ink writers, at least for the nonrecurrent signals of concern to the physiologist. For some applications multielement moving-mirror oscillographs have been used but they have not found wide favor among physiologists, in part because of expense and the inconvenience of visualization and of recording with expanded time scale.

Double-Beam Tubes

A significant new tool is made available with the release of the first commercial double-beam cathode-ray tubes made in this country. English-made single-gun split-beam tubes have been in use for several years in a few continental and British physiological laboratories. The American two-gun tubes differ in the possibility of independent beam

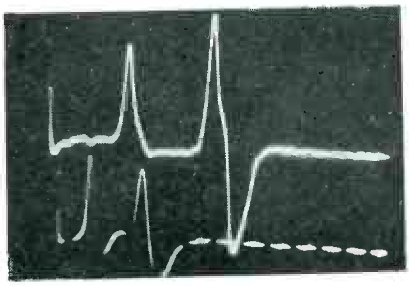

FIG. 1—Nerve impulses in giant fibers of the earthworm

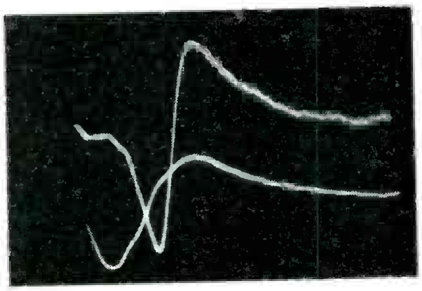

FIG. 2—Simultaneous recording of two potentials in cortex of brain under Dial narcosis, using one-fifth second sweep

modulation and horizontal deflection as well as push-pull vertical deflection.

Some of the uses of this new cathode-ray tool in experimental neurology and related fields will be pointed out, and one convenient method of using such a tube in existing oscillographic equipment will be described. Complete dual-channel oscillographs for the American two-gun tubes are being designed and will doubtless be available in the near future.

Double-Beam Applications

Probably the commonest situation in which dual-channel cathode-ray recording will be used is in the simultaneous checking of two points within the same system. This may be for one of several purposes.

An essentially qualitative comparison of the nature of electrical activity at locus B when locus A is active in a certain pattern is a common problem. Sometimes a more quantitative comparison may be needed, such as the voltage at locus A in relation to that at B, or time relations at these points. The dual-beam c-r tube lends itself especially to the determination of time or phase relations of transients requiring time axes expanded too greatly for convenient moving film (mirror galvanometer), ink writing, or electronic switch recording. Here the triggered sweep is used, initiated by an outside source bearing some relation to the transient or initiated by the transient itself.

An example of initiation by an outside source related to the

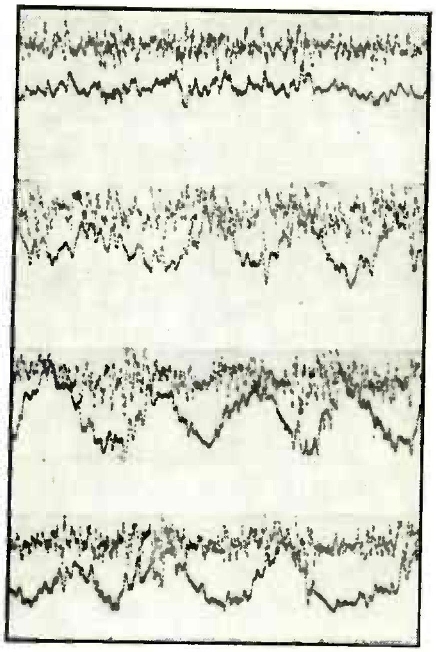

FIG. 3—Recordings of the same potential with different filtering, taken at four different times to illustrate effect of sudden light on eyes of a grasshopper

transient is shown in Fig. 1. In the upper record a small electric shock (seen as the first deflection) is delivered to the nerve cord of an earthworm and the impulses in its two giant nerve fibers are picked up at measured distances from the site of stimulation by pairs of fine wire electrodes, the nearer pair leading to the lower beam, the pair farther away to the upper. The lower beam is modulated by a 1,000-cps signal which serves to time both beams since they are swept together.

An experiment representing the case in which a transient, which is not produced by a shock and is therefore unpredictable in time, triggers its own sweep and records significant comparison of the activity at another point during the same interval is shown in Fig. 2. These are spontaneously occurring, synchronized discharges of many nerve cells induced by local application of strong strychnine to the cerebral cortex. Two pairs of electrodes pick up the activity at two loci on the cortex and the sweep is triggered by a certain downward deflection of the lower beam.

Checking Vision of Grasshopper

A quite different application is illustrated in Fig. 3. Here the activity at the same locus is treated differently, by bandpass filters in the two amplifying channels. Two aspects of the same activity, otherwise not readily observed at the same time, may be studied for phase and other relations. This will apply particularly to problems involving slow and fast component activity of widely different amplitudes. In the experiment illustrated, potentials are picked up by a single pair of electrodes on the head of a grasshopper and passed through two amplifiers. One amplifier filters out low frequencies and permits a higher gain setting to visualize the small, fast activity (upper channel), while the other amplifier passes both slow and fast components (lower channel). The top record shows activity in the dark. The next three were taken at intervals after illuminating the eyes and reveal a certain partial synchronization of the small spike-like activity with the phases of the large slow waves. The record was made

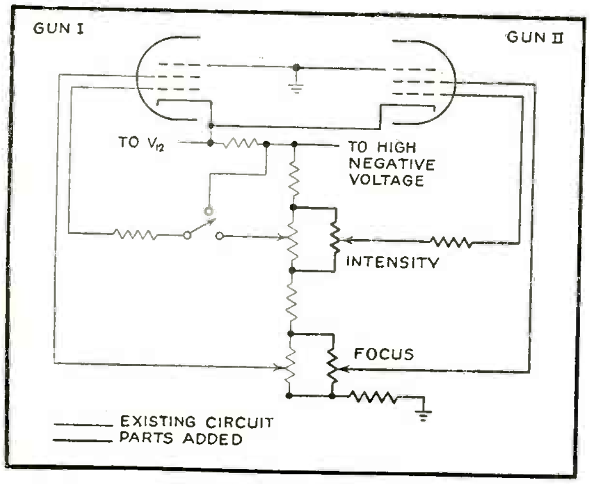

FIG. 4—Heavy lines show components added to DuMont type 247 oscilloscope for contact of extra gun

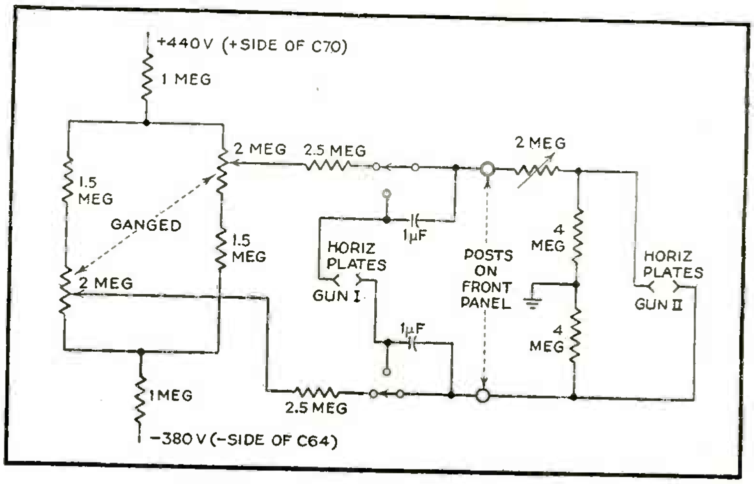

FIG. 5—Components added to type 247 oscilloscope for horizontal switching and for positioning of extra electron beam independently of normal beam

with a commercial electronic switch and shows the limitations imposed thereby for transient studies. It is seen that a serious loss of detail in the fast activity is suffered. Even at moderate film speeds, therefore, a double beam may be desirable.

Modifying a Standard Oscilloscope

For the greatest flexibility the two beams should be controlled by completely duplicated accessory circuits but the following method of using a two-gun tube with a single-channel oscilloscope of an existing type sacrifices few features and should fill the requirements of many applications. The oscilloscope available was the DuMont type 247 whose power supply is capable of operating

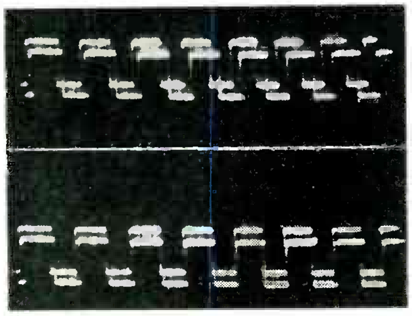

FIG. 6—In the upper pair of traces, both beams are deflected by the same sweep voltage but one gun is more sensitive than the other. Lower traces show how this has been corrected by slight attenuation of the faster beam and use of an independent position control

both guns of the type 5SP tube. It is only necessary to add, as in Fig. 4, potentiometers in parallel with the existing ones for focus and intensity control of the extra beam. It may be necessary to move one or both sets of potentiometers up or down the high-voltage bleeder a little. The proper position is easily determined by trial.

The horizontal plates of both guns may be connected to the sweep circuit of the type 247 or one beam may be swept from an outside time base circuit. One beam then will have the vertical amplifier provided in the oscilloscope, while the other must be deflected directly. In physiological applications this is generally easy since the specially built preamplifiers required for most recording are ordinarily capable of deflecting a cathode-ray beam directly.

In the case where both beams are swept by the oscilloscope time base circuit the beams will be automatically locked together, single sweeps will be initiated at the same instant for both beams, and the automatic beam blanking which extinguishes the spot between single sweeps operates for both spots. If the horizontal deflections are arranged to be of the same length, then the sweeps will be perfectly synchronized so that regardless of imperfections of linearity or slight changes in sweep speed, corresponding points on the two horizontal axes will always represent the same instant of time.

Position Controls

Since the neutral positions of the two spots will probably not fall on the same vertical line, it is desirable to provide a separate position control for the extra beam. In the tube tested in this laboratory the neutral positions are less than 0.1 inch apart horizontally so that for many purposes this can be neglected or corrected for. The two pairs of horizontal plates can then be direct coupled and the position control provided in the oscilloscope can be used to control both beams.

Where it is necessary to position the beams independently this can be done as in Fig. 5 by throwing a switch, capacitively coupling the extra beam with the oscilloscope sweep circuit and introducing a positioning voltage derived from the low-voltage supplies. It is now possible not only to correct for slight misalignment of the spots but to displace the beams relative to each other intentionally. Even if only the former is desired the available positioning voltage must be great enough to move the spot not 0.1 inch but 2 inches or more in order to put the start of the single sweep at the left. The capacitive coupling of the sweep

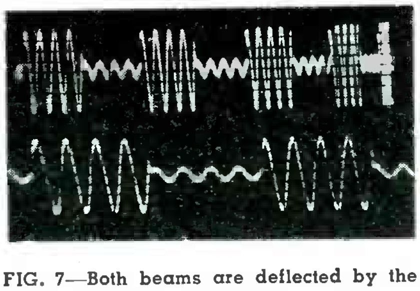

FIG. 7—Both beams are deflected by the same signal here, but one sweep is compressed by attenuating the sweep voltage

necessarily results in temporary interaction of the beams but this happens only at the moment of manipulating the position control.

Obtaining Two Writing Rates

It is likely to be found that the deflection sensitivities of the two guns are not identical. In this case a control must be added to attentuate slightly the more sensitive gun, as in Fig. 6.

It will be noted that by attenuating considerably the extra beam and increasing horizontal gain so that this beam is deflected full scale (the other beam now going far off-screen), the writing rates of the two spots can be made quite different. Though starting together—at the same left position, or not, as desired—one will show what is hap-

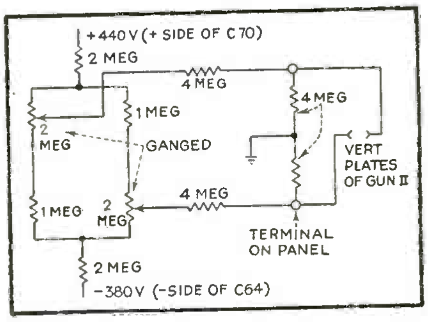

FIG. 8—Components added to type 247 oscilloscope for vertical positioning of the extra beam. The source for vertical deflection must tolerate a d-c voltage and must not be too low in resistance

pening in the vertical axis for a relatively long period, the other will expand a portion of this time for more detailed observation, as in Fig. 7.

The final control added to the oscilloscope was for vertical positioning. This could be done externally. As shown in Fig. 8, it is not independent of the resistance of the external circuit providing the vertical deflection, but unless that is very low it will bring the beam far enough off center to provide a satisfactory separation of the two sets of signals.

All the additions are easily made and inexpensive, do not change any of the critical adjustments of the oscilloscope circuits, and permit ready return at any time to the usual single-beam tube.

The biological research work described here was aided by a grant from the University of Missouri Research Council.

Electronic FIRE and

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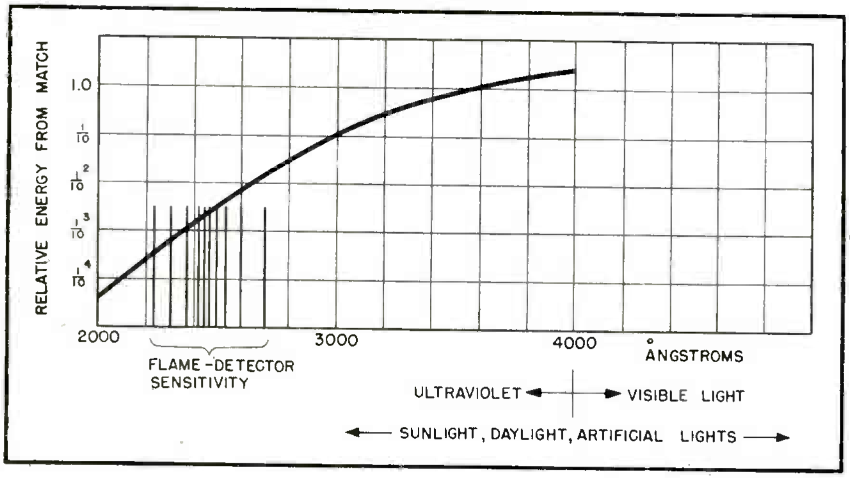

FIG. 1—Spectral distribution of sunlight, daylight, artificial light sources, energy radiated from a match, and sensitive region of flame detector

STUDY of the spectral constituents of light sources encountered in every-day life shows that ultraviolet radiation is rarely found. Even near ultraviolet radiation, wavelengths between 3000 and 4000 Angstroms including the "tanning" range, must be sought either in direct sunlight under favorable atmospheric conditions or from especially constructed ultraviolet lamps. Radiation at wavelengths still shorter than 3000 Å (the far ultraviolet) is still rarer, and special devices such as arc lamps and quartz-enclosed discharge tubes must be used for their production.

Most light sources emit light of wavelengths far into the infrared as well as into the far ultraviolet, the amount depending only on the temperature of the source. However, in the case of sunlight, the earth's atmosphere (presumably its ozone content) acts to absorb ultraviolet light so strongly that we find essentially no energy below 3000Å, this being particularly so for daylight or diffuse sunlight. In artificial sources, any ordinary glass enclosure will immediately eliminate radiation below about 3300Å even though the source itself, the tungsten filament, may be hot enough to radiate quanta in the far ultraviolet region.

In the case of unprotected fire, flames, or sparks, however, all the radiation emitted is free to radiate without an ultraviolet absorber, other than whatever absorption takes place in the surrounding air. While the amount of far ultraviolet, below 3000Å, is determined by the laws of temperature radiation, its presence differentiates such sources as open fires, flames, sparks, and electric arcs from sources of illumination and otherwise ever-present daylight. It is this radiation which is utilized in a new electronic fire-detector* which is practically instantaneous in response, and has proved to be sensitive to minute sources of fire or sparking.

Magnitude of Basic Effect

The demands made on a detecting system which is to operate on the above principle can best be estimated by applying the law of temperature radiation to a source such as an ordi-

* Patent applied for

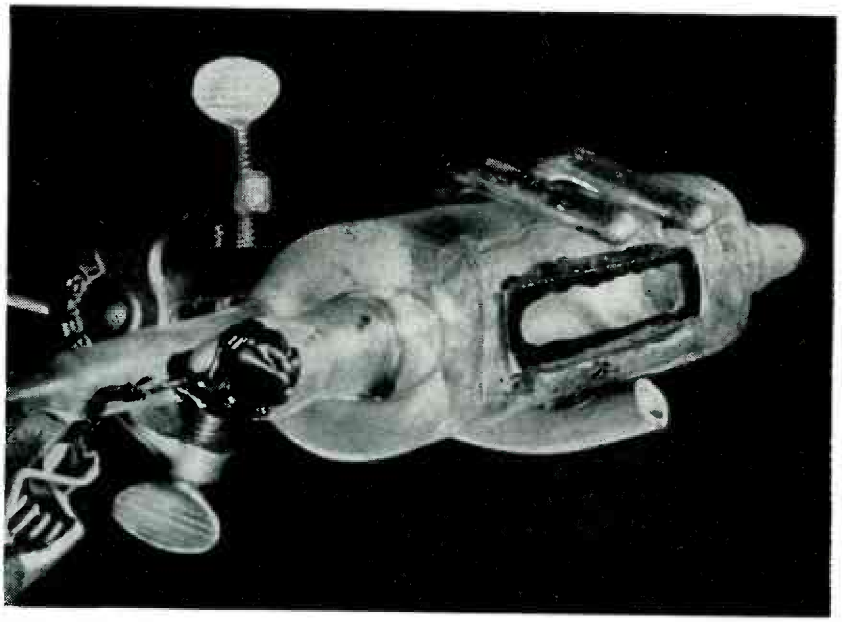

FIG. 2—Experimental detector tube containing a quartz radiation window in front of the cathode opening

FLAME DETECTOR

An extremely sensitive detector of flames, electric sparks, and arcs, yet not affected by daylight or artificial light, is provided by a Geiger-Mueller tube that responds only to ultraviolet light. A burning card triggers the relay circuit at 60 feet

nary burning match. The amount of far ultraviolet radiation can then be estimated.

We have

$$J = 3.7 \times 10^{-5} \int_{\lambda_1}^{\lambda_2} [\lambda^5(e^{1.43/\lambda T} - 1)]^{-1} d\lambda \quad (1)$$

Where J is the energy radiated over a hemisphere per square centimeter of radiating area per second, measured in ergs, for a wavelength range from λ_1 to λ_2 (in cm), at an absolute temperature T.

Assuming a temperature of 1700 degrees Kelvin for a burning match we find that at an ultraviolet wavelength of 2600Å, there is still radiated roughly one millionth of the energy radiated in the yellow portion (6000Å).

The law described in Eq. 1 refers to a perfect black-body, but for orientation purposes regarding the order of magnitude of effect we may well consider an object such as an ignited match as a black-body. At 1700 K, and the wavelength range of 2550 to 2650Å, we find approximately

$$J \simeq \frac{1}{100} \text{ ergs/cm}^2 \text{ per hemisphere per second} \quad (2)$$

Since the energy of each light quantum is $E = hc/\lambda$ we have for the number of quanta

$$N = \frac{J}{E} = \frac{J\lambda}{hc} i \quad (3)$$

where h = Planck's constant, c = light velocity. Using an average λ = 2600Å, Eq. 2 and 3 give

$$N \simeq 10^9 \text{ quanta/cm}^2 \text{ per hemisphere per second} \quad (4)$$

For a detector of this radiation which has an effective area of 30 cm^2 located at a distance of 30 feet (10^3 cm), the sensitive area represents a fraction, $k = 10^{-5}$, of a hemisphere, so that the number of ultraviolet quanta received is, from Eq. 4, about 10^4 quanta per second from a square centimeter of radiating flame area.

With a photoelectric cell assumed to be 100 percent efficient for this radiation, the current yield could not be more than 10^{-15} ampere, so that this method of detection is not practical. Figure 1 shows the ultraviolet distribution from the match as calculated above, together with the spectral regions of other light sources.

Tube Construction

The Geiger-Mueller tube known best from atomic radiation detection affords detection of individual particles. By designing such a tube so that the ultraviolet radiation can enter its cathode cylinder, and thereby providing a surface which is photoelectric at the desired wavelengths, but not at a longer wavelength, a most efficient detector for these light quanta can be obtained.

Figure 2 shows the first experimental tube. It consists of a semicylindrical cathode of copper. This metal was chosen because its photoelectric threshold lies in the desired wavelength region. The photoelectric yield is highest at wavelengths just below the photoelectric threshold wavelength which in case of copper is approximately 2500 Å. A quartz plate serves as the radiation window on the side on which the cathode cylinder is open. The total effective

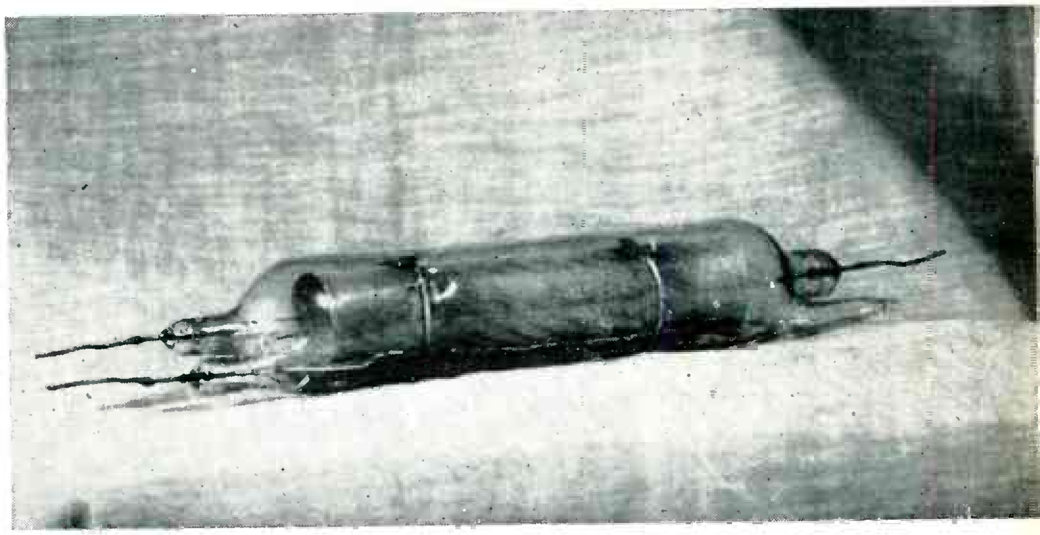

FIG. 3—Final design of fire-detector tube that is sensitive in all directions. The special glass envelope provides about 80 percent transmission at a wavelength of 2600 Angstroms

solid angle in this tube was limited to about 40 by 120 degrees.

A second design shown in Fig. 3 was finally developed, allowing sensitivity in all directions. The cylinder consists of copper screen of about 50 percent area copper coverage. This was carefully prepared to avoid point discharges, and sealed in an envelope of Corning 9741 glass which allows about 80 percent or more transmission at 2600 Å wavelength. This tube, processed and filled with suitable gases, proved to be most suitable for the fire, flame, and spark detection. Figure 4 shows the spectral sensitivity as measured with a hydrogen arc as a light source and a quartz monochromator.

Tube Circuit

The electronic circuit required in connection with the detector tube is shown in Fig. 5. This must operate a relay as soon as the average input pulse rate as supplied by the Geiger-Mueller tube increases to or above a certain predetermined value. This is accomplished by a circuit which injects a charge on a capacitor-resistor combination for every pulse received, thus essentially integrating or averaging the pulse rate over a time interval of the order of the time constant τ of the combination.

In Fig. 5, the negative pulses received from the sensitive tube are inverted in one triode unit, fed into a cathode-follower type R-C tank, the potential across the latter controlling a thyratron relay circuit which in turn controls whatever alarm device is to be activated.

The averaging time constant τ is given by the product RC. The sensitivity is determined mainly by the duration of the positive control pulses reaching the cathode follower determined by the product RC, and by the absolute magnitude of the charging tank capacitor C. Also, the negative grid bias control of the thyratrons, accomplished by potentiometer P, provides a simple adjustment over a limited range of sensitivity.

Optimum Sensitivity

The minimum number of quanta that can be detected is limited only by the natural background count due to cosmic ray and natural radioactivity responses of the Geiger-Mueller tube.

The number of such background pulses is approximately proportional to the product of diameter and length of the cathode cylinder. The pulse rate due to an ultraviolet radiation source is also proportional to that product, the projected cylinder area. It may seem, therefore, that it would be immaterial to what size the detector is designed. However, this is not the case. For optimum sensitivity it will be advantageous to make the effective detector area large.

The detector tube of Fig. 3 has a projected cylinder area of about 30 cm^2, resulting in a natural average background rate of about 50 pulses per minute, or a little less than two pulses per second.

In a rough calculation of the average number of light quanta available for detection from a match at a distance of 30 feet, we obtained above about 10^4 quanta per second for the same effective tube area. Thus, if the efficiency of photoelectron emission from the incident quanta is at all reasonable, and it might be expected to be of the order of one percent, a very appreciable pulse rate should be detectable; about 100 per second based on rough assumption, regarding the "blackness" of the flame, its effective area, and the photoelectric efficiency of the detector. This figure demonstrates quantitatively the basic phenomena responsible for the great sensitivity achieved in this device.

Maximum Sensitivity

The device will respond practically instantaneously (within about 0.1 second) of the striking of a match at a distance of 60 feet or less in any direction from the detector tube. At greater distances larger flames will be as effective, the minimum flame area increasing approximately as the square of the distance. Flame centers of higher temperatures will increase the minimum distance or decrease the necessary flame area rapidly. Thus the device is extremely sensitive to sparks or electrical arcing. A gas lighter when struck only once anywhere in a room of 800 square feet sets the alarm relay off immediately.

This extreme sensitivity may in many practical applications be undesirable. It is possible to reduce this sensitivity by any number of means, the most natural one being in choosing the proper dimensions of R, R_1, C, and C_1 so that the charge transmitted to C per pulse received is small enough to require an appropriately large number of pulses to trigger the thyratron.

Limitations at Optimum

The background pulse rate represents an average number of pulses received per unit of time, and is made up of pulses succeeding each other at random time intervals. For a given averaging time element, given by τ, the actual number of pulses may fluctuate to some extent above and below the average rate. If this average pulse rate per interval τ seconds is q, then the probability that k_0 times this many pulses will arrive during the same interval is given by Poisson's distribution

$$p\,(k_0,q) = \frac{q^{k_0 \cdot q}}{(k_0 q)\,!}\, e^{-q}. \qquad (5)$$

This provides a means to predict to what maximum sensitivity the circuit may be adjusted without exceeding a given probability of accidental triggering by the background. The factor k_0 is directly related to the sensitivity in that the instrument can be adjusted to trigger if the pulse rate ever reaches k_0 times the background rate.

Using Stirling's approximation, we can obtain from Eq. 5 an approximate formula for the relationship between the required k_0 when a certain background rate q is given and a small probability p_{des} is desired

$$q = \frac{1}{k_0} \frac{A}{2.3 \log_{10} k_0 + \frac{1}{k_0} - 1} i$$

$$A = \left(2.3 \log_{10} \frac{1}{p_{des}}\right) - 1 \qquad (6)$$

For two probabilities $p_1 = 10^{-8}$ and $p_2 = 10^{-4}$ the relationship expressed by Eq. 6 is graphically represented in Fig. 6.

Strictly, a circuit of the type used should be considered as responding to the occurrence of a pulse-rate of (kq) or larger, which would require modification of Eq. 5 to

$$p\,(k_0,q) = e^{-q} \int_{k_0}^{\infty} \frac{q^{kq}}{(kq)!}\, dk$$

However, it can be seen that for any

large value k_0 the contributions to the integral from all $k > k_0$ are so small as to be negligible for the present purpose.

The chart of Fig. 6 makes it possible to determine the maximum sensitivity which can be used for a given ultraviolet detector tube having a background count of pulses per interval τ without exceeding a certain small probability for accidental triggering. As an example, suppose that we have a time constant of three seconds, and the detector tube has a background count of 3.3 per second, or $q = 10$. For a probability of 10^{-8} (which corresponds to an accidental trigger event per interval $\tau/p_{des} = 3 \times 10^8$ seconds, or 10 years!) Figure 6 yields $k = 3.5$. This means that the circuit may be adjusted to trigger the relay circuit when the pulse rate reaches 3.5 times the background.

It would be necessary to receive at least six times the intensity of radiation to trigger the circuit had it been designed to operate in the same way with a smaller detector having a background rate of only one per second ($q = 3$). Generally, a radiation detector of this type can be made more sensitive the larger the effective detecting area, even though the background rate too increases proportionally.

Conclusion

In many practical applications it may not only be unnecessary but even undesirable to design for such optimum sensitivity. Even an insensitive arrangement in the sense of the discussion regarding background fluctuations, may mean that a flame the size of a burning postal card will trigger the relay circuit within two seconds at a distance of 60 feet or more.

While the fundamental method and elements of the device have been described, there remains a great deal to be said about simplifying design and engineering aspects, about possible designs for the simultaneous use of many detectors in various buildings or rooms controlling a central indicating system, about monitoring special parts or apparatus such as in aircraft, or in manufacturing processes. Some speculation has been devoted to the possibility of forest-fire detection in inaccessive areas since it is possible to combine the detecting tube with suitable parabolic mirrors of any area to increase the effective ultraviolet detecting area.

Thanks are due Mr. A. G. Nester for assistance in constructing the experimental tubes and to Dr. W.F.G. Swann for making available the instrumental facilities of the Bartol Research Foundation.

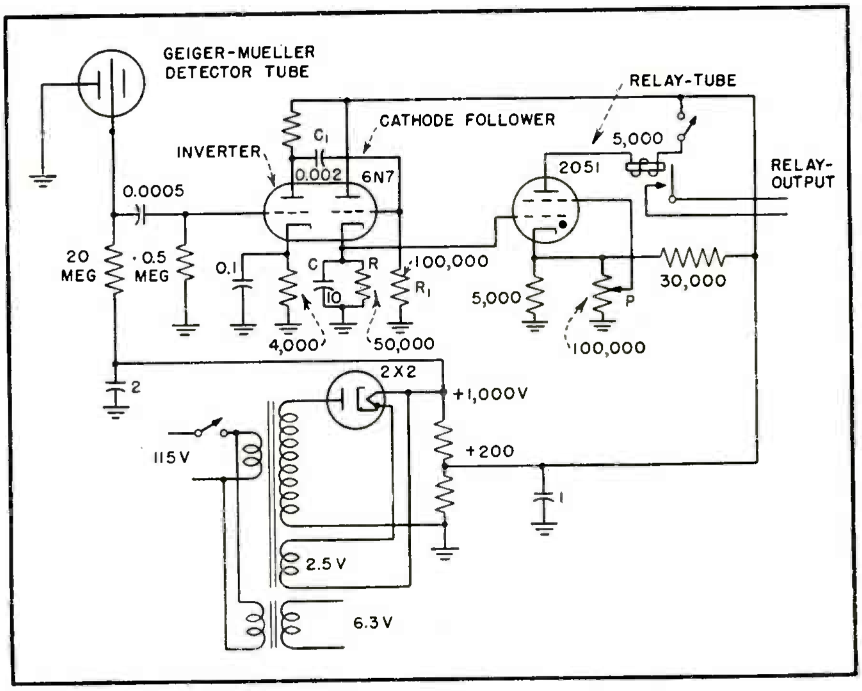

FIG. 5—Fire-detecting trigger circuit which fires thyratron when received impulses due to far ultraviolet radiation cause potential across capacitor C to rise above a predetermined value

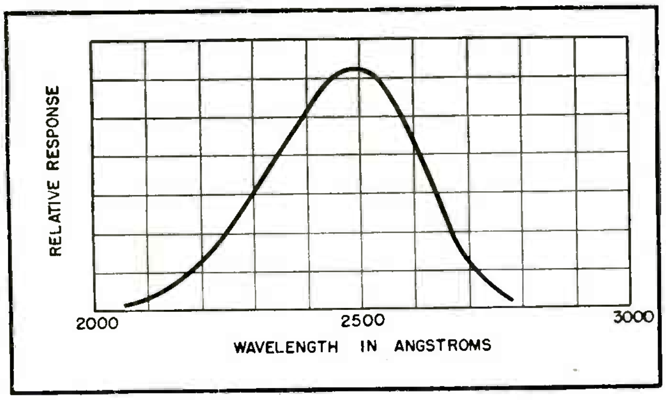

FIG. 4—Spectral sensitivity of copper-cathode detector

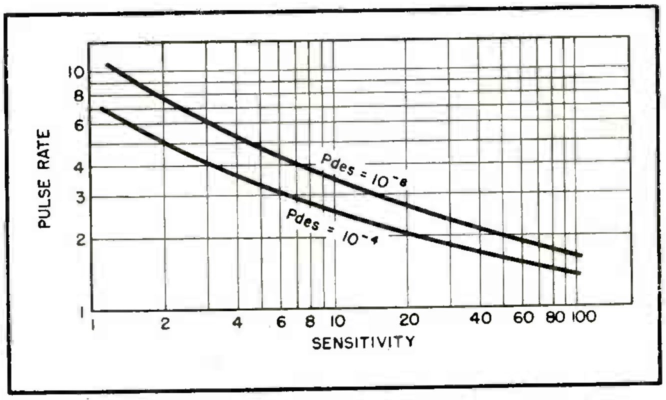

FIG. 6—Relationship of background pulse rate of detector and optimum sensitivity

Measuring and Monitoring

Left to right, the controlled multivibrator unit, receiver for reception of WWV, and a d-c amplifier and counter for determining the beat frequency. The large dial on the multivibrator is the fine frequency adjustment, the other two knobs control the input and output signals

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THIS PAPER describes a method for measuring or monitoring radio frequencies against the Bureau of Standards primary frequency emissions from WWV without the use of an intervening standard. The method is particularly applicable to frequencies which are integral multiples of ten kilocycles, such as standard broadcast station frequencies, and it offers an unusually high degree of accuracy.

Principle of Operation

The process is illustrated in the block diagram of Fig. 1. The signal to be checked is taken from the oscillator or buffer stage in the transmitter and is used to synchronize the multivibrator. One of the multivibrator harmonics is compared with one of the emissions of WWV by means of an ordinary radio receiver. The resulting beat frequency can be measured by any of several commonly used methods, such as an electronic frequency meter or a counting mechanism.[1, 2]

To determine the frequency deviation from the assigned frequency the following analysis is used: Let

F = frequency under measurement

F_m = fundamental frequency of multivibrator

$N = F/F_m$ = synchronization ratio

F_s = standard frequency emission used

$n = F_s/F_m$ = order of the multivibrator harmonic used

$f = F_s - nF_m$ = beat frequency in receiver

Then $F_m = F/N$, and the signal compared with F_s is $nF_m = (n/N)F$

Let ΔF be the deviation between correct (assigned) and actual value of F; then the signal compared with F_s is $(n/N)(F - \Delta F)$, and the measured beat will be

$$f = (n/N)F - (n/N)(F - \Delta F)$$
$$= (n/N)\Delta F \text{ or}$$
$$\Delta F = (N/n)f \qquad (1)$$

For example, consider a broadcast station with an assigned frequency F of 1230 kc and a multivibrator having a frequency F_m of 10 kc and synchronized at a ratio N of 123/1. The 1500th harmonic of the multivibrator is then beat in the receiver against the standard frequency emission from WWV at 15 megacycles (F_s). Suppose the beat between the two latter signals ($F_s - nF_m$) to be 18 cps. Substituting these values in Eq. 1, we get $\Delta F = (123/1500)18 = 1.476$ cps.

The method offers no way of determining the sign of ΔF, or whether the measured frequency is above or below the assigned frequency. However, raising or lowering the transmitter frequency a cycle or so and noting whether the beat frequency increases or decreases will yield this information.

Equipment

The multivibrator frequency F_m was chosen at 10 kc as this value contains harmonic components which fall on all standard emissions from WWV as well as those of broadcast stations. While, for the majority of frequencies involved in the band, synchronization of the multivibrator could be accomplished in two or more steps with reasonably low synchronization ratios, there are 19 frequency channels which are prime multiples of 10 kc. In these latter cases, synchronizing the 10-kc multivibrator must be done in one step—involving synchronization ratios of from 59/1 to as high as 149/1.

All the available information at hand indicated a practical synchronization ratio limit at about 50/1. Therefore the first problem was to investigate the possibility of practical synchronization at ratios of at least as high as 150/1. To accomplish this, the natural unsynchronized frequency of the multivibrator had to possess a high degree of inherent frequency stability and it also had to be isolated from any reactions due to adjustments or variations in the input synchronizing circuit and the output circuit.

The first problem was solved by using high-quality resistors of ample rating and an extremely stable voltage regulator. The regulator used was adapted from that developed by Bousquet[3], and produced an unusually high degree of regulation of the d-c output voltage.

Pentode tubes in the input and

Broadcast Frequencies

The beat note between the harmonic of a multivibrator synchronized with the station frequency and a signal from WWV is measured by means of a counter or frequency meter

output circuits provided ample isolation when their operating voltages were also regulated. Gain of these stages could not be controlled by any variation of the operating voltages such as would result from a conventional cathode-bias control.

To obtain sufficient output on high harmonics, it was necessary to tune the plate circuit of the output amplifier over the range from 5 to 15 mc. Below 5 mc, the circuit is untuned as shown in the circuit of Fig. 2.

Synchronization of the unit at a particular ratio is achieved with various combinations of natural uncontrolled multivibrator frequency and synchronizing voltage amplitude.

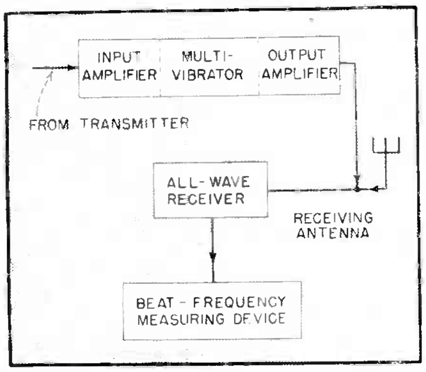

FIG. 1—Functional block diagram of the monitoring system

The combination resulting in the greatest stability is found by noting when the adjustment on the multivibrator frequency can be shifted the greatest amount without the loss of synchronism. As a typical example, this resulted with a natural multivibrator frequency of approximately 9.5 kc when synchronized to 10 kc using a 100/1 ratio.

No attempt was made to find a limit of synchronization ratio, but the unit constructed has been synchronized with complete stability at ratios as high as 200/1.

The unit was installed experimentally at a local broadcast station (KVNU, 1230 kc) for a thorough test under operating conditions. The input synchronizing voltage was obtained by bridging the low-impedance transmission line to the station frequency monitor from the crystal oscillator stage of the transmitter. The output of the multivibrator was connected to the antenna terminal of an all-wave receiver. A short horizontal antenna outside the transmitter building was used to pick up WWV and other signals.

Performance

After the multivibrator unit had become reasonably stabilized as to temperature, no further adjustments were necessary over a period of several days. During daylight hours, the 10 and 15-mc signals from WWV were used to check the operation of the unit. At night, the 5 and 2.5-mc signals were used. Other broadcast stations were also used as check frequencies both day and night. For a strong beat frequency in the receiver, a reasonable relationship between the strength of the received radio signal and the harmonic of the multivibrator is maintained by adjustment of the output control of the multivibrator unit.

In the modern broadcast station, the frequency control of the transmitter and the usual frequency monitor are of the same order of stability and should a large frequency deviation be indicated by the monitor, there may exist a reasonable doubt as to which is in error. In such cases, the immediate determination of the true transmitter frequency is of considerable value. For this particular application, an audible check of the beat frequency in the receiver would suffice for checking and for resetting the transmitter to assigned frequency.

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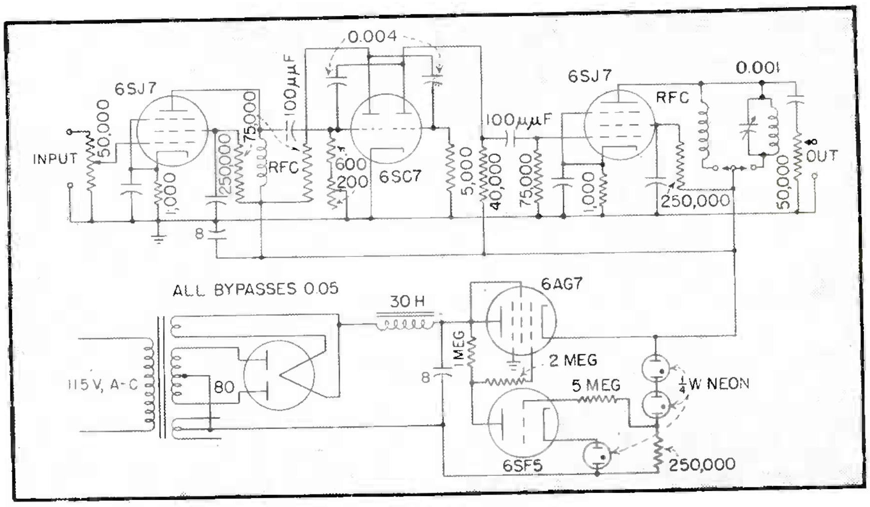

FIG. 2—Complete circuit of the multivibrator unit

CRYSTAL RECTIFIERS

Recent developments in the manufacture of germanium and silicon crystals have provided a new, efficient rectifying device, necessary for radar and of increasing usefulness in commercial microwave applications

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THE demands of microwave radar necessitated the development of more than thirteen different types of crystal rectifiers which were produced by the million. Basic improvements in stability and performance may enable the crystal to displace the diode tube in many applications, particularly because of its effectiveness at high frequencies. Even at low frequencies, certain kinds of crystals may prove more stable, have less weight and take up less space than a diode and filament transformer.

What a Crystal Rectifier is

A modern crystal rectifier consists of a small-area contact between a metal like tungsten and a suitable semiconductor such as galena, germanium, or silicon. Many names have been used to describe these rectifiers, such as silicon-crystal rectifier, dry-point contact rectifier, barrier-layer rectifier, point-contact semiconductor rectifier, converter crystal, mixer crystal, video crystal, and detector crystal. These differ from copper-oxide and selenium rectifiers in having a small contact area and usually a smaller power-handling capacity. On the other hand, their reduced capacitance makes them very useful at high frequencies.

A typical crystal rectifier is shown diagrammatically in Fig. 1. The ceramic cartridge with brass ends holds the whisker and semiconductor in stable contact. The pointed whisker is soldered into the pin end and the semiconductor, soldered on the end of a stub, is pushed in from the other end till the contact is made. The whisker spring is compressed slightly and the stub locked by a set screw. The cavity is then filled with wax to make the contact moisture-proof.

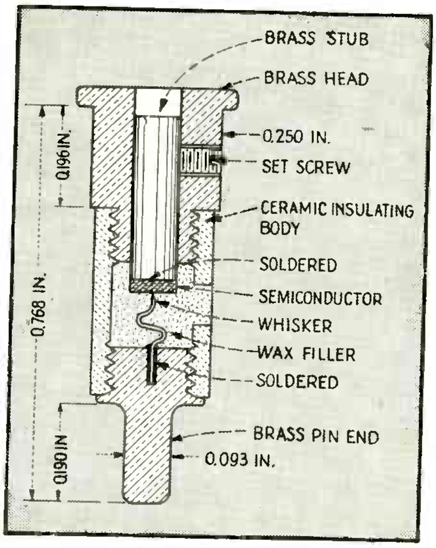

Fig. 1—Cross-section of a typical crystal rectifier. The dimensions are approximate

Semiconductor Properties

Although the contact area is critical, probably the most important part of the rectifier is the semiconductor. Semiconductors are materials having a high electrical resistance, between that of metals and insulators, usually with a temperature coefficient of resistance different from that of metals. Semiconductors are much more sensitive to small amounts of impurities or imperfections in the crystal lattice than metals.

The addition of a fraction of a percent of certain other elements will lower the resistance of some semiconductors to that of poor metals. In this condition, good rectification can often be obtained by making small-area contact to the surface of the semiconductor with a suitable metal. It is thought that the difference in work function between the metal and semiconductor produces a potential barrier to the flow of electrons. This barrier drops slowly on the semiconductor side owing to the space charge effect of the unneutralized impurity ions present in the semiconductor, and practically stops the flow of electrons from the metal to the semiconductor under any conditions. However, the electrons can flow from the semiconductor if the electronic potential of the semiconductor is raised enough to allow the electrons to pass over the barrier. This also requires that appreciable voltage drop occur at the semiconductor contact, which is achieved by making the contact area small and producing a spreading resistance in the semiconductor. Consequently, the barrier will allow current to pass in one direction and

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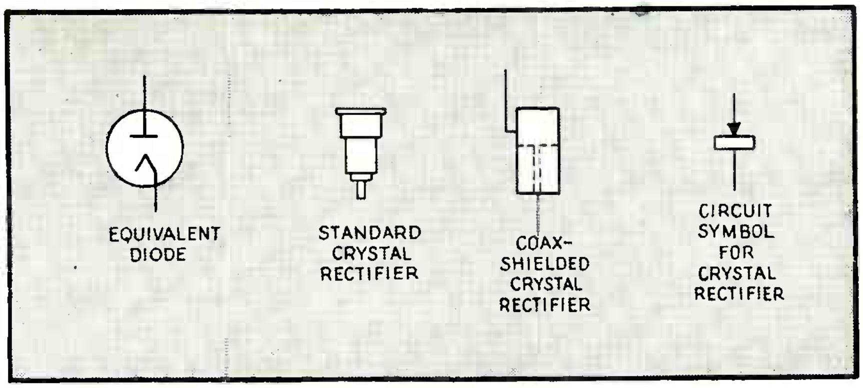

Symbols for diode and crystal rectifiers and the physical appearance of corresponding crystal units. The greatest current will flow when the top connection is positive

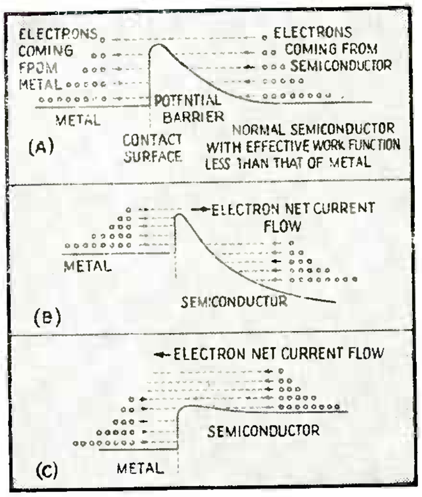

Fig. 2—Schematic diagram showing contact between metal and germanium semiconductor. In A, no voltage is applied, and hence the two electron flows are just equal. At B, the semiconductor has been made positive, lowering its electronic potential and decreasing electron current from the semiconductor, so that a slight net current flows. The semiconductor has been made negative at C, raising its electronic potential and increasing current from the semiconductor

not in the other, as shown in Fig. 2. Similar effects occur at the back surface of the silicon. For good rectification, the contact area at the back surface must be large in order to eliminate any spreading resistance over which a potential drop can occur. This approximate description of the rectifying action indicates that a major part of the art of crystal rectifier production lies in the preparation of the semiconductor and its surface. Two typical curves of the current-voltage characteristic at low frequency for a properly prepared crystal are shown in Fig. 3.

Uses for Crystal Rectifiers

The primary attribute of the crystal rectifier which makes its use for microwave radar imperative is the small area of the region where rectification occurs. Very probably this region is smaller than 10^{-6} cm in thickness. Consequently, the time for electrons to cross this film will be small enough to eliminate transit-time effects, even at microwave frequencies. Furthermore, since these crystals have small capacitance in the contact, their rectifying properties are little affected by frequencies up to several megacycles.

Table I—Composition of Crystal Rectifiers

Bulk material	Impurities added: High-frequency mixer crystals	High-back voltage crystals	Low-frequency rectifiers
Silicon	Aluminum Boron	Germanium also Ni Sn Bi Ca	Aluminum Boron Germanium also Mo Ta Zr Co W Re Be Fe
Germanium	Antimony also P Fe	Tin also Ca Ni Sr Bi N	Antimony Tin
Galena	Unknown	None known	Unknown
Iron pyrites	Unknown	None known	Unknown

So far there have been three main uses for crystal rectifiers—as detectors of microwaves, as mixers or converters of microwaves, and as higher-voltage low-frequency diodes. This classification is not profound, but serves to illustrate the different electrical characteristics required of the crystal types developed for these purposes.

As a detector, the crystal is connected between the receiving antenna and ground across the input to the video amplifier. Used in this fashion, microwave powers of the order of 10^{-8} watt picked up by the antenna can be detected. When smaller amounts of power are to be received, a local oscillator, usually producing 0.7 volt at 30 or 60 mc from the signal, is connected to the crystal. Then the two signals are mixed by the crystal and the converted intermediate frequency fed into the i-f amplifier. Used in this fashion, microwave signals as small as 10^{-15} watt can often be detected.

Crystals are also used at frequencies lower than those corresponding to microwaves. As a second detector, the crystal converts the intermediate frequency of 30 mc into d-c. This service requires crystals which will stand higher voltages than the normal limit of 1 or 2 volts. Other low-frequency uses include d-c restorers and voltmeter rectifiers.

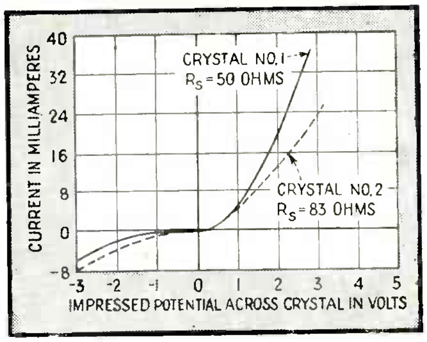

Fig. 3—Current-voltage curves for two different crystals

Preparation of Crystals

Most present-day crystals are

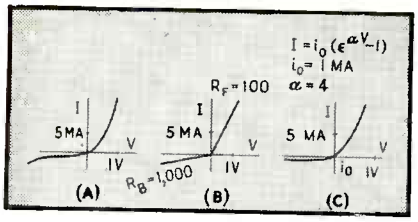

Fig. 4—The experimentally observed current-voltage curve at A agrees reasonably well with the curve deduced from front and back resistance constant at B and that from diode theory at C

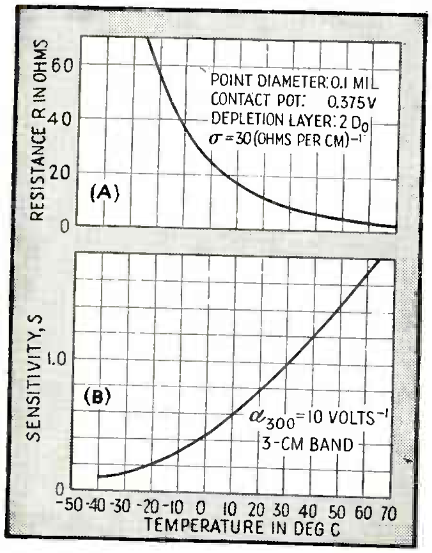

Fig. 5—Variation of resistance (A) and sensitivity (B) of a representative crystal with temperature

made from silicon which is initially prepared in a very pure form by crystallization at a high temperature from silicon tetrachloride. The resulting needles are melted in a quartz crucible in a good vacuum (10^{-5} mm Hg) at about 1,500 C with a small amount of the desired impurity added to the melt, as indicated in Table I. After slowly cooling from the bottom the melt is cracked loose from the crucible and sawed into slabs about 1 mm thick. Both sides of the slab are rough-ground flat. One side is finished with fine carborundum and then polished with No. 000 emery paper to a mirror-like surface. The slab is then heated to about 1,050 C in air for several hours until a blue color appears, indicating the formation of a thin oxide layer. The unpolished side of

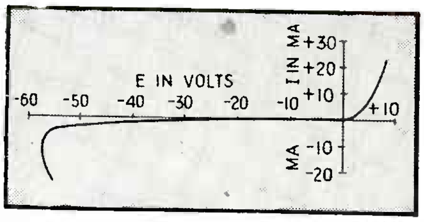

Fig. 6—The typical d-c characteristic curve of a high-back-voltage silicon crystal

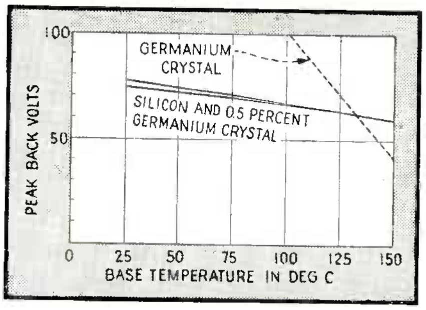

Fig. 7—A comparison of peak back voltage as a function of base temperature for two crystals of different composition

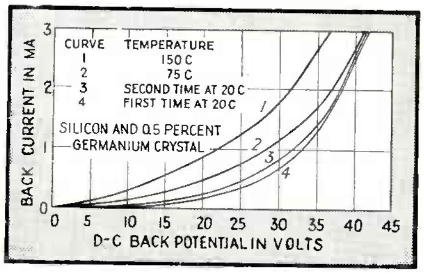

Fig. 8—D-c back voltage characteristic curves at different temperatures for the silicon crystal shown in Fig. 7

the slab is next electroplated with nickel. The slab is broken or sawed into small pieces about 2 mm square. These small pieces are then soldered onto the brass stub (see Fig. 1), trimmed, and the oxide washed off the polished surface with hydrofluoric acid. The semiconductor is then ready for assembly.

Tungsten Catwhisker

The whisker is usually made from pure annealed tungsten wire of diameters up to 10 mils. The desired lengths are plated at one end with gold or other material suitable for soldering. The wire is next soldered into the pin and formed in the correct shape by a crimper. The point is sharpened by electrolytic polishing or by grinding on an Arkansas stone to a smooth cone of about 60 deg included angle. The whisker and silicon are then assembled in the cartridge. The set screw is tightened somewhat and the stub pushed in till the whisker makes contact with the semiconductor surface. This position is detected by continuously measuring the resistance between the ends of the crystal or watching the current-voltage curve on an oscilloscope. The stub is pushed in about a mil farther to compress the crimped wire and make firm contact. The cartridge is usually tapped to stabilize the contact. Then the cavity in the ceramic body is vacuum impregnated at elevated temperature with a mixture such as opal wax and paratac. Sometimes the hole is plugged up with alundum cement. The crystal cartridge is tested, labeled, and then packed in a metallic shield to protect it from picking up electric charges which might injure it. Care must always be taken in handling a crystal to avoid any appreciable discharge through it.

Electrical Characteristics

In describing the electrical characteristics of crystals we shall refer mainly to rectifiers made from silicon doped with aluminum and/or boron and prepared as described above. Other techniques and materials can be used, but most crystals are at present made in this fashion.

The d-c rectification curve in Fig. 3 shows that the difference between the resistance in the front and back direction is a measure of ability to rectify, and the back-to-front ratio was an early criterion of a good rectifier. The ratio of back resistance at 1 v to the front resistance at 0.3 v is greater than ten to one for a good crystal. The rectification curve can be well approximated by a simple formula with two constants:

$$i = i_0(\epsilon^{\alpha V} - 1)$$

where i is the instantaneous current and V the instantaneous voltage across the contact, i_0 and α being constants. The value of α varies from 2 to 20 volts^{-1} in ordinary crystals although it has been observed larger; i_0 is of the order of milliamperes, but varies from crystal to crystal.

Figure 4 shows typical approximations compared to a typical observed current-voltage curve. At low frequencies the rectification depends primarily on α. Actually, for appreciable current carried in the forward direction the applied voltage does not all appear across the contact. A voltage drop occurs across the spreading resistance owing to the small size of the contact to the semiconductor (this is evident from Fig. 3), and the fact that the semiconductors do not have as high a conductivity as metals. This spreading resistance R_S varies from 5 to 100 ohms depending on the diameter of the whisker and, consequently, necessitates a correction $(V_{\text{applied}} - iR_S)$ to the voltage across the contact. The slope of the current-voltage curve at zero bias is the low-level or video resistance and varies from several thousand to fifty thousand ohms.

Temperature Variations

These resistances vary appreciably with temperature. In fact, the low-level or zero-bias resistance varies exponentially with the reciprocal of the temperature. This variation is essentially the same as that of a thermistor. This is because of the change with temperature of i_0 which can be expressed as $i_0\epsilon^{-\phi/kT}$ where ϕ is an effective barrier height in electron volts and kT is the thermal energy in electron volts. (At room temperature kT is 1/40 e-v). The value of ϕ is usually between 0.1 and 0.4 e-v and $k = 8.6 \times 10^{-5}$ e-v per degree Kelvin.

The curve in Fig. 5A shows the calculated variation of the low-level or zero-bias resistance with temperature of a typical crystal. The only practical way found so far to reduce this variation is to control the crystal temperature. A reduction in ϕ which will reduce the temperature coefficient of resistance also decreases the sensitivity of the crystal as a detector.

The front and back resistances and spreading resistance do not vary as rapidly with temperature as the low-level resistance. Typical variations of front and back resistance are +20 percent at −20 C and −40 percent at +70 C from the room temperature value 22 C.

Square-law rectification is to be expected of any rectifier as long as the voltage swing is limited to the region where departure from linearity of the characteristic curve is small. Most crystals show square-law rectification up to powers of the order of several microwatts or voltages of the order of 0.1 v. Below this level, the short-circuit rectified current $i_{d\text{-}c}$ is directly proportional to the input a-c power, in the relation:

$$i_{d\text{-}c} = SP_{a\text{-}c}$$

where S (Fig. 5B) is the sensitivity. This low-frequency sensitivity is greater than 2 for good crystals. Actually, at low frequencies, S should be one-half of α.

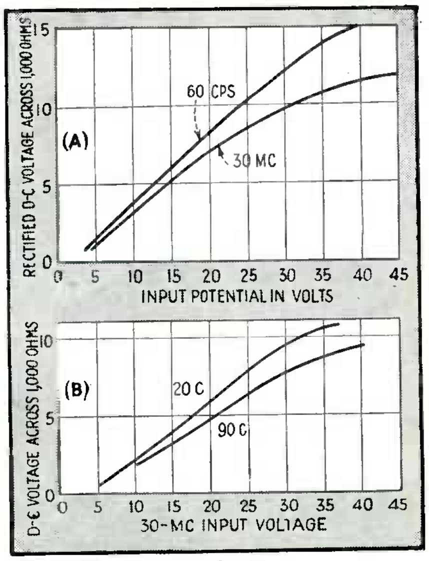

Fig. 9—Rectified d-c from a high-back-voltage silicon crystal as a function of input voltage as affected by frequency (A) and temperature (B)

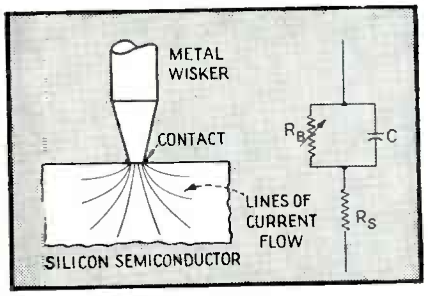

Fig. 10—Lumped parameter circuit to approximate crystal contact. R_B and C are resistance and capacitance of the contact and R_S is the spreading resistance in the semiconductor caused by small area of contact

As the power level is increased above microwatts, the rectified current becomes more nearly proportional to the square root of the input power. If the load resistance is not small, the crystal will bias itself and reduce the rectification. As rectified currents of milliamperes are reached, the voltages increase to the order of whole volts and the resistance in the back direction may start decreasing. This puts a limit on the amount of input power which can be used without saturation of rectification. Further increase of voltage may damage the crystal. In fact, voltages of the order of 4 v or rectified currents of greater than 30 ma will damage the more sensitive types of crystals.

High-Back-Voltage Crystals

When certain impurities are added, both germanium and silicon have been found to withstand large voltages in the back direction. A typical curve is shown in Fig. 6. In general, hbv germanium gives much better back-to-front ratios than have been found so far with hbv silicon. Consequently, most high back voltage crystals are at present made from germanium. Silicon, on the other hand, shows promise for temperature-insensitive and frequency-insensitive high-back-voltage crystals. Silicon has much better rectifying properties at microwaves and less variation of back resistance and peak back voltage with temperature than most hbv germanium. A typical variation of peak back voltage with temperature is shown in Fig. 7. The variation of back current with temperature is shown in Fig. 8.

These hbv crystals are in many cases better for rectifiers than diodes such as the type 6H6. For several volts of 60-cps input, hbv crystals give more rectified current than a 6H6 with both plates in parallel. The change in rectified current as the frequency is increased to 30 mc is shown in Fig. 9A. The variation of rectified current with temperature is shown in Fig. 9B. Germanium hbv crystals still in development have better low-level rectification and give larger currents in the forward direction.

Noise

By careful control of manufacture, the noise generated by crystals has been greatly reduced. In many cases, the i-f noise observed from a crystal used as a mixer is no more than that experienced from a resistance of equivalent magnitude. However, crystals often give more noise than would be expected from thermal agitation and shot effect. This has been designated extra noise, and is observed when either d-c or r-f voltage is imposed on the crystal.

The spectrum of this extra noise is not uniform in the manner of thermal agitation. Much more low-frequency noise is observed than that at high frequencies, varying inversely with frequency from 50 cps to 1 mc, when it tapers off and approaches thermal agitation noise. Consequently, at an i-f of 30 mc the noise is not bothersome, whereas for i-f values in the audio range the extra noise from the crystal is very large.

High-Frequency Operation

At high frequencies, the capacitance across the blocking layer (barrier) becomes important because it can bypass the barrier if its impedance becomes less than the resistance of the barrier, as indicated in Fig. 10. This happens first in the back direction and reduces the back-to-front ratio. The high-level rectification efficiency is then measured

Table II. Crystal Characteristics

		Mixer Crystals				
		Least sensitive	Medium sensitivity	More sensitive	Most sensitive	High burnout
30						*1N25**
	L					Less than 8.0 db
	t					Less than 2.5 x
	NF_r					Less than 13.4 db
	B_p					7 w d-c
	B_d					26 w d-c
10		1N21 (obsolete)	1N21A	1N21B*	1N21C	1N28*
	L	Less than 8.5 db	Less than 7.5 db	Less than 6.5 db	Less than 5.5 db	Less than 7 db
	t	Less than 4 x	Less than 3 x	Less than 2 x	Less than 1.5 x	Less than 2 x
	NF_r	Less than 15.5 db	Less than 13.5 db	Less than 11.3 db	Less than 9.5 db	Less than 11.8 db
	B_p		0.3 erg	2 ergs	2 ergs	5 ergs
3		1N23	1N23A	1N23B*		
	L	Less than 10 db	Less than 8 db	Less than 6.5 db		
	t	Less than 3 x	Less than 2.7 x	Less than 2.7 x		
	NF_r	Less than 16.0 db	Less than 13.7 db	Less than 12.2 db		
	B_p	0.3 erg	1.0 erg	0.3 erg		
1		1N24 (obsolete)	1N26* coax-shielded cartridge			
	L	Less than 14 db	Less than 8.5 db			
	t		Less than 2.5 x			
	NF_r		Less than 13.9 db			
	B_p		0.1 erg			

L: loss
t: noise temperature
B_p: burnout proof test
B_d: burnout design test
NF_r: noise figure of receiver (3 db receiver)
* Army-Navy preferred list
A and B crystals are physically interchangeable

High-Back-Voltage Crystals		
Second detector crystal pigtail cartridge	d-c restorer (r-f) crystal pigtail cartridge	d-c restorer crystal pigtail cartridge
W. E. D171561	W. E. D171612	W. E. D172925

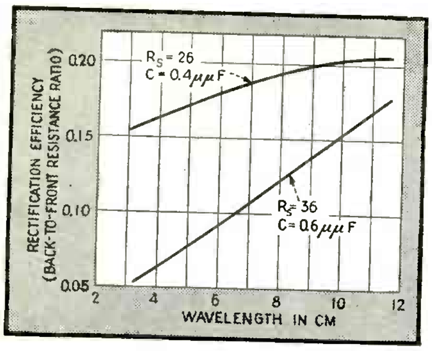

Fig. 11—Rectification efficiency (back-to-front resistance ratio) of two different crystals as a function of wavelength. The lower curve shows the effect of larger contact capacitance

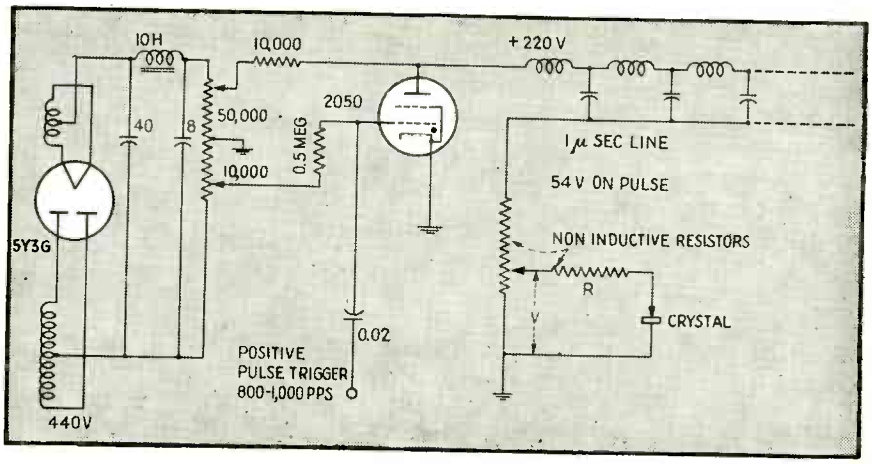

Fig. 12—The d-c pulser circuit used in the burnout tester

According to Wavelength Used

High-Back-Voltage Crystals		
E_1 more than 5 v E_2 more than 0.10 v E_3 more than 15 mv V_B more than 50 v	E_3 more than 15 mv R_B more than 0.1 meg (− 1 v) V_B more than 50 v R_{30} more than 2,000 ohms	E_3 more than 15 mv R_B more than 0.06 meg (− 50 v) More than 0.25 meg (− 5 v) I_F more than 5 ma (+ 1 v) R_{30} more than 2,000 ohms

cm	Video Crystals			Medium high burnout
30		1N29 L_{10} less than 8.0 db R_{d-c} greater than 6,500 ohms at 40 mv		
10	M R_{d-c} B_d	1N27 Greater than 60 0 to 4,000 ohms	1N32* Greater than 100 5,000 to 20,000 ohms 0.3 w d-c	1N33 Greater than 30 but less than 140 2,000 to 10,000 ohms 2.5 w d-c
3	M R_{d-c}	1N30 Greater than 55 7,000 to 21,000 ohms	1N31* Coax-shielded cartridge Greater than 55 6,000 to 23,000 ohms 0.02 w d-c	M: figure of merit R_{d-c}: d-c resistance at + 5 mv

Crystal diode pigtail cartridge
1N34 V_r less than 10 v I_F less than 5 ma (+ 1 v) R_B less than 0.025 meg (− 50 v) R_B less than 0.2 meg (− 10 v) V_B less than 50 v

Instrument Rectifier	
1N22	
Sylvania	W. E.
R_B more than 2,000 ohms R_F less than 60 ohms I_{10} more than 0.45 ma I_3 more than 0.4 ma B_p 0.3 erg	L less than 10 db t less than 6 x I_{10} more than 0.4 ma B_p 0.3 erg

E_1 : d-c output voltage with 24.7 v peak 30-mc input
E_2 : a-c output voltage with 24.7 v peak 30-mc modulated 0.92 v peak as input
E_3 : d-c output voltage with 0.5 v peak 30-mc input
V_r : d-c voltage at the output with 30 v rms 60-cps input; (the capacitor is omitted and the load resistance is 500 instead of 1,000 ohms)
V_B : peak back voltage the crystal is required to stand
R_B : static d-c resistance at the back voltage indicated
R_{30} : impedance at 30 mc
I_F : d-c in the forward direction at the voltage indicated

by the ratio of the back resistance (shunted by the capacitance) to the front resistance. This begins to decrease when $1/\omega C$ becomes less than R_B. The value of C has been measured at about 0.2 $\mu\mu$f so that $1/\omega C$ becomes less than 1,000 ohms at a frequency of 1,000 mc.

Figure 11 shows the decrease in rectification efficiency with decrease of wavelength (increase in frequency) for two early crystals. The crystal with the larger capacitance shows a faster drop in rectification efficiency. Newer crystals have better rectification efficiencies than are shown in these examples.

A corresponding decrease in efficiency occurs in mixer performance and low-level detection. In general, the lower the contact capacitance, the better the high-frequency performance. Consequently, except for problems of r-f and i-f match, a crystal good at high frequency is also good at lower frequencies.

Low-level sensitivity drops even faster with increasing frequency than mixer performance or rectification efficiency. Whereas rectification efficiency might be expected to vary roughly as $1/(1 + R_B\omega C)$, low-level sensitivity should drop as

$$1/(1 + \omega^2C^2R_BR_S).$$

Actually, in many cases, crystal performance does not decrease as fast as expected with frequency.

Stability

The stability of present-day crystals is well displayed by the mechanical, electrical, and exposure tests which production samples are required to stand.

The mechanical design test involves dropping the crystal three times from a height of 30 in. onto a wood block, twisting the crystal ends with a torque of 1.5 in.-lb so as to unscrew the parts, and applying a force of one pound to the tip of the crystal at right angles to the axis of the crystal while the head is clamped. A crystal must withstand immersion in warm water for fifteen minutes, in room-temperature water for fifteen minutes, and several cycles of heating and cooling between 70C and −40 C. The electrical burnout tests are described below. After being subjected to all of these tests the performance of 80 percent of the samples is required to be within specified limits, but 90 percent of the samples must be within the limits after any single design test.

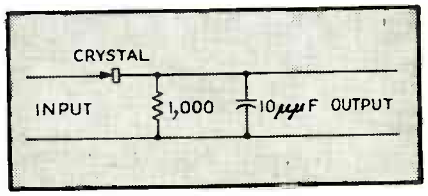

Fig. 13—Circuit used for measuring second detector characteristics

There are two types of burnout tests intended only to indicate rough differences in ability to withstand overloading and to ensure production quality. The first consists in discharging a charged concentric line through the crystal. By this means, a pulse of approximately three microseconds width is sent through the crystal. This time is determined by the length of the line and is chosen to be shorter than the time constant for heat dissipation of the crystal contact. The energy contained in this pulse is determined by the capacitance of the line and the voltage to which it is charged. If the voltage is very high, some dissipation of the pulse energy seems to be experienced when the contact is made for the discharge which simulates the spike which gets through the transmit-receive gas tube before it breaks down to protect the crystal from the transmitted radar pulse.

Another method of testing crystals for burnout consists in exposing the crystal to a d-c pulse of about one-microsecond width, obtained by discharging an artificial line through a thyratron into the crystal. A circuit for accomplishing this is shown in Fig. 12. Only a rough correlation exists between these methods of testing crystals for burnout because multiple pulses have more effect than single pulses and the method is less erratic. The match of the crystal to the pulsing circuit is important for reliable testing and in actual radar practice additional protection can often be afforded by r-f mismatch in the holder to overload pulses. Design tests which are given to samples of production crystals are also usually more stringent than the proof tests which are applied to every crystal produced.

Crystal Types

Table II shows the present crystal types grouped in horizontal rows according to the wavelength band for which they are recommended. The grouping in vertical columns is according to use, sensitivity, and burnout. Mixer crystals are for use with local oscillators, whereas video crystals are for detector use. Table III gives test specifications.

The characteristics listed in the tables are further defined below. L is the loss in db of the crystal used as mixer.

$L = 10 \log_{10} l$ where l is the ratio of r-f signal power input to i-f power output. A perfect diode might be expected to have an efficiency of 50 percent ($l = 2$) or $L = 3$ db.

The noise temperature t of the crystal is the ratio of the average of the square of the noise voltage produced by the crystal to the thermal agitation or Johnson noise voltage squared of a resistance equal to the i-f impedance of the crystal.

$$t = \frac{V_c^2}{V_r^2} = \frac{V_c^2}{RW(1.6 \times 10^{-20})}$$

where R is the i-f impedance and W is the integrated bandwidth of the mixer and amplifier, V_c is the crystal noise, and V_r the noise voltage from an equivalent resistance. The value of t is usually given as a ratio, and

Table III. Results of

VIDEO OR LOW LEVEL CRYSTALS

RMA No.	Description and band in mc	Test freq in mc	Test holder	Maximum test power in milliwatts	Minimum figure of merit	Range of video resistance in ohms	Burnout test
1N27	For pulse discrimination 10	3,295	Rad. Lab. drawing B3424 tunable	5	60	0 to 4,000	
1N29	Special use 30	10 cm	IN21 type	Same as 10 cm mixers	Conversion loss at 10 cm 8 db max	6,500 min at + 40 mv	
1N30	Original 3	9,375	TPX—56GM tunable	5	55	7,000 to 21,000	Proof test 0.3 erg
1N31	Improved stability 3	9,375	Rad. Lab. drawing B7389 fixed tune	5	55	6,000 to 23,000	Design test 0.02 w d-c 1-μsec pulse
1N32	Improved sensitivity 10	3,295	Rad. Lab. drawing B7389 fixed tune	5	100	5,000 to 20,000	Design test 0.03 w d-c 1-μsec pulse
1N33	Improved burnout 10	2,880	Hazeltine fixed tune	5	40 min 130 max	2,000 to 10,000	Design test 2.3 w d-c 1-μsec pulse

HIGH-BACK-VOLTAGE CRYSTALS

Western Electric No.	Description	Freq	Rectification in test circuit				60 cps conversion at high level		Peak back voltage min d-c	30 mc impedance in ohms	d-c resistance
			Low level		High level						
			In	Out min	In	Out min	In	Out min			
D171561	2nd detector	30 mc	0.5 v peak 30 mc	15 mv d-c	24.7v peak 30 mc	5 v d-c	0.92 v peak 60 cps modulation	0.10v 60 cps	50 v		
D171612	D-C restorer (r-f)	30 mc							50 v	2,000	0.1 meg at − 1 v
D172925	D-C restorer	30 mc								2,000	0.06 meg at − 50 v 0.25 meg at − 5 v

appears in the tables as $t = 2x$ where x indicates it is a ratio; a crystal would be considered perfect if t were equal to unity.

An overall criterion of performance is NF_r, the noise figure of the receiver, which gives the ratio of the average of the output noise voltage squared to the output signal voltage squared when the input signal power is just equal to the thermal agitation noise power

$$NF_r = l(NF_{i-f} + t - 1)$$

where all the terms are ratios. Assuming the noise figure of the average amplifier $NF_{i-f} = 2x$ (or 3 db), then in db, $NF_r = 10 \log_{10}[l(t+1)]$ where l and t are ratios. The best NF_r of a perfect diode would be 6 db for a 3-db receiver, with image matched. The noise figure in db of the crystal by itself (NF_c) can be expressed as

$$NF_c = 10 \log_{10}(tl)$$

where t and l are ratios.

The video impedance R_{d-c} is measured at 5 mv in the forward direction. M is the figure of merit of a crystal as used for the input to a video amplifier. It is a measure of the output signal voltage V_0 to the output thermal agitation noise voltage V_N (background).

$$\frac{V_0}{V_N} = \frac{P_i R_{d-c}}{\sqrt{W}\, 1.26 \times 10^{-10} b \sqrt{R_{d-c} + r}} = \frac{P_i M}{1.26 \times 10^{-10} \sqrt{W}}$$

where $M = R_{d-c}/b(R_{d-c} + r)^{\frac{1}{2}}$, $i = SP$ (input r-f), P_i is r-f input power, and r is a fictitious series resistance of the grid of a first tube which would give a noise equivalent to the amplifier noise. An s equal to one is desirable and r is of the order of 1,200 ohms.

B_p and B_d are the proof and design burnout test required for the crystal. The number of ergs given is the energy in a spike or pulse of roughly 3 microseconds duration from a Torrey concentric line pulser used to proof test each crystal. The power in watts is the peak available (or matched) power in r-f or d-c microsecond pulses.

Design Tests on Crystals

HIGH-BACK-VOLTAGE CRYSTALS

RMA No. 1N34	Crystal diode	60 cps	30 v (rms)	10 v d-c	(500 ohms load resistance: no capacitor)		50 v			0.025 meg at − 50 v 0.2 meg at − 10 v

MIXER OR LOCAL OSCILLATOR DRIVEN CRYSTALS

RMA No.	Description and band in cm	Test freq in mc	Test holder	Test power level in milliwatts	Max Conversion loss in db	Min noise ratio	i-f impedance in ohms	Min rectified current ma	Burn-out proof test in ergs
1N21	Obsolete 10	3,060	Bell Labs ES4	0.5	8.5	4 x	Approx 400		
1N21A	Standard 10	3,060		0.5	7.5	3 x			0.3
1N21B	Improved sensitivity and burnout 10	3,060		0.5	6.5	2 x		0.4	2.0
1N21C	Most sensitive 10	3,060		0.5	5.5	1.5 x			2.0
1N23	Standard 3	9,375	TPX-36GM	1.0	10	3 x	Approx 400		0.3
1N23A	Improved sensitivity	9,375		1.0		1.7 x	400		1.0
1N23B	Most sensitive 3	9,375		1.0	6.5	2.7 x	400		0.3
1N24	Obsolete	1-cm band	Mounted in wave guide		14				
1N25	High burnout 30	1,000		1.25 0.9	8	2.5 x	100 to 400		7 watts 1-μsec pulses
1N26	Coax-shielded cartridge 1	21,000	TPK-15 HU	1.0	8.5	2.5 x	300–600 measured at 3 cm	0.5	0.1
1N28	High burnout 10	3,060		0.4	7	2 x	Approx 250	0.4	5
1N22	Instrument rectifier at 10 or 3	Western Electric		10 cm	10	6 x		0.4	0.3
		Sylvania		3 cm			10 cm 3 cm	0.45 0.4	0.3

Future

Point contact rectifiers offer many possibilities in addition to the present uses as radar mixers, second detectors, beacon detectors and low-frequency diodes. They can replace many diodes with a saving in volume, weight, and filament power consumption. The low capacitance of the contact makes their use in high-frequency applications desirable. Special kinds, such as welded point crystals and silicon high back voltage crystals, are still capable of further development and use.

Exciter-Regulator

By PAUL T. HADLEY, ARTHUR W. FORSBERG and O. KRAUER
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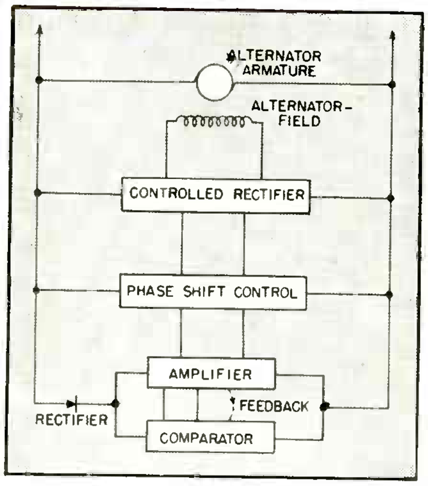


FIG. 1—Block diagram showing the operating principle of the single-phase device

THE RELATIVE MERITS of direct-current and alternating-current power in airplanes have been discussed in a number of excellent articles. It is generally recognized that the alternating-current system is preferable on large aircraft which require relatively large amounts of power for electrical auxiliaries.

This article describes a self-excited alternating-current system which employs an electronic exciter controlled by an electronic voltage regulator. Two variations of this system have been developed; one for three-phase, 400-cycle, constant-frequency main power supply, and the other for single-phase, variable-frequency, 380 to 1,000-cycle auxiliary power.

Self-Excited System

Field excitation is obtained from the output of the alternator through controlled rectifiers. Such a system is preferable to a separately-excited system, for the following reasons: The weight of the alternator is reduced approximately 25 percent. Problems of commutation at high altitudes are eliminated. The mechanical design of the alternator is simplified. The alternator may be operated at higher speeds due to the simplified design of the shaft and the absence of a commutator, thus allowing a further reduction in weight.

One inherent disadvantage of the self-excited system is its tendency to collapse under certain short-circuit conditions and thus prevent clearing of faults. It was found possible to design the circuit in such a way that voltage collapse is not experienced on faults which have sufficient impedance to maintain approximately 35 percent of rated voltage at the alternator terminals.

The problem of clearing a three-phase, zero-impedance short-circuit remained to be solved. A satisfactory solution was obtained without adding materially to weight by the use of a circuit breaker with automatic reclosing characteristics. It was found that the timing of the reclosing cycle was not critical provided that the circuit breaker opened before the voltage collapsed entirely and remained open until the voltage recovered to approximately 90 percent of normal. A practical reclosing cycle for the particular circuit constants involved consisted of equal closed and open periods of approximately 12 cycles, or 0.03 seconds each. By this method an rms value of current substantially above full load was maintained through the fault.

Constant-Frequency Circuit

A block-diagram of the single-phase self-excited alternator is shown in Fig. 1. The complete circuit of the constant-frequency exciter-regulator is shown in Fig. 2.

The function of the voltage-indicating circuit is to measure the deviation of the alternator line voltage from a set standard. This standard consists of a d-c bridge circuit which is supplied through a 5R4GY vacuum-tube rectifier from the alternator terminals. A glow-discharge type VR150 voltage-regulator tube is used as a primary standard and the bridge is balanced when the a-c voltage equals a value determined by the adjustment of rheostat R_h. Any deviation of a-c voltage produces a

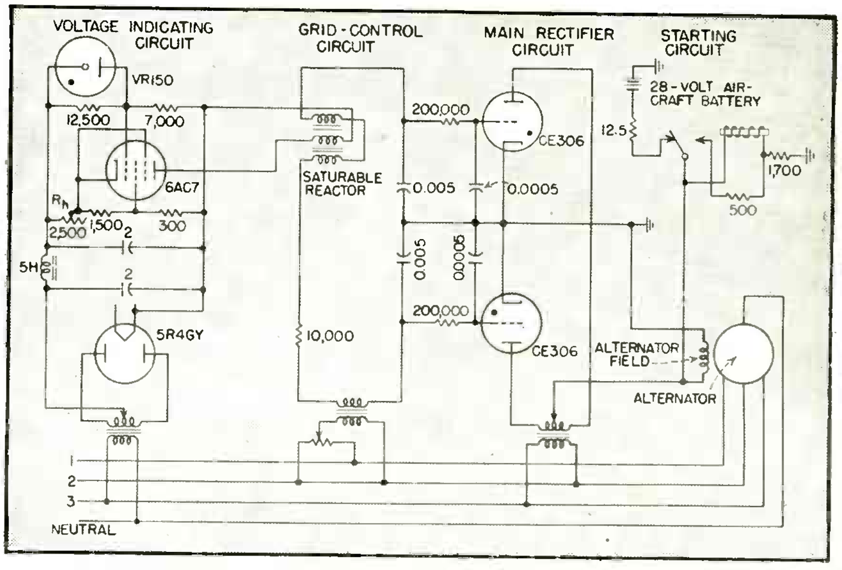


FIG. 2—Schematic of the three-phase, constant-frequency system

for Aircraft Alternators

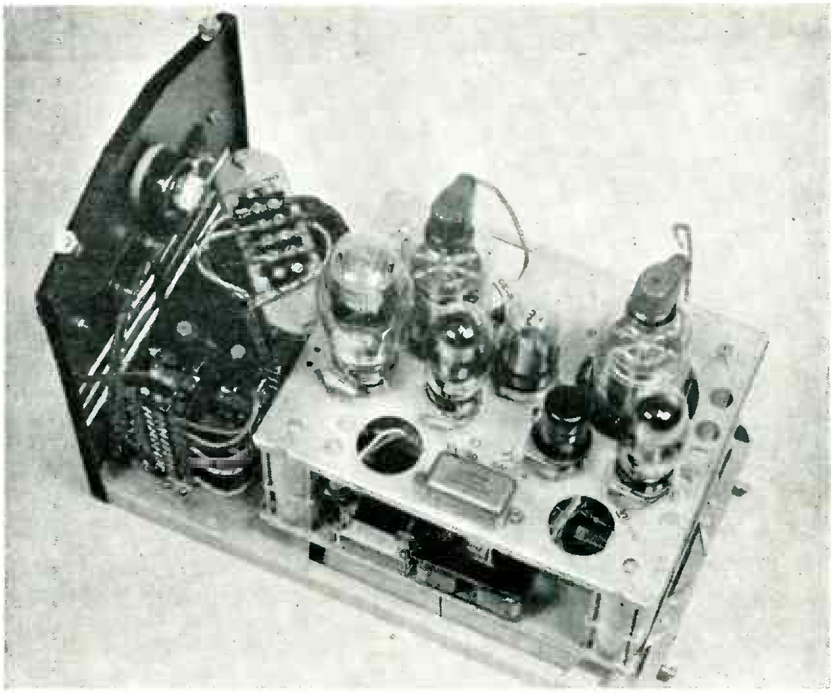
Circuit diagrams and performance characteristics of two exciters controlled by electronic voltage regulators. One is for three-phase, 400-cps constant-frequency main power supplies and the other for single-phase, 380 to 1,000-cps variable-frequency auxiliaries

change in grid voltage of the 6AC7 amplifier tube with respect to its cathode and a corresponding change in the plate current, which excites a saturable reactor.

In the grid-control circuit, variations in reactance caused by changes of the d-c excitation of the saturable reactor produce corresponding phase shifts of the grid voltage of the CE306 thyratron main rectifier tubes.

The main rectifiers are connected for full-wave rectification. The output of the tubes, which flows through the alternator field, is determined by the relative phase angles of their grid and anode potentials. A change in voltage at the alternator terminals will unbalance the bridge, producing a change in the d-c excitation of the saturable reactor and a consequent shift of phase angle of the thyratron grid voltage, which raises or lowers the output of the thyratrons and the alternator excitation until the bridge is again balanced.

A 24-volt aircraft battery was available for use with the constant-frequency unit to provide the excitation necessary to initiate voltage buildup in the starting circuit. When the unit is started, battery voltage is applied to the alternator field through a series resistance which is adjusted to produce approximately 60 percent normal voltage at no load. At this voltage the heater current in the thyratron tubes is sufficient to start ionization. The low a-c voltage causes the bridge to call for full output from the thyratrons and, when ionization commences, the rectified voltage from the thyratrons adds to the battery voltage, increasing the excitation and a-c voltage cumulatively until normal voltage is reached. A relay opens the battery circuit when the field voltage reaches a self-sustaining value.



The single-phase, variable-frequency exciter-regulator

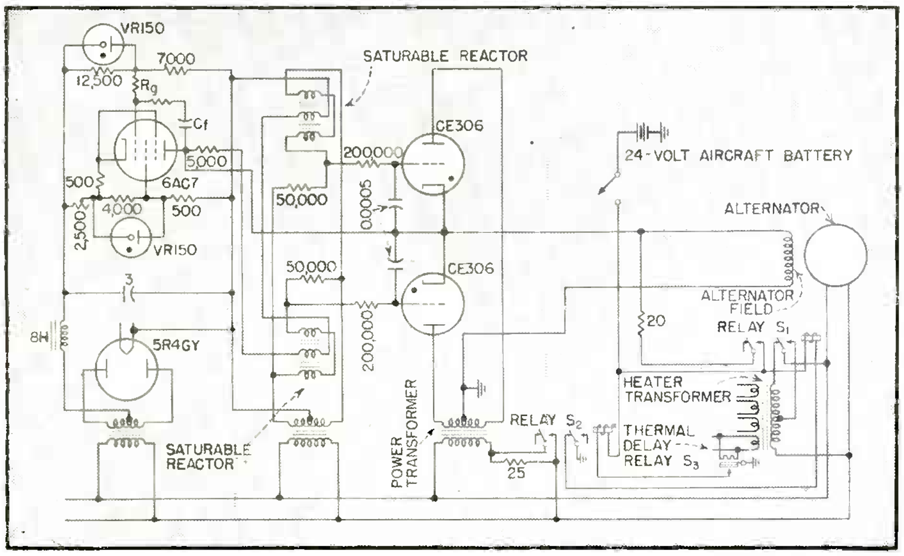


FIG. 3—Circuit of the single-phase, variable-frequency unit

Variable-Frequency Circuit

A battery was also available for starting the variable-frequency unit. In order to assure buildup at the lowest speed and prevent damage to the tubes when starting at the higher speeds, additional relays are employed in the circuit. Referring to Fig. 3, the sequence of operation is as follows:

When battery voltage is applied to

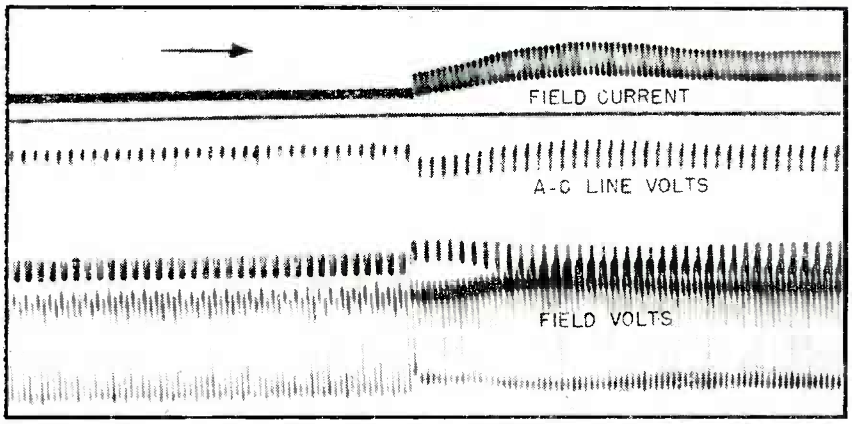


FIG. 4—Oscillogram showing the performance of the variable-frequency exciter-regulator upon application of a sudden 68-ampere, 0.8 power-factor load at 510 cycles

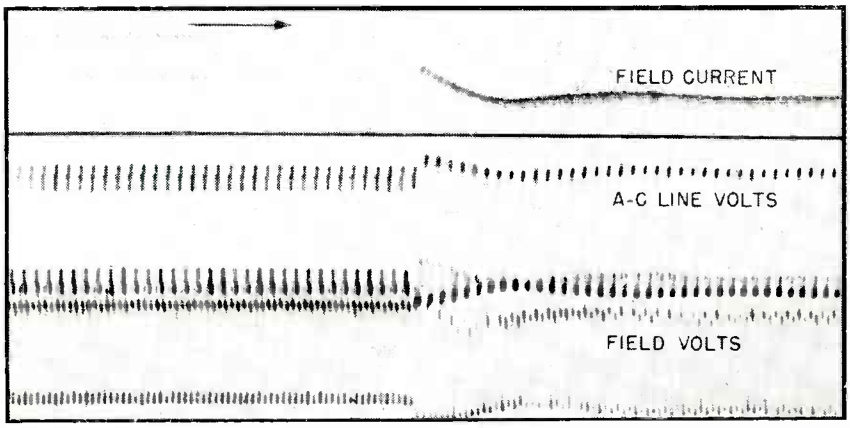


FIG. 5—Oscillogram showing the performance of the variable-frequency exciter-regulator upon sudden interruption of a 68-ampere, 0.8 power-factor load at 485 cycles

the unit, relay S_1 is energized through a normally-closed contact on relay S_2. Closing of relay S_1 applies battery voltage to the alternator field and also connects one side of the a-c bus to a tap on the primary of the heater transformer. The tap is adjusted to give approximately 60 percent rated heater voltage at the lowest speed at which the unit is to be started.

Cumulative buildup proceeds as described previously. A resistance in series with the power transformer primary limits the current flow through the thyratrons during the starting period. A thermal time-delay relay S_3, which has characteristics which closely approximate those of the thyratrons, is connected across one of the heater circuits. When the thyratrons have reached operating temperature S_3 closes and energizes S_2. S_2 short-circuits the resistance in series with the power transformer primary and also deenergizes S_1; thus the heater primary is switched from tap to full winding and, at the same time, the battery circuit is opened.

When starting at the highest operating speeds, the heater voltage is approximately 50 percent above rated voltage. The thyratrons are protected against overheating by the characteristics of the thermal relay, but the life of the amplifier and rectifier tubes may be shortened because of their smaller thermal capacity.

A sudden change in a-c voltage, with a corresponding change in bridge voltage, causes current proportional to the rate of change of voltage to flow through capacitor C_f. This current, flowing through R_g, produces a potential on the grid which tends to oppose the change produced by the change in bridge voltage. The result is to slow down the response and prevent overshooting. The cathode resistor also provides degenerative feedback and aids in preventing hunting.

Performance

The laboratory setup used to test the constant-frequency system consisted of two 40-kva, three-phase, 400-cycle, 208 or 120-volt, 6,000-rpm alternators, each belt-driven from a 3,600-rpm induction motor and each alternator excited and controlled by its own exciter-regulator.

The variable-frequency system test setup consisted of an 8-kva, single-phase, 4,000 to 10,000-rpm, 115-volt alternator, belt-driven from a 15-hp, 4-speed induction motor and with electronic exciter-regulator. Variable-pitch sheaves were used in the drive so that intermediate speeds could be obtained.

With the frequency constant within approximately 10 percent, the regulator is capable of maintaining constant voltage under steady-state conditions within 1 percent or better. On the variable-frequency application, with a frequency range of 2.5 to 1, an accuracy of 2 percent was obtained.

The response to sudden transient changes in load was extremely rapid. The oscillograms shown in Fig. 4 and 5, taken on the variable-frequency unit, are typical. Figure 4 is a record of the sudden application of approximately full load on the alternator. It will be noted that complete recovery of line voltage was attained within 25 cycles, or approximately 0.05 seconds. Figure 5 shows the results of sudden removal of load from the alternator. Complete voltage recovery was reached in 23 cycles, or less than 0.05 seconds. The stability of the system is demonstrated in these oscillograms. Only one cycle of oscillation can be detected in either.

The pulley ratios of the belt-drives for the two 40-kva alternators were slightly different and, as a consequence, the speeds of the two units differed by approximately 1.5 percent. Under these conditions, the alternators could be paralleled at random without synchronizing, with relatively small voltage disturbance and rapid recovery. The application for which the variable frequency unit was designed and built did not require parallel operation and, therefore, no such tests were made.

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INTERMODULATION TESTING

Fidelity of audio amplifiers, especially those used in f-m transmitters and receivers, is best determined by intermodulation tests. Correlation with actual listener tests is higher for intermodulation tests than for harmonic distortion tests

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STANDARDS of good engineering practices concerning f-m broadcasting, published by the Federal Communications Commission, specify an audio frequency bandwidth of from 50 to 15,000 cycles. These standards indicate that it is the intention for f-m broadcasters not merely to transmit the designated wide audio band but also to transmit this band with minimum distortion. To obtain this objective it will be necessary for most engineers to alter radically their audio frequency design and measuring techniques, and to revise their concepts of high fidelity.

In transmitting signals covering a wide frequency range, it is necessary that all the elements of distortion be reduced to a very low degree. This requirement is particularly true when the frequency range approaches the full capabilities of the human ear. If distortion is not satisfactorily controlled, the results of extending the frequency range will be to produce a quality which is less pleasing than that obtained with a limited bandwidth.

The error of transmitting a wide band without sufficient reduction of distortion has been repeated many times and in each case the public has reacted unfavorably to what was expected to be an improvement. Experience in the sound motion picture field has indicated that widening of the frequency range should be the last step in design improvement. Reduction of distortion comes first and then, with proper experience, if the distortion and noise level are sufficiently low, the frequency band can be extended. If the new standards of the FCC are to be properly met, a new set of standards for measuring permissible distortion is essential. I refer not only to distortions of frequency and amplitude, but also to distortions caused by hum, noise, and distortion caused by interaction of complex frequencies, which has come to be known as intermodulation.

Tests for Fidelity

For an amplifier system to provide excellent quality without distortion while transmitting the band from 50 to 15,000 cycles, the complete amplifier system should be capable of passing the following tests:

(1) Total hum and other noises measured throughout the entire band should be at least 66 db below the full modulation or overload point.

(2) As determined by means of an oscillator and oscilloscope, the maximum sine wave carrying capacity for the system should be determined for all frequencies in the transmitted band. It is desirable for the amplifier system to have reserve sine wave carrying capacity of at least six decibels beyond full modulation over the entire pass band.

(3) Frequency response runs should be made at maximum operating level as determined by the preceding test. Additional frequency response measurements should be made at 30 db below that point and 60 db down from the maximum operating level. There should be no significant difference in the frequency response of the amplifier system at these three levels of output power.

(4) Determine intermodulation products of the amplifier system by methods outlined herein. For direct transmission, six percent intermodulation should not be exceeded anywhere in the frequency band. If the signal is to be recorded and re-recorded, or if it is to be transmitted through a network of amplifier systems, it is desirable for the intermodulation products to be held below four percent. Amplifier systems which will meet all of these requirements can be built, but they require much greater attention to design than they have been previously accorded.

Amplifier systems which will not meet these tests will fail to meet the

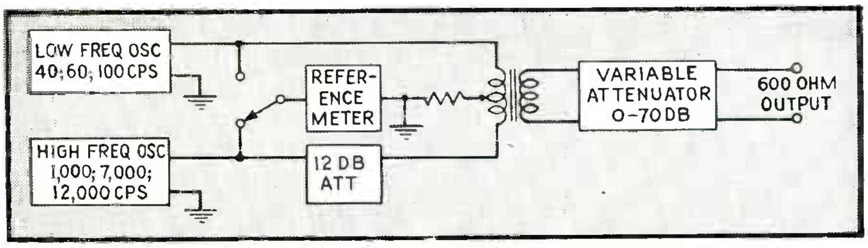

FIG. 1—Signal generator for intermodulation testing consists of two independent oscillators and a linear circuit for mixing their outputs

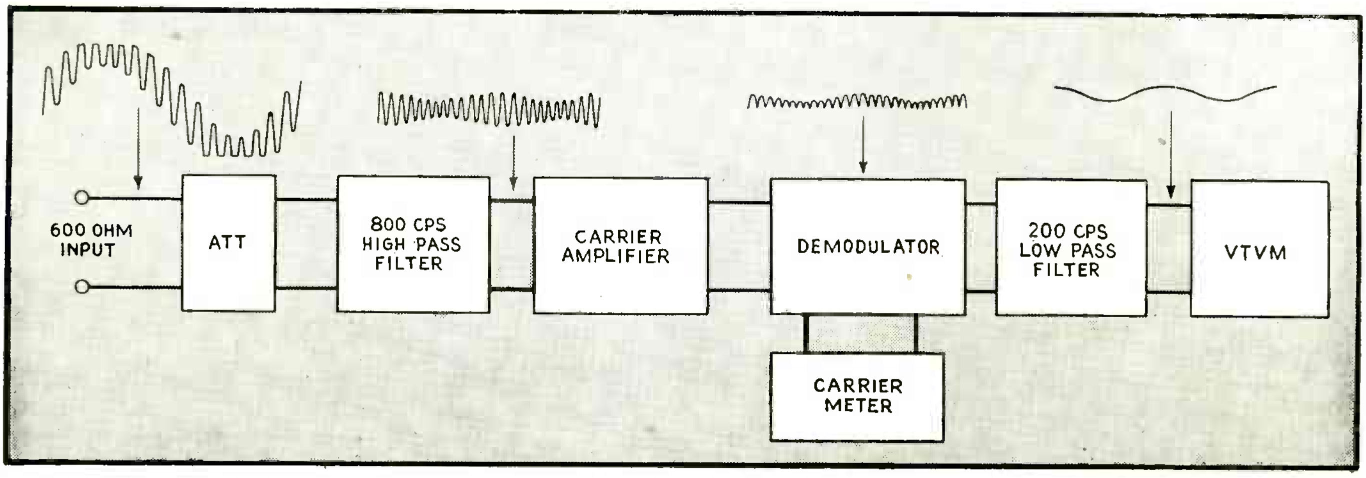

FIG. 2—Intermodulation analyzer detects high frequency modulation developed by nonlinearity of amplifier under test. (Word just received from author explains that 1,000 cps in test oscillator has been replaced by 2,000 cps so that analyzer accepts more sidebands—bandwidth is now 500 instead of 200 cps—eliminating tendencies for cancellation of sidebands of 100 cps.)

objective of truly high quality reproduction. Measurements of hum and other noises, measurement of maximum sine wave carrying capacity for the entire band, and measurement of frequency response at the designated levels all utilize techniques with which the audio frequency engineer is familiar.

Intermodulation

Over the past ten years, Frayne and Scoville of the Western Electric Company, Scott of the General Radio Company and Harries, Narath, Janovsky and the writer have discussed the problem of measuring intermodulation distortion.

During the past eight years I have been using the intermodulation method in designing audio amplifiers and film and disc recording apparatus. As a result of this experience, I believe a discussion of these measurements may be interesting and helpful to those designing f-m transmitters that will meet the new FCC requirements.

Intermodulation tests consist of transmitting simultaneously two known frequencies through the equipment under test and then measuring the degree of interaction and distortion of these two frequencies by determining the magnitude of new frequencies which have been generated.

Two known frequencies are applied to the input of the amplifier under test from a signal generator. The output attenuator of the signal generator is adjusted to produce the required power from the amplifier under test. The output of the amplifier or system being tested is connected to the input circuit of the intermodulation analyzer. The input attenuator on the analyzer is then adjusted until a carrier level meter reads 100 percent. An intermodulation percentage meter then reads directly the amount of distortion present.

Signal Generator

Figure 1 shows a block diagram of a conventional signal generator used for intermodulation testing. It contains two independent resistance-capacitance sine-wave oscillators. We have a choice of 40, 60, or 100 cycles from the low frequency oscillator and 1,000, 7,000, or 12,000 cycles from the high frequency oscillator. The output level of each oscillator is independently controlled. A reference meter can be switched to either oscillator for metering its level. The output of each oscillator is transmitted by a cathode follower to a hybrid coil which combines the two oscillator outputs.

A 12 db fixed attenuator is provided in the high frequency oscillator output so that the low frequency is transmitted 12 db higher than the high frequency. This differential ratio of low to high frequency amplitudes is arbitrary and is used to obtain the maximum, low frequency sensitivity of the test.

For other test conditions, in particular where distortion is predominantly at high frequencies, it may be advisable to use other amplitude ratios for the two test frequencies.

An output meter, a variable attenuator of 30 db range, and fixed attenuation of either 20 or 40 db are available by means of a selector switch to control the output. A ganged dual potentiometer at the input of cathode followers gives a

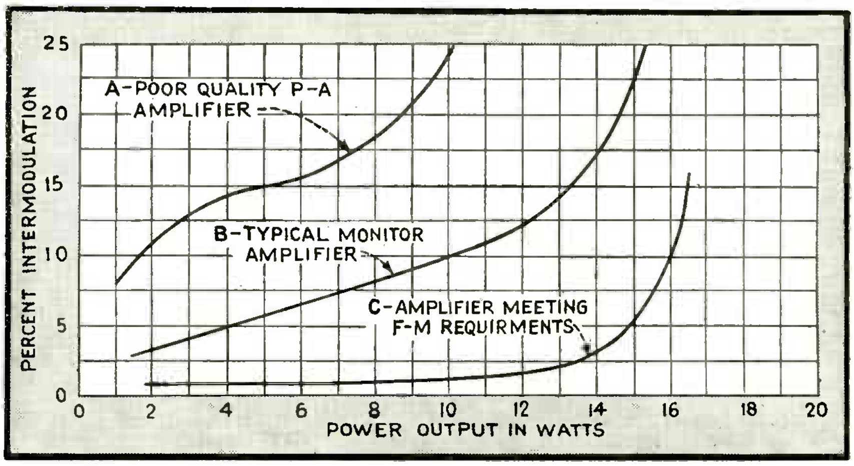

FIG. 3—Intermodulation tests indicate the increasing nonlinearity of amplifiers as they are called upon to handle larger signals

vernier adjustment of output power.

A block diagram of an intermodulation analyzer is shown in Fig. 2. The input attenuator system is adjustable over a 90 db range in one decibel steps, and is capable of dissipating 50 watts. The input impedance is 600 ohms.

Intermodulation Analyzer

Equipment under test receives its input from the signal generator and delivers its output to the analyzer. The output of the equipment under test consists of a low frequency with a high frequency superimposed upon it, plus harmonics of the original tones, plus intermodulation distortion. In order to measure this intermodulation, it is necessary to remove the original low frequency component. This removal is accomplished by an 800 cycle high pass filter which follows the attenuator. The output of the filter consists of what may be termed a carrier and its resultant sidebands. This carrier is then amplified to a predetermined level and demodulated. The reference level is obtained by adjusting the input attenuator to provide a 100 percent reading on the carrier meter. The output of the demodulator is transmitted through a 200-cycle low-pass filter which removes the carrier frequency and transmits only sideband components up to 200 cycles.

Discussion in the literature has indicated that both first and second-order intermodulation components generally are present in the distortion of audio frequency transmission equipment. For this reason it is considered essential that measuring equipment should record many such components rather than limit itself to only first order components.

The 200 cycle cutoff frequency has been set so that at least the second order terms will be accepted for all the original low frequencies, more being accepted for the 60 and 40 cycle tones.

The choice of the 800 cycle cut off for the high-pass filter has been dictated by the requirement that at least 60 db of discrimination be inserted against all low frequencies in order that values of intermodulation can be measured down to 0.1 percent.

The ripple components or intermodulation products are amplified and measured by a vacuum tube voltmeter. The meter is calibrated directly in percentage total intermodulation and has six ranges with full scale sensitivities of 0.3, 1.0, 3.0, 10, 30 and 100 percent. The analyzer can also be used as a voltmeter by bridging the filters. The frequency range as a millivoltmeter is flat within 1 db from 20 to 20,000 cycles per second and on the voltmeter scale its range is flat from 20 to 50,000 cycles.

The inclusion of the vacuum tube voltmeter provides a method of accurately measuring signals or noise levels. The meter scales read in volts, with maximum sensitivity corresponding to a full scale reading of 0.3 mv, and in db relative to one milliwatt across 600 ohms. In shifting from the measurement of percentage intermodulation to voltage, the termination of the amplifier under test is not altered.

Sensitivity for zero on the db scale has a range from minus 70 to plus 40 dbm in 12 steps of 10 db each. Because the scale is calibrated so that a −20 db point is readable, a range down to −90 dbm is possible.

Frequency response curves and noise levels can be obtained by using the voltmeter and millivoltmeter. Two scales enable data to be taken in either decibels or volts. A bridging jack is provided so that the vacuum tube voltmeter can be bridged across any portion of a circuit where a shunt of 1.4 megohms will not influence circuit conditions.

Apparent cancellation of intermodulation effects (usually near

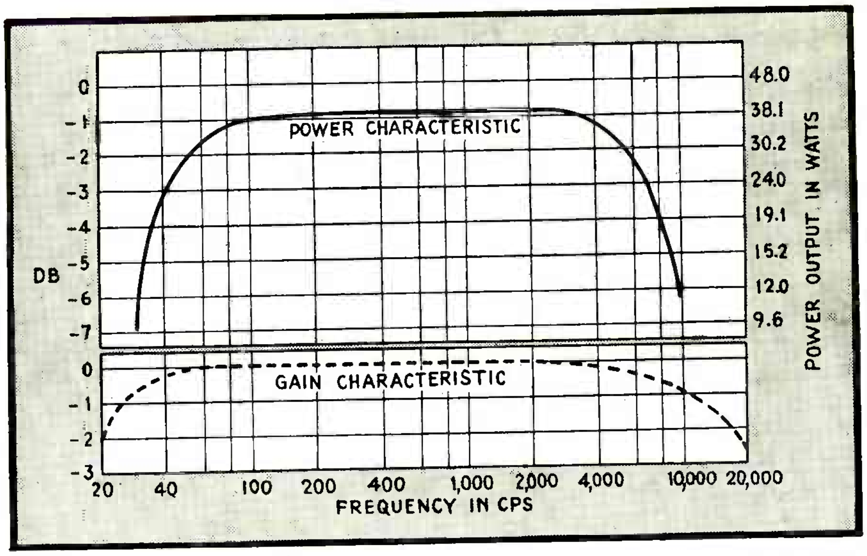

FIG. 4—Maximum undistorted power obtainable for a particular amplifier falls rapidly at low frequencies

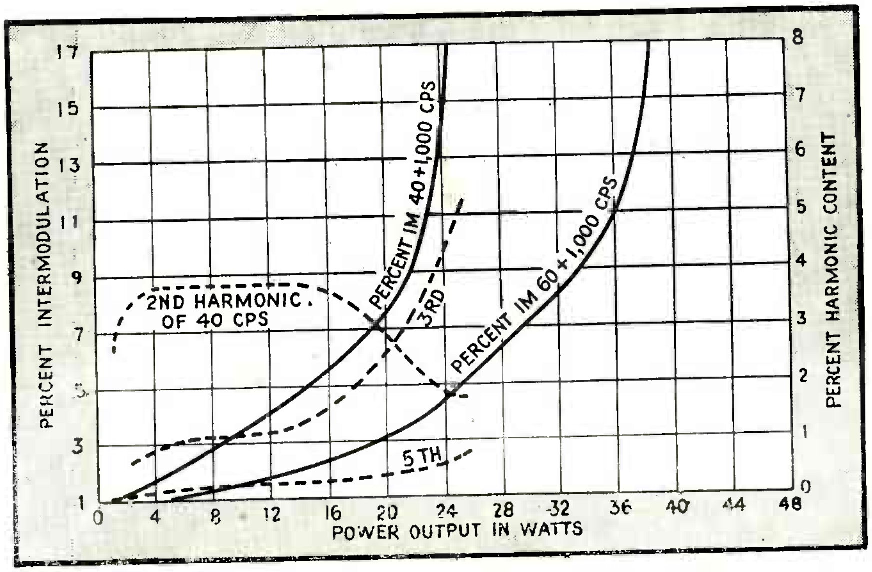

FIG. 5—Intermodulation and harmonic distortion of the amplifier whose characteristics are given in Fig. 4

amplifier overload point) is a phenomenon which has been observed in some cases. In these cases it has been found that the pass band of the intermodulation analyzer was not sufficiently wide to accept the higher order distortion terms.

Analyzer Calibration

Calibration of the intermodulation analyzer is made using two frequencies, namely 1,000 and 1,060 cycles. A 20 db attenuator is switched into the 1,060 cycle oscillator output so that when these two frequencies are combined, the 1,060 cycle output will be 20 db below the 1,000 cycle output. By definition this is a condition of ten percent intermodulation. This complex signal is then transmitted directly to the analyzer with the range switch set for ten percent intermodulation. The input level is then adjusted for a ten percent reading on the intermodulation meter, and the carrier meter is set to 100 percent.

Calibration of the voltmeter is accomplished by checking against a standard a-c voltmeter. By inserting a 60 db attenuator ahead of the analyzer, the same voltage can be used to check the millivolt range.

Low Frequency Overloading

The writer wishes to stress the importance of linear transmission of amplitudes and wave forms of the low frequencies which occur simultaneously with the higher frequencies of speech and music. These low frequency components originate in drums and other percussion instruments, in the reproduction of gun shots, explosions, thunder and earthquakes.

Unless a transmission system has the carrying capacity at low frequencies to handle these sound effects, distortion results. Therefore, it is considered essential to test a transmission system in such a manner as to stress these low frequencies. Transformers and other devices which change their impedance at low frequencies are a major cause of distortion, because this impedance change limits the carrying capacity of the tubes. For this reason, limited power capacity will appear at low frequencies more readily than in the midrange.

Analysis indicates that all types of systems show least distortion near the middle portion of their transmission band. Therefore, test equipment is designed so that test frequencies lie near the outer portions of the frequency band.

Apparatus which shows low intermodulation distortion at 40 cycles will meet the most rigid low frequency demands, while systems which pass the intermodulation test only at 60 or 100 cycles should be used only where a corresponding sacrifice in quality is permissible. This information, together with a corresponding study of high frequency properties, will determine the bandwidth for which a particular system is suitable.

Figure 3 shows intermodulation curves on three classes of amplifier. Curve A represents a poor public address amplifier which is not suitable for any application even though the amplifier is rated at 14 watts, because distortion is excessive at one or two watts. Curve B is representative of the average, high grade amplifier now used for radio station and recording purposes. Curve C is an amplifier which will meet the rigid specifications called for by f-m standards of good engineering.

Correlation of Harmonic and Intermodulation Distortions

Figure 4 shows the power and gain characteristic of a pushpull parallel 6L6 amplifier rated by its manufacturer at 50 watts. The power curve is obtained by observation of

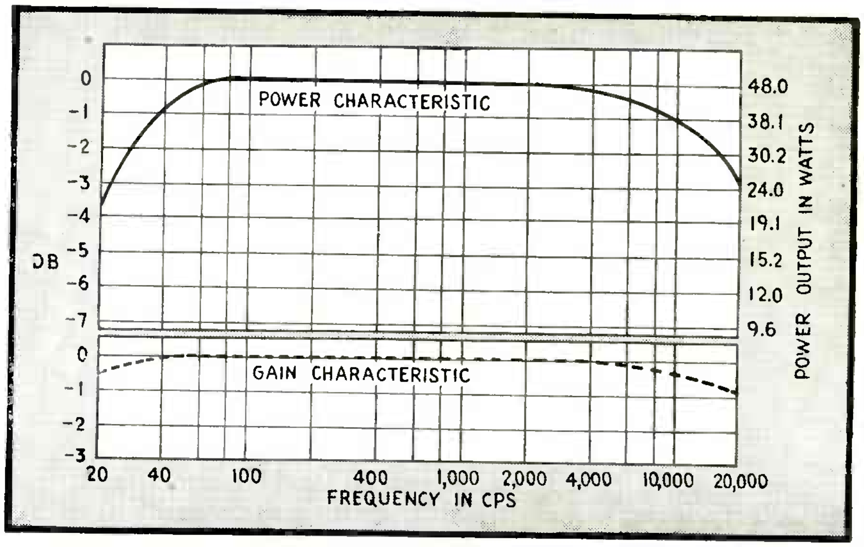

FIG. 6—Although not rated for as high power as the amplifier of Fig. 4 and 5, this amplifier has better high and low frequency response

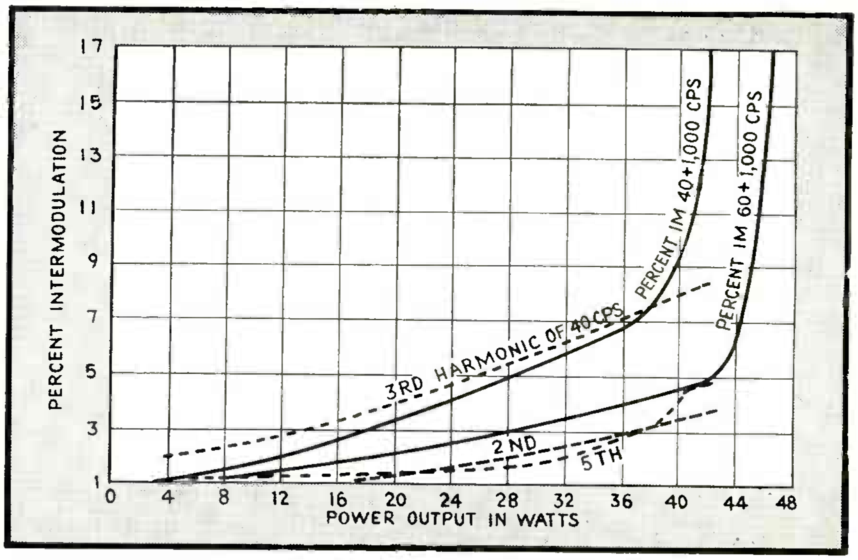

FIG. 7—Intermodulation distortion of the amplifier whose characteristics are shown in Fig. 6 remains low up to its rated output power

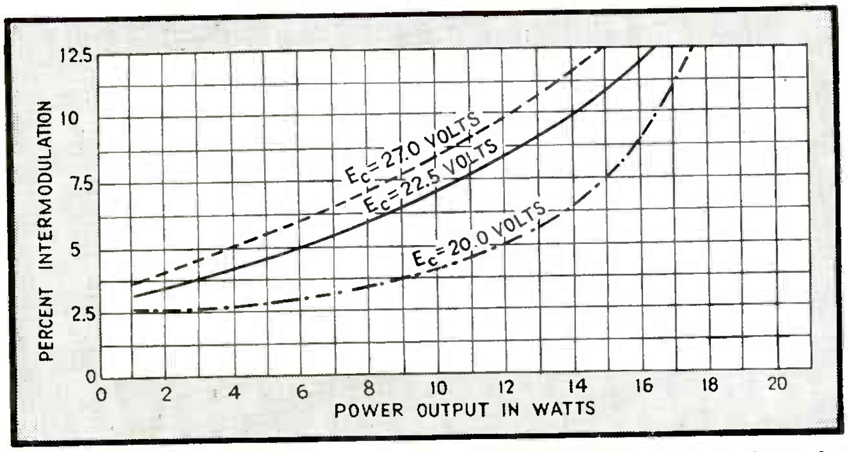

FIG. 8—Effect of cathode bias on linear operation of output tubes is shown by intermodulation tests

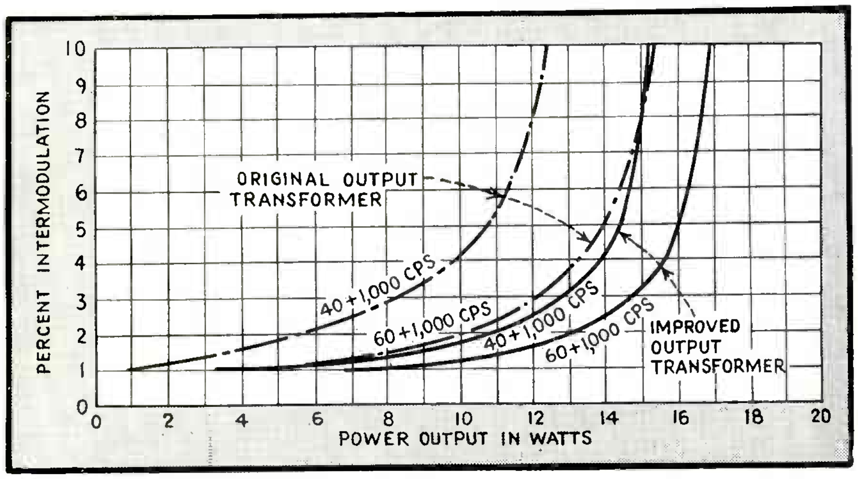

FIG. 9—Intermodulation testing shows the importance of the output transformer at low frequencies

the maximum power that can be generated before departure of the output from a sine wave is observable on an oscilloscope. The gain characteristic had to be measured at a low level so as to be within the limitation of the power curve.

Figure 5 shows the distortion analysis for this amplifier, giving the 40 cycle harmonic analysis for 2nd, 3rd, and 5th harmonics as well as the percentage intermodulation for 40 and 1,000 cycles and for 60 and 1,000 cycles. It will be observed that the 40 cycle intermodulation products rise very rapidly in the vicinity of 25 watts. For this particular amplifier the 3rd harmonic shows a rapid increase at the same power. The fact that the 60 cycle intermodulation curve is lower for the same power indicates a deficiency in the output transformer as was indicated in Fig. 4 by the reduction in power handling capacity at low frequencies.

Figure 6 shows power and gain characteristics for an amplifier having a manufacturer's rating of 40 watts. In this case the power and frequency response are more uniform over a wider frequency range. Figure 7 shows the harmonic content at 40 cycles for 2nd, 3rd and 5th harmonics together with the intermodulation curves for 40 and 1,000 cycles and for 60 and 1,000 cycles. It will be noted in this case that the harmonic distortion for all orders of terms increases gradually with power. Because both total harmonic and intermodulation distortion are low, except near its rated maximum power, the amplifier can be considered to be comparatively free of distortion.

In our design and development work on amplifiers, we have found that proper design and adjustment are attained only when the curve shows low values of intermodulation at low levels and rises gradually as maximum power is reached.

A good example of how the intermodulation method can be helpful in design work is shown in Fig. 8. Here are shown three intermodulation curves showing the effect on intermodulation of improper bias of the amplifier's power stage. The requirement of low intermodulation products at low operating levels forces the bias nearer the condition of strictly Class A operation in amplifiers. In other words, excessive bias must be avoided for highest quality performance in the operating range.

Intermodulation Tests

Intermodulation testing has facilitated advancements in transformer design. Figure 9 shows the improvement which can be made in an amplifier by substituting an improved output transformer. It will be observed that the low frequency carrying capacity has been increased and the distortion has been reduced for all levels of operation.

Most of these curves have shown conditions where overload occurs first at low frequencies. In some amplifiers high frequency distortion predominates. To test these amplifiers the two frequencies from the signal generator are adjusted to be of equal amplitude. The intermodulation measurements will indicate the presence of high frequency distortion when it is not masked by low frequency distortion.

Without exception it has been the writer's experience that listening tests will confirm the relative intermodulation test figures. All other things being equal, critical listeners will select the system having the lowest percentage of intermodulation in a performance test.

The intermodulation test does not of itself provide all information required by engineers. It needs to be supplemented by frequency response, noise, and power tests mentioned earlier in this paper. When used in conjunction with these other tests, it is the writer's belief that this intermodulation method of testing represents a major tool, essential in design, production, and maintenance of amplifier systems which meet FCC standards of good engineering practice.

The writer wishes to acknowledge the important work done by W. C. B. Evans, who has shared the responsibilities of designing the equipment and who has supplied much of the laboratory data used in this paper.

Measurement of VELOCITY OF PROPAGATION in Cable

In determining electrical length of vhf lines, it is necessary to know the velocity of propagation in the particular cable that is used. A simple, resonant, substitution measurement made with the instrument described gives that information

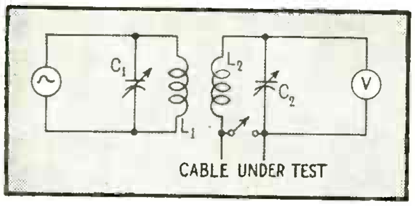

FIG. 1—Frequency is adjusted until cable under test presents a short circuit to the instrument

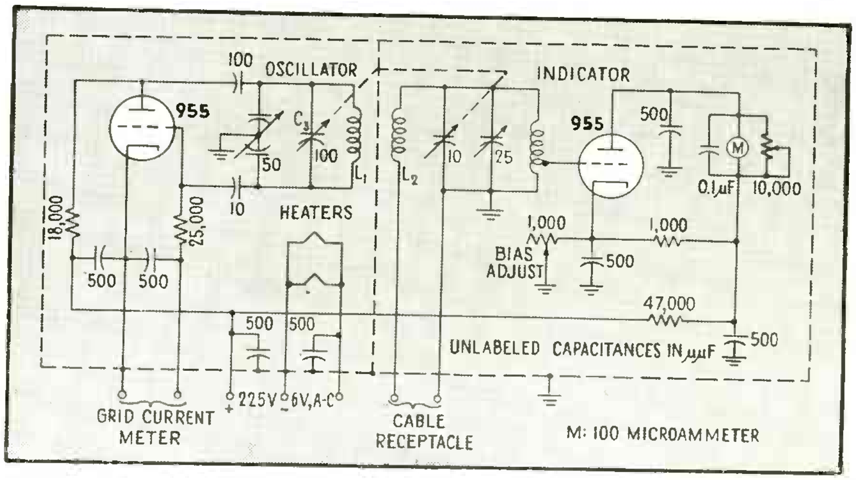

FIG. 2—Complete circuit of the velocity of propagation measuring instrument

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ONE OF THE important characteristics of an ultrahigh-frequency transmission line is the velocity at which an electromagnetic wave propagates through it. Not only is knowledge of this velocity essential in determining the lengths of solid dielectric tuning stubs used for impedance matching, but it is also vital when the line is used as a harness where exact physical lengths must represent exact electrical lengths.

For these reasons and as a method of quality control it is necessary to measure the velocity of propagation of each reel of transmission line. This becomes a large scale operation where, for example, over two million feet of polyethylene insulated transmission line is manufactured in a month.

Velocity of propagation varies inversely as the square root of the dielectric constant of the material separating the inner and outer conductors of a coaxial, transmission line. The relative velocity of propagation is found by the relation $v/c = 1/\sqrt{k}$ where the significance of the letters is given in Table I. Thus it can be seen that any change in the dielectric constant will result in a variation in the velocity of propagation.

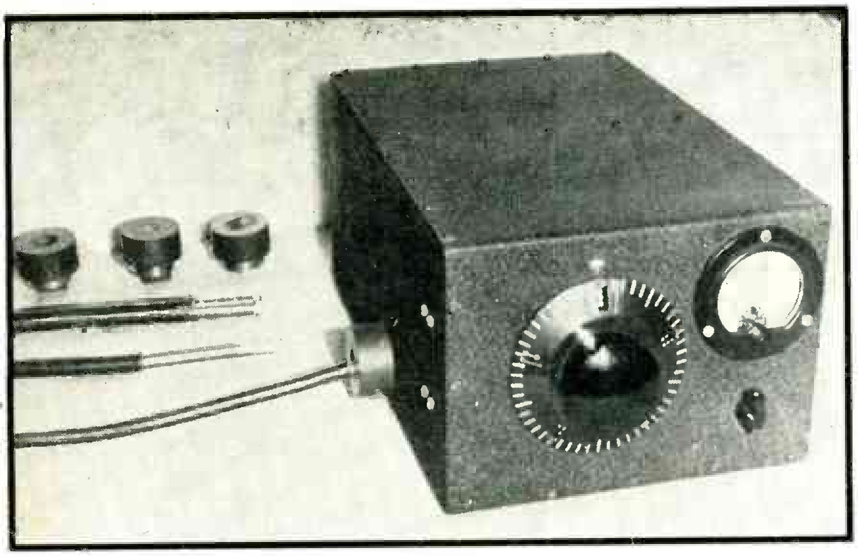
The two following expressions from transmission line theory are the basis for the method of measuring the velocity of propagation, which is described in a Naval Research Laboratory report, "Methods of Measuring the Electrical Characteristics of Transmission Lines at Ultra High Frequencies".

The velocity of propagation is equal to the wavelength times the frequency in cycles per second or $v = \lambda f$, and the input impedance of an open-circuited, low-loss line is given by the expression $Z_i = jZ_0 \cot (2\pi l/\lambda)$. It can be seen that when l is equal to an odd number of quarter wavelengths the quantity $\cot 2\pi l/\lambda$ is equal to zero and therefore the line will act as if its input end were short circuited.

Method of Measurement

Referring to Fig. 1, which is a simplified schematic of the velocity-of-propagation meter circuit, one sees that two circuits L_1C_1 and L_2C_2 will resonate at the same frequency if the transmission line acts as a short circuit. This will occur only when the frequency of the generator is such that the electrical length of the transmission line is exactly an odd number of quarter wavelengths.

This condition of zero impedance



An odd quarter, electrical wavelength of line is inserted in the instrument. The single dial simultaneously tunes both oscillator and indicator. When the meter indicates resonance by maximum reading, the frequency indicated on the dial is proportional to velocity of propagation

TABLE I—DEFINITION OF SYMBOLS

c	— wave velocity in air, 3×10^{10} cm per sec
f	— frequency, see text preceding each equation
k	— dielectric constant
l	— length of line, in cm
v	— wave velocity in line, in cm per sec
Z_0	— characteristic impedance of line, in ohms
Z_I	— input impedance of line, in ohms
λ	— wavelength in line, in cm

is approached by first tuning capacitor C_1 so that the whole circuit is in resonance and then short circuiting the input end of the transmission line. If resonance is disturbed the circuit is returned with capacitor C_2. The procedure is repeated until open and short circuiting the transmission line does not disturb the resonant condition of the measuring circuit. By measuring the frequency at which no resonant disturbance occurs and, knowing the physical length of the transmission line, the velocity of propagation can be determined.

The method just outlined is obviously not adaptable to mass production methods which require accurate results, rapidly obtainable by unskilled personnel. The Naval Research Laboratory, recognizing this, developed an instrument for precise measurement which they have called the VP Meter. In this instrument, which employs the principles outlined, it is only necessary to insert the prepared end of a transmission line of predetermined length and adjust a single dial until a maximum indication is shown on the meter. The relative velocity of propagation is then read directly from the frequency dial or from a calibration table.

The instrument developed and built by Federal's engineers is based on this design but is modified to enable it to be used for a wide variety of sizes of coaxial and dual transmission lines, and to have a finer tuning control.

The sample of solid polyethylene transmission line is cut exactly 150 cm long which represents ¾ of a wavelength at approximately 100 megacycles for the velocity of propagation of this particular cable.

The velocity of propagation in percent is calculated as follows when frequency is in mc $v/c = \lambda f \times 10^6/c$. From the above values, $l = \frac{3}{4}\lambda = 150$ cm, thus $\lambda = 200$ cm. Substituting this value of wavelength into the foregoing equation gives $v/c = 200f \times 10^6/3 \times 10^{10} = \frac{2}{3}f$. Thus the relative velocity is a direct function of the resonant frequency.

Measuring Instrument

The speed of measurement on the VP Meter is due to the fact that the oscillator and indicator circuits are ganged together and always tuned to the same frequency when the transmission line receptacle is short circuited. As before, this condition will occur when the frequency is such that the cable is exactly $\frac{3}{4}\lambda$ and is indicated by a maximum reading on the vacuum-tube voltmeter which is a sensitive, resonance indicator.

Figure 2 is a schematic circuit of the VP Meter. On the lefthand side is the oscillator circuit which can be tuned from 95 to 105 megacycles by means of capacitor C_3. The inductor L_1 is very loosely coupled through an electrostatic shield to inductor L_2 in the indicator circuit. Padding capacitors are provided in each circuit to obtain close tracking throughout the frequency range.

To insure the accuracy of results, it is only necessary to check the frequency calibration of the dial and the tracking between the two circuits. Frequency calibration is easily checked against a calibrated frequency standard. Tracking is checked by merely inserting a copper shorting rod in the line receptacle and noting the change in meter deflection over the frequency range. A two-percent change in meter deflection would still represent negligible error in measurement. No change in meter deflection indicates perfect tracking.

Three calibrated, test samples are used for frequently checking the calibration of the instrument. The samples consist of solid dielectric lines that have been pulled into a tight fitting copper tube and sealed, the tube serving as the outer conductor. The velocities of propagation in these samples have been adjusted so as to bracket the range of the instrument.

The time required to measure the relative velocity of a prepared cable sample with this instrument is only about ten seconds. The total error due to working limitations is estimated to be less than two percent. The standard deviation in the measurement of a large number of samples of a single type of transmission line does not exceed 0.08 percent, the major part of which is due to variations in the samples themselves.

Rotary Wave Radar

Continuous-wave system for commercial use employs circular polarization to permit simultaneous transmission and echo reception without sacrifice of transmitted or received signal power. Chief use is in low-power applications requiring minimum weight and bulk

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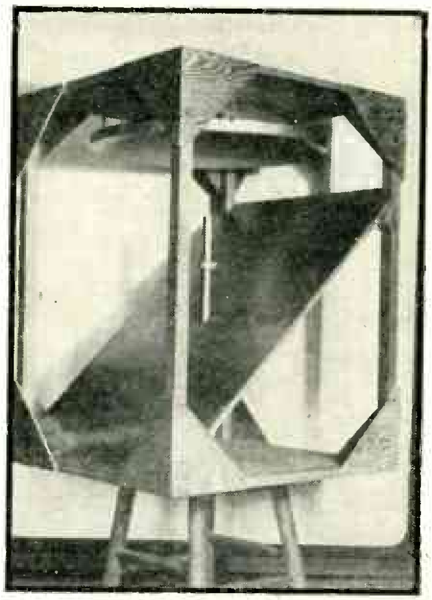
THE commonly used radar system employs short pulses of radiation. Between the end of one pulse and the beginning of the next the radiating system acts as a receiving antenna for picking up the echo of the previously transmitted pulse. There are some radar applications, however, which require continuous-wave radiation. Reception must then be carried out continuously and simultaneously with transmission.

Various methods have been proposed to avoid having separate antennas for simultaneous transmission and reception, but unfortunately most of these schemes involve a serious sacrifice of power. A typical expedient employs a Wheatstone bridge having the resistance of the antenna transmission line as one arm and a resistor as another arm. Since the receiver and transmitter are connected to conjugate points, the receiver is not affected by the transmitter power. However, half the transmitter power is wasted in the bridge arm, and only a fraction of the total incoming signal power reaches the receiver.

Basic Principle of System

The basis of the method to be described is the use of two orthogonal planes of polarization. When applied to a circular waveguide, it takes the form shown in Fig. 1. The waveguide is energized by a probe which terminates a coaxial line leading from a transmitter serving as a source of microwave power. A horn causes the resulting energy to be radiated in a narrow beam and also provides a nearly nonreflective termination for the guide. The receiving probe projects into the guide at right angles to the transmitting probe and is preferably displaced a number of half wavelengths along the axis. Energy picked up by this probe is carried by a coaxial line to a crystal detector in the receiver.

The detector probe will not pick up the outgoing power of this transmitter because there is no component of the pickup probe along the direction of the electric field of the transmitted waves. On the other hand, if incoming signals have their electric field parallel to the detector probe all their power can be absorbed in the detector and none in the transmitter. Thus simultaneous transmission and reception can be accomplished with a single horn or dish radiating system without impairing the efficiency of either function if the planes of polarization of outgoing and incoming waves are at right angles to each other.



Arrangement of Fig. 3, employing an 18-inch concave reflecting dish above a flat reflecting sheet set at 45 degrees

The system as so far described has only limited usefulness for radar-type applications where the received signal is the echo of the transmitted wave, because few if any targets will rotate the plane of polarization a full 90 degrees during reflection. For example, if the radar signal is reflected from a spherical body its polarization will be unaltered and the echo will not affect the detector. The same is true if the reflecting body consists of one or more thin conductors parallel to the electric field of the transmitter. If such conductors are perpendicular to the field there will be no reflection and no echo. However, such conductors in any other orientation will produce an echo that has a component along the detector probe. The miscellaneous reflecting objects encountered in practice will usually produce components having polarization suitable for the detector, but even in the most favorable case (reflecting wires at 45 deg to the transmitter probe) the power received by the detector is only a quarter of what it could be.

Circular Polarization of Echo

The special feature of the system under discussion is a means for rotating the plane of polarization of the echo 90 degrees, whereby all the echo power is made available to the detector. To see how this can be done, imagine the outgoing wave to be replaced by a pair of components having polarization planes at right angles. That is, one component has its electric field oriented half-way between the directions of the transmitter and receiver probes, and the

A 3-cm wave system as in Fig. 1, plus tuning screws and telescoping (line stretcher) section to produce rotary polarization and provide control of crystal current

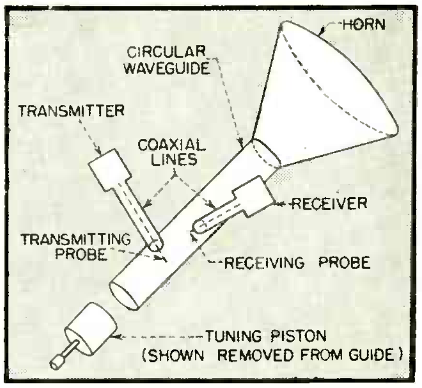


FIG. 1—Placing transmitting and receiving probes at right angles in a circular wave guide, as shown here, permits simultaneous transmission and reception

other component is of equal magnitude and like phase but its field is at right angles to that of the first component. Next, imagine that something is done to the waveguide (or the radiator) anywhere beyond the detector which results in one outgoing component gaining a quarter period over the other. Then if the target reflects both components, the first-named component will gain another quarter period during its passage back to the detector. The echo on reaching the detector will then have two components of equal magnitude but at right angles in space and 180 degrees different in phase. These are the components of a plane-polarized wave having its plane of polarization along the detector probe, which is the result sought. The wave emitted under the above assumptions is circularly polarized.

Phase-shifting Techniques

There are available a variety of ways to bring about the required quarter-period phase shift between the two radiated components. For example, a thin strip of polystyrene can be inserted in the guide with its plane midway between the directions of the probes. The length of the strip is determined by cut and try, the length being increased until the radiation is observed to be approximately circular. Bending the guide in the above-mentioned plane will also do the trick if the curvature and length of the bent portions are chosen correctly.

Both phase control and impedance matching can theoretically be obtained also by a sufficient number of tuning screws acting on each wave component. Alternately, if a dish is used in a way that involves reflection by a flat reflector, this reflector can be a composite affair, one portion reflecting one component only and the other portion lying an eighth of a wave behind it. Whether horn or dish is used, it is always possible to cause the radiated beam to traverse an area composed of a bundle of short rectangular waveguides (like looking through a honeycomb) whose dimensions are chosen to give the desired quarter-period gain of one component over the other.

The most convenient method in practice is to squeeze the guide slightly somewhere between the radiator and the nearest probe. The less the guide exceeds its cutoff diameter the less the squeeze required, and the longer the squeezed portion, the less the squeeze. The direction of squeeze is midway between the directions of the probes (or perpendicular to this direction). In either case the wavelength in the guide is increased for one component and decreased for the other.

Target Characteristics

Assuming that the system has been adjusted to emit a circularly polarized field, let us consider the nature of the echos from various types of targets. An isotropic target, such as is approximated by many objects in actual practice, reflects any wave without change in its type of polarization. This results in maximum possible signal on the detector, as explained previously. A polarizing target such as a dipole, however, can reflect only half the power of a rotary wave, and the reflected wave is plane polarized. It can be shown that only

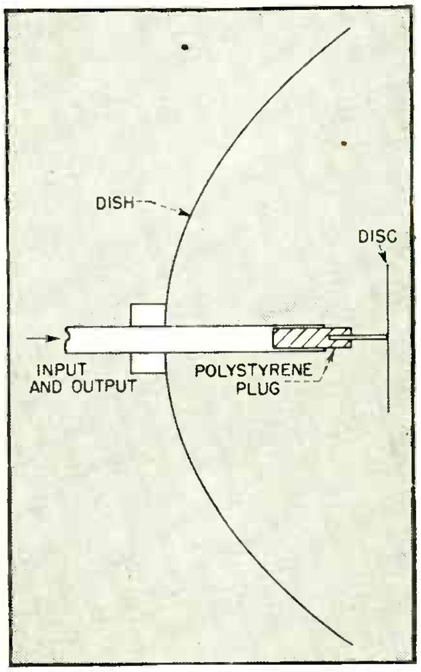


FIG. 2—Use of adjustable plug to control crystal current

half the power of this reflected wave can be absorbed by the detector (it cannot reach the detector both plane polarized and along the detector axis). This power loss from a polarizing target is not so bad as it sounds, however, because polarizing targets are not the rule and because even quarter-power response is better then none. The combination of detector and circular polarizing means (without transmitter) constitutes a receiver that will receive equally well signals polarized in any plane.

Need for Some Direct Coupling

In all the foregoing it has been assumed that the detector and transmitter probes are accurately at right angles and that the horn or other radiator terminates the guide nonreflectively. In such a case the detector receives no energy except by reflection from the target. So exact a balance is fortunately not necessary—in fact, it would be undesirable.

At least some of the transmitter power must be impressed directly on the detector if the system is to be used in either of its two most important applications. In both of these applications it is required to measure the difference in frequency between the outgoing signal and the echo. The only practical way to do this is to let the two frequencies mix in the detector and observe the beat frequency. Furthermore, the amplitude of this beat frequency depends upon the magnitude of the directly impressed voltage on the detector as well as upon the strength of the echo, so that up to a certain point at least, it is advantageous to augment the inherent direct coupling between transmitter and detector.

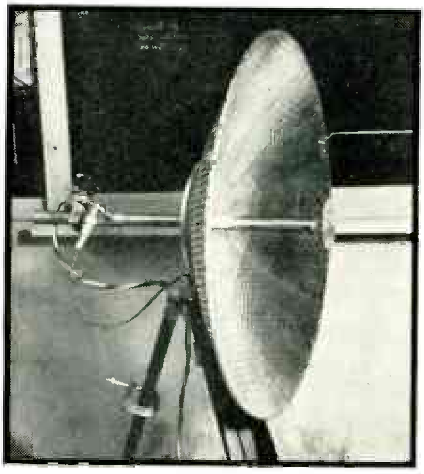
Doppler-Effect Radar Application

Suppose a tugboat is operating in fog in a harbor. The pilot is interested in being warned if the distance between himself and any nearby object is diminishing. The simple Doppler-effect radar setup of Fig. 1 will do this. The equipment might comprise, for example, a low-power microwave transmitter, a horn or dish to produce a moderately sharp beam, means to produce approximately circular polarization of the beam, a crystal detector, and an audio amplifier preferably with the higher-frequency response cut off. If another boat approaches and is in the beam of the transmitter, the frequency of the echo produced will be shifted by virtue of Doppler's principle (due to relative movement of transmitter and target) so that an audio-frequency tone will be heard in a loudspeaker (or seen on an oscilloscope) connected to the amplifier. The pitch of this tone is a measure of the rate of approach, being twice the relative speed expressed in wavelengths per second. (If three-centimeter waves are used, the pitch in cps is approximately 30 times the rate of approach expressed in miles per hour.) If dangerously close the tone will be strong, but of course the size of the target has a good deal to do with signal strength so that distance cannot be reliably inferred. The same sort of signal results if the tug is approaching a stationary object, it being only the relative speed that counts.

In practice the beam might be arranged to rotate continuously on a vertical axis so as to cover all directions of approach. When a signal is picked up, particularly in the forward direction, the rotation could be stopped and a more accurate bearing obtained by manual pointing.

F-M Radar Application

In f-m radar a beat tone is likewise obtained, but in a different way. Let us suppose the transmitter frequency is changing. By the time the echo comes back the transmitter frequency is slightly shifted and a beat tone is formed whose pitch is proportional to the target distance and to the rate of change of frequency. It is not possible to keep the frequency changing in one direction indefinitely, but if the frequency is swung back and forth less than some twenty times per second, a recognizable pitch, although of an intermittent nature, will be heard. This pitch as judged by ear is of course only a qualitative measure of distance, but that is enough for many purposes.



Rotary wave radar unit using two-foot diameter reflecting dish arranged as in Fig. 2

Another method of indication is to use the same alternating voltage both to swing the transmitter frequency and to act as sweep voltage of an oscilloscope, in which case the number of waves seen on the scope is a measure of distance. In case the target is moving, the pitch is due to a combination of f-m and Doppler effects, but the mean value of the pitch is still a correct measure of range. For indicating rate of approach only, the frequency sweep is preferably switched off. If used in an airplane with the beam pointed down, the f-m system becomes a terrain clearance indicator.

Whether used in Doppler or f-m fashion, the present system is believed to have its chief application in cases where the ultimate in cheapness and compactness is a prerequisite, such as for small boats and airplanes. The reason for this is that if the transmitter power is made too great there is danger of burning out the crystal detector during adjustment of the crystal current produced by direct coupling unless the adjustment is carried out at reduced power. Also, if increased range of operation is attempted by using a superheterodyne receiver with high gain, vibrations of the dish or horn, which cause a variation in reflection by the radiating system, constitute troublesome microphonics. Finally, to apply f-m conveniently it is desirable to use a reflex-klystron type of transmitting oscillator since the frequency of these tubes can be varied by applying alternating voltage to the repellor electrode, and these tubes are at present low-power devices.

While the rotary wave system has been explained with particular reference to c-w radar and wave guides, it should be applicable to low-power pulse radar operation as well, and to operation with conventional antennas and transmission lines. In the latter case, a pair of crossed dipoles in a dish would be used, fed from a common point by way of individual lines differing in length by a quarter wave. The detector would be coupled differentially between points on the two lines equidistant from the common point.

Adjustment of Crystal Current

With a well-designed horn the mismatch between guide and horn is likely to be so small that direct coupling due to reflection of the outgoing signal here will not be sufficient, and crystal current will have to be increased to obtain the optimum value of about 0.1 ma.

The arrangement in Fig. 2 provides enough elements to control

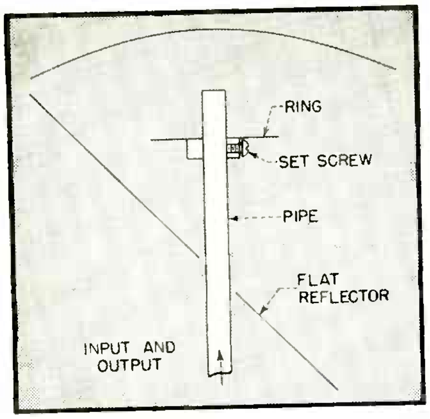


FIG. 3—Control of crystal current with sliding ring on circular waveguide

crystal current. It requires a reflecting disc to throw the radiation back onto the dish, and hence some means to support it. If a polystyrene plug is used, its length and position affect the match, as well as the spacing of the disc from the end of the guide and the position of the whole assembly in the dish. A considerable range of adjustment of all those quantities is possible with nearly maximum beam sharpness. In addition, a fine control of current may be had by varying the frequency.

An arrangement that avoids the reflecting disc is shown in Fig. 3. In this case a ring slidable on the outside of the pipe sets up a reflection whose phase rotates rapidly with motion along the guide, but whose amplitude varies only slowly. The size of ring required is determined by experiment. This adjusting means is not capable of producing exact balance unless the ring happens to be of an exactly correct size, but works well enough. It will give correct phase and nearly correct amplitude. Further adjustment is possible by slightly varying the frequency or the position of the guide with respect to the dish. The arrangement of Fig. 3 permits rotating the beam continuously by rotating only the reflecting plane which has no wires connected to it.

To adjust by squeezing the wave guide, it is well to provide a pair of strips with thumb screws, to fit over the guide. The squeezed portion is preferably one and a half guide wavelengths or more, and the diameter of the guide fairly close to cutoff, say about 10 percent greater than cutoff.

While a crystal probe has been shown for purposes of explanation, it is more convenient to take off detector power by way of a rectangular guide fitted to the round guide as shown in Fig. 4A. The guide extends parallel to the transmitter probe, but the crystal axis is still perpendicular to it. A movable piston is shown in the round guide but this may be replaced by a fixed end plate once the best position is determined. The detector guide is shown provided with a piston and a tuning screw in a slot but these can also be eliminated without much loss in detector sensitivity.

Coupling Adjustments

The transmitter power may also be coupled to the circular waveguide by way of a rectangular guide. This makes it possible to use any source of waves arranged to feed a rectangular guide. One way of doing this is shown in Fig. 4B. This scheme is desirable because it permits matching the round guide to the rectangular guide supplying the waves, without affecting conditions in the receiving system. The guide may be tapered from round to rectangular section or the two sections may be simply fitted together. A tuning screw in a slot will provide the required matching. It is desirable to connect a thin strip or wire across the end of the round guide to act as a short for signals polarized to act on the detector. The center of the detector guide is located a quarter of a wavelength (in the round guide) from this shorting strip. Similarly, a wire across the end of the detector guide will assist the flow of transmitter power past the detector.

Before applying any squeeze, the transmitter should be adjusted for maximum output from the radiator. If there is any observable detector current, adjust the detector for maximum sensitivity. If not, apply a slight squeeze in order to obtain enough current to do so, adjust the matching to bring the detector current as low as possible, apply more squeeze and repeat. When the transmitter, detector, squeeze, and matching adjustments have been gone over a few times, the detector current will be maximum with respect to all adjustments except matching. It will be off from minimum with respect to matching only enough to provide optimum crystal current.

Performance

Preliminary tests of rotary wave radar with miscellaneous arbitrary targets served adequately for determining effects of changes in design, but the data obtained by no means represents maximum performance because improvements in the system are still being made. Using an 18-inch dish and flat reflector arranged as in Fig. 3, an oil tank 840 yards away gave a signal-noise value of 29 db; interpolating from this gives 4600 yards as the range for such a target at which signal and noise are equal. The estimated average signal-equals-noise value for airplanes is 1000 yards, and for a 6-inch square-corner reflector is 870 yards. It remains to be seen whether such large targets as steel ships, icebergs, etc will give appreciably greater ranges.

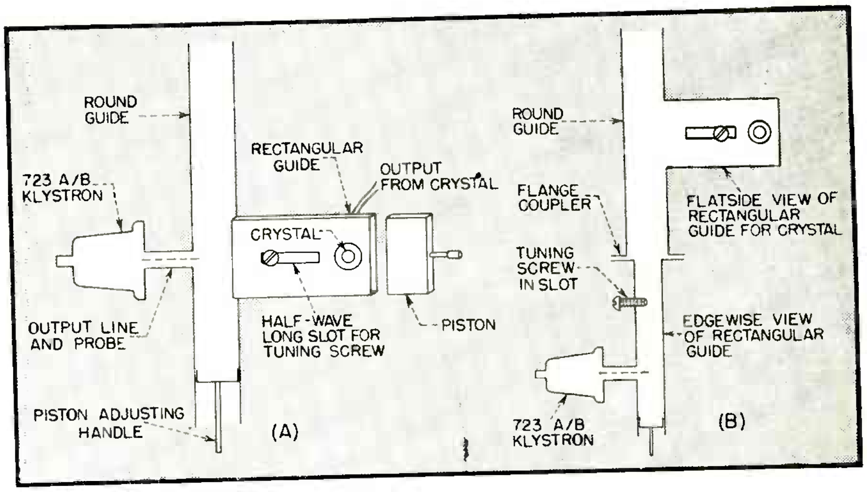


FIG. 4—Use of rectangular guide instead of probe to take off power for crystal detector (A) and to couple a klystron to the round guide (B)

Complete electronic comparator gage in use for the production gaging of roller bearings. The principal circuits used to convert spindle displacement to meter reading and lamp indication are contained in the box at the right

Electronic

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THE PROBLEM of accurately measuring physically small dimensions is not new but increased demands for closer tolerances and faster production methods have placed more emphasis on improved gaging equipment. An answer to this problem is found in the gage described below.

There are several requirements which must be considered in the development of a sensitive gage. It must be stable and not influenced by external factors. Rapid indication is essential. The contact point must operate properly regardless of the material to be measured. It is desirable to have a linear relation between the physical displacement and its output indication. A high order of accuracy and a large range are useful to accommodate a wide variety of applications. The gage must be rugged, foolproof, and easy to place in operation. It should measure at high speeds, to predetermined tolerances with the ability to repeat itself.

Operating Principle

The problem of measurement of small dimensions has been approached by using optical and mechanical magnification, and variation of electrical circuit parameters. Electrical methods, to achieve sufficient sensitivity for gaging, may employ a balanced bridge. Here the unbalance (proportional to the displacement) is measured on a sensitive meter. Or they may depend upon a variation in capacitance or inductance in resonant circuits. The electronic gage to be described operates on the change of inductance of a coupled circuit at low radio frequency. After the phase of the resulting voltage is corrected, it is amplified and then rectified. The meter indication is linearly proportional to the displacement causing the change of inductance. This may be seen from the block diagram in Fig. 1.

The gage head contains two coils, one fixed and connected to a 100-kc oscillator, the other mounted on a spindle which is actuated by the work piece. The second coil is coaxial to the fixed coil and as it moves a varying voltage is applied to a phase-correcting network and to the attenuator. The output voltage from a variocoupler, also fed from the 100-kc oscillator, is combined with the gage-head output. This permits the gage to be set to zero anywhere in its operating range by balancing out the gage-head voltage. The voltage from the attenuator is amplified. The amplifier is conventional and has practically no phase shift. Its output goes to the rectifier and thence to the indicating meter. The voltage developed across the load resistor in this circuit is applied to the grids of a limit tube in which the bias is varied so that the limit lights may be preset to selected tolerances. This provides within limit, above and below limit indication.

Problems of Design

The design considerations arising in the development of this type of gage present several problems. The electrical aspects of the more inter-

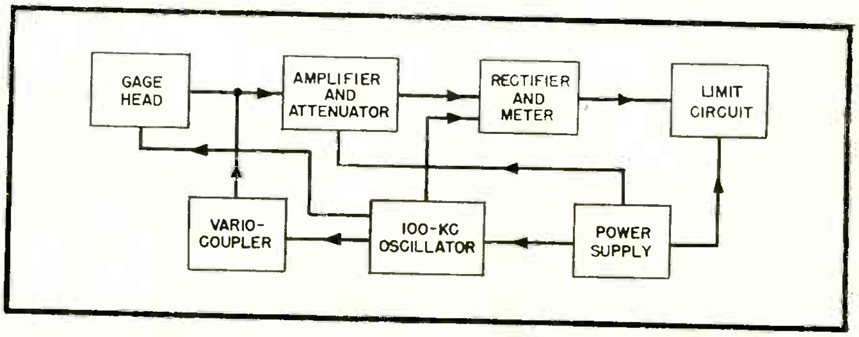


FIG. 1—Block diagram of the principal circuit elements used in the comparator gage. The variocoupler is used to set the indicating meter to zero center. The limit circuit flashes colored lights to show whether the work being gaged is under or over size, while the meter shows exactly how much

Comparator Gage

A standard-size piece of work is used to balance an indicating meter to center. Desired limits of deviation are then set up. Movement of the gage point in production inspection varies the inductive relationship between two coils to light lamps indicating standard oversize, and undersize

esting problems will be mentioned.

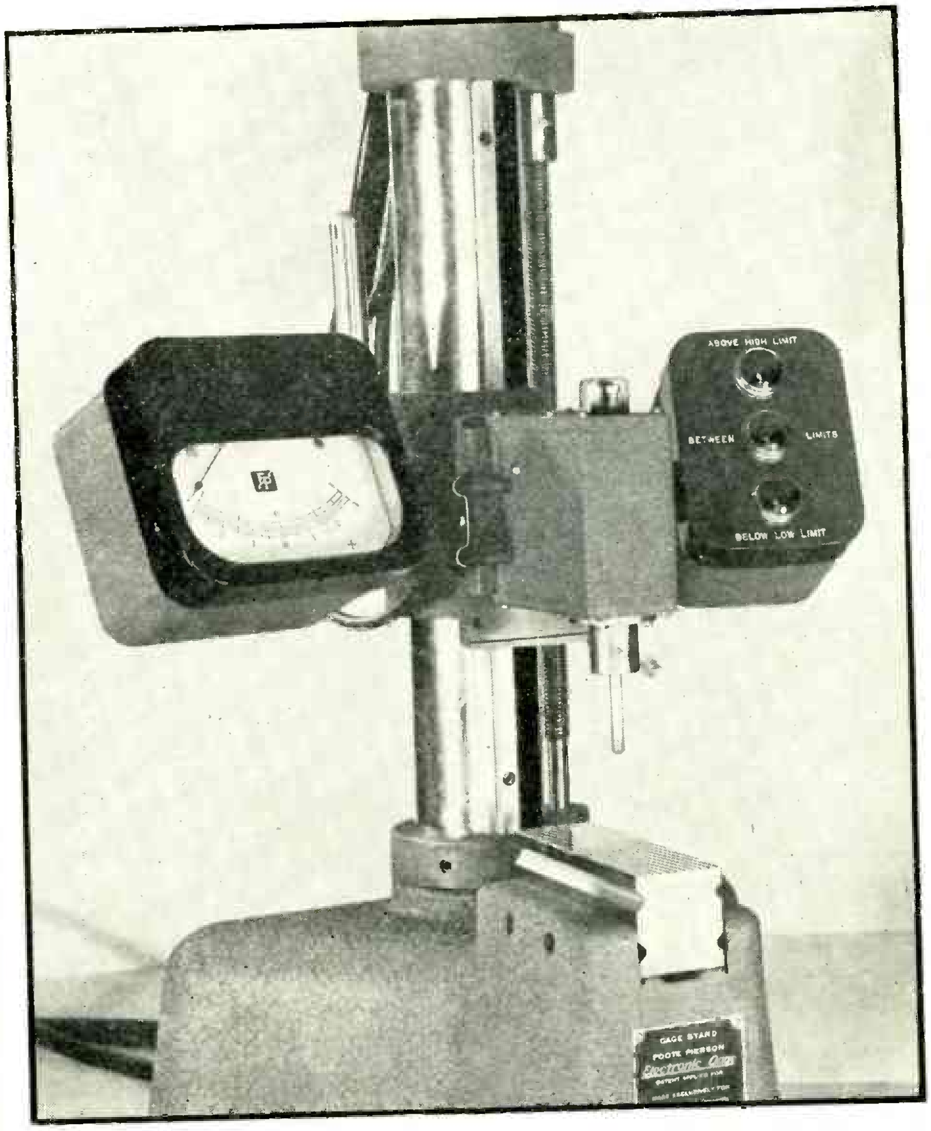
The gage head itself represents the solution to one of the main problems since a minute motion of the diamond contact point of the spindle must produce enough voltage to give a usable output. The fixed coil is wound in two sections, one in an opposite direction to the other. This provides an electrical center for the coil mounted on the spindle which moves up and down inside its form. As stated before, these coils are coaxial. If the spindle should move downward, however, so that its coil passes the electrical center, an output current would flow which might confuse the operator. It is necessary, then, to eliminate this mechanically or electrically. Mechanical means of stopping the spindle at the proper position have their attendant difficulties and add to the problem of manufacturing the gage head. In this gage an electrical method was used, as shown in Fig. 2.

Meter Indication

The rectifier is similar to a diode vacuum-tube voltmeter. A voltage from the oscillator is injected on the grid in such a manner that it is out of phase with the voltage from the amplifier when the spindle coil is below electrical center. This prevents any current flow in the load. The second section of the 6SN7GT is connected as across the rectifier and biased to give protection to the meter. The output of the meter is linear with spindle displacement over the operating range of the gage. This relationship is shown in Fig. 3. The meter shown in the photograph has two zero-centered scales which are calibrated directly for the four ranges ± 0.003, ± 0.001, ± 0.0003, and ± 0.0001 inch.

The limit control circuit in Fig. 4 provides a means of measuring within predetermined tolerances. This is a great advantage in sorting or where rapid inspection is required.

The output voltage across the 50,000-ohm load resistor (Fig. 2) ap-



The gage stand, showing the diamond-point contact, indicating meter, and limit lamps pears on the grids of a 6SN7GT. The cathodes of this tube are biased from a voltage divider and are adjusted so that the relays operate at the desired output voltage (for a predetermined value on the meter scale). In actual practice the operation of the limit circuit is illustrated by the following example. If the diameters of ¼-inch roller bearings are to be sorted to within ±0.00005 inch, the gage would be set to its most sensitive range (±100 microinches). On this range each division represents 10 microinches. The meter pointer is set to zero with a master roller under the spindle. The upper limit is then established by moving the needle pointer +5 divisions on this scale and varying R_2 until its relay operates. The lower limit is found by moving the needle to −5 scale divisions and varying R_1 until its relay pulls in. With the meter pointer returned to zero with a master roller under the spindle, one can sort rollers to the above tolerances. Those within the limits cause the green light to operate. Those above or below cause the red or amber light to operate.

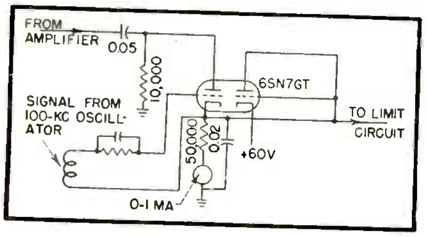


FIG. 2—The rectifier and meter protection circuit is arranged to simplify the mechanical problems in the gage head. It also avoids ambiguity in the readings by feeding a phasing signal from the 100-kc oscillator onto the grid of the rectifier tube

Delayed Indicator for Sorting

The idea of limit control for sorting may be extended so that the utility of the gage is increased. The d-c output voltage of the rectifier (made available at the back of the chassis) can be used to actuate another type of limit circuit, which has a cathode-follower input driving the grids of properly biased thyratrons for operating the lamp indicating relays. This unit has a timing circuit which permits instantaneous or delayed lamp indication. The result is a unique method for very rapid measurement with high repetitive accuracy. The idea may be extended to more than a two-limit operation, allowing the operator to sort in several groups of predetermined tolerances.

The complete gaging equipment is illustrated. The gage head is mounted on a moving casting and is positioned by a screw. The meter and limit lights are also mounted on this casting. The design of the entire stand must be well balanced if one is to make measurements to a few microinches. The box contains the remaining equipment. A one-milliampere meter with a large illuminated face is used because both accuracy and ruggedness are required for many different operating conditions.

The performance of the gage is illustrated by its ability to maintain accuracy under various tests. Regulation of the power supply and stability of the amplifier and oscillator are such that a ±10 percent line-voltage variation produces an error of only 2 percent on the meter when the gage is operating on its most sensitive range (±100 microinches). Pressure applied to the column or gage head on the stand produce deflections but the meter returns to the same calibration point when the pressure is removed.

Surface Inspection

The sensitivity and the high speed of the meter also permit inspection of surfaces. The variations in gage block dimensions can be quickly detected, since changes of three to five microinches are readily observed on the meter. Thus the gage may be set with a standard gage block and then used as a standard. The temperature of the gage stand, gage block (or master) and work piece must be the same for accurate measurements. Unless proper care is exercised heat transmitted from the operator's hand to the material to be gaged will cause an error of several microinches.

Acknowledgment

This article is based on the original development of Mr. H. A. Snow, formerly of Foote Pierson & Co., Inc.

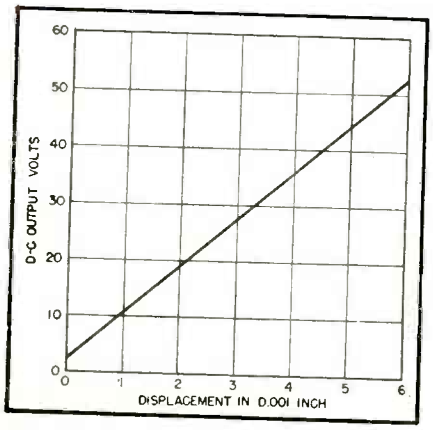


FIG. 3—The output voltage from the rectifier to the indicating meter is a linear function of the gage spindle displacement, but the curve does not pass through the origin

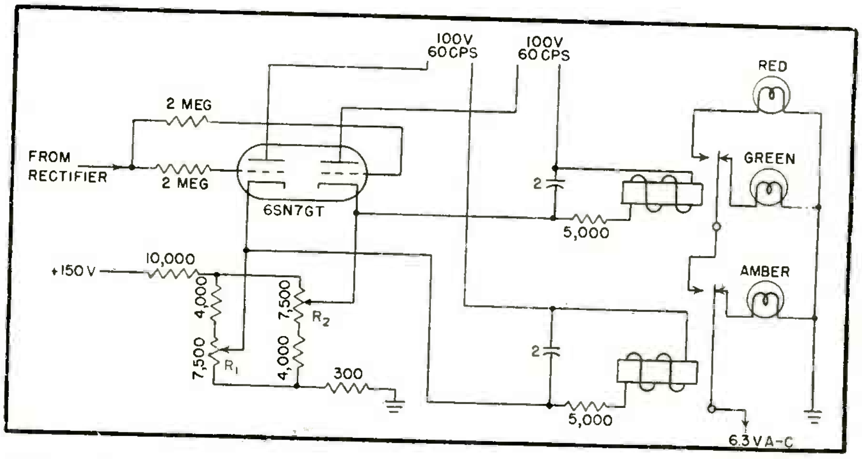


FIG. 4—The desired limits to the deviation from a standard are quickly adjusted by setting the positions of potentiometers R_1 and R_2. This is a simple operation which can be rechecked at any time, correlating a meter reading with the flashing of the appropriate limit lamp

Ionosphere Measuring Equipment

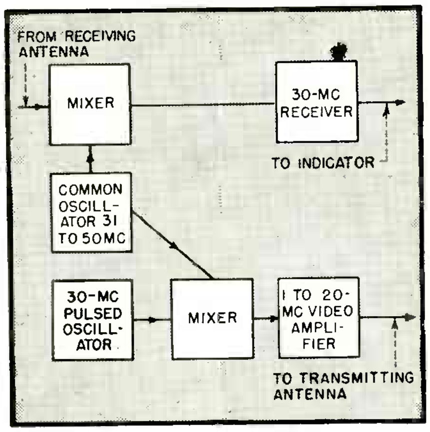


FIG. 1—Block diagram of the ionosphere sounding equipment, showing the common oscillator

The pulse-reflection technique of ionosphere investigation requires a transmitting and receiving system which sweeps the region from 1 to 20 megacycles rapidly. Equipment described utilizes a common oscillator to facilitate tracking, and broad-band response to obviate tuning

By P. G. SULZER*

Cheyney, Penna.

THE pulse method of ionosphere investigation[1] employs a series of radio signals of short duration which are transmitted, reflected, and received, as in radar. The pulses are longer, however, and the distances (and elapsed times) are greater. Much lower frequencies are used, as the purpose is the investigation of the ionospheric characteristics on all frequencies between 1 and 20 megacycles.

It is necessary to make measurements over the entire frequency range in as short a time as possible, so that the ionosphere will not change noticeably during the recording. This paper describes a system which eliminates nearly all mechanical problems and provides perfect tracking of the transmitter and receiver.

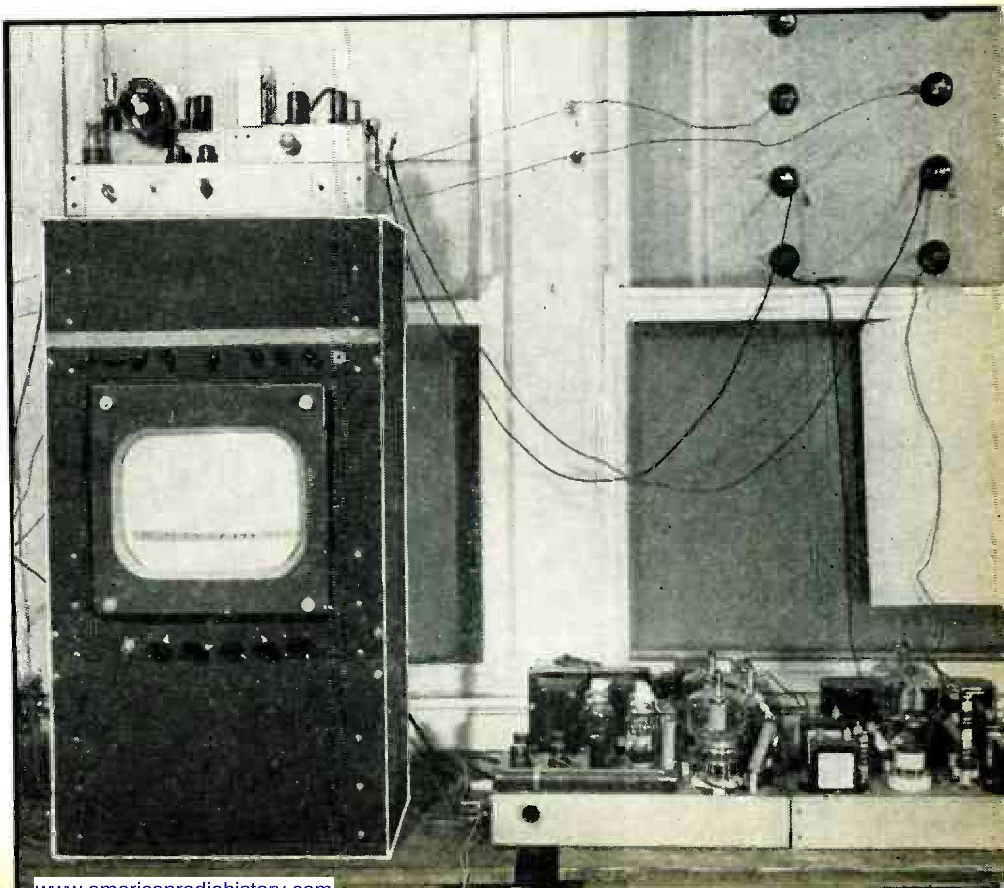
Systems Now in Use

One system which is used in equipment developed by The Bureau of Standards[2] has a pulsed transmitter linked to a receiver by a beat-frequency system. The output of a variable-frequency oscillator is mixed with the output of an oscillator operating at the intermediate frequency of the receiver. The difference of these two frequencies is selected and amplified in the transmitter. Signals to be received are mixed with the output of the variable oscillator, the frequency difference then being the receiver intermediate frequency which is amplified and detected in the usual manner.

In this instrument the variable oscillator, converter and power amplifier are tracked by means of cams. This system appears to have the usual disadvantages that are connected with mechanical tuning arrangements. One very good characteristic of the system, however, is the heterodyne scheme which insures that the receiver and transmitter are always operating on the same frequency.

Another system currently employed is that in the Type 249 equipment of National Physical Laboratory (British) design, which uses the frequency-modulation method of developing pulses.[3] The transmitter is tuned rapidly by a motor-driven rotating capacitor through the fre-

Experimental model of the measuring equipment with receiver, timing generator and viewing scope at the left and transmitter at the right



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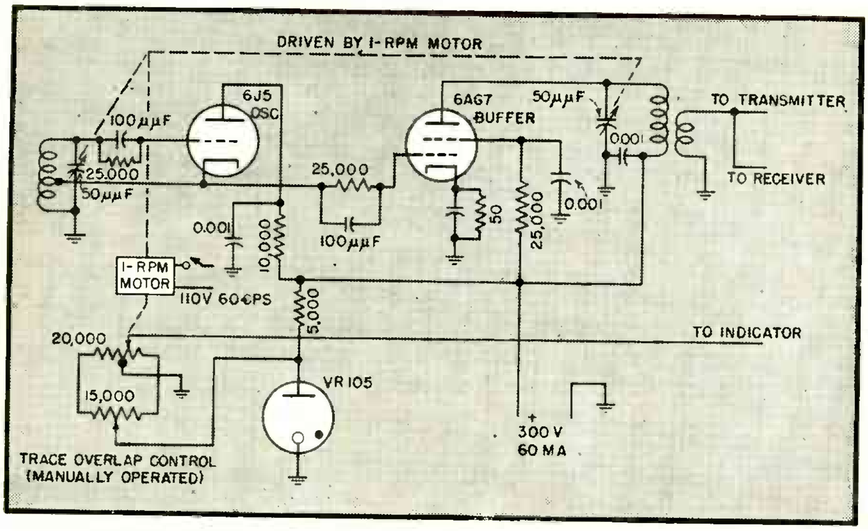

FIG. 2—Simplified schematic wiring diagram of the common oscillator

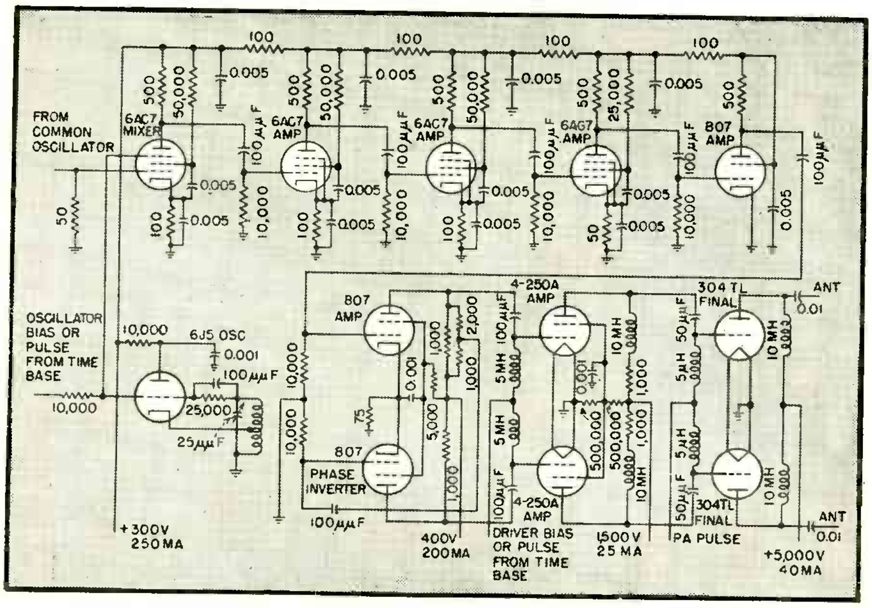

FIG. 3—Schematic circuit diagram of the wide-band pulsed transmitter

quency on which the receiver is operating; the receiver is therefore subjected to a pulse whose shape and duration depend on the bandwidth of the receiver and the rate of change of transmitter frequency. The portion of the energy in the pass band of the receiver which is radiated and returned to the installation by the ionosphere will be recorded as a pulse. The frequency modulation method as employed in this equipment is inefficient as compared to pulse methods since the transmitter is operating continuously and only a portion of the total received energy is utilized by the receiver. Another disadvantage of the system is the fact that the effective pulse width will in general not be constant, unless the rate of change of the transmitter frequency is maintained at a uniform level over the frequency range, which is usually not the case. As a result the height resolution of the equipment varies over the frequency band employed. To produce narrow pulses, the transmitter frequency must be varied rapidly across the receiver frequency range by a high speed motor-driven inductor or capacitor.

Experimental System

The system to be described employs a heterodyne method similar to that used in the Bureau of Standards equipment in that the receiver and transmitter are linked by a beat-frequency arrangement. In the new system, however, complicated tuning arrangements are avoided by the use of untuned receiver input and transmitter circuits. Figure 1 shows a block diagram of the system. It will be noted that the common oscillator (common to both the transmitter and the receiver) is tuned from 31 to 50 megacycles. In the transmitter these frequencies are mixed with the output of a 30 megacycle pulsed oscillator. The difference frequency, which varies from 1 to 20 megacycles, excites an untuned wide-band amplifier, which feeds the antenna. In the receiver, incoming signals whose frequencies vary from 1 to 20 megacycles are mixed with the 31 to 50 megacycles from the common oscillator. The difference frequency, which is constant at 30 megacycles, is amplified and detected with a superheterodyne receiver. Since the transmitter and receiver are controlled by the same oscillator they are always operating on the same frequency.

The system under discussion has no serious mechanical limitations; there are no variable capacitors rotating at high speed and there are no cams. The frequency range may be covered as rapidly as desired, since it is necessary to rotate only one small variable capacitor to tune the transmitter and receiver from 1 to 20 megacycles. It is comparatively easy to obtain high output power.

There are, however, two undesirable features of the system. In the first place the untuned receiver input circuits permit cross-modulation from local stations, generating a series of interfering voltages at frequencies throughout the entire frequency range. This has not been sufficiently serious to prevent good records from being obtained. Second, because the transmitter is untuned a large number of stages of amplification is necessary to obtain high power. This does not seriously decrease the overall efficiency.

Basic Units of New System

The experimental model of the system, which will be described below, consists of five basic units; the common oscillator, transmitter, receiver, time base, and indicator. As illustrated in Fig. 2, the common oscillator uses a 6J5 tube connected in the cathode-tap Hartley circuit. Voltage from the cathode drives the buffer 6AG7 isolating the oscillator from the transmitter and receiver circuits. The oscillator and buffer capacitors are ganged and driven by a 1-rpm motor. Since these capacitors have semi-circular plates, the complete frequency range is covered in 180 degrees rotation of the capacitor shafts, which takes 30 seconds. Link coupling is used between the buffer tank circuit and the coaxial lines to the transmitter and receiver. The motor also drives a center-tapped potentiometer that is connected to develop a positive voltage. This voltage is zero when the oscillator is operating on 31 megacycles, and increases to +50 volts at 50 megacycles. It is used to drive the horizontal deflection circuits in the indicator, deflection depending on the operating frequency of the equipment. Since the tuning capacitors are always rotating in the same direction, the oscillator will pass through a given frequency once when the capacitor plates are meshing and once when they are unmeshing. It is necessary that the horizontal deflection voltage supplied to the indicator be the same for these two positions. A trace overlap control is provided to correct for errors in the location of the potentiometer center-tap.

Limitations to Rate of Frequency Sweep

With this arrangement there is a limitation to the speed in covering the frequency range—the speed with which the capacitors can be rotated. However, if the operating frequency is changed too rapidly, it is found that by the time the echoes return to the receiver the common beating oscillator is tuned to another frequency, and the echo signals are received on the slope of the selectivity curve of the i-f amplifier, resulting in a loss of sensitivity and distortion of the received pulse. If the frequency range from 1 to 20 megacycles is covered in 30 seconds, echoes from a height of 1,000 kilometers will be detuned 4.2 kilocycles. This amount of detuning is not considered to be serious and the use of the 1 rpm appears to be satisfactory.

The transmitter, Fig. 3, begins with a pulsed Hartley oscillator, using a type 6J5 operating at 30 megacycles. The time base supplies a bias of −150 volts to the oscillator grid; this fixed bias is removed during the pulse, when the tube operates. This oscillator drives the suppressor grid of a 6AC7 mixer, the control grid of which is driven by the common oscillator. The mixer is of the plate-detector type, and operates with a 500-ohm load resistance. This low value was chosen to provide uniform gain over the band of frequencies covered by the equipment. The most important frequency appearing across this load is the difference-frequency, which varies from 1 to 20 megacycles. Since the output of the mixer is down 3 db at 15 megacycles, any sum or higher-order frequencies are of little importance. Following the mixer are two stages of amplification using 6AC7's which also have 500-ohm load resistors. Next is a 6AG7 amplifier with a 500-ohm plate resistor. This stage is slightly overdriven, the result of which is a limiting action that helps to maintain constant output. The 6AG7 drives a single 807 amplifier, with zero bias and high plate current (150 milliamperes). This tube develops 30 volts rms across 500 ohms, which is sufficient to excite the push-pull 807 stage. This stage is in effect, a phase inverter, the grid of the lower tube on the diagram being driven by the plate of the upper tube. These tubes develop 120 volts plate-to-plate,

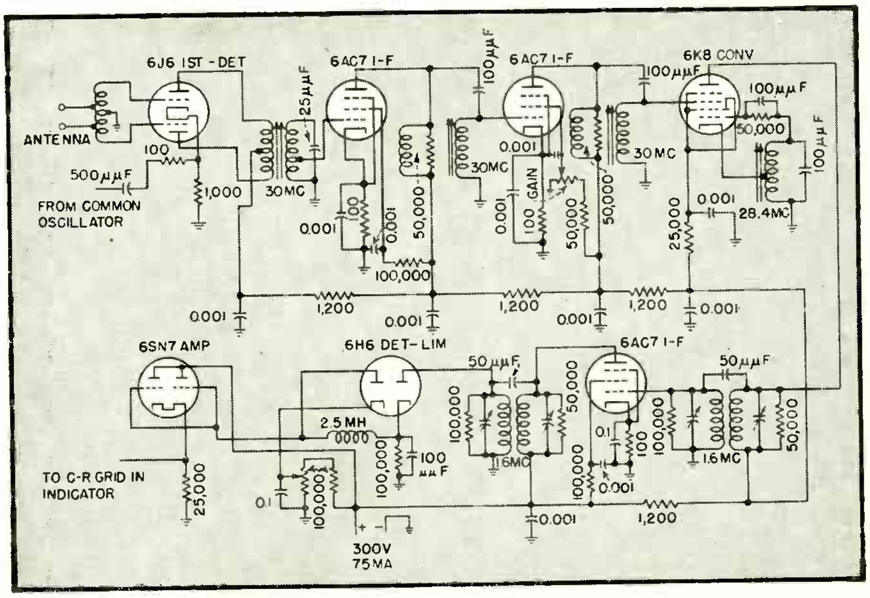

FIG. 4—Circuit diagram of the wide-band receiver used to measure the delay between the transmitted signal and that reflected from the ionosphere

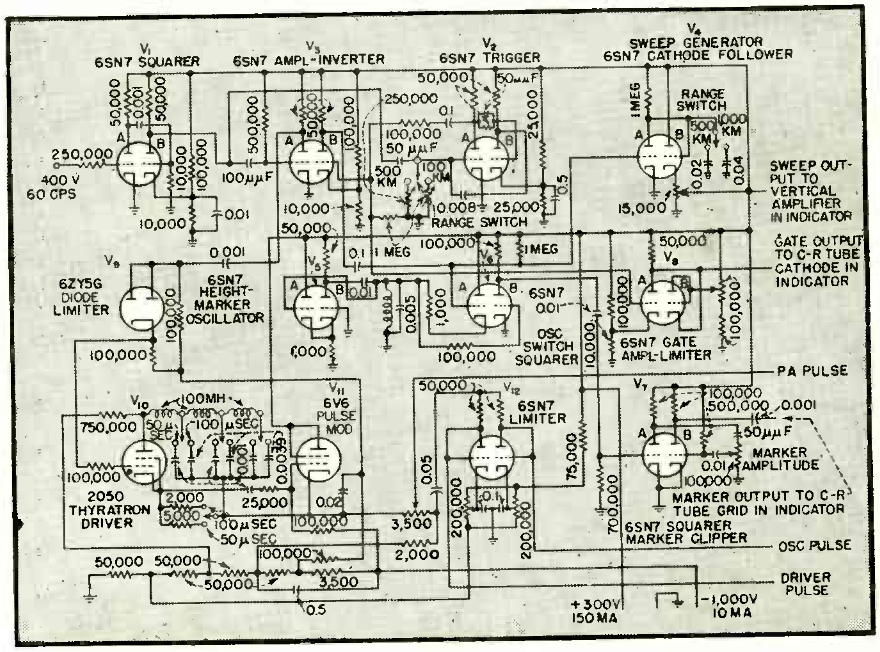

FIG. 5—Timing circuits used to trigger the transmitter and provide time marks

which is enough to excite the 4-250A stage, which is a pulsed class-A amplifier. Normally the time base supplies sufficient bias for plate current cutoff; when the transmitter is pulsed the bias is −10 volts and each tube draws 500 milliamperes of plate current on peaks. Continuous operation under these conditions would, of course, be out of the question because of plate dissipation and power supply limitations. The 4-250-A's drive the final amplifier, push-pull 304TL's, which have a plate supply of 5,000 volts and a normal grid bias of −1,000 volts. This is decreased to −50 volts when the transmitter pulses, and each plate draws 2.5 amperes peak current during the pulse. The load on this stage is a vertically directed rhombic antenna, which presents an average impedance of 800 ohms over the frequency range used. The power output at 1 megacycle is 7 kw peak in a 1,000-ohm load, decreasing to 1 kw at 20 megacycles.

Receiver Design

The receiver, Fig. 4, is a double intermediate frequency superheterodyne. The first detector uses a 6J6 operated as a balanced mixer. Voltage from the common oscillator is applied to the cathodes of this tube in parallel, while the incoming signals are applied to the grids in push-pull. The plates are also connected in push-pull, with the plate coil inductively coupled to the first i-f grid circuit. It was found that cross modulation from stations operating in the broadcast band was serious in this stage, and it was necessary to use a high-pass filter to decrease the strength of these signals. In its present form this is merely the shunt coil shown in the diagram, which also acts as a transformer to connect the receiving antenna to the mixer grids. Like the transmitter, the receiver also uses a vertically directed rhombic antenna. It was found that the sensitivity of the first receiver model was very poor below 2 megacycles. This was caused by the blocking of the first i-f stage by the common oscillator, which is near the 30-megacycle i-f when the equipment is working in this frequency range. The sensitivity was improved by increasing the selectivity of the tuned circuit in the grid of the first 30-megacycle i-f stage by tapping the grid down on the coil, as shown in the diagram. The 30-megacycle i-f amplifier consists of two stages employing 6AC7 tubes. The gain of the receiver is controlled by varying the screen voltage of the second stage. Following these is the 6K8 second converter, which changes the i-f to 1.6 megacycles. Then there is one 6AC7 i-f stage at the 1.6 megacycle frequency. Following it is a detector using one section of a 6H6, the other half of which is used as a limiter. The bandwidth of the receiver is 20 kilocycles for 3 db down, while the sensitivity is better than 1 microvolt for 1-volt output over the entire frequency range.

The present experimental model receiver is not entirely satisfactory for the following reasons: low sensitivity between 1 and 2 megacycles; cross modulation between the common oscillator and harmonics of the receiver local oscillator used to convert to 1.6 megacycles (Result is many dead spots across the band. This effect could probably be eliminated by better shielding).

Time Base Generator

The functions of the time base, Fig. 5, are synchronized to the power-line frequency. Tube V_1 is a distorting amplifier, whose output is a square wave. This is differentiated and used to drive V_2, a conventional trigger circuit. The plate voltage of V_{2A} is a positive pulse whose duration can be easily controlled. In this equipment it is 3,300 or 6,600 microseconds long, depending on whether the range switch is set at 500 or 1,000 kilometers. This pulse drives an inverting amplifier, V_{3B}, which operates the sweep generator and height-marker generator. The output of the sweep generator is a sawtooth wave, which gives a linear sweep in the indicator. The height-marker generator contains a switch tube, a negative-resistance oscillator, a squarer, and an amplifier. The oscillator, V_5, is of the negative-resistance type, with cathode coupling[4]. This is switched on by means of a cathode follower, V_{6A}. The sine wave from the oscillator is squared by V_{6B} and V_{7A}. The square wave is differentiated and applied to the grid of V_{7B}, an amplifier whose output is a series of positive pulses, one for each cycle from the oscillator. These are applied to the grid of the cathode-ray tube in the indicator, producing lines at the proper intervals. Since 100-kilometer markers were desired, the total distance the waves will travel between markers will be 200 kilometers, corresponding to a time of 200/300,000 or 1/1,500 second. The oscillator frequency was therefore set at 1,500 cycles.

Bootstrap Pulser

The trigger tube, V_{2A}, also drives the gate amplifier, V_{8A}, whose output is a negative pulse. This is applied to the cathode of the cathode-ray tube,

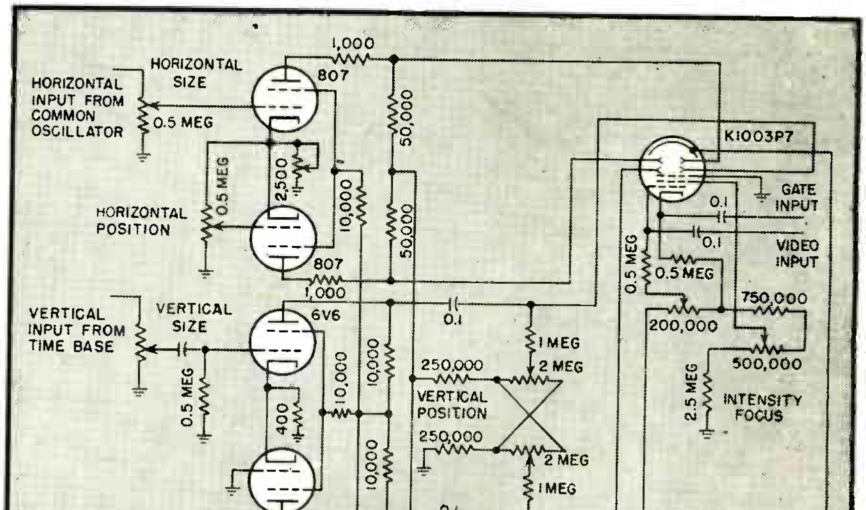

FIG. 6—Simplified schematic diagram showing the signal inputs to the plates of the cathode-ray tube indicator used to display the ionosphere characteristic information

increasing its intensity during the sweep.

The transmitter pulsing circuit uses the so-called bootstrap amplifier, used in the modulators of some of the early loran and radar transmitters. The 60-cycle square wave from the plate of V_{1B} is differentiated and used to drive the grid of V_3, an amplifier, with an output of positive pulses. These are passed through V_9, a diode, to the grid of V_{10}, a thyratron. This tube effectively connects a charged artificial transmission line across a load resistance. The discharge of the line is in the form of a positive rectangular pulse, whose duration depends on the constants of the line. The pulse is applied between the control grid and cathode of V_{11}, the modulation tube, which has its load resistance in its cathode circuit. The output is a positive pulse of 1,000 volts amplitude, which is used to pulse the power amplifier. The modulator might at first appear to be a cathode follower; there is, however, no degenerative action, since cathode voltage is not subtracted from the driving voltage. The thyratron, with its associated circuits, follows the cathode potential of the modulator hence the name bootstrap. There are two other pulse outputs, obtained from a tap on the modulator load. The amplitudes of these pulses are controlled by the two halves of V_{12}, which are connected as diode limiters. One of these pulses operates the 30 megacycle oscillator in the transmitter, while the other controls the 4-250-A stage.

When the cathode of the modulator goes positive, the cathode and plate of the thyratron also go positive. If the grid of the thyratron were connected directly to the pulse circuits of V_{10}, it would remain negative for a time, and would be bombarded by positive ions. The combination of the diode V_9, and various decoupling resistors allows the grid to go positive also, preventing this bombardment.

The indicator, Fig. 6, uses a K1003P7 12-inch cathode-ray tube, with a total accelerating voltage of 10,000. Video signals from the receiver and height markers from the time base are applied to its grid with positive polarity. The cathode-ray tube is gated by means of negative pulses applied to its cathode. The vertical deflection amplifier, which is driven by voltage from the potentiometer in the common oscillator unit, uses a pair of 807's in push-pull. It was necessary to use direct coupling between these tubes and the horizontal deflection plates because of the low sweep frequency used (1/30-second). Positioning is obtained by varying a positive bias on the control grid of one of the 807's; this system is similar to that used in some DuMont oscilloscopes. The vertical deflection amplifier, which uses 6V6's, is driven by the sweep output of the time base. Positioning is obtained in this case by the usual dual potentiometer.

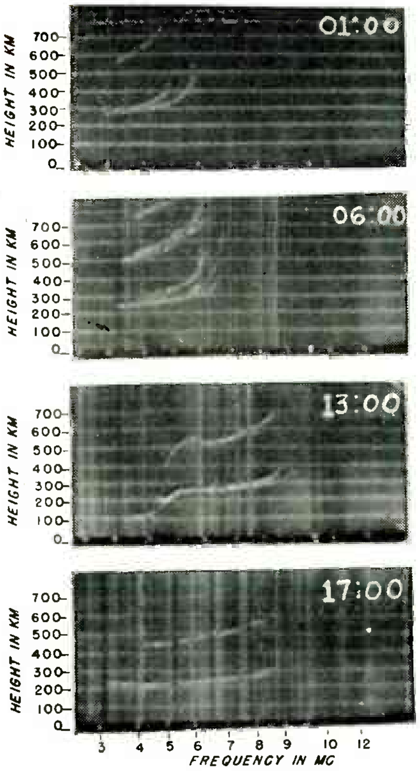

FIG. 7—Photographs of cathode-ray tube patterns obtained with the ionosphere measuring equipment. Layer heights are plotted vertically and frequency horizontally

Recording Ionosphere Characteristics

The record now obtained in ionosphere sounding usually takes the form of an h'-f curve, in which the vertical heights h' are plotted as a function of frequency f. These data are normally recorded on film or paper. In the new equipment permanent records have not been made automatically, although there is under development a system for doing this. The h'-f curve appears on the screen of a long-persistence cathode-ray tube. The vertical sweeps take place every 1/60-second, and have durations of 3,300 or 6,600 microseconds, to give full-scale virtual heights of 500 or 1,000 kilometers. The vertical sweep line is moved across the face of the tube as the frequency changes, giving a two-dimensional record. Although automatic photographic recording has not yet been provided, it is possible to take time-exposure photographs of the runs, a few of which are included in Fig. 7. The height markers appear as horizontal lines, while the frequency markers are dots along the bottom of the record.

The record marked 13:00 shows the layers that usually appear during the day. Proceeding from left to right, the E-layer starts at 3 megacycles and extends slightly past 4. The increase in height from 100 kilometer to 140 indicates an E critical frequency. Immediately above this the F_1 layer starts at a height of 220 kilometers. The height decreases slightly as the frequency is raised, and then increases to 260 kilometers at 5 megacycles; this is the F_1 critical frequency. From here on the record shows F_2 layer which splits at 7.5 megacycles because of the earth's magnetic field. There are two critical frequencies associated with this, the ordinary at 8.5 megacycles and the extraordinary at 9.2 megacycles. The F_1 layer is frequently split, but that does not appear on this record. A multiple reflection may be seen above the F_1 and F_2 regions. In this case the down-coming echo has been reflected by the earth and makes one more trip up and down. The vertical lines are interference from stations in the operating range of the equipment.

The writer wishes to acknowledge the cooperation of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, whose facilities were used in the construction and testing of the equipment.

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AUDITORY PERCEPTION

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Factors affecting design and use of inverse volume-expansion circuits, bandpass and cut-off filters, tone controls, and other methods of obtaining system response having a subjective effect that approaches true high-fidelity reproduction indistinguishable from original sounds

In discussions of fidelity, intelligibility, and related subjects, it is important to differentiate between loudness and intensity. The former is a subjective effect, and the latter a physical measure of energy. The ear is affected by a change in pressure and transmits an indication of such change to the brain. The accuracy of the report is limited to a relatively short range of frequencies, by definite ratios of intensities and other considerations.

Loudness is also affected by many factors other than intensity. With single-cycle impulses, the loudness experienced by an observer will vary greatly with the wave form. If the change in pressure is too slow or too fast, the ear is incapable of audio perception regardless of the intensity. With continuous tones the minimum time for a repetitive change in pressure to be perceptible to the ear is approximately 50 microseconds (2 kc per sec). A continuous tone of constant peak amplitude will approximately quadruple in loudness as the frequency is increased from 20 to 60 cps. The audible frequency spectrum is defined by these characteristics.

A single-cycle sine wave can be shown to contain harmonic components infinite in number. The number of overtones varies inversely with the number of successive cycles so that a sine wave tone must be of infinite duration to be devoid of harmonic content.

In reporting the loudness of a single cycle, the ear still functions as a frequency analyzer. This has been demonstrated by computing the Fourier components of a single-cycle complex wave, evaluating each in terms of the frequency-vs-intensity curves of the ear and arriving at a value closely approximating the actual loudness experienced by an observer.[1]

Loudness versus Frequency

The fact that the relative loudness response of the ear to various frequencies is not constant at all intensity levels is of major importance in music reproduction. It is well known that the subjective effect of music reproduced with a flat frequency response cannot be the same as the effect of the original unless the intensities are equal. This is one reason for the use of tone controls.

There are many other factors that contribute to the total effect, such as the familiar fact that loudspeakers have too much inertia and mechanical damping to permit sufficient swing for proper low-frequency response to signals of small amplitude. The inertia of the average listener is also important, for most people will not bother to adjust a variety of controls.

The trend in all phases of receiver-phonograph design is toward reducing operating requirements to a minimum. Most methods developed to date are inadequate, not only because many are incapable of sufficient compensation but also because the equipment is not calibrated in terms of the actual variation in subjective frequency response at different intensity levels, and few are automatic. Furthermore, it requires a great deal of experience and knowledge to adjust tone controls properly, even when they are correctly calibrated. This problem is worthy of serious consideration, for most observers will consider correct compensation of this kind a greater contribution to faithful reproduction of the subjective experience than many refinements of fidelity commonly treated as having greater importance.

Tone Control

It is an unfortunate fact that too few engineers and technicians have done sufficient critical listening to live music to acquire a valid basis on which to judge reproducing systems. Every person engaged in this industry should make a practice of occasionally attending symphonies and listening to live dance bands, with a conscious effort toward improving his audio discrimination. A general broadening of perspective and appreciation of tonal range on the part of the men responsible for the design of audio systems will do much to defeat the tendency to be too easily pleased.

The literature is replete with

UNDERSTANDING THE EAR

The human ear is a living, electrically active microphone with changing response characteristics that place a limitation on the audible communication of intelligence. Because a high percentage of those in the electronic industry are concerned with sound reproduction devices, an understanding of human hearing and its relation to various types of tone-compensating arrangements is an aid in evaluating and solving problems encountered in perfecting audio transmission and reproduction systems.

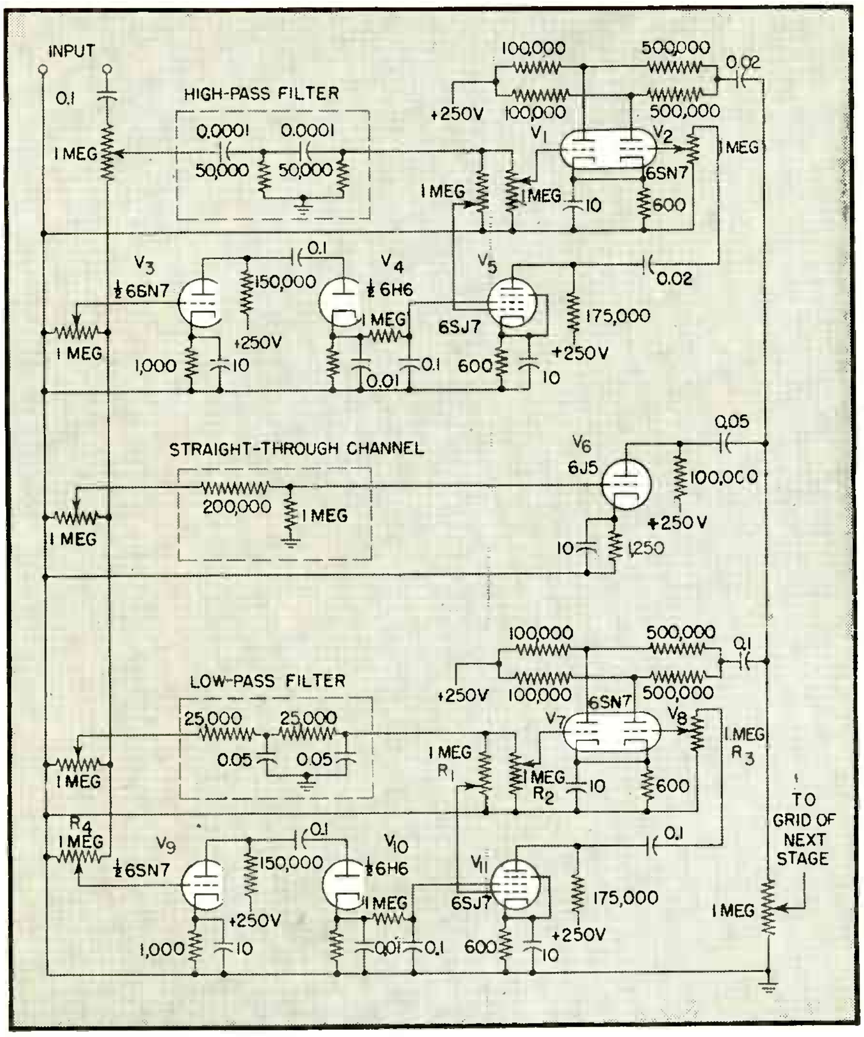


FIG. 1—Inverse volume-expansion circuit for automatic tone control compensates for changes in the response of the human ear at different intensity levels

tone control circuits varying from simple capacitive shunts to resonant chokes and three-channel filter systems. A discussion of these is not within the scope of this article, but it is pointed out that the successful design of any frequency compensation system requires a full understanding of the actual frequency distortion that requires correction. If it must be accomplished at minimum cost, then at least the most nearly satisfactory values of *RC* filter networks should be selected. Too often a designer casually writes in a 0.1-μf shunting capacitor without troubling to seek optimum values. Actually there are many tone control systems using nothing more than *RC* filters that do accomplish excellent results.

Many different methods may be used to produce automatic frequency compensation at varying output levels. The simplest is a capacitive shunt across the low-level section of the audio input potentiometer. Other systems have been operated by mechanical coupling of volume and tone controls. This category of approach to the problem would be more satisfactory if signal inputs were constant and the output entirely dependent on the so-called volume control. Any completely satisfactory system must depend on the magnitude of the signal in circuits beyond all level control devices.

Inverse Volume Expansion Circuit

One solution based on inverse volume expansion in the high and low channels is illustrated in the circuit of Fig. 1. The values given are strictly experimental, and the final selection of components must depend on the judgment of the designer and the requirements of specific applications. The filters are affected by associated circuit components, and although the values indicated provide a satisfactory experimental starting point, the most desirable networks to use will vary considerably. It is necessary to isolate the channels in order to avoid inter-shunting action, particularly if both high and low compensation is employed.

The input signal is divided into high, straight-through, and low-frequency channels. The straight-through channel is entirely conventional for flat overall frequency response. The principles of operation in the high and low channels are the same, and only the action of the low channel is described here.

All but the low-frequency components of the signal are filtered out, and the remaining voltage is developed across potentiometers R_1 and R_2 in the control grid circuits of V_7 and V_{11}. The signal is shifted 180 degrees in phase by V_{11}, and this output is applied across R_3 in the grid circuit of V_8. The signals on the grids of V_7 and V_8 are now identical in frequency content but 180 degrees out of phase. The outputs of these tubes are mixed in the plate circuits and cancellation takes place. Controls R_1, R_2, and R_3 may be set so that the output of the low-frequency channel is zero.

A portion of the unfiltered input signal is developed across R_4, amplified by V_9 and rectified by V_{10} to supply the screen voltage for V_{11}. Thus the gain of V_{11} depends on the magnitude of the input signal to the system. This means that when the input to the system diminishes, the signal on the control grid of V_{11} will decrease and the screen voltage also will go down. Thus the output of V_{11} to V_8 will go down proportionally more with decreased drive to the system than will the input to V_7.

If the various controls are adjusted for zero output from the low-frequency channel when the input is at a very high level, then any decreased drive will result in lowering the output of V_8 more than V_7. Only partial cancellation will take place, and some output will appear from the low-frequency channel. The output of this channel will, in fact, vary inversely with the input to the overall system. The rapidity with which the bass channel will follow changes in overall level depends on the time constant of the screen supply circuit for V_{11}. The rate at which bass boost will take place is varied by the setting of R_4.

Treble and Bass Channel Adjustments

In the initial adjustment of the output from the treble and bass channels at high level, it may be desirable to set them at some value other than zero output in order to effect permanent compensation for inherent faults in associated circuits, the acoustic environment, or the taste of the listener. The controls and principles by which these compensation circuits operate permit great flexibility in adjustment and application.

For example, in disc recording it is necessary to compress the input to the cutting head in order to avoid overlapping between grooves during heavy passages. Actually, only the low-frequency swings are broad enough to require this dynamic compression. The problem may be solved automatically with the circuit of Fig. 1, providing the low frequencies are eliminated from the straight-through channel. At a moderate driving signal to the system, the signals on the grids of V_7 and V_8 are adjusted so that the output of V_7 is of sufficiently greater amplitude than that of V_8 for a normal percentage of low frequencies to pass through the system. As the input drive to the entire circuit increases, the signal to V_8 grows proportionally more than the signal to V_7, a higher percentage of cancellation takes place, and the relative output of low frequencies is compressed.

Possible Circuit Simplifications

Under playback conditions the initial adjustment is made at the same moderate input level, but V_8 is set higher than V_7. Thus, V_8 provides the output signal and V_7 the cancellation. As the input drive to the system increases, the output of V_8 goes up proportionally more than V_7 and expansion of the low-frequency output is obtained. In practice, these settings should be accomplished by switching arrangements and fixed values.

In the design of commercial radio-phonographs where economic considerations are important, a number of simplifications suggest themselves. If the screen supply for V_{11} is taken from a point far enough along in the audio amplifier, V_9 may be eliminated. Another arrangement with fewer components uses the circuit consisting of V_9, V_{10}, and V_{11} for a middle-frequency band-pass channel with the bass and treble channels consisting of conventional amplifiers. In such an arrangement the output of the band-pass channel may be made to vary proportionally more with changes in the basic input signal than the bass and treble channels. In other words, the middle frequencies would show a greater percentage change with a change in drive than either high or low-frequency components, effectively producing automatic frequency compensation.

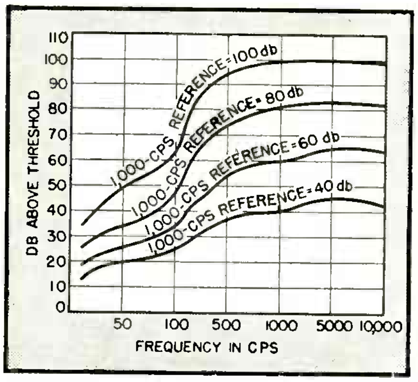


FIG. 2—Curves showing how response of human ear varies with intensity of sound. Each curve is for a definite loudness sensation to the ear, and shows the actual intensity in db above threshold required to produce that loudness sensation at various frequencies. The curves were obtained in each case by starting with a desired loudness sensation (40, 60, 80, and 100 db) at 1000 cps, hence in each case sensation and intensity are the same at this reference frequency

Another circuit using only two additional tubes operates on the variation of input capacitance that may be obtained with a variation in gain. The input capacitance of an audio stage is increased deliberately with a low-value capacitor from grid to plate. The input capacitance is equal to $C_{gk} + C_{gp}\ (K + 1)$, where K is the actual gain of the stage. By applying amplified avc to this tube, the input capacitance may be made to vary over a fairly wide range. As the output signal decreases, the avc bias to the tube goes down, causing an increase in gain and a consequent increase of the input capacitance. Thus the high frequencies are increasingly shunted as the output decreases and a relative increase in bass response is obtained.

Countless other methods will suggest themselves to the ingenious designer. The important emphasis is on the need for automatic frequency compensation circuits in the inevitable trend toward more consistent faithful reproduction.

Speech-Music Switches

The preceding discussion referred only to bass and treble boosting circuits. The opposite effect is sometimes desirable, but with reference to speech-music switches the following report is of interest. Forty observers, two experienced radio announcers, and two untrained speakers took part in an investigation made under various acoustic conditions with a wide variety of electronic facilities available. The results were conclusive in determining that (1) with frequency compensation introduced to provide faithful music reproduction, speech was both intelligible and pleasing, elimination of low frequencies definitely detracted from the pleasing quality of speech without a significant contribution to intelligibility, and (2) with over-compensation of the bass channel, or broad capacitive shunting of highs, speech was neither intelligible nor pleasing. Reducing low-frequency components from these arrangements definitely increased intelligibility.

In all of these experiments the observers constantly emphasized the natural voice qualities in the setup where no change was made from speech to music. It seems apparent from the above that speech-vs-music compensation is necessary and desirable only in poor-quality systems, devices with rainbarrel resonance, and under circumstances where the signal source is faulty. Most speech-music switches defeat the purpose of selecting radio announcers and speakers in terms of pleasing voice qualities. The problem is not the same as in telephone or long-range radio communication where intelligibility is the only important factor.

Figure 2 consists of a graphic representation of the results obtained with twenty observers with normal hearing in a study of intensity vs frequency for equal loudness. These figures agree reasonably well with those published by other investigators.[2] It is recognized that subjective measurements are inherently divergent between experimental results as compared with instrumental observations of physical quantities. However, for the establishment of compensation requirements, this information is a valid and important aid. It is evident that low-frequency compensation must be of greater magnitude. However, the importance of high-frequency compensation is not proportional to the amount required.

Cutoff Filters

In the elimination of high- and low-frequency distortion, extraneous interference, and needle scratch, it is common practice to use filters with a sloped characteristic. This is typical of capacitive shunt tone controls. In eliminating the high frequencies, the upper middle-range frequencies are partially shunted and the result is muddy and undesirable. The sharp cutoff type of filter is very much more satisfactory. The average observer is greatly irritated by high-frequency noise, and the general impression that the public does not like highs may be partially attributed to this condition. The result is that most listeners sacrifice clarity to avoid hash and listen perpetually to reproduction of considerably lower fidelity than was intended by the designer of the equipment.

Tone controls designed to eliminate high-frequency distortion should be stepped rather than continuously variable. Sharp cutoff at various frequencies may be obtained in many ways. Perhaps the ideal method is to use a three- or four-section filter with each section resonated to discriminate against a band approximately 1,500 cycles wide. Thus, for 5,000-cycle cutoff the first section would be tuned to eliminate from 5,000 to 6,500, the second from 6,500 to 8,000, and so on. Such filters may be very sharply tuned. Inductances are usually required, which increases the cost and introduces the problem of hum pickup.

A less expensive method is to use several shunting capacitors between successive stages. For eliminating low frequencies, the combination of small cathode and screen bypass capacitors in cascaded stages, as well as a lower value of coupling capacitor, may be used to produce abrupt attenuation at a selected frequency.

The successful design of sharp-cutoff filters of either high- or low-pass types requires careful calculation and experiment. When the results are considered in terms of the improvement, not merely in how well the set may be operated but in the way it will be operated by the average user, the added cost may be well worthwhile even in commercial equipment which is moderately priced.

TABLE 1. DEFINITIONS OF MUSICAL TERMS

BRIGHTNESS—An attribute assigned to a tone, expressing the content of upper harmonics and also varying directly with intensity and frequency. The term density is often used synonymously.

FREQUENCY—An objective measurement of the number of cycles in a unit of time. (Should not be used synonymously with pitch.)

INTENSITY—A physical measure of the magnitude of acoustic force.

LOUDNESS—A subjective observation of intensity. The perception of loudness also varies with frequency.

PITCH—A subjective observation of sound, varying directly with frequency. This experience is also affected by the intensity of the sound. At low frequencies pitch varies directly with intensity, and at high frequencies, inversely.

Harmonic Distortion

There is experimental evidence that less distortion can be tolerated at low levels than at high outputs. A quantitative knowledge of these effects is a valuable guide in determing the distortion limits allowable in various applications of reproducing equipment.

Harmonics are generated to an important degree by the structures of the ear. The magnitude of this distortion may be conceived from an examination of Fig. 3 which shows curves representing data derived by Fletcher.[3] If a pure sine wave is generated at high intensity, the second and third harmonics produced by the ear itself may be distinguished by the central nervous system. Even-order harmonics rise in magnitude with increasing intensity of the stimulus up to a certain point and then tend to decrease. Odd harmonics flatten out at their maximum and do not diminish at higher intensities of stimulation. It is evident from this that the ear departs from symmetry at a certain low level (about 50 db above the threshold of hearing), and then tends to return to symmetry at some high level (around 100 db). The nonlinearity which produces odd harmonics increases steadily and remains at maximum. Perhaps the most important point is that both odd and even harmonics undergo an effect of volume expansion as the intensity of stimulation is increased from approximately 50 to 100 db. In other words, they vary directly and exponentially with stimulus intensity over that range.

These characteristics have been determined more rigorously than most measurements concerned with hearing. Fletcher and others have presented evidence based on the subjective observation of beat notes produced from aural harmonics beating with acoustic tones. In this technique the ear is stimulated with, say, a 1,000-cps tone. The fourth harmonic would be 4,000 cps. A second stimulating tone is introduced at a frequency somewhat higher or lower than 4,000 cps, and

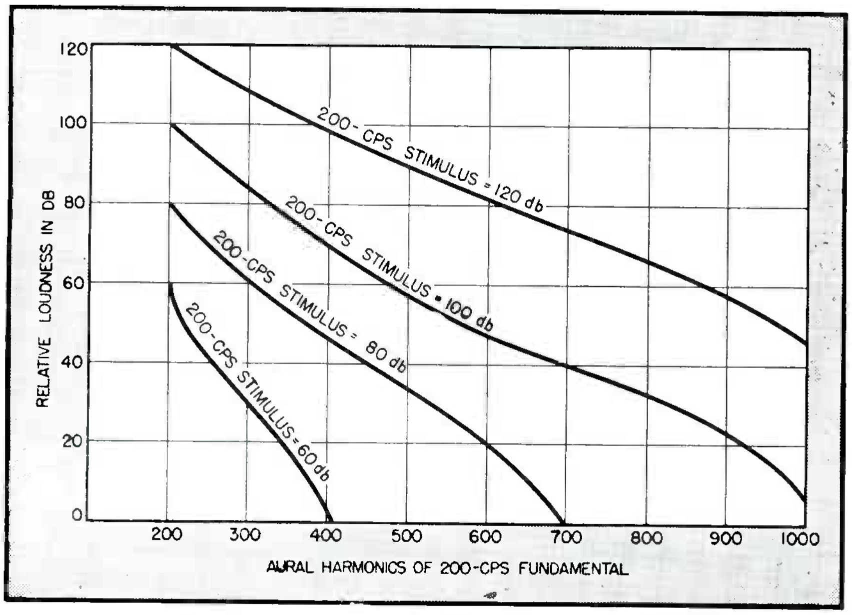


FIG. 3—Relative loudness of harmonics generated by the human ear when a stimulant 200-cps tone is applied at various intensity levels. The 2nd harmonic becomes important as the stimulus tone approaches 80 db, the third harmonic for 90 db, etc.

the presence of the harmonic is determined by the observation of the amplitude-modulation beat between them. Furthermore, the beats will be most pronounced when the exterior stimulating tone is of equal intensity with the aural harmonic, and in this manner the intensity of the aural harmonic can be determined.

Cat's-ear Experiments

Wegel and Lane[4] have measured the potentials generated at harmonic frequencies by attaching an electrode to the round window in the the ears of cats and guinea pigs and running the output through a wave analyzer.

Using this same method, Newman, Stevens and Davis[5] stimulated the ear of a cat with 700 and 1,200-cps sine waves simultaneously, and were able to determine electrically the presence of 66 other frequencies. All of this evidence is in substantial agreement.

This provides two explanations for the effects mentioned. At relatively low levels the ear follows Hooke's law, and distortion is negligible. As the intensity increases, the ear generates harmonics within itself and these tend to mask harmonic distortion originating from the exterior source of energy. The second point is that the central nervous system is educated by the distortion characteristics of the ear to expect and tolerate more distortion at high levels. It is evident that harmonic distortion may be more irritating in home radio-phonographs than in outdoor or concert hall sound reenforcement systems.

The response curve of the ear falls at low frequencies. Hence, with fundamental tones of low frequency the ear will be more sensitive to the harmonics than to the fundamental. It is also true that with high-frequency fundamentals only a few of the harmonics are within the spectrum of audible sounds. These facts make it clear that factors tending to produce distortion in the low-frequency range are particularly important, and that such distortion is an important limitation on the use of extended frequency range devices.

Response to Vibrato

The use of a vibrato is an important musical embellishment, and the characteristics of the ear in perceiving it are of particular interest to designers of electronic musical instruments. The vibrato produced by both violinists and vocalists is a rapid fluctuation of frequency above and below the fundamental tone. This is accomplished at a rate approaching seven per second for violinists. It is at approximately this speed that the ear loses the ability to follow the changing pitch and observes the result simply as an amplitude modulation. Thus, at a rate of seven vibrations per second or faster, the ear is incapable of distinguishing between a frequency vibrato and an intensity vibrato. It is, in fact, difficult for an observer to differentiate a seven per second frequency (or amplitude) vibrato from one that is produced by beating two frequencies together. This latter method is used by pipe organ manufacturers who design a stop (celeste string) that produces this effect by tuning two sets of pipes at slightly different frequencies.

It is more difficult to produce a frequency vibrato in electronic musical instruments than to provide a device that simply varies the gain, and because the ear cannot differentiate between them at rates above seven per second, many designers use the latter method. This is not entirely successful as a simulation of acoustic instrumental effects because the ear is aware of the difference in terms of timbre. The quality of fullness or richness of a tone undergoing frequency modulation is directly related to the bandwidth of the modulation. The vibrato used by most well trained vocalists is just fast enough so that a single pitch is assigned by an observer, and it covers a broad enough frequency band to provide maximum richness.[6, 7, 8] Violinists have a faster vibrato but it usually covers no more than a quarter-tone peak to peak and does not produce as complex a spectrum of harmonics.

It has been suggested that the seven-per-second blend from frequency-to-amplitude perception is a function of the rate of decay in the central nervous system responses.[9] This persistence effect has been calculated as approximately 0.14 second to reach threshold. The curious fact is that although the rate of decay may change, the total time to fall to the threshold of perception appears to be constant at 0.14 second, regardless of initial intensity. Stevens and Davis suggest this as being the ideal on and off, or build-up and decay time to provide an impression of instantaneity without the usual on and off clicks and other transient disturbances.

This switching time is important in electronic musical instrument design, in telegraph keying and in many other problems. The writers have investigated the phenomenon at some length, conducting experiments with 30 observers having normal hearing. The results approximated the figures given above but the ideal build-up time for high-intensity tones appeared somewhat longer. The best results associated with on times were obtained with even harmonic combination tones reaching the maximum of 90 db above hearing threshold in 0.165 second. The time for odd harmonic combinations, contrary to expectations, was 0.01 second less. Off effects in all cases appeared as close to ideal as can be achieved at 0.14 second. There is no auditory effect of persistence or latent images comparable to those common to vision.

Audio Perspective

There have been many experiments in the last decade to improve the illusion of reproduced vs live music by introducing audio perspective. Certainly the distribution of orchestral instruments in space is a contributing factor in the total sensation experienced by the listener. The use of three-channel microphone pickup and playback through corresponding placement of loudspeakers contributes considerably to the realism of reproduction. Even two channels is a marked improvement, but more than three follows a rapid diminishing returns curve. At the New York World's Fair an outdoor stereophonic installation demonstrated the value of the effect reasonably well, but the illusion is more impressive in an enclosed room. The Walt Disney picture "Fantasia" was another experiment in this direction, and in theaters where a satisfactory installation could be made the results were remarkable.

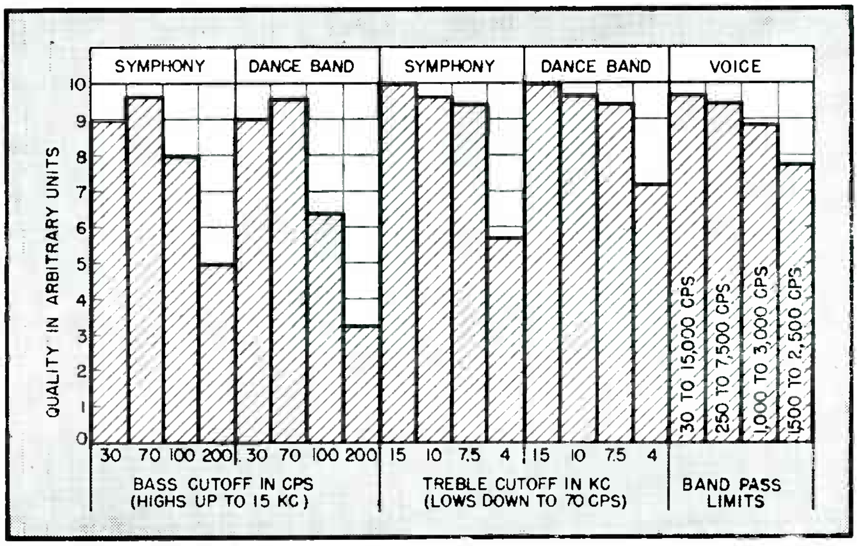
Ideally, a concert hall should not be too highly damped, but should have a perceptible reverberation time. Under such conditions the percentage of reverberation reaching the listener will vary directly with the distance of the source. Thus, in reproduction the apparent closeness of the sound will vary inversely with the amount of reproduced reverberation in either multiple- or single-channel recording.[10] These effects have importance in sound motion picture developments. However, in connection with speech the psychological effect of synchronization between visual lip reading and the sound itself is such as to minimize the need of stereophonics. Furthermore, the increased use of public address systems with live music, often with little regard to directional distortion, increasingly educates audiences not to expect coordination of visual and audible sources.

Even in systems for the reproduction of music where the original pickup was through a single channel, the spatial distribution of acoustic output is desirable. Although the trend has been toward single speakers of large cone diameter for improved low-frequency response, the use of multiple small speakers will often accomplish this result more satisfactorily. Furthermore, the distribution of high frequencies is distinctly improved and the cost for equal total power handling ability is approximately the same or less for the multi-speaker arrangement. As a specific example, four 7½-inch accordion cone speakers may be mounted in a horizontal row along the top of a completely enclosed cabinet. Such a system will handle 12 watts complex wave with an extended high-frequency response and unusually smooth bass reproduction. Most observers find that the horizontal spread of such a sound source contributes measurably to the illusion of perfect reproduction. The speakers must, of course, be phased together.

The most interesting data regarding stereophonic sound systems has been presented by Fletcher.[11] These preliminary investigations indicated that observers found two-channel stereophonic reproduction extending to 5,000 cps more pleasing than a single channel with a range to 15,000 cps. Additional data in this paper showed that a 65-db volume range and a frequency spectrum of 60 to 8,000 cps produced substantially complete fidelity in the transmission of music, while 40 db and 100 to 7,000 cps were comparable requirements for speech.

Intensity Range

The ear is capable of responding to a wide range of intensities, and the limits are set at points consistent with the auditory environment. Thus, the threshold of hearing is in the region where any increase in sensitivity would make it possible to perceive the constant sound produced by the random agitation of the basic particles of air. Man would then be afflicted with the irritation of ceaseless noise, somewhat comparable to the condition of persons suffering from tinnitus (head noises). The minimum displacement of the eardrum which produces audio sensation has been calculated by Stevens and Davis at approxi-



Results of subjective experiments with listeners, giving their judgment of quality of reproduction in arbitrary units for various cutoff and bandpass adjustments of the amplifier during three different types of programs

mately 10^{-10} cm, less than the wavelength of visible light, or less than one percent of the diameter of a hydrogen molecule.

The intensity at which audibility blends into the sensation of feeling varies between 60 and 70 db above a pressure of one dyne per square centimeter. The actual subjective experience varies with frequency and with the individual, and ranges from dizziness and physical vibration to tickling, burning, and painful reactions.[12]

Low-frequency Cutoff

At very low frequencies the subjective loudness and pitch of a tone do not vary linearly but in distinct steps, with the most abrupt change occurring at around 18 cps according to Bekesy and others. It is at approximately this frequency that the sensation merges from one of feeling, at lower frequencies, to the experience of hearing. The rough quality continues up to about 50 cps.

The ear tends to fill in the subjective observation of a fundamental tone when presented with a series of harmonic frequencies. This experience is so compelling an illusion that even the most critical observers usually fail to perceive the difference between the response of an audio amplifier cut off at around 70 cps and one which extends to lower frequencies. This cutoff value is chosen as optimum because it includes the second harmonic of the lowest notes commonly occurring in orchestral music, but permits attenuation at the often annoying 60-cps frequency of supply lines.

Phase Relationships

It is widely but erroneously believed that the ear is insensitive to phase relationships. According to Ohm's acoustic law, the ear is an analyzer that perceives a complex sound wave in terms of its frequency components. This principle in general is true, but not absolute because the structures of the ear are not sharply tuned.

Sound waves of equal frequency and intensity but 180 degrees out of phase produce silence.[13] It is clear that the total intensity of a sound wave will vary with the phase relationships of its components, which may be additive or subtractive, and that this is translated into loudness by the ear. The generation of aural harmonics has been mentioned, and the phase between these and the harmonics produced by the acoustic source will also be summated algebraically by the auditory system. Furthermore, the phase relationships of component frequencies in a continuous resultant wave form may produce either amplitude or frequency modulation effects. This means that the central nervous system may experience a slow variation in either pitch or loudness, depending on phase relationships.

It was mentioned in a preceding section that the response to frequency and amplitude modulation above a repetition rate of six to seven per second could not be differentiated by the ear. At a lower rate than this, the difference is clearly perceived as an instability of loudness or frequency. Finally, and particularly at fundamental frequencies below 100 cps, various phase relations between the harmonics will distinctly alter the quality of a tone.[14] Phase conditions producing the greatest amount of intercancellation are characterized by smoothness, and additive phases by roughness.

The timbre of musical tones is not usually changed in a noticeable way by variations in phase relationships. This is evidenced by the fact that complex phase shifts varying with frequency take place in almost all audio electronic circuits without the ear's being aware of them. The acoustic conditions of an auditorium will greatly vary the phase of sound waves reaching the ear. However, while the subjective experience may be much the same and equally pleasant, the approach to identity is definitely diminished where large differences in phase relationships occur between the original and the reproduced sound.[15, 16, 17]

Conclusions

Electronics has made an enormous contribution to the widespread enjoyment of music. Surely it is important to continue in the effort to expand the techniques available so as to encompass the full range of possible sensation. Efforts to determine the desirability of high fidelity on the basis of observers comparing two devices of different degrees of imperfection are fallacious. True high fidelity would be indistinguishable from the original. It is obvious that a decision must be based on comparisons between reproduced and live music.

There are many subtle differences between live and reproduced performances that are observed subconsciously. Even with the finest contemporary equipment, an observer entering the studio blindfolded will rarely be deceived. It is inevitable that initially developed methods will appear expensive and cumbersome in comparison with the improvement gained. This is the historic cycle of progress. Simplification, cheaper and more efficient methods always follow. It is the responsibility of the entire radio industry to work toward preserving the heritage of musical progress and expanding, not limiting, the musical vocabulary of the future.

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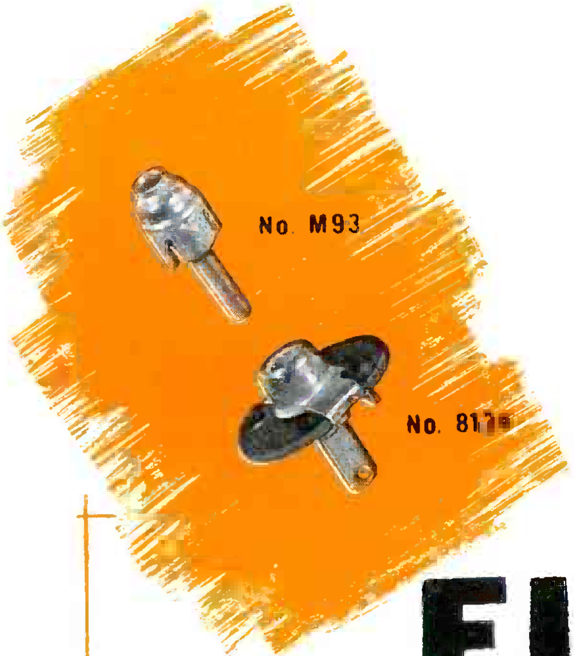

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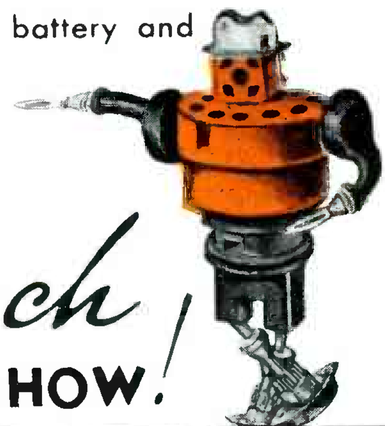

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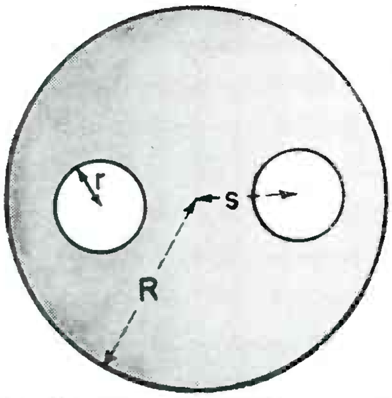
Characteristic Impedance OF BALANCED LINES



Comparison of three equations for Z_0 of a balanced two-wire transmission line with a cylindrical shield, and expressions for the errors in the equations

By PETER J. SUTRO
Columbia University
New York, N. Y.

CONSIDER a balanced transmission line composed of two inner conductors plus a shield. The inner conductors are circular cylinders of outer radius r whose axes are separated by a distance $2s$. The shield is a circular cylinder of inner radius R, symmetrically placed with respect to the two inner conductors.

If, by definition, $x = r/s$ and $y = s/R$, the characteristic impedance Z_0 in ohms between the inner conductors can be expressed in terms of x, y, and the dielectric constant ϵ of the dielectric filling the line.

Sommer[1] derives an expression for the capacitance between the inner conductors of such a transmission line, following a method used by Kaden[2]. This expression can be transformed into

$$Z_0 = \frac{120}{\sqrt{\epsilon}} \left\{ \log_e \left(\frac{2}{x} \frac{1-y^2}{1+y^2} \right) - \frac{1}{4} x^2 \left(1 - \frac{4y^2}{1-y^4} \right)^2 - \frac{1}{32} x^4 \left[3 + \frac{32y^4(1+2y^2)}{(1-y^4)^2} - \frac{128y^4(1-2y^2-2y^6-3y^8)}{(1-y^4)^4} \right] - \ldots \right\} \quad (1)$$

This is presumably correct as far as the series is carried, the next term being one in x^6. When the shield is removed (that is, as R approaches infinity or as y approaches zero) the formula reduces to the series expansion of the exact expression for the characteristic impedance of the unshielded balanced line

$$Z_0 = \frac{120}{\sqrt{\epsilon}} \cosh^{-1} \left(\frac{1}{x} \right) = \frac{120}{\sqrt{\epsilon}} \left\{ \log_e \left(\frac{2}{x} \right) - \frac{1}{4} x^2 - \frac{3}{32} x^4 - \frac{10}{192} x^6 - \ldots \right\} \quad (1a)$$

Thus the error in Eq. 1 always enters in the terms in x^6 and higher powers.

The second formula is transformed similarly from an expression for the capacitance of the line which Sommer, in the same article, attributes to Breisig[3]. The result of this transformation can be written

$$Z_0 \pm \frac{120}{\sqrt{\epsilon}} \cosh^{-1} \left[\frac{1}{x} \frac{1 - y^2(1-x^2)}{1 + y^2(1-x^2)} \right] \quad (2)$$

This formula is a good approximation for large values of R, giving a value which is too small by an amount

$$\Delta Z_0 = \frac{120}{\sqrt{\epsilon}} \left\{ \frac{x^2 y^2}{(1+y^2)^2} - \frac{1}{16} x^4 y^2 (10 + y^2 + \ldots) + \ldots \right\} \quad (2a)$$

The error can be seen to go to zero when the shield is removed ($y = 0$), as is obvious from the fact that Eq. 2 then reduces to the closed form given above for the unshielded line.

It is interesting to compare Eq. 1 and 2 with the formula given by Terman[4], which can be written

$$Z_0 \pm \frac{120}{\sqrt{\epsilon}} \left\{ \log_e \left(\frac{2}{x} \frac{1-y^2}{1+y^2} \right) - \frac{1}{4} x^2 (1 - 4y^2) - \frac{1}{16} x^4 (1 - 4y^2) \right\} \quad (3)$$

This equation appears to neglect terms in y of higher order than y^8 and terms in x of higher order than x^4. The terms in x^2 and x^4 are incorrect, however, and the expression gives a value which is too small by

$$\Delta Z_0 = \frac{120}{\sqrt{\epsilon}} \left\{ \frac{x^2 y^2}{(1-y^4)^2} (1 - 4y^2 - y^8) - \frac{1}{32} x^4 (1 + 8y^2 - \ldots) + \ldots \right\} \quad (3a)$$

Note that while the error in the x^2 term goes to zero if there is no shield ($y = 0$), the error in the x^4 term does not.

Breisig's expression, Eq. 2, is more useful on the whole than Eq. 3. If y is large, the error in Breisig's equation is very nearly the same as that in Eq. 3, while for small y the error in the second equation is considerably less than that in the third. This may be of importance when x is large.

In general, Eq. 1 is the most accurate. It is better than Breisig's equation everywhere except when y is very small. In most practical cases, it is sufficient to keep only the first two terms of Eq. 1, dropping the term in x^4 (which then gives the error). On the other hand, Eq. 2 is a more convenient form, and is sufficiently accurate for most purposes if x and y are not too large (x and y are always less than one).

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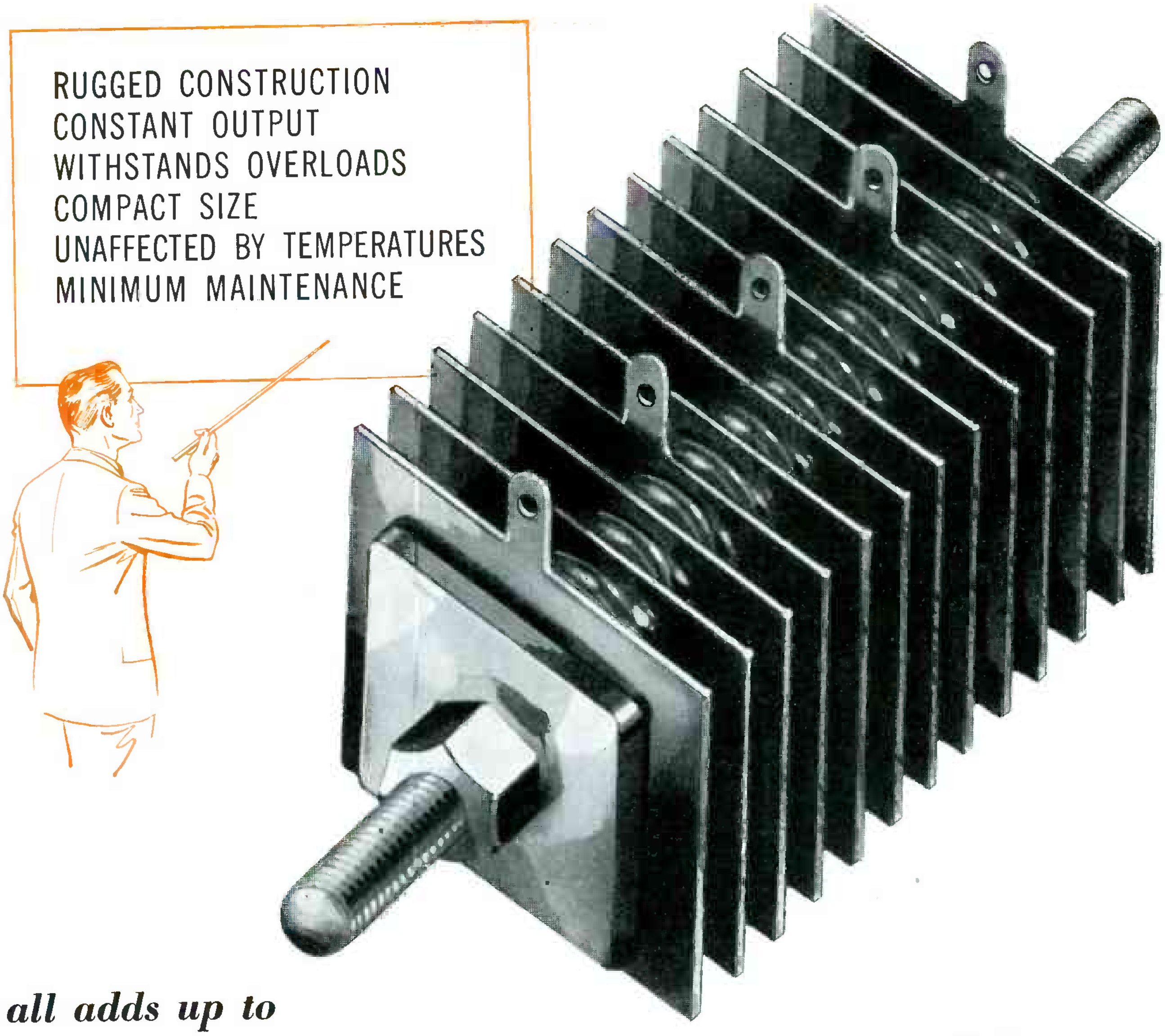

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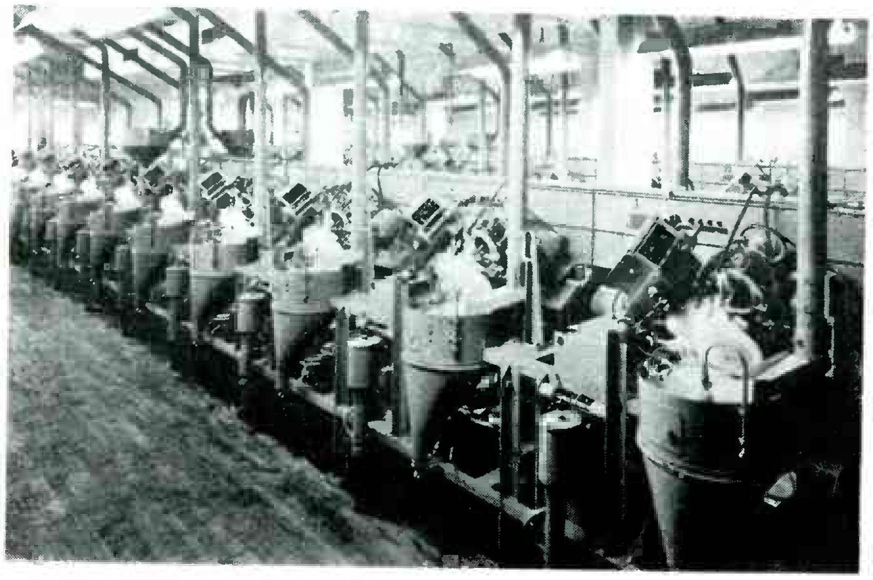
In modern equipment, acceptance or rejection of each bean or other object depends on the respective percentages of red and green light reflected by it. The beans are fed down a chute to a rotary feed that passes them, one at a time, through an optical system consisting of an incandescent lamp, a focusing lens, two mirrors, and two phototubes.

Rays from the light source are reflected by the bean through the lens to the partial or 50 percent mirror. It reflects part of the light through a red color filter to the first phototube, but transmits another part of the light to the second mirror, a normal mirror, which reflects it through a green color filter to the second phototube. The first phototube is especially sensitive to red light, the second to green light.

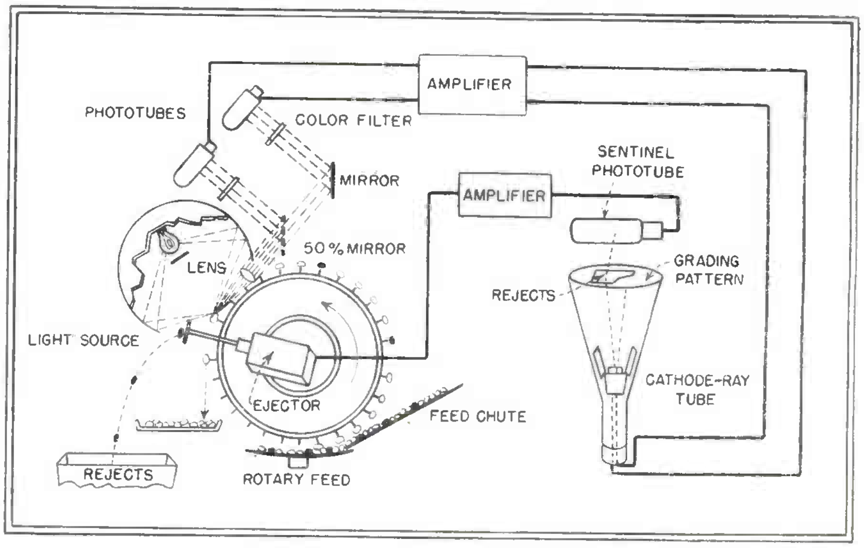
The amplified output of each phototube is applied to a pair of deflection plates in a cathode-ray tube. Thus, one phototube controls the horizontal sweep of the electron beam in the cathode-ray tube, while the other phototube controls the vertical sweep of the beam. The amount of deflection is governed by the respective amounts of red and green light reaching the phototubes.

The screen of the cathode-ray tube on which the electron beam will appear when controlled by the color range of an acceptable bean is covered by a partial mask that provides a grading pattern. When a bad bean passes through the optical system, the color of the reflected light affects the output of the phototubes, and this in turn alters the sweep of the electron beam so that it causes the phosphor to glow outside the mask area. A sentinel phototube picks up this extra glow and its amplified output actuates an ejector mechanism that trips the bad bean into the reject bin.

Tube types employed in the sorting machines include the RCA 908 cathode-ray tube, 2050 thyratron, and phototubes 918 and 1P29. Tube life has been estimated to be an average of more than 8,800 hours by the Electric Sorting Machine Company, manufacturers of the equipment.



Billions of beans pass through this plant of the Michigan Bean Company where RCA phototubes and cathode-ray tubes control a sorting mechanism that separates good little beans from bad ones. Mirrors and lenses are used with the phototubes to judge the color range of each individual bean



Essential elements of the electronic bean sorting system. A partial mask provides a grading pattern on the screen of the c-r tube

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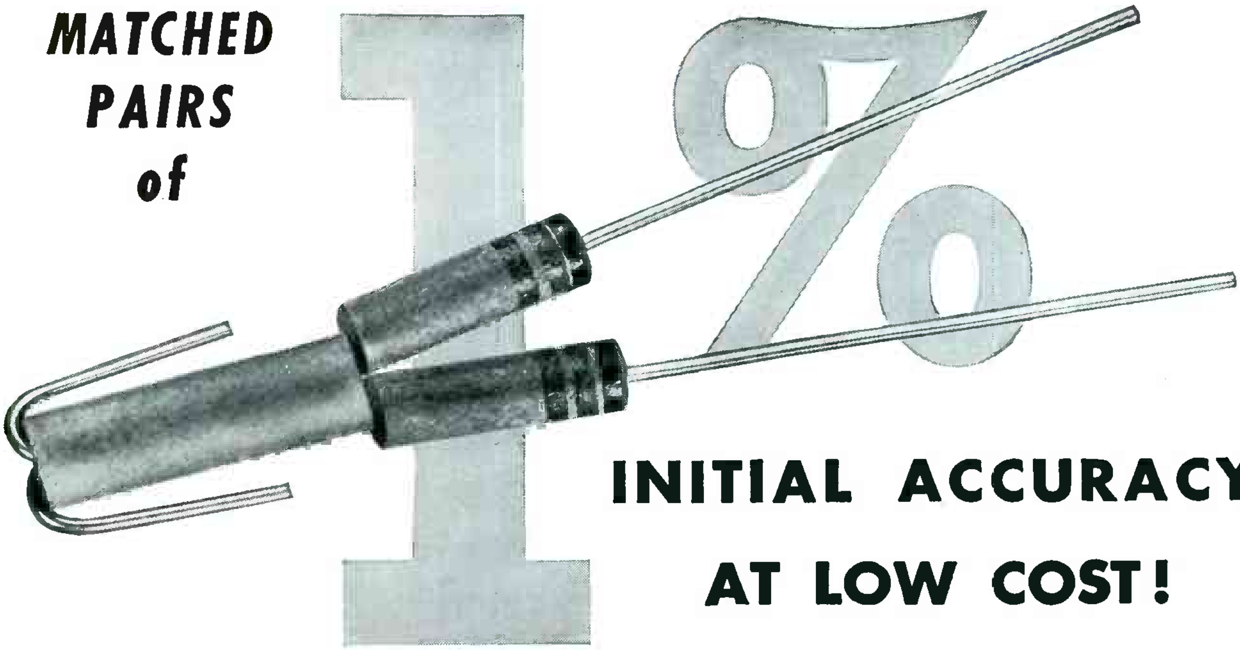

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BW-2	3.75 Ohms	4100 Ohms	15 Ohms	16,400 Ohms
BTS	235 Ohms	10.0 Megohms	940 Ohms	40.0 Megohms
BTA	165 Ohms	10.0 Megohms	660 Ohms	40.0 Megohms
BT-2	235 Ohms	10.0 Megohms	940 Ohms	40.0 Megohms

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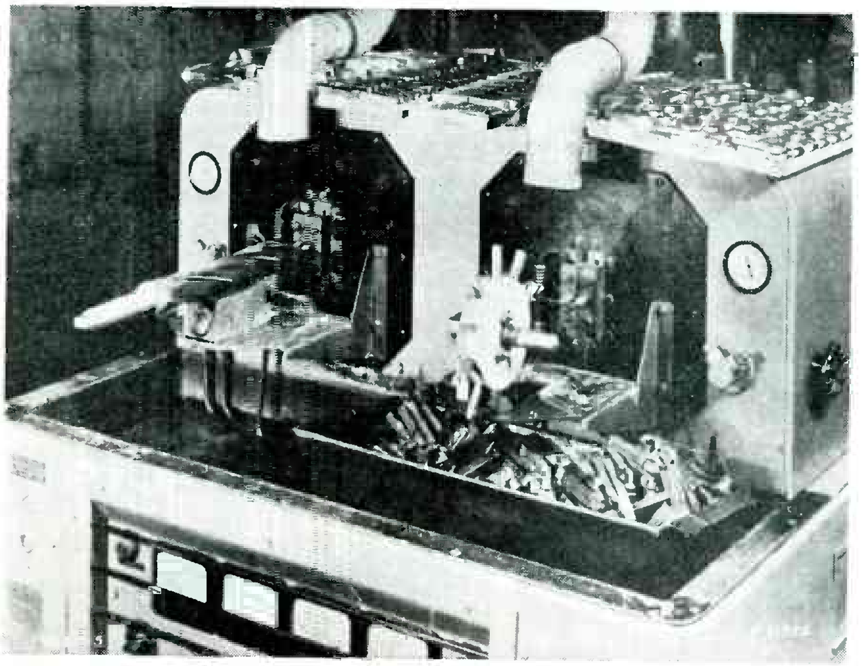


At left is a magnetic chuck block holding a large drill for induction brazing of tungsten carbide tip. The tips on small tools are held in place by the adhesion of the brazing material. At right a rotary fixture holds seven tools ready for brazing

that one tool producer was able to amortize the cost of his two induction machines in three months time.

The inherent characteristics of high-frequency currents to concentrate on a selected area make induction heating an ideal medium for tool brazing. The heat can be restricted to the tip end which leaves the remainder of the shank cool enough so that in most cases an operator can handle the finished piece with a gloved hand. Tongs are needed only on the smaller tools.

To braze a tip to any of the many tools produced in the Willey's Carbide Tool Company, Detroit, the operator places the tool beneath the inductor with the tip and brazing material positioned in the recess. The heating cycle may run from three seconds upwards to a minute depending upon the type of tool being brazed. As the heating progresses, the operator, by use of a small rod, wipes the tip into place as the material softens. Cycles can be controlled automatically or manually.

The rotary fixture is turned manually by the operator to present each tool to the heating coil when brazing

Tools are held beneath the inductor by one of three holders, a rotary chuck, a screwclamp fixture, or a magnetic chuck block of which two sizes are used. With the magnetic block, big tools can be rapidly positioned beneath the inductor and held firmly during the brazing cycle.

Rotary Tool Holder

The rotary fixture holds the tools in place by spring tension and, as the operator rotates the block manually, the tool enters the field of the inductor coil where it becomes heated. The tip is wiped in place by the operator during the heating and passes down and out of the inductor as the very short cycle concludes. Held by mechanical tension until it arrives at the vertical, the tool is released automatically from the fixture and drops into a tote box or a conveyor.

These operations are being performed on two Tocco 15 kw, two-station, 9,600-cycle units of Ohio Crankshaft Company equipped with watercooled inductor coils that are changed to accommodate different tools.

One advantage of the induction method is reported to be the silver-soldering of high-speed steel tips without drawing the hardness of the tip. Also, induction heat simplifies the removal of a brazed tip from a shank by quickly remelting the brazing material.

Larger tools are now being treated in greatly increased quantities. Two girl operators turn out 85 of these an hour on a two-station unit in contrast to the 80 tools per 8-hour day by older methods. It is with these larger tools that the method's economies are seen to best advantage. Here a single magnetic chuck block 6 inches long is used for holding the big shanks.

A two-tipped tool has been brazed by the induction process for the first time without the wiring required to secure the tips for treatment by other methods. The tips are held in place during the heating without extra support. The treating of drills, reamers and counter-bores is done in the same manner.

Brazing of diamond dressing tools, for straight or radius dressing, having but a single diamond were always difficult to handle and slow to braze. Now, after the stone is positioned and the matrix base is pressed into the tool cavity around the diamond, one girl can braze 150 to 200 half-inch tools an hour. The cycle is three seconds heating per dresser.

Variable Timing Up to Thirty Seconds

By Donald G. Haines
Consulting Engineer
Chicago, Illinois

For control purposes, it is often necessary to turn electrical equipment on and off after a definite time interval. With the instrument to be described, the time interval is adjustable from ½ to 30 seconds by the operator.

The instrument was designed primarily for accurately controlling exposure time in the use of a photographic printer or enlarger. Adjustment of the timing range is provided

by a single low-resistance control. By setting this control at any desired point in this range, the required time interval may be obtained by simply pressing a button.

A disadvantage of the usual resistance-capacitance discharge circuit is the impracticability of calibration of a single high-resistance control. However, the principle difficulty is the inherent lack of stability of the method which seriously affects the accuracy of the timed interval. In combination with a triode tube, this new circuit permits the use of a low-resistance control to obtain the same range of time discharge as would be obtained with the high-resistance type.

Figure 1 shows the circuit diagram. The timing control is a 0.25-

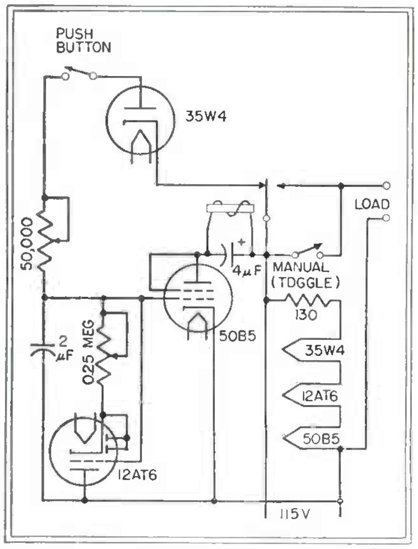
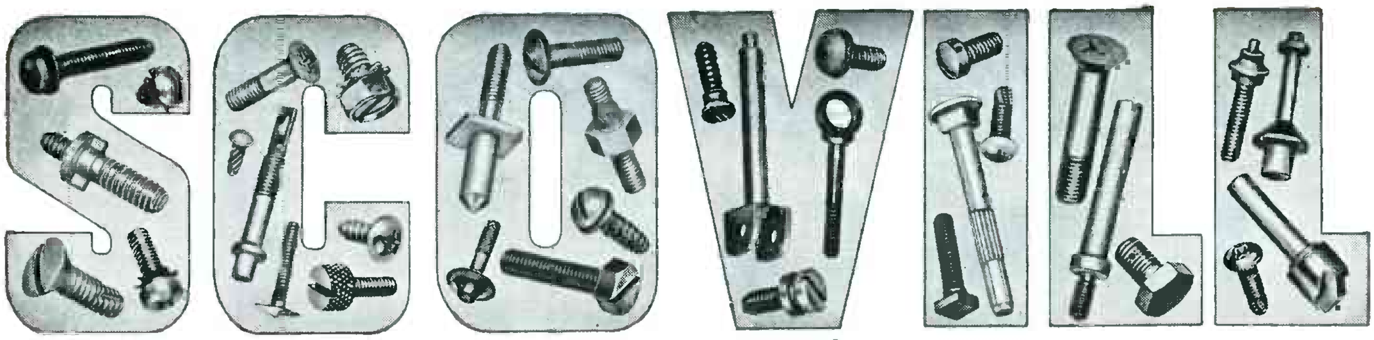
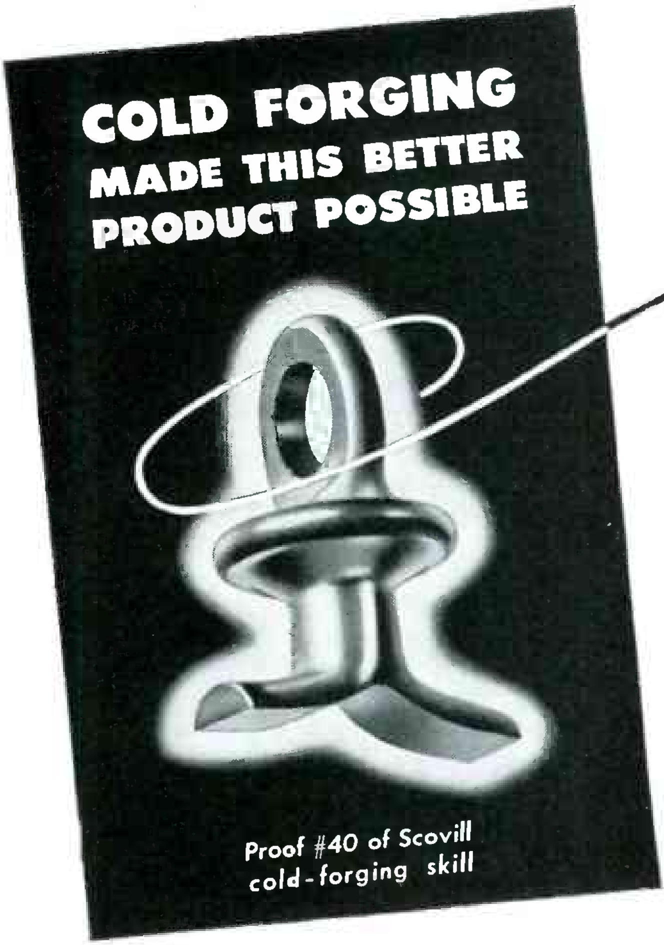


Fig. 1—Time intervals from ½ second to 30 seconds are provided by this electronic relay circuit

megohm variable resistor in the cathode circuit of a triode. Pressing the pushbutton charges the 2-μf capacitor negatively, causing the relay to open. The discharge current from the capacitor flows through the triode and through the variable cathode resistor which places a negative bias on the triode grid. This causes the triode plate resistance to increase dependent upon the value of discharge current. The degenerative effect produced permits use of a low-resistance control to obtain a wide range in the value of the plate resistance of the triode.

As the capacitor discharges, the negative voltage controlling the 50B5 tube is reduced to the point where





The part shown here is another instance where Scovill cold-forging ingenuity and equipment helped improve a product — and also resulted in more efficient production.

The problem was to devise a better fastening for sink washers than the old-style metal ring — a new kind of fastening that simply would not pull out.

The problem was partially solved by designing the stud shown in the illustration at the left. Scovill cold-forging skill then solved the next and major part of the problem — how to produce the stud economically. Here again Scovill fastenings experts combined a practical knowledge of *what* to do — plus *how* to do it.

Scovill experts in cold-forging for special fastenings have helped many manufacturers reduce assembly time, cut costs, and produce better products. If you would like to improve a product through better fastenings — or if you have a product needing fastenings that is in the design stage now, call one of the Scovill experts listed below. It will not obligate you.

★ For production efficiency, call Scovill on these standard fastenings, too . . . Phillips Recessed Head Screws . . . Clutch Head Screws . . . Sems Washer-Screw Assemblies.

SCOVILL MANUFACTURING COMPANY

WATERVILLE SCREW PRODUCTS DIVISION

WATERVILLE 48, CONN. **TEL. WATERBURY 3-3151**

NEW YORK, Chrysler Building • **DETROIT**, 6460 Kercheval Avenue • **CHICAGO**, 135 South LaSalle Street • **PITTSBURGH**, 2882 W. Liberty Ave.
SYRACUSE, Syracuse-Kemper Insurance Building • **LOS ANGELES**, 2627 South Soto Street • **SAN FRANCISCO**, 434 Brannan Street

sufficient current flows through the relay to cause it to close again. The degenerative action of the triode maintains a high rate of change of current through the relay, assuring positive action. Figure 2 shows the linear time-discharge curve of the

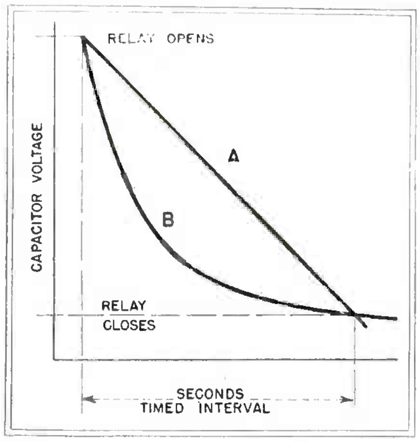


Fig. 2—Time-discharge relation showing the advantage of the linear discharge *A* over the logarithmic discharge *B* of a conventional R-C circuit

degenerative circuit as compared to the logarithmic curve obtained by use of a pure resistance. The flattening out of the logarithmic curve toward the end of the discharge time presents a critical period in the operation of the relay during which inaccuracy of timing may occur.

Another variable resistance, shown in the charging circuit, provides a means of compensation for variation in tubes and in line voltage conditions. This control is intended for initial adjustment of the instrument but may be employed at any time to correct the calibration.

• • •

Dielectric Heating Seals Giant Balls

ELECTRONIC HEAT-SEALING techniques learned in making solar stills during the war for obtaining drinking water from the ocean have been applied to the manufacture of giant toy balls. In the method, dielectric heating is used to join large strips of Vinylite in airtight, watertight seams that are as strong as the thermoplastic material itself.

The sections of the thermoplastic to be sealed are placed between metal electrodes supplied with r-f power from an RCA two-kilowatt electronic

mitchell-rand offers 6 different brands of Varnished Tubing

HYGRADE

DOUBLE SATURATED

STANDARD

TRIPLE STRENGTH

MIRAC

IMPREGNATED

...TO COVER EVERY KNOWN REQUIREMENT

FIBERGLAS (INORGANIC) VARNISHED TUBINGS

M-R Fiberglas Varnished Tubings are made in four grades: *Standard; Double Saturated; Triple Strength and Impregnated.*

STANDARD GRADE

has maximum flexibility, is treated with a minimum of varnish and recommended for high temperatures where dielectric strength is not a factor.

DOUBLE SATURATED

has all qualities of the Standard Grade but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

TRIPLE STRENGTH

is built up with coats of especially flexible insulation varnish for dielectric ratings up to 2500 volts and is particularly suited where assembly operations include the possibility of rough handling.

IMPREGNATED

is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc. IMPREGNATED has a dielectric rating beyond 7000 volts and is unequalled for Long Life Under Most Severe Conditions. *Write For Samples.*

FOR USERS OF COTTON YARN VARNISHED TUBINGS

The Mitchell-Rand MIRAC and HYGRADE Varnished Tubings of long staple fiber yarn are comparable to Fiberglas Tubings in dielectric ratings, tensile strength, flexibility and long life. *Write For Samples.*

FREE FOR THE ASKING

Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drills, etc.

HEADQUARTERS THE ELECTRICAL INSULATION FOR 57 YEARS
MR

MITCHELL-RAND INSULATION COMPANY, INC.

51 MURRAY STREET · CORtlandt 7-9264 NEW YORK 7, N.Y.

A PARTIAL LIST OF M-R PRODUCTS

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

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

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

oscillator. The temperature at the interface of two overlapped edges of the material increases more rapidly than that of the outer surfaces. This is due to the fact that heat is conducted away from the outer surfaces by the unheated metal electrodes in contact with them, leaving the interface at a higher temperature, and

Seam-sealing with an electronic generator at the Lombard, Ill. plant of DuPage Plastics Company. When the upper electrode is lowered, strips of Vinylite are joined in airtight seams

this heat differential is increased progressively by the capacity of the warmer area to absorb a greater amount of power.

Each ball is 22 inches in diameter, has a wall 0.006 inch thick and weighs nine ounces when inflated. It can be bounced, rolled, kicked, thrown, tumbled on, or used as a punching bag, a hassock, or a surf float without bursting, and will withstand heat and cold as well as salt water. According to the DuPage Plastics Company, it is the first big, tough, lightweight bladderless ball that has ever been successfully manufactured.

The job could not be done on a practicable basis by any other heating method. If the seams were stitched in the conventional manner, a separate waterproofing operation would be required.

• • •

Plant Truck Traffic Control with Intercoms

In Toledo, Spicer Manufacturing Corp. uses many power-driven trucks to convey material from one part of the plant to another, or from

one department to another. This created a problem: how to know where any truck was at a given time so that a department which needed a truck could be served on very short notice.

The two sections of the plant cover several acres and trucks constantly were being lost in the shuffle. Much time was wasted by departments waiting for material and by departments which had material to be moved out.

Quick communication was needed between the operators of roving trucks and a central point from which the trucks could be controlled and their operations coordinated. An internal trucking department was set up and the two separate central-control intercommunications systems made by Executone, Inc., New York, were installed.

Two control stations are placed in the truck dispatcher's office. Seventeen substations are located at strategic points to give complete coverage of the plant. Nine substations in one section of the plant are connected to one control station and eight substations in another section are connected to the other control station.

A control chart, called the dispatch board, is placed on a large desk in

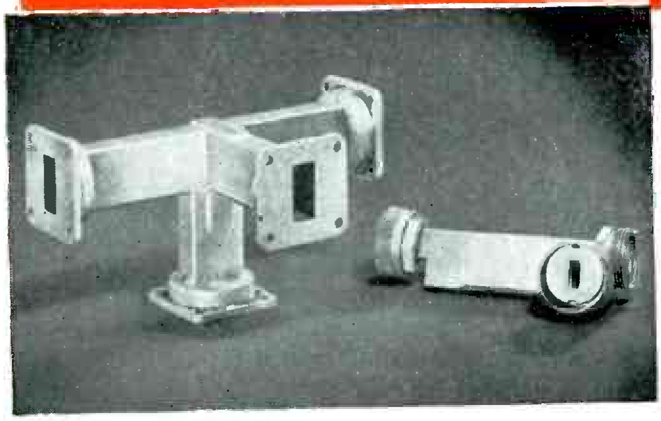
Calls to a central dispatcher are transmitted from this substation by operators of power-driven plant trucks

the dispatcher's office. An outline of both sections of the plant is painted on the board, and holes drilled in the board show the location of each department and the location of each substation. Pegs are numbered to represent different trucks and two

An extensive line of A.R.C. radio and electronic components

Precision Built to Aircraft Standards

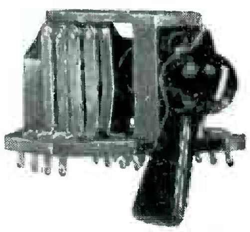
Since 1928 the Aircraft Radio Corporation has devoted its engineering and production facilities to the design and manufacture of high-quality radio equipment for aircraft use. Components similar to those listed here proved their worth in the A.R.C. receivers and transmitters used in nearly all military aircraft during the war.



ARC "Magic Tee" and Microwave Coupler

MICROWAVE PLUMBING AND ACCESSORIES — A complete line of Microwave Plumbing and Accessories, engineered to A.R.C. precision standards, is now available. With the increasing emphasis on microwave transmission in modern aircraft navigation and control, A.R.C. has pioneered in the design of equipment for this type of operation. Typical of A.R.C. Microwave Accessories are the "Magic Tee" and Directional Coupler illustrated. Other items, such as the 24,000 megacycle attenuator, use the unique "split plate" construction developed by A.R.C.

Miniaturized D.C. Relay by ARC



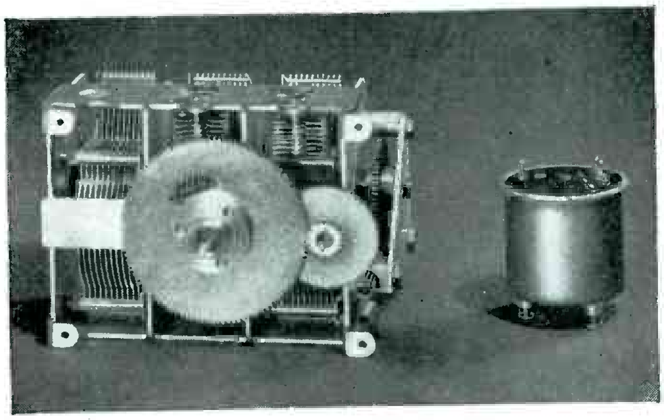
Precision Built "Music Box" Type Switch

RELAYS AND SWITCHES — Compact, lightweight relays designed by A.R.C. have had years of use under the extreme conditions of vibration, humidity and temperature encountered in military aircraft operation. Available in several types and sizes, they meet rigid requirements for reliability and specified performance.

A.R.C. Precision-built Switches are made in Drum-Type, "Music-Box" Type, and special Toggle and Push Types, and are available in various contact combinations. All are designed to stand up under the hardest usage, and are manufactured to the highest standards of the aviation industry.

ARC Multi-contact Connector with Ceramic Inserts

MULTI-CONTACT CONNECTORS WITH CERAMIC INSERTS — A.R.C. has developed a line of Ceramic-Insulated Multi-Contact Plugs and Receptacles to combat carbon-tracking due to flashover. Floating, self-aligning female contacts and replaceable pin-plugs mean ease of maintenance and assembly as well as efficient service. Completely interchangeable with A.R.C. Bakelite insulated Plugs and Receptacles, the Ceramic type is provided in all types and sizes for use with shielded or unshielded cable, or with open wiring.



ARC Variable Air Condenser and Sealed, Oil Paper Type

CONDENSERS — VARIABLE, ADJUSTABLE, AND SEALED — Variable and adjustable air condensers by A.R.C., designed for use in both receivers and transmitters, are available in both single and multiple sections. Features of this equipment include the use of forked springs to provide positive grounding of rotor shafts, a special glass-ball method of stator support which keeps dielectric losses to a minimum, and cadmium plating of rotor and stator assemblies.

A complete line of Sealed Oil Paper and Dry Electrolytic Condensers have been designed by A.R.C. in both cylindrical and rectangular types, sealed in cadmium-plated brass cans. Minimum leakage path to ground is approximately 1/16th inch, good for a breakdown test of 2000 volts D.C.

Sealed Chokes and Transformers are also available in the cylindrical design.

For complete Parts Catalog, or specific information, write

AIRCRAFT RADIO CORPORATION

BOONTON, NEW JERSEY

dispatchers place these pegs in the holes representing different departments as each truck operator at the completion of a job calls the dispatcher from one of the substations and reports that he is ready for another assignment.

In the morning, each driver of a truck takes his truck to the substation to which he is assigned. Now, suppose that Department 17 needs a truck. The operator at the dispatch board uses his master station to call the truck which is nearest to that department. The peg, bearing the number of this truck operator, is then placed at Department 17. As soon as the driver completes his work, he goes to the nearest substation and reports to the dispatcher's office that he is ready for another assignment.

Much time is saved, efficiency is increased and over-all truck operation is greatly speeded up through the coordination of truck operations made possible by the system.

• • •

Streamlining C-R Tube Production

By M. SILVERMAN, *Production Manager*
Cathode Ray Tube Division
North American Philips Company, Inc.
Dobbs Ferry, N. Y.

MASS PRODUCTION METHODS are now used in many phases of cathode-ray tube manufacture. One of these steps, bulb coating, is ideally suited for such procedure.

Bulbs are first washed at one end of a long narrow room, then placed in a long conveyor which carries them

View of bulb coating room in which conveyor belts transport bulky c-r tubes to the several operations

NEW VARNISHED INSULATION SLEEVING AND TUBING WITH HIGH HEAT RESISTANCE

TURBOTUF

—will not swell, run or shrink under severe conditions!

Heat usually means trouble! But where "hot spots" are unavoidable in installation techniques or on-the-job conditions, you will avoid trouble by specifying TURBOTUF. This tough insulating material is made to stand up under higher heat levels than are usually experienced. Flame resistant as well as heat resistant, TURBOTUF varnished fabric tubing and sleeving is the answer where ordinary heat conditions prevail. But where excessively high ranges are anticipated, specify TURBO varnished Glass Fiber tubing . . . a remarkable material woven from strands of spun glass as fine and supple as silk yarn . . . with all the heat and chemical resistance of glass itself.

Improved impregnating methods, using an exclusive TURBO varnish applied to the fabric to saturation, provide—in addition to superior heat resistance—high dielectric values . . . extremely valuable bend and twist breakdown resistance . . . and protection against moisture, chemicals and oils.

Write on your company letterhead for the free TURBO Sample Board with testing specimens and sizes of each.

THERMOPLASTIC INSULATED WIRE: TURBOTHERM wire features high dielectric properties and resistance to heat and other destructive elements. Nos. 18 to 30 stranded and solid conductor.

FLEXIBLE VARNISHED TUBING: TURBOTUF tubings in two top grades—Magneto and Radio grade available in standard sizes from No. 24 (.020" ID) to No. 1 (1.000" ID).

SATURATED SLEEVING: TURBOTUF Sleeving—an all-purpose insulation for the lower dielectric ranges—in standard sizes from No. 20 (.034" ID) to No. ½ (.500" ID).

FIBROUS GLASS TUBING: TURBO Glass Fibre Tubing possesses superior electrical and physical characteristics—supplied in sizes from No. 20 (.034" ID) to No. ⅜ (.375" ID).

EXTRUDED PLASTIC TUBING: A smooth wall plastic tubing with notable resistance to severe low temperatures and subsequent embrittlement.

REMEMBER.. IF IT'S

TURBO

..IT SAFEGUARDS!

WILLIAM BRAND & COMPANY

276 FOURTH AVE., NEW YORK 10, N.Y.
325 W. HURON ST., CHICAGO 10, ILL.

to the opposite end of the room where the face is baked in an oven.

Next, they go to an automatic spraying machine. The operator places the bulb in position, pulls the trigger, and an oscillating spray gun coats the face of the rotating tube with fluorescent powder.

Another conveyor takes the tube to an inspector, to a rough wiper, to a fine wiper, to an operator who applies Dixonce to the inner surface, and finally to a rotating oven. The oven operator inspects the bulb and then places it in the oven. Here it passes through four compartments where it is baked at 320, 480, 520 and down again to 320 C. When baking is completed, the bulb is reinspected and sent to the sealing department.

Cathodes, 165 of them, are coated with a spray gun while they are held in a special platen. The operation is one step in mass production of c-r tubes at the Philips plant

In this bulb-coating set-up, every operation is completely mechanical. No operator needs to transport bulbs from one place to another—in fact, he need not move from his position. The capacity of this system is tremendous, considering the fact that it occupies a floor space measuring only 16 by 70 feet. Capacity of the bulb coating room with 10 operators is 1400 tubes per day or more.

—✣—

HERTZ discovered in 1887 that certain metals give off electrical energy under the influence of light, the basic principle of phototubes.

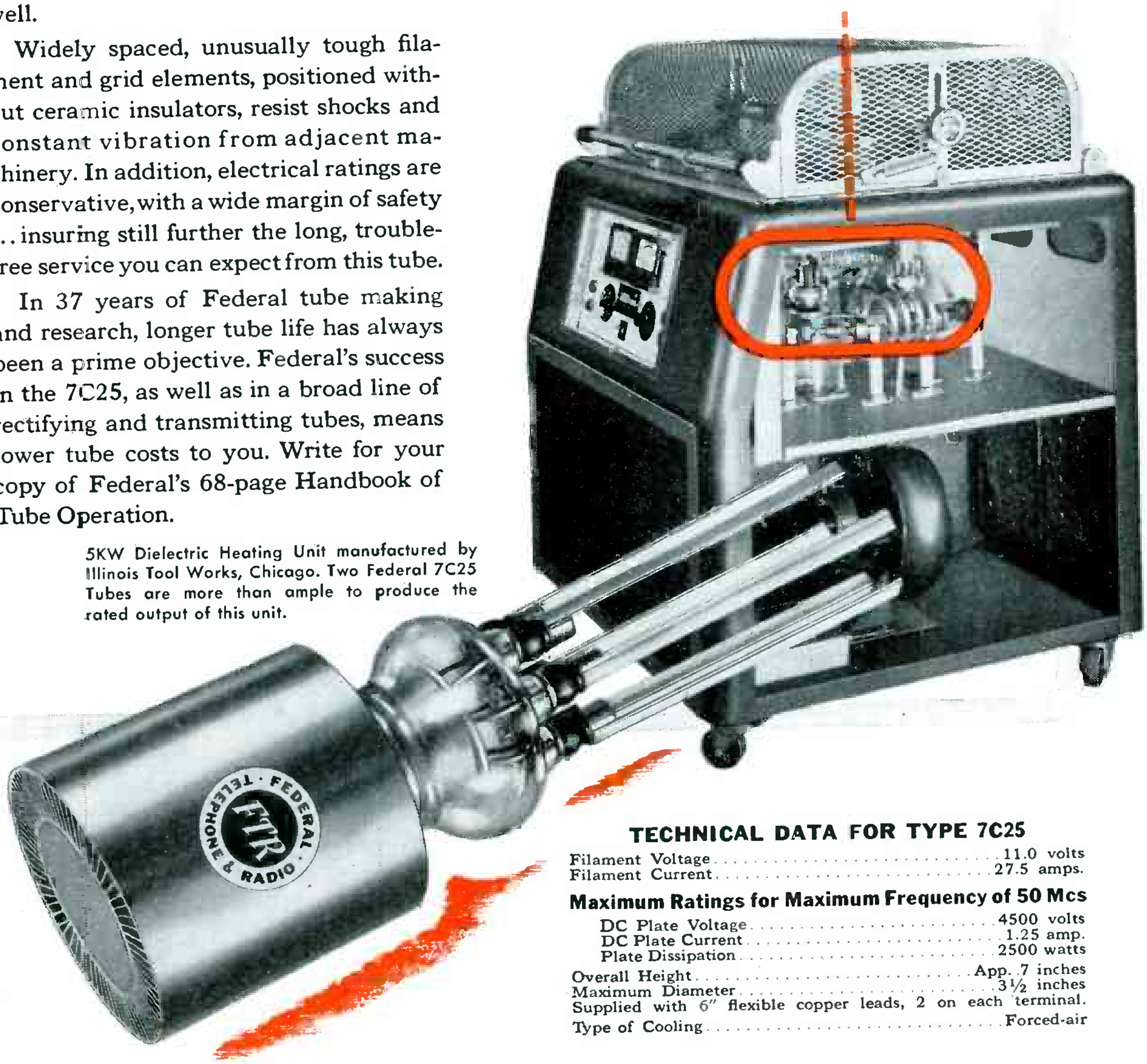
FEDERAL'S INDUSTRIAL POWER TUBES ... Built to perform better and last longer

FEDERAL'S 7C25 is *especially* designed for hard working conditions. It withstands not only the abuse of extreme load variations in electronic heating operations... but mechanical deterioration as well.

Widely spaced, unusually tough filament and grid elements, positioned without ceramic insulators, resist shocks and constant vibration from adjacent machinery. In addition, electrical ratings are conservative, with a wide margin of safety ... insuring still further the long, trouble-free service you can expect from this tube.

In 37 years of Federal tube making and research, longer tube life has always been a prime objective. Federal's success in the 7C25, as well as in a broad line of rectifying and transmitting tubes, means lower tube costs to you. Write for your copy of Federal's 68-page Handbook of Tube Operation.

... in industrial electronic equipment such as this 5KW dielectric heating unit



5KW Dielectric Heating Unit manufactured by Illinois Tool Works, Chicago. Two Federal 7C25 Tubes are more than ample to produce the rated output of this unit.

TECHNICAL DATA FOR TYPE 7C25

Filament Voltage	11.0 volts
Filament Current	27.5 amps.

Maximum Ratings for Maximum Frequency of 50 Mcs

DC Plate Voltage	4500 volts
DC Plate Current	1.25 amp.
Plate Dissipation	2500 watts
Overall Height	App. 7 inches
Maximum Diameter	3½ inches
Supplied with 6" flexible copper leads, 2 on each terminal.	
Type of Cooling	Forced-air

Federal Telephone and Radio Corporation

Newark 1, New Jersey

AN IT&T ASSOCIATE — FEDERAL TELEPHONE & RADIO FTR

Export Distributor:
International Standard Electric Corporation

TUBES AT WORK

F-M and A-M Receiver for Comparison Tests

By WILLIAM F. FRANKART
Design Engineer
Compton, California

THE RECEIVER TO BE described was designed to tune over the range of 15 to 170 megacycles and to have an overall sensitivity of two microvolts. It receives amplitude-modulated signals having high adjacent channel interference and also receives wide-band frequency-modulation signals. It was used for making direct comparisons between frequency modulation and amplitude modulation reliability-of-communication tests.

The receiver had to be stable, of known sensitivity, known passband characteristics and rapid changeover from a-m to f-m. It is also suitable for the determination of maximum frequency and minimum phase deviation and of the mean carrier frequency tests as described by Crosby (pages 85-87, Hund, "Frequency Modulation"). For these tests, a receiver that has narrow passband characteristics on a-m is necessary and no commercial communication receiver in this frequency range was found suitable.

Crystal Diodes

Two separate i-f channels are used, tuned to ten megacycles. The a-m channel has a pass band of six kilocycles. Of special interest in this channel is the use of Sylvania 1N34 germanium crystal diodes. The crystals are used in a circuit that is, in addition to being the second detector, a noise limiter that is very effective on pulses of steep wave front and short duration such as automobile ignition interference.

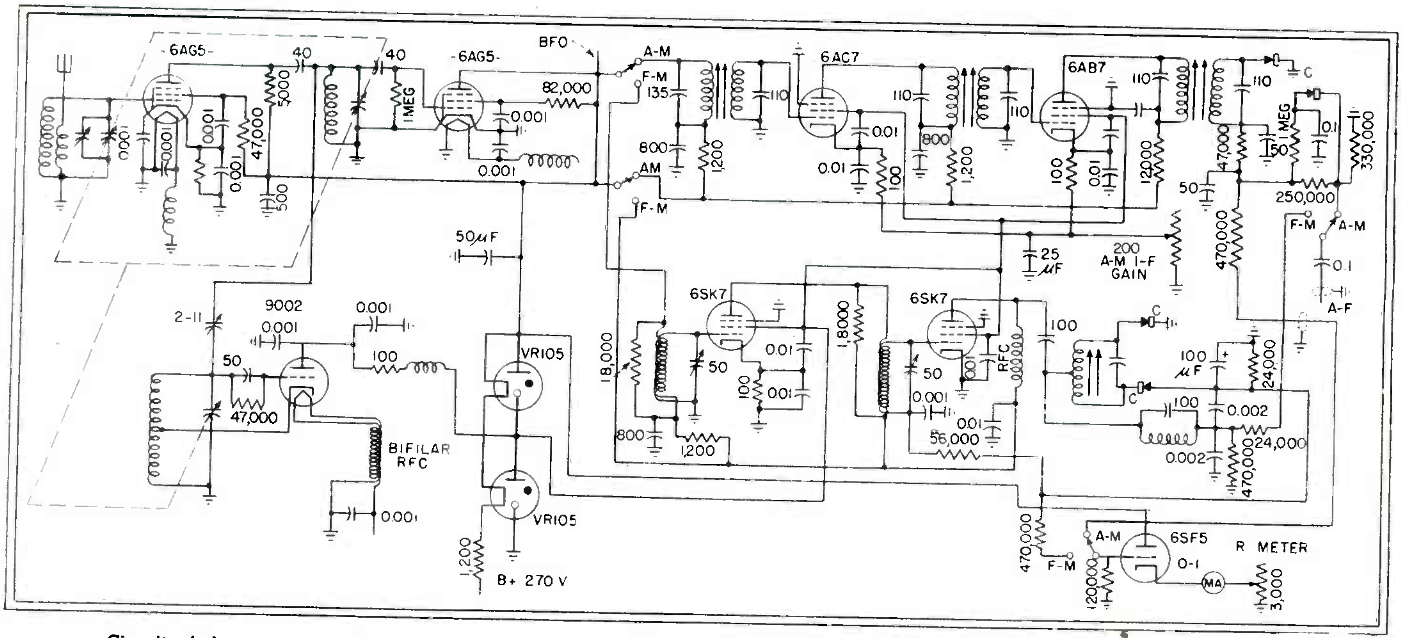
The second detector and noise-limiter circuit operation was greatly improved because the germanium crystal diode starts to work at much less signal level than the typical 6H6 diode. Also, the electrostatic capacitance of the crystal diode is much less than the 6H6. The blocking characteristic of the crystal is another factor that contributed to operation as a peak pulse noise limiter.

The f-m i-f channel has a passband of 300 kilocycles, this being wide enough for f-m reception. The circuit features the use of bifilar-wound single-tuned i-f transformers and germanium crystals in the Seely ratio detector. By using the bifilar-wound i-f transformer, certain advantages were had; more gain per stage, a high degree of stability, less components necessary, one circuit to align, and wider passband characteristics.

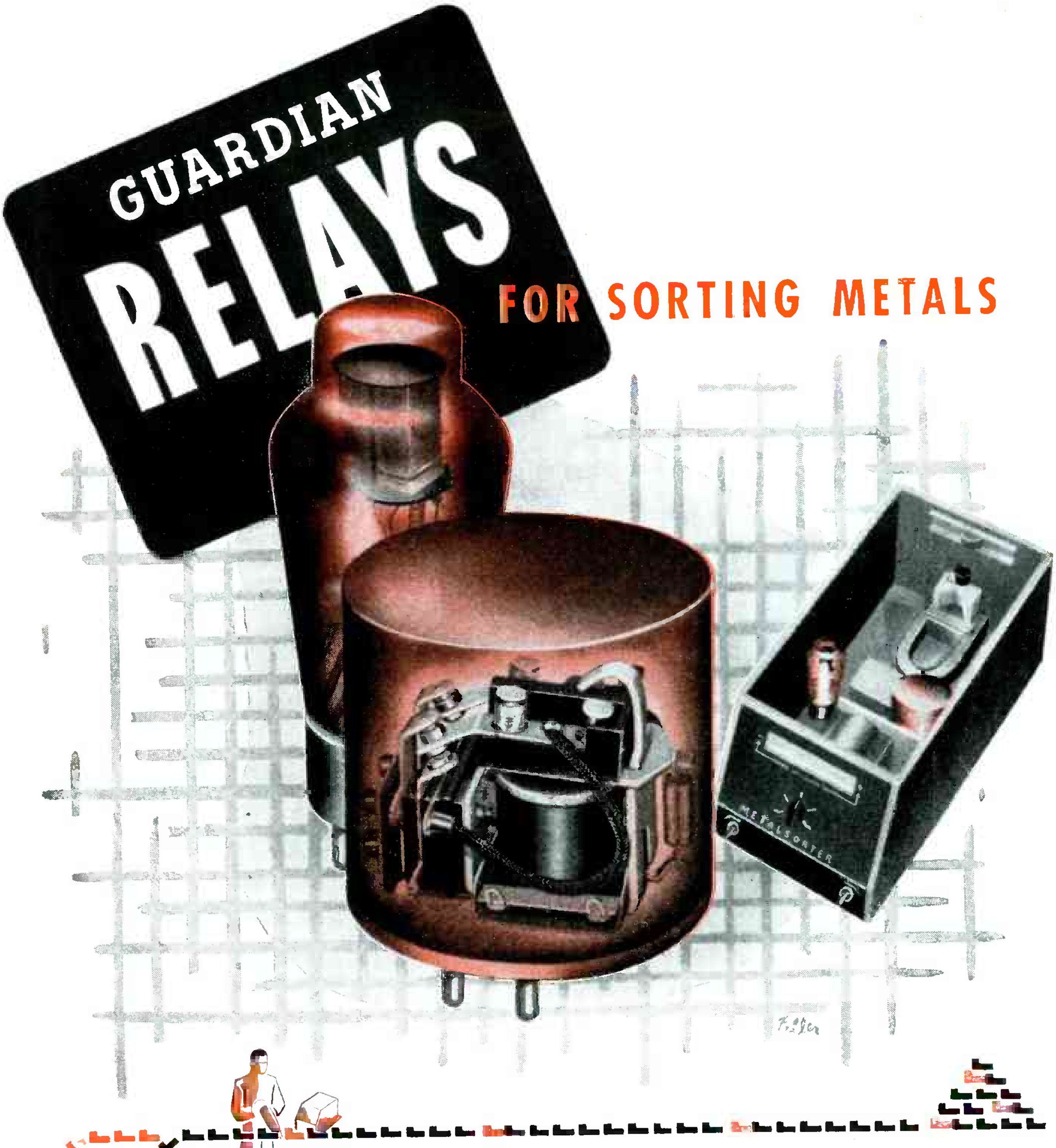
All bypass capacitors under 0.001 μf are silver mica and all capacitors below 0.011 μf are low-loss mica. The a-m i-f transformers are Aladdin No. 1201 with capacitors as called for in the schematic. These transformers are normally designed to operate on 12.6 megacycles and the capacitance increase was necessary to obtain the characteristics desired. The ratio detector i-f transformer is a Bendix No. AL 73026-1.

Facsimile to Moving Train via VHF

FIRST TRANSMISSION of a facsimile message to a speeding train was done from the Capitol Building in Washington, in the same room that Samuel



Circuit of the r-f and i-f stages of the combination receiver designed for convenient comparison of f-m and a-m signals



Photos courtesy Control Equipment Company, 547 Brushton Avenue, Pittsburgh 21, Penna.

In this interesting application a Guardian Relay, the Series 150-A, regulates the duty cycle of a Thyratron tube to control the time involved operating a testing tool for metal sorting.

Unit shown is the Metalsorter which employs the tribo-electric effect on metals, steel and non-ferrous alloys. The principle is simple. An acceptable or standard metallic specimen is placed in the holding chuck of a reciprocating tool, and the test is made by rubbing the standard against the unknown for a controlled time.

When a chemical or metallurgical dissimilarity between the chuck-held specimen and the unknown material occurs, a minute electrical current is generated and registered by an indicator on a calibrated dial. If the metals are alike, there is no current flow. Consequently, the operator is enabled to quickly identify, sort, or accomplish non-destructive testing of each item.

Again the association of a Guardian Relay and an electron tube solves an intricate control problem.

GUARDIAN ELECTRIC

1625-H W. WALNUT STREET CHICAGO 12, ILLINOIS

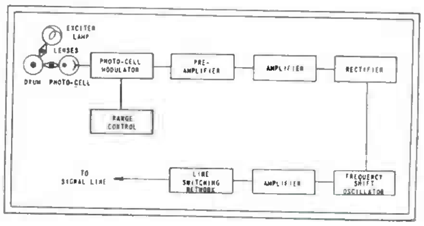
A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

F. B. Morse flashed his famous message, "What hath God wrought", 102 years ago. The same message, written by Miss Margaret Truman, the President's daughter, was transmitted to a moving train of the Baltimore & Ohio.

The demonstration was staged by Press Wireless Manufacturing Corp. in cooperation with the Baltimore and Ohio Railroad and Bendix Radio Division of Bendix Aviation Corp. and employed facsimile equipment consisting of a scanner and page recorder of their own design in the demonstration of radio facsimile transmission between fixed stations and a moving train.

Transmitting Equipment

The scanner unit at the transmitter contains two seven-inch rotatable drums measuring slightly less than three inches in diameter and placed end to end on a common axis. To these is fastened the subject copy. The drums may be operated singly or in tandem to accommodate large copy.

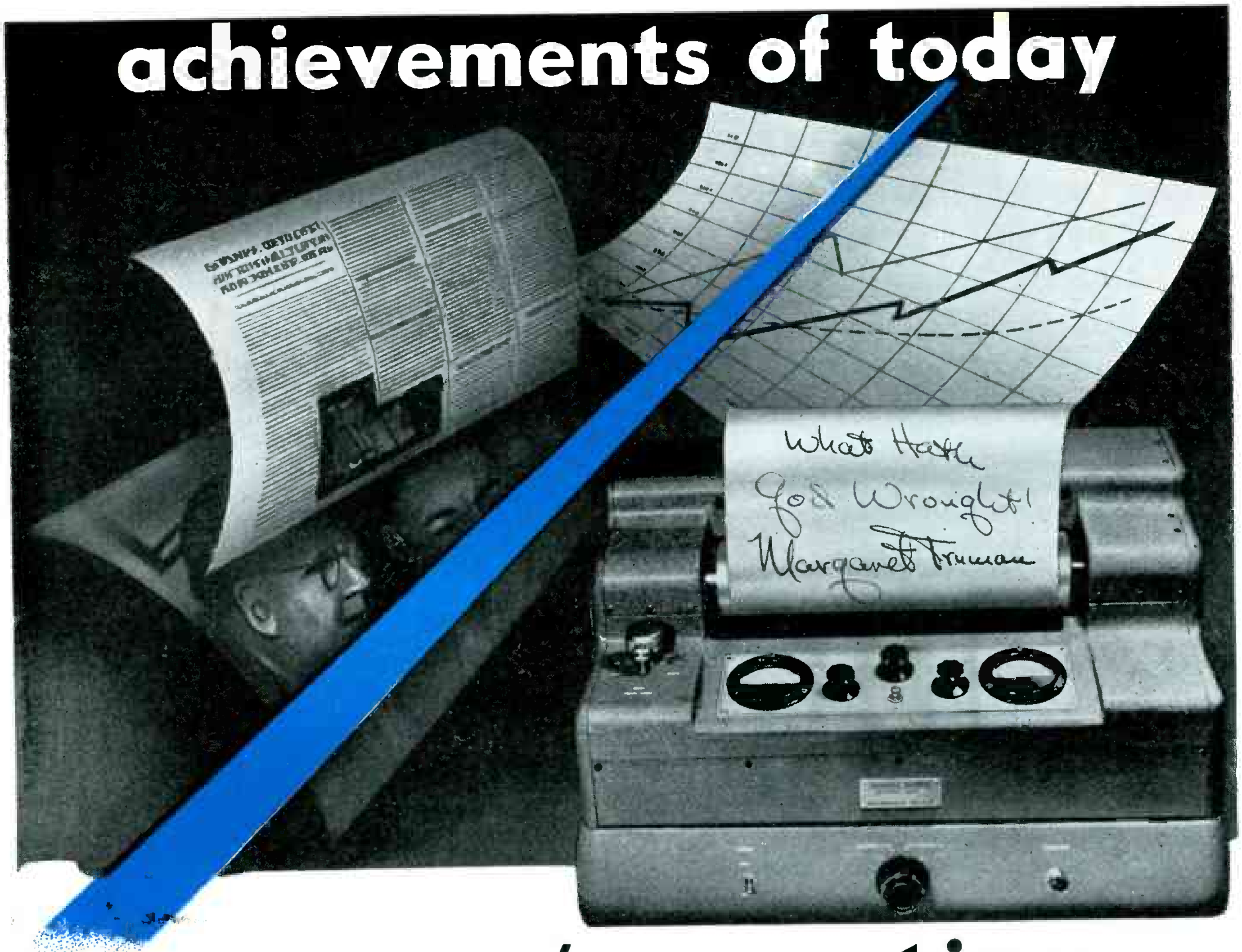


Block diagram of facsimile transmitter when using frequency-shift modulation. Similar stages are used for amplitude modulation but a re-keyer circuit is substituted for the frequency-shift oscillator

At the rear of the unit, a small optical scanning head controlled by a precision-threaded lead-screw moves across the instrument from left to right. The scanning head contains a tungsten filament, constant-intensity exciter lamp, a photoelectric cell and a precision lens assembly.

The lens before the exciter lamp is so arranged that a minute pinpoint of light strikes the revolving copy at right angles, while another lens assembly picks up only the angular reflected or incident light which is then focused upon the photoelectric cell. Copy variations from black to white are thus converted to variations in

achievements of today



tomorrow's routine

Achievement indeed was Samuel B. Morse's invention of the Telegraph, symbolized by his first message "What Hath God Wrought" . . . and today 102 years later another achievement takes form . . . reproduced above is the message Miss Margaret Truman, daughter of President Truman, wrote and which was Press Wireless Photo-Facsimilied from the Law Library of the Capitol to a train speeding from Baltimore to Washington, D. C. . . . today's achievements are tomorrow's routine . . . and so it is and will be with Press Wireless Photo-Facsimile Communications . . . letters, memoranda of instruction and commerce, newspaper copy, charts, maps, graphs, photos and anything that can be put on paper will be split-second transmitted and received by this communication system.

Illustrated is Press Wireless PHOTO-FACSIMILE SCANNER FT-1 . . . a precision instrument which is the sending part of the Photo-Facsimile Communication System. The equipment is simple to operate and works on a standard 110-220 volt, single-phase power source. Either an amplitude-modulated 1800-cycle signal or a frequency-shifted audio tone is available at the output.

Actual synchronization between this unit and the recording equipment is not necessary due to the precision frequency-controlled circuits employed.

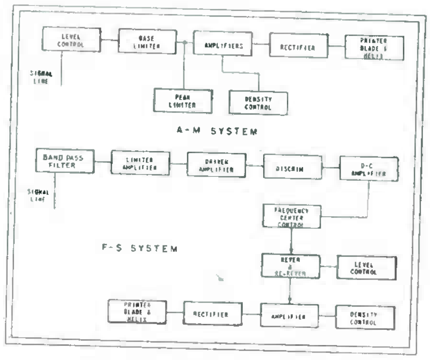
CHARACTERISTICS

Index of cooperation	289.5
Drum Speed	100 rpm
Drum Diameter	2.83 inches
Drum Length	Two 7" drums (may be used singly or in tandem to accommodate 14" copy.)
Lines per inch	102.3
Subject copy size	7" x 8.5"
Frequency Control	Compensated Tuning Fork
AM Carrier Frequency	1800 cps
FS Frequency Range	2100 to 3000 cps
Output Level (AM)	8 to 28 vu
Output Level (FS)	8 vu

PRESS WIRELESS MANUFACTURING CORPORATION

Executive Offices: 38-01 35th AVENUE, LONG ISLAND CITY 1, NEW YORK light intensity arriving at the cathode of the photoelectric cell in a modulator circuit of the scanner unit.

As the copy revolves, the thread on the lead screw advances the scanning head approximately 1/100 of an inch for each rotation of the drum so that the copy is scanned by approximately 100 lines per inch as the head travels across the subject matter. Thus each line consists of sequential series of picture elements resulting from the photo-optical analysis of the copy by the scanning head which are then translated to electrical impulses in an electronic circuit and, after suitable amplification, transmitted by wire or radio using frequency-shifted or amplitude-modulated signals.



Essential stages of Press Wireless facsimile recording equipment for both amplitude modulation and the frequency-shift method

Synchronizing

A mechanical tuning-fork oscillator circuit, accurate to 1 part in 100,000, is used to govern the drum speed on the units. The output of the oscillator is amplified and sub-harmonics of the fundamental frequency are locked up in multivibrators. The output of the multivibrators is then amplified and supplies the constant frequency a-c voltage and current required to drive the small synchronous motor which in turn drives the drums.

This method is common to both units and since the frequency tolerance is held very close it is not necessary to synchronize the transmitting and receiving equipment except at the start of transmission when push-button phasing or framing insures

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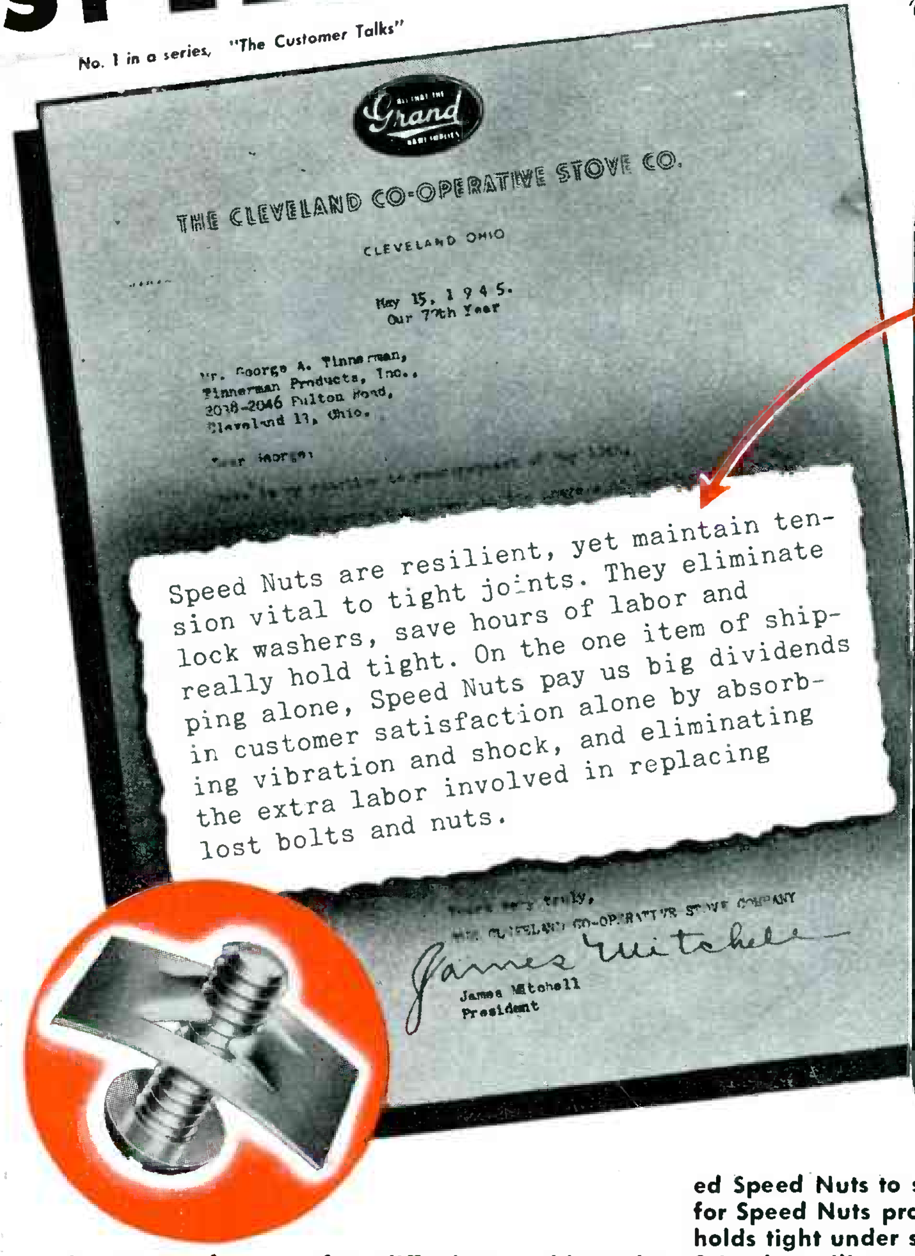
Grand
THE CLEVELAND CO-OPERATIVE STOVE CO.
CLEVELAND OHIO

May 15, 1945.
Our 77th Year

Mr. George A. Tinnerman,
Tinnerman Products, Inc.,
2038-2046 Fulton Road,
Cleveland 13, Ohio.

Dear George:

Speed Nuts are resilient, yet maintain tension vital to tight joints. They eliminate lock washers, save hours of labor and really hold tight. On the one item of shipping alone, Speed Nuts pay us big dividends in customer satisfaction alone by absorbing vibration and shock, and eliminating the extra labor involved in replacing lost bolts and nuts.

Yours very truly,
THE CLEVELAND CO-OPERATIVE STOVE COMPANY
James Mitchell
James Mitchell
President

ASSEMBLY ADVANTAGES

- Prevent vibration loosening
- Protect fragile materials against damage
- Eliminate lock washers
- Eliminate handling of material
- Applied faster
- Perform multiple functions
- Will not "clog" or "freeze"
- Reduce assembly costs
- Weigh less

Stove manufacturers face difficult assembly problems. The severe vibration and shock that stoves are subject to during transportation to the ultimate consumer must be met. Allowance must also be made for expansion and contraction of porcelain enamel parts when the stove is heated up to 500 degrees.

The Cleveland Cooperative Stove Company selected Speed Nuts to solve their fastening problems, for Speed Nuts provide a spring tension lock that holds tight under severe vibration and yet is sufficiently resilient to prevent damage to porcelain enamel surfaces. In addition, Speed Nuts eliminate lock washers, reduce assembly time and weigh less.

Speed Nuts will pay you big dividends, too. In writing for samples, please give complete assembly details, as Speed Nuts are made in more than 3000 shapes and sizes.

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In Canada: Wallace Barnes Co., Ltd., Hamilton, Ontario
In England: Simmonds Aerocessories, Ltd., London
In France: Aerocessoires Simmonds, S. A., Paris
In Australia: Simmonds Aerocessories, Pty. Ltd., Melbourne

Speed Nuts* PATENTED

*Trade Mark Reg. U. S. Pat. Off.

FASTEST THING IN FASTENINGS

centering the recorded copy on the record sheet.

The recorder contains a revolving insulated drum which is driven in similar manner to the scanner drums. A fine, stainless steel wire stretched over a spiral helix on the drum comprises the positive signal electrode. The negative electrode consists of a

Engineers watch the facsimile reproduction of Margaret Truman's handwriting as it is traced out on the recorder paper

printer blade positioned in an axis parallel to the drum axis and across the unit immediately above the scanning helix.

An automatic puller draws a continuous eight-inch-wide strip of premoistened chemically treated paper from the humidor at the front of the recorder. This paper passes between the two electrodes (under the printer blade and over the drum and helix) and emerges at the top of the unit.

Facsimile audio signals arriving at the input to the recorder pass through the circuits of the unit and appear as direct-current signal pulses on the helix wire. Since the drum is revolving, the helix scans the recorded sheet passing under the printed blade. When these d-c pulses appear on the helix, they pass through the moistened paper to the printer blade, and in passing through the recorded page, the chemical in the paper is darkened by the current

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The MB moving coil element is only *one inch* in diameter. Housed in anodized aluminum 1-inch cases, you get the smallest instruments made today. And in only a *1½-inch* case, there's room to *self-contain* rectifier, shunt or multiplier.

2 ACCURATE!

Built to conform to AWS specifications, accuracy of ± 2% of full scale deflection at any point is *standard* with all MB instruments.

3 SENSITIVE!

Powerful Alnico No. 5 magnet with soft iron pole pieces provides dense, uniform air-gap flux...and the resultant torque from even microampere currents provides MB instruments with sensitive, fast response. What's more, damping characteristics are excellent, for easy reading.

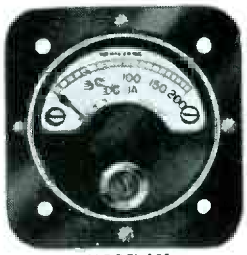
4 DEPENDABLE!

MB instruments are built to last. Not only will the lighter movement withstand shock and vibration better . . . but, steel-pivoted in sapphire bearings, it also resists wear indefinitely. Sturdy anodized cases are sealed against dust and moisture.

5 AVAILABLE IN MANY RANGES!

1-inch instruments produced in DC ranges from 0-100 microamperes to 0-10 milliamperes. 1½-inch instruments available completely self-contained in all standard ranges, including rectifier AC types.

MODEL 152


MODEL 101


MODEL 102

MODEL 151

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INSTRUMENT DIVISION

MINIATURE ELECTRICAL INSTRUMENTS FOR ANY PURPOSE

to correspond with the minute original picture elements.

A manual switching control permits inversion of the recording process so that a white image will appear on a black background. When the facsimile copy is completely recorded, the paper may be withdrawn from the rear of the page recorder and torn off.

Radio Equipment

The facsimile equipment can be operated from either amplitude-modulated or frequency-shift signals in which the amplitude of the transmitted carrier is held essentially constant while the frequency is shifted above or below that of the assigned carrier.

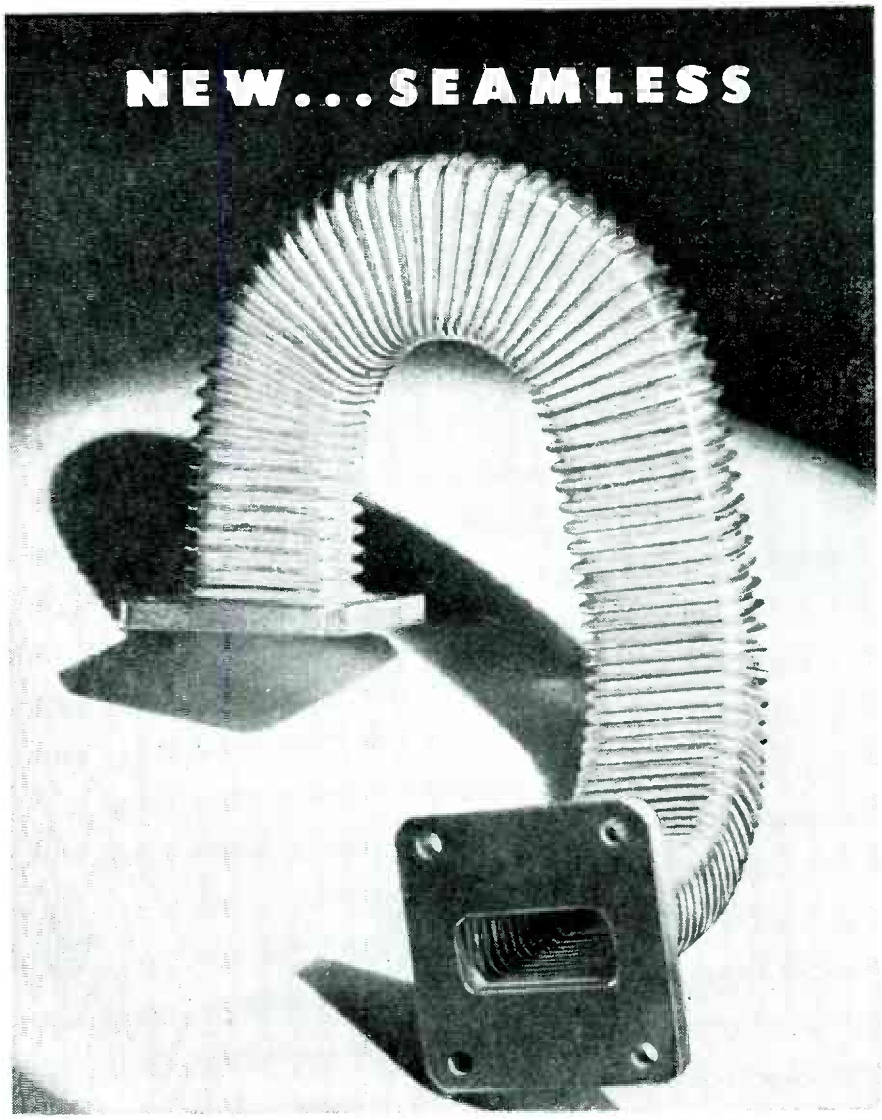
The frequency shift method of impressing intelligence on an r-f carrier minimizes selective fading, interference, and static disturbances. This method is preferred by Press Wireless for radio service and, in many cases, may be more desirable for land-line use. Amplitude modulation is recommended only for land-line service or local point-to-point contact.

Radio Units

The radio equipment used in the demonstration was composed of standard units of Bendix railroad radio system and operated on an experimental frequency of 156.525 mc. The facsimile signals from the Capitol were amplified and fed by land line to three transmitters located along the route from Washington to Baltimore. Each of these is equipped with a broadband biconical antenna. Aboard the train, a ground-plane antenna, nicknamed the "cartwheel", was used.

The communications equipment accomplishes phase shift of the carrier by injecting signals from the audio system onto the grids of a pair of mixer tubes connected 90 degrees out of phase. Output from the parallelled plates of these tubes is fed into the grid of a quadrupler stage. The carrier frequency is shifted in proportion to the applied audio voltage and the equivalent frequency deviation is proportional to the audio frequency and phase shift.

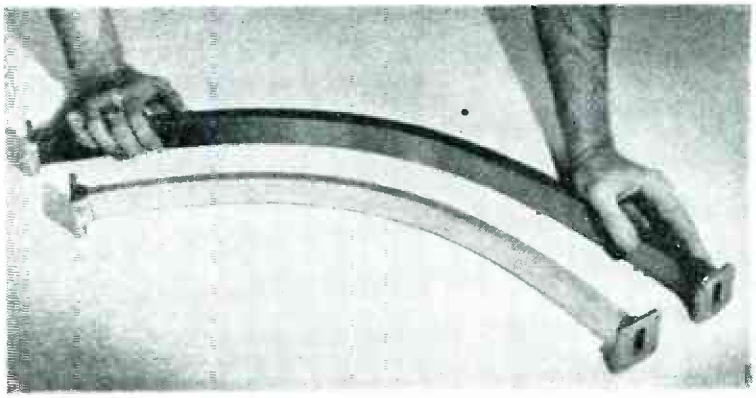
The cartwheel antenna is an artifically shortened quarterwave radi-



Seamless Flexible Wave Guide made from thin-wall rectangular metallic tube. Can be extended, compressed, or bent in two planes to small radii. Withstands large number of flexures of moderate amplitude.

Vertebra type . . . a series of choke-plate wafers inserted in synthetic rubber jacket. Flexes easily, withstands large number of repeated deformations, such as bend, shear, twist, stretch or compression.

"Moldlock" type made of spirally wound, formed metallic strip with interlocked edges. Ordinarily furnished with rugged, pressure-tight synthetic jacket. Can be bent in any plane and twisted appreciably.



Now—for commercial use *Flexible* WAVE GUIDES

AMERICAN FLEXIBLE WAVE GUIDES are made in various types, mating electrically and mechanically with common sizes of rigid guide, for operation at wave lengths from 20 to less than 3 Cm.

These high precision units are suitable for use where relative motion is involved, such as with shock-mounted or vibrating units, to provide for misalignment, for the fabrication of complicated twists and bends, as flexible couplings to fragile components, and for other applications.

The various types of American Flexible Wave Guides differ principally in mechanical properties. We will gladly aid in selecting the most appropriate type, based on specific requirements of the installation.

Write for our "Electronics Data Book."

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American Metal Hose Branch
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Subsidiary of Anaconda Copper Mining Company
In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

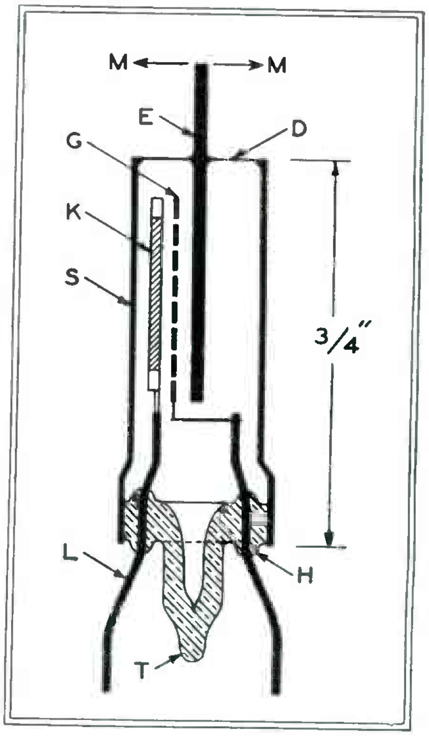
ator worked against a quarterwave radius ground plane and is designed for mobile equipment where overhead clearance is small.

• • •

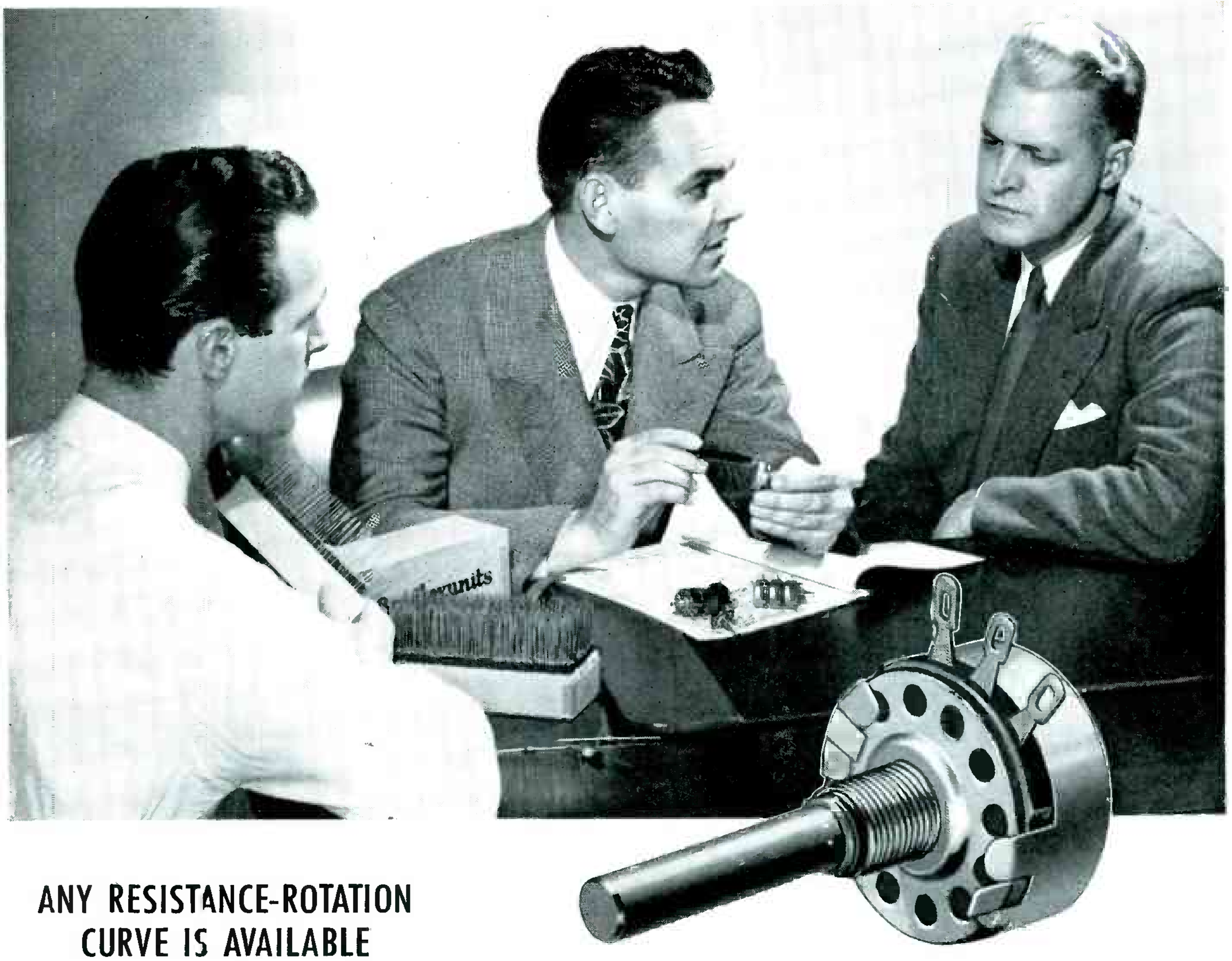
Mechanical Modulation of Electron Flow

A METAL electron tube weighing only 1/15 of an ounce, which converts mechanical motion directly into variable electron flow, will find wide application in future designs of phonograph pickups. It can also be used in microphones, and in industrial equipment where translation of mechanical motion to electron circuits is desirable for purposes of control or measurement. The new electron tube is not yet in production, but a limited number are available to manufacturers of electronic equipment who are interested in experimenting with it for use in future products.

Called the Vibrotron, the tube is



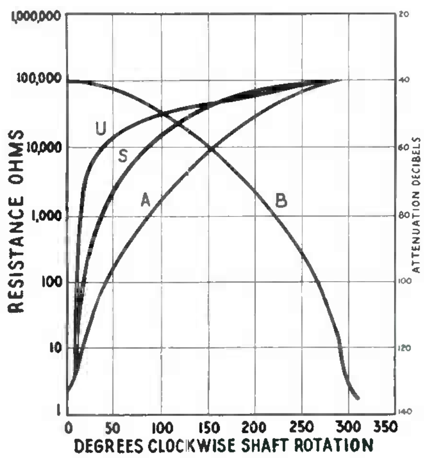
Construction of the new Vibrotron tube. Motion of the movable anode *E* in direction *M-M* is transferred through the thin metal diaphragm *D* to produce a proportional change in electron flow of the triode formed by *K*, *G*, and *E*. The envelope *S* is metal and leads such as *L* are brought out through a vacuum-tight glass header *H* with exhaust tip *T*



ANY RESISTANCE-ROTATION CURVE IS AVAILABLE

The resistor of the Type J Bradleyometer is a solid molded ring. During manufacture the resistor material is varied throughout the circumference of the molded ring to provide any desired resistance-rotation curve. (See chart below.)

The resistor unit is molded as a one-piece ring with terminals, face plate, and threaded bushing imbedded in the ring. The contact between brush and resistor unit improves with age.



These A-B Adjustable Resistors are solid-molded for permanence

The resistor is a thick ring of solid-molded material, heat-treated under pressure to produce a unit that is unaffected by heat, cold, moisture, or length of service.

Since it is not a film or paint-type resistor, its resistance-rotation characteristic remains permanent. Moreover, the Type J Bradleyometer is the only continuously adjustable composition resistor having a 2-watt rating with a good safety factor. Bradleyometers are available in single-, dual-, and triple-unit type, with or without line switch. Complete specifications on application.

Allen-Bradley Company, 110 W. Greenfield Ave.
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FIXED & ADJUSTABLE RADIO RESISTORS

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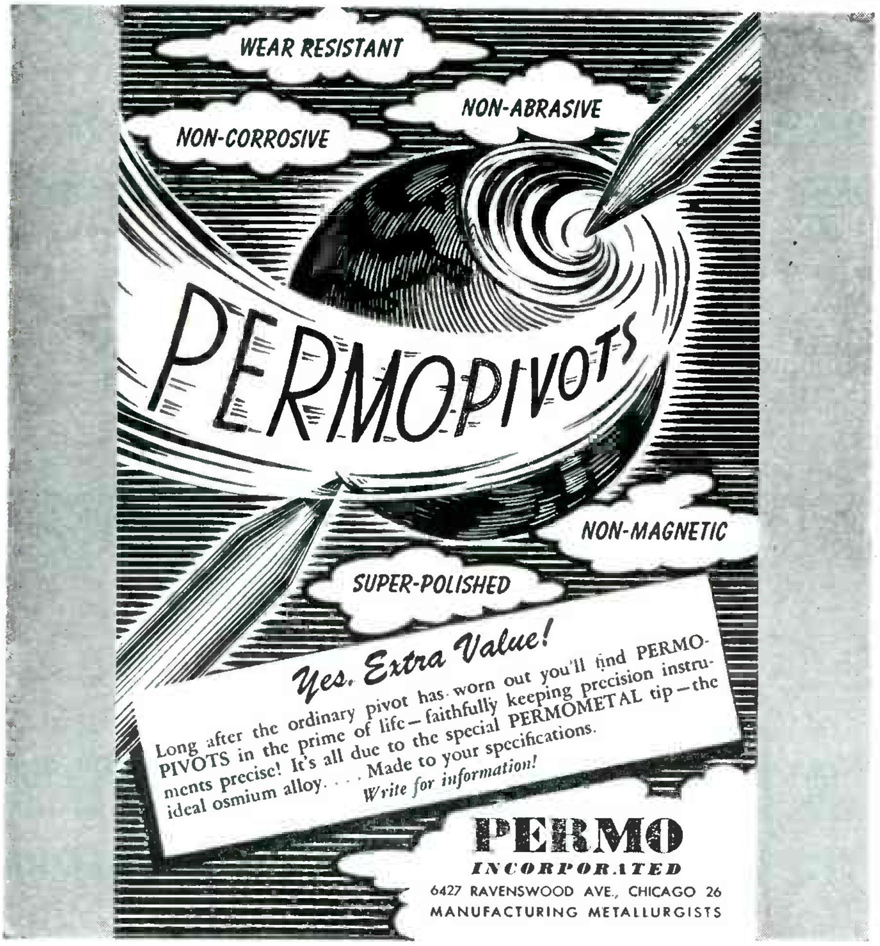
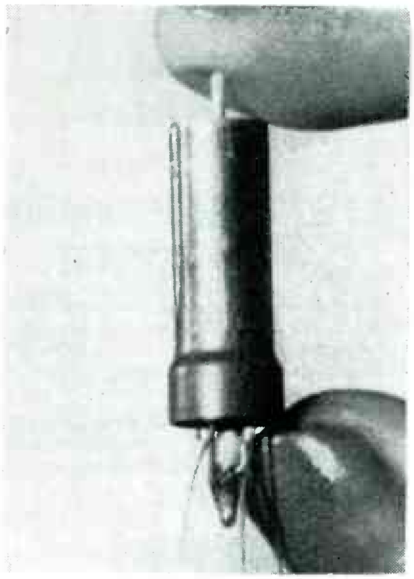


a metal triode about one inch long and about ¼ inch diameter. Leads are brought out through a glass seal at one end. The other end consists of a flexible metal diaphragm that transfers external motion to a movable anode within the tube. Details of the construction are shown in the drawing.

Difficulties were experienced with the selection of a suitable diaphragm for transmitting the external mechanical motion to the inner electrode without introducing distortion of the motion. This problem was solved by using a thin metal diaphragm, about half the thickness of a human hair, as a flexible window in the tube envelope. Through this vacuum-tight metal diaphragm, the rod used as a lever is free to vibrate



Close-up of the Vibrotron tube for converting mechanical motion to a variable electron flow. The movable anode appears at the top

without distortion over a wide range of audio frequencies.

Life tests have shown the tube withstands severe treatment over long periods of time, and is stable under temperature and humidity changes. It operates as an integral part of the pickup head and the radio phonograph amplifier, without the need of a preamplifier or coupling transformer.

Preliminary work on the Vibrotron was done by Dr. Harry F. Olsen

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at the RCA Laboratories at Princeton and was later transferred to the RCA tube laboratories at Harrison where the development progressed under George Rose.

A tube apparently similar to the one described has been announced by Bendix Radio Division of Bendix Aviation Corp. but no technical details have been released.

• • •

Improved Modulated-Oscillator Pickup

By Henry Kalmus

*Engineering Department
Zenith Radio Corp.
Chicago, Ill.*

Exact analysis of the original circuit of the Cobra pickup described in Electronics, Jan. 1946, showed that

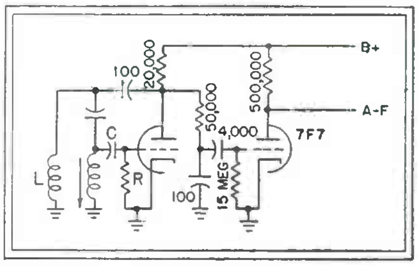

Fig. 1—Circuit arrangement of the modulated-oscillator pickup

if a circuit modification is made the audio output increases by 15-20 db, the hiss is reduced by the same ratio, and microphonics are reduced by 6 db. In addition, any volume change due to gap-width variation is cancelled out entirely in the electrical system and a longer pickup lead can be used.

In the old circuit, grid detection was used, counteracted in part by plate-bend detection. In the new circuit, only plate-bend rectification takes place.

Figure 1 shows the circuit; the difference between the old and the new one consists in different time constants for R and C. The new time constant changes operating conditions entirely. In the new circuit, the time constant of R and C is large, say, R of five megohms and C of 0.05 microfarad.

If the time constant of R and C is too small, grid rectification may

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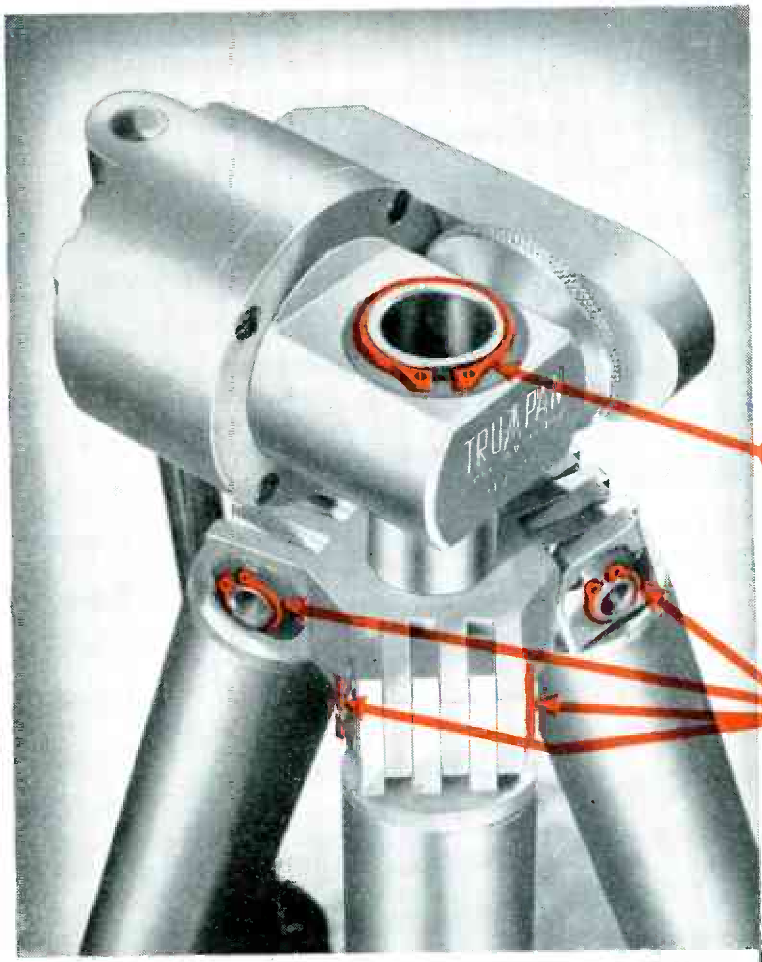


Trupan Tripod Manufactured by Accmatool Co., Inc., N. Y. 25

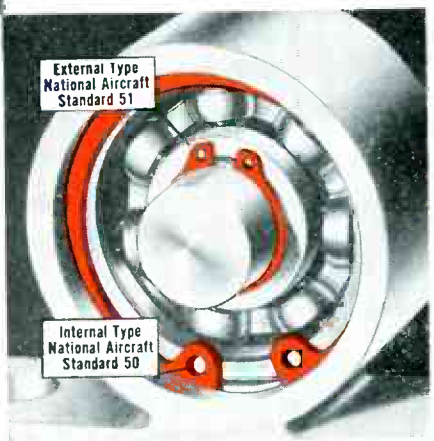
NINE TRUARC RINGS ELIMINATE EXPENSIVE MACHINING ON ACCMATOOL "TRUPAN" TRIPOD

Use of 9 TRUARC retaining rings in manufacture of the TRUPAN Tripod has resulted in a light, compact design—with reduced production costs. Truarc rings eliminate expensive machining required for nuts, threads, screws and shoulders.

1 A *Truarc Bowed ring* and a standard Truarc ring position the vital center pivot pin. The bowed ring exerts a downward pressure of 50 lbs.—gives two-way spring action—***takes up end-play resiliently.*** "Shimmy" from cumulative tolerances in manufacture, or from constant wear is eliminated.

2 Each leg is positioned on its hinge by a spring washer and a standard Truarc ring mounted at either end of a small steel hinge pin. This construction assures constant tension. The Tripod sets up accurately without adjustments, indefinitely.

Waldes Truarc precision retaining rings eliminate costly machining by replacing nuts, shoulders, collars and cotter pins. They allow lighter, more compact units—make assembly and disassembly quicker, easier. Truarc rings give better, more dependable retention because their mathematically precise construction insures lasting, perfect circularity—insures a never failing grip. There's a Truarc ring for every mechanical product.



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occur near 100 cycles and counteract plate-bend detection. In calculating the time constant, it must be considered that the generator impedance for the audio voltage at the grid is much smaller than R because the grid current-grid voltage characteristic has the curvature of an e-function and not a sharp cutoff. The generator impedance is actually 250,000 ohms if the r-f amplitude is two volts and R is five megohms. The crossover frequency for these values is 32 cycles, and the audio range is therefore not affected. The eccentricity frequency of 1.3 cycles (corresponding to 78 revolutions per minute) produces voltage fluctuations on the grid, counteracting the plate-bend detection.

The electrical nonlinearity depends on the r-f amplitude on the grid. If it is smaller than 1.8 volts, the audio-output increases for a smaller gap (as in the old circuit); if larger than 1.8 volts, it decreases. For 1.8 volts we obtain no volume changes at all and the pickup behaves like a well-balanced dynamical system.

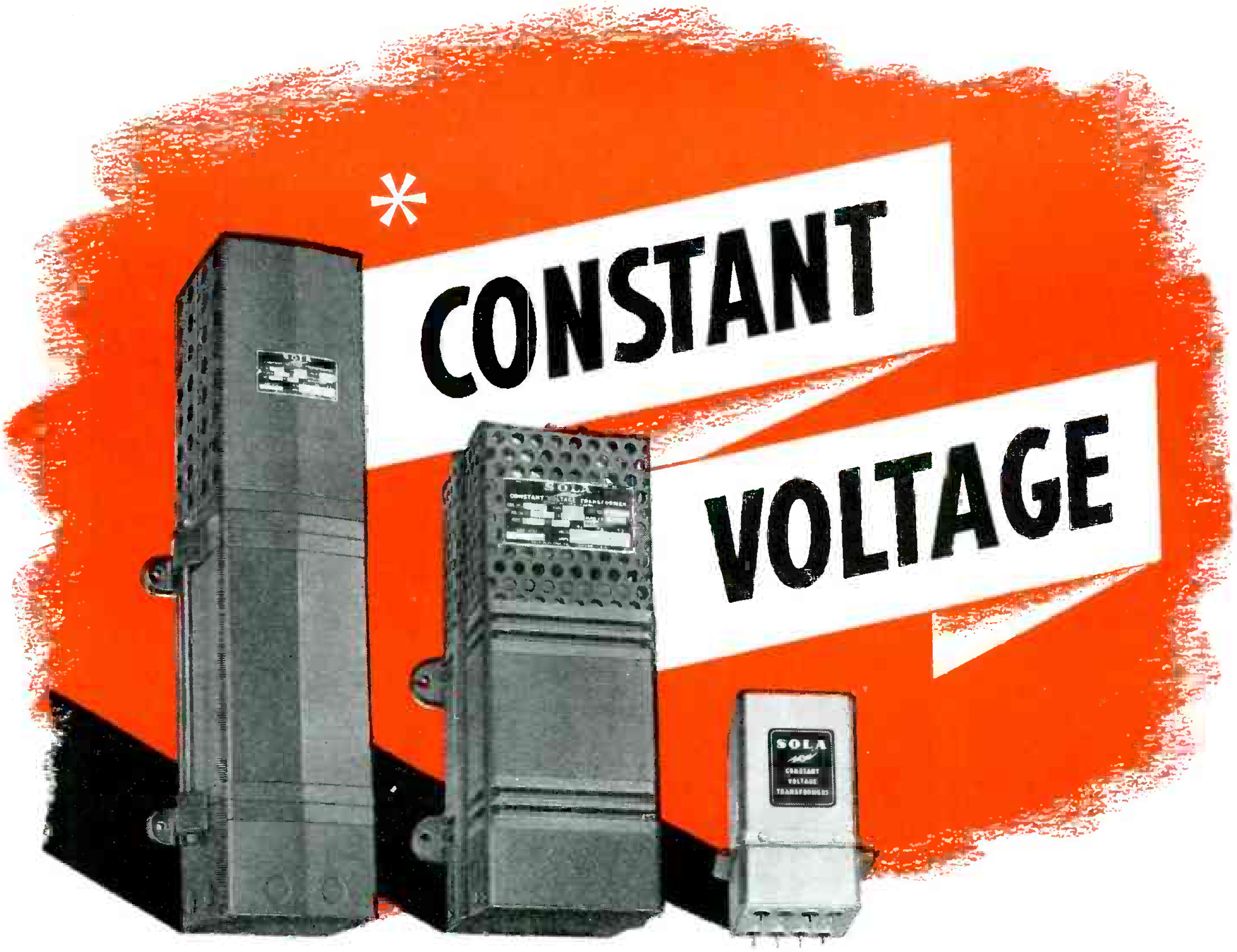
Advantages

The stability of the oscillator for line voltage changes or aging tubes is not affected by the large time constant. If the oscillator voltage is too high or if unsuitable tubes are used, superregeneration may occur. The 7F7 triodes are free from superregeneration if the plate is not bypassed for audio frequencies and if the grid amplitude is smaller than 2.6 volts.

Twenty 7F7 tubes were tested in order to find out whether the new circuit is safe for mass production. The tubes were still oscillating at a line voltage of 85 volts and minimum gap between coil and vane. They did not show superregeneration at a line voltage of 135 volts and maximum gap.

The higher audio output of the new circuit is not only due to the higher modulation percentage but also because plate bend detection alone is used. The hiss in the new circuit is inaudible even if the volume control is set above overload level.

There are two kinds of micro-



Regardless of size or capacity, a SOLA Constant Voltage Transformer does just one thing. It takes line voltages coming in like this ⁓⁓ and feeds them to your equipment like this —.

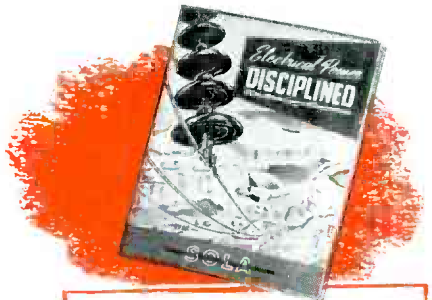
If there is any doubt as to the need for voltage regulation, hook a recording volt meter to your supply line. The tracings may provide the answer to much unsatisfactory equipment performance.

Voltage from a supply line may vary as much as 30% from its rated value. Against these sudden lags and surges no electrical or electronic equipment can perform at peak efficiency, no matter how much leeway has been provided in the label rating.

Without manual supervision (no dials to turn or adjustments to make), a SOLA Constant Voltage Transformer instantly corrects supply line variations as high as 30% to within ±1% of the label rating. SOLA Constant Voltage Transformers have no moving parts, no tubes or networks—nothing to get out of order. They protect both themselves and your equipment against short circuit.

Standard designs are available for any electronic or electrically operated equipment requiring capacities from 10VA to 15KVA—many designed specifically for chassis mounting. As a built-in component they eliminate other, more expensive elements, and reduce the cost of equipment maintenance.

If standard designs do not meet your requirements, special units can be built to your exact design specifications.



Write for New Handbook

Here's the answer to a problem that confronts every manufacturer or user of electrically operated or electronic equipment.

Ask for Bulletin DCV-102

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Oil Burner Ignition • Radio • Power • Controls • Signal Systems • etc. **SOLA ELECTRIC COMPANY, 2525 Clybourn Avenue, Chicago 14, Illinois**

Manufactured in Canada under license by FERRANTI ELECTRIC LIMITED, Toronto phonics: Production of audio voltage in the first triode and modulation of the oscillator. The first kind is reduced by 15 to 20 db. The second kind, which amounts unfortunately to 80 percent of the total microphonics, is not changed because the improved detection efficiency affects desired and undesired modulation to the same degree. The total improvement of microphonics is about 6 db. A real remedy would be to use tubes with a stiffer grid structure. The type 7F8 double triode looks promising.

If the new circuit is used with the pickup coil between grid and ground,

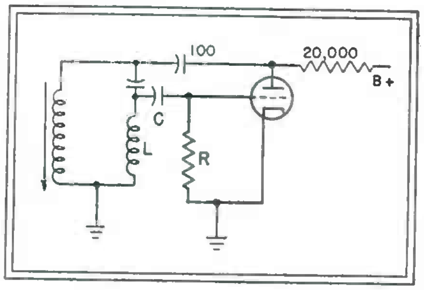

Fig. 2—This simplified circuit provides less hum sensitivity than that shown in Fig. 1

it is more hum-sensitive than the old one. The new R-C combination does not prevent low-frequency hum from controlling the first system and all voltages induced magnetically or by common ground in the pickup circuit become audible.

Connecting the pickup coil between plate and ground as shown in Fig. 2 is an improvement. The values shown form an effective low-cut filter and the pickup coil and lead are not hum sensitive.

The stationary coil must be well shielded from the motor field because any hum voltage induced in this coil can now control the first system. It was found that a drawn steel can prevents hum induction even if the amplifier unit is mounted one inch from the motor.

The increase in audio output of the new circuit makes it now possible to use a 3-foot pickup lead. The preamplifier can then be mounted far away from the motor field so that hum induction can be entirely avoided.

THE ELECTRON ART

SMPE Spring Technical Conference

PAPERS PRESENTED at the conference of the Society of Motion Picture Engineers held in New York from May 6 through 10 contained much information on television and sound pertinent to electronic engineers. Of special interest was a paper outlining improvements in studio equipment, which are equally applicable to television, and which producers hope manufacturers will soon develop. Throughout the meeting desirable improvements in equipment were outlined. In abstracting speakers' comments these requirements have been given special emphasis as they suggest paths for further study and development.

Inspection trips were made to television studios of DuMont and RCA-NBC, in addition to the holding of business meetings and social events. A scroll of achievement was presented by the SMPE to Warner Brothers Pictures, Inc. for pioneering leadership in development of sound motion pictures. Thomas Armat, father of the motion picture projector, was awarded a scroll in commemoration of the fiftieth anniversary of his introduction of a practical projector.

Concurrently with the SMPE conference was the annual meeting of the Inter-Society Color Council and a 16-mm industry show, the latter illustrating growing interest in compact equipment for use with visual aids to teaching. National meeting of the Acoustical Society of America was held in New York on May 10 and 11. In addition, engineers en route to New York were shown General Electric Co. television studios in Schenectady.

Measuring Radioactive Seawater

Radioactivity of seawater caused by atomic bomb test at Bikini will be measured by this electronic equipment. Geiger counter output is amplified and used to operate an indicating meter. Col. S. Warren, Radiological Safety Advisor to Joint Task Force One, shows Capt. A. C. Thorington what the indications will mean in terms of personnel safety

Abstracts of Papers

Modernization Desired in Studio Equipment

By LOREN L. RYDER

Director of Recording Paramount Pictures, Inc. Hollywood, Calif.

REALISTIC RENDITION is the objective of the producer. Three-dimensional color pictures with stereophonic sound, already tested by Twentieth Century Fox, may be the ultimate goal. Opinions differ as to whether truly three-dimensional or subjectively stereophonic sound will best match stereoscopic pictures. Technical developments are more certain than other improvements, however the diversity of equipment required by producers has hampered manufacturers. More unified equipment requirements would enable the manufacturer, who does most of the basic research bearing on equipment and techinques, to concentrate on essential needs.

Servo-controlled gyro-stabilized camera mounts are being developed to free cameras from location restrictions. Such mounts will simplify the building of costly tracks for dollies, coordination of foreground and background shots, and repetition of camera movement in shooting special effects.

A microphone that is directional at low frequencies but non-directional at high frequencies is needed. A microphone boom by which directivity of the microphone, as well as its orientation, can be controlled and that does not cast a shadow, or at

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Doolittle
RADIO, INC. *Builders of Precision Communication Equipment*

7421 SOUTH LOOMIS BLVD., CHICAGO 36, ILLINOIS least casts a shadow wth a soft edge, would be welcome.

Use of the image-orthicon both to eliminate noisy film handling equipment on the lot and to effectively increase film speed would facilitate photography. Just as the sound is recorded at a remote location after handling through mixers, so the picture could be recorded at a central location after monitoring. Smaller mixers are needed.

Equipment could be made smaller if 400-cps power were used. Higher voltages for power sources would improve the lighting. Brighter lights are needed. Simpler, cheaper set construction, possibly using plastics and laminated wood, and a fast-drying paint with high gloss are also needed.

Theater Television

By L. B. Isaac
Director of Projection and Sound
Loew's Inc.
New York, N. Y.

Television in motion picture theaters will be accepted by the public on the basis of its entertainment value, not on its novelty. Theaters, in the opinion of the author, will not interrupt features to show televised news events. Only scheduled events could be fitted into the program, but these the public would stay home to watch on their own television receivers. Film image-storage is just another news-reel service. No projector giving an adequately large and bright image and operating from the regular projection booth has been demonstrated to date.

Unified Approach to Film Pickup Tubes, and the Eye

By Albert Rose
RCA Laboratories
Princeton, N. J.

Examination of fundamental factors that determine performance of photographic film, television pickup tubes, and the human eye indicates ultimate limitations of these devices. The halftone discrimination of the eye requires that pictures must be photographed or picked up at increased brightness if the brightness of reproduction is increased.

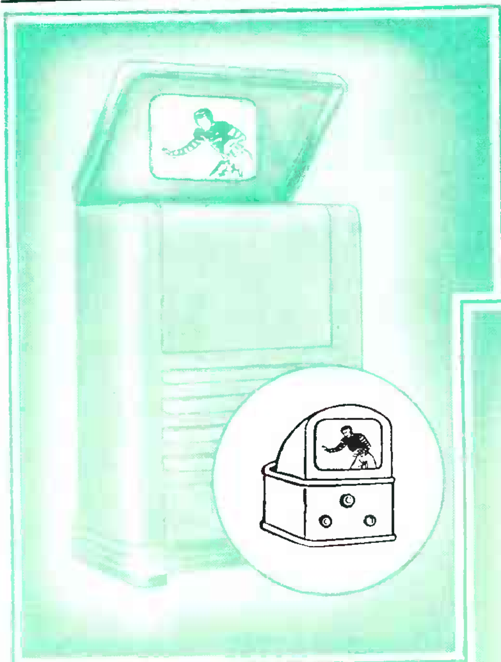
Departmentalization of science has separated study and recording; hence notation used by physiologists studying the eye, photographers studying film, and electronic engineers studying television pickup

SYLVANIA NEWS

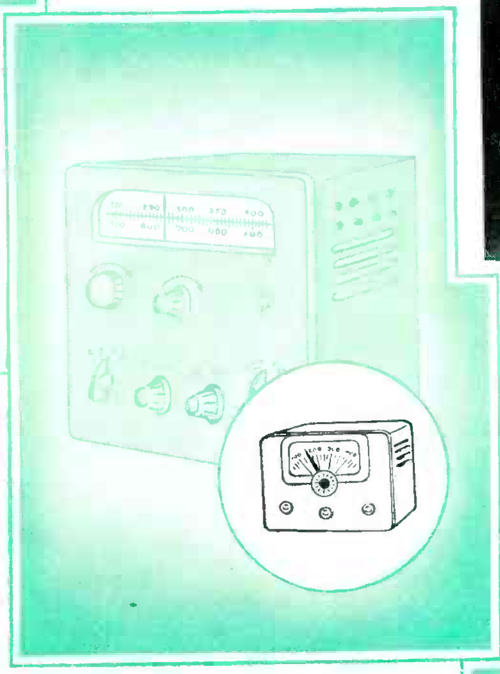
CIRCUIT ENGINEERING EDITION

JULY — *Prepared by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. — 1946

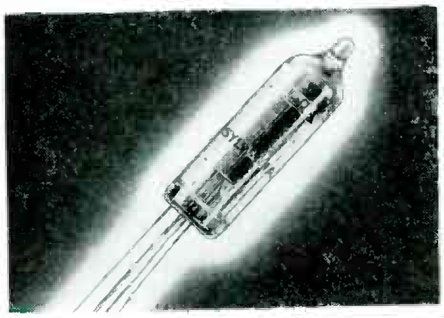
RUGGED ELECTRONIC TUBE TINY ENOUGH TO REVOLUTIONIZE DESIGN OF RADIO RECEIVERS AND OTHER EQUIPMENT



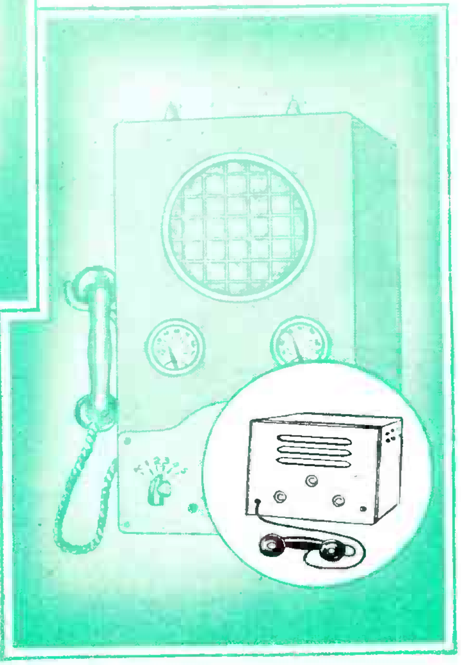
More compact television receivers will be made possible by the T-3.



Weight-saving features of the T-3 will be of special value in air-borne equipment.



The T-3 tube is shown here in its actual size.



Equipment for motor boats and yachts can be made smaller and lighter.

Much Smaller Sets Possible

Radical reductions in the size and weight of many types of electronic equipment are seen as a distinct possibility arising from Sylvania Electric's development of the extremely small T-3 tube. The T-3 is the commercial version of the peanut-sized electronic tube of proximity fuze fame.

Tiny as it is, the T-3 tube is characterized by exceptional ruggedness. It has a life of hundreds of hours, and is ideally suited for operation at high frequencies.

Savings in Space and Weight

The small size of the T-3 contributed directly to compactness and lightness in the design of radio and television receivers and other types of electronic equipment. Other features of the tube make possible still further reductions in space and weight.

Range of Applications

The design possibilities opened by the T-3 are naturally of greatest interest in the case of portable and air-borne equipment. However, its potentialities are not limited to these fields. *Write Sylvania Electric Products Inc., Emporium, Pa.*

SYLVANIA ELECTRIC

Emporium, Pa.

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS tubes differs. Rather than comparing the eye, whose performance is measured in terms of the distance at which it can distinguish a candle, with a film, whose performance is given in object resolution and grain, or a television pickup tube, whose characteristic is given in microamperes output per lumen input, on their individual methods of measurement, they can be compared on the basis of their signal-to-noise ratios.

Random fluctuation in the conversion of light to an image signal is dependent on the quantum N incident on the picture area, taken as a square of fixed size and having dimensions h. The S/N, represented by R, equals $N^{\frac{1}{2}}$. Scene brightness, represented by B is given by a constant K times N/h^2. Thus $B = K(R/h^2)$ from which, given R and B, one can find h, the resolution of the device. The constant contains factors of the lens system and photo efficiency.

On the basis of this relation, Super-XX film at a resolution of 525 lines has a signal-to-noise ratio of 25, Panatomic-X has a signal-to-noise ratio of 35. These figures, rather than the ultimate line resolution of which the film is capable, form the basis for comparison with television pickup tubes.

Using the relation derived, photo-efficiency of various devices can be compared: Film, 0.5 percent; Television tube, 1.0 percent; Eye 1 to 10 percent, depending on scene brightness. As scene brightness enhances the halftone discrimination of the eye, a greater contrast range is required of devices that reproduce bright images.

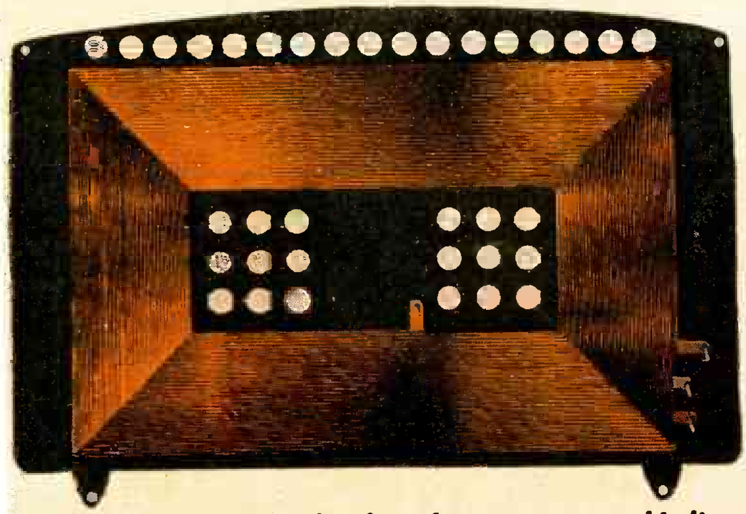
Instead of comparing the three mediums on the bases of limiting resolution of film, frequency response of a pickup tube, and minimum resolvable angle of the eye, all should be compared on the basis of picture elements obtainable at a given signal-to-noise level.

Color Television

By P. C. GOLDMARK
Columbia Broadcasting System, Inc.
New York, N. Y.

AFTER REVIEWING reasons for using an additive color system and describing techniques of picture transmission and reproduction presented elsewhere, the speaker outlined the pos-

Franklin AIRLOOPS have left the stage of experiment and investigation!



HUNDREDS OF THOUSANDS ARE NOW BEING PRODUCED FOR SOME OF THE LARGEST MANUFACTURERS OF RADIO RECEIVERS.

IF
loops are bottlenecking your assembly lines?
you want the best loop for your set?
you are cost conscious?

consult Franklin

for large scale delivery of

AIRLOOPS

A radio engineer's dream come true! The greatest development in loop antenna design and manufacture since 1920! Flat sheets of copper die-stamped into perfect supersensitive loops . . . air dielectric throughout their entire length . . . being rectangular they have 27% more effective area . . . better performance at lower cost . . . no set builder can afford to overlook the significance of the AIRLOOP.

Compare these AIRLOOP values with conventional loop values and you too will SPECIFY AIRLOOPS.

- Optimum sensitivity
- High uniform "Q" over entire band
- Inductance to close tolerance without adjustable turn
- Low distributed capacity
- 27% greater effective loop area
- Electrical and mechanical stability
- Backboard and loop in one
- Lower cost
- Elimination of individual loop adjustment on assembly line
- Maximum space utilization
- No haywire

Franklin AIRLOOP corp.
175 VARICK ST., NEW YORK 14, N. Y.

sibilities of an electronic color separator and synthesizer.

The electron beam would have to change the effective dye concentration, not the transmissivity. Known photoconductive crystals lack proper dye color and storage. An electronically controlled sheet that changes its color for each frame would accomplish the required result. For reproduction, luminescent material of the tube could be formed in narrow stripes of different colors, or a stripe filter could be placed over the tube. The scanning beam would then be made to register with appropriately colored stripes for each color frame.

Before color television progresses further it is desirable, and possible, to standardize colors, color repetition, image repetition, resolution, and sound quality. As the choice between a color repetition of 40 or 48 cps is arbitrary, it would be desirable to operate at a whole-number multiple of the color motion picture rate, that is, at 48 color frames per second. Flicker, which becomes more noticeable with increased image brightness, is not noticeable at this rate until the picture is reproduced at 8 foot-lamberts; 4 foot-lamberts is the highest brightness currently economical.

Because invention of electronic color scanning will in no way affect the transmitted television signal, standardization on the present mechanical color disk system can be made. When electronic scanning is developed it will merely replace the color wheel. (For material included in this paper readers are referred to: Color Television on Ultra High Frequencies, ELECTRONICS, p. 109, April 1946, and Color Television by P. C. Goldmark et al, Part I, *Proc. I R E*, p. 162, April 1942; Part II, *Proc. IRE* Sept. 1943.)

Factor Governing Frequency Response

By M. RETTINGER AND K. SINGER
RCA Victor Div, RCA Hollywood, Calif.

THEORETICAL characteristics of the sound recording channel can be obtained for designing equipment rather than relying on empirically derived characteristics currently used. The characteristics are reached by considering high frequency loss due to the finite slit width of the light gate in the vari-

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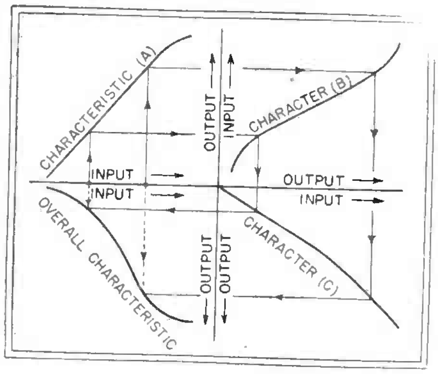
able-area film recording head, need to compensate for changes in voice quality at different levels, effect of set reverberation on intensity of different frequencies reaching the microphone, and the fact that theater reproduction is five decibels above normal, which means that the listener's ear is operating at a different constant-loudness contour than it would be, were the sound reproduced at its original level.

From these and like considerations of microphone response, it turns out that microphone equalization should



A graphical method is used to find overall characteristic of channel when transfer characteristic of each element is known, or to determine required characteristic of an equalizer to produce desired overall characteristic. For example, if the microphone has characteristic A, the film gamma a character B, and the reproducing system a character C, then the overall channel characteristic of a film recording system is as shown

be introduced ahead of the compressor; that is, compensations for such variables as actor's voice, set reverberation, and particular microphone are made to bring all signals to the same spectrum content. Then comes the equalizer, which is designed to have an acting time of 0.002 sec. and a release time of 0.5 sec. Fixed equalizations such as those for film gamma curve are introduced after the equalizer. Following stages are all flat except for the 100 to 8,000 cps filter.

Compression avoids over-shooting in recording—comparable to swinging tube beyond cutoff, decreases sibilance, and permits overriding audience noise without resorting to painfully loud levels. The dynamic range between what is necessary to override audience noise and the level of pain is about 15 db. Compressors

Almost Unbelievable!

Only 8 Watts Drive for ½ K.W.* Phone Input with NEW UNITED GRAPHITE TRIODES

Highest Ratings On Record for Graphite Anode Tubes Made Possible by New Getter Trap

A great development in graphite anode tubes ...the United *Isolated Getter Trap*... has resulted in new, clear glass tubes free from the familiar dark metallic deposit on the bulbs, and utilizing for the first time all the superior advantages of graphite.

The net result of this United achievement in the two types illustrated is a very low cost replacement for lower rated tubes of the 40 or 55 watt plate dissipation class as well as original tubes for new equipment with minimum driver construction cost.

Choice of two types, V-70-D and 812-H bridge many replacement needs with little or no circuit changes.*A pair of either type will take ½ K.W. phone input at 30Mc—up to 60Mc with reduced input. Available now at all leading Radio Parts Distributors.

Type	Filament		Max. Plate Dissipation	Capacitances uuf			Max. input per tube	Max. Plate	
	Volts	Amps		cgp	cgf	cpf		Volts	Mils
V-70-D	7.5	3.25	85 Watts	4.5	4.5	1.7	300 Watts	1750	200
812-H	6.3	4.0	85 Watts	5.3	5.3	0.8	300 Watts	1750	200

812-H

5^{90} ea.

V-70-D

2/3 actual size

LOOK FOR THIS GETTER TRAP in all UNITED TUBES

UNITED ELECTRONICS COMPANY
AMATEUR RADIO DEPARTMENT
42 SPRING ST. • NEWARK 2, N. J.

Transmitting Tubes EXCLUSIVELY Since 1934 must, therefore, reduce dynamic range to this range.

Theater Servicing Test Equipment

By EDWARD STANKO AND P. V. SMITH
RCA Service Co. Camden, N. J.

PORTABLE METERS can be made smaller and sturdier by using alnico magnets in indicating instruments. The greater flux density of these magnets use of higher torque springs, increasing ruggedness of the meters. Subminiature, shock-proof tubes decrease size of the equipment and have made possible a VoltOhmyst containing its own battery power supply.

An audio amplifier with sufficient gain and output power to give speaker output from lowest level channels finds wide uses both in signal tracing and as an auxiliary amplifier.

Technical Highspots

OTHER TECHNICAL information presented at the conference included effects of spectral distributions of light sources, which, although they may combine to give apparently the same color light, do not result in the same color rendition of objects being illuminated. Sound dubbing studios were built to reduce outside noises to acceptably low levels. By placing an intervening hallway between the noisiest outside wall and the studios and leaving a 6-in. dead-air space flanked by celotex sheathing between studio inside and outside walls, a 45 db attenuation was obtained. Reverberation in studios was controlled by placing reflecting surfaces opposite absorbing surfaces.

A concentrated-arc light source consisting of an inert gas and refractory cathode inside a glass bulb gives a bright white light having a continuous spectral distribution. The light source can be made small enough to approach a point source thereby improving projector image sharpness and depth of focus.

Using photocells to measure light in an integrating sphere and to obtain a balance on an optical bench, the absolute photometric lens aperture can be found. Because of surface reflections in the lens system this aperture has a larger f number than the geometrically determined

aperture as given by $f_n^* = f_n/\sqrt{\eta}$ where f_n^* is the photometric aperture, f_n is the geometrical aperture, and η is the effective lens transmittance. This calibration technique might lead to new standards. Matched photocells are needed. It was found that the cells differed in fatigue characteristics. Phototubes gave similar problems. More uniform characteristics in these photoelectric transducers would facilitate the measurements.

Film for photographing television tubes was described. It was developed to have sufficient sensitivity to record the image on a P4 screen with a 1/30-sec exposure, to give resolution of 33 lines per mm on 16 mm film, as required to record the lines of the television image, and to have a contrast ratio of 1:10 which is consistent with contrast of television images.

The optical system whereby color film is scanned for televising was described. The equipment uses an image dissector tube to avoid overlapping of stored images produced through the previous color filter. Five coplanar lens segments are successively exposed to the continuously moving film by a rotating slit gate. Image motion as it enters the dissector tube is compensated by scanning motion of the dissector itself.

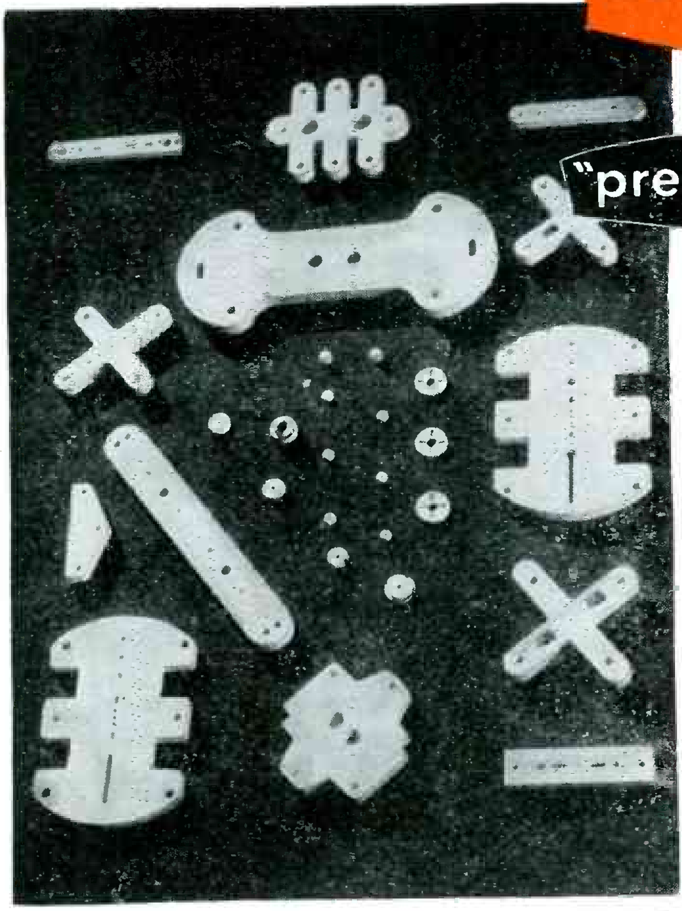
• • •

German Industrial Techniques

ALLIED TECHNICAL MISSIONS have learned from interrogation of German personnel and study of their equipment the techniques and products that had been kept secret during the war. Reports of these missions, some containing material of interest to electronic engineers, are becoming available through the Technical Industrial Intelligence Branch of the Joint Intelligence Objectives Agency, Office of the Joint Chiefs of Staff, and printed by the Publications Board of the Department of Commerce (ELECTRONICS, p. 316, April 1946).

The following abstracts of some of these reports indicate the kind of material being found, report number and number of pages follow each abstract. Most reports give in detail the manufacturing processes and machinery, some familiar to American industry, some new. Among other

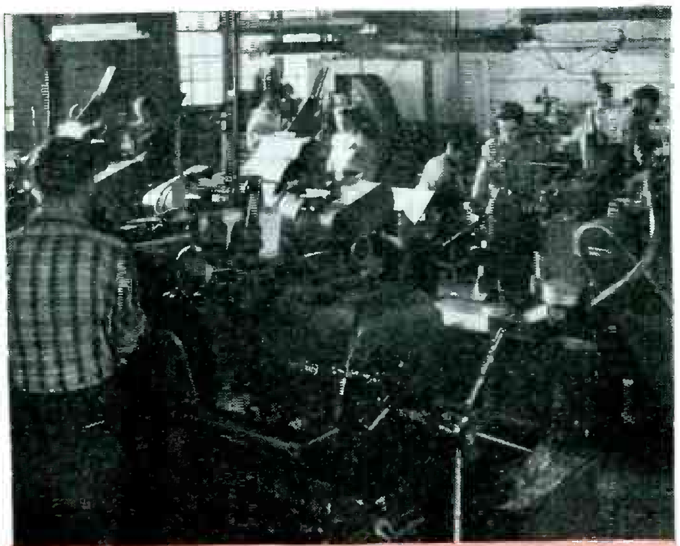
STUPAKOFF ceramic products



"precision made" means fewer headaches for you

Ceramic parts that are dimensionally accurate and mechanically strong are "headache eliminators" for your production men. Stupakoff takes special precautions throughout all steps of design and manufacture to see that every item is as nearly perfect as modern precision mass-manufacturing methods can make it. As a result, your production of assemblies is speeded, and you have less waste of labor and materials.

The dependable high quality of Stupakoff ceramics assures complete satisfaction.



Precision grinding of fired ceramic parts assures uniformity.

Electrolimit gauging checks dimensions to the fifth decimal.

STUPAKOFF

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interesting processes found by the 17 industry units collecting information in Germany is the manufacturing of metallized capacitors (ELECTRONICS, p. 303, May 1946) which is covered by U.S. Patent 2,244,090 held by the Alien Property Custodian and available for licensing (ELECTRONICS p. 306, July 1945), manufacture of high dielectric ceramics used in the form of paint to reduce radar reflection from submarines, tape recording equipment, and selenium rectifiers.

The Germans developed a nation-wide wired broadcasting system using telephone lines and modulated carriers of between 100,000 and 200,000 cps.

Studies of the effects of ionization of air on peoples' health and sensations indicated that positive ionization is physically and psychologically deleterious. However, negative ionization lowers blood pressure, reduces rate of respiration, and exhilarates the spirits of individuals. The report suggests that production of equipment to ionize the air negatively could become as great an industry as manufacture of air conditioning units.

Depositing Metallic Films

Glow discharge bombardment of glass mirror base surfaces has been developed for production of mirrors up to three meters in diameter. After the surface is cleaned, the gas chamber is evacuated to high vacuum and aluminum evaporated onto the surface by low-frequency current. Quartz to a thickness of one micron is evaporated over the aluminum to prevent tarnishing. In another evaporating process, titanium dioxide films are applied to glass to reduce reflection of light (C-1;3 p).

Vacuum-tight glass to metal seals were produced by heating pyrex until the sodium light appeared in the flame, removing the glass and spraying it with molten aluminum from a metallizing gun until an opaque coating was obtained. Masks controlled the area of application. To this coating copper or other metal was sprayed at room temperature giving a surface to which solder could be applied. Hydrogen voltage regulators were built using these seals. Selenium rectifiers using an aluminum electrode were built by evaporating the selenium into the electrode

DEPENDABLE AIR-TO-GROUND RECEPTION

. . . with *Federal's New*

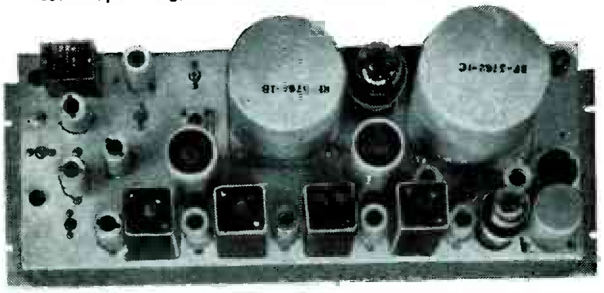
VHF RADIO RECEIVER 139A

Ordered in Quantity by Eastern Airlines

FEDERAL'S NEW single channel ground station receiver 139A is especially designed for post-war commercial aviation service, in the band from 108 to 132 Mc; this range covers the recently assigned band for air-to-ground communication. This receiver offers many time- and trouble-saving features, with emphasis on reliability and simplicity of operation and maintenance.

This compact unit permits clear, dependable AM voice reception for airport control towers or remote unattended stations. Airlines and airport owners will find it a valuable means of safeguarding their vital communication systems. Eastern Airlines has already ordered a quantity of these units.

Front view, showing panel in operating position. Hinged at the bottom, this panel, when open, allows voltage measurements and inspection of all components to be made while set is operating, without removing it from the rack.



Rear view, showing transformers and tubes horizontally mounted on back, for free ventilation and ready accessibility.

Design Features of the FTR-139A

1. Designed for compact mounting in standard 19-inch relay rack
2. Front panel is hinged at bottom, giving unobstructed access to wiring for checking or maintenance
3. Designed for expected 100 KC channel separation
4. Crystal-controlled superhet circuit gives high performance
5. Either heated or unheated crystal holder can be used
6. Has carrier-operated noise-suppression circuit with adjustable threshold control
7. Includes provision for remote rf gain control
8. Amplified AVC

DATA

Power Output . . . . . Max. undistorted, 750 MW
Max. output, 1000 MW

Frequency Range . . . . . 108 to 132 Megacycles

Power Input
70 Watts, 105-125 Volts, 50 to 60 Cycles

Dimensions . . . . 19" long by 7" high by 9" deep

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at a critical temperature. For high-frequency or low-voltage circuits, a thin layer of polystyrene was deposited between the selenium and a low melting-point alloy used as second electrode. About 50 times the current of other units was obtained by this design. By cooling in liquid bath, these rectifiers could be used at 50 times their rating. High dielectric constant and magnetic ceramic materials were developed. This report also describes production and molding of ceramics, making resistors of carbon deposited on ceramic tubes, production of steatite and high dielectric materials for capacitors, the manufacture of high-voltage insulators and carbon film resistors, and use of glass as a binder for carbon resistors (C-58: 21 p).

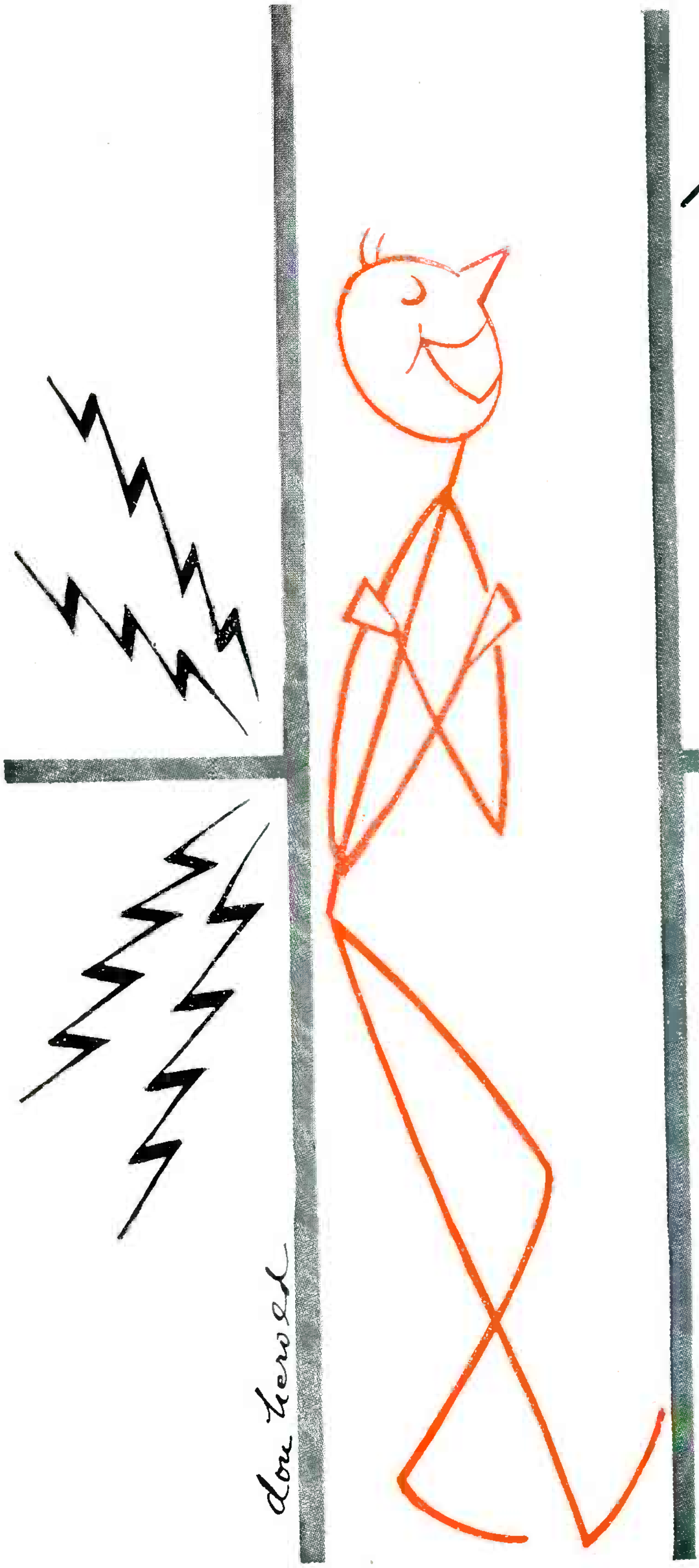
Radar

Radar calibrating shells of various types were tested by the Germans. Shells loaded with dipoles and equipped with time fuses to explode the shells at predetermined ranges were shot. On explosion the shell ejected the dipoles which served as a radar target. Aluminum foil dipoles were unsatisfactory because they did not straighten out and were torn on ejection. Wire proved satisfactory. Little difference was observed between aluminum and iron wires. (C-6: 5 p).

Radar test equipment for 30, 10, and 3-cm bands including frequency meters, power meters, range calibrators, and phantom targets followed the same fundamentals and designs as American equipment. Extremely stable thermistors with fast reaction time were manufactured from uranium oxide and Traganth (C-8: 4 p).

Transmit-receive boxes followed two general designs. A glass doughnut containing water vapor, maintained by an internal heater, filled the cross section between two coaxial tubes of a cable. The other form consisted of plates within a box filled with water vapor. The wave passed between the plates. A potential point, 200 volts, introduced into the box accelerated ionization of the vapor (C-13: 1 p).

Magnetic cores were injection molded from mixtures of iron and bakelite for cores of coils. Had cobalt been available, magnets for mag-



You can't shock us!

For many years, the Schweitzer Paper Co. has been a leader in the manufacture of thin gauge insulating papers for capacitors, coils, transformers, and other equipment where top quality and performance are so necessary. Your requirements, regardless of how exacting, will not shock us for our specialty has been the production of thin gauge insulating papers ranging in thickness from .0002″ to .004″ to meet the most stringent requirements.

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Plants: Jersey City, Mt. Holly Springs, Pa.
Research Laboratories: Chrysler Bldg.
New York, N. Y.

SPECIALISTS IN THIN GAUGE INSULATING PAPERS netrons could have been reduced to half their size. Mixing with ceramics to stabilize carbonyl mixtures with respect to time and temperature did not produce an improvement comparable to the extra effort (C-38: 1 p).

Oscillators having wavelengths from 30 cm down used a triode or magnetron coupled to a cavity. Two plungers provided tuning; a large one for coarse adjustment; a small one for fine adjustment. Wavelengths were measured using a Michelson interferometer. A mirror, about 40 cm square and with a 200 mm travel, was used for the movable reflector. Accuracy was estimated to be 2×10^{-4} parts in one (C-18:3 p).

Cyclotrons were used mostly to prepare tracer materials for biological research. Some of the tracers so produced were radioactive phosphorus, copper and bromine. Bombarded bromine was used as tracer in a bromine compound intended for uses similar to those of penicillin (C-49:10 p).

Quartz crystals were grown artificially by many experimenters in the development of improved optical, piezoelectric, and electro-optic properties (C-65:7 p).

German Ceramic Secrets

Methods of loading cellulose acetate films with ceramic powder for use as capacitor dielectrics, a special technique for making extremely thin ceramic samples, production of high-permittivity ceramics, and other developments at Lutz and Co., Lauf-Pegnitz, Germany, are described in a 29-page report, PB-497, available from Office of the Publication Board, Department of Commerce, Washington 25, D. C. at $2.00 for photostats and $.50 for microfilm.

The finished elastic plastic film reportedly has a dielectric constant of 10. Its softening temperature is about 90 C. Ceramic samples as thin as 0.3 mm, with permittivity values in excess of 100 and as high as 2,000 were made by this German firm, with titanium oxide reportedly playing an important part. Capacitor microphones with an element consisting of a plate of high-permittivity ceramic, silvered on both sides, are claimed to have greater output than normal types of capacitor microphones.

We who live sleep and even dream plastics molding, maintain the most profound respect for Resistors! These tricky tantalizers, by reason of their intricate pattern and precise specifications, begin demonstrating their *resistance* powers long prior to entering service. The minute they leave the drafting boards they seem to say . . . "Double-dare you to mold us". We know . . . because we do mold them . . . all types . . . and with a success that can come only with experience, facilities and a thorough understanding.

For the Resistor Spool, shown here, Consolidated also engineered and constructed, in its own plant, the special four-cavity, semi-automatic type of mold required for the part's quantity production. Although this advertisement illustrates Consolidated quality at work for others, we invite the opportunity to apply its plastics know-how to your own product. Inquiries invited!

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NEW PRODUCTS

Latest developments in new apparatus, components, materials. New literature

Facsimile Equipment

FINCH TELECOMMUNICATIONS, INC., 10 E. 40th St., New York 16, N. Y. New facsimile equipment designed primarily for f-m broadcasters has just been announced. Chief among these is a complete studio facsimile transmitter-monitor system (type FBC 147-A) which consists of two broadcast facsimile scanners, each with associated monitor receiver, power units, amplifiers and selective switching arrangements for insuring uninterrupted transmission for any number of facsimile pages.

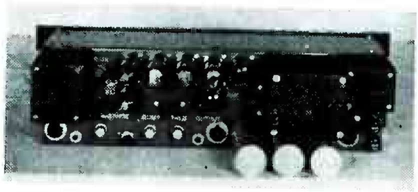
Provided with automatic copy loading and ejection it also includes a receiver operating on the outgoing signal of the unit thus making it possible to observe the program. Two complete scanning units are supplied with control console to facilitate an uninterrupted flow of programs. Switching is provided to enable the operator to control the installation in the same manner as the output of a studio.

The single facsimile scanner shown (type FB-146-A) is sufficient for limited facsimile broadcasting.

Regulated Output Amplifier

SCHUTTIG AND CO., Ninth and Kearny Sts., N. E., Washington 17, D. C. The Series S139 amplifier has been designed for use in airways and other voice communications circuits to provide automatic noise suppression and level control.

Basically, it is a high gain push-pull amplifier with two additional features; one holds the rms output level to within 1 db with input level variations as great as 40 db, and another automatically reduces the gain by a factor of up to 22 db during periods of circuit idleness. The frequency response is uniform to within 1 db over a range of 100 to 4,000 cycles, and for a condition of 40 db compression the distortion does not exceed 3 percent. The output level may be adjusted to regulate at any point within the range of -10 to $+10$ db and the noise suppression circuits may be adjusted over a range of 0 to -22 db. There are no sustained transients caused by abrupt input level changes, full automatic control being established within approximately two voice cycles at any frequency. Hum and noise level are over 45 db down from zero level. This equipment is available for use as a 75 db microphone amplifier or as a 50 db line amplifier. Physically, it consists of a vertical panel and chassis combination with all components, controls and adjustments mounted on the rear of the chassis. The panel and one side of the chassis may be removed to facilitate servicing.

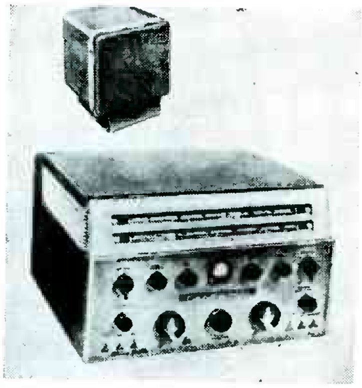


Visual Curve Tracer

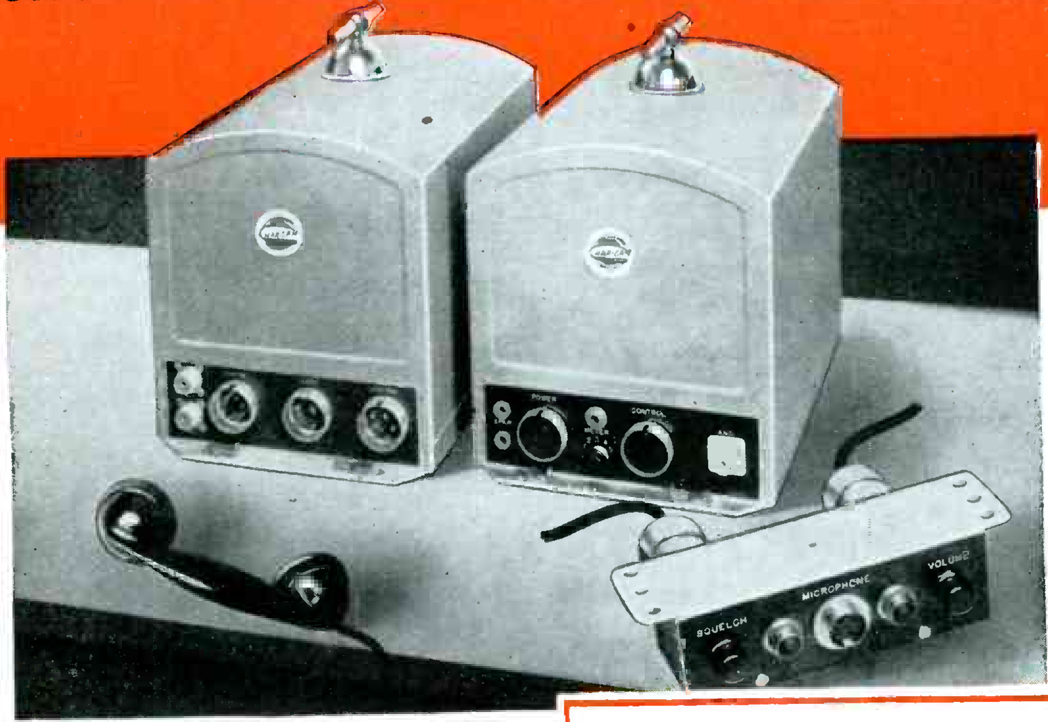
RAYMOND M. WILMOTTE, INC., 236 West 55th St., New York 19, N. Y. New production testing equipment for rapid adjustment of i-f coils is now available. Unskilled personnel can accurately adjust overcoupled types at about ten per minute by means of a cathode-ray oscilloscope which presents at the same time traces of upper and lower limit standards and a trace resulting from the coil under adjustment. The Visi-Limit unit can be operated in the range 85 kilocycles to 11 megacycles by simple replacement of the standard oscillator assembly. It is arranged to plug into any normal commercial oscilloscope for viewing and can be rack-mounted or left in its cabinet for bench use. The unit measures 21 x 10¼ x 14 inches and weighs 35 pounds. Price of the basic unit is $475 fob Washington, D. C., with an additional charge for standard or special coil-testing jigs or additional oscillator assemblies.

Communications Receiver

THE ALLEN D. CARDWELL MFG. CORP., 97 Whiting St., Plainville, Conn. The model CR-54 deluxe communications receiver gives complete coverage from 0.54 to 40 megacycles in six bands, with provision for replacing the broadcast band by a 40 to 54 megacycle range. Power output to the separate speaker is 8 watts with less than 5 percent distortion. Electrical band spread is provided for six amateur bands. Some of the major features which make the receiver different from most of those at present on the market are 18 miniature tubes, including rectifiers, a secondary frequency standard (built-in 100 and 1,000 kilocycle calibrator), temperature-compensated oscillator, new type noise limiter, and mechanical coupling to the shafts brought out at the rear for linkage to other units. An unusually high signal-to-noise ratio is claimed as a result of using



HAR-CAM *Mobile* Transmitters and Receivers for Better PERFORMANCE — Greater FLEXIBILITY



A few of the many important construction and operating features that make HAR-CAM Emergency Communications Equipment standards of quality and performance:

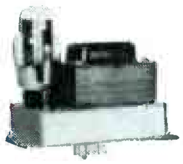
FM-AM RECEIVER

13 tube, crystal controlled double conversion superheterodyne
Either AM or FM available by throwing toggle switch
Frequency Range: 30-44 megacycles
Selectivity: 40 kc off resonance (adjacent channel) greater than 60 db down.
Selectivity: 80 kc off resonance greater than 120 db down
Image response greater than 100 db down
FM Quieting Signal: not greater than .3 microvolts
Greatly improved squelch control for the FM receiver equally effective when receiver is used on AM. Squelch control adjustable from .1 microvolt to 1 microvolt.

FM TRANSMITTERS

Power Outputs — 25, 40 or 70 watts
Frequency Range — 30 to 44 megacycles
Frequency Modulation — deviation 15 kc either side of center frequency

RECEIVER POWER SUPPLIES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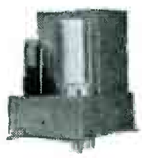
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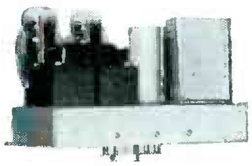
TRANSMITTER POWER SUPPLIES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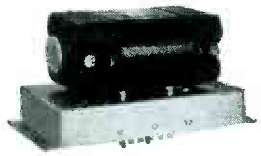

D. C.

HAR-CAM POWER SUPPLIES

Either AC or DC operation is made available instantly with HARVEY'S plug-in type power supplies like those shown here. No other electrical or mechanical changes in the circuit are required.

Characteristics of 152-162 mc equipment essentially similar. For further information on HAR-CAM Transmitters and Receivers write for Bulletins H-35 and H-36.

HAR-CAM
HARVEY OF CAMBRIDGE

HARVEY RADIO LABORATORIES, INC.
439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

two grounded-grid radio-frequency amplifiers. Necessary beat-frequency oscillator and crystal filter have been furnished for code reception. The self-contained power supply operates on 105 to 125 volts, 60 cps, and consumes 120 watts.

Small Oscilloscope

WATERMAN PRODUCTS CO., INC., Philadelphia, Pa. The Pocketscope is a compact cathode-ray oscilloscope, complete with amplifiers, employing a 2-inch cathode ray tube. All other tubes are miniature types. A double-triode multivibrator produces a substantially linear trace from 10 cps to 50 kc. Amplifier response is within 0 to minus 2 db from 20 cps to 100 kc

and within minus 6 db to 200 kc. With maximum gain, vertical and horizontal deflection sensitivities of about 0.1 volt rms per inch are obtained. Input resistance is 0.5 megohms and shunt capacitance is 36 microfarads. The self-contained power supply operates on 105 to 125 volts, 50 to 60 cps with a power consumption of 23 watts under normal operating conditions. The unit measures 6$\frac{3}{4}$ x 3$\frac{3}{4}$ x 10 inches and weighs only 5$\frac{1}{2}$ pounds.

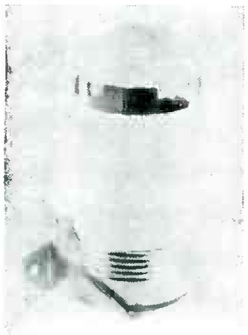
Resistor Limit Bridge

ASSOCIATED RESEARCH, INC., 231 S. Green St., Chicago 7, Ill., has announced production of the Model 81-A bridge for the accurate, rapid testing of large quantities of resistors or other devices having an ohmic resistance. Limits are set up by a supervisor before a production run and the components are accepted or discarded on the basis of a simple meter reading. The device is completely self-contained, powered by

three No. 6 dry cells. Resistance from a fraction of an ohm up to 20,000 ohms can be checked to tolerances of from plus or minus 1 percent to plus or minus 20 percent. An external battery can be connected if greater sensitivity is desired.

Photoelectric Lighting Control

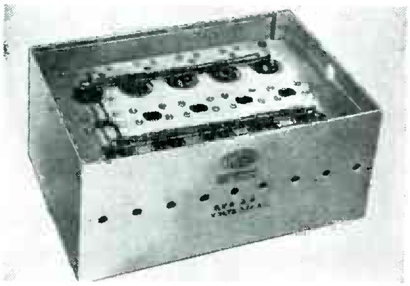
FISHER-PIERCE COMPANY, 82 Ceylon St., Boston 21, Mass., has developed a photoelectric unit for individual control of multiple street lighting systems and similar purposes which operates on low voltages (105 to 130 volts) and can control up to 500 watts of lamp load (a capacity of 30 amperes can be provided on production quanity orders). The new control unit permits individual street lights to be connected, through it, directly to the 120-volt distribution line. It can be set to turn on the light when north sky illumination is reduced to any preset value between $\frac{1}{2}$ and 6 foot-candles, and to turn off the light when the illumination intensity reaches 2 foot-candles above the turn-on point. A time de-



lay of 15 seconds is incorporated in the circuit to prevent operation of the unit by temporary brightness from lightning or passing lights, and provision is made whereby the light stays turned on in the event of any functional failure of the unit. The control consumes 6 to 7 watts of current, is 4$\frac{7}{8}$ inches in diameter by 10$\frac{1}{8}$ inches high, and has a bracket for mounting directly to the distribution pole.

Power-factor Corrector

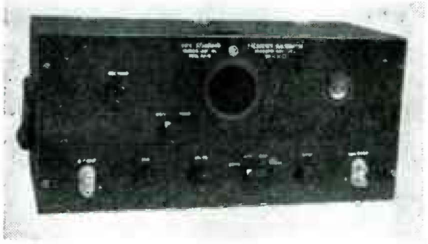
TOBE DEUTSCHMANN CORP., Canton, Mass. A new power-factor correction block providing up to 2 kva at 230 volts, 50 to 60 cycles, is constructed of 10 $\mu\mu$f center-tapped units bolted into rigid steel housing. Accurate load balancing can be obtained by disconnecting individual sections, and the assembly as a whole may be



connected for either single-phase or three-phase operation. The capacitor sections, which are impregnated with mineral oil and hermetically sealed in oil-filled metal cases, show little drift through wide ranges of temperature, and are said to be capable of continuous operation at temperatures ranging as high as 75 C. Overall dimensions of the unit are 9$\frac{3}{8}$ x 6$\frac{3}{4}$ x 14 inches.

Frequency Calibrator

BROWNING LABORATORIES, INC., 742 Main St., Winchester, Mass., has recently developed a frequency calibrator, Model RH-10 which depends upon the transmissions from the National Bureau of Standards radio station WWV. The equipment is



MORE COMPACT COILS WOUND FASTER

FORMEX MAGNET WIRE AIDS DESIGN ENGINEERS SPEEDS MANUFACTURE

Many design improvements that depend on the size, shape, and construction of coil windings are made practical by the unusual qualities of Formex magnet wire.

Replacing fibrous-covered wire, Formex puts more turns and more copper in a given coil cross-section area, particularly if square or rectangular Formex wire is used. Coil shapes requiring "acute-angle" bends and other severe distortion of the wire can be adopted with reduced insulation failure.

In production, too, you can go to higher winding speeds without increasing rejects. Time-saving steps in coil assembly that you wouldn't dare to use with ordinary magnet wire become practical because of the toughness of the insulation on Formex wire.

FIRST COST IS LOW

In most sizes, Formex magnet wire brings you these extra design and production advantages at lower first cost than fibrous-covered wire, and only slightly more than plain enameled wire.

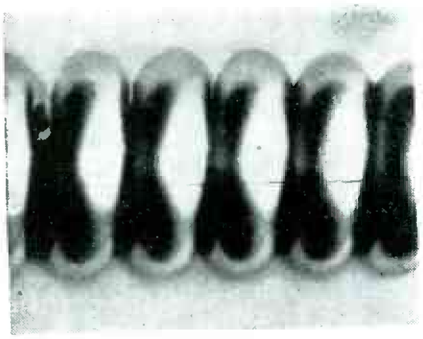
Ordering G-E Formex magnet wire is the first step toward faster winding of better, more uniform coils, and long apparatus life. For complete information on what Formex can mean in savings to you, call in your local G-E representative or write for Bulletin GEA-3911. *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*

Types and Sizes of FORMEX

Insulation thickness. Formex wire is available throughout the entire standard range of wire sizes with single (F) and heavy (HF) insulation. Triple Formex (TF) is available in sizes from 25 AWG to 40 AWG, and quadruple Formex (QF) in sizes from 8 AWG to 34 AWG.

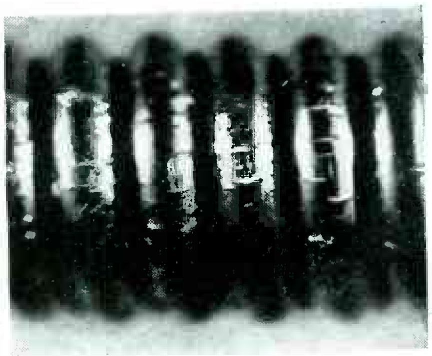
Round Formex. Round Formex wire is supplied in all the standard sizes from 8 AWG through 40 AWG, and in Ultrafine sizes from 41 AWG through 44 AWG, and in diameters of 0.00175 inch, 0.00125 inch, and 0.100 inch.

Rectangular and Square Formex. These two types of Formex wire possess all the desirable characteristics of round Formex, such as winding space factor, toughness, flexibility and resistance to abrasion, moisture and shock. It is available in a wide range of narrowly separated sizes, from 100 mils wide and 0.025 inch thick (3.50 ohms per M ft) to 284 mils wide, 0.180 inch thick (0.168 ohm per M ft).



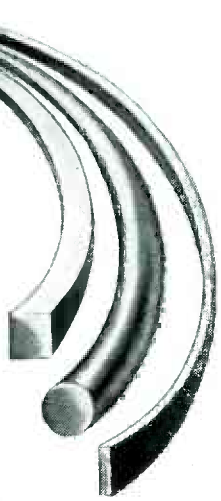
Why Formex magnet wire stands up

Enlarged photograph showing the absence of cracks in the insulation of Formex magnet wire stretched 20 per cent, then wound upon its own diameter. This tough wire may be hammered flat without damage to insulation, and shows no shelf or heat aging to lower the insulation's initial dielectric strength. Measured on the repeated scrape abrasion tester, Formex is 30 times as resistant to abrasion as conventional enameled wire.



This enlarged photograph shows enameled magnet wire stretched 10 per cent—half as much as the Formex wire in the top illustration—and wound upon *twice* its own diameter. Note the cracks in the insulation, the absence of cracks in the Formex wire.

● *Another G-E Achievement Resulting from "Full-range" Research* An example of G-E full-range research in action is the development of Formex magnet wire. Realizing that no major improvement in enameled magnet wire was probable as long as drying oils were a principal ingredient, G-E research turned to resins. G-E laboratories developed the first polyvinyl-acetate resin ever to be applied as an insulation for magnet wire; an insulation greatly superior, in most important characteristics, to any enamel. Full-scale production techniques were developed by G-E production engineers. The result is G-E Formex magnet wire; more compact than fibrous-covered enameled wire, more "windable," and so non-hygroscopic that no further moisture-resistant treatment is required.



GENERAL ELECTRIC

503-27-1200

pretuned for 5 and 10 megacycles, either of which may be selected. Provisions are made for coupling secondary standards or other r-f sources and comparing their fundamentals or harmonics with the standard frequencies transmitted by WWV. A cathode-ray indicator permits frequency comparisons to be made to at least 0.1 cycle. A dual filter allows the selection of either the 440 or 4,000 cycle modulation. This allows these audio frequencies to be employed as a primary standard.

Sensitivity of the RH-10 is better than 0.5 microvolt and the image-rejection ratio is more than 50 db. The unit is supplied in a cabinet as shown or rack mounting with dust cover. Dimensions are 9 x 19 x 11 inches and the weight is 30 pounds.

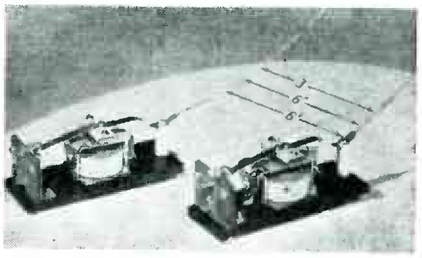
Dielectric Plastic Preheater

GENERAL ELECTRIC COMPANY, Schenectady, N. Y., announces a new dielectric preheater developed principally for plastic preforms, which is designed to operate at 40 megacycles. The unit makes use of a water-cooled oscillator tube with a short-time overload capacity, which permits the use of an average full-power 5-kilo-

watt output during the entire heating cycle and thus speeds up the preheating operation without the use of complex control equipment. Operation of the heater is largely automatic, and to prevent tampering, all controls except the pushbutton starter are located behind a locked front panel. The plastic preforms are placed on the electrode of the heater, the cover is closed, and the preheat cycle is started. The rest of the operation is entirely automatic, and the oven cover opens automatically at the end of the heating cycle.

Antenna Switchover

LEACH RELAY CO., Los Angeles, Calif. announces the models 1723 and 1723-S9 a-c operated and the 1623 and 1623-S9 d-c operated relays which are particularly designed for high-frequency switching operations



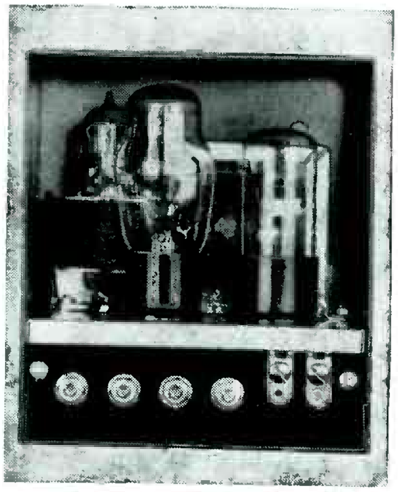
such as antenna changeover. The contacts and contact arms contain no loops, are insulated with Mycalex and Isolantite. The S9 types include a spst auxiliary contact for signal or other purposes. The spacing limitations often experienced with this type of relay are overcome by using two units, one in each feeder line as illustrated.

Vibrator Replacement Converter

OHIO TOOL CO., Cleveland 11, Ohio. The Dynectron rotary converter is, in effect, a small electric motor operating a sealed mercury contactor which interrupts current in a manner claimed to be superior to that of the conventional vibrator. Extremely long life is guaranteed. List price of the plug-in unit is $6.15.

Electronic Safety Switch

UNITED CINEPHONE CORP., 13 New Litchfield St., Torrington, Conn. Pressureless limit switching and floatless control of liquid levels is possible with a new electronic switch model 8336. It can be operated safely in the presence of explosive gases. A glass-enclosed plunger-type mercury relay, rated at 30 amperes, is energized from a 2050 thyratron. Operation is controlled by a voltage applied to the grid of the thyratron tube. The control circuit current is limited to a few



microamperes by the high grid-circuit resistance. Controlling is accomplished through switching of precision or delicate contacts or by conduction through a conductive medium such as water, acid or salt solution. The minute current used in the input circuit prevents arcing and welding of operating contacts. Input circuit can be modified to operate from control voltages developed in a Wheatstone bridge or special apparatus.

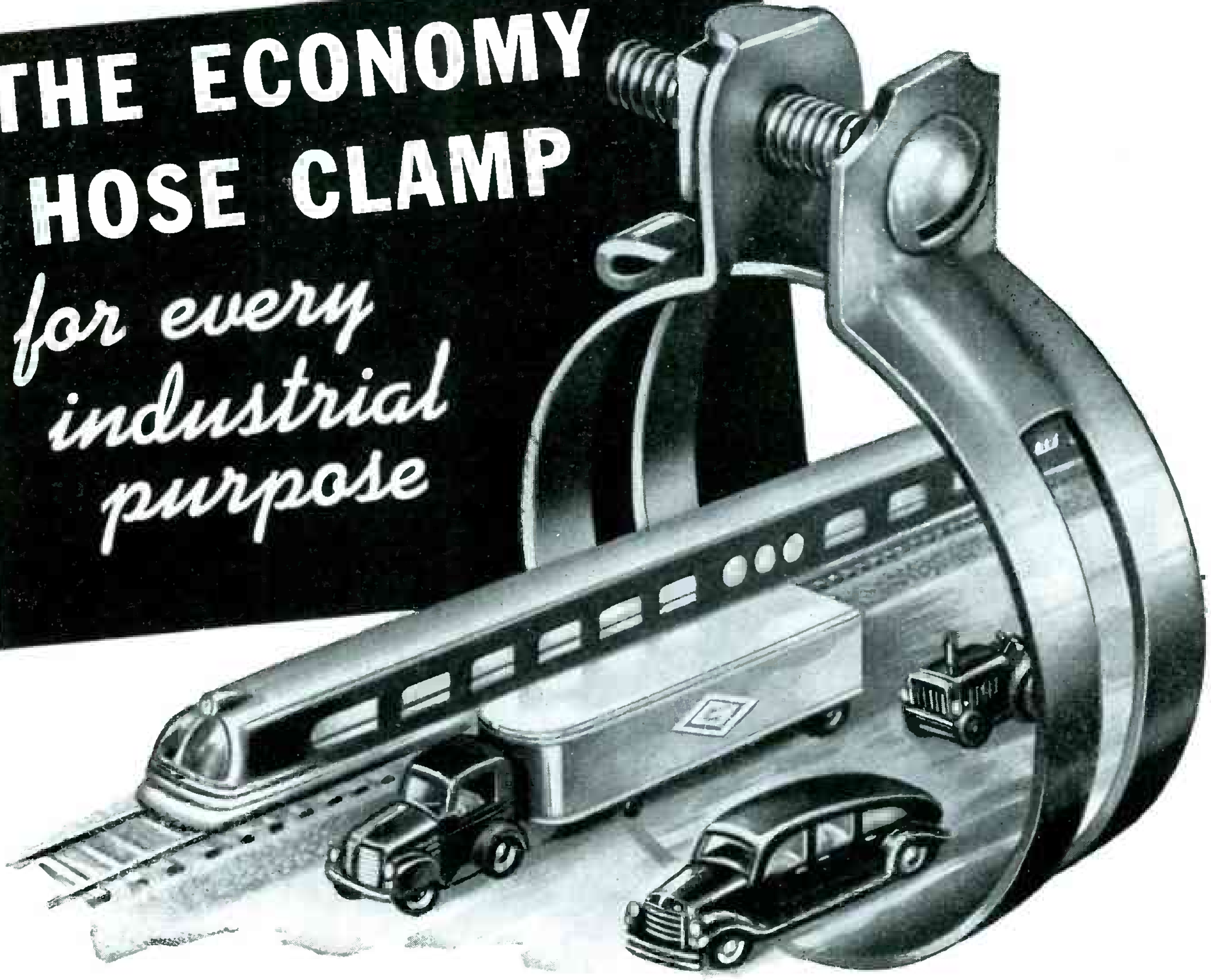
The glass-enclosed thermal time-delay unit prevents injury to the thyratron if it is operated before normal temperature is reached. A mercury-type relay reduces maintenance to a minimum.

Wind Velocity Indicator

SCHUTTIG AND CO., Ninth and Kearny Sts., N. E., Washington 17, D. C. The Type S116A electronic anemometer responds to velocities of less than one mile an hour and gives accurate indication of velocities up to 100 miles an hour.

Basically, the circuits consist of an accurate audio-frequency meter which measures the frequency of audio pulses generated in the anemometer head by interrupting a light beam with a rotating perforated disc. The mechanical system is practically frictionless, and the electronic tubes used in the head are of the filamentless type, thus minimizing maintenance problems. Extensive tests have shown that the performance and reliability are unaffected by adverse weather conditions. Recordings may be taken by merely

THE ECONOMY HOSE CLAMP *for every industrial purpose*



MAXIMUM CLAMPING POWER
CUTS LEAKS...LOSSES...REPLACEMENTS

For maximum clamping power on hose lines where you want to cut leaks . . . reduce losses . . . and eliminate costly replacements—specify Diamond G Hose Clamps. For connections in automotive, pneumatic, hydraulic, electric, marine, railway, and other applications, they are the economy clamp for every industrial use.

Diamond G Hose Clamps have been designed, developed, and proved in service to be the ideal clamp where low cost and high operating efficiency are the key factors.

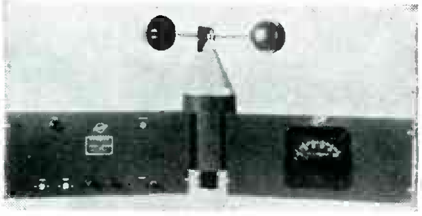
Each and every Diamond G Hose Clamp is rust proof for protection and long life under all operating conditions. The "captive" nut, guarded by sturdy flanges, assures a positive tight grip. Heavy duty reinforced shoulders, plus powerful spring action provide uniform pressure and grip around the circumference.

Whatever your need in hose clamps, Diamond G has the answer for you. A complete range of sizes for delivery of air, water, gasoline, oil, and chemical. For full details write—

GEORGE K. GARRETT CO., INC.
1421 CHESTNUT STREET, PHILADELPHIA 2, PA.
MANUFACTURERS OF

DIAMOND G PRODUCTS

LOCK WASHERS • • FLAT WASHERS • • STAMPINGS • • SPRINGS • • HOSE CLAMPS • • SNAP AND RETAINER RINGS



connecting a standard 5 ma d-c Esterline-Angus recorder. The anemometer may be located at a point distant from the electronic measuring circuits and its output energy fed to one or several indicating instruments through wire lines. Because of the low mechanical inertia, it responds quickly to gusts and localized air disturbances. Also, several anemometers may be connected through a selective switch to a common indicator so as to provide a local area velocity pattern for airport traffic control work.

Motor Starting Capacitors

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J., announces the Type ETW a-c electrolytic motor

starting capacitor which is designed for mounting in a clip-type bracket. The capacitor is enclosed in a plastic case. Capacitance range is 25 to 450 microfarads.

Magnetic Control Tube

GENERAL ELECTRIC CO., Schenectady, N. Y. A new magnetically-controlled

You can get FIBERGLAS advantages in laminated plastics parts

Fiberglas-base laminates afford many advantages and a unique combination of characteristics. Made with many different kinds of resins, laminates with *Fiberglas Cloth or Fiberglas Mat* as a base are used to solve a wide range of electrical and mechanical problems.

The finished materials—available in sheet form, in rods or tubes, or molded or shaped into special forms—are used in motors and generators as slot sticks, armature or stator end laminations, as brush holders, spacer blocks, in dry-type transformers, etc. The low-electrical-loss properties of several types of Fiberglas-base laminates have led to their wide use for radio and electronic applications.

If the products you are designing or manufacturing require a material with high dielectric strength, dimensional stability, moisture and temperature resistance and/or adequate mechanical strength for high-frequency, low-electrical-loss parts—investigate Fiberglas-base laminates.

Most manufacturers of laminates make one or more types of Fiberglas-base products. If your supplier can't furnish the type you need, write—Owens-Corning Fiberglas Corp., Dept. 860, Toledo 1, Ohio. Branch Offices in Principal Cities.

In Canada: Fiberglas Canada Ltd., Oshawa, Ontario

OWENS-CORNING
FIBERGLAS
T.M. REG. U.S. PAT. OFF.

diode tube, type 2B23 has been designed to supplement the advantages available with conventional grid-control tubes in d-c amplifier applications. Low-voltage high-current or high-voltage low-current circuits can be used for the control, depending upon the proper choice of the control solenoid. When used as an electronic switch, the tube has a d-c plate voltage of 150 volts and a plate current operating range of 30 milliamperes.

Remote Cutoff Pentode

SYLVANIA ELECTRIC PRODUCTS INC., 500 Fifth Ave., New York 18, N. Y. A new semiremote cutoff pentode amplifier has been designed for use in portable receivers in which the

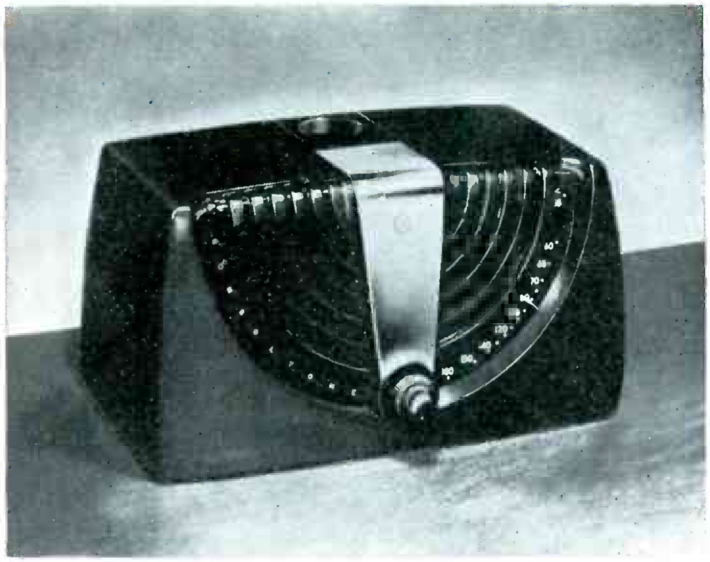
plate supply voltage may drop as low as 45 volts. The type 1LG5 is better suited for avc circuits, for instance, than the type 1LC5. Typical operation with d-c filament voltage of 1.4 volts and filament current of 0.05 ampere at a plate voltage of 45 shows a plate current of 1.5 milliamperes, screen current of 0.45 milliampere and mutual conductance of 800 micromhos. Plate resistance under these conditions is approximately 0.35 megohm.

Marine Radar

WESTINGHOUSE ELECTRIC CORP., Box 868, Pittsburgh, Pa. Marine radar for pilotage and collision protection operable from 100 yards to 32 miles has just been announced.

Provided with a plan position indicator scope, the equipment has range scales of 2, 8, and 32 nautical miles. Range discrimination is sufficient to indicate as separate targets any two objects lying on the same bearing but differing in range by 100 yards or more. General performance will show high coast lines at the maximum range of 32 miles, cargo vessels

DUREZ PHENOLIC PLASTICS... INSIDE AND OUT



Style and performance make this new Zenith radio. The wide traverse dial and the excellent, rich tone quality that make this 1946 model outstanding are recent developments of Zenith engineers.

Durez phenolic plastics permit its attractive cabinet design...contribute to its physical and electrical qualities.

Why Plastics?

In addition to...and more important than...the tuning knobs and cabinets which are quite often molded of plastics, are the vital but "hidden" operating parts of radios.

These unseen items make the difference between good and bad performance. Many of them are constructed in whole or in part of plastics because plastics are better suited for these important jobs than any other material.

Why Phenolic Plastics?

Excellent moldability, heat resistance, diversity of finish, moisture resistance, good dielectric properties...all are inherent characteristics of phenolic plastics. Add to these their practicability for economical mass production, their long-wearing, non-warping qualities, and you have the ideal material for the radio field, where versatility is the prime requisite.

Why Durez Phenolic Plastics?

As specialists in the production of these most-versatile-of-all-plastics, Durez technicians, backed by more than a quarter century's successful product development experience, are equipped to counsel the design engineer wisely on all phases of the molded phenolic picture.

Add to this rich background the more than 300 Durez phenolic molding compounds . . . each carefully developed for a specific purpose...and you can readily understand why custom molders and radio manufacturers everywhere look to Durez for the plastics which fit their jobs.

Experienced Assistance Available

Any aid which the Durez staff can give towards solving your plastic material problems is available to you and your custom molder for the asking. Durez Plastics & Chemicals, Inc., 87 Walck Road, North Tonawanda, N.Y. *Export Agents: Omni Products Corporation, 40 East 34th St., New York, N. Y.*

DUREZ

PHENOLIC RESINS

MOLDING COMPOUNDS

INDUSTRIAL RESINS

OIL SOLUBLE RESINS

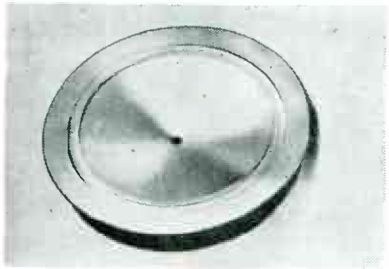
PLASTICS THAT FIT THE JOB

at a range of from 12 to 15 miles, and standard buoys at a range of approximately 3 to 4 miles.

Operation is from 115-volt, single-phase, 60-cycle power with a voltage regulation of plus or minus 5 volts, and a frequency stability of plus or minus 2 cycles. Not more than 1,000 watts of alternating current at 85 percent power factor are required. Peak power output is over 15 kw at a repetition rate of 2,000 cycles per second. Operating frequency is 9,320-9,430 mc.

Hearing-aid Microphone

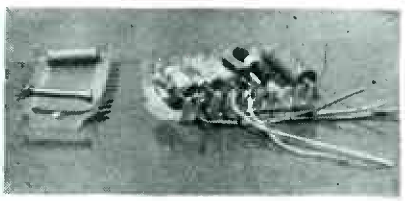
TIBBETTS INDUSTRIES, INC., Camden, Maine. First of a new line of piezoelectric devices to be manufactured by this company is a crystal hearing-aid microphone which comprises sev-



eral developments including metal-clad construction and moisture proofing. Output of the normal hearing aid equipment can be increased by the sensitivity of the new microphone.

Terminal Mounting Strip

YATES ENGINEERING SERVICES, Two Hampton Road, Cranford, N. J. A new type of component mounting strip providing good electrical characteristics and mechanical strength has been developed for either production assembly or replacement use. Mounting strips can be had in glass, ceramics and rubbers in addition to the laminated plastic board shown. With this choice of insulations these component terminal strips are adaptable to most types of r-f circuit assembly as well as audio, power supply or industrial electronic application. Strips come in various stand-



ard and in special lengths and widths for any desired grouping of components. No spacer posts or standoffs are required for direct mounting on a metal chassis. For subassembly production tube socket terminals can be brought through the base plate of the strip for direct wiring.

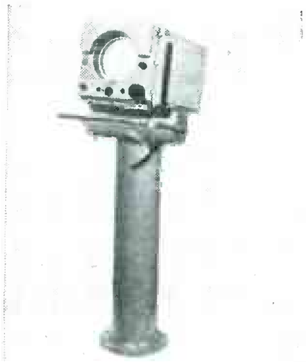
Ten-inch Television Tube

THE RAULAND CORP., Chicago 41, Ill., announces the type R-6025 virtually flat-face cathode ray tube for direct viewing television reception. It em-

ploys electromagnetic focusing and deflection. Face of the tube is 10 inches in diameter.

Navigator's Radar

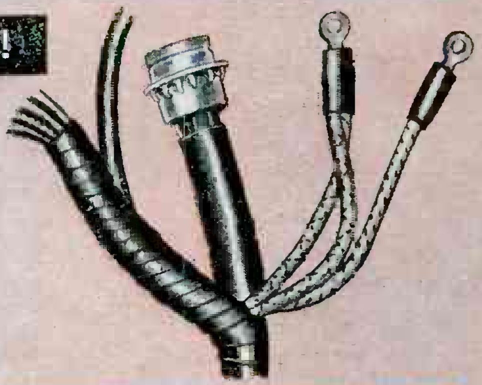
RAYTHEON MANUFACTURING CO., Waltham 54, Mass. The Mariners Pathfinder is a 10-centimeter radar with four range scales, 0-1.5 miles up to 0-50 miles employing an indicator 14½ x 14½ x 24 inches and a 7-foot parabolic reflector weighing less than 150 pounds. The indicator illustrated carries the seven active controls necessary for operation. Transmitting and receiving equipment is contained in an enclosed cabinet. Ranges are accurate to within 2 percent or 100 yards, whichever is greater. The equipment



ELECTRICAL INSULATION NEWS

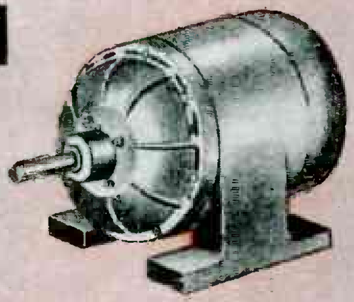
FROM INSULATION HEADQUARTERS

NEW USE FOR PLASTIC TAPE!



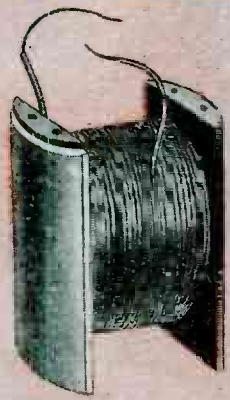
Irvington Fibron Plastic Tape is a "natural" for wrapping intricate, many-branched wire harnesses. Flexible and elastic, it wraps smoothly and evenly over irregular surfaces and will not bulk in sharp corners. Fibron Plastic Tape is tough — having superior abrasion resistance, excellent weathering qualities, high resistance to oils, acids, and alkalis. After wrapping, the harness can be heat-sealed, forming a homogeneous mass of insulation.

SILICONE IS HERE!



Irvington Silicone-coated Fiberglas cloth — totally inorganic flexible insulation — can be used at operating temperatures up to 175 deg. C. It is highly moisture resistant and has excellent dielectric strength. The best heat resistant flexible insulation yet developed, Silicone-coated Fiberglas is added protection against overload failures. Available: 36" wide, tapes, and bias strips.

SILK NOW AVAILABLE!



Immediate deliveries can be made on Irvington Varnished Silk *for any application*. Combining high dielectric strength, excellent oil and water resistance with extreme thinness and elasticity, its return will be welcomed for insulating very small coils and for taping over irregular surfaces.

Additional Information and Generous Samples of these Products will be sent on Request.

IRVINGTON INSULATION — STANDARD OF THE WORLD

IRVINGTON *Varnish and Insulator Company*

IRVINGTON 11, NEW JERSEY, U.S.A.

operates on 115 volts, 50 to 70 cycles. Power required is less than 2 kva. An interesting feature of the system's use is the intended employment of Mackay Radio and Telegraph Co. field representatives as well as those of Raytheon for preventive maintenance of the equipment.

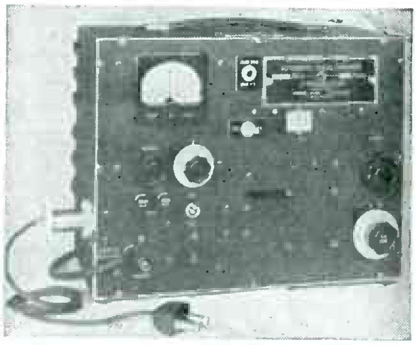
Regulated Power Supply

ELECTRONIC MEASUREMENTS CO., Red Bank, N. J. The Model 204A power supply furnishes 300 milliamperes at 0-500 volts d-c (continuously variable) and 6 amperes at 6.3 volts a-c, center-tapped and unregulated. Regulation of the high voltage is within 1 percent between 30 to 500 volts from

no load to full load. The equipment employs 14 receiving tubes and consumes about 525 watts full load from a 105 to 125 volt, 50 to 60 cps line. Adequately equipped with two meters, three controls, output terminals and fuses, the unit is suitable for table or relay-rack mounting. It measures 19 x 10½ x 15 inches and weighs approximately 70 pounds.

F-m Signal Generator

MEASUREMENTS CORPORATION, Boonton, N. J. The Model 78-FM frequency-modulated signal generator operates directly, without the use of frequency-multiplying stages, across the range of the 88-108 megacycle f-m broadcast band. A mutual inductance attenuator which provides constant output impedance of 17



All right, General Sherman...

WHAT WOULD YOU CALL THE POST-WAR

After all, you picked out a nice tart word for your own war . . . give us a name for this mess we're in now!

Tell us what to say when our suppliers are unable to give us half the material we need to fill our urgent orders!

Tell us what to say when our customers are disappointed—our suppliers, due to no fault of their own, are unable to fill our requirements—and we're in the middle of the muddle!

Tell us . . . weren't we happier back in the nice, calm depression days when all we had to worry about was losing our shirts?

One of these days when things get back to normal we're going to be giving that old-time, fast, high-speed, we-mean-right-now, Lenz service again. Then we're going to take time out to study Webster's Unabridged and find out what to call this POST-War.

In the meantime, General . . . give us a word for it!

LENZ

LENZ ELECTRIC MFG. CO.

1751 N. WESTERN AVE., CHICAGO 47, ILL.

ohms is calibrated directly in microvolts. Frequency deviations up to 500 kilocycles over most of the tuning range are accompanied with only a slight amount of amplitude modulation, and at the standard deviation of 75 kilocycles, there is less than 5 percent.

Aircraft Transmitter-receiver

HALLICRAFTERS CO., 43 East Ohio St., Chicago 11, Ill. The Skyfone model CA-2 covers all radio-range frequencies and the standard broadcast band as a receiver and transmits on the frequencies assigned for personal aircraft contacts with airfields. De-

signed for foolproof operation in the hands of private fliers, the equipment weighs only 8 pounds.

Sealed Plug-in Relay

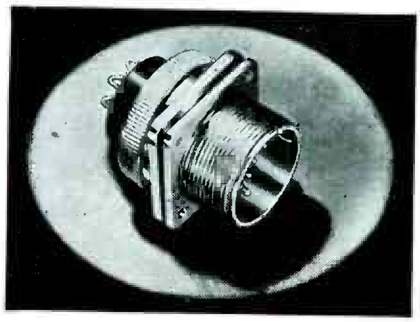
WARD LEONARD ELECTRIC CO., Mount Vernon, N. Y. has developed a new relay designed for a-c or d-c operation in equipment where space is limited. Completely encased in a cylindrical can, these midget relays

provide protection against adverse atmospheric conditions such as moisture, dust, and corrosion. Relay coil and contact connections are totally enclosed within the metal housing and are brought to the prongs of a standard octal-plug base. Plug-in relays are available in contact combinations to double-pole, double-throw with a-c contact ratings (at commercial frequencies) of 4 amperes from 0 to 115 volts and d-c

contact ratings of 0.5 ampere from 25 to 115 volts.

Special Connectors

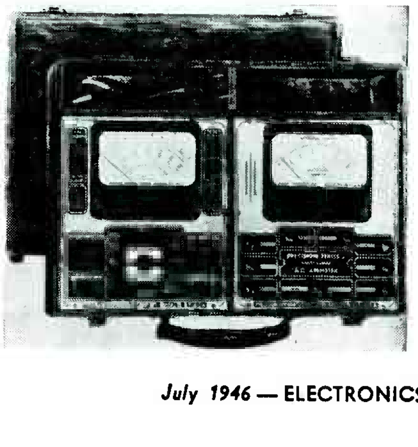
H. H. BUGGIE & CO., Toledo, Ohio. A new type of connector with built-in capacitors is now available for use in radio and other electronic devices. Units can be supplied in either water-tight, pressurized or nonpressurized types. The bypass feature in these new units is such that currents of undesirable frequencies are filtered from the leads. Each pin is provided with a bypass to the aluminum shell (ground or chassis) at capacitances



from 50 to 1,800 micromicrofarads, 350 working volts, using tubular ceramic capacitors. The unit is available with various AN pin arrangements as well as with special pin arrangements to meet other specifications.

Industrial Circuit Tester

PRECISION APPARATUS CO., INC., 92-27 Horace Harding Blvd., Elmhurst, N. Y. The industrial circuit tester, Series 856-J, is essentially a double-meter a-c/d-c volt-ohm-milliammeter which can be used on 25 up to 60 cps. D-c and a-c voltages up to 6,000 volts, d-c up to 12 amperes and a-c up to 60 amperes can be measured. The double meter allows simultaneous measurement of a-c voltage and current. The overall



ANNOUNCING ANOTHER SANGAMO **FIRST!**

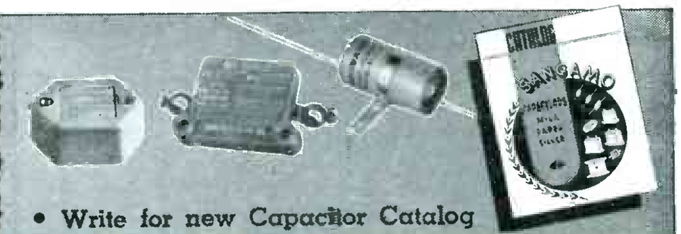
PLASTIC MOLDED

PAPER TUBULAR CAPACITORS

TWENTY-THREE years ago Sangamo was first to announce the development of Molded Mica Capacitors. Today Sangamo scores again with another "First": New Paper Tubular Capacitors which are molded in a thermo-setting plastic. Molding in plastic means the same thing in paper tubulars as it does in micas—more stable capacity values. Other advantages of this new molded product are apparent at once: all moisture is permanently kept out—capacity values are sealed in. This means longer life; lower power factor; application at higher temperatures. The molded finish is smooth—less susceptible to catching dust. From a cost standpoint, too, comes good news: Sangamo Plastic Molded Paper Tubulars are priced only sligthly higher than ordinary types. Use them in all circuits which call for paper tubular capacitors.

HERE IS THE SANGAMO CAPACITOR LINE AND NEW CATALOG WHICH DESCRIBES IT . . .

- MOLDED Paper Tubulars
- Metal-Encased Tubulars (Paper)
- Transmitting Oil-Filled
- Bathtub (Oil or Wax-Filled)
- Diaclor (A Paper Transmitting)
- Mineral Oil (For E Characteristics)
- Ballast Capacitors (Paper)
- Motor Starting, for A. C. and D. C.
- Tubular Transmitting (Oil-Filled Paper)
- Tubular Transmitting (Diaclor, Paper)
- Receiving Micas
- Transmitting Micas
- Silvered Micas
- Silvered Mica Buttons



• Write for new Capacitor Catalog

SANGAMO ELECTRIC COMPANY
SPRINGFIELD • ILLINOIS

size of the hardwood case is 11 x 15 x 6 inches.

Energy Storage Capacitors

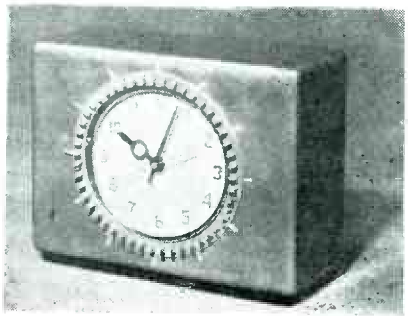
AEROVOX CORP., New Bedford, Mass. A line of capacitors for energy-storage applications has been designed for the fields of flash photography, discharge welding and impulse generation.

Maximum watt-second energy and minimum weight and cost for individual applications are achieved in these capacitors by special ratings consistent with the duty cycle. Each unit is provided with an extra large

number of internal connections in order to minimize inductance. Also, to handle the high currents involved, units are divided into many sections to further reduce the currents in individual connections. This new line of capacitors covers watt-second ratings from 50 to 540, in voltages from 2,000 to 4,000 inclusive.

Clock Switch

GENERAL ELECTRIC CO., 1285 Boston Ave., Bridgeport 2, Conn., is now producing the Select-O-Switch, an electric clock which will control appliances or equipment drawing



KNIT MONEL MESH

Shielding Rings

for h-f electronic applications

HERE'S a war development that may offer an answer to your shielding problems in high-frequency equipment.

It is shielding rings of resilient Monel mesh. They were first used by the U. S. Army Signal Corps.

The resiliency of Monel mesh assures continuous contact at all points. And, Monel's corrosion resistance minimizes any loss of over-all conductivity from attack by moisture-laden air or sea water.

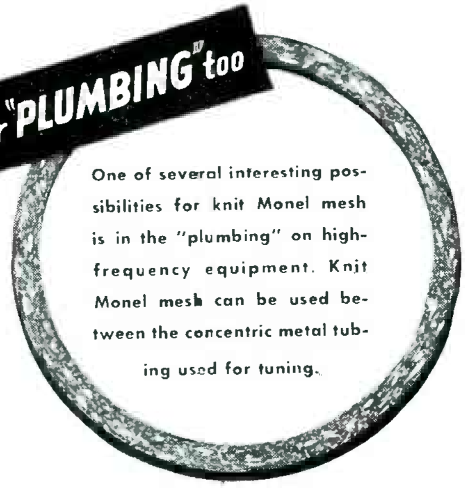
When used in place of fabricated sheet metal shields, these rings speed production and assembly . . . reduce space requirements . . . simplify disassembly.

And, where fluid seal attachments are needed, designers find that Monel can be satisfactorily bonded to rubber-like materials.

Most important, Monel mesh shielding rings do a fine job of "frustrating" straying h-f currents. Currents that "want out" have to run around in circles until they crawl back into the box.

Investigate this new shielding method. Knit Monel mesh can be made into rings of all types and sizes to fit individual requirements. For more information write: Metal Textile Corporation, Orange, New Jersey.

for "PLUMBING" too



THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

get to know all the— **NICKEL** INCO TRADE MARK **ALLOYS**

MONEL* • "K" MONEL* • "R" MONEL* • "KR" MONEL* • "S" MONEL*
INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL* *Reg. U. S. Pat. Off.

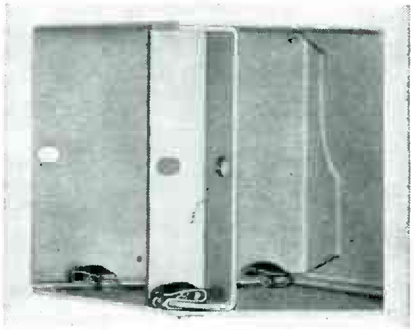
power up to 1,650 watts for preselected intervals over any 12-hour period. The clock measures 6½ x 5 x 3 inches and is enclosed in a plastic case.

Fluorescent Lighting Capacitors

AEROVOX CORP., New Bedford, Mass., offers a new line of capacitors suitable for fluorescent lighting service. Extra ruggedness has been attained by a careful selection of tissue and foil, followed by thorough impregnation of sections using long pumping cycles. The impregnant is Hyvol, a synthetic high-dielectric compound with stable characteristics. These fluorescent capacitors are now available in all standard types, and also in special sizes and shapes, to suit any requirements. Some of the more popular items have a capacitance of 3.5 μf at 330 volts in a 2 x 2-inch round can. Others have a 4.75 μf capacitance, 115 volts, oval can, size 1$\frac{1}{32}$ x 2$\frac{1}{16}$ x 3$\frac{7}{8}$ inches.

Sheet-metal Fastener

TINNERMAN PRODUCTS, INC., 2106 Fulton Road, Cleveland 13, Ohio, is producing the J-type speed nut use-



ful in junction-box assembly. The nut snaps over the screw hole in a self-retaining position and is provided with a cap which prevents injury to wiring.

Laboratory Tester

REINER ELECTRONICS CO., INC., 152 West 52nd St., New York 1, N. Y. The Model 333 volt-ammeter is particularly designed for schools and laboratories as well as for amateur use. It comprises a hermetically sealed meter and a drawerful of shunts and multipliers, the combinations of which are guaranteed to

THE SCOPE OF THE SORENSEN REGULATOR . . . *is amazing!*

Unretouched photograph of output waveform of illustrated Model 1000 under full load.

Compensates in LESS THAN 1/10 of a second for

- **Frequency variations of ±15%.**
- **Input voltage fluctuations of 95-130 volts.**
- **Load changes of ±75%.**

OUTPUT VOLTAGE CONSTANT TO

0.2%

. . . even at extremes of rated load, frequency, or input variation.

- **No moving parts.**
- **Independent of load power factor.**
- **Wave form distortion less than 5%.**
- **Readily adapted to current regulation.**
- **Regulators available in load ranges from 25-15,000 va.**

The MODEL 1000 (range 100-1000 va.)

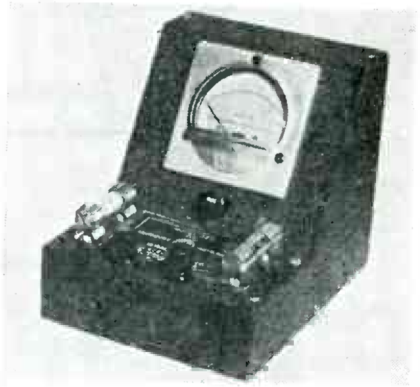
For precision measurements—

SPECIFY SORENSEN REGULATORS

Write for descriptive literature.

SORENSEN & COMPANY, Inc. **STAMFORD, CONN.**

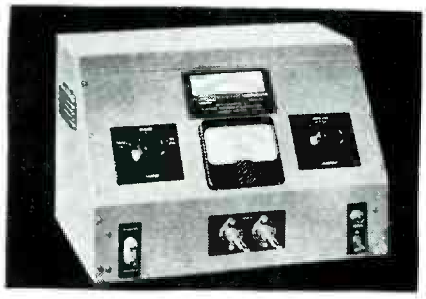
within 1-percent accuracy. Voltages to 1,000 and currents from 2.5 milliamperes to 10 amperes can be



measured. This model is used for d-c measurements. Other models are available for a-c or a-c/d-c use.

Resistance Comparator

CLIPPARD INSTRUMENT LARORATORY, INC., 1440 Chase Ave., Cincinnati 23, Ohio. The type PR-4 resistance comparator has been designed for production testing of resistors over the range 100 ohms to 100 megohms. The resistors under test are checked



with a standard within the limits minus 25 to plus 30 percent. The accuracy of the instrument is guaranteed within plus or minus 1 percent over the entire range. Maximum wattage across the resistor under test is 0.36 watt for the 100-ohm size, less for larger types. The apparatus operates from a 105 to 125 volt a-c line and is independent of line voltage within this range.

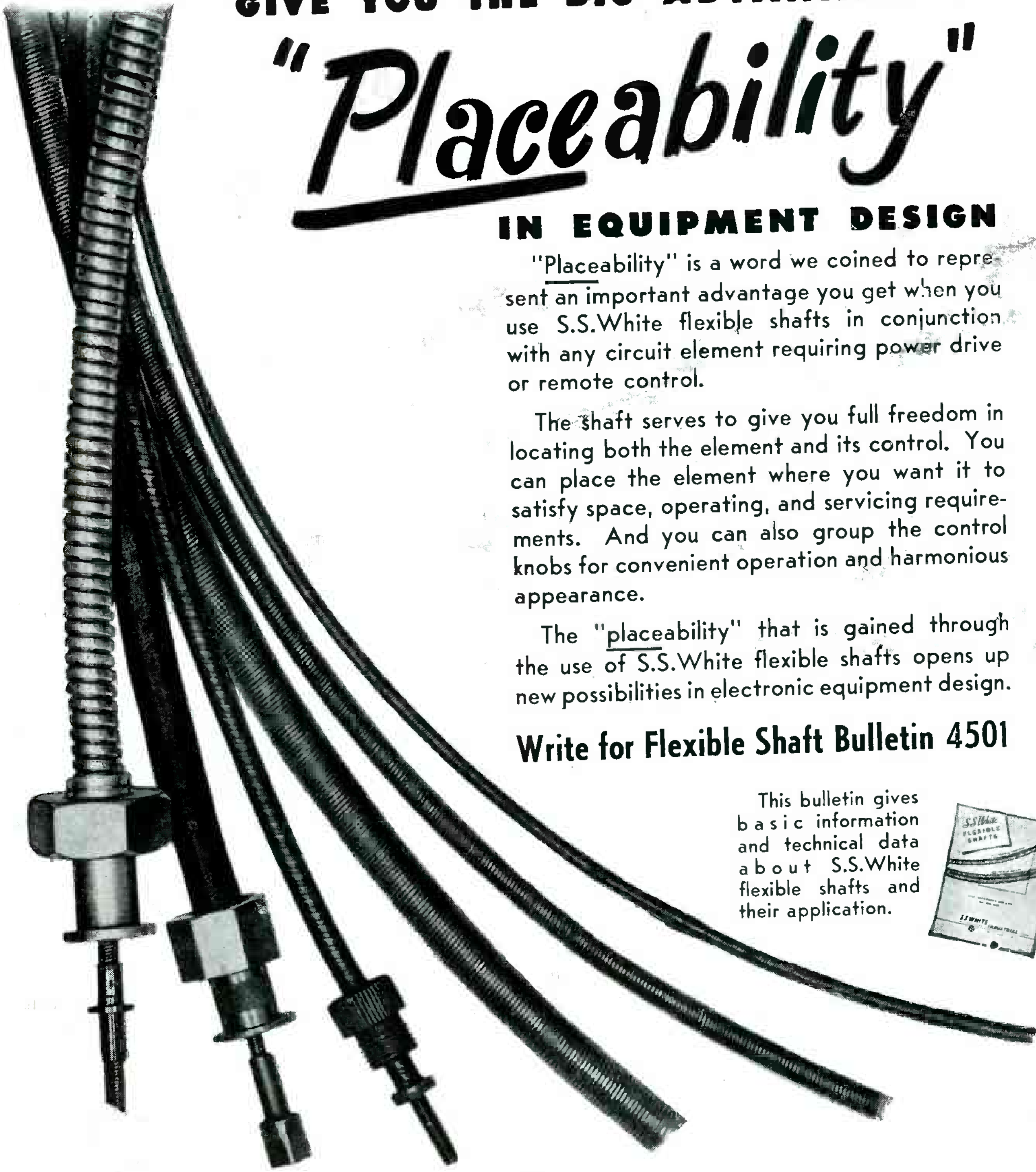
Oscilloscope Calibrator

POLARAD ELECTRONICS CO., 135 Liberty St., New York 6, N. Y. The Voltascope is used to supply peak-to-peak voltages of 0.1, 1.0 and 10 volts to a cathode-ray oscilloscope for calibration purposes or to compare a signal of unknown amplitude with the standard through manipulation

S.S.WHITE FLEXIBLE SHAFTS

GIVE YOU THE BIG ADVANTAGE OF

"Placeability"



IN EQUIPMENT DESIGN

"Placeability" is a word we coined to represent an important advantage you get when you use S.S.White flexible shafts in conjunction with any circuit element requiring power drive or remote control.

The shaft serves to give you full freedom in locating both the element and its control. You can place the element where you want it to satisfy space, operating, and servicing requirements. And you can also group the control knobs for convenient operation and harmonious appearance.

The "placeability" that is gained through the use of S.S.White flexible shafts opens up new possibilities in electronic equipment design.

Write for Flexible Shaft Bulletin 4501

This bulletin gives basic information and technical data about S.S.White flexible shafts and their application.

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. E, 10 EAST 40th ST., NEW YORK 16, N. Y.

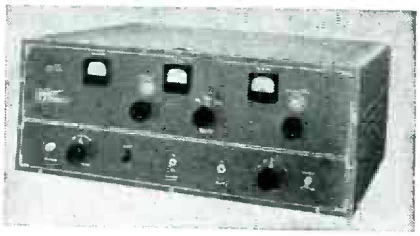
FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

One of America's AAAA Industrial Enterprises of the oscilloscope gain control. Output of the device is dependent upon line voltage from the 115-volt 50- to 60-cps line to which it is connected

for operation. The unit measures 3 x 4 x 5 inches, weighs 2 pounds and costs $15 in New York.

Phone—C-W Transmitter

TRANSMITTER EQUIPMENT MANUFACTURING Co., 345 Hudson St., New York, N. Y. The Model 75GA 75 to 100 watt amateur radio transmitter is suitable for operation on all bands from 3.5 to 28 megacycles, using



either crystal or variable frequency oscillator control. The unit can also be used as the driver for a 500-watt power amplifier. Circuits are provided for break-in operation, including grid-block keying and an anten[illegible] transfer relay.

Power Triode

MACHLETT LABORATORIES, Springdale, Conn., announce dition of an improved type high frequency, water-cooled to their line of high power tra[illegible] ting tubes. This tube feature[illegible] use of heavy sections of Kovar the glass seals rather than th[illegible] ventional type of feath[illegible] per seals. The gr[illegible] structures are mc[illegible] piece high-conduc[illegible]

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GIVE YOU THE BIG ADVANTAGE OF

"Placeability"

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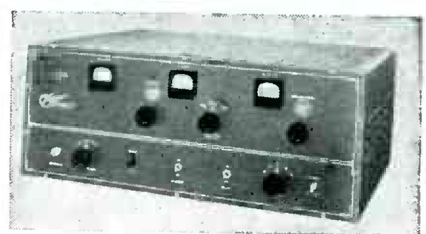
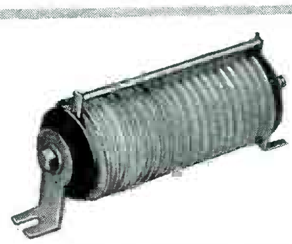


either crystal or variable frequency oscillator control. The unit can also be used as the driver for a 500-watt power amplifier. Circuits are provided for break-in operation, including grid-block keying and an antenna transfer relay.

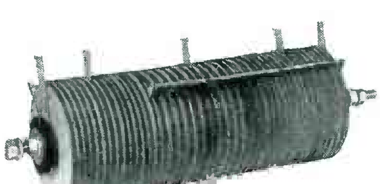
Power Triode

MACHLETT LABORATORIES, INC., Springdale, Conn., announce the addition of an improved type 889-A high frequency, water-cooled triode to their line of high power transmitting tubes. This tube features the use of heavy sections of Kovar for the glass seals rather than the conventional type of feather-edge copper seals. The grid and filament structures are mounted from one-piece high-conductivity copper sup-

Selenium Rectifiers, 4 volts, 0.1 milliamperes d-c



Selenium Rectifier, 60 volts, 1 amp, d-c



Selenium Stack, 110 volts, 5 amp, d-c

G-E SELENIUM RECTIFIERS

Savings in both space and weight are features of G-E Selenium Rectifiers. Engineered and produced in a wide choice of sizes and capacities, they do a big job where limited space is a factor. They're designed to withstand extreme variances in ambient temperatures, humidities, atmospheric pressures.

They can be depended upon to deliver faithful service in series, parallel, and series-parallel circuits. G-E Selenium Rectifiers are noted for long and economical service. Write for booklet, "G-E Selenium Rectifier Stacks." Section A 11-7119, Appliance and Merchandise Department, General Electric Company, Bridgeport, Connecticut.

GENERAL ELECTRIC

ports which also form the contacts to which grid and filament connections are made. Being gold plated externally, minimum contact and lead resistance are obtained. This

tube finds use in radio transmission for frequencies up to 50 megacycles at full-power input and for dielectric heating purposes.

Multivoltmeter

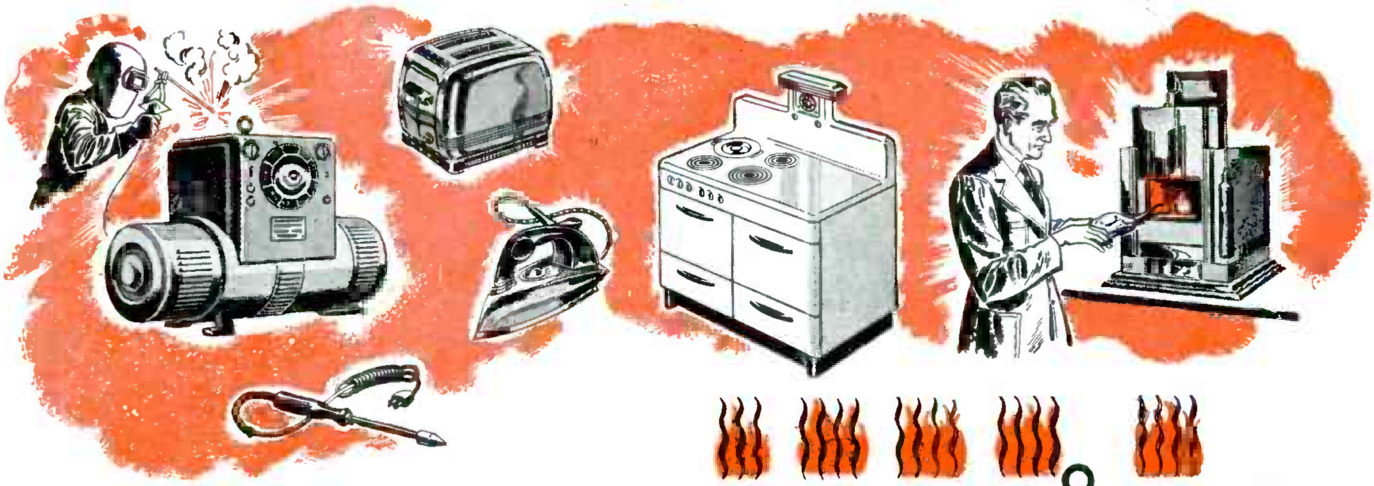
RAWSON ELECTRICAL INSTRUMENT Co., 111 Potter St., Cambridge, Mass. has developed two new multirange d-c voltmeters. Range of the type

501F is 0.01 to 1,000 volts full scale and that of type 501G, 0.1 to 100 volts full scale. All resistors are wire wound and an accuracy of 0.5 percent is guaranteed for the instruments.

Two- and Three-pole Relays

KURMAN ELECTRONICS CORP., 35-18 37th St., Long Island City 1, N. Y., announces a new line of two- and three-pole relays, Series 16. This type is designed so that the armature is insulated from the contact arms by a bakelite link providing insulation good to 1,500 volts between all contacts and ground. Rated for 2-watt operation, the coil will dissipate as much as 4 watts in continuous operation without

BH SPECIAL TREATED FIBERGLAS SLEEVING



HEAT RESISTANT TO 1200°F!

SNUB TEST

Proves BH Non-Fray Feature

Make this test yourself. Tap a piece of ordinary saturated sleeving on your desk top and see how easily it frays. Then do the same with BH *Extra Flexible* Fiberglas Sleeving. It only fuzzes a little—doesn't break down—doesn't fray.

THE RESULT

BH *EXTRA FLEXIBLE* FIBERGLAS SLEEVING

2 WAYS BETTER

NON-FRAYING • NON-STIFFENING

IF YOU NEED an electrical insulation that's not affected by temperatures up to 1200°F., yet is unusually flexible, workable and durable, you'll find it in BH Special Treated Fiberglas Sleeving. Even in direct contact with heat units this remarkable sleeving won't burn.

Reason? It's made of inorganic Fiberglas and treated by the exclusive BH process. No saturant is used, yet the sleeving won't fray when cut and it is *permanently* flexible. In addition to many other properties it is moisture, oil and grease resistant . . . works easier, simplifies assembly and lasts longer. Made in natural color only—all standard sizes. Get your free samples today and compare!

HERE'S ANOTHER NON-BURNING SLEEVING

BH *Extra Flexible* Fiberglas Sleeving won't burn because both yarns *and* impregnation are non-inflammable. This high quality sleeving has all the advantages of pure Fiberglas, is toughened against abrasion, is non-fraying and non-stiffening. It lasts indefinitely without rotting or cracking—the ideal all-purpose electrical insulation for all kinds of industrial equipment and home appliances. Available in all standard colors and sizes from No. 20 to 5/8", inclusive. Put it to the toughest tests you know and watch the results!

ALL BH PRODUCTS AVAILABLE IN STANDARD 36" LENGTHS AND 500-FT. COILS

BH PRODUCTS

ALSO SLOW-BURNING IMPREGNATED MAGNETO TUBING • SLOW-BURNING FLEXIBLE VARNISHED TUBING • SATURATED SLEEVING • A.S.T.M. SPECIFICATIONS

BENTLEY, HARRIS MANUFACTURING CO.

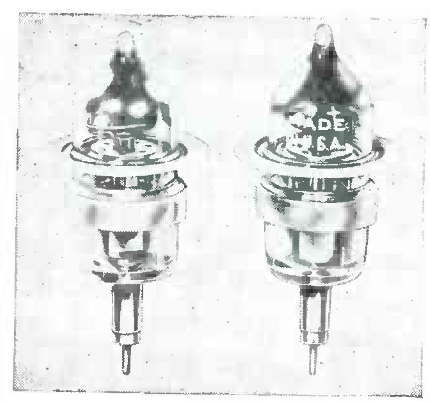
Dept. E Conshohocken, Penna.

overheating. Any two- or three-pole contact combination is available. The contacts are rated to carry 2 amperes at 100 watts. A coil may

be selected for any d-c voltage between 0.5 and 150 volts, and any a-c voltage between 3 and 500 volts. The approximate dimensions are 2 x $1\frac{5}{16}$ x $1\frac{3}{4}$ inches. The weight is approximately 4 ounces. Additional information may be obtained in Bulletin 1646.

Microwave Tubes

SYLVANIA ELECTRIC PRODUCTS, INC., Two new vhf triodes are particularly suitable for application to relatively simple wave-guide systems for many



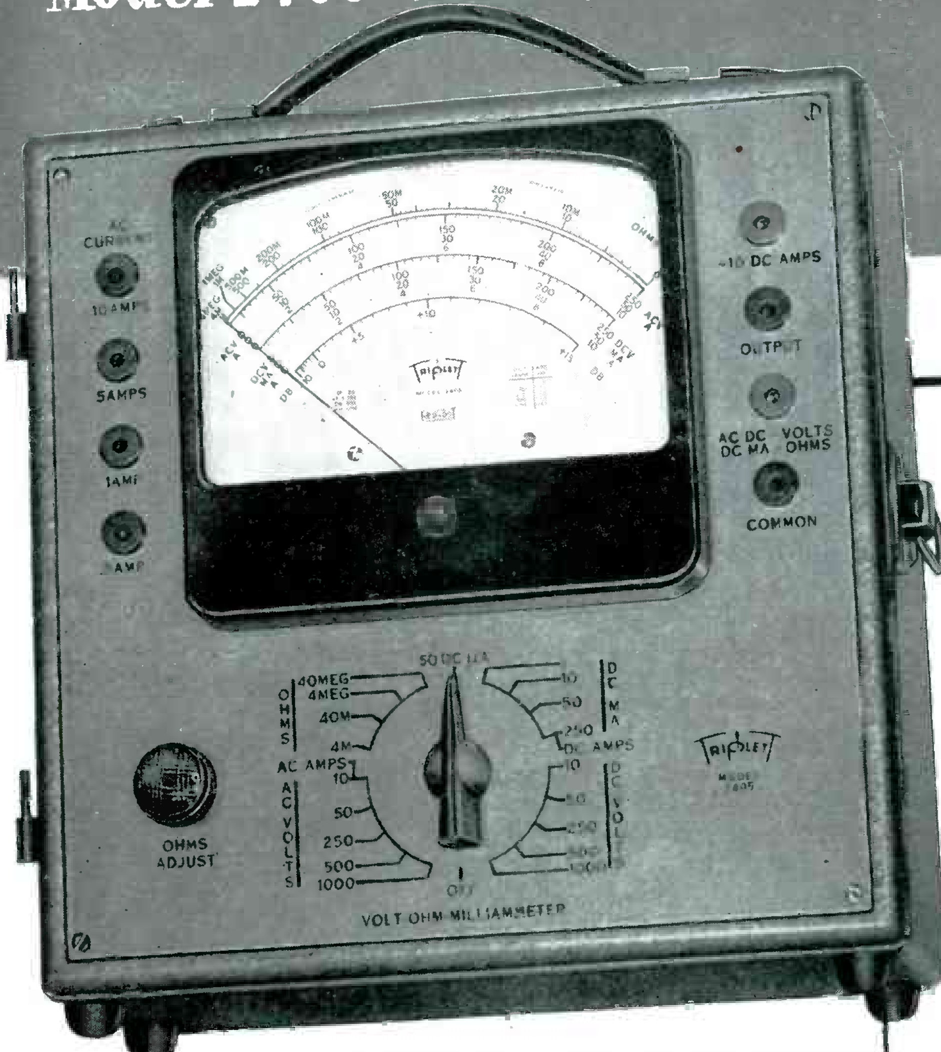
industrial electronic control, inspection and sorting applications. The new tubes feature streamlined cathode assembly, planar grids, minimum interelectrode capacitance, minimum transit-time effect and low power-input requirements. The type 2C36, shown at left, and type 2C37, shown at right, measure only $2\frac{1}{8}$ inches overall.

Welding Timer

WELTRONIC CO., 19500 West Eight Mile Road, Detroit 19, Mich. The Model 120-75 timer-contactor for resistance welders uses only two relays and is built to mount on either

Model 2405 Volt • Ohm • Milliammeter

25,000 Ohms per volt D.C.



Specifications

NEW "SQUARE LINE" metal case, attractive tan "hammered" baked-on enamel, brown trim.

√ **PLUG-IN RECTIFIER**

Replacement in case of overloading is as simple as changing radio tube.

√ **READABILITY**

The most readable of all Volt-Ohm-Milliameter scales—5.6 inches long at top arc.

√ **RED • DOT LIFE-TIME GUARANTEE**

on 6" instrument protects against defects in workmanship and material.

New **ENGINEERING** • *New* **DESIGN**
New **RANGES** •

(50 RANGES)

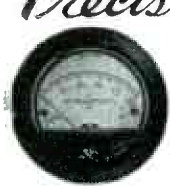
Voltage:	5 D.C. 0-10-50-250-500-1000 at 25000 ohms per volt. 5 A.C. 0-10-50-250-500-1000 at 1000 ohms per volt.
Current:	4 A.C. 0-.5-1-5-10 amp. 6 D.C. 0-50 microamperes—0-1-10-50-250 milliamperes—0-10 amperes
4 Resistance	0-4000-40,000 ohms—4-40 megohms.
6 Decibel	—10 to +15, +29, +43, +49, +55.
Output	Condenser in series with A.C. volt ranges.

Model 2400 is similar but has D.C. volts Ranges at 5000 ohms per volt.

WRITE FOR COMPLETE DESCRIPTION.

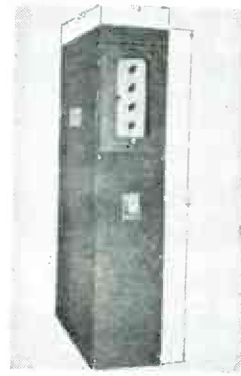
STANDARDS ARE SET BY TRIPLETT

Precision first ... to last



Triplett

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO the right or left side of the welder. Brackets are provided for B- or



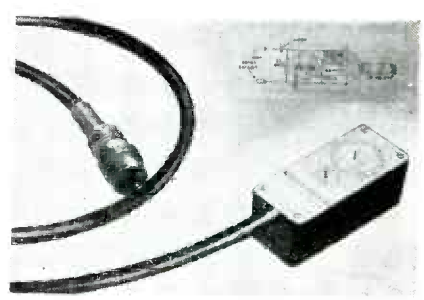
C-size ignitron tubes and adapters for A-type tubes can be supplied. The timing element itself can be plugged in or removed easily. A glass cover allows viewing the position of controls without their being immediately accessible. The unit measures 8½ x 20 x 40 inches.

Turntable Motor

ALLIANCE MANUFACTURING Co., Alliance, Ohio, has announced the Phonomotor, Model 80, which features uniform table speed. Motor and idler plate are shock-mounted to reduce vibration and forced ventilation is achieved by a fan. The motor turns at 78 rpm, operating from a 110-volt 60-cps line.

High Frequency Probe

ALFRED W. BARBER LABORATORIES, 34-14 Francis Lewis Blvd., Flushing, N. Y. A practical answer to the problem of measuring voltages in very high frequency circuits is offered in the Model 29 high fre-



quency probe. Most existing probes have an input capacitance of 5 micro-microfarads or more. The effect of loading and detuning of very high frequency circuits is therefore greatly reduced in the new probe which has an input capacitance of

0.5 to 1 micromicrofarad, extending the range of measurements ten times, from 50 to 500 megacycles. The new probe, replacing the standard probe of the Model VM-27 vacuum tube voltmeter, is adjusted accurately to one-tenth the sensitivity of the standard probe. Consequently, all voltage readings are exactly ten times the indicated values. Thus the voltmeter has full-scale ranges of 10, 30, 100, 300 and 1,000 volts.

Frequency Meter and Tachometer

COMMUNICATIONS MEASUREMENT LABORATORY, 120 Greenwich St., New York 6, N. Y. The Model 1800 is a visual frequency meter which can be used to determine frequencies in

the range of 10 to 20,000 cps with an overall accuracy of better than 1 percent. The addition of a stroboscopic lamp allows its use as an electronic tachometer. Pulses of practically any wave form up to 50 micro-seconds duration can also be measured. External recorders or meters can be used for graphical or remote indications.

Vacuum-tube Voltmeter

GENERAL ELECTRIC CO., Schenectady 5, N. Y. announces a new vacuum-tube voltmeter identified as Type AA-1. It has ten calibrated voltage ranges, the lowest being 10 millivolts full scale for readings as low as 1 millivolt, and the highest 300 volts. The complete rating is from 0 to 0.01 up to 0 to 300 volts so that a wide range of measurements can be made without reading below one-third of the full-scale value. For all frequencies between 15 cycles and 500 kilocycles the accuracy is ±3 percent; and between 500 kilocycles and 1 megacycle it is ±5 percent. The instrument can be used with rea-

For faster product assembly and better product performance

We stand ready to produce and deliver to your most exacting specifications superior, METALTEX copper Circuit Connectors in any gauge or pattern for use on low-voltage electrical appliances such as hearing aids or controls.

Also METALTEX non-woven close-mesh screening in any size, shape or pattern desired. METALTEX screening is available in copper or copper-alloy coated gasket shims to any tolerance. (Not illustrated)

Both are precision products of exceptional uniformity with quality evident in every detail of construction and finish.

Further, we are in a position to contribute engineering skill and know-how to the interpretation and solution of your problems.

Mail coupon below for samples or send us your blueprints.

METALTEX screening is produced by the electroplating process, which assures maximum accuracy in perforation and pattern.

THE HEADDEN COMPANY
17 Academy St., Newark 2, N. J.

Judge the quality for yourself. Mail coupon at right.

THE HEADDEN COMPANY
17 Academy St., Newark 2, N. J.
Send samples as checked below:
☐ METALTEX Non-Woven Screening
☐ Circuit Connectors

Company..
Address..
Signed..

sonable accuracy between 10 to 15 cycles, and 1 to 1.5 megacycles.

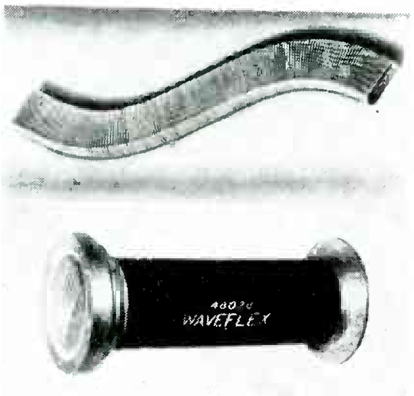
The instrument is also graduated in decibels and covers a range of minus 65 to plus 45 from a reference level of 6 milliwatts into 500 ohms. The input resistance is 2 megohms. A ten-position pushbutton switch mounted on the front panel allows

any working range to be selected without passing through intermediate ranges.

The vacuum-tube voltmeter is contained in an aluminum case having a sloping front panel which supports the indicating instrument. For convenience in carrying, a leather handle is attached to the top of the case.

Flexible Wave Guides

TITEFLEX, INC., 500 Frelinghuysen Ave., Newark 5, N. J. Because it is frequently desirable to substitute a flexible section of wave guide for a more complicated fitting composed

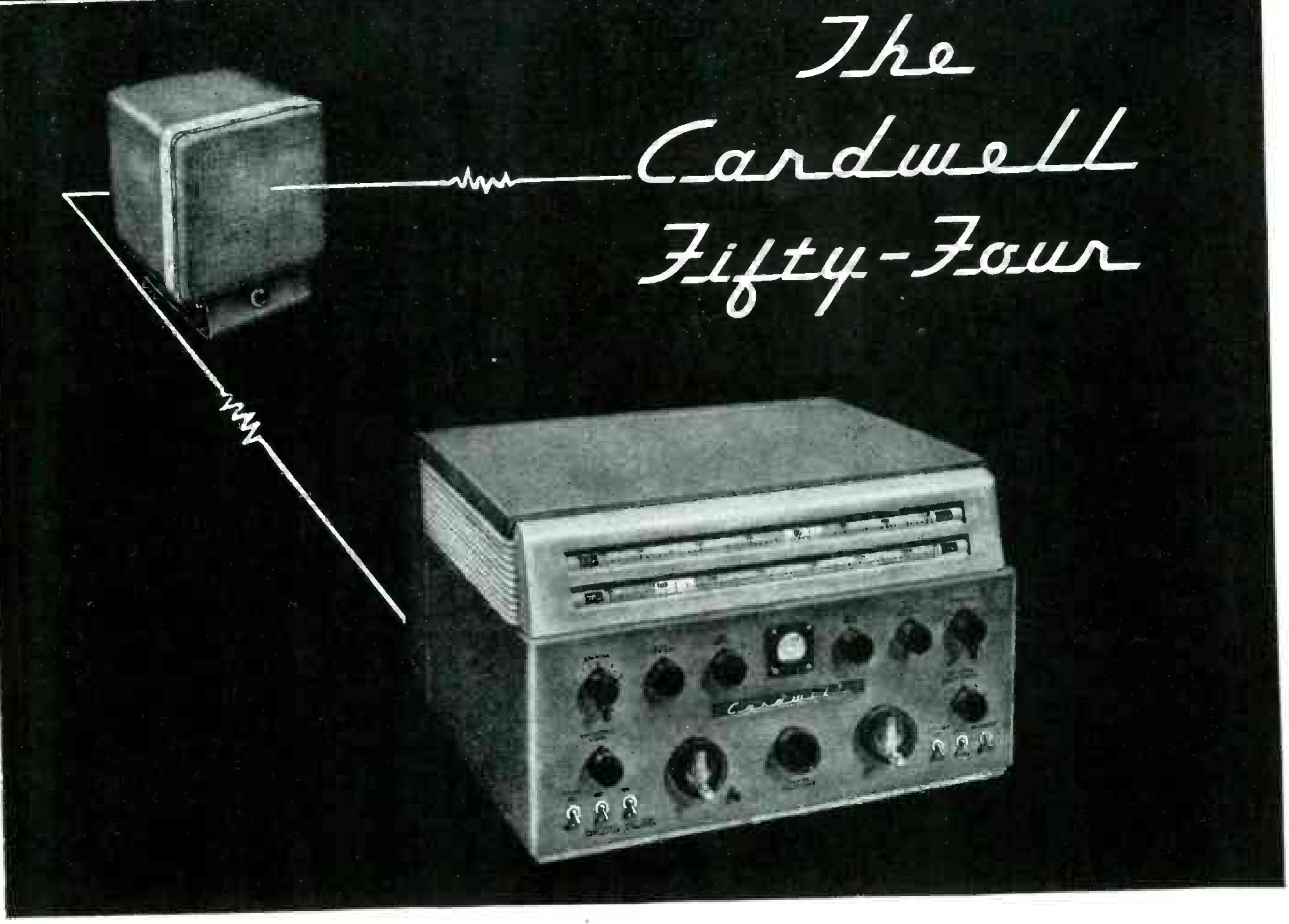


of bends and angles, the various microwave conductors made from flexible tubing are necessary. Illustrated are a section of tubing and below it, a finished wave guide.

Railroad Antenna

AMERICAN PHENOLIC CORP., Chicago 50, Ill., has designed a broad band 160 megacycle ground plane antenna

IT'S AS GOOD AS IT LOOKS!



the first really new communications receiver in years

The crowd was so dense around the Cardwell Fifty-Four at the Radio Parts Show in Chicago that we thought it would be only fair to give you another look at it. Here it is. Check and compare these 18 outstanding features—then plan to order by September.

1. Full Turret Type R.F. Section.
(Sturdy cast aluminum construction assures absolute mechanical and electrical stability.)

2. Wide Frequency Coverage.
(Range .54 to 54.0 mcs. Basic turret covers .54 through 40 mcs. Extra coil strip supplied with set extends range to 54 mcs. and can be installed in ten minutes using only a screwdriver.)

3. Secondary Frequency Standard.
(Unique type crystal calibrator provides check points of either 100 or 1000 kcs. and can also be used to check sensitivity or realign set.)

4. "Custom Built" Gang Condensers by Cardwell.
(STANDARD OF COMPARISON.)

5. Variable Selectivity Crystal Filter.
(Combined with variable selectivity I.F. amplifier circuit allows choice of 5 degrees of selectivity—three with crystal, two without.)

6. Exceptionally Good Signal to Noise Ratio.
(Two grounded grid R.F. amplifier stages assure actual receiver noise less **than 6 db above** thermal!)

7. New Type Noise Limiter.
(A really effective aid in reducing local ignition interference and similar noises.)

8. Electrical Band Spread.
(Band spread scales, excluding standard broadcast, calibrated directly. Arbitrary scale 0-100 also visible on each setting.)

9. Large Direct Reading Precision Dials.
(Excellent visibility—pointer travel better than $10\frac{1}{2}$ inches on every range—velvet smooth dial action that is a pleasure to use.)

10. Temperature Compensated Oscillator.
(Stability is better than 25 parts per million per degree centigrade. V.R. tube maintains maximum frequency stability against line voltage fluctuations.)

11. Mechanical Coupling Provisions.
(Control shafts are brought out at rear for linkage to other units such as a transmitter exciter.)

12. All Miniature Tubes.
(18, including rectifiers.)

13. Threshold Squelch.
(Operating level controllable from 5 to 100,000 micro volts.)

14. Panoramic Adaptor Jack.
(Provision is made for connecting a panoramic adaptor unit.)

15. All Aluminum Unit Construction.
(Receiver and power supply combined in one sturdy lightweight unit $18\frac{1}{4}$" wide x 16" deep x 11" high. Weight approximately 70 lbs.)

16. Heavy Duty Speaker.
(Compact tilting unit $9\frac{1}{4}$" wide x $8\frac{1}{4}$" deep x 11" high for wall or table mounting. Angle of sound projection adjustable to individual preference.)

17. Eight Watts Audio Output.
(Push-pull class AB—with four output impedances. Connections are provided for feeding the audio section from an external source such as phono pick up or microphone.)

18. Rack Mounting Model.
(Will be available.)

WRITE FOR COMPLETE TECHNICAL BULLETIN

THE ALLEN D. CARDWELL MANUFACTURING CORP.

MAIN OFFICE & FACTORY: 97 WHITING STREET PLAINVILLE, CONN.

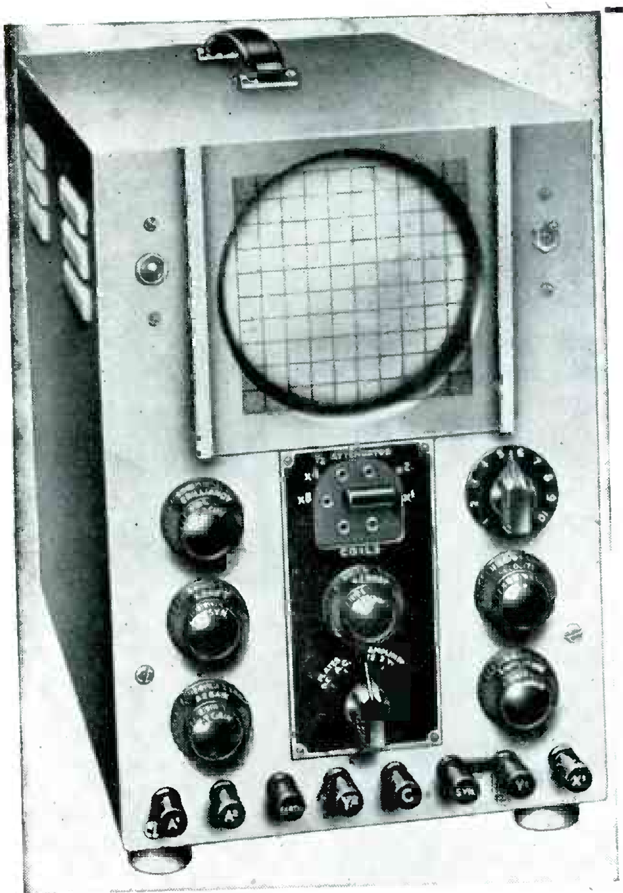
for two-way communication between train and fixed station and end-to-end service. This antenna utilizes the metal top of the car for its ground plane. It is fed by armored 52-ohm coaxial transmission line. The radiation pattern in the horizontal plane is circular in shape and the voltage standing wave ratio is less than 1.5 to 1 from 152 to 162 mc. The gain of the antenna is 0.5 decibel less than a dipole. The assembly is constructed of steel, heavily cadmium plated and has an overall height of 14½ in. It is secured to the car by three ¼-20 bolts.

F-m Railroad Equipment

WESTINGHOUSE ELECTRIC CORP., Box 868, Pittsburgh 30, Pa., has designed f-m equipment for short-range communication, as between locomotive and caboose, using the 152-162 megacycle band. There are fixed station assemblies for use in stations and yards, and mobile assemblies equipped with rotary converters to make equipment operable from either 32 or 64-volt d-c supplies. The equipments are crystal controlled and otherwise designed for foolproof operation in this exacting service.

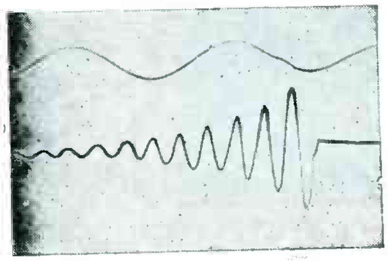
Aircraft Transmitter

MAGUIRE INDUSTRIES, INC., 1437 Railroad Ave., Bridgeport, Conn., announce the Skyline aircraft radio transmitter, Model ART-1 comprising an 8-watt, 3,105-kc crystal-controlled unit with a working range of from 15 to 30 miles on a fixed antenna. The necessity of a trailing wire is eliminated by an antenna loading coil, adjustable for resonance with any fixed antenna from 11 to 40 feet long. Storage battery drain is 5 amperes while actually transmitting. The transmitter and



presenting the

DOUBLE



BEAM

OSCILLOGRAPH

Model 339 D. B. OSCILLOGRAPH, PRICE £40 Net F.O.B.

PERFORMANCE DATA

TIME BASE . . . 5 — 250,000 c.p.s.

AMPLIFIER	Gain	Frequency Band in c.p.s.	Sensitivity mV.RMS/m m
1 stage	28	10 — 100,000	43.0
2 stage High Gain	900	10 — 100,000	1.3
Wide Band	106	10 — 2,000,000	10.0

Seven years after its appearance in 1938, the Cossor Double Beam Oscillograph is still unique. The intrinsic value of the technique introduced by this instrument, which provides true *simultaneous indication of any effects* on a common time axis, has long been proved in all fields of research and production testing—both on recurrent and transient work. It is an understatement to say that practice has revealed no sphere of investigation where its use is not at least advantageous. Although of enhanced performance, the instrument is in essence, an oscillograph of conventional design in which, through the interchangeability of COSSOR single and double beam trapezimum-corrected tubes, true double beam technique has been provided without inherent limitations or distortions. These fundamental qualities have been responsible for its selection as the standard Oscillograph for most of the Allied Nations' Armed Services. Thus precluded earlier from acquainting American users of the "double beamer", we are now able to make good this omission and satisfy also the friendly urging of A.E.F. Technicians who have all wanted "the folks back home" to know about it.

A. C. COSSOR Ltd

INSTRUMENT DIVISION

HIGHBURY LONDON N.5. ENGLAND

CABLE ADDRESS: Amplifiers London

CABLE CODES: Bentley's

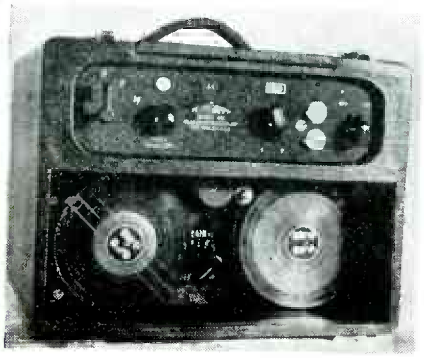
power supply are incorporated in a single housing and are remotely controlled. This feature facilitates the mounting of the equipment since the unit may be fastened in any out-of-the-way place and only the remote control box need be placed within reach of the pilot.

Beam Antenna

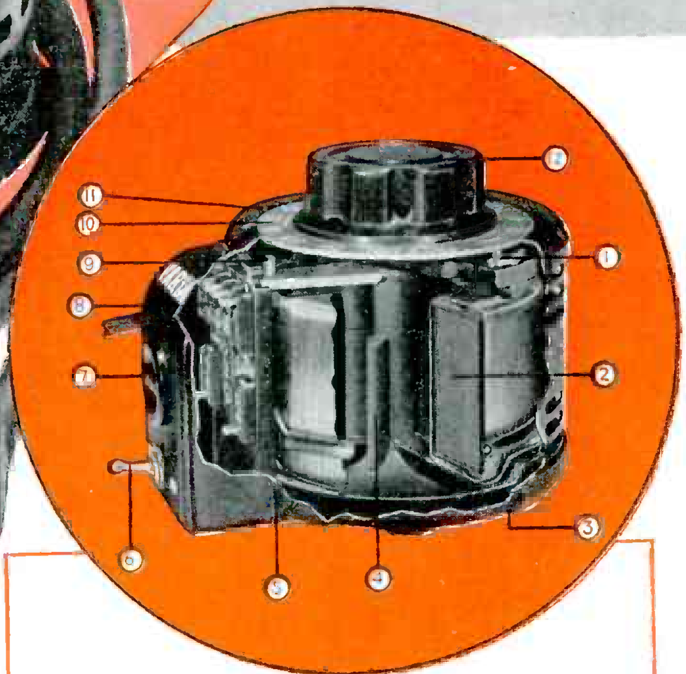
THE WORKSHOP ASSOCIATES, 66 Needham St., Newton Highlands 61, Mass. Designed primarily for operation in the amateur 2-meter band, a 6-element beam antenna is now available for either point-to-point use or adapted to rotary motion. The radiating and reflecting elements are made of half inch aluminum tubing sealed in the ends and supported in two heavy plastic heads. The half-power angle of either the vertical or horizontal pattern is between 60 and 70 degrees. Fifty-ohm coaxial line is used to feed the array.

Film Dictating Machine

MILES REPRODUCER CO., INC., 812 Broadway, New York 3, N. Y. The Filmgraph Model HM electronic dictating machine is completely self-contained. The recording medium is a film, $\frac{3}{8}$ inch wide, which provides 100 sound tracks. A numbered dial allows quick selection of the desired track and a footage dial completes the indexing mechanism. Each film roll provides about 33 hours of re-



NEW VARIACS with these 12 Features



for

Improved Performance
Greater Convenience
Longer Life

● This new Type V-5 VARIAC replaces the popular Type 200-C. Through entirely new design and radical changes in basic structure the new model is 25% lighter, with the same rating of 860 va. This is achieved both through improved magnetic performance of the core and less copper, and through use of aluminum in most of the structure.

Some of the new VARIAC's many features are listed at the right. Externally, the new VARIAC has been streamlined to eliminate all sharp corners. The cord on the mounted model is arranged to be wound around the VARIAC, plugged into the outlet, and then used as a carrying strap.

This is the first radical change in basic design of the VARIAC since it was introduced by G-R almost 15 years ago. These many changes were made not to dress up the VARIAC in a new case but to provide real improvements to better its performance, increase its convenience and lengthen its life, and to be sure that when you use a VARIAC you are using the best means possible for controlling any alternating-current operated device where perfectly s-m-o-o-th variation in voltage is desired.

TYPE V-5 860 va VARIAC

TYPE	STYLE	PRICE
V-5	Basic (115-volt input) unmounted model	$16.50
V-5M	Above with protective case around winding	17.50
V-5MT	A V-5 with protective case, terminal cover, 6-foot cord, switch and outlet	20.00
V-5H	Same as V-5, except for 115- or 230-volt input	21.50
V-5HM	Same as V-5M, except for 115- or 230-volt input	22.50
V-5HMT	Same as V-5MT, except for 115- or 230-volt input	25.00

WRITE FOR COMPLETE DATA

1. *New G-R Unit Brush — low sprung weight reduces hammering and arcing under vibration — correct pressure provided by coil spring — holder cannot make contact with winding and cause short-circuit — brush changed quickly without tools.*
2. *New grain-oriented core of cold-finished silicon-steel with guaranteed maximum core loss — strip wound.*
3. *Three rubber feet prevent marring table top and make it unnecessary to screw units down to prevent slippage.*
4. *Aluminum structure contributes to greatly increased output per pound.*
5. *Only two screws hold both case and terminal cover — a screwdriver or a spare dime remove each in a second.*
6. *Heavy-duty switch breaks both sides of the line, in mounted models.*
7. *Polarity indication provided in convenience outlet — useful if one side of line is grounded.*
8. *Improved molded terminal plate protected by a metal, fiber-lined cover — molded barriers between terminals prevent short-circuits from whiskers on stranded wire — both screw and solder terminals — engraved circuit diagram shows normal VOLTAGES between terminals — 2 extra terminals for use with auxiliary transformers.*
9. *New resilient stop allows brush arm to bounce instead of break if you are too vigorous in rotating knob.*
10. *BIG calibration figures and extra points on dial — easy to read at a distance — easier to reset — pointer provided for panel mounting.*
11. *A single screw, readily accessible under dial, loosens shaft for reversing dial and knob to change from table to panel mounting without affecting brush or stop settings.*
12. *Newly designed, larger knob — easier to hold — easier to turn.*

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 950 N. Highland Ave., Los Angeles 38

cording at a cost of about five cents an hour. Various features, such as the rapid rewind, automatic voice-actuated starter and hearing-aid receiver (which can be used in place of the loudspeaker) make the device practical for operation by inexperienced personnel. Operated from a 115-volt, a-c outlet, the equipment measures 13¾ x 14¾ x 10 inches and weighs 25 pounds.

Tower Beacon

ANDREW CO., 363 E. 75th St., Chicago 19, Ill., has designed the type 300MM code beacon required by CAA

for radio towers over 150 feet high. The fixture accommodates two 500-watt prefocus lamps and is equipped with red pyrex filters and cylindrical fresnel lens. The beacon is 32¼ inches high.

Literature

Chemicals and Hardware. Walter L. Schott Co., Beverly Hills, Calif. announces that Catalog No. 46 is ready for distribution. The 16-page catalog contains a complete line of electronic hardware items and radio chemicals and may be obtained free of charge by writing to Dept. 125.

Stage Switchboard. Ward Leonard Electric Co., 31 South Street, Mount Vernon, N. Y. has prepared a 12-page bulletin describing a new line of electronic reactance dimmers for control of modern stage lighting. Bulletin 74 includes simple equipment suitable for a school auditorium and more complicated desk type switchboards for large theatres.

Quartz Crystals. Standard Piezo Co., Carlisle, Pa., manufacturer of quartz crystals has published a

16-page illustrated catalog describing its product. Standard units are available and a new midget series operating in the frequency range 900 to 20,000 kc and measuring 7/8 inch in diameter, 7/32 inch thick and weighing 1/2 ounce is featured.

Panoramic Handbook. Panoramic Radio Corp., 242-250 W. 55th St., New York 19, N. Y. Although this booklet is designed as an instruction manual for the use of the Model PCA-2 Panadaptor, it serves to show how the panoramic system of visual reception operates. Its 34 well-illustrated pages describe the various functions which can be performed, such as measuring the deviation caused by modulation in a frequency-modulated signal, as a modulation indicator and for the analysis of keying transients, as well as the accurate determination of carrier frequency. The price is 50 cents.

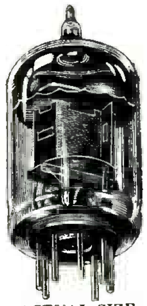
Electronic Pyrometer. Bailey Meter Co., 1050 Ivanhoe Road, Cleveland 10, Ohio. A 16-page bulletin No. 232 describes the new Pyrotron electronic potentiometer pyrometer and illustrates various indicating, recording and controlling combinations. Performance data and principles of operation are included in this bulletin.

Research Report. Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill. The 9th annual report of this Foundation occupies 20 pages and touches upon many electronic developments such as the magnetic wire sound recorder, cathode-ray tube screen, voltage regulator, radio and radar components and the a-c network calculator. In this publication are described other bulletins issued by the Foundation of interest to industry.

Resistor-Capacitor Catalog. Sprague Products Co., North Adams, Mass., has just issued a new 40-page catalog describing its line of resistors and capacitors, testing equipment and radio interference filters for radio service and experimental use.

Flow-Rate Meter. Fischer & Porter Co., Department 2N-4, Hatboro, Pa. Catalog 52-A describes an electronic low-flow-rate measuring instrument which indicates accurately drop by drop flow rates down to less than 5

more efficient ...in miniature



ACTUAL SIZE

With the aid of a little hand microphone, the ship's officer, speaking in a normal voice, can be heard by any vessel in the fleet. Contrast this to the ineffectual bellowings through the huge megaphone of yesterday. The trend of science has been to develop greater efficiency in miniature. It was true of the megaphone, it is true of the electron tube.

TUNG-SOL Miniatures offer many advantages, especially in high-frequency currents. They are more impervious to shock and vibrations. The glass bases have better dielectric properties. They offer lower lead inductance, lower inter-element capacitance and higher mutual inductance.

TUNG-SOL engineers will be glad to help you interpret your tube requirements in terms of Miniatures. TUNG-SOL is a tube manufacturer, not a set builder. The disclosures of your plans you make in consultation will be held in strictest confidence.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS, INC., NEWARK 4, NEW JERSEY

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 milliliters of liquid per minute and gases to less than 25 milliliters per minute. The Rota-Tronic remote instrument utilizes a servo motor and an electronic power relay as its principal indicating element.

Audio Publication. Audio Devices, Inc., 444 Madison Ave., New York 22, N. Y., publishes a 4-page monthly bulletin known as Audio Record, containing items of interest to those using transcriptions. Among the items of interest in the current issue is a glossary of disk-recording terms.

Vhf Antenna. Radio Corporation of America, Camden, N. J. The type CA-1a (non-directional) and type CA-2a (directional antennas are described in a 2-page leaflet issued by the company. The antenna, which is of the ground-plane type, can be used in the frequency range 30 to 170 mc.

Loran Publication. The Bureau of Ships, Navy Department, has announced that it will place on public sale a 60-page profusely illustrated handbook entitled "Loran Handbook for Shipboard Operators." Originally confidential, the pamphlet is now available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. at 30 cents a copy.

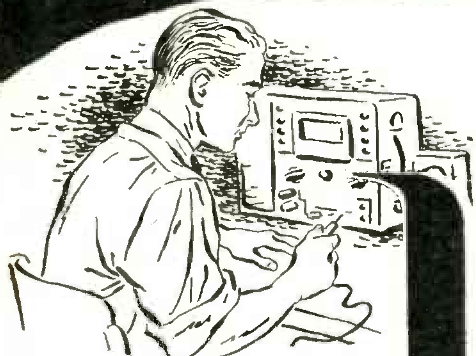
Amateur Publication. General Electric Co., Schenectady, N. Y. Titled Ham News, Vol. 1, No. 1 of a new publication addressed to the amateur radio man leads off with a ten-meter transmitter description featuring the type 813 tube. Two half-page departments, Questions and Answers, and Tricks and Topics may well prove of interest to engineers. The four-page leaflet will be published bi-monthly.

Microphone Catalog. Universal Microphone Co., Inglewood, Calif., has published its first new catalog since 1941; eight pages in standard looseleaf size list the entire line of microphones and recording components. A preview of the 1947 line is also given.

Belt Manual. J. F. D. Manufacturing Co., 4111 Fort Hamilton Parkway, Brooklyn, N. Y. Any service

TWO STAR PERFORMERS BY RCP

fully engineered for better industrial testing



Here are two fine RCP instruments that will serve a wide variety of test applications in your plant. Developed through years of scientific research and engineering, these testers represent the most advanced types of instrumentation for modern industry. Greater than ever in technical refinements, manufactured to close tolerances in every detail—RCP instruments make testing easier, faster, more exact. Write for Catalog No. 128 and see why RCP gives you more instrument value—feature for feature, dollar for dollar.

WRITE TODAY

for the new RCP catalog showing the complete line of standard test instruments.

ultra sensitive multitester MODEL 488A

Dual D.C. sensitivity of 1,000 ohms per volt and 20,000 ohms per volt. Design and construction have been field-proven for sustained performance by many of the country's largest manufacturers of radio, electrical and electronic products.

★ A.C. sensitivity 1,000 ohms per volt ★ Wide-scale, 2% accurate, 4½" meter with movement of 50 microamps. ★ Readings as low as 1 microamp. and 0.25 ohms ★ All multipliers are matched and accurate to 1% ★ Batteries are readily accessible and easily replaced ★ Overall accuracy of 3% on D.C. and 5% on A.C. voltages and currents ★ Long, insulated high voltage test leads ★ Plug-in type copper oxide rectifier

RANGES D.C. Voltmeter: 0/3/12/60/300/600/1200/6000 volts • A.C. Voltmeter 0/3/12/60/300/600/1200/6000 volts • Output Voltmeter: 0/3/12/60/300/600/1200/6000 volts • D.C. Microammeter: 0/60/300 microamps. • D.C. Milliammeter: 0/3/20/120/600 milliamps. • D.C. Ammeter: 0/12 amps. A.C. Ammeter: 0/3/6/12 amps. • Ohmmeter: 0/3000/300,000 ohms, 30 megs.

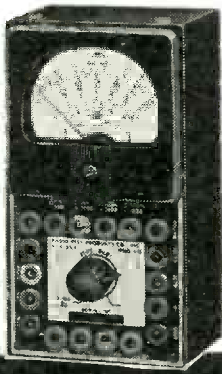
Supplied ready to operate, complete with self-contained battery, test probes and a convenient carrying case with removable cover. **Price: $71.50**

pocket multitester MODEL 449

This highly accurate, vest pocket size model is custom-built for general circuit testing and fast trouble shooting. Despite its small size, this meter gives you the accuracy of any large instrument. It will perform dependably anywhere in your factory.

★ High and low ranges ★ 3" square, high-visibility meter—accurate to 2% ★ Sensitivity movement of 200 microamps. (5,000 ohms per volt) ★ Readily accessible battery, mounted in spring clips ★ Combines 6 instruments in one miniature unit ★ Metallized, matched voltage multipliers with tolerance of 1% ★ Sensitive zero meter adjusting screw

RANGES D.C. Voltmeter: 0/5/50/250/1000 volts • A.C. Voltmeter: 0/5/50/250/1000 volts • Output Voltmeter: 0/5/50/250/1000 volts • D.C. Milliammeter: .5/10/100/1000 milliamps. • Ohmmeter: 0/1000/10,000/100,000/1,000,000 ohms • Decibel Meter: —6 to +10, —14 to +26, —28 to +40, —40 to +52 db. Range is calibrated to line of 500 ohms impedance. For other impedances, correction charts are supplied.



Housed in black metal case, complete with self-contained batteries. **Price: $24.50**

RADIO CITY PRODUCTS COMPANY, INC.

127 West 26th Street, New York 1, N. Y.

Manufacturers of Precision Electronic Limit Bridges • Vacuum Tube Voltmeters • Volt-Ohm-Milliammeters • Signal Generators • Analyzer Units • Tube Testers • Multitesters man or dealer may obtain a copy of the 64-page catalog which contains information on replacing woven fabric radio dial belts for over 1,500 models of radio receivers.

Mycalex Booklet. General Electric Co., Pittsfield, Mass. A new 24-page booklet describes the properties, available types, fabricated parts and machining factors for six grades of Mycalex, the stone-like mica and glass insulator.

Transformers. Acme Electric & Manufacturing Co., Cuba, N. Y. A 12-page well-illustrated catalog describes the complete line of power, audio and luminous tube transformers together with the manufacturing facilities available. Bulletin LT-156 describes the luminous tube transformers in more detail.

Strain Gages. Statham Laboratories, 8222 Beverly Blvd., Los Angeles 36, Calif. A price sheet and catalog pages are available describing the strain gage operating on the principle of a change in the electrical resistance of a stretched wire. A line of pressure transmitters, and accelerometers are fully explained and described.

Resistor Catalog. International Resistance Co., Philadelphia, Pa., has just started distribution of Service Catalog No. 50 describing the standard line of fixed and variable resistors now in manufacture.

Variable Autotransformers. Superior Electric Company, Bristol, Conn. Powerstats in the 2-kva range are described in the new Bulletin 30. These variable autotransformers provide outputs of zero to somewhat higher than line voltage and feature fuse protection. A price list of all types is included with the catalog.

Audio Components. Altec Lansing Corp., 250 W. 57th St., New York 19, N. Y. Components such as loudspeakers, audio transformers and package units like amplifiers are described on separate sheets or folders furnished by the company which are available upon request.

Insulating Tubing. Industrial Synthetic Corp., 60 Woolsey St., Irvington, N. J. Voltron is a flexible plastic for electrical insulation. When used as a transparent sleeving insulation, it permits the immediate in-

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spection of soldered or solderless connections without removal of the sleeve. It has high abrasion and wear resistance. Test data is presented in a brochure available from the company.

Testing Plastics Parts. Society of the Plastics Industry, Inc., 295 Madison Avenue, New York 17, N. Y. Advance chapter No. 4 of the SPI Handbook has been designed as a guide to industry in setting up its own performance tests on plastics parts. The general principles of product testing are set forth in a 14-page booklet.

Galvanometers. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. Catalog ED comprising 37 pages of complete specifications, prices and illustrations for the extensive line of d-c and a-c galvanometers and astatic dynamometers is now available.

Meter Catalog. Burlington Instrument Co., Box 589, Burlington, Iowa, has recently issued Catalog No. 46 describing a complete line of indicating instruments and auxiliary equipment. Complete dimensional drawings and layouts, ranges, scale divisions, resistances and list prices are included.

Power Transformers. Jefferson Electric Co., Bellwood, Ill. Bulletin 461-PCT describes in twelve well-illustrated pages how to choose the proper power circuit transformers for certain capacity requirements. Transformer dimensions and wiring diagrams are included.

Platinum-Gold-Silver. The American Platinum Works, Newark 5, N. J. A 4-page bulletin describes the various uses of the noble metals particularly those in the platinum series with their industrial applications.

Switchboard Meters. The Norton Electrical Instrument Co., Manchester, Conn. Catalog No. 17 describes in as many pages the line of switchboard and portable meters now available to the public by the company. Ordering information and prices are given.

Wire-Wound Resistors. Shallcross Manufacturing Co., Collingdale, Pa. A series of bulletins and sheets describes the complete line of wire-wound resistors, resistance standards, low resistance test sets, precision switches, d-c bridges and measuring apparatus manufactured by the company.

Tube Characteristics. General Electric Company, Schenectady, N. Y. has filled 37 pages in publication ETR-15 with characteristics and ratings, base connections and outline drawings of receiving-type electronic tubes.

New Microphone. Electro-Voice, Inc., 1239 South Bend Avenue, South Bend 24, Ind. A 4-page bulletin describes the new Model 950 Cardax microphone, a crystal type with cardioid response. A filter can be switched in to change the flat response to a rising response at high frequencies.

X-Rays in the Foundry. North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y. offers a new 4-page booklet No. R1023, titled X-Ray As a Foundry Control Tool. The booklet is a reprint of an article which appeared recently in a trade publication.

Conductivity Cells. Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J. A comprehensive survey of conductivity checking equipment for laboratory and plant use has been provided in a catalog which deals primarily with a large selection of conductivity cells for the checking of various liquids under different conditions.

Servomechanisms. G. C. Wilson & Company, Box 389, Chatham, N. J., has prepared a memorandum describing the uses of servomechanisms for control, indication and computation. A single page contains the basic information and a brief history of wartime use of the servo.

Supersonics. G. C. Wilson & Company, Box 389, Chatham, N. J. Supersonics is the science dealing with sound-like waves above the audible range; it is usually considered being above 20,000 cycles per second. A memorandum summarizing supersonic phenomena and methods of generating supersonic waves is presented.

Radio Encyclopedia. Howard W. Sams & Co., Inc., 2924 E. Washington St., Indianapolis, Ind., will begin distribution of a radically different radio service encyclopedia after June 15. Subscribers to the new service have been assured delivery of a complete service folder within 90 days after a given set goes on sale.

Powder-Metallurgy. North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y. offers a new 4-page booklet R1022, titled Geiger-Counter Used in Powder Metallurgy. Data is presented to illustrate how analysis time has been reduced in some cases from two days to 35 minutes. This booklet is a reprint of an article which recently appeared in a trade publication.

Instrument Rectifier. Conant Electrical Laboratories, 6500 O Street, Lincoln 5, Neb. A 39-page booklet priced at 35 cents is now available which describes the use of instrument rectifiers with particular emphasis on types manufactured by this company. Several pages are devoted to characteristic curves of these rectifiers.

Switches. Centralab Division of Globe Union, Inc., Milwaukee 1, Wis. Selector switches of all kinds are described in a 32-page catalog recently issued by the company. Complete dimensional and mounting information is given for each type. Interstage shielding, mounting straps and other hardware are included.

Enamel Resistors. Ward Leonard Electric Co., 31 South Street, Mount Vernon, N. Y. has compiled Catalog D-2 describing wire-wound vitreous enamel resistors used by the radio, television and radar industries. Complete ordering information and list prices are given for fixed, adjustable, plaque, non-inductive and other types of resistors in various wattage ratings.

Wire Gage Comparer. American Smelting & Refining Co., 120 Broadway, New York 5, N. Y. A convenient table with sliding scale compares wire gage numbers with the diameter in inches according to Brown & Sharpe and Birmingham gages. The other side shows the melting and solid temperatures of solders with varying tin and lead content.

Precision Resistors. Ohmite Manufacturing Co., 4835 W. Flournoy St., Chicago 44, Ill. Bulletin No. 126 just issued gives detailed information on the complete line of Ohmite Rite-ohm ½ watt and 1 watt nonconductive wire-wound precision resistors. These resistors are accurate within plus or minus 1 per cent.

Lever Switches. General Control Company, 1200 Soldier's Field Road, Boston 34, Mass. Catalog No. 200 describes an interesting line of lever switches, multiple spring contact, pushbutton and multiple cam switches. Contacts can be furnished in locking and non-locking positions, and in many combinations of multipole, make-before-break and other special types. Complete ordering information and prices are furnished.

Snap Switches for Gaging. Micro Switch Division, Freeport, Ill. Bulletin No. 36 treats the special application of Micro Switches in the measurement of tolerances, go and no-go indications, high-speed mica gages and for automatic graduation engraving. The 16 pages are well illustrated.

Industrial Frequency Chart. Sherman Industrial Electronics Company, 503 Washington Avenue, Belleville 9, N. J. A convenient chart is available which indicates the industrial frequency spectrum from 60 cycles through X-ray frequencies. Various frequencies are identified with equipment used therein such as motor generators, spark-gap generators, and electronic high frequency generators. Formulas relating frequency to wavelength in meters as well as Angstrom units are given. The chart is black on white, smooth-coated blotter stock, size 4 x 7 inches.

Service Manual. Hoffman Radio Corp., Los Angeles, Calif., is now publishing a service manual in loose-leaf form covering all its products. Leaflet supplements keep the information up to date. Topically arranged, with schematic diagrams and line drawings, they are edited by the firm's technical publications section, and include descriptions, specifications, tube complement, normal operating voltage, normal operating currents, alignment procedure and other pertinent data.

NEWS OF THE INDUSTRY

Synchrotron; radio in Britain; French radio budget; Signal League; history of sonar; precipitation static; industrial news

Radio Station Census

TOTAL NUMBERS of standard broadcast, nonstandard broadcast, safety, and special radio stations in service as of June 30, 1945 are given as follows in the latest annual report of the Federal Communications Commission:

Class of Station	Number
Standard broadcast	931
High-frequency broadcast, f-m	53
Low-frequency relay	261
High-frequency relay	299
Television (experimental)	47
Television (commercial)	9
International broadcast	38
Developmental broadcast	27
ST (studio-transmitter)	8
Facsimile	3
Noncommercial educational	12
Aeronautical	411
Aeronautical fixed	98
Aircraft	2,998
Airport control	31
Flying school	5
Marker beacon	3
Municipal police	2,051
State police	477
Zone police	85
Interzone police	30
Forestry	940
Special emergency	566
Municipal fire	12
Geological	411
Motion picture	8
Provisional	142
Mobile press	3
Relay press	5

V-2 Rocket Tests

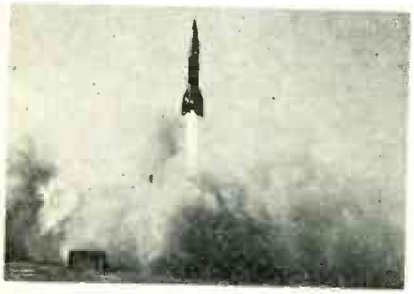
SIGNAL CORPS radar equipment especially modified for the purpose succeeded in tracking a 15-ton V-2 rocket throughout its entire hundred-mile-high trajectory during a recent test at White Sands Proving Ground, New Mexico. Radar impulses from a self-powered radio beacon in the nose and reflections from three tail surfaces were utilized in this first test. During flight, the receiver is triggered from a ground radar set by pulses picked up by antennas in plastic housings on the fins, causing the transmitter in the rocket to repeat the pulses back to the ground radar. This permits the complete trajectory to be recorded photographically. Conventional radar equipment also tracks the V-2 for its entire flight without the aid of beacons, simulating conditions of warfare.

Nerve center of the test area is a blockhouse with 10-foot-thick concrete walls and a pyramidal roof 27 feet thick at the apex, located 350 feet from the firing points. Narrow slots containing heavy flameproof

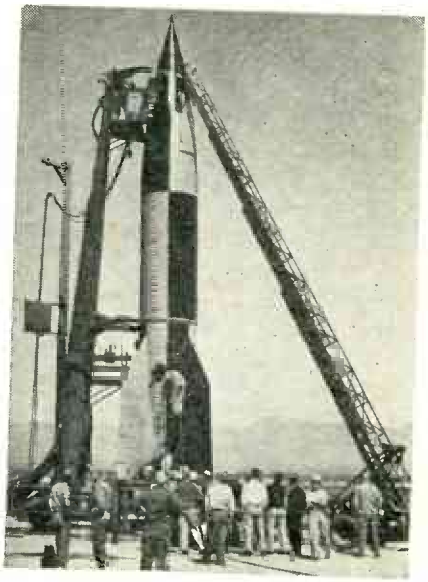
Master control room for V-2 tests, in blockhouse with concrete walls 10 feet thick. Each rocket has 20 channels for sending back by radio and radar the readings of the various instruments being carried into hitherto unexplored regions of interstellar space

Ground radar used for tracking V-2 rockets in flight

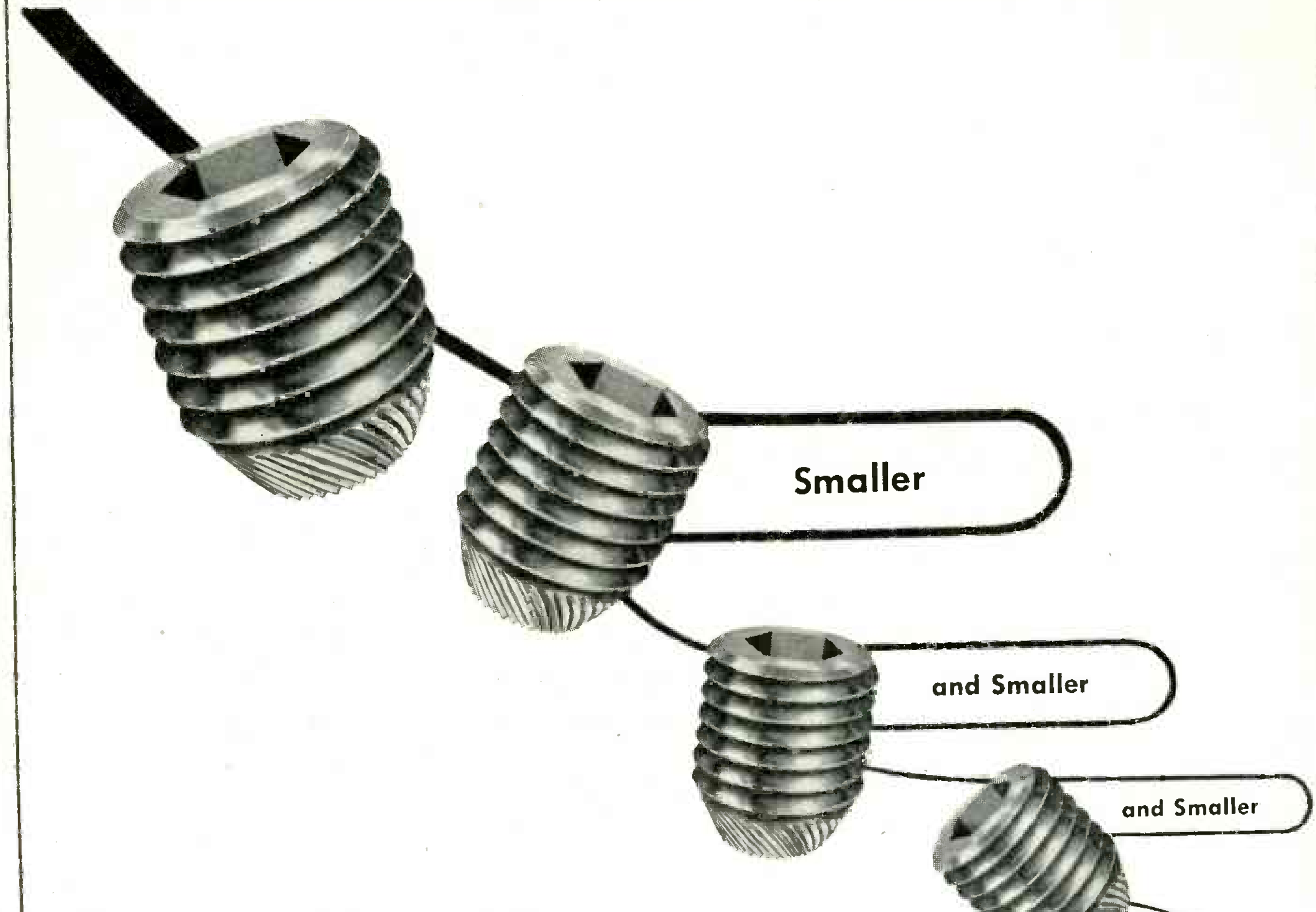
Control desk from which rocket can be fired and its fuel cut off by radio if trouble develops during flight



A V-2 rocket taking off from White Sands Proving Ground, New Mexico. It could easily carry a man up a hundred miles since the maximum 6-G acceleration is below that at which pilots black out, but getting down safely is another problem



Almost ready to go, with technicians making final adjustments. The vertical support and firetruck-type ladder are both part of the trailer used for transporting the rocket to its launching site



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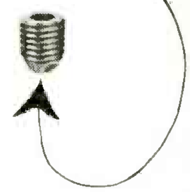

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. . . This extremely small "UNBRAKO" Socket Set Screw has the Knurled point

So tiny you can hardly see them, yet perfect in every detail, the reduced size of the "Unbrako" socket set screws with knurled point makes them invaluable in the electronics and small instrument field. Yet, they are made with all the accuracy, strength, and dependability of their larger counterparts, and like them they have the added feature of their points being *knurled* . . . the knurled point digs-in and holds firm . . . against even the most stubborn vibration! It can easily be backed-out and used again and again! The internal wrenching feature facilitates tight screws and compact designs, too. In sizes from #4 to 1½"; write for the "Unbrako" Catalog.

The "Unbrako" Socket Cap Screw (far right) and "Unbrako" Socket Set Screw with Knurled Thread, (right) which is also a *self-locker*, regardless of the style of point.

"Unbrako" and "Hallowell" products are sold entirely through distributors.

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JENKINTOWN, PENNA., BOX 596 • BRANCHES: BOSTON • CHICAGO • DETROIT • INDIANAPOLIS • ST. LOUIS • SAN FRANCISCO glass permit direct observation during launching, and periscopes provide indirect views. Here is the electric timer that sends signals accurate to 0.00001 second to tracking equipment, and radio equipment for communication with observation posts as well as for cutting off fuel to the rocket by radio in the event that something goes wrong. This radio remote control was used during an earlier test of a smaller American rocket, the WAC Corporal, when a fin broke off soon after launching.

Synchrotron Whirls Electrons

A VARIATION of the cyclotron that is capable of accelerating electrodes to energies of 300 million volts, by whirling each one 200,000 times inside a hollow doughnut, is now under construction at the University of California. This newest atom-smashing machine is the result of a phase stability theory developed by Professor Edwin M. McMillan, co-discoverer of element 93.

The new machine, called a synchrotron and scheduled for completion early next year, will enable atomic scientists to circumvent limitations imposed by the theory of relativity on the energies which can be reached in the acceleration of particles. In accordance with this theory, particles become heavier as their energy is increased. This increased weight results in a tendency of the particles to lag, arriving at the cyclotron-type gap too late to be pushed by the magnetic field. In the synchrotron the magnetic field is in-

• • •

NEWEST THEATRE TELEVISION

Rauland television projector installed in Civic Playhouse at Schenectady, N. Y. fills an 11 by 16-foot screen. The program is carried by microwave radio relay from General Electric television station WRGB

creased as the energy of the particles increases, compensating for the change in mass.

The synchrotron borrows the cyclotron idea of repeated acceleration in a circular path, but differs in construction and operation because the mass or weight of an electron is very small compared to that of the heavy particles—protons, deuterons, and alpha particles—accelerated in the cyclotron. Because the electron is so light, the increase in mass as the electron gains energy is proportionately huge, and appears at relatively low energies. At 300 million electron volts energy, an electron weighs 600 times as much as it does at rest.

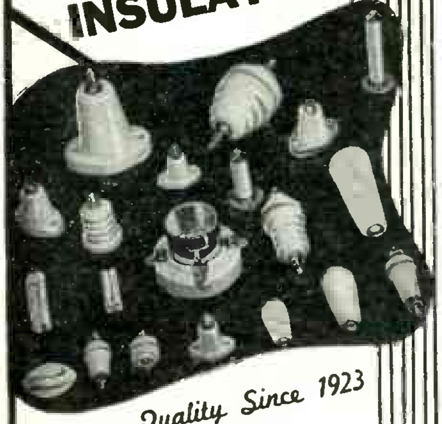
There is no limit to the number of times the electron can be accelerated, but the strength of the magnetic field limits the ultimate energy attained. When the field is no longer able to jerk the lagging projectiles up to the pushing point at the correct time, projectiles fall out of step and lose their acceleration. In the synchrotron now being built, this limitation will become effective at 300 million electron volts.

The machine will operate as a betatron up to 2 million electron volts, at which point it will begin to operate as a synchrotron. At 300 million electron volts the particles will have traveled around the circular pathway 200,000 times before emerging in a beam. With this electron energy, atom-smashing will mount a threshold. It may be possible to split protons and neutrons, and it will definitely be possible to study cosmic rays or mesotrons. A 300 million electron volt electron is itself a cosmic ray, and such a particle will produce cosmic ray showers such as occur in nature, under controllable conditions permitting studies heretofore impossible.

Empire State Building Gets New 61-Foot Antenna

THE LONG-FAMILIAR four-football antenna atop the Empire State Building has been replaced with a 61-foot steel mast supporting three antennas which will radiate on four different frequencies. A 16-element array serves both for 67.25-mc video and 71.75-mc sound of NBC television station WNBT in its newly-assigned channel 4. Another antenna serves NBC's f-m station WEAF-FM, and a 288-mc television test antenna at the

CERAMIC PORCELAIN & STEATITE INSULATORS



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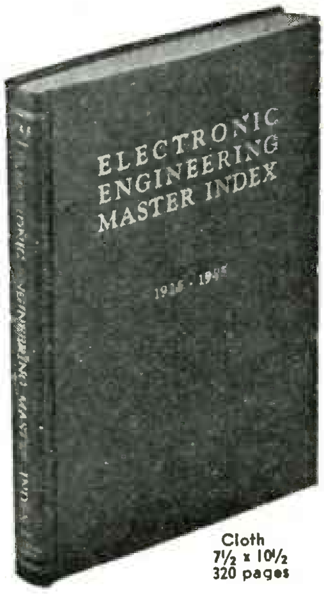

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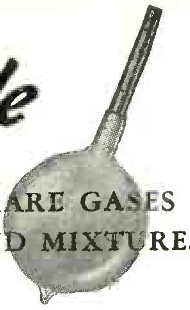

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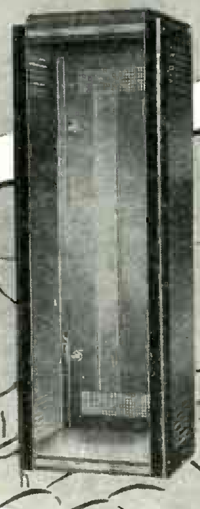

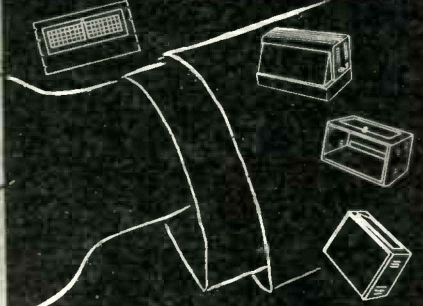

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pinnacle of the mast completes the array.

Erection of the antenna was accomplished by assembling the upper portions, raising them gradually through a hole in the top deck of the building, and adding the lower portions. The working deck for this operation is only nine feet in diameter, 1,250 feet above the sidewalks. Basic design of the new broadband television antenna, delivering an effective radiated signal 100 percent more powerful than its predecessor, was worked out by Raymond F. Guy, NBC radio facilities engineer, and Dr. George H. Brown of RCA Laboratories. New sound and picture transmitters are also being installed on the northeast corner of the 85th floor.

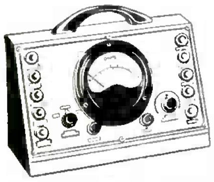
Highway Radiophone Rates

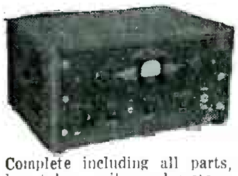
THREE CLASSES of radiotelephone service for vehicles are now being offered in St. Louis by Southwestern Bell Telephone Co. on an experimental basis but under regular commercial conditions: (1) general two-way telephone service between any vehicle and any regular telephone or other mobile unit; (2) two-way dispatch service between a customer's office and his own mobile units only; (3)

Slide-out type telephone set being used in St. Louis mobile radiotelephone system. Operation is in the 152-162 mc band, with a 250-watt central transmitting station and a 20-watt transmitter in each vehicle. Fixed receiving stations are located in various sections of the city for reliable pickup of the low-power mobile transmitters

one-way signaling service to notify the driver of a mobile unit that he should comply with prearranged instructions.

Rates for a three-minute general service message are from 30 to 40 cents depending on the location of the land telephone within the St. Louis mobile service area, with toll





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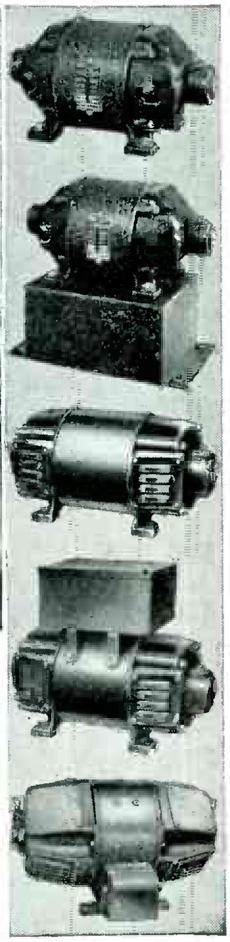
CONVERTERS
UP TO 3.2 K.V.A.



rates applying outside this area. The charge for a one-minute two-way dispatch call is 15 cents. The radio equipment on the vehicle may be provided either by the customer or the telephone company; if by the latter, the installation charge is $25 and the monthly service charge is $15.

Harbor Sonar

HARBOR ECHO-ranging and listening sonar developed by RCA Victor in 1942 provided a means for detecting the approach of enemy surface and submersible vessels at harbors and at entrances to inland waterways. The equipment was installed on shore except for the projector and training gear, which were installed under water and connected to the shore station by cable for remote training control and conduction of signals.

Rural Radio Telephone

THE FIRST CONSTRUCTION permit for radio stations authorized to handle commercial traffic in the proposed rural telephone service has been granted to Mountain States Telephone and Telegraph Co., Cheyenne Wells, Colorado. To determine the practicability of radio for telephony in this sparsely populated part of Colorado, a 60-watt central fixed station will operate on 44.5 mc in Cheyenne Wells, and four 10-watt subscriber stations will be installed on ranches within a 20-mile radius, using 48.3 mc and 48.5 mc. A sixth station will be operated as a portable transmitter for testing the effectiveness of the system.

LONDON NEWS LETTER

By JOHN H. JUPE
London Correspondent

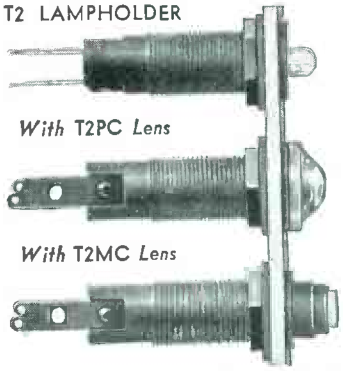
Free Radio Servicing. A new radio company in Britain is making big capital out of the fact that buyers of its sets will get free maintenance for two years by the firm's engineers, with tube replacement included as well. No radio man in his senses believes that the service is truly free but the company, which is in the hands of good engineers, has struck a sound psychological chord in giving the buyer confidence in his purchases.

Many people believe that the success or failure of television will rest

KIRKLAND Pioneer
INDICATING LAMPS

TYPE T2 UNITS

T2 LAMPHOLDER



T2 lampholder, molded of bakelite, holding lip, dia. 11/16". Tip of lamp bulb protrudes sufficiently to be removed from front of panel without use of special tool.

Very low current consumption bulb (0.038 max. amp. on 24 volts). Series resistor of small size on 120-220-440 volts, etc.

T2PC Lens-cap, molded in plastic.

T2MC Lens-cap, metal with glass lens.

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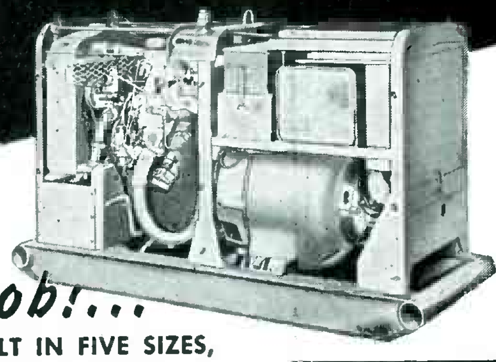

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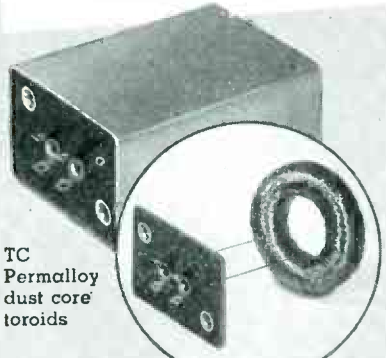

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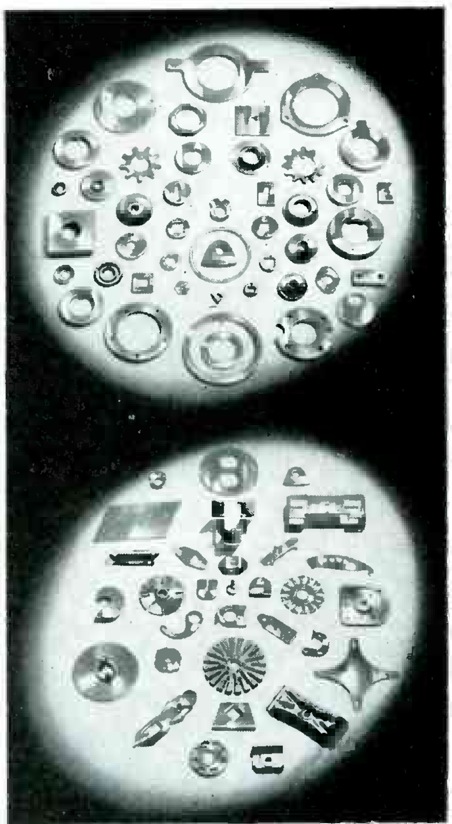

STAMPINGS
OF EVERY DESCRIPTION

Blanking
Forming
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Let us quote on your requirements.

WROUGHT WASHER MFG. CO.
THE WORLD'S LARGEST PRODUCER OF WASHERS
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entirely on satisfactorily solving the servicing problem. In a sound receiver the listener can tolerate a surprising amount of distortion and noise, but with vision only a tiny amount can be stood. Now this means that the sets have to be kept up to concert pitch, and whether the average radio serviceman will be able to tackle it properly is a question. The alternative is service organizations run and controlled by the set manufacturers.

To Sponsor or Not. Now that the question of renewing the Charter of the British Broadcasting Corp. is the number one radio problem in Britain, listeners are more or less taking sides in the argument as to whether sponsored programs should be allowed. Those in favor generally quote the U. S. A. as the shining example of how advertising produces better programs. It may or may not, but sponsored radio is naturally part of the American way of life, whereas a nonsponsored ether is naturally part of the British way of life and to compare the results of one with those of the other is pointless.

The average American listener apparently likes to be courted by the manufacturers. He is an important fellow from their point of view and there is no reason why he should not enjoy it.

British, on the other hand, look on advertising in a different way. They feel that the whole aim of advertising is to sell something they do not want, and in rather a vulgar manner at that. Maybe it is just plain snootiness, but a great many British listeners just do not want sponsoring in radio. That, however, does not prove that it is a bad thing in the U. S. A.

French Radio Budget

McGraw-Hill World News
Paris, France

THE FRENCH GOVERNMENT has budgeted a $19,000,000 program of radio construction and research, of which about $3,700,000 will be spent in 1946. Most of the 1946 appropriation will be spent on the national radio network, with $1,800,000 going for new equipment and $850,000 for construction. The short-wave station Paris-Mondial and various middle-wave stations will get new equipment. Reconstruction work will be begun on the long-wave stations

MICROPHONE NEWS

The NEW St. Louis OUTDOOR RUGGED

MICROPHONE

One of the "Finest Line of Modern Dynamic Microphones." Each engineered to fit your specific applications. Modern design—Rugged construction. Range: 40-9000 Cycles. Built to take the toughest treatment under the worst operating and climatic conditions. Alnico-V Magnet. Variable impedance output adjustable to low, 200, 500 or high. Gunmetal Gray, Black Lacquer or Olive Drab Finishes.

Write today for further information on the Complete St. Louis Line.

Licensed under Patents of the American Tel. & Tel. Co. and Western Electric Company, Inc.

ST. LOUIS MICROPHONE CO.
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S.S.White MOLDED RESISTORS

The "All-Weather" Resistors

TYPE 65X

Actual Size
Other types available in the lower values

RESISTOR BULLETIN 4505 GIVES FULL DETAILS...

It shows illustrations of the different types of S. S. White Molded Resistors and gives details about construction, dimensions, etc. A copy, with Price List will be mailed on request. Write for it—today.

- Noiseless in operation
- Strong and durable
- Good performance in all climates

STANDARD RANGE
1000 ohms to 10 megohms
• NOISE TESTED •

At slight additional cost, resistors in the Standard Range are supplied with each resistor noise tested to the following standard: "For the complete audio frequency range, resistor shall have less noise than corresponds to a change of resistance of 1 part in 1,000,000."

HIGH VALUES
15 to 1,000,000 megohms

S.S.WHITE THE S. S. WHITE DENTAL MFG. CO. **INDUSTRIAL** DIVISION
DEPT. 10 EAST 40th ST., NEW YORK 16, N. Y.

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

Lavite STEATITE CERAMIC

Properties and Characteristics of Our LAVITE S1-5 Steatite Ceramic Body

Compressive Strength	96,000 lbs. per square inch
Tensile Strength	7,200 lbs. per square inch
Flexural Strength	10,500 lbs. per square inch
Modulus of Rupture	20,000 bs. per square inch
Dielectric Strength	235 volts per mil
Dielectric Constant	6.42 (Frequency of 1 megacycle)
Loss Factor	2.90 (Frequency of 1 megacycle)
Power Factor	.446 (Frequency of 1 megacycle)
Bulk Specific Gravity	2.664%
Density (from above gravity)	0.096 lbs. per cubic inch
Hardness (Mohr scale)	7.0
Softening Temperature	2,350°F.
Linear Coefficient of Expansion	8.13×10^{-6}
Moisture Absorption (ASTM D-116-42-A)	0.009%

Design engineers and manufacturers in the radio, electrical and electronic fields are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

D. M. STEWARD MFG. COMPANY
Main Office & Works: Chattanooga, Tenn.
Needham, Mass. Chicago Los Angeles

Toroids.. by DX

Doughnut Coils for electronic and telephone purposes. High Permeability Cores are hydrogen annealed and heat treated by a special process developed by DX engineers. Send us your "specs" today—ample production facilities for immediate delivery.

DX RADIO PRODUCTS CO.
GENERAL OFFICES 1200 N. CLAREMONT AVE., CHICAGO 22, ILL., U.S.A.

DX COILS "the heart of a good receiver"

Strasbourg and Allouis, and a new powerful station at Nancy is to be started. Several new studios will be built.

For television about a third of a million dollars is scheduled for this year, principally for the Paris sender and studio and for a program of research. Research on radar and wideband transmission will take a quarter-million dollars, and small sums are provided for other research.

The French African radio network will be expanded considerably in 1946, at a cost of about $400,000. Receipts from the tax on radio receiving sets are estimated at $11,-000,000 for 1946.

Signal League Organized

A CIVILIAN ASSOCIATION of wartime communications officers and manufacturers, to be known as the Signal League, has been organized in Chicago with Major General James A. Code, Jr. (retired, and now vice-president of Automatic Electric Co.) as chairman of the board of governors, William J. Halligan of Hallicrafters as president, and S. I. Neiman (wartime director of public relations for the Signal Corps) as executive secretary.

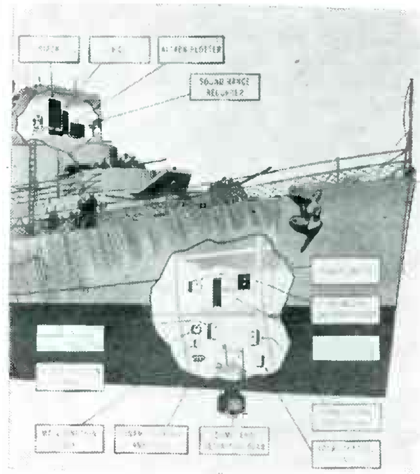
The League's charter is written to admit as members manufacturers who made "a significant contribution" to production for the armed forces, other civilians who contributed time, services or support to the communications branches, and former members of the armed forces who contributed leadership or helped expedite production.

Early Echo Ranging Sonar

The first experimental echo ranging sets operated at frequencies between 20,000 and 40,000 cps. These supersonic voltages were generated by a transmitter that fed the transducer (the combined radiating and receiving unit) which protruded through the ship's bottom. The four-inch thick transducer consisted of quartz slabs sandwiched between steel discs about 16 inches in diameter. It "pinged" out one-quarter second pulses of energy which traveled horizontally in a cone-shaped path. When part of the sound wave struck the target submarine, a small portion of the energy was

reflected back to the transducer, which in turn fed the echo through an electronic amplifier to earphones and a range, or distance, indicator. The direction in which the transducer was facing indicated the target's bearing. Only about 20 watts of power was transferred to the water and echoes were obtained from a few hundred feet distance. The equipment gave results while the ship in which it was installed was underway at speeds below three or four knots. In 1927, several naval vessels commenced sea trials with echo ranging sonar.

At the same time, the Submarine



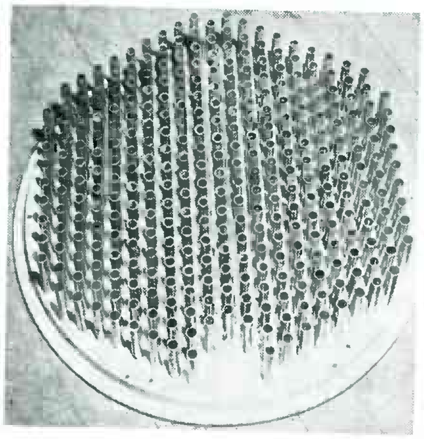
Locations of major components of modern echo ranging sonar installation on an escort ship. Attack plotter and bdi (bearing deviation indicator) are developments of World War II that greatly increased the effectiveness of sonar in action

Signal Company was producing water-depth indicators, called fathometers. The transmitter consisted of an electromagnet which banged a piston against a diaphragm facing the ocean bottom, thereby emitting a 1,000-cycle sound wave which was reflected from the ocean bottom to a button-type microphone. This echo was fed to a calibrated scale where neon light flashes indicated the depth. Fathometers were eventually installed in most naval vessels.

The JK Hydrophone

By 1929, NRL had produced a listening sonar device which replaced the acoustical SC tubes in submarines. It was designated JK, and was in effect the listening portion of the echo ranging sonar. The listening head had the shape of crystal transducers, but in place of the quartz crystals used in echo ranging, the newly developed Rochelle salt

crystals were employed since they were more sensitive. The transducer was mounted topside to permit use of the sonar only when the submarines were submerged. The JK increased listening ranges to about five miles under average water conditions and gave bearings accurate to within a few degrees. Shortly afterwards they were modified by the addition of a small transmitter which provided a feature similar to the ping feature in echo ranging. This feature was used for communication between submarines. A few JK's also were modified for underwater voice communication. For many years the JK remained as the most valuable listening equipment in submarines.



Diaphragm of sonar transducer, showing nickel magnetostriction tubes. Energizing coils are wound around the individual tubes

QB Sonar for Submarines

The QB echo ranging sonar for submarines was developed by NRL about 1931. It was practically identical to the surface vessel sonar except that it employed Rochelle salt crystals instead of the quartz crystals used in surface ship transducers. The QB's were subsequently installed in new submarines where the transducer protruded through the keel, thereby enabling use of the QB at ship speeds up to about five knots whether the submarines were surfaced or submerged.

The QB sonar operated satisfactorily up to ship speeds of about five knots, but beyond that the roar and crackle of water noises drowned out target noises and echoes. To reduce the turbulence caused by the movement of the flatfaced transducers through the water, a spherical cover about 19 inches in diameter,

made of sound-transparent rubber, was developed by NRL in collaboration with the Goodrich Rubber Co. This dome permitted 10-knot speeds before water noises became excessive, and was subsequently incorporated in all transducers.

About this time a transducer was invented in which magnetostriction tubes replaced the quartz or salt crystals. These tubes were small electromagnets consisting of a three-inch long, $\frac{3}{8}$-inch diameter nickel alloy hollow tube, around which was wound a coil of wire. The tubes elongated or contracted when their magnetic flux was changed. The electrical energy from the transmitter caused movements of the magnetostriction tubes which vibrated the diaphragm of the transducer, thereby emitting pings. Conversely, when sound waves which struck the diaphragm caused a change in the magnetic flux of the magnetostric-

Driver unit of modern echo ranging sonar, being checked with portable test monitor. This unit energizes the magnetostriction transducer that sends the sound signal into the water

tion tubes, an electric current was generated which resulted in signals corresponding to the sound source, i.e., propeller noises, echoes from pings, etc. In 1934, the Bureau of Ships designed and the Submarine Signal Company commenced production of the magnetostriction echo ranging equipments. Magnetostric-

flexible shafts

Flexible Shafts that carry power around any corner have many new uses in peacetime developments.

Faithful, dependable power drives or remote control in airplane, automobiles, radio, and many other commercial products.

Shafts made to your specifications. Our engineering department will work out your particular power problem without obligation.

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Absolute thoroughness in design and manufacture is *one part* of Electronic Engineering Company policy. The other part is *detailed inspection* at every manufacturing phase. This is your assurance of dependable performance—because every Electronic Engineering transformer gets this Inspection Plus.

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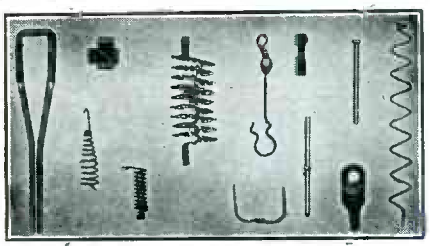
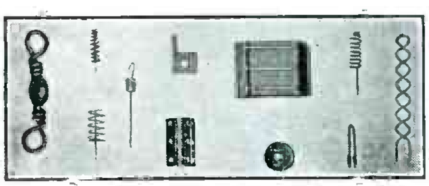


SMALL PARTS

Filaments, anodes, supports, springs, etc. for electronic tubes. Small wire and flat metal formed parts to your prints for your assemblies. LUXON fishing tackle accessories, double pointed pins, fine size wire straightened. Inquiries will receive prompt attention.

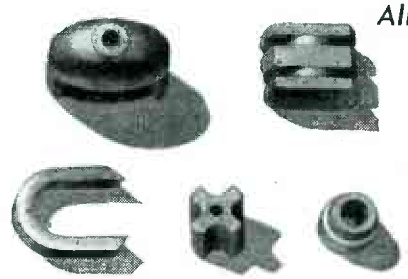
ART WIRE AND STAMPING CO.

227 High St. Newark 2, N. J.



PERMANENT MAGNETS

Alloys: **COBALT • CHROME • ALNICO**

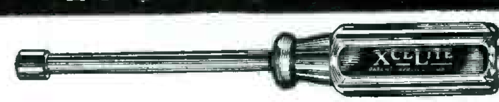


The making of permanent magnets is an alloy, too . . . of experience, engineering, facilities. We'll be glad to tell you more. Write for bulletin.

Thomas & Skinner

THOMAS & SKINNER STEEL PRODUCTS CO.
1116 E. 23rd St., Indianapolis 5, Ind.

For Originality LOOK TO **XCELITE**



XCELITE tools will soon be back! Sales of these quality-built XCELITE tools (such as the XCELITE nut driver above) have outpaced production . . . but will soon be available to you again for faster, easier, more accurate work!

PARK METALWARE CO., INC.
Dept. C, Orchard Park New York

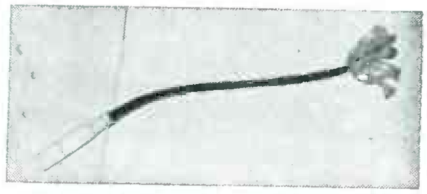
Quality Tools **PREFERRED BY EXPERTS** tion echo sounding equipment for measuring water depth gradually replaced the fathometer in naval vessels. To provide more equipment, the Radio Corporation of America was placed under contract by the Bureau of Ships and commenced production of echo ranging sonar in the summer of 1939.

Report on Precipitation Static

ONE OF THE THREE great problems of bad-weather flying, the interruption of aircraft radio communications by precipitation static, has been overcome. As a result of three years of intensive research by Army and Navy physicists under the leadership of Dr. Ross Gunn, aircraft radio communication, radio aids to navigation, and radar can be used with little fear that static will block them out.

Since precipitation static is largely caused by corona on antennas and nearby points, the way to eliminate static is to eliminate corona on or near the antenna. This can be done in three ways:

(1) The electric field on the airplane can be reduced by the use of electrostatic dischargers which reduce the amount of stored charge and thereby lower the field. The



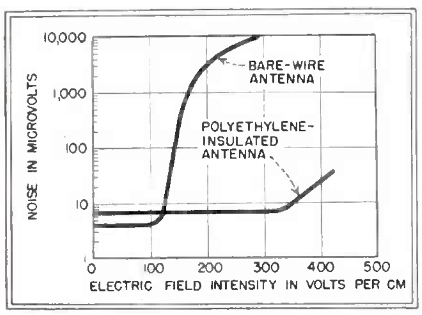
Installation of up to a dozen electrostatic wick dischargers like this at strategic points on an average plane will reduce charge on airplane by 50 percent, with corresponding reduction in precipitation static

project has developed a silver-impregnated cotton wick, about 13 inches long, covered with a plastic material for mechanical protection. Wicking is frayed at the outer end by the air stream, producing a multitude of small fibers on which the surface field is very high. The discharge from these wicks is corona but the amplitudes of the associated voltage transients are so greatly attenuated by the high resistance of the wick fibers that they produce a negligible amount of static noise in aircraft radio receivers. Ten to twelve wicks should be installed on average airplanes, the exact number and location being determined by the type of airplanes.

(2) Antennas may be placed in shielded positions on the airplane. Since corona always breaks out first on the exposed points of small radii of curvature the corona can be transferred away from the antenna to a more exposed point if the antenna is brought within the area shielded by more exposed points.

(3) Antennas and antenna masts may be covered with insulation of high dielectric strength which will prevent corona discharge from the antenna even though the surface field is high. The best insulation material for this purpose found so far is polyethylene, a tough, flexible plastic of high dielectric strength, low dielectric loss, and relative inertness to sunlight and solvents. The wire now being used is 51-mil solid Copperweld wire covered with polyethylene to an outside diameter of 183 mils.

All bare portions of the antenna system should be insulated. A polyethylene tape may be used for this purpose, if applied with considerable tension to avoid air pockets. After first removing any sharp projections and building up any irregularities with tape, a smooth spiral with ½ to ⅜ overlap should be wound, extending 1½ inches over adjoining insulators.



Effect of antenna insulation on radio noise due to precipitation static

The polyethylene covering of the antenna system will prevent corona until the intensity of the electric field becomes so great that a puncture the size of a pin hole will develop. A device has been developed which will indicate when any puncture has been made.

Nearby Corona

Even though the antenna system be perfectly insulated, any corona in the immediate vicinity will be coupled into the system in sufficient degree to cause some interference. Metal antenna masts and pitot tubes are frequently used on airplanes. A metal antenna mast should be replaced by plastic if possible, or if not possible, should be smooth and well-rounded, all edges having a radius of at least 1 inch, and all sharp points smoothed off and wrapped with polyethylene tape.

Portions of antenna wire used only for support should be removed wherever possible. Both grounded sections and floating sections in the antenna system may nullify the effort in improving the antenna to eliminate corona.

MEETINGS TO COME

SEPT. 10-14; NATIONAL CHEMICAL EXPOSITION; Coliseum, 15th and Wabash Ave., Chicago, Ill.

SEPT. 16-20; INSTRUMENTATION FOR TOMORROW—EXHIBIT AND CONFERENCE; Wm. Penn Hotel, Pittsburgh, Pa.; daily technical sessions and program of short educational courses.

OCT. 3-5; NATIONAL ELECTRONICS CONFERENCE; Edgewater Beach Hotel, Chicago, Ill.; technical programs under three main heads—communications, industrial electronics, and scientific and medical developments.

OCT. 10-11; TELEVISION BROADCASTERS ASSOCIATION CONFERENCE; Waldorf-Astoria Hotel, New York City; latest television equipment will be exhibited.

BUSINESS NEWS

ST. JOHN X-RAY LABORATORY has moved all facilities to its own building in Califon, N. J.

AIREON MFG. CORP. of Kansas City has transferred its Cinaudagraph Speakers, Inc. subsidiary from Chicago, Ill. to Slater, Missouri, where additional facilities are available for the manufacture of loudspeakers.

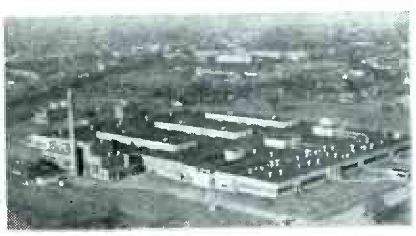
AIRBORNE INSTRUMENTS LABORATORY, INC., Mineola, Long Island has been set up to carry on for both commercial and military interests some of the research projects begun during the war at MIT's Radiation Laboratory, Harvard's RRL, and Columbia's Airborne Instruments Laboratory. All stock is owned by Aeronautical Radio, Inc. Personnel now numbers 171, of whom 65 are scientists and engineers and 20 are skilled technicians. Air traffic controls and radar warning devices are among immediate projects sponsored by commercial airlines.

KELLOGG SWITCHBOARD AND SUPPLY Co., Chicago, has purchased Select-O-Phone Co. of Providence, R. I., manufacturers of automatic telephone systems.

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. has purchased an eight-story building in Worcester, Mass., three floors of which it had leased during the war for production of the tiny capacitors used in proximity fuzes.

FEDERAL TELEPHONE AND RADIO CORP. announces that construction is well under way for its new manufacturing plant and administration building at Clifton, N. J. When completed, the company will have approximately 20 acres of floor space at Clifton.

RCA VICTOR DIVISION purchased from the U. S. Navy Department for $4,362,500 the Lancaster, Pa. tube manufacturing plant which they



Considered the most modern electron and television tube manufacturing plant in the world, this Lancaster, Pa. one-floor air-conditioned building purchased from the Navy by RCA provides 326,000 square feet of manufacturing space

built and operated for the Navy during the war, and will invest an additional $2,000,000 to expand and further modernize the plant's high-speed production equipment for cathode-ray tubes.

McQUAY-NORRIS MFG. CO., St. Louis, producers of the v-t proximity fuze during the war, have purchased the L. M. Persons Corp. and the Southern Electronics Co., both also in St. Louis. Expansion plans are under way for entry into the post-war electronic and electric products field.

ELECTRONIC ASSOCIATES INC., Long Branch, N. J., organized by officers and men of the New Equipment Introductory Detachment in the Office of the Chief Signal Officer while they were still in uniform, is now providing electronic consulting, engineering, design, and development services for industrial firms and government agencies.

RESISTORS, INC., Chicago, Ill., has been organized by Joseph J. Cerny, formerly president and general manager of Lectrohm, Inc., to manufacture a complete line of resistors and associated products.

ARMOUR RESEARCH FOUNDATION, Chicago, has established a Magnetic Recorder Division headed by Carl L. Titus. Thirty companies are now licensed to produce its recorders, the last four being Garrard Engineering and Mfg. Co., Ltd. of England, Ateliers de Constructions Electriques de Charleroi of Belgium, Avery Sound Instrument Corp. in New York City, and Magnicord, Inc. in Chicago.

SERDEX, INC., Boston, Mass., has been formed to do development work in meteorological instrumentation, electronics, and communications. D. C. Bradford, formerly with Radiation Laboratory, is chief engineer.

FEDERAL ELECTRIC MFG. CO., LTD. OF CANADA has been organized in Montreal as a wholly-owned subsidiary of Federal Telephone and Radio Corp., Newark, N. J. to produce telephone, radio, and electrical equipment for Federal's customers in Canada. Norman E. Wunderlich, new executive sales director of Federal, announces receipt of an order from CBC already for two 50-kw a-m broadcast transmitters, one for Winnipeg, Manitoba, and the other for Edmonton, Alberta.

EMERSON RADIO AND PHONOGRAPH CORP., New York, N. Y., received the Naval Ordnance Development Award for its contribution to the radio proximity fuze research and development program.

ANACONDA WIRE AND CABLE CO. received the Naval Ordnance Development Award for development of a still-secret device used in connection with magnetic underwater ordnance. It involves a gradiometer coil so sensitive that a piece of steel no larger than a penny is sufficient, when in the field of the coil, to detonate the associated explosive charge.

APPLIED PHYSICS LABORATORY, Silver Spring, Md., was presented with the Naval Ordnance Development Award for outstanding research and development work on the radio proximity fuze, gun directors Mark 57 and 61, a torpedo explorer, and guided missiles.

PHILIPS Co., Eindhoven, Holland, has recovered from Germany the complete equipment of its radio tube factory, consisting of 1,200 machines, and is now operating at better than 60 percent of prewar capacity. Labor shortages at Eindhoven are forcing removal of some operations to other parts of the country, with one new plant for processing radio tubes being scheduled for Sittard. The present labor force of 17,000 is considered inadequate to handle the orders coming in.

CROSLEY CORPORATION, Cincinnati, Ohio, received on behalf of its Primrose Plant 9 the Naval Ordnance Development Award for contributions to the success of the variable-time fuze for projectiles. By Feb. 1943, the 5,000 employees in this plant were turning out 5,000 fuzes a day. A total of 5,250,000 units of 47 different types of v-t fuzes were produced at Crosley, and 500 different types of fuzes were engineered.

PERSONNEL

H. RUSSELL BROWNELL, formerly with the engineering department of Western Electric Co., has opened his own offices and laboratory at 188 West Fourth St. in New York City and offers consulting services on electrical, electronic, and magnetic testing and measurement problems, along with calibration and repair of special measuring equipment.

ROSEL H. HYDE, with the FCC and its predecessor since 1928, has been appointed Commissioner to fill the unexpired term of the late Governor William H. Wills.

WILLIAM HEBAL succeeds Dan Gellerup as broadcast technical supervisor for the Milwaukee Journal radio stations WTMJ and WTMJ-FM.

FRED P. ANDREWS, commanding officer of Alaska Communications System for the last five years, was made assistant to the president of Press Wireless, Inc., New York City.

KENNETH G. MORRISON, chief engineer of radio station KRE in Berkeley, California for four years and on the engineering staff of NBC in San Francisco for three years prior to wartime work on the Manhattan Project, has been made assistant radio sales manager of the Graybar Electric Co., New York City.

K. G. Morrison

M. B. Lamont

M. B. LAMONT, one of the pioneers in auto radio development, became products manager for Bendix Radio Division in Baltimore, in charge of electrical detail in radio, f-m, and television.

WILL WHITMORE of Western Electric Co. is a member of the electronics staff of Captain C. L. Engleman, Electronics Coordinating Officer of Joint Army-Navy Task Force One, and will participate in electronics activities in connection with the atomic bomb tests.

HENRY C. SHEVE becomes a staff engineer for Stromberg-Carlson Co., Buffalo, N. Y. At the time of his release from active service in March, 1946 he was assistant director of the electronics test division of the U. S. Naval Air Test Center at Patuxent River, Maryland.

L. M. LEEDS has been made consulting engineer in the Transmitter Division of General Electric Co. in Syracuse, N. Y. In 1938 he supervised development of the first G-E television station, W2XB, in the Helderberg Mountains outside Schenectady.

JOHN P. KEARNEY terminated three years of cathode-ray tube design for the Electronics Division of the Bureau of Ships to become assistant manager of the Industrial Products Division of the Libbey Glass Co., Toledo, Ohio, where he will specialize in glassware for the electronics field.

WALTER ALBERT RUSH, Controller of Radio in the Department of Transport, was awarded the 1946 Administration medal of the Professional Institute of the Civil Service of Canada for his wartime work in organizing the work of Canadian scientists, especially in the field of radio, the monitoring of enemy messages, and the establishment of long-range high-frequency radio d-f stations.

ARTHUR L. SAMUEL is leaving Bell Telephone Laboratories after 18 years of vacuum tube research and development work there to become a member of the electrical engineering faculty at the University of Illinois, where he will direct the work of graduate students in research and development of electron tubes.

PAUL WITTLIG has been named manager of technical operations for CBS television station WCBW. He has been with CBS since April 1934.

LUIS DE FLORES, deputy chief of the Office of Research and Inventions, and H. Struve Hensel, Assistant Secretary of the Navy, headed a group of experts that has been in London coordinating the work of ORI here with research and development activities now being carried on in England.

R. A. MONFORT, formerly with NBC in New York, has been appointed chief engineer for the Times-Mirror Co. in connection with color television and f-m activities of the company on Mt. Disappointment near Los Angeles.

L. GRANT HECTOR, who was director of engineering for National Union Radio Corp. before taking charge of the OSRD group responsible for developing the subminiature tubes used in proximity fuzes, has been appointed director of research and engineering for Sonotone Corp., Elmsford, N. Y.

L. G. Hector

R. B. Albright

ROBERT B. ALBRIGHT now heads laboratory operations of the Bendix Radio Division of Bendix Aviation Corp., Baltimore, and will concentrate on the electrical design of broadcast radio receivers.

NEW BOOKS

The Development of Mathematics

By E. T. BELL, *Professor of Mathematics, California Institute of Technology. McGraw-Hill Book Co., Inc., New York*, 1945, *second edition*, 637 *pages*, $5.00.

THIS CRITICAL historical summary of mathematical concepts was written to tell students where advanced mathematical study could lead them. It also surveys the field in broad sweeps that orient one's mathematical thinking. It is a book about concepts, not techniques. Although satirical at every turn, it serves admirably to place mathematics in its relative position in logical and social thinking, as well as to orient the divisions of mathematics in the mind of a novice. Mathematicians will take sides with and against Professor Bell's comments, but all will agree that his irony is well written.—F.R.

• • •

The Birth and Death of the Sun

By GEORGE GAMOW, *Professor of Physics, George Washington University. Penguin Books, Inc., New York*, 1945, 219 *pages*, $.25.

A PAPER-BACK REPRINT of a nonfiction work originally published in 1940, worthy of consideration not only because of its excellent technical chapters on atomic theory, radioactivity and transmutation of elements, but also because it lends promise of more technical books emerging in convenient pocket-size, twenty-five cent editions. The publishers are to be commended particularly for the excellent rendition of detail in the 24 halftone illustrations of electronic and astronomical subjects.—J. M.

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Radio Tube Vade-Mecum

By P. H. BRANS. *Published by Algemeene en Technische Boekhandel (General Technical Bookstore), Prins Leopoldstr.* 28, *Antwerpen (Borgerhout), Belgium*, 1945, 208 *pages, price* 105 *Belgian francs.*

HERE AT LAST is the radio tube handbook radio engineers have dreamed of, covering the products of receiving tube manufacturers throughout the world (including Russian) in seven carefully prepared tables and charts and with prefatory instructions in four languages—Dutch, French, English, and German. The first and main table occupies 107 pages and gives characteristics of the most widely used tubes, arranged alphabetically and numerically much as in National Union's little pre-war tube manuals, with code references to the 559 schematic symbols and base connection diagrams in Table V. The data includes as far as possible the static characteristics and such working data as plate load, coupling resistance, cathode bias resistance, and screen grid series feed resistance. Use of code numbers for the various technical phrases encountered in tube specifications permits crowding a wealth of useful data into Table I.

Table II, covering about 40 pages, gives similarly the characteristics of tubes, mostly British, that are less used on the Continent, with the manufacturer's name in each case. Table III lists tubes having similar characteristics to those in Table I but omitted therefrom to avoid repetition of data and conserve space. Points of difference in basing or minor characteristics are indicated. Table IV is a more elaborate and complete world-wide tube interchangeability chart. Russian tubes are listed in Table VI, arranged like Tables I and II. Table VII ends the book with designations of different military services for identical tubes.

All in all, this is a valuable and essential reference for anyone having to peruse the foreign technical literature on electronic subjects or work with foreign electronic equipment.—J.M.

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High Vacuum Technique

By J. YARWOOD. *John Wiley & Sons, Inc., New York, N. Y. Second Edition Revised,* 1945, 140 *pages,* $2.75.

A COMPLETE COVERAGE is made of the present-day techniques and tools necessary to the production and maintenance of high vacuum. Written in a style which is easily read and understood, this book treats all the usual forms of mechanical pumps, diffusion pumps, gages, and speed measuring devices. It is profusely illustrated with sketches and graphs and in addition contains over fifty tables of information pertinent to the subject matter. For more detailed investigation, many references are cited and a very complete bibliography is provided. Degassing and gettering, metal film evaporation, and sputtering methods are described. Since there are all too few works in this field, this book is almost a must for workers in high vacuum.—GLENN L. MELLEN

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Relay Engineering

By CHARLES A. PACKARD, *Chief Engineer, Struthers-Dunn, Inc. Published by Struthers-Dunn, Inc., Philadelphia, Pa.*, 640 *pages*, $3.00.

THIS NEW engineering handbook gives the answers to thousands of questions on selection and application of relays and timers to electronic and electrical equipment. A section on servicing and inspection of relays gives many original short-cuts, along with practical advice on locating and mounting of relays in industrial installations, maintenance and test procedures, and detailed trouble-shooting instructions. A 26-page section of relay definitions, a bibliography of books and articles dealing with relays, an appendix of relay design charts and tables, and a section on American Standards for Industrial Control Apparatus add appreciably to the reference value of this handy pocket-size, limp-leatherette volume.—J. M.

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The Cavendish Laboratory

By ALEXANDER WOOD, M.A., D.Sc., *Fellow of Emmanuel College, Cambridge. University Press, Cambridge, England; The Macmillan Co., New York*, 1946, 59 *pages*, $1.00.

THIS LITTLE VOLUME describes how, under Maxwell, Rayleigh, J. J. Thomson, Rutherford, and others, the Cavendish Laboratory in Cambridge, England has contributed to the world's fund of knowledge in the physcal sciences. The importance of pure research to practical engineering is pointed up by brief descriptions such as Rutherford's development of a magnetic detector for electromagnetic waves. By January 1896, he had successfully detected waves a distance of over half a mile and forsaw ship-to-shore radio communication. That he finally turned his efforts to what we now know as nuclear physics, leaving the more practical aspects of communication to others, has in no whit impoverished the world nor the honor due Cavendish Laboratory.—A. A. MCK.

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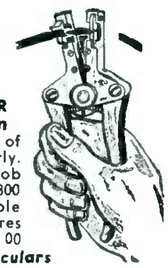

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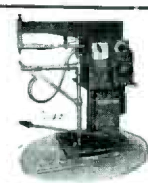

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Germanium Research

Dear Editor:

IN MY TALK before the IRE on November 13, 1945, which was the basis for my article, "The Germanium Crystal Diode," published in February, 1946, ELECTRONICS, I was aided in part by investigations made by Purdue appearing in a number of OSRD reports, as well as by considerable investigation in this field by Sylvania and others. In my talk, I pointed out the work done by the Purdue physics group. However, I feel that I did not elaborate sufficiently on the Purdue work in the text of the published article, merely mentioning the article of S. Benzer, "The High Voltage Germanium Rectifier" in the bibliography. I hope that subsequent publications will give full credit to the work completed in the laboratories at Purdue.

E. C. CORNELIUS
North Andover, Mass.

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Cathode Follower in Vtvm

Dear Sir:

I HAVE WITH ME at the moment your July 1945 issue of ELECTRONICS, and my interest in vacuum-tube voltmeters has prompted me to write to you. I refer to the article entitled "Improved Vacuum-Tube Voltmeters", by J. T. McCarthy.

About six months ago I constructed a vtvm, to use for coil Q measurements, and in the course of my experiments I covered several of the points raised in your article. To keep the input capacitance low I used a 954 biased to cutoff, and to obviate any arrangement to balance residual plate current due to contact potential, I used a second 954, in a bridge arrangement similar to those described in your paper. Although

(*Continued on page* 300)

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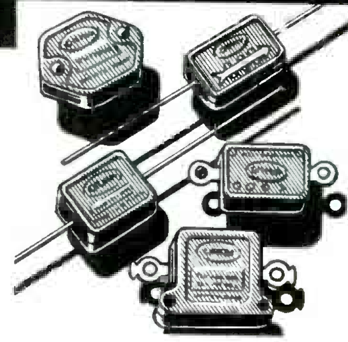

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.05 mfd 1000 vdc (G.E. pyranol)............. .35
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1,888	lbs.	¼	N.S. 17P5 Type FBM
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150	lbs.	5/16 38 x 38	NS 17-P-5 From S Ty FBM
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270	lbs.	½ 38 x 39	Grade C GLM Spec.
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high-transconductance tubes such as the 6AC7 and 6AG7 were unobtainable, I did try amplifiers using the cathode-coupled arrangement, but had a good deal of difficulty in keeping the whole thing stable. I finally finished up by using a 0-100 μa meter without any amplifier after the 954 as this gave me the required sensitivity.

Most of us who have been in the armed forces and engaged on radio work, appear highly enthusiastic about the advantages of cathode followers and grounded-grid triodes. However, in the matter of the amplifier, I had assumed (apparently wrongly) that the best plan would be to operate two balanced tubes in Class A for the sake of linearity. However, after studying your article it is apparent that in the case of Fig. 2 anyway the algebraic sum of the two bias voltages will result in the 6AG7 grids operating in the region of positive potential. I have no curves for the 6AG7, but if they are running with positive grid potential, I would like to see some more information on the subject. More information is needed on this point, particularly with regard to stability over long periods of time.

I had difficulty in securing adequate stability with amplifiers after the 954 tube but the 6AC5 tube may have some possibilities in this arrangement. Although its transconductance is not unusually high, it does normally operate with a positive grid potential, which would be very handy with the cathode coupled circuit.

E. B. Menzies
Auckland, New Zealand

• • •

Phantastron

Editor:

I regret that an error has been made in the article which we wrote on H2X radar (Electronics, May 1946). The error appears in the spelling of "phantastron" which was spelled as "phanastron" in the manuscript that we submitted.

I don't know how it got by the four or five people at Radiation Laboratory that read the manuscript, and I hope that you have not been deluged with a flood of letters pointing out the mistake.

A. D. Cole
Cole, Holdam and McGrath
Boston, Mass.

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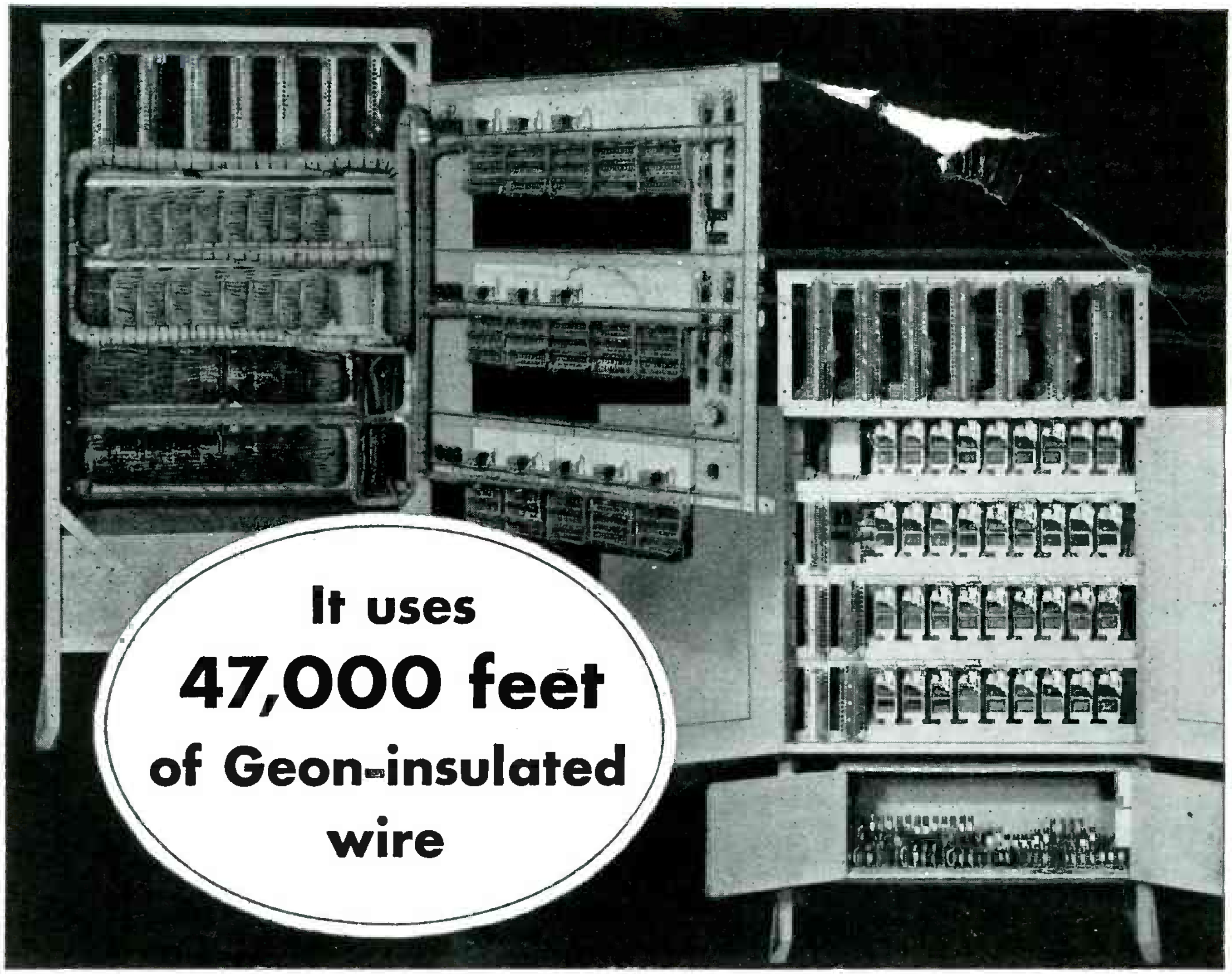
SEARCHLIGHT SECTION

(Classified Advertising)



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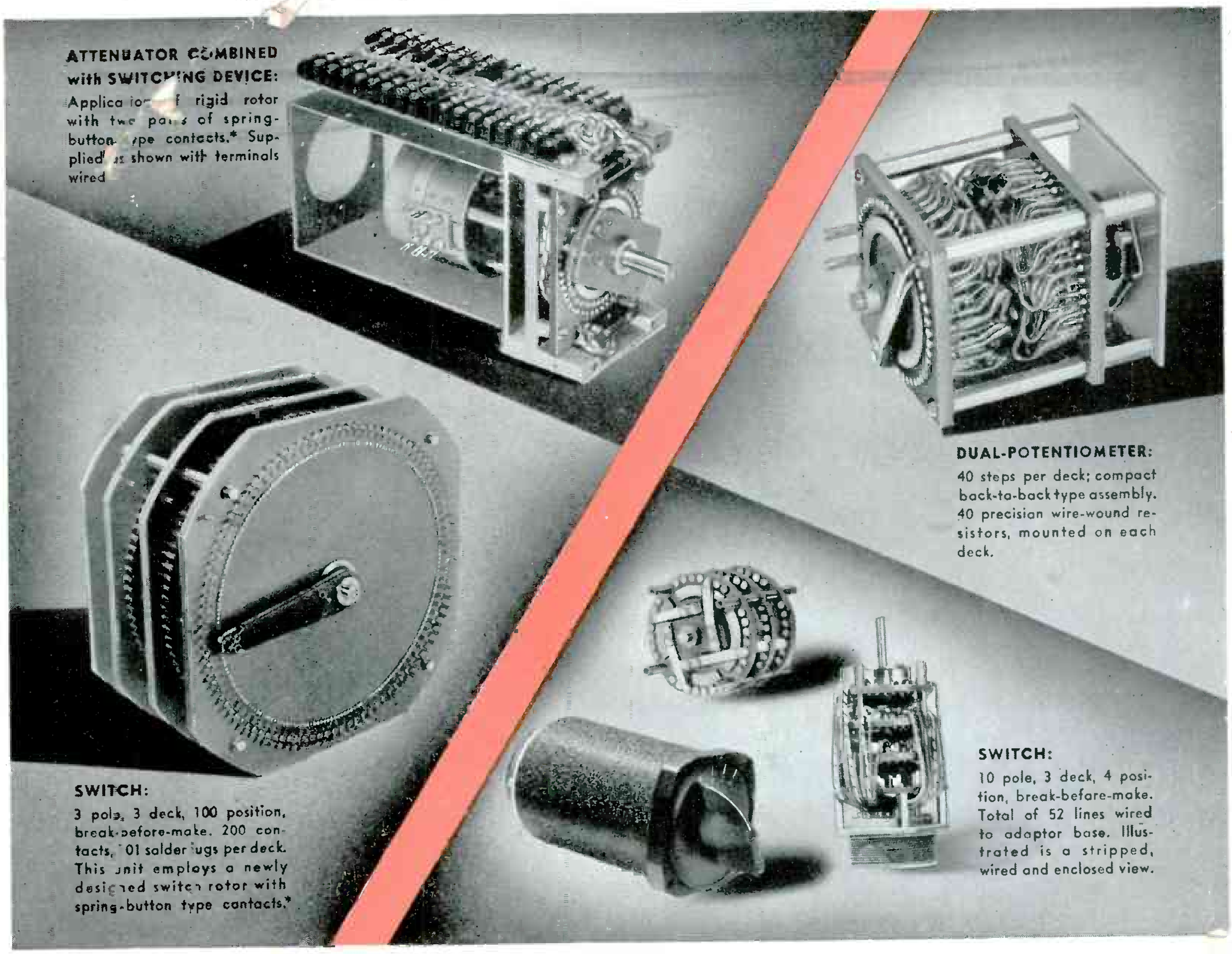

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