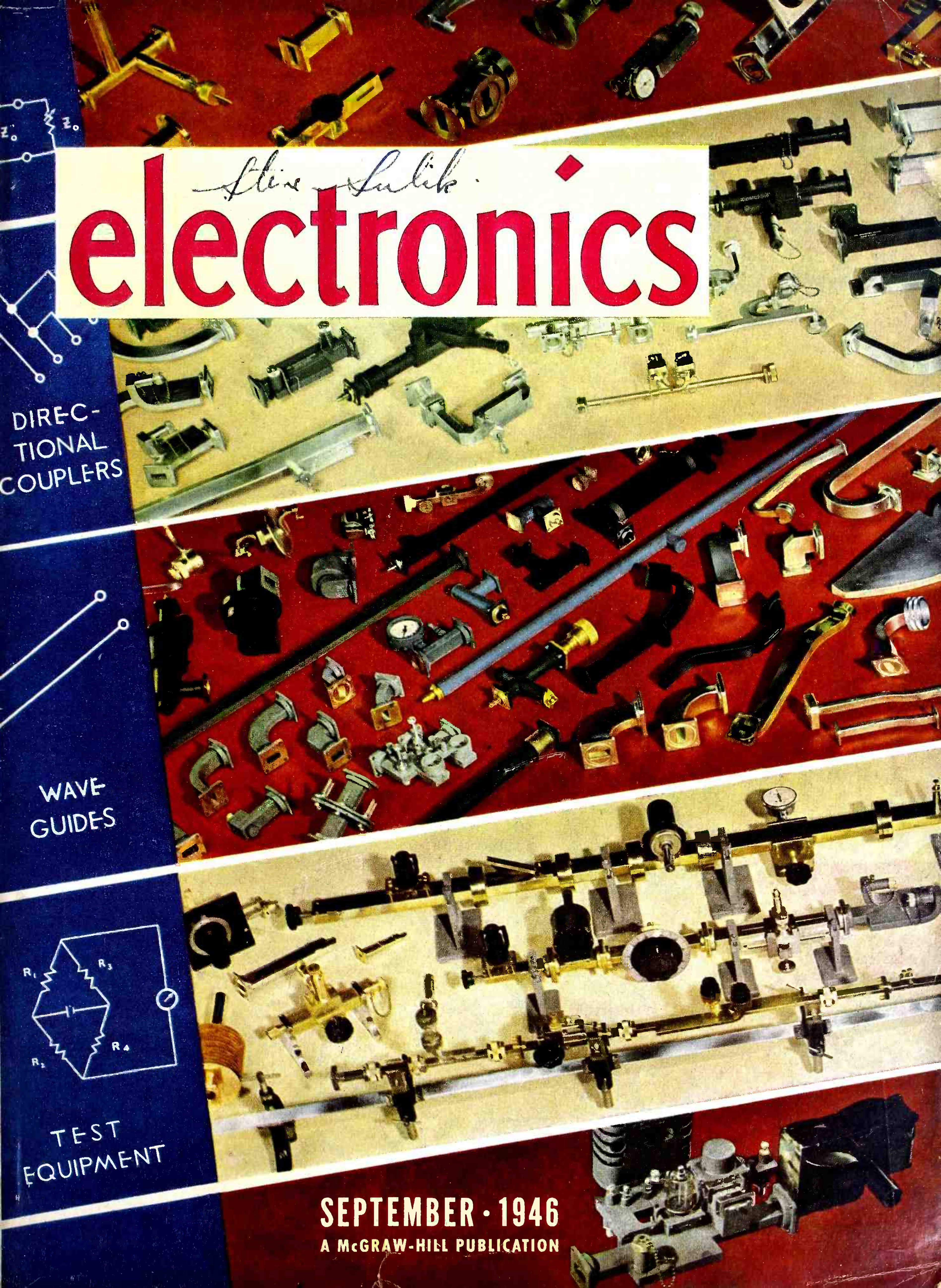
electronics
DIRECTIONAL COUPLERS
WAVE GUIDES
TEST EQUIPMENT
SEPTEMBER · 1946
A McGRAW-HILL PUBLICATION

electronics

A McGRAW-HILL PUBLICATION

SEPTEMBER • 1946

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Compact, rectangular design for efficient use of sub-chassis space; mounting by solid wire connecting leads.

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★ Dumont engineers scored in the greatest single achievement in paper tubular capacitors . . . meeting the most exacting requirements. This type P6 has the ends sealed in BAKELITE RESINOID. Leads cannot PULL OUT or MELT OUT. Bakelite treated tubes sealed in vacuum.

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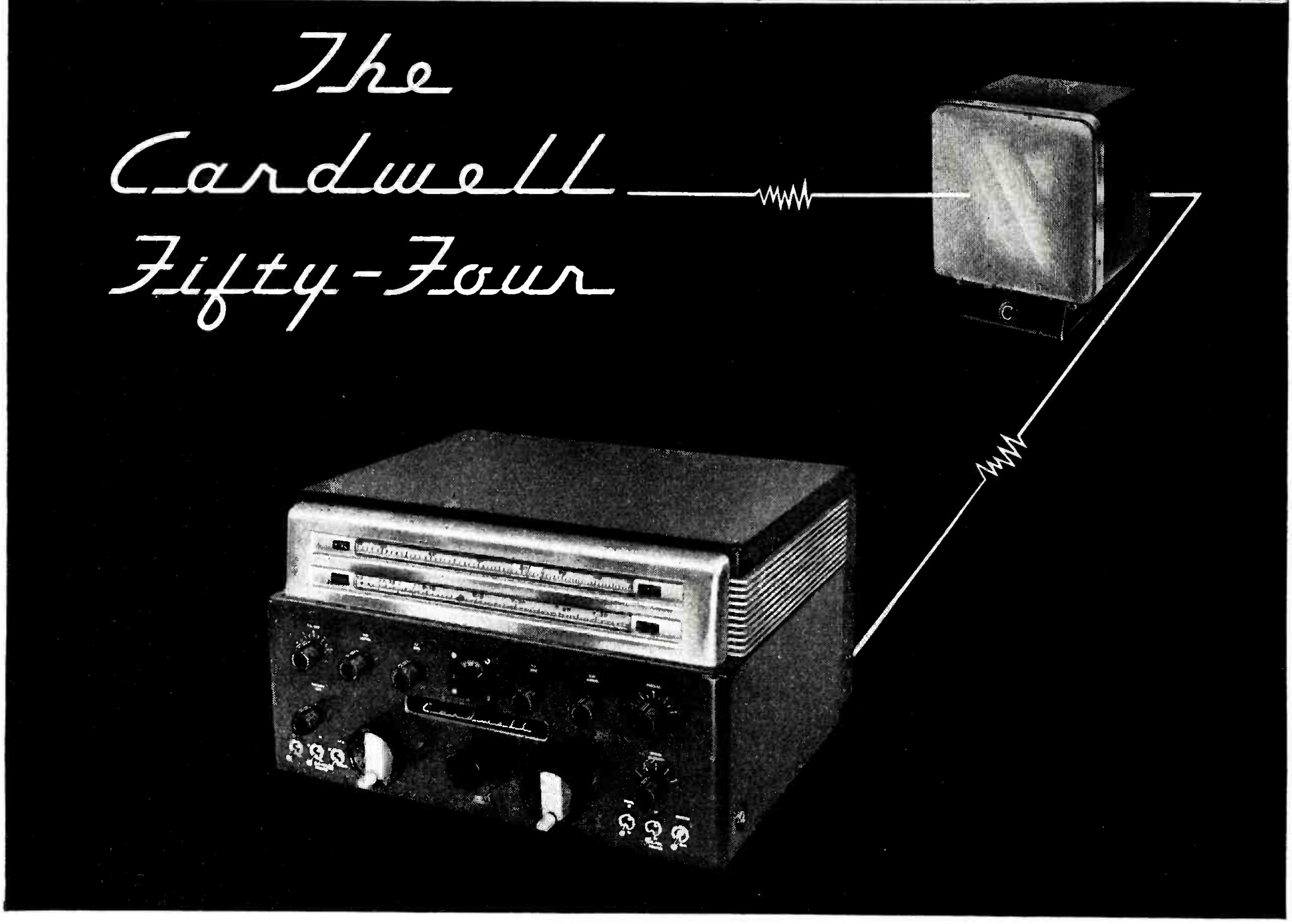
*P-7
OIL UNITS

BUILT TO CARDWELL STANDARDS



truly a postwar communications receiver

It is gratifying to note how many orders followed the recent announcement of the Cardwell Fifty-Four . . . gratifying, because these orders were placed regardless of price . . . indicating unmistakable recognition of Cardwell quality. This completely new communications receiver will be ready for delivery this fall. Check the following outstanding features:

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 NoiseRatio.
(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 10½ 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 0 to 10,000 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 18¼" wide x 16" deep x 11" high. Weight approximately 70 lbs.)

16. Heavy Duty Speaker.
(Compact tilting unit 9¼" wide x 8¼" 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.)

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THE ALLEN D. CARDWELL MANUFACTURING CORP.

MAIN OFFICE & FACTORY: 97 WHITING STREET PLAINVILLE, CONN.

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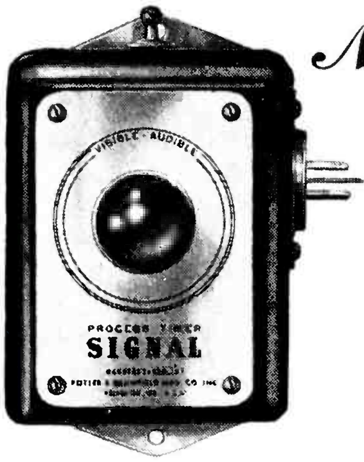
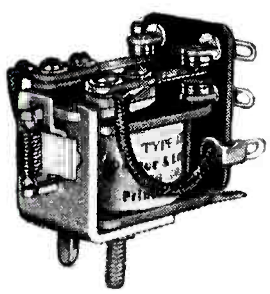
. . . the high standard of your name is assured when you build in POTTER & BRUMFIELD relays and timers

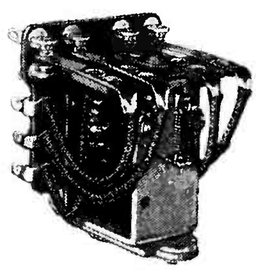


New **—Synchronous Manual Reset Timer with remote signal indicator**

- Adjustable positive stop
- 1 kw or 1 hp load capacity
- Molded bakelite housing
- Can be set as low as 1% of full scale
- Wide range of time cycles available
- Load either off or on during cycle
- Signal contains both light and buzzer
- Signal may be either adjacent or remote
- Both housings 5½ x 3½ x 3½
- Standard time cycles 15, 30 min., 1, 12 hrs.
- Price—TA Timer $15.00—A Signal $5.00



SMALL LIGHT DUTY



Light Duty Multiple Contact

P & B STANDARD RELAYS

Potter & Brumfield standard relays will meet most relay requirements and specials can be supplied if required. Our 14 years of experience in the manufacture of relays assures you that the type recommended for your job will give better service.

Write NOW for your copy of our new 1946 catalog, illustrating and describing in detail a complete line of relays and timers.

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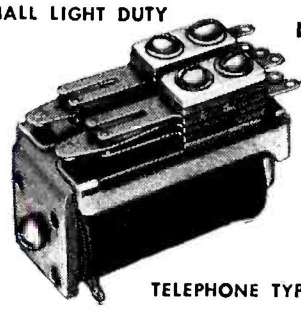
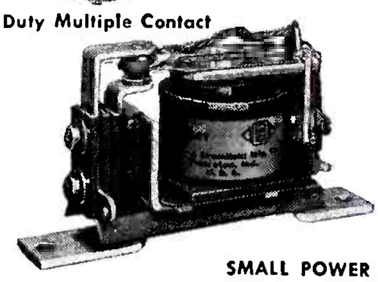
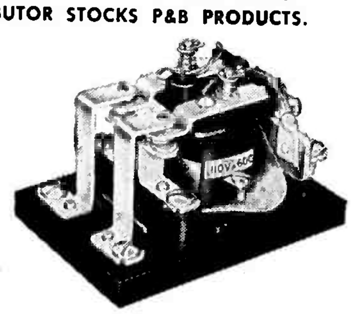


TELEPHONE TYPES



SMALL POWER



HEAVY DUTY POWER

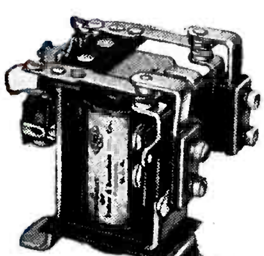
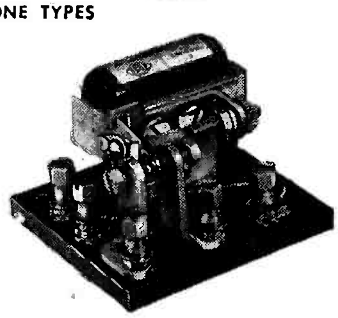
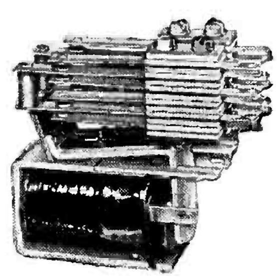


PLATE CIRCUIT



SENSITIVE



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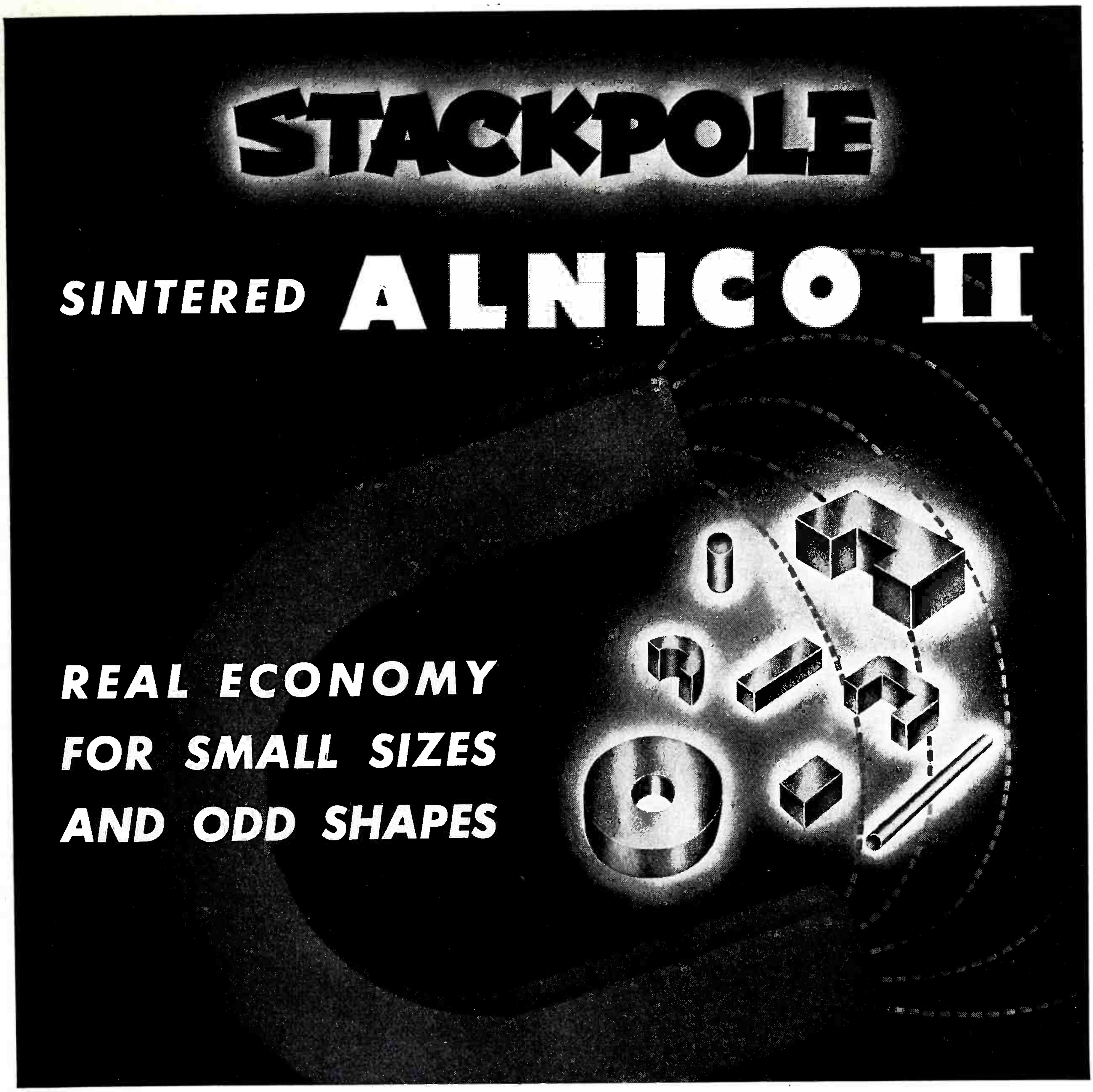

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Here is new help on permanent magnet problems—from one of the largest, oldest and most widely experienced producers of molded and sintered components in the industry.

Stackpole *Alnico II offers notable economy in the production of units up to two ounces. Odd shapes are a specialty. Engineering recommendations based on your requirements gladly submitted.

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

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Or is it Brazing? Soldering? Annealing? Forging? If it's any of these, why not find out today how induction heating can be applied to your job. Write for Bulletin 14B6430 "Selective Heat" which describes induction heating and its application to industry. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

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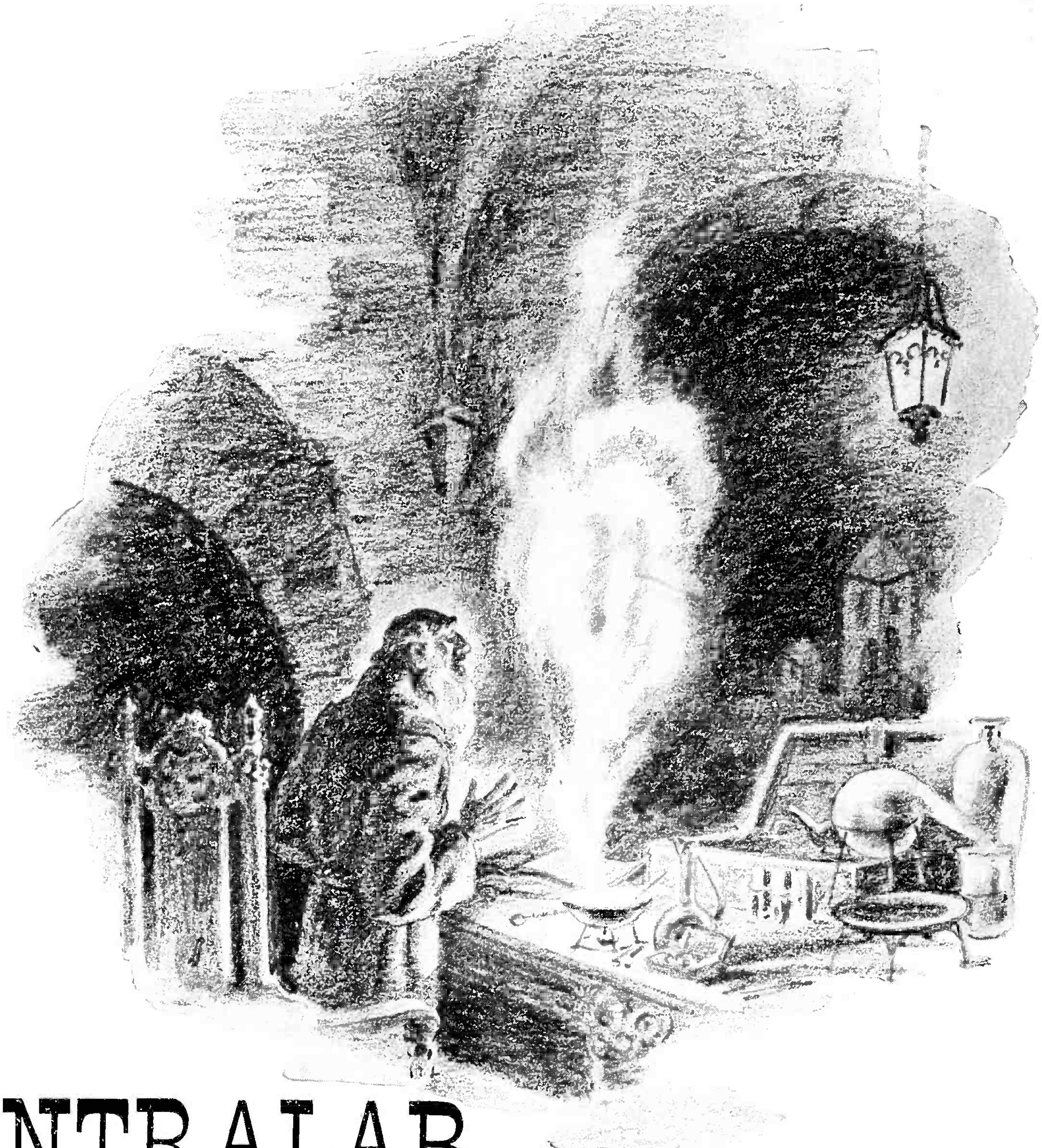

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CENTRALAB controls porosity in ceramics. • Centralab controls heat-shock characteristics. Centralab controls physical strength. • Centralab holds tolerances of ± .001″ where grinding is feasible. Centralab is prepared to supply you with ceramics harder than the hardest quartz (7½ on Moh Scale). If you need a versatile ceramic for specialized or standard applications, invoke the magic name of Centralab.

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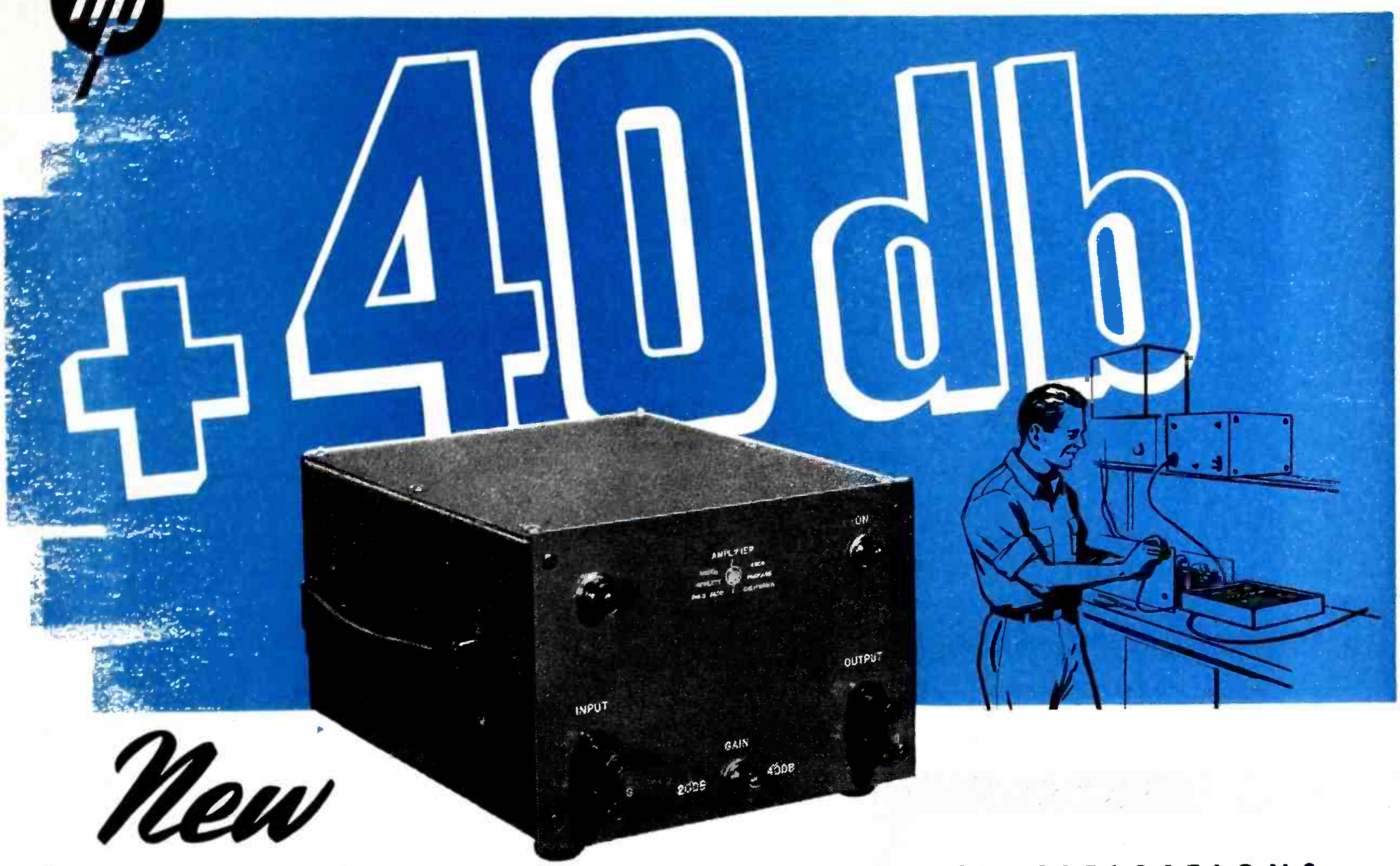
LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY



New

-hp- 450A AMPLIFIER

A Stable, Wide-band, General Purpose Laboratory Instrument

This versatile *-hp-* Amplifier is ideal for general laboratory use. It provides unusual stability at 40 or 20 db gain, and new freedom from spurious responses. Low phase shift is assured by a straightforward, resistance-coupled amplifier design, together with inverse feedback. Frequency response is flat within ½ db between 10 and 1,000,000 cycles. Varying tube voltages or aging tubes have no appreciable effect on the gain or other characteristics. The amplifier is fully operated from a 115 volt 60 cycle power supply.

When used in conjunction with the *-hp-* 400A Vacuum Tube Voltmeter, this amplifier increases the voltmeter's sensitivity by *100* times (300 microvolts full scale) at 40 db. At 20 db gain, sensitivity is multiplied *10* times (3 millivolts full scale). And since the 450A is designed for use with the 400A, both have identical base sizes to permit stacking and short leads.

This rugged, compact amplifier is ready now for early shipment. Your inquiry or order will be given prompt attention.

SPECIFICATIONS

GAIN:
40 db (100X) or 20 db (10X)
(Panel Selector Switch)

FREQUENCY RESPONSE:
at 40 db gain:
within ± ½ db between 10 and 1,000,000 cps
within ± 1 db between 5 and 2,000,000 cps
at 20 db gain:
within ± ½ db between 5 and 1,000,000 cps
within ± 1 db between 2 and 1,200,000 cps

INPUT IMPEDANCE: 1 megohm shunted by approximately 15 μμfd

OUTPUT: 10 Volts maximum to 3,000 ohms or higher resistive load

INTERNAL IMPEDANCE: Less than 150 ohms over entire range

POWER SUPPLY: 115 volts 50/60 cycles 40 watts

MOUNTING: Metal Case, leather carrying handle

SIZE: 7½" wide, 5¼" high, 9½" deep
Net weight 10 lbs.
Shipping weight 18 lbs.

PRICE: $125.00 FOB Palo Alto, California

INCREASES SENSITIVITY OF -hp- 400A 100 TIMES!

HEWLETT-PACKARD COMPANY

1278A Page Mill Road, Palo Alto, California, U. S. A.

....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.

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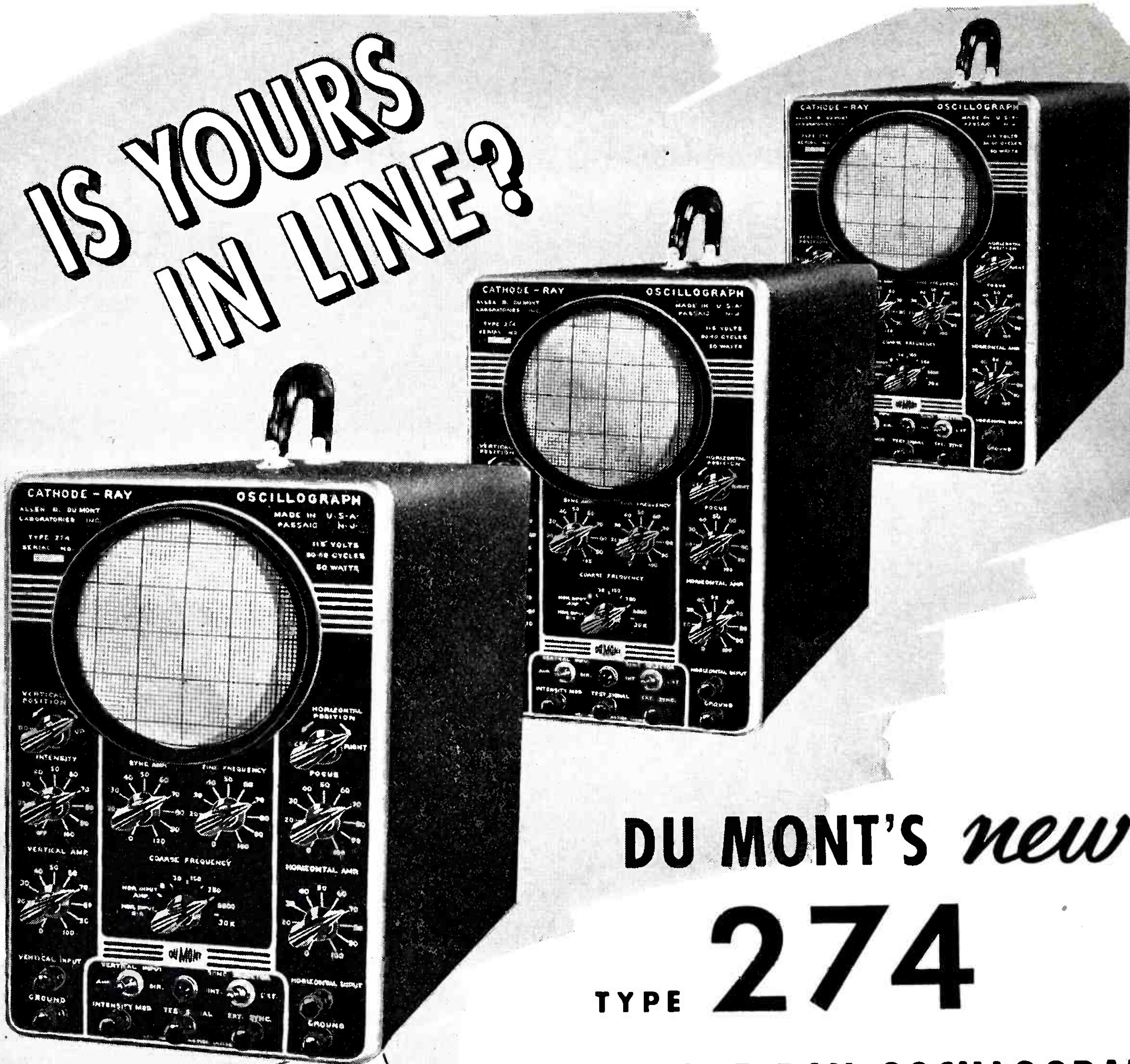

MEMO: at $99.50 it's your "best buy"

DU MONT'S *new* TYPE 274

5" CATHODE-RAY OSCILLOGRAPH

➧ It's handsome... it's accurate... it's Du Mont quality throughout! Among the many fine features of the Type 274 are: 5BP cathode-ray tube; identical vertical and horizontal amplifiers uniform within 20% from 20 to 50,000 c.p.s.; linear time base, 8 to 30,000 c.p.s. with synchronization from vertical amplifier or external signal; provision for intensity modulation.

➧ ***Send for descriptive literature!***

DUMONT *Precision Electronics & Television*

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Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

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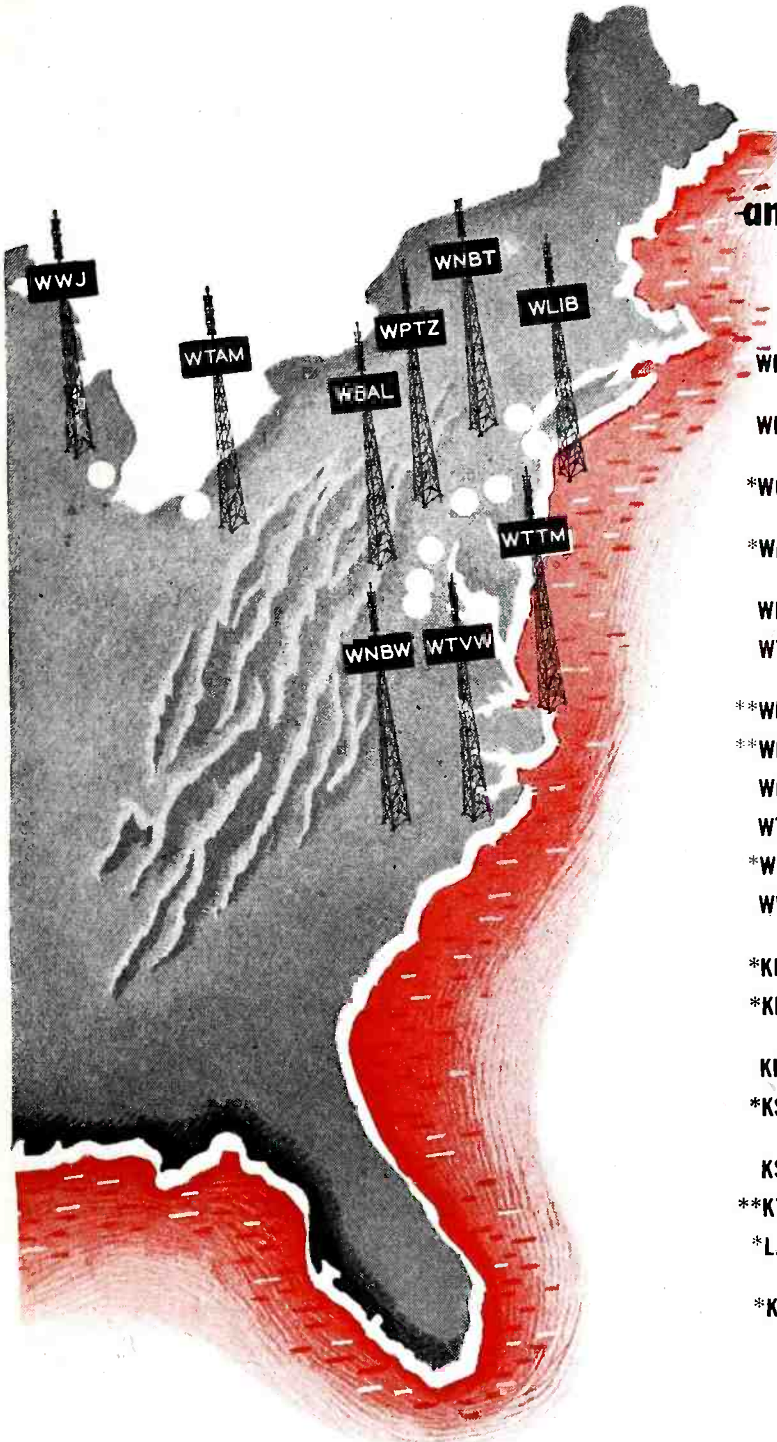
take the lead in television



The broadcasters listed below have placed firm orders for RCA Television Equipment and will provide television service to a combined audience of 34,000,000 people

WBAL—Hearst Radio, Inc., Baltimore, Md. Owned by Hearst newspapers and publications including "Baltimore News-Post", and others.

WBAP—Carter Publications Inc., Fort Worth, Texas. Publishers of "The Fort Worth Star-Telegram."

***WGN**—WGN, Inc., Chicago, Ill. Subsidiary of The Tribune Co., publishers of "Chicago Tribune."

***WLIB**—WLIB, Inc., Brooklyn, N. Y. Owned by Theodoro Corp., Dorothy S. Thackrey, Pres., publisher "New York Post."

WMAQ—National Broadcasting Co., Inc., Chicago, Ill.

WTVW—Evening Star Broadcasting Co., (WMAL), Washington, D. C., Subsidiary of "The Evening Star."

****WNBT**—National Broadcasting Co., Inc., New York, N. Y.

****WPTZ**—Philco Television Broadcasting Corporation, Philadelphia, Pa.

WNBW—National Broadcasting Co., Inc., (WRC), Washington, D. C.

WTAM—National Broadcasting Co., Inc., Cleveland, Ohio.

***WTTM**—Trent Broadcast Corp., Trenton, N. J.

WWJ—Evening News Association, Detroit, Michigan, publishers of "The Detroit News."

***KFI**—Earl C. Anthony, Inc., Los Angeles, Calif.

***KLAC**—(Formerly KMTR) Los Angeles, Calif. Owned by Dorothy S. Thackrey, publisher of "New York Post."

KKOB—Albuquerque Broadcasting Co., (KOB), Albuquerque, New Mexico.

***KSD**—Pulitzer Publishing Co., St. Louis, Mo., publishers of the "St. Louis Post-Dispatch."

KSTP—KSTP, Inc., Minneapolis/St. Paul, Minnesota.

****KTSL**—Don Lee Broadcasting System, Hollywood, Calif.

***L. A. TIMES**—"Los Angeles Times," published by the Times-Mirror Co., Los Angelès, Calif.

***KYA**—San Francisco, Calif. Owned by Dorothy S. Thackrey, publisher of "New York Post."

*Construction subject to FCC approval

**Already broadcasting on a regular schedule

THE companies listed above have indicated by firm orders that they are anxious to start telecasting immediately and have authorized us to say that they plan to start as soon as their equipment is ready and FCC approval is granted. It is interesting to note that ten of the stations are owned by publishers.

The coming months should see all of these stations bringing television programs to their respective areas. Almost every item necessary for a television station has now been fully developed by RCA. Most equipments are now in production. Deliveries have already begun on such items as monoscope cameras and synchronizing generators. Shipments on existing orders for portable field equipment, relays, antennas, 5-kw transmitters, and studio equipment will begin this Fall.

It will pay you to investigate RCA television equipment immediately, so that you will also be ready to explore the tremendous potential promised by this new market. Write: Dept. 30-I, Radio Corporation of America, Camden, New Jersey.

TELEVISION BROADCAST EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

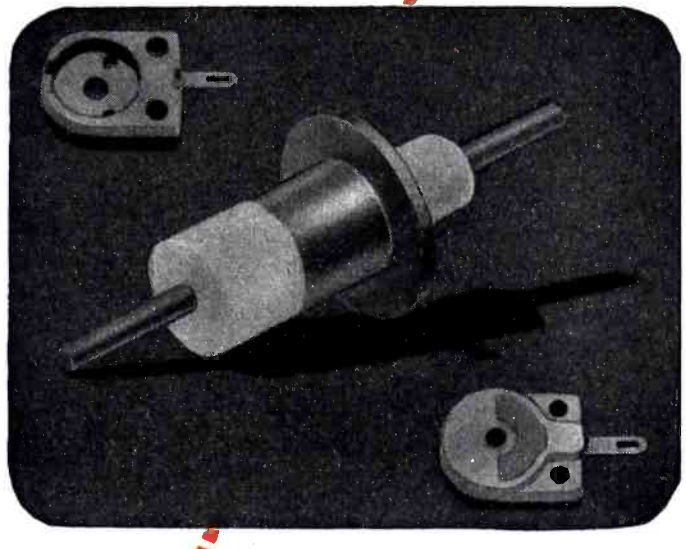
Here's why MYCALEX 410 is the "Last Word" in low loss insulation

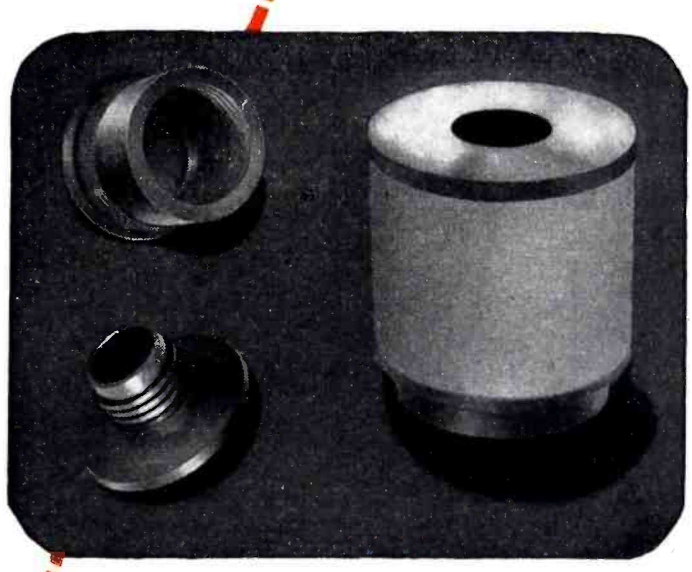
For more than 27 years MYCALEX has consistently demonstrated its superiority as an insulating material — supplanting one old-fashioned material after another as electronic advancements have made insulating needs more exacting.

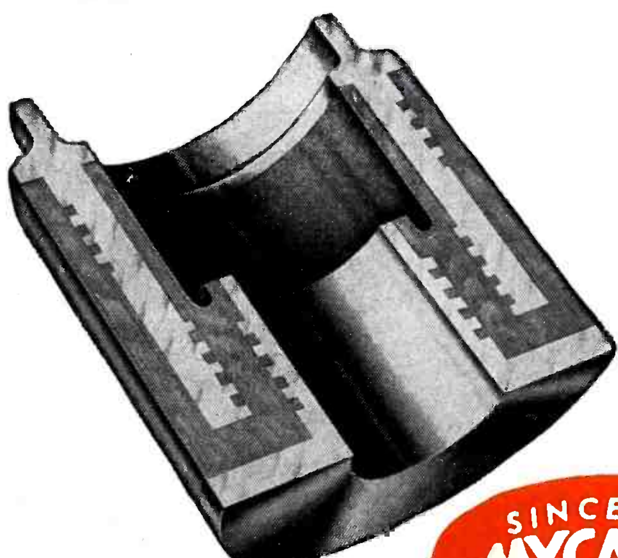
MYCALEX excels wherever high dielectric strength and extremely low loss factor are important . . . where resistance to arcing and high temperature is desired . . . where imperviousness to oil and water must be virtually 100%.

Latest and greatest of MYCALEX advancement is MYCALEX 410 (Molded Mycalex). This highly perfected insulation, together with our exclusive injection-molding techniques, now makes available a wide variety of unusual or intricate shapes . . . especially with metal inserts or electrodes molded in to form a perfect bond or hermetic seal.

Our engineers invite your inquiries on all insulating problems.







SOME PROPERTIES OF MYCALEX 410

Electrical Properties	
Power factor, 1 megacycle, dry	0.0015
Dielectric constant, 1 megacycle	8.3
Volume resistivity, ohm-cm	6.0×10^{17}
Arc resistance, ASTM seconds	250
Dielectric strength, volts/mil	400
Mechanical Properties	
Flexural strength, psi	13,000
Tensile strength, psi	6,000
Compressive strength, psi	20,000
Hardness, Brinell	150
Modulus of elasticity, psi	8×10^{6}
Maximum safe operating temperature, °C	400
Density, lb./cu. in.	0.136
Specific gravity	3.8

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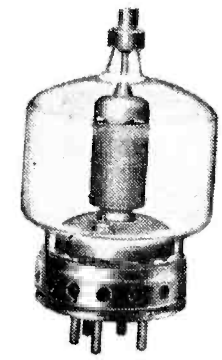
Eimac Tetrodes *lead the way to simplified* CRYSTAL FREQUENCY CONTROL FOR DIATHERMY *and* ELECTRONIC HEATING

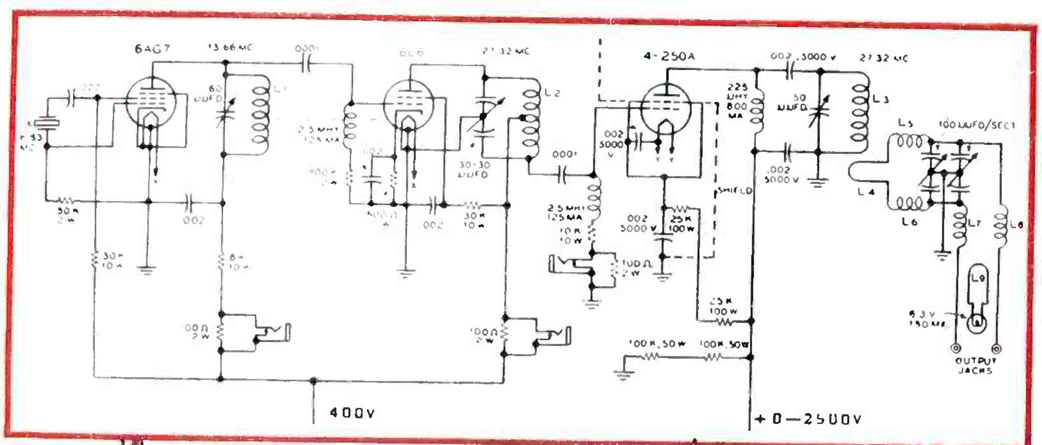
Crystal control of frequency now becomes the practical answer to the new frequency stability requirements. Eimac tetrodes make crystal frequency control feasible and simple. *Crystal control through Eimac tetrodes means maximum frequency stability, end of objectionable radiation, and handy portability for electronic heating units of the future.*



Eimac 4-250A Tetrode

Here's How an Eimac Tube Makes This Practical

The way just one Eimac 4-250A tetrode makes crystal frequency control practical is shown in this *operative,* experimental circuit assembled by Eimac engineers. The circuit is also applicable to other forms of electronic heating.



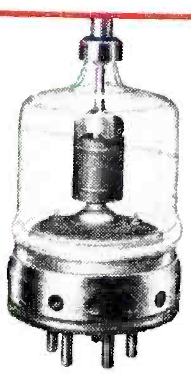
Greater Stability...Longer Life

Both tetrodes have specially treated elements that insure longer life. Both have non-emitting grids which give great operating stability.

Because of their low grid-plate capacitance (0.12 *uu*fd in the 4-250A and 0.05 *uu*fd in the 4-125A), these tubes normally require no neutralization at diathermy or heating frequencies. (In fact, the 4-250A normally requires no neutralization up to 70 Mc; 4-125A ordinarily needs none even at 120 Mc.)

Eimac Tetrodes for Power Amplification Throughout the Useful Frequencies

Dependable, durable Eimac tetrodes are admirably suited for diathermy or electronic heating work, or for almost any power amplification assignment at any frequency, including VHF. Write today to Eimac's local representatives or factory engineers for complete data on these tubes.



Eimac 4-125 Tetrode

Here's Why Eimac Tubes Make Crystal Frequency Control Practical

Because of their unique characteristics, Eimac power tetrodes such as the 4-250A and 4-125A are ideal for use in circuits like the one above.

These tubes have an unusually high power-gain for efficient performance at medium, high, or the very high frequencies used in diathermy and heating. For example, the 4-250A (at frequencies up to 70 Mc.) develops power output of 750 watts with a driving power of less than 5 watts. The 4-125A tetrode delivers 375 watts output with less than 3 watts drive.

Follow the Leaders to **Eimac** REG. U. S. PAT. OFF. TUBES

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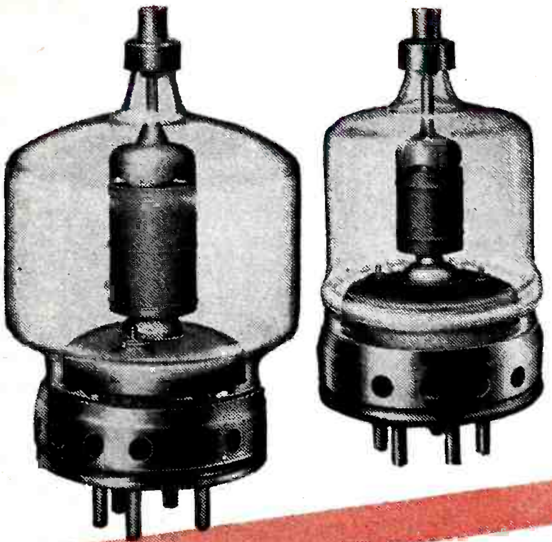

CRYSTAL CONTROL with Eimac tetrodes means pin-point frequency stability plus ready portability for tomorrow's electronic heating units!

This experimental diathermy unit WORKS...and it proves that the easy, simple, SURE way to solve frequency stability problems is with crystal controlled Eimac tetrodes.

In the experimental diathermy application shown here, one Eimac 4-250A tetrode is driven by a simple crystal frequency controlled r-f exciter unit employing a handful of parts and *only two* receiving type tubes. Exciter frequency multiplication plus great power amplification by the Eimac tetrode permits approximately 500 *watts output* at 27.32 Mc. And because of the low plate-to-grid capacitance of this tetrode, no neutralization is necessary.

The success of Eimac's experimentation with crystal frequency control through Eimac tetrodes has proved the usefulness of this combination—not only in diathermy—but in industrial electronic heating as well. Eimac's 4-250A, 4-125A or other Eimac tetrodes may well solve your electronic heating problem. Your inquiry will receive full and prompt attention from either Eimac representatives or factory engineers.

Once again—Eimac engineers have pioneered the way to new developments in the electronic field.

CALL IN AN EIMAC REPRESENTATIVE FOR INFORMATION

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VERNER O. JENSEN, Verner O. Jensen Company, 2616 Second Ave., Seattle 1, Wash., Phone: Elliott 6871.

M. B. PATTERSON (W5CI), Patterson & Co., 1124 Irwin-Keasler Bldg., Dallas 1, Tex., Phone: Central 5764.

ADOLPH SCHWARTZ (W2CN), 220 Broadway, Room 2210, New York 7, N. Y., Phone: Cortland 7-0011.

HERB BECKER (W6QD), 1406 So. Grand Avenue, Los Angeles 15, California, Telephone: Richmond 6191.

TIM COAKLEY (W1KKP), 11 Beacon Street, Boston 8, Massachusetts, Telephone: Capitol 0050.

RONALD G. BOWEN, 1886 South Humboldt Street, Denver 10, Colorado, Telephone: Spruce 9368.

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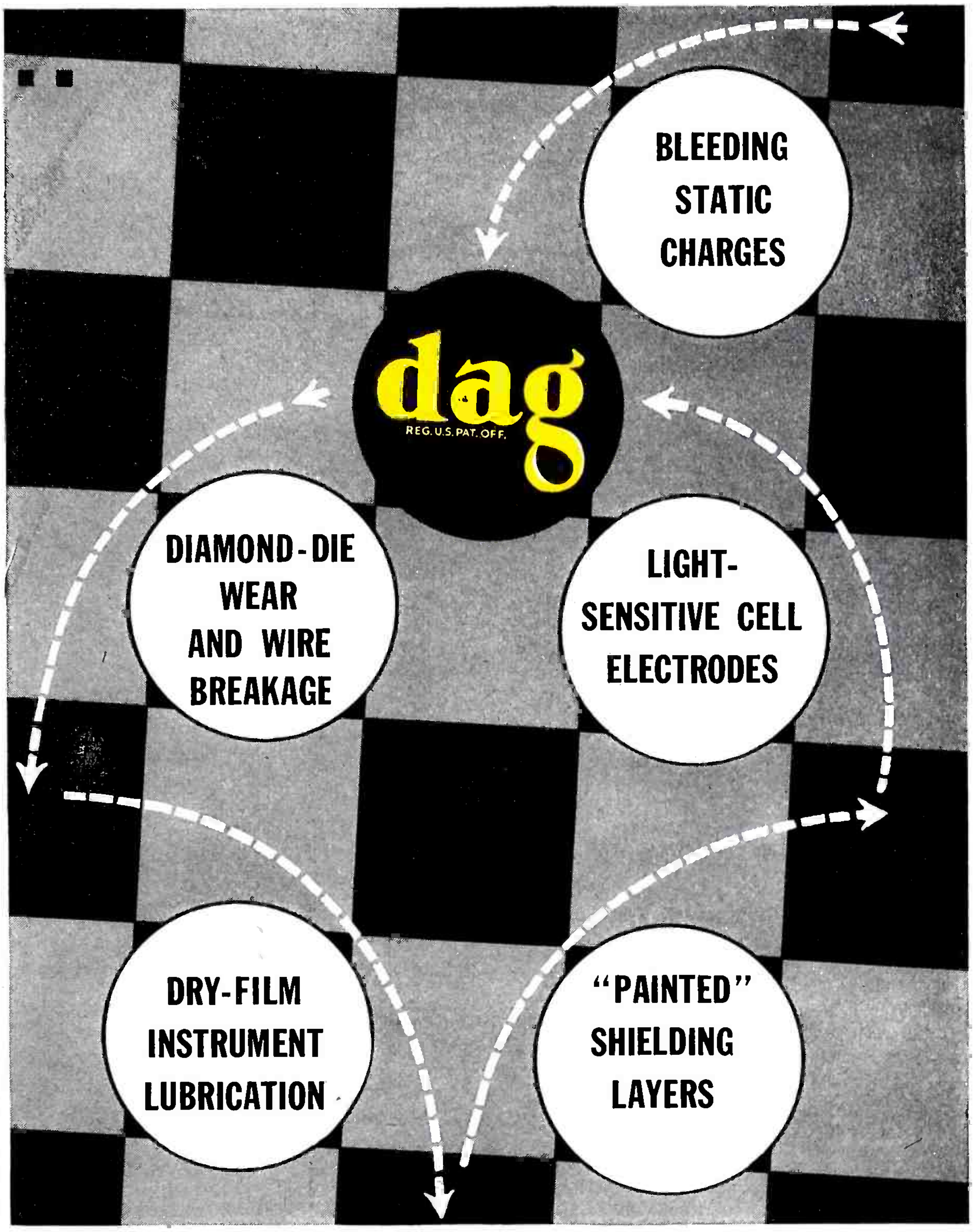

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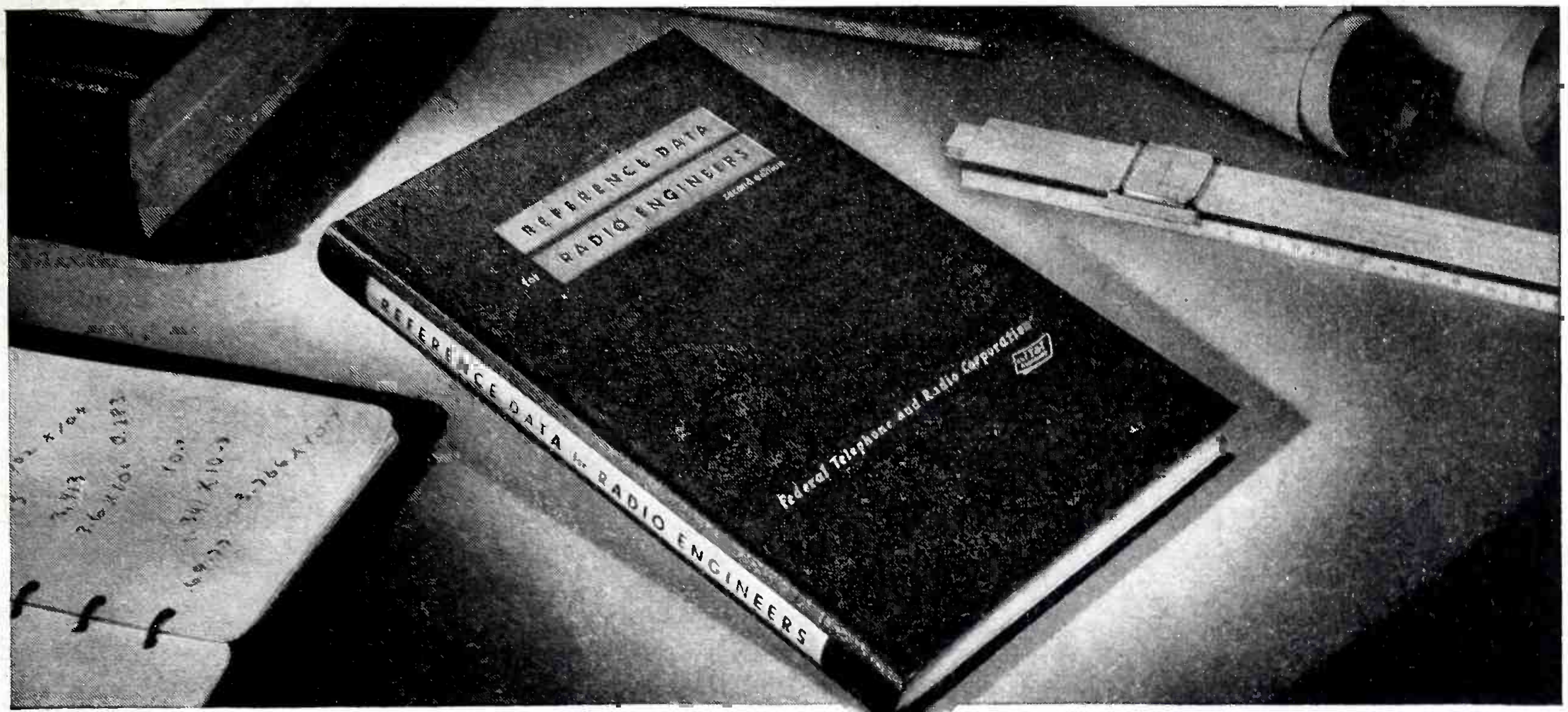

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> *"It is so chock full of useful data that I am urging all students to purchase their own personal copies . . . fills a long-felt need for a convenient compilation of both mathematical and engineering data, and the combination will be appreciated by all who have to work with radio circuits and their concomitant mathematics. That applies especially to teachers and students and I should not be surprised if it becomes a must in many college courses."*

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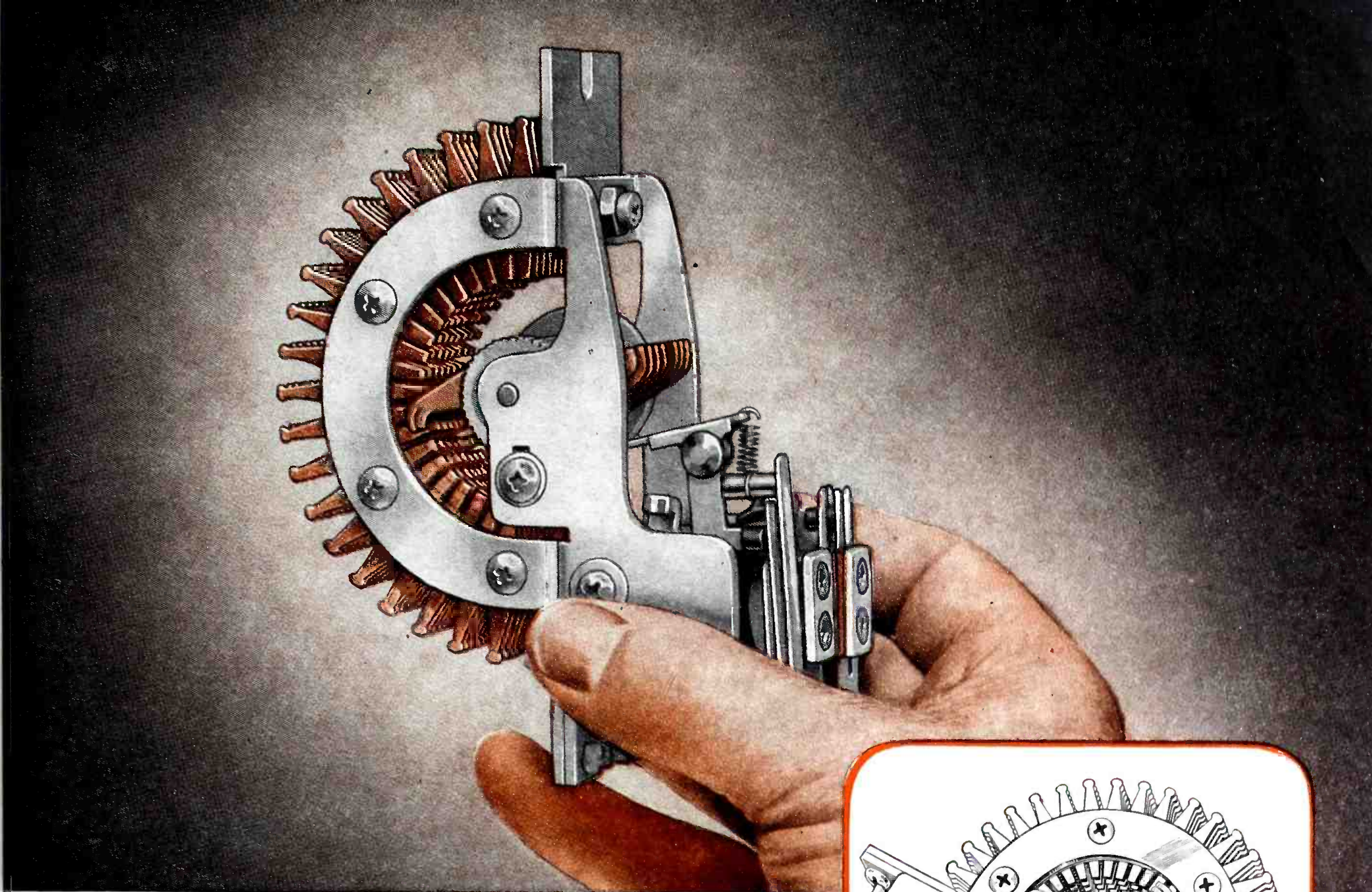

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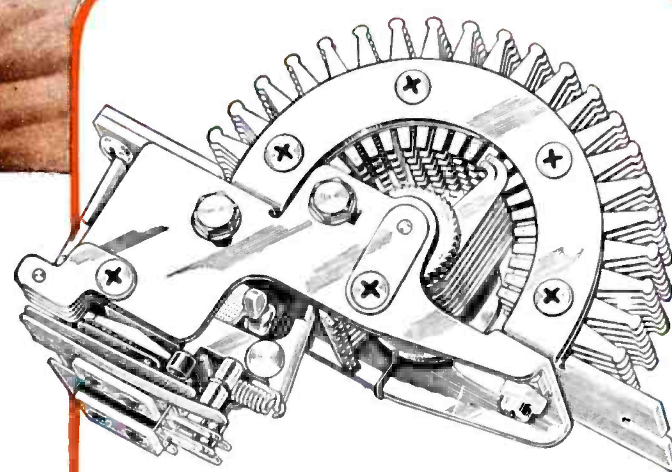

SPECIFICATIONS

OPERATION
Automatic, or remote-controlled.

WIPERS
One to eight, traversing individual contact levels.

INTERRUPTER SPRINGS
Usually Form 1B, to open operating current at the end of each step. As many as eight contact springs may be provided. Contacts: single.

OPERATE SPEED
Remote-controlled operation—30 steps per second maximum; Self cycling operation—60 steps per second average.

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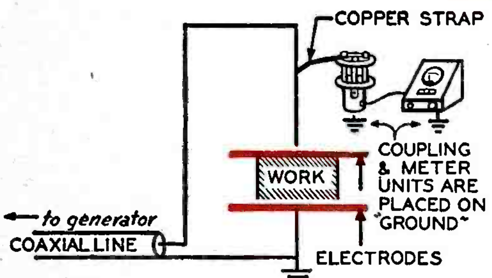
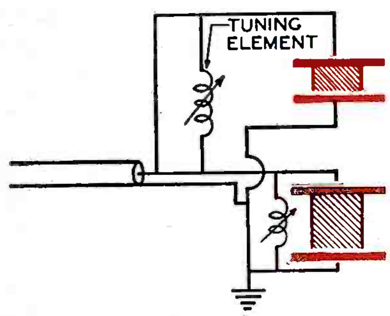
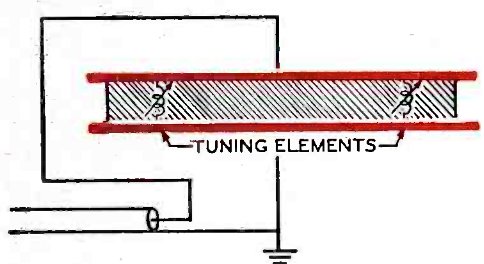
with coupling unit



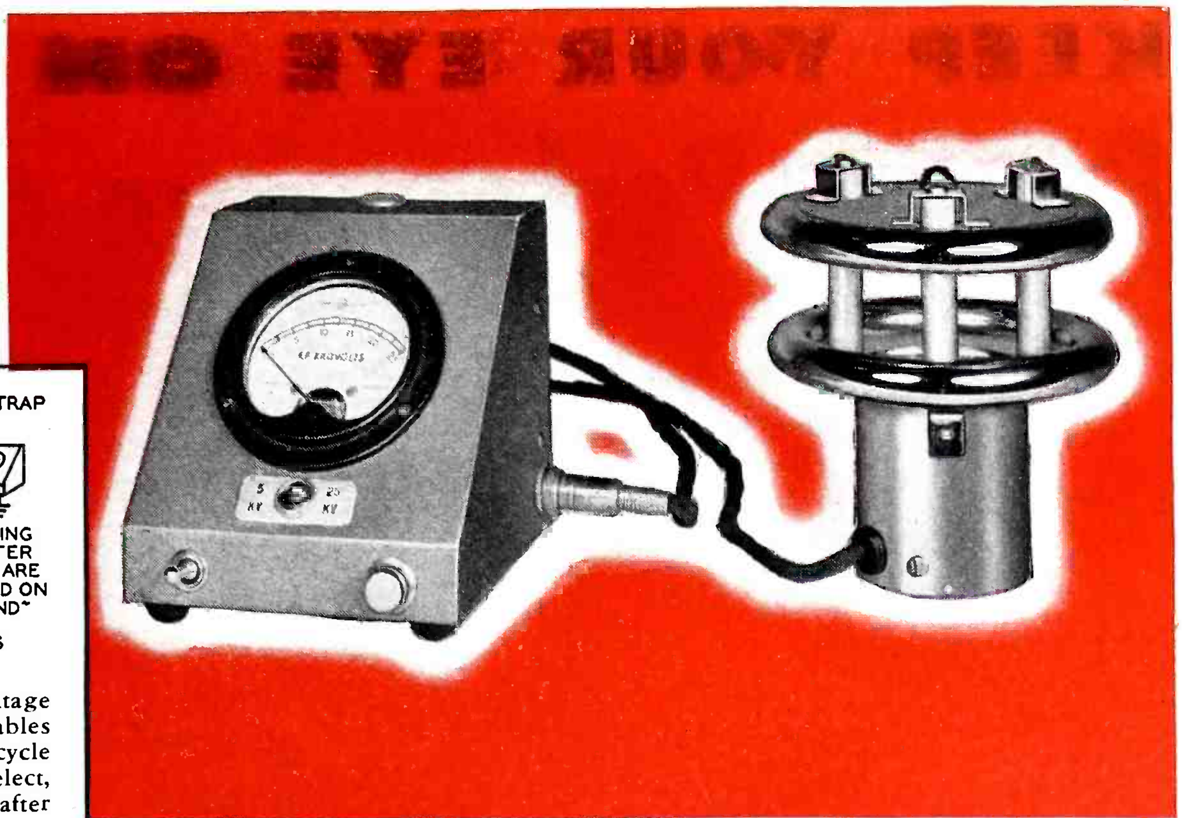
Quickly and directly measures r-f voltage between applicator electrodes. Enables you to vary load voltage during heat cycle in accordance with any pattern you select, or regulate the voltage on one load after another to assure uniform results.



Simplifies the adjustment of a setup consisting of two or more pairs of electrodes connected in parallel. The heating rate of each can be adjusted as desired.



Makes it easy to measure voltage variations ("standing waves") on long electrodes. Auxiliary compensating inductances or "tuning stubs" to distribute the power evenly can be quickly and accurately adjusted.



A HANDY GUIDE to better electronic-heater adjustment

Correct adjustment of your dielectric heating installation is made much simpler with one of these specially designed radio-frequency voltmeters. It measures directly the potential existing between the applicator electrodes.

This instrument consists of the two units shown above: an indicating unit and a coupler. The indicating unit incorporates a small rectifier and a sensitive meter calibrated in two scale ranges: 0 to 5 and 0 to 25 kilovolts.

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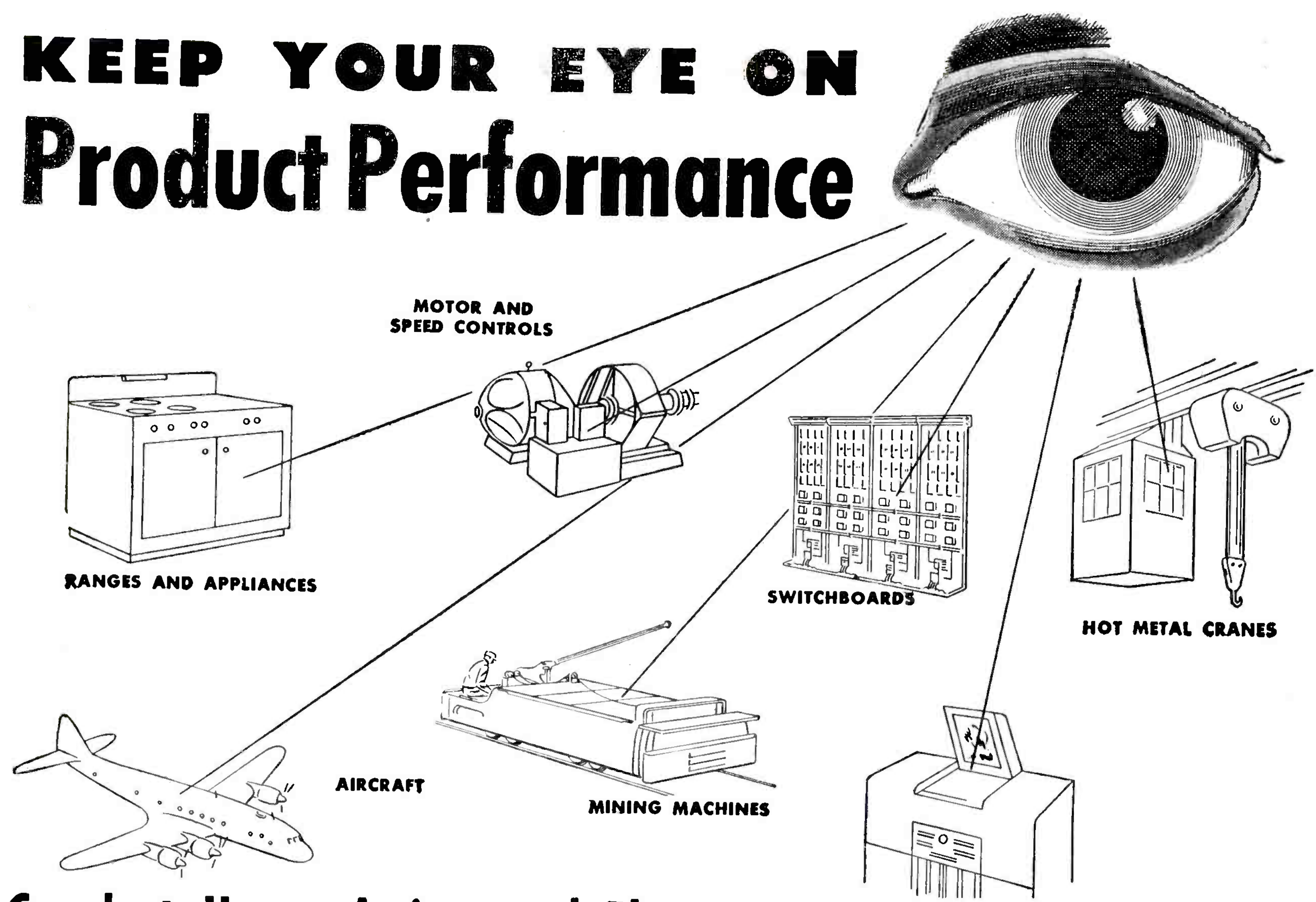

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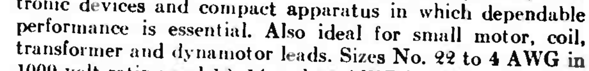

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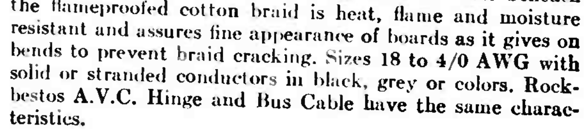
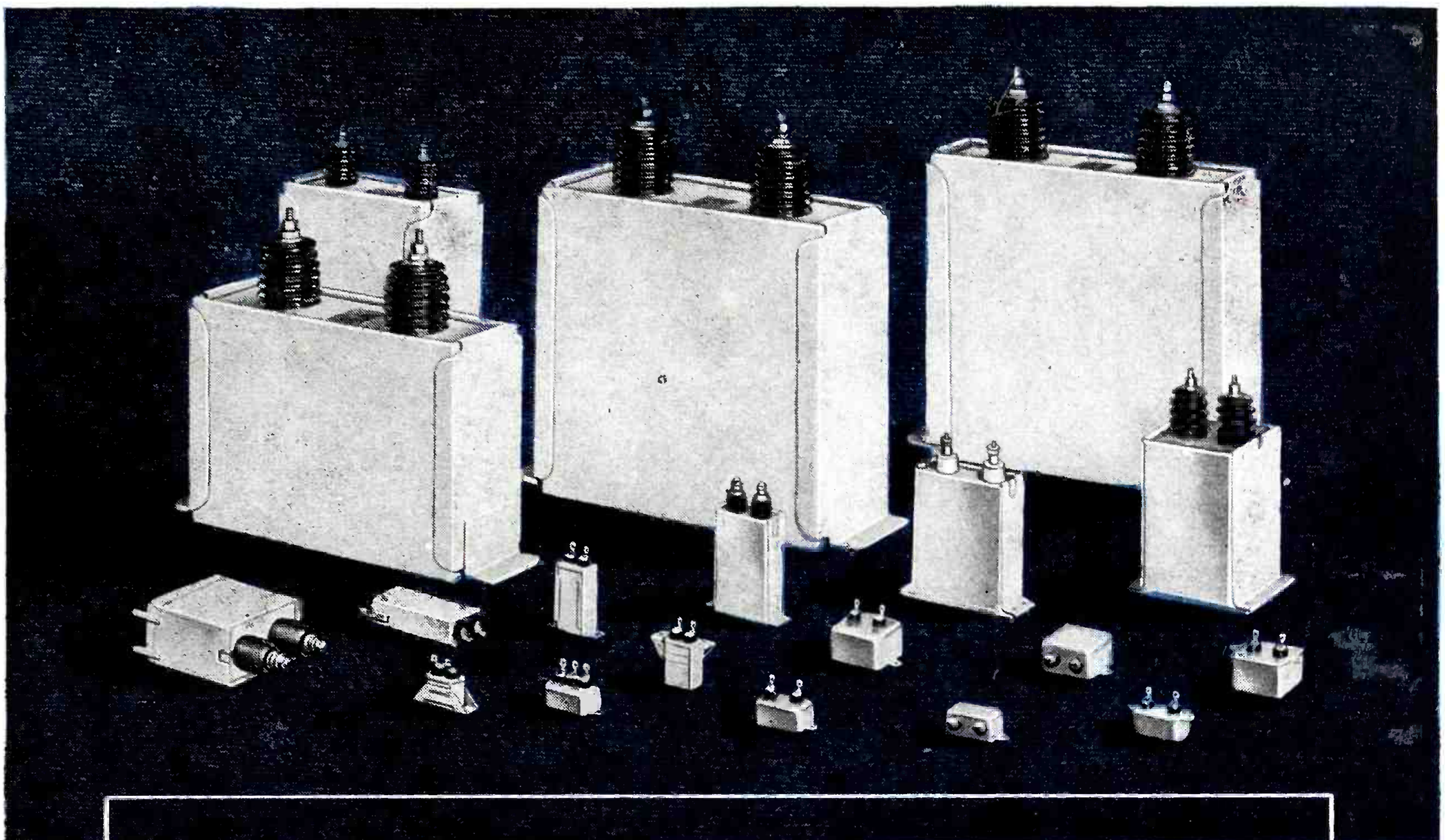
This wire was designed to make complicated wiring jobs permanent. The impregnated felted asbestos wall beneath the flameproofed cotton braid is heat, flame and moisture resistant and assures fine appearance of boards as it gives on bends to prevent braid cracking. Sizes 18 to 4/0 AWG with solid or stranded conductors in black, grey or colors. Rockbestos A.V.C. Hinge and Bus Cable have the same characteristics.



ROCKBESTOS A.V.C. 600 VOLT MOTOR LEAD CABLE
(National Electrical Code Type AVA)

Use this apparatus cable for coil connections, motor and transformer leads exposed to overloads or high ambient temperatures. It makes a permanent installation as it is resistant to heat, flame, oil, grease and moisture. Sizes No. 18 AWG to 1,000,000 CM insulated with two walls of impregnated asbestos and a high-dielectric varnished cambric insert, with a heavy asbestos braid overall.

HERE'S A *New Line* OF D-C CAPACITORS



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It's an open secret among the trade that G-E Pyranol capacitors, which enjoyed such an enviable reputation before the war, are now better than ever!

The reason for this is obvious. Some pretty tough demands had to be satisfied during the war. The strict quality control methods, new manufacturing techniques, and improved materials, instituted at that time have produced outstanding results which General Electric has now incorporated in a new line of Pyranol capacitors designed to meet commercial requirements.

This new listing makes available a wider range of sizes, ratings, and mounting arrangements with characteristics for operation over wider temperature ranges (−55°C to +85°C), at altitudes up to 7500 ft.

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**Pyranol is General Electric's non-inflammable liquid dielectric for capacitors.*

D-C Capacitors

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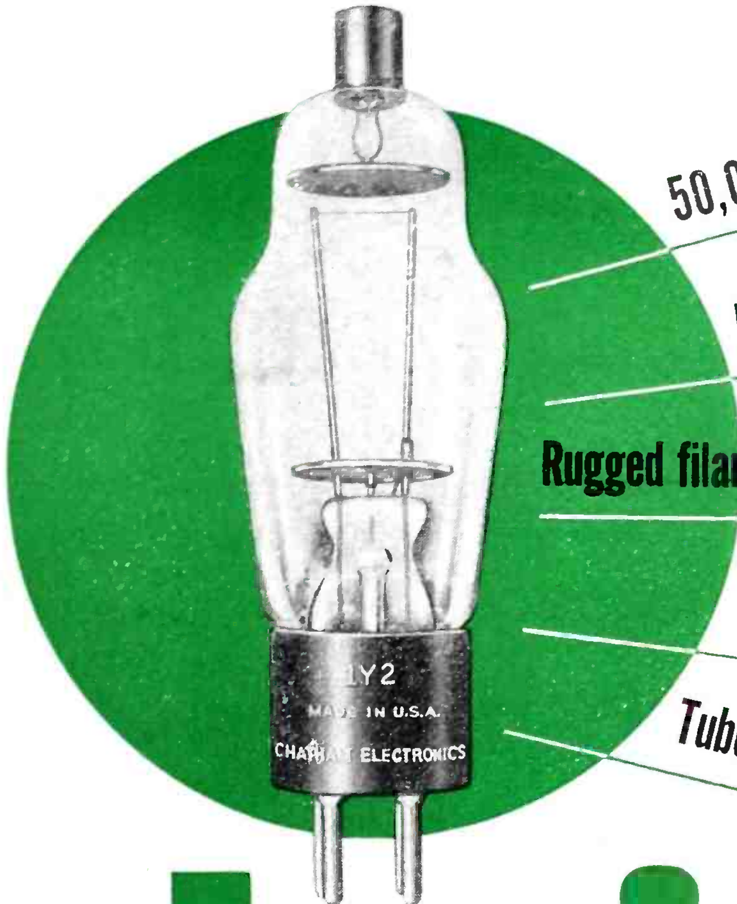
Address ....

City .... State ....



50,000 volts peak inverse rating

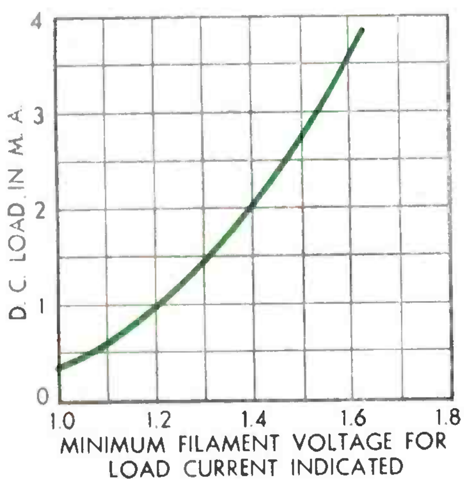
Low filament power for RF operation

Rugged filament construction for 60 cycle operation

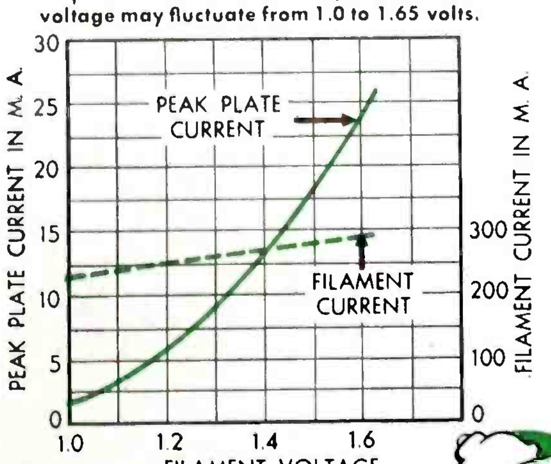
Filament voltage is not critical

Tube permits use of low cost circuit

television



Note: Curves indicate that in a television receiver rectifier circuit supplying 250 micro-amperes D. C. load current, the filament voltage may fluctuate from 1.0 to 1.65 volts.



RECTIFIER

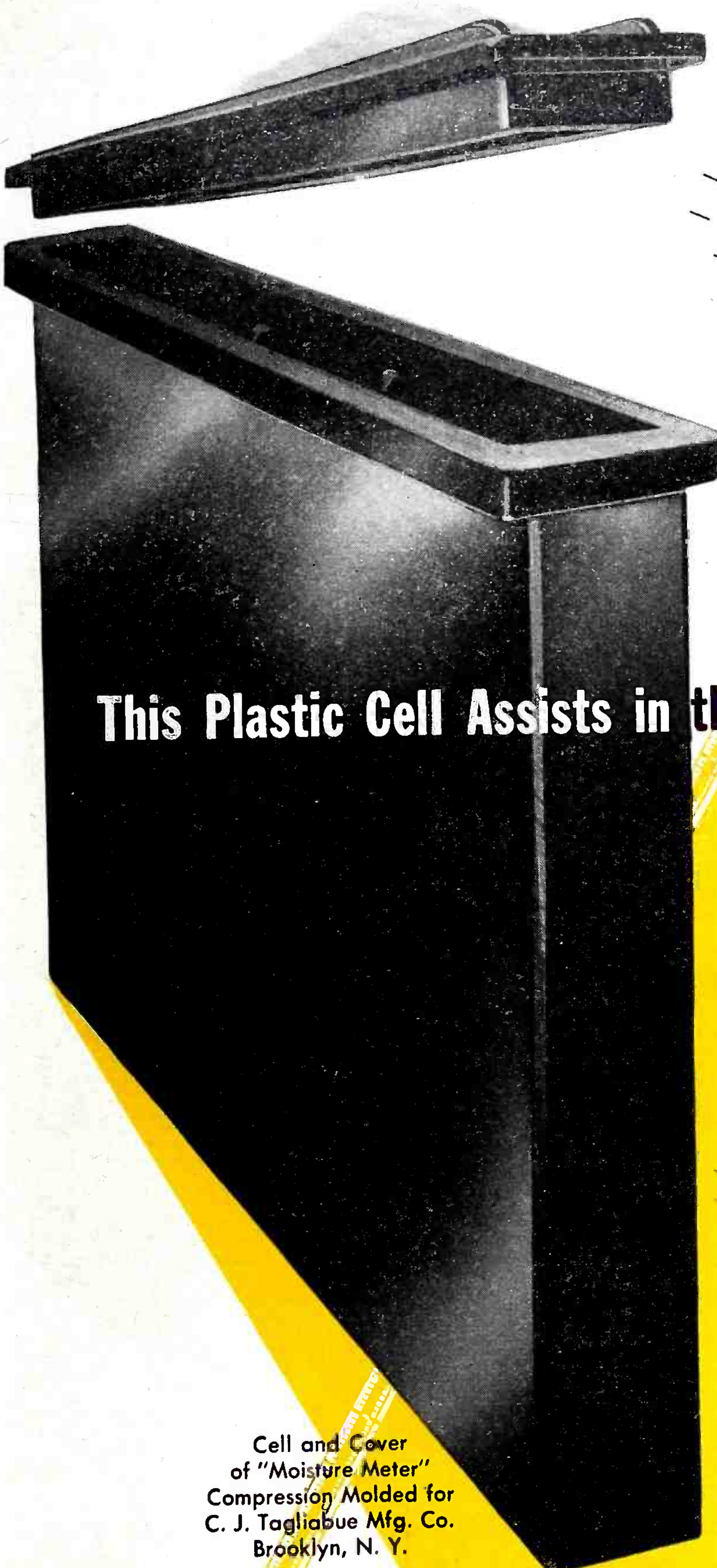
Chatham Electronics presents the new 1Y2

This new CHATHAM high vacuum rectifier is designed to withstand severe operating conditions and give long trouble-free service. Because of the rugged filament construction, repeated overloads do not seriously impair tube life. The 50,000 volt peak inverse voltage rating enables the tube to deliver approximately 25,000 volts D. C. output in a single tube circuit and approximately 50,000 volts D. C. output in a voltage doubling circuit.

The wide filament voltage operating range, extremely low interelectrode capacitance and low heater power renders this tube ideally suited for operation with high frequency supplies. Another important feature built into this tube is the almost complete absence of back emission. This feature prevents undue loading of the oscillatory circuit. For further details call or write today.

CHATHAM ELECTRONICS

475 WASHINGTON ST., NEWARK 2, NEW JERSEY



What is the Moisture Content of Given Samples?

This Plastic Cell Assists in the Determination of Correct Answers

Cell and Cover
of "Moisture Meter"
Compression Molded for
C. J. Tagliabue Mfg. Co.
Brooklyn, N. Y.

This cell and cover are functional parts to a piece of equipment that records the amount of moisture present in selected specimens such as soap, flour, dehydrated foods, etc.

Were you to look at these two compression molded parts with a molder's eyes, you would see, as we see, a beauty that is more than skin deep; in fact, the cell section is exceedingly deep . . . 5¼" — and extremely narrow . . . 1". The inside cavity surface is smooth, flawlessly squared. Side and bottom wall thicknesses are uniform, rigid, dimensionally true (no warp!). The carefully designed cover sets tightly in place . . . a perfect straight-to-the-line fit!

The rugged mold construction called for the molder's best . . . and we gave it plenty! If you could study the parts and catch the gleam of their brilliant, molded-in finish, you'd certainly share our molder's love for them.

In detailing this particular achievement, we, of Consolidated, have in mind that the completeness of our facilities may be helpful to others with similar problems. The opportunity to serve you is cordially solicited. Inquiries invited!

COMPRESSION molding
INJECTION molding
TRANSFER molding

CMP
"YOUR BLUEPRINT IN PLASTIC"

Consolidated
MOLDED PRODUCTS *Corporation*
309 CHERRY STREET, SCRANTON 2, PA.

Branches: NEW YORK • CHICAGO • DETROIT BRIDGEPORT • CLEVELAND

HOW TO BE SURE OF
INDUSTRIAL CONTROLS

You can't complete nor ship electrically operated equipment without controls.

There are several precautions you can take to assure having proper controls when needed. First is to deal with a dependable source of supply. Then make your selection from as near stock units as possible to avoid special operations and order at the earliest possible date.

As a leading producer of Electric Controls, Ward Leonard fully appreciates the manufacturer's problem and is doing a remarkable job in the face of present day problems. The line is broad, thus offers wide selection. Engineering Service works in the customer's interest. Production is maintaining the highest possible standards. There is no better source of supply for Electric Controls, than Ward Leonard.

Bulletins are available describing Ward Leonard Relays, Resistors, Rheostats and Motor Controls. Send for the bulletins of interest to you.

WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control devices since 1892

WARD LEONARD ELECTRIC COMPANY
32 SOUTH STREET, MOUNT VERNON, N.Y. • OFFICES IN PRINCIPAL CITIES

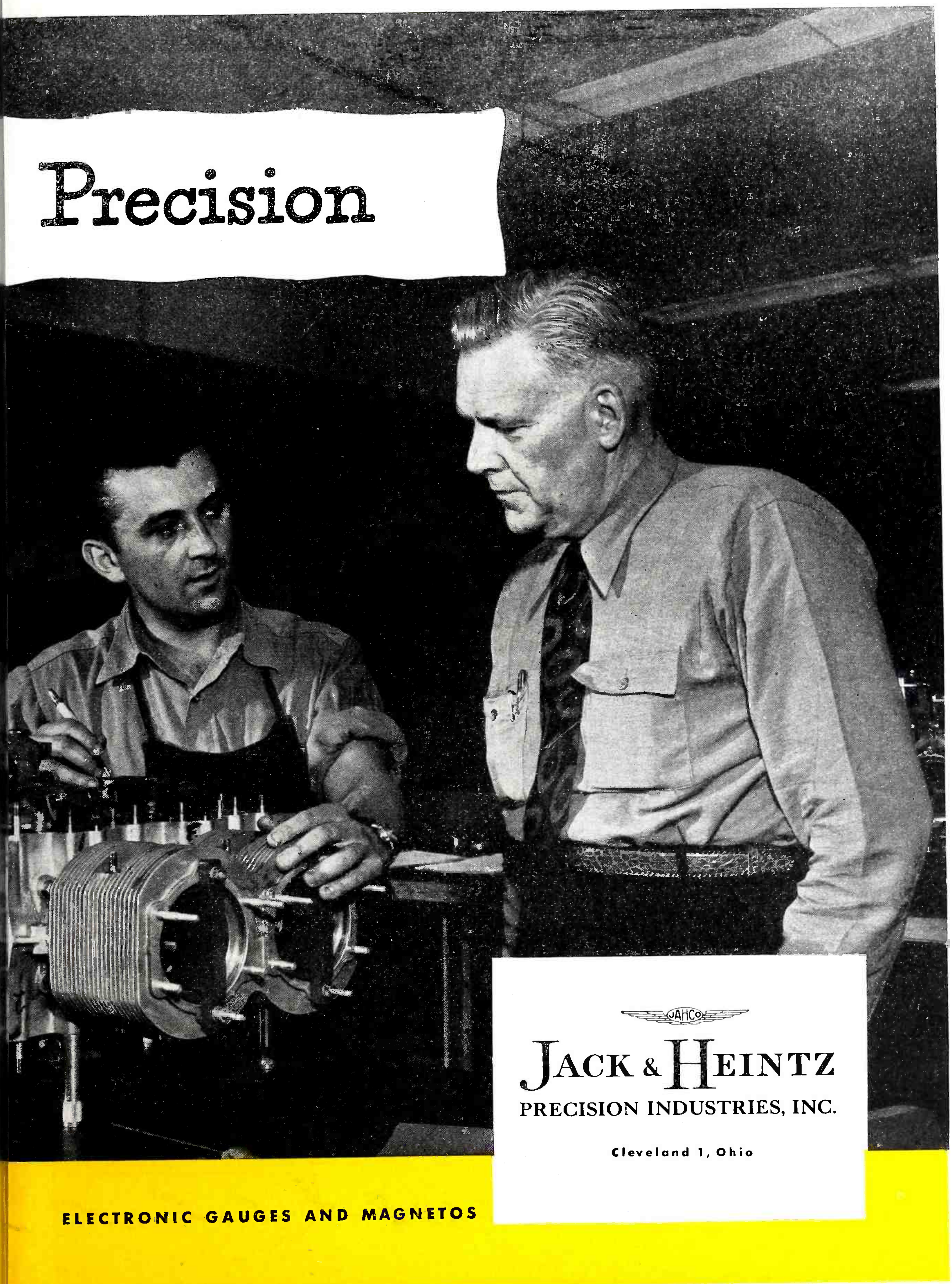
Engineering for Mass

...an achievement of Jack & Heintz

TEAMWORK

Working in an environment of rewarded initiative, Jack & Heintz engineers and craftsmen have developed a unique team spirit. Something new has been created in industry—8,000 workers, every one as enthusiastic, as determined to produce well and quickly as the managers themselves. Out of this enthusiasm and teamwork, has come a potent new engineering force. Jack & Heintz design engineers, development engineers and production engineers have created a new high standard of engineering coordination by which revolutionary designs and unheard-of *precision* have become *mass-production* realities. This combination . . . *engineering for mass precision* . . . created high-precision products by the millions to help win the war. This same teamwork . . . *engineering for mass precision* . . . is here today at Jack & Heintz as clearly, as forcefully as in the heat of war and it always will be. *And you can expect it in startling Jack & Heintz developments tomorrow.*

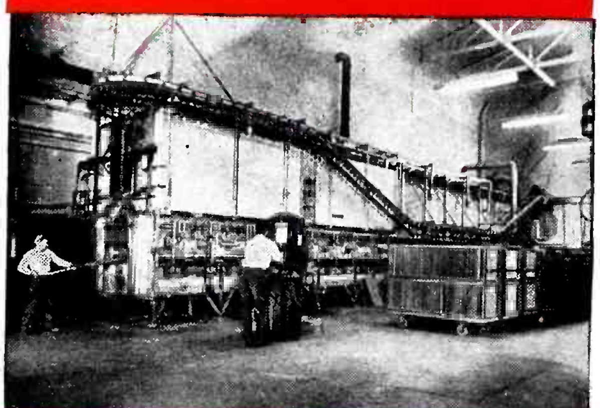
● **MANUFACTURERS OF MOTORS, BEARINGS, AIRCRAFT ACCESSORIES,**


Precision
JAHCO
JACK & HEINTZ
PRECISION INDUSTRIES, INC.
Cleveland 1, Ohio
ELECTRONIC GAUGES AND MAGNETOS

NEED MICA CERAMIC INSULATION?

One of several batteries of precision presses for molding Mykroy. Here are produced a large percentage of all molded mica ceramic parts now being used in many industries.

In this, the largest exclusive mica ceramic fabricating plant in the world, Mykroy is machined to customer's specifications on rapid delivery schedules. Mykroy can be shaped to extremely close tolerances.



The largest sheets of mica ceramic insulation available (19¼ x 29¾) made only by Electronic Mechanics are produced in this firing kiln followed by 12 to 36 hour annealing in the Lehr. This removes all internal stresses and strains in the sheets assuring great physical stability.

order MYKROY

PERFECTED MICA CERAMIC INSULATION

from

ELECTRONIC MECHANICS...Largest Manufacturer and Fabricator of Glass Bonded Mica Insulation

IT IS now recognized by leading engineers and manufacturers that Mykroy . . . the perfected Glass-Bonded Mica Ceramic, is one of the best and most usable insulating materials yet developed for general and high frequency applications. They also know that Electronic Mechanics, exclusive manufacturer and fabricator of Mykroy, is a very dependable source of supply. Whether it is required in sheets—rods—machined or molded to specifications, Mykroy is delivered *on time!*

Mykroy speaks for itself. Although there are several brands of Glass-Bonded Mica Insulation there is a vast difference between them. Exacting tests conducted by independent testing laboratories and government agencies on samples of Mykroy picked at random from production runs have proved its superiority. (Meets L4 specifications and is approved for Army and Navy equipment.) *That is why Mykroy outsells all other brands combined!*

Electronic Mechanics, now in its tenth year, is a company of nationally known electronic engineers, who have specialized in research devoted entirely to improving the formulas and methods of processing Mykroy . . . to perfecting this extensively used high frequency insulation.

The stability of Mykroy and the company behind it are your positive assurance of superior insulation and dependable deliveries. If you have used Mica Ceramic Insulation and need more, send us your order. We'll take care of it promptly. If it's new to you, write for a sample and a complete set of Mykroy Engineering bulletins.

MADE EXCLUSIVELY BY

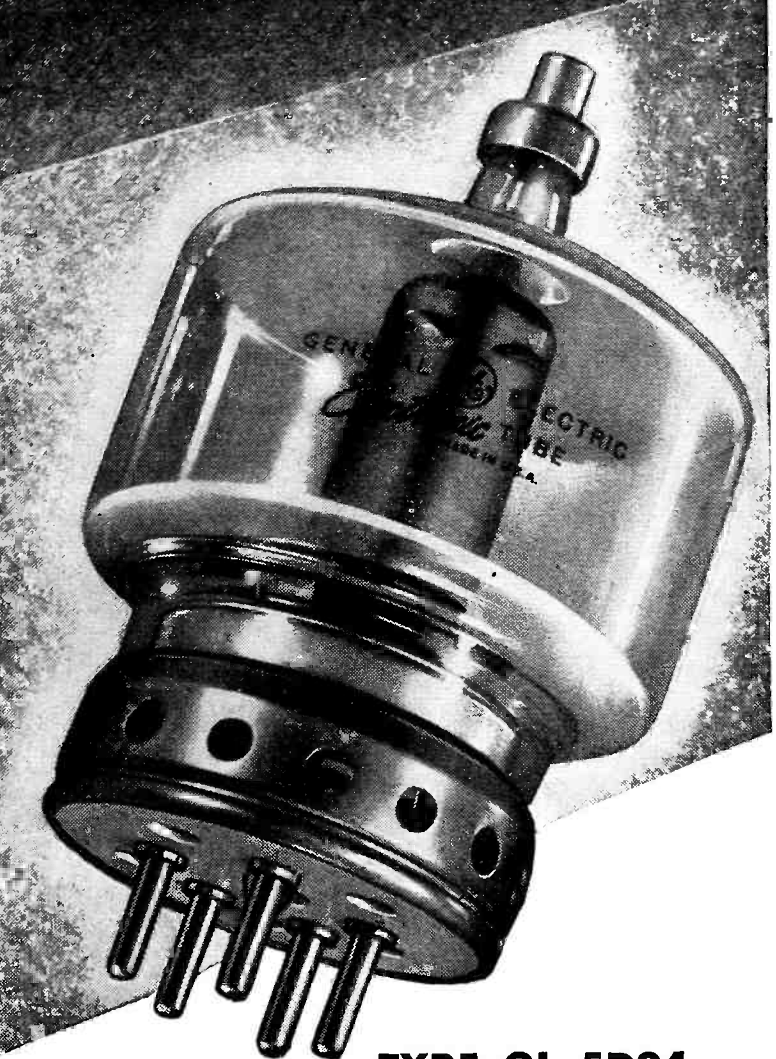
ELECTRONIC MECHANICS INC.

70 CLIFTON BLVD., CLIFTON, N. J.
CHICAGO 47: 1917 N. Springfield Ave., Tel. Albany 4310
EXPORT OFFICE: 89 Broad Street, New York 4, New York

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

CORNERSTONE

of your new FM transmitter circuit



TYPE GL-5D24
POWER TETRODE

GENERAL ELECTRIC'S TYPE GL-5D24—modern, compact, efficient—is the basic power tube for new FM transmitters you are designing and building. Output is sufficiently large for the tube to handle the final stage of low-power transmitters, while serving as a driver in higher-power circuits.

AMPLIFIER, OSCILLATOR, OR CLASS B MODULATOR—all three jobs are part of the GL-5D24's performance. The tube's suitability for FM use is emphasized by the high frequency characteristic, ranging up to 85 mc at max ratings and well beyond that figure at somewhat lower ratings.

SHORT INTERNAL LEADS bring lead inductance down to a point where neutralization usually is not required—or if it is, the circuit easily can be neutralized by tuning out the screen lead inductance.

EXTREMELY LOW DRIVING POWER gives economy of operation that appeals to transmitter users. Strong, well-braced design and construction mean longer life in hard service. Among important special features is the zirconium-coated plate, which both radiates heat well, and helps to maintain a high degree of vacuum by serving as a "getter".

SEE YOUR NEAREST G-E OFFICE for price and other information about this up-to-the-minute, cost-saving h-f power tube. Or write to *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

ELECTRICAL CHARACTERISTICS

Filament voltage	5 v
Filament current	14.1 amp
Avg interelectrode capacitances:	
grid-plate	0.06 mmfd
input	12.7 mmfd
output	4.5 mmfd
Frequency at max ratings	85 mc
Type of cooling	forced-air

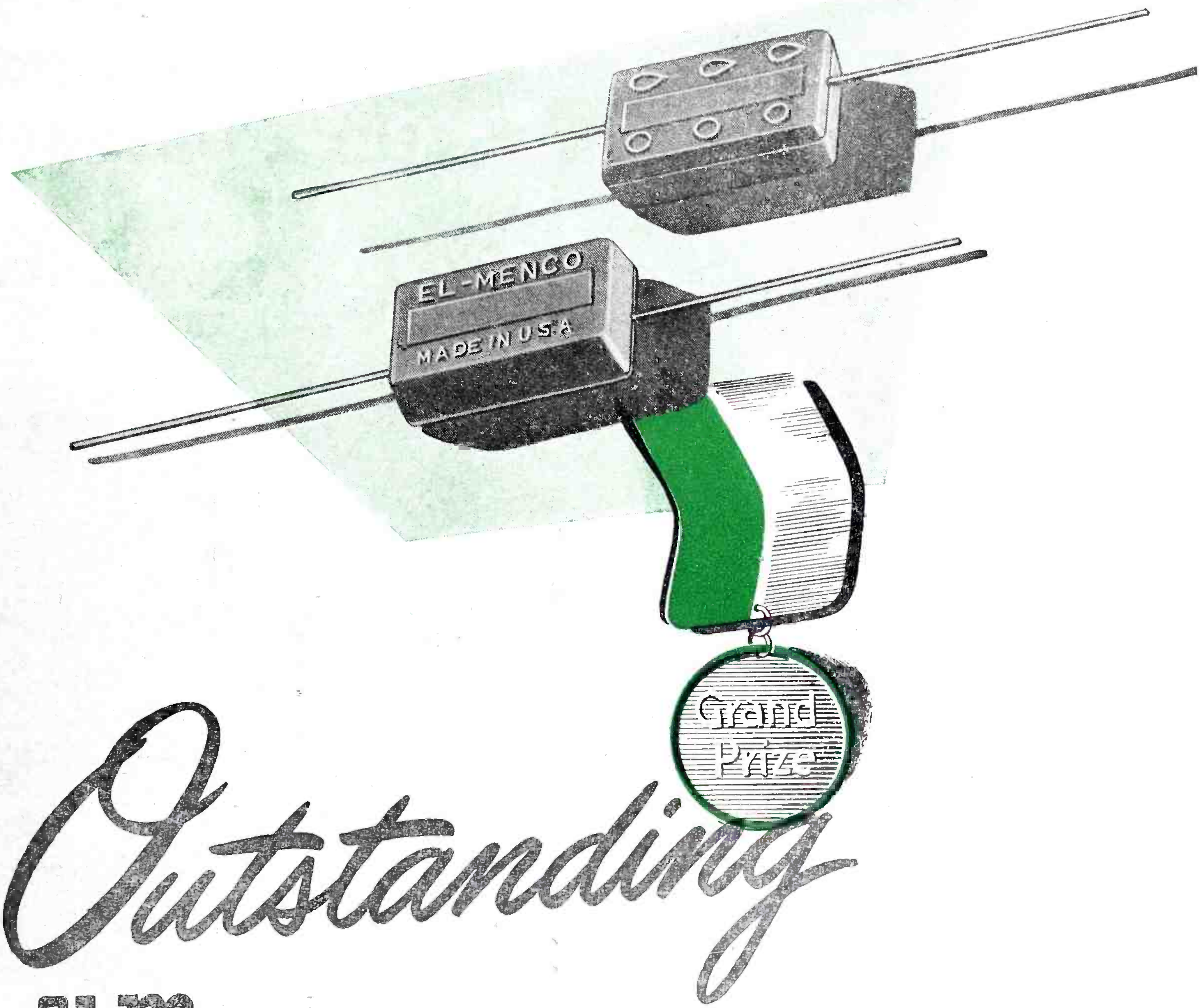
MAX CLASS C RATINGS (CCS)

Plate voltage	3,500 v
current	350 ma
input	600 w
dissipation	200 w
Screen voltage	600 v

GENERAL ELECTRIC

161-E13-8850

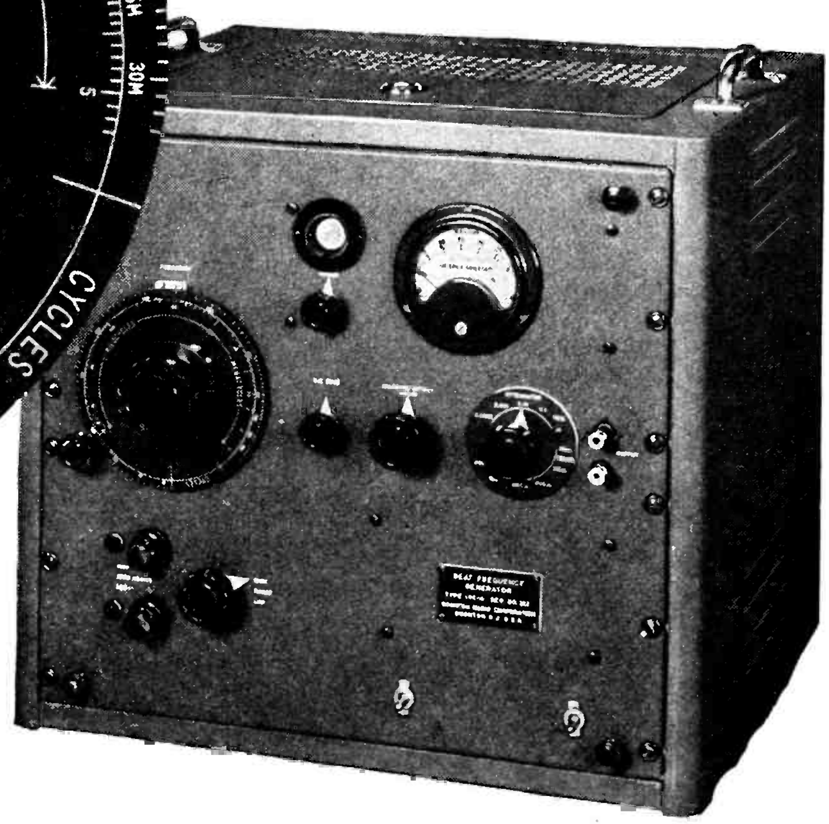
FIRST AND GREATEST NAME IN ELECTRONICS


EL-MENCO
MADE IN U.S.A.
Grand Prize
Outstanding

ENGINEERED FOR EASE OF OPERATION AND ADJUSTMENT

THE BEAT FREQUENCY GENERATOR

TYPE 140-A



AN IMPORTANT FEATURE

of this instrument is the large dial scale which has been planned for maximum readability and rapid setting—the overall dial scale length from 20 cycles to 5 megacycles exceeds 22 inches. The low frequency scale overlaps the high frequency scale at 30 kc, permitting continuous frequency coverage over the entire audio spectrum without bothersome range switching.

One of the most valuable instruments in the laboratory is a generator of signal voltage. Boonton Radio Engineers in designing the Type 140-A Beat Frequency Generator have provided an instrument of wide frequency coverage, capable of supplying accurate output voltages ranging from several microvolts to 30 volts and having a variety of output impedances from 20 ohms to 1000 ohms.

A 1-inch cathode ray tube has been provided to standardize the low frequency range against the power line frequency and to allow multiples of this frequency to be set with excellent accuracy by means of the cathode ray tube pattern.

An output attenuator having five decimal steps permits accurate setting of voltages as little as 1 microvolt. Engineers making gain or sensitivity measurements will particularly appreciate this feature.

Write for Catalog "C"

FREQUENCY RANGE 20 cycles to 5 megacycles in two ranges. Low range: 20 to 30,000 cycles. High range: 30 kc to 5 megacycles.

FREQUENCY CALIBRATION: Accuracy ±2 cycles up to 100 cycles, ±2% above 100 cycles.

STABILITY: About 5 cycles drift below 1000 cycles. On low range, drift becomes negligible percentage with increasing frequency. On high range, drift is 3% or less.

ADJUSTMENT: High and low ranges have individual zero beat adjustments. Low range may be checked against power line frequency with front panel 1-inch cathode ray tube.

OUTPUT POWER AND IMPEDANCES: Rated power output: One watt, available over the low frequency range from output impedances of 20, 50, 200, 500, 1000 ohms, and over both high and low frequency ranges from an output impedance of 1000 ohms.

DISTORTION: 5% or less at 1 watt output, 2% or less for ½ voltage output.

VOLTMETER ACCURACY: ±3% of full scale reading.

BOONTON RADIO Corporation
BOONTON·N·J·U·S·A·

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

FEDERAL'S *Intelin* HIGH-FREQUENCY COAXIAL CABLES *offer you all three...*

1. LOW LOSSES
2. FLEXIBILITY
3. DURABILITY

K-12 ... the most popular cable for FM and AM antenna transmission lines.

- Copper Conductor — solid or stranded.
- Polyethylene Dielectric between central conductor and outer braid.
- Copper Braid, closely woven over dielectric sheath.
- Outer Jacket of Federal's IN-102, a plasticized vinyl resin, extremely durable with remarkable abrasive resistance, and highly resistant to most acids and alkalis, smoky atmospheres, oils and greases.

INTELIN COAXIAL CABLES are especially designed for high-frequency transmission line service — the vital link between transmitter and antenna.

Their unusually low attenuation losses, obtained by careful selection of dielectrics, conductor spacings, and rigid quality control, assure the most efficient transfer of energy with minimum radiation. They are extra flexible, too — can be bent without cracking at temperatures as low as minus 30°C. Whatever your operating conditions, you'll find that the extra durability of Intelin cables — their outstanding resistance to abrasion, weathering and corrosion — means long uninterrupted service.

Federal's complete line of many sizes and types of coaxial cables enables you to select the *right* transmission line for practically every field of application. Write today for Bulletin D514 giving complete data and specifications.

PARTIAL LIST OF FEDERAL CABLES COVERING POLICE. BROADCAST AND AMATEUR BAND

High-Frequency Coaxial Cable Data

Type Number	Characteristic Impedance Ohms	Capacitance Per Ft. mmf	Attenuation Db. Per 100 Ft.					Power Rating Kilowatts					Physical Dimensions	
			Frequency in Megacycles					Frequency in Megacycles					Conductor Dia.	O.D. Over Jacket
			1.0	1.7	30	100	300	1.0	1.7	30	100	300	Solid Copper	
K12	52	29	.066	.086	.425	.83	1.70	39	30	8.50	3.0	1.5	.188"	.885"
K13	52	29	.058	.076	.320	.69	1.45	51	43.8	13.5	5.4	2.3	.250"	1.135"
K14	71	21	.070	.092	.460	.93	1.90	36.5	27.8	5.55	2.71	1.34	.114"	.885"
													Stranded Copper	
K45	52	29	.155	.202	.900	2.1	4.20	13	9.9	2.4	.96	.480	.086"	.415"
K49	75	20	.182	.237	1.03	2.1	3.80	9.1	6.9	2.1	.79	.435	.048"	.415"

Federal Telephone and Radio Corporation

In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal
Export Distributor:—International Standard Electric Corporation

Newark 1, New Jersey

* Reg. U. S. Pat. Off.

Now! Make Your Own Duplicate Recordings

PRESTO
300-A RE-RECORDER

Illustration shows the PRESTO 300-A Re-Recorder on the popular PRESTO Model K Recorder. It can also be used on the PRESTO Model Y Recorder and can be adapted for use on both PRESTO 6-N and 8-N Recording Turntables.

YOU'LL FIND dozens of ways to multiply the usefulness of your PRESTO recording equipment when you have a 300-A Re-Recorder to go with it.

You can build a valuable reference file of duplicate recordings ... make extra records for artists' personal use ... duplicate, and at the same time *edit* recordings of special events to combine the high spots for final recording.

The 300-A costs much less than a second turntable, usually used to duplicate recordings. And it has two important advantages:

1. The rotation of the recording and playing turntables is locked together so that playing time and pitch are identical.
2. The tables may be stopped and started during the re-recording since variations in speed occur simultaneously in both turntables.

You can get prompt delivery of PRESTO 300-A through your local electronic equipment distributors.

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

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.

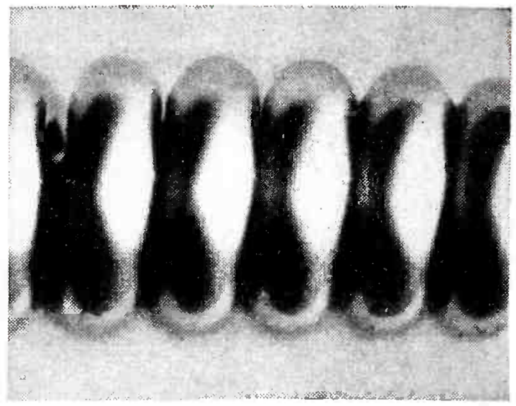
Ordering G-E Formex magnet wire is the first step toward faster winding of better, more uniform coils, and long apparatus life. For complete information on what Formex can mean in savings to you, call in your local G-E representative or write for Bulletin GEA-3911. *Apparatus Dept., General Electric 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.

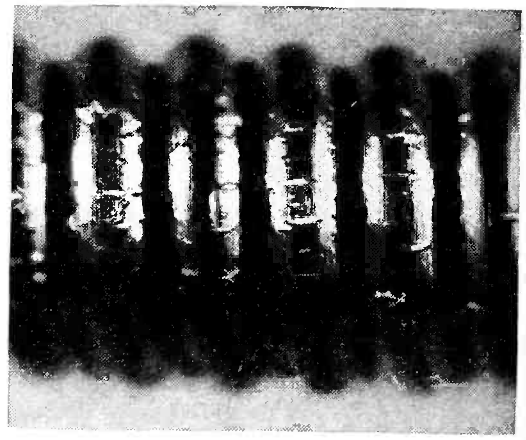
Round Formex. Round Formex wire is supplied in all the standard sizes from 8 AWG through 40 AWG, and in Ultrafine sizes from 41 AWG through 44 AWG, and in diameters of 0.00175 inch, 0.00125 inch, 0.001 inch, and 0.0015 inch.

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.

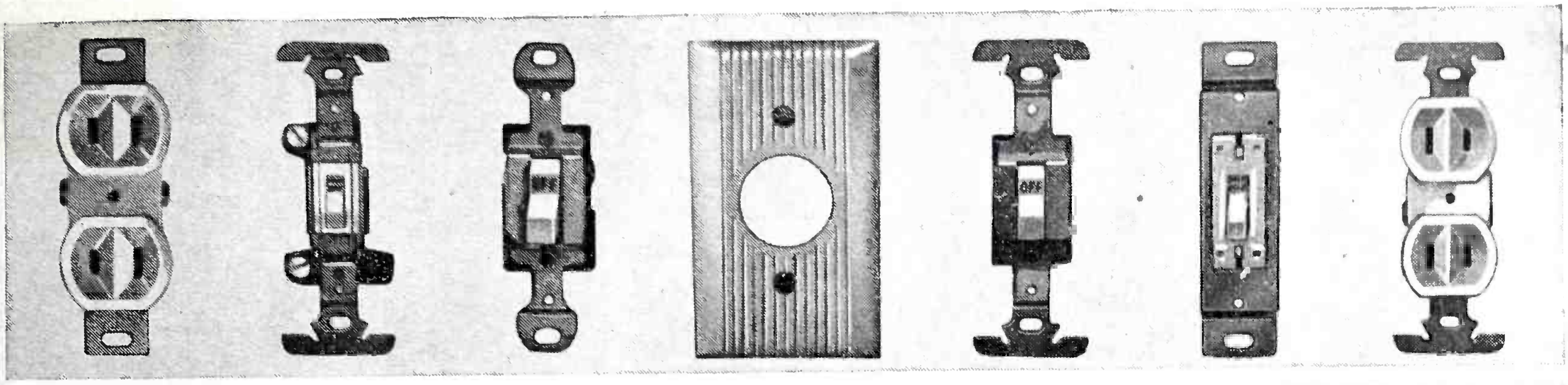


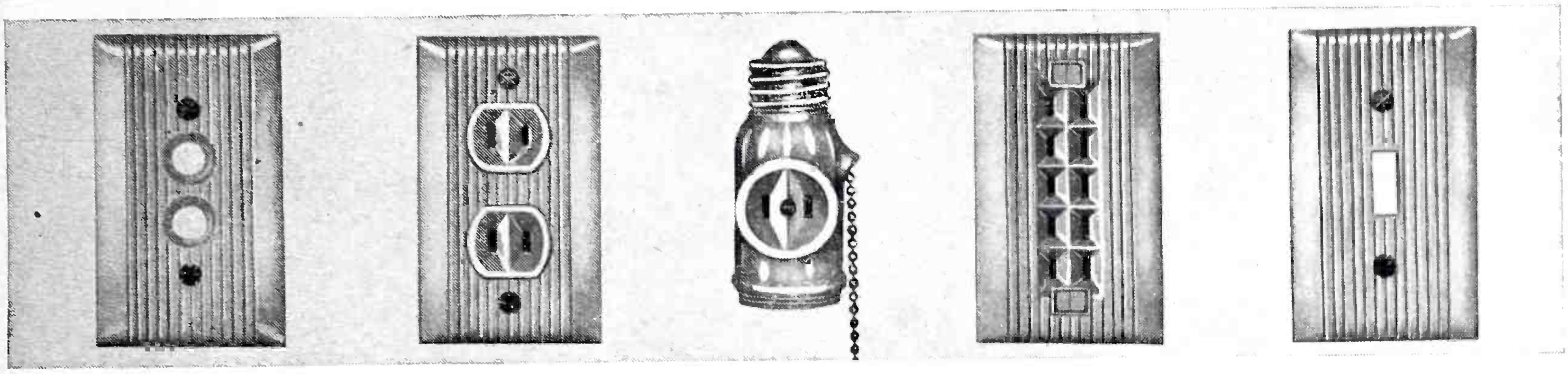
This enlarged photograph shows enameled magnet wire stretched 10 per cent—half as much as the Formex wire in the top illustration—and wound upon *twice* its own diameter. Note the cracks in the insulation, the absence of cracks in the Formex wire.

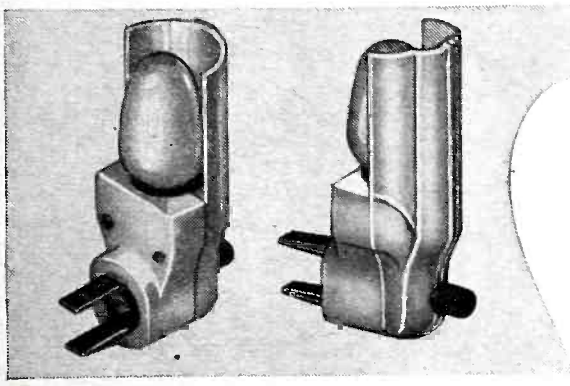
● *Another G-E Achievement Resulting from "Full-range" Research* An example of G-E full-range research in action is the development of Formex magnet wire. Realizing that no major improvement in enameled magnet wire was probable as long as drying oils were a principal ingredient, G-E research turned to 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.

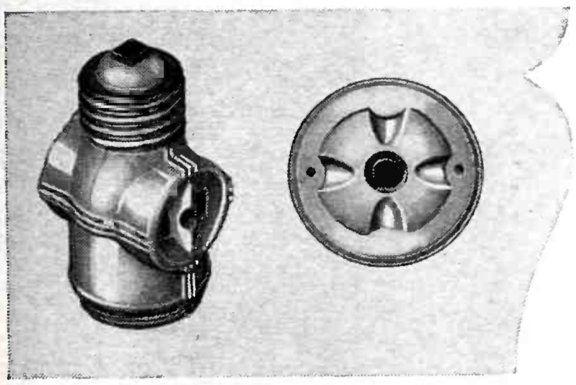
GENERAL ELECTRIC

503-27-1200









PLASKON • • • ideal materials for electronic and electrical manufacturing

● Plaskon urea-formaldehyde and melamine-formaldehyde molding compounds offer many advantages for economy and efficiency in electrical manufacturing. The molded compounds perform equally well at extremes of temperature and humidity; they have a low power factor, high dielectric strength and arc resistance; and they do not track after arcing. Good dimensional stability is an important feature. Other advantages include hardness, permanence, resistance to shock, high chemical resistance, non-inflammability, and beauty of colors.

Your production plans may benefit by Plaskon Molded Color. Our experienced field men will be glad to help adapt them to your requirements.

PLASKON

TRADE MARK REGISTERED

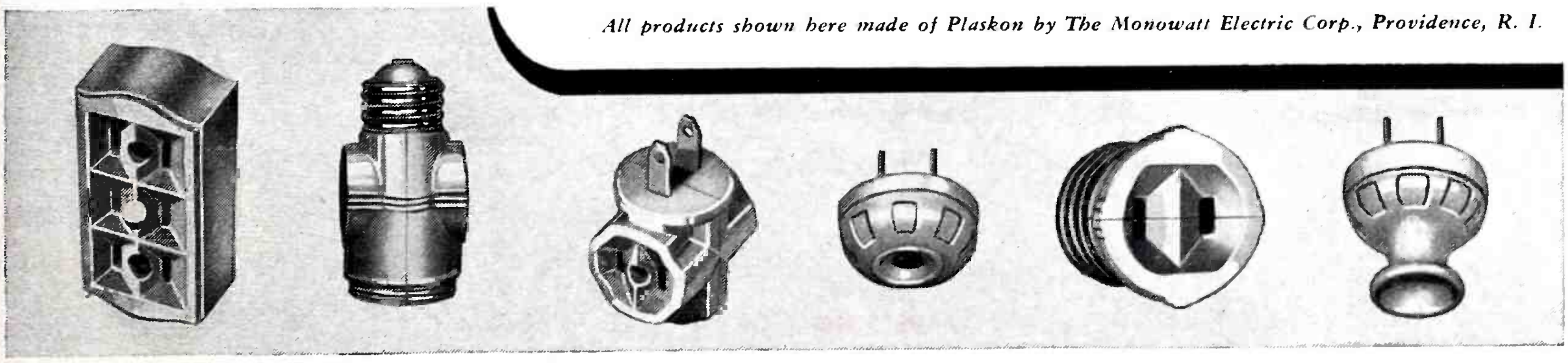
MOLDED COLOR

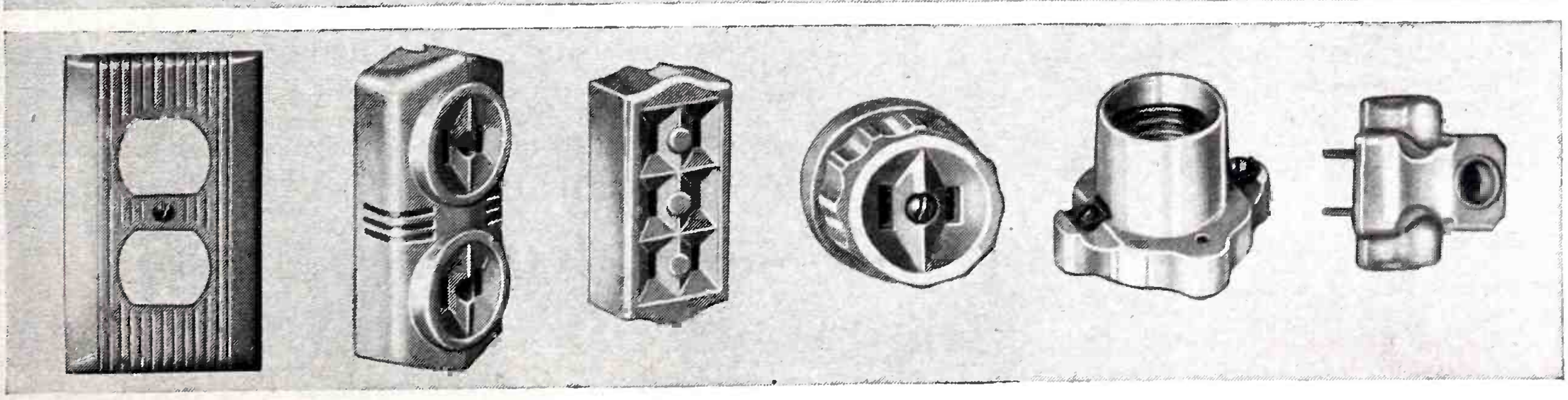
PLASKON DIVISION

LIBBEY • OWENS • FORD GLASS COMPANY • 2136 Sylvan Avenue, Toledo 6, Ohio

Canadian Agent: Canadian Industries, Ltd., Montreal, P. Q.

All products shown here made of Plaskon by The Monowatt Electric Corp., Providence, R. I.





YOU WON'T BELIEVE IT TILL YOU HEAR IT!

NEW
Western Electric
728B LOUDSPEAKER

The first time you hear this revolutionary Western Electric loudspeaker in action, you'll get an entirely new conception of sound reproduction. It delivers speech and music with such "presence," such emotional quality, that you'll find it hard to believe you're listening to *reproduced* sound!

New design features, developed by Bell Laboratories scientists, make the 728B ideal for broadcast studios and sound systems where high quality reproduction is a "must".

For complete technical details and information on delivery, talk to your Graybar Broadcast Equipment Representative—or write Graybar Electric Company, 420 Lexington Ave., New York 17, N.Y.

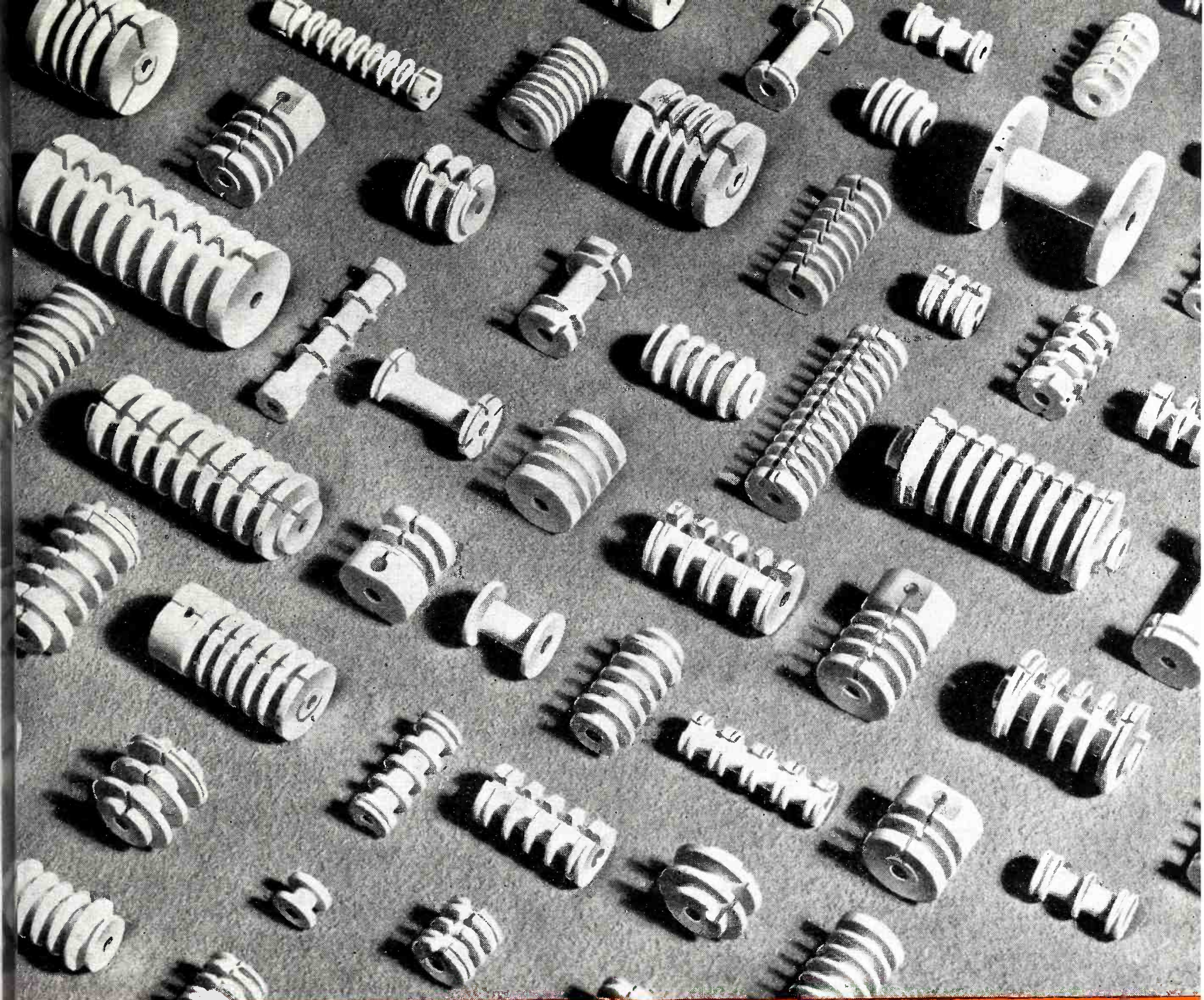
TECHNICAL DATA

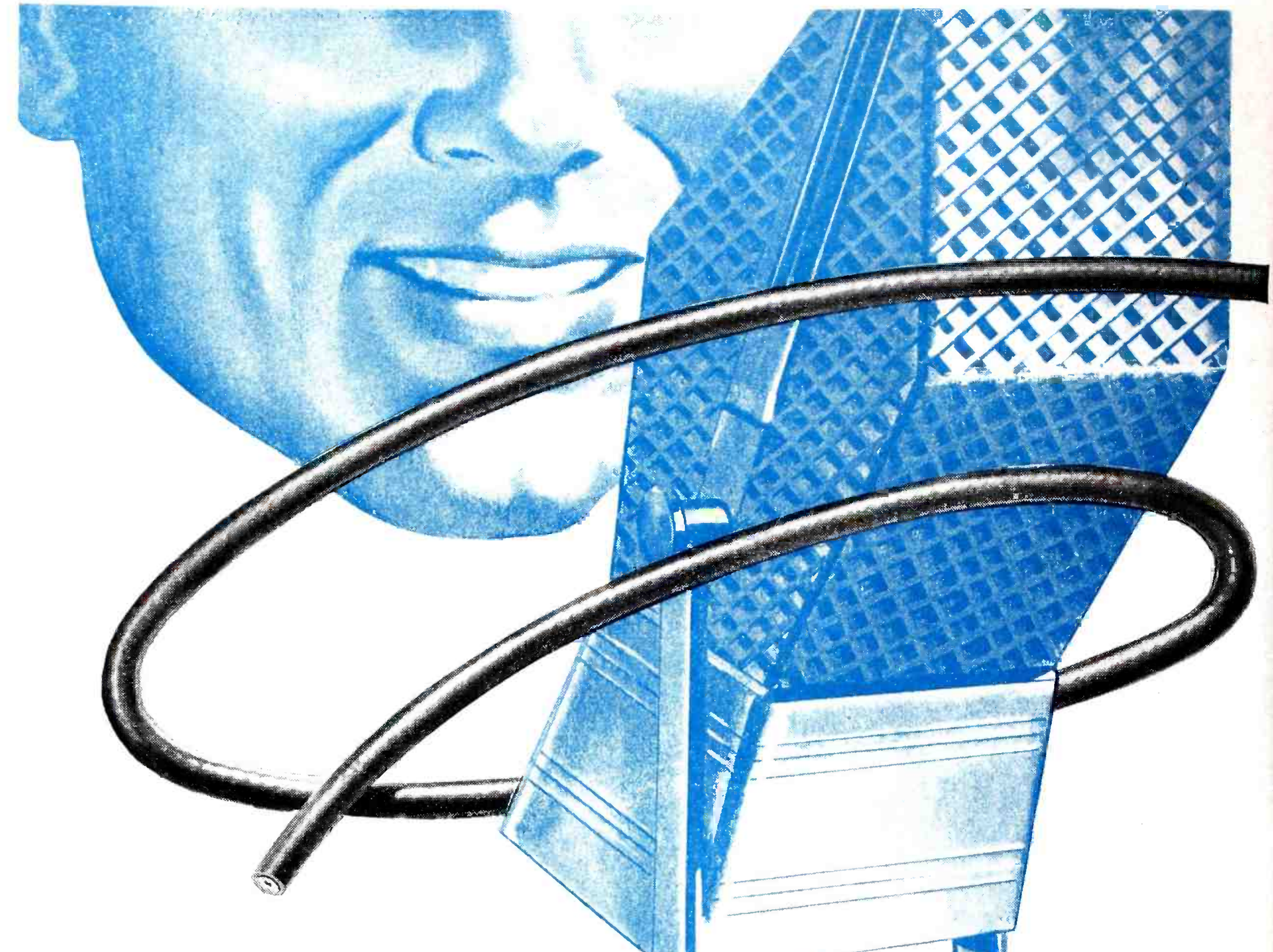
FREQUENCY RANGE: 60 to 10,000 cycles.
IMPEDANCE: 4 ohms.
EFFICIENCY: At a distance of 100 feet on axis, the 728B will produce a level of 81 db above 10^{-16} watt per sq. cm. at 30 watts. This level is on a basis of a warble frequency covering a range from 500 to 2500 c.p.s.
COVERAGE ANGLE: 50 degrees.
POWER CAPACITY: 30 watts continuous.
DIMENSIONS: Diameter 12-11/32"; depth 4".
WEIGHT: Approximately 18 pounds.
BAFFLE HOLE DIAMETER: 11".
MOUNTING: An enclosure of approximately 2½ cubic feet of space is required.

— QUALITY COUNTS —

Western Electric

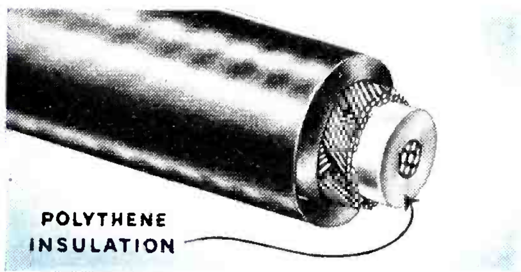
Distributed by Graybar





THE VOICE COMES CLEARLY

...when the Microphone Cable is insulated with **Du Pont POLYTHENE**



The chief function of the crystal microphone cable made by Lenz Electric Mfg. Co. is to carry the speaking voice over public address systems, in lecture halls, offices, factories. And the chief reason Lenz chose Du Pont Polythene for insulating this cable is this: *No matter whether the frequency is 60 cycles or 60 megacycles, the dielectric properties of polythene remain constant—bring the voice in clearly.*

Cross-section (4 times actual size) of microphone cable No. 1253-A made by Lenz Electric Manufacturing Co., 1751 North Western Ave., Chicago, Ill. Construction is as follows: Conductor stock—8 strands No. 36 AWG tinned copper, 2 strands No. 31 AWG phosphor bronze. 1/32-inch wall of polythene, applied to an O.D. of .082 inch. Shield of No. 36 AWG tinned copper, 4 ends. 1/32-inch wall outer jacket.

This constancy of polythene is *one* of the reasons polythene is widely used in television, in radar, in high-frequency cable of many other kinds. Other advantages of polythene are:

- **Because of the high dielectric characteristics of polythene, only a minimum thickness is needed.**
- **The dielectric constant of polythene (2.2–2.3) and its power factor (less than 0.0005) remain almost constant in temperatures from −50°F. to 220°F.**
- **Polythene is chemically inert, and light in weight (specific gravity: 0.92).**
- **Polythene retains its toughness and flexibility at temperatures from −50°F. to 200°F.**

For complete data on polythene, write E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Room 159, Arlington, N.J.

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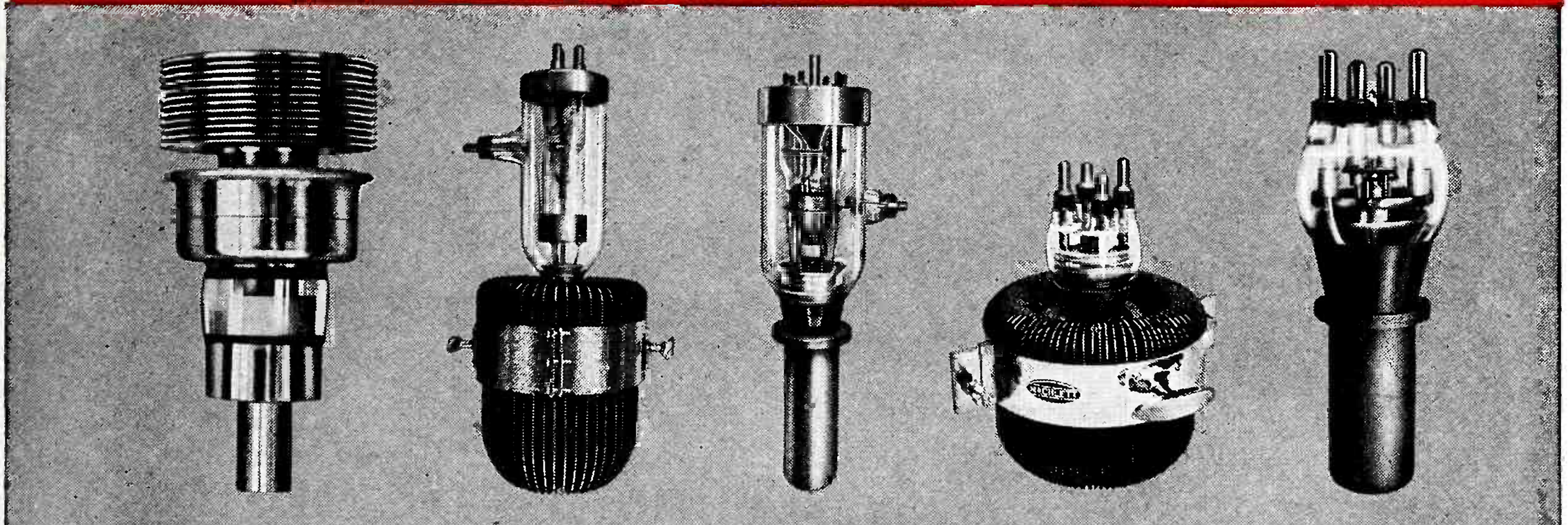
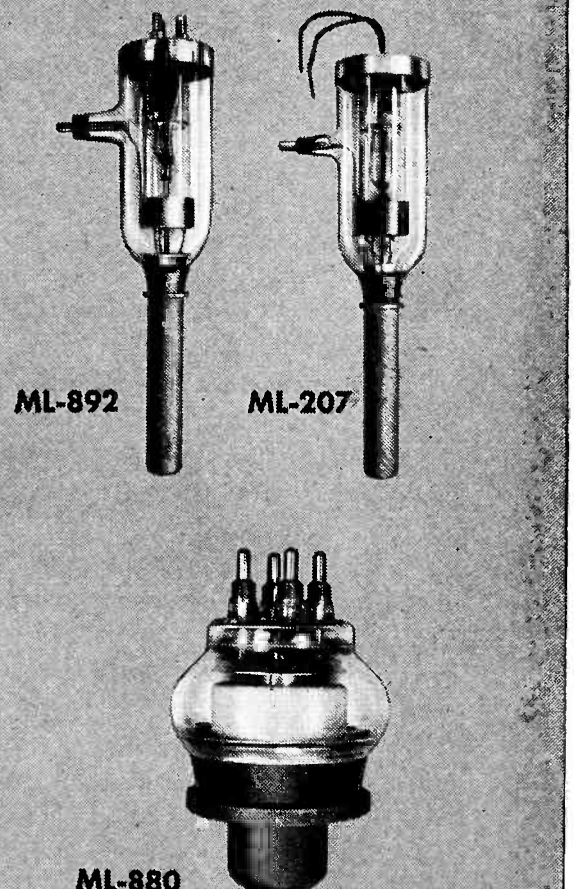
BETTER THINGS FOR BETTER LIVING ...THROUGH CHEMISTRY

MACHLETT ELECTRON TUBES FOR ALL RADIO TRANSMITTING AND INDUSTRIAL PURPOSES



2C-39 ML-891R ML-893A ML-889RA ML-889A



ML-892 ML-207 ML-880

MACHLETT LABORATORIES, Incorporated, one of the country's earliest producers of electron tubes, and today the world's largest supplier of tubes for X-ray purposes, brings to the radio and industrial fields its half century of electron tube experience. The tubes illustrated are typical examples of the Machlett line of radio transmitting and industrial tubes.

Machlett's comprehensive background of leadership in the design and production of X-ray tubes places it in a most effective position to meet the increasingly stringent requirements of modern electron tube manufacture. The production methods used in the manufacture of quality X-ray tubes are, more than ever before, essential to meet the constantly increasing requirements for higher power, higher frequencies and higher voltages in practically all fields of electron tube application. Processes essential to assure quality, performance and long useful life at voltages of 50 KV and higher, precision assembly of parts for the accurate control of electron stream, complete and permanent outgassing of the assembled tube and its individual parts have long been characteristic of X-ray tube manufacture and inherent in Machlett's design and productive operation. These skills and techniques developed for, and long used in its X-ray activities, now find unique additional value in their application to electron tubes for radio and industrial purposes.

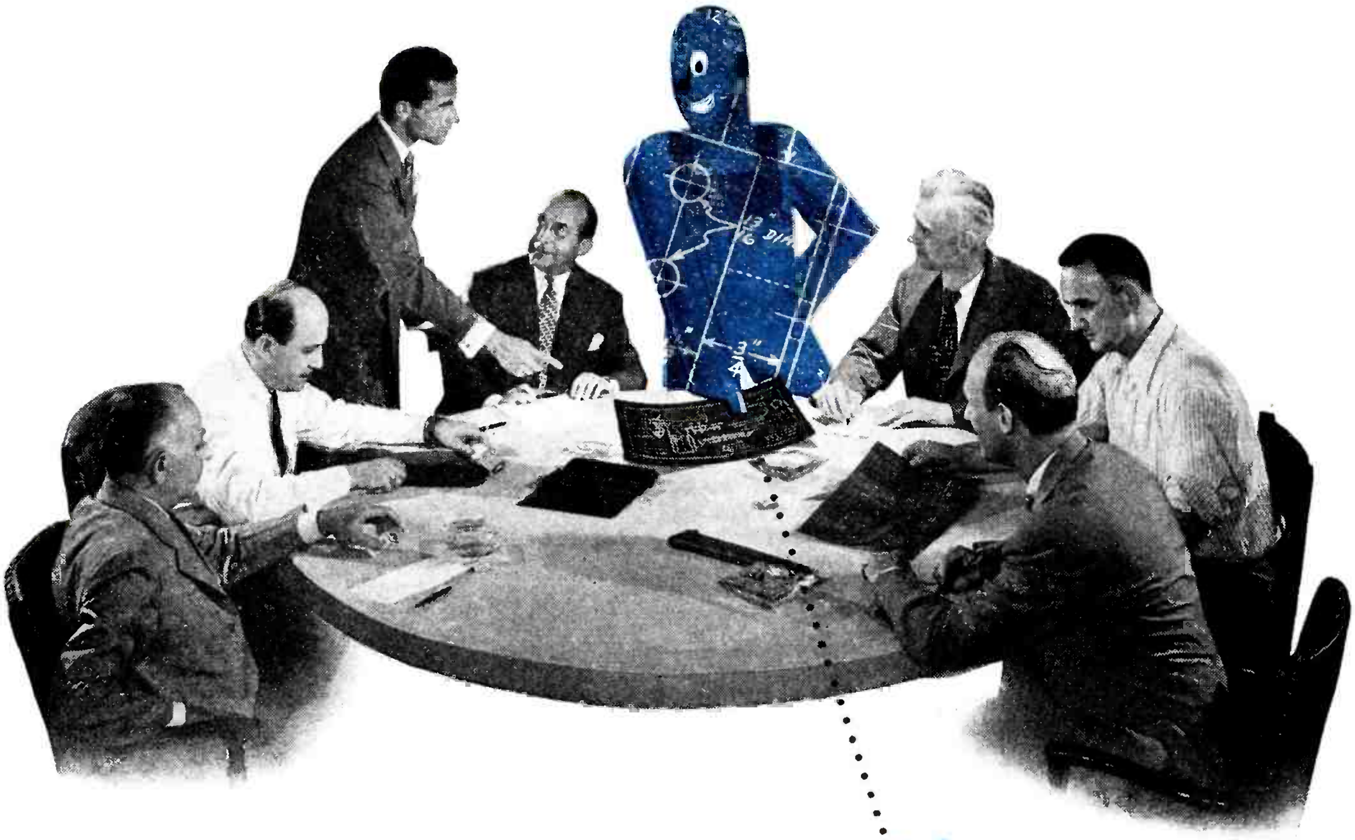
The Machlett background of almost 50 years of continuous electron tube production, modern, laboratory-like manufacturing facilities, and up-to-the-minute experience assures the user that he will receive tubes engineered and processed for a long life of trouble-free operation.

For complete information write our nearest representative, or the factory at Springdale, Connecticut.

MACHLETT LABORATORIES, INC., Springdale, Connecticut

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES
ITS 49 YEARS OF ELECTRON TUBE EXPERIENCE



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When you bring your sheet metal fabrication problems to KARP, you immediately set in motion a "round table" board of experts whose combined specialized skill and experience is without an equal in the field. This group includes the president, chief engineer, chief draftsman-designer, chief toolmaker, plant superintendent, production manager and cost accountant.

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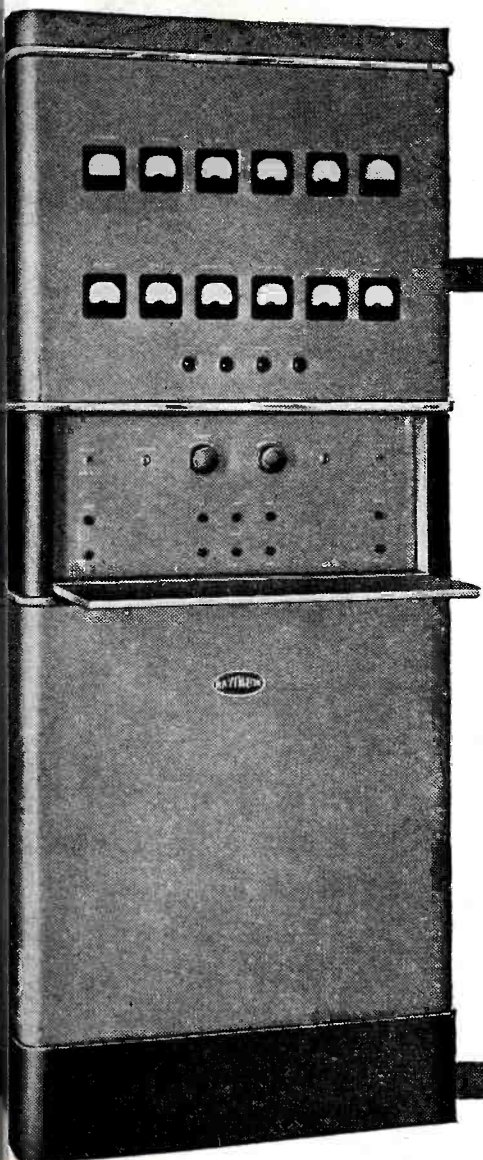
More and More 250 Watt Stations

are being powered by Raytheon



Here's the AM Transmitter that small-station owners are turning to...for its dependable, simpler circuits...its advanced design ...its modern, "dress-up" beauty!

HERE'S WHAT THE SMALL STATION NEEDS!

...Study these RAYTHEON features before you choose any transmitter, for replacement or new installation.

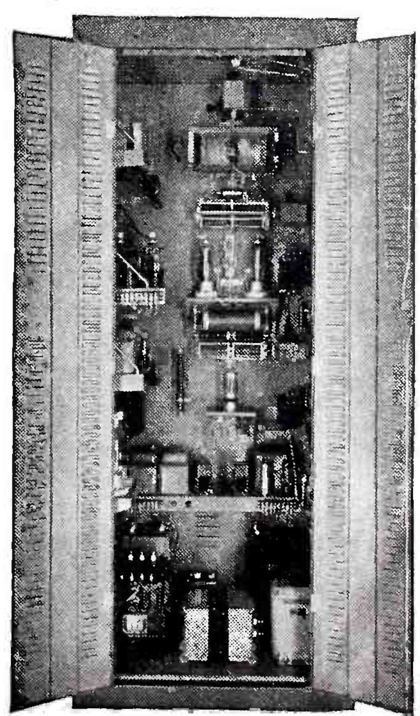
1. **Simplified, More Efficient Circuits**—A high level modulation system eliminates necessity of complicated and critical adjustment of linear amplifiers and minimizes harmonic distortion.
2. **Increased Operating Efficiency**—The use of the most modern improved components which are operated at well below their maximum capacity together with simplified circuit design greatly increases overall operating efficiency.
3. **Greater Dependability**—Due to the use of Triode type tubes, feedback failure will not cause a complete breakdown and the signal quality will still be good. Cooled by natural convective air currents, it is not subject to damage or fire caused by a blower failure.
4. **Simple, Speedy and Accurate Tuning**—All operational controls are centralized on the front panel; every circuit is completely metered and instantly checked. A clutch-equipped low-speed motor makes micrometer adjustment of the two tuned stages very easy.
5. **No Buffer Stage Tuning**—The use of a Video type amplifier in the buffer stage eliminates this complicated tuning.
6. **Silent Operation**—Natural air cooling means no blower noise, permits microphones in same room with transmitter.
7. **Low Audio Distortion**—Triode type tubes used in the audio stages have inherently lower distortion level. Specially designed audio transformers reduce audio distortion still further.
8. **Easy Servicing**—Vertical chassis, symmetrical mechanical layout and complete accessibility through double rear doors and hinged side panels make the RA-250 a favorite.
9. **Easily Meets All F.C.C. Requirements**—All electrical characteristics are well within the F.C.C. requirements. Noise level is −60 db below 100% modulation. Frequency response ±1 db from 30 to 10,000 cycles per second.

OUNCED only a few short months ago, aytheon 250 Watt AM transmitter has dy won its way into the forefront of station broadcasting. Presented as a mitter of unsurpassed n, unsurpassed styling nsurpassed engineering ence, it has proved its s on all three points. rs exclaim over its striking, modern beauty . . . beauty that gives a "show-place" air to any station. Station owners are delighted with its dependable performance . . . its silent operation . . . and the high fidelity signal it puts on the air.

Before you select a 250 Watt transmitter, be sure you possess *all* the facts. Write or wire for our specification bulletin.

RAYTHEON

Excellence in Electronics

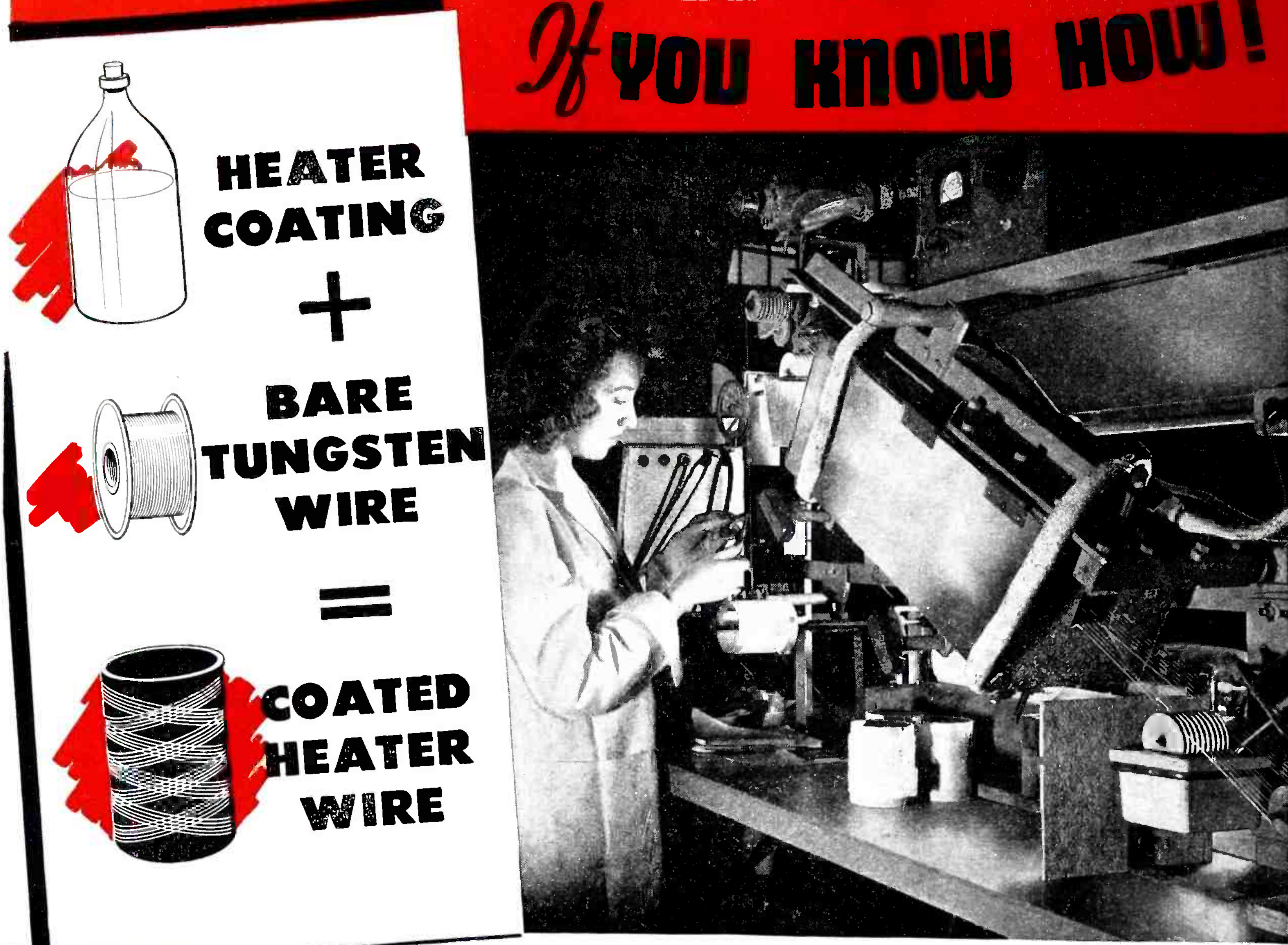


RAYTHEON MANUFACTURING COMPANY

Broadcast Equipment Division, 7517 No. Clark Street, Chicago 26, Illinois

TED TO RESEARCH AND MANUFACTURE FOR THE BROADCASTING INDUSTRY

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



HYTRON KNOW-HOW MAKES EASY THE APPARENTLY EASY

MERELY to apply an insulating coating to tungsten heater wire—that should be easy. To say the illustrated heater-wire coating machine simplifies the job appears a paradox. Why, the machine looks like a product of Rube Goldberg's fertile mind!

Imagine, however, the complexity of producing a thin but perfect insulating coating—a dielectric with a resistance of tens of megohms—yet capable of operating at over 1500° Kelvin! Chemical purity of the coating must be rigidly controlled. Application must be in thin multiple layers to achieve uniform adhesion and density. Thickness must be exact for correct stacking of the folded heater when inserted into the cathode sleeve. Just the right degree of hardness must be maintained to provide stiffness without brittleness.

A complex precision machine actually does simplify the job. Fundamentally its compact mechanism unspools and spools the wire. Guided by threading pulleys, the wire passes eighteen times through coating cups and drying oven via a cross-over figure-8 path. Speed and oven temperature are finely regulated. An ingenious electromagnetic device smoothly maintains proper wire tension. Completely coated wire is wound by a spooling head in a basket-weave pattern.

The know-how of this Hytron coating operation is hidden away within the cathode sleeve. Trouble-free tube performance, however, gives you concrete proof of the know-how Hytron constantly strives to expand.

SPECIALISTS IN RADIO RECEIVING TUBES SINCE 1921

HYTRON

RADIO AND ELECTRONICS CORP.

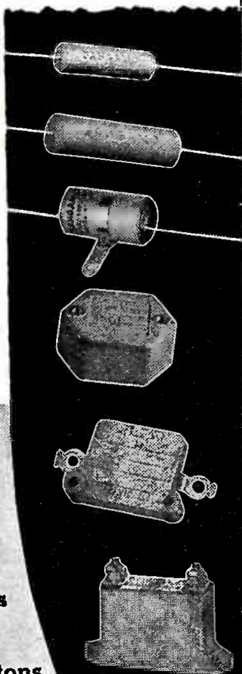
MAIN OFFICE: SALEM, MASSACHUSETTS

IF YOU USE CAPACITORS YOU WILL BE INTERESTED IN . .

SANGAMO PLASTIC MOLDED [LIKE MICAS] TUBULAR PAPER CAPACITORS

PERMANENTLY SEALED AGAINST:

- MOISTURE
- CHANGING CAPACITY VALUES
- WILL NOT LEAK AT LEAD ENTRANCES



Sangamo, pioneer capacitor manufacturers, were first, in 1923, to design and mold mica capacitors. If you use paper tubular capacitors, you will be interested to know that Sangamo now offers these, too, in plastic molded form. Being plastic molded means that these new paper tubulars are sealed permanently: moisture stays out—capacity values will not change. The resulting advantages are: low power factor—application at higher temperatures—long life—and a smooth, molded, non-dust-catching finish. From an economy standpoint, these new Sangamo Plastic Molded paper tubulars are priced only slightly higher than ordinary types, but readily justify themselves in long-run satisfaction. Specify Sangamo Plastic Molded wherever you use paper tubulars.

- Receiving Micas
- Transmitting Micas
- Silvered Micas
- Silvered Mica Buttons

WRITE FOR CATALOG LISTING THE SANGAMO LINE . . . .

- 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)

SANGAMO ELECTRIC COMPANY
SPRINGFIELD • ILLINOIS

THE RIGHT *Combination*

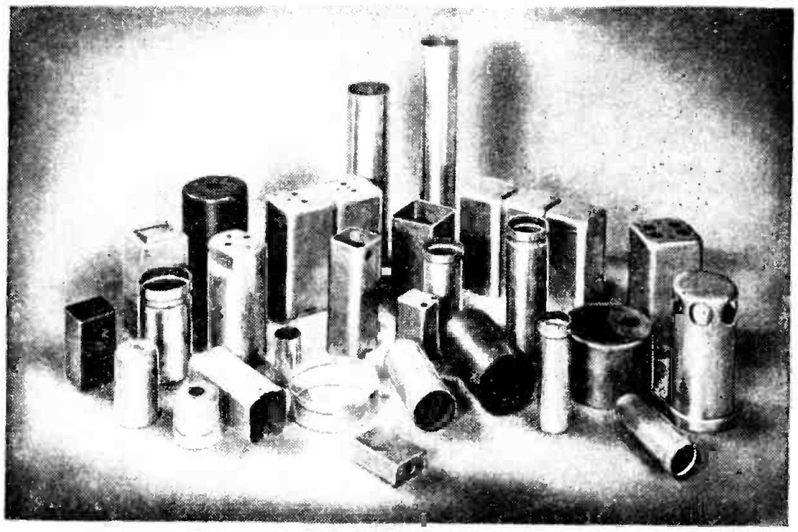
FOR EFFICIENT PRODUCTION

of drawn shells, coil shields, housings,

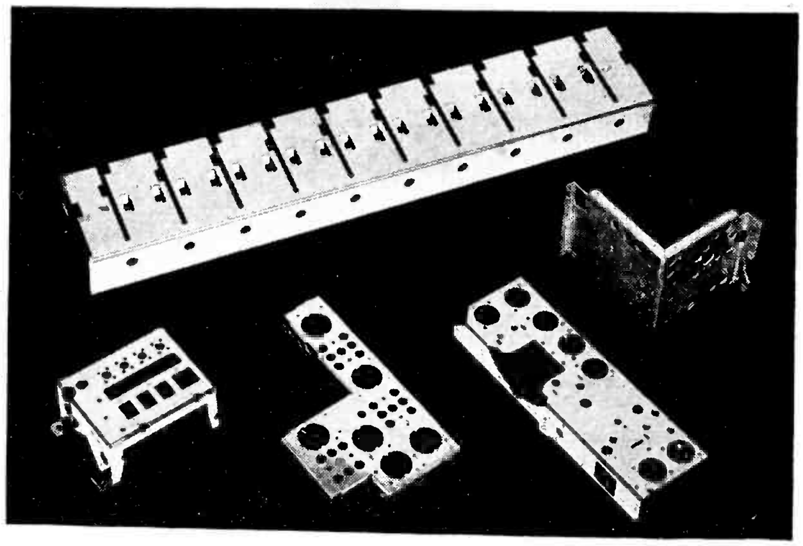
radio chassis and complete or sub-assemblies

Paul and Beekman has the men, the machines and the experience to produce component parts economically for you. Many of the items shown here were made in lots of from 100,000 to millions. All of them were made to exacting specifications . . . finished carefully . . . *and completed on schedule.*

Find out about the advantages of letting Paul and Beekman act as your Parts Division. Our engineers are always available for preliminary consultation . . . with no obligation to you. Write us.



Drawn cans and housings from aluminum, steel and copper.



Chassis and sub-assemblies for the radio and electronic industries.

Below: Paul & Beekman plant, largest producer in the East of cans for the radio industry.

PAUL and BEEKMAN *Division* **1810 Courtland St., Philadelphia 40, Pa.**

PORTABLE PRODUCTS CORPORATION

MANUFACTURERS OF: LAWN MOWERS • ELECTRICAL APPLIANCES • PRECISION STAMPINGS
INDUSTRIAL INSTRUMENTS • RADIOS • SAFETY EQUIPMENT

INSTANT

ACTION

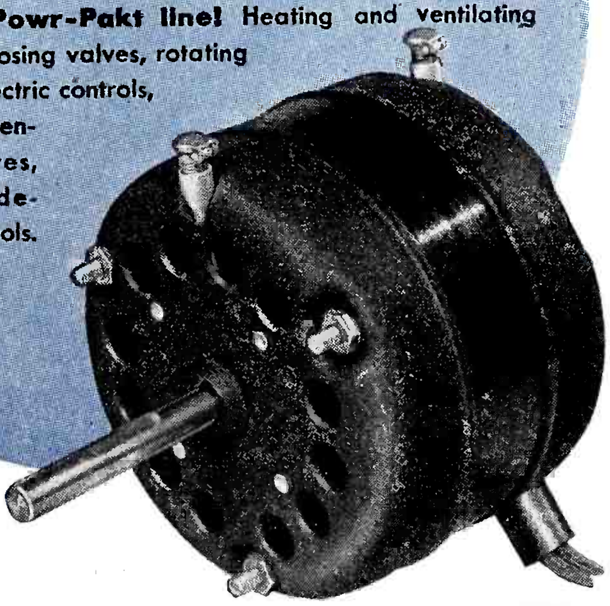
● when you want it
● where you want it . . . . . with

alliance MOTORS

The New Model A shaded pole induction type motor. 1/30th horsepower, size 2¾ inches x 4⅝ inches, for voltages up to 220 and frequencies of 50 or 60 cycles. Suitable for driving fans, and for continuous or intermittent duty.

Alliance Powr-Pakt Motors are manufactured in shaded pole induction, and split phase resistor type. Ratings range from less than 1/400th up to 1/20th horsepower.

New uses for the Powr-Pakt line! Heating and ventilating controls, opening and closing valves, rotating fans, electronic and electric controls, signals, automatic dispensers, turntable drives, automatic tuning devices, radio controls.



Modern design calls for "tailored power"

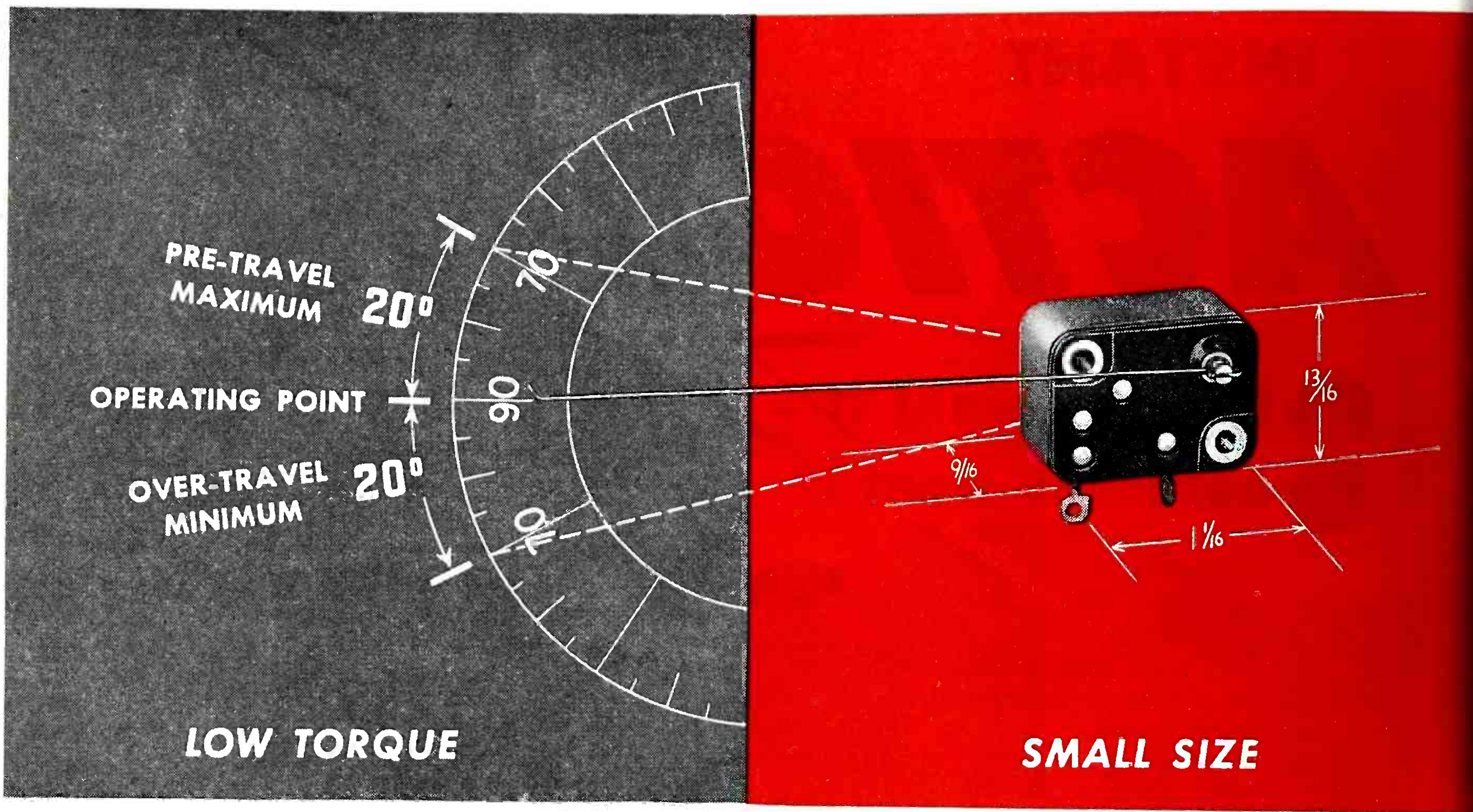
Alliance motors are rated as low as 1/400th h.p. on up to 1/20th h.p. They are small, compact and some weigh less than one pound. They furnish economical driving energy to meet the special demands of small loads. Some are uni-directional—others are reversible—some are for continuous duty—others for intermittent operation.

Alliance Powr-Pakt motors are mass produced, precision made and low in cost. They can help you get *instant action*—when you want it—and where you want it! Write today.

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

It Requires Only To Operate This New



All the Desirable Features of Micro Switch Snap-Action Packed Into a Housing Not as Big as Your Thumb

• The new rotating shaft or pivot actuator, low torque operation, and the small size make this switch useful in applications such as thread and fine wire breakage-detectors, paper counters, coin chutes on vending machines, and for similar applications.

Low torque of .14 ounce-inches gives practically a feather touch actuation. Pretravel of the actuating arm is 20° maximum, overtravel is 20° minimum.

The small size is a decided advantage, as it can be used in many places that would otherwise be restricted—however, performance is "big" and dependable.

Being enclosed keeps out dust and dirt, and assures trouble-free operation. Time-tested and proven dependability, based on experience gained in making millions of switches, gives users an assurance of freedom from trouble. If you are looking for a switch that can do all the "tricks" necessary to meet your requirements, it will pay to write direct to Micro Switch, Freeport, Illinois, outlining your problem or requirements.

Now Being Specified for These Six Reasons

1. Long life.
2. Low operating torque.
3. High capacity.
4. Dependability.
5. Precise repeat operation.
6. Contacts protected from dirt and damage.

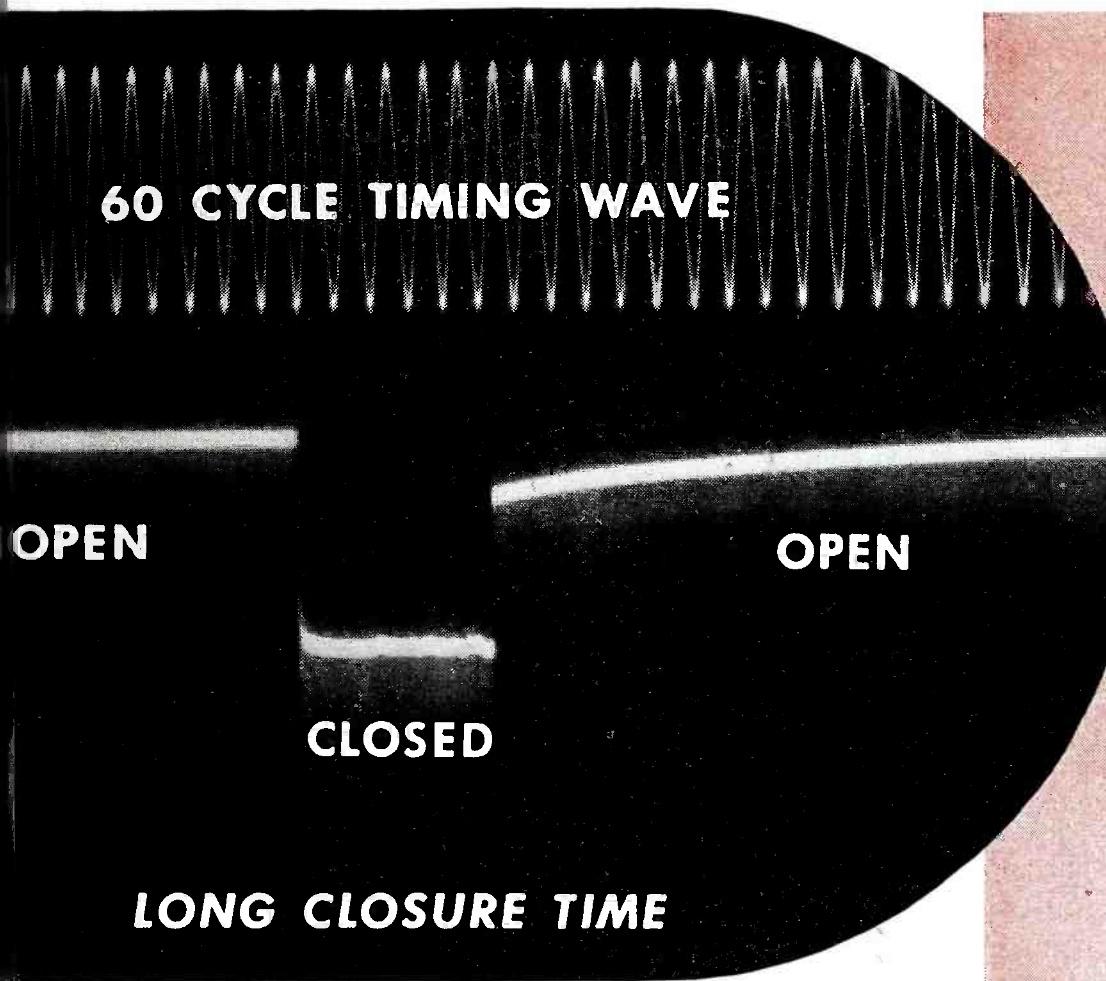
MICRO SWITCH TRADE MS MARK

A DIVISION OF FIRST INDUSTRIAL CORPORATION

FREEPORT, ILLINOIS, U. S. A.

Sales Offices in Principal Cities

.14 ounce-inches
Micro Low Torque Switch

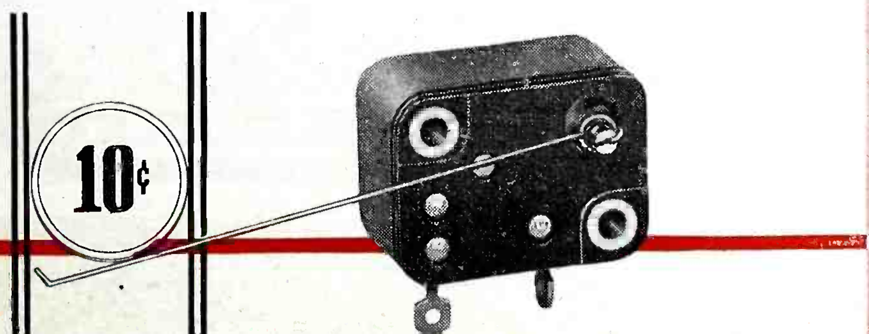


Long Closure Time for Operation with Relays

The above oscillogram shows a closure time of .0835 second (allowing 5¼ cycles) on one application of the switch when used as a coin actuated switch. This oscillogram also illustrates clean make and break without contact bounce. This long closure time is important where the switch has to operate relays, as several cycles of voltage are usually necessary to actuate them.

How It Is Used in Coin Operated Machines

When you use the Micro Coin Operated Switch in coin machines, the actuator is placed through a slit in the coin chute. The long operating life of the switch, maximum duration of contact, low torque with high resistance to shock and vibration, and a generous spacing between terminals are all factors in its popularity. In addition, correct pretravel, ample overtravel, and absolute dependability make this Micro Switch product a favorite among those who produce coin operated machines.

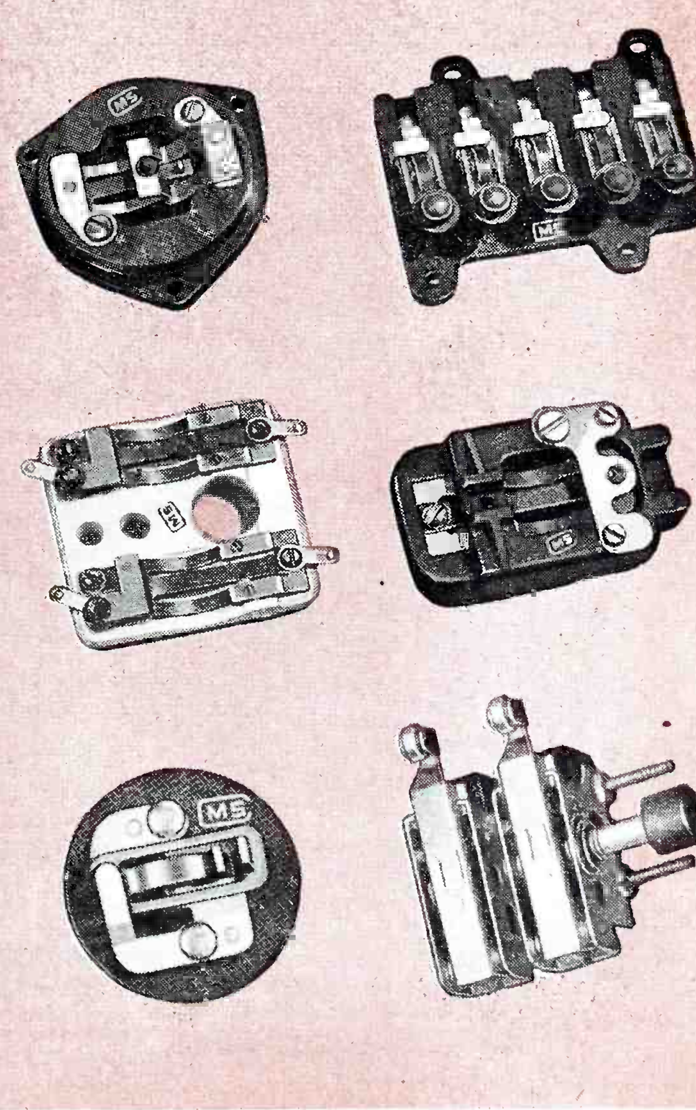


MICRO SWITCH
Snap-Action
Can Be Made With Varied Housings and Actuators

The requirements placed upon Micro Switch snap-action have created a demand for many varied housings and actuators. Shown here are a few made special—for specific jobs—that illustrate ingenious forms and adaptations of Micro Switch snap-action, and suggest the unlimited possibilities for building this type switch into your products.

You can use Micro Switch snap-action to advantage. Do not think of Micro Switch snap-action as a set type of switch, but as a basic switch principle which can be adapted to meet practically any problem.

The illustrated snap-action switches, due to their special construction, are not available in sample form, but we can suggest one for your specific switching problem.



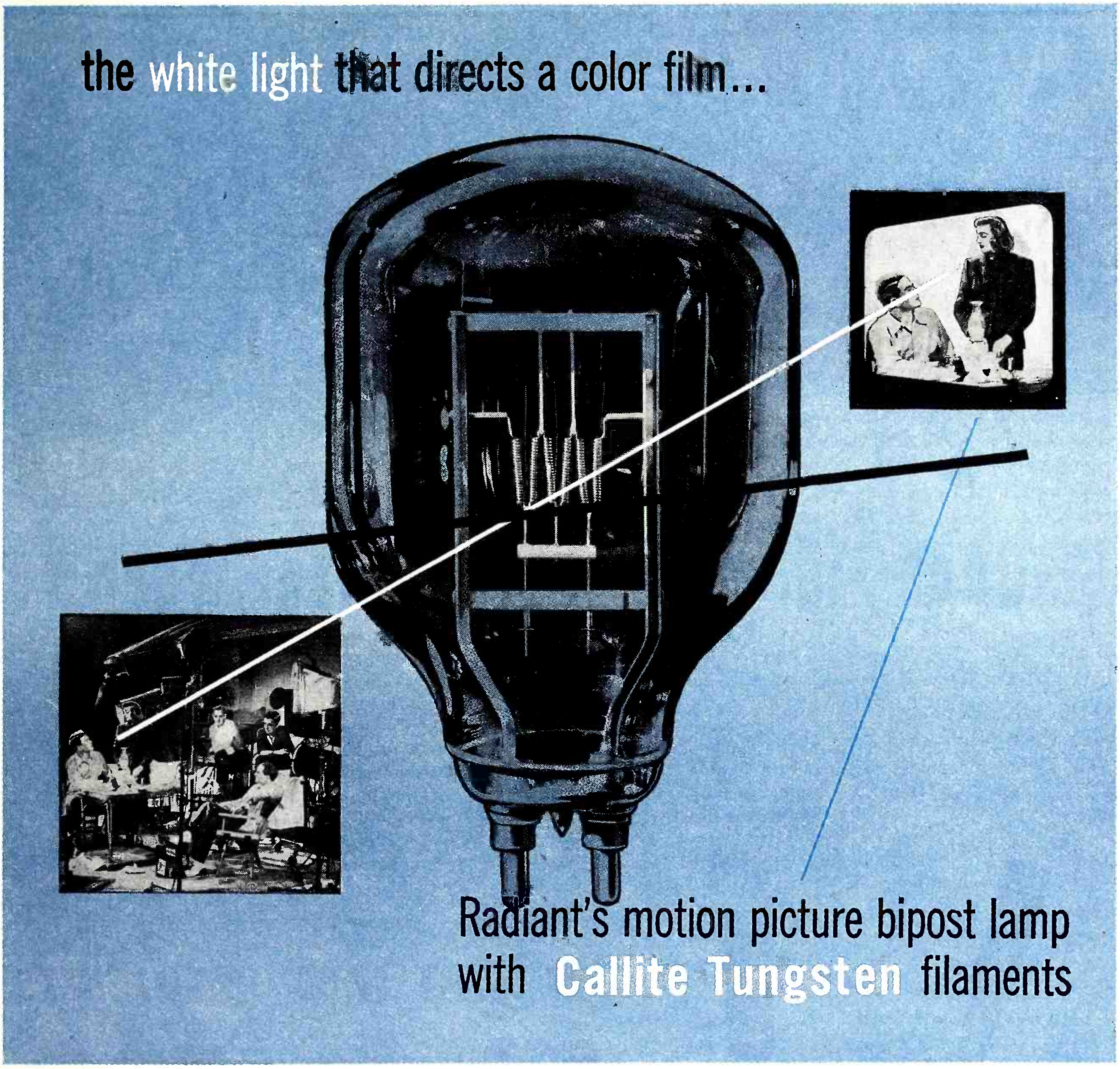
IN THE BROADCASTING STATIONS throughout the nation, when a live program is recorded for broadcast — when an off-the-air program is recorded for rebroadcast — when recordings are made for clients or for rehearsal and audition purposes — when recordings are made for reference files — in fact when any recording work is done, Audiodiscs are used three to one.

This outstanding preference for Audiodiscs has been recently confirmed by a double-check survey covering 400 radio stations. Approximately half these stations were called upon and reported the actual number of discs used — Audiodiscs and others. The remainder reported by letter stating the proportion of Audiodiscs used to all other makes. In the first group the Audiodisc percentage was 81, in the second 78%.

Since first produced, these fine discs have consistently maintained those qualities required in the increasingly important work of radio recording. Thus Audiodiscs have gained their place of eminent leadership in the field of sound reproduction.

Audiodiscs are manufactured in the U.S.A. under Exclusive License from La Societé des Vernis Pyrolac—France.

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



Radiant Lamp Corporation designed the 5000 W. T64 Mogul Bipost Lamp for colored film motion picture production. Specifications called for an intense white light, that would give the exact "color temperature" to closely match the color sensitivity of the film. Much depended, too, on the unwavering qualities of the light source.

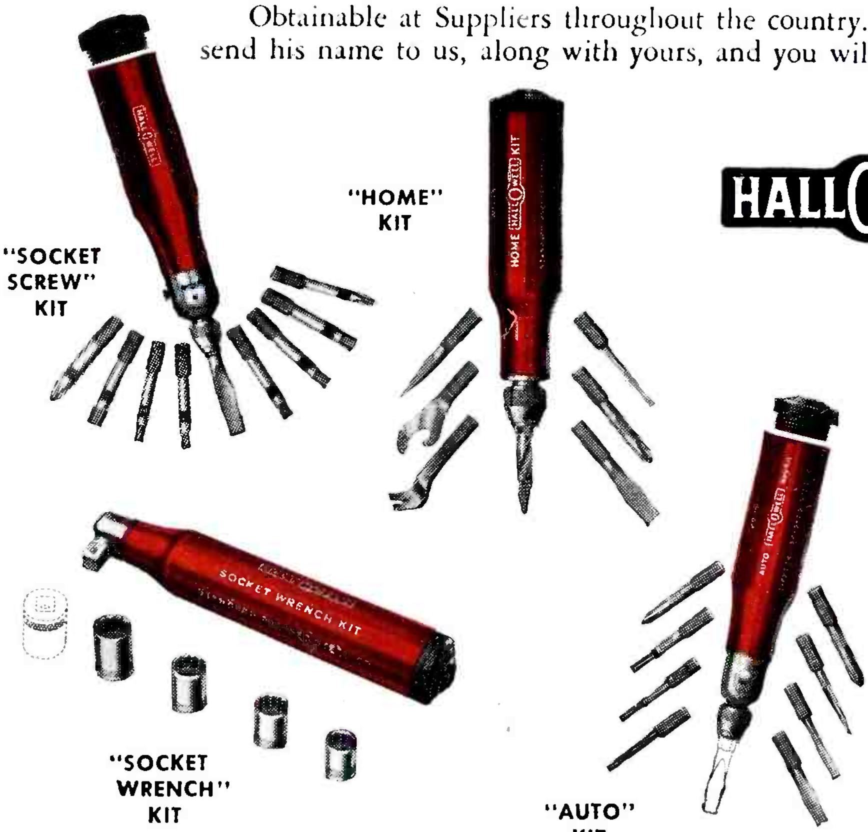
Working closely with Radiant's engineers, Callite developed a specially processed tungsten filament wire that provides a steady, brilliant white light of accurate rating and color matching properties.

This compact helically coiled bent filament—about 5′ long, and 1/32″ in diameter when extended—will not sag or distort at the extremely high operating temperature of 3,400° Kelvin. Its actual melting point of 3,655° Kelvin adds extra safety margin. Callite is ably equipped—with the men, resources, experience and ability—to fill all your requirements for tube and lamp components. Whether it's a standard or special application, call on Callite. Write for Catalog No. 156 to: Callite Tungsten Corporation, 544 39th Street, Union City, N. J. Branch offices: Chicago, Cleveland.

Callite LAMP COMPONENTS

CALLITE TUNGSTEN CORPORATION

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



"SOCKET SCREW" KIT
"HOME" KIT
"SOCKET WRENCH" KIT
"AUTO" KIT

LABOR DAY • 1946

–Time for wise union leadership

Labor Day, 1946, finds one hopeful element in the relations between American management and labor which was not there on Labor Day, 1945. It comes in recent expressions by a number of national leaders of organized labor that increased "real" wages depend upon *increased productivity,* i.e. increased output per man-hour. Increased money wages which are promptly offset by higher prices do nobody any good.

SPOT CHECK ON LABOR OUTPUT

In the absence of reliable general statistics on what has happened to productivity of labor since V-J Day (because of strikes and reconversion complications) the McGraw-Hill Publishing Company asked the executives of a cross section of American industry to report their own impressions. The questions asked and summaries of the replies, which varied markedly from industry to industry and plant to plant, follow.

Question No. 1. How well have workers performed since V-J Day as compared to their pre-war effort?

Answer. Worker effort has been below pre-war. There are exceptions, particularly among older and more experienced workers, and there are quite a few signs of improvement.

Question No. 2. How much headway have you been able to make since V-J Day in improving labor productivity by better equipment and organization?

Answer. Some headway is generally being made, but it has been greatly retarded by inability to get new equipment and, in some cases, by lack of labor cooperation in improvements in organization.

Question No. 3. How much improvement in equipment and organization is to be anticipated in your business over the next year?

Answer. Marked improvement in productivity (in a few cases as much as 20 per cent) can generally be made if there is sustained production and full cooperation between labor and management.

If these expressions, *which still remain to be substantiated by practical performance,* come to be accepted by the rank and file of labor in each community, Labor Day, 1946, can usher in a period of great and perhaps unprecedented improvement in the economic wellbeing of wage earners – as well as the wellbeing of the country at large. If, on the contrary, they remain merely window dressing and there is a continuation of the post V-J Day process of increasing wages and then prices, the outcome can only be the bursting of an inflationary bubble, with attendant suffering for workers and the community generally.

Competition requires management to bear down heavily on increased labor productivity as a prelude to wage increases. Management, however, has rarely made a more forthright statement on the importance of increasing labor productivity than that contained in a recent issue of LABOR'S MONTHLY SURVEY, an official publication of the American Federation of Labor.

William Green, the Federation president, led off with a "message to American workers." He remarked, "Our major need is increased volume of production." Observing that "wage increases this spring have been paid for by raising prices," the survey itself goes on to say that "Today America's ability to raise wages without increasing prices and living costs depends on increasing productivity in civilian industries . . . Here is the challenge to free labor and free enterprise today: *Cooperate to increase productivity and raise living standards without strikes.*" (Italics supplied.)

The importance of increasing production was also recently stressed by Walter Reuther, President of the United Automobile Workers, C.I.O., who remarked that his union "is just as eager as management to get the (automobile) industry into maximum production." In taking this general line he was in accord with the position of Philip Murray, head of the C.I.O., who in a book, "Organized Labor and Production" written with Morris L. Cooke, remarks that, "The modern labor leader also realizes that to receive a good day's pay a man must do a good day's work and that *increased productivity has been the vital factor in the country's industrial supremacy and its relatively high wage scale.*" (Italics supplied.)

In citing increased productivity as the key to increased "real" wages these labor leaders—and management – have the historical record entirely on their side. In the 40 years prior to the outbreak of World War II output per man-hour for the country as a whole was approximately doubled. Over the same period the "real" hourly earnings of industrial workers were also approximately doubled. There were, of course, great variations in the increase of output per man-hour from one line of activity to another. Also, there were periods when increases in "real" wage rates lagged behind increases in productivity. But for the 40 year period as a whole and the economy as a whole there is no mistaking the fact that the route to increased "real" wage rates was increased productivity.

Three economic factors played major roles in this doubling of production per man-hour which has made America the industrial marvel of the modern world. One was the skill and diligence of American workers. A second was the skill and diligence of American management in organizing production. A third was the improvement of machinery and the increased application of power to it.

Wartime Record

During World War II this sustained increase in the productivity of labor in *civilian* manufacturing industries, which had averaged about 3 per cent a year, was brought to an abrupt halt. Much of the most efficient segment of the nation's labor force went to war or war industry. Also, civilian industry was starved for new equipment while we equipped our arsenals. The result was that the productivity of labor in those civilian manufacturing industries for which the government keeps records actually declined throughout most of the war. By 1945 it was no higher than in 1941, whereas, if it had maintained the long run average, it would have been about 12 per cent higher. In the meantime, however, average hourly wages in these civilian industries had increased about 40 per cent.

In *war* industry, which started from low levels of production at strange tasks, there were substantial increases in output per man-hour. Many of these increases involved new processes, improved techniques, and better machines which can be adapted over a period of time to the improvement of productivity of labor in civilian industry.

Since V-J Day, however, labor, led on by a misguided government, has had its sights on higher money wages instead of improving productivity which would have laid the foundation for increased "real" wages. Consequently, debilitating industrial strife ended in a round of wage increases which, in the absence of increased productivity, is being washed out by higher prices.

To Keep Production Rolling

However, as indicated by the summary of a McGraw-Hill sampling of the current experience of industry in increasing output per man-hour, which appears in the center of the page, there is hope that the situation ahead can be improved. After agonizing delays because of work stoppages, material shortages, and reconversion complications, industrial production is beginning to roll again. Allowed to roll it will not be long before it will be making those advances in productivity which are the only true basis for increased "real" wages.

If the process of keeping American industry rolling to new highs of productivity is to be resumed, management must see that the past practice of translating increased output per man-hour into increased "real" wages is not only sustained but wherever possible accelerated. For its part organized labor must abandon its manifold feather bedding rules and other production-restricting practices which afflict considerable segments of American industry. Further it must give incentive systems of pay, honestly conceived and honestly administered, a fair break. *Management and labor and government and the community at large must collaborate in removing that specter of working one's self out of a job which has been one of the greatest causes of restriction of output.*

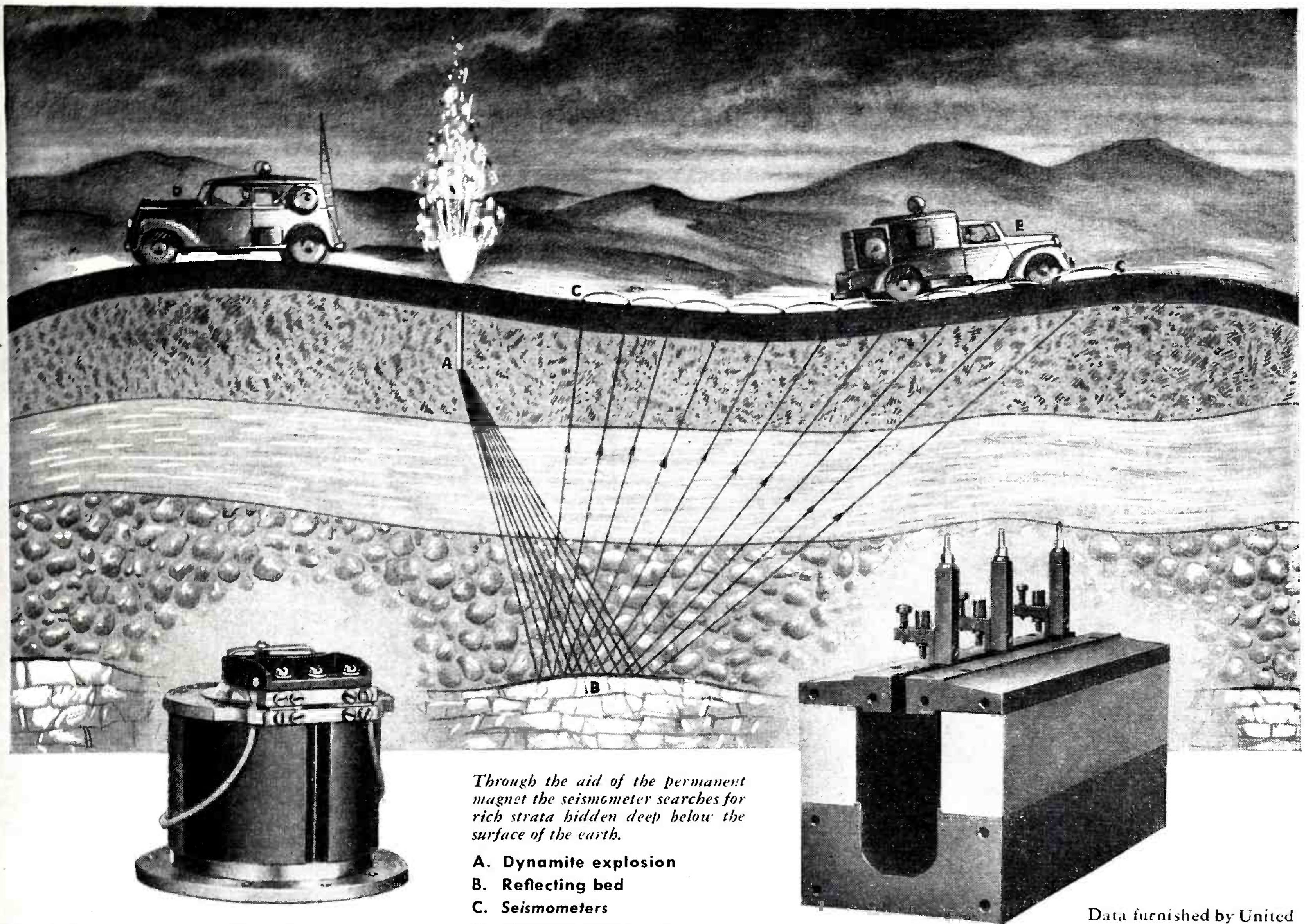
The current emphasis by leaders of organized labor on the economic truth that increased output per man-hour is the only road to increased "real" wages is important. The next step is to see that recognition of this truth seeps into the rank and file of labor and industry and becomes the basis of a program of action at the local level. If it does, and quickly, Labor Day, 1946, may mark a tremendous turning point toward sustained prosperity not only for labor but the community at large. If it does not, union leadership will fail in its responsibility and must answer to the American people for the consequences of such a failure.

James H. McGraw, Jr.

President McGraw-Hill Publishing Company, Inc.

THIS IS THE 50TH OF A SERIES

PERMANENT MAGNETS MAY DO IT BETTER!



Through the aid of the permanent magnet the seismometer searches for rich strata hidden deep below the surface of the earth.

- A. Dynamite explosion
- B. Reflecting bed
- C. *Seismometers*
- D. Shooting Truck
- E. Recording Truck

Seismometer assembly, showing magnet and bakelite bobbin at top.

Galvanometer Assembly

Data furnished by United Geophysical Company, Inc., Pasadena, California

PERMANENT MAGNETS HELP REVEAL HIDDEN RESOURCES

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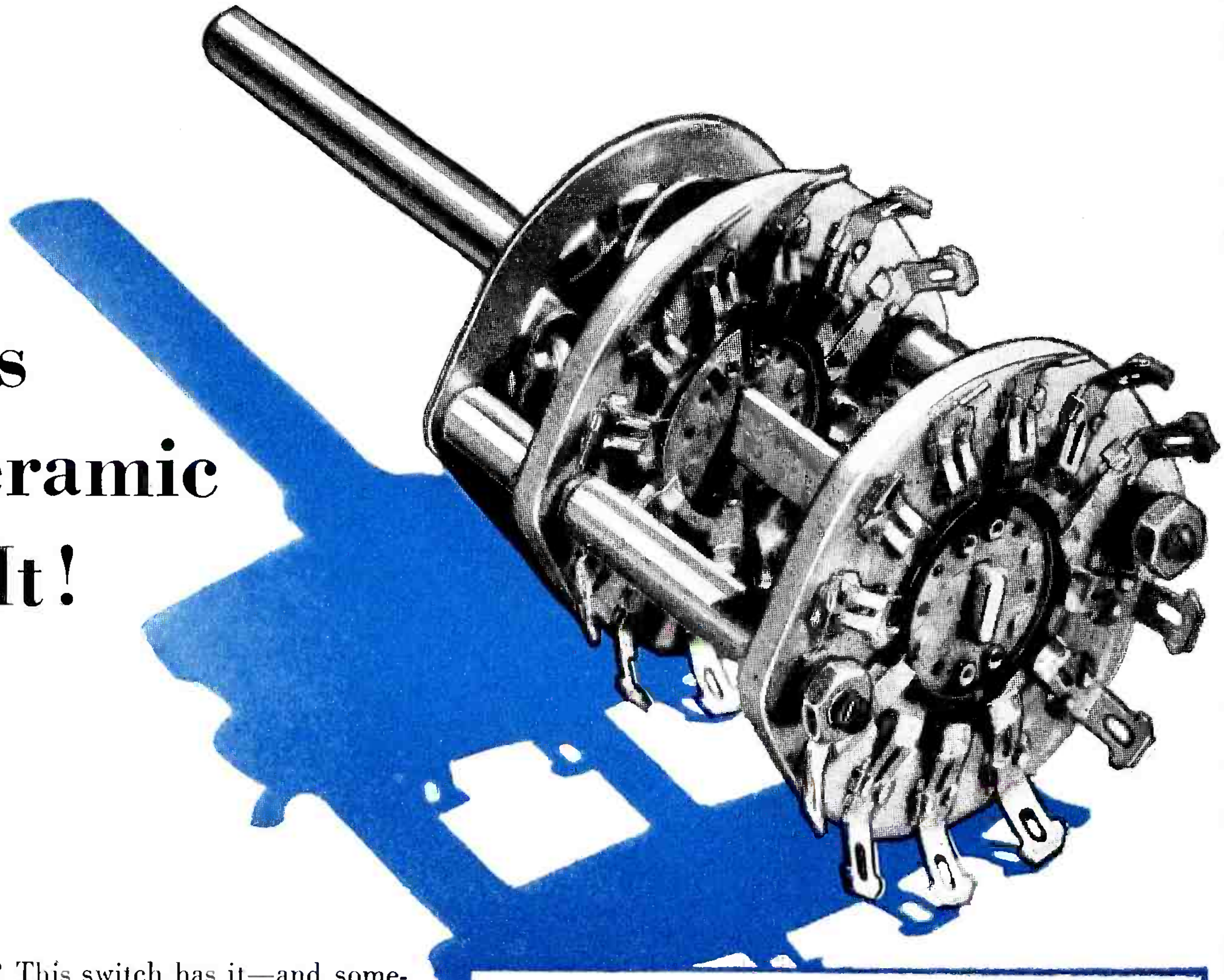

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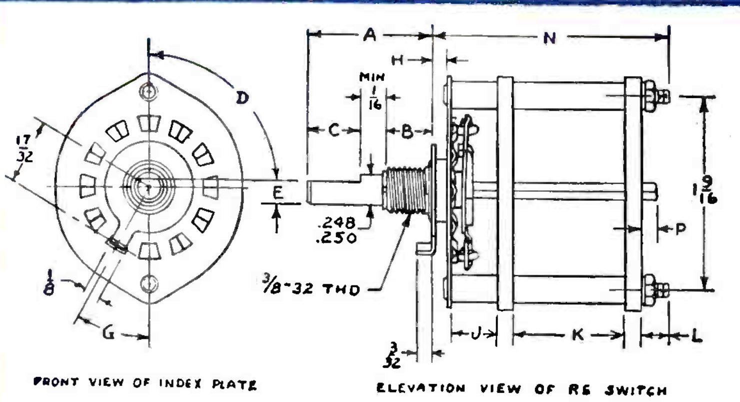

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CROSS TALK

► **BIKINI** . . . There is little doubt in anybody's mind back here in the United States that the broadcast of the first bomb drop at Bikini came near being a complete flop. Local noises and racket picked up in transmission were so great that little could be heard of the intensely dramatic goings-on at the scene. Furthermore the broadcasters cannot seem to get out of their minds the feeling that everything must be reported in language somewhere between a football game and a honey-worded advertisement.

Part of the technical blame for the poor broadcast must be laid at the Navy's door for inadequate preparation and rehearsal of the event for it was Navy equipment that did the job. This is the more to be regretted because of the intense public interest in every activity of our Navy.

Some of the trouble was cleaned up by the time of the underwater blast; technically the job was much better done. One still wished, however, that the man at the mike would please just shut up for a minute or two to let us hear what was transpiring. A second of silence is more than any announcer can stand, apparently.

Aside from the blasts themselves and what the Navy will learn from them, there was much at Bikini on which the man in the street can ponder. Successful operation of the drones, those radio-controlled planes that scooted hither and yon through the radioactive cloud is, if anything, only slightly less terrifying than the atomic bomb itself. There seems to be no longer any reason why bombing planes need carry any men at all. Such planes now can be merely wings attached to bombs. Indubitably the day of the piloted airplane bombing mission is ended.

Thus, even if the atom bomb never existed, the ingredients are here for wars vastly worse than this last world-wide conflict. Along with the atomic scientists, electronic experts must share the curse of the immeasurable uneasiness with which the world is afflicted. With two television sets to scan the sky ahead and a selected group of flight control instruments, all governed by men far away from the scene of trouble, a "modern" bomber can be directed to its target, turned around and brought back to base for its bomb racks and gas tanks to be filled up again.

This, of course, is only one aspect of radio-controlled missiles such as those called Azon, Razon, Rock and Tarson. Ground-to-ground long-range busters like those hitherto only used as a stratosphere sounding machine only add to the list of playthings which man will have available for future battles. World War II has been called an electronic war but the winning of it came about more by the marvels of mass production than by electronic skill. It is the next war that will truly be electronic, if not atomic.

Army and Navy are correct in working overtime at new research into new weapons. To wait until world politics catches up with world wish for security and really does something about it would catalog historically our armed forces like Nero who fiddled while Rome burned.

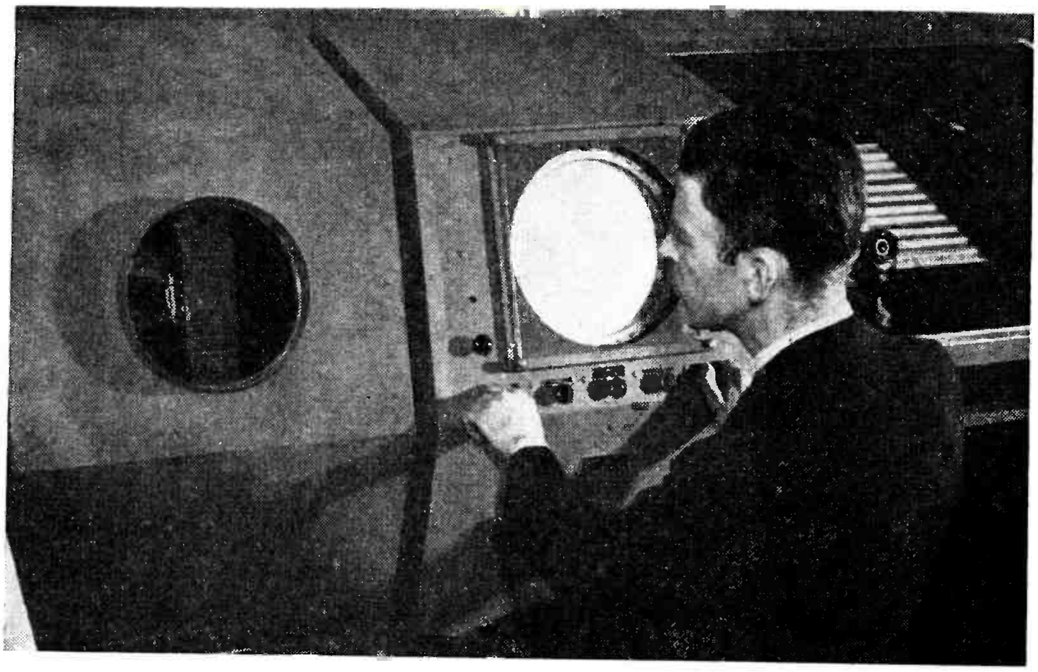
► **TRIM** . . . Effective with this (September) issue, the trim size of ELECTRONICS will become standard at 8¼x11¼ inches along with practically all other McGraw-Hill papers, a move which regrettably must be done now instead of with next January issues. Paper shortage makes this change in size necessary now.

For those who bind their issues, the mechanical problem can be solved by having the binder fill in September through December issues at the stitching edge so as to equal the remainder of the issues in width. The top and bottom margins of the first eight months' issues are sufficiently wide to allow for trimming to the new length.

Since there is very little likelihood that the page size will return to its pre-war dimensions, this temporary inconvenience will be more than equalled by the advantage of a standardized size from now on.

All-Weather

Left—Rotating radar antenna on 60-foot tower, for use in air traffic control at Indianapolis Experimental Station. So far, radar alone isn't able to identify accurately specific planes in a group circling for a landing through overcast



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There is growing evidence of impatience regarding the alleged lag in making available to civil aviation important wartime developments. Questions are being asked, most of them relating to the adoption of the radar landing system used by the Army and Navy during the war and to the use of other aids to navigation and of anticollision equipment.

Officials of the Civil Aeronautics Administration are fully aware of the impatience and questioning, due to the spectacular nature of wartime developments and the growth of commercial aviation by leaps and bounds. They contend, however, that in reality there is no lag. They point out that military and civilian uses are far from identical and that the speed and timing with which war advances are applied to civilian aviation depend upon their safety and practicability, still to be tested and proven under an entirely different set of conditions.

The vhf instrument landing system is being installed on the basis of a priority list of airports given CAA by the Air Transport Association. The radar ground-controlled approach system used by the Army and Navy during the war is undergoing continual tests and further development at CAA's Indianapolis Experimental Station. CAA officials have stated that as radar aids prove their usefulness, they will be combined with the vhf system.

Before anything new can be adopted along the airways, it must have the approval of both airline pilots and airline officials through their representative groups, and it must be shown to contribute to the safety of the flying public. The scope of the work that can be undertaken depends in large part upon the size of the appropriation granted by Congress to CAA to conduct research and development for the adaptation of military appliances to civilian purposes. One official outside CAA, but closely in touch with its technical program, has estimated that the amount should be from five to ten million dollars, whereas present indications are for an appropriation of $875,000 for the fiscal year July 1, 1946-June 30, 1947 to cover all CAA technical developments. Of this, roughly $300,000 is for radio and radar development work.

Instrument Landings

Airlines plan to begin use of the CAA instrument landing system next winter to facilitate approach and landing of aircraft under adverse weather conditions, according to a joint announcement from the Air Transport Association and CAA. The use of this system even as an approach aid in the case of low ceilings would eliminate many serious air traffic control problems which exist now at large terminals when bad weather prevails. The system is being installed at 50 civil

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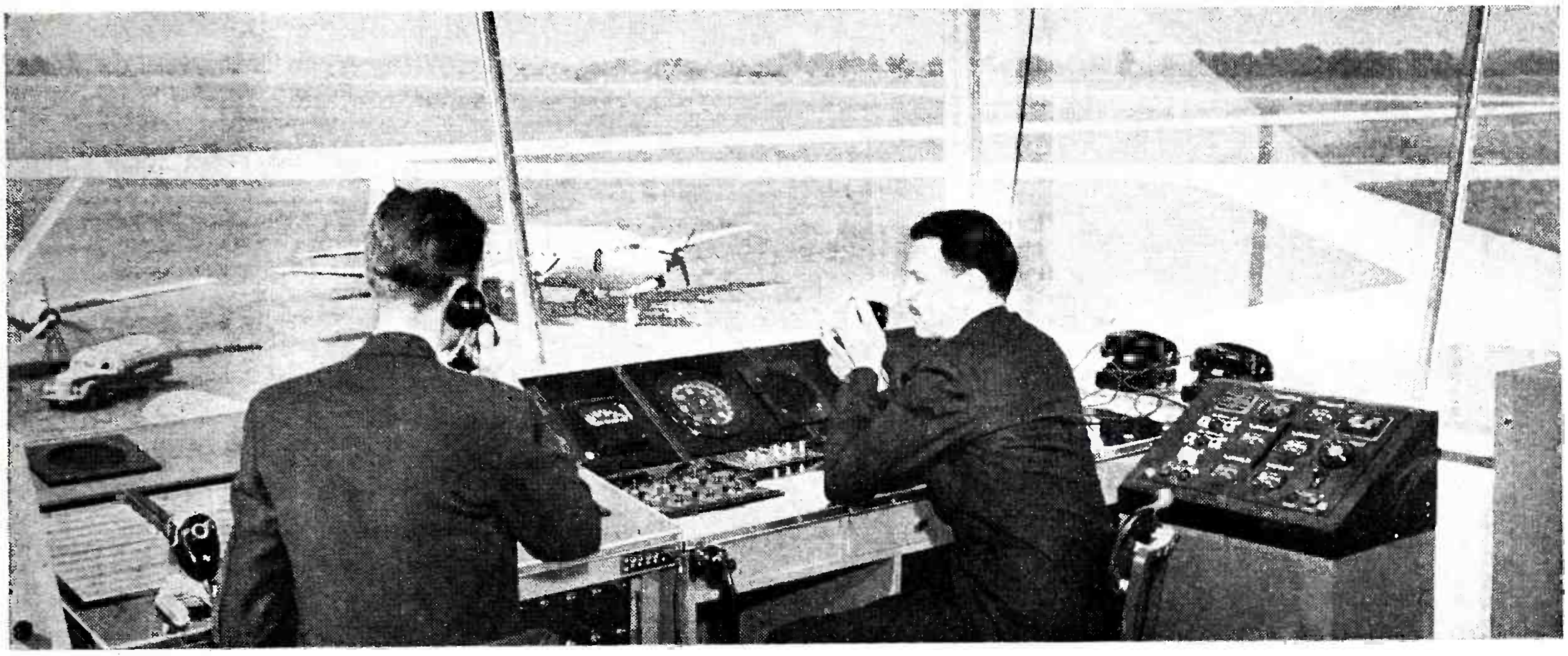

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The instrument system now being installed by CAA, which was used by the Army during the war under the military designation of SCS-51, is already well known and consists of the familiar localizer, glide path and marker beacons. Of the three elements, the marker beacon is considered fully developed. The localizer, heretofore operated on a basis of amplitude comparison with 90 cycles transmitted on one side and 150 cycles on the other side of the line to define the course along the runway, already has been improved by using phase comparison instead of two 60-cycle signals. This change has resulted in a simplification of the transmitter on the ground, and a lightening of the airborne receiver.

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Las Vegas	Wichita
New Orleans	
Construction completed but radio equipment not installed	
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Buffalo	Knoxville
Dallas	Louisville
Dayton	N. Y. (Idlewild)
Denver	Philadelphia
Eugene	Reading
Construction under way	
Albuquerque	Minneapolis
Amarillo	Okla. City
Charleston	Raleigh
Cincinnati	Salt Lake City
El Paso	San Antonio
Houston	Tulsa
Memphis	
Plans complete; proposals issued	
Columbus	Long Beach
Detroit	Newark
Jackson	South Bend
Jacksonville	Willow Run

CAA instrument landing installation at Indianapolis. Antenna building is at left, in line with the end of the runway, while transmitters are in smaller building at right and 300 feet away

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Development work on the distance indicator and the low-frequency omnidirectional radio range, both basic future aids to air navigation, has reached the point where CAA considers that the technique and facilities can be made available for use on continuous flights. However, tests at Indianapolis will continue in order to improve various phases of the overall system.

The distance-measuring equipment was operated successfully as an experiment for about a year on 212 mc. Recently, it has been necessary to shift to 1,000 mc and experimental equipment is now operating on this frequency. A unit has been developed to the point where it can go into production, but it may be two years before it can be obtained commercially.

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As an illustration of the need for positive radar identification of planes, recently at Indianapolis two aircraft were observed on the operator's screen. The operator, thinking he knew which was which, ordered one aircraft to make a left turn. After making the turn, the pilot discovered the other plane directly in front of him, and only by expert maneuvering was he able to avoid a collision.

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The automatic landing feature involves the use of electronic coupling devices to connect the automatic pilot with the instrument landing system. These are now under test, but have not gone into production. The electronic autopilot is at present in production by several manufacturers.

Anticollision Systems

The anticollision device is a difficult subject. Technically, no convenient combination of lights, dials, or signals has given the pilot a picture of obstacles or other aircraft adequate to enable him to avoid collision. A military search radar, APS-10, has been under test at the experimental station but its presentation on a cathode-ray screen is not ideal for the pilot. It is, however, feasible to study and interpret signals in large aircraft where the weight of this apparatus, about 125 pounds, plus that of an operator, offers no handicap.

There is a possible application for APS-10 equipment in combination with the vertical separation indicator, and it is expected that continued development of the equipment and the technique in using this equipment will bring about the desired anticollision features. The development of the stratoscope and vertical separation indicator was intended to provide the pilot with information concerning the existence of other aircraft at 1,500 feet above or below his airplane and to indicate automatically his elevation along with that of all other aircraft on the monitor screen in the control tower. Its operation is based on the use of an aneroid cell, which varies the frequency of a c-w transmitter from 154 to 148 mc as the aircraft ascends from sea level to 10,000 ft. Weight is a problem here since the device as it now stands weighs approximately 45 pounds.

Panoramic type scanning is used on ground equipment to spread the received frequencies on a cathode-ray screen in proportion to the elevation. The scanning screen will be used to supplement the present method of stacking planes at 1,000-foot altitude intervals while the lowest plane is cleared to come in and land by the tower traffic controller. It gives the controller a plan picture of all aircraft within 30 miles of the airport. The picture appears on a cathode-ray tube screen 12 inches in diameter.

As a result of this application of radar it is expected that it will be possible to bring planes in safely at two- and perhaps one-minute intervals in place of the three-minute intervals achieved with the CAA system. In its present form, the screen gives distance and direction information; further research, it is believed, will lead to a means of determining altitude and identity.

Ground-Controlled Approach

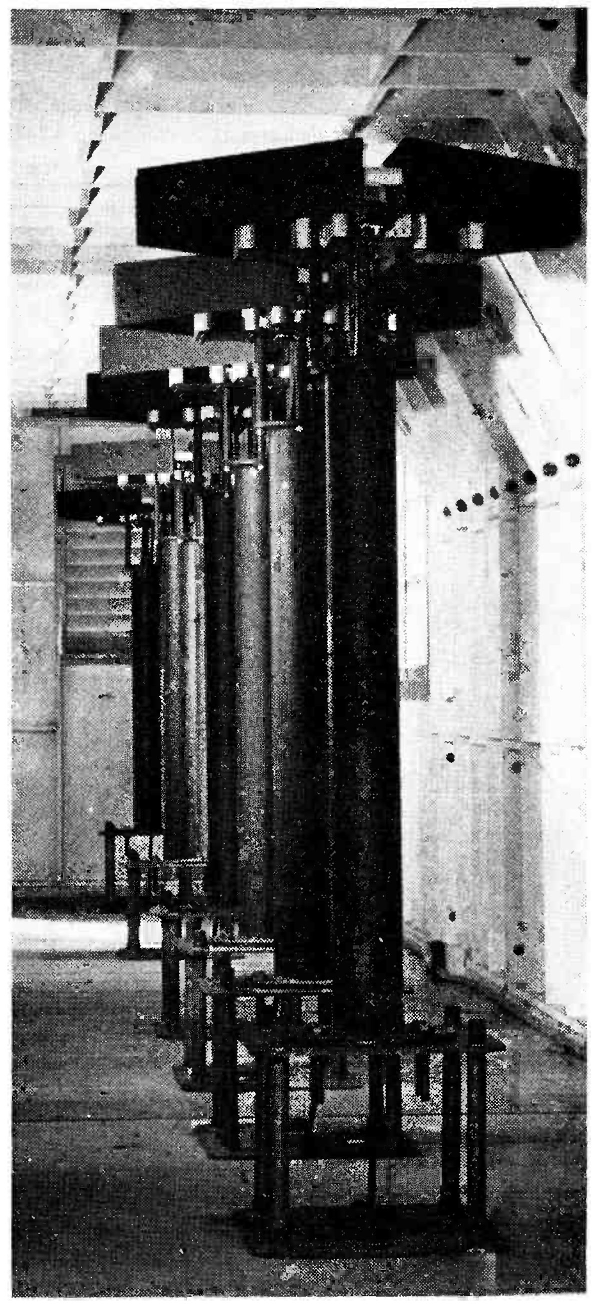
Two radar systems are under test at Indianapolis. The Army, using a C-54 four-engine plane and a number of different pilots, is making comparative tests of the CAA system and also the ground-controlled approach system. At the same time, the CAA is testing gca equipment given it by the Army and Navy and comparing with its own, using planes of different types.

As a result of these tests, an improved search antenna has been developed which is not affected by rain and is extremely stable. It allows the CAA operator to observe airplanes at high elevation above the station as well as those at horizontal distances.

A practical difficulty with radar has been the necessity of keeping crews on the ground to operate it. During the war the Army often used a crew of 16 men with each installation. One of the radar equipments recently has been converted so that a single operator can land an airplane by observing the screen and talking directly to the airplane. However, if more than one ship is involved in traffic and landing, more operators will be required. This would involve a large increase of CAA personnel at airports for instrument landings alone. In addition gca in its present stage requires a great deal of maintenance.

Economic Considerations

An overall view of radar developments is that expressed by Dr. Harry Diamond of the Bureau of Standards, called the father of CAA's instrument landing system: "Many people think that unless advances are brought about by radar they are not modern. There are many excellent methods of measuring distance that do not involve pulses. Many radar developments are in the 'gleam in the eye' stage. We should study the various systems but hesitate to adopt anything different until we are convinced that it will give better performance, and until we are sure the material is available at a reasonable price."



Inside of antenna building, showing array required to produce a straight localizer course. Technical details of this system were given in the February and March 1945 issues of ELECTRONICS

Most private pilots with small planes will use contact flying for some time to come and keep out of bad weather. Before such a pilot could arrive at a place equipped for instrument landing he would have to be flying in "instrument" weather. This would mean that instruments in his plane would cost about $1,000; also, he would need about $500 worth of training to learn how to use them. Such expenses are out of the question for the average pilot.—G.T.M.

ALL-WEATHER

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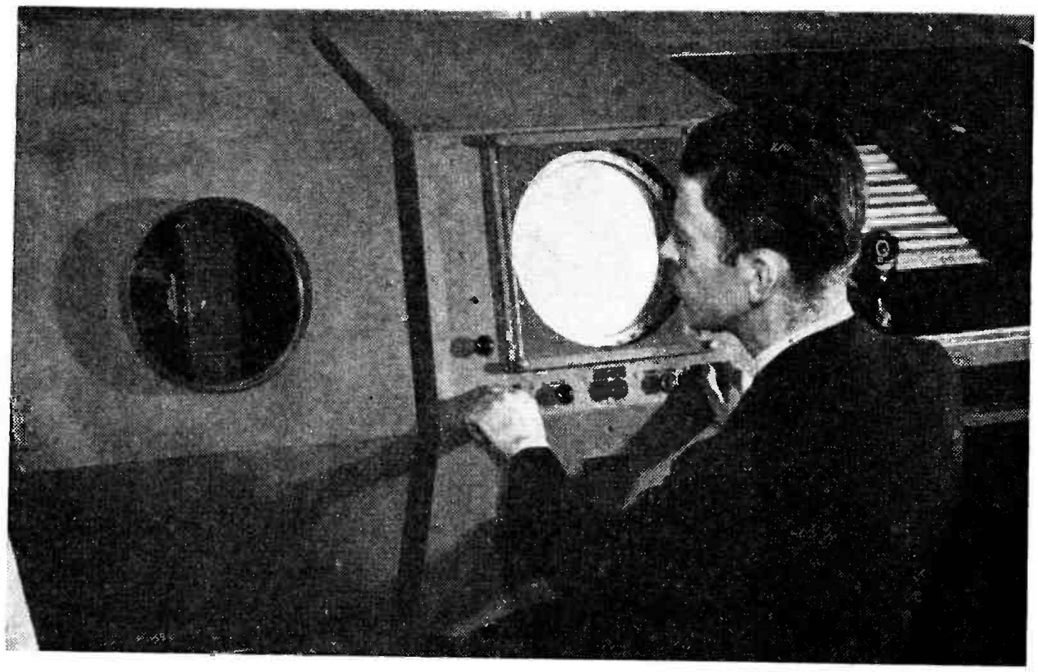

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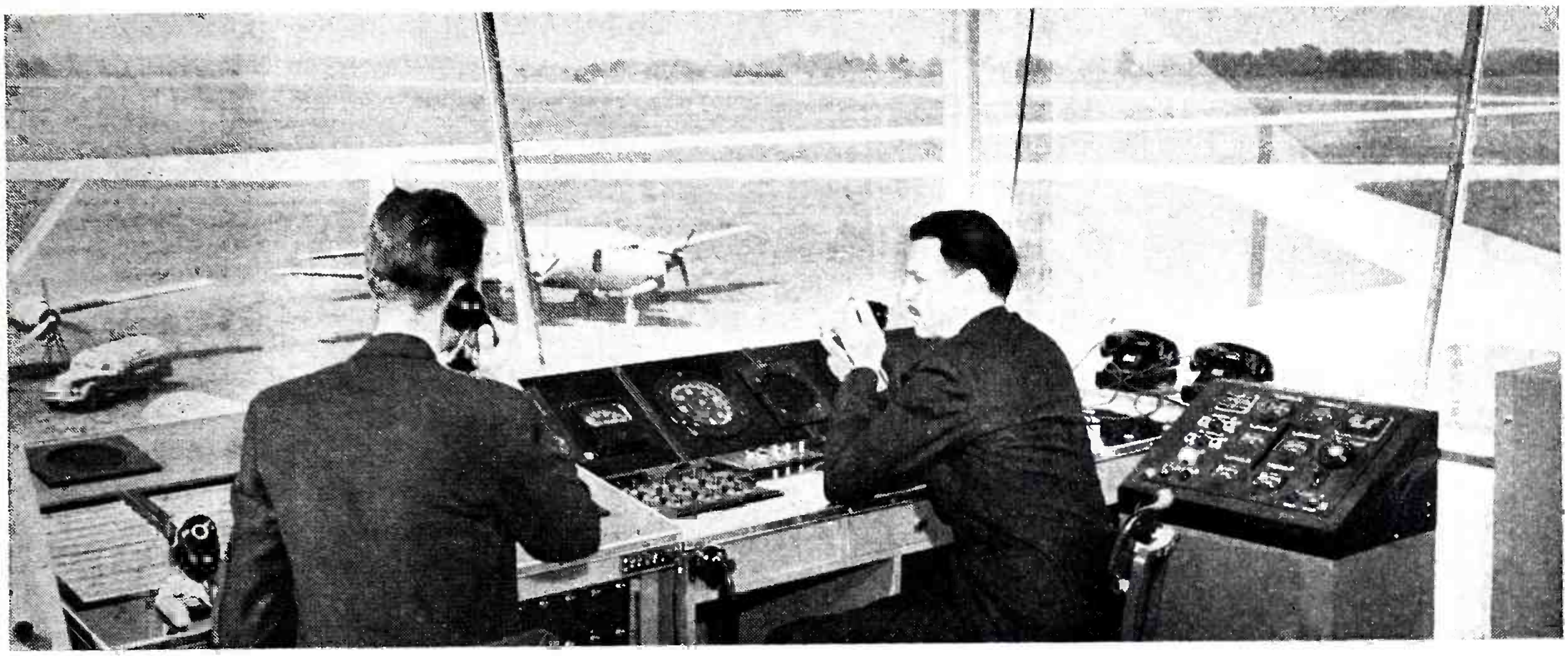

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Eugene	Reading
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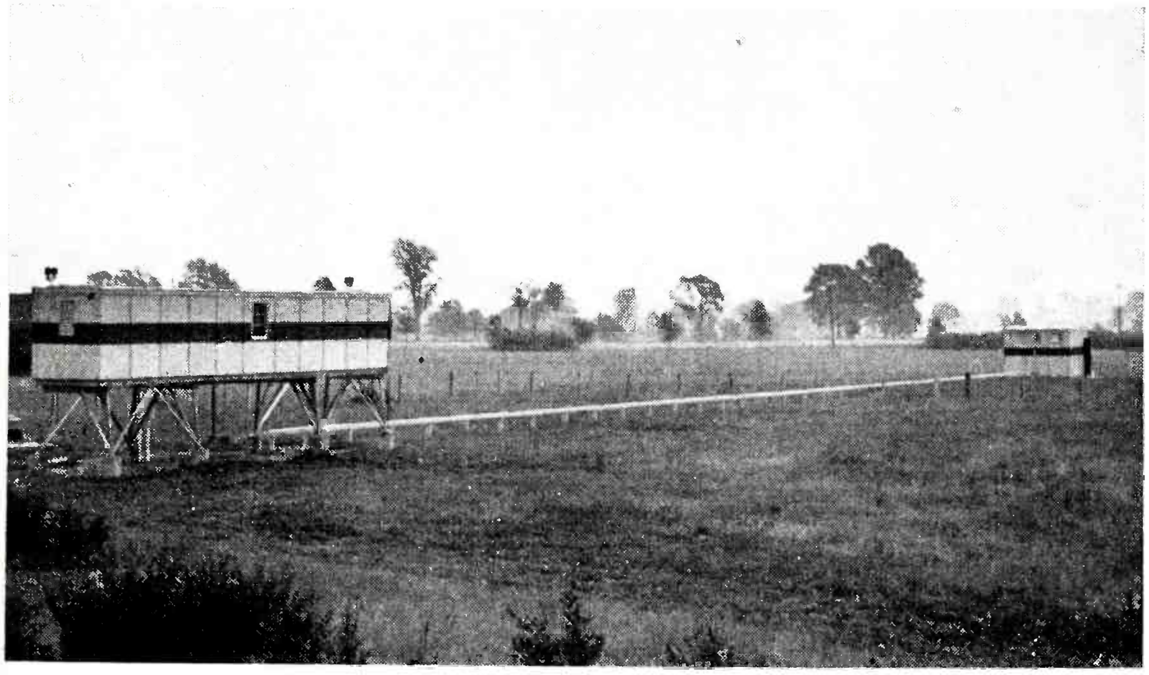

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Anticollision Systems

The anticollision device is a difficult subject. Technically, no convenient combination of lights, dials, or signals has given the pilot a picture of obstacles or other aircraft adequate to enable him to avoid collision. A military search radar, APS-10, has been under test at the experimental station but its presentation on a cathode-ray screen is not ideal for the pilot. It is, however, feasible to study and interpret signals in large aircraft where the weight of this apparatus, about 125 pounds, plus that of an operator, offers no handicap.

There is a possible application for APS-10 equipment in combination with the vertical separation indicator, and it is expected that continued development of the equipment and the technique in using this equipment will bring about the desired anticollision features. The development of the stratoscope and vertical separation indicator was intended to provide the pilot with information concerning the existence of other aircraft at 1,500 feet above or below his airplane and to indicate automatically his elevation along with that of all other aircraft on the monitor screen in the control tower. Its operation is based on the use of an aneroid cell, which varies the frequency of a c-w transmitter from 154 to 148 mc as the aircraft ascends from sea level to 10,000 ft. Weight is a problem here since the device as it now stands weighs approximately 45 pounds.

Panoramic type scanning is used on ground equipment to spread the received frequencies on a cathode-ray screen in proportion to the elevation. The scanning screen will be used to supplement the present method of stacking planes at 1,000-foot altitude intervals while the lowest plane is cleared to come in and land by the tower traffic controller. It gives the controller a plan picture of all aircraft within 30 miles of the airport. The picture appears on a cathode-ray tube screen 12 inches in diameter.

As a result of this application of radar it is expected that it will be possible to bring planes in safely at two- and perhaps one-minute intervals in place of the three-minute intervals achieved with the CAA system. In its present form, the screen gives distance and direction information; further research, it is believed, will lead to a means of determining altitude and identity.

Ground-Controlled Approach

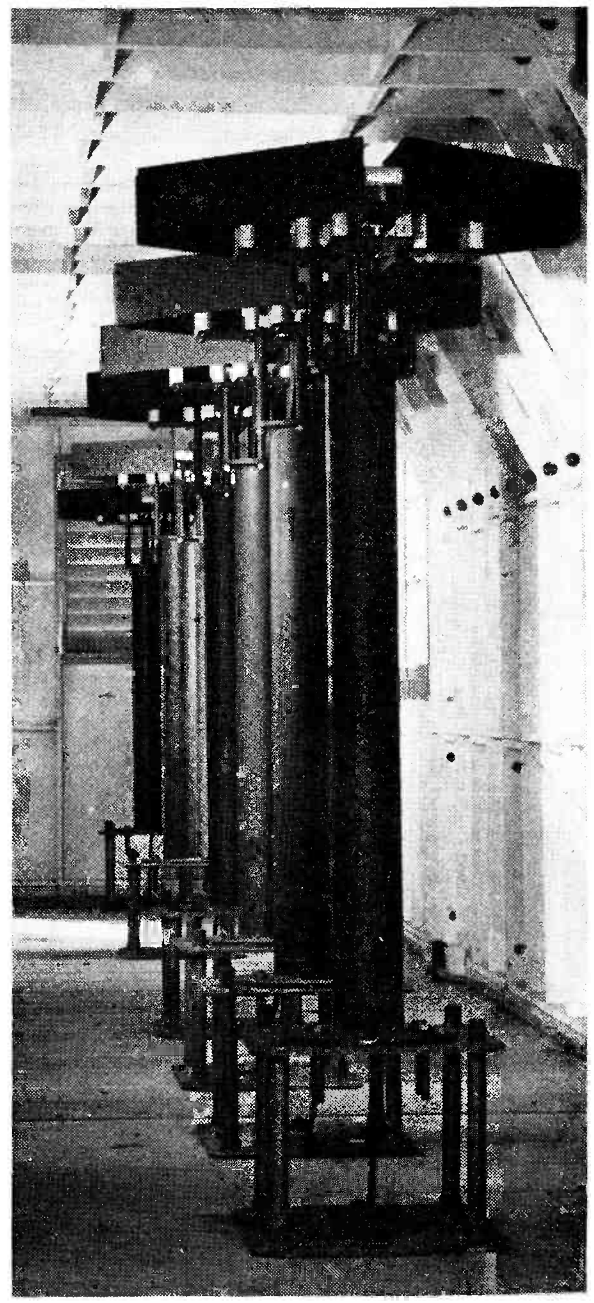
Two radar systems are under test at Indianapolis. The Army, using a C-54 four-engine plane and a number of different pilots, is making comparative tests of the CAA system and also the ground-controlled approach system. At the same time, the CAA is testing gca equipment given it by the Army and Navy and comparing with its own, using planes of different types.

As a result of these tests, an improved search antenna has been developed which is not affected by rain and is extremely stable. It allows the CAA operator to observe airplanes at high elevation above the station as well as those at horizontal distances.

A practical difficulty with radar has been the necessity of keeping crews on the ground to operate it. During the war the Army often used a crew of 16 men with each installation. One of the radar equipments recently has been converted so that a single operator can land an airplane by observing the screen and talking directly to the airplane. However, if more than one ship is involved in traffic and landing, more operators will be required. This would involve a large increase of CAA personnel at airports for instrument landings alone. In addition gca in its present stage requires a great deal of maintenance.

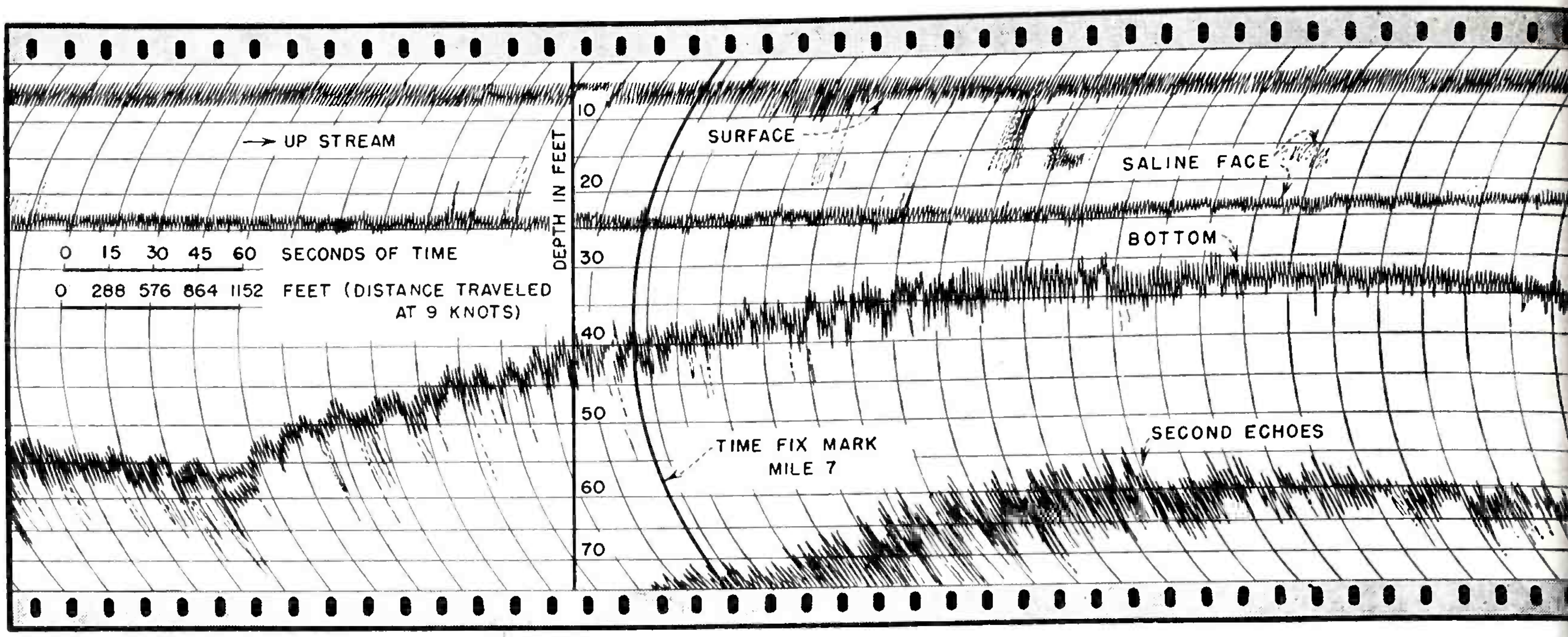
Economic Considerations

An overall view of radar developments is that expressed by Dr. Harry Diamond of the Bureau of Standards, called the father of CAA's instrument landing system: "Many people think that unless advances are brought about by radar they are not modern. There are many excellent methods of measuring distance that do not involve pulses. Many radar developments are in the 'gleam in the eye' stage. We should study the various systems but hesitate to adopt anything different until we are convinced that it will give better performance, and until we are sure the material is available at a reasonable price."



Inside of antenna building, showing array required to produce a straight localizer course. Technical details of this system were given in the February and March 1945 issues of ELECTRONICS

Most private pilots with small planes will use contact flying for some time to come and keep out of bad weather. Before such a pilot could arrive at a place equipped for instrument landing he would have to be flying in "instrument" weather. This would mean that instruments in his plane would cost about $1,000; also, he would need about $500 worth of training to learn how to use them. Such expenses are out of the question for the average pilot.—G.T.M.



Profile of river bottom along 1.75-mile stretch of Southwest Pass, near mouth of Mississippi River, as made with precision shallow-water depth recorder. In addition to bottom depth, an experienced operator can accurately interpret such additional information as

Echo Depth Sounder

By G. B. SHAW

Engineer
Submarine Signal Co.
Boston, Mass.

FROM TIME IMMEMORIAL mariners have been plagued with the problem of knowing the exact depth of water beneath the keels of their ships. As the contour of a river bed or the ocean floor can change very abruptly even at low ship speeds, the means for determining this depth must be accurate, rapid, and self-indicating. The inadequacy of early methods employing weights, drag lines, and other ingenious devices has been long apparent.

Echo-sounding, made practical by electronics, is a modern answer to this marine problem. It solves most of the difficulties of the past and has some unique features of its own. Foremost among the latter is the ability of such apparatus to detect the presence of objects between ship and sea-bottom. This feature has gained tremendous importance in the determination of the location and magnitude of schools of fish.

All echo-sounding devices operate on the principle of (1) measuring the time interval between the transmission of an acoustical signal and its return as an echo and (2) the conversion, by visual and/or graphical means, of this time interval into some unit of linear distance (feet, fathoms, or meters).

Shallow Depth Sounding

Although modern echo-sounding equipment combines essentially the same elements as the 1920 Submarine Signal Co. model, namely a supersonic signal generator, a motor-driven pulsing switch and synchronous registering device, an electronic echo amplifier, and either one or two magnetostriction transducers, the elements themselves have undergone radical revisions. Many of these design revisions have been imposed by the following basic requirements of an accurate shoal-water depth sounder:

(1) A means of accurately measuring and permanently recording the relatively short time intervals encountered in shoal-water sounding, of the order of a few thousandths of a second. The inherent accuracy of indication is a direct function of the ability of the driving motor to maintain a speed of rotation predetermined by the velocity of sound in water. If a synchronous a-c motor is employed, the maintained accuracy of frequency of the power source becomes the determining factor. Accuracies within 0.5 to 1.0 percent can normally be expected.

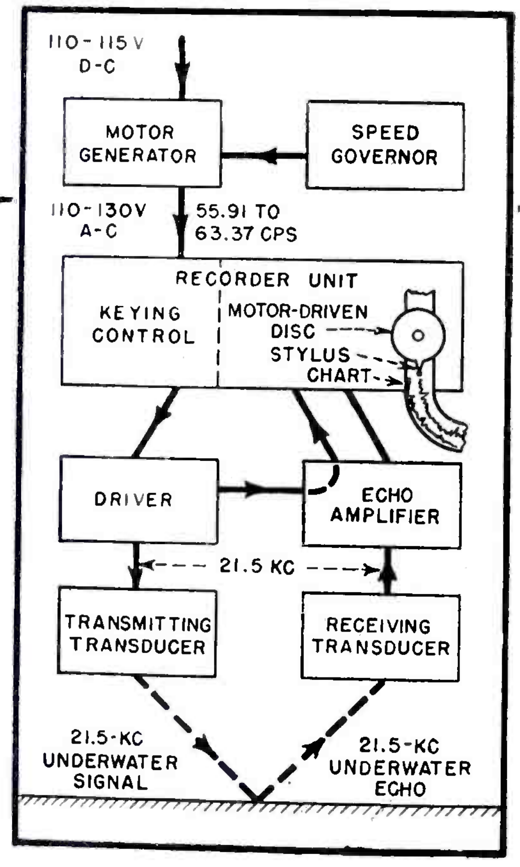
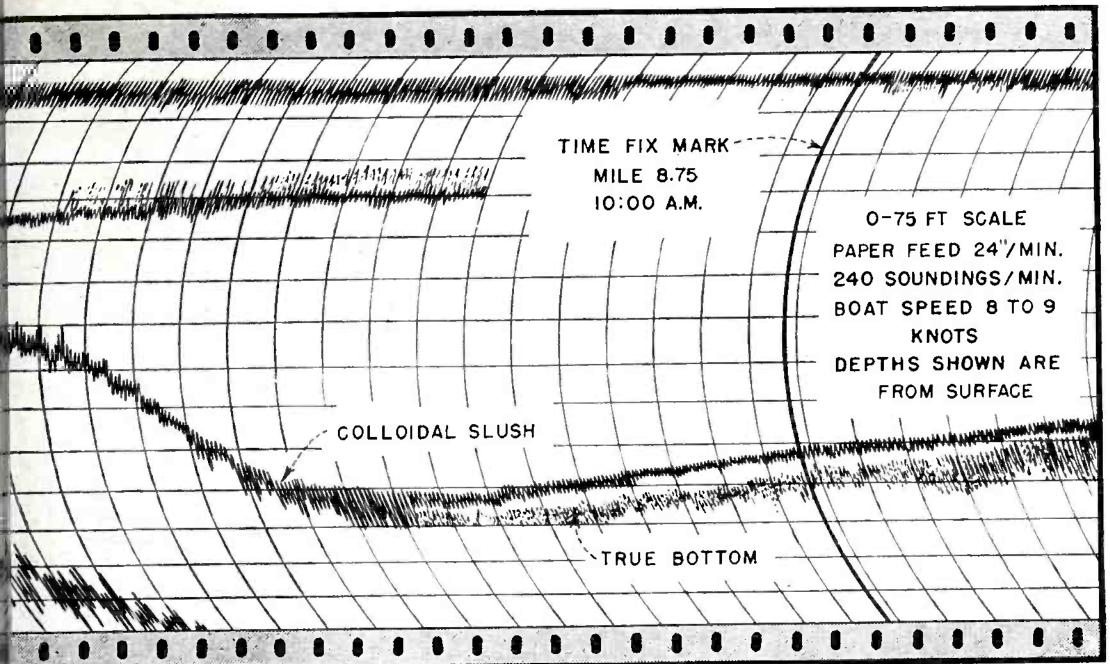
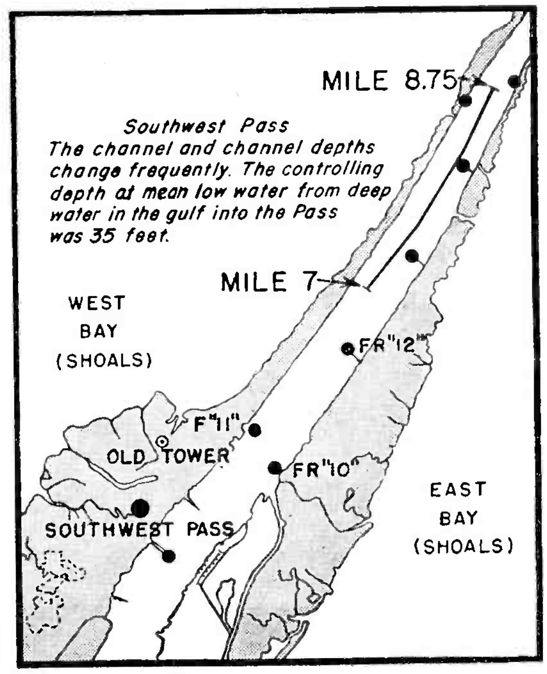


FIG. 1—Block diagram of precision depth recorder employing echo-ranging principle

(2) Ability of the apparatus to





positions of saline faces, colloidal slush, second echoes in shallow water, wrecked ships on the bottom, and even schools of fish. Map at right shows route taken by ship while record was made

For Shallow Water

Modern marine accessory, developed originally for hydrographic surveys, plots accurate profile of sea bottom on strip chart. Unique capacitor-discharge system in driver excites magnetostriction transducer to produce desired 21.5-kc supersonic signal

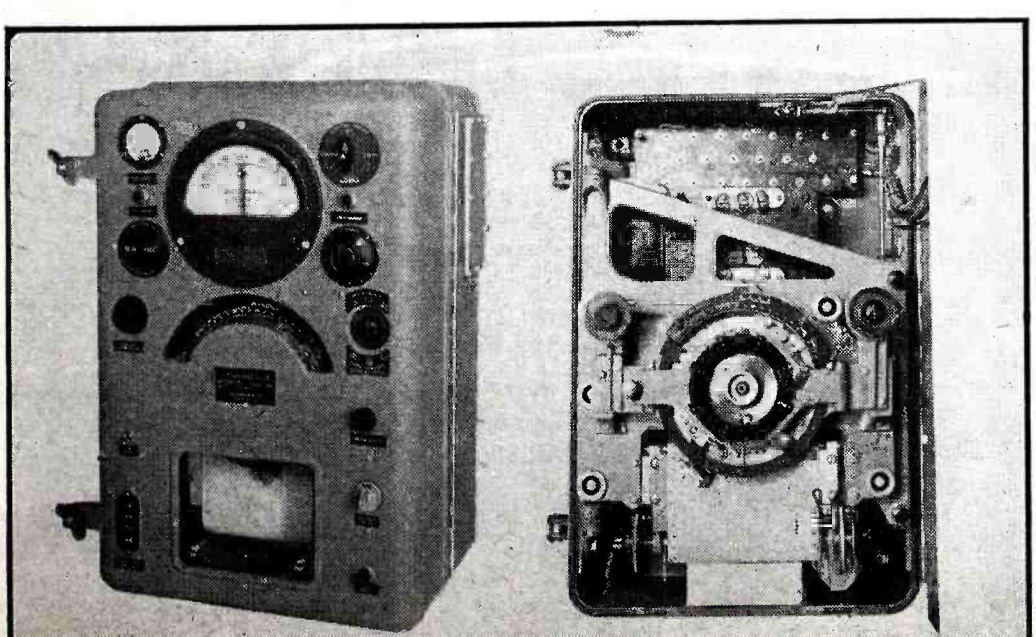
prepare itself for the reception of short-time echo signals. Such ability is a function of emitted signal length, echo amplifier recovery time following the emitted signal, and the Q of the transducers and associated circuits. Impact excitation of a magnetostriction transducer of relatively high Q has proven the most satisfactory method of obtaining very short signal lengths for use in shallow depths, where the sustained signal of a c-w oscillator is neither desirable nor necessary.

(3) A high degree of detail of profile of irregular bottoms, which is a function of the speed of sounding and the signal frequency. This can best be accomplished by the use of the higher supersonic frequencies, which also facilitates concentration of sound energy in the desired direction and greatly minimizes the interference from random lower-frequency sounds.

Hydrographic Survey Requirements

Precision depth recording, such as is needed in hydrographic surveys, dictates the use of a permanent graphical recording and also requires the recognition of several known variables external to the equipment proper. These variables, for which compensation must be provided, include draft (distance from transducers to water surface when vessel is at rest, and dependent on loading), squat (the slight change of draft of a vessel underway and which may be positive or negative depending on the position of the transducers along the hull and the loading), tide, water level or river stage with respect to the arbitrary datum plane to which the depths are referred, and variations in sound velocity due to the variations of temperature and salinity of the water.

In the case of navigation by visual indication, the necessary corrections in depth indications resulting from taking account of the

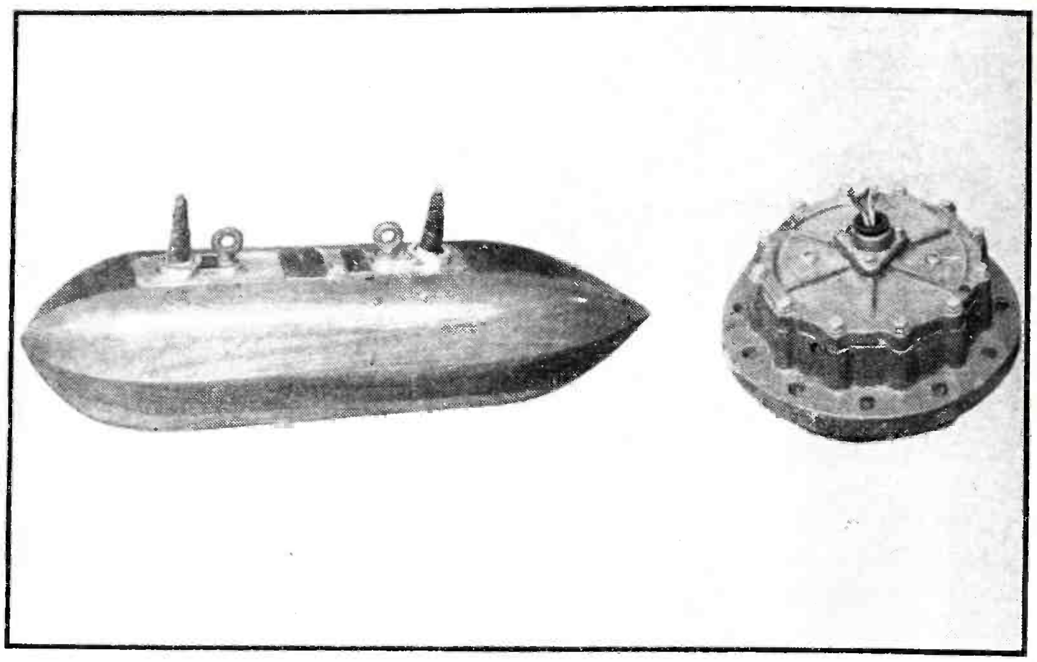


Recorder unit of Submarine Signal Co. model 788A precision depth sounder. The stylus-supporting wheel is on the shaft of an a-c motor that rotates continuously at a speed proportional to the velocity of sound in the water being explored, and current pulses burn marks in the chart as the stylus sweeps over it once in each revolution

above may be, and usually are, simple on-the-spot mental calculations which amply fulfill accuracy requirements. Unless accomplished automatically, however, these corrections represent a tremendous amount of work and a potential source of error when a survey vessel may be making up to 75,000 soundings in a single day of operation.

Precision Depth Recorder

Automatic compensation for all of the previously-mentioned variables is incorporated in the type 788A depth recorder, specially designed to meet the most stringent specifications of the United States Army Engineers for river, lake, harbor, and channel surveys where extremely precise measurements are required for accurate chart making to insure the safety of peacetime navigation and the success of wartime landing operations. The overall range is 75 feet, and this range may be positioned anywhere between 3 and 250 feet, depending on the adjustment of the compensation scales at the time of recording and on the setting of a range selector. Depths less than 3 feet below the vessel cannot be satisfactorily measured. Continuous direct readings, automatically corrected as required, are obtained with an accuracy of plus or minus three inches for minimum depths up to 50 feet, of plus or minus six inches for depths between 50 feet and 125 feet, and within 1 percent for depths up to the maximum range. Calibrated compensation controls for draft, squat, tide, elevation, and sound velocity, in addition to the necessary means for monitoring and controlling the operating functions, are provided on the front of the recorder unit.



Streamlined outboard "fish" used to support portable magnetostriction units for hydrographic survey work, and one of the magnetostriction units

Like earlier depth recorders, depths are registered as marks on a moving chart paper at the beginning and end of each signal epoch. The record is made by a stylus on the end of a rotating radial arm which passes over the paper at a predetermined constant velocity and marks it permanently at the instants of signal transmission and echo reception. Thus an interval of peripheral travel of this stylus represents a given time interval and, if the speed of rotation and the velocity of sound in water are properly related, also represents a given depth as indicated by a scale printed directly on the paper.

Details of System

The complete precision depth recorder system, shown functionally in Fig. 1, includes a motor-generator source of power, a driver for shock-exciting the magnetostriction transmitting transducer at its 21.5-kc supersonic operating frequency, a magnetostriction receiving transducer, an echo amplifier, and a recorder unit in which is incorporated a keying control for the driver. The transducers may be mounted in the hull of the survey vessel or combined for semiportable work in

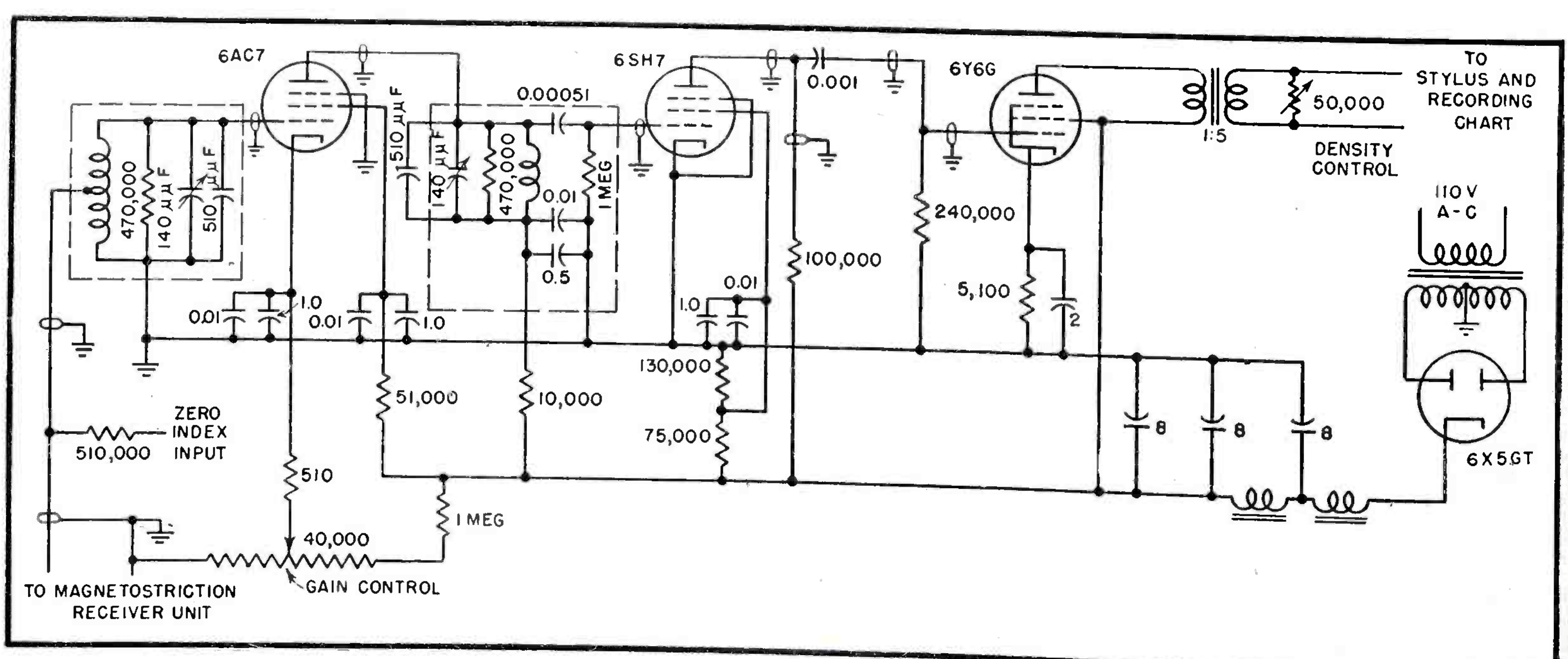


FIG. 2—Circuit diagram of echo amplifier, which is connected between the magnetostriction receiver unit and the recorder, and delivers output pulses strong enough to burn the desired marks on the recording paper

a streamlined housing or fish carried by an outboard rigging. The entire equipment operates from a 110-volt d-c line and draws about 550 watts of power.

In operation, the driver is pulsed 240 times per minute by cam-actuated keying contacts operating from a shaft rotating in synchronism with the radial stylus arm of the recorder. The pulsing rate is based on a sound velocity of 4,829 feet per second for average sea water. A small portion of the emitted signal is fed into the echo amplifier to provide a zero index mark on the chart from which echo depth indications are measured. Simultaneous movement of the paper at right angles to the direction of stylus motion causes successive marks to form graph lines.

The recorder has three sets of keying contacts arranged throughout the entire 360-degree rotation of the stylus arm, any one of which can be selected for use by the range selector switch. This permits a control of the phasing of the stylus position with respect to the chart when a signal is emitted into the water. As the stylus actually traverses the chart only during a portion of each revolution, any one of the three 75-foot intervals up to 230 feet may thus be caused to appear wholly on the chart paper.

Compensating Controls

Draft (and squat) compensation correction is provided up to 15 feet, while tide compensation corrections up to 25 feet above mean low water can be made. Also, elevation corrections up to 75 feet are provided, for use in localities where the water level is referred to a lower datum plane. These compensations are accomplished by varying, throughout a limited range, the position of the recorder stylus with respect to the chart at the time sound is transmitted to the water. Physically these compensating adjustments are obtained by a slight relative motion of the keying contact carriage and the driving cam shaft, in a manner similar to that employed in the ignition timing mechanisms of an internal combustion engine. Once the graduated compensation scales have been set for given conditions, these adjustments need not be revised unless controlling factors are altered sufficiently to introduce unacceptable errors.

Corrections of sound velocity due to the variation of water temperature and salinity are made by a control that adjusts the centrifugally-governed speed and consequently the output frequency of the a-c generator providing power for the recorder motor. In this manner the speed of the latter may be varied throughout a range corresponding to sound velocities of 4,500 to 5,100 feet per second. The sound velocity corresponding to any motor speed is indicated by a large front-panel sound-velocity meter, which in reality is a recalibrated frequency meter. This correction may be made, while running, to any known value of velocity and maintained at that value by reference to the index pointer on the meter.

Compensation for salinity and temperature can be effected without direct knowledge of or measurement of these variables by lowering a metal bar in a horizontal position at a known depth beneath the transducers, the bar acting as a false bottom to produce an echo. Controls can then be set so that the recorded and actual values of depth agree.

Carbonized Dry Paper Used

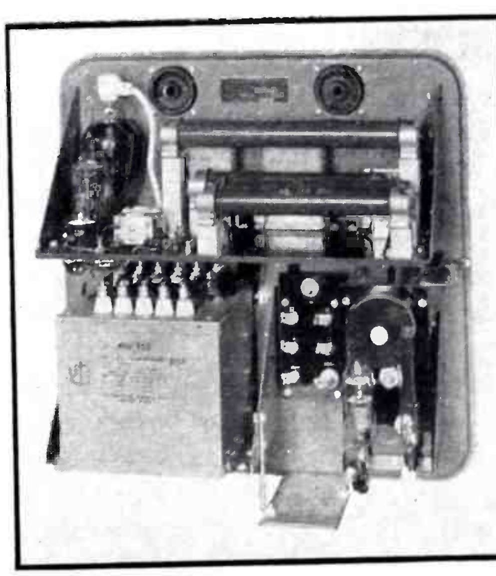
The depth record appears upon a black-bodied carbonized dry paper whose surface is coated with a special light-colored composition which disintegrates upon passage of electric current through it, exposing a black background at that point. In operation, a voltage of the order of several hundred volts is obtained from the echo amplifier and applied between the rotating stylus and a conductive platen behind the paper. The intensity of the record is nearly proportional to this applied voltage and, exclusive of any limiting or avc action in the amplifier, is therefore proportional to echo intensity. The record is visible through an observation window as it is being made, and pertinent data can be added directly by pencil or in ink.

A 75-foot roll of paper will last for from 2.9 to 11.7 hours of continuous scanning, and is adjustable in four steps according to the degree of detail required in the record. The recording width is 6.25 inches. A warning lamp and a buzzer are actuated when only two feet of chart paper remain for use. Color and dimensional changes in the paper are less than one percent even under conditions of excess heat or humidity.

Echo Amplifiers

The echo amplifier is a conventional three-stage, single-channel unit with self-contained power supply, as shown in Fig. 2. The first two stages are semifixed-tuned impedance-coupled at the signal frequency of 21.5 kc, and resistance-coupled to the third. The gain or sensitivity control varies the gain of the first stage by adjusting the control grid bias voltage thereof and is essentially linear and continuous to 100 percent gain. The input impedance is approximately 15 ohms; the output impedance to the stylus is of the order of 100,000 ohms when no signal is being recorded and drops to a few ohms under marking conditions. A chart density control is provided as shown to permit optimum density of marking under all conditions and to prevent excessive burning under strong-signal conditions.

The first stage (6AC7) is operated as a class A pentode amplifier with medium-negative bias voltage; the second stage (6SH7) is essentially a zero-bias amplifier, there being no fixed grid bias voltage. The operating bias voltage is obtained from the preceding stage output signal, applied across the grid resistor and affording some limiting action. The third stage (6Y6G) is a power-type pentode operating at a point as close to cut-



Driver unit with cover removed, showing special gaseous trigger tube in lower right corner off as the cathode resistor method of obtaining bias voltage will permit. On positive peaks of amplified signal voltage from the preceding 6SH7, large pulses of d-c plate current are caused to flow in the 6Y6G. Such rapid changes in magnetic flux lines in the output transformer produce the relatively high voltage (180 volts) necessary to produce disintegration of the paper coating beneath the stylus.

At the operating frequency of 21.5 kc an input voltage of 2 microvolts is necessary to mark the paper when the amplifier gain is set at 100 percent. Under those conditions the bandwidth is 2 kc at the usual 3 db down reference point. The amplifier is designed to match the Q of the transducer, which is approximately 10. Higher degrees of sensitivity and selectivity are normally not required in depth sounding.

The ocean floor is an extensive reflector and strong echo-signal levels are usually available. Under these conditions the input signal is relatively broad and optimum efficiency requirements dictate a compromise as to sensitivity and selectivity to a degree consistent with the maintenance of an acceptable signal-random noise ratio.

Contrary to general belief, feedback and regeneration conditions can occur at supersonic frequencies unless the usual rules of design are adhered to. Consequently, the foundation chassis of this unit is made as one complex aluminum casting, giving excellent shielding.

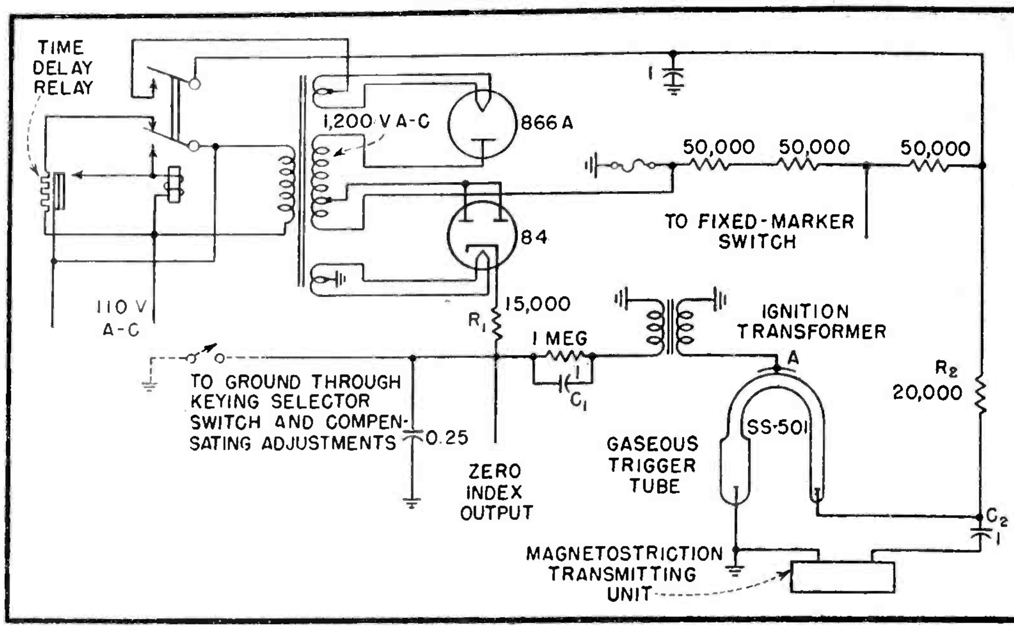


FIG. 3—Circuit diagram of driver unit, showing use of two diode rectifiers to charge capacitors C_1 and C_2. Discharge of C_1 by keying contacts ionizes trigger tube, allowing C_2 to discharge through magnetostriction unit and shock-excite it into vibration at its mechanical resonant frequency of 21.5 kc to produce the desired supersonic signal

The Driver

The schematic diagram of this unit, in Fig. 3, shows it to be somewhat unconventional. Capacitor C_1 is normally charged to a medium-high potential by a winding of the power transformer, the circuit being completed through the 84 rectifier, the primary of the ignition transformer, and current-limiting resistor R_1. Simultaneously, capacitor C_2 is normally charged to a very high potential (approximately 1,500 volts) by another power transformer winding through the 866A rectifier, the transmitting transducer, and current-limiting resistor R_2. Closing any set of keying contacts in the recorder unit permits C_1 to discharge through the primary of the ignition transformer without benefit of a current-limiting resistor. The high surge of current through this winding induces a very high potential between external plate A of the gaseous trigger tube and ground. As this tube has the potential of C_2 across its terminals, it is instantly ionized, allowing C_2 to discharge through the coils of the transducer without benefit of a series current-limiting resistor. This pulse of current, with an instantaneous maximum value approaching 200 amperes, causes the magnetostriction elements to vibrate at their mechanical resonant frequency of 21.5 kc and so produce an acoustical signal in the water.

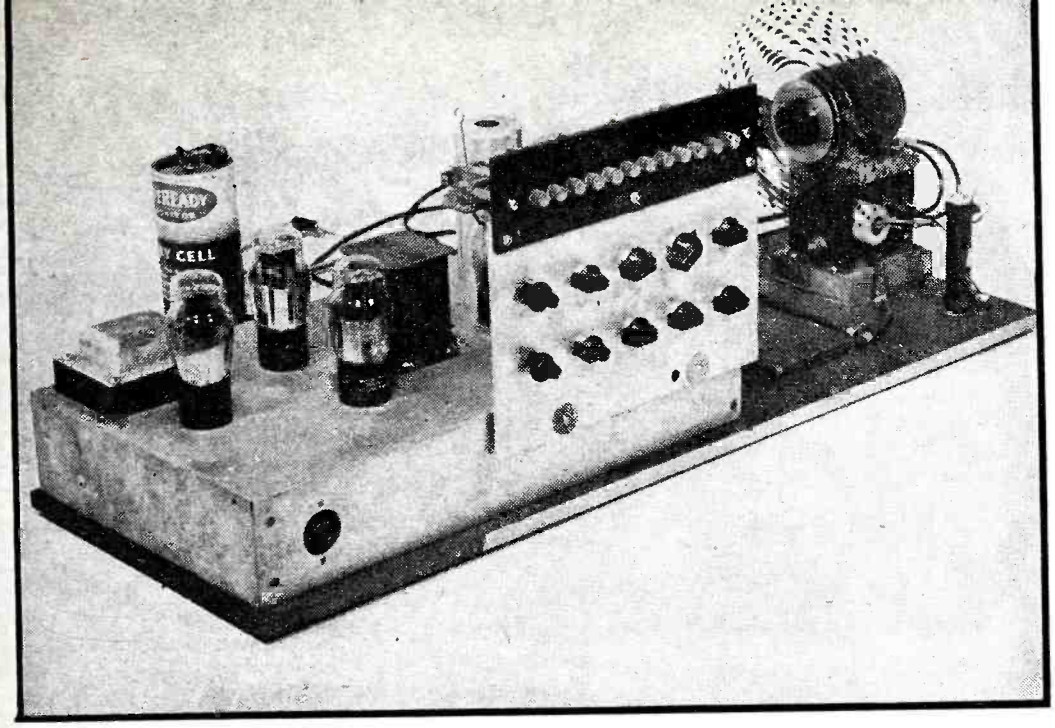
Opening of the keying contacts allows the two capacitors to recharge at low rates in preparation for the next cycle of the same operation. The special U-shaped argon-filled trigger tube serves essentially as a relay between the keying contacts and the transducer, providing the necessary control of the large current required to excite the transducer. A portion of the transmitted signal is taken from the circuit for zero index timing in the recorder unit. High voltage is available at another terminal for use with the Fix Marker switch for spotting points on the chart.

The transmitting and receiving transducers are identical, each consisting of a 5-inch diameter, 21.5-kc magnetostrictive element, immersed in oil and mounted in a cast circular case with a polished diaphragm. They are attached through the ship's hull, as parallel to the surface of the water as possible by means of fairing, with through-bolts or by brazing or welding. To minimize errors in indicated depth they should not be more than three feet apart, as depth is measured by the elapsed time for a round trip of the signal. The extra distance added by the angle between the units can appreciably lengthen the signal path in shoal waters. Rolling does not introduce serious errors since the total signal path is maintained relatively constant if the two units are mounted symmetrically on either side of the keel.

For semiportable work both elements are mounted in a free-flooding, streamlined mahogany fish that is towed along by an outboard rigging specifically designed for each application.

Motor-Generator

This unit operates from a 110-volt d-c ship's supply line and furnishes 110-120-volt a-c power at 55.9 to 63.4 cycles to the other units. Except for the special remotely-controlled speed governor, it is quite conventional. A standard centrifugal governor is so modified that its control contacts and setting may be altered by the operation of a small reversible motor under the control of a switch on the recorder unit, to provide correction for sound velocity. Limit switches in the governor prevent excessive travel of this adjusting motor in either direction.



Front view showing tone generator out of its cabinet. Pushbuttons turn individual lamps on and off, while rheostats below permit changing brilliancy of any lamp to vary the amplitude of the corresponding harmonic

By LYMAN E. GREENLEE
Anderson, Indiana

Photoelectric TONE GENERATOR

Precisely drawn patterns rotated through ten light beams directed onto a phototube generate a fundamental and nine harmonics. These may be combined in any desired manner for aural and oscilloscope observation in connection with design of electronic musical instruments

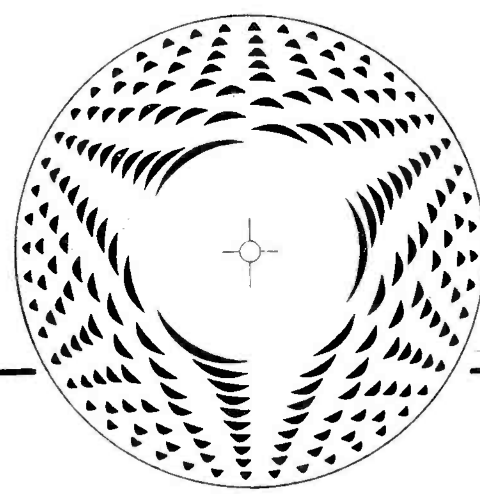


FIG. 1—Reproduction of tone wheel providing a fundamental and 2nd, 3rd, 4th, 5th, 6th, 8th, 10th, 12th and 16th harmonics. Only half of each sine-wave cycle is required because the reflected half of the pattern closely resembles the other half

IN connection with research into the subject of electronic musical instruments, it became necessary to generate a fundamental audio frequency, vary that frequency through the entire audible range, and introduce certain wanted harmonics in varying proportions while eliminating all unwanted harmonics.

In its present form, the instrument has answered a lot of questions concerning what and why is music. It has proved several points that are often debated pro and con, and it now appears that an entirely new musical instrument may be forthcoming as a result of these observations and experiments.

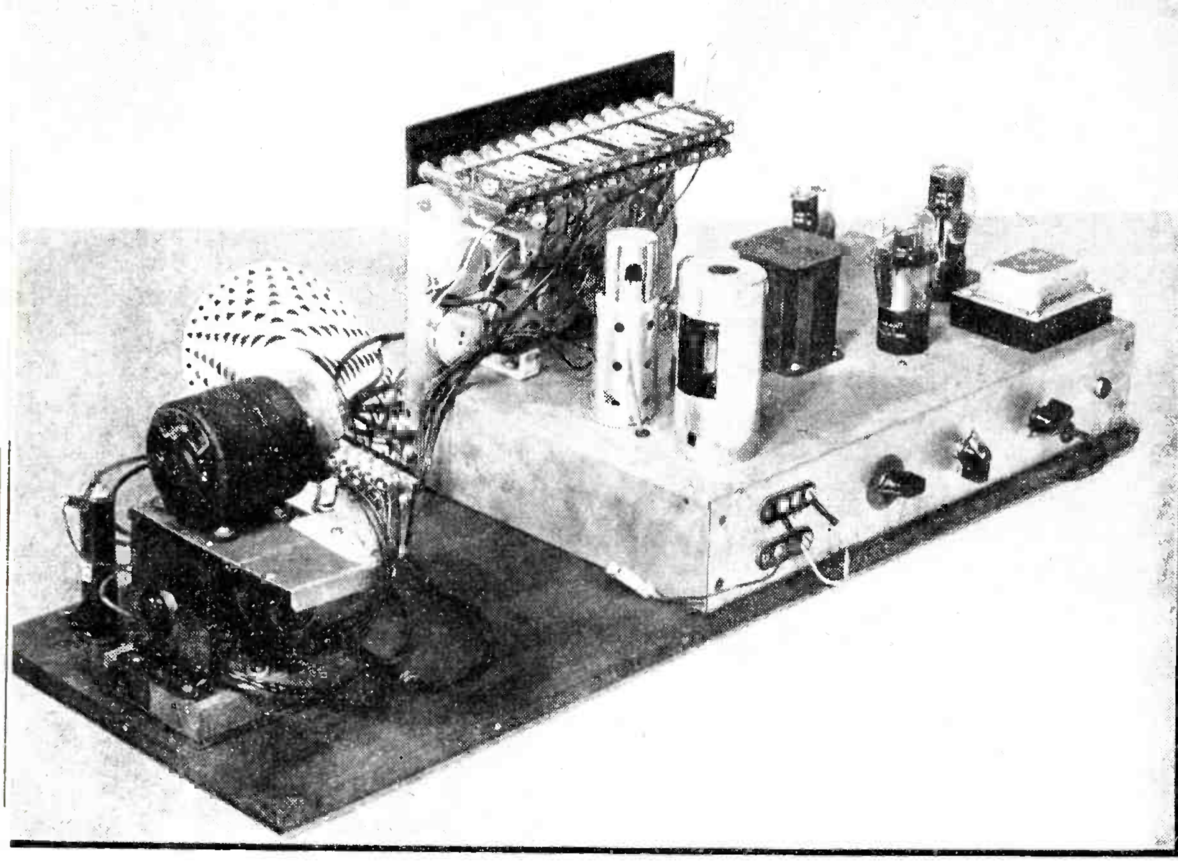
Construction Details

The basic principles of operation are simple and well known. A beam of light shining through the rotating tone wheel of Fig. 1 falls on a phototube and the resulting pulsations are amplified and fed to a loudspeaker and the deflecting plates of an oscilloscope. A disc carrying the tone pattern (in this case a sheet of positive photographic film) is rotated by a variable-speed motor in front of a series of Mazda 112(TL-3) 1.1-volt pink-bead flashlight bulbs, as indicated in Fig. 2. There are ten of these bulbs mounted in two rows in holes punched in a zinc plate.

Since there was not room to use any existing type of socket, the bulbs were fastened in place in the punched holes with Duco cement, and wiring connections were soldered directly to the bases. These bulbs are mounted sufficiently close to the tone wheel so that each bulb illuminates a space equal to the width of one set of tone patterns without overlapping.

It was found through experiment that it was possible to eliminate all other shutter arrangements by using these particular flashlight bulbs spaced close together and focused directly on the phototube through the tone wheel. Spacing between the bulbs and the tone wheel is about ⅛ inch but this spacing may vary as much as 1/16 inch either way without affecting the performance. A four-ohm rheostat is connected in series with each bulb and a dry cell used as a common source of filament power.

A pushbutton switch unit permits turning on bulbs individually or in any combination. This feature allows harmonics to be blended with the fundamental in an infinite variety of combinations. Speed control



Rear view showing tone wheel and its driving motor, with the ten tiny projection lamps mounted on the bracket just behind the tone wheel

is by means of a rheostat and also by means of a movable brush built into the variable-speed motor that was originally designed for a 16-mm motion picture projector.

The Amplifier

The amplifier is of conventional design, with care being taken to eliminate hum and secure a reasonably good undistorted frequency response with a usable output of two or three watts. The phototube was mounted on rubber to limit transfer of mechanical vibration.

A wood case was made to cover the entire analyzer when in use, and was painted black on the inside to minimize reflections. It was found, however, that the case is really needed only when working with artificial light, which will introduce a hum from the 60-cycle power lines.

The Tone Wheel

The heart of the instrument is, of course, the tone wheel. Numerous trials resulted in the following process for constructing a satisfactory tone wheel: The wheel was laid out on a sheet of wallboard four feet square, then reduced photographically to a disc 8 inches in diameter. The type of wallboard having a pasteboard surface was found most suitable for this purpose. Plywood was unsatisfactory, owing to variations in grain. The surface was prepared by giving it two coats of white casein (water) wall paint. Oil paint was found to be unsatisfactory. Guide lines were carefully drawn in lightly with pencil, and the pattern was made up by cementing on pieces of black paper cut to the exact shape wanted.

The form of these wave patterns was calculated to reproduce a sine wave, and the waveform is very nearly true when viewed on the screen of the oscilloscope. The innermost pattern is slightly distorted owing to the slow speed at which it runs and possibly to the fact that there are only three waveforms and spacing may be off slightly. The same thing is true of the outer pattern or 16th harmonic. To cut out all the black paper patterns of the waveforms, a master pattern for each size was made from metal and used as a template. Any number of tone wheels can be made, with even or odd harmonic rings as desired.

Other methods of making the tone wheel were tried, but the one described gave the only usable results. Use of the black paper cut-outs for each waveform was found to save a lot of time and trouble. Painting or inking such a large drawing is really a major undertaking and the final results were found to be unsatisfactory because it was impossible to obtain the uniform clean-cut effect necessary. Work on the large master pattern must be carefully done, the spacing of each waveform being particularly important. Irregular spacing will produce noise instead of a musical note.

An ordinary camera was found to be unsuitable for making the negative from which the positive film is made. A photo-engraving camera was the answer to the problems of distortion encountered with an ordinary 8 x 10-inch view camera. Both negative and positive should be made with process film, and extreme care must be used to prevent distortion in development and drying of the film. Distortion can be partially corrected by stretching the film in the opposite direction. This can be accomplished by supporting the film with clamps along two edges and hanging up to dry with enough weight to produce the desired effect.

Any defect, pinhole, scratch or

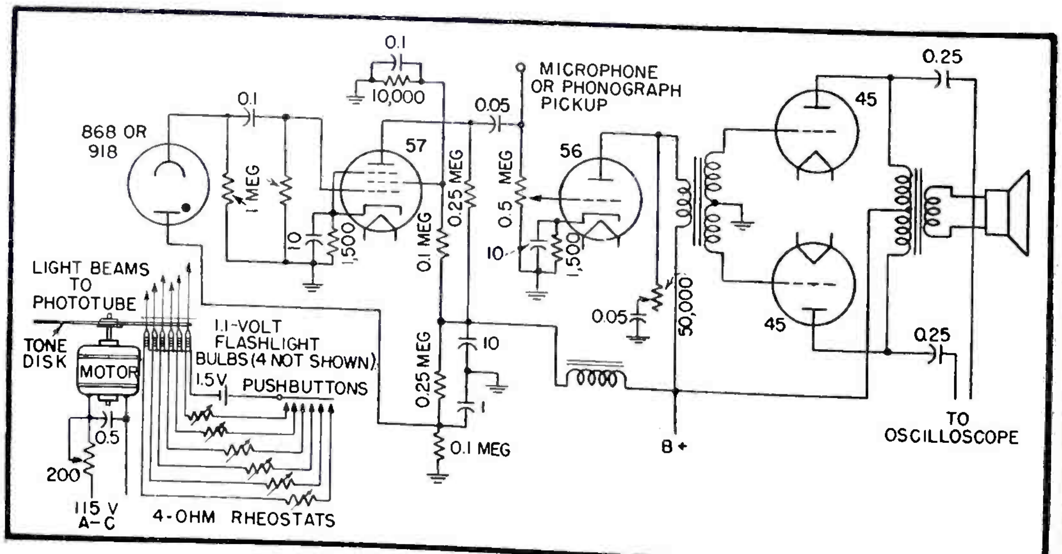


FIG. 2—Circuit diagram of photoelectric tone generator. A conventional power pack using a type 80 tube as full-wave rectifier with speaker-field choke and two 8-μf, 450-volt electrolytics is adequate. A separate filament winding serves the output stage, with a 750-ohm resistor in the center-tap lead for bias

other blemish will cause an error in the final reproduction. A final check with a pair of dividers will indicate distortion and any measurable variations will show up in the final results. Prints made on paper invariably show so much distortion due to stretching of the paper as to be worthless for other than illustrative purposes.

Either the positive or the negative may be used as a tone wheel. Results are superior when the positive is used. This is probably because more light reaches the phototube. Speed of rotation tends to keep the film flat enough so no transparent backing is needed. Glass dry-plates in the 8 x 10-inch size would be satisfactory except for the difficulty of cutting a hole in the center and trimming the outside to a circular shape.

The tone wheel is a one-sided affair as half of each sine-wave pattern is missing. It would be possible to construct a push-pull arrangement with the 920 twin phototube and a tone wheel having both sides of the wave pattern, and thus secure a more uniform response, but since only the upper half of the pattern is viewed on the oscilloscope screen the construction of such a tone wheel did not seem to be either necessary or desirable. Actually, the result deviates only slightly from a true sine wave because the reflected half of the pattern closely resembles the other half.

Uses for Tone Generator

A typical problem for analysis concerns the reproduction of a pleasing musical note such as a note of a pipe organ. A single note or group of notes on the organ may be recorded on a phonograph disc for future study or picked up with a microphone for immediate observation through the oscilloscope. The next step in the process is to adjust the output of the tone generator to simulate the same musical result obtained by playing the musical instrument under observation. By comparison, little differences which add or detract much from the final tone picture can be discovered.

Obviously, this type of analysis applies only to instruments producing sine waves. However, we may observe any complex waveform on the screen of the oscilloscope, and then transfer a similar pattern to a special tone wheel for reproduction and analysis. Changes in the tone can be made when the patterns are laid out on the drafting board, either to eliminate distortion or to create new effects. The number of effects possible is endless.

A study of the qualities of a pleasing musical note is especially interesting. Certain imperfections give music its pleasing qualities, and prevent its sounding purely mechanical. Many electronic musical instruments are not overly pleasing to the ear because the music they make is too nearly perfect, and the tone qualities created by the little differences and variations or distortions present in other instruments is lacking. The principles involved in the tone generator may be applied to a study of these qualities that mean the difference between pleasing music and mechanical music.

It is possible to simulate the tones of most string and wind instruments to a surprising degree, by observing their waveforms on the oscilloscope and using this observation for making up a waveform for a tone wheel. As a matter of fact, we need not confine ourselves to musical tones. Various noises, vowel sounds, spoken words, etc, may be used as a basis for our waveform pattern.

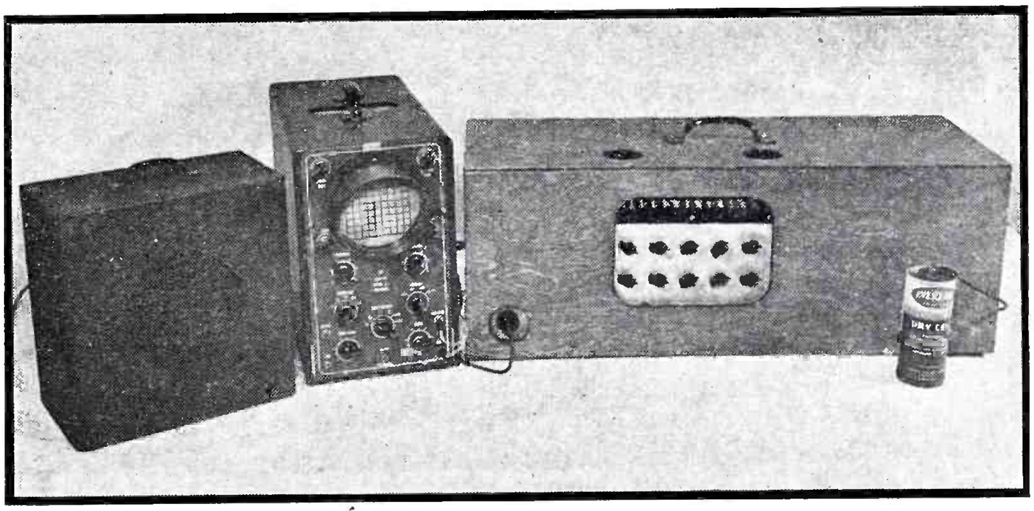
Actually, it is not even necessary to observe a tone pattern on the screen of the oscilloscope. The entire result may be calculated mathematically and the tone wheel constructed on that basis. It is fascinating to lay out a musical tone on the drawing board, and then turn those black and white patterns into a tone wheel that will reproduce a musical note with new timbre.

With the tone wheel revolving at any given speed, the frequency of any note being reproduced may be checked by comparison with a calibrated audio oscillator or tuning fork. Harmonics may be added or removed at will by turning on lights and adjusting the rheostats to give the required effect. To prevent line voltages from causing speed variations of the driving motor, some form of voltage-regulating transformer is desirable.

Conclusion

It is hoped that this discussion of the tone generator will bring forth comments and discussions from others interested in the fields of recorded music, electronic musical instruments, and music in general. It may be that somewhere in the not-too-distant future we may have music written and produced like cartoon movies—on a drafting board. It can be done.

The author is indebted to Rollin E. Campbell, Forse Corporation engineer and to Kenneth James for the contribution of many helpful suggestions in connection with the development and construction of the harmonic tone analyzer.



Photoelectric tone generator in its cabinet, with oscilloscope and loudspeaker at left

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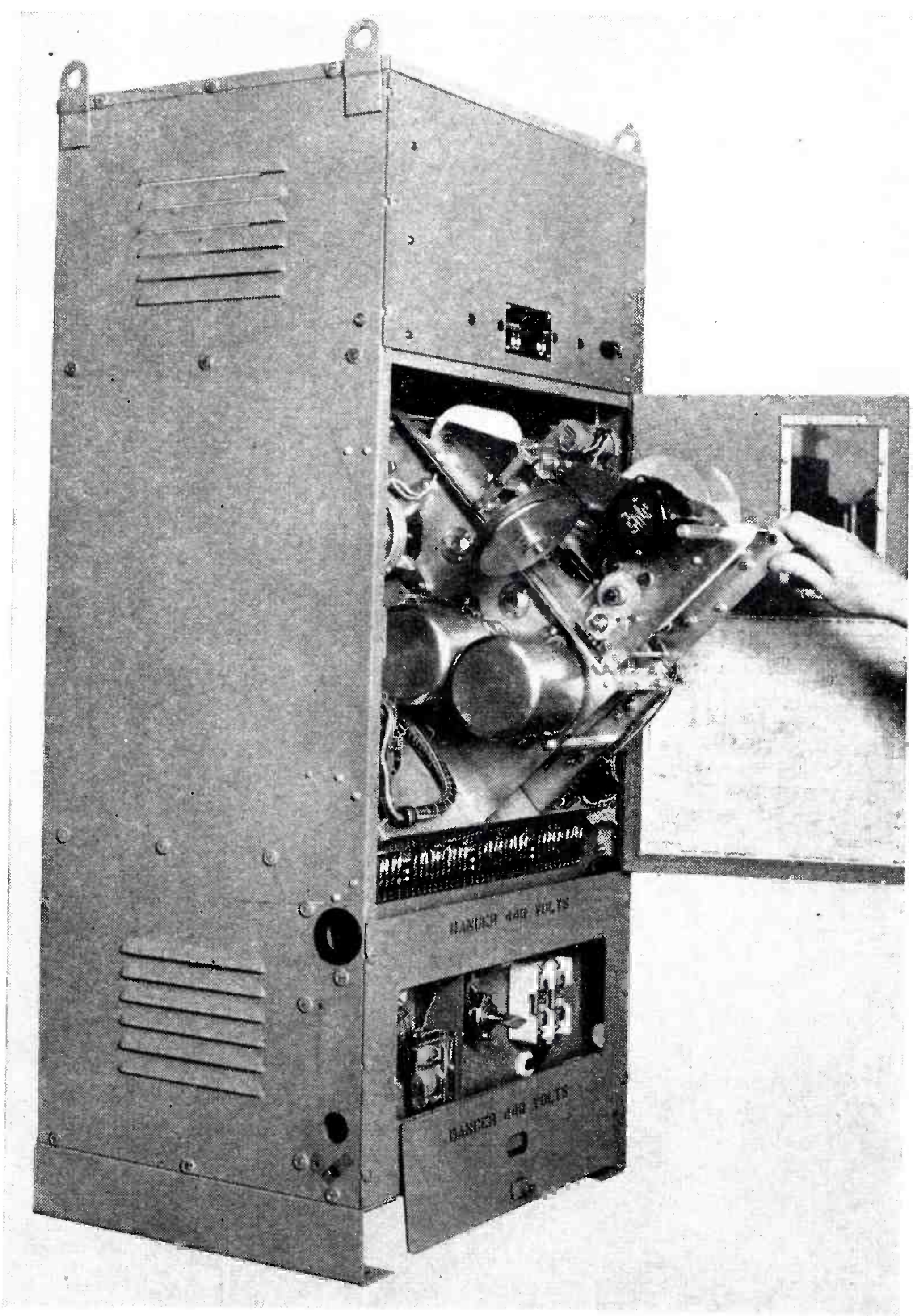
Campbell, R. E., and Greenlee, L. E., Photo-Electronic Organ, *Radio News*, June 1946, p 25, and July 1946, p 36.

Recorder-Controller FOR TEMPERATURE

An electronically actuated temperature and humidity printing recorder that also controls dehumidifying equipment on the basis of averaged measurements from eight stations. Accuracy is essentially unaffected by tube aging



Central station recorder with the tape printer tilted forward for access

THE cost of combating corrosion represents a national outlay of many millions of dollars a year. Corrosive agents existing in all atmospheres are water vapor, oxygen, and carbon dioxide.

The most variable constituent is moisture, being of such a low value in dry climates as not to support corrosion at all. While there are many other important types of destructive agents, such as chlorine and sulphur compounds, molds and bacteria, oxidation is probably the most important. However, the results of scientific investigation show conclusively that at ordinary temperatures practically all types of corrosive deterioration cease if the relative humidity is maintained below 30 percent.

At the suggestion of the Bureau of Ships, U. S. Navy, a thorough investigation was made of the factors involved in the storage of naval vessels. The result of this study was the development of an electronic recorder-controller actuated by eight remote measuring stations. The equipment has also been found useful in controlling factors affecting human comfort and in manufacturing processes.

Recorder Limits

The controller-recorder equipment consists of the central unit illustrated and eight measuring stations. Connections between the central unit and each station require five unshielded conductors. The eight measuring stations are scanned every fifteen minutes. The record is printed as shown on

AND HUMIDITY

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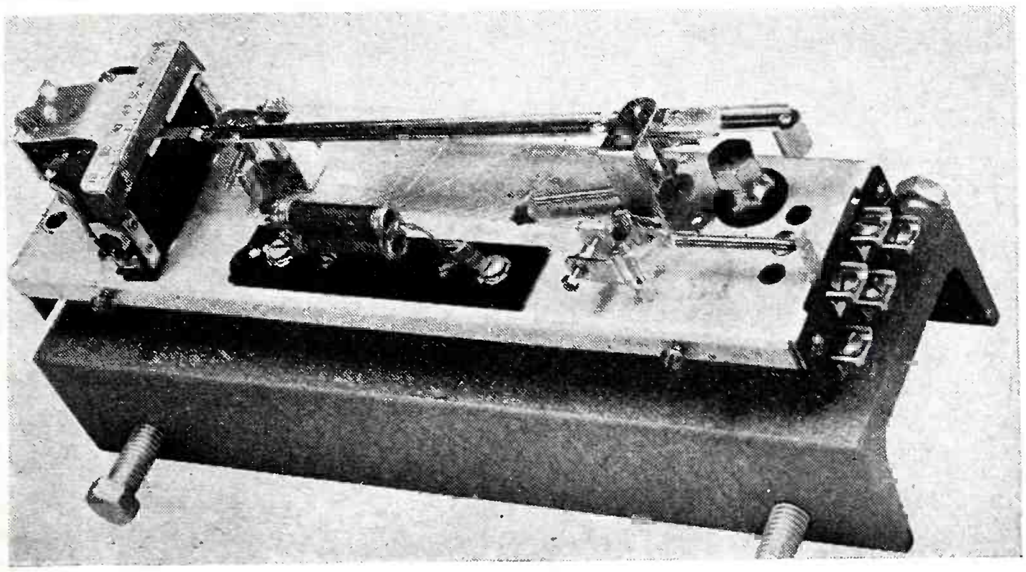


Remote measuring station, showing the two ceramic resistors and the freely moving humidity element. The scale at the left is attached to the clamp that lowers at the moment of measurement

standard adding machine paper and includes the measuring station identification number, temperature from 0 to 120 F, relative humidity 10 to 90 percent, and time of measurement, 00 to 24 hours. The controller mechanism operates on the average of the indications of the eight stations, and may be set to operate at any point between 25 and 55 percent relative humidity with an adjustable differential of from 2 to 10 percent.

Remote Stations

Each measuring station is provided with two human-hair humidity-responsive elements. Mechanism has been designed to present the least possible mechanical load to the hair elements. Since the hair changes length with changes in humidity, it is subject to the same laws as other null point indicators, and it follows that the point of equilibrium for highest accuracy is coincident with a point of zero mechanical force. Useful control, by means of the carefully-balanced low-friction mechanism, is made possible by an electrically operated mechanical clamping device. When measurement is made the clamping device illustrated causes the balanced pointer to make contact with a strip resistor. The value of resistance present in the circuit at the time of clamping controls the voltage in the humidity bridge circuit at the central recorder, permitting the continuously-rotating printing wheel potentiometer system to pass through a null point balance. At balance the percent humidity is printed on a paper strip. Immediately following the humidity measurement for the particular station, the electrical clamping device at that station is released.

Temperature indications are obtained by means of a special ceramic

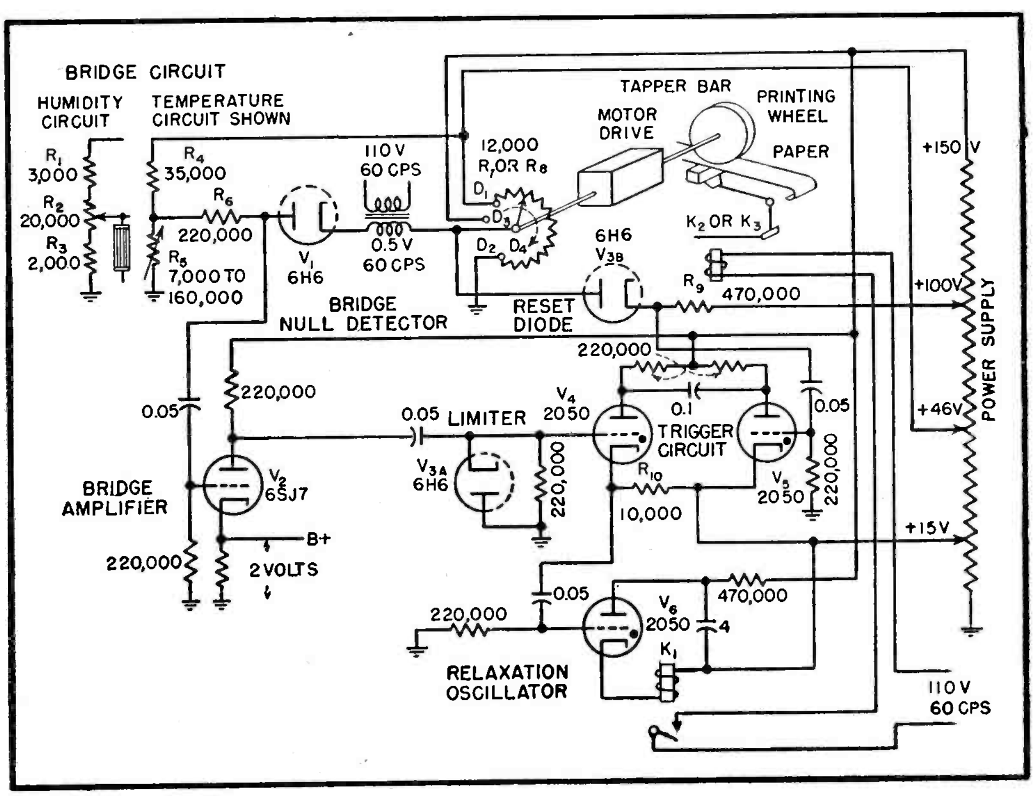


FIG. 1—Simplified wiring diagram of the recorder, showing the interconnection of the remote temperature and humidity station elements

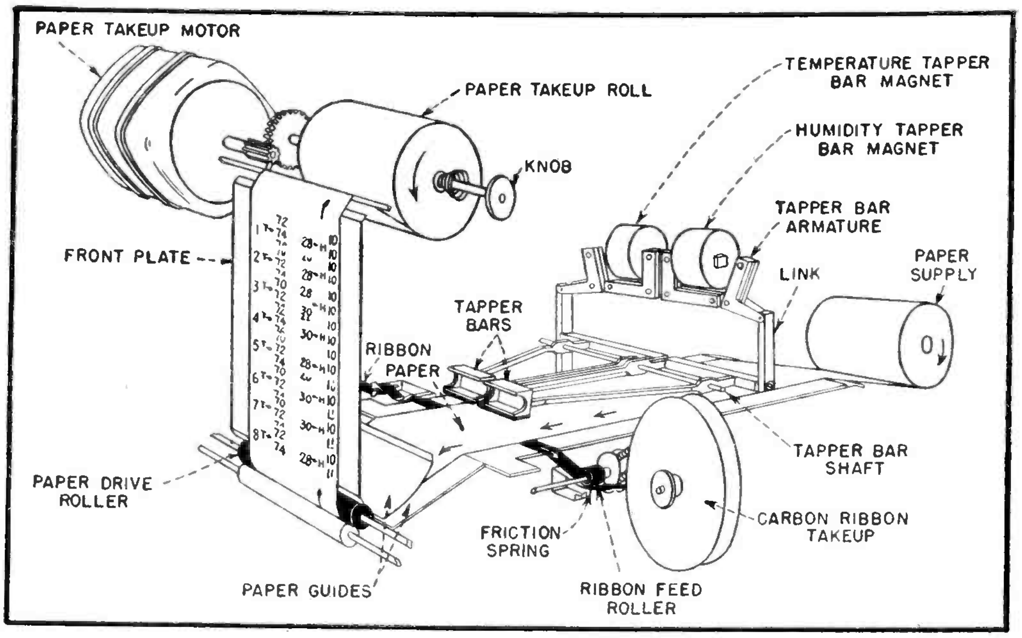


FIG. 2—Sketch of the printing mechanism in the electronic recorder, showing how the paper is fed between the printing wheels and the tapper bars

resistor that has a negative temperature-resistance characteristic. The resistance varies in the order of 4 percent per degree Centigrade. A suitable pair of such resistors located in the measuring station permits temperature measurements to be made by the same method as that used in making the humidity measurements. The electronic unit utilizes nine vacuum tubes including rectifiers and voltage regulators. The plate supply is regulated by a VR150 and a VR105, the latter being used to decouple the effects of the load produced by the clamping relay in the measuring station.

Circuit Diagram

The simplified circuit diagram in Fig. 1 shows a bridge circuit consisting of potentiometers R_7 (temperature) or R_8 (humidity) as two legs of the bridge, and resistors R_4 and R_5 (temperature) or R_1, R_2 and R_3 (humidity) as the other two legs of the bridge. Resistor R_5 is the temperature-responsive ceramic resistor, and R_2 is the humidity-controlled resistor (connected as a potentiometer), both of which furnish appropriate voltages in the bridge circuit as functions of temperature and humidity, whichever is under measurement.

The bridge null detector consists of a circuit containing R_6, V_1 (6H6 diode) with a 0.5-volt, 60-cycle injected voltage in the cathode circuit.

When potentiometer arm D_4 (R_7 or R_8) rotates in the direction shown by the arrow, from point D_1 (the high-voltage end), to point D_2 (the low-voltage end), balance is obtained at some point in the arc, depending on the voltage that the measuring station happens to be transmitting. As the arm passes through voltage balance, the negative half-cycles of the injected voltage pass through V_1, producing a voltage drop across R_6. The contact potential and initial velocity of emission of the V_1, about 0.75 volt, is corrected for in the initial calibration. Rough calibration is obtained by rotating the potentiometer R_7 or R_8 on its mounting, to coincide with the proper figures on the appropriate printing wheel. Variable resistors in series with each potentiometer serve for fine calibration purposes. The voltage across the bridge is approximately 48 volts d-c.

At balance the signal across R_6 is amplified by V_2. This amplified signal at the plate of the tube V_2 is 180 degrees out of phase with the input signal, and therefore, appears as positive half-cycle pulses at the grid of V_4. This tube and V_5 are type 2050 gas discharge tubes connected in a modified Eccles-Jordan trigger circuit with the grids biased to cutoff so that only one tube is conducting at any time. Prior to passage of the bridge through voltage balance, tube V_5 is in the conducting state so that the amplified signal from R_6 will cause tube V_4 to conduct. When V_4 becomes conducting the drop across R_9 triggers V_6, which is a relaxation oscillator biased to cutoff. As V_6 pulses it closes relay K_1, thereby energizing printing bar relay K_2 or K_3, and thus the figure on the printing wheel corresponding with the position of the potentiometer arm D_4 is printed on the record paper. The mechanical arrangement is shown in Fig. 2.

After passing the balance point, the grid of V_4 continues to receive signal voltage. Since this tube remains conducting after the very first signals reach its grid, further signals have no effect unless they drive the grid too far negative, which might extinguish the tube. To prevent extinction, the diode V_{3A} is connected across the grid to limit the negative signal peaks.

When potentiometer arm D_4 reaches position D_2, the end of the potentiometer winding, all switching is performed in the recorder, such as selecting the next measuring station and changing from humidity to temperature circuits. Since V_4 is still conducting, transients which might occur during switching are without effect, thus eliminating any possibility of spurious printing.

Resetting Circuit

After all switching has been completed, potentiometer arm D_4 contacts point D_3 which is at +150 volts and current flows through V_{3B}, whose cathode is biased to +100 volts. Thus 50 volts appears across V_{3B} and its associated resistor R_0. This voltage change across the resistor appears at the grid of V_5 and makes it conductive, and therefore tube V_4 becomes nonconducting, resetting the trigger circuit for the next passage through balance.

Potentiometer arm D_4, after passing D_3, reaches point D_1 to begin the next measuring cycle and so on. Thus, each station is selected in sequence, first printing humidity, then temperature.

Amplifier V_2 is used to produce a steep change in signal at balance so as to provide printing at the earliest possible time after the balance point is reached. A large rate of change of signal at balance is desirable since it limits the errors that would otherwise occur because of the lifetime changes in striking potential of the gas discharge tube V_4 and changes in gain of the amplifier. These design principles produce an electronic system the operation of which is substantially independent of tube characteristics.

Program Sequence

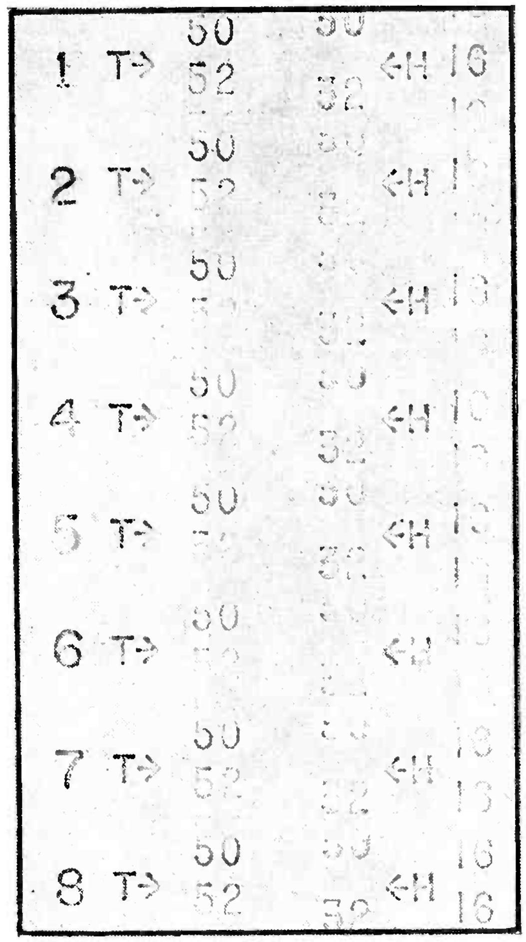
In the recorder a synchronous motor furnishes driving power and through suitable gear reduction simultaneously rotates: temperature and humidity printing wheels, temperature and humidity sweep potentiometers, a main cam and switch assembly, and a single-rise cam which in cooperation with a ratchet wheel advances the station selector switch. The gear ratio is such that the temperature and humidity printing wheels make two revolutions for each selector switch position. During the first revolution, the main cam and switch assembly connects into the circuit the humidity resistor of a measuring station, the humidity sweep potentiometer, the magnet coil for the humidity and time printing bar, and the electronic unit. During the second revolution, it connects into the circuit the temperature-responsive resistor of the measuring station, the temperature sweep potentiometer, the magnet coil for the temperature and station number printing bar, and the electronic unit. Each time that temperature and station number is printed a pawl is released from a four-tooth ratch which allows the paper drive roll to advance the recording paper.

Dehumidifying Control

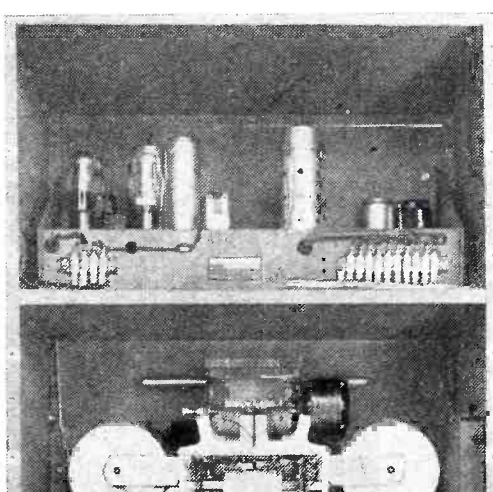
The main cam and switch assembly carries a second cam that closes a switch at the 10 percent relative humidity position which operates the closing coil of a mechanical latch relay to start the humidity radial summation cam drive motor. When the humidity bridge passes through balance the impulse from V_4 operates the humidity printing bar and unlatches the contacts of a mechanical latch relay, thus stopping the summation cam motor. Therefore the angle of rotation of the summation cam depends on the angle of rotation of the humidity potentiometer prior to reaching balance.

After the value of humidity of the eighth station has been determined, a three-position switch closes if the sum of the eight humidity readings exceeds a manually set value. This switch operates the closing coil of a mechanical latch relay which in turn starts the dehumidifying equipment. The radial summation cam is provided with an adjustable dwell between the upper and lower limits. After scanning eight stations, if the three-position switch is in the dwell position, neither of its contacts is closed. Therefore no change is made in the mechanical latch relay and the dehumidifier machine will continue to run, if it has previously been started. This mechanism provides a manually adjustable ON and OFF control point together with an independently adjustable differential. A cam and switch are provided to operate the magnet in the control assembly after the eighth station is scanned. This releases a brake on the controller, permitting the radial cam to return to the initial position by means of a return spring, indexing it for the next cycle of eight stations.

The recorder-controller sequence is continuous. However, recording periods are optional as determined by the position of a manually-operated switch or an adjustable cam. Since the record paper and carbon printing tape are advanced only by the printing operation, a minimum amount of record paper is used.



Sample of the record obtained. At station 6 (see digits in extreme left column) the temperature is 51.5 and humidity is 31 percent at about 16 hours (4 pm)



Rear of the central station. Below the electronic equipment chassis is the electromechanical printer and averaging device. The sequence switch is shown at the right. Power supply below is omitted

The recorder paper take-up roll is actuated by a stalled shaded-pole induction motor which is continuously energized. Previous recordings may be viewed by grasping the paper tape and pulling it from the reel, driving the stalled motor backwards against the generated torque and thus providing automatic take-up when the paper is released.

Industrial Possibilities

Direct-reading printing recorders of this type are a valuable development in telemetering applications. Transfer of information to automatic business machine cards is quickly accomplished without the errors often encountered in graphic interpretation by unskilled personnel. Significant economy is effected by the use of ordinary adding machine paper. The recorder also illustrates a sensible application of electronic methods to an essentially mechanical device.

LOW IMPEDANCE FOR BROADCAST RECEIVERS

Using a large low-impedance loop antenna improves pickup over that of a smaller high-impedance loop. Design of transformer for optimum coupling of low-impedance loop to grid of first stage is described. Curves give conditions for maximum gain

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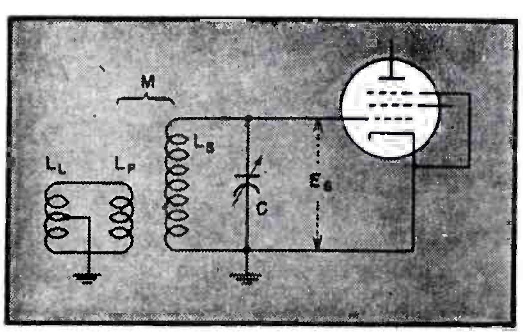
LOW-IMPEDANCE LOOP antennas have been used for some time in direction finders, and just prior to the war were beginning to find favor in home receivers. They are of particular value in large console models where advantage can be taken of available area to install efficient antennas.

In addition, low-impedance loop antennas are stable. That is, their inductance will ordinarily not change with age and humidity as much as will that of high-impedance loops. Placement of leads from loop to receiver is not as critical for low-impedance loops as for high-impedance loops. Also, the low-impedance loop is easier to manufacture than the high-impedance loop because its inductance need not be adjusted to within such narrow limits; normal manufacturing variations can be compensated with the antenna trimmer. Of course the coupling transformer must be closely adjusted, but this is standard procedure in coil manufacture.

FIG. 1—Low-impedance loop antenna is coupled by step-up transformer to input of first stage



Coupling Transformer

The heart of the low-impedance loop antenna is the step-up transformer that couples the loop to the grid of the r-f or mixer tube. The characteristic of this circuit is given by the expression, derived in Appendix I

$$Gain = kQ_S(L_{EQ}/L_L)^{1/2} \times [m(1 + m - mk^2)/(1 + m)]^{1/2} \times (1 + m + 2mk^2)^{-1} \quad (1)$$

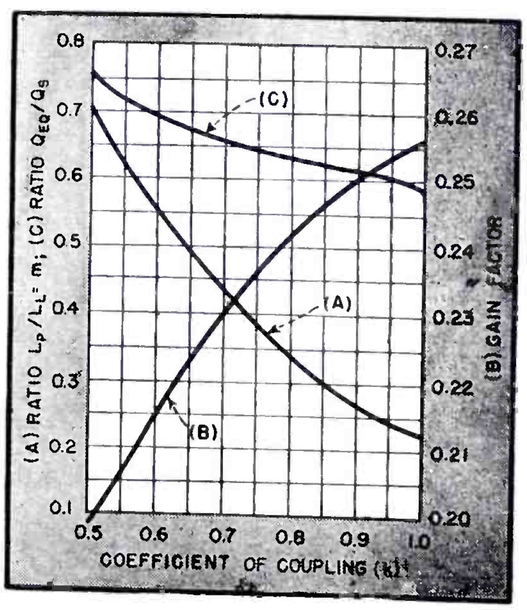


FIG. 2—Curve (A): Inductance ratio as a function of coupling coefficient for maximum gain. Curve (B): Gain factor as a function of coupling coefficient for optimum inductance ratio. Curve (C): Ratio of Q's for optimum inductance ratio varies with coupling coefficient

in which the significance of the terms is shown in Fig. 1 and Table I.

In the schematic diagram of Fig. 1, the inductance L_L is the loop, which can or cannot be center-tapped. Neither case will affect the results because capacitance coupling between primary and secondary windings is very small compared to inductive coupling.

Equation 1 will be analysed to determine the optimum design of the coupling transformer and to compare merits of the low-impedance loop to those of the high-impedance loop.

Optimum Gain

Of primary interest in determining maximum gain of the coupling transformer is the magnitude of the quantity m in Eq. 1. Because the values L_{EQ}, L_L and Q_S are roughly fixed by other design considerations, we specifically wish to substitute various values of k in Eq. 1 to find what value m must be for maximum gain. While the maximum point could be found by differentiating this equation, the resultant derivative is a sixth order equation and extremely difficult to handle. Accordingly the information was obtained graphically and is shown by curve (A) in Fig. 2.

Knowing the realizable coefficient of coupling which we can obtain in our transformer design, we can find

LOOP ANTENNA

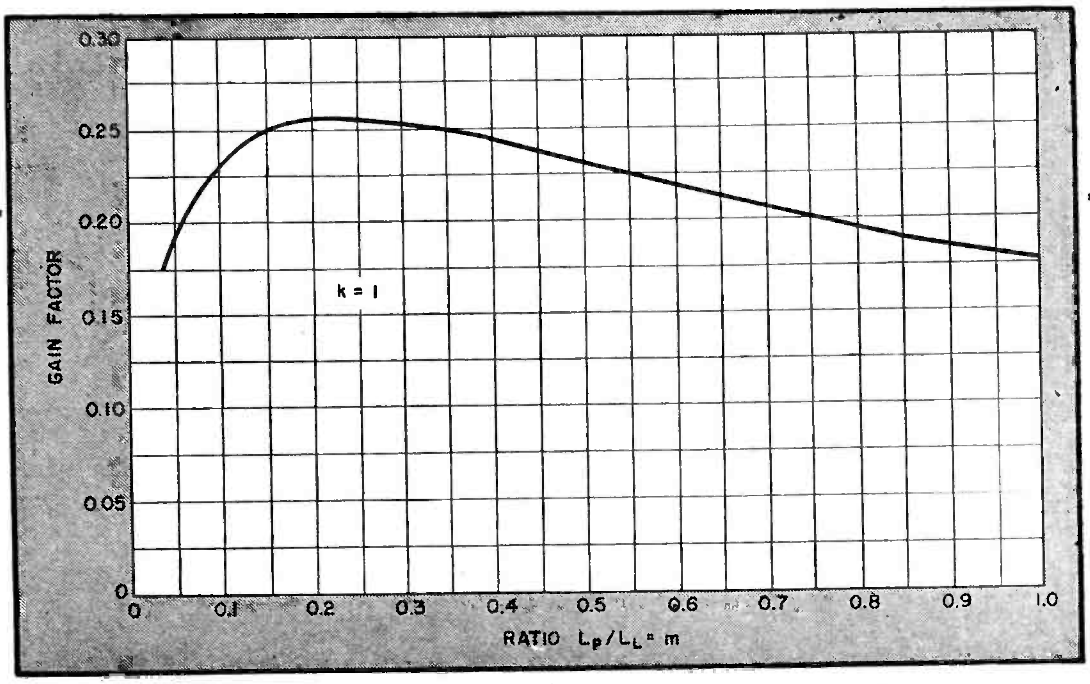


FIG. 3—Gain factor as a function of inductance ratio for constant coupling coefficient shows a broad maximum

m directly. From this value of m and the loop inductance L_L we can find the required primary inductance L_P. Inasmuch as the quantity L_{EQ} is fixed by tuning considerations, only the quantity

$$k[m(1 + m - mk^2)/(1 + m)]^{1/2} \times (1 + m + 2mk^2)^{-1}$$

of Eq. 1 can be varied freely. Call this quantity the *gain factor* and plot it against k as shown by curve (B) in Fig. 2.

Obviously k should be as large as possible for maximum gain, but the difference in performance between a coil having a k of 85 percent and one having a k of 95 percent hardly justifies extraordinary or costly precautions to obtain the higher coupling coefficient. Small powdered-iron core coils normally can be made with a k of 85 percent. Such a design is usually satisfactory from both cost and performance standpoints. The addition of powdered-iron cups surrounding the coils may bring k to over 90 percent, but the additional cost is considerable. If a coil is designed without powdered-iron, the coupling coefficient usually obtainable hardly justifies the degradation in performance.

The curve of gain factor as a function of m, allowing k to remain constant, shows the maximum to be rather broad as illustrated in Fig. 3. Thus with k fixed at unity, m can have any value from 0.17 to 0.3 without noticeable loss in gain. Curves for other values of k can be plotted.

Conductor Size

It is usually of interest to estimate the overall total Q of the coil in the circuit. The ratio of this value Q_{EQ} to Q_S is plotted as curve (C) in Fig. 2 against coupling coefficient. This ratio holds for values of m to give maximum gain as shown in curve (A) in Fig. 2, and the assumptions are the same as were made in the calculations for that curve, namely that Q_L equals Q_P and the total primary quality (i.e., of L_L and L_P combined) equals one-half Q_S.

The choice of conductor size for L_L, L_P, and L_S is the determining factor in fixing selectivity and must therefore be carefully considered by the designer. When an iron core is used, the secondary can be properly wound with 5/41, 7/41, or 10/44 sse litz wire, and excellent secondary quality thus obtained. Either the loop antenna is constructed of heavy copper wire (No. 10 B&S gage or larger) or it may be made of flat copper ribbon. Such copper ribbon should usually be at least 0.01-inch thick to give satisfactory loop quality. A fairly typical large console loop constructed of ⅜-inch wide flat copper ribbon 0.01-inch thick showed Q measurements of 100 at 600 kc and 175 at

Table I—Symbols Used in Text

A	: Area in square meters of loop antenna (Eq. 2)
α	: Algebraic factor, introduced in Appendix II, $\alpha = (1 + m)/m$, see m
E	: Potential; E_L induced into loop antenna, E_G developed across grid of first tube
k	: Coefficient of coupling between transformer windings, see M
L	: Inductance; L_L of loop antenna, L_P of transformer primary, L_S of transformer secondary, L_{EQ} as given in Eq. 5
λ	: Wavelength in meters (Eq. 2)
M	: Mutual inductance between transformer windings: $M = k(L_PL_S)^{1/2}$
m	: Ratio of transformer primary inductance to loop antenna inductance, $m = L_P/L_L$, introduced in Appendix I, value for maximum gain given in Fig. 2
N	: Number of turns in loop antenna (Eq. 2)
Q	: Quality; Q_L of loop antenna, Q_P of transformer primary, Q_S of transformer secondary, Q_{EQ} as given in Eq. 4
R	: Resistance; R_L of loop antenna, R_P of transformer primary, R_S of transformer secondary, R_{EQ} as given in Eq. 6
V	: Voltage picked up by loop in a field of one volt per meter (Eq. 2)

For quantities not listed here, see Fig. 1, 4, and 5.

1,400 kc, before the chassis was mounted in the cabinet.

The choice of conductor for the primary winding of the transformer is more difficult. A tabulation of quality obtained in a nine-turn solenoid such as would be used for the primary winding, wound on a 0.43-inch outside diameter Bakelite form through which was placed a ⅜-inch diameter iron core, is given in Table II.

From this table it would appear that No. 28 F. (single coat of vinyl-acetal insulation) solid wire is a good conductor to use. However, there are other factors which must be taken into account. The primary winding being closely associated with the secondary, in order to obtain close coupling, causes a pronounced loss in quality due to eddy currents induced in the primary conductor.

Due to the high cost of 20/44 or 30/44 litz wire, a suitable compromise may often be found in some such size as 10/41 litz. It should be noted that conductor cross-sectional area is of importance in determining inductor quality as well as the multistranding. Thus 10/41 litz will give better quality than 10/44, and 7/41 litz is usually preferable to 10/44 litz for the same reason, at least as far as the primary winding is concerned.

Comparison of Loops

We now have sufficient information to compare mathematically the performance of a low-impedance loop with that of a high-impedance loop. In designing a receiver it was decided to change from an average-sized high-impedance loop mounted underneath the shelf of a console to a low-impedance loop mounted on a frame within the console cabinet. The frame was swiveled to allow some adjustment of position, but was only slightly smaller in area than the inside of the console.

Voltage pickup of a high-impedance loop in a field of one volt per meter is given by[1]

$$V = 2\pi\, NA/\lambda \qquad (2)$$

The figure of merit of the loop is equal to Eq. 2 multiplied by the loop quality Q_L.

The high-impedance loop which had been used had an inductance of 200 μh (as determined by tracking considerations). Dimensions were

Table II—Quality of Coil Obtained With Different Wires

Wire Type	Frequency in kc 1,400	1,000	600
7/41 litz	65	45	35
10/41 litz	73	52	40
20/44 litz	80	53	42
30/44 litz	100	73	57
No. 34 F.	45	32	25
No. 28 F.	67	52	45

10.5 by 8.5 inches, and there were 19 turns. At 1,000 kc, 300 meters, the figure of merit, Eq. 2 times Q_L, equals 2.77.

In the case of the low-impedance loop, the voltage pickup is obtained by Eq. 2 as before, but the figure of merit is this expression multiplied by the gain of the coupling transformer given by Eq. 1. This gain is derived from known constants of the coupling transformer and the loop inductance. For this case where the equivalent inductance must remain 200 μh because we will use the same tuning gang, and the antenna inductance will equal 8.4 μh (the inductance of a two-turn loop whose dimensions are 21 by 30 inches), the gain is given by $Q_S(L_{EQ}/L_L)^{\frac{1}{2}}$ times the gain factor. For a k of 85 percent from curve (B) in Fig. 2 the gain factor is 0.246, and because Q_S of the coil under consideration is 140 at 1,000 kc, the gain is 168. The figure of merit, Eq. 2 times this gain, equals 2.87.

Thus we have improved the figure of merit of the pickup system although we had to increase the area from 0.058 square meters to 0.408 square meters to do so. It is to be noted that a number of refinements such as spacing between turns of the loop and space factor[2] have been neglected, but results check reasonably well with measurement.

DERIVATION of Eq. 1, upon which the transformer design depends, is based on simple circuit theory. However, because the steps of the derivation indicate the function of the circuit and the limitations of the final design equation, the derivation is given. As will be recognized, the results are applicable to transformer couplings used in other applications than that considered here.

Appendix I

The equivalent circuit of Fig. 1 is as shown in Fig. 4A.[3] We are to find the ratio of E_G to E_L, the gain of the network. Let us lump R_L plus R_P and R_S into one equivalent resistance R_{EQ} which we shall place in the secondary circuit as in Fig. 4B.

By Thévenin's theorem we can write

$$E_{AB} = \frac{\omega M E_L}{\omega(L_L + L_P - M + M)}$$
$$= \frac{ME_L}{L_L + L_P}$$

At resonance

$$I_C = \frac{ME_L/(L_L + L_P)}{R_{EQ}}$$
$$= \frac{ME_L}{(L_L + L_P)R_{EQ}}$$

And

$$E_G = \frac{1}{\omega C} \times \frac{ME_L}{(L_L + L_P)R_{EQ}}$$

Because at resonance the total inductive reactance as seen at the grid of the tube is equal to the capacitive reactance, we can replace $1/\omega C$ with ωL_{EQ}, which is the combined reactances of L_S, L_P, and L_L when connected as shown. Thus

$$E_G = \omega L_{EQ} \times \frac{ME_L}{(L_L + L_P)R_{EQ}}$$

But $\omega L_{EQ}/R_{EQ} = Q_{EQ}$, and because $M = k(L_PL_S)^{\frac{1}{2}}$ we can write

$$\frac{E_G}{E_L} = \frac{MQ_{EQ}}{L_L + L_P}$$

or

$$Gain = \frac{k(L_PL_S)^{1/2}Q_{EQ}}{L_L + L_P}$$

Although this expression gives the gain of the coupling transformer, it does not clearly indicate the manner in which the transformer constants affect its gain. To convert this equation into a more informative form we proceed as follows:

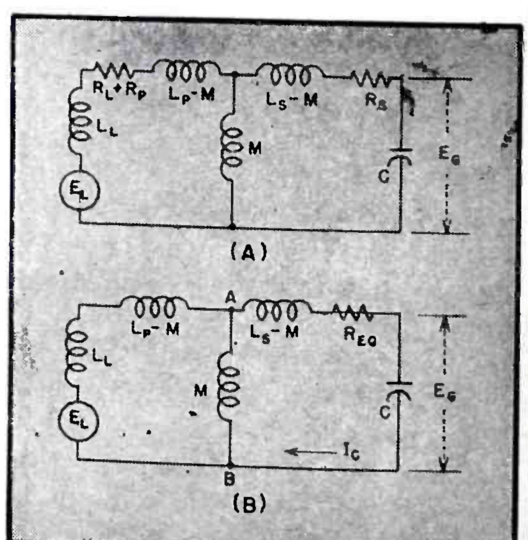


FIG. 4—(A) Equivalent circuit of Fig. 1 can be further simplified to that at (B)

The primary inductance will always be dependent on the inductance of the antenna loop, so let us choose some arbitrary constant which will be the ratio of these inductances. In fact, it is the value of this ratio which gives maximum gain which we wish to find. Therefore, define $L_P = mL_L$, then

$$Gain = kQ_{EQ}\sqrt{\frac{L_S}{L_L}} \times \frac{\sqrt{m}}{1+m} \qquad (3)$$

This equation is quite valid, but the equivalent quality is not directly known, although it can be measured by connecting a Q-meter across the secondary winding with the primary winding connected to the antenna loop. Also it will not be the value of the secondary inductance which will be known when a design is calculated, but the value of the equivalent inductance, because that is fixed by the value of the tuning capacitance and the required tuning range. Therefore this equation will be modified to an expression in terms of the equivalent inductance and the quality of the secondary coil alone, for these are the quantities which are usually known.

In Appendix II the equivalent inductance is found to be

$$L_{EQ} = L_S\frac{1+m-mk^2}{1+m}$$

In Appendix III the equivalent resistance is found to be

$$R_{EQ} = R_S\frac{1+m+2mk^2}{1+m}$$

From these results, and because $Q_{EQ} = \omega L_{EQ}/R_{EQ}$ and $Q_S = \omega L_S/R_S$ the equivalent quality is

$$Q_{EQ} = Q_S\frac{1+m-mk^2}{1+m+2mk^2} \qquad (4)$$

Substituting into Eq. 3 this expression for the equivalent quality and writing L_S in terms of L_{EQ}, we obtain the design equation

$$Gain = kQ_S(L_{EQ}/L_L)^{1/2} \times [m(1+m-mk^2)/(1+m)]^{1/2} \times (1+m+2mk^2)^{-1}$$

Appendix II

To determine the equivalent inductance of the coupling transformer and loop antenna we write from Fig. 4B the inductance to the left of points A-B as

$$\frac{(L_L+L_P-M)M}{L_L+L_P-M+M}$$

This quantity can be simplified using the previously defined relation that $L_P = mL_L$, and by defining $(1 + m)/m = \alpha$, and using the relation $M = k(L_PL_S)^{\frac{1}{2}}$ to the expression

$$\frac{\alpha k(L_PL_S)^{1/2} - k^2L_S}{\alpha}$$

The inductance to the right of points A-B in Fig. 4B is likewise simplified to the expression

$$L_S - k(L_PL_S)^{\frac{1}{2}}$$

Note that the mutual inductance between points A and B has been considered as a parallel branch of the inductance to the left of A-B. The total equivalent inductance across the tuning capacitance is the sum of these two inductances, thus

$$L_{EQ} = \frac{\alpha k(L_PL_S)^{1/2} - k^2L_S}{\alpha} + L_S - k(L_PL_S)^{1/2} = \frac{L_S(\alpha - k^2)}{\alpha}$$

Substituting the expression in m for which α stands gives

$$L_{EQ} = L_S\frac{1+m-mk^2}{1+m} \qquad (5)$$

Appendix III

Likewise, to determine the equivalent resistance of the coupling transformer and loop antenna we simplify the circuit of Fig. 4A to that of Fig. 5A. This simplification is done by considering such a circuit as that at Fig. 5B which we wish to replace with an equivalent series circuit. The impedance seen to the left of terminals C-D is

$$\frac{j\omega L_D(R_C + j\omega L_C)}{R_C + j\omega L_C + j\omega L_D}$$

The real terms are the only ones of interest at present because we wish to find an equivalent resistance for R_L. Call this equivalent resistance R_C', then

$$R_C' = (R_C\omega^2L_D^2)/(R_C^2 + \omega^2L_C^2 + 2\omega^2L_CL_D + \omega^2L_D^2)$$

In the denominator, the R_C^2 term is small compared with the other terms, therefore the expression can be simplified to

$$R_C' = R_C\left(\frac{L_D}{L_C+L_D}\right)^2$$

Because the circuits under discussion have reasonably high quality ($Q>40$), the inductances can be combined without regard to their resistances. Therefore we can replace the circuit shown in Fig. 5B with the equivalent series circuit shown in Fig. 5C. In this manner we obtain the circuit of Fig. 5A.

Assume that Q_L equals Q_P, then $R_L = R_P/m$ and total primary resistance is $R_P + R_P/m$ or $R_P(1 + m)/m$, which is the primary resistance of the circuit shown in Fig. 4A. The equivalent primary resistance for the circuit of Fig. 5A is

$$R_P\frac{1+m}{m}\left(\frac{M}{L_L+L_P}\right)^2$$

Let us call this expression R_P', and use the previously given relations $(1 + m)m = \alpha$, $mL_L = L_P$, and $M = k(L_PL_S)^{\frac{1}{2}}$ to simplify it to

$$R_P' = R_P(k^2L_S/\alpha L_P)$$

Let us also assume that the combined quality of the loop and primary inductances is one half the quality of the secondary inductance. On the average this condition usually exists. The combined quality of loop and primary inductance will be designated by Q_P'; then $2Q_P' = Q_S$, or $2\omega L_P/R_P = \omega L_S/R_S$, so that we have $R_P = 2L_PR_S/L_S$, which when substituted into the foregoing gives

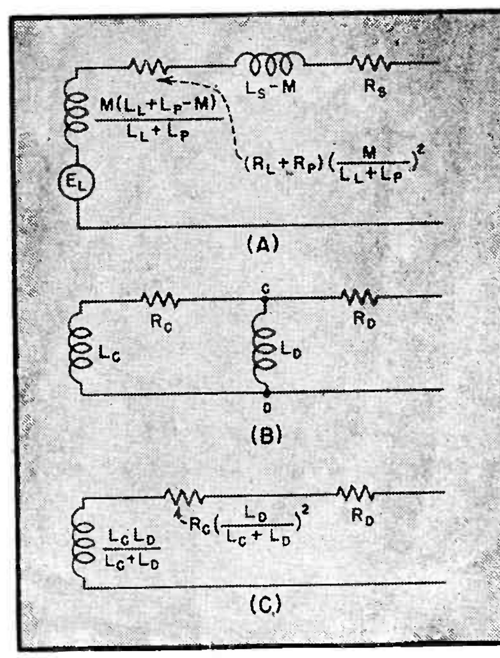


FIG. 5—Equivalent resistance is found from circuit at (A), which is derived from that at Fig. 4A by steps shown here at (B) and (C)

$$R_P' = \frac{2L_PR_S}{L_S} \times \frac{k^2L_S}{\alpha L_P}$$

If we add R_S to this value we obtain the total equivalent resistance which we were seeking, thus

$$R_{EQ} = R_P' + R_S = \frac{R_S(2k^2+\alpha)}{\alpha}$$

Substituting the expression in m for which α stands gives

$$R_{EQ} = R_S\frac{1+m+2mk^2}{1+m} \qquad (6)$$

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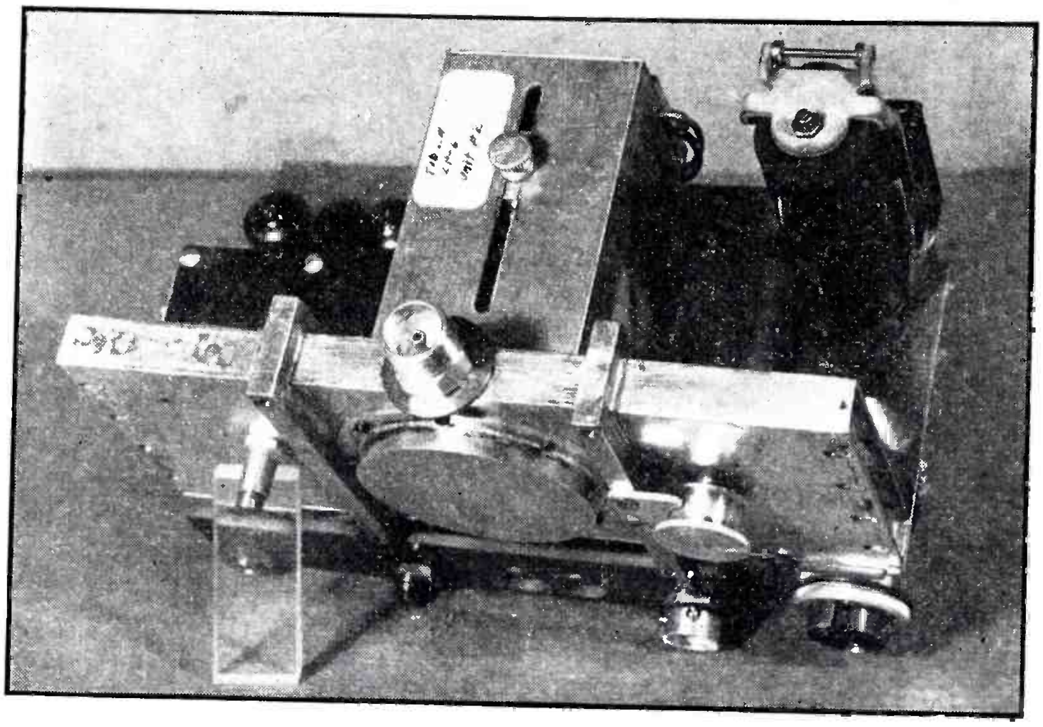
2,700-Mc Transceiver

Narrow-beam uhf communication system developed during war for front-line use weighs only 56 lb per station. Solenoid-actuated dielectric plunger in cavity of type GL-446 lighthouse tube makes transmitting and receiving frequencies of oscillator the same



Transceiver chassis with cover removed. Fitting for coaxial line going to antenna can be seen at top center of rectangular cavity inside which is mounted the GL-446 lighthouse tube serving as r-f oscillator

A HIGHLY PORTABLE, highly directional microwave telephone that two men could get to the front lines of a battlefield for observation, having a minimum battery life of four hours, a maximum support height of 5 feet, and capable of furnishing communication over a 10-mile distance free from enemy interception—such were some of the requirements posed by the Signal Corps early in 1942 to a group of RCA Communications engineers working under OSRD Contract OEMsr-442.

The equipment developed under this contract actually furnished reliable communication between two units 30 miles apart and up to 38 miles when favorable hills were employed as sites. One complete station including antenna, reflector and tripod could be carried as two packs weighing 25 and 31 pounds. The operating frequency was of the order of 2,700 mc. Interception of signals was not likely due to the narrow beam of the antenna and because of rapid attenuation below line of sight. At 80 degrees F the batteries lasted 6 to 8 hours. The transceiver had only one tuning knob and could be adjusted by skilled personnel to any one of 6 channels 4 mc apart. Units could operate on a common frequency if separated about 50 feet and if the path in front of each unit was clear of reflecting objects.

Antenna and R-F Unit

The antenna used a paraboloid about 30 inches in diameter, spun from sheet aluminum. The surface was cut vertically to form three sections held together by guide pins and clamp strips, with the r-f unit mounted on the back of the center section. The radiator element consisted of a half-wave dipole and a parasitic reflector housed in a plastic weatherproof box. The dipole was fed by a concentric line that coupled into the cavity of the oscillator, balanced feed being obtained by means of quarter-wave sleeves at the end of the line next to the dipole. The antenna gain over a half-wave dipole was 23 db.

A cavity oscillator using a GL-446 lighthouse tube connected as in Fig. 1 and mounted as in Fig. 2 furnished power to the antenna for transmitting, and was cathode-modu-

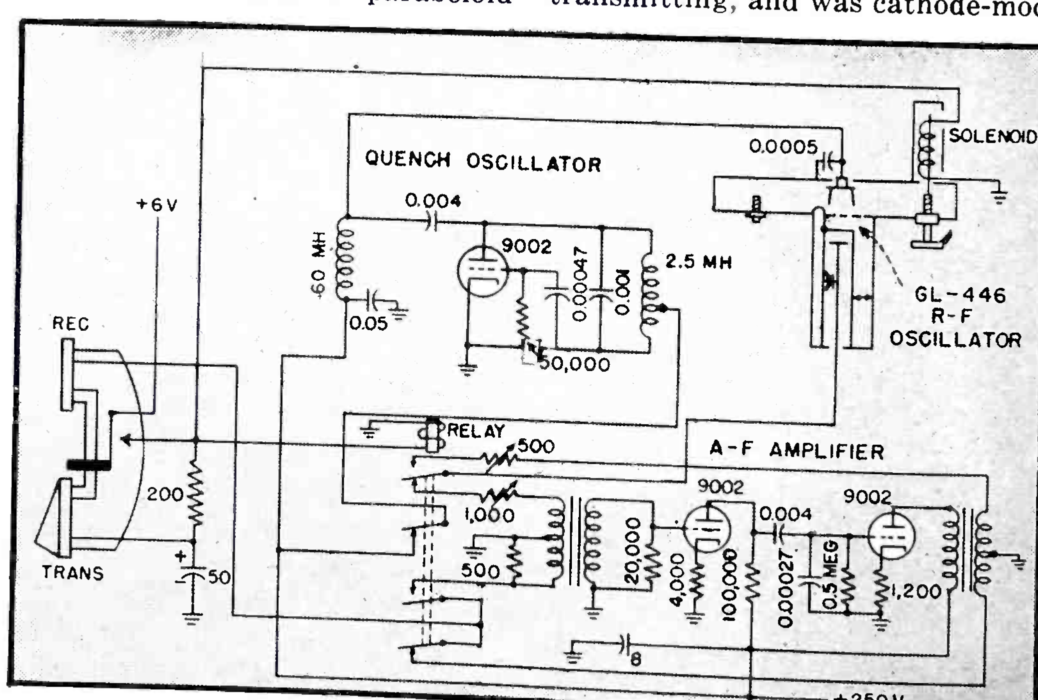
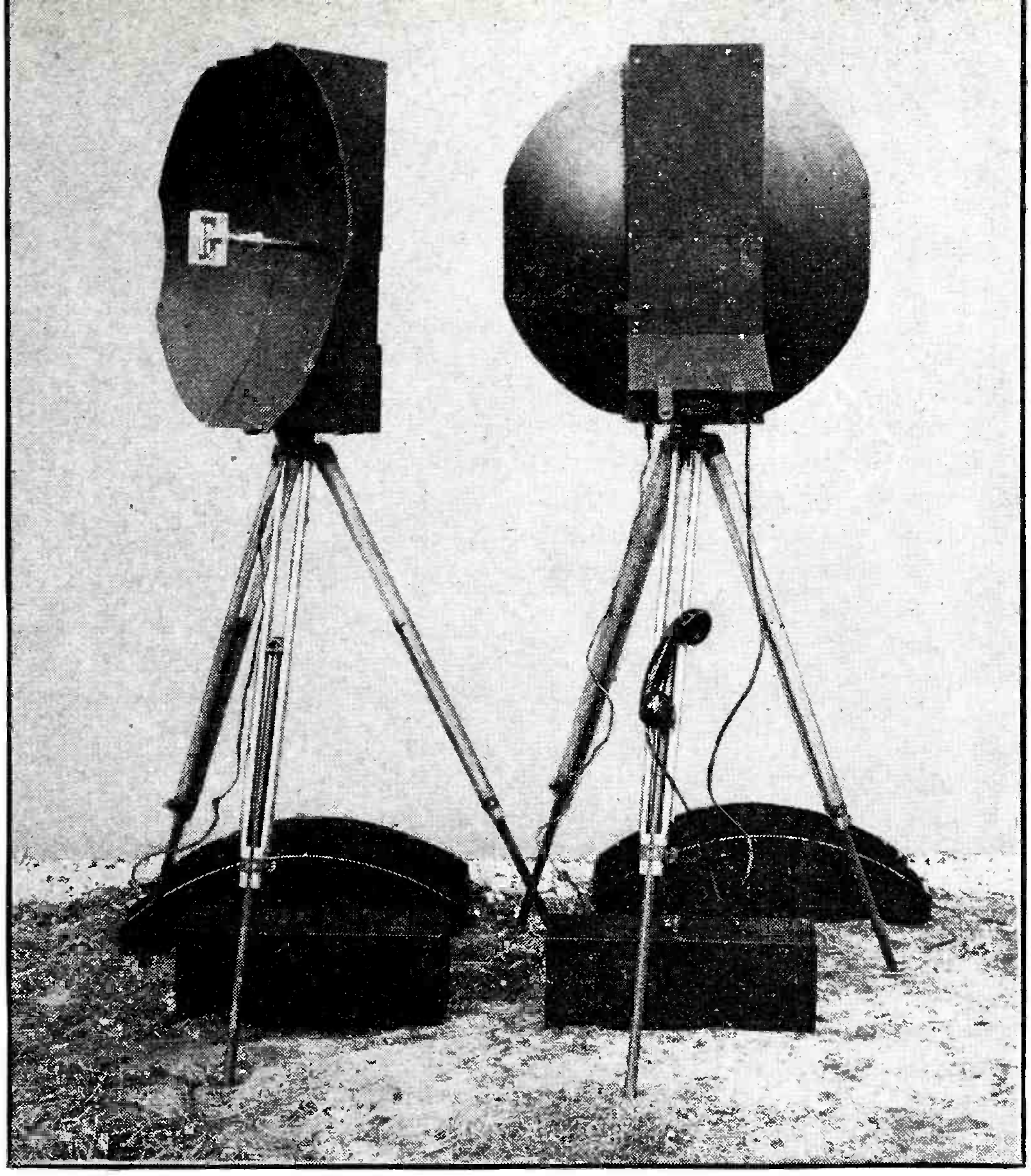


FIG. 1—Circuit of 2,700-mc portable transceiver, with relay and handset switch in receiving position. Lighthouse tube is mounted in cavity, and coaxial line going to dipole antenna is coupled into cavity at right angles to plane of diagram



Two complete transceiver units set up for operation on standard Signal Corps tripods

lated by a two-stage audio amplifier utilizing 9002 triodes. Power output was 400 milliwatts with 5 watts input. For receiving, the lighthouse tube was used as a superregenerative detector, with a separate quench oscillator and two-stage audio amplifier.

Measurements indicated that the transmit and receive frequencies of the oscillator would differ by 0.5 to 1.5 mc. To overcome this common transceiver fault, a solenoid-actuated compensating device was added to the cavity as illustrated in Fig. 2. When the push-to-talk button is pushed for transmitting, the armature of the solenoid pulls a dielectric plunger into the cavity, bringing the cavity to the desired transmitting frequency as previously determined by adjustment of the frequency-setting screw. When the button is released, the solenoid releases, allowing the dielectric plunger to move out of the cavity by spring action and shifting the oscillator frequency on receive just enough to equal the transmitting frequency. The receiver may be tuned over a band of ±2 mc by a knob that changes the at-rest position of this plunger.

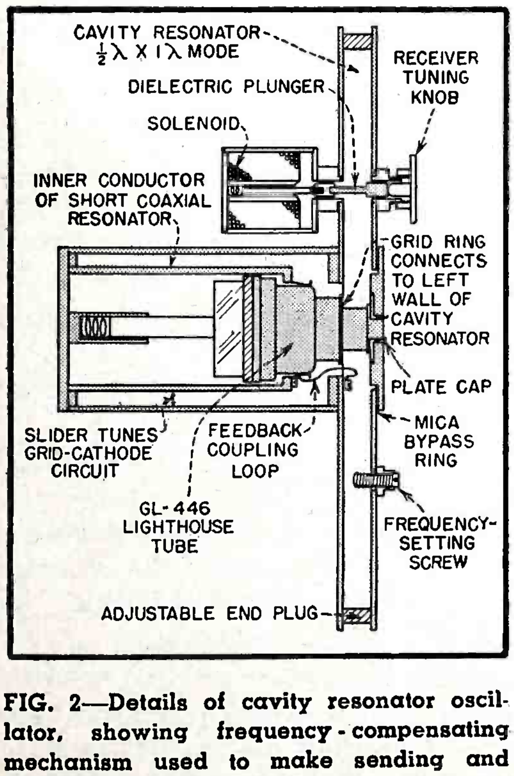


FIG. 2—Details of cavity resonator oscillator, showing frequency-compensating mechanism used to make sending and receiving frequencies the same

Superregenerative Receiver

On receiving, the GL-446 is followed by the two-stage audio amplifier and is modulated by another 9002 tube acting as a quench tube. Tests for optimum quench amplitude and frequency dictated a quench output of 100 volts at 100 kc.

The ratio of actual receiver noise to calculated ideal receiver noise (the excess noise ratio) for this transceiver in the receiving condition varied from 41 db at an input of 500 microvolts to 32 db at a 10-microvolt input. For comparison, superheterodyne receivers using tube converters have a ratio of about 20 db, while converters using silicon crystals have ratios down to 12 db.

The audio-frequency equivalent bandwidth of the receiver was 5 kc, the response being essentially flat over the voice frequency band of 200 to 3,000 cycles.

A light-weight plastic-cased spill-proof lead-acid battery produced by Willard Battery Co. for the Signal Corps was selected as the primary source of power for use with a vibrator power pack to supply 1.65 amperes at 6 volts and 25 ma at 250 volts. When receiving, the total load on the batteries was 3 amperes; when transmitting, this increased to 3.5 amperes.

Field Results

With antenna gains of 23 db at receiver and transmitter, the effective power gain was 40,000 or the equivalent of 14 kw working into a dipole at each end. The frequency drift with battery life was minus 1 mc in 8 hours of operation.

The longest path over which communication was accomplished in model tests was along Long Island Sound over salt water. One terminal was on a 220-foot hill and the other on a 120-foot hill. The total distance was 38 miles. The visibility was calculated to be 36 miles based on 4/3 earth's radius. This path showed some fading since it exceeded the optical range. Strong signals were received over distances of 5 to 12 miles. Means for multichannel operation were not worked out since the high directivity of the system indicated that units would probably be operated in pairs.—K.H.

CAPACITIVE

Variations in oscillator frequency caused by minute movements of the capacitive circuit element are converted to output voltage changes in this practical electronic gage. The same principle has been successfully used for dilatometer, manometer, roughness-gage and hardness testing apparatus

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TWO SENSITIVE electronic micrometers have recently been described in the literature, both of which operate by measuring the variation in capacitance between a fixed and a movable part.[1, 2] The principles on which these two instruments are based have long been known, and sporadic attempts have been made to apply them, but it has remained for recent advances in electronic technique to make them practically useful.

Simply stated, these two devices use variations in capacitance to change the resonant frequency of high-frequency oscillators, and discriminators to convert the frequency changes into voltages or current changes which may be indicated or recorded. The device developed by one of the authors[2] differs from that described by Bradshaw[1] in an important respect; the device to be described uses a limiting amplifier to free the instrument from errors which might otherwise be caused by amplitude variations in the input to the discriminator.

Fundamental Circuit Elements

A block diagram of a typical capacitive micrometer is shown in Fig. 1. The sensitive capacitor *C*, shown conventionally in the diagram, may actually take a number of forms depending on the use to which the instrument is put. To obtain highest sensitivity, however, a parallel-plate capacitor is used, one of the plates being connected to or made part of the object being measured, and the other fastened rigidly to the fixed reference point.

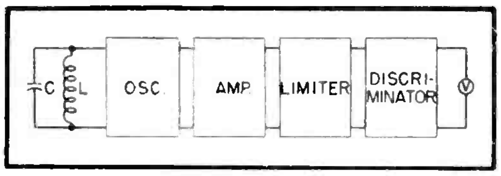


FIG. 1—Functional block diagram of the capacitive micrometer. The probe is represented by the capacitor at the left

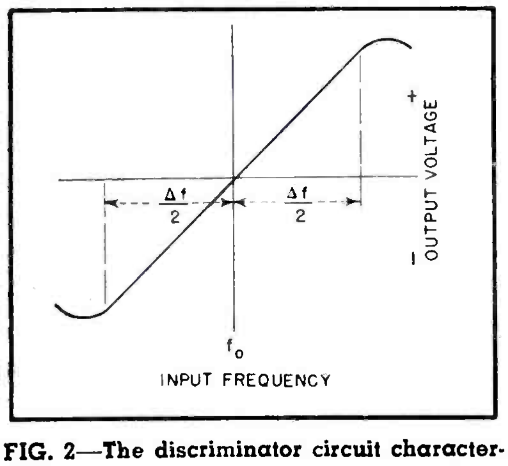


FIG. 2—The discriminator circuit characteristic shows the change in output voltage caused by change of input frequency

The capacitor *C* is connected across inductor *L* to form a resonant circuit that determines the frequency of the oscillator. The oscillator can be of any stable type suitable for the frequency chosen. The output of the oscillator is amplified to a level sufficient to saturate the limiter, and the output of the limiter, which has constant amplitude, is applied to the discriminator. A convenient type of discriminator has the relation between input frequency and output voltage shown in Fig. 2.

Testing Lathe Spindles

The micrometer under discussion was first used to test lathe spindles, in the apparatus shown in Fig. 3. A precision lathe spindle is held in a cradle, and on its end is fastened a carefully ring-lapped steel cylinder. The position of this cylinder relative to the frame of the machine is measured along each of two axes by the two capacitor assemblies, one of which is shown in Fig. 4. The capacitor proper consists of the two insulated steel plates visible in the end of the brass box in the illustration. These plates are lapped to the same radius as the cylindrical spindle extension. They form essentially a split-stator capacitor whose rotor is the spindle extension. When the spindle extension is close to the plates, the total capacitance varies with the spacing as if the combination constituted a single parallel-plate capacitor of half the area or twice the spacing. The area of each of the curved capacitor plates is nearly 0.75 square inch, and the spacing is usually kept at 0.03 inch, so that the capacitance is about 3 micromicrofarads.

The circuit of one of the two micrometers used when testing spindles is shown in Fig. 5. The capacitor C_1 and the inductor L_1 resonate near 3,200 kc, and form the tuned circuit of a push-pull Hartley oscillator composed of tubes V_1 and V_2. The oscillator is directly coupled to the buffer V_3, V_4 which isolates the oscillator circuit from the output coaxial cable. All the tubes in the capacitor assembly are miniature types to conserve space.

The output of the buffer is applied to the frequency converter V_5, as is the beat-frequency voltage from oscillator V_6. The oscillator output frequency is thus heterodyned to within the pass-band of the i-f amplifier V_7 and limiter V_8, which are tuned to 465 kc. The output of the limiter is applied to the discriminator V_9 at a level of about 300 volts. The d-c output of the discriminator is ample to deflect the 5-inch cathode-

MICROMETER

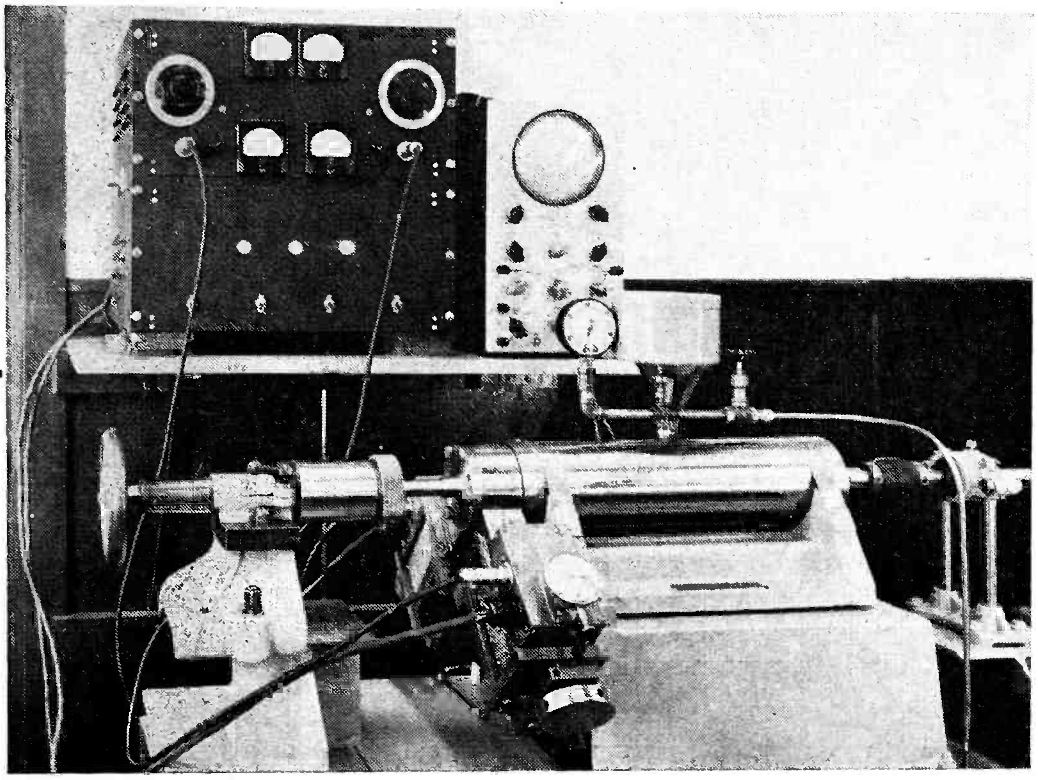


FIG. 3—Complete spindle-testing apparatus. The capacitive probes are at right angles to each other and equally distant from the precision-turned shaft extension. Amplifier and cathode-ray oscilloscope are on the shelf above

ray oscilloscope beam directly without further amplification.

The second micrometer used in spindle tests, reading position along a line perpendicular to the first, is an exact duplicate in all respects. Each micrometer channel output is connected normally to one pair of plates of an oscilloscope.

The pattern produced on the oscilloscope screen by rotation of the spindle represents the position of the spindle axis during a revolution relative to the axis of the spindle extension. Such a pattern for a precision lathe spindle containing both plain and ball bearings is shown in Fig. 6, the micrometer magnification being 10,000.

The micrometer permits the identification of the source of small spindle errors which contribute to roughness of machined parts, and has given information useful in the design of new and improved spindles.

Principle Applied to Dilatometer

A later application of an electronic micrometer to a very different problem is illustrated in Fig. 7. This shows dilatometer design to measure the thermal expansion of metal-tube specimens during rapid heating and cooling.

The specimen is 2 inches long by about ½ inch in diameter, and is supported by a quartz loop. A quartz rod rests on top of the specimen, and supports, at its upper end, a grounded metal cylinder of 1-inch outside diameter. This cylinder is coaxial with, and inside, an insulated cylinder of 1.004-inch inside diameter. The two cylinders are of equal length, but the inner one is not wholly inserted in the outer one, so together they compose a capacitor that varies as the inner cylinder moves up or down. The quartz loop supporting the specimen is fastened rigidly to the outer cylinder, so that expansion of the specimen causes the inner cylinder to move into the outer one and increase its capacitance to ground.

The device described is the main tuning capacitor of a circuit resonating near 4.3 mc, which is made the grid circuit of the triode oscillator section of a 6K8 triode-hexode tube. Oscillation is maintained by a tickler in the triode plate circuit, which is coupled to the grid circuit. The hexode section of the 6K8 provides a buffer amplifier to isolate the oscillator.

The circuit diagram of the dilatometer is shown in Fig. 8. The oscillator-buffer 6K8 is connected by a coaxial cable link to the first of two limiter-amplifiers, a 6AC7 and 6AG7 in cascade, the output voltage of which is controlled by changing the screen voltage. The second limiter feeds the 7A6 discriminator, the output circuit of which is arranged to operate into the load provided by the Speedomax high-speed recorder.

A typical record is shown in Fig. 9. The recorder prints one point per second; one set of alternately occurring points represents the length of the sample, intervening points record its temperature. The recorder element is switched automatically from one circuit to the other. The chart indicates temperature directly, while each 100 F chart interval represents a 0.001-inch expansion of the 2-inch length specimen. Portions of two records are shown. The lower record shows the heating and expansion of a steel specimen in the normalized condition (in which the iron carbide of the steel is present in very fine lamellar plates). The specimen was inserted in the furnace and

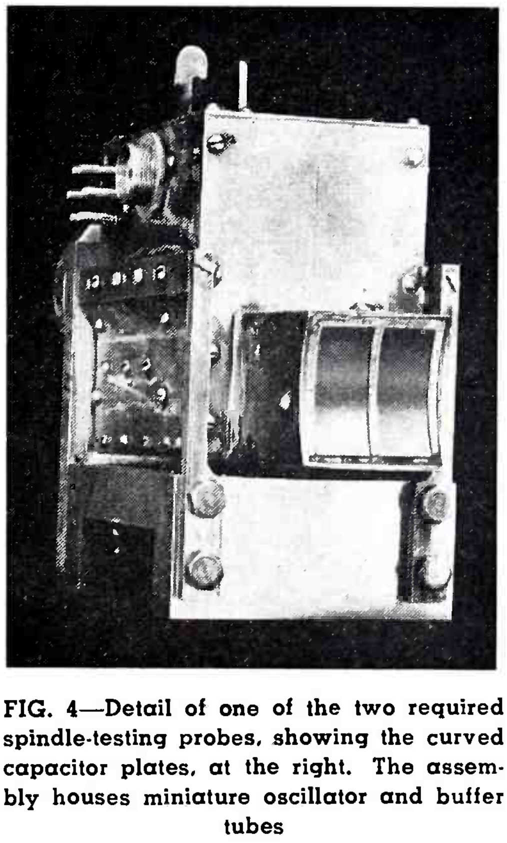


FIG. 4—Detail of one of the two required spindle-testing probes, showing the curved capacitor plates, at the right. The assembly houses miniature oscillator and buffer tubes

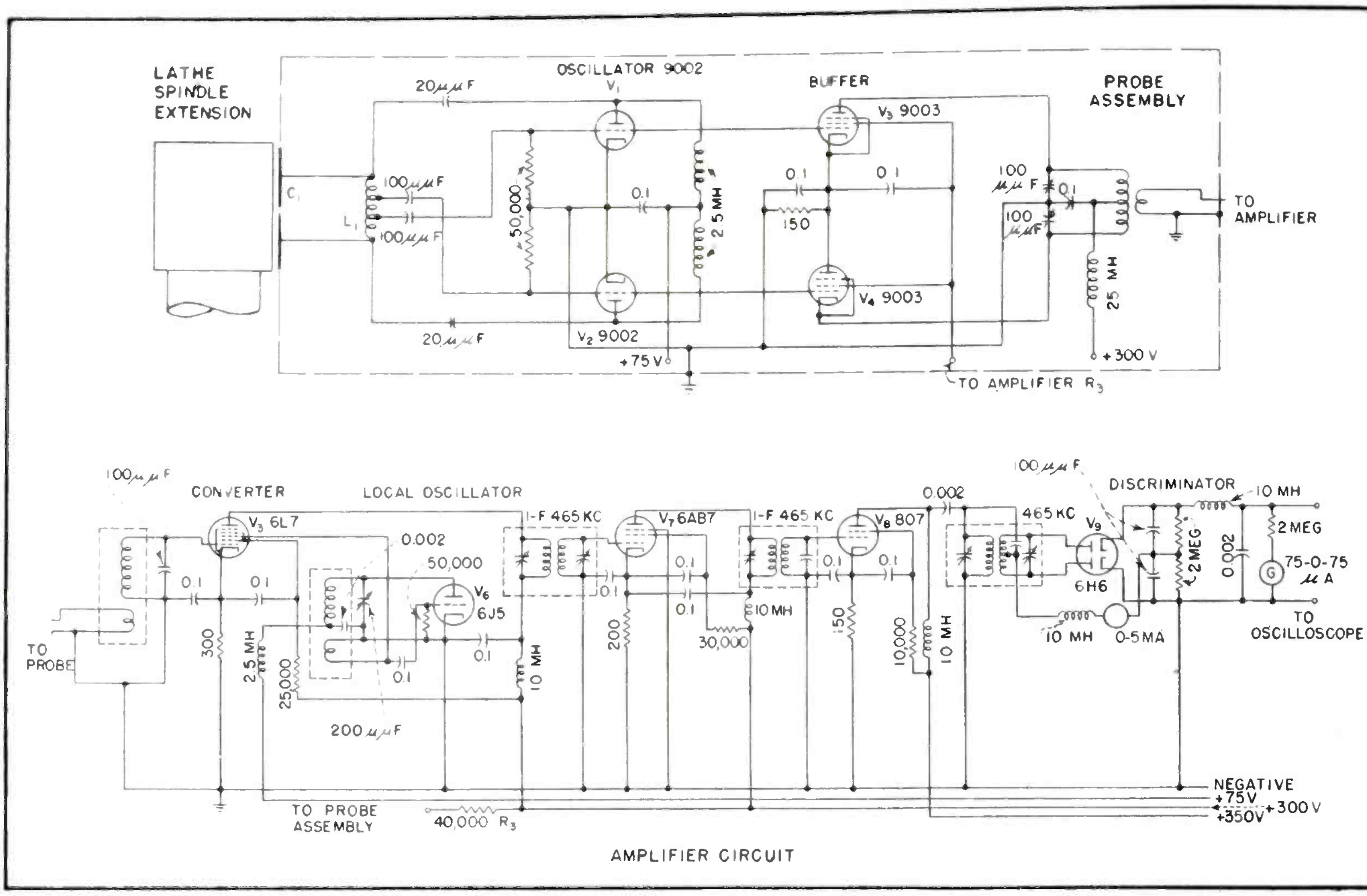


FIG. 5—Complete circuit diagram of one probe assembly and amplifier channel. Two complete channels are used in spindle testing

allowed to heat to 1,850 F. The specimen was then immediately withdrawn and cooled in air. The heating required about 33 seconds, and the dilation curve shows that it altered crystalline form at about 1,650 F during heating. The steel was in its high-temperature crystalline state about 25 seconds before transforming again.

The upper part of the figure shows the identical sample heated after annealing, that is, when the iron carbide plates were slightly coarser than in the first case. A visual comparison of the two dilation curves show that this subtle difference in physical condition of the steel altered its response to rapid heating quite radically. The implications of this type of result are not pertinent here, but it is seen that the information given by this instrument can be valuable in explaining the phenomena which occur, for instance, during welding of steels.

Recording Manometer

A nearly identical circuit has been used in order to make a recording manometer in an apparatus for the continuous extraction and measurement of gases from steel. The extraction is done automatically in runs as long as 48 hours, and continuous reliable records had to be made of the readings of a number of manometers. At first, resistance wire was sealed into the manometer so that a rise in the mercury level shorted out a portion of the wire; the resistance of the whole cell was measured and used to operate a potentiometer recorder. It was found impossible to rely upon this system because of the poor contact which frequently occurred between the mercury column and the resistance

Table 1—Characteristics of Capacitive Micrometers Designed to Measure Different Distances

Instrument	A	B	C
Range	1 microinch	100 microinches	0.01 inch
Instability — I	0.28 percent	0.28 percent	1 percent
Nonlinearity — N	0.55 percent	0.55 percent	2.25 percent
Capacitor Spacing	13 microinches	1300 microinches	0.095 inch
Oscillator Instability — p	1 in 10,000	1 in 10,000	1 in 10,000
Stray Capacitance	10 $\mu\mu f$	10 $\mu\mu f$	10 $\mu\mu f$
Area Sensitive Capacitor — A	0.01 sq in.	1 sq in.	1 sq in.
$\frac{\Delta f}{f_o} = \frac{\text{bandwidth}}{\text{operating frequency}}$	3.6 percent	3.6 percent	3.6 percent
$\frac{f_o}{f'} = \frac{\text{operating frequency}}{\text{maximum frequency}}$	0.235	0.235	0.90

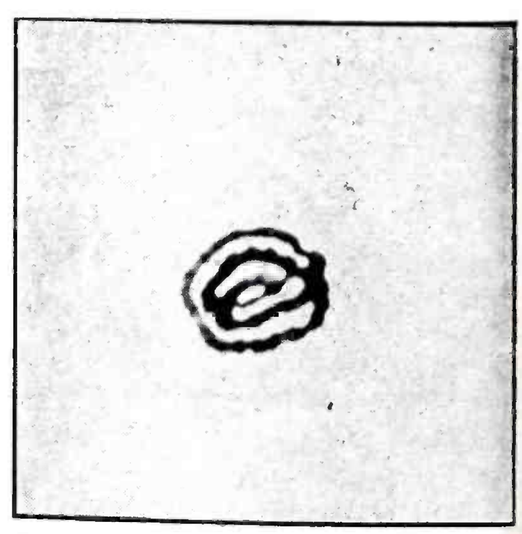


FIG. 6—Oscillogram of spindle center motion

wire, which could not, of course, be of a material which was wet by the mercury, lest the wire dissolve. A 1-inch brass tube placed coaxially around the mercury column was found to make a satisfactory tuning capacitor for the same type oscillator as was used in the dilatometer just described.

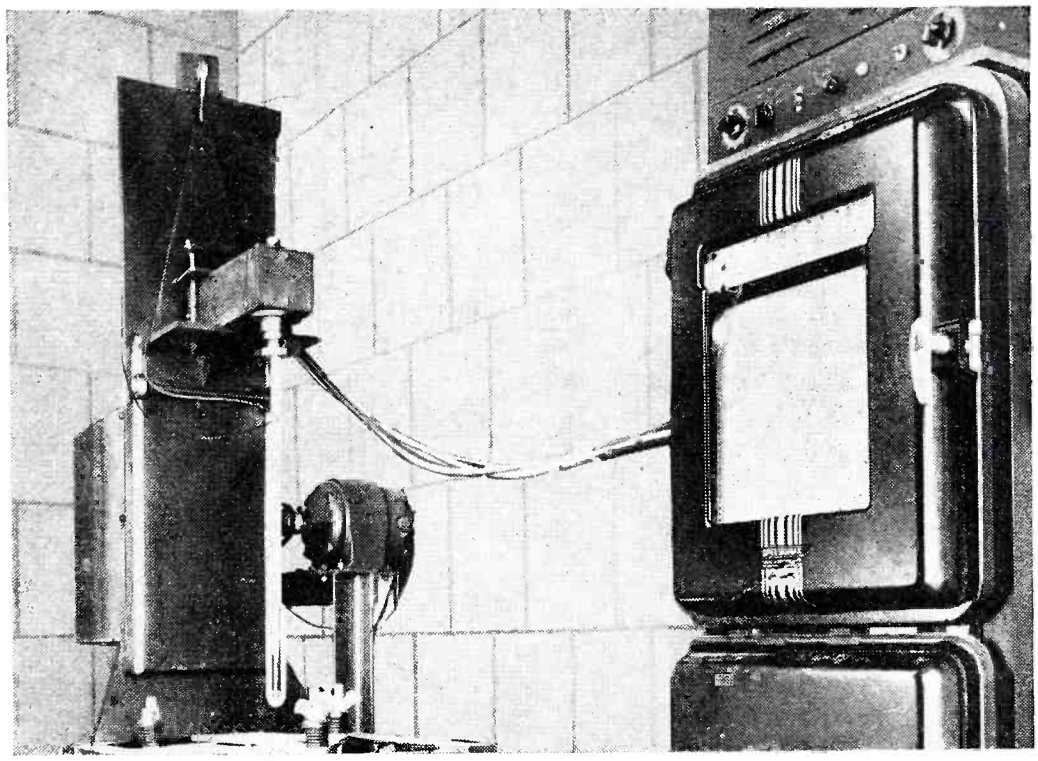


FIG. 7—High-speed dilatometer (left) and recorder

Scratch-depth Measurement

Most surface measuring instruments incorporate magnetic or piezoelectric pickups coupled to audio amplifiers, so that they respond only when the pickup is moved across the surface. The capacitive surface measuring instrument uses the surface itself as one plate of a capacitor, the other plate being supported by a stylus resting on the surface, as shown in Fig. 10. The stylus used is a sapphire phonograph playback needle, with a tip radius of 0.002 inch. Vertical motions of the stylus increase or decrease the spacing between the capacitor plate and the surface.

Two traverses across a compound specimen polished for microscopic examination but containing two scratches are shown in Fig. 11. The specimen consists of two pieces of steel of differing hardness, in each of which a scratch was made with a diamond stylus which had a tip radius of 0.008 inch, loaded with 200 grams. The vertical magnification used is about 20,000 times, the horizontal 80. Such a device can possibly be used as a hardness tester as well as for roughness measurements.

Limits to the Capacitive Technique

In considering the general applicability of micrometers of the type described, their outstanding property is high sensitivity, good electrical stability, and the ability to respond to rapid movements. The sensitivity which can be used is limited primarily by the availability of small motions which it is desired to measure. If the capacitor plates were put 0.0005 inch apart, a motion of either of them of 0.005×10^{-4} inch could be indicated. Unfortunately, such a small motion is likely to be caused by numerous influences other than the particular one it might be desired to measure; for instance, a 0.001 F temperature change of a half-inch length of steel would cause it to change by this amount.

The high sensitivity of the device is another way of saying that it is capable of extremely high magnification of motion, or very high amplification. The f-m device described here is unusual among electronic amplifiers in that it maintains the static or d-c component through a stable amplifier. The output voltage may be made high, to operate a cathode-ray oscilloscope, or the output impedance low, by the incorporation of a simple cathode-follower stage, to operate low-impedance devices such as self-balancing recording potentiometers.

Even if the superheterodyne f-m micrometer is used at an intermediate frequency of 465 kc, the bandwidth is from 15 to 20 kc, so that motions at rates above 10,000 cycles per second, or 600,000 cycles per minute, may be amplified by this device. Mechanical devices rarely move at rates approaching these figures, but many move at rates too high for the convenient use of other types of amplifier.

Design Considerations

Since the parallel-plate capacitor is the most useful for sensitive in-

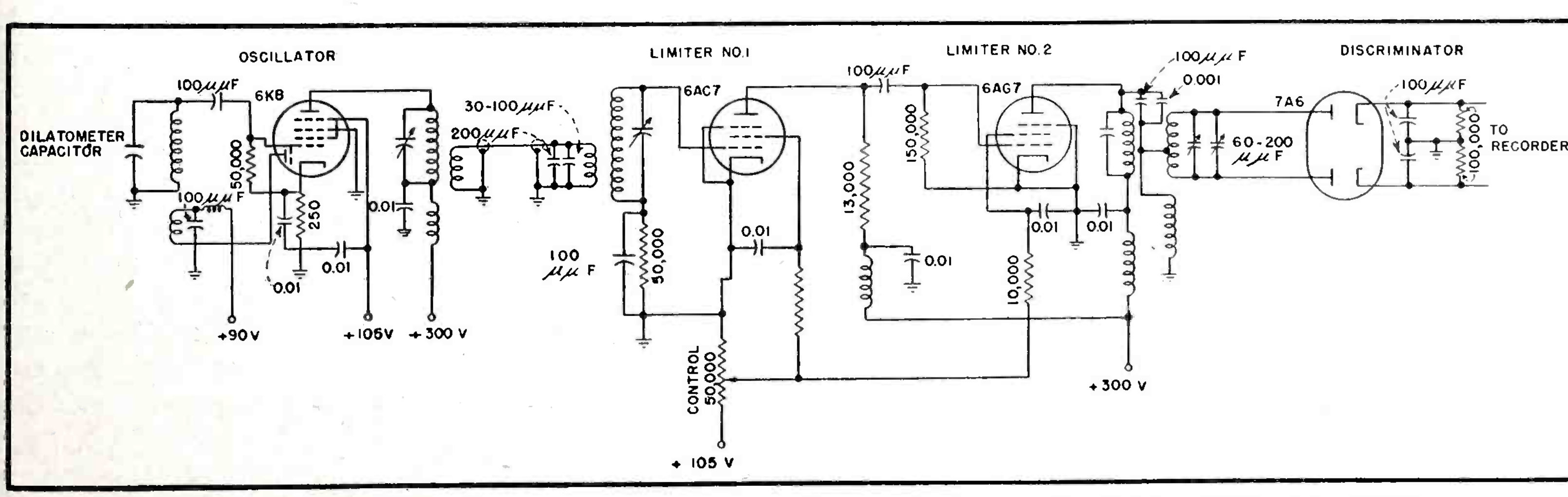
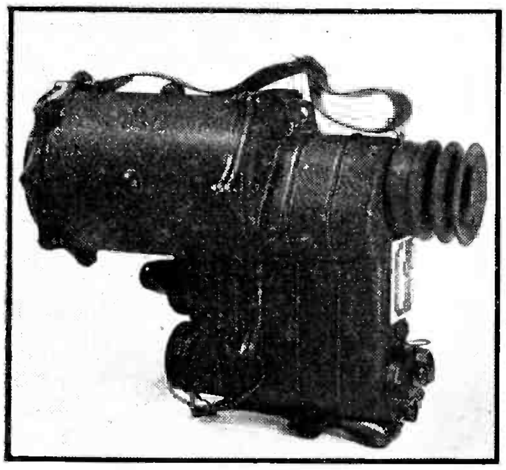


FIG. 8—Single-channel dilatometer circuit diagram. The recorder input and switching details are omitted



Infrared telescope used by the U. S. Navy for long-range signaling

Infrared IMAGE TUBE

Principle of operation of the 1P25 type that sees in the dark. Possible applications in industry, for night flying or driving, and by law-enforcement agencies are discussed

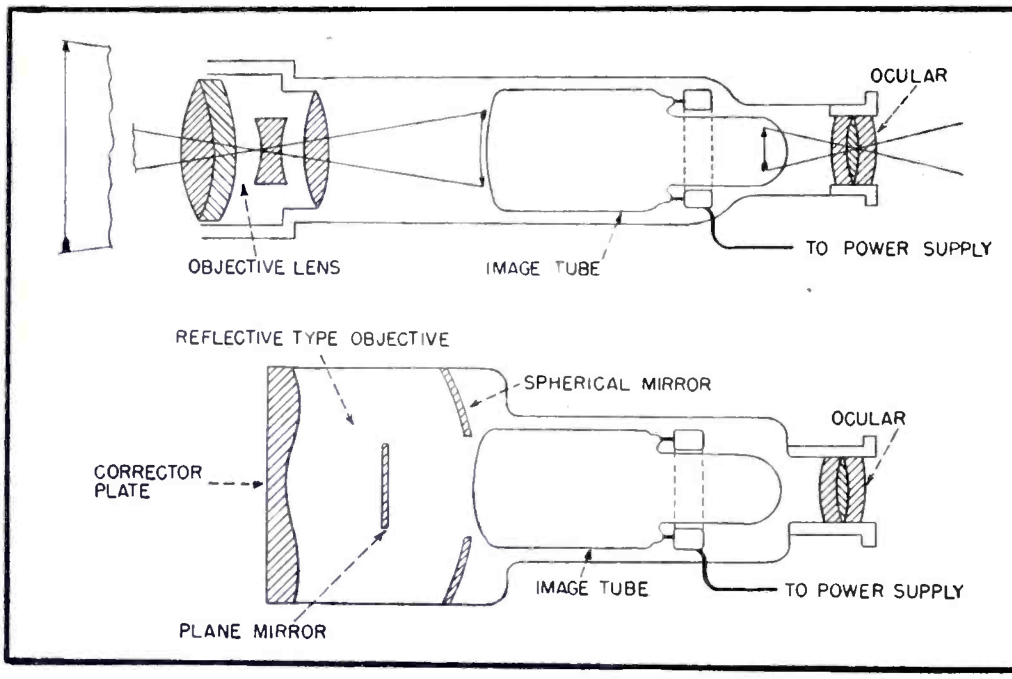


FIG. 1—Schematic diagrams of two infrared telescopes using the 1P25 tube. The refractive system at top is useful for short range; the reflective type is more suitable for long range

FORESEEING the value of the security afforded by the application of infrared viewing in certain night operations, the National Defense Research Committee, acting under Army and Navy directives, undertook the development of equipment suitable for the purpose.*

Basically, the infrared telescopes developed consist of an objective for imaging the object being viewed on the photo-cathode of an image tube, the tube which converts the infrared image to a visible image, and an ocular for viewing the visible reproduction. The object may either be self luminous in the infrared region of the spectrum, as in the case of a signal light, or may be illuminated by radiation from an infrared spot or searchlight. The viewing ocular is so arranged that the virtual image seen by the observer approximately coincides with the object viewed so that the user has the impression of looking through the instrument at the object, rather than that of examining a screen close to his eyes.

The general arrangement of two types of infrared telescopes is shown in Fig. 1. One form employs refractive optics to image the scene on the image tube cathode, the other employs reflective optics. The former has the advantage of simplicity and greater depth of focus, as is required for short-range reconnaissance, while the second has the extremely high sensitivity required of a long-range signalling instrument.

Tube Construction

The image tube forms the basis of the telescopes and is illustrated schematically in Fig. 2, together with its optical analogue. It consists of a photocathode, a fluorescent screen and an electron lens system contained in an evacuated glass envelope approximately 4½ inches long and 1⅞ inches maximum diameter. When an infrared image is focused on the cathode, electrons are emitted from it with a density distribution which corresponds to the distribution of illumination on the cathode. These electrons are accelerated and focused by the electron lens into an image which impinges upon the fluorescent screen. Here the electron energy is converted into visible light reproducing the infrared image incident on the photo-cathode. The electron optical system employed produces an inverted image with magnification of one half.

The electron lens system comprises a series of coaxial cylinders at various potentials as indicated. The main imaging lens is between the anode cylinder G_4 and its neighboring electrode G_3. Between this lens and the cathode are a series of weak lenses (G_1 and G_2) which serve to reduce curvature of the electron image field and minimize the "pincushion" distortion. To further correct inherent image defects, the

* This paper is based, in whole or in part, on work done for the National Defense Research Committee on Contract OEMsr 169 and Contract OEMsr 440 with Radio Corporation of America.

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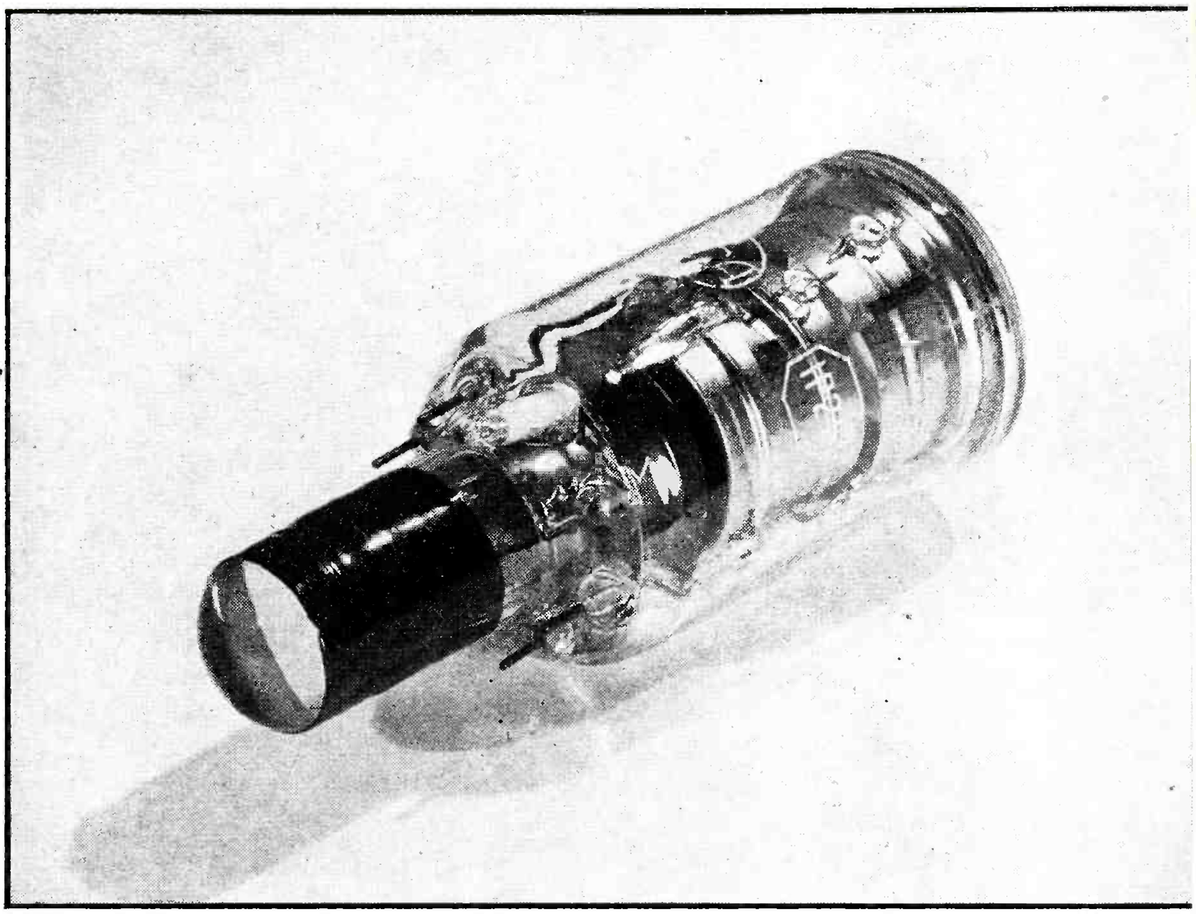

FIG. 3—The 1P25 image tube

cathode is curved, with a radius of curvature of 2⅜ inches. This curvature matches the curvature of the image field of the reflective optical system used in the Navy telescope. A detailed discussion of this type of electron lens system has been published in connection with earlier investigations of image tubes.[1, 2]

Semi-transparent Cathode

To obtain high infrared sensitivity, the cathode requires special processing. A base layer of silver is first deposited on the glass surface of the tube. This layer is then completely oxidized and processed with additional silver, caesium and silver, with an appropriate thermal treatment. The cathode is semi-transparent, so that when illuminated through the glass electrons are emitted from its inner face. The sensitivity of a well activated cathode is 20 to 40 microamperes per lumen for whole light. Its spectral response has a maximum at 8500 A and extends to 12000 or 14000 A.

Synthetic willemite was used as the phosphor in the 1P25. This forms a fluorescent screen which is highly sensitive, produces a high-definition image and is stable in the presence of caesium. The decay time constant is such that the brightness falls to ten percent of its initial value in about 0.04 seconds. This is adequate for most purposes.

The overall sensitivity to an unfiltered incandescent light source, operated at a color temperature of 2870 K, is such that one lumen on the photo-cathode produces 0.5 to 1 lumen at the fluorescent screen. The definition which can be obtained in the image ranges from 450 to 1000 lines (television standards) in the center of the image and somewhat lower at the edges. At the brightness levels at which the tube is commonly used, the eye rather than the tube limits the resolution of the telescope. A photograph of the tube is shown in Fig. 3.

Power Supply

The overall voltage required is 4,000 to 5,000 volts. In addition, lower voltages, including one variable voltage, are needed to supply various electrodes in the tube. The problem of meeting these requirements in a small lightweight power supply is rather severe. The compactness which has been attained in some of the units is only possible because of the very small currents required. The image tube itself needs only a fraction of a microampere and the voltage divider commonly used for obtaining the other voltages only slightly more. The total power drain from the supply is therefore of the order of a tenth of a watt.

The most practical means of obtaining the necessary high voltage from low-voltage batteries is a vibrator - transformer - rectifier converter. These differ from the conventional type of vibrator power

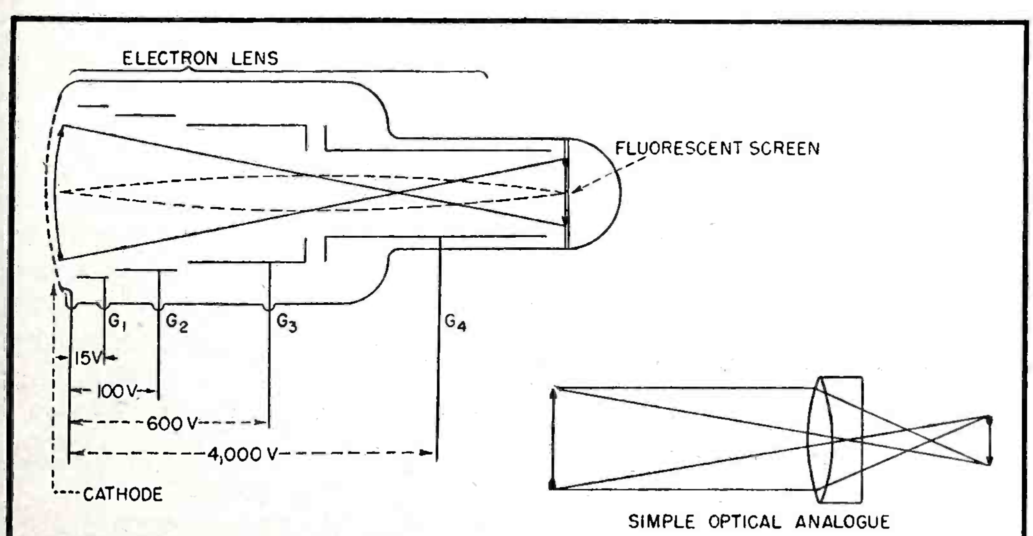

FIG. 2—Arrangement of the electrodes in the image tube, and the potentials required

supply in that use is made of the relatively high voltage peak appearing across the tuned primary of the transformer when the magnetic field collapses as the primary circuit is opened by the vibrator. The effective primary voltage can thus be made ten to twenty times greater than the battery voltage. This makes possible a great reduction in the size of the transformer. A circuit diagram of this type of vibrator power supply is shown in Fig. 4.

Since no rectifier was available which met the voltage requirements and at the same time was of small size and low filament consumption, a special tube was developed. This tube is shown in Fig. 5 and is now manufactured as type 1654. In the circuit shown it will deliver 100 microamperes at 5,000 volts.

While a high degree of overall voltage stability is not required, it is essential that the ratio of voltages on the various electrodes remain constant. This necessitated considerable care in the design of the resistance voltage divider, because a majority of resistors of the high value needed for this application are not ohmic and have large thermal coefficients. However, by a proper choice of components, it is possible to design dividers in such a way that the variations compensate one another and the voltage ratios remain constant over a temperature range of from −40C to +75C and for a considerable range of battery voltages.

Applications

During the course of the project, a wide variety of instruments was developed for different applications, based on one or the other of the two types of telescopes. Included were instruments for night driving and flying, telescopes for signalling and marker-light identification, reconnaissance equipment, and gun aiming units. A number of types was used in quantity by the Armed Forces during the war. Among them were the Navy infrared telescope, the Snooperscope and the Sniperscope.

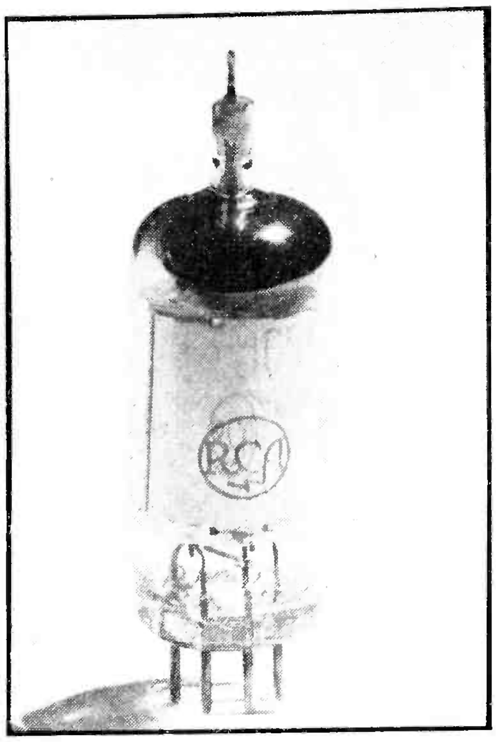

FIG. 5—New high-voltage rectifier tube, type 1654

The Navy infrared telescope was primarily a marine signalling instrument. It employed a 2½″ focal length F/0.9 reflective type objective, to give high sensitivity and a wide angular field of view. With it, signal light communication could be carried out over distances of many miles with no visible light.

The Snooperscope consisted of a monocular telescope and an infrared source mounted on a suitable handle. The Sniperscope employed an identical telescope and source attached to a carbine, in such a way that the telescope could be used for aiming the gun. Since considerable depth of focus was required in these applications, it was necessary to use refractive optics. Therefore, 3½-inch focal length F/2 objectives were provided, giving the telescopes an overall magnification of about 1.6. Production units of these instruments were developed by The Engineer Board of the Army for the Corps of Engineers. Other reconnnaissance instruments were designed with larger, faster optics which gave much greater ranges in conjunction with infrared searchlights.

The power packs for the Snooperscope and Sniperscope presented a special problem of silencing, since these instruments were to be used under conditions where extreme quiet and secrecy were essential. While the conventional rubber mounting of an automobile radio type vibrator is effective for damping out high frequency vibration, additional acoustic filters are needed to remove low frequencies. Several stages of sponge rubber cushioning around the usual vibrator can were found to be sufficient to bring the noise level below the maximum permissible value.

The preceding discussion includes only the military application of infrared telescopes. There are a number of interesting peacetime uses for this type of device, in police service, science, industry and medicine. The requirements to be met for many of these problems are very different from those of military equipment and entirely new instruments are needed to fulfill them.

The authors wish to express their appreciation for the advice and encouragement given them by Dr. V. K. Zworykin, Director of Electronic Research, RCA Laboratories, and acknowledge the important part played by Dr. J. E. Ruedy, G. L. Krieger, and Dr. P. Rudnick in this project. Credit should go to Dr. L. B. Headrick, Miss H. C. Moodey and Dr. R. B. Janes of the RCA Lancaster plant for work on the production design of the image tube.

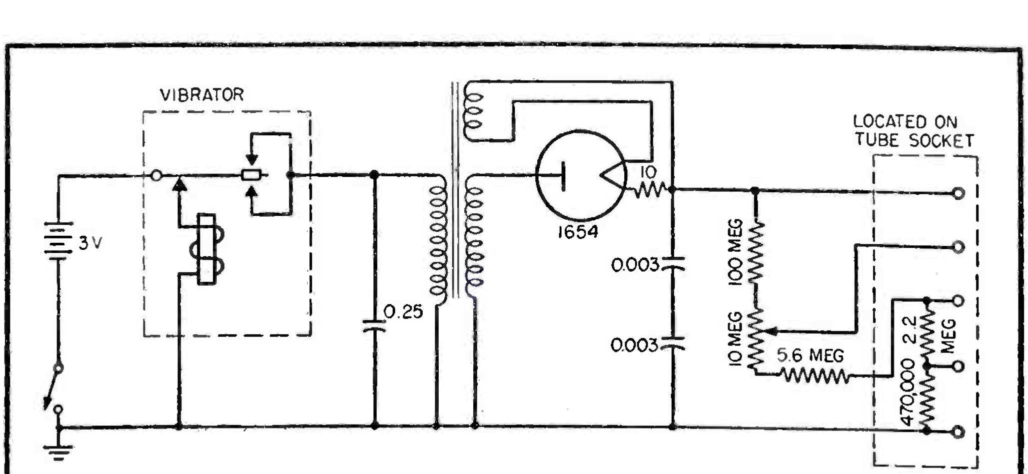

FIG. 4—Circuit of 5,000-volt pocket-size power supply

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Composite Tank Circuit for Uhf

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To obtain a physical, external, tank circuit at the highest frequency at which a negative-grid triode will oscillate, the resonant transmission line is inserted into a cavity that both stabilizes the circuit and provides coupling to the output

THIS article has an interesting history. The author sent his manuscript to a radio amateur friend in America who forwarded it to ELECTRONICS. The editors wrote to the author asking for additional photographs. To their question the author replied that, although he would be glad to send them, unfortunately the retreating Germans had dismantled the laboratory of the Fivre plant in Florence at which the experiments had been conducted

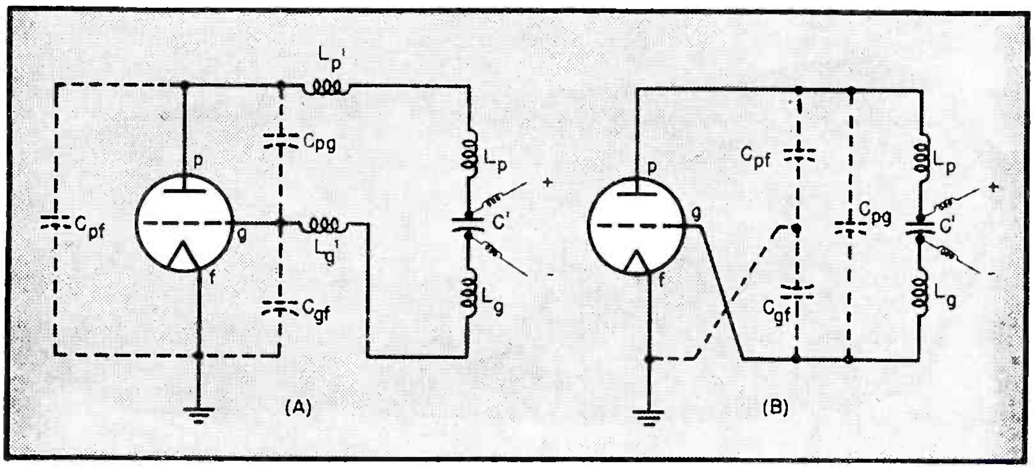
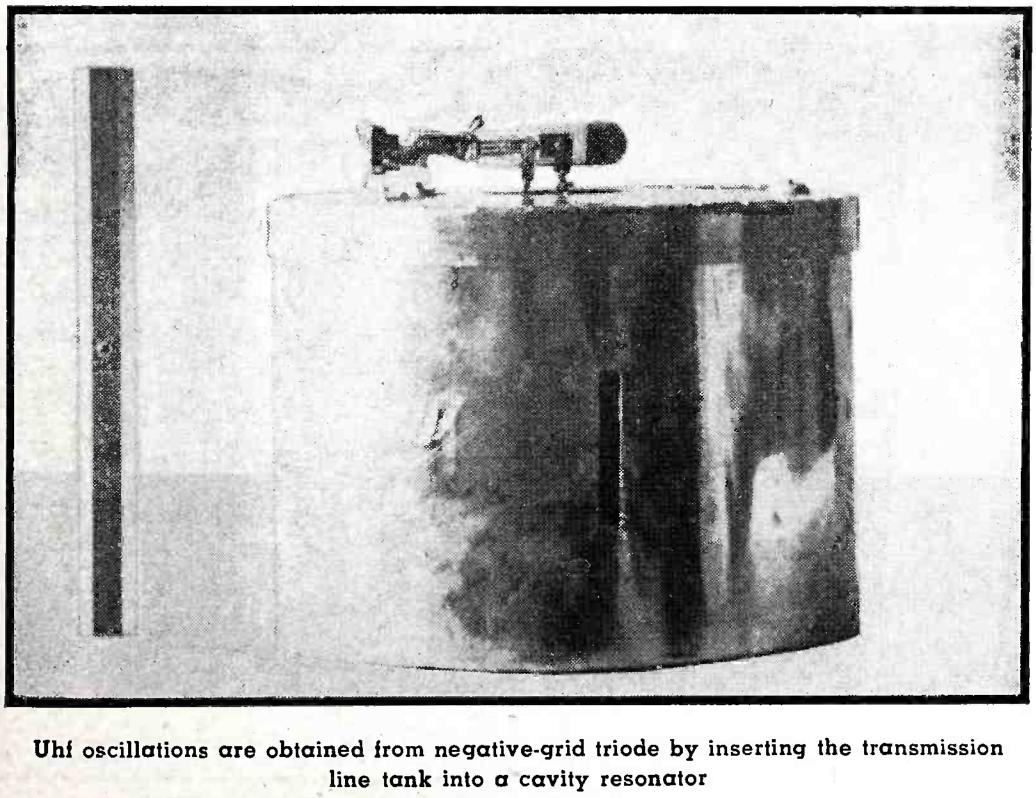


FIG. 1—The combination of interelectrode capacitances and tube lead inductances, plus—if necessary—externally added inductance, gives a high-frequency oscillator (A) which is basically a Colpitts circuit (B)

AN oscillator of novel design is described which makes possible the generation of frequencies up to and beyond the limit frequency fixed for a certain tube by its internal inductances and capacitances. The arrangement, among other advantages, facilitates the extraction of the oscillatory emergy from the tube and its transfer to the load.



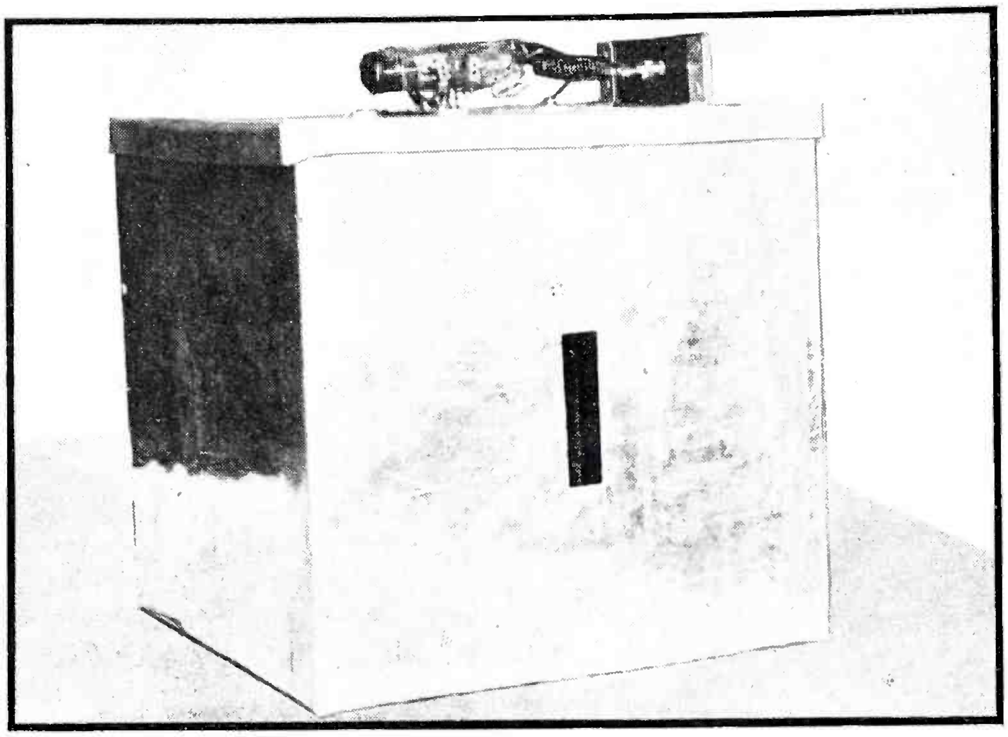
Uhf oscillations are obtained from negative-grid triode by inserting the transmission line tank into a cavity resonator

Fundamentally the arrangement consists of two features: (1) cancellation of the residual impedance of the tube elements and leads, and (2) prevention of parasitic oscillation.

Operating Principle

The internal impedance of the tube was found, by experimentation, to be inductive at lower frequencies, but to become capacitive as the upper frequency limit of the tube's oscillating range was approached. To cancel this internal tube impedance using a shorted transmission line as a resonant circuit, requires making the line shorter than a quarter wavelength over the lower frequency range. The highest attainable frequency is reached when the inductance of the short across the tube equals the internal tube capacitance.

By using an open transmission line as the resonant circuit, it is



Any cavity shape can be used for the composite tank circuit. Energy can readily be withdrawn from the cavity through a suitably placed slit

necessary, over the lower frequency range, to make the line longer than a quarter wavelength to present to the tube the necessary capacitive reactance. In this way the physical, external tank from which power is coupled is enlarged, which is advantageous. At the upper end of the frequency range where the input to the grid-plate is capacitive, the line must present an inductance, which it does if it is shorter than a quarter wavelength, but has some physical size. Again the tank is large enough to permit coupling to an output circuit.

However, such an open line is unstable in an oscillator, therefore a cavity is coupled to it. In addition to providing shielding for the resonant circuit, the cavity also cooperates with the line tank to sustain an oscillating field only at the frequency for which both line and cavity are resonant. The two circuits do not have parasitic or higher modes at the same frequencies, thus only the one frequency is maintained.

Among several circuits proposed for negative-grid triode oscillators the layout reproduced in Fig. 1A, which as Fig. 1B indicates is a derivation of the Colpitts circuit[1], offers some particular advantages. These advantages were emphasized in a recent comparative study[2] starting with theoretical considerations which were confirmed by later experiments.

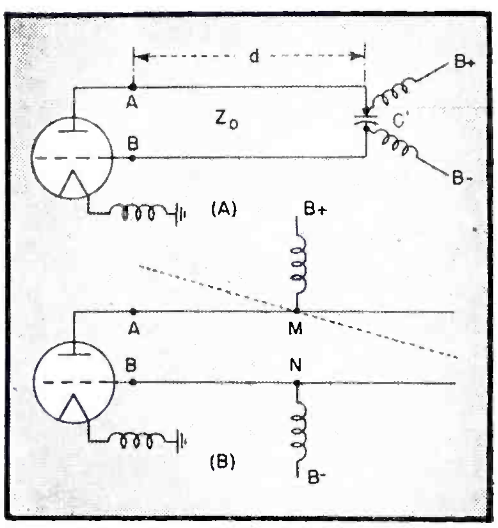


FIG. 2—(A) Transmission line version of the circuit at Fig. 1A. (B) Extension of line beyond feed points gives longer physical tank without increasing the wavelength

Basic Oscillator Circuits

The oscillatory circuit is composed of the external inductances L_p and L_g, the internal inductances L_p' and L_g', and the capacitance C resulting from the combination of the three internal capacitances of the tube—C_{pg}, C_{pf}, and C_{gf}. The capacitor C' is of very high susceptance and is chiefly used as a bypass and blocking capacitance respectively for r-f and d-c components. After selection of a certain tube, values of internal inductive elements L_p' and L_g' are fixed, along with the internal capacitance value.

$$C = C_{pg} + \frac{C_{pf}\,C_{gf}}{C_{pf} + C_{gf}} \qquad (1)$$

The only variable elements are therefore the external inductances L_p and L_g.

At the higher frequencies these inductances conveniently assume the form of a transmission line section[3], either of the coaxial or of the parallel-wire type, having a length d usually shorter than one quarter wavelength, such as to locate between points A and B of Fig. 2A a reactance

$$X_L = jZ_0 \tan 2\pi d/\lambda \qquad (2)$$

where Z_0 is the characteristic impedance of the line. The circuit of Fig. 1A takes then the aspect illustrated in Fig. 2A. It is evident from the above mentioned facts and from Eq. 2 that extremely high frequencies are reached giving to the external elements the least reactance value, this being obtained when both Z_0 and d are small.

It was also suggested to use special tubes of cylindrical electrode construction, so as to simulate within the tube the continuation of an external coaxial line having a convenient value of characteristic impedance[4]. In this case the line is

Table 1—Reactance of Transmission Line Used in Composite Tank

Wavelength in cm	l'/λ	Line reactance
	Tube Type UC20	
31	0.21	−
32	0.22	−
38	0.23	−
40	0.24	−
42	0.26	+
	Tube type 1628	
59	0.25	0
53	0.26	+
60	0.27	+
70	0.31	+
	Tube type UC160	
50	0.24	−
60	0.25	0
70	0.26	+
	Tube type TS6	
70	0.20	−
80	0.22	−

no longer affected by plate-grid capacitance C_{pg}, being in effect loaded only by the capacitance formed by the series connection of C_{pf} and C_{gf}; the resulting length of the line is therefore greater.

Nevertheless, for a given tube, a certain frequency is reached for which the external inductance reduces itself to the shortest possible connection between plate and grid leads. It might be possible, however, provided certain cares are taken ,to reach also in this case the condition of steady oscillation, but the circuit has no practical importance because, in absence of any external circuit, it is extremely difficult or even impossible to extract from the tube the eventually available amount of oscillatory energy.

It must be remembered, in this connection, that tube catalogues often have near the indication of the value of this extreme frequency, which is also called limit frequency, the following notice: "Resonant frequency of the grid-plate circuit when the grid is connected to the plate through the shortest possible connection. Output power approximately zero."

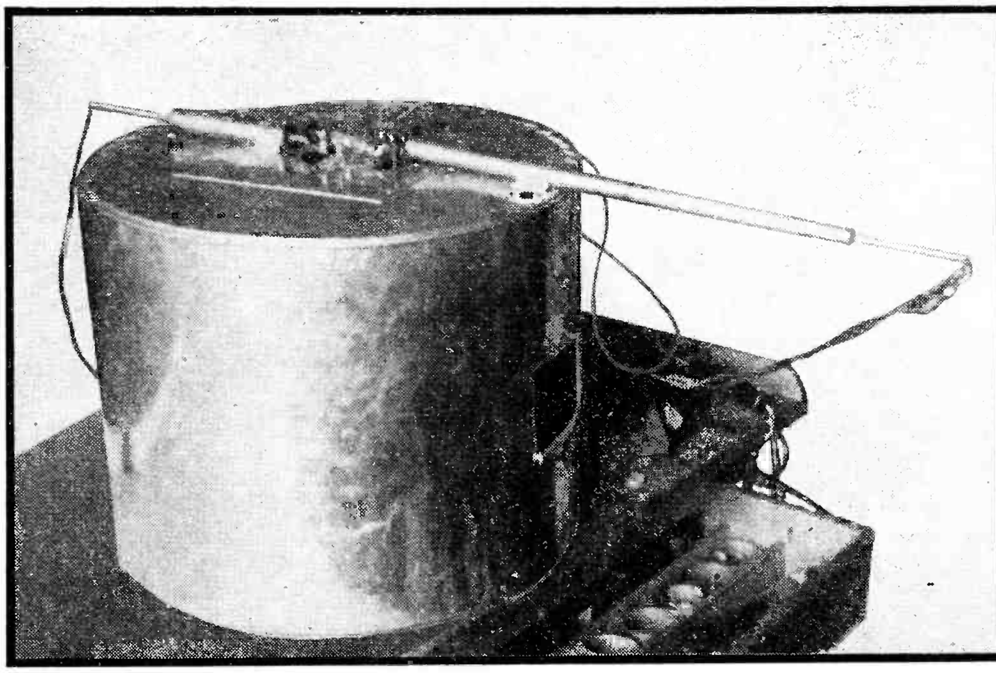
Circuit Modification

In addition to transit time effects, fundamentally influent at these ex-

Table II—Parameters of Tubes Used in Composite Tank Circuit Oscillators

Tube type*	UC20	1628	UC160	TS6
Plate dissipation in watts	20	40	160	200
Filament potential in volts		3.5		2
Filament current in amperes	3.5	3.25	15	31
Mutual conductance in μmhos	2000	3000	5000	5000
Amplification factor	20	23	18	10
Grid-plate capacitance in $\mu\mu f$	1.5	2	3.5	5
Grid-filament capacitance in $\mu\mu f$	1.75	2	3	4.5
Plate-filament capacitance in $\mu\mu f$	0.3	0.5	0.8	1.5

*Editors' Note: These tubes are made by Fivre, a European manufacturer.



Quarter-wave stubs can be used in place of inductances to prevent reaction on the tank from the feed lines

treme frequencies but not included in this study, it must be stated that in most cases the problem of the practical use of a given tube is

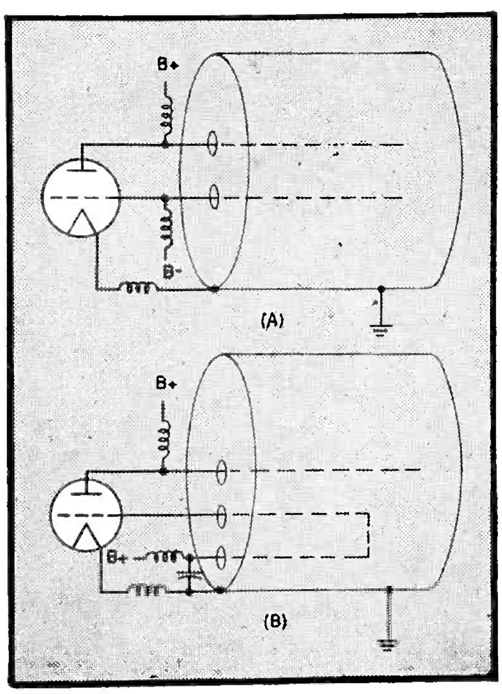


FIG. 3—(A) The circuit of Fig. 2B does not oscillate in the desired mode unless the line is inserted in a cavity. (B) A modification is to loop one of the lines in the cavity back on itself, bringing its end out of the cavity for connection to the d-c feed line

mainly a problem of circuits. Therefore, considerations on some variations of the basic circuit will be discussed.

Referring to Fig. 2A it is worthwhile seeing what takes place when the capacitance C', previously used as a bypass, is made small. Then between points A and B an impedance will be found equal to

$$Z_{AB} = Z_0 \frac{Z_d + jZ_0 \tan 2\pi d/\lambda}{Z_0 + jZd \tan 2\pi d/\lambda} \quad (3)$$

which, because $Z_d = 1/j\omega C$, reduces itself to a reactance

$$Z_{AB} = jZ_0 \frac{(\tan 2\pi d/\lambda) - (1/\omega C' Z_0)}{+ (\tan 2\pi d/\lambda)/(\omega C' Z_0)} \quad (4)$$

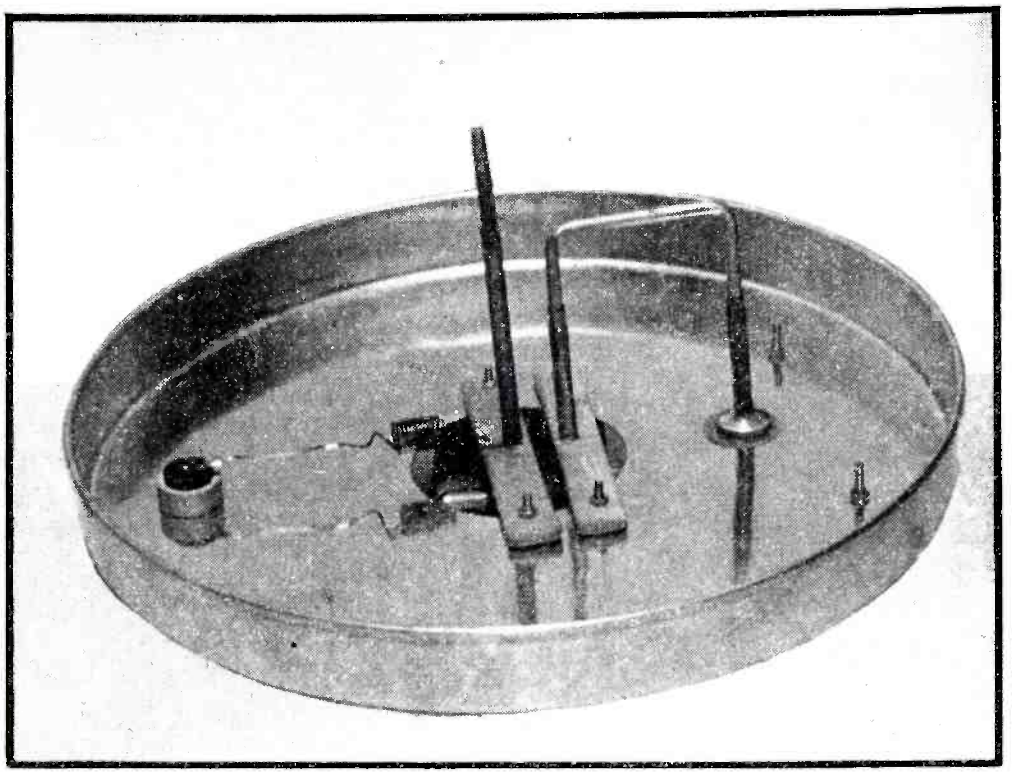
the value of which is determined not only by the characteristics of the line but also by the end reactance due to C'.

It is easy to see that, with all other conditions unchanged, when C' assumes decreasing values the resonance condition is reached when the length of the line is increased. If $C' = 0$, the line length, taking into account the loading effect of the tube, which as before is less than a quarter wavelength, will be now between one-quarter and one-half wavelength.

To provide an external circuit of greater extension, the oscillator could be arranged according to the layout illustrated in Fig. 2B where a possible distribution of the r-f voltage on the line is also indicated, the d-c voltages being applied to the points M, N of the line at which there is the minimum r-f potential. Proceeding further in the study of the condition $C' = 0$, consider a certain line for which

$$X_{AB} = - jZ_0 \cot 2\pi d/\lambda \quad (5)$$

The line length should be such as to



Internal disposition of lines indicates that they act as a resonant electric and magnetic exciter for the cavity

place between points A and B, for increasing values of frequency, first a decreasing inductive reactance, then a zero resistance, and finally an increasing capacitive reactance. In the last case the only inductive elements of the circuit are the internal inductances L_p' and L_g'. The limit frequency would be reached when the inductive reactance between A and B would equal the reactance of the shortest possible connection between plate and grid lead, the frequency of the eventually generated oscillations becoming therefore higher than the limit frequency when a zero resistance, or better, a capacitive reactance would be placed between points A and B. The oscillations will stop, apart from transit time effects, when the Q of the circuit reaches too low a value.

Experience indicates, however, and theoretical consideration confirms that while it is possible in reality to produce with the circuit of Fig. 2B steady oscillations at relatively low frequencies, at higher frequencies the same circuit fails because either no oscillations at all are generated, or they start on a lower parasitic frequency corresponding to the closed-end line case illustrated in Fig. 2A, the capacitance C' being formed in some way by the d-c feed wires and by the protruding line sections.

Advantages of Composite Tank

During an investigation on various circuits proposed for uhf generators a new method which entirely removes the above-mentioned difficulties was evolved. The start was made with the idea to design an oscillator using triodes connected to cavity resonators[5] in such a way as to reduce the loading of the resonator by the tubes[6].

A new circuit was obtained using the disposition of Fig. 2B to introduce the transmission line section in a convenient cavity resonator. When the oscillation of the line circuit is compatible with that of the cavity a quite regular operating condition is reached thanks to the cavity itself. Oscillations stop immediately, however, when the line is taken out of the resonant space. Figure 3A shows an oscillator of the new type using a cylindrical resonator. The resonator performs the following functions:

(1) Blocks oscillations of lower spurious frequencies such as those obtained from the circuit of Fig. 2A.

(2) Exalts oscillations of the desired frequency when the frequency pertinent to the line and tube circuit is equal or close to the frequency corresponding to certain modes of vibration of the resonator.

(3) Stabilizes frequency.

(4) Completely screens those parts of the circuit subject to high r-f voltages.

(5) Provides a coupling element between tube and load.

Many experiments carried on with different types of tubes and resonators working in the frequency range from 300 to 1000 mc confirmed the above stated ideas. Circuits were realized, all exhibiting regular and relatively highly efficient operation. Several laboratory models are depicted elsewhere in this article.

Direct voltages are brought to the tube through chokes or convenient lengths of coaxial transmission lines. Either grid or plate can also be fed by bending one of the line conductors on itself as shown in Fig. 3B until it protrudes from the resonator base and can be grounded to it at the feed point through a suitable bypass capacitor. In this case the connection between tube and resonator becomes particularly suggestive; the internal electric field excites the plate rod and the internal magnetic field embraces the bent conductor forming the grid turn.[7]

The cathode circuit will, as usual at these frequencies, comprise a reactance sufficient to attain regeneration, this reactance being formed by a choke or by a convenient length of a transmission line.

By collecting all the data from the many oscillators which have been constructed and operated, it has been possible to trace the graphs of Fig. 4, where for four different types of tubes, the lengths of the elements l_p and l_g appear as functions of the generated wavelength. These lengths were measured after having experimentally reached the optimum operating conditions.

No indications are reported here about the resonators actually employed because all the more usual forms (cylindrical, spherical, or prismatic) gave satisfactory results. So far as the dimensions of the resonators are concerned, it was experimentally found that those making the fundamental frequency of the cavity fall between 0.95 and

0.70 times the frequency of the generated oscillations were particularly convenient, the higher value becoming more critical at the highest frequencies obtained with any tube.

It will be noticed that the line conductor tied to the plate is longer than the conductor tied to the grid. The transmission line section is therefore no longer symmetrical. This external asymmetry is necessitated by the internal asymmetry of the tube capacitances (usually C_{gf} is greater than C_{pf}). A similar effect is also to be found on the oscillators of the closed-end line type (Fig. 2A) in which the minimum r-f voltage is usually not found on the shorting bar but rather somewhat displaced toward the grid terminal. At higher frequencies a certain compensation takes place which is possibly due to the distribution of voltages in the tube and eventnally associated with transit time effects.

Taking the average length $l' = (l_p + l_g)/2$ it is found that the ratio of it to the generated wavelength is actually greater than 0.25 for the lower frequencies, for which an inductive reactance is required between points A and B. The ratio exactly equals 0.25 when between points A and B there is localized a zero resistance. The ratio is less than 0.25 for the higher frequencies for which a capacitive reactance is found between points A and B. Table I summarizes the results for the four types of tubes used. (Characteristics of these tubes are listed in Table II.) It is easily seen how closely experiments confirm the theory.

The importance of the internal inductances L_p' and L_g' and of the inductances of the connecting leads must not be overlooked. Take for instance the experimental data about tube type 1628, operating with a line composed of two parallel conductors having a diameter of 10 mm and a spacing of 28 mm and thus possessing a characteristic impedance of 203 ohms. The values of the line reactance X_{AB} and those of the inductance L_{AB} appearing in Table III were calculated. The table indicates also the values of inductance L_{RBS} required to attain resonance with the capacitance offered by the tube, and also gives the value of the residual inductance $L_{RDL} = L_{RBS} - L_{AB}$.

Table III—Comparison of Line and Lead Inductances

The following values were calculated from data taken on a FIVRE type 1628 triode operting into a line of 203 ohms characteristic impedance. The total shunt tube capacitance, calculated from values given in Table III, is 2.33 $\mu\mu f$

λ in cm	70	60	49
f in mc	428	500	613
l' in cm	21.8	17.0	12.2
X_{AB} in chms	$j82.2$	$j43.1$	0
L_{AB} in μh	0.0306	0.0137	0
L_{RBS} in μh	0.0594	0.0434	0.0290
L_{RDL} in μh	0.0288	0.0297	0.0290

It is seen that at the wavelength of 70 cm the residual inductance is of the same order of magnitude as the line inductance, while at the wavelength of 49 cm the only inductance in the circuit is in effect the residual one.

In the description of the functions which the resonator performs in this circuit, mention has been made of the coupling to an external load. For obtaining such a coupling one has to follow the usual resonator technique. Probes or turns may be employed at will, respectively giving either electric or magnetic coupling. Another method is to use a partially opened resonator when the oscillatory energy has to be radiated into space. Having eliminated any intermediate circuit, one obtains a high overall efficiency[8]. In addition a suitable electromagnetic horn[9] can be applied to the partially opened resonator to obtain directional characteristics.

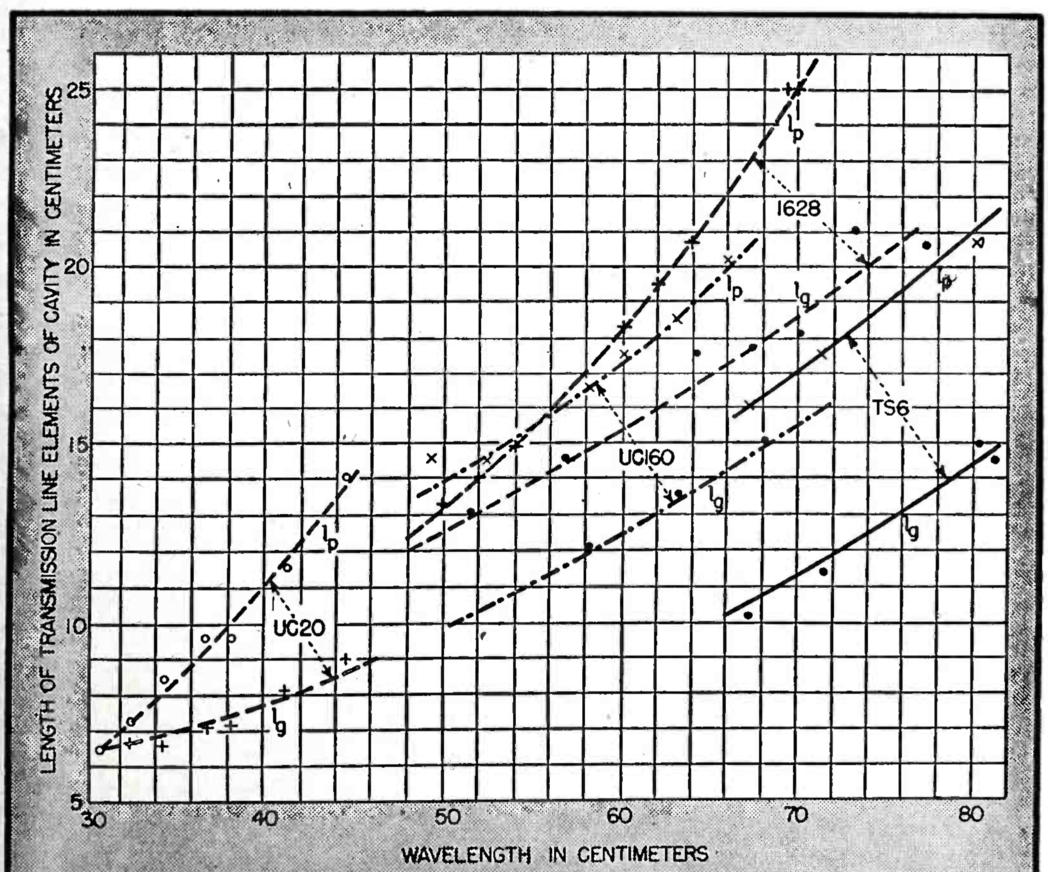


FIG. 4—Grid and plate line lengths as functions of wavelengths for the composite tank of an oscillator were plotted from data taken on about twenty different oscillators, some of which are illustrated in this article

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Current Oscillator for TELEVISION

Electron beam deflection in kinescopes and camera tubes is provided by this saw-tooth current oscillator in conjunction with the horizontal deflection yoke. Full deflection with excellent linearity is obtained in a 12-inch, 38-degree kinescope

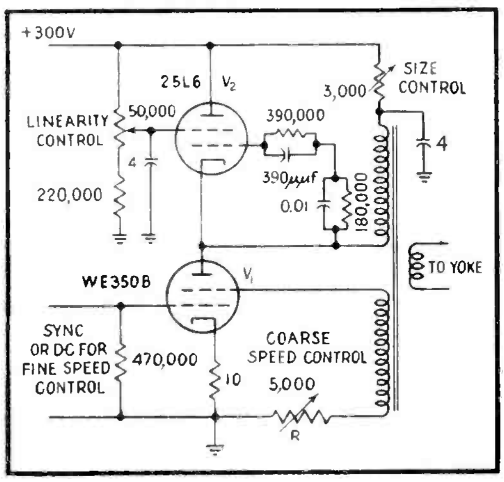

FIG. 1—Circuit of saw-tooth current oscillator used to feed horizontal deflection yoke

THE SUGGESTION of using the output voltage across the horizontal winding of the deflection yoke in a cathode-ray tube for triggering the sweep output tube has been frequently considered in the past. In a conventional television receiver, for instance, a blocking oscillator and a discharge tube may be eliminated if the horizontal output tube is made to oscillate and produce a saw-tooth waveform.

Problem

Saw-tooth current oscillators have been described in the literature[1,2] and patents.[3-7] Practically all the saw-tooth current generators referred to had four inadequacies in common:

(1) Lack of linearity in the long portion of the saw-tooth wave.

(2) Interdependence of the amplitude and frequency controls, making the adjustment of the device very difficult. In some cases, to permit amplitude variation without falling out of synchronization, a wide locking-frequency range was required, making necessary the use of large synchronizing pulses.[6]

(3) Difficulty of synchronization. Most generators described in the literature require large-amplitude signals for lock-in, and, due to their instability, have to follow the signals over a wide range, tending to make the deflection susceptible to noise disturbances. Farnsworth[4] proposed high-impedance (auxiliary grid) injection of the synchronizing pulses, in a system where the effect of this auxiliary electrode was less than that of the oscillator grid.

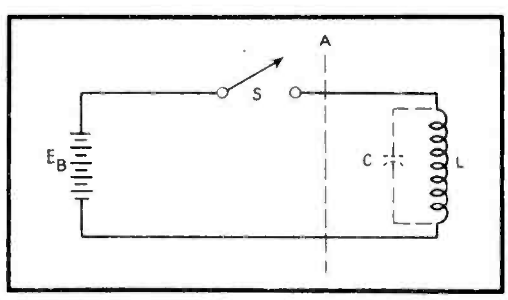

FIG. 2—Basic circuit of a reactive saw-tooth current oscillator

In the last few years the superior operation of automatic frequency-controlled type of deflection has been demonstrated as compared to the more conventional lock-in type of synchronization. This type of operation requires a sensitive reaction of frequency change to a small change of applied direct potential. Such control was not provided in the oscillators referred to above.

(4) Lack of stability. In some applications, such as non-synchronized picture sources, when no convenient stable frequency source is available for locking the oscillator, it is highly desirable to keep the scanning frequency constant. This requirement is not fulfilled even by conventional pulse generators (such as blocking oscillators and multivibrators) unless stabilizing circuits are provided.

Besides these general faults, practically all the schemes have further disadvantages peculiar to their particular design. For example, Rhea's circuit[6] requires the yoke circuit to have an alternating potential to ground, increasing crosstalk difficulties. In Wheeler's and Bahring's circuits, the tube grids are loaded considerably. In spite of these disadvantages, saw-tooth current oscillators were used in Europe, where tube cost considerations outweighed the shortcomings of these circuits.

The circuit shown in Fig. 1 is practically free from the faults described, and is more economical than most of the prior saw-tooth current oscillators. To fully understand its operation, it may be advisable to review the fundamentals of saw-tooth current generation in electromagnetic deflection circuits.

Basic Principles

A reactive saw-tooth current generator is shown in its idealized form in Fig. 2. The battery symbol E_B represents a power source (which can be replaced by a charged capacitor); S is an ideal switch capable of high-speed operation, able to withstand high voltages in its open position, and having perfect bidirectional conduction in its closed position; L represents the inductance of the yoke, and C the incidental capacitance. For the time being, no resistance is assumed anywhere in the circuit.

When the switch is first closed (Fig. 3, curves, time t_1), the current

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SWEEP

will increase linearly with time according to

$$di/dt = E_B/L$$

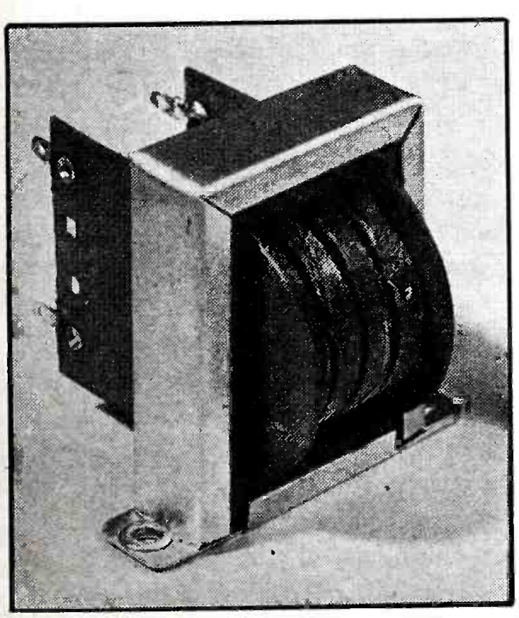
until at time t_2 the switch is opened. The current stored in inductance L will then be discharged through capacitor C in an oscillatory manner. The solution for the equilibrium equation is

$$L\frac{di}{dt} + \frac{1}{C}\int i\,dt = 0$$

$$i = -\frac{E_B}{\sqrt{L/C}}\sin\frac{t}{\sqrt{LC}}\Big)$$

If the switch is then closed at time t_3 at the end of a half period of the self resonance, the inductance returns its energy to the battery again with a current linearly changing with time until t_4, at which time there is a current equilibrium, and from there on the battery will deliver current in a linear manner to the yoke again.

If there were no resistance in the circuit, and a perfect switch could be provided, no external energy would be required to provide a sawtooth current (which would be a wattless current in that case, and the purely reactive load would behave the same way as zero power-factor loads behave with sinusoidal currents). By deflecting the electron beam periodically, there is actually no work done; the reactance of the yoke acts as a fly-wheel moving the beam bidirectionally.



The assembled oscillator transformer has four pie windings. Construction details are given under Specifications

In Fig. 3, curve a represents the voltage that would appear to the left of dotted line A in Fig. 2 if no load were applied to the battery-switch combination. Curve b shows the current flowing through the inductance, and curve c shows the voltage appearing across the inductance,

$$E_L = L\frac{di}{dt}$$

It may be observed that the form of this voltage is substantially identical with the required input voltage. This voltage is, however, far greater than the input voltage, the ratio being

$$E_L = 1.41\,E_B\frac{t_5 - t_3}{t_3 - t_2}$$

Since the yoke always has some resistance, the current going into the yoke has to satisfy the equation

$$iR + L\,di/dt = E_B$$

and it will take the exponential form

$$i = \frac{E_B}{R}\left(1 - \epsilon^{-\frac{R}{L}t}\right)$$

spoiling the linearity of the sawtooth. Greater difficulties are, however, encountered with the resistance of the switch. Normally a grid-controlled electron tube is used for this purpose, with a resistance many times that of the resistance in the yoke. We may resort to impedance transformation, but a limit is found by the fact that the return time is determined by the inductance and the distributed capacitance of the transformer

$$(t_3 - t_2 = \pi\sqrt{LC}).$$

Another difficulty is met by the fact that the electron tube is not bidirectional. It does not conduct until the yoke is discharged, and the voltage across the yoke retains its oscillatory nature until the voltage across it drops below the supply potential, at which time the plate of the tube becomes positive again. In Fig. 3, curve d shows the potential across the yoke under this condition, while curve e shows the corresponding current flowing through the yoke.

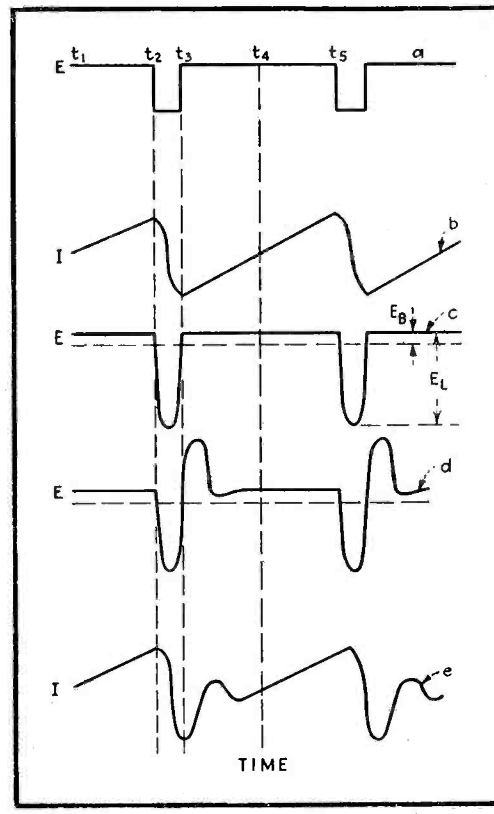


FIG. 3—Current and voltage variations in the circuit of Fig. 2 when the switch is operated

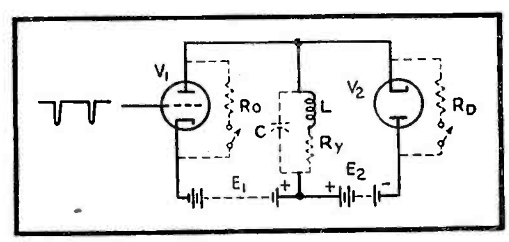


FIG. 4—Elements of basic damping circuit that acts like the switch of Fig. 2

Damping Tube

Blumlein[8] proposed the connection of an inverted diode across the inductance to damp the oscillation and to act as the switch during the period while the amplifier tube is not conducting due to reversed potential on its plate. The analysis of the operation of the damping tube has been described in detail in patent literature.[7-9]

The damped output circuit is shown in its simplest form in Fig. 4. The output tube V_1 is pulsed by a grid voltage as shown, and builds up the current exponentially in the yoke due to its own resistance R_o and the resistance in the yoke R_y until the grid is biased beyond cutoff by the pulse (this pulse must be of considerable amplitude since the plate voltage during the return time assumes a very high value). At this time the yoke current begins its decaying oscillation until the potential across it becomes larger than E_2, at which time the damper tube starts to conduct and maintains a constant potential across the yoke.

Figure 5 shows the currents flowing through the output tube (I of V_1) and the damper tube (I of V_2); it may be seen that they add in the form of a linear total current output. This operation was frequently compared to the push-pull operation of class B amplifiers.

The Tolson and Wheeler patents each show the use of a grid-controlled damping tube[5, 6] to change the impedance of the damper, and thereby improve the linearity of the saw-tooth. The damper, while adding to the available saw-tooth a sizeable portion (about 30 percent greater amplitude), is not a perfect counterpart of the ideal switch, since it does not return the stored energy to the battery E_1, but dissipates the power through another battery E_2, which is normally replaced by an R-C circuit.

The plate of the damping tube V_2 must be connected to the positive terminal of E_1 rather than to the cathode of V_1 due to its high impedance. This requires a higher potential than available from the back swing, as shown in curve d of Fig. 3, to pass the current from the yoke back to battery E_1. To provide a damper tube with a lower impedance, larger cathode area has to be provided, with correspondingly higher filament power requirements, making inroads in the overall efficiency. The damping tube must be able to withstand the high voltage generated across the deflecting circuit during the return time.

Oscillator Operation

The type of pulse required to drive the output tube is identical with the voltage wave shape developed across the deflection yoke or any winding of the output transformer. In Fig. 1, a separate winding on the output transformer is used to feed the pulses to the grid. It was found that by feeding this signal to the control grid of a tube, the frequency adjustment made by R-C in the grid circuit will change the saw-tooth output amplitude materially, and in reverse, any change in the amplitude adjustment altered the frequency. Since the grid in that case was drawing current for a considerable time, and appeared heavily loaded, a sizeable signal was required for synchronizing.

By using the screen of a beam power output tube for feed-back, the control grid was made available for synchronizing purposes. Due to the high transconductance of the control grid, a very small synchronizing signal is adequate to lock in the oscillator. By changing the d-c potential of the control grid, the frequency varies approximately 3 percent per volt change, without any noticeable change of the saw-tooth amplitude.

Figure 6 shows the saw-tooth frequency plotted against the voltage

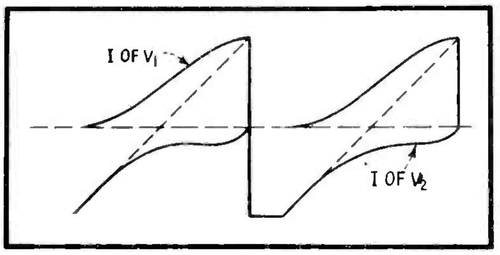


FIG. 5—The combination of the current through the damping tube and the output tube form a linear total current (dashed line)

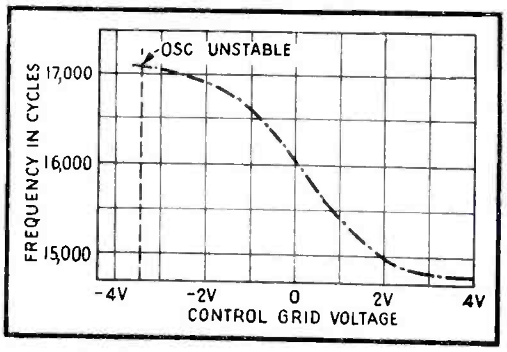


FIG. 6—Saw-tooth frequency and grid voltage for one value of screen voltage

applied to the control grid, at one particular adjustment of the coarse speed control (R in the screen return circuit). The zero-bias frequency may be shifted by the coarse speed control. This sensitivity and behavior make this deflection circuit particularly adaptable for control by automatic frequency control circuits.

The frequency of the saw-tooth current oscillation is determined by the forward and return periods (t_3 to t_5 and t_2 to t_3), but the return time is determined purely by the natural periods of the yoke circuit since during that time the tube is disconnected. The forward period may be determined from the grid voltage developed during that time

$$E_g = E_D + L_g \frac{di_g}{dt} + L_p \frac{di_p}{dt}$$

where E_g is the voltage developed between the screen and the cathode of the oscillator tube, E_D is the voltage drop across the coarse speed control resistance, L_g and L_p are the inductances reflected across the screen grid and plate circuits, respectively, and i_g and i_p are the grid and plate currents.

Since the derivatives of the plate and screen grid currents are constant during the time t_3 and t_4, and the boundary conditions for the forward period are determined by this time and the maximum currents, the value of the last two parts of the above equation may be evaluated as

$$L_g \frac{di_g}{dt} + L_p \frac{di_p}{dt} = \frac{L_g i_{g\,\max} + L_p i_{p\,\max}}{t_4 - t_3}$$

Substituting this value, and solving for the time, we obtain

$$t_4 - t_3 = \frac{L_g i_{g\,\max} + L_p i_{p\,\max}}{E_g - E_D}$$

where the denominator is the potential appearing across the grid winding of the transformer, and is therefore equal to the plate voltage multiplied by the transformer ratio. This final equation shows that the period increases as the resistance in the screen grid circuit is reduced, since i_g *max* then increases in contrast with the conventional blocking oscillator.

Due to the resistance in the circuit, the long portion of the saw-tooth follows an exponential curve, unless provision is made to linearize it. This is accomplished by varying the impedance of the damper tube, in accordance with the inverse of the non-linearity of the trace. In addition, the impedance of the damper tube is made to compensate for the nonlinear characteristics of the oscillator tube. The impedance of the damper tube is varied by controlling the grid through an R-C circuit as shown in Fig. 1. The average value of the impedance may be adjusted by the potential of the screen which serves as a linearity control.

The cathode of the damper tube will be several thousand volts above ground during the return time, and it may break down to the filament if

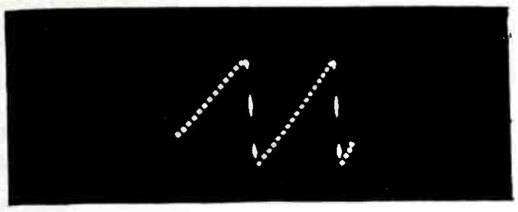


FIG. 7—Saw-tooth current through the deflection yoke

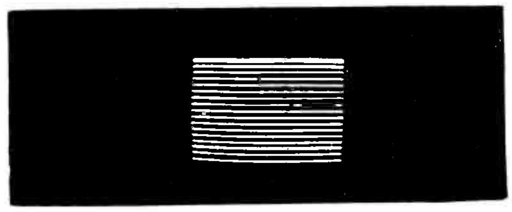


FIG. 8—Linearity of the horizontal deflection

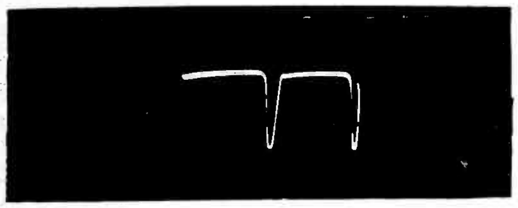


FIG. 9—Voltage across grid winding of transformer

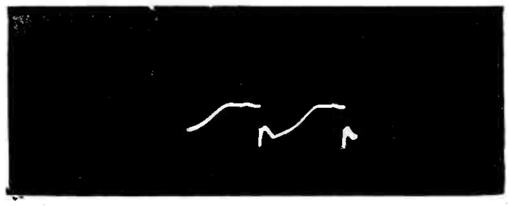


FIG. 10—Cathode current of oscillator tube

the latter is at ground potential. The capacitance of the cathode to ground also must be minimized, since it appears directly across the transformer, and it will influence the length of the return time. This situation can be easily remedied by floating the filament above ground either by using a separate filament transformer with low capacitance for the damper tube, or by connecting the filament to the supply through a double choke so that the cathode-filament capacitance is in series with this inductance. Such chokes can be made very economically, and specifications for one may be found at the end of this article.

Figure 7 is an oscilloscopic picture of the trace of the saw-tooth current through a five-ohm resistor connected in series with the deflection yoke. The beam was modulated by a voltage with a frequency of approximately 300 kilocycles to show the length of the retrace time.

To show the linearity of the deflection, the horizontal deflection frequency of the oscilloscope was lowered to make the dots form lines as shown in Fig. 8; the even distribution of the horizontal lines provides an indication of the degree of linearity obtained.

Figure 9 shows the voltage across the grid winding of the transformer and Fig. 10 shows the current flowing through the cathode resistor of the oscillator tube.

Several tetrodes, pentodes, and beam power amplifier tubes were tried as the oscillator, such as types 6Y6, 6L6, 6V6, 6F6, 6K6, 48, 807, and Western Electric types 339A and 350B. The largest deflection currents were obtained with the last two types. The Western Electric type 350B is very similar to the 6Y6G type, but the screen dissipation is four watts against the 1.75-watt rating of the 6Y6, or 2.5 watts of the 6L6.

The screen potential is approximately 100 volts during the forward trace, and it draws a current of 20 to 40 milliamperes. If this power is permitted to heat the screen excessively during the retrace period, when the screen swings 1,000 or more volts negative, it will emit thermionically, and some of the electrons are collected by the No. 1 grid, charging it negative and increasing the frequency as can be seen from Fig. 6.

Due to the thermionic conduction to the No. 1 grid, the synchronizing input impedance is lowered and the pulse, or d-c control source, will be loaded. It is possible to feed the afc potential through one of the i-f amplifiers and take the d-c variations of the cathode resistor of the same tube. However, this seems to be an unnecessary complication when a tube with proper screen dissipation can be constructed.

In certain applications when no primary synchronizing source is available, it is desirable to have a basic stability, comparable to that of sinusoidal oscillators. It was found that by connecting a high-Q resonant circuit in the control grid circuit, this circuit will be shock excited and produce a sine wave determined by its inductance and capacitance. The oscillator will then lock in on this frequency, and the stability will depend primarily on the constancy of the L-C circuit.

Figure 11 shows the circuit diagram of the stabilized oscillator. In this case the damping tube is connected across the grid winding, thereby placing the cathode near ground potential. This circuit eliminates the necessity of floating the filament, but, due to the leakage inductance, it places slight ripples in the return trace. These are not objectionable unless the pulse is to be used for d-c reinsertion, keyed avc, or like purposes.

Specifications

Oscillator Transformer

Core: 30211-3 and 30211-4
Center leg: 37/64-inch square stack
Window: 37/64 x 17/16 inch
MLMC: 10.6 centimeter
Height: 2-5/16 inch
Width: 1-⅝ inch
Material: 0.003-inch silicon steel P.S. 188 Butt Joint
Coil: Wind yoke winding first, 80 turns No. 24 wire layer wound. Plate winding, 400 turns No. 30 wire, two 3/16 pies, universal winding. Grid winding—same as plate winding. Plate and Grid windings are wound on top of yoke winding side by side.

Dual Filament Choke

Core: 63917-2
Center leg: ½ inch, square stack
Window: ¼ x 13/16 inch
MLMC: 8.4 centimeter
Height: 1-11/32 inch
Width: 1-½ inch
Material: 0.014-inch silicon steel
Air gap: 0.05 inch
Coil: 500 turns each of No. 34 wire wound parallel, 0.002-inch paper between layers
Inductance of one winding: 0.5 henry
Total resistance: 125 ohms

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(8) Blumlein, A. D., U. S. Patent 2,063,025.
(9) Tolson, W. A., U. S. Patent 2,280,733.

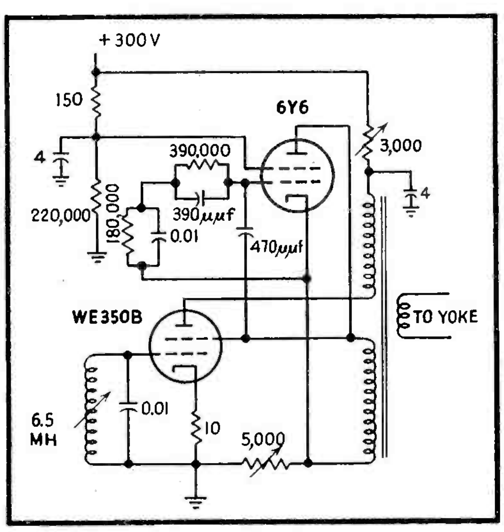
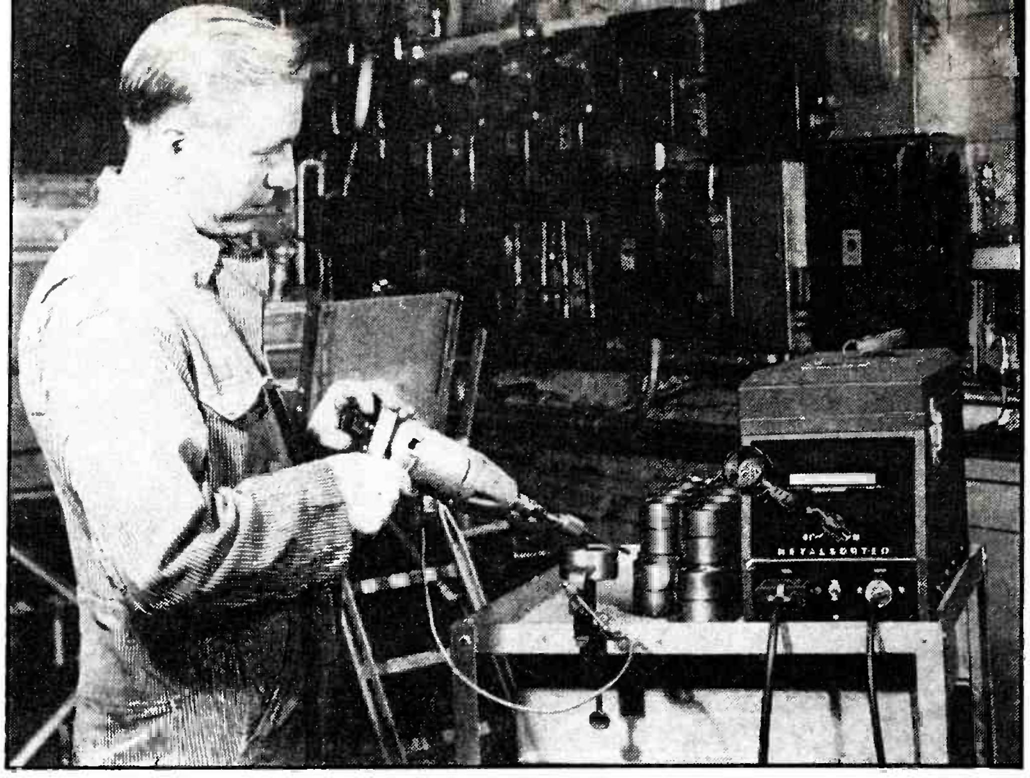


FIG. 11—To stabilize the saw-tooth oscillator, a resonant circuit is introduced into the grid circuit



Checking machined alloy products to make sure all have same composition. Operator is adjusting knob on reciprocating tool to balance out stray voltages before making test

SORTING

Portable instrument for machine shops sorts mixed-up bar stock, transformer laminations, billets or castings according to chemical composition by rubbing a known metal against the unknown for an interval determined by an electronic timer. The resulting triboelectric voltage is measured with a mirror galvanometer, using a bias rectifier for balancing

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Unavoidable mixups of steels and other alloys in various stages of fabrication have always existed in metal-working plants. For instance, a stack of billets may upset and spill over, upsetting adjacent stacks having the same size and appearance but different composition. Machining operations obliterate paint, tag, or stamped identification markings, and oftentimes unused portions of bar stock are replaced after the painted ends have been cut off.

Increased production rates, highly critical end uses, closer chemical specifications, and the need for conserving scarce alloy constituents combined in recent years with this accidental mixing of metals to focus technological attention on development of a rapid method of sorting both ferrous and nonferrous alloys. One solution to this problem, described here, employs the triboelectric effect for sorting metal pieces of any shape or size at a rate of approximately thirty pieces per minute.

When two metallurgically dissimilar metals in contact with each other are moved, a voltage ranging from a fraction of a microvolt to several millivolts is generated, depending upon the metals. The principle is that of triboelectrification, observed by Thales of Miletus in 600 B.C. when he rubbed amber against another material, and is caused by a redistribution of electrons on the interfaces of chemically dissimilar substances that are brought into intimate contact and then moved so as to generate some friction. With dielectric materials the observed effect is a static charge measurable with an electroscope, whereas with conductors the redistributed electrons can be made to flow through a connected circuit and produce a measurable current.

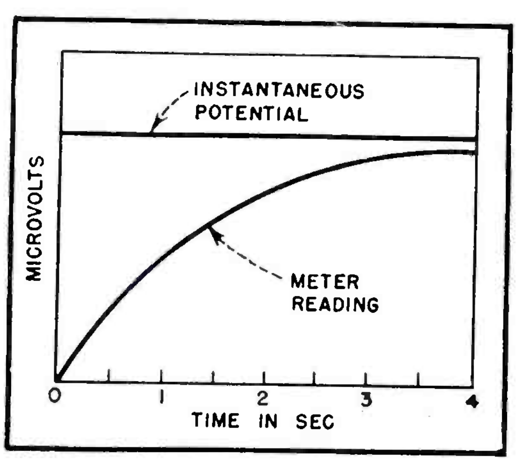

FIG. 1—Manner in which reading of microvoltmeter builds up from zero to approach instantaneous triboelectric voltage value

Since heat treatment of most alloys produces chemical changes, the method can also be used to distinguish between heat-treated and hot-worked alloys coming from the same heat or melt. The manner of creating the moving contact is not critical provided it is carried on long enough to develop saturation potential. For a reciprocating tool operating at ten strokes per second this is about four seconds, as illustrated in Fig. 1. A lubricant is used on the surface of the standard metal during tests to minimize chances of scoring, because any scoring or erosion of metal during the test will introduce an error in indication.

Circuit

In the commercial instrument utilizing the triboelectric principle, the electronic circuit shown in Fig. 2 controls the total operating time for a test and provides a biasing potential to balance out any parasitic or thermoelectric currents. A commercially available motor-driven reciprocating tool having a ⅜-inch stroke provides the motion. A known or standard rod of metal is placed in the chuck of the tool, one connection is made to the unknown specimen through the standard rod, and the other through the tool fork. The known metal is held stationary on the unknown while a control on the

Commercial version of triboelectric instrument, used here for sorting transformer laminations accidentally punched from two different grades of steel

ALLOYS

tool is adjusted to bring the meter indicator to zero. Pressing a button on the tool then starts the reciprocating motion of the known metal in the chuck. The reading of the microvoltmeter is taken after the tool has been automatically stopped. If the reading is substantially zero, known and unknown metals are identical; if different, the polarity and magnitude of the reading are indicative of the degree and nature of the dissimilarity.

In general, all metals and alloys may be arranged in a triboelectric series such that a metal which precedes another metal in the table will always be found to be positive with respect to the succeeding metal. Thus, if five metals—A, B, C, D, and E—are arranged in this way, C will be slightly positive with respect to D and more positive with respect to E, and conversely, C will be negative with respect to A and B.

The portable mirror galvanometer serving as microvoltmeter is connected across the junction between known and unknown metals. Any reading obtained before the reciprocating tool is started is balanced out by adjusting the one-ohm rheostat, which introduces in the meter circuit the required small bucking voltage with whatever polarity is required. This voltage is obtained from a full-wave rectifier circuit operating with 6.3 volts on the filament and plates; no filtering is required since the period of the galvanometer is far longer than that of the 60-cycle power line.

Capacitor *C* is normally charged from the 90-volt source to the indicated polarity by grid rectification of the 2050 thyratron, the circuit being completed through the series motor and the contacts of the relay each half-cycle. When the start switch is closed, 90 volts a-c is applied to the series motor in the tool and to the thyratron timing circuit. Reciprocating action starts, but capacitor *C* holds the thyratron grid sufficiently negative to prevent the tube from firing. The start switch changes the grid voltage to a much lower value determined by the setting of the time control potentiometer, so that *C* begins discharging through its 2-megohm shunt resistor the instant the switch is closed. When the capacitor voltage drops sufficiently, the thyratron fires and its plate current pulls in the relay, opening the motor circuit and terminating the test. A snubbing circuit across the relay coil ($8\mu f$ in series with 750 ohms) keeps the relay armature closed between rectified pulses. Releasing the start switch button allows the relay to drop out, reclosing the tool circuit and recharging *C* for the next cycle.

The 6X5 tube, a slow-heating rectifier connected as a diode in the thyratron plate circuit, protects the thyratron against damage in the event that the start button is pressed before the thyratron heater is up to temperature.

Since this instrument is nondestructive, it may be applied to identification of built-up machinery, assembled vehicles, or any combination of metals. The fact that the pieces being tested may be in metallic and electrical contact with adjoining members does not affect the accuracy.

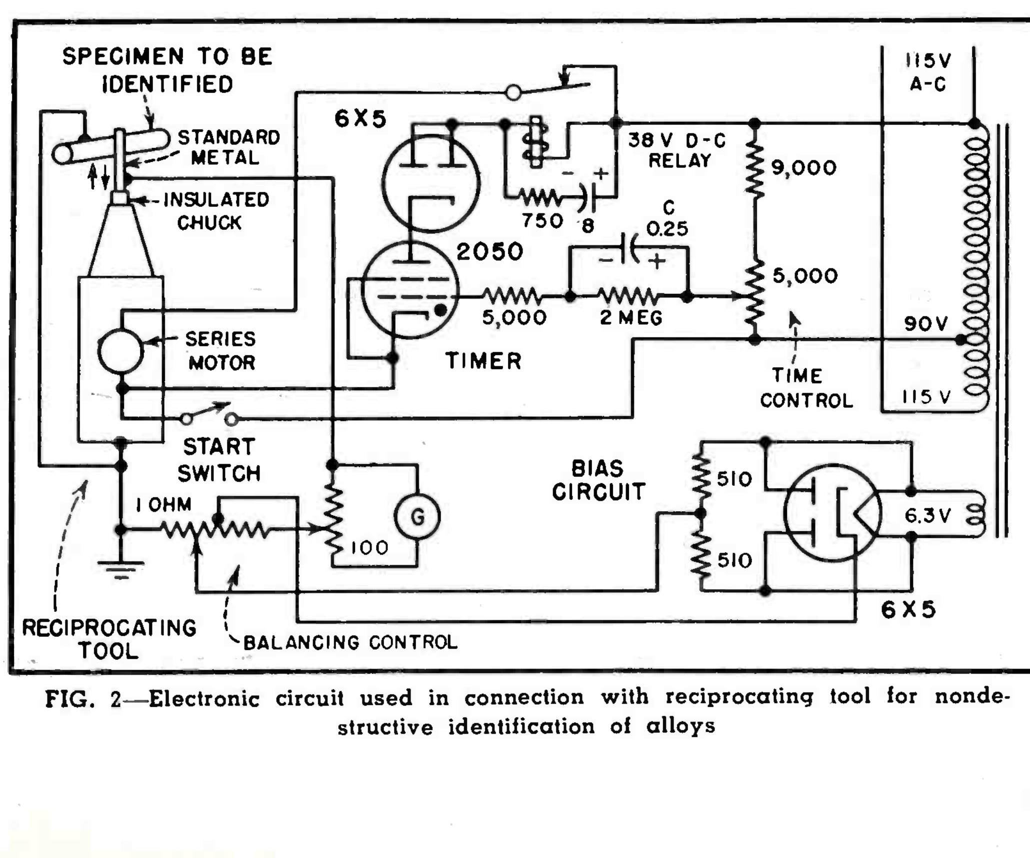

FIG. 2—Electronic circuit used in connection with reciprocating tool for nondestructive identification of alloys

Pulse Modulating System

Functions performed by circuits of pulse-position modulated communication equipment are described. Although these are familiar circuits, their uses are novel. Circuits must provide extremely accurate timing to minimize circuit noise and to prevent interchannel crosstalk

MICROWAVE RADIO SETS for long distance communication, perfected during the war, are being applied to domestic telephone circuits. One such application is the Bell Telephone Company's installation of pulse modulation equipment between Chicago, Ill. and Milwaukee, Wis. This circuit can handle telephone, telegraph, and facsimile, and uses equipment of the type manufactured for military use and identified as radio set AN/TRC-6.

Set Characteristics

The radio set, shown perspectively in Fig. 1, is a combination ultrahigh frequency radio transmitter and receiver with multiplex arrangements for providing eight two-way radio telephone channels between two line of sight points. The set has been used successfully up to distances of over one hundred miles line of sight, and by placing radio sets back to back a radio relay of any desired length is possible.

The radio transmitter employs a highly directive antenna system shown in Fig. 2 that gives a beam whose width is approximately plus or minus two degrees measured where the decrease in signal is five decibels from the maximum. The carrier wavelength is in the order of six centimeters; average output power is approximately a quarter watt.

Any one of the eight channels is so designed that it can carry voice frequency, telegraph, teletypewriter, or facsimile signals. Carrier telegraph terminal equipment can be directly connected to the equipment, thus giving an arrangement whereby four carrier telegraph channels can be carried on one voice frequency channel. The multiplex permits either four or two wire termination in combination to give up to eight channels (see ELECTRONICS May 1946, p 124).

A relatively new type of modulation is employed on the system, namely pulse-position modulation with time-division multiplex. This multiplex, in effect, consists of sending eight different channels in sequence, only one channel pulse being transmitted at any instant. Each channel pulse occupies about ten per-cent of the total transmission time. The pulse-position modulation is such that a channel pulse that is generated in the transmitting circuit is changed in its position relative to other transmitted pulses in accordance with the amplitude and frequency of the impressed voice frequency.

Set Installation

Four carrier-frequency bands are

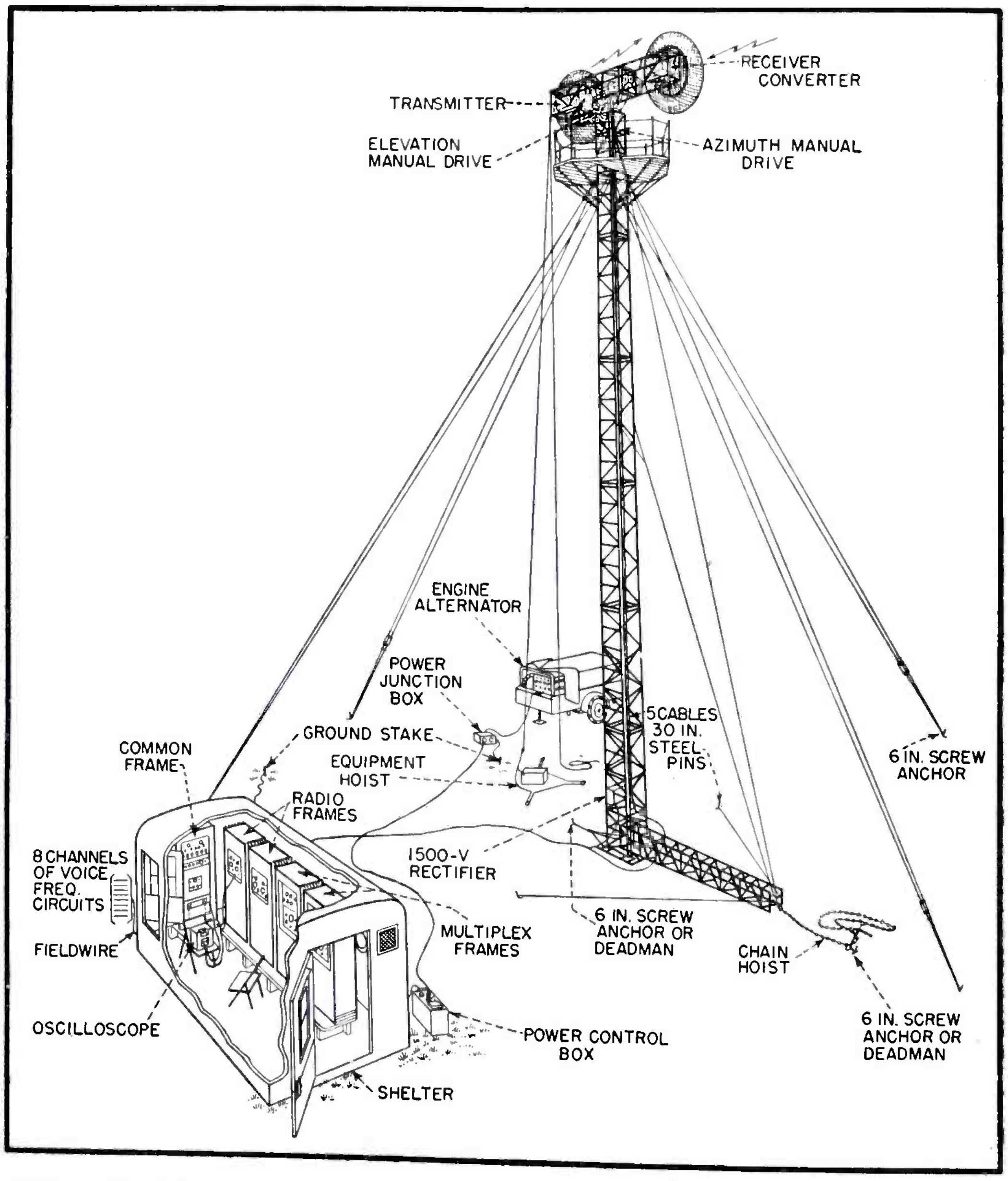

FIG. 1—Field layout of pulse modulation voice multiplex microwave communication terminal

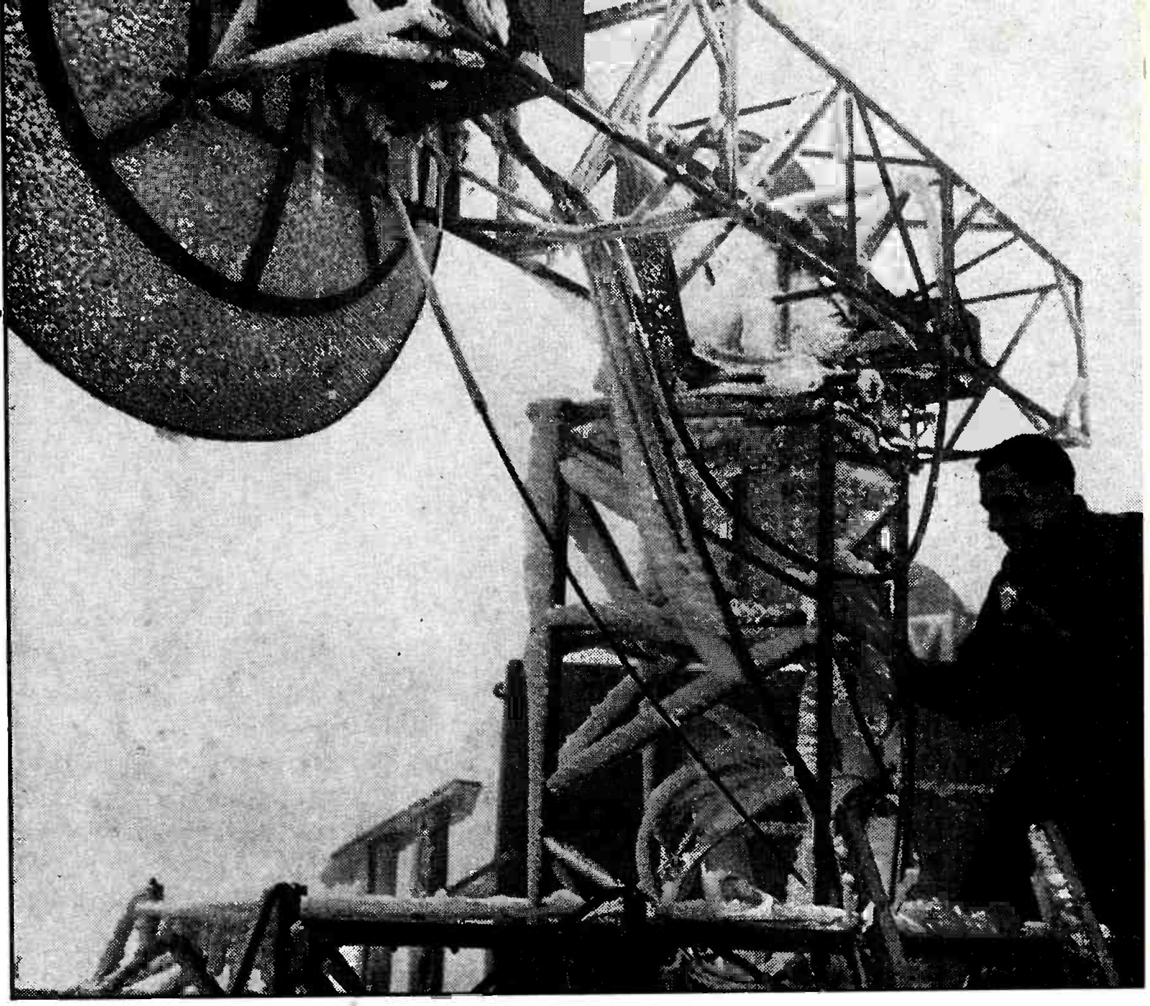

FIG. 2—Author checks operation of equipment. Alpine winter weather did not interfere with microwave radio communication

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available, each band having a separation from the adjacent band of 150 mc. This separation is provided so that several sets can be operated at the same location without causing interference between sets.

The main components of the set consist of a common frame, multiplex frame, radio frame, the radio transmitter, and the radio receiver converter. The functions of each of these component parts will be discussed in detail.

At a relay station it is necessary to patch the incoming received signal to the outgoing transmitter and this may be done by either of two methods. One method is to use the multiplex and bring all eight channels down to voice frequency and then patch to the next transmitting multiplex. However, a better method is to use the video repeater in the common frame, which brings the signals down only to a video frequency, and then patch this to the new video input. When the latter method is used an arrangement is offered whereby one channel is automatically brought to voice frequency so that it can be used as an order-wire or engineering channel.

The equipment is so designed that it is self contained and very easily transportable. The time required for a complete installation averages about four hours. Arrangements must be made beforehand as to when to go on the air and when to begin searching for a contact because of the sharpness of the antenna pattern. This procedure is quite simple and requires no more than correct azimuth and coordination of time. Once contact has been made between two stations, the gain of the circuit may be improved by local tuning at each station. Manual drives shown in Fig. 1 are for aiming antennas.

The transmitting multiplex is that component in which the voice frequency signals are superimposed on the various channels and are converted into "pulse-position modulated time-division" signals which in turn are carried to the radio transmitter by means of coaxial cable for transmission over the radio relay system.

The pulse-position modulated signal is of fixed amplitude and is for one microsecond duration, with a recurrence period of 125 microseconds. As each channel will occupy only a very small fraction of the total time for each complete 125 microsecond cycle, the term time division is used, each channel having an equal share of the total time.

The channel is so set up that from its own center, a pulse cannot go too far from the unmodulated position, thus preventing overlap of pulses, which would cause crosstalk between channels. In this connection, the tolerances of the circuit components in some cases must be within one percent while in other cases a tolerance of five percent is permissible. These narrow tolerances insure that timing will be within the required accuracy to prevent crosstalk. The amplitude of the voice frequency signal will determine the displacement of the channel pulse at the time it is modulated. The system is so arranged that when modulated with voice frequency the total width through which the pulse is displaced cannot be greater than 12 microseconds per channel. Each channel is alloted a width of approximately 15 microseconds. With the channel recurring every 125 microseconds, and allowing 12 microseconds per modulated channel, a duty cycle of about ten is obtained. The input voice frequency signal is limited by a low-pass filter so that it is cut off for any frequency greater than 3,000 cycles per second.

Figure 3 shows a simple block schematic of a typical channel, and while all channels are very similar a slight difference is actually incorporated into the various channels so that the time division will be correct. However only one channel will be described in detail, the same basic circuits applying to any channel. With each group of eight channel pulses there is a marker pulse, whose duration is four microseconds, and precedes the pulse of channel one. This marker pulse may be considered as the master timer for the entire system and, as it is not modulated, it requires no extra space to prevent crosstalk. The complete cycle, i.e. the marker pulse and the eight channel pulses, has a recurrence frequency of 8,000 cps.

Figure 4 shows a complete 125

microsecond cycle of the marker pulse and the eight unmodulated channel pulses. When there is no modulation present on any channel this is the envelope that the transmitter sends over the air.

Modulator Circuits

The basic *oscillator* of Fig. 3 is of the Hartley type and has a fundamental frequency of 8,000 cps, which fixes the recurrence frequency, and provides a suitable waveform with which to trigger the channel pulse generators and the marker pulse generator. The output of the oscillator is a positive-going rectangular wave, whose positive portion is for 90 microseconds, and whose negative portion is for 35 microseconds duration.

For the *clipper* the oscillator output voltage is fed back through a feedback circuit the output of which is in turn clipped, thus giving the desired rectangular waveform which triggers the several pulse generators.

The *marker generator* is employed to generate the four-microsecond pulse. This pulse then passes through a *marker amplifier* where it is clipped so as to give the desired rectangular waveform. It is then mixed with the channel pulses in the video amplifier. The marker pulse is generated and placed in its correct position in the transmitting multiplex, but it does not however enter into the actual voice transmission. Its primary function is in the receiving multiplex where it is used to maintain synchronism for receiving circuits.

The *exciter* for the channel is started at the same time as the marker generator and produces a positive-going rectangular pulse which is fed to the pulse-position modulator. The output pulse of the exciter is a pulse of two-microseconds duration.

The voice frequency to be impressed on the channel passes through a 3,000 cps low-pass filter to the input of a *voice-frequency amplifier*. The amplified voice-frequency signal is then sent to the pulse-position modulator where it is impressed on the channel pulse.

The *pulse-position modulator* is a form of a one-kick multivibrator, whose various components are so chosen that no free oscillations will take place, except when it is externally excited.

A dual triode (6SL7GT) is used as the pulse-position modulator, the cathodes of which are tied to ground through a resistance. The grid of the second section is positive so that the cathode potential is 50 volts above ground. The first grid is at a steady potential of 35 volts above ground, hence there is no plate current flowing in the first section. When a short positive going pulse of more than 15 volts in amplitude hits the grid of the first section, the tube conducts for the duration of the pulse. The resulting flow of current in the first section drops the plate voltage of this section and this drop reduces the grid voltage of the second section. The cathode load completes the positive feedback loop.

When the plate current of the second section drops, the cathode potential drops; hence a steady plate current flows to the first section after the triggering pulse has ceased. The transit time is adjusted to place the triggering pulse in its unmodulated position.

The *video amplifier* serves several purposes. First it receives the signals from the pulse-position modulator and amplifies them. Secondly it takes these received pulses and by means of clipping produces a wave which is extremely rectangular in shape. Before the final stage of video amplification the marker generator pulse is combined, in time, with the eight channel pulses and the complete group of pulses go to the final stage. This stage is operated as a cathode follower, and the cathode output is sent to the radio transmitter through a coaxial cable.

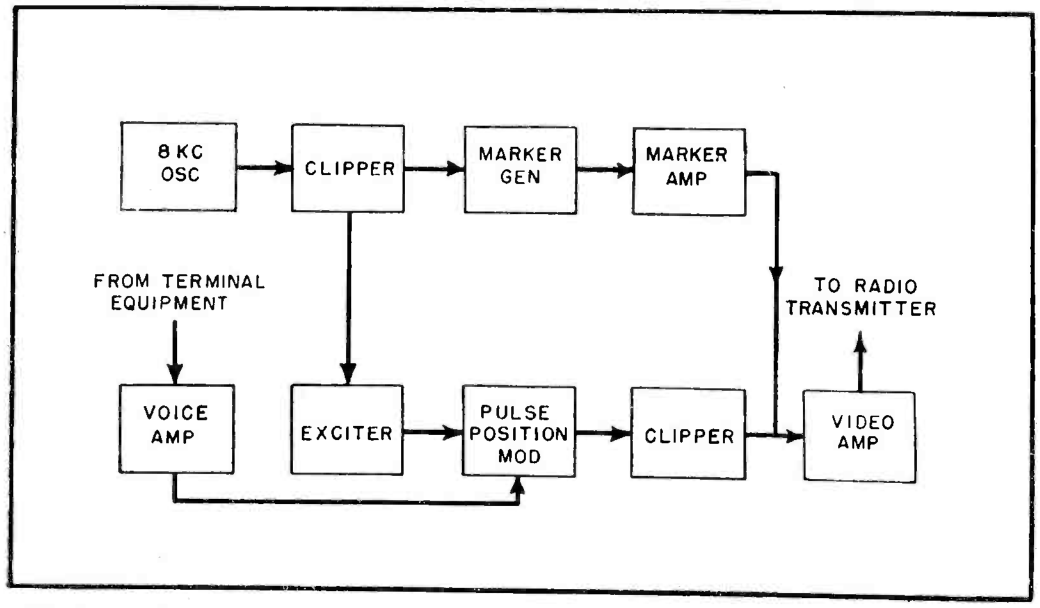

FIG. 3—Block diagram indicates sequence in which one channel of the voice signal position-modulates the pulses for transmission

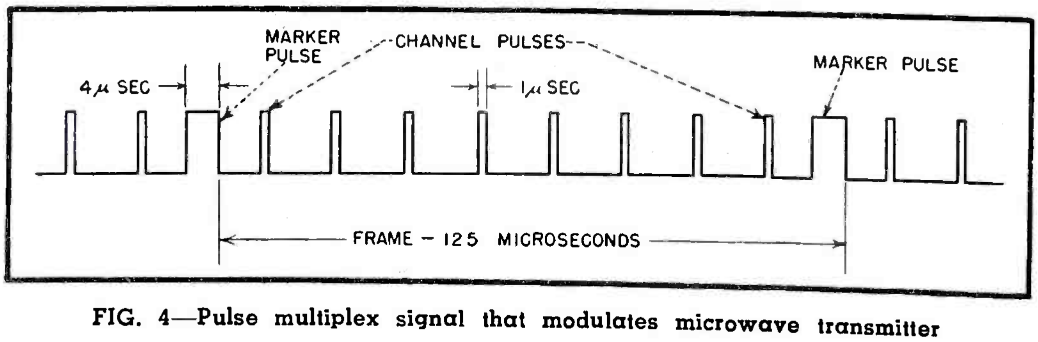

FIG. 4—Pulse multiplex signal that modulates microwave transmitter

Radio Frequency Circuits

The radio transmitter which sends the group pulses over the line of sight path is of the pulsed ultrahigh frequency design. The video triggering pulses from the transmitting multiplex are further amplified by two more stages of video amplifier located in the radio transmitter. These stages also provide a wave shaping circuit which corrects some of the loss of wave shape introduced by the relatively long video cable.

The modulator tube develops a negative 1,000-volt pulse in its plate circuit, being fed by the last video stage. This pulse in turn triggers the transmitter tube, which is a velocity modulated vacuum tube; namely a reflex Klystron. It should be noted that oscillations occur only during

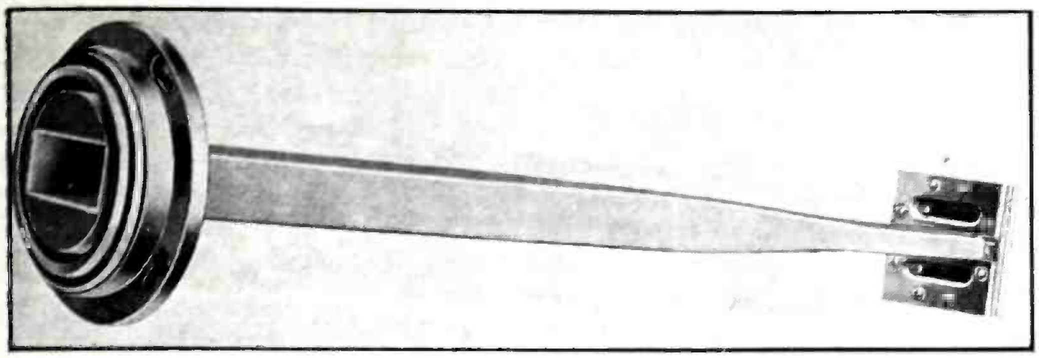

FIG. 5—Waveguide from transmitter is terminated in slot dipoles, at extreme right, which radiate back toward the parabolic reflector

the interval when the modulator supplies power. The oscillator tube can be tuned to the desired frequency by adjusting the physical dimension of its cavity resonator. The output from the transmitter is fed into an adjustable wave guide and is then sent to the remainder of the antenna system. This system for the transmitter consists of a wave guide as shown in Fig. 5 and a parabolic reflector as shown in Fig. 2.

A small portion of the signal being sent over the air is taken off and used for monitoring, using a crystal rectifier. The peak radio-frequency power output is about 2.5 watts, the average power being approximately 0.25 watt. The transmitter tube is so designed that it can be tuned to any one of four different frequencies. The circuit is shown in Fig. 6.

Receiving Multiplex

The receiving multiplex receives the marker pulse and the eight channel pulses at the recurrence frequency of 8,000 cps from the receiver radio converter (described later), and separates the channel pulses and converts each one to its original voice frequency. To do this separation it is necessary to generate gate pulses at the correct time for each channel pulse. Also the voice-frequency signal must be amplified and filtered before being sent to the termination equipment.

Figure 7 shows a simplified block schematic of a typical channel of the receiving multiplex. As in the transmitting multiplex, all channels are similar and hence only one channel will be described in detail.

The uhf radio receiver converter sends to the receiving multiplex the channel pulses and the marker pulse as a video signal through a coaxial cable. The output of the *video amplifier* in the receiving multiplex is divided into two parallel signals. The output of the video amplifier is a series of negative pulses whose amplitudes are in the order of ten volts.

These pulses go to both a pulse amplifier and to the marker selector circuit. It is desirable to use the trailing edge of the received pulses due to the fact that they are straighter and less noisy than the leading edge.

To use the trailing edges new pulses are generated in the *pulse amplifier*. However the trailing edges of the newly generated pulses correspond in time to the leading edges of the pulses which are received from the transmitter. Hence in reality a wave shaping circuit is employed. By accurately selecting the circuit components the amplifier will deliver these new pulses with only a slight error in time, which in effect has only a small increase on the noise of the channels. The new pulses are further amplified and the output is a positive going series of pulses whose amplitude has been increased to approximately 25 volts; these new pulses are then delivered to the eight pulse converters, one being used for each channel.

The *marker selector* stage is a pentode tube, and during the interval between pulses the grid is very slightly positive, and the plate voltage is low. The negative pulses from the video amplifier of ten volts amplitude, cut off the plate current in the tube. The components of the circuit are so chosen that this one-microsecond pulse will not cause the tube to operate; however the four microsecond marker pulse produces four times the charge of the one microsecond pulse thereby tripping the tube, and this pulse is received between every group of eight channel pulses.

Output of this pentode is amplified

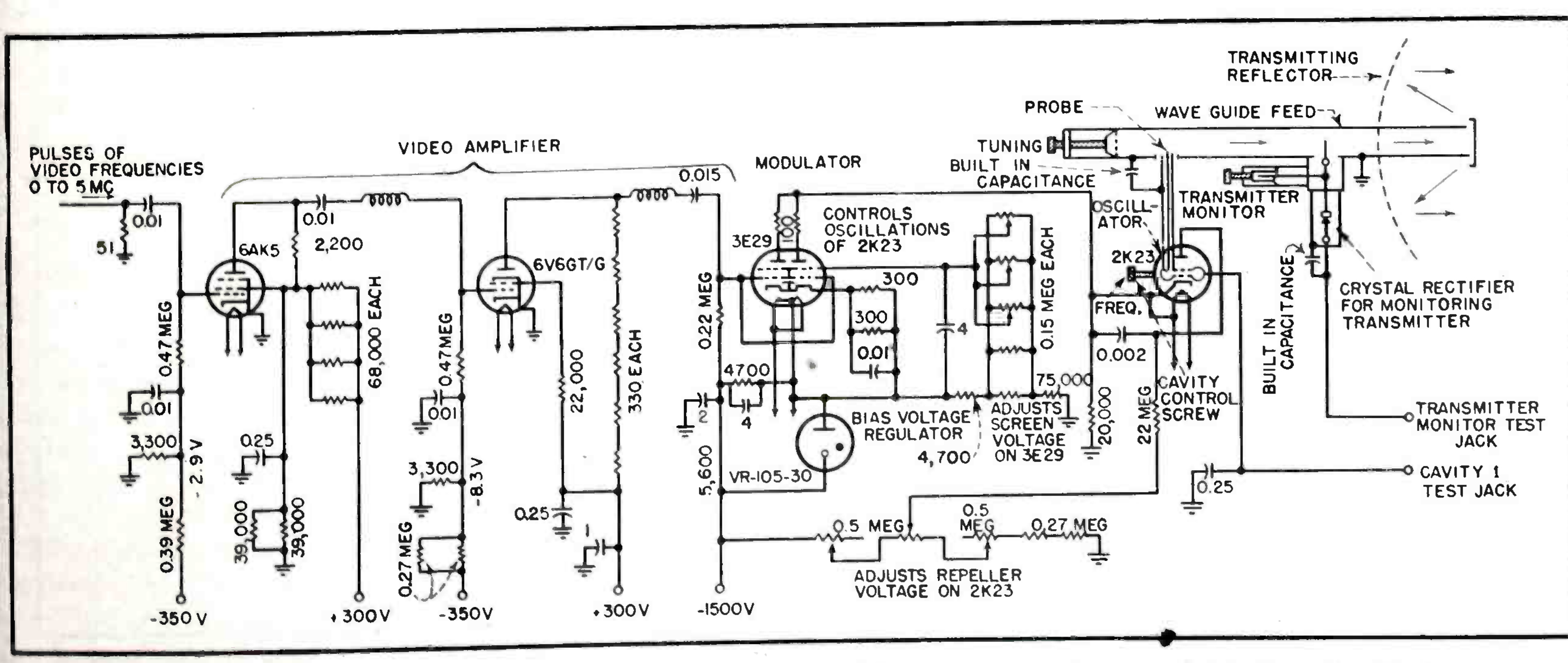

FIG. 6—After additional amplification, the multiplex position-modulated pulses amplitude modulate the reflex Klystron

by the *marker pulse amplifier* which is biased at about 20 volts so that if the marker selector passes the channel pulses they will not cause plate current to flow. However the marker pulse will cause the flow of plate current.

To separate the channel pulses it is necessary to have gates at the proper time, which will synchronize properly with the eight channel pulses. The *square wave generator* used to develop these gates is a multivibrator, which operates on the pulse from the marker amplifier. The multivibrator is synchronized very accurately with the marker pulse, the circuit constants being so chosen that if it does not synchronize it will run somewhere below 8,000 cps.

The multivibrator output goes to the *sweep generator* which delays the various channel pulses by the desired duration. This delay is accomplished by the generation of sweep voltages and starting the gate pulses at a time when the sweep voltage crosses a given reference voltage level, different for each channel.

The gate is produced in a *gate generator*. When the pulses are received from the pulse amplifier they are all present, each channel being in its correct position with respect to time. There are eight gate generators, and each one generates a gate of about 13 microseconds, each being spaced correctly with respect to time. The gate for any given channel will lift the channel pulse from the group of pulses and place it on top of the gate pulse. The marker pulse is also present but the gates are so arranged that they will reject it as it is useless for this part of the circuit; it has already been picked off by the marker selector circuit.

The pulses received at this stage are voice modulated, but it is now necessary to remove the pulse and leave only a voice frequency signal. This is done by the *pulse converter*. The channel pulse, which is still one microsecond in width, is varying in time according to the degree of voice frequency modulation. Hence it may be said to be position modulated. If now the pulse-position modulated signal is converted to pulse-length modulation, an audio signal will be obtained.

To do this conversion a relaxation circuit is employed. The pulse which is being modulated by a voice frequency rides on the gate, the gate itself being insufficient to cause plate current to flow through the tube. However, the gate voltage plus the channel-pulse voltage is sufficient to cause the tube to conduct, starting the relaxation circuit. The end of the gate causes the grid to go negative again and cuts off the tube in the relaxation circuit, which will return to its normal condition until such time as it receives another pulse superimposed on a gate.

The edge of the pulse which is being varied at an audio rate by the superimposed voice frequency from the transmitting multiplex is then passed through a 3,000 cps *low-pass filter*. It is also desired to eliminate any of the 8,000 cycle per second recurrence frequency which may have gotten through so there is also a rejection filter for this frequency. The voice frequency is now passed through a voice frequency amplifier to a hybrid coil whence it terminates in either a two-wire or a four-wire system.

Ringing and Alarm Circuits

Ringing in the transmitting multiplex is accomplished by a 20 cps ringer, and this in turn removes the channel pulse from the particular channel on which it is desired to signal.

In the receiving multiplex the channel pulses are normally being received, and these pulses are fed simultaneously to the pulse amplifier and to the ringing circuit. They enter the ringing circuit and under normal (non ringing) conditions are impressed across a Varistor circuit. The following ringing stage is thus held at negative cutoff. When the pulses are removed at the transmitting end, the ringing stage goes positive and causes a ringing relay to operate, thus signaling the next station on the particular channel. Arrangements have been made whereby ringing is from terminal to terminal (not relay to relay) except on the order-wire channel.

The marker alarm circuit is similar to the ringing circuit and operates whenever the marker pulse is removed from the circuit. This pulse however cannot be removed, as the channel pulses are for ringing, hence the removal of the marker pulse signifies that there is trouble between stations.

Various keys (bridge and testing) are provided so that any channel can be isolated for quick maintenance or in case of a failure on any channel. Thus the loss of one channel pulse will not render the remaining channels inoperative.

Radio Receiving Equipment

The radio receiver consists of two parts, namely the receiver converter, and the i-f amplifiers and associated circuits. The converter is located on the tower behind the receiving waveguide and the receiving parabolic reflector. The uhf pulses being received from the transmitter are hetrodyned with a beating-oscillator voltage giving an output of 60 mc

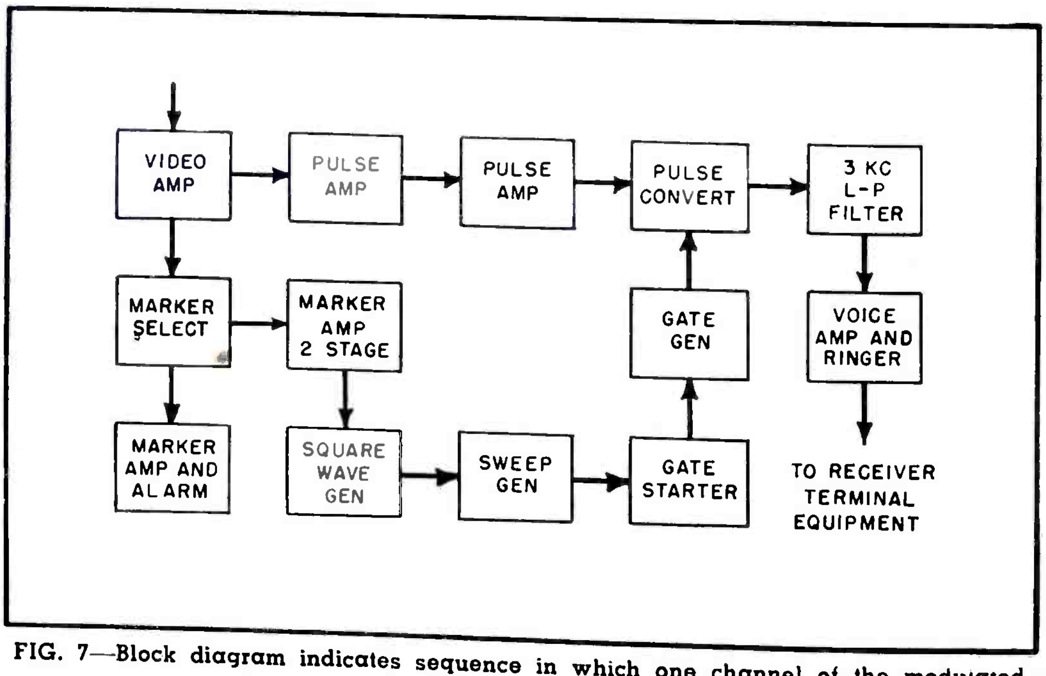

FIG. 7—Block diagram indicates sequence in which one channel of the modulated pulses is converted to voice signal in reception

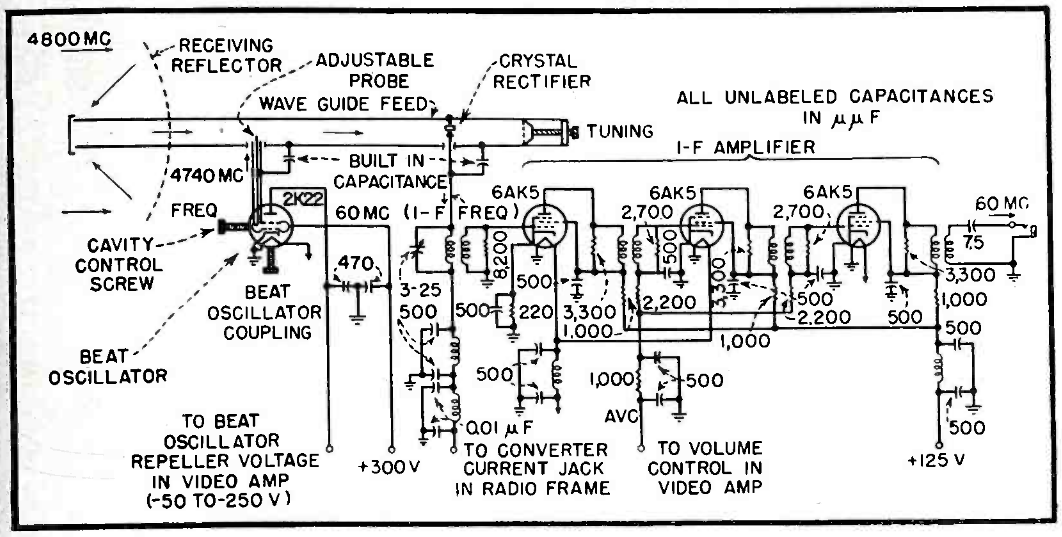

FIG. 8—Using a reflex Klystron as a local oscillator, the receiver converts the microwave carrier to the intermediate frequency in a crystal

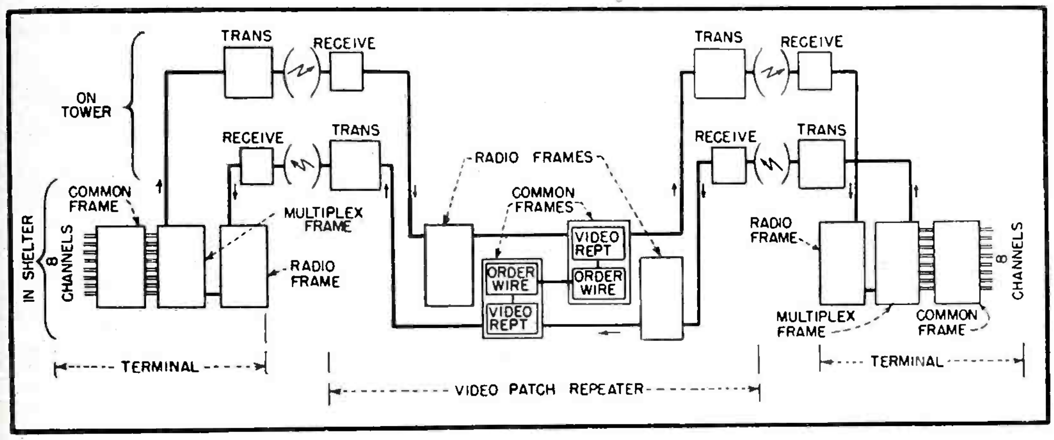

FIG. 9—Two sets connected back to back through their radio frames act as relays for links longer than line of sight

as shown in Fig. 8. This i-f frequency is passed through several stages of pre-amplification and then passed down through a coaxial cable to the remaining receiving equipment.

The beating oscillator is of the velocity modulated type, and is similar to the reflex Kylstron used in the transmitter. A crystal frequency converter is employed which is incorporated in the wave-guide feed line.

The i-f frequency after leaving the coaxial cable is passed through five more stages of amplification, then detected and the resultant video frequency is further amplified and clipped by means of a several stage video amplifier. The new output is taken to the receiving multiplex where it is again amplified and passed on to both the pulse amplifiers and the marker selector.

Included in the receiving circuits are both an autovolume control and an automatic frequency-control circuit. The automatic volume-control circuit is conventional and the automatic frequency-control circuit makes use of a discriminator coil, which operates when the frequency departs from the resonant frequency.

Automatic Frequency Search

An interesting circuit is employed in the receiving equipment to take care of a case where for any reason the received carrier frequency that be interrupted, thus causing the absence of the i-f frequency which in turn operates the automatic frequency control. When such is the case it is possible that the beating oscillator may drift so widely from the received carrier frequency that when transmission is again resumed the i-f may be so different that it cannot be passed through the highly selective circuits in the amplifiers. To eliminate such a case, the beating oscillator is made so that it will search for its operating frequency.

This operation is done by a frequency search circuit. By the use of a saw-tooth voltage, which is generated when the transmitter pulses are lost for any reason, the beating oscillator repeller voltage is made to vary over a predetermined voltage range. This sweeping will continue as long as the signal is not received. The frequency swing is a broad 30 mc sweep. Arrangements are made by which the sweeping stops at the correct point past which it is sweeping when a signal from the transmitter is received. A manual frequency search is also obtainable and when this is being used the automatic frequency search is held quiescent until such time as it is desired to return to automatic operation.

Common Frame

The Common Frame consists of a regular and spare video repeater, a voice frequency telegraph arrangement and the required binding posts and circuit breakers. The telegraph arrangement will not be discussed here, but suffice it to say that it consists of a 425 cps voice-frequency carrier arrangement. The binding posts permit the termination of either two or four wire by the use of hybrid coils.

The video repeater is in reality a miniature multiplex with arrangements for channel one to be used as an order wire, while the remaining seven channels are kept at a video level as illustrated in Fig. 9. Incorporated in the video repeater is an emergency pulse supply and an automatic electronic transfer device, which comes into operation if the backward transmitter should fail. While this failure would stop all communications over the entire link, it does however permit the trouble to be localized to any one relay station, and thus reduce the time to bring spare equipment into use.

The fidelity of the speech over the radio link is excellent and surpasses most other forms of telephone communications. The loss between stations can be brought back to the normal transmitting level thus assuring a most workable condition. This radio relay was used very successfully between such military headquarters as that of the 12th Army Group, commanded by General Bradley and that of 3rd Army Headquarters commanded by the late General Patton.

Multi-voltage

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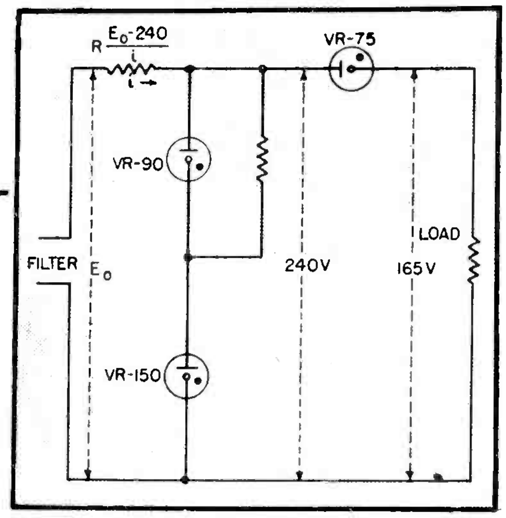

FIG. 1—Simple circuit for providing 165 volts of regulated output

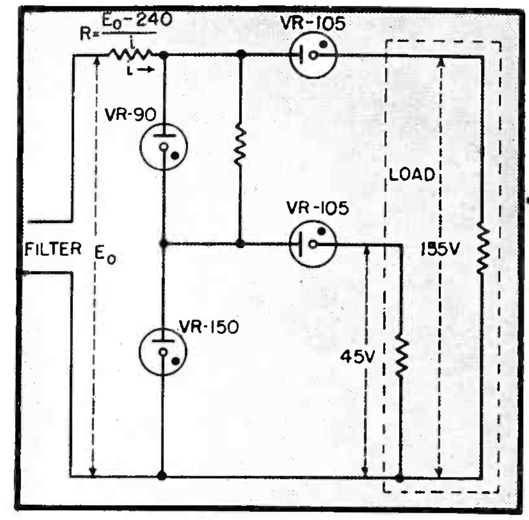

FIG. 2—Two widely different output voltages are provided by this arrangement

SEVERAL VALUES of stable voltage are often required for the testing of equipment which is normally battery operated. These can be obtained from a conventional power supply by using four standard types of gas-filled voltage regulator tubes, the VR-75, VR-90, VR-105, and VR-150. They make it possible to secure any regulated voltage which is a multiple of 15 volts, up to the nearest multiple of 15 volts below the available output voltage from the power supply filter, which is necessary for ignition.

To obtain the various voltages it is necessary to use the tubes in combinations wherein the voltages across some are added and the voltages across others are subtracted. The problem of getting the desired voltage is one of finding two combinations of 75, 90, 105, and 150 volts whose difference is the desired voltage. Either combination may involve any or all of the four voltages. For example, assume that it is desired to have 165 volts regulated output. This may be obtained by subtracting 75 volts from the sum of 150 volts and 90 volts.

The method of getting the sum of any voltages is to put the tubes in series across the line with an appropriate dropping resistor in series with the tubes. The subtraction of any voltage from this sum is then accomplished by putting the combination of tubes whose voltage total is to be subtracted in series with the load. This is shown in Fig. 1, for an output of 165 volts.

Table I—Procedure for Computing Values

Step	Method
1 Compute R_4	$R_4 = \dfrac{2\,E_4}{i_{L\max} + i_{L\min} - i_{t\max} - i_{t\min}}$
2 Compute R_3	$R_3 = \dfrac{2\,E_3}{i_{h\max} + i_{h\min} - i_{t\max} - i_{t\min}}$
3 Compute i_{R4}	$i_{R4} = \overline{i_L} - \overline{i_t}$
4 Compute i_{R3}	$i_{R3} = \overline{i_h} - \overline{i_t}$
5 Compute R_o	$R_o = \dfrac{\overline{E_o} - E_1 - E_2}{i_{R4} + i_{R3} + 3\,\overline{i_t}}$
6 Compute R_1	$R_1 = \dfrac{E_1}{\dfrac{\overline{E_o} - E_1 - E_2}{R_o} - i_{R3} - 2\,\overline{i_t}}$
7 Compute limit on $i_{h\max}$	$i_{h\max} \leqq \overline{i_h} + i_{t\max} - \overline{i_t}$
8 Compute limit on $i_{h\min}$	$i_{h\min} \geqq \overline{i_h} - (\overline{i_t} - i_{t\min})$
9 Compute limit on $i_{L\max}$	$i_{L\max} \leqq \overline{i_L} + i_{t\max} - \overline{i_t}$
10 Compute limit on $i_{L\min}$	$i_{L\min} \geqq \overline{i_L} - (\overline{i_t} - i_{t\min})$
11 Compute upper limit of $E_{o\max}$	$E_{o\max} \leqq (E_1 + E_2) + R_o\,(i_{h\min} + i_{L\min} + i_{t\max})$
12 Compute lower limit of $E_{o\min}$	$E_{o\min} \geqq (E_1 + E_2) + R_o\,(i_{h\max} + i_{L\max} + i_{t\min})$
13 Compute Z_{AC} back from high-voltage load	$Z_{hAC} \cong R_{3AC} + R_{1AC} + R_{2AC}$
14 Compute Z_{AC} back from low-voltage load	$Z_{LAC} \cong R_{4AC} + R_{2AC}$

$i_{h\max}$ and $i_{h\min}$, respectively, are the maximum and minimum values of the high voltage load current.
$i_{L\max}$ and $i_{L\min}$, respectively, are the maximum and minimum values of low voltage load current.
$i_{t\max}$ and $i_{t\min}$, respectively, are the maximum and minimum rated gas tube operating currents.
Denote the average values of all varying quantities by a bar above the quantity symbol, e.g., $E_{o\,ave} = \overline{E_o}$.
Denote the a-c resistance of a given tube by R_{AC}, e.g., for V_1 use R_{1AC}.

Two-voltage Output

In case more than one voltage output from a given power supply is desired, the method may be extended. Although the problem may be somewhat more complex, depending upon the output voltages desired, the same procedure can be applied. As an example, it might be desirable to have a power supply to be used for testing equipment which is designed to operate from battery voltages of 135 volts and 45 volts.

The higher voltage may be established by subtracting the voltage across a VR-105 from the sum of the voltages across a VR-150 and a VR-90 in series as shown in Fig. 2. The 45 volts may be obtained by subtracting the voltage across a VR-105 from the voltage across the

Regulated Power Supplies

Two regulated output voltages at extreme values of current are provided by using glow discharge tubes in the proper combination

VR-150 which is in series with the VR-90.

Current Variations

In Fig. 2, more current would normally flow through the VR-90 than would flow through the VR-150, so it is advisable to shunt the VR-90 with a resistor which will carry the excess current at the voltage established across it by the VR tube which it shunts. This equalizes the current operating ranges of the tubes in series.

The load current range for the circuit is determined by the fact that the current through the input series line resistor must be constant to produce the constant drop between the filter output and the two VR tubes in series across the line. As the load currents are caused to vary in any order, the current through the VR-150 must vary by an amount equal and opposite to the algebraic sum of the load current variations. Since the current through the VR-150 must not be less than 5 ma and not greater than 40 ma, the sum of the load current variations cannot be greater than 35 ma.

Although the current range of the single VR-150 sets a limit on the total variation of load current, the magnitude of the load currents available may be increased by shunting the series dropping tubes by suitable resistance. For example, if it is desired to have a load current of 100 ma available at 135 volts and 60 ma at 45 volts, the VR-105 in the 135-volt line should be shunted with a resistor which will carry the current in excess of the rated current through the VR-105.

If 100 ma is the maximum current required at 135 volts, a current well up in the operating range of the VR-105 may be selected. By allowing 30 ma through the tube, the resistor must carry the remaining 70 ma at 105 volts. This would require a resistor of 1500 ohms for shunting the VR-105.

If a current in the VR-105 in the 45-volt line is picked at 30 ma, this would then require a shunting resistor which would carry the remaining 30 ma of load current at 105 volts or a resistance of 3500 ohms across this VR-105. The series dropping resistor would then have to carry the total load current of 160 ma plus the current through the VR-150.

If the 160-ma load current is the maximum load current of a range of load currents, the current in the VR-150 should be of a minimum operating value. This would assure the maximum compensating value of the VR-150 current as it increases with decreasing total load current. Assuming a current in the VR-150 of 10 ma, the total filter current will be 160 ma plus 10 ma or 170 ma.

The series dropping resistor at the filter output is computed by application of Ohm's Law:

$$R_o = \frac{E_o - 240}{0.170} \text{ ohms}$$

where E_o is the output voltage of the filter, and 240 volts is the voltage across the VR-90 and VR-150 in series.

The VR-90 should then be shunted by an equalizing resistor to make the currents in the VR-90 and the VR-150 equal. The resistor must carry all of the load current of the 45-volt output. This is 60 ma, and the resistor voltage will be 90 volts as determined by the tube. The resistor will be 1500 ohms. The schematic diagram will then be as shown in Fig. 3.

If the load current requirement from a regulator of this type is too low in one or more branches, a shunting bleeder of suitable resistance may be employed to increase the load drain to an operable value in the load branches involved.

Since the low voltage is obtained by taking the difference between two larger voltages, this may yield a larger tolerance on low output voltage on a percentage basis than the rated percentage tolerance of any of the individual tube voltages. The tolerance in volts, however, will not be greater than the sum of the voltage tolerances of the tubes which determine the low output voltage.

Table I gives a general method of solving for the circuit components when two output voltages and the extreme values of load currents are specified. Certain restrictions must necessarily be put on the output current variations. The solution yields the permissible input voltage variation for the range of load currents desired, and the internal a-c impedance looking back from the load.

The component symbols used in Table I apply to Fig. 3. Measured values of regulation were 2 volts variation of the 135-volt output and 1.3 volts variation of the 45-volt output for an a-c line voltage variation from 105 volts to 125 volts.

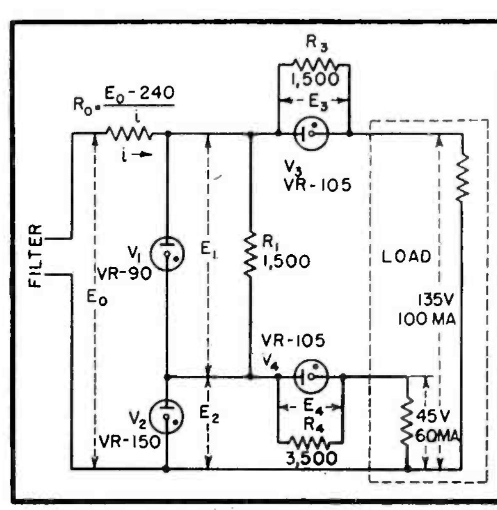

FIG. 3—For high-current requirements, resistors are shunted across the voltage-regulator tubes in series with the loads

Photoelectric Street Lighting Control

Predetermined foot-candle levels of light near twilight and dawn actuate a phototube and electronic amplifier to switch secondary circuits on and off. Storms causing premature darkness also actuate lights to promote pedestrian and motorist safety

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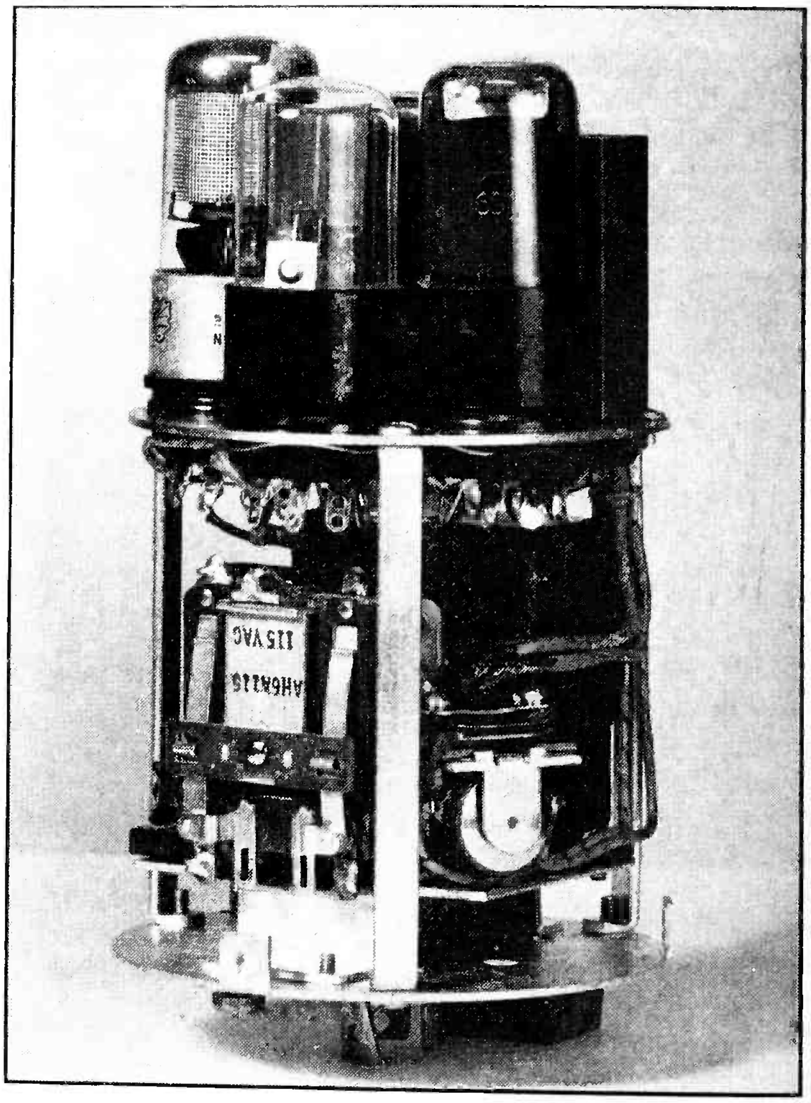


Interior of the switch, showing phototube and amplifier tubes on the top deck, component parts below, and connection socket at the bottom

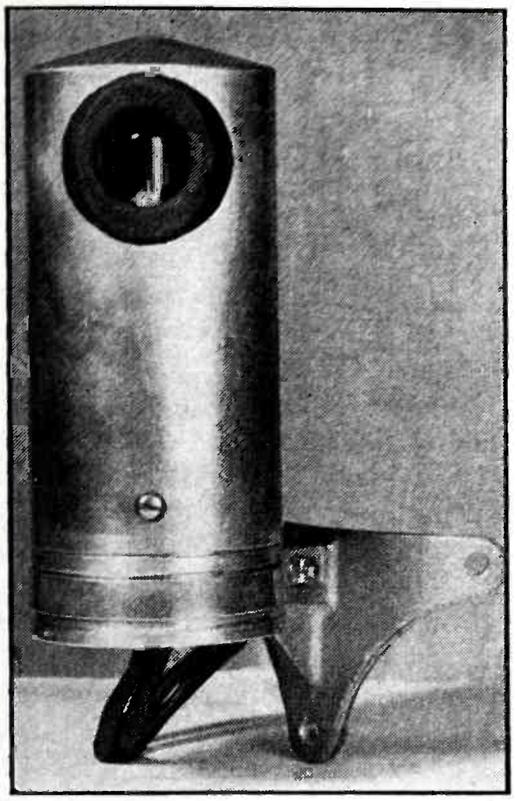
THE AUTOMATIC CONTROL of street lighting by photoelectric relays has been the subject of considerable research and experimentation for several years. As far back as 1937 a utility company in New York State replaced manual and mechanical means of simultaneously switching about 200 city lighting circuits, having a load of about 3,000 kilowatts, with photoelectric equipment. The successful use of photoelectric relays to control existing primary circuits has now made utility engineers conscious of the possibilities of utilizing this method to switch individual lights on secondary circuits.

Foremost among the objectives prompting research has been the promotion of safety for pedestrians and motorists. This is accomplished by turning on lights when local conditions, such as early evening overcasts or storms, require it. Another objective has been to provide such service without increasing cost. Lights are promptly turned off when local storms pass.

Operating Principle

The Sunswitch, to be described, employs predetermined foot-candle levels of daylight to operate a magnetic relay through the medium of a phototube and vacuum tube amplifiers.

Referring to Fig. 1, daylight falling on the cathode of the phototube causes current to flow, and this oper-



Sunswitch suitable for mounting on a street lighting system pole

ates 6SJ7 pentode amplifier V_1. The output of V_1 charges a time-delay network in the grid circuit of the first triode (V_2) of a 6SN7 dual triode. The output of V_2 charges a time-delay network in the grid circuit of the second triode section (V_3) of the 6SN7. The output of V_3 controls a magnetic relay. Contacts on the relay switch the lighting circuit on or off according to the level of daylight falling on the phototube.

The time-delay networks provide a fixed time delay, of 15 to 20 seconds, before the magnetic relay operates after a change in the light level on the phototube.

Installation

The photoelectric switch is located in close proximity to the lighting circuit which it controls. It may be used to control one or more lights. If the lighting load current exceeds the rating of the relay contacts, then auxiliary relays are used.

The unit is installed to receive light as viewed from a northerly direction. This is done to prevent direct rays of the sun from entering the light aperture. The light level at which the control is usually set to operate occurs before and after the rise and setting of the sun.

Light is received through a glass window on the side of the weatherproof aluminum housing. The entire assembly is mounted on a bracket designed for attachment to a conventional street lighting pole. The upper section contains the electronic components and can be detached for ease of replacement and servicing.

Wiring is brought into the control through a three-terminal plug connector located in the bottom. One terminal is common to the supply line and the load circuit, the second is for connection to the high side of the 110-v line, and the third is for connection to the switched side of the lighting circuit. The lighting-control leads may be connected directly to the lamp load, or through a 110-volt pilot circuit to the load.

Design

The primary consideration in design was to develop a product that would meet the exacting mechanical and electrical specifications and standards found in present-day utility lighting equipment, and having the control features discussed here.

The control operates at a minimum average light level of one foot-candle. After making continual test of daily light conditions in a specific area over an extended period of time it was found that this level was present approximately 25 minutes before sunrise and 25 minutes after sunset. Collaboration with utility companies showed this minimum level to be suitable for street-lighting control.

A second requirement was that a time delay take place before the lighting circuit operated, after the light level on the phototube increased or decreased. This was to prevent intermittent operation of the lighting circuit by momentary changes in light caused by passing clouds, flying objects, and lightning flashes.

Transformer, tube and relay selection resulted from a close study of application requirements. Experience in the industrial control field has indicated that low-voltage heater tubes are long-lived and reliable. The selection of such tubes required that a transformer be incorporated. Other arrangements would require higher heater voltage and series voltage-dropping resistors, with an accompanying waste of power.

It appeared desirable to maintain a potential of less than 100 volts between the heater and cathode of the various tubes to insure long life. This was accomplished, as shown in Fig. 2, by connecting one end of the heater winding of the 6SN7 to a 55-volt tap on the transformer.

An adjustable sensitivity control permits the setting of the operating point of the control for any light level between one and ten foot-candles. This control varies the bias voltage of the first triode amplifier.

It was desirable to have a minimum of moving parts in the control to forestall failure due to wear or sticking, therefore the necessary time delay periods were obtained by

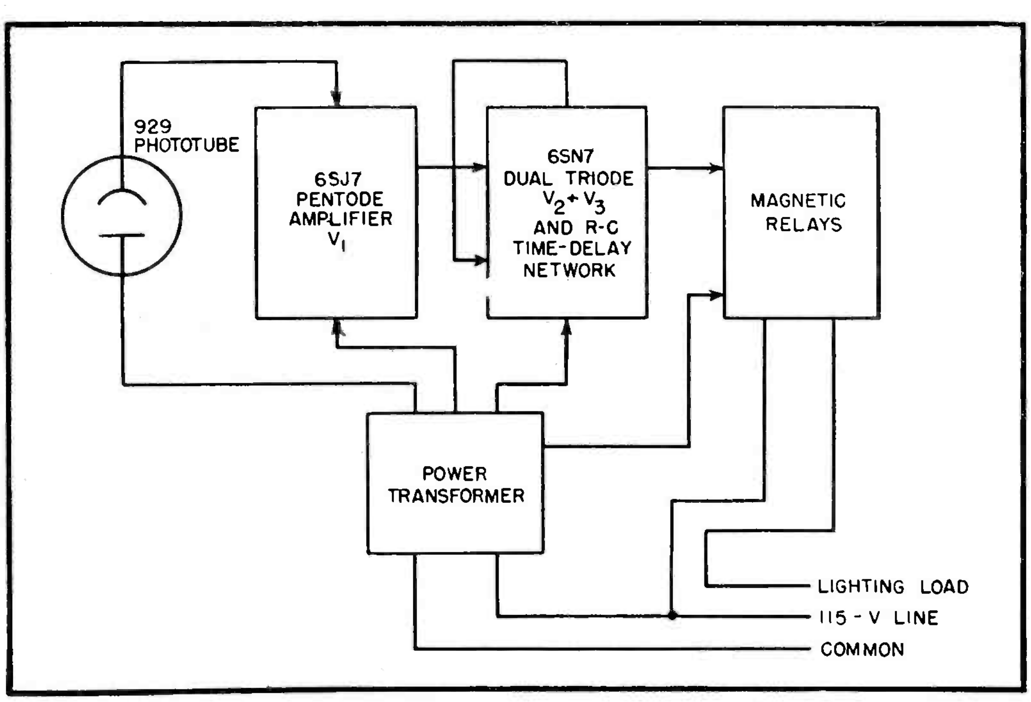


FIG. 1—Block diagram of the photoelectric street lighting control

the use of a capacitor and resistor network for each of the required periods. Time delay is always 20 seconds or more when the daylight level is high compared to the sensitivity setting of the control. When decreasing daylight level approaches this setting, however, the time delay diminishes. Just before the critical level at which operation takes place, any momentary interruption of light on the phototube will cause the relay to operate.

Due to the differential between the turn-on and the turn-off level, the light controlled by the switch will remain on after the interruption has passed. The reverse of this is true when the level of daylight increases and again approaches the critical sensitivity setting of the control, but from the opposite direction.

Circuit Action

In a study of the circuit, the instantaneous polarity of the voltage from the transformer must be taken into account.

The phototube and amplifiers are actually half-wave rectifiers, conducting only when their anodes are positive. The inherent characteristics of uncompensated direct-coupled amplifiers, such as drift and instability, are of minor importance in this application. The operating period, when the control will respond to a certain light level, will only occupy several minutes out of any one day. At all other times when the light level is high, or below the operating point, the amplifiers are operating either at zero bias or well beyond cutoff.

The circuit has exceptional sensitivity. With the sensitivity control set at maximum, it requires a power input of only two microwatts at the grid of the 6SJ7 for operation. That is sufficient to control 500 milliwatts in the plate circuit of V_3, and represents a gain of 53.9 db.

The choice of a phototube with high sensitivity combined with good stability was imperative. The 929, a high-vacuum type with a rubidium cathode, was finally selected. This phototube has its peak sensitivity in the blue region of the spectrum. It is the blue light before dawn that is the primary medium for operating the unit.

Assuming that incident light striking the phototube cathode is greater than one foot-candle (four millilumens on cathode area), sufficient current will flow through R_1 to reduce the grid voltage of V_1 to zero. The 6SJ7 will now conduct on every half cycle when the plate is positive. The voltage developed across load resistor R_2 will charge capacitor C_1 through R_3. When C_1 is charged to its maximum value (140 volts) V_1 need only supply current, necessary to make up the losses, on a small portion of its conducting cycle. Grid current of the succeeding triode, flowing through R_2 and R_3 supplies the rest.

Variations of plate current due to changes of light at the phototube have no immediate effect on V_2 unless those changes are of a greater time constant than C_1 and $R_2 - R_3$. The grid of V_2 is biased negative beyond cutoff under this condition. No voltage is developed across the plate load resistor R_4.

It will be noted that the combination of C_2, R_4 and R_5 is another timing network, similar to that in the plate circuit of V_1. Capacitor C_2 in this timing network will be discharged when there is more than one foot-candle of light on the phototube. The grid of the last amplifier V_3 is, under this condition, at zero bias. With 200 volts on the anode, it draws ten milliamperes of plate current, which energizes the 5,000-ohm coil of relay CR_1. Capacitor C_3, across the relay coil, smooths out pulsating current.

Relay CR_1, acting as a pilot relay, controls the load indirectly by switching relay CR_2. Because this relay is energized when there is light on the phototube, failure of the tubes or the transformer will be indicated by the lamp load burning continually during daylight hours.

When the light level falls below a predetermined value, the voltage drop across phototube load resistor R_1 is reduced and the fixed bias-voltage takes control of the V_1 grid. Exactly the opposite of what was explained above now takes place. With the flow of 6SJ7 plate current cut off, the timing network begins to discharge. The potential across C_1 must decay below 15 volts before V_2 will start conducting. When the power in the relay coil of CR_1 drops below 45 milliwatts the contacts close and energize CR_2.

Tests have shown that it is not practical to switch more than a few hundred watts with the contacts of CR_1. When the contacts close at the peak of the voltage cycle, the surge current for cold incandescent lamps is ten times the normal value. This current surge has a tendency to weld the contacts and sufficient power must be developed in the coil to break the weld.

A spark gap is provided for use in suppressing transient surges in the power line caused by lightning discharges. When the switch is located in an outlying area, away from town, these transients may otherwise reach a peak great enough to break down the transformer insulation.

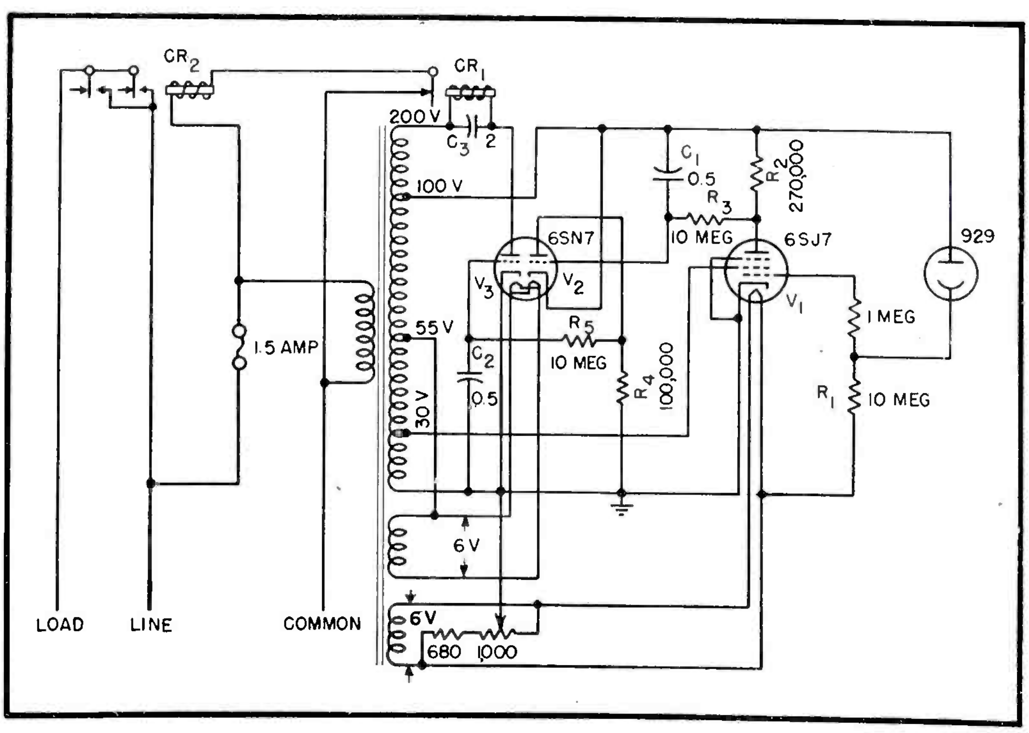


FIG. 2—Circuit diagram of the photoelectric street lighting control

TRACKING Permeability-Tuned Circuits

By A. W. SIMON
Stewart-Warner Corp.
Chicago, Ill.

THE system of tuning shown in Fig. 1A employs ganged, identical variable capacitors with a series (padder) capacitor and a shunt (trimmer) capacitor to restrict the range of the oscillator section in superheterodyne receivers. It has its exact counterpart in permeability-tuned systems (ganged, identical, iron cores and coils) except that, on account of the inverse relationship between capacitance and inductance, the series capacitor is replaced by a shunt coil, and the shunt trimmer by a series coil, as indicated in Fig. 1B.

The theory of tracking, or maintainance of a constant frequency difference between the r-f and oscillator sections, has been discussed for the case of ganged capacitors by various authors. Two general methods of analysis have been presented, one of which is based on the solution of a cubic equation,[1] and the other on the properties of an equilateral hyperbola.[2] The latter method is much less laborious than the former, and is accordingly applied to the solution of the permeability-tuned system problem.

It should be noted, in connection with the circuit of Fig. 1B, that the series coil L_s could also be placed on the capacitor side of the shunt coil L_p, or coils could be placed in both positions, without departure from three-point tracking.

If the problem is treated according to the method of Roder, we compute three pairs of values x_i y_i (i = 1, 2, 3) according to the equations

$$x_i = 1/4\pi^2 f_i^2 C_1 \qquad (1)$$

$$y_i = 4\pi^2 F_i^2 C_1 \qquad (2)$$

where f_i and F_i represent a pair of corresponding signal and oscillator frequencies, respectively, at which perfect tracking is desired (taken preferably in ascending order) and from these in turn compute three auxiliary parameters x_o, y_o and K given by

$$x_0 = D_x/D \qquad (3)$$

$$y_0 = D_y/D \qquad (4)$$

$$K = (x_i - x_0)(y_i - y_0) \qquad (5)$$

where

$$D_x = \begin{vmatrix} (x_1y_1 - x_2y_2) & (x_1 - x_2) \\ (x_2y_2 - x_3y_3) & (x_2 - x_3) \end{vmatrix} \qquad (6)$$

$$D_y = \begin{vmatrix} (y_1 - y_2) & (x_1y_1 - x_2y_2) \\ (y_2 - y_3) & (x_2y_2 - x_3y_3) \end{vmatrix} \qquad (7)$$

$$D = \begin{vmatrix} (y_1 - y_2) & (x_1 - x_2) \\ (y_2 - y_3) & (x_2 - x_3) \end{vmatrix} \qquad (8)$$

The desired values of the circuit constants sought are then given by

$$L_p = K/y_0 \qquad (9)$$

$$L_s = -x_0 \qquad (10)$$

$$C_2 = C_1/K \qquad (11)$$

A practical example

A numerical example will make the foregoing clear. (In practice the $4\pi^2$ is best carried along as a factor since it cancels out in most of the operations.) The computations are carried out in practical units, — cycles, farads and henrys. Let it be required to calculate L_p, L_s and C_2 given that $C_1 = 80\mu\mu$f, $f_1 = 600$ kc, $f_2 = 1{,}000$ kc and $f_3 = 1{,}500$ kc, for an intermediate frequency of 455 kc, so that $F_1 = 1{,}055$ kc, $F_2 = 1{,}455$ kc, and $F_3 = 1{,}955$ kc.

Eq. 1 and 2 yield

$$\begin{aligned}
4\pi^2 x_1 &= 3.4723 \times 10^{-2} \\
y_1/4\pi^2 &= 89.04 \\
x_1y_1 &= 3.0917 \\
4\pi^2 x_2 &= 1.2500 \times 10^{-2} \\
y_2/4\pi^2 &= 169.36 \\
x_2y_2 &= 2.1170 \\
4\pi^2 x_3 &= 5.5556 \times 10^{-3} \\
y_3/4\pi^2 &= 305.76 \\
x_3y_3 &= 1.6987
\end{aligned}$$

so that we have

$$\begin{aligned}
D_x/4\pi^2 &= +2.5275 \times 10^{-3} \\
4\pi^2 D_y &= -99.39 \\
D &= -2.4735
\end{aligned}$$

the values of the auxiliary parameters are

$$\begin{aligned}
x_0 &= 2.5884 \times 10^{-6} \\
y_0 &= 1.5863 \times 10^{3} \\
K &= 1.7476
\end{aligned}$$

so that the required circuit parameters are

$$\begin{aligned}
L_p &= 1127.3\mu h \\
L_s &= 25.88\ \mu h \\
C_2 &= 45.777\ \mu\mu f
\end{aligned}$$

While the calculations are somewhat lengthy, they involve none but arithmetic operations. The use of logarithms greatly shortens the labor of computation.

REFERENCES

(1) Landon, V. D. and Sven, E. A., Solution of the Superheterodyne Tracking Problem, ELECTRONICS, p 250, August 1932.
(2) Roder, Hans, Oscillator Padding, *Radio Engineering*, p 7, March 1935.

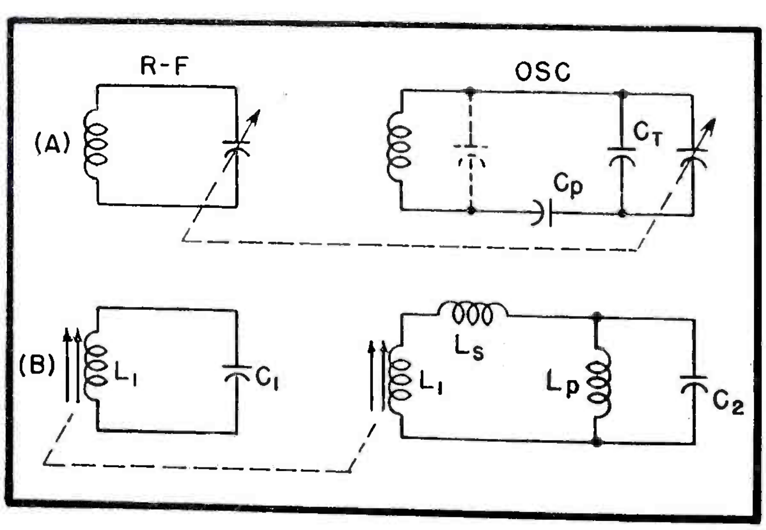


FIG. 1—Conventional variable-capacitance tuned r-f and local oscillator circuits (A) and equivalent permeability tuned circuits (B) as used in a superheterodyne receiver

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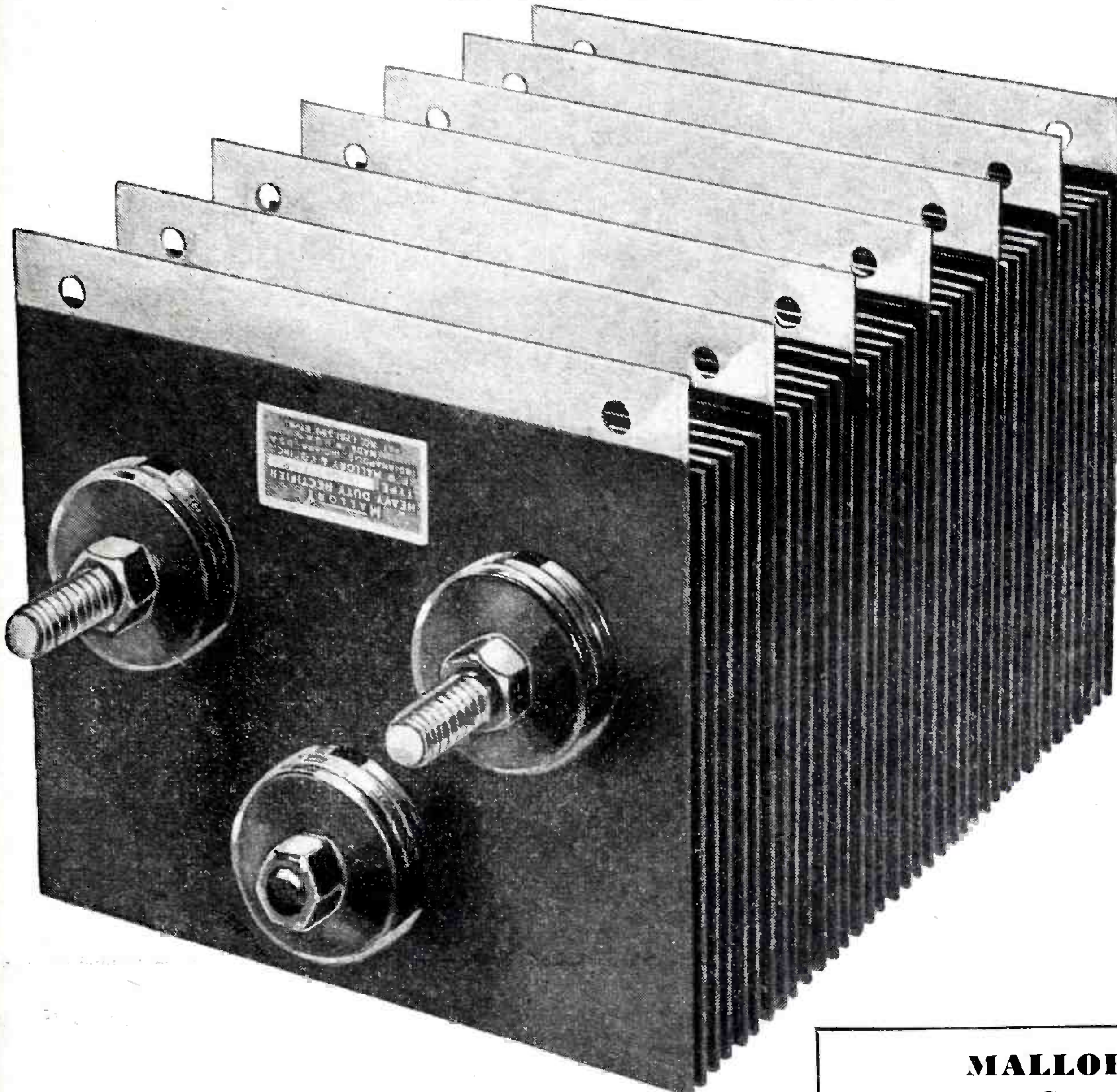

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TUBES AT WORK

Edited by VIN ZELUFF

Surgeless Volume Expander

By A. Nelson Butz, Jr.
Assistant Director, Ordnance Research Laboratory
The Pennsylvania State College
State College, Pennsylvania

With few exceptions, volume expander systems have utilized the change in transconductance of a vacuum tube, as a function of one of grid voltages, to vary the amplification in such fashion as to enhance the dynamic range of the program being reproduced.

For the expansion action to be as unobtrusive as possible, the attack time must be made sufficiently rapid to permit complete expansion almost immediately upon the beginning of a loud passage. Decay of the expanded level, however, must occur considerably slower lest rapid increases and decreases of level, in staccato passages in particular, should modulate lower-level intervals. Another reason for requiring a fairly slow decay time is to permit a realistic decay of reverberation in reproducing music produced in live concert halls or studios. It is obvious that a rapid decay of expansion would accentuate the decay of reverberation and deaden quite effectively the normal studio characteristics.

Need for Pushpull

In securing expansion through variation of transconductance, a change of plate current in the expander stage necessarily occurs. If an expander circuit is constructed in as simple a form as possible, with a single controlled tube, this dynamic change of plate current appears as a component of the program being reproduced. As a result, the time constant of expansion attack must be made sufficiently long to place the components of the plate current surge in the subaudible region. In an amplifying system with good low-frequency response, this factor necessitates a minimum attack time of about 0.5 second, which is so slow as to produce a noticeable gradual increase in the louder passages.

The problem is aggravated by the fact that the absolute plate voltage change caused by expansion is usually considerably larger in magnitude than the desired signals. The obvious method of avoiding the effect of plate current surges has been incorporated in certain systems which use a pushpull expander stage. In this case, the d-c surge in each expander tube is cancelled out in the pushpull transformer of the expander system. However, the expense of a high-quality output transformer for such a system would place it beyond the economic reach of many users. In addition, a pushpull input transformer would be required to secure rapid expansion action because an RC input circuit would necessarily introduce an undesirable system time constant.

Single-ended System

The expander circuit shown in Fig. 1 represents a method of balancing out changes in plate current while maintaining the entire system single-ended with respect to ground and eliminating the necessity of using expensive transformers. In addition, the inherent system distortion is extremely low over a controlled range of approximately 15 db. The attack time may be made extremely short without

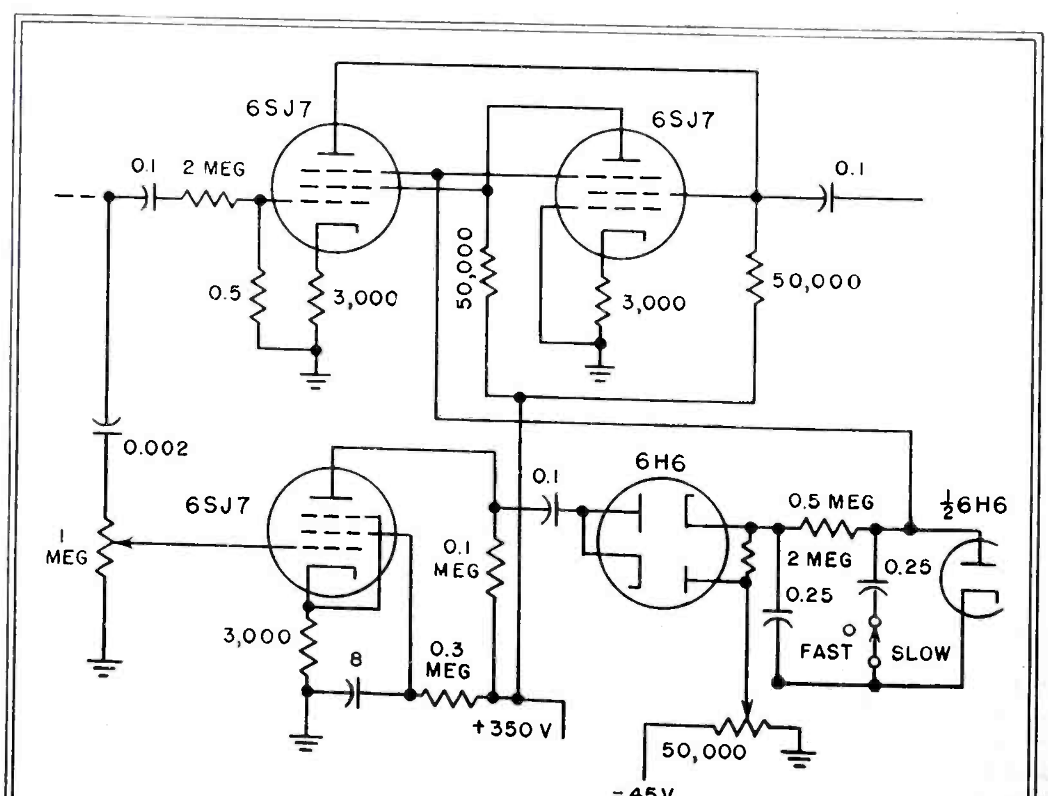


Fig. 1—Circuit of single-ended volume expander that requires no pushpull transformer for canceling out the d-c surge in each expander tube

causing undesirable surges, while the release time may be made as long as desired.

The audio signal is applied to grid 1 in a conventional fashion while the variable expander bias is applied to the suppressor. As the suppressor is made more positive, from a given negative value, the screen current decreases while the plate current increases. In the 6SJ7, the negative transconductance to the screen and the positive transconductance to the plate match closely when the plate transconductance is changed over a wide range without altering the total cathode current. Unfortunately, as the suppressor bias is varied, the sum of control grid to screen and control grid to plate transconductances remains constant, and if screen and plate of a single tube were tied together, no appreciable variation of overall gain will occur.

Use of Dummy Tube

The plate of the signal amplifier is connected to the screen of a dummy 6SJ7, and since expansion voltage is applied to the suppressor of both tubes, the dynamic change in plate current in the signal amplifier is balanced by the opposite change of screen current in the dummy. In a similar fashion, screen current change in the signal amplifier is cancelled by plate current change in the dummy. Consequently, variation of the effective transconductance of the signal amplifier is secured without introducing current surges in the signal circuit.

The maximum signal input to the expander stage is approximately 0.25 volt, and the maximum signal output of the system is of the order of several volts. The diode rectifier incorporated in the suppressor circuit prevents the expander rectifier from driving the suppressor positive, which would produce blocking and loss of expansion control. The time constants of the expansion rectifier systems are such that 75 percent of final gain is achieved in the *Fast* position in approximately 0.02 second. This time constant is tripled in *Slow* position. The two decay times are about 0.5 and 1.2 second respectively.

Two-frequency I-F Transformers

By ROBERT T. THOMPSON
Engineering Department
Zenith Radio Corporation
Chicago, Illinois

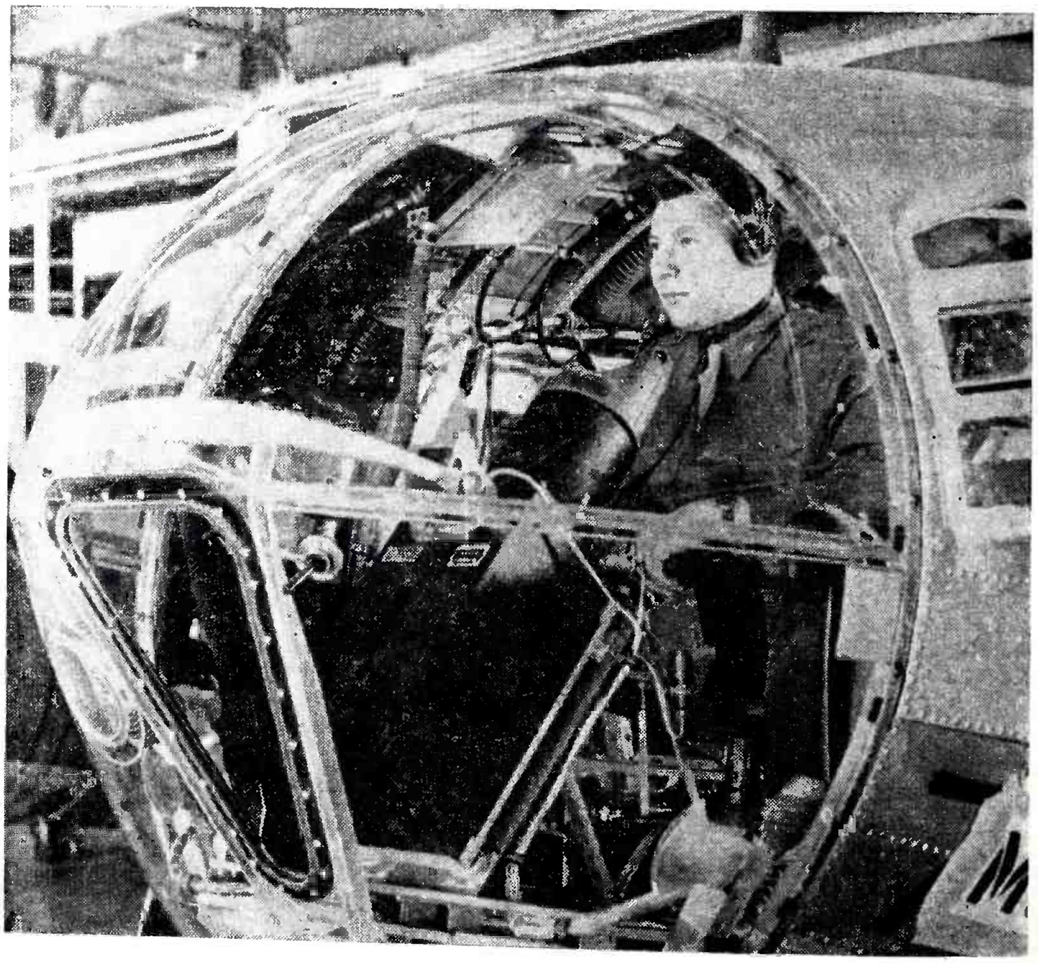
THE TWO-FREQUENCY i-f transformers to be described were designed to provide something smaller, more stable, and less costly than prewar units for a-m/f-m receivers. Most such receivers used a standard 455-kc transformer in series with another transformer at some higher frequency or else an entirely separate i-f channel, tubes and all, for the f-m band.

It was found two i-f stages could be cheaper than one because the extra components were required for the 8.3-mc channel, and the cost of four high-Q windings in a small can was greater than six low-Q coils. The added cost of the two silver mica capacitors was negligible because of a feature of the assembly.

The two-stage i-f channel is about $1\frac{1}{2}$ kc wider at $2\times$ and about 10 kc narrower at $1{,}000\times$. The two-stage channel uses coils having a Q in air of about 50 and a silvered mica capacitor of about 400 $\mu\mu$f. Production experience with these units has shown further savings because low-gain, low-Q units have less production variations and fewer rejects. The sensitivity at the converter grid is about 25 microvolts for 50 milliwatts output. If gain needs to be increased or decreased for different models, the position of the tap on the secondary of the second i-f transformer is a convenient means to this end.

The combination circuit appeared

Crossroads Drone Pilot



Radio-controlled Flying Fortresses that flew into the blast cloud in the atom bomb tests were maneuvered by a pilot using equipment shown above. The joy-stick box controlled the drone's flight and the operator viewed the flying path of the drone on the screen of television monitor. While passing through the bomb clouds, the drones were guided by Minneapolis Honeywell automatic pilots

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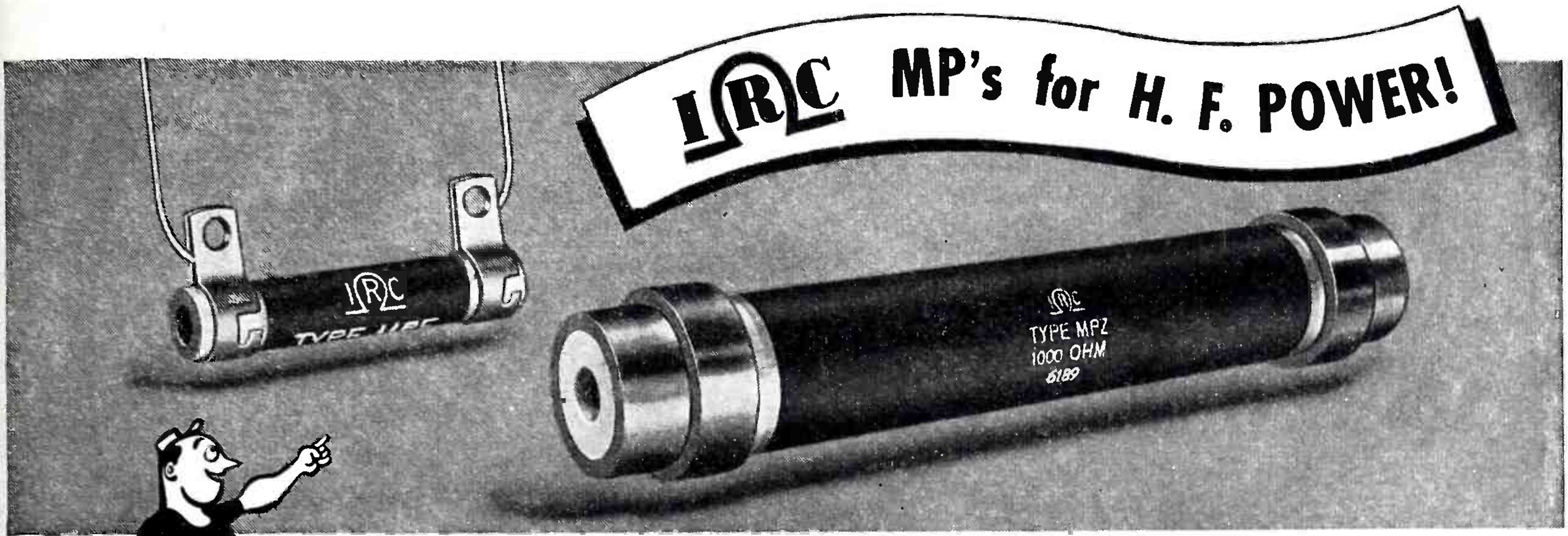

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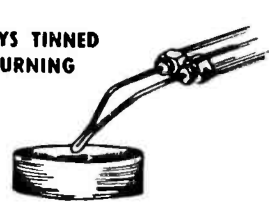

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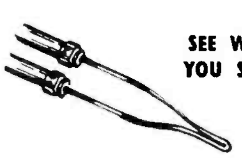

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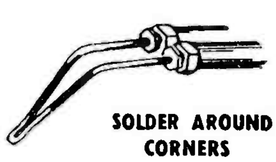

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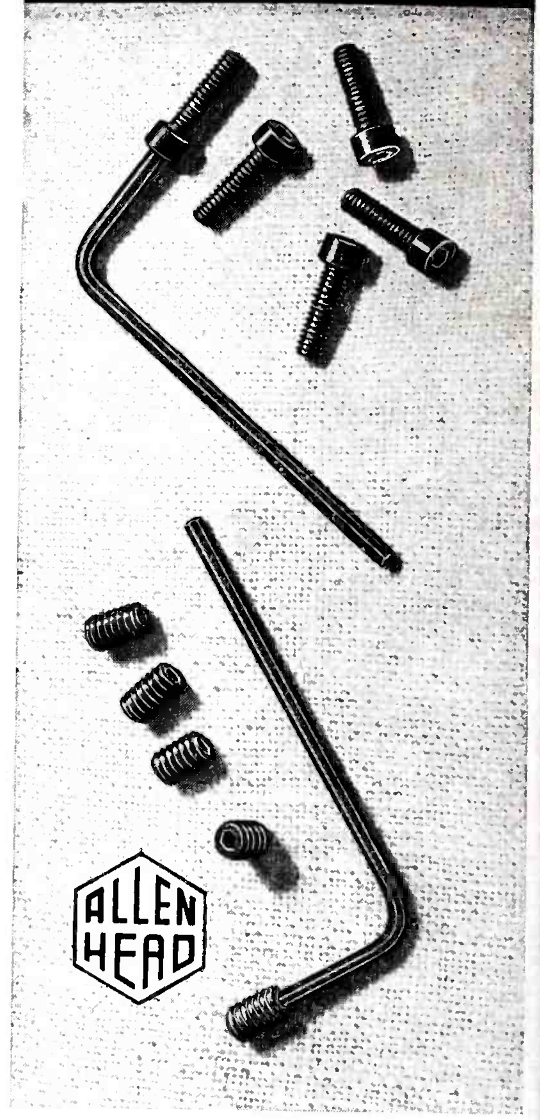

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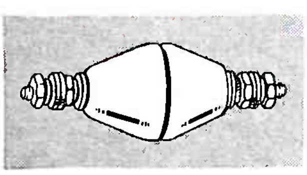

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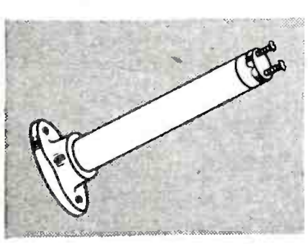

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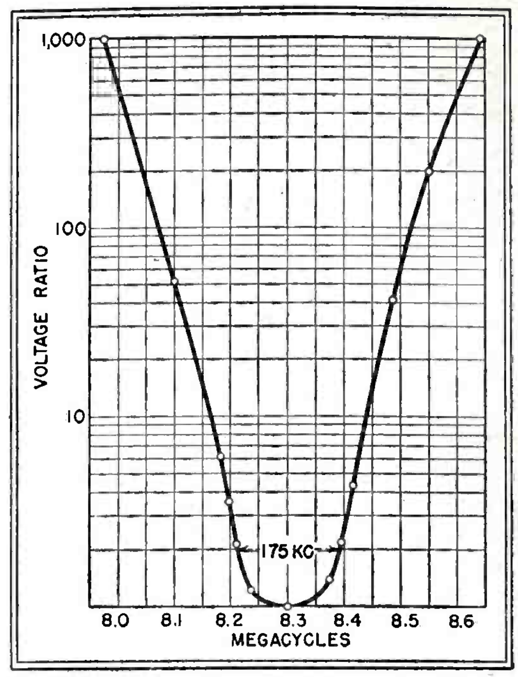

Fig. 1—Selectivity of 8.3-mc channel

in ELECTRONICS for August, 1946.

The 455-kc coils are in series with the 8.3-mc coils, with the exception of the third i-f secondary which is connected to a diode plate of the 6S8. This diode plate is used only on a-m.

The response of the 8.3-mc channel is shown in Fig. 1, as measured after a production-line scope alignment. The bandwidth at 2 × down is 175 kc and at 1,000 × down, 665 kc. Sensitivity at the converter grid is on the order of 75 microvolts for a one-volt rise at the limiter grid.

The discriminator characteristic is shown in Fig. 2. The curve was plotted on a production receiver using an input to the limiter grid of one volt. The bandwidth is about 300 kc between plus and minus voltgage peaks with about

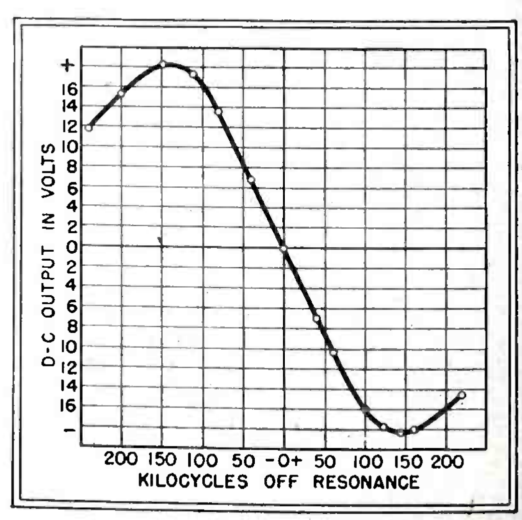

Fig. 2—Discriminator response of a production receiver

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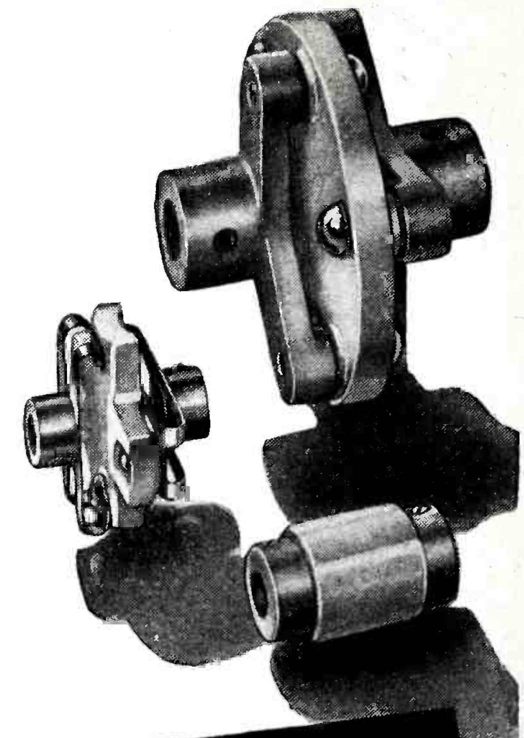

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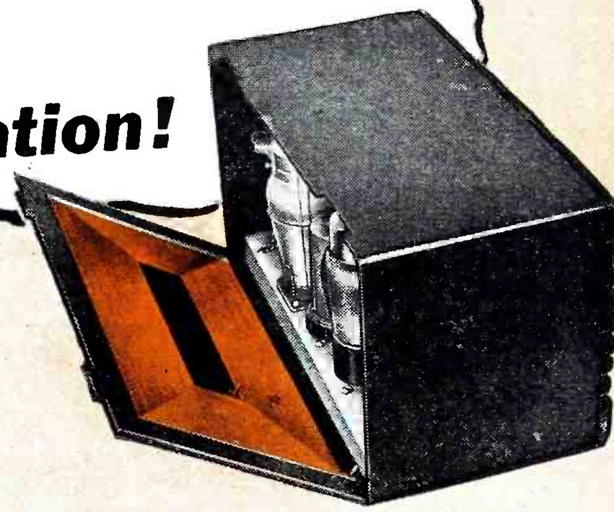

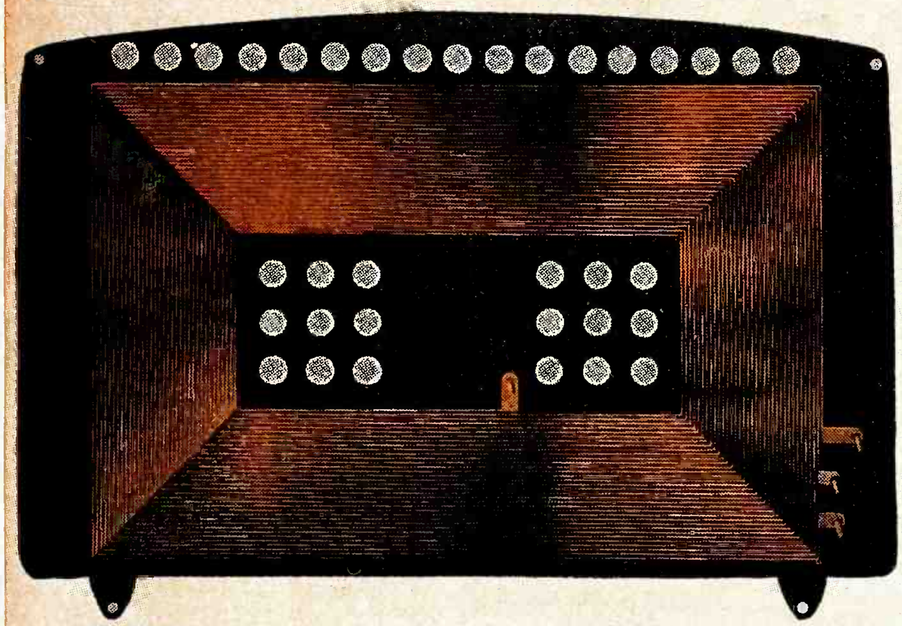

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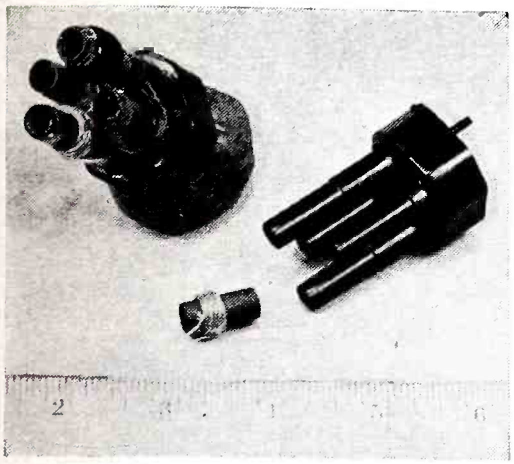

Fig. 3—The i-f coils are slipped over the posts on the molded piece at right to form the complete assembly at left

18 volts developed at the 6S8 cathode.

The supporting structure for the coils, capacitors, and cores is a molded piece shown in Fig. 3. An 8.3-mc primary on a short post and an 8.3-mc secondary on a long post make up one transformer, while the other two posts support the 455-kc coils.

The permeability and Q requirements are not severe and the same grade of threaded iron core is used at both 8.3-mc and 455 kc. The cores are beveled at one end and shaped at the other end to guide the screwdriver blade into the slot.

The silver mica capacitors across the tuned circuits are assembled in a capacitor well with suitable contacts on each side. Figure 4 shows the four patterns which are used in various receivers. These four basic silver mica patterns range from 26 to 475 $\mu\mu$f and have one side of the mica completely silvered except for the $\frac{1}{16}$-inch border adjacent to the cut edges.

The plates shown in Fig. 5 serve the triple purpose of capacitor contacts, coil terminals, and chassis wiring terminals. The full plate

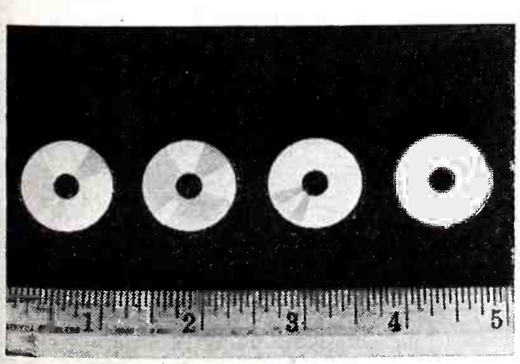

Fig. 4—Four basic silvered mica pat-

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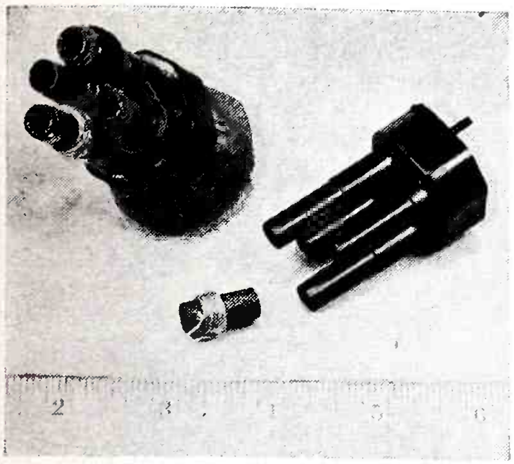

Fig. 3—The i-f coils are slipped over the posts on the molded piece at right to form the complete assembly at left

18 volts developed at the 6S8 cathode.

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The plates shown in Fig. 5 serve the triple purpose of capacitor contacts, coil terminals, and chassis wiring terminals. The full plate

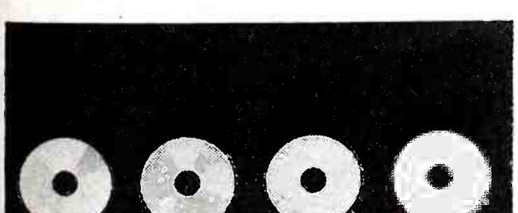
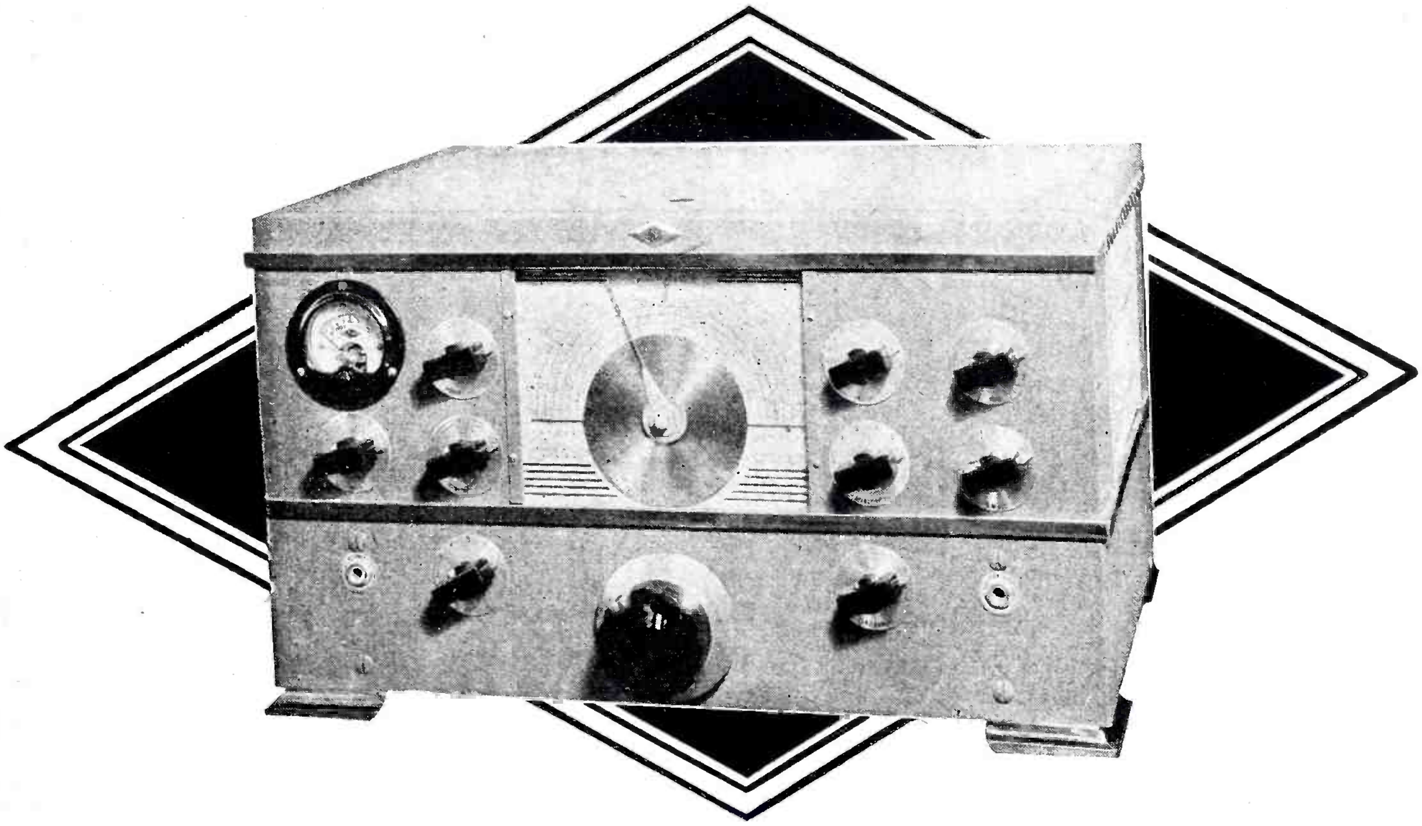


Fig. 4—Four basic silvered mica patterns used for several required capacitances



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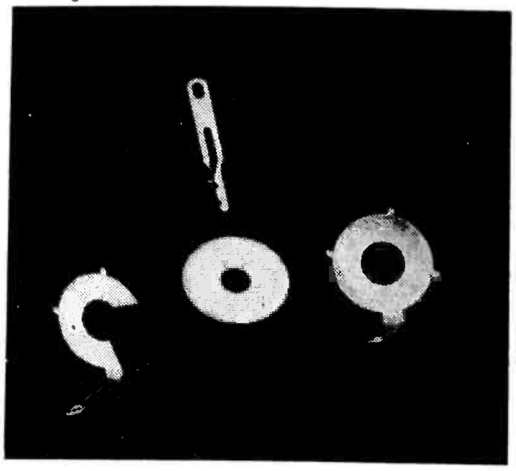

Fig. 5—Plates used as capacitor contacts and terminals

makes contact to the fully silvered side, the partial plate contacts a 400-$\mu\mu$f capacitor for the 455-kc coil, and the small contact picks up the 26-$\mu\mu$f portion for the 8.3-mc coil.

When three capacitors are placed on one piece of mica, a full plate and three small contacts are used, the latter being placed roughly 120 degrees apart so that the parts will stack up evenly. The discriminator, for example, uses this construction. The pair of 70-$\mu\mu$f capacitors which tune the secondary and the 26 $\mu\mu$f which tunes the primary have a common element connected to the plate of the limiter tube.

The entire capacitor assembly, including polystyrene washers which separate primary and secondary capacitors, is fastened together with a screw and nut.

Mounting

The can fastening features a single-hole mounting. After the coil has passed a jig test, it is slipped into the can up to four positioning notches and four more notches are put into the side of the can, effectively locking the Bakelite base between the two set of notches.

Details of the mounting are shown in Fig. 6. The screw through the capacitor stack mounts the transformer on the chassis. A special cutout is required, characterized by a bridge of metal across a square opening. To keep the can from turning, a "kickup" out of the chassis fits into the two corners of the can not used by the bridge. To further insure good grounds, the kickups are spaced and shaped so

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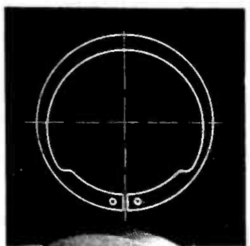
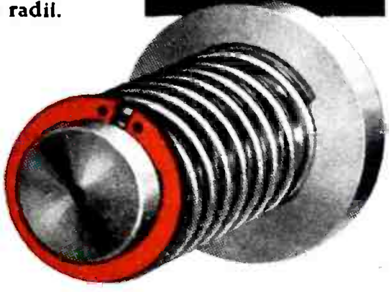

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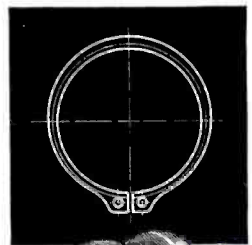
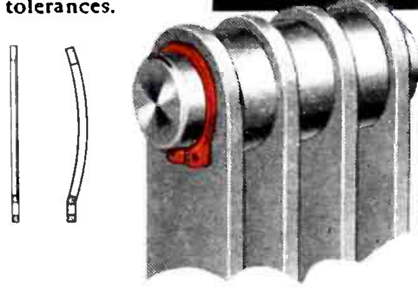

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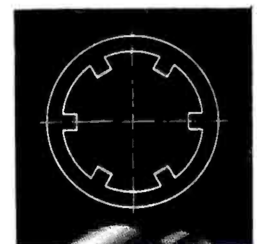
Economical where thrust is moderate — holds fast, yet shaft requires no machining.

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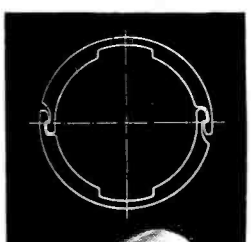


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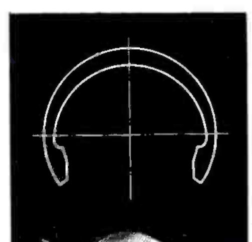


E-Ring

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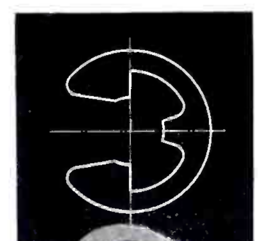
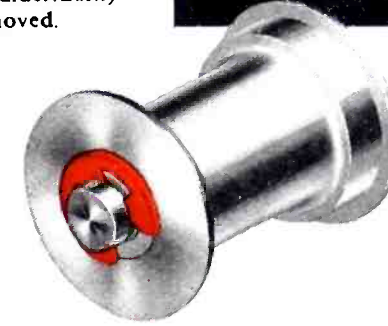

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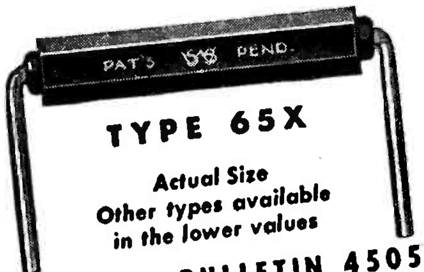

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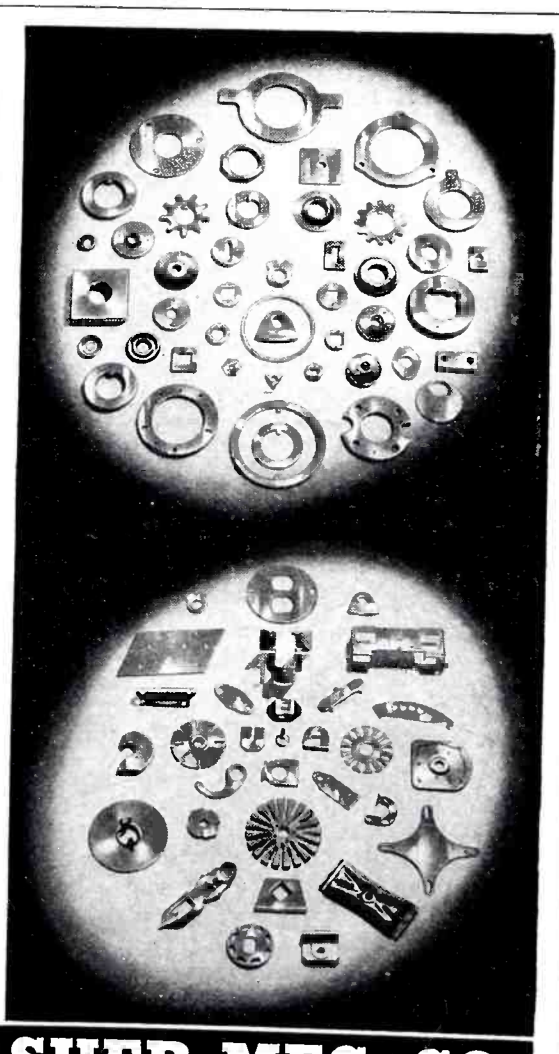

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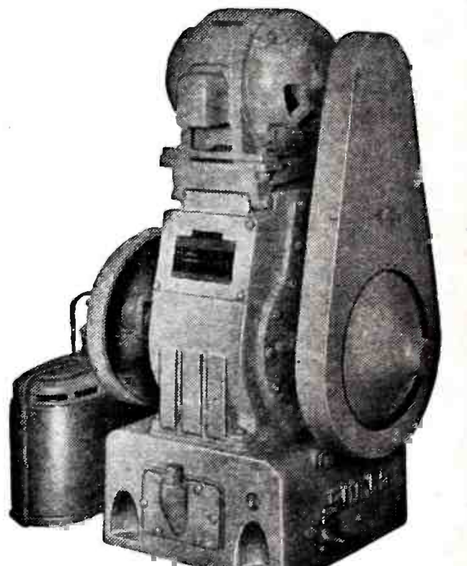

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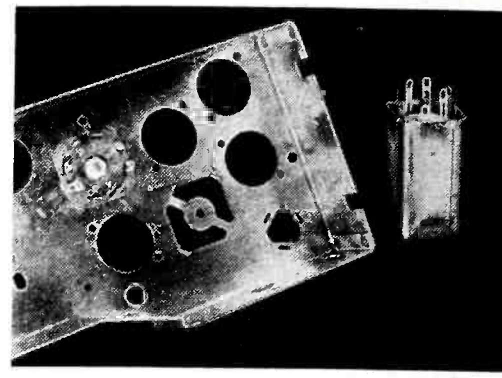


Fig. 6—Portion of chassis showing bridged cutout and a mounted i-f transformer

they bite into the inner corners of the can when it is placed on the chassis. To prevent solder from running down between the chassis and the soldering lugs, a thin Bakelite wafer is slipped over the eight lugs and held in place by the single mounting nut.

In production, the single-hole mounting has made it practical to mount the three i-f cans and the discriminator in one operation. The four units are placed upside down in a jig, the chassis is pressed into place, and the four nuts tightened by a torque wrench.

Similar models have been built using higher-gain tubes at 10.7 mc. In addition, the basic features have been used in experimental i-f channels as high as 21.3 mc.

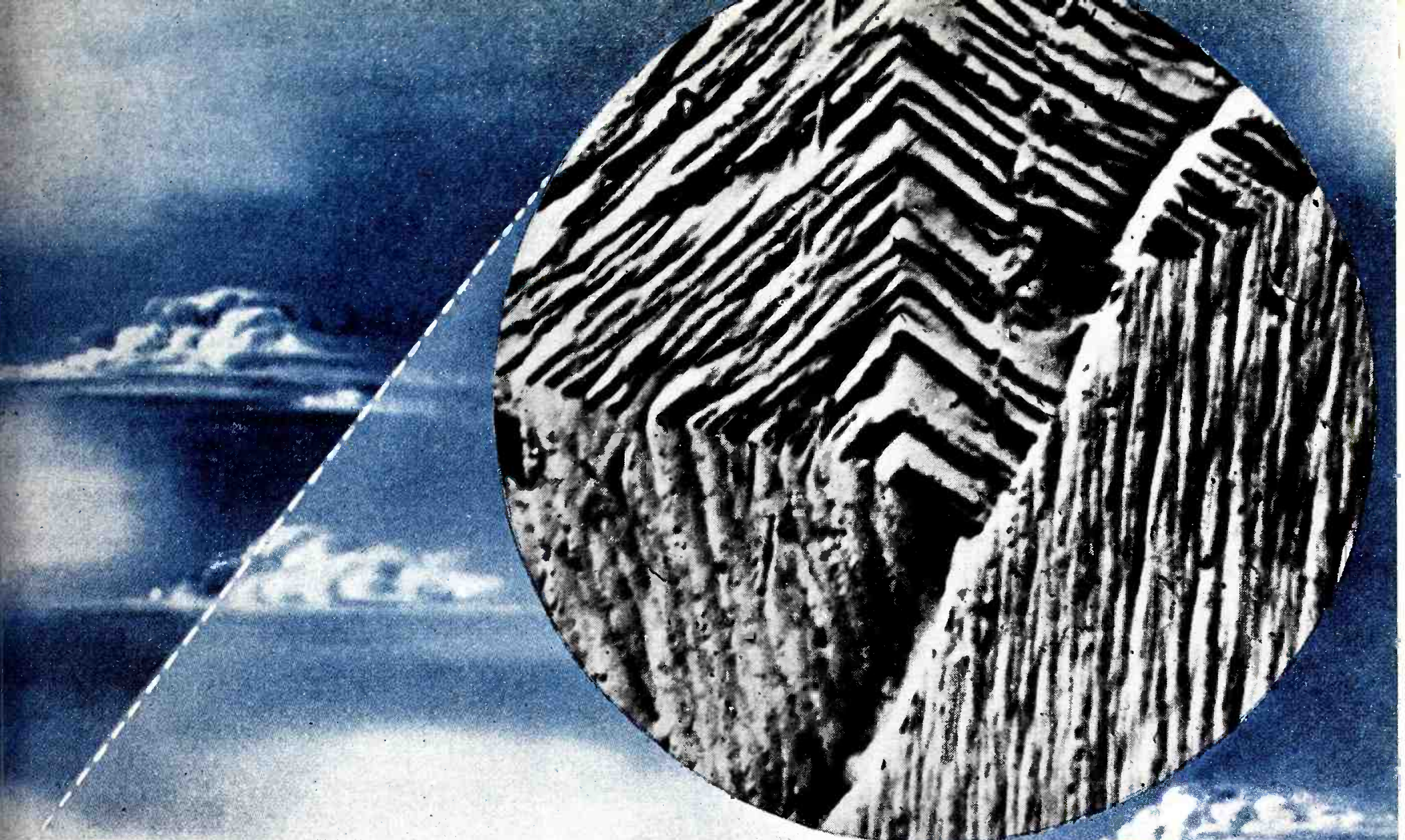
• • •

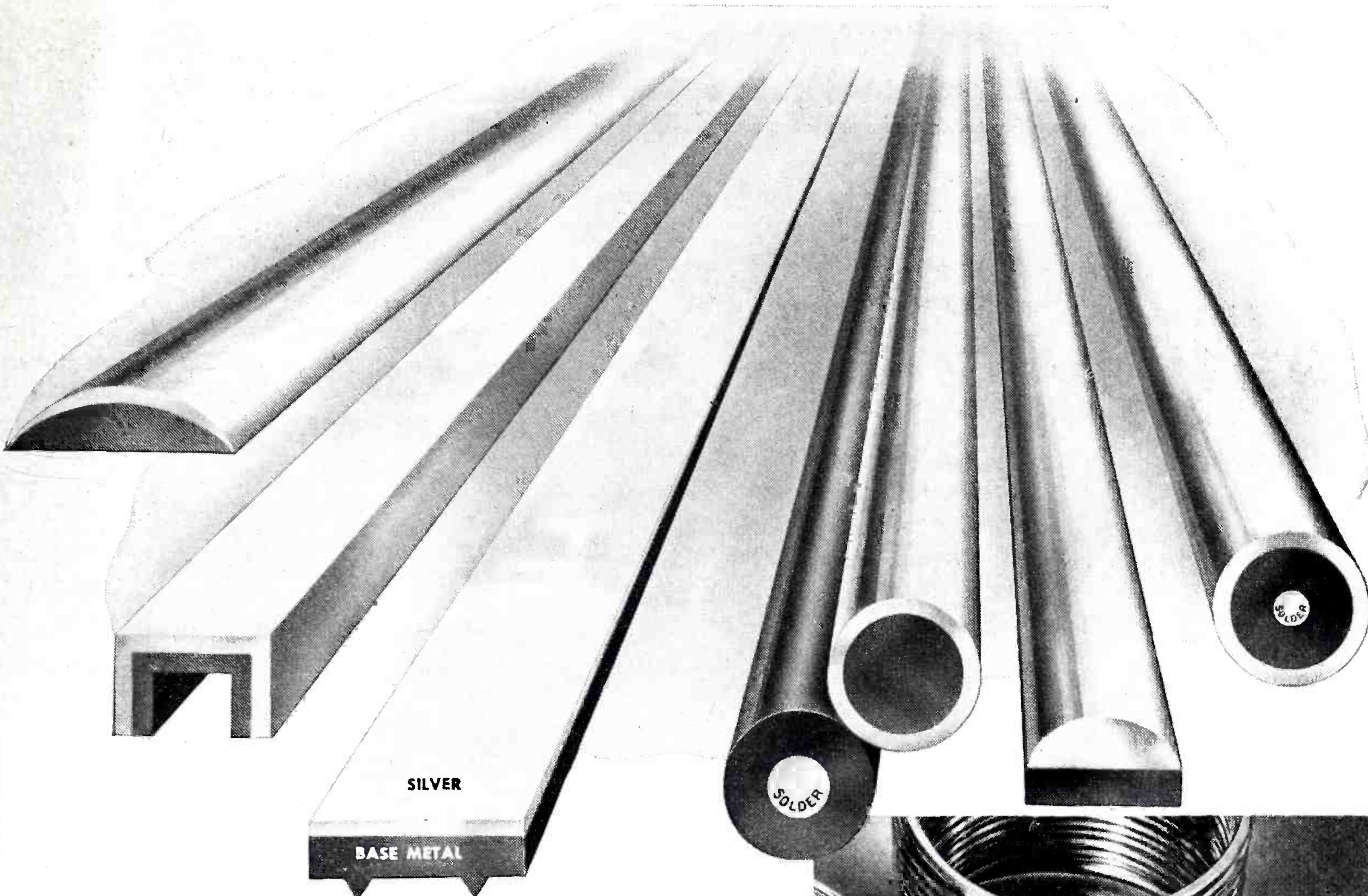
Clip-on Antenna Meter

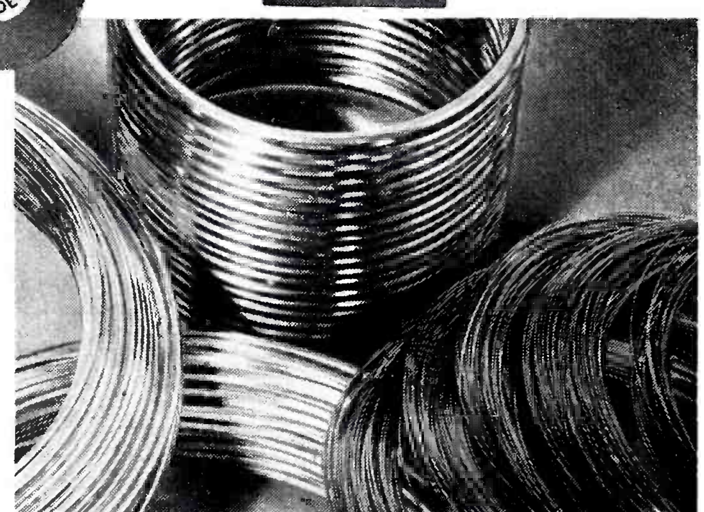
IN THE LOS ANGELES repair and installation shops of the Highway Patrol, California Department of Motor Vehicles, senior radio technician H. A. Holcomb has put together a useful antenna meter for a quick check on the output of 30-watt Motorola transmitters, of which the patrol uses almost 450.

Illustrated herewith, the unit comprises a small piece of Lucite sheet with a model 507 Weston thermogalvanometer, two large battery clips and a 50 $\mu\mu$f mica capacitor. The current-squared meter has a resistance of 5.2 ohms and its readings are used arbitrarily.

The meter is connected in series with the capacitor, which is placed between the instrument and the upper clip. The unit is simply clipped onto the whip antenna with the lower clip in contact with the







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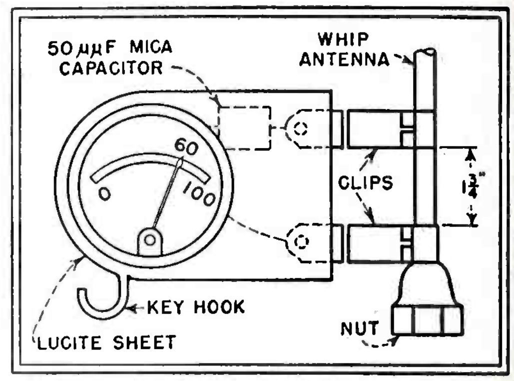
ATTLEBORO, MASSACHUSETTS

compression nut at the bottom of the whip. A reading of 60 on the scale is taken to indicate a normally operating transmitter. A midscale value was chosen by manipulation of the distance between the two clips. A spacing of $1\frac{3}{4}$-inch worked out correctly for the particular combination of units.

The same unit is used for determining the output of 6-watt motorcycle transmitters whose power is too low to actuate the meter in its



Essential elements of the clip-on antenna meter. The key hook was found to be the most essential item

standard form. A special clip lead is attached to the meter side of the capacitor and clipped to the antenna at a point determined by its extreme length to produce a similar reading on the instrument.

The last, and perhaps most important feature of the unit is the small hook at the lower left. On this hook the serviceman places the ignition keys of the radio car to prevent it from being driven away with the tester still attached to the antenna.

• • •

Carbon Phonograph Pickup

By ALVIN B. KAUFMAN AND EDWIN N. KAUFMAN

Electronic Engineers
Hollywood, California

A PHONOGRAPH PICKUP capable of supplying between 6 and 45 volts output from conventional records would be highly desirable. With such a high output, it would be possible to design and construct phonograph amplifiers having only one or two tubes.

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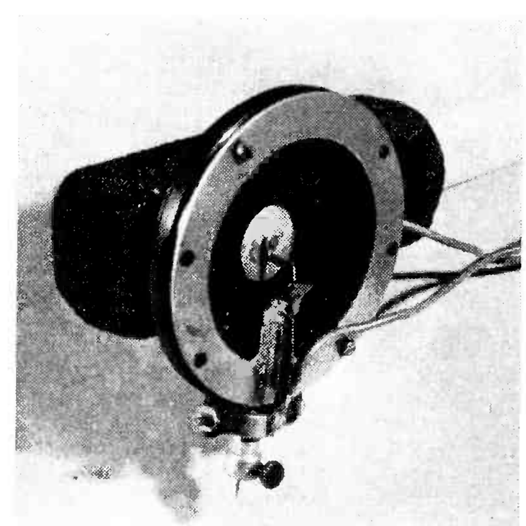
nograph needle having a pivoted arm which is arranged to mechanically actuate a carbon microphone button (single or double). The operation is such that the phonograph needle is displaced mechanically by its movement in the groove of a phonograph record.

The pickup utilized a standard type of crystal pickup arm with the carbon button assembly mounted in place of the crystal cartridge. The carbon button was constructed in an acoustical tone arm head. Fortunately, the needle pressure did not exceed five ounces and so the pickup arm was not rebalanced for the preliminary tests. The diaphragm was replaced by the metal diaphragm from a small single-button Universal microphone. This was glued securely around the edge to the head assembly, and secured to the pivot arm by a small machine screw, as shown in the photograph. Carbon granules were then placed behind the metal diaphragm and held in place with felt washers while backed with another metal plate forming the other electrode.

With the volume control at maximum, there was no noticeable hum or carbon hiss. Due to the large diaphragm area exposed, the pickup was found to act as a microphone and cause oscillation when placed too close to the loudspeaker. This diaphragm area was eventually acoustically insulated by felt padding without affecting the operation to any large extent.



Mechanical arrangement of needle assembly and diaphragm mountings on the carbon-button pickup

The frequency response of the

pickup is not limited at the low-frequency end of the spectrum, any variation in needle position causing a change of button current. However, the high-frequency response is definitely limited by the mass of the pivoted arm and diaphragm and their resonant frequency. The pickup and its associated components had a frequency response essentially flat between 100 and 6,000 cycles as checked with a Columbia tone record.

The noise level produced by the needle operating in an unmodulated record groove was high. As the output voltage was much higher than needed, the pivoted arm was damped to produce less amplitude modulation of the carbon button for a given groove amplitude. For this reason, the pivoted arm was soldered to an arm projecting from the head assembly. This reduced the noise level and output voltage considerably. It was noted that vibration of the head assembly was shaking the carbon granules and causing an output of noise. Thus it became apparent that the difference in phase between the voltage caused by the pickup head vibrating to the recorded subject and that of the signal impressed by the needle movement was causing excessive intermodulation and distortion.

This is as far as our experiments progressed. There are, however, two cures for the last-mentioned trouble. One is to allow the phonograph needle to vibrate the pickup head, with the carbon button being driven only by this vibration and not connected in any way to the needle. This method would probably result in poor frequency response and possible excessive wear on the record. The second method would be to build the unit like a crystal pickup cartridge. A thin sheet of carbon could be arranged to have one end fixed, the other end being flexed by the phonograph needle. A contact on either side of the carbon sheet would then

---

AVERAGE WEEKLY earnings in the radio and phonograph manufacturing industry during February 1946 were $39.01 for an average workweek of 39.7 hours, according to Bureau of Labor statistics.


Type TS2A Ceramicon Trimmer
1.5-7 MMF 3-13 MMF 4-30 MMF
3-12 MMF 5-20 MMF 7-45 MMF
Feed-Thru Ceramicons
3 MMF—1,000 MMF
Insulated Hi-K Ceramicons
271 MMF—5,000 MMF
Non-Insulated Hi-K Ceramicons
271 MMF—15,000 MMF
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ERIE RESISTOR has developed and manufactured a complete line of Ceramic Condensers for receiver and transmitter applications; Silver-Mica and Foil-Mica Button Condensers; Carbon Resistors and Suppressors; Custom Injection Molded Plastic Knobs, Dials, Bezels, Nameplates and Coil Forms. Complete technical information will be sent on request.
High Voltage Double Cup Ceramicons
20 MMF—600 MMF
Type 554 Ceramicon Trimmer
3-12 MMF 5-30 MMF
5-25 MMF 8-50 MMF
Cinch-Erie Plexicon Tube Sockets with
1,000 MMF built in by-pass condensers
Stand-Off Ceramicons
1 MMF—2,500 MMF
Type 680A High Voltage, High KVA
Multiple Plate Transmitting Ceramicons
120 MMF—1,800 MMF
Types 504B, ½ Watt—518B, 1 Watt
Resistors
10 ohms—22 megohms
Disc Ceramicons
51 MMF—7,500 MMF
Temperature Compensating
Insulated Ceramicons
0.5 MMF—360 MMF
Temperature Compensating
Non-Insulated Ceramicons
0.5 MMF—1,100 MMF
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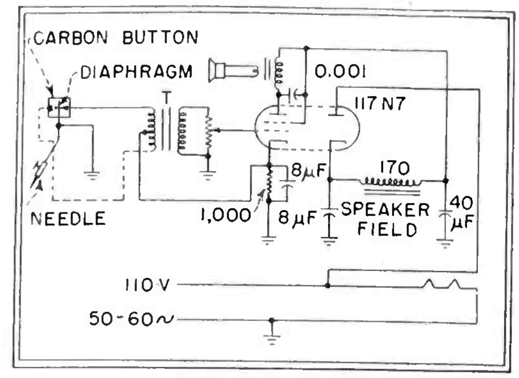


One-tube amplifier and rectifier circuit used in testing the carbon pickup. A double-button unit could be connected as shown by the dashed line

have varying pressures applied to it.

The circuit of the amplifier employed for these tests is shown. The bias voltage of the tube was six volts, which was enough to supply adequate button current. The carbon button and primary of the transformer are placed in series and across the bias resistor. At the start the cathode circuit was heavily bypassed so as to supply a steady source of direct current. The overall frequency response was from 100 to 6,000 cycles, including the pickup.

The cathode bypass was then removed and it was noted that the phasing of the primary winding would cause either regeneration or degeneration. Connected for degeneration, the volume fell off slightly and the frequency response was extended. The distortion remained the same because it was not produced by the tube circuit, but by the pickup. The plate circuit of the tube was bypassed sufficiently to remove high-frequency components caused by scratch or distortion.

ERRATUM: The article entitled "Electronic Fire and Flame Detector" in the July issue of ELECTRONICS contained an error in byline. The manuscript specified "By Paul B. Weisz, Bartol Research Foundation of the Franklin Institute, Swarthmore, Pa." with a footnote reading "Now with Socony-Vacuum Oil Company, Research and Development Laboratories, Paulsboro, N. J." As published, this appeared as "Socony-Vacuum Research and Development Laboratories, Swarthmore, Pa."

Shown here is microphotograph of a diamond being drilled. It shows the precise Philips workmanship.

Tolerances so close they must be weighed

That's right—the tolerances of the fine wire made by North American Philips cannot be measured by micrometers—the wire must be weighed on delicate balances.

That kind of precision craftsmanship—which goes back to and beyond even the smallest component—has made possible the production of wire so fine that 2,000 pieces laid side by side measure but an inch.

To draw wire this fine—with tolerances and characteristics maintained—Philips developed its own methods of drilling precision diamond dies. These dies are in daily use in Philips and other factories, insuring fine wire users of a more precise product.

Such fine wire—drawn through Philips precision diamond dies—is a vital component of electronic tubes manufactured by Philips and others.

Thus the skill of an organization, known for over fifty years for its devotion to *precision craftsmanship* down to the smallest *component*, is evidenced in the increasing acceptance and use of Philips products.

An organization with a background of over 50 years in electricity

In addition to fine wire and diamond dies, North American Philips also manufactures quartz crystals, cathode ray tubes, industrial and medical X-ray tubes and equipment, tungsten and molybdenum products.

Norelco Reg. U. S. Pat. Off. ELECTRONIC PRODUCTS

NORTH AMERICAN PHILIPS COMPANY, INC.

DEPT. S-9, 100 EAST 42nd STREET
NEW YORK 17, N. Y.

INDUSTRIAL CONTROL

Edited by VIN ZELUFF

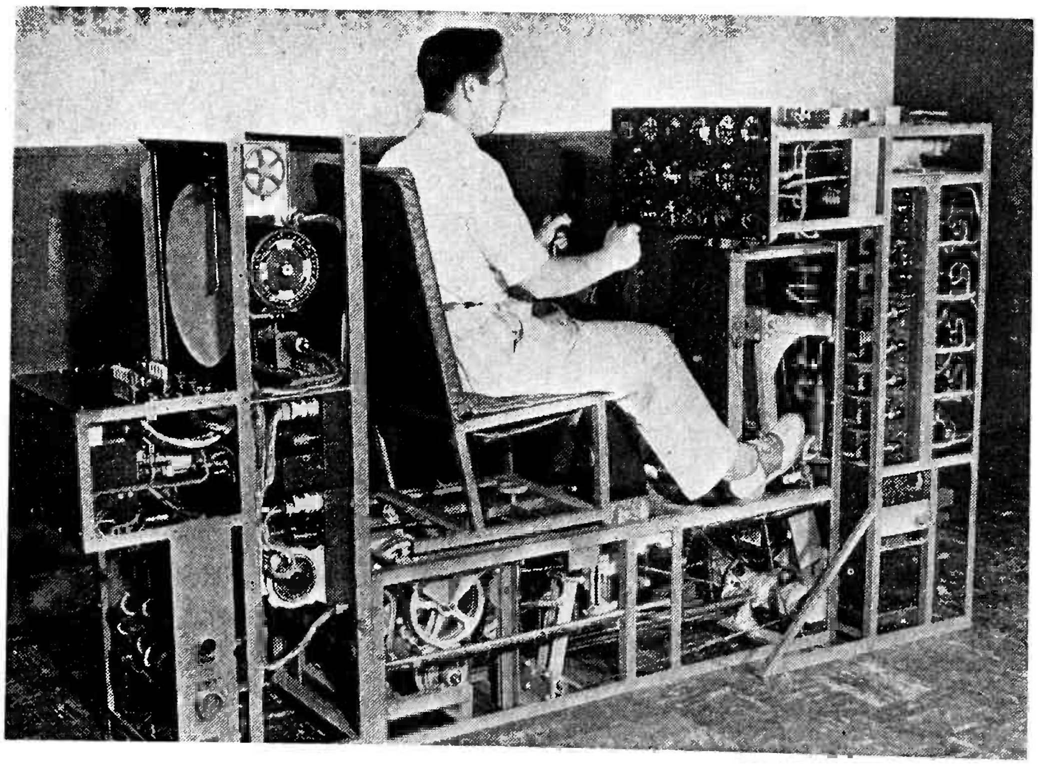
Electronic Flight Trainer

AN ELECTRONIC computing system which continuously, instantly, and simultaneously solves the differential equations expressing the motion of an airplane in space is the basis of the Curtiss-Wright Dehmel electronic flight trainer with automatic radio range. The trainer embodies full aircraft instrumentation as well as completely automatic four-course A-N radio range, two-course visual-audio vhf radio range, and blind landing system.

The basic computing circuit is a multiservo system in which the variables are introduced as potentials obtained from voltage dividers actuated by the controls. All the interacting effects between lift, drag, thrust, and the various other moments and forces causing the airplane to maneuver, stall, or spin in space are developed as electrical voltages when the controls are operated. These voltages are sent as signals to the computing system of the trainer, which delivers the correct answers and translates them continuously and smoothly into meter indications in the cockpit of the trainer, into variations in engine sound effect and control loading, and into actuation of the course-plotting unit and radio navigation aids.

Flight Computer and Instrumentation

The nine electronic servos making up the flight computing system are each driven by a small ball-bearing polyphase motor that is energized by a control voltage applied through a compact amplifier. Each servo drives a multicontact spider through a simple gear train to select voltages from a number of the contoured potentiometers operated from a particular servo assembly.



Flight characteristics of an AT-6 airplane in the air are simulated by the prototype version shown above stripped of its aluminum fuselage. Produced for the Army Air Forces by Curtiss-Wright, it uses servos to feed an electronic computer

Automatic Radio Range and Recorder

The electronic flight trainer incorporates a completely automatic radio range and blind landing simulation. This incorporates four arms which may be set so as to represent the course legs of any radio range station in the country. A polar type of flight path recorder is provided, comprising a circular paper chart 15 inches in diameter, the orientation of which is controlled by an amplifier-driven servo system. The pen mechanism is responsive to range and is driven by a second servo. By this method, precision recording of the horizontal projection of any flight path is obtained. Since the flight path recorder and the A-N signal system are intimately and permanently connected together, the audible signal received at any instant is a direct function of the position of the pen, and is not dependent therefore on the interpretation of an instructor.

Flight-path recorder and automatic radio range of the Curtiss-Wright Dehmel electronic flight trainer for embryonic pilots

Two controls locate the starting point of a problem; one sets up the east-west distance and the other the north-south distance from the range station to the take-off position. Two other controls may be varied to add wind from any direction up to 120 miles per hour.

Appropriately keyed fan markers may be set up at any distance from the range station and will be received by the pilot when his flight path passes through the marker position. In addition, the Z marker and cone of silence associated with

a range station will also be received if the path passes directly over the range station. An interphone system for communication between pilot and supervisor may be used to discuss the progress of the work, or to simulate radio contacts with ground stations.

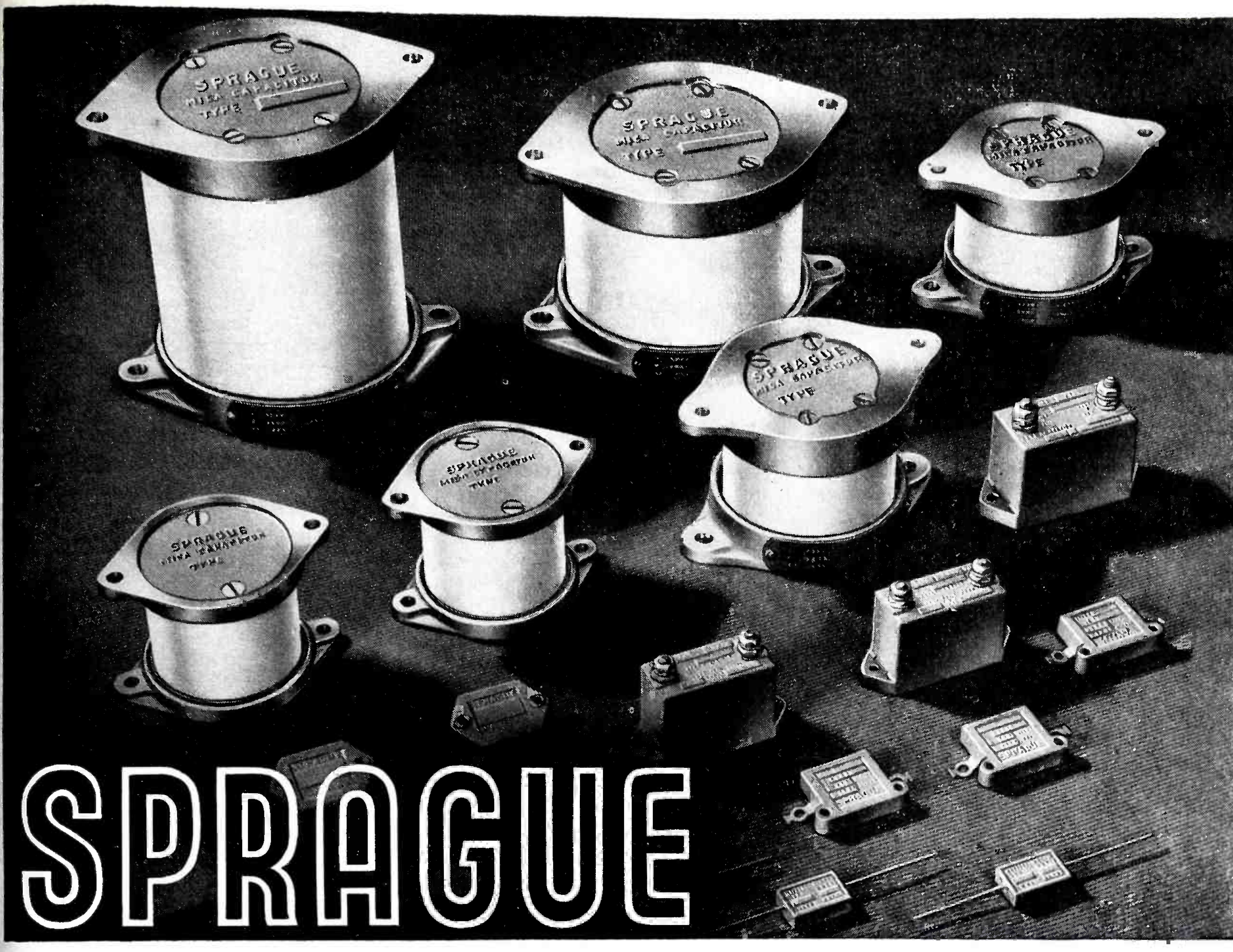
Additional manual controls include static simulation and volume adjustment for the intercommunication system. A switch provides selection of any one of five station identification cams furnished with the range signal keyer. These five cams may be readily interchanged with any other station signal cams which may be required for the particular section of the country covered by the flight problems being taught.

A fully automatic blind landing system of the SCS-51 type is normally furnished with the automatic radio range. This system is complete with boundary, middle, and outer markers appropriately keyed, and a localizer and glide path simulation which actuates the needles of the cross-pointer meter in the cockpit. With the position controls set at zero-zero, the system may be utilized to represent the new vhf two-course visual-audible ranges now being installed by the CAA throughout the country.

An aural null and radio direction finding simulation is incorporated to provide automatic indication of direction from the aircraft position to the range station, or may be used to locate and approach the range station using the conventional rdf procedures. This system may also be used to simulate the action of a loop-type radio compass.

In appearance the Dehmel AT-6 trainers purchased by the AAF resemble a single-seat airplane fuselage, minus wings and tail section. The enclosed fuselage contains the pilot's seat, aircraft controls and lighted instrument panel. An amplifier provides variable engine noises such as occur in flight. A flight path recorder and instructor's instrument panel are built into the trainer. The fuselage can be mounted on a rotating base if desired, and can be revolved in response to the operation of the controls.

Because it can be adapted to the



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WRITE FOR CATALOG 30

Contains data on all standard Sprague Mica Capacitors and outlines the many special types that can be engineered and produced as required.

ARMY E NAVY

SPRAGUE ELECTRIC COMPANY
NORTH ADAMS, MASS.

instruments and flight characteristics of any type airplane, the Dehmel trainer offers unlimited possibilities in the field of flight training. By alteration of the components of the electronic computing system and insertion of the appropriate instrument panel in the dummy cockpit, the changing requirements of new types of aircraft can be duplicated in the trainer accurately and satisfactorily.

• • •

Decca Navigation System for Ships and Planes

OF INTEREST to commercial aviation and merchant shipping, the English chain of Decca electronic navigator stations was declared officially in operation in July. Transmissions from this chain will be made throughout 24 hours of each day, and provide navigational aid service to ships and aircraft fitted with Decca navigator receivers over an area which extends to a minimum distance of 300 miles from London.

In daylight hours, transmissions from the stations can be recorded and used for navigational purposes up to more than 1,000 miles. Within this service area, any ship or aircraft fitted will, by reference to the indicating meters, be able to fix its position with a very high degree of precision. This precision will become increasingly greater as the coasts of Great Britain are approached and will be precise enough to allow the system to be used as an aid to pilotage in the main estuaries and ports around the English coast.

The immediate purpose of the stations is to secure data and test the efficiency of the system in connection with consideration of its adoption as the standard worldwide navigational aid for aircraft and marine vessels.

This first chain of Decca navigator stations comprises four stations, three of which are now operational, and the fourth nearing completion. One of the stations, at Buntingford, in Hertfordshire, is termed the master, the other stations being the slaves. Each slave is identified by a color. The first is the Red slave station at Stokeholy Cross, near Norwich. The second

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LINDE Nitrogen provides an ideal means of protection against oxidation and corrosion by air. For packaging dehydrated foods; for deaerating, processing, storing and packaging fats and oils of all kinds; or for providing an inert atmosphere, free of impurities, for the complete protection of practically any material susceptible to oxidation, use LINDE Nitrogen.

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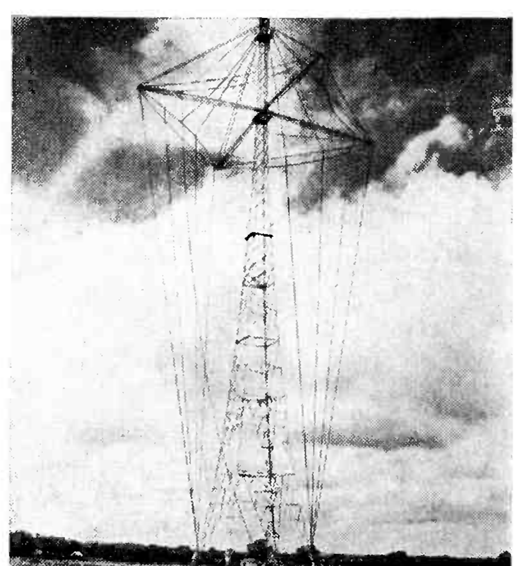
Spokane, Wash.

is the Green slave station at East Hoathley, near Lewes in Sussex, and the third is the Purple slave, which will be at Wormleighton, Warwickshire.

Antenna System

The principal feature of each station is the aerial system, which is hung on a 325-foot steel mast. The master station consists of such a mast, together with a transmitter building and reserve power building. The slave stations are similar in construction, except the transmitter building houses the automatic phase control units by means of which the slave transmissions are locked to the master signal. These phase control units ensure that a very high degree of synchronization is maintained between the slave and master transmissions. On both the master and slave stations, extreme precautions are taken to ensure that no failure either in the public supply power service or in the radio equipment can cause failure of the radio transmissions from the station.

Transmissions from the master and each slave station in turn are picked up on the receiver in the aircraft or ship. These transmissions are compared by electronic means, and by consideration of the known speed at which radio waves travel, the position of the receiver is fixed with relation to the distance from the master and each slave. This fix of position, given instantaneously and continuously as the ship or aircraft moves, is displayed on meter dials similar to a speed-



Antenna system and transmitter building of the Red slave station of the new Decca system at East Hoathley, England

CELCON is the Plastic for all-temperature toughness!

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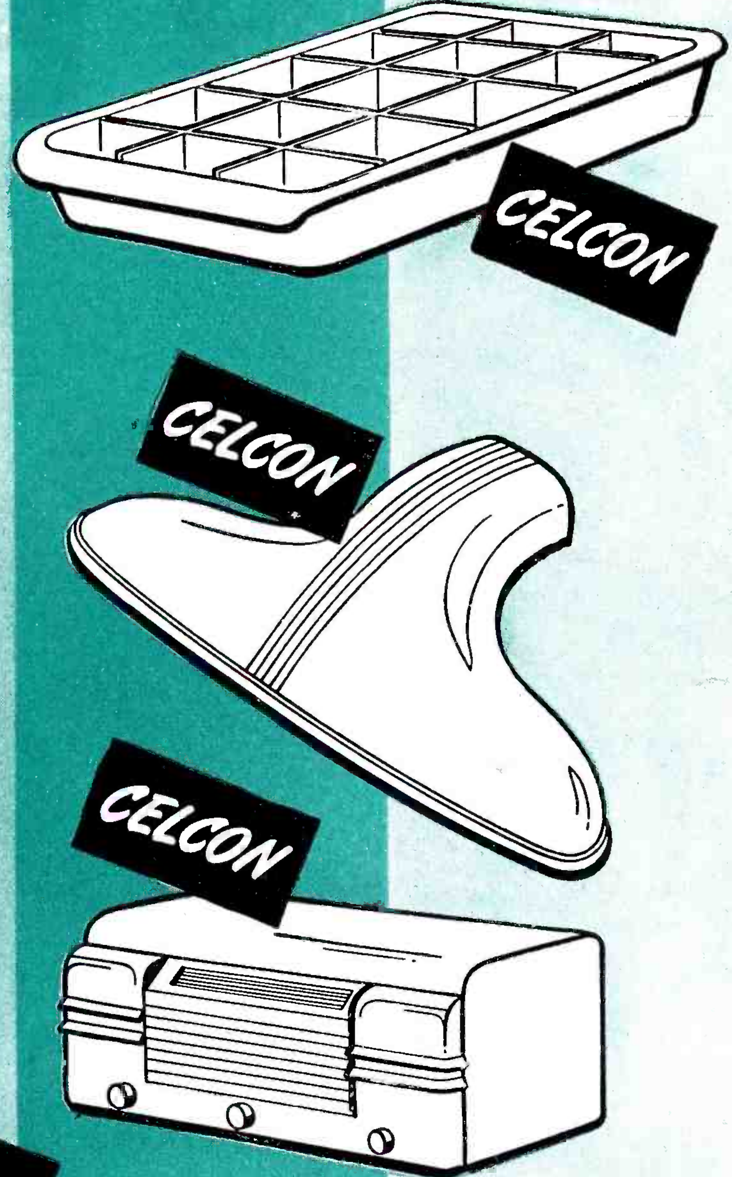

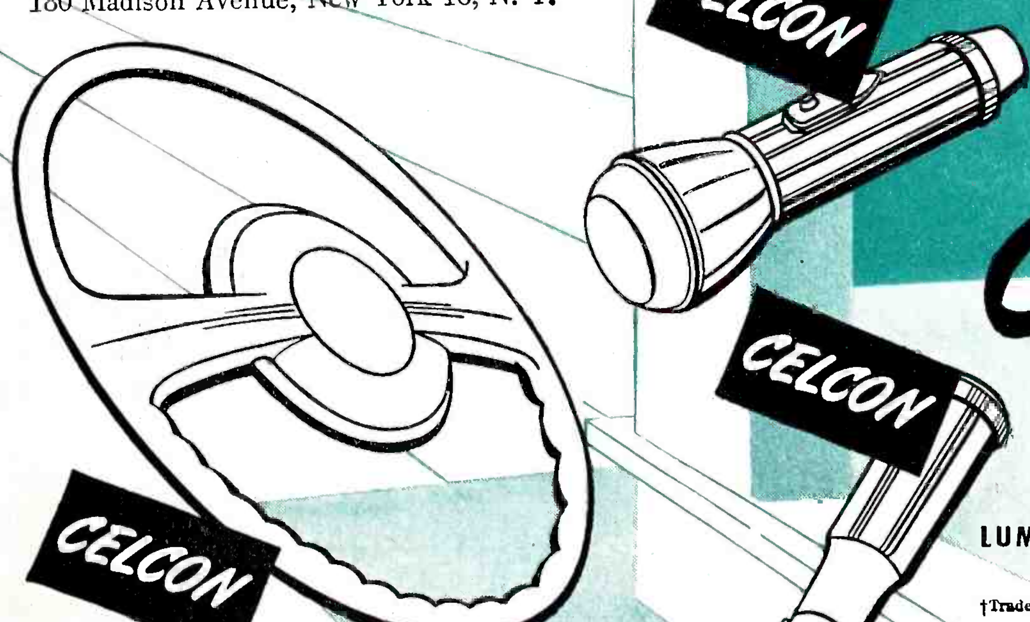

Celanese* Plastics

LUMARITH* FORTICEL* CELCON†
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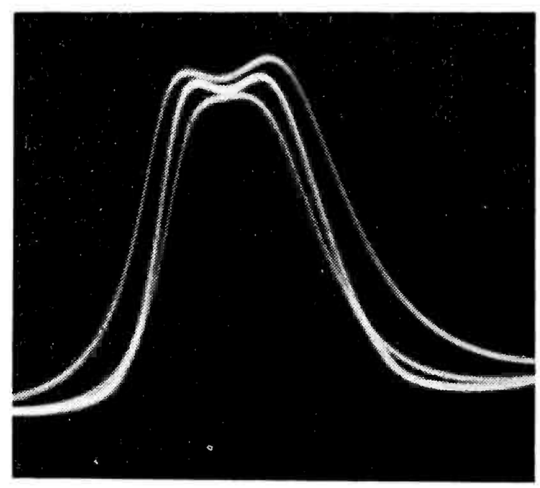
†Trademark *Reg. U.S. Pat. Off.

work to operate a new instrument that uses a cathode-ray tube as the indicating device. The representation of the i-f response curve of the component under test is such that it must fit between the traces of limit coils of the same receiver design which are continually shown on the scope screen. If it does not, it is immediately rejected as outside limits. The degree of over, under or critical coupling may readily be observed in the shape of the traces.

The equipment consists of a frequency-modulated oscillator, reference and test i-f stages, electronic switching and sweep circuits, and an oscilloscope. The frequency-modulated oscillator is of the conventional reactance tube type and may be set at any frequency between 85 kc and 11 mc by means of plug-in oscillator coil assemblies. The oscillator is followed by a buffer amplifier which feeds the reference and test i-f stages. Three i-f stages are in parallel and equal signal is given to all three. The output of each stage is an infinite-impedance detector. The three detectors are connected together in a common cathode resistor which represents about one-third of their cathode load.



The production coil is adjusted so that its curve falls within the limit traces that have been previously standardized

The electronic switching alternates each of these three channels in sequence (test, low limit, test, high limit), so that at any one time only one channel is effective in producing a trace on the screen of the oscilloscope. The saw-tooth sweep generator is synchronized with the electronic switching and sweeps both the reactance tube circuit and the horizontal plates of the oscilloscope. Overcoupled coils may be tuned in

The Collins 212A-1 Studio Console

The Collins 300G 250 Watt Broadcast Transmitter

The excellence of Collins broadcast equipment is an accepted tradition, backed by years of reliable service under continuous operation. During the war years, when maintenance was a major problem, owners and operators of Collins equipment found their faith thoroughly justified by the thousands of hours of uninterrupted operation logged on their stations.

The new Collins transmitters and speech equipment reflect the soundest principles of design and construction. By careful attention to detail, and by combining foresight with experience, we have developed high fidelity broadcast equipment that is outstanding for endurance, style, and accessibility.

The 300G 250/100 watt AM transmitter is designed for continuous high fidelity service. The frequency response is within ±1.0 db from 30-10,000 cps, and distortion and noise are far better than FCC requirements. Stabilized feedback maintains the excellent performance over variations in operating conditions.

The Collins 212A-1 speech input console is a packaged unit providing simultaneous auditioning or rehearsing, cueing, and broadcasting from any combination of two studios, an announce booth, a control room announce microphone, two turntables, and six remote lines. The frequency response of 30-15,000 cps is ideal for AM, FM, and Television applications. The chassis rotates within the end supports, permitting maintenance during operation.

Write today for illustrated bulletins describing these and other Collins broadcast equipments.

FOR BROADCAST QUALITY, IT'S . . . COLLINS

Collins Radio Company, Cedar Rapids, Iowa

11 West 42nd Street, New York 18, N. Y.   458 South Spring Street, Los Angeles 13, California

a few seconds since it is immediately obvious whether or not they are within the specified limits by the position of the test trace with respect to the two limit traces.

Operation

The operator makes but three adjustments: the two tuning screws on the coil under test and a gain control giving a small amount of control to the stage under test. This gain control is not sufficient to allow an out-of-limits coil to fall within limits and may be locked at any desired setting.

Voltage variations which normally cause decentering of the scope pattern cause no error as all three traces move together. Frequency shift affects all three traces in the same manner and, thus produces no error in the system. Gain variations in the scope or amplifier circuits cancel out as all three signals are amplified in the same channel. The two limit traces serve as a constant check on each other and any serious change in either limit channel immediately shows up as a change in the scope presentation.

The use of an external oscilloscope having good low-frequency response is required for the Visi-limit curve tracer, made by Raymond M. Wilmotte Inc., New York. Setting up the scope is a minor problem as the internal sweep of the equipment is brought out to a plug and cord and can be applied to the horizontal gain amplifier of the scope. This eliminates synchronization problems.

• • •

Mobile Two-way F-M in Cabs

TESTS OF F-M two-way radio are being made in Philadelphia to determine how widely the equipment may be utilized in Yellow Cab Company's 1,172 taxicabs and 15 Cabulances. The company plans to install two-way radio in about 25 of the automobiles used by the company's street supervisors. The next step would be to install mobile equipment in 50 cabs, to be available for emergencies.

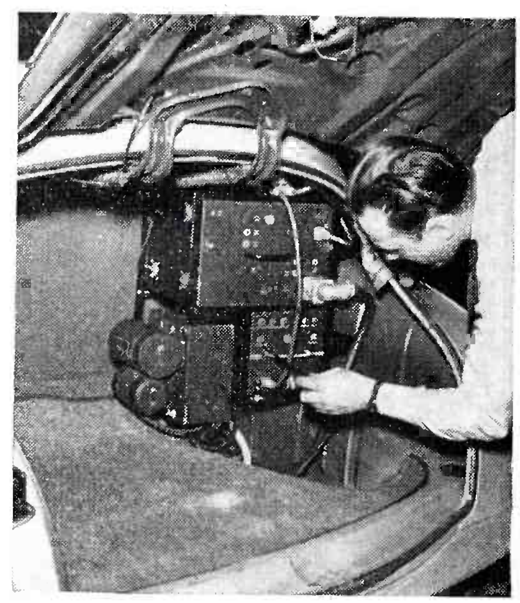
When the system is placed in full operation, communication by telephone will be established between the station on the roof of the Aldine Trust Building and the headquarters of the cab company's dispatch-

ers several blocks away, permitting operation of the entire system from the latter point. A dial system will enable dispatchers to call any individual cab.

Developed by engineers of RCA Victor Division of RCA, the mobile equipment consists of a small control box and a handset installed on the dashboard of the cab; a 40-watt f-m transmitter, a dynamotor, and an f-m receiver, all in the cab's baggage trunk; and an 18-inch antenna on the cab roof.

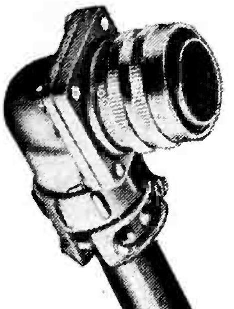
The station equipment includes a 45-watt f-m transmitter, power supply, and f-m receiver, and an 18-inch ground plane or "Whirling Joe" antenna mounted on a mast on the roof of the Aldine Trust Building.

The equipment operates in the new frequency band of 152 to 162 megacycles, which was opened up by the Federal Communications Commission last year for tests by urban transit, police, and similar services. Preliminary reports indicate that blind spots and shadows experienced in down-town areas in large cities on lower frequencies are not encountered on the new frequency allocation.



In the baggage trunk of the cab are mounted the 40-watt f-m transmitter at top, receiver at lower right, and dynamotors at lower left

A METHOD of viewing an object by projecting upon it electromagnetic waves of short wavelength is described in British patent 292,185 granted to J. L. Baird in 1926.



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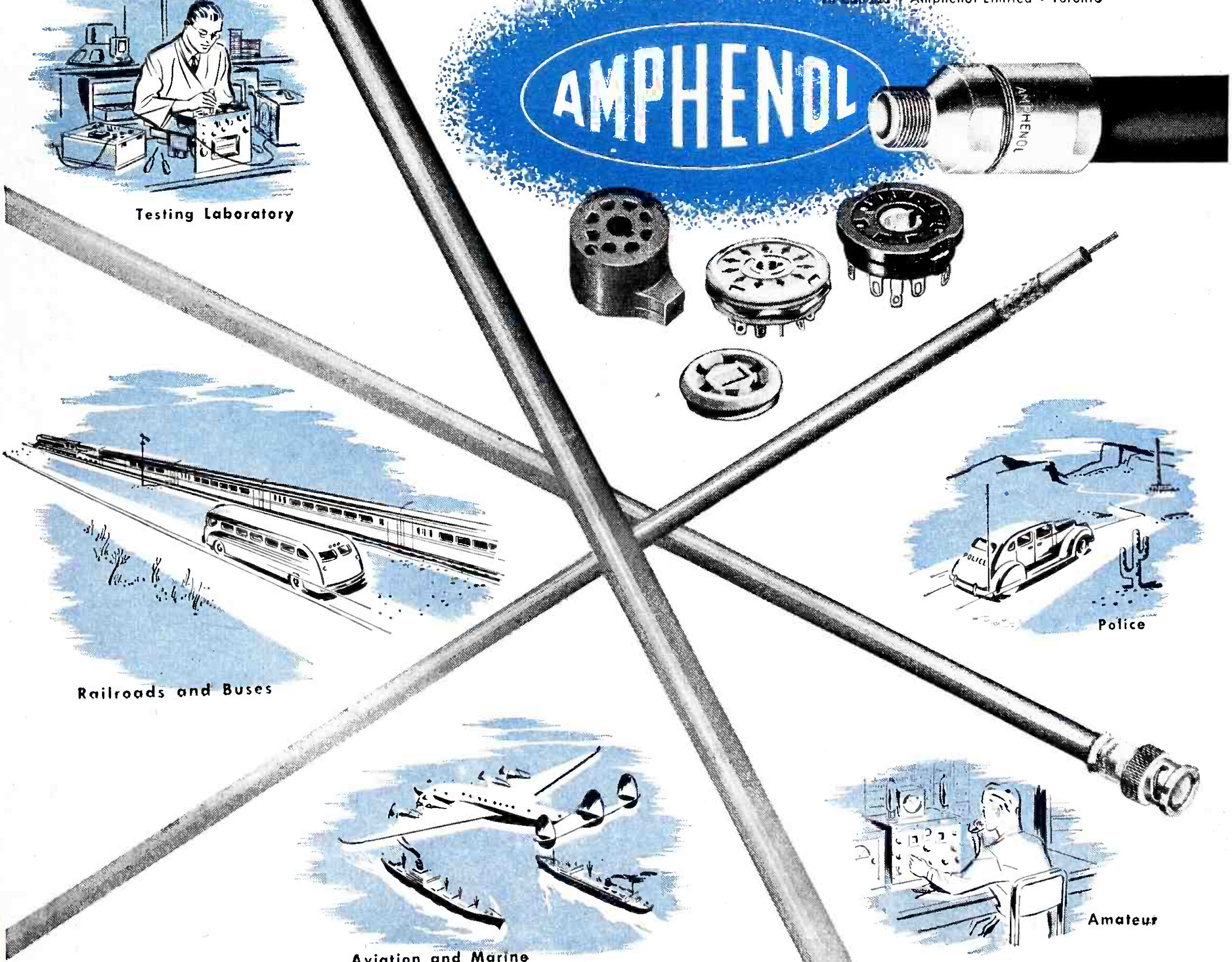

COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RADIO • COMPONENTS • PLASTICS FOR ELECTRONICS ers several blocks away, permitting operation of the entire system from the latter point. A dial system will enable dispatchers to call any individual cab.

Developed by engineers of RCA Victor Division of RCA, the mobile equipment consists of a small control box and a handset installed on the dashboard of the cab; a 40-watt f-m transmitter, a dynamotor, and an f-m receiver, all in the cab's baggage trunk; and an 18-inch antenna on the cab roof.

The station equipment includes a 45-watt f-m transmitter, power supply, and f-m receiver, and an 18-inch ground plane or "Whirling Joe" antenna mounted on a mast on the roof of the Aldine Trust Building.

The equipment operates in the new frequency band of 152 to 162 megacycles, which was opened up by the Federal Communications Commission last year for tests by urban transit, police, and similar services. Preliminary reports indicate that blind spots and shadows experienced in down-town areas in large cities on lower frequencies are not encountered on the new frequency allocation.

In the baggage trunk of the cab are mounted the 40-watt f-m transmitter at top, receiver at lower right, and dynamotors at lower left

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A METHOD of viewing an object by projecting upon it electromagnetic waves of short wavelength is described in British patent 292,185 granted to J. L. Baird in 1926.

THE ELECTRON ART

Edited by FRANK ROCKETT

Impedance Nomograph

By GERSHON J. WHEELER
Brookline, Mass.

THIS NOMOGRAPH presents a simple means for converting $R \pm jX$ to Z/θ or vice versa. Enter the graph with the value of R as the abscissa and the value of X as the ordinate. The point so located lies on or near an arc which represents a value of Z to be read at either end of the arc. The angle θ is found by laying a straight edge through the origin and the point found above. The value is read on the outside quadrant.

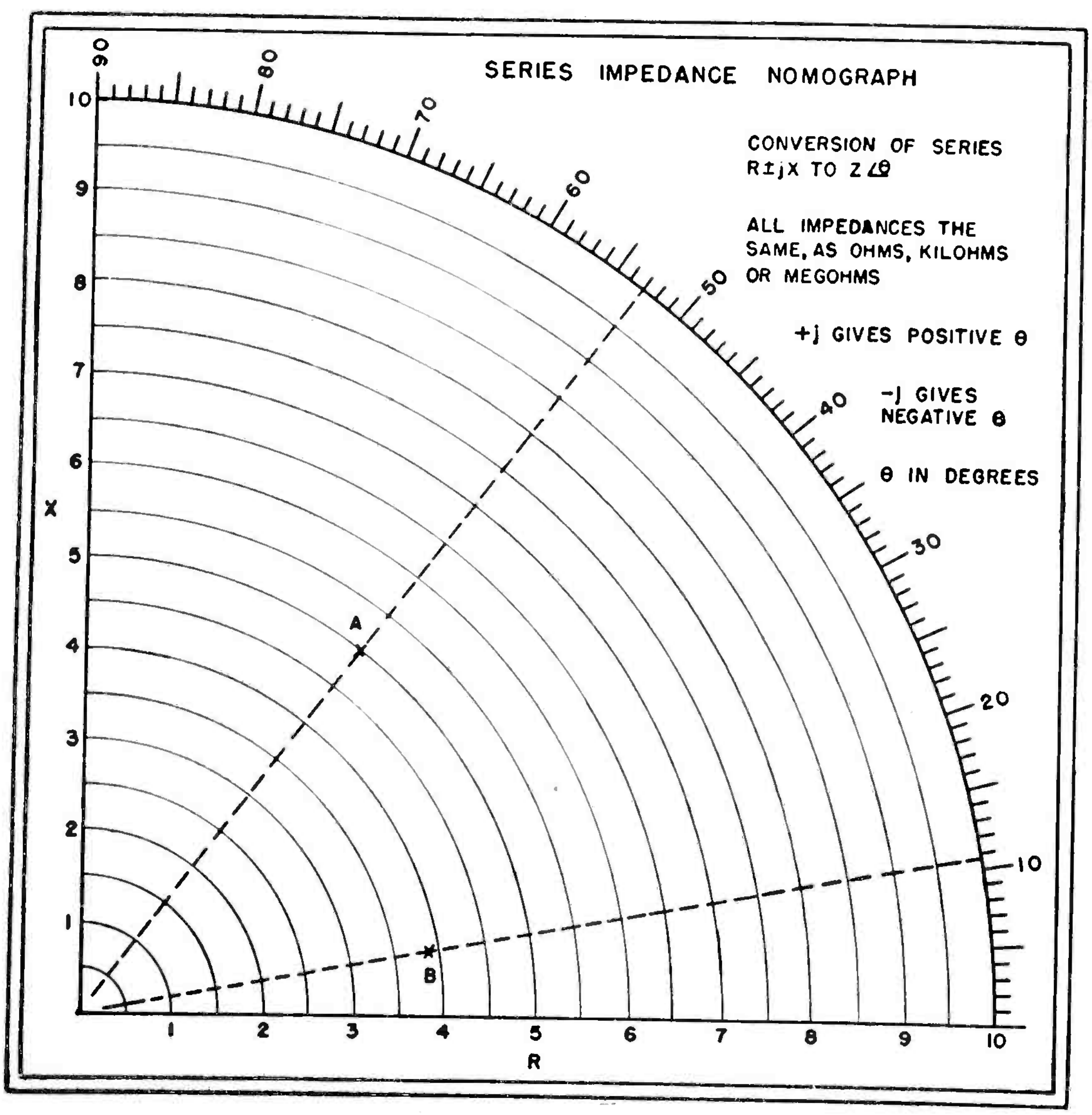
For example: R is 3 ohms, X is 4 ohms. The point located as above is point A on the graph. It lies on an arc which has a 5 at either end. A straight edge through A and the origin intersects the quadrant at about 53 degrees. Thus Z is 5 ohms and θ is 53 degrees. If R is 30 and X is 40, then Z would be 50. That is, the units may be ohms, tens of ohms, fractions of ohms, etc, as long as R, X, and Z are in the same units.

If R is 38 ohms and X is 7 ohms, the intersection is now at point B. Here the units are tens of ohms. Z is approximately 39 ohms and θ is about 10.7 degrees.

If Z/θ is given, the process is reversed.

If R is ten times X or greater, or if X is ten times R or greater, then Z is approximately equal to the larger value, and θ cannot be determined accurately but is larger than 84 degrees or smaller than 6 degrees as the case may be.

If X is negative, θ is negative.



Production Research

MEASUREMENT OF FORCES on high speed cemented, or sintered carbide-tipped milling tools is being done with a cathode-ray oscillograph. Need for high production rates from milling machines led to the use of carbide-tipped tools. However, little was known of the proper feed, rakes of tool cutting edges, and cutting speeds. After much observation of tool wear and life, strain gages were mounted on a single-tooth cutter assembly and strains observed on the oscillograph shown in Fig. 1.

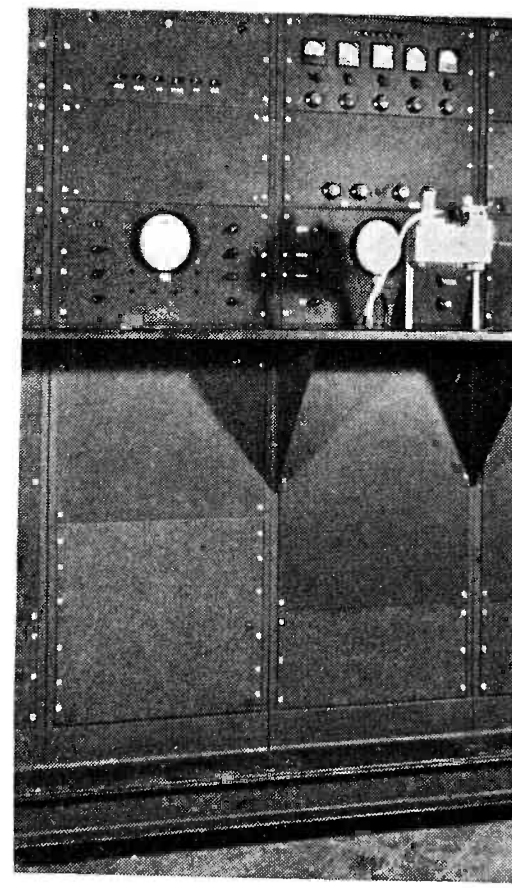
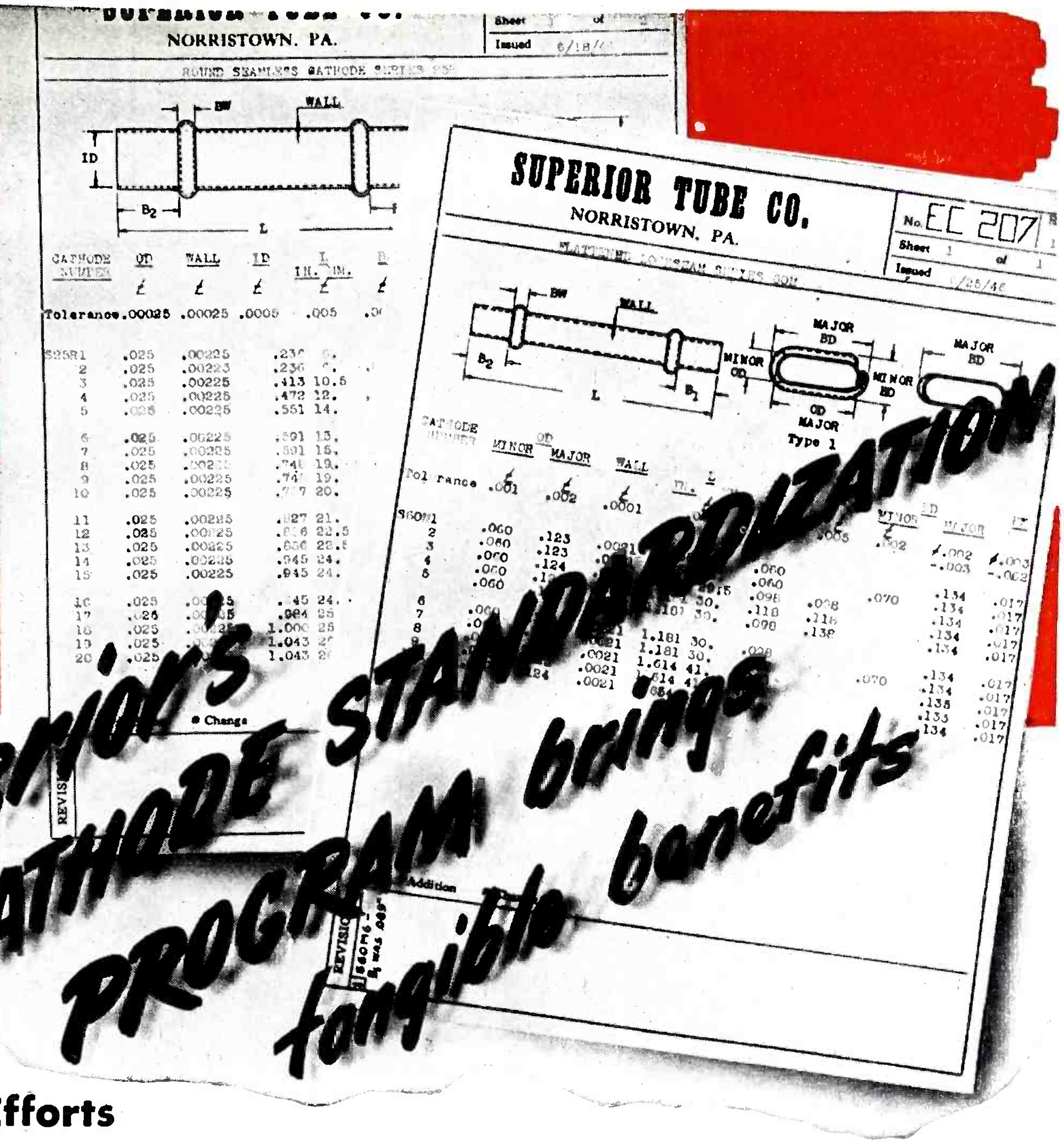


Fig. 1—Two sections of the five-channel oscillograph used to record forces in milling cutter

Oscillographic Studies

The five channel cathode-ray oscilloscope, designed and built at California Institute of Technology, consists of individual cathode-ray tubes and their associated circuits; five cameras automatically photograph the oscilloscope patterns. Resistance-wire strain gages are located on the cutter to measure tangential, axial, radial or instantaneous torques. A fifth gage was mounted between the

TWO TYPICAL EXAMPLES of SUPERIOR'S STANDARD TOLERANCE Specification Sheets



Collaborative Efforts with Radio Tube Industry result in:

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The Superior Tube Company Electronics Division, working closely with the needs of the radio tube industry, has developed over the years a program of measurement and control which has re-defined reasonable expectations in cathode sleeve design and production. Mutual benefits have been the result, for Superior now offers to the tube manufacturer, a line of cathode sleeves to standard specifications which are to tolerances closer than would be possible otherwise.

For special requirements, closer than standard specifications can be met.

You are cordially invited to bring both cathode and anode problems to us. The Engineering Staff of Superior Electronics Division will gladly work with you.

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work and the table. Connections between strain gages and oscillograph are made by slip rings connected at the rear of the cutter spindle. With this equipment, data can be collected much faster than with the earlier practice of observing various cutting procedures.

Effect of angle of rake was studied from such traces as the one shown in Fig. 2. By measuring the areas un-

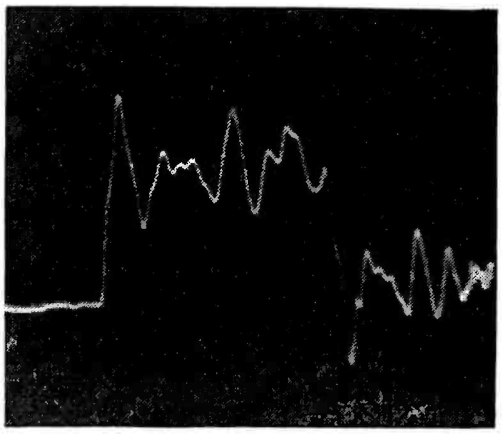

Fig. 2—Oscillograph indicates magnitude and frequency of forces in cutter as tool passes through the work

der a number of these curves with a planimeter the graph of Fig. 3 was obtained. Similiar graphs for all forces are being prepared.

Reporting Findings

Research projects, originated by the Office of Production Research and

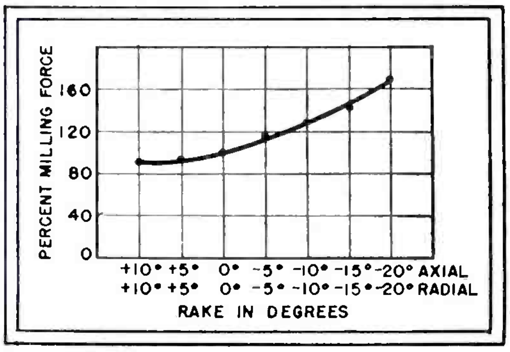

Fig. 3—Effect of rake on milling forces is plotted from many oscillograms

Development of the WPB, were suggested by the Manufacturing Engineering Committee of The American Society of Mechanical Engineers. During the war the ASME collected and published the findings and experiences of numerous manufacturers and users of millers and the results of research centered at California Institute of Technology and the University of Michigan. The oscillograph was developed at Cal Tech toward the close of the war.

DE MORNAY • BUDD
STANDARD TEST EQUIPMENT

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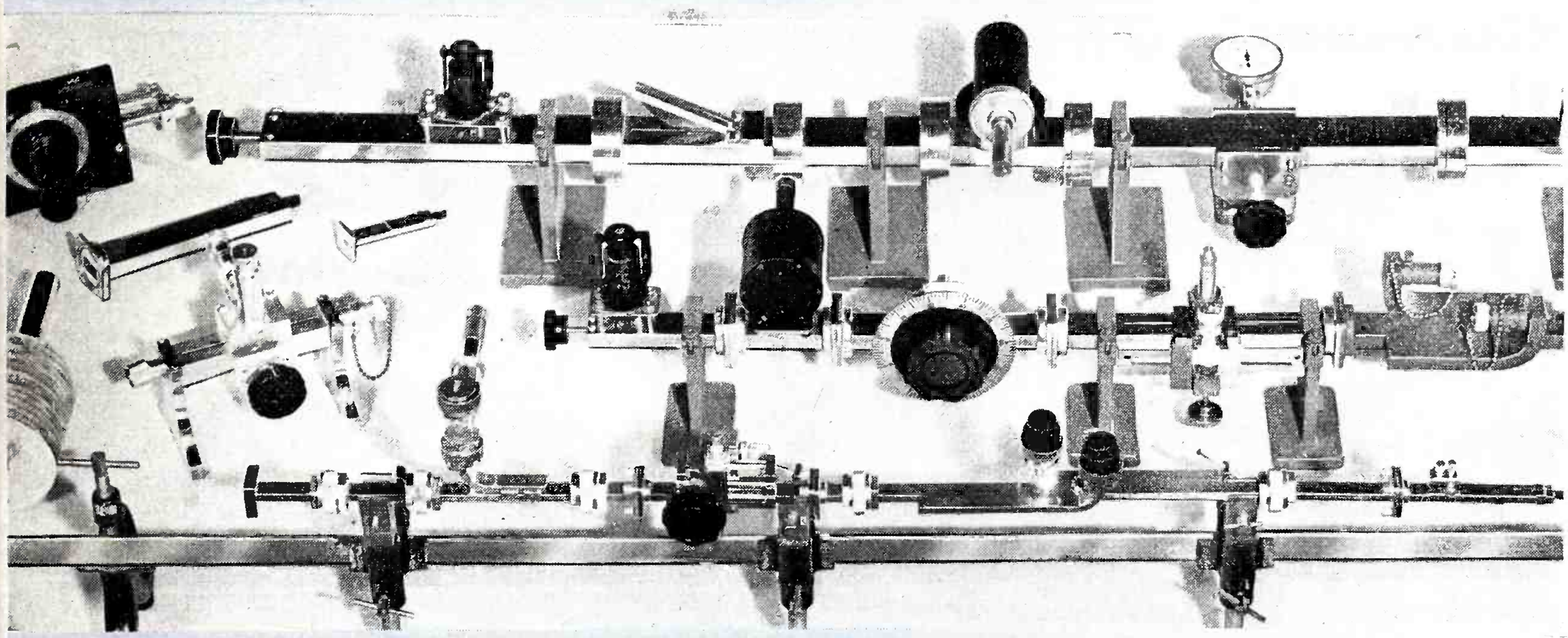

The complete line of De Mornay • Budd standard test equipment covers the frequency range from 4,000 mcs. to 27,000 mcs. It provides all R. F. waveguide units necessary for delicate, precision test work requiring extremely high accuracy in attenuation measurements, impedance measurements, impedance matching, calibration of directional couplers, VSWR frequency measurements, etc.

To eliminate guesswork, each item of this De Mornay • Budd test equipment is individually tested and, where necessary, calibrated, and each piece is tagged with its electrical characteristics. All test equipment is supplied with inner and outer surfaces gold plated unless otherwise specified.

Our greatly expanded microwave research facilities are at your disposal for consultation.

The three test set-ups illustrated above include:

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- Frequency Meter
- Calibrated Attenuator
- Tee
- Stub Tuner
- Tunable Dummy Load
- Standing Wave Detector
- Type "N" Standing Wave Detector
- Directional Coupler
- High Power Dummy Load
- Cut-Off Attenuator

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ing society can provide. Results of these projects were published as the work progressed thereby enabling industry to make immediate use of new knowledge and techniques. As a consequence it is not now necessary to try to gather and publish all the information that was learned. The ASME hopes to continue the project with the cooperation of industry.

• • •

A New Resonant Circuit

PHASE INVERSION of electronic tubes combined with either resistance and capacitance, or resistance and inductance, produces electrical resonance. The capacitance form of the circuit is useful as a selective filter and ampilfier for very low audio frequencies. The inductance form is useful at high frequencies.

The action of inductance-capacitance resonant circuits is dependent upon the 180-degree phase difference between the two reactances. This same phase difference can be obtained by converting a reactance into the complementary type by means of a vacuum tube, and combining the resultant electrical reactance with a physical reactance of the original type. For example: A capacitance (−90°) is converted by a tube (+180°) to an inductance (+90°) which is then combined with another capacitance to produce resonance.

Characteristics

Whereas familiar vacuum-tube circuits that are frequency selective, such as those used in resistance-capacitance oscillators, depend for their operation on the introduction of negative resistance and therefore are

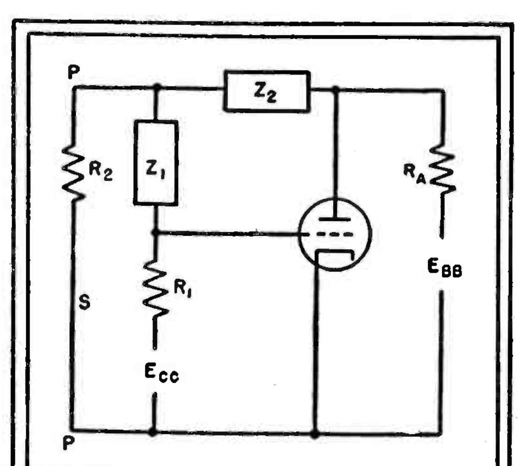
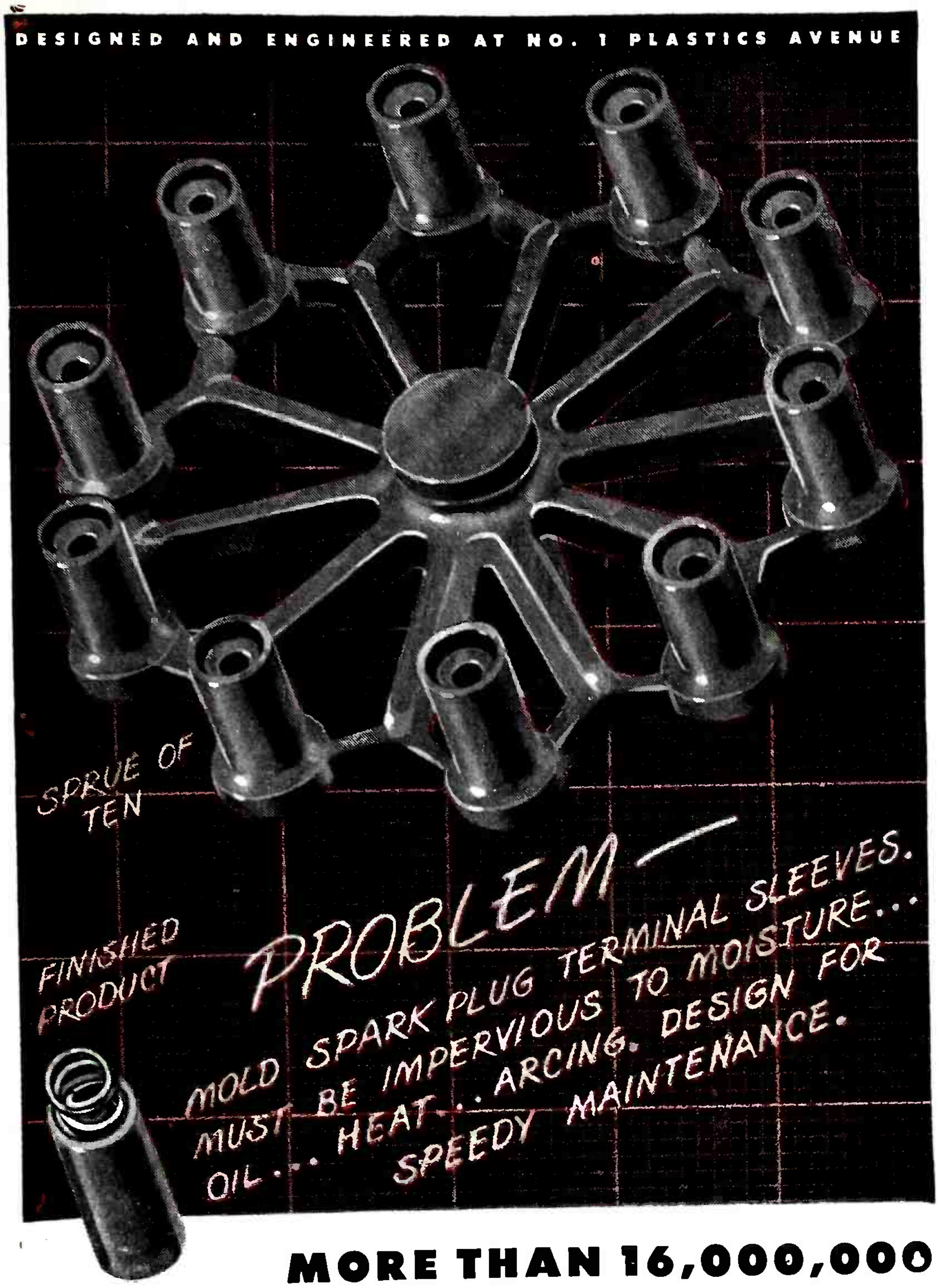


Fig. 1—In this resonant circuit, the reactances shown as blocks are both either inductors or capacitors



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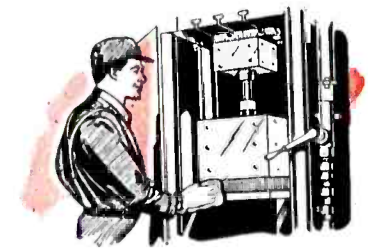

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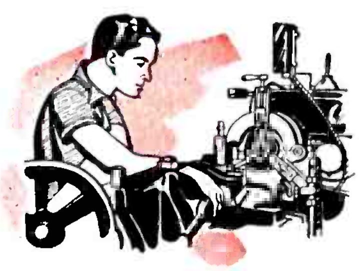

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GE MYCALEX

GENERAL ELECTRIC

CD46-M18

not stable, this circuit depends on the phase inversion introduced by the tube. Although this circuit is not capable of self oscillation, it is stable under all conditions. (ED. NOTE: This circuit could be used as the resonant element in an oscillator.) The basic circuit is shown in Fig. 1.

An analysis of the circuit indicates that capacitive circuit

$$\omega_0 = 1/(m'R_1R_2C_1C_2)^{1/2}$$
$$Q = (m'R_2C_2/R_1C_1)^{1/2}/g$$

inductive circuit

$$\omega_0 = (m'R_1R_2/L_1L_2)^{1/2}$$
$$Q = (m'R_2L_1/R_1L_2)^{1/2}/g$$

where the damping factor is

$$g = 1 + \frac{R_2}{R_1} + \frac{r_1}{R_1} + \frac{H_1}{H_2}\left(\frac{R_2}{R_1} + \frac{R_3}{R_1} + \frac{r_2}{R_1}\right)$$

$$m' = m + 1 + \frac{R_3}{R_1} + \frac{R_3}{R_2} + \frac{r_1}{R_1} + \frac{r_1R_3}{R_1R_2} + \frac{r_2}{R_2} + \frac{r_2}{R_1} + \frac{r_1r_2}{R_1R_2}$$

and m, the voltage amplification ratio of the tube, is g_mR_3 for a pentode, R_3 being the parallel resistance of the tube plate resistance and R_A, and H is the reactance operator and r the loss resistance of Z, where, for the capacitive circuit, $H = 1/CD$ and, for the inductive circuit, $H = LD$, D being d/dt.

Applications

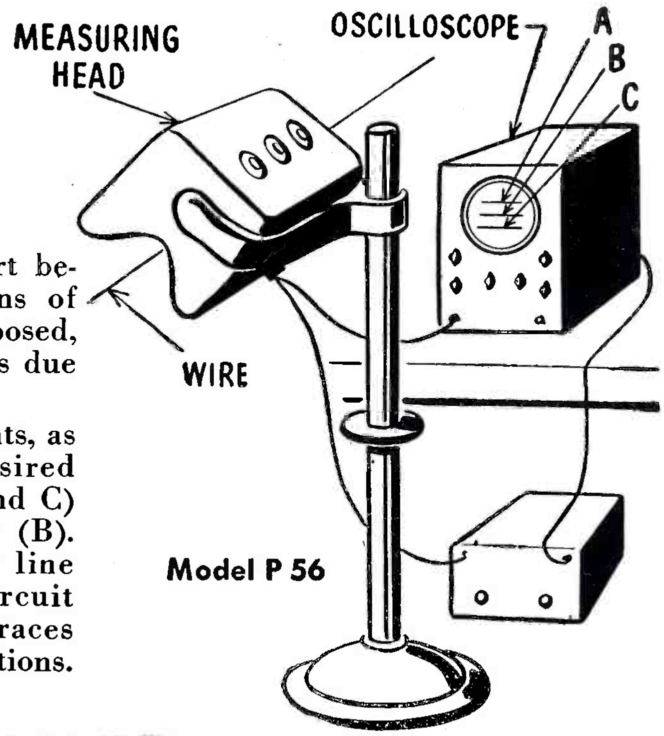
The network can be used as a parallel resonant circuit by connecting to it at points P-P, Fig. 1, or as a series resonant circuit by opening and entering it at point S. As the selective element in an amplifier, the network provides a constant gain, tunable, low frequency analyzer for biological and other purposes dealing with frequencies in the order of cycles per minute. Such a selective amplifier can be used either to isolate a desired frequency component or to analyze the frequency spectrum of very slow cyclic phenomena. (A new Type of Electrical Resonance by E. E. Schneider, *The Philosophical Mag*, June 1945, p 371. Circuit operating conditions are explained and equations derived. References.)

• • •

Multicarrier Communication

TO COVER large geographic areas at 100 mc for police and fire services, diversity amplitude-modulated transmission is used in England.[1] Several

Wilmotte "Visi-Limit" Electronic Micrometer

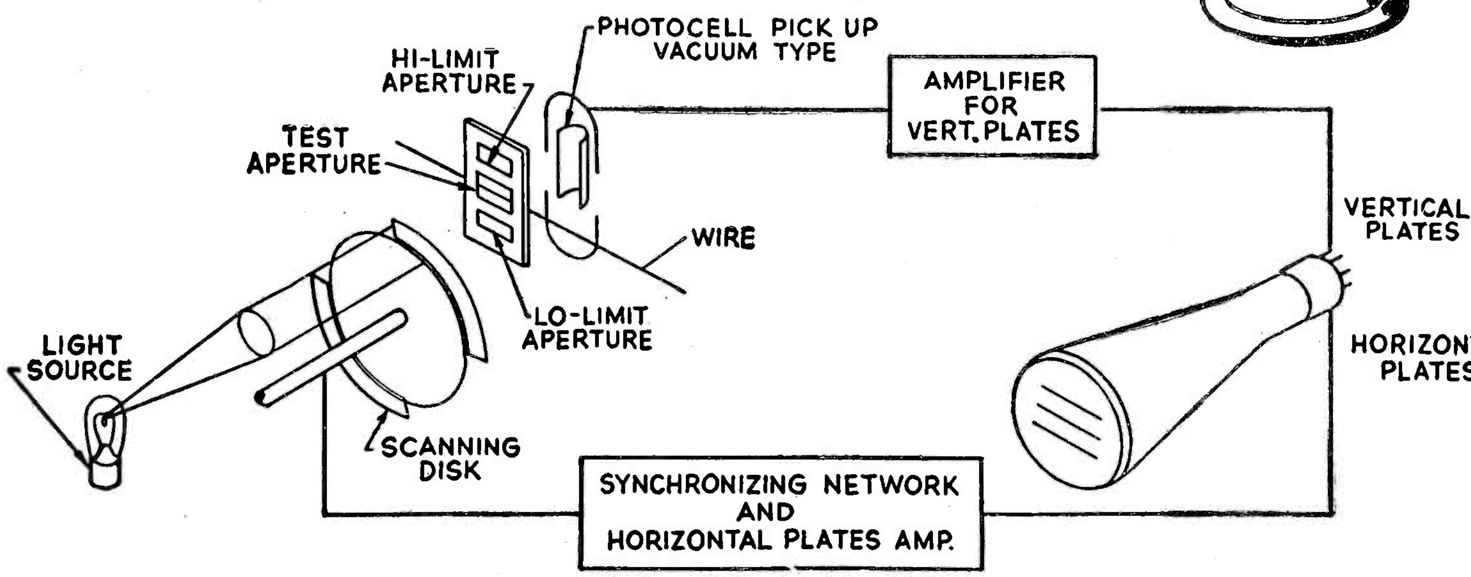


Model P 56

An important advance in the field of measurement. Manufactured for direct installation on the production line for continuous indication of outside diameter of wire, tubing or rod, edge-to-edge dimensions on machined or extruded parts, strip stock, thickness of sheets.

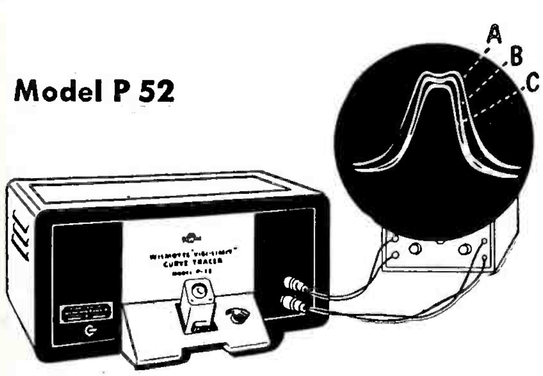
Size range of standard unit is .005" to .600" in diameter. Items of other sizes can be accepted through special design. Tolerance limits are + or − .0002" without physical contact with the part being measured. No limitations of speed of operation are imposed, nor are there any inaccuracies due to deformation of the part.

The "scope" screen presents, as three parallel lines, the desired tolerance requirements (A and C) with the measured quantity (B). No error is introduced by line voltage fluctuations or circuit changes since all three traces maintain their relative positions.



Wilmotte "Visi-Limit" Curve Tracer

Model P 52



For rapid alignment of I.F. coils of frequencies from 85 kc to 11 mc. Operator adjusts test trace (B) to fall between traces of limit coils (A and C), set up to production specifications. Defective coils immediately detected. All error is eliminated as circuit changes or line voltage variations affect all three traces equally.

Standard equipment includes one plug-in oscillator assembly at frequency specified by purchaser, and jigs for limit and test coils having "pig tail" leads. Jigs for special applications furnished to purchaser's specifications.

We Look Forward

to the forthcoming exposition conducted by the

INSTRUMENTS SOCIETY OF AMERICA

at which we shall have the pleasure of meeting you and demonstrating these industrial electronic devices.

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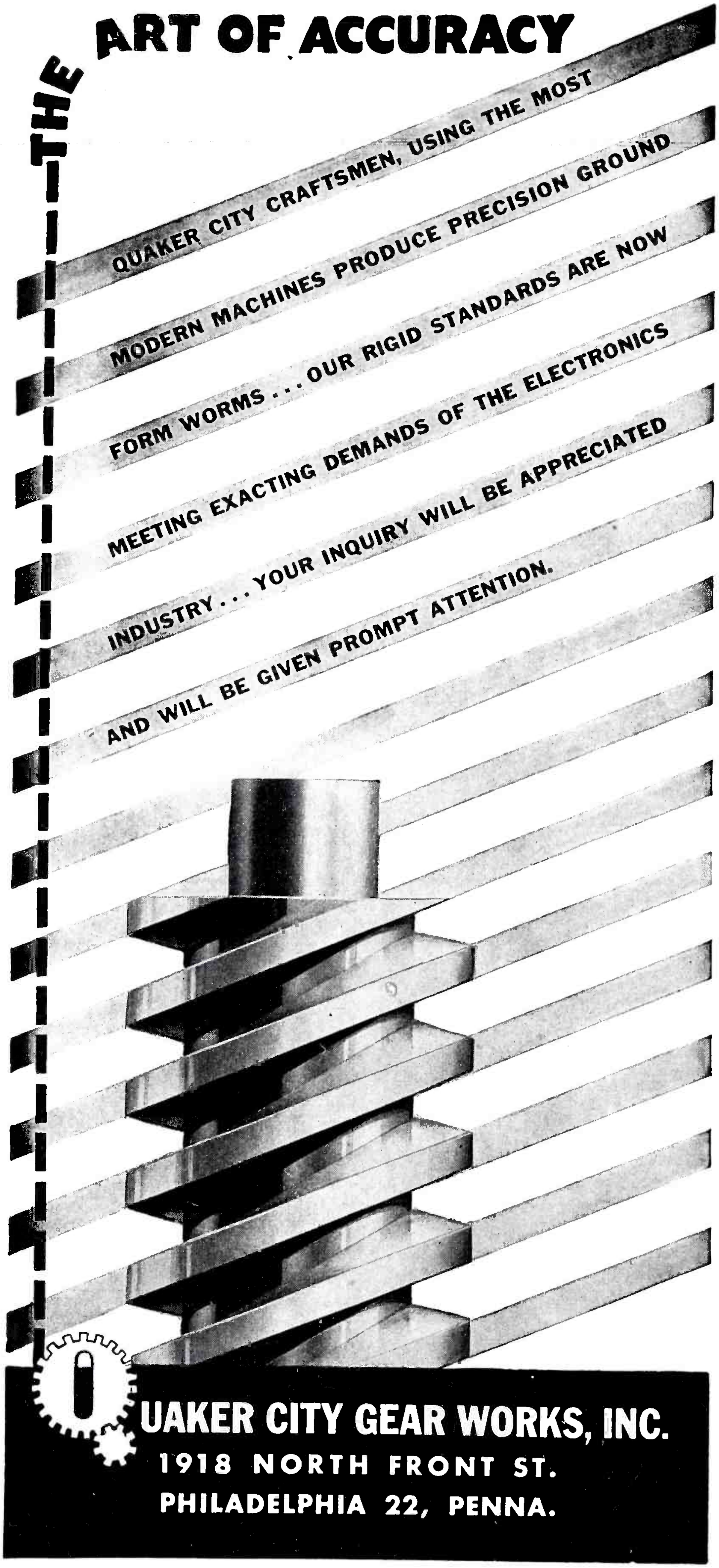


transmitters are located throughout the area to be covered. Extremely good penetration of streets, valleys, and even tunnels is obtained. The several transmitters operate on adjacent carrier frequencies spaced widely enough to prevent audible beats between carriers yet closely enough spaced to be accepted at one setting of the wideband receiver.

Preference for A-m Over F-m

The system consists of a control point, which can be at or away from the actual control office, and several satellite stations as shown in Fig. 1. The problems of synchronizing the

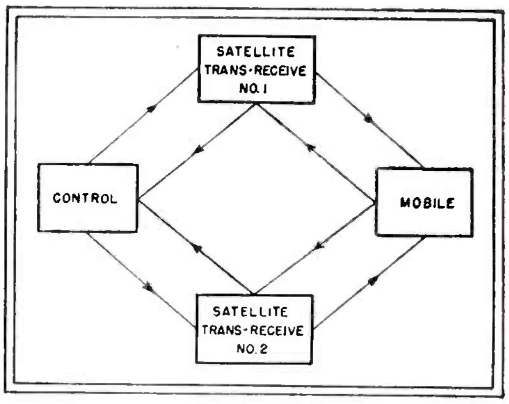
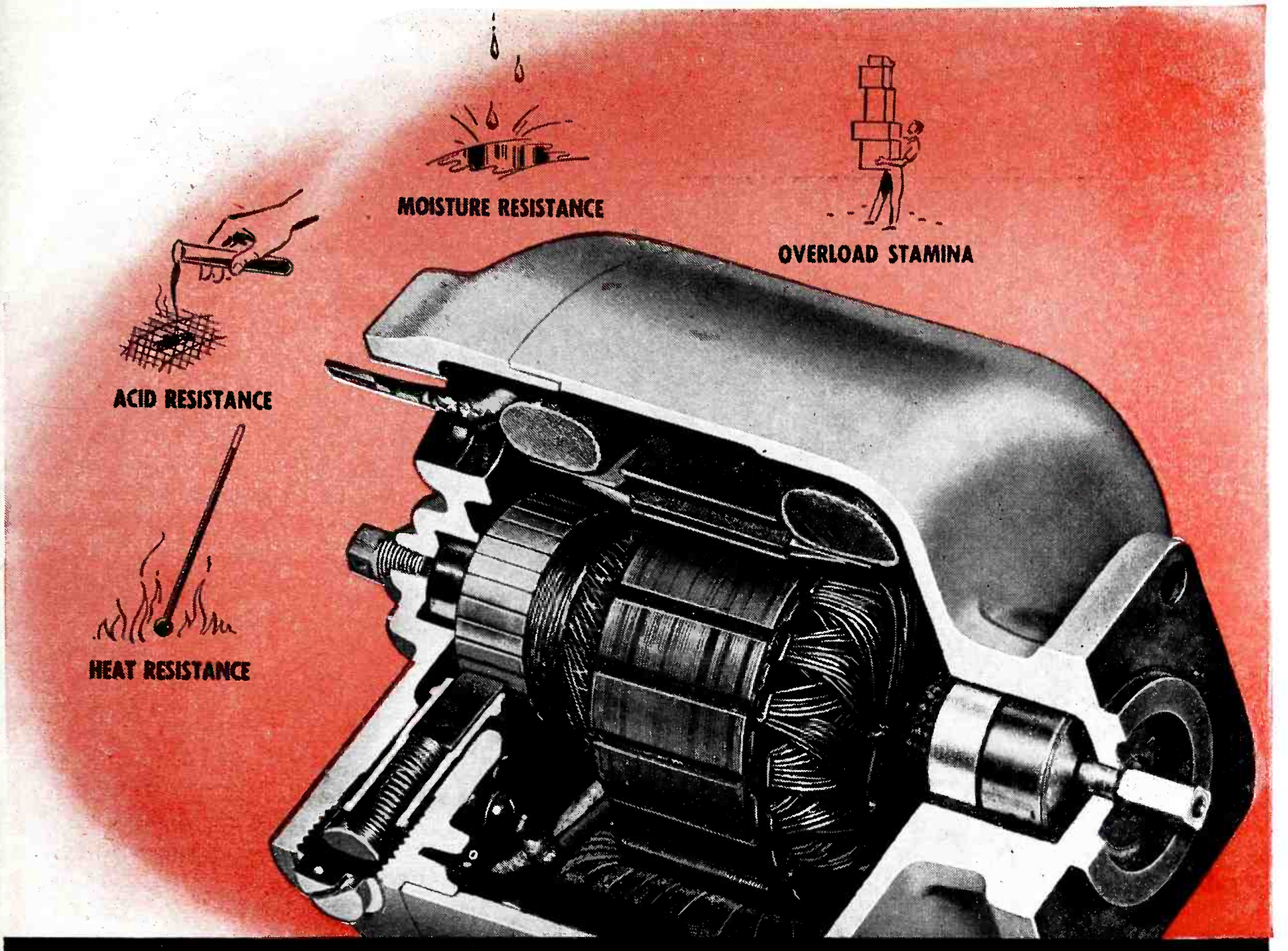


Fig. 1—Multicarrier diversity transmission system provides wide coverage at uniform signal strength

several transmitted carriers are too complex to justify trying to do so. Even if the carriers were in synchronism at their respective transmitting antennas, they would not be in synchronism at the receiving antenna located nearer one transmitter than the other. Therefore the system was designed to operate on multiple carriers.

To eliminate the necessity of returning to the strongest carrier at any position as a patrol car moved about, the receiver was designed to accept all transmitted carriers. Under this condition all carriers are simultaneously present in the receiver. If frequency modulation were used, distortion would be introduced by interaction of the unharmonicly related sidebands and differences in path lengths. Field tests further indicated that the area of no-capture was large and variable.[2] Amplitude-modulated carriers introduced none of these difficulties. Only a high-order heterodyne between differences in carrier frequencies was noticed on a three-station system.

For these reasons, the multicarrier amplitude-modulation system



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Fortunately, the cost of added protection against the penalties frequently imposed by these conditions is slight—far less than the penalty imposed by failures that can be avoided. For the advantages of High-Safety-Factor Insulation can be added at only a small fraction of the cost of the equipment.

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Fiberglas is the trade name for these electrical insulation materials and many other products made from fine, strong, pliable, moisture and heat-resistant, ageless glass fibers.

was used in such installations as that in greater London. The bandwidth that would have been required for a wideband frequency-modulation system was utilized for a multicarrier amplitude system. The signal to noise ratio that could have been obtained by a single high powered frequency modulation station was obtained in the same bandwidth by using several geographically spaced, low powered stations on adjacent carriers.

Field tests conducted elsewhere some years ago[3] indicate that by using frequency modulation and geographically distributed transmitters, a wide area could be covered. Regions of no-capture were negligible; signal to noise ratio was high.

REFERENCES

(1) Multi-Carrier Communication System, *Wireless World*, Feb. 1946, p. 59.
(2) A Method of Increasing the Range of V. H. F. Communication Systems by Multi-Carrier Amplitude Modulation by J. R. Brinkley. *The Inst of Elect Eng* (British), to be published.
(3) Field Tests of Frequency-and-Amplitude-Modulation with Ultrahigh-frequency Waves by I. R. Weir, *Gen Elec Rev*, *Part I*, May 1939, p. 188, Part II, June 1939, p. 270.

• • •

Electrophoresis

FRACTIONATION of human blood, both to determine its content and to obtain essential biologicals for medical use, is followed by an analysis of each byproduct for its purity. These protein mixtures cannot be chemically analyzed because under such treatment they break down and lose their identity. Instead, a technique invented by Arne Tiselius, in which the molecules of protein are negatively charged and made to migrate

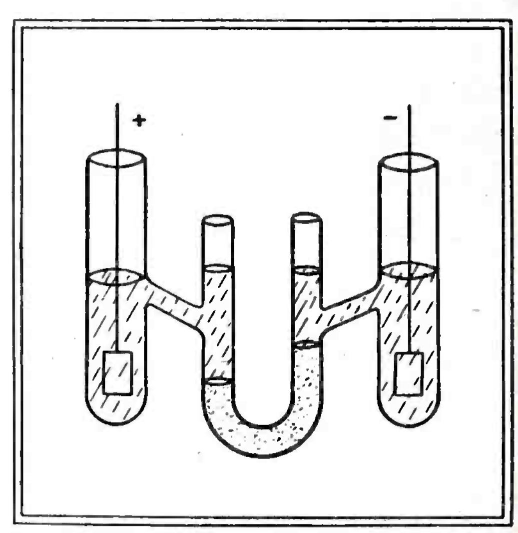

Fig. 1—Proteins are separated from one another by their differential migration in an electric field

Save audio power

WITH THE MS-92A

Eliminate multiple audio outputs from receivers — eliminate separate interphone amplifiers. Flight engineered to Bendix Radio's rigid performance requirements, the MS-92A is a new type of audio selector jack box having an attenuation network which reduces coupling between a multiplicity of selected receivers.

It permits simultaneous reception of a variety of receivers by a number of crew members without interference due to audio coupling between the receivers—multiple audio outputs from each receiver no longer required.

Desired signals from the attenuation network are returned to original level by use of an amplifier inside the box. This amplifier, which also serves as interphone amplifier, uses a type 28D7 tube with filament and plates operating entirely from 28 v.d.c. A front panel masking plate may be engraved per customer's order, permitting unlimited flexibility in use of the jack box with any desired complement of receiving or transmitting equipment. The MS-92A Jack Box is fully approved by the CAA for scheduled air carrier aircraft installation.

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BENDIX RADIO

STANDARD FOR THE AVIATION INDUSTRY

in an electric field, is used to separate the different proteins in the mixture. To obtain the necessary constant electric potential, an electronically regulated power supply is used. The process is called electrophoresis.

Electrophoretic Photography

A sample of protein whose purity is to be determined is loaded in solution into the U-shaped tube of Fig. 1. An electronically regulated constant potential is applied across the two electrodes in the outer vessels. Under this potential the molecules of protein are charged negatively and then made to migrate toward the positive pole. The whole assembly is immersed in a temperature-controlled bath at 0.7 C. Because of the differences in charge and mass between protein ions, they migrate at different rates toward the positive pole. In this way the proteins are separated in about four hours.

Monochromatic light is projected through an optical system including a slit and the U-tube and focused immediately in front of the object lens of a camera. Due to the different indices of refraction of the different proteins, a chart indicating the proportional quantitative analysis of the sample is produced when the film and a shutter in front of the camera are moved in synchronism. Cutter laboratories are using this research technique on a production basis. Their setup is shown in Fig. 2. The long barrel of the camera has been

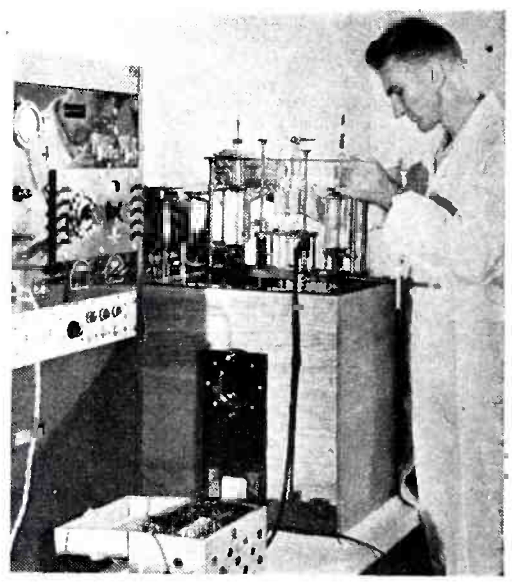

Fig. 2—Research technique is done on a production basis using an electronically regulated voltage source to maintain the same accuracy as under laboratory conditions

Here's How Radio Industry Says "OK"

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The "landslide" of orders which followed the announcement of this new rectifier means just one thing — another outstanding contribution which fills a great need in the electronic industry. Now, in hundreds of applications, this 5-plate rectifier stack is proving its value — in money saved, reduced assembly time, new space savings, longer life, instant starting. It measures only 1¼ x 1$\frac{5}{32}$ x ⅝ inches, and will go into restricted spaces where a tube and socket won't fit.

Though miniature in size, this rectifier embodies "full-scale" quality throughout, with **Center-Contact** construction and all of the other features which have made Federal Selenium Rectifiers the standard of quality in the industry. They're available now — in quantity. Write to department F513 for prices and data.

CHARACTERISTICS:

Type 403D2625 Rectifier

Maximum RMS Voltage	130 volts
Maximum Inverse Voltage	380 volts
Maximum Peak Current	1200 ma.
Maximum RMS Current	325 ma.
Maximum DC Output	100 ma.
Approximate Rectifier Drop	5 volts

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In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal
Export Distributors—International Standard Electric Corporation

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Newark 1, New Jersey

removed from the hole in the black mask on the box. The final reduction of data is done with a planimeter.

• • •

Patents

MAGNETRONS in superregenerative receiver circuits were described by Maurice Ponte of Paris, France (U. S. patent 2,045,995 issued June 30, 1936) and by Ernst Gerhard, Germany (U. S. patent 2,230,108 issued Jan. 28, 1941). Although various circuit modifications are proposed, the superregenerative detectors use magnetrons in either self-quenching detecting oscillators or in externally quenched oscillators. Gerhard found sharp peaked pulses applied in magnetron plate circuit to provide the best shape for the interrupting voltage.

• • •

Rectifier Wave-Form Control

By GERHARD B. HAGEN

Telefunken Gesellschaft fur Drahtlose Telegraphie m. b. H.
Patented July 2, 1935, No. 2,006,806

TO PRODUCE a rectified wave that can more readily be filtered for the production of a direct current the circuit of Fig. 1 was developed. Vacuum triodes are used in place of diodes. The phase shifter composed of series *RLC* tuned to potential

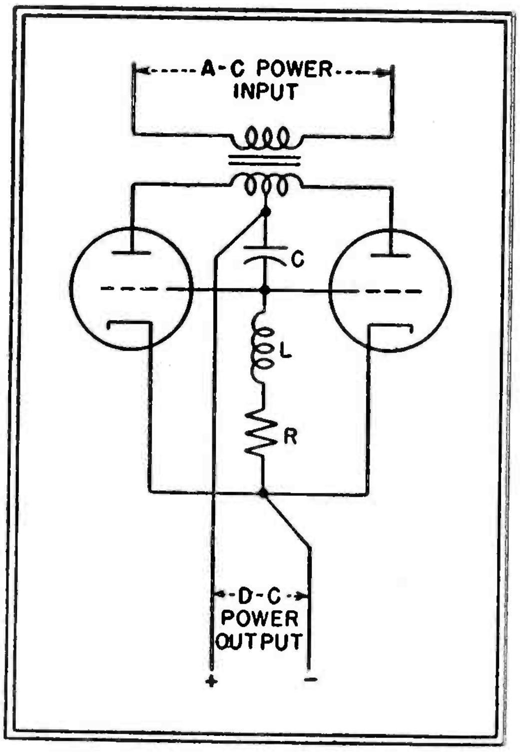


Fig. 1—Electronic control of the rectifiers provides some filtering

resonance with the working wave feeds the grids with a potential shifted 90 degrees from the plate potential.

Figure 2 illustrates the behavior of the circuit. Curve *A* is the current delivered by a conventional vacuum diode, full-wave rectifier. In the circuit described in this patent, the grid potential, shown by curve *C*,

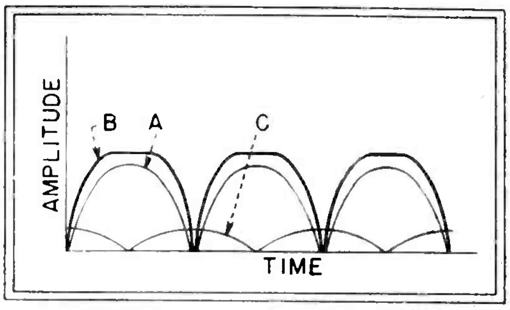


Fig. 2—Comparison of the wave shapes produced by conventional and wave-form controlled rectifiers shows closer approach to d-c in the output of the latter

reduces the peaks of the plate current giving an output with a flattened top as shown by curve *B*. This wave shape is more readily filtered than that shown by curve *A*.

To obtain the same average output by this method the transformer may have to be designed to supply a higher plate potential. The time constant of the filter can be reduced from slightly less than a half period to about a quarter period.

• • •

AMUSEMENT DEVICE for registering ones emotions employs a bridge in which one arm is the plate resistance of a pentode, controlled by the tube's grid which is connected to the cathode by a path including "spaced points on the surface of the subject" and a polarizing potential (U. S. Patent 2,379,955, Wolgen Co.).

PATENT REGISTRATION and classification — Commissioner Ooms announced that owners have registered for license or sale over 10,000 patents, inquiries concerning approximately 50 percent of them have been made to owners—changes and additions in the manual of patent classification are listed in the April 2, 1946 Official Gazette—Farnsworth Television & Radio Corp., Fort Wayne 1, Ind. is offering under standard terms licenses on all patents that it owns or controls.

NEW PRODUCTS

Edited by A. A. McKENZIE

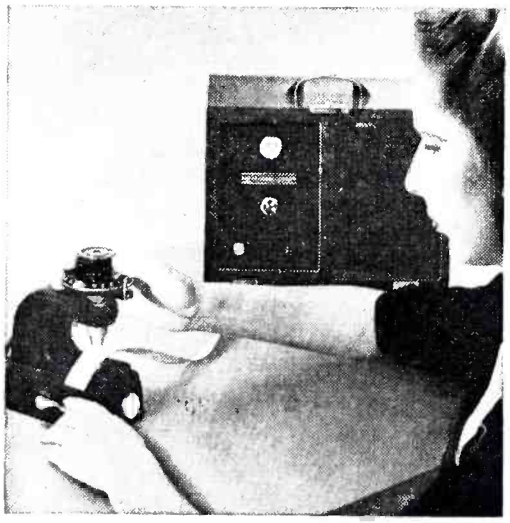
Latest developments in new apparatus, components, materials. New literature

Dictating Machine

ELLINWOOD INDUSTRIES, 150 W. Slauson Ave., Los Angeles 3, Calif. A new dictating machine uses thin discs from which errors can be erased. The discs are so inexpensive that they are discarded instead of regrooving. The machine weighs only 8 pounds and measures 9½ x 6 x 7 inches.

Electronic Micrometer

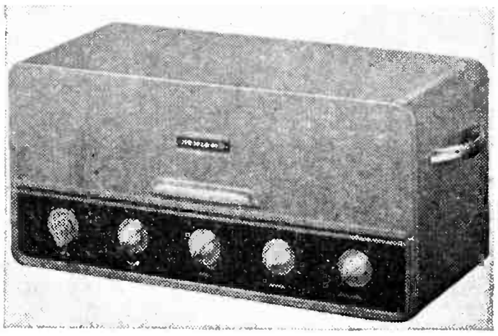
CARSON MICROMETER CORP., 28 Edison Place, Newark 2, N. J. Several models are available in a line of micrometers that electronically



measure the instant of contact between a calibrated lead screw and the material being gaged without exerting pressure. The units are operated from any a-c outlet.

Phonograph Amplifier

NEWCOMB AUDIO PRODUCTS, Los Angeles, Calif. The KXP-30 amplifier supplies 30 watts of audio power at less than 5 percent distortion and has a frequency response from 20 to 20,000 cps within 1 db. The crystal pickup input has an impedance of ½ megohm, another input channel utilizes plug-in transformers se-



lected for the service desired. Gain measured from the high impedance input is 85 db, and is somewhat less using transformer input. Bass compensation ranges from minus 17 to plus 24 db and treble from minus 24 to plus 24 db. The seven tubes used consume 144 watts. The metal cabinet measures 7 × 8½ × 15 and the shipping weight is 26 pounds.

Copper-oxide Rectifiers

BRADLEY LABORATORIES, INC., 82 Meadow St., New Haven, Conn. New Coprox battery rectifiers rated for 2, 3 and 4½ volts d-c output for currents up to 1½ amperes are now available. Various models in different sizes and shapes are designed to combat aging.

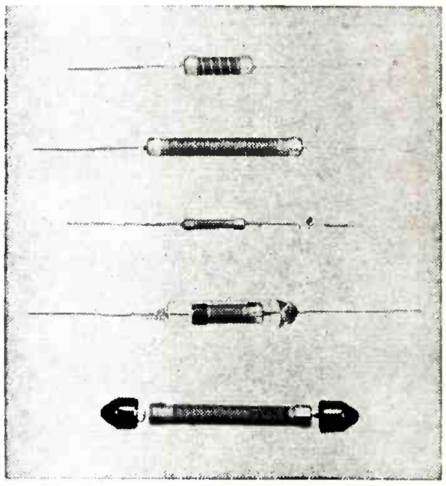
Cardioid Microphone

ELECTRO-VOICE, INC., 1239 South Bend Ave., South Bend 24, Indiana. The new Cardyne microphone has

an output level 53 db below 1 volt/dyne/cm² on open circuit. It is available in 50, 250, 500, or 25,000 ohms. Model 731 has a flat response from 30 to 12,000 cycles and the Model 726 is substantially flat from 40 to 10,000 cycles. It is fully described in Bulletin 131.

Film-type Resistors

WILKOR PRODUCTS, INC., 3835 W. 150th St., Cleveland 11, Ohio. One-watt and two-watt film resistors having a resistance range of 10



ohms to 35 megohms and 10 ohms to 100 megohms at 1-percent accuracy are available in sizes ½-inch by ⅞ inch or 2 inches respectively.

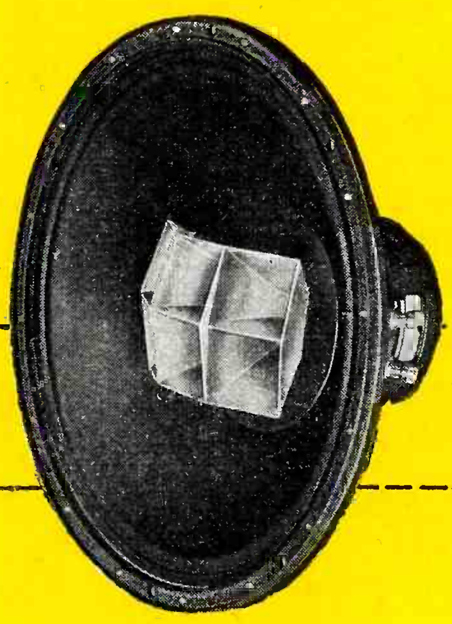
Sixty-cycle Filter

FREED TRANSFORMER CO., INC., 72-78 Spring St., New York 12, N. Y. The type 1050 instrument is essentially a pure 60-cps source to be used for the calibration of instruments in which form factor is important. It consists of a constant-voltage transformer, a

variac, a 60-cps low-pass filter, a decade attenuator, and a 1-percent a-c voltmeter. Voltages in 1-volt increments from 0 to 110 volts with less than 0.5 percent harmonic distortion are thus available for calibration purposes. Power supply for the unit

Announcing

ALTEC LANSING'S MODEL 603 MULTICELL DIA-CONE SPEAKER



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operates on 105 to 125 volts, 60 cps. Overall dimensions of the equipment in its metal cabinet are 10½ × 14½ × 22 inches. Weight is 75 pounds.

Traveling Wave Tube

BELL TELEPHONE LABORATORIES, 463 West St., New York 14, N. Y. A new tube recently developed will be suitable for high-gain amplification in television and other wide-band applications. A power gain of 10,000 times over a band width of 800

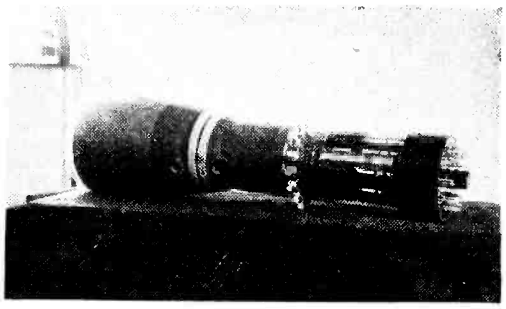
megacycles is typical of the device. The tube is a foot long and a few inches in diameter. Its amplifying property results from the transfer of energy from an electron stream to a wave moving on a helix surrounding the stream.

Ground Station Receiver

BENDIX RADIO, BALTIMORE 4, MD. The MR-71B receiver is a single-channel, crystal-controlled fixed-frequency unit providing radiophone reception on frequencies between 118 and 132 megacycles. Operating on 117-volt, 50- to 60-cps lines, it has a power consumption of about 130 volt-amperes. Sensitivity and frequency response of the rack-mounted equipment make it suitable for airways monitoring.

Four-gun Cathode-ray Tube

ELECTRONIC TUBE CORP., 1200 East Mermaid Ave., Chestnut Hill, Philadelphia 18, Pa. The newly developed ET-5Z4P7 cathode-ray tube is available for applications requiring the



display of four separate signal indications on a five-inch screen. Deflection plates are brought out to sixteen separate terminals. A twenty-seven-pin special base is used. The screen can be supplied in various types of phosphors. Overall length of the tube is 18½ inches.

Coil Testers

GENERAL ELECTRIC CO., Schenectady, N. Y. High-speed testing of electric coils can be accomplished using one of two new coil testers. A low-voltage tester shows the pres-

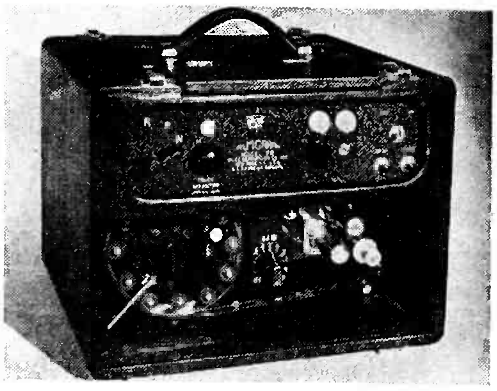
ence of short-circuited turns. The high-voltage unit indicates the induced volts per turn and faulty coils that break down under test. Additional details are given in bulletin GEA 4539.

Multivoltmeter

RAWSON ELECTRICAL INSTRUMENT Co., 110 Potter St., Cambridge 42, Mass. The type 501F has a resistance of 10,000 ohms per volt and measures from 1 millivolt up to 1,000 volts full scale. Readings are guaranteed to be within 0.5 percent of full-scale reading for all ranges. The type 501G meter measures up to 100 volts but has a resistance of 100,000 ohms per volt. Net prices are respectively \$160 and \$155, fob Cambridge.

Continuous Tape Recorder

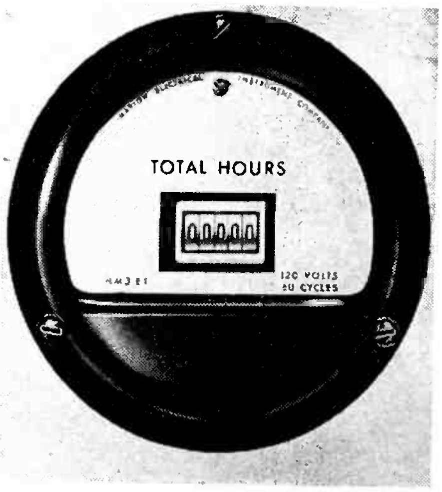
MILES REPRODUCER CO., 812 Broadway, New York, N. Y. The Filmgraph model FR uses a continuous loop of plastic tape that carries a total of 100 grooves to allow up to 3 hours of continuous recording. Movement of the stylus from one groove to the next unused channel is accom-



plished automatically. A dial indicates the position of the recording stylus with respect to the grooves so that a log of recordings allows instant selection of the desired portion. The unit operates from any 100-volt, 60-cps line, measures 11½ × 9½ × 13 inches and weighs 24 pounds.

Elapsed-time Indicator

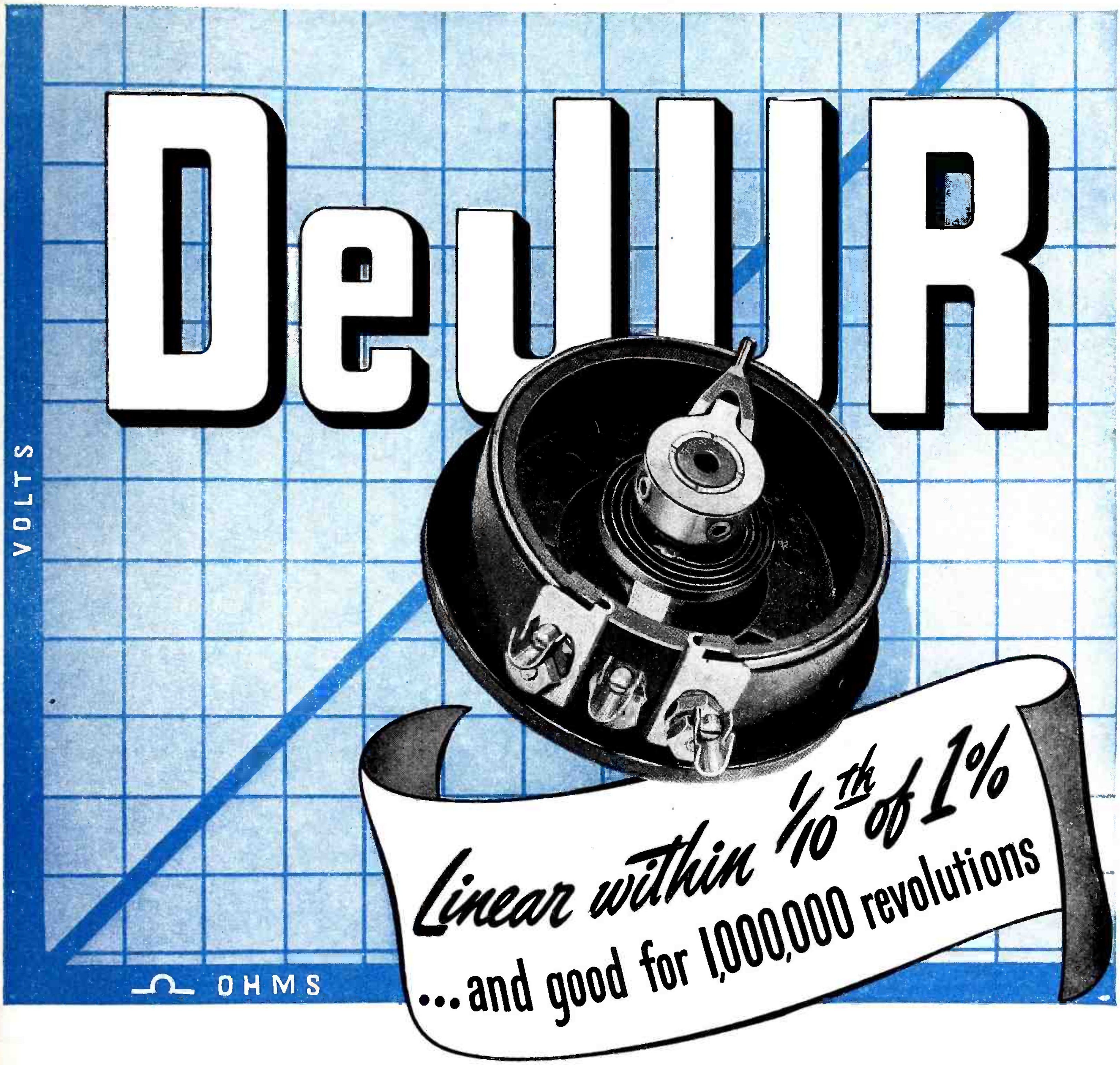
MARION ELECTRICAL INSTRUMENT Co., Manchester, N. H. The Model HM3 elapsed-time indicator oper-



ates on 115 volts 60 cycles to indicate time from zero to 9,999.9 hours. The meter is hermetically sealed.

Shipboard Radar

RADIOMARINE CORP. OF AMERICA, 75 Varick St., New York 13, N. Y. Model CR-101 radar features north-stabilized bearings, four range



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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°

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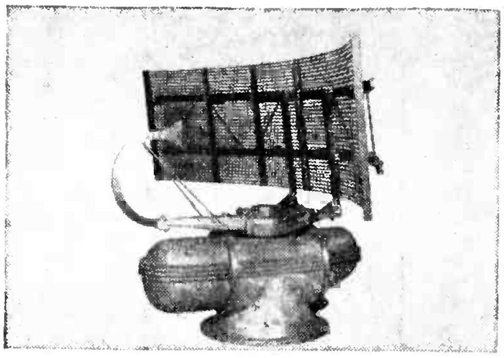
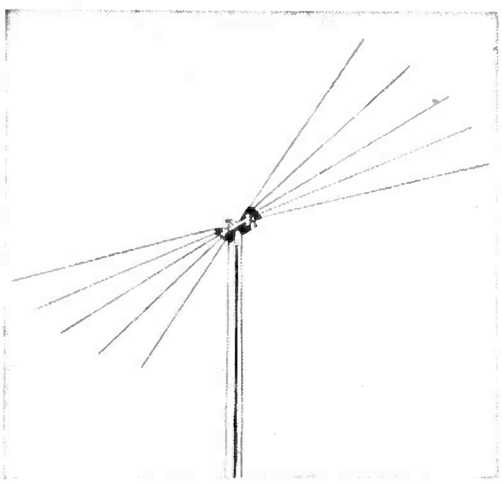


scales from 100 yards to 50 miles and the compact, rugged antenna illustrated. The equipment operates from 115-volt 60-cycle power.

Broad-band Receiving Antenna

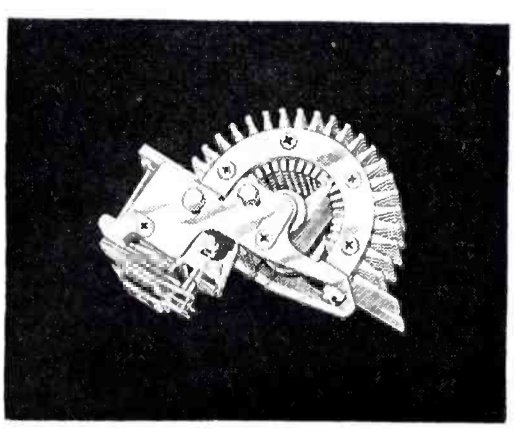
ANDREW CO., Chicago 19, Ill. The new Di-Fan television and f-m antenna consists of five dipole-like antennas radiating like a pair of



fans from a central vertical pole. Aluminum alloy elements are used. Supporting members are plated steel.

Stepping Switch

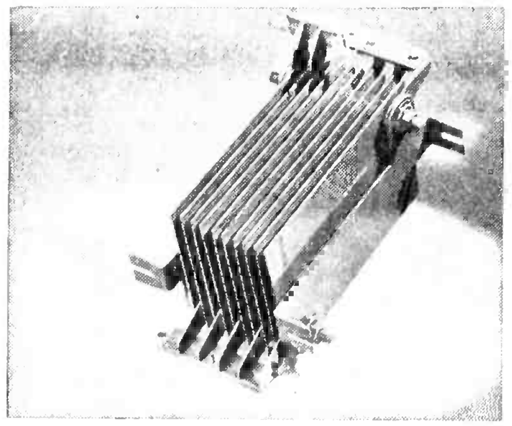
C. P. CLARE CO., 4719 West Sunnyside Ave., Chicago 30, Ill. A new pulse-controlled stepping switch is available with either 20 or 40 points,



making a maximum of 8 or 4 contacts, respectively. Operated from a telephone-type dial pulser the maximum operating speed is 30 steps a second, or double that speed with self-cycling operation.

Heavy Duty Rectifier Stack

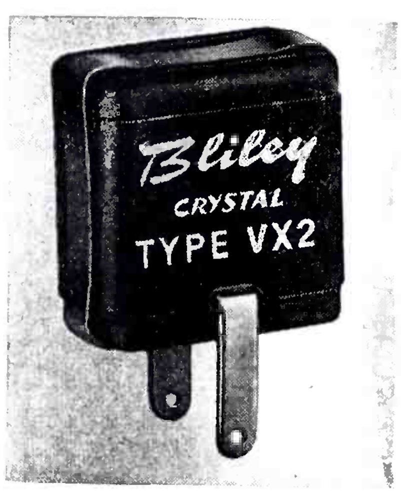
FEDERAL TELEPHONE AND RADIO CORP., Newark, N. J. A new development in selenium rectifiers makes available stacks composed of plates



designed to withstand an rms voltage of 26 volts. The method of mounting improves air circulation, so that the stack can be mounted vertically or horizontally.

Airplane Crystal

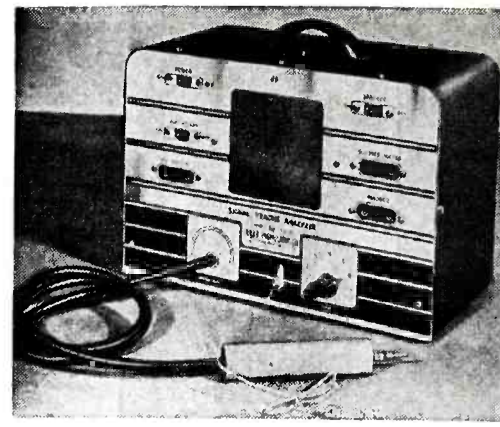
BLILEY ELECTRIC CO., Erie, Pa. The Type VX2 is a compact, sealed crystal assembly with soldering lugs.



It is supplied at 3,105 kilocycles for private aircraft transmitters but is also available at any frequency in the range 3,000 to 11,000 kilocycles.

Signal Tracing Analyzer

FEILER ENGINEERING CO., 803 Milwaukee Ave., Chicago, Ill. The TS-2 analyzer is designed for use with a signal source applied to the input of



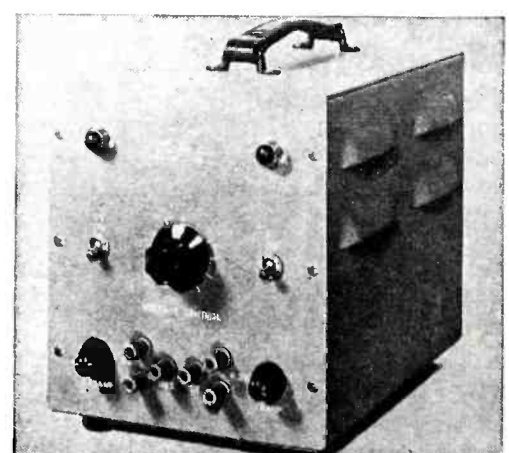
the receiver under test. Equipped with a Bakelite probe which picks up the signal, the main unit converts the resultant signal into an audible tone or a vacuum-tube meter reading. Loudspeaker or phones can be employed. Complete with batteries the unit weighs $10\frac{1}{2}$ pounds and measures only $8 \times 11\frac{1}{2} \times 6$ inches.

Sensitive Relay

PRICE ELECTRIC CORP., Church St., Frederick, Md. A single-pole, double-throw relay that can be made to operate on 0.009 watt d-c will carry a non-inductive a-c load of 1 ampere at 115 volts. Diameter of the unit is $1\frac{13}{16}$ and height is $2\frac{3}{16}$ inches.

Regulated Power Supply

HEWLETT-PACKARD CO., Palo Alto, Calif. The Model 710A regulated power supply has been designed as a source of regulated voltage for general laboratory and production

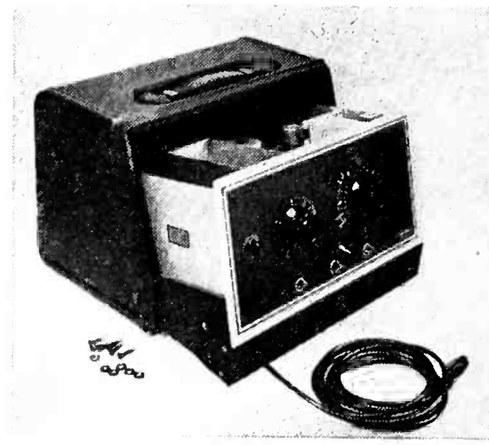


use. Output is continuously variable from 180 to 360 volts, and will remain constant to within 1 percent for loads from 0 to 75 milliamperes, and for line-voltage variations of plus or minus 10 percent. Either the positive or negative out-

put terminal may be grounded. Total noise and hum is less than 0.005 volt for any condition of operation. The unit also provides 6.3 volts a-c center-tapped for heating filaments. It weighs 18 pounds. Price, $75.00.

Audiometer

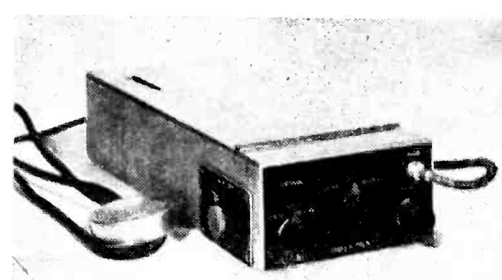
WESTERN ELECTRIC CO., INC., 195 Broadway, New York 7, N. Y. The 6BP Audiometer used for measuring hearing loss is a table model



that can be carried about. Certain changes in the technique of its use have allowed a simplification over earlier equipment.

Pocket Wire Recorder

RAYTHEON MANUFACTURING CO., Chapel St., Newton 58, Mass. Tentative data has been released on the Model 5 wire recorder designed to furnish a half hour of recording or



playback. Four subminiature tubes are used with small batteries having a life well in excess of the maximum time for a continuous recording. The unit measures $9\frac{1}{2} \times 4\frac{1}{4} \times 2\frac{1}{4}$ inches and weighs $4\frac{1}{2}$ pounds.

Photographic Timer

LEKTRA LABORATORIES, INC. 30 E. 10th St. New York. The Model TM-5-R electronic timer is arranged to start at the moment the platen switch of the printer is operated and it stops the exposure at the end of the preselected interval. Timing intervals ranging from 0.2

four points

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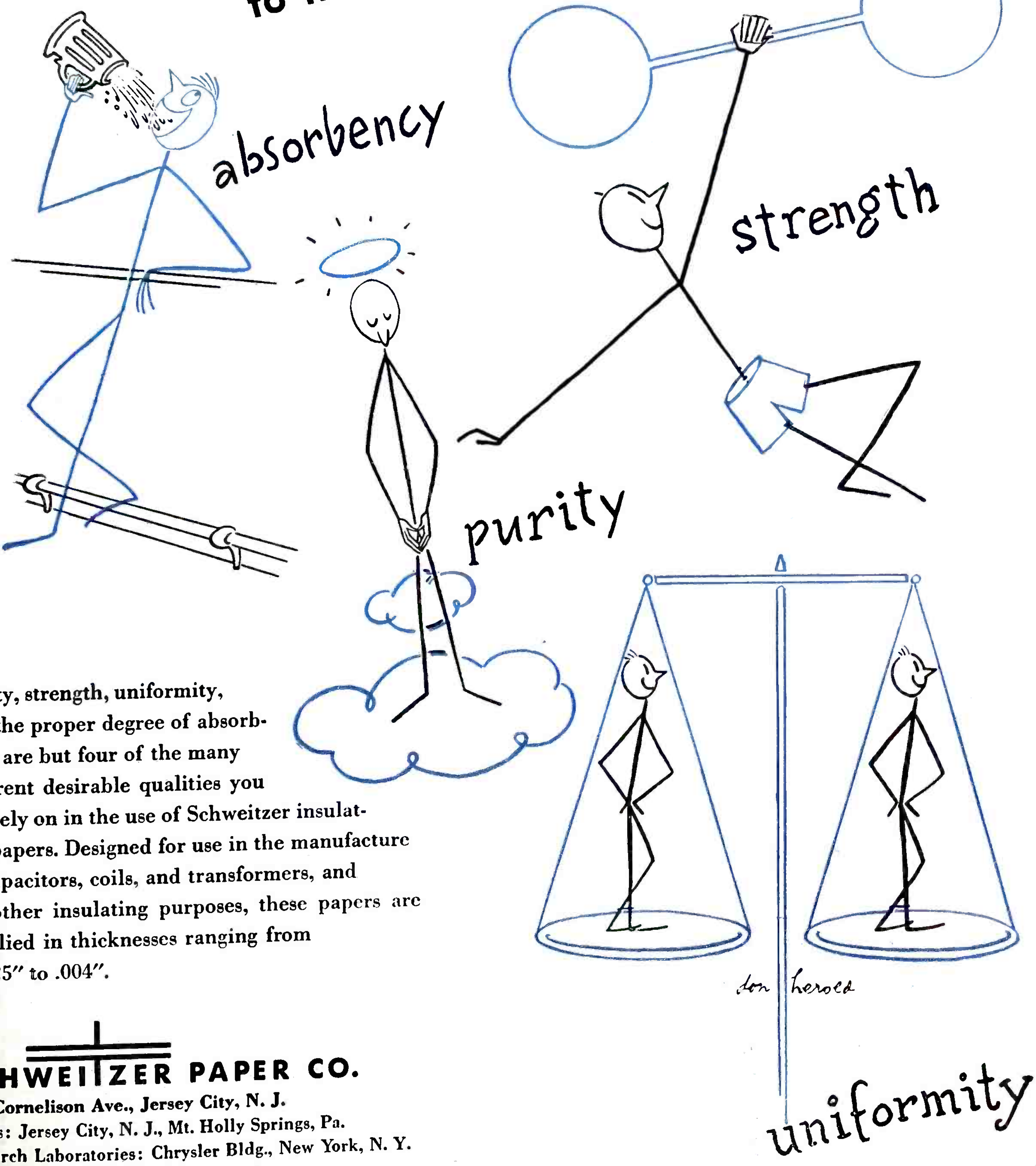

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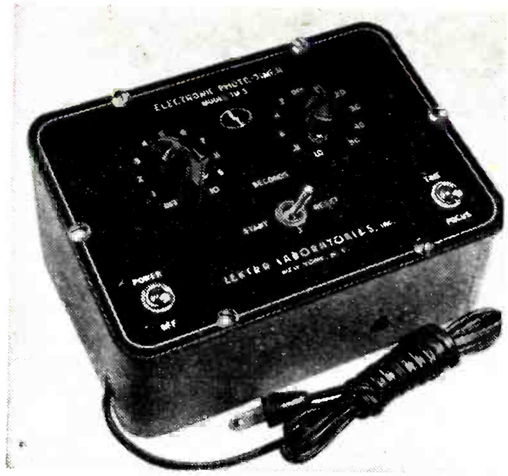
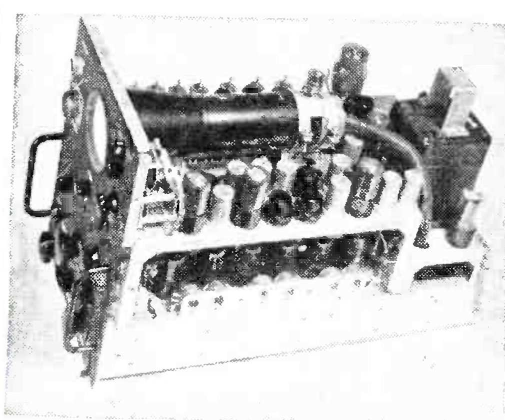


to 60 seconds are available at an accuracy of 10 percent. The unit weighs 3 pounds and measures $5\frac{1}{2} \times 8 \times 3\frac{1}{4}$ inches. It operates on a-c or d-c.

Loran Receiver

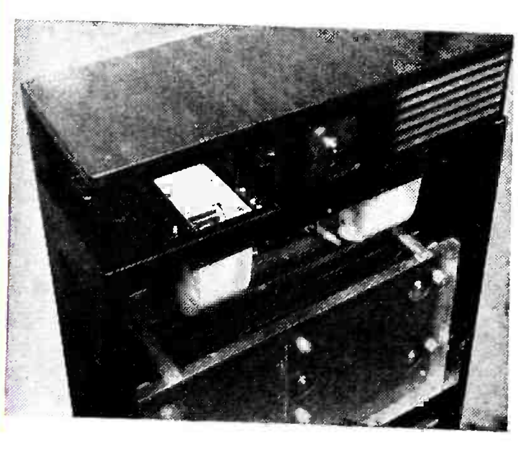
RADIO CORPORATION OF AMERICA, Camden, N. J. The type AVR-26 Loran Receiver is suitable for the reception of loran navigation sys-



tem signals over land or sea. The equipment is particularly suitable for aircraft installation, weighing a little less than 36 pounds.

Home Dust Precipitator

RAYTHEON MFG. CO., INC. 60 East 42nd St., New York 17, N. Y. Room unit dust precipitators $39 \times 26 \times 9$ inches in size and operating from 110-volt, 60-cycle lines at a power of 100 watts are now available. The



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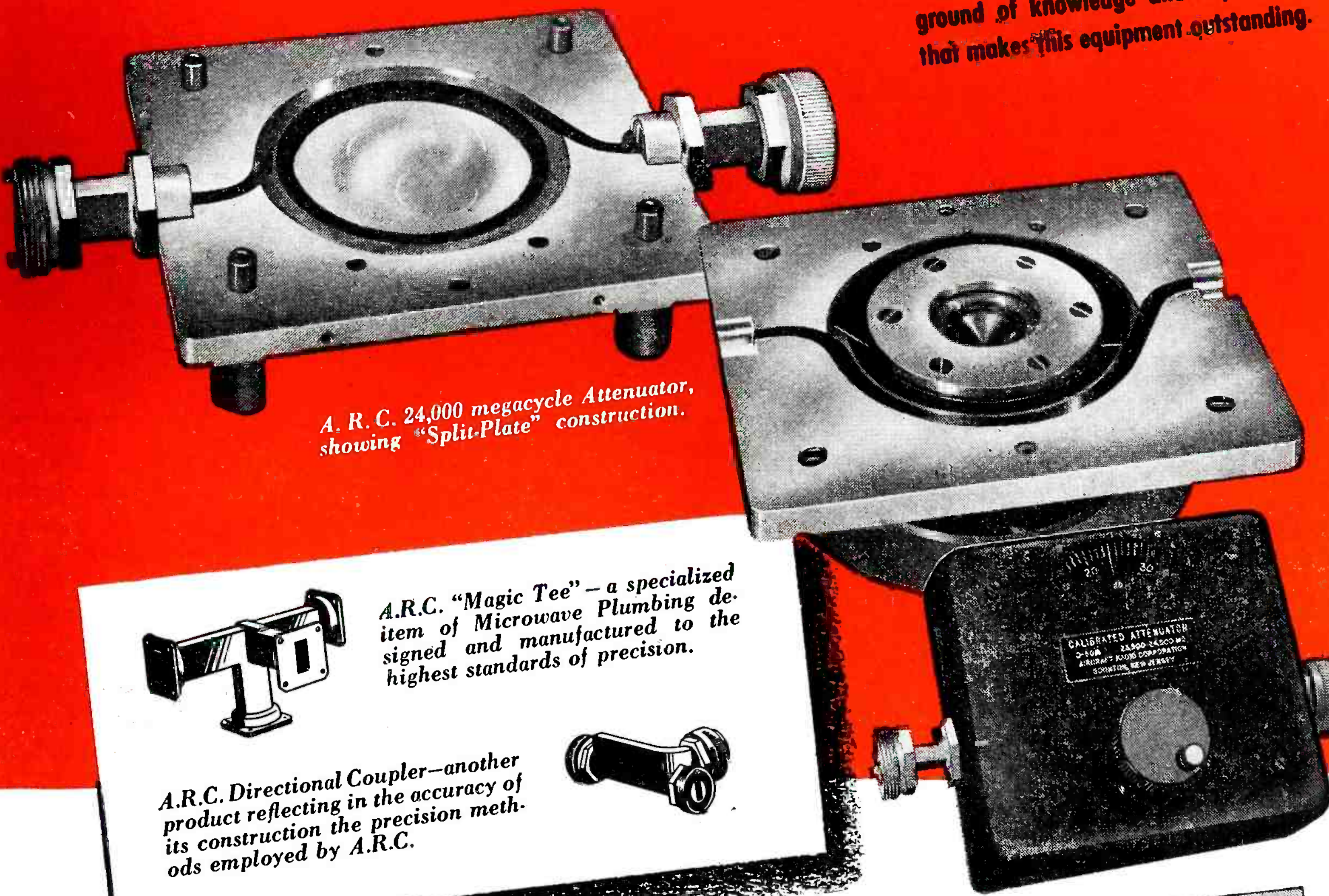

A. R. C. 24,000 megacycle Attenuator, showing "Split-Plate" construction.

A.R.C. "Magic Tee" – a specialized item of Microwave Plumbing designed and manufactured to the highest standards of precision.

A.R.C. Directional Coupler—another product reflecting in the accuracy of its construction the precision methods employed by A.R.C.

The ever-increasing importance of microwave transmission in the field of electronic navigation, communication, and industrial controls turns the spotlight on the A.R.C. line of equipment and accessories to serve this field.

The A.R.C. 24,000 megacycle attenuator with its unique "split-plate" construction typifies the quality of A.R.C. design and manufacture. This design (patent pending) permits the machining of the wave-channel to an accuracy impossible to achieve through other methods of construction, while the jointure of the plates themselves is so precise as to leave no possibility of leakage and loss.

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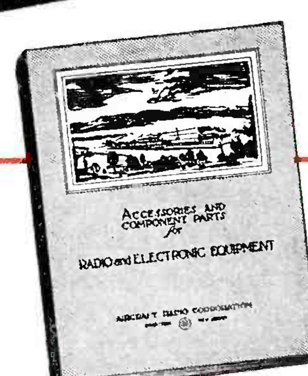

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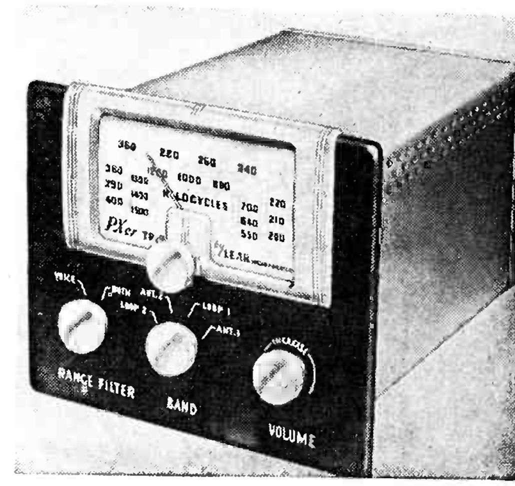
AIRCRAFT RADIO CORPORATION

BOONTON, NEW JERSEY

blower motors shown are claimed to be practically noiseless and the unit automatically turns off when the enclosure is opened. The high-voltage collector cell need be cleaned only every three or four months.

Aircraft Transmitter-Receiver

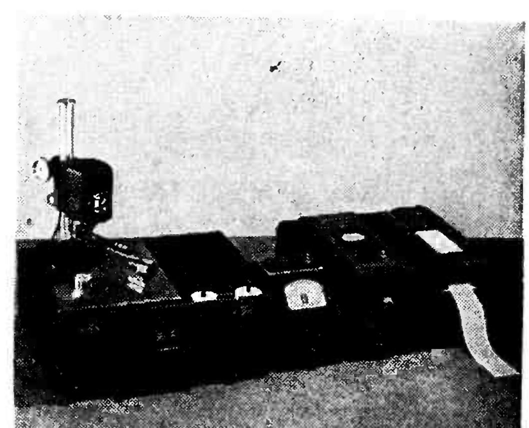
LEAR, INC., Grand Rapids, Mich. The Model TR-2B is a complete radio transmitter and receiver package consisting of two units for communication and navigation using



the broadcast and radio range frequencies. Total weight is 10 pounds and the equipment lists at about $175 without antenna and direction loop.

Surface Analyzer

THE BRUSH DEVELOPMENT CO., 3405 Perkins Ave., Cleveland 14, Ohio. The Model BL-103 Surface Analyzer checks smoothness of surface fin-



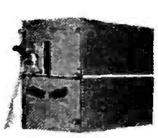
ishes from 1 to 5,000 microinches. Visual and graphic indications are given of surface finishes of metals, glass, plastics, plated and painted materials.

Recording Disc Equalizer

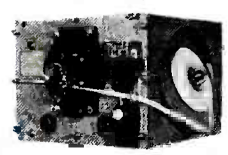
CINEMA ENGINEERING CO., 1510 W. Verdugo Road, Burbank, Calif. The type No. 3991 diameter equalizer is

16 words per second and never a slip for this fast, recording team

A PRESS WIRELESS *Recording Achievement*



This variable Tape Puller has been designed for use with the Press Wireless Ink Tape Recorders. They are built as separate equipment fully enclosed. The Tape Puller has a speed that is continuously variable from 5 to 1,000 words-per-minute. Drive mechanism is extremely smooth in operation. No gears or clutch need be changed to cover operating range. Unique coupling system affords long life to the rotating members. Under light or no load a minimum of pressure is exerted on the friction drive. As the load increases, the friction automatically increases to compensate.



Simply, yet expertly engineered, the Model ITR-2 more than meets all requirements of high-speed recording. This automatic ink tape recorder can rapidly transcribe code signals at rates up to 1,000 word per minute. A slender, hollow stylus, actuated by the incoming tone signal, from a receiver or land-line, records the message in the form of inked square wave pulses on a narrow paper tape. Used in conjunction with the Variable Tape Puller, VTP-11, the ITR-2 forms a *Press Wireless* Recording team that is a "must" for any automatic receiving assembly.

FEATURES

• Operation from 115 volt, 50/60 cycles, A.C. • Power switch: D.P.S.T. to permit cross connection of the STAND-BY switch of the Recorder • Terminals: An A.C. female and male outlet are located on the rear of the unit • Power cord: Six-foot A.C. cord with a female connector at one end and a male connector on the other end • Modern finish: Smooth, grey enamel • Dimensions: 10 inches high, 7⅝ inches wide, 12¼ inches deep (in cabinet).

FEATURES

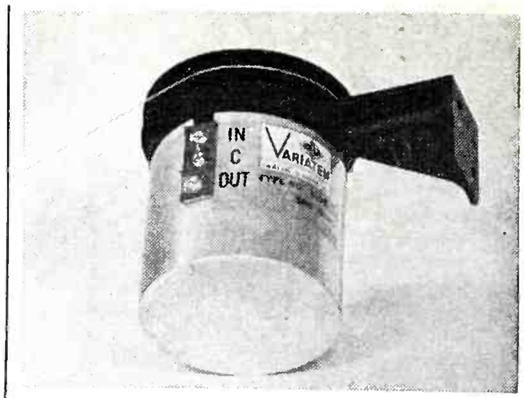
• Simplicity of controls and ease of adjustment • Power requirements: 115 volts 50/60 cycles, A.C. 150 watts • Terminals INPUT: A.C. female and male outlets located on rear of unit • Power cord: Six-foot A.C. cord with a female connector at one end and a male connector at the other end • Cabinet mounting • Modern finish: Smooth, grey enamel • Dimensions: 10 inches high, 15 inches wide, 12 inches deep.

PRESS WIRELESS PreWi INC. PW

For complete information on these units and other Press Wireless communications equipment write to:

PRESS WIRELESS MANUFACTURING CORP.

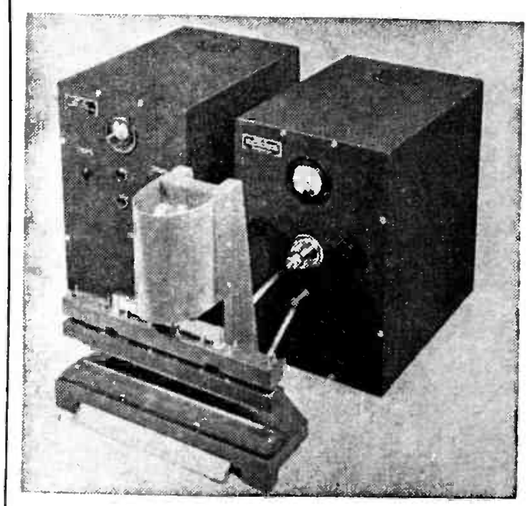
Executive offices: 1475 Broadway, New York 18, N.Y. Cable Address: PRESSRAD NEWYORK



adjusted automatically as the cutting head of a recording lathe progresses across the disc, equalizing from 8 db at 5 inches to 0 db at 12 inches at 10,000 cycles. Impedance of the device is 500 ohms and the insertion loss is 10 decibels.

Plastic Sealer

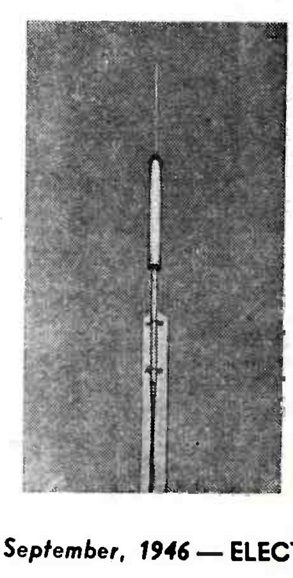
ELECTRONIC PROCESSES CORP., 6 Franklin Ave., Ridgewood, N. J. Thermoplastic materials can be effectively bonded or sealed in two or



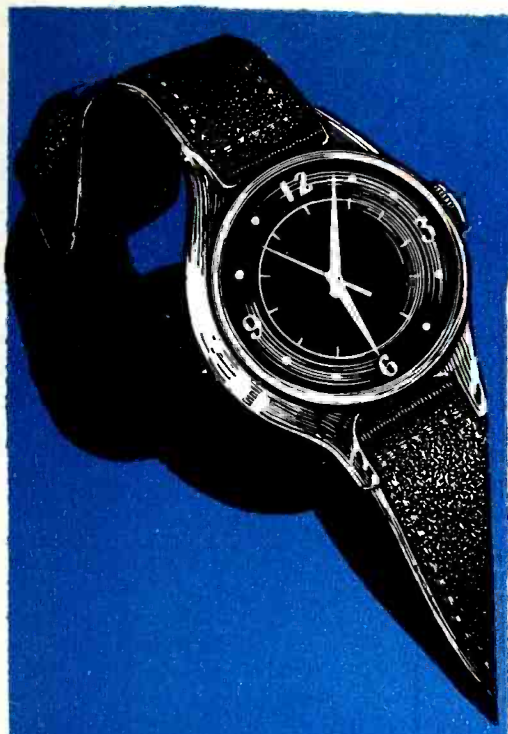
more thicknesses by means of the electronic heater illustrated. The equipment operates from conventional 115-or 230-volt lines capable of supplying about 1,400 watts.

Amateur Antenna

ANDREW CO., 363 E. 75th St., Chicago 19, Ill. The type 704 coaxial antenna can be used for transmit-



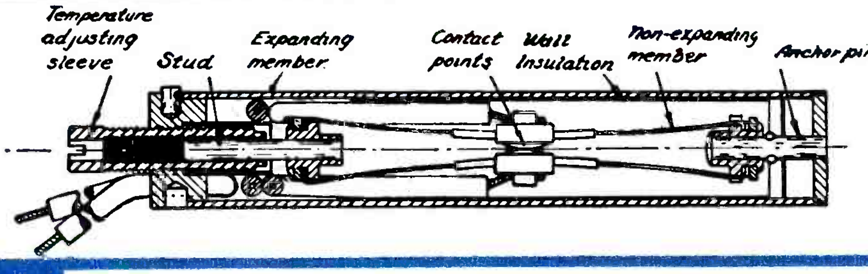
ENCLOSED ASSEMBLY*



Protection of the electrical contact assembly from contamination or physical damage, without interfering with sensitivity, is essential to accurate thermostat operation. The outer shell of the FENWAL THERMOSWITCH Control serves both as the temperature sensitive element *and* as a protective enclosure for the internal parts. No additional protective material or covering is necessary to give the THERMOSWITCH Control contact assembly complete protection under normal use. In applications where excess vapor is present, moistureproof seals are available for further protection. This protective feature in design assures continuous accurate temperature control.

Cross-section drawing of the basic Cartridge THERMOSWITCH Control shows the enclosed assembly. The photograph of the Submersion THERMOSWITCH Control is an example of a Fenwal unit with additional moisture proofing device.

No other temperature control offers so many advantages. Test and compare — you'll find FENWAL controls best suited for your application. *Send for the Thermotechnics Booklet* Fourteen Facts in FENWAL'S Favor *which will help you solve your temperature control problems.*



ENCLOSED ASSEMBLY

SUBMERSION 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

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

Fenwal

FENWAL INCORPORATED

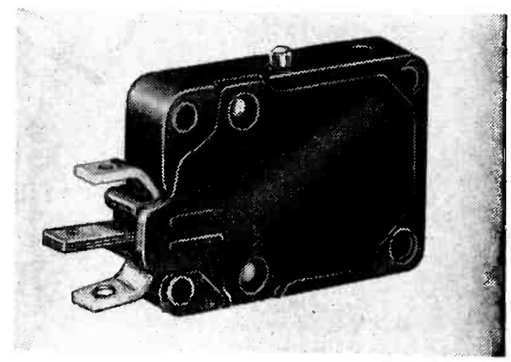
43 PLEASANT STREET

ASHLAND MASSACHUSETTS

Thermotechnics for Complete Temperature Regulation ting or receiving at frequencies in the range 108 to 180 megacycles, making it suitable for police, airport, or amateur communications. Since the structure is essentially a half-wave dipole fed at the center it radiates nondirectionally when erected vertically. Complete with mounting straps and 15 feet of coaxial cable it lists at $16. Net weight of the antenna alone is 3½ pounds.

Miniature Switch

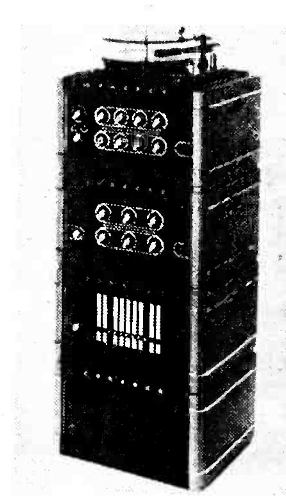
ACRO ELECTRIC CO., 1316 Superior Ave., Cleveland 14, Ohio. The model M snap-action switch is rated at 10 amperes, 125 volts a-c. Four of



these switches can be mounted in a width of 1⅛ inches. They are available in single-pole single- or double-throw combinations.

Unit Amplifiers

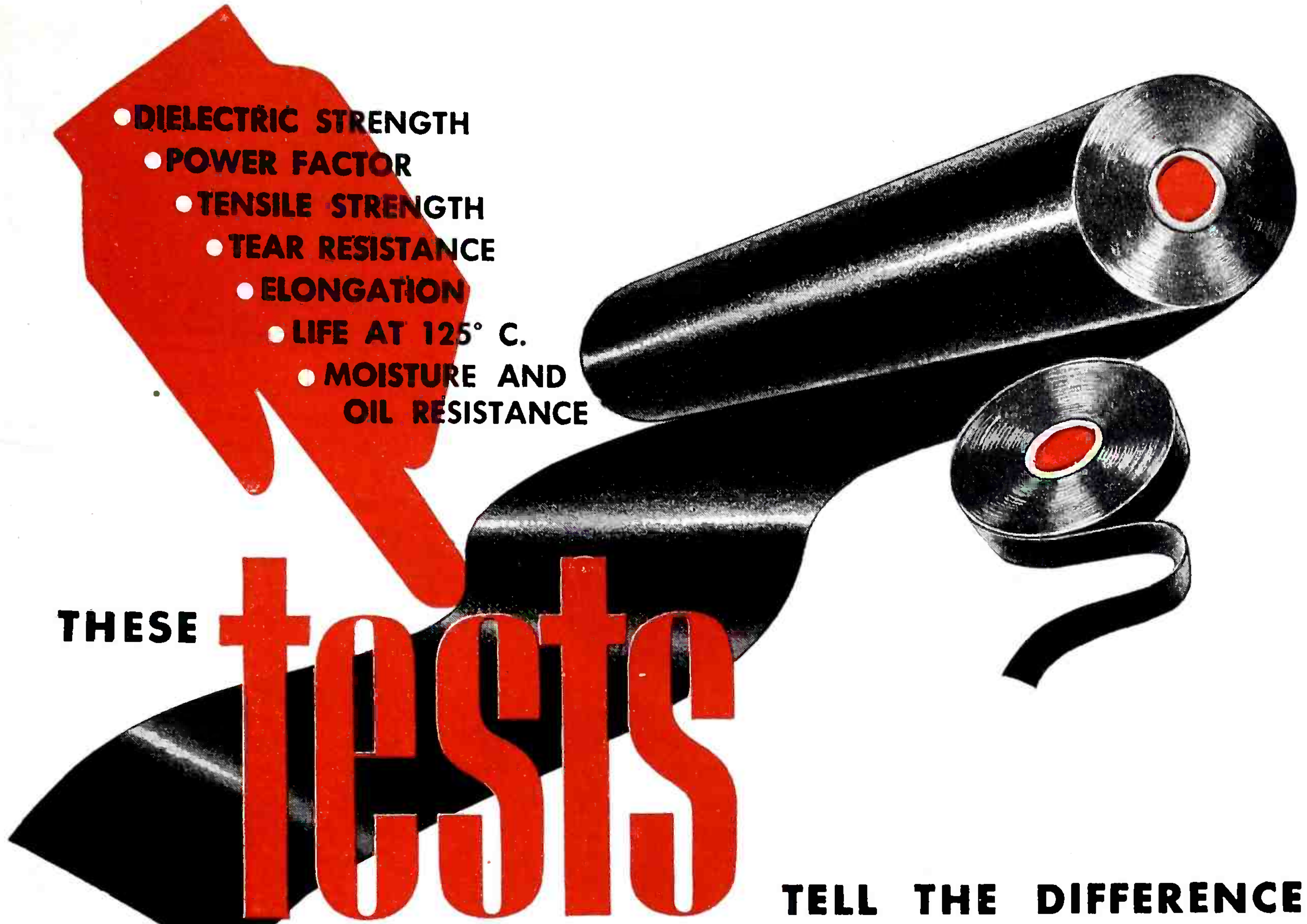
CONCORD RADIO CORP., Chicago, Ill. and Atlanta, Ga. The line of Multiamp units makes possible a gradual building of public-address or record-



playing systems of increasing power and complexity, one unit at a time. Connection of new equipment is accomplished by plug and jack method.

Electrostatic Voltmeter

RAWSON ELECTRICAL INSTRUMENT CO., 110 Potter St., Cambridge 42, Mass. The type 518 line of electro-



THESE tests TELL THE DIFFERENCE *in Varnished Insulations*

To help you make specific service and cost comparisons . . . Irvington will gladly supply generous test samples of any of its varnished insulations.

Each Irvington product will test high in every property, because:

In the manufacture of varnished insulation, Irvington starts right . . . with base fabrics made to exacting Irvington standards . . . fabrics high in mechanical strength, of uniform thickness and smooth finish. *Only by using a smooth, uniform base fabric can excessive pimples, thin varnish areas and other "weak spots" be avoided.*

These carefully selected base fabrics are then uniformly coated with Irvington insulating varnishes . . . manufactured entirely of tested ingredients . . . specific gravity and viscosity controlled for coating fabric. *Only by using insulating varnishes that are correctly formulated and processed can varnished insulations with full dielectric strength, moisture resistance, heat resistance and long life be secured.*

To assure the best possible insulation values and meet hundreds of different customer specifications, Irvington Varnished Insulations are quality-controlled by over 65 checks. Convince yourself of their outstanding characteristics. Write for samples to make comparative tests.

The red core identifies Irvington insulating cloth and tape.

Look to IRVINGTON for Continued Leadership in Insulation

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

IRVINGTON

Varnish and Insulator Company

IRVINGTON 11, NEW JERSEY, U. S. A.

static voltmeters represents improvements over existing equipment, particularly in the reduction of leakage. For a-c measurements, a true rms value is very little dependent upon frequency. Accuracy of 1 percent or better is possible. Instruments with ranges from 300 up to 35,000 volts are available.

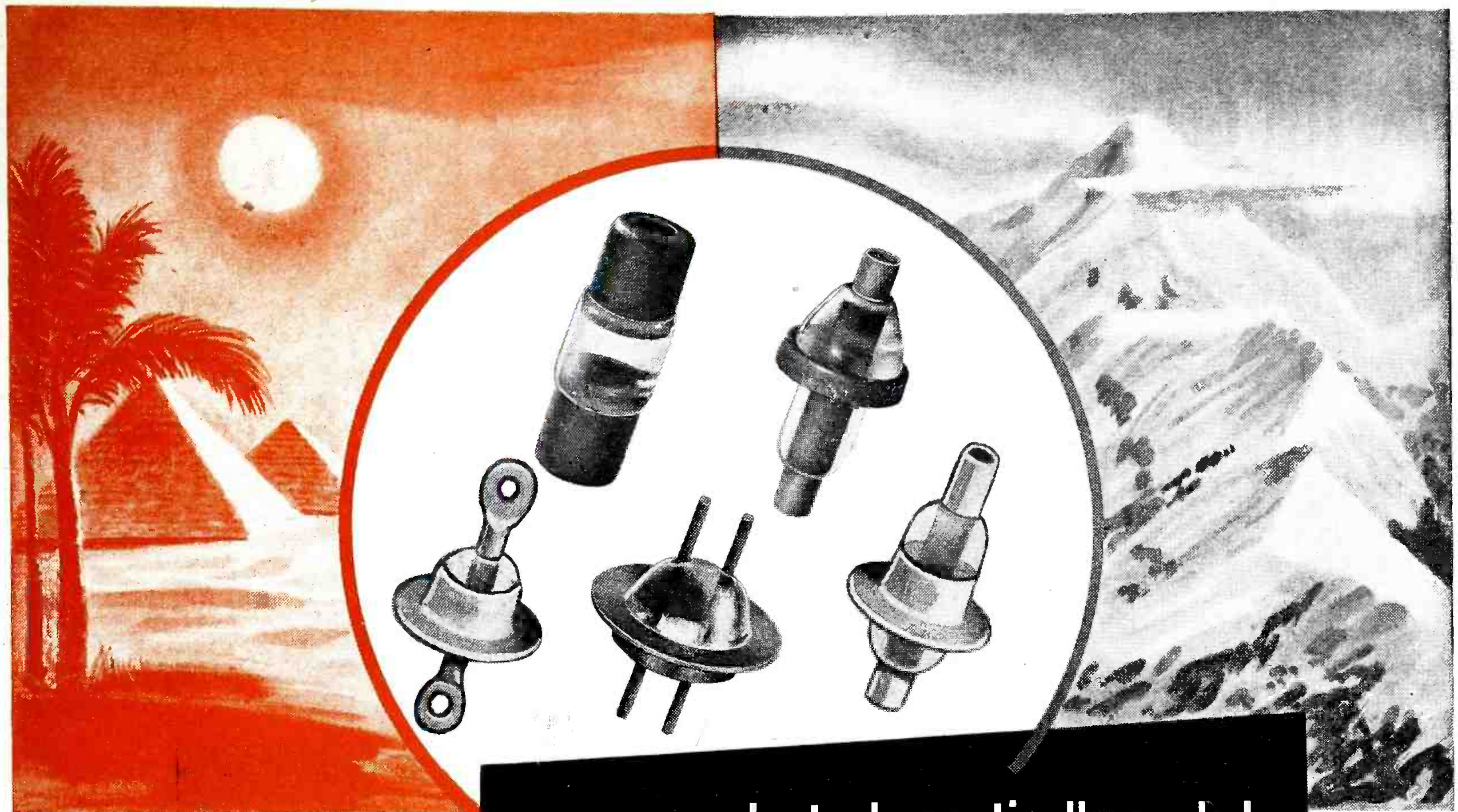
Test Scope

ALLEN B. DU MONT LABORATORIES, INC., 2 Main Ave., Passaic, N. J. The new Type 274 oscilloscope employing a 5-inch tube is suitable for

testing and radio servicing. Vertical and horizontal amplifiers have a range from 20 to 50,000 cycles. Deflection sensitivity at full gain is 0.65 rms volt per inch. List price is $99.50.

Dual Power Supply

COMMUNICATIONS MEASUREMENTS LABORATORY, 120 Greenwich St., New York, N. Y. The CML 1115 dual power supply comprises a 70-milliampere, 300-volt circuit and a bias current up to 75 volts. Less than 7 millivolts ripple is furnished from the latter circuit and less than 25



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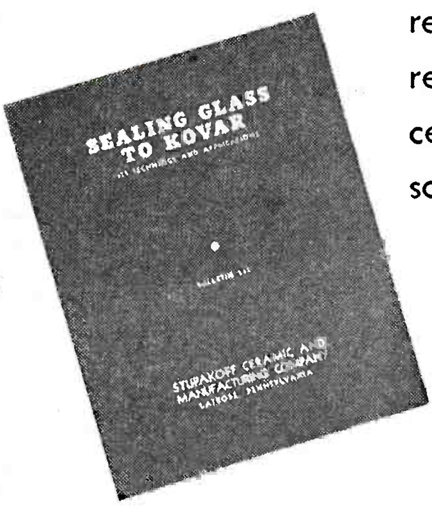
against Extreme Climatic Conditions

..with STUPAKOFF KOVAR*-GLASS SEALS

Stupakoff metal-glass terminals form permanent pressure-tight seals, without cement or gaskets. They protect your products under most adverse climatic conditions and guard against humidity, fungus and other elemental hazards.

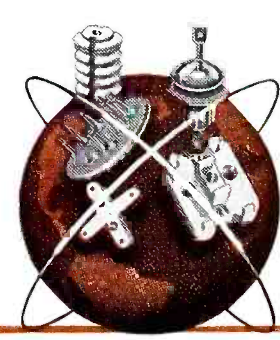
Stupakoff Kovar-glass seals are made in standard shapes and sizes or to your exact specifications for electronic tubes, transformers, resistors, capacitors, condensers, vibrators, switches, relays, instruments, gauges, transmitters, meters, receivers and other components . . . with single, multiple, solid or tubular electrodes.



Write today for Bulletin

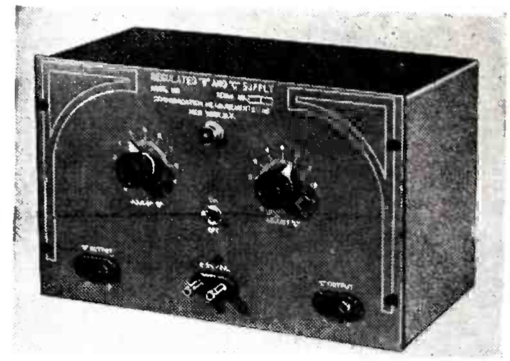
for complete data on Stupakoff Kovar-glass seals.

* Trade Mark 337962 Reg. U.S. Pat. Off.



STUPAKOFF

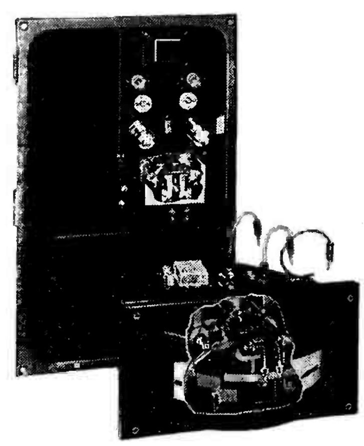
CERAMIC AND MANUFACTURING CO. · LATROBE, PA.



millivolts from the former. The high voltage is variable from 180 to 300 volts and the bias continuously from 0 to 75 volts. A 6.3-volt unregulated winding furnishes 2 amperes.

Pyrometer Controller

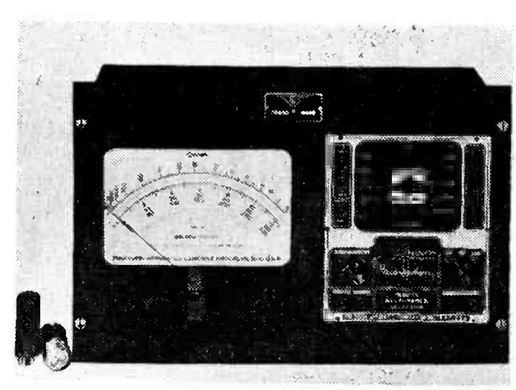
WHEELCO INSTRUMENTS CO., 847 W. Harrison St., Chicago, Ill. The Multronic Capacitrol is essentially a mul-



tiposition electronic pyrometer controller used in heat treating, or in gas, oil and electric-fired equipment. All control operations are carried out using electronic means.

Circuit Tester Panel

PRECISION APPARATUS CO., INC., 92-27 Horace Harding Blvd., Elmhurst, N. Y. The Series 864 a-c/d-c circuit tester is relay rack mounted combin-



ing a 9-inch meter with a remote control range selector that can be removed from the panel assembly and operated at the end of a 7-foot cord. Voltage, current, resistance and out-

.. for awhile, I was saying:

I'm Being Gypped!

I was paying a high-priced technician to test my tubes, and he didn't even work up a sweat .

So I called the bird aside and asked him, "How come?" Then he told me about the time-saving RCP Tube Tester #322. He can test more tubes, more quickly with less effort than ever before. He saves me money on equipment bills, too, because of this instrument's unique versatility and low-obsolescence features.

RCP DYNOPTIMUM TUBE TESTER

MODEL 322

★ Checks all types of receiving tubes on market today. ★ Especially adapted for checking individual sections of multi-purpose tubes. ★ Headphone for noisy, swinging, or high resistance connections. ★ Closer tolerances are obtained due to extremely low voltage drop of test circuit. ★ 4½" square meter with high torque Alnico movement. ★ Compact, sturdy construction. ★ Neon lamp for rapid short and leakage tests between elements.

RCP's **DYNOPTIMUM** circuit, an exclusive RCP feature, eliminates waste switching motion. Fewer controls, jacks and switches permit speedy yet accurate testing of all tubes, including miniatures and sub-miniatures. Incorporates the newest tube developments to provide a low-cost, long range utility tube-tester for the laboratory, inspection booth or service shop.

COUNTER MODEL NO. 322 { complete with sloping steel case, about $39.50

PORTABLE MODEL NO. 322P { complete with oak case and handle about $43.50

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ORDER FROM YOUR LOCAL JOBBER OR WRITE DIRECT FOR OUR NEW CATALOG NO. 129.

RADIO CITY PRODUCTS COMPANY, INC.

127 WEST 26th STREET NEW YORK CITY 1, N.Y.

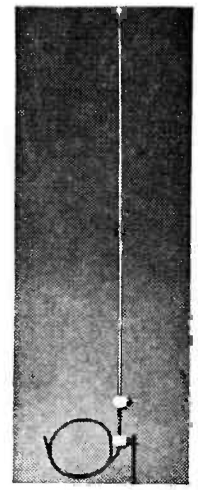
RCP

MANUFACTURERS OF PRECISION ELECTRONIC LIMIT BRIDGES, VACUUM TUBE VOLTMETERS, VOLT-OHM-MILLIAMMETERS, SIGNAL GENERATORS ANALYZER UNITS, TUBE TESTERS, MULTI - TESTERS.

put measurements can be made up to 6,000 volts a-c and d-c, 0 to 300 microamperes and 0 to 12 amperes d-c, 0-20 megohms and output from minus 12 to plus 70 db.

Coaxial Dipole

ENGINEERING ELECTRONICS CO., 50 Fairfield St., Montclair, N. J. First item in a line of equipment designed for amateur operators is a 2-meter



coaxial dipole. It is supplied with two standoff insulators, feed-through bolts and a 4-foot length of transmission line attached to the center of the antenna. The top section is adjustable.

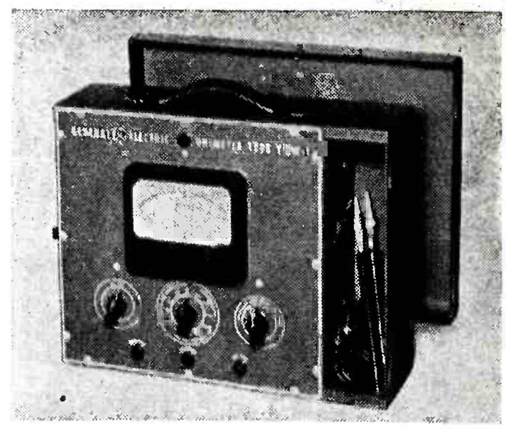
Crystal Microphone

ELECTRO - VOICE, INC., 1239 South Bend Ave., South Bend 24, Indiana. A new combination one-piece molded plastic desk stand and crystal micro-

phone has a substantially flat response from 70 to 7,000 cps. Voltage developed by normal speech (10 dynes per square centimeter) is 0.0394 volt. The unit works into a high-impedance input amplifier. The model 902 microphone lists at $13.25.

Unimeter

GENERAL ELECTRIC CO., Syracuse, N. Y. The type YMW-1 meter is rated at 20,000 ohms per volt and is



arranged to measure all voltages, currents, resistances and output ranges ordinarily encountered in electronic work. Most measurements are made without changing the position of the plug-in leads.

Weatherproof Speaker

RADIO CORPORATION OF AMERICA, Camden, N. J. As a part of new drivein theater equipment, a weatherproof loudspeaker with individual

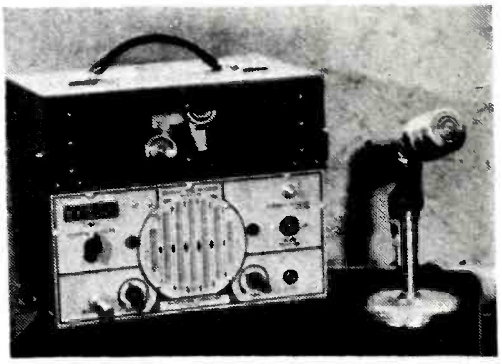
volume control and coiled cord has been designed. The speaker can be hung in any convenient place in the car after it has been removed from its outdoor shelf by the patron himself.

Variable Capacitors

AIRADIO, INC., Stamford, Conn. Two and three-gang variable capacitors of the RMA Class B type are now being manufactured with an oscillator section providing a maximum of 162 micromicrofarads for tracking with an 455 kilocycle i-f and an antenna section providing up to 452 micromicrofarads.

Magnetic Wire Recorder

BELL AND HOWELL CO., 7100 McCormick Road, Chicago 45, Ill. The Peirce Model 55A magnetic wire recorder provides 66 minutes of continuous recording. It is furnished



with a 5-inch permanent magnet speaker, a desk stand microphone, and is priced at $595, less tax. The unit operates from 115-volt alternating current.

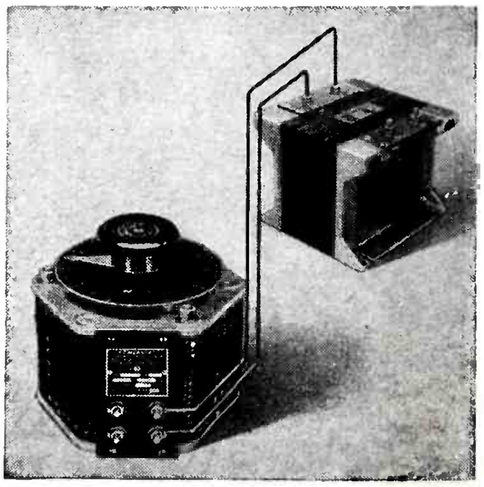
Tubular Capacitors

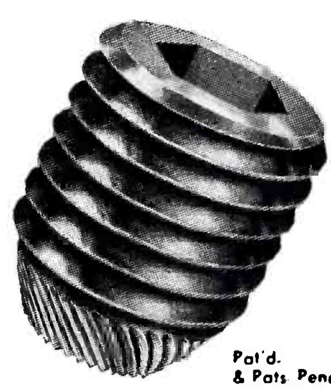
J. P. O'DONNELL AND SONS, 316 Stuart St., Boston 16, Mass., is now producing paper tubular capacitors with capacitance ratings from 0.001 to 1.0 microfarads at voltage ratings of

200, 400, 600, and 1,000 volts d-c. Large scale production of special midget capacitors of the types formerly used in the proximity fuze is planned for the future.

Line-voltage Control

SUPERIOR ELECTRIC CO., Bristol, Conn. Relatively slow deviations of line voltage during the course of a day can frequently be compensated by use of a variable voltage transformer and a fixed-ratio step-down

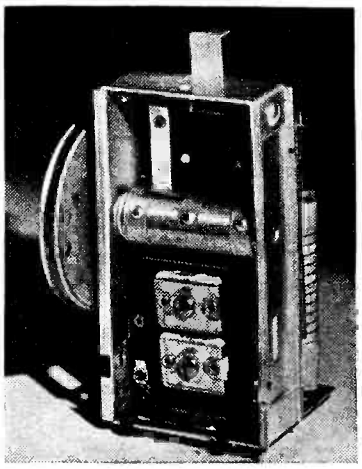




transformer. The type LC Powerstat now furnished with a built-in fuse can be supplied for single- and three-phase operation from 115, 230 or 440-volt lines.

Iron-core Tuner

ELECTRONIC LABORATORIES, INC., Indianapolis 4, Ind. A new iron-core tuner is now available to manufacturers. One of its main features is a fiber carriage to which are attached the iron cores. Tuning is accom-



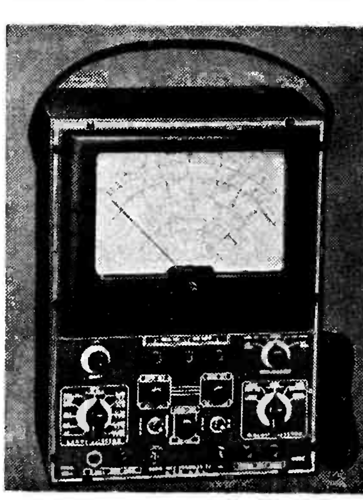
plished by moving the carriage along a rack by means of brass ribbons terminated on a brass cylinder of about $\frac{5}{8}$-inch diameter as illustrated. The movement is positive and claimed to be noiseless.

Midget Rectifier

GENERAL ELECTRIC CO., 1285 Boston Ave., Bridgeport 2, Conn. The conventional filament-type rectifier tube employed in small radio and electronic equipment can be replaced by a small dry-disc rectifier recently produced. The unit is 1 inch in diameter and $\frac{3}{4}$ inch long.

Insulation Tester

RADIO CITY PRODUCTS CO., Inc., 127 W. 26th St., New York, N. Y. Essentially a vacuum-tube voltmeter, the Model 665A instrument is de-



A little-known property of Nickel keeps temperatures right in the SIMMONS ELECTRONIC BLANKET

Acting as the temperature-sensitive element in an electronic control is a new use for Nickel.

Here's how the job is carried out in the Simmons Electronic Blanket:

In the embedded gridiron pattern of heating wires is 355 feet of fine Nickel wire. Acting as a "feeler," it constantly measures blanket temperature.

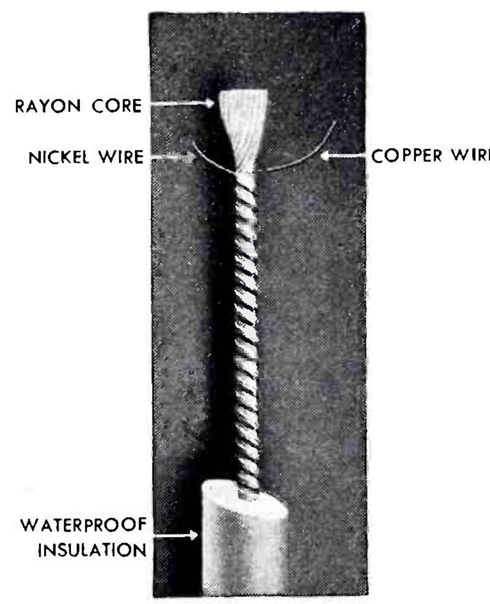
If temperature falls below a chosen level, the decreased resistance of the Nickel wire instantly transmits a signal to the control box. There, electronic tubes amplify the signal, making it strong enough to actuate a relay that sends current through the heater wires.

Once the chosen temperature has been restored, signals from the "feeler" wire similarly shut off the current.

Nickel was selected for this job because its coefficient of electrical resistivity is higher than that of any other commercial metal—.0043-.0050 (68-212°F.). But, as so often occurs when Nickel or Nickel Alloys are used, there were contributing advantages. Nickel offers fatigue resistance *(needed to withstand repeated flexing)*. Nickel is rustless and corrosion resisting *(important, since the blanket must be washable)*. Nickel is both workable and strong *(the "feeler" wire is only 0.0037" in diameter)*.

Remember to investigate **Nickel and INCO Nickel Alloys whenever you need metals with a** *combination* **of hard-to-find properties.**

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

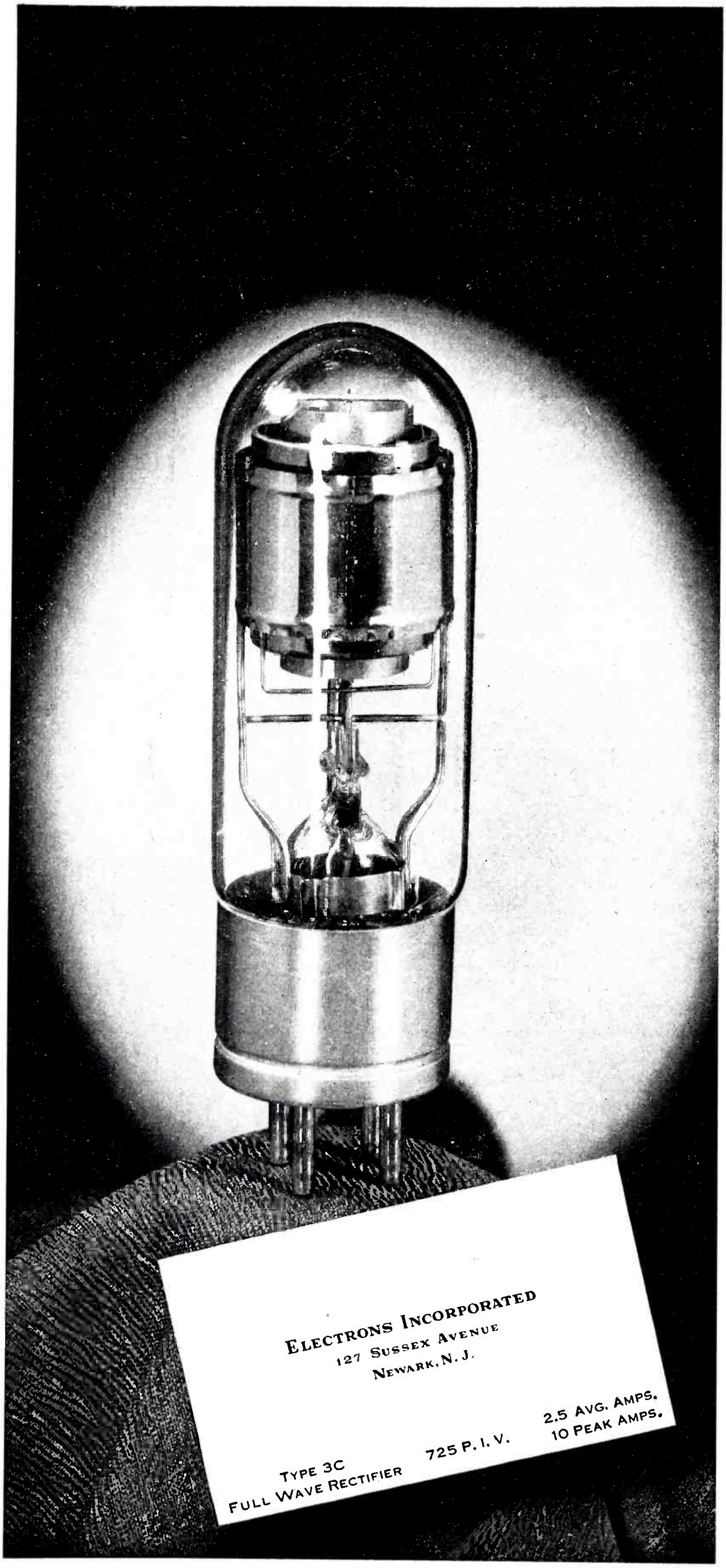


THE HEATING ELEMENT

Shown above is the heating element of the Electronic Blanket made by the Simmons Company. Floating in channels inside the blanket, it is composed of two conductors, each insulated from the other by enamel and both covered by an over-all jacket of waterproof plastic insulation. One conductor is the heating wire. The other conductor, consisting of 355 feet of fine Nickel wire, acts as a "Feeler" and constantly measures blanket temperature.

Nickel plays an important role in the control box, too. For, with 3 electronic tubes used, there are jobs that can be done only by Nickel . . . jobs like the anodes, grids, supporting rods and lead-ins, which require Nickel's great thermal endurance, strength and corrosion resistance.

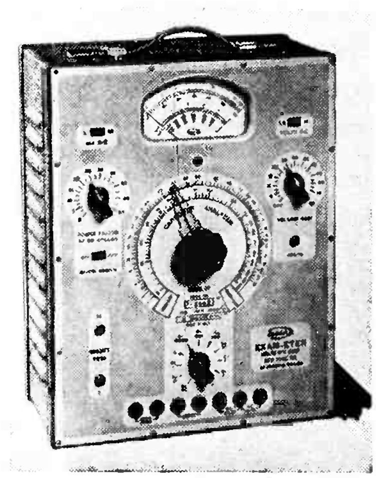
Nickel NICKEL INCO ALLOYS MONEL* • "K" MONEL* • "S" MONEL* • "R" MONEL* • "KR" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL*
*Reg. U. S. Pat. Off.



signed to test insulation from 1 megohm to 10,000 megohms at 500 volts. Capacitance and voltages to 6,000 volts can also be measured. The unit is housed in a metal case $9\frac{3}{4} \times 12\frac{1}{2} \times 6$ inches and weighs 13 pounds.

Capacitor Analyzer

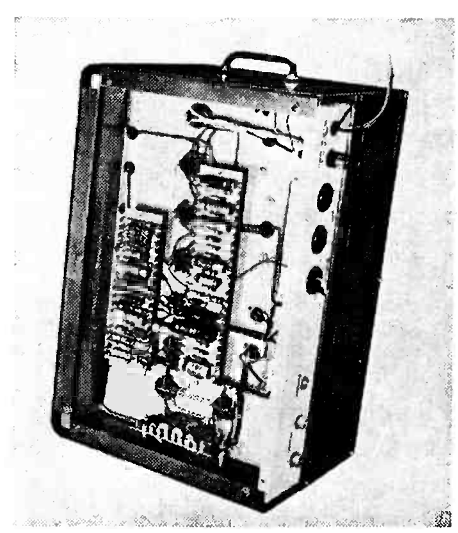
SOLAR MANUFACTURING CORP., 285 Madison Avenue, New York 17, N. Y. The Exam-eter has been designed to check faulty capacitors in circuit



and comprises a d-c bridge to measure capacitance from 10 micromicrofarads to 2,000 microfarads and resistance from 100 ohms to 7.5 megohms. A supplementary circuit allows measurement of resistance up to 10,000 megohms.

Public Address Amplifiers

CLARK RADIO EQUIPMENT CORP., 4313 Lincoln Ave., Chicago 18, Ill. A line of amplifiers rated at 10, 20,



and 30 watts with frequency response virtually flat from 30 to 15,000 cycles is now in production.

Deluxe Recorder

JEFFERSON-TRAVIS CORP., 245 E. 23rd St., New York, N. Y. The epitome of a line of embossed tape recorders is one combined with a time

Helipot

Trademark of the HELIcal POTentiometer!

THE REVOLUTIONARY Potentiometer that Gives You 46½" of Slide Wire in a Panel Space 1½" in Diameter!

Throughout the electronic industry—wherever quality electronic instruments are designed, manufactured or used—the big news is HELIPOT, the helical potentiometer-rheostat that is making possible entirely new standards of accuracy, convenience and compactness in modern electronic equipment. Briefly, here's what makes the *Helipot* so unique . . . .

Instead of a single partial turn of slide wire as found in the conventional potentiometer, the Helipot has *many* full turns of slide wire coiled into a compact helix *requiring no more panel space than the ordinary potentiometer.* The sliding contact follows the long helical path of the slide wire from end to end when a *single* knob is rotated. Thus, the Helipot requires the same panel space—the same single control knob—as a conventional potentiometer...yet it provides the wide range control and accuracy of a slide wire approximately *twelve* times as long.*

In other words, whereas the conventional rheostat gives approximately 300° of rotation, the 10-turn Helipot gives *3600°* of rotation in the *same* panel space.

Think what this important advancement can mean in simplifying the control, increasing the convenience and improving the accuracy of *your* electronic equipment. Helipots are already being used in a wide range of devices—depth sounding equipment, flight control instruments, electrical computors, strain-gage circuits, oscilloscopes and other indicating and measuring apparatus, and a great variety of other electronic applications. Let our engineering staff study *your* control problem and show you how Helipots can increase the accuracy, utility and simplicity of your equipment. There's no obligation, of course. **Send for the Helipot booklet.**

*For the standard 10 turn, 1½" unit. Other sizes proportional.

Some Important Helipot *Features*

HIGH LINEARITY—As a result of fulfilling wartime requirements for ultra-precision circuit controls, Helipots are mass-produced with linearity tolerances of *one tenth of one per cent*—and even less!

PRECISE SETTINGS—Because of the many-times longer slide wire, settings can be made with an accuracy impossible with single turn units.

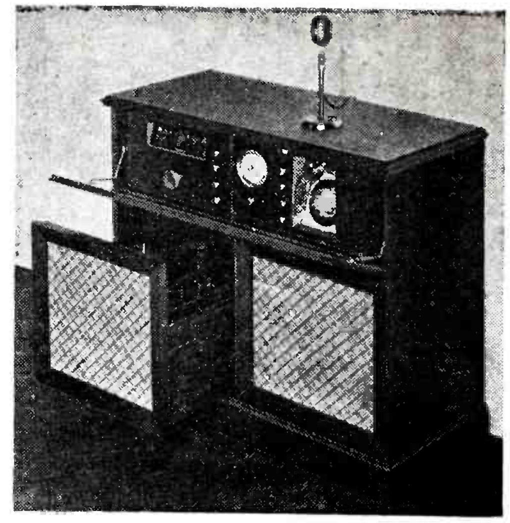
WIDE RANGE—By coiling a long potentiometer slide wire into a helix, the Helipot provides *many times* the range possible with a single turn unit of comparable diameter and panel space.

LOW TORQUE—Of special interest for servo applications—the Helipot has unusually low torque characteristics. The 1½" Helipot—for example—has a torque of *only one inch-ounce.*

HELIPOTS are available with virtually any commercially-obtainable types of resistance wire, limited only by physical characteristics in certain resistance ranges. Three standard sizes are available; the Type A, ten turn and the Type C, three turn models, having 1½" diameter coils, and the Type B, fifteen turn model with 3" coils. The Type A can be wound with fewer than ten turns on special order, while the Type B can be made in sizes up to forty turns, if desired. The versatility of the design permits the addition of taps and extra sliding contacts. Write for full details.

We are also equipped to supply other types of potentiometer-rheostats. Send us your requirements.

● THE HELIPOT CORPORATION, 1011 MISSION STREET, SOUTH PASADENA 2, CALIFORNIA ●



switch and broadcast receiver, making possible the automatic recording of programs in the absence of the set owner. In addition, a disc record album can be continuously embossed on the film from the turntable and pickup with which the console is equipped. Other recorders suitable for office and home use are also available.

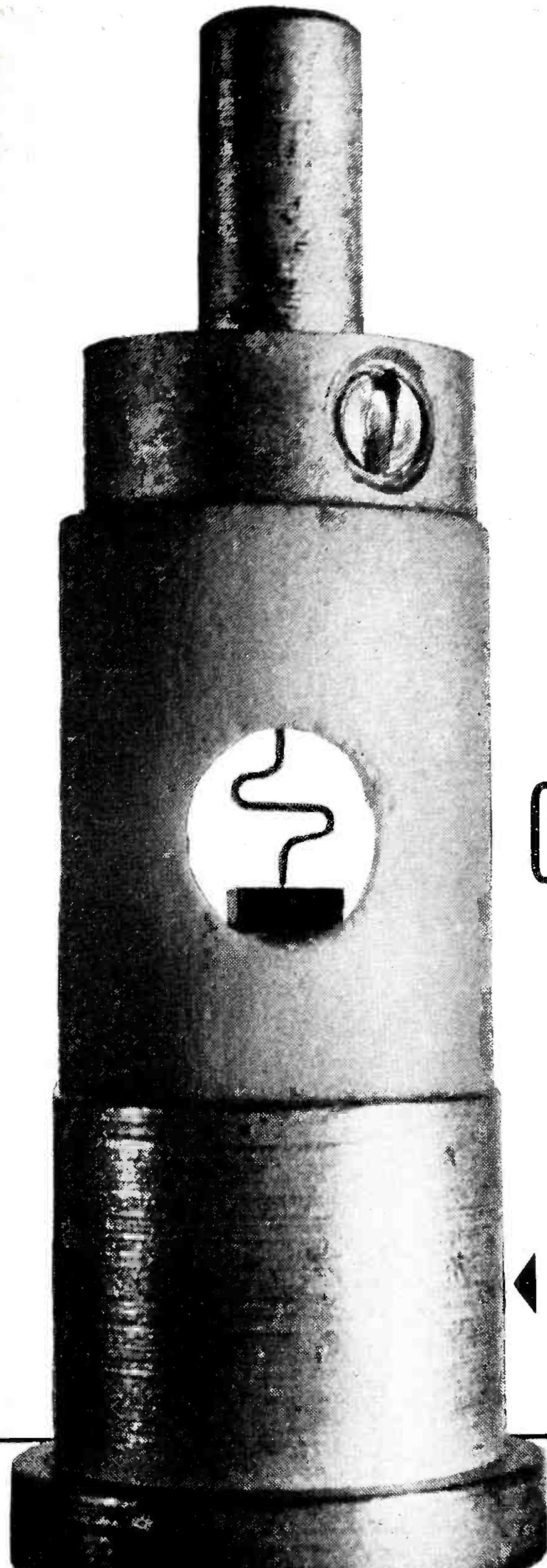
Photoelectric Control

Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass. A general purpose photoelectric control for industrial purposes has been announced in Bulletin 317-P. The equipment operates over a 20-foot

distance within 1/20th second. Contacts will carry up to 10 amperes at 115 volts a-c, noninductive. The equipment operates on 115-or 230-volt lines, 50 to 60 cycles. Weight is 11 pounds.

Temperature Controller

Automatic Temperature Control Co., 34 E. Logan St., Philadelphia 44, Pa. The Electronic Balancer Input Controller can be installed in



Crystal detector—1946 model

ENLARGED
8 TIMES

ONE INCH

Remember the crystal detector in the first radios — hunting for the right spot with a cat's whisker? For years the detector lay discarded in favor of the vacuum tube. But when microwaves came, and with them the need to convert minute energy to amplifiable frequencies, a Bell Laboratories' scientist thought back to the old crystal.

Silicon of controlled composition, he discovered, excelled as a microwave detector. Unlike the old-style natural crystals, it was predictable in performance, stable in service. From 1934 to Pearl Harbor, the Laboratories developed silicon units to serve microwave research wherever needed.

Then Radar arrived. The silicon crystal came into its own, and found application in long-distance microwave Radar. Working with American and British colleagues, the Laboratories rapidly perfected a unit which the Western Electric Company produced in thousands. It became the standard microwave detector.

Crystal detectors are destined to play a big role in electric circuits of the future. They will have an important part in Bell System microwave radio relay systems. In various forms, they may reappear in radio sets. Here again Bell Laboratories' research has furthered the communication art.

BELL TELEPHONE LABORATORIES

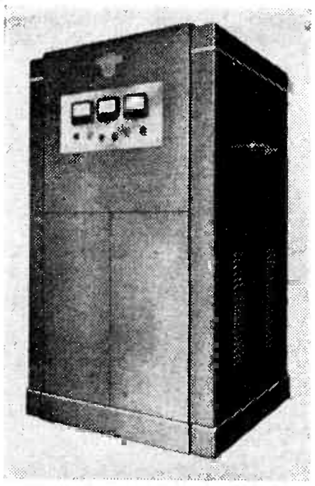
AMERICAN TELEPHONE & TELEGRAPH CO. BELL SYSTEM AND ASSOCIATED COMPANIES

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

any electric furnace temperature control system to proportion the amounts of time that pulses of power are applied to the heating elements. With this system, even control of temperature is effected by varying the ON and OFF pulse periods. The equipment is described in detail in Bulletin T-50.

Induction Heater

INDUCTION HEATING CORP., 389 Lafayette St., New York 3, N. Y. When fully loaded, the Model 1400 high-frequency induction heater delivers 1,400 Btu per minute. It is semiautomatic in operation and includes a number of safety features. The equipment is housed in a metal cabinet about 43 x 39 x 74 inches and weighs 3,700 pounds.



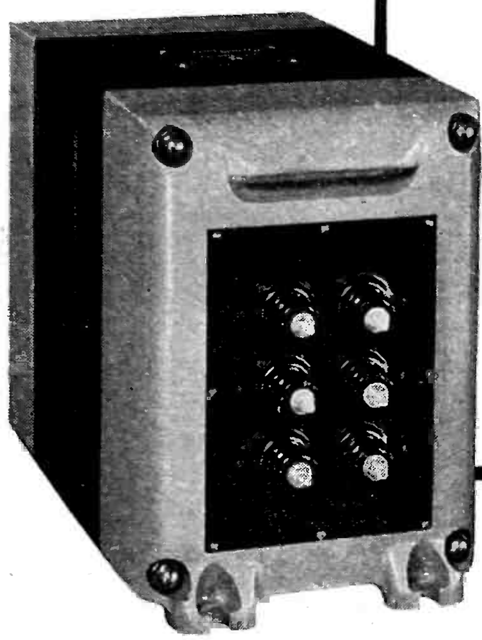
Touch Timer

KAY ELECTRIC CO., 47 North Grove St., East Orange, N. J. A negative feedback circuit is used to extend the normal *RC* time constant so that a relatively simple circuit can be used for timing intervals as long as 30 minutes. A pushbutton control resets the timing cycle. A heavy-duty relay included in the equipment can be used to make or break a 10-ampere, 115-volt circuit. The

For Outstanding Product Performance!

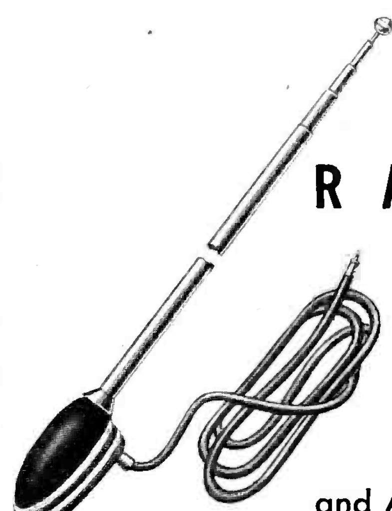
MEISSNER COILS

The standard of comparison for more than 24 years. Meissner coils are precision-built to the most exacting requirements and are designed to provide long, trouble-free performance. Unexcelled in stability and completely dust-proof, these quality units are in no wise affected by humidity changes. Meissner also manufactures a complete line of standard, plastic and Ferrocart transformers for every electronic requirement!



THORDARSON TRANSFORMERS

51 years of outstanding reputation for quality transformer manufacture! That's what you get when you buy Thordarson. Also manufacturers of Tru-Fidelity Amplifiers.



RADIART AERIALS

Rust-Proof Aerials for all cars. Featuring Static Muffler Ball to minimize corona discharge static and Anti-Rattler for smooth quiet operation. Send for free catalog.

THORDARSON · MEISSNER · RADIART PRODUCTS LISTED AND RECOMMENDED BY PHOTO-FACT FOLDERS.

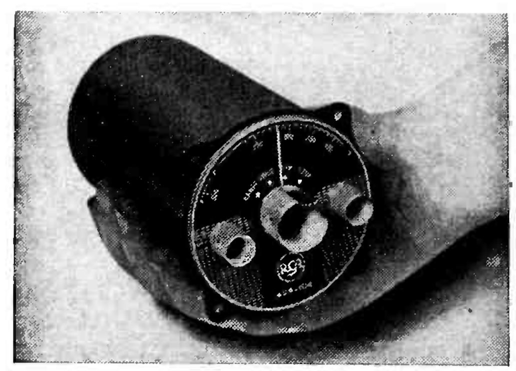
ELECTRONIC DISTRIBUTOR AND INDUSTRIAL SALES DEPARTMENT

MAGUIRE INDUSTRIES, INCORPORATED · 936 NORTH MICHIGAN AVENUE, CHICAGO 11, ILLINOIS

timer is available for two ranges, 3 seconds to 5 minutes at $25 and 3 seconds to 30 minutes at $35. Prices are f.o.b. East Orange.

Aircraft Receiver

Radio Corp. of America, Camden, N. J. The control unit of the AVR-104 receiver has been designed to fit a standard instrument panel opening. The i-f, a-f, and power



units can be mounted in out-of-the-way places. The receiver tunes from 200 to 415 kilocycles, but can be switched to the traffic control channel on 278 kilocycles without disturbing the position of the variable tuning dial. A range filter for 1,020 cycles is also available.

Vibrator Inverter

Electronic Laboratories, Inc., Indianapolis, Ind. A new vibrator inverter has been designed to permit

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

Unit 524
Transcription
Turntable

FM Performance

IF IT'S ON THE RECORD IT'S ON THE AIR!

Let's start with the record. Disc recording has attained a fidelity that is uncanny. Fine quality disc recordings actually duplicate the original sound. It is difficult, even for the trained ear, to distinguish the recording from the original live studio performance.

What has this to do with FM performance? Just this. FM sound reproduction equipment must also possess a fidelity that is uncanny! It must keep the record "alive"!

FM performance puts a premium on precision-built sound equipment that has been engineered for wide dynamic range, minimum distortion content and wide frequency range.

Fairchild has long anticipated the needs of FM. The Unit 524 Transcription Turntable is one outstanding example. It is completely new. The drive and turntable were designed especially for cabinet installation. Turntable noise, rumble and vibration are practically non-existent because of the unique method of mounting the drive and filtering out vibration.

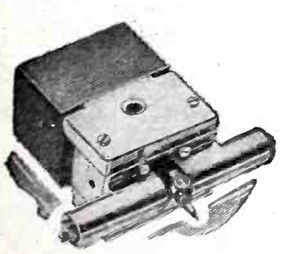
'WOW'-free operation is assured at either 33.3 or 78 rpm by the famed Fairchild direct-from-the-center drive. Evenness of speed is attained by a carefully calculated loading of the drive mechanism that keeps the synchronous motor pulling constantly. Intermittent grab and release is prevented by precision control of all alignments.

If you're interested in FM performance for either FM or AM recorded broadcasts, you'll be interested in Fairchild Sound Equipment.

SOUND EQUIPMENT

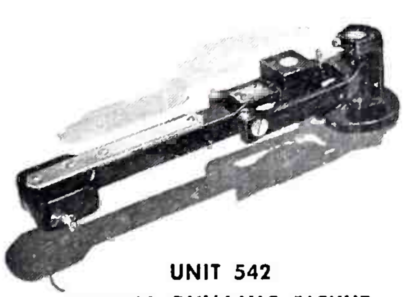
FCI Fairchild CAMERA AND INSTRUMENT CORPORATION

FOR IMPROVED PERFORMANCE



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. For complete information address: 88-06 Van Wyck Boulevard, Jamaica 1, New York.

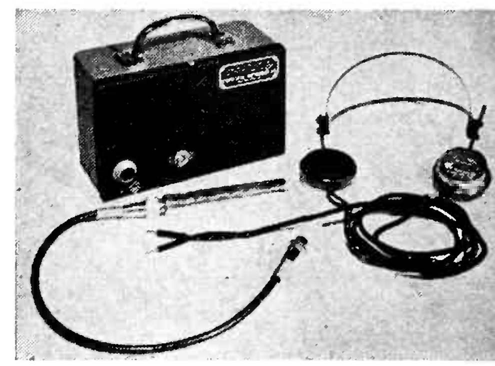


UNIT 542
LATERAL DYNAMIC PICKUP

operation of a-c phonographs or small synchronous motors from direct current lines. With 115 volts d-c input the inverter furnishes 25 watts of power at 110 volts 60 cycles. It measures 4½ x 4 x 2½ inches and weighs 14 ounces.

Radioactivity Detector

GEOPHYSICAL INSTRUMENT CO., Key Boulevard and Nash St., Arlington, Va. The Model 5A radioactivity detector is extremely light and compact, designed for portable operation. Indication is by means of



headphones. An internal oscillator converts 135 volts from the B battery to a counter operating potential of over 1,000 volts. The unit measures 7 x 5 x 3 and weighs 4¾ pounds without batteries. It costs $150 complete, f.o.b. Arlington.

Impulse Scaler

INSTRUMENT DEVELOPMENT LABORATORIES, 817 E. 55th St., Chicago 15, Ill. A new scaling device for the counting of beta particles and gamma rays requires only a Geiger tube in addition to the self-contained equipment shown. The unit

has an input sensitivity of 0.25 volt and a resolving time of better than 5 microseconds. It is little affected by changes in line voltage. Input line voltage can vary between 95 and 130 volts.

Dial Light

DIAL LIGHT CO. OF AMERICA, INC., 900 Broadway, New York 3, N. Y. A new series of pilot light assem-

WHEN CIRCUIT SYMBOLS INCLUDE ARROWS

think of

S. S. WHITE FLEXIBLE SHAFTS

Arrows mean variable elements. And some variable elements, such as condensers and resistors, call for operational adjustments.

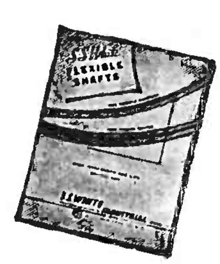
The placing of these elements introduces some nice problems in designing the actual equipment. Naturally, they should be located for optimum circuit efficiency and where they will be easy to assemble and to wire. At the same time, you want to locate the control knobs or dials for convenient operation.

S.S.White remote control flexible shafts offer you a simple answer to these problems. Use them to couple the variable elements and their controls, and you are free to place both the elements and the controls anywhere you want them.

You will find too, that operation with these shafts is as smooth and sensitive as a direct-connection—regardless of curves or distance. That's because they're engineered expressly for such service.

WRITE FOR BULLETIN 4501

It will give you basic facts and engineering data about S.S.White flexible shafts and their application. Every engineer should have a copy.



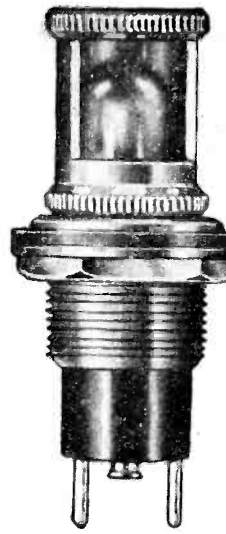
S.S.WHITE INDUSTRIAL DIVISION

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

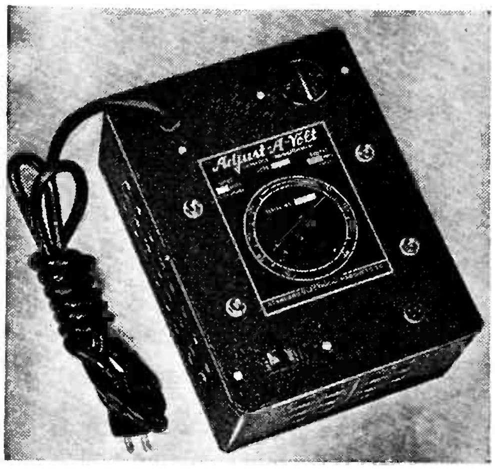
One of America's AAAA Industrial Enterprises



blies uses a type NE-51 neon lamp and a light shield that can be rotated in a full circle to light the desired spot at any angle from the source. Incandescent lamps can be supplied for this series.

Variable Transformer

STANDARD ELECTRICAL PRODUCTS Co., Dayton 3, Ohio. The Adjust-A-Volt variable transformer is used to vary 115- or 230-volt input between



70 and 140 volt output. It is not an autotransformer and so serves to isolate primary and secondary circuits. There are four models available with maximum rating at 1,000 volt-amperes.

Induction Heating Generators

RADIO CORP. OF AMERICA, Camden, N. J. Two new models of induction-type electronic power generators are available with 2 and 15 kilowatts output. The low-power equipment illustrated (Model 2-BL) consists of a generator and the applicator unit shown above it. Power output of the equipment can be controlled over a wide range, and is applied through a timer with a 0.2-

Impromptu Discussions about Miniature Tubes

Of course I'm using a TUNG-SOL Miniature Power Amplifier in this circuit. You can get them now for a wide range of radio receiver applications. They all have high efficiency beam construction and provide for maximum Class A. power output ranging from ¼ to 4½ watts. You'll find that miniatures generally give even better performance than the big ones.

Take the TUNG-SOL 50B5 for example. It's designed as the miniature tube equivalent of type 50L6GT. It's outstanding for its power sensitivity and adaptability to AC/DC circuits. In the 50B5 this high performance standard has been maintained with a volume displacement of less than 30% of the 50L6GT. With the same internal dissipation, the bulb operating temperatures are higher in the smaller envelope but, several type 50B5 tubes may be safely operated in an enclosed cabinet with an ambient temperature as high as 150° centigrade.

Small physical size of the 50B5 and ability to perform in "transformerless" circuits permits unusual applications. Power outputs as high as 1.9 watts afford ample volume for intercommunication systems. Its ability to deliver 130 milliamperes of peak plate current with 5.25 rms. volts signal may suggest use as a trigger tube or to operate control relays.

Either as a tetrode or triode, its transconductance of 7500 umhos means high circuit efficiency. Even though it is designed as a Class A power amplifier, the 50B5 may be adaptable to certain oscillator applications at low and medium frequencies.

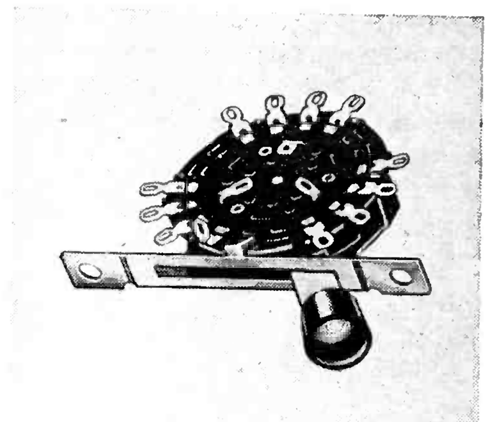
If you want the real low down on this or other unusual applications, write to the TUNG-SOL Commercial Engineering Department. You see those fellows are only interested in tubes. They aren't set builders. Your consultations with them are held in strictest confidence.

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

to 120-second operating period. The circuit of the 15-kilowatt equipment can be keyed as high as 40 cycles per minute.

Lever Action Switches

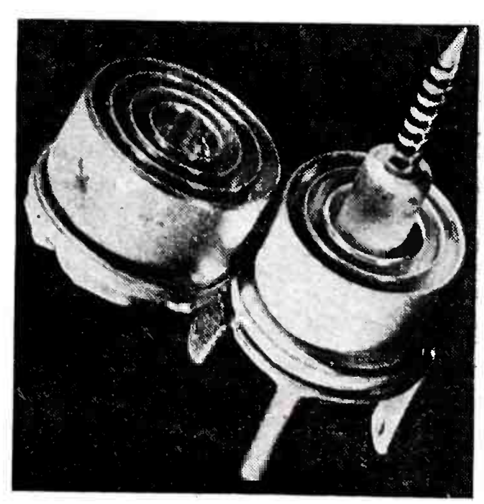
P. R. MALLORY & Co., INC., 3029 Washington St., Indianapolis 6, Ind. A new line of lever action switches is available including 3- and 4-position types with shorting



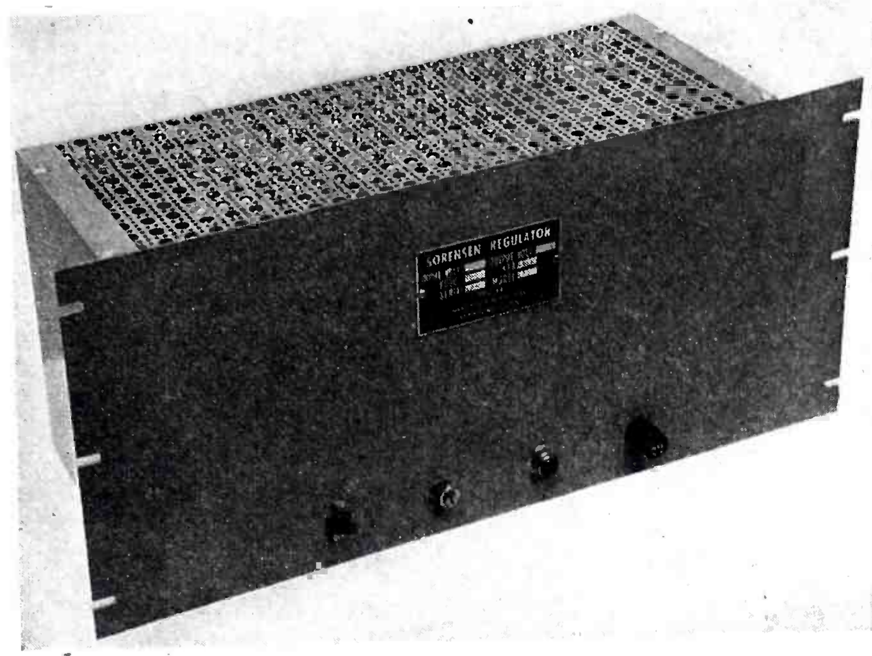
or nonshorting contact combinations. Contacts will make or break circuits carrying 120 milliamperes at 110 volts. A folder is available describing Series 5000 and 6000 switches.

Air Capacitor

NORTH AMERICAN PHILIPS Co., INC., 100 East 42nd St., New York 17, N. Y. A new high-*Q* air capaci-



Sorensen
AC Voltage
Regulators



MODEL 250 (illustrated)
has a range of 25-250 va.

STEADY!

output voltage held to ±0.2%

FAST!

output voltage stabilized in less than 6 cycles.

INDEPENDENT!

of frequency variations ±15%.
of load variations—10% to 100% of load rating.
of input voltage fluctuations from 95-125 volts.
of load power factor.

DEPENDABLE!

Distortion less than 5%.
Output adjustable from 110-120 volts.
Ranges available from 25-15,000 va.
Easily converted into current regulator.

Write for our bulletin giving schematic and details

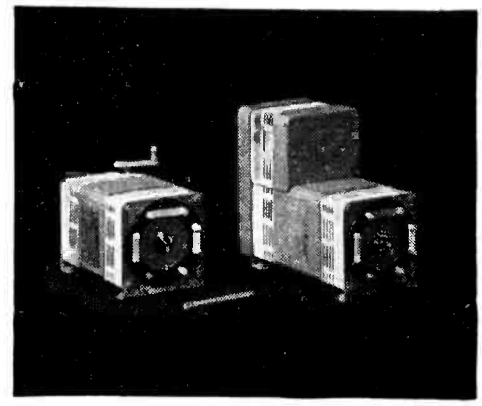
SORENSEN & COMPANY, INC.

STAMFORD, CONN.

tor consists of two sets of concentric aluminum cylinders that are moved together or apart by means of a screw. The capacitance range is 3 to 30 micromicrofarads. The units are less than ½ inch in diameter and 1 1/16 inches long. They are light enough to be mounted directly on connecting leads.

Line Voltage Regulator

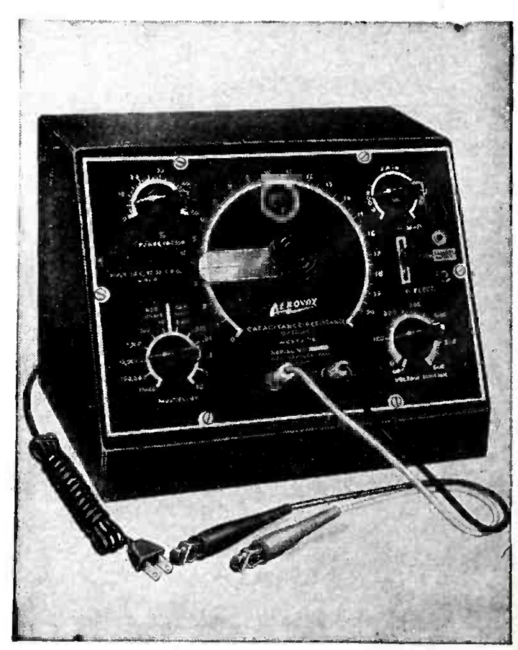
General Electric Co., Schenectady 5, N. Y. Induction voltage regulators including 300- and 600-volt-ampere ratings are available for communication and industrial control use. They can be supplied to



maintain constant voltage output from varying lines or they can provide variable voltage from relatively constant lines. Wave-form distortion is seldom encountered and the units have no effect on the power factor of the circuits in which they are used.

Resistance-Capacitance Bridge

Aerovox Corp., New Bedford, Mass. The Model 76 resistance-capacitance bridge measures capacitance from 100 micromicrofarads to 200



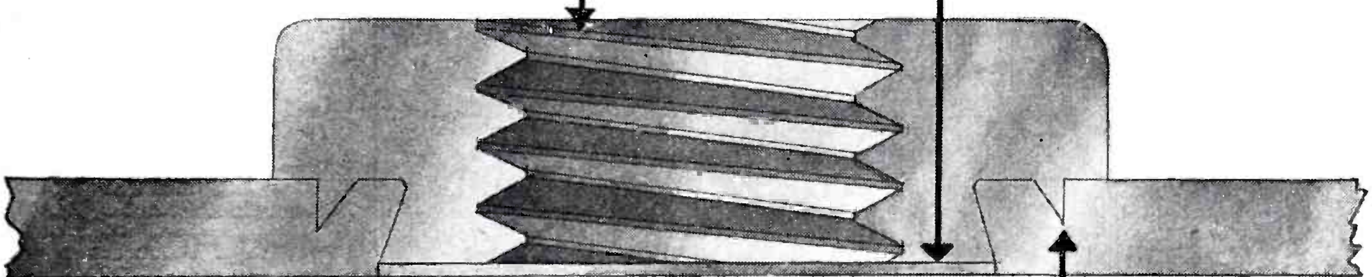
NEW!

Self-Clinching Fastener

PROVIDES LOAD-CARRYING THREADS IN THIN STEEL, ALUMINUM, COPPER OR BRASS SHEET!

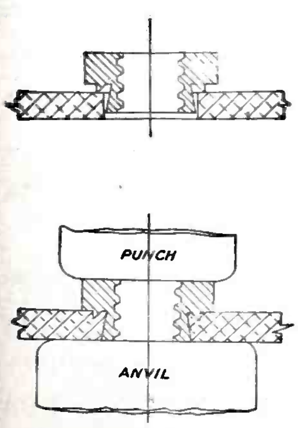
1 *Provides load-carrying threads in thin steel, aluminum, copper, or brass sheet!*

2 *Shank length can be equal or less than thickness of sheet.*



3 *Countersinking of hole not necessary. Reverse side of sheet remains flush!*

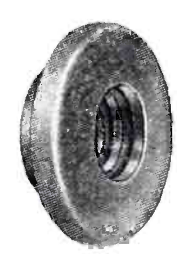
4 *Ring clinches fastener and prevents turning.*



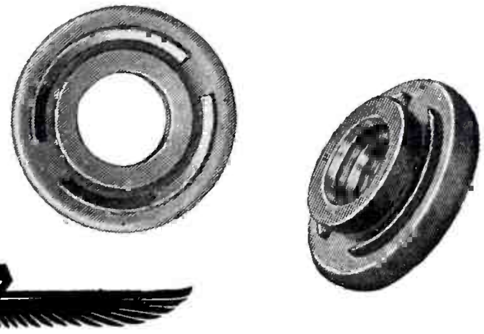
IT'S THIS EASY!

Punch straight hole, insert fastener in sheet, and apply pressure to head of fastener.

PEM Self-Clinching Fasteners solve assembly problems involving steel, aluminum, copper, or brass sheet. Because no special tools are required, PEM Self-Clinching Fasteners save time, labor, and weight; mean faster, more simplified clinching. For complete information, write to *Penn Engineering and Manufacturing Corporation, Doylestown, Pennsylvania.*



Enlarged to show detail. Available in thread sizes #2-56, #4-40, #6-32, #8-32, #10-32, and #10-24.



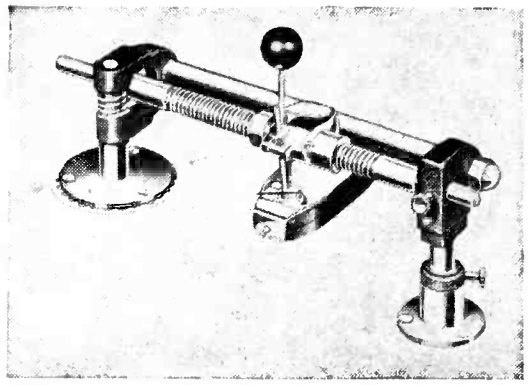
PEM

PENN ENGINEERING & MANUFACTURING CORP., DOYLESTOWN, PA.

microfarads, and resistance from 10 ohms to 200 megohms. It provides high voltage and a means of checking leakage and power factor of paper and electrolytic capacitors.

Recording Cutter

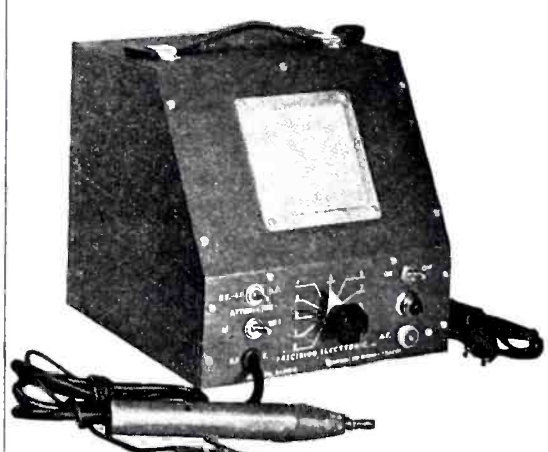
TECHNO-CRAFT PRODUCTS CO., 200 Hudson St., New York 13, N. Y. Two models of a new recording mechanism are now available at



low cost for 12- or 16-inch discs. Cutting pitch is 110 lines per inch, outside-in. Four types of Astatic cutting heads are presently available. The 16-inch model sells for $55.

Signal Tester

RADOLEK CO., 601 West Randolph St., Chicago 6, Ill., is distributor for the Precision Electronic Model 200 signal tester. This equipment is essentially a low-capacitance probe

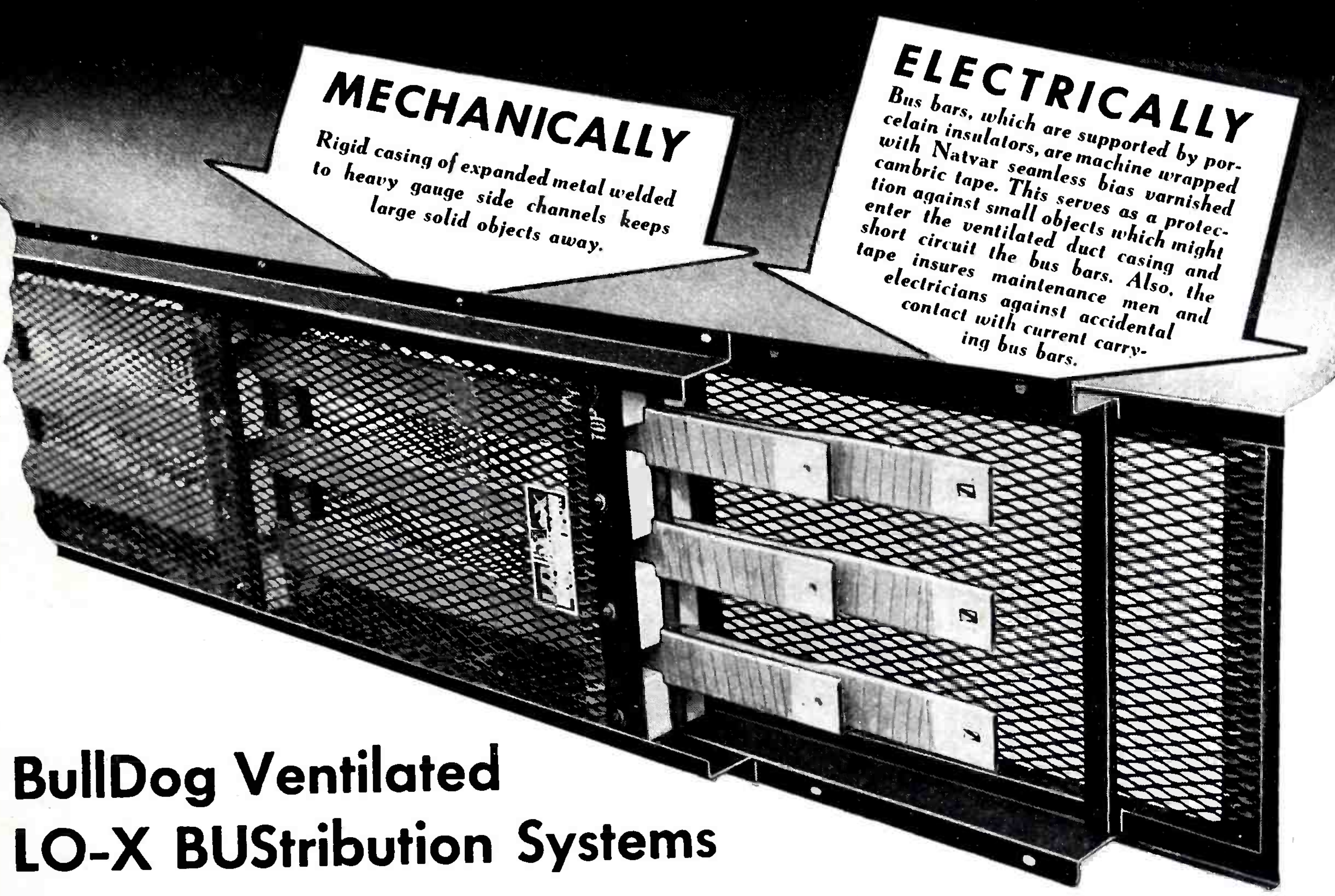


with associated detector and loudspeaker used in tracing modulated r-f signals through receivers and allied electronic equipment. The equipment operates from a 110- to 120-volt 60-cycle line. It lists at $29.95.

Welding Timer-Contactors

ELECTRONIC PRODUCTS CO., Box 204A, RR 1, Aurora, Ill. Two types of timer-contactors for the control

DOUBLY PROTECTED ... from accidental grounding or shorting



BullDog Ventilated LO-X BUStribution Systems

VENTILATED "Lo-X" BUStribution Duct, manufactured by BullDog Electric Products Company, Detroit, makes plant layout flexible because it gives access to adequate power supply up to 4000 amp., wherever it is needed. Wide, flat bus bars supported by porcelain insulators are arranged in closely spaced, paired phase design to assure low voltage drop by reducing reactance loss.

The expanded metal enclosure of Ventilated "LO-X" BUStribution Duct simulates the effect of bus bars in open air, thus reducing temperature rise. The principal dielectric is air, which is the only insulation that has the faculty of restoring its dielectric properties when and if a power arc occurs. Bus bars are machine wrapped with *Natvar* seamless bias varnished cambric tape because of its high uniformity and because it gives the required balance of high dielectric and high mechanical strength.

If you require insulating materials with good physical and electrical performance characteristics and exceptional uniformity—plus prompt delivery—plus service, it will pay you to use Natvar. Get in touch with your Natvar wholesaler or with us direct. Write, wire or phone.

Natvar

- Varnished cambric — straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished silk
- Varnished special rayon
- Varnished Fiberglas cloth
- Varnished papers
- Varnished tubings and sleevings
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded vinyl tubing
- Extruded vinyl identification markers

Write for Catalog No. 20

THE NATIONAL VARNISHED PRODUCTS *Corporation*

TELEPHONE RAHWAY 7-2171

CABLE ADDRESS NATVAR: RAHWAY, N. J.

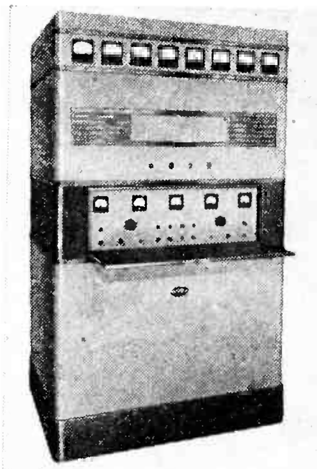
201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

9-NVP-1

of welding equipment are available as complete units that can be added to existing welding equipment. Quality of welds is improved as a result of applying successive currents in the same phase relation by means of electron tubes.

Kilowatt Transmitter

RAYTHEON MFG. CO., 60 East 42nd St., New York 17, N. Y. The RA-1000 is a high-level modulated broadcast transmitter now in use. Noise level is better than 60 db below 100 percent modulation. The unit is designed to operate from a 230-volt, 3-wire, 3-phase, 50- to 60-cycle line. The audio input circuit requires a zero level for 100 percent modulation. Output circuit feeds a 70- to 250-ohm transmision line.



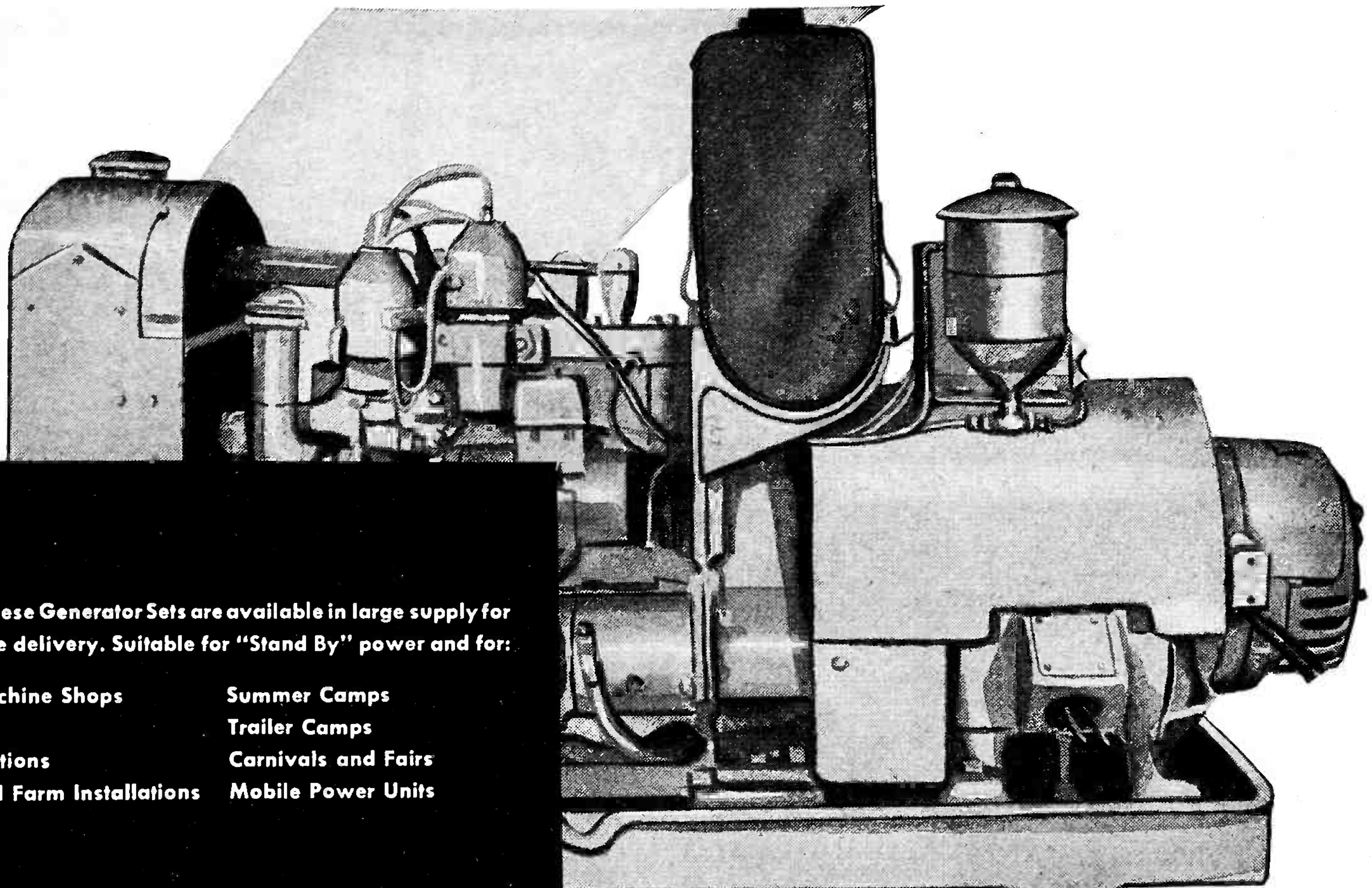
Literature

Engineering Service. Conlan Design & Engineering Division, 1042 Atlantic Ave., Brooklyn 16, N. Y., offers a brochure describing its complete engineering service from FCC construction permit application to finished studio and station.

Tube Manual. Chatham Electronics, 475 Washington St., Newark 2, N. J., presents a catalog of its tubes. As additional products become available, new data sheets will be issued.

Resistor Catalog. Model Engineering & Mfg., Inc., Huntington, Ind., successor to Carter Radio and Utah Products, offers a new 8-page, 2-color catalog describing a line of vitreous enameled resistors.

Relays. Electra Voice Corp., 5215 Ravenswood Ave., Chicago 40, Ill. Telephone type relays for a-c or



Some of these Generator Sets are available in large supply for immediate delivery. Suitable for "Stand By" power and for:

Small Machine Shops	Summer Camps
Saw Mills	Trailer Camps
Radio Stations	Carnivals and Fairs
Rural and Farm Installations	Mobile Power Units

✓ 120 VOLTS TO 480 VOLTS

✓ 1½ KW TO 30 KW

✓ FROM $250 TO $2500

PORTABLE *Generator* SETS

GOVERNMENT-OWNED SURPLUS

Many Generator Sets, produced by well known manufacturers, are now available from government-owned surplus. The majority of them are new, unused sets, and include the following types:

Gasoline engine driven	Alternating current, 50 and 60 cycle, single and three phase	120 Volts to 480 Volts
Diesel engine driven		1½ KW to 30 KW
Direct current 120-250 Volts		From $250 to $2500

Used sets in good condition at further reduced prices. All items subject to prior sale.

HOW TO PURCHASE:

1 If you can claim a priority obtain your priority certificates at the nearest W.A.A. Certifying Office, (contact the W.A.A. Office below for Certifying Office address) and make application to purchase.

2 If you do not have priority status simply call any W.A.A. Office below; state the approximate KW rating you desire and the type of machine. You will be told where the machines you wish may be seen and how to complete purchase.

3 If the equipment you wish is not available in your local W.A.A. Regional Office—ask to have national inventories checked by the W.A.A. Inter-Regional Division of your local office and wait for notification of availability.

All Portable Generator Sets are subject to priority regulations. VETERANS OF WORLD WAR II are invited to be certified at the War Assets Administration Certifying Office serving their area, and then to purchase the equipment offered herein.

EXPORTERS:

Most surplus property is available to the export market. Merchandise in short supply is withheld from export and if such items appear in this advertisement they will be so identified by an asterisk.

WAR ASSETS ADMINISTRATION

GOVERNMENT OWNED SURPLUS

Offices located at: Atlanta · Birmingham · Boston · Charlotte · Chicago · Cincinnati · Cleveland · Dallas · Denver · Detroit · Fort Worth · Helena · Houston · Jacksonville · Kansas City, Mo. · Little Rock · Los Angeles · Louisville · Minneapolis · Nashville · New Orleans · New York · Oklahoma City · Omaha · Philadelphia · Portland, Ore. · Richmond · St. Louis · Salt Lake City · San Antonio · San Francisco · Seattle · Spokane

655-1

d-c operation can be supplied in slow-operate, slow-release, two-section coil and rotary types and are illustrated in a bulletin recently issued.

Vacuum Capacitors. General Electric Co., Syracuse, N. Y. offers 16-page bulletin ETX-3 listing various types of vacuum capacitors and their use.

Resistor Specification Chart. Shallcross Mfg. Co., Collingdale, Pa. Engineering data on Akra-Ohm resistors appears on a wall chart that shows JAN style numbers beside the equivalent manufacturer's number.

Ceramics. General Ceramics and Steatite Corp., Keasbey, N. J. Devoted to insulators for electronic service, a 48-page catalog (No. 2,000) has just been issued that includes data on bushings, coil forms as well as design criteria for other classes of ceramic insulators.

Midget Relays. Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y., offers Bulletin 104 describing midget metal-base relays designed for aircraft and other applications where space and weight must be limited.

Merchandising Guide. Superintendent of Documents, Washington 25, D. C. The Department of Commerce has prepared a paper-covered book entitled, "Establishing and Operating an Electrical Appliance and Radio Shop" that is available from field offices of the Department or from the Superintendent of Documents for 35 cents. Legal, credit and marketing information are included among the many other topics necessary for consideration in the radio or any other business field.

F-m Broadcast Transmitters. Federal Telephone and Radio Corp., Newark 1, N. J. Technical data on 10-, 20-, and 50-kilowatt f-m transmitters is presented in a large booklet just issued.

Metals for Electronic Use. Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa. offers booklet B-3369 as a guide to the properties

and applications of recent metallurgical developments of importance to the field of communications and electronics.

Electronic Voltmeters. Ballantine Laboratories, Inc., Boonton, N. J., has summed up in 11 pages its line of electronic voltmeters and accessories, including amplifiers, multipliers, precision resistors and an artificial ear.

Subminiature Tubes. Raytheon Mfg. Co., 60 E. 42nd St., New York 17, N. Y. Data sheets have recently been printed for types 2E32, 2E36, 2E42, and 2G22 tubes.

Capacitors and Filters. Tobe Deutschmann Corp., Canton, Mass. A 40-page catalog has been formulated as an aid to engineers in the design of equipment using capacitors and noise-elimination filters, listing the complete line of these items manufactured by the company.

High Nickel Alloy Steel. The Carpenter Steel Co., Reading, Pa. has just issued a comprehensive booklet on special steels used in the electronic and allied fields.

Synthetic Jewels. Linde Air Products Co., 30 East 42nd St, New York 17, N. Y. A 27-page booklet describes the properties, production techniques and uses of synthetic sapphire, ruby and spinel. These artificial gems have been used for precision gages and suspending meter movements.

Welding Code. American Welding Society, 33 West 39th St., New York 18, N. Y. A "Standard Code for Arc and Gas Welding in Building Construction" has recently been approved and is for sale at 50 cents a copy.

Navigation Survey. Office of Technical Services, Dept. of Commerce, Washington 25, D. C. "The Future of Hyperbolic Navigation" by J. A. Pierce, has been declassified from the secret list and is now available through the Department of Commerce as report PB-2834 in photostat form at $2 or on microfilm for 50 cents. Included are an evaluation of Gee, Loran and the British Admiralty Decca system.

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Production statistics; meetings to come; activities of electronic manufacturers; changes in engineering personnel

June Radio Set Production Breaks All Records

THOUGH STILL far short of present capacity, the radio industry broke all previous production records by producing a combined output by RMA member-companies of 1,052,597 radio sets of all types during June, and an estimated total of 1,378,000 sets for all manufacturers (Civilian Production Administration figure). The month's output far exceeded the prewar monthly average of 1,110,000 sets in 1941.

Production of f-m sets is gaining steadily, with 17,273 reported for June by RMA. The shortage of wood cabinets for consoles has been largely responsible for the small f-m receiver output. Over 88 percent of the sets were table models, and 6 percent were auto radios. Indications are that the overall total for January-through-June radio set production will be approximately 5,500,000 sets. In this half-year period only 200 television sets, chiefly show models, were reported.

FCC Predicts Radio's Future

THE MASTER PLAN of the newly formed Field Engineering and Monitoring Division of the FCC for policing the enormously expanded postwar radio spectrum went into effect July 1. It is based on the following estimated increases in traffic in the next few years: Standard broadcast stations, from 1,000 to 1,400; f-m stations, from 50 to 3,000; television stations, from six to 200 or 300; radio-equipped planes, from 3,000 to 50,000; aviation ground stations, from 700 to 2,500; two-way service for autos, taxicabs, etc., from one city to 200 cities; radio-equipped railroads, from one road to 150; fire department radio, from no cities to 5,000; citizen's walkie-talkie, from none to 200,000; amateur operators, from 60,000 to 100,000.

In addition, there will be thousands of channels for radar, point-to-point communication, diathermy, and other electromedical and industrial heating machines, ship-to-shore communication, multipurpose microwave relay links, and many other safety and special services. Furthermore, with highly developed small radio transmitters readily available, criminals can be expected to increase their efforts to use this weapon to outwit the law.

The new Division, a merger of the Radio Intelligence Division (RID) of wartime counterespionage fame with the Field Division, will be headed by George Turner and will be under the Field and Research Branch of the Engineering Department headed by assistant chief engineer George E. Sterling. George P. Adair remains chief of the Engineering Department.

Stereophonic Broadcasting

IN A SUCCESSFUL demonstration of three-dimensional radio program reproduction over the Netherlands radio on June 12, two appropriately positioned microphones picked up the same programs for two stations on different frequencies. Listeners in homes used two receivers, set at right angles and each tuned to one of the stations. Listeners found it easy to distinguish where the various instruments in the orchestra were placed, and found the return to one-radio listening disillusioning.

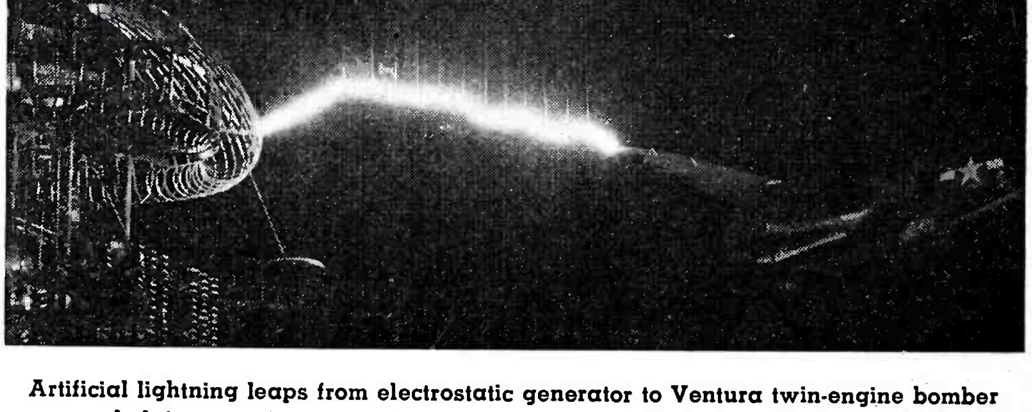
New RTPB Officers

THE FOLLOWING persons will serve as officers of the Radio Technical Planning Board for a period of one year beginning October 1, 1946: Chairman—Mr. Haraden Pratt of Mackay Radio and Telegraph Co.; Vice Chairman—Mr. J. L. Middlebrooks of the National Association of Broadcasters, Inc.; Secretary—Mr. George W. Bailey, President of the American Radio Relay League and Executive Secretary of the Institute of Radio Engineers, Inc.; Treasurer—Mr. Will Baltin of the Television Broadcasters Association.

Technical Agencies Merge

TWO EMERGENCY WARTIME technical agencies, the Office of Production Research and Development and the National Inventors Council, have been quietly merged into an agency to be known as the Office of Technical Services. The new technical agency will be headed by John Green, who was chief of OPRD and still has around a million dollars of its funds to spend in support of worthwhile research projects.

FIGHTING PRECIPITATION STATIC



Artificial lightning leaps from electrostatic generator to Ventura twin-engine bomber suspended from roof of special laboratory at Wold-Chamberlain Airport, Minneapolis during research on causes and cures for precipitation static

ANNOUNCING WILCO NI-SPAN C

A New and Unique Constant Modulus Alloy with Extremely High Physical Properties . . . . . higher hardness and tensile strength through heat treatment and the extremely important feature of a controlled thermoelastic coefficient permitting uniform production and performance of parts.

APPLICATIONS. All types of instruments and devices for stressed parts under load which must remain constant under temperature changes. *Example*—precision springs ranging from watch hairsprings to accurate scale springs; tuning forks; diaphragms for pressure instruments; bourdon tubes; strain gauges; proving rings. An ideal material for these and many other applications.

CONSULT OUR ENGINEERING DEPARTMENT. A representative of the WILCO Sales and Engineering Department will gladly help develop the proper application of WILCO special alloys to your products.

WILCO PRODUCTS INCLUDE

CONTACTS
Silver — Platinum
Tungsten — Alloys
Sintered Powder Metal

THERMOSTATIC BIMETAL
All temperature ranges, deflection rates and electrical resistivities.

SILVER CLAD STEEL JACKETED WIRE
Silver on Steel, Copper, Invar or other combinations requested.

ROLLED GOLD PLATE AND WIRE

SPECIAL MATERIALS

THE H. A. WILSON COMPANY
105 Chestnut St., Newark 5, N. J.
Branch Offices: Chicago, Detroit, Los Angeles

SPECIALISTS FOR 30 YEARS IN THE MANUFACTURE OF THERMOMETALS • ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS

WPB Statistics on Production of Components

THE FOLLOWING STATISTICS give the numbers of units shipped in 1944 and in the first half of 1945 for various radio and radar components, as compiled by the Radio and Radar Division of the War Production Board.

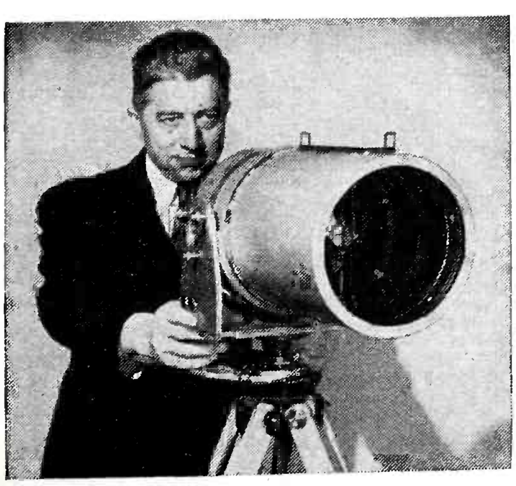
Capacitor Shipments

Type	Jan.-Dec. 1944	Jan.-June 1945
All types total	421,228,900	263,709,900
Mica, total	91,356,400	32,806,100
CM 20, CM 25	51,394,800	15,939,100
CM 30–35	28,396,300	12,021,000
CM 40	3,470,500	2,232,300
CM 45–50	3,460,500	1,676,700
CM 55–61	2,765,300	577,500
CM 65	454,500	24,400
CM 70, CM 75–95, Types 7, 8	1,414,500	335,100
Paper, total	236,267,600	169,247,700
Nonmetallic	121,905,300	117,311,900
Metal case	1,898,800	6,155,300
Metal tubular	38,802,000	8,929,500
Bathtub	16,226,800	6,878,500
Molded	27,283,900	13,206,200
Round can	8,199,000	6,253,100
Rectangular	19,769,600	10,513,200
Transmitting	2,182,200	....
Electrolytic, total	20,584,500	13,856,300
Cardboard case	5,536,500	3,818,800
Metal tubular	5,277,300	4,025,200
Bathtub	1,268,400	668,800
Octal base and rectangular	336,300	362,300
Round can	8,166,000	4,981,200
Ceramic tubular	66,932,100	36,777,700
Others*	6,088,300	11,022,100

* Includes miscellaneous types such as lectrofilm, mica button, mica toothpick, mica transmitting, mica bakelite tubular, ceramic potted, ceramic transmitting, ceramic molded, ceramic bakelite tubular, ceramic button, metal case potted, paper bakelite tubular, gas filled, vacuum, glass, and power factor button.

(*Continued on page* 261)

Heat Detector

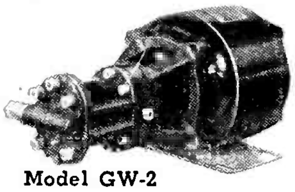


Thermistor bolometer developed for armed forces by Bell Telephone Laboratories can detect heat of person's body one-quarter mile away, locate chimneys of factories and stacks of ships at night, and increase the precision of temperature measurements in industry

TWO NEW SMALL EASTERN HIGH PRESSURE PUMPS

These two new gear pumps, GW-1 and GW-2, were specifically designed by Eastern to provide pumps to handle small volumes of liquids at high pressures. They are designed for pumping water or beverages. In addition, there is the GR series which is particularly suited for pumping light or heavy oils, fuel oil, glycerine, glycol, and other organic lubricating liquids. Because of the hardened steel gears used in the GR series they are not suited for use with water. Neither the GW nor the GR pumps require lubrication and therefore the possibility of any contamination of the liquid being pumped is eliminated.

CONSTRUCTION—The pump is close coupled to the motor and is driven through a splined shaft. Furnished with mechanical rotary seal only.



Model GW-2

MOTORS AVAILABLE—Semi-enclosed, totally enclosed or explosion proof Class I, Group D.

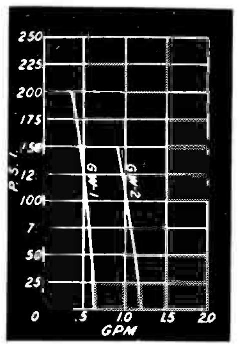
BELT DRIVE—An adaption of this unit is available for either belt drive or drive through a flexible coupling. Outlet and inlet tapped for 1/4" N.P.T. pipe thread.

PRIMING AND CONTROL—These pumps are self-priming with 6 foot lift. A built-in bypass can be furnished for pressure regulation.

ALLOYS—Available in bronze with special hardened stainless steel gears. Other alloys are available.

SPECIFICATIONS—Type: Gear. Size: 12 1/4" x 7" x 6". Weight: 26 lbs. Power: 1/8 H.P. split phase induction motors. Available in different motor enclosures in 110 volts and 220 volts A.C. Also other voltages.

PERFORMANCE—See Chart.



Eastern builds many other types of small industrial pumps, centrifugals both single and multistage, positive pressure pumps, laboratory pumps, air driven pumps, belt driven pumps and special purpose pumps. Whatever pumping need you have, especially where small size and light weight combined with high performance and economy of operation are factors, can be quickly filled by either one of Eastern's wide range of standard models or a specially designed pump. These pumps are described in the NEW CATALOG. Write for your copy now.

EASTERN ENGINEERING COMPANY

84 FOX STREET **NEW HAVEN, CONN.**

Find Out Now About

★ STAR ★ CERAMICS

There are many kinds for special uses, such as applications calling for resistance to electricity, heat, moisture, chemicals or weathering agents. There are more than a score of formulas in actual production at one time in our factory.

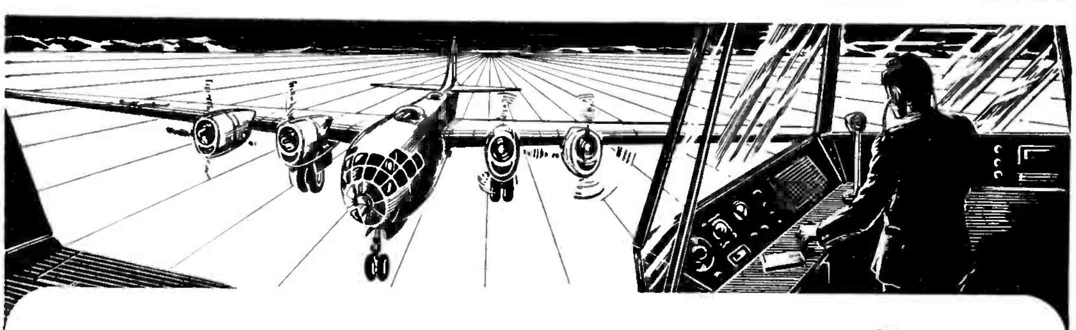
Send for "A Brief Survey of Technical Characteristics of Molded Ceramic Products." It is right to the point.

★

The STAR PORCELAIN CO.

Electronics Dept.

Trenton 9, N. J.



An Invitation to All Electrical Designers to

TRY SILVER GRAPHALLOY

for RELAYS MOTORS CONTROLS ELECTRONICS

FOR BRUSHES

High current density, low contact drop, low electrical noise, and self-lubrication are characteristics of this silver-impregnated molded graphite that may be the answer to your electrical brush problems

FOR CONTACTS

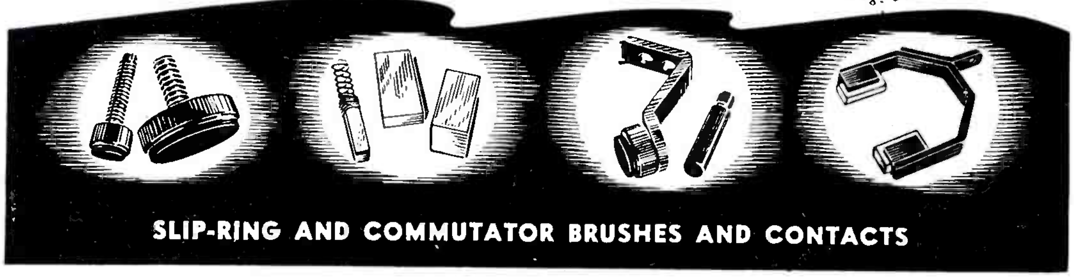
Low contact resistance and non-welding when breaking surge currents are inherent properties of this unique combination of conductive silver and self-lubricating graphite

SAMPLES of Silver Graphalloy will be gladly furnished for test on your applications. Silver Graphalloy is usually silver plated to permit easy soldering to leaf springs or holders. Why not WRITE NOW for your test samples?

ALWAYS SPECIFY GRAPHALLOY Trade Mark Reg. U.S. Pat. Off

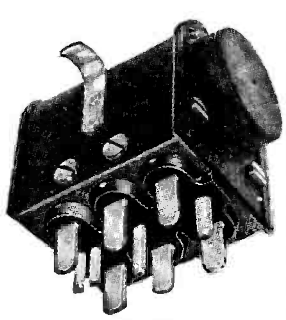
GRAPHITE METALLIZING CORPORATION

1055 NEPPERHAN AVE • YONKERS, NEW YORK

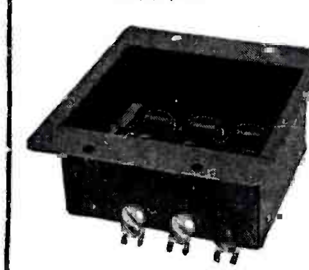


JONES 500 SERIES PLUGS and SOCKETS

(Heavy Duty)



P-506-CE



S-506-DB

Designed for 5000 Volts and 25 amperes per contact. Socket Contacts of phosphor bronze, knife-switch type, silver plated. Plug Contacts are of hard brass, silver plated. Made in 2, 4, 6, 8, 10 and 12 Contacts. All Plugs and Sockets are Polarized. Long leakage path from Terminal to Terminal and Terminal to ground. Caps and Brackets are of steel, parkerized. Plug and Socket blocks interchangeable in Caps and Brackets. This series is designed for heavy duty electrical work and will withstand severest type of service.

Write for Bulletin No. 500 describing this line of Heavy Duty Plugs and Sockets.

HOWARD B. JONES DIVISION

CINCH MFG. CORP.

2460 W. GEORGE ST. CHICAGO 18

Resistor Shipments

Type	Jan.-Dec. 1944	Jan.-June 1945
All types, total.....	585,936,200	338,127,300
Fixed composition, total..............	453,095,100	288,839,100
Insulated..............	433,759,800	280,854,000
Noninsulated..........	19,335,300	7,985,100
Variable composition..	19,932,600	8,601,800
Fixed wire wound....	38,547,300	14,922,100
Variable wire wound..	12,047,000	5,659,700
Precision wire wound.	3,871,700	3,149,200
Others*............	58,442,500	16,955,400

*Includes fixed wire-wound-molded, voltmeter multipliers, attenuators, suppressors, etc.

Component	July-Dec. 1944	Jan.-June 1945
Elec. indicating instr., total..............	2,109,399	1,724,778
Panels..............	1,802,875	1,482,597
Switchboards........	88,940	81,612
Polarized vanes......	217,584	160,569
Vibrators............	1,389,422	1,559,255
Switches..............	6,917,574	5,697,455
Coaxial cable, feet......	40,906	35,468

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.

NOV. 11-14; INTERNATIONAL MUNICIPAL SIGNAL ASSOCIATION—Annual Meeting; Miami, Florida; technical program and exhibits cover fire and police radio, signaling, etc.

NOV. 18-22; THE NATIONAL METAL EXPOSITION; Municipal Auditorium, Atlantic City, N. J.; held in conjunction with annual meetings of The American Industrial Radium and X-Ray Society, The American Welding Society, The American Society for Metals, and two sections of

the American Institute of Mining and Metallurgical Engineers.

DEC. 2-7; NATIONAL POWER SHOW; Grand Central Palace, New York City.

BUSINESS NEWS

HERLEC CORPORATION, Milwaukee, Wisconsin announces its formation for production of lines of fixed and variable ceramic capacitors and specialized switches. Organizers are Thos. B. Hunter, G. M. Ehlers, and H. W. Rubinstein, all formerly with Centralab.

DX RADIO PRODUCTS CO., INC. has moved into a modern three-story building at 2310 W. Armitage Ave. in Chicago.

PILOTLESS PLANE DIVISION is the new name of Ranger-Lark Division of Fairchild Engine and Airplane Corporation, Jamaica, N. Y.

BELL SYSTEM has filed applications with FCC for mobile radiotelephone stations along three more highways, between Washington and New York, between Buffalo and New York via Albany, and between Los Angeles and San Diego. Construction of stations for the New York-Boston and Chicago-St. Louis routes is already under way.

PACIFIC ELECTRONICS announces that its newly acquired Los Gatos, Calif. branch will manufacture and repair all types of transmitting and rectifier tubes, and may also enter the receiving tube picture within a year.

RCA VICTOR announces a field demonstration of closed-circuit televi-

Electronics Park

Model of General Electric's new electronics center in Syracuse, N. Y., being studied by Governor Thomas E. Dewey of New York (left) and Dr. W. R. G. Baker, G-E vice-president in charge of electronics

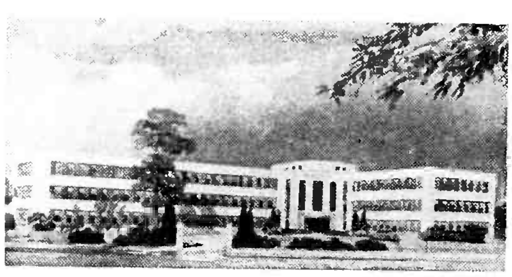
sion at the Iowa State Fair Aug. 21-30, using the new image orthicon television cameras.

HERMAN H. SMITH, INC., Mount Vernon, N. Y. has been organized by H. H. Smith, former president of Radio Essentials, Inc., to manufacture a line of radio and electronic components and hardware.

BRITISH ENGINEERS' ASSOCIATION, 32, Victoria St., London, S.W.1, has reopened the BEA-REGISTER, which provides a means for U. S. engineers, merchants, and importers to become linked with progress of British industry.

SUBMARINE SIGNAL CO. becomes the Marine Division of Raytheon Mfg. Co., its parent as a result of their recent merger. All Raytheon products with marine applications, including the new Mariners Pathfinder radar, will be distributed by Submarine Signal's present sales and service organization along with Fathometers, radio direction finders, and radiotelephones. The Marine Division of Mackay Radio and Telegraph Co. will continue to act as agent for distribution and maintenance of Raytheon's marine radar in the U. S.

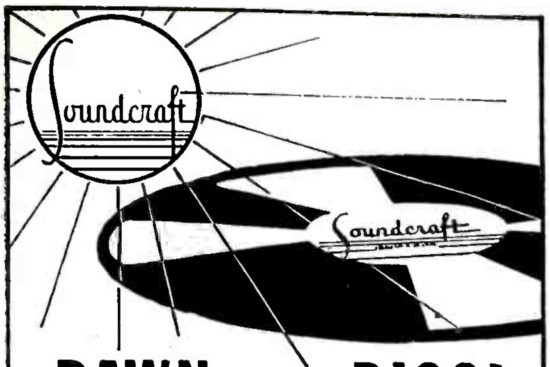
WESTON ELECTRICAL INSTRUMENT CORPORATION is constructing a T-shaped three-story engineering and administration building on the plant grounds at Newark, N. J. Floor area will be 78,620 square feet.



Artist's sketch of new Weston building

REEVES INSTRUMENT CORPORATION is the new name of the Apparatus Department of Reeves-Ely Laboratories, Inc., New York City. It is set up as a new corporation but ownership and management remain the same as before.

COLUMBIA BROADCASTING SYSTEM is starting construction of buildings to house experimental color television equipment on its Mount



DAWN OF A DISC!

The Features
You've Always *Wanted*
You Can Now *Have*

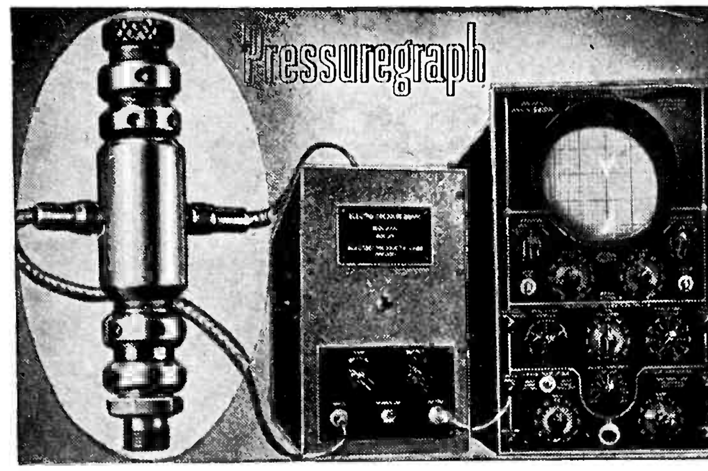
- MORE PERFECT RECORDING SURFACE. Soundcraft discs are free from outer-edge ridge — increasing usable area.
- "FULL SPECTRUM" FREQUENCY RESPONSE. Soundcraft's superior coating consistency provides the utmost resistance to break down of minute modulations.
- LOWER SURFACE NOISE. Soundcraft's coating lacquer is filtered microscopically clean, thus reducing the most objectional type of surface noise, the crackle.
- NEW QUALITY CONTROL. Soundcraft's *Disc Prover*, a revolutionary testing method, eliminates the need for numbering discs to locate poor lots in the field. "Mistake" discs cannot reach the shipping room.

Ask your radio parts jobber or write for the new Soundcraft Catalog

REEVES SOUNDCRAFT CORP.
10 EAST 52 ST., NEW YORK 22, N. Y.
PROGRESS ALONG SOUND LINES

New! PRESSUREGRAPH

LINEAR PRESSURE — TIME — CURVE INDICATOR



Indicates in linear response, on screen of cathode ray oscillograph, the pressure - time-curve of any internal combustion engine, pump, airline, or other pressure system where pressure measurements are desired. Covers wide range of engine speeds and pressures up to 10,000 p.s.i. Screws into cylinder and can be calibrated using static pressures. Vibration-proof. Accurate, dependable for frequent engine tuning. Simple operation—only one control.

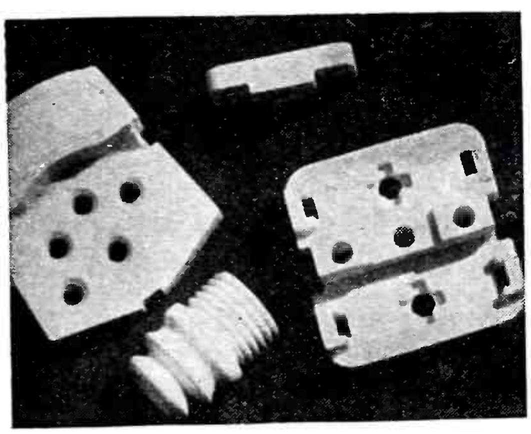
Also Pioneer Manufacturers of

THE FAMOUS Electro BATTERY ELIMINATORS

A complete line—Models for use anywhere beyond high line connections (operate from 6 volt battery)—Others for operation from 110 volt AC. Improve radio reception. Greatly reduce battery drain.

For complete information write

ELECTRO PRODUCTS LABORATORIES
549 W. Randolph St., Chicago 6, Ill. **Phone STate 7444**



Lavite STEATITE CERAMIC

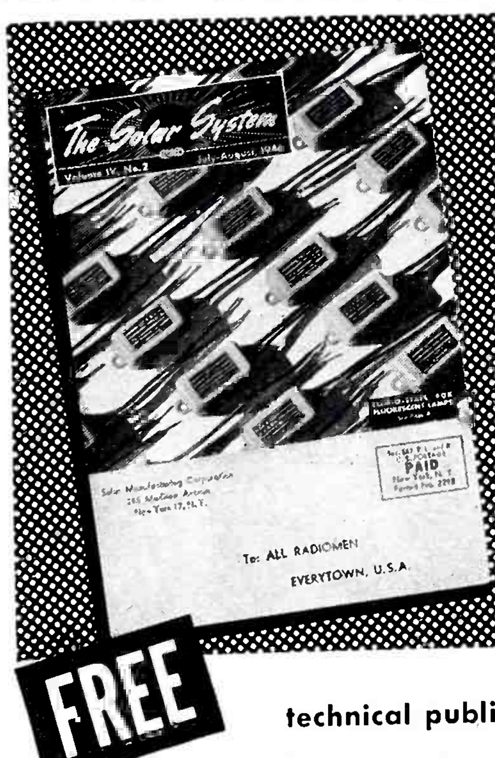
Properties and Characteristics of Our LAVITE S1-5 Steatite Ceramic Body

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 lbs. per square inch
Dielectric Strength	235 volts per mil
Dielectric Constant	6.42 } Frequency of 1 megacycle
Loss Factor	2.90 }
Power Factor	446 }
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	8.13x10—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



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Have You Seen The Solar System?

It's a bi-monthly magazine of authoritative information on new developments in the capacitor field. Simply fill in the coupon below if you'd like to receive this *easy-to-read* technical publication regularly at your home or at your office.

1689

EL

Solar Manufacturing Corporation
285 Madison Avenue, New York 17, N. Y.

Gentlemen: Please send me the SOLAR SYSTEM regularly, starting with the current issue.

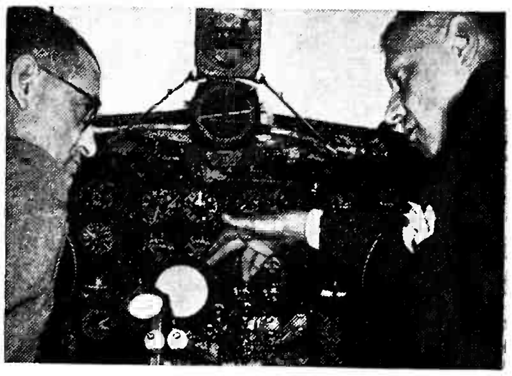
Name..........

Address..........

City.......... Zone No.......... State..........

Wilson site in California. The transmitter to be used is completed and under test already in the East.

General Electric Co. has installed an Army Air Forces APS-10 radar set in the Experimental Airlab Flagship of American Airlines to determine the practicability of radar for anticollision and weather-detecting



R. W. Ayer of American Airlines points to radar scope on flagship Alpha. W. R. G. Baker, G-E vice-president, is seated in pilot's compartment

purposes on commercial airlines. Equipment weighs 125 lb, and gives a ppi presentation on a five-inch scope located near the pilot. Antenna under nose of plane rotates to give 360-degree scanning.

Lear, Inc. has leased 68,000 square feet of floor space in the Grand Rapids plant of General Motors, for construction of variable capacitors and other radio components and for production of radio consoles, radio-phonograph combinations, record changers, and wire recorders.

Westinghouse Radio Stations, Inc. was granted FCC permission to construct an Experimental Class 2 radio station for operation of a portable radar set to be used in determining the position of Stratovision aircraft. A waiver of FCC rules for transmission of call letters was granted. The 2,700-2,900 megacycle band was assigned on a temporary basis.

National Bus Communications, Inc. has been granted its petition that the FCC make available for exclusive use of the intercity passenger bus industry a certain number of the frequencies available in the new general mobile radio service. Determination of the exact number of frequencies to be assigned has been deferred by the FCC pending results of experimental operation and a subsequent hear-

ing at which requests of other general mobile users will be considered. Particular bus lines may still elect to use radiotelephone service offered by existing general communications common carriers.

WILMOTTE MFG. CO. was granted the Naval Ordnance Development Award in recognition of distinguished service in connection with research and development of fire control radar Mark 29.

THE PIONEER ELECTRIC AND RESEARCH Corp., Forest Park, Illinois, has moved into a new and larger building in the same community and will expand its facilities for manufacturing coils. C. S. Linell, formerly with Carron Mfg. Co., is chief engineer.

REEVES SOUNDCRAFT CORP. has been formed in New York City for the manufacture of instantaneous recording discs, with Hazard E. Reeves as president.

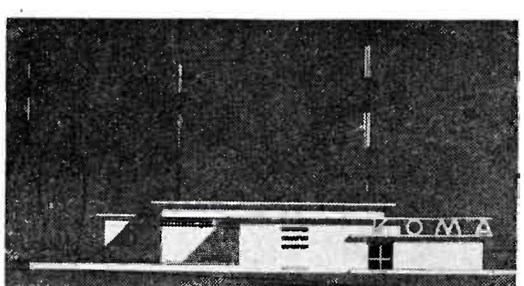
ALLEN B. DUMONT LABORATORIES, INC. has been granted a construction permit by FCC for a 5-kw television station in Washington, D. C. and will use the call letters WTTG, the last three letters of which are the initials of Dr. Thomas T. Goldsmith, Jr., director of research and engineering.

BENDIX RADIO DIVISION has been licensed to produce color television receivers under CBS patents.

CLIPPARD INSTRUMENT LABORATORY, INC., have acquired a new plant in Cincinnati, Ohio that will eventually furnish over 50,000 sq ft of floor space for manufacture of all types of r-f coils and coil assemblies, as well as specialized test equipment.

NATIONAL CARBON CO., INC., has acquired from the RFC the Charlotte, N. C. battery-manufacturing plant it

50 KW IN OIL FIELD



Artist's sketch of new KOMA 50-kw transmitter installation now under construction in the heart of a derrick-crowded oil-field nine miles south of Oklahoma City

operated for the Government during the war, and conversion to peacetime production of Mini-Max batteries is well under way.

RCA VICTOR DIVISION officially opened in Chicago its 160,000 sq ft plant devoted exclusively to the manufacture of automobile radios. About 700 persons, 70 percent female, are expected to be employed when full production is achieved.

LEAR, INCORPORATED, Grand Rapids, Mich., has begun mass production of variable capacitors to overcome market shortages, with 10,000 sq ft of plant space initially assigned for the purpose.

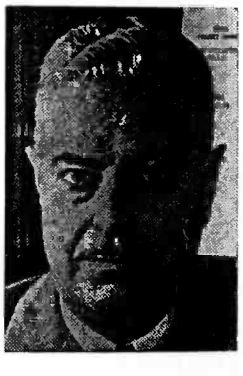
PHILCO CORPORATION has licensed the Radio Corporation of America to use approximately 600 Philco patents and inventions, including the Philco Advanced FM System.

ELECTROVOX CO., INC., has moved its factory and general offices to 31 Fulton St., Newark, N. J., where it will continue manufacture of Walco jewel-tipped phono needles.

PERSONNEL

LESTER N. HATFIELD becomes chief engineer of Press Wireless Manufacturing Corporation, Long Island City, N. Y. He was formerly chief sales engineer, and prior to that was a technician and engineer with CBS for ten years, chief engineer of radio station KWSC for three years, and served two years during the war as lieutenant with the electronics division of the Bureau of Ships.

L. N. Hatfield



P. Goldsborough

PAUL GOLDSBOROUGH, former president of Aeronautical Radio, Inc., has been named director of communications for Trans World Airline, where he will supervise TWA communications and air navigation policies for both transcontinental

and international divisions. Captain Goldsborough was released from active Navy duty June 15 after over four years of service on naval communications assignments.

RENALD P. EVANS, for the past three years general manager of The Turner Co., Cedar Rapids, Iowa, is now president. David Turner, founder of the company, becomes chairman of the board of directors.

FELIX L. YERZLEY has been appointed director of research and engineering for Mycalex Corporation of America, Clifton, N. J.

ARTHUR L. JOHNSON has opened a radio and chemical laboratory for general practice in Hutchinson, Kansas.

R. C. COSGROVE, vice-president and general manager of The Crosley Corp., was reelected president of the Radio Manufacturers Association.

HARRY S. JONES became chief engineer in charge of Research and Development for Lear, Incorporated, following a recent reorganization of engineering activities.

HARRY E. RICE became chief engineer of the Lear Home and Aircraft Radio Division.

JOHN A. PROCTOR, who served with ATSC, Army Air Forces, with the rank of Colonel during the war and contributed to development and production of communication and radar equipment, has been elected a director and vice-president of Mycalex Corporation of America, New York, N. Y.

J. A. Proctor

E. N. Wendell

EDWARD N. WENDELL is now vice president in charge of Federal Telephone and Radio Corp., Newark, N. J. He has been associated with IT&T, the parent company, since

1925 and was in charge of radio installations aboard the Queen Mary, directed engineering development of the Eiffel Tower television station in Paris, and directed Indianapolis tests of the IT&T instrument landing system.

MEADE BRUNET, a vice-president of RCA Victor Division at Camden, received a promotion to managing director of the RCA International Division with headquarters in New York City. He has been associnated with RCA since 1921, and was for five years in charge of production and distribution of RCA Radiotrons and Radiolas.

W. W. WATTS succeeds Meade Brunet as vice-president in charge of the Engineering Products Department of RCA Victor Division, Camden, N. J. He joined RCA Victor Division last February as general sales manager after serving in the Signal Corps during the war.

JAMES L. MIDDLEBROOKS, new engineering director of the National Association of Broadcasters, was awarded the Legion of Merit for his work during the war with the Electronics Division of the Bureau of Ships, where he attained the rank of Commander.

JAMES W. MCRAE has been appointed director of the Radio Projects and Television Research division of Bell Telephone Laboratories. He was recently released from active duty as a Colonel in the Signal Corps, and received the Legion of Merit award for his work in connection with development of airborne radar and radio and radar countermeasures. From 1937 to 1942 he carried out research at Bell Labs on transoceanic radio transmitters and on microwave communications equipment.

ARTHUR E. NEWLON, senior engineer in the research department of Stromberg-Carlson Co., was elected chairman of the IRE Rochester section.

THOMAS W. HOPKINSON has joined the staff of the Institute of Textile Technology, Charlottesville, Va. and will carry out research in electronics. For the last four years he was engaged in military electronic research at NRL, Washington, D. C.

NEW BOOKS

Electronics for Electricians and Radio Men

By THE TECHNICAL STAFF, *Coyne Electrical School. Coyne Electrical School, Chicago,* 1945, 426 *pages.*

THE MATERIAL in this text has been assembled to give the practical technician a start in the field of industrial electronic controls and processes. It is in no sense an engineering text, and on that account will be the more acceptable to the man to whom it is addressed. There is a regrettable but understandable gap between the circuit fundamentals and the finished commercial equipment described. A number of pages are devoted to a fairly comprehensive index of the material presented and to a chapter on maintenance and trouble shooting.—A.A.MCK.

• • •

Soul of Lodestone

BY ALFRED STILL. *Murray Hill Books, Inc., New York* 16, *N. Y.,* 1946, 233 *pages,* $2.50.

A FASCINATING compilation of speculations, investigations, and superstitions about lodestones and magnetism, from ancient times up through Oliver Heaviside but with emphasis on ideas extant in the Middle Ages, the Dark Ages, and the era of William Gilbert (1544-1603). The author has unearthed a wealth of human-interest anecdotes and quotations dealing with the attributed magical and healing qualities of lodestones and with early ideas about the magnetic compass. A nontechnical book that can be a valuable source of audience-awakening anecdotes for engineers called upon to speak before nontechnical audiences.—J. M.

• • •

Inductance Calculations

By FREDERICK W. GROVER. *D. Van Nostrand Co, Inc., New York, N. Y.,* 1946, 286 *pages,* $5.75.

FOR MANY YEARS the literature has been dotted with Dr. Grover's work on the calculation of inductance of various coil forms. Hence it is only natural that a book on the subject complete with working formulas, tables, and examples of such calculations should appear over his name. In it he has had the guiding

desire to simplify inductance calculations and inductor design. To this end he has provided for each special type of inductor a single simple formula involving only the parameters that naturally enter, together with numerical factors interpolated from tables computed for the purpose.

As the author says, although the literature is replete with inductance formulas, many of them involve elliptic integrals or allied functions, zonal harmonic functions, hyperbolics, or other forms of mathematics which make it appear to the engineer easier to wind and measure the coil than to design it beforehand. In all the more important cases Dr. Grover has found it possible to simplify the procedure and even in the more complex arrangements of conductors to outline a straightforward procedure. The mere task of computing the tables in this book could easily be described as monumental. An accuracy of one part in a thousand is possible in general, but for the most part use of the tables will lead to better precision.

The first several chapters deal with methods of using the working formulas; then follow 250 pages of the calculations and procedures themselves involving two general types of circuits—those whose elements are straight filaments and those made up of circular elements.
—K. H.

• • •

Electronics in Industry

By George M. Chute, *Application Engineer, General Electric Co. McGraw-Hill Book Co., New York* 18, *N. Y.*, 1946, 461 *pages*, $5.00.

Since this book is written primarily for the users of packaged electronic equipment already designed and built, it will be of little interest to the designer or builder of new equipment. The electrical engineer in industry will find the contents quite readable and useful, however, as his beginning text in a field that is demanding more and more of his own attention. There is no mathematics except for a bit of simple arithmetic in example problems, and no previous knowledge of tubes is assumed. The diagrams are well drawn and appropriately labeled, but the author's

conscientious attempts to employ the new ASA symbols without appreciably deviating from old electrical drafting styles has resulted in a few that would be rather bewildering to an electronic engineer.

The material is commendably arranged to maintain interest rather than follow a logical order, making the book highly desirable for home study, evening classes in industrial electronics, and vocational school use as well as for electrical engineering courses in colleges and universities. Chapters on tubes and basic circuits alternate with chapters on practical equipment, thereby making the doses of essential theory as small and painless as possible.

Equipment covered includes photoelectric relays, precipitrons, electronic timers, flame-failure controls, ignitrons, welding controls, motor controls, voltage and speed regulators, high-current rectifiers, electronic heating generators, photoelectric register controls, electronic test instruments, and non-electronic devices such as amplidynes, selsyns, dry-disc rectifiers, and saturable reactors.

Review questions, chiefly of the true-or-false type, appear at the end of each chapter, and appropriate films and filmstrips for use as visual aids are listed in the appendix.—J. M.

• • •

X-Rays in Practice

By Wayne T. Sproull, *Physicist, General Motors Corp. McGraw-Hill Book Co., New York* 18, *N. Y.*, 1946, 615 *pages*, $6.00.

A COMPREHENSIVE survey of practical radiographic techniques being used today in industry and in research, plus one chapter on the use of x-rays in the medical field. Material is arranged in logical sequence for college-level instructional purposes, with questions and problems at the end of each chapter. At the same time, the work is completely indexed for quick reference when answers to specific questions are desired, and extensive bibliographical footnotes provide a starting point for specialized study of a particular subject.

Of the twenty-four chapters, the first ten deal with history, fundamentals, types of tubes and equip-

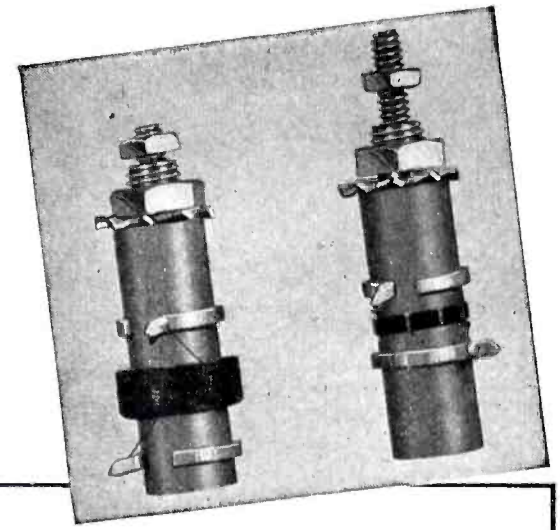
ment available, and basic principles of radiography and radioactivity. These chapters constitute also an excellent presentation of atomic theory, and give basic equations for those requiring quantitative relationships. The next two chapters give details of practical applications in the medical field and in industry. Such miscellaneous applications as fluoroscopy, automatic x-ray inspection, microradiography, coloring of glass with x-rays, biological and botanical mutation, instantaneous radiography, and measurement of wall thickness comprise a highly interesting chapter, bringing the reader just about to the middle of the book.

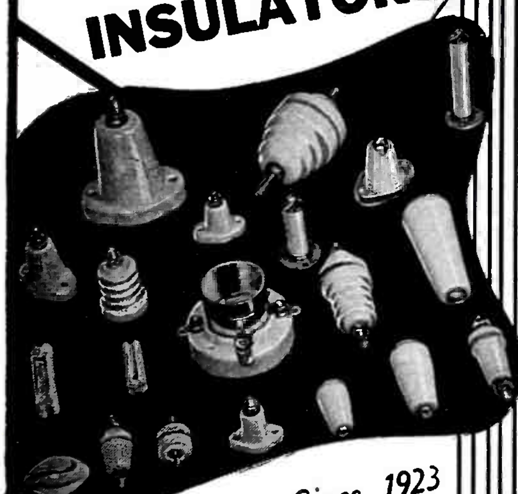
The remainder of the book covers crystallography and diffraction, with eleven chapters on x-ray diffraction for investigation of molecular and atomic structure, chemical analysis, measurement of strain, powder diffraction patterns of metals, orientation of quartz crystals, and textile fiber research. The final chapter deals with electron diffraction, included in the book because its theory and applications have evolved along lines similar to those for x-ray diffraction.

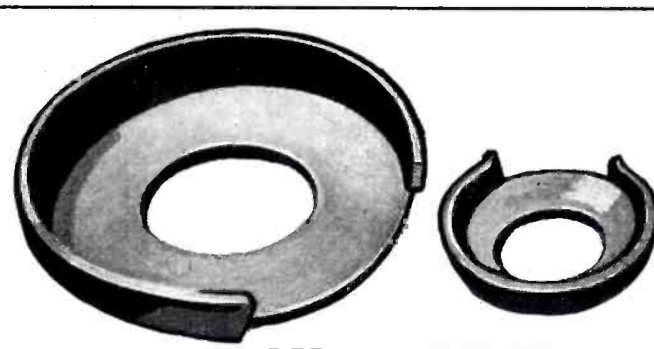
The chapters on x-ray operating techniques in industry cover such practical details as use of lead shot for masking to prevent fogging where x-rays go around edges of metal objects, use of mirrors or periscopes in fluoroscopic examination of oranges on a conveyor so operator will not be in the path of the rays, and use of two films in the holder to cut the time of long exposures in half yet obtain the same negative density by viewing both negatives at the same time.

In general, this is a clearly written piece of work that will bring engineers in electronic, electrical, and allied fields up to date in this fast-growing art and enable them to determine if any of the new techniques are applicable to their own work.—J. M.

TELEVISION with a 567-line image repeated 25 times per second on a 30 by 40-cm screen has been demonstrated by Philips Laboratories in Holland.







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.

Greek

THROUGH AN inexplicable chain of circumstances the following statement appeared in a new product item concerning an equation counter manufactured by the Consolidated Engineering Corporation of Pasadena and published in the May issue: "As an example of the performance of this computer, the expression Ευσυνείδητος can be solved for *E* in less than 5 seconds." The Editors hasten to state that this statement did not appear in the manufacturer's release and that they would be as much in the dark about the meaning of the Greek expression as anyone else had not the following letter been received—proving among other things that New Product items are closely read!
—The Editor.

Dear Sir:
I WANT TO bring to your attention an error on page 250 of the May, 1946 issue of ELECTRONICS. I find as the last sentence of an interesting account of an equation computer the following: "As an example of the performance of this computer, the expression Ευσυνείδητος can be solved for *E* in less than 5 seconds". Having some knowledge of the Greek language, I checked this word in the 8th Edition of the Liddell and Scott Greek Lexicon, p. 616, and found, as I thought, that the word means, "with a good conscience" and is found apparently only once in classical Greek in M. Anton. 6:30.

How this computer, wonderful as modern science is, can in five seconds compute "with a good conscience" is beyond the knowledge of your correspondent, unless, of course, you are implicitly giving to the inanimate computer a consci-

ence. Besides all this, the word was incorrectly spelled. There should be a smooth breathing mark, ʼ, before the E, and in the second place, there was a Latin "i" for the Greek iota in the third syllable of the word.

THE REVEREND JAMES MORGAN
Affiliation in
The Cathedral of Saint John the Divine
New York, N. Y.

• • •

Church Sound System

Dear Sir:

IN THE MARCH 1946 issue of ELECTRONICS there is an article on page 206 titled "Massive Speaker Cabinet" by Christian A. Volf. The author comments on the poor results obtained from carillons installed in modern church buildings. He states, "It is not that the concrete mass is detrimental, but that the steel girders, which form the skeleton of the structure, conduct the sound away from where it is wanted."

I believe the author has made an unfortunate mistake in his selection of examples to illustrate his points. The second church mentioned as an example is the East Liberty Presbyterian Church and not the Mellon Church as it is occasionally called. The church proper, exclusive of the Parish House, is a Gothic structure and the amount of steel used in the construction is practically negligible. It is a masonry vault with no steel frame work such as is usually associated with building construction today. Finally, there is no carillon installed in our belfry. At the present time there is one large bell which is used in the usual manner. We have installed in this belfry also four loud speakers. These have exponential horns and there is a Western Electric Type 555 reproducer attached to each horn. They can handle a total of only 20 watts electrical power. These are used for re-

—✧—

A TWENTY MILLION VOLT betatron unit has been installed at Picatinny Arsenal for use as an x-ray machine for revealing cavitation in the bursting charge of a shell or bomb or imperfections in the steel casings. It can take radiographs through 12 inches of steel.

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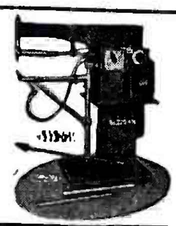

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CONTACTS

SECTION

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producing chime recordings and give very good reproduction in the vicinity of the church. No effort has been made to have the music carry to any great distance.

I do not know from what source the author of the article obtained his information regarding this church. The selection of this church as an example does not illustrate any of the points which the author is trying to emphasize in the article. I hope this letter will correct a false impression regarding this edifice.

WM. E. COCHRAN

East Liberty Presbyterian Church
Pittsburgh, Pa.

• • •

Crystal Rectifiers

Dear Sir:

IN YOUR HANDLING of my manuscript published in the July 1946 issue of ELECTRONICS, page 112, under the title "Crystal Rectifiers", several omissions and errors crept in.

The introductory paragraph, page 112, should include these sentences from the original manuscript. 'In this summary of present crystal rectifiers, no attempt is made to give credit or make reference to the work of numerous laboratories and individuals, which work produced the achievements described here. This credit will undoubtedly be given in technical articles, released NDRC reports and in one of the books of the Radiation Laboratory Technical Series.'

On page 117, fourth from last line and on page 119, 21 lines from the end, '3 microseconds' should be changed to 'three thousandths of a microsecond'.

Figure 5 title should read: 'Theoretical variation of resistance (A) and sensitivity (B) of a representative crystal with temperature'.

In caption of Figure 11 and in the ordinate label '(back to front resistance ratio)' should be omitted. Table II, page 116, top of first column 'Band (cm)' should be inserted. Table II, page 117, top '(Cont.)' should be inserted after High-Back-Voltage Crystals. Table III page 118, second column top 'mc' should be changed to cm.

W. E. STEPHENS

University of Pennsylvania
Philadelphia, Pa.

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E.

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RADIO INSTRUCTORS. Receiver servicing experience. College degree preferred. $3600 a year to start, $4200 after four months. Work in the heart of the Radio Industry. Write Raleigh G. Dougherty, 158 Market Street, Newark 2, New Jersey, c/o New York Technical Institute of New Jersey.

ENGINEER-PHYSICIST of inventive turn of mind with Ph.D. degree or equivalent who has knowledge of the fundamentals of electrical and mechanical engineering and a fair knowledge of inorganic chemistry. To work on fundamental problems involving pool type rectifier tubes for use in applications requiring motion and extreme impact shock. P-213, Electronics, 330 W. 42nd St., New York 18, N. Y.

ENGINEERS: JUNIOR and senior electrical engineers or physicists for general development engineering in television and allied radio and electronic fields. Established manufacturing concern located suburban New York City. P-214, Electronics, 330 W. 42nd St., New York 18, N. Y.

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SALARIED POSITIONS $2,500-$25,000. This thoroughly organized confidential service of 36 years' recognized standing and reputation carries on preliminary negotiations for supervisory, technical and executive positions of the calibre indicated, through a procedure individualized to each client's requirements. Retaining fee protected by refund provision. Identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 278 Dun Bldg., Buffalo 2, N. Y.

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TRANSFORMER ENGINEER: age 27, desires position in West or Midwest. Four years experience in design or power, audio, reactor, welding, wave filter components. Salary secondary to stability and location. PW-216, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

COMMUNICATIONS: LIEUTENANT Commander with demonstrated executive ability. Extensive civilian and Navy experience in radio, telephone, teletype, radar. Planning, traffic engineering, technical and traffic operation, training and management many diverse employees. Complementary interest in electrical, electronic. Theory and practice. BS (ME). Age 39. Now available, suitable contract US or overseas. Prefer warm climate. PW-217, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRICAL ENGINEER: 7 years experience. Presently employed. B.S. degree. Available for position in electrical or electronic engineering. PW-218, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

HEARING AID Engineer, 27, five years experience in design, development and production of modern hearing aids, home radio receivers, test and general electronic equipment, 3 years technical college, desires suitable position with well-established firm. PW-219, Electronics, 330 W. 42nd St., New York 18, N. Y.

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LARGE RECORDING Studio, completely equipped for commercial recordings. Write P. O. Box 913, Columbus, Ohio.

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The College of Applied Science, Syracuse University, is seeking candidates for two positions in its Department of Electrical Engineering, one of which will include the Chairmanship of the Department.

It is desired that each applicant have the following qualifications, although it is not expected that all will be fully met:

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4. Have had considerable background and training in Electro-magnetic theory.
5. Have had a few years' experience with commercial organizations as design or development engineer on radio equipment.
6. Age range preferred, 35 to 45 years.

Address correspondence to:

Louis Mitchell, *Dean*
College of Applied Science
SYRACUSE UNIVERSITY
Syracuse 10, New York

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5 Electronic Engineers

experienced in the development and design of high power transmitting tubes either ultra-high frequency or broadcast frequency experience desired.

P-206, Electronics
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Radio-Service Engineer WHO CAN WRITE!

A permanent, interesting and good-paying position for the right man *who can write* on modern post-war equipment and service methods. This may be "the very thing you've been looking for." Write, giving full qualifications and experience.

P-205, Electronics
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PHYSICISTS AND ELECTRICAL ENGINEERS

Wanted for

Vacuum Tube Research

Apply by letter stating qualifications to:

Director of Research

NATIONAL UNION RADIO CORPORATION
57 State Street, Newark, New Jersey

RADIO

COMPONENTS ENGINEER

experienced in design of R. F. & I. F. Components and circuits, both A. M. & F. M. essential. Locations New York area.

Excellent opportunity for qualified man with long established concern.

Box 537 Realservice 110 West 34th St. N. Y.

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Acoustic Engineers
Acoustic Physicists
Acoustic Research Assistants
to do
Research in the field of Acoustics

Full time or part time while carrying Graduate Work in Allied Subjects at Washington University. Stipend commensurate with proven ability and past earnings. Contact:

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Weston, 301, 3½" short scale galv, 10 microamperes ea side of center, scale 0-20 . . $3.95

Weston, 506, 2½" met case, 30-0-30 microamp mvt, 20-0-20 bk sc, Increased Sen. Near O . . . $3.50

Weston, 301, 3½" 50 microamp . . . $11.00

W.E., 3½" 100-0-100 microamp concentric sc . . . $4.00

Marion, 2½" 200 microamp undamped mvt, spec sc . . . $3.50

Weston, 301, 3½" 200 microamp . . . $7.50

G.E., DO-41, 3½" 200 microamp mvt, spec sc, knife edge pointer, comp with paper V-O-M.A. scale . . . $6.00

G.E., DO-41, 3½" 500 microamp mvt scale 20 K.V., comp with paper V-O-M.A. sc . . $4.95

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Weston, 301, 3½" metal case, 30 volt . . . $4.50

W.E., 40 volt D.C. 400 microamp mvt, 4½" round concentric style meter . . . $3.95

Weston, 506, 2½" dual range 0-50-500 volt, bk sc, 1000 ohms per volt . . . $3.95

W.H., BX, 2½" dual range 0-3.5-140 volt . . . $1.98

Weston, 301, 3½" 150 volt, 200 r/v . . . $4.95

Weston, 301, 3½" 150 volt, black sc . . . $4.50

Weston, 643, 4½" 150 volt . . . $9.00

Gruen, 2½" 150 volt . . . $3.50

Weston, 506, 2½" 200 volt D.C . . . $3.95

G.E., DO-41, 3½" 500 volt, 1000 r/v bk sc, $5.95

W.E., 3½" 500 volt, 1000 r/v, concentric style . . . $5.00

W.H., NX-35, 3½" 750 v, 1000 r/v . . . $10.50

G.E., DO-41, 3½" 1.5 K.V. comp with 1000 r/v ext prec resist . . . $6.95

G.E., DO-53, 3½" Square 15 K.V., comp with 1000 r/v ext prec resist . . . $16.00

W.H., NX-35, 3½" 15 K.V. comp with 1000 r/v ext prec resist L.P. $160.00. Your cost . . . $16.00

W.H., NX-35, 3½" 20 K.V., comp with 1000 r/v ext prec resist L.P $210.00. Your cost . . . $21.00

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Weston, 506, 2½" metal case, 1 M.A., bk blank sc, caption "Tuning" . . . $2.95

G.E., DO-41 1 M.A. mvt, knife edge pointer, spec bk sc comp with paper V-O-M.A. sc . . . $3.95

Weston, 506, 2½" met case, 1 M.A., bk sc . . . $3.50

G.E., DW-41, 2½" 1 M.A . . . $3.95

G.E., DO-41, 3½", 1 M.A . . . $4.95

G.E., DO-53, 3½" square, 1 M.A. mvt, 5000 ohm resist, 0-50 sc . . . $3.95

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Hickok, 3½", I-177 Dyn mutual cond tube checker meter, 0-1.6 M.A. mvt . . . $5.50

G.E., DO-41, ring mtd 3", 0-2.5-25 M.A. dual range, zero center . . . $2.50

Weston, 506, 2½", 3 M.A . . . $3.00

Simpson #127, 2" square, 5 M.A. mvt, spec sc . . . $2.50

G.E., DO-53, 3½", square, 20 M.A . . . $4.95

W.H., NX 35, 3½", 24 M.A . . . $2.50

G.E., DO-41, 3½" 30 M.A . . . $3.95

Weston, 506, 2½" 50 M.A . . . $3.95

Weston, 301, 3½" 50 M.A . . . $4.95

G.E., DO-41, 3½" 50 M.A. bk sc . . . $3.95

G.E., DO-41, 3½" 50 M.A . . . $4.50

G.E., DO-53, 3½" square case 50 M.A . . $4.50

G.E., DO-41, 3½" 80 M.A . . . $4.50

Simpson #26, 3½" 100 M.A . . . $4.50

Simpson #26, 3½" 200 M.A . . . $4.95

Marion, 3½" 200 M.A . . . $4.50

G.E., DO-41, 3½" 200 M.A . . . $4.95

Weston, 506, 2½" 200 M.A . . . $3.95

W.H., NX-33, 2½" 500 M.A . . . $3.95

D. C. AMMETERS

G.E., DO-41, 3½" 1 Amp, bk sc . . . $3.00

Weston, 643, 4½" 1.5, Amp, Bk sc . . . $7.00

Weston, 301, 3½" 2-0-2 Amp . . . $4.00

W.H., NX-35, 3½" 10 Amp . . . $4.95

Weston, 643, 4½" Surf Mtd 10-0-20 Amp . $8.00

Weston, 506, 2½" 15 Amp . . . $3.95

Triplett-Gruen 0321-T, 3½" 15 Amp . . . $4.50

W.E., 3½" 20-0-20 Amp, concentric sc . . $3.00

Hoyt 17-3, 2½" 50 Amp . . . $3.95

Weston, 506, 2½" 200 Amp with ext shunt . . . $9.50

G.E., DO-41, 3½" 200 Amp with ext shunt . . . $12.50

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W.H., NT-35, 3½" 50 M.A., L.P. $50.00. Your cost . . . $15.00

G.E., DO-44, 3½" 50 M.A., L.P. $50.00. Your cost . . . $15.00

G.E., DW-52, 2½" 250 M.A., bk sc, "0-5" "Antennae Current" 0-10 divis, comes with external couple. This combination has almost linear characteristics . . . $3.50

Weston, 425, 3½" 1 Amp Surf Mtd . . . $6.50

G.E., DO-44, 3½" 1.5 Amp . . . $6.50

Simpson, 2" 3 Amp, expanded at lower part of scale . . . $3.50

Weston, 507, 2½" 3 Amp bk sc . . . $3.50

G.E., DW-44, 2½" 4 Amp bk sc . . . $3.50

Simpson, 35, 3½" 5 Amp . . . $6.50

A. C. AMMETERS

Weston, 517, 2½" 3 Amp . . . $3.95

G.E., AO-22, 3½" 5 Amp movement, 50 Ampere scale, comes comp with external current trans. By adding primary turns to the "donut" trans the range of the meter can be made to 5-10-25 & 50 Amperes A.C. Diagram furnished . . . $7.00

G.E., AO-22, 3½" 50 Amp self contained . $4.50

Simpson, 3½" square case 60 Amp S.C. . $4.50

G.E., AO-22, 3½" 80 Amp S.C . . . $3.50

Weston, 476, 3½" 0-120 Amp, comp with external current transformer . . . $6.50

A. C. VOLTMETERS

Weston, 476, 3½" 8V . . . $4.00

G.E., AW-42, 2½" 10V . . . $3.95

G.E., AO-22, 3½" 15V bk sc . . . $4.50

Weston, 517, 2½" ring mtd, met case 15V . . . $2.95

G.E., AO-22, 3½" 1000 cycle, 50 volts, mtd on metal angle bracket with 6' Tyrex leads & clips . . . $2.50

Weston, 517, 2½" ring mtd met case 75V . $2.95

Weston, 476, 3½" 130 volt . . . $4.50

W.H., NA-35, 3½" 150 volt . . . $5.50

G.E., AO-22, 3½" 150 volt . . . $5.50

G.E., AO-22, 3½" 150 volt bk sc . . . $4.50

G.E., AO-25, 3½" sq case 150 volt . . . $5.50

W.H., BA-33, 2½" 150 volts . . . $2.95

Triplett, 232, 2½" 250 volt . . . $4.95

G. E., AO-22, 3½" 300 volt . . . $8.00

SPECIAL METERS

Weston, 301, 3½", Type 61 Decibel-10+6, 6 M.W. 600 ohms high speed type .29-.35 sec. to final reading L.P. $24.50. Your cost $9.50

G.E., DW-46, 2½", DB-10+5, 6 M.W. 600 ohms zero DB = 1.90 volts . . . $4.50

Weston, 301 Power Level Indicator, 625 Microamp 1.2 volt A.C. mvt, self cont rect, blank sc . . . $6.00

G.E., DO-46, 3½" 400 Microamp 3 volt A.C. mvt, self cont. rect, Spec sc . . . $5.50

W.E., 3½" D.B. Suppressed Zero, F.S=2M.A. D.C . . . $1.95

Marion, 2½" ring mtd "S" meter made for National Co. 1 M.A. mvt, scale "1-9 S units 0-40 D.B. above S 9" . . . $3.50

Biddle, M.F. 7, 3½" Freq. 57-63 cycles 100-150V, 7 reed . . . $6.00

Weston, 705, Sensitrol relay 100 microamp, Solenoid reset, S.P. norm closed . . . $7.50

G.E., Totalizing hour meter, 3½" 5 Digits, 99,999 hrs, 115 volt 60 cycle . . . $4.95

Hickok, 47, 3½" Wattmeter 0-75 Watts, 120 volts 1.6 Amp, bk sc . . . $6.00

G. E., miniature, 1½" square, 1 M.A. 100 ohm mvt, 10 divis sc, bk sc . . . $2.75

Roller Smith, miniature, 1½" sq 1.37 M.A. mvt, spec bk sc . . . $2.50

Roller Smith, miniature, 1½" sq 2 M.A. mvt, with 2' lead & plug jack 0-10 div sc . . $2.50

All meters are white scale in round, flush, bakelite cases, unless specified otherwise.
Add sufficient money on parcel post orders, excess will be refunded.

MARITIME SWITCHBOARD • Worth. 4-8217 • 336 Canal St., New York 13, N. Y.

AIRCRAFT METERS

W. H., 2½" Aircraft type 0-150 volt A.C. bk sc lum markings, suitable for use from 25 to 125 cycles $1.50

W.H., 2½" Aircraft type 0-30 volt D.C., bk sc, lum mkgs 5 M.A. movement 6000 ohm resist $1.25

G.E., 2½" Aircraft type, spec black 10 div scale, lum mkgs 1-0-1 M.A. mvt $1.00

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WESTON MODEL 528

Dual Range 0-3 Amp. and 0-15 Amp. full scale for use on any frequency from 25 to 500 cycles. The ideal instrument for all commercial, industrial, experimental, home, radio, motor and general repair shop testing. Comes complete with a genuine leather, plush-lined carrying case and a pair of test leads. A very convenient pocket sized test meter priced at **less than 50% of manufacturers list.**

Your cost **ONLY** $12.50

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FOUR METERS

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A. C. VOLTMETER Westinghouse, 2½", Aircraft Type 0-150 Volts, Black scale, luminous markings. Suitable for use from 25 to 125 cycles.

D. C. VOLTMETER General Electric, 2½", Aircraft Type, 0-30 Volts, Bl. sc., lum. mkgs., 5 M.A. movement.

D. C. MILLIAMMETERS General Electric, 2½", Aircraft Type, special black 10 division scale, lum. mkgs. 1-0-1 milliampere movement.

D. C. MILLIAMMETER General Electric 1¾" square miniature meter, special black scale 1.37 M.A. movement full scale.

Total List Price Approximately $60.00

Now Available at

ONLY $4.95 F.O.B. N.Y.C.

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6 TEST INSTRUMENTS

An ideal set of meters for laboratory, shop and industrial use.

- **Matching meters**
- **Flush mounting, 5½", Square**
- **Movement accuracy ±1%**
- **Large 5" scale**
- **Knife edge pointers**
- **34 A.C. & D.C. ranges**

This set consists of the 6 following Westinghouse meters types HA and HX.

D.C. MICROAMMETER, 0-150 ua movement with 0-150 and 0-750 microampere scale. Complete with ext. shunt to increase range to 0-750 microamperes.

D.C. MILLIAMMETER, 0-1 M.A., 0-750 MV movement, with 0-15 and 0-75 scale. Complete with ext. shunts to increase range to 0-1½, 0-7½, 0-15, 0-75, 0-150, 0-750, 0-1500 milliamperes and 0-7½, 0-15, and 0-75 amperes.

D.C. VOLTMETER, 0-750 MV 0-1 M.A. movement with 0-75 scale. Complete with ext. resistor to increase range from ¾ volt to 0-1½, 0-7½, 0-15, 0-75, 0-150, 0-750 and 0-1500 volts.

A.C. MILLIAMMETER, 0-150 and 0-750 M.A. A.C. movement with 0-150 and 0-750 scale.

A.C. AMMETER, 0-5 Amp. movement with 0-1, 0-5, 0-10 scale complete with transformer to make the following ranges 0-1, 0-5, 0-10, 0-50 amperes full scale.

A.C. VOLTMETER, 0-3, and 0-75 volt dual voltmeter movement. Complete with resistors to make these ranges, 0-3, 0-6, 0-15, 0-30, 0-75, 0-150, 0-750, 0-1500 volts A.C.

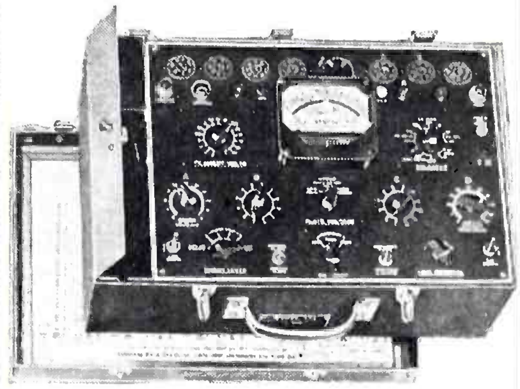
SURPLUS NEW GUARANTEED

This combination has a total List Price of approximately $400 and can now be purchased for

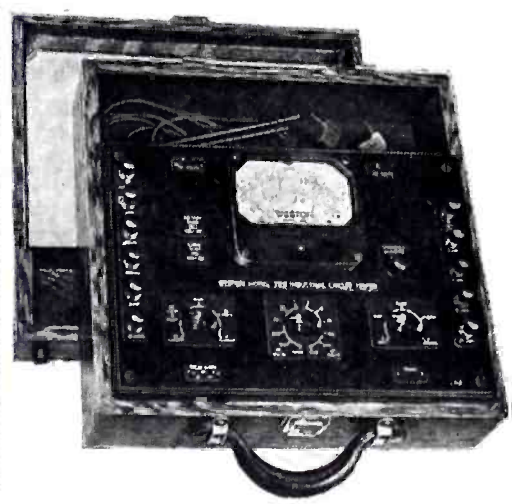
ONLY $85.00 F.O.B. N.Y.C.

NEW WESTON Test Equipment

In Stock— For Immediate Delivery



MODEL 798—JUST OUT—MUTUAL CONDUCTANCE TUBE CHECKER & SET ANALYZER. Tube Checker Ranges 0-3000, 6000, 12,000 micromhos and Good-Bad Scale. Analyzer Ranges 0-15, 150, 750 Volts A.C. & D.C. 7.5 & 150 M.A. D.C., 100,000 & 1,000,000 ohms $182.64



MODEL 785—INDUSTRIAL CIRCUIT TESTER—Ideal for Radio & Industrial Applications For Shop Use, less carrying case $85.37
With carrying case $101.63

MODEL 779—SUPERSENSITIVE ANALYZER—For Simplified Radio Set Analysis $74.62

MODEL 697—VOLT-OHM MILLIAMMETER $25.89

All Above Factory Guaranteed for 90 days

Shipped Anywhere In U. S. prepaid

MARITIME SWITCHBOARD

336 Canal St. Worth 4-8217

SIGNAL CORPS TEST UNIT

1-85-D

Made by Wester Elect Co. Consists of a Weston, 301, 3½", 0-1 Milliammeter with a 5 point switch and precision resistors in a metal case. Made for measurements of 50, 500 & 1000 Volts D.C. and 25 & 250 M.A. D.C. Can be readily adapted for use as a volt-ohm-milliammeter. Comes Complete with paper V-O—M.A. scale

Only $7.50

We carry a complete line of electrical instruments. Send us your requirements. METERS ARE OUR SPECIALTY.

MARITIME SWITCHBOARD • Worth. 4-8217 • 336 Canal St., New York 13, N. Y.

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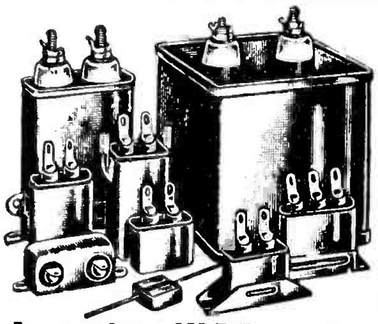

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In quality, WAA surplus units are equal or superior to commercial items. All units have passed government inspection to Army and Navy specifications—a reinforced quality assurance.

As Agents of the War Assets Administrator, Tobe Deutschmann Corporation places these enormous stocks—products of all the principal manufacturers—directly at your disposal.

WRITE . . . WIRE . . . PHONE . . . FOR IMMEDIATE SHIPMENT!

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Acting as Agents of the War Assets Administrator Under Contract No. SIA-2-34

ABUNDANT STORES OF GOVERNMENT SURPLUS

Instruments - Receivers - Transmitters
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Varieties and quantities ample for manufacturers' production, and for needs of industrial, school and college labs. Now available from one of the largest Central Clearing Agencies in the East for War Assets Administrator under Contract No. S1A-3-54. Write, wire, or phone for descriptive bulletins and price lists. Tel. LAFayette 7392.

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55,000 Sq. Ft. of Government-owned electronic parts and equipment. All material inspected and tested; backed by usual 90-day manufacturers' guarantee.

Sorry, no retail sales; all purchases against company orders only.

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Central Agent for War Assets Adm.
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Main Office: 120 Greenwich St., New York 6

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ELECTRO-TECH *Equipment Co.*
119 Lafayette St., New York 13, N. Y.

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Electrical instruments, Tube Checkers and Analyzers repaired.
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Universal Coil Winding Machine #96 and 103

NEW ENGLAND TRANSFORMER CORPORATION
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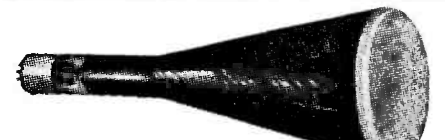
CATHODE RAY TUBES BRAND NEW!!

MADE BY NORTH AMERICAN PHILLIPS CO.



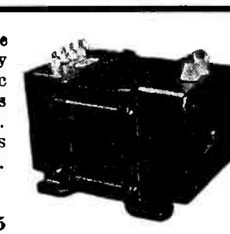
Tube Type	Approx. List	Your Cost
2AP1	9.00	3.75
3BP1	15.00	3.95
3FP7	27.00	5.35
5BP1	20.00	4.95
5BP4	27.00	5.95
5CP1	28.00	4.95
5CP7	45.00	6.00
5FP4	47.00	6.25
5JP1	50.00	13.50
5JP2	48.00	13.50
5JP4	54.00	13.50
5LP1	41.00	8.00
723 a/b	38.00	7.75
813		10.00

Klystron Converter-Amplifier with 2—6AC7's & 2—723 a/b's . . . . $26.

We have many of these tubes in large quantities for manufacturers. Inquire!

HI - VOLTAGE plate transformer, made by Amertran. 115v 60c input. Secondary is 6200 v-ct @ 700 mils. Physical dimensions 10"x14x11. List $200.

Specially Priced at $39.95



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RAK-7 Navy Receiver 9 tubes, regulated power pack, frequency range: 15KC to 600 KC. 115v ac operation. With tubes and 73 lb. spare parts case. Price reduced to $73.50

BC-412 Oscilloscope from the SCR-268. Complete with tubes, and conversion diagram. Operates on 115v 60 cycle. . . . $54.50

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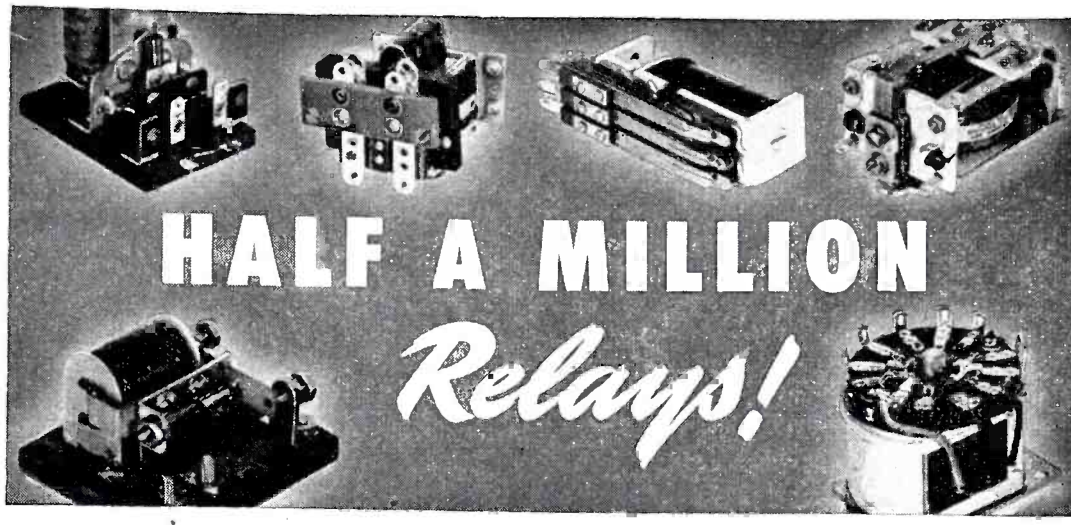

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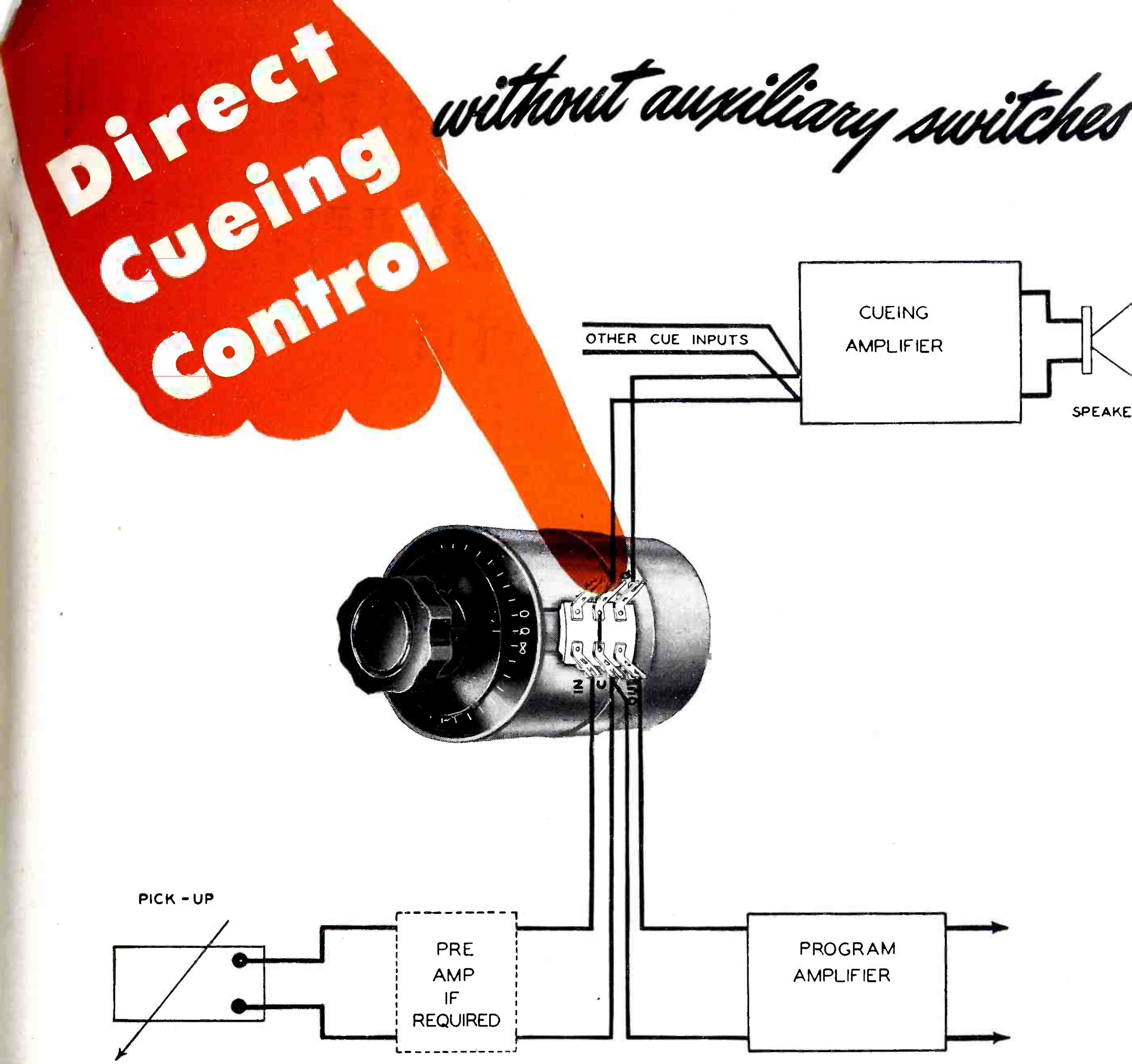

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